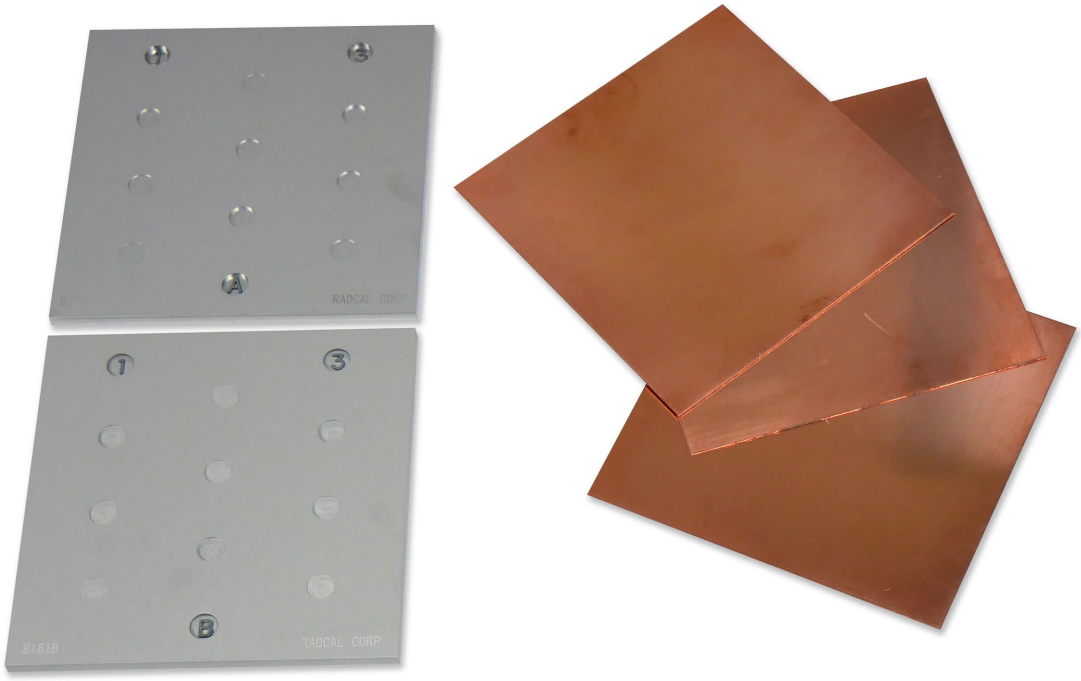
Model 8161AFFT
Fluoro Contrast
Test Tool

User Manual



1.1 Description

The Model 8161AFFT Fluoro 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 Tool 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 detector input as illustrated in Figure 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 2 and 3, respectively. Each plate has three columns of three targets with a moderately large (≅3%) contrast increment between adjacent targets in the same column. The outer two columns have increasing target contrast increments while the middle column 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. In general use, at the typical clinical SID (source-to-image distance) the copper sheets should be placed at the source and the aluminum Test Plates at and centered on the image detector, and the lowest level fluoroscopy noise reduction (recursive filtering) setting selected.

2. For conventional geometry fluoroscopic units (under patient x-ray tube/over patient 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 detector (or intensifier input phosphor) as shown in Figure 1. The image receptor should be positioned 12" to 16" above the tabletop.

3. If the fluoroscopic unit has an over head x-ray tube/under patient imaging chain, place the copper sheets directly beneath the collimator and Test Plate A on the table top or on the image receptor as shown in Figure 4.

4. A fluoroscopy unit typically has several field-of-view (FOV) selections. In acceptance testing a new installation it is often useful to obtain results for all FOVs for future checks if fluoroscopy image quality problems arise. For routine quality control audits, select the 22 cm (9") FOV or the FOV that is closest to 22 cm. For FOVs larger than 22 cm, the x-ray beam should be collimated to slightly larger than the Test Plate

5. Note the fluoroscopic kVp. Visually scan the image and note the number of targets that can be seen in each column.

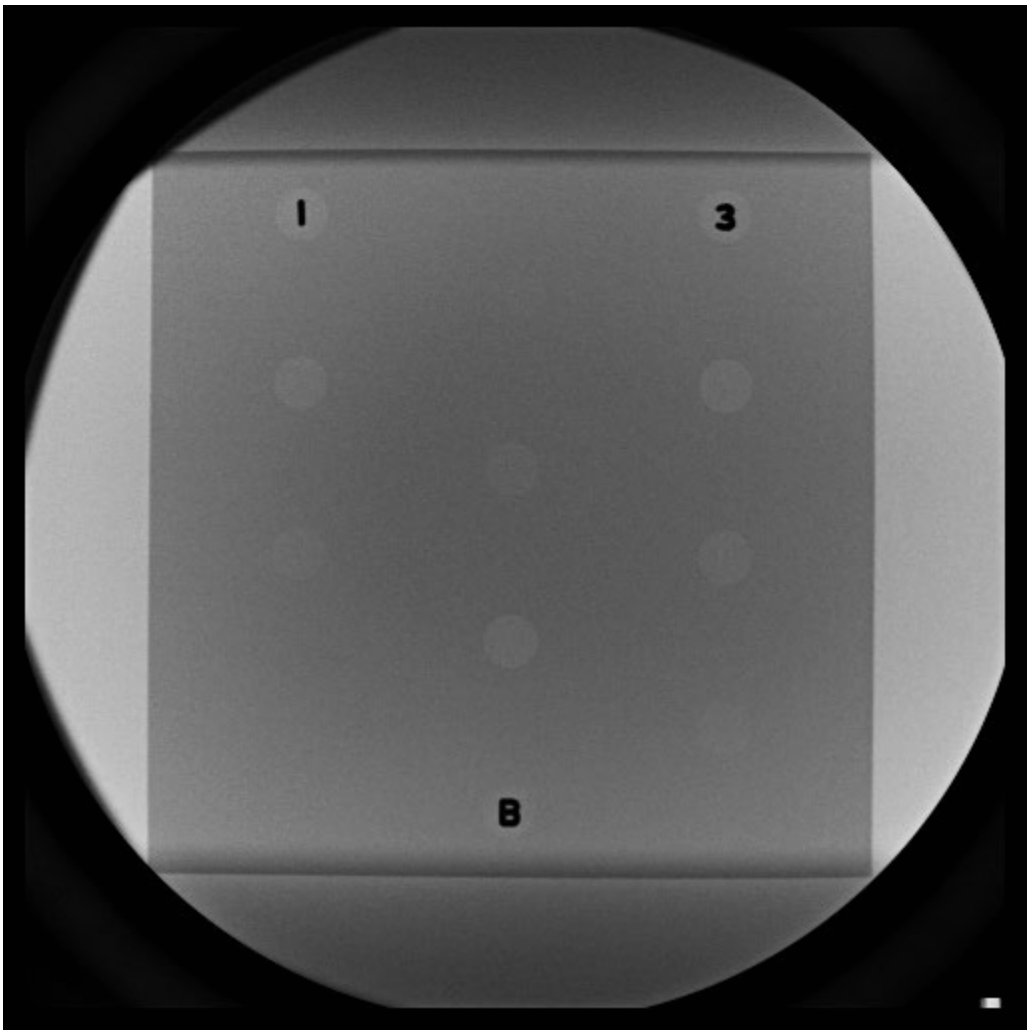
6. Replace Test Plate A with Test Plate B and repeat step 3. In general, the fluoroscopic kVp will remain the same.

7. 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 (typically 2.0 mm of Cu for a general fluoroscopy unit and 1.0 mm Cu for a mini C-arm unit) and Test Plate A are positioned as depicted in Figure 1 or Figure 4. The fluoroscopic tube potential stabilizes at 80 kVp. In the fluoroscopic image of Test Plate A two targets are seen in Column 1, two targets are seen in Column 2 and three targets are seen in Column 3, Test Plate A is removed and replaced with Test Plate B. In the fluoroscopic image of Test Plate B (see picture below) two targets are seen in Column 1, two targets are seen in Column 2 and three targets are seen in Column 3.



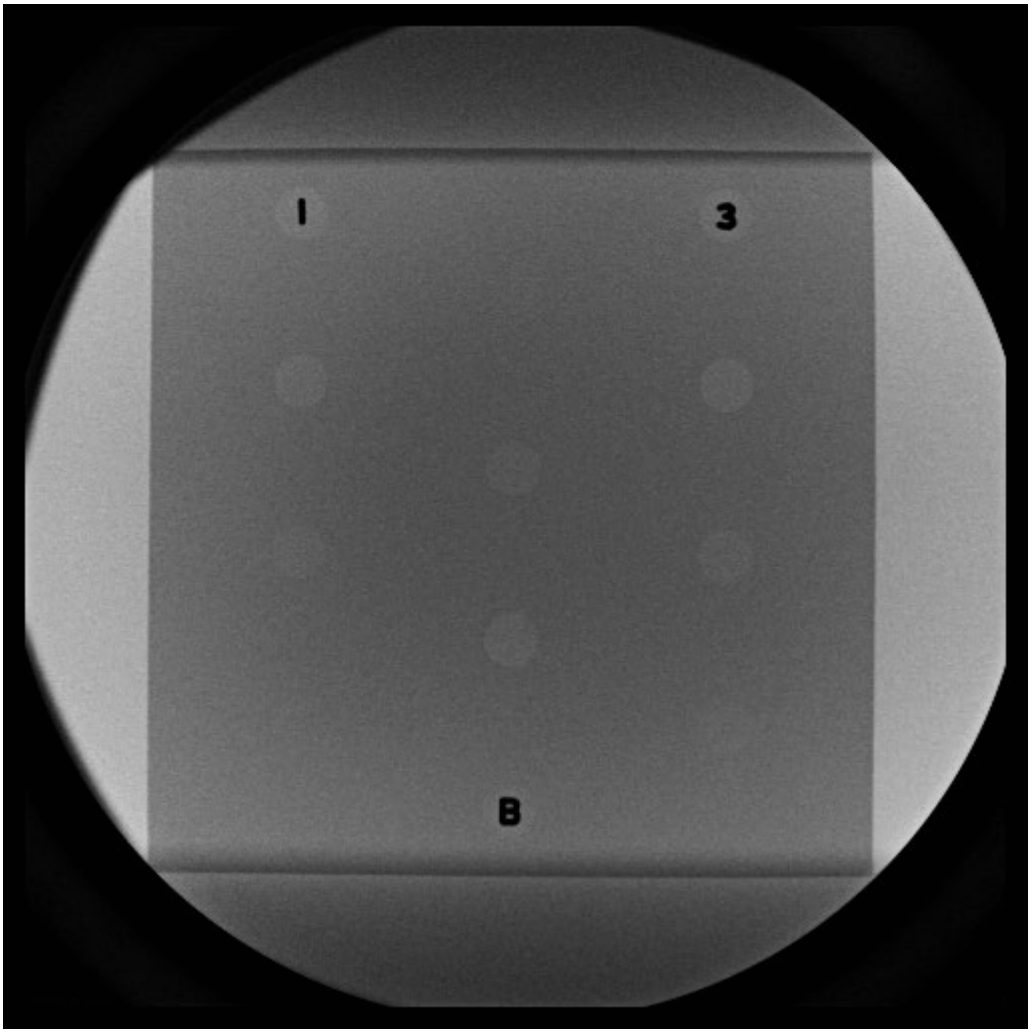
Interpretation of Readings

If the fluoroscopic x-ray tube potential stabilizes at 80 kVp with 2.0 mm Cu filtration, the contrast of the targets is given by their target or hole number (see Figure 1 and Table 1). The lowest contrast target that is visualized is target 3 in Column 3 of Test Plate B and the low contrast resolution of the fluoroscopic unit is 2.5%.

1.2.2 Example Two

Image Readings

The copper sheets (a total of 2.0 mm of Cu) and Test Plate A are positioned on general fluoroscopy unit as depicted in Figure 1. The fluoroscopic tube potential stabilizes at 90 kVp. In the fluoroscopic image of Test Plate A, two targets are seen in Column 1, two targets are seen in Column 2 and two targets are seen in Column 3. Test Plate A is removed and replaced with Test Plate B. In the fluoroscopic image of Test Plate B (See picture below) two targets are seen in Column 1, two targets are seen in Column 2 and two targets are seen in Column 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 Column 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 on a mobile C-arm fluoroscope. The fluoroscopic tube potential stabilizes at 64 kVp. In the fluoroscopic image of Test Plate A two targets are seen in Column 1, three targets are seen in Column 2 and three targets are seen in Column 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 Column 1, two targets are seen in Column 2 and three targets are seen in Column 3.

Interpretation of Readings

The lowest contrast target seen is Target 2.0 in Column 2 of Plate A. The contrast of this target at 64 kVp can be determined by interpolating between the 60 and 70 kVp target contrast values in Table 1. The contrast of Target 2.0 at 60 kVp is 2.62%. At 70 kVp the target contrast is 2.23%. Interpolating between the two values one obtains a contrast resolution of 2.5%.

1.2.4 Example Four

Image Readings

A copper sheet (a total of 1.0 mm of Cu) and Test Plate A are positioned on a Mini C-arm as depicted in Figure 4. The fluoroscopic tube potential stabilizes at 74 kVp. In the fluoroscopic image of Test Plate A two targets are seen in Column 1, three targets are seen in Column 2 and three targets are seen in Column 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 Column 1, two targets are seen in Column 2 and three targets are seen in Column 3.

Interpretation of Readings

The lowest contrast target seen is Target 2.0 in Column 2 of Plate A. The contrast of this target at 74 kVp can be determined by interpolating between the 70 and 80 kVp target contrast values in Table 2. The contrast of Target 2.0 at 70 kVp is 2.45%. At 80 kVp the target contrast is 2.19%. Interpolating between the two values one obtains a contrast resolution of 2.3%.

1.2.5 Example Five

Image Readings

A copper sheets (a total of 2.0 mm of Cu) and Test Plate A are positioned on a cardiac cath unit as depicted in Figure 1. The fluoroscopic tube potential stabilizes at 68 kVp with 0.2 mm pre-patient filtration added in the collimator filtration by the left coronary fluoroscopy protocol. In the image of Test Plate A, two targets are seen in Column 1, three targets are seen in Column 2 and three targets are seen in Column 3. Test Plate A is removed and replaced with Test Plate B. In the image of Test Plate B two targets are seen in Column 1, two targets are seen in Column 2 and three targets are seen in Column 3.

Interpretation of Readings

The lowest contrast target seen is Target 2.5 in Column 3 of Plate B. The contrast of this target at 68 kVp can be determined by interpolating between the 60 and 70 kVp target contrast values in Tables 1

and 3. The contrast of Target 2.5 at 60 kVp in Table 1 is 3.28%. At 70 kVp the target contrast is 2.79%. Interpolating between the two values one obtains a contrast resolution of 2.89% for 2.0 mm Cu. The contrast of Target 2.5 at 60 kVp in Table 3 is 3.13%. At 70 kVp the target contrast is 2.66%. Interpolating between the two values one obtains a contrast resolution of 2.75% for 3.0 mm Cu. Interpolating between the 2.0 mm and 3.0 mm Cu values one obtains a contrast resolution of 2.8% for 2.4 mm Cu and 68 kVp.

1.3 Discussion

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 column, 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 columns 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 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. In acceptance testing a new installation it is advantageous to measure this index for all FOVs as this provides a reference for future checks in case image quality problems arise. For routine quality control audits and confirming image quality consistency, it is only necessary to determine threshold contrast resolution for one FOV (i.e., ≈22 cm) that is commonly used.

Factors that affect fluoroscopic low contrast resolution are image detector DQE (detective quantum efficiency), detector input exposure rate and, fluoroscopy digital image processing and degree of digital image averaging or recursive filtering. For a given image detector input exposure rate, the better the detector DQE, the lower the contrast resolution. If the detector input exposure rate is increased, the fluoroscopic image contrast resolution will decrease and therefore improve. Likewise, if digital averaging is activated and the level increased, contrast resolution will decrease and therefore improve.

Often on a poor imaging chain, the detector input 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.

The rationale for placing the aluminum plates at the image receptor, and the Cu sheets at or close to the x-ray source is twofold: 1) the design of the Test Tool assumed minimal scatter, placing the Cu sheets close to the collimator results in the x-rays incident on the image receptor passing through the Cu and only a modest difference between the x-ray intensities at the image receptor behind and adjacent to the aluminum plate, and minimal effects of the scatter that occurs in the image receptor and image receptor cover degrading the threshold contrast visualized; and 2) placing the aluminum target plates close to image receptor results in minimum target magnification variations for different fluoroscopy geometries.

With different target plate magnifications, the size of the imaged contrast targets will vary as will the number of detected photons associated with the target area and associated with comparable adjacent areas for a given image receptor radiation level. With virtually the same target plate magnification and using the following tables, one can put a number on the threshold contrast visualized and compare the contrast resolution of different fluoroscopy systems.

As noted above the Test Tool is based on the work of Wagner, Barnes and Wu [1]. In 1990 when they did their design work, the old Bureau of Radiological Health (later Center of Devices and Radiological Health) Test Stand was in wide spread use and the dimensions of the target plates were consistent with the Test Stand. The Stand was 16" high and in assessing the contrast resolution of a classic under table x-ray tube fluoroscopy unit, one placed the Cu sheets on the tabletop and the target plate on top of the stand

and lowered the bottom of the imaging chain tower to ≈1/2" above the target plate. Since the old BRH-CDRH Test Stand is no longer available or in wide spread use, Radcal developed the Test Tool Holder. The Holder facilitates positioning of the target plates at the image detector for an over table or lateral image detector geometries, or copper sheets at x-ray source for an overhead source assembly geometry. Also noteworthy is that image receptor exposure rates in fluoroscopy (or exposures in radiography) are often measured with copper filtration positioned at the x-ray collimator. The Test Tool Holder and copper sheets can also be used for these measurements.

[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. 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 2. Percent Contrast for Fluoro-Test Threshold Contrast Resolution Plates with 1 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 3 Percent Contrast for Fluoro-Test Threshold Contrast Resolution Plates with 3 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

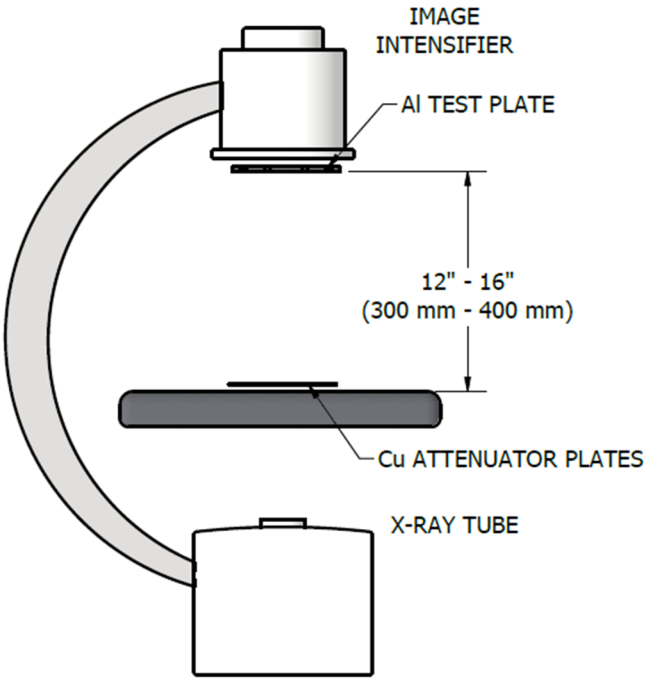


Figure 1 - Fluoro Test Tool imaging geometry shown with above patient image receptor

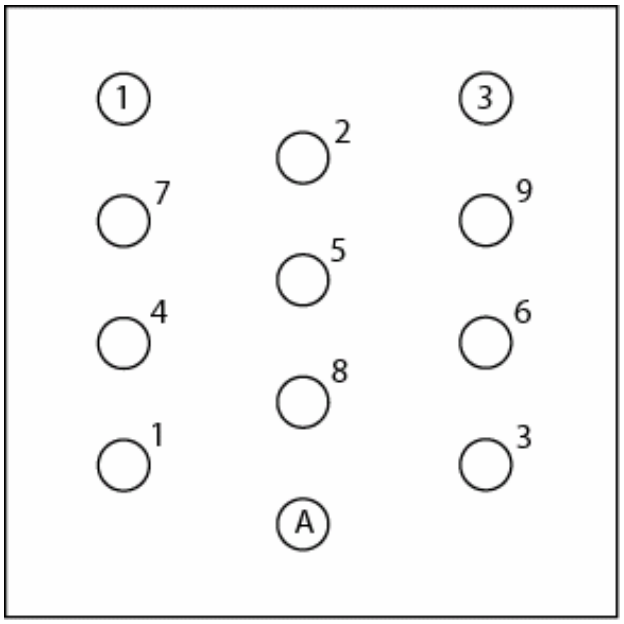


Figure 2 - Test objects numbered to indicate calibrated contrast at 80 kVp and 2.0 mm Cu for the Integer Test Plate

1, 3 Column lead identification markers
A. Test Plate lead identification marker

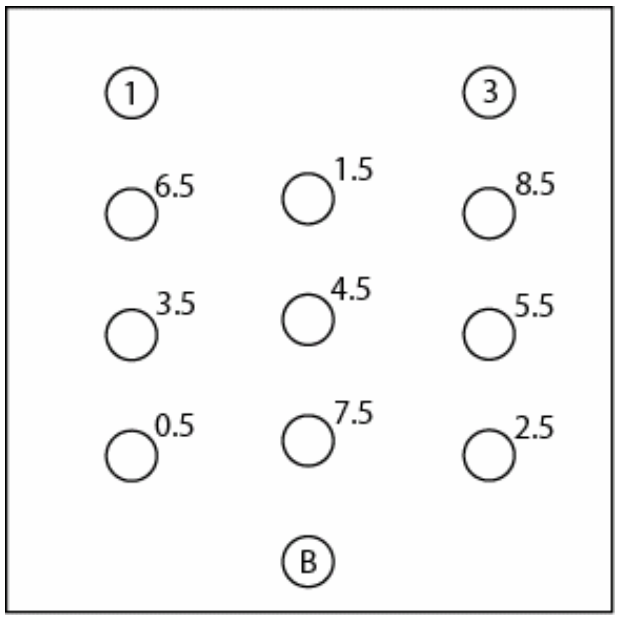
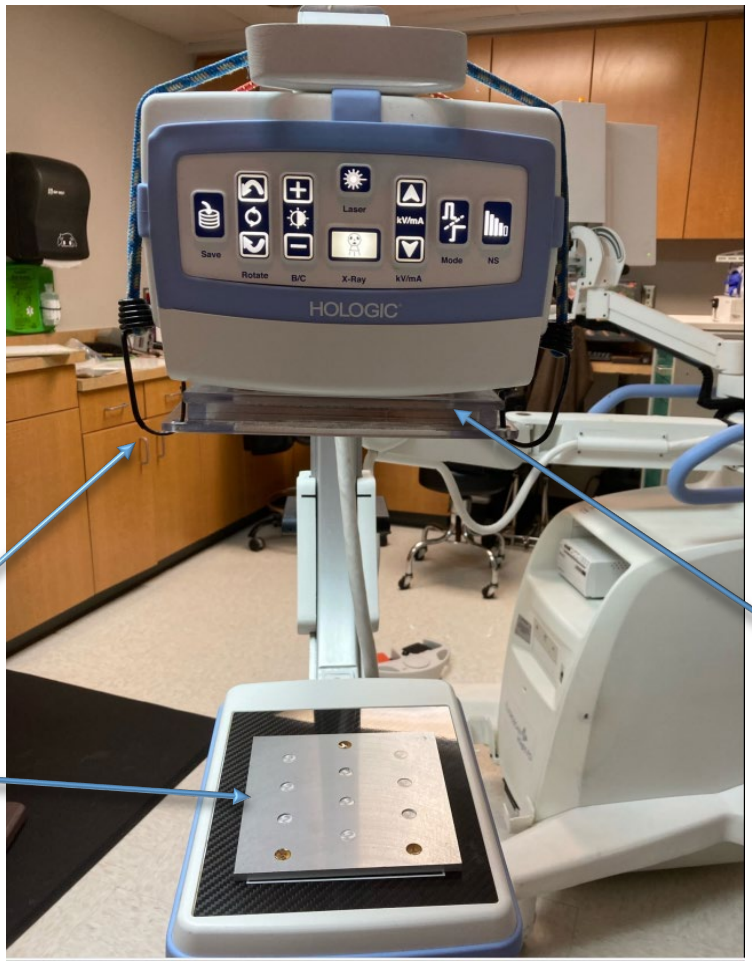


Figure 3 - Test objects numbered to indicate calibrated contrast at 80 kVp and 2.0 mm Cu for the Half Integer Test Plate

1, 3 Column lead identification markers
B. Test Plate lead identification marker

Attach the Attenuator Holder as shown using the bungee cords as appropriate

Place the Plate A or B on the imager



Use holder for Cu attenuator plates (shown) or Al Test Plate if above-table imager

Figure 4 - Holder with 1.0 mm Cu sheet positioned below collimator and Test Plate on image receptor

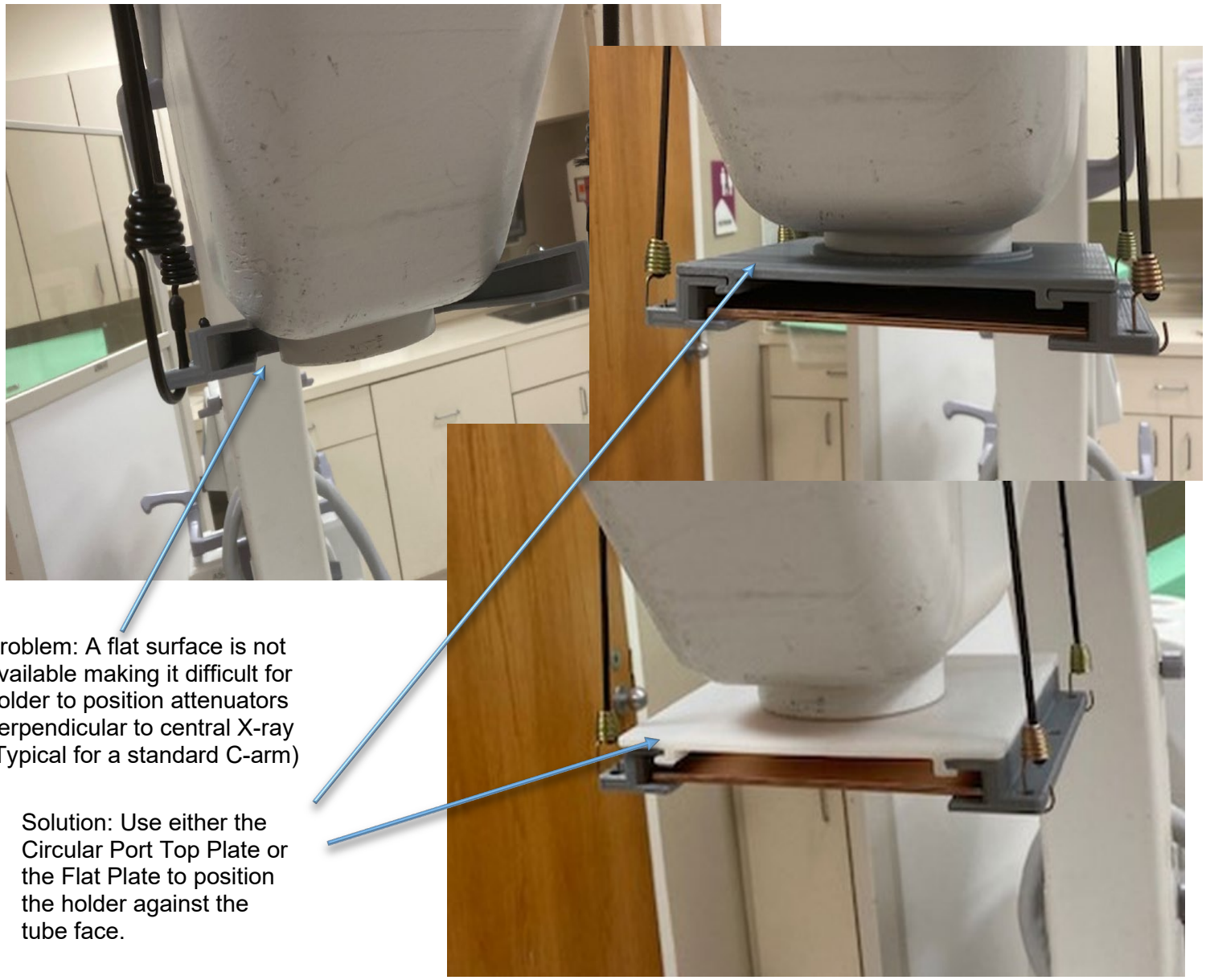
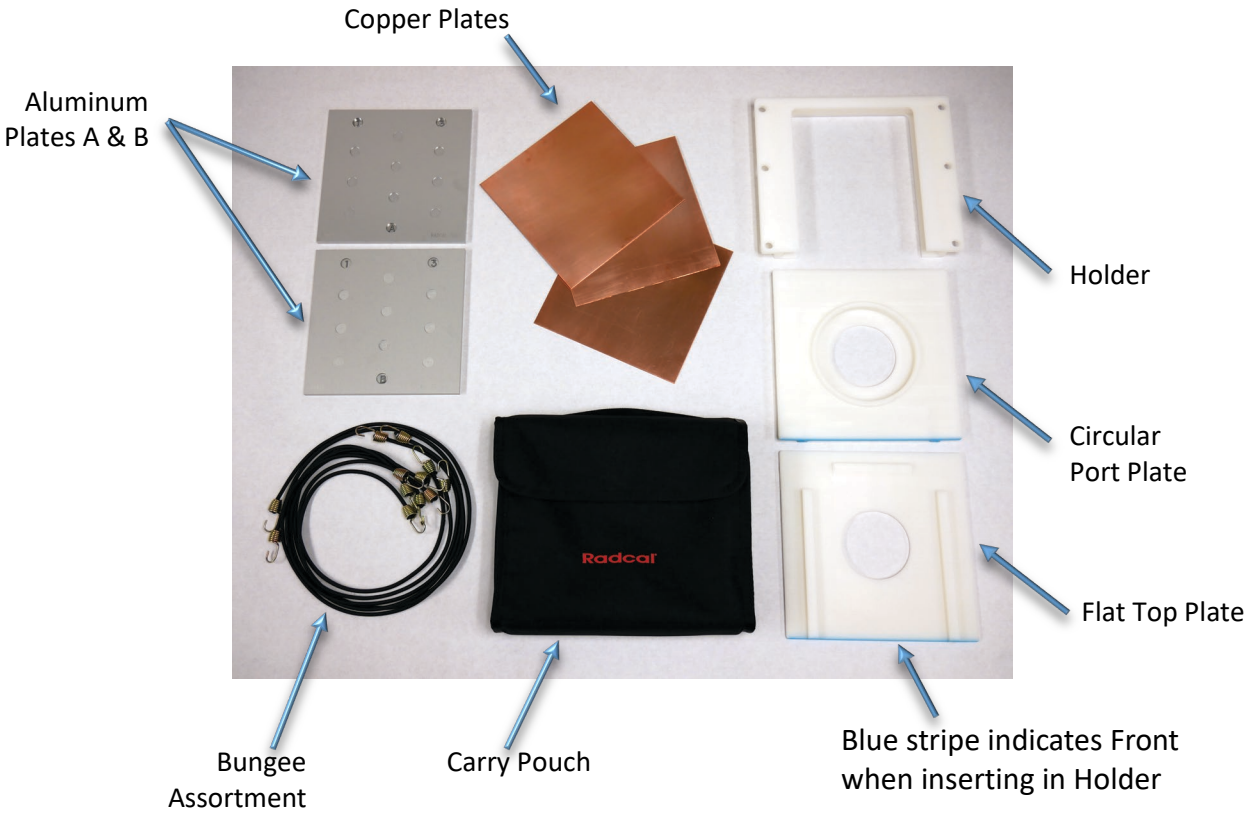


Figure 5 - In testing mobile C-arm fluoroscopes and measuring radiation output one typically rotates the C-arm 180° and positions the source assembly over head. Shown with this geometry are two different Cu attenuator holder configurations.

Model 8161AFFT Kit



Basic Kit
1 each Aluminum Plates, A and B
(3) 1.0 mm Cu plates 6” x 6” (150 mm x 150 mm)

Accessories
Carry pouch
Holder
Circular Port Top Plate
Flat Top Plate
(2) 18” (0.46 m) bungees
(2) 24” (0.61 m) bungees
(2) 30” (0.76 m) bungees

Storing Parts in the Pouch

Radcal Corporation
426 West Duarte Road
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