

X-ray Equipment Safety Orientation

May 4, 2018



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What do you need to know to use X-ray equipment at the University?

After reviewing this information package you will know

- What are the hazards associated with working with X-rays
- How to identify X-ray equipment in your workplace
- How to work safely with (and around) X-ray equipment
- What you need to do to meet regulations

CAUTION:

X-ray equipment
May be in Use



EMERGENCY CONTACTS

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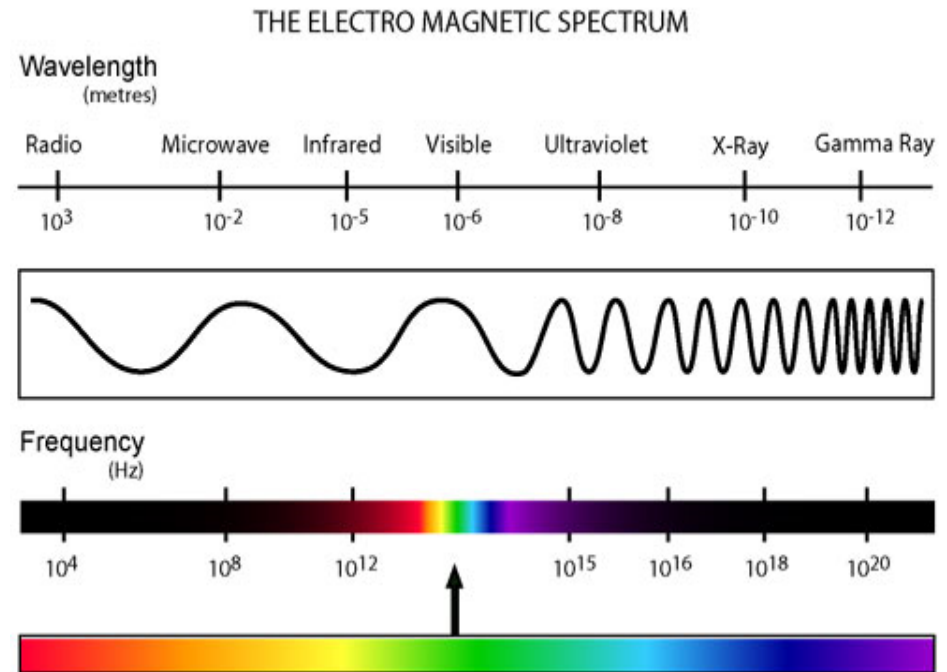
¹ – After normal working hours, call Security Services at “555”, “#555”
 (using cell phone with Rogers Wireless or MTS) or dial 474-9341.



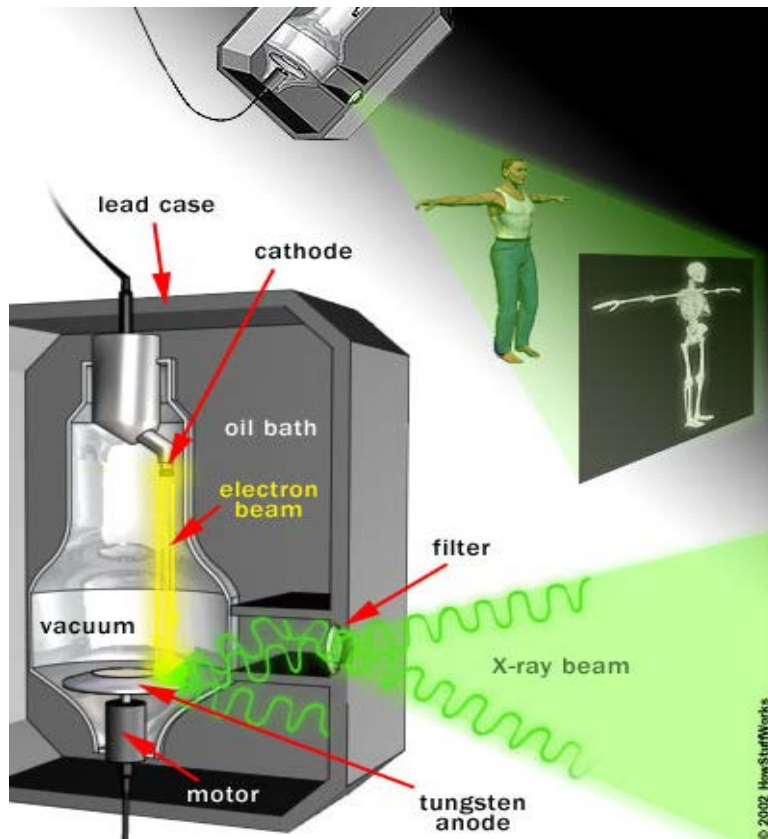
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What is an X-ray?

- X-rays are a form of ionizing radiation and exposure to X-rays can be a health hazard
- X-rays are part of electromagnetic spectrum (energy range of 10eV – 120KeV)
- This training is related to X-ray produced by machines – when the power is off, no X-rays are produced



How does X-ray equipment work?



- The heart of conventional X-ray equipment 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.

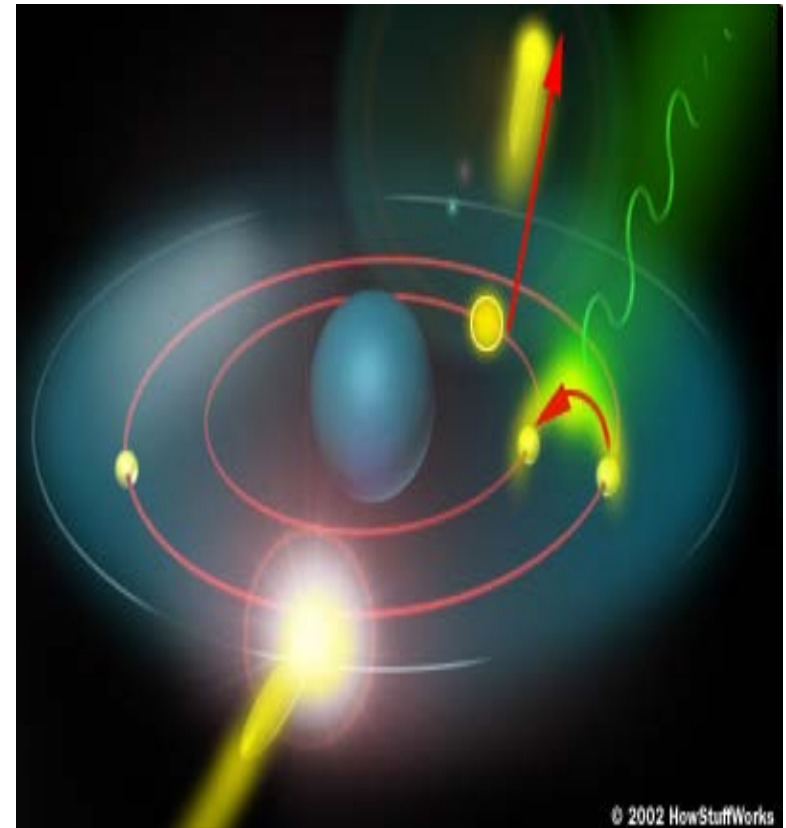
(from <http://health.howstuffworks.com/medicine/tests-treatment/x-ray2.htm>)



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How does X-ray equipment work?

- 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.



([from http://health.howstuffworks.com/medicine/tests-treatment/x-ray2.htm](http://health.howstuffworks.com/medicine/tests-treatment/x-ray2.htm))



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How is X-ray equipment labelled?



What are common uses of X-ray equipment at the University?

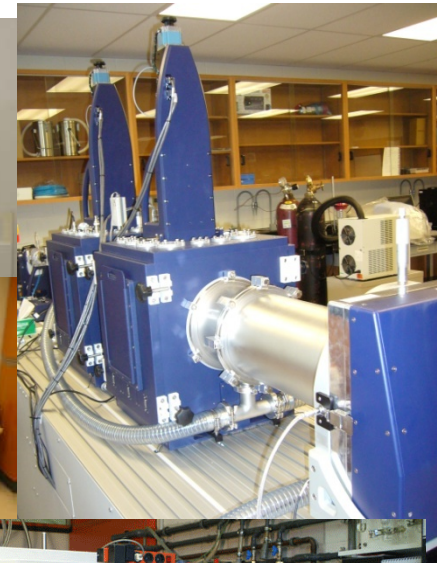
Dental



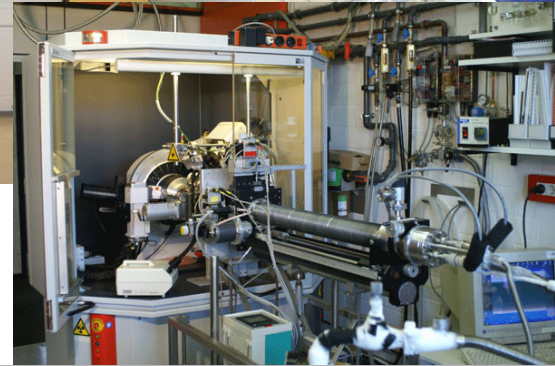
DXA (measures bone density or lean muscle mass)



X-ray spectrometer



X-ray diffractometer



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How does Clinical X-ray equipment work?

- Clinical X-ray equipment 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.



What is 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.



Analytical X-ray equipment

- Generally refers to X-ray diffraction and spectrographic systems designed primarily for performing microscopic examinations or analyzing X-ray spectra of matter at the atomic or crystalline level
- Typically X-ray diffraction devices and X-ray spectrometers, have been designed to utilize very intense X-ray beams in order to facilitate microscopic examinations or atomic analyses of materials
- Modern equipment is interlocked and shielded to limit worker exposure. **Detailed safe work procedures are required for any device that may be operated without the interlocks and shielding in place.**



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 may have been inadvertently placed in the normal location of the X-ray beam.



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.

This training is related to X-ray produced by machines – when the power is off, no X-rays are produced.

There are other regulations and requirements for X-ray devices that use radioactive materials (instead of electricity as the source of the X-ray radiation).



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
- Registration of X-ray equipment with Radiation Protection, Cancer Care Manitoba
- Restrictions on who may operate X-ray equipment



University Governance

- Radiation Safety [Policy](#) and [Procedure](#) covers both radioactive material and X-ray equipment
- The [Terms of Reference](#) of the Radiation Protection Committee set out the requirements for registering all X-ray equipment and permitting research X-ray equipment.



What is Environmental Health and Safety responsible for?

EHS's 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 is used.

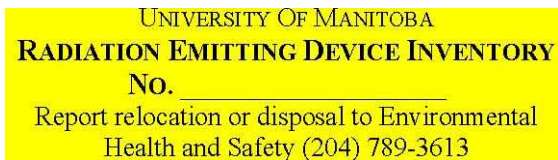
The information that follows outlines what you need to know to work safely and meet the legal requirements.



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All X-ray equipment in areas controlled by the University must be registered with EHS

Registered X-ray equipment will have this sticker



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X-ray Caution Sign

The entrance to the any room where X-ray equipment is used must have the appropriate warning sign posted.

Contact the people listed on the sign if you have any questions related to the X-ray equipment in the room.

Contact EHS if you need a sign or need to update a sign.

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Do you need a permit to use X-ray equipment?

At the University, X-ray equipment can be categorized into the following categories that have different regulatory requirements

- Clinical X-ray equipment
- Research X-ray equipment



Clinical 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 University, X-ray equipment in dental care is considered to be Clinical X-ray equipment. This X-ray equipment is low risk because:

- The X-ray beam is collimated (focused)
- They are only used on humans only as prescribed by a dentist
- **the operation is supervised by licensed dentist**
- Clinical X-ray equipment is inspected by the province at least every 3 years

If all of the above parameters are met, an Internal X-ray Permit is not required.



Research X-ray equipment

Research X-ray equipment refers to X-ray equipment that is not used to provide medical or dental care for a human subjects, that is, either:

- Analytical X-ray equipment use on inanimate materials (not used on humans)
- Any X-ray equipment when it is used to irradiate humans under a research study protocol

All research X-ray equipment may only be used in accordance with the conditions of an Internal X-ray Permit issued by University Environmental Health and Safety.



Research X-ray equipment must be permitted by EHS, and

- The conditions of the Internal X-ray Permit must be met
- The X-ray equipment, the location and the usage must be listed on the Permit.

For interlocked and enclosed X-ray systems

- The X-ray equipment must be tested for leakage at least annually and after any move or modification to the equipment.
- The operator must be supervised by a Designated Worker listed on the permit.

****For open beam X-ray equipment, the operator must be a Designated Worker listed on the permit.****



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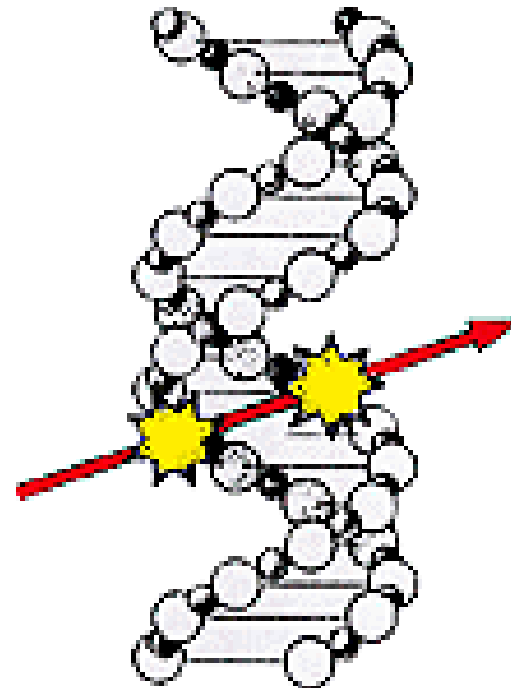
Additionally, if X-ray equipment will be used on humans for research,

- The project must have Research Ethics approval
- *The subject must have a physician's prescription*
- The conditions of the Internal X-ray Permit must be met
- The operator must hold a valid certificate for Certified Clinical Densitometrist (CCD), Certified Bone Densitometry Technologist (CBDT) or Certified Densitometry Technologist (CDT).
- The operator, the X-ray equipment, the location and the usage must be listed on the Permit.



How does Ionizing Radiation do harm?

- Ionizing radiation has enough energy that during an interaction with an atom, it can remove tightly bound electrons from the orbit of an atom, causing the atom to become charged or ionized.
- These charged atoms (ions) have enough energy to damage the internal structures of living cells.
- The material surrounding the charged atom absorbs the energy causing chemical bonds to break.



What types of harm 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*.

At the University, the radiation that X-ray workers receive is measured by dosimetry. Based on past dosimetry results, as long as the equipment is used correctly, the radiation doses are insignificant in relationship to cancer risks or genetic effects.

At the University, dosimetry results indicate that 99 % of X-ray workers do not receive occupational doses above the ionizing radiation from background. Exposures above background are measured occasionally but well below dose limits.



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Skin Burns

For relatively large areas of skin, exposure to radiation 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.

Compared to about 0.004 Sv per year is the radiation dose received from environmental background radiation.

To date, X-ray workers at the University typically receive no measureable radiation above 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 **100mSv** are capable of producing cataracts in the lens of the eye.

Compared to about 4 mSv per year (0.004 Sv/yr) is the radiation dose received from environmental background radiation.

To date, X-ray workers at the University typically receive no measureable radiation above background.



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Radiation Dose Limits

The University has adopted the 'member of the public' dose limits set out in the Canadian Radiation Protection Regulations. Although these limits are much lower than the limits in the Provincial X-ray regulation for X-ray workers, the University is committed to the lower limits.

Maximum Permissible Effective Doses of Ionizing Radiation

Organ or Tissue	Member of the Public (mSv per year)	Nuclear Energy Worker (mSv per year)
Whole Body	1	50 5 yr cumulative max 100mSv balance of pregnancy max 4 mSv
Lens of an eye	15	150
Skin	50	500
Hands & Feet	50	500
Gonads (testes and ovaries)	0.2	10
Red bone marrow, colon, lung, stomach	0.012	6
Bladder, breast, liver, esophagus, thyroid gland	0.05	2.5
Skin (when the skin of the whole body in exposed)	0.01	0.5
Bone surfaces	0.01	0.5
All other organs	0.05	2.5

Effective Dose Effective Dose includes weighting factors for the different types of radiation and susceptibility of different tissues.



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Measuring Radiation Exposure

At the University of Manitoba, people are required to wear a whole body dosimeters when operating

- Clinical X-ray equipment
- Research X-ray equipment and they are listed as a designated worker on an X-ray Permit



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Measuring Radiation Exposure

Whole body (or badge) dosimeters

- are normally worn clipped to the chest pocket of the person's lab coat or at the waist
- must be worn under shielding such as lead aprons to accurately estimate the worker's exposure
- for research X-ray equipment, will be worn as specified in the permit conditions



Measuring Radiation Exposure

- Each dosimeter is only be worn by one individual during the wearing period
- Dosimeters are only worn at University clinic locations or permitted research labs
- Dosimeters are stored away from X-ray areas or where radioactive materials are used or stored
- Dosimeters are not worn during or after a medical procedure involving radioactive materials (Nuclear Medicine procedures) or by the worker when the worker is receiving an X-ray for medical purposes
- Dosimeters are exchanged quarterly or monthly. Keep yours accessible.



How can you protect yourself from X-rays? Follow these safety precautions:

Minimize the time

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

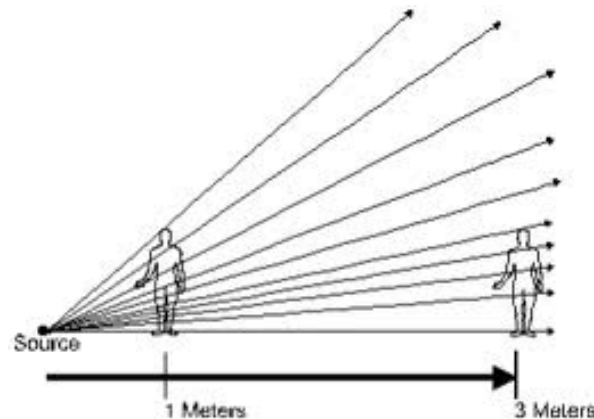
Shielding:

- 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 often 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 be referred to the hazardous waste program at the University.



To be used for research purposes, X-ray equipment must:

- have an Internal X-ray Permit
- *Be operated only by 'Designated Workers' or as specified on the permit*
- *Operated in compliance with the conditions listed on the permit.*
- *Enclosed and interlocked devices must be checked at least annually for leakage. Contact EHS to arrange additional leakage tests whenever the X-ray equipment is moved or modified.*

More details are on [the web](#) or

http://umanitoba.ca/admin/vp_admin/risk_management/ehso/rad_safety/reds.html



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New X-ray equipment, transferring, modifying, disposing

First contact the University Radiation Safety Officer (RSO) at radsafety@umanitoba.ca

- EHS maintains an inventory of X-ray equipment and links tracks the people responsible for the equipment and the location of the equipment.
- In Manitoba, the Radiation Protection staff at Cancer Care Manitoba MUST be informed of changes to equipment or locations and the University RSO will do that for you.
- *It could be a violation of provincial regulations to use X-ray equipment that has been relocated or modified before the University RSO and Cancer Care have responded to the notice of the change.*



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Safe Operating Procedures/ Safe Work Procedures (SWPs)

- Follow the procedures in the Radiation Safety Manual, RSP-2, 5 and 6
- Any additional 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 equipment.
- The safety of ancillary staff is to be considered in developing X-ray SWPs.
- When possible engineering controls shall be implemented before administrative procedures or personal protection.



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 in accordance with the conditions of the Internal X-ray Permit.
- 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.



X-ray Accidents

Worker may be accidentally exposed to the X-ray beam from either being directly in the primary beam or from exposure to leakage or scatter.

The most common causes of accidents are

- Workers not following training or not following the lab specific safe work procedure
- Improper configuration of equipment
- Handling samples when the machine is energized



Reporting Accidents

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 EHS as soon as possible at 204 474-6633 or
- University Security at 204-474-9341 or 555 after hours



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Before you use any X-ray equipment at the University, make sure you know:

- ✓ What are X-ray hazards
- ✓ How to identify X-ray equipment in your work area
- ✓ The Safe Work Procedure that includes
 - ✓ How to safely operate the X-ray equipment
 - ✓ How to work safely around others



Acknowledgement

This completes the University X-ray equipment Safety Orientation.

Please read and complete the following, print a copy and forward it to your supervisor. Is you operate Research X-ray equipment, a signed copy of this acknowledgement must be filed at the back of the Radiation Manual binder along with the Safe Work Procedure for operating the X-ray equipment.

I acknowledge having completed the University X-ray equipment Safety Information 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.

To demonstrate my knowledge, I will complete the [X-ray Self Study Assignment](#) and send with my [PRCF-X](#) to the Environmental Health and Safety Office to be added to an Internal X-ray Permit to use X-ray equipment for research purposes.

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

EMPLOYEE SIGNATURE

DATE



EMPLOYEE NAME (Please PRINT)

SUPERVISOR SIGNATURE

DATE



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SUPERVISOR NAME (Please PRINT)