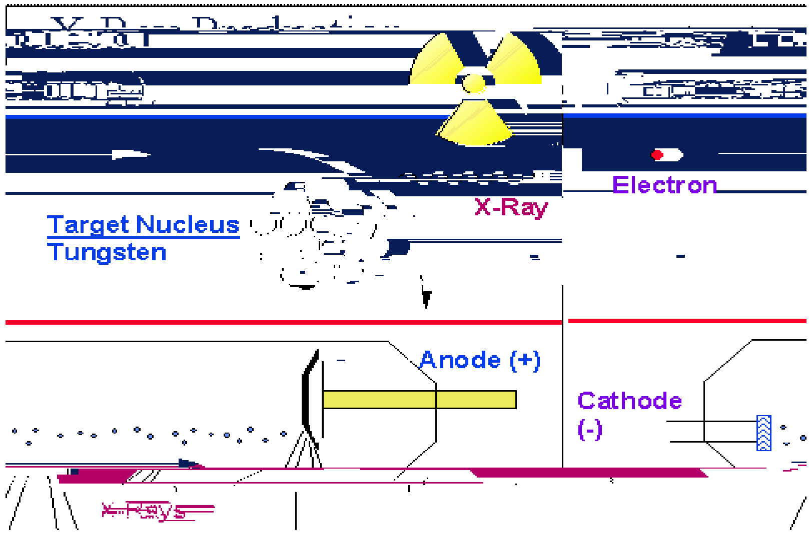

The Manual will:

Provide the basic fundamentals of X-ray devices.
Explain the hazards of X-ray devices used in USF research.
Provide THREE ways to reduce x-ray exposure.
Explain USF requirements and responsibilities for the safe use of X-ray devices.
Help X-ray users recognize and respond to unsafe conditions.

UNIVERSITY OF SOUTH FLORIDA
Radiation Safety Office
Adam Weaver, MS, CHP

Manual contents

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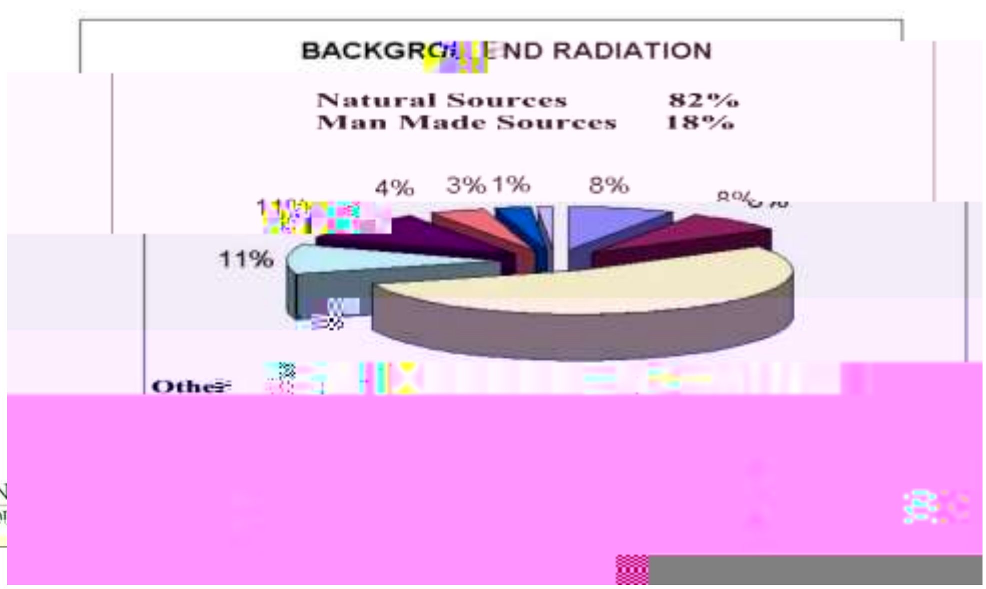
Introduction

USF research operations require the use of X-ray equipment. X-rays are used for analysis of samples, non-destructive testing, or diagnostic imaging. X-ray devices at USF can be and have been operated safely for years. X-ray users must understand hazard(s) of device and follow operating procedure and/or owner manual instructions for device. If you have any questions or concerns about X-ray devices at USF, contact USF RSO Adam Weaver.

Radiation is energy in the form of waves or particles. Radiation high enough in energy to cause ionization is called **ionizing radiation.** It includes particles and rays given off by radioactive material, stars, and high-voltage equipment. Ionizing radiation includes x-rays, gamma rays, beta particles, alpha particles, and neutrons.

Without the use of monitoring equipment, humans are not able to "find" ionizing radiation. In contrast to heat, light, food, and noise, humans are not able to see, feel, taste, smell, or hear ionizing radiation.

The background radiation we are all exposed too has two sources Natural Background and Man-Made Radiation. The NCRP Report No. 93 states that the average background dose in the US is 360 mrem/year.



X rays are a form of electromagnetic radiation, which arises as electrons are deflected from their original paths, or inner orbital electrons change their orbital levels around the atomic nucleus. X rays, like gamma rays, are capable of traveling long distances through air and most other materials. Like gamma rays, x rays require more shielding to reduce their intensity than do beta or alpha particles. X and gamma rays differ primarily in their origin: x rays originate in the electronic shell, gamma rays originate in the nucleus.

X-rays were discovered in 1895 when **Wilhelm Conrad Roentgen** observed that a screen coated with a barium salt fluoresced when placed near a cathode ray tube. Roentgen concluded that a form of penetrating radiation was being emitted by the cathode ray tube and called the unknown rays, **X-rays**.

Like radio waves, light, and gamma rays, x-rays are a form of electromagnetic radiation. All electromagnetic radiation is characterized by the movement of massless waves of energy called

Each X-ray Tube has the following Components

Cathode: The cathode acts to excite electrons to the point where they become free from their parent atom and are then able to become part of the electron beam. The cathode acts as a negative electrode and propels the free elections, in the form of an electron beam, towards the positive electrode (the anode).

Anode: The anode acts as a positive electrode, attracting the free electrons and accelerating the electrons through the electromagnetic field that exists between the anode and cathode. This acts to increase the velocity of the electrons, building potential energy. The higher the kV rating, the greater the speed at which the electrons are propelled through the gap between the cathode and anode. The electrons then impact a target (most commonly made of tungsten, but this target can also be molybdenum, palladium, silver or other metal). This causes the release of the potential energy built up by the acceleration of the electrons comprising the electron beam. Most of this energy is converted to heat and is radiated by the copper portions of the anode. The remainder is refracted off of the target in the form of high energy photons, or x-rays, forming the x-ray beam.

Glass envelope: The above components are sealed into a glass envelope. This allows for gases

confined to areas that are not accessible to the operator. Localized radiation effects, such as burns, are only possible if safety devices are disabled and parts of the body are placed in the direct X-ray beam. This is why it is important to be familiar with the safety devices, warning systems, and procedures that are in place for your x-ray diffraction equipment.

When a beam of monochromatic X-rays strikes matter, X-rays are scattered in all directions. In crystalline materials atoms are organized in an orderly manner with sets of parallel planes arranged in a lattice structure. Irradiating a crystal with monochromatic X-rays will result in X-rays emanating from the sample in an orderly pattern that is dependent on the position and intensity of each reflected beam. This directional dependence of the diffracted beam is called a diffraction pattern. It can be used to identify compounds, study phase transformations, determine crystalline size, measure stress or strain, and other similar structure related properties of materials. Since X-ray diffraction is applicable to the study of most solid materials, 722. G8ateri5(r y)11(o)-3(u)-3(r x)] TJETQq0.0

B) There are two main types of diagnostic X-ray devices: Radiograph a picture with film or image is sent direct to computer screen and Fluoroscopic
functions

Diagnostic radiology is the branch of medicine that has traditionally been known for taking and reading X-rays. Like every other field of medicine, technology has radically changed this specialty

detect disease sooner and pinpoint its location more accurately is a huge factor in stopping disease in its tracks.

C) Industrial X-rays are used for non-destructive testing and has applications in a wide range of industries. Non-destructive testing (NDT) by means of the X-ray beam inspects the integrity of industrial products or processes without damaging the items under observation. Industrial radiography is a form of NDT that uses ionizing radiation. Industrial X-ray machines are used primarily to find defects in castings, structures, and welds. These units help to find foreign material in food products. X-ray machines are used for the inspection of luggage at airports and buildings.

1.The primary beam: The primary beam is most hazardous because of the extremely high exposure rates. Exposure rates of 4 x 10^5 R/min at the port have been reported for ordinary diffraction tubes.

2.Leakage or scatter of the primary beam through cracks in ill fitting or defective equipment: The leakage or scatter of the primary beam through apertures in ill fitting or defective equipment can produce very high intensity beams of possibly small and irregular cross section.

3.Penetration of the primary beam through the tube housing, shutters or diffraction apparatus: The hazard resulting from penetration of the useful beam through shutters or the x-ray tube housing is slight in well-designed equipment. Adequate shielding is easily attained at the energies commonly used for diffraction and florescence analysis.

4.Diffracted rays: Diffracted beams also tend to be small and irregular in shape. They may be directed at almost any angle with respect to the main beam, and occasionally involve exposure rates of the order of 80 R/h for short periods.

The main causes of exposure Using **ANALYTICAL** X-ray devices are:

- Putting fingers in X-ray beam to change sample
- Aligning X-ray beam visually
- Modification of shielding
- Failure to realize X-rays are emitted from several ports
- Failure to read & follow manufacturers X-ray operating instructions

X-ray Safety Components

Shielding must be adequate to ensure that stray radiation escaping into the room does not exceed permissible dose limits and is as low as reasonably achievable. **Contact USF RSO with any concerns about X-ray shielding.**

Diffraction equipment the housing may contain up to four **ports** to allow the primary beam to exit from the tube. Unused ports must be effectively closed to prevent the beam from emerging and

accidentally exposing a worker. Ports must be secured in such a manner that tools are required to open the ports.
The **shutter** is located immediately in front of the port of the tube and behind the collimator coupling. The purpose of the shutter is to place a piece of highly absorbent material such as lead in front of the port to block the emergence of the primary beam.

Collimators are connected to the shutter to limit the size of the x-ray beam and reduce the amount of background scatter.

Interlocks are used to prevent access to the primary beam by either cutting off the high voltage supply or closing the shutter.

The effects of x-ray exposure depend upon the duration of exposure, how fast the dose is delivered, Energy - How much energy was in the x-ray, and total Dose - The magnitude of the dose.

Time, Distance and Shielding are three fundamental strategies to protect you from unnecessary exposure to X-

X-ray devices must be registered with State of Florida, Department of Health, Bureau of Radiation Control.
Each X-ray system MUST meet State of Florida requirements.
Each system must have a radiation protection plan (RPP) reviewed yearly in January by USF RSO.
The State of Florida routinely inspects X-rays devices per F.A.C. 64E-5.

If you acquire any X-ray devices YOU MUST ***Notify*** USF radiation safety office!
USF Radiation Safety inspects X-ray devices annually.
Each system must have a USF RSO approved radiation protection plan (RPP) reviewed yearly in January.
X-ray users must be approved by device Principal Investigator.
X-ray users need to complete Research X-ray Safety Fundamentals ON-LINE course prior to unsupervised use of an X-ray device.

Responsibilities of X-ray owners & users

Operate x-ray device only as specified in manufacturers operating instructions.
Notify USF Radiation Safety Office of any repairs, modifications, disposal, or relocation of X-ray device.
X-ray owners & users are required to read USF Radiation Protection Plan (RPP) posted in X-ray area!
At USF personnel monitoring is required if there is a possibility that an X-ray user might receive greater than 10% of the State of Florida maximum permissible dose limit.
Most analytical X-ray devices at USF **do not require** users to be issued personnel monitoring devices.
X-ray users should address any radiation safety concerns to USF Radiation Safety Officer @ 813-974-1194.

SURVEYING ANALYTICAL X-RAY EQUIPMENT

USF Radiation Safety Office conducts an annual radiation survey of X-ray devices in use at USF using a thin window (1-2 mg/cm^2) Geiger Muller (GM) counter. With its fast response and sensitivity, the GM is ideal for detecting leaks in the shielding and around couplings. If a leak has been detect
chamber. Appropriate actions, such as adding shielding, will then be taken to correct the problem.

Any PI that may have a research need to purchase, borrow, or build a radiation generating
(RSO).
USF Radiation Safety will inspect X-ray devices and facilities annually during the month of January.
Any changes to an X-ray device (new tube, design modifications, etc.) MUST be approved by USF RSO. *Call 813-974-1194*

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