



77 Massachusetts Avenue,
Cambridge, MA 02139



Analytical X-Ray Safety Guide

(617)-452-3477

environment@mit.edu

ehs.mit.edu



Delegation of Authority

MIT has a standing institute **Committee on Radiation Protection** to oversee all uses of radiation at the Institute and its associated off campus locations. They give the RPP authority to stop any experiment or process involving radiation that is deemed unsafe.

Administrative Controls

- Area "Caution" postings
- Normal Operating Procedures approved by RPP and device's user manual are available to the user
- All users are registered with RPP
- Hands-on training with the equipment

Hazards

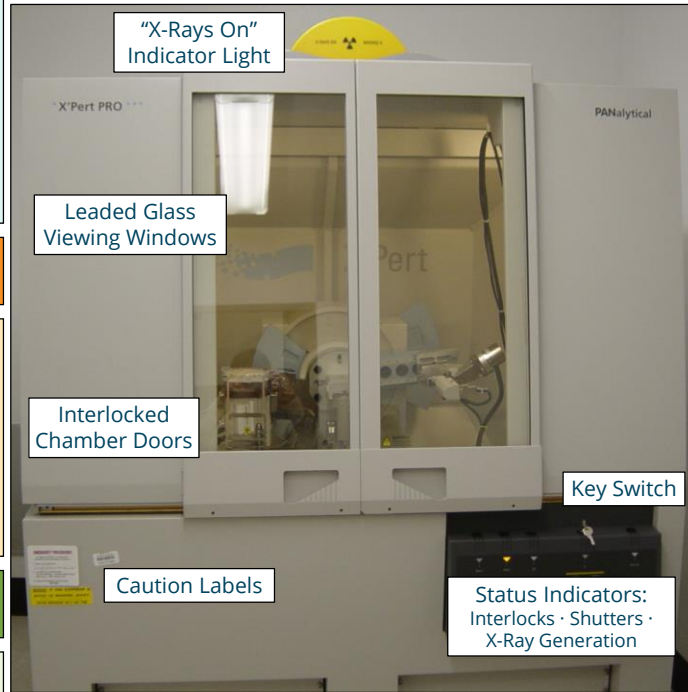
Main Hazard: Skin Burns

Exposure to the primary beam could result in a radiation burn, which can occur around 200 rads. Symptoms may not be present until well after the exposure. Itching, tingling, swelling, or redness at the site of exposure may arise.

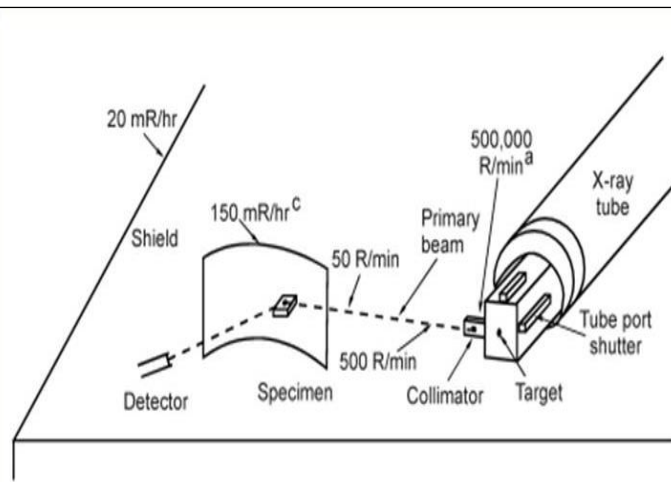
Go to MIT Medical if a burn is suspected, and inform RPP immediately of any exposure to the primary beam!

- The main hazards associated with an X-Ray machine are from exposure to the **primary beam, leakage radiation, and scatter radiation.**
- Very high exposure rates can be found just outside the collimator.
- **All exposure rates outside the cabinet must be less than 2 mR/hr at 5 cm.**

Typical Cabinet X-Ray Device and Safety Mechanisms



Exposure Rates Example

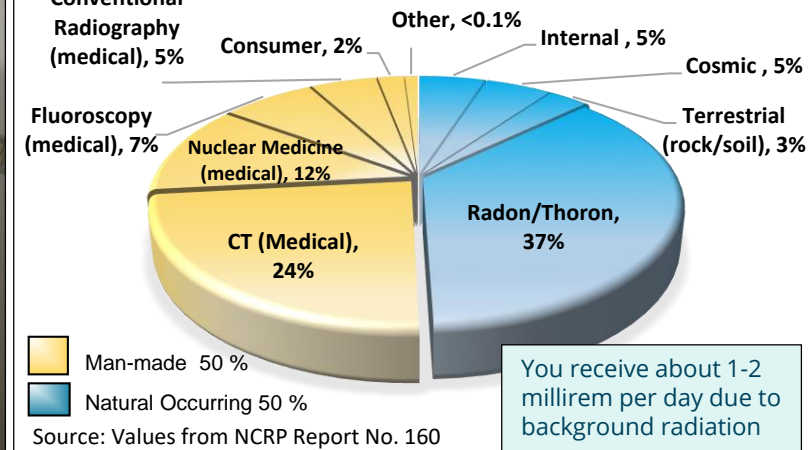


Area Monitoring

- X-ray machines are assigned radiation monitoring badges to verify that radiation levels in the area of the equipment are not elevated.
- Dosimeters are changed quarterly.

Call RPP to request the results for a particular machine!

BACKGROUND RADIATION



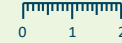
■	Living next to a nuclear power plant	<1 mrem	■	Cosmic Radiation (Denver)	80 mrem
■■■	Eating 1 banana a day	3.5 mrem	■■■	Radon in Avg. Home	228 mrem
■	Terrestrial Radioactivity	21 mrem	■■■	Whole Body CT (1-time)	1000 mrem
■	Cosmic Radiation (sea-level)	30 mrem	■■■	Radiation Worker Limit (Whole Body)	5000 mrem

ALARA

As Low As Reasonably Achievable



Minimize Time



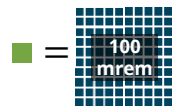
Maximize Distance



Use Shielding



Plan ahead



Annual radiation dose comparison. Data from epa.gov/radiation/radiation-sources-and-doses. Inspired by xkcd.com/radiation

X-Ray Registration

1. Contact RPP prior to ordering any X-Ray equipment.
2. Fill out registration form and submit to RPP for approval.
3. RPP Officer will perform a hazard assessment and help write Normal Operating Procedures.

Definitions

Absorbed Dose: The energy imparted per unit mass of material. Measured in rad, where 1 rad = 0.01 Joules per kilogram of absorbing material. The SI Unit is the Gray (Gy). Note 1 Gy = 100 rad = 1 J/kg.

Bremsstrahlung X-Rays: The electromagnetic radiation produced by the deceleration of a charged particle when deflected by another charged particle, such as an electron deflected by an atomic nucleus.

Characteristic X-Rays: X-rays emitted from heavy elements when their electrons make transitions between the lower atomic energy levels.

Dose Equivalent: The product of the absorbed dose and the appropriate quality factor for the type of radiation. Measured in rem. The SI Unit is the Sievert (Sv). Note 1 Sv = 100 rem.

Dosimeter: A passive form of monitoring ionizing radiation, typically without a direct-reading capability. Dosimeters may be assigned to and worn by personnel or posted in a lab to monitor area radiation levels.

Exposure: A measure of the ionization produced in air by x-ray or gamma radiation. Measured in Roentgen (R), where 1 R = 2.58 x 10⁻⁴ Coulombs per kilogram of dry air at STP.

Leakage Radiation: Radiation which penetrates (or "leaks") through cracks, voids, holes or ill-fitting equipment, such as misaligned cabinet doors or seams between shielding panels.

Primary Beam: Radiation which passes through an aperture of the source housing by a direct path from the x-ray tube or a radioactive source located in the radiation source housing.

Radiation: Energy transmitted in the form of electromagnetic waves or subatomic particles.

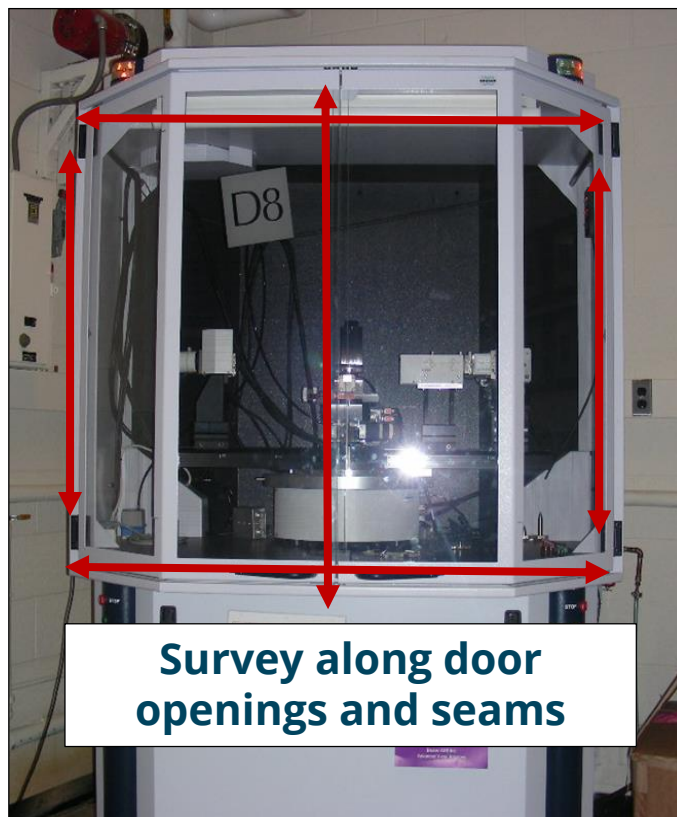
Survey Meter: A direct-reading instrument capable of detecting ionizing radiation (e.g. Geiger Counter).

X-Ray: An electromagnetic wave of high energy and very short wavelength with a high penetration ability and the capability to ionize atoms (called "ionizing radiation").

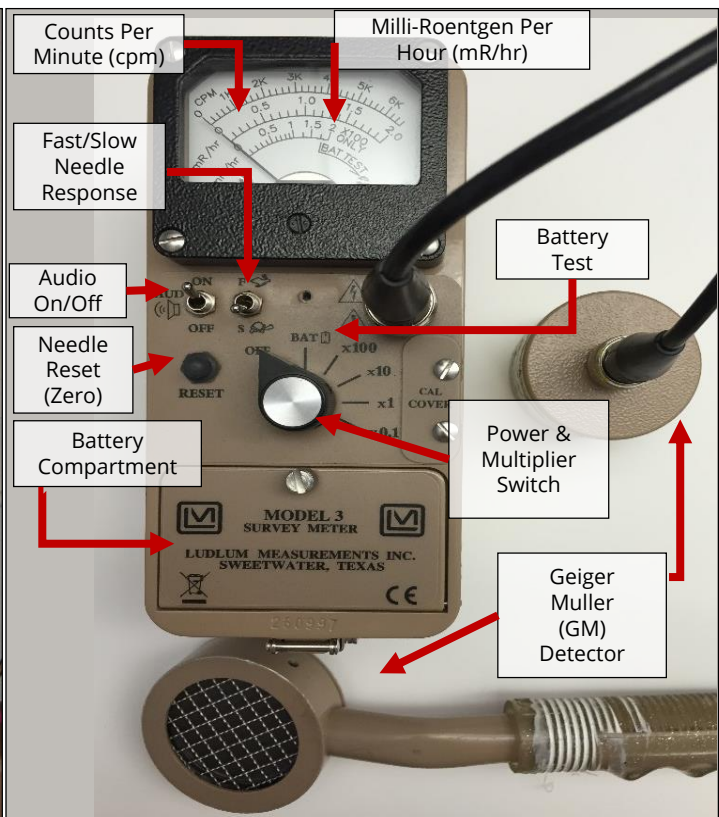
Using the Survey Meter to Perform a Leakage Survey

While operating an X-Ray device, it is best practice to perform a survey of the area to ensure the dose rates around the device are less than 2 mR/hr at 5 cm.

- Check calibration date on detector
- Check battery
- Check response using source on instrument.
- Measure the background exposure rate in an area known to have no radiation.
- Scan the work area by holding detector face ~1 cm above surface moving slowly (about 5 cm/s).
- Survey along door openings and operators station.
- Notify RPP if exposure rate is greater than background.



Survey along door openings and seams



When to Contact RPP

- Leakage radiation detected significantly above background
- Suspected or possible exposure to the primary or scatter beam
- Prior to performing equipment modifications
- Prior to performing any operations requiring bypassing of interlocks (or beyond Normal Operating Procedure's scope)

9 Traits of a Positive Safety Culture

1. Leadership Safety Values and Actions
2. Problem Identification
3. Personal Accountability
4. Work Processes
5. Continuous Learning
6. Environment for Raising Concerns
7. Effective Safety Communication
8. Respectful Work Environment
9. Questioning Attitude