



# SANFORD UNDERGROUND RESEARCH FACILITY

**SOUTH DAKOTA SCIENCE AND TECHNOLOGY AUTHORITY**

## **Radiation Safety Standard**

## **Table of Contents**

<b>1.0</b>	<b>Purpose .....</b>	<b>4</b>
<b>2.0</b>	<b>Scope .....</b>	<b>4</b>
<b>3.0</b>	<b>Definitions.....</b>	<b>4</b>
<b>4.0</b>	<b>Responsibilities .....</b>	<b>5</b>
<b>5.0</b>	<b>Instructions.....</b>	<b>6</b>
<b>6.0</b>	<b>Documented Information/Related Documents.....</b>	<b>12</b>

## Revision History

Rev	Date	Section	Paragraph	Summary of Change	Authorized by
04	7/09/2025	1.0,2.0,3.0,4.0,5.0,6.0	4.1.3.4.2,4.2.1,4.3,4.3.2.,4.4.1.,4.4.8.,4.5.4.,4.6,4.6.1.,4.7.2.,4.7.4.,5.1.2.,5.1.3.,5.1.4.,5.3.1.,5.3.2.,5.3.4.,5.5.1.,5.6.1.,5.6.2.,5.6.3.,5.7.5.7.1.,5.8,5.8.1.,5.8.2.,5.8.3.,5.8.4.,5.9,6.1,6.5,6.6,6.7,6.8,6.9	Updated/added definitions, updated position titles, updated/added content	CCR 1121
05	2/26/2026	4, 5 & 6	4.1, 4.2.1, 4.3.2, 5.3.4, 5.4.3, 5.7.1, 5.8.1, 5.9.1, & 6.1-6.4	Updated document due to change to the document numbering of controlled documents due to the change from DocuShare system to SharePoint system	CCR 1227

## 1.0 Purpose

The South Dakota Science and Technology Authority (SDSTA) protects employees, users, visitors, and the general public from excessive radiation encountered during any activity at SDSTA. This standard establishes procedures and processes to effectively manage exposure to radiation.

## 2.0 Scope

The standard covers all work with sources of ionizing radiation at the Sanford Underground Research Facility (SURF) and applies to all personnel onsite.

The Nuclear Regulatory Commission (NRC) is the regulator for radioactive materials at SURF.

Accelerator-produced radiation at SURF is covered by the ANSI/HPS Standard N43.1 “Radiation Safety for the Design and Operation of Particle Accelerators” and registered by the South Dakota Department of Agriculture and Natural Resources (SD DANR).

Other radiation-producing equipment is regulated by Occupational Health and Safety Administration (OSHA).

Sources of radiation outside of NRC licensing can be used at SURF if they are controlled under other regulatory jurisdictions. Coordination with the SDSTA Radiation Safety Officer (RSO) and formal agreements are required.

## 3.0 Definitions

**ALARA – As Low As Reasonably Achievable** – Every reasonable effort is made to maintain exposures to ionizing radiation as far below the dose limits as practical, consistent with the purpose for which the licensed activity is undertaken, taking into account the state of technology, the economics of improvements in relation to state of technology, the economics of improvements in relation to benefits to the public health and safety and other societal and socioeconomic considerations, and in relation to utilization of radioactive materials in the public interest.

**Authorized Management Representative** – A person with the authority to ensure compliance and necessary resources for the radiation safety program. The SDSTA Executive Director is the Authorized Management Representative.

**Authorized User** – An individual whose education, radiation training, and experience have been reviewed and approved by the RSO per the SDSTA NRC license. There are ongoing training requirements associated with this status.

**Background Radiation** – Background radiation is a measure of the level of ionizing radiation present in the environment at a particular location which is not due to deliberate introduction of radiation sources. Background sources include cosmic radiation, naturally occurring radioactive materials, including radon (except as a decay product of radioactive sources or special radioactive material); and global fallout from nuclear weapon testing and nuclear accidents.

**Nuclear Regulatory Commission (NRC)** – The regulator for licensed radioactive materials at SURF.

**Occupational Dose** – The radiation dose received by a SDSTA employee or user acting in their occupational capacity. Individuals can receive an occupational dose without being designated as a Radiation Worker.

**Public or Member of the General Public** – Any individual not receiving an occupational dose.

**Radiation Area** – An area, accessible to employees or users, in which radiation levels could result in an equivalent dose to the whole body in excess of 5 mrem/hour (0.05 mSv/hour) at 30 cm from the source or from any surface that the radiation penetrates. **High Radiation Area** for areas with equivalent dose in excess of 100 mrem/hour (1 mSv/hour) at 30 cm **Very High Radiation Area** for areas with in which an individual could receive an absorbed dose in excess of 500 rads/hour (5 grays/hour) at 1 meter. Each radiation area shall have signs bearing the radiation symbol and the respective words according to 10 CFR §20.1901 and §20.1902.

**Radiation Safety Officer (RSO)** – The person identified in the SDSTA NRC license who is responsible for implementing and managing the radiation safety program at SURF.

**Radiation User or Worker** – Either an Authorized User or a Supervised User.

**Radioactive Material Area** – An area containing radioactive material in which the total activity of radioactive material exceeds the applicable values provided in 10 CFR 20, Appendix C. The area shall have signs bearing the radiation symbol and the words “Caution, Radioactive Material(s)” according to 10 CFR §20.1901.

**Supervised User** – An individual authorized by the RSO to handle radioactive materials under the supervision of an Authorized User. Evidence of training is required to be designated as a Supervised User, and there are ongoing training requirements associated with this status.

## 4.0 Responsibilities

### 4.1. SDSTA Executive Director

- 4.1.1. Ensure that SDSTA’s responsibilities are fulfilled per NRC license and amendment applications as well as other applicable guidelines.
- 4.1.2. Serves as the Authorized Management Representative for the SDSTA NRC license.
- 4.1.3. Appoints the SDSTA Radiation Safety Officer.

### 4.2. Director of Environment, Safety and Health (ESH)

- 4.2.1. Concurs with the SDSTA Executive Director the appointment of the SDSTA Radiation Safety Officer.

### 4.3. Director of Science

- 4.3.1. Appoints Radiation Subcommittee members to evaluate:
  - The introduction of radioactive materials into shared laboratory spaces.
  - The effects of radiation-producing machines on experimental operations.
- 4.3.2. Concurs with the SDSTA Executive Director the appointment of the SDSTA Radiation Safety Officer.

### 4.4. Radiation Safety Officer (RSO)

- 4.4.1. Ensures radiological safety and compliance with NRC regulations and the conditions of the NRC license, including supervising radiation monitoring and surveys as appropriate.

- 
- 4.4.2. Applies for NRC license amendments and renewals.
  - 4.4.3. Ensures compliance with Department of Transportation regulations (Title 49, Code of Federal Regulation).
  - 4.4.4. Registers ionizing radiation-producing machines as required by the SD DANR.
  - 4.4.5. Ensures appropriate radiation monitoring equipment is available, maintained and calibrated.
  - 4.4.6. Reviews radiation shielding designs for use at SURF.
  - 4.4.7. Reviews designs of radiation safety interlock systems at SURF.
  - 4.4.8. Approves Authorized Users and Supervised Users at SURF.
  - 4.4.9. Ensures implementation of the radiation safety training program at SURF, including conducting and evaluating radiation safety training as appropriate.
  - 4.4.10. Ensures records of the radiation safety program are completed and retained as required.
  - 4.4.11. Supervises shipments of radioactive materials entering or leaving SURF.
  - 4.4.12. Coordinates with Authorized Users on the movement of radioactive materials and radiation-producing equipment at SURF.
  - 4.4.13. Completes required training and maintains NRC license-required certification(s).
- 4.5. Authorized User
- 4.5.1. Ensures that radioactive materials and machines under their supervision are used safely and in accordance with this standard.
  - 4.5.2. Ensures that the ALARA principle is applied to activities under their supervision, thereby minimizing radiation doses to all personnel.
  - 4.5.3. Coordinates shipments of radioactive materials at SURF with the RSO.
  - 4.5.4. All Supervised User responsibilities.
- 4.6. Supervised User
- 4.6.1. Follows SDSTA radiation safety procedures and completes all required radiation safety training.
  - 4.6.2. Reports unsafe conditions to their supervisor and to the RSO. Stops work as necessary.
  - 4.6.3. Reports any irregularities or abnormal events, as specified in SDSTA's incident reporting procedures.
- 4.7. Warehouse Shipping/Receiving Personnel
- 4.7.1. Identifies a package containing radioactive material according to labeling, shipping papers and associated prior notification.
  - 4.7.2. Segregates packages containing radioactive materials from other incoming items in a secured area until released by the RSO.
  - 4.7.3. Notifies the RSO when radioactive materials are received.
  - 4.7.4. Completes all required radiation safety and awareness training.

## 5.0 Instructions

Regulatory Authorities:

The applicable radiation safety regulations are determined based on how the radiation is produced (e.g., machine-produced radiation or from radioactive materials.). Different radiation dose limits apply to individuals depending on their role (see Table 1).

5.1.1. Nuclear Regulatory Commission:

- The NRC regulations apply only to licensed materials. The NRC specifies separate dose limits for workers and members of the public.

**5.1.2. Occupational Safety and Health Association (OSHA):**

- OSHA has dose limits for workers from all types of ionizing radiation (“small” sources and machine-produced) but does not address members of the public.
- OSHA regulations apply to radiation exposure not covered by other agencies (e.g., NRC or Department of Energy).

**5.1.3. Mining Safety and Health Administration (MSHA); specifically, radon:**

- Radon is a radioactive colorless, odorless, tasteless noble gas generated by the decay of uranium and thorium. Both materials are present in the geology at SURF as naturally occurring radioactive materials. Furthermore, the Homestake Mine was never mined for either of these elements.
- Radon gas presents a health hazard, and SDSTA will follow MSHA guidance for radon monitoring and controls.

**Table 1: Radiation Exposure Regulators with Dose Limits**

<b><u>Regulator</u></b>	<b><u>Occupational Dose Limit (for adult workers)</u></b>	<b><u>General Public Dose Limit</u></b>
<b>NRC:</b> 10 CFR 20 (licensed radioactive materials)	The annual total effective dose equivalent for the whole body is 5 rem (0.05 Sv). The annual sum of the deep-dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye is 50 rem (0.5 Sv). The annual limits to the lens of the eye, to the skin of the whole body, and to the skin of the extremities, are as follows: (i) A lens dose equivalent of 15 rem (0.15 Sv), and (ii) A shallow-dose equivalent of 50 rem (0.5 Sv) to the skin of the whole body or to the skin of any extremity. (10 CFR §20.1201)	The total effective dose equivalent is: (i) 100 mrem (1 mSv)/year, and (ii) 2 mrem (0.02 mSv) in any one hour (not including background radiation, nor radon)  (10 CFR §20.1301)
<b>OSHA:</b> 29 CFR §1910.1096	Whole body: Head and trunk; active blood-forming organs; lens of eyes; or gonads: 1.25 rem/quarter Hands and forearms; feet and ankles: 18.75 rem/quarter Skin of whole body: 7.5 rem/quarter (29 CFR §1910.1096 Table G-18)	None
<b>MSHA - Radon:</b> 30 CFR 57 Subpart D	4 Working Level Months in any calendar year, and 1 Working Level in active working areas. (30 CFR §57.5038 and §57.5039)	None

---

**5.1.4.** ANSI/HPS 43.1 Radiation Safety for the Design and Operation of Particle Accelerators:

- This reference applies to all phases of the accelerator facility's life cycle, including design, installation, commissioning, operation, maintenance, upgrade, and decommissioning. This standard specifies requirements and recommendations for radiation safety program management and technical aspects. SDSTA has adopted this as technical guidance on the "how" to achieve the requirements set forth in OSHA.

**5.2.** Transportation, Material Receipt & Accountability:

- 5.2.1.** All packages containing radioactive materials shall be delivered to the main shipping and receiving warehouse at the Rounds Operation Center. Warehouse shipping/receiving personnel shall identify and segregate the package(s) and notify the RSO. Due to regulatory time constraints, it is important to coordinate shipments of radioactive materials to and from SURF property with the RSO.

**5.3.** Dose Considerations

**5.3.1.** Occupational Dose

- In general, the occupational dose rate for individuals who are not Radiation Workers shall be controlled to be less than 500 mrem/year and less than 5 mrem/hour at 30 cm.
- The following practices are used to minimize dose rates for all workers in accordance with the ALARA principle:
  - When evaluating requirements for radioactive sources, the activity shall be chosen to be as low as possible.
  - All radioactive sources shall be placed in lockable storage safes, with appropriate shielding, when not in use. Exceptions shall be approved by the RSO.

**5.3.2.** Public Dose

- The radiation dose to the public shall be controlled to be less than 100 mrem/year (1 mSv/year) and less than 2 mrem/hour (0.02 mSv/hour); see Table 1.

**5.3.3.** Dose Surveys

- Dose-rate surveys by or under the direction of the RSO will be performed in locations where radiation doses are expected to exceed 10% of the applicable annual or hourly dose limit (see Table 1 for full dose limits for individuals in various categories).

**5.3.4.** Dosimetry

- Dosimetry is required by:
  - NRC
    - ◆ If the projected annual occupational dose rate is greater than 10% of the applicable dose limit.
    - ◆ If entering a High or Very High radiation area (in excess of 100 mrem/hour at 30 cm).
  - OSHA
    - ◆ If the likely to receive occupational dose is greater than 25% of the quarterly dose limit.
    - ◆ If they enter a high radiation area.
    - ◆ This can include personal and area dosimetry.
- Dosimetry is recommended when dose rates are above the general-public limit.
- Dosimeters are requested using ESH-11000-F-004 Personnel Radiation Monitoring Badge Request Form.

**5.4.** Work Practices & Emergency Procedures

- 
- 5.4.1.** Work Practices – Work instructions for handling radioactive materials and machines are reviewed and approved by SDSTA personnel (including the RSO) and include emergency considerations.
  - 5.4.2.** Contamination Surveys – Surveys for radioactive contamination will be conducted periodically in all areas where sources are used, or immediately if there is a suspicion of a leak.
  - 5.4.3.** Emergency Procedures – Details of how emergencies are handled at SURF can be found in the ESH-11000-WI-001 Radioactive Material Emergency/Spill Processes.
- 5.5. Authorization**
- 5.5.1.** Authorization for Authorized Users and Supervised Users will be issued by the RSO upon receiving evidence of training and acknowledgement of specific SDSTA expectations, e.g., training and NRC requirements.
- 5.6. Training**
- 5.6.1.** The RSO, or their designee, will deliver the NRC required training to Radiation Workers and periodic retraining. Subject to SDSTA RSO review and approval, science collaborations may implement radiation safety training and periodic retraining programs.
  - 5.6.2.** Individuals who work with radioactive sources, work in areas of radioactive source usage or storage (Radioactive Material Areas), or in the vicinity of radiation producing machines shall receive basic radiation safety training that familiarizes them with radiation sources, risks in perspective to potential doses, methods to minimize dose, source hazards, control measures and emergency procedures.
  - 5.6.3.** Documentation and Recordkeeping
    - Radiation safety training documentation is required and must be defensible and auditable. See Section 5.9.
- 5.7. Experiment Radiation Safety Plan (ERSP)**
- 5.7.1.** An ERSP (Experiment Radiation Safety Plan) is created by using ESH-11000-F-001 Experiment Radiation Safety Plan. A plan to maintain safe operations shall be written for each specific experiment with significant radiation hazards, as determined by the RSO, and at a minimum shall include:
    - o Radiation source(s) and/or radiation producing equipment description
    - o Facility area description and access control
    - o Radiation levels and dose estimates in the experiment area and the facility boundary
    - o Radiation area classifications based on shielding design, source handling procedures and/or equipment operations
    - o Personnel monitoring and dosimetry plan (see Section 5.3.4)
    - o Control and handling of radioactive sources, radioactive waste and radiological environmental protection
    - o Emergency procedures, radioactive spill procedures and contamination monitoring
    - o Decommissioning
- 5.8. Radiation-Producing Equipment**
- 5.8.1.** An ERSP (Experiment Radiation Safety Plan) is created by using ESH-11000-F-001 Experiment Radiation Safety Plan. In addition to details listed in 5.7.1, the ERSP for radiation-producing equipment shall include:
    - o An area monitoring program to assure the dose rates and integrated doses within and external to the experiment area are within acceptable limits. At a minimum, the radiation levels around the machine shall be monitored.

- o The ERSP shall evaluate (via measurements or calculations) the potential for activation or contamination of the equipment, its components or the surrounding media.

**5.8.2. Radiation Control System**

- The radiation control system for radiation-producing equipment at SURF shall be a combination of equipment (e.g. shielding) and procedures aimed to minimize radiation to background levels outside of radiation-controlled areas. It shall be designed or reviewed by a radiation safety professional and may include mechanical or electrical interlocks.
- The radiation control system shall be designed conservatively to keep dose ALARA and to limit the maximum annual dose to less than:
  - o Radiation Workers: < 500 mrem/year (5 mSv/year)
  - o General public: < 100 mrem/year (1 mSv/year)
- Any changes to the radiation control system shall be reviewed and approved by the RSO.

**5.8.3. Access Control System**

- An access control system for radiation-producing equipment at SURF is required for areas with estimated dose rates to individuals > 5 mrem/hour (0.05 mSv/hour). This access control system may require startup warnings, enclosures, personnel entryway doors/gates, interlocks and exclusion areas as specified in Table 2.
- If required, the access control system shall be:
  - o Reliable, fail-safe, tamper-resistant
  - o Subject to configuration control during operation and maintenance
  - o Function and integrity checks conducted periodically
  - o Certified annually

<b>Table 2: Graded access control system features for prompt radiation hazards<sup>1</sup></b>						
<b><u>Dose rate<sup>2</sup></u></b> <b><u>(rem/hour)</u></b>	<b><u>Dose</u></b> <b><u>category</u></b>	<b><u>Start-up</u></b> <b><u>warning</u></b>	<b><u>Enclosure</u></b>	<b><u>Personnel</u></b> <b><u>entryway</u></b> <b><u>door/gate</u></b>	<b><u>Interlock</u></b> <b><u>redundancy</u></b>	<b><u>Area secure</u></b> <b><u>system</u></b>
0.005 – 0.1	Minimum	None	Rope	No restriction	None	
0.1 – 1	Low	Visible & audible	Barrier	Locked or interlocked	Recommended	Not required
1 – 10	Moderate	Visible & audible; emergency-off recommended	Barrier	Locked; interlock recommended	Recommended	Required (exclusion area)
>10	High	Visible & audible; emergency-off	Barrier	Locked and interlocked	Required	

<sup>1</sup> Adopted from ANSI/HPS N43.1 -2011.

<sup>2</sup> Dose rate values refer to the maximum effective dose expected during any 1 hour due to prompt radiation inside an accelerator or beamline housing area (operated within the operation envelope).

---

#### 5.8.4. Radiation-producing Equipment Operations

- A readiness review shall be conducted prior to equipment commissioning, and formal authorization from SDSTA is required prior to any production of radiation.
- Commissioning shall be conducted prior to routine operation. Commissioning shall include:
  - Verification that equipment operation and radiation hazards are controlled.
  - Shielding verification survey.
- Operations shall be conducted only by Radiation Workers who are qualified and authorized operators using written procedures reviewed and approved by SDSTA personnel, including the RSO.
- Routine maintenance and safety system repairs shall be part of operational plan and schedule.
- The equipment control panel shall be staffed during operation (e.g., during radiation production, or when potential radiation hazards exist).
  - When the operator is not present, the equipment should be turned off or the control panel access secured.
  - Under special operating conditions, a radiation-producing machine may be operated unattended, providing:
    - ◆ Potential emergencies are addressed beforehand.
    - ◆ Operating parameters and resulting radiation hazards are controlled by engineering means.
    - ◆ Long term unattended operation requires regular status monitoring.
    - ◆ If operational parameters exceed preset ranges, the operation shall be terminated automatically. Startup may only resume after renewed authorization by the RSO.
- No unapproved interlock bypass nor deviation from safety procedures shall occur. All interlock bypasses or deviations from safety procedures shall be approved by the RSO, the Director of Science and Director of ESH. All interlock bypasses and removals shall be documented. Normal interlock operation shall be resumed as soon as the bypass has served its purpose.

#### 5.9. Recordkeeping

##### 5.9.1. All radiation safety records shall be stored (e.g., electronically in the respective experiment areas on DocuShare):

- Work instructions or procedures related to handling radioactive materials and operations of radiation-producing equipment are reviewed and approved by SDSTA, as outlined in the SDSTA ESH manual.
- Inventory of radioactive materials (ESH-11000-F-002 Radioactive Source Inventory Form).
- List of Authorized Users and Supervised Users and radiation safety training records, including retraining records (alternatively using a Learning Management System).
- Radioactive material shipping and receiving records and radioactive material custody forms.
- Radioactive material surface swipe surveys records.
- Commissioning and post-operation survey records for radiation-producing equipment.
- Dosimetry records are subject to privacy regulations and are kept confidential as outlined in 10 CFR §20.2106.

## **6.0 Documented Information/Related Documents**

- 6.1.** ESH-11000-F-001 Experiment Radiation Safety Plan
- 6.2.** ESH-11000-F-002 Radioactive Source Inventory Form
- 6.3.** ESH-11000-F-004 Personnel Radiation Monitoring Badge Request Form
- 6.4.** ESH-11000-WI-001 Radioactive Material Emergency/Spill Processes
- 6.5.** NRC: 10 CFR Part 20
- 6.6.** OSHA: 29 CFR Part 1910.1096
- 6.7.** MSHA: 30 CFR 57 Subpart D
- 6.8.** Transportation (DOT): Title 49 CFR
- 6.9.** ANSI/HPS N43.1 “Safe Operating Practice for Users of Non-Medical X-Ray Radiographic and Radioscopic Equipment”, 2011