Shielding Plan Review Guidance

February 2025

Before starting construction for a new ionizing radiation machine installation or modifying an existing installation, facilities must submit their floor plans, shielding specifications and equipment arrangement to the Health Department for review and approval. Use this checklist to make sure you include all the information required in your submission.

If you need help accessing or understanding this information, contact AHS.VDHRadiologicalHealth@vermont.gov.

Information Required for Evaluation of Radiation Shielding

Your submission must include a dimensional, scaled drawing of your facility that shows:

- Direction of north
- Normal location of the X-ray imaging system's radiation port
- Port's travel and traverse limits
- General direction of the useful beam
- Any windows and doors
- Operator's booth
- X-ray control panel
- Structural composition and thickness of all walls, doors, partitions, floor and ceiling of the room
- Room dimensions and distance between floors if space above or below is occupied
- Type of occupancy of all adjacent areas, including space above and below
- Distance to the closest areas where people may be present if there is an exterior wall
- A description of the X-ray imaging system and components, including the make and model of the equipment
- Type of examinations or treatments the equipment will be used for
- Information on the anticipated workload of the X-ray imaging system
- Whether this plan is for a new structure or a modification to an existing structure

Design Requirements for an Operator's Booth

Space Requirements

The operator should have at least 0.7 m^2 (8 ft^2) of unobstructed floor space in the booth.

- The operator's booth can be any configuration with no dimension less than 0.6 m (2 ft).
- The X-ray control panel is free of anything that can block access.
- The booth is located or constructed so that unattenuated scatter radiation from the examination table or at the wall cassette cannot reach the operator.

Structural Requirements

- Walls are permanently fixed barriers at least 2 m (6.5 ft) high.
- Doors or movable panels must have an interlock to prevent exposure when they are not closed in shielding position.
- Shielding meets the requirements of Section 7.0.

Viewing System Requirements

Each booth must have at least one viewing device consisting of a window, mirror, or closed-circuit viewing system placed so that the operator can fully view:

- The patient during exposure
- Any occupants in the room
- Any entry into the room

If any door allowing access into the room cannot be seen from the booth, the door must either have an interlock to prevent exposure or activate a warning light at the control panel if the door is not closed.

When the viewing system is a **window**, these requirements also apply:

- The viewing area must be at least 0.1 m2 (1 ft2)
- The operator's position when viewing the patient and operating the X-ray system is at least 0.5 m (1.5 ft) from the edge of the booth
- The window has at least the same lead equivalence as required in the wall where the window is mounted.
- When the viewing system is a **closed-circuit viewing system**, there must be an alternate viewing system as a backup for the primary system in case of failure.

Content of a Shielding Design

The shielding design prepared by a qualified expert must include:

- The name and contact information of the qualified expert who created the shielding design.
- Facility information, including name, address, owner and contact phone numbers and email addresses.
- Evaluation of the floor plan with consideration for radiation protection, including:
  - The location and configuration of any radiation-producing machines in each room
  - Evaluation of workload, based on the volume of work and anticipated equipment usage relative to the overall layout
- Detailed consideration, using guidelines based on the National Council on Radiation Protection and Measurements Report No. 147, "Structural Shielding Design for Medical Imaging Facilities," or equivalent guidance, of:
  - Location and types of permanent and temporary barriers and shielding
  - Location of controls and any control booth
  - Location of exposure switch
  - Interior and exterior walls, doors and windows, and floors and ceilings
  - Calculations of potential exposures based on occupancy and workload distribution
- A current dimensional drawing for each room a stationary X-ray imaging system is located, with specifications for construction and layout to meet all requirements, especially those to prevent anyone from receiving a dose over the limits in Section 7 of the Radiological Health Rule.
- The signature of the qualified expert who prepared the shielding design and the date signed

Requirements for Radiation Therapy Machine Shielding Plan Reviews

In addition to the requirements listed above, therapeutic radiation machine facilities should develop, document and maintain shielding plans on file that contain this additional information:

All Therapeutic Radiation Machines

- The location of the radiation machine's control panel

- If the control panel is inside the treatment room, note the location of the operator's booth. The operator's station at the control panel must be behind a protective barrier.
- Equipment manufacturer and model number
- The maximum technique factors
- The maximum design workload for the facility including:
  - Total weekly radiation output expressed in gray (rad) or air kerma at one meter
  - Total beam-on time or monitor units (MU) per day or week
  - The average treatment time or monitor units (MU) per patient
  - The anticipated number of patients to be treated per day or week
- Structural composition and thickness or lead/concrete equivalent of all walls, doors, partitions, floor and ceiling of the room.
- The type of occupancy of all adjacent areas including space above and below.
- Distance to the closest areas where people may be present if there is an exterior wall.
- At least one example calculation showing the methodology used to determine the amount of shielding required for each physical condition (for example, primary and secondary leakage barriers, restricted and unrestricted areas, entry doors, maze) and shielding material in the facility
- If commercial software is used to generate shielding requirements, note:
  - The software used and the version/revision date.
  - Quality control sample calculations to verify the result if the software used is not commercially available.
- Primary barriers must be installed in all wall, floor and ceiling areas struck by the useful beam
- Secondary barriers must be provided in all wall, floor and ceiling areas without primary barriers.

Therapeutic Radiation Machines Over 150 kV

In addition to the requirements for all therapeutic radiation machines, facilities that produce photons with a maximum energy **above 150 kV** or electrons must develop, document and maintain shielding plans on file that contain, this additional information:

- Gray (rad) at the isocenter

- The energy(s) and type(s) of radiation produced (photon or electron)
- The target to isocenter distance
- Facility drawing to scale (including both floor plan and elevation views) showing:
- Relative orientation of the therapeutic radiation machine:
- Type, thickness and minimum density of shielding material
- Locations and size of all penetrations through each shielding barrier (ceiling, walls, and floor)
- Details of the door and maze
- A description of all assumptions used in shielding calculations including:
    - Design energy (for example, a room may be designed for a 6 MV unit although only a 4 MV unit is currently proposed)
    - Workload
    - Presence of integral beam-stop in unit
    - Fraction of time that the useful beam will intercept each permanent barrier (walls, floor and ceiling)
    - Radiation exposure in both restricted and unrestricted areas

Neutron Shielding

In addition to the requirements listed for all therapeutic radiation machines, facilities that are capable of operating **above 10 MV** must document, develop, and maintain shielding plans on file that contain this additional information:

- Structural composition, thickness, minimum density and location of all neutron shielding material
- A description of all assumptions that were used in neutron shielding calculations including:
    - Neutron spectra as a function of energy
    - Neutron fluence rate
    - Absorbed dose
    - Dose equivalent (due to neutrons) in both restricted and unrestricted areas
    - Method and instrumentation that will be used to verify the capability of all neutron shielding installed in the facility.