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Radiation Protection Training at Uranium Hexafluoride and Fuel Fabrication Plants

U.S. Nuclear Regulatory Commission

Office of Nuclear Regulatory Research

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This document does not impose requirements.

Abstract

This report provides general information and references useful for establishing or operating radiation safety training programs in plants that manufacture nuclear fuels, or process uranium compounds that are used in the manufacture of nuclear fuels. In addition to a brief summary of the principles of effective management of radiation safety training, the report also contains an appendix that provides a comprehensive checklist of scientific, safety, and management topics, from which appropriate topics may be selected in preparing training outlines for various job categories or tasks pertaining to the uranium nuclear fuels industry. The report is designed for use by radiation safety training professionals who have the experience to utilize the report to not only select the appropriate topics, but also to tailor the specific details and depth of coverage of each training session to match both employee and management needs of a particular industrial operation.

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1. INTRODUCTION

For licensees of the U.S. Nuclear Regulatory Commission, Section 19.12, "Instructions to Workers," of 10 CFR Part 19, "Notices, Instructions and Reports to Workers; Inspections," requires that individuals be given instruction in radiation protection that is commensurate with the potential radiation protection problems that they may encounter in restricted areas as defined in paragraph 19.3(e) of 10 CFR Part 19 (1). Paragraph 20.1(c) of 10 CFR Part 20, "Standards for Protection Against Radiation," states that occupational radiation exposure should be kept "as low as is reasonably achievable" (ALARA) (2). Appropriate training, with the objective of providing the worker with sufficient knowledge of radiation protection principles applicable to his work with radioactive materials, is essential for keeping radiation exposure ALARA. In the United States, existing uranium fuel plants have already developed training programs to meet these needs. This document has been developed by NRC staff in cooperation with, and incorporating the ideas and experience of, radiation safety professionals and training officers in the nuclear fuels industry. The purpose of the document is to provide a readily accessible, organized, source of training information to assist the industry in maintaining its high safety standards with additional convenience and consistency.

The report is designed for use by experienced industry professionals who can select topical material and match the level of technical coverage to specific industry operating jobs and tasks. It provides basic information and a topical list for developing or updating radiation protection training (RPT) consistent with the ALARA objective, consistent with effective industrial safety management, and consistent with training programs already accepted by NRC staff for meeting the training requirement of 10 CFR Part 19, for individuals who work at uranium fuel fabrication or uranium hexafluoride production plants (abbreviated UHFFPs).

Although a list of topics is provided (see Table 1), this document does not provide detailed training programs and lesson plans for each plant, since the industrial training manager in each plant is best qualified to design specific programs for his plant. NCRP Report No. 71 (1) provides general guidance for planning and conducting training programs. General principles of radiation safety training and an outline of topics pertaining to UHFFPs are given in this report. Regulatory Guide 8.10, "Operating Philosophy for Maintaining Occupational Exposures As Low As Is Reasonably Achievable," may provide information useful for training in the philosophy and management principles related to the ALARA concept.

2. GENERAL CONSIDERATIONS IN ORGANIZING A RADIATION PROTECTION TRAINING PROGRAM

2.1 Establishing Training Needs*

In determining appropriate radiation protection training (RPT) for an individual, the following should be considered:

*The training needs for an escorted visitor or a short-term worker who is to be escorted by a worker who has had appropriate RPT may be abbreviated, but the use of escorts must not be used to circumvent timely appropriate training required by 10 CFR Part 19.

1. Primary duties and responsibilities.
2. Secondary duties and responsibilities.
3. Previous experience.
4. Previous training.**

2.2 Training Methods

Training should consist of classroom training, on-the-job training, and a mechanism to evaluate and document the effectiveness of the training received. Training should be conducted by qualified personnel. Training should be conducted in such a manner that the individual being trained knows the specific objectives of the training and receives feedback on his or her performance in meeting the training objectives.

2.3 Management Oversight

The RPT program should be periodically reviewed by facility management with input from the radiation protection manager. The radiation protection manager should remain cognizant of the RPT program. Changes in training needs warranted by changes in operations, license conditions, and regulations should be implemented promptly. Review of the RPT program should include a review of training documentation and performance records.

2.4 Who Should Receive Radiation Protection Training

The radiation protection training program should include all personnel, including supervisors, whose duties require them to work in, or frequently enter restricted areas, whether or not they are employees of the licensee. This includes visitors and transient workers. It also includes secretaries and others who normally would not work in restricted areas but may occasionally have need to enter such areas. They should know the precautions necessary to avoid undue radiation exposure or the spread of contamination to themselves and others.

Visitors may be defined as people who enter the plant for purposes other than to work for the licensee and who are not expected to receive radiation doses, although they may enter restricted areas incident to their activities (e.g., salespersons or students).

Transient workers may be defined as people who enter the plant to work in restricted areas for a definite but limited period of time and who are directly involved in plant operations, maintenance or repair, or the direct support of these activities (whether or not they are employees of the licensee). Examples of transient workers are equipment manufacturers' representatives, individuals employed in short-term maintenance and repair work, vendor personnel employed to temporarily augment the radiation protection staff, transport workers, and licensee employees temporarily assigned to the UHFFP.

Transient workers should receive on-site plant-specific training specific to their job assignments, as well as a background of training in the more general

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**The appropriateness of previous training should be assessed by a performance test, a written test, oral examination, or inquiry to the organization that gave the training. In most cases, site-specific training will be a necessary supplement to an individual's previous training. The appropriateness of previous training should be documented.

(non-plant specific) areas of radiation protection, to meet the requirements of 10 CFR Part 19(1).

2.5 When Training Should Occur

Prior to working in a restricted area, each individual should be trained in all aspects of radiation protection necessary to his or her immediate duties. In addition, those persons who will routinely work in restricted areas should receive instructions at their job sites concerning the radiation protection aspects of their jobs.

Appropriate RPT for each individual should be conducted in accordance with a schedule established by the licensee. Classroom training and on-the-job training may be intermixed. New employees should be accompanied by a trained escort, specially supervised, or provided other precautions to ensure that an individual is not subject to risks from situations for which he has not yet been fully trained.

Individuals should receive formal periodic refresher RPT each year. Such training should not be a simple repetition of previous training. It should include appropriate topics addressing the needs of the worker, changes in facility operations, and changes in methods of radiation protection directly relevant to their duties and responsibilities. Training/retraining needs should be evaluated when a worker is reassigned to a former job or is assigned to a job with significantly different duties and responsibilities, and training/retraining should be conducted if warranted. In general, an individual reassigned to a job from which he/she has been absent for over a year should be retrained.

Besides the formal RPT and retraining, there should be a mechanism to communicate radiological protection developments, changes in procedures, and changes in plant operations through informal meetings. Such meetings should allow workers opportunity to discuss perceived radiation protection problems directly with radiation protection staff.

2.6 Training Evaluation

The RPT program should include appropriate mechanisms for evaluating its effectiveness. Mechanisms for evaluating the knowledge and understanding gained by the employee may consist of a written exam, an oral interview, and an on-the-job performance evaluation. The extensiveness of the testing or mechanisms should be related to the needs for training (i.e., potential hazard of the work for which the worker is being trained). The training and testing of a secretary or a visitor touring a restricted area differ from that appropriate for a worker whose entire duties are to be conducted within a restricted area on a full-time basis.

In all forms of evaluation, there should be ways to formally document the materials covered, the tests and evaluations, and the feedback given to the employee. In on-the-job evaluations and oral evaluations, a check list or similar device should be used for the documentation of the feedback received from the employee for each question. Evaluation mechanisms should emphasize the most important parts of the RPT (i.e., the skills and knowledge directly related to the specific job's day-to-day practices and emergency procedures). A high percentage should be used (some plants use 80 percent) to determine a passing score for written

and oral examinations. Practical or on-the-job evaluations may be graded on a pass/fail basis. The first remedy for a failing score is retraining and reevaluation.

Additional test features should:

1. Stress the importance of safety in a controlled area.

2. Assess the individual's attitude toward the rights and obligations of a controlled area worker.

3. Reinforce the key points of training.

4. Demonstrate the ability to recognize and cope with radiation hazards, and to apply radiation protection principles in actual situations at the facility.

Besides the formal evaluation procedures, a mechanism should exist for supervisors and radiation protection personnel to initiate a reassessment of an individual's training needs based on observed job performance. Should such an assessment indicate a need, additional training should be conducted as soon as practical.

The evaluation program may also include confidential questionnaires to obtain feedback and suggestions from the trainees for improving the training program (see Tables 2 and 3).

2.7 What Records of Training Should Be Maintained

Although NRC regulations do not require that records of radiation protection training at UHFFPs be kept, such records are beneficial in managing training programs and in establishing evidence of training adequacy and compliance with company policies. Records may help eliminate unnecessary repetition of training as well as ensure appropriate periodic refresher training and requalification training for new work assignments. Also, some workers (especially transient workers) may work in and be trained at several different facilities. Appropriate records would identify site-specific training and non-site-specific training in outlines, syllabuses, and other training materials. Records systems may include coded references to information sources and other training aids in order to reduce bulk.

Such trainee-specific training records may include:

1. The worker's name, Social Security number, pay number, and any other useful identification

2. Job codes

3. Work locations

4. Department code

5. Supervisor

6. Inclusive dates for each segment of training or for each different training program.

7. A specific description of all training completed satisfactorily by the worker, including references to pertinent lesson plans, course outlines, syllabuses, brochures, video tapes, texts, tests (including test questions and oral and on-the-job checklists). Specific reference may be made to such materials by date, edition, issue, etc.

8. A performance rating for each different training program completed by the worker. This rating normally consists of a numerical or letter grade or a written evaluation.

9. The source of training, i.e., the training facility and its location.

10. The name and signature of each instructor and examiner involved in each segment of training.

11. Copies of written examinations, including grades, signed and dated by the examiner.

3. ELEMENTS OF A RADIATION PROTECTION TRAINING PROGRAM

3.1 Objectives

A licensee's radiation protection training program may include the following objectives:

1. Provide the information needed by each person to effectively control his/her exposure to radiation and radioactive material and the exposures others may receive as a result of his/her actions.

2. Provide the information needed by each person as a basis for understanding (a) the biological effects of radiation (including both immediate and latent effects), and (b) how different levels of radiation dose affect the human body.

3. Provide information needed by each person for complying with license conditions, NRC Regulations, and plant rules and procedures and for properly responding to warnings and alarms under both normal and accident conditions.

4. Provide the information needed by each person for understanding the function of radiation detection and measurement instruments and knowing how to respond to data provided by them.

3.2 Content

The RPT program should include for each class of trainees the topics listed in Table 1 that are appropriate for their specific job categories. The inclusion of topics and the depth of treatment of each topic should be varied to meet the needs of each individual or group requiring training and should include those radiation safety subjects specific to the plant in which the worker will be employed. Once the topics are selected for the specific class, instructors should adhere to lesson plans and outlines in order that training records will

accurately reflect the training given each worker, including references and training aids. Some useful documents relevant to UHFFP training are listed in the Reference section of this guide.

3.3 Training with Mockups

Experience has established that training effectiveness is greatly enhanced when, in addition to classroom training, equipment or facility mockups are used to allow trainees to become familiar with tasks (especially repair and maintenance procedures) in a realistic context prior to beginning their work with radioactive materials or equipment containing radioactive materials. This type of training is especially valuable for work involving tasks that may result in exposure of personnel to surface contamination or airborne radioactive material and for work involving a potential for accidental criticality.

3.4 Role of Radiation Protection Staff

The radiation protection staff should be thoroughly conversant with the subject discussed in the training program and should personally participate in the training so that employees will know the role and functions of radiation safety personnel, and have confidence in management's interest in their personal safety. Radiation safety staff members may themselves serve as training personnel or may provide technical support to the training staff in the development and conduct of the RPT.

TABLE 1*

SUBJECTS THAT MAY BE INCLUDED IN TRAINING PROGRAMS FOR EMPLOYEES OF URANIUM HEXAFLUORIDE AND FUEL FABRICATION PLANTS.

Items with asterisks are not usually appropriate for the average plant worker but may be included in extended training for supervisory engineers, scientists, and radiation safety technicians.

I. INTRODUCTION TO THE PLANT RADIATION PROTECTION PROGRAM

A. Purposes of Training

1. Maintenance of safe workplace.

   a. Areas of plant where radiation exposure may occur.

   b. Safety is part of the job.

2. Acquaint worker with plant radiation safety program and staff.

3. Acquaint worker with plant rules and procedures for the safety of himself or herself and others.

4. Acquaint worker with government regulations and license conditions that the plant must follow for his or her protection and the protection of others, including provisions of 10 CFR Part 19 for articles, instructions, reports and inspections.

5. Motivate worker to follow safe practices and procedures.

B. General Organization and Description of Plant Operations where Radiation Exposure is Possible.

C. Organization of the Radiation Safety Program

1. Relationships between radiation safety and other plant safety programs.

2. Management's responsibilities for protection of workers and the public.

   a. Provide safe environment.

   b. Provide radiation safety program.

*This table is not intended to represent a particular course outline. It is a checklist of topics in a particular order that may aid the qualified trainer to prepare outlines for particular training courses with coverage of each topic in the depth appropriate for the audience and facility. Additional more detailed breakdowns of some of this subject material may be found in IAEA Technical Report No. 166, Reference 22.

3. The worker's responsibilities and rights.

   a. Reporting to supervisor conditions leading to violations.

   b. Following safety rules and procedures.

   c. The right to request inspections, exposure information, and discussions with inspectors where radiation exposure is possible.

4. The radiation safety training program.

5. Where to obtain further information.

   a. Radiation safety staff and management availability.

   b. 10 CFR Part 19 information and posting requirements, state agency provisions.

   c. Other references - Regulatory Guides 8.13 and 8.29. Bibliography in this guide.

D. Motivations for Learning About Radiation Protection

1. Lower personal risks.

2. Lower risks to others.

3. Lower liabilities and losses to self and company.

4. Help employer meet regulatory and license requirements (10 CFR Part 19, 10 CFR Part 20, Licenses posted).

5. Employee's responsibility to report promptly any conditions that may lead to violations of license conditions or regulations, or cause unnecessary exposures.

E. Need for Worker Feedback in Training Sessions

1. Importance of examinations.

2. Mistakes as a requisite for learning.

3. Importance of questions.

4. Importance of training exercises and drills.

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*Items with asterisks are not usually appropriate for the average plant worker, but may be included in extended training for supervisory engineers, scientists, and radiation safety technicians.

5. On-the-job versus formal training.

6. Verbal interactions to bring out and integrate worker's (past) experiences.

7. Evaluations of training by the worker (See Tables 2 and 3).

II. CONCEPTS OF RADIATION, RADIOACTIVITY, RADIATION EXPOSURE, AND DOSE*

A. Concepts of Ionizing vs. Nonionizing Radiation

1. Definition of "radiation."

2. Familiar examples of nonionizing radiation.

3. Familiar examples of ionizing radiation.

B. Radionuclides vs. Stable Elements and Isotopes

C. Types of Ionizing Radiation

1. Alpha particles.

a. Nature - mass, charge, constituents.

b. Velocity and energy*

c. Shortness of range, high (specific) ionization in short range.

d. Energies of alphas from uranium isotopes and other fissionable nuclides.*

2. Beta particles.

a. Nature - mass, charge, constituents.

b. Negatrons and positrons.*

c. Velocities and energy spectra.*

d. Ranges and rates of attenuation in different materials. heavy materials.*

f. Self-absorption of uranium feed and fuel materials.*

g. Beta surface exposure potentials in plant operations, e.g., 50-100 mrem/hour near the surface of pellet trays and boats and 5-10 mrem/hour near surfaces of fuel rods and bundles.

3. Gamma rays and X-rays.

a. Nature - electromagnetic, but energy packaged as photons. Origins of gamma and x-radiation (including bremsstrahlung) in plant operations.

b. Velocity and discrete energies.

c. Absorption and scattering - types of interactions with electrons and atoms.*

d. Ranges and rates of attenuation different materials.

e. Relative exposure potential in various plant locations - 1 to 2 mrem/hour at 1 foot from surface of UO_2 pellet trays or boats, fuel rods and bundles, higher or multiply-used UF_6 cylinders or where operations involving melting or reduction to uranium metal are conducted and the thorium and protactinium daughters of uranium become separated as "bottoms," scale, or residue.

4. Neutrons

a. Nature and origin

b. Description of the fission process, neutron chain reactions, and plant areas where criticality is possible.

c. Description of other neutron sources that may be used in the facility.

d. Criticality concepts and their importance - mass and geometry control principles, density dependence, moderation, enrichment dependence.

D. Radiation Exposure and Dose Concepts

1. Exposure - energy absorption density in air.

2. Measurement of exposure - ionization chambers, secondary detectors-film, TLD, chemicals.

3. Units of Exposure - roentgen, joules, subunits, for x or gamma; kerma; fluence (versus energy) for neutrons.

4. Absorbed dose (D) - energy absorption density in tissue or other materials.

5. Units of absorbed dose - rad, gray, subunits.

6. Differences in whole body and partial body exposure and dose.

7. Concept of dose equivalent (DE) - for intercomparing and adding biological effects of different kinds and energies of radiation.

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*Items with asterisks are not usually appropriate for the average plant worker, but may be included in extended training for supervisory engineers, scientists, and radiation safety technicians.

8. Units of dose equivalent:

   a. Quality factors (QF)

   b. rem, sievert, subunits

   c. Practical calculation of DE for radiation protection purposes: DE = D x QF

9. Use of new ICRP26 weighted DE for summing partial body exposures.*

10. Decrease with distance of D and DE from point sources (inverse square law).

11. Decrease with distance of D and DE from area and volume sources.*

12. Orientation to relative magnitudes of background radiation exposures, exposures in uranium fuel fabrication operations, and individual and population doses in various segments of the nuclear fuel cycle.

III. BIOLOGICAL EFFECTS OF RADIATION AND COMPARISONS OF RISK

A. General Nature of Biological Damage from Radiation

1. Damage to cell nucleus and cytoplasm.*

2. Production of ionization and chemical radicals near critical biochemical sites.

3. Multiple-hit, multiple-target concepts of production of lethal damage to cells and carcinogenic and genetic transformations.*

4. Repair of biochemical lesions.*

5. Dependence of repair and biological effects on dose rate, linear energy transfer (LET), and fractionation of dose.*

6. QF of neutrons vs QF for gamma, beta, and internal alpha dose.

B. High Dose Effects (More than 25 rem)

1. Blood changes begin about 50-100 rem.

2. Acute radiation syndrome above about 100 rem in 1 day.

   a. Nausea, vomiting, fatigue, leukopenia (lower resistance to infection), hair loss.

   b. Lethality above about 200 rem - hemopoietic vs. GI vs. CNS death.

   c. Loss of fertility.

   d. Possible long-term increase in cancer.

3. Effects of spreading out dose

   a. No acute syndrome expected at 5 rem/year for 20 years.

   b. Increase chances of cancer by up to a few percent.

   c. Recent National Academy of Sciences BEIR III estimates, UNSCEAR 1982 estimates.*

4. Cataracts, above 200 rem.

5. Effects on pregnant women.

   a. Effects on mother as above.

   b. Teratogenic effects on child (serious above 25 rem, keep dose to fetus less than 0.5 rem during gestation).

   c. Higher cancer (including leukemia) incidence in children irradiated in utero.

   d. Summary of instructions in Regulatory Guide 8.13, NCRP Report 40.

6. Sterility

   a. Possible azospermia and temporary sterility above about 50 rem.

   b. Permanent sterility possible only at exposures in lethal range.

7. Skin or surface tissue "burns" for partial body or extremity exposures.

   a. Erythema above about 200 rad.

   b. Ulceration, permanent scarring above about 800 rad.

   c. Necrosis, amputation, late cancer possible above about 1500 rad.

C. Low Dose Effects (Less than 25 rem)

1. Slight blood changes.

2. Chromosomal anomalies above about 5 rems.

3. Genetic effects - first generation and equilibrium.

4. Cancer - relative risks and latent periods.

5. Chances of cancer and genetic effects vs. dose - kinds of dose-response relationships.

6. Nonthreshold concept for gene mutations.

7. Comparisons of radiation risks, risks from other industrial employment, and common risks of everyday life.

8. Possible synergism between low dose radiation and chemical exposures.

9. Balancing individual and collective dose risks.

IV. RADIATION EXPOSURE AND DOSE LIMITS

A. Whole Body Exposure and Dose Limits

1. Current 10 CFR Part 20 limits.

   a. Application of dose limits to whole body, head and trunk, active blood forming organs, lens of eyes, and gonads, to the specific plant operating conditions.

   b. Practical application of weekly or monthly dose limits according to plant radiation safety programs.

   c. Actions when exceeded and employee's responsibilities in meeting regulatory and plant requirements.

   d. Practical conversions of R to rad and rem.

   e. New SI units.*

2. ICRP 26 dose limiting system.*

B. Partial Body Exposure and Dose Limits

1. Current 10 CFR Part 20 limits.

   a. Hands and forearms, feet and ankles.

   b. Skin.

   c. Management of dose limits according to plant procedures.

2. Conversion and summing of partial body doses to obtain weighted dose-equivalent of whole body exposure according to ICRP 26.*

C. Requirements and Company Policies for Keeping Doses "As Low As Reasonably Achievable (ALARA)".

1. Citations in 10 CFR Part 20, regulatory guides, ICRP and NCRP.

2. Biological reasons for maintaining doses ALARA.

D. Limits on Concentrations and Intakes of Radioactive Material

1. Current 10 CFR Part 20 limits on air and water concentrations of uranium and daughter radionuclides.

2. Importance of plant equipment for limiting and monitoring air concentrations.

3. More recent information on chemical toxicity of uranium.

4. Forms and compounds in plant for which chemical toxicity may be significant relative to radiological toxicity, if any.

5. Target organs receiving greatest doses for uranium compounds that may become airborne.

6. Need to maintain intakes and internal doses ALARA.*

E. Plant Contamination Limits

1. Suspension and resuspension of contamination as possible sources of airborne radioactivity - nonvolatile dusts, mists, metal, fumes.

2. Possibilities for ingestion of unsealed radioactive material.

3. Use of practical contamination limits to control exposure ALARA to intake of radioactive material (reference Regulatory Guides 8.24 and 8.21).

V. PRINCIPLES AND WORK PRACTICES FOR THE EMPLOYEE'S CONTROL OF OWN RADIATION EXPOSURE

A. Principles of Self-Protection from External Radiation

1. Field Use of Radiation Survey Instruments by the worker.

a. Types of survey instruments and their functions.

b. Selection and proper use of survey instruments by the worker.

2. Limiting time of exposure

a. Interpreting exposure or dose rates per hour in terms of minutes and seconds of exposure.

b. Exposure is proportional to time in the radiation field.

c. Plan operations and practice with nonradioactive materials to reduce handling times where appropriate.

d. Maximum beta dose rates near uranium compounds are 200 to 250 millirad per hour.

e. Maximum gamma exposure rates near purified uranium compounds are 2 to 3 mR/hour except during criticality.

f. Exposure rates in areas where uranium daughter products may be concentrated.

3. Maximizing distance

   a. Inverse square reduction of dose rate with distance for small gamma ray sources.

   b. Rapid attenuation of beta exposures with distance in air - keep skin of whole body at arm's length where possible.

   c. Use tongs and handling equipment rather than hands for manipulating radioactive materials except where written procedures indicate limited handling of certain materials to save time.

4. Criticality safety

   a. Examples of criticality incidents

   b. Methods of prevention - geometry (approved containers storage), mass limits (safe batches), density, moderation, maximum enrichment, procedural controls, material identification.

   c. Protective actions when criticality alarm sounds.

   d. Collection of wastes in safe batch containers.

   e. Maintenance of integrity of waste storage facility.

   f. Preventing loss or misidentification when transporting materials between areas or laboratories.

   g. Inventory control and accountability of special nuclear materials.

5. Use of shielding

   a. Attenuation of gamma rays by shielding provided in plant equipment.

   b. Need to shield beta rays with light (low Z) materials to avoid additional x-radiation.

   c. Protective clothing as partial shielding against beta radiation.

   d. Self-shielding of material in bulk form (self-absorption).

6. Proper use of personnel monitoring equipment.

B. Principles of Self-Protection from Internal Radiation Exposure (due to breathing or eating (ingesting) radioactive material).

1. Processes that generate airborne radioactivity or contamination.

   a. Uranium hexafluoride evaporation - importance of early leak detection, actions.

b. Uranium hexafluoride - ammonium diuranate conversion.

c. Milling - ball, hammer, jet

d. Blending

e. Powder pressing operations

f. Sintering

g. Grinding of sintered products

h. Glove boxes used in ball milling, screening, blending, pellet pressing operations.

i. Hoods and exhaust ducts for equipment used in fabricating uranium pellets.

j. Hoods vented through filters for grinding, cutting, powder mixing, pressing, powder sampling.

h. Radioactive chips and dusts from lathes, welding fixtures, and drill presses.

i. Changing of filters and prefilters in hood exhausts and ventilation exhaust plenums.

j. Sources of contamination in chemical and process technology laboratories.

k. Scrap recovery processes.

l. Incinerator

m. Decontamination and waste disposal operations.

2. Rules for protecting against ingestion and inhalation of radioactive material:

a. Wearing work gloves according to plant procedures.

b. Proper use of protective clothing.

c. Proper use of change room facilities and separation of clean areas, step-off line.

d. Procedures and order of donning and removal of shoe covers, coveralls, gloves, head covers, and respiratory protective equipment. Exit surveys - alarms and actions for contamination.

e. Rules against smoking, drinking, eating, gum and tobacco chewing, and application of cosmetics in potentially contaminated areas.

f. Use of radiation survey instruments for checking contamination:

(1) Alpha contamination survey meters.

(2) Beta contamination surveys.

(3) Gamma emitter contamination surveying.

(4) Interpretation of contamination surveys, action levels, and actions (See Regulatory Guide 8.24).

(5) Need for daily survey meter checks and 6-month calibrations.

g. Choice of respiratory protective equipment - dust, mists, metal fumes, chemical cartridges, removal mechanisms (Reference 13, NUREG-0041).

h. Rules and procedures for fitting, wearing and storing respiratory protective equipment.

i. Responses to air monitor readings and alarms.

j. Visual detection of certain forms of uranium contamination.

k. Need to maintain integrity of smooth work and floor surfaces.

l. Proper removal of protective clothing, monitoring, showering and decontamination at end of workshift and before lunch periods of other periods when leaving controlled areas.

3. Rules for use of hoods, glove boxes, and other enclosures for containment of radioactive dusts and fumes:

a. Maintenance of integrity of laminar flow in hoods.

b. Maintenance of gloves in gloveboxes

c. Glove changing methods

d. Checking air flow or negative pressure indicators

e. Entry to and removal of materials from containment systems.

4. Radiation caution signs and controls for access to restricted areas. Radiation areas, airborne radioactivity areas, radiation work permit signs, uranium storage signs, shipping labels, door symbols, door seals.

5 Action levels for reporting personal, equipment, or area contamination to supervisor or the Radiation Safety Office.

6. Procedures for surveying and opening packages.

7. General good housekeeping - prevent contamination buildup.

C. Other Plant Operating Procedures Related to Maintaining Exposures ALARA During the Storage, Transfer or Use of Radioactive Materials

1. Proper storage of radioactive materials not in use.

2. Use of fire extinguishers in fires involving special nuclear material.

VI. RADIATION PROTECTION PROGRAM PROVIDED BY MANAGEMENT

A. General surveillance of plant safety - locations of radiation protection offices.

B. Surveys of radiation and radioactive contamination

1. External beta-gamma exposure level monitoring.

2. Monitoring surfaces with alpha detectors.

3. Smear surveys of plant areas.

4. Leak testing of sealed sources.

C. Personnel Monitoring for External Exposure

1. Providing and collecting personnel monitoring badges (film, TLD, etc.).

2. Providing and collecting pocket dosimeters.

3. Calibration or quality control checks on dosimeter evaluations.

4. Dosimeter evaluation or arrangements for vendor evaluation.

5. Review of personnel exposure data and reports.

6. Maintenance of exposure record and retrieval systems.

7. Preparation of reports to workers, plant management, and the government as required by government regulations and plant policies.

8. Special exposure investigations and notifications to regulatory agencies, as appropriate.

D. Internal Exposure Monitoring ("Bioassay")

1. Need for excretion analyses and in vivo counting to evaluate possible intakes of radioactive material.

2. Precautions necessary in sample collection to obtain representative, uncontaminated samples. Showering necessary for in vivo or "whole body" counting.

3. Calculation of internal doses from bioassay analyses by radiation safety staff using mathematical models of ICRP and others.*

4. Actions levels for different forms of uranium and actions that may be taken (See Regulatory Guide 8.11).

5. Record maintenance and reports.

6. Availability to worker of information in the internal dose record.

7. Scheduling workers for bioassay or in vivo ("whole body" or "lung counting") measurements.

E. Special Exposure and Job-Time Studies as Requested by Managers

F. Air Monitoring to Protect Against Radioactive Material Intake

1. General air monitoring.

2. Breathing zone stationary air samplers for work station monitoring.

3. Ventilation checks - need to ensure integrity and proper air flow for all hoods, fans, and air intake and exhaust systems.

4. Personal or lapel air samplers.

G. Radiation Safety Instrument Calibration and Maintenance

1. Calibration.

2. Battery replacement and adjustment.

3. Pocket chamber and Personnel Monitoring Badge Calibrations or Quality Control Checks.

4. Survey instrument repair.

5. Instrument selection and distribution.

6. Check source calibrations and inventory.

H. Protection of Environment Outside Plant

1. Environmental sampling program.

2. Air filtration system checks and maintenance.

3. Importance of maintaining integrity of ventilation filtration systems.

4. Waste disposal program.

I. Responsibilities of, and Services Available from, the Radiation Safety Office (Administration, Consultation, Worker and Public Information)

1. Review or approval from radiation safety standpoint of facilities, equipment, and procedures used in areas where radioactive materials are handled.

2. Assisting management in preparation of license applications and amendments.*

3. Preparation of safety evaluation reports for licensing.*

4. Programming of routine required surveys.*

5. Supervision of routine radiation safety operations.

6. Training and retraining all personnel in radiation safety and criticality principles and rules at levels of depth and breadth related to jobs and tasks.

7. Training in the wearing of respirators.

8. Consultation with management on radiation safety matters.*

9. Counseling workers as requested on radiation safety matters - answering questions dealing with incidents of personal contamination or intake.

10. Conduct radiation safety audits with management.*

11. Conduct radiation safety inspections with government inspectors.*

12. Selecting, ordering, and maintaining radiation safety instruments, equipment, and supplies.

13. Radiation record maintenance and related computer programming.

14. Planning responses to incidents and emergencies involving radioactive materials.

15. Providing instructions to outside agencies (e.g., fire department) that would respond to an emergency situation involving or potentially involving radiation.*

16. Meeting to keep up with radiation safety technology and regulatory changes.*

17. Preparation of radiation safety reports to management.*

VII. EMERGENCY PLAN AND DRILLS

A. Plant safety and accident control procedures.

B. Methods of dealing with process malfunctions, checking fixed station samplers for contamination immediately upon suspicion of a release of uranium.

C. Emergency signals and alarms.

D. Evacuation routes, evacuation route signs, and evacuation procedures.

E. Assembly areas and individual reporting locations (staging areas).

F. Emergency communications and command center.

G. Location of any necessary emergency equipment.

H. First aid instructions.

I. Conduct during emergency drills.

TABLE 2

STUDENT EVALUATION OF COURSE

Name:

Instructor:

The following statements are to be rated on a scale of 1 to 5. A rating of 5 indicates complete agreement with the item while a 1 indicates that you do not agree at all. Ratings of 3 mean general agreement.

	COMPLETELY		GENERALLY		NOT AT ALL
1. The objectives of the course were fully explained at the beginning of the course.	5	4	3	2	1
2. Training objectives of the course are realistic and obtainable.	5	4	3	2	1
3. Training objectives are proper for the stated content of the course.	5	4	3	2	1
4. Course materials were organized in a clear and understandable manner.	5	4	3	2	1
5. Tests were representative of the course content.	5	4	3	2	1
6. The grading of tests and performance standards were explained at the beginning of the course.	5	4	3	2	1
7. The instructors use of instructional aids and training devices were adequate for this course.	5	4	3	2	1
8. I am satisfied with the course.	5	4	3	2	1
9. This course will help me perform my job.	5	4	3	2	1
10. I am aware of how this course fits with all of my previous and planned future training.	5	4	3	2	1

Student Evaluation of Course

(From P. M. Haas et al., Reference 4, 1983. This type of form may be helpful in providing feedback for training improvements and in giving the employee motivation in cooperating with the training staff.)

TABLE 3

STUDENT EVALUATION OF INSTRUCTOR

Name:

Instructor:

The following statements are to be rated on a scale of 1 to 5. A rating of 5 indicates complete agreement with the item while a 1 indicates that you do not agree at all. Ratings of 3 mean general agreement.

	COMPLETELY		GENERALLY		NOT AT ALL
1. The instructor's presentations are clear.	5	4	3	2	1
2. The instructor is prepared for class.	5	4	3	2	1
3. I can communicate with the instructor.	5	4	3	2	1
4. Questions that come up in class are always answered.	5	4	3	2	1
5. The instructor has a good grasp of the course content.	5	4	3	2	1
6. The instructor stimulates discussion.	5	4	3	2	1
7. The instructor shows enthusiasm for his job during class sessions.	5	4	3	2	1
8. All levels of student understanding are addressed by the instructor.	5	4	3	2	1
9. At the end of each class the instructor summarizes what has been taught.	5	4	3	2	1
10. The instructor uses class time efficiently.	5	4	3	2	1

Student Evaluation of Instructor

(From P.M. Haas et al., NUREG/CR-3414, 1983, Reference 4.)

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This report provides general information and references useful for establishing or operating radiation safety training programs in plants that manufacture nuclear fuels or process uranium compounds that are used in the manufacture of nuclear fuels. In addition to a brief summary of the principles of effective management of radiation safety training, the report also contains an appendix that provides a comprehensive checklist of scientific, safety, and management topics, from which appropriate topics may be selected in preparing training outlines for various job categories or tasks pertaining to the uranium nuclear fuels industry. The report is designed for use by radiation safety training professionals who have the experience to utilize the report to not only select the appropriate topics, but also to tailor the specific details and depth of coverage of each training session to match both employee and management needs of a particular industrial operation.

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