# Assessment of Photomultiplier Tube Balance

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***We developed a quick and simple test to determine photomultiplier tube balance using a small disk source of Co-57. Using this procedure assures that imbalanced photomultiplier tubes will be located and corrected before image quality is affected.***

Accurate diagnosis of clinical nuclear medicine images depends upon day-to-day stability in the imaging device. Fluctuations in instrument performance can degrade scintigraphs to such an extent as to make them clinically unsuitable. Such performance fluctuations include line voltage changes, increased background radiation, crystal yellowing, and photomultiplier tube (PM-tube) imbalance (*1*). These instabilities generally appear as either bright or dark areas superimposed upon the image. Appearance of these areas of altered film density at known PM-tube locations, however, offers the most dependable clue to improper PM-tube balance (*2*).

Previously, the accepted method to detect the presence of PM-tube imbalance entailed comparing flood field images—alternately obtained with the camera's pulse height analyzer (PHA) symmetrically centered around the photopeak, followed by flood images obtained with the PHA settings adjusted at approximately 25% below and again at 25% above the proper photopeak (*1*). In images obtained in such a manner, the presence of imbalanced photomultiplier tubes appears as bright or dark regions on the mis-peaked scintigraphs. Generally, bright regions in one off-peak image, which correspond to dark regions in the other, are indicative of imbalanced PM-tubes.

This method of determining PM-tube balance suffers from two disadvantages. The first is the difficulty inherent in properly adjusting the Anger camera's PHA for specific energy ranges, especially in cameras not equipped with a multichannel analyzer (*3*). Precise adjustment of the PHA is necessary for proper visualization of this effect. The second disadvantage is the inability to specify which PM-tube (or tubes) is imbalanced from these scintigraphs because of generalized patterns of bright and dark regions that appear on the off-peaked images. Typical images produced by this technique are shown in Fig. 1. The interpretation of images produced in such a manner is left to each viewer's subjectivity. Because we feel that a more objective determination of photomultiplier-tube balance would be more beneficial to nuclear medicine personnel than this test, we developed the following technique to evaluate photomultiplier tube balance.

## Materials and Methods

In the development of this test, we used two scintillation camera systems: the Searle Pho/Gamma IV (Searle Radiographics, Des Plaines, IL) and the Elscint CE-1 gamma camera (Elscint Inc., Hackensack, NJ). Both systems are equipped with 37-PM tubes arranged in the familiar hexagonal pattern. Another similar feature of both these systems, and of most modern camera systems, is the demarcation of the PM-tube's location upon the exterior surface of the NaI(Tl) crystal. It is this feature that makes our test possible.

To image the test film, the collimator was removed and the camera head was rotated upward. A 9.5-$\mu$Ci disk source of Co-57 was positioned over PM-tube No. 1, and using a 20% window, the Co-57 photopeak was symmetrically positioned using the analog calibration spectrum. After the photopeak was properly centered within the window, 14,000 counts were recorded on film at PM-tube No. 1. Sequentially, 14,000 counts were recorded on the same film for each of the 37-PM tubes, thereby recording approximately 500,000 total counts on the film. Total accumulation of 500,000 counts was chosen since this is an accepted technique for evaluation of scintillation camera characteristics obtained under clinical imaging conditions (*4*). The film was then developed and the film density of each PM-tube was visually inspected.

## Results and Discussion

Placing a sealed radioactive source over the camera's PM-tubes allows the exact location of these PM-tubes to be recorded on film. Accumulation of an identical number of counts per PM-tube ensures that the apparent film density of all PM-tubes will be equivalent, assuming each PM-tube is properly balanced. An example of properly balanced PM-tubes is shown in Fig. 2.

The high-voltage supply to a PM-tube that has become unbalanced can either have experienced an increase or

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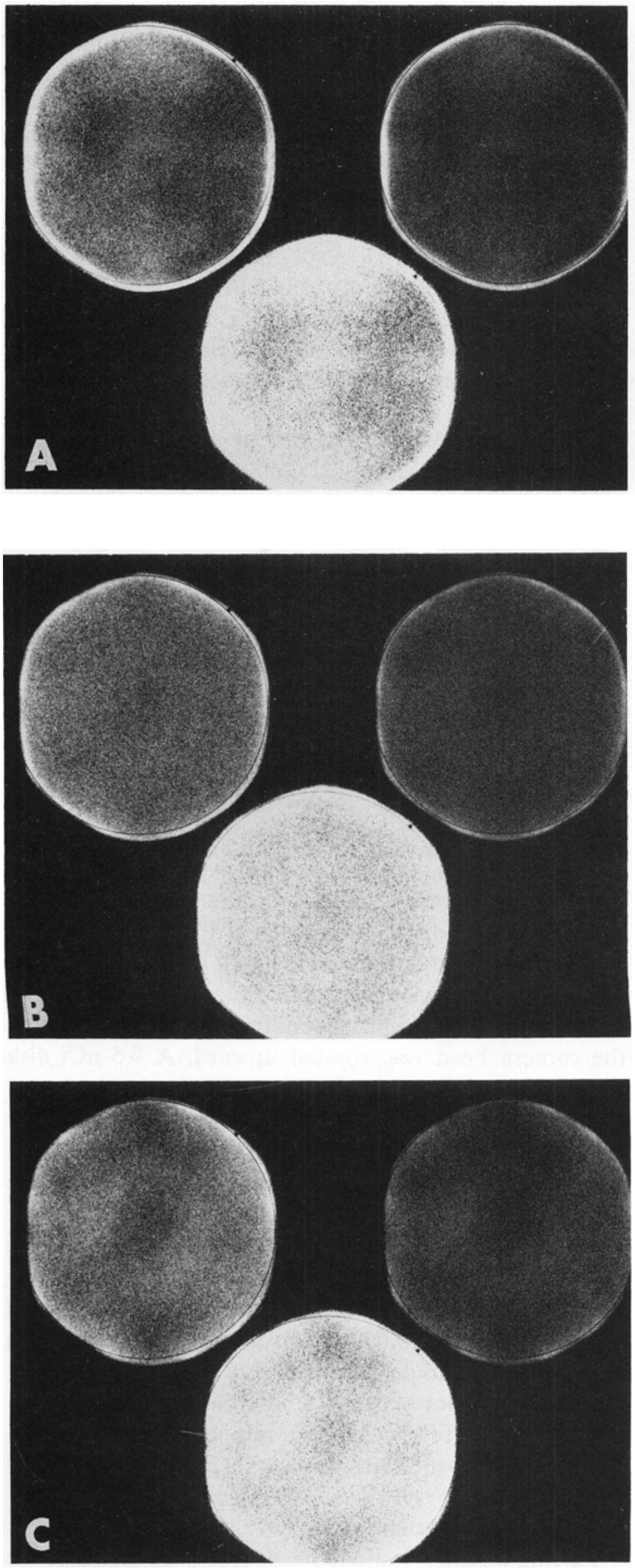


**Fig. 1.** Scintigraphs showing the flood field technique for determination of PM-tube balance. These images were obtained using a point source of Tc-99m with (A) pulse height analyzer set approximately 25% below the photopeak, (B) proper Tc-99m peak; and (C) approximately 25% above photopeak. Note the difficulty in interpreting PM-tube balance from this technique.

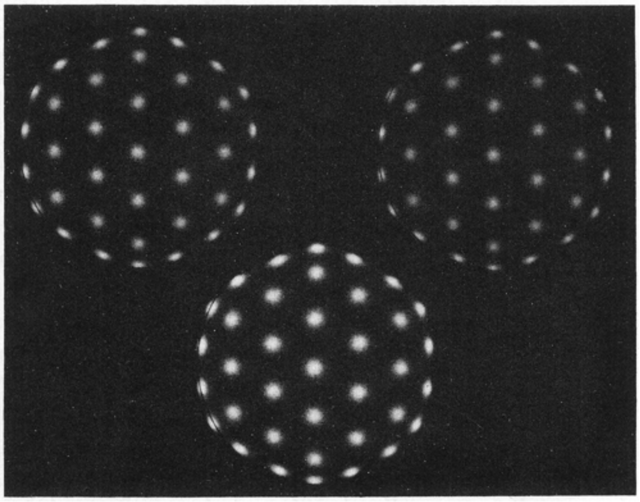

**Fig. 2.** Scintigraph of properly balanced photomultiplier tubes.

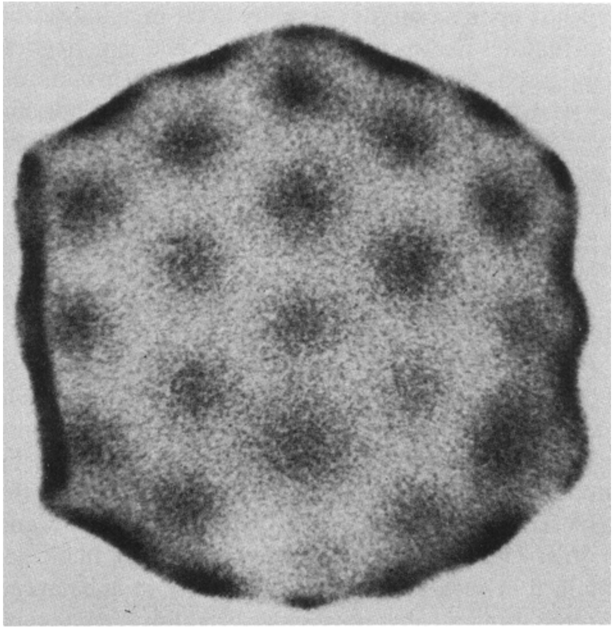

**Fig. 3.** Scintigraph of unbalanced photomultiplier tubes using our technique. Note lighter PM-tubes in lower right quadrant. One darker tube, located at the top of the scintigraph, shows increased voltage supply.

decrease in voltage as compared to the remaining PM-tubes. In either case, the result would be a differential response of the imbalanced PM-tube to the scintillations of the NaI(Tl) crystal. This differential response would be transmitted through the camera's electronics and ultimately be recorded on film as areas of differing density. Any abnormality in the response of a PM-tube can, therefore, be visualized with the unaided eye on standard film modalities currently used in nuclear medicine (Fig. 3).

This quality control test can easily be performed by a technologist during a department's routine camera qual-

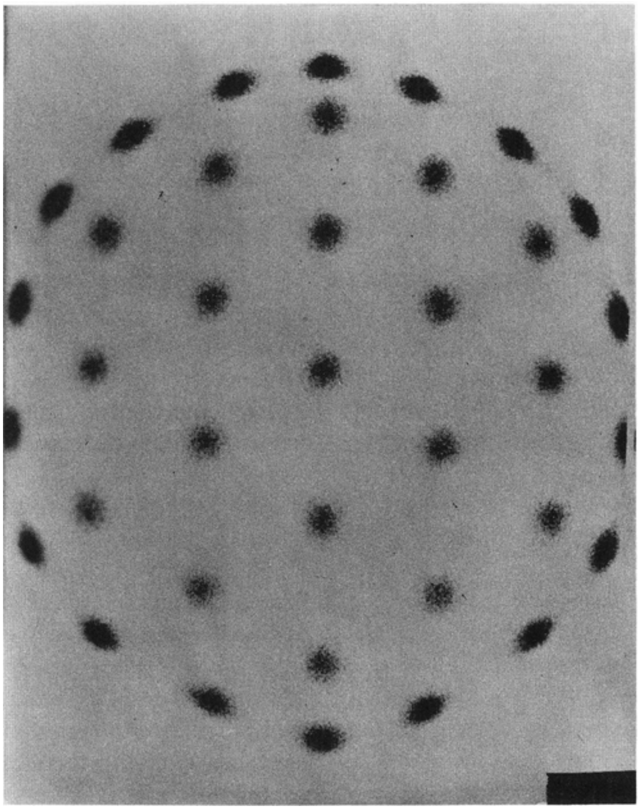

**Fig. 4.** Scintigraph shows that outer ring of PM-tubes is noticeably darker than other tubes, showing the edge effect. Also, densities of the inner PM-tubes are not identical, showing ease with which imbalanced PM-tubes can be detected with our technique.

ity control; it requires only five additional minutes of imaging time. We recommend that this test be performed on a weekly basis, preferably on Monday mornings, before patient imaging begins. Comparison of weekly test films will quickly demonstrate the presence of any acute PM-tube fluctuation that has occurred over the weekend, as well as detect the presence of any long term PM-tube instability. Imbalanced PM-tubes, diagnosed in such a manner, can be adjusted either by the technologist, on those cameras offering such a feature, or an authorized service representative, before image quality is affected.

We wish to point out an imaging artifact that occured consistently during our development of this test. Figure 4, besides showing an area of imbalanced PM-tubes in the lower right quadrant, also shows that the outer ring of PM-tubes are, seemingly, also imbalanced. This is not the case; it is merely another manifestation of the edge effect, normally observed in flood field images and, thus, should be disregarded. The drawback of our test, therefore, is that valid results are only attainable for the inner rings of PM-tubes. However, this is only a minor problem for those departments that have newer camera systems which possess a minimum of 37 PM-tubes.

We have developed a quick and simple test to ascertain PM-tube instabilities before the diagnostic quality of a department's scintigraphs are degraded.

## References


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