INTERNATIONAL ATOMIC ENERGY AGENCY
UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION
INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS
I.C.T.P., P.O. BOX 586, 34100 TRIESTE, ITALY, CABLE: CENTRATOM TRIESTE

H4-SMR 471/07

COLLEGE ON MEDICAL PHYSICS

10 - 28 SEPTEMBER 1990

REDUCTION OF RADIATION DOSES TO PATIENTS AND PERSONNEL IN DIAGNOSTIC RADIOLOGY

Monica Gustafsson

Department of Radiation Physics
University Hospital
Lund
Sweden

College on Medical Physics, Trieste, 10-28 September 1990

Principles of dosimetry:
REDUCTION OF RADIATION DOSES TO PATIENTS AND PERSONNEL IN DIAGNOSTIC RADIOLOGY

Monica Gustafsson, Department of Radiation Physics,
University Hospital, S-221 85 Lund, Sweden

There is no doubt that the most beneficial use of ionizing radiation is its use in medicine. It gives, however, the largest man-made contribution to the population dose, and the frequency and total use of medical radiation is expected to increase.

The largest part of this irradiation derives from diagnostic radiology, so no efforts should be spared in the protection of patients in diagnostic radiology.

The ICRP rule that "all radiation doses shall be kept as low as reasonably achievable, economic and social factors being taken into account" means that the X-ray examination shall be conducted in such a way that the required information is received at the minimal radiation risk to the patient. The optimization of image quality and patient exposure should be based on adequate knowledge of the health effects of ionizing radiation as well as of the influences of technical and methodological factors on the irradiation of the patient.

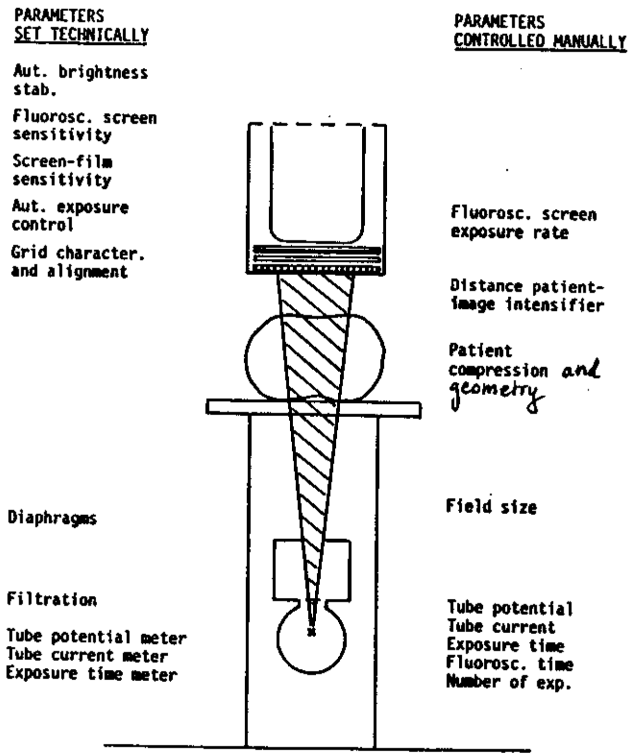
It is possible to sort out three different fields where decisions are taken or actions made, influencing patient irradiation, namely

Planning and purchase

Maintenance and quality control

Examination-technique and performance.

In this lecture some factors of great importance for the irradiation of patients and personnel will be discussed on basis of the attached illustrations.



Schematic listing of parameters influencing the patient irradiation in examinations including fluoroscopy and radiography. Some parameters supersede others; with brightness stabilization, for example, tube potential and/or tube current are not set manually, while automatic exposure control excludes manual influence of tube current and exposure time.

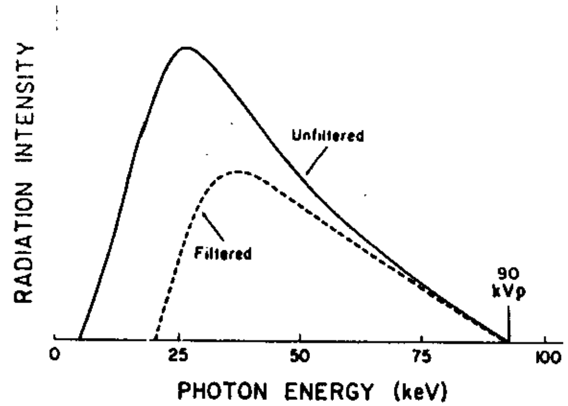
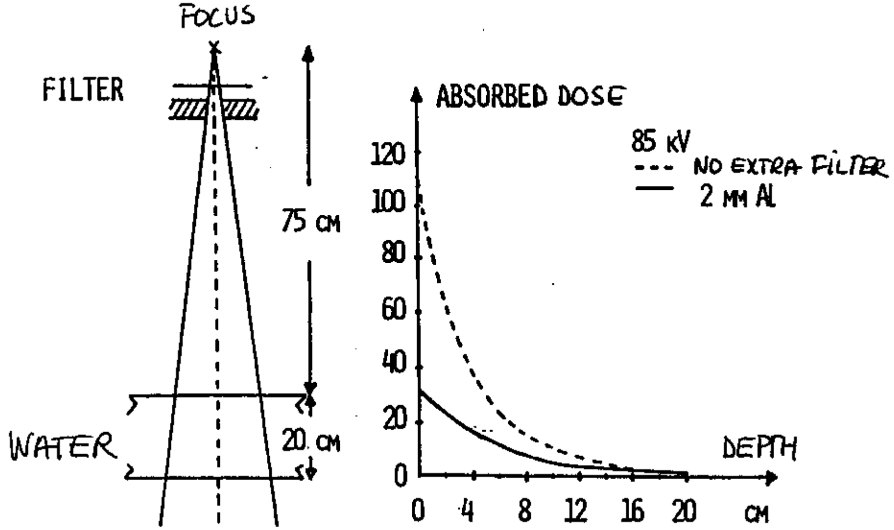


Figure 6–1 Energy and intensity of unfiltered and filtered polychromatic radiation

From "Christensen's Physics in Diagnostic Radiology" T.S. Curry et al. 1990



ABSORBED DOSE MEASURED ALONG THE CENTRAL BEAM IN A WATER PHANTOM, FIELD SIZE 30×40 cm² AT THE BOTTOM

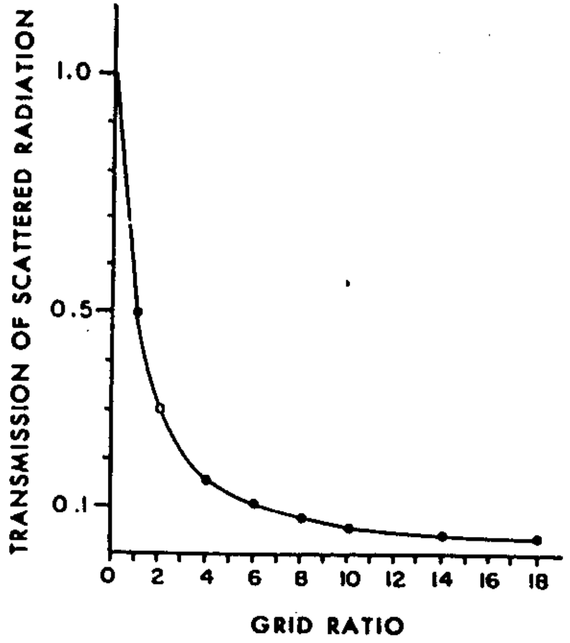


Figure 8–20 Fractional transmission of scatter radiation through grids (Courtesy of Sven Ledin and the Elema Shoenander Company)

Table 8–4. Loss of Primary Radiation from Lateral Decentering for Grids Focused at 40 Inches

GRID RATIO	LOSS OF PRIMARY RADIATION (%) LATERAL DECENTERING (in.) 1	2	3	4	5	6
5:1	13	25	38	50	63	75
6:1	15	30	45	60	75	90
8:1	20	40	60	80	100	
10:1	25	50	75	100		
12:1	30	60	90	100		
16:1	40	80	100			

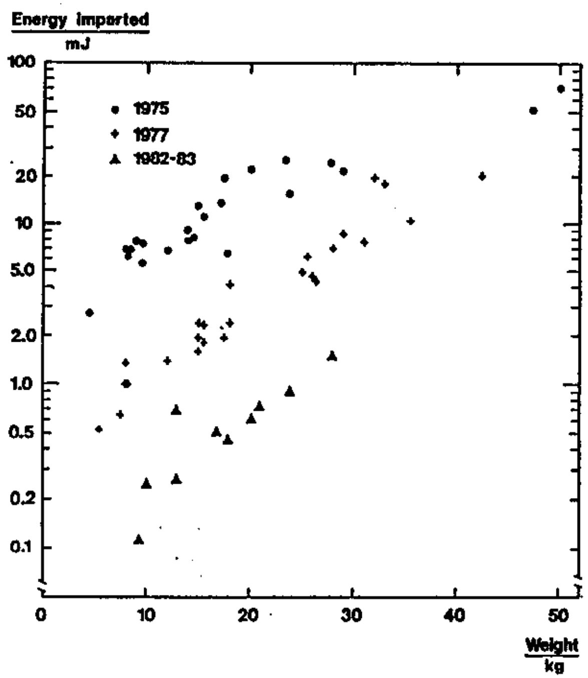
From "Christensen's Physics in Diagnostic Radiology"
T.S. Curry et al. 1990

Table 7. Resolution and speed of x-ray intensifying screens

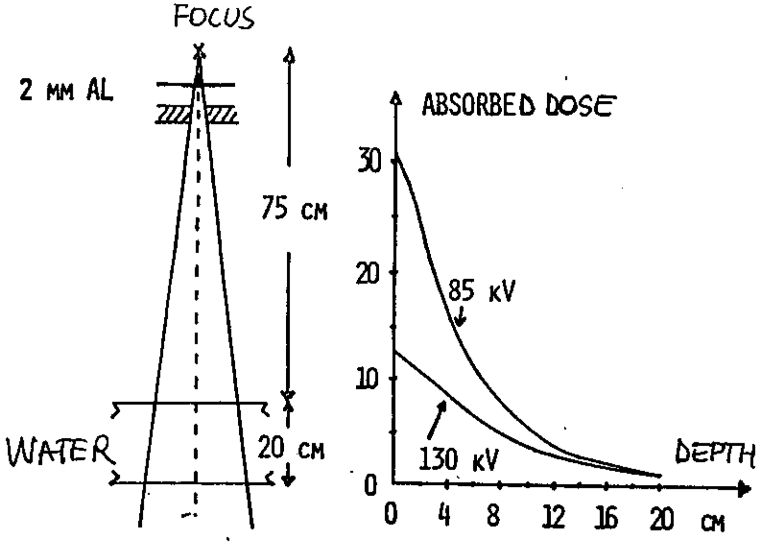
Type of screen	Approximate relative speed (at density of 1)*	Resolution line pair/mm
Radiographic (L2):		
Slow— calcium tungstate	1	18
Medium—calcium tungstate	4	8
Fast— calcium tungstate	12	5
Fine— rare earth	16	15
Regular— rare earth	32	5–8
Mammography— rare earth	—	15

* Relative speed is defined as the reciprocal of the exposure (such as mAs) required to produce a specified density on a film used to record the exposure (C1).

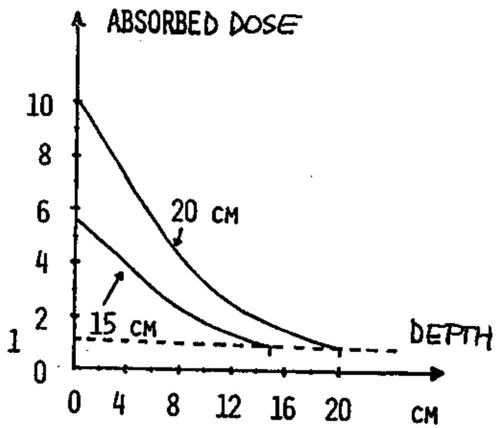
FROM: ICRP Publication 34



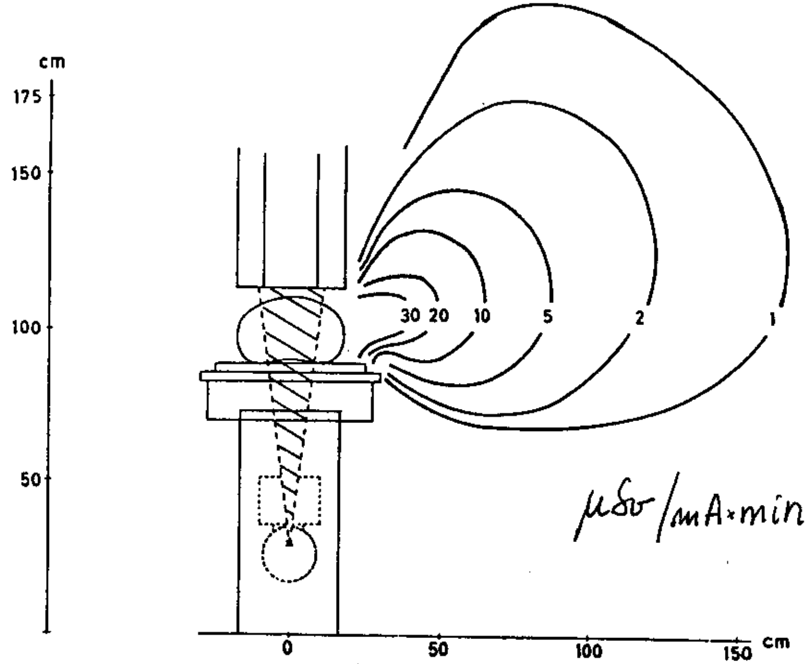
Energy imparted related to patient weight at voiding cystourethrography. 1975 (•) $CaWO_4$-screens, 1977 (+) LaOBr: Tm-screens, 1982-83 (▲) 105 mm film.



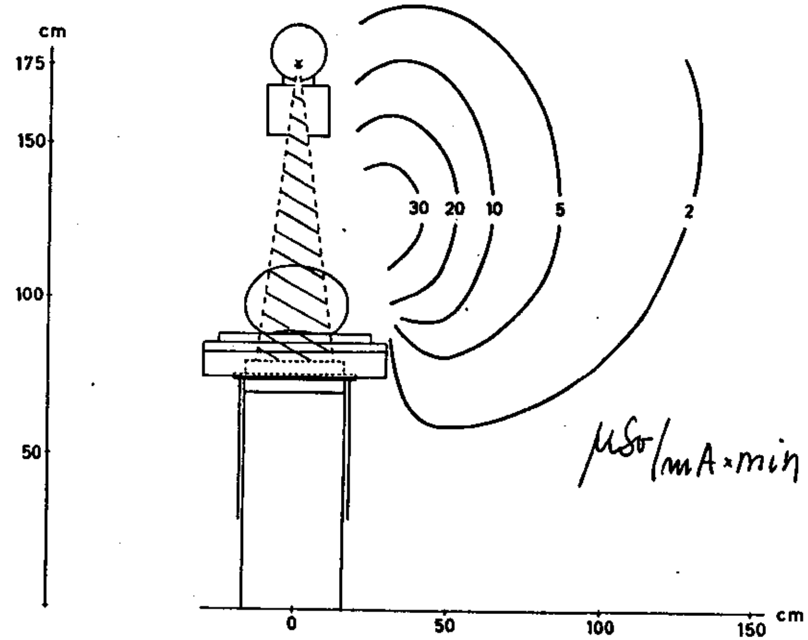
ABSORBED DOSE MEASURED ALONG THE CENTRAL BEAM
FIELD SIZE AT BOTTOM OF THE WATER PHANTOM 30×40 cm^2



ABSORBED DOSE MEASURED ALONG THE CENTRAL BEAM
IN A WATER PHANTOM. 130 kV, 3mm Al EXTRA FILTER
FIELD SIZE AT BOTTOM OF THE PHANTOM 30×40 cm^2

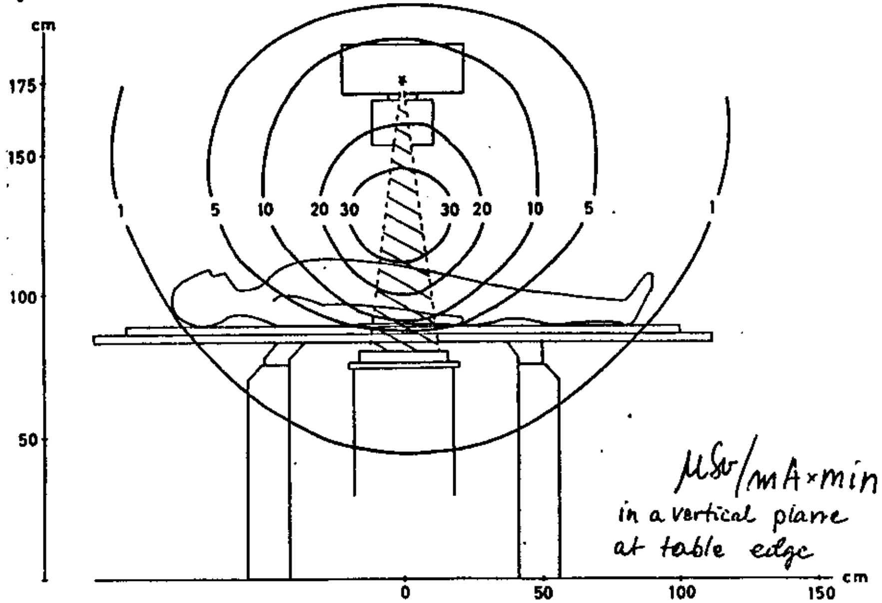


80 kV, HVL = 3 mm Al, 15.5×15.5 cm^2 at FSD = 59 cm

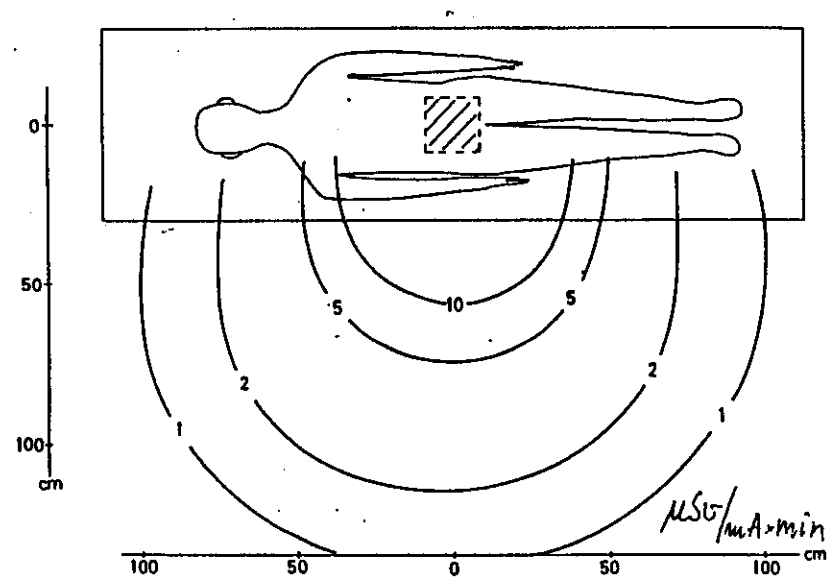


79 kV, HVL = 3 mm Al, 17.5×17.5 cm^2 at FSD = 65 cm

From "Strålefysikk, -terapi, -hygiene, -biologi" Oslo 197



79 kV, HVL=3mm Al, 17.5×17.5 cm² at FSD=65 cm



79 kV, HVL=3mm, 17.5×17.5 cm² at FSD=65 cm

From "Strålefysikk, -terapi, -hygiene, -biologi" Oslo 1975 In Norwegian

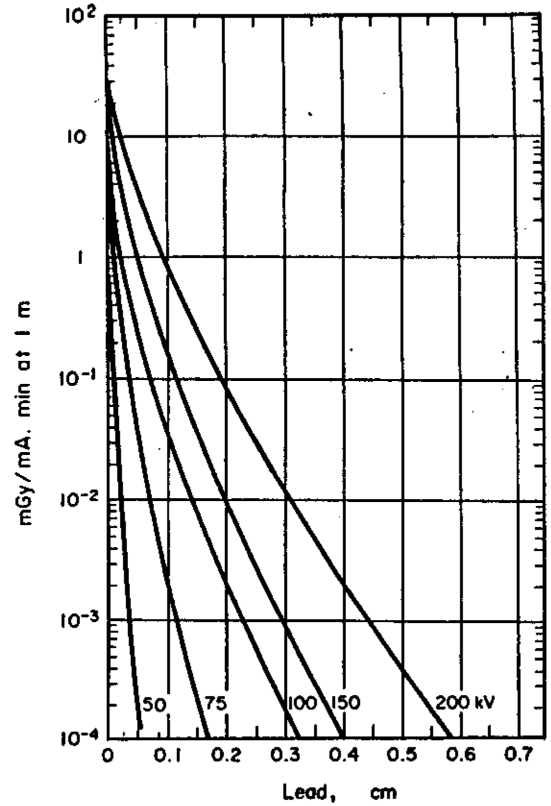


Fig. 7. Broad-beam transmission of x rays through lead, density 11 350 kg m^{-3}. Constant potential generator; tungsten reflection target; 2 mm aluminium total beam filtration. Ordinate intercepts are 28.7 at 200 kV, 18.3 at 150, 9.6 at 100, 6.1 at 75, 2.6 at 50.

Table 5. Lead equivalence of various materials for low energy x rays[a]

Material	Material density (kg m^{-3})	Material thickness (cm)	cm lead equivalent at applied kilovoltages of							
			50	75	100	150	200	250	300	400
Clay brick[b]	1 600	10	0.06	0.08	0.09	0.08	0.08	0.10	0.11	0.13
		20	0.14	0.17	0.19	0.17	0.17	0.23	0.30	0.45
		30	0.22	0.27	0.31	0.26	0.26	0.40	0.55	0.85
		40	—	0.38	0.45	0.37	0.37	0.60	0.83	1.27
		50	—	—	—	0.48	0.48	0.81	1.13	1.71
Barytes plaster or concrete[b]	3 200	1.0	0.09	0.15	0.18	0.09	0.07	0.06	0.06	0.08
		2.0	0.18	0.27	0.33	0.18	0.14	0.13	0.14	0.16
		2.5	0.23	0.33	0.40	0.22	0.17	0.17	0.18	0.20
		5.0	—	—	—	0.43	0.34	0.36	0.39	0.43
		7.5	—	—	—	0.59	0.50	0.56	0.61	0.68
		10.0	—	—	—	—	0.68	0.77	0.84	0.95
		12.5	—	—	—	—	—	—	1.08	1.21
Steel[c,d]	7 800	0.1	—	0.01	0.02	0.01	0.01	—	—	—
		0.2	—	0.03	0.03	0.02	0.02	—	—	—
		0.3	—	0.05	0.05	0.03	0.03	—	—	—
		0.4	—	0.07	0.07	0.04	0.04	—	—	—
		0.5	—	0.09	0.09	0.05	0.04	0.03	0.03	0.04
		1.0	—	—	—	0.09	0.08	0.08	0.08	0.09
		2.0	—	—	—	0.17	0.16	0.17	0.19	0.24
		3.0	—	—	—	0.25	0.23	0.28	0.33	0.43
		4.0	—	—	—	0.33	0.30	0.38	0.47	0.65
		5.0	—	—	—	0.40	0.37	0.49	0.63	0.88

[a] See text regarding geometry.
[b] Binks (1955).
[c] Kaye et al. (1938).
[d] Trout and Gager (1950).

From ICRP Publication 33