Comparison of doses under Automatic Exposure Control (AEC) conditions for DDR X-ray systems using different protocols

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Purpose

- Direct Digital Radiographic (DDR) X-ray systems are calibrated by manufacturers using specific protocols and phantoms.
- Medical physicists perform acceptance testing / Quality Assurance of DDR systems using established test protocols.
- Physicist / Manufacturer protocols can differ in terms of phantoms and methodology.

The purpose of this work is to provide a comparative study of doses under Automatic Exposure Control (AEC) conditions for DDR X-ray systems using these different protocols / phantom types in an effort to establish if a commonality exists between the different approaches.

Introduction

AEC tests performed using 2 protocols

- **1: IPEM based tests[1]:** Patient Exit Dose measurements using
  a. 1mm Cu placed at X-ray tube head, grid removed
  b. Water equivalent material placed at DR detector, grid removed

- **2: Manufacturer tests:** Patient Exit Dose measurement using metal phantom (Al /Cu) placed at X-ray tube head with grid in place. Suppliers use 21mm Al or varying thicknesses of Cu (0.6, 1.2, 2.1mm)

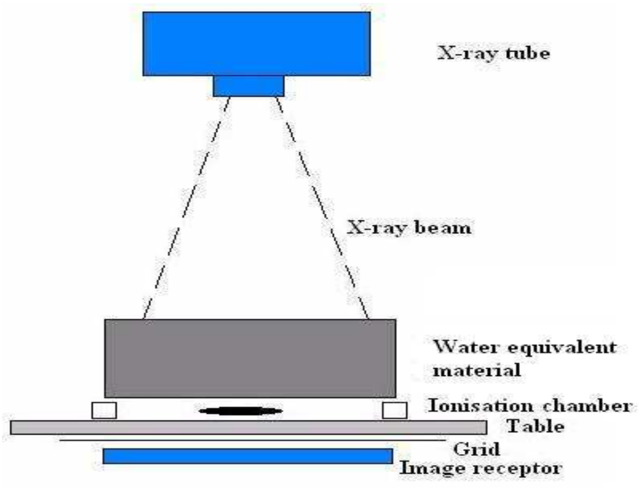


Figure 1: Clinically representative set-up with water equivalent material at detector. All chambers covered

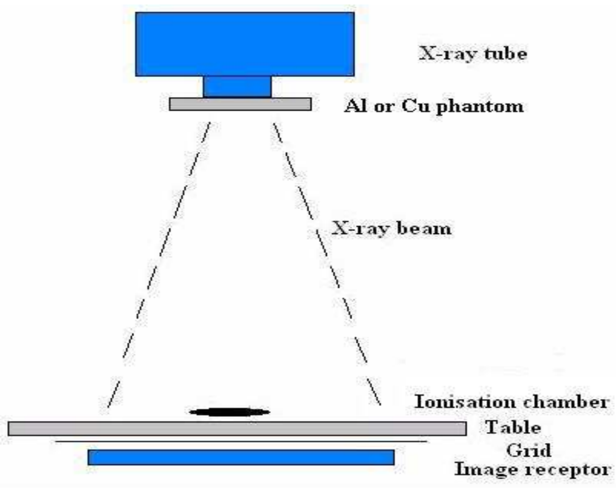


Figure 2: Set-up using manufacturer phantoms at tube head. All chambers covered

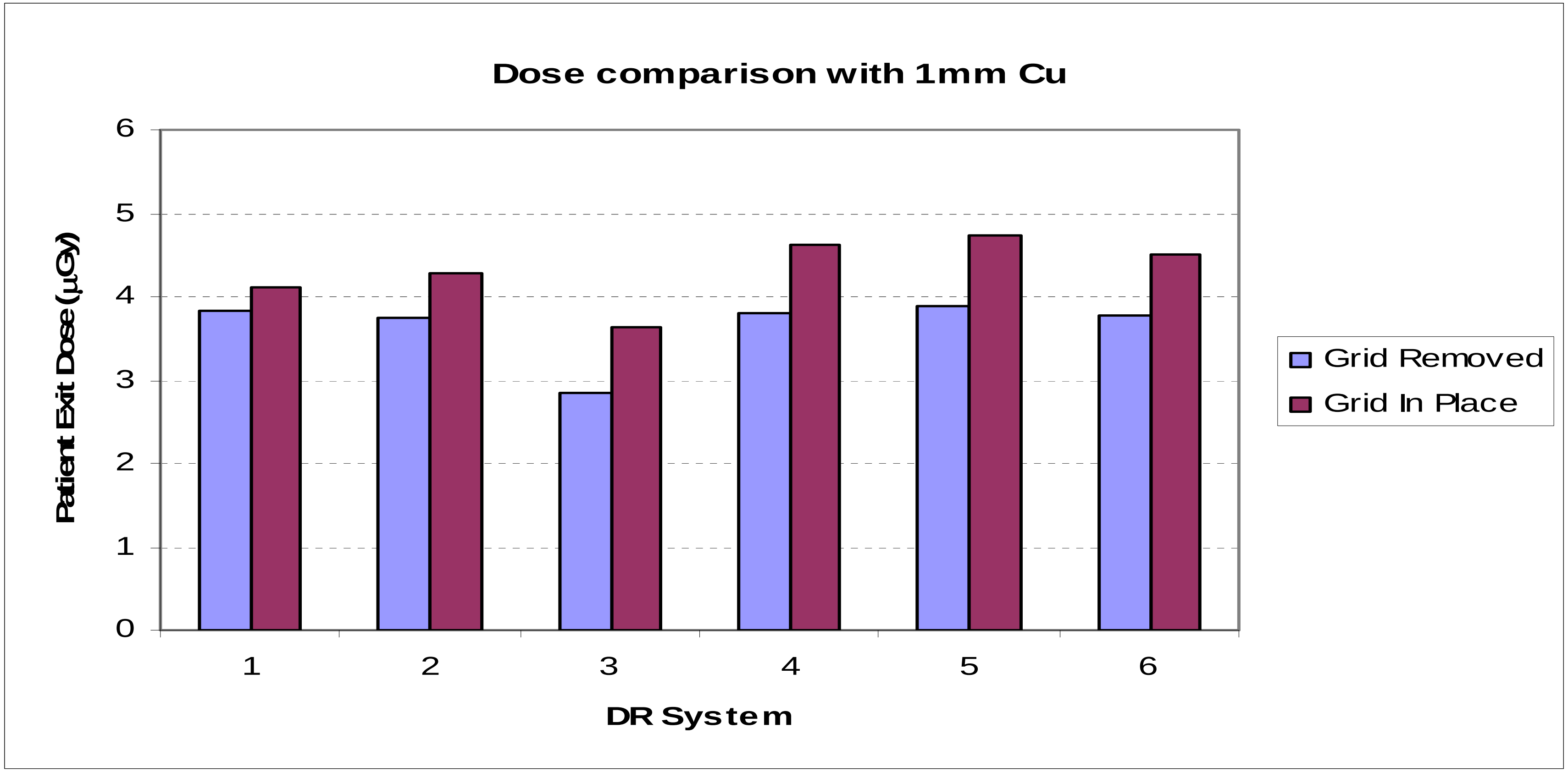
Materials and Methods

3 Manufacturers: Philips, GE, Siemens (6 DR detectors)

Summary of QA parameters to measure patient exit dose using 2 different protocols:

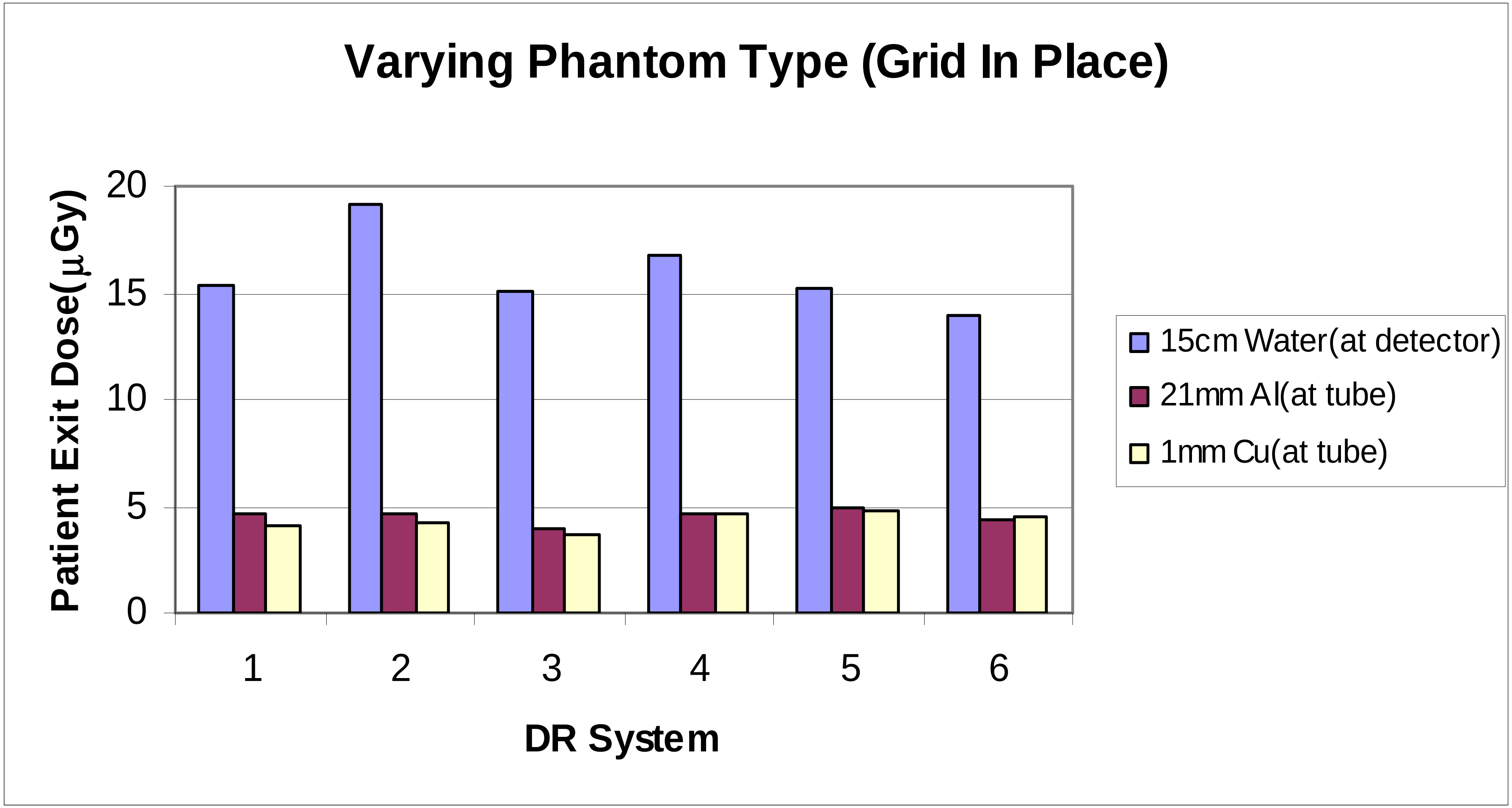
- 70kVp, Centre Chamber, Broad focus[2]
- Table Bucky (SID=1m), Vertical Bucky (SID=1.5/1.8m)
- Dosimeter: Radcal 60cm^3 calibrated ionisation chamber (positioned to avoid covering AEC chambers)
- Phantoms: 1mm Cu sheet (at tube head), 15cm water equivalent material placed close to DR receptor, 21mm Al (at tube head)
- Tests with Grid In Place and Grid Removed

Results



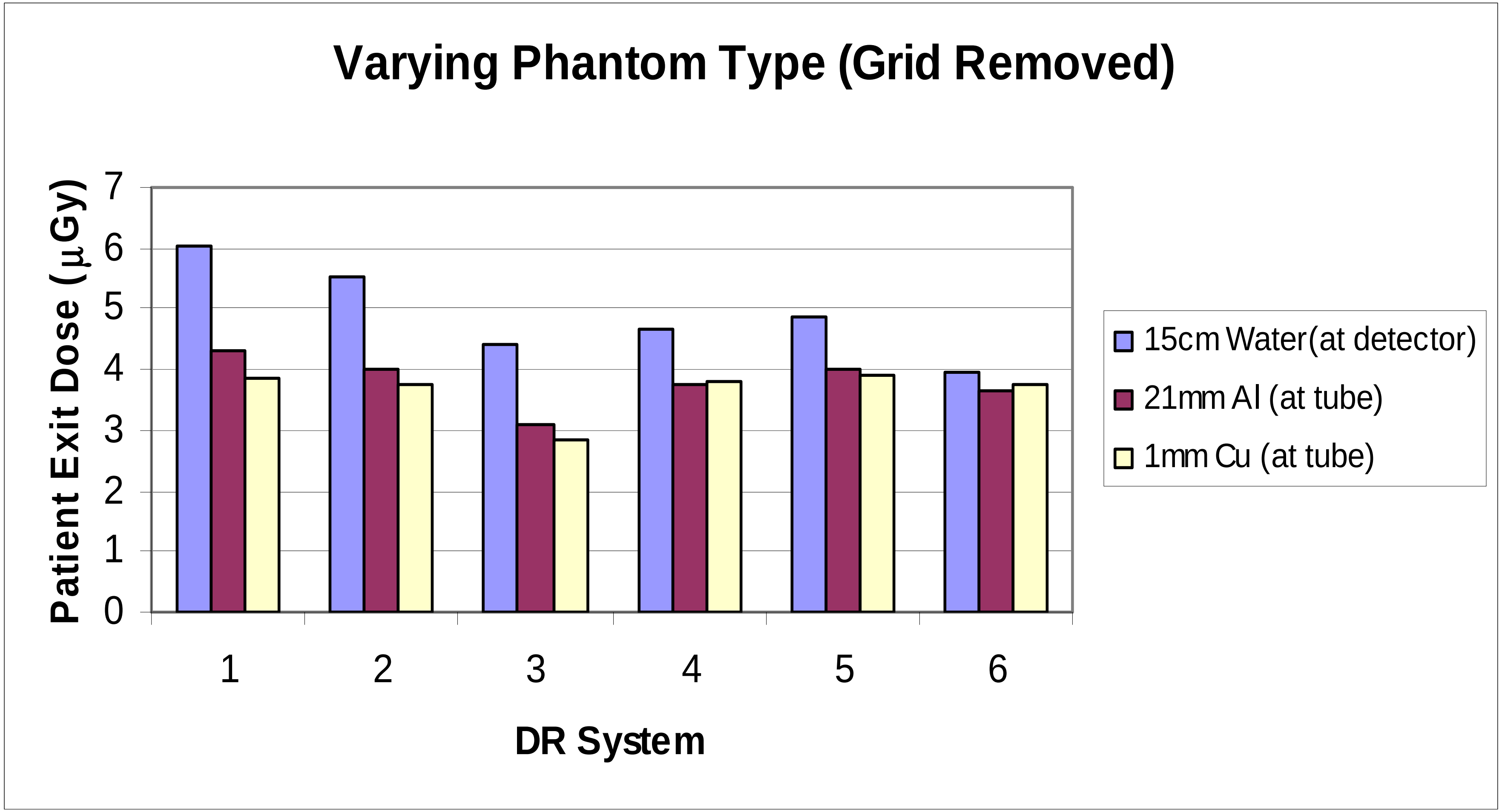
- Patient Exit Dose comparison with 1mm Cu placed at tube head:
  - *Grid Removed as per IPEM Protocol[1] (Image receptor dose test)*
  - *Grid In Place as per Manufacturer's Protocol*

Results



Varying Phantom Type (Grid In Place)
Patient Exit Dose(μGy)
20
15
10
5
0
1
2
3
4
5
6
DR System
15cm Water(at detector)
21mm Al(at tube)
1mm Cu(at tube)

Results



Varying Phantom Type (Grid Removed)
Patient Exit Dose (μGy)
7
6
5
4
3
2
1
0
1
2
3
4
5
6
DR System
15cm Water(at detector)
21mm Al (at tube)
1mm Cu (at tube)

Results

Grid In Place:

Phantom Type	Patient Exit Dose (μGy)	
	Mean	Range
1mm Cu	4.3	3.6 – 4.7
21mm Al	4.5	3.9 – 5.0
15cm Water	15.9	13.9 – 19.1

Grid Removed:

Phantom Type	Patient Exit Dose (μGy)	
	Mean	Range
1mm Cu	3.7	2.9 – 3.9
21mm Al	3.8	3.1 – 4.3
15cm Water	4.9	4.0 – 6.1

Detailed Patient Exit Dose survey for Water equivalent material and Al for DR detectors is presented by L. Bowden, Scientific Session 5A, S5.04, International Conference in Radiation Protection in Medicine, Varna, 2010.

Conclusions

1. Patient Exit Dose measurements on DDR X-ray systems are dependent on phantom type / position / grid status.

2. Patient Exit Dose measurements using 21mm Al / 1mm Cu phantoms are comparable to each other for each system tested with grid in place and also with grid removed.

3. Mean Patient Exit Dose measurements using water equivalent material with grid removed are higher by ~30-35% than 21mm Al / 1mm Cu due to contribution of scatter from the water equivalent material which is placed close to the image receptor.

4. Doyle and Martin(2006)[3] advise that copper is not used for calibrating AECs for digital radiography due to issues with X-ray beam quality on the detector. IPEM(2010)[4] also states that copper should only be used for routine QA.

References

1. *IPEM Report 91. Recommended Standards for the Routine Performance Testing of Diagnostic X-ray Imaging Systems, 2005.*

2. *IPEM Report 32, Part IV, X-ray Intensifying Screens, Films, Processors and Automatic Exposure Control Systems, 1997.*

3. *P. Doyle and C.J. Martin, Calibrating automatic exposure control devices for digital radiography, Phys. Med. Biol.* ***51****, 5475-5485, 2006.*

4. *IPEM Report 32, Part VII, A. Mackenzie et al, Measurement of the Performance Characteristics of Diagnostic X-ray Systems: Digital Imaging Systems, 2010.*

5. *C. Walsh et al, Quality Assurance of Computed and Digital Radiography Systems, Radiation Protection Dosimetry, Vo. 129, No. 1-3, 271-275, 2008.*