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BIOENVIRONMENTAL ENGINEERING

Ionizing Radiation

QUALIFICATION TRAINING PACKAGE

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STS Line Item 4.9.2.6: Identify radiological/nuclear hazards

TRAINER GUIDANCE

Proficiency Code:	2b
PC Definition:	Can do most parts of the task. Needs assistance only on hardest parts. Can determine step-by-step procedures for doing the task.
Prerequisites:	None
Training References:	• AFIOH Report IOH-SD-BR-SR-2005-0004, *Bioenvironmental Engineer's Guide to Ionizing Radiation, October 2005* • AFI 48-148, *Ionizing Radiation Protection, 21 September 2011*
Additional Supporting References:	• N/A
CDC Refer*ence:*	4B051
Training Support Material:	• Labeled source of ionizing radiation such as Troxxler, or medical/industrial X-Ray source
Specific Techniques:	Conduct hands-on training and evaluation.
Criterion Objective:	Given a source of ionizing radiation and installation inventory, determine hazards presented to workers and general public successfully completing all checklist items with limited trainer assistance.

Notes:

Identifying sources of ionizing radiation typically fall on the installation radiation safety officer (IRSO), and requires a technician to do no more than consult the radioactive material inventory maintained by the IRSO. Under some circumstances a technician may be required to identify new hazards that will need to be reported to the IRSO. New sources may be reported from a shop supervisor, or identified during routine or special surveillance.

The purpose of this objective is not to *measure* radiation levels, as that is performed elsewhere. Instead it is meant to determine if radiation is present and how it is produced; either from radiactive material, such as Cs-137, or from another process, such is in an an x-ray tube head.

TASK STEPS

1. Determine if device/material *contains* radioactive material or *produces* radiation through other means.[1]

2. Identify device/material on RAM inventory.[2]

3. Record all pertinent information if necessary.[3]

4. Determine potential population at risk.[4]

LOCAL REQUIREMENTS:

NOTES:

1. Devices containing radioactive material should be labeled with radioactive sticker and isotope contained within. Serial number of source and equipment will be recorded to compare to the inventory.

2. X-ray tubes should be labeled with a radiation sticker, if KvP and mA settings are not labeled on machince, other sources of intel should be used, such as an interview with the operator.

3. If device/material is not listed on the installation inventory, record all pertinent information to report to IRSO. This includes, but is not limited to:
   - Manufacturer
   - Model
   - Serial number of device
   - Source isotope, activity, and date activity was measured
   - Serial number of radiation source (if applicable)
   - Machine parameters (KvP, mA, duration of exposure) (if applicable)
   - Using organization
   - Location: Bldg #, Room # for both use and storage areas (if different)

4. Take in to consideration operators/users, adjacent rooms and areas, and if area is accessible by the general public. This is necessary when determining priority for special surveillance.

TRAINEE REVIEW QUESTIONS

STS Line Item 4.9.2.6: Identify radiological/nuclear hazards

1. What x-ray machine parameter controls the number of electrons fired from the cathode (filament)?
2. What information can be determined by knowing the isotope of concern, activity, and date of a source?

PERFORMANCE CHECKLIST

STS Line Item 4.9.2.6: Identify radiological/nuclear hazards

Proficiency Code:	2b
PC Definition:	Can do most parts of the task. Needs assistance only on hardest parts. Can determine step-by-step procedures for doing the task.

DID THE TRAINEE…		YES	NO
1. Determine if device/material contains radioactive material, or produces radiation through other means?			
2. Identify device/material on RAM inventory?			
3. Record all pertinent information if necessary?			
4. Determine potential population at risk?			

TRAINEE NAME (PRINT) TRAINER NAME (PRINT)

ANSWERS

1. What x-ray machine parameter controls the number of electrons fired from the cathode (filament)?

   A: milliamperes (mA).

   (Source: 4B051 CDC)

2. What information can be determined by knowing the isotope of concern, activity, and date of a source?

   A: Type of decay, energy level, half-life, and current activity.

   (Source: 4B051 CDC)

STS Line Item 4.9.2.8: Perform RAM storage and use surveys (area survey)

TRAINER GUIDANCE

Proficiency Code:	2b
PC Definition:	Can do most parts of the task. Needs help only on hardest parts. Can determine step-by-step procedures for doing the task.
Prerequisites:	QTP 4.9.2.11.1 – Ion Chamber (i.e. Victoreen 451P) QTP 4.9.2.11.3 – Geiger-Mueller (i.e. ADM 300)
Training References:	• AFIOH Report IOH-SD-BR-SR-2005-0004, *Bioenvironmental Engineer's Guide to Ionizing Radiation* • AFI 48-148, *Ionizing Radiation Protection* • AFI 40–201, *Management of Radioactive Material in the U.S. Air Force*
Additional Supporting References:	• 29 CFR 1910.1096, *Occupational Safety and Health Standards - Ionizing Radiation* • 10 CFR 20, *NRC Regulations - Standards for the Protection Against Radiation*
CDC Reference:	4B051
Training Support Material:	• Victoreen 451P Ion chamber • ADM-300 with AP-100 and BP-100 probes • Whatman #41 filter paper discs • Nitrile gloves • Documentation materials (clipboard, paper, writing utensil) • Measuring tape • BGIR 2005 (Bioenvironmental Engineer's Guide to Ionizing Radiation) • AFI 48-148, *Ionizing Radiation Protection* • AF Form 495
Specific Techniques:	Conduct hands-on training and evaluation.
Criterion Objective:	Given survey meters and a radiation source, perform RAM storage and use surveys while successfully completing all checklist items with limited trainer assistance only on the hardest parts.
Notes:	

TASK STEPS

1. Select appropriate radiation detection equipment.[1]
2. Record diagram of radiation storage area, including all adjacent areas.[2]
3. Take background measurements in a radiation-free area near RAM storage area.
4. Measure gamma/x-ray radiation exposure rate using ion chamber.[3]
5. Subtract background readings from readings at each location (in order to obtain net exposure rates).
6. Determine appropriate Occupancy Factor (OF) for each measurement point.[4]
7. Calculate estimated annual exposure for each measurement point.[5]
8. Compare measurements and calculated values to appropriate standards.
9. Prepare survey documentation.[6]
10. Utilize OEHMIS (DOEHRS or equivalent), as applicable.

LOCAL REQUIREMENTS:

NOTES:

1. Refer to the Radiation Detection Instrument Selection Guide (TABLE 6-19) found on page 71 of BGIR 2005 for instrument selection assistance. In addition, subtasks to this step should include:
   - Check battery on selected equipment.
   - Perform "bump check" on selected equipment.
   - Ensure calibration date on selected equipment is current.

2. Subtasks to this step should include:
   - Identify all locations where readings will be taken.
   - Identify adjacent areas where workers/general public (GP) may be present (hallways, offices, parking lots, doorways

3. Normally, average readings should be taken. Readings may be taken in exposure rate mode or cumulative exposure mode over a period of time. Cumulative exposure may be preferable when readings fluctuate greatly. In addition, ion chambers usually read in units of microroentgen or milliroentgen per hour. 1 R/hr of radiation exposure equals approximately 1 rem/hr of gamma or x-ray radiation dose. Take measurement 30 cm (12 inches) from any surface displaying radiation penetration. Include key locations within area and surrounding areas in order to assess worker and GP exposures.

   - Refer to AFIOH Report IOH-SD-BR-SR-2005-0004, *Bioenvironmental Engineer's Guide to Ionizing Radiation*

4. If more reliable source of occupancy data is available, it may be used instead of the OF as long as it is documented and defensible.

5. The projected annual **general public** dose rate is calculated using the following formula:

$$\text{reading}\left(\frac{\mu R}{hr}\right) \times 365 \left(\frac{days}{yr}\right) \times 8 \left(\frac{hrs}{day}\right) \times \text{ OF } \times \left(\frac{1mR}{1000\mu R}\right) = \frac{mrem}{yr}$$

   This value is then compared to the 100 mrem/yr standard for the general public.

   For **occupational exposure**, the dose equivalent is calculated as follows:

$$\text{reading}\frac{\mu R}{hr} \times 2000\frac{hours}{yr} \times \text{fraction } or \text{ OF } \times \frac{1mR}{1000\mu R} = \frac{mrem}{yr}$$

   This value is then compared to the 5 rem/yr standard for the radiation workers.

6. Legally defensible documentation must be accurately reported and should contain (at a minimum) the following:
   1. Diagram of the RAM storage/use area (with details on adjacent areas).
   2. Information on the RAM or radiation producing services being used/stored.
   3. Instruments used for the survey (with serial number and calibration specifications).
   4. Individual(s) conducting the survey.
   5. AF permit number (if applicable).
   6. Exposure evaluation conclusions.

TRAINEE REVIEW QUESTIONS

STS Line Item 4.9.2.8: Perform RAM storage and use surveys (area survey)

1. State the meaning of a "survey" as defined in AFI 48-125:
2. What is the purpose for radiation storage and use surveys?
3. Survey documents should diagram the RAM storage/use area with what information?

PERFORMANCE CHECKLIST

STS Line Item 4.9.2.8: Perform RAM storage and use surveys (area survey)

Proficiency Code:	2b
PC Definition:	Can do most parts of the task. Needs help only on hardest parts. Can determine step by step procedures for doing the task.

DID THE TRAINEE…		YES	NO
1. Select the proper radiation detection instrument?			
2. Accurately record diagram of radiation storage area, including adjacent areas?			
3. Properly take background measurements?			
4. Correctly use ion chamber to measure radiation exposure rate?			
5. Correctly calculate net exposure rates?			
6. Accurately determine Occupancy Factor (OF) for each measurement point?			
7. Accurately calculate estimated annual exposure for each measurement point?			
8. Compare measurements and calculated values to dose limit standards?			
9. Prepare accurate and comprehensive documentation of survey findings?			
10. Utilize OEHMIS (DOEHRS or equivalent), as applicable?			
Did the trainee successfully complete the task?			

TRAINEE NAME (PRINT) TRAINER NAME (PRINT)

ANSWERS

1. State the meaning of a "survey" as defined in AFI 48-125.

A: An evaluation of the radiological conditions and potential hazards incident to the production, use, transfer, release, disposal, or presence of radioactive material or other sources of radiation. When appropriate, such an evaluation includes a physical survey of the location of radioactive material and measurements or calculations of levels of radiation, or concentrations or quantities of radioactive material present.

(Source: AFI 48-125, *Personnel Ionizing Radiation Dosimetry*, page 74)

2. What is the purpose for radiation storage and use surveys?

A: Annual surveys must be accomplished in these areas to verify adherence to annual radiation exposure limits.

(Source: *Bioenvironmental Engineer's Guide to Ionizing Radiation*)

3. Survey documents should diagram the RAM storage/use area with what information?

- Adjacent areas.
- Information on the RAM or radiation producing devices being used/stored.
- Instruments used for the survey with serial number and calibration specifications.
- Individual(s) conducting the survey.
- Air Force permit number (if applicable).
- Exposure evaluation conclusions (e.g., the area is unrestricted/restricted, meets or does not meet public exposure limits, etc.).

(Source: *Bioenvironmental Engineer's Guide to Ionizing Radiation*)

STS Line Item 4.9.2.9: Perform medical and industrial diagnostic x-ray scatter surveys (ION Chamber Method)

TRAINER GUIDANCE

Proficiency Code:	2b
PC Definition:	Can do most parts of the task. Needs help only on hardest parts. Can determine step-by-step procedures for doing the task.
Prerequisites:	Training Module 4.9.2.11.1 – Ion Chamber (i.e. Victoreen 451P) Training Module 4.9.2.11.3 – Geiger-Mueller (i.e. ADM 300)
Training References:	• AFIOH Report IOH-SD-BR-SR-2005-0004, *Bioenvironmental Engineer's Guide to Ionizing Radiation*, 14 February 2013 • AFI 48-148, *Ionizing Radiation Protection*, 21 September 2011
Additional Supporting References:	• 29 CFR 1910.1096, *Occupational Safety and Health Standards - Ionizing Radiation* • 10 CFR 20, *NRC Regulations - Standards for the Protection Against Radiation* • AF BE Risk Communication Guide , May 2011 • AFI 90-802, *Risk Management*, 11 Feb 2013 • 21 CFR 1020
CDC Refer*ence:*	4B051
Training Support Material:	• Radiation detection instruments 1. Victoreen 451P (ion chambers – preferred, set to "integrate mode") 2. ADM-300 (energy-compensated G-M tubes, set to "rate mode") • Paper and pencil • Personal radiation monitoring devices 1. Thermo-Luminescent Dosimeters (TLDs) 2. Electronic Personal Dosimeters (EPDs) • 1- gallon Cubitainer® (or equivalent plastic container) filled with water
Specific Techniques:	Conduct hands-on training and evaluation.
Criterion Objective:	Given survey meters and a radiation source, evaluate ionizing radiation controls and perform ionizing radiation surveys successfully completing all checklist items with limited trainer assistance on only the hardest parts.
Notes:	

TASK STEPS

Measure Scatter Radiation Using Instrument (Ion Chamber) Survey Meter Method

1. Determine measurement points.[1]
2. Have technician set-up X-ray machine.[2]
3. Place dummy load 1-gallon Cubitainer® (or equivalent plastic container) filled with water as the target for the x-ray beam.
4. Select appropriate range on survey meter.
5. Position survey meter at 1st location.[3]
6. Have the technician take a table shot.[4]
7. Record measurement.
8. Allow the tube to cool between shots to prevent burnout of the X-ray tube.
9. Repeat shots as necessary to get all the desired readings.
10. Have the technician take a chest x-ray shot.[4]
11. Record measurement.
12. Allow the tube to cool between shots to prevent burnout of the X-ray tube.
13. Repeat shots as necessary to get all the desired readings.
14. Repeat the process for all other locations.
15. Review measurements/readings and estimate annual exposure.
16. Calculate and check to see that no location exceeds standards.[5]
17. Complete survey results.[6]
18. Utilize OEHMIS (DOEHRS or equivalent), as applicable.

Dental X-ray Scatter Surveys

1. Have technician set-up X-ray machine.[7]
2. Place a wastebasket in the dental chair and a 1-gallon cubitainer© (or equivalent plastic container) filled with water on the wastebasket to simulate the patient's head.
3. One exposure is made with the X-ray tube parallel to the floor and in contact with the Cubitainer® (simulating the shot to be made through the ear of the patient).
4. Record measurement and allow the tube to cool between shots to prevent burnout of the X-ray tube
5. Repeat shots as necessary to get all the desired readings.
6. Second exposure is made on the opposite side, through the other 'ear.'
7. Record measurement and allow the tube to cool between shots to prevent burnout of the X-ray tube.
8. Repeat shots as necessary to get all the desired readings.
9. Review measurements/readings and estimate annual exposure.
10. Calculate and check to see that no location exceeds standards. [5]
11. Complete survey results.[6]
12. Utilize OEHMIS (DOEHRS or equivalent), as applicable.

LOCAL REQUIREMENTS:

NOTES:

1. Measurement points typically include:
   - At the operator's location inside the X-ray room
   - Outside the door to the X-ray room
   - Exposure room door
   - In adjacent waiting areas and/or offices
   - On the other side of the wall from the chest cassette holder
   - Along exterior of walls, focusing on the door area
   - Locations above and below the room, if occupied
   - Film pass through opening

2. Device Settings
   - Use a high kilovolt peak (kVp) setting that is appropriate for the exposure.
   - Use the highest milliamperes (mA) setting that is appropriate for the exposure

3. Take measurements at each location of interest:
   - Tube head oriented for a table shot (vertical position pointed downward toward the table)
   - Tube head oriented for a chest X-ray (horizontal position pointed at the wall, source to film distance of 72 inches)
   - 3 feet above floor
   - 30 cm (12 inches) from surface for radiation fields penetrating surfaces (like walls)

4. The technician should take the shot in the same manner they would for that type of x-ray

5. Calculate and check to see that no location exceeds standards:
   - Consider occupancy factors (length of time someone might stay at that location)
   - To find the yearly exposure, find the number of films exposed per week (see formula below)
   - Standard is 100mr/yr
   - Also need to consider radiation exposures in radiation worker areas.

6. Survey results shall include:
   - A description or drawing of each measurement location
   - Measured dose or contamination levels at each location
   - The type, model number, serial number and calibration date of the instrument
   - Name of individual performing the survey
   - Date and time of the survey and applicable comments

7. Use a high kilovolt peak (kVp) setting that is appropriate for the exposure.

<u>Formula</u>:

$$\mathrm{mR/wk} = \frac{\text{scatter reading (mR/hr)} \times \text{number of films/wk} \times \text{sec/film}}{3600\ \text{sec/hr}}$$

$$X_{\text{Annual}} = T \times \left(\frac{50\ \text{wk}}{\text{yr}}\right) \times \left[\sum_{i=0}^{n} \frac{X_{i(\text{survey})}}{\text{mAs}_{i(\text{survey})}}\right] \times W_i$$

X_{Annual} = Total annual exposure in mR/yr for a single location (all configurations)
T = Occupancy Factor: fraction of time spent at surveyed locations (NCRP 147, etc.)
i = information specific to a particular machine configuration (i.e., chest film, etc.)
$X_{i(\text{survey})}$ = Measured Integrated Exposure in mR for specific location/configuration
$\text{mAs}_{\text{Annual}}$ = mAs setting for measured shot (from radiation technician)
W = Workload: Average Total mAs per week mAs/wk for specific configuration.

EPDs - Electronic Personal Dosimeters
TLD - Thermo-Luminescent Dosimeter

Note: See AFIOH Report IOH-SD-BR-SR-2005-0004 for occupancy factors.

TRAINEE REVIEW QUESTIONS

STS Line Item 4.9.2.9: Perform medical and industrial diagnostic x-ray scatter surveys (ION Chamber Method)

1. What is the occupancy factor of a hallway/corridor?
2. Name the two ways you can collect measurements.
3. In order to properly simulate a scattering medium in the beam line, what is normally used as a surrogate?

PERFORMANCE CHECKLIST

STS Line Item 4.9.2.9: Perform medical and industrial diagnostic x-ray scatter surveys (ION Chamber Method)

Proficiency Code:	2b
PC Definition:	Can do most parts of the task. Needs help only on hardest parts. Can determine step-by-step procedures for doing the task.

DID THE TRAINEE…		YES	NO
MEASURE SCATTER RADIATION USING INSTRUMENT (ION CHAMBER) SURVEY METER METHOD			
1. Determine measurement points?			
2. Have technician set-up X-ray machine?			
3. Place dummy load 1-gallon Cubitainer® (or equivalent plastic container) filled with water as the target for the x-ray beam?			
4. Select appropriate range on survey meter?			
5. Position survey meter at 1st location?			
6. Have the technician take a table shot?			
7. Record measurement?			
8. Allow the tube to cool between shots to prevent burnout of the X-ray tube?			
9. Repeat as necessary to get all desired readings?			
10. Have the technician take a chest x-ray shot?			
11. Record measurement?			
12. Allow the tube to cool between shots to prevent burnout of the X-ray tube?			
13. Repeat as necessary to get all desired readings?			
14. Repeat the process for all other locations?			
15. Review measurements/readings and estimate annual exposure?			
16. Calculate and check to see that no location exceeds standards?			

17. Complete survey results?			
18. Utilize OEHMIS (DOEHRS or equivalent), as applicable?			
DENTAL X-RAY SCATTER SURVEYS			
1. Have technician set-up X-ray machine?			
2. Place a wastebasket in the dental chair and a 1-gallon Cubitainer® (or equivalent plastic container) filled with water in the wastebasket to simulate the patient's head?			
3. One exposure is made with the X-ray tube parallel to the floor and in contact with the Cubitainer© (simulating the shot to be made through the ear of the patient)?			
4. Record measurement and allow the tube to cool between shots to prevent burnout of the X-ray tube?			
5. Repeat as necessary to get all desired readings			
6. Second exposure is made on the opposite side, through the other 'ear'?			
7. Record measurement and allow the tube to cool between shots to prevent burnout of the X-ray tube?			
8. Repeat as necessary to get all desired readings?			
9. Review measurements/readings and estimate annual exposure?			
10. Calculate and check to see that no location exceeds standards?			
11. Complete survey results?			
12. Utilize OEHMIS (DOEHRS or equivalent), as applicable?			
Did the trainee successfully complete the task?			

TRAINEE NAME (PRINT) TRAINER NAME (PRINT)

ANSWERS

1. What is the occupancy factor of a hallway/corridor?

   A: 0.2

   (Source: 4B051 CDC)

2. Name the two ways you can collect measurements.

   A: TLDs and potable instruments

   (Source: 4B051 CDC)

3. In order to properly simulate a scattering medium in the beam line, what is normally used as a surrogate?

   A: Gallon container of water

   (Source: 4B051 CDC)

STS Line Item 4.9.2.10: Perform swipe tests of radiological sources

TRAINER GUIDANCE

Proficiency Code:	3c
PC Definition:	Can do all parts of the task. Needs only a spot check of completed work. Can identify why and when the task must be done and why each step is needed
Prerequisites:	Training Module 4.9.2.11.1 – Ion Chamber (i.e. Victoreen 451P) Training Module 4.9.2.11.3 – Geiger-Mueller (i.e. ADM-300)
Training References:	• AFIOH Report IOH-SD-BR-SR-2005-0004, *Bioenvironmental Engineer's Guide to Ionizing Radiation* • AFRL-SA-WP-SR-2012-0008, *LABORATORY SAMPLING GUIDE*, 11 May 2012
Additional Supporting References:	• 29 CFR 1910.1096, *Occupational Safety and Health Standards - Ionizing Radiation* • 10 CFR 20, *NRC Regulations - Standards for the Protection Against Radiation*
CDC Reference:	4B051 Vol 4b
Training Support Material:	• Victoreen 451P Ion chamber • ADM-300 with AP-100 and BP-100 probes • Whatman #41 filter paper discs • Deionized water • Nitrile gloves • Documentation materials (clipboard, paper, writing utensil) • Measuring tape • BGIR 2005 (Bioenvironmental Engineer's Guide to Ionizing Radiation) • AF Form 495
Specific Techniques:	Conduct hands-on training and evaluation.
Criterion Objective:	Given survey meters and swipe media, properly perform and analyze a swipe sample successfully completing all checklist items with NO trainer assistance.

TASK STEPS

7. Select appropriate radiation detection equipment (ADM-300 with AP-100 or BP-100 probe) based on source.[1]
8. Record appropriate information on AF form 495 or label.
9. Don protective gloves.
10. Select filter paper; indicate side to be swiped by making an *X*.[2]
11. Take background count measurements.
12. Wipe work surface (removable contamination) or instrument source (leak testing).[3]
13. Collect measurements.
14. Place disc in AF 495 envelope or ziplock bag.
15. Calculate and record contaminant activity.[4]
16. Compare activity (or activity per 100 cm^2) to the appropriate standard.
17. Prepare survey documentation.[5]
18. Utilize OEHMIS (DOEHRS or equivalent), as applicable.

LOCAL REQUIREMENTS:

NOTES:

1. Refer to the Radiation Detection Instrument Selection Guide (TABLE 6-19) found on pages 71-74 of BGIR 2005 for instrument selection assistance. In addition, subtasks associated with this step should include:
   - Check battery on selected equipment.
   - Perform "bump check" on selected equipment.
   - Ensure calibration date on selected equipment is current.

2. **Reminder:** Annotate all locations to be swiped.

3. Laboratory sampling guide recommends wetting swipe.

4. **Contaminant activity:** For a leak test, calculate activity in disintegrations per minute (dpm); for a swipe, calculate dpm per 100cm^2 of surface area.

$$\text{activity (dpm)} = \frac{\text{gross count (cpm)} - \text{ background } (cpm)}{\text{detection efficiency } \times \text{swipe efficiency}}$$

$$\frac{\text{dpm}}{100\ \text{cm}^2} = \frac{\dfrac{\text{gross count } (cpm) - \text{ background } (cpm)}{\text{detection efficiency } \times \text{swipe efficiency}}}{100\ \text{cm}^2}$$

5. Legally defensible documentation must be accurately reported and should contain (at a minimum) the following:

- Diagram of the RAM storage/use area (with details on adjacent areas).
- Information on the RAM or radiation producing services being used/stored.
- Instruments used for the survey (with serial number and calibration specifications.
- Individual(s) conducting the survey.
- AF permit number (if applicable).
- Exposure evaluation conclusions.

TRAINEE REVIEW QUESTIONS

STS Line Item 4.9.2.10: Perform swipe tests of radiological sources

1. What is the area swiped for a surface?
2. What type of filter paper do you use for radiological swipes?
3. Explain if and why the filter paper must be wet or dry before taking a radiological swipe?

PERFORMANCE CHECKLIST

STS Line Item 4.9.2.10: Perform swipe tests of radiological sources

Proficiency Code:	3c
PC Definition:	Can do all parts of the task. Needs only a spot check of completed work. Can identify why and when the task must be done and why each step is needed

DID THE TRAINEE…		YES	NO
1. Select appropriate radiation detection equipment (ADM-300 with AP-100 or BP probe)[1] based on source?			
1. Record appropriate information on AF form 495 or label?			
2. Don protective gloves?			
3. Select filter paper; indicate side to be swiped by making an *X*?			
4. Take background count measurements?			
5. Wipe work surface (removable contamination) or instrument source (leak testing)?			
6. Collect measurements?			
7. Place disc in AF 495 envelope or ziplock bag?			
8. Calculate and record contaminant activity?			
9. Compare activity (or activity per 100 cm^2) to the appropriate standard?			
10. Prepare survey documentation?			
11. Utilize OEHMIS (DOEHRS or equivalent), as applicable?			
Did the trainee successfully complete the task?			

TRAINEE NAME (PRINT) TRAINER NAME (PRINT)

ANSWERS

1. What is the area swiped for a surface?

   A: 100 cm2

   (Source: 4B051 CDC)

2. What type of filter paper do you use for radiological swipes?

   A: Whatman® No. 41 or equivalent

   (Source: 4B051 CDC)

3. Explain if and why the filter paper must be wet or dry before taking a radiological swipe?

   A: It is now recommended that swipe samples should be taken wet by adding a few drops of deionized water (DI) to dampen the swipe/swab. Previously, guidance was given that swipe samples should be taken using a dry swipe. Recent studies have demonstrated that this results in a very low collection efficiency of removable activity, as low as 10%. It has been shown that wet swipes have a much higher efficiency of up to 90%. Thus, to obtain more representative samples, wet swipes are now recommended.

   (Source: AFRL-SA-WP-SR-2012-0008, *LABORATORY SAMPLING GUIDE*, 11 May 2012, page 85)

STS Line Item 4.9.2.10.1: Perform field analysis of samples (utilizing probe efficiency)

TRAINER GUIDANCE

Proficiency Code:	2b
PC Definition:	Can do most parts of the task. Needs help only on hardest parts. Can determine step-by-step procedures for doing the task.
Prerequisites:	Training Modules 4.9.2.10 and 4.9.2.11.3
Training References:	• AFIOH Report IOH-SD-BR-SR-2005-0004, *Bioenvironmental Engineer's Guide to Ionizing Radiation, October 2005* • AFI 48-148, *Ionizing Radiation Protection, 21 September 2011* • AFRL-SA-WP-SR-2012-0008, *Laboratory Sampling Guide, 11 May 2012*
Additional Supporting References:	• Chart of Nuclides, www.nndc.bnl.gov/**chart**
CDC Reference:	4B051
Training Support Material:	• Labeled source of ionizing radiation such as Troxler, or medical/industrial X-Ray source
Specific Techniques:	Conduct hands-on training and evaluation.
Criterion Objective:	Given ADM-300 with BP-100 probe, BE Guide to Ionizing Radiation, Chart of Nuclides, and swipe sample; determine radiation activity (in DPM) of the swipe sample successfully completing all checklist items with limited trainer assistance on only the hardest parts.

Notes:

*****The intent of this training is to accurately perform analysis of results collected by the ADM-300 beta probe to obtain surface activity in dpm/100cm^2. The concepts provided here carry over to other probes and equipment with minimal effort.

Correctly analyzing swipe samples utilizing efficiency of the swipe and probe used provides invaluable information prior to having a sample analyzed by the USAFSAM radioanalytical laboratory. The BE Guide to Ionizing Radiation provides efficiency tables for the BP-100 in Figure B-1.

The chart of nuclides at www.nndc.bnl.gov/**chart** can be used to determine beta particle energy. Once the isotope of concern is selected, select "decay radiation" under the chart and find the 'End-point energy' (keV) with the highest 'Intensity' (from all 'Beta' data sets) use that value (keV)" in table B-1 to find the BP-100 efficiency.

If the swipe is taken over a 100cm^2 area, the calculation below will give activity (dpm) per 100cm^2, adjustments must be made if a greater area is swiped, or if surface measurements are taken directly with the probe.

100cm^2 swipe:

$$\frac{dpm}{100cm^2} = \left(\frac{gross\ count - background}{detection\ efficiency * swipe\ efficiency}\right)/100cm^2$$

Direct measurement using BP-100:

$$\frac{dpm}{100cm^2} = \left(\frac{\frac{gross\ count - background}{detection\ efficiency * swipe\ efficiency}}{0.155}\right)/100cm^2$$

TASK STEPS

1. Perform a 1-minute scaler blank reading on swipe using BP-100 probe.

2. Collect a $100cm^2$ surface sample using Watman 41 swipe.

3. Perform a 1-minute scaler survey reading on swipe using BP-100 probe.

4. Determine probe efficiency for isotope of concern using BE Guide to Ionizing Radiation Figure B-1 and Chart of Nuclides.

5. Determine swipe efficiency using the Laboratory Sampling Guide (p85) – the BE Guide to Ionizing Radiation typically uses 0.25; consult the lab the sample will be shipped to for further guidance.

6. Calculate dpm/100cm2 using the calculation:

$$\frac{dpm}{100cm2} = \left(\frac{gross\ count - background}{detection\ efficiency * swipe\ efficiency}\right)/100cm^2$$

LOCAL REQUIREMENTS:

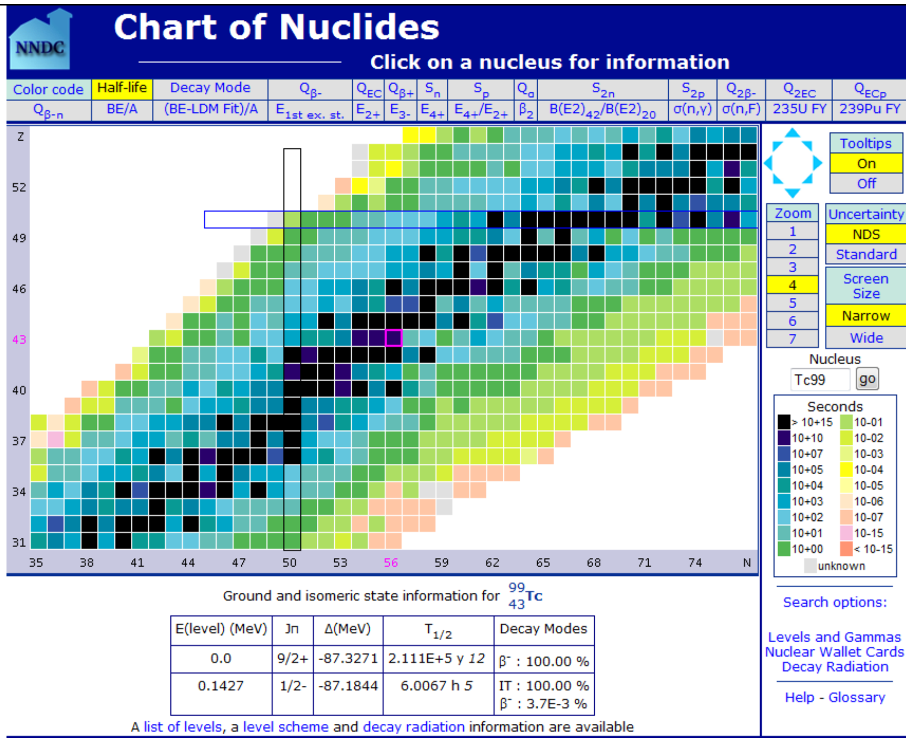
NOTES:

1. Follow all sampling protocol for swipe samples and ADM-300 use closed out in TMs 4.9.2.10 and 4.9.2.11.3. *Give the trainee a result of 4 cpm.*

2. Follow all sampling protocol for swipe samples closed out in TM 4.9.2.10

3. Follow all sampling protocol for swipe samples and ADM-300 use closed out in TMs 4.9.2.10 and 4.9.2.11.3. *Give the trainee a result of 273cpm.*

4. The isotope of concern for this sample is Tc-99 with an energy of 292 keV; *giving a 4π efficiency of 0.95*



5. Use an efficiency of Watman 41 paper of *0.25*.

6. The calculated dpm/100cm^2 will be *1133 dpm/100cm^2*.

TRAINEE REVIEW QUESTIONS

STS Line Item 4.9.2.10.1: Perform field analysis of samples (utilizing probe efficiency)

1. Using the chart of nuclides and Figure B-1 from the BE guide to Ionizing Radiation, what is the BP-100 4π efficiency of:

   A: K-40

   B: Ar-39

PERFORMANCE CHECKLIST

STS Line Item 4.9.2.10.1: Perform field analysis of samples (utilizing probe efficiency)

Proficiency Code:	2b
PC Definition:	Can do most parts of the task. Needs help only on hardest parts. Can determine step-by-step procedures for doing the task.

DID THE TRAINEE…		YES	NO
1. Perform a 1-minute scaler blank reading on swipe using BP-100 probe?			
2. Collect a 100cm^2 surface sample using Watman 41 swipe?			
3. Perform a 1-minute scaler survey reading on swipe using BP-100 probe?			
4. Determine probe efficiency for isotope of concern using BE Guide to Ionizing Radiation Figure B-1 and Chart of Nuclides?			
5. Determine swipe efficiency using Laboratory Sampling Guide?			
6. Calculate dpm/100cm2 using the calculation?			

TRAINEE NAME (PRINT)

TRAINER NAME (PRINT)

ANSWERS

1. Using the chart of nuclides and Figure B-1 from the BE guide to Ionizing Radiation, what is the BP-100 4π efficiency of:

   A: K-40
      A: End Point Energy: 1311 keV Efficiency: ~0.21

   B: Ar-39
      A: End Point Energy: 565 keV Efficiency: ~0.17

(Source: Chart of Nuclides, www.nndc.bnl.gov/chart and *Bioenvironmental Engineer's Guide to Ionizing Radiation*, October 2005, Figure B-1")

STS Line Item 4.9.2.10.2: Identify common isotopes and determine types of decay

TRAINER GUIDANCE

Proficiency Code:	2b
PC Definition:	Can do most parts of the task. Needs help only on hardest parts. Can determine step-by-step procedures for doing the task.
Prerequisites:	N/A
Training References:	• AFIOH Report IOH-SD-BR-SR-2005-0004, *Bioenvironmental Engineer's Guide to Ionizing Radiation, October 2005* • Chart of Nuclides, www.nndc.bnl.gov/**chart**
Additional Supporting References:	N/A
CDC Ref*erence:*	4B051
Training Support Material:	• Computer with internet access
Specific Techniques:	Conduct hands-on training and evaluation.
Criterion Objective:	Given the chart of nuclides, determine the type(s) of decay, half life, and daughter product of the isotope of concern successfully completing al checklist items with limited trainer assistance on only the hardest parts

Notes: ***The intent of this training is to accurately determine the mode of decay for various isotopes commonly used in Air Force operations.

One of the key pieces of information needed to analyze and control radioactive material, is the mode of decay and half-life of the isotope of concern. While Bioenvironmental Engineering Journeymen are not expected to memorize every isotope and its associated information, they should be able to quickly and accurately determine the information using official references such as the chart of nuclides published by the Department of Energy at www.nndc.bnl.gov/chart.

Using the chart is relatively simple: The vertical axis is the number of protons (Z number), the horizontal axis is the number of neutrons. Any isotope encountered in the Air Force can be located on the chart. Once the isotope of concern is selected, the half-life and decay mode are displayed on the bottom of the screen. More information, such as daughter products and particle energy, can be found by clicking on "decay radiation."

TASK STEPS

1. Select isotope of concern using the chart of nuclides.[1]
2. Determine half-life ($T_{1/2}$).[2]
3. Determine decay mode.[3]
4. Determine daughter product.[4]

LOCAL REQUIREMENTS:

NOTES:

1. Isotope of concern can be found by following vertical axis to element, then horizontal axis to isotope. For example Cs_{55}^{137} has a Z number of 55, and N of 82 (137-55).

2. Half-life is listed under ($T_{1/2}$) once isotope is selected.

3. Decay mode is listed under "Decay Modes". % given is a percentage of the times a given isotope decays via the given mode. Multiple decay modes are possible. Always list percentage along with mode.

4. Daughter product can be determined by clicking the link "decay radiation", then under Daughter Nucleus.

TRAINEE REVIEW QUESTIONS

STS Line Item 4.9.2.10.2: Identify common isotopes and determine types of decay

1. Using the chart of nuclides, determine the half-life, decay mode(s), and daughter products for the following isotopes:

Isotope	Decay Mode (%)	Half-life	Daughter Product
${}^{90}_{38}Sr$			
${}^{3}_{1}H$			
${}^{32}_{15}P$			
${}^{210}_{84}Po$			
${}^{241}_{95}Am$			
${}^{192}_{77}Ir$			
${}^{22}_{11}Na$			

PERFORMANCE CHECKLIST

STS Line Item 4.9.2.10.2: Identify common isotopes and determine types of decay

Proficiency Code:	2b
PC Definition:	Can do most parts of the task. Needs help only on hardest parts. Can determine step-by-step procedures for doing the task.

DID THE TRAINEE…		YES	NO
1. Select isotope of concern using the chart of nuclides?			
2. Determine half-life ($T_{1/2}$)?			
3. Determine decay mode?			
4. Determine daughter product?			

TRAINEE NAME (PRINT)

TRAINER NAME (PRINT)

ANSWERS

1. Using the chart of nuclides, determine the half-life, decay mode(s), and daughter products for the following isotopes:

Isotope	Decay Mode (%)	Half-life	Daughter Product
$^{90}_{38}Sr$	*β- : 100.00 %*	*28.79 years*	*Y-90*
$^{3}_{1}H$	*β- : 100.00 %*	*12.32 years*	*He-3*
$^{32}_{15}P$	*β- : 100.00 %*	*14.262 days*	*S-32*
$^{210}_{84}Po$	*α : 100.00 %*	*138.376 days*	*Pb-206*
$^{241}_{95}Am$	*α : 100.00 %* *SF : 4E-10 %*	*432.6 years*	*Np-237*
$^{192}_{77}Ir$	*β- : 95.24 %* *ε : 4.76 %* *β- : 0.0175 %* *IT: 99.9825 %*	*73.829 days* *73.829 days* *1.45 minutes* *1.45 minutes*	*Pt-192* *Os-192* *Pt-192* *Ir-192*
$^{22}_{11}Na$	*ε : 100.00 %*	*2.6027 years*	*Ne-22*

(Sources: Common isotopes used from Bioenvironmental Engineer's Guide to Ionizing Radiation, October 2005, Table 3-4 and Decay mode, half-life, and daughter products from www.nndc.bnl.gov/chart)