LA-UR-17-27223
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Title: RCT: Module 2.04, Dosimetry, Course 8769

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Intended for: Training

Issued: 2017-12-18 (rev.1)

RCT: Module 2.04, Dosimetry

Course 8769

August 2017

Los Alamos NATIONAL LABORATORY
EST. 1943
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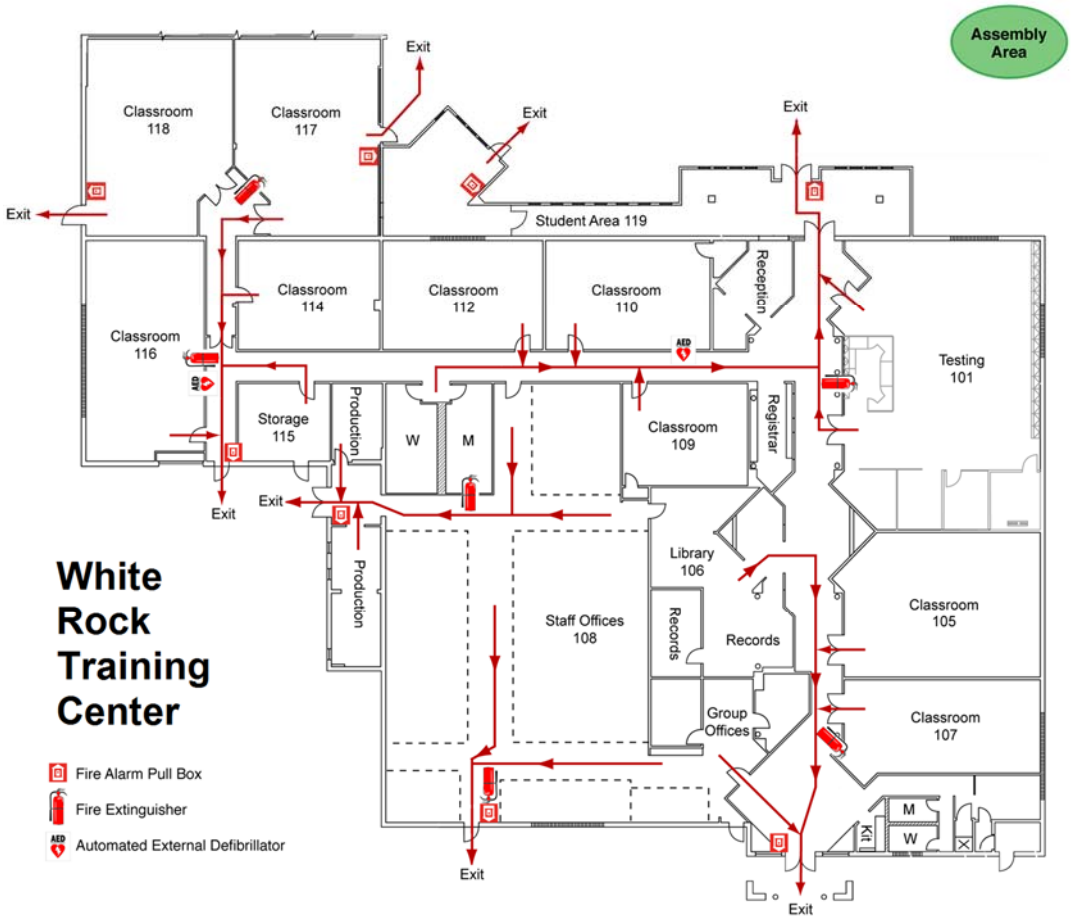

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Course Number: 8769
August 2017
LA-UR-17-27223
Controlled Document Number: RCT_2.04_Dosimetry_8769_SM,R1.0

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Introduction

Course Overview

This course will introduce the types of instruments used to measure external and internal radiation to people. Dosimetry is the quantitative assessment of radiation received by the human body.

Several types of dosimeters are used worldwide. This information is valuable to all radiological control personnel because dosimeters are the only direct method to measure and document personnel radiation exposure and ensure regulatory compliance with applicable limits.

This course will cover dosimetry terms, Department of Energy (DOE) limits, Los Alamos National Laboratory (LANL) administrative guidelines, thermoluminescent dosimeters (TLDs), LANL dosimetry, and bioassay assessment methods.

This course will prepare the student with the skills necessary for radiological control technician (RCT) qualification by passing quizzes, tests, and the RCT Comprehensive Phase 1, Unit 2 Examination (TEST 27566) and providing in-the-field skills.

Course Objectives

2.04.01 Identify the DOE external exposure limits for general employees.

2.04.02 Identify the DOE limits established for the embryo/fetus of a declared pregnant female general employee.

2.04.03 Identify the administrative exposure control guidelines at your site, including those for the:

a. General employee
b. Member of the public/minor
c. Incidents and emergencies
d. Embryo/fetus

2.04.04 Identify the requirements for a female general employee who has notified her employer in writing that she is pregnant.

2.04.05 Determine the theory of operation of a thermoluminescent dosimeter (TLD).

2.04.06 Determine how a TLD reader measures the radiation dose from a TLD.

2.04.07 Identify the advantages and disadvantages of a TLD compared to a film badge.

2.04.08 Identify the types of beta-gamma TLDs used at your site.

2.04.09 Identify the types of neutron TLDs used at your site.

2.04.10 Determine the requirements for use of TLDs used at your site.

2.04.11 Determine the principle of operation, and the types used, for the personnel neutron dosimeters used at your site.

2.04.12 Determine the principle of operation of self-reading dosimetry (SRD) used at your site.

2.04.13 Determine the principle of operation, and guidelines for use, for the alarming dosimeters used at your site.

2.04.14 List the types of bioassay monitoring methods at your site.

2.04.15 List different uses of area monitoring dosimeters.

Target Audience

This course is designed for LANL new-hire RCT employees with no operational experience.

Acronyms

ALARA	as low as reasonably achievable
ALI	annual limit on intake
CED	committed equivalent dose
DAC	derived air concentration
DESH	Environment, Safety, and Health (ESH) Deployed
DOE	Department of Energy
EPD	electronic personal dosimeter
GM	Geiger-Müller
LANL	Los Alamos National Laboratory
pc	pocket chamber
PNAD	personal neutron accident dosimeter
PSE	planned special exposure
RCT	radiological control technician
RHAP	Reproductive Health Assistance Program

RLM	responsible line manager
RP	radiation protection
RP-PROG	Radiation Protection Programs
RPO	radiation protection observation
RWP	radiological work permit
SRD	self-reading dosimetry
SRPD	self-reading pocket dosimeter
TED	total effective dose
TLD	thermoluminescent dosimeter

Notes. . . .

Dosimetry Terms

Absorbed Dose (D): Energy absorbed by matter from ionizing radiation per unit mass of irradiated material at the place of interest in that material. The absorbed dose is expressed in units of rad (or gray) (1 rad = 0.01 gray).

Equivalent Dose (H): The product of the absorbed dose (D) (in rad or gray) in tissue and a radiation weighting factor (w_R). Equivalent dose is expressed in units of rem (or sievert) (1 rem = 0.01 sievert).

Deep Dose (obsolete): The equivalent dose derived from external radiation at a tissue depth of 1 cm in tissue (1000 mg/cm^2).

Shallow Dose (obsolete): The equivalent dose derived from external radiation at a depth of 0.007 cm in tissue (7 mg/cm^2).

Whole Body: For the purposes of external exposure, head, trunk (including male gonads), arms above and including the elbow, or legs above and including the knee.

Extremity: Hands and arms below the elbow or feet and legs below the knee.

Committed Equivalent Dose (CED): The equivalent dose calculated to be received by a tissue or organ over a 50-year period after the intake of a radionuclide into the body. It does not include contributions from radiation sources external to the body. The CED is expressed in units of rem (or sievert).

Radiation Weighting Factor (Wt): The fraction of the overall health risk, resulting from uniform, whole-body irradiation, attributable to specific tissue (T). The dose equivalent to the affected tissue is multiplied by the appropriate weighting factor to obtain the effective dose equivalent contribution from that tissue.

TISSUE WEIGHTING FACTORS FOR VARIOUS ORGANS AND TISSUES

Organs or tissues, T	Tissue weighting factor, w_T
Gonads	0.20
Red bone marrow	0.12
Colon	0.12
Lungs	0.12
Stomach	0.12
Bladder	0.05
Breast	0.05
Liver	0.05
Esophagus	0.05
Thyroid	0.05
Skin	0.01
Bone surfaces	0.01
Remainder [1]	0.05
Whole body [2]	1.00

[1] "Remainder" means the following additional tissues and organs and their masses, in grams, following parenthetically: adrenals (14), brain (1400), extrathoracic airways (15), small intestine (640), kidneys (310), muscle (28,000), pancreas (100), spleen (180), thymus (20), and uterus (80). The equivalent dose to the remainder tissues ($H_{remainder}$), is normally calculated as the mass-weighted mean dose to the preceding ten organs and tissues. In those cases in which the most highly irradiated remainder tissue or organ receives the highest equivalent dose of all the organs, a weighting factor of 0.025 (half of remainder) is applied to that tissue or organ and 0.025 (half of remainder) to the mass-weighted equivalent dose in the rest of the remainder tissues and organs to give the remainder equivalent dose.

[2] For the case of uniform external irradiation of the whole body, a tissue weighting factor (w_T) equal to 1 may be used in determination of the effective dose.

Committed Effective Dose: The sum of the CED to various tissues, excluding the skin and lens of the eye, in the body, each multiplied by the appropriate weighting factor (Wt). The committed effective dose is expressed in units of rem (or sievert).

Total Effective Dose (TED): The sum of the effective dose equivalent (for external exposures) and the committed effective dose (for internal exposures).

Annual Limit on Intake (ALI): The limit for the amount of radioactive material taken into the body of an adult worker by inhalation or ingestion in a year. ALI is the smaller value of intake of a given radionuclide in a year by the reference man (ICRP Publication 23) that would result in a committed effective dose of 5 rems (0.05 sievert) or a CED of 50 rems (0.5 sievert) to any individual organ or tissue.

Derived Air Concentration (DAC): For the radionuclides listed in Appendix A of 10 CFR 835, the airborne concentration that equals the ALI divided by the volume breathed by an average worker for a working year of 2000 hours (assuming a breathing volume of 2400m^3).

Bioassay: The determination of kinds, quantities, or concentrations, and, in some cases, locations of radioactive material in the human body, whether by direct measurement or by analysis, and evaluation of radioactive material excreted or removed from the human body.

In Vivo: A direct bioassay measurement of radioactivity in living tissue—for example, a whole-body count or chest count.

In Vitro: The bioassay measurement of radioactivity by means of internal representative sampling to estimate the radioactivity in tissue. Examples are analysis of urine and fecal collections.

Background: Radiation from naturally occurring radioactive material that has not been technologically enhanced, cosmic sources, global fallout as it exists in the environment (such as from the testing of nuclear explosive devices), radon and its progeny in concentrations or levels existing in buildings or the environment that have not been elevated as a result of current or prior activities, and consumer products containing nominal amounts of radioactive material or producing nominal amounts of radiation.

Declared Pregnant Worker: A woman who has voluntarily declared to her employer, in writing, her pregnancy for the purpose of being subject to the occupational exposure limits to the embryo/fetus, as shown in Table 4-2. This declaration may be revoked, in writing, at any time by the declared pregnant worker. [P121]

General Employee: A DOE or DOE contractor employee; an employee of a subcontractor to a DOE contractor; or an individual who performs work for or in conjunction with DOE or uses DOE facilities. [P121]

Radiological Worker: A general employee performing radiological work or who is likely to be routinely occupationally exposed above 0.1 rem per year total effective dose equivalent. [P121]

Notes. . . .

DOE External Exposure Limits for General Employees

2.04.01 Identify the DOE external exposure limits for general employees.

A general employee is defined as a DOE or DOE contractor employee, an employee of a subcontractor to a DOE contractor, or an individual who performs work for or in conjunction with DOE or uses DOE facilities.

Guidance for occupational dose limits can be found in the Radiation Protection Program policy document P-121 Section *422 Occupational Dose Limits.*

Occupational dose limits are provided in Table 4-2 and must not be exceeded except for planned special exposures (PSEs) and authorized emergency exposures [see 835.202(a)]. All occupational doses received during the current calendar year (including offsite occupational dose), except the dose resulting from PSEs and authorized emergency exposures [see 835.1(c)], must be:

Table 4-2. Summary of Occupational Dose Limits	
Type of Exposure	**Limit**
General employee (non-radiological worker): whole body (internal + external) (TED)	0.1 rem/year

Notes. . . .

DOE Limits Established for the Embryo/Fetus of a Declared Pregnant Female General Employee

2.04.02 Identify the DOE limits established for the embryo/fetus of a declared pregnant female general employee.

For a declared pregnant worker who chooses to continue work that involves occupational exposure, the following must apply:

- The dose limit for the embryo/fetus for the entire gestation period is 0.5 rem.
- The dose to the embryo/fetus must be equal to the sum of doses received from external doses, sources inside the mother, and sources inside the embryo/fetus.
- Efforts should be made to avoid exceeding 0.05 rem per month to the pregnant worker.
- If the dose to the embryo/fetus is determined to have already exceeded 0.5 rem when a worker notifies her employer of her pregnancy, the worker must not be assigned to tasks where additional occupational radiation exposure is likely during the remainder of the gestation period.

Notes. . . .

LANL Administrative Exposure Control Guidelines

2.04.03 Identify the administrative exposure control guidelines at your site, including those for the
a. General employee
b. Member of the public/minor
c. Embryo/fetus
d. Incidents and emergencies

Occupational dose limits are provided in Table 4-2 of the LANL Radiation Protection Policy, document P-121, and must not be exceeded, except for planned special exposures (PSEs) and authorized emergency exposures. All occupational doses received during the current calendar year (including offsite occupational dose), except the dose resulting from PSEs and authorized emergency exposures, must be included when demonstrating compliance with Table 4-2 limits.

Table 4-2. Summary of Occupational Dose Limits

Type of Exposure	Dose Limit (1)
Radiological worker: whole body (internal + external) total effective dose (TED) [see 835.202(a)] (2,3)	5 rem/year
Radiological worker: lens of the eye (external) [see 835.202(a)] (4)	15 rem/year
Radiological worker: skin and extremities (internal + external) [see 835.202(a)] (5)	50 rem/year
Radiological worker: any organ or tissue (other than lens of eye) (internal + external) [see 835.202(a)] (6)	50 rem/year
Declared pregnant worker: embryo/fetus (internal + external) [see 835.206(a)]	0.5 rem /gestation period
Minors: whole body (internal + external) (TED) [see 835.207]	0.1 rem/year
Minors: lens of the eye, skin, and extremities [see 835.207]	10% of radiological worker limits
General employee (nonradiological worker): whole body (internal + external) (TED)	0.1 rem/year
Member of the public (nonradiological worker): whole body (internal + external) (TED) [see 835.208] (7)	0.1 rem/year

Notes to Table 4-2. All references are to sections within P-121:

1. Exposures resulting from background radiation, as with a patient undergoing therapeutic and diagnostic medical procedures or participating as a subject in medical research programs, must not be included in either personnel radiation dose records or the assessment of dose against the limits in this table [see 835.202(c)].

2. The TED must be the effective dose from external exposures + the CED from internal exposures [see 835.2(a), .203(a)].

3. Determinations of the effective dose must be made using the radiation and tissue weighting factor values provided in 835.2(b) [see 835.203(b)].

4. An equivalent dose to the lens of the eye must be determined at a tissue depth of 0.3 cm [see 835.2(b)].

5. This reflects the sum of the equivalent dose to the skin or to any extremity (determined at a tissue depth of 0.007 cm) and the committed equivalent dose to the skin or to any extremity [see 835.2(b), .202(a)].

6. The annual limit of dose to “any organ or tissue” must be based on the committed equivalent dose to that organ or tissue resulting from internally deposited radionuclides plus the equivalent dose to the whole body from external exposures during the year [see 835.202(a)(2), .202(a)].

7. Although not considered an “occupational dose,” the dose limit for members of the public is included here for brevity.

Incidents and Emergencies

Guidance for permissible exposures for incidents and emergencies comes from Table 2-2 of P-121.

Table 2-2. Emergency Exposure Guidance		
Dose Control Level (external whole-body dose)	**Activity Performed**	**Conditions**
To 10 rem	Protecting major property	Where lower dose is not practical
To 25 rem	Lifesaving or protection of large populations	Where lower dose is not practical
Greater than 25 rem	Lifesaving or protection of large populations	Only on a voluntary basis to personnel who are fully aware of the risk involved

In addition to the above dose limits, LANL has also established dose action levels. The following guidance comes from P-121:

Section 442 Action Levels

1. LANL has established action levels to help identify and manage higher-level worker doses, maintain individual doses below regulatory limits, and focus as-low-as-reasonably achievable (ALARA) efforts.

2. Action levels are dose thresholds (shown in Table 4-3) that require notifying the worker, the responsible line manager (RLM), Environment, Safety, and Health (ESH) Deployed (DESH), and the Radiation Protection (RP) Division Leader. RP Programs (PROG) issues these notifications electronically after dosimetry data become available.

Table 4-3. Default LANL Action Levels

Dose Being Reported	Notification Action Level (per year)
Whole-body dose	1 rem
Lens of the eye	3 rem
Extremities/organ/tissue	10 rem
Embryo/fetus	0.1 rem

Notes. . . .

Requirements for a Female General Employee Who Has Notified in Writing That She Is Pregnant

2.04.04 Identify the requirements for a female general employee who has notified her employer in writing that she is pregnant.

A declared pregnant worker is a woman who has voluntarily declared to her employer, in writing, her pregnancy for the purpose of being subject to the occupational dose limits to the embryo/fetus as provided in Table 4-2. This declaration may be revoked, in writing, at any time by the declared pregnant worker.

Further guidance can be found in Section 423 of P-121:

Embryo/Fetus Dose Limits

1. Once a female worker submits a written declaration of pregnancy with Occupational Health, she is considered to be a declared pregnant worker and is subject to the Reproductive Health Assistance Program (RHAP) process. Notification and declaration are voluntary; RHAP processes are accessible from the RP Division home page.

2. For a declared pregnant worker who chooses to continue work that involves occupational exposure, the following must apply:
   a. The dose limit for the embryo/fetus from conception to birth (entire gestation period) as a result of the occupational exposure of the declared pregnant worker must be 0.5 rem [see 835.206(a)]. The dose to the embryo/fetus must be equal to the sum of doses received from external doses, sources inside the mother, and sources inside the embryo/fetus; and
   b. Measures must be taken to avoid substantial variation above the uniform exposure rate necessary to meet the 0.5-rem limit for the gestation period [see 835.206(b)].

Guidance Note: Avoid exceeding 0.05 rem per month for the declared pregnant worker.

3. If the dose to the embryo/fetus is determined to have already exceeded 0.5 rem when a worker notifies her employer of her pregnancy, the worker must not be assigned to tasks in which additional occupational radiation exposure is likely during the remainder of the gestation period [see 835.206(c)].

4. The pregnant worker may at any time withdraw her declaration of pregnancy, in writing, in accordance with the RHAP process [see 835.2(a)].

Thermoluminescent Dosimeter (TLD) Theory of Operation

2.04.05 Determine the theory of operation of a thermoluminescent dosimeter (TLD).

Thermoluminescence (see Figure 1) is the ability of some materials to convert the energy from radiation to a radiation of a different wavelength, normally in the visible light range:

- Fluorescence: This emission of light occurs during or immediately after irradiation (within fractions of a second) of the phosphor. This reaction is not particularly useful for TLD use.

- Phosphorescence: This emission of light occurs after the irradiation period. The delay time can be from a few seconds to weeks or months. This principle of operation is used for TLDs.

TLDs use phosphorescence as their means of detection of radiation. Ionizing radiation transfers energy to the electrons of the phosphor atoms in the TLD. These excited electrons detach from the phosphor atoms in the TLD and eventually become trapped (see Figure 2). When the TLD is heated, these excited electrons escape from the traps and return to the ground state, going from a higher energy state to a lower state.

In going to a lower energy state, these excited electrons give up stored energy in the form of light photons. The light emitted is detected/measured by a photomultiplier tube. The energy received by the TLD is directly proportional to the number of electrons trapped. When heated, all traps release their electrons so that the intensity of the light flash produced is directly proportional to the amount of energy that was deposited in the TLD by ionizing radiation.

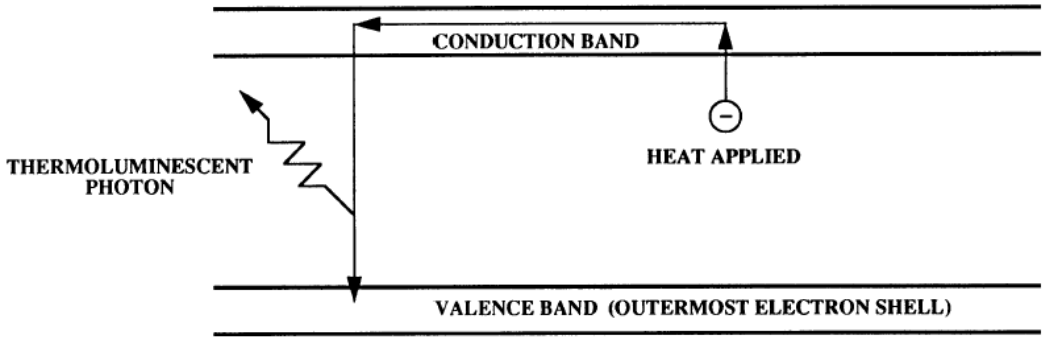


Figure 1. Thermoluminescence.

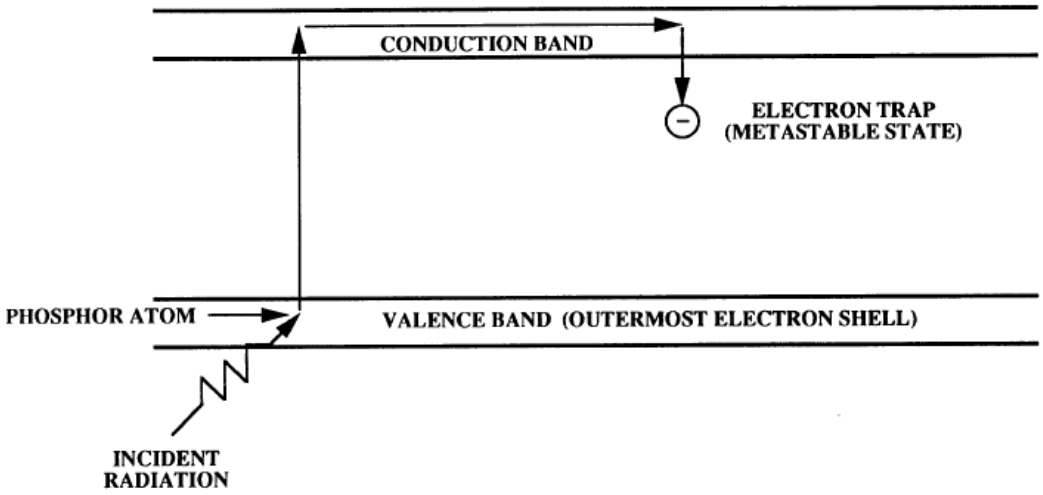


Figure 2. Electron entrapment.

TLD Reader Measurements

2.04.06 Determine how a TLD reader measures the radiation dose from a TLD.

Heating the thermoluminescent material causes the trapped electrons to return to the valence band. When this happens, energy is emitted in the form of visible light. The light output is detected and measured by a photomultiplier tube, and a equivalent dose is then calculated.

A typical basic TLD reader contains the following components:

- heater—raises the phosphor temperature,
- photomultiplier tube—measures the light output, and
- meter/recorder—display and record data.

A glow curve (see Figure 3) can be obtained from the heating process. Multiple peaks result as the material is heated and electrons trapped in “shallow” traps are released. This process results in peaks as these traps are emptied. As heating continues, the electrons in deeper traps are released. This process results in additional peaks.

The area under the curve represents the radiation energy deposited on the TLD.

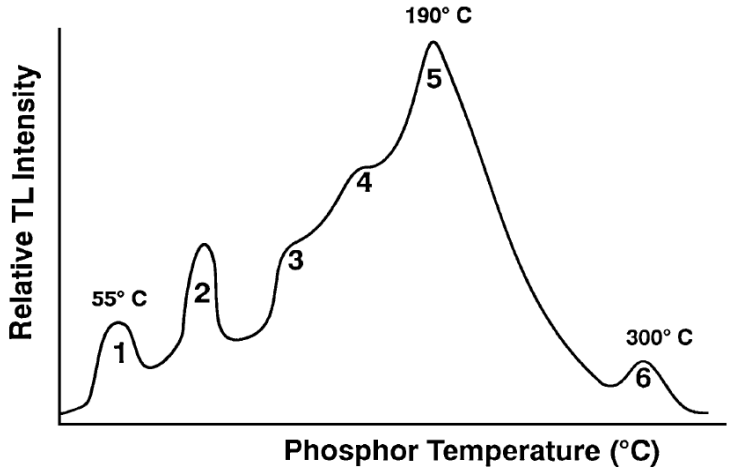


Figure 3. Glow curve.

Notes. . . .

TLD Advantages and Disadvantages (vs Film Badges)

2.04.07 Identify the advantages and disadvantages of a TLD compared to a film badge.

The advantages of a TLD (as compared with film dosimeter badges) include

- the ability to measure a greater range of doses,
- doses that may be more easily obtained,
- quicker turnaround time for readout, and
- the ability to be reused.

Disadvantages include that

- each dose cannot be read out more than once.

The TLD materials used in the LANL badge are lithium fluoride (LiF) and calcium fluoride (CaF_2).

The LANL TLD has two cards, each with four chips of LiF or CaF_2. The top card measures betas and gammas, and the bottom card measures betas, gammas, and neutrons.

Notes. . . .

Beta-Gamma TLDs at LANL

2.04.08 Identify the types of beta-gamma TLDs used at your site.

The top two TLD chips are located behind the Mylar windows at the top of the badge. One Mylar window is twice as thick as the other. This design allows some energy discrimination of betas and soft x-rays. These two chips measure the shallow dose.

The next row of TLD chips is located behind a layer of plastic that is about 600 mg/cm^2 thick. These chips are designed to measure the deep dose or whole-body dose. One of these chips is made of ^{7}LiF; the other is CaF_2; both measure the gamma dose. The CaF_2 is more sensitive to low-energy gammas than the ^{7}LiF.

Notes. . . .

Neutron TLDs at LANL

2.04.09 Identify the types of neutron TLDs used at your site.

The TLD-700 chip, made with ^{7}LiF, is sensitive to betas and gammas; the TLD-600, made with ^{6}LiF, is sensitive to betas, gammas, and neutrons. The neutron dose is calculated from the difference of a TLD-600 and TLD-700 pair.

The bottom card uses four TLD chips, arranged as two pairs, to measure the neutron dose. One TLD-600 and TLD-700 pair is shielded from the front with cadmium (Cd), which absorbs thermal neutrons. A second pair is shielded with Cd from the rear.

Albedo Neutron Dosimetry

Albedo neutron dosimetry refers to the measurement of neutrons that are moderated and reflected from the body. The LANL TLD uses the principle of albedo neutron dosimetry. The TLD600 and TLD700 pair that is shielded at the front with Cd is designed to detect albedo neutrons reflected from the body.

PN-3 Track-Etch Dosimeter

High-energy neutrons knock protons out of hydrogen atoms or other light nuclei. The recoil protons cause secondary ionization.

A chemical bath etches the track left by the recoil proton in plastic detectors. These etched tracks scatter light in the automatic reader. The amount of scattered light is proportional to the number of tracks, which is proportional to the neutron dose.

Notes. . . .

TLD Use Requirements at LANL

2.04.10 Determine the requirements for use of TLDs at your site.

Personnel dosimetry is required for personnel who may receive an occupational external whole-body dose equivalent of 100 mrem/year. TLDs are usually required for entry into a controlled area, which is controlled for external radiation.

Dosimeters shall be issued only to personnel formally instructed in their use and shall be worn only by those to whom the dosimeters were issued. Personnel shall return dosimeters to the dosimeter custodian in their group for processing monthly or quarterly, as required. If they do not, they may be restricted by line management from performing radiological work until the dosimeters are returned.

Personnel shall wear their primary dosimeters on the chest area, between the waist and the neck. Personnel should not expose their TLDs to security x-ray devices, excessive heat, or medical radiation sources. If a TLD is accidentally exposed, inform the deployed ESH organization.

A person whose dosimeter is lost, damaged, or contaminated should

- place work in a safe condition,
- exit the area, and
- report the occurrence to the RCT and their supervisor.

Personnel shall not wear dosimeters issued by LANL while being monitored with a dosimeter at another offsite location. Temporary dosimeters for special assignments may be issued for offsite use with prior approval of the Radiation Protection Program. Temporary TLDs may be obtained from a dosimeter custodian or from the Dosimetry Team. Temporary TLDs may also be used for special studies, such as measuring how much dose a worker receives on a particular job, performing area monitoring, or measuring the dose at a particular location.

Multiple dosimeters may be issued to personnel to assess whole-body exposure in nonuniform radiation fields.

Wrist dosimeters are used at LANL to measure extremity radiation dose of radiological workers. A radiological worker whose extremity dose equivalent might exceed 5 rem per year should be issued a wrist dosimeter, or it can be required in a radiation work permit (RWP). Wrist dosimeters are worn on either wrist, with the active chip facing the palm.

Notes. . . .

Personnel Neutron Dosimeters at LANL

2.04.11 Determine the principle of operation, and the types used, for the personnel neutron dosimeters at your site.

LANL uses a small dosimetry package known as a personal nuclear accident dosimeter (PNAD), which is required by 10 CFR 835.1304 for facilities possessing sufficient quantities of fissile material to potentially constitute a critical mass. The PNAD packet consists of a 2.5-in.-long-by-0.75-inch-wide, clear plastic holder containing three foils and one pellet:

- one bare indium foil for thermal neutrons,
- one Cd-covered indium foil for fast neutrons,
- one copper foil for intermediate and fast neutrons, and
- one sulfur pellet for fast neutrons.

These materials undergo neutron activation when they are exposed to neutron radiation, such as that produced in a criticality accident. Each material is sensitive to a particular range of neutron energies. The amount of radioactivity induced in the four materials indicates both the levels and the energies of the neutrons involved.

In the event of a criticality accident, the neutron dose received by an individual can also be estimated from the neutron activation of hair [$^{32}S(n,p)^{32}P$] and blood [$^{23}Na(n,gamma)^{24}Na$].

Notes. . . .

Self-Reading Dosimetry (SRD) at LANL

2.04.12 Determine the principle of operation of self-reading dosimetry (SRD) at your site.

A. Supplemental Dosimetry

1. Required for entry into high or very high radiation area.
2. Must be worn with a TLD.
3. Used to provide immediate estimate of a person's exposure to x-ray or gamma radiation only.
4. Calibrated with Cs-137.

B. LANL Self-Reading Dosimeters

1. Supplemental dosimeters are discussed in the procedure RP-1-DP-21, “External Exposure Control Standard.” The most commonly used is the “pencil dosimeter” ion chamber, also called a “pocket chamber” or “pc.”
2. Before it can be used, the chamber must be charged to a predetermined voltage so that the scale reading indicates 0. As the chamber is exposed to radiation, the charge is dissipated, causing the scale reading to increase.
3. Pocket chambers contain a quartz fiber electroscope that can be read on a scale by holding the pocket chamber up to the light.
4. The total integrated dose can be checked periodically simply by noting the degree of discharge of the chamber as indicated on the electroscope.
5. Workers should be instructed to check their self-reading dosimeters periodically and to report to an RCT if the reading exceeds 75% of full scale or if it exceeds the planned dose.
6. A pc may discharge if it is dropped or hit. Because a charged pc reads zero and a discharged pc reads high, this action could cause an individual worker's pc to read off-scale, thus indicating a large dose.

7. Each facility keeps a “supplemental dosimetry issue sheet” and a “dose tracking report” to document the data obtained from self-reading dosimeters. When the TLD results are available (every month), the results must be compared by the RCT. A difference of more than 50% must be investigated.

8. If the preliminary investigation indicates that the exposure is above the facility administrative control level, initiate a radiation protection observation (RPO) in accordance with RPO-MAN-001, “Radiation Protection Observations Desktop Instructions.”

C. Self-Reading Pocket Dosimeters (SRPDs)

1. The direct reading pocket dosimeter consists of an ionization chamber sensitive to a desired radiation, a quartz fiber electrometer to measure the charge, and a microscope to read the fiber image off a scale (reticle).

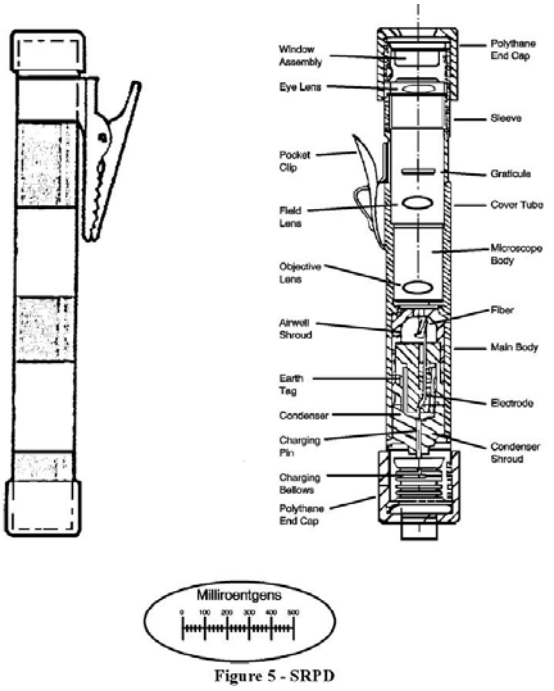


Figure 5 - SRPD

2. The electrometer embodies two electrodes, one of which is a moveable quartz fiber and the other a metal frame. When the electrometer is charged to a predetermined voltage, the electrodes assume a calibrated separation.

3. As the dosimeter is exposed to radiation, ionization occurs in the surrounding chamber, decreasing the charge on the electrode in proportion to the exposure. The deflection of the moveable quartz fiber electrode is projected by a light source through an objective lens to a calibrated scale and read through a microscope eyepiece.

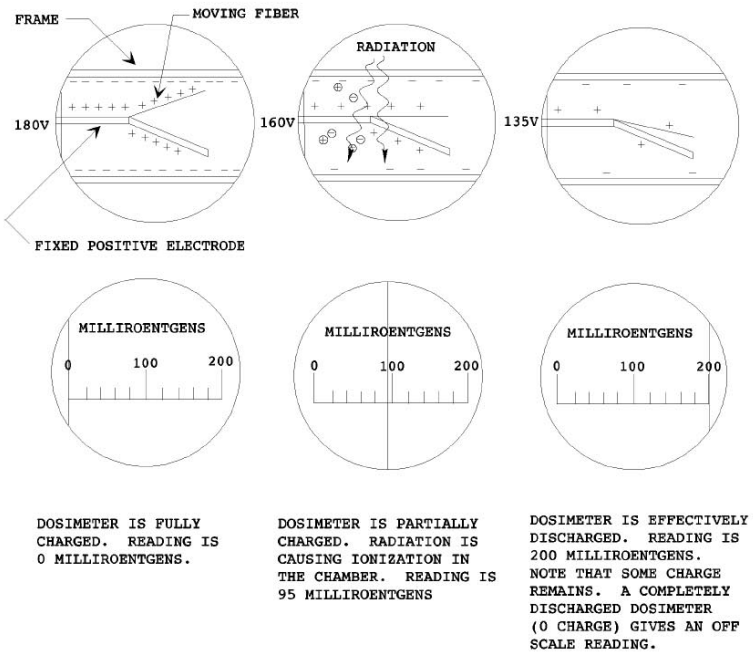


Figure 6 - SRPD Reading

4. Illumination for the optical system is obtained by pointing the dosimeter at any convenient light source. Light passes through the clear glass bottom seal to illuminate the scale.

5. The bottom is sealed by a bellows containing an insulated charging pin. When charging, the charging pin moves up to contact the electrometer, closing the circuit. Sufficient voltage is applied to recharge the system. The entire dosimeter system is hermetically sealed in a protective barrel.

Notes. . . .

Alarming Dosimeters at LANL

2.04.13 Determine the principle of operation, and guidelines for use, for the alarming dosimeters at your site.

Alarming Radiation Detectors

1. Pocket chirpers are suitable for supplemental use only and should always be worn in conjunction with a TLD badge. Chirpers are used mainly to warn the wearer of high-gamma exposure rates; they do not measure total gamma radiation doses, so they should not be called dosimeters.

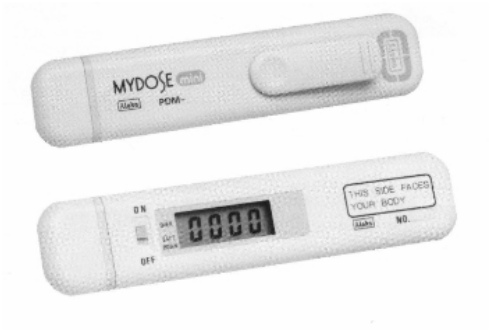
2. One model used at LANL is the Eberline RT-1 (rad-tad). Chirpers range in response frequency from 2 to 20 chirps/minute for 1 mR/hour.

3. Chirpers use Geiger-Müller (GM) tubes, which generally overrespond to low-energy gammas. Alphas, betas, and very-low-energy gammas will not penetrate the metal housing.

4. Siemens and Aloka Electronic Dosimeters

   Electronic dosimeters, such as those made by Siemens or Aloka, are used at LANL. These dosimeters combine the features of a self-reading dosimeter and an alarming dosimeter.

   Although the electronic personal dosimeter (EPD) is much bulkier than the pc, it has many advantages, such as the digital display of



- accumulated shallow doses,
- accumulated penetrating doses,
- shallow dose rates, and
- penetrating dose rates.

Alarms can be set for two different levels of

- total accumulated dose and
- dose rate.

The EPD is sensitive to both beta and photon radiations (photons include both gamma and x-ray photons, with the exception of photons from pulsed radiation fields) with energies of

- 20 keV–1.5 MeV (±30% accuracy),
- 1.5 MeV–10 MeV (±50% accuracy), and
- averaged beta energy 250 keV–1.5 MeV (±30% accuracy).

The disadvantages of electronic dosimeters are that they

- are sometimes affected by cellular phones or radios and
- underrespond in pulsed fields, such as from a flash x-ray device.

Bioassay Monitoring Methods at LANL

2.04.14 List the types of bioassay monitoring methods at your site.

Bioassay is the term used to describe the assessment of the quantity of radioactive material present in the body.

The two types of bioassay measurements used in nuclear industries are in vivo and in vitro:

- In vivo bioassay involves counting the living tissue.
- In vitro involves counting an excreted sample, such as urine.

Bioassay programs are designed to fulfill two needs:

- Evaluate the effectiveness of contamination control practices
  - Routine bioassay programs use the submission and analysis of samples from workers in facilities where the likelihood of intake exists.
  - Programs are limited primarily to urinalysis because of the ease of sample collection.
  - This program also includes initial, routine, and termination whole-body counts.
- Evaluate the potential consequences of accidental inhalation or ingestion of large quantities of radioactive material
  - The consequences can involve all types of bioassay measurements with the collection and analysis of nasal, urine, and fecal samples.
  - Whole-body counts provide immediate indications for given radionuclides if the individual(s) involved is free of external contamination.

In Vivo Measurements

In vivo techniques consist of direct measurements of photon radiation originating in the body. This method is very useful for any radionuclide that emits (or has daughters that emit) photons of sufficient energy to escape the body. This method is possible only for those radionuclides emitting penetrating radiation.

Direct counting of the individual without prior preparation (e.g., changing into clean clothes and external decontamination) may give misleading results.

At LANL, the lung counter is located in the sub-basement of the Health Research Laboratory (HRL) building, which is shielded with 8-inch-thick steel walls. A new whole-body counter is located at TA03-0130. The steel was obtained from World War II battleships to ensure that the steel does not contain trace amounts of plutonium or fission products.

The detector system includes high-purity germanium detectors for high-resolution gamma detection. This system is capable of measuring

- radioiodine in the thyroid gland,
- radionuclides in the chest, and
- radionuclides in the intestine.

Advantages of the system include that

- no sample is required,
- results are obtained quickly,
- some equipment design allows field use, and
- time and manpower requirements are minimized.

Disadvantages of the system include

- that it is limited to detection and measurement of gamma emitters.
- that the individual must be free of external contamination,
- that a relatively high minimum detection level is needed for transuranics,
- that long count times are needed for identification,
- the effects of background,
- expense, and
- the quantification error due to differences in tissue structure from one person to another as compared with calibration phantom.

In Vitro Measurements

The amount of material present in the body is estimated using the amount of material present in excretions or secretions from the body. Samples include urine, feces, blood, sputum, saliva, hair, and nasal discharges. Calculations require the knowledge and use of metabolic models that allow sample activity to be related to activity present in the body. The resulting dose calculations to quantify committed and effective dose are estimates with large uncertainties. These calculations indicate effectively that soluble radioactive material has been deposited in the blood for transport to various organs.

Difficulties include the

- possibility of contamination if the sample is taken at work and
- problem of collecting a sample from which the total excretion of radionuclides per unit time can be calculated.

Almost all employees are willing to provide a limited number of urine samples; however, prolonged urine sampling involving samples taken both at home and at work will often meet with increasing employee resistance.

Fecal Analysis

An appreciable fraction of the particles entering the gastrointestinal tract may not be absorbed; these appear in the feces within 24 hours. Fecal analysis is an excellent and relatively rapid indicator that an exposure has occurred; it is particularly useful for inhaled, insoluble materials that do not appear in the urine for weeks. This analysis can also contribute to the estimate of the lung burden.

The disadvantages of fecal analysis include that

- employees are very resistant to providing fecal samples and
- fecal content and organ depositions have very little correlation.

Fecal analysis is primarily a qualitative method used only for detecting the intake of insoluble materials and providing an indication of the clearance of such materials from the lungs. Fecal sampling is normally done immediately following an incident because the correlation is best when intake times are known.

Sputum and Saliva

When obtainable, sputum may contain insoluble material initially deposited in the lung and later eliminated by ciliary action. Clearance time for sputum is very rapid, and samples must be taken immediately after an incident. Saliva may be analyzed to detect internal contamination, but the only practical case in which saliva can be used to estimate body content is that of tritium oxide.

Nasal Discharge

The presence of radionuclides in nasal discharge and nasal swabs generally gives an indication of the deposition of the coarsest inhaled particles in the nose. Measurement of the amounts present cannot always be used for quantitative estimation of the amount in the body, but it can be useful in detecting significant exposures and identifying the radionuclide involved in an accident.

The most common in vitro measurement involving an RCT is the nose swipe. Nose swipes are taken whenever there is any suspicion of internal intake by inhalation (e.g., after a continuous air monitor alarm; after working in airborne radioactivity areas; and when a person has contamination on his/her skin or personal clothing, especially the face). Some RCTs obtain nose swipes whenever a worker removes a respirator.

The advantages include that swipes can be used to

- estimate neutron doses using activation product concentration in hair and blood (P-32 and Na-24) and
- quantify the presence of materials that decay by alpha and beta emission to allow detection and measurement with external detector systems.

The disadvantages include that the process requires

- sample submission and analysis and
- time and manpower.

Bioassay Scheduling Program (Baseline/Routine/Exit Evaluations)

A routine bioassay program is set up for personnel who work on a regular or intermittent basis with at least 1 Ci of tritium oxide or who work on systems that have contained at least 1 Ci of tritium, 0.1 Ci of tritium oxide, or 0.1 Ci of organic tritium. This program can be used to estimate neutron doses using the activation product concentration in hair and blood (P-32 and Na-24).

A urinalysis program has been established for personnel performing hands-on work with uranium. A urinalysis and fecal program has been established for personnel working with plutonium. For personnel who experience more casual encounters with plutonium, routine sampling at the rate of once per year is sufficient.

Annual Sampling—personnel routinely performing chemical or metallurgical operations with less than 10 g of ^{239}Pu, ^{242}Pu, or less than 0.04 g of ^{238}Pu.

Semiannual Sampling—personnel routinely performing chemical or metallurgical operations with 10 g or more of ^{239}Pu, or ^{242}Pu, or 0.04 g or more of ^{238}Pu (approximately 0.6 or 0.8 Ci of either isotope).

A urinalysis program has been established for workers exposed to americium. Workers who perform chemical, metallurgical, or disposal-packaging operations with mixtures of materials containing 0.1 g or more of ^{241}Am must submit a urine sample annually.

A urinalysis program is established for workers who perform specific hands-on operations involving uranium. Samples are collected every 2 weeks.

Special Evaluations—during an off-normal situation, different procedures may be followed.

Tritium—for a minor or severe uptake, the individual must

- notify the RCT,
- completely empty his/her bladder without collecting a specimen, and
- after approximately 2 hours, collect a spot urine sample and submit it to the RCT.

Uranium, plutonium, americium—During an off-normal situation, personnel are required to submit special, nonroutine, spot urine samples on the day following the incident.

Notes. . . .

Uses of Area Monitoring Dosimeters

2.04.15 List different uses of area monitoring dosimeters.

Although area monitoring dosimeters are used at LANL, they fall under the purview of the External Dosimetry department. Most are found at TA-54 and TA-53 as area boundary monitors.

RCTs are not be required to calibrate, deploy, maintain, or monitor area dosimeters. Interactions with this equipment are limited to reporting dosimetry equipment that has fallen or has otherwise been found on the ground to their supervision or the External Dosimetry department.

Notes. . . .

RCT: Module 2.10, ACCESS CONTROL AND WORK AREA SETUP

Course 8776

August 2017

Overview

This course presents information on radiological work permits (RWPs), various types of postings used in radiological areas, radiological area setups, access controls, and releases of material from radiological areas. All of these are fundamental duties of RCTs.

Objectives

2.10.01 State the purpose of and information found on a Radiological Work Permit (RWP) including the different classifications at LANL.

2.10.02 State responsibilities in using or initiating an RWP.

2.10.03 State the document that governs the ALARA program at LANL.

2.10.04 Describe how exposure/performance goals are established at LANL.

Objectives

2.10.05 State the conditions under which a pre-job ALARA review is required at LANL.

2.10.06 State the conditions under which a post-job ALARA review is required at LANL.

2.10.07 State the purpose of radiological postings, signs, labels, and barricades; and the RCTs responsibilities for them.

Objectives

2.10.08 Identify the following radiological postings at your site, requirements for posting/barriers, and requirements for entry:

a. Radiological Buffer Area
b. Radiation Area
c. High Radiation Area
d. Very High Radiation Area
e. Hot Spot
f. Contamination Area
g. High Contamination Area
h. Airborne Radioactivity Area
i. Fixed Surface Contamination
j. Soil Contamination
k. Radioactive Material Area
l. Underground Radioactive Material Area

Objectives

2.10.09 Describe good practices, support equipment to use, and common discrepancies in setting up radiological areas.

2.10.10 List discrepancies frequently observed in containment devices.

2.10.11 Describe good practices in setting up portable ventilation systems and count rate meters.

2.10.12 List the requirements individuals should follow while working in RBAs.

2.10.13 State the requirements for removing or releasing materials from any radiological area.

2.10.01 – Purpose of a Radiological Work Permit (RWP)

The RWP is an administrative mechanism used to establish radiological controls for intended work activities. The RWP informs workers of area radiological conditions and entry requirements and provides a mechanism to relate worker exposure to specific work activities.

2.10.01 – Purpose of a Radiological Work Permit (RWP)

RWPs are required for entry into the any Radiological Areas. Radiological Areas are defined in P121, *Radiation Protection*, as:

- Radiation Areas (RAs)
- High Radiation Areas (HRAs)
- Very High Radiation Areas (VHRAs)
- Contamination Areas (CAs)
- High Contamination Areas (HCAs)
- Airborne Radioactivity Areas (ARAs)

2.10.01 – Purpose of a Radiological Work Permit (RWP)

Required information:

- The RWP should include the following information:
  - Description of work
  - Work area/process radiological controls
  - Dosimetry requirements
  - Pre-job briefing requirements, as applicable
  - Training requirements for entry
  - Protective clothing and respiratory protection requirements
  - Radiological control coverage requirements and stay time controls, as applicable
  - Limiting radiological conditions that may void the RWP

2.10.01 – Purpose of a Radiological Work Permit (RWP)

Required information: *(continued)*

- Special dose or contamination reduction considerations
- Special personnel frisking considerations
- Technical work document number, as applicable
- Unique identifying number
- Date of issue and expiration
- Authorizing signature

2.10.02 – Responsibilities for RWP Use

Workers accessing an area permitted by an RWP are required to attend a pre-job briefing performed by an RCT and sign the RWP before initially entering the work area, after making any revisions to the RWP, and when performing the pre-job briefing to the frequency specified in the RWP.

This process signifies that the worker understands the RWP. The worker's signature signifies that he/she is aware of the radiological conditions and agrees to comply with the requirements.

2.10.02 – Responsibilities for RWP Use

Pre-Job Briefings

- Pre-job briefings are conducted by the cognizant RCT and should include the
  - Scope of work to be performed
  - Radiological conditions of the workplace
  - RWP requirements
  - Special radiological control requirements
  - RWP limits – conditions, such as contamination or radiation levels that may void the RWP
  - Health physics/radiological control hold points

2.10.02 – Responsibilities for RWP Use

Pre-Job Briefings *(continued)*

- Communications and coordination with other groups
- Provisions for housekeeping and final cleanup
- Consideration of potential accident situations or unusual occurrences and a review of abnormal and emergency procedures and plans
- Emergency response provisions

2.10.02 – Responsibilities for RWP Use

Radiological Hazard Analysis and Work Planning

- P300, *Integrated Work Management* (IWM), defines requirements and a process for conducting work in a safe, secure, and environmentally responsible manner. The hazard identification, hazard analysis, and definition of controls are essential elements of the IWM process.

2.10.02 – Responsibilities for RWP Use

RP-1-TBD-1, *Radiological Work Control Package (RWCP) Technical Basis*

- The RWCP consists of four phases, which implement the five steps of IWM. Table 1 explains the relationship between the RWCP process and IWM.

Table 1 RWCP's Implementation of IWM

RWCP Phase		IWM
Phase I:	RWCP Request	1) Define the work
Phase II:	Radiological Work Analysis	2) Analyze hazards 3) Develop and implement controls
Phase III:	Issue a Radiological Work Permit and Perform Work	4) Perform the Work
Phase IV:	Extending or Closing RWPs	5) Feedback and improvement

2.10.02 – Responsibilities for RWP Use

P121, *Radiation Protection*, Chapter 11, *Radiological Work Control*

- P121 defines the process to ensure that radiological hazards are appropriately captured and integrated with the IWM process, addressing both safety and regulatory requirements to control radiological hazards.
- Work is managed through the IWM process, which drives the requirement for developing an Integrated Work Document (IWD). A radiological hazard analysis must be performed by a radiation protection (RP) subject matter expert (SME) in accordance with the requirements of P121 Chapter 11, and in some cases, a facility radiation protection requirements document (FRPR) or RWP is required.

2.10.02 – Responsibilities for RWP Use

P121, *Radiation Protection*, Table 11-4, Hazard Grading IWDs and RWPs

Table 11-4. Radiological Work Permit (RWP) and Integrated Work Document (IWD) Decision Requirements for Radiological Work

Hazard Grading Questions	Examples
Does the work involve any of the following? ▪ Work that could contaminate uncontrolled areas or the environment; ▪ Work in (or likely to create) an Airborne Radioactivity Area (ARA) with levels >40 derived air concentration (DAC); ▪ Dose Rate >1 rem/hr in the work area (equivalent dose to whole body, at 30 cm from accessible surfaces); ▪ Extremity / shallow dose rate >10 rem/hr (considering all radiations, at contact with accessible material or device); or ▪ Work expected to create uncharacterized radiological conditions, including: – working outside engineered controls, or – breaching engineered containment systems.	▪ Remediation of legacy contamination in proximity to uncontrolled areas ▪ Decontamination of liquid waste containment systems ▪ Opening a highly contaminated radioactive material shipment ▪ Retrieving, packaging, shipping, and receiving high activity activation products ▪ Breach of internally contaminated systems where the breach could create an airborne radioactivity hazard, including maintenance or troubleshooting activities on actinide hoods, gloveboxes, and associated ventilation systems ▪ Decontamination and demolition of radiological facilities or contaminated systems
YES – This is ***High-Hazard*** radiological work, and an Integrated Work Document (IWD) and Radiological Work Permit (RWP) are required. NO – Continue with questions below.	

2.10.02 – Responsibilities for RWP Use

P121, *Radiation Protection*, Table 11-4, Hazard Grading IWDs and RWPs *(continued)*

Table 11-4. Radiological Work Permit (RWP) and Integrated Work Document (IWD) Decision Requirements for Radiological Work	
Hazard Grading Questions	**Examples**
Does the work involve any of the following? ▪ Dose Rate >5 mrem/hr and <1 rem/hr (equivalent dose to the whole body, at 30 cm from accessible surfaces); ▪ Extremity / shallow dose rate >50 mrem/hr and <10 rem/hr (considering all radiations, at contact with accessible material or device); ▪ Work in (or likely to create) a High Contamination Area (HCA); ▪ Work in (or likely to create) a Contamination Area (CA); or ▪ Work in (or likely to create) an Airborne Radioactivity Area (with levels between 1 and 40 DAC or > 12 DAC-hr in a week).	▪ Use of an accountable source with a dose rate greater than 5 mrem/hr at 30 cm to performance test health physics instruments ▪ Routine handling of dispersible radioactive materials within intact engineered controls, where the activity and work area are stable, well-characterized, controlled in accordance with the Facility Radiation Protection Requirements document (FRPR), and where sustained performance demonstrates effective controls (such as routine glovebox work).
YES – This is ***Moderate-Hazard*** radiological work, and an IWD (or "qualified worker") and either an RWP or FRPR (for routine, stable, well-characterized conditions) are required. See Table 11-3 for RWP thresholds; work with a high activity radioactive sealed source (RSS) >100 mrem/hr at 30 cm requires an RWP. NO – Continue with questions below.	

2.10.02 – Responsibilities for RWP Use

P121, *Radiation Protection*, Table 11-4, Hazard Grading IWDs and RWPs *(continued)*

Table 11-4. Radiological Work Permit (RWP) and Integrated Work Document (IWD) Decision Requirements for Radiological Work

Hazard Grading Questions	Examples
Does the work involve routine activities in a facility within the following limits? ▪ Dose Rate <5 mrem/hr (equivalent dose to the whole body, at 30 cm from accessible surfaces); ▪ Extremity / shallow dose rate <50 mrem/hr (considering all radiations, at contact with accessible material or device); ▪ Contamination < Table 14-2 on readily accessible surfaces or penetration of internally contaminated systems; and ▪ Measurable airborne radioactivity < 1 DAC.	▪ Administrative work such as management walkarounds or inspections ▪ Handling robust containers of radioactive material such as closed, surveyed, Department of Transportation (DOT), or standardized special nuclear material (SNM) containers ▪ Leak-testing of accountable sealed sources (<5 mrem/hr @ 30 cm) ▪ Conducting routine radiological surveys ▪ Analyzing laboratory samples
YES –This is ***Low-Hazard*** radiological work, occupational exposure will likely be less than 100 mrem/year, and neither an IWD nor RWP are required. Follow the Integrated Work Management (IWM) process to address nonradiological hazards. NO – Continue with questions below.	

2.10.02 – Responsibilities for RWP Use

P121, *Radiation Protection*, Table 11-4, Hazard Grading IWDs and RWPs *(continued)*

Table 11-4. Radiological Work Permit (RWP) and Integrated Work Document (IWD) Decision Requirements for Radiological Work

Hazard Grading Questions	Examples
Does the work only involve the following? • Work with commercially available analytical devices containing RSSs when used as designed, and with source remaining inside the device (does not include high dose rate sources such as irradiators, soil density gauges); • Work with consumer products containing radioactive material incidental to their operation (e.g., exit signs, welding rods, camera lenses, luminous dials, smoke detectors); • Work with radiation generating devices (RGDs) categorized as cabinet x-ray devices, unattended RGD installations, or electronic devices that produce ionizing radiation incidentally (<0.5 mrem/hr at 5 cm) as defined in Chapter 18, *Radiation Generating Device (RGD) Control*; • Work with naturally occurring radioactive material that has not been technologically enhanced; or • Storage, handling, or use of RSSs less than 10% of accountability thresholds in Appendix 16A.	• Servicing or replacing smoke detectors • Work with thoriated lenses, thorium or uranium-containing lantern mantles, tritium exit signs, radium dial watches, etc. • Work with uranium ore • Operating certified cabinet x-ray systems • Handling low activity check sources, including RCT source-checking instruments
YES – These activities are considered ***nonradiological*** work, occupational exposure will be much less than 100 mrem/year, and an IWD and RWP are not required. Follow the IWM process to address nonradiological hazards. NO – Contact a Radiation Protection Subject Matter Expert (RPSME) for guidance.	

2.10.02 – Responsibilities for RWP Use

Radiological Hazard Analysis and Work Planning *(continued)*

- When performing the hazard analysis, a walk-down of the area may be appropriate. Walk-downs are particularly important when specifying air-sampling locations, the use of containment tents, or the use of local exhaust ventilation.
- RCTs will perform pre-job surveys and participate in walk-downs with the RP SME, identifying and analyzing radiological hazards and establishing controls.
- When concurrent nonradiological hazards are present in a work step, the RP SME, RCT, and supporting safety or industrial hygiene professional will consult to determine the best controls to mitigate all hazards.

2.10.02 – Responsibilities for RWP Use

Radiological Controls in Work Control Documents

- The RWP is used to document the results of radiological hazard identification and hazard analysis and to specify controls and is deemed equivalent to the IWM-driven hazard analysis for moderate and high radiological hazards. In accordance with IWM requirements, controls relevant to workers must be resolved and incorporated specifically or referenced in the IWD.
- When RWPs are required, they must serve as the focal point for keeping radiological records associated with that work.

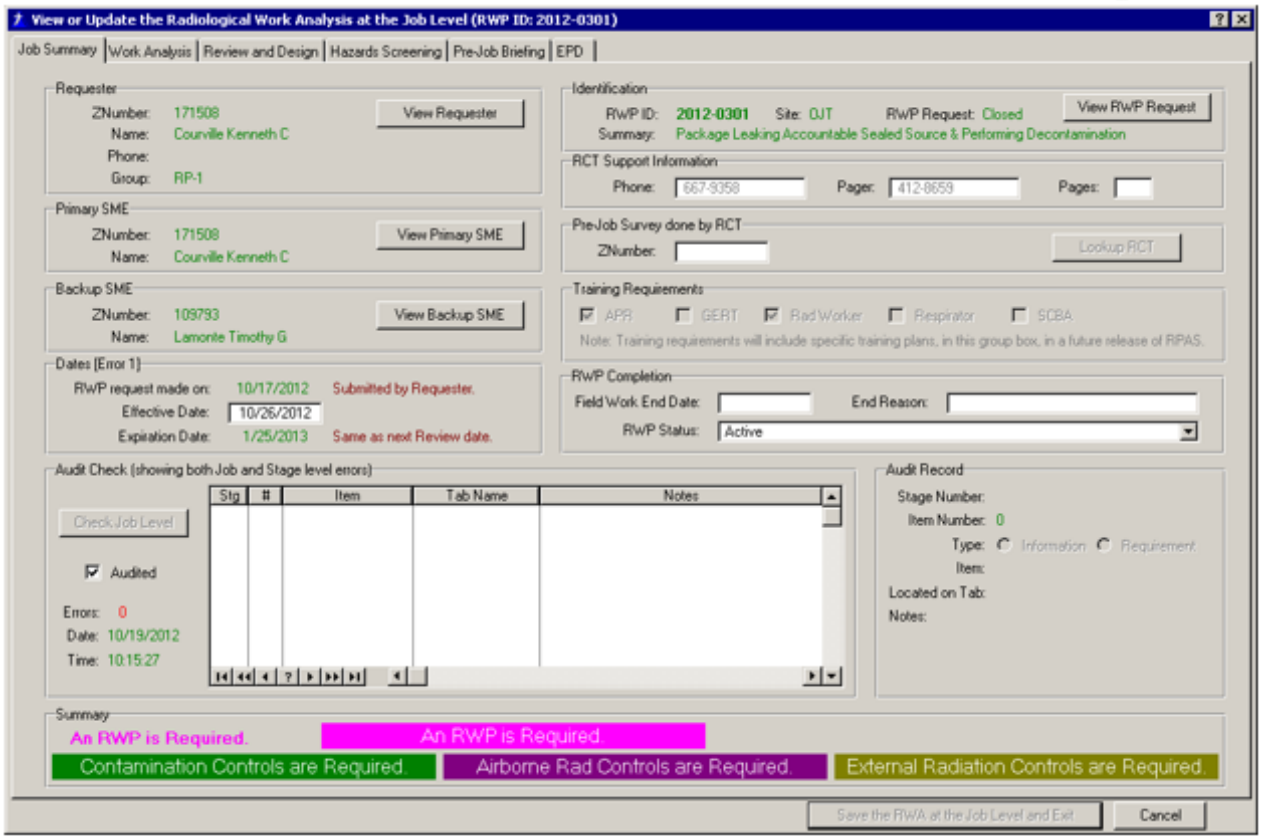
2.10.02 – Responsibilities for RWP Use

RWCP Process – Radiological Work Analysis (RWA)

- Once the processes, procedures, and objectives of the job are defined and documented by the RWP Requester, the RP RWCP SME begins the Radiological Work Analysis (RWA).
- The RWA consists of a job-level analysis, stage-level analysis, and peer review. The RWA part of RWCP process documents that an ALARA review of the work was performed, and that controls and requirements were set to keep the radiological risk ALARA.
- The RCT reviews the RWP request, RWA, and the RWP with the RP RWCP SME or the HPFC before beginning a job under the RWP.

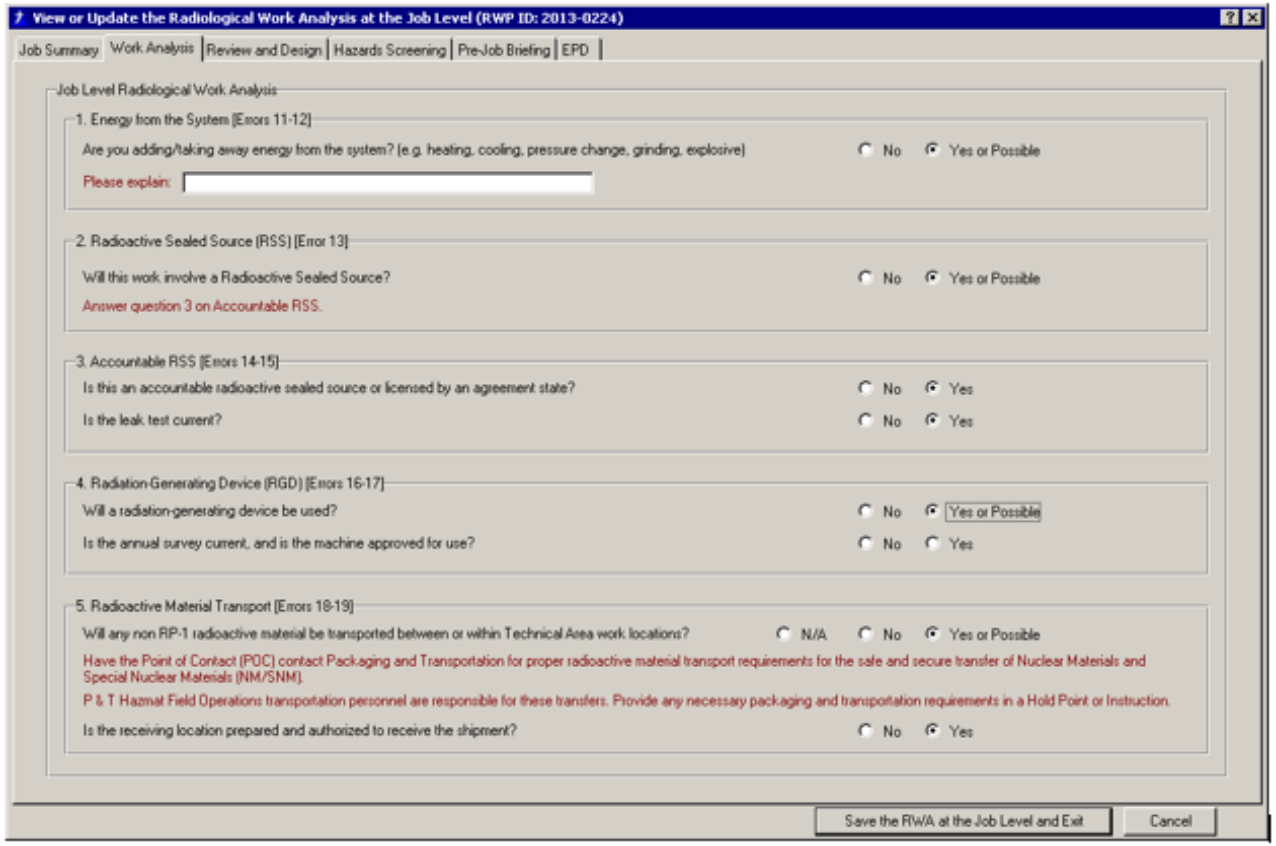
2.10.02 – Responsibilities for RWP Use

RWCP Process – Radiological Work Analysis (RWA) *(continued)*



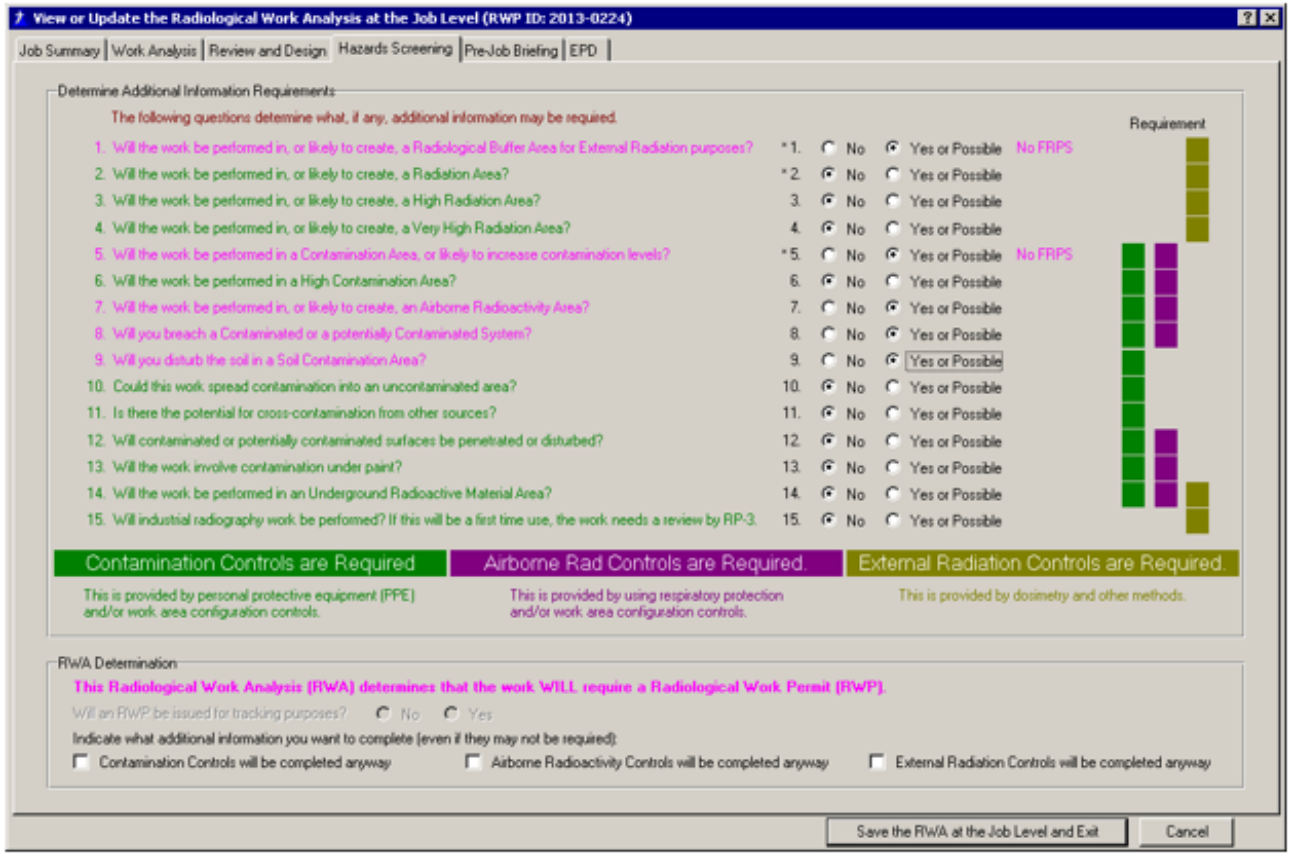
2.10.02 – Responsibilities for RWP Use

RWCP Process – Radiological Work Analysis (RWA) *(continued)*



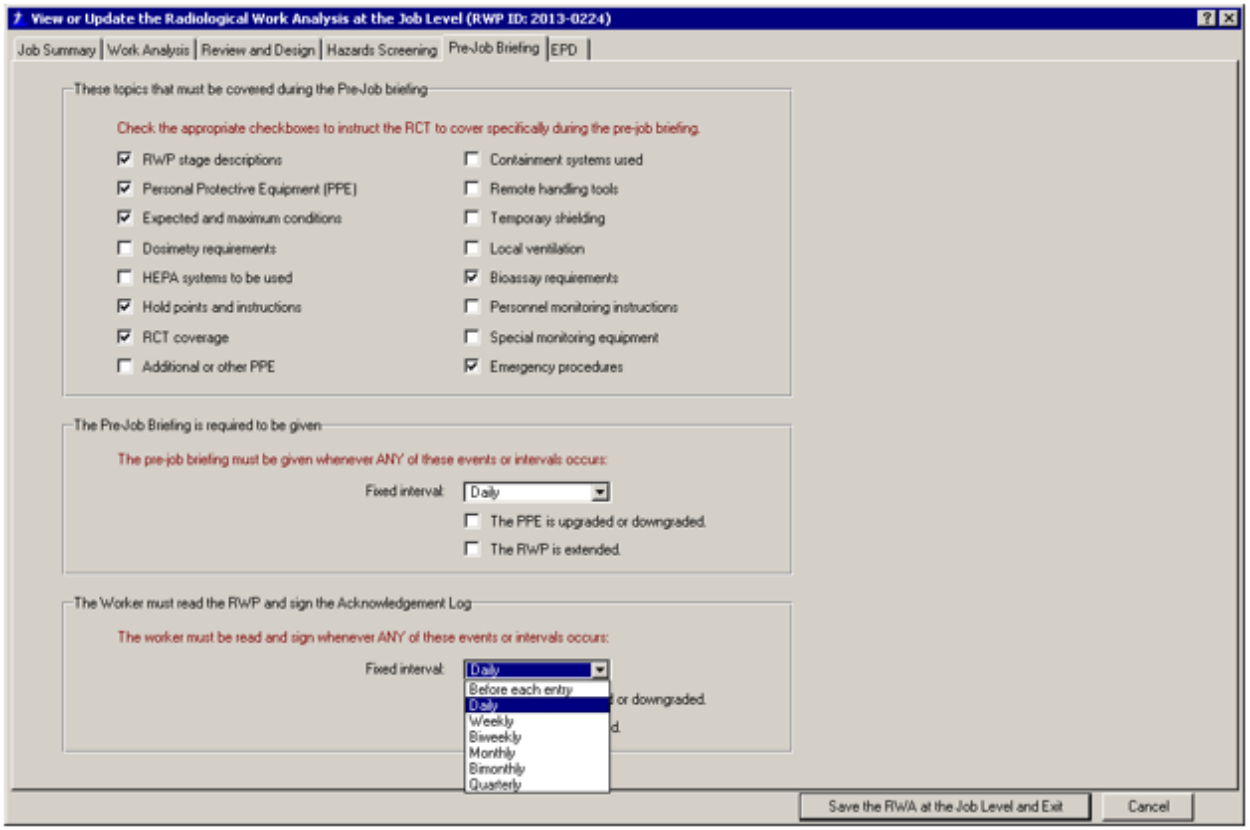
2.10.02 – Responsibilities for RWP Use

RWCP Process – Radiological Work Analysis (RWA) *(continued)*



2.10.02 – Responsibilities for RWP Use

RWCP Process – Radiological Work Analysis (RWA) *(continued)*



2.10.02 – Responsibilities for RWP Use

Radiological Activity Reviews and IWDs

- According to P121, *Radiation Protection*, and current Laboratory integrated work management requirements (P300), RP SME approval is not required for IWDs; however, P121 does require that RP SMEs review radiological IWDs.
- P121 requires that an RP SME review moderate hazard and high or complex hazard IWDs (Table 11-5, Article 1123), approve work control documents that prescribe radiological controls (Table 11-5, Article 1123), and perform new-activity ALARA reviews (NAARs) (Articles 912, 1126).

2.10.02 – Responsibilities for RWP Use

Radiological Activity Reviews and IWDs *(continued)*

- RP-1-DP-05.05, *Radiological Activity Reviews,* is used to perform and document the review of high-hazard radiological and moderate-hazard radiological IWDs (see Table 11-4, P121).
- RP-1-DP-05.05, *Radiological Activity Reviews* also describes the qualification process for RP SMEs.
- RP SMEs may delegate responsibility for review completion or comment phases of a radiological document review (RDR) or any portions thereof when appropriate, but they must approve the RDR when it is completed by those not authorized as RP SMEs.

2.10.02 – Responsibilities for RWP Use

Radiological Activity Reviews and IWDs *(continued)*

- In conducting the review, the RP SME or designee will do the following:
  - Complete an RP-1-Form 10, Radiological Document Review, to document a review of a radiological work control document.
  - Determine the hazard grading of the work described in the work document according to Table 11-4 of P121. An RDR is not required, but rather is optional, for IWDs used for low-hazard radiological work or nonradiological work.
  - RDR review is required for IWDs used for high-hazard or moderate-hazard radiological work.

2.10.02 – Responsibilities for RWP Use

Radiological Document Review (RDR), RP-1-Form-10

Radiological Document Review (RDR)

Document Title:	
Document Number:	Revision or Issue Date:

Section 1: Type of Review

Ongoing or previously reviewed activity

- ❑ IWD ❑ Other work document
- ❑ New activity. If this box is checked, STOP. A new activity ALARA review (NAAR) (RP-1-Form-11) is required

2.10.02 – Responsibilities for RWP Use

Radiological Document Review (RDR), RP-1-Form-10 *(continued)*

Section 2: RDR Screening

1. Does document or should the document specify radiological controls?	❑ Yes ❑ No
If ***yes***, continue. If ***no***, you may STOP. Attachment A is not required.	
2. Are the activities considered facility maintenance, the work is adequately addressed in the FRPR or an RWP will be used for the activities, and there is no change in a process or use of radioactive material?	❑ Yes ❑ No
If ***yes***, you may STOP. Use a FRPR or an RWP. Continuing this form is optional. If ***no***, continue.	
3. Was the document previously reviewed and the review documented on an RDR by RP-1?	❑ Yes ❑ No
4. If question 3 is yes, have there been changes in radiological controls or hazards since last review?	❑ Yes ❑ No
If ***yes***, continue. If question 4 is ***no***, complete section 5 (and 6 if required), completion of remaining questions is optional.	
Determine hazard grading of work (see Table 11-4, P121). Check one: ❑ High-hazard ❑ Moderate-hazard ❑ Low-hazard ❑ Non-radiological	
5. Are the activities considered low hazard radiological work or non-radiological work and the only radiological controls needed are adequately addressed in the FRPR?	❑ Yes ❑ No
If ***yes***, complete section 5 (and 6 if required), further review is optional. If ***no***, continue with next section.	

2.10.02 – Responsibilities for RWP Use

Radiological Document Review (RDR), RP-1-Form-10 *(continued)*

Section 3: Document Review

Answer the following questions about the activities described in the radiological work control document under review. Credit may be taken for radiological controls described in the FRPR for the areas where the activities will be performed.	Yes	No
1. Are new or modified engineered controls required?		
2. Are new or different access controls required?		
3. Are new or additional administrative controls required?		
4. Are new or different types of radiological instruments needed?		
5. Are changes in PPE required?		
6. Are radiological posting changes required?		
7. Is different dosimetry required (consider both internal and external dosimetry)?		
8. Are changes in workplace monitoring required?		
9. Is increase radiation protection coverage required?		
10. Is there anything described that is not consistent with or in conflict with the FRPR?		
11. Is an RWP required? (Required for high-hazard radiological work, moderate-hazard work that the FRPR does not address, and entry into radiological areas in accordance with table 11-3 in P121)		
If the answer to <u>all</u> of the above questions is ***no***, then complete sections 5 (and 6 if required). If the answer to <u>any</u> questions above is ***yes***, then complete the next section.		

2.10.02 – Responsibilities for RWP Use

Radiological Document Review (RDR), RP-1-Form-10 *(continued)*

Section 4: Issue and Comment Description

*Complete the section below for any questions that were answered **yes** in the previous section. Add rows or attach a continuation sheet if more room is needed.*

Question	Comment/Issue
Is a continuation sheet for additional comments or issues attached? ❑ Yes ❑ No	

Section 5: Document Review Completion Signature

Complete this section to document that review was completed.

_____ _____ _____ _____
Name *Signature* *Z-Number* *Date*

Review completed by authorized RP SME? ❑ Yes ❑ No

If ***no***, then RP-1 SME signature is required in section 6 irrespective of document type.

Section 6: Approval Signature (RP-1 Use Only)

An RP-1 authorized SME completes this section if:

- *Document is not an IWD, or*
- *Reviewer completing and signing section 5 is not an authorized RP SME*

By signature below, signee indicates that comments/issues are satisfactorily resolved and document is approved.

_____ _____ _____ _____
Name *Signature* *Z-Number* *Date*

2.10.03 – ALARA Program at LANL

Exposure to ionizing radiation is typically quantified, tracked, and controlled in terms of the dose equivalent that workers receive, or could potentially receive, in given situations. Management policy is to maintain the radiation exposure of employees, subcontractors, visitors and members of the general public not only within applicable DOE and administrative limits, but ALARA.

2.10.03 – ALARA Program at LANL

P121, *Radiation Protection*, Chapter 3, *ALARA Program*, governs the ALARA program at LANL.

The ALARA program at LANL comprises

- Management Commitment;
- Training,
- Design Review,
- Radiological Work Review,
- Performance Assessment, and
- Documentation.

2.10.04 – ALARA (exposure/performance) Goals at LANL

P121, *Radiation Protection*, Chapter 3, *ALARA Program*. Article 325.1.d indicates that the ALARA Goals Process is established and administered by the Institutional Radiation Safety Committee (IRSC). Goals are established by participating organizations before each calendar year begins and are tracked throughout the year by the organizations and the IRSC. The IRSC provides oversight and review of the ALARA Goals Process; respective organizations are responsible for goals, performance, and associated ALARA efforts.

2.10.05 – Pre-job ALARA Review at LANL

New-Activity ALARA Review (NAAR)

- A NAAR must be conducted by an RP SME to prescribe access controls commensurate with radiological hazards.
- A NAAR must be conducted for the following conditions before initiating the activity:
  - New, uncharacterized radiological operations;
  - An increase in the source term (e.g., the quantity of radioactive material or increased beam strength) above what is currently authorized and approved;
  - A change in the type of hazard, including a new radionuclide or physical/chemical form of material;

2.10.05 – Pre-job ALARA Review at LANL

New Activity ALARA Review (NAAR) *(continued)*

- A change in the process or tools that would increase the hazard or result in an uncharacterized condition;
- A change or new location from what is currently authorized and approved;
- A reduction of or significant change in engineered controls; or
- Activities that have not been performed for a period of 24 months or more, regardless of whether they have been previously reviewed and approved.

2.10.06 – Post-Job ALARA Review at LANL

Radiological post-job reviews allow the opportunity to critique the work performance. Although they will not affect the dose already received for a particular job, they can be effective in reducing the doses received the next time that job is performed.

As a minimum, the post-job review should include the following, as applicable:

- Any changes/modifications made to original work instructions.
- The time required to perform the job.
- The resources required for the job.

2.10.06 – Post-Job ALARA Review at LANL

- The estimated collective dose vs the actual collective dose summary.
- The effectiveness of exposure controls implemented.
- Problems encountered and solutions.
- Abnormal events/situations causing the use of stop work.
- Lessons learned.
- Actions taken to prevent recurrence of problems or situation.

2.10.06 – Post-Job ALARA Review at LANL

P121, *Radiation Protection*, Chapter 3, *ALARA Program*. Article 324.d, Radiological Work Review:

- A Radiological Work Permit (RWP) must be utilized according to thresholds in Chapter 11, Radiological Work Control, to document an ALARA work review, radiological hazard analysis, specification of controls, and post job evaluation specific to radiation protection.

2.10.06 – Post-Job ALARA Review at LANL

RP-1-DP-004.06, *Radiological Work Control Package (RWCP) Procedure,* provides a standardized means for RP personnel to establish radiological controls for radiological work coverage based on information provided by a requester in the RWP system.

RCT responsibilities for RWP use include

- Conducting a post-job survey and review,
- Attaching appropriate documentation, and
- Closing out the RWP when directed to do so by supervisory personnel.

2.10.06 – Post-Job ALARA Review at LANL

HPFC or Team Leader responsibilities for RWP use include:

- Reviewing pre-job, hot job, and post-job surveys.
- Ensuring that all surveys and supporting documents are attached to the RWP.
- Ensuring the closeout of the RWP at the conclusion of the job.
- Ensuring that all documentation is filed in accordance with RP procedures.

2.10.07 – Radiological Postings, Signs, Labels, and Barricades and RCT Responsibilities

The purpose of radiological postings, signs, and labels is to identify items or areas that have the potential for, or actually contain, radiological hazards; identify the radiological hazard(s) present in an area and prevent workers from inadvertently entering radiological area(s) and/or mishandling radioactive materials.

Each individual is responsible to read and comply with all information identified on radiological postings, signs, and labels. Because more than one radiological hazard may be identified on a posting, sign, or label, it is important to read all of the information and not just the first line.

2.10.07 – Radiological Postings, Signs, Labels, and Barricades and RCT Responsibilities

All access points into an area must be posted to ensure that workers are adequately warned of the hazards in the area. Postings and status boards (if applicable) should be promptly updated after a survey is completed to reflect the corrected conditions in the area.

If necessary, the RWP should be amended to reflect any changes in the area. The information on status boards, RWPs, postings, and survey maps should be consistent. Any discrepancy should be immediately corrected. Workers could review erroneous data that have not been updated and subsequently become contaminated or receive unnecessary radiation exposure.

2.10.07 – Radiological Postings, Signs, Labels, and Barricades and RCT Responsibilities

RCTs should immediately update postings after performing a survey. The RWP and any status boards must also be updated.

Areas should be posted if there is a strong potential for the situation to exist, even if it is not now present. Areas can be posted as ARAs or surface contamination areas, if equipment in the area has been known to leak and create airborne or contamination hazards. Posting areas in such a situation will ensure that the proper protective equipment is used and could prevent personnel contamination or unplanned internal exposure.

2.10.07 – Radiological Postings, Signs, Labels, and Barricades and RCT Responsibilities

If areas are posted only when the appropriate limits have been reached, personnel can be subjected to hazards when the hazard could otherwise have been minimized.

Disregarding any radiological posting, sign or label can lead to unnecessary or excessive radiation exposure and/or personnel contamination.

Unauthorized removal or relocation of radiological postings, signs and labels may lead to disciplinary actions up to and including job termination.

2.10.07 – Radiological Postings, Signs, Labels, and Barricades and RCT Responsibilities

If any type of material used to identify radiological hazards is found outside an RBA, it should be reported to radiological control personnel immediately. The RCT would then perform a survey of the sign, posting or label and conduct a survey of the area in which it was found.

Any contamination or higher-than-expected radiation levels must be promptly reported to the RCT supervisor.

RP personnel (RCTs, HPFCs, and health physicists) are responsible for determining and applying postings.

2.10.07 – Radiological Postings, Signs, Labels, and Barricades and RCT Responsibilities

Posting Requirements, P121, Radiation Protection, Chapter 7; and 10-CFR-835

- Areas shall be posted to warn individuals of the presence, or potential presence, of radiation and/or radioactive materials.
- Postings and labels shall include the standard radiation warning trefoil in black or magenta imposed on a yellow background.
- Signs shall be clearly and conspicuously posted and may include radiological protection instructions.

2.10.07 – Radiological Postings, Signs, Labels, and Barricades and RCT Responsibilities

Posting Requirements, P121, Radiation Protection, Chapter 7; and 10-CFR-835 *(continued)*

- Controlled Areas: Each access point to a controlled area shall be posted whenever radiological areas exist in the area. Individuals who enter only the controlled area without entering radiological areas are not expected to receive a total effective dose equivalent of more than 100 mrem (0.001 Sievert) in a year.

2.10.07 – Radiological Postings, Signs, Labels, and Barricades and RCT Responsibilities

Posting Requirements, P121, Radiation Protection, Chapter 7; and 10-CFR-835 *(continued)*

- Radiological Areas: Each access point to a radiological area shall be posted with conspicuous signs.
- Radiological Areas include the following:
  - Radiation Area
  - High Radiation Area
  - Very High Radiation Area
  - Contamination Area
  - High Contamination Area
  - Airborne Radioactivity Area

2.10.07 – Radiological Postings, Signs, Labels, and Barricades and RCT Responsibilities

Posting Requirements, P121, Radiation Protection, Chapter 7; and 10-CFR-835 *(continued)*

- Exceptions to posting requirements are allowed for periods of less than 8 continuous hours when the area is placed under the continuous observation and control of an individual knowledgeable of, and empowered to implement, required access and exposure control measures.

2.10.08 – Radiological Postings at LANL; Posting/Barriers; Entry Requirements

Radiological Controlled Areas (RCAs)

Table 4 Criteria for posting RCAs

Criteria	Required Posting	Minimum Entry Requirements	Minimum Exit Requirements
Reasonable Potential but Unlikely that individual receives ≥100 mrem/year, and/or removable surface contamination levels >Table 14 2	Notice Controlled Area Access Controlled For Radiological Purposes	Training: • GERT • Facility-specific training If RCA is controlled for contamination: • Long pants • Shoes that enclose the foot	RCAs controlled for external radiation: • None RCAs controlled for contamination: • Hand and foot frisk • Monitor other areas of the body suspected of contamination

2.10.08 – Radiological Postings at LANL; Posting/Barriers; Entry Requirements

a. Radiological Buffer Areas (RBAs)

- RBAs provide secondary boundaries within the RCA to minimize the spread of contamination and to limit doses to general employees who have not been trained as radiological workers. RBAs are considered part of the RCA. However, RBAs are considered to be an area of relatively higher radiological risk.

2.10.08 – Radiological Postings at LANL; Posting/Barriers; Entry Requirements

a. Radiological Buffer Areas (RBAs) *(continued)*

- An RBA should be established as a secondary boundary around Radiological Areas (CAs, HCAs, ARAs, RAs, HRAs, and VHRAs). The size of the RBA should be commensurate with the potential for the spread of contamination or where the expected dose to individuals routinely accessing the areas adjacent to these areas would be greater than 0.1 rem per year.
- An RBA should be established for contamination control as a secondary boundary around CAs, HCAs, and ARAs. The size of the RBA should be commensurate with the potential for the spread of contamination.

2.10.08 – Radiological Postings at LANL; Posting/Barriers; Entry Requirements

a. Radiological Buffer Areas (RBAs) *(continued)*

- An RBA should be established as a secondary boundary around RAs, HRAs, and VHRAs, where the expected dose to individuals routinely accessing the areas immediately adjacent to these radiological areas would be greater than 0.1 rem per year.
- RBA postings must contain the wording CAUTION, RADIOLOGICAL BUFFER AREA and any other information required for hazard communication.

2.10.08 – Radiological Postings at LANL; Posting/Barriers; Entry Requirements

a. Radiological Buffer Areas (RBAs) *(continued)*

Table 6 Criteria for posting RBAs

Criteria	Required Posting	Minimum Entry Requirements	Minimum Exit Requirements
Reasonable Potential and likely that Individual receives ≥100 mrem/year and/or removable surface contamination levels >Table 14-2	Caution Radiological Buffer Area	Training: • Radiological Worker • Facility-specific training RBAs controlled for external radiation: • TLD RBAs controlled for contamination: • Anti-C labcoat • Booties • Long pants • Shoes that enclose the foot	RBAs controlled for external radiation: • None RBAs controlled for contamination: • Hand and foot frisk • Monitor other areas of the body suspected of contamination

2.10.08 – Radiological Postings at LANL; Posting/Barriers; Entry Requirements

External Radiation Posting Areas: b. Radiation Area; c. High Radiation Area; d. Very High Radiation Area

Table 7 Criteria for posting external radiation hazards

Area	Criteria	Required Posting	Minimum Entry Requirements	Minimum Exit Requirements
Radiation area (RA)	> 0.005 rem in 1 hour at 30 cm	Caution Radiation Area	• Radiological worker, facility specific training • TLD • FRPR or RWP	None
High radiation area (HRA)	> 0.1 rem in 1 hour at 30 cm and ≤ 1 rem	Caution High Radiation Area	• Radiological worker, facility specific training • TLD , supplemental dosimeter • FRPR or RWP	None
	> 1 rem in 1 hour at 30 cm	Danger High Radiation Area	• Radiological worker, facility specific training • TLD , supplemental dosimeter • RWP	None
Very high radiation area (VHRA)	> 500 rad in 1 hour at 100 cm	Grave Danger Very High Radiation Area	• Training to be determined and approved by the RP division leader • For other requirements, see chapter 4, part 3 in P121, *Radiation Protection*	To be determined

2.10.08 – Radiological Postings at LANL; Posting/Barriers; Entry Requirements

External Radiation Posting Areas: d. Very High Radiation Area

- Individuals must be prevented from unauthorized or inadvertent entry to VHRAs. Normally, access to VHRAs must not be allowed. Only under the most stringent control or emergency conditions will access be allowed to an area where these radiation levels may be present.

2.10.08 – Radiological Postings at LANL; Posting/Barriers; Entry Requirements

External Radiation Posting Areas: c. High Radiation Area; d. Very High Radiation Area

- Entry to an area where an HRA or VHRA existed, with the assumption that the HRA or VHRA no longer exists, requires positive verification that the HRA or VHRA no longer exists. This verification requires real-time radiation monitoring to verify that the source of the HRA or VHRA is appropriately deenergized or shielded.

2.10.08 – Radiological Postings at LANL; Posting/Barriers; Entry Requirements

External Radiation Posting Areas: c. High Radiation Area; d. Very High Radiation Area *(continued)*

- Other controls may be used in lieu of real-time radiation monitoring for entering an area that was an HRA, provided that they are
  - Designed and tested to be robust;
  - Approved by an RP SME; and
  - Formally documented in association with the activity or work area (e.g., RWP, FRPR, or operating procedure).

2.10.08 – Radiological Postings at LANL; Posting/Barriers; Entry Requirements

e. Hot Spots (Labeling)

- Hot spots are localized sources of radiation having contact radiation levels greater than a 100-millirem-per-hour penetrating radiation dose and more than five times greater than the general area dose rate.
- Hot spots may be labeled; however, larger areas may be posted as radiological areas when practical.
- A label reading "Caution, Hot Spot" and marking the location of the hot spot should be placed on or as near the spot as practicable.
- Labeling hot spots is not required in areas with general area dose rates greater than 1 rem/h.

2.10.08 – Radiological Postings at LANL; Posting/Barriers; Entry Requirements

Posting Areas for Contamination: f. Contamination Area; g. High Contamination Area; h. High Contamination Area

Table 8 Criteria for posting contamination hazards

Area	Criteria	Required Posting	Minimum Entry Requirements	Minimum Exit Requirements
Contamination area (CA)	Removable contamination levels greater than, or likely to exceed, table 14-2 values but do not exceed 100 × the values of table 14-2 of P121	Caution Contamination Area	• Radiological worker, facility specific training • FRPR or RWP • Level I Clothing	Whole body frisk
High contamination area (HCA)	Removable contamination levels greater than, or likely to exceed, 100 × the values of table 14-2 in P121	Danger High Contamination Area	• Radiological worker, facility specific training • RWP • Level II Clothing	Whole body frisk
Airborne radioactivity area (ARA)	Airborne concentrations above background that are greater than, or likely to exceed, the DAC values or that would result in an individual (without respirator) being exposed to greater than 12 DAC-h in a week	Caution Airborne Radioactivity Area	• Radiological worker, facility specific training • RWP • Level I or II Clothing, hood, any required respiratory protection equipment	Whole body frisk

2.10.08 – Radiological Postings at LANL; Posting/Barriers; Entry Requirements

P121, Radiation Protection, Table 14-2 for Posting Criteria:
i. Fixed Surface Contamination

Table 14-2. Surface Contamination Values[1]		
Radionuclide	Removable[2,4] (dpm/100 cm^2)	Total (Fixed + Removable)[2,3] (dpm/100 cm^2)
U-natural, U-235, U-238, and associated decay products[9]	1,000[7]	5,000[7]
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	20	100[10]
Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	200	1,000
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above. Includes mixed fission products containing Sr-90.[5,8]	1,000 beta-gamma	5,000 beta-gamma
Tritium and special tritium compounds (STCs)[6]	10,000	See Footnote 6

2.10.08 – Radiological Postings at LANL; Posting/Barriers; Entry Requirements

i. Fixed Surface Contamination (Labeling)

- Areas outside radiological areas that have total contamination exceeding the total surface contamination values but removable contamination levels below those values specified in Table 14-2 are subject to the following:
  - RP SMEs ensure the appropriate control of fixed contamination, including decontamination; application of fixative coatings, painting, surveying; and management of these areas;
  - Areas must be labeled or posted to warn individuals of their fixed contamination status. This action may be accomplished by individually labeling spots of fixed contamination or posting larger areas if labeling individual spots is not practical.

2.10.08 – Radiological Postings at LANL; Posting/Barriers; Entry Requirements

j. Soil Contamination

- Areas with soil contamination that have a reasonable potential to cause more than 15 mrem/year off-site or more than 30 mrem/year on-site must be posted as SCAs.
- SCAs are not normally controlled for occupational hazard and are managed and posted by the Environmental Protection Division (ENV). Nevertheless, when work is conducted in these areas, the potential for personnel exposure exists, and occupational hazards are managed in accordance with P121.

2.10.08 – Radiological Postings at LANL; Posting/Barriers; Entry Requirements

k. Radioactive Material Area (RMA)

- RMAs shall be posted “Caution, Radioactive Material” and require GERT or facility-specific training for entry.
- Accessible areas where radioactive materials are used, handled, or stored must be identified with RMA posting except when:
  - The amount of radioactive material does not exceed the values of appendix 16A in P121.
  - The area is posted as a radiological area.
  - Each item or container of radioactive material in the area is labeled in accordance with P121.
  - The material of concern consists solely of components/structures that have been activated.

2.10.08 – Radiological Postings at LANL; Posting/Barriers; Entry Requirements

I. Underground Radioactive Material Area (RMA)

LANL does not have any underground RMAs.

2.10.08 – Radiological Postings at LANL; Posting/Barriers; Entry Requirements

Access Control

- 10 CFR 835 requires the following:
- §835.501 Radiological Areas
  - Personnel entry control shall be maintained for each radiological area.
  - The degree of control shall be commensurate with existing and potential radiological hazards within the area.
  - One or more of the following methods shall be used to ensure control:
    - Signs and barricades;
    - Control devices on entrances;

2.10.08 – Radiological Postings at LANL; Posting/Barriers; Entry Requirements

Access Control *(continued)*

- Conspicuous visual and/or audible alarms;
- Locked entrance ways; or
- Administrative controls.

– Written authorizations shall be required to control entry into and perform work within radiological areas. These authorizations shall specify radiation protection measures commensurate with the existing and potential hazards.

– No control(s) shall be installed at any radiological area exit that would prevent rapid evacuation of personnel under emergency conditions.

2.10.08 – Radiological Postings at LANL; Posting/Barriers; Entry Requirements

Access Control *(continued)*

- § 835.502 High and very high radiation areas.
  - The following measures shall be implemented for each entry into a high radiation area:
    - The area shall be monitored as necessary during access to determine the exposure rates to which the individuals are exposed;
    - Each individual shall be monitored by a supplemental dosimetry device or other means capable of providing an immediate estimate of the individual's integrated deep dose equivalent during the entry.

2.10.08 – Radiological Postings at LANL; Posting/Barriers; Entry Requirements

Access Control *(continued)*

- Physical controls. One or more of the following controls shall be used for each entrance or access point to a high radiation area where radiation levels exist such that an individual could exceed a deep dose equivalent to the whole body of 1 rem (0.01 Sievert) in any one hour at 30 centimeters from the source or from any surface that the radiation penetrates:

2.10.08 – Radiological Postings at LANL; Posting/Barriers; Entry Requirements

Access Control *(continued)*

- A control device that prevents entry to the area when high radiation levels exist or that, upon entry, causes the radiation level to be reduced below the level that defines an HRA;
- A device that functions automatically to prevent the use or operation of the radiation source or field while individuals are in the area;
- A control device that energizes a conspicuous visible or audible alarm signal so that the individual entering the HRA and the supervisor of the activity are made aware of the entry;

2.10.08 – Radiological Postings at LANL; Posting/Barriers; Entry Requirements

Access Control *(continued)*

- Entryways that are locked. During periods when access to the area is required, positive control over each entry is maintained;
- Continuous direct or electronic surveillance that is capable of preventing unauthorized entry;
- A control device that will automatically generate audible and visual alarm signals to alert personnel in the area before use or operation of the radiation source and in sufficient time to permit evacuation of the area or activation of a secondary control device that will prevent use or operation of the source.

2.10.08 – Radiological Postings at LANL; Posting/Barriers; Entry Requirements

Access Control *(continued)*

- VHRAs. In addition to the above requirements, additional measures shall be implemented to ensure that individuals are not able to gain unauthorized or inadvertent access to VHRAs.
- No control(s) shall be established in an HRA or VHRA that would prevent the rapid evacuation of personnel.

2.10.08 – Radiological Postings at LANL; Posting/Barriers; Entry Requirements

Access Control *(continued)* – P121, *Radiation Protection,* Access Control Requirements for Posted Areas

Table 9-3. Area Designation and Minimum Required Control Levels	
Area Designation	**Control Level**
Any Radiological Controlled Area (RCA)	1
Any Radiological Buffer Area (RBA)	1
Radioactive Material Area (RMA), Soil Contamination Area (SCA)	1
Radiation Area (RA) and High Radiation Area (HRA) that is less than or equal to 1 rem in 1 hr at 30 cm	1
HRA that is greater than 1 rem in 1 hr at 30 cm	2
Very High Radiation Area (VHRA)	3
Contamination Area (CA)	1
High Contamination Area (HCA)	1
Airborne Radioactivity Area (ARA)	1

2.10.08 – Radiological Postings at LANL; Posting/Barriers; Entry Requirements

Access Control *(continued)* – P121, *Radiation Protection,* Access Control Requirements for Posted Areas

Table 9-4. Required Controls for Areas Posted for Radiological Hazards	
Level	**Criteria**
Level 1	Administrative controls (see Chapter 11, *Radiological Work Control*) and/or signs and barricades, or any Level 2 control.
Level 2	One or more of the following must be used at access points to control entry or occupancy: • A control device that prevents entry to the area when radiological hazards that define the area are present or that, upon entry, causes the radiation hazard to be reduced below that defining level (e.g., reduces radiation below 100 mrem/hr for a High Radiation Area [HRA]). • A device that functions automatically to prevent the creation of a radiological hazard while personnel are in the area. • A control device that energizes a conspicuous visible or audible alarm signal so that the individual entering the area and the supervisor of the activity are made aware of the entry. • Entryways that are locked. During periods when access to the area is required, positive control over each entry must be maintained. • Continuous direct or electronic surveillance that is capable of preventing unauthorized entry. • A control device that will automatically generate audible and visual alarm signals to alert personnel in the area before use or operation of the radiation source and in enough time to permit evacuation of the area or activation of a secondary control device that will prevent use or operation of the source.
Level 3	In addition to a Level 2 control, at least one other measure must be implemented to ensure that individuals are not able to gain inadvertent or unauthorized access. This requires a control that meets the following criteria: • an additional Level 2 control that is separate (may be redundant) and • sufficiently robust to prevent inadvertent or unauthorized access

2.10.09 –Setting Up Radiological Areas

Good Practices

- Establish walkways in low dose areas.
- Do not store radioactive materials near walkways or where personnel frequently work.
- Place rope boundaries as close to the source of contamination as possible to minimize the size of the contaminated area.
- Ensure that the area is not so limited that contamination is easily spread across the boundaries.
- Use drip trays or containment devices to prevent the spread of contamination.

2.10.09 –Setting Up Radiological Areas

Good Practices *(continued)*

- Establish laydown areas for equipment to limit personnel safety hazards and/or radiation exposure.
- Set up SOPs upwind of contamination hazards.
- Post all accessible sides and entrance(s) to areas containing radiological hazards.
- Use personnel contamination monitors (PCMs), along with portable contamination survey instrumentation. PCMs are more likely to detect contamination on individuals because personnel tend to survey too quickly.

2.10.09 –Setting Up Radiological Areas

Discrepancies to Avoid

- Posting information not updated or information otherwise incorrect.
- Boundaries not verified for contamination, radiation, and airborne radioactivity hazards.
- Survey instruments out of calibration or defective.
- SOPs not set up for the efficient removal of protective clothing (not enough room to prevent contaminating the SOPs) and not near survey instrumentation.
- Laundry and waste receptacles not placed for efficient use or not placed at all.

2.10.09 –Setting Up Radiological Areas

Discrepancies to Avoid *(continued)*

- Receptacles not properly labeled as to their contents.
- Boundaries of areas setup too far from the hazards interfering with access to areas otherwise unaffected.
- Count rate meters not located close to the SOPs.
- Status boards or survey maps do not reflect where SOPs and boundaries lie.
- Status board not kept up to date. The information on status boards, postings, and RWPs should agree.
- Tripping hazards exist from wires, hoses, or cables.

2.10.09 –Setting Up Radiological Areas

Discrepancies to Avoid (continued)

- Background radiation in the monitoring area is too high for the efficient detection of low-level contamination.
- Portable contamination survey instrumentation is not set up for proper operation.
- Protective clothing (gloves and booties) is not readily available in a personnel contamination event.
- Phones or other communication devices are not available near the SOP or portable contamination survey instrumentation.
- Not posting all access points into the area.
- Failure to post dress and undress procedures.

2.10.09 –Setting Up Radiological Areas

Support Equipment

- SOPs.
- Portable contamination survey instrumentation.
- Yellow and magenta rope, ribbon, or tape.
- Laundry receptacles.
- Waste receptacles (clean and radioactive waste receptacles).
- Postings, signs, labels, and posting inserts.
- Communication equipment that is readily available.
- Additional protective clothing.
- Dose rate meters and smears.

2.10.10 – Containment Devices

Containment devices include glove boxes, glove ports, hot cells, huts, and windbreaks. Discrepancies include

- Holes/leaks in the containments, or the containment is maintained at a positive pressure, facilitating the spread of contamination.
- Liquids accumulate in hoses or main portions of the containment.
- Airlocks are too small to remove protective clothing without spreading contamination.
- Ventilation exhaust is not directed to the plant's ventilation system.

2.10.10 – Containment Devices

Discrepancies *(continued)*

- Material is allowed to accumulate inside containments, limiting safe and/or efficient use.
- Sharp objects are used inside containments.
- Devices are not tethered to prevent introduction into systems.
- Transfer sleeves/ports are not used or are unavailable.
- Containment is not provided with a HEPA filter or ventilation exhaust.
- Containments are not periodically surveyed inside and out.
- No means of quickly verifying loss of ventilation exists.

2.10.10 – Containment Devices

Discrepancies *(continued)*

- Containment is not decontaminated before being dismantled.
- Adequate access is not provided for lines or hoses.
- Containment is not maintained at a negative pressure.
- Containment is not supported properly to minimize stress from minor ventilation
- Changes are not structurally supported to maintain its configuration during use.
- Containments are not inspected before use and periodically during use.

2.10.10 – Containment Devices

Discrepancies *(continued)*

- Appropriate containment devices are not used for leaks.
- A funnel is not used to collect leakage.
- Plastic components show fatigue or wear.
- A funnel is not positioned to collect all leaking fluid.
- Drain lines are kinked, allowing the buildup of liquids.
- Drain lines are not secured properly to the collection device.
- The containment device is not labeled to indicate hazards that are present.

2.10.11 – Portable Ventilation Systems and Count Rate Meters

Good Practices – Portable Ventilation Systems

- Use only HEPA filters with pre-filters (roughing filters)
- Perform radiation survey on filters periodically while in use.
- Have radiological limits established for filter replacement.
- Exhaust filter discharge to the plant ventilation system whenever possible.
- Ensure that there are no openings in the trunk or between the blower and the filter.

2.10.11 – Portable Ventilation Systems and Count Rate Meters

Good Practices – Portable Ventilation Systems *(continued)*

- Monitor the filter differential pressure (d/p) periodically.
- Establish the filter d/p at which the filter must be replaced.
- Remove filters, and place them into plastic bags to prevent the release of activity.
- Position streamers to signify the flow of ventilation through doorways or through containment devices.

2.10.11 – Portable Ventilation Systems and Count Rate Meters

Good Practices – Portable Survey Instrumentation and PCMs

- Place them in low background area.
- Equip them with a reliable power supply.
- Position them to facilitate easy access by workers.
- Set alarms to site administrative control levels or DOE limits.
- Ensure that the instrument is source checked and calibrated.
- Check extension cords for electrical safety.

2.10.11 – Portable Ventilation Systems and Count Rate Meters

Good Practices – Portable Survey Instrumentation and PCMs *(continued)*

- Place portable contamination survey instrumentation and PCMs upwind of contaminated areas.
- Do not place the instrumentation near radioactive material storage areas or other areas where the background radiation can change.
- Provide portable contamination survey instrumentation with sources to source check the instrument.

2.10.12 – Requirements for Working in RBAs

Workers who receive radiation exposures from other nuclear facilities must report the exposure to site radiological control personnel and their supervisor upon returning to the site.

Avoid contact with potentially contaminated surfaces.

Any management/supervision or site radiological control personnel should give stop work or evacuation orders if unanticipated radiation or contamination is encountered or if the appropriate RWP is not being followed.

Wear dosimetry in accordance with the postings and the RWP.

Maintain exposure ALARA.

2.10.12 – Requirements for Working in RBAs

Report all injuries.

Monitor clothing and exposed skin as required and report the presence of radioactive contamination.

Place contaminated items and waste in approved radioactive waste containers.

Wash your hands when leaving the RBA and before eating food or using tobacco products.

Do not enter areas posted as “Respiratory Protection Required” if you are not respiratory qualified.

2.10.12 – Requirements for Working in RBAs

Hot Particles

- Hot particles are small, discrete, highly radioactive particles capable of causing extremely high doses to a localized area in a short period of time. Hot-particle contamination may be present or generated when contaminated systems are opened or when operations such as machining, cutting or grinding are performed on highly radioactive materials.
- Hot particles are further defined in P121 as having an activity of nominally 15,000 dpm or greater (α or β/γ) and/or being capable of producing an equivalent dose to the skin greater than 100 mrem in 1 h.

2.10.12 – Requirements for Working in RBAs

Hot Particles *(continued)*

- Special surveys must be performed in areas with the potential for hot-particle contamination.
- Areas must be posted to specifically identify the presence of hot particles.
- Access to hot-particle areas should be controlled through a job-specific RWP. The following controls should be considered for inclusion in the RWP:
  - Periodically monitor personnel during the work activity at a frequency based on the potential magnitude of skin exposure
  - Provide additional personal protective equipment and clothing

2.10.12 – Requirements for Working in RBAs

Hot Particles *(continued)*

- Provide direct radiological control coverage during work or assistance during protective clothing removal
- Use sticky pads or multiple SOPs.
- Segregate personal protective equipment and clothing used in hot-particle areas from other radiological protective equipment and clothing during laundering, and survey them before reuse.

2.10.12 – Requirements for Working in RBAs

Hot Particles *(continued)*

- The response to hot-particle skin contamination should include the following:
  - Immediate removal and retention of the hot particle for subsequent analysis
  - Analysis of the particle
  - Assessment of worker dose
  - Evaluation of work control adequacy

2.10.13 – Removing or Releasing Material from Radiological Areas

Removing Material

- Facility operations require that radioactive and nonradioactive material be removed from radiological areas, RBAs, and the site. Before this material is allowed to leave, important steps outlined in the procedures must be followed. 10 CFR 835, §835.1101 requires the following:
  - Except as provided below, material and equipment in CAs, HCAs, and ARA shall not be released to a controlled area if
    - Removable contamination levels on accessible surfaces exceed the removable surface contamination values specified in Appendix D of 10 CFR 835; or

2.10.13 – Removing or Releasing Materials from Radiological Areas

Removing Material *(continued)*

- Prior use suggests that the removable contamination levels on inaccessible surfaces are likely to exceed the removable surface contamination values specified in Appendix D of 10 CFR 835.

– Material and equipment exceeding the removable surface contamination levels specified in Appendix D of 10 CFR 835 may be conditionally released for movement onsite from one radiological area for immediate placement to another radiological area only if appropriate monitoring is performed and appropriate controls for the movement are established and exercised.

2.10.13 – Removing or Releasing Materials from Radiological Areas

Removing Material *(continued)*

- Material and equipment with fixed contamination levels that exceed the limits specified in Appendix D of 10 CFR 835 may be released for use in CAs outside radiological areas only under the following conditions:
  - Removable surface contamination levels are below the removable surface contamination values specified in Appendix D of 10 CFR 835; and
  - The material or equipment is routinely monitored and clearly marked or labeled to alert personnel to the contaminated status.

2.10.13 – Removing or Releasing Materials from Radiological Areas

Releasing Material

- RP-1-DP-23.04, *Release of Items from Radiological Control and Tagging Items with Radioactive Materials*, describes the process of determining survey requirements and documenting the release of items from radiological control.
- The release of items may be authorized after release criteria are met based on a combination of process knowledge and careful monitoring of the items.

2.10.13 – Removing or Releasing Materials from Radiological Areas

Releasing Material *(continued)* – RP-1-DP-12.04
Exclusions do not apply to the

- unrestricted release for reuse or recycling of volumetrically contaminated or activated metals as addressed in DOE's January 12, 2000 Moratorium.
- unrestricted release for recycling of metals from radiological areas as addressed in DOE's July 13, 2000 Suspension.
- unrestricted release of other volume-contaminated or activated items, such as bulk materials, construction debris, or soil.

2.10.13 – Removing or Releasing Materials from Radiological Areas

Releasing Material *(continued)*

- Items leaving RCAs for contamination, DU shrapnel, or volume contamination must be surveyed by an RCT for release.
- RCTs must release items only after a survey indicates < minimum detectable activity (MDA). Items with > MDA require additional approval.

2.10.13 – Removing or Releasing Materials from Radiological Areas

Releasing Material *(continued)*

- Hand-carried personal items (e.g., notebooks, pagers, and flashlights) do not require a survey if the items have not come into contact with any potentially contaminated surfaces; have not entered a CA, HCA or ARA; have not left direct possession of individual; and have no contamination detected on the individual when surveyed upon exiting.

2.10.13 – Removing or Releasing Materials from Radiological Areas

RCA for Legacy Contamination

- This posting is used to designate areas that have not been released from radiological controls due to past radiological activities and the potential for legacy contamination. Workers need to be conscientious and exercise judgment when working in these areas.
- Health physics/radiation protection approval is required before working on or breaching facility systems, facility surfaces, and programmatic equipment. RCT surveys may be required.

2.10.13 – Removing or Releasing Materials from Radiological Areas

RCA for Legacy Contamination *(continued)*

- The type of work that will require RP evaluation in legacy areas include
  - Penetrating walls/floors
  - Opening ventilation systems
  - Removing installed equipment
  - Opening machines for routine maintenance
  - Opening utility and access panels
  - Moving equipment with potential historical contamination
- Routine operations on programmatic equipment do not require health physics/radiation protection approval beyond that specified in standard work documents.

2.10.13 – Removing or Releasing Materials from Radiological Areas

RCA for Legacy Contamination *(continued)*

- Most items coming out of areas controlled for legacy contamination do not require an RCT survey.
- The individual requesting the item release must determine whether the item is affected by legacy contamination (e.g., installed equipment, facility system components, historical equipment or materials subject to past radiological use, and known radiological use).
- If the item is affected by legacy contamination, the item must be evaluated and surveyed by an RCT for release.