RADIOLOGICAL WORKER II TRAINING

STUDY GUIDE

Jefferson Lab Radiological Control Group
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Jefferson Lab Radiation Worker II Training

1.0 Introduction and Qualifications

Welcome to Radiation Worker II Training (RWT2). The purpose of this training is to ensure that you have necessary knowledge and skill needed to work in contamination areas and with contaminated material.

RWT2 is required for all personnel who must enter contamination areas and work with contaminated material. When you have completed this course, you will:

- Be qualified to enter and work in contamination areas and work with contaminated material.

- Be issued a sticker for you dosimeter which identifies your level of qualification.

- Be qualified in all aspects of Radiation Worker II Training common to all DOE sites. *Note: You must receive site-specific training to be fully qualified at another DOE site.*

Retraining for RWT2 is required biannually. To requalify, or to transfer your RWT2 qualification from another DOE facility, you may obtain a RWT2 study guide from the RCG training office (Bldg 52C) and take the exam at your convenience (omit the formal classroom training).

2.0 Objectives

On completion of this training course, you should have the knowledge to work safely in areas controlled for contamination purposes using proper contamination control practices. Participants will demonstrate their knowledge by scoring $\geq$ 75% on a written examination and successfully completing a practical evaluation (simulated work in a contamination area).

Participants will demonstrate knowledge of the following by selecting from a group of responses:

1 The definition of fixed, removable, and airborne contamination.

2 General sources of contamination and sources of contamination particular to Jefferson Lab.

3 Methods used to control and prevent the spread of contamination.

4 Methods used for decontamination of personnel and equipment.

5 The definition of Contamination Area, High Contamination Area, and Airborne Radioactivity Area.

6 The requirements for entry, working in, and exiting the areas listed in the above objective.

7 The proper use of protective clothing including donning and removal techniques.

8 The proper response to a spill or spread of radioactive material.

9 The actions to be taken if a worker suspects that they have become contaminated.

10 The proper technique for personnel monitoring when exiting a contamination area.

11 The appropriate response if a personnel contamination monitor indicates contamination above the limits.

3.0 Contamination

3.1 Types of contamination

Radioactive material is any item that contains radioactive atoms. Though this material may be contained, it can still emit radiation and be an external dose hazard to the body. When this material is not properly contained, it can possibly be spread to surrounding areas and personnel. This type of radioactive material is referred to as radioactive contamination.

Radioactive contamination is simply defined as radioactive material in an undesirable location. It can further be broken down into three categories:

- Fixed contamination – radioactive material that cannot be readily removed from surfaces by nondestructive means. It may be released when the surface is aggressively disturbed (buffing, grinding, welding, etc.)

- Removable contamination – radioactive material that can be removed from surfaces by nondestructive means, such as casual contact, wiping, brushing, or washing.

- Airborne radioactivity – radioactive material in any chemical or physical form that is present in ambient air, above natural background.

3.2 Sources of Contamination

Radioactive contamination may exist in the form of either solid or liquid and is a concern due to the potential for its spread to personnel. The following are some general sources of radioactive contamination:

- Leaks or opening of radioactive liquid systems
- Airborne contamination depositing on surfaces
- Air filters and air handling equipment in areas where airborne radioactivity can be produced
- Accelerator components that have become highly activated

At Jefferson Lab, low level contamination has been found in several systems that meet the criteria of the above general sources. The following are some examples:

- The beam dump cooling water systems for Hall-A and Hall-C
- Target irradiator and beam diffuser cooling water systems
- The beam switchyard dump local cooling water system
- Air filters removed from all beam enclosures with the exception of Hall-B
- The beam dump dehumidification systems in Hall-A and Hall-C
- Vacuum pump oil used in the beam enclosures
- The beam dump stubs in Hall-A and Hall-C
- Target systems in Hall-A and Hall-C
- The target exit lines in Hall-A and Hall-C
- Certain beam-line components with localized hot-spots > 250mr/hr

3.3 Contamination Units

Contamination is generally reported as the amount of activity measured over a known surface area. For example, the DOE removable contamination limit for beta-gamma emitters is 1000 disintegrations per minute (dpm) as measured over a surface area of 100 cm^2 (1000 dpm/100cm^2).

3.4 Exposure from Contamination

There are two radiological concerns (or *modes of exposure*) from contamination. Contamination may be an external or internal exposure hazard. In both cases, the amount of dose received is highly dependent on the type(s) of radiation emitted by the material. At Jefferson Lab, contaminants can generally be divided into two groups – charged particle emitters (i.e. beta radiation emitters) and non-charged particle emitters (i.e. gamma-only emitters). Beta emitters deliver more dose to the exposed tissue than materials which emit only gamma radiation. The following examples show this effect.

<u>External Exposure</u>

For a gamma-only emitter, the dose received is due to the gamma radiation from the material. The following rule of thumb can be used to estimate the gamma dose received:

- 1 Curie = 2.22 E12 dpm
- 1000 dpm/100cm^2 = 4.5 E-10 Ci/100cm^2
- An area of 100cm^2 is considered small for radiological purposes
- Rule of thumb: 1 Curie of a small gamma emitting source will give you a measured dose rate of about 1 R/hr at one meter, therefore the dose rate emitted from 1000 dpm of contamination spread over an area of 100cm^2 would be:

(1000 dpm)(1Ci / 2.22E12 dpm)(1 R/hr/1Ci)(1000 mR/hr/1 R/hr) = 0.00000045 mR/hr

Remember, this number is measured at one meter from the contaminated surface. Using other calculations, it can be determined that the contact dose rate from this same surface would be about 0.0007 mR/hr. Whatever the case, this is a negligible dose rate and cannot be measured over normal background dose rates. Only in cases of gross contamination to the skin would there be a significant dose received.

For a beta emitter (i.e. Co-60) deposited on a small area of the skin, the dose to the skin would be considerably higher than in the previous example. This is because essentially all the beta radiation is stopped by the dermis before it has the possibility to pass through the soft body tissue (internal organs). For a typical beta emitter, the dose to the skin if contaminated at a level of 1000 dpm/100cm^2 is about 0.02 mr/hr.

Internal Exposure

Internal exposure is controlled based on a limit for the amount of radioactive material taken into the body in a year. Each radionuclide has a specific limit called the Annual Limit of Intake (ALI).
The ALI is the amount of a radionuclide which, if taken into the body, would result in a dose equal to the maximum allowable annual dose for the organ(s) of concern. For instance, the ALI for Co-60 is 24 uCi – this would result in an effective dose to the whole body of 5 rem.

The ALIs vary considerably for each nuclide based on the actual dose received if the material is taken into the body. Again, because of the higher dose received from a beta emitter, the ALI for these nuclides is lower (more restrictive) than gamma-only emitters. Internal dose can be easily calculated based on the amount of material taken into the body.

Example

- Recall from above, the ALI for Co-60 (a charged particle emitter) is 24 uCi. Therefore, if you had in intake of 24 uCi of this nuclide, you would receive your legal dose limit of 5 rem for the year. So, for example, if 50,000 dpm of this nuclide was inhaled or ingested, the resulting dose to the whole body would be about 4 mrem.

- The ALI for Be-7 (a gamma-only emitter) is 1.92 E4 uCi (800 times higher than Co-60). Therefore, if you inhaled or ingested 50,000 dpm of this nuclide, the effective dose to the whole body would be about 0.005 mrem.

The fact that Co-60 emits beta radiation makes it more “potent” for delivering dose. In addition, this also makes it much easier to detect using radiological field instrumentation. Most of the contamination limits were based on the ease of detection of this and other similar isotopes. However, this same limit still applies to non-beta emitters, such as Be-7.

At Jefferson Lab, Be-7 is produced from the electron beam interaction with air. Because Be-7 does not emit a charged particle, it is not easily detectable with instruments used in the field. Often, the presence of other isotopes in the contamination eliminates this concern. However, some systems at Jefferson Lab can be found to contain Be-7 contamination solely. In order to detect Be-7 contamination at the limit of 1000 dpm/100cm^2, field samples must be analyzed with highly sensitive gamma detectors. When Be-7 (or other non-particle emitters) are known or suspected to be the major component in a source of contamination, enhanced contamination controls will be used in the field to minimize the potential for transferring the material to personnel. The purpose of these controls is to help ensure that the statutory limits are met, *not* because of the radiological impact of the work.

4.0 Contamination Control

4.1 Contamination Control Methods

The most important aspect of preventing the spread of contamination is to control it at the source. This will reduce the potential for internal exposure and personnel contamination. Contamination control methods can be broken down into two categories:

Preventative Methods

- Frequent inspection of liquid systems for leaks or potential problems
- Establish adequate controls prior to beginning work (including a radiological briefing)
- Change protective clothing frequently (gloves in particular) as necessary to prevent the cross-contamination of equipment
- Place protective wrapping around non-contaminated items if applicable
- Practice good housekeeping and post job clean-up
- Minimize the amount of material taken into a contamination area (use only what is needed)
- Follow approved procedures (radiation work permit) when working in contamination areas or with contaminated material

Engineered Control Methods

- Careful consideration is given when selecting materials used in various systems subject to activation
- Water quality is maintained in cooling water systems to minimize corrosion
- Work-site ventilation is used at times to maintain air-flow from areas of least contamination to areas of higher contamination
- High efficiency particulate (HEPA) filters are often used to remove radioactive particles from the air

- Containment (glovebags, drapes, fume hoods, etc.) are used at times to control contamination as close to the source as possible

5.0 Decontamination

5.1 Decontamination Methods

Decontamination is the process of removing radioactive material from locations where it is not wanted. If the presence of removable contamination is discovered, decontamination is a valuable means of control.

- Personnel decontamination is normally accomplished using mild soap and lukewarm water. Depending on the extent of the contamination, the radiological technologist may also attempt to remove the contamination by performing a "tape press". This simple procedure is highly effective for removing small, localized areas of contamination.

- Material decontamination can be accomplished by various means. The simplest procedure is to basically wipe the material down with a dry cloth. Other means include mild washing, ultrasonic sinks, and industrial abrasive measures.

Note: If personnel or material contamination is suspected, <u>NEVER</u> attempt to perform the decontamination yourself. All decontamination efforts must be performed by a qualified radiological technologist.

5.2 Alternatives to Material Decontamination

In some situations, material decontamination is not always feasible. For instance, the cost of time and labor to decontaminate the material may outweigh the hazards of the contamination present. Another instance would be that the dose rates or other radiological conditions present far exceed the benefits of decontamination. Some alternatives to decontamination are:

- Store contaminated material for decay

- Store contaminated material so that it may be used again in contamination areas

- Dispose of the material as radioactive waste

Whatever the case, the final disposition of contaminated items will be made by the radioactive material coordinator of the area where the material was generated, in coordination with the RadCon Group.

6.0 Contamination Areas

6.1 Contamination Areas Definitions and Limits

- Contamination Area – an area where removable contamination levels are greater than specified DOE limits (1000 dpm/100cm^2 for beta-gamma emitters)

- High Contamination Area – an area where removable contamination levels are 100 times greater than specified DOE limits (100,000 dpm/100cm^2 for beta-gamma emitters)

- Airborne Radioactivity Area – an area where the concentration of airborne radioactivity, above natural background, exceeds or is likely to exceed specified DOE limits. Airborne areas are required to be posted at 10% of the specified limit.

For further definition of area posting requirements and limits, refer to Appendix D of this study guide.

6.2 Requirements for Entering and Working in Contamination Areas

Requirements for entry

- Jefferson Lab Radiation Worker II Training
- Personnel dosimetry
- An approved Radiation Work Permit
- Pre-job briefing
- Protective clothing and/or respiratory equipment as specified in the RWP

Requirements for working in the area

- Avoid unnecessary contact with contaminated surfaces
- Secure all equipment (lines, hoses, cables, etc.) that cross the contamination boundary
- When possible, wrap or sleeve material and equipment to prevent cross-contamination

- Do not touch exposed skin surfaces (e.g., rubbing nose or mouth) – this is by far the major factor in many skin contamination incidents

- Place contaminated materials in appropriate containers when finished with your work

- Material which enters or exits the area must go across the step-off pad

Requirements for exiting the area

- Exit only at the step-off pad

- Follow the posted procedure for removing protective clothing

- Tools and equipment that will be removed from the area should be placed in a clean bag and placed on the step-off pad

- Perform a whole body frisk at the designated frisking station

7.0 Protective Clothing

Protective clothing is required when entering contamination areas. This will help prevent the cross-contamination of personnel skin and clothing. The degree of protective clothing required is dependent on the work area radiological conditions and the nature of the job. These requirements will always be identified in the Radiation Work Permit (RWP).

Protective clothing generally consists of the following:

- Coveralls (cloth or paper)

- Cotton glove liners

- Gloves (rubber or surgical) – two sets required for full dress-out

- Plastic shoe covers

- Rubber overshoes

- Hood (full-face or surgeons cap)

Once again, it is important to note that the degree of clothing required will be specified in the RWP. This determination will be made by the radiological technologist responsible for job oversight and approved by the RCG coordinator.

7.1 Donning protective clothing

After you have reviewed the RWP and have determined what clothing is needed, you should inspect all clothing for damage prior to dressing out. In particular, you should as a minimum look for the following:

- Inspect the coveralls for rips or tears
- Inspect all gloves for holes – gloves that have been in storage under certain atmospheric conditions are susceptible to dry-rot
- Make sure that the shoe covers and overshoes fit correctly

After you have inspected the clothing, the following procedure should be performed for donning the clothing:

Note: This procedure should be followed when performing a full dress-out

- Stage two pieces of duct tape that will be long enough to wrap around the wrists – use ‘buddy tabs’ on the tape so that it is easier to handle with gloves
- Don the plastic shoe covers – these may be stretched by hand in order to get them to fit over the shoes
- Don the cotton glove liners
- Don the coveralls
- Don the rubber overshoes
- Don the hood
- Don the first set of rubber gloves – use the duct tape that was staged to tape the gloves to the coveralls
- Don the final set of rubber gloves

7.2 Requirements for working in contamination areas

It is important to remember that, when working in contamination areas, one must keep in mind that contamination must be controlled as close to the source as possible. You should assume that once you handle a contaminated item or surface that the outer set of gloves are contaminated and subsequently, anything else that you touch, may also become contaminated. A few good work practices are listed below:

- Always work from areas of higher contamination to lower contamination
- Perform frequent change-out of the outer set of gloves
- Do not touch exposed skin surfaces – primarily the facial region when utilizing a full set of protective clothing
- Avoid contact with liquids – special plastic suits may be required when working with liquid systems
- You will always be required to wear your TLD badge – this shall be worn under the protective clothing between your neck and your waist on the front of the body
- If supplemental dosimetry is required for the work you are performing, the radiological technologist will place the dosimeter in a clear plastic bag and tape it to the outside of the coveralls
- If protective clothing becomes damaged while working in the area, exit to the step-off pad and inform the radiological technologist

7.3 Protective clothing removal

There is a deliberate process to be followed when removing protective clothing. This is to minimize the possibility of spreading contamination to the skin or clothing during removal. Due to the fact that Jefferson Lab does not have the facilities to recycle contaminated clothing, all clothing worn in contamination areas will be placed in the waste receptacle located at the step-off pad. Protective clothing shall be removed in the following order:

- Remove the outer set of rubber gloves
- Remove the tape from the inner set of gloves and/or coveralls
- Remove rubber overshoes

- Remove the inner set of rubber gloves
- Remove the hood
- Remove the coveralls by rolling them from inside to outside
- Remove the plastic shoe covers while stepping onto the step-off pad
- Remove the cotton liners

8. Personnel Monitoring

Personnel monitoring is required when exiting from contamination areas and airborne radioactivity areas. Monitoring may also be required when exiting from radiological areas that are adjacent to contamination areas. A whole body frisk will normally be required when exiting from contamination areas, but there are certain conditions that may only require a certain part of the body to be monitored. Monitoring requirements will always be specified in the Radiation Work Permit for the area in which you are working.

8.1 Personnel Monitoring Equipment

Contamination monitoring equipment is used to detect radioactive contamination on personnel and equipment. Specific features required for personnel monitoring equipment are listed below:

- The monitor (frisker) must have an audible response
- The frisker must also have both an audible and visual alarm
- The frisker **should** be set up in areas where the background count rate is less than 100 counts per minute (cpm)
- The frisker **must** be set up in an area where the background count rate is less than 300 cpm – this will help to notice an increase in the audible count rate when doing a frisk
- The instrument shall be set to alarm at 100 cpm above the background count rate

8.2 Frisking Procedure

The following procedure should be followed when performing a whole body frisk:

- Verify that the instrument is in service and the audio is working properly
- Verify that the instrument scale multiplier is at the lowest setting
- If equipped with a response switch, it should be set to the "slow" position
- Frisk your hands before touching the probe
- To maintain the proper counting efficiency, the probe should be within ½" from the surface being monitored
- Move the probe slowly over the surface – approximately 1-2" per second
- While frisking, you should pay close attention to the area being surveyed to ensure that the proper distance is maintained – you do not have to watch the meter face because the audible count rate is faster
- The whole body frisk does not require a check of the complete body – it is a cursory check that should take the average person about 2-3 minutes
- Survey the body in a methodical manner and pay close attention to the following areas:
  - Head – check carefully around the facial area
  - Neck, shoulders, and arms
  - Chest and abdomen
  - Back, hips, and seat of pants
  - Legs – pay close attention to the knees
  - Feet – check the soles of you shoes carefully
- If you notice an increase in the audible count rate during the frisk, pause for 5-10 seconds over the area and look at the meter face
- **100 cpm above the background count rate is equivalent to 1000 dpm – this is the DOE limit for beta-gamma surface contamination**
- If contamination is indicated, contact the RCG immediately – if no one else is available to call, proceed to the nearest phone and inform the RCG of your egress path

- Upon completion of the frisk, return the probe face up to it's holder

9 Casualty Response

Personnel should be ready to respond to possible casualties while working in contamination areas. Two in particular are listed below:

9.1 Contaminated Injured Person

In accordance with the Jefferson Lab EH&S manual, a serious injury will always require certain actions to be taken. Most notably, the first thing required for a serious injury will be a 911 telephone call. **It is important to note that, for all serious injuries in radiological areas, the injury will always take precedent over the radiological concerns. At no time should one prohibit emergency personnel from entering a contamination area if a determination is made that emergency assistance is required.** If the injury occurs in a contamination area, the following actions shall also be taken:

- Administer emergency first aid as required
- It is not necessary to remove the person from the area
- When relieved by emergency response personnel, perform a whole body frisk

9.2 Spill

A spill is defined as an uncontrolled release of radioactive material. This could possibly be in the form of liquid or the dry, contaminated contents of a bag which has been compromised. In the event of a spill, it is important to remember the following acronym: *SWIM'N.*

- **S** Stop the source or spread of the spill – for example, upright an overturned container, close a valve, place absorbent material around the area
- **W** Warn others in the area
- **I** Isolate the area – close doors or use convenient items to form a barrier
- **M** Minimize your exposure – complete initial steps and move away from the area
- **N** Notify radiological control personnel ASAP

It is important to note that these steps do not have to be performed in a certain order. The best advice is to use your initial instinct if you confront a spill.

Appendix A
RWT2 Glossary

Activation:	Process of producing radioactive material by bombardment with neutrons, protons or other nuclear particles.
Airborne Radioactivity:	Radioactive material in any chemical or physical form that is present in ambient air, above natural background.
Airborne Radioactivity Area:	An area where the measured concentration of airborne radioactivity, above natural background, exceeds either 10 percent of the Derived Air Concentration (DAC) averaged over 8 hours or a peak concentration of 1 DAC.
Annual Limit on Intake (ALI):	The quantity of a single radionuclide which, if inhaled or ingested in one year, would irradiate a person, represented by reference man, to the limiting value for control of occupational exposure.
Background Radiation:	Radiation present in the environment that all people are exposed to. Background radiation comes from natural radioactivity and radiation, and from manmade sources such as global fallout and certain consumer products.
Charge Particle:	An ion – a particle carrying a positive or negative charge.
Containment Device:	Barrier such as a glovebag, glovebox, or tent for inhibiting the release of radioactive material from a specific location.
Contamination Area:	Area where contamination levels are greater than the values specified in Appendix D of this study guide, but less than or equal to 100 times those levels.
Contamination Survey:	Use of swipes or direct instrument surveys to identify and quantify radioactive material on personnel, on equipment, or in areas.
Decontamination:	Process of removing radioactive contamination and materials from personnel, equipment, or areas.
Derived Air Concentration:	The concentration of a radionuclide in air that, if breathed over the period of a work year, would result in the ALI for that radionuclide being reached. The DAC is obtained by dividing the ALI by the volume of air breathed by an average worker during a working year ($2400 m^3$).

Disintegration per Minute (dpm):	The rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.
Engineered Controls:	Use of components and systems to reduce airborne radioactivity and the spread of contamination by using piping, containments, ventilation, filtration, or shielding.
Fixed Contamination:	Radioactive material that cannot be readily removed from surfaces by nondestructive means, such as casual contact, wiping, brushing, or washing.
High Contamination Area:	An area where contamination levels are greater than 100 times the values specified in Appendix D of this study guide.
Hot Spot:	A localized source of radiation or radioactive material normally within facility piping or equipment. The radiation levels of hot spots exceed the general area radiation level by more than a factor of 5 and are greater than 100 mrem/hr on contact.
Personnel Monitoring:	The monitoring of personnel, their excretions, skin or any part of their clothing to determine the amount of radioactivity present.
Protective Clothing:	Clothing provided to personnel to minimize the potential for skin and personal contamination.
Radioactive Material:	Any material containing unstable atoms which decay with the release of ionizing radiation.
Radiologically Controlled Area	Any area where a person could receive a dose in excess of 100 mrem in one year, assuming nominal occupancy of 2000 hours.
Radionuclide:	A radioactive isotope of an element that decays spontaneously, emitting radiation.
Removable Contamination:	Radioactive material that can be removed from surfaces by nondestructive means, such as casual contact, wiping, brushing, or washing.

Appendix A RWT2 Glossary

Step-off Pad:	Transition area between contaminated and non-contaminated areas that is used to allow exit of personnel and removal of equipment.

Appendix B
Review Session

1. The DOE limit for posting a Contamination Area (for beta-gamma emitters) is:

   a. 10,000 dpm/100cm^2
   b. 100,000 dpm/100cm^2
   c. 5,000 dpm/100cm^2
   d. 1,000 dpm/100cm^2

2. Which of the following would be considered a source of contamination?

   a. Airborne contamination depositing on surfaces
   b. Dusty components in high beam-loss areas
   c. Air filters in the beam switchyard
   d. All of the above

3. A typical whole body frisk for an average person should take:

   a. 5 minutes
   b. 2-3 minutes
   c. 30-45 seconds
   d. 1 hour

4. While performing a whole body frisk, you notice an increase in the audible count rate meter. What should you do?

   a. Call radcon for assistance
   b. Continue the frisk because you did not receive an alarm
   c. Pause 5-10 seconds over the area to allow adequate time for instrument response
   d. Adjust the alarm level on the count rate meter to 150 cpm

5. Radioactive contamination is a concern because:

   a. It is considered an external dose hazard
   b. It is hard to detect over normal background radiation levels
   c. High levels of contamination deposited on a small body surface can cause a skin dose
   d. All of the above

6. Which of the following best describe an engineering control method:

    a. Selecting system materials which have a low probability for activation
    b. Using lukewarm water and mild soap for personnel decontamination
    c. Minimize the amount of material that is taken into contaminated areas
    d. All of the above

7. The minimum requirement for entry into a posted contamination area is:

    a. A full set of protective clothing
    b. Jefferson Lab Respiratory Protection training
    c. Verbal permission from the RCG manager
    d. Jefferson Lab Radiation Worker II training

8. Why should protective clothing be removed in a specific order?

    a. To prevent cross-contamination of the RCG technologist who is helping you remove the clothing
    b. To minimize the possibility of spreading contamination to the skin or clothing during removal
    c. So that they may be worn again for work in the area
    d. To follow a certain order which will help prevent chaos in one's life

Answers:

1	d
2	d
3	b
4	c
5	d
6	a
7	d
8	b