X-ray Safety Training

Presented by:
Human Resources
Occupational Health and Safety
Radiation Safety Coordinator

Human Resource Services
Health & Safety - Training

- Mission: We enable the learning of safe work behaviour. We do this by providing opportunities for individuals to learn the knowledge and skills to take personal ownership of their health and safety.
- Vision: Our vision is the use of safe work behaviour as a life skill.
- Website: http://www.uwo.ca/humanresources

Bill C-45 - New Criminal Legislation affecting Workplace Safety

Bill C-45 establishes criminal liability for organizations and individuals when they fail to take reasonable steps to prevent workplace accidents that affect workers or the general public- conviction will result in a criminal record.

What's New – Key Elements

- The legal duty is similar to the general duty clauses currently found in the Occupational Health and Safety Act of Ontario. However, it elevates the penalty to the of a crime with a permanent criminal record.

Bill C-45 - New Criminal Legislation affecting Workplace Safety

What's New (continued)

- It applies to "everyone who undertakes, or has the authority, to direct how another person does work or performs a task….". Bill C-45 extends legal duties to a new level that could potentially apply from a co-worker up to the president.
- The requirement "to prevent bodily harm to that person, or any other person, arising from that work or task" goes farther than any current OH&S legislation in Canada. Bill C-45 casts the net to include all employees as well as the public that may be affected by the work or task.

Bill C-45 - New Criminal Legislation affecting Workplace Safety

Practical Impact

An effective program with demonstrated clear communication helps not only to ensure compliance but helps to ensure the health and safety of employees.

The first line of defence against death and injury in the workplace remains an organization's and an individual's proactive compliance with the existing workplace health and safety regulations.

Human Resources
Occupational Health & Safety - Programs

- Biosafety
- Construction and Facility Safety
- Laboratory and Environmental Safety
- Nuclear Radiation, X-ray & Laser Safety

Training Objective

- Understand X-ray physics, X-ray protection, detection and measurement
- Describe biological effects of X-ray
- Types of non-medical X-ray equipment
- Main causes of accidents and general safety procedures
- Your responsibilities to work safely with X-ray equipment

X-ray Safety Regulation & Guidelines

- X-ray Safety Regulation (Reg. 861) under the Occupational Health and Safety Act (R.S.O. 1990, c.O.1)
- Safety Requirements and Guidance for Analytical X-ray Equipment, 1994 (Safety Code 32) from Health Canada
- Radiation Protection in Veterinary Medicine (Safety Code 28) from Health Canada

UWO Mandate

- Comply with OHS Act, X-ray regulation and safety codes
- Keep radiation exposures to ALARA (As Low As Reasonably Achievable) by:
  - Management control over work practices
  - Personnel qualification and training
  - Control of occupational and public exposure to radiation
  - Planning for emergency or unusual situations

X-ray Safety Program Organization

- Permit Holders and X-ray Workers
- Radiation Safety Coordinator
- Radiation Safety Committee
- Senior Management

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University Policies

- ALARA policy
- Personal Exposure policy
- Purchase and Disposal policy
- Training policy
- X-ray Worker policy
- Inspection and Compliance policy

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Standard Operating Procedures

- New Permit
- Permanent X-ray Location
- Purchasing new X-ray Equipment
- Permit Amendments
- Safety Operating Procedures
- Emergency Procedure

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X-ray Permit Requirements

- The University issues an Internal Permit to:
  - Principle investigator or person in charge of the locations where X-ray machines are used or stored
  - Applicant who is responsible for ensuring that X-ray safety regulation and UWO policies and procedures are in full compliance
- Permit Holders are responsible for day to day supervision of their workers and the designated labs under the permits

Permit Holder & User's Requirements

- At least 18 years of age
- Have a Permit or work under a Permit
- Be designated as X-ray Worker
- Comply with the University Policies, Safety Code, Regulation and follow the safe use and operation of the X-ray equipment
- Be familiar with the X-ray Safety Manual
- Wear a required dosimeter

Permit Holder & User's Requirements

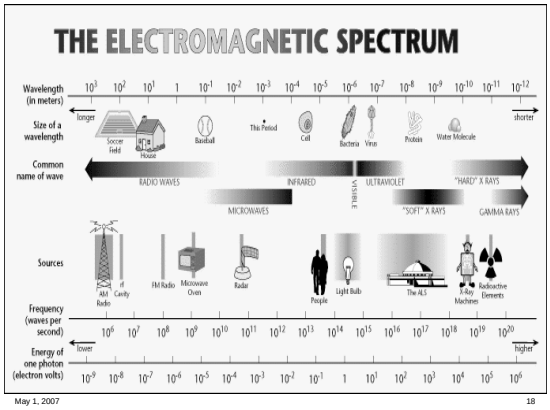
- Complete the UWO safety training program:
  - General X-ray Safety. Refresher training is required every two years (available on webCT)
  - Specific training on particular equipment, topic and/or procedures
- Pregnant X-ray worker must inform her permit holder and the Radiation Safety Coordinator as soon as she is aware of her condition

What Is Radiation?

- Radiation is energy traveling in the form of waves (electromagnetic) or particles
- Ionizing radiation: removal of one or more electrons of an atom in the medium, results in creation of positively charged atom and a free electron which are known as an ion pairs.

What Are X-rays?

- X-rays are photons (electromagnetic radiation) which originate outside the nucleus of an atom, as opposed to gamma rays, which are produced in the nucleus of an atom
- X-rays are produced when accelerated electrons interact with a target, usually a metal absorber. This method of x-ray production is known as Bremsstrahlung



Radiation Sources

- Background radiation is natural nuclear substances are present on earth, bodies, water, soil and air such as Uranium 238, Potassium 40, etc.
- Artificial radiation is nuclear substances or radiation devices other than background radiation such as Cobalt 60, Iodide 131, Phosphorus 32, X-ray equipment, Laser, etc.

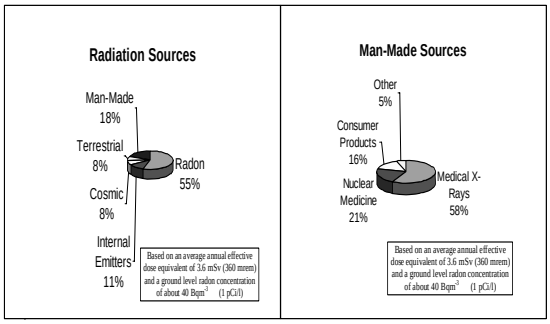
Radiation Dose

- Radiation Exposure Dose (1 roentgen = 2.58 X 10^{-4} coulomb/kg
  - Describes the ionizing ability of X-rays or gamma rays in the air
- Radiation Absorbed Dose (rad or gray): 1 Gray = 100 rad = 114.55 roentgens)
  - Measure the energy deposited in a medium by any type of radiation

Radiation Dose (cont.)

- Quality Factor (QF): The use of relative biological effectiveness
  - X-ray, gamma, beta: QF = 1
  - Neutron (0.1 Mev-2 Mev), alpha = 20
- Dose Equivalent (rem or sievert): This unit takes into account the biological effects of different types of radiation.
  - Dose Equivalent is equal to Absorbed Dose multiplied by a Quality Factor (QF)

Total Radiation Exposure



Occupational Dose Limit (OH&S-Regulation 861)

- X-ray workers dose equivalent annual limit is 50 mSv* to the whole body (uniform irradiation)
- Pregnant X-ray worker does not exceed 5 mSv during the pregnancy
- UWO action level is 2.0 mSv/year

Biological Effects Of Radiation

- Most radiosensitive: bone marrow, lymphoid tissue and reproductive organs
- Least radiosensitive: muscle, brain, nerve and bone cells
- Age at irradiation, absorbed dose, time distribution and dose distribution
- Most radiation overexposures from analytical X-ray equipment are extremities and skin

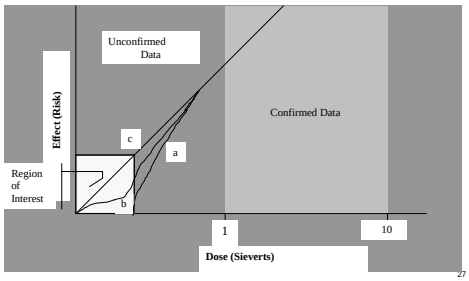
Non-stochastic Effects (Acute Exposure)

- Required extremely high radiation dose to the whole body at one time (1 Sv or higher)
- Un-repairable damaged cells at reproduction
- Enough damaged or dead cells to inhibit tissue function - temporary or permanent.
- The principle effects on the developing fetus are death, growth retardation and abnormal development

Stochastic Effects (Chronic Exposure)

- Concern of incorrectly repaired cells: division and multiplication
- Unconfirmed data or no evidence of a lower threshold of the stochastic effect
- Reduce the probability of the stochastic effect by minimizing the risk associated with radiation exposure - ALARA (As Low As Reasonably Achievable) principle

Radiation Dose Response



Radiation Protection

- ***Time***: Limiting the time spent in a radiation field or near the X-ray beam - direct proportional
- ***Distance***: Increasing the distance from a radiation field will decreasing the amount of radiation exposure - inverse square law
- ***Shielding***: Using appropriate shielding for type of radiation. Shielding for analytical X-ray equipment can range from the use of leaded glass to enclosures constructed of tin-impregnated polycarbonate

Monitoring Instrument

- A thin window GM detector or solid scintillation detector can be used to detect a leakage or scattered radiation from an X-ray machine but it is not appropriate for quantitative assessment of radiation levels
- An ionization chamber dose rate meter should be used to assess the levels of leakage or scattered radiation.

A Thin Window GM Detector

A Ionization Chamber Dose Rate Meter

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X-ray Monitoring

- Perform operational checks (battery, response, etc.)
- Record the background level
- Place the detector at the monitored locations such as: tube housing, joint or interface between beam ports and collimators, shutters (used and unused), radiation enclosure system, operator's position, camera, etc.
- Record the reading when the meter scale is stable

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Types of Non-Medical X-ray Equipment

- Analytical X-ray
- Veterinary Radiology
- Industrial Radiography

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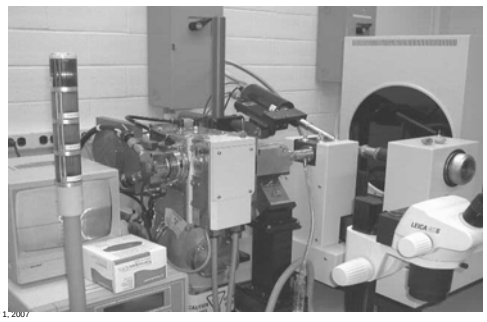
Analytical X-ray

Types Of Analytical X-ray Equipment

- Open X-ray equipment: The open X-ray beam can be extremely hazardous if it is not operated properly or has major radiation leakage/scatter
- Cabinet or enclosed with interlocked X-ray equipment: If a panel is opened while the X-ray machine is being used, the interlock will shut off the X-ray machine or close the shutter

Open X-ray Equipment



Cabinet X-ray Equipment

Safety Devices

- Shielding
- Enclosures and Control of Access
- Safety Shutters
- Interlocks
- Warning Lights and Signs

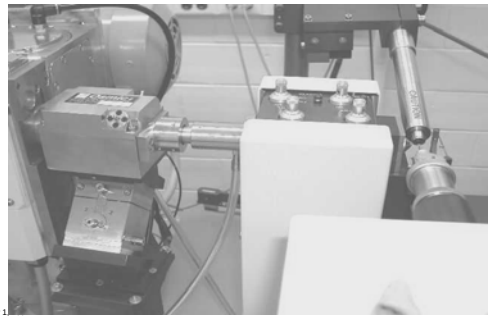
Safety Devices

X-ray Monitoring (cont.)

Regulatory limit is 5 µSv per hour at 5 cm from any surface of the equipment

X-ray Monitoring (cont.)

X-ray Monitoring (cont.)



Radiation Intensity Analytical X-ray Equipment

Location	Possible Dose Rate
Primary beam at tube port	several tens of Sievert per second
Primary beam at end of 10 cm collimator	several tens of Sievert per minute
Scattered radiation near sample	several milliSievert per hour
Scattered radiation near table	1milliSievert per hour

Burns Produced by X-rays

Tissue Damage	Approximate Dose Required (Sieverts)
• Visible reddening of skin	3
• Serious burn with blistering	15
• Very serious burns requiring skin grafts or amputation	30

- The burn symptoms may require from one to several weeks to develop depending on the dose

An Example of Burns Produced by X-rays

Main Causes Of Accidents

- Inadequate training or not follow procedure: Improper use of equipment, overriding interlocks, loading sample when shutter is opened, etc.
- Manipulation of equipment when energized: Adjustment of samples or alignment of cameras when X-ray beam is on, etc.

Main Causes of Accidents

- Equipment or safety devices failure: shutter failure, warning light failure, interlock failure, etc.
- Poor equipment configuration: unused beam ports not shielded or covered
- Pre-operational safety checks was not performed

How to Prevent Accidents

- Group 1
- Group 2

General Safety Precaution

- Receive hands-on training and follow procedures
- Know the location of the X-ray beam
- Use appropriate shielding if necessary
- Shutter must be closed when loading sample
- Perform maintenance when X-ray tube is not energized

General Safety Precaution

- Perform pre-operational safety checks (interlocks, shutters, warning lights, etc) at least once a month
- Complete a radiation survey whenever the equipment is moved or reconfigured
- Unused beam port must be covered
- Use the main switch to turn off the machine
- STAY OUT OF THE X-RAY BEAM!

Failure of Safety Devices or Accident

- Stop the operation immediately
- Turn off the X-ray equipment
- Alert everyone in the lab or facility
- Report to the Permit Holder as soon as possible
- Report to the Radiation Safety Coordinator the failure of any safety devices on X-ray equipment or other incident occurs that may resulted in an X-ray worker receiving a radiation exposure

Veterinary X-ray

Veterinary X-ray

Veterinary X-ray (cont.)

- Radiographic procedures shall be performed in a designated room where practicable
- Air kerma due to the leakage radiation from the X-ray tube housing shall not exceed 1 milligray/hr at a distance of 1 meter.
- Exposure duration shall be controlled by a preset timing mechanism (switch) and operated by the user at least 2 meter from the tube housing.
- A record of radiographic exposures (date, kVp, mA & sec) shall be maintained and kept for at least 1 year.

Veterinary X-ray (cont.)

- Dimensions of the useful beam shall be restricted to not more than those of the film.
- The film cassette shall not be held by hand during an exposure.
- The animal being X-rayed shall be restrained or supported by mechanical means where practicable.
- A protective apron and gloves (min 0.5 mm lead) shall be worn by any person providing the restraint or support of the animal.

Personal Protection Equipment (PPE)

Computed Axial Tomography (CAT or CT Scan)

What is CAT or CT Scan?

- An X-ray procedure or test that produces cross-sectional images of the body using X-rays and a computer.
- Radiation field is much higher than a standard X-ray.

General Safety Procedures

- Post X-ray warning sign
- Shield CT room
- Install door locks or interlocks
- Set up a computer control station outside of the CT room
- Perform a complete radiation survey
- Stay out of the CT scan room during X-ray procedure or imaging

Examples of CT Scanner

Personal Action Plan

- ✓ Think “safety first”
- ✓ Inform your supervisor/permit holder that you have completed the general X-ray safety training and ask for your name to be added to the X-ray permit
- ✓ Receive specific training on particular equipment, topic and/or procedures
- ✓ Review the X-ray safety inspection checklist posted on UWO Human Resources web site
- ✓ Review the emergency response plan
- ✓ Work safely to reach your goal

Questions?