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BIOENVIRONMENTAL ENGINEERING

Calibration and Operation of
Radiation Detection Equipment

QUALIFICATION TRAINING PACKAGE

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STS Line Item 4.9.2.11.1: Ion Chamber (i.e. Victoreen 451P)

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:	None
Training References:	• Victoreen® 451P Ion Chamber Survey Meter Operators Manual
Additional Supporting References:	• Final Guidance Document for Use of the Victoreen 451P Ion Chamber Survey Meter, January 2007
CDC Reference:	4B051
Training Support Material:	• Equipment User's Manual. • Victoreen 451P survey meter. • Cesium-137 check source.
Specific Techniques:	Conduct hands-on training and evaluation of calibration and operation of equipment with verification of steps.
Criterion Objective:	Given a Victoreen survey meter and a cesium-137 check source, demonstrate how to perform a pre-operational check and how to operate the survey meter successfully completing all checklist items with limited trainer assistance on only the hardest parts.

Notes:

*****This QTP was written based on Victoreen Model 451P as this is the survey meter listed on the allowance standard. If your flight has another version of a Victoreen survey meter then modifications to the QTP can be made under the LOCAL REQUIREMENTS area. Any Victoreen survey meter your flight has is calibrated each year, likely through the Precision Measurement Equipment Laboratory (PMEL) at your installation. Proper instrument response can be verified before each use. This is referred to as a pre-operational check. This TRAINING MODULE outlines the steps for performing a pre-operational check and steps on how to operate the survey meter. To perform a pre-operational check, you will need a cesium-137 check source. The check source can be found in the ADM-300 Test/Verification Kit. Anytime check sources are involved, you must maintain proper control of the source at all times and secure the source once your check is completed.

The 451P is an air-filled ionization chamber with an electrically conductive inner wall and central anode and a relatively low applied voltage. When primary ion pairs are formed in the air volume, from x-ray or gamma radiation interactions in the chamber wall, the central anode collects the electrons and a small current is generated. This in turn is measured by the electrometer circuit and displayed digitally. The 451P is designed to provide an accurate measurement of absorbed dose to air which, through appropriate conversion factors, can be related to dose to tissue. Common readout units are milliroentgens and roentgen per hour (mR/hr and R/hr).

It must be noted that: (1) performing a pre-operational check on a Victoreen survey meter is consider *best practice* – <u>not a requirement</u>, and (2) a check is required on each Victoreen immediately after annual calibration with PMEL to establish a baseline dose rate to compare future pre-operational check values. The decision whether or not to perform a pre-operational check prior to each use rests with your flight leadership.

TASK STEPS

1. Perform pre-operational check of the Victoreen 451p survey meter:[1]

2. Properly configure the Victoreen 451p in the appropriate mode: [2]

3. Properly operate the Victoreen 451p survey meter:[3]

LOCAL REQUIREMENTS:

NOTES:

1. When the 451P survey meter is first turned on, it runs through a functional self-test procedure. During this self-test, the firmware version of the unit is displayed. If the unit passes the self-test, it will go into the normal operating mode. The bar graph and digital display will show a reading that decreases as the instrument stabilizes. The initial reading usually starts in the 5 R/h range and decreases through the lower ranges to a reading of less the 50 µR/h within 120 seconds. When the only elements remaining in the display are those necessary for normal operation, you can begin the measurement process. If the unit fails the self-test, it will remain locked and the unit should be returned to the manufacturer for corrective action.

- The warm-up time for the 451P that has been OFF 12 or more hours is about 4 minutes for readings less than 20µR/h in a 10 µR/h or less background.

- The same cesium-137 check source should be used every time a pre-operational check is performed to ensure accuracy of results.

- The pre-operational check reading should be within ± 10 percent of the baseline value established immediately following the return of the survey meter from its annual calibration with PMEL. This baseline reading and the serial number of the check source used should be documented and retained to ensure availability of readings for future operational checks.

2. When turned on, the 451P defaults to the DOSE RATE mode. This mode is typically used when monitoring for industrial scatter surveys as well as emergency response when monitoring for external radiation exposures. The dose rate mode should only be used when there is no need for remote monitoring.

- INTEGRATE mode is accessed by pressing the mode button one time. This mode is activated 30 seconds after the 451 is initially turned on. In the integrate mode, the 451P accumulates total dose that the 451P has absorbed. The INTEGRATE mode is most commonly used to monitor medical scatter surveys. Due to the low power, and typically shielded rooms within the medical facility, it is very difficult to get a response using dose rate or freeze modes. Therefore, the common practice is to continue taking medical x-ray shots until the 451P registers a dose in the integrate mode. These numbers are then

- The FREEZE mode can be accessed by pressing and holding the mode button prior to pressing the power button. The mode button must be held down until the only word showing on the 451P display is the word FREEZE. Once turned on, the FREEZE mode will display the current dose rate, and the maximum dose rate measured by the meter will be displayed as a single line in the bar graph under the dose rate. It is important to note the FREEZE mode will register false readings during the meter self-test when first powered on. To reset the FREEZE bar, press mode to switch to DOSE RATE mode, wait for the readings to steady around the background, then press mode again to reenter the FREEZE mode. This mode is best used whenever remote monitoring is required. For example, if readings need to be taken inside a hangar, and dose rate measurements are uncertain, it is best to use FREEZE mode to ensure BE personnel are not exposed to elevated dose rates. This ensures ALARA principles are followed.

3. Proper operation of the Victoreen requires the operator to power on the unit, allow it to warm up for at least 4 minutes and perform a pre-operational check (if required by your base) to ensure accurate response to a radioactive source.

- Where you collect readings will depend upon the situation (i.e. type of survey, type of radiation, source strength, extent of contamination, etc.). Where you collect readings should be pre-determined and outlined in the sampling strategy. Be aware of your position at all times. Position yourself so you can obtain useful readings, but without overexposing yourself.

- Position of the meter also depends upon the sampling situation. When measuring radiation in air, hold the meter by the handle and extend your arm pointing the meter in the direction of the suspected source. When surveying radioactive materials for shipment, external radiation is monitored 10 centimeters (cm) from the surface of the package. Additionally, radiation levels cannot exceed 10 mR/hr at 10 cm from any point on the external surface of an unpackaged material.

- If decontamination is required, the survey meter can be cleaned by wiping with a damp cloth using any commercially available cleaning or decontaminating agent. Do not immerse the survey meter, it is not waterproof, liquid could damage the circuits.

TRAINEE REVIEW QUESTIONS

STS Line Item 4.9.2.11.1: Ion Chamber (i.e. Victoreen 451P)

1. What type of radioactive source can be used to perform a pre-operational check?
2. When measuring radiation in air, describe how the meter should be positioned?
3. During a sample operation, why must we collect background readings?

PERFORMANCE CHECKLIST

STS Line Item 4.9.2.11.1: Ion Chamber (i.e. Victoreen 451P)

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 pre-operational check of the Victoreen 451P survey meter?			
2. Properly configure the Victoreen 451P in the appropriate mode?			
3. Properly operate the Victoreen 451P survey meter?			
Did the trainee successfully complete the task?			

TRAINEE NAME (PRINT)

TRAINER NAME (PRINT)

ANSWERS

1. What type of radioactive source can be used to perform a pre-operational check?

A: Cesium-137 check source.

(Source: 4B051 CDC)

2. When measuring radiation in air, describe how the meter should be positioned?

A: Hold the meter by the handle and extend your arm pointing the meter in the direction of the suspected source.

(Source: Final Guidance Document for Use of the Victoreen 451P Ion Chamber Survey Meter, January 2007 Para 1.5 and Checklist 3.1.)

3. During a sample operation, why must we collect background readings?

A: Background readings must be subtracted from all readings obtained.

(Source: 4B051 CDC)

STS Line Item 4.9.2.11.2: Gamma Spec (i.e. SAM-940)

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:	None
Training References:	• Berkeley Nucleonics Corporation, (2007). *Instruction Manual Model 940.* • Berkeley Nucleonics Corporation, (n.d). *Introduction to SAM 940 & Real Time Spectroscopy* • Berkeley Nucleonics Corporation, (n.d) *Real-Time Radionuclide Identification*
Additional Supporting References:	• *Berkeley Nucleonics Corporation, (2011). Addendum 1.01 to SAM 940 Instruction Manual*
CDC Reference:	4B051
Training Support Material:	• SAM 940 • Cesium-137 check source.
Specific Techniques:	Conduct hands-on training and evaluation of calibration and operation of equipment with verification of steps.
Criterion Objective:	Given a SAM 940 with probe and a Cs-137 source, calibrate and demonstrate how to operate the meter successfully completing all checklist items with limited trainer assistance on only the hardest parts.

Notes:

***** The SAM 940 is a hand-held radiological surveillance and measurement system that detects and identifies multiple radio-nuclides. The SAM 940 is light weight (less than 4.5 lbs.) and relatively compact. The SAM 940s external probe contains a 2x2 sodium iodide (NaI) crystal. The external probe must be connected with the supplied cable. It will detect photon emissions (gamma and x-ray) with energies between 18 keV and 3 MeV. It supports USAF radiation related emergency responses (industrial accidents, radiation dispersal devices, improvised nuclear devices, or nuclear warfare) by real-time identification of unknown radionuclides. The SAM 940 should not be used as a primary radiation hazard search tool, but in support of assessing health hazards. That is, the SAM 940 would be used when other instruments such as the ADM-300, Victoreen 451P, or EPDs indicate the presence of a radiological hazard. The SAM 940 identifies and measures the intensity of isotopes, determines risk scenarios and allows personnel to perform appropriate standard operating procedures immediately.

Unlike some other radiation meters such as the ADM-300 and Victoreen, the SAM 940 is course calibrated by the user. This QTP outlines the steps for performing the course calibration and how to operate the instrument. To calibrate the instrument you'll need a cesium-137 source, such as used to field check ADM 300 survey meter. You must maintain proper control of the radioactive source as you use it to calibrate the instrument and secure the source when finished.

The SAM 940 also has the ability to communicate with a computer through the use of Quantitative Analysis Software which is available on the ESOH Service Center website.

TASK STEPS

CALIBRATION, BACKGROUND AND OPERATION OF THE SAM 940

1. Turn on the meter[1]
2. Press "enter" when prompted
3. Select the "administrator" user-mode and press enter
4. Press the menu key to open the menu
5. Press the over button and highlight the cog wheel, which is "field settings"
6. Scroll down and highlight the "course calibrate with Cs-137"
7. Press enter, move the Cs-137 source next to the detector when prompted[2]
8. Press enter to begin calibration[2]
9. Upon completion of calibration, the SAM 940 will return to the "field settings" screen
10. Press the "back" button or select "exit" and press enter to return to the dial screen
11. Remove check source.[3]
12. Highlight "background" by utilizing the directional pad and press enter
13. Ensure there are no sources located next to the SAM 940, then press enter
14. When background is complete it will return to the dial mode screen
15. Position the meter close enough to begin identification[4,5]
16. Highlight the "identify" function and press enter
17. Observe the "results" screen when finished identifying

LOCAL REQUIREMENTS:

NOTES:

1. The instrument will automatically begin a self-test when turned on, and the status will be indicated on the screen.

2. The SAM 940 will indicate on the display screen when you should place the calibration source on the probe and will start a 60 second count down. Place the check source in the middle of the 2 x 2 detector (probe) window. Make sure there are no other significant radiation sources nearby that could interfere.

3. Once the calibration is complete, you will have the opportunity to take a "background" sample to establish a baseline for natural radiation. ***Do not skip this step*** because the SAM automatically subtracts natural background and may function improperly without a background sample. The background adjustment takes 1 minute. The Cs-137 source should be at least 10 feet from the SAM when conducting the background reading.

4. Hold the SAM 940 in front of you so you can read the display. Take readings by placing the sample as close as possible to the detector window. The sensitive direction is broadside to the back of the unit.

5. The SAM automatically begins detection in the default search mode (Dial) after acquiring a background reading. There are four search modes of operation:

- **Dial Search:** The main purpose of the *Dial* screen is to provide a quick visual indication, similar to that given by a handheld dose meter or Geiger counter, showing the amount of radioactivity being measured. When the dial pointer is in the gray area, there is little radioactivity present most of the counts are coming from either cosmic rays or naturally occurring sources such as potassium-40. Once the pointer moves up into the green area (on either the gamma dial or, if present, on the neutron dial), there is an indication of some unusual activity. Within the green area, an **Identify** operation should be started. Finally, if the pointer moves into the red area, the activity is too high for a correct identification. It is *strongly advised that you move back from the radioactive source*, if at all possible, before attempting to identify it.

- **Finder Mode:** The *Finder* screen shows a similar type of count-rate-based information. However, it is displayed as part of a bar graph that continually moves to the left at 10 steps every second. The full chart displayed on the screen represents approximately the last 20 seconds. This mode can be extremely helpful when you are walking through an area looking for a radioactive source. This is giving you cold/warmer/hot feedback as you move, so that you can localize the source effectively. Once you have narrowed in on the source, you should do an **Identify** operation. The low area shown on the screen corresponds to the gray area on the *Dial*; the ID area matches the green portion; and the high area matches the red portion. **Identify** will be most effective when the top of the rolling chart is falling within the ID area.

- **Bars Mode:** The *Bars* screen provides a very different sort of information, organized around *what* is present rather than on *how much*. The numbers at the top right still indicate the count and dose rates, but the individual bars indicate the different radioisotopes that are thought to be present. The symbol and name of the isotope are listed to its left. Above each bar is a class indication. Each bar shows an estimated dose rate attributable to that particular isotope.

- **Spectrum Mode:** The *Spectrum* screen is designed for users with a Health Physics background to see the data collection and statistics in real time. Certain changes in the spectrum shape, such as that produced by beta particle interactions, can be interpreted by the trained eye, even when it cannot be identified by the automated algorithms. This screen provides a dynamic display for this particular set of users.

TRAINEE REVIEW QUESTIONS

STS Line Item 4.9.2.11.2: Gamma Spec (i.e. SAM-940)

1. What type of radioactive source is be used to calibrate the SAM 940?
2. What user mode do you select to use the SAM 940?
3. If you want the SAM 940 to analyze isotopes, which mode of operation should you select?
4. What operation should be conducted frequently in the actual monitoring location to provide a point of reference and correct for ambient radioactivity?

PERFORMANCE CHECKLIST

STS Line Item 4.9.2.11.2: Gamma Spec (i.e. SAM-940)

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. Turn on the meter?			
2. Press “enter” when prompted?			
3. Select the “administrator” user-mode and press enter?			
4. Press the menu key to open the menu?			
5. Press the over button and highlight the cog wheel, which is “field settings”?			
6. Scroll down and highlight the “course calibrate with Cs-137?			
7. Press enter; move the Cs-137 source next to the detector when prompted?			
8. Press enter to begin calibration[2]?			
9. Upon completion of calibration, the SAM 940 will return to the “field settings” screen			
10. Press the “back” button or select “exit” and press enter to return to the dial screen			
11. Remove check source			
12. Highlight “background” by utilizing the directional pad and press enter			
13. Ensure there are no sources located next to the SAM 940, then press enter			
14. When background is complete it will return to the dial mode screen			
15. Position the meter close enough to begin identification			
16. Highlight the “identify” function and press enter			
17. Observe the “results” screen when finished identifying			

Did the trainee successfully complete the task?			

TRAINEE NAME (PRINT)

TRAINER NAME (PRINT)

ANSWERS

1. What type of radioactive source is be used to calibrate the SAM-940?

   A: Cesium-137.

   (Source: SAM-940 User Manual)

2. What user mode do you select to use the SAM-940?

   A: Administrator

   (Source: SAM-940 User Manual)

3. If you want the SAM-940 to analyze isotopes, which mode of operation should you select?

   A: Identify

   (Source: SAM-940 User Manual)

4. What operation should be conducted frequently in the actual monitoring location to provide a point of reference and correct for ambient radioactivity?

   A: Taking a background.

   (Source: SAM-940 User Manual)

STS Line Item 4.9.2.11.3: Geiger-Mueller (i.e. ADM-300)

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:	None
Training References:	• Equipment User's Manual. • *Final Guidance Document For Use Of The Canberra ADM-300 Multifunction Survey Meter,* January 2008, Air Force Institute of Operational Health (now USAFSAM). • Consultative Letter, IOH-SD-BR-SR-2006-0037, *ADM-300 "E" Kit (Cs-137/Th-232 Check Sources) Certification,* Air Force Institute of Operational Health (now USAFSAM).
Additional Supporting References:	• *Fundamentals of Industrial Hygiene*, 6th edition. • *Basic Radiation Protection Technology, 6th* Edition. • IOH-SD-BR-SR-2005-0004, *Bioenvironmental Engineer's Guide to Ionizing Radiation,* October 2005, Air Force Institute of Operational Health (now USAFSAM).
CDC Reference:	4B051
Training Support Material:	• Equipment User's Manual. • ADM-300. • Alpha probe (AP-100). • Beta probe (BP-100). • X-ray probe (XP-100). • ADM-300 Kit E, Test/Verification Kit (including check sources).
Specific Techniques:	Conduct hands-on training and evaluation of calibration and operation of equipment with verification of steps.
Criterion Objective:	Given an ADM-300 meter with probes, perform field checks on the meter using each probe and demonstrate how to operate the meter successfully completing all checklist items with limited trainer assistance on only the hardest parts.

Notes:
*****The ADM-300 meter is calibrated each year, most likely, through your Precision Measurement Equipment Laboratory (PMEL). Proper instrument response is verified by performing a pre-operational check before and after each mission and every 180 days. This QTP outlines the steps for performing a pre-operational check and how to operate the ADM-300 survey meter alone and with external probes. Your Air Force purchased ADM-300 survey meter will should come equipped with three probes:

1. The alpha probe (AP-100) for alpha monitoring.
2. The beta probe (BP-100) for beta monitoring.
3. The x-ray probe (XP-100) designed specifically for plutonium-239 detection (17 keV window) such as in broken arrows or nuclear incidents.

The ADM-300 Kit E, Test/Verification Kit, contains two radioactive check sources (thorium 232 and cesium 137). Using the check sources the trainer can set up a training environment in a controlled area having the trainee locate and measure the energy from each source. You must maintain proper control of these sources as you use them to check the meter response and return the kit and sources to the secure storage area when finished.

TASK STEPS

USER PRE-OPERATIONAL CHECK OF THE ADM-300 METER WITHOUT A PROBE:

1. Remove cesium-137 check source from the TS-100 test source container.
2. Insert the cesium-137 check source into the test source container, facing upward, in the circular insert.
3. Turn the ADM-300 meter ON (in an area away from the source – at least six feet) and verify that "*Rate*" is displayed.
4. Place the ADM-300 meter on the test source container.
5. Allow rate reading to stabilize for 20 seconds.
6. Note the rate reading.
7. Confirm that the displayed rate reading is within the upper and lower check source values listed for the current year[1].
8. If the meter readings are not within the upper and lower values, repeat steps 1-7[2].
9. Turn ADM-300 meter OFF and return cesium-137 to the TS-100 container.

USER PRE-OPERATIONAL CHECK OF THE ADM-300 METER WITH THE ALPHA PROBE (AP-100):

1. Remove thorium-232 check source from the TS-100 test source container.
2. With the ADM-300 meter turned OFF, attach the alpha probe to the meter[3].
3. Turn the ADM-300 meter on[4].
4. Lay the thorium-232 check source in position on the alpha probe window with the thorium-232 facing the window.
5. Allow rate reading to stabilize for 20 seconds.
6. Note the rate reading.
7. Confirm that the displayed rate reading is within the upper and lower check source values for the current year[1].
8. If the meter readings are not within the upper and lower values, repeat steps 1-7[2].
9. Turn ADM-300 meter OFF, replace the alpha probe's protective cover, disconnect the alpha probe from the survey meter, and return the thorium-232 source to the TS-100 container.

USER PRE-OPERATIONAL CHECK OF THE ADM-300 METER WITH THE BETA PROBE (BP-100):

1. Remove cesium-137 check source from the TS-100 test source container.
2. Place the cesium-137 check source into the test source container, facing upward, in the circular insert.
3. With the ADM-300 meter turned OFF, attach the beta probe to the meter[3].
4. Turn the ADM-300 meter on[5].
5. Allow rate reading to stabilize for 20 seconds.
6. Note the rate reading.
7. Confirm that the displayed rate reading is within the upper and lower check source values for the current year[1].
8. If the meter readings are not within the upper and lower values, repeat steps 1-7[2].
9. Turn ADM-300 meter OFF, disconnect the beta probe, and return the cesium-137 source to the TS-100 container.

USER PRE-OPERATIONAL CHECK OF THE ADM-300 WITH THE X-RAY PROBE (XP-100):

1. Remove thorium-232 check source from the TS-100 test source container.
2. Place the thorium-232 check source on a flat surface with the circle facing upwards.
3. With the ADM-300 meter turned OFF, attach the x-ray probe to the meter[3].
4. Turn the ADM-300 meter on[6].
5. Place the probe on the test source, center of the circle, with the probe face flat against the source.
6. Allow rate reading to stabilize for 20 seconds.
7. Note the rate reading.
8. Confirm that the displayed rate reading is within the upper and lower check source values for the current year[1].
9. If the meter readings are not within the upper and lower values, repeat steps 1-8[2].
10. Turn the ADM-300 meter OFF, disconnect the x-ray probe, and return the thorium-232 source to the TS-100 container.

OPERATE THE ADM-300 METER:

(The following steps are standard any time the ADM-300 is operated regardless of configuration.)

1. Perform a battery check.
2. Visually check meter and probe for tears, holes, cracks, and missing or broken pins.
3. Determine the appropriate for the type of radiation being measured[7].
4. Perform a user pre-operational check appropriate to the type of radiation being measured.
5. Select the desired mode of measurement (*rate* or *scalar*) [8].
6. Measure background radiation well away from the area/surface to be monitored.

Operate ADM-300 meter without probe to measure gamma radiation:

1. Close the beta window[9].
2. Determine the sample location[10].
3. Position the meter holding it at a consistent angle[11].
4. Note the rate reading.
5. Subtract the background value from the reading.

Operate ADM-300 meter without probe to measure gamma and beta radiation:

1. Open the beta window[9].
2. Determine the sample location[10].
3. Position the meter holding it at a consistent angle[12].
4. Record the rate reading.
5. Close the beta window.
6. Note the rate reading.
7. Compare the two readings[11].

Operate ADM-300 meter with alpha probe to measure alpha radiation, demonstrating ability to perform measurements with meter and proper probe orientation during use:

1. Remove cover from the alpha probe.
2. Determine the sample location[10].
3. Position the meter holding it at a consistent angle[13].
4. Note the rate reading.
5. Subtract the background value from the reading.

Operate ADM-300 meter with beta probe to measure beta radiation, demonstrating ability to perform measurements with meter and proper probe orientation during use:

1. Determine the sample location[10].
2. Position the meter holding it at a consistent angle[14].
3. Note the rate reading.
4. Subtract the background value from the reading.

Operate ADM-300 meter with x-ray probe to measure x-ray radiation, demonstrating ability to perform measurements with meter and proper probe orientation during use:

1. Determine the sample location[8].
2. Position the meter holding it at a consistent angle[15].
3. Note the rate reading.
4. Subtract the background value from the reading.

LOCAL REQUIREMENTS:

NOTES:

1. Recall that radioisotopes release energy as they decay in an effort to reach a stable state; therefore, source strength will decrease over time. Upper and lower source strength values are listed on the test source containers in progressive calendar year groups. You will need to locate the upper and lower values that correspond to the current year. Meter readings must be within the upper and lower values to be considered acceptable. If the meter reading is not within the range, repeat the steps.
   - During calibration/verification using an alpha probe, if the thorium-232 source is expired ensure the readings are ±20 percent of the acceptable values identified inside the lid of the TS-100 container.
   - During calibration/verification using a beta probe, if the cesium-137 source is expired multiply the last acceptable values on the inside lid of the TS-100 container by 0.933 for the set of acceptable limits for the next three years.
   - During calibration/verification using an x-ray probe, if the thorium-232 is expired ensure the readings are ±20 percent of the acceptable values identified inside the lid of the TS-100 container.

   AP-100 and XP-100: No decay is required for the thorium-232 check source due to its long half-life. Upon receipt from calibration, each alpha probe and x-ray probe detector should be placed against the thorium-232 source per the manufacturer's response check instructions. The will calculate acceptable response values for those probes at that time. Acceptable values are ±20 percent. To calculate this value, multiply the source activity by 0.8 for the lower acceptable value and multiply the source activity by 1.2 for the upper acceptable value. Document each detector specific acceptable response values with calibration records and with the detector.

2. If the meter reading fails twice to fall within these values, do not use the meter and return it to the manufacturer for maintenance.

3. Each external probe is configured such that during power-up of the survey meter, the type of prove is recognized electronically by the survey meter. The ADM-300 meter provides power to operate the probe. External probes are connected to the survey meter through the 7-pin connector on the back panel while the ADM-300 meter is turned OFF. The survey meter MUST be turned OFF before connecting the external probe. After connection, when the survey meter is turned ON, the meter automatically gets all the necessary configuration and calibration data from the probe. Since each probe contains its own calibration information, any probe can be used with any ADM-300 meter and maintain its calibration.

4. Turn the survey meter power ON. The unit displays "Please Wait" then "Alpha Probe" and units of measure. The unit automatically begins to measure alpha radiation. If *"Alpha Probe"* does not appear on the display automatically, press and release the *INC* key on the meter until it does. Three units of alpha measurement are available:
   - .000 cpm (counts per minute).
   - .000 µCi/MxM (micro-Curie per square meter).
   - .000 DPM/CMxCM (disintegrations per minute per 100 square centimeters).

5. Turn the survey meter power ON. The unit displays "Please Wait" then "Beta Probe" then displays units of measurement. The unit automatically begins to measure Beta radiation. If the *"Beta Probe"* does not appear on the display automatically, press and release the *INC* key on the meter until it does.

6. Turn the survey meter power ON. The unit displays "Please Wait" then "X-RAY Probe" and units of measure.

7. When measuring gamma radiation, no probe is used. When measuring alpha, beta, or x-ray, select the probe appropriate

for the type of radiation being measured and attach it to the meter (when the meter is turned OFF).

8. The ADM-300 meter has the option of collecting the measurement in *rate* or *scalar* (integrate) modes. Due to fluctuations in meter response while in rate mode, it is easier to make quantitative measurements in the scalar mode when using an alpha or beta probe.

9. When monitoring for beta radiation, use extreme care to protect the beta window when the beta window cover is open as sharp objects can rupture the beta window.

10. Where you collect readings will depend upon the situation (i.e., type of survey, type of radiation, source strength, extent of contamination, etc.). Be aware of your position at all times. Position yourself so you obtain useful readings, but without overexposing yourself. See IOH-SD-BR-SR-2005-0004, *Bioenvironmental Engineer's Guide to Ionizing Radiation*, October 2005, Air Force Institute of Operational Health (now USAFSAM), for specific measurement techniques.

11. The ADM-300 meter, with the shutter closed, should be held parallel to the surface, using a slow and steady sweeping motion. It will detect gamma radiation from several meters away from a source.

12. In this configuration, the meter can *detect*, <u>not measure</u>, beta radiation; the meter will not provide accurate dose rate readings. If the reading with the beta window open is greater than the reading with the window closed, beta radiation is present.

13. Recall that alpha radiation travels only centimeters. Therefore, the probe will need to be as close as possible to the source for an accurate reading, approximately 1/8th to 1/16th of an inch away from the surface being monitored. The alpha probe should be held parallel to the surface, using a slow and steady sweeping motion.

14. The beta probe should be held parallel to the surface, using a slow and steady sweeping motion, a few centimeters from the suspected contamination in order for the probe to detect it.

15. The x-ray probe is directional and should be held vertically to the surface, using a slow and steady sweeping motion, approximately 1/8th of an inch away from the surface being monitored.

TRAINEE REVIEW QUESTIONS

STS Line Item 4.9.2.11.3: Geiger-Mueller (i.e. ADM-300)

1. Which check source is used to field check the ADM-300 meter configured without a probe?
2. Which check source is used to field check the ADM-300 meter configured with an alpha probe (AP-100)?
3. What must you do if the meter reading exceeds the upper check source when field checking a probe?
4. After placing the meter or probe against a check source, what must you do before recording the meter reading?
5. Assume you are field checking an ADM-300 meter configured with an x-ray probe (XP-100). After recording the reading from the check source, what is the next step?

PERFORMANCE CHECKLIST

STS Line Item 4.9.2.11.3: Geiger-Mueller (i.e. ADM-300)

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
USER PRE-OPERATIONAL CHECK OF THE ADM-300 METER WITHOUT A PROBE:			
1. Remove cesium-137 check source from the TS-100 test source container?			
2. Insert the cesium-137 check source into the test source container, facing upward, in the circular insert?			
3. Turn the ADM-300 meter ON (in an area away from the source – at least six feet) and verify that "*Rate*" is displayed?			
4. Place the ADM-300 meter on the test source container?			
5. Allow rate reading to stabilize for 20 seconds?			
6. Note the rate reading?			
7. Confirm that the displayed rate reading is within the upper and lower check source values listed for the current year?			
8. If the meter readings are not within the upper and lower values, repeat steps 1-7?			
9. Turn ADM-300 meter OFF and return cesium-137 to the TS-100 container?			
USER PRE-OPERATIONAL CHECK OF THE ADM-300 METER WITH THE ALPHA PROBE (AP-100):			
1. Remove thorium-232 check source from the TS-100 test source container?			
2. With the ADM-300 meter turned OFF, attach the alpha probe to the meter?			
3. Turn the ADM-300 meter on?			
4. Lay the thorium-232 check source in position on the alpha probe window with the thorium-232 facing the window?			
5. Allow rate reading to stabilize for 20 seconds?			

6. Note the rate reading?			
7. Confirm that the displayed rate reading is within the upper and lower check source values for the current year?			
8. If the meter readings are not within the upper and lower values, repeat steps 1-7?			
9. Turn ADM-300 meter OFF, replace the alpha probe's protective cover, disconnect the alpha probe from the survey meter, and return the thorium-232 source to the TS-100 container?			
USER PRE-OPERATIONAL CHECK OF THE ADM-300 METER WITH THE BETA PROBE (BP-100):			
1. Remove cesium-137 check source from the TS-100 test source container?			
2. Place the cesium-137 check source into the test source container, facing upward, in the circular insert?			
3. With the ADM-300 meter turned OFF, attach the beta probe to the meter?			
4. Turn the ADM-300 meter on?			
5. Allow rate reading to stabilize for 20 seconds?			
6. Note the rate reading?			
7. Confirm that the displayed rate reading is within the upper and lower check source values for the current year?			
8. If the meter readings are not within the upper and lower values, repeat steps 1-7?			
9. Turn ADM-300 meter OFF, disconnect the beta probe, and return the cesium-137 source to the TS-100 container?			
USER PRE-OPERATIONAL CHECK OF THE ADM-300 WITH THE X-RAY PROBE (XP-100):			
1. Remove thorium-232 check source from the TS-100 test source container?.			
2. Place the thorium-232 check source on a flat surface with the circle facing upwards?			
3. With the ADM-300 meter turned OFF, attach the x-ray probe to the meter?			
4. Turn the ADM-300 meter on[6]?			
5. Place the probe on the test source, center of the circle, with the probe face flat against the source?			
6. Allow rate reading to stabilize for 20 seconds?			
7. Note the rate reading?			
8. Confirm that the displayed rate reading is within the upper and lower check source values for the current year?			
9. If the meter readings are not within the upper and lower values, repeat steps 1-8?			
10. Turn the ADM-300 meter OFF, disconnect the x-ray probe, and return the thorium-232 source to the TS-100 container?			

OPERATE THE ADM-300 METER:			
1. Perform a battery check?			
2. Visually check meter and probe for tears, holes, cracks, and missing or broken pins?			
3. Determine the appropriate for the type of radiation being measured?			
4. Perform a user pre-operational check appropriate to the type of radiation being measured?			
5. Select the desired mode of measurement (*rate* or *scalar*)?			
6. Measure background radiation well away from the area/surface to be monitored?			
Operate ADM-300 meter without probe to measure gamma radiation:			
1. Close the beta window?			
2. Determine the sample location?			
3. Position the meter holding it at a consistent angle?			
4. Note the rate reading?			
5. Subtract the background value from the reading?			
Operate ADM-300 meter without probe to measure gamma and beta radiation:			
1. Open the beta window?			
2. Determine the sample location?			
3. Position the meter holding it at a consistent angle?			
4. Record the rate reading?			
5. Close the beta window?			
6. Note the rate reading?			
7. Compare the two readings?			
Operate ADM-300 meter with alpha probe to measure alpha radiation, demonstrating ability to perform measurements with meter and proper probe orientation during use:			
1. Remove cover from the alpha probe?			
2. Determine the sample location?			
3. Position the meter holding it at a consistent angle?			

4. Note the rate reading?			
5. Subtract the background value from the reading?			
Operate ADM-300 meter with beta probe to measure beta radiation, demonstrating ability to perform measurements with meter and proper probe orientation during use:			
1. Determine the sample location?			
2. Position the meter holding it at a consistent angle?			
3. Note the rate reading?			
4. Subtract the background value from the reading?			
Operate ADM-300 meter with x-ray probe to measure x-ray radiation, demonstrating ability to perform measurements with meter and proper probe orientation during use:			
1. Determine the sample location?			
2. Position the meter holding it at a consistent angle?			
3. Note the rate reading?			
4. Subtract the background value from the reading?			
Did the trainee successfully complete the task?			

TRAINEE NAME (PRINT)

TRAINER NAME (PRINT)

ANSWERS

1. Which check source is used to field check the ADM-300 meter configured without a probe?

   A: Cesium-137.

   (Source: *Final Guidance Document For Use Of The Canberra ADM-300 Multifunction Survey Meter,* January 2008, Air Force Institute of Operational Health (now USAFSAM), pg. 24, Checklist 4.3)

2. Which check source is used to field check the ADM-300 meter configured with an alpha probe (AP-100)?

   A: Thorium-232.

   (Source: *Final Guidance Document For Use Of The Canberra ADM-300 Multifunction Survey Meter,* January 2008, Air Force Institute of Operational Health (now USAFSAM), pg. 24, Checklist 4.4)

3. What must you do if the meter reading exceeds the upper check source when field checking a probe?

   A: Repeat field check procedures.

   (Source: *Final Guidance Document For Use Of The Canberra ADM-300 Multifunction Survey Meter,* January 2008, Air Force Institute of Operational Health (now USAFSAM), pg. 24, Checklist 4.4)

4. After placing the meter or probe against a check source, what must you do before recording the meter reading?

   A: Allow the rate reading to stabilize for 20 seconds.

   (Source: *Final Guidance Document For Use Of The Canberra ADM-300 Multifunction Survey Meter,* January 2008, Air Force Institute of Operational Health (now USAFSAM), pg. 24, Checklist 4.3.)

5. Assume you are field checking an ADM-300 meter configured with an x-ray probe (XP-100). After recording the reading from the check source, what is the next step?

A: Compare the meter reading to the upper and lower source values to confirm reading is within the range of values.

(Source: *Final Guidance Document For Use Of The Canberra ADM-300 Multifunction Survey Meter*, January 2008, Air Force Institute of Operational Health (now USAFSAM), pg. 24, Checklist 4.7.)

STS Line Item 4.9.2.11.4: EPD (i.e. MK-2 & N-2)

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:	Electronic Personal Dosimeter (EPD), Web-Based Training.
Training References:	• Equipment User's Manual. • *Final Guidance Document for Use of the EPD Mk2 and EPD N2 Electronic Personal Dosimeters, Mar 2008*
Additional Supporting References:	• IOH-SD-BR-SR-2005-0004, *Bioenvironmental Engineer's Guide to Ionizing Radiation*, October 2005, Air Force Institute of Operational Health (now USAFSAM).
CDC Reference:	4B051
Training Support Material:	• Equipment User's Manual. • Electronic Personal Dosimeter (EPD).
Specific Techniques:	Conduct hands-on training and evaluation of calibration and operation of equipment with verification of steps.
Criterion Objective:	Given an Electronic Personal Dosimeter (EPD), perform a pre-operational check on the EPD and demonstrate how to operate the dosimeter successfully completing all checklist items with limited trainer assistance.

Notes:

* Electronic Personnel Dosimeters (EPDs) have been issued to the Bioenvironmental Engineering Flight (BEF) as part of the Home Station Response Allowance Standard also referred to as the 886H Allowance Standard. Each BEF has been issued, at minimum, four model Mk2s and two N2s EPDs. EPDs serve as alternative or supplemental equipment to TLDs during radiological monitoring. One of the greatest advantages of the EPD is that it detects and records real-time doses and dose-rates of ionizing radiation for first responders and routine occupation personnel. By using the EasyEPD2 software, personnel are able to take the information, display it on a computer, and put it into a graph showing when the user received a specific dose and the length of time of the exposure. Using an infrared (IR) communication link, the EasyEPD2 software program:

- Reads data from the EPD.
- Displays it on a computer/laptop.
- Writes threshold points and other parameters to the EPD.
- Displays dose rate and exposure rate.

The EasyEPD2 software can operate on any computer with the Microsoft Windows™ operating system. However, there must be an external IR reader connected to the computer/laptop.

The EPD Mk2 detects/responds to both beta and photon radiation. The EPD N2 detects/responds to photon and neutron radiation. Results of the EPD Mk2 and N2 are real-time quantitative exposures, and should be compared to applicable exposure guidelines (situation dependent) in support of health risk assessments (HRAs).

TASK STEPS

OPERATING AN EPD:

(The following steps are standard any time an EPD is operated regardless of model: Mk2 or N2.)

1. Inspect the EPD to ensure there is no physical damage and no *Default* display showing on the LCD.
2. Verify the EPD's calibration is current[1].
3. Confirm that the EPD has the appropriate mounting device attached[2].
4. Conduct a successful confidence test[3].
5. Verify the EPD has been programmed properly[4].
6. Issue the EPD to user[5].
7. Instruct the user how to properly wear the EPD, its purpose, and what to do in the event the alarm sounds[6].
8. Ensure the user correctly attaches EPD to their body properly ensuring the dosimeter is not covered by protective clothing.
9. De-issue the EPD from user when work is complete[7].

LOCAL REQUIREMENTS:

NOTES:

1. Each dosimeter should be calibrated and routinely maintained by the USAFSAM Radiation Dosimetry Laboratory. Additional calibration is not needed.

2. The mounting device is the lanyard or belt-clip which is attached to the dosimeter so it can be attached to the body.

3. Monitor the initialization sequence by checking that an '8888' appears on the display for about three seconds. Then the dosimeter should check the status of its own software and run a confidence test. If the confidence test is successful, the ***default display*** should appear – the EPD Mk2 shows Hp(10) for deep-dose exposure and the EPD N2 shows HpG (for gamma/x-rays). Once the default display appears, the dosimeter is now in operation.

4. Open the EasyEPD2 program on the PC or laptop – you must have an infrared (IR) adapter to communicate with both the N2 and the Mk2. Place the dosimeter with button facing, and within range of the IR adapter. Once in range, the *Dose and Alarms* screen will automatically pop-up. Manually input the user name and SSN (recommended practice is to use the user's SSN without the dashes). Continue by manually inputting the *Dose Alarm Thresholds* and *Rate Alarm Thresholds*. *Final Guidance Document For Use Of The EPD® Mk2 and EPD® N2 Electronic Personal Dosimeters*, March 2007, Air Force Institute of Operational Health (now USAFSAM), Tables 2-6 and 2-7 contain recommended settings (alarm set points) based on the situation. Be aware of the units sieverts versus rem and micro versus milli. Once thresholds and personnel data are established, click the *Write to EPD®* button in the tool bar (second yellow button from the left). Now you are ready to issue the dosimeter to the user.

5. The EasyEPD2 software does not keep a record of who had what EPD and what dose was received. Therefore, a Utilization Log must be maintained by the issuing organization. It is recommended that a spreadsheet or database program be used to keep the data organized and secure. For each EPD issue and subsequent de-issue, the following information must be recorded:

- Serial number of the EPD (located on the back of the EPD).

- User's name, SSN, gender, and date of birth.
- The time the EPD was issued and the time it was de-issued (returned).
- The dose the person received while wearing the EPD.

The dose values will be displayed on the Dose and Alarms window when the EPD is placed in front of the IR reader during de-issue. Be sure to record the numbers in the Dose column and not the numbers in the Total dose column. If there are not enough EPDs for all individuals on a team, then issue one EPD per team. Issue it to the worker who is likely to receive the highest dose – the team leader or the one working closest to the ionizing radiation source.

6. For most operating conditions, it is recommended that the EPD be worn on the front torso area, outside of any personal protective equipment (PPE), with the push-button control facing outwards (away from the user's body). By wearing the dosimeter on the exterior of the PPE, the user has the ability to read the LCD display, see the visual alarm LED, and manually operate the dosimeter. The dosimeter can be placed inside a clear, sealable plastic bag to minimize/prevent contamination of the unit; however, this affects the measured dose of beta radiation. In the event that the alarm sounds, the user is instructed to evacuate the area immediately.

7. After use, the EPD should be downloaded to record dose and dose-rate. Use the IR communication link of the EPD for this. When the EPD is placed in front of the IR reader the dose values are automatically displayed on the *Dose and Alarms* windows. This information should be recorded and sent to USAFSAM Radiation Dosimetry Laboratory for inclusion into the individual's Longitudinal Exposure Record (LER).

PERFORMANCE CHECKLIST

STS Line Item 4.9.2.11.4: EPD (i.e. MK-2 & N-2)

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 PROPERLY…		YES	NO
1. Inspect the EPD to ensure there is no physical damage and no *Default* display showing on the LCD?			
2. Verify the EPD's calibration is current?			
3. Confirm that the EPD has the appropriate mounting device attached?			
4. Conduct a successful confidence test?			
5. Verify the EPD has been programmed properly?			
6. Issue the EPD to user?			
7. Instruct the user how to properly wear the EPD, its purpose, and what to do in the event the alarm sounds?			
8. Ensure the user correctly attaches EPD to their body properly ensuring the dosimeter is not covered by protective clothing?			
9. De-issue the EPD from user when work is complete?			
Did the trainee successfully complete the task?			

TRAINEE NAME (PRINT) TRAINER NAME (PRINT)

STS Line Item 4.9.2.11.5: High Volume Air Sampler (i.e. RADeCO)

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..2.11.3 Geiger-Mueller (i.e. ADM-300)
Training References:	• Final Guidance Document for the use of the RADeCO H-809VII Variable Flow Sampler July 2007 • IOH-SD-BR-CL-2006-0017 "Minimum Air Sample Volume for the RADeCO High Volume Air Sampler Model H-809 VII," 7 Feb 06 • IOH-SD-BR-CL-2005-0081 "Alpha Correction Factor for New BE Air Sampling Equip - RADeCO Model H-809 VII," 21 Sep 05 • RADeCO USAF High Volume Air Sampling Kit, education resource from RADeCO inc, from ESOH Service Center website
Additional Supporting References:	• N/A
CDC Ref*erence:*	4B051
Training Support Material:	• RADeCO Variable Flow Sampler, Calibrator, Filter Adaptor, Filters, Tripod and generator.
Specific Techniques:	Conduct hands-on training and evaluation.
Criterion Objective:	Given a RADeCO, ADM-300, and associated supplies, collect and analyze a sample for airborne radioactive material successfully completing all checklist items with limited trainer guidance.

Notes:

*The purpose of this training is to become proficient in using the RADeCO high volume air sampler in to collect samples for radioanalytical analysis. Calibration of the RADeCO is not covered in this training.

The final guidance document for the RADeCO provides step-by-step instructions for setting up and using the RADeCO. The trainee should have access to this document at all times during training and evaluation, as should the guidance document for determining the minimum sample volume to be collected.

Any training or use involving the RADeCO should be conducted outdoors using the generator, as this is the environment it would be used in, and trainees should be familiar with operation of the generator used by your shop as well as the RADeCO.

TASK STEPS

DETERMINE RADIATION HAZARDS

1. Determine sample locations following a radiological incident where airborne contamination is suspected.

2. Determine required volume, flow rate, and collection time for a representative sample using appropriate guidance document.

3. Set flow rate by using calibrator and sample media of the same type used in the sample.

4. Set up sampler on tripod, ~5 feet above ground and ~2 building heights away from nearby structures.

5. Collect background of sample paper using ADM-300 Alpha probe and 1 minute scaler.

6. Run sample for appropriate amount of time.

7. Without removing sample paper, survey using the ADM-300 Alpha probe and 1 minute scaler.

LOCAL REQUIREMENTS:

NOTES:

1. Sample locations should include: several locations downwind of incident, filter facing into the wind, 5-6 feet off the ground, and at least 2 building heights away from nearest structure. For example, if setting up near a 20' building, the sampler should be placed no closer than 40'. One RADeCO should also be set up several hundred feet upwind of the incident to obtain background measurements.

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2. Sample volume collected is dependant on local conditions. If dust loading is a concern at your base, or sampling following a radiation dispersal device, 100ft^3 should be collected, if not, 1000ft^3 is the recommended sample volume. At a 20 cfm flow rate, this equates to 5 minutes for 100ft^3 or 50 minutes for 1000ft3 for 1000ft^3.

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3. Compare rotometer reading at 20 cfm to calibrator reading. Rotometer should be accurate within 5%. If not, adjust using "RADeCO USAF High Volume Air Sampling Kit" found on the ESOH Service Center website. Always use a generator when and allow RADeCO to warm up at least 5 minutes prior to performing this check.

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4. RADeCO will be set up on the tripod at full height (~5ft), and adjusted to be level. Filter will face into the wind for all downwind samples (towards the incident), and 2 building heights away from nearest building. Start generator prior to plugging in the RADeCO.

---

5. Ensure all surfaces, and filter holder are free of contamination and use ADM-300 with AP-100 to collect background on filter paper (using 1 minute scaler). Record background reading.

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6. Collect sample at 20cfm for appropriate amount of time for your base/incident; 5 minutes for high dust/RDD, 50 minutes standard.

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7. When sampler stops running (and no sooner) collect survey reading without removing filter holder (1 minute scaler).

TRAINEE REVIEW QUESTIONS

STS Line Item 4.9.2.11.5: High Volume Air Sampler (i.e. RADeCO)

1. The filter paper for the RADeCO has a porous side and a fibrous side, which side faces out (collects the sample)?
2. According to the consultative letter on minimum air sample volume for the RADeCO, what is the recommended minimum sample volume following a nuclear weapons incident?
3. How often is calibration required?

PERFORMANCE CHECKLIST

STS Line Item 4.9.2.11.5: High Volume Air Sampler (i.e. RADeCO)

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 sample locations following a radiological incident where airborne contamination is suspected?			
2. Determine required volume, flow rate, and collection time for a representative sample using appropriate guidance document?			
3. Set flow rate by using calibrator and sample media of the same type used in the sample?			
4. Set up sampler on tripod, ~5 feet above ground and ~2 building heights away from nearby structures?			
5. Collect background of sample paper using ADM-300 Alpha probe and 1 minute scaler?			
6. Run sample for appropriate amount of time?			
7. Without removing sample paper, survey using the ADM-300 Alpha probe and 1 minute scaler?			

TRAINEE NAME (PRINT)

TRAINER NAME (PRINT)

ANSWERS

1. The filter paper for the RADeCO has a porous side and a fibrous side, which side faces out (collects the sample)?

   A: Fibrous or textured side.

   (Source: RADeCO USAF High Volume Air Sampling Kit, RADeCO inc, "Taking a Sample")

2. According to the consultative letter on minimum air sample volume for the RADeCO, what is the recommended minimum sample volume following a nuclear weapons incident?

   A: $1000ft^3$ unless dust loading is a concern, then $100ft^3$ may be used.

   (Source: OH-SD-BR-CL-2006-0017 "Minimum Air Sample Volume for the RADeCO High Volume Air Sampler Model H-809 VII," 7 Feb 06, paragraph 1)

3. How often is calibration required?

   A: Annually

   (Source: 4B051 CDC)

STS Line Item 4.9.2.13: Perform ionizing radiation calculations (dose, dose rate, stay time, protection factors, decay, etc.)

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:	None
Training References:	• *Fundamentals of Industrial Hygiene*, *6*th, Edition, Chapter 10. • *Basic Radiation Protection Technology*, 5th Edition, Chapter 5.
Additional Supporting References:	• IOH-SD-BR-SR-2005-0004, *Bioenvironmental Engineer's Guide to Ionizing Radiation*, October 2005, Air Force Institute of Operational Health (now USAFSAM).
CDC Reference:	4B051
Training Support Material:	• Calculator • Paper • Writing utensil
Specific Techniques:	Conduct hands-on training and evaluation.
Criterion Objective:	Given mathematical problems and equations, perform ionizing radiation calculations successfully completing all checklist items with limited trainer assistance on only the hardest parts.

Notes:

See Notes Section for formulas.

TASK STEPS

1. Calculate activity at an earlier date (A_o) using current activity.[1]
2. Calculate radioisotope decay (current activity – A_t) when given activity at an earlier date.[2]
3. Calculate disintegration rate (dpm).[3]
4. Calculate rem value (dose equivalent).[4]
5. Calculate gamma exposure rate at given distance when the activity is known (I).[5]
6. Calculate exposure rate at a given distance when given an exposure rate at that distance at an earlier date (I_t).[6]
7. Calculate exposure rate (intensity) at a given distance using Inverse Square Law.[7]
8. Calculate a distance to a desired exposure rate using Inverse Square Law.[8]

LOCAL REQUIREMENTS:

NOTES:

1. Calculate activity at an earlier date (A_o) using current activity.

a. Identify current activity (At), time elapsed between present and earlier date (t), and isotope half-life (T1/2).

b. Substitute At, t and T1/2 values in the equation and solve.

c. Convert answer from common unit to SI.

d. Formula for calculating activity at an earlier date (A_o) using current activity**:**

$$\boldsymbol{A_t = A_o e^{(-\lambda t)}}$$

OR

$$A_t = A_o e^{-\left(\frac{0.693}{T_{1/2}}\right)(t)}$$

<u>Where:</u>

A_t = current activity (curies)

A_o = original activity (curies)

e = 2.71828 (base of the natural logarithm system)

λ = decay constant simplified to $\left(\frac{0.693)}{T_{1/2}}\right)$

t = elapsed time between A_o and A_t

2. Calculate radioisotope decay (current activity – A_t) when given activity at an earlier date.

a. Identify original activity (A_o), time elapsed since original activity was recorded (t), and isotope half-life ($T_{1/2}$).
b. Substitute A_o, t, and $T_{1/2}$ values in the equation and solve.
c. Convert answer from common unit to SI).
d. Formula for calculating radioisotope decay (current activity – A_t) when given activity at an earlier date**:**

$$A_o = \frac{A_t}{e^{-\lambda t}} \quad \textbf{OR} \quad A_o = \frac{A_t}{e^{-\left(\frac{0.693}{T_{1/2}}\right)(t)}}$$

Where:

A_t = current activity (curies)

A_o = original activity (curies).

e = 2.71828 (base of the natural logarithm system)

λ = decay constant simplified to $\left(\frac{0.693)}{T_{1/2}}\right)$

t = elapsed time between A_o and A_t

3. Calculate disintegration rate (dpm).

a. Identify counts per minute reading and instrument efficiency rating (found in manufacturer's literature).
b. Substitute CPM and efficiency rating values in the equation and solve.
c. Convert answer from common unit to SI.
d. Formula for calculating disintegration rate (dpm):

$$\textbf{Disintegrations per minute } (\textbf{dpm}) = \frac{\textbf{count rate } (\textbf{cpm})}{\textbf{detector efficiency}}$$

4. Calculate rem value (dose equivalent).

a. Determine/measure radiation activity.
b. Identify/convert to rad value.
c. Determine quality factor based on radiation type.
d. Substitute values in the equation and solve.
e. Convert answer from common unit to SI.
f. Formula for calculating rem value (dose equivalent):

$$\textbf{Dose equivalent } (\textbf{rem}) = \textbf{rads} \times \textbf{Quality Factor } (\textbf{QF})$$

Where:

QF for x-ray, gamma and beta = 1

QF for neutrons of unknown energy and high energy protons = 10

QF for alpha particles, multi-charged particles, and fission fragments = 20

5. Calculate gamma exposure rate at given distance when the activity is known (*I*).

a. Identify known activity (C), energy of the emission (E), percent of disintegrations that occur with the given energy emission (n), and the known distance (D).
b. Substitute C, E, n, and D values in the equation and solve.
c. Formula for calculating gamma exposure rate at given distance when the activity is known (I):

$$\boldsymbol{I = \frac{6CEn}{D^2}}$$

Where:

I = intensity (R/hr) at a given distance

C = Curies (Ci). Units must be expressed in curies

E = energy of emission (MeV)

n = % of disintegrations that occur with the given energy emission

D = distance (in feet)

6. Calculate exposure rate at a given distance when given an exposure rate at that distance at an earlier date (I_t).

a. Identify the original exposure rate (I_o), time elapsed between present and earlier date (t), and isotope half-life ($T_{1/2}$).
b. Substitute I_o, t, and $T_{1/2}$ values in the equation and solve.
c. Formula for calculating exposure rate at a given distance when given an exposure rate at that distance at an earlier date (I_t):

$$I_t = I_o e^{-\lambda t}$$

Where:

Io = original exposure rate

e= 2.71828 (base of the natural logarithm system)

$T_{1/2}$ = radiological half life

λ = decay constant simplified to $\left(\frac{0.693)}{T_{1/2}}\right)$

t = elapsed time since original exposure (I_o)

7. Calculate exposure rate (intensity) at a given distance using Inverse Square Law.

a. Identify the original intensity (I_1) at the original distance (D_1) *(Example: you've measured 10 mR at 30 feet from a source).*
b. Identify the distance at which you wish to know the intensity (D_2) (Example: you want to know the intensity at 50 feet from the same source).
c. Substitute I_1, D_1, and D_2 values in the equation and solve.
d. Formula for calculating exposure rate (intensity) at a given distance using Inverse Square Law:

$$I_2 = \frac{I_1 D_1^2}{D_2^2}$$

Where:

Ix = intensity

Dx = distance

8. Calculate a distance to a desired exposure rate using Inverse Square Law.

a. Identify the original intensity (I_1) at the original distance (D_1) *(Example: you've measured 10 mR at 30 feet from a source).*
b. Identify the desired intensity (I_2) *(Example: you want to know how far the 2 mR line is from the same source).*
c. Substitute I_1, D_1, and I_2 values in the equation and solve.
d. Formula for calculating a distance to a desired exposure rate using Inverse Square Law:

$$D_2 = \sqrt{\frac{I_1 D_1^2}{D_2^2}}$$

Where:

Ix = intensity

Dx = distance

Conversions:

Radiation Measurements

	Radioactivity	Absorbed Dose	Dose Equivalent	Exposure
Common Units	curie (Ci)	rad	rem	roentgen (R)
SI Units	becquerel (Bq)	gray (Gy)	sievert(Sv)	colomb/kilogram (C/kg)

Conversion Equivalence

1 curie = 3.7×10^{10} disintegrations per second		1 becquerel = 1 disintegration per second
1 millicurie (mCi)	=	37 megabecquerels (MBq)
1 rad	=	0.01 gray (Gy)
1 rem	=	0.01 sievert (Sv)
1 roentgen (R)	=	0.000258 coulomb/kilogram (C/kg)
1 megabecquerel (MBq)	=	0.027 millicuries (mCi)
1 gray (Gy)	=	100 rad
1 sievert (Sv)	=	100 rem
1 coulomb/kilogram (C/kg)	=	3,880 roentgens

Conversion Factors

To convert from	To	Multiply by
Curies (Ci)	becquerels (Bq)	3.7×10^{10}
millicuries (mCi)	megabecquerels (MBq)	37
microcuries (µCi)	megabecquerels (MBq)	0.037
millirads (mrad)	milligrays (mGy)	0.01
millirems (mrem)	microsieverts (µSv)	10
milliroentgens (mR)	microcoulombs/kilogram (µC/kg)	0.258
becquerels (Bq)	curies (Ci)	2.7×10^{-11}
megabecquerels (MBq)	millicuries (mCi)	0.027
megabecquerels (MBq)	microcuries (µCi)	27
milligrays (mGy)	millirads (mrad)	100
microsieverts (µSv)	millrems (mrem)	0.1
microcoulombs/kilogram (µC/kg)	milliroentgens (mR)	3.88

TRAINEE REVIEW QUESTIONS

STS Line Item 4.9.2.13: Perform ionizing radiation calculations (dose, dose rate, stay time, protection factors, decay, etc.)

1. Calculate the remaining activity of a cesium-137 source that had a certified activity of 10 mCi on today's date, 5 years ago. Given a half-life of 30.0 years.

2. Convert the answer for problem #1 from mCi to MBq.

3. Calculate the original activity of a Co-60 source 6 months ago if you have 75 mCi today. Given a half-life of 5.271 years.

4. Calculate disintegration rate for a sample measuring 400 cpm using an instrument that has a rated efficiency of 35%.
5. Convert the answer for problem #3 from disintegrations per minute to becquerel.
6. Calculate the exposure rate of 50 mCi of I-133 at 10 feet. Given: E = 0.53 MeV and n = 90%.
7. At what distance from a source is the 2mR line if you initially measured 10mR at 30 feet?

PERFORMANCE CHECKLIST

STS Line Item 4.9.2.13: Perform ionizing radiation calculations (dose, dose rate, stay time, protection factors, decay, etc.)

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. Calculate activity at an earlier date (A_o) using current activity?			
2. Calculate radioisotope decay (current activity – A_t) when given activity at an earlier date?			
3. Calculate disintegration rate (dpm)?			
4. Calculate gamma exposure rate at given distance when the activity is known (I)?			
5. Calculate rem value (dose equivalent)?			
6. Calculate exposure rate at a given distance when given an exposure rate at that distance at an earlier date (I_t)?			
7. Calculate exposure rate (intensity) at a given distance using Inverse Square Law?			
8. Calculate a distance to a desired exposure rate using Inverse Square Law?			
Did the trainee successfully complete the task?			

TRAINEE NAME (PRINT) TRAINER NAME (PRINT)

ANSWERS

1. Calculate the remaining activity of a cesium-137 source that had a certified activity of 10 mCi on today's date, 5 years ago. Given a half-life of 30.0 years.

$$A_t = A_o e^{-\left(\frac{0.693}{T_{1/2}}\right)(t)}$$
$$A_t = 10\text{mCi} * 2.71828^{-\left(\frac{0.693}{30\text{ yr}}\right)(5\text{yr})}$$
$$A_t = 10 * 2.71828^{-(0.0231)(5)}$$
$$A_t = 10 * .89137$$
$$A_t = 8.9\text{ mCi}$$

(Source: Step 1 of this QTP)

2. Convert the answer for problem #1 from mCi to MBq.

$$\frac{8.9\text{ mCi}}{1} \times \frac{37\text{ MBq}}{1\text{ mCi}} = 329.3\text{ MBq}$$

(Source: Conversion note of this QTP)

3. Calculate the original activity of a Co-60 source 6 months ago if you have 75 mCi today. Given a half-life of 5.271 years.

$$A_o = \frac{A_t}{e^{-\left(\frac{0.693}{T_{1/2}}\right)(t)}}$$
$$A_o = \frac{75\text{ mCi}}{2.71828^{-\left(\frac{0.693}{5.271\text{ yr}}\right)(.5\text{ yr})}}$$
$$A_o = \frac{75}{2.71828^{-(0.132)(.5)}}$$
$$A_o = \frac{75}{2.71828^{-0.066}}$$
$$A_o = \frac{75}{0.936}$$
$$A_o = \underline{80.1\text{ mCi}}$$

(Source: Step 2 of this QTP)

4. Calculate disintegration rate for a sample measuring 400 cpm using an instrument that has a rated efficiency of 35%.

$$\text{dpm} = \frac{\text{cpm}}{\text{detector efficiency}}$$

$$\text{dpm} = \frac{400\ \text{cpm}}{.35}$$

$$\text{dpm} = 1143$$

(Source: Step 3 of this QTP)

5. Convert the answer for problem #3 from disintegrations per minute to becquerel.

$$\frac{\text{DPM}}{1} \times \frac{1\,\text{min}}{60\,\text{sec}} \times \frac{1\,\text{Bq}}{1\,\text{dps}}$$

$$\frac{1143}{1} \times \frac{1\,\text{min}}{60\,\text{sec}} \times \frac{1\,\text{Bq}}{1\,\text{dps}} = 19.05\,\text{Bq}$$

(Source: Conversion note of this QTP)

1. Calculate the exposure rate of 50 mCi of I-133 at 10 feet. Given: E = 0.53 MeV and n = 90%.

$$I = \frac{6CEn}{D^2}$$

$$I = \frac{6\,(.05\,\text{Ci})(.53)(.90)}{10^2}$$

$$I = \frac{0.1431}{100}$$

$$I = 0.001431\ \text{R/hr}\ \ \text{OR}\ \ 1.431 \times 10^{-3}\ \text{R/hr}$$

(Source: Step 5 of this QTP)

7. At what distance from a source is the 2mR line if you initially measured 10mR at 30 feet?

$$I_1 D_1^2 = I_2 D_2^2$$

$$D_2 = \sqrt{\frac{I_1 D_1^2}{I_2}}$$

$$D_2 = \sqrt{\frac{(10)(30^2)}{2}}$$

$$D_2 = \sqrt{\frac{(10)(900)}{2}}$$

$$D_2 = \sqrt{4500}$$

$$D_2 = 67.1\,\text{ft}$$

(Source: Step 7 of this QTP)

STS Line Item 4.9.2.16: Survey radioactive materials for shipment or transport

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:	4.9.2.10 - Perform swipe tests of radiological sources 4.9.2.11.1 – Ion Chamber (i.e Victoreen 451P) 4.9.2.11.3 – Geiger-Mueller (i.e. ADM 300)
Training References:	• IOH-SD-BR-SR-2005-0004, *Bioenvironmental Engineer's Guide to Ionizing Radiation, October 2005* • Department of Transportation Regulation 49 CFR (available online)
Additional Supporting References:	
CDC Reference:	4B051
Training Support Material:	• AF Form 495 (or ziplock bag with label) • Swipe Container • Disposable protective gloves • Victoreen 450, 451, or 451P (portable ion chamber) • ADM-300 with AP-100 or BP-100 probe (or equivalent) • Swipe paper - NSN 6640-00-836-6870 o Filter paper disc 4.25 cm or less o Whatman No. 41 or equivalent • Sealable plastic bag • Pencil
Specific Techniques:	Conduct hands-on training and evaluation. The trainer may develop a scenario based on an actual industrial operation found on base.
Criterion Objective:	Given radioactive materials for shipment or transport, perform a package survey for external radiation levels and removable contamination, successfully completing all checklist items with trainer assistance only on the hardest parts.
Notes:	

TASK STEPS

1. Characterize the sources to be shipped and determine and record parameters.[1]
2. Determine the description for the item.[2]
3. Perform a swipe/leak test according to the license/permit for sealed sources, instruments, and articles.[3]
4. Determine individual and total activity levels to be shipped for each radionuclide and source, then compare to DOT hazardous materials definitions.[4]
5. Classify material to be shipped as "Class 7" (radioactive) material if the material is not exempt from DOT regulation.
6. Calculate DOT shipping quantity and determine DOT Class 7 categories.[5]
7. Select the DOT shipping name.[6]
8. Select the appropriate package and use appropriate PPE to package the item(s).[7]
9. Continuing to wear appropriate PPE and perform a 300-cm^2 swipe of the exterior surface of the package and compare results to regulatory limits.[8]
10. Perform field measurement of exposure levels at appropriate distances from the package and ensure it is labeled properly IAW 49 CFR 173.441 and 49 CFR 172.403 (and any additional limits placed on the specific type of RAM shipment per 49 CFR 173.421-173.426) and compare results to regulatory limits.[9]
11. Ensure completion of proper paperwork, "marking" of the package, and "label" if necessary.[10]
12. Utilize OEHMIS (DOEHRS or equivalent), as applicable.

LOCAL REQUIREMENTS:

NOTES: The following numbered items correspond to the task steps footnotes for surveys to comply with DOT requirements and are listed for further reference.

1

- half-life __________
- decay mechanism __________
- radiation __________
- energies __________

References for characterizing sources include:

Department of Transportation Regulations, 49 CFR 173 subpart I (Class 7):
http://ecfr.gpoaccess.gov/cgi/t/text-idx?c=ecfr&sid=e02ca57f54f328b6e9645ea1789996fa&rgn=div6&view=text&node=49:2.1.1.3.8.9&idno=49

The Brookhaven National Laboratory's National Nuclear Data Center provides a free online *Chart of Nuclides* http://www.nndc.bnl.gov/chart/.

Lockheed Martin publishes the Knolls Atomic Power Laboratory's *Chart of the Nuclides* http://www.chartofthenuclides.com/.

2
Using *49 CFR 173 Subpart I* (Class 7), determine whether or not the RAM is:
- special or normal form
- instrument or article
- limited quantity
- fissile material
- low specific activity
- surface-contaminated object

3
- Allow sufficient lead time for USAFSAM laboratory results (if required)
- Reference TM 4.9.2.10 for sealed source leak test

4
Are the activity levels for individual radionuclides in the consignment high enough for the DOT to consider those sources radioactive?
- The DOT does not regulate exempt items as radioactive.
- See table in 49 CFR 173.436, Exempt Material Activity Concentrations and Consignment Activity Limits for Radionuclides.

Does the consignment include a reportable DOT "Hazardous Substance"?
- Most BE shipments will not include reportable RAM items, but Troxler and Niton gauges containing Am-241 become notable exceptions.
- The unity rule applies for a mixture of different radionuclides.

Mark packages and paperwork with "RQ" for reportable quantities.
- See table Selected Radionuclides from Table 2, Appendix A, 49 CFR 172.101 LIST OF HAZARDOUS SUBSTANCES AND REPORTABLE QUANTITIES.

5
Are the radionuclides/sources in the consignment "excepted" quantities?
- ***"EXCEPTED" DOES NOT EQUAL "EXEMPT".***
- See tables DOT Activity Limits for Limited Quantities, Instruments, and Articles (Table 4, 49 CFR 173.425)

Are the radionuclides/sources in the consignment Type A quantities?

- Sources that aren't "exempt" or "excepted" but less than or equal to appropriate "A1" and "A2" values fall into this category.
- See table DOT A1 and A2 Values of Radionuclides used in AF* (49 CFR 173.435). It depicts "A1" and "A2" values for radionuclides important/common to the USAF.

Are the radionuclides/sources in the consignment fissile materials (i.e., Pu-238, Pu-239, Pu-241, U-233, U-235, etc.)?
- Determine if material is an exception (49 CFR 173.453)
- Fissile Material Requirements (49 CFR 173.457)
    1. Packages containing fissile radioactive material which are not excepted under §173.453 must be assigned by the offeror, in accordance with their definitions in §173.403, a criticality safety index (CSI) and a transport index (TI).
    2. Fissile material packages and conveyances transporting fissile material packages must satisfy the radiation level restrictions of §173.441.
    3. Except for consignments under exclusive use, the CSI of any package or overpack may not exceed 50. A fissile material package with CSI greater than 50 must be transported by exclusive use.
    4. For non-exclusive use shipments of fissile material packages, except on vessels, the total sum of CSI's in a freight container or on a conveyance may not exceed 50.
    5. For exclusive use shipments of fissile material packages, except on vessels, the total sum of CSI's in a freight

container or on a conveyance may not exceed 100.

6. Exclusive use shipments of fissile material packages must satisfy the radiation level and administrative requirements of §173.441(b).
7. The number of packages, overpacks and freight containers containing fissile material stored in transit in any one storage area must be so limited that the total sum of the CSI's in any group of packages, overpacks or freight containers does not exceed 50. Groups of packages shall be stored so as to maintain a spacing of a least 6 m (20 ft) between the closest surfaces of any two groups.
8. Provisions for shipment by vessel of Class 7 (radioactive) material packages, including fissile material packages by vessel are described in §§176.700–176.720 of this subchapter.
   - For low specific activity (LSA) and surface-contaminated objects (SCO), observe requirements in 49 CFR 173.427.

6
See table from 49 CFR 172.101 Hazardous Materials Table

7
- "Type A quantities" ship in "Type A containers"
- Excepted packages may be shipped in a "strong tight container"
- See table DOT Package Requirements (49 CFR)

Refer to the maximum activity allowed for that type of RAM/packaging (package limit) if shipping multiple items.
- Verify Class 7 package certification for Type A or B packaging materials.
  - Requirements for various types of packages (i.e., Type A, fissile material, etc.) may be found in 49 CFR 173 Subpart I.

8
Select appropriate instrument, if any, for field measurement (i.e., swipe counts and exposure levels) of package and package swipes based on your characterization of the radioactive source (i.e., daughter products, radiation types, energies, etc.).
- The BEE Guide to Ionizing Radiation 2005 provides excellent information on BE instrumentation employment, capabilities, and limitations.
- Low-energy radiation (i.e., that from H-3, Ni-63, etc.) may not be detectable by your instrumentation.
  - Perform field measurement of the 300-cm2 swipe
  - Calculate surface contamination level
  - Compare it to the "non-fixed" external radioactive contamination wipe-test limits in 49 CFR 173.443
    - See table DOT Non-Fixed (Removable) Contamination Limits for External Surfaces of Packages (Modified from Table 9, 49 CFR 173.443).

The amount of radioactivity measured on any single wiping material, when averaged over the surface wiped, cannot exceed the limits set by the Department of Transportation (DOT) and outlined below at any time during the transport process.

DOT Non-Fixed (Removable) Contamination Limits for
External Surfaces of Packages (Modified from Table 9, 49 CFR 173.443)

Contaminant	**Maximum permissible limits[1]**			
	per cm^2		per 300 cm^2	
	Becquerel	dpm	Becquerel	dpm
Beta and gamma emitters and low toxicity alpha emitters[2]	4	220	1,200	66,000
All other alpha emitting radionuclides	0.4	22	120	6,600

a) 49 CFR 173.443(a)(1) specifies that an area of 300 cm^2 on the external surface of a package shall be wiped and sufficient measurements must be taken in the most appropriate locations to yield a representative assessment of nonfixed contamination levels.

b) Low-toxicity α-emitters are: natural uranium, depleted uranium, and natural thorium; and ores, concentrates, or tailings containing ^{235}U, ^{238}U, ^{232}Th, ^{228}Th, ^{230}Th, and those with half-life less than 10 days.

Where:

Becquerel per centimeters squared is represented as Bq/cm^2
Microcuries per centimeter squared are represented as $\mu Ci/cm^2$
Disintegrations per minute per centimeters squared are represented as dpm/cm^2

9
See table DOT Radiation Limits and Label Categories (49 CFR 172.403, 173.441, and 173.421 - .426).

Radiation levels must not exceed 10 mR/hr from any point on the external surface of the unpackaged material or 0.5 mR/hr at any point around the external surface of the package.

10
Example worksheets for recording results may be found in Table B-5 in the back of the BEE Guide to Ionizing Radiation (2005).

See table Communication Requirements Summary for Class 7 (radioactive) Material Excepted and Fissile-Excepted Packages (49 CFR).

TRAINEE REVIEW QUESTIONS

STS Line Item 4.9.2.16: Survey radioactive materials for shipment or transport

1. Why do we survey radioactive materials prior to shipment?
2. Who regulates the transportation of radioactive materials?
3. What two items are monitored, when a package containing radioactive material is received or is ready for shipment on your base?
4. What should always be done before and during the monitoring process?
5. Name two instruments used to monitor packages containing radioactive material.

PERFORMANCE CHECKLIST

STS Line Item 4.9.2.16: Survey radioactive materials for shipment or transport

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. Characterize the sources to be shipped and determine and record parameters?			
2. Determine the description for the item?			
3. Perform a swipe/leak test according to the license/permit for sealed sources, instruments, and articles?			
4. Determine individual and total activity levels to be shipped for each radionuclide and source, then compare to DOT hazardous materials definitions?			
5. Classify material to be shipped as “Class 7” (radioactive) material if the material was not exempt from DOT regulation?			
6. Calculate DOT shipping quantity and determine DOT Class 7 categories?			
7. Select the DOT shipping name?			
8. Select the appropriate package and use appropriate PPE to package the item(s)?			
9. Continuing to wear appropriate PPE and perform a 300-cm2 swipe of the exterior surface of the package and compare results to regulatory limits?			
10. Perform field measurement of exposure levels at appropriate distances from the package and ensure it is labeled properly IAW 49 CFR 173.441 and 49 CFR 172.403 (and any additional limits placed on the specific type of RAM shipment per 49 CFR 173.421-173.426) and compare results to regulatory limits?			
11. Ensure completion of proper paperwork, “marking” of the package, and “label” if necessary?			
12. Utilize OEHMIS (DOEHRS or equivalent), as applicable?			
Did the trainee successfully complete the task?			

TRAINEE NAME (PRINT)

TRAINER NAME (PRINT)

ANSWERS

1. Why do we survey radioactive materials prior to shipment?

A: To keep radiation and radioactive material from affecting the environment during transportation and to keep the environment from affecting the integrity of the radioactive material.

(Source: 4B051 CDC)

2. Who regulates the transportation of radioactive materials?

A: Regulated jointly by the NRC and the Department of Transportation

(Source: 4B051 CDC)

3. What two items are monitored, when a package containing radioactive material is received or is ready for shipment on your base?

A:

- External radiation levels – electromagnetic radiation
- Contamination – particulate radiation

(Source: 4B051 CDC)

4. What should always be done before and during the monitoring process?

A: Wear the proper protective clothing

(Source: 4B051 CDC)

5. Name two instruments used to monitor packages containing radioactive material.

A: Victoreen 451 and ADM-300

(Source: 4B051 CDC)