

The lectures I have added in this course are to be used as a supplement to the Fluoroscopy Syllabus. In some case the lecture are intended to give more explanation to what is in the syllabus, others is additional information. This is in outline form, not written as paragraphs in most cases

Lectures for Sections --III A, B, C & D

Image Intensifier and x-ray tubes

Section III A. An X-ray tube has two primary parts (1) cathode and (2) anode. Both are enclosed in a lead lined housing.

1. Protective housing: x-rays are produced isotopically and we can only use those which come through the window. The protective housing protects from excessive radiation exposure, electric shock and is used for heat dissipation.

a. must reduce level of leakage to below

100 mR/hr at 1 m

b. also used as mechanical support

2. Glass envelope= creates a vacuum

a. Made of Pyrex glass to withstand high heat

b. vacuum allows for more efficient x-ray production and longer tube life.

c. With age the tungsten vaporizes and coats the inside of the envelope. Current reacts with this and can cause tube failure.(arching)

d. Window is thinner for less absorption of x-rays, thereby allowing more to be directed towards the patient

3. Cathode=negative charge (-)

a. filament coil of tungsten 2 mm diameter= 1-2 cm long

b. Thermionic emission (heated by mA) outer shell electrons are boiled off and ejected from the filament. The higher the mA setting, the hotter so more electrons are "boiled off".

c. Focusing cup== negative charge (-) .. size shape and charge will affect the effectiveness. Remember like charges repel

4. Anode== positive side (+). Remember different charges attract.

a. Stationary or rotating

b. Receives electrons, conducts then back through the tube to high voltage section (electrical conductor, provides mechanical support for the tube, and is a good thermal conductor.

c. 99 % of the interactions produce heat and only 1% are converted to x-rays and an even smaller percent leaves the tube at the window to reach the patient.

d. Target of tungsten has high atomic number, with higher efficiency,, good thermal conductor, high melting point of 3410 C

e. Is turned by electromagnetic inductor motor. Outside is a stator= electromagnetic device= the rotor shaft is made of bars of copper and soft iron.

5. Difference is amperage in Fluoroscopy. Usually 5 mA vs. much higher in diagnostic.

6. Brems vs. Characteristic== if you need review of this, please refer to a radiologic physics text.

IMAGE INTENSIFICATION (TUBE)

1. Purpose is to amplify electronically the brightness of an image by converting exit x-rays and converting them to light. It was developed in the early 1950's.

2. 57 cm is used for abdomen and the smaller 23 cm is used for higher resolution such as the heart.

3. Tube is a vacuum and mounted inside a metal container to protect it from leakage . It is curved on the bottom to give equal distance to the center (maintains distance between each point on the input screen and a corresponding point to the output screen which minimizes distortion).

4. I have added information in a separate lecture that explains specifically how the II works. Please refer to this material for additional information. But, Basically this is how it works.

a. X-rays interact with the cesium iodide in the input phosphor (X-rays to Light)

b. This light interacts with the photo cathode (bonded to the input phosphor with transparent adhesive) It is a metal layer composed of cesium and antimony compounds. The process is called photo emission and it turns the light into electrons. The number of electrons is directly proportional to the intensity of the light falling on it. (Light to Electrons)

c. electrostatic focusing lenses with a positive charge focus the electrons, the anode also has a positive charge which further attracts the electrons. The syllabus is not really clear on this and it discusses the anode as being the part that does the acceleration. BUT, in fact the len(s) do both; focus and accelerates because of the difference in the charges. The anode assists with this and as such is called an acceleration anode. The anode does not focus the electrons.

d. The output phosphor is zinc cadmium sulfide crystals. Newer II's use fiber optics to eliminate retrograde emission.

5. Flux gain is the ratio of the number of light photons at the output phosphor to the number produced at the input phosphor.

6. Minification gain is the ratio of the square of the diameter of the input phosphor to the square of the diameter of the output phosphor. Opposite of magnification it takes an image and makes it smaller.

7. Brightness gain is minification gain X flux gain. Most are 5000 to 20000.

Section III B. Dual focus. Standard in digital fluoroscopy. Come in many sizes but the most common are 25 cm or 17 cm. When using the smaller focal point the exposure to the patient is greater as is the image because the minification gain is reduced and there are fewer photoelectrons and a dimmer image is the result. to counter the dimmer image the tube mA is automatically increase. Patient dose is about 2.2 times as great.

Section III C. Image Quality Consideration

1. Quantum mottle=

a. random nature = x-rays interact with the image receptor.

- b. the radiographic noise===as an undesirable fluctuation in the optical density of the image==
- c. if an image is produced with just a few x-rays the noise will be higher than if the image is formed from a large number of x-rays
- d. grainy or blotchy appearance caused by insufficient radiation to produce a uniform image.
- e. x-rays are emitted at random variations in x-ray intensity and are more evident when the fewest number of photons are used (low mAs values)
- f, Mottle is a problem in flora because unit operation is based on the minimum number of photons required to activate the flora screen through the automatic brightness stabilization.
- g. start with an inferior x-ray image and must be intensified to be viewed.
- h. As a result, need more mA= so you will need to increase but gives more patient exposure
- i. BUT you can increase brightness gain, viewing system use the flora boost

2. Contrast...basically dependent upon the subject (called **subject contrast** and is based on the attenuation of the tissues and the kVp)

a. =controlled through the amplitude of the video signal.

b. scatter radiation and kVp diminish contrast so does two other factors

(1) lack of absorption of all photons and

(2) light scatter leading to retrograde light flow.

c. The input screen does not absorb all photons from the x-ray beam. some are absorbed by the output screen.

d. it is a kind of fog the retrograde (reflection and refraction) from the output screen also cause fog.

e. Contrast also decreases at the edge of the images, more bright at the center

f. Also as the image intensifies ages.

g. the electrons that are retro go to the photocathode and electrons are emitted. these electrons are accelerated to the output screen where they contribute additional exposure to the image area and further reduce contrast. The contrast reduction in modern intensifier tubes is generally in the range of 5 to 15%.

3. resolution

a. The factors affecting the geometry (resolution) of the images are the 1 video monitor (primary factor),

1 minification gain,

2 the electrostatic focal spot,

3 the diameter of the input and output screens,

4 object to image receptor distance (OID)

5 and phosphor size and thickness,

b. TV monitor can resolve to 1-2 line pairs per millimeter,

c. optical mirror system is capable of resolving 3 lp/mm

d. II resolves up to 4 lp/mm

e. and magnification -multi-field image intensifiers are capable of resolving up to 6 lp/mm in magnification mode.

f. More line pairs per mm the better resolution.

g. several potential sources of blur and loss of detail within the system.

1. the spreading of light in the input and output screens of the image intensifier tube produces blur,

2. as it does in intensifying screens. with dual-mode tubes, the larger field generally produces more blur and less detail than the smaller field.

3. Blur is also produced by improper focusing of the electron in the tube. Most intensifier system have controls that can be used by the service engineer to adjust the electron focus.

4. distortion

a. Primary influence on size distortion is OID in both static and dynamic radiographic system.

b. even though input screen is concave edge distortion at the output screen is not completely eliminated. pincushion ==

c distortion and loss of brightness through vignetting is caused by the repulsion of electrons and the divergence of the primary beam from the focal spot of the x-ray tube.

d. distortion is minimized and contrast is improved at the center of the fluoroscopic image.

5. Vignetting==

a. fall off in brightness at the periphery of the field the electrons striking the output put screen do so such that the image is proportional to input screen.

b. However in practice the electrons at the peripheral edge of the output screen are angled more that those at the center of the screen this creates distortion decreased sharpness and reduces the brightness.

6. Veiling Glare=

a. a scattering of light that reduces contrast it is inherently built into the II and you have no control over this problem in much the same way that you have no control over the effects of off-focus radiation in a diagnostic x-ray tube.

Section III D= ABS

This is much like the old term Photo Timing.. this system reads the amount (number, quantity) of radiation reaching the II and maintains the proper amount of contrast for viewing. The syllabus listed the factors which should be present in a properly designed ABS

1 Variations with x-ray factors

- a. The brightness on an image intensifier can be increased by increasing the flora mA or kVp .
- b. As patient size or body part density increases, the brightness may decline due to a reduction of x-ray photons to maintain the appropriate brightness of the image.
- c. On earlier flora equipment mA and kVp controls can be adjusted by the operator to maintain an optimum image.
- d. On newer equipment a photoelectric cell is often positioned to measure the brightness of the output phosphor.
- e. the photoelectric cell is attached to a circuit that adjusts the fluoroscopic cell is attached to a circuit that adjust the fluoroscopic kVp or mA to maintain a preset level of brightness at the out put phosphor.
- f. Some fluoroscopic units are capable of adjusting both mA and kVp to maintain brightness. This may be advantages because increasing the kVp alone may increase output phosphor brightness, but may also result in quantum mottle.

2 Please refer to the syllabus for the ways image brightness can be sensed.

3. Please refer to the syllabus for the various types of ABS circuits

Please go to next lecture section for the remainder of Chapter III lectures

Sections III E -K

Section III E =Closed-Circuit Television Systems

There are 3 parts

1. Camera.. this is placed on the top of the II and it conveys the image from the output phosphor if the II into a TV camera where it is amplified. The camera sweeps the information into 525 lines of dots. The lag or smearing occurs because it takes time for the image to "build up" on the monitor.
- 2.Camera Control Unit...amplifies the video signal, regulates the focusing and synchronies the video signal between the camera and the monitor.
3. Monitor... just like your TV...525 lines that are scanned 30 times a second to give the image (newer screens can scan 1050 lines in the same amount of time for better resolution to demonstrate motion). The camera and the monitor alter the contrast (camera -0.8 whereas the monitor is a +2). Net result is improvement over the II alone. Brightness must be carefully controlled by the uses, using the controls on the monitor. Regardless of the size of the monitor.. the number of lines do not increase or decrease from the 525 or 1050 (depending on which one you are using).

Section III F= Television Image Quality. Refer to the syllabus for this section

Section III G =Cameras

- 1.Plumbicon has less lag time but there is a problem of the time to correct for quantum mottle
- 2.Charge Coupled Devise is solid state and what is going to be the norm in the future of fluoroscopy cameras

advantages ==smaller in size, lower in power consumption lower in price and longer life. and elimination of lag

Section III H=Dynamic Image Recording video tape recorders and cinefluorography

1. Video==recording the fluoroscopic image on magnetic media As a recorder it receives a video signal from the camera control unit and for playback it transmits the signal to a TV monitor . VHS 1/2 and U-matic 3/4 inch recorders or 1 or 2 in

advantages

- a. no additional dosage to patient
- b. instant replay just rewind
- c. doesn't require film processing
- d. Provides stop-motion studies
- e. reuse of the tape

disadvantages

- a. poor resolution
- b. potential loss as image caused by constant use of the tape

- c. lesser quality slow motion effect
- d. slower frame rate than cine (fixed 30/frames per second)

CONSTRUCTION

- a. polyester base tape coated on wide side with a magnetic film (2 inch gives best image quality but more expensive) HAS A SHELF LIFE OF TWO YEARS
- b. three essential components
 - a. magnetic tape
 - b. writing/recording head
 - c. tape transport system

MISC:

Writing head converts an electric signal into a fluctuating magnetic field for recording, and converts a magnetic signal into an electrical signal for replay.

Play back tape is rewound, play button is depressed and the tape moves across the head inducing the identical magnetic field pattern then an electric current of equal intensity is transferred to the monitor and then a visible image.

Tape transport system is the machine -can be reel to reel or cassette

2. Cine- cinefluorography (cine camera is a motion picture camera) Uses generally 16- 35 mm format larger the film the greater the image quality but also the patient dose is greater. Spot films taken in series

Images are 18 x 24 mm in size NOT THE BEST FOR OUR GENERAL NEEDS: USUALLY USED FOR HEART CATHS

Typical systems the image from the II enters an image distribution box where the image can be diverted by mirrors one or more recording systems.

A. cine camera is driven by an electronic synchronous motor.

synchronization==means that the x-ray pulses and cine shutter are synchronized== There are two electrical signals that originate from within the cine system which cause this.

One signal coordinates the x-ray exposure with the open time of the camera shutter, and the other maintains a constant level of intensifier illumination by varying the exposure factors for areas of different thickness or density (ABC)

Didn't use to be this way ==continuous exposure and unnecessary exposure when shutter was closed

B. all cine cameras are similar to commercial movie cameras

a. basic components are: lens, iris diaphragm,shuttle aperture, pressure plate pulldown arm

and film transport mechanism

b. light enters the camera through the lens and is restricted by the aperture=a rectangular opening in the front of the camera. This is the restriction of the 16 mm or 35 mm which is a really 18 x 24

- c. Shutter =rotating disc with a section cut out. It is in front of the aperture.--As it rotates it interrupts light flow into the camera, The size of the shutter opening is express as the number of degrees in the cutout portion. 160 0 is usually used for cinefluorography
- d. While the shutter is closed the pulldown arm advances the film to the next exposure ,, The pressure plate holds the film against the camera aperture so that it is located in the proper image plane.
- e. An electric drive motor advances the film from the supply reel past the aperture to the take up reel.
- f. then a meter attached to the supply reel indicates the amount of unexposed film in the camera.

MISC:

framing frequency== synchronous motor drives the camera and the number of frames per second that are recorded is normally divisible by 60/ Most common frame rates include 7.5, 15, 30 and 60 frames per second.

framing and patient radiation dose= when doing cine at 60 frames per second the max exposure time of the film is 1/120 of a second. Since the shutter of the camera is closed approximately 50 % of the time during cine run, ..makes no sense to run x-ray all the time exposure and heat to the tube.

cine requires more mA than conventional fluoroscopy due to the short time available to allow the light entering the camera to produce and image on the film. More exposure to the patient

Disadvantages to cine

- a. stress on the x-ray tube
- b. cost of the equipment
- c. special processing viewing projectors

Advantages

- a. detail resolution
- b. stop motion
- c. ability to examine individual high-resolution still frames

FRAMING Rectangular film and circular II output phosphors --controlled by the lens of the cine camera

1. exact framing The whole image 100% is recorded but only 60- 79% of the film is used
2. Overframing The entire film is used but only 60- 64% of the image is recorded--Standard for cardiac imaging some of the output image is not recorded. Extremes of overframing is not used because of patient exposure

Framing characteristics are established when the cine system is installed

Typical cine exposures at the II input are about 15-30 mR per frame

90% of the II output light goes to cine and 10% goes to the TV camera, which permits the operator to monitor the procedure.

Section III I= Static Imaging Recording

1. Video disc recording

- a. use a rigid magnetic or optical disc recording medium not flexible tape.
- b. store thousands of individual images and will be part of the electronic file room of the future
- c. advantage over the disc recorded is that the image is not worn away by viewing individual frames
- d. other advantages
 1. displays an image at normal, slow or reverse speeds
 2. provides stop-motion studies what designed for
 3. freezes a single television frame for comparison or subtraction
 - a. short burst of x-ray can be used to freeze a projection of a hip pinning then another freeze for comparison they can also be superimposed NEED more than one monitor
 - b. book==can use up to 95 % less dose but still not considered less than radiography
 4. grooves are numbered and can go to any desired number
- e. look like phonographic records -but each groove is separate track-one picture frame recorded per track and can get 1 to 30 images per second
- f. and when selected for replay same picture is shown over and over 20 times a second for as long as desired.
- g. typical application are angioplasty, arterial embolizations and hip pinning.

2. Photospot Film Cameras

- a. photograph the image on the output phosphor of the image intensifier 10-20 % of the light goes to the recording device
- b. higher mA short exposure time dose 20-5- times higher per frame than fluoroscope still less than spot films with conventional cassettes
- c. takes serial films in succession up to 12 per second (can show movement of slow moving organs such as esophagus during swallowing
- d. larger film better image quality but more dosage
- e. exposure through an aperture closes and forwards the film
- f. synchronized with exposure
- g. need processor for development
- h. can be in rolls or sheets

advantages

Photo spot Film

NOT
Cassettes

- ADVANTAGES
1. lower exposure
 2. less wear and tear on x-ray tube
 3. multiple film per second capability
 4. don't need to change cassettes
 5. reduced exam time
 6. reduced film cost
 7. short exposure time (50 m/sec) reduces pt movement artifacts
 8. can record and view at same time

disadvantages

1. lesser resolution to conventional spot film
2. limited field size
3. cost of equipment
4. problem of running through processor

3. spot film with conventional cassettes

- a. between patient and image intensifier
- b. takes a while for anode to be energized to higher speed to get to mA of 100 or more
also delay of 3/4 to 2 seconds for film to get into place from park position
- c. good resolution
- d. high pt exposure
- e. inexpensive equipment many 1/2 9 on one etc
- f. phototimers controls length of exposure
- g. 80-90 kVp standard fluoroscope kVp

4. High level boost

- a. higher tube currents for 10-20 mA even up to 40 mA.
- b. higher dose rates
- d. used in interventional see small guidewires and catheters
- e. New regulation limits maximum tabletop dose rate to 20 rads per minute when acquiring images without recording devices such as video tape.

1. must have special activation at control panes
2. audible signal in room when used

Sections III J and K have no additional information