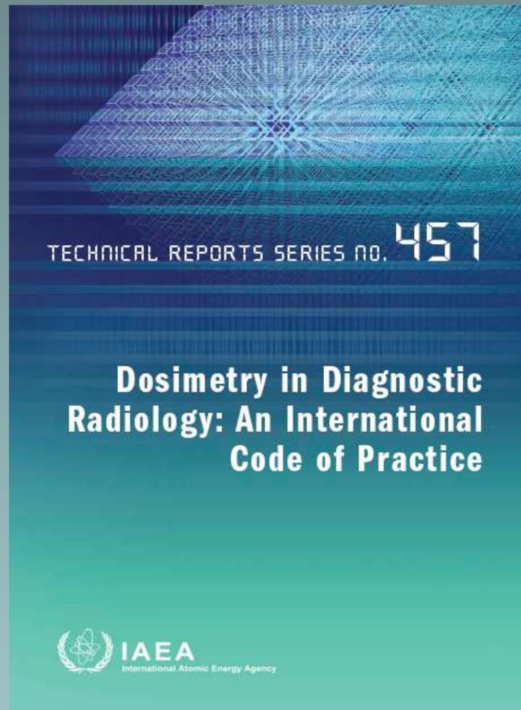
Mammography Patient Dose Measurements Using the Methodology of the International Code of Practice for Dosimetry in Diagnostic Radiology



F. Giczi*[1], S. Pellet[2], I. D. McLean[3], A. Meghzifene[3]

[1] Széchenyi István University, Győr, Hungary, giczif@sze.hu

[2] National Center for Healthcare Audit and Inspection, Budapest, Hungary

[3] International Atomic Energy Agency, Vienna, Austria

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Importance of patient dosimetry

Justification,

Risk- benefit analysis

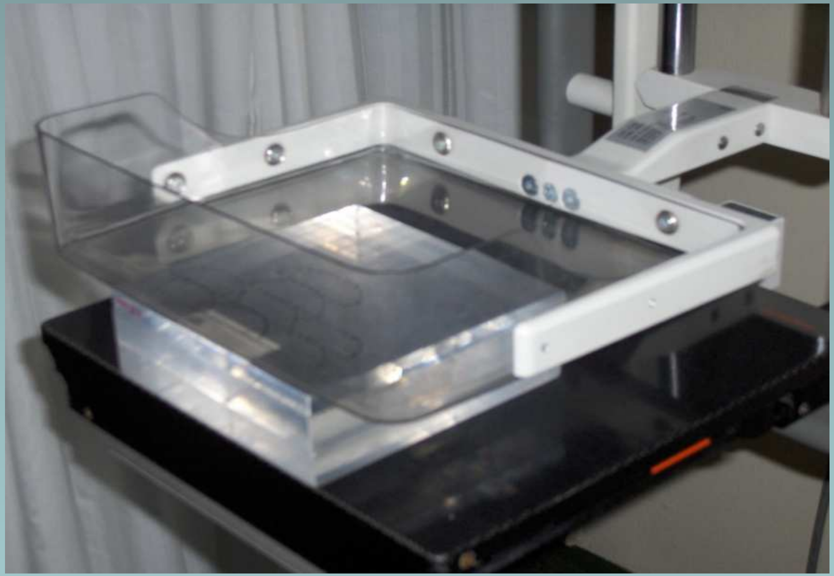
Measurements on patients.

Optimization,

Diagnostic reference levels

Measurements using phantoms.

Determination of tube loading



- 45 mm thick PMMA phantom simulates a standard breast of thickness 50 mm and glandularity 50% for cranio-caudal (CC) projection,
- Compression plate brought onto the phantom,
- Loaded cassette,

Exposure factors selected by the operator:

Tube voltage: 27 kV,
Target/filter: Mo/Mo

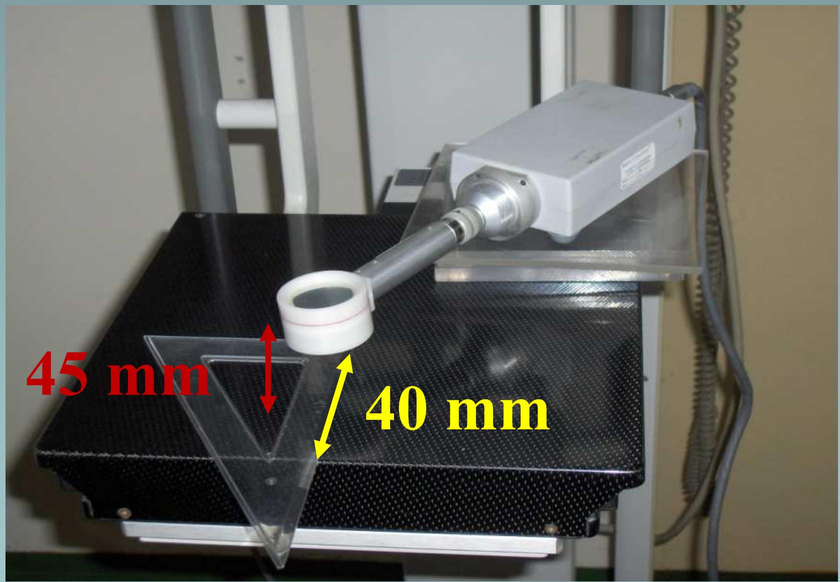
(Exposure is terminated by the AEC)

Tube loading displayed:

$$P_{\mathrm{lt,auto}} = 59\,\mathrm{mAs}$$

$$\left(P_{It,\mathrm{auto}} = \frac{P_{It,1} + P_{It,2} + P_{It,3}}{3} \right)$$

Measurement of the incident air kerma



Tube voltage: 27 kV,
Target/filter: Mo /Mo
$P_{it,auto}$=59 mAs

Tube loading selected manually:

$$P_{It,manual} = 63\ \text{mAs}$$

Dosimeter reading:

$$\overline{M}_{manual} = 7{,}048\ \text{mGy}$$

- **Phantom removed,**
- **Radiation detector at the mammographic reference point,**

Dosimeter reading at $P_{it,auto}$:

$$M_{\text{auto}} = P_{It,auto}\left(\frac{\overline{M}_{manual}}{P_{It,manual}}\right) = 6.601\ \text{mGy}$$

Determination of the HVL

Al filter thickness (mm Al)	M (mGy)
0,00	2,788 (M_{01})
0,30	1,559
0,40	1,327
0,00	2,807 (M_{02})

$$\overline{M}_0 = \frac{M_{01} + M_{02}}{2} = 2{,}798 \text{ mGy}$$

$$\frac{\overline{M}_0}{2} = 1{,}399 \text{ mGy}$$

Interpolated HVL

0,369 mm Al

Calculation of incident air kerma

$$K_i = M_{auto} \cdot N_{K,Q_0} \cdot k_Q \cdot k_{TP}$$

Dosimeter calibration coefficient: $N_{K,Q_0} = 1{,}017 \quad (20\ {}^0C, 101{,}325\ \ kPa)$

Beam quality correction: $k_Q = 1$

Temperature and pressure correction: $k_{TP} = \left(\frac{273{,}15 + 24}{273{,}15 + 20}\right) \cdot \left(\frac{101{,}325}{102{,}0}\right) = 1{,}007$

$M_{auto} = 6{,}601\ mGy$ ⇒

Incident air kerma

$K_i = 6{,}760\ mGy$

Mean glandular dose for the standard breast

$$D_G = c_{D_{G50},K_{i,PMMA}} \cdot s \cdot K_i$$

Spectral corrections:

Target/ filter	s
Mo/Mo	1,000
Mo/Rh	1,017
Rh/Rh	1,061
Rh/Al	1,044
W/Rh	1,042

HVL=0.369 mm Al

$$c_{D_{G50},K_{i,PMMA}} = 0{,}210$$

Dose conversion coefficients:

Filter thickness (mm Al)	$c_{D_{G50},K_{i,PMMA}}$
0,25	0,149
0,30	0,177
0,35	0,202
0,40	0,223
0,45	0,248
0,50	0,276
0,55	0,304
0,60	0,326
0,65	0,349

$$D_G = 1{,}42 \pm 0{,}12 \text{ mGy}$$

(Estimation of uncertainties)

Measurements on patients

Data collection

X-ray tube output measurements

L/R breast	Projection	Target/filter	Tube voltage	Tube loading, $P_{It,pat}$	Breast thickness	Distance, d_P	Y_{ref}
			kV	mAs	mm	mm	mGy·(mA·s)$^{-1}$
R	CC	Mo/Mo	27	32	40	585	0.113
L	CC	Mo/Mo	27	32	40	585	0.113
R	CC	Mo/Mo	27	51	50	585	0.113
L	CC	Mo/Mo	27	49	50	585	0.113
R	CC	Mo/Mo	27	44	55	585	0.113
N=40							
	Mean			**45 mAs**	**47 mm**		
	Min			12	20		
	Max			90	70		

Measurements on patients

Dose calculations

L/R breast	Projection	Target/ filter	Incident air kerma, K_i	HVL	s-factor	c_{D_{G50},K_i}	$c_{D_{Gg},D_{G50}}$	Mean glandular dose, D_G
			mGy	mm Al		mGy·mGy^{-1}	mGy·mGy^{-1}	mGy
R	CC	Mo/Mo	3.550	0.369	1	0.245	1	0.87 ± 0.09
L	CC	Mo/Mo	3.550	0.369	1	0.245	1	0.87 ± 0.09
R	CC	Mo/Mo	5.871	0.369	1	0.191	1	1.12 ± 0.12
L	CC	Mo/Mo	5.641	0.369	1	0.191	1	1.08 ± 0.11
R	CC	Mo/Mo	5.161	0.369	1	0.178	1	0.92 ± 0.10
N=40								
	Mean		**5,28 mGy**					**1,04 mGy**
	Min		1,20					0,56
	Max		10,5					1,88

(Similar methods to the phantom measurements)

Conclusions

- Standard methods,
- Comparable results,
- Applicable in clinical environment,
- Measurements on patients and measurements using phantoms are different methods for different purposes (justification and optimization).