



Radiation Safety

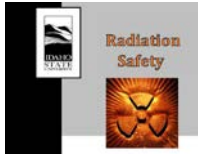


RADIATION PROCEDURES MANUAL PROCEDURE COVER SHEET

Procedure Title: Radiation Producing Machine Inspections
Procedure Number: RS-10 Rev 0
Effective Date: May 1, 2021

Reviewed By: Mason Jausi Date: 4/19/2021
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Radiation Safety Officer



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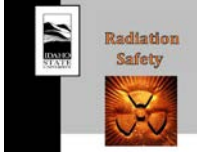
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1. INTRODUCTION

A radiation safety inspection of radiation producing machines is a systematic review of all operation and administrative radiation protection requirements for any device that produces ionizing radiation. The term radiation producing machine is used collectively in this procedure to include analytical and medical x-ray machines, particle accelerators, and neutron generators.

2. PURPOSE

This procedure provides instructions to Radiation Safety Department staff for performing, recording, and reporting the results of radiation producing machine inspections.

3. SCOPE

This procedure applies to annual radiation safety evaluations of laboratory spaces permitted for the use of radiation producing machines.

4. ROLES AND RESPONSIBILITIES

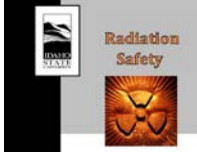
The Radiation Safety Officer (RSO) has the responsibility to perform an annual evaluation of each authorized user that is permitted the use of radiation machines. The responsibility of the machine inspection may be designated to radiation safety staff members and is at the discretion of the RSO.

The Authorized User (AU) has the responsibility to comply with requirements of their issued permit, requirements set in the Radiation Safety Manual, and the requirements in the Idaho Department of Health and Welfare regulations. The AU also has a responsibility to allow the radiation safety department to perform the inspection.

Radiation Safety Staff have the responsibility, when designated, to perform the laboratory evaluation in accordance with this procedure.

5. REQUIRED MATERIAL(S)

- Authorized Users Permit and Training Records
- List of State registered radiation producing machines
- RPR 10A – Radiation Producing Machine Inspection: Analytical X-Ray Machines
- RPR 10B – Radiation Producing Machine Inspection: Dental X-Ray Machines
- RPR 10C – Radiation Producing Machine Inspection: Medical X-Ray Machines
- RPR 10D – Radiation Producing Machine Inspection: Accelerators
- X-ray dose evaluation spreadsheet (as applicable)



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6. PROCEDURE

Prior to performing the inspection, the evaluator should be aware of the laboratory's status with regard to radiation producing machines. Prior to performing the physical audit, the evaluator should contact the Authorized User and schedule a time to walk through the laboratory.

6.1. Preliminary Steps (Records Verification)

Review the Authorized Users permit paying specific attention to the listed radiation producing machine(s) and permit requirements. Select the appropriate RPR 10 form for the Authorized User.

- RPR 10A is for permits with Analytical X-ray machines (Section 6.2).
- RPR 10B is for permits with Dental X-ray machines (Section 6.3).
- RPR 10C is for permits with Medical X-ray machines (Section 6.4).
- RPR 10D is for permits with Accelerators (Section 6.5).

6.1.1. Inventory

- a. Review the Authorized Users permitted radiation producing machine(s) and compare with the list of State registered radiation producing machines. List any inconsistencies on the RPR 10 form to be corrected on either the permit or with the State registration.

6.1.2. Dosimetry

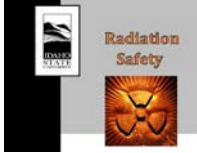
- a. Review the Landauer database to view all assigned occupational and area dosimetry. Note on the RPR 10 form if dosimetry has been issued to the Authorized User and their machine operators.

6.1.3. Dosimetry Records

- a. Review the dose quarterly and annual dose records for the assigned dosimeters and note if any recorded doses exceed the limits specified on the RPR10 form.

6.1.4. Training Records

- a. Contact the Authorized User for a list of all current laboratory workers.
- b. Verify the Authorized User and machine operators have completed the x-ray radiation safety training within the last 12 months by searching for each individual in the training records database.



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- c. Cross-reference the provided list with the current workers in the database. Ensure all laboratory workers are assigned the department applicable to the Authorized User. Archive any laboratory workers that no longer work for the university or operate radiation generating devices.

6.1.5. Safety Device By-Passes

- a. Review the RSO Documents (330) –Interlock Bypass folder on box for any active/inactive by-passes since the last inspection. If a by-pass record is present for the machine(s), note the nature and duration of the by-pass on the RPR 10 form and verify its status during the inspection.

6.1.6. Corrective Actions

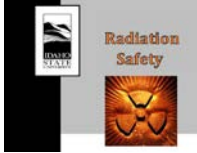
- a. Review the last inspection for any listed deficiencies. If deficiencies were identified, list them on the RPR 10 form and verify they have been corrected during the inspection.

6.2. Radiation Producing Machine Inspections – RPR 10A: Analytical X-Ray Machines

The State of Idaho Department of Health and Welfare regulates the use of Analytical X-ray machines under IDAPA 16.02.27. The State of Idaho has adopted the applicable sections of the Suggested State Regulations for Control of Radiation, Volume 1 (SSRCR): Part D (March 2003), Part H (January 1991), Part J (March 2003) as its regulatory requirements for the safe use of Analytical X-ray machines.

6.2.1. Postings, Labels, and Signs

- 6.2.1.1. Visually inspect the entrance door postings and ensure the following postings are present, in good condition, and up to date.
 - a. Current State Academic License
 - b. Chimera Signs (or equivalent)
 - c. X-ray Documents Notice
 - d. Radiation Safety Call List
 - e. Caution X-ray Generating Devices (or equivalent) sticker is on the entrance door.
 - f. Idaho X-ray Notice.
 - g. Idaho Department of Health and Welfare enforcement actions are posted as applicable.



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6.2.2. Facilities

- 6.2.2.1. Verify that work areas are uncluttered and adequate for approved procedures.
- 6.2.2.2. Verify the entrance doors to the x-ray machines are locked when unattended.

6.2.3. Equipment

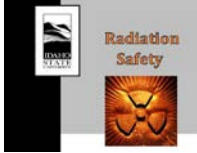
- 6.2.3.1. Verify the machine(s) appear to be in good operating condition.
- 6.2.3.2. Verify all machines are labeled with, the radiation symbol, and CAUTION – HIGH INTENSITY X-RAY BEAM on the source housing and CAUTION RADIATION – THIS EQUIPMENT PRODUCES RADIATION WHEN ENERGIZED near the switch, or words of similar intent.
- 6.2.3.3. Verify warning lights, with the words ‘X-RAY ON’ or similar is present and operating correctly.
- 6.2.3.4. Verify x-ray cabinet is interlocked and the cabinet cannot be opened while the beam is ON and that if any interlock is breached the primary beam is shut-off.
- 6.2.3.5. Verify the x-ray machine is secured from unauthorized access, inquire if there is key access control or the software is password protected.
- 6.2.3.6. Verify all indicators and controls that operate the beam are labeled and identifiable.

6.2.4. Administrative Controls

- 6.2.4.1. If dosimeters are required for operation, verify they are worn when necessary and correctly.
- 6.2.4.2. Verify if any safety devices have been by-passed since the last inspection. If yes, indicate if they were authorized in writing by the RSO, if each machine bypassed was properly posted, and if the machine was surveyed following the expiration of the safety bypass.

6.2.5. Records

- 6.2.5.1. Verify the Authorized User and all operators are current on their X-ray radiation safety training.
- 6.2.5.2. Verify if any maintenance or repair has been performed since the last survey. If yes, is there a maintenance record for each machine? Was a survey performed following the repair or maintenance?



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6.2.6. Operational Survey

- 6.2.6.1. Perform an operational survey with the machine running. The survey should be performed with an ion chamber that is sensitive to low-energy x-rays, i.e., Ludlum 9 open window. Take dose rate measurements 5-cm from the cabinet (x-ray tube housing) and record the highest exposure rate. Take subsequent measurements at the operator's location and location of the nearest public area, record the highest exposure rate readings.

6.3. Radiation Producing Machine Inspections – RPR 10B: Dental X-Ray Machines

The State of Idaho Department of Health and Welfare regulates the use of dental X-ray machines under IDAPA 16.02.27. The State of Idaho has adopted the applicable sections of the Suggested State Regulations for Control of Radiation, Volume 1 (SSRCR): Part D (March 2003), Part F (May 2009), Part J (March 2003) as its regulatory requirements for the safe use of Dental X-ray machines.

6.3.1. Postings, Labels, and Signs

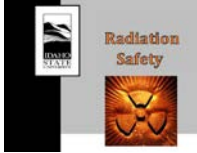
- 6.3.1.1. Visually inspect the clinic postings and ensure the following postings are present, in good condition, and up to date.
- a. Current State Medical License
 - b. State Notice to Workers
 - c. X-ray Documents Notice
 - d. Radiation Safety Call List.
 - e. Idaho Department of Health and Welfare enforcement actions are posted as applicable.

6.3.2. Facilities

- 6.3.2.1. Verify all entrance doors are locked if unattended.
- 6.3.2.2. Verify that exposure control is permanently mounted in a protected area for fixed dental systems.

6.3.3. Equipment

- 6.3.3.1. Verify the x-ray machine(s) appear to be in good operating condition.



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- 6.3.3.2. Does the control panel containing the main power switch bear the following label: “WARNING: This x-ray unit may be dangerous to patient and operator unless safe exposure factors, operating instructions and maintenance schedules are observed.”?
- 6.3.3.3. Verify the control panel provides visual indication whenever x-rays are produced and that all lights, and indicators of the primary beam are present, and an audible signal indicates to the operator an exposure has been terminated.
- 6.3.3.4. Verify that a radiation exposure is only possible through deliberate action of the operator and that the machine is secured from unauthorized operation.
- 6.3.3.5. For mounted system(s) verify that a tube stand or other mechanical support is used.
- 6.3.3.6. Verify each machine(s) nominal fixed kVp is not less than 50.
- 6.3.3.7. Verify that a secondary radiation block is used when hand-held dental x-ray systems are operated.

6.3.4. Administrative

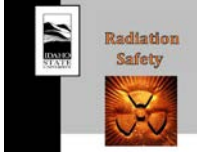
- 6.3.4.1. Verify dosimeters (area or personnel) are in use and worn or placed in the appropriate locations.
- 6.3.4.2. Verify that written operating procedures are available for all operators of the x-ray machines.

6.3.5. Records

- 6.3.5.1. Verify appropriate x-ray radiation safety training records are on file for all operators.
- 6.3.5.2. Verify maintenance records are available for each machine.
- 6.3.5.3. Verify that facility specific training records are on file for all x-ray machine operators.

6.3.6. Operational Survey

- 6.3.6.1. Access the X-ray dose evaluation spreadsheet and perform integrated dose measurements, with the Ludlum 9DP or equivalent instrument, with x-ray source directly in contact with the active area of the detector centered on the dimple. Record kV, mA, and dose. If possible note annual and total X-ray count for the machine. Repeat for each system.



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6.4. Radiation Producing Machine Inspections – RPR 10C: Medical X-Ray Machines

The State of Idaho Department of Health and Welfare regulates the use of Medical X-ray machines under IDAPA 16.02.27. The State of Idaho has adopted the applicable sections of the Suggested State Regulations for Control of Radiation, Volume 1 (SSRCR): Part D (March 2003), Part F (May 2009), Part J (March 2003) as its regulatory requirements for the safe use of Medical X-ray machines.

6.4.1. Postings, Labels, and Signs

6.4.1.1. Visually inspect the entrance door postings and ensure the following postings are present, in good condition, and up to date.

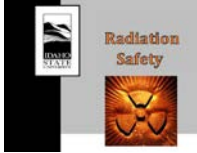
- a. Current State Medical License
- b. State Notice to Workers
- c. X-ray Documents Notice
- d. Radiation Safety Call List.
- e. Idaho Department of Health and Welfare enforcement actions are posted as applicable.

6.4.2. Facilities

6.4.2.1. Verify all entrance doors are locked if unattended.

6.4.3. Equipment

- 6.4.3.1. Verify the x-ray machine(s) appear to be in good operating condition.
- 6.4.3.2. Does the control panel containing the main power switch bear the following label: “WARNING: This x-ray unit may be dangerous to patient and operator unless safe exposure factors, operating instructions and maintenance schedules are observed.”?
- 6.4.3.3. Verify the x-ray control panel provides visual indication when x-rays are produced, and an audible signal indicates to the operator an exposure has been terminated.
- 6.4.3.4. Verify the x-ray machine is secured from unauthorized personnel when not in operation.
- 6.4.3.5. Verify that a tube stand or other mechanical support is used for portable x-ray system(s).



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- 6.4.3.6. Verify that a radiation exposure is only possible through deliberate action of the operator.

6.4.4. Administrative

- 6.4.4.1. Verify dosimeters (area or personnel) are in use and worn or placed in the appropriate locations.
- 6.4.4.2. Verify that written operating procedures are available for all operators of the x-ray machines.

6.4.5. Records

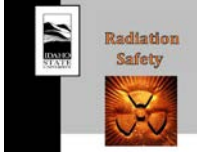
- 6.4.5.1. Verify appropriate x-ray radiation safety training records are on file for all operators.
- 6.4.5.2. Verify maintenance records are available for each machine (e.g. Turn Key equipment performance evaluation records).
- 6.4.5.3. Verify that facility specific training records are on file for all x-ray machine operators.

6.5. Radiation Producing Machine Inspections – RPR 10D: Accelerators

The State of Idaho Department of Health and Welfare does not regulate the use of particle accelerators under IDAPA 16.02.27. However, ISU particle accelerators are registered with the State of Idaho as Academic X-ray Producing machines. The RPR 10D inspection form was developed using recommendations from the Suggested State Regulations for Control of Radiation, Volume 1 (SSRCR): Part I (January 1991).

6.5.1. Postings, Labels, and Signs

- 6.5.1.1. Visually inspect the entrance door postings and ensure the following postings are present, in good condition, and up to date.
- a. Current State Academic License
 - b. State Notice to Workers
 - c. X-ray Documents Notice
 - d. Radiation Safety Call List.
 - e. Idaho Department of Health and Welfare enforcement actions are posted as applicable.



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6.5.2. Facilities

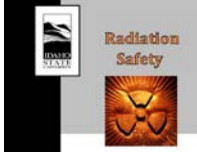
- 6.5.2.1. Verify all entrance doors are locked if unattended.

6.5.3. Equipment

- 6.5.3.1. Verify the accelerator control console(s) appear to be in good operating condition; all instrumentation, readouts, and controls are clearly identifiable.
- 6.5.3.2. Verify that each entrance to a high radiation area is interlocked and shuts the machine down under conditions of barrier penetration.
- 6.5.3.3. Verify easily observable flashing warning lights are present at the entrance to each high radiation area.
- 6.5.3.4. Verify that each high radiation area has an audible warning device which is activated for 15 seconds prior to the creation of a high radiation area.
- 6.5.3.5. Verify that all barriers and pathways leading to a high radiation area are properly posted.
- 6.5.3.6. Verify all safety interlock systems (including SCRAMs) are on independent circuits, of fail-safe design, must be manually reset when tripped, are easily identifiable, and the accelerator cannot be powered up if an interlock has tripped.
- 6.5.3.7. Verify that a radiation exposure is only possible through deliberate action of the operator and that the machine is secured from unauthorized operation.
- 6.5.3.8. Verify a 'Beam-On' light is present and functioning near any switch that energizes the system.
- 6.5.3.9. Verify the control panel containing the main power switch bear the following label: "Caution Radiation: This equipment produces radiation when energized".

6.5.4. Administrative

- 6.5.4.1. Verify dosimeters are in use and worn appropriately.
- 6.5.4.2. Verify that written operating and emergency procedures are available for all accelerator operators.
- 6.5.4.3. Confirm that safety interlock systems are not used to turn off the primary beam (except in an emergency) and the all safety interlock systems are tested quarterly.
- 6.5.4.4. Verify that electrical circuit diagrams of the accelerator and associated interlock systems are maintained and available to each accelerator operator.



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6.5.4.5. Verify if any safety system has been bypassed since the last inspection. If yes, indicate if the AU has received written permission from the RSO to bypass the safety system, if the bypass is still in effect, and if a permanent record of the bypass has been logged.

6.5.5. Records

- 6.5.5.1. Verify radiation safety training records are on file for all operators.
- 6.5.5.2. Verify that facility specific training records are on file for all accelerator operators.
- 6.5.5.3. Verify that periodic contamination surveys have been performed in the accelerator halls and recorded for operations above 10 MeV.

6.5.6. Instrumentation

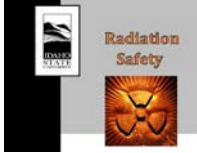
- 6.5.6.1. Verify all instruments are calibrated, properly ranged, checked prior to operation, functioning properly, and a record exists for each check.

6.5.7. Safety Device Testing

- 6.5.7.1. Test all safety system warning lights, alarms, interlocks, and SCRAM buttons to verify proper operation. Note the devices tested in the General Comments section. If any device fails, or is out of service, notify the Authorized User.

7. REFERENCES

None.



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Supplement 1 – Survey Procedure for X-Ray Producing Machines

This supplement outlines the procedure for performing barrier verification and shielding adequacy surveys for installation or modification of x-ray generating devices. In addition, instructions are provided for surveying high voltage equipment such as electron microscopes to ensure the X-ray dose rate is below the threshold for registration with the Idaho Department of Health and Welfare (B.4.a.).

Barrier Verification Survey

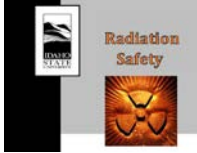
The shielding survey is performed prior to the installation of an x-ray machine and is intended to look for voids in the shielding materials such as electrical outlets, improper joints, or improperly installed shielding. Obtain a low-energy gamma emitting source (e.g. Co-57 or Cd-109) of sufficient activity. The RSO is to be involved in this process to ensure all transportation and license requirements are met with the transfer and use of the source.

- 1) The source is placed on one side of the barrier around possible locations of inadequate shielding.
- 2) Using a NaI scintillation detector (Ludlum Model-19) or GM frisker in audible mode measure the other side of the barrier. Record the highest dose rate or count rate measurement at each location. Also perform measurements of barrier points known to be complete for comparison.
- 3) The RSO will review the data to determine if any repairs are necessary.

Shielding Adequacy Survey

The initial survey is intended to be performed following the installation of a diagnostic x-ray machine. See NCRP 147 Chapter 6 for details. The survey process is as follows:

- 1) Position a phantom in the primary beam
- 2) Irradiate the phantom with the x-ray machine at the highest expected voltage and exposure time and measure the integrated exposure with a Ludlum 9DP or equivalent at the closest position to the machine operator. (This might be non-conservative if there is line of sight to the operator because the detection threshold for the 9DP is 40 keV. Personnel dosimeters worn for a year will ensure that operators are not exposed above applicable limits).
- 3) Irradiate the phantom with the x-ray machine at the highest expected voltage and exposure time and measure the integrated exposure with a Ludlum 9DP or equivalent on the exterior of each wall and door around the room and above/below the floor and ceiling for rooms above and below. Include one measurement in line with the x-ray beam.



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- 4) Obtain the expected usage of the machine for a year from the authorized user.
- 5) Multiply the exposure per use for each location by the expected usage to determine the total exposure for the year.
- 6) Compare the annual exposure predictions to the regulatory dose limits and recommend any shielding adjustments or ALARA controls as necessary.

Survey of Other High Voltage Equipment (e.g. electron microscopes)

The survey of high voltage equipment (transmission electron microscopes (TEMs), focused ion beams (FIBs), etc.) is performed to verify the chamber adequately reduces the dose rate to less than 0.5 mrem/hr at 5-cm from the instrument housing. Perform the dose rate measurements with a Ludlum Model 9 open window at 5-cm from the housing and record the highest reading. Document the survey and indicate if the dose rate is less than or exceeds the 0.5 mrem/hr limit. If the dose rate exceeds the limit, contact the RSO. The RSO will evaluate if shielding adjustments or ALARA controls are necessary. File the survey for the instrument in the appropriate Box Records folder.