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# Mammography Quality Assurance

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# MAMMOGRAPHY QUALITY ASSURANCE

*LARRY A. DeWERD, Ph.D.*

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*The most important aspects for mammographic quality assurance are (1) evaluation of image quality with a phantom, (2) measurement of kVp with a meter, (3) measurement of radiation dose, and (4) maintenance of good processor quality with a quality assurance program.*

*LARRY A. DeWERD, Ph.D.*

Mammography (x-ray imaging of the breast) is increasing in importance for early detection of breast cancer, the second highest fatal cancer for women in the United States. Early detection of breast cancer increases chance of cure.

The objective of quality assurance in mammography is to obtain the best image at the lowest exposure so that minimum (early-stage) disease is detected—to obtain the maximum diagnostic information at minimum risk. The importance of quality assurance is demonstrated by the findings of the U.S. Breast Exposure Nationwide Trend (BENT) Study of 1980, which showed 50% of mammography machines had poor image quality.

Good quality images depend on the correct operation and precision of settings of (1) *x-ray machine,* (2) *film system* and (3) *processor*. This paper discusses x-ray film systems and film processors. (Further information on the xeroradiographic processor can be obtained in the booklet Artifact Sources in the Xeroradiographic System: Quality Assurance.[1])

Quality Assurance for Mammography can be considered in three parts: Check of (1) the entire mammographic system, (2) the film processor system and (3) the x-ray machine parameters. Some machine parameters do not need to be checked as frequently as others. For example, the focal spot size of the x-ray tube need not be checked other than when the tube is installed and, possibly, once or twice throughout the tube's lifetime. The following discussion deals with (1) an overall system check, (2) the parameters of the x-ray machines, and (3) the quality assurance associated with the processor.

## SYSTEM PERFORMANCE—PHANTOM IMAGES

The imaging capabilities of the entire mammographic system can be checked by the use of *phantoms*. Mammographic phantoms simulate the attenuation of important pathology that may occur in a breast. Thus some of the test objects contained in the phantom are indicative of the pathological structures found in the breast—*specks* (to simulate calcification), *fine-threads* (to simulate tissue fibrils and ductal structures), and *masses* (to simulate tumors). Resolution test patterns, step wedges and other devices can be used for other quantitative measurements of the system.

The Wisconsin Detail Phantom (Figure 1) is an example of a phantom with test objects indicative of pathology of the breast. Figure 2 shows test objects in the phantom.

Figure 3 shows how various mammography machines detected these phantom objects of various sizes. Few machines visualized the smaller test objects. Although all machines in the study could visualize the largest speck, 1% could not visualize any masses, and 6% could not visualize any fibrils.

This phantom and others were the subject of a Center for Devices and Radiological Health Study on Mammographic Phantoms.[3,4] In this study, a panel of three radiologists judged the quality of mammograms from different institutions, and correlated this quality with various phantom images. An *image-quality index* was obtained for the various mammograms.

The score for the RMI Wisconsin Detail Phantom Test Object correlated the best with this image-quality index, which is a good indicator of mammographic image quality.

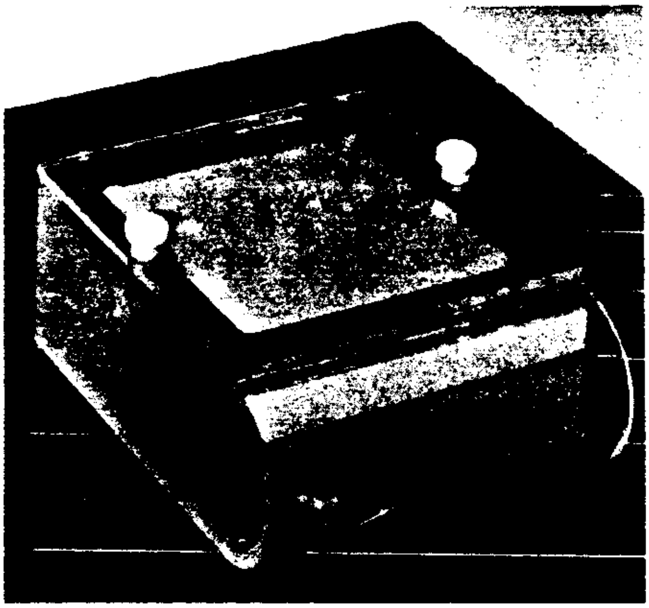

FIGURE 1. Wisconsin Detail Phantom RMI Model 152D.

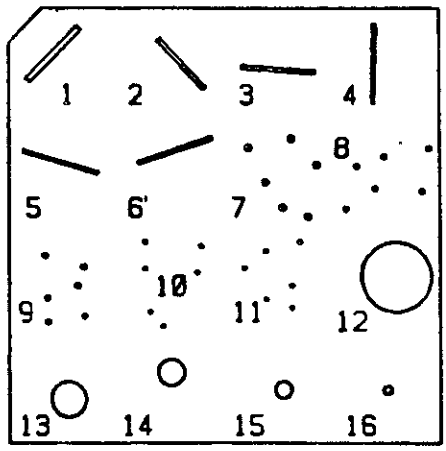


FIGURE 2. Elements of Mammographic Detail Phantom showing test object sizes and position numbers (used for reference only). Test objects are randomly placed within the reference area and will also have random spatial orientation to further simulate actual clinical conditions. Region materials: 1) 1.56mm nylon fiber; 2) 1.12mm nylon fiber; 3) .89mm nylon fiber; 4) .75mm nylon fiber; 5) .54mm nylon fiber; 6) .40mm nylon fiber; 7) .74mm Al speck (6ea); 8) .54mm Al speck (6ea); 9) .32mm Al speck (6ea); 10) .24mm Al speck (6ea); 11) .20mm Al speck (6ea); 12) 2mm mass; 13) 1mm mass; 14) .75mm mass; 15) .5mm mass; 16) .25mm mass.

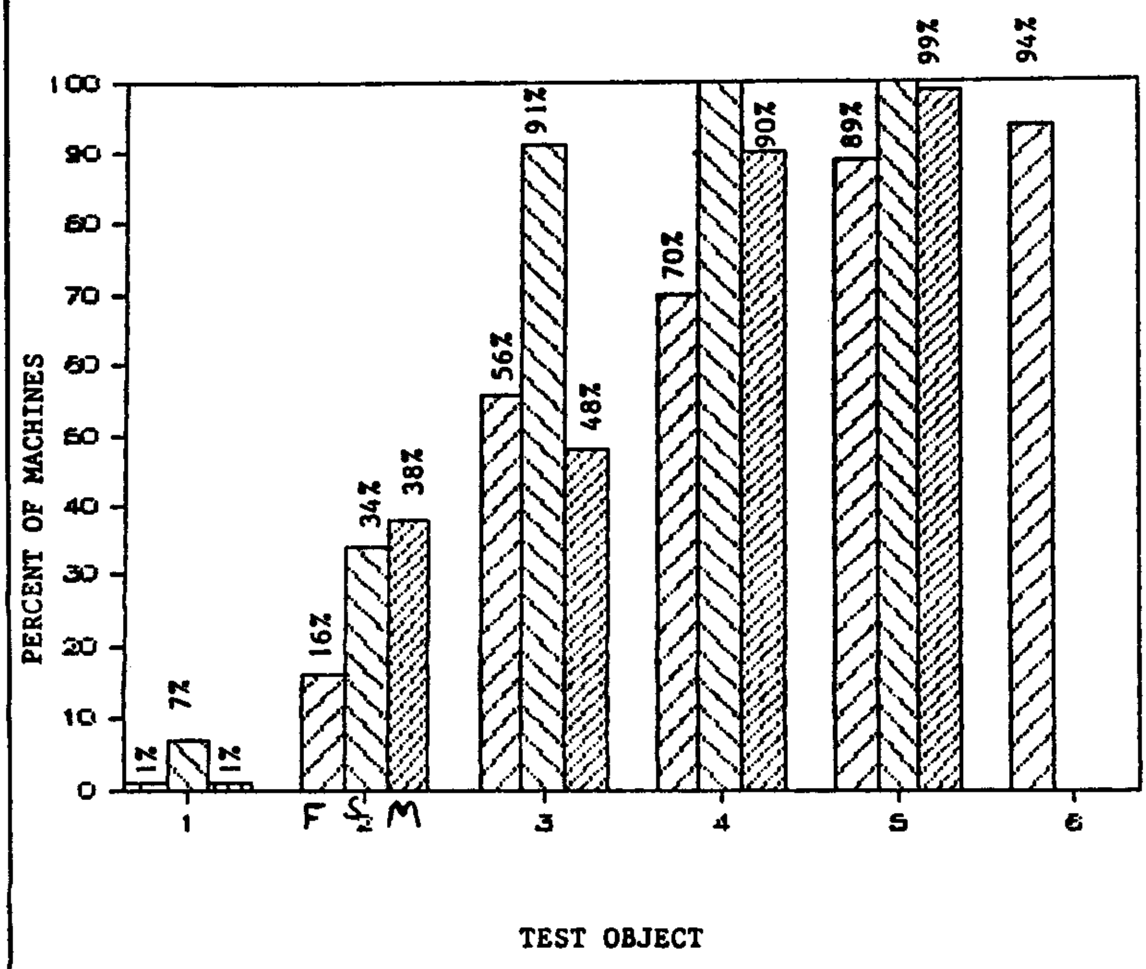


FIGURE 3. Percentage of 218 mammography machines that could visualize differing sized test objects in the RMI-Wisconsin Detail Phantom. The smallest sized fibril (F), speck (s) or mass (m) is labeled 1, and ranges to the largest sized fibril labeled 6.

The usefulness of a phantom can be seen from the above studies. The greater the correlation of phantoms with the radiologist observation, the more useful the phantoms.

Phantoms can also be used to determine the best techniques to use when setting up a new machine. The phantoms can be used also on a periodic basis, such as once each week, to assure the continuing correct performance of the entire mammographic system.

## PARAMETERS OF THE X-RAY MACHINE

The objective of x-ray machine tests is to assure that the machine provides the greatest possible detail and resolution with the lowest radiation dose. Table 1 includes some suggested tests and their frequencies.

Two tests are especially important—(1) *kVp* and (2) *exposure time*. The kVp can be checked noninvasively with a calibrated kVp cassette (Figure 4) or a mammographic kVp meter (Figure 5)—or invasively with a voltage divider. (The mammographic cassette and kVp meter are presently solely provided by RMI.)

The simplest device to use is the digital kVp meter. This measurement is important because the actual kVp may be different from that set on the generator, and a small variation in kVp can result in significant changes in the image. The kVp meter has been shown to have a precision of 0.1 kV, with a range from 22 to 60 kVp settings.

The measurement of kVp can also indicate anomalous waveforms or unusual filtration.

The *exposure* is easily monitored with *Thermoluminescent Dosimeters* (TLDs) —available from the University of Wisconsin Medical Physics Department. This test has the advantage of an *in-vivo* measurement, as well as being able to monitor the exposure variation of the mammographic system performance. (This is explained in further detail by Wochos, Fullerton and DeWerd.[5])

## PROCESSOR QUALITY ASSURANCE

A Processor Quality Assurance program should be established and followed for mammographic facilities (similar to QA programs for general diagnostic-image processors). Techniques for quality-assurance programs have been well established.[6,7,8]

A quality assurance program is especially important in mammography because many problems can be traced to the processor system. The detection of pathology can be greatly affected by a poorly operating processor. For example, small lesions may be missed because of processor artifacts.

The same comments apply to the xeroradiographic system.[1] A good processor quality assurance program is essential for optimum mammographic images.

## CONCLUSION

The process of quality assurance in mammography is especially important because the mammographic procedure is a specialized examination. A small variation in one of several parameters can result in a major change in image quality. The importance of the use of a mammographic phantom cannot be overemphasized.

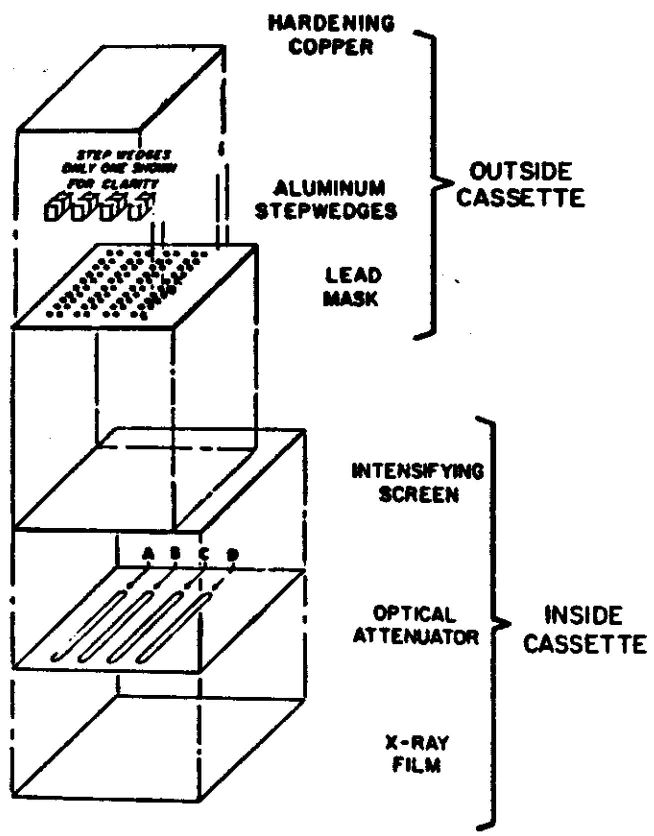


FIGURE 4. Construction of mammographic kVp cassette.

**TABLE 1 - X-RAY MACHINE TEST PARAMETERS**

| PARAMETER | SUGGESTED TOLERANCE | SUGGESTED FREQUENCY | NOTES |
|---|---|---|---|
| 1. kVp | ±5% | Monthly or quarterly | |
| 2. Exposure or calculated glandular dose | ±10% | Monthly or quarterly | Can be performed in-vivo with the use of TLDs, or using an ionization chamber calibrated for the mammography region. |
| 3. Exposure Timer Reproducibility | ±5% | Quarterly | On Phototimer units, the linearity of the Phototimer and the backup timer should be checked. |
| 4. Linearity of mA stations | ±5% | Quarterly or yearly | Can be determined by mR/mAs. |
| 5. HVL | ±10% of initial measurements | Yearly | Also check after repairs that could affect filtration |

6. Focal Spot Size ~ 20% Yearly

FIGURE 5. RMI Digital Mammographic kVp meter. Specs include range of 22-60 kVp; accuracy ±1 kV + 2%; reproducibility ±0.3 kV; and resolution 0.1 kV.

The most important aspects for mammographic quality assurance are (1) evaluation of image quality with a phantom, (2) measurement of kVp with a meter, (3) measurement of radiation dose via TLDs, and (4) maintenance of good processor quality with a quality assurance program. □

## REFERENCES


1. L. A. DeWerd, Artifact sources in the xeroradiographic system: *Quality Assurance*, CRP Report #2 (1979).
2. DeWerd, L. A., Wochos, J. F., Cameron, J. R., "Wisconsin Mammographic Phantoms" in *Reduced Dose Mammography*, W. W. Logan and E. P. Muntz, eds. pp 301-306, Masson, NY (1979).
3. Mammographic Phantom Evaluation Project, U.S. Dept. of Health & Human Services. FDA 83-8213 (1983).
4. Mammography - A User's Guide, National Council of Radiation Protection & Measurements, NCRP Report No. 85 (1986).
5. J. F. Wochos, G. D. Fullerton and L. A. DeWerd, *Am. J. Roentgenology 131:* 617-619 (1978).
6. Photographic Quality Assurance in Diagnostic Radiology, *Nuclear Medicine and Radiation Therapy*, Volume 1: The Basic Principles of Daily Photographic Quality Assurance FDA 76-8043 (1976).
7. Photographic Quality Assurance in Diagnostic Radiology, *Nuclear Medicine and Radiation Therapy*, Volume 2: The Basic Principle of Daily Photographic Quality Assurance FDA 77-8018 (1977).
8. *Radiographic Film Processing Quality Assurance:* A Self-Teaching Workbook FDA 81-8146 (1981).


### THE AUTHOR


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