

**RADIOLOGICAL CONTROL MANUAL**

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**CHAPTER 5, RADIOLOGICAL HEALTH SUPPORT OPERATIONS****Part 1, External Dosimetry****Article 511, General Provisions**

1. Personnel dosimetry shall be provided to and used by individuals as follows:
  - a. Radiological workers who are expected to receive from external sources an effective dose equivalent of 100 mrem or more in a year or a ~~shallow~~ dose equivalent to the extremities, lens of the eye, or skin of 10% or more of the corresponding limits specified in Table 2-1 [see 10 CFR 835.402(a)(1)].
  - b. Declared pregnant workers who are expected to receive from external sources a dose equivalent of 50 mrem or more to the embryo/fetus during the gestational period [see 10 CFR 835.402(a)(2)].
  - c. Occupationally exposed minors likely to receive an ~~exposure from external sources~~ dose in excess of 50 mrem in a year from external sources [see 10 CFR 835.402(a)(3)].
  - d. Members of the public ~~who enter the~~ entering a controlled area ~~and are~~ likely to receive an ~~annual external deep dose equivalent of~~ dose in excess of 50 mrem ~~or more~~ in a year from external sources [see 10 CFR 835.402(a)(4)].
  - e. Individuals entering a high or very high radiation area [see 10 CFR 835.402(a)(5)].
2. Neutron dosimetry shall be provided when an individual is likely to exceed any of the criteria provided in Article 511.1 from neutrons [see 10 CFR 835.401(b)(2) and 10 CFR 835.402(a)].
3. Dosimeters should be issued only to individuals knowledgeable of their proper use and worn only by those to whom the dosimeters were issued. ~~If dosimeters are issued at multiple facilities, only one should be worn at a time.~~
4. To minimize the number of individuals in the dosimetry program, issuing dosimeters is discouraged except to individuals entering areas where the likelihood of external exposure exceeds the monitoring thresholds established in Article 511.1.
5. Individuals should return dosimeters for processing as scheduled or upon request, ~~and should be restricted by line management from continued radiological work until dosimeters are returned.~~
6. Individuals should wear their ~~primary dosimeters~~ (TLD (unless otherwise stated, TLD is the primary dosimeter)s) on the chest area, on or between the waist and the neck, or in the manner prescribed by radiological control procedures or work authorizations.
7. The practice of taking TLDs off-Site is discouraged, except to storage areas established at town facilities.

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8. Individuals should not wear dosimeters issued by their resident facilities while being monitored by a dosimeter at another facility unless authorized by the Radiological Control director or designee.

Note: Transportation Safeguard Division couriers who have been provided with primary dosimeters from Sandia National Laboratories (SNL) should not be issued Site primary dosimeters (TLDs). However, facilities may issue supplemental direct-reading dosimeters to the SNL couriers, and may elect to maintain records of the dose indicated by the supplemental direct-reading dosimeters (DRDs) or electronic dosimeters (ED). Transportation Safeguard Division dosimeters are processed quarterly by SNL. Therefore, the records should not be retained more than one quarter beyond the date when SNL processes the Transportation Safeguard Division dosimeters. The supplemental DRD and ED records ~~and~~ provide objective evidence of dose received at the Site. The information would support SNL in performing a dose investigation for the couriers if an anomalous primary dosimeter reading were obtained.

9. Individuals should not expose their dosimeters to security x-ray devices, excessive heat, or medical sources of radiation.

Note: If such exposure inadvertently occurs, individuals should report the event to the appropriate facility ~~Radiation~~Radiological Control personnel.

10. An individual whose dosimeter is lost, damaged, or contaminated should place work in a safe condition, immediately exit the area, and report the occurrence to the Radiological Control organization. The individual should be restricted from entry into radiological areas until a review has been conducted and management has approved reentry. A dose assessment should be performed for each instance of a lost, damaged, or contaminated personnel dosimeter.

### Article 512, Technical Provisions for External Dosimetry

1. External dosimetry programs shall be adequate to demonstrate compliance with Table 2-1 limits [see 10 CFR 835.402(b)]. The requirements for accreditation of personnel external dosimetry monitoring programs by the DOE Laboratory Accreditation Program (DOELAP) are specified in DOE-STD-1095-95, "Department of Energy Laboratory Accreditation Program for Personnel Dosimetry Systems." Technical basis documents on the personal photon-beta dosimeter and the neutron dosimeter have been developed for the external dosimetry program (~~Andersen 2001; Gesell et al. 1996~~). Personnel external dosimeters include, but are not limited to, TLDs, track-etch dosimeters, film badges, and neutron-sensitive film. External dosimetry programs implemented to meet the requirements of Article 511.1 shall meet at least one of the following criteria:
- Accredited by DOELAP [see 10 CFR 835.402(b)(1)].  
~~Or~~
  - Excepted from accreditation by the DOELAP [see 10 CFR 835.402(b)(1)].  
Or

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- c. Otherwise approved by the DOE Assistant Secretary for Environment, Safety and Health [see 10 CFR 835.402(b)(2)].
2. ~~A~~The technical basis document ~~will~~ address dosimeters used for monitoring radiation outside the scope of DOELAP, such as dosimetry associated with high-energy accelerators and extremity dosimeters.
3. The Site contractor should participate in intercomparison studies for external dosimetry programs.
4. Multiple dosimeters should be issued to individuals to assess the deep-dose equivalent in nonuniform radiation fields. Nonuniform radiation fields exist when the dose to a portion of the whole body will exceed the dose to the ~~primary dosimeter (TLD)~~ by more than 50% and the anticipated whole-body dose is greater than 100 mrem. Standard HPS N 13.41-1997, "Criteria for Performing Multiple Dosimetry," describes the methodology used to determine the dose of record when multiple dosimeters are used and when ~~primary dosimeters (TLDs)~~ are relocated on workers.
  - a. When the radiation field is well characterized and the worker's orientation is known, relocation of the TLD is permitted in lieu of issuing multiple dosimeters. Under such conditions, the individual's TLD will be relocated to the portion of the whole body likely to receive the highest dose. Radiological Control personnel should determine the location of the TLD.
  - b. Dosimeter relocation will be conducted to conform ~~with~~to facility procedures or specific work authorizations such as RWPs.
5. A dose assessment should be performed for each instance of a lost, damaged, or contaminated personnel dosimeter.
6. Permanent monitoring programs implemented at the discretion of the Site contractor (i.e., for personnel monitoring that is not required by Article 511.1) need not be accredited under the DOELAP. Programs implemented outside the scope of DOELAP should include:
  - a. Documented assessment of each individual's potential occupational dose to support the decision to operate outside the DOELAP. Such assessments should be based on facility design reviews, the results of a comprehensive workplace-monitoring program, and if available, the result of previous individual monitoring results.
  - b. Comprehensive routine surveys of areas that may be entered by these individuals to ensure that individual doses are not likely to exceed Article 511.1 monitoring thresholds.

**Article 513, Pocket and Electronic Dosimeters**

Pocket and electronic dosimeters are supplemental dosimeters that provide real-time indication of exposure to radiation and assist in maintaining personnel doses lower than administrative control levels.

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1. Each individual entering a high radiation or very high radiation area ~~at any facility/project~~ 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. ~~alarmed electronic dosimeter (see Article 334 for entry requirements)~~ [see 10 CFR 835.502(a)(2)]. At any facility/project a supplemental, alarming, electronic dosimeter should be used by individuals entering into a high radiation, - locked high radiation area, or very high radiation area -(see Article 334 for entry requirements). Supplemental ED also will be issued when planned activities could cause an individual to exceed 50 mrem or 10% of a facility administrative control level from external gamma radiation in 1 work day, whichever is greater, or when required by an RWP. While not an issue with electronic dosimeters because of their large measurement range, pocket dosimeters, which are used only in special cases, will be selected with the lowest range applicable (typically 0 to 200 mR) for anticipated personnel exposures.
2. Supplemental dosimeters, in general a DRD or an ED, should be worn adjacent to the TLD and located in accordance with Article 511.6.
3. Supplemental dosimeters should be read periodically while in use. Work should be stopped if a DRD exceeds 75% of full scale.
4. Individual exposures above 100 mrem for a job will be specifically authorized by appropriate ALARA review and RWP. Work authorized by written authorization will be stopped when supplemental electronic dosimeter readings indicate that the total dose is greater than 100 mrem. If specified exposure limits are reached or exceeded, work will be stopped and The Radiological Control management organization will be consulted prior to the continuation of continuing the work.
5. The energy dependence and radiation sensitivity of supplemental dosimeters, particularly to low-energy beta and neutron radiation, will be considered in determining their applicability and need for correction factors.
6. When the dose totals from the DRD or ED differs from the TLD by more than 50% ~~and when~~ the TLD dose is greater than 100 mrem, an investigation will be initiated to explain the difference.

**Article 514, Area Monitoring Dosimeters**

Establishment and maintenance of a comprehensive area-monitoring program can minimize the number of areas requiring personnel dosimeters and would demonstrate that doses outside radiological areas are negligible. Minimizing the number of personnel dosimeters issued reduces dosimetry program operational costs and costs associated with maintaining personnel with enhanced training and qualifications.

1. Area monitoring dosimeters should be used to record and document radiation levels in routinely occupied areas adjacent to areas where radiation exists ~~or and radiological~~ operations ~~with radiation~~ are conducted. This monitoring provision does not apply when the radiation arises solely from low-energy beta sources (e.g., C-14 or tritium).

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2. Area monitoring dosimeter results should be used to support dosimetry investigations where individuals express concerns about their work environments and exposure to ionizing radiation.
3. Area monitoring dosimeters should be used in controlled areas to supplement existing monitoring programs and to provide data in the event of an emergency.

**Article 515, Nuclear Accident Dosimeters**

1. Facilities that possess fissile material in sufficient quantities to potentially constitute a critical mass that could result in ~~an~~ excessive exposure of ~~an~~ individuals ~~in~~ to radiation from a nuclear accident shall provide nuclear accident dosimetry to all affected individuals [see 10 CFR 835.1304(a)].
2. The nuclear accident dosimetry system shall include the following:
  - a. A method to conduct initial screening of potentially exposed individuals to identify those who have received significant doses [see 10 CFR 835.1304(b)(1)].
  - b. Equipment and methods sufficient to analyze appropriate biological samples [see 10 CFR 835.1304(b)(2)].
  - c. A system of fixed nuclear accident dosimeter units [see 10 CFR 835.1304(b)(3)] capable of measuring the estimated neutron dose and approximate neutron spectrum.
  - d. Personnel nuclear accident dosimeters [see 10 CFR 835.1304(b)(4)].
3. The fixed dosimeters discussed above should be capable of the following:
  - a. Determining the neutron dose from 10 rads to approximately 10,000 rads with an accuracy of  $\pm 25\%$ .
  - b. Measuring fission gamma radiation from 10 rads to approximately 10,000 rads in the presence of neutron radiation with an accuracy of approximately  $\pm 25\%$ .
4. Personnel nuclear accident dosimeters should be capable of measuring an absorbed dose in or on a phantom from 10 rads to approximately 1,000 rads with an accuracy of  $\pm 25\%$ . ~~A phantom is a device, generally made of synthetic material to simulate human tissue, organs, or bone structure, that is used to calibrate radiation detection equipment. Types include a realistic torso phantom and lung, thyroid, or liver calibration phantoms.~~
5. An analysis of the fixed dosimetry system needs should be documented and should consider such factors as the nature of operations, the structural design of the facility, area accessibility, the number of dosimeters and their location, and the effect of intervening shielding. The analysis should be reevaluated as necessary to ensure that facility modifications do not impair the capabilities of the fixed dosimetry system.

**Part 2, Internal Dosimetry****Article 521, General Provisions**

1. The following individuals shall participate in an internal dosimetry program:

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- a. Radiological workers who are likely to receive a CEDE of 100 mrem or more from all radionuclide intakes in ~~1~~+a year [see 10 CFR 835.402(c)(1)].
  - b. Declared pregnant workers likely to receive intakes resulting in a dose equivalent to the embryo/fetus of 50 mrem or more during the gestational period [see 10 CFR 835.402(c)(2)].
  - c. Occupationally exposed minors likely to receive a CEDE in excess of 50 mrem from all radionuclide intakes in ~~1~~+a year [see 10 CFR 835.402(c)(3)].
  - d. Members of the public who enter a controlled area and are likely to receive an intake resulting in a CEDE exceeding 50 mrem in ~~1~~+a year [see 10 CFR 835.402(c)(4)].
2. The estimation of internal dose shall be based on bioassay data rather than air concentration values unless one of the following conditions exists [see 10 CFR 835.209(b)]:
    - a. Bioassay data are unavailable.
    - b. Bioassay data are inadequate.
    - c. Internal dose estimates based on representative air concentration values are demonstrated to be as or more accurate.
  3. Individuals should participate in follow-up bioassay monitoring when their routine bioassay results indicate an intake in the current year with a CEDE of 100 mrem or more.
  4. Individuals whose routine duties may involve exposure to surface or airborne contamination or to radionuclides readily absorbed through the skin, such as tritium, should be considered for participation in the bioassay program.
  5. The bioassay program should establish appropriate frequencies for the collection of bioassay samples such as urine or fecal samples and participation in bioassay monitoring such as whole body or lung counting. Individuals should participate at the frequency required by the bioassay program.
  6. Individuals should be notified promptly of positive bioassay results and the results of dose assessments and subsequent refinements. Dose assessment results shall be provided in terms of ~~roentgen equivalent man (rem)~~ or millirem [see 10 CFR 835.2(b), dose term definitions, and 10 CFR 835.4].

**Article 522, Technical Provisions for Internal Dosimetry**

1. All bioassay programs implemented to demonstrate compliance with Article 521.1 shall meet at least one of the following criteria:
  - a. Accredited by DOELAP in accordance with the provisions in DOE-STD-1112-98, "The Department of Energy Laboratory Accreditation Program for Radiobioassay" [see 10 CFR 835.402(d)(1)].

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- b. Excepted from accreditation by DOELAP [see 10 CFR 835.402(d)(1)].  
~~Or~~
- c. Otherwise approved by the Assistant Secretary for Environment, Safety and Health [see 10 CFR 835.402(d)(2)].  
~~Or~~  
~~d. The Site contractor demonstrates compliance with the requirements for bioassay program accreditation.~~
2. ~~The INEEL M&O Contractor Technical Basis for Internal Dosimetry (Reilly 2001), a~~ Site wide technical basis document ~~shall be, has been~~ developed for the internal dosimetry program.
3. Baseline bioassay monitoring of individuals who are likely to receive intakes resulting in a CEDE greater than 100 mrem in 1 year should be conducted before they begin work that may expose them to internal radiation exposure.
4. Routine bioassay monitoring methods and frequencies should be established for individuals who are likely to receive intakes resulting in a CEDE greater than 100 mrem in ~~1~~ year. ~~Facility-specific engineering design files compose t~~The technical basis for the methods and frequency of bioassay monitoring ~~should be documented (e.g., Horton 2003).~~
5. Management will determine whether a termination bioassay monitoring is required when a radiological worker terminates employment or concludes work involving the potential for internal exposure. The number of people failing to achieve this monitoring should be reviewed periodically and used to determine whether further efforts to get cooperation are warranted.
6. Bioassay monitoring should be performed when any of the following occurs:
  - a. Facial or nasal contamination is detected that indicates a potential for internal contamination exceeding any monitoring threshold established in Article 521.
  - b. Airborne monitoring indicates the potential for ~~an individual radioactivity intakes resulting in a dose that exceeds~~ intakes 100 mrem CEDE.
  - c. Upon direction of the Radiological Control organization when an intake is suspected.
7. Levels of intake that warrant the consideration of medical intervention are established for Site-specific radionuclides. The effectiveness of medical intervention, such as blocking or chelating agents, should be documented using bioassay results.
8. A preliminary assessment of any intakes detected should be conducted prior to permitting an employee to return to radiological work.
9. Internal dosimetry program personnel should use radionuclide standards from or traceable to the National Institute of Standards and Technology.

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10. Internal dosimetry program personnel should participate in the conduct of intercomparison studies and will use the “DOE Phantom Library.” ~~The library lends in vivo calibration phantoms to DOE and other in vivo laboratories and is operated by Pacific Northwest National Laboratory in Richland, Washington, for the DOE Office of Worker Protection Programs and Management.~~
11. Bioassay programs implemented at the discretion of the Site contractor—that is, personnel monitoring not required by Article 521.1—need not be accredited under DOELAP. Programs implemented outside the scope of DOELAP should include:
  - a. Documented assessment of each individual’s potential occupational exposure to support the decision to operate outside the DOELAP.
  - b. Comprehensive monitoring of the areas that may be entered by these individuals to ensure that individual doses are not likely to exceed the Article 521.1 monitoring thresholds.

**Article 523, Technical Provisions for Dose Assessment**

1. Interpretations of bioassay results and subsequent dose assessments should include the following:
  - a. Radionuclide characteristics such as the chemical and physical form.
  - b. Bioassay results and the individual’s previous exposure history.
  - c. Exposure information such as route of intake and time and duration of exposure.
  - d. Biological models used for dosimetry of radionuclides.
  - e. Models to estimate intake or deposition and to assess dose.
  - f. Intradepartmental coordination between the Radiological Control organization and the Occupational Medical organization for doses that may require medical intervention.

**Part 3, Respiratory Protection Program**

Respiratory protection equipment includes respirators with particulate or gas-filtering cartridges, supplied air respirators, self-contained breathing apparatus, and air-line supplied-air suits and hoods.

**Article 531, General Provisions**

1. Use of respiratory protection shall be reduced to the minimum practicable by implementing engineering controls and work practices to contain radioactivity at the source [see 29 CFR 1910.134].
2. Respiratory protection requirements at facilities/projects are controlled by the Site Industrial Hygiene Respiratory Protection Program.
3. Respirator shall be issued based on the specific types required by the specific conditions only to individuals who are trained, fitted, and medically qualified to wear the specific type of respirator to be issued [see 29 CFR 1910.134 and ANSI Z88.2-1992].

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4. Positive controls should be maintained for the issue, use, and return of respirators to ensure that only qualified individuals wear respirators.
5. Facility safety analyses should not take credit for the use of respiratory protection for routine work involving potential exposure to airborne radioactive materials.

**Article 532, Medical Assessment**

Each prospective respirator wearer shall have a medical assessment prior to being fit-tested in accordance with Articles 531.2 and 531.3 [see 29 CFR 1910.134 and ANSI Z88.2-1992].

**Article 533, Use of Respiratory Protection**

The use of respiratory protection devices can impair worker mobility and vision, causing workers discomfort and stress. For these reasons, the issue and use of respiratory protective devices must be controlled.

Individuals using respiratory protection shall:

1. Perform fit checks of close-fitting respirators to ensure a proper seal before entering areas requiring respirator use.
2. Be clean shaven in the area of fit, if applicable.
3. Use corrective lenses, if required, that are approved for respirators.
4. Be trained to leave the work area when experiencing respirator failure.
5. Be trained to remove their respirators to avoid life-threatening situations when or before exiting an area after respirator failure [see 29 CFR 1910.134 and ANSI Z88.2-1992].

**Article 534, Heat Stress**

Heat stress may result from working in areas of high heat, humidity, and radiant heat; working in protective clothing; and using respirators, particularly where other protective equipment is required. Heat stress has occurred at ambient temperatures lower than 70°F (21°C) when multiple sets of protective clothing or plastic suits were in use or strenuous work was required.

Note: Removal of personal protective equipment will take precedence over radiological controls when necessary to prevent personnel injury.

1. The planning stages for work in hot environments should address heat stress controls in accordance with the Site Industrial Hygiene Respiratory Protection Program.
2. Job supervisors should inform their personnel of heat stress precautions prior to commencing work on job assignments in hot environments. Precautions that should be considered during work that includes a high probability of heat stress include the following:
  - a. Engineering controls to moderate the work area environment.
  - b. Appropriate stay-time controls.
  - c. Use of protective clothing made of materials that wick perspiration away from the body.

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- d. Use of body cooling devices.
  - e. Provision of beverages at or near the work site, using appropriate contamination controls.
  - f. Relaxation of protective clothing requirements.
3. If an individual begins to feel symptoms of heat illness, the individual should immediately notify the nearest coworker, exit the area, remove personal protective equipment, notify the supervisor, and rest in a cool area. In such cases, medical assistance should be provided.

**Article 535, Half-Face Respirators**

Half-face respirators have limited applications in the radiation protection program because of the design of the facial seal area. As a result, their permitted protection factor is low. Full-face respirators are generally preferred over half-face respirators because of the significant increase in protection offered with minimal loss of worker comfort.

1. The use of half-face respirators is permitted in situations where intakes of radioactive material will be low, such as those resulting in a few millirem, and where industrial and safety considerations warrant, such as during the operation of heavy equipment.
2. The use of half-face respirators must have the approval of the Radiological Control director or his designee for use with radiological material.

**Part 4, Handling Radiologically Contaminated Personnel****Article 541, Skin Contamination**

1. When workers detect skin contamination, they should notify the Radiological Control organization.
2. The extent of skin contamination should be determined prior to or in conjunction with initiating decontamination procedures.
  - a. Decontamination should be initiated as soon as practicable to reduce the individual dose. This action may be concurrent with further actions to determine the extent of skin contamination. Contaminants ~~and materials~~ should be retained, as practicable, to aid in the analysis process. Skin contamination measurements may be used to evaluate dose.
3. Skin decontamination methods should be established for Site-specific radionuclides as appropriate. Skin abrasion should be avoided during the decontamination process. Intrusive decontamination methods such as tissue removal require medical assistance.
4. Skin dose assessments are required if the dose exceeds 100 mrem. Particles (with an area less than 1 cm<sup>2</sup>) causing a count rate exceeding 6,000 counts per minute (on a [survey instrument](#) ~~Geiger-Mueller counter equipped~~ with a pancake [Geiger-Mueller \(GM\)](#) probe) for 1 hour, may cause a 100 mrem dose to the skin.

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5. Individuals with skin contamination that triggers the need for dose assessment should be informed of the initial dose estimate to their skin as soon as practicable, preferably prior to the end of their work day.
6. Individuals with skin contamination for which dose assessment was not performed should be informed of the nature of the contamination and an upper estimate on the potential dose (such as less than 10 mrem) as soon as practicable, preferably prior to the end of their work day.
7. An assessment of skin exposure requires time to conduct a detailed evaluation. Requirements for assessments are provided in Appendix 2A. Promptly after completion, the results should be explained to the affected individuals.

**Article 542, Contaminated Wounds**

1. Emergency medical care should be administered immediately for injuries involving radioactive materials in accordance with the National Council on Radiation Protection (NCRP) Report 65, *Management of Persons Accidentally Contaminated with Radionuclides* (NCRP 1980). Medical treatment of injuries takes precedence over radiological control considerations.
2. The treatment of contaminated injuries should include the following:
  - a. Treatment of contaminated wounds by medically qualified personnel.
  - b. Monitoring of wounds and associated bandages for contamination including alpha emitters if applicable.
  - c. Identification of the radionuclides involved.
  - d. Medical determination of the need for therapeutic intervention such as blocking or chelating agents.
  - e. Initiation of appropriate bioassay monitoring.
  - f. Determination of the need for work restrictions.
3. An injured individual should be counseled promptly on the medical and radiological implications resulting from contaminated wounds that result in internal doses greater than 2% of Table 2-1 limits. The counseling should be performed by senior Radiological Control personnel and medical professionals.

**Article 543, Handling Individuals Exposed to Airborne Radioactivity**

~~Potential Unplanned~~ intakes of radioactive material are indicated when individuals without respiratory protection are exposed to ~~facial contamination,~~ airborne radioactivity ~~at concentrations higher than planned,~~ or when respiratory protection has been compromised. If intakes of radioactive material are indicated that could result in an individual receiving a CEDE greater than 100 mrem, the following actions should be taken:

1. Identify individuals potentially exposed to airborne radioactivity.
2. Obtain nasal smears for a qualitative indication of intakes where appropriate.

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3. Analyze air samples to determine airborne concentrations where appropriate.
4. Determine the duration of potential exposure to airborne radioactivity.
5. Perform bioassay appropriate for the type and quantity of radionuclides involved.
6. Evaluate dose prior to permitting the worker to return to radiological work.

## Part 5, Radiological Monitoring

### Article 551, General Provisions

Workplace monitoring provides a basis for posting and labeling, development of RWPs and other work authorizations, implementation of ALARA measures, issuance of individual monitoring devices, and verification of the efficacy of design measures and engineering controls. Development of a workplace monitoring program sufficient to meet the provisions of this chapter should include consideration of the following factors to ensure the adequacy of the program.

1. Radiological monitoring of radiation exposure levels, contamination, and airborne radioactivity shall be conducted to:
  - a. Characterize workplace conditions and detect changes in those conditions [see 10 CFR 835.401(a)(2) and (3)].
  - b. Verify the effectiveness of physical design features and engineering and process controls [see 10 CFR 835.401(a)(5)].
  - c. Demonstrate regulatory compliance [see 10 CFR 835.401(a)(1)].
  - d. Detect the gradual buildup of radioactive material in the workplace [see 10 CFR 835.401(a)(4)].
  - e. Identify and control potential sources of personnel exposure [see 10 CFR 835.401(a)(6)].
  - f. For high or very high radiation areas, monitor as necessary during access to determine the exposure rates to which the individuals are exposed. [see 10 CFR 835.502(a)(1)].
2. Monitoring shall be performed only by individuals who have the appropriate education, training, and skills [see 10 CFR 835.103]. The instruments used shall be [see 10 CFR 835.401(b)]:
  - a. Periodically maintained and calibrated.
  - b. Appropriate for the types, levels, and energies of radiation to be detected.
  - c. Appropriate for existing environmental conditions.
  - d. Routinely tested for operability.
3. Monitoring for radiation, contamination, and airborne radioactive materials should be performed as specified in technical work documents and RWPs.

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4. Portable instruments used to perform radiation monitoring will be response-checked daily or prior to operation during normal work periods. When response checks indicate abnormal operation, the instrument should be taken out of service.

Note: During nonworking and reduced activity periods ~~up to 3 days in length~~, such as weekends and holiday periods, in areas where only operational or safety-related tours and routine inspections are conducted, daily response checks of the portable survey instruments are not required.

5. Weekly performance checks, using a known source will be conducted on in-use portable instruments. When performance checks are not within  $\pm 20\%$  of the expected value, the instrument should be taken out of service. When performance checks are not feasible, such as with instruments used to measure neutrons or tritium, compensatory actions should be established to ensure proper instrument performance.

~~6.~~ Sample/smear counting instruments (scalers) should be performance-checked daily or prior to operation. Facilities will determine performance check/response check requirements for contamination monitors (e.g., portal, hand and foot) and document in a technical procedures or EDFEngineering Design File.

~~6.7.~~ Emergency equipment such as Fire Department kits and facility emergency kits will be performance checked monthly and after use.

~~7.8.~~ Neutron, unique research and development, and tritium instruments will be performance checked monthly or prior to use or as established in a technical basis document.

~~8.9.~~ Monitoring of radiological conditions should include a sufficient number of survey points to characterize the radiation present to verify boundaries and the effect on adjacent areas.

~~9.10.~~ Monitoring should be performed before, during, and at the completion of work that has the potential for causing changes in levels of radiation and radioactivity.

~~10.11.~~ Monitoring frequencies should be established based on potential radiological conditions, probability of change in conditions, and area occupancy factors.

~~11.12.~~ Monitoring results should be reviewed by the cognizant facility/project Radiological Control foreman to ensure that all required surveys ~~and logs~~ have been performed and that the documentation is accurate and complete as a record. Periodic trending reports should be submitted to cognizant Radiological Control management.

~~12.13.~~ Results of current surveys or survey maps should be available to inform personnel of the radiological conditions.

~~13.14.~~ Survey results should be made available to line management and used in support of pre- and post-job evaluations, preparation or selection of appropriate RWPs, ALARA preplanning, contamination control, and management of radiological control operations.

### **Article 552, Radiation Exposure Monitoring**

1. In addition to the requirements of Article 551, routine radiation monitoring programs should be established to ensure that surveys are performed at a frequency that is consistent with the existing and potential hazards and activities planned in the area.

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Survey frequencies in routinely occupied areas will be as established in facility approved routines using the [belowfollowing](#) guidelines:

- a. Quarterly, in office space located in radiological buffer areas and other areas surrounding radiological areas where the potential exists for external radiation exposure.
  - b. Annually, for operating HEPA-filtered ventilation units. An alternate survey frequency may be established based on a documented technical evaluation of system use and accessibility.
  - c. Upon entry, and when levels are expected to change in high radiation areas.
2. Radiation monitoring should include dose rate measurements of the general area, dose rates at a distance of 30 cm from a source or surface of interest to evaluate potential whole-body exposures, and dose rates on contact with potential sources of radiation where a potential exists for hands-on work or other direct contact.

**Article 553, Area Radiation Monitors**

1. In addition to the requirements and recommendations of Article 551, area radiation monitors should be installed in frequently occupied locations with the potential for unexpected increases in dose rates and in remote locations where a local indication of dose rates is required prior to personnel entry.
2. The necessity and placement of ~~worker protection~~ area radiation monitors [for worker protection](#) should be documented and assessed when changes to facilities, systems, or equipment occur.
3. If installed instrumentation is removed from service for maintenance or calibration, a radiation monitoring program providing similar detection capability should be maintained, consistent with the potential for unexpected increases in radiation dose rates.
4. Where an area radiation monitor is incorporated into a safety interlock system, the circuitry should be configured so that a failure of the monitor either prevents entry into the area or prevents operation of the radiation-producing device. If the circuitry is required to ensure compliance with the high radiation area access control requirements of 10 CFR 835.502, then the circuitry shall be fail-safe.

**Article 554, Contamination Monitoring**

1. In addition to the requirements of Article 551, contamination monitoring programs should be established to ensure that ~~removable contamination~~ surveys are performed at a frequency that is consistent with the existing and potential hazards and activities planned in the area. Survey frequencies in routinely occupied areas are as established in facility-approved routines using the following guidelines:
  - a. Prior to transfer of equipment and material from high contamination areas within the same radiological buffer area unless precautions such as bagging or wrapping are taken prior to transfer.
  - b. Monthly for change areas.

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- c. Weekly for step-off pads when in use.
  - d. Daily in high-potential areas.
  - e.e. Weekly, in routinely occupied radiological buffer areas.
  - d.f. During initial entry into a known or suspected contamination area, periodically during work, at completion of job, or as specified in a radiological work permit.
  - e.g. Annually, in areas of fixed contamination.
2. Site buses and other government vehicles should be periodically surveyed. Survey frequencies should be based on historical and current use of a vehicle.
  3. Contamination surveys should incorporate techniques to detect both removable and fixed contamination.
  4. Smear surveys for removable contamination should be recorded in units of disintegrations per minute per 100 cm<sup>2</sup> (dpm/100 cm<sup>2</sup>). For smear surveys of small items covering less than 100 cm<sup>2</sup>, the results should be recorded in units of dpm per area smeared. If contamination levels exceed the range of the available count rate meters, the smears should be analyzed by holding an appropriate exposure rate meter within ½ in. and the results should be recorded in units of ~~radiation absorbed dose (rad)~~ or millirad per hour.
  5. Large area wipes are encouraged and should be used to supplement standard smear techniques in areas outside of contamination areas and high contamination areas. If an evaluation indicates that an area wiped is contaminated, a more thorough contamination smear survey should be performed. If no contamination is detected on large area wipes, no ~~swipe or~~ smear survey is necessary.
  6. Areas identified as either contaminated with, or having the potential for being contaminated with, highly radioactive particles (“hot particles”) should be surveyed using special survey techniques to collect hot particles, such as tape and large area wipes.

**Article 555, Airborne Radioactivity Monitoring — ~~Approved Routine Facility~~**

Survey frequencies in routinely occupied areas are as established in facility-approved routines using the following guidelines:

1. In addition to the requirements of Article 551, air monitoring programs should be established to ensure that airborne radioactivity monitoring is performed at a frequency that is consistent with the existing and potential hazards and activities planned in the area. Selection of air monitoring equipment should be based on the specific job being monitored. Air monitoring equipment includes portable and fixed air sampling equipment and continuous air monitors.
2. Air sampling equipment shall be used where an individual is likely to receive an annual exposure of 40 or more DAC-hours [see 10 CFR 835.403(a)(1)]. This intake generally represents a CEDE to an individual of approximately 100 mrem. Samples also shall be taken as necessary to characterize the hazard in areas where respiratory protection

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- devices have been prescribed for protection against airborne radionuclides [see 10 CFR 835.403(a)(2)]. Air samples should be adequate to evaluate the concentrations of airborne radioactive materials at the individual's work locations.
3. Continuous(or real-time) air monitors are used to provide early warning to individuals of events that could lead to substantial unplanned exposures to airborne radioactivity. Such exposures could result from a breakdown of engineered controls or improper establishment of boundaries during work that creates airborne radioactivity. Real-time air monitoring shall be performed as necessary to detect and provide warning of airborne radioactivity concentrations that warrant immediate action to terminate inhalation of airborne radioactive material [see 10 CFR 835.403(b)].
  4. Air sampling equipment should be positioned to measure air concentrations to which individuals are exposed. If this cannot be achieved, a program of personal breathing-zone air sampling should be initiated.
  5. Air monitoring equipment shall be routinely calibrated and maintained on an established frequency [see 10 CFR 835.401(b)]. Air monitoring equipment should be calibrated at least once each year. Continuous air monitors should be capable of measuring 1 DAC when averaged over 8 hours (8 DAC-hours) under laboratory conditions.
  6. Real-time air monitoring equipment required by Article 555.3 should have alarm capability and sufficient sensitivity to alert individuals that immediate action is necessary to minimize or terminate inhalation exposures.
  7. A technical basis document should be developed for the airborne-radioactivity monitoring program. The technical basis document should provide the basis for air monitor selection, placement, and operation.
- ~~8. The proper operation of continuous air monitoring equipment should be verified daily by performing an operational check. Operational checks should include the following:~~
- ~~a. Positive airflow indication.~~
  - ~~b. Non-zero response to background activity.~~
  - ~~c. Internal check sources or 60 Hz electronic checks when available.~~
  - ~~d. Instrument response with a check source.~~
  - ~~e. Complete a continuous air monitor filter change. Facility Radiological Control personnel should routinely review response check data. If a continuous air monitor shows an increase in the rate of failure during the weekly check, then an increase in response checks may be warranted or the continuous air monitor should be taken out of service until repairs have been completed.~~
- ~~9.8. Real-time air monitoring equipment operation including internal check sources or 60 Hz electronic checks when available should be verified weekly by checking for instrument response with a check source or with ambient levels of radon and thoron daughters. The proper operation of continuous air monitoring (CAM) equipment should be verified weekly by performing an operational check. Operational checks should include (1)~~

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positive airflow indications, (2) non-zero response to background activity, (3) internal check of 60 Hz electronic checks when available (4) instrument response with a check source, (5) complete a CAM Filter change. Facility Radiological- Control personnel should routinely review response check data, if a CAM shows an increase in rate of failure during the weekly check then an increase in response checks may be warranted or the CAM should be taken out of service until repairs have been completed.

## Part 6, Instrumentation and Calibration

### Article 561, Standardization

Standardization of the use of commercially available radiological instrumentation at the Site is encouraged.

### Article 562, Inspection, Calibration, and Performance Tests

1. Radiological instruments shall be used only to measure the radiation for which their calibrations are valid [see 10 CFR 835.401(b)(2)]. Two standards, ANSI N323A-1978<sup>97</sup>, “Radiation Protection Instrumentation Test and Calibration-~~Portable Survey Instruments~~,” and ANSI Z540.1-1994, “Calibration Laboratories and Measuring and Test Equipment General Requirements,” provide the guidance for establishing and operating a radiological instrumentation calibration program. Calibrations should use National Institute of Standards and Technology traceable standards, intrinsic standards, or international standards approved by the Health Physics Instrument Laboratory manager. When traceability to international or national standards of measurement is not cost effective, traceability requirements may be satisfied by any one of the following:
  - a. Participation in a suitable program of interlaboratory comparisons or proficiency testing.
  - b. Internationally accepted standards.
  - c. Suitable reference materials.
  - d. Ratio or reciprocity-type measurements.
  - e. Mutual consent standards that are clearly specified and mutually agreed upon by all parties concerned.
2. Calibration procedures will be developed for each radiological instrument type and should include frequency of calibration, precalibration requirements, primary calibration requirements, periodic performance test requirements, calibration record requirements, and maintenance requirements.
3. All radiological monitoring instruments, including pocket and electronic dosimeters and area radiation monitors, shall be maintained and calibrated at an established frequency [see 10 CFR 835.401(b)(1)]. Calibration frequencies will be determined and documented based on the guidance in National Conference of Standards Laboratories Recommended Practice RP-1, “Establishment and Adjustment of Calibration Intervals,” or national consensus standards ~~ANSI Z540.1 or~~ ANSI N323A.

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4. The effects of environmental conditions including interfering radiation on an instrument shall be known prior to use [see 10 CFR 835.401(b)(3)].
5. Operational tests should be used to assess instrumentation designs that include alarms or that involve a process control. An operational test should be developed to test all components involved in an alarm or trip function and performed at least annually.
6. In unusual and limited situations, using an instrument in an application other than that envisioned by the manufacturer may be necessary. Special calibrations should be performed for use of instrumentation outside manufacturer's specifications. The instrument should be adjusted, calibrated, and labeled to identify the special conditions and used only under the special conditions for which it was calibrated.

~~Note: Unique calibration activities related to research and development should be documented in a technical basis document and approved by the Radiological Control director.~~

7. Measures should be implemented to ensure that individuals using an instrument can verify its calibration status.
8. Instruments whose "as found" readings indicate that the instrument may have been used while out of calibration should be reported to the Radiological Control organization. The Radiological Control organization should conduct and document reviews of surveys performed with the instrument while it was out of calibration and consider the need for additional surveys.

**Article 563, Maintenance**

1. A program for preventive and corrective maintenance of radiological instrumentation should be established and documented.
2. Preventive and corrective maintenance should be performed using components and procedural recommendations at least as stringent as those specified by the manufacturer of the instrument.
3. Radiological instruments should undergo calibration prior to use following any preventive or corrective maintenance or any adjustment that voids the previous calibration. A battery change normally is not considered maintenance.
4. Radiological instruments containing internal calibration sources should be maintained by authorized maintenance or repair personnel. If the internal source needs to be removed, it should be removed in accordance with a technical work document.

**Article 564, Calibration Facilities**

1. Radiological monitoring instrument inspections, calibrations, performance tests, calibration equipment selection, and quality assurance should be performed in accordance with the recommendations of ANSI N323-A-1997 and ANSI Z540.1-1994. Responsible individuals should complete the following actions:
  - a. Locate activities in a manner to control radiation exposure to operating personnel and to personnel in adjacent areas.

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- b. Minimize sources of interference, such as backscatter and nonionizing radiation, during the calibration of instrumentation and correct for any interference as necessary.
- c. Operate in accordance with the referenced standards.  
~~Note: Unique calibration activities related to research and development should be documented in a technical basis document and approved by the Radiological Control director.~~
- d. Generate records in accordance with the referenced standards.