QC MEASUREMENTS FOR FLUOROSCOPY SYSTEMS IN EIGHT COUNTRIES PARTICIPATING IN THE SENTINEL EU COORDINATION ACTION

J. Zoetelief, F.W. Schultz, S. Kottou, L. Gray, U. O'Connor, D. Salat, K. Kepler, P. Kaplanis, J. Jankowski, A. Schreiner and J. Vassileva

April 26, 2007

Interfaculty Reactor Institute

TU Delft
Delft University of Technology

Outline of presentation

- Introduction
- Materials and methods
- Results and discussion concerning MoniQA and MPBE protocol
- Conclusions

Introduction

- Quality control and quality assurance are becoming increasingly important
  - Overexposed detectors do no longer provide a natural dose limitation for digital systems
  - Equipment settings are automatically selected
  - Image handling is performed according to manufacturer's wishes. Raw data hardly available

Introduction

- For QC of fluoroscopy it was decided
  - to select a SENTINEL toolkit containing equipment and instructions for assessment of equipment performance
  - to circulate the toolkit among SENTINEL partners
  - to have partners performing measurements at (modern) fluoroscopy systems
  - To use the experience of the participants to improve the protocols used for the trial with the toolkit

Materials and methods

- The SENTINEL toolkit circulated in Europe together with
- The protocol for fluoroscopy of the MPBE department, Dublin and the MoniQA monitor test tool
  - Bulgaria made measurements using their own equipment (customs problems)
  - Seven participants used the toolkit to perform measurements between August 8 and November 3, 2006
  - The contents of the toolkit is shown in the following slide

M&M: Toolkit contents

Table 1. Contents of the SENTINEL toolkit for the trial on QC of fluoroscopy units

Leeds Test Objects (S/N 20)
0.5 mm Copper filtration (15 cm x 15 cm)
1 mm Copper filtration (15 cm x 15 cm)
1.5 mm Copper filtration (15 cm x 15 cm)
SW4 grey scale test object
FSG4 matrix / field size test object
Huttner line pair resolution phantom type 18
SSM4 710 micron woven mesh test object
LCD4 noise test object
TCD4 contrast detail test object
VS4 edge test object
Manual
BNC cable + 3 connectors
Instruments
Unfors Instruments kVp meter, Type 9001, S/N 91728
Unfors Instruments Mult-O-Meter, Type 731L, S/N 125534
+ Prova 15 AC/DC mA Current Probe (clamp), no. 02200480
+ Pen detector holder
Manual for Mult-O-Meter + Addendum
Manual for Test-O-Meter
Radcal Corporation Radiation Monitor Controller, Model 2026C, S/N 260276
Radcal Corporation Electrometer / Ion Chamber, Model 20x6-60, S/N 21860
Serial connector cable
Certificate of calibration (John Perry Radiation Metrology Laboratory, job no. 7168)
Instructions for use
Shielding material
4 mm Lead filtration (13 cm x 10 cm); weight 600 g
Documents/Quality Assurance Protocols
MPBE Quality Control, Fluoroscopy System
MPBE Quality Assurance, General X-ray System (for background information only)
Reference to website to download MoniQA software

M&M: transportation of toolkit

- An international company was asked to perform the transport of the toolkit
  - Options were:
  - Transportation from one participant to the next one and so on
    - This seemed quite convenient
  - Transportation from Delft to a participant, return to Delft, transportation to next participant et cetera (export/import option)
    - This seemed laborious
- It appeared impossible to have the equipment insured choosing the first option. Moreover the export/import option was cheaper
- A time interval of one week between successive participants was sufficient for transportation

TUDelft

M&M: overview measurements

Table 2. Overview of the measurements made by the partners using the Toolkit

Partner	Fluoroscopy protocol	Imaging system	Monitor tests
2, Ireland	Siemens Multistart	II + CCD	No
	Philips Easy Diagnost	II + TV	
8, Luxembourg	Siemens Axiom Artis	Flat panel	No
11, Greece	Philips Integris V3000	II + CCD	Yes
12, Poland	GE Innova 2000	Flat panel	To be performed
13, Cyprus	Mecall Superix 180N	II + CCD	No
14, Slovakia	Siemens Artis dFC	Flat panel	No
	Chirana Chiraskop 2000	II + CCD	
15, Estonia	Toshiba KXO-60G	II + CCD	No monitor on system
19, Bulgaria	Siemens Axiom Iconos MD	II + CCD	No

TUDelft

M&M: overview measurements

- The participants had the toolkit available for measurements during one week
- Large variety of fluoroscopy systems.
- The results of the monitor tests were quite disappointing, i.e. only one participant was able to perform the tests with MoniQA.
  - It appeared not simple to install the software
    - assistance required from suppliers of monitors.
  - The suppliers hesitant to install other software than their own.

TUDelft

Results and discussion

Table 3. System details

Partner	2[a]	2[b]	8	11	12	13	14[a]	14[b]	15	19
Equipment										
Manufacturer	y	y	y	y	y	y	y	y	y	y
Make/Model	y	y	y	y	y	y	y	y	y	y
Serial No.	n	n	n	y	n	y	n	y	y	n
Screening Tube	n	y	n	y	n	n	n	y	n	y
Over Couch Tube	n	n/a	n	n		n	n	y	y	n
Under Couch Tube			y		y					
Image Intensifier	n	y		n	y	n		y	y	n
Flat panel detector (FPD)			y	y	y		y			
Nominal Rating	n	y	n	y	y	n/y	n	n	y	y
Nominal Filtration	n	y	y	y	y	n	n	n	y	n
Installation Date	n	y	y	y	y	n	y	y	y	y
Instruments										
Ionisation chamber		y[1]					y	y	y[1]	y[7]
Multimeter		y[2]			y[2]		y/y[5]	y/y[5]	y[2]/y[6]	
Oscilloscope					y[3]				y[3]	
Tube voltage meter							y	y		
Leeds test objects		y[4]					y[4]	y[4]		y[8]

TUDelft

Results and discussion

System details: Conclusions

- This information should be included in the protocol
- Options of under couch tube and flat panel detector should be added to the list.
- Test equipment (instruments) could be presented in advance as options in the table. This would make completion easier.
- Maybe some participants presumed that the equipment was known, but no one referred to the toolkit.
- Clear instructions are needed on how to distinguish between "not applicable" or "no information".

TUDelft

Progress WP 1.2

Table 4. Tube and generator Performance

Partner	2[a]	2[b]	8	11	12	13	14[a]	14[b]	15	19
Tube output										
Constant current (CC) varying potential (VP)	n	1p	y	n	[2]	[3]	[4]	y	y[5]	[3,4]
Constant potential (CP) varying current (VC)	n	[1]	-	n	y	n	y	y	y[5]	n
Tube output consistency	n	y	y	n	y	y	y	y	y	y
Tube potential										
Varying tube current at fixed tube voltage	n	[1]	n	n	n	n	[4]	y	y	n
Varying tube potential at fixed tube current	n	1p	n	n	n	n	[4]	y	y	n
Specification of performance	n	n	n	n	n	n	n	n	n	n

[1]Not available, [2]Alternative for AEC system, where tube voltage is varied and tube current varies automatically (table needs adaptation), [3]Current cannot be stabilised, [4]No manual control, [5]Measured with two instruments

TUDelft

Progress WP 1.2

Tube and Generator Performance: Conclusions

- Various quality control measurements concerning tube and generator performance are not well possible for modern equipment.
- Since tube and generator performance of modern equipment is usually much better than for older equipment, the measurements could be restricted to "tube output – varying potential" and to "tube output consistency".
- The specification of performance should be given explicitly.
- Present formulation (Fig. AII.11 and General Protocol) presumes background information.
- Add: test is passed/failed and consequences (also elsewhere)

TUDelft

Results and discussion

Table 5. Automatic exposure control

Partner	2[a]	2[b]	8	11	12	13	14[a]	14[b]	15	19
II entrance dose rate	y	y	y[5]	n	n	n	n	n	y	y
According to specification of performance	[1]	[1]	[5]	n	-	n	-	-	[1]	1
II entrance air kerma rate for 7 cm x 7 cm field	n	n	n	n	n	y	n	n	y	y
At each level of operation (push button control or maximum and minimum)	y	y	-	y	y	y	n	n	y	y[7]
At clinical settings	y	y	-	-	y	-	y[7]	y	n	n
At magnification settings	y	y[2]	-	y	y[6]	y	n	y	n	y
II entrance dose rate										
Pulsed fluoroscopy	y	y	y	n	y	y	y	n	n	y
Digital acquisition		y								
Patient entrance dose rates		y	y	y	y	y	n	y		
Maximum dose *rate* patient can receive		n	n	n	y	y	y	n	y	y
Pulsed mode and magnification settings	y	y[3]	y	y	n	y	y	n	n	y
Digital acquisition		y	n	n	n	n	n	n	n	n
Specification of performance	n	n	n	n	n	n	n	n	n	n

[1]Yes but not concluded, [2]Already in previous measurements, [3]Adaptation of table needed?, [4]Flat panel detector, only pulsed mode, [5]Detector entrance dose rates do only fulfil entrance dose rate requirement for Fluoro LD and ND and 6p/s, [6]For pulsed mode, [7]Values appear very high

TUDelft

Results and discussion

Automatic exposure control: Conclusions

- In the protocol replace image intensifier (II) by Image Detection System (IDS), other systems than II are used.
- It is not clear why the reference measurements for IDS dose rate (incident air kerma rate?) (full field and 7 cm x 7 cm field) are not always made.
- There is a criterion for performance for full field but not for 7 cm x 7 cm field.
- More extended tables for IDS and patient incident air kerma could be produced.
- Performance criteria, if given, are not applied to evaluate the results.
- "Rate" should be added to maximum patient dose.
- The copper filter can cause problems for FPD systems

TUDelft

Results and discussion

Table 6. Leeds test objects

Partner	2[a]	2[b]	8	11	12	13	14[a]	14[b]	15	19
Video voltage output	n	n/a[1]	n	n	y	n	n	n	y	n
Specification of performance	n	n/a[1]			y[2]				y[2]	
Grey scale test							[1]			
No. of Steps visible	10	10	y	y	y	10	10	10	y	10
Black and white discs visible	y	y	y	y	y	y	2	y	y	y
Monitor adjustment	n	n	n	n	n	n	y	y	n	n
Specification of performance	y	[1]					[1]	[1]		
Low contrast (noise) test object										
No. discs visible (full field)	11	10.5	9	10	11	11	9	10	10	15
No. discs visible (mag. 1)	11	12	10	10	11	12	9	11	n	14
No. discs visible (mag. 2)	11	12	10	10	11	12	9	11	n	14
Other kerma rates?	n	y	n?	n	n	n	y	y	y	n
Specification of performance	y[2]	y[2]	n[3]	n[2]	n[2]	n[2]	n[3]	n[2]	n[2]	n[2]
New systems?	n[3]	y[3]	n[3]	n[3]	n[3]	n[2]	n[3]	n[3]		n[2]
Contrast detail test object		[1]					[1]			
Test performed?	y	y	n	y	y	y	y	y	y	y
Plot detection index values	y	y	n	n	n	n	n	n	n	n
Specification of performance	y[3]	n[3]	n[3]	n[3]	n[3]	n[3]	n[3]	n[3]	n[3]	n[3]

TUDelft

Results and discussion

Leeds test objects: Conclusions 1

- The Leeds test objects referred to in the protocol (GS2, N3, TO10, M1, MS1, MS3, MS4) are replaced by a new series (SW4, LCD4, TCD4, FSG4, SSM4).
  - Does this have any implication on the protocol? If not add these phantoms
- The video voltage output test difficult to be performed
  - measurement is too invasive for modern systems?
  - Measurement could be skipped?
- No specifications of performance for the Gray scale test.
  - Replace "Steps visible" by "No. of steps visible".
- Low contrast (noise) test object performance criteria
  - commonly complied with for old systems
  - hardly fulfilled as formulated for new systems.
    - surprising since most systems are relatively new.
- Contrast-detail test object
  - No system complies, criteria too strict?

TUDelft

Results and discussion

Table 6. Leeds test objects

Field coverage test object		[1]					[1]			
Full field	y	y	y	n	y	y	y	y	y	y
Magn. 1	y	y	y	y	y	y	y	y	n	y
Magn. 2	y	y	y	y	y	y	y	y	n	y
S-distortion	y	y	y	n	y	n	y	y	y	y
Pincushion distortion	y	y	y	n	y	y	n	n	y	y
Specification of performance	n	n	y	n	y	n	n	n	y	y
Radiation field/image field	y	y	y	n	y	n	n	n	y	y
Specification of performance	y	y[2]	y	n	y	n	n	n	y	n
inverse?	y									
Limiting resolution test object										
Full field	y	y			y				y	y
Magn. 1	y	y			y				n	y
Magn. 2	y	y			y				n	y
Full field digital	y	y								
Magn. 1 digital	y	y								
Magn. 2 digital	y	y								
Full field pulsed		n	y	y		y	y	y		y
Magn. 1 pulsed		n	y	y		y	y	y		y
Magn. 2 pulsed		n	y	y		y	y	y		y
Specification of performance		y[2]	y	y[2]	y[2]	y[2]	y[2]	y[2]	y[2]	y[2]
Specification of perform. digital		y[2]								

TUDelft

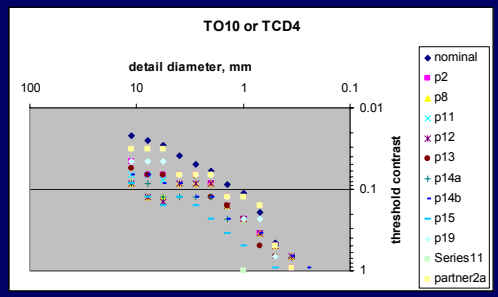
Results and discussion

Leeds test objects: Conclusions 2

- The field coverage test object seems too small.
- Instructions for scoring S-distortion and pincushion distortion should be given.
- The radiation field should be smaller than the image field.
  - This means that the criterion should be inversed.
- The limiting resolution test object (Huettner) seems to be easy to use.
  - The specification of performance is not always indicated.

TUDelft

Results and discussion



TUDelft

Results and discussion

Table 6. Leeds test objects

Uniformity of focus test objects	[1]								
MS1	y	n	y	y	n	n	n	n	y	y
MS3	y	n	y	y	n	n	n	n	n	y
MS4	y	y	y	y	n	n	n	n	n	y
Specification of performance	y									

[1]New kit, [2]Fulfilled but not indicated, [3]Not fulfilled but not indicated.

TUDelft

Results and discussion

Leeds test objects: Conclusions 3

- Specifications of performance for the mesh phantoms are absent in the protocol.

TUDelft

Results and discussion

Table 7. A summary of the measurements for fluoroscopy on image quality of system 2a using the Leeds Test objects.

Test object	requirement	Type of test	Test result
Grey Scale Test Object (GS2):	All 10 Grey Steps, Black and White Discs visible	Baseline	Satisfactory
Low Contrast Test Object (N3):	FF: 0.033 M1: 0.033 M2: 0.033 M3: 0.030	< 0.04	Pass Similar to previous inspection
Contrast Detail Test Object (TO10):	Graph	Baseline	Satisfactory Similar to previous inspection
Field Coverage Test Object:	FF: 0.80 M1: 0.89 M2: 0.88 M3: 0.93	0.85 - 1.0	Partial Pass Similar to previous inspection
Limiting Resolution Test Object (Hüttner):	FF: 1.25lp/mm M1: 1.70lp/mm M2: 2.00lp/mm M3: 2.80lp/mm	FF: ≥ 0.7lp/mm M1: ≥ 0.9lp/mm M2: ≥ 1.0lp/mm M3: ≥ 1.25lp/mm	Pass Similar to previous inspection
Uniformity of Focus (Mesh Test Objects: MS1, MS3, MS4):	MS1: Visible throughout MS3: Visible throughout MS4: Not visible	Baseline	Satisfactory
Equipment Condition:			Satisfactory

TUDelft

Results and discussion

- **Some of the requirements in the table differ from those in the protocol**
  - **for GS2 here a requirement is given**
  - **for N3 here only the requirement for old equipment is shown**
  - **for TO10 the graph does not fulfil the nominal values (results better than for the other units)**
  - **for the field coverage test object the requirement is here as expected, i.e. 1 at maximum**
  - **the requirements for the limiting resolution are less strict than in the protocol**
  - **for uniformity of focus here requirements are given.**

TUDelft

Conclusions

•General conclusions

- The MPBE protocol appeared a good starting point for QC of fluoroscopy systems
- Not all tests seem useful or applicable for modern systems
- Wording in some parts be improved for digital systems
- Criteria are not always present or fulfilled
- Compliance (pass/fail) with requirements should be added
- The circular cross section of the phantoms need adaptation to rectangular FPD systems

TUDelft