FLUKE®
Biomedical

Nuclear Associates 07-645

Fluoro-Test™ Tool

Users Manual

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Table of Contents

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Section 1
Instructions

1.1 Description

The Fluoro-Test Tool™ is a fluoroscopic contrast resolution test tool that is based on the work of Wagner, Barnes and Wu [1]. The test tool consists of two 6" x 6", 6.1 mm (¼") thick aluminum plates with each plate containing an array of 1.1 cm targets of varying contrast. Also included in the Fluoro-Test kit are three 6" x 6", 1 mm thick copper sheets. The test tool is designed to be used with the copper attenuator sheets positioned close to the source (i.e., at table top) and the aluminum test plate located close to the image intensifier input as illustrated in Figure 1-1. With 2 mm of copper attenuator in the beam and a fluoroscopic x-ray tube potential of 80 kVp, the contrast of the targets in Plates A and B are given in Figure 1-2A and 1-2B, respectively. Each plate has three rows of three targets with a moderately large (≅3%) contrast increment between adjacent targets in the same row. The outer two rows have increasing target contrast increments while the middle row is offset and has decreasing increments. At 80 kVp with 2 mm of Cu attenuator the targets range in contrast from ≅1% to ≅9% in Plate A (integer phantom) and from ≅0.5% to ≅8.5% in Plate B (half-integer phantom).

1.2 Instructions for Use

1. For conventional geometry fluoroscopic units (under-table x-ray tube/over-table imaging chain) place two copper sheets (i.e., a total copper thickness of 2.0 mm) on the tabletop and aluminum Test Plate A directly beneath the image intensifier input phosphor or spot film device cover as shown in Figure 1-1. The spot film device/imaging chain should be positioned 12" to 16" above the tabletop. If the fluoroscopic unit has an over table x-ray tube/under table imaging chain, place the copper sheets directly beneath the collimator and Test Plate A on the table top or on the image intensifier. In either geometry the copper sheets and Test Plate should be centered in the fluoroscopic field-of-view (FOV).
2. If the image intensifier has different FOVs, select the 22 cm (9") FOV or the FOV that is closest to 22 cm.
3. Note the fluoroscopic kVp. Scan the image and note the number of targets that can be seen in each row.
4. Replace Test Plate A with Test Plate B and repeat step 3. In general the fluoroscopic kVp will remain the same.
5. The target contrast visibility threshold or low contrast resolution can be ascertained by determining the lowest contrast target that is seen in the two plates. The contrast of targets on Plate B are slightly less (≅0.5%) than the targets in Plate A and, if the same number of targets are seen on each plate, the contrast resolution is the lowest contrast target seen in the image of Plate B. If more targets are seen in the image of Plate A, the contrast resolution is the lowest contrast target seen in Plate A. The contrast of the targets for a beam hardened by 2.0 mm of copper are given in Table 1 as a function of fluoroscopic x-ray tube potential.

1.2.1 Example One

Image Readings

The copper sheets (a total of 2.0 mm of Cu) and Test Plate A are positioned as depicted in Figure 1-1. The fluoroscopic tube potential stabilizes at 80 kVp. In the fluoroscopic image of Test Plate A two targets are seen in Row 1, two targets are seen in Row 2 and three targets are seen in Row 3, Test Plate A is removed and replaced with Test Plate B. In the fluoroscopic image of Test Plate B two targets are seen in Row 1, two targets are seen in Row 2 and two targets are seen in Row 3.

Interpretation of Readings

If the fluoroscopic x-ray tube potential stabilizes at 80 kVp, the contrast of the targets are given by their target or hole number (see Figure 1-2 and Table 1-1). The lowest contrast target that is visualized is target 3 in Row 3 of Test Plate A and the low contrast resolution of the fluoroscopic unit is 3.0%.

1.2.2 Example Two

Image Readings

The copper sheets (a total of 2.0 mm of Cu) and Test Plate A are positioned as depicted in Figure 1-1. The fluoroscopic tube potential stabilizes at 90 kVp. In the fluoroscopic image of Test Plate A two targets are seen in Row 1, two targets are seen in Row 2 and two targets are seen in Row 3. Test Plate A is removed and replaced with Test Plate B. In the fluoroscopic image of Test Plate B two targets are seen in Row 1, two targets are seen in Row 2 and two targets are seen in Row 3.

Interpretation of Readings

When the number of targets seen on both plates are the same, the lowest contrast target seen is on Plate B. In this example it is Target 3.5 in Row 1. The contrast of Target 3.5 at 90 kVp and 2.0 mm of copper beam attenuator is given in Table 1 and is 3.2%.

1.2.3 Example Three

Image Readings

The copper sheets (a total of 2.0 mm of Cu) and Test Plate A are positioned as depicted in Figure 1-1. The fluoroscopic tube potential stabilizes at 65 kVp. In the fluoroscopic image of Test Plate A two targets are seen in Row 1, two targets are seen in Row 2 and three targets are seen in Row 3. Test Plate A is removed and replaced with Test Plate B. In the fluoroscopic image of Test Plate B two targets are seen in Row 1, two targets are seen in Row 2 and three targets are seen in Row 3.

Interpretation of Readings

The lowest contrast target seen is Target 2.5 in Row 3 of Plate B. The contrast of this target at 65 kVp can be determined by interpolating between the 60 and 70 kVp target contrast values in Table 1. The contrast of Target 2.5 at 60 kVp is 3.28%. At 70 kVp the target contrast is 2.79%. Interpolating between the two values one obtains a contrast resolution of 3.0%.

1.3 Discussion

The test object is compact and the dimensions of the target plates are consistent with the commonly used Center of Devices and Radiological Health test stand. The target arrangement is designed to reduce the ambiguity and difficulty associated with employing a sequential array of targets with small differences in contrast between adjacent targets. With the Fluoro-Test target plates the observer focuses on a subset of three targets at a given time. In each subset or row, large differences (≅3%) are present between adjacent targets and it is easy to decide if a target is visualized or not. As noted above the threshold contrast for a plate is the lowest of the values observed for the three rows of targets, and a threshold contrast resolution precision of 0.5% is obtained by the sequential use of the two plates. Of practical importance is that the effect of fluoroscopic tube potential can be taken into account employing Table 1 which lists the percent contrast for the Fluoro-Test targets with 2 mm of Cu attenuator as a function of tube potential from 50 to 130 kVp in 10 kV increments. If in the event that a 1 mm or 3 mm Cu attenuator is employed rather than a 2 mm attenuator, the percent contrast of the test plate targets for these thicknesses of Cu attenuators are listed in Tables 2 and 3. If one needs the contrast values of the targets for a 1.2 or 2.4 mm Cu attenuator, the two decimal place accuracy of the Tables 1-3 permit one to develop an interpolated table for the desired in-between copper thickness.

The Fluoro-Test is designed to yield a quantitative assessment of fluoroscopic threshold contrast resolution. This index along with limiting high contrast resolution and image intensifier input phosphor exposure rate should be measured during acceptance testing and routine quality control audits. High contrast spatial resolution and image intensifier input phosphor exposure rate should be measured for each image intensifier mode i.e., 9", 6" and 4.5". However, it is only necessary to determine threshold contrast resolution in the 9" image intensifier mode. If one has a 12", 9", and 6" image intensifier, threshold contrast should also be assessed in the 9" mode.

Factors that affect fluoroscopic contrast resolution are the quality of the imaging chain, the image intensifier input phosphor exposure rate and, on fluoroscopic units equipped with digital image processing and averaging, the degree of digital averaging. For a given image intensifier input phosphor exposure rate, the better the imaging chain, the lower the contrast resolution. If the input phosphor exposure rate is increased, the fluoroscopic image contrast resolution will decrease and therefore improve. Likewise, if digital averaging is activated, contrast resolution will decrease and therefore improve.

For a typical image intensifier input phosphor exposure rate (3.6 mR/min with the grid out and 2.0 mm of copper in the beam), the low contrast resolution of a reasonable imaging chain will range from 3 to 4%. A good imaging chain will achieve a low contrast resolution of less than 3.0% and the low contrast resolution of a poor imaging chain will be as high as 5 or 6%. Often on a poor imaging chain, the input phosphor exposure rate is increased to achieve acceptable low contrast resolution and image quality. For additional information and further discussion, the user is referred to the paper by Wagner, Barnes and Wu [1], It is anticipated that tracking the threshold contrast resolution of a fluoroscopic imaging chain following acceptance testing will allow one to quantify its performance over time and determine when adjustments and maintenance need to be performed or when imaging chain components need to be replaced.

1. *A.J. Wagner, G.T. Barnes and X. Wu, "Assessing fluoroscopic contrast resolution: A practical and quantitative test tool," Med. Phys. 18, 894-899 (1991).*

Table 1-1. Percent contrast for Fluoro-Test Threshold Contrast Resolution Plates with 2 mm Cu Attenuator

	kVp								
Hole Number	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**	**130**
0.5	0.84	0.66	0.56	0.50	0.46	0.43	0.41	0.39	0.38
1	1.67	1.31	1.11	1.00	0.92	0.87	0.82	0.79	0.76
1.5	2.51	1.97	1.67	1.50	1.39	1.30	1.24	1.18	1.14
2	3.34	2.62	2.23	2.00	1.85	1.74	1.65	1.58	1.52
2.5	4.18	3.28	2.79	2.50	2.31	2.17	2.06	1.97	1.90
3	5.01	3.94	3.34	3.00	2.77	2.60	2.47	2.37	2.28
3.5	5.85	4.59	3.90	3.50	3.23	3.04	2.88	2.76	2.66
4	6.68	5.25	4.46	4.00	3.70	3.47	3.30	3.16	3.03
4.5	7.52	5.90	5.01	4.50	4.16	3.91	3.71	3.55	3.41
5	8.35	6.56	5.57	5.00	4.62	4.34	4.12	3.95	3.79
5.5	9.19	7.22	6.13	5.50	5.08	4.77	4.53	4.34	4.17
6	10.02	7.87	6.69	6.00	5.54	5.21	4.94	4.74	4.55
6.5	10.86	8.53	7.24	6.50	6.01	5.64	5.36	5.13	4.93
7	11.69	9.18	7.80	7.00	6.47	6.08	5.77	5.53	5.31
7.5	12.53	9.84	8.36	7.50	6.93	6.51	6.18	5.92	5.69
8	13.36	10.50	8.92	8.00	7.39	6.94	6.59	6.31	6.07
8.5	14.20	11.15	9.47	8.50	7.86	7.38	7.01	6.71	6.45
9	15.04	11.81	10.03	9.00	8.32	7.81	7.42	7.10	6.83

Table 1-2. Percent Contrast for Fluoro-Test Threshold Contrast Resolution Plates with1 mm Cu Attenuator.

	kVp								
Hole Number	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**	**130**
0.5	0.91	0.72	0.61	0.55	0.50	0.47	0.46	0.44	0.43
1	1.83	1.44	1.22	1.09	1.01	0.95	0.93	0.89	0.86
1.5	2.74	2.16	1.84	1.64	1.51	1.43	1.39	1.33	1.28
2	3.65	2.88	2.45	2.19	2.02	1.90	1.85	1.78	1.71
2.5	4.57	3.61	3.06	2.73	2.52	2.38	2.32	2.22	2.14
3	5.48	4.33	3.67	3.28	3.03	2.85	2.78	2.67	2.57
3.5	6.39	5.05	4.29	3.83	3.54	3.33	3.25	3.11	3.00
4	7.31	5.77	4.90	4.38	4.04	3.80	3.71	3.56	3.43
4.5	8.22	6.49	5.51	4.92	4.55	4.28	4.17	4.00	3.86
5	9.13	7.21	6.12	5.47	5.05	4.75	4.64	4.45	4.28
5.5	10.05	7.94	6.74	6.02	5.56	5.23	5.10	4.90	4.71
6	10.96	8.66	7.35	6.57	6.06	5.70	5.57	5.34	5.14
6.5	11.88	9.38	7.96	7.11	6.57	6.18	6.03	5.79	5.57
7	12.79	10.10	8.58	7.66	7.07	6.66	6.50	6.23	6.00
7.5	13.71	10.82	9.19	8.21	7.58	7.13	6.96	6.68	6.43
8	14.62	11.55	9.80	8.76	8.09	7.61	7.42	7.12	6.86
8.5	15.54	12.27	10.42	9.30	8.59	8.08	7.89	7.57	7.29
9	16.45	12.99	11.03	9.85	9.10	8.56	8.35	8.02	7.72

Table 1-3 Percent Contrast for Fluoro-Test Threshold Contrast Resolution Plates with3 mm Cu Attenuator.

	kVp								
Hole Number	**50**	**60**	**70**	**80**	**90**	**100**	**110**	**120**	**130**
0.5	0.80	0.63	0.53	0.48	0.44	0.41	0.39	0.37	0.36
1	1.60	1.25	1.06	0.96	0.88	0.82	0.78	0.75	0.72
1.5	2.40	1.88	1.60	1.43	1.32	1.24	1.17	1.12	1.08
2	3.20	2.51	2.13	1.91	1.76	1.65	1.56	1.50	1.44
2.5	4.00	3.13	2.66	2.39	2.20	2.06	1.95	1.87	1.80
3	4.80	3.76	3.19	2.87	2.64	2.47	2.34	2.24	2.16
3.5	5.60	4.39	3.72	3.34	3.08	2.89	2.73	2.62	2.52
4	6.40	5.01	4.25	3.82	3.52	3.30	3.13	2.99	2.87
4.5	7.20	5.64	4.79	4.30	3.96	3.71	3.52	3.37	3.23
5	8.00	6.27	5.32	4.77	4.40	4.12	3.91	3.74	3.59
5.5	8.80	6.89	5.85	5.25	4.84	4.53	4.30	4.11	3.95
6	9.60	7.52	6.38	5.73	5.28	4.95	4.69	4.49	4.31
6.5	10.40	8.14	6.91	6.21	5.72	5.36	5.08	4.86	4.67
7	11.20	8.77	7.44	6.68	6.16	5.77	5.47	5.23	5.03
7.5	12.00	9.40	7.98	7.16	6.60	6.18	5.86	5.61	5.39
8	12.80	10.02	8.51	7.64	7.04	6.60	6.25	5.98	5.75
8.5	13.60	10.65	9.04	8.12	7.48	7.01	6.64	6.36	6.11
9	14.40	11.28	9.57	8.59	7.92	7.42	7.03	6.73	6.47

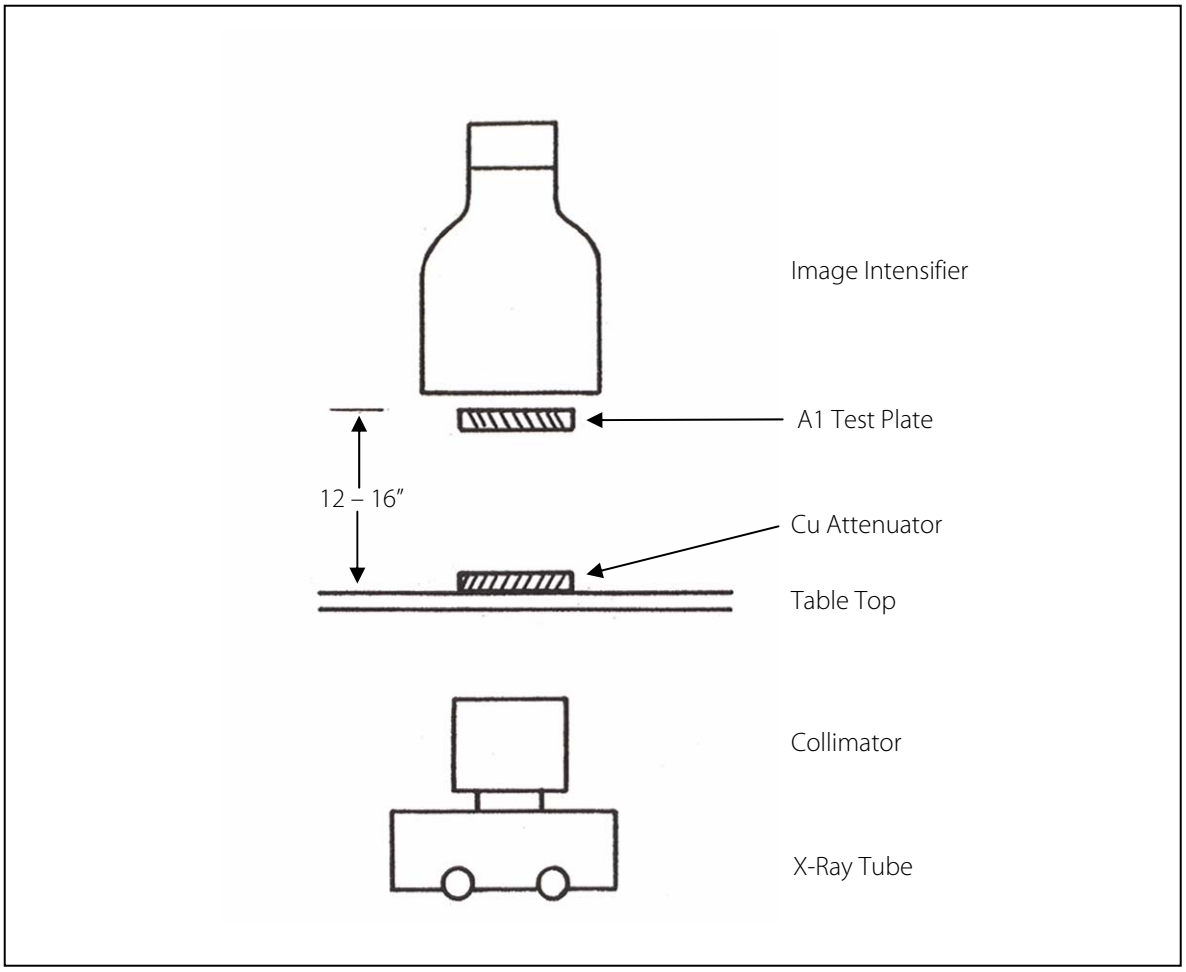

Figure 1- 1. Fluoro-Test Threshold Contrast Resolution Imaging Geometry.

a

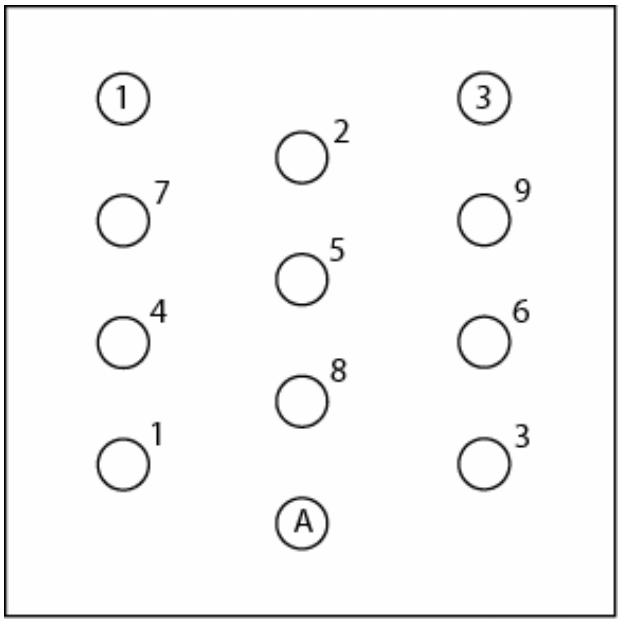

Figure 1- 2A. Test object numbered to indicate calibrated contrast at 80 kVp for the Integer Phantom.

1, 3 Lead Orientation Markers
A. Identification Marker.

b

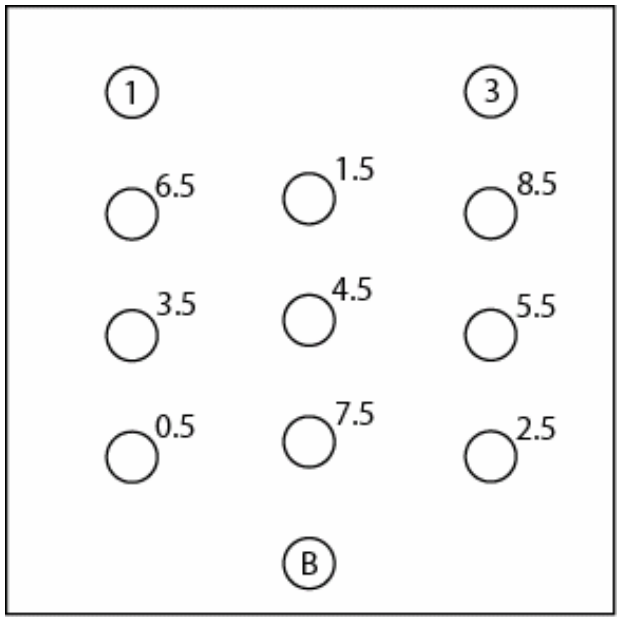

Figure 1-2B. Test object numbered to indicate calibrated contrast at 80 kVp for the Half-Integer Phantom.

1, 3 Lead Orientation Markers
B. Lead Identification Marker.

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