# Table of Contents

- Executive Summary ................................................................................................................................. 5
- Introduction ................................................................................................................................................. 6
- Potential Hazards of X-Ray and Radiation-Generating Devices .............................................................. 6
  - Analytical X-Ray Devices ..................................................................................................................... 6
  - Industrial Radiography and Cabinet Irradiation Devices ................................................................... 7
- Definitions .................................................................................................................................................. 8
- Responsibilities ......................................................................................................................................... 9
  - University Radiation Safety Officer and the Radiation Safety Section (RSS) ..................................... 9
  - Principle Investigator (PI) ................................................................................................................... 9
  - Individual Users .................................................................................................................................. 9
  - X-ray Subcommittee of the University Radiation Safety Committee (URSC) ..................................... 9
- Planning .................................................................................................................................................... 10
- Inspections, Surveys, and Inventory ........................................................................................................ 10
- Violations ................................................................................................................................................ 10
- Availability of Applicable Documents ...................................................................................................... 10
- Radiation Safety Procedures .................................................................................................................. 11
  - Electron Microscopes ......................................................................................................................... 11
  - Industrial Analytical Radiation-Generating Equipment ..................................................................... 13
  - Industrial Radiography and Irradiation Devices ................................................................................. 15
  - Bone Densitometers – Non-Human Use Only .................................................................................... 19
- Radiation Dose Limits and Notification to the Ohio Department of Health of Overexposures ............... 21
  - Occupational Dose Limits .................................................................................................................. 21
- Instructions for Principal Investigators and Individual Users ................................................................. 21
- Instructions for Radiation Safety Section .............................................................................................. 21
Executive Summary

X-ray generating machines and other ionizing radiation-generating devices (RGD) present a potential safety hazard to students, staff, and faculty if the device is not used and/or stored properly. Safety requirements for electron microscopes, bone densitometers, and analytical, industrial radiography, and irradiation x-ray devices are listed in this manual and the Ohio Department of Health regulations.

The Ohio Department of Health (ODH) regulates the registration, use, transfer, and disposal of radiation-generating devices in the State of Ohio.

This document outlines The Ohio State University (University) rules and regulations for the safe operation of radiation-generating devices (non-human use) and specifies practices to aid radiation-generating equipment users in minimizing their exposure to radiation. These measures are taken to comply with ODH regulations, and shall succeed only when each user follows the actual guidelines contained in this document.

Examples of analytical equipment and instruments that may generate secondary x-rays include:

- X-ray Diffractometers,
- X-ray Photoelectron Spectrometers,
- X-ray Fluorescence Spectrometer,
- Transmission or Scanning Electron Microscopes, and
- Gauging Units.

In addition to analytical equipment, other types of regulated radiation-generating devices include:

- X-ray Baggage Units,
- Industrial Radiography Devices,
- X-Ray Irradiation Devices,
- Portable X-ray Radiography
- Bone Densitometers,
- Industrial/Research Computed Tomography,
- Industrial/Research Tomography, and
- Particle Accelerator.

These machines may be intended for laboratory or field use, with applications in academic settings. Much of this equipment is manufactured commercially, however, custom-built x-ray generating equipment is found at the University. Some of the older x-ray generating devices do not meet current regulatory safety standards.

This manual was developed to assist University personnel in meeting safety and regulatory requirements, and provide integration of state occupational radiation protection standards. Reviewed in this manual are types of equipment, occupational radiation exposure limits, and radiation protection regulations and recommendations. Additionally, safety program issues pertaining to equipment, facilities, and personnel are discussed.

Surveys of various instruments and equipment have shown that changes in operating conditions or components have the potential for increasing ambient radiation fields. The implementation of sound radiation safety principles when operating x-ray generating equipment will provide personnel protection from acute radiation hazards, and limit chronic radiation exposure to levels as low as reasonably achievable (ALARA).
Introduction

X-ray generating machines and other ionizing RGDs present a potential safety hazard to students, staff, and faculty if the device is not used and/or stored properly. The Radiation Safety Section of Environmental Health and Safety is required to register, maintain a current inventory / registration, and through inspection ensure the compliance of all x-ray devices located within the University to applicable regulatory standards / guidance. The ODH will inspect the University’s x-ray devices and operations on a periodic basis. For research and analytical devices this period is every three (3) years. The ODH has the authority to issue violations for any regulation that an x-ray user, researcher, or Principal Investigator (PI) is not following.

This manual is intended to inform non-human/non-medical use x-ray device users of the regulations with which they are required to comply. If there are any questions concerning the applicability of any regulation, please contact the Radiation Safety Section of Environmental Health and Safety at:

1) (614) 292-1284 (Main Office)
2) radiation.safety@osu.edu

Radiation Emergency Cell Phone – (614) 561-7969 (24-Hour)

Additional information and standard operating procedure templates for electron microscopes and analytical radiation-generating equipment can be found at ehs.osu.edu.

Potential Hazards of X-Ray and Radiation-Generating Devices

Analytical X-Ray Devices

The most common non-medical x-ray device found throughout the University is referred to as an analytical x-ray or analytical radiation-generating device. This includes x-ray diffractometers, x-ray photoelectron spectrometers, x-ray fluorescence spectrometers, and electron microscopes. These types of devices are used to evaluate the elemental or chemical composition or microscopic structure of a material. These devices feature a primary x-ray beam consisting of low energy x-rays at a very high intensity and are strictly collimated to examine the properties of a material. For that reason the exposure to the primary x-ray beam can result in a high amount radiation absorbed (dose) to the user. Despite the low energy of the x-rays, primary beam intensities up to 40,000 roentgens per minute (R/min) may be possible. Exposure of extremities to the primary x-ray beam can result in severe radiation burns in a matter of seconds. Radiation burns are the principle hazard associated with the use of analytical x-ray devices.

The primary x-ray beam is not the only hazard associated with these devices. Leakage or scatter of the primary x-ray beam through apertures in ill-fitting or defective devices can produce very high intensity beams of possibly small and irregular cross section. Dose rates near the device from scattered radiation can also be very high. Although not likely to cause burns, exposure to and subsequent absorbed doses from the scattered radiation can exceed regulatory limits if the beam is not properly enclosed or contained. In fluorescence, the primary beam strikes the sample inside a shielded enclosure, and only scattered radiation and secondary beam radiation excited in the sample as a result of irradiation emerges from the machine for analysis. Consequently, external levels are much lower in the fluorescence mode than in the x-ray diffraction mode.

Modern x-ray diffraction machines incorporate shielding and safety design features to prevent both acute local accidental exposure and chronic exposure to radiation. Operators should be especially cognizant of protective devices incorporated into their machines and the possibility for failure or malfunction. In addition, decreasing time, increasing distance, and shielding represent the most practical methods a radiation worker can use to minimize radiation exposure.
Industrial Radiography and Cabinet Irradiation Devices

X-ray radiography systems use non-destructive methods to examine the macroscopic structure of materials. Radiography systems can be categorized as open beam systems which are generally contained within a permanent radiographic installation or an enclosed system where the primary beam is contained within a closed cabinet and excludes all personnel and extremities from admittance.

Cabinet irradiation systems are used to alter the chemical, biological, or physical properties of a material or to sterilize a material. Cabinet irradiation systems by definition are irradiations that occur within a cabinet x-ray system; an x-ray system that is installed within a shielded enclosure termed a cabinet, such that the dose rates at all exterior surfaces comply with regulations while excluding all personnel and extremities from admittance.

For these reasons an even greater potential hazard due exists with these devices as higher applied voltages and the longer exposure times are used as compared to analytical x-ray devices. Typical applied voltages of 200 kiloelectron volts (keV) or greater are common. Additional regulations apply to these devices.
Definitions

- “Analytical radiation-generating equipment” means a group or system of components which produce ionizing radiation as either a primary or a secondary result and is used to determine properties of materials being measured or analyzed. Analytical radiation-generating equipment includes, but is not limited to, gauging units, electron microscopes, x-ray diffraction, and spectrometer devices.
- "Annual" means at least once a year, not to exceed fourteen months.
- "Cabinet irradiation" means irradiation conducted using a cabinet x-ray system.
- "Cabinet radiography" means radiography conducted using a cabinet x-ray system.
- "Cabinet x-ray system" means an x-ray system with the x-ray tube installed in a shielded enclosure termed a cabinet, such that every location on the exterior of the cabinet meets the dose limits for individual members of the public as specified in rule 3701:1-38-13 of the Administrative Code. A cabinet x-ray system is independent of existing architectural structures except the floor on which it may be placed; is intended to contain at least that portion of a material being irradiated; and must exclude all personnel, including extremities, from its interior during the generation of radiation.
- "Calibration" means the determination of the response or reading of an instrument relative to a series of known radiation values over the range of the instrument, or the radiation output of a source of radiation relative to a standard.
- "Collimator" means a device or mechanism by which the x-ray beam is restricted in size.
- "Enclosed system" means industrial radiation-generating equipment operated in an enclosure or cabinet and may include, but is not limited to, cabinet radiography, irradiation devices, and other equipment.
- "Fail-safe characteristics" means a design feature which causes beam port shutters to close, or otherwise prevents emergence of the primary beam, upon failure of a safety or warning device.
- "Hand-held" means radiation-generating equipment that is specifically designed to be held in the hand during operation.
- "Individual user" is a trained and qualified operator using RGD under the supervision of a PI.
- "Industrial radiation-generating equipment" means any x-ray device other than those used on patients for medical diagnosis or therapy purposes, including, but not limited to, industrial radiography equipment, irradiators, analytical devices, and particle accelerators.
- "Industrial radiographer" means any individual who performs or personally supervises industrial radiographic operations and who is responsible to the registrant for assuring compliance with the requirements of these regulations and certification of registration conditions.
- "Industrial radiography equipment" means radiation-generating equipment which produces ionizing radiation to examine the macroscopic structures of material by nondestructive testing methods.
- "Irradiation devices" means radiation-generating equipment used to alter the chemical, biological, or physical properties of materials or to sterilize materials.
- "Leakage radiation" means all radiation coming from within the x-ray tube housing except the useful beam.
- "Nondestructive testing (NDT)" means the development and application of technical methods to examine materials or components in ways that do not impair future usefulness and serviceability in order to detect, locate, measure and evaluate flaws; to assess integrity, properties and composition; and to measure geometrical characteristics.
- "Open-beam" means analytical radiation-generating equipment in which an individual could place any part of his or her body in the primary beam during normal operation.
- "Permanent radiographic installation" means an enclosed shielded room, cell, or vault, not located at a temporary jobsite, in which industrial radiography is performed. Permanent radiographic installation includes a cabinet x-ray system used for industrial radiography that is large enough to walk into.
- "Principal Investigator (PI)" is the individual responsible for the operation and handling of the device.
- "Shutter" means a device, fixed to any industrial radiation-generating equipment housing to intercept the useful beam.
Responsibilities

University Radiation Safety Officer and the Radiation Safety Section (RSS)

1) Maintain an accurate inventory and registration of all devices with ODH.
2) Perform audits / inspections, surveys, and inventory checks of all registered RGDs at intervals required.
3) Actively advise PIs and individual users on the safe use of RGD.

Principle Investigator (PI)

1) Primary authority, responsibility, and accountability for ensuring regulatory compliance and radiological safety within their work group as set forth in this manual and with the ODH regulations.
2) Notify RSS of the acquisition, relocation, transfer, or disposal of any x-ray or RGD.

Notification should be submitted in a timely fashion via form RGD-1 “Registration for the Use/Storage of Radiation-Generating Devices,” located at:

Registration for the Use/Storage of Radiation-Generating Devices

Please email the completed form to radiation.safety@osu.edu.

3) Actively train and advise individual users on the safe use of RGD.
4) Reporting any unsafe working conditions and/or defective devices to Radiation Safety.

Individual Users

1) Compliance with this manual and the ODH regulations.
2) Reporting any unsafe working conditions and/or defective devices to their associated PI and/or Radiation Safety.

X-ray Subcommittee of the University Radiation Safety Committee (URSC)

1) Provide recommendations to the URSC regarding research and clinical uses of ionizing radiation-generating devices.
2) Monitor the University program to maintain occupational doses as low as reasonably achievable including a review of investigations into ALARA level II exposures.
3) Review and make recommendations on inspection results from the Ohio Department of Health and corrective actions implemented by the University.
4) Perform an annual audit of the X-ray Safety Program.
5) Review radiation incidents with respect to cause and corrective actions.
Planning

The importance of planning the installation and use of machines cannot be overemphasized. Adequate lead times must be allowed for review of facilities that require new construction or remodeling and registration with ODH. Pre-operational evaluation of shielding and operating procedures shall be also required before routine use of such machines can be authorized.

Inspections, Surveys, and Inventory

The ODH will inspect all x-ray and radiation-generating devices on a periodic basis, the current ODH inspection schedule is every three (3) years. ODH has the authority to issue violations of the regulations. If the device PI does not correct these violations within 30 days, the ODH has the authority to issue a “Cease Operations Order”. Financial penalties may also be assessed the PI.

The Radiation Safety Section shall perform audits / inspections, surveys, and inventory checks with the appropriate frequencies as indicated in the appropriate section of the ODH regulations. RSS will also perform an annual inventory of all inoperable units.

Violations

It is the responsibility of the PI to provide written corrective actions to inspections performed by the ODH to the Radiation Safety Section of Environmental Health and Safety. RSS is responsible for providing a collective response to the ODH. Failure of a PI to provide the written corrective action within the 30-day period may result in civil penalties by the ODH and a “Cease Operations Order” from the ODH.

Violations posing an imminent health hazard shall result in immediate cessation of the specific activity in that facility.

Administrative violations not corrected promptly will be referred to the University Radiation Safety Officer and/or the X-ray Subcommittee of the URSC for resolution and may result in temporary suspension of the use of the equipment.

Availability of Applicable Documents

Copies of the University’s registrations, inspection findings, and a current copy of the Ohio Administrative Code are available for review in the Radiation Safety Section of Environmental Health and Safety located in Room 106, Research Center Building, 1314 Kinnear Road, Columbus, Ohio 43212.

A copy of the Ohio Administrative Code (OAC) regulations can also be located at:

1) ODH Radiation Protection Rules and Regulations
2) Industrial Radiation-Generating Equipment
   a. 3701:1-68-03 ~ Industrial Radiography and Irradiation Devices
   b. 3701:1-68-04 ~ Industrial Analytical Radiation-Generating Equipment
Radiation Safety Procedures

Electron Microscopes

- Principle investigators and individual users of electron microscopes must maintain compliance with OAC 3701:1-68-04.

Note that handlers of electron microscopes and photoelectron spectrometers shall be exempt from the requirements of paragraphs (C)(2)(b) to (C)(2)(f), paragraph (C)(3), paragraphs (C)(4)(a) to (C)(4)(b), and paragraphs (C)(4)(d) to (C)(4)(e) of OAC 3701:1-68-04.

- Requirements include (but are not limited to) the following items:
  - Submission of a completed RGD-1 Form, “Registration for the Use/Storage of Radiation Generating Device” to Radiation Safety as described in the Responsibilities section (Page 7).
  - Laboratory/device location should be labeled as follows (or similar). Contact Radiation Safety or your Laboratory Compliance Officer for room signage.

  ![CAUTION X-RAY RADIATION]

  - All analytical radiation-generating equipment shall conspicuously display a clearly legible label or labels bearing the radiation symbol and the words "CAUTION - THIS EQUIPMENT PRODUCES RADIATION WHEN ENERGIZED" or appropriate words having a similar intent, near any switch or control that directly energizes the unit. Contact Radiation Safety or your Laboratory Compliance Officer for labels. Example:

    ![CAUTION X-RAYS THIS EQUIPMENT PRODUCES X-RAYS WHEN ENERGIZED]

  - Radiation measured at five (5) centimeters from the surface shall not exceed 0.25 millirem in one hour. Radiation Safety will perform a radiation survey of the device post installation; requests for additional radiation surveys of your device can be made at any time to Radiation Safety.
  - No PI shall permit any individual to operate the device until such individual has received a copy of, and instruction in, the operating procedures for the equipment and has demonstrated competence in its use. Maintain documentation that individual users have received appropriate training.
  - Maintain written standard operating procedures. This may include the manufacturer’s manual, but may not rely exclusively upon it.
A template standard operating procedure (SOP) including a training log for electron microscopes is available from Radiation Safety (http://ehs.osu.edu/RadSafety/Xray.aspx).

- Inform Radiation Safety of the repair, acquisition, relocation, transfer, or disposal of any unit. Radiation Safety must also be notified if an operable unit becomes inoperable or an inoperable unit is returned to service.
- ODH “Notice to Employees” is conspicuously posted. Contact Radiation Safety or your Laboratory Compliance Officer for a copy of this posting.

- Radiation Safety Responsibilities:
  - Perform an initial radiation survey of all newly installed electron microscopes.
  - Perform an annual inspection / audit of all operable devices including device documentation.
  - Perform an annual inventory of all inoperable devices.
  - Maintain the ODH registration of all electron microscopes.
Industrial Analytical Radiation-Generating Equipment

- Principle investigators and individual users of industrial analytical radiation-generating equipment must maintain compliance with OAC 3701:1-68-04.

Note that handlers of gauging units shall be exempt from the requirements of paragraphs (C)(2)(c) to (C)(2)(e) of OAC 3701:1-68-04.

Handers of hand-held open beam analyzer systems shall maintain compliance with paragraph (F) of OAC 3701:1-68-04.

- Requirements include (but are not limited to) the following items:
  - Submission of a completed RGD-1 Form, “Registration for the Use/Storage of Radiation Generating Device” to Radiation Safety as described in the Responsibilities section (Page 7).
  - Laboratory/device location should be labeled as follows (or similar). Contact Radiation Safety or your Laboratory Compliance Officer for room signage.

  o All analytical radiation-generating equipment shall conspicuously display a clearly legible label or labels bearing the radiation symbol and the words "CAUTION - THIS EQUIPMENT PRODUCES RADIATION WHEN ENERGIZED" or appropriate words having a similar intent, near any switch or control that directly energizes the unit.

Analytical radiation-generating equipment with open-beam configurations shall have an additional warning label on or near the x-ray housing with the radiation symbol with the words "CAUTION - HIGH INTENSITY X-RAY BEAM" or appropriate words having a similar intent. Contact Radiation Safety or your Laboratory Compliance Officer for labels. Examples:

  - Open-beam configurations and all other equipment installed after February 10, 2006, shall be provided with a readily visible warning light labeled with the words "X-RAY ON" or symbols having a similar intent, and be located near the x-ray source and its controls and be illuminated when the x-ray source is energized. In addition, open beam configurations shall be provided with a readily discernible indication of:
• X-ray source power "on-off" status located near the radiation source housing, if the primary beam is controlled in this manner; or
• Shutter "open-closed" status located near each radiation port on the source housing, if the primary beam is controlled in this manner.

  o Except for gauging units, open-beam systems installed after February 10, 2006, shall have warning devices, or a system of warning devices, such as redundant lights with fail-safe characteristics.
  o Each radiation source housing shall be equipped with an interlock that shuts off the radiation beam before the source is removed from the radiation source housing or before the housing is disassembled. For each radiation source installed prior to the effective date of OAC 3701:1-68-04 (February 15, 2001) and not equipped with an interlock, administrative controls shall be instituted to include that the power shall be disconnected before any disassembly.
  o Unused radiation ports on radiation source housings shall be secured in the closed position, or mechanically blocked.
  o Radiation measured at five (5) centimeters from the surface shall not exceed 0.25 millirem in one hour. Radiation Safety will perform a radiation survey of the device post installation and annually thereafter. Additional radiation surveys may be necessary as described below.
  o No PI shall permit any individual to operate the device until such individual has received a copy of, and instruction in, the operating procedures for the equipment and has demonstrated competence in its use. Maintain documentation that individual users have received appropriate training.
  o Maintain written standard operating procedures. This may include the manufacturer’s manual, but may not rely exclusively upon it.

A template standard operating procedure (SOP) including a training log for analytical RGD is available from Radiation Safety (http://ehs.osu.edu/RadSafety/Xray.aspx).

  o Inform Radiation Safety of the repair, acquisition, relocation, transfer, or disposal of any unit. Radiation Safety must also be notified if an operable unit becomes inoperable or an inoperable unit is returned to service.
  o ODH “Notice to Employees” is conspicuously posted. Contact Radiation Safety or your Laboratory Compliance Officer for a copy of this posting.

• Radiation Safety Responsibilities:

  o Perform radiation surveys:
    ▪ Upon installation of the analytical radiation-generating equipment.
    ▪ Following any change in the initial arrangement, number, or type of local components in the system.
    ▪ Following any maintenance requiring the disassembly or removal of a local component in the system.
    ▪ During the performance of maintenance and alignment procedures if the procedures require the presence of a primary x-ray beam when any local component in the system is disassembled or removed.
    ▪ Any time a visual inspection of the local components in the system reveals an abnormal condition.
    ▪ Whenever personnel monitoring reports show an unexplained increase over the previous monitoring period or the readings are approaching the limits specified in rules adopted pursuant to Chapter 3701:1-38 of the Administrative Code.
    ▪ Perform semi-annual inspections of all radiation safety devices, such as interlocks, lights, and labels. Additionally a semi-annual audit of the device documentation will be performed.
    ▪ Perform an annual radiation survey.
    ▪ Perform an annual inventory of all inoperable units.
    ▪ Maintain the ODH registration of all industrial analytical radiation-generating equipment.
Industrial Radiography and Irradiation Devices

- Principle investigators and individual users of industrial radiography and irradiation radiation-generating equipment must maintain compliance with OAC 3701:1-68-03.

Note cabinet irradiation devices not large enough to walk into and designed to exclude all personnel, including extremities, from the interior of the cabinet during the generation of radiation, are exempt from paragraphs (A) to (H)(1) of OAC 3701:1-68-03 but must comply with paragraphs (H)(2) through (H)(5).

These include:

- Submission of a completed RGD-1 Form, “Registration for the Use/Storage of Radiation Generating Device” to Radiation Safety as described in the Responsibilities section (Page 7).
- Laboratory/device location should be labeled as follows (or similar). Contact Radiation Safety or your Laboratory Compliance Officer for room signage.

- All irradiation radiation-generating equipment shall conspicuously display a clearly legible label or labels bearing the radiation symbol and the words "CAUTION - THIS EQUIPMENT PRODUCES RADIATION WHEN ENERGIZED" or appropriate words having a similar intent, near any switch or control that directly energizes the unit. Contact Radiation Safety or your Laboratory Compliance Officer for labels. Example:

- No PI shall permit any individual to operate the device until such individual has received a copy of, and instruction in, the operating procedures for the equipment and has demonstrated competence in its use. Maintain documentation that individual users have received appropriate training.
- Maintain written standard operating procedures. This may include the manufacturer’s manual, but may not rely exclusively upon it.
- Tests for proper operation of high radiation area control devices, interlocks, warning lights, and labels shall be conducted, recorded, and maintained on three (3) month intervals, not to exceed fourteen (14) weeks.
A certified enclosed system shall be maintained in compliance with requirement in 21 C.F.R. 1020.40 (as published in the April 1, 2007 Code of Federal Regulations) and Radiation Safety shall maintain documentation of compliance between inspections.

Radiation emitted from the cabinet system shall not exceed a dose equivalent of 0.5 millirem in one hour at any point five (5) centimeters outside the external surface.

Irradiation devices shall not be used to intentionally irradiate human beings for any purpose.

ODH “Notice to Employees” is conspicuously posted. Contact Radiation Safety or your Laboratory Compliance Officer for a copy of this posting.

The remainder of these requirements apply to traditional industrial radiography equipment only and include (but are not limited to) the following items:

- Submission of a completed RGD-1 Form, “Registration for the Use/Storage of Radiation Generating Device” to Radiation Safety as described in the responsibilities section (Page 7).
- Industrial radiographers and assistants must be certified (40 hr training) through an independent approved program.
  - No individual other than an industrial radiographer or an industrial radiographer assistant who is under the personal supervision of an industrial radiographer shall manipulate controls or operate equipment used in radiographic operations.
- Laboratory/device location should be labeled as follows (or similar) as applicable. Contact Radiation Safety or your Laboratory Compliance Officer for room signage.
- A lock designed to prevent unauthorized or accidental production of ionizing radiation shall be provided.
  - Industrial radiography equipment and irradiation devices shall be kept locked at all times, to prevent tampering or removal by unauthorized personnel, except when under the direct surveillance of an industrial radiographer or industrial radiographer assistant.
- Permanent installations having a high radiation area shall be equipped with the following:
  - Failsafe interlock at each entrance used for personnel access to the high radiation area.
  - A visible signal that is activated when radiation is produced.
  - An audible signal that is activated when an attempt is made to enter the high radiation area while radiation is being produced.
- A readily visible warning light, labeled with the words "X-RAY ON" or words or symbols having a similar intent, shall be located on or near the source of radiation and its controls and shall be illuminated when the radiation source is energized.
- Industrial radiography and irradiation devices shall be checked prior to each day or shift of use to identify any obvious defects.
- Entrance control devices and alarm systems shall be tested at the beginning of each day of equipment use for proper operation.
- A physical inventory and tests for proper operation of high radiation area control devices, interlocks, warning lights, and labels shall be conducted, recorded, and maintained on three (3) month intervals, not to exceed fourteen (14) weeks of all industrial radiography devices to assure proper functioning of components important to safety.
o All industrial radiography and irradiation devices shall be labeled with a readily discernible sign or signs bearing the radiation symbol and the words:

- "CAUTION - HIGH INTENSITY X-RAY BEAM", or appropriate words having a similar intent, on or near the housing of the source of radiation.

- "CAUTION - THIS EQUIPMENT PRODUCES RADIATION WHEN ENERGIZED", or appropriate words having a similar intent, near any switch or control that directly energizes the unit.

o Sufficient calibrated and operable radiation survey instruments shall be maintained to make physical radiation surveys. Instrumentation shall have a range such that two (2) millirem per hour through one (1) rem per hour can be measured and be calibrated at intervals not to exceed six (6) months and after each instrument servicing other than battery replacement.

- No radiographic operation shall be conducted unless calibrated and operable radiation survey instrumentation is available and used at each site where radiographic exposures are made.
- Radiation survey instrumentation shall be checked at the beginning of each day of use and at the beginning of each work shift using check sources or other appropriate means to ensure it is operating accurately.
- A physical radiation survey shall be made after each radiographic exposure to verify that the radiation-generating device is not still producing radiation.

o Users must wear a whole body personnel dosimeter.
- Users must maintain/wear an operable, calibrated direct read dosimeter.

o A utilization log shall be maintained between inspections showing the following information for each piece of industrial radiography equipment used:

- Manufacturer, model number, and serial number.
- Dates each industrial radiography device is energized.
- Results of radiation surveys.
- Dates that each piece of industrial radiography equipment is removed from storage and returned to storage.
- Operating kilovoltage, tube current, and exposure time for each radiographic exposure.
- Identity and signature of the industrial radiographer.

o Maintain operating and emergency procedures.
Industrial radiography devices shall not be used to intentionally irradiate human beings for any purpose. ODH “Notice to Employees” is conspicuously posted. Contact Radiation Safety or your Laboratory Compliance Officer for a copy of this posting.

- Radiation Safety Responsibilities (Industrial Radiography and Irradiation Devices):
  - Perform radiation surveys:
    - Upon installation of the industrial radiography and/or irradiation device.
    - Following any change in the initial arrangement, number, or type of local components in the system.
    - Following any maintenance requiring the disassembly or removal of a local component in the system.
    - During the performance of maintenance and alignment procedures if the procedures require the presence of a primary x-ray beam when any local component in the system is disassembled or removed.
    - Any time a visual inspection of the local components in the system reveals an abnormal condition.
    - Whenever personnel monitoring reports show an unexplained increase over the previous monitoring period or the readings are approaching the limits specified in rules adopted pursuant to Chapter 3701:1-38 of the Administrative Code.
  - Perform quarterly inspections of all radiation safety devices, such as interlocks, lights, and labels. Additionally an audit of the device documentation will be performed on a semi-annual basis.
  - Perform an annual radiation survey.
  - Perform an annual inventory of all inoperable units.
  - Maintain the ODH registration of all industrial radiography and/or irradiation devices.
Bone Densitometers – Non-Human Use Only

- Principle investigators and individual users of bone densitometers must maintain compliance with OAC 3701:1-66-02, 04, and particular attention should be given to OAC 3701:1-66-11.

- Requirements include (but are not limited to) the following items:
  - Submission of a completed RGD-1 Form, “Registration for the Use/Storage of Radiation Generating Device” to Radiation Safety as described in the Responsibilities section (Page 7).
  - All bone densitometers shall conspicuously display a clearly legible label or labels bearing the radiation symbol and the words "CAUTION - THIS EQUIPMENT PRODUCES RADIATION WHEN ENERGIZED" or appropriate words having a similar intent, near any switch or control that directly energizes the unit. Contact Radiation Safety or your Laboratory Compliance Officer for labels. Example:

    ![CAUTION X-RAYS THIS EQUIPMENT PRODUCES X-RAYS WHEN ENERGIZED]

    - A readily visible warning light, labeled with the words "X-RAY ON" or words or symbols having a similar intent, shall be located on or near the source of radiation and its controls and shall be illuminated when the radiation source is energized.
    - The operator shall be positioned at least one (1) meter (3.3 feet) from the primary beam or behind a protective barrier containing a minimum of 0.25 millimeter of lead equivalent materials.
    - No PI shall permit any individual to operate the device until such individual has received a copy of, and instruction in, the operating procedures for the equipment and has demonstrated competence in its use. Maintain documentation that individual users have received appropriate training.
    - Maintain written standard operating procedures.
    - Maintain a readily available copy of the manufacturer’s manual.
    - Maintain a written quality assurance program as described in OAC 3701:1-68-04, to include but not limited to the following requirements:
      - A list of the tests to be performed as specified by the manufacturer.
      - The frequency of performance as specified by the manufacturer.
      - The acceptability limits for each test as specified by the manufacturer.
      - A brief description of the procedures and test equipment to be used for each test.
    - Inform Radiation Safety of the repair, acquisition, relocation, transfer, or disposal of any unit. Radiation Safety must also be notified if an operable unit becomes inoperable or an inoperable unit is returned to service.
    - ODH “Notice to Employees” is conspicuously posted. Contact Radiation Safety or your Laboratory Compliance Officer for a copy of this posting.

- Radiation safety is responsible for the following:
  - Perform radiation surveys:
    - Upon installation of the bone densitometer.
    - Following any change in the initial arrangement, number, or type of local components in the system.
    - Following any maintenance requiring the disassembly or removal of a local component in the system.
During the performance of maintenance and alignment procedures if the procedures require the presence of a primary x-ray beam when any local component in the system is disassembled or removed.

Any time a visual inspection of the local components in the system reveals an abnormal condition.

Whenever personnel monitoring reports show an unexplained increase over the previous monitoring period or the readings are approaching the limits specified in rules adopted pursuant to Chapter 3701:1-38 of the Administrative Code.

- Perform semi-annual inspections of all radiation safety devices, such as interlocks, lights, and labels. Additionally an audit of the device documentation will be performed.
- Perform an annual radiation survey.
- Perform an annual inventory of all inoperable units.
- Maintain the ODH registration of all bone densitometers.
Radiation Dose Limits and Notification to the Ohio Department of Health of Overexposures

Occupational Dose Limits

In order to detect and evaluate exposure to external radiation, individual monitoring devices will be issued to individuals who are likely to receive, in one year from sources external to the body, a dose in excess of ten (10) percent of the applicable annual limits.

### Annual Limits

<table>
<thead>
<tr>
<th>Category</th>
<th>ODH Dose Limit (rem per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult Worker</td>
<td></td>
</tr>
<tr>
<td>Total Effective Dose Equivalent</td>
<td>5</td>
</tr>
<tr>
<td>Total Organ Dose Equivalent</td>
<td>50</td>
</tr>
<tr>
<td>Lens of Eye</td>
<td>15</td>
</tr>
<tr>
<td>Extremities / Skin</td>
<td>50</td>
</tr>
<tr>
<td><strong>Declared Pregnant Worker (Embryo / Fetus)</strong></td>
<td></td>
</tr>
<tr>
<td>Total Effective Dose Equivalent</td>
<td>0.5 rem per 9 months</td>
</tr>
<tr>
<td><strong>Minor (Less than 18 Years of Age)</strong></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>10% of Adult Limits</td>
</tr>
</tbody>
</table>

Most radiation injuries are "local" injuries, frequently involving the hands. These local injuries seldom cause the classical signs and symptoms of the acute radiation syndrome. Symptoms may include a skin lesion, erythema, blistering, dry or wet desquamation, epilation, ulceration. Local injuries to the skin evolve very slowly over time and symptoms may not manifest for days to weeks after exposure.

### Instructions for Principal Investigators and Individual Users

All suspected occupational radiation overexposures shall be immediately reported to the Radiation Safety Section (RSS) of the Office of Environmental Health and Safety by contacting the RSS 24-hour emergency response cell phone, (614) 561-7969. If any redness or unusual discoloring of the skin occurs (erythema), mention this to RSS and seek attention from a medical doctor for possible radiation overexposure.

### Instructions for Radiation Safety Section

All occupational radiation exposures measured by whole-body dosimeters and finger rings are reviewed every quarter by the Health Physicist with responsibility for dosimetry operations. Any results above action levels I or II will require documented review and action as per the dosimetry procedures of the Radiation Safety Standards for The Ohio State University.

Any radiation overexposures, pursuant to Chapter 3701:1-38 of the Ohio Administrative Code, will be reported to the Director of the Ohio Department of Health in accordance with the Radiation Safety Standards for The Ohio State University. Radiation overexposures will be reported in the same manner regardless of the occupational source. Any verbal notifications will be followed up with written notification.