What is the purpose of this in-service?

- The Ohio Department of Health mandates that all handlers of fluoroscopic radiation-generating equipment who perform fluoroscopic procedures shall comply with the following Rules of the Ohio Administrative Code Chapter 3701:1-66-07 Fluoroscopic Radiation-Generating Equipment

Chapter 3701:1-66-07 (G)

1. All personnel participating in or performing fluoroscopic procedures shall receive at least 2 hours of radiation safety training prior to performing or participating in fluoroscopic procedures.

Instructions for Program Completion

- Read through the complete lesson.
- Complete post-test. A score of 80% must be achieved to receive credit.
- Submit test.

Who is required to complete the Radiation Safety Training “Handlers of Fluoroscopy Radiation-Generating Equipment”?

- All personnel and or departments participating in or performing fluoroscopic procedures in the following areas:
  - Radiology
    - Special Procedures
    - Fluoroscopy
  - GI Lab
  - Surgery
  - Cardiac Catherization Lab
  - EP Lab
  - Speech Therapy
  - Outreach (Mobile Coach)
  - Emergency Departments
  - Mini C-arms operators
  - Surgery Centers
What are examples of procedures involving extended fluoroscopy exposures?

- Radiofrequency Cardiac Catheter Ablation
- Percutaneous Transluminal Angioplasty (PTCA, PTA)
- Vascular Embolization
- Stent and Filter Placement
- Thrombolytic and Fibrinolytic Procedures
- Percutaneous Transhepatic Cholangiography
- Endoscopic Retrograde Cholangiopancreatography (ERCP)
- Transjugular Intrahepatic Portosystemic Shunt (TIPS)
- Percutaneous Nephrostomy, biliary drainage, or stone removal

Why Fluoroscopy Training?

Because the use of x-ray fluoroscopy has increased dramatically in recent years and spread beyond the radiology department fluoroscopy training is required to:

- Assure that the facility is in compliance with all state and federal regulations
- Assure that the facility is keeping up with the advances in medical technology that has resulted in the development of more powerful x-ray machines used during complex procedures requiring extensive use of fluoroscopy
- Assure an understanding of the precautions and of the complexity of procedures aiding in the management of radiation exposures
- Assure that radiation exposure to patients, staff and visitors is maintained ALARA (As Low As Reasonably Achievable) Refer to the education module titled ODH-Radiation Safety Training for the Occupational Worker

How are X-rays Produced?

- X-rays are produced in X-ray tubes (see illustration)
- Electric current flows through a connection called a cathode (see illustration 1)
- The heated cathode releases electrons
- Voltage applied across the cathode and a connection called the anode forces the electrons to strike a tungsten target
- When this occurs X-rays are produced
- Only a small fraction of the energy imparted by the decelerating electrons is converted to X-rays
- Lead housing surrounding the x-ray tube limits x-ray emissions through a small opening
- X-ray beam is further controlled by additional lead shutters, or collimators that can be adjusted to provide different beam shapes or sizes
- X-ray goes through an object onto a sheet of photographic film to produce a still image on the film

Illustration 1
How is fluoroscopy different than X-rays?

- Fluoroscopy is a diagnostic medical procedure that uses x-rays.
- X-rays produce still images on a film.
- Fluoroscopy is *continuous* exposure to x-rays where the x-rays are converted into an image that is recorded by a television camera.
- This image is viewed on a TV monitor.
- The physician sees a “live” image of the object that he is viewing.

Refer to illustration:

- The x-ray tube is beneath the table.
- A device called an “Image Intensifier” is suspended above the patient.
- X-rays pass through the patient and form an invisible image in the image intensifier.
- The image intensifier converts the x-rays into a visible image that is recorded by a television camera.
- The “live” image can than be seen on the TV monitor (video output) or the output can also be distributed to a film or cinematography recording system.

Types of Fluoroscopic Units

- **Conventional Fluoroscopy**
  Pose the least patient hazard. Procedures are short and they cover multiple areas. Patient dose rates are usually 2R to 9R/min.
- **Cardiac Catherization & ElectroPhysiology Labs (EP)**
  Usually offer the highest patient exposure due to the lengthy procedures irradiating the same small skin areas.
- **BI-Plane C-arm**
  Sophisticated units capable of exposing x-ray beams from 2 different angles at the same time.
- **Cystoscopy and Overtable x-ray tube Units**
- **Digital and Pulsed Fluoroscopy Units**
  Markedly increase doses, however the ability to utilize the pulsed mode reduces this dose by electronically filling in pulses.
- **Mobile C-arms**
  Are utilized in Emergency Rooms and Operating Rooms.

Fluoroscopic Modes of Operation

- Modern fluoroscopy machines produce images with what is called an Image Intensifier or II. (refer to illustration 2)
- The II brightens the image level sufficiently so that the TV tube can display the image on a video screen.
A. Normal Mode:

Normal Mode is used in the majority of fluoroscopy procedures. The radiation output is sufficient to provide video images for guiding procedures or observing dynamic functions. Different types of normal modes that the machine can be operated in are:

1. **Manual mode**
   
   Manual mode allows the user to select the exact mA and kVp required. The radiation exposure is independent of the patient size, body part imaged and tissue type when manual mode is used. However, the image quality and brightness are greatly affected by these factors when the operator "pans" across tissues with different thickness and composition.

2. **ABC mode**
   
   Automatic Brightness Control is the mode of choice for most fluoroscopic procedures. ABC mode allows a consistent image quality during dynamic imaging by automatically adjusting to bring brightness to a constant level.

3. **Pulse mode**
   
   Pulse mode modifies the fluoroscopic output by cutting out exposure between pulses.

B. Boost Mode:

Boost The use of higher radiation rates or “boost” modes are useful in situations requiring high video image resolution. The FDA limits the maximum ESE to 20R/min. Audible alarms are activated during “boost” modes.

**How is radiation output defined?**

- X-ray machine output is described in terms of Entrance Skin Exposure (ESE)
- ESE is defined as the amount of radiation delivered to the patient’s skin at the beam’s entrance point
- ESE can also be defined as “table-top-dose”
- Units of ESE are roentgens per minute (R/min)

**Radiation Exposure and Dose Units**

<table>
<thead>
<tr>
<th>Radiation Absorbed Dose Unit – Rad or Gray (Gy) Units</th>
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<tbody>
<tr>
<td>Radiation Dose Equivalent Man Unit – Rem or Sievert (Sv) Units</td>
</tr>
<tr>
<td>Roentgen – Unit of Exposure in Air</td>
</tr>
</tbody>
</table>

THE ROENTGEN, RAD AND REM ARE ALMOST ALL EQUIVALENT FOR X-RAY ENERGIES

1 RAD = 1000 mRAD  100 RAD = 1 GRAY (Gy)

**Radiation Exposure During Fluoroscopy**

- Exposure during fluoroscopy is directly proportional to the length of time the unit is activated by the foot switch
- Unlike regular x-ray units, fluoroscopic units do not have an automatic timer to terminate the exposure after it is activated
- As long as the foot switch is depressed the exposure is activated.
- Fluoroscopy machines are equipped with timers and alarms
- The alarms serve as reminder of the elapsed time and can be reset
- Newer machines document fluoroscopy time for each procedure
- The typical exposure rate at the x-ray beam entrance into the patient (ESE) is 2R/min to 5R/min
- For routine fluoroscopy applications, the ODH limits the maximum ESE to 10R/min
Case Studies of Radiation Injuries

Non-Symptomatic Skin Reactions

- Patients may not be aware of skin changes that take place as a result of lengthy fluoroscopic procedures. The following examples were in areas not visible to the patients - were only identified upon physical examinations.
- One year following coronary angioplasty identified a 1 x 2.5-cm de-pigmented area with telangiectasia on the patient’s left shoulder - fluoroscopy time 34 minutes.
- One year after PTCA involving 66 minutes of fluoroscopy, a 10-cm diameter hyper-pigmented area with telangiectasia was evident on the patient’s right shoulder.

Symptomatic Skin Reactions

- 40-year-old male underwent coronary angiography
- coronary angioplasty
- second angiography procedure (due to complications)
- followed by a coronary artery by-pass graft
- Total fluoroscopy time estimated to be > 120 minutes
- Area of injury six to eight weeks following the procedures was described as:
  - “turning red about one month after the procedure
  - peeling a week later
  - approximately 1 ½ months later had the appearance of a second-degree burn

Appearance of skin injury approximately 16 to 21 weeks following the procedures with small ulcerated area present

Appearance of skin injury approximately 18 to 21 months following procedures, evidencing tissue necrosis

Appearance of patient’s back following skin grafting procedure
Symptomatic Skin Reactions

- patient was released from the hospital the day after the procedure
- at the time there were no complaints
- no indication of erythema
- 3 – weeks after the procedure a bright erythema was demonstrated
- the condition worsened
- 5 – months a large ulcer the size of the collimated x-ray port developed
- at 8 – months a de-bridement was performed and a surgical flap was put in place

Thresholds for Biological Effects

100 Rads – FDA recommends patients be told of erythema risks

- > 1 Gy
- 2 Gy
- 3 Gy
- 6 Gy
- 7 Gy
- 100 Rads
- 200 Rads
- 300 Rads
- 600 Rads
- 700 Rads
- Cataracts
- Mild temporary erythema
- Temporary loss of hair
- Main erythema
- Permanent loss of hair

Fluoroscopy Regulations

- The FDA regulates the manufacturer and assembly of fluoroscopy equipment
- The Ohio Department of Health regulates the use of them
- The Ohio Department of Health has adopted standards for x-ray equipment used to perform any type of fluoroscopic procedure, including x-ray equipment, which is mobile or used for special imaging. Those rules are available on the Radiation Safety Services Web Page.

Summary of Fluoroscopic Regulations

- Any individual who is in the room during the fluoroscopic procedure shall be required to wear a protective lead or lead equivalent apron
- Protective lead (or lead equivalent) gloves shall be worn by all individuals who have their hands within the useful beam
- All individual who perform fluoroscopic procedures on human beings shall hold a radiographer license or shall be a licensed practitioner (refer to Chapter 3701-72 Ohio Administrative Code)
- All handlers of fluoroscopic radiation-generating equipment shall comply with the following:
  - Personnel performing radiologic procedural tasks for all fluoroscopic procedures, including but not limited to cardiac catherization, shall be licensed radiographers as required by chapter 4773 of the Revised Code. Personnel other than radiologists and cardiologists, who do not meet the requirement of rules 3701-72-01 to 3701-72-04 of the OAC, shall not perform radiologic procedural tasks.
  - All personnel participating in or performing fluoroscopic procedures shall receive at least two hours of radiation protection training in addition to the training requirements of Chapter 3748 of the Revised Code prior to performing or participating in fluoroscopic procedures.
  - Additionally, each individual shall receive one hour of re-training each year thereafter whenever the individual receives in excess of 30% of the allowable applicable dose within the previous twelve months.
In Summary

- Mount Carmel is committed to ensuring that individuals working under their control are properly supervised, trained with regard to safe working habits and properly equipped to accomplish their duties.
- Information pertaining to Radiation Safety may be found on the Radiation Safety Services Web Page on InSight.
  - InSight
  - MC Information
  - Departments
  - Radiation Safety Services
    - Policies
    - Links:
      - Rules and Regulations
      - Resource Links
      - Professional Society Links
    - Forms
    - Emergency contact numbers