

Products by Use

Medical Radiography

The Phantom Test

By now, everyone involved in breast imaging is familiar with the mammography phantom utilized in the American College of Radiology (ACR) Mammography Accreditation Program. This phantom, currently available from RMI and Nuclear Associates, simulates a 4.5 cm compressed breast that is composed of 50% fatty tissue and 50% glandular tissue. It primarily consists of two components — a thick acrylic block and a thin, pink wax insert which contains six nylon fibers, five groups of aluminum oxide specks, and five masses. These objects range in size from very visible to nearly invisible on a radiograph.

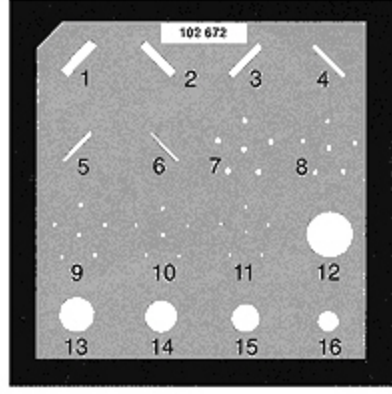
Not everyone may be familiar, however, with the reasons why the phantom test is an important part of a quality assurance program. Moreover, there may be uncertainty over the correct procedure for performing and evaluating the phantom test and what the results reveal about the quality of mammography performed in a facility.

Why the Phantom Test?

High-quality mammographic images are dependent on everything in the mammographic imaging chain. This complex chain includes the darkroom and processing environments, the screen-film combination, the x-ray equipment, and the unique characteristics of each individual patient. Using a phantom eliminates the variables of differences in breast tissue, positioning, and levels of compression from patient to patient. What's left are the non-patient components and procedures. The phantom image verifies that everything is working together properly, that image quality standards have been met, and that any mammography performed in the facility can adequately provide the diagnostic information needed by the radiologist.

Changes in the phantom image also signal when one or more of the components in the imaging chain are falling short of the quality standards. In such cases, pathology may be poorly imaged. Poor image quality can potentially affect long-term patient survival rates.

The phantom test should be performed at least once a week.



The wax insert in the phantom contains six nylon fibers (1-6), five groups of six Al₂O₃ specks (7-11), and five masses (12-16).

Note: The numbers 1-16 have been added to the illustration for explanation purposes only and they do not appear on the wax insert radiograph provided by the phantom manufacturer.

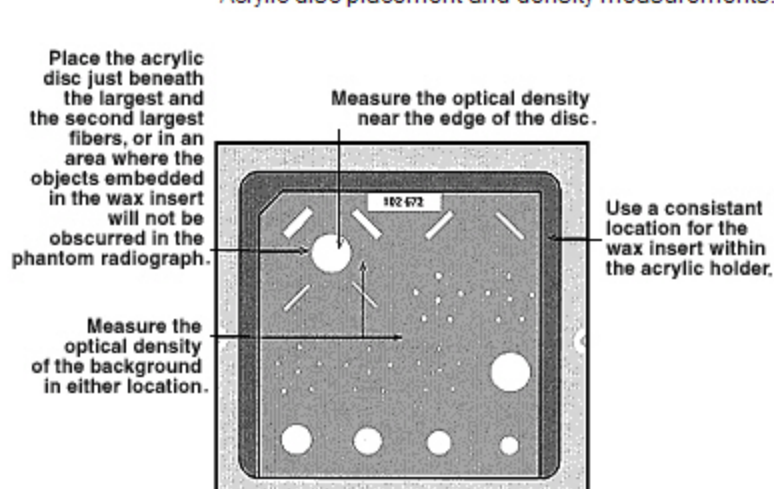
How to Perform the Phantom Test

As in all quality control procedures, first establish a baseline for future comparisons. Then use consistency to ensure meaningful results.

To perform the Phantom Test, follow these steps:

1. Verify that the processor and processing environment are functioning according to the manufacturer's recommendations.
2. Assemble the necessary tools:
 - o the mammography phantom
 - o a mammographic cassette
 - o mammography film
 - o an acrylic disc
 - o a densitometer
 - o a magnifying glass
 - o phantom worksheets and control charts.
3. Perform a screen-film contact test on the cassette or check the results of the last contact test (see [The Screen-Film Contact Test](#)). Select a cassette which exhibits good screen-film contact (that is, areas of increased density are no larger than 1 cm in diameter). Record the screen-cassette identification number (from the back panel of the cassette) on your phantom control chart so the same cassette is used on all phantom tests.
4. Clean the cassette and allow it to dry.
5. Load a sheet of mammography film from the film bin into the cassette. Do not use film from the box set aside for processor quality control because the phantom test evaluates the entire imaging chain, including the film used for patient radiographs. Since the emulsion number of the film used for the phantom test may change each time the test is performed, record the emulsion number of the film from the film bin along with the date the phantom test is performed on the back of the control chart.
6. Place the loaded cassette in the moving Bucky grid of the x-ray unit.
7. Place the phantom on top of the moving Bucky grid so that the labeled side of the acrylic block is aligned with the chest wall edge of the Bucky grid. Notice that the wax insert tends to shift easily within the acrylic holder. For consistency, standardize the location of the wax insert within the acrylic holder by making certain (1) the edge of the wax insert closest to the chest wall is in direct contact with the edge of the acrylic holder and (2) the wax insert is centered left to right within the acrylic holder.
8. Place an acrylic disc on the phantom, just beneath the largest and second largest fibers, or in an area where the objects imbedded in the wax insert will not be obscured on the phantom radiograph. Use the same disc each time you perform the phantom test, since slight differences in thickness from disc to disc may affect test results. To ensure that the disc is correctly placed each time the phantom test is performed, mark the location on the cover of the phantom (if using a standard location for the insert). The disc may also be glued to the top of the phantom, but the glue used could affect the optical density readings taken from the area of the disc on the radiograph.
9. Lower the compression paddle until it rests on top of the phantom and disc. Position the photocell (if using automatic exposure control) beneath the center of the wax insert. Use the same position each time the phantom test is performed.
10. Select a technique (kVp, mAs, etc.) that is typically used for patients whose breast tissue compresses 4 to 5 cm and is composed of 50% fatty tissue and 50% glandular tissue. The optical density of the background on the phantom radiograph should be at least 1.40 and never be less than 1.20. The preferred optical density of the background can be determined by having the radiologist(s) view phantom images at several density levels. The optical density of the background, once determined, should be maintained within the control limits of ± 0.20 . *Note: many facilities are exposing the phantom between 1.60 and 2.00 optical density.*
11. Expose the phantom and process the film.

Acrylic disc placement and density measurements.

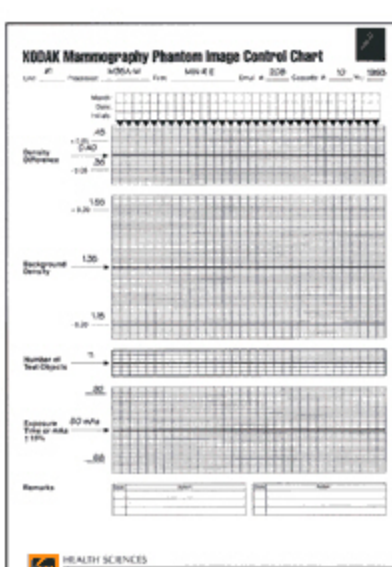


"The Phantom image verifies that everything is working together properly, that image quality standards have been met, and that any mammography performed in the facility can adequately provide the diagnostic information needed by the radiologist."

Evaluating the Phantom Image

One person should be assigned to generate successive phantom images at the same time of the day and make several optical density measurements and evaluations.

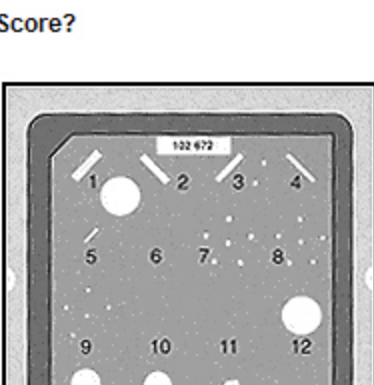
1. Measure the optical density of the background of the phantom radiograph with a densitometer (measure at the center of the wax insert, or just outside the edge of the disc). The density should be whatever has been determined as optimal.
2. Record this value on the phantom control chart as the aim for background density.
3. On the control chart, record the exposure time—or mAs—used to obtain the background optical density. This value should not deviate by more than 15% with each phantom test.
4. Calculate 15% of the exposure time (mAs) and enter these values as the upper and lower limits on your chart.
5. Next, measure the optical density of the disc close to the edge of the disc.
6. Determine the difference in density by subtracting the optical density of the disc from the background optical density (OD(background)-OD(disc)). Record this value on the control chart as the aim for density difference. (The density difference value should be at least 0.40.) If using a high contrast mammography film, such as Kodak Min-R 2000 Film, a higher density difference should be obtained, e.g. 0.43 to 0.47. Assign control limits of ± 0.05 to the density difference and enter these values as the upper and lower limits on the chart. (The density difference may also be affected by the placement and thickness of the disc, heel effect of the equipment, technique used, processing, chemical quality, etc. Consult your medical physicist for assistance, especially if you have a density difference that is lower than 0.40.) *Note: When performing all subsequent phantom test, be sure to take density measurements in the same locations on the radiographs.*
7. Place the radiograph on a viewbox. Mask the film to exclude all extraneous light from the viewbox.



Record the aim values as well as the upper and lower limits on the phantom image control chart.

8. Next, score the phantom image according to the following criteria:
 - o A minimum of the four largest fibers in their entirety (four of six) should be seen. The entire fiber must be seen to give it a score of 1; if a fiber cannot be completely seen, that fiber may be scored 0.5. Start by counting the largest fiber. Continue scoring the individual fibers, adding the results together and moving from larger toward smaller as long as a full score (whole number) is achieved. Once a partial score (0.5) is given, a smaller fiber may not be counted.
 - o A minimum of the three largest speck groups (three of five) should be seen. Four to six specks in a group must be seen to give it a score of 1; if only two or three specks out of six in a group are seen, that group may be scored 0.5. Start by counting the number of specks in the largest group. Continue scoring the speck groups, adding the results together and moving from larger toward smaller as long as a full score (whole number) is achieved. Once a partial score (0.5) is given, a smaller speck group may not be counted.
 - o A minimum of the three largest masses (three of five) should be seen. If both a density difference and the entire circumscribed edge can be seen, it will receive a score of 1; if only the density difference or part of the edge is seen, that mass may be scored 0.5. Start by evaluating the largest mass. Continue scoring the masses, adding the results together and moving from larger toward smaller as long as a full score (whole number) is achieved. Once a partial score is given (0.5), a smaller mass may not be counted.
 - o Examine the background for any artifacts that appear similar to a fiber, speck or mass. If such is the case, the last half or whole score of the fibers and masses should be subtracted. For speck-like artifacts, subtract speck for speck from the speck count from the last group. (For example, 5 specks in the third largest speck group were counted, giving a score of 1 for that group and a total speck count of 3; the examination of the background reveals two minus density artifacts that look like the specks; this changes the individual speck count from 5 to 3, the third largest speck group count from 1 to 0.5, and the total speck score from 3 to 2.5. The presence of minus density artifacts indicates the need to clean the screen and cassette.)
 - o Finally, record individual scores of the fibers, specks, and masses on the control chart. Perform the test at least monthly. The score for any individual group should not decrease by more than 0.5.

Phantom Test: What's the Score?



The State of Your Image Quality

FIBERS:	1 <u>1</u>	Fiber Score:	<u>4.5</u>
	2 <u>1</u>	Are there any fiber-like artifacts?	<u>No</u>
	3 <u>1</u>		
	4 <u>1</u>		
	5 <u>0.5</u>		
	6 <u> </u>	Total Fiber Score:	<u>4.5</u>
SPECKS:	7 <u>(6) 1</u>	Speck Score:	<u>3.0</u>
	8 <u>(6) 1</u>	Are there any speck-like artifacts?	<u>Yes, 2</u>
	9 <u>(5) 1</u>	5 specks (#9)	between fibers 3 - 4)
	10 <u> </u>	= 2 speck-like artifacts	
	11 <u> </u>	= 3 specks = 0.5 score	
		Total Speck Score:	<u>2.5</u>
MASSES:	12 <u>1</u>	Mass Score:	<u>3.5</u>
	13 <u>1</u>	Are there any mass-like artifacts?	<u>No</u>
	14 <u>1</u>		
	15 <u>0.5</u>		
	16 <u> </u>	Total Mass Score:	<u>3.5</u>
		Total Phantom Score:	<u>10.5</u>

A score of at least 4 for fibers, 3 for the speck groups, and 3 for masses — that is, 10, indicates that you have met the standards of the American College of Radiology — that mammography in your facility demonstrates the standard of care across the United States.

Achieving this quality is only the beginning. Image quality must be continually monitored by performing the phantom test regularly and in a consistent fashion. The standards used will inevitably evolve, ensuring high-quality mammography for every woman throughout the country.

Note: The KODAK Mammography Phantom Image Control Chart, Cat. No. 1624220, publication M7-170, may be purchased by calling KODAK Health Customer Service at 1-800-677-9933 or 1-585-588-8973.