MODULE 3.0: CONTAMINATION CONTROL

Introduction

Welcome to Module 3.0 of the General Health Physics Practices for Fuel Cycle Facilities Self-Study Course! This is the third of seven modules in this self-study course. The purpose of this module is to assist the trainee in describing the basic features of an effective contamination control program at fuel cycle facilities. This self-study module is designed to assist you in accomplishing the learning objectives listed at the beginning of the module. There are seven learning objectives in this module. The module has self-check questions and an activity to help you assess your understanding of the concepts presented in the module.

Before You Begin

It is recommended that you have access to the following materials:

- Trainee Guide
- Regulatory Guide 8.24, Health Physics Surveys During Enriched Uranium-235 Processing and Fuel Fabrication
- Regulatory Guide 8.25, Air Sampling in the Workplace
- Regulatory Guide 8.30, Health Physics Surveys in Uranium Recovery Facilities

Complete the following prerequisites:

- Module 1.0 Health Physics Fundamentals
- Module 2.0 Radiological and Chemical Properties of Uranium

How to Complete this Module

1. Review the learning objectives.
2. Read each section within the module in sequential order.
3. Complete the self-check questions and activities within this module.
4. Check off the tracking form as you complete the self-check questions and/or activity within the module.
5. Contact your administrator as prompted for a progress review meeting.
6. Contact your administrator as prompted for any additional materials and/or specific assignments.
7. Complete all assignments related to this module. If no other materials or assignments are given to you by your administrator, you have completed this module.
8. Ensure that you and your administrator have dated and initialed your progress on the tracking form.
9. Go to the next assigned module.

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MODULE 3.0: CONTAINMENT CONTROL

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MODULE 3.0: CONTAMINATION CONTROL

LEARNING OBJECTIVES

3.1 Upon completion of this module, you will be able to describe the basic features of an effective contamination control program at fuel cycle facilities.

3.1.1 Identify airborne contamination hazards.

3.1.2 Recognize special considerations necessary to properly control and assess airborne contamination.

3.1.3 Identify surface contamination hazards.

3.1.4 Recognize special considerations necessary to properly control and assess surface contamination.

3.1.5 Identify personnel contamination hazards.

3.1.6 Recognize special considerations necessary to properly control and assess personnel contamination.

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MODULE 3.0: CONTAMINATION CONTROL

Learning Objective

When you finish this section, you will be able to:

3.1.1 Identify airborne contamination hazards.

AIRBORNE CONTAMINATION HAZARD

Sources of Airborne Material

Many of the sources of airborne radioactive material at fuel cycle facilities are similar to sources of airborne contaminants at conventional facilities.

A list of potential airborne sources specific to fuel cycle facilities includes the following:

- Yellowcake drying and packaging areas
- "Dirt-moving" activities for recontouring tailings piles or cleaning up contaminated areas
- Process areas where liquids spill and then dry (at a conventional uranium recovery facility)
- Radium filter press (at in-situ leach facilities)
- Mechanical fragmentation, i.e., grinding, abrasive saws, sandblasting
- Combustion, such as an accidental uranium fire
- Heating, such as a uranium melting operation
- Formation from bubbles, foams, or highly agitated liquids, possible during some steps in the conversion process and in uranium melting operations
- Condensation of liquid or solid particles from the gas phase, such as a release at a uranium enrichment facility
- Formation of particles from the products of gas-phase reactions such as the production of uranyl fluoride ($UO_2 F_2$) from the reaction of uranium hexafluoride (UF_6) with water in moist air
- Formation of solid, radioactive nuclides from gaseous parent nuclides that may then attach to nonradioactive aerosol particles, such as radon decay products
- Adsorption of gaseous, radioactive materials on nonradioactive aerosols such as radon

Such possible sources should be identified at each stage of the fuel cycle and monitored as appropriate.

Self-Check Questions 3-1

INSTRUCTIONS: Answers are located in the answer key section of the Trainee Guide.

Complete the following questions. Answers are located in the answer key section of the Trainee Guide.

1. List three sources of airborne material in mining and recovery facilities.

You have completed this section.
Please check off your progress on the tracking form.
Go to the next section.

MODULE 3.0: CONTAMINATION CONTROL

Learning Objective

When you finish this section, you will be able to:

3.1.2 Recognize special considerations necessary to properly control and assess airborne contamination.

AIRBORNE CONTAMINATION CONTROL

Types of Samplers

Air samplers can be broadly divided into two categories: general air samplers (GAS) and breathing zone samplers (BZS).

GASs are typically used for the following:

- Determining the intake of material by workers
- Detecting the loss of containment
- Evaluating the need for respiratory equipment
- Verifying contamination control
- Trending activity in an area over long periods of time

BZSs are used to determine the intake of material by workers. They are located in the work area, as close to the worker's breathing zone as practical. Breathing zone monitors may be "fixed" (designed to stay in one location) if workers primarily work in one area, or may be "portable" (carried with the worker).

Studies conducted in facilities with processes similar to those at fuel cycle facilities have indicated that GASs are often not good predictors for intake by workers.

For example, a study by Gonzales et al., Relationship Between Air Sampling Data from Glove Box Work Areas and Inhalation Risk to the Worker, Los Alamos National Laboratory Informal Report LA-5520-MS, 1974, studied glove box environments and indicated that levels in the breathing zone of workers could be up to 250 times the levels measured a few feet away by a general air sampler. The breathing zone can be more representative than the General Area. Similar results have been found at other facilities handling uranium. Such studies indicate the need for positive verification of the validity of general air sampling if it is to be used to determine worker intake. Techniques for such validation are described in Regulatory Guide 8.25, Air Sampling in the Workplace.

Air Filters

Because the primary hazard of an intake at a fuel cycle facility is the alpha radiation, care must be taken in the selection of filters to ensure that proper analysis can be conducted. In many cases, an isotopic analysis of the filter will not be needed because the composition of the materials is known. Therefore, fiberglass filters or cellulose filters may be used and counted by proportional counters, scintillation counters, or other appropriate alpha counting systems, provided that corrections are made for losses due to burial of the alpha-emitting material in the filter. An alternative would be to count the filters by liquid scintillation counting, in which case the burial losses would be nonexistent. If alpha spectroscopy of the filters is required, a surface-loading filter such as a membrane filter is required.

Beta-gamma counting of air samples can be obtained easily with standard beta-gamma counting equipment such as Geiger-Müeller (G-M) detectors and scintillation counters. Likewise, gamma spectroscopy can be accomplished with standard high-purity germanium (HPGe) systems or use of thallium-activated sodium iodide[NaI(Tl)] systems.

Frequency and Limits of Air Sampling

Recommended frequencies for air sampling that are applicable to fuel cycle facilities are provided in Table 3-1, Survey Frequencies For Enriched U-235 Processing and Fuel Fabrication (Regulatory Guide 8.24-8), and Table 3-2, Summary of Survey Frequencies (Regulatory Guide 8.30-9), for uranium recovery operations. Limits for air concentrations in terms of annual limits on intake (ALIs) and derived air concentrations (DACs) are listed by radionuclide and solubility class in Appendix B, 10 CFR Part 20.

Note: Module 4.0 discusses ALIs and DACs in detail.

Radon Considerations

Radon and radon-daughter hazards are primarily associated with the mining and recovery operations in the fuel cycle. Recommendations for techniques for surveying for radon daughters are provided in section 2.3 of Regulatory Guide 8.30. The modified Kusnetz method is recommended and described in some detail, but other techniques are also discussed. Uranium recovery facilities routinely use “working levels” to characterize airborne radon daughter concentrations. The use of this unit is in no way inconsistent with the current 10 CFR Part 20.

Special Considerations in Air Sampling

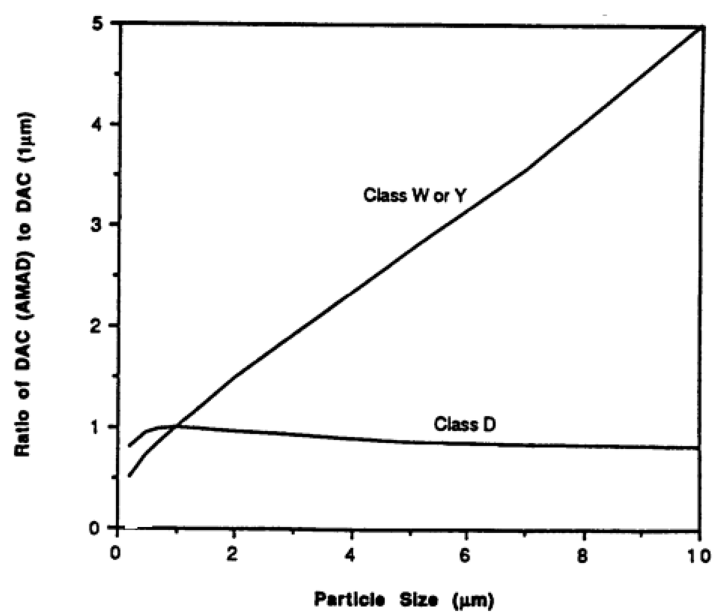
Special considerations in air sampling are concerned with particle-size distribution, solubility, and transuranics.

Particle-size distribution

If no information is available regarding the particle-size distribution, a conservative assumption is normally made that the activity median aerodynamic diameter (AMAD) is 1 micron, 1 x 10^{-6} meters. The 1-micron AMAD is the default particle size on which the ALIs and DACs of 10 CFR Part 20 are based. The AMAD is a commonly used measure of the size of radioactive particles in the air. An AMAD of 1 micron implies that half of the particles in a particular air sample have smaller diameters than 1 micron, and half have larger diameters. Particles significantly larger than 1 micron often do not represent as serious a health hazard, since they are not as likely to be inhaled deeply into the lungs. According to NRC Regulatory Guide 8.25, adjustments to the DACs are permitted.

An example of a correction for U-235 is given in Figure 3-1, DAC Ratios for U-235. This figure clearly shows that for class W or Y materials, the DAC can be increased almost linearly with the particle size. In fuel cycle facilities in which the particle sizes are suspected to be large, measurement of particle size by cascade impactors or similar techniques may be advantageous in order to allow the use of less conservative DAC values.

Figure 3-1. DAC Ratios for U-235



Solubility

Solubility classes (D, W, or Y) for various uranium compounds are given in a variety of references including Appendix B of 10 CFR Part 20. However, at some fuel cycle facilities, the appropriateness of some of these solubility classes is questionable. In those cases, solubility studies can be conducted to determine the correct solubility classes. Such adjustments are discussed in Regulatory Guide 8.25.

Transuranics

While transuranic materials are normally not present in hazardous levels at most fuel cycle facilities, their very low DAC values, high specific activities, and their emission of very little penetrating radiation make them extremely difficult to assay. If transuranics are suspected to be present as the result of recycled uranium or for other reasons, careful analysis techniques including replicate samples and large volumes may be needed to properly quantify the hazards.

Table 3-1. Survey Frequencies for Enriched U-235 Processing and Fuel Fabrication

Plant Area	External Radiation Surveys	Air Sampling	Removable Surface Contamination Survey
Uranium receiving, warehousing shipping	Monthly	Continuous air sampling; samples changed weekly and following any indication of release leading to airborne concentrations of uranium	Monthly and following any indication or release
Active processing areas UF_6 - UO_2 conversion, chemical processing, scrap recovery, powder processing, rod loading, decontamination, waste processing, change rooms	Monthly	Continuous air sampling; samples changed each shift, following any change in equipment or process control, and following detection of any event that may have released uranium, i.e., leakage (valves, pipes, tanks, trays), spillage, or blockage of process equipment (conveyors, elevators, hoppers)	Weekly and following any indication of release
Chemical-metallurgical laboratory	Monthly	Continuous air sampling; samples changed each shift	Weekly
Fuel assembly, inspection, storage	Monthly	Continuous sampling; samples changed weekly	Monthly
Lunch rooms, cafeterias, snack bars, vending machine areas	Quarterly	--	Daily

Table 3-2. Summary of Survey Frequencies for Uranium Recovery Facilities (Source: NRC Regulatory Guide 8.30, rev 1, May 2002)

Type of Survey	Type of Area	Survey Frequency	Lower Limit of Detection
1. Uranium ore dust	Airborne radioactivity areas Other indoor process areas Outdoor areas	Weekly grab samples Monthly grab samples Quarterly grab samples	5×10^{-12} µCi/ml (uranium)
2. Yellowcake	Airborne radioactivity areas Other indoor process areas Special maintenance involving high airborne concentrations of yellowcake	Weekly grab samples Monthly grab samples Extra breathing zone grab samples	1×10^{-11} µCi/ml
3. Radon daughters	Areas that exceed 0.08 working level Areas that exceed 0.03 working level Areas below 0.03 working level	Weekly radon daughter grab samples Monthly radon daughter grab samples Quarterly radon daughter grab samples	0.03 WL
4. External radiation: Gamma Beta	Throughout the UR facility Radiation areas Where workers are in close contact with yellowcake	Semiannually Quarterly Survey by operation done once plus whenever procedures change	0.1 mR/hr 1 mren/hr
5. Surface contamination	Yellowcake areas Eating rooms, change rooms, control rooms, offices	Daily Weekly	Visual 500 dpm alpha per 100 cm^2
6. Skin and personal clothing	Yellowcake workers who shower Yellowcake workers who don't shower	Quarterly Each day before leaving	500 dpm alpha per 100 cm^2
7. Equipment to be released	Equipment to be released that may be contaminated	Once before release	500 dpm alpha per 100 cm^2
8. Packages containing yellowcake	Packages	Spot-check before release	500 dpm alpha per 100 cm^2
9. Ventilation	All areas with airborne radioactivity	Daily	Not applicable
10. Respirators	Respirator face pieces and hoods	Before reuse	100 dpm alpha per 100 cm^2

Self-Check Questions 3-2

INSTRUCTIONS: Answers are located in the answer key section of the Trainee Guide.

Answers are located in the answer key section of the Trainee Guide.

1. What are two categories of air samplers?

2. Fill in the blanks.

   - Determining the intake of__________ by workers.
   - Detecting the______________of containment
   - Evaluating the need for__________________equipment
   - Verifying contamination ___________
   - Trending activity in an area over __________periods of time

3. Name two NRC sources of information that discuss techniques for validation of air samples.

4. Care must be taken in the selection of filters to ensure that: (circle one)

   A. Isotopic analysis of the filter will not be needed
   B. Proper analysis can be conducted
   C. Alpha radiation is not present
   D. Particle size distribution is evenly spaced

5. In active processing areas UF_6 - UO_2 conversion, chemical processing, scrap recovery, powder processing, rod loading, decontamination, waste processing, and change rooms, when should air sampling occur and how often should samples be changed?

6. Name a resource where limits for air concentrations in terms of ALIs and DACs are listed by radionuclide and solubility class.

7. What is activity median aerodynamic diameter (AMAD)?

8. What does Figure 3-1, DAC Ratios for U-235, indicate?

Answer True or False to the following statements.

9. ______ At some fuel cycle facilities, the appropriateness of some of the solubility classes (D, W, or Y) is questionable.

10. ______ If transuranics are suspected to be present as the result of recycled uranium or for other reasons, careful analysis techniques including replicate samples and large volumes may be needed to properly quantify the hazards.

You have completed this section.
Please check off your progress on the tracking form.
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Self-Check Questions 3-3

INSTRUCTIONS: Answer is located in the answer key section of the Trainee Guide.

1. Because of its low specific activity, uranium contamination on surfaces generally does not present a significant hazard to personnel unless the material __________.

   A. Ignites
   B. Is swept
   C. Becomes resuspended and is inhaled
   D. Is spread over a wide surface area

You have completed this section.
Please check off your progress on the tracking form.
Go to the next section.

Learning Objectives

When you finish this section, you will be able to:

3.1.3 Identify surface contamination hazards.

3.1.4 Recognize special considerations necessary to properly control and assess surface contamination.

SURFACE CONTAMINATON HAZARD

Overview of Surface Contamination Control

Because of its low specific activity, uranium contamination on surfaces generally does not present a significant hazard to personnel unless the material becomes resuspended and is inhaled. However, good as low as reasonably achievable (ALARA) practices require that surface contamination be kept within reasonable levels in order to minimize the transport of contamination to clean areas, minimize personnel contamination, and prevent inadvertent intake of materials.

SURFACE CONTAMINATION CONTROL

Characterization of Uranium Surface Contamination

The chemical and physical characteristics of uranium contamination on surfaces vary widely from one facility to another and even from one area of some facilities to another. In some cases, such as a UF_6 release, uranyl fluoride is produced, which is easily dispersible, settles as a fine dust over large areas, and can easily be resuspended by entry into the area. Other forms of uranium such as uranyl nitrate, are highly soluble and tend to remain in solutions. However, spills of such materials may represent a hazard if allowed to dry and disperse. Physical factors such as grinding, machining, etc., may also greatly affect the extent and characteristics of surface contamination.

Radiological characteristics also factor into the detection of material and level of hazard. For example, low enrichment uranium and its immediate decay products typically have an alpha-to-beta ratio of nearly one. See Table 3-3, Calculated Alpha and Beta Activity of Uranium in Equilibrium with Initial Short-Lived Daughters, and Figure 3-2, Alpha Beta Ratios versus Enrichment. This allows for easy detection of the contamination with standard thin-window Geiger-Müeller detectors or other portable survey instruments that readily respond to the beta radiation. However, as enrichment increases, the alpha-to-beta ratio greatly increases to levels exceeding 100 to 1 at high enrichments. Therefore, alpha monitoring becomes the method of choice at high enrichments or around uranium that has recently been chemically separated from its immediate decay products.

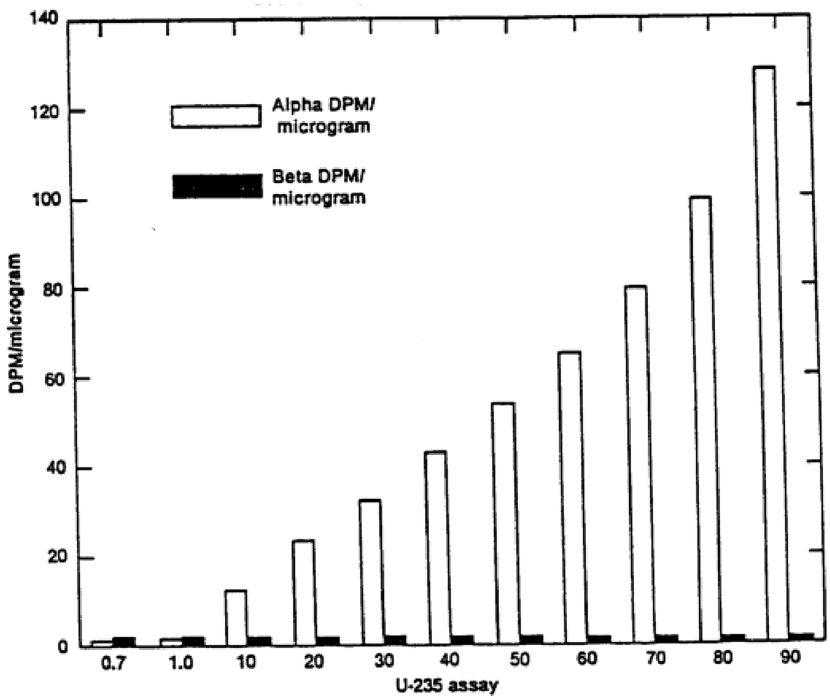
Note: In uranium mining and recovery facilities, alpha or beta/gamma monitoring may be used, dependent on the particular radionuclides, or mix of radionuclides, present and on necessary detection sensitivity.

Contaminants present as the result of recycled uranium or for other reasons need to be considered as well. In some cases, such contaminants may be concentrated in certain areas and may represent significant hazards when the level of uranium is much less. For example, technetium-99 tends to concentrate in the high-enrichment stream at gaseous diffusion plants. Other recycled uranium contaminants may concentrate in various waste streams of uranium recovery operations. For example, fission products will concentrate in the raffinates from the solvent extraction process while the transuranics may remain in the uranyl nitrate, depending upon the recovery process used.

Table 3-3. Calculated Alpha and Beta Activity of Uranium in Equilibrium with Initial Short-Lived Daughters

% U-235 Enrichment	Alpha DPM Per Microgram	Beta DPM Per Microgram
0.7	1.3	2.1
1	1.6	2.1
10	12.5	2.0
20	23.6	1.9
30	32.3	1.8
40	43.0	1.7
50	53.7	1.6
60	64.9	1.4
70	79.4	1.3
80	99.3	1.2
90	127.8	1.1

Figure 3-2. Alpha Beta Ratios versus Enrichment



Special Precautions for Surface Contamination Control

Since the primary risk of uranium is from internal intake of material (resulting from inhalation, ingestion, or penetration of the skin), the major goal of surface contamination surveys is the determination of the removable contamination levels. Removable contamination is uranium contamination present on a surface that can be transferred to a dry-smear by rubbing with moderate pressure. Fixed contamination levels will normally only be an external hazard.

Recommended methods for determining removable levels of contamination are given in Regulatory Guide 8.24, Health Physics Surveys During Enriched Uranium-235 Processing and Fuel Fabrication, Section 1.4; and Regulatory Guide 8.30, Health Physics Surveys in Uranium Recovery Facilities, Section 2.5.

Standard smear techniques (dry smears over 100 cm^2) and standard counting techniques for alpha and beta-gamma contamination are recommended. However, because of the low specific activity of uranium, contamination may be visible before contamination limits are reached. For example, Regulatory Guide 8.30 discusses the fact that, in uranium yellowcake areas, daily visual inspections can be conducted to determine if contamination needs to be removed. However, this visual test would not be applicable in areas such as lunch rooms where lower levels of contamination should be maintained. Also, care should be taken in the removal of such contamination to ensure that material is not resuspended. Techniques that may stir up contamination such as dry floor-sweeping should be avoided. Instead, filtered vacuum systems should be used or materials should be hosed into floor sumps.

Recommended frequencies for surface contamination and limits for removable contamination are provided in Regulatory Guides 8.24 and 8.30.

The relevant tables in Regulatory Guide 8.24 are:

- Survey Frequencies for Enriched U-235 Processing and Fuel Fabrication (reproduced in this guide as Table 3-1)
- Limits for Removable Surface Contamination (Alpha Activity) in Enriched Uranium Processing and LWR Fuel Fabrication Plants (reproduced in this guide as Table 3-4)

Those in Regulatory Guide 8.30 are:

- Summary of Survey Frequencies for Uranium Recovery Facilities (reproduced in this guide as Table 3-2)
- Surface Contamination Levels for Uranium and Daughters on Equipment to be Released for Unrestricted Use, Clothing, and Nonoperating Areas of Uranium Recovery Facilities (reproduced in this guide as Table 3-5)

Table 3-4. Limits For Removable Surface Contamination (Alpha Activity) in Enriched Uranium Processing and LWR Fuel Fabrication Plants

Item	Limit	
	DPM/100 cm^2	μCi/cm^2
Controlled areas	5,000	2.3×10^{-5}
*Protective clothing worn only in controlled areas	1,000	4.5×10^{-6}
Uncontrolled areas onsite	200	9×10^{-7}
*Personal clothing worn outside restricted areas	200	9×10^{-7}
Skin	0**	0**

* Determined by direct measurement.

** Decontamination attempts without a medical consultant present should be restricted to approved decontamination procedures agreed upon by the licensee and licensee's medical consultant. If such attempts do not reduce the contamination to acceptable levels, the aid of a physician should be obtained.

Table 3-5. Surface Contamination Levels for Uranium and Daughters on Equipment to be Released for Unrestricted Use, Clothing, and Nonoperating Areas of Uranium Recovery Facilities*

Average	5,000 dpm alpha per 100 cm^2	Averaged over no more than 1 m^2
Maximum	15,000 dpm alpha per 100 cm^2	Applies to an area of not more than 100 cm^2
Removable	1,000 dpm alpha per 100 cm^2	Determined by smearing with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the smear

Note: The contamination levels are given in units of dpm/100 cm^2 because this is the minimum area typically surveyed. When performing a smear or wipe test, the area should roughly approximate the area to be smeared.

Additional Note: Lower values are to be used when contamination is primarily a single radionuclide, such as Th-230.

* These values are taken from: Regulatory Guide 1.86, Termination of Operating Licenses for Nuclear Reactors, and Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for By-Product Source or Special Nuclear Material, Division of Fuel Cycle and Material Safety, USNRC, June 1974.

Self-Check Questions 3-4

INSTRUCTIONS: Answer True or False to the following statements. Answers are located in the answer key section of the Trainee Guide.

1._____ The chemical and physical characteristics of uranium contamination on surfaces does not vary from one facility to another.

2._____ In a UF_6 release, uranyl fluoride is produced, which is indispersible.

3._____ Other forms of uranium, such as uranyl nitrate, are highly soluble and tend to remain in solutions. However, spills of such materials may represent a hazard if allowed to dry and disperse.

4._____ Physical factors such as grinding and machining may greatly affect the extent and characteristics of surface contamination.

5._____ Alpha monitoring is the method of choice at high enrichments or around uranium that has recently been chemically separated from its immediate decay products.

6._____ In uranium mining and recovery facilities, alpha or beta/gamma monitoring may be used, dependent on the particular radionuclide, or mix of radionuclides, present and on necessary detection sensitivity.

7._____ Recycled uranium contaminants may concentrate in various waste streams of uranium recovery operations.

8._____ The major goal of surface contamination surveys is the determination of the removable contamination levels.

9._____ Removable contamination is uranium contamination present on a surface that can be transferred to a dry-smear by rubbing with moderate pressure.

10.____ Because of the low specific activity of uranium, contamination may be visible before contamination limits are reached.

11.____ Removal of contamination should occur through dry floor sweeping.

You have completed this section.
Please check off your progress on the tracking form.
Go to the next section.

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MODULE 3.0: CONTAMINATION CONTROL

Learning Objective

When you finish this section, you will be able to:

3.1.5 Identify personnel contamination hazards.

PERSONNEL CONTAMINATION HAZARD

Because there are radioactive contamination hazards at fuel cycle facilities, requirements have been established for qualified personnel to develop health physics programs that protect health and minimize danger to life and property and ensure that the proposed equipment, facilities, and procedures are also adequate.

In order to protect personnel, the following types of activities are normally required:

- Adequate surveys
- Limits for worker exposure to external radiation
- Limits to airborne radioactive material
- Personnel radiation dosimeters
- Personnel protective equipment requirements
- Posting of warning signs and controlling access
- Records of radiation surveys and personnel monitoring reports
- Reports of over exposures

Identifying the Hazards

Operations personnel should be cognizant of those areas, subsystems, and processes that are prone to leaking or spreading “loose” contamination. Facility airflow and monitoring will alert personnel if a control problem exists. Facility personnel contamination monitors will alert of activities that occurred leading to the generation of contamination. Observation of the processes include—activities generating dust, change out of pumps, valves, fans, waste collection, etc.—should alert personnel to be ever mindful of “contamination potential” and therefore, control and avoidance.

Self-Check Questions 3-5

INSTRUCTIONS: Fill in the missing word in each statement. Answers are located in the answer key section of the Trainee Guide. Choose from the following words.

airborne	dosimeters	external	over
personnel	protective	surveys	warning

In order to protect personnel, the following types of activities may be required:

1. Adequate __________________
2. Limits for worker exposure to______________ radiation
3. Limits to_____________radioactive material
4. Personnel radiation ______________________
5. Personnel__________________equipment requirements
6. Posting of__________________signs and controlling access
7. Records of radiation surveys and_________________monitoring reports
8. Reports of__________________exposures

You have completed this section.
Please check off your progress on the tracking form.
Go to the next section.

Learning Objective

When you finish this section, you will be able to:

3.1.6 Recognize special considerations necessary to properly control and assess personnel contamination.

PERSONNEL CONTAMINATION CONTROL

Recommended limits for contamination on personal clothing and skin were previously given in Table 3-4, Limits For Removable Surface Contamination (Alpha Activity) in Enriched Uranium Processing and LWR Fuel Fabrication Plants, and Table 3-5, Surface Contamination Levels for Uranium and Daughters on Equipment to be Released for Unrestricted Use, Clothing, and Nonoperating Areas of Uranium Recovery Facilities.

Note that the limit for skin in Table 3-4 is listed as zero; however, in Section 2.6 of Regulatory Guide 8.24, it is stated that skin contamination levels may be proposed and justified by the license applicant. In Regulatory Guide 8.30, Section 1.6, it further states that contamination on personal clothing and skin should always be considered removable; therefore, the limit of 1,000 dpm alpha per 100 cm^2 should be used.

Special Precautions for Personnel Contamination Control

Other considerations for personnel contamination control programs are company-issued clothing and/or protective clothing to reduce the risk of personnel contamination, and the use of respiratory protective equipment to reduce the inhalation of airborne particulates. Selection of respiratory protective equipment should include consideration of other hazards besides radioactive particulates that may occur at fuel cycle facilities. For example, uranium processing operations may involve hazards due to solvent vapors as well as uranium particulates.

Self-Check Questions 3-6

INSTRUCTIONS: Answers are located in the answer key section of the Trainee Guide.

1. What do Regulatory Guides 8.24 and 8.30 state about skin contamination levels?

2. List three special considerations for personnel contamination control programs.

You have completed this section.
Please check off your progress on the tracking form.
Go to Activity 1.

Activity 1: NRC Regulatory and Guidance Documents

PURPOSE: The purpose of this activity is to review an example of loss of contamination control.

INSTRUCTIONS: Read the case study and then complete the questions. Answers are located in the answer key section of the Trainee Guide.

Chemical Operator's Skin Contamination

The following case study from a gaseous diffusion facility represents an example of loss of contamination control:

> The operator received the polybottles of acid solution and was told by a material handler that they were contaminated. The polybottles were encased in plastic bags. There were no health physics (HP) tags on the polybottles nor an HP survey with them. The operator wore neoprene gloves taped to her coveralls. Under the neoprene gloves were latex gloves over cotton gloves. She also had rubber shoe covers on her company-issued shoes and safety glasses. The X-705 personnel had known the uranium concentration and assays of the polybottles, but knew nothing about technetium. After transporting the polybottles to the processing unit, she donned a rubber apron and face shield as per the operating procedure. Each of the polybottles was opened and dumped onto the Cylinder Rinse Pit floor. A squeegee was used to assist the solution in reaching the pit drain where a pump transferred the solution to the processing columns.
>
> A caustic solution was poured into the hose stream to adjust the pH and, as required, a squeegee was used to guide the solution back to the processing columns. The operating procedure does not contain these steps. The operator was using her logbook entries as her procedure. These steps had been followed during a previous development test performed under a Nuclear Criticality Safety Field Agreement. Caustic addition was stopped when the pH of the solution reached 9.1. The operator placed the unit in a recycle mode, removed the face shield and apron, took the empty polybottles to the Small Parts Pit, and rinsed the polybottles with water. The neoprene gloves were then taken off.
>
> At the boundary control area, the operator took off her latex gloves, leaving on the cotton gloves. She then removed her shoes and stepped into the noncontaminated side of the station. Using portable survey instruments, she found that her coveralls were contaminated in the shin area at a level greater than 100 cpm over background radiation.

With the aid of supervision and HP, the operator took off her coveralls, donned paper coveralls, and proceeded to the hand and foot monitors. At the monitor, no contamination was found on the skin of her legs after a complete body scan. However, skin on her right and left index fingers was contaminated (200 cpm) and subsequently cleaned without further problems.

Later, the operator set up the system to filter the pH adjusted solution through the microfilters. She had donned the same protective devices as listed above. Again a squeegee was used to direct the clear filtrate to the pit drain. The pit drain pump transferred the filtrate to the overhead storage system.

When the filtering steps were completed, the unit was set up to recycle back to the pit through the sample valve/hose, with the column recycle pump on, to add nitric acid to the slurry material left in the system for pH adjustment. Again, the pit drain pump transferred the solution to the processing columns. After pH adjustment, the sample valve was closed and the pit drain pump was turned off. The hose attached to the sampling port was placed into a polybottle. Reaching across the pit wall, the operator opened the sample valve to fill each bottle and closed the valve when the bottle was full. After the last bottle was filled, the area was rinsed and prepared for the next batch of polybottles.

The operator went to the boundary control station and again showed contamination of her pant legs at a level of 100 cpm. An HP technician told the operator to don paper coveralls over her contaminated cloth ones and proceed to the Berthold monitor. At the monitor, the operator showed contamination on the pant legs at a beta/gamma level of 500,000 dpm. The arms of the coveralls were also beta/gamma contaminated at a 2,500,000 dpm level. The operator was taken to the shower room for a complete body frisk by the HP technician. No contamination of the legs was present, but the skin of her forearms and above her left temple was contaminated (beta/gamma).

She washed two times and still showed the same contamination ranging from 2,000 to 10,000 cpm on the arms and 500 cpm on the temple.

Cause

The operating procedure had been reviewed by health physics personnel and others and was found to provide adequate protection. However, changes to the operating scheme were made during the development test without making the appropriate modifications to and subsequent reviews of the operating procedure of the unit. These changes increased the operator's exposure to splashing and open liquids, yet there were no increases made in the personal protective equipment requirements.

There was no radiation work permit (RWP) in effect for the system and one was not required at that time. The pit area showed high levels of contamination after the incident ranging from removable beta/gamma up to 70,000 dpm and removable alpha up to 80,000 dpm.

MODULE 3.0: CONTAMINATION CONTROL

Technetium entered the gaseous diffusion equipment through the addition of recycled spent nuclear fuel as feed to the cascade. Generally, the higher assay processing equipment contains the greater quantity of technetium. The laboratory, in analyzing various samples throughout the cascade, had generated the mixed acids solution with varying concentrations of technetium. Technetium had been a sampling requirement for polybottle solutions in the past, but was not currently. The technetium concentration in the batch was 500 ppm or 10 times the design value of the Cylinder Rinse Unit as seen in the Final Safety Analysis Report.

The X-705 building doffing orientation was geared to visitors at the facility rather than building workers in the exiting portion: "...Take your totes off one at a time and step onto the Non-Rad side of the boundary. Place each tote in the barrel labeled for totes. Take off gloves and deposit them in the burn barrel." There was no mention in the doffing orientation for the building workers to take off their company shoes, place them in the bin, step to the non-rad side, and then take off the latex gloves.

The operator's coveralls were found to be contaminated in the shin area at both times she left the work area. The operator had also noticed that the lower portion of her coveralls was wet in past operations at the unit, but did not show contamination. Splashing solution from the chemical additions, use of the squeegee, and polybottle dumping resulted in the coverall contamination problem. Her shoes were later found to be highly contaminated. Again, the splashing solution was the cause. Her fingers became contaminated when she exited by taking off her latex gloves and then her contaminated shoes.

The contaminated skin area above the left temple was a result of wiping her face with the left forearm portion of her coveralls after that area had become contaminated. The following were possible causes of the contamination of the arms:

1. The filtrate was routed through the vent line back to the pit pump. Taking a sample from the filtrate stream would have led to the operator's arm becoming contaminated with the splashing solution. The neoprene gloves got wet during this operation. The filtrate contained high levels of technetium. Technetium is a beta-emitter and her arms were beta-contaminated.

2. The processed solution was transferred to polybottles through a sample valve and hose instead of the system's polybottle fill station. The operator had to reach across the pit wall, which showed high levels of contamination after the incident, to operate the sample valve. She rested her arms atop the wall in order to quickly shut the valve as each polybottle became full.

3. Chemicals were added to the pit drain with a recycled stream that was routed through a hose. Splashes as a result of the addition or use of the squeegee caused the arm contamination.

Questions

1. What actions or lack of actions by personnel were noted in the case study?

2. What changes/corrections are needed to improve the situation?

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.

PROGRESS REVIEW MEETING FORM

Date Scheduled: ________________________________**Location:**______________________

I. The following suggested items should be discussed with the administrator as to how they pertain to your current position:

- Sources of airborne material
- General air samplers versus breathing zone samplers
- Selection of air filters
- Special considerations in air sampling: particle-size distribution, solubility, and transuranics
- Use of activity median aerodynamic diameter (AMAD)
- Frequency and limits of air sampling
- Radon considerations
- Use of lower limit of detection
- Chemical and physical characteristics of uranium contamination on surfaces
- Smear and standard counting techniques
- Regulatory Guide 8.24, Health Physics Surveys During Enriched Uranium-235 Processing and Fuel Fabrication
- Regulatory Guide 8.30, Health Physics Surveys in Uranium Recovery Facilities
- Limits for removable surface contamination
- Limits for contamination on personal clothing and skin
- Activity 1 – Case Study

MODULE 3.0: CONTAMINATION CONTROL

II. Use the space below to take notes during your meeting.

III. As a Regulator:

- ◙ What particular sources of airborne radioactive material should I be aware of in the fuel cycle facilities work assigned to me?
- ◙ When I visit a particular fuel cycle facility, what areas will have general air samplers versus breathing zone samplers?
- ◙ When I review licensee air filter information, what should I look for in the documentation? What do I need to know or look for concerning air filters when I visit at a particular site?
- ◙ Tell me about some basic features of an effective contamination control program at fuel cycle facilities and why they were effective. Tell me about some ineffective contamination control programs and why they were ineffective.

MODULE 3.0: CONTAMINATION CONTROL

Use the space below to write your specific questions.

IV. Further assignments? If yes, please note and complete. If no, initial completion of progress meeting on tracking form.

Ensure that you and your administrator have dated and initialed your progress on your tracking form for this module.
Go to the module summary.

MODULE SUMMARY

Control of contamination is a key element in the radiation protection programs at fuel cycle facilities. The primary purpose of contamination control is to minimize the intake of uranium compounds and associated radioactive products.

Other important considerations include the prevention of the spread of contamination into uncontrolled areas and the reduction of external exposure problems. For these reasons, contamination control needs to be a major part of an effective ALARA program at fuel cycle facilities.

Congratulations! You are ready to go to the next assigned module.