

FLUKE®

Biomedical

Nuclear Associates 07-706

Patient Phantom/Penetrometer System

Users Manual

**Fluke Biomedical
Radiation Management Services**

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Section 1

Introduction

1.1 Introduction

The U.S. Department of Health, Education and Welfare have published standards of performance for diagnostic x-ray systems, and most state and local agencies will probably follow the same guidelines. The Code of Federal Regulations, Title 21, Subchapter J*, Part 1020, includes the following sections:

Entrance Exposure Rate Limits

1020.32 (d-1) Equipment with Automatic Exposure Rate Control

Fluoroscopic equipment, which is provided with automatic exposure rate control, shall not be operable at any combination of tube potential and current which will result in an exposure rate in excess of 10 R/min at the point where the center of the useful beam enters the patient.

1020.32 (d-2) Equipment without Automatic Exposure Rate Control

Fluoroscopic equipment, which is not provided with automatic exposure rate control, shall not be operable at any combination of tube potential and current which will result in an exposure rate in excess of 5 R/min at the point where the center of the useful beam enters the patient.

1020.32 (d-3)

- (i) If the source is below the table, the exposure rate shall be measured 1 cm above the tabletop or cradle.
- (ii) If the source is above the table, the exposure rate shall be measured at 30 cm above the tabletop, with the end of the beam-limiting device or spacer positioned as close as possible to the point of measurement.
- (iii) In a C-arm type of fluoroscope, the exposure rate shall be measured 30 cm from the input surface of the fluoroscopic imaging assembly.

NOTE

*Copies of the regulations are available from:
Bureau of Radiological Health, Food and Drug
Administration, 12720 Twinbrook Parkway,
Rockville, MD 20852.

Use of the Patient Phantom/Penetrator in a
basic QA program is described in the AAPM Report
No. 4, "Basic Quality Assurance in Diagnostic
Radiology," which is available from the American
Association of Physicists in Medicine, 111 East
Wacker Drive, Chicago, IL 60601.

Measuring the Patient Entrance Exposure Rate in Image-Intensified Fluoroscopic Equipment

Equipment

07-706 Patient Phantom/Penetrometer

06-526 "Rad-Check Plus" X-Ray Exposure Meter

07-707 Stop Watch (or equivalent)

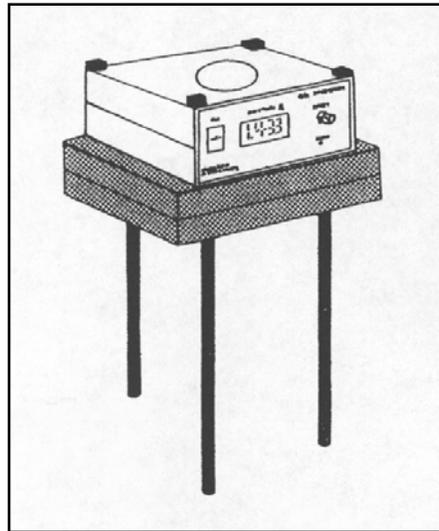


Figure 1-1

Procedure for Maximum Exposure Rate

A. Source Under Table

1. Position the "Rad-Check Plus" (detector side down) on the x-ray table so its sensitive volume is in the center of the x-ray field. This is best done by viewing the fluoroscopic image of the "Rad-Check Plus" and moving it or the x-ray tube as necessary. The detector presents a circular shape in the fluoroscopic image. When properly centered, lock the tube carriage and mark the position of the "Rad-Check Plus" on the table.
2. Place the Patient Phantom/Penetrometer (2 blue blocks plus lead block) on the "Rad-Check Plus" (see Figure 1-2). Collimate the beam so it does not extend beyond the edges of the phantom. Lower the image tube intensifier to its lowest height (but not less than 30 cm from the tabletop).

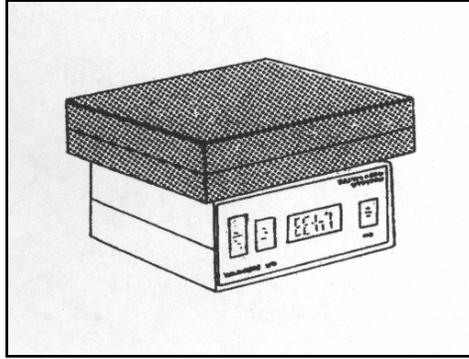


Figure 1-2

3. Turn on the “Rad-Check Plus” and press the “Reset” button. Set the fluoroscopic controls to maximum, with the automatic brightness control on. Activate the controls for 10 seconds, and multiply the “Rad-Check Plus” reading by 6 to obtain the tabletop exposure in R/min. Use a stopwatch since the clock supplied with most fluoroscopes is usually not accurate for less than one minute. The resulting exposure rate represents the maximum tabletop output for equipment operating in the automatic brightness mode.
4. To determine the patient exposure rate for an adult abdomen, use the two aluminum blocks only. For a child (about 13 cm tissue thickness) or an adult chest, repeat steps 1 to 3 with the top blue block removed.
5. By repeating this procedure for various voltage brightness settings and the cine controls (frames/sec), one can determine the patient exposure rate for a variety of operating conditions. To find the maximum recommended exposure rate, see Table 2 (taken from National Council on Radiation Protection Report No. 33). *

NOTE

*The National Council on Radiation Protection and Measurements consists of recognized authorities acting in the public interest. In liaison with other national and international organizations, the N.C.R.P. collects, analyzes, develops and disseminates information and recommendations on the many facets of radiation protection. Available from N.C.R.P. Publications, P.O. Box 4867, Washington, DC 20008.

B. Source Over the Table

1. To obtain the entrance exposure for fluoroscopes that use overhead x-ray tubes, raise the phantom 30 cm above the tabletop, using the long legs (Figure 1-1). Place the "Rad-Check Plus" on the phantom to obtain the exposure rate at the position where the beam enters the patient.
2. Follow the same procedure as in steps 3, 4, and 5 of Section A.

Consists of 4 metal plates.

- (a) Two 7" x 7" x 3/4" blocks of high-purity aluminum, which represent the equivalent absorption of 26 cms of water and simulate a thick or heavy-set patient at 90 kVp. A single block is the equivalent of a child or adult chest. Aluminum simulates the scatter characteristics of the human body.
- (b) One 7" x 7" x 1/8" lead beam-stop plate. When placed in the beam, this plate allows automatic brightness-control machines to deliver maximum output.

A 7" x 7" x 1/32" thick aluminum penetrometer plate with 1/4", 0.176", 1/8", 0.088" and 1/16" holes are provided. The area of each hole is twice the area of the next smaller one. Place this plate between the two aluminum blocks to ascertain the contrast gradient of the penetrometer on the image-amplified systems.

Size 7" x 7" x 1 7/8" high (17.8 cm x 4.7 cm)

Net 9 1/2 lbs (4.3 kg)

Table 2 *Effect of Tube Potential, Distance and Filtration on Air Exposure Rate at Panel of Fluoroscopes**

Potential kVp	Source to Panel Distance		Equivalent Total Aluminum Filtration				
			1 mm	2 mm	2.5 mm	3 mm	4 mm
	cm	inches	Roentgens per Milliampere Minute				
70	30	12	5.3	2.7	2.2*	1.8	1.3
	38	15	3.5	1.7	1.4 [†]	1.2	0.8
	46	18	2.4	1.2	1.0	0.8	0.6
80	30	12	7.0	3.9	3.2*	2.6	2.0
	38	15	4.6	2.5	2.1 [†]	1.7	1.3
	46	18	3.2	1.8	1.4	1.2	0.9
90	30	12	9.0	5.2	4.3*	3.6	2.8
	38	15	5.8	3.3	2.8 [†]	2.3	1.8
	46	18	4.0	2.3	1.9	1.6	1.2
100	30	12	11.0	6.6	5.5*	4.7	3.7
	38	15	7.0	4.2	3.5 [†]	3.0	2.3
	46	18	4.9	2.9	2.5	2.1	1.6
110	30	12	13.1	8.0	6.8*	5.9	4.6
	38	15	8.4	5.1	4.4 [†]	3.8	3.0
	46	18	5.8	3.5	3.0	2.6	2.0
120	30	12	14.7	9.3	8.0*	7.0	5.5
	38	15	9.5	6.0	5.1 [†]	4.5	3.6
	46	18	6.5	4.1	3.6	3.1	2.5
130	38	15	--	6.8	5.9 [†]	5.2	4.2
	46	18	--	4.7	4.1	3.6	2.9
140	38	15	--	7.6	6.6 [†]	5.9	4.8
	46	18	--	5.3	4.6	4.1	3.3
150	38	15	--	8.5	7.5 [†]	6.7	5.4
	46	18	--	5.8	5.2	4.6	3.7

* Typical exposure rates produced by equipment with medium length cables, derived from references (8) and (14) by interpolation and extrapolation. Filtration includes that of the tabletop and the x-ray tube with its inherent and added filter. As used above, panel means either panel or tabletop.

Section 3.1.2(a) When the fluoroscope is operated at 80 kVp, the exposure rate in air at the position where the beam enters the patient shall not exceed 3.2 R/mA-min at 30 cm and should not exceed 2.1 R/mA-min at 38 cm. For other tube potentials, the exposure per unit charge shall not exceed the values marked with an asterisk (*) or a dagger (†).

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