Equipment Standards and Test Protocols

J. Zoetelief

Lecture

February 17, 2006

Faculty of Applied Sciences, R3, RIH

TU Delft
Delft University of Technology

Outline

- Introduction
- Summary of quality control (QC) tests and requirements or tolerances
- Conclusions

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Introduction

- Importance of QC for digital equipment
  - Digital radiology is increasingly coming into use
  - Detectors in digital systems have a large dynamic range
  - High (or too low) doses are hardly noticeable in images
  - For digital equipment QC is essential to avoid unnecessarily high doses and to achieve good image quality

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Introduction

- QC of digital equipment compared to conventional equipment
  - For digital radiology part of the QC similar to that for conventional equipment
  - For digital equipment, however, additional equipment standards and test protocols have to be available to the users
  - To investigate the present situation in QC a questionnaire was drafted in the spring of 2005 to be completed by various SENTINEL partners

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Introduction

- Questionnaire on equipment and equipment standards for digital radiology
  - the aim of the questionnaire was
    - to collect information on the available or accessible digital equipment
    - the equipment standards, i.e. methods for quality control (QC) used
    - the requirements for equipment
    - the equipment available for performing QC.

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Introduction

- The questionnaire was distributed among 10 SENTINEL partners who expressed to have an interest in WP1.2 and particularly in WP1.2.1 on June 1, 2005
- A reminder was sent on August 12, 2005 to those partners that did not respond by then
- SENTINEL partners 2, 8, 11, 12, 13, 14, 15 and 19 responded to the questionnaire
  - specifications were provided for
    - 15 units available for digital fluoroscopy
    - 11 units available for digital imaging (radiography)

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Introduction

- A summary of QC of digital fluoroscopy systems is shown in the next table
  - Additional tests and the general protocols used are given after the table

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Introduction

- Summary of quality control (QC) of digital fluoroscopy systems by partners responding to the SENTINEL questionnaire

Partner number	2	8	11	12	13	14	15	19
X-RAY TUBE AND GENERATOR								
Tube output and consistency	y	y	y	y	y	y	y	y
Tube voltage accuracy	y	y	y	y	y	y	y	y
Beam quality (HVL)	y	y	y	y	y	y	y	y
Automatic brightness (dose rate) control	y	y	y	n	y	y	y	y
X-ray tube focal spot size	y	y	n	y	y	y	y	y
X-RAY TUBE CONTROL SYSTEM								
X-ray field limitation	y	y	y	y	y	y	n	y
Minimum source-to-skin distance	n	y	y	n	n	n	y	n
Image Quality	y	y	y	n	y	y	y	y
Patient Dose								
PATIENT ESD RATE UNDER ABC	y	y	y	y	y	y	y	y
IMAGE II DOSE RATE UNDER ABC	y	y	y	y	y	y	n	y
Protective Devices for Occupational Exposure	y	Y	y	y	y	y	n	y

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Introduction

- Additional tests related to digital imaging: field size and distortion
  - Protocols: own protocols, IPEM (IPEMB) 32, 77, IEC 61223-3-1, IEC 60601-3-1, IEC 60336
  - KCARE is mentioned for digital systems

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Introduction

- A summary of QC of digital imaging (radiography) systems is shown in the next table
  - Additional tests and the general protocols used are given after the table

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Automatic brightness (dose rate) control	y	y	y	y	y	y	y
X-ray tube focal spot size	y	y	n	y	y	y	y
X-RAY TUBE CONTROL SYSTEM							
X-ray field limitation	y	y	y	y	y	y	y
Agreement of light field and x-ray field	y	y	y	n	n	y	n
Display Station and Hard Copy Cameras QC							
Display station	?	Y	y	y	n	n	n
Hard copy camera	n	y	y	y	n	n	n
Image Quality	y	y	y	y	y	y	y
Patient Dose							
PATIENT ESD UNDER AEC	y	y	y	y	y	n	y
IMAGE RECEPTOR DOSE UNDER AEC	y	n	y	y	y	n	y

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Introduction

- Additional tests related to digital imaging:
  - CR: Dark noise, Linearity and system transfer properties, Erasure cycle efficiency, Detector dose indicator, Detector dose indicator calibration, Detector dose consistency, Laser beam function
  - FPD: Dark noise, Linearity and system transfer properties, Image retention, Detector dose consistency
  - Linearity, system transfer properties and dark noise, Detector dose indicator monitoring, uniformity, threshold contrast detail detectability, limiting spatial resolution
  - Reproducibility of tube voltage, tube current and loading time; tube current linearity; tube current accuracy; Loading time accuracy
- Protocols: own protocols, IPEM (IPEMB) 32, 77, IEC 61223-3-1
- KCARE is mentioned for digital systems

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Introduction

- Most of the responders restrict the QC to x-ray tube and generator, x-ray tube control system, image quality and patient dose
- Checks on display station and hard copy camera are only made by approximately half of the responders
- For fluoroscopy no additional QC tests for noise, linearity and system transfer properties are mentioned
- For QC methods, reference is made to reports of the Institute of Physics and Engineering in Medicine (IPEM) and its predecessors and of the International Electrotechnical Commission (IEC)

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Introduction

- A summary will be given of test methods other than for x-ray tube and generator, x-ray tube control system, image quality and patient dose, according to
  - the Department of Medical Physics & Bioengineering (MPBE) in Dublin QC for fluoroscopy systems
  - MPBE QC for digital fluorography systems (based on image intensifiers)
  - KCARE protocol for QA of computed radiography (CR) systems Draft 8.0 (01/06/2005)
  - KCARE protocol for QA of DDR systems Draft 8.0 (01/06/2005)

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MPBE QC for fluoroscopy systems

- Set-up for the use of Leeds test objects
  - 1 mm Cu present? _____
  - Manual/automatic screening at _____kVp (calibrated at 70 kV)
  - SID: _____ [> 75 cm]
  - Grid Removed ? _____
  - Added filtration: _____
  - Tube Current: _____
  - II entrance exposure rate: _____ [Normally: 0.2 - 1.0 mGy/sec]

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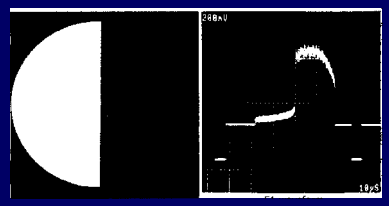
MPBE QC for fluoroscopy systems

- Leeds test object (TO) bisected field used to measure video wave form parameters, TO.E1



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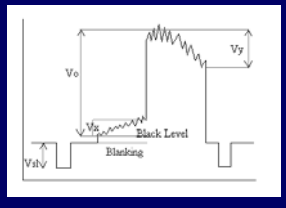
MPBE QC for fluoroscopy systems

- **Video Voltage Output:**
- 75W Termination used ? _____
- Test object E1 in place ? _____



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MPBE QC for fluoroscopy systems

- Sync. Pulse: _____mV **[V_{SL}]**
- Pedestal (blanking to black): _____mV **[V_B]**
- Signal Voltage (blanking to mean peak white): _____mV **[V_0]**
- Contrast Loss + Dark Current (black level to white edge): _____ mV **[V_x]**
- Quantum + Camera noise (peak noise amplitude): _____mV **[V_y]**
- Vignetting (full field): _____ RHS; _____LHS.
- V_0 under automatic control: _____ mV
- Manual systems V_0 variation with II $K_{a,i}$

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MPBE QC for fluoroscopy systems

- **Specification of performance for video voltage output**
  - Normal Values (within 10 %):
  - Max V_0: 0.6 - 1.0 V, some systems: 0.3 V; V_{sl} : 0.3 - 0.4 V;
  - V_B: 0.05 - 0.15 V; V_x: < 0.15V_0; V_y : ≤ 0.5 V_0

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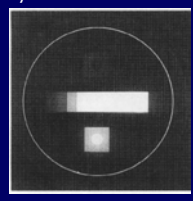
MPBE QC for fluoroscopy systems

Leeds test object TO.GS2. Greyscale linearity: 10 % contrast steps (+ peak black and white level) to adjust monitor brightness/contrast (180 mm diameter). Circular geometry to check TV scan linearity (150 mm)



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MPBE QC for fluoroscopy systems

- **Set-up:** as above and Grid removed ? _____
- Requirements
  - Grey scale steps visible: _____
  - Black and White discs visible: _____
  - Monitor adjustment: _____

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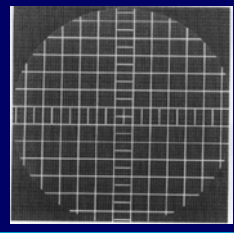
MPBE QC for fluoroscopy systems

- Leeds matrix test object TO.M1. Rectangular geometry 20 mm square matrix used to check overall geometric distortion (250 mm diam.). Image field size: spacings marked every 10 mm



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Field Coverage Test Object (M1):

Full Field: _____ cm vert; _____ cm horiz.;
Mag 1: _____ cm vert; _____ cm horiz.;
Mag 2: _____ cm vert; _____ cm horiz.;

Distortion: S-distortion:_____
Pin-Cushion:_____

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Distortion

Using the following equation a measure of distortion using the M1 test object may be calculated on each field size:

$$d = [(D(x) \cdot y)/(x \cdot D(y) - 1] \cdot 100\%$$

where

- d = distortion
- D (x) = the measured lengths of the diagonals of the central 20 mm x 20 mm square
- D (y) = the measured lengths of the diagonals of the 14cm * 14 cm square
- x = actual length of central square i.e. 20 mm
- y = actual length of the larger square i.e. 140 mm

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- **Radiation Field size:**
- Place a large cassette over image intensifier and measure radiation field size vs imaged field size to ensure that radiation field does not extend beyond Image Intensifier.

- **Specification of performance:**
- Radiation field size diameter/Image field size diameter should be in range 1.0 - 1.1.

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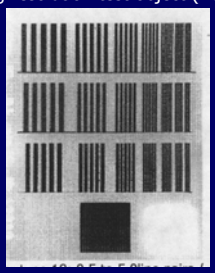
MPBE QC for fluoroscopy systems

- Leeds limiting resolution test object (Hüttner type 18)



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MPBE QC for fluoroscopy systems

- **Set-up:** as above and Grid removed ? _____
  Cu Filter removed ? _____
  Set kVp: _____ [50 kVp]
  II entrance Air-Kerma Rate: _____ [approx 1.0 mGy/sec]
- Conditions: full field, mag1, mag2, pulsed mode

- **Specification of Performance (within 10 %):**
- 36cm : ≥0.9 - 1.0 lp/mm; 30cm: ≥ 1.12 lp/mm;
- 23cm: ≥ 1.2 lp/mm; 15cm: ≥ 1.6 lp/mm

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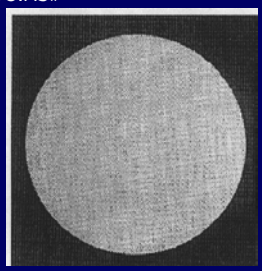
MPBE QC for fluoroscopy systems

Leeds mesh TO.MS#



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MPBE QC for fluoroscopy systems

Leeds mesh TO.MS# to check focal homogeneity over the image field (220 mm diameter)

- TO.MS1: spatial frequency 0.64 mm^{-1}
- TO.MS3: spatial frequency 0.86 mm^{-1}
- TO.MS4: spatial frequency 1.23 mm^{-1}

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MPBE QC for fluoroscopy systems

Pulsed screening

- Pulse Duration: _____
- Pulse Interval: _____
- II entrance Air-Kerma per pulse: _____
- Patient entrance Air-Kerma per pulse: _____
- Repeat above tests for pulsed fluoroscopy as required

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MPBE QC for digital fluorography

Set-up for Leeds DSF Test Objects:

- 75 kVp Selected ? _____ mm Cu filter at tube ? _____
- Grid Removed ? _____ Additional Filtration ? _____
- mA: _____
- *Tests should be carried out at exposure levels within the range recommended by the manufacturer.*
- Television system operation :
- *Interlaced camera scanning with / without multiple frame integration.*
- *Sequential (progressive) scanning at normal or slow line rates.*
- *Normal / High line - 5122, 10242*
- Reference Video Peak Level: _____% [Usually 80%]
- Gain: _____
- Exposure Rate: _____
- Framing Rate: _____
- II Entrance Dose / Exposure: _____
- II Entrance Dose / Frame: _____
- SID: _____ [1 meter]
- Test objects on table & table height brought to II ? _____
- Field Size Selected: _____ [Nearest 10"]
- Diaphragms retracted to edge of image field ? _____

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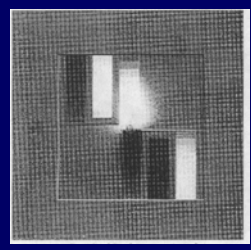
MPBE QC for digital fluorography

Leeds jig test object TO.J3. Log/Linear subtraction ADC and DAC operation: 10 step linear transmission wedge, 9 step logarithmic transmission.



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MPBE QC for digital fluorography

- **Jig Test Object:**
- **Set-up:**
- Red/white lines aligned. Take mask image. Then rotate upper part by 180° to align white/white lines.
- Operating Headroom
- **Viewing Conditions:**
- "Console" Contrast: _____
- "Console" Brightness: _____
- Display Gain: _____
- Post Processing
- Density Profile Obtained ? _____
- Hard copy Image ? _____
- No. of steps visible: _____ (4% each)
- Video peak level (100-4n)% _____%

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MPBE QC for digital fluorography

- Linear Wedge, Logarithmic Wedge
- **Viewing Conditions:**
- "Console" Contrast: _____
- "Console" Brightness: _____
- Display Gain: _____
- Post Processing : _____
- Density Profile Obtained ? _____
- Hard copy Image ? _____

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MPBE QC for digital fluorography

- Analyse density profile of both step wedges after log. and linear subtraction.

The images may be used to check:

- Display monitor contrast and brightness settings and grey scale reproducibility.
- Compatibility and stability of hard-copy imager contrast and brightness settings.
- Effects of film processing.

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MPBE QC for digital fluorography

- Low Contrast Square
- **Viewing Conditions:**
- "Console" Contrast: _____
- "Console" Brightness: _____
- Display Gain: _____
- Post Processing : _____
- Density Profile Obtained ? _____
- Hard copy Image ? _____
- SNR: _____

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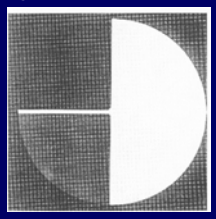
MPBE QC for digital fluorography

Leeds quadrant test object TO.Q3. Dynamic range of imaging capability. Contains quadrants of 100 , 33, 10 and 3.3 % relative transmission. Each quadrant contains 16 details, 8 mm diameter with contrast ranges 0.18 to 0.001



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MPBE QC for digital fluorography

- **Quadrant Test Object (TO.Q3)**
- **Set-up:**
- Place the quadrant detail plate on top of the quadrant filter plate and align peripheral markers. Take mask image and then replace upper detail plate with blank plate (TO.blank).
- **Viewing Conditions:**
- "Console" Contrast: _____
- "Console" Brightness: _____
- Display Gain: _____
- Post Processing : _____
- Hard copy Image ? _____

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MPBE QC for digital fluorography

Record No. of details visible in each quadrant. (Clockwise, Quadrant 1 : Top Right)

Quadrant 1 Quadrant 2 Quadrant 3 Quadrant 4

Repeat for different conditions (Gain, frame-integration, Exp. / frame, cont./bright.):

Setting Quadrant 1 Quadrant 2 Quadrant 3 Quadrant 4

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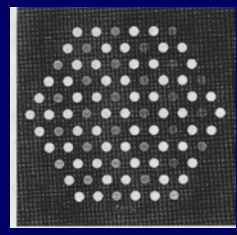
MPBE QC for digital fluorography

Leeds dalmation test object TO.D3. Systematic mis-registration artefacts: 91 details, 11 mm diameter, contrasts 0.83, 0.46, 0.13



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MPBE QC for digital fluorography

Dalmation Test Object (TO.D3)

- **Set-up:**
- Test object to remain in a fixed position for mask and subtracted images.
- **Viewing Conditions:**
- "Console" Contrast: _____
- "Console" Brightness: _____
- Display Gain: _____
- Post Processing used for display: _____
- Hard copy Image ? _____
- Contrast dependent misregistration:
- 83% X-ray Contrast:_____
- 46% X-ray Contrast:_____
- 13% X-ray Contrast:_____

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KCARE protocol for QA of CR systems

List of equipment for commissioning tests

- Tape measure
- Adhesive tape
- 1.0 mm Copper filtration (>10 x 10 cm)
- 1.5 mm Copper filtration (>10 x 10 cm)- for Agfa only
- 0.5 mm Copper and 1mm Aluminium filtration (>10 x 10 cm) – for Kodak only
- TO20 threshold contrast test object
- Resolution test object (e.g. Huttner 18)
- M1 geometry test object or lead ruler
- Contact mesh
- Ionisation chamber
- Small lead or Copper block (~5 x 5 cm)
- Steel ruler

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KCARE protocol for QA of CR systems

- **1.1 Dark Noise**
- *Purpose:* To assess the level of noise inherent in the system
- a) Erase an image plate and without making an exposure read it using the following parameters:
  - Agfa: S=800, examination type - 'System Diagnosis', processing – 'Flat Field'
  - Fuji: Readout mode – 'Fixed', S = 10000, L = 1
  - Kodak: Mode – 'pattern'
  - Konica: Readout mode – Fix

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KCARE protocol for QA of CR systems

- b) Examine the images visually for uniformity and record the detector dose indicator value for Agfa (SAL – at centre of plate) and Kodak (Exposure Index).
- c) Record a mean pixel value using region of interest analysis (for systems not offering ROI analysis see appendix for details of how to measure a mean pixel value).
- d) If possible either archive or print the image for future reference.

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KCARE protocol for QA of CR systems

Tolerance

- For Agfa and Fuji systems a uniform artefact free image should be expected.
- Kodak systems add a collector profile to the image to compensate for non uniform collection efficiency across the place. This results in series of bands appearing across the image.
- Agfa systems should have an SAL < 100.
- For Fuji the pixel value should be <280.
- For Kodak the EI value should be <80 for GP plates and <380 for GP plates.
- For Konica a pixel value >3975 should be expected.

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KCARE protocol for QA of CR systems

1.2 Dosimetry

- *Purpose:* To measure receptor doses required for later tests 1.3,1.5, 1.6, 1.7 and 1.11
- a) Position an ion chamber at ~1.2 m from the focus (see figure 1) and at least 30 cm above the table (record the actual distances). Collimate to the ion chamber
- Expose the chamber at 70 kVp with 1.0mm of copper in filtration at the tube head. The mAs should, by 'trial and error', be set such that the inverse square law corrected dose to the table level is approximately 10μGy

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KCARE protocol for QA of CR systems

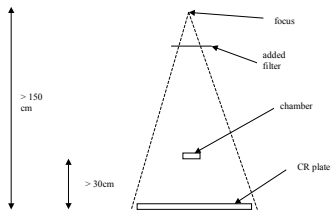

Figure 1: Set-up for exposure index calibration

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KCARE protocol for QA of CR systems

- c) Record the measured dose and repeat twice.
- d) Under the same beam conditions determine the mAs required to deliver a receptor entrance air kerma of 1μGy, 4μGy 12μGy and 50μGy

If a Fuji system is being tested determine the mAs to deliver a receptor entrance air kerma of 10μGy at 80kVp with no filtration in the beam.

If a Kodak system is being tested determine the mAs to deliver a receptor entrance air kerma of 10μGy at 80kVp with 1mm Al and 0.5mm Cu filtration at the tube head.

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KCARE protocol for QA of CR systems

1.3 Linearity and System transfer properties

- *Purpose:-* To establish the relationship between receptor dose and pixel value (for correction in tests 1.4 and 1.7). Also to establish that the indicated exposure (calculated from the detector dose indicator) responds linearly to increases in dose.
- a) Place a 24 x 30 cm cassette on the table at ~1.50m (as described for test 1.2). Set the field to just cover the cassette. Mark the corners of the cassette on the table with transpore, so that the cassette can be easily repositioned.
- b) Expose a plate at 70kVp with 1.0mm copper at the tube head to deliver a dose of order 1μGy as measured in test 1.2.
- c) After a minimal fixed time delay (e.g.1 to 5 mins), read the plate as described below.
- Agfa: S=200, system diagnosis/flat field processing
- Kodak: Pattern mode body part.
- Fuji: semi-auto, L=1 or 2
- Konica: QC S-value, E and F processing turned off

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KCARE protocol for QA of CR systems

d) Record the detector dose indicator value.

- Agfa: SAL (draw a region of interest covering at least 10000 pixels at the centre of the image)
- Kodak: Exposure index (EI)
- Fuji: Linearity mode (S=200)
- Konica: Fix mode

e) Record a pixel value from the centre of the image.

- For Agfa systems the SAL values obtained from ROI analysis on the review workstation should be used.
- For Fuji, Konica and Kodak systems the images should be transferred to reporting workstations to use ROI analysis tools if available.

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KCARE protocol for QA of CR systems

f) Repeat for doses of order 4μGy, 12μGy and 50μGy.

g) Plot a graph of pixel value versus receptor dose using a graph plotting package (e.g. Microsoft excel). Obtain the equation of the trend-line for this graph (i.e. the pixel value as a function of receptor dose). This equation is the system transfer properties (STP) equation and is used for making corrections in tests 1.4 and 1.7. An equation of the form

dose =f(pixel value)

- where f is some arbitrary function is required

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KCARE protocol for QA of CR systems

Tolerance:

- For all images the ratio, k, of indicated exposure to exposure should not differ by greater than ±10% from the mean k value. The trend-line plotted in excel should have an R^2 fit value >0.95. There is no tolerance for the system transfer properties (STP) equation. However the pixel value to dose relationship should be a simple relationship (e.g. log, linear or square root). For systems evaluated by KCARE the following has been found.

Manufacturer	STP Relationship
Agfa	Square root *
Fuji	Logarithmic
Kodak	Logarithmic
Konica	Logarithmic

- * For the Agfa system there is a square root relationship between SAL values and dose. The relationship between raw data pixel values and dose however was logarithmic for systems evaluated by KCARE

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KCARE protocol for QA of CR systems

1.4 Erasure cycle efficiency

- *Purpose: To test that minimal residual signal (ghosting) remains on a plate after readout and erasure.*
- a) Position a plate on the table at ~1.5 m. Set a 10 cm x 10 cm field and position a piece of attenuating material (e.g. Copper or lead) at the centre of the CR plate. Expose at 80kVp, 25mAs with no filtration.
- b) Read the plate (the readout parameters are not important).
- c) Re-expose the plate with a 9 cm x 9 cm field centred on the same point on the plate with no attenuating material in place, using 80kVp, 0.5mAs and no filtration.
- d) Read the plate using the following parameters

Agfa: S=200, exam.type - 'System Diagnosis', proces. – 'Flat Field'

Kodak: Mode – 'Pattern'

Fuji: Readout mode – 'Semi Auto', L = 1 or 2

Konica: Semi fix, g=1

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KCARE protocol for QA of CR systems

- e) Set a very narrow window and adjust the level. Visually inspect the image for any remnant of the previous image (look for both the attenuating material and the position of the collimators). If a remnant is visible, use region of interest analysis to quantify the difference in pixel value between the ghosted and unghosted areas.
  - For Agfa systems the SAL values obtained from ROI analysis on the review workstation should be used.
  - For Fuji, Konica and Kodak systems the images should be transferred to reporting workstations to use ROI analysis tools if available.
- The ROI values should be used to calculate indicated receptor doses using the STP equation established in test 1.3

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KCARE protocol for QA of CR systems

Tolerance

- If no evidence of ghosting is found from visual inspection of the images then the test is passed and there is no need to perform ROI analysis.
- There should be <1% (remedial) difference between the STP corrected pixel values in the ghosted region and the surrounding areas.
- A suspension level of <5% is set.

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KCARE protocol for QA of CR systems

1.5 Detector dose indicator calibration

- *Purpose: To assess the accuracy of the plate exposure values calculated using exposure indicators.*

a) Position a 24×30 plate on the table as described for test
b) Expose the plate to a known dose of ~10 μGy using the kVp and filtration listed below (use mAs found in test 1.2).

CR system	Filtration	Tube Voltage (kVp)
Agfa	1.5mm Cu	75
Kodak	0.5mm Cu +1mm Al	80
Konica	info not known	not known
Fuji	none	80

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KCARE protocol for QA of CR systems

c) Read the plate out as described below

- Agfa: no delay between exposure and readout, S=200, system diagnosis/flat field processing and linear sensitometry.
- Kodak: A 15 minute delay between exposure and readout, readout on Pattern mode body part.
- Fuji: A 10 minute delay between exposure and readout, readout using semi-auto, L=1 or 2
- Konica: Details of the Konica calibration protocol are not available

d) Record the detector dose indicator, and calculate the indicated exposure using the equations given below.

- For Agfa systems the indicated exposure, E_{Agfa}, in μGy, for a 200 speed readout is given by

$$E_{Agfa} = 5.90 \times 10^{-6} \times SAL^2 \quad (1)$$

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- For Kodak systems the indicated exposure, E_{Kodak}, in μGy, is given by

$$E_{Kodak} = 8.7 \times 10^{n}, \text{ where } n = (EI\text{-}2000)/1000 \quad (2)$$

- For Fuji systems the indicated exposure, E_{fuji}, in μGy, is given by

$$E_{fuji} = 1740/S \quad (3)$$

- *For Konica systems the equation linking to dose and S value is not available*
- e) Repeat twice and take a mean value of the indicated exposures.

Tolerance

The indicated and measured exposure should agree within 20%.

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1.6 Detector dose indicator consistency

- *Purpose:* To assess the variation of sensitivity between plates, and set a baseline for monitoring system sensitivity for future QA testing
- a) Place a 24 x 30 cm CR cassette on the couch and set up as described for test 1.2/1.3 (see figure 1) and with 1.0mm Cu filtration.
- b) Expose the plate at 70kVp to give a known dose of ~10 μGy. The dose to the plate calculated from inverse square law corrected ion chamber measurements should be recorded (see test 1.2)
- c) Read the plate as described for test 1.5.
- d) Record the detector dose indicator, and calculate the indicated exposure using equations 1-3. Repeat twice for the same plate.

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e) Calculate the indicated exposure using equations given in test 1.5

f) Repeat this test for all plates for acceptance testing(making only one exposure to each plate). It is helpful at this point to identify a plate that has a detector dose indicator in the middle of the range for future QA.

Tolerance

- The variation in the calculated indicated exposures should not differ by greater than 20% between plates.
- The measurements repeated on the same plate should be used to lay down a baseline for future QA tests.
- All images should be inspected for gross artefacts

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1.7 Uniformity

- *Purpose: To assess the uniformity of the recorded signal from a uniformly exposed plate. A non-uniform response could affect clinical image quality.*
- a) Expose a plate as described for test 1.6 but with half the mAs.
- b) Rotate the plate through 180o about the vertical axis and re-expose using the same parameters (this should largely cancel out the non uniformities due to the anode heal affect).
- c) Read the plate as described for test 1.3.
- d) Visually inspect all images obtained in test 1.3, 1.5 and 1.6 for uniformity and artefacts. Likely artefacts include dust on the plate or readout optics, and scratches on plates

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e) The uniformity of the image obtained in 1.7b should be assessed using region of interest analysis (ROI) if available, to measure the mean pixel values in positions a-e, as indicated in figure 2 below (i.e.at the centre of the image, and at the centre of each of the four quadrants of the image). The size of ROI should be of order 10000 pixels.

- For Agfa systems the SAL values obtained from ROI analysis on the review workstation should be used.
- For Fuji, Konica and Kodak systems the images should be transferred
- to reporting workstations to use ROI analysis tools if available.

f) The five values obtained from ROI analysis should be used to calculate five indicated receptor dose values using the STP equation obtained in test 1.3

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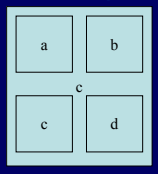

- Fig. 2 Positions of the ROI's for uniformity tests
- f) The five values obtained from ROI analysis should be used to calculate five indicated receptor dose values using the STP equation obtained in test 1.3

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Tolerance

- The images should not have obvious artefacts.
- The ratio of the standard deviation of the 5 STP corrected ROI values to their mean (the coefficient of variation) should be less than 10%

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1.8 Scaling errors

- ***Purpose: To assess the accuracy of software distance indicators and check for distortion.***
- a) Position the Leeds TO.M1 test object directly on the centre of a CR cassette at > 150 FDD.
- b) Expose at 50-60 kVp with no filtration and 10mAs.

  N.B. A lead ruler could be used in place of the M1 test object. If so 2 exposures should be made with the ruler placed in first the scan direction then the subscan direction.

- c) Read out plate using processing as for test 1.3.

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d) Using the distance measuring software tools measure the dimensions (x and y) of five central squares in both fast and slow scan directions. Calculate the aspect ratio x/y.

- For Agfa systems the review workstation software can be used.
- For Fuji, Kodak and Konica systems the images should be transferred to the reporting workstation to use distance measuring software tools if available. If images are reported from film then they should be printed at full size. Distances can then be measured with a ruler.

e) Reposition the test object over the edge of the plate as indicated in figure 3 and repeat steps b and c

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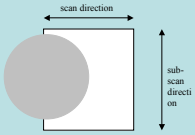

Fig. 3 Horizontal scan direction, vertical sub-scan direction

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f) Along the edge of the plate measure the horizontal (x1) and vertical (y1) sizes of two squares as indicated in figure 4. Calculate the aspect ratio x1/y1.

g) If possible download the image as a DICOM file. Open the image using a DICOM viewer such as Santeviewer. Hold the curser over a corner of a square in the grid. Record the position within the image (i.e. the x and y coordinates). Move the curser to the corner of the square of the grid 10cm from the first corner in the x direction. Record the coordinates again. Calculate the pixel pitch, p(mm)=100/n, where n =number of pixels covering 10cm of the grid. Repeat for the y direction. This test is only necessary on commissioning. Compare the pixel pitch to that stated by the manufacturer. The difference should be no greater than the estimated measurement error.

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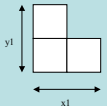

Figure 4 Measurement areas

Tolerance

- The measured distances x and y should agree within 3% of the actual distances at the centre of the plate and 5% at the edge
- All calculated aspect ratios should be within 1.00 ± 0.03 at the centre of the plate, or 1.00 ± 0.05 at the edge.

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1.9 Blurring

- *Purpose:* To test for any localised distortion or blurring of the image.

a) With the contact mesh in placed on the cassette at >150cm FDD, expose at 50-60 kVp, fine focus, with no filtration and 10mAs. Read the plate as described for test 1.3.

b) Visually inspect the image for distortions. If distortion occurs clean the plate and repeat.

c) Repeat for at least two other plates.

d) Repeat with a fine mesh if available.

- *Tolerance:* No blurring should be present. If blurring is present on all plates this suggests the reader is at fault, whilst imperfections in individual plates may also lead to blurring. If blurring remains on a region of a plate after cleaning it should not be used clinically.

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1.12 Laser beam function

- *Purpose: To assess laser beam scanline integrity and jitter*

a) Place a steel ruler slightly angled to the subscan direction on a large cassette.

b) Expose at ~70 kVp, 150cm FSD and an mAs to deliver an incident exposure of ~50μGy. Read the plate as described for test 1.3

c) Using the software magnify the image x10. This will usually require the image to be viewed from a reporting monitor. Select a narrow window width such that the image appears largely polarised to black or white. This should allow the edge to be easily differentiated from the background. Laser beam jitter can be evaluated by examining the edge of the ruler on the image.

Tolerance

- The edge should be continuous across the full length of the image.
- Stair step characteristics should be uniform across the length of the image.
- Regions of over or undershoot of the scan lines indicate a timer or laser beam modulation problem.

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1.13 Moiré Patterns

- *Purpose:* To test for the presence of Moiré pattern artefacts caused by grids.
-
- a) Place a CR cassette in the bucky such that the scan lines are vertical to the gridlines. The cassette should be 1.5m from the focus, and the collimation should cover the whole plate.
- b) Expose at 70 kVp using the AEC with 1.0 mm of copper in the beam, and the grid in place.
- c) Read the plate as described for test 1.3.
- d) Visually inspect the image for Moiré line pattern artefacts.
- e) Repeat with the CR cassette positioned in the bucky such that the scan lines are horizontal to the gridlines.
- f) Repeat for all buckies and grids that may be used with the CR system, including any grids used in mobile radiography.

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Tolerance

- No Moiré patterns should be visible.
- If Moiré patterns are visible with a particular grid, it should not be used with the CR plates.
- The cause of Moire patterns may be the failure of the motion of moving grids or insufficient grid density

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Annual QA tests

- *The following routine QA tests should be performed approximately annually*
- *1.2 Dosimetry (only for 4μGy and 10μGy with 70kVp and 1.0mmCu)*
- *1.4 Erasure cycle efficiency*
- *1.6 Detector dose indicator consistency/sensitivity (for 1 plate of each size)*
- *1.7 Uniformity*
- *1.8 Scaling errors*
- *1.9 Blurring*
- *1.10 Limiting resolution (45° only)*
- *1.11 TCDD (only 4μGy).*

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KCARE protocol for QA of DDR systems

Except for test 1.5 (detector dose indicator calibration) the tests for DDR are quite similar to those for CR

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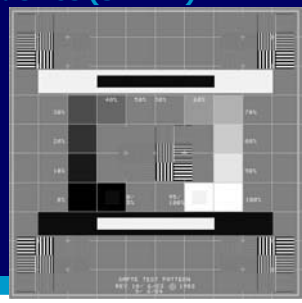
QC tests display station and hard copy device (SMPTE)



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QC measurements: display station

- SMPTE test generator on monitor (Sony model PVM-20N5E, colour video, contrast 75, brightness 25)
- contrast
  - 5 % visible in 0 %? yes
  - 95 % visible in 100 %? yes
- luminance homogeneity
  - top left: 161.2 cd m^{-2} , top right: 159.3 cd m^{-2}
  - bottom left: 4.2 cd m^{-2} , bottom right: 4.1 cd m^{-2}
  - top left: 48.1 cd m^{-2} , top right: 43.2 cd m^{-2}
  - bottom left: 46.6 cd m^{-2} , bottom right: 45.9 cd m^{-2}
- line pairs visible except 2 pixels horizontal

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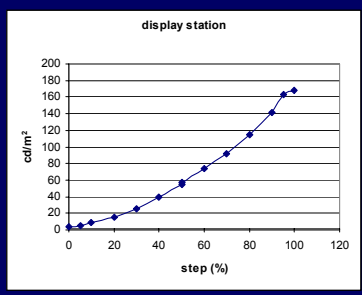
QC measurements: display station



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Display station assessment

- SMPTE test generator requirements
  - 5 % visible in 0 %? yes
  - 95 % visible in 100 %? Yes
  - all line pairs visible
- one set of line pairs missed

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QC measurements: hard copy device

- SMPTE test generator on monitor (Agfa laser printer Drystar 2000)
  - 5 % visible in 0 %? no
  - 95 % visible in 100 %? yes
- homogeneity
  - edges not fully printed, but homogeneity for DIGRAD phantom okay
- all line pairs visible

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hard copy device assessment

- SMPTE test generator requirements
  - 5 % visible in 0 %? yes
  - 95 % visible in 100 %? Yes
  - all line pairs visible
- 5 % not visible in 0 %

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Conclusions

- There is quite a number of QC tests available, even when disregarding conventional tests, dose and image quality
- To be able to perform QC test the number of test and the frequency of testing has to be restricted
- A complete protocol should include the name of the test, purpose, measurement method, requirements (tolerances) and test frequency
- Requirements (tolerances) and test frequencies are not always available
- It would also be useful to have an indication on the test duration

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Conclusions

- Image quality of paediatric system worse than chest radiology system
- Dose of paediatric system high rather insensitive image receptor system
- Image quality of chest radiology system similar to average in Dutch survey
- Dose of chest system rather low compared to Dutch survey and small compared to EC reference doses

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