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College on Medical Physics

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Quality Assurance in Mammography

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QUALITY ASSURANCE:
A Key to Early Detection

Early detection of breast cancer is only as reliable as the mammogram from which a diagnosis is made.

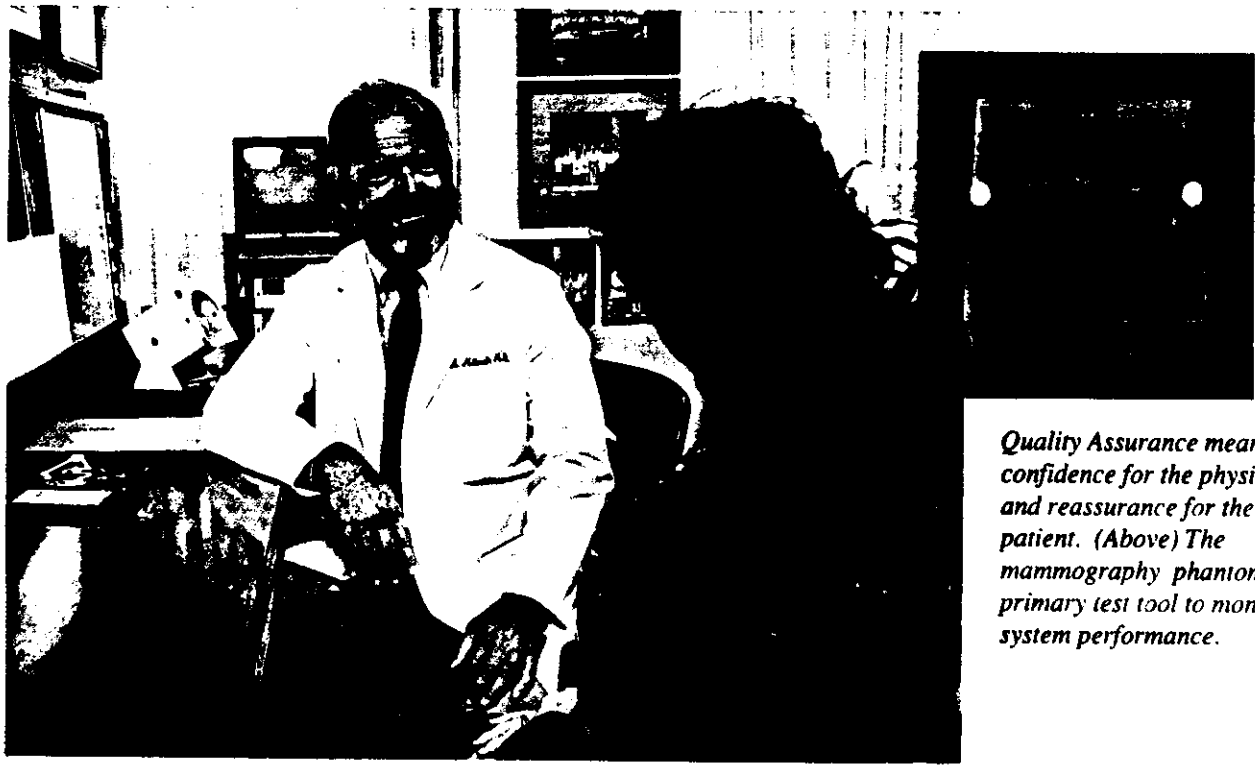
And the mammogram is only as accurate as the system that produces it.

Mammography's ability to image pre-clinical pathology depends upon the precise and peak performance of each system component. If even one parameter within the system is inaccurate, a small lesion may be invisible or unrecognizable.

Maintaining the entire mammographic system in optimum condition is absolutely essential in producing consistently high-quality images with low dose. *Every* mammographic system requires regular monitoring to maintain consistent performance. Properly applied, a Quality Assurance (QA) program can detect a system problem before it affects diagnostic outcome.

Quality Assurance includes a broad spectrum of quality control procedures and administration. QA is particularly important in mammography because this modality, with its specialized x-ray tubes and kV range, is more sensitive to small changes than other types of x-ray. A minor variation in even one parameter can cause degradation in image quality.

Additionally, every mammographic system deteriorates with time, gradually producing less accurate images. Without the use of specific quality control techniques, even the experienced professional may not detect the slow and subtle



Quality Assurance means confidence for the physician and reassurance for the patient. (Above) The mammography phantom is the primary test tool to monitor system performance.

image degradation. QA provides the necessary assurance that the image contains all the information possible for the delivered dose.

Quality Assurance also offers the only reliable way to ensure the lowest possible radiation dose for the patient. A QA program can be routine, convenient, non-invasive, and an ideal way to document the delivery of high-quality diagnostic services in a mammography facility. Credibility demands that every mammographic facility conduct QA, keeping records of system performance.

Awareness of the need for QA in mammography is growing. Government and medical authorities are setting standards for mammographic systems and personnel. New York State has mandated QA standards, while other states have adopted recommendations. The new standards of the Joint Commission on Accreditation of Healthcare Organizations focus attention on dose and image quality for mammography.

Non-governmental groups are also interested in QA. The American College of Radiology (ACR) has instituted a mammographic accreditation program covering the complete imaging chain including technologist and physician. The program uses a mammographic phantom to analyze images and assure good imaging by setting a minimum acceptable level of image quality.

Participants in the American Cancer Society's (ACS) screening programs must meet specified QA standards. In addition, ACS uses the ACR-accredited list of mammography sites as a basis for referrals and also performs its own QA program using Radiation Measurements, Inc. (RMI) phantoms. Thus, a facility meeting ACR standards can attract more patients and establish an advantage in the market.

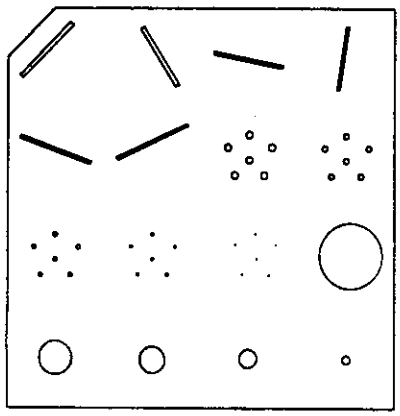
RMI, the leader in mammographic QA, has developed a program specifically designed to allow routine quality control of the system by the technologist or physician who performs the mammogram. An on-site record of all QA test results serves as early warning that one or more parameters need attention. The comprehensive, integrated RMI Mammography QA program is the industry standard for quality maintenance.

An important mission for RMI is QA education. The information on the following pages describes the important procedures involved in mammographic QA.❑

PHANTOMS:

Testing the Total Mammographic System

(Left) Each phantom is precisely constructed by hand at RMI. (Below) The phantom contains test objects to simulate actual pathology placed with random spatial orientation.



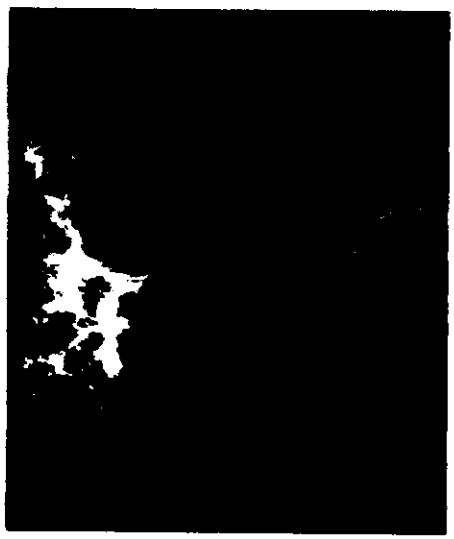
A mammographic phantom mimics the attenuation and pathology that can be found in a breast. It is the primary test tool to monitor the performance and stability of the whole mammographic system.

When used in place of breast tissue, the phantom indicates how well the entire mammographic system is operating by measuring the ability to visualize simulated pathology. Test objects in the phantom include specks to simulate microcalcifications, fine threads to simulate fibrils and ductal structures, and parts of spheres to simulate tumors or masses.

A properly adjusted mammographic system should detect a minimum of 3 fibrils, 2 specks, and 3 masses in the phantom, giving the radiologist an index of image quality. If these objects are not seen, or visibility deteriorates over time, something in the system needs attention, such as the film processor, kVp, phototimer setting, or beam quality.

Monitoring with a phantom is important because mammography is more sensitive to minor deviations than other forms of x-ray imaging. A weekly phantom check monitors proper system functioning; if the phantom image is good, the system may need no further testing; if it is poor, more testing is necessary.

In a study of mammographic phantoms by the Center for Devices and Radiological Health (CDRH), RMI's phantom was found to be the best indicator of image quality. (For further information on the mammographic phantom, see the CDRH Mammographic Evaluations Project, NTIS-PB83-256933, or the National Council of Radiation Protection & Measurements, Report No. 85, *Mammography—A User's Guide.*) ❑



Clearly visible pathology demonstrated by system with proper Quality Control.

kVp MEASUREMENT:

Ensuring Machine Setting Accuracy

Visualization of pathology in these images is questionable due to (left) high kVp and (right) low kVp.

kVp, a measure of the peak kilovoltage applied across the x-ray tube, affects the mammogram's density, contrast and detail. A small variation in kVp can make a significant change in the quality of the mammogram, possibly resulting in a misdiagnosis.

It is important to know the machine's actual kVp, since it may be different from the setting on the generator. One can quickly discover such a discrepancy using a device specifically designed to measure the mammographic range of 22-60 kVp.

The mammographic unit's kVp can be checked non-invasively with a meter or with a calibrated kVp cassette. Checking is simpler and more accurate with the meter.

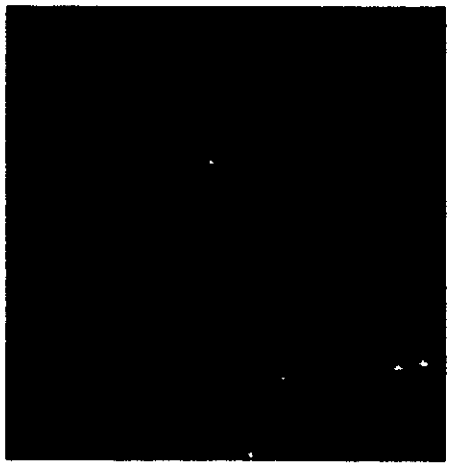
Since kVp is such an important contributor to image quality, an error in kVp may significantly compromise the image. If the kVp error exceeds the manufacturer's stated accuracy, a service call should be scheduled.

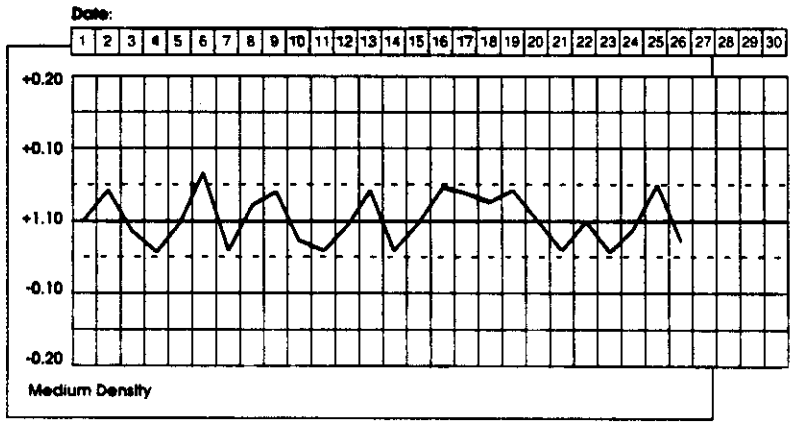
RMI's digital mammographic meter is a convenient, fast and accurate tool to measure a wide range of kVp. It handles all wave forms, the x-ray tube anode materials, and the filter materials used by the various manufacturers. It is simply placed in the x-ray beam and the digital readout recorded. It is a convenient way to help ensure good image resolution and patient safety. ❑

kVp meter in use.

PROCESSOR QUALITY CONTROL:

Ensuring Maximum Presentation of Information





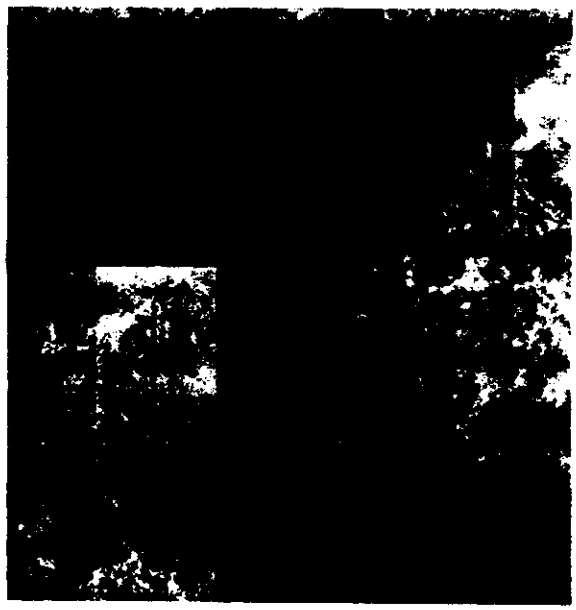
Left: Technologist uses a sensitometer in the darkroom. Above: A graph showing processor Quality Control on a daily basis using the medium optical density of 1.10 as an example.

The film processor is the component of a mammographic system that needs the most frequent attention. Images in which small lesions may be lost could be caused by a poorly operating processor. The rollers may be dirty, for example, or the temperature of the solutions or the activity of the chemicals may be less than optimal.

Film processing is sometimes described as the most problematic link in the mammographic chain. For this reason, the manufacturer's instructions should be carefully followed in all aspects of processor control.The processor should be checked daily with three test tools: a *sensitometer* to expose film to a constant, reproducible light source so that stepped densities are produced when the film is developed; a *densitometer* to read film density; and a *thermometer* to monitor developer temperature.

One can detect drifts that indicate a problem within the processor or darkroom by daily charting of temperature as well as the three film measurements of base plus fog, mean density (speed) and contrast.

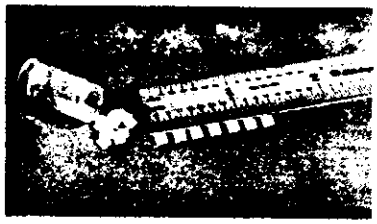
Film density and contrast depend upon both x-ray exposure through the patient and film processing. To produce maximum contrast, the image processor must be operating at its peak. Only a maximum-contrast image is able to show subtle differences within soft tissue. Processor Quality Control enhances mammography's ability to find small lesions. ❑



Roller marks, scratches, and other artifacts can contribute to loss of quality.

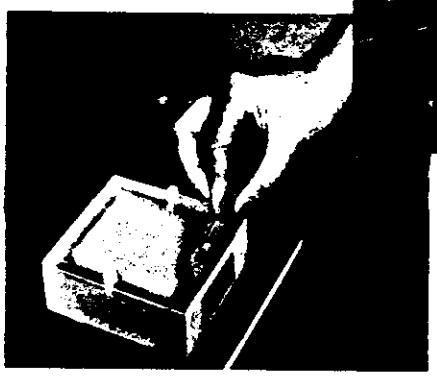
DOSIMETRY:

Ensuring Maximum Information From the Given Dose



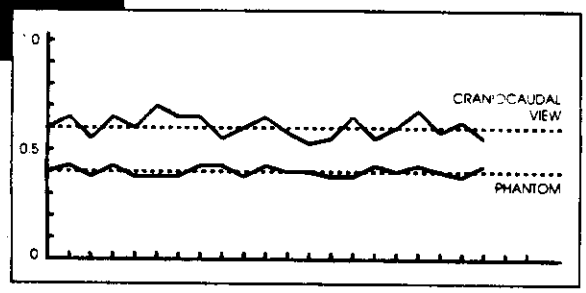
Thermoluminescent dosimeters (TLDs)

Ion chamber



A TLD strip placed on a phantom

Photos: Three tools available for measuring radiation exposure. Graph: Monitoring of mammographic patient exposure with TLDs.



Exposure (R) over time in weeks

Mammography has improved to the point where, properly performed, the risk of harm from the required radiation is considered minimal, while the benefit of early detection of breast cancer is well established. Nonetheless, it is essential that radiologists and technologists remain vigilant to keep radiation doses as low as possible while maintaining the best image.

It is within the limits of all film-screen and Xerox imaging systems to produce diagnostic mammograms with a mean glandular dose of one rad or less for two views of the breast. The NCRP (1980) has recommended that this be considered the maximum acceptable dose for a two-view mammogram of the average patient. Further, the dose per examination should be kept as low as possible consistent with optimum image quality. (NCRP, Report No. 85.)

Results from exposure measurements may be used to calculate mean glandular dose, provided the x-ray tube half value layer (HVL) and breast thickness are known. HVL is defined as the thickness of aluminum filtration required to cut the beam intensity in half. It is an indication of the x-ray beam energy, which is important in determining image contrast and dose required.

Exposure can be monitored with a thermoluminescent dosimeter (TLD) or an ionization chamber. Both must be calibrated for the mammography region. TLDs, which can be placed directly on the breast or used in conjunction with a phantom, measure the level of entrance radiation exposure to ensure operation within the generally accepted levels. Results of TLD measurements plotted over a period of time will indicate whether problems are developing in either the x-ray unit and/or film processor.

If the unit has a phototimer (a device that automatically controls the amount of radiation), dosimetry checks are especially important. The phototimer may compensate for a problem in another part of the system, such as drift in kVp, by increasing the amount of mA and time, thus increasing radiation exposure to the patient.

When patients ask about their exposure to radiation, it can be reassuring to tell them that the machine's exposure is carefully monitored to maintain operation within acceptable levels. This is an essential part of good Quality Control. ❑

PARAMETERS TO BE TESTED FOR GOOD MAMMOGRAPHY QA

Test	Frequency	Test Tool	Performed by
Film processor	Daily	Densitometer Sensitometer Thermometer	Technologist
Image quality	Weekly	152D Detail Phantom or 156 Accreditation Phantom	Technologist and/or Physician
kVp	Monthly	kVp meter or kVp cassette Dyanalyzer	Technologist Physicist
Retake rate analysis	Monthly	Calculation based on number of rejected films	Technologist
Phototimer Reproducibility	Monthly	Phototimer consistency test tool	Technologist Physicist
Timer	Monthly	Digital timer	Technologist
Dose/Patient exposure Mean glandular dose	Monthly Annually Annually	TLD Ion chamber Calculated from exposure measurements	Technologist Physicist Physicist
Film/Screen contact	Semi-annually	Contact test tool	Technologist
Half value layer (HVL)	Semi-annually	Aluminum HVL set with ion chamber or pen dosimeter	Physicist
mA (mAs)	Semi-annually	Dyanalyzer	Physicist or OEM service representative
mAs linearity	Semi-annually	Ion chamber or digital timer	Physicist or OEM service representative
Exposure reproducibility (mR/mAs)	Annually	Ion chamber	Physicist or OEM service representative
Focal spot	Annually	Star pattern	Physicist

The tools available from RMI today allow the physician or technologist to carry out all the non-invasive tests required to ensure a good QA program. The RMI Quality Assurance program in mammography is designed to monitor system performance on a day-by-day basis. Additional tests must be carried out by a physicist or OEM service representative at less frequent intervals. The chart on this page shows the tests, their recommended frequency, the personnel, and the tools needed for comprehensive QA. ❑