B.SC. IN RADIOLOGY AND IMAGING TECHNIQUES

1st Year

Prepared By

Paramedical & Allied Science Dept.

Radiology and Imaging Techniques

MIDNAPORE CITY COLLEGE

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Department of Paramedical and Allied Health Sciences
B.Sc. in Radiology and Imaging Techniques
First Year
Paper Title: General and Radiation Physics & Physics of Diagnostic Radiology
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Syllabus

A. Congruence of Radiation and Optical field and beam.
B. Determination of focal spot size of diagnostic X-ray tube.
C. K.V. and Exposure time testing.
D. Linearity testing of the Timer.
E. Consistency of M.A. loading.
F. Consistency of Radiation Output.
G. Evaluation of Total filtration of the tube.
H. Film screen contact testing.
I. Table top Exposure rate measurement in fluoroscopy.
J. Radiation protection survey, in and around of diagnostic installations.

CONGRUENCE OF RADIATION AND OPTICAL FIELD AND BEAM.

Optical field in the equipment is used for defining the radiation field and limit the area of interest.
If optical field and radiation field are not congruent there may be loss of information and repeat the examination.
Collimator test tool is used for testing the congruence.
It consist of a glass fiber board 24 X 27 cm with a rectangular area 22- 16 cm marked on it by coating of X-Ray Opaque material.
The rectangular divided into four equal segment.

FFD =100

<u>Central Beam Alignment</u>

• If the x-ray beam is not perpendicular to the image receptor, the image may be distorted.

If grid is used, the distortion will be magnified resulting in complete loss of minute

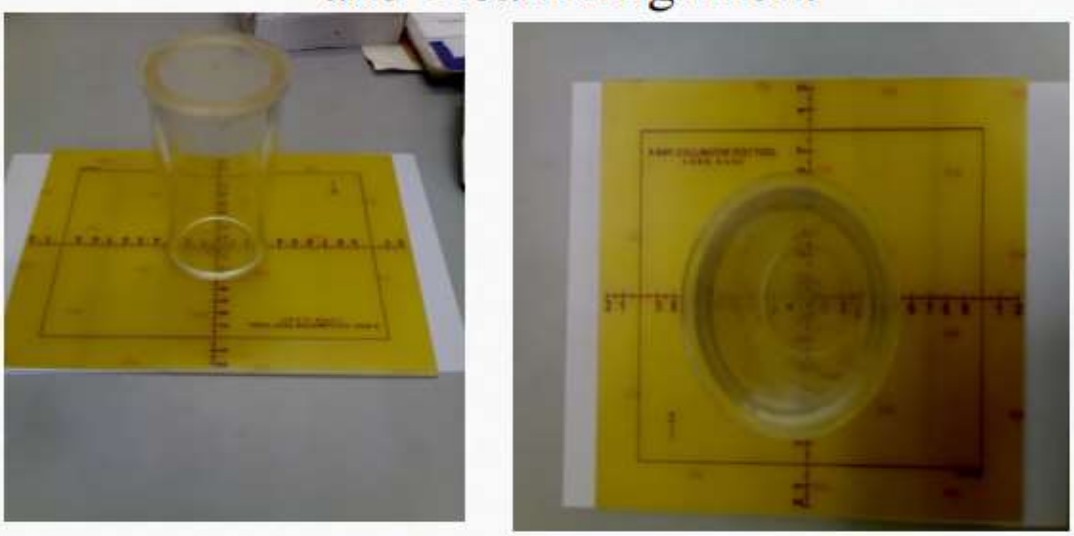
details.

• Beam alignment test can be done simultaneously with the test for congruence of optical

and radiation field

• Tolerance Central beam alignment < 1.5°

Congruence of Radiation and Optical Fields and Beam Alignment



Beam alignment test tool

DETERMINATION OF FOCAL SPOT SIZE OF DIAGNOSTIC X-RAY TUBE.

<u>Effective Focal Spot Size measurements:</u>

Focal Spot size is defined in two ways:

The actual focal spot size is the area on the anode that is struck by electrons and it is primarily determined by the length of cathode filament and the width of the focusing cup slot.

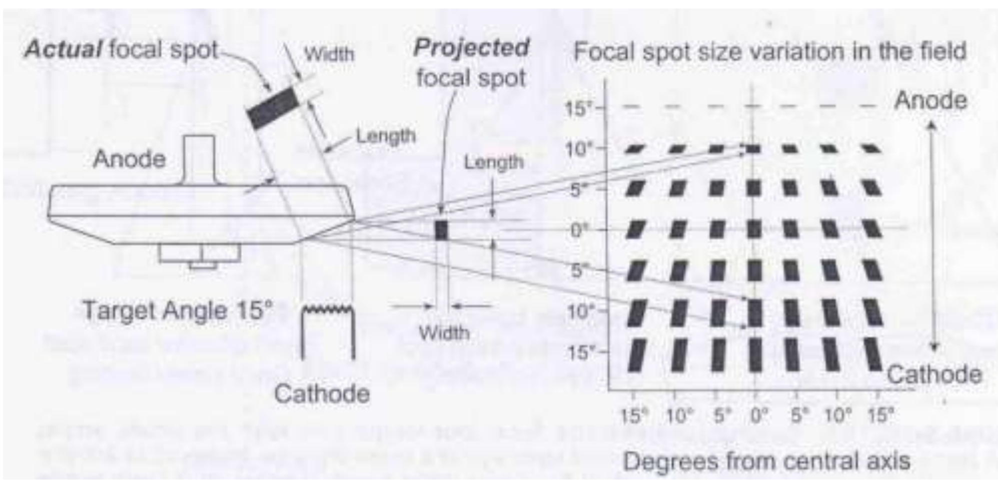
The effective focal spot size is the length and width of the focal spot as projected down the central ray in the x-ray field.

The effective focal width is equal to the actual focal width and therefore is not affected by the anode angle.

However, the anode angle causes the effective focal spot length to be smaller than the actual focal spot length.

Effective focal length = Actual focal length x Sin Ø

Here, Ø is the anode angle



Effective Focal Spot Size Measurements:

Tools used for effective focal spot size measurements:
- Pinhole camera
- Slit camera
- Star pattern
- Resolution bar pattern Tolerance:

for f < 0.8 mm	+0.5 f
for 0.8 ≤f≤1.5 mm	+0.4 f
for f > 1.5 mm	+0.3f

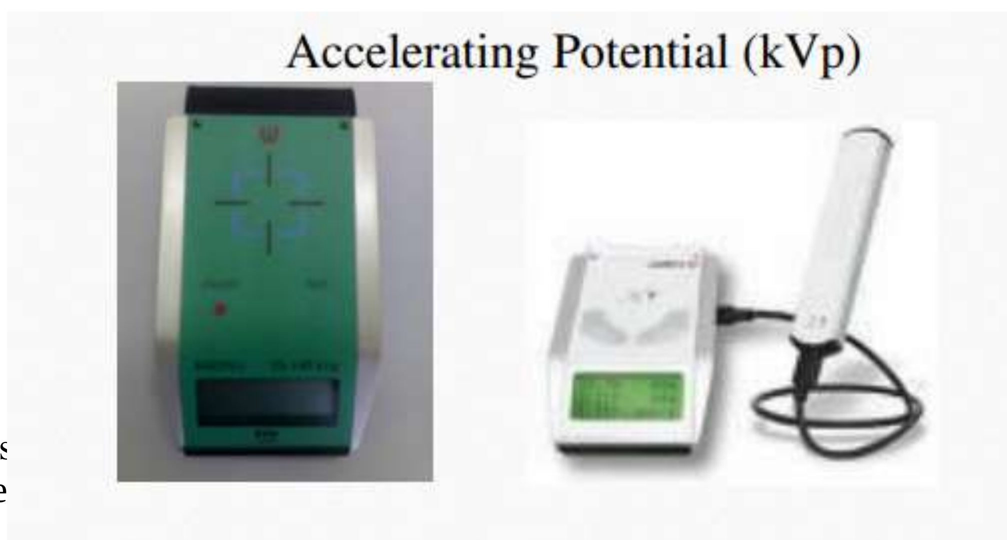
Bar pattern images demonstrate the effective resolution parallel and perpendicular to the A-C axis for a given magnification geometry.

K.V. AND EXPOSURE TIME TESTING.

Accelerating Potential (kVp)

• The peak potential of the x-ray generator affects quality of the x-ray beam and exposure to the patient.

• Presently solid – state detectors, which employ non-invasive method for peak tube potential measurement are quite handy for this test.



• Assess … that set on the e…

Tolerance : ± 5kV

LINEARITY TESTING OF THE TIMER.

Accuracy of Exposure Timer

• If the exposure time of the x-ray unit is not in order, the radiograph can be under exposed or overexposed.

• For this, absolute timer method is adopted by measuring set and measured time with digital timers.

Tolerance: Accuracy of exposure timer % Error ± 10 %

CONSISTENCY OF M.A. LOADING

Linearity of mA loading stations

• The tube current (mA) is equal to the number of electrons flowing from the cathode to the anode per unit time.

• The exposure of the beam for a given kVp and filtration is proportional to the tube current.

• This test is carried out to check the linearity of radiation output with respect to change in tube current (mA) stations by keeping timer station constant at a particular kV station.

FFD=100 cm **Radiation field size = 20 cm x 20 cm**

• Keeping exposure time and kVp constant, radiation output is measured at different mA stations.

• Measurement for mA loading station is to be repeated for a number of times each to eliminate statistical errors.

• Radiation output readings of each mA loading station readings are averaged and the coefficient of linearity (CoL) is evaluated from average mR/mAs or mGy/mAs as follows:

Coefficient of linearity = (X max -Xmin) ÷ (Xmax + X min)

Tolerance: Coefficient of Linearity < 0.1

Linearity of timer loading stations

- The exposure time is the duration of X-ray production.
- Keeping the kVp and mA constant, radiation output is measured at different timer stations and Coefficient of Linearity is evaluated.
- This test is carried out to check the linearity of radiation output with respect to change in timer stations by keeping mA station constant at a particular kV station.
- Tolerance: Coefficient of timer linearity < 0.1

CONSISTENCY OF RADIATION OUTPUT

• To check the constancy of radiation output

• Keeping fixed mA and time, radiation output is measured at various available kV stations. Average(X) of (mR/mAs) or (mGy/mAs) is calculated.

• Consistency at each kV station is checked by evaluating the coefficient of variation.

Coefficient of variation

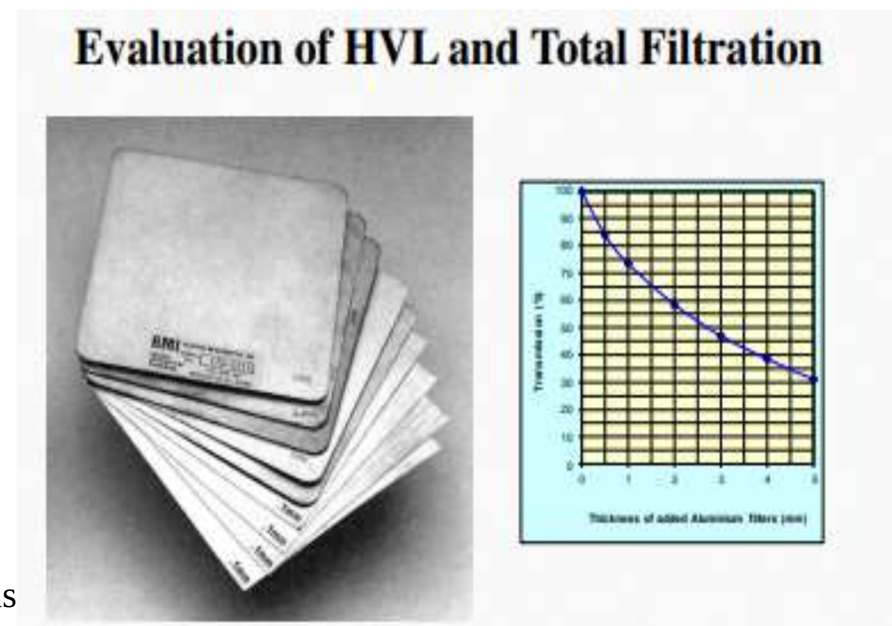
• COV $= 1/ X \times [(\sum (X_i - X)^2) /(n-1)]^{1/2}$

• Tolerance : Coefficient of Variation < 0.05

EVALUATION OF TOTAL FILTRATION OF THE TUBE

Total Filtration of X-ray tube

- To cutoff low energy components from X-ray beam, which do not contribute to diagnostic image formation but result in unnecessary patient exposure.
- If the filtration is too high, image contrast will be poor and unit will be overloaded.
- Therefore it is necessary that the total filtration (inherent + added) provided for the X-ray tube be as per the recommended value.
- The determination of half value thickness (HVT) of the X-ray beam is the method of evaluation of total aluminum equivalent filtration of the X-ray tube.
- Total aluminum equivalent filtration of the x-ray tube is evaluated by determining the half value thickness of the beam.



- Trans g a graph between the absorber thickness and corresponding percentage transmission.
- The absorber thickness for 50 % transmission will be the half value thickness of the x-ray beam.
- Total aluminum filtration could be determined from HVT using calibration tables.
- Presently, new solid state detectors directly gives the values of HVT and total filtration used in diagnostic X-ray equipment.

Minimum Filtration for X-ray tubes

For ensuring radiation quality of the x-ray beam, the total filtration in the x-ray source assembly shall comply with the Half- Value Layer requirements.
Material Used : Aluminum filters of purity 99.99% or higher and density 2.70 g cm-3
Tolerance : 1.5 mm Al for kV ≤ 70
2.0 mm Al for 70 ≤ kV ≤ 100
2.5 mm Al for kV > 100

Aluminum Equivalence of table top (Couch) ≤ 1.2 mm Al

<u>Radiation leakage through tube housing</u>

The radiation leakage measurement is carried with an ionization chamber/semiconductor based radiation survey meter. For checking the leakage radiation, the collimator of the tube housing should be fully closed and the tube should be energized at maximum rated tube potential and tube current at that kVp.

• The exposure rate at one meter from the focal spot is measured at different locations (anode side, cathode side, front back and top) from the tube housing and collimator.

• From the maximum leakage rate (mR/h) from both tube housing and collimator, leakage radiation in one hour is computed on the basis of the workload of the unit.

• Work load = 180 mA-min in one hour (for Radiography/Radiography & Fluoroscopy/C-Arm/Interventional Radiology/ dental OPG and dental CBCT equipment)

• Work load = 20 mA-min in one hour for dental (Intra- oral) equipment

• Work load = 40 mA-min in one hr for mammography unit

<u>Radiation leakage from tube housing</u>

Max leakage from tube housing

$$= \frac{\text{mA}-\text{ min in one hour X }----\text{Max.leakage radiation level (mR/hr)}}{\text{60 min X }-----\text{ mA used for measurement}}$$

Tolerance limit:
1. Radiation Leakage at 1 m distance from the focus < 1 mGy in one hour (for Radiography/Radiography & Fluoroscopy/C-Arm/Interventional Radiology/ dental OPG and dental CBCT equipment)
2. Radiation Leakage limit at 5cm from the external surface of mammography unit < 0.02 mGy in one hour
3. Radiation Leakage limit at 1m distance from the focus of dental (intra-oral) unit < 0.25 mGy in one hour

<u>TABLE TOP DOSE RATE (FLUOROSCOPY)</u>

The air kerma rate, measured in air at the position where the central of the useful beam enters the patient, shall be less than 5cGy/min for units without automatic brightness control (ABC) and less than 10 cGy/min for units with ABC.

The focus-to-table top distance shall be not less than 30 cm for fluoroscopy equipment.

RADIATION PROTECTION SURVEY, IN AND AROUND OF DIAGNOSTIC INSTALLATIONS.

Fluoroscopic Image Quality Parameters High Contrast Resolution or Spatial Resolution

High Contrast or Spatial resolution refers to the ability of imaging system to visualize small detail, and an imaging system has higher spatial resolution if it can demonstrate the presence of smaller objects in the image.
Tolerance: Mesh pattern of 30 lines/inch or bar pattern of 1.5 lp/mm must be resolved.

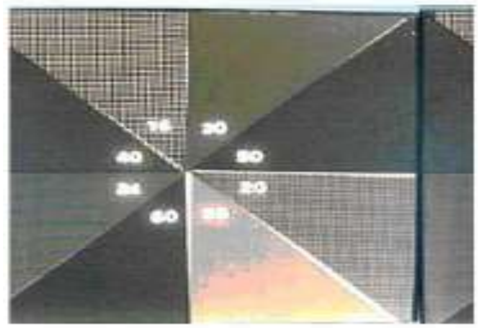


Figure 1: Resolution test tool.

Fluoroscopic Image Quality Parameters Low Contrast Resolution

Contrast in a radiographic image is the difference in the gray scale of the image. Low contrast sensitivity refers to the ability of a imaging system to visualize low-contrast objects or structures that differ slightly in radio opacity from the surrounding area.
Tolerance: Minimum diameter of 3 mm hole size of test pattern must be resolved.

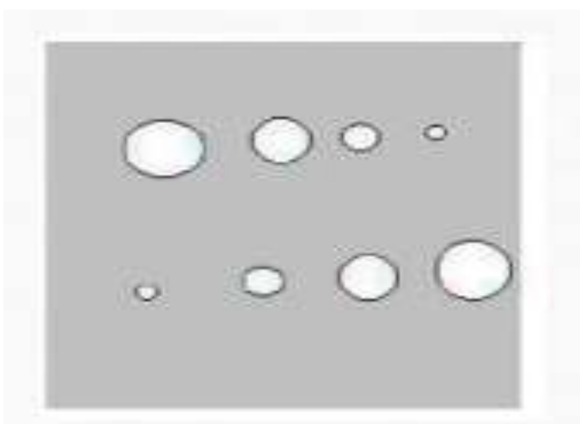


Fig: Contrast Resolution tool