Carestream

Technical Data Sheet

Issued 2017-03

MIN-R S Film

MIN-R S Film is a medium speed, dual coated, orthochromatic medical x-ray film for mammographic use with single green-emitting intensifying screens. It uses a fine grain silver halide emulsion that is coated on a blue, approximately 0.2 mm (7-mil) polyester base that has a base density of approximately 0.207. MIN-R S Film provides contrast to view the dense breast parenchymal tissue together with exposure latitude to view overall breast anatomy. MIN-R S Film is intended for standard cycle processing using hardened developers such as X-OMAT EX II or RP X-OMAT Developer and Replenisher. The MIN-R S Film and MIN-R 2000 Screen speeds have been optimized to provide the maximum resolution at the specified system speeds.

Sensitometric and Photographic Properties:

Screen	System Speed
MIN-R 2000	150
MIN-R 2190	190

Sensitometric Parameters:

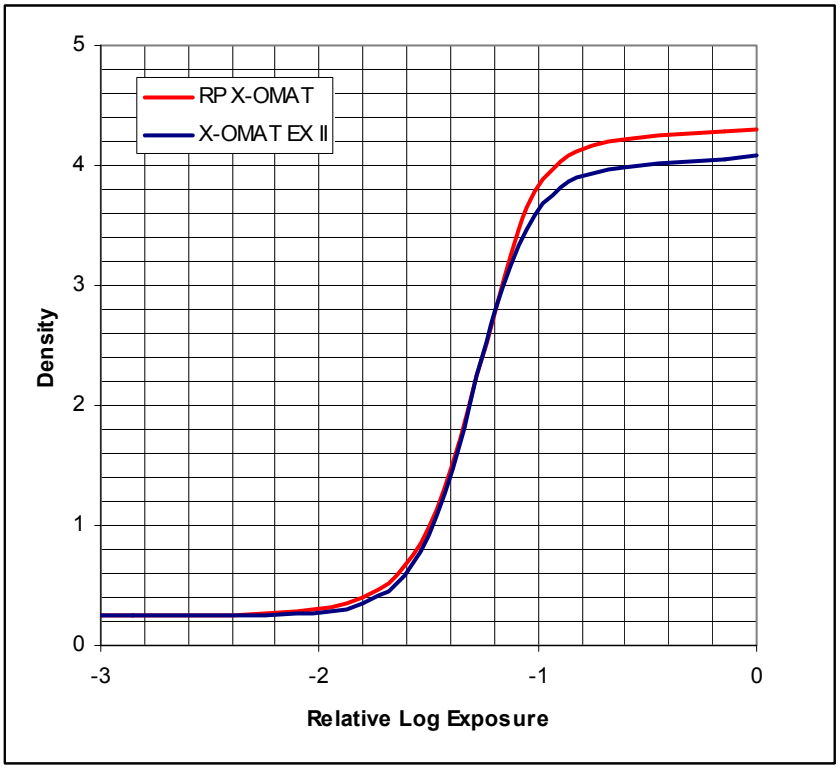
Speed	Measured at 1.0 OD above Gross Fog
Contrast	Measured as slope of the straight line portion of the sensitometric curve, and computed as the value for the rise for any three consecutive steps.
Gross Fog	Density of film base plus processing fog.

Contrast		D-Max
RP	**EX II**	
3.90	4.10	≥4.1

Recommended Starter Volumes

Developer	Starter (Added to processor developer tank
RP, EX II	89 ml (3 fl. Oz.) per 3.78 Litres (1 gallon)

MIN-R S Film
1/2 second Simulated Green Screen Exposure;
MIN-R Mammography Processor; 33.3 °C (92 °F); Diffuse Visual Densitometry



Notice: The data in this publication represent product tested under the conditions of exposure and processing specified. They are representative of production coatings, and therefore do not apply to a particular box or roll of photographic material. They do not represent standards or specifications that must be met by Carestream Health, Inc. The company reserves the right to change and improve product characteristics at any time.

Automatic Processing Recommendations:
In general, processing is recommended in MIN-R Mammography, X-OMAT and RP X-OMAT Processors using RP X-OMAT or X-OMAT EX II Developer and Replenisher and RP X-OMAT LO Fixer and Replenisher.

Influence of developer temperature in case of automatic processing

-2 ºC	Ref	+2 ºC
0	Base fog	0
-5 %	Sensitivity	+10 %
+1 %	Contrast	-1 %

Replenishment Rate Recommendations for dedicated MIN-R Mammography, X-OMAT or RP X-OMAT Processors (Replenishment by length)

Film Feeding	Use Condition	Average Number of Films per 8 hours processor operation	Replenishment Rates (ml per 18 x 24 cm)	
			Developer	Fixer
Single	Medium - High	60 sheets or more	30-40	30
	Low	60 sheets or less	Flooded	Flooded
Double	Medium - High	60 sheets or more	60-80	60
	Low	60 sheets or less	Flooded	Flooded

Please refer to Service Bulletin No. 30, available on the Carestream website or upon request, for additional processing recommendations.

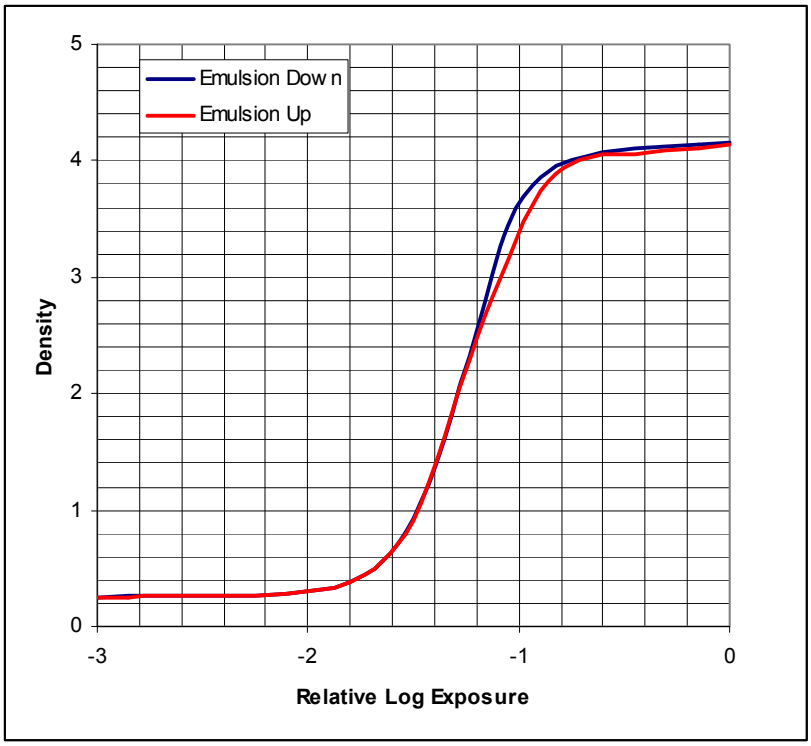
Processing MIN-R S Film
(Emulsion up versus down)

As with all current Carestream mammography films, we recommend processing MIN-R S Film primary emulsion side down in the MIN-R, 270 RA, 3000 RA and M35 series processors as well as in other manufacturers' shallow tank processors.

Processing non-uniformity, characterized by uneven optical densities on radiographs may occur due to the accumulation of processing by-products adjacent to the film emulsion inside the developer rack.

Processing the film primary emulsion side down allows the developer solution to reach the primary emulsion more efficiently, reducing the occurrence of non-uniform development.

MIN-R S Film
RP X-OMAT Developer / MIN-R Mammography Processor



Sensitometric Quality Control
(required for Germany and Switzerland)

The film was tested with a calibrated light sensitometer and processed in a MIN-R Mammography processor, filled with fresh RP X-OMAT Developer and RP X-OMAT LO Fixer.

Characteristics are measured according to DIN 6868-55

LE = 1.59 +/- 0.09
LK = 4.03 +/- 11 %

EI = 1.02 step = 10
KI = 1.80 step = 12 - 10

Note : the results obtained are dependent on exposure and processing conditions

Processing Chemistry:

Storage Considerations

A well-designed concentrate is relatively stable if stored properly. At room temperature (21.1 °C or 70 °F) concentrate solutions can have a shelf life of up to two years. Storage and use of chemicals at temperatures higher than recommended can accelerate oxidation and reduce shelf life. Using a floating lid to prevent aerial oxidation is highly recommended. Developer and fixer replenisher solutions should be mixed only in quantities large enough to be used up within two weeks.

Chemical Mixers

There are two basic types of commercial chemical mixers used in radiographic processing. Both types can be reliable in the preparation of solutions.

1. A specific gravity mixer will mix a solution by adding water until a determined specific gravity is reached. A probe is used that is calibrated to the specific gravity

2. A volumetric mixer employs an electronic probe to determine the necessary volume of the mix.

Important considerations with chemical mixers:

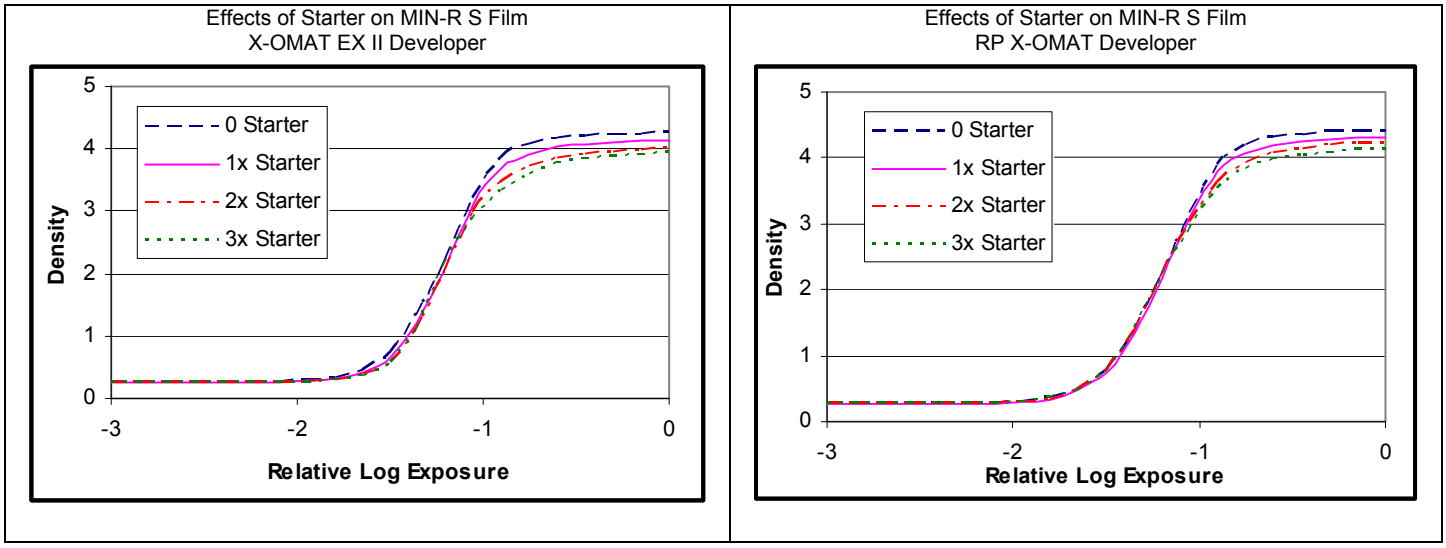
- Concentrates should always be added in the correct order. X-OMAT EX II and RP X-OMAT concentrates are designated to indicate mix order. The Part A should be added first, then Part B, then the Part C if applicable.
- Proper templates that match the bottles should be used.
- Thorough mixing is necessary after each addition.
- The mixed solution should not be uncovered or have too much contact with air as premature oxidation may occur.
- Ideally, the mixer should have a floating lid to protect the solutions from oxidation.
- If concentrates are used that have been repackaged by a distributor, the user should be certain the correct quantities of each concentrate are used.
- The concentrates should be examined to be certain there is no premature oxidation due to excessive handling.
- The manufacturer's recommended water-mixing temperature should be observed.
- A new mix of developer and/or fixer should only be made when indicated by the solution level in the mixer.
- **The processor should be turned off when mixing.**
- To aid in verifying that the chemistry is acceptable, the pH and specific gravity can be measured. It is important to make these measurements at the recommended temperatures for the instrument used.

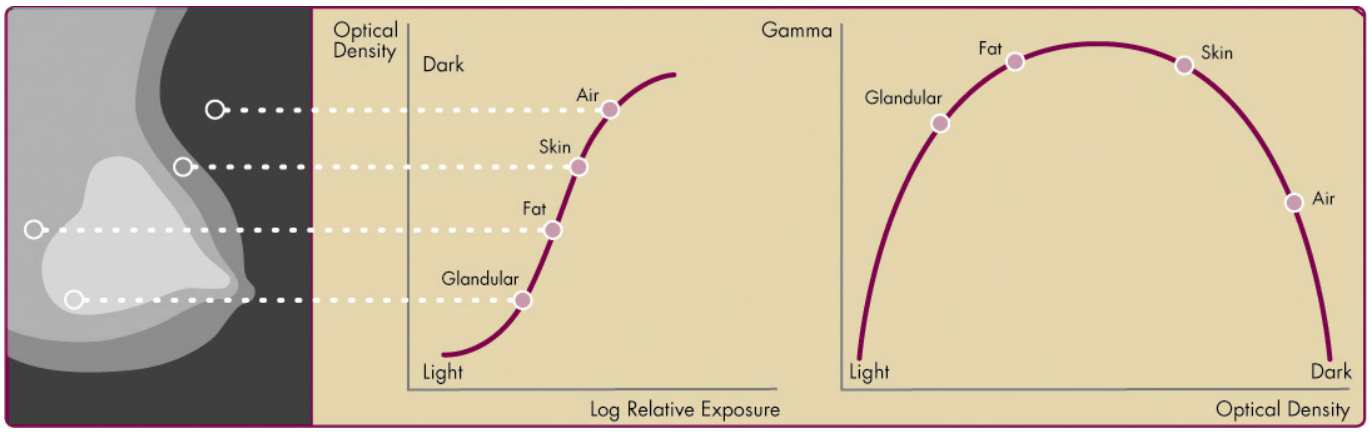
Why is Starter Important?

Starter is added to a developer when fresh solution has been placed in a processing tank. Starter will minimize changes in fog, speed and contrast during seasoning. The proper amount of starter should be used.

Over and Under Use of Starter

While the effects of over-and under-use of starter varies by film type as well as by different brands of starter, in general for some mammography films, not using starter will result in an increase in speed and D-max and a decrease in contrast on the H&D curve as well as the clinical image. Adding too much starter may also change speed, contrast and D-Max.





Optimizing exposure

The quality of the clinical images is the ultimate test of proper exposure technique in mammography. With no set standards, and a heavy dependence on the facility's processing and viewing conditions, as well as preferences of the radiologists, it can be difficult to optimize techniques for taking high quality mammographic images.

Film acts in combination with the view box as the display device. The display of the images must be carefully considered to optimize the simultaneous roles as recording and display device. Exposing an optical density series of images is a practical approach where actual images are used to evaluate the optical density to which images should be exposed. The use of images takes into consideration both recording of the image, as well as the viewing and display preferences of the observer.

Optical density series

Procedure #1: for assessing the effect of optical density on image quality
The following is a procedure that can be used to assess the effect of optical density on image quality. The procedure will produce phantom images that can be evaluated to assess image quality as the optical density is changed. MIN-R S Film will produce high quality images over a range of optical densities, and the choice at a given facility will be heavily dependent on the viewing conditions and the preferences of the radiologists.
This technique might be helpful in determining an optical density range to confirm with clinical images.

1. Assemble the tools which will be needed:
   - Mammographic phantom (e.g., phantom that adheres to the ACR mammographic accreditation phantom and/or anthropomorphic phantom).

- Mammographic cassette of the type used clinically (ideally, the same cassette should be used for all exposures).
- Fresh box of MIN-R S Film (all images must be made using the same emulsion).
- Spot reading densitometer.
- Prepare a mask for the images by exposing a 35 x 43 cm film to light, processing the film and cutting the mask and films to accommodate the images.

NOTE: *Mask to the edge of wax insert if using the ACR accreditation phantom.*

2. For each exposure, in the darkroom under appropriate safelighting, load a sheet of film into a clean mammographic cassette. Wait at least 5 minutes prior to each exposure.

3. Prepare to make the first exposure:
- Place the cassette into the moving grid cassette holder of the mammographic unit.
- Position the phantom on top of the grid.
- Lower the compression device until it contacts the top of the phantom. Ensure that all the images are taken with the same compression, preferably disabling the compression release if possible.
- Position the photoreceptor so it is centered underneath the phantom.
- The maximum exposure time of any image should not exceed some pre-determined value, such as 2 seconds.

NOTE: *The kVp and filtration should be fixed between all images at settings typically used for clinical images. The next section describes a procedure for evaluating kVp and filtration.*

4. Expose a series of phantom images using automatic exposure control in a fixed kVp mode, e.g., 28, and varying the density control setting.
For example, make exposures using the -2, -1, 0, +1, and +2 settings on the density control. Aim for the background optical density of all phantom images to range from a minimum of 1.40 to approximately 2.2. Use the densitometer to check the actual optical density in the center of each image.

5. Place the masked phantom images sequentially, labelled with the optical density used, on an illuminated viewbox used for mammography in a darkened room and examine the images.

6. Identify the image that shows the greatest amount of information (details). The optical density of the preferred image may indicate the optical density that should be used clinically.

7. Verify that the selected optical density produces adequate contrast in clinical images by making several exposures with the settings that produce that optical density in the phantom. It may be necessary to increase the optical density if glandular tissue is under-penetrated, or lower the optical density, if fatty tissue is overexposed.

Spectral changes (kVp series)

Procedure #2: for assessing the effect of varying kVp on image quality:

The following is a procedure that can be used to assess the effect of kVp on image quality. The procedure will produce phantom images that can be used to evaluate image quality as kVp is changed. It is expected that lower kVp will produce the best contrast – however, in some circumstances it may be desirable to use higher kVp to lower dose, or comply with exposure regulations. This technique might be helpful in determining how much kVp can be increased before image quality is adversely affected. (Filtration will also change the energy spectrum and hence impact the contrast in the image. The following procedure can be adapted to explore the impact of filtration changes on image quality by adjusting the filtration between exposures at a given kVp.)

(The following procedure assumes satisfactory kVp accuracy and reproducibility.)

1. Assemble the tools which will be needed:
- Mammographic phantom (e.g., phantom that adheres to the ACR mammographic accreditation phantom and/or anthropomorphic phantom).
- Mammographic cassette of the type used clinically (ideally, the same cassette should be used for all exposures).

- Fresh box of MIN-R S Film (all images must be made using the same emulsion).
- Spot reading densitometer.
- Prepare a mask for the images by exposing a 35 x 43 cm film to light, processing the film and cutting the mask and films to accommodate the images.

NOTE: *Mask to the edge of wax insert if using the ACR accreditation phantom.*

2. For each exposure, in the darkroom under appropriate safelighting, load a sheet of film into a clean mammographic cassette. Wait at least 5 minutes prior to each exposure.

3. Prepare to make the first exposure:

- Place the cassette into the moving grid cassette holder of the mammographic unit.
- Position the phantom on top of the grid.
- Lower the compression device until it contacts the top of the phantom.

Ensure that all the images are taken with the same compression, preferably disabling the compression release if possible.

- Position the photoreceptor so it is centered underneath the phantom.
- The maximum exposure time of any image should not exceed some predetermined value, such as 2 seconds.

NOTE: *The target optical density should be as typically used clinically. Each image in the following series should be within 0.05 of the target optical density.*

4. Expose a series of phantom images in an auto-time mode of the AEC, varying the kVp by one kVp increments, from the lowest kVp to the highest (i.e., 25–30 kVp).

5. Place the masked phantom images sequentially, labelled with the kVp, used on an illuminated viewbox used for mammography in a darkened room and view.

6. Identify the image that shows the greatest amount of information (details). The kVp and optical density of the preferred image may indicate the best technique for the phantom on the specific piece of mammographic x-ray equipment used.

7. Verify that the selected kVp produces adequate contrast in clinical images by making several clinical exposures at that kVp setting.
If more contrast is desired consider lowering the kVp. If less contrast is desired or could be tolerated, the kVp could be raised.

(Review of the optical density and kVp series):

- The above procedures can be a guide to selecting the optimal kVp according to the specific phantom used, which simulates one specific breast thickness and type only. The facility should establish an optimal kVp range for different breast thicknesses and densities. In particular, the use of one kVp for all breast types is not recommended.

- Study the images to assess the impact of changing kVp and optical density has on contrast. Optical density can have a significant affect on image contrast. The higher contrast of MIN-R S may make it possible to utilize higher kVps than those used previously.

- Phantoms comparing Mo to Rh can also be useful to assess the impact on contrast. Please reference Hendrick R, Berns E.,*Optimizing Mammographic Techniques*, RSNA Categorical Course in Breast Imaging, 1999; 79-89, for a discussion of some of the benefits that may be achieved by using the Rhodium filter.

NOTE: *These procedures are meant as a guide and starting point only for determining technique selection. Clinical images of various different breast types and thicknesses must be assessed to ensure that the radiologist preferences for contrast and optical density are met.*

Quick Reference Guide

To raise contrast

- Lower kVp
- Select Mo anode and Mo filtration
- Optimize film processing
- Select X-OMAT EX II Developer and Replenisher
- Adjust optical density within the range (1.5–1.8)

To lower contrast

- Raise kVp
- Select Rh filtration
- Select Rh or Wo anode with Rh filtration
- Select RP X-OMAT Developer and Replenisher (versus X-OMAT EX II)
- **Do not alter processing to lower contrast**

To lower noise

- Lower kVp
- Select Mo anode and Mo filtration
- Raise optical density (i.e. increase exposure time). Do not exceed 2.0 optical density on the accreditation phantom.
- Select RP X-OMAT Developer over EX II Developer
- Use a slower screen, e.g., MIN-R 2000 vs. MIN-R 2190

To lower dose (may increase perception of noise)

- Raise kVp
- Use faster screen (e.g. MIN-R 2000 Screen vs. MIN-R 2190 Screen)
- Select Rh filtration
- Select Rh or Wo anode and Rh filtration
- Lower optical density

Keys to success

- Proper processing set up
- X-ray unit calibrated to MIN-R S screen-film system
- Optical density optimized
- Proper viewing conditions
- Team communication

These recommendations should be taken as guidelines only. The radiologist/medical practitioner is responsible for interpreting the mammogram. They must be consulted when MIN-R S techniques are established.

Processor QC

Introduction: What is Processor QC?

Processor QC is a method for daily monitoring of the performance and consistency of the processor and chemistry. Small changes in the speed and contrast are expected. These levels will vary due to the release of chemicals during the development process, changes in film volume, quality of solutions, etc.

Aim values for speed, contrast and base + fog can be used to monitor the processing environment and ensure that adequate processing is being maintained. Processor QC is a means of not only identifying when the processor chemistry is out of control but to help identify trends and take corrective action before the processor is out of limits and cannot be used to process mammograms.

Establishing aims

Please note that MIN-R S Film should be exposed with the primary emulsion side down (facing the light source of the sensitometer). When making the exposure it is not necessary to use a dual sided sensitometer setting. The following Dip Switch settings are recommended for X-rite sensitometers models 394 and 396:

- SINGLE and GREEN settings at Exposure Setting No. 4
- 1-down, 2-down, 3-up, 4-down
  - Using a lower exposure setting will decrease the optical density, using a higher exposure setting will increase the optical density.

Process Control Procedure for Mammographic Processors

Items Needed

- Sensitometer with 21 density steps.
- Densitometer.
- Thermometer (not mercury) with accuracy of +/- 0.30 °C (+/- 0.50 °F)
- Fresh box of 18 x 24 cm film, the same as that used for mammography.
- Control charts

Establishing the Baseline

1. Ensure that:
   - the processor is thoroughly clean and functioning properly
   - the processor is filled with properly mixed fresh chemicals
   - the proper amount of developer starter has been added
   - the proper developer temperature and replenishment rates have been set.

2. Set aside a fresh box of 18 x 24 cm film that is used for mammography.
Designate it as your “QC” film and record the complete emulsion number on the control chart.

3. Set the sensitometer for the appropriate film spectral sensitivity (green) and for single-emulsion film.

4. On five (5) consecutive days, expose a sensitometric strip using film from the “QC” box; process immediately.

Note that:

a. the processor must be at the right temperature
b. the probe of the thermometer should be placed consistently in the same area on the non-drive side of the processor developer tank
c. single-emulsion film must be inserted into the sensitometer so the emulsion side faces the light exposing source
d. the sensitometric strip must be consistently fed into the processor so that the less-exposed end is fed first.
e. On the fifth day, use the densitometer to read the 21 density steps on each processed film.

NOTE: *Take the reading from the middle of each step.*

5. Average the values of the 21 steps for the five days.

Determining Mid-Density (MD)

1. Determine which step has an average density closest to 1.20. Designate this step as the mid-density (MD) step for all future MD determinations and record the step number on the chart.

2. Write the average MD value on the middle line.

Determining Density Difference (DD)

1. Select the step with the average density closest to 2.20.

2. Select the step with the average density closest to, but not less than, 0.45.

3. Subtract the density value determined in step 2 from the density value determined in step 1.
This value will be the density difference (DD).

4. Designate the two steps as those to be used for all future DD determinations and record the step numbers on the chart. Write the average DD value on the middle line.

Determining Base + Fog

1. The five-day average of the least exposed step (usually the first step) determines the Base + Fog of the film. (Any clear area of the film may also be used to determine Base + Fog.)

2. Write the average Base + Fog value on the middle line.

Developer Temperature

1. On the middle line, write the developer temperature recommended by the film manufacturer for your:
   - type of film
   - developer (chemicals)
   - processor
   - length of developer immersion time

Establishing Operating Limits

1. The preferred mammography MD and DD operating limits are +/- 0.10.
The maximum outermost limits are +/- 0.15.

2. Add 0.10 and 0.15 to the values on the middle line for MD and DD; write the preferred and maximum upper limits on the control chart.

3. Subtract 0.10 and 0.15 from the values on the middle line for MD and DD; write the preferred and maximum lower limits on the control chart.

4. Add 0.03 to the value on the middle line for Base + Fog; write the upper limit on the control chart. (There is no lower limit for Base + Fog.)

Daily Processor Quality Control

1. Expose and process a sensitometric strip each morning that mammography films will be processed.

2. Use the densitometer to read the values for MD, DD and Base + Fog, using the same steps recorded on the control chart.

3. Plot the MD, DD, Base + Fog, and measured temperature values on the control chart.

4. Evaluate the results and make any necessary adjustments before processing any films.

Evaluating the Control Chart

1. Points that are plotted on the control chart for MD and DD that are within the +/- 0.10 control limits should be considered normal process variations.

2. If any points are plotted on the control chart for MD and DD between +/- 0.10 and +/- 0.15, expose and process another sensitometric strip for comparison.
Mammography films may be processed. The processor should be closely monitored to make certain that the outermost limits are not exceeded.

3. If any plotted points on the control chart for MD and DD reach or exceed +/- 0.15, expose and process another sensitometric strip for comparison. If the same results are obtained, no mammography films may be processed until the cause is determined and corrected. Plot the results obtained after the process has been brought back “in

control."

Note the action(s) taken to achieve this in the "Remarks" section on the control chart.

4. Any points plotted for Base + Fog that are within 0.03 are considered to be normal process variations; any points plotted for Base + Fog that exceed +0.03 require immediate analysis.

5. The developer temperature should remain as close as possible to the temperature recommended by the film manufacturer; it should not vary by more than +/- 0.30 °C (+/- 0.50 °F).
6. A trend exists if a series of consecutive points (three or more) progress steadily upward or downward. Such a trend may be a shift taking place slowly and visibly with respect to time. Monitor the processor closely.

7. Trends or gross fluctuations should be noted and evaluated. If necessary, appropriate action should be taken. ***The "Remarks" section of the control chart should be used to note reasons for fluctuations such as routine preventive maintenance, fresh chemicals or developer starter added, etc.***

Final Comments

It is recommended that a processor maintenance log be kept for each processor to record all service on the unit. This log can be used to correlate processor service with processor performance. The calibration of the sensitometer, densitometer and thermometer should be checked periodically according to the recommendations, where available, of the manufacturer. The processing control chart may be used in various ways to monitor processor performance. For example, a new chart may be used for each month or information may be plotted continuously and a new chart started every 31 days.

Prior to establishing processor control limits, it is imperative that the processor be set up correctly following Service Bulletin No. 30. Clinical images must also be acceptable.

The processor will season to an equilibrium. The "seasoning effect" (the change in QC values between a fresh developer start up and the developer once it has reached equilibrium) is the rationale for averaging QC strips from multiple days to establish a baseline.

Seasoning is dependent on a variety of factors: chemistry, replenishment rates, film optical density and the area of exposed film.

The baseline should be established on a seasoned processor. Establishing an aim prior to the point at which seasoning is reached will result in an aim that is higher or lower than the true operating point for the setup conditions. This will shorten one side of the operating range and could result in unnecessary service calls or QC concerns.

Carestream recommends a minimum of five days (preferably including a weekend) to establish aims, but a longer period may ensure equilibrium. (This recommendation is based on amount of time to "turn-over" the solutions in the processor tank, and to balance out small variations due to setup of processor and typical fluctuations in processing volume and use. Testing has indicated that 75 % of the seasoning change occurs with one tank turn-over, 95 % with two tank turn-overs and 99 % with three.

i) a temporary aim must be established (from several strips acquired at the time of fresh start). If the processor was set-up properly, the control variables should not exceed the typical control limits during the averaging period. If greater variability is noted while establishing aims, the cause must be investigated, corrected and a new average should be started.

ii) if the daily QC is consistently above or below the aim then the processor may have not reached equilibrium before the aim was established. Consider establishing new aims based on additional days following the initial set-up and document the rationale.

Re-establishing Aims

The re-establishment of aims is recommended if there is any change in:

- film brand/type

- chemical brand/type
- replenishment rates
- specific gravity automixer settings
- film volume
- optical density
- sensitometer and densitometer
- processing cycle
- processor

If new aims are established it is important to validate that the clinical image quality is still acceptable!
NOTE: *Replacement of chemistry (same brand/type) as part of routine preventative maintenance should not necessitate establishment of new operating levels.*

Film Crossover Procedure

Perform a crossover procedure when a new box of QC film is opened to adjust the originally established parameters for speed, contrast, and base plus fog on the processor QC chart for the characteristics of the new emulsion. An adjustment is required because film used in medical imaging is produced in batches and there may be slight differences in the sensitometric characteristics from batch to batch. The conditions under which the film is stored (i.e., temperature, relative humidity, exposure to fumes from chemicals or to ionizing radiation, etc.) and the age of the film can also affect the sensitometric characteristics of film.

Performing a crossover procedure is necessary to maintain a controlled processing environment. Note the following important points:

1. The crossover should be performed on the same day rather than over five consecutive days as when the processor QC program was initially established.

2. Expose and process all of the films required for the crossover:
   - At the same time of day that processor QC is normally performed because slight sensitometric changes due to fluctuations in film feeding patterns throughout the day are common.
   - **All at the same time, without interruptions.**
   - **With the same delay (e.g., a few seconds) between exposure and processing that is normally used.**
   - Alternating the films from the existing QC box and from the new box.
   - Expose and process the followed by the first film from the new box, the second film from the existing box, the second film from the new box, etc. This distributes any sensitometric changes due to seasoning equally among the 10 films. The films from the existing box and new box can easily be distinguished from each other before processing by marking one set of films with a lead pencil or by cutting a corner of one set of films, etc.
   - The computations and adjustments to the control chart may be delayed until a more convenient time later in the day, if preferred.

3. The chemicals in the processor should be seasoned when a crossover is performed on a single day.

Generally, for this purpose, it is important to avoid performing a crossover immediately after a preventive maintenance procedure (PM). Monitor both the number of films remaining in the QC box and when the next processor PM will be performed so that the crossover can be performed before the PM occurs and with fully seasoned chemicals in the developer tank. A good rule of thumb is that a minimum of 10 to 15 films should remain in the existing box of QC film when beginning a crossover procedure. A piece of cardboard from the film box inserted between the last 15 films and the balance of the box makes a good divider and serves as a reminder that a crossover must be performed.

4. The processor should be in control (within the +/- 0.10 control limits for speed and contrast) for crossovers performed all on a single day. It is extremely unlikely, however, that the speed and contrast of the processor will be at the operating level originally established. It will be necessary, therefore, to adjust the new operating levels (taken from the characteristics of the new film) by the difference between the originally established aims and the current box of film.

5. The developer in the processor must have reached its operating temperature before doing a crossover procedure.

6. The crossover procedure should be fully outlined in the policy and procedures manual, and all QC personnel should be trained.

Performing a Crossover

Follow these steps:
1. Alternately expose and immediately process five sensitometric strips each from the current and new boxes of film.

2. Determine the average of the steps previously chosen for processor quality control (i.e., step 11 for speed, steps 13 and 9 for contrast, and step 1 for base plus fog for the five films from the current box and for the five films from the new box).

3. Adjust the aim operating levels on the control chart for speed, contrast, and base plus fog by the difference in the average values between the current and new boxes of film, as shown in the following equations:

Step 1:
New Box Average – Current Box Average = Difference
Step 2:
Original Aim + Difference = New Operating Aim

To confirm that the correct adjustment has been made, check that the offset (or difference) between the new operating level and the point which represents the average of the five films from the new box of QC film is exactly the same as the offset (or difference) between the old operating level and the point which represents the average of the five films from the current box of QC film.

- Record the complete emulsion number of the new box of film on the control chart.
- Make a notation in the “remarks” section recording the date and the fact that a crossover was performed.

Emulsion Number Log

Film manufacturers designate each box of x-ray film with a multiple-digit emulsion number. This number provides important information such as which particular emulsion batch was used as well as which roll it came from,
and the specific part (slit) of the roll. Keeping track of the emulsion number of the film used for processor quality control is done for processor quality control. It is also extremely advantageous to keep track of the complete emulsion numbers of all film used clinically. Doing so allows film manufacturers to make comparisons in speed, contrast, D-max, etc., between current clinical images and images taken one or more years previously. Such comparisons may assist in troubleshooting image quality concerns. (Please refer to the Split Film Phantom procedure.)

The easiest way to retain this information is to start an emulsion number log. The log should be posted in a convenient area and contain the following information:

- Type of film
- Date the box of film was opened
- Film size
- Complete emulsion number
- Any other comments, such as which emulsions were used for processor QC or phantom images. Every time a box of film with a different emulsion number is opened, a new entry should be made in the log.

Troubleshooting

Prior to troubleshooting and/or changing anything in the Imaging Chain, it is important to determine if the concern is with the QC charts, phantom charts or clinical image or any combination.

Benchmarking

Most QC programs specify a period of time for which to keep QC records (typically greater than 1 year) including

the routine test for **processor QC** and **phantom QC**. It is helpful to refer to these records and earlier images when problems arise.

Since a quality control test specifically for **clinical image quality** has not been defined, Carestream also recommends that facilities keep a log of some initial patient images at the time of successful conversion to MIN-R S Film, or when a major change to the system was made as well as the processor, QC film and a phantom image to serve as a benchmark. When a concern arises over clinical image quality, these images can be retrieved and compared to the present image quality.

A processing environment that is properly setup and maintained will produce very consistent image quality.

As part of maintaining the processing environment, most QC programs should have a test for monitoring the properties of processed film. Note that daily processor QC must be performed prior to any clinical imaging.

Several factors are important in understanding processor QC.

1. Processor QC is only as good as the initial reference so it is important that the processor is set up correctly.

2. The QC film should be processed at the same time each day, after the processor has been started and has had time to warm-up prior to clinical imaging or batch processing.

3. A change in processor QC is not necessarily a change in clinical image quality. Concern for changes in processor QC should be tempered by the quality of the clinical image.

4. If processor QC shows a trend or falls outside of control limits, then all the elements of the film and processing environment should be considered.

5. Processor QC monitors only several easily measured characteristics of the film processing environment. Some processing related factors such as image tone and dye stain may not be detected by monitoring processor QC only.

6. If the processor QC is out limits or is showing a trend:
- Redo the test
- Verify that the processor is set up correctly
- Determine if the workload has changed
    - Replenishment rates may need to be adjusted

Troubleshooting the Phantom

Optical Density Changes:

When the phantom is too dark or too light, consider/ensure the following:
- Redo the test
- Is the processor is in control?
- Was the same cassette used?
- Refer to the benchmark phantom to determine the reference optical density.
- Has the clinical image changed?
- Have the technical factors changed?
- Ensure that the phantom position and Automatic Exposure Position (AEC) are the same as in the benchmark test.
- Perform a split phantom test to determine if clinical film emulsions differ.

If the split phantom test indicates that the difference in optical density between emulsions is greater than 0.30, the film manufacturer should be consulted. If the processor is not in control, corrective action must be taken. The phantom test must be repeated once the processor is in control
- Do not make adjustments until it is determined what the impact on the clinical image will be.

Density Difference (Contrast) Changes:

When the density difference or contrast of the phantom changes, consider the following:

- Redo the test
- Is the processor is in control?
- Was the same cassette used?
- Ensure that the position of the phantom, compression and position of the AEC detector is the same as in the benchmark phantom.
- Have the exposure factors changed?
- Higher kVp, use of Rhodium filter and/or Rhodium and Tungsten anodes can reduce the density difference.

Changes in the Phantom Score

When there are changes in the phantom score, consider the following:

- Redo the test
- Is the processor in control?
- Technique change (i.e., kVp, mAs)
- Compare to benchmark phantom for optical density and density difference.
- Ensure that the position of the phantom, compression and position of the AEC detector are the same.
- Record reasons for increase or decrease in score.

BEST PRACTICE: If the score increases, investigate and document what has changed and then implement the change(s) into clinical practice.

Clinical Image Quality

The clinical image involves the entire imaging chain so any problem in the system has the potential to affect the clinical image. Monitoring clinical image quality, therefore, is critical to ensuring high quality images. Since all aspects of the imaging chain are involved in the creation of the image, it can be difficult to determine the impact changes in the imaging chain can have without an organized approach to troubleshooting. The clinical image must be combined with the analysis from the processor and phantom QC as these are the most likely sources of routine changes.

When clinical images vary from the previous without a change in the phantom or processor QC consider:

1. A change in technical factors (e.g., change in optical density, change in kVp). A patient identification (id) camera which includes the technical factors used (exposure mode, time or mAs, kVp, sensor/detector position, breast thickness, compression force and anode filter combination and other factors) is useful to compare to the technical factors used for a previous clinical image.

2. Viewing condition changes (intensity and uniformity of the viewbox) – clean or replace dirty or damaged diffusers. Verify that the use of masking and control of ambient light has not changed.

3. A drift in QC parameters – i.e., small changes over time which may have resulted in an adjustment of the QC parameters without verifying the impact on clinical image quality.
Previous QC records from the successful conversion to MIN-R S will be helpful in determining if there has been a change from the baseline QC

4. Radiologist preference change:
Images that were identified at the time of conversion, as representative of the preferred image quality can be helpful. Confirm the preferred technique by performing the following:

- kVp series
- Optical density series

Troubleshooting the Clinical Image

First, review the present technique factors as they compare to techniques used previously. A facility's techniques may "drift" from previously established parameters.

This may be associated with

- exposure control adjustments
- drifts in processing
- changes in viewing conditions
- changes in preferences.

When comparing exams of the same patient from year to year, to determine the cause of variability.

- Is it positioning?
- Is it technique?
- Is it compression?
- Is it contrast?
- Is it too dark?
- Is it too light?

Tips for Troubleshooting and Improvement

When using automatic exposure control, differences in compression and positioning can result in different technical factors that will affect contrast.

Poor compression may cause motion blur.

NOTE: *It is very important to determine whether the loss of image quality is due to contrast or optical density changes.*

Contrast

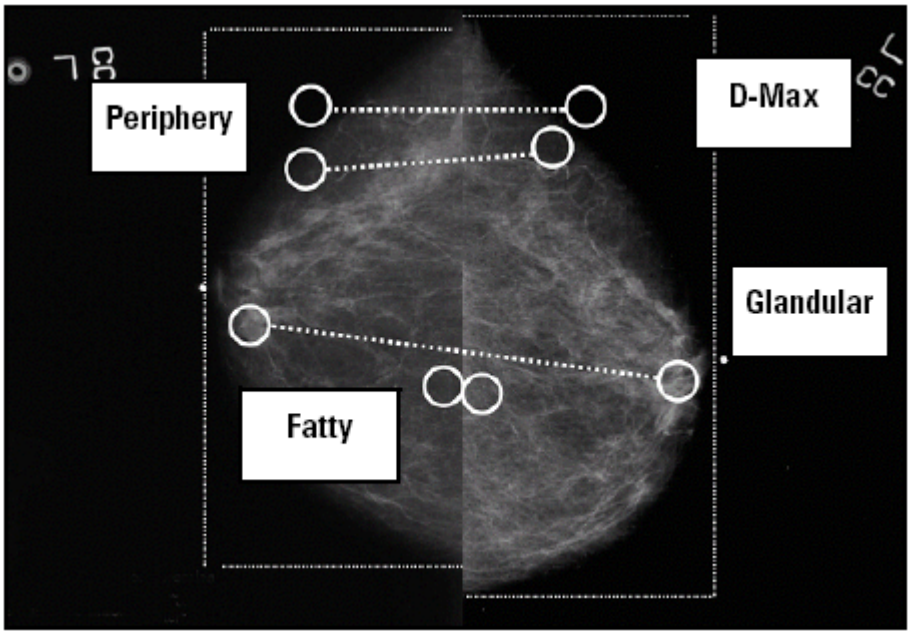
Increased contrast

– Images appear black/white
– Fatty tissue overexposed
– Glandular tissue may be under exposed
– Loss of skinline and breast periphery.

Check

– Processor changes
– kVp too low
– Anode filter Mo/Mo when Mo/Rh, Rh/Rh or Wo/Rh should be selected for breast type imaged.

NOTE: *the high film contrast of MIN-R S Film may result in high radiographic contrast. Consider adjusting technique factors. Use of higher kVp or Rhodium can lower dose to the patient and still produce excellent image quality.*



Note differences in compression and density in matched images

1. Compare kVp, compression, positioning, anode and filter, screens and x-ray equipment versus your previous.
    a. Measure the optical density in the glandular tissue, fatty areas, pectoralis muscle and the D-Max (area of darkest density) and compare to your previous clinical image.
    b. Determine if there is any tone difference between present and previous image.

Subject Contrast	+	Film Contrast	=	Too High Radiographic Contrast
kVp low Mo/Mo		MIN-R S high or Processing Changes		

Decreased Contrast

- Images appear flat, grey
- Washed out, lack crispness and sparkle

Check

- Processor changes (please refer to QC Trends)
- kVp too high

Anode Filter	
Rh/Rh Mo/Rh Wo/Rh	When Mo/Mo should be selected for breast type imaged.

Optical density too low

Subject Contrast	+	Film Contrast	=	Too Low Radiographic Contrast
High kVp Rh/Wo Anode Rh Filter		MIN-R S and/ or Processing Changes		

Optical Density

- Overexposed (too dark)
    - Breast periphery and fatty tissue may appear lower in contrast

If the optical density is set too high, glandular tissue may be penetrated, but other areas of the breast will be too dark. Fatty tissue and breast periphery may appear low in contrast.

- Under exposed (too light)
    - Glandular tissue will not be penetrated – abnormalities may be missed.

If the optical density is too low, portions of the breast image will be under exposed and may exhibit low contrast. The
breast parenchyma may not be adequately penetrated.

Check:

- Processing changes?
- Technical Factors changed
    - Follow established techniques
- AEC detector position
    - Place the detector under the glandular tissue or the area of interest
- Correct screens used-are different speeds of screens used in the department?
- Emulsion changes
    - Perform split phantom test,
- Viewing Conditions

Split Phantom Test

A split phantom test should be performed to radiographically determine relative speed differences between two different emulsions of film, one of which is suspected of being much faster or slower than the film in current use for either clinical films or for processor quality control. Speed comparisons made using a sensitometer may not accurately reflect the differences in speed between two films exposed by light from an intensifying screen as is done clinically.

The procedure is as follows:

Tools:

- A phantom used for mammography quality control testing.
- The 18 x 24 cm mammography cassette normally used for the phantom test.
- A piece of cardboard from the film box cut in half to use as a guide.
- A pair of scissors.
- A lead pencil.

The mammography x-ray unit and the processor will also be used for this test.

Note that roomlight film-handling systems may not be able to remove the two pieces of film from the cassette or the films may not transport properly. If the roomlight film-handling equipment is installed through the darkroom wall and has a back door, the two films may be processed using that route. Place the film in larger cassettes. Alternatively, the two films may be processed in the processor used as backup for the mammography processor, or in any other processor available elsewhere in the facility.

1. In the darkroom, in total darkness to reduce any additional density added to the films due to long safelight exposure, cut a sheet of film from the current box in half by using the cardboard as a guide. (This can be done by lining up the 18 cm edges of the cardboard and film, with the film closest to the countertop and the cardboard half on top.)

Use care in cutting the film in the dark.

2. Place the film emulsion side up in the cover of the opened cassette with the film on the right side and the cut edge toward the right edge of the cassette; use a lead pencil to mark the corner N for normal.

3. Cut a sheet of film from the suspect box in half by using the cardboard as a guide.

4. Place the film emulsion side up in the cover of the opened cassette with the film on the left side and the cut edge toward the left edge of the cassette; use the lead pencil to mark the corner S for suspect.

5. Make sure the film edges in the center of the cassette are directly adjacent to one another and not overlapping before closing the cassette.

6. Place the cassette with the two film halves in the bucky (image receptor) of the mammography x-ray unit.

7. Place the phantom on top of the grid in the standard location used for mammography quality control testing.

8. Position the photocell beneath the center of the phantom (standard location), assuming the phantom exposure is always made using the phototimer.

9. Select the same technique factors usually employed when imaging the phantom (same kVp, etc.).

10. Make the exposure and process the two film halves immediately in the same manner (e.g., emulsion side up and on the right side of the processor).

NOTE: *Daylight handling system should not be used to unload the cassette. Place in larger cassettes. Film halves should be manually fed through the processor.*

11. Use a densitometer to take two optical density readings in the center of the phantom, just to the right and left of the cut edges (one on the normal and one on the suspect film).

12. Calculate the density difference by subtracting the optical density value of the suspect film from the optical density value of the normal film.

- If the density difference is a negative value and the suspect film is darker than the clinical film, the suspect film is faster.
- If the density difference is a positive value and the suspect film is lighter than the clinical film, the suspect film is slower.

According to the American College of Radiology (ACR) in *Mammography Quality Control Manual (1999)*:
"If a change in phantom image background optical density or DD reaches or exceeds the recommended performance criteria, then it will be necessary to determine the source, or sources, of this change, e.g., the processor, film emulsion batch, X-ray generator, etc., and the problem should be corrected immediately. Document corrective action for future reference and compliance with MQSA regulations. If the change in film optical density is confirmed to be due to a change in the film emulsion batch, and if the magnitude of the change is within the expected batch-to-batch variation for that film type, then an adjustment of the density control setting to bring the phantom background optical density back into control is an appropriate corrective action." (page 186).

The 1995 ACR publication, *Recommended Specifications for New Mammography Equipment*, suggests that

- "A density difference of 0.30 between any two films of the same type from the same manufacturer, exposed and processed together, is a reasonable maximum to be expected from manufacturing variability for films of roughly the same age and storage conditions.
- If the difference between the two film densities exceeds 0.30 at a density of approximately 1.25 (as specified by the test), then the film supplier should be contacted to determine the source of the problem."

Note that a difference of 0.30 at a density of approximately 1.25 may translate into a bigger difference for clinical films exposed at a greater optical density. For example, high-contrast mammography films, such as MIN-R S Film, are frequently exposed at an optical density between 1.60–1.90 in order to maximize contrast. The density difference at this optical density level may be greater due to the increased contrast.

Image Tone

- Optical Density will play a major role in the appearance of tone (higher density=less blue, warmer or browner).

- Tone can be influenced by the spectrum and intensity of light from the viewbox. Viewbox factors include:
    - the spectrum from the fluorescent lamps,
    - the spectral transmission of the diffuser and
    - the reflective interior of the viewbox
- To compare tone between images it is essential they be of the same optical density and viewed on the same lightbox.

Factors affecting image tone:

- The structure of the film (morphology of developed silver grain, support density)
- The developer formulation and condition can effect silver morphology
- Type and condition of fixer
- Temperature of water (wash and mixing)

Troubleshooting image tone concerns

- Determine if the complaint is tone, dye stain or contrast.
- Examine phantom images over time
- Review the processing conditions – chemistry type, properly mixed, fresh or oxidized
    - replenishment rates
    - developer, fix and wash water temperature
    - chemistry mixing temperature
- Ensure that optical density matches between the previous and present clinical images when comparing tone. If optical density has increased, images will appear warmer in tone. This is a characteristic of all silver halide films.

Quick Reference Guide:

Mammographic x-ray units should be calibrated for the MIN-R S system by qualified service personnel.

Optical density:

- For MIN-R S Film, the recommended optical density range is between 1.4–1.8 (good tradeoff between exposure times, viewing conditions and film contrast).
    - Depends heavily on viewing conditions, observer preferences, film screen combination.
    - Higher optical density (1.7–1.8)
- Optimum viewing conditions:
    - Bright viewboxes
    - Masking
    - Ambient light controlled
- Increases exposure time
    - Motion blur could result
    - Fatty tissue may be overexposed with reduced contrast
    - Tone may be warmer/browner

- Lower Optical Density (<1.4)
    - Glandular tissue underexposed
        - Abnormalities may not be visualized
        - Tissue appears lower contrast

kVp

- Lower kVp will increase subject contrast, higher kVp will reduce subject contrast.
    - The use of the high contrast MIN-R S Film may balance this.
- Lower kVp will increase exposure time and patient dose; higher kVp will shorten exposure time and decrease patient dose.
- kVp should be as low as possible to achieve the desired optical density and keep the exposure time reasonable (between 0.5 and 2.0s) depending on breast composition and thickness.
- A general rule of thumb would be low kVp (24–-27) for thinner fatty breasts and higher kVp (27–31) for thicker dense breasts.

Anode/filter

- Selection of anode/filter combination should be made according to breast thickness and composition:
  - Mo-Mo is reasonable for most thinner fatty breasts.
  - Rh anodes and filters should be considered for thicker denser breasts in order to shorten exposure times.

Exposure time

- Exposure times that are too short may not be reproducible and image consistency will not be maintained. Images may appear noisy.
- Exposure times that are too long (>2.0s in an average breast) increase patient dose and may lead to motion blurring
- To reduce exposure time consider raising kVp (or lowering optical density).

Exposure modes

- Most machines offer timed automatic exposure mode where the operator selects kVp and filtration and the exposure is controlled for the time the x-rays are on.

Some machines will have other automatic modes in which kVp and filtration can also be selected automatically. If this mode of operation is used, the operator should monitor the kVp and filtration selection. The automatic algorithm should not select the higher kVps or Rh anodes and filtrations except in very thick and dense breasts (see tips above). The x-ray equipment manufacturer should be consulted to ensure that the automatic algorithms match the preferences of the facility.

Understanding Automatic Exposure Control

It is difficult to determine breast composition by breast thickness. Manual selection of technique factors can result in mammograms of under or over exposure as well as poor contrast. Properly calibrated AEC will automatically select all or some of the technique factors which will produce more consistent images.

Types of AEC

Manually select kVp, anode and filter	AEC will select mAs
Manually select kVp	AEC will select mAs, anode and/or filter
AEC will select all technique factors	kVp, mAs, anode, filter

NOTE: *If the automatic exposure control is operating and has been calibrated correctly, the optical density should be consistent when technical factors change,*i.e., kVp ↑ mAs ↓ = OD = kVp ↓ mAs ↑

Parameter				Subject Contrast	O.D.	Dose	Possible Issue
Anode	Filter	kVp	mAs				
Mo	Mo	↓	↑	↑	=	↑	Motion blur/black/white
Mo	Mo	↑	↓	↓	=	↓	Grey/flat
Mo	Rh	↑	↓	↓↓	=	↓↓	Flat, Noise ↑
Rh/Wo	Rh	↑	↓	↓↓↓	=	↓↓↓	Noise ↑ , grey, more skin line

Caution: Grid lines can occur if exposure time is too short.

Trends in QC Charts

What is a trend?

A trend is any deviation in the same direction from the established aim for longer than three days.

When Mid Density (MD) or Speed Index (SI), Density Difference (DD) or Contrast Index (CI), and Base + Fog (B + F) differ greatly from expected values and/or indicate an out-of-control processing environment (e.g., reaching or exceeding ±0.15 of the operating levels for MD and DD), always generate another sensitometric strip, making sure that:

- The primary emulsion side of the film was toward the light source of the sensitometer.
- The temperature of the developer solution in the processor has stabilized before exposing and processing the sensitometric strip.
- The settings on the sensitometer were properly set (i.e., single-sided exposure for single emulsion films, double-sided for double-sided films, appropriate spectral sensitivity (green or blue), recommended DIP switches if the sensitometer is exposure adjustable, etc.).
- The film used was taken from the box set aside for processor quality control.
- The delay between exposing and processing the film is as normally occurs from day to day. (Note that immediate processing after exposure of the sensitometric strip by the sensitometer is recommended.)
- The same densitometer was used to measure MD, DD, and B + F values.
- The calibration of the densitometer is correct.
- If an automatic scanning densitometer is used, the correct channel was used and the programming has not been changed.
- ***It may be recommended to expose another phantom image at normal settings and determine if the same trend visible on the QC chart is also visible on the phantom's background density and density difference.***

Please Note:

- If the numbers are out of limits, adding additional starter or partially filling the developer tank with fresh developer is not recommended.
- **Retaining the developer solution after a processor maintenance is not required.**

Compare MD, DD, and B + F results from the processing control chart to the information below to determine possible causes and corrective actions.

Trends in Graph	Possible Causes	Corrective Actions
MD: ↑ DD: ↑ B+F: → D-Max: → or ↑	Severe under-replenishment	• Check developer replenishment rate • Check that rate is set as recommended in Service Bulletin No. 30 • Check for kinked or air-locked developer replenishment line • Check for improperly mixed (over diluted) developer replenisher • Check amount of water added • Check chemical usage • Check for change in film volume since rate was set and adjust accordingly (raise) • Communicate changes in film volume to processor service firm
MD: ↑ DD: ↑ B+F: → The image tone will appear browner.	Very Severe Contamination of developer with fixer (Developer will smell strongly of ammonia, may be green in color)	• Call service to clean the processor • Drain developer tank • Thoroughly flush tank and developer rack with water • Change the developer filter • Use splash guards • Remove and insert the fixer rack carefully • Process films with edges in contact with film feed tray guides to avoid film jam
MD: ↓ DD: ↓ B+F: → D-Max: ↓ The image tone will appear browner	Severe oxidation of developer	• Always use a floating lid on top of the developer replenisher inside the holding tank • Check the developer replenishment rate • Call service to check the processor
	Exhausted developer	• Check developer replenishment rate • Check that rate set as recommended in Service Bulletin No. 30 • Check chemical usage • Check for change in film volume since rate was set and adjust accordingly • Communicate changes in film volume to processor service firm • Check processor ventilation
MD: ↑ DD: ↓	Expired film	• Check film expiration date • Manage film inventory using first-in, first-out method

D-Max: ↓ B+F: ↑	Film stored above the recommended temperature and relative humidity	• Store unprocessed/unexposed film and processed radiographs between 10–24 ˚C (50–75 ˚F) and 30–50 %RH
MD: ↑ DD: ↓ B+F: ↑ or → D-Max: ↑	Over-replenishment	• Check Service Bulletin No. 30 for recommended rates and adjust accordingly
	No starter added to fresh developer in processor developer tank	• Check Service Bulletin No. 30 for the amount recommended for chemistry, film and processor in use • Add the correct amount of RP X-OMAT Developer Starter or X-OMAT Developer Starter
	Insufficient amount of starter added to fresh developer	• Add the correct amount of RP X-OMAT Developer Starter or X-OMAT Developer Starter
	Safelight Fog	• Perform darkroom fog test.
MD: ↑ DD: ↓ or ↑ B+F: → D-Max: → or ↑ Image tone may appear browner	Slight Contamination of developer with fixer	• Call service to clean the processor • Drain developer tank • Thoroughly flush tank and developer rack with water • Change the developer filter • Use splash guards • Remove and insert the fixer rack carefully • Process film with edges in contact with film feed tray guides to avoid film jams
MD: ↑ DD: ↓ or → B+F: ↑ or →	Developer temperature higher than recommended [within 3 ˚C (5 ˚F)]	• Measure developer temperature using accurate or calibrated thermometer • Verify developer temperature set as recommended in Service Bulletin No. 30 for model of processor • Lower thermostat to correct temperature • Check thermostat to correct temperature • Check water flow and temperature
	Water temperature higher than recommended (if developer temperature set above set point)	• Check temperature of incoming water • Verify water temperature set as recommended in Service Bulletin No. 30 for model of processor • Install mixing valve to regulate water temperature
	Developer time longer than recommended	• Check immersion time using time-in-solution test tool

MD: ↓ DD: → or ↓ B+F: →	Developer temperature lower than recommended [within 3 ˚C (5 ˚F)]	• Measure the developer temperature using accurate or calibrated thermometer • Verify developer temperature set as recommended in Service Bulletin No. 30 for model of processor • Raise thermostat to correct temperature • Check thermostat and recirculation pump for malfunction • Check water and temperature
	Water temperature lower than recommended (if developer temperature below set point)	• Check temperature of incoming water • Verify water temperature set as recommended in Service Bulletin No. 30 for model of processor • Install mixing valve to regulate water temperature
	Developing time shorter than recommended	• Check immersion time using time-in-solution test tool
MD: ↓ DD: ↑ B+F: → D-Max: ↓	Too much starter added to fresh developer (>50 percent)	Check Service Bulletin No. 30 for the amount recommended for the model of processor in use. • Add the correct amount of RP X-OMAT Developer Starter or X-OMAT Developer Starter

MIN-R S Film Response to Seasoning, Over and Under Replenishment
RP X-OMAT Developer and RP X-OMAT LO Fixer

Parameter	Over-Replenished	Normal Starter	Normal Seasoning	Under-replenished
Base+Fog (gross fog)	"="	"="	=	=
Speed (measured at 1.0 above Base+Fog)	↑	"="	↑	↑
Contrast (Average Gradient or Contrast Index) /(Mid-scale)	↓	=	↓	↑↑
Toe Contrast (Whites)	=	=	"="	↑
Shoulder Contrast ↑Increased shoulder contrast (less skin line or breast periphery) ↓ More visible skin line	=	=	↑	↓↓↓
D-Max (dark surround)	↑	=	↑↑	↑
Image Tone ↑ bluer ↓ browner/warmer	=	=	=	↓
Dye Stain ↓ (lower = bluer, higher= pinker) Mainly visible on QC film	=	=	↓	=

Processed in a MIN-R Mammography Processor
"=" is equivalent to results obtained with "Normal" starter
"Normal" Starter (25 ml/l or 3 ounces/gallon RP X-OMAT Developer Starter or X-OMAT Developer Starter) is the baseline.
Speed: ↑ is a 2.5 % change in optical density at the speed point when measured at 1.0 above Base+Fog.
Contrast: ↑ is a 0.10 change in average gradient
Toe: ↑ is a 0.05 change
Shoulder Contrast: ↑ is a 0.2 change
D-Max: ↑ is a 0.1 change in optical density

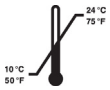
MIN-R S Film Response to Seasoning, Over and Under Replenishment
X-OMAT EX II Developer and RP X-OMAT LO Fixer

Parameter	Over-Replenished	Normal Starter	Normal Seasoning	Under-replenished
Base+Fog (gross fog)	=	=	=	=
Speed (measured at 1.0 above Base+Fog)	↑↑↑	=	↑↑↑	=
Contrast (Average Gradient or Contrast Index) (Mid-scale)	↓↓	=	=	↑↑↑
Toe Contrast (Whites)	"="	=	=	↑
Shoulder Contrast ↑ Increased shoulder contrast (less skin line or breast periphery) ↓ More visible skin line	"="	=	=	↓↓↓↓
D-Max (dark surround)	↑	=	↑↑↑	↑↑
Image Tone ↑ bluer ↓ browner/warmer	=	=	↓	↓
Dye Stain ↓ (lower = bluer, higher= pinker) Mainly visible on QC film	=	=	=	=

Processed in a MIN-R Mammography Processor
"=" is equivalent to results obtained with "Normal" starter
"Normal" Starter (25 ml/l or 3 ounces/gallon RP X-OMAT Developer Starter or X-OMAT Developer Starter) is the baseline.
Speed: ↑ is a 2.5 % change in optical density at the speed point when measured at 1.0 above Base+Fog.
Contrast: ↑ is a 0.10 change in average gradient
Toe: ↑ is a 0.05 change
Shoulder Contrast: ↑ is a 0.2 change
D-Max: ↑ is a 0.1 change in optical density

Storage and Handling

Storage -

Unexposed:		10–24 °C (50–75 °F) Do not refrigerate or freeze as this can cause condensation to occur.
		30–50 %RH
		Protect from heat and radioactive sources. Film is to be properly shielded from x-rays, gamma rays, or penetrating radiation.
Exposed:	Keep cool, dry, and properly shielded from penetrating radiation. Process as soon as possible.	
Processed:	16–27 °C (60–80 °F), 30–50 %RH	

The film should be used before the expiration date  indicated on the box with the lot number LOT.

Handling -

Hands must be clean, dry and free of lotions, etc. Film should be handled carefully by the edges to avoid physical strains such as pressure, creasing, or buckling. Luminous watches, cell phone and darkroom light leaks should be avoided.

Do not re-use. Film is a single use medical device.

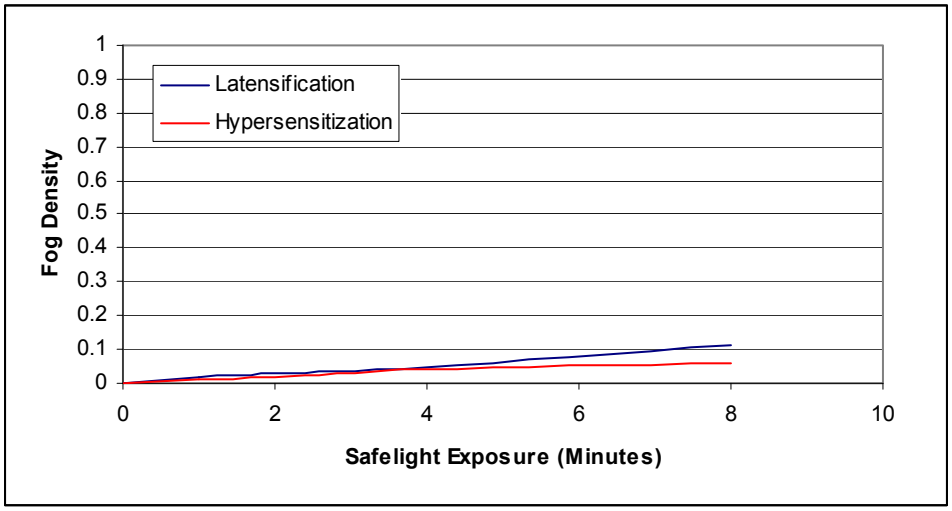
Safelight Filter

Use a Ruby Red Safelight Filter, such as GBX-2, with a frosted 7.5-watt bulb located at least 1.22 metres (48 inches) from the film.

Latensification: Safelight exposure after primary x-ray exposure.

Hypersensitization: Safelight exposure prior to primary x-ray exposure.

MIN-R S Film
GBX-2 Safelight Filter, 7.5-watt bulb / 1.22 metres (48 inches)
X-OMAT 5000 RA Processor, RP X-OMAT Chemicals, 35 °C (95 °F)



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