U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
*Protecting People and the Environment*

# General Health Physics Practices for Fuel Cycle Facilities

## Directed Self-Study Course

## Administrator Guide

**This self-study guide has been developed as a text and reference document for the Fuel Cycle Processes Course.**

**This self-study guide was compiled by the Oak Ridge Institute for Science and Education under an interagency agreement between the U.S. Department of Energy and the U.S. Nuclear Regulatory Commission, Associate Director for Training and Development, Specialized Technical Training (U.S. NRC Technical Training Center), Office of Human Resources.**

**This self-study guide was developed strictly for the use of NRC personnel for training and subsequent reference. It is not intended for distribution outside of the NRC without the approval of the USNRC Technical Training Center.**

**Any error detected in or any comments concerning the contents of this self-study guide should be forwarded to the address or faxed to the numbers listed below.**


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The **Oak Ridge Institute for Science and Education (ORISE)** is a U.S. Department of Energy institute focusing on scientific initiatives to research health risks from occupational hazards, assess environmental cleanup, respond to radiation medical emergencies, support national security and emergency preparedness, and educate the next generation of scientists. ORISE is managed by Oak Ridge Associated Universities.




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## PREFACE

Health physics is an interdisciplinary science that deals with the safe design and operation of facilities that use radioactive material or radiation generating machines. The principal function of the health physicist is to ensure that employees at the facility and nearby population groups to the facility are protected from exposure to radiation.

In the case of uranium nuclear fuel cycle facilities, health physicists contribute to the design of the equipment, the process, and operation to ensure that contamination is controlled and that personnel exposures to radiation are "As Low As Reasonably Achievable" (ALARA).

Important aspects of health physics are concerned with the:

- Physical measurements of different types of radiation and radioactive materials
- Establishment of quantitative relationships between radiation exposure and biological damage
- Movement of radioactivity through the environment
- Design of radiologically safe equipment, processes, and environments

Because fuel cycle facilities use and refine radioactive materials as their primary function, it is not feasible to eliminate radioactive sources in order to control exposure to personnel and the environment. It is therefore of primary importance to ensure that all fuel cycle facilities have the elements of a sound and comprehensive radiological protection program.

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# INTRODUCTION

## Welcome!

Welcome to the General Health Physics Practices for Fuel Cycle Facilities Directed Self-Study course! The purpose of this course is to provide a basic understanding of health physics activities for uranium fuel cycle facilities.

Upon completion of the course, the trainee will be able to:

- Recognize basic fundamentals of radiation and terms that are common to the health physics and nuclear industries.
- Recognize basic chemical, physical, and radiological properties of uranium and other radioactive materials present at fuel cycle facilities that are associated with the health physics program.
- Describe basic features of an effective contamination control program at fuel cycle facilities.
- Describe the process necessary to conduct bioassays, calculate how intakes of radionuclides are determined based on bioassays, and determine how resulting internal doses to individuals are calculated.
- Discuss the sources of external dose and describe methods to minimize worker exposure.
- Describe the possible radiological effects resulting from accidents at fuel cycle facilities and the appropriate health physics role during an emergency.
- Determine whether the licensee is complying with regulatory requirements related to radiation protection.

## Why Should The Trainee Complete This Course?

The U.S. Nuclear Regulatory Commission (NRC) has made a commitment to ensure safe operations at NRC licensed facilities. The Commission recognizes that NRC personnel share responsibility for safe operations with licensees because they assist licensees in recognizing potential problems and ensuring that effective solutions are implemented on a daily basis.

Faced with ever-reducing budgets and yet an ever-constant need to provide training to NRC personnel, this directed self-study course for general health physics practices for fuel cycle facilities has been developed to provide a basic understanding of health physics terminology and activities at fuel cycle facilities.

## ADMINISTRATOR GUIDE

This course has been designed to allow the trainee to study at their own pace, to self-check their own progress, and to interact with experienced NRC personnel in a positive, nonthreatening, learning environment.  So whether the trainee is new or an experienced employee, this course provides opportunities to explore the discipline of health physics as it relates to uranium fuel cycle facilities.

In addition, this course prepares the trainee for a training exam that, upon request, can be administered by the training coordinator.  After successful completion of the exam, pertinent information is placed in the trainee's training record and a certificate of completion is awarded.

# WHAT IS A DIRECTED SELF-STUDY COURSE?

## What is a Directed Self-Study Course?

A directed self-study course is a specially designed instructional course that allows the trainee, to undertake readings or research on a particular subject area with guidance.

## What are the Advantages of a Directed Self-Study Course?

There are many advantages to a directed self-study course. With today's busy work schedules and tight budgets, it can be difficult to arrange the time and travel to attend classroom training sessions. Self-study is an alternative approach for instruction. It can be administered almost anywhere and at anytime. Some of the other advantages of directed self-study include:

- Can meet the needs of trainees with different entry-level skills, knowledge, or experience.
- Allows the trainee to control the pace and sequence of instruction.
- Provides opportunities for trainees to evaluate the extent to which they meet learning objectives.

## What are the Disadvantages of a Directed Self-Study Course?

There are several disadvantages to a directed self-study course that may need to be overcome. Some disadvantages may include:

- The trainee may lack sufficient motivation and initiative.
- The learning objectives may not be understood by the trainee.
- Research has shown that new trainees may not know enough about the subject to make proper decisions as to how it is best learned.

## How is This Course Designed to be Successful?

To help overcome the disadvantages previously mentioned, the General Health Physics Practices for Fuel Cycle Facilities Directed Self-Study Course is designed to help the trainee explore the subject of health physics in a semi-structured learning environment. This course guide explains the self-study course format, and the trainee's role and responsibilities. It identifies the necessary steps and resources for completing the course modules. Some resources are readily available in the course package; other resources may need to be obtained. For a list of all materials refer to the Materials List in the Trainee Guide or the Administrator Guide.

## ADMINISTRATOR GUIDE

To record course accomplishments, a tracking form is included to allow the trainee to check-off, date, and initial progress. This form is located in the Trainee Guide and in the Administrator Guide.

To help the trainee's motivation and understanding of both the goal of the learning objectives, and the support needed for the self-study course, an administrator(s) is designated by the trainee's supervisor. To enhance contact between the administrator(s) and the trainee, a progress review meeting form is available to plan and focus discussions. This form is located in each individual module.

### What Roles Do a Supervisor and an Administrator Play in This Course?

The trainee's supervisor contacts the training coordinator for the self-study course materials. The supervisor also identifies and arranges for an administrator(s) to meet specific subject-matter needs for the trainee.

**Note:** In some situations, the supervisor may act as the course administrator or designate someone.

The **supervisor** is also the individual who:

- Arranges for the trainee, the administrator(s), and the supervisor to meet in order to initiate course orientation, such as introducing the course materials, presenting roles and responsibilities, and producing logistics for course completion.
- Provides assistance if questions or concerns arise from the trainee or the administrator(s).
- Acknowledges sign-off by the administrator(s), and initials the trainee's completed tracking form.
- Contacts the training coordinator to request the final exam.

An **administrator** is an individual who:

- Provides an orientation to the Trainee Guide and/or modules.
- Recognizes, encourages, and fosters the trainee's potential.
- Provides assistance if questions or concerns arise.
- Provides constructive feedback and candid advice.
- Makes specific assignments for learning and monitors the trainee's progress.

- Initials the trainee’s completed tracking form, and acknowledges the trainee’s success or failure to meet learning objectives.

## When Does a Trainee Interact with an Administrator?

The trainee will interact with an administrator in an initial meeting with their supervisor. This allows all parties involved to collectively decide the best plan for meeting the trainee’s needs during course implementation.

After the initial meeting, the trainee may arrange to meet with the administrator at anytime throughout the study of the course modules.

Upon completion of each course module, the trainee is prompted to prepare a progress review meeting form and to schedule a meeting with the administrator. During this meeting the trainee and the administrator are encouraged to discuss major issues, to exchange questions and answers, and to further explore work activities or documentation that may directly relate to the module subject matter. During this exchange, the administrator may assign further instruction to provide practical application of health physics information to the trainee’s current or future job assignments.

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# COURSE PACKAGE

## Course Package

The General Health Physics Practices for Fuel Cycle Facilities Directed Self-Study Course package consists of the following components:

- One Administrator Guide
- One Trainee Guide
- Seven Modules:
  - 1.0 Health Physics Fundamentals
  - 2.0 Radiological and Chemical Properties of Uranium
  - 3.0 Contamination Control
  - 4.0 Internal Dose Control
  - 5.0 External Dose Control
  - 6.0 Accidents and Emergencies at Fuel Cycle Facilities
  - 7.0 Health Physics Inspection Activities

## Administrator Guide

The Administrator Guide provides a brief introduction to the course, describes the self-study process, and explains what an administrator is and what role and responsibilities he/she has in the success of this self-study course. In addition, it provides guidance on how to successfully interact with the trainee in completing the course materials.

## Trainee Guide

The Trainee Guide provides an introduction to the course, describes the self-study process, and provides guidance for successfully completing this self-study course. In addition, it provides guidance on how to successfully interact with the administrator in completing the course materials.

## Course Modules

The course modules provide learning objectives, instructional text, self-check questions, activities, and a progress review form for a structured approach to self-study learning. There are a total of seven modules in this course. It is recommended that the modules be completed in a sequential order. Refer to the section on Module Format for further explanation regarding module design and content.

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## MATERIALS LIST

The following materials are referenced in this directed self-study course. Questions for an exam will be tied to the course modules. The other materials listed are referenced in the course and will not be on the exam. However, the administrator may suggest that the trainee review them for independent study. **Note:** Some excerpts are available within the individual modules. The trainee will be directed to the course administrator for guidance in obtaining the materials that are not excerpted.

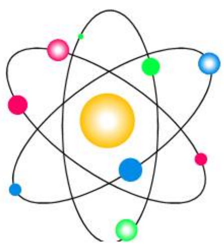
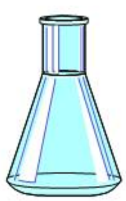
| | | |
|---|---|---|
| **Module 1.0** | **Health Physics Fundamentals** | ◙ Trainee Guide |
| **Module 2.0** | **Radiological and Chemical Properties of Uranium** | ◙ Trainee Guide |
| **Module 3.0** | **Contamination Control** | ◙ Trainee Guide<br>◙ NUREG-1400, *Air Sampling in the Workplace*<br>◙ Regulatory Guide 8.24, *Health Physics Surveys During Enriched Uranium-235 Processing and Fuel Fabrication*<br>◙ Regulatory Guide 8.25, *Air Sampling in the Workplace*<br>◙ Regulatory Guide 8.30, *Health Physics Surveys in Uranium Mills* |
| **Module 4.0** | **Internal Dose Control** | ◙ Trainee Guide<br>◙ 10 CFR 20 Part 20, *Standards for Protection Against Radiation*<br>◙ NUREG/CR-4884, *Interpretation of Bioassay Measurements*<br>◙ Regulatory Guide 8.34, *Monitoring Criteria and Methods to Calculate Occupational Radiation Doses*<br>◙ Regulatory Guide 8.7 Revision 1, *Instructions for Recording and Reporting Occupational Radiation Exposure Data*<br>◙ 10 CFR Part 19.13, *Notifications and Reports to Individuals* |
| **Module 5.0** | **External Dose Control** | ◙ Trainee Guide |

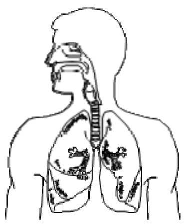
| | | |
|---|---|---|
| **Module 6.0** | **Accidents and Emergencies at Fuel Cycle Facilities** | ◙ Trainee Guide<br>◙ 10 CFR Part 70.24, *Criticality Accident Requirements*<br>◙ Inspection Procedure 88050, *Emergency Preparedness**<br>◙ NRC Management Directive (MD) 10.131, Volume 10, Part 5, *Protection of NRC Employees Against Ionizing Radiation*, Handbook 10.131, Part VI*<br>◙ NUREG-1140, *A Regulatory Analysis on Emergency Preparedness for Fuel Cycle and Other Radioactive Material Licensees*<br>◙ Regulatory Guide 3.42, *Emergency Planning for Fuel Cycle Facilities and Plants Licensed Under 10 CFR Parts 50 and 70*<br>◙ Regulatory Guide 3.67, *Standard Format and Content for Emergency Plans for Fuel Cycle and Materials Facilities*<br>◙ Regulatory Guide 8.31, *Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Mills Will be As Low As Reasonably Achievable*<br>◙ U.S. Nuclear Regulatory Commission Response Technical Manual (RTM-96)*<br>* Excerpts are included in this module. |
| **Module 7.0** | **Health Physics Inspection Activities** | ◙ Trainee Guide<br>◙ 10 CFR Part 19, *Notices, Instructions, and Reports to Workers: Inspection and Investigations**<br>◙ 10 CFR Part 20, *Standards for Protection Against Radiation**<br>◙ 10 CFR Part 40, Appendix A – Criterion 8<br>◙ NRC Form 3, Notice to Employees<br>◙ NRC Information Notice 93-60, Supplement 1: *Reporting Fuel Cycle and Materials Events to the NRC Operations Center**<br>◙ NRC Form 5, Occupational Exposure Record for a Monitoring Period<br>◙ NRC Inspection Procedure 83822, *Radiation Protection**<br>◙ NRC Regulatory Guide 8.10, *Operating Philosophy for Maintaining Occupational Radiation Exposures As Low As Reasonably Achievable*<br>*Excerpts are included in this module. |

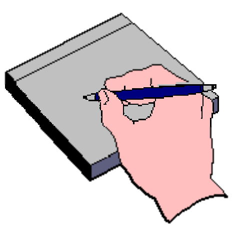
# MODULE CONTENT

## Module Content

There are seven modules in the General Health Physics Practices for Fuel Cycle Facilities Directed Self-Study Course. The following table provides a brief description of each module.

| Module | Description |
|---|---|
| **1.0 Health Physics Fundamentals**  | ◙ Identifies basic particles of an atom.<br>◙ Defines common health physics terminology.<br>◙ Identifies basic types of ionizing radiation.<br>◙ Identifies common units used to measure radiation, contamination, and radioactivity.<br>◙ Identifies possible effects of radiation on cells.<br>◙ Distinguishes acute and chronic radiation exposure.<br>◙ Identifies contributions to U.S. population dose from various radiation sources.<br>◙ Identifies the ALARA concept, basic exposure reduction concepts, and the purpose of radiological postings. |
| **2.0 Radiological and Chemical Properties of Uranium**  | ◙ Discusses properties of uranium as used in the fuel cycle.<br>◙ Describes the effect of enrichment on the hazards.<br>◙ Describes properties of decay products and recycled uranium.<br>◙ Identifies the human response indicators of uranium exposure.<br>◙ Compares the chemical versus radiological hazards of uranium at various enrichments and solubilities. |

| | |
|---|---|
| **3.0 Contamination Control**<br> | ◙ Identifies airborne, surface, and personnel contamination hazards.<br>◙ Identifies special considerations necessary to properly control and assess airborne, surface, and personnel contamination hazards. |
| **4.0 Internal Dose Control**<br> | ◙ Describes the primary and derived limits for internal dose in 10 CFR 20.<br>◙ Describes the standard International Commission on Radiological Protection (ICRP) 30 models, including those for lung, GI tract, and bone; discusses how particle size affects lung deposition.<br>◙ States acceptable procedures and relative merits of whole-body counting and excreta analysis for intake assessment.<br>◙ Describes the various endorsed methods for intake assessment and dose calculation.<br>◙ Describes appropriate responses to a potential intake; includes pathway determination, material characterization, and effect on dose assessment.<br>◙ Describes acceptable methods for bioassay scheduling and record keeping, reporting requirements, and quality assurance in an internal dosimetry program. |

| | |
|---|---|
| **5.0 External Dose Control**  | ◙ States the most common source of external dose as a result of handling uranium.<br>◙ Identifies when chemical processes could result in higher external doses.<br>◙ Compares the relative hazard of beta versus gamma radiation at uranium facilities.<br>◙ States the appropriate personal protective equipment (PPE) to be used when directly handling uranium.<br>◙ Identifies appropriate survey instrumentation to assess external dose.<br>◙ Identifies methods used to reduce external dose at fuel cycle facilities. |
| **6.0 Accidents and Emergencies at Fuel Cycle Facilities**  | ◙ Describes health physics actions and activities related to emergency planning, preparedness, response, and recovery.<br>◙ Identifies the health physics role in accidents and emergencies at fuel cycle facilities.<br>◙ Identifies the types of accidents involving the release of radioactive materials that might occur at fuel cycle facilities. |
| **7.0 Health Physics Inspection Activities**  | ◙ Reviews regulatory requirements and inspection activities to determine non-compliance with regulatory requirements related to radiation protection. |

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# MODULE FORMAT

## Module Format

There are common components that make up the format of each module. The modules include:

- A **preparation page** which provides a brief introduction, a list of materials to obtain and prerequisites to complete prior to beginning the module, and steps on how to complete the module.
- A **table of contents** that highlights each section area in bold print and lists subtitles that support each main section area. It also lists **tables** and **figures** included in the module for easy referencing.
- **Learning objectives** that list what the trainee should be able to accomplish upon completion of the module.
- **Section headings and subtitles** for instructional information that supports the learning objectives. Main section headings are written in upper case letters. Supporting subtitles follow a main section heading; and are written in initial capitals as appropriate.
- **Figures and tables** to support instructional text. Figures and tables are numbered and titled throughout the module sections.
- **Self-check questions** to help the trainee review at their own progress. They consist of short answer, fill-in-the blank, multiple choice, matching, or true and false statements, and immediately follow instructional text. Answers to the self-check questions are provided in the Answer Key section of the Trainee Guide and the Administrator Guide.
- **Transitional statements** that provide directional steps to continue through the module sections, to schedule progress review meetings with the administrator, or to complete module steps in preparation for the next module.
- **Activities** that enhance learning. Activities are numbered, titled, and provide mental stimulation to support the learning of the instructional text; are in the form of a crossword puzzle, a case study, simple hand calculations, or other paper and pencil applications with purpose and instructions included with each activity; answers to the activities are provided in the Answer Key section of the Trainee Guide and the Administrator Guide.

A **progress review meeting form** that assists the trainee in discussing the understanding of the instructional text with the administrator. It provides suggested items for discussion, space for taking notes, opportunities to ask pre-developed questions or to write the trainee's own specific questions, and an area to record further assignments.

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## SYMBOLS

Throughout this Directed Self-Study Guide, the following symbols have been used to provide instructions.

| Symbol | Denotes |
|---|---|
|  | **Learning Objectives** |
|  | **Self-Check Questions** |
| **You have completed this section. Please check off your progress on the tracking form.**<br>**It's time to schedule a progress meeting with your administrator. Review the progress meeting form on the next page. In Part III, as a Regulator, write your specific questions to discuss with the administrator.**  | **Transitional Statements**<br>**or**<br>**Time To Schedule A Progress Review Meeting** |
|  | **Activity** |

# ADMINISTRATOR GUIDE

| | |
|---|---|
|  | **Progress Review Meeting** |

# ADMINISTRATOR TIPS

## Stages of the Directed Self-Study

There are basically four stages of successful relationships during the directed self-study process.

**Initiation**
In this stage administrators gain satisfaction from the fact that trainees are actively seeking their advice, while trainees gain a sense of importance from the administrator's attention to them.

Administrators are enthusiastic about transmitting their legacy of values and perspectives and trainees develop strong feelings of admiration for them.

**Cultivation**
This is the stage of greatest stability and mutual satisfaction. At this point, individuals are less starry-eyed about the relationship, perceive each other in a more realistic light, and are making progress toward practical goals.

**Separation**
This is the point at when the formal relationship ends because the trainee has outgrown the need for the administrator's guidance and direction and the relationship no longer fills the needs of either or both of the individuals.

**Redefinition**
Relationships grow beyond the administrator/trainee arrangement and achieve a higher level of maturity. The new relationship is a strong friendship in which the two persons see each other as peers and the administrator does not directly influence the other's career development.

## Conducting a Successful Administrator/Trainee Session

Having a successful directed self-study experience is important to the administrator as well as to the trainee. The following tips may be useful to an administrator.

- Put the trainee at ease by being warm and friendly.
- Define the reason for the session.
- Solicit the trainee's feelings about the directed self-study process.
- Review the objectives to be achieved through the process.
- Agree upon appropriate actions to accomplish module objectives.
- Identify technical resources to be used in completion of any activities.

- Be available for progress review meetings. Plan for the meeting by reviewing the instructional materials and the progress review meeting form located at the end of the module.

  **Note:** The trainee will be prompted when to schedule a progress review meeting with the administrator; however, the administrator and the trainee may make arrangements for more than one meeting.

- Provide positive and constructive feedback on the trainee's progress; suggest supplemental materials that will help the trainee to meet his/her training needs.

## How to Avoid Administrator Pitfalls

Avoiding administrator pitfalls will lead to a more positive learning environment for the trainee and a more pleasant experience for the administrator. The following tips will assist the administrator in overcoming common pitfalls.

| Pitfall | Tip |
|---|---|
| Trying to wing it | Familiarize yourself with the instructional materials; use the progress review form to prepare for meetings with the trainee. |
| Failure to meet the trainee's needs | Find out as much as possible about the training needs of the trainee so that you can focus on those requirements and use examples that specifically apply to his/her job. |
| Prejudging the trainee | Remember, each trainee will proceed through the training material at a different rate depending on his/her background and experience. |
| Criticizing or demeaning the trainee | Just like you, the trainee wants to be treated with respect. Think about your feedback before you give it to the trainee; avoid controlling language such as "I want you to . . ." or "You should . . . " instead use "I recommend that you . . . " "You might want to consider . . . " |
| Gossip | Be sympathetic, but steer the trainee back on track if he/she goes off track in an inappropriate direction. |

| Pitfall | Tip |
| --- | --- |
| Silence | Silence can allow you and the trainee time to think. If silence begins to make either of you uncomfortable, take the initiative to refocus the session into continued dialogue or to move the session to conclusion. |
| Taking the responsibility to learn away from the trainee | Guide trainees to insight and understanding, but don't give all the answers. Encourage the trainee to think through situations by asking "What do you think you should do next?" |
| Being too casual | Set ground rules before training begins; discuss scheduling of meetings and agree on what to do if a meeting needs to be postponed or canceled by you or the trainee. Be sure to plan and then focus on the objectives of your meeting. |
| Over-tasking of supplemental material | Only assign what is necessary for learning the material or skill; do not assign a whole book in which only one chapter is relevant. |

## Final Words of Advice

A few final words of advice to help in the administration role:

- Expect to invest considerable time and effort. Like any other strong relationship, the one between administrator and trainee requires a solid foundation of mutual trust and understanding.
- Be prepared to initiate the relationship; trainees often are apprehensive about approaching administrators. Help them past this obstacle by making the first move.
- When the time is right, be ready to let trainees go. Gradually, over the course of the relationship, give them increasing independence to act and make decisions on their own, and prepare mentally for the separation.
- Have realistic expectations of the relationship. Don’t expect lifelong gratitude; some trainees may consider this a business arrangement to which they owe improved job performance only.

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## TRAINEE TIPS

### Participating in a Successful Directed Self-Study Course

Having a successful directed self-study experience is important to the trainee as well as to the administrator. Since this may be the trainee's first time in a directed self-study situation, the following tips may be useful to suggest to the trainee.

- Be eager to learn. Self-study allows the trainee to explore new topic areas at their own pace, and allows them to have support and guidance as needed.
- Read the Trainee Guide. It provides the trainee with an introduction to the self-study course and the directed self-study process, and provides steps on completing the course.
- Express feelings about the directed self-study process; solicit the administrator's feelings about the directed self-study process. Come to an understanding of the best plan for the trainee to complete the self-study course.
- Review the objectives to be achieved for the assigned module; seek clarification from the administrator if objectives seem unclear.
- Read the instructional text for each section within the module.
- Complete the self-check questions for each section within the assigned module. Self-check questions relate to what has been read in the module. They help the trainee check their own progress. Answers for the self-check questions are provided in the Answer Key located in the Trainee Guide.
- Complete any activities within the assigned module. Activities are designed to reinforce the trainee's new knowledge. Check answers in the Answer Key located in the Trainee Guide.
- When prompted, the trainee should schedule a meeting with the administrator to discuss the instructional material. Plan for the meeting by using the progress review meeting form located toward the end of the assigned module.

  **Note:** The trainee may schedule meetings as needed throughout the study of the module; discuss frequency of meetings with the administrator. Also discuss what to do if meetings need to be canceled by the trainee or the administrator.

- Agree upon appropriate actions by the trainee and the administrator to accomplish each module.

## ADMINISTRATOR GUIDE

- Schedule a follow-up meeting with the administrator to review completed activities and to ensure module objectives are met.
- Evaluate progress, and encourage the administrator to provide advice on how to meet particular needs.

# DIRECTED SELF-STUDY COURSE PROCESS

The following steps are recommended for course completion.

- ◙ Directed self-study courses consist of a Trainee Guide and an Administrator Guide. You will receive a personal copy of the Administrator Guide.
- ◙ Directed self-study guide materials will be stored and made available at the Technical Training Center (TTC) in Chattanooga, Tennessee.
- ◙ Final examinations and answer keys will be kept at the TTC until requested by the training coordinator.

A. When a need is identified for an individual to take a self-study course, the supervisor identifies an administrator. The supervisor is responsible for providing the trainee with an adequate learning environment and the necessary time and resources to complete the course.

**Note:** As provided for in Inspection Manual, Chapter 1246, Section 1246-11, Exceptions, management has the option to allow the trainee to challenge the examination (complete an equivalency examination) or waive the trainee from the course if they are deemed to be already qualified by prior experience and education.

B. The trainee goes to the NRC online training catalog to register for a self-study course. Supervisor approval will be automatically required.

C. The TTC will then send the self-study manuals to the trainee and the administrator. If required, the TTC will send the materials to the supervisor or designee for distribution to the trainee and the administrator.

D. The trainee then proceed with the self-paced study program, directed by the administrator. Each course will have a specified time period for completion, generally four to six months. The trainee’s progress will be noted by the trainee and the administrator on appropriate areas of the tracking sheet located in the Trainee Guide. The trainee’s supervisor initials the completed tracking sheet and acknowledges sign-off by the administrator.

E. The trainee will complete the Notice of Course Completion located in the Trainee Guide and give it to their supervisor. The supervisor or designee will then contact the TCC when the trainee is ready to take the examination.

F. The TTC will send the examination to the supervisor/designee who will arrange for proctoring of the exam.

G. The supervisor/designee will administer the examination at a mutually agreed upon time with the trainee and the proctor. Both the proctor and the trainee will sign the exam cover sheet.

**Note:** A course evaluation form is contained in the Trainee Guide. The trainee should complete this form and give it to their supervisor or designee who should return it to the TCC along with the examination.

H. The supervisor or designee will send the completed examination with the completed cover sheet to the TTC for grading. Minimum passing score on the examination is 70 percent. At the same time, the supervisor or designee will also forward the completed trainee evaluation form to the TTC.

I. The TTC will grade the examination and return it with a course certificate by memorandum to your division director, with a copy to the trainee.

## TRACKING FORM

**Instructions:** To complete this form:

- ◙ Check off, date, and then initial completion of module activities.
- ◙ Discuss any concerns with the administrator.
- ◙ Ask the administrator to initial completion of module activities.
- ◙ Give the form to the supervisor as proof of course completion.

| **Module 1.0: Health Physics Fundamentals** | **Date** | **Trainee Initials** | **Administrator Initials** |
|---|---|---|---|
| Self-Check Questions:<br>1-1 _____ 1-2 _____ 1-3 _____<br>1-4 _____ 1-5 _____ 1-6 _____<br>1-7 _____ 1-8 _____ | | | |
| Activity 1 | | | |
| Progress Review Meeting | | | |
| Independent Study:<br>________________________<br>________________________<br>________________________ | ______<br>______<br>______ | | |
| **Module 2.0: Radiological and Chemical Properties of Uranium** | **Date** | **Trainee Initials** | **Administrator Initials** |
| Self-Check Questions:<br>2-1 _____ 2-2 _____ 2-3 _____<br>2-4 _____ | | | |
| Activity 1 | | | |
| Progress Review Meeting | | | |
| Independent Study:<br>________________________<br>________________________<br>________________________ | ______<br>______<br>______ | | |

| **Module 3.0: Contamination Control** | **Date** | **Trainee Initials** | **Administrator Initials** |
|---|---|---|---|
| Self-Check Questions:<br>3-1 _____ 3-2 _____ 3-3 _____<br>3-4 _____ 3-5 _____ 3-6 _____ | | | |
| Activity 1 | | | |
| Progress Review Meeting | | | |
| Independent Study:<br>________________<br>________________<br>________________ | _____<br>_____<br>_____ | | |
| **Module 4.0: Internal Dose Control** | **Date** | **Trainee Initials** | **Administrator Initials** |
| Self-Check Questions:<br>4-1 _____ 4-2 _____ 4-3 _____<br>4-4 _____ 4-5 _____ 4-6 _____<br>4-7 _____ 4-8 _____ | | | |
| Activity 1 _____ Activity 2 _____ Activity 3 _____ | | | |
| Progress Review Meeting | | | |
| Independent Study:<br>________________<br>________________<br>________________ | _____<br>_____<br>_____ | | |
| **Module 5.0: External Dose Control** | **Date** | **Trainee Initials** | **Administrator Initials** |
| Self-Check Questions:<br>5-1 _____ 5-2 _____ 5-3 _____<br>5-4 _____ | | | |
| Progress Review Meeting | | | |
| Independent Study:<br>________________<br>________________<br>________________ | _____<br>_____<br>_____ | | |

## ADMINISTRATOR GUIDE

| **Module 6.0: Accidents and Emergencies at Fuel Cycle Facilities** | **Date** | **Trainee Initials** | **Administrator Initials** |
|---|---|---|---|
| Self-Check Questions:<br>6-1 _____ 6-2 _____ 6-3 _____<br>6-4 _____ | | | |
| Progress Review Meeting | | | |
| Independent Study:<br>________________________________________<br>________________________________________<br>________________________________________ | _____<br>_____<br>_____ | | |
| **Module 7.0: Health Physics Inspection Activities** | **Date** | **Trainee Initials** | **Administrator Initials** |
| Self-Check Questions:<br>7-1 _____ 7-2 _____ 7-3 _____<br>7-4 _____ 7-5 _____ 7-6 _____<br>7-7 _____ 7-8 _____ 7-9 _____<br>7-10 _____ | | | |
| Progress Review Meeting | | | |
| Independent Study:<br>________________________________________<br>________________________________________<br>________________________________________ | _____<br>_____<br>_____ | | |

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# PROGRESS REVIEW MEETINGS

The purpose of these meetings is to discuss major issues, exchange questions and answers, assure that the subject matter is well understood, and provide encouragement and positive feedback to the trainee.

The following table illustrates an example of preparation and conduct of a typical meeting. Actual Progress Review Meeting forms are located at the end of each course module.

| Step | Administrator | Trainee |
|---|---|---|
| 1 | ◙ Agree on a meeting place, date, and time with the trainee. | ◙ Request a Progress Review Meeting.<br>◙ Arrange for a place and time. |
| 2 | ◙ Review the module(s) and the discussion questions for the meeting.<br>◙ Add questions.<br>◙ Note personal experiences that can enhance the lesson.<br>◙ Review assignments from the previous meeting.<br>◙ Identify additional materials that can help clarify concepts should these be needed. | ◙ Review the module(s).<br>◙ List questions for the administrator.<br>◙ Identify areas needing clarification.<br>◙ Complete assignments from the previous meeting. |
| 3 | ◙ Arrive on time for the meeting.<br>◙ Review assignments from the previous meeting.<br>◙ Answer questions from trainee.<br>◙ Use discussion questions to evaluate trainee comprehension of the subject matter.<br>◙ Review additional materials to clarify concepts, as needed. | ◙ Arrive on time for the meeting.<br>◙ Provide completed assignments from the previous meeting.<br>◙ Ask questions.<br>◙ Answer questions. |
| | ◙ Make assignments, as | |

| Step | Administrator | Trainee |
|---|---|---|
| | appropriate.<br>◙ Set a date and time for a follow-up meeting for the module(s) under discussion, if needed. | |
| 4 | ◙ Date and initial tracking form. | ◙ Date and initial tracking form. |

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## ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| **Ac** | Actinium |
| **ADU** | Ammonium Diuranate |
| **ALARA** | As Low As Reasonably Achievable |
| **ALI** | Annual Limit on Intake |
| **AMAD** | Activity Median Aerodynamic Diameter |
| **ANSI** | American National Standards Institute |
| **AVLIS** | Atomic Vapor Laser Isotope Separation |
| **Bi-214** | bismuth-214 |
| **Bq** | Becquerel |
| **BZS** | Breathing Zone Sampler |
| **CDE** | Committed Dose Equivalent |
| **CEDE** | Committed Effective Dose Equivalent |
| **CFR** | Code of Federal Regulations |
| **Ci** | Curie |
| **CINDY** | Code for Internal Dosimetry |
| **Co-60** | cobalt-60 |
| **cpm** | Counts per minute |
| **Cs-137** | cesium-137 |
| **DAC** | Derived Air Concentration |

| | |
|---|---|
| **DCFs** | Dose Conversion Factors |
| **DDE** | Deep Dose Equivalent |
| **DE** | Dose Equivalent |
| **DIL** | Derived Investigation Level |
| **DoD** | Department of Defense |
| **DOE** | Department of Energy |
| **DOT** | Department of Transportation |
| **dpm** | Disintegrations per Minute |
| **Dps** | Disintegrations per Second |
| **DU** | Depleted Uranium |
| **EDE** | Effective Dose Equivalent |
| **EPA** | Environmental Protection Agency |
| **ERO** | Emergency Response Organization |
| **GAS** | General Air Sampler |
| **GDP** | Gaseous Diffusion Plant |
| **GE** | General Electric |
| **GI** | Gastrointestinal |
| **G-M** | Geiger-Müeller |
| **g** | Gram (sometimes reported “gm”) |
| **Gy** | Gray |
| **HEU** | High Enriched Uranium |

| | |
|---|---|
| **HF** | Hydrogen Fluoride |
| **HP** | Health Physics |
| **HPGe** | High Purity Germanium |
| **HQ** | Headquarters |
| **hr** | Hour |
| **ICRP** | International Commission on Radiological Protection |
| **IRF** | Intake Retention Function |
| **ISL** | In-situ Leach |
| **keV** | Kilo Electron Volt |
| **kg** | Kilogram |
| **KPA** | Kinetic Phosphorescence Analysis |
| **lbs** | pounds |
| **LEU** | Low-enriched Uranium |
| **LiF** | Lithium Fluoride |
| **LWR** | Light Water Reactor |
| **Max** | Maximum |
| **MD** | Management Directive |
| **MDA** | Minimum Detectable Activity or Amount |
| **MeV** | Mega Electron Volts |
| **ml** | Milliliter (1/1000 liter) |
| **mR** | Milliroentgen (1/1000 Roentgen) |

| | |
|---|---|
| **mrad** | Millirad (1/1000 rad) |
| **mrem** | Millirem (1/1000 rem) |
| **NALI** | Nonstochastic Annual Limit on Intake |
| **NaI(TI)** | Thallium-activated sodium iodide |
| **NCRP** | National Council on Radiation Protection and Measurements |
| **$NH_3$** | ammonia |
| **NIST** | National Institute of Standards and Technology |
| **NMSS** | Office for Nuclear Material Safety and Safeguards |
| **NQA** | Nuclear Quality Assurance |
| **NRC** | Nuclear Regulatory Commission |
| **Pa-231** | protactinium-231 |
| **Pa-234m** | protactinium-234m (m for meta stable) |
| **Pb-210** | lead-210 |
| **Pb-214** | lead-214 |
| **PNNL** | Pacific Northwest National Laboratory |
| **Po** | polonium |
| **PORTS** | Portsmouth |
| **PPE** | Personal Protective Equipment |
| **Pu** | plutonium |
| **QA** | Quality Assurance |
| **QC** | Quality Control |

| | |
|---|---|
| **R** | Roentgen |
| **Ra** | radium |
| **Ra-226** | radium-226 |
| **rad** | radiation absorbed dose |
| **rem** | Roentgen equivalent man |
| **REMedy** | Internal Dosimetry Evaluation System |
| **Rn** | radon |
| **Rn-222** | radon-222 |
| **RPP** | Radiation Protection Program |
| **RTM** | Response Technical Manual |
| **RWP** | Radiological Work Permit |
| **SALI** | Stochastic Annual Limit on Intake |
| **SI** | International System of Units |
| **SOP** | Standard Operating Procedure |
| **SpA** | Specific Activity |
| **Sv** | Sievert |
| **T** | Ton |
| **Tc-99** | technetium-99 |
| **TEDE** | Total Effective Dose Equivalent |
| **Th-228** | thorium-228 |
| **Th-231** | thorium-231 |

| | |
|---|---|
| **Th-232** | thorium-232 |
| **Th-234** | thorium-234 |
| **TLD** | Thermoluminescent Dosimeter |
| **TODE** | Total Organ Dose Equivalent |
| **U** | uranium |
| **μ** | Micro |
| **U-230** | uranium-230 |
| **U-231** | uranium-231 |
| **U-232** | uranium-232 |
| **U-233** | uranium-233 |
| **U-234** | uranium-234 |
| **U-235** | uranium-235 (Actinium series) |
| **U-236** | uranium-236 |
| **U-237** | uranium-237 |
| **U-238** | uranium-238 (Uranium series) |
| **U-239** | uranium-239 |
| **U-240** | uranium-240 |
| **$U_3O_8$** | Triuranium Octoxide (Yellowcake); also called Uranium Oxide |
| **$UF_4$** | Uranium Tetrafluoride (Green Salt) |
| **$UF_6$** | Uranium Hexafluoride |
| **UNH** | Uranyl Nitrate |

| | |
|---|---|
| **$UO_2$** | Uranium Dioxide (Brown Oxide or Uraninite) |
| **$UO_2F_2$** | Uranyl Fluoride |
| **$UO_3$** | Uranium Trioxide (Orange Oxide) |
| **$UO_4 \cdot nH_2O$** | Uranium Peroxide |
| **USNRC** | United States Nuclear Regulatory Commission |
| **WBC** | Whole-body Count |
| **WLM** | Working Level Month |
| **$w_T$** | Tissue Weighting factor |

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## GLOSSARY

**Absorbed dose (D)**. Energy absorbed by matter from ionizing radiation per unit mass of irradiated material at the place of interest in that material. The absorbed dose is expressed in units of rad (or gray) (1 rad = 0.01 gray).

**Activity median aerodynamic diameter (AMAD)**. A commonly used measurement of the size of radioactive particles in the air.

**Acute dose**. A radiation dose received over a short period of time. Generally, of most concern in radiation protection programs are acute doses that, in the most extreme case, are large enough to cause deterministic effects. In the lesser case, an acute dose that leads to a dose that exceeds annual dose limits under the license.

**Adsorption**. The method by which gaseous contaminants are collected as they adhere to surfaces of solid bodies they contact as they pass through cartridges or tubes packed with solid granules known as adsorbers.

**Air sampling**. The collection and analysis of samples of air to measure its radioactivity or to detect the presence of radioactive substances, particulate matter, or chemical pollutants.

**Airborne radioactivity**. Radioactive material in any chemical or physical form that is dissolved, mixed, suspended, or otherwise entrained in air.

**Airborne radioactivity area**. Any area where the concentration of airborne radioactivity, above natural background, exceeds or is likely to exceed 10 percent of the derived air concentration (DAC) values.

**Airborne release**. Release of any material or effluent into the air.

**Alarm**. Series of alerting devices that may include effluent or stack monitor alarms, duress alarms, vault alarms, gas alarms, entry alarms, radiation monitor alarms, or other alarms.

**Albuminuria**. The presence of serum albumin in urine.

**Alpha activity**. This term is used to describe the process by which a high-Z atom spontaneously decays by alpha particle emission, ejecting from its nucleus the doubly-charged alpha particle.

## ADMINISTRATOR GUIDE

**Alpha particle (alpha radiation)**. An alpha particle is the nucleus of a helium atom, consisting of four nucleons – two neutrons. Because an alpha particle is highly energetic, having been ejected from the nueleus of high-atoms, the two electrons that were otherwise present on a neutral helium atom, are "stripped" off. Thus, we say an alpha particle carries a charge of +2 (lost 2 electrons). The symbol for an alpha particle is commonly shown as: α (Greek letter), ${}^{4}_{2}He$ (4 nucleons, 2 of which are protons), or ${}^{4}_{2}He^{+2}$ (showing the charge of +2 in addition to the mass number). Alpha particle is synonymous with alpha ray, alpha radiation, or simply alpha. The nuclear fuel cycle makes use of isotopes that decay by alpha particle emission, and hence, these particles drive many of the safety requirements for safe handling and use.

**Analysis (physical or chemical)**. The determination of physical or chemical properties or composition of a material.

**Annual limits on intake (ALIs)**. Limits for air concentrations are given in Appendix B, 10 CFR 20, listed by radionuclide and solubility class.

**As low as reasonably achievable (ALARA)**. Practices to keep contamination within reasonable levels in order to minimize the transport of contamination to clean areas, minimize personnel contamination, and prevent inadvertent intake of materials. On a broader scale, action taken to reduce radiation exposure to ALARA.

**Atom**. The smallest particle of an element that cannot be divided or broken up by chemical means. It consists of a central core called the nucleus, which contains protons and neutrons. Electrons revolve in orbits in the region surrounding the nucleus.

**Atomic number**. The number of positively charged protons in the nucleus of an atom.

**Becquerel (Bq)**. The SI unit used to report the quantity of radioactivity. One becquerel is the quantity of a radioactive material that will have one transformation in one second. Often radioactivity is expressed in larger units such as thousands (kBq), millions (MBq), or even billions (GBq) of becquerels. As a result of having one becquerel being equal to one transformation per second, there are $3.7 \times 10^{10}$ Bq in one curie.

**Beta activity**. This term is used to describe the process by which an atom spontaneously decays by beta particle emission, ejecting from its nucleous the singly-charged beta particle.

**Beta correction factors**. A multiplier applied to the reading of a radiation survey instrument to correct for over or under response when detecting beta particles.

**Beta particle (beta radiation)**. A beta particle is identical to an electron, but unlike an electron, originates from the nucleus of an atom. Whereas electrons are negatively charged, beta particles are either negatively charged (sometimes called a negatron) or positively charged (called a positron). The symbol for a beta particle is commonly shown as β. In cases where the distinction between a negative or positive beta particle needs to be made, the symbol is $\beta^-$ or $\beta^+$, respectively. Within the nuclear fuel cycle, hazards associated with beta particles are normally secondary to hazards associated with alpha particles.

**Beta window**. A thin window on a radiation survey instrument that allows detection of most betas.

**Bioassay**. The determination of the kind(s), quantity(s) or concentration(s), and location(s) of radioactive material in the human body by direct (in vivo) measurement or by analysis of materials excreted or removed from the body.

**Bremsstrahlung**. Electromagnetic radiation emitted as x-rays when a fast-moving charged particle (usually an electron or beta particle) loses energy upon being accelerated and deflected by the electric field surrounding a positively charged atomic nucleus.

**By-product material**. (1) Any radioactive material (except special nuclear material) yielded in, or made radioactive by, exposure to the radiation incident to the process of producing or utilizing special nuclear material; and (2) the tailings or wastes produced by the extraction or concentration of uranium or thorium from ore processed primarily for its source material content, including discrete surface wastes resulting from uranium solution extraction processes. Underground ore bodies depleted by these solution extraction operations do not constitute "by-product material" within this definition.

**Chronic dose**. A chronic dose occurs when a person receives a small radiation dose over a long period of time. For example, 1 rem received every year for 30 years is a chronic dose.

**Class (or lung class or inhalation class)**. A classification scheme for inhaled material according to its rate of clearance from the pulmonary region of the lung. Materials are classified as D, W, or Y, which applies to a range of clearance half-times: for Class D (Days) of less than 10 days, for Class W (Weeks) from 10 to 100 days, and for Class Y (Years) of greater than 100 days.

**Collective dose**. The sum of the total effective dose equivalent values for all individuals in a specified population. Collective dose is expressed in units of person-rem (or person-sievert).

**Committed dose equivalent ($H_{T,50}$)**. The dose equivalent calculated to be received by a tissue or organ over a 50-year period after the intake of a radionuclide into the body. It does not include contributions from radiation sources external to the body. Committed dose equivalent is expressed in units of rem (or sievert).

**Committed effective dose equivalent ($H_{E,50}$)**. The sum of the committed dose equivalents to various tissues in the body ($H_{T,50}$), each multiplied by the appropriate weighting factor ($w_T$)–that is $H_{E,50} = \Sigma\ w_T H_{T,50}$. Committed effective dose equivalent is expressed in units of rem (or sievert).

**Compliance**. The act of complying. To comply is to act in accordance with a request, demand, order, or rule.

**Compound**. A chemical combination of two or more elements combined in a fixed and definite proportion by weight.

**Containment**. Barriers or other physical confinements of airborne or liquid material released or that could be released into the environment.

**Contaminant**. A substance that causes contamination. Contamination refers to the presence of unwanted matter.

**Contamination**. The deposition of unwanted radioactive material on the surfaces of structures, areas, objects, or personnel.

**Contamination control**. Actions taken to limit personnel exposure through ingestion or inhalation of uranium compounds and controlling external exposure to uranium decay products. Actions also include prevention of the spread of radioactive materials into uncontrolled areas.

**Controlled area**. Any area to which access is managed in order to protect individuals from exposure to radiation and/or radioactive materials. Individuals who enter only the controlled area without entering radiological areas are not expected to receive a total effective dose equivalent of more than 0.1 rem (0.001 sievert) in a year.

**Counts per minute (cpm)**. Represents the number of radiations detected per minute by a radiation detection instrument.

**Criticality**. In the nuclear industry, the minimum condition wherein a system or medium is capable of sustaining a nuclear chain reaction.

**Curie (Ci)**. A unit used to report quantity of radioactivity. One curie is that quantity of a radioactive material that will undergo 37,000,000,000 transformations in one second. Often radioactivity is expressed in smaller units such as thousandths (mCi), one millionths (uCi), or billionths (nCi) of a curie. The relationship between becquerels and curies is $3.7 \times 10^{10}$ Bq in one curie.

**Daughter product**. A nuclide, stable or radioactive, formed by radioactive decay of another nuclide, which in this context is called the parent.

**Decay products**. Same as daughter product and adopted by the ICRU as the replacement for the term daughter product.

**Decontamination**. Process of removing radioactive contaminants or other hazardous materials from personnel, equipment, or areas.

**Deep dose equivalent (DDE)**. The dose equivalent derived from external radiation at a tissue depth of 1 cm in tissue.

**Derived air concentration (DAC)**. Equivalent to the concentrations listed in Appendix B to 10 CFR Part 20.

**Derived investigation levels**. The quantity of a radionuclide in a bioassay sample that with the use of standard dosimetry models, would indicate a dose at or above the investigation level.

**Disintegrations per minute (dpm)**. Describes the number of atoms disintegrating in one minute by a radioactive source. This is often estimated by correcting the counts per minute observed by an appropriate detector for background efficiency, and geometric factors associated with the instrumentation.

**Disintegrations per second (dps)**. The number of atoms disintegrating in one second by a radioactive source.

**Dose**. The amount of energy deposited in body tissue due to radiation exposure. Various technical terms, such as dose equivalent, effective dose equivalent and collective dose, are used to evaluate the amount of radiation an exposed worker receives. These terms are used to describe the differing interactions of radiation with tissue as well as to assist in the management of personnel exposure to radiation.

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

**Dose commitment ($D_c$)**. The total radiation dose equivalent to the body or specified part of the body that will be received from an intake of radioactive material during the 50-year period following the intake.

**Dose equivalent (H)**. The product of the absorbed dose (D) (in rad or gray) in tissue, a quality factor (Q), and all other modifying factors (N). Dose equivalent is expressed in units of rem (or sievert) (1 rem = 0.01 sievert).

**Effluents**. Any treated or untreated air emission or liquid discharge, including stormwater runoff.

**Emergency response plan**. The administrative document that establishes the licensee's commitments to emergency preparedness, response, and recovery during a radiological emergency.

**Enriched uranium**. Uranium that contains more of the fissionable isotope uranium-235 than the naturally occurring fraction, which is 0.00711 by weight.

**Enrichment**. A process that changes the isotopic ratio in a material; e.g., the ratio of uranium-235 to uranium-238 may be increased by gaseous diffusion of uranium hexafluoride.

**Environmental**. Having to do with the environment. The environment is the sum of all external conditions and influences affecting the development and life of organisms. The aggregate of all conditions and the influences that determine the behavior of a physical system.

**Evacuation**. Actions taken during an emergency to remove oneself from the dangerous area.

**Exposure**. 1) Being in the presence of ionizing radiation 2) A measure of ionization produced in air by X- and $\gamma$ radiation 3) The product of the average concentration of radioactive material in air and the period of time during which an individual was exposed to that average concentration (DAC-hr).

**Exposure pathway**. The pathway between the source of released material and intake by individuals.

**External dose or exposure**. That portion of the dose equivalent received from radiation sources outside the body (i.e., "external sources").

**Extremity**. According to 10 CFR Part 20, extremity is defined as hand, elbow, arm below the elbow, foot, knee, or leg below the knee.

**Facility**. Any equipment, structure, system, process, or activity that fulfills a specific purpose. Examples include accelerators, storage areas, fusion research devices, nuclear reactors, production or processing plants, coal conversion plants, magnetohydrodynamics experiments, windmills, radioactive waste disposal systems and burial grounds, testing laboratories, research laboratories, transportation activities, and accommodations for analytical examinations of irradiated and unirradiated components.

**Fuel assembly**. In the nuclear industry, a grouping of fuel elements that is not taken apart during the charging and discharging of a reactor core.

**Fuel cycle facility**. A facility that conducts activities related to the nuclear fuel cycle. This includes sites that conduct mining, milling, conversion, enrichment, and fuel fabrication operations.

**Fuel element**. In the nuclear industry, the smallest structurally discrete part of a reactor that has fuel as its principal constituent.

**Fuel rod**. A long slender column of material containing fissile nuclides, normally encapsulated by metallic tubing.

**Gamma activity**. The spontaneous emission from the nucleus of high-energy, short-wavelength, electromagnetic radiation.

**Gamma rays (gamma radiation)**. Electromagnetic waves or photons from the nucleus (center) of an atom.

**Geiger-Müeller (G-M) detector**. Standard beta-gamma counting equipment.

**Genetic effects**. Effects manifested in the offspring of exposed persons.

**Glucosuria**. The presence of glucose in urine.

**Gray (Gy)**. The SI unit used to measure quantity called absorbed dose. This relates to the amount of energy actually absorbed in some material, and is used for any type of radiation and any material. One gray is equal to one joule of energy deposited in one kilogram of a material. The unit gray can be used for any type of radiation, but it does not describe the biological effects of the different radiations. Absorbed dose is often expressed in terms of hundredths of a gray, or centigrays. One gray is equivalent to 100 rads.

**Green salt**. Toxic, radioactive, corrosive green crystals; insoluble in water; used in the manufacturing of uranium metal. Also known as uranium tetrafluoride.

**Half-life**. The time it takes for one-half the radioactive atoms present in a radioactive sample to decay.

**Hazard**. The potential that a chemical or physical characteristic of a material, system, process or plant will cause harm or produce adverse consequences.

**Health Physics**. An interdisciplinary science and its application for the radiation protection of humans and the environment. Health Physics combines the elements of physics, biology, chemistry, statistics, and electronic instrumentation to provide information that can be used to protect individuals from the effects of radiation.

**High purity germanium (HPGe) systems**. Gamma spectroscopy systems using HPGe detectors, high resolution solid state gamma detectors, capable of detecton most secondary photon emissions from radiative material, and associating with each constituent isotope.

**Intake**. The quantity of radioactive material entering the human body; for inhalation, it is the product of the exposure and the breathing rate.

**Internal dose or exposure**. That portion of the dose equivalent received from radioactive material absorbed by the body (e.g., "internal sources").

**In vivo measurements**. Measurements of gamma-rays or x-rays emitted from radioactive material located within the body for the purpose of estimating the quantity of radioactive material present.

**Ionization**. The process of removing electrons from atoms.

**Ionization (Ion) chamber**. A radiation detector used to measure the exposure rate from ionizing radiation.

**Ionizing radiation**. Radiation with enough energy so that during an interaction with an atom, it can remove tightly bound electrons from their orbits, causing the atom to become charged or ionized. Examples are alpha particles, beta particles, gamma rays, x-rays, and neutrons.

**Lens of the eye dose equivalent**. The external exposure of the lens of the eye is taken as the dose equivalent at a tissue depth of 0.3 cm.

**Lithium fluoride (LiF)**. Poisonous, white powder melting at 870° C, boiling at 1670° C; insoluble in alcohol, slightly soluble in water, and soluble in acids; used as a heat exchange medium, as a welding and soldering flux, in ceramics, and as crystals in infrared instruments and thermoluminescent radiation dosimeters.

**Mass spectrometry**. A destructive analytical technique used to determine the relative weight percent of uranium isotopes contained in a sample.

**Mill tailings**. Naturally radioactive residue from the processing of uranium ore into yellowcake in a mill. Although the milling process recovers about 93 percent of the uranium, the residues, or tailings, contain several radioactive elements, including uranium, thorium, radium, polonium, and radon.

**Natural uranium**. Uranium as found in nature. It contains 0.711 percent uranium-235, 99.3 percent uranium-238, and a trace of uranium-234.

**Neutrons**. Neutral particles that are normally contained in the nucleus of all atoms and may be removed by various interactions or processes like collision and fission.

**Noble gases**. Gases in group O of the periodic table of the elements; they are monatomic and, with limited exceptions, chemically inert. Also known as inert gas, and hence do not combine chemically with other gases.

**Nonionizing radiation**. Radiation without enough energy to remove tightly bound electrons from their orbits around atoms. Examples are microwaves and visible light.

**Nonstochastic (or deterministic) effect**. Effects that can be related directly to the dose received. The effect is more severe with a higher dose, i.e., the burn gets worse as dose increases. It typically has a threshold, below which the effect will not occur. A skin burn from radiation is a nonstochastic effect.

**Nontransportable**. Slowly removed from the pulmonary region of the lung by gradual dissolution in extracellular fluids, or in particulate form by translocation to the GI tract, blood, or lymphatic system; **Class (W)**, nontransportable dust with 50-day biological half-life in the lung; **Class (Y)**, nontransportable dust with 500-day biological half-life in the lung.

**Nuclear fuel cycle**. The complete cycle of nuclear activities that includes mining, milling, conversion, enrichment, fuel fabrication, nuclear power plant operation, spent fuel storage, reprocessing (if applicable), and waste management operations.

**Occupational dose**. An individual's dose due to exposure to ionizing radiation (external and internal) as a result of that individual's work assignment. Occupational dose does not include planned special exposures, exposure received as a medical patient, background radiation, or voluntary participation in medical research programs.

**Offsite responses**. Protective responses that need to be taken by affected individuals (located around or in close proximity to the affected site/facility) during a radiological emergency. Offsite responses include protective sheltering or evacuation.

**Pellet**. A briquet or compact, usually cylindrical, formed by pressing a powder in a die. The pellet may or may not have been sintered following compaction.

**Personal protective equipment (PPE)**. Devices worn by the worker to protect against hazards in the environment. Respirators, gloves, and hearing protection are examples.

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

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

**Polyuria**. Excess volume of urine.

**Process area**. An area in which fissionable material is handled, stored, or processed.

**Protective responses**. Actions that are taken to avoid or minimize personnel and public exposures to hazardous or radioactive material release. These responses concentrate on minimizing the inhalation or ingestion of materials.

**Protective sheltering**. Action taken during an emergency in which residents in the affected areas shut down their ventilation systems, seal their homes and occupied structures, and remain inside those structures until instructed to leave.

**Proteinuria**. Excess serum protein in urine.

**Pyrophoric**. Igniting spontaneously.

**Quality assurance**. Planned and systematic actions necessary to provide adequate confidence in the results of a measurement program.

**Quality control**. A component of quality assurance implemented to provide a means to control and measure the characteristics of measurement equipment and processes to establish measurement requirements.

**Quality factor**. The principal modifying factor used to calculate the dose equivalent from the absorbed dose; the absorbed dose (expressed in rad or gray) is multiplied by the appropriate quality factor (Q).

**Rad (radiation absorbed dose)**. A cgs unit used to measure a quantity called absorbed dose. This relates to the amount of energy actually absorbed in some material, and is used for any type of radiation and any material. One rad is defined as the absorption of 100 ergs per gram of material. The unit rad can be used for any type of radiation, but it does not describe the biological effects of the different radiations.

**Radiation**. Energy in transit in the form of high-speed particles and electromagnetic waves. We encounter electromagnetic waves every day. They make up our visible light, radio and television waves, ultra violet (UV), and microwaves with a spectrum of energies. These examples of electromagnetic waves do not cause ionizations of atoms because they do not carry enough energy to separate molecules or remove electrons from atoms.

**Radioactive contamination**. Radioactive material distributed over some area, equipment, or person. It tends to be unwanted in the location where it is, and has to be cleaned.

**Radioactive decay**. The process of radioactive atoms releasing radiation over a period of time to try to become stable (non-radioactive). Also known as disintegration.

**Radioactive material**. Any material that contains radioactive atoms.

**Radioactivity**. The spontaneous transformation of an unstable atom and often results in the emission of radiation. This process is referred to as a transformation, a decay, or a disintegration of an atom.

**Radiological Assessment Procedures**. Administrative procedures that describe the actions and types of activities that emergency response health physics personnel may conduct or become involved in.

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

**Radionuclide**. A radioactive nuclide. There are several hundred known radionuclides; radionuclides are characterized by the number of neutrons and protons in an atom's nucleus.

**Radium (Ra)**. A radioactive metallic element with atomic number 88. As found in nature, the most common isotope has a mass number of 226. It occurs in minute quantities associated with uranium in pitchblend, carnotite, and other minerals.

**Radon (Rn)**. A radioactive element that is one of the heaviest gases known. Its atomic number is 86, and its mass number is 222. It is a daughter of radium.

**Rem**. A unit used to derive a quantity called equivalent dose. This relates the absorbed dose in human tissue to the effective biological damage of the radiation. Not all radiation has the same biological effect, even for the same amount of absorbed dose. Equivalent dose is often expressed in terms of thousandths of a rem, or millirem. To determine equivalent dose (rem), multiply absorbed dose (rad) by a quality factor (Q) that is unique to the type of incident radiation. (1 rem = 0.01 sievert).

**Roentgen (R)**. A unit used to measure a quantity called exposure. This can only be used to describe an amount of ionization produced by gamma and x-rays, and only in air. The main advantage of this unit is that it is easy to measure directly, but it is limited because it is only for deposition in air, and only for gamma rays and x-rays.

**Scintillation counters**. Standard beta-gamma counting equipment. Scintillators are also available for alpha counting.

**Sealed source**. Nuclear material (generally for use in test and calibration) that has been packaged to be environmentally and critically safe.

**Shallow dose**. The dose that applies to the external exposure of the skin, taken as the dose at a tissue depth of 0.007 cm averaged over 1 $cm^2$.

**Shallow dose equivalent**. The dose equivalent deriving from external radiation at a depth of 0.007 cm in tissue.

**Sievert (Sv)**. A unit used to derive a quantity called dose equivalent. This relates the absorbed dose in human tissue to the effective biological damage of the radiation. Not all radiation has the same biological effect, even for the same amount of absorbed dose. Dose equivalent is often expressed in terms of millionths of a seivert, or micro-seiverts. To determine dose equivalent (Sv), you multiply absorbed dose (Gy) by a quality factor (Q) that is unique to the type of incident radiation. (1 Sv = 100 rem).

**Sodium iodide thallium activated (NaI[Tl]) systems**. Gamma spectroscopy systems using NaI[Tl] detectors, low resolution gamma scintillation detectors, capable of identifying isotope constituents in radioactive material.

**Solubility**. The ability of a substance to form a solution with another substance.

**Solubility classes (D, W, or Y)**. Classification established for various uranium compounds, are given in a variety of references including Appendix B of 10 Code of Federal Regulations Part 20 (10 CFR 20).

**Solution mining**. The extraction of soluble minerals from subsurface strata by injection of fluids, and the controlled removal of mineral-laden solutions.

**Somatic effects**. Effects from some agent, like radiation, that are seen in an individual who receives the agent.

**Specific activity (SA)**. The number of nuclear disintegrations of a radionuclide per unit time per unit mass. The unit for specific activity is Ci/g or Ba/g. The quantity applies per unit mass of that radionuclide.

**Standard (or Reference) man**. A theoretical physically fit man of standard (average) height, weight, dimensions, and other parameters (blood composition, percentage of water, lung capacity, etc.), used in studies of the effects of ionizing radiation or heat upon humans.

**Standard operating procedures**. The primary way the quality of each measurement activity is controlled and data comparability ensured.

**Stochastic effects.** Effects that occur on a random basis with the effects being independent of the size of dose. The effect typically has no threshold and is based on probabilities, with the chances of seeing the effect increasing with dose. Cancer is a stochastic effect.

**Teratogenic effects**. Developmental malformations from some agent that are seen in the offspring of the individual who received the agent. The agent must be encountered during the gestation period.

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

**Total effective dose equivalent (TEDE)**. The sum of the effective dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures). Deep dose equivalent (DDE) to the whole body may be used as effective dose equivalent (EDE) for external exposures.

**Tissue weighting factor ($w_T$)**. The fraction of the overall health risk, resulting from uniform, whole body irradiation, attributable to specific tissue (T). The dose equivalent to the affected tissue, HT, is multiplied by the appropriate weighting factor to obtain the effective dose equivalent contribution from that tissue.

**Total organ dose equivalent (TODE)**. The sum of the committed dose equivalent (CDE) and the deep dose equivalent (DDE) from external penetrating radiation.

**Toxicity**. The relative property of a chemical agent; refers to the ability of a substance to produce an unwanted effect on a living organism by other than mechanical means.

**Toxin**. Any agent capable of producing an unwanted effect in a biological system.

**Transportable**. Dissolved upon contact with extracellular fluids and translocated to the blood; Class (D), transportable dust with rapid clearance from the lung.

**Transuranic elements**. Elements that have atomic numbers greater than 92; all radioactive, are products of artificial nuclear changes, and are members of the actinide group.

**Uptake**. The quantity of radioactive material entering the body that is absorbed into the transfer compartment (i.e., extracellular fluids.)

**Uranium hexafluoride**. A corrosive chemical compound in the nuclear fuel cycle. Uranium octoxide ($U_3O_8$) or yellowcake is converted to uranium hexafluoride ($UF_6$), in the so-called "conversion process." With the application of heat, $UF_6$ becomes a gas that permits the concentration (enrichment) of uranium-235, the uranium isotope required for reactor fuel.

**Uranium milling**. Any activity that results in the production of by-product material as defined in 10 CFR Part 40.4.

**Waste**. Nuclear material residues that have been determined to be uneconomical to recover.

**Whole body**. For the purposes of external exposure, head, trunk (including male gonads), arms above and including the elbow, or legs above and including the knee.

**Whole body dose**. The sum of the annual deep dose equivalent (DDE) for external exposures and the committed effective dose equivalent (CEDE) for internal exposures.

**Working level (WL)**. Any combination of short-lived radon progeny (for radon-222: polonium-218, lead-214, bismuth-214, and polonium-214; and for radon-220: polonium-216, lead-212, bismuth-212, and polonium-212) in 1 liter of air that will result in the ultimate emission of $1.3 \times 10^5$ MeV of potential alpha particle energy.

**Working level month (WLM)**. An exposure to 1 working level for 170 hours (2,000 working hours per year/12 months per year = approximately 170 hours per month).

**X-rays**. Electromagnetic waves or photons not emitted from the nucleus, but normally emitted by energy changes in electrons. These energy changes are either in electron orbital shells that surround an atom or in the process of slowing down, such as in an x-ray machine.

**Yellowcake**. A uranium ore concentrate, consisting mostly of uranium octoxide ($U_3O_8$). It is usually yellow-green in color.

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