



Sanford

Underground Research Facility

South Dakota Science and Technology Authority

Radiation Safety Standard

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Revision History

Rev	Date	Section	Paragraph	Summary of Change	Authorized by
01	8/8/2022	NA	NA	Initial Release	CCR 589
02	9/20/2022	5 & 6	5.8.1 & 6.4	Corrected ESH-(11000-F)-190166 Operational Radiation Safety within document and add ESH-(11000-F)-200744 Personnel Radiation Monitoring Badge Request Form,	CCR 619

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 shall be implemented through the establishment of procedures and processes designed to keep exposures As Low As Reasonably Achievable (ALARA).

2.0 Scope

The standard covers all work with sources of ionizing radiation at 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 licensed by the South Dakota Department of Agriculture and Natural Resources (SDDANR)

Other machines producing ionizing radiation are regulated by Occupational Health and Safety Administration (OSHA) regulations.

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 means radiation from cosmic sources; naturally occurring radioactive material, including radon (except as a decay product of source or special nuclear

material); and global fallout as it exists in the environment from the testing of nuclear explosive devices or from past 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 an Authorized User or a Radiation Worker.

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

Radiation Safety Officer (RSO) – The person responsible for implementing and managing the radiation safety program and the NRC license.

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

4.0 Responsibilities

4.1. 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.

4.2. Environment, Safety and Health (ESH) Director

- 4.2.1. Appoints the SDSTA Radiation Safety Officer.

4.3. Science Director

- 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.

4.4. Radiation Safety Officer (RSO)

- 4.4.1. Ensures radiological safety and compliance with NRC.
 - Applies for license amendments and renewals.
- 4.4.2. Ensure compliance with Department of Transportation regulations (Title 49, Code of Federal Regulation).
- 4.4.3. Ensures radiological safety and compliance with recommendations of ANSI/HPS N43.1.
- 4.4.4. Registers ionizing radiation-producing machines as required by the SDDANR.
- 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 Radiation Users at SURF.
- 4.4.9. Ensures implementation of the radiation safety training program at SURF, including conducting and evaluating radiation training as appropriate.

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- 4.4.10. Ensures radiological protection records 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 Radiation Worker responsibilities.
- 4.6. Radiation User
- 4.6.1. Follows SDSTA radiation safety procedures and completes all required radiation training.
 - 4.6.2. Reports unsafe conditions to their supervisor and to the RSO. Stop work as necessary.
 - 4.6.3. Reports any irregularities or abnormal events, as specified in SDSTA's incident reporting procedures.
- 4.7. Radiation Worker
- 4.7.1. Completes all required radiation training.
 - 4.7.2. Reports unsafe conditions to their supervisor and to the RSO. Stop work as necessary.
 - 4.7.3. Reports any irregularities or abnormal events, as specified in SDSTA's incident reporting procedures.
- 4.8. Warehouse Shipping/Receiving Personnel
- 4.8.1. Identifies a package containing radioactive material according to labeling, shipping papers and associated prior notification.
 - 4.8.2. Segregates the package from other incoming items in a secured area until released by the RSO.
 - 4.8.3. Notifies the RSO when radioactive materials are received.
 - 4.8.4. Completes all required radiation protection training.

5.0 Instructions

- 5.1. Regulatory Authorities:
- 5.1.1. 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).
 - 5.1.2. NRC: The NRC regulations apply only to licensed materials. The NRC specifies separate dose limits for workers and members of the public.
 - 5.1.3. 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.
 - 5.1.4. 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).

5.1.5. Radon: Mining Safety and Health Administration:

- 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.
- Under the Intergovernmental Agreement, SDSTA will follow MSHA guidance for radon monitoring and controls.

Table 1: Radiation Exposure Regulators with Dose Limits

<u>Regulator</u>	<u>Occupational Dose Limit (for adult workers)</u>	<u>General Public Dose Limit</u>
NRC (licensed radioactive materials)	<p>The annual total effective dose equivalent for the whole body is 5 rem (0.05 Sv).</p> <p>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).</p> <p>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:</p> <p>(i) A lens dose equivalent of 15 rem (0.15 Sv), and</p> <p>(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.</p> <p>(10 CFR Part 20.1201)</p>	<p>The total effective dose equivalent is:</p> <p>i. 100 mrem (1 mSv)/year and</p> <p>ii. 2 mrem (0.02 mSv) in any one hour (not including background radiation (See Radon Regulatory Analysis in references).</p> <p>(10 CFR Part 20.1301)</p>
ANSI/HPS 43.1-2011 Recommended limit for accelerators	500 mrem/yr (5 mSv/yr) (10% of annual limit)	100 mrem/yr (1 mSv/yr) Matches NRC limit
OSHA: 29 CFR Part 1910.1096	Whole body: Head and trunk; active blood-forming organs; lens of eyes; or	None

	<p>gonads, 1.25 rem/quarter</p> <p>Hands and forearms; feet and ankles, 18.75 rem/quarter</p> <p>Skin of whole body, 7.5 rem/quarter</p> <p>(29 CFR Part 1910.1096)</p>	
<p>5.2. Radon: Mining Safety and Health Administration Title 30 CFR §§ 57.5038</p> <p>guidance</p>	<p>4 Working Level Months per year 1 Working Level in active working areas.</p>	

5.3. Transportation, Material Receipt & Accountability:

- 5.3.1.** 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.

5.4. Dose Considerations

5.4.1. Occupational Dose

- In general, the occupational dose rate for individuals who are not Authorized Users or 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.

5.4.2. 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/hr (0.02 mSv/hr); see Table 1.

5.4.3. 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).

5.4.4. 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 (100 mRem/hr at 30 cm).
 - OSHA
 - ◆ If the likely to receive 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)-200744 Personnel Radiation Monitoring Badge Request Form

5.5. Work Practices & Emergency Procedures

5.5.1. Work Practices – Work instructions for handling radioactive materials and machines are reviewed and approved by SDSTA personnel (including the RSO) and include emergency considerations.

5.5.2. 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.

5.5.3. Emergency Procedures – Details of how emergencies are handled at SURF can be found in the ESH-(11000-WI)-190169 Radioactive Material Emergency/Spill Processes

5.6. Authorization

5.6.1. Authorization for Authorized Users and Radiation Users will be issued by the RSO upon receiving evidence of training and acknowledgement of specific SDSTA expectations, e.g., training and NRC requirements.

5.7. Training

5.7.1. The RSO, or their designee, will deliver the NRC required training. Science collaborations shall be responsible for implementation of safety training and periodic retraining programs subject to SDSTA RSO review and approval.

5.7.2. Individuals who work with radioactive sources shall receive basic radiation safety training that familiarizes them with radiation sources, risks in perspective to potential doses, methods to minimize dose, source hazards and control measures.

5.7.3. Documentation

- Radiation safety documentation is required and must be defensible and auditable.

5.8. Radiation-Producing Machines

5.8.1. A safety assessment document shall be written which sufficiently covers safe operation at SURF. At a minimum, it shall include:

- Description of the facility.
- Beam parameters for all operational modes.
- Radiation hazard analysis, including risks to workers, the public and the environment.
- Engineered and administrative safety systems adequate to prevent unacceptable risk to individuals and the environment.
- A quality control and configuration control system shall be implemented (validated during the equipment commissioning) to assure safety systems are in place (for passive systems) and operated (for active systems) as designed.

5.8.2. Radiation Control System

- The radiation control system shall be a complete shielding system so that negligible radiation is detectable outside radiation-controlled areas. It shall be designed or reviewed by a radiation safety professional. It may include beam or radiation interlocks.
- The shield system shall be designed conservatively to keep dose ALARA and to limit the maximum annual dose to less than:
 - Radiation Users: < 5 mSv/year (500 mrem/year).
 - Public: < 1 mSv/year (100 mrem/year).
- Off-site dose to maximally exposed individual: < 0.1 mSv/year (10 mrem/year).
- Any changes to the radiation control system shall be approved by the RSO.

5.8.3. Access Control System

- An access control system is not required for areas with dose rates < 0.05 mSv/hour (5 mrem/hour). Machines capable of generating dose rates greater than this will require startup warnings, enclosures, personnel entryway doors/gates, interlocks and exclusion areas as specified in the current version of ANSI/HPS N43.1 -2011 Table 5.1 (see below).

Dose rate (mSv h ⁻¹) ^a	Dose category	Start-up warning	Enclosure	Personnel entryway door/gate	Interlock redundancy	Area secure system
0.05–1	Minimum	None	Rope	No restriction	None	
1–10	Low	Visible & audible	Barrier	Locked or interlocked	Recommended	Not required
10–100	Moderate	Visible & audible; emergency-off recommended	Barrier	Locked; interlock recommended	Recommended	Required (exclusion area)
> 100	High	Visible & audible; emergency-off	Barrier	Locked and interlocked	Required	

^a 1 mSv h⁻¹ = 0.1 rem h⁻¹.

The dose rate values refer to the maximum effective dose expected during any 1 h due to prompt radiation inside an accelerator or beamline housing area (operated within the operation envelope).

An ACS is required for an area with dose rates > 0.05 mSv h⁻¹ (5 mrem h⁻¹). Areas with dose rate levels ≤ 0.05 mSv h⁻¹ (5 mrem h⁻¹) are not subject to the ACS requirements in this section. Administrative access control requirements and recommendations to areas with dose rate ≤ 0.05 mSv h⁻¹ (5 mrem h⁻¹) are described in Section 8.0.

- If required, the access control system shall be:
 - ◆ Reliable, fail-safe, tamper-resistant
 - ◆ Subject to configuration control during operation and maintenance
 - ◆ Function and integrity checks conducted periodically
 - ◆ Certified annually

5.8.4. Machine Operations

- A readiness review shall be conducted prior to machine commissioning and formal authorization from SDSTA is required prior to any production of radiation.
- Machine commissioning shall be conducted prior to routine operation. Commissioning shall include:
 - Verification that machine operation and hazards are controlled.
 - Shielding verification survey.

- Machine operations shall be conducted only by radiation workers who that 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 machine control panel shall be staffed during operation (when the beam is turned on or potential hazards exist).
 - When the operator is not present, the machine should be turned off or the control panel access secured.
 - Under special operating conditions, a machine may be operated unattended, providing:
 - ◆ Potential emergencies are addressed beforehand.
 - ◆ Operating parameters and resulting 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 RSO permission.
- 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 and the Science Director and ESH Director. 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. Operational Radiation Safety Plan (ORSP)

- 5.9.1.** An ORSP (Operational Radiation Safety Plan) is created by using ESH-(11000-F)-190166 Operational Radiation Safety Plan shall be written for each specific experiment with significant radiation hazards as determined by the RSO; the ORSP shall be incorporated into routine practices and shall be clearly assigned to individuals who are trained and authorized to perform these tasks. The ORSP shall specify the activities, process measurements and evaluations necessary to maintain safe operations. At a minimum it shall include the following elements appropriate to the hazard (ESH-(11000-F)-190168 Radiation Producing Equipment Safety Assessment Form).
- Facility area access control.
 - Personal monitoring plan (See Section 5.3).
 - Measurement and control of radiation levels in the workplace and facility boundary.
 - Radiation instrument use and calibration.
 - Control of radioactive sources and waste.
 - Contamination monitoring and control.
 - Radiological environmental protection.
 - Facility cleanup and decommissioning.
- 5.9.2.** Areas of the facility with potential radiation hazards shall be classified and posted based on shielding design and area monitoring results.
- 5.9.3.** An area monitoring program shall be established to assure the dose rates and integrated doses within and external to the facility are within acceptable levels. At a minimum, the radiation levels around the machine shall be monitored.
- 5.9.4.** The facility shall evaluate (via measurements or calculations) the potential for activation or contamination of the accelerator or beam line components as well as the surrounding media
- 5.9.5.** The identification, characterization, processing, storage, transport, use or disposal of potentially radioactive sources or waste shall be addressed.

5.10. Training

- The RSO, or their designee, will deliver the NRC required training. Science collaborations shall be responsible for implementation of safety training and periodic retraining programs subject to SDSTA RSO review and approval.
- Individuals who work with radioactive sources shall receive basic radiation safety training that familiarizes them with radiation sources, risks in perspective to potential doses, methods to minimize dose, source hazards and control measures.
- Science collaborations shall be responsible for implementation of safety training and periodic retraining programs subject to SDSTA RSO review and approval.
- Individuals who operate or work in the vicinity of machines shall receive basic radiation safety training that familiarizes them with radiation sources, risks in perspective to potential doses, methods to minimize dose, machine hazards and controls.

5.11. Recordkeeping

5.11.1. All radiation safety records, including those listed below, shall be stored:

- Work instructions related to handling radioactive materials are reviewed and approved by SDSTA and are available in the respective experiment areas on DocuShare.
- Inventory of radioactive materials (ESH-(11000-F)-190167 Radioactive Source Inventory Form).
- List of Authorized Users and Radiation Users.
- Radioactive material receipts.
- Leak and contamination swipe test results.
- Procedures associated with accelerator operations (in respective science collaboration areas).

6.0 Documented Information/Related Documents

- 6.1.** ESH-(11000-F)-190168 Radiation Producing Equipment Safety Assessment Form
- 6.2.** ESH-(11000-F)-190166 Operational Radiation Safety Plan
- 6.3.** ESH-(11000-F)-190167 Radioactive Source Inventory Form
- 6.4.** ESH-(11000-F)-200744 Personnel Radiation Monitoring Badge Request Form
- 6.5.** ESH-(11000-WI)-190169 Radioactive Material Emergency/Spill Processes
- 6.6.** ANSI/HPS N43.1 “Safe Operating Practice for Users of Non-Medical X-Ray Radiographic and Radioscopic Equipment”, 2011
- 6.7.** OSHA 29 CFR Part 1910.1096
- 6.8.** Mining Safety and Health Administration Title 30 CFR §§ 57.5038
- 6.9.** DOT Title 49, Code of Federal Regulation