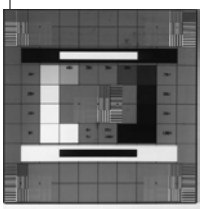


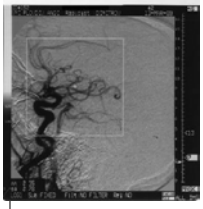


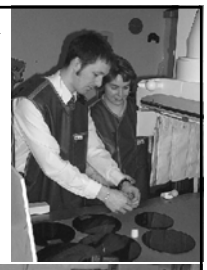
**IMAGE QUALITY ASSESSMENT IN X-RAY FLUOROSCOPIC SYSTEMS - PRACTICAL QC**


Dr Slavik Tabakov

Dept. Medical Eng. & Physics,
King's College London

E-mail : slavik.tabakov@kcl.ac.uk


## Main steps for a QC survey in Diagnostic Radiology



- General X-ray tube & generator assessment
- Image quality assessment
- Specific parameters assessment
- Quality Control protocols

**Fluoroscopy delivers very high patient dose.**
**This can be illustrated with an example:**

The electrical energy imparted to the anode during an exposure is

$$A = C_1 . U_a . I_a . T$$

The X-ray tube anode efficiency is

$$E = C_2 . Z . U_a$$

From the two equations follows that the energy produced in a single exposure will be

$$X = C . A . E = C . Z . (U_a)^2 . I_a . T = (C . Z) . kV^2 . mAs$$

**Radiography of the lumbar spine (with parameters 80 kV, 30 mAs):**

$$X = k . 80.80.30 = k . 192{,}000$$

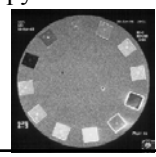
**Fluoroscopy - 3 minutes Barium meal (with parameters 80 kV, 1mA)**

$$X = k . 80.80.1.3.60 = k . 1{,}152{,}000$$

**In this example fluoroscopy delivers approx. 6 times more X-ray energy (dose)**

## QC equipment for Fluoroscopy

- Dosimeter - dose rate - (flat ion. chamber)
- Image quality test objects (at least for contrast scale, limiting spatial resolution, II field size and contrast delectability)
- Attenuators (at least 1mm Cu)
- Special test objects for Digital Fluoroscopy
- (Oscilloscope)



## Automatic Brightness Control (ABC/ABS)

- Check fluoroscopy timer-guard (2 min.)
- Measure the maximum dose delivered
- Measure Image Intens. entrance dose with standard beam attenuation (1mm Cu) for all II field sizes (inter-equip. comparison)

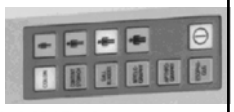
| II field size cm | Read kV | Read mA | Dose rate (1mm Cu) (mR/min) | (mGy/s) |
|---|---|---|---|---|
| 30 | 75 | 0.9 | 10.9 | 0.0016 |
| 23 | 75 | 2.4 | 24.8 | 0.0036 |
| 17 | 75 | 4.2 | 40.2 | 0.0058 |

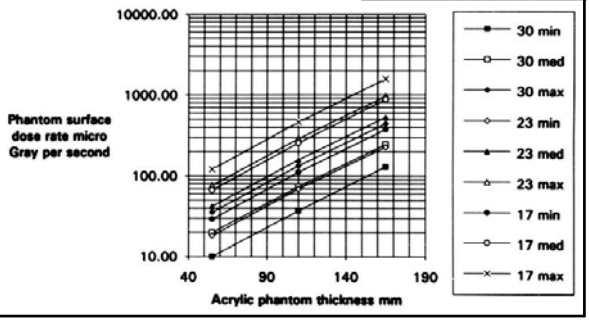
## ABC - skin entrance dose

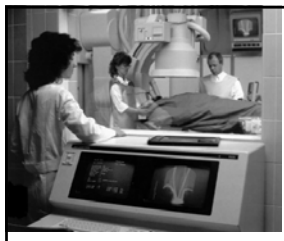
- Test all II field sizes (cm) and dose settings (patient thick.) with various attenuation (perspex ~ 50-200mm)
- Maximal patient skin entrance dose should not exceed 100 mGy/min
- II entrance dose measured together with the skin entrance dose (separately from 1mm Cu)

| Field size | Read kV | Read mA | Phantom | I.I. entrance dose | | Phantom surf' dose | |
|---|---|---|---|---|---|---|---|
| cm | | | thick' mm | (mR/min) | (mGy/s) | (mR/min) | (mGy/min) |
| 30 | 75 | 0.3 | 55 | 29.9 | 0.004 | 264 | 2.27 |
| | 75 | 1.4 | 110 | 43.3 | 0.006 | 1010 | 8.69 |
| | 75 | 5.6 | 165 | 68.5 | 0.010 | 3880 | 33.37 |

Typical phantom surface (patient entrance) doses - **µGy/sec** during fluoroscopy with ABC

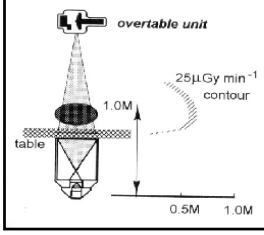


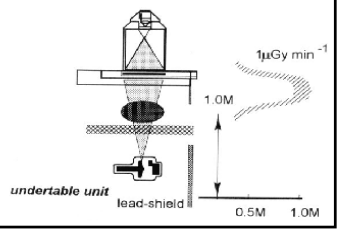


**Scatter radiation in fluoroscopy**

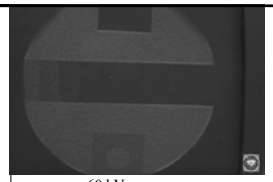
when the II is above the patient table the scatter radiation to staff is lower



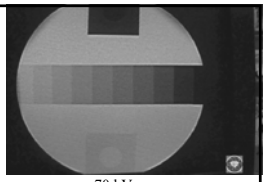




## Image quality assessment

- Contrast scale
- Image uniformity and distortion
- Spatial (high contrast) resolution
- Noise (and Video signal)
- Contrast (low contrast) resolution
- Overall Image Quality (Contrast/Detail Diagr.)
- IQ dependence of "window" and matrix
- IQ dependence of reconstruction/frame rate
- IQ dependence of image processing (F,Sub)
- Artefacts



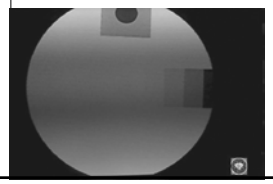
60 kV



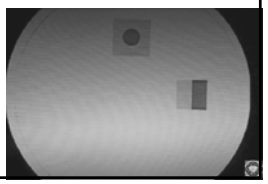
70 kV

II contrast with different kV (constant mA)

90 kV



100 kV



## Fluoro analogue image quality assessment:

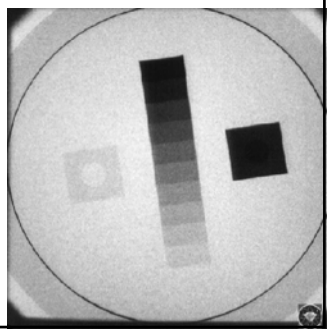
- Subjective assessment (eyes condition)
- Attenuate the X-ray output (1mm Cu)
- Check all II field sizes with all test objects
- Adjust TV monitor (contrast/brightness)
- II visible field size/distortions/homogeneity
- II noise, contrast resolution (contrast/detail)
- II lim.spatial resolution (*no attenuation*)
- (Video signal)

- Attenuating the X-ray tube output with 1mm Cu filter
- Selecting appropriate Test Objects (TO)
- Normally performed by two physicists

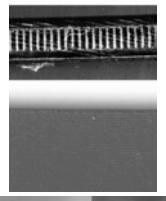
**Assessment of Contrast Scale (TV monitor adjustment)**

All test objects should be placed at the front of the II

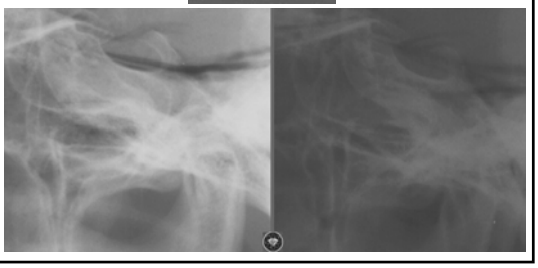
(the presence/absence of the anti-scatter grid must be noted in the QC protocol)



With anti-scatter grid



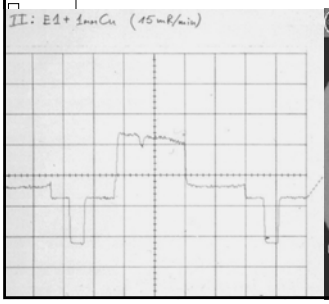
Without anti-scatter grid

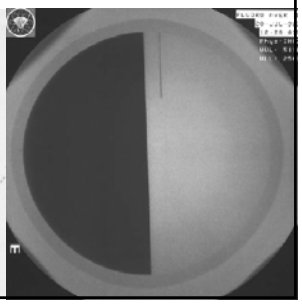


**Assessment of Sensitivity of the Imaging system (video signal assessment)**

- use of a TV line selector is recommended

- do not measure the TV monitor input when assessing digital fluoroscopic systems

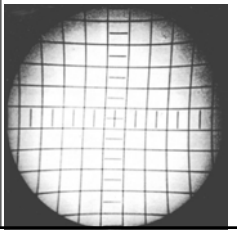


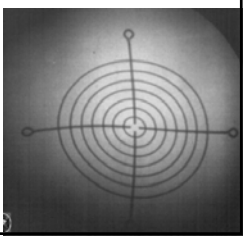



**Assessment of Image Geometry and Sizing**

- measuring of all II field sizes (horiz. and vert.)

- assessment of image distortion



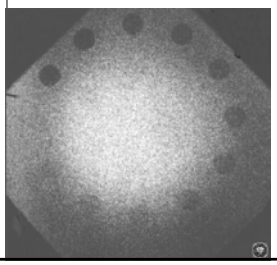


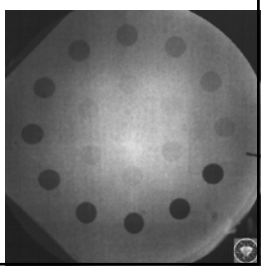
**Assessment of Image Noise**

- for all II field sizes

- proper adjustment of "Window" (and record of WW, WC !) is essential in digital fluoroscopy

- record the kV/mA displayed for all image quality tests!

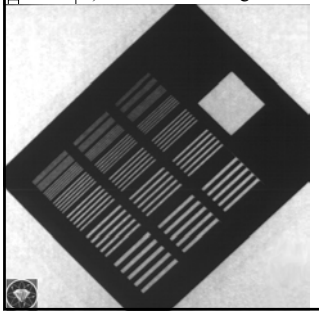




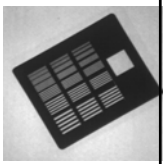
**Assessment of Limiting Spatial Resolution (Unsharpness) !! REMOVE the 1mm Cu filter !!**

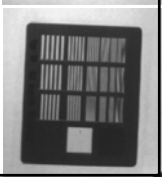
- for all II field sizes

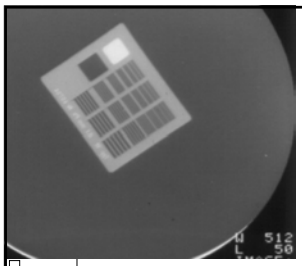
- proper adjustment of "Window" (and record of WW, WC !) is essential in digital fluoroscopy



**Place the test object at 45$^0$ to TV raster!**



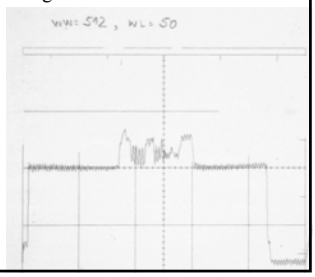


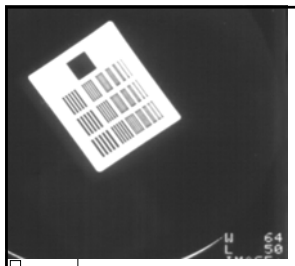


**WINDOW PARAMETERS**

**IN DIGITAL FLUOROSCOPY**

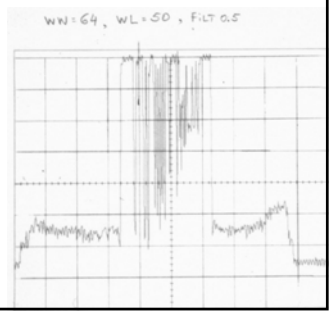
WW changes the image contrast - its amplitude is well seen from the video signal of the displayed image.



Small WW increases the contrast dynamic, what lead to visual increase of the spatial resolution.

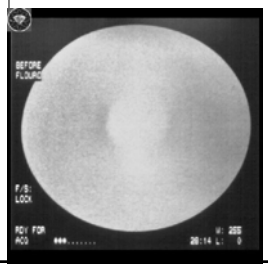
**WW and WC change dramatically the digital image quality!**

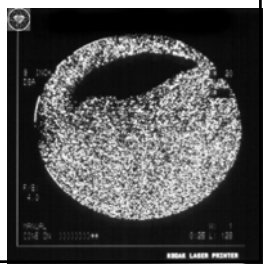



**Example of II non-uniformity**

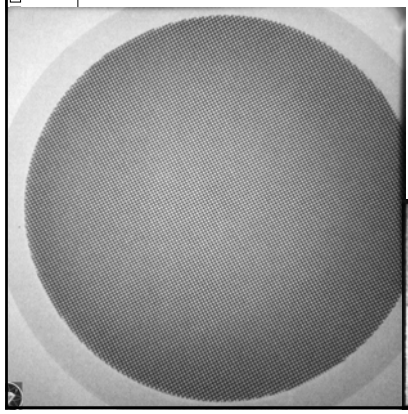
Note that using default WW and WC (on the left image) does not visualise the non-uniform region.

The substantial II defect is seen only with a narrow WW and precise WC (the right image).

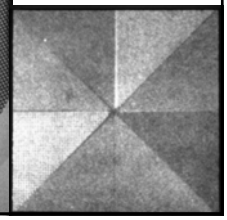




**Assessment of II uniformity (non-uniformity)**



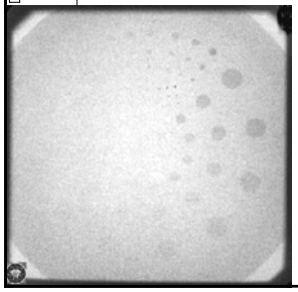
The Mesh "uniformity" test objects can also be used for assessment of spatial resolution.

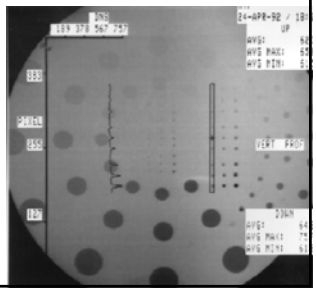


**Overall Image Quality Assessment (Contrast Resolution)**
**!! WITH 1mm Cu filter !!**

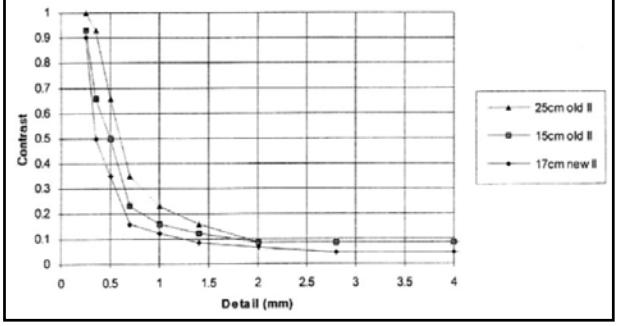
- for all II field sizes

- proper adjustment of "Window" (and record of WW, WC !) is essential in digital fluoroscopy





Typical Contrast/Detail diagram for the *Leeds TO 10* phantom for various II filed sizes (old and new II)



## Fluoro digital image quality assessment

- Objective/subjective assessment
- Perform set-up/calibration of imaging chain
- Record the Window parameters for each measurement (width/centre ; contr/bright)
- Record image processing parameters used (filters, matrix, masks, subtract., frame rate)
- Use the built-in measuring functions and densoprofile
- Special (quantitative) functions
- Other specific parameters (Grey level/Dose, etc)

## Non-uniform image and loss of contrast most often due to:

- Non-uniform cassette/film contact
- Poor film developing
- TV contrast/brightness misadjustment
- Non-uniform dose distribution
- Exhausted Image Int.,TV camera, monitor
- Incorrect Window parameters
- Frame speed problem, incorrect filtering

## Blurred image & loss of spatial resolution most often due to:

- Exhausted X-ray tube (Broad focus)
- Incorrect bucky/grid centring
- Poor film developing
- Defocused II/TV camera
- Small matrix, incorrect filtering
- Incorrect Window parameters
- Noisy imaging chain