RADIATION WORKER II TRAINING

STUDY GUIDE

Jefferson Lab Radiation Control Department
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1 Introduction and Qualifications

Welcome to Radiation Worker II Training (RWT2). The purpose of this training is to ensure that you have the necessary knowledge and skills needed to work in Contamination Areas and 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 RWT2 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 re-qualify, or to transfer your RWT2 qualification from another DOE facility, you may review this handout on your own and take the exam at your convenience (omit the formal classroom training).

2 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. You will demonstrate this knowledge by scoring $\geq$ 75% on a written exam and by successfully completing a practical evaluation (simulated work in a Contamination Area).

On the exam, you 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 entering, working in, and exiting the areas listed above.
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 you suspect that you have become contaminated.
10. The appropriate response if a personnel frisker indicates contamination above the limits.

3 Contamination, Introduction

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. When this material is not properly contained, it can possibly be spread to surrounding areas and personnel. This “spreadable” radioactive material is referred to as radioactive contamination.

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

1. ***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.).
2. ***Removable contamination* –** radioactive material that can be removed from surfaces by nondestructive means such as casual contact, wiping, brushing, or washing.
3. ***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 as either a solid or a liquid and is a concern due to the potential for its spread to personnel. The following are some general sources of radioactive contamination:

- Leaks from or open 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 general descriptions above. The following are some examples:

- The beam dump cooling water systems for Hall A and Hall C
- The 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
- The vacuum pump oil used in 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 > 250 mR/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 $100cm^2$ ($1000\ dpm/100cm^2$).

3.4 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.

<u>External Exposure</u>

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.* This is because essentially all the beta particles are stopped by the dermis.

Emission Type	Exposure at 1m from 1Ci	Exposure at 1m from 1000 dpm/100cm^2	Exposure on contact from 1000 dpm/100cm^2
Gamma only	~ 1 R/h	~ 4.5×10^{-10} R/h	~ 0.0045 mR/h*
Beta and Gamma (or Beta only)	--	--	0.02 mR/h

*this is a negligible amount that cannot be distinguished from background rates.

<u>Internal Exposure</u>

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 example, 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 for gamma-only emitters. Internal dose can be easily calculated based on the amount of material taken into the body.

Example:

Let's compare your whole body dose if you inhaled one ALI of Co-60 (a beta-gamma emitter) versus one ALI of Be-7 (a pure gamma-emitter):

Nuclide	**ALI**	**Amount Inhaled**	**Whole Body Dose**
Co-60	24 µCi	50,000 dpm	4 mrem
Be-7	1.92E4 µCi (800 times higher than Co-60!)	50,000 dpm	0.005 mrem

The fact that Co-60 emits beta radiation in addition to the gamma radiation makes it more "potent" for delivering dose. Coincidentally, this makes it much easier to detect using a frisker. Most of the contamination limits were actually based on the ease of detection of this and other similar radionuclides. However, there are limits for gamma-only emitters such as Be-7.

At Jefferson Lab, Be-7 is produced from the electron beam's 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 radionuclides in the contamination eliminates this concern. However, some systems at Jefferson Lab can be found to contain Be-7 contamination only. In order to detect Be-7 contamination at the limit of 1000 dpm/100 cm^2, field samples must be analyzed with highly sensitive gamma detectors. When Be-7 (or another non-particle emitter) is 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 Contamination Control

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:

4.1 Administrative Methods

- Frequently inspect liquid systems for leaks or potential problems
- Establish adequate controls prior to beginning work (including a radiological briefing)
- Change protective clothing (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

4.2 Engineering 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 (glove bags, drapes, fume hoods, etc.) is used at times to control contamination as close to the source as possible

5 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, a “tape press” may also be used. 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 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, NEVER attempt to perform the decontamination yourself. All decontamination efforts must be performed by qualified RCD personnel.

5.2 Alternatives to Material Decontamination

In some situations, material decontamination is not 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 during decontamination 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 contaminated 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 conjunction with the RCD.

6 Contamination Areas

6.1 Definitions and Limits

Contamination Area **–** an area where removable contamination levels are greater than specified DOE limits (1000 dpm/100 cm^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 Radioactivity Areas are required to be posted at 10% of the specified limit.

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

It is important to remember that, when working in contaminated areas, the contamination must be controlled as close to the source as possible. You should assume that once you handle a contaminated item or surface 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:

- Secure all equipment (lines, hoses, cables, etc.) that crosses the contamination boundary
- When possible, wrap or sleeve material and equipment to prevent cross-contamination
- Avoid unnecessary contact with contaminated surfaces
- Do not touch exposed skin surfaces (i.e., 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
- Always work from areas of higher contamination to lower contamination
- Avoid contact with liquids – special plastic suits may be required when working with liquid systems
- You will always be required to wear your dosimeter – 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 radiation technologist will place the dosimeter in a clear plastic bag and tape it to the outside of your coveralls
- Perform frequent change-out of the outer set of gloves
- If protective clothing becomes damaged while working in the area, exit to the step-off pad and inform the radiation technologist

<u>Requirements for exiting the area</u>

- Exit only at the step-off pad
- Follow the procedure for removing protective clothing (see below)
- 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 Protective Clothing

7.1 Overview

Protective clothing is required when entering Contamination Areas. This will help prevent the cross-contamination of 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.

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 surgeon’s 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 radiation technologist responsible for job oversight and approved by the RCD Manager.

7.2 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 four pieces of duct tape that will be long enough to wrap around the wrists/ankels – use “buddy tabs” on the tape so that it is easier to handle with gloves
- Stage one piece of duct tape that will be long enough to cover the zipper on your coveralls.
- Don the plastic shoe covers (booties) – these may be stretched by hand in order to get them to fit over the shoes
- Don the cotton glove liners
- Don the coveralls- use the duct tape that was staged to tape the coveralls over the booties and cover the zipper
- 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 over the coveralls
- Don the final set of rubber gloves

7.3 Removing Protective Clothing

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 contaminated 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, booties and zipper
- Remove the 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 booties 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, 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 RWP.

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 shall also have an audible and/or a visual alarm (light)
- The frisker should be set-up in an area where the background count rate is less than 100 counts per minute (cpm)
- The frisker <u>must</u> be set up in an area where the background count rate is less than 300 cpm – this will help you notice an increase in the audible count rate when doing a frisk
- The instrument <u>shall</u> 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 in. of the surface being monitored
- Move the probe slowly over the surface – approximately 1-2 in. per second
- While frisking, you should pay close attention to the area being surveyed to ensure that you maintain the proper distance – you do not have to watch the meter face because the audible count rate is faster/more reliable
- 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 the pants

  - Legs – pay close attention to the knees
  - Feet – check the soles of your 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 RCD immediately – if no one else is available to call for you, proceed to the nearest phone and inform the RCD of your egress path
- Upon completion of the frisk, return the probe to its holder face up

9 Casualty Response

You should be ready to respond to possible casualties while working in contaminated areas.

9.1 Contaminated Injured Person

If an injury occurs in a radiological area, the health concerns will always take precedence over the radiological concerns. Immediately call 911 and then 4444. If the injury occurs in a contaminated area, the following actions shall also be taken:

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

At no time should you prohibit emergency personnel from entering a Contamination Area if a determination is made that emergency assistance is required.

9.2 Spill

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

Stop the source or spread of the spill – for example, upright an overturned container, close a valve, place absorbent material around the area

Warn others in the area

Isolate the area – close doors or use convenient items to form a barrier

Minimize your exposure – complete initial steps and move away from the area

Notify the Radiation Control Department 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 C
Instructions for Practical Factors Evaluation

The intent of the practical factors exercise is to ensure that all personnel trained to be RW-II can apply their knowledge of radiation safety by participating in an evaluated practical scenario designed to check for key elements of proper radiological work practices.

The practical elements that each participant should demonstrate are:

- Identify and comply with RWP requirements
- Record appropriate information on the RWP
- Select and don protective clothing and dosimeter(s) as per the RWP
- Enter a simulated area and perform a specified task/job using contamination control and ALARA techniques
- Respond to abnormal radiological conditions and alarms
- Remove protective clothing and dosimeter(s) in accordance with instructions
- Monitor for personnel contamination in accordance with instructions

Your instructor will provide a briefing on the simulated RWP prior to beginning the evaluation. He/ she will identify and demonstrate key elements to be performed. **You should ask questions during the demonstration and ask for practice if you are unsure about radiological information or how a particular element is to be carried out.** *Your instructor will not coach or show you how to perform the tasks once your evaluation has begun*.

Suggestions for preparation:

- Read the RWP carefully and make sure you have all your questions about it answered. Study the survey map.
- Form a mental picture of the area and the associated radiation/contamination levels; keep this in mind when working in the area.
- Take note of the highest dose rates and contamination levels in the area, and based on these, determine what the area posting should be. When preparing to enter the area, check all the postings to make sure they are appropriate for the levels noted.
- All discrepancies noted in postings or radiological conditions for the area should be brought to the attention of the instructor.
- Be alert for any conditions that do not seem appropriate for the area.
- To the extent possible, perform actions as you would in an actual radiological area – do not linger in or around areas of high radiation levels and minimize the spread of contamination.