Collimation Assessment Using GAFCHROMIC® XR-M

I. *Introduction*

A method of collimation assessment for GE Senographe full-field digital mammography (FFDM) systems is described that uses a self-developing film as an auxiliary image receptor. The film used, GAFCHROMIC® XR-M, incorporates a scale that is imaged by the digital image receptor providing the means to establish both the light field–to–x-ray field deviation and the detector–to–x-ray field deviation. The XR-M film does not require wet chemistry processing or any other form of ancillary processing equipment. The film is insensitive to visible light, but after exposure to x-rays, an image is formed essentially instantaneously.

The XR-M film is less sensitive than conventional mammographic film used with an intensifying screen. The dose needed to obtain useful contrast leads to saturation of the digital detector. However, by interposing a suitable attenuator between the film and the detector, satisfactory images can be achieved on both the film and the digital image receptor.

II. *Test Equipment*

- Four GAFCHROMIC XR-M film strips for each x-ray field to be tested.
- An x-ray beam attenuator having a cross-section sufficiently large to cover the entire field of view of the detector and also support the film strips, which can extend about 4 cm beyond the light field on each edge.

  The purpose of the attenuator is to enable the use of a sufficiently high exposure to the film to obtain useful contrast in the image of the x-ray field edge while avoiding saturation of the image acquired by the digital detector. A 3.2 mm-thick sheet of aluminum has been found to work well. Other materials or thicknesses that suit the purpose might also be used. ***To avoid causing any damage to the acrylic test plate used for flat field calibration and testing, do not use that plate as the attenuator for this collimation assessment.***

Note: If the attenuator does not completely cover the field of view, a ghost image will be imposed on the digital image receptor at the edge of the attenuator. Ensure that the entire field of view is covered by the attenuator.

- Coin or other marker if also testing compression paddle alignment.

III. *Procedure*

1. Install the Bucky on the image receptor.
2. Place the attenuator on the breast support surface of the Bucky.

Note: To achieve better contrast of the edge of the light field, it is recommended to tape a sheet of white paper to the top of the attenuator. See Fig. 1.

3. Set the collimator to the field size and, for an Essential system, location to be tested.
4. Remove the compression paddle to assure a sharp indication of the edge of the light field.
5. Label each film strip with the anode track (Mo or Rh) and field edge (chestwall, anterior, left, or right) to be tested. See Fig. 2.
6. Turn on the collimator light and place one of the film strips near the center of each side of the light field. See Fig. 1.

Note: To achieve better contrast of the edge of the light field, it is recommended to place the XR-M film strips with the white side facing the collimator, orange side down.

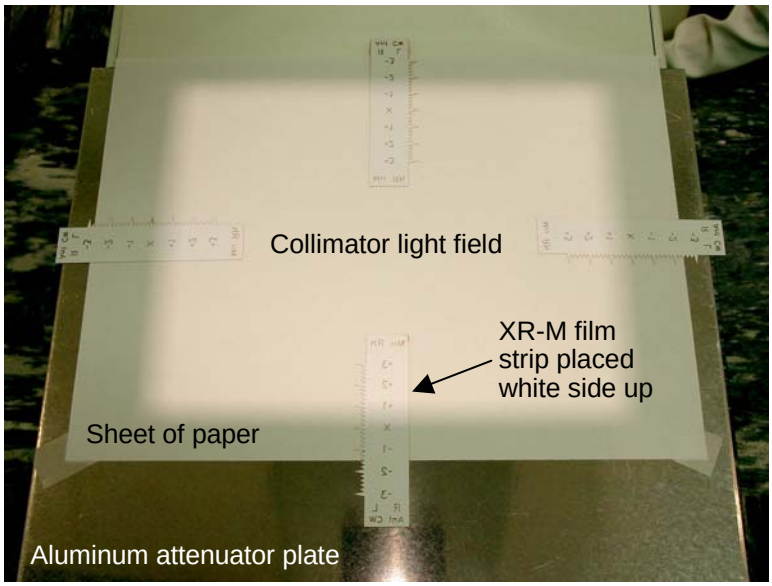


Figure 1. Equipment setup for making the collimation assessment.

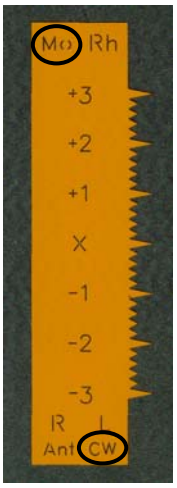


Figure 2. Labeling of film strip to identify anode track and field edge. Film strip labeled for chest wall edge of Mo track.

7. Align a reference line on the film strip with the edge of the light field. See Fig. 3.

Note: Among the labels cut into the film strip, the minus sign, the horizontal bar of the plus sign, and the center of the "X" align with the associated major "teeth" of the saw tooth pattern that constitutes the measuring scale. Hence, two references points are available for alignment of the light field edge at each of the major scale markers.

Note: It is possible to use one XR-M film strip for more than one measurement. For example, for the Mo track one could align the light field at the "–1" position with the "–3" end of the film strip inside the x-ray field. Then for the Rh track one could align the light field at the "+1" position with the "+3" end of the film strip inside the x-ray field.

Note: At the anterior edge of the field (opposite the chestwall edge), the Bucky enclosure might interfere with the film strip. See Fig. 4. The user could elevate the attenuator while keeping it parallel to the breast support surface of the Bucky or select a reference line of the film strip that avoids the interference (Fig. 5).

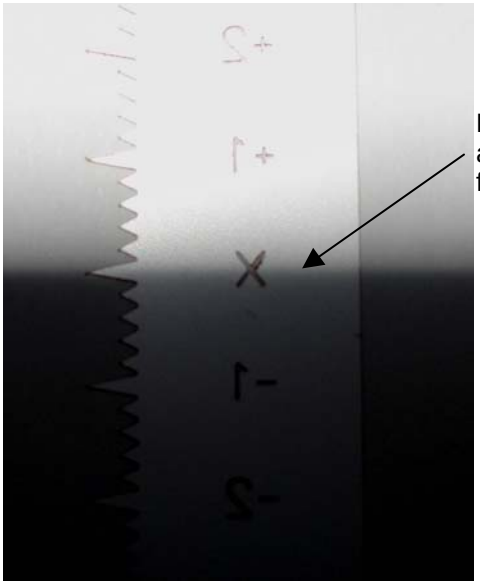


Figure 3. Alignment of edge of light field with reference mark of XR-M film strip.

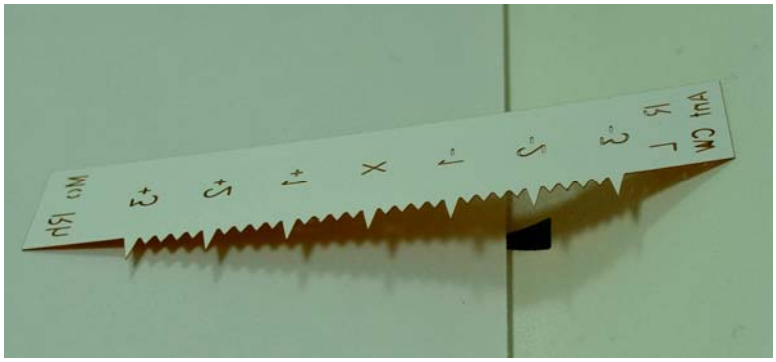


Figure 4. Interference of XR-M film strip with Bucky enclosure.

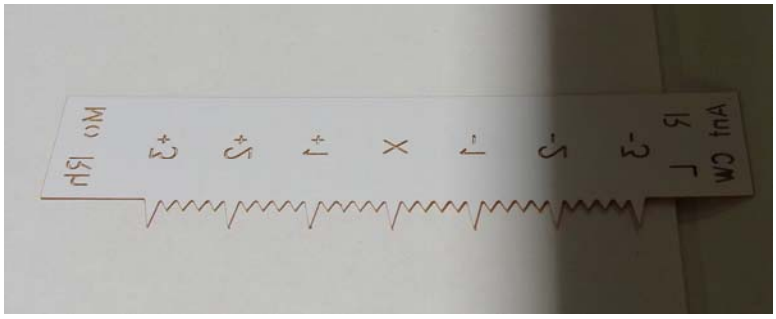


Figure 5. XR-M film strip repositioned to avoid interference with Bucky enclosure.

8. If the alignment of the compression paddle is also being tested at this time,
   - tape the coin to the underside of the paddle, tangent to the inner, vertical surface of the compression paddle at the chest wall edge. Position the coin near the center of the chest wall edge but at a location where it will not block the irradiation of the film strip at that edge.
   - Install the compression paddle and position it approximately 4.2 cm from the breast support surface.

9. Select
   - manual exposure mode,
   - the track/filter combination, either Mo/Mo or Rh/Rh,
   - 30 kVp,
   - 200 mAs.

   and make an exposure.

Note: If the compression paddle has been installed to also test the alignment of the compression paddle, there might be a need to increase the mAs to compensate for the attenuation of radiation by the compression paddle, typically about 25%.

10. Perform Steps III.3 through III.9 for the large focal spot of both the Mo and Rh anode tracks. If doing a mammography equipment evaluation on an Essential, also test the offset field positions.

IV. *Analysis*

1. The light field–x-ray field deviation in the plane of the XR-M film strip can be read directly from the strip using the incorporated ruler. See Fig. 6. Here the edge of the x-ray field is 5 mm inside the edge of the light field. Note that the distance between the major "teeth" of the saw tooth pattern is 1 cm; the tooth-to-tooth distance is 2 mm.

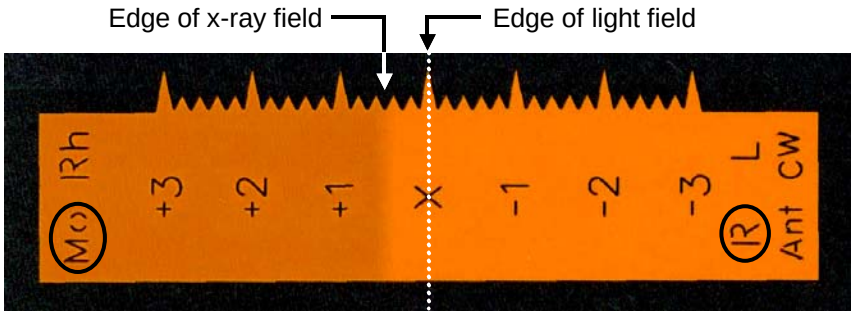


Figure 6. Determination of light field–x-ray field deviation in the plane of the XR-M film strip. For this determination, the light field was aligned at the "X."

2. View the digital image of the XR-M film strip. See Fig. 7. Determine the location of the detector edge based on the extent of the XR-M film strip imaged. For example, in Fig. 7, the edge of the detector is 9 mm from the "X."

   Knowing the location of the x-ray field edge from IV.1, one can determine the deviation of the x-ray field edge from the detector edge in the plane of the film strip. For this example, the edge of the x-ray field is 5 mm from the "X" and the edge of the detector is 9 mm from the "X." Hence, the detector–to–x-ray field deviation is 4 mm. The relative positions of the edges of the light field, x-ray field, and detector become more apparent when the x-ray image is scaled and superimposed on the film strip as illustrated in Fig. 8.

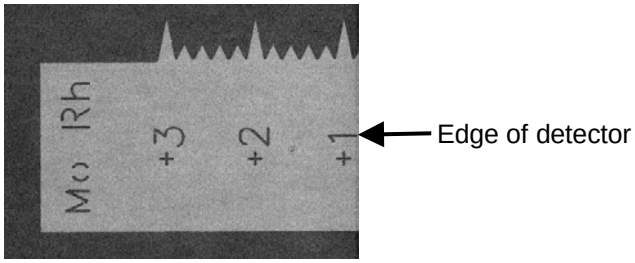
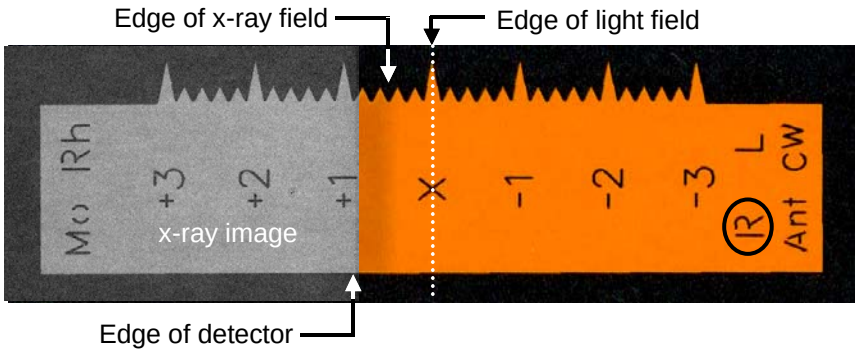


Figure 7. Extent of the film strip of Fig. 6 that is included within the detector's field of view and seen in the x-ray image. The edge of the detector is about 9 mm interior to the "X" of the film strip in the plane of the strip.



X-ray field-to-Detector deviation = 4 mm in plane of XR-M film

Figure 8. Superposition of scaled x-ray image (Fig. 7) over film strip (Fig. 6) to demonstrate the relative positions of the light field, x-ray field, and detector.

3. For Senographe FFDM systems, the deviations are to be referred to the image receptor plane. The following method, which uses the ***Segment*** tool of the image ***Viewer*** of the Acquisition Workstation, may be used to establish a factor, *s*, to scale measurements in the film strip plane to the image receptor plane. See Fig. 9.

   - Measure on the XR-M film strip the distance, d_1, between two reference marks, e.g., major "teeth" on the ruler, that also appear in a digital image.
   - Measure the corresponding distance, d_2, in the digital image using the ***Segment*** tool.

   The ***Segment*** tool measures distance in a plane 2 cm above the breast support surface. The magnification factor from this surface to the image receptor plane is 1.063. Hence, to scale measurements from the film strip plane to the image receptor plane, the scale factor is

   $s = 1.063 \times (d_2 / d_1)$.

4. Finally, scale the measurements from IV.1 and IV.2 to the image receptor plane by multiplying the results by the scale factor *s*.

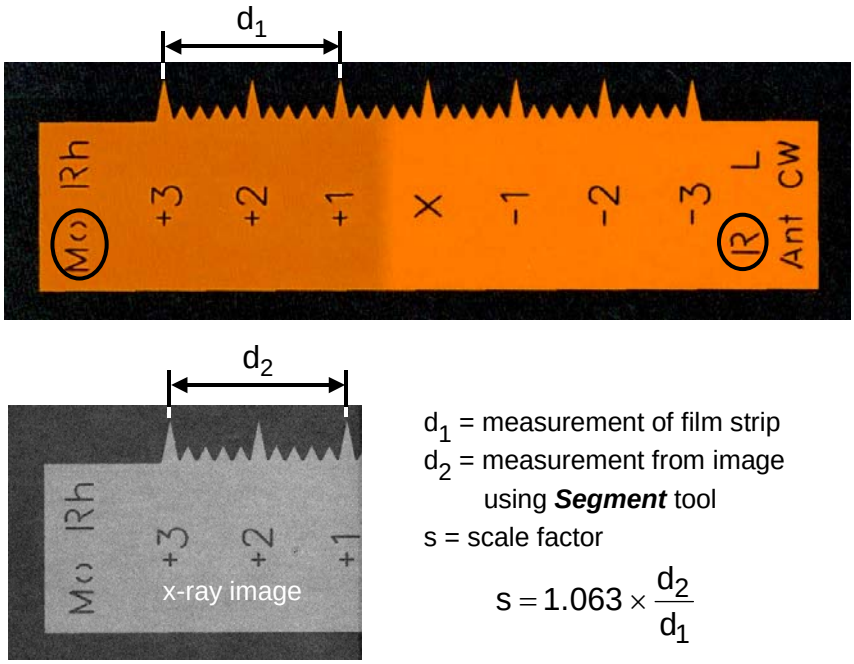


Figure 9. Determination of the scaling factor, *s*, to reference deviations measured in the film strip plane to deviations in the image receptor plane.

5. If the alignment of the compression paddle is also being tested at this time, measure the deviation between the alignment of the edge of the compression paddle (indicated by the outer edge of the coin) and the edge of the image receptor. Scale the deviation to the plane of the image receptor. If the deviation was determined from the digital image of the coin using the ***Segment*** tool, the scale factor is 1.063.