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Reaffirmation with Errata
May 2004

DOE HANDBOOK

Radiological Worker Training

U.S. Department of Energy
Washington, D.C. 20585

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April 2004 Reaffirmation changes to DOE-HDBK-1130-98, Radiological Worker Training

Section/page/para	Change
Part 1, page 3	Under "Student's Guide" deleted reference to draft not being included. Revised Wordperfect 9.0 to Word 2002. Revised web address: http://tis-nt.eh.doe.gov/wpphm/rst/rst.html To: http://www.eh.doe.gov/whs/rhmwp/RST/rstmater.htm
Part 2, page 4 and part 3 page 3	A.1. Deleted "similar to the way planets orbit our sun" and twice revised atomic weight to mass number.
Part 2, page 8 and part 3 page 6	7.a Revised to read: It is important to note that exposure to ionizing radiation, without exposure to radioactive material, will not result in contamination of the worker.
Part 2, page 22 and part 3 page 17	Under "Man made sources…" deleted domestic water supply and revised 1st sentence to read: The difference between manmade sources of radiation and naturally occurring sources is the origin of the source, i.e., where the radiation is either produced or enhanced by human activities.
Part 2, page 26 and part 3 page 20	1.b. Revised into to: Acute doses to the whole body
Part 3, Cover	Revised date to May 2004

Foreword

This Handbook describes an implementation process for core training as recommended in Implementation Guide G441.12, *Radiation Safety Training*, and as outlined in the *DOE Radiological Control Standard* (RCS). The Handbook is meant to assist those individuals within the Department of Energy, Managing and Operating contractors, and Managing and Integrating contractors identified as having responsibility for implementing core training recommended by the RCS. This training is intended for radiological workers to assist in meeting their job-specific training requirements of 10 CFR 835. While this Handbook addresses many requirements of 10 CFR 835 Subpart J, it must be supplemented with facility-specific information to achieve full compliance.

This Handbook contains recommended training materials consistent with other DOE core radiological training materials. The training material consists of the following documents:

Program Management Guide - This document contains detailed information on how to use the Handbook material.

Instructor's Guide - This document contains a lesson plan for instructor use, including notation of key points for inclusion of facility-specific information.

Student's Guide - This document contains student handout material and also should be augmented by facility-specific information.

This Handbook was produced in Word 2002 and has been formatted for printing on an HP 4M (or higher) LaserJet printer. Copies of this Handbook may be obtained from either the DOE Radiation Safety Training Home Page Internet site (http://www.eh.doe.gov/whs/rhmwp/RST/rstmater.htm) or the DOE Technical Standards Program Internet site (http://tis.eh.doe.gov/techstds/). Documents downloaded from the DOE Radiation Safety Training Home Page Internet site may be manipulated using the software noted above.

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DOE-HDBK-1130-98

Part 1 of 3

Radiological Worker Training

Program Management Guide

Coordinated and Conducted
for
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U.S. Department of Energy

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Introduction

Purpose and Scope

This guide describes the DOE Radiological Worker I and II (RW I and II) training programs. It includes standards and policies as well as recommendations for material development and program administration. It is intended for use by DOE contractors for the development of facility-specific radiological worker training.

Compliance with 10 CFR 835-Subpart J

The DOE core training materials for RW Training reflect the requirements identified in 10 CFR 835-Subpart J, "Radiation Safety Training" and recommendations identified in the DOE Implementation Guide G441.12, *Radiation Safety Training*, and in the *DOE Radiological Control Technical Standard.* When implemented in its entirety and supplemented as noted with appropriate facility-specific information, this handbook will generally meet the requirements of 10 CFR 835-Subpart J for radiological worker training. However, it is incumbent on management of each facility to review the content of this course against the radiological hazards present to ensure that the training content is appropriate to each individual's prior training, anticipated and actual assignments, and degree of exposure to potential radiological hazards.

Training described in this guide does not eliminate the need for additional training for facility-specific hazards. Notations throughout the program documents indicate the need for facility-specific information. If the noted section is not applicable to the facility, no information is required to be presented. The site Radiological Control Manager or designee should concur in facility-generated radiological training material.

Goal of Training Program

The goal of the core training program is to provide a high level of knowledge and skills in radiological fundamentals for the radiological worker at all DOE facilities.

Organizational Relationships and Reporting Structure

DOE Office of Worker Protection Policy and Programs (DOE EH-52) is responsible for approving and maintaining the core training materials associated with the RW I and II training programs.

The establishment of a comprehensive and effective contractor site radiological control training program is the responsibility of line management and their subordinates. The training function may be performed by a separate training organization, but the responsibility for quality and effectiveness rests with line management.

Training Program Descriptions

Overview of Training Program

Radiological Worker I Training is intended for radiological workers whose job assignments require unescorted access to Radiological Buffer Areas, Radiation Areas, or Radioactive Materials Areas. The RW I program consists of the core academic material plus the appropriate practical factors evaluation and lessons learned.

The High/Very High Radiation (HR/VHR) Area module may be added to the Radiological Worker I course to give personnel unescorted entry into High Radiation Areas where contamination is not present.

Radiological Worker II Training is intended for radiological workers whose job assignments involve unescorted entry to High Radiation Areas, Contamination Areas, High Contamination Areas and Airborne Radioactivity Areas. Further, workers who have potential contact with hot particles or use of gloveboxes with high contamination levels should complete Radiological Worker II training.

The RW II program consists of the RW core academic material, the HR/VHR Area module (this may be deleted for certain sites, such as uranium mill tailings remediation projects, which do not have HR/VHR Areas), the Contamination Control module, the applicable practical factors evaluation, and lessons learned.

Description of Programs

Core Academic Material is approximately 8 hours in length but will vary dependent upon the amount of facility-specific material. RW Core Academic Training includes the following modules (1-7):

Radiological Fundamentals (Module 1)

- Atomic Structure
- Definitions and Units of Measure
- The Four Basic Types of Ionizing Radiation
- Units of Measure for Radiation

Biological Effects (Module 2)

- Sources of Radiation
- Effects of Radiation on Cells
- Acute and Chronic Radiation Dose
- Prenatal Radiation Exposure
- Risks in Perspective

Radiation Limits (Module 3)

- Basis for and Purpose of Radiation Dose Limits and
- Administrative Control Levels
- Dose Limits and Administrative Control Levels
- Worker Responsibilit ies Regarding Dose Limits

ALARA Program (Module 4)

- ALARA Program
- Responsibilities for the ALARA Program
- External and Internal Dose Reduction
- Radioactive Waste Minimization

Personnel Monitoring Programs (Module 5)

- External Dosimetry
- Internal Monitoring
- Methods for Obtaining Radiation Dose Records

Radiological Access Controls and Postings (Module 6)

- External Dosimetry
- Internal Monitoring
- Methods for Obtaining Radiation Dose Records

Radiological Emergencies (Module 7)

- Emergency Alarms and Responses
- Radiological Emergency Situations
- Considerations in Rescue and Recovery Operations

Radiological Worker I

Radiological Worker I training consists of the RW core academic material (Modules 1-7) plus the applicable practical factors (Module 10.1).

Practical Factors for RW I (Module 10.1)

The recommended evaluation for RW I consists of the following topics:

- Review an Appropriate Radiological Work Permit (RWP)
- Record the Appropriate Information on the RWP
- Select and Wear Required Dosimeter(s)
- Enter Simulated Area and Demonstrate ALARA Techniques
- Monitor for Contamination (e.g., hand and foot monitoring on exiting RBA)
- Respond to Emergency Situations or Abnormal Radiological Situations

It may be necessary for an RW I qualified individual to enter an HR Area. If this becomes necessary, then the HR/VHR training should be presented, along with the applicable practical factors (Modules 10.1 and/or 10.2).

High/Very High Radiation Area Training (Module 8)

The materials for the HR/VHR Area Module include the following:

- High and Very High Radiation Area Definitions
- Signs and Postings
- Entry, Work In, and Exit from High Radiation Areas
- Access Controls for High and Very High Radiation Areas

Practical Factors for High Radiation Areas (Module 10.2)

The recommended evaluation for RW I (High Radiation Area) consists of entry, work, and exit requirements:

- Identify High Radiation Area signs
- State special controls on RWP
- State area radiation levels (with appropriate units)
- State facility-specific administrative control levels
- Select dosimetry in accordance with RWP
- Wear dosimetry in accordance with procedures
- Perform pre-operational checks (as appropriate) on survey meter and/or dose rate indicating device
- Record appropriate information on RWP prior to entry
- Verify current radiation survey prior to first entry
- Enter only areas designated on RWP
- Maximize distance from higher radiation areas
- Do not loiter
- State appropriate actions to take when a radiation area monitor alarms
- Record appropriate information on RWP upon exit

Radiological Worker II

RW II Core Training is approximately 16 hours in length but will vary dependent on the amount of facility-specific material. RW II includes the core academic material modules (1 - 7), HR/VHR Area module (8), Contamination Control module (9), and RW II Practical Exercise module (10.3).

Radioactive Contamination Control (Module 9)

The radioactive contamination control module includes the following topics:

- Comparison of Ionizing Radiation and Radioactive Contamination
- Types of Contamination
- Sources of Radioactive Contamination
- Contamination Control Methods
- Contamination Monitoring Equipment
- Decontamination
- Types of Contamination Areas
- Lessons Learned

Practical Factors for RW II (Module 10.3)

The recommended evaluation for RW II consists of the following topics:

- Review an Appropriate Radiological Work Permit (RWP)
- Record the Appropriate Information on the RWP
- Select Required Dosimeter(s) and Protective Clothing
- Don Protective Clothing and Dosimeter(s)
- Enter Simulated Area and Demonstrate Contamination Control Practices
- Remove Protective Clothing and Dosimeter(s)
- Monitor for Contamination
- Respond to emergency situations or abnormal radiological situations

Specialized Radiological Worker Training

Specialized Radiological Worker Training should be completed for non-routine operations or work in areas with changing radiological conditions. This training is in addition to Radiological Worker II training and is required for personnel planning, preparing, and performing jobs that have the potential for high radiological consequences. Such jobs may involve special containment devices, the use of mockups, and ALARA considerations. In some cases, depending on facility-specific criteria, pre-job briefings provide an acceptable alternative to Specialized Radiological Worker Training.

Individuals who install, inspect, or work in radiological containments shall be trained commensurate with their duties. Individuals that wear respiratory protection need to be medically qualified and wear the equipment as trained in accordance with OSHA standards and DOE requirements. This training is in addition to Radiological Worker II training.

Refresher Training

Refresher training programs for RW I and II training may be implemented in the alternate year when full retraining is not completed or in response to observations or indications of poor radiological performance. Refresher training is intended to maintain and enhance the proficiency of the worker. The refresher training for RW I and II training should be documented.

RW I and II refresher training may be accomplished through any available media. This may include video, handout, computer- based training or classroom training.

RW I and II refresher training should include changes in requirements and lessons learned from operations and maintenance experience, and occurrence reporting for the site and across the DOE complex. The following topics may be included: New procedures and changes to existing procedures

- New equipment and changes or modifications to existing equipment or facilities
- Lessons learned from facility operating experiences
- Lessons learned from industry operating experiences
- Identified deficiencies from post training evaluations

Proficiency Requirements

In accordance with 10 CFR 835-Subpart J, each individual shall demonstrate knowledge of the radiation safety training topics established in § 835-Subpart J, commensurate with the hazards in the area and required controls, by successful completion of an examination and performance demonstrations prior to being permitted unescorted access to radiological areas and prior to performing unescorted assignments as a radiological worker.

A written examination and a practical factors evaluation shall be used to demonstrate satisfactory completion of RW I, HR/VHR Area, and RW II training (10 CFR 835 - Subpart J). These exams may be combined into one exam if the training is presented as one training class.

- The minimum passing score for any written examination should be 80%.
- A minimum passing score on the practical evaluation should be 80%.
- Computer-based and other electronic methods of examination are acceptable.

Retraining

In accordance with 10 CFR 835-Subpart J, RW retraining shall be provided to individuals when there is a significant change to radiation protection policies and procedures that may affect the individual and at intervals not to exceed 24 months. The requirements of 10 CFR 835-Subpart J for examination apply.

Retraining should include selected fundamentals of the initial training with emphasis on seldom-used knowledge and skills. Retraining should be tailored to subjects for which trainee evaluations and experience indicate that special emphasis and depth of coverage is needed.

A self-study method may be used, when possible, for retraining. A suggestion for a self-study method is to allow the workers to self study the training material; present any updates or changes, lessons learned, etc.; then allow the workers to take the examination and applicable practical exercise.

Minimum requirements for RW I and RW II retraining should be successful completion of the written examination, practical exercise, and training on lessons learned/new procedures.

Materials developed in support of retraining should be documented in accordance with 10 CFR 835.704 "Administrative Records."

Instructor Training and Qualifications

All classroom instruction should be provided by instructors qualified in accordance with the contractor's site instructor qualification program. Training staff (contractor and subcontractor, if used) should possess both technical knowledge and experience, and the developmental and instructional skills required to fulfill their assigned duties.

1. Training staff responsible for program management, supervision, and development should have and maintain the education, experience, and technical qualifications required for their jobs.

2. Instructors should have the technical qualifications, which include adequate theory, practical knowledge, and experience for the subject matter that they are assigned to teach.

3. Methods should be in place at each contractor site to ensure that individual instructors meet and maintain position qualification requirements.

4. Subject matter experts, without instructor qualification, may provide training in their area of expertise. However, if these subject matter experts are to be permanent instructors, they should be trained as instructors in the next practical training cycle. Qualifications for trainers at nuclear facilities can be found in DOE Order 5480.20A, "Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities."

Training Program Material Development

Training Material Presentation

Training materials for the core programs consist of lesson plans and study guides. To ensure compliance with 10 CFR 835-Subpart J, facility-specific materials must be added to the core materials when necessary to adequately train individuals for facility-specific radiological hazards.

Training Certificates

A training certificate that identifies current training status of core training may be provided to qualified personnel. Each facility is responsible to administer and track the certificates. Facilities have the option of utilizing the certificates as proof of training.

However, it should be noted that 10 CFR 835-Subpart J requires each facility to ensure radiological workers have adequate training for the hazards present. The training certificate from another DOE site does not, in itself, relieve the facility from ensuring the worker has had adequate training.

It is appropriate for facilities to supplement a visiting radiological worker's training with facility-specific training sufficient to ensure an adequate level of training for the hazards present. It may also be appropriate to confirm the adequacy of the worker's training with a standard examination and practical evaluation.

Training Aids

Facility-specific training aids may be developed at the facility to suit individual training styles. Each facility may add information, activities, a glossary, and/or view graphs to enhance their program.

Training Program Standards and Policies

Training Examinations

Written examinations and/or computer-based training (CBT) examinations shall be used to demonstrate satisfactory completion of theoretical and classroom material for RW I and RW II. The examinations should:

- Be completed with a minimum passing grade of 80%,
- Cover material representative of the learning objectives from both core material and facility-specific material,
- Be varied from class to class and within classes when the class size is large,

- Not use true/false questions, and
- Be acknowledged by trainee signature participation in a post-examination review.

An example core examination question bank is available from DOE EH-52. Each question in the examination bank should be numbered in accordance with the corresponding learning objective. All questions should consist of the multiple choice type question.

The facility should develop an appropriate exam bank, and the DOE example questions may be used as a basis. Example questions may be used verbatim, but the order of answers should be changed. The DOE example exam bank is not held confidential. The facility exam bank should be held confidential in accordance with facility practices for exam confidentiality. The practice should ensure students do not have knowledge of specific answer keys.

Rad Worker I Written Examination: The Rad Worker I exam is the responsibility of each facility and should consist of a minimum of thirty (30) questions.

The remedial action for failure of this examination is the responsibility of each facility.

HR/VHR Area Written Examinations: The HR/VHR Area exam is the responsibility of each facility and should consist of a minimum of five (5) questions.

The remedial action for failure of this examination is the responsibility of each facility.

Rad Worker Written II Examinations: The Rad Worker II exam is the responsibility of each facility and should consist of a minimum of fifty (50) questions. The remedial action for failure of this examination is the responsibility of each facility.

Initial challenge examinations may be appropriate for experienced radiological workers and those with current qualifications at another DOE facility. They should be designed to cover the core RW training core learning objectives only. Challenges should not apply to facility-specific topics. Each learning objective should be represented on the challenge examination. Failure of a challenge examination should result in the attendance of a scheduled initial training session. Successful completion of the initial challenge examination does not exempt the employee from the facility-specific examination, practical factors evaluation, and training in lessons learned/new procedures.

Practical Factors Evaluation: A practical factors evaluation should be used to demonstrate satisfactory completion skills for RW I, RW I HR/VHR Area, and RW II training. A minimum score of 80% should be attained for each practical factor evaluation. The criteria for a satisfactory score is outlined in the attachments to the Instructor's Guide. Successful completion of the written examination should be a prerequisite for the practical evaluation.

Lectures, Seminars, Training Exercises, etc.

RW I and II core training programs are designed to be delivered in a classroom setting. An alternate delivery method may be implemented with CBT equipment. The presentation of RWT should include core materials and facility-specific information. In all cases, regardless of the setting or delivery method, examination requirements of 10 CFR 835-Subpart J shall be followed.

Delinquent Training/Failure Procedures and Policies

Radiological workers who are delinquent on retraining shall lose their Radiological Worker access status until successful completion of the delinquent training requirement. These workers shall not be allowed unescorted entry into associated radiological areas.

Currently trained radiological workers who fail a challenge or retraining exam shall lose their training status until successful completion of the examination and practical factors evaluation. These workers should not be allowed unescorted entry into associated controlled/radiological areas.

Exceptions and Waivers

Successful completion of the core courses for RW I, RW I HR/VHR Area, and RW II training at one DOE site may be recognized by other DOE sites. However, the determination as to the adequacy of training as required by 10 CFR 835-Subpart J is the responsibility of the facility. It may be appropriate to accept this training as the basis for a challenge exam covering generic topics. However, this training may not adequately cover facility-specific topics.

Administration

Training Records

Training records and course documentation shall meet the requirements of 10 CFR 835.704 "Administration Records" and be in accordance with local DOE Records Disposition Schedules.

Training Program Development/Change Requests

All requests for program changes and revisions should be submitted to EH-52 using the DOE Technical Standard Program form "Document Improvement Proposal" F 1300.3. This form is available from the DOE Technical Standards Home Page - Maintenance of DOE Technical Standards TSPP-09). (See the Foreword of this document for website address).

Audits (internal and external)

Internal verification of training effectiveness may be accomplished through senior instructor or supervisor observation of practical applications and discussions of course material. Results should be documented and maintained by the organization responsible for Radiological Control Training.

The RW I, RW I HR/VHR Area, and RW II core training program materials and processes will be evaluated on a periodic basis by DOE-HQ. The evaluation should include a comparison of program elements with applicable industry standards and requirements.

Evaluating Training Program Effectiveness

Verification of the effectiveness of Radiological Control training should be accomplished by surveying a limited subset of former students in the workplace. This evaluation should include observation of practical applications, discussion of the course material, and may include an associated written examination. DOE/EH has issued guidelines for evaluating the effectiveness of radiological training through the DOE Operations Offices and DOE Field Offices.

These guidelines are included as an attachment to the Program Management Guide to DOE-HDBK-1131-98, General Employee Radiological Training.

For additional guidance, refer to DOE STD 1070-94, "Guide for Evaluation of Nuclear Facility Training Programs." The guidelines contained in these documents are relevant for the establishment and implementation of post-training evaluation and retention testing programs.

In response to the Defense Nuclear Facilities Safety Board (DNFSB) Recommendation 91-6, DOE committed to develop an implementation plan to upgrade radiation protection programs at DOE defense nuclear facilities.

The implementation plan detailed DOE's plans to develop and implement radiation protection post-training evaluation and retention testing programs. Post-training evaluations will be used to identify opportunities for improving course materials, upgrading instruction methods and techniques, and the need for additional training. Retention testing will indicate when individual performance or testing fails to meet expectations. Corrective actions for deficiencies identified in retention testing will be incorporated in the individual's development plan and the site's training program on an appropriate schedule.

In addition, Article 613.7 of the DOE Radiological Control Standard states that sites should implement a training effectiveness verification program. This program, which is in addition to performance evaluations routinely performed by the site's training department, is to verify the effectiveness of radiological control training by surveying a limited subset of former students in the workplace. This recommendation applies to both

DOE defense nuclear facilities and DOE facilities not classified as defense nuclear facilities.

Per DOE's commitment to DNFSB, it is expected that all defense nuclear facilities will implement these or equivalent programs. DOE facilities not classified as defense nuclear facilities should also strive to implement such programs. Line management should monitor progress of program implementation.

The guidance contained in DOE STD-1070-94 is not meant to be prescriptive. Training organizations should review this guidance and determine its applicability, taking into consideration the existence of similar programs already in place at their facility.

Forward evaluation results indicating a possible need to revise core training programs to EH-52 using the "Request for Change to DOE Core Training Materials" form.

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(Part 2 of 3)

Radiological Worker Training

Instructor's Guide

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Training Program Overview

DOE Radiological Health and Safety (DOE P 441.1) Safety Policy.

"It is the policy of the Department of Energy to conduct its radiological operations in a manner that ensures the health and safety of all its employees, contractors, and the general public. In achieving this objective, the Department shall ensure that radiation exposures to its workers and the public and releases of radioactivity to the environment are maintained below regulatory limits and deliberate efforts are taken to further reduce exposures and releases as low as reasonably achievable. The Department is fully committed to implementing a radiological control program of the highest quality that consistently reflects this policy."

In meeting this policy, the Department shall:

"Ensure personnel responsible for performing radiological work activities are appropriately trained. Standards shall be established to ensure the technical competency of the Department's workforce, as appropriate, through implementation of radiological training and professional development programs."

A. DOE Course Design

The DOE training material for radiological workers consists of four areas.

1. Core Academics (Modules 1-7)

   This area includes modules 1 through 7. These modules discuss the theory that a worker should know to work safely around radiological hazards.

   The core academics are recommended for radiological workers whose job assignments limit required unescorted access to Radiological Buffer Areas, Radiation Areas, and Radioactive Material Areas.

2. High/Very High Radiation Area (Module 8)

   This module should be added to the core academics for personnel whose job assignments require unescorted entry into High Radiation Areas where contamination is not present or whose job assignments require work near High/Very High Radiation Areas.

3. Contamination Control (Module 9)

   This module is recommended for workers who require unescorted access to Contamination, High Contamination, and/or Airborne Radioactivity Areas.

4. Practical Factors Evaluations (Module 10)

   This module contains generic practical exercises that provide hands-on experience for the worker. These exercises are for the levels of training needed by different radiological workers.

B. Overview of Courses

The DOE training material can be divided into the following levels of radiological worker training:

1. Radiological Worker I (RW I) Training

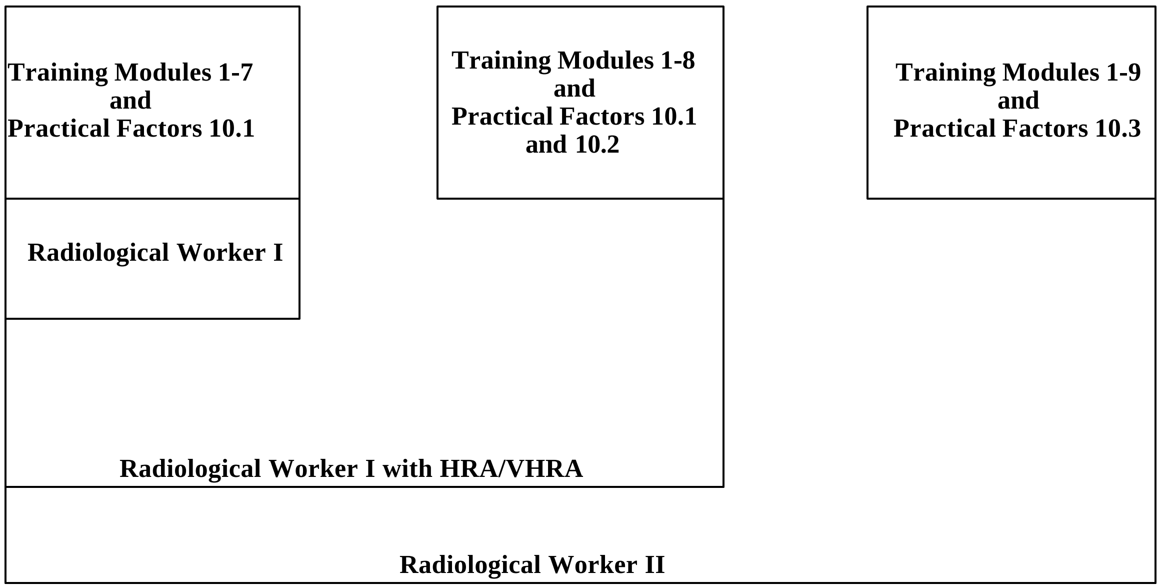
   This course contains the core academics and the appropriate practical factors. This training is for radiological workers whose job assignments require access to Radiological Buffer Areas and Radiation Areas. RW I training is also suggested for unescorted entry into Radioactive Material Areas containing either sealed radioactive sources or radioactive material labeled in accordance with 10 CFR 835.

   RW I training alone does not prepare the worker to work around higher radiation levels or with contaminated materials. It is suggested that RW I tasks be limited to inspections, tours, and activities that involve work on nonradiological systems.

2. Radiological Worker I Training with High/Very High Radiation Area Training

   This course contains the core academics, the High/Very High Radiation Area (HR/VHR) module, and the appropriate practical factors. The HR/VHR Area lesson plan may be added to the RW I course to give personnel unescorted entry into High Radiation Areas where contamination is not a concern.

Figure 1
Three Levels of Radiological Worker Training with Associated Training Requirements



3. Radiological Worker II (RW II) Training

This course consists of the core academics, the High/Very High Radiation Area module, the Contamination Control module, and the appropriate practical factors. This training is recommended for the radiological worker whose job assignments involve unescorted entry into High Radiation Areas, Contamination Areas, High Contamination Areas, and Airborne Radioactivity Areas. Further, workers who have potential contact with hot particles or use gloveboxes with high contamination levels should complete RW II training.

RW II training prepares the worker to work around higher radiation levels and with contaminated materials normally associated with radiological facilities/activities.

C. Evaluation Criteria

At the completion of the applicable course, the participant must successfully complete a written exam <u>and</u> a practical evaluation to be considered to have successfully completed the training. Successful completion of the written exam should be a prerequisite for the practical factors evaluation.

1. Written Examination

   Successful completion of the written examination typically requires a minimum passing score of 80 percent or equivalent. The written exam is based on the objectives in the theory portion of the course (Modules 1-7).

2. Practical Factors Evaluation

   Successful completion of the practical factors evaluation typically requires a minimum score of 80 percent or equivalent. The practical factors evaluation includes entry into a simulated controlled work environment. This evaluation is based on the application of the theory portion of the applicable course (Modules 1-7).

D. Documentation of Training

(Insert facility-specific information.)

E. Periodic Training and Refresher Training

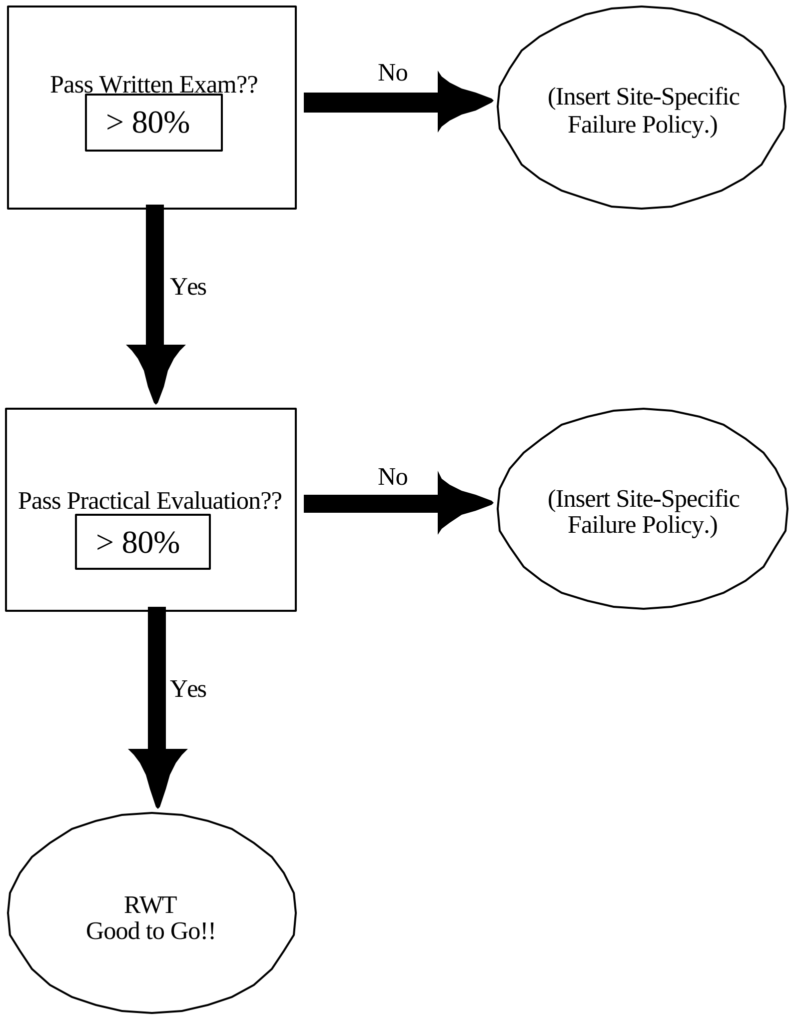
1. Training

   Training is required at intervals not to exceed every 24 months.

2. Refresher Training

   Refresher training should be conducted in the off year when periodic training is not due.

Figure 2
Evaluation Overview Diagram



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Course Title: Radiological Worker Training (Core Academics)

Module 1: Radiological Fundamentals

Terminal Objective :

Given various radiological concepts, the participant will be able to define the fundamentals of radiation, radioactive material, and radioactive contamination in accordance with the approved lesson materials.

Enabling Objectives :

The participant will be able to select the correct response from a group of responses to verify his/her ability to:

EO1 Identify the three basic particles of an atom.
EO2 Define radioactive material, radioactivity, radioactive half-life, and radioactive contamination.
EO3 Identify the units used to measure radioactivity and contamination.
EO4 Define ionization and ionizing radiation.
EO5 Distinguish between ionizing radiation and non-ionizing radiation.
EO6 Identify the four basic types of ionizing radiation and the following for each type:
- a. Physical characteristics
- b. Range
- c. Shielding
- d. Biological hazard(s)
- e. Sources at the site

EO7 Identify the units used to measure radiation.
EO8 Convert rem to millirem and millirem to rem.

Instructional Aids :

1. Student Guide
2. Transparencies
3. Activities (as applicable)
4. Self-check quizzes (as applicable)

I. MODULE INTRODUCTION

I. MODULE INTRODUCTION

A. Self Introduction

1. Name
2. Phone Number
3. Background

Post information in room. Have students introduce themselves: name, background

B. Module Overview

Nuclear science is truly a product of the 20th century. This module will discuss several nuclear science topics at a basic level appropriate for the radiological worker. These concepts are necessary for the worker to understand the nature of radiation and its potential effect on health. The topics covered include basic particles of the atom, types of radiation, and the definition of units used to measure radiation.

C. Objectives Review

D. Introduction

This module introduces the worker to basic radiological fundamentals and terms that are common in the DOE complex. After learning the fundamentals of radiation, radioactive material, and radioactive contamination, the worker will build from the basic to the more in-depth concepts presented in the other modules.

II. MODULE OUTLINE

A. Atomic Structure

1. The basic unit of matter is the atom. The three basic particles of the atom are protons, neutrons, and electrons. The central portion of the atom is the nucleus. The nucleus consists of protons and neutrons. Electrons orbit the nucleus.

EO1 Identify the three basic particles of an atom.

a. Protons

1) Protons are located in the nucleus of the atom.

2) Protons have a positive electrical charge.

3) The number of protons in the nucleus determines the element.

(Optional)
Insert diagram of the atom. Have students label the three basic particles.

b. Neutrons

1) Neutrons are located in the nucleus of the atom.

2) Neutrons have no electrical charge.

3) Atoms of the same element have the same number of protons, but can have a different number of neutrons.

4) Atoms which have the same number of protons but different numbers of neutrons are called isotopes.

NOTE: Common notation for describing isotopes is to list the atomic symbol for an element followed by its mass number. The mass number is the sum of protons and neutrons. For example, tritium has 1 proton and 2 neutrons, and is denoted as H-3.

5) Isotopes have the same chemical properties; however, the nuclear properties can be quite different.

c. Electrons

1) Electrons are in orbit around the nucleus of an atom.

2) Electrons have a negative electrical charge.

3) This negative charge is equal in magnitude to the proton's positive charge.

Table 1-1
Basic Particles

3 Basic Particles	Location	Charge	Comments
Protons	Nucleus	+ (positive)	Number of protons determines the element. If the number of protons changes, the element changes.
Neutrons	Nucleus	No Charge	Atoms of the same element have the same number of protons, but can have a different number of neutrons. This is called an isotope.
Electrons	Orbit nucleus	- (negative)	This negative charge is equal in magnitude to the proton's positive charge.

2. Stable and unstable atoms

Only certain combinations of neutrons and protons result in stable atoms.

a. If there are too many or too few neutrons for a given number of protons, the nucleus will not be stable.

b. The unstable atom will try to become stable by giving off excess energy. This energy is in the form of particles or rays (radiation). These unstable atoms are known as radioactive atoms.

3. Charge of the atom

The number of electrons and protons determines the overall electrical charge of the atom. The term "ion" is used to define atoms or groups of atoms that have a net positive or negative electrical charge.

Optional:

Insert diagram that illustrates the different charges.

a. No charge (neutral)

If the number of electrons equals the number of protons, the atom is electrically neutral. This atom does not have a net electrical charge.

b. Positive charge (+)

If there are more protons than electrons, the atom is positively charged.

c. Negative charge (-)

If there are more electrons than protons, the atom is negatively charged.

B. Definitions and Units of Measure

1. Radioactive material

EO2 Define radioactive material.

Radioactive material is any material containing unstable atoms that emit radiation.

Give facility-specific examples of radioactive isotopes at the site.

2. Radioactivity

Radioactivity is the process of unstable (or radioactive) atoms becoming stable. This is done by emitting radiation. This process over a period of time is referred to as radioactive decay. A disintegration is a single atom undergoing radioactive decay.

EO2 Define radioactivity.

Give example of radioactive decay.

3. Radioactivity units

Radioactivity is measured in the number of disintegrations radioactive material undergoes in a certain period of time.

a. Disintegrations per minute (dpm)
b. Disintegrations per second (dps)
c. Curie (Ci)

One curie equals:

- 2,200,000,000,000 disintegrations per minute ($2.2x10^{12}$ dpm), or
- 37,000,000,000 disintegrations per second ($3.7x10^{10}$ dps), or
- 1,000,000 microcuries ($1x10^{6}$ uCi).

EO3 Identify the units used to measure radioactivity and contamination.

4. Radioactive half-life

Radioactive half-life is the time it takes for one half of the radioactive atoms present to decay.

EO2 Define radioactive half-life.

5. Radioactive contamination

Radioactive contamination is radioactive material that is uncontained and in an unwanted place. (There are certain places where radioactive material is intended to be.)

EO2 Define radioactive contamination.

Contamination is measured per unit area or volume.

- dpm/100 cm^2
- uCi/ml
- uCi/g.

EO3 Identify the units used to measure radioactivity and contamination.

6. Ionization

Ionization is the process of removing electrons from neutral atoms.

a. Electrons will be removed from an atom if enough energy is supplied. The remaining atom has a positive (+) charge. The ionized atoms may affect chemical processes in cells. The ionizations may affect the cell's ability to function normally.

b. The positively charged atom and the negatively charged electron are called an "ion pair."

c. Ionization should not be confused with radiation. Ions (or ion pairs) produced as a result of the interaction of radiation with an atom allow the detection of radiation.

EO4 Define ionization.

7. Ionizing radiation

Ionizing radiation is energy (particles or rays) emitted from radioactive atoms, and some devices, that can cause ionization. Examples of devices that emit ionizing radiation are X-ray machines, accelerators, and fluoroscopes.

a. It is important to note that exposure to ionizing radiation, without exposure to radioactive material, will not result in contamination of the worker.

EO4 Define ionizing radiation.

b. Radiation is a type of energy, and contamination is radioactive material that is uncontained and in an unwanted place.

8. Non-ionizing radiation

a. Electromagnetic radiation that doesn't have enough energy to ionize an atom is called "non-ionizing radiation."

EO5 Distinguish between ionizing radiation and non-ionizing radiation.

b. Examples of non-ionizing radiation are radar waves, microwaves, and visible light.

C. The Four Basic Types of Ionizing Radiation

The four basic types of ionizing radiation of concern in the DOE complex are alpha particles, beta particles, gamma or X rays, and neutrons.

1. Alpha particles

a. Physical characteristics

1) The alpha particle has a large mass and consists of two protons, two neutrons, and no electrons.

2) It is a highly charged particle (charge of plus two) that is emitted from the nucleus of an atom.

EO6 Identify the four basic types of ionizing radiation and the following for each:
a. Physical characteristics
b. Range
c. Shielding
d. Biological hazards
e. Sources

3) The positive charge causes the alpha particle (+) to strip electrons (-) from nearby atoms as it passes through the material, thus ionizing these atoms.

b. Range

1) The alpha particle deposits a large amount of energy in a short distance of travel.

2) This large energy deposit limits the penetrating ability of the alpha particle to a very short distance.

3) Range in air is about 1-2 inches.

c. Shielding

Most alpha particles are stopped by a few centimeters of air, a sheet of paper, or the dead layer (outer layer) of skin.

d. Biological hazards

1) Alpha particles are not considered an external radiation hazard. This is because they are easily stopped by the dead layer of skin.

2) Internally, the source of the alpha radiation is in close contact with body tissue and can deposit large amounts of energy in a small volume of living body tissue.

e. Sources

(Insert facility-specific information.)

Table 1-2
Alpha Particles

Physical Characteristics	• Large mass (2 protons, 2 neutrons, 0 electrons). • +2 charge.
Range	• Very short (about 1-2 inches in air). • Deposits large amount of energy in a short distance of travel.
Shielding	• Few centimeters of air. • Sheet of paper. • Dead layer of skin (outer layer).
Biological Hazards	• No external hazard (dead layer of skin will stop alpha particles). • Internally, the source of alpha radiation is in close contact with body tissue. It can deposit large amounts of energy in a small amount of body tissue.
Sources	Insert facility-specific information.

2. Beta particles

a. Physical characteristics

1) The beta particle has a small mass and is positively or negatively charged. Positively charged beta particles are called positrons and have an electrical charge of plus one. Negatively charged beta particles are high-energy electrons and have an electrical charge of minus one.

2) A negatively charged beta particle is physically identical to an electron.

EO6 Identify the four basic types of ionizing radiation and the following for each type:
a. Physical characteristics
b. Range
c. Shielding
d. Biological hazards
e. Sources

3) The beta particle ionizes target atoms due to the force between itself and the electrons of the atom. Both have a charge of minus one.

b. Range

1) Because of its charge, the beta particle has a limited penetrating ability.

2) The range in air of beta particles depends on the energy of the beta particle. In the case of tritium (H-3), the range is only an inch; in the case of phosphorous-32 (P-32) or strontium-90 (Sr-90), the range is 20 feet in air.

c. Shielding

Beta particles are typically shielded by plastic, glass, or safety glasses.

d. Biological hazards

1) If ingested or inhaled, a beta emitter can be an internal hazard when the source of the beta radiation is in close contact with body tissue and can deposit energy in a small volume of living body tissue.

2) Externally, beta particles are potentially hazardous to the skin and eyes.

3) Provide facility-specific information on the additional risks or concerns from high-energy beta sources (e.g., P-32, Y-90), as appropriate.

e. Sources

(Insert facility-specific information.)

Table 1-3
Beta Particles

Physical Characteristics	Small mass. -1 charge or + 1 charge.
Range	Short distance (one inch to 20 feet).
Shielding	Plastic. Glass. Safety glasses.
Biological Hazard	Internal hazard (this is due to short range). Externally, may be hazardous to skin and eyes.
Sources	Insert facility-specific information.

3. Gamma rays/X rays

a. Physical characteristics

1) Gamma/X-ray radiation is an electromagnetic wave (electromagnetic radiation) or photon and has no mass and no electrical charge.

2) Gamma rays are very similar to X rays. The difference between gamma rays and X rays is that gamma rays originate inside the nucleus and X rays originate in the electron orbits outside the nucleus.

3) Gamma/X-ray radiation can ionize as a result of direct interactions with orbital electrons.

EO6 Identify the four basic types of ionizing radiation and the following for each type:
a. Physical characteristics
b. Range
c. Shielding
d. Biological hazards
e. Sources

b. Range

1) Because gamma/X-ray radiation has no charge and no mass, it has very high penetrating ability.

2) The range in air is very far. It will easily go several hundred feet.

c. Shielding

Gamma/X-ray radiation is best shielded by very dense materials, such as lead. Water or concrete, although not as effective as the same thickness as lead, are also commonly used, especially if the thickness of shielding is not limiting.

d. Biological hazards

Gamma/X-ray radiation can result in radiation exposure to the whole body.

e. Sources

(Insert facility-specific information.)

Table 1-4
Gamma Rays/X-Rays

Physical Characteristics	• No mass. • No charge. • Electromagnetic wave or photon. • Similar (difference is the place of origin).
Range	• Range in air is very far. • It will easily go several hundred feet. • Very high penetrating power since it has no mass and no charge.
Shielding	• Concrete. • Water. • Lead.
Biological Hazard	• Whole body exposure. • The hazard may be external and/or internal. This depends on whether the source is inside or outside the body.
Sources	Insert facility-specific information.

4. Neutrons

a. Physical characteristics

1) Neutron radiation consists of neutrons that are ejected from the nucleus.

2) A neutron has mass, but no electrical charge.

EO6 Identify the four basic types of ionizing radiation and the following for each type:
a. Physical characteristics
b. Range
c. Shielding
d. Biological hazards
e. Sources

3) An interaction can occur as the result of a collision between a neutron and a nucleus. The nucleus recoils due to the energy imparted by the neutron and ionizes other atoms. This is called "secondary ionization."

4) Neutrons may also be absorbed by a nucleus. This is called neutron activation. A charged particle or gamma ray may be emitted as a result of this interaction. The emitted radiation can cause ionization in other atoms.

b. Range

1) Because of the lack of a charge, neutrons have a relatively high penetrating ability and are difficult to stop.

2) The range in air is very far. Like gamma rays, they can easily travel several hundred feet in air.

c. Shielding

Neutron radiation is best shielded by materials with a high hydrogen content such as water, concrete, or plastic.

d. Biological hazards

Neutrons are a whole body hazard due to their high penetrating ability.

e. Sources

(Insert facility-specific information.)

Table 1-5
Neutrons

Physical Characteristics	• No charge. • Has mass.
Range	• Range in air is very far. • Easily can go several hundred feet. • High penetrating power due to lack of charge (difficult to stop).
Shielding	• Water. • Concrete. • Plastic (high hydrogen content).
Biological Hazard	• Whole body exposure. • The hazard is generally external.
Sources	Insert facility-specific information.

D. Units of Measure for Radiation

1. Roentgen (R)

a. Is a unit for measuring external exposure.

b. Defined only for effect on air.

c. Applies only to gamma and X rays.

d. Does not relate biological effects of radiation to the human body.

e. 1 R (Roentgen) = 1000 milliroentgen (mR).

EO7 Identify the units used to measure radiation.

2. Rad (Radiation absorbed dose)

a. A unit for measuring absorbed dose in any material.

Absorbed dose results from energy being deposited by the radiation.

b. Is defined for any material.

c. Applies to all types of radiation.

d. Does not take into account the potential effect that different types of radiation have on the body.

e. 1 rad = 1000 millirad (mrad).

3. Rem (Roentgen equivalent man)

a. A unit for measuring dose equivalence.

b. Is the most commonly used unit.

c. Pertains to the human body.

d. Takes into account the energy absorbed (dose) and the biological effect on the body due to the different types of radiation.

The Quality Factor (QF) is used as a multiplier to reflect the relative amount of biological damage caused by the same amount of energy deposited in cells by the different types of ionizing radiation. Rem = rad x QF.

Quality Factors:

alpha	= 20
beta	= 1
gamma/x-ray	= 1
neutron	= 2-11(depending on the energy)

e. 1 rem = 1,000 millirem (mrem).

EO8 Convert rem to millirem and millirem to rem.

4. Radiation dose and dose rate

a. Radiation dose rate is the dose per time.

b. Example:

1) Radiation dose rate = dose/time.

2) Radiation dose equivalent rate = mrem/hr.

3) Radiation absorbed dose rate = mrad/hr.

Table 1-6
Radiation Units

Roentgen (R)	Rad (Radiation Absorbed Dose)	Rem (Roentgen Equivalent Man)
Unit for measuring exposure.	Unit for measuring absorbed dose in any material.	Unit for measuring dose equivalence (most commonly used unit).
Defined only for effect on air.	Defined for any material.	Pertains to human body.
Applies only to gamma and X-ray radiation.	Applies to all types of radiation.	Applies to all types of radiation.
Does not relate biological effects of radiation to the human body.	Does not take into account the potential effect that different types of radiation have on the body.	Takes into account the energy absorbed (dose) and the biological effect on the body due to the different types of radiation. Equal doses of different types of radiation (as measured in rad) can cause different levels of damage to the body (measured in rem).

III. SUMMARY

(Insert facility-specific information.)

IV. EVALUATION

(Insert facility-specific information.)

Refer to RWT Program Management Guide for evaluation guidance.

Module 2: Biological Effects

Module 2: Biological Effects

Terminal Objective :

Given various radiation doses and sources of radiation, identify natural and manmade sources of radiation and the biological risks associated with radiation dose in accordance with lesson materials.

Enabling Objectives :

The participant will be able to select the correct response from a group of responses to verify his/her ability to:

EO1 Identify the major sources of natural background and manmade radiation.
EO2 Identify the average annual dose to the general population from natural background and manmade sources of radiation.
EO3 State the method by which radiation causes damage to cells.
EO4 Identify the possible effects of radiation on cells.
EO5 Define the terms "acute dose" and "chronic dose."
EO6 State examples of chronic radiation dose.
EO7 Define the terms "somatic effect" and "heritable effect."
EO8 State the potential effects associated with prenatal radiation dose.
EO9 Compare the biological risks from chronic radiation doses to health risks workers are subjected to in industry and daily life.

Instructional Aids :

1. Student Guide
2. Transparencies
3. Activities (as applicable)
4. Self-check quizzes (as applicable)

I. MODULE INTRODUCTION

A. Self Introduction

1. Name
2. Phone Number
3. Background

B. Module Overview

The fact that ionizing radiation produces biological damage has been known for many years. We have gained most of our knowledge of these effects since World War II.

In this module, we will discuss the potential for biological effects and risks due to ionizing radiation and put these potential risks into perspective when compared to other occupations and daily activities. With this information, it is hoped that employees will develop a healthy respect for radiation rather than fear or disregard.

C. Objectives Review

D. Introduction

We know more about the biological effects of ionizing radiation than most other environmental factors. Rather than just being able to base our information on animal studies, we have a large body of information available regarding exposures to humans. There are four major groups of people that have been exposed to significant levels of radiation.

The first group includes early radiation workers, such as radiologists. These workers received large doses of radiation before the biological effects were recognized. Since that time, standards have been developed to protect workers.

The second group is the more than 250,000 survivors of the atomic bombs dropped at Hiroshima and Nagasaki. Some of these survivors received doses estimated to be in excess of 50,000 mrem.

The third group includes individuals who have been involved in radiation accidents.

The fourth and largest group of individuals are patients who have undergone radiation therapy for cancer and other diseases.

II. MODULE OUTLINE

Introduce objectives

A. Sources of Radiation

We live in a radioactive world and always have. In fact, the majority of us will be exposed to more ionizing radiation from natural background radiation than from our jobs.

1. Natural sources

There are several sources of radiation that occur naturally. The radiation emitted from these sources is identical to the radiation that results from manmade sources.

EO1 Identify the major sources of natural background and manmade radiation.

The four major sources of naturally occurring radiation exposures are:

- Cosmic radiation
- Sources in the earth's crust, also referred to as terrestrial radiation
- Sources in the human body, also referred to as internal sources
- Radon

a. Cosmic radiation (total average dose ~ 28 mrem/yr)

1) Cosmic radiation comes from the sun and outer space. It consists of positively charged particles and gamma radiation.

2) At sea level, the average annual cosmic radiation dose is about 26 mrem.

3) At higher elevations, the amount of atmosphere shielding cosmic rays decreases; therefore, the dose increases.

b. Sources in earth's crust (terrestrial) (total average dose ~ 28 mrem/yr)

There are natural sources of radiation in the ground (i.e., rocks and soil).

1) Some of the contributors to terrestrial sources are the natural radioactive elements radium, uranium, and thorium.

2) Many areas have elevated levels of terrestrial radiation due to increased concentrations of uranium or thorium in the soil.

c. Internal (total average dose ~40 mrem/yr)

1) The food we eat and the water we drink contain trace amounts of natural radioactive materials.

2) These naturally occurring radioactive materials deposit in our bodies and cause internal exposure to radiation.

3) Some naturally occurring radioactive isotopes include Sodium-24 (Na-24), Carbon-14 (C-14), Argon-41 (Ar-41), and Potassium-40 (K-40). Most of our internal exposure comes from K-40.

d. Radon (total average dose ~ 200 mrem/yr)

1) Radon comes from the radioactive decay of uranium, which is naturally present in the soil.

2) Radon is a gas. It can travel through the soil and enter through building foundation cracks. The greatest concentrations of indoor radon are found in basements.

3) Radon emits alpha radiation. It presents a hazard only when taken into the body (e.g., when inhaled).

Review characteristics of alpha radiation.

2. Manmade sources

The difference between manmade sources of radiation and naturally occurring sources is the origin of the source, i.e., where the radiation is either produced or enhanced by human activities.

E01 Identify the major sources of natural background and manmade radiation.

The top sources of manmade radiation exposures are:

- Tobacco products
- Medical radiation
- Building materials

a. Tobacco products (total average dose ~1300 mrem/yr for smokers)

b. Medical radiation sources (total average dose ~ 54 mrem/yr)

1) X rays (total average dose ~ 40mrem/yr)

a) X rays are similar to gamma rays; however, they originate outside the nucleus.

b) A typical radiation dose from a chest X ray is about 10 mrem.

2) Diagnosis and therapy (total average dose ~14 mrem/yr)

In addition to X rays, radioactive materials and radioactive sources are used in medicine for diagnosis and therapy.

c. Building materials (total average dose ~7 mrem/yr)

d. Other minor contributors

Other contributors to dose include consumer products, industrial sources, and atmospheric testing of nuclear weapons.

Discuss: It has been more than 20 years since atmospheric testing has been conducted.

3. Average annual dose

The average annual total effective dose equivalent to the general population (non-smokers) from naturally occurring and manmade sources is about 360 mrem.

EO2 Identify the average annual dose to the general population from natural background and manmade sources of radiation.

B. Effects of Radiation on Cells

The human body is made up of many organ systems. Each system is made up of tissues. Specialized cells make up tissues. Ionizing radiation can potentially affect the normal function of cells.

1. Biological effects begin with the ionization of atoms

a. The method by which radiation causes damage to human cells is by ionization of atoms in the cells. Atoms make up the cells that make up the tissues of the body. Any potential radiation damage begins with damage to atoms.

EO3 State the method by which radiation causes damage to cells.

Review the four types of ionizing radiation.

b. A cell is made up of two principal parts, the body of the cell and the nucleus. The nucleus is like the brain of the cell.

c. When ionizing radiation hits a cell, it may strike a vital part of the cell like the nucleus or a less vital part of the cell, like the cytoplasm.

2. Cell sensitivity

Some cells are more sensitive than others to environmental factors such as viruses, toxins, and ionizing radiation.

a. Actively dividing and non-specialized cells

1) Cells in our bodies that are actively dividing are more sensitive to ionizing radiation.

2) Cells that are rapidly dividing include blood-forming cells, the cells that line our intestinal tract, hair follicles, and cells that form sperm.

b. Less actively dividing and more specialized cells

Cells that divide at a slower rate or are more specialized (such as brain cells or muscle cells) are not as sensitive to damage by ionizing radiation.

3. Possible effects of radiation on cells

Several things can happen when a cell is exposed to ionizing radiation. The following are possible effects of radiation on cells.

EO4 Identify the possible effects of radiation on cells.

a. There is no damage

b. Cells repair the damage and operate normally

1) The body of most cells is made up primarily of water. When ionizing radiation hits a cell, it is most likely to interact with the water in the cell. One of the byproducts of radiation-induced ionization of water is hydrogen peroxide. Hydrogen peroxide can damage cell atomic structures.
2) Ionizing radiation can also hit the nucleus of the cell. The nucleus contains the vital parts of the cell, such as chromosomes. The chromosomes determine cell function. When chromosomes duplicate themselves, the chromosomes transfer their information to new cells. Radiation may cause a change in the chromosome that does not affect the cell.
3) Damage to chromosomes and other cell structures can be repaired. In fact, our bodies repair a very large number of chromosome breaks every day (References 7 and 10).

c. Cells are damaged and operate abnormally

1) Cell damage may not be repaired or may be incompletely repaired. In that case, the cell may not be able to function properly.
2) It is possible that a chromosome in the cell nucleus could be damaged but not be repaired correctly. If the cell continues to reproduce, this is called a mutation and may result in cancer.

d. Cells die as a result of the damage

At any given moment, thousands of our cells die and are replaced by normal functioning cells. However, the radiation damage to a cell may be so extensive that the cell dies prematurely.

C. Acute and Chronic Radiation Dose

Potential biological effects depend on how much and how fast a radiation dose is received. Radiation doses can be grouped into two categories: acute and chronic dose.

1. Acute radiation doses

a. High doses of radiation received in a short period of time are called acute doses. The body's cell repair mechanisms are not as effective for damage caused by an acute dose.

EO5 Define the terms "acute dose" and "chronic dose."

b. Acute doses to the whole body

After an acute dose, damaged cells will be replaced by new cells and the body will repair itself, although this may take a number of months. Only in extreme cases, such as with the Chernobyl firefighters (500 rem), would the dose be so high as to make recovery unlikely.

c. Acute doses to only part of the body

1) X-ray machines

It is possible that radiation exposure may be limited to a part of the body, such as the hands.

There have been accidents, particularly with X-ray machines, in which individuals have exposed their fingers to part of the intense radiation beam. In some of these cases, individuals have received doses of <u>millions</u> of mrem to their fingers, and some individuals have lost their finger or fingers. It is important for individuals who work with X-ray or similar equipment to be trained in the safe use of this equipment.

2) Radiation therapy

Reference 5.

a) Radiation therapy patients receive high doses of radiation in a short period of time, but generally only to a small portion of the body (not a whole body dose).

b) The skin and limited tissue of these patients may receive significant doses, but doses to the region of a tumor are many times higher.

c) Ionizing radiation is used to treat cancer in these patients because cancer cells are rapidly dividing and therefore sensitive to ionizing radiation. Some of the side effects of people undergoing radiation therapy are hair loss, nausea, and tiredness.

d. Probability of a large acute dose

What is important to understand is that it takes a large acute dose of radiation before any physical effect is seen. These acute doses have occurred in Hiroshima/Nagasaki, and in a few radiation accidents, including Chernobyl. The possibility of a radiological worker receiving a large acute dose of ionizing radiation on the job is extremely low. Typically, radioactive materials are handled in small quantities that do not produce a large amount of radiation. Where there is a potential for larger exposures, many safety features are required.

2. Chronic radiation doses

A chronic radiation dose is typically a small amount of radiation received over a long period of time. An example of a chronic dose is the dose we receive from natural background every day of our lives. The body's cell repair mechanisms are better able to repair a chronic dose than an acute dose.

EO5 Define the terms "acute dose" and "chronic dose."

EO6 State examples of chronic radiation dose.

a. The body has time to repair damage because a smaller percentage of the cells need repair at any given time.

b. The body also has time to replace dead or non-functioning cells with new, healthy cells.

3. Biological effects of radiation exposure

Somatic effects refer to the effects radiation has on the individual receiving the dose.

Genetic effects refer to mutations due to radiation damage to the DNA of a cell. When this change is in the DNA of parental reproductive cells, it is called a heritable effect.

EO7 Define the term "heritable effect."

a. Somatic Effects

Somatic effects can best be described in terms of prompt and delayed effects as discussed below.

3) Prompt Effects

Although rare in the nuclear industry, large doses are typically acute radiation doses representing serious overexposures. The biological effects of large acute doses are as follows:

Table 2-1
Prompt Biological Effects

Dose (rem)	Effect
0-25	None detectable through symptoms or routine blood tests.
25-100	Changes in blood.
100-300	Nausea, anorexia.
300-600	Diarrhea, hemorrhage, and possible death

Effects are dependent on medical intervention and the individual.

2) Delayed Effects

Delayed effects may result from either a single large acute overexposure or from continuing low-level chronic exposure. Cancer in its various forms is the most important potential delayed effect of radiation exposure. Other effects noted include cataracts, life shortening and, for individuals exposed in the womb, lower IQ test scores.

b. Heritable Effects

A heritable effect is a physical mutation or trait that is passed on to offspring. In the case of heritable effects, the parental individual has experienced damage to some genetic material in the reproductive cells and has passed the damaged genetic material onto offspring.

1) Heritable effects from radiation have never been observed in humans but are considered possible. They have been observed in studies of plants and animals.

2) Heritable effects have not been found in the 77,000 Japanese children born to the survivors of Hiroshima and Nagasaki (these are children who were conceived after the atom bomb -- i.e., heritable effects). Studies have followed these children, their children, and their grandchildren.

4. Factors affecting biological damage due to exposure to radiation

a. Total dose

In general, the greater the dose, the greater the potential for biological effects.

b. Dose rate (how fast)

The faster the dose is delivered, the less time the body has to repair itself.

c. Type of radiation

For example, internally deposited alpha emitters are more damaging than beta or gamma emitters for the same energy deposited.

d. Area of the body that receives a dose

In general, the larger the area of the body that receives a dose, the greater the biological effect.

Extremities are less sensitive than blood forming and other critical organs. That is why the annual dose limit for extremities is higher than for a whole body dose that irradiates internal organs.

e. Cell sensitivity

The most sensitive cells are those that are rapidly dividing. Examples include blood cells, hair follicles, and the cells lining the gastrointestinal tract.

f. Individual sensitivity

Some individuals are more sensitive to environmental factors such as ionizing radiation.

The developing embryo/fetus is the most sensitive, and children are more sensitive than adults.

In general, the human body becomes relatively less sensitive to ionizing radiation with increasing age. The exception is that elderly people are more sensitive than middle-aged adults due to the inability to repair damage as quickly (less efficient cell repair mechanisms).

D. Prenatal Radiation Exposure

Although no effects were seen in Japanese children conceived after the atomic bomb, there were effects seen in some children who were in the womb when exposed to the atomic bomb radiation at Hiroshima and Nagasaki. Some of these children were born with a slightly smaller head size, lower average birth weight, and increased incidence of mental retardation. Some later showed lower IQ test scores and slower scholastic development, smaller physical size, and increased incidence of behavioral problems.

EO8 State the potential effects associated with prenatal radiation dose.

1. Sensitivity of the fetus

Embryo/fetal cells are rapidly dividing, which makes them sensitive to many environmental factors including ionizing radiation. The embryo/fetus is most susceptible to developing adverse health effects if exposed during the time period of 8 - 15 weeks after conception.

2. Factors for potential effects associated with prenatal exposures

   Many chemical and physical (environmental) factors are suspected of causing or known to have caused damage to a fetus, especially early in the pregnancy. Radiation, alcohol consumption, exposure to lead, and heat, such as from hot tubs, are only a few such factors.

E. Risks in Perspective

Current radiation protection standards and practices are based on the premise that any radiation dose, no matter how small, can result in health effects such as cancer. Further, it is assumed that these effects are produced in direct proportion to the dose received (i.e., doubling the radiation dose results in a doubling of the risk of the effect). These two assumptions lead to a dose-response relationship, often referred to as the linear, no-threshold model, for limiting health effects at very low radiation dose levels.

However, it should be noted that this is a conservative assumption made in the absence of more conclusive evidence. Health effects (primarily cancer) have been observed in humans only at doses in excess of 10 rem delivered at high dose rates. Below this dose, estimation of adverse health effects is speculative. Risk estimates that are used to predict health effects in exposed individuals or populations are based on epidemiological studies of well-defined populations (e.g., the Japanese survivors of the atomic bombings in 1945 and medical patients) exposed to relatively high doses delivered at high dose rates. It is generally accepted that studies have not demonstrated adverse health effects in individuals exposed to small doses (less than 10 rem) delivered over a period of many years.

1. Risk from exposures to ionizing radiation

a. No increases in cancer have been observed in individuals who receive a dose of ionizing radiation at occupational levels. The possibility of cancer induction cannot be dismissed even though an increase in cancers has not been observed. Risk estimates have been derived from studies of individuals who have been exposed to high levels of radiation.

b. The risk of cancer induction from radiation exposure can be put into perspective. This can be done by comparing it to the normal rate of cancer death in today's society. The current rate of cancer death among Americans is about 20 percent. Taken from a personal perspective, each of us has about 20 chances in 100 of dying of cancer. A radiological worker who receives 25,000 mrem over a working life increases his/her risk of cancer by 1 percent, or has about 21 chances in 100 of dying of cancer. A 25,000 mrem dose is a fairly large dose over the course of a working lifetime. The average annual dose to DOE workers is less than 100 mrem, which leads to a working lifetime dose (40 years assumed) of no more than approximately 4,000 mrem.

Review: There are many other causes of cancer, not just radiation.

2. Comparison of risks

EO9 Compare the biological risks from chronic radiation doses to the health risks workers are subjected to in industry and daily life.

a. Table 2-2 compares the estimated days of life expectancy lost as a result of exposure to radiation and other health risks.

The following information is intended to put the potential risk of radiation into perspective when compared to other occupations and daily activities.

Table 2-2
Estimated Loss of Life Expectancy from Health Risks

Health Risk	Estimated Loss of Life Expectancy
Smoking 20 cigarettes a day	6 years
Overweight (by 15%)	2 years
Alcohol consumption (U.S. average)	1 year
Agricultural accidents	320 days
Construction accidents	227 days
Auto accidents	207 days
Home accidents	74 days
Occupational radiation dose (1 rem/y), from age 18-65 (47 rem total)	51 days
All natural hazards (earthquakes, lightning, flood)	7 days
Medical radiation	6 days

References 1 and 12 of the PMG.

The estimates in Table 2-2 indicate that the health risks from occupational radiation doses are smaller than the risks associated with normal day-to-day activities that we have grown to accept.

b. Acceptance of a risk:

1) is a personal matter.

2) requires a good deal of informed judgment.

c. The risks associated with occupational radiation doses are generally considered acceptable as compared to other occupational risks by most scientific groups who have studied them. There are some scientific groups who claim that the risk is too high. DOE continues to fund and review worker health studies to address these concerns.

III. SUMMARY

In summary, the estimated risk associated with occupation radiation dose is similar to other routine occupational risks and much less than some risks widely accepted in society. The risk of work in a radiation environment is considered within the normal occupational risk tolerance by national and international scientific groups. However, acceptance of risk is an individual matter and is best made with accurate information. A radiological worker should understand the risk of working in a nuclear environment in relation to the risks of daily life and the risks presented by work in other professions. The intent of this module is to give you the facts about radiation exposure risks and provide you with an opportunity to ask questions about radiation risk. It is hoped that understanding radiation risk and risk in general will help you to develop an informed and healthy respect for radiation, and that your understanding will eliminate excessive fear of or indifference to radiation.

IV. EVALUATION

(Insert facility-specific information.)

Refer to RWT Program Management Guide for evaluation guidance.

Module 3: Radiation Limits and Administrative Control Levels

Terminal Objective :

Given various time frames and different parts of the body, identify the applicable DOE dose limits, DOE administrative control levels, and facility-specific administrative control levels in accordance with the lesson material.

Enabling Objectives :

The participant will be able to select the correct response from a group of responses to verify his/her ability to:

EO1 State the purposes of administrative control levels.
EO2 Identify the DOE radiation dose limits, DOE recommended administrative control level, and the facility administrative control level.
EO3 State the site policy concerning prenatal radiation exposure.
EO4 Identify the employee's responsibilities concerning radiation dose limits and administrative control levels.

Instructional Aids:

1. Student Guide
2. Transparencies
3. Activities (as applicable)
4. Self-check quizzes (as applicable)

I. MODULE INTRODUCTION

A. Self Introduction

1. Name
2. Phone Number
3. Background

B. Module Overview

This module will address DOE dose limits and administrative control levels.

C. Objectives Review

Introduce objectives.

D. Introduction

DOE limits and administrative control levels have been established for the purpose of restricting occupational radiation exposures to levels of acceptable risk.

II. MODULE OUTLINE

A. Basis for and Purpose of Radiation Dose Equivalent Limits and Administrative Control Levels

1. Basis for DOE dose limits

a. DOE has established radiation dose equivalent limits for general workers. These limits are based on guidance from national and international scientific groups and government agencies, such as:

1) International Commission on Radiological Protection (ICRP)

2) National Council on Radiation Protection and Measurements (NCRP)

3) U.S. Environmental Protection Agency (EPA)

b. The radiation protection standards for all DOE workers are described in 10 CFR 835, "Occupational Radiation Protection." These regulations apply to DOE, its contractors, and persons utilizing or working in DOE facilities and include dose equivalent limits.

2. Facility administrative control levels for general employees The facility administrative control levels for workers are lower than the DOE limits and are set to: a. Ensure the DOE limits and control levels are not exceeded. b. Help reduce individual and total worker population radiation dose (collective dose).	EO1 State the purpose of administrative control levels.
B. Dose Equivalent Limits and Administrative Control Levels	EO2 Identify the DOE radiation dose limits and facility administrative controls levels.

Table 3-7
Dose Equivalent Limits and Controls

	DOE Dose Equivalent Limit rem/year	DOE Recommendations rem/year	Facility Administrative Control Level rem/year
Whole body	5	2	facility-specific
Extremity	50	N/A	facility-specific
Skin & other organs	50	N/A	facility-specific
Lens of the eye	15	N/A	facility-specific
Member of the public	0.1	N/A	facility-specific
Declared pregnant worker	0.5/gestation period	N/A	facility-specific

(Optional -- leave chart blank and have student complete chart.)

NOTE: 1) The chart is based on limits and control levels for routine conditions. The limits and control levels are also based on the sum of internal and external dose. External dose is from sources outside the body. Internal dose is from sources inside the body. 2) The internal dose reported in a given calendar year is actually the projected dose the individual will receive over the next 50 years from intakes in that calendar year. Radioactive material may be inhaled, ingested, or absorbed through the skin or open wound.

1. Whole body

a. Definition

The whole body extends from the top of the head down to just below the elbow and just below the knee. This is the location of most of the blood-producing and vital organs.

b. Limit and control levels

The DOE whole body dose equivalent limit is based on the sum of internal and external dose.

1) DOE radiation dose equivalent limit during routine conditions is 5 rem/year.

2) Because DOE's objective is to maintain personnel radiation dose well below the regulatory limits, the DOE Radiological Control Technical Standard recommends a DOE administrative control level during routine conditions of 2 rem/year.

3) Facility administrative control level.
(Insert facility-specific information.)

2. Extremities

c. Definition

Extremities include the hands and arms below the elbow, and the feet and legs below the knees.

b. Limit and control level

Extremities can withstand a much larger dose than the whole body because there are no major blood-producing organs located here.

1) DOE radiation dose equivalent limit for extremities is 50 rem/year.

2) Facility administrative control levels.
(Insert facility-specific information.)

3. Skin and other organs

a. DOE radiation dose equivalent limit for skin and other organs is 50 rem/year.

b. Facility administrative control level
(Insert facility-specific information.)

4. Lens of the eye

a. DOE radiation dose equivalent limit for lens of the eye is 15 rem/year.

b. Facility administrative control level.
(Insert facility-specific information.)

5. Declared pregnant worker: Embryo/fetus

After a female worker voluntarily notifies her employer in writing that she is pregnant, she is considered a declared pregnant worker. For the purposes of radiological protection of the fetus/embryo, DOE requires a special limit for dose to the fetus/embryo. In addition, the DOE RCS recommends that the employer provide the option of a mutually agreeable assignment of work tasks, with no loss of pay or promotional opportunity, such that further occupational radiation exposure is unlikely.

This declaration may be revoked, in writing, at anytime by the declared pregnant worker.

a. DOE limit

For a declared pregnant worker who continues working as a radiological worker, the following radiation dose limit will apply.

1) The dose equivalent limit for the embryo/fetus (during the entire gestation period) is 500 mrem.

a) Measures must be taken to avoid substantial variation above the uniform exposure rate necessary to meet the 500 mrem limit for the gestation period.

b) The DOE RCS recommends that efforts be made to avoid exceeding 50 mrem/month to the embryo/fetus of the declared pregnant worker.

2) If the dose equivalent to the embryo/fetus is determined to have already exceeded 500 mrem when a worker notifies her employer of her pregnancy, the worker shall not be assigned to tasks where additional occupational radiation exposure is likely during the remainder of the pregnancy.

b. Site policy

(Insert facility-specific information.)

E03 State the site policy concerning prenatal radiation exposure.

c. Facility administrative control level

(Insert facility-specific information.)

6. Members of the public

a. DOE radiation dose equivalent limit is 100 mrem/year.

b. Facility administrative control levels
(Insert facility-specific information.)

C. Worker Responsibilities Regarding Dose Limits

EO4 Identify the employee's responsibilities concerning radiation dose limits and administrative control levels.

1. It is each employee's responsibility to comply with DOE dose limits and facility administrative control levels.

2. If you suspect that dose limits or administrative control levels are being approached or exceeded, you should notify your supervisor immediately.

3. (Insert facility-specific information.)

III. SUMMARY

(Insert Site Summary.)

IV. EVALUATION

(Insert facility-specific information.)

Refer to RWT Program Management Guide for evaluation guidance.

Module 4: ALARA Program

Terminal Objective :

Given different radiological conditions, identify the techniques for minimizing exposure to radiation and radioactive material in accordance with lesson materials.

Enabling Objectives :

The participant will be able to select the correct response from a group of responses to verify his/her ability to:

EO1 State the ALARA concept.
EO2 State the DOE/Site management policy for the ALARA program.
EO3 Identify the responsibilities of management, the Radiological Control Organization, and the radiological worker in the ALARA Program.
EO4 Identify methods for reducing external and internal radiation dose.
EO5 State the pathways by which radioactive material can enter the body.
EO6 Identify methods a radiological worker can use to minimize radioactive waste.

Instructional Aids:

1. Student Guide
2. Transparencies
3. Activities (as applicable)
4. Self-check quizzes (as applicable)

I. MODULE INTRODUCTION

A. Self Introduction

1. Name
2. Phone Number
3. Background

B. Module Overview

This module is designed to inform the student of the concept of ALARA (As Low As Reasonably Achievable). This module discusses radiation hazards. Methods for reducing both external and internal doses from radiation and radioactive material are also discussed.

C. Objectives Review

Introduce objectives.

D. Introduction

DOE establishes dose limits and administrative control levels for general employees. However, radiological workers and their management strive to keep radiation dose well below these limits. Radiological workers should always try to maintain their radiation dose As Low As Reasonably Achievable (ALARA).

II. MODULE OUTLINE

A. ALARA Program

ALARA stands for As Low As Reasonably Achievable. ALARA is an approach to radiation safety that strives to manage and control doses (both individual and collective) to the work force and the general public to as low as is reasonable taking into account social, technical, economic, practical, and public policy considerations.

1. ALARA concept

EO1 State the ALARA concept.

a. ALARA stands for As Low As Reasonably Achievable.

b. Because some risk, however small, exists from any radiation dose, all doses should be kept ALARA. ALARA includes reducing both internal and external radiation dose.

c. The ALARA concept is an integral part of all site activities that involve the use of sources of ionizing radiation.

d. ALARA is the responsibility of all employees.

2. DOE Management Policy for the ALARA program

EO2 State the DOE/Site management policy for the ALARA program.

Personal radiation exposure shall be maintained As Low As Reasonably Achievable. Radiation exposure to the work force and public shall be controlled such that:

- Radiation doses are well below regulatory limits.
- There is no radiation exposure without an overall benefit.

3. Site policy

(Insert facility-specific information.)

B. Responsibilities for the ALARA Program

EO3 Identify the responsibilities of Management, the Radiological Control Organization, and the radiological worker in the ALARA Program.

The individual radiological worker is ultimately responsible for maintaining his/her radiation dose ALARA. However, management and Radiological Control personnel also play an important role in the ALARA program. The following are some of the responsibilities of the three groups:

1. Management

(Insert facility-specific information.)

2. Radiological Control Organization

(Insert facility-specific information.)

3. Radiological workers

Each radiological worker is expected to demonstrate responsibility and accountability. This is accomplished through an informed, disciplined, and cautious attitude toward radiation and radioactivity.

(Insert facility-specific information.)

C. External and Internal Radiation Dose Reduction

Engineering controls should be the primary method to control exposure (e.g., enclosed hoods). Administrative controls is the next method to control exposures (e.g., postings). Personnel protective equipment is the last method (e.g., respirators).

1. Basic protective measures used to minimize external dose include:

- Minimizing time in radiation areas
- Maximizing the distance from a source of radiation
- Using shielding whenever possible
- Reducing the amount of radioactive material (source reduction)

EO4 Identify methods for reducing external and internal radiation dose.

a. Methods for minimizing time

Reducing the time spent in a field of radiation will lower the dose received by the workers.

1) Plan and discuss the task thoroughly prior to entering the area. Use only the number of workers actually required to do the job.

2) Have all necessary tools present before entering the area.

3) Use mock-ups and practice runs that duplicate work conditions.

4) Take the most direct route to the job site if possible and practical.

5) Never loiter in an area controlled for radiological purposes.

6) Work efficiently and swiftly.

7) Do the job right the first time.

8) Perform as much work outside the area as possible. When practical, remove parts or components to areas with lower dose rates to perform work.

9) Do not exceed stay times. In some cases, the Radiological Control Organization may limit the amount of time a worker may stay in an area due to various reasons. This is known as "stay time." If you have been assigned a stay time, do not exceed this time.

(Insert facility-specific information.)

b. Methods for maximizing distance from sources of radiation

EO4 Identify methods for reducing external and internal radiation dose.

The worker should stay as far away as possible from the source of radiation.

DR: Dose Rate

1) Stay as far away from radiation sources as practical given the task assignment. For point sources (such as valves and hot spots), the dose rate follows a principle called the inverse square law. This law states that if you double the distance, the dose rate falls to 1/4 of the original dose rate. If you triple the distance, the dose rate falls to 1/9 of the original dose rate.

$$DR_A = DR_B \times \frac{Distance^2{}_A}{Distance^2{}_B}$$

2) Be familiar with radiological conditions in the area.

3) During work delays, move to lower dose rate areas.

4) Use remote handling devices when possible.

5) (Insert facility-specific information.)

c. Proper uses of shielding

Shielding reduces the amount of radiation dose to the worker. Different materials shield a worker from the different types of radiation.

EO4 Identify methods for reducing external and internal radiation dose.

1) Take advantage of permanent shielding, such as non-radiological equipment/structures.

2) Use shielded containments when available.

3) Wear safety glasses/goggles to protect your eyes from beta radiation, when applicable.

4) Temporary shielding (e.g., lead or concrete blocks) can only be installed when proper procedures are used.

5) Temporary shielding will be marked or labeled with wording such as "Temporary Shielding - Do Not Remove Without Permission from Radiological Control."

6) Once temporary shielding is installed, it cannot be removed without proper authorization.

- When evaluating the use of shielding, the estimated dose saved is compared to the estimated dose incurred during shield installation and removal.

(Insert facility-specific information.)

d. Source Reduction

Source reduction is another method of reducing radiation doses. Source reduction often involves procedures such as flushing radioactive systems, decontamination, and removal of contaminated items. This is done to reduce the amount of radioactive materials present in/on a system because these materials can add to radiation levels in an area.

2. Internal radiation dose reduction

a. Pathways

EO5 State the pathways through which radioactive material can enter the body.

Internal dose is a result of radioactive materials being taken into the body. Radioactive material can enter the body through one or more of the following pathways:

1) Inhalation

2) Ingestion

3) Absorption through the skin

4) Absorption through wounds

This information excludes exposure from natural internal sources of radioactivity that is discussed in Unit 305.

b. Methods to reduce internal radiation dose

EO4 Identify methods for reducing external and internal radiation dose.

Reducing the potential for radioactive materials to enter the body is important. As previously stated, install or use engineering controls followed by administrative controls as the primary methods to control internal exposure. PPE is the last choice for controlling internal exposure. In addition, the following are methods the worker can use.

1) Wear respirators properly when required. Respirators should only be used by personnel qualified to wear them.

2) Report all wounds or cuts (including scratches and scabs) to the appropriate facility-specific organization before entering any area controlled for radiological purposes.

(Discuss reporting wounds or cuts with facility-specific information.)

3) Comply with the requirements of the controlling work documents.

4) Do not eat, drink, smoke, or chew in Radioactive Materials Areas, Contamination Areas, High Contamination Areas, or Airborne Radioactivity Areas, as dispersible radioactive materials may be present.

5) (Insert facility-specific information.)

3. Lessons Learned

Review lessons learned from your site or other sites to demonstrate what may be learned from mistakes leading to excessive personnel exposures.

(Insert facility-specific information.)

D. Radioactive Waste Minimization

One of the potential consequences of working with radioactive materials is the generation of radioactive waste. This radioactive waste must be properly disposed. Examples of radioactive waste include:

- Paper
- Gloves
- Glassware
- Rags
- Brooms, mops

The ALARA concept also applies to minimizing radioactive waste. This will reduce personnel exposure associated with the handling, packaging, storing, and disposing of radioactive waste. This will also reduce the resultant costs. It is very important for each radiological worker to minimize the amount of radioactive waste generated.

1. Methods to minimize radioactive waste

The following information identifies methods to minimize radioactive waste.

EO6 Identify methods a radiological worker can use to minimize radioactive waste.

a. Minimize the materials used for radiological work.

1) Take only the tools and materials you need for the job into areas controlled for radiological purposes. This is especially important for contamination areas.

2) Unpack equipment and tools in a clean area. This will help to avoid bringing unnecessary material to the job site. This material can become radioactive waste if it is contaminated.

3) Use tools and equipment that are identified for radiological work when possible. (Add facility-specific information about where such tools are stored.)

4) Use only the materials required to clean the area. An excessive amount of bags, rags, and solvent adds to radioactive waste.

5) Sleeve, or otherwise protect with a covering such as plastic, clean materials brought into contaminated areas.

6) (Insert facility-specific information.)

b. Separate radioactive waste from nonradioactive waste.

1) Place radioactive waste in the containers identified for radioactive waste. Do not place radioactive waste in nonradioactive waste containers.

2) Do not throw nonradioactive waste, or radioactive material that may be reused, into radioactive waste containers.

3) (Insert facility-specific information.)

c. Separate compactible material from noncompactible material.

d. Minimize the amount of mixed waste generated. Mixed waste is waste that contains both radioactive and hazardous materials.

e. Use good housekeeping techniques.

(Insert facility-specific information.)

III. SUMMARY

This module addressed key points for the implementation and success of the Site's ALARA Program. Responsibilities for all employees and methods to achieve the ALARA concepts were also discussed.

IV. EVALUATION

(Insert facility-specific information.)

Refer to RWT Program Management Guide for evaluation guidance.

Module 5: Personnel Monitoring Programs

Terminal Objective :

Given different personnel monitoring programs, identify the purpose, types, and worker responsibilities for each in accordance with lesson material.

Enabling Objectives :

The participant will be able to select the correct response from a group of responses to verify his/her ability to:

EO1 State the purpose and worker responsibilities for each of the external dosimeter devices used at the site.
EO2 State the purpose and worker responsibilities for each type of internal monitoring method used at the site.
EO3 State the methods for obtaining radiation dose records.
EO4 Identify worker responsibilities for reporting radiation dose received from other sites and from medical applications.

Instructional Aids:

1. Student Guide
2. Transparencies
3. Activities (as applicable)
4. Self-check quizzes (as applicable)

I. MODULE INTRODUCTION

A. Self Introduction

1. Name
2. Phone Number
3. Background

B. Module Overview

The various types of personnel monitoring devices and the employee's responsibilities concerning each will be discussed.

C. Objectives Review

Introduce objectives.

D. Introduction

External exposure results from radiation that comes from radioactive material outside of the body. A "personnel dosimeter" is a device used to measure external dose. Internal dose is radiation that comes from radioactive material within the body. The whole body counter, chest counter, and bioassay sampling are methods for measuring internal dose.

Personnel monitoring for radiation dose involves assessing exposure due to external sources and internal sources.

II. MODULE OUTLINE

A. External Dosimetry

A personnel dosimeter is a device used to measure radiation dose. Different types of external dosimeters may be used. Radiological Control personnel determine which type(s) are needed. The following information identifies the different types used at this facility.

1. Purpose

EO1 State the purpose and worker responsibility for each of the external dosimeter devices used at the site.

(Insert facility-specific information to describe purpose, and basic operation of each type.)

2. Worker responsibilities for external dosimetry include the following:

a. Wear dosimeters when required.

Radiological Control personnel identify the requirements. Check signs and radiological work permits (RWPs) for the requirements.

b. Wear dosimeters properly.

1) Primary dosimeters should be worn on the chest area. This area is on or between the neck and the waist. Radiological control procedures or work authorizations may also identify proper placement.

2) Supplement dosimeters are worn in accordance with site policy. This includes pocket, electronic dosimeters, extremity dosimetry, or multiple dosimeter sets.

c. Take proper actions if dosimeter is lost, damaged, contaminated, or off-scale. If in an area controlled for radiological purposes, take the following actions:

1) Place work activities in a safe condition.

2) Alert others.

3) Immediately exit the area.

4) Notify radiological control personnel.

d. Store the dosimeter in the proper storage location.

Instructor's Notes: Discuss facility-specific policy for storage of dosimeters.

e. Return dosimeters for processing as directed. Personnel that fail to return dosimeters may be restricted from continued radiological work.

f. Dosimeters issued from the permanent work site cannot be worn at another site.

g. (Insert facility-specific information.)

B. Internal Monitoring

Whole body counters, chest counters, and/or bioassay samples may be used to monitor radioactive material in the human body. In some cases, the locations of radioactive material may be determined. An internal dose estimate may be performed based on these measurements.

1. Purpose of each type of internal monitoring.

(Insert facility-specific information.)

EO2 State the purpose and work responsibilities for each type of internal monitoring method used at the site.

2. Worker responsibilities

(Insert facility-specific information.)

C. Methods for Obtaining Radiation Dose Records

1. Individuals who are monitored for exposure at DOE facilities have the right to request reports of that exposure as follows:

EO3 State the method for obtaining radiation dose records.

a. Upon the request from an individual terminating employment, records of radiation dose shall be provided by the DOE facility within 90 days. If requested, a written estimate of radiation exposure received by the terminating employee shall be provided at the time of termination.

b. Each individual required to be monitored for radiation exposure at a DOE facility shall receive a report of that exposure on an annual basis.

c. Detailed information concerning any individual's dose shall be made available to the individual upon request of that individual.

d. When a DOE contractor is required to report to the Department, pursuant to Departmental requirements for occurrence reporting and processing, any exposure of an individual to radiation and/or radioactive material, or planned special exposure, the contractor shall also provide that individual with a report on his/her exposure data included therein. Such a report shall be transmitted at a time not later than the transmittal to the Department.

2. Reporting radiation dose received from other facilities and medical applications

EO4 Identify worker responsibilities for reporting radiation dose received from other sites and from medical applications.

a. Notify Radiological Control personnel prior to and following any radiation dose received at another facility so that dose records can be updated.

b. Notify Radiological Control of medical radioactive applications. This does not include routine medical and dental X rays. This does include therapeutic and diagnostic radio- pharmaceuticals.

(Insert facility-specific information.)

III. SUMMARY

(Insert facility-specific information.)

IV. EVALUATION

Refer to RWT Program Management Guide for evaluation guidance.

(Insert facility-specific information.)

Module 6: Radiological Access Controls and Postings

Terminal Objective :

Given an area controlled for radiological purposes, the participant will be able to enter and exit the area in accordance with radiological access controls and postings.

Enabling Objectives :

The participant will be able to select the correct response from a group of responses to verify his/her ability to:

EO1 State the purpose of and information found on Radiological Work Permits (RWPs).
EO2 Identify the worker's responsibilities in using Radiological Work Permits.
EO3 Identify the colors and symbol used on radiological postings.
EO4 State the radiological and disciplinary consequences of disregarding radiological postings, signs, and labels.
EO5 Define the areas controlled for radiological purposes.
EO6 Identify the minimum or recommended requirements for entering, working in, and exiting:
  a. Radiological Buffer Areas
  b. Radiation Areas
  c. Radioactive Material Areas
  d. Underground Radioactive Material Areas
  e. Soil Contamination Areas
  f. Fixed Contamination Areas
EO7 Identify the areas a Radiological Worker I trained person may enter.
EO8 Identify the purpose and use of personnel contamination monitors.

Instructional Aids:

1. Student Guide
2. Transparencies
3. Activities (as applicable)
4. Self-check quizzes (as applicable)

I. MODULE INTRODUCTION

A. Self Introduction

1. Name
2. Phone Number
3. Background

B. Module Overview

Radiological Work Permits (RWP) used to control access into areas controlled for radiological purposes will be addressed. In addition, radiological requirements for working in these areas will be presented.

C. Objectives Review

Introduce objectives.

D. Introduction

The previous modules discussed some important radiological topics from a theoretical perspective. The current module will discuss the application of this theory to control radiological work in a safe but efficient manner.

II. MODULE OUTLINE

A. Radiological Work Permits (RWPs)

1. Purpose of RWPs

   RWPs may be used to establish radiological controls for entry into areas controlled for radiological purposes. They serve to:

   a. Inform workers of area radiological conditions.

   EO1 State the purpose of and information found on Radiological Work Permits (RWPs).

   b. Inform workers of entry requirements.

   c. Provide a record relating radiation doses to specific work activities.

2. Types of RWPs

   The type of RWP used will depend on the radiological conditions in the area.

a. General Radiological Work Permit

1) This should be used to control routine or repetitive activities such as tours and inspections or minor work activities in areas with well characterized, stable radiological conditions.

2) General RWPs should not be approved for periods longer than 1 year.

3) Examples of use

(Insert facility-specific information.)

b. Job-specific radiological work permit

1) This should be used to control nonroutine operations or work in areas with changing radiological conditions.

2) It should only remain in effect for the duration of a particular job.

3) Examples of use

(Insert facility-specific information.)

c. An alternate formal mechanism, such as written procedures, experiment authorizations, or other written authorization, may be used in lieu of an RWP. The alternate method should include the elements of an RWP.

3. Information found on the RWP

The RWP should include the following information:

a. Description of work.

b. Work area radiological conditions

This information may also be determined from area radiological survey maps/diagrams or the radiological posting for that area.

c. Dosimetry requirements.

d. Pre-job briefing requirements.

Pre-job briefings generally consist of discussions among workers and supervisor(s) concerning various radiological aspects of the job. The purpose of the briefings should be to discuss radiological exposure and appropriate actions for unplanned situations.

e. Required level of training for entry.

f. Protective clothing/equipment requirements.

g. Radiological Control coverage requirements and stay time controls, as applicable.

h. Limiting radiological condition that may void the permit.

i. Special dose or contamination reduction. considerations.

j. Special personnel frisking considerations.

k. Technical work document to be used, as applicable.

l. Date of issue and expiration.

m. Authorizing signatures and unique identifying designation or number.

4. Responsibilities of the worker when using an RWP

EO2 Identify the worker's responsibilities in using Radiological Work Permits.

a. Workers must read and comply with the RWP requirements.

b. Workers must acknowledge they have read, understood, and agreed to comply with the RWP prior to entering the area and after any revision to the RWP. This is done by signature or through electronic means.

c. Radiological Control or a supervisor should be contacted prior to work if the RWP appears to be incorrect or is difficult to understand.

d. Do not make substitutions for specified requirements.

e. Report to Radiological Control personnel if radiological controls are not adequate or are not being followed.

B. Radiological Postings

1. Radiological postings are used to:

a. Alert personnel to the presence of radiation and radioactive materials.

b. Aid in minimizing personnel dose.

c. Prevent the spread of contamination. In addition, 10 CFR 835 - Subpart F specifies requirements for personnel entry controls for HR and VHR Areas.

2. Posting requirements

a. Areas and materials controlled for radiological purposes will be designated with a magenta or black standard three-bladed radiological warning symbol (trefoil) on a yellow background.

EO3 Identify the colors and symbol used on radiological postings.

b. Fixed barriers such as walls, rope, tape, or chain will designate the boundaries of posted areas. Where possible, the barriers will be yellow and magenta in color.

c. The barriers should be placed to clearly mark the boundary of the radiological areas.

d. Entrance points to radiologically controlled areas should have signs or postings stating the entry requirements, such as "Personnel Dosimeters, RWP and Respirator Required."

e. In some cases, more than one radiological condition may be present. The area shall be posted to include all of the radiological conditions that are present.

See 10 CFR 835.603.

f. In areas of ongoing work activities, the dose rate and contamination levels (or ranges of each) may be included in postings.

g. The posting will be placed where it is clearly visible to personnel.

3. Responsibilities of the worker

EO2 Identify the worker's responsibilities in using Radiological Work Permits.

a. Before entering an area controlled for radiological purposes, read all of the signs. Since radiological conditions can change, the signs will also be changed to reflect the new conditions. A sign or posting that you saw one day may be replaced with a new one the next day.

b. Obey any posted, written or oral requirements including "Exit," "Evacuate," "Hold Point," or "Stop Work Orders." These requirements may be included in RWPs and work procedures, and may come from Radiological Control personnel at the job site.

1) Hold points are specific times noted in a procedure, work permit, etc., where work must stop for Radiological Control or other evaluations.

2) Stop Work Orders are usually a result of:

a) Inadequate radiological controls

b) Failure to implement radiological controls

c) Radiological hold point not being observed

d) Changing or unexpected conditions.

c. Report unusual conditions such as leaks, spills, or alarming area monitors to the Radiological Control personnel.

d. Be aware of changing radiological conditions. Be aware that others' activities may change the radiological conditions in your area.

e. If any type of material used to identify a radiological hazard is found outside an area controlled for radiological purposes, it should be reported to Radiological Control personnel immediately.

4. Consequences of disregarding radiological postings, signs, and labels

EO4 State the radiological and disciplinary consequences of disregarding radiological postings, signs, and labels.

a. It is each worker's responsibility to read and comply with all the information identified on radiological postings, signs, and labels.

b. Disregarding any of these or removing/relocating them without permission can lead to:

1) Unnecessary or excessive radiation dose.

2) Personnel contamination.

3) Disciplinary actions such as formal reprimand, suspension, or even termination.

C. Areas a RW I Trained Person Can Enter

The level of training a radiological worker has successfully completed determines the types of areas he/she can enter.

EO7 Identify the areas a Radiological Worker I-trained person may enter.

1. Radiological Buffer Areas (RBAs)

EO5 Define the areas controlled for radiological purposes.

RBAs are intermediate areas which DOE RCS recommends be established to prevent the spread of radioactive contamination and to protect personnel from radiation exposure. This area designation is not required by 10 CFR 835 and its use may vary from site to site.

a. Posting Recommendations:

"CAUTION, RADIOLOGICAL BUFFER AREA"

b. Recommended requirements for unescorted entry should include:

1) Appropriate training, such as Radiological Worker I Training.

EO6 Identify the minimum or recommended requirements for entering, working in, and exiting Radiological Buffer Areas.

2) Personnel dosimetry, as appropriate.

3) (Insert facility-specific information.)

c. Recommended requirements for working in RBA

(Insert facility-specific information.)

d. Recommended requirements for exiting an RBA:

Personnel exiting a RBA containing a Contamination Area, High Contamination Area, or Airborne Radioactivity Area should, at a minimum, perform a hand and foot frisk.

1) General guidelines for handheld monitoring using a hand-held radioactive contamination survey instrument include the following:

E08 Identify the purpose and use of personnel contamination methods.

a) Verify the instrument is on, set to the proper scale, and within the calibration date.

b) Verify instrument response and source check.

c) Ensure the audible function of the instrument is on and can be heard.

d) Determine the instrument background.

(Insert facility-specific information concerning acceptable background rates).

e) Survey hands before picking up the probe.

f) Hold the probe approximately ½" from the surface being surveyed for beta/gamma and ¼" for alpha radiation.

g) Move probe slowly over the surface, approximately 2" per second.

h) If the count rate increases during frisking, pause for 5 to 10 seconds over the area to provide adequate time for instrument response.

2) Alarm response for hand-held survey instrument

a) If contamination is indicated, remain in the area and notify the Radiological Control personnel.

b) Minimize cross contamination. For example, put a glove on a contaminated hand while waiting for the Radiological Control personnel to arrive.

3) Portal monitors

(Insert facility-specific information.)

2. Radiation Areas (RAs)

E05 Define the areas controlled for radiological purposes.

RAs are any areas accessible to individuals in which radiation levels could result in an individual's receiving a deep dose equivalent in excess of 5 mrem/hr. This is established based on dose rates at 30 cm from the source of radiation.

a. Posting Requirements:

"CAUTION, RADIATION AREA"

Additionally, the posting may state:

"Personnel Dosimetry Required for Entry"

b. Minimum requirements for unescorted entry should be:

E06 Identify the minimum or recommended requirements for entering, working in, and exiting Radiation Areas.

1) Appropriate training, such as Radiological Worker I Training.

2) Personnel dosimeter.

3) Worker's signature on the RWP, as applicable.

4) (Insert facility-specific information.)

c. Minimum requirements for working in an RA

1) Don't loiter in the area.

2) Follow proper emergency response to abnormal situations.

3) Avoid hot spots.

Hot spots are localized sources of radiation or radioactive material normally within facility piping or equipment. The radiation levels of hot spots exceed the general area radiation level by more than a factor of 5 and are greater than 100 mrem per hour on contact.

Posting:

"Caution, Hot Spot"

4) (Insert facility-specific information.)

d. Minimum requirements for exiting a RA:

1) Observe posted exit requirements

2) Sign-out on RWP or equivalent, as applicable

3) Insert facility-specific information

3. Radioactive Materials Area (RMA)

EO5 Define the areas controlled for radiological purposes.

RMA means an area, accessible to individuals, in which items or containers of radioactive material exist and the total activity of rad-material exceeds ten times the applicable value provided in 10 CFR 835 Appendix E.

a. Radioactive material may consist of equipment, components, or materials that have been exposed to contamination or have been activated. Sealed or unsealed radioactive sources are also included.

b. Radioactive material may be stored in drums, boxes, etc., and will be marked appropriately.

c. Posting Requirements:

"CAUTION, RADIOACTIVE MATERIAL(S)"

d. Exceptions to posting requirements.

See 10 CFR 835.604

1) Areas may be excepted from the posting requirements for periods of less than 8 continuous hours when placed under continuous observation and control of an individual knowledgeable of, and empowered to implement, required access and exposure control measures.

2) The following areas may be excepted from the radioactive material area posting requirements:

a) Areas posted Radiation Area, High Radiation Area, Very High Radiation Area, Airborne Radioactivity Area, Contamination Area, or High Contamination Area

b) Areas in which each item or container of radioactive material is clearly and adequately labeled in accordance with 10 CFR 835 such that individuals entering the area are made aware of the hazard.

c) The radioactive material consists solely of structures or installed components which have been activated.

d) Areas containing only packages received from radioactive material transportation labeled and in a non-degraded condition need not be posted in accordance with 10 CFR 835 until the packages are surveyed.

e. Minimum requirements for unescorted entry should include:

1) Appropriate training, such as Radiological Worker I Training.

EO6 Identify the minimum or recommended requirements for entering, working in, and exiting Radioactive Materials Areas.

2) For entry into Radioactive Material Areas where whole body dose rates exceed 5 mrem/hour, the Radiation Area entry requirements will apply.

3) For entry into Radioactive Material Areas where removable contamination levels exceed the specified DOE limits, the Contamination Area entry requirements will apply.

Show sign.

4) (Insert facility-specific information.)

f. Minimum requirements for working in an RMA

(Insert facility-specific information.)

g. Minimum requirements for exiting an RMA

(Insert facility-specific information.)

EO5 Define the areas controlled for radiological purposes.

4. Fixed Contamination Area (Recommended)

This area designation is recommended by the DOE RCS. It may be an area or equipment that contains radioactive material that cannot be easily removed from surfaces by nondestructive means, such as wiping, brushing, or laundering. This type of area designation is not required by 10 CFR 835 and its use may vary from site to site.

EO6 Identify the minimum or recommended requirements for entering, working in, and exiting Fixed Contamination Areas.

a. Recommended Posting:

"CAUTION, FIXED CONTAMINATION"

Show sign.

b. Contact the Radiological Control Organization for entry and exit requirements.

c. (Insert facility-specific information.)

5. Soil Contamination Areas (for work that doesn't disturb the soil) (Recommended)

EO5 Define the areas controlled for radiological purposes.

This area designation is recommended by the DOE RCS. It contains surface soil or subsurface contamination levels that exceed the recommended DOE limits. This type of area designation is not required by 10 CFR 835 and its use may vary from site to site.

a. Posting:

EO6 Identify the minimum or recommended requirements for entering, working in.,and exiting Soil Contamination Areas.

"CAUTION, SOIL CONTAMINATION AREA"

b. Contact the Radiological Control Organization for entry and exit requirements.

Show sign.

c. (Insert facility-specific information.)

6. Underground Radioactive Materials Areas (URMAS) (when an individual is not likely to receive a dose of >0.1 rem in a year) (Recommended)

EO5 Define the areas controlled for radiological purposes.

URMAS are area designations recommended by the DOE RCS. They are established to indicate the presence of underground items that contain radioactive materials such as pipelines, radioactive cribs, covered ponds, inactive burial grounds, and covered spills. This type of area designation is not required by 10 CFR 835, and its use may vary from site to site.

a. Posting:

Show sign.

"UNDERGROUND RADIOACTIVE MATERIALS"

Special instructions such as, "Consult with Radiological Control Organization before Digging" or "Subsurface Contamination Exists" may be included.

b. General requirements:

EO6 Identify the minimum or recommended requirements for entering, working in, and exiting Underground Radioactive Material Areas.

1) An Underground Radioactive Materials Area may be exempt from the general entry and exit requirements if individual doses do not exceed 100 mrem in a year.

2) Contact the Radiological Control Organization prior to entry.

c. (Insert facility-specific information.)

D. Areas a RW I Trained Person May Not Enter

1. High Radiation Areas (HRAs)

HRA is any area accessible to individuals in which radiation levels could result in an individual receiving a deep dose equivalent in excess of 100 mrem/hr at 30 centimeters from the source.

a. Posting Requirements:

"CAUTION or DANGER, HIGH RADIATION AREA"

Additionally, the posting may state:

Show sign.

"Personnel Dosimetry Required for Entry"

b. Unescorted entry into this area requires appropriate training, such as RW II or RW I with the High Radiation Area training module.

2. Very High Radiation Areas (VHRs)

A VHR is any area accessible to individuals in which radiation levels could result in an individual receiving an absorbed dose in excess of 500 rad/hr at 1 meter from the source of radiation.

a. Posting Requirements:

"GRAVE DANGER, VERY HIGH RADIATION AREA"

Show sign.

3. Contamination Areas (CAs)

CAs are those areas, accessible to individuals, in which removable contamination levels are greater than 1 time but less than or equal to 100 times the specified limits in Appendix D of 10 CFR 835.

a. Posting Requirements:

"CAUTION, CONTAMINATION AREA"

b. Unescorted entry into this area requires appropriate training, such as RW II training.

4. High Contamination Areas (HCAs)

An HCA is an area, accessible to individuals, in which removable contamination levels are 100 times or more the specified limits in Appendix D of 10 CFR 835.

a. Posting Requirements:

"CAUTION or DANGER, HIGH CONTAMINATION AREA"

Show sign.

Additionally, the posting may state:

"RWP REQUIRED FOR ENTRY"

b. Unescorted entry into this area requires appropriate training, such as RW II training.

5. Airborne Radioactivity Areas (ARAs)

ARAs are those areas, accessible to individuals, where the concentration of airborne radioactivity, above natural background, exceeds or is likely to exceed the specified limits in 10 CFR 835.

a. Posting Requirements:

"CAUTION or DANGER AIRBORNE RADIOACTIVITY AREA"

Additionally, the posting may state:

Show sign.

"RWP REQUIRED FOR ENTRY"

c. Unescorted entry into this area requires appropriate training, such as RW II training.

III. SUMMARY

(Insert facility-specific information.)

IV. EVALUATION

(Insert facility-specific information.)

Refer to RWT Program Management Guide for evaluation guidance.

Module 7: Radiological Emergencies

Terminal Objective:

Given a radiological emergency or alarm, identify the appropriate responses in accordance with approved lesson materials.

Enabling Objectives:

The participant will be able to SELECT the correct response from a group of responses to verify his/her ability to:

EO1 State the purpose and types of emergency alarms.
EO2 Identify the correct responses to emergencies and alarms.
EO3 State the possible consequences of disregarding radiological alarms.
EO4 State the site administrative emergency radiation dose guidelines.

Instructional Aids:

1. Student Guide
2. Transparencies
3. Activities (as applicable)
4. Self-check quizzes (as applicable)

I. MODULE INTRODUCTION

A. Self Introduction

1. Name
2. Phone Number
3. Background

B. Module Overview

This module discusses off-normal and emergency situations and the appropriate response to each. Radiological alarms associated with monitoring equipment will also be discussed.

C. Objectives Review

Introduce objectives.

D. Introduction

Monitoring systems are used to warn personnel when off-normal radiological conditions exist. Radiological workers must become familiar with these alarms and know the response to each. These responses will help to minimize exposure and personal contamination during off-normal conditions.

II. MODULE OUTLINE

A. Emergency Alarms and Responses

Equipment that monitors radiation dose rates and airborne contamination levels is placed throughout DOE radiological facilities. It is essential for radiological workers to recognize the equipment and the associated alarms and know the appropriate response.

EO1 State the purpose and types of emergency alarms.

1. Area Radiation Monitors

   - Types and purpose
   - Operational check (if appropriate)
   - Alarms
   - Appropriate response

   (Insert facility-specific information.)

2. Airborne Contamination Monitors

   - Types and purpose
   - Operational check (if appropriate)
   - Alarms
   - Appropriate response

EO2 Identify the correct responses to emergencies and alarms.

   (Insert facility-specific information.)

3. Disregard for Radiological Alarms

EO3 State the possible consequences of disregarding radiological alarms.

   Disregarding any of these radiological alarms may lead to:

   - Possible excessive radiation dose
   - Unnecessary spread of contamination
   - Unnecessary personal contamination
   - Disciplinary action

B. Radiological Emergency Situations

Working in a radiological environment requires more precautionary measures than performing the same job in a nonradiological setting. If an emergency arises during radiological work, response actions may be necessary to ensure personnel safety.

1. Personnel injuries in areas controlled for radiological purposes.

EO2 Identify the correct responses to emergencies and/or alarms.

   (Insert facility-specific information.)

2. Situations that require immediate exit from an area controlled for radiological purpose.

   (Insert facility-specific information.)

3. An accidental breach of a radioactive system or spill of radioactive material.

   a. For radioactive spills involving highly toxic chemicals, workers should immediately exit the area without attempting to stop or secure the spill. They should then promptly notify Industrial Hygiene or the Hazardous Material team and Radiological Control personnel.

b. For other spills:

Stop or secure the operation causing the spill, if it can be done safely

Warn others in the area and notify Radiological Control personnel

Isolate the spill area, if possible

Minimize individual exposure and contamination

Secure unfiltered ventilation (fan, open windows, etc.)

C. Considerations in Rescue and Recovery Operations

1. In extremely rare cases, emergency exposure to high levels of radiation may be necessary. This is done to rescue personnel or protect major property.

2. Rescue and recovery operations that involve radiological hazards can be very complex.

3. The type of response to these operations is generally left up to the official in charge of the emergency situation. The official's judgment is guided by many variables that include determining the risk versus the benefit of an action and deciding how best to implement the action.

4. No individual shall be required to perform a rescue action that might involve substantial personal risk. All personnel selected to provide emergency response shall be trained commensurate with the hazards in the area and required controls. They shall be briefed beforehand on the known or anticipated hazards to which they shall be subjected.

5. The DOE guidelines for control of Emergency Exposure are as follows:

Table 7-1

Guidelines for Control of Emergency Exposures

Refer to Table in Student's Guide

6. Site administrative emergency dose guidelines for rescue and recovery operations.

   (Insert facility-specific information.)

EO4 State the site administrative emergency radiation dose guidelines.

III. SUMMARY

(Insert facility-specific information.)

IV. EVALUATION

(Insert facility-specific information.)

Refer to RWT Program Management Guide for evaluation guidance.

Module 8: High/Very High Radiation Area Training

Prerequisite: **Core Academics (Modules 1-7)**

Terminal Objective:

Given a High or Very High Radiation area sign, define the area and identify the requirements for entry to High Radiation Areas in accordance with the lesson material.

Enabling Objectives:

The participant will be able to select the correct response from a group of responses to verify his/her ability to:

EO1 Define "High Radiation Area" and "Very High Radiation Area."
EO2 Identify sources and locations that may produce High Radiation Areas and Very High Radiation Areas at the site.
EO3 State the minimum requirements for entering, working in, and exiting High Radiation Areas.
EO4 State the administrative and physical controls for access to High Radiation Areas.

Instructional Aids:

1. Student Guide
2. Transparencies
3. Activities (as applicable)
4. Self-check quizzes (as applicable)

I. MODULE INTRODUCTION

A. Self Introduction

1. Name
2. Phone Number
3. Background

B. Module Overview

This module discusses information regarding entry, work in, and control of High Radiation Areas and the materials and systems that can emit high radiation levels.

C. Objectives Review

Introduce objectives.

D. Introduction

1. The High Radiation Area lesson plan familiarizes the participant with requirements for entry, work in, and exit from High Radiation Areas.

2. Radiological Worker Modules 1-7 (core academic material) are a prerequisite for this module. If prerequisite requirements are met, this module may be taught alone.

II. MODULE OUTLINE

A. High and Very High Radiation Area Definitions

1. High Radiation Area

EO1 Define High Radiation Area and Very High Radiation Area.

A High Radiation Area is any area, accessible to individuals, in which radiation levels could result in an individual receiving a deep dose equivalent in excess of 0.1 rem (100 mrem), but less than or equal to 500 rad in one hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

30 cm is approximately = to 1 foot (11.81 inches)

2. Very High Radiation Area

A Very High Radiation Area is any area, accessible to individuals, in which radiation levels could result in an individual receiving an absorbed dose in excess of 500 rads in one hour at 1 meter from a radiation source or from any surface that the radiation penetrates.

1m is slightly more than 1 yard (39.37 inches)

B. Signs and Postings

1. High Radiation Area

High Radiation Areas will be posted with a standard radiation symbol colored magenta (or black) on a yellow background, reading:

"CAUTION"
or
"DANGER
HIGH RADIATION AREA"

Show sign.

Additionally the posting may state:

"Personnel Dosimeter, Supplemental Dosimeters, and RWP Required for Entry"

2. Very High Radiation Area

Very High Radiation Areas will be posted with a standard radiation symbol colored magenta (or black) on a yellow background, reading:

"GRAVE DANGER,
VERY HIGH RADIATION AREA"

Show sign.

Additionally the posting may state:

"Special Controls Required for Entry"

EO2 Identify sources and locations that may produce High Radiation Areas and Very High Radiation Areas.

Some HRAs and VHRAs only exist when machinery is energized, such as radiation producing devices. For example, a posting could be:

"High Radiation Area When Warning Light is On"
"Controlled Area When Warning Light is Off"

3. Radiation sources

(Insert facility-specific information on radiation sources that can produce High/Very High Radiation Areas and the location of each.)

Table 8-1

High and Very High Radiation Area

Definitions and sources

(Objectives EO1 and EO2)

Refer to Table in Student's Guide

C. Entry, Work In, and Exit from High Radiation Areas

EO3 State the minimum requirements for entering HRAs.

1. Minimum requirements for entering HRAs

a. Appropriate training (e.g., Radiological Worker I Training plus High Radiation Area Training or Radiological Worker II Training).

b. Worker signature on the appropriate Radiological Work Permit (RWP).

c. Personnel and supplemental dosimeter.

Workers need to receive proper training prior to using a dose rate indicating device.

d. Survey meter(s) or dose rate indicating device available at the work area (may be required for certain jobs).

e. Access control.

f. A radiation survey prior to first entry.

g. Notification of operations personnel.

h. Additional requirements where dose rates are greater than 1 rem in an hour. These should include:

1) Determination of worker's current dose.

2) Pre-job briefing, as applicable.

3) Review and determination by the RCO regarding the level of RC technician coverage.

Required by 10 CFR 835.

4) Access Points secured by control devices.

i. Additional measures to ensure personnel are not able to gain unauthorized or inadvertent access to Very High Radiation Areas.

j. (Insert facility-specific information.)

2. Minimum requirements for working in HRAs

EO3 State the minimum requirements for working in HRAs.

a. Don't loiter.

b. Practice ALARA.

c. (Insert facility-specific information.)

3. Minimum requirements for exiting HRAs

EO3 State the minimum requirements for exiting HRAs.

No controls shall be established in a Radiological Area that would prevent rapid evacuation of personnel.

a. Sign out on RWP, as applicable.

b. (Insert facility-specific information.)

D. Access Controls for High and Very High Radiation Areas

There are different controls that are used to prevent the inadvertent entry or unauthorized access into Radiological Areas. The following identifies administrative and physical controls that are used for HRAs.

EO4 State the administrative and physical controls for access to HRAs.

1. Administrative controls

The following are administrative controls that may be used to control access to HRAs. These are used in addition to physical controls.

a. Formal radiological reviews.

b. RWPs.

c. Pre-job briefings.

d. Procedures.

e. Postings.

f. Administrative control levels (ACLs).

g. (Insert facility-specific information.)

2. Physical controls

EO4 State the administrative and physical controls for access to HRAs.

One or more of the following features should be used for each entrance or access point to an HRA and shall be used for HRAs >1 rem in any one hour.

It should be noted again that no controls shall be established in an HRA or VHRA that would prevent rapid evacuation of personnel.

a. A control device that prevents entry or upon entry causes the radiation level to be reduced below that level defining an HRA.

b. An automatic device that prevents use or operation of the radiation source.

c. A control device that energizes a visible or audible alarm.

d. Entryways that are locked. Maintain positive control over each entry.

e. Continuous direct or electronic surveillance.

f. (Insert facility-specific information.)

3. Consequences of violating radiological signs or postings, or bypassing physical access controls:

a. Equipment damage.

b. Personnel injury.

c. Excessive and unplanned personnel exposure.

d. Disciplinary action.

E. Access to VHRAs

Due to the extremely high dose rates in a VHRA, personnel access to these areas needs to be strictly monitored and controlled. Additional training would be required, as well as enhanced monitoring.

III. SUMMARY

(Insert facility-specific information.)

IV. EVALUATION

(Insert facility-specific information.)

Refer to RWT Program Management Guide for evaluation guidance.

Module 9: Radioactive Contamination Control

Prerequisites: **Core Academics - (Modules 1-7)**

Terminal Objective:

Given different types of radioactive contamination, identify the methods used to control the spread of radioactive contamination in accordance with lesson material.

Enabling Objectives:

The participant will be able to select the correct response from a group of responses to verify his/her ability to:

EO1 Define fixed, removable, and airborne contamination.
EO2 State sources of radioactive contamination.
EO3 State the appropriate response to a spill of radioactive material.
EO4 Identify methods used to control radioactive contamination.
EO5 Identify the proper use of protective clothing.
EO6 Identify the purpose and use of personnel contamination monitors.
EO7 Identify the normal methods used for decontamination.
EO8 Define "Contamination," "High Contamination," and "Airborne Radioactivity Areas."
EO9 Identify the minimum requirements for entering, working in, and exiting Contamination, High Contamination, and Airborne Radioactivity Areas.

Instructional Aids:

1. Student Guide
2. Transparencies
3. Activities (as applicable)
4. Self-check quizzes (as applicable)

I. MODULE INTRODUCTION

A. Self Introduction

1. Name
2. Phone Number
3. Background

B. Module Overview

This module is designed to inform the worker about radioactive contamination and discuss methods used to control the spread of contamination.

C. Objectives Review

Instructor's Notes: Introduce objectives.

D. Introduction

Contamination control is one of the important aspects of radiological protection. Using proper contamination control practices helps to ensure a safe working environment. It is important for all employees to recognize potential sources of contamination and to use appropriate contamination control methods.

II. MODULE OUTLINE

A. Comparison of Ionizing Radiation and Radioactive Contamination

1. Ionizing radiation

   Energy (particles or rays) emitted from radioactive atoms or generated from machines such as X-ray machines that can cause ionization (e.g., gamma rays, X rays, beta particles, and other particles capable of ionizing atoms).

2. Radioactive contamination

   Radioactive material is material that contains radioactive atoms. When radioactive material is properly contained, it still emits radiation and may be an external dose hazard, but it is not a contamination hazard. When radioactive material escapes its container, it is then referred to as radioactive contamination.

3. Radiation is energy; contamination is a material.

B. Types of Contamination

EO1 Define fixed, removable, and airborne contamination.

Radioactive contamination can be fixed, removable, or airborne.

1. Fixed contamination is contamination that cannot be easily removed from surfaces.

   a. It cannot be removed by casual contact.

   b. It may be released when the surface is disturbed (buffing, grinding, using volatile liquids for cleaning, etc.).

   c. Over time it may "weep," leach, or otherwise become loose or removable.

2. Removable contamination is contamination that can easily be removed from surfaces. Any object that comes in contact with it may become contaminated.

a. It may be transferred by casual contact, wiping, brushing, or washing.

b. Air movement across removable contamination could cause the contamination to become airborne.

3. Airborne contamination is contamination suspended in air.

Table 9-1
Types of Radioactive Contamination

See Student's Guide for Table

C. Radioactive Contamination

Radiological work is required in areas and in systems that are contaminated by design (e.g., maintenance of valves in radioactive fluid systems).

EO2 State sources of radioactive contamination.

Regardless of the precautions taken, radioactive material will sometimes contaminate objects, areas, and people.

1. Sources

The following are some sources of radioactive contamination.

a. Leaks or breaks in radioactive fluid systems.

b. Leaks or breaks in air-handling systems for radioactive areas.

c. Airborne contamination depositing on surfaces.

d. Leaks or tears in radioactive material containers such as barrels, plastic bags or boxes.

e. Another common cause of contamination is sloppy work practices. These may lead to contamination of tools, equipment, and workers. Examples include:

1) Opening radioactive systems without proper controls.

2) Poor housekeeping in contaminated areas.

3) Excessive motion or movement in areas of higher contamination.

4) Improper usage of step-off pads and change areas.

5) Violation of contamination control ropes and boundaries.

f. Hot particles: Small, sometimes microscopic pieces of highly radioactive material may escape containment. These pieces are known as "hot particles."

1) Hot particles may be present when contaminated systems leak or are opened. These particles may also be present when machining, cutting, or grinding is performed on highly radioactive materials.

2) Hot particles can cause a high, localized radiation dose in a short period of time if they remain in contact with skin.

2. Indicators of possible contamination:

Radiological workers should be aware of potential radioactive contamination problems. Potential contamination problems should be reported to the Radiological Controls Organization. Examples include:

a. Leaks, spills, or standing water that is possibly from a radioactive fluid system.

b. Damaged or leaking radioactive material containers.

c. Open radioactive systems with no observable controls.

d. Dust/dirt accumulations in radioactive contamination areas.

e. Torn or damaged tents and glove bags or containments on radioactive systems.

3. Radiological worker response to a spill of radioactive material

EO3 State the appropriate response to a spill of radioactive material.

Each of the examples listed above may be a spill of radioactive material. Here is the minimum response to a spill of radioactive material:

a. Stop or secure the operation causing the spill, if qualified.

b. Warn others in the area.

c. Isolate the area.

d. Minimize exposure to radiation and contamination.

e. Secure unfiltered ventilation.

f. Notify Radiological Control personnel.

D. Contamination Control Methods

Every radiological worker should perform work in such a manner as to minimize the generation of radioactive contamination and confine the spread of radioactive contamination to the smallest area possible. By controlling contamination, the worker minimizes the potential for internal exposure, and personnel contamination can be minimized.

Examples of methods used to control the spread of radioactive contamination follow:

1. Prevention

EO4 Identify the methods used to control radioactive contamination.

A sound maintenance program can prevent many radioactive material releases.

a. Establish a solid routine maintenance program for operating systems to minimize failures and leaks that lead to contamination.

b. Repair leaks as soon as identified to prevent a more serious problem.

c. Establish adequate work controls before starting jobs.

d. During pre-job briefings, discuss measures that will help reduce or prevent contamination spread. The agreed upon measures should be implemented by workers at the job site.

e. Change protective gear (e.g., gloves) as necessary (typically as directed by Radiological Control personnel) to prevent cross-contamination.

f. Stage areas to prevent contamination spread from work activities.

1) Cover work area to minimize cleanup afterward.

2) Cover piping/equipment below a work area to prevent dripping contamination onto cleaner areas.

3) Cap contaminated pipes or systems when not in use.

g. Prepare tools and equipment to prevent contamination.

1) Bag or sleeve hoses and lines to prevent contamination.

2) Minimize the equipment and tools taken into and out of contamination areas.

3) Cover/tape tools or equipment used during the job to minimize decontamination after the job (i.e., taping up a screwdriver before use).

h. Use good housekeeping practices; clean up during and after jobs.

"Good Housekeeping" is a prime factor in an effective contamination control program. Each radiological worker should keep his/her work area neat and clean to control the spread of contamination.

i. Use standard contamination control procedures as established by the Radiological Control Organization.

1) Do not violate contamination area ropes or barricades.

2) Frisk materials out of contamination areas as directed by site procedures.

3) Use change areas and step-off pads as directed.

4) Do not pass items out of contamination areas without following site procedures.

5) Be alert for potential violations to contamination control procedures.

j. Ensure ventilation systems are operating as designed (i.e., no unauthorized modifications).

k. Radiological workers should always ensure that the proper entry, exit, and equipment control procedures are used to avoid the spread of contamination. Comply with procedures!!

2. Engineering controls

EO4 Identify methods used to control radioactive contamination.

a. Ventilation

1) Systems and temporary spot ventilation (e.g., temporary enclosures with HEPA filters) are designed to maintain airflow from areas of least contamination to areas of most contamination (e.g., clean to contaminated to highly contaminated areas).

2) A slight negative pressure is maintained on buildings/rooms/enclosures where potential contamination exists.

3) High efficiency particulate air (HEPA) filters are used to remove radioactive particles from the air.

HEPA - High Efficiency Particulate Air filter.

b. Containment

Permanent and temporary containments are used for contamination control. Examples include vessels, pipes, cells, glovebags, gloveboxes, tents, huts, and plastic coverings.

3. Personal Protective Measures

Sometimes engineering controls cannot eliminate contamination. Personnel protective measures, such as protective clothing and respiratory equipment, will be used at this point.

a. Protective clothing

EO5 Identify the proper use of protective clothing.

1) Protective clothing is required for entering areas containing contamination and airborne radioactivity levels above specified limits to prevent personnel contamination.

2) The amount and type of protective clothing required is dependent on work area radiological conditions and nature of the job.

3) Personal effects such as watches, rings, jewelry, etc., should not be worn.

4) Full protective clothing generally consists of:

a) Coveralls.

b) Cotton liners.

c) Rubber gloves.

d) Shoe covers.

e) Rubber overshoes.

f) Hood.

NOTE: Cotton glove liners may be worn inside rubber gloves for comfort, but should not be worn alone or considered as a layer of protection against contamination.

5) Proper use of protective clothing

a) Inspect protective clothing for rips, tears, or holes prior to use. If you find damaged protective clothing, discard properly.

b) Supplemental and multiple dosimeters should be worn as prescribed by the Radiological Control Organization.

c) After donning protective clothing, proceed directly from the dress-out area to the work area.

d) Avoid getting coveralls wet. Wet coveralls provide a means for contamination to reach the skin/clothing.

e) Contact Radiological Control personnel if clothing becomes ripped, wet, or otherwise compromised.

b. Respiratory protection equipment

This is used to prevent the inhalation of radioactive materials. This training course DOES NOT qualify a worker to wear respiratory protection equipment.

E. Contamination Monitoring Equipment

EO6 Identify the purpose and use of personnel contamination monitors.

1. Purpose

Contamination monitoring equipment is used to detect radioactive contamination on personnel and equipment.

2. Types and uses

Hand Held Contamination Monitor:

Modify with site specific procedures as necessary.

a. Verify instrument is in service, set to proper scale, and has functioning audio equipment.

b. Note background count rate at frisking station.

c. Frisk hands before picking up the probe.

d. Hold probe approximately ½ inch from surface being surveyed for beta/gamma and ¼ inch for alpha.

e. Move probe slowly over surface, approximately 2 inches per second.

f. Perform frisk as follows:

DOE RCS.

1) Head (pause at mouth and nose for approximately 5 seconds).

2) Neck and shoulders.

3) Arms (pause at each elbow).

4) Chest and abdomen.

5) Back, hips, and seat of pants.

6) Legs (pause at each knee).

7) Shoe tops.

8) Shoe bottoms (pause at sole and heel).

9) Personnel and supplemental dosimetry.

g. The whole body survey should take at least 2-3 minutes.

h. Carefully return the probe to holder. The probe should be placed on the side or face up to allow the next person to monitor.

i. If the count rate increases during frisking, pause for 5-10 seconds over the area to provide adequate time for instrument response.

j. Take appropriate action if contamination is indicated:

EO6 Identify the purpose and use of personnel contamination monitors.

1) Remain in the area.

2) Notify Radiological Control personnel.

3) Minimize cross-contamination (e.g., put a glove on a contaminated hand).

F. Decontamination

Decontamination is the removal of radioactive materials from locations where it is not wanted. If removable contamination is discovered, decontamination is the normal means of control.

1. Personnel decontamination

EO7 Identify the normal methods used for decontamination.

a) Normally accomplished using mild soap and lukewarm water per radiological control organization instructions.

b) More aggressive decontamination techniques are performed under the guidance of the Radiological Controls Organization.

2. Equipment and area decontamination

Equipment and area decontamination is the removal of radioactive materials from tools, equipment, floors, and other surfaces in the work area.

NOTE: In some situations, decontamination is not possible.

a. Economic considerations: Cost of time and labor to decontaminate the location may outweigh the hazards of the contamination present.

b. Radiological conditions: Radiation dose rates or other radiological conditions may present hazards which exceed the benefits of decontamination. The decontamination activity may not be ALARA, in that it costs, rather than saves personnel dose.

c. Hazardous conditions: The physical or chemical conditions in the area may prevent entry for decontamination purposes.

G. Types of Contamination Areas

EO8 Define Contamination, High Contamination, and Airborne Radioactivity Areas.

1. Definitions and posting requirements

a. Contamination Area

A Contamination Area is an area where removable contamination levels are, or are likely to be, greater than the limits specified in 10 CFR 835 Appendix D, but do not exceed 100 times these levels. Posting requirements include:

"CAUTION, CONTAMINATION AREA"

b. High Contamination Area

Discuss facility specific program for other information such as training, dosimetry, and PPE requirements.

A High Contamination Area is an area where contamination levels are likely to be greater than 100 times the Contamination Area limits. Posting requirements include:

"DANGER or CAUTION, HIGH CONTAMINATION AREA"

Additionally, the posting may state:

"RWP REQUIRED FOR ENTRY"

c. Airborne Radioactivity Area

An Airborne Radioactivity Area is an area where airborne radioactivity exceeds specified limits. Posting requirements include:

"CAUTION OR DANGER, AIRBORNE RADIOACTIVITY AREA"

additionally the posting may state:

"RWP REQUIRED FOR ENTRY"

2. Minimum requirements for entering Contamination, High Contamination, and Airborne Radioactivity Areas without an escort.

EO9 Identify the minimum requirements for entering Contamination, High Contamination, and Airborne Radioactivity Areas.

a. Appropriate training, such as Radiological Worker II training.

b. Personnel dosimetry, as appropriate.

c. Protective clothing and respiratory protection as specified in the RWP.

d. Worker's signature on the RWP, as applicable.

e. Pre-job briefings, as applicable.

f. (Insert facility-specific information.)

3. Minimum requirements for working in Contamination, High Contamination, and Airborne Radioactivity Areas.

EO9 Identify the minimum requirements for working in Contamination, High Contamination, and Airborne Radioactivity Areas.

a. Avoid unnecessary contact with contaminated surfaces.

b. Secure equipment (lines, hoses, cables, etc.,) to prevent them from crossing in and out of contamination areas.

c. When possible, wrap or sleeve materials, equipment, and hoses.

d. Place contaminated materials in appropriate containers when finished.

e. Do not touch exposed skin surfaces. High levels of skin contamination can cause a significant skin dose. It may also lead to internal contamination with radioactive material.

f. Avoid stirring contamination as it could become airborne.

g. Do not smoke, eat, drink, or chew. Do not put anything in your mouth.

h. Exit immediately if a wound occurs or if your protective clothing is compromised (e.g., becomes wet, torn, or otherwise compromised.)

i. (Insert facility-specific information.)

4. Minimum requirement for exiting Contamination, High Contamination, and Airborne Radioactivity Areas.

EO9 Identify the minimum requirements for exiting Contamination, High Contamination, and Airborne Radioactivity Areas.

a. Exit only at step-off pad.

b. Remove protective clothing carefully. Follow posted instructions.

c. Frisk or be frisked for contamination when exiting a contaminated area. If personal contamination is found, stay in the area, notify the Radiological Control Technician, and minimize the potential for cross contamination.

d. Survey all tools and equipment prior to removal from the area.

e. Observe RWP and control point guidelines.

f. Use proper techniques to remove protective clothing.

g. Do not smoke, eat, drink, or chew.

h. Do not put anything in your mouth.

i. When exiting, perform a whole-body frisk at the location provided by the Radiological Control Organization. If personal contamination is found, stay in the area, notify the Radiological Control Technician, and minimize the potential for cross-contamination (e.g., place a glove over a contaminated hand).

H. Lessons Learned

(Insert facility-specific information.)

III. SUMMARY

(Insert facility-specific information.)

IV. EVALUATION

(Insert facility-specific information.)

Refer to RWT Program Management Guide for evaluation guidance.

Module 10.1: Practical Factors for Radiological Worker I

Prerequisites: Successful completion of a written examination based on modules 1-7 must be accomplished prior to the evaluation of the practical factors.

NOTE: This module may be taught prior to the written examination, but the student should not be evaluated until he/she successfully completes the written examination.

Terminal Objective:

Given an RWP, a simulated radiological area, and the necessary materials and tools, the student will enter, work in, and exit the area using ALARA techniques in accordance with Radiological Control procedures.

Enabling Objectives:

Given an RWP, a simulated radiological area, and applicable materials, the student will:

EO1 Identify and comply with RWP requirements.
EO2 Record appropriate information on the RWP.
EO3 Select and wear dosimeter(s) as per RWP.
EO4 Enter a simulated area and perform a specified task/job using ALARA techniques.
EO5 Respond to abnormal radiological conditions and alarms.
EO6 Monitor for personnel contamination in accordance with posted instructions.

Instructional Aids:

1. Student Guide
2. Attachments to Module 10.3 (Instructor use only)
    - Attachment 1 - Instructions for Evaluators
    - Attachment 2 - Sample Grading Checklist
    - Attachment 3 - Sample Job Scenario
    - Attachment 4 - Sample Survey Map
    - Attachment 5 - Sample Questions

I. MODULE INTRODUCTION

A. Self Introduction

1. Name
2. Background

B. Module Overview

1. Demonstration/activities

   The practical factors module consists of various activities/demonstrations that are led by the instructor, but participation by the entire class is encouraged. These activities are provided as a practice session for the student before he/she is evaluated.

   Instructors should review Module 10.3, Attachment 1, "Instructions for Evaluators" for guidance on:

   - Pre-staging mock-up area
   - Establishing scoring criteria
   - Conducting evaluation

   This module will:

   a. Provide the radiological worker with "hands-on" training.

   b. Apply the basic knowledge and skills obtained from the theory portions of Radiological Worker Training that are required to enter and exit Radiological Buffer Areas and Radiation Areas at the site.

   c. Review good radiological work practices.

   d. Review lessons learned (when applicable) from on-site and off-site occurrences.

2. Evaluation

   Upon completion of the "hands on" training, each student shall demonstrate the ability to enter, work in, and exit a simulated Radiological Buffer Area/Radiation Area following facility-specific guidelines. The scope of the practical evaluation shall cover the minimum requirements as set out in references 1, 2, and 3.

   Inform students that the evaluation is based on the objectives.

   See Module 10.3, Attachment 2, for a sample scoring checklist.

C. Objectives Review

1. Terminal objective

2. Enabling objectives

D. Introduction

Prior knowledge of radiological conditions can reduce the potential for personnel radiation dose. Using proper radiological techniques and information provided by Radiological Control personnel will help ensure a safe working environment for all employees.

II. MODULE OUTLINE

This module allows each student to practice identifying requirements for entering, working in, and exiting a simulated Radiological Buffer Area and Radiation Area using ALARA techniques. The instructor should correct errors or answer student questions.

Suggested activities for conducting this practical exercise are cited in the body of the lesson plan. The suggestions may be used as is or altered to fit the need of the facility.

A. Review an Appropriate Radiological Work Permit (RWP)

EO1 Identify and COMPLY with RWP requirements. (DOE RCS, Articles 321-323)

Each worker must review an RWP to identify the specific requirements and special instructions for the job.

- Suggest: Using a facility-specific RWP and, if applicable, a survey map, conduct a pre-job brief. Have students review the RWP and survey map and answer questions regarding each.

- Suggest: Conduct small group activity where one group can give the brief to the rest of the class or provide a questionnaire and have groups complete.

- Incorporate lessons learned occurrences, if applicable. (Demonstrate or discuss occurrence.)

B. Record the Appropriate Information on the RWP

EO2 Record appropriate information on the RWP. (DOE RCS Article 322)

After reviewing the RWP and identifying the applicable requirements, workers must record the appropriate information.

- Suggest: Using a facility-specific RWP, have students practice completing appropriate information on RWP sign-in sheet.
- Incorporate lessons learned occurrences, if applicable. (Demonstrate or discuss occurrence.)

C. Select and Wear Required Dosimeter(s)

EO3 Select and wear dosimeter(s) as per RWP. (DOE RCS, Chapter 5.)

Radiological Control personnel identify the dosimeter requirements necessary for entry on the RWP. Supplemental pocket dosimeters should be worn near the primary dosimeter.

- Suggest: Using a facility-specific RWP, have students select dosimeter(s) per RWP and properly wear the device.
- Incorporate lessons learned occurrences, if applicable. (Demonstrate or discuss occurrences.)

D. Enter Simulated Area and Demonstrate ALARA Techniques

EO4 Enter a simulated area and perform a specified task/job using ALARA techniques.

- Suggest: From this point on, the instructor should demonstrate entering, performing tasks ,and exiting simulated area using the techniques listed in the lesson plan. This demonstration should cover sections D and E of this lesson plan. After instructor has completed demonstration, if practical, have student do the same.
- Incorporate lessons learned occurrences, if applicable (Demonstrate or discuss occurrences).

Once the worker has donned the dosimeter(s) and recorded the appropriate information on the RWP sign in sheet, he/she should proceed directly to the work area. At a minimum, the following ALARA techniques should be used.

1. Take only the necessary tools and equipment into a Radiological Buffer Area or a Radiation Area.

2. Read and comply with all posted instructions.

3. Perform work safely and efficiently.

4. Use time, distance, and shielding.

a. When possible, maximize distance from higher levels of radiation.

b. When possible, stay in areas that have lower levels of radiation.

c. Do not loiter in the Radiation Area or Radiological Buffer Area.

5. Use good housekeeping techniques.

6. Advise Radiological Control personnel of any unusual conditions or situations that may alter the status of the job or the work area.

EO5 Respond to abnormal radiological conditions and alarms.

- Suggestion: During demonstration, pre-stage abnormal situations and discuss appropriate response.

- Abnormal situations or conditions may include off-scale dosimeter, spill of water, shielding that has slipped, posting that is different from pre-job brief information, etc.

7. Take appropriate actions to radiological alarms. Be familiar with location of area monitors.

8. Personnel and equipment must be monitored.

E. Monitor for Contamination

Immediately upon exiting an RBA that contains a Contamination, High Contamination Area, or Airborne Radioactivity Area, you are required to monitor for contamination.

EO6 Monitor for personnel contamination in accordance with posted instructions. (DOE RCS, Appendix 3D.)

- Suggest: Using facility-specific posted instructions and contamination control techniques, monitor for contamination. If practical, have students do the same.

- Incorporate lessons learned occurrences, if applicable (demonstrate or discuss occurrences).

III. SUMMARY

The practical factor exercise provided an opportunity for each student to practice the skills required to safely perform work within a simulated radiological area.

IV. EVALUATION

A. Review Evaluation Rules/Process

Each facility must develop a practical factors evaluation. Incorporating the requirements of the DOE Radiological Control Standard is recommended, and facility-specific procedures should also be included (guidance for conducting a practical factors evaluation is contained in Attachment 1).

1. Review areas to be evaluated

   Students should be evaluated based on:

a. Pre-job preparation

1) Wearing of dosimeter(s).

2) Compliance with RWP, work documents.

3) Compliance with facility-specific entry procedures.

b. Job or task performance

1) Minimization of dose.

2) Compliance with facility-specific procedures and RWP requirements.

3) Response to abnormal situation(s) – alarm/condition.

c. Exiting simulated area

1) Compliance with facility-specific procedures.

2) Self-monitoring technique.

2. Explain acceptable role-playing during evaluation

a. Student responsibilities

Students are expected to conduct themselves as though the evaluation was in an actual radiological area (e.g., chewing gum is not permitted).

b. Instructor interface/responsibilities

Evaluators have two main roles during the evaluation:

1) The primary role is to evaluate whether student performs the entire scenario in accordance with pre-established criteria.

2) The secondary role is to role-play as Radiological Control specialist, supervisor, co-worker, etc., to relay information that is necessary for the role-playing evaluation.

B. Review Pass/Fail Criteria

(Guidance for establishing scoring criteria is contained in Attachment 1.)

C. Provide Students With Necessary Documentation/ Materials for Evaluation

Once the facility-specific pass/fail criteria has been reviewed, provide the following materials at a minimum for the evaluation:

1. RWP.

2. Work procedure or task assignment (scenario). (Attachment 2 is an example.)

3. Survey map of area (optional). (Attachment 4 is an example.)

4. Dosimeter(s).

5. Any other applicable item(s).

Module 10.2: Practical Factors for High Radiation Areas

Prerequisites: The instructional material of this module may be presented prior to the written examination; however, participants must pass a written examination based on the High Radiation Areas module before being evaluated in accordance with the guidelines of this module.

Terminal Objective:

Given an RWP, a simulated High Radiation Area and the necessary materials and tools, the student will enter, work in, and exit the area using ALARA techniques in accordance with Radiological Control procedures.

Enabling Objectives:

Given an RWP, a simulated radiological area, and applicable materials, the student will:

EO1 Identify and comply with RWP requirements.
EO2 Record appropriate information on the RWP.
EO3 Select and wear appropriate dosimeter(s) as per RWP.
EO4 Enter a simulated High Radiation Area and perform a specified task/job using ALARA techniques.
EO5 Respond to abnormal radiological conditions and alarms.
EO6 Demonstrate proper exit from a simulated High Radiation Area.

Instructional Aids:

1. Student Guide
2. Attachments to Module 10.3 (Instructor use only)
- Attachment 1 - Instructions for Evaluators
- Attachment 2 - Sample Grading Checklist
- Attachment 3 - Sample Job Scenario
- Attachment 4 - Sample Survey Map
- Attachment 5 - Sample Questions

I. MODULE INTRODUCTION

Introduce Objectives

A. Self Introduction

1. Name
2. Phone Number
3. Background

B. Module Overview

1. Demonstration/activities

The practical factors module consists of various activities/demonstrations that are led by the instructor, but participation by the entire class is encouraged. These activities are provided as a practice session for the participant before he/she is evaluated.

Instructors should review Module 10.3, Attachment 1, "Instructions for Evaluators" for guidance on:
– Pre-staging mock-up area
– Establishing scoring criteria
– Conducting evaluation

This module will:

a. Provide the Radiological Worker with "hands-on" training.
b. Apply the knowledge obtained from the theory portions of High Radiation Area training.
c. Review good radiological work practices for dose control.

Review lessons learned (as applicable) from on-site and off-site occurrences.

2. Evaluation

Upon completion of the presentation, each participant shall demonstrate the ability to enter, work in, and exit a simulated High Radiation Area following facility-specific guidelines. The scope of the practical evaluation shall cover the minimum requirements as set out in references 1, 2, and 3.

Inform participants that the evaluation is based on the objectives.

See module 10.3, Attachment 2 for a sample scoring checklist.

C. Objectives Review

D. Introduction

Prior knowledge of radiological conditions can reduce unnecessary personnel exposure. Using proper radiological techniques and information provided by Radiological Control personnel will help ensure a safe working environment for all employees.

Each site shall develop a practical factors evaluation for High Radiation Radiation Areas (as applicable). The site may choose to incorporate the High Radiation Area practical factor into the Radiological Worker I practical factors, or develop a separate practical factors lesson for High Radiation Areas.

II. MODULE OUTLINE

Entry, Work, and Exit Requirements

The instructor should evaluate student knowledge of requirements. Suggested items to be evaluated follow:

A. Identify High Radiation Area signs.

B. State special controls on RWP.

C. State area radiation levels (with appropriate units).

D. State facility-specific administrative control levels.

E. Select dosimetry in accordance with RWP.

F. Wear dosimetry in accordance with procedures.

G. Perform pre-operational checks (as appropriate) on survey meter and/or dose rate indicating device.

H. Record appropriate information on RWP prior to entry.

I. Verify current radiation survey prior to first entry.

J. Enter only areas designated on RWP.

K. Maximize distance from higher radiation areas.

L. Do not loiter.

M. State appropriate actions to take when a radiation area monitor alarms.

N. Record appropriate information on RWP upon exit.

III. SUMMARY

The practical factor exercise provided an opportunity for each student to practice the skills required to safely perform work within a simulated High Radiation Area.

IV. EVALUATION

A. Review Evaluation Rules/Process

Each facility must develop a practical factors evaluation. Incorporating the requirements of the DOE Radiological Control Technical Standard and facility-specific procedures is recommended (guidance for conducting a practical factors evaluation is contained in Attachment 1).

1. Review the skills to be evaluated for each student:

a. Pre-job preparation

1) Donning of dosimeter(s).

2) Compliance with RWP, work documents.

3) Compliance with facility-specific entry procedures.

b. Job or task performance

1) Minimization of dose.

2) Compliance with facility-specific procedures and RWP requirements.

3) Response to abnormal situation(s) – alarm/condition.

c. Exiting simulated area

1) Compliance with facility-specific procedures.

2) Self-monitoring technique.

2. Explain acceptable role-playing during evaluation

a. Student responsibilities

Students are expected to conduct themselves as though the evaluation was in an actual radiological area (e.g., chewing gum is not permitted).

b. Review Pass/Fail Criteria

(Guidance for establishing scoring criteria is contained in Attachment 1.)

c. Provide Students With Necessary Documentation/ Materials for Evaluation

Once the facility-specific pass/fail criteria has been reviewed, provide the following materials at a minimum for the evaluation:

1) RWP.

2) Work procedure or task assignment (scenario). (Attachment 2 is an example.)

3) Survey map of area (optional). (Attachment 4 is an example.)

4) Dosimeter(s).

5) Any other applicable item(s).

Module 10.3: Practical Factors for Radiological Worker II

Prerequisites: The instructional material of this module may be presented prior to the written examination; however, students must pass a written examination based on the modules 1-9 before being evaluated in accordance with the guidelines of this lesson.

Terminal Objective:

Given an RWP, a simulated radiological area and the necessary materials and tools, the student will enter, work in, and exit the area using contamination control and ALARA techniques in accordance with Radiological Control procedures.

Enabling Objectives:

Given an RWP, a simulated radiological area, and applicable materials, the student will:

EO1 Identify and comply with RWP requirements.
EO2 Record appropriate information on the RWP.
EO3 Select and don protective clothing and dosimeter(s) as per RWP.
EO4 Enter a simulated area and perform a specific task using contamination control and ALARA techniques.
EO5 Respond to abnormal radiological conditions and alarms.
EO6 Remove protective clothing and dosimeter(s) in accordance with facility-specific instructions.
EO7 Monitor for personnel contamination in accordance with facility-specific instructions.

Instructional Aids:

1. Student Guide
2. Attachments (Instructor use only)
   - Attachment 1 - Instructions for Evaluators
   - Attachment 2 - Sample Grading Checklist
   - Attachment 3 - Sample Job Scenario
   - Attachment 4 - Sample Survey Map
   - Attachment 5 - Sample Questions

I. MODULE INTRODUCTION

Introduce Objectives

A. Self Introduction

1. Name
2. Phone Number
3. Background

B. Module Overview

1. Demonstration/activities

The practical factors unit consists of various activities/demonstrations that are led by the instructor, but participation by the entire class is encouraged. These activities are provided as a practice session for the student before he/she is evaluated.

Instructors should review Module 10.3, Attachment 1, "Instructions for Evaluators" for guidance on:
– Pre-staging mock-up area
– Establishing scoring criteria
– Conducting evaluation

This module WILL:

a. Provide the radiological worker with "hands-on" training.

b. Apply the basic knowledge and skills obtained from the theory portions of Radiological Worker Training that are required to enter and exit radiological areas at the site.

c. Review good radiological work practices for contamination control and dose control.

d. Review lessons learned (when applicable) from on-site and off-site occurrences.

2. Evaluation

Upon completion of the "hands on" training, each student shall demonstrate the ability to enter, work in, and exit a simulated radiological area following facility-specific guidelines. The scope of the practical evaluation shall cover the minimum requirements as set out in references 1, 2, and 3.

Inform students that the evaluation is based on the objectives.

See Attachment 2 for a sample scoring checklist.

C. Introduce Objectives

1. Terminal objective.

2. Enabling objectives.

D. Introduction

Prior knowledge of radiological conditions and proper use of protective clothing can reduce the potential for personnel radiation dose and contamination. Using proper radiological techniques and information provided by Radiological Control personnel will help ensure a safe working environment for all employees.

II. MODULE OUTLINE

This module allows each student to practice identifying work requirements for entering, working in, and exiting a simulated radiological area using contamination control and ALARA techniques. The instructor should correct errors or answer student questions.

Suggested activities for conducting this practical exercise are cited in the body of the module. The suggestions may be altered to fit facility needs.

A. Review an appropriate Radiological Work Permit (RWP)

Each worker must review an RWP to identify the specific requirements and special instructions for the job.

EO1 Identify and COMPLY with RWP requirements. (DOE RCS Articles 321-323.)

- Suggest: Using a facility-specific RWP and, if applicable, a survey map, conduct a pre-job brief. Have students review the RWP and survey map and answer questions regarding each.

- Suggest: 1) Conduct small group activity where one group can give the brief to the rest of the class. 2) Provide a questionnaire for the groups to complete.

- Incorporate lessons learned occurrences. (Demonstrate or discuss occurrence.)

B. Record the Appropriate Information on the RWP sign in sheet

EO2 RECORD appropriate information on the RWP. (DOE RCS, Article 322.)

After reviewing the RWP and identifying the applicable requirements, workers must record the appropriate information.

- Suggest: Using a facility-specific RWP, have students practice completing appropriate information on RWP sign in sheet.

- Incorporate lessons learned occurrences. (Demonstrate or discuss occurrence.)

C. Select Required Dosimeter(s) and Protective Clothing

EO3 SELECT and DON protective clothing and dosimeter(s) as per RWP. (DOE RCS, Appendix 3C.)

- Suggest: Using a facility-specific RWP, have students select dosimeter(s) and protective clothing as per RWP.

- Incorporate lessons learned occurrences. (Demonstrate or discuss occurrences.)

1. Dosimetry requirements

Radiological Control personnel identify the dosimeter requirements necessary for entry on the RWP.

a. Supplemental pocket dosimeters should be worn outside the protective clothing, accessible to the worker.

b. Workers should protect dosimeter from contamination by placing in a coverall pocket or in plastic bags or pouches.

2. Protective clothing

Protective clothing is provided for all employees who enter contamination areas.

a. Effective use of protective clothing will minimize skin and personal contamination.

b. The required clothing will be identified on the RWP.

D. Don Protective Clothing and Dosimeter(s)

EO3 SELECT and WEAR protective clothing and dosimeter(s) as per RWP. (DOE RCS, Appendix 3C.)

Once the radiological worker has obtained appropriate items, he/she must properly don the protective clothing. Workers should inspect protective clothing prior to use for tears, holes, or split seams that would diminish protection. Any defective items should be replaced with intact protective clothing.

- Suggest: Using facility-specific posted instructions, the instructor should don the protective clothing. If practical have students do the same.

- Incorporate lessons learned and occurrences, if applicable. (Demonstrate or discuss occurrences.)

E. Enter Simulated Area and Demonstrate Contamination Control and ALARA Techniques

EO4 ENTER a simulated area and PERFORM a specified task/job using contamination control and ALARA techniques.

Once the worker has donned protective clothing and recorded the appropriate information on the RWP, he/she should proceed directly to the work area. At a minimum, the following contamination control and ALARA techniques should be used.

- Suggest: The instructor should demonstrate entering, performing tasks, and exiting simulated area using the techniques listed in the lesson plan. This demonstration should cover sections E through G of this lesson plan. After instructor has completed demonstration, if practical, have student do the same.

- Incorporate lessons learned occurrences. (Demonstrate or discuss occurrences.)

1. Take only the necessary tools and equipment into a Radiological Buffer Area or a Contamination Area.

2. Read and comply with all posted instructions.

3. While in a radiological area, do not touch any uncovered portions of the body.

4. Perform work safely and efficiently.

5. Use time, distance, and shielding.

a. When possible, maximize distance from higher radiation areas.

b. When possible, stay in areas that have lower contamination levels.

c. Do not loiter in the area.

d. Avoid hot spots.

6. Change outer gloves when instructed by Radiological Control personnel, or periodically while working with contaminated or highly contaminated equipment.

7. Use good housekeeping techniques.

8. Advise Radiological Control personnel of any unusual conditions or situations that may alter the status of the job or the work area.

EO5 RESPOND to abnormal radiological conditions and alarms.

- Suggest: During demonstration, pre-stage abnormal situations, and discuss appropriate response.

- Unusual situations or conditions may include off-scale dosimeter, spill of water, shielding that has slipped, posting that is different from pre-job brief information, etc.

9. Take appropriate actions to radiological alarms. Be familiar with location of area monitors.

10. Personnel and equipment must be monitored.

F. Remove Protective Clothing and Dosimeter(s)

Once the job has been completed, the worker should proceed directly to the step-off pad area and follow facility-specific instructions.

1. General requirements

EO6 REMOVE protective clothing and dosimeter(s) in accordance with posted instructions. (DOE RCS, Appendix 3C.)

a. Protective clothing should be removed without spreading contamination and, in particular, without contaminating the skin.

b. Workers should be instructed not to touch the skin or place anything in the mouth during protective clothing removal.

c. Posted instructions for protective clothing removal should be posted adjacent to the step-off pad.

2. Removal process

- Suggest: Using facility-specific posted instructions, remove protective clothing and dosimeter(s). If practical, have students do the same.

- Incorporate lessons learned occurrences. (Demonstrate or discuss occurrences.)

G. Monitor for Contamination

EO7 MONITOR for personnel contamination in accordance with posted instructions. (DOE RCS, Appendix 3D.)

Immediately upon exiting Contamination, High Contamination, Airborne Radioactivity Areas or prior to exiting a Radiological Buffer Area that contains these areas, monitoring for contamination is required.

- Suggest: Using facility-specific instructions and contamination control techniques, monitor for contamination. If practical, have students do the same.

- Incorporate lessons learned occurrences. (Demonstrate or discuss occurrences.)

III. SUMMARY

The practical factor exercise provided an opportunity for each student to practice the skills required to safely perform work within a simulated radiological area.

IV. EVALUATION

A. Review Evaluation Rules/Process

Each facility must develop a practical factors evaluation incorporating the requirements of the DOE Radiological Control Standard and facility-specific procedures. (Guidance for conducting a practical factors evaluation is contained in Attachment 1.)

1. Review areas to be evaluated

Student should be evaluated based on:

a. Pre-job preparation

1) Wearing of protective clothing and dosimeter(s).

2) Compliance with RWP, work documents.

3) Compliance with facility-specific entry procedures.

b. Job or task performance

1) Minimization of dose.

2) Contamination control practices.

3) Compliance with facility-specific procedures and RWP requirements.

4) Response to abnormal situation(s) – alarm/condition.

c. Exiting simulated area

1) Undress procedure (techniques and sequence).

2) Contamination control practices.

3) Compliance with facility-specific procedures.

4) Self-monitoring technique.

2. Explain acceptable role-playing during evaluation

a) Student responsibilities

Students are expected to conduct themselves as though the evaluation was in an actual radiological area (e.g., chewing gum is not permitted).

b) Instructor interface/responsibilities

Evaluators have two main roles during the evaluation:

1) The primary role is to evaluate whether the student performs the entire scenario in accordance with pre-established criteria.
2) The secondary role is to role-play as Radiological Control specialist, supervisor, co-worker, etc., to relay information important to the conduct of the evaluation.

B. Review Pass/Fail Criteria

(Guidance for establishing scoring criteria is contained in Attachment 1.)

C. Evaluation

Provide students with necessary documentation/materials for evaluation.

Once the facility-specific pass/fail criteria has been reviewed, provide the following materials for the evaluation:

1. RWP.
2. Work procedure or task assignment (scenario). (Attachment 2 is an example.)
3. Survey map of area (optional). (Attachment 4 is an example.)
4. Protective clothing.
5. Dosimeter(s).
6. Any other applicable item(s).

ATTACHMENT 1 - Instructions for Evaluators

I. INTRODUCTION

One of the criteria for successful completion of Radiological Worker Training is that the student demonstrate proficiency in certain skill areas. Therefore, each facility must develop a practical factors evaluation and should base the evaluation on the criteria set forth in the DOE RCS, objectives listed in the practical factors unit of this program, and facility-specific procedures. The practical factors exercise modules (10.1, 10.2, or 10.3) are designed as a practice session before the students are evaluated. (See Attachment 2 for Sample Evaluation Checklist for RW II trainees.)

This attachment provides guidance on:

- Setting-up practical factors mock-up area.
- Establishing scoring criteria for practical factors evaluation.
- Conducting the practical factors evaluation.

The guidance provided is appropriate for facilities that have both radiation and contamination concerns. It may be modified for facilities without both concerns.

II. SET-UP PRACTICAL FACTORS MOCK-UP AREA

Instructors are required to pre-stage a mock-up area for the practical factors evaluation. (See Attachment 4 for an example of a mock-up layout.) Once your facility establishes a mock-up area, it is recommended that a mechanism be established to ensure consistency from one evaluation to the next. (The following may not be an all inclusive list.)

A. Pre-job Brief/Dressing Area

The pre-job brief and/or dressing area may be in the classroom or in a separate change area. The following materials should be included.

1. RWP (the RWP used for the evaluation should be different from that used in the practice session).
2. Dosimeter(s).
3. Necessary equipment/tools for job (e.g., clipboard, tools, etc.).
4. Survey map/status board (if applicable).

B. Simulated Radiological Area as per the DOE Radiological Control Technical Standard, Chapter 6.

1. The Radiological Worker I and RW I with High Radiation Area practical factors should encompass, at a minimum, the following:

   a) Entering and exiting simulated Radiological Buffer Areas and Radiation Areas (and High Radiation Areas when such training is included).

   b) Performance of frisking for personnel contamination, as applicable.

   c) Verification of instrument response and source check.

   d) Anticipated response to alarm situations.

2. The Radiological Worker II practical factors should encompass, at a minimum, the following:

   a) Donning of protective clothing.

   b) Entering a simulated Radiological Buffer Area, Contamination Area, and High Radiation Area to perform a task.

   c) Anticipated response to simulated abnormal situations.

   d) Anticipated response to simulated alarms or faulty radiological control equipment.

   e) Removing protective clothing and equipment and subsequently exiting the simulated area.

   f) Performance of frisking for personnel contamination.

   g) Verification of instrument response and source check.

III. ESTABLISH SCORING CRITERIA

When reviewing this section and establishing facility-specific scoring criteria, it is recommended that facilities review Attachment 2, “Sample Grading checklist.” This attachment is an example of a completed checklist appropriate for RW II that uses a weighted point system and incorporates the guidelines listed below.

A. General Guidelines

Before developing the facility-specific scoring criteria, it is recommended that the following general guidelines be considered.

1. Identify key elements or facility-specific procedures that relate to the objectives.

   • In Attachment 2, the elements correspond to the objectives of Module 10.3.

2. Develop a checklist or grading form. (See Attachment 2. It is recommended that a weighted point system be used.)

3. No partial credit should be given for any item graded as inadequate during the evaluation. (Either full credit given or no credit.)

4. Student should receive a passing score of 80% or greater.

5. Develop an "Evaluation Standard." This standard should specifically identify the objectives and actions or non-actions that would require points to be deducted for the objective.

B. Categorize and Define Specific Actions

Once the list of key elements is developed, it is important that each facility categorize the action(s) related to the item as acceptable or unacceptable. When determining unacceptable actions (mistakes), the following categories are suggested:

- Minor mistakes (self-identified vs. instructor-identified).

- Significant mistakes (self-identified vs. instructor-identified).

- Automatic failures.

The following provides suggested definitions and examples of each of the above categories. In addition, guidelines on giving credit for the examples cited are provided.

1. Minor mistake

   a. Definition

      A minor mistake is one that does NOT involve any of the following:

      1) Violating instructions in a manner that leads to unnecessary worker exposure.

      2) Violating instructions in a manner that leads to the contamination of personnel or clean areas.

      3) Jeopardizing radiological safety and/or creating a radiological hazard.

   b. Example

      An example of a minor mistake is that the worker placed protective clothing in the wrong receptacle.

      1) Give credit if minor mistake is identified by worker.

      2) No credit given if minor mistake is not identified by worker.

2. Significant mistake

   a. Definition

      A significant mistake is one that INVOLVES any of the following:

      1) Violating instructions in a manner that would lead to unnecessary worker exposure.

      2) Violating instructions in a manner that would lead to the contamination of personnel or clean areas.

      3) Jeopardizing personnel safety and/or creating a radiological hazard.

b. Example

An example of a significant mistake is crossing the radiological boundary in violation of procedures.

1) No credit is given if significant mistake is identified by worker, but do not record an automatic failure.

2) If significant mistake is NOT identified by worker, no credit given for specific item and an automatic failure is recorded.

3. Automatic failure

a. Definition

An automatic failure must be recorded if any significant mistake is made that is NOT identified by the worker.

– It is recommended that if using a weighted point system, some type of numerical value be linked to an automatic failure action. This numerical value will help eliminate a situation where a student receives a total of 95 points out of 100, but still fails. (A student may be confused if they're informed they received a 95%, but did not pass.)

b. Examples of an automatic failure

The following are only examples of what may constitute an automatic failure. This list is not an all inclusive list. It is recommended that each facility develop a facility-specific list of automatic failure actions and provide the list to the students.

1) Entering the area without dosimeter(s).

2) Chewing gum inside the area.

3) Reaching/entering into an area without meeting site procedural requirements.

4) Failure to monitor upon exit.

IV. CONDUCTING EVALUATION

Once the instructor has ensured a simulated radiologically controlled area is pre-staged correctly, it is recommended that the practical factors evaluation be conducted in accordance with the following criteria listed in this section.

– Although the evaluation process is broken into steps (e.g., pre-brief, donning PCs (as applicable), performing job, exiting, etc.), the instructor should evaluate the practical factors exercise as a whole. This will permit the student to correct a mistake within a reasonable time frame.

A. General Rules

1. Job scenarios and associated RWPs and survey maps must be developed that incorporate all objectives.

   a) The scenario used during the classroom practice lesson should not be used for the evaluation (see Attachments 3 and 4 for sample job scenario and map).

   b) The job scenario and simulated area should be such that the student has to make decisions such as: the best path to the job location and how to best perform the specific task. The student should DEMONSTRATE that they know where lower radiation levels exist and how to proceed using this information. They should not be allowed to verbally simulate the appropriate actions.

2. Student/instructor ratio should be one student per instructor.

   Each student should have the undivided attention of the evaluator.

3. It is recommended that the design of the practical evaluation be such that the worker's actions are graded rather than the worker's statements. If this is not feasible, verbal responses should be limited to specific segments of the demonstration. All other segments should be evaluated through student actions.

   a) A list of questions permitted for the evaluation should be identified in the lesson plan to ensure consistency within the training group (see Attachment 5 for sample questions).

   b) The interaction between the instructor and the student should be minimal.

4. Students should complete all phases of the practical factors evaluation even if an automatic failure is recorded.

5. Once evaluation is completed, the checklist must be reviewed with the student.

   a. Note strengths.

   b. Discuss any weaknesses noted.

   c. Ensure both the student and the evaluator sign the checklist.

   d. If student failed, discuss the failure policy.

B. Evaluation Process

The instructor should review the rules for evaluation, scoring criteria, and failure policy with the class and then pass out the RWP for the evaluation.

NOTE: The instructor should be available for the pre-job briefing and to answer questions, but NOT to re-teach the lesson.

1. Pre-job brief

   a. Direct the class to review the RWP and survey map as a group.

      - This may be done in small groups or, if class size is small, as a class.

   b. Provide the opportunity for the students to ask questions.

      – The instructor should not ask the questions, but allow this opportunity for students.

   c. Give directions to the storage location for materials and tools and the check-in/waiting area and the Job Site.

2. Record appropriate information

   The instructor should ask the student if he/she has any questions before the evaluation begins.

   When student questions have been answered, direct him/her to record appropriate information on RWP.

   a. Student is to record appropriate information on RWP in accordance with key points listed for objectives.

      – Instructor is to observe performance and score in accordance with key points listed for objectives.

b. Instructor takes the RWP from the student for use in evaluation of student's understanding of RWP requirements (see section 4 below). (Student should not use RWP to answer evaluation questions.)

3. Select/wear dosimeter(s)

When the student has reviewed the RWP, he/she is to proceed to begin selecting and wearing dosimeter(s) in accordance with the posted instructions and RWP.

a. Student is to wear dosimeter(s) in accordance with the key points listed for objectives.

b. Once dosimeter(s) is donned, student should not be allowed to view other students performance during evaluation. Doing so may provide the waiting student an unfair advantage.

4. Evaluate understanding of RWP requirements

Instructor is to question the student on RWP requirements in accordance with the key points listed for the objectives. (See Attachment 5 for sample questions.) This may be accomplished by the instructor playing the role of a control point technician discussing the entry with the student.

a. Each student must state the purpose for entering area.

– If student does not volunteer that information, the instructor should ask the two questions listed for the objectives.

b. Each student must state the radiation levels in the area.

– If the student does not volunteer that information, the instructor should ask two of the key questions listed for the objectives.

c. Each student must state the special instructions identified on the RWP.

– If the student does not volunteer that information, the instructor should ask one of the key questions listed for objectives.

5. Visual evaluation of compliance with donning instructions and RWP requirements.

– The instructor evaluates student compliance with RWP and posted instructions. Score in accordance with key points listed for objectives.

6. Evaluation of area entry and task performance.

When the discussion between the simulated Control Point Technician and the worker is completed, the worker is given permission to enter the radiologically controlled area. Establish method of contact between you and student (e.g., tell student how to contact Radiological Control personnel).

a. Worker must read and comply with all posted instructions.

– Instructor evaluates performance and scores in accordance with key points listed for objective.

b. Worker must perform task in accordance with procedures and RWP requirements.

– Instructor evaluates performance and scores in accordance with key points listed for objective.

c. Student must respond in accordance with procedures to unusual situations.

– Instructor must ask student one of the questions concerning proper response to a radiation alarm.

d. Student must proceed to frisking station once task is completed.

7. Evaluation of monitoring for contamination

a. Student must perform frisk in accordance with posted instructions and key points listed for objective.

– Instructor evaluates performance of frisking techniques and scores in accordance with key points listed for objective.

b. Student must respond in accordance with posted instructions when the count rate increases and the count rate meter alarms.

– Instructor questions student at some point during the frisk about increased clicks and count rate meter alarm and score in accordance with key points listed in lesson plan.

9. Evaluation of post job information recording

Student must record appropriate information on RWP in accordance with key points listed for objective.

– Instructor evaluates performance and scores in accordance with key points listed for objective.

10. Review checklist with student

a. Instructor reviews score and performance with student.

b. Ensure both student and instructor sign checklist.

ATTACHMENT 2 - Sample Grading Checklist for RW II
TRAINING COMPLETION RECORD

Name SSN/EMPLOYEE# COMPANY

Item Evaluated	Pt Val	Score
Pre-Job Preparation total 20 pts.		
Selected proper PCs.	5	
Selected and properly wear dosimetry.	5	
** Donned PCs properly.	5	
Recorded appropriate information.	5	
Knowledge Level (See Attachment 5) total 20 pts.		
Enter results of knowledge-level evaluation.	20	
Radiological Work Practices total 20 pts.		
** Minimized exposure while completing task.	4	
Minimized Radioactive Waste.	4	
Didn't walk thru contamination unnecessarily.	4	
Didn’t spread contamination.	4	
Chose low exposure route.	4	
Emergency Response total 20 pts.		
** Responded to alarm.		
Exited area.	5	
Notified RCT upon exit.	5	
Exit Practices total 20 pts.		
** Followed undress procedure.	3	
Did not contaminate step-off pad.	3	
** Did not contaminate self.	7	
** Performed whole body survey properly.	5	
Surveyed DRD.	1	
Read DRD correctly upon exit.	1	
	100 pts.	

I was instructed on the proper performance of all items for which my performance was unsatisfactory. I had the opportunity to ask questions. I understand that failure of this exercise restricts me from entering the following areas:

Student____Date

Instructor____Date

Note: Comments on reverse. ** Indicates significant mistake. If not identified by student, deduct 21 points.

ATTACHMENT 3 - Sample Job Scenario

Each facility should develop a job scenario and record it on a facility-specific RWP. (Refer to DOE Radiological Control Technical Standard for guidance on the development of RWPs.) The following is an example of a job scenario and radiological information.

JOB DESCRIPTION: Enter mock-up area and move the box that is located on the floor in a lower dose rate area to the storage cabinet located in the area. (A contamination area is located near the Job Site.)

LOCATION: Mock-up area, Building 2.

SPECIAL INSTRUCTIONS: RWP not valid for Contamination Area.
Avoid drum in Radiation Area.

RADIATION LEVELS: 80 mR/hr near drum on left side of work area.
25 mR/hr near cabinet and panel on north wall.
5 mR/hr near step-off pad area.

CONTAMINATION LEVELS: 5,000 dpm/100 cm^2 floor of Contamination Area.

PROTECTIVE CLOTHING: None.

DOSIMETER(S): TLD and pocket dosimeter (self-reader).

ATTACHMENT 4 - Sample Survey Map

(Insert facility-specific sample survey map)

ATTACHMENT 5 - Sample Questions

STATE PURPOSE OF ENTRY (Ask both questions.)

1. What is your job description?
2. Where is it located?

STATE RADIATION LEVELS IN THE AREA (include units) (Ask two questions.)

1. What is the highest dose rate in the radiological area?
2. Where is the highest dose rate in the radiological area?
3. What is the work area dose rate?
4. What is the lowest dose rate in the radiological area?
5. Where is the lowest dose rate in the radiological area?

STATE SPECIAL INSTRUCTIONS LISTED ON RWP (Ask one question.)

1. What are two of the special instructions?
2. What are the areas that you cannot enter?

STATE RESPONSE TO AREA RADIATION ALARM

1. A radiation monitor has alarmed. What should you do?

STATE RESPONSE TO CRM INCREASE AND ALARMS (Ask both questions.)

1. You hear increased clicks as you survey your ______________. What should you do?
2. The CRM has alarmed. What should you do?

(Part 3 of 3)

Radiological Worker Training

Student's Guide

Coordinated and Conducted
for
Office of Environment, Safety & Health
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Table of Contents

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Module 1: Radiological Fundamentals

Terminal Objective:

Given various radiological concepts, the participant will be able to define the fundamentals of radiation, radioactive material, and radioactive contamination in accordance with the approved lesson materials.

Enabling Objectives:

The participant will be able to select the correct response from a group of responses to verify his/her ability to:

EO1 Identify the three basic particles of an atom.
EO2 Define radioactive material, radioactivity, radioactive half-life, and radioactive contamination.
EO3 Identify the units used to measure radioactivity and contamination.
EO4 Define ionization and ionizing radiation.
EO5 Distinguish between ionizing radiation and non-ionizing radiation.
EO6 Identify the four basic types of ionizing radiation and the following for each type:
- a. Physical characteristics
- b. Range
- c. Shielding
- d. Biological hazard(s)
- e. Sources at the site

EO7 Identify the units used to measure radiation.
EO8 Convert rem to millirem and millirem to rem.

Instructional Aids:

1. Student Guide
2. Transparencies
3. Activities (as applicable)
4. Self-check quizzes (as applicable)

I. MODULE INTRODUCTION

A. Self Introduction

1. Name
2. Phone Number
3. Background

B. Module Overview

Nuclear science is truly a product of the 20th century. This module will discuss several nuclear science topics at a basic level appropriate for the radiological worker. These concepts are necessary for the worker to understand the nature of radiation and its potential effect on health. The topics covered include basic particles of the atom, types of radiation, and the definition of units used to measure radiation.

C. Objectives Review

D. Introduction

This module introduces the worker to basic radiological fundamentals and terms that are common in the DOE complex. After learning the fundamentals of radiation, radioactive material, and radioactive contamination, the worker will build from the basic to the more in-depth concepts presented in the other modules.

II. MODULE OUTLINE

A. Atomic Structure

1. The basic unit of matter is the atom. The three basic particles of the atom are protons, neutrons, and electrons. The central portion of the atom is the nucleus. The nucleus consists of protons and neutrons. Electrons orbit the nucleus.

   a. Protons

      1) Protons are located in the nucleus of the atom.

      2) Protons have a positive electrical charge.

      3) The number of protons in the nucleus determines the element.

   b. Neutrons

      1) Neutrons are located in the nucleus of the atom.

      2) Neutrons have no electrical charge.

      3) Atoms of the same element have the same number of protons, but can have a different number of neutrons.

      4) Atoms which have the same number of protons but different numbers of neutrons are called isotopes.

         NOTE: Common notation for describing isotopes is to list the atomic symbol for an element followed by its mass number. The mass number is the sum of protons and neutrons. For example, tritium has 1 proton and 2 neutrons, and is denoted as H-3.

      5) Isotopes have the same chemical properties; however, the nuclear properties can be quite different.

   c. Electrons

      1) Electrons are in orbit around the nucleus of an atom.

      2) Electrons have a negative electrical charge.

      3) This negative charge is equal in magnitude to the proton's positive charge.

Basic Particles

3 Basic Particles	Location	Charge	Comments
Protons	Nucleus	+ (positive)	Number of protons determines the element. If the number of protons changes, the element changes.
Neutrons	Nucleus	No Charge	Atoms of the same element have the same number of protons, but can have a different number of neutrons. This is called an isotope.
Electrons	Orbit nucleus	- (negative)	This negative charge is equal in magnitude to the proton's positive charge.

2. Stable and unstable atoms

   Only certain combinations of neutrons and protons result in stable atoms.

   a. If there are too many or too few neutrons for a given number of protons, the nucleus will not be stable.

   b. The unstable atom will try to become stable by giving off excess energy. This energy is in the form of particles or rays (radiation). These unstable atoms are known as radioactive atoms.

3. Charge of the atom

   The number of electrons and protons determines the overall electrical charge of the atom. The term "ion" is used to define atoms or groups of atoms that have a net positive or negative electrical charge.

   a. No charge (neutral)

      If the number of electrons equals the number of protons, the atom is electrically neutral. This atom does not have a net electrical charge.

   b. Positive charge (+)

      If there are more protons than electrons, the atom is positively charged.

   c. Negative charge (-)

      If there are more electrons than protons, the atom is negatively charged.

B. Definitions and Units of Measure

1. Radioactive material

Radioactive material is any material containing unstable atoms that emit radiation.

2. Radioactivity

Radioactivity is the process of unstable (or radioactive) atoms becoming stable. This is done by emitting radiation. This process over a period of time is referred to as radioactive decay. A disintegration is a single atom undergoing radioactive decay.

3. Radioactivity units

Radioactivity is measured in the number of disintegrations radioactive material undergoes in a certain period of time.

a. Disintegrations per minute (dpm)
b. Disintegrations per second (dps)
c. Curie (Ci)

One curie equals:

- 2,200,000,000,000 disintegrations per minute (2.2×10^{12} dpm), or
- 37,000,000,000 disintegrations per second (3.7×10^{10} dps), or
- 1,000,000 microcuries (1×10^{6} μCi).

4. Radioactive half-life

Radioactive half-life is the time it takes for one half of the radioactive atoms present to decay.

5. Radioactive contamination

Radioactive contamination is radioactive material that is uncontained and in an unwanted place. (There are certain places where radioactive material is intended to be.)

Contamination is measured per unit area or volume.

- dpm/100 cm^2
- μCi/ml
- μCi/g.

6. Ionization

Ionization is the process of removing electrons from neutral atoms.

a. Electrons will be removed from an atom if enough energy is supplied. The remaining atom has a positive (+) charge. The ionized atoms may affect chemical processes in cells. The ionizations may affect the cell's ability to function normally.

b. The positively charged atom and the negatively charged electron are called an "ion pair."

c. Ionization should not be confused with radiation. Ions (or ion pairs) produced as a result of the interaction of radiation with an atom allow the detection of radiation.

7. Ionizing radiation

Ionizing radiation is energy (particles or rays) emitted from radioactive atoms, and some devices, that can cause ionization. Examples of devices that emit ionizing radiation are X-ray machines, accelerators, and fluoroscopes.

a. It is important to note that exposure to ionizing radiation, without exposure to radioactive material, will not result in contamination of the worker.

b. Radiation is a type of energy, and contamination is radioactive material that is uncontained and in an unwanted place.

8. Non-ionizing radiation

a. Electromagnetic radiation that doesn't have enough energy to ionize an atom is called "non-ionizing radiation."

b. Examples of non-ionizing radiation are radar waves, microwaves, and visible light.

C. The Four Basic Types of Ionizing Radiation

The four basic types of ionizing radiation of concern in the DOE complex are alpha particles, beta particles, gamma or X rays, and neutrons.

1. Alpha particles

a. Physical characteristics

1) The alpha particle has a large mass and consists of two protons, two neutrons, and no electrons.

2) It is a highly charged particle (charge of plus two) that is emitted from the nucleus of an atom.

3) The positive charge causes the alpha particle (+) to strip electrons (-) from nearby atoms as it passes through the material, thus ionizing these atoms.

b. Range

1) The alpha particle deposits a large amount of energy in a short distance of travel.

2) This large energy deposit limits the penetrating ability of the alpha particle to a very short distance.

3) Range in air is about 1-2 inches.

c. Shielding

Most alpha particles are stopped by a few centimeters of air, a sheet of paper, or the dead layer (outer layer) of skin.

d. Biological hazards

1) Alpha particles are not considered an external radiation hazard. This is because they are easily stopped by the dead layer of skin.

2) Internally, the source of the alpha radiation is in close contact with body tissue and can deposit large amounts of energy in a small volume of living body tissue.

e. Sources

(Insert facility-specific information.)

Table 1-2
Alpha Particles

Physical Characteristics	· Large mass (2 protons, 2 neutrons, 0 electrons). · +2 charge.
Range	· Very short (about 1-2 inches in air). · Deposits large amount of energy in a short distance of travel.
Shielding	· Few centimeters of air. · Sheet of paper. · Dead layer of skin (outer layer).
Biological Hazards	· No external hazard (dead layer of skin will stop alpha particles). · Internally, the source of alpha radiation is in close contact with body tissue. It can deposit large amounts of energy in a small amount of body tissue.
Sources	Insert facility-specific information.

2. Beta particles

   a. Physical characteristics

      1) The beta particle has a small mass and is positively or negatively charged. Positively charged beta particles are called positrons and have an electrical charge of plus one. Negatively charged beta particles are high-energy electrons and have an electrical charge of minus one.

      2) A negatively charged beta particle is physically identical to an electron.

      3) The beta particle ionizes target atoms due to the force between itself and the electrons of the atom. Both have a charge of minus one.

   b. Range

      1) Because of its charge, the beta particle has a limited penetrating ability.

      2) The range in air of beta particles depends on the energy of the beta particle. In the case of tritium (H-3), the range is only an inch; in the case of phosphorous-32 (P-32) or strontium-90 (Sr-90), the range is 20 feet in air.

   c. Shielding

      Beta particles are typically shielded by plastic, glass, or safety glasses.

   d. Biological hazards

      1) If ingested or inhaled, a beta emitter can be an internal hazard when the source of the beta radiation is in close contact with body tissue and can deposit energy in a small volume of living body tissue.

      2) Externally, beta particles are potentially hazardous to the skin and eyes.

      3) Provide facility-specific information on the additional risks or concerns from high-energy beta sources (e.g., P-32, Y-90), as appropriate.

   e. Sources

      (Insert facility-specific information.)

Table 1-3
Beta Particles

Physical Characteristics	· Small mass. · -1 charge or + 1 charge.
Range	· Short distance (one inch to 20 feet).
Shielding	· Plastic. · Glass. · Safety glasses.
Biological Hazard	· Internal hazard (this is due to short range). · Externally, may be hazardous to skin and eyes.
Sources	Insert facility-specific information.

3. Gamma rays/X rays

   a. Physical characteristics

      1) Gamma/X-ray radiation is an electromagnetic wave (electromagnetic radiation) or photon and has no mass and no electrical charge.

      2) Gamma rays are very similar to X rays. The difference between gamma rays and X rays is that gamma rays originate inside the nucleus and X rays originate in the electron orbits outside the nucleus.

      3) Gamma/X-ray radiation can ionize as a result of direct interactions with orbital electrons.

   b. Range

      1) Because gamma/X-ray radiation has no charge and no mass, it has very high penetrating ability.

      2) The range in air is very far. It will easily go several hundred feet.

   c. Shielding

      Gamma/X-ray radiation is best shielded by very dense materials, such as lead. Water or concrete, although not as effective as the same thickness as lead, are also commonly used, especially if the thickness of shielding is not limiting.

   d. Biological hazards

      Gamma/X-ray radiation can result in radiation exposure to the whole body.

e. Sources
(Insert facility-specific information.)

Table 1-4
Gamma Rays/X-Rays

Physical Characteristics	· No mass. · No charge. · Electromagnetic wave or photon. · Similar (difference is the place of origin).
Range	· Range in air is very far. · It will easily go several hundred feet. · Very high penetrating power since it has no mass and no charge.
Shielding	· Concrete. · Water. · Lead.
Biological Hazard	· Whole body exposure. · The hazard may be external and/or internal. This depends on whether the source is inside or outside the body.
Sources	Insert facility-specific information.

4. Neutrons

a. Physical characteristics

1) Neutron radiation consists of neutrons that are ejected from the nucleus.

2) A neutron has mass, but no electrical charge.

3) An interaction can occur as the result of a collision between a neutron and a nucleus. The nucleus recoils due to the energy imparted by the neutron and ionizes other atoms. This is called "secondary ionization."

4) Neutrons may also be absorbed by a nucleus. This is called neutron activation. A charged particle or gamma ray may be emitted as a result of this interaction. The emitted radiation can cause ionization in other atoms.

b. Range

1) Because of the lack of a charge, neutrons have a relatively high penetrating ability and are difficult to stop.

2) The range in air is very far. Like gamma rays, they can easily travel several hundred feet in air.

c. Shielding

Neutron radiation is best shielded by materials with a high hydrogen content such as water, concrete, or plastic.

d. Biological hazards

Neutrons are a whole body hazard due to their high penetrating ability.

e. Sources

(Insert facility-specific information.)

Table 1-5
Neutrons

Physical Characteristics	· No charge. · Has mass.
Range	· Range in air is very far. · Easily can go several hundred feet. · High penetrating power due to lack of charge (difficult to stop).
Shielding	· Water. · Concrete. · Plastic (high hydrogen content).
Biological Hazard	· Whole body exposure. · The hazard is generally external.
Sources	Insert facility-specific information.

D. Units of Measure for Radiation

1. Roentgen (R)

a. Is a unit for measuring external exposure.

b. Defined only for effect on air.

c. Applies only to gamma and X rays.

d. Does not relate biological effects of radiation to the human body.

e. 1 R (Roentgen) = 1000 milliroentgen (mR).

2. Rad (Radiation absorbed dose)

   a. A unit for measuring absorbed dose in any material.

   b. Is defined for any material.

   c. Applies to all types of radiation.

   d. Does not take into account the potential effect that different types of radiation have on the body.

   e. 1 rad = 1000 millirad (mrad).

3. Rem (Roentgen equivalent man)

   a. A unit for measuring dose equivalence.

   b. Is the most commonly used unit.

   c. Pertains to the human body.

   d. Takes into account the energy absorbed (dose) and the biological effect on the body due to the different types of radiation.

      The Quality Factor (QF) is used as a multiplier to reflect the relative amount of biological damage caused by the same amount of energy deposited in cells by the different types of ionizing radiation. Rem = rad x QF.

      Quality Factors:

alpha	= 20
beta	= 1
gamma/x-ray	= 1
neutron	= 2-11 (depending on the energy)

   e. 1 rem = 1,000 millirem (mrem).

4. Radiation dose and dose rate

   a. Radiation dose rate is the dose per time.

   b. Example:

1) Radiation dose rate = dose/time.

2) Radiation dose equivalent rate = mrem/hr.

3) Radiation absorbed dose rate = mrad/hr.

Table 1-6
Radiation Units

Roentgen (R)	**Rad (Radiation Absorbed Dose)**	**Rem (Roentgen Equivalent Man)**
Unit for measuring exposure.	Unit for measuring absorbed dose in any material.	Unit for measuring dose equivalence (most commonly used unit).
Defined only for effect on air.	Defined for any material.	Pertains to human body.
Applies only to gamma and X-ray radiation.	Applies to all types of radiation.	Applies to all types of radiation.
Does not relate biological effects of radiation to the human body.	Does not take into account the potential effect that different types of radiation have on the body.	Takes into account the energy absorbed (dose) and the biological effect on the body due to the different types of radiation. Equal doses of different types of radiation (as measured in rad) can cause different levels of damage to the body (measured in rem).

III. SUMMARY

(Insert facility-specific information.)

IV. EVALUATION

(Insert facility-specific information.)

Module 2: Biological Effects

Terminal Objective:

Given various radiation doses and sources of radiation, identify natural and manmade sources of radiation and the biological risks associated with radiation dose in accordance with lesson materials.

Enabling Objectives:

The participant will be able to select the correct response from a group of responses to verify his/her ability to:

EO1 Identify the major sources of natural background and manmade radiation.
EO2 Identify the average annual dose to the general population from natural background and manmade sources of radiation.
EO3 State the method by which radiation causes damage to cells.
EO4 Identify the possible effects of radiation on cells.
EO5 Define the terms "acute dose" and "chronic dose."
EO6 State examples of chronic radiation dose.
EO7 Define the terms "somatic effect" and "heritable effect."
EO8 State the potential effects associated with prenatal radiation dose.
EO9 Compare the biological risks from chronic radiation doses to health risks workers are subjected to in industry and daily life.

Instructional Aids:

1. Student Guide
2. Transparencies
3. Activities (as applicable)
4. Self-check quizzes (as applicable)

I. MODULE INTRODUCTION

A. Self Introduction

1. Name

2. Phone Number

3. Background

B. Module Overview

The fact that ionizing radiation produces biological damage has been known for many years. We have gained most of our knowledge of these effects since World War II.
In this module, we will discuss the potential for biological effects and risks due to ionizing radiation and put these potential risks into perspective when compared to other occupations and daily activities. With this information, it is hoped that employees will develop a healthy respect for radiation rather than fear or disregard.

C. Objectives Review

D. Introduction

We know more about the biological effects of ionizing radiation than most other environmental factors. Rather than just being able to base our information on animal studies, we have a large body of information available regarding exposures to humans. There are four major groups of people that have been exposed to significant levels of radiation.

The first group includes early radiation workers, such as radiologists. These workers received large doses of radiation before the biological effects were recognized. Since that time, standards have been developed to protect workers.

The second group is the more than 250,000 survivors of the atomic bombs dropped at Hiroshima and Nagasaki. Some of these survivors received doses estimated to be in excess of 50,000 mrem.

The third group includes individuals who have been involved in radiation accidents.

The fourth and largest group of individuals are patients who have undergone radiation therapy for cancer and other diseases.

II. MODULE OUTLINE

A. Sources of Radiation

We live in a radioactive world and always have. In fact, the majority of us will be exposed to more ionizing radiation from natural background radiation than from our jobs.

1. Natural sources

There are several sources of radiation that occur naturally. The radiation emitted from these sources is identical to the radiation that results from manmade sources.

The four major sources of naturally occurring radiation exposures are:

· Cosmic radiation

· Sources in the earth's crust, also referred to as terrestrial radiation

· Sources in the human body, also referred to as internal sources
· Radon

a. Cosmic radiation (total average dose ~ 28 mrem/yr)

1) Cosmic radiation comes from the sun and outer space. It consists of positively charged particles and gamma radiation.

2) At sea level, the average annual cosmic radiation dose is about 26 mrem.

3) At higher elevations, the amount of atmosphere shielding cosmic rays decreases; therefore, the dose increases.

b. Sources in earth's crust (terrestrial) (total average dose ~ 28 mrem/yr)

There are natural sources of radiation in the ground (i.e., rocks and soil).

1) Some of the contributors to terrestrial sources are the natural radioactive elements radium, uranium, and thorium.

2) Many areas have elevated levels of terrestrial radiation due to increased concentrations of uranium or thorium in the soil.

c. Internal (total average dose ~40 mrem/yr)

1) The food we eat and the water we drink contain trace amounts of natural radioactive materials.

2) These naturally occurring radioactive materials deposit in our bodies and cause internal exposure to radiation.

3) Some naturally occurring radioactive isotopes include Sodium-24 (Na-24), Carbon-14 (C-14), Argon-41 (Ar-41), and Potassium-40 (K-40). Most of our internal exposure comes from K-40.

d. Radon (total average dose ~ 200 mrem/yr)

1) Radon comes from the radioactive decay of uranium, which is naturally present in the soil.

2) Radon is a gas. It can travel through the soil and enter through building foundation cracks. The greatest concentrations of indoor radon are found in basements.

3) Radon emits alpha radiation. It presents a hazard only when taken into the body (e.g., when inhaled).

2. Manmade sources

The difference between manmade sources of radiation and naturally occurring sources is the origin of the source, i.e., where the radiation is either produced or enhanced by human activities.

The four top sources of manmade radiation exposures are:

- Tobacco products
- Medical radiation
- Building materials

a. Tobacco products (average dose ~1300 mrem/yr)

b. Medical radiation sources (total average dose ~ 54 mrem/yr)

1) X rays (total average dose ~ 40mrem/yr)

a) X rays are similar to gamma rays; however, they originate outside the nucleus.

b) A typical radiation dose from a chest X ray is about 10 mrem.

2) Diagnosis and therapy (total average dose ~14 mrem/yr)
In addition to X rays, radioactive materials and radioactive sources are used in medicine for diagnosis and therapy.

c. Building materials (total average dose ~7 mrem/yr)

d. Domestic water supply (total average dose ~5 mrem/yr)

e. Other minor contributors

Other contributors to dose include consumer products, industrial sources, and atmospheric testing of nuclear weapons.

3. Average annual dose

The average annual total effective dose equivalent to the general population (non-smokers) from naturally occurring and manmade sources is about 360 mrem.

B. Effects of Radiation on Cells

The human body is made up of many organ systems. Each system is made up of tissues. Specialized cells make up tissues. Ionizing radiation can potentially affect the normal function of cells.

1. Biological effects begin with the ionization of atoms

a. The method by which radiation causes damage to human cells is by ionization of atoms in the cells. Atoms make up the cells that make up the tissues of the body. Any potential radiation damage begins with damage to atoms.

b. A cell is made up of two principal parts, the body of the cell and the nucleus. The nucleus is like the brain of the cell.

c. When ionizing radiation hits a cell, it may strike a vital part of the cell like the nucleus or a less vital part of the cell, like the cytoplasm.

2. Cell sensitivity

Some cells are more sensitive than others to environmental factors such as viruses, toxins, and ionizing radiation.

a. Actively dividing and non-specialized cells

1) Cells in our bodies that are actively dividing are more sensitive to ionizing radiation.

2) Cells that are rapidly dividing include blood-forming cells, the cells that line our intestinal tract, hair follicles, and cells that form sperm.

b. Less actively dividing and more specialized cells

Cells that divide at a slower rate or are more specialized (such as brain cells or muscle cells) are not as sensitive to damage by ionizing radiation.

3. Possible effects of radiation on cells

Several things can happen when a cell is exposed to ionizing radiation. The following are possible effects of radiation on cells.

a. There is no damage

b. Cells repair the damage and operate normally

   1) The body of most cells is made up primarily of water. When ionizing radiation hits a cell, it is most likely to interact with the water in the cell. One of the byproducts of radiation-induced ionization of water is hydrogen peroxide. Hydrogen peroxide can damage cell atomic structures.

   2) Ionizing radiation can also hit the nucleus of the cell. The nucleus contains the vital parts of the cell, such as chromosomes. The chromosomes determine cell function. When chromosomes duplicate themselves, the chromosomes transfer their information to new cells. Radiation may cause a change in the chromosome that does not affect the cell.

   3) Damage to chromosomes and other cell structures can be repaired. In fact, our bodies repair a very large number of chromosome breaks every day (References 7 and 10).

3. Average annual dose

The average annual total effective dose equivalent to the general population from naturally occurring and manmade sources is about 360 mrem.

c. Cells are damaged and operate abnormally

   1) Cell damage may not be repaired or may be incompletely repaired. In that case, the cell may not be able to function properly.

   2) It is possible that a chromosome in the cell nucleus could be damaged but not be repaired correctly. If the cell continues to reproduce, this is called a mutation and may result in cancer.

d. Cells die as a result of the damage

   At any given moment, thousands of our cells die and are replaced by normal functioning cells. However, the radiation damage to a cell may be so extensive that the cell dies prematurely.

C. Acute and Chronic Radiation Dose

Potential biological effects depend on how much and how fast a radiation dose is received. Radiation doses can be grouped into two categories: acute and chronic dose.

1. Acute radiation doses

   a. High doses of radiation received in a short period of time are called acute doses. The body's cell repair mechanisms are not as effective for damage caused by an acute dose.

   b. Acute doses to the whole body

      After an acute dose, damaged cells will be replaced by new cells and the body will repair itself, although this may take a number of months. Only in extreme cases, such as with the Chernobyl firefighters (500 rem), would the dose be so high as to make recovery unlikely.

   c. Acute doses to only part of the body

      1) X-ray machines

         It is possible that radiation exposure may be limited to a part of the body, such as the hands.

         There have been accidents, particularly with X-ray machines, in which individuals have exposed their fingers to part of the intense radiation beam. In some of these cases, individuals have received doses of <u>millions</u> of mrem to their fingers, and some individuals have lost their finger or fingers. It is important for individuals who work with X-ray or similar equipment to be trained in the safe use of this equipment.

      2) Radiation therapy

         a) Radiation therapy patients receive high doses of radiation in a short period of time, but generally only to a small portion of the body (not a whole body dose).

         b) The skin and limited tissue of these patients may receive significant doses, but doses to the region of a tumor are many times higher.

         c) Ionizing radiation is used to treat cancer in these patients because cancer cells are rapidly dividing and therefore sensitive to ionizing radiation. Some of the side effects of people undergoing radiation therapy are hair loss, nausea, and tiredness.

d. Probability of a large acute dose

What is important to understand is that it takes a large acute dose of radiation before any physical effect is seen. These acute doses have occurred in Hiroshima/Nagasaki, and in a few radiation accidents, including Chernobyl. The possibility of a radiological worker receiving a large acute dose of ionizing radiation on the job is extremely low. Typically, radioactive materials are handled in small quantities that do not produce a large amount of radiation. Where there is a potential for larger exposures, many safety features are required.

2. Chronic radiation doses

A chronic radiation dose is typically a small amount of radiation received over a long period of time. An example of a chronic dose is the dose we receive from natural background every day of our lives. The body's cell repair mechanisms are better able to repair a chronic dose than an acute dose.

a. The body has time to repair damage because a smaller percentage of the cells need repair at any given time.

b. The body also has time to replace dead or non-functioning cells with new, healthy cells.

3. Biological effects of radiation exposure

Somatic effects refer to the effects radiation has on the individual receiving the dose.

Genetic effects refer to mutations due to radiation damage to the DNA of a cell. When this change is in the DNA of parental reproductive cells, it is called a heritable effect.

a. Somatic Effects

Somatic effects can best be described in terms of prompt and delayed effects as discussed below.

1) Prompt Effects

Although rare in the nuclear industry, large doses are typically acute radiation doses representing serious overexposures. The biological effects of large acute doses are as follows:

Table 2-1
Prompt Biological Effects

Dose (rem)	Effect
0-25	None detectable through symptoms or routine blood tests.
25-100	Changes in blood.
100-300	Nausea, anorexia.
300-600	Diarrhea, hemorrhage, and possible death

2) Delayed Effects

Delayed effects may result from either a single large acute overexposure or from continuing low-level chronic exposure. Cancer in its various forms is the most important potential delayed effect of radiation exposure. Other effects noted include cataracts, life shortening and, for individuals exposed in the womb, lower IQ test scores.

b. Heritable Effects

A heritable effect is a physical mutation or trait that is passed on to offspring. In the case of heritable effects, the parental individual has experienced damage to some genetic material in the reproductive cells and has passed the damaged genetic material onto offspring.

1) Heritable effects from radiation have never been observed in humans but are considered possible. They have been observed in studies of plants and animals.

2) Heritable effects have not been found in the 77,000 Japanese children born to the survivors of Hiroshima and Nagasaki (these are children who were conceived after the atom bomb -- i.e., heritable effects). Studies have followed these children, their children, and their grandchildren.

4. Factors affecting biological damage due to exposure to radiation

a. Total dose

In general, the greater the dose, the greater the potential for biological effects.

b. Dose rate (how fast)

The faster the dose is delivered, the less time the body has to repair itself.

c. Type of radiation

For example, internally deposited alpha emitters are more damaging than beta or gamma emitters for the same energy deposited.

d. Area of the body that receives a dose

In general, the larger the area of the body that receives a dose, the greater the biological effect.

Extremities are less sensitive than blood forming and other critical organs. That is why the annual dose limit for extremities is higher than for a whole body dose that irradiates internal organs.

e. Cell sensitivity

The most sensitive cells are those that are rapidly dividing. Examples include blood cells, hair follicles, and the cells lining the gastrointestinal tract.

f. Individual sensitivity

Some individuals are more sensitive to environmental factors such as ionizing radiation.

The developing embryo/fetus is the most sensitive, and children are more sensitive than adults.

In general, the human body becomes relatively less sensitive to ionizing radiation with increasing age. The exception is that elderly people are more sensitive than middle-aged adults due to the inability to repair damage as quickly (less efficient cell repair mechanisms).

D. Prenatal Radiation Exposure

Although no effects were seen in Japanese children conceived after the atomic bomb, there were effects seen in some children who were in the womb when exposed to the atomic bomb radiation at Hiroshima and Nagasaki. Some of these children were born with a slightly smaller head size, lower average birth weight, and increased incidence of mental retardation. Some later showed lower IQ test scores and slower scholastic development, smaller physical size, and increased incidence of behavioral problems.

1. Sensitivity of the fetus

   Embryo/fetal cells are rapidly dividing, which makes them sensitive to many environmental factors including ionizing radiation. The embryo/fetus is most susceptible to developing adverse health effects if exposed during the time period of 8 - 15 weeks after conception.

2. Factors for potential effects associated with prenatal exposures

   Many chemical and physical (environmental) factors are suspected of causing or known to have caused damage to a fetus, especially early in the pregnancy. Radiation, alcohol consumption, exposure to lead, and heat, such as from hot tubs, are only a few such factors.

E. Risks in Perspective

Current radiation protection standards and practices are based on the premise that any radiation dose, no matter how small, can result in health effects such as cancer. Further, it is assumed that these effects are produced in direct proportion to the dose received (i.e., doubling the radiation dose results in a doubling of the risk of the effect). These two assumptions lead to a dose-response relationship, often referred to as the linear, no-threshold model, for limiting health effects at very low radiation dose levels.

However, it should be noted that this is a conservative assumption made in the absence of more conclusive evidence. Health effects (primarily cancer) have been observed in humans only at doses in excess of 10 rem delivered at high dose rates. Below this dose, estimation of adverse health effects is speculative. Risk estimates that are used to predict health effects in exposed individuals or populations are based on epidemiological studies of well-defined populations (e.g., the Japanese survivors of the atomic bombings in 1945 and medical patients) exposed to relatively high doses delivered at high dose rates. It is generally accepted that studies have not demonstrated adverse health effects in individuals exposed to small doses (less than 10 rem) delivered over a period of many years.

1. Risk from exposures to ionizing radiation

   a. No increases in cancer have been observed in individuals who receive a dose of ionizing radiation at occupational levels. The possibility of cancer induction cannot be dismissed even though an increase in cancers has not been observed. Risk estimates have been derived from studies of individuals who have been exposed to high levels of radiation.

b. The risk of cancer induction from radiation exposure can be put into perspective. This can be done by comparing it to the normal rate of cancer death in today's society. The current rate of cancer death among Americans is about 20 percent. Taken from a personal perspective, each of us has about 20 chances in 100 of dying of cancer. A radiological worker who receives 25,000 mrem over a working life increases his/her risk of cancer by 1 percent, or has about 21 chances in 100 of dying of cancer. A 25,000 mrem dose is a fairly large dose over the course of a working lifetime. The average annual dose to DOE workers is less than 100 mrem, which leads to a working lifetime dose (40 years assumed) of no more than approximately 4,000 mrem.

2. Comparison of risks

a. Table 2-2 compares the estimated days of life expectancy lost as a result of exposure to radiation and other health risks.

The following information is intended to put the potential risk of radiation into perspective when compared to other occupations and daily activities.

Table 2-2
Estimated Loss of Life Expectancy from Health Risks

Health Risk	Estimated Loss of Life Expectancy
Smoking 20 cigarettes a day	6 years
Overweight (by 15%)	2 years
Alcohol consumption (U.S. average)	1 year
Agricultural accidents	320 days
Construction accidents	227 days
Auto accidents	207 days
Home accidents	74 days
Occupational radiation dose (1 rem/y), from age 18-65 (47 rem total)	51 days
All natural hazards (earthquakes, lightning, flood)	7 days
Medical radiation	6 days

The estimates in Table 2-2 indicate that the health risks from occupational radiation doses are smaller than the risks associated with normal day-to-day activities that we have grown to accept.

b. Acceptance of a risk:

1) is a personal matter.

2) requires a good deal of informed judgment.

c. The risks associated with occupational radiation doses are generally considered acceptable as compared to other occupational risks by most scientific groups who have studied them. There are some scientific groups who claim that the risk is too high. DOE continues to fund and review worker health studies to address these concerns.

III. SUMMARY

In summary, the estimated risk associated with occupation radiation dose is similar to other routine occupational risks and much less than some risks widely accepted in society. The risk of work in a radiation environment is considered within the normal occupational risk tolerance by national and international scientific groups. However, acceptance of risk is an individual matter and is best made with accurate information. A radiological worker should understand the risk of working in a nuclear environment in relation to the risks of daily life and the risks presented by work in other professions. The intent of this module is to give you the facts about radiation exposure risks and provide you with an opportunity to ask questions about radiation risk. It is hoped that understanding radiation risk and risk in general will help you to develop an informed and healthy respect for radiation, and that your understanding will eliminate excessive fear of or indifference to radiation.

IV. EVALUATION

(Insert facility-specific information.)

MODULE 3: RADIATION LIMITS AND ADMINISTRATIVE CONTROL LEVELS

Terminal Objective:

Given various time frames and different parts of the body, identify the applicable DOE dose limits, DOE administrative control levels, and facility-specific administrative control levels in accordance with the lesson material.

Enabling Objectives:

The participant will be able to select the correct response from a group of responses to verify his/her ability to:

EO1 State the purposes of administrative control levels.
EO2 Identify the DOE radiation dose limits, DOE recommended administrative control level, and the facility administrative control level.
EO3 State the site policy concerning prenatal radiation exposure.
EO4 Identify the employee's responsibilities concerning radiation dose limits and administrative control levels.

Instructional Aids:

1. Student Guide
2. Transparencies
3. Activities (as applicable)
4. Self-check quizzes (as applicable)

I. MODULE INTRODUCTION

A. Self Introduction

1. Name

2. Phone Number

3. Background

B. Module Overview

This module will address DOE dose limits and administrative control levels.

C. Objectives Review

D. Introduction

DOE limits and administrative control levels have been established for the purpose of restricting occupational radiation exposures to levels of acceptable risk.

II. MODULE OUTLINE

A. Basis for and Purpose of Radiation Dose Equivalent Limits and Administrative Control Levels

1. Basis for DOE dose limits

a. DOE has established radiation dose equivalent limits for general workers. These limits are based on guidance from national and international scientific groups and government agencies, such as:

1) International Commission on Radiological Protection (ICRP)

2) National Council on Radiation Protection and Measurements (NCRP)

3) U.S. Environmental Protection Agency (EPA)

b. The radiation protection standards for all DOE workers are described in 10 CFR 835, "Occupational Radiation Protection." These regulations apply to DOE, its contractors, and persons utilizing or working in DOE facilities and include dose equivalent limits.

2. Facility administrative control levels for general employees

   The facility administrative control levels for workers are lower than the DOE limits and are set to:

   a. Ensure the DOE limits and control levels are not exceeded.

   b. Help reduce individual and total worker population radiation dose (collective dose).

B. Dose Equivalent Limits and Administrative Control Levels

Table 3-7
Dose Equivalent Limits and Controls

	DOE Dose Equivalent Limit rem/year	DOE Recommendations rem/year	Facility Administrative Control Level rem/year
Whole body	5	2	facility-specific
Extremity	50	N/A	facility-specific
Skin & other organs	50	N/A	facility-specific
Lens of the eye	15	N/A	facility-specific
Member of the public	0.1	N/A	facility-specific
Declared pregnant worker	0.5/gestation period	N/A	facility-specific

NOTE: 1) The chart is based on limits and control levels for routine conditions. The limits and control levels are also based on the sum of internal and external dose. External dose is from sources outside the body. Internal dose is from sources inside the body. 2) The internal dose reported in a given calendar year is actually the projected dose the individual will receive over the next 50 years from intakes in that calendar year. Radioactive material may be inhaled, ingested, or absorbed through the skin or open wound.

1. Whole body

a. Definition

The whole body extends from the top of the head down to just below the elbow and just below the knee. This is the location of most of the blood-producing and vital organs.

b. Limit and control levels

The DOE whole body dose equivalent limit is based on the sum of internal and external dose.

1) DOE radiation dose equivalent limit during routine conditions is <u>5 rem/year</u>.
2) Because DOE's objective is to maintain personnel radiation dose well below the regulatory limits, the DOE Radiological Control Technical Standard recommends a DOE administrative control level during routine conditions of <u>2 rem/year</u>.

3) Facility administrative control level.
   (Insert facility-specific information.)

2. Extremities

a. Definition

Extremities include the hands and arms below the elbow, and the feet and legs below the knees.

b. Limit and control level

Extremities can withstand a much larger dose than the whole body because there are no major blood-producing organs located here.

1) DOE radiation dose equivalent limit for extremities is <u>50 rem/year</u>.

2) Facility administrative control levels.

   (Insert facility-specific information.)

3. Skin and other organs

a. DOE radiation dose equivalent limit for skin and other organs is <u>50 rem/year</u>.

b. Facility administrative control level

(Insert facility-specific information.)

4. Lens of the eye

a. DOE radiation dose equivalent limit for lens of the eye is <u>15 rem/year</u>.

b. Facility administrative control level.

(Insert facility-specific information.)

5. Declared pregnant worker: Embryo/fetus

   After a female worker voluntarily notifies her employer in writing that she is pregnant, she is considered a declared pregnant worker. For the purposes of radiological protection of the fetus/embryo, DOE requires a special limit for dose to the fetus/embryo. In addition, the DOE RCS recommends that the employer provide the option of a mutually agreeable assignment of work tasks, with no loss of pay or promotional opportunity, such that further occupational radiation exposure is unlikely.

   - This declaration may be revoked, in writing, at anytime by the declared pregnant worker.

   b. DOE limit

      For a declared pregnant worker who continues working as a radiological worker, the following radiation dose limit will apply.

      1) The dose equivalent limit for the embryo/fetus (during the entire gestation period) is <u>500 mrem</u>.

         a) Measures must be taken to avoid substantial variation above the uniform exposure rate necessary to meet the 500 mrem limit for the gestation period.

         b) The DOE RCS recommends that efforts be made to avoid exceeding 50 mrem/month to the embryo/fetus of the declared pregnant worker.

      2) If the dose equivalent to the embryo/fetus is determined to have already exceeded 500 mrem when a worker notifies her employer of her pregnancy, the worker shall not be assigned to tasks where additional occupational radiation exposure is likely during the remainder of the pregnancy.

   b. Site policy

      (Insert facility-specific information.)

   c. Facility administrative control level

      (Insert facility-specific information.)

6. Members of the public

   a. DOE radiation dose equivalent limit is <u>100 mrem/year</u>.

   b. Facility administrative control levels

      (Insert facility-specific information.)

C. Worker Responsibilities Regarding Dose Limits

1. It is each employee's responsibility to comply with DOE dose limits and facility administrative control levels.

2. If you suspect that dose limits or administrative control levels are being approached or exceeded, you should notify your supervisor immediately.

3. (Insert facility-specific information.)

III. SUMMARY

(Insert Site Summary.)

IV. EVALUATION

(Insert facility-specific information.)

MODULE 4: ALARA PROGRAM

Terminal Objective:

Given different radiological conditions, identify the techniques for minimizing exposure to radiation and radioactive material in accordance with lesson materials.

Enabling Objectives:

The participant will be able to select the correct response from a group of responses to verify his/her ability to:

EO1 State the ALARA concept.
EO2 State the DOE/Site management policy for the ALARA program.
EO3 Identify the responsibilities of management, the Radiological Control Organization, and the radiological worker in the ALARA Program.
EO4 Identify methods for reducing external and internal radiation dose.
EO5 State the pathways by which radioactive material can enter the body.
EO6 Identify methods a radiological worker can use to minimize radioactive waste.

Instructional Aids:

1. Student Guide
2. Transparencies
3. Activities (as applicable)
4. Self-check quizzes (as applicable)

I. MODULE INTRODUCTION

A. Self Introduction

1. Name

2. Phone Number

3. Background

B. Module Overview

This module is designed to inform the student of the concept of ALARA (As Low As Reasonably Achievable). This module discusses radiation hazards. Methods for reducing both external and internal doses from radiation and radioactive material are also discussed.

C. Objectives Review

D. Introduction

DOE establishes dose limits and administrative control levels for general employees. However, radiological workers and their management strive to keep radiation dose well below these limits. Radiological workers should always try to maintain their radiation dose As Low As Reasonably Achievable (ALARA).

II. MODULE OUTLINE

A. ALARA Program

ALARA stands for As Low As Reasonably Achievable. ALARA is an approach to radiation safety that strives to manage and control doses (both individual and collective) to the work force and the general public to as low as is reasonable taking into account social, technical, economic, practical, and public policy considerations.

1. ALARA concept

a. ALARA stands for As Low As Reasonably Achievable.

b. Because some risk, however small, exists from any radiation dose, all doses should be kept ALARA. ALARA includes reducing both internal and external radiation dose.

c. The ALARA concept is an integral part of all site activities that involve the use of sources of ionizing radiation.

d. ALARA is the responsibility of all employees.

2. DOE Management Policy for the ALARA program

   Personal radiation exposure shall be maintained As Low As Reasonably Achievable. Radiation exposure to the work force and public shall be controlled such that:

   · Radiation doses are well below regulatory limits.

   · There is no radiation exposure without an overall benefit.

3. Site policy

   (Insert facility-specific information.)

B. Responsibilities for the ALARA Program

The individual radiological worker is ultimately responsible for maintaining his/her radiation dose ALARA. However, management and Radiological Control personnel also play an important role in the ALARA program. The following are some of the responsibilities of the three groups:

1. Management

   (Insert facility-specific information.)

2. Radiological Control Organization

   (Insert facility-specific information.)

3. Radiological workers

   Each radiological worker is expected to demonstrate responsibility and accountability. This is accomplished through an informed, disciplined, and cautious attitude toward radiation and radioactivity.

   (Insert facility-specific information.)

C. External and Internal Radiation Dose Reduction

Engineering controls should be the primary method to control exposure (e.g., enclosed hoods). Administrative controls is the next method to control exposures (e.g., postings). Personnel protective equipment is the last method (e.g., respirators).

1. Basic protective measures used to minimize external dose include:

   · Minimizing time in radiation areas

   · Maximizing the distance from a source of radiation

   · Using shielding whenever possible

   · Reducing the amount of radioactive material (source reduction)

   a. Methods for minimizing time

      Reducing the time spent in a field of radiation will lower the dose received by the workers.

      1) Plan and discuss the task thoroughly prior to entering the area. Use only the number of workers actually required to do the job.

      2) Have all necessary tools present before entering the area.

      3) Use mock-ups and practice runs that duplicate work conditions.

      4) Take the most direct route to the job site if possible and practical.

      5) Never loiter in an area controlled for radiological purposes.

      6) Work efficiently and swiftly.

      7) Do the job right the first time.

      8) Perform as much work outside the area as possible. When practical, remove parts or components to areas with lower dose rates to perform work.

      9) Do not exceed stay times. In some cases, the Radiological Control Organization may limit the amount of time a worker may stay in an area due to various reasons. This is known as “stay time.” If you have been assigned a stay time, do not exceed this time.

      10) (Insert facility-specific information.)

   b. Methods for maximizing distance from sources of radiation

      The worker should stay as far away as possible from the source of radiation.

      1) Stay as far away from radiation sources as practical given the task assignment. For point sources (such as valves and hot spots), the dose rate follows a principle called the inverse square law. This law states that if you double the distance, the dose rate falls to 1/4 of the original dose rate. If you triple the distance, the dose rate falls to 1/9 of the original dose rate.

2) Be familiar with radiological conditions in the area.

3) During work delays, move to lower dose rate areas.

4) Use remote handling devices when possible.

5) (Insert facility-specific information.)

c. Proper uses of shielding

Shielding reduces the amount of radiation dose to the worker. Different materials shield a worker from the different types of radiation.

1) Take advantage of permanent shielding, such as non-radiological equipment/structures.

2) Use shielded containments when available.

3) Wear safety glasses/goggles to protect your eyes from beta radiation, when applicable.

4) Temporary shielding (e.g., lead or concrete blocks) can only be installed when proper procedures are used.

5) Temporary shielding will be marked or labeled with wording such as "Temporary Shielding - Do Not Remove Without Permission from Radiological Control."

6) Once temporary shielding is installed, it cannot be removed without proper authorization.

   - When evaluating the use of shielding, the estimated dose saved is compared to the estimated dose incurred during shield installation and removal.

7) (Insert facility-specific information.)

d. Source Reduction

Source reduction is another method of reducing radiation doses. Source reduction often involves procedures such as flushing radioactive systems, decontamination, and removal of contaminated items. This is done to reduce the amount of radioactive materials present in/on a system because these materials can add to radiation levels in an area.

2. Internal radiation dose reduction

   a. Pathways

      Internal dose is a result of radioactive materials being taken into the body. Radioactive material can enter the body through one or more of the following pathways:

      1) Inhalation

      2) Ingestion

      3) Absorption through the skin

      4) Absorption through wounds

b. Methods to reduce internal radiation dose

Reducing the potential for radioactive materials to enter the body is important. As previously stated, install or use engineering controls followed by administrative controls as the primary methods to control internal exposure. PPE is the last choice for controlling internal exposure. In addition, the following are methods the worker can use.

1) Wear respirators properly when required. Respirators should only be used by personnel qualified to wear them.

2) Report all wounds or cuts (including scratches and scabs) to the appropriate facility-specific organization before entering any area controlled for radiological purposes.

3) Comply with the requirements of the controlling work documents.

4) Do not eat, drink, smoke, or chew in Radioactive Materials Areas, Contamination Areas, High Contamination Areas, or Airborne Radioactivity Areas, as dispersible radioactive materials may be present.

5) (Insert facility-specific information.)

3. Lessons Learned

Review lessons learned from your site or other sites to demonstrate what may be learned from mistakes leading to excessive personnel exposures.

(Insert facility-specific information.)

D. Radioactive Waste Minimization

One of the potential consequences of working with radioactive materials is the generation of radioactive waste. This radioactive waste must be properly disposed. Examples of radioactive waste include:

- Paper
- Gloves
- Glassware
- Rags
- Brooms, mops

The ALARA concept also applies to minimizing radioactive waste. This will reduce personnel exposure associated with the handling, packaging, storing, and disposing of radioactive waste. This will also reduce the resultant costs. It is very important for each radiological worker to minimize the amount of radioactive waste generated.

1. Methods to minimize radioactive waste

   The following information identifies methods to minimize radioactive waste.

   a. Minimize the materials used for radiological work.

      1) Take only the tools and materials you need for the job into areas controlled for radiological purposes. This is especially important for contamination areas.

      2) Unpack equipment and tools in a clean area. This will help to avoid bringing unnecessary material to the job site. This material can become radioactive waste if it is contaminated.

      3) Use tools and equipment that are identified for radiological work when possible. (Add facility-specific information about where such tools are stored.)

      4) Use only the materials required to clean the area. An excessive amount of bags, rags, and solvent adds to radioactive waste.

      5) Sleeve, or otherwise protect with a covering such as plastic, clean materials brought into contaminated areas.

      6) (Insert facility-specific information.)

   b. Separate radioactive waste from nonradioactive waste.

      1) Place radioactive waste in the containers identified for radioactive waste. Do not place radioactive waste in nonradioactive waste containers.

2) Do not throw nonradioactive waste, or radioactive material that may be reused, into radioactive waste containers.

3) (Insert facility-specific information.)

c. Separate compactible material from noncompactible material.

d. Minimize the amount of mixed waste generated. Mixed waste is waste that contains both radioactive and hazardous materials.

e. Use good housekeeping techniques.

f. (Insert facility-specific information.)

III. SUMMARY

This module addressed key points for the implementation and success of the Site's ALARA Program. Responsibilities for all employees and methods to achieve the ALARA concepts were also discussed.

IV. EVALUATION

(Insert facility-specific information.)

MODULE 5: PERSONNEL MONITORING PROGRAMS

Terminal Objective:

Given different personnel monitoring programs, identify the purpose, types, and worker responsibilities for each in accordance with lesson material.

Enabling Objectives:

The participant will be able to select the correct response from a group of responses to verify his/her ability to:

EO1 State the purpose and worker responsibilities for each of the external dosimeter devices used at the site.
EO2 State the purpose and worker responsibilities for each type of internal monitoring method used at the site.
EO3 State the methods for obtaining radiation dose records.
EO4 Identify worker responsibilities for reporting radiation dose received from other sites and from medical applications.

Instructional Aids:

1. Student Guide
2. Transparencies
3. Activities (as applicable)
4. Self-check quizzes (as applicable)

I. MODULE INTRODUCTION

A. Self Introduction

1. Name

2. Phone Number

3. Background

B. Module Overview

The various types of personnel monitoring devices and the employee's responsibilities concerning each will be discussed.

C. Objectives Review

D. Introduction

External exposure results from radiation that comes from radioactive material outside of the body. A "personnel dosimeter" is a device used to measure external dose. Internal dose is radiation that comes from radioactive material within the body. The whole body counter, chest counter, and bioassay sampling are methods for measuring internal dose.

Personnel monitoring for radiation dose involves assessing exposure due to external sources and internal sources.

II. MODULE OUTLINE

A. External Dosimetry

A personnel dosimeter is a device used to measure radiation dose. Different types of external dosimeters may be used. Radiological Control personnel determine which type(s) are needed. The following information identifies the different types used at this facility.

1. Purpose

(Insert facility-specific information to describe purpose, and basic operation of each type.)

2. Worker responsibilities for external dosimetry include the following:

a. Wear dosimeters when required.

Radiological Control personnel identify the requirements. Check signs and radiological work permits (RWPs) for the requirements.

b. Wear dosimeters properly.

1) Primary dosimeters should be worn on the chest area. This area is on or between the neck and the waist. Radiological control procedures or work authorizations may also identify proper placement.

2) Supplement dosimeters are worn in accordance with site policy. This includes pocket, electronic dosimeters, extremity dosimetry, or multiple dosimeter sets.

c. Take proper actions if dosimeter is lost, damaged, contaminated, or off-scale. If in an area controlled for radiological purposes, take the following actions:

1) Place work activities in a safe condition.

2) Alert others.

3) Immediately exit the area.

4) Notify radiological control personnel.

d. Store the dosimeter in the proper storage location.

e. Return dosimeters for processing as directed. Personnel that fail to return dosimeters may be restricted from continued radiological work.

f. Dosimeters issued from the permanent work site cannot be worn at another site.

g. (Insert facility-specific information.)

B. Internal Monitoring

Whole body counters, chest counters, and/or bioassay samples may be used to monitor radioactive material in the human body. In some cases, the locations of radioactive material may be determined. An internal dose estimate may be performed based on these measurements.

1. Purpose of each type of internal monitoring.

(Insert facility-specific information.)

2. Worker responsibilities

(Insert facility-specific information.)

C. Methods for Obtaining Radiation Dose Records

1. Individuals who are monitored for exposure at DOE facilities have the right to request reports of that exposure as follows:

   a. Upon the request from an individual terminating employment, records of radiation dose shall be provided by the DOE facility within 90 days. If requested, a written estimate of radiation exposure received by the terminating employee shall be provided at the time of termination.

   b. Each individual required to be monitored for radiation exposure at a DOE facility shall receive a report of that exposure on an annual basis.

   c. Detailed information concerning any individual's dose shall be made available to the individual upon request of that individual.

   d. When a DOE contractor is required to report to the Department, pursuant to Departmental requirements for occurrence reporting and processing, any exposure of an individual to radiation and/or radioactive material, or planned special exposure, the contractor shall also provide that individual with a report on his/her exposure data included therein. Such a report shall be transmitted at a time not later than the transmittal to the Department.

2. Reporting radiation dose received from other facilities and medical applications

   a. Notify Radiological Control personnel prior to and following any radiation dose received at another facility so that dose records can be updated.

   b. Notify Radiological Control of medical radioactive applications. This does not include routine medical and dental X rays. This does include therapeutic and diagnostic radio-pharmaceuticals.

   (Insert facility-specific information.)

III. SUMMARY

(Insert facility-specific information.)

IV. EVALUATION

(Insert facility-specific information.)

Module 6: Radiological Access Controls and Postings

Terminal Objective:

Given an area controlled for radiological purposes, the participant will be able to enter and exit the area in accordance with radiological access controls and postings.

Enabling Objectives:

The participant will be able to select the correct response from a group of responses to verify his/her ability to:

EO1 State the purpose of and information found on Radiological Work Permits (RWPs).
EO2 Identify the worker's responsibilities in using Radiological Work Permits.
EO3 Identify the colors and symbol used on radiological postings.
EO4 State the radiological and disciplinary consequences of disregarding radiological postings, signs, and labels.
EO5 Define the areas controlled for radiological purposes.
EO6 Identify the minimum or recommended requirements for entering, working in, and exiting:
- a. Radiological Buffer Areas
- b. Radiation Areas
- c. Radioactive Material Areas
- d. Underground Radioactive Material Areas
- e. Soil Contamination Areas
- f. Fixed Contamination Areas

EO7 Identify the areas a Radiological Worker I trained person may enter.
EO8 Identify the purpose and use of personnel contamination monitors.

Instructional Aids:

1. Student Guide
2. Transparencies
3. Activities (as applicable)
4. Self-check quizzes (as applicable)

I. MODULE INTRODUCTION

A. Self Introduction

1. Name

2. Phone Number

3. Background

B. Module Overview

Radiological Work Permits (RWP) used to control access into areas controlled for radiological purposes will be addressed. In addition, radiological requirements for working in these areas will be presented.

C. Objectives Review

D. Introduction

The previous modules discussed some important radiological topics from a theoretical perspective. The current module will discuss the application of this theory to control radiological work in a safe but efficient manner.

II. MODULE OUTLINE

A. Radiological Work Permits (RWPs)

1. Purpose of RWPs

RWPs may be used to establish radiological controls for entry into areas controlled for radiological purposes. They serve to:

a. Inform workers of area radiological conditions.

b. Inform workers of entry requirements.

c. Provide a record relating radiation doses to specific work activities.

2. Types of RWPs

   The type of RWP used will depend on the radiological conditions in the area.

   a. General Radiological Work Permit

      1) This should be used to control routine or repetitive activities such as tours and inspections or minor work activities in areas with well characterized, stable radiological conditions.

      2) General RWPs should not be approved for periods longer than 1 year.

      3) Examples of use

         (Insert facility-specific information.)

   b. Job-specific radiological work permit

      1) This should be used to control nonroutine operations or work in areas with changing radiological conditions.

      2) It should only remain in effect for the duration of a particular job.

      3) Examples of use

         (Insert facility-specific information.)

   c. An alternate formal mechanism, such as written procedures, experiment authorizations, or other written authorization, may be used in lieu of an RWP. The alternate method should include the elements of an RWP.

3. Information found on the RWP

   The RWP should include the following information:

   a. Description of work.

   b. Work area radiological conditions

      This information may also be determined from area radiological survey maps/diagrams or the radiological posting for that area.

   c. Dosimetry requirements.

   d. Pre-job briefing requirements.

      Pre-job briefings generally consist of discussions among workers and supervisor(s) concerning various radiological aspects of the job. The purpose of the briefings should be to discuss radiological exposure and appropriate actions for unplanned situations.

   e. Required level of training for entry.

f. Protective clothing/equipment requirements.

g. Radiological Control coverage requirements and stay time controls, as applicable.

h. Limiting radiological condition that may void the permit.

i. Special dose or contamination reduction. considerations.

j. Special personnel frisking considerations.

k. Technical work document to be used, as applicable.

l. Date of issue and expiration.

m. Authorizing signatures and unique identifying designation or number.

4. Responsibilities of the worker when using an RWP

a. Workers must read and comply with the RWP requirements.

b. Workers must acknowledge they have read, understood, and agreed to comply with the RWP prior to entering the area and after any revision to the RWP. This is done by signature or through electronic means.

c. Radiological Control or a supervisor should be contacted prior to work if the RWP appears to be incorrect or is difficult to understand.

d. Do not make substitutions for specified requirements.

e. Report to Radiological Control personnel if radiological controls are not adequate or are not being followed.

B. Radiological Postings

1. Radiological postings are used to:

a. Alert personnel to the presence of radiation and radioactive materials.

b. Aid in minimizing personnel dose.

c. Prevent the spread of contamination.

In addition, 10 CFR 835, Subpart F, specifies requirements for personnel entry controls for HR and VHR Areas.

2. Posting requirements

a. Areas and materials controlled for radiological purposes will be designated with a magenta or black standard three-bladed radiological warning symbol (trefoil) on a yellow background.

b. Fixed barriers such as walls, rope, tape, or chain will designate the boundaries of posted areas. Where possible, the barriers will be yellow and magenta in color.

c. The barriers should be placed to clearly mark the boundary of the radiological areas.

d. Entrance points to radiologically controlled areas should have signs or postings stating the entry requirements, such as “Personnel Dosimeters, RWP and Respirator Required.”

e. In some cases, more than one radiological condition may be present. The area shall be posted to include all of the radiological conditions that are present.

f. In areas of ongoing work activities, the dose rate and contamination levels (or ranges of each) may be included in postings.

g. The posting will be placed where it is clearly visible to personnel.

3. Responsibilities of the worker

   a. Before entering an area controlled for radiological purposes, read all of the signs. Since radiological conditions can change, the signs will also be changed to reflect the new conditions. A sign or posting that you saw one day may be replaced with a new one the next day.

   b. Obey any posted, written or oral requirements including “Exit,” “Evacuate,” “Hold Point,” or “Stop Work Orders.” These requirements may be included in RWPs and work procedures, and may come from Radiological Control personnel at the job site.

      1) Hold points are specific times noted in a procedure, work permit, etc., where work must stop for Radiological Control or other evaluations.

      2) Stop Work Orders are usually a result of:

         a) Inadequate radiological controls

         b) Failure to implement radiological controls

         c) Radiological hold point not being observed

         d) Changing or unexpected conditions.

   c. Report unusual conditions such as leaks, spills, or alarming area monitors to the Radiological Control personnel.

   d. Be aware of changing radiological conditions. Be aware that others’ activities may change the radiological conditions in your area.

   e. If any type of material used to identify a radiological hazard is found outside an area controlled for radiological purposes, it should be reported to Radiological Control personnel immediately.

4. Consequences of disregarding radiological postings, signs, and labels

   a. It is each worker’s responsibility to read and comply with all the information identified on radiological postings, signs, and labels.

   b. Disregarding any of these or removing/relocating them without permission can lead to:

      1) Unnecessary or excessive radiation dose.

      2) Personnel contamination.

      3) Disciplinary actions such as formal reprimand, suspension, or even termination.

C. Areas a RW I Trained Person Can Enter

The level of training a radiological worker has successfully completed determines the types of areas he/she can enter.

1. Radiological Buffer Areas (RBAs)

RBAs are intermediate areas which DOE RCS recommends be established to prevent the spread of radioactive contamination and to protect personnel from radiation exposure. This area designation is not required by 10 CFR 835 and its use may vary from site to site.

a. Posting Recommendations:

"CAUTION, RADIOLOGICAL BUFFER AREA"

b. Recommended requirements for unescorted entry should include:

1) Appropriate training, such as Radiological Worker I Training.

2) Personnel dosimetry, as appropriate.

3) (Insert facility-specific information.)

c. Recommended requirements for working in RBA

(Insert facility-specific information.)

d. Recommended requirements for exiting an RBA:

Personnel exiting a RBA containing a Contamination Area, High Contamination Area, or Airborne Radioactivity Area should, at a minimum, perform a hand and foot frisk.

1) General guidelines for handheld monitoring using a hand-held radioactive contamination survey instrument include the following:

a) Verify the instrument is on, set to the proper scale, and within the calibration date.

b) Verify instrument response and source check.

c) Ensure the audible function of the instrument is on and can be heard.

d) Determine the instrument background.

(Insert facility-specific information concerning acceptable background rates).

e) Survey hands before picking up the probe.

f) Hold the probe approximately ½" from the surface being surveyed for beta/gamma and ¼" for alpha radiation.

g) Move probe slowly over the surface, approximately 2" per second.

h) If the count rate increases during frisking, pause for 5 to 10 seconds over the area to provide adequate time for instrument response.

2) Alarm response for hand-held survey instrument

a) If contamination is indicated, remain in the area and notify the Radiological Control personnel.

b) Minimize cross contamination. For example, put a glove on a contaminated hand while waiting for the Radiological Control personnel to arrive.

3) Portal monitors

(Insert facility-specific information.)

2. Radiation Areas (RAs)

RAs are any areas accessible to individuals in which radiation levels could result in an individual's receiving a deep dose equivalent in excess of 5 mrem/hr. This is established based on dose rates at 30 cm from the source of radiation.

a. Posting Requirements:

"CAUTION, RADIATION AREA"

Additionally, the posting may state:

"Personnel Dosimetry Required for Entry"

b. Minimum requirements for unescorted entry should be:

1) Appropriate training, such as Radiological Worker I Training.

2) Personnel dosimeter.

3) Worker's signature on the RWP, as applicable.

4) (Insert facility-specific information.)

c. Minimum requirements for working in an RA

1) Don't loiter in the area.

2) Follow proper emergency response to abnormal situations.

3) Avoid hot spots.

Hot spots are localized sources of radiation or radioactive material normally within facility piping or equipment. The radiation levels of hot spots exceed the general area radiation level by more than a factor of 5 and are greater than 100 mrem per hour on contact.

Posting:

"Caution, Hot Spot"

4) (Insert facility-specific information.)

d. Minimum requirements for exiting a RA:

1) Observe posted exit requirements

2) Sign-out on RWP or equivalent, as applicable

3) Insert facility-specific information

3. Radioactive Materials Area (RMA)

RMA means an area, accessible to individuals, in which items or containers of radioactive material exist and the total activity of rad-material exceeds ten times the applicable value provided in 10 CFR 835 Appendix E.

a. Radioactive material may consist of equipment, components, or materials that have been exposed to contamination or have been activated. Sealed or unsealed radioactive sources are also included.

b. Radioactive material may be stored in drums, boxes, etc., and will be marked appropriately.

c. Posting Requirements:

"CAUTION, RADIOACTIVE MATERIAL(S)"

d. Exceptions to posting requirements.

1) Areas may be excepted from the posting requirements for periods of less than 8 continuous hours when placed under continuous observation and control of an individual knowledgeable of, and empowered to implement, required access and exposure control measures.

2) The following areas may be excepted from the radioactive material area posting requirements:

a) Areas posted Radiation Area, High Radiation Area, Very High Radiation Area, Airborne Radioactivity Area, Contamination Area, or High Contamination Area

b) Areas in which each item or container of radioactive material is clearly and adequately labeled in accordance with 10 CFR 835 such that individuals entering the area are made aware of the hazard.

c) The radioactive material consists solely of structures or installed components which have been activated.

d) Areas containing only packages received from radioactive material transportation labeled and in a non-degraded condition need not be posted in accordance with 10 CFR 835 until the packages are surveyed.

e. Minimum requirements for unescorted entry should include:

1) Appropriate training, such as Radiological Worker I Training.

2) For entry into Radioactive Material Areas where whole body dose rates exceed 5 mrem/hour, the Radiation Area entry requirements will apply.

3) For entry into Radioactive Material Areas where removable contamination levels exceed the specified DOE limits, the Contamination Area entry requirements will apply.

4) (Insert facility-specific information.)

f. Minimum requirements for working in an RMA

(Insert facility-specific information.)

g. Minimum requirements for exiting an RMA

(Insert facility-specific information.)

4. Fixed Contamination Area (Recommended)

This area designation is recommended by the DOE RCS. It may be an area or equipment that contains radioactive material that cannot be easily removed from surfaces by nondestructive means, such as wiping, brushing, or laundering. This type of area designation is not required by 10 CFR 835 and its use may vary from site to site.

a. Recommended Posting:

"CAUTION, FIXED CONTAMINATION"

b. Contact the Radiological Control Organization for entry and exit requirements.

c. (Insert facility-specific information.)

5. Soil Contamination Areas for Work that Doesn't Disturb the Soil (Recommended)

This area designation is recommended by the DOE RCS. It contains surface soil or subsurface contamination levels that exceed the recommended DOE limits. This type of area designation is not required by 10 CFR 835 and its use may vary from site to site.

a. Posting:

"CAUTION, SOIL CONTAMINATION AREA"

b. Contact the Radiological Control Organization for entry and exit requirements.

c. (Insert facility-specific information.)

6. Underground Radioactive Materials Areas (URMAS) Where an Individual is not Likely to Receive a Dose > 0.1 rem in a Year (Recommended)

URMAS are area designations recommended by the DOE RCS. They are established to indicate the presence of underground items that contain radioactive materials such as pipelines, radioactive cribs, covered ponds, inactive burial grounds, and covered spills. This type of area designation is not required by 10 CFR 835, and its use may vary from site to site.

a. Posting:

"UNDERGROUND RADIOACTIVE MATERIALS"

Special instructions such as, "Consult with Radiological Control Organization before Digging" or "Subsurface Contamination Exists" may be included.

b. General requirements:

1) An Underground Radioactive Materials Area may be exempt from the general entry and exit requirements if individual doses do not exceed 100 mrem in a year.

2) Contact the Radiological Control Organization prior to entry.

c. (Insert facility-specific information.)

D. Areas a RW I Trained Person May Not Enter

1. High Radiation Areas (HRAs)

HRA is any area accessible to individuals in which radiation levels could result in an individual receiving a deep dose equivalent in excess of 100 mrem/hr at 30 centimeters from the source.

a. Posting Requirements:

"CAUTION or DANGER, HIGH RADIATION AREA"
Additionally, the posting may state:

"Personnel Dosimetry Required for Entry"

b. Unescorted entry into this area requires appropriate training, such as RW II or RW I with the High Radiation Area training module.

2. Very High Radiation Areas (VHRs)

   A VHR is any area accessible to individuals in which radiation levels could result in an individual receiving an absorbed dose in excess of 500 rad/hr at 1 meter from the source of radiation.

   a. Posting Requirements:

      "GRAVE DANGER, VERY HIGH RADIATION AREA"

3. Contamination Areas (CAs)

   CAs are those areas, accessible to individuals, in which removable contamination levels are greater than 1 time but less than or equal to 100 times the specified limits in Appendix D of 10 CFR 835.

   a. Posting Requirements:

   "CAUTION, CONTAMINATION AREA"

   b. Unescorted entry into this area requires appropriate training, such as RW II training.

4. High Contamination Areas (HCAs)

   An HCA is an area, accessible to individuals, in which removable contamination levels are 100 times or more the specified limits in Appendix D of 10 CFR 835.

   a. Posting Requirements:

      "CAUTION or DANGER, HIGH CONTAMINATION AREA"

      Additionally, the posting may state:

      "RWP REQUIRED FOR ENTRY"

   b. Unescorted entry into this area requires appropriate training, such as RW II training.

5. Airborne Radioactivity Areas (ARAs)

   ARAs are those areas, accessible to individuals, where the concentration of airborne radioactivity, above natural background, exceeds or is likely to exceed the specified limits in 10 CFR 835.

   a. Posting Requirements:

      "CAUTION or DANGER AIRBORNE RADIOACTIVITY AREA"
      Additionally, the posting may state:

"RWP REQUIRED FOR ENTRY"

b. Unescorted entry into this area requires appropriate training, such as RW II training.

III. SUMMARY

(Insert facility-specific information.)

IV. EVALUATION

(Insert facility-specific information.)

Module 7: Radiological Emergencies

Terminal Objective:

Given a radiological emergency or alarm, identify the appropriate responses in accordance with approved lesson materials.

Enabling Objectives:

The participant will be able to SELECT the correct response from a group of responses to verify his/her ability to:

EO1 State the purpose and types of emergency alarms.
EO2 Identify the correct responses to emergencies and alarms.
EO3 State the possible consequences of disregarding radiological alarms.
EO4 State the site administrative emergency radiation dose guidelines.

Instructional Aids:

1. Student Guide
2. Transparencies
3. Activities (as applicable)
4. Self-check quizzes (as applicable)

I. MODULE INTRODUCTION

A. Self Introduction

1. Name

2. Phone Number

3. Background

B. Module Overview

This module discusses off-normal and emergency situations and the appropriate response to each. Radiological alarms associated with monitoring equipment will also be discussed.

C. Objectives Review

D. Introduction

Monitoring systems are used to warn personnel when off-normal radiological conditions exist. Radiological workers must become familiar with these alarms and know the response to each. These responses will help to minimize exposure and personal contamination during off-normal conditions.

II. MODULE OUTLINE

A. Emergency Alarms and Responses

Equipment that monitors radiation dose rates and airborne contamination levels is placed throughout DOE radiological facilities. It is essential for radiological workers to recognize the equipment and the associated alarms and know the appropriate response.

1. Area Radiation Monitors

- Types and purpose
- Operational check (if appropriate)
- Alarms
- Appropriate response

(Insert facility-specific information.)

2. Airborne Contamination Monitors

   - Types and purpose
   - Operational check (if appropriate)
   - Alarms
   - Appropriate response

   (Insert facility-specific information.)

3. Disregard for Radiological Alarms

   Disregarding any of these radiological alarms may lead to:

   - Possible excessive radiation dose
   - Unnecessary spread of contamination
   - Unnecessary personal contamination
   - Disciplinary action

B. Radiological Emergency Situations

Working in a radiological environment requires more precautionary measures than performing the same job in a nonradiological setting. If an emergency arises during radiological work, response actions may be necessary to ensure personnel safety.

1. Personnel injuries in areas controlled for radiological purposes.

   (Insert facility-specific information.)

2. Situations that require immediate exit from an area controlled for radiological purpose.

   (Insert facility-specific information.)

3. An accidental breach of a radioactive system or spill of radioactive material

   a. For radioactive spills involving highly toxic chemicals, workers should immediately exit the area without attempting to stop or secure the spill. They should then promptly notify Industrial Hygiene or the Hazardous Material team and Radiological Control personnel.

b. For other spills:

- Stop or secure the operation causing the spill, if it can be done safely
- Warn others in the area and notify Radiological Control personnel
- Isolate the spill area, if possible
- Minimize individual exposure and contamination
- Secure unfiltered ventilation (fan, open windows, etc.)

C. Considerations in Rescue and Recovery Operations

1. In extremely rare cases, emergency exposure to high levels of radiation may be necessary. This is done to rescue personnel or protect major property.
2. Rescue and recovery operations that involve radiological hazards can be very complex.
3. The type of response to these operations is generally left up to the official in charge of the emergency situation. The official's judgment is guided by many variables that include determining the risk versus the benefit of an action and deciding how best to implement the action.
4. No individual shall be required to perform a rescue action that might involve substantial personal risk. All personnel selected to provide emergency response shall be trained commensurate with the hazards in the area and required controls. They shall be briefed beforehand on the known or anticipated hazards to which they shall be subjected.
5. The DOE guidelines for control of Emergency Exposure are as follows:

Table 7-1
Guidelines for Control of Emergency Exposures

Dose limit[1] (whole body)	Activity performed	Conditions
5 rem 10 rem 25 rem	All activities Protecting major property. Lifesaving or protection of large populations.	 Where lower dose limit is not practicable.
>25 rem	Lifesaving or protection of large populations.	Only on a voluntary basis to personnel fully aware of the risks involved.
[1]The lens of the eye dose guideline is three times the listed values. The shallow dose guideline to the skin of the whole body and the extremities is 10 times the listed values. These doses are in addition to and accounted for separately from the doses received under the limits in §§835.202 and 835.205.		

6. Site administrative emergency dose guidelines for rescue and recovery operations.

   (Insert facility-specific information.)

III. SUMMARY

(Insert facility-specific information.)

IV. EVALUATION

(Insert facility-specific information.)

Module 8: High/Very High Radiation Area Training

Prerequisite: **Core Academics (Modules 1-7)**

Terminal Objective:

Given a High or Very High Radiation area sign, define the area and identify the requirements for entry to High Radiation Areas in accordance with the lesson material.

Enabling Objectives:

The participant will be able to select the correct response from a group of responses to verify his/her ability to:

EO1 Define "High Radiation Area" and "Very High Radiation Area."
EO2 Identify sources and locations that may produce High Radiation Areas and Very High Radiation Areas at the site.
EO3 State the minimum requirements for entering, working in, and exiting High Radiation Areas.
EO4 State the administrative and physical controls for access to High Radiation Areas.

Instructional Aids:

1. Student Guide
2. Transparencies
3. Activities (as applicable)
4. Self-check quizzes (as applicable)

I. MODULE INTRODUCTION

A. Self Introduction

1. Name

2. Phone Number

3. Background

B. Module Overview

This module discusses information regarding entry, work in, and control of High Radiation Areas and the materials and systems that can emit high radiation levels.

C. Objectives Review

D. Introduction

1. The High Radiation Area lesson plan familiarizes the participant with requirements for entry, work in, and exit from High Radiation Areas.

2. Radiological Worker Modules 1-7 (core academic material) are a prerequisite for this module. If prerequisite requirements are met, this module may be taught alone.

II. MODULE OUTLINE

A. High and Very High Radiation Area Definitions

1. High Radiation Area

A High Radiation Area is any area, accessible to individuals, in which radiation levels could result in an individual receiving a deep dose equivalent in excess of 0.1 rem (100 mrem), but less than or equal to 500 rad in one hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

2. Very High Radiation Area

A Very High Radiation Area is any area, accessible to individuals, in which radiation levels could result in an individual receiving an absorbed dose in excess of 500 rads in one hour at 1 meter from a radiation source or from any surface that the radiation penetrates.

B. Signs and Postings

1. High Radiation Area

High Radiation Areas will be posted with a standard radiation symbol colored magenta (or black) on a yellow background, reading:

"CAUTION"
or
"DANGER
HIGH RADIATION AREA"

Additionally the posting may state:

"Personnel Dosimeter, Supplemental Dosimeters,
and RWP Required for Entry"

2.Very High Radiation Area

Very High Radiation Areas will be posted with a standard radiation symbol colored magenta (or black) on a yellow background, reading:

"GRAVE DANGER,
VERY HIGH RADIATION AREA"

Additionally the posting may state:

"Special Controls Required for Entry"

Some HRAs and VHRAs only exist when machinery is energized, such as radiation producing devices. For example, a posting could be:

"High Radiation Area When Warning Light is On"
"Controlled Area When Warning Light is Off"

3. Radiation sources

(Insert facility-specific information on radiation sources that can produce High/Very High Radiation Areas and the location of each.)

Table 8-1

High and Very High Radiation Area

Definitions and sources (Objectives EO1 and EO2)

Sign	**Definition**	**Sources**
Insert HRA sign	> 100 mrem in 1 hour This is taken at 30 centimeters from the source of radiation or any surface that the radiation penetrates.	(Insert facility-specific sources and locations.)
Insert VHRA sign	> 500 rad in 1 hour This is taken at 100 centimeters from the source of radiation, or any surface that the radiation penetrates.	(Insert facility-specific sources and locations.)

C. Entry, Work In, and Exit from High Radiation Areas

1. Minimum requirements for entering HRAs

a. Appropriate training (e.g., Radiological Worker I Training plus High Radiation Area Training or Radiological Worker II Training).

b. Worker signature on the appropriate Radiological Work Permit (RWP).

c. Personnel and supplemental dosimeter.

d. Survey meter(s) or dose rate indicating device available at the work area (may be required for certain jobs).

e. Access control.

f. A radiation survey prior to first entry.

g. Notification of operations personnel.

h. Additional requirements where dose rates are greater than 1 rem in an hour. These should include:

1) Determination of worker's current dose.

2) Pre-job briefing, as applicable.

3) Review and determination by the RCO regarding the level of RC technician coverage.

4) Access Points secured by control devices (required by 10 CFR 835).

i. Additional measures to ensure personnel are not able to gain unauthorized or inadvertent access to Very High Radiation Areas.

j. (Insert facility-specific information.)

2. Minimum requirements for working in HRAs

a. Don't loiter.

b. Practice ALARA.

c. (Insert facility-specific information.)

3. Minimum requirements for exiting HRAs

   No controls shall be established in a Radiological Area that would prevent rapid evacuation of personnel.

   a. Sign out on RWP, as applicable.

   b. (Insert facility-specific information.)

D. Access Controls for High and Very High Radiation Areas

There are different controls that are used to prevent the inadvertent entry or unauthorized access into Radiological Areas. The following identifies administrative and physical controls that are used for HRAs.

1. Administrative controls

   The following are administrative controls that may be used to control access to HRAs. These are used in addition to physical controls.

   a. Formal radiological reviews.

   b. RWPs.

   c. Pre-job briefings.

   d. Procedures.

   e. Postings.

   f. Administrative control levels (ACLs).

   g. (Insert facility-specific information.)

2. Physical controls

   One or more of the following features should be used for each entrance or access point to an HRA and shall be used for HRAs >1 rem in any one hour.

   It should be noted again that no controls shall be established in an HRA or VHRA that would prevent rapid evacuation of personnel.

   a. A control device that prevents entry or upon entry causes the radiation level to be reduced below that level defining an HRA.

   b. An automatic device that prevents use or operation of the radiation source.

   c. A control device that energizes a visible or audible alarm.

   d. Entryways that are locked. Maintain positive control over each entry.

   e. Continuous direct or electronic surveillance.

f. (Insert facility-specific information.)

3. Consequences of violating radiological signs or postings, or bypassing physical access controls:

   a. Equipment damage.

   b. Personnel injury.

   c. Excessive and unplanned personnel exposure.

   d. Disciplinary action.

Access to VHRAs

Due to the extremely high dose rates in a VHRA, personnel access to these areas needs to be strictly monitored and controlled. Additional training would be required, as well as enhanced monitoring.

III. SUMMARY

(Insert facility-specific information.)

IV. EVALUATION

(Insert facility-specific information.)

Module 9: Radioactive Contamination Control

Prerequisites: Core Academics - (Modules 1-7)

Terminal Objective:

Given different types of radioactive contamination, identify the methods used to control the spread of radioactive contamination in accordance with lesson material.

Enabling Objectives:

The participant will be able to select the correct response from a group of responses to verify his/her ability to:

EO1 Define fixed, removable, and airborne contamination.
EO2 State sources of radioactive contamination.
EO3 State the appropriate response to a spill of radioactive material.
EO4 Identify methods used to control radioactive contamination.
EO5 Identify the proper use of protective clothing.
EO6 Identify the purpose and use of personnel contamination monitors.
EO7 Identify the normal methods used for decontamination.
EO8 Define "Contamination," "High Contamination," and "Airborne Radioactivity Areas."
EO9 Identify the minimum requirements for entering, working in, and exiting Contamination, High Contamination, and Airborne Radioactivity Areas.

Instructional Aids:

1. Student Guide
2. Transparencies
3. Activities (as applicable)
4. Self-check quizzes (as applicable)

I. MODULE INTRODUCTION

A. Self Introduction

1. Name

2. Phone Number

3. Background

B. Module Overview

This module is designed to inform the worker about radioactive contamination and discuss methods used to control the spread of contamination.

C. Objectives Review

D. Introduction

Contamination control is one of the important aspects of radiological protection. Using proper contamination control practices helps to ensure a safe working environment. It is important for all employees to recognize potential sources of contamination and to use appropriate contamination control methods.

II. MODULE OUTLINE

A. Comparison of Ionizing Radiation and Radioactive Contamination

1. Ionizing radiation

Energy (particles or rays) emitted from radioactive atoms or generated from machines such as X-ray machines that can cause ionization (e.g., gamma rays, X rays, beta particles, and other particles capable of ionizing atoms).

2. Radioactive contamination

Radioactive material is material that contains radioactive atoms. When radioactive material is properly contained, it still emits radiation and may be an external dose hazard, but it is not a contamination hazard. When radioactive material escapes its container, it is then referred to as radioactive contamination.

3. Radiation is energy; contamination is a material.

B. Types of Contamination

Radioactive contamination can be fixed, removable, or airborne.

1. Fixed contamination is contamination that cannot be easily removed from surfaces.

a. It cannot be removed by casual contact.

b. It may be released when the surface is disturbed (buffing, grinding, using volatile liquids for cleaning, etc.).
c. Over time it may “weep,” leach, or otherwise become loose or removable.

2. Removable contamination is contamination that can easily be removed from surfaces. Any object that comes in contact with it may become contaminated.

   a. It may be transferred by casual contact, wiping, brushing, or washing.

   b. Air movement across removable contamination could cause the contamination to become airborne.

3. Airborne contamination is contamination suspended in air.

Table 9-1
Types of Radioactive Contamination

Types	Definitions (Objective EO1)
Fixed Contamination	Cannot be removed by casual contact. It may be released when the surface is disturbed (buffing, grinding, using volatile liquids for cleaning, etc.). Over time, may become loose or removable.
Removable Contamination	May be transferred by casual contact. Any object that makes contact with it may in turn become contaminated. Air movement across removable contamination may cause the contamination to become airborne.
Airborne Contamination	Airborne contamination is contamination suspended in the air.

C. Radioactive Contamination

Radiological work is required in areas and in systems that are contaminated by design (e.g., maintenance of valves in radioactive fluid systems).

Regardless of the precautions taken, radioactive material will sometimes contaminate objects, areas, and people.

1. Sources

   The following are some sources of radioactive contamination.

   a. Leaks or breaks in radioactive fluid systems.

   b. Leaks or breaks in air-handling systems for radioactive areas.

   c. Airborne contamination depositing on surfaces.

d. Leaks or tears in radioactive material containers such as barrels, plastic bags or boxes.

e. Another common cause of contamination is sloppy work practices. These may lead to contamination of tools, equipment, and workers. Examples include:

   1) Opening radioactive systems without proper controls.

   2) Poor housekeeping in contaminated areas.

   3) Excessive motion or movement in areas of higher contamination.

   4) Improper usage of step-off pads and change areas.

   5) Violation of contamination control ropes and boundaries.

f. Hot particles: Small, sometimes microscopic pieces of highly radioactive material may escape containment. These pieces are known as "hot particles."

   1) Hot particles may be present when contaminated systems leak or are opened. These particles may also be present when machining, cutting, or grinding is performed on highly radioactive materials.

   2) Hot particles can cause a high, localized radiation dose in a short period of time if they remain in contact with skin.

2. Indicators of possible contamination:

Radiological workers should be aware of potential radioactive contamination problems. Potential contamination problems should be reported to the Radiological Controls Organization. Examples include:

a. Leaks, spills, or standing water that is possibly from a radioactive fluid system.

b. Damaged or leaking radioactive material containers.

c. Open radioactive systems with no observable controls.

d. Dust/dirt accumulations in radioactive contamination areas.

e. Torn or damaged tents and glove bags or containments on radioactive systems.

3. Radiological worker response to a spill of radioactive material

Each of the examples listed above may be a spill of radioactive material. Here is the minimum response to a spill of radioactive material:

a. Stop or secure the operation causing the spill, if qualified.

b. Warn others in the area.

c. Isolate the area.

d. Minimize exposure to radiation and contamination.

e. Secure unfiltered ventilation.

f. Notify Radiological Control personnel.

D. Contamination Control Methods

Every radiological worker should perform work in such a manner as to minimize the generation of radioactive contamination and confine the spread of radioactive contamination to the smallest area possible. By controlling contamination, the worker minimizes the potential for internal exposure, and personnel contamination can be minimized. Examples of methods used to control the spread of radioactive contamination follow:

1. Prevention

A sound maintenance program can prevent many radioactive material releases.

a. Establish a solid routine maintenance program for operating systems to minimize failures and leaks that lead to contamination.

b. Repair leaks as soon as identified to prevent a more serious problem.

c. Establish adequate work controls before starting jobs.

d. During pre-job briefings, discuss measures that will help reduce or prevent contamination spread. The agreed upon measures should be implemented by workers at the job site.

e. Change protective gear (e.g., gloves) as necessary (typically as directed by Radiological Control personnel) to prevent cross-contamination.

f. Stage areas to prevent contamination spread from work activities.

1) Cover work area to minimize cleanup afterward.

2) Cover piping/equipment below a work area to prevent dripping contamination onto cleaner areas.

3) Cap contaminated pipes or systems when not in use.

g. Prepare tools and equipment to prevent contamination.

1) Bag or sleeve hoses and lines to prevent contamination.

2) Minimize the equipment and tools taken into and out of contamination areas.

3) Cover/tape tools or equipment used during the job to minimize decontamination after the job (i.e., taping up a screwdriver before use).

h. Use good housekeeping practices; clean up during and after jobs.

"Good Housekeeping" is a prime factor in an effective contamination control program. Each radiological worker should keep his/her work area neat and clean to control the spread of contamination.

i. Use standard contamination control procedures as established by the Radiological Control Organization.

   1) Do not violate contamination area ropes or barricades.

   2) Frisk materials out of contamination areas as directed by site procedures.

   3) Use change areas and step-off pads as directed.

   4) Do not pass items out of contamination areas without following site procedures.

   5) Be alert for potential violations to contamination control procedures.

j. Ensure ventilation systems are operating as designed (i.e., no unauthorized modifications).

k. Radiological workers should always ensure that the proper entry, exit, and equipment control procedures are used to avoid the spread of contamination. Comply with procedures!!

2. Engineering controls

   a. Ventilation

      1) Systems and temporary spot ventilation (e.g., temporary enclosures with HEPA filters) are designed to maintain airflow from areas of least contamination to areas of most contamination (e.g., clean to contaminated to highly contaminated areas).

      2) A slight negative pressure is maintained on buildings/rooms/enclosures where potential contamination exists.

      3) High efficiency particulate air (HEPA) filters are used to remove radioactive particles from the air.

   b. Containment

   Permanent and temporary containments are used for contamination control. Examples include vessels, pipes, cells, glovebags, gloveboxes, tents, huts, and plastic coverings.

3. Personal Protective Measures

   Sometimes engineering controls cannot eliminate contamination. Personnel protective measures, such as protective clothing and respiratory equipment, will be used at this point.

   a. Protective clothing

      1) Protective clothing is required for entering areas containing contamination and airborne radioactivity levels above specified limits to prevent personnel contamination.

      2) The amount and type of protective clothing required is dependent on work area radiological conditions and nature of the job.

3) Personal effects such as watches, rings, jewelry, etc., should not be worn.

4) Full protective clothing generally consists of:

a) Coveralls.

b) Cotton liners.

c) Rubber gloves.

d) Shoe covers.

e) Rubber overshoes.

f) Hood.

NOTE: Cotton glove liners may be worn inside rubber gloves for comfort, but should not be worn alone or considered as a layer of protection against contamination.

5) Proper use of protective clothing

a) Inspect protective clothing for rips, tears, or holes prior to use. If you find damaged protective clothing, discard properly.

b) Supplemental and multiple dosimeters should be worn as prescribed by the Radiological Control Organization.

c) After donning protective clothing, proceed directly from the dress-out area to the work area.

d) Avoid getting coveralls wet. Wet coveralls provide a means for contamination to reach the skin/clothing.

e) Contact Radiological Control personnel if clothing becomes ripped, wet, or otherwise compromised.

b. Respiratory protection equipment

This is used to prevent the inhalation of radioactive materials. This training course DOES NOT qualify a worker to wear respiratory protection equipment.

E. Contamination Monitoring Equipment

1. Purpose

Contamination monitoring equipment is used to detect radioactive contamination on personnel and equipment.

2. Types and uses

Hand Held Contamination Monitor:

a. Verify instrument is in service, set to proper scale, and has functioning audio equipment.

b. Note background count rate at frisking station.

c. Frisk hands before picking up the probe.

d. Hold probe approximately ½ inch from surface being surveyed for beta/gamma and ¼ inch for alpha.

e. Move probe slowly over surface, approximately 2 inches per second.

f. Perform frisk as follows:

   1) Head (pause at mouth and nose for approximately 5 seconds).

   2) Neck and shoulders.

   3) Arms (pause at each elbow).

   4) Chest and abdomen.

   5) Back, hips, and seat of pants.

   6) Legs (pause at each knee).

   7) Shoe tops.

   8) Shoe bottoms (pause at sole and heel).

   9) Personnel and supplemental dosimetry.

g. The whole body survey should take at least 2-3 minutes.

h. Carefully return the probe to holder. The probe should be placed on the side or face up to allow the next person to monitor.

i. If the count rate increases during frisking, pause for 5-10 seconds over the area to provide adequate time for instrument response.

j. Take appropriate action if contamination is indicated:

   1) Remain in the area.

   2) Notify Radiological Control personnel.

   3) Minimize cross-contamination (e.g., put a glove on a contaminated hand).

F. Decontamination

Decontamination is the removal of radioactive materials from locations where it is not wanted. If removable contamination is discovered, decontamination is the normal means of control.

1. Personnel decontamination

a) Normally accomplished using mild soap and lukewarm water per radiological control organization instructions.

b) More aggressive decontamination techniques are performed under the guidance of the Radiological Controls Organization.

2. Equipment and area decontamination

Equipment and area decontamination is the removal of radioactive materials from tools, equipment, floors, and other surfaces in the work area.

NOTE: In some situations, decontamination is not possible.

a. Economic considerations: Cost of time and labor to decontaminate the location may outweigh the hazards of the contamination present.

b. Radiological conditions: Radiation dose rates or other radiological conditions may present hazards which exceed the benefits of decontamination. The decontamination activity may not be ALARA, in that it costs, rather than saves personnel dose.

c. Hazardous conditions: The physical or chemical conditions in the area may prevent entry for decontamination purposes.

G. Types of Contamination Areas

1. Definitions and posting requirements

a. Contamination Area

A Contamination Area is an area where removable contamination levels are, or are likely to be, greater than the limits specified in 10 CFR 835 Appendix D, but do not exceed 100 times these levels. Posting requirements include:

"CAUTION, CONTAMINATION AREA"

b. High Contamination Area

A High Contamination Area is an area where contamination levels are, or are likely to be, greater than 100 times the Contamination Area limits. Posting requirements include:

"DANGER or CAUTION, HIGH CONTAMINATION AREA"

Additionally, the posting may state:

"RWP REQUIRED FOR ENTRY"

c. Airborne Radioactivity Area

An Airborne Radioactivity Area is an area where airborne radioactivity exceeds specified limits. Posting requirements include:

"CAUTION OR DANGER, AIRBORNE RADIOACTIVITY AREA"

additionally the posting may state:

"RWP REQUIRED FOR ENTRY"

2. Minimum requirements for entering Contamination, High Contamination, and Airborne Radioactivity Areas without an escort.

   a. Appropriate training, such as Radiological Worker II training.

   b. Personnel dosimetry, as appropriate.

   c. Protective clothing and respiratory protection as specified in the RWP.

   d. Worker's signature on the RWP, as applicable.

   e. Pre-job briefings, as applicable.

   f. (Insert facility-specific information.)

3. Minimum requirements for working in Contamination, High Contamination, and Airborne Radioactivity Areas.

   a. Avoid unnecessary contact with contaminated surfaces.

   b. Secure equipment (lines, hoses, cables, etc.,) to prevent them from crossing in and out of contamination areas.

   c. When possible, wrap or sleeve materials, equipment, and hoses.

   d. Place contaminated materials in appropriate containers when finished.

   e. Do not touch exposed skin surfaces. High levels of skin contamination can cause a significant skin dose. It may also lead to internal contamination with radioactive material.

   f. Avoid stirring contamination as it could become airborne.

   g. Do not smoke, eat, drink, or chew. Do not put anything in your mouth.

   h. Exit immediately if a wound occurs or if your protective clothing is compromised (e.g., becomes wet, torn, or otherwise compromised.)

   i. (Insert facility-specific information.)

4. Minimum requirement for exiting Contamination, High Contamination, and Airborne Radioactivity Areas.

    a. Exit only at step-off pad.

    b. Remove protective clothing carefully. Follow posted instructions.

    c. Frisk or be frisked for contamination when exiting a contaminated area. If personal contamination is found, stay in the area, notify the Radiological Control Technician, and minimize the potential for cross contamination.

    d. Survey all tools and equipment prior to removal from the area.

    e. Observe RWP and control point guidelines.

    f. Use proper techniques to remove protective clothing.

    g. Do not smoke, eat, drink, or chew.

    h. Do not put anything in your mouth.

    i. When exiting, perform a whole-body frisk at the location provided by the Radiological Control Organization. If personal contamination is found, stay in the area, notify the Radiological Control Technician, and minimize the potential for cross-contamination (e.g., place a glove over a contaminated hand).

H. Lessons Learned

(Insert facility-specific information.)

III. SUMMARY

(Insert facility-specific information.)

IV. EVALUATION

(Insert facility-specific information.)

Module 10.1: Practical Factors for Radiological Worker I

Prerequisites: Successful completion of a written examination based on modules 1-7 must be accomplished prior to the evaluation of the practical factors.

NOTE: This module may be taught prior to the written examination, but the student should not be evaluated until he/she successfully completes the written examination.

Terminal Objective:

Given an RWP, a simulated radiological area, and the necessary materials and tools, the student will enter, work in, and exit the area using ALARA techniques in accordance with Radiological Control procedures.

Enabling Objectives:

Given an RWP, a simulated radiological area, and applicable materials, the student will:

EO1 Identify and comply with RWP requirements.
EO2 Record appropriate information on the RWP.
EO3 Select and wear dosimeter(s) as per RWP.
EO4 Enter a simulated area and perform a specified task/job using ALARA techniques.
EO5 Respond to abnormal radiological conditions and alarms.
EO6 Monitor for personnel contamination in accordance with posted instructions.

Instructional Aids:

1. Student Guide
2. Attachments to Module 10.3 (Instructor use only)
   - Attachment 1 - Instructions for Evaluators
   - Attachment 2 - Sample Grading Checklist
   - Attachment 3 - Sample Job Scenario
   - Attachment 4 - Sample Survey Map
   - Attachment 5 - Sample Questions

I. MODULE INTRODUCTION

A. Self Introduction

1. Name

2. Background

B. Module Overview

1. Demonstration/activities

The practical factors module consists of various activities/demonstrations that are led by the instructor, but participation by the entire class is encouraged. These activities are provided as a practice session for the student before he/she is evaluated.

This module will:

a. Provide the radiological worker with "hands-on" training.

b. Apply the basic knowledge and skills obtained from the theory portions of Radiological Worker Training that are required to enter and exit Radiological Buffer Areas and Radiation Areas at the site.

c. Review good radiological work practices.

d. Review lessons learned (when applicable) from on-site and off-site occurrences.

2. Evaluation

Upon completion of the "hands on" training, each student shall demonstrate the ability to enter, work in, and exit a simulated Radiological Buffer Area/Radiation Area following facility-specific guidelines. The scope of the practical evaluation shall cover the minimum requirements as set out in references 1, 2, and 3.

C. Objectives Review

1. Terminal objective

2. Enabling objectives

D. Introduction

Prior knowledge of radiological conditions can reduce the potential for personnel radiation dose. Using proper radiological techniques and information provided by Radiological Control personnel will help ensure a safe working environment for all employees.

II. MODULE OUTLINE

This module allows each student to practice identifying requirements for entering, working in, and exiting a simulated Radiological Buffer Area and Radiation Area using ALARA techniques. The instructor should correct errors or answer student questions.

A. Review an Appropriate Radiological Work Permit (RWP)

Each worker must review an RWP to identify the specific requirements and special instructions for the job.

- Suggest: Using a facility-specific RWP and, if applicable, a survey map, conduct a pre-job brief. Have students review the RWP and survey map and answer questions regarding each.
- Suggest: Conduct small group activity where one group can give the brief to the rest of the class or provide a questionnaire and have groups complete.
- Incorporate lessons learned occurrences, if applicable. (Demonstrate or discuss occurrence.)

B. Record the Appropriate Information on the RWP

After reviewing the RWP and identifying the applicable requirements, workers must record the appropriate information.

- Suggest: Using a facility-specific RWP, have students practice completing appropriate information on RWP sign-in sheet.
- Incorporate lessons learned occurrences, if applicable. (Demonstrate or discuss occurrence.)

C. Select and Wear Required Dosimeter(s)

Radiological Control personnel identify the dosimeter requirements necessary for entry on the RWP. Supplemental pocket dosimeters should be worn near the primary dosimeter.

- Suggest: Using a facility-specific RWP, have students select dosimeter(s) per RWP and properly wear the device.
- Incorporate lessons learned occurrences, if applicable. (Demonstrate or discuss occurrences.)

D. Enter Simulated Area and Demonstrate ALARA Techniques

- Suggest: From this point on, the instructor should demonstrate entering, performing tasks ,and exiting simulated area using the techniques listed in the lesson plan. This demonstration should cover sections D and E of this lesson plan. After instructor has completed demonstration, if practical, have student do the same.
- Incorporate lessons learned occurrences, if applicable (Demonstrate or discuss occurrences).

Once the worker has donned the dosimeter(s) and recorded the appropriate information on the RWP sign in sheet, he/she should proceed directly to the work area. At a minimum, the following ALARA techniques should be used.

1. Take only the necessary tools and equipment into a Radiological Buffer Area or a Radiation Area.

2. Read and comply with all posted instructions.

3. Perform work safely and efficiently.

4. Use time, distance, and shielding.

   a. When possible, maximize distance from higher levels of radiation.

   b. When possible, stay in areas that have lower levels of radiation.

   c. Do not loiter in the Radiation Area or Radiological Buffer Area.

5. Use good housekeeping techniques.

6. Advise Radiological Control personnel of any unusual conditions or situations that may alter the status of the job or the work area.

   · Suggestion: During demonstration, pre-stage abnormal situations and discuss appropriate response.

   · Abnormal situations or conditions may include off-scale dosimeter, spill of water, shielding that has slipped, posting that is different from pre-job brief information, etc.

7. Take appropriate actions to radiological alarms. Be familiar with location of area monitors.

8. Personnel and equipment must be monitored.

E. Monitor for Contamination

Immediately upon exiting an RBA that contains a Contamination, High Contamination Area, or Airborne Radioactivity Area, you are required to monitor for contamination.

· Suggest: Using facility-specific posted instructions and contamination control techniques, monitor for contamination. If practical, have students do the same.

· Incorporate lessons learned occurrences, if applicable (demonstrate or discuss occurrences).

III. SUMMARY

The practical factor exercise provided an opportunity for each student to practice the skills required to safely perform work within a simulated radiological area.

IV. EVALUATION

A. Review Evaluation Rules/Process

Each facility must develop a practical factors evaluation. Incorporating the requirements of the DOE Radiological Control Standard is recommended, and facility-specific procedures should also be included (guidance for conducting a practical factors evaluation is contained in Attachment 1).

1. Review areas to be evaluated

   Students should be evaluated based on:

   a. Pre-job preparation

      1) Wearing of dosimeter(s).

      2) Compliance with RWP, work documents.

      3) Compliance with facility-specific entry procedures.

   b. Job or task performance

      1) Minimization of dose.

      2) Compliance with facility-specific procedures and RWP requirements.

      3) Response to abnormal situation(s) – alarm/condition.

   c. Exiting simulated area

      1) Compliance with facility-specific procedures.

      2) Self-monitoring technique.

2. Explain acceptable role-playing during evaluation

   a. Student responsibilities

      Students are expected to conduct themselves as though the evaluation was in an actual radiological area (e.g., chewing gum is not permitted).

   b. Instructor interface/responsibilities

      Evaluators have two main roles during the evaluation:

      1) The primary role is to evaluate whether student performs the entire scenario in accordance with pre-established criteria.

2) The secondary role is to role-play as Radiological Control specialist, supervisor, co-worker, etc., to relay information that is necessary for the role-playing evaluation.

B. Review Pass/Fail Criteria

(Guidance for establishing scoring criteria is contained in Attachment 1.)

C. Provide Students With Necessary Documentation/ Materials for Evaluation

Once the facility-specific pass/fail criteria has been reviewed, provide the following materials at a minimum for the evaluation:

1. RWP.

2. Work procedure or task assignment (scenario). (Attachment 2 is an example.)

3. Survey map of area (optional). (Attachment 4 is an example.)

4. Dosimeter(s).

5. Any other applicable item(s).

Module 10.2: Practical Factors for High Radiation Areas

Prerequisites: The instructional material of this module may be presented prior to the written examination; however, participants must pass a written examination based on the High Radiation Areas module before being evaluated in accordance with the guidelines of this module.

Terminal Objective:

Given an RWP, a simulated High Radiation Area and the necessary materials and tools, the student will enter, work in, and exit the area using ALARA techniques in accordance with Radiological Control procedures.

Enabling Objectives:

Given an RWP, a simulated radiological area, and applicable materials, the student will:

EO1 Identify and comply with RWP requirements.
EO2 Record appropriate information on the RWP.
EO3 Select and wear appropriate dosimeter(s) as per RWP.
EO4 Enter a simulated High Radiation Area and perform a specified task/job using ALARA techniques.
EO5 Respond to abnormal radiological conditions and alarms.
EO6 Demonstrate proper exit from a simulated High Radiation Area.

Instructional Aids:

1. Student Guide
2. Attachments to Module 10.3 (Instructor use only)
   - Attachment 1 - Instructions for Evaluators
   - Attachment 2 - Sample Grading Checklist
   - Attachment 3 - Sample Job Scenario
   - Attachment 4 - Sample Survey Map
   - Attachment 5 - Sample Questions

I. MODULE INTRODUCTION

A. Self Introduction

1. Name

2. Phone Number

3. Background

B. Module Overview

1. Demonstration/activities

The practical factors module consists of various activities/demonstrations that are led by the instructor, but participation by the entire class is encouraged. These activities are provided as a practice session for the participant before he/she is evaluated.

This module will:

a. Provide the Radiological Worker with "hands-on" training.

b. Apply the knowledge obtained from the theory portions of High Radiation Area training.

c. Review good radiological work practices for dose control.

d. Review lessons learned (as applicable) from on-site and off-site occurrences.

2. Evaluation

Upon completion of the presentation, each participant shall demonstrate the ability to enter, work in, and exit a simulated High Radiation Area following facility-specific guidelines. The scope of the practical evaluation shall cover the minimum requirements as set out in references 1, 2, and 3.

C. Objectives Review

D. Introduction

Prior knowledge of radiological conditions can reduce unnecessary personnel exposure. Using proper radiological techniques and information provided by Radiological Control personnel will help ensure a safe working environment for all employees.

Each site shall develop a practical factors evaluation for High Radiation Radiation Areas (as applicable). The site may choose to incorporate the High Radiation Area practical factor into the Radiological Worker I practical factors, or develop a separate practical factors lesson for High Radiation Areas.

II. MODULE OUTLINE

Entry, Work, and Exit Requirements

The instructor should evaluate student knowledge of requirements. Suggested items to be evaluated follow:

A. Identify High Radiation Area signs.

B. State special controls on RWP.

C. State area radiation levels (with appropriate units).

D. State facility-specific administrative control levels.

E. Select dosimetry in accordance with RWP.

F. Wear dosimetry in accordance with procedures.

G. Perform pre-operational checks (as appropriate) on survey meter and/or dose rate indicating device.

H. Record appropriate information on RWP prior to entry.

I. Verify current radiation survey prior to first entry.

J. Enter only areas designated on RWP.

K. Maximize distance from higher radiation areas.

L. Do not loiter.

M. State appropriate actions to take when a radiation area monitor alarms.

N. Record appropriate information on RWP upon exit.

III. SUMMARY

The practical factor exercise provided an opportunity for each student to practice the skills required to safely perform work within a simulated High Radiation Area.

IV. EVALUATION

A. Review Evaluation Rules/Process

Each facility must develop a practical factors evaluation. Incorporating the requirements of the DOE Radiological Control Technical Standard and facility-specific procedures is recommended (guidance for conducting a practical factors evaluation is contained in Attachment 1).

1. Review the skills to be evaluated for each student:

   a. Pre-job preparation

      1) Donning of dosimeter(s).

      2) Compliance with RWP, work documents.

      3) Compliance with facility-specific entry procedures.

   b. Job or task performance

      1) Minimization of dose.

      2) Compliance with facility-specific procedures and RWP requirements.

      3) Response to abnormal situation(s) – alarm/condition.

   c. Exiting simulated area

      1) Compliance with facility-specific procedures.

      2) Self-monitoring technique.

2. Explain acceptable role-playing during evaluation

   a. Student responsibilities

      Students are expected to conduct themselves as though the evaluation was in an actual radiological area (e.g., chewing gum is not permitted).

B. Review Pass/Fail Criteria

(Guidance for establishing scoring criteria is contained in Attachment 1.)

C. Provide Students With Necessary Documentation/ Materials for Evaluation

Once the facility-specific pass/fail criteria has been reviewed, provide the following materials at a minimum for the evaluation:

1) RWP.

2) Work procedure or task assignment (scenario). (Attachment 2 is an example.)

3) Survey map of area (optional). (Attachment 4 is an example.)

4) Dosimeter(s).

5) Any other applicable item(s).

Module 10.3: Practical Factors for Radiological Worker II

Prerequisites: The instructional material of this module may be presented prior to the written examination; however, students must pass a written examination based on the modules 1-9 before being evaluated in accordance with the guidelines of this lesson.

Terminal Objective:

Given an RWP, a simulated radiological area and the necessary materials and tools, the student will enter, work in, and exit the area using contamination control and ALARA techniques in accordance with Radiological Control procedures.

Enabling Objectives:

Given an RWP, a simulated radiological area, and applicable materials, the student will:

EO1 Identify and comply with RWP requirements.
EO2 Record appropriate information on the RWP.
EO3 Select and don protective clothing and dosimeter(s) as per RWP.
EO4 Enter a simulated area and perform a specific task using contamination control and ALARA techniques.
EO5 Respond to abnormal radiological conditions and alarms.
EO6 Remove protective clothing and dosimeter(s) in accordance with facility-specific instructions.
EO7 Monitor for personnel contamination in accordance with facility-specific instructions.

Instructional Aids:

1. Student Guide
2. Attachments (Instructor use only)
    - Attachment 1 - Instructions for Evaluators
    - Attachment 2 - Sample Grading Checklist
    - Attachment 3 - Sample Job Scenario
    - Attachment 4 - Sample Survey Map
    - Attachment 5 - Sample Questions

I. MODULE INTRODUCTION

A. Self Introduction

1. Name

2. Phone Number

3. Background

B. Module Overview

1. Demonstration/activities

The practical factors unit consists of various activities/demonstrations that are led by the instructor, but participation by the entire class is encouraged. These activities are provided as a practice session for the student before he/she is evaluated.

This module WILL:

a. Provide the radiological worker with "hands-on" training.

b. Apply the basic knowledge and skills obtained from the theory portions of Radiological Worker Training that are required to enter and exit radiological areas at the site.

c. Review good radiological work practices for contamination control and dose control.

d. Review lessons learned (when applicable) from on-site and off-site occurrences.

2. Evaluation

Upon completion of the "hands on" training, each student shall demonstrate the ability to enter, work in, and exit a simulated radiological area following facility-specific guidelines. The scope of the practical evaluation shall cover the minimum requirements as set out in references 1, 2, and 3.

C. Introduce Objectives

1. Terminal objective.

2. Enabling objectives.

D. Introduction

Prior knowledge of radiological conditions and proper use of protective clothing can reduce the potential for personnel radiation dose and contamination. Using proper radiological techniques and information provided by Radiological Control personnel will help ensure a safe working environment for all employees.

II. MODULE OUTLINE

This module allows each student to practice identifying work requirements for entering, working in, and exiting a simulated radiological area using contamination control and ALARA techniques. The instructor should correct errors or answer student questions.

A. Review an appropriate Radiological Work Permit (RWP)
Each worker must review an RWP to identify the specific requirements and special instructions for the job.

- Suggest: Using a facility-specific RWP and, if applicable, a survey map, conduct a pre-job brief. Have students review the RWP and survey map and answer questions regarding each.

- Suggest: 1) Conduct small group activity where one group can give the brief to the rest of the class. 2) Provide a questionnaire and have groups complete it.

- Incorporate lessons learned occurrences. (Demonstrate or discuss occurrence.)

B. Record the Appropriate Information on the RWP sign in sheet

After reviewing the RWP and identifying the applicable requirements, workers must record the appropriate information.

- Suggest: Using a facility-specific RWP, have students practice completing appropriate information on RWP sign in sheet.

- Incorporate lessons learned occurrences. (Demonstrate or discuss occurrence.)

C. Select Required Dosimeter(s) and Protective Clothing

- Suggest: Using a facility-specific RWP, have students select dosimeter(s) and protective clothing as per RWP.

- Incorporate lessons learned occurrences. (Demonstrate or discuss occurrences.)

1. Dosimetry requirements

   Radiological Control personnel identify the dosimeter requirements necessary for entry on the RWP.

   a. Supplemental pocket dosimeters should be worn outside the protective clothing, accessible to the worker.

   b. Workers should protect dosimeter from contamination by placing in a coverall pocket or in plastic bags or pouches.

2. Protective clothing

   Protective clothing is provided for all employees who enter contamination areas.

   a. Effective use of protective clothing will minimize skin and personal contamination.

b. The required clothing will be identified on the RWP.

D. Don Protective Clothing and Dosimeter(s)

Once the radiological worker has obtained appropriate items, he/she must properly don the protective clothing. Workers should inspect protective clothing prior to use for tears, holes, or split seams that would diminish protection. Any defective items should be replaced with intact protective clothing.

- Suggest: Using facility-specific posted instructions, the instructor should don the protective clothing. If practical have students do the same.
- Incorporate lessons learned and occurrences, if applicable. (Demonstrate or discuss occurrences.)

E. Enter Simulated Area and Demonstrate Contamination Control and ALARA Techniques

Once the worker has donned protective clothing and recorded the appropriate information on the RWP, he/she should proceed directly to the work area. At a minimum, the following contamination control and ALARA techniques should be used.

- Suggest: The instructor should demonstrate entering, performing tasks, and exiting simulated area using the techniques listed in the lesson plan. This demonstration should cover sections E through G of this lesson plan. After instructor has completed demonstration, if practical, have student do the same.
- Incorporate lessons learned occurrences. (Demonstrate or discuss occurrences.)

1. Take only the necessary tools and equipment into a Radiological Buffer Area or a Contamination Area.
2. Read and comply with all posted instructions.
3. While in a radiological area, do not touch any uncovered portions of the body.
4. Perform work safely and efficiently.
5. Use time, distance, and shielding.
    a. When possible, maximize distance from higher radiation areas.
    b. When possible, stay in areas that have lower contamination levels.
    c. Do not loiter in the area.
    d. Avoid hot spots.
6. Change outer gloves when instructed by Radiological Control personnel, or periodically while working with contaminated or highly contaminated equipment.
7. Use good housekeeping techniques.

8. Advise Radiological Control personnel of any unusual conditions or situations that may alter the status of the job or the work area.

    - Suggest: During demonstration, pre-stage abnormal situations, and discuss appropriate response.

    - Unusual situations or conditions may include off-scale dosimeter, spill of water, shielding that has slipped, posting that is different from pre-job brief information, etc.

9. Take appropriate actions to radiological alarms. Be familiar with location of area monitors.

10. Personnel and equipment must be monitored.

F. Remove Protective Clothing and Dosimeter(s)

Once the job has been completed, the worker should proceed directly to the step-off pad area and follow facility-specific instructions.

1. General requirements

    a. Protective clothing should be removed without spreading contamination and, in particular, without contaminating the skin.

    b. Workers should be instructed not to touch the skin or place anything in the mouth during protective clothing removal.

    c. Posted instructions for protective clothing removal should be posted adjacent to the step-off pad.

2. Removal process

    - Suggest: Using facility-specific posted instructions, remove protective clothing and dosimeter(s). If practical, have students do the same.

    - Incorporate lessons learned occurrences. (Demonstrate or discuss occurrences.)

G. Monitor for Contamination

Immediately upon exiting Contamination, High Contamination, Airborne Radioactivity Areas or prior to exiting a Radiological Buffer Area that contains these areas, monitoring for contamination is required.

- Suggest: Using facility-specific instructions and contamination control techniques, monitor for contamination. If practical, have students do the same.

- Incorporate lessons learned occurrences. (Demonstrate or discuss occurrences.)

III. SUMMARY

The practical factor exercise provided an opportunity for each student to practice the skills required to safely perform work within a simulated radiological area.

IV. EVALUATION

A. Review Evaluation Rules/Process

Each facility must develop a practical factors evaluation incorporating the requirements of the DOE Radiological Control Standard and facility-specific procedures. (Guidance for conducting a practical factors evaluation is contained in Attachment 1.)

1. Review areas to be evaluated

   Student should be evaluated based on:

   a. Pre-job preparation

      1) Wearing of protective clothing and dosimeter(s).

      2) Compliance with RWP, work documents.

      3) Compliance with facility-specific entry procedures.

   b. Job or task performance

      1) Minimization of dose.

      2) Contamination control practices.

      3) Compliance with facility-specific procedures and RWP requirements.

      4) Response to abnormal situation(s) – alarm/condition.

   c. Exiting simulated area

      1) Undress procedure (techniques and sequence).

      2) Contamination control practices.

      3) Compliance with facility-specific procedures.

      4) Self-monitoring technique.

2. Explain acceptable role-playing during evaluation

      a) Student responsibilities

         Students are expected to conduct themselves as though the evaluation was in an actual radiological area (e.g., chewing gum is not permitted).

b) Instructor interface/responsibilities
Evaluators have two main roles during the evaluation:

1) The primary role is to evaluate whether the student performs the entire scenario in accordance with pre-established criteria.

2) The secondary role is to role-play as Radiological Control specialist, supervisor, co-worker, etc., to relay information important to the conduct of the evaluation.

B. Review Pass/Fail Criteria

(Guidance for establishing scoring criteria is contained in Attachment 1.)

C. Evaluation

Provide students with necessary documentation/materials for evaluation.

Once the facility-specific pass/fail criteria has been reviewed, provide the following materials for the evaluation:

1. RWP.

2. Work procedure or task assignment (scenario). (Attachment 2 is an example.)

3. Survey map of area (optional). (Attachment 4 is an example.)

4. Protective clothing.

5. Dosimeter(s).

6. Any other applicable item(s).

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CONCLUDING MATERIAL

Review Activities:

DOE	Ops Offices	Field Offices
DP	AL	RFSO
EH	CH	OH
EM	ID	GFO
ER	NV	
FM	OR	
LM	RL	
NE	SR	
NS		
PR		
SA		

Area Offices	National Laboratories
Amarillo	BNL
Ashtabula	LANL
Carlsbad	LLNL
Columbus	PNNL
Fernald	Sandia
Kansas City	FNL
Kirtland	
Los Alamos	
Miamisburg	
Pinellas	
West Valley	

Preparing Activity:

DOE EH-52 Peter O'Connell

Project Number:

TRNG-0002

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