CAUTION:
X-ray equipment
May be in Use

EMERGENCY CONTACTS

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1 – After normal working hours, call Security Services at "555", "#555"
(using cell phone with Rogers Wireless or MTIS) or dial 474-9341.
So you plan to use an X-ray equipment at the University of Manitoba...

Then, there are some things you need to know about:

- X-ray hazards
- How to identify X-ray equipment in your work area
- How to work safely with X-ray equipment
- How to work safely around others
What is an X-ray?

X-rays are a form of \textit{ionizing radiation}, and exposure to them can be a health hazard.
At the University, what are common uses for X-ray equipment?

Dental

Fluoroscope

DEXA - measures bone density - lean mass
At the University, what are common uses for X-ray equipment?

- X-ray spectrometer
- X-ray diffractometer
- Electron microscope
How is X-ray equipment labeled?
The heart of a conventional X-ray machine is an electrode pair -- a cathode and an anode -- that sits inside a glass vacuum tube.

The cathode is a heated tungsten filament, like you might find in an older incandescent lamp.

The machine passes current through the filament, heating it up.

The heat sputters electrons off of the filament surface.

The positively-charged anode, called a target, draws the electrons across the tube. The X-ray spectrum (wavelengths) depends on the composition of the anode (e.g. W, Cu, Fe, Mo. Etc.) and the accelerating voltage.
The voltage difference between the cathode and anode is extremely high, so the electrons fly through the tube with a great deal of force.

**When a speeding electron collides with a target atom, it knocks loose an electron in one of the atom's lower orbitals.**

An electron in a higher orbital immediately falls to the lower energy level, releasing its extra energy in the form of a photon, X-ray.
How does X-ray equipment work?

Free electrons can also generate X-rays without hitting an atom.
An atom's nucleus may attract a speeding electron just enough to alter its course.
Like a comet whipping around the sun, the electron slows down and changes direction as it speeds past the atom.
This "braking" action causes the electron to emit excess energy in the form of an X-ray photon.
How do X-rays machine work?

A clinical X-ray machine is essentially a camera that uses X-rays to expose the film (rather than visible light).

X-rays are like light in that they are **electromagnetic waves**, but they are more energetic so they can penetrate many materials to varying degrees.

When the X-rays hit the film, they expose it just as light would.
Digital Radiography

- **Digital radiography** is a form of X-ray imaging, where digital X-ray sensors are used instead of traditional photographic film. Advantages include time efficiency through bypassing chemical processing and the ability to digitally transfer and enhance images. Also less radiation can be used to produce an image of similar contrast to conventional radiography.
How is the X-ray hazard regulated and evaluated (at the University)?

X-ray equipment can be categorized by risk into the following categories:

- Clinical X-ray Equipment
- Research X-ray Equipment
Clinical X-ray equipment refers to X-ray equipment that is used on human subjects to provide medical or dental care.

In locations controlled by the UofM, only dental care is provided by X-ray equipment, that is considered low risk as – beams used on humans are:

- Collimated (focused)
- Used on humans only as prescribed by a dentist
- Supervised by licensed dentist or registered X-ray Technologist
- X-ray equipment registered with MB and surveyed at least every 3 years
At the University, when is an X-ray machine considered “Research X-ray equipment”?

Research X-ray equipment shall refer to X-ray equipment that is not used to provide medical or dental care on human subjects, that is, either:

- **Analytical X-ray equipment** is equipment that is not used on humans
- Any X-ray equipment when it is used to irradiate humans under a research study protocol.
What factors affect the risk assessment to faculty, staff or students related to the use of research X-ray equipment?

At the UofM:

- Most research X-ray equipment is interlocked into a cabinet (not open beam)

If used on humans then it is open beam and can only be used:

- With Research Ethics approval
- Must have a physician's prescription
- Operator must have appropriate education and experience and be ‘authorized by the MB Minister of Health’.
What factors affect the risk assessment to faculty, staff or students related to the use of research X-ray equipment?

Open beam X-ray equipment which is not used on humans includes:

- Fluoroscope used on research animals
- Research equipment, such as diffractometer, requiring manual alignment of the beam
Fluorescence spectrometers

- Utilize a special interlocked sample chamber, which encloses the beam.

- In this equipment the beam is more intense than that required for diffractometers.

- In addition, the sample must usually be closer to the beam port.

- In order to prevent access to the high radiation levels of the primary beam, fluorescence equipment must be equipped with an interlocked sample chamber. Access to the sample requires removal of an interlocked cover. Removal of the cover shuts off the power or blocks the beam thereby preventing injury to fingers, which are carelessly placed in the sample chamber.
What types of injuries or illness can happen from X-ray exposure?

The hazards most often associated with exposure to X-ray radiation include increased risk of cancer and increased risk of genetic effects in exposed populations.
Skin Burns

- Experience with exposure of relatively large areas of skin to radiation has shown that it requires doses of approximately 3 Sv to produce a visible reddening of the skin.
- Doses of approximately 15 Sv are required in order to produce serious burns with blistering.
- When doses reach 30 Sv very serious burns requiring skin grafts or amputation may result.
- The burn symptoms may require from one to several weeks to develop, depending on the dose.

Compare: about 4 mSv/yr. is the radiation dose received from the background
Eye Damage

- There have occasionally been reports of accidental exposure of the eye during use of analytical X-ray equipment. Doses capable of causing skin burns are capable of producing serious permanent damage to the eye.

- Studies have also shown that doses greater than 2 Sv are capable of producing cataracts in the lens of the eye.
How can you protect yourself from X-rays?

Minimize the time:

- Avoid or minimize direct exposure of the open beam (or the reflected beam) to inadvertent placement of fingers at the beam port for even a second can result in serious burns.

Shielding:

- Do not remove the housing or use X-ray equipment with a damaged enclosure.

- Wear a lead apron and other personal protective equipment where applicable.
Distance!

The intensity of the X-ray beam decreases very rapidly as the distance from the tube increases.

The dose rate as a function of the distance from the tube follows the well known inverse square relationship.
Additional hazard: Beryllium

Beryllium is used for “windows” on X-ray tubes because of its property of being essentially transparent to X-rays.

Beryllium and beryllium containing materials present health hazards by the inhalation route only.

Soluble salts of beryllium may present additional ingestive, eye and skin hazards.

Normal use of an X-ray tube does not present danger to the health as it will not generate beryllium dust or fumes.

As no indications have been found that corrosion products (which could be soluble beryllium salts) spread there will be no danger when standard industrial hygiene rules are applied when handling tubes.

Be advised that beryllium as present in X-ray tubes is recognized as a hazardous substance and may create hazards to persons when not handled and disposed of properly.

To avoid any such hazards the material must be handled with great care in connection with the installation, operation and servicing of the equipment.

Disposal of beryllium should referred to the hazardous waste program at UofM
Who makes the rules for X-ray Equipment?
Governing Regulations

MB 217/2006 Workplace Safety and Health Regulation, section 18 regulates the use of radiation in the workplace.

MB 341/88R X-ray Safety Regulation also regulates X-ray equipment under the Public Health Act.
MB 217/ 2006 Workplace Safety and Health Regulation, Sec 18 requires:

- Develop and implement Safe Work Procedures (SWP) to ensure dose limits are not exceeded
  - Train workers in SWP
  - Ensure workers comply with SWP
  - If a worker may exceed dose limits, implement controls
  - Inform workers that may be exposed to the potential hazard
MB 341/ 88R X-ray Safety Regulation, Public Health Act, requires:

- Control of occupational exposure and exposure to public
- Dosimetry for X-ray workers
- Requirement for ‘physician’s Rx’ to irradiate humans
- Restrictions on who may operate X-ray equipment
- Registration of X-ray equipment with Radiation Protection, Cancer Care Manitoba
The Environmental Health and Safety Office is responsible:

- EHSO role is to provide assistance and guidance so Departments can meet their responsibilities to provide a safe working environment for staff and students where X-ray equipment in used.
At the UofM, there is Registration of X-ray Equipment

- The Environmental Health and Safety Office, in conjunction with The University of Manitoba Radiation Protection and X-ray Committees, has initiated a registration program for all X-ray equipment in areas controlled by the UofM.

- This registration is the first step to assess the compliance with the new regulation and develop a comprehensive program.
X-ray Caution Sign – First step

The entrance to the room where X-ray equipment is used must be posted with the appropriate warning sign.
X-ray Control Measures are documented in X-ray SWPs that are site specific and appropriate for each type of experiment or procedure involving the X-ray.

The safety of ancillary staff is to be considered in defining X-ray SWPs.

When possible engineering controls shall be implemented before administrative procedures or personal protection.

Where required, dosimeters will be used to measure the exposure of X-ray workers.
Sample of SWP: Fluoroscope

The unit can only be operated by certified personnel. All authorized personnel must receive instruction and demonstrate an understanding of operation of the machine before starting work. The Responsible User must document training.

- Only individuals required for the fluoroscopic procedure shall be in the room during the exposure and all such persons shall wear lead aprons and gloves if necessary. The operator should not stand in the primary beam. The tube housing should not be held by the operator.

- Lead protective clothing (including aprons and gloves, if applicable) shall be maintained in good repair and shall be inspected annually by the user. If they fail inspection, they shall be removed from service until they are repaired or replaced.

- Whole body and extremity dosimeters are required for all personnel working with fluoroscopic units. The dosimeter must be worn on the collar, outside of the lead apron.

- Use of the fluoroscopic unit must follow the procedures described in the manufacturers' operating manual. Any variations in those procedures must be approved, in writing, by the X-ray Committee.

- The fluoroscopic field shall be restricted to the area of interest.
Sample of SWP: Research and development units

- An operational fail-safe light must be visible to the operator indicating when X-rays are being produced.
- Use interlocks, barriers or administrative controls to ensure no one can gain access to the primary beam or high scatter radiation areas.
- X-ray equipment is only to be operated by authorized users.
- In the case where interlocks are to be overridden, signs must be clearly posted stating that this is occurring.
- Make sure that the X-ray source is off before reaching into the primary beam path.
- Use of a whole body dosimeter is mandatory.
ANYONE WITH A KNOWN OR SUSPECTED INJURY SHOULD OBTAIN IMMEDIATE MEDICAL ATTENTION. TIME OF TREATMENT CAN OFTEN CHANGE THE OUTCOME AND REDUCE LONG TERM EFFECTS.

Call EHSO as soon as feasible at 474-6633 or 555 after hours.
Before you use any X-ray equipment at the University of Manitoba, make sure you know:

✓ What are X-ray hazards
✓ How to identify X-ray equipment in your work area
✓ How to work safely with X-ray
✓ How to work safely around others
This completes the X-ray Safety Information package.

(Please read and complete the following, print a copy and forward it to your supervisor)

I acknowledge having completed the X-ray Safety Information package and I have read and understood the information presented. In particular, I understand my rights and responsibilities as an individual working with or around X-ray equipment at the University of Manitoba.

If I have questions on any matter, I also acknowledge that I may contact my supervisor or the Environmental Health & Safety Office for clarification.

______________________________________________________________       ________________
EMPLOYEE SIGNATURE DATE

______________________________________________________________
EMPLOYEE NAME (Please PRINT)

______________________________________________________________  ________________
SUPERVISOR SIGNATURE DATE

______________________________________________________________
SUPERVISOR NAME (Please PRINT)