

## Establishing daily quality control (QC) in screen-film mammography using leeds tor (max) phantom at the breast imaging unit of USTH-Benavides Cancer Institute

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**Abstract.** Daily QC tests performed on screen film mammography (SFM) equipment are essential to ensure that both SFM unit and film processor are working in a consistent manner. The Breast Imaging Unit of USTH-Benavides Cancer Institute has been conducting QC following the test protocols in the IAEA Human Health Series No.2 manual. However, the availability of Leeds breast phantom (CRP E13039) in the facility made the task easier. Instead of carrying out separate tests on AEC constancy and light sensitometry, only one exposure of the phantom is done to accomplish the two tests. It was observed that measurements made on mAs output and optical densities (ODs) using the Leeds TOR (MAX) phantom are comparable with that obtained from the usual conduct of tests, taking into account the attenuation characteristic of the phantom. Image quality parameters such as low contrast and high contrast details were also evaluated from the phantom image. The authors recognize the usefulness of the phantom in determining technical factors that will help improve detection of smallest pathological details on breast images. The phantom is also convenient for daily QC monitoring and economical since less number of films is expended.

### 1. Introduction

The Breast Imaging Unit of USTH- Benavides Cancer Institute has been conducting QC program to constantly evaluate the mammography system performance with the goal of improving the detection of punctate calcifications, tumour masses, fibrous extensions and other pathological details to even smaller dimensions.

Daily QC on the SFM equipment in the facility is performed by the assigned QC radiologic technologist following the test protocols in the IAEA Human Health Series No.2 manual. Two films, at least, are used for light sensitometry and for AEC constancy. Though presently, the facility has acquired the Leeds TOR (MAX) breast phantom through the IAEA Coordinated Research Project (CRP) E13039. Only one exposure of the phantom is done to accomplish the two tests, hence, the economy of films used.

The objective of this paper is to verify that measurements made using Leeds phantom are comparable with that obtained from the usual conduct of tests and can be assessed with the



performance criteria specified in the IAEA manual. Also, other quantifiable details in the phantom are separately evaluated against the limiting criteria provided in the user manual.

## 2. Methodology

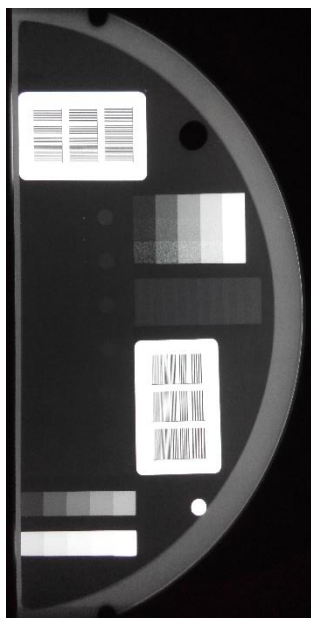
Daily tests were performed on the same time every morning before any patient films were processed. The films used for the AEC constancy and light sensitometry tests were processed first. The film for the Leeds phantom image is followed. These films were processed at  $31 \pm 1^\circ\text{C}$  developer temperature. All films used were taken from the same box and were exposed using the same cassette ID.

Film exposures were carried out with Mo/Mo target/filter combination at 28 kVp, “0” density control setting, and with AEC chamber at chest wall position. The attenuator stacks used in the AEC constancy test and Leeds breast phantom exposure are the semi-circular acrylic plates of 22 cm in diameter. In AEC constancy test, 45 mm- thick plates (four pieces 10 mm plus 5 mm) are mounted on the breast support and sufficient amount of compression is applied. The same compression force is applied to the 10 mm- thick Leeds test plate on top the stack of 35 mm- thick acrylic plates. The first 10 mm- thick of acrylic plate placed at the bottom of the stack has a lead disc for measurement of the true base + fog level of the film and a 1 cm- hole to serve as high density test point.

The leeds phantom set up simulates the “standard breast” recommended by the British Institute of Physical Sciences in Medicine (IPSM). It simulates the average breast of 45 mm thickness with 50% glandular tissue and 50% adipose tissue-composition under compression [1].

The displayed mAs on the console were recorded and the film densities were measured with a densitometer. The mean background optical density (OD) on the film image was consistently measured at a point 40 mm from the chest wall margin and laterally centered. Test forms available in the IAEA manual and in the Leeds user manual were utilized for data recording. The baseline values were determined over a six-day period. Data gathered in the months of June and July 2015 (a total of 40 days) were used in the assessment.

## 3. Results



**Figure 1.** This is a sample image of the Leeds TOR (MAX) breast phantom. The phantom image is drawn from this study. Several test objects are embedded on the Leeds test plate to produce this image. It has two sets of resolution gratings (each with 1 to 20 lp/mm), low-contrast bar patterns (1.8 to 5 lp/mm), micro-particle stepwedge in 3 grades, 10-point greyscale stepwedge, base + fog test point, 1 cm- hole for the high density test point, twelve circular details of 5.6 mm- diameter in diminishing contrasts, two groups of eleven 0.5 mm and 0.25 mm- sized details in diminishing contrasts. The high contrast details (0.5 mm and 0.25 mm sizes) are too small to be seen in this image. But in actual layout, they are lined up in series, between rows of low-contrast circular details.

A 9x magnifying lens available with the phantom set is used in aid of the visualization of these test details.

Tables 1 and 2 show the results of the mAs output, the film density measurements and the evaluation of film images over a six-day period for baseline values.

**Table 1.** Baseline values for the mAs output, mean background OD and essential film ODs in sensitometry.

Tests	mAs output	Density Measurement			
		Mean background OD	B+F	Speed index	Contrast index
AEC constancy & light sensitometry	66.9	1.91	0.24	1.40	0.87
leeds phantom image assessment	54.3	1.88	0.24	1.42	2.12

**Table 2.** Baseline scores for other quantifiable details from the Leeds phantom image.

Density measurement (OD)			Visual contrast [1- (speed index/mean bkgd. OD)]	Unsharpness measurement (lp/mm)			Low-con sensitivity	Small detail visibility		Micro-particles
B+F test pt.	HD test pt.	Scatter		// Rhs Grating	⊥ Rhs Grating	Low-conbars		5.6 mm diam.	0.50 mm	0.25 mm
0.24	3.54	0.0	0.25	20	20	10	7	9	7	3
Numbers detected										

Tables 3 and 4 present the observed range of measured and calculated data as well as the results from the evaluation of the image quality parameters within the 40-day period.

**Table 3.** Observed range in mAs and in measured film ODs.

Tests	Observed mAs range	Observed range in the measured ODs			
		Mean background OD	B+F	Speed index	Contrast index
AEC constancy & light sensitometry	63.7 – 67.9	1.78 – 2.04	0.23 – 0.25	1.30 – 1.51	0.83 – 1.00
Leeds phantom image assessment	51.0 – 55.7	1.75 – 2.07	0.24 – 0.25	1.32 – 1.55	1.88 – 2.18

**Table 4.** Observed range in OD measurements and number of frequently resolved circular details.

B+F test pt.	0.24 – 0.26	Circular details		Numbers detected				
HD test pt.	3.34 – 3.64			6	7	8	9	10
Scatter	0.00 – 0.01	Low-contrast	5.6 mm	52.5%	47.5%			
Visual contrast	0.19 – 0.28	High contrast	0.5 mm		37.5%	45.0%	17.5%	
			0.25 mm	37.5%	57.5%	5.00%		

Data from unsharpness measurement and grade number of micro-particles were observed to not vary from the baseline scores over this period.

#### 4. Discussion

The baseline output from the exposure of the 45 mm Leeds phantom was observed to be lower by 12.6 mAs relative to the baseline output from exposure of the routine 45 mm acrylic plates (refer to table 1). This could be due to the presence of test objects embedded in the test plate. Hence, the degree of attenuation is different between the two set-ups.

The contrast index also differ since 21-step sensitometer is used following the IAEA protocol, while Leeds phantom has 10-point greyscale step wedge. The contrast index from Leeds phantom image is determined by the difference between the high-density (HD) point and the speed index. Thus, a film gamma calculation can be drawn from the data. But in the IAEA protocol, it suggests average gradient to indicate film contrast [2]. Nevertheless, other results for the mean background OD, base plus fog, and speed index did not differ considerably between two set-ups.

Other quantifiable details from the Leeds phantom image were presented in table 2. The base plus fog (B+F) test point OD is compared to the OD from step 1 in the grey scale wedge to determine the

presence of scattered radiation. The baseline scatter measurement was zero. On the other hand, the measurement for visual contrast estimate changes with applied tube kV and there was no performance criterion available, yet. Nonetheless, baseline visual contrast in the phantom image was observed at 0.25.

Resolution limit of the screen-film combination was observed to consistently demonstrate maximum number of lines per millimeter (lp/mm) under a 9x magnifying lens. However, the number of low contrast circular details that was frequently resolved is 7 out of 12. The numbers of resolved 0.5 mm and 0.25 mm small details were 9 and 7, respectively. There is a need for improvement in the detection of these circular details.

Observed range in data from each evaluated parameter were presented in tables 3 and 4. Deviations of measurements against the baseline values can be observed from these tables. Over the 40- day assessment, the mAs output data were within the  $\pm 10\%$  of baseline mAs and the mean background ODs were within  $\pm 0.2$  tolerance as specified in the IAEA protocol for AEC constancy. Also, the sensitometry data met the minimum B+F, speed index and contrast index tolerances indicated in the IAEA protocol. Results from the evaluation of the image quality parameters were consistent to the baseline scores.

## 5. Conclusion

It is verified that Leeds TOR (MAX) phantom is convenient to use for daily QC monitoring. Measurements from using the phantom were agreeable with that of the measurements obtained from the separate tests on AEC constancy and light sensitometry. Results from the evaluation of the image quality parameters were observed to demonstrate consistency with the baseline scores. However, this could still be improved by determining technical factors that can resolve the smallest details that the phantom has provided.

## References

- [1] Leeds Test Objects TOR MAX user manual.
- [2] IAEA 2009 Human Health Series No.2 Quality Assurance Programme for Screen Film Mammography (Vienna, Austria: IAEA)

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