11 MISCELLANEOUS TESTS AND TECHNIQUES

In almost any book, certain topics defy classification in a logical manner. Consequently, we have grouped a series of unrelated tests in this chapter. This is not to imply that these tests are unimportant or that they have been added as an afterthought. In fact, some of the topics in this chapter may be more important than those that have already been covered.

VIDEO HARD-COPY CAMERAS

Any diagnostic imaging system is only as good as the weakest link in the imaging chain. This is equally true with video hard-copy cameras used to make permanent images from CT scanners, ultrasound equipment, fluoroscopic video images, and digital radiographic systems as well as from many imaging systems in nuclear medicine. These cameras, also known as multiformat cameras, take a video signal and display it on a cathode ray tube (CRT) and then optically transfer it to film.

Many of the older cameras used phototiming circuits with a photocell monitoring the output phosphor of the CRT. These systems usually work for CT applications, but they create many problems in ultrasound, where the amount of image information may vary from scan to scan, especially with B-mode scans. Since there is less information on the monitor (i.e., less light) in some images, the photocell attempts to compensate for this by increasing the exposure time. We strongly recommend that, if you have this type of camera, the phototiming circuit should be disabled and you should work with a fixed exposure time on the order of 1 second. (This feature is not to be confused with the microprocessor-controlled circuits on newer cameras that monitor the video signal levels.)

On many cameras, the video monitors are not black-level clamped. This means that as you change the contrast, the brightness will shift to a different level. This creates considerable difficulty in that changes in contrast also change the overall density of the film, making adjustments difficult and time consuming.

Whenever adjustments are being made to these cameras, or to any video device, changes should be made in only the contrast or brightness. Never change both contrast and brightness at the same time. Adjust the brightness to obtain the desired density on the film (usually in the background or low-density area) and then adjust the contrast to give a pleasing image. In addition, when adjusting the brightness and contrast, view the monitor and assure that you can see a dim, low-contrast image. If the brightness and contrast are driven to a high level on the monitor, the scanning spot tends to increase in size, decreasing the sharpness and resolution of the images.

The more recent developments in hard-copy cameras have included the addition of microprocessor circuits that monitor the video level of the signal entering the camera and set the exposure appropriately. Most of these devices work quite well as long as the video signal meets the EIA standard RS-170 (Electronics Industries Association, 1957). Many pieces of imaging equipment do not meet this standard. For example, one ultrasound camera produced a 1.5-V signal for the alphanumerics and white mask overlaying the image (a maximum of 1.0 V is specified in

RS-170) while the image information was contained in the signal between 0.0 and 0.6 V. Since the camera monitored the peak video signal, it did an excellent job of assuring that the 1.5-V signal was reproduced correctly on the film, but the diagnostic information was produced at an exceedingly low contrast and was quite dark. It is essential that the signal output from any video equipment meets the RS-170 standard if an optimal image is to be displayed and recorded.

Some of the newer cameras offer a raster blending feature. Contrary to popular belief, this is not achieved by making the scanning spot larger, but rather by moving either the scanning spot or the entire raster up and down slightly (less than one line width) to fill in the space between the scanning lines. This does not affect the vertical resolution since the blending only fills in the open spaces, nor does it affect the horizontal resolution since the scanning spot is as small as it would be if the feature was not used (Figure 11.1). However, to realize the best possible results from raster blending, it is necessary to record at least eight video frames. If you record one frame, no blending will be present; with two frames some improvement will be noticed; and so on. It is recommended that you record at least 16 frames for the best results or (ideally) 30 frames, which results in a 1-sec exposure and also allows the use of the camera with minimum brightness settings on the CRT.

Some of the new cameras offer "frame-grabbing" or "on-the-fly" modes. This is particularly useful when real-time recording is desired, such as in real-time ultrasound or in the recording of fluoroscopic images where motion is a problem. However, in recording a single frame, the image quality will be poorer (contain more noise) than if you record (average) more frames in a single image. This is the inevitable trade-off between low-noise images with long exposures and the need to make images with a short exposure time to reduce motion.

IMAGE QUALITY TESTS FOR PRODUCT COMPARISONS

It is frequently necessary to evaluate new products to assess their effects on image quality and patient exposure. This may be done to assure that the depart-

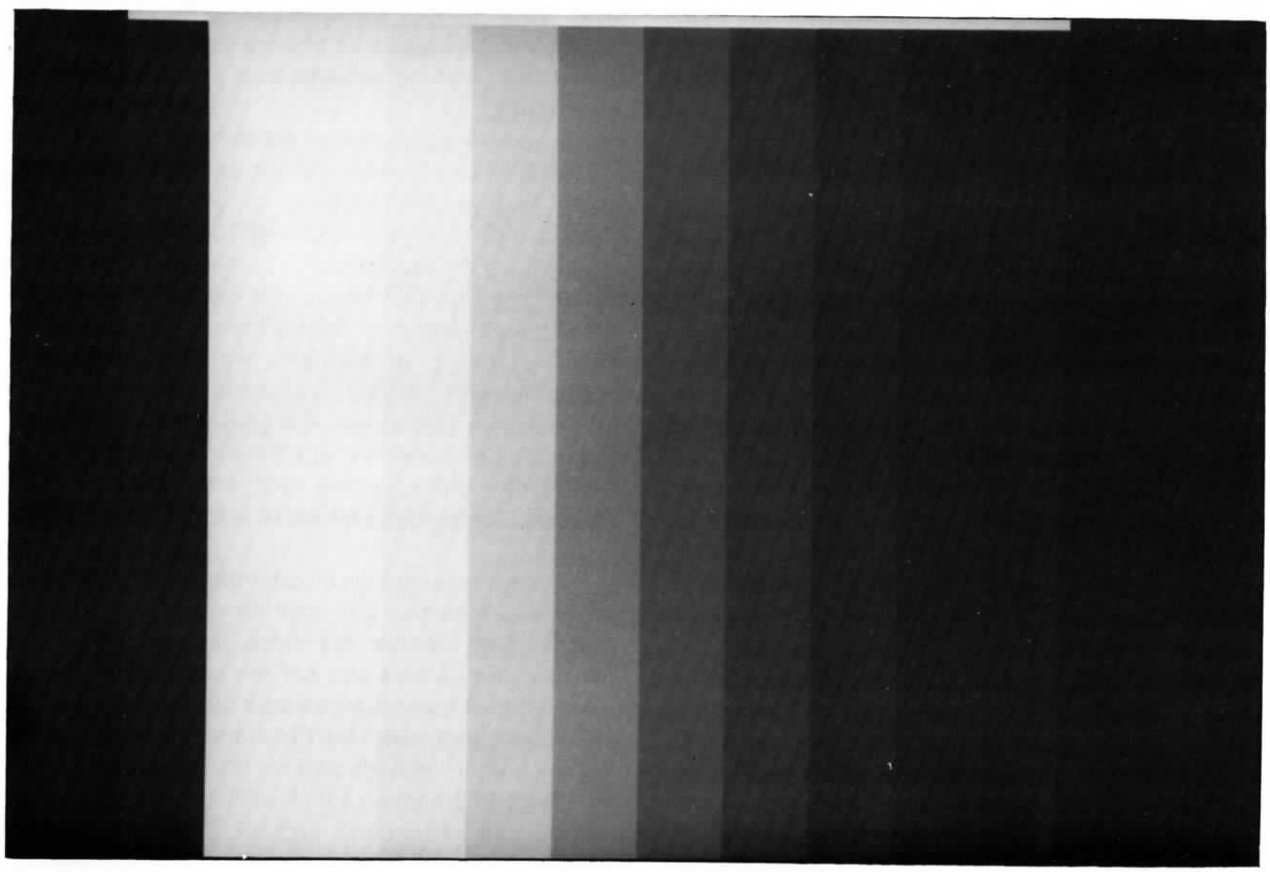

Figure 11.1a. Video image demonstrating the effects of raster blending. Video image of entire display of an electronically generated gray scale.

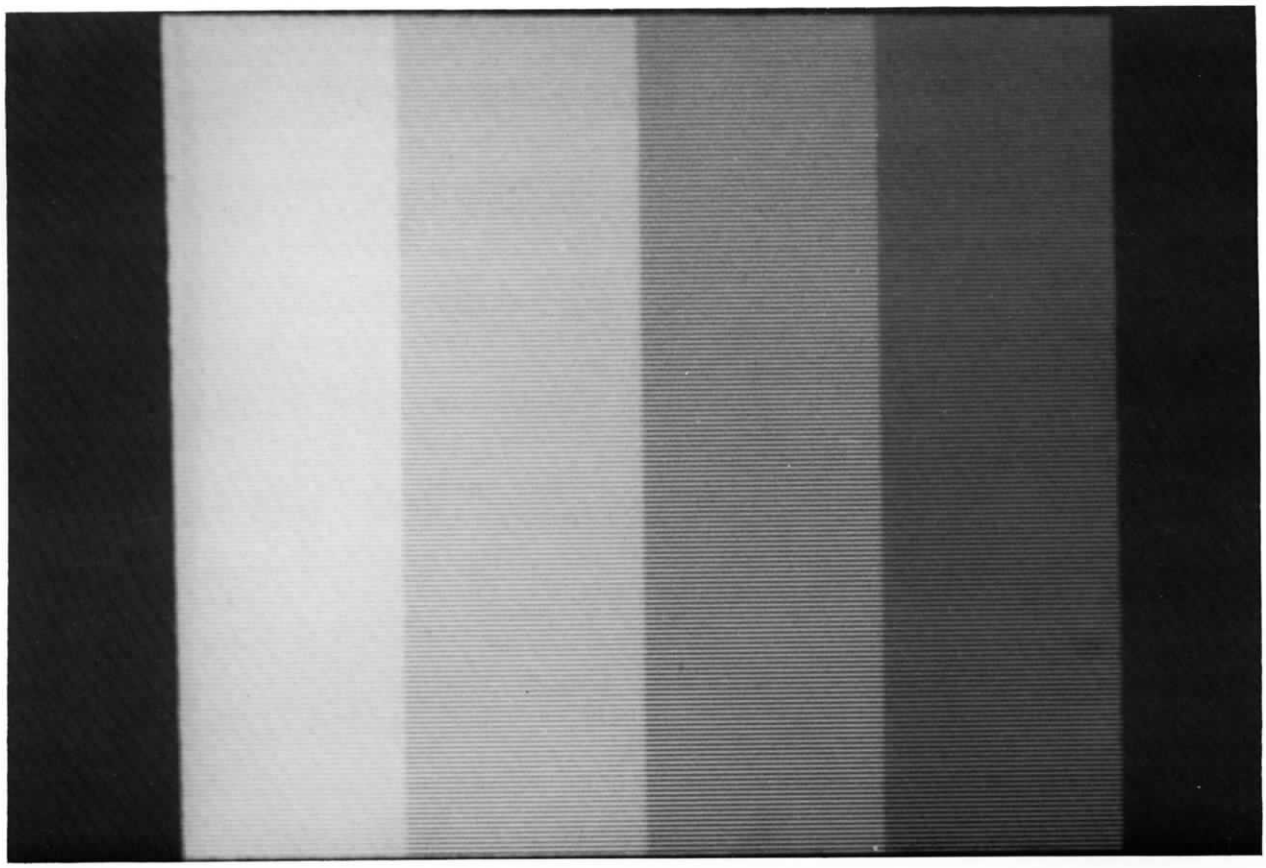

Figure 11.1b. Close-up of gray scale without raster blending.

ment is using the best available and/or most economical products, such as screens and films, in its patient examinations. Since the QC technologist is the person in the department who has the test equipment and the expertise in its use, product comparisons are a logical part of his or her duties.

A vendor should make samples of new products available at no cost to your department. Also, the evaluation should be carried out in your department in the way the product will be used. One firm showed comparison chest films of two patients made using two products. The old product was used to make a chest radiograph of a 250-pound (115-kg), 5-foot 5-inch (165-cm) male; the new product was used to make a "comparison" chest radiograph of a 120-pound (55-kg), 5-foot 8-inch (170-cm) female (best described as having "centerfold anatomy"). Needless to say, everyone can predict in advance which chest radiograph will look "best."

In blind product comparisons, and in many other evaluations, the individuals doing the comparison will spend most of their time trying to determine which of the two films, for example, is the new one. In order to avoid this problem, all markings on the films should be eliminated except for numerical markings used for identification purposes, which should have no relationship to the speed or types of products being evaluated. This includes trimming off *all* edge markings on the films and from the screens.

Slight differences in the way the films are made can influence the impressions of the individuals making comparisons. Through experience, we have found that the density on phantom films, be they PEP films or anatomical phantom films, must be matched to ± 0.05 in density at a density of about 1.0. If they are not matched to this level, differences will be noted by the radiologists, who will attribute this to differences in the products.

Before a final decision is made to purchase a new product or change to another brand, clinical films must be made for comparison purposes since phantom films are sometimes misleading. Even anatomical phantom films do not really provide images identical to patient films since phantoms are made with dry bones, material *simulating* tissue, and materials that do not really mimic the patient and various anatomical information. However, patient studies must be carried out with extreme care.

Any time a second film is made on the same patient that is not needed for diagnosis, this must be

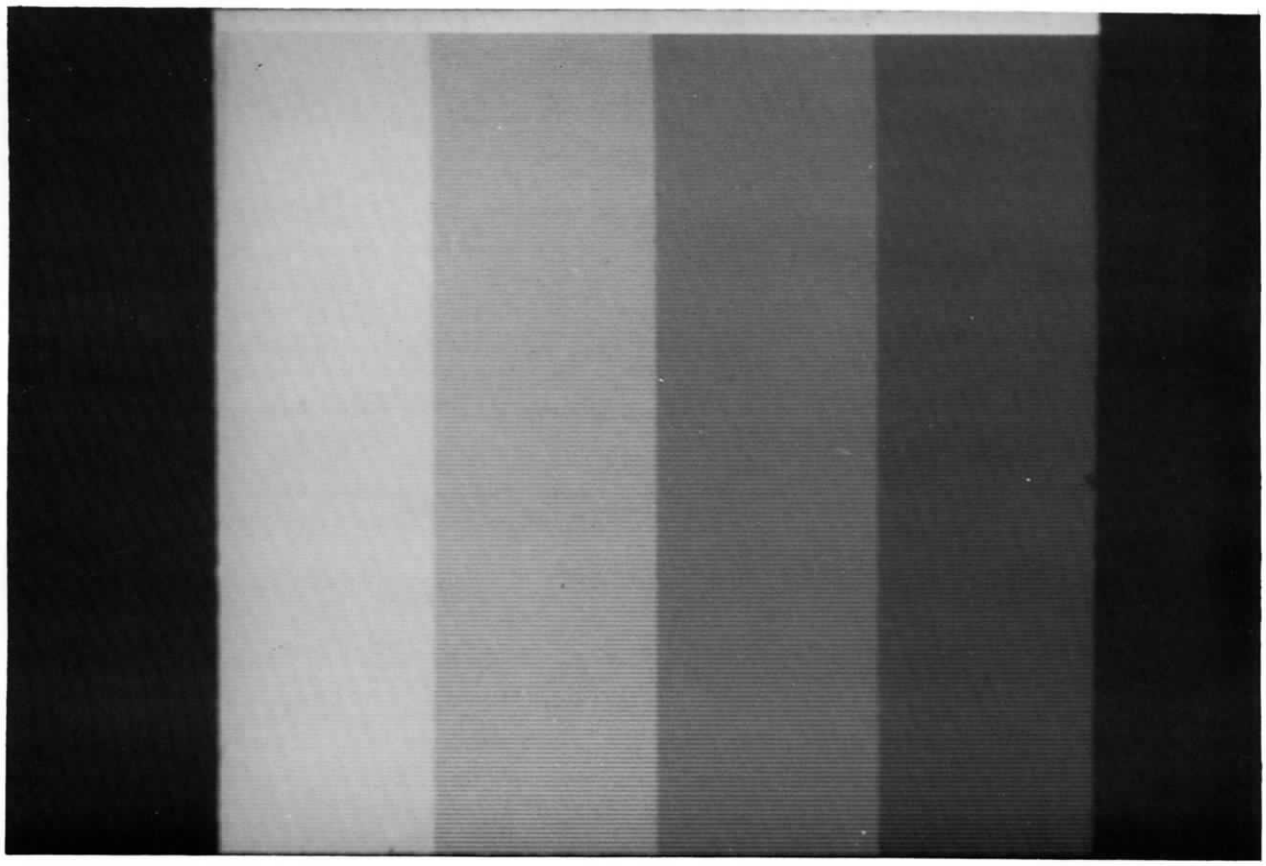

Figure 11.1c. Close-up of gray scale with raster blending. Note that the edge sharpness is maintained with raster blending.

considered as human research or human studies. Such films should not be made without the informed consent of the patient. In addition, most institutions require that such studies be approved by the radiation control committee and the human studies committee. In all cases, before any new product is introduced into the clinical environment, the technologist should discuss this completely with the chairman of the department and be sure of all the implications of the tests and the test procedure.

Ideally, you should expose two films on the same patient in comparing screens or films. For example, if chest radiography is of interest, then two films should be made on the same patient, in the same position, exposed within a short period of time, and in such a manner that the densities match as closely as possible. (In this case, ± 0.10 is usually acceptable in terms of density variation between films.) However, this involves informed consent and approval by various committees, and, in fact, in many institutions studies requiring two exposures of the same patient, where the second provides no additional diagnostic information, may not be approved.

There are alternative methods that can be used. For example, the various images in a series for excretory urograms may be made on different films. Where both left and right extremities are to be radiographed, one film or screen to be compared can be used on the left and the other on the right. For mammography comparisons, the left breast can be imaged with one image receptor and the right with the other. Although this is not the best way to evaluate new products, it does avoid the problem of committee approval and informed consent. If this method is used, then the left should not consistently be radiographed on the old product and the right on the new; rather, the products being compared should be used randomly. Also, the total number of patients involved in such a study should be kept to the absolute minimum, both to minimize the dose and risk to the patient and to avoid as much confusion as possible with multiple imaging systems in the radiology department.

ATTENUATION MEASUREMENTS

Attenuation is the proportion of radiation that is absorbed by the item being measured, whereas transmission is the proportion of radiation that is transmitted through the item. In other words, the transmission

is equal to 100% minus the percentage of attenuation. We discuss the measurement of the attenuation in this section since the transmission can be derived from that.

In evaluating various products, it is often necessary to determine the attenuation or transmission of the product. In addition, you should determine the attenuation of the tabletop and grid combination to assist in balancing technique charts and to assist in reducing patient exposure differences from room to room.

In the determination of attenuation, it is essential to make all measurements using the same beam quality you would encounter where the product is being used. For example, if you were to measure the attenuation of a cassette front at 70 kVp with no phantom in the beam, you would find that the attenuation is much higher than if the measurements were made at 70 kVp through the PEP. In the first case, all of the soft radiation in the beam reaches the cassette front and is preferentially absorbed. In the second case, with the phantom, the soft radiation is absorbed by the phantom so that primarily harder radiation is reaching the cassette front, showing a relatively lower attenuation. This is particularly important in comparing materials that have different spectral absorptions, such as aluminum and carbon fiber. One manufacturer claimed that a carbon fiber product had 50% less attenuation than an aluminum counterpart. Making the measurements as described in this section, we noted only 7% less attenuation, a difference that was substantiated in clinical tests.

COPY FILM

Next to the excuse for the poor quality of portable radiographs being "well, they are just portables," comes the often-heard excuse that "the films are not good because they are just copies." Neither of these are really excuses and should never be accepted in a radiology department that is concerned with quality.

Copy films are specifically designed by the manufacturer to reproduce *faithfully* the exact densities of the original film up to a density of 2.3 to 2.5. Since copy film is a single-emulsion film, the entire density range of a radiograph (in excess of 3.0) will never be duplicated with presently available films. However, for 95% of the uses, a duplicate with today's films will look identical to the original radiograph (except for the shiny surface on some copy films).

One of the major failures in copying films comes from attempting to lighten a radiograph that is too dark or darken one that is too light. This will *never* produce a quality duplicate, let alone produce a duplicate of the radiograph as it should have been made in the first place. The copy procedure should be set up as described in this chapter to duplicate exactly the density and contrast of the original, and changes should only be made when deviations from these ideal settings are required because of changes in the copy film or light source.

You should be able to display a properly made duplicate on a viewbox next to the original radiograph without a radiologist being able to consistently tell which is the duplicate and which is the original.

METHODS OF LOWERING THE FLUOROSCOPIC EXPOSURE RATE

In many cases, a piece of fluoroscopic equipment is set up to produce the best image quality with little attention to the exposure rate. One method of producing a high-quality, noise-free image is to operate the generator at a high exposure rate. These high-dose images are very pleasing to the eye but may not, and in most cases do not, increase the ability to make the diagnosis over a slightly noisier, less pleasing image, especially in high-contrast procedures such as GI studies. With current awareness and concern about the effect of exposure to ionizing radiation, many radiology departments have found that they can lower the fluoroscopic exposure rate considerably and not hamper the ability to make the diagnosis. This can be done by eliminating the use of grids (Gray and Swee, 1982) and by the techniques described in this section.

Before considering changing the exposure rates, a thorough evaluation of the use of your equipment and the needs of your department must be made by everyone involved. In addition, some judgment must be made on what quality of image is needed to make the diagnosis.

The most noticeable change in a low-dose image will be an increase in image noise (quantum mottle) and a loss of low-contrast resolution. There should be little or no change in the medium- to high-contrast resolution and very little change in the overall contrast.

The age and condition of your equipment is an important factor. An older piece of equipment may not allow the degree of exposure reduction that a new piece of equipment can tolerate. Some types of fluoroscopic equipment have an optional high-exposure mode. This option gives you the opportunity to lower the dose rate in the standard mode, but still have a higher exposure mode for exams that require a lower-noise image, such as chest fluoroscopy. Fluoroscopic systems that have vidicon camera tubes can tolerate lower exposure rates better than systems with plumbicon tubes since the lag in the vidicon

system smooths the appearance of the quantum mottle or noise.

Particular areas that should be considered for reduced-dose fluoroscopy include portable image intensifiers used in surgical procedures, fluoroscopic localization used for tomography or GI filming, catheter placement during special procedures, and GI studies.

WHAT TO DO BEFORE THE SERVICE ENGINEER LEAVES

One word that should be emphasized in this section is *"before." Before* the engineer leaves and even *before* the covers are put back on the equipment, the QC technologist should verify the integrity of the equipment and the quality of the images being produced. This also assumes that the QC technologist will verify that the original problem has been corrected and that the equipment is producing images of a quality similar to or better than before service was requested.

The main reason for testing the equipment before the service engineer leaves is to assure that the problem has been corrected, and that more problems have not been introduced so that the service engineer will not have to return later. Remember that every service call is billed at the rate of about $60 per hour including travel time! Also, this helps to avoid developing an adversary relationship between the QC technologist and the service engineer. If the QC technologist can work with the service engineer in sorting out problems, a better relationship will result than would be the case with the technologist calling the engineer after he has left and telling him that he did not do the job properly, to say nothing of the cost involved in this latter approach.

FILM VIEWBOXES

Although no specific procedure has been included for the quality control of film viewboxes, standard policies and procedures should be developed to assure consistency throughout the department. Improper or inconsistent illumination can affect the diagnostic potential of even the finest radiograph. A difference in illumination or ambient lighting conditions between the film stacking and film interpretations areas can create misunderstanding and confusion within a diagnostic imaging department.

One way to approach the problem is to establish a policy of cleaning the viewboxes and changing *all* of the bulbs in the viewboxes periodically. Only one type of bulb should be used in all viewboxes throughout the department, and that type should be made by one manufacturer only. If one bulb needs to be replaced in a viewbox, then all bulbs in that bank of viewboxes should be replaced at the same time. This may seem like a costly policy, but it assures that all viewboxes will be of the same brightness and color. In addition, the investment in equipment and manpower required to produce quality radiographs must be kept in mind; in looking at the total cost of producing radiographs, the cost of replacing all viewbox light bulbs is minimal.

How often should bulbs be replaced and viewboxes cleaned? Bulbs should be replaced annually if they are used for even a few hours each day. The boxes should be cleaned at least twice a year—this means cleaning the inside and outside surfaces of all viewboxes, including the area behind the light bulbs. The outside surfaces should also be cleaned at any time dirt or marks are apparent.

Alternate methods of assuring consistency through measuring viewbox light levels with a photometer or a photographic light meter are described by Hendee and Rossi (1979).

PROCEDURES

11.1. VIDEO HARD-COPY CAMERAS

Purpose

To assure that the film images of video displays, e.g., from CT, ultrasound (US), and digital radiographic systems, reproduce the full range of information displayed on the cathode ray tube (CRT).

Equipment Needed

1. Densitometer
2. Processor control chart

Procedure—Setting up Video Hard-Copy Cameras

1. It is our feeling that older-style phototiming in CT and US applications creates more problems than it solves. We recommend that you have the phototiming circuits in your camera disconnected by a service engineer.
2. If the phototimer has been disconnected, or if your camera doesn't have phototiming, set the exposure time to approximately 1 sec for recording static images. (This will assure a complete fill-in of the CRT image.)
3. Set the lens aperture at f/5.6 to f/8 if an aperture setting is present.
4. View the displayed image and adjust the CRT to produce a dim, low-contrast image with no flare.
5. Make a series of films varying *only* the *brightness* control.
6. Select the image that produces a density approximately 0.05 above base-plus-fog (B + F) for US (or a density of 0.20 above B + F in the background for a black-on-white display) and 0.10 above B + F for CT on the lightest step of the step wedge.
7. Make a series of images varying *only* the contrast control, using the brightness setting selected in Step 6.
8. Select the contrast setting that produces the most pleasing image.
9. Recheck the density of the lightest step to assure that it has not changed. If the density has shifted make another series of films varying *only* the *brightness.*
10. Repeat this procedure until the proper density and a pleasing image is produced (Figure 11.2).
11. White-on-black US images require a slightly different approach. Follow Steps 1 through 9 but read the densities from an average US image, not the step wedges. Adjust the CRT brightness to produce a density of 0.05 to 0.10 above B + F for the strongest echoes (skin reflection at the scan surface). Then adjust the contrast to produce a density as close as possible to 1.6 above B + F from the weakest echoes.

Procedure—QC Monitoring

1. After the correct density and contrast have been established, select the step from the step wedge that has a density closest to 1.0 above the B + F to be monitored as the mid-density level. Use a step near 0.20 above B + F (low) and a step that has a density closest to 1.8 above B + F (high) to calculate the density difference (the high minus the low density).
2. Monitor these steps on a daily basis initially, then on a weekly basis if it is apparent that the density levels are not shifting on a day-to-day basis.
3. Record the mid-density and the density difference on a processor control chart.
4. If you do not wish to disconnect your phototiming system and still wish to monitor the film density, a perfectly reproduced phantom scan must be used to produce the film and gray scale needed for monitoring the film density.
5. If you use Polaroid film, follow the setup procedure (Steps 1 through 11 above), then visually check the step wedge on the edge of the image regularly. You should be able to see the difference in density between the two lightest steps and between the two darkest steps.

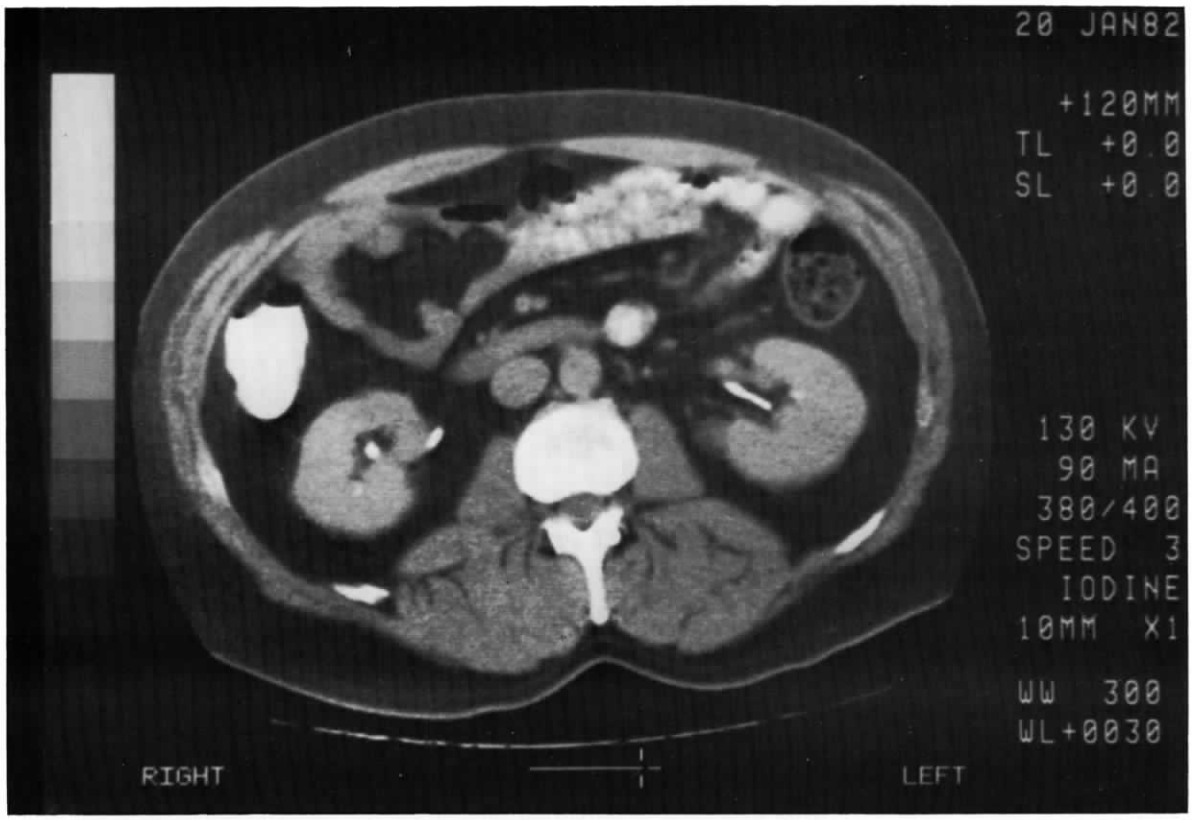

Figure 11.2a. CT image produced with a video hard-copy camera.

6. Be sure to record all the exposure factors, including f-stops, exposure time, brightness, and contrast settings, on the control charts.

Problems and Pitfalls

1. Phototimed systems make it almost impossible to carry out quality control since the exposure depends on the image.
2. Some older and poorly designed multiformat cameras are designed so that the brightness and contrast controls are not independent, making it impossible to adjust the contrast without changing the brightness.

Acceptance Limits

If your processor is in control, set your limits for the mid-density and density difference at ± 0.10.

Corrective Action

1. Adjust the brightness and contrast controls to bring the density and contrast back within the control limits.
2. Clean the face of the CRT and camera lens monthly with a soft brush, then use lens tissue and lens cleaning solution.

11.2. IMAGE QUALITY TESTS FOR PRODUCT COMPARISONS

Purpose

To compare under clinical conditions the differences in image quality from different products, such as intensifying screens, films, or grids.

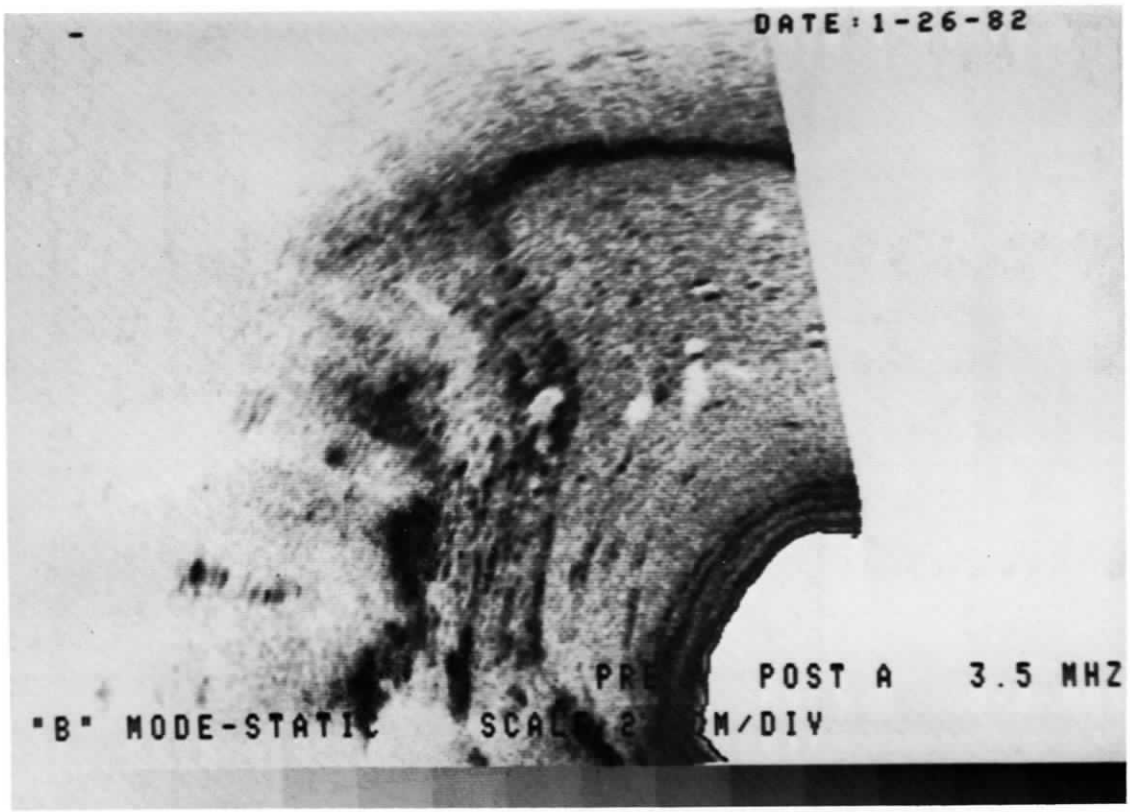

Figure 11.2b. Ultrasound image produced with a video hard-copy camera.

Equipment Needed

1. Anatomical phantom
2. Flat metal washer with $^3/_8$-inch hole
3. Densitometer
4. Lead markers
5. Dosimeter

Procedure

1. Tape the flat metal washer to the top surface of the anatomical phantom in a location such that its image will appear in an exposed portion of the radiograph (an area where the density will be about 1.0). For example, if an abdomen phantom is used, locate the washer over the kidney region. This is done to assure that densitometer readings used to obtain a close density match are made at the same point on the comparison radiographs.
2. Set up the generator, phantom, and x-ray tube for routine radiography. Position the dosimeter chamber on the phantom to record entrance exposure to the skin in the area of interest. The setup will vary depending upon the product being evaluated.
3. Place lead markers on the cassette to identify the products being evaluated, but do not use the product names—use only numerical identification.
4. Make a radiograph using technical factors appropriate for the anatomic phantom for the product currently used in the department and record the dosimeter reading.
5. Process this radiograph and check for proper positioning of the phantom, metal washer, and dosimeter chamber (Figure 11.3).
6. Repeat Step 4 if needed to obtain a typical radiograph and satisfactory location of the metal washer.

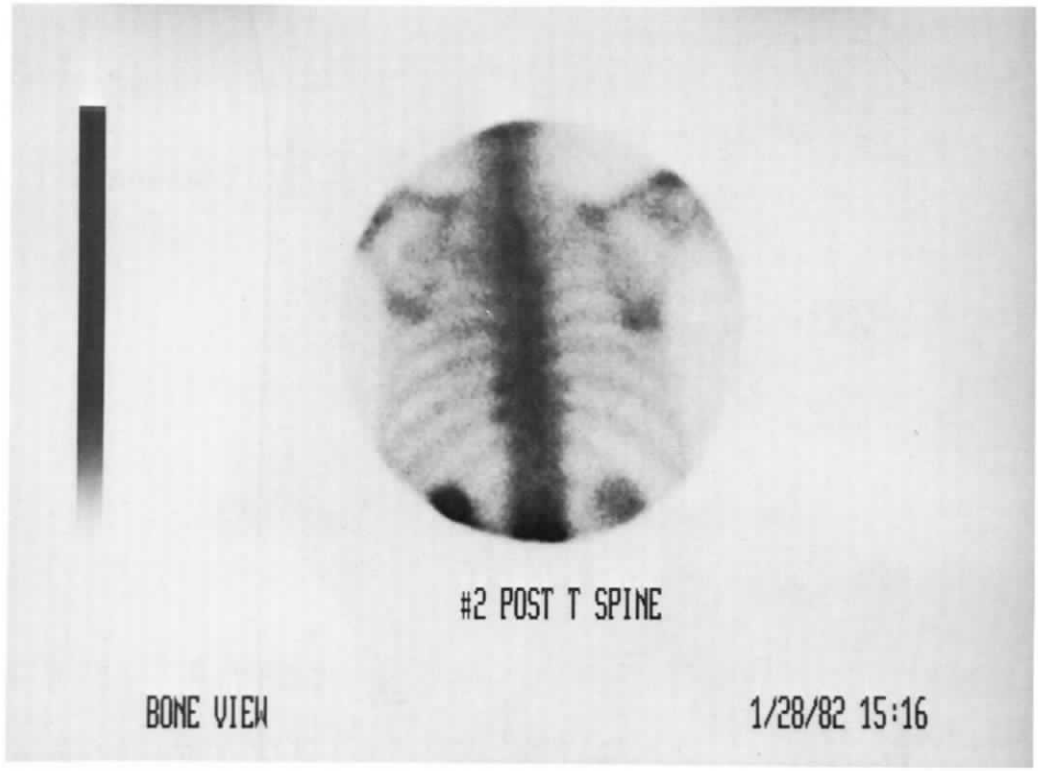

Figure 11.2c. Nuclear medicine digital image produced with a video hard-copy camera.

7. Do not alter the radiographic setup once a satisfactory radiograph has been obtained until the testing series has been completed.
8. Expose a radiograph with technical factors appropriate for the product being tested and record the dosimeter reading.
9. Process the comparison radiograph in the same processor.
10. Make densitometer readings in the open area of the washer and record the readings. Repeat radiographs if necessary to attain a density match within ± 0.05 (ideally), or within ± 0.10 if necessary.

Problems and Pitfalls

1. It is essential that the test be conducted in a manner such that the only difference that will be noted in the comparison radiographs will be due to differences in the products tested—in this case, between the currently used and new product. For this reason, problems will be avoided if you:
   a. Make the comparison radiographs at the same kVp setting.
   b. Make exposure adjustments with exposure time. Avoid changing mA initially, if possible. Calibration of the x-ray generator may be inaccurate between mA stations and changing to a different mA station may also result in a change of the focal spot size.
   c. Use the same cassette when comparing films or grids.
   d. Process the radiographs in as short of a time period as possible in the same processor.
2. A mismatch in light level or color on adjacent illuminator panels used to view comparative radiographs can significantly affect results.
3. Unbiased evaluations require that other observers not be able to identify the product from the identification markers, or manufacturer's edge markings, on film and screens.
4. It is essential that densities of the comparison films are matched as closely as possible. A slight difference in density can significantly alter the appearance of the radiographic contrast and sharpness.

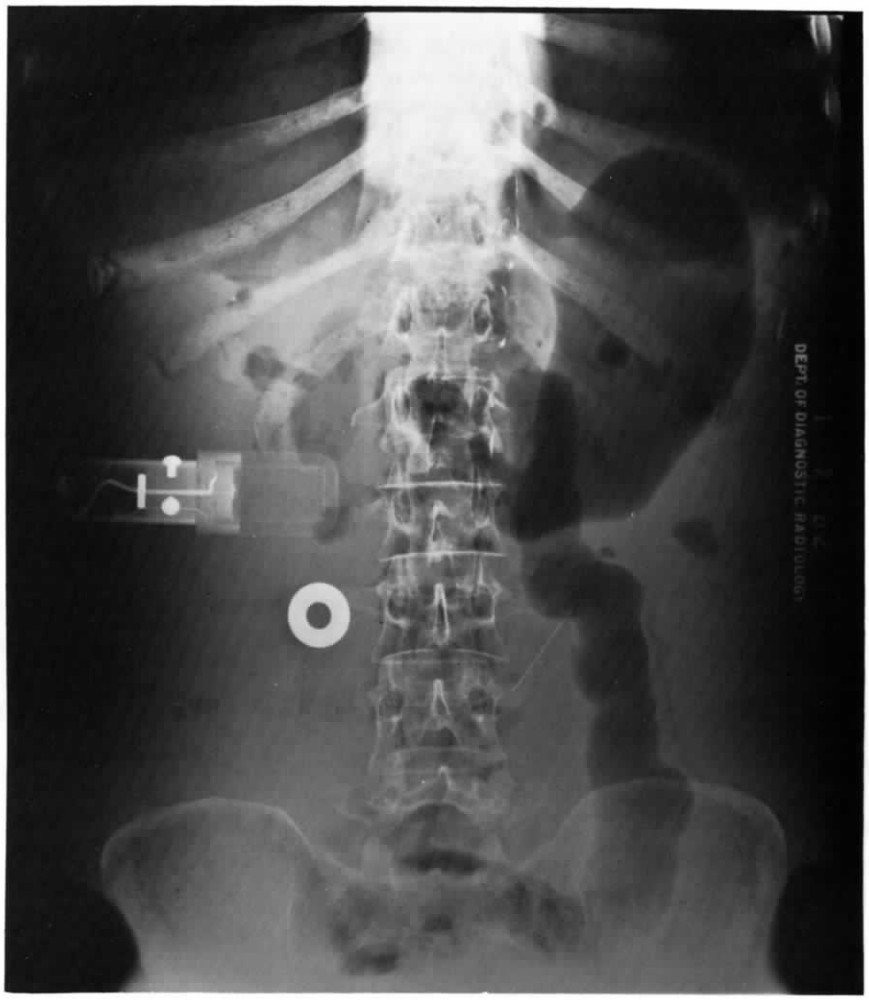

Figure 11.3. Product comparison phantom film. Each image should contain a washer to mark the spot for density matching, lead letter identification information that is not related to the product name, and an ionization chamber for monitoring the phantom entrance exposures. All edge markings are then trimmed from the film so that neither the film nor the screen can be identified by the viewer.

Acceptance Limits

Densitometer readings on the comparison radiographs should be in the general range of 0.80–1.0 and should ideally match within ± 0.05, but you may have to accept ± 0.10. Make additional radiographs if needed to attain matched densities within these limits.

Image Analysis

1. View comparison radiographs on adjacent panels of well-matched viewboxes under normal viewing conditions for interpretation. Form and record subjective impressions regarding differences, i.e., information equally well visualized, better visualized, or less well visualized.
2. Review the results with a radiologist to determine further action. If the new product at this point offers sufficient advantages to warrant clinical use (i.e., provides the same information at a lesser dose or more information at the same dose), further testing that may involve comparison patient radiographs will be required before a final decision is made.

   If comparison patient radiographs are made, good radiation safety practices dictate that these be:

   a. Kept to a minimum
   b. Made only on patients who require a particular examination
   c. Made only on patients beyond the usual childbearing age

d. Limited to not more than one comparison radiograph on any given patient
e. Made only after approval by the chairman of the radiology department and in many institutions after approval by the human studies and radiation control committees.

11.3. ATTENUATION MEASUREMENTS

Purpose

To accurately determine the attenuation or transmission of materials under clinical conditions.

Equipment Needed

1. Patient equivalent phantom (PEP) with base
2. Direct readout dosimeter with an ionization chamber that fits in the Bucky tray plus a large conventional chamber
3. A 14 × 17-inch (35 × 43-cm) sheet of ½-inch (1.3-cm) plywood backed with lead. An opening should be cut into the plywood to hold the ionization chamber and assure that it is centered in the Bucky (Figure 11.4).

Procedures—Measuring Attenuation of Cassette Fronts, Grids, Tabletop Pads, Lead Aprons, etc.

1. Place the PEP and base on the table, set the x-ray tube at the normal working distance, and center it to the PEP.
2. Place the large chamber in the base opening under the PEP and assure that it is centered under the phantom.
3. Set the generator to about 50 mAs and to a kVp that would be typical for the use of the product you are working with.
4. Make three exposures, determine the average of the three, and record the data in a log book.
5. Place the item that you are measuring between the phantom and the base (Figure 11.5). Care should be taken not to damage the product being tested.
6. Repeat Step 4 above.
7. Determine the attenuation using the following formula:

$$\left[1 - \left(\frac{\text{Exposure with sample}}{\text{Exposure without sample}}\right)\right] \times 100\% = \%\ \text{Attenuation}$$

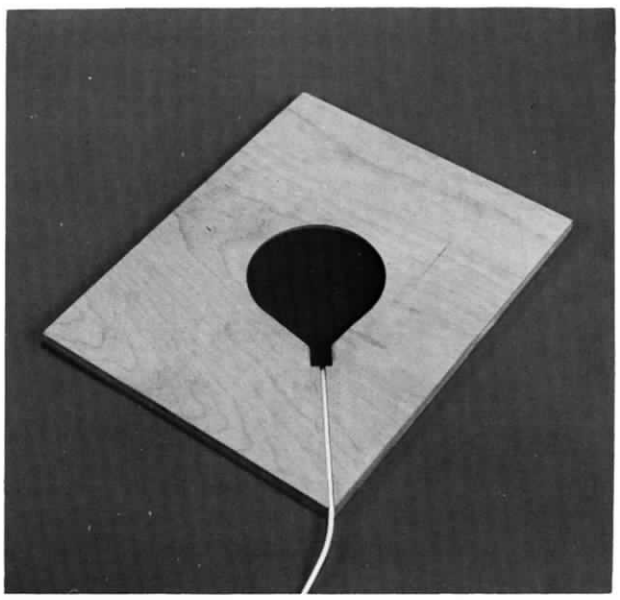

Figure 11.4. Bucky tray ionization chamber holder. This holder is designed to center the ionization chamber in the Bucky tray as well as to provide protection from variations in backscatter (by utilizing lead backing under the plywood sheet).

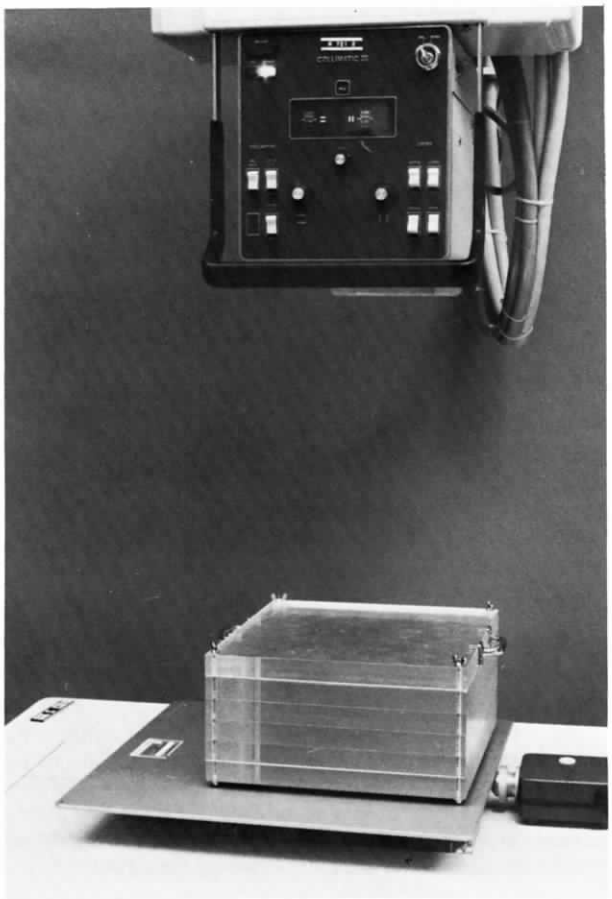

Figure 11.5. Attenuation measurement test setup for product evaluation. Care must be taken not to damage the product being evaluated when the PEP is placed on top of it.

For example, assume your dosimeter read 100 mR without the sample and 10 mR after the sample was inserted in the beam; then

$$\left[1 - \left(\frac{10\text{ mR}}{100\text{ mR}}\right)\right] \times 100 = 90\%\text{ attenuation}$$

The transmission is equal to 100% – percentage of attenuation; i.e., (100% – 90%) = 10% transmission.

8. If the attenuation of another product is to be determined at this time, place the product between the phantom and the base. Note that it is not necessary to make the initial three measurements without the product (Step 4) again, since the exposure will be the same.

Procedure—To Measure Tabletop and Grid Attenuation

1. Place the PEP and base on the table, set the x-ray tube to the normal working distance, and center the tube to the phantom.
2. Place the 14 × 17-inch (35 × 43-cm) sheet of plywood in the Bucky tray and center the Bucky tray to the x-ray tube.
3. Collimate to the phantom.
4. Place the Bucky ionization chamber under the phantom, on top of the table, assuring that it is centered under the phantom and x-ray beam.
5. Set the generator to about 50 mAs and the typical kVp used in the room.
6. Make three exposures, take the average of the three, and record the data in a log book.
7. Place the Bucky ionization chamber in the cutout of the plywood sheet in the Bucky tray (Figure 11.6).
8. Make three exposures, take the average of the three, and record the data in a log book.
9. Use the formula in Step 7 of the procedure above to determine the attenuation.

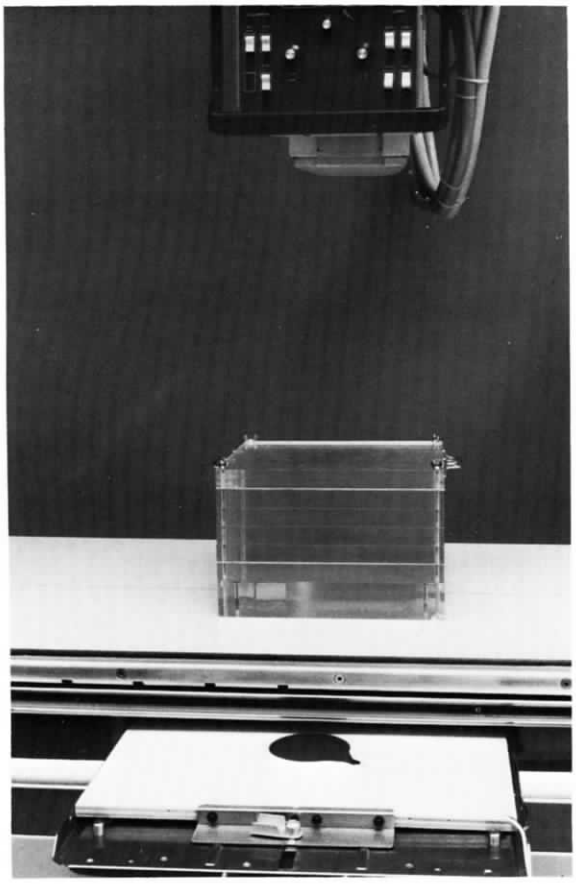

Figure 11.6. Attenuation measurement test setup for tabletop and grid attenuation. Care must be taken not to damage or crimp the cable coming from the Bucky ionization chamber. Since the signal is not digitized at this point, the cable is carrying extremely low currents and is sensitive to induced currents as a result of flexing the cable.

Problems and Pitfalls

1. If the product being evaluated is to be used over a wide range of kVp values, then the attenuation must be determined over the same range (usually 20-kVp increments is sufficient).
2. It is essential to evaluate the product under the conditions that are typical of its use. For example, measurements made of cassette fronts must be made through a phantom and, ideally, through a grid also. Grids, whether of primary or secondary interest in making attenuation measurements, must be used at the proper distance to assure accurate data.
3. **Do not change the generator** between the various measurements, since it is difficult to reset the generator to the identical technique.

Acceptance Limits

There are no acceptance limits for this test. However, table pads should have a minimum amount of attenuation, as should cassette fronts and tabletops. Under the conditions described, grids will appear to have large attenuation factors since they are removing scattered radiation. You may also want to measure the attenuation of grids without the phantom. This attenuation value (for primary radiation) should be minimized. In general, a difference in attenuation of 10% or less between two products will not result in a visible difference in the radiographs produced.

11.4. COPY FILM

Purpose

To provide copy films of quality similar to the original.

Equipment Needed

1. Aluminum step wedge (2 mm-thick steps)
2. Copper mesh resolution target or lead resolution target
3. Aluminum used to measure HVL
4. Fine-screen mesh

Procedure

1. Make a radiograph of the step wedge and resolution target. Make sure that a full range of useful densities (0.25 to 2.5) is exposed on the wedge. For an average step wedge you will need to place about 8 mm of aluminum over the resolution target to prevent overexposure of the target. (You should obtain a density of about 1.0 *beside* the test target.) Also, make a radiograph of the fine-screen mesh (Figure 11.7).
2. Expose a copy film with the original test film made in Step 1. Also expose a copy film of the fine-screen mesh radiograph.
3. Read and compare the densities of the original and the copy with a densitometer.
4. Match the density of the original and copy film to within 0.10 at the density on the step wedge closest to 1.0. This is accomplished by adjusting the timer or the light intensity setting on the copy machine.
5. Compare the resolution of the original and the copy film.
6. Check the copy of the mesh radiograph for contact over the entire image.
7. Repeat this procedure on a monthly basis.
8. Save the original and the current copy film in your QC room log.

Problems and Pitfalls

1. Typically, the high and low density may be less dense than the original.

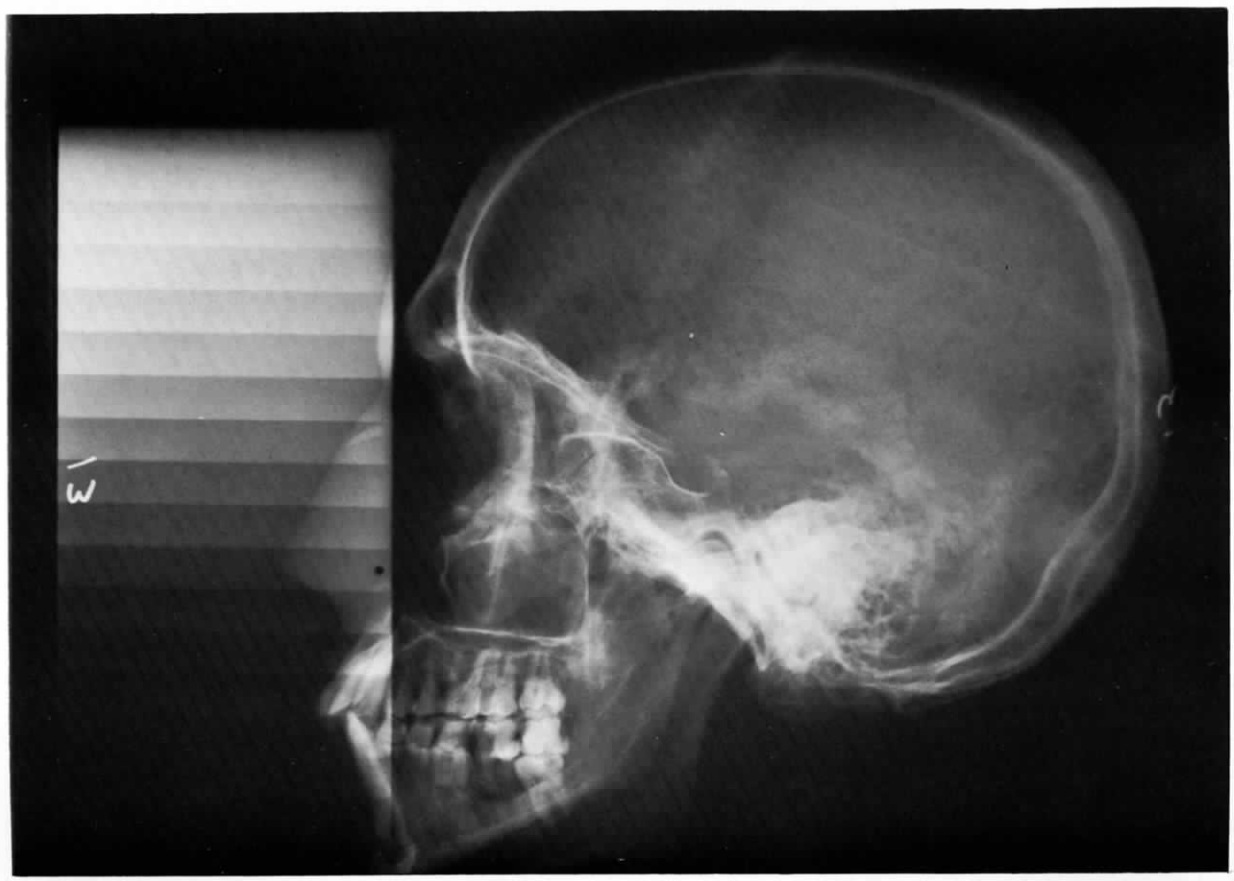

Figure 11.7a. Original radiograph of step wedge and skull phantom.

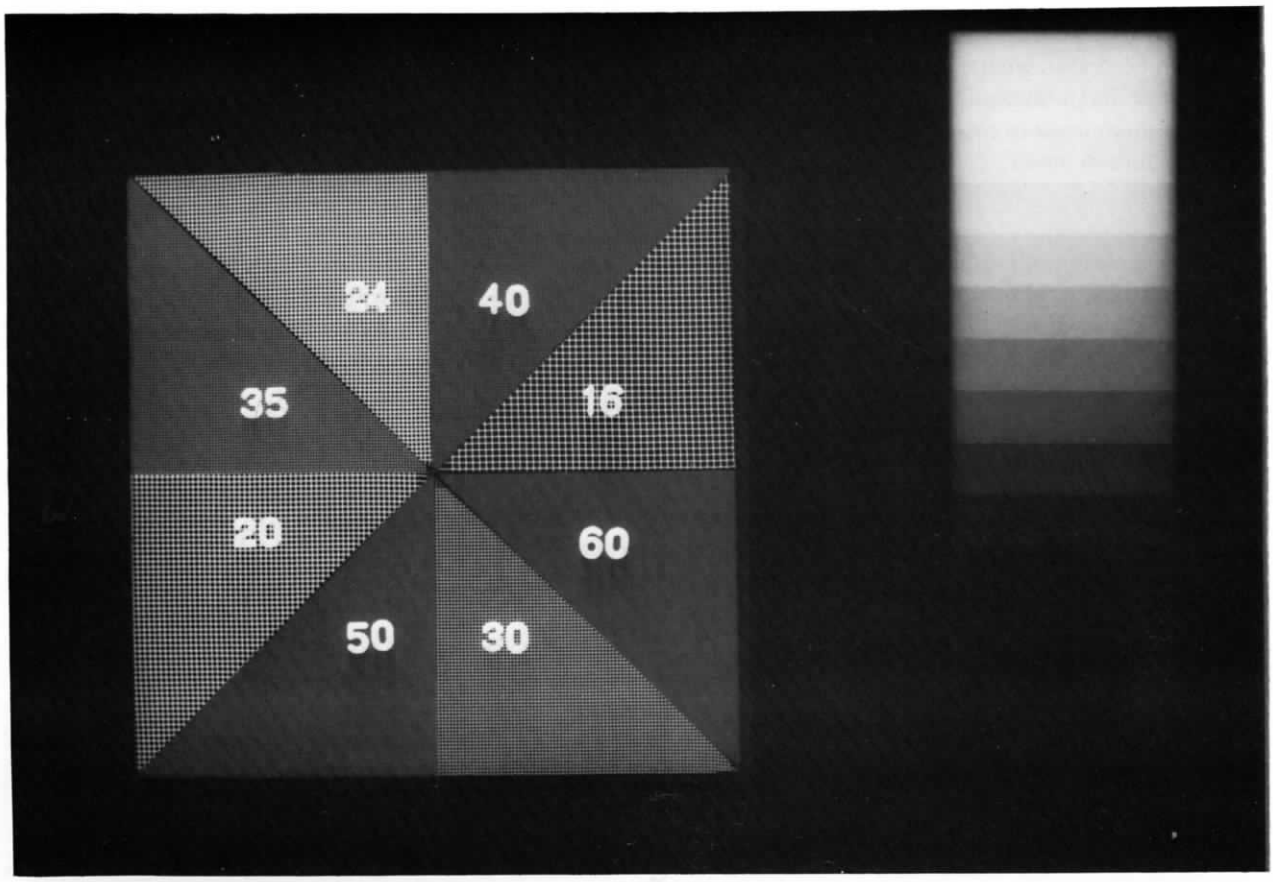

Figure 11.7b. Original radiograph of step wedge and mesh resolution target.

2. If the duplicating bulb must be replaced, make sure to use the bulb recommended by the manufacturer.

Acceptance Limits

1. The copy film density should be within 0.10 of the original at a density around 1.0. Visually, there should be very little difference between any original and copy.
2. There should be little or no loss of resolution between the original and the copy film.

Corrective Action

1. Adjust the timer or light intensity to produce the correct density.
2. If the densities cannot be matched, or if resolution is lost, consult a service representative from the copy film or machine manufacturer.

11.5. METHODS OF LOWERING THE FLUOROSCOPIC EXPOSURE RATE

Purpose

To minimize the fluoroscopic procedure dose to the patients and staff while maintaining image quality sufficient for diagnostic purposes.

Equipment Needed

1. Patient equivalent phantom (PEP)
2. Copper mesh resolution test tool or lead resolution target
3. Low-contrast resolution test tool

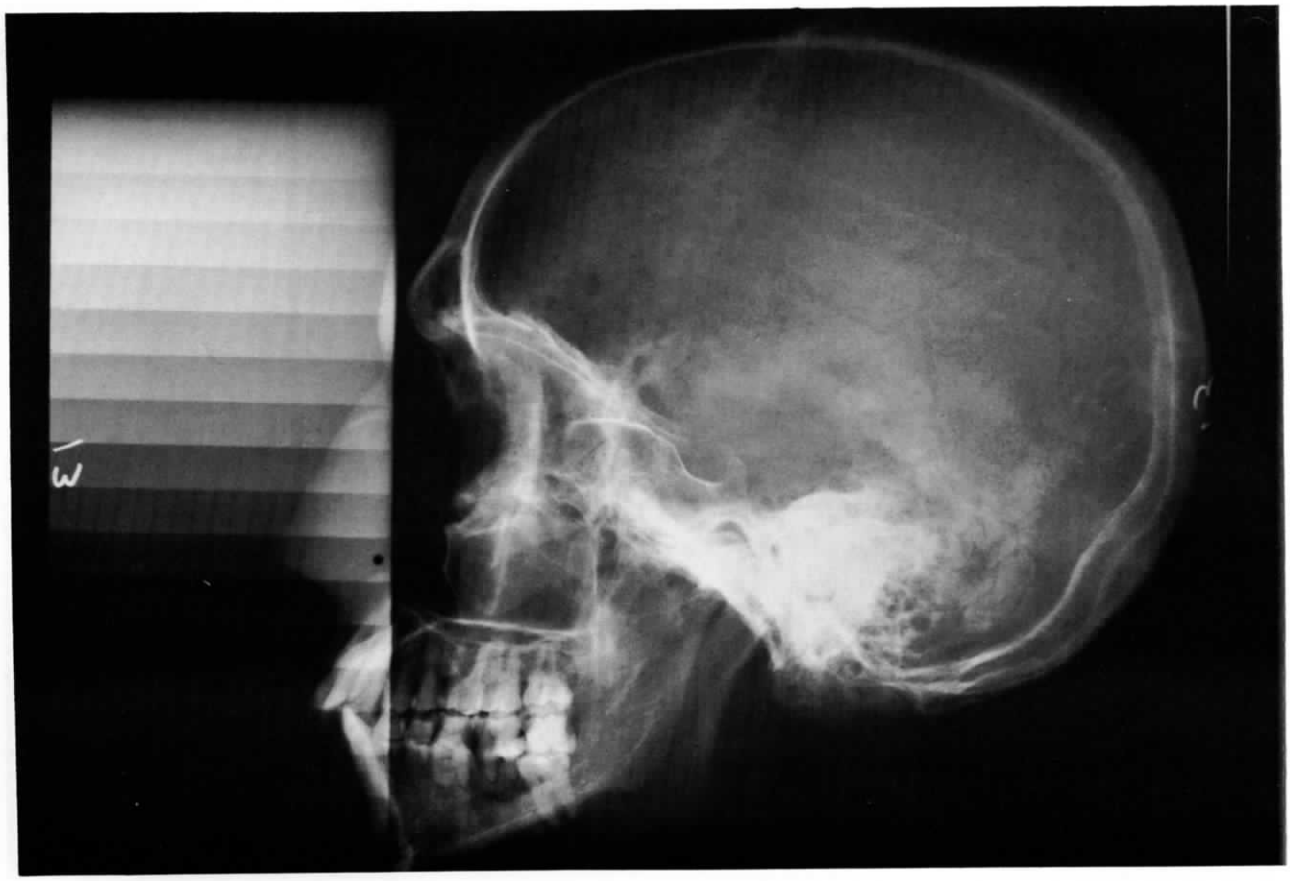

Figure 11.7c. Copy film of Figure 11.7a.

4. Dosimeter (and stopwatch if pen dosimeter is used)

Procedures—Fluoroscopy

1. Measure and record the standard fluoroscopic exposure rate as described on pages 136–137 before changing the exposure rate.
2. Place the copper mesh or lead resolution target on the PEP and note the maximum resolution before the exposure rate is changed.
3. Place the low-contrast test tool on the table and note the smallest hole size resolved before the exposure rate is changed (see Figure 9.18).
4. Observe the noise level during all tests before the exposure rate is changed.
5. With the assistance of a service engineer, gradually lower the fluoroscopic exposure rate. [***Note:*** Changes in the aperture of the TV camera lens will have to be made to meet the light requirements of some TV cameras. In fiberoptically coupled systems it will be necessary to vary the video gain.]
6. Check and compare the image quality (resolution, contrast, and noise) and exposure rate with each step until the desired image quality and/or exposure rate is obtained.
7. Record the final exposure rate, kVp, mA, and image quality data in the QC room log.

Procedure—Grid Versus Nongrid Fluoroscopy and Photofluorospot (PFS) Films

1. Compare the image quality and exposure levels as described above through the PEP with and without the fluoroscopic grid.
2. Make PFS films of all the test objects through the PEP with and without the grid. [***Note:*** The kVp used for the PFS films without the grid may have to be lowered if the exposure time is in minimum response range of the phototiming circuit, typically 10 msec.]

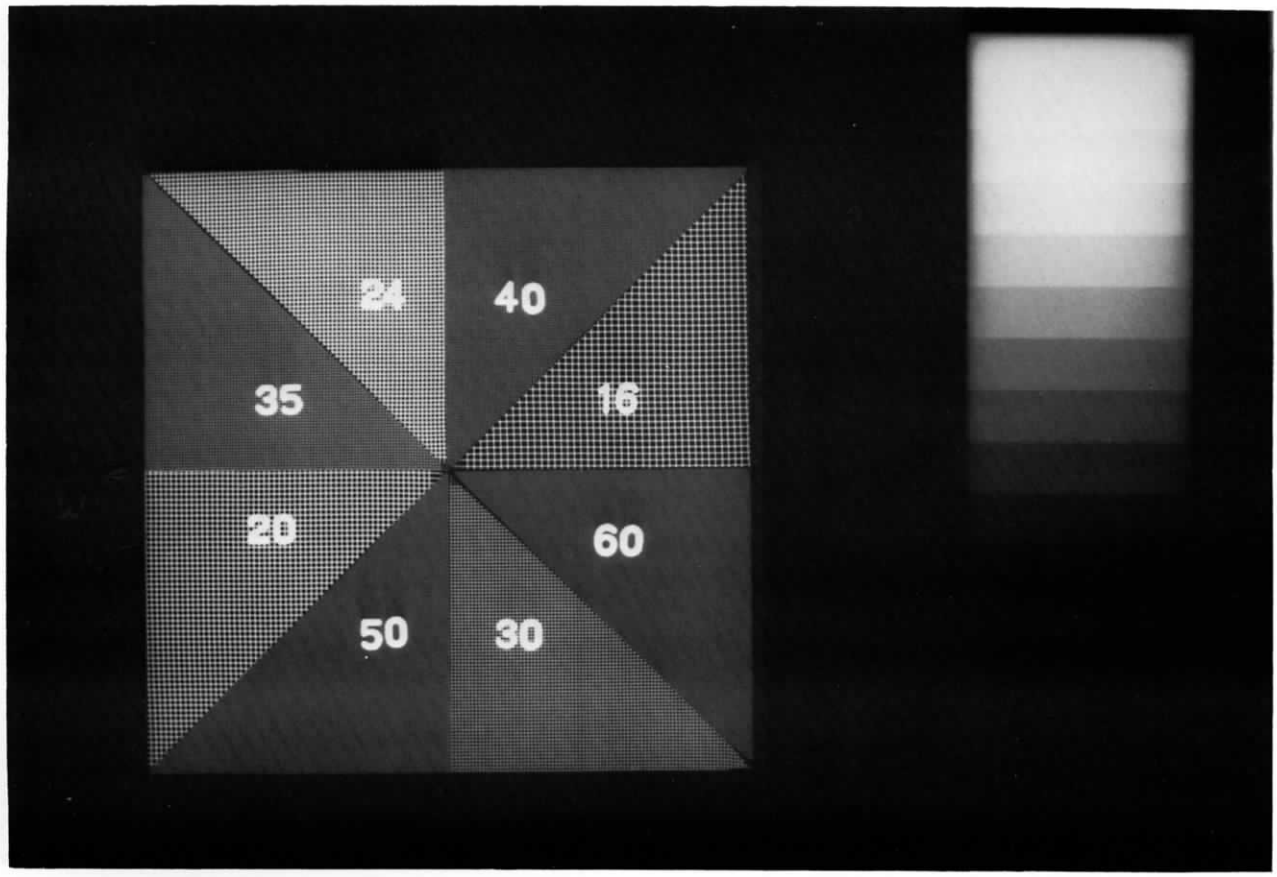

Figure 11.7d. Copy film of Figure 11.7b.

3. Consult your radiologists with the data and exposure measurements. [See Gray and Swee (1982) for further information and data.]
4. Initiate a patient trial if the data are favorable.
5. If it is apparent that the fluoroscopic exams and PFS films can be performed without the grid, discontinue its use; this will reduce both patient and staff exposure.
6. Record the exposure levels for the standard phantom and the image quality data in the QC room log.

11.6. WHAT TO DO BEFORE THE SERVICE ENGINEER LEAVES

Purpose

To assure that the x-ray equipment that you as a technologist are responsible for is mechanically and electrically safe and that the equipment is producing high-quality, consistent radiographs at a minimum dose to the patient.

Equipment Needed

1. The entire quality control test kit that you have developed
2. The QC room log
3. Patient equivalent phantom (PEP)
4. An understanding of the x-ray equipment, how it functions, and the problems the service engineer is trying to correct
5. Good rapport between the quality control technologist and the service engineer

Procedure

1. Verification of the integrity of x-ray equipment after it has been serviced is an important part of the quality control program that is often overlooked. This is the responsibility of the QC technologist and is best taken care of *before* the service engineer leaves. In fact, it is even better if it can be taken care of before the service engineer replaces all of the covers on the equipment.
2. Work closely with the service engineer, if possible, so that he understands the problem that you called him to repair and to assist him in any way possible. In some cases your test tools may provide results that differ from the engineer's measurements, so you will have to work together to resolve this problem.
3. Provide the service engineer with whatever test equipment he needs that you may have, which can make his job easier. For example, provide him with your phantom and dosimeter so he can set the fluoroscopic exposure rates to the levels you specify and under the conditions you normally use in evaluating the equipment.
4. Before the service engineer leaves test all aspects of the equipment function that he may have affected through his service. Most service engineers will be pleased to have you do this while they are there so that they can see what you are doing and to avoid the necessity of a second trip to your institution to correct a problem they thought was already corrected. In addition, avoiding this second trip can be financially advantageous to your institution since most vendors now charge between $50 and $60 per hour for service work, door-to-door. In other words, you are paying for the time the service engineer takes to get to your institution from his office, do his work, and return to his office from your institution, plus mileage.
5. Finally, make several radiographs of the PEP to assure that patient films will be acceptable.

Problems and Pitfalls

Often the QC technologist is not available when the service engineer is ready to leave or an adversary relationship develops between the QC technologist and the service engineer. Remember, your institution is paying for the engineer's services so you should make every effort to assist him and make his job as easy as possible. There is no sense in developing an adversary relationship (e.g., "I'm checking up on you since we don't trust the work you do"), because this will benefit no one. Good rapport and a close working relationship are essential—e.g., "I would like to work closely with you and assist you in any way that I can to better explain the problem we are having and to minimize the number of return trips you have to make to eliminate this problem."

12 EQUIPMENT SPECIFICATION, PURCHASE, AND ACCEPTANCE TESTING

The purchase of new x-ray equipment is complex, the equipment is expensive, and attempting to understand the differences in the equipment from various vendors can be overwhelming. We do not go into detail concerning how to go about specification and acceptance testing, but we do provide some general guidelines and suggestions on how to make this task easier and how to make sure you get what you want.

The first thing to consider is that the more complex the equipment and the more flexible the usage of the room, the more expensive the equipment will be to purchase and the more difficult it will be to maintain. However, inexpensive equipment may not be reliable and may require more service than slightly more expensive equipment. If the service for a particular manufacturer's equipment is difficult to obtain, if it takes a long time for the service man to respond to calls, and if parts are difficult to locate, then, for the most part, that manufacturer should be excluded from consideration unless you have an adequate in-house service organization.

The best way to start the specification process is to consider what you really need from the equipment you are about to purchase. Many single-phase units now provide excellent timing capabilities and with the faster screen-film systems now in use it may not be necessary to consider three-phase equipment. Be sure to determine not only what maximum mA is required (e.g., 600 mA is satisfactory for most radiographic and fluoroscopic rooms) but also what kVp is required. Many generators are capable of producing 150 kVp, but most radiographic examinations are carried out at 125 kVp or below so it is not necessary to pay for the additional kVp capability. Do not indicate to the vendor that you wish to purchase a 600-mA, 125-kVp generator without indicating a kW rating. A firm could quote, for example, a 600-mA, 125-kVp generator that is rated at only 50 kW, which means that the 600 mA station can only be used up to 80 kVp. To be able to use the entire capability of 600 mA and 125 kVp you need a generator that is rated at 75 kW.

Most practical radiographic and fluoroscopic imaging systems today should be equipped with 0.6-mm and 1.2-mm focal spot x-ray tubes for the best detail and the most flexibility. However, it will not be possible to use the small focal spot for more than about 200 mA unless you specify a high-speed rotor for the x-ray tube. Consequently, many vendors will quote a 1.0-mm and 2.0-mm focal spot combination and not mention the possibility of the smaller focal spots with a high-speed rotor, which would cost $3,000 to $4,000 more but allow you much more flexibility and use of the small focal spot at higher techniques.

Many other considerations must be reviewed before asking for quotations from the vendors. Remember that the vendors' job is to sell equipment and they may or may not have your best interests at heart. Talk to several vendors and ask what they would suggest. Talk to other x-ray departments that have equipment similar to that which you are considering and see what the service history has been. Visit other institutions and assure yourself that the equipment you are considering is easy to use. Especially, talk to the technologists who are using the equipment on a day-to-day basis and see what they have to say about it.

What about quotes and specifications? We will assume that you have decided what type of equipment you wish to purchase. You can ask several vendors to provide you quotes and specifications on the equipment. However, this results in a deluge of brochures with the pertinent information scattered

throughout and makes the job of comparing the various vendors' quotes almost impossible. In addition, most vendors prefer to quote a package price, so you have no idea what you are paying for separate options. For example, a 4-way power tabletop may cost as much as $15,000 to $20,000 more than a comparable 2-way power top, but this won't be obvious from a package price quote. Since most vendors are reticent to provide prices for each item in a room of x-ray equipment, the easiest way to determine the cost differences is to ask them to "option" certain items. For example, a high-speed rotor for an x-ray tube may be optioned at $4,000, a 100-mm camera may be optioned at $30,000, and a 2-way power top may be optioned at "less $16,000" (compared to the price of the 4-way power top). Most vendors will give you a package price and then list the options, either as add-ons or subtractions from the package price at the end of the quote. Never tell one vendor that you favor his equipment over another during the specification and quoting process.

Equipment specifications are difficult to obtain from most vendors in a manner in which they can easily be compared. There are two approaches you could take to help solve this problem. One is to write up your own *detailed* specifications and ask the vendors to bid on the basis of these. However, this means that you must specify such things as what the kVp calibration accuracy must be, what the resolution in the center and edges of the image intensifier must be (and how it will be tested), and how the television system will perform. In addition, the vendors may not be able to meet some of your specifications and decide not to bid. This also tends to promote an adversary relationship between your department and the vendors, since you are telling them how to build the equipment.

We have found that it is much easier to ask the vendors to fill out a standard specification form (Appendix B) and provide the information necessary to determine how the tests were carried out. Most importantly, the vendor must be advised verbally, and in writing as part of the final purchase order, that the equipment must meet these specifications after delivery and installation at your facility. (Some vendors will want to specify that the equipment meets their specifications when it is preassembled at their factory!) If you cannot carry out all of the tests necessary for acceptance testing, then it would be worthwhile to hire a consulting service engineer and physicist to assure that the equipment meets the appropriate specifications.

The standard specification form saves you many hours in comparing equipment specifications from various vendors since you can lay out each page from the different vendors side by side and see how the equipment compares. This in itself may be educational in that some vendors may note that their equipment cannot do this or that, so you should immediately question whether their competitors' equipment is of the same type. As an example, one vendor noted that his equipment did not meet the EIA RS-170 video standards set by the broadcast industry and two others left this question blank. After inquiring it was discovered that none of the three vendors' equipment met the standard. (This standard is especially important if you want to tape-record your video images on conventional recording equipment.)

The acceptance testing process is the responsibility of the QC technologist. You may have considerable assistance if you have in-house service engineers who can be with the vendor's installation crew during the entire installation, assuring that the equipment is being installed to your standards and being properly calibrated. (When the in-house engineer works with the vendor's crew during installation, two other benefits result: 1) the engineer is receiving training on the new equipment and will become quite familiar with the entire installation, including the setup and calibration procedures; and 2) the engineer is providing an extra pair of hands to assist in the installation, so the vendor should be willing to compensate your facility in some way for this by either reducing the equipment price slightly or by providing, at no cost, service schooling at the manufacturer's facility on the new equipment.)

If you have similar equipment in your facility the standards that should be expected from the equipment are already known and will make acceptance testing easier. For the most part, acceptance testing means working through the entire room QC checks you would normally carry out on similar equipment and assuring that each item meets the standards of similar equipment and the specifications set forth by the vendor in his specification sheet and price quote. (This is why it is important that the vendor be advised, and that the purchase order note, that the specifications must be met prior to final payment for the equipment.)

Most vendors are willing to work closely with your department to assure that the equipment is meeting their specifications. They will normally replace x-ray tubes if the focal spots are too large, replace image intensifiers if the resolution does not meet specifications, and so forth. However, some difficulties may be encountered in that the measurement techniques they use may be considerably different from yours. In this case you can request that

they provide their test equipment and demonstrate to you that the system meets the specifications that they have provided you.

Only after *all* problems have been corrected and *all* specifications have been met should the final payment be made for the equipment.

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Appendix A QUALITY CONTROL FORMS AND CHARTS

CONTENTS

Location _____

From _____ To _____

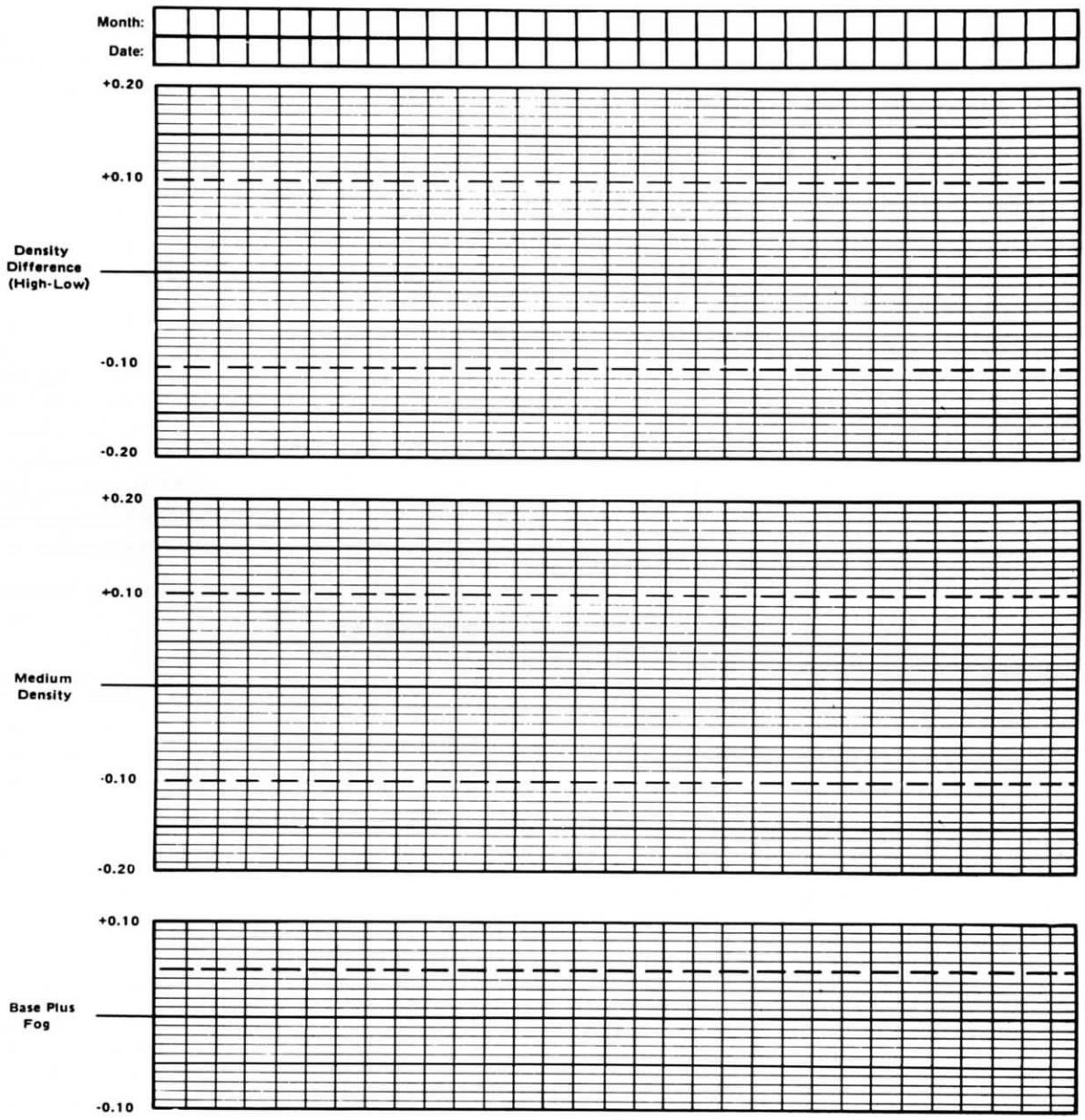
Reject/Repeat Analysis

Cause	Number of Films	Percentage of Rejects	Percentage of Repeats
1. Positioning			
2. Patient Motion			
3. Light Films			
4. Dark Films			
5. Clear Film			
6. Black Film			
7. Tomo Scouts			
8. Static			
9. Fog—Darkroom			
10. Fog—Cassettes			
11. Mechanical			
12. Q.C.			
13. Miscellaneous (?)			
14. Good Films			
Total Waste (1-14) ____ %			
Total Rejects (All except 5 and 12)			
Total Repeats (1-4, 6, 8-11, 14)			

Total Film Used _____

X-Ray Processing Control Chart

Processor: _____ Month: _____



REPLENISHMENT RATE

Date	Developer	Fixer

TEMPERATURE

Date	Developer	Wash

REMARKS

Date	Action

Date	Action

Room Equipment Survey
Page 1 of _____
Date _____

Building _____ Section _____ Room # _____ MDH # _____

X-RAY GENERATOR:

Manufacturer _____
Model _____
Serial # _____
Date purchased _____
Fixed _____ Mobile _____
CD _____ Battery _____ 110 _____ 220 _____
Single phase _____ Three phase _____
Maximum kVp _____ Maximum mA _____

OVERHEAD:

Manufacturer _____
Date purchased _____
Model _____

COLLIMATOR:

Manufacturer _____
Model _____
Serial # _____
Date purchased _____
Source-to-image distance _____ cm
Source-to-tabletop distance _____ cm
(fluoro)

GRID:

Manufacturer _____
Date purchased _____
Grid ratio _____
Lines per inch _____
Focus _____ to _____ cm
Interspace material _____
Stationary: yes _____ no _____

HEAD UNITS:

Manufacturer _____
Model _____
Date purchased _____

TOMOGRAPHIC UNITS:

Manufacturer _____
Model _____
Serial # _____
Date purchased _____
Linear _____ Circular _____
Oval _____ Tri-spiral _____
Hypocycloidal _____

FILM CHANGERS:

Manufacturer _____
Serial # _____
Date purchased _____
Model _____ Film size _____
Cut film _____ Roll film _____

USAGE:

Maximum kVp used _____
Maximum time used _____
Number of exams per week _____
Number of films per week _____
Maximum mA used _____
Maximum mAs used _____

MISCELLANEOUS/COMMENTS:

Room Equipment Survey
Page _____ of _____
Date _____

Building _____ Section _____ Room # _____

X-RAY TUBES:

Manufacturer _____ Fixed _____ Mobile _____

Model _____ Focal spot sizes _____

Serial # _____ Radiographic _____ Fluoro _____

Date installed _____ Grid pulse _____ High speed _____

Date removed _____ Bias focus _____

Horns: 0° _____ 90° _____ 135° _____

180° _____ 270° _____

OVERLOAD PROTECTION FACTORS:
Single ( ) or Three ( ) Phase

The following techniques should be allowed by the overload protection circuits:

mA	kVp	Time
Low speed		
High speed		

The following techniques should *NOT* be allowed by the overload protection circuits:

kVp	or	Time

Room Equipment Survey
Page _____ of _____
Date _____

Building _____ Section _____ Room# _____

TV MONITOR:

Manufacturer _____ Fixed _____ Mobile _____

Model _____ Size _____

Serial # _____

Date purchased _____

IMAGE INTENSIFIER:

Manufacturer _____ Fixed _____ Mobile _____

Model _____ ZnCds _____ CsI _____

Serial # _____ Size - Input _____ (cm)

Date purchased _____ Output _____ (cm)

TV CAMERA:

Manufacturer _____ Fixed _____ Mobile _____

Model _____ Plumbicon _____ Vidicon _____

Serial # _____ Other (Specify) _____

Date purchased _____ 525 _____ Other (Specify) _____

MISCELLANEOUS/COMMENTS:

Visual and Manual Quality Control Checks

Building: _____ Section: _____ Room # _____ Tube: _____

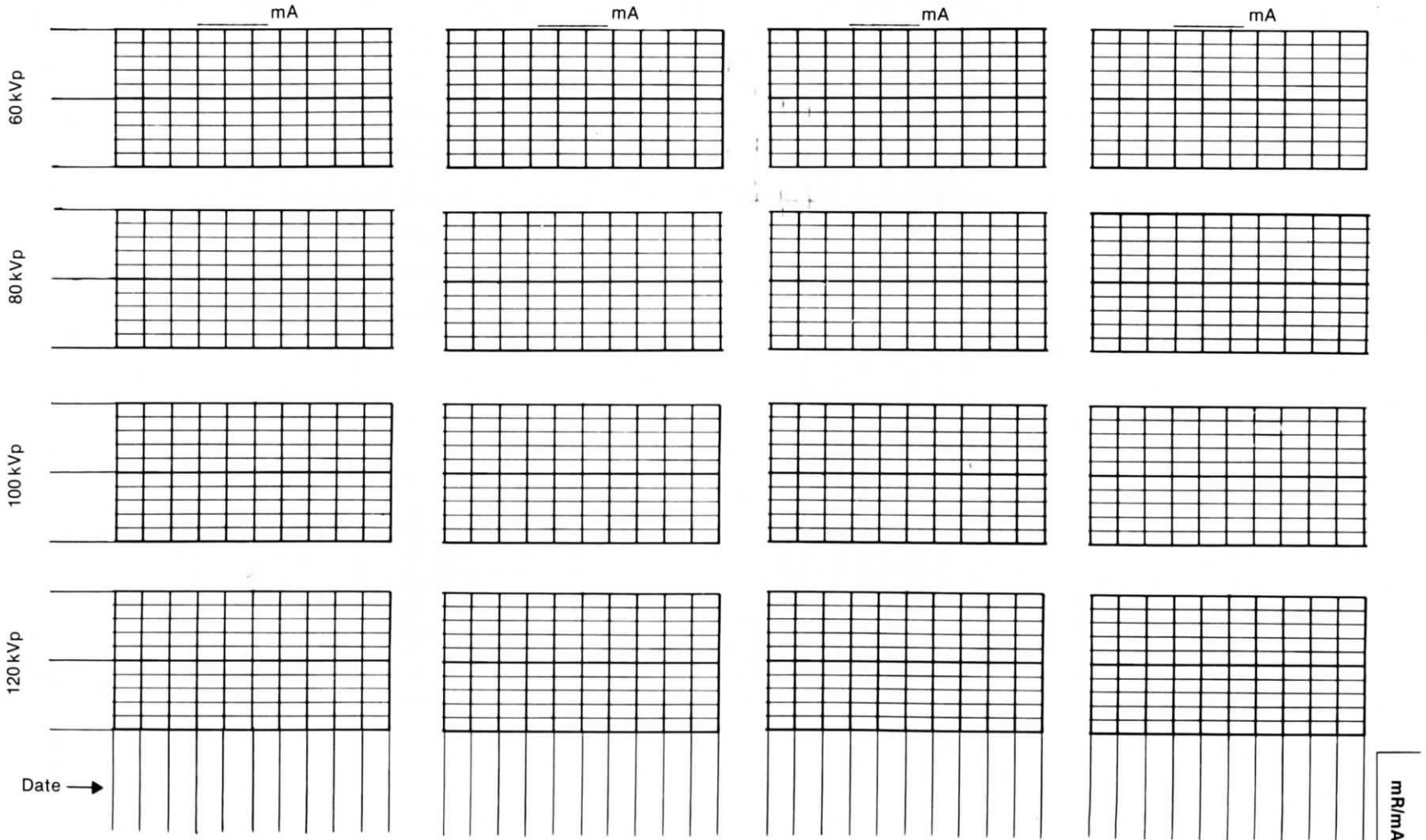
		DATE
OVERHEAD TUBE CRANE	TFD indicator or marks	
	Angulation indicator	
	Locks (all)	
	Perpendicularity	
	Field light	
	Bucky center light	
	High tension cable/other cables	
TABLE	Overhead crane movement	
	Bucky lock	
	Cassette lock	
	Float and power top switches	
	Measuring caliper	
	Step stool	
	Angulation indicator/stop	
	Foot board and shoulder braces	
CONTROL BOOTH	Hand switch placement	
	Window	
	Panel switches/lights/meters	
	Technique charts	
	Overload protection	
FLUOROSCOPIC SYSTEM	Locks (all)	
	Power assist	
	Motion smoothness	
	Switches/lights/meters	
	Compression device/spoon	
	Fluoroscopic monitor	
	Fluoroscopic grid	
	Fluoroscopic timer	
	Fluoroscopic drapes	
	Park position interrupt	
	Fluoro shutters visible-high	
	-low	
OTHER	Gonad shield/aprons/gloves	
	Bucky slot cover	

PASS = ✓
FAIL = F
DOES NOT APPLY = NA

Building _____ Section _____ Room # _____ Tube _____ Focal spot _____

TECHNIQUE: Time _____ Source-detector distance _____ Bucky _____ Tabletop _____

Phantom _____



Linearity

Building _____ Section _____ Room # _____ Tube _____

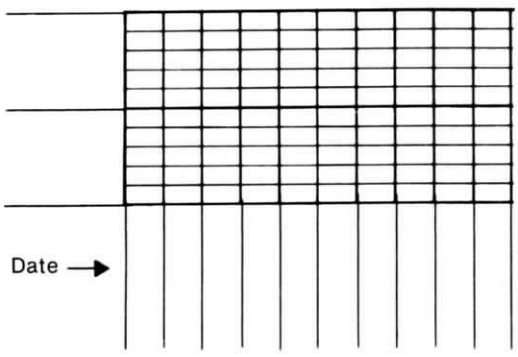
TECHNIQUE:

kVp _____ Focal spot _____ SID _____

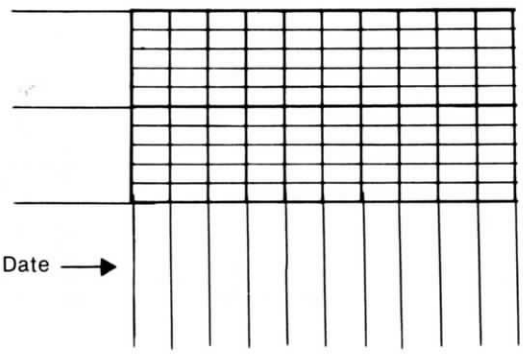
Tabletop _____ Bucky _____

mA	_____	_____	_____	_____	_____
Time	_____	_____	_____	_____	_____
mAs	_____	_____	_____	_____	_____

Average mR/mAs



Variation (± %)



Repeatability

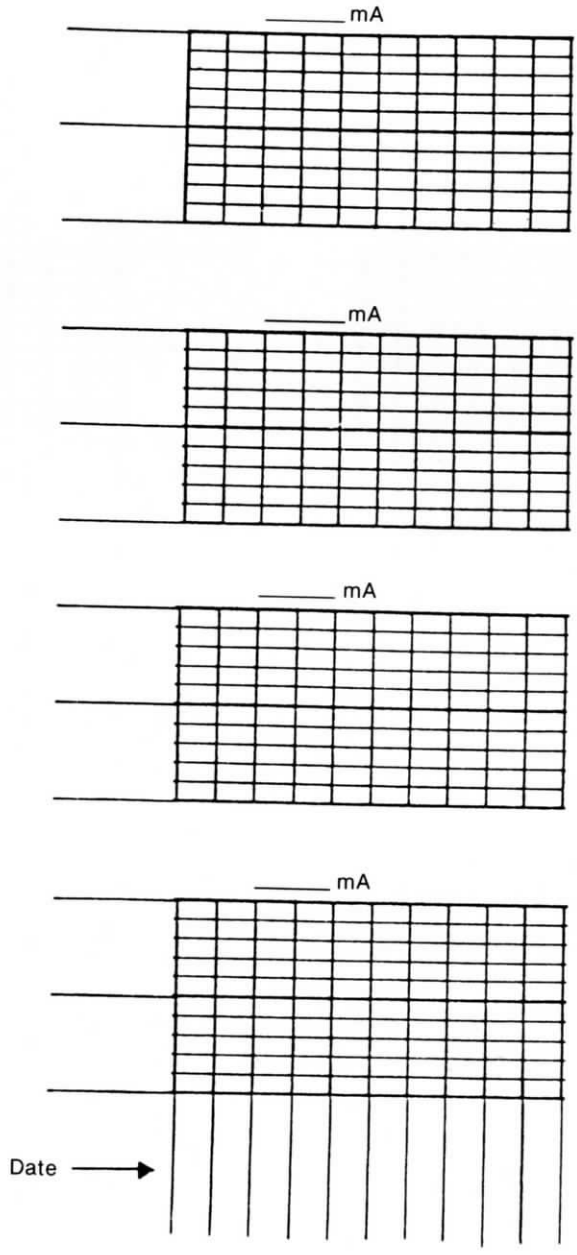
Building _____ Section _____ Room # _____ Tube _____

TECHNIQUE:

kVp _____ Focal spot _____ SID _____

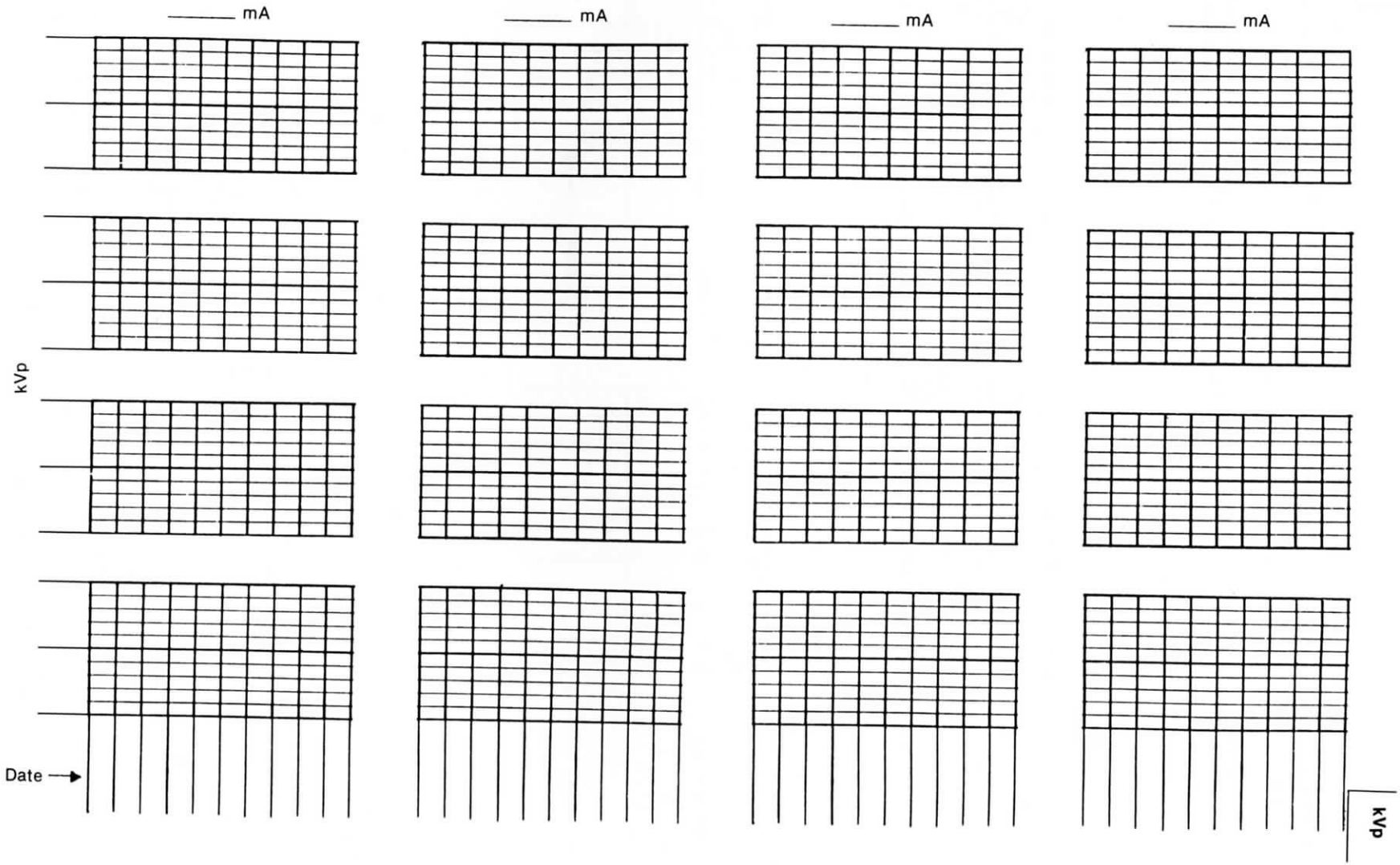
Tabletop _____ Bucky _____

Variation (± %)



Building _____ Section _____ Room # _____ Tube _____ Focal spot _____

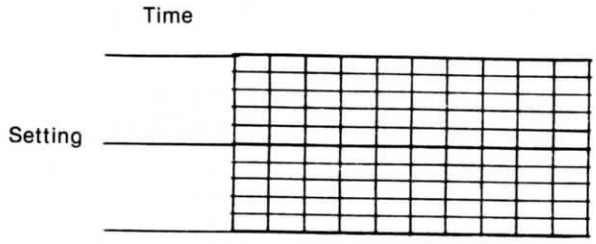
TECHNIQUE: Time _____ Source-detector Distance (60) _____ (80) _____ (100) _____ (120) _____

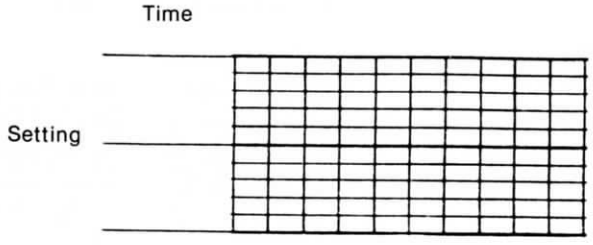


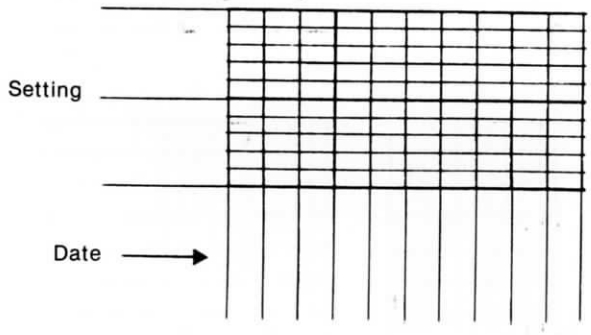
Timer Accuracy

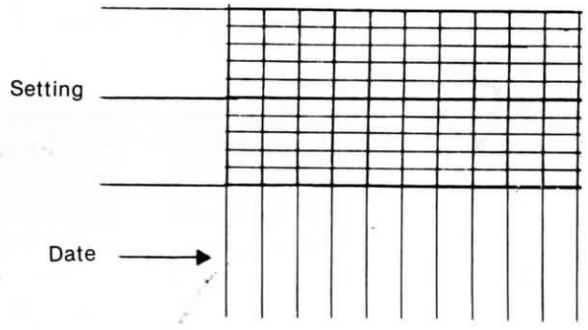
Building _____ Section _____ Room # _____ Tube _____

TECHNIQUE: kVp _____ mA _____ Focal spot _____









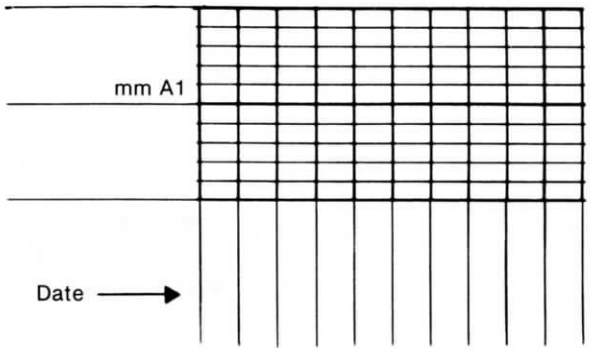
Half-Value Layer

Building _____ Section _____ Room # _____ Tube _____

TECHNIQUE:

kVp _____ mA _____ time _____

Added filtration _____ Focal spot _____



Focal Spot Size

Building _____ Section _____ Room # _____ Tube _____

TECHNIQUE:

kVp _____

Screen-film type _____

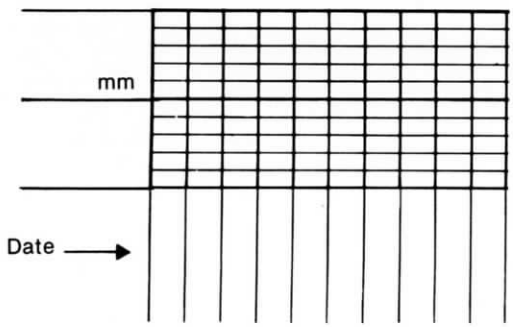
SID _____ SOD _____

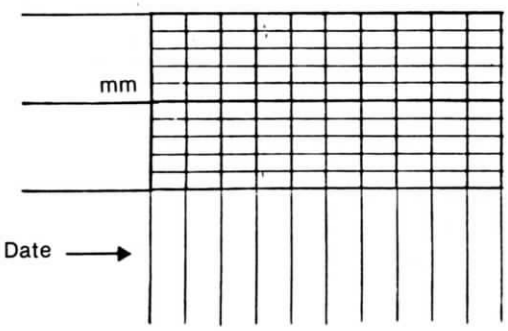
Test tool _____

Small Focal Spot

Nominal size _____ mm

mA _____ time _____

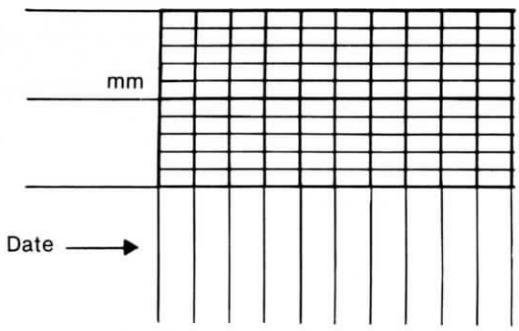


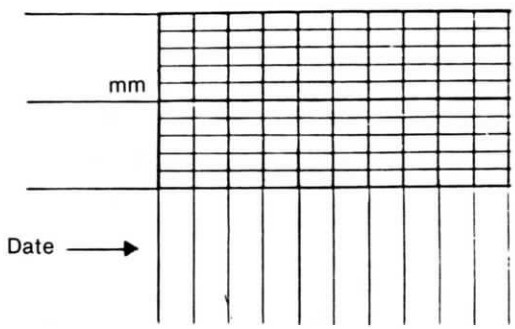


Large Focal Spot

Nominal size _____ mm

mA _____ time _____





Collimator

Building _____ Section _____ Room # _____ Tube _____

TECHNIQUE:

SID _____

kVp _____ mA _____ Time _____

Tabletop _____ Bucky _____

Date	Deviation (mm)				Align-ment	Automatic Field Size			
	Left	Right	Top	Bottom		8 × 10	10 × 12	11 × 14	14 × 17

Standard Fluoroscopic Exposure Rate

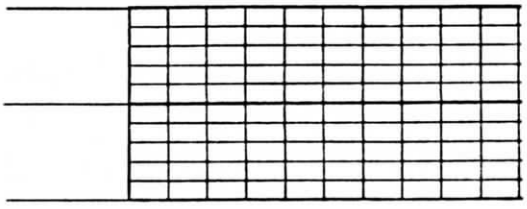
Building _____ Section _____ Room # _____ Tube _____

Standard phantom (6″ Lucite, 3 mm Al) on support, image intensifier 6″ above phantom.

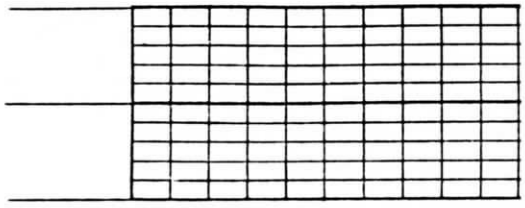
Measurement distance (if other than standard setup) _____

Entrance exposure rate (R/min)

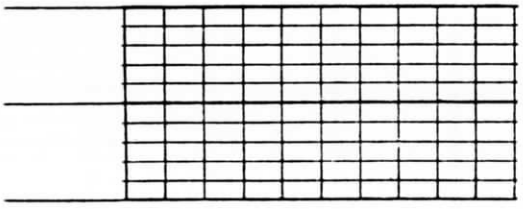
6″ mode

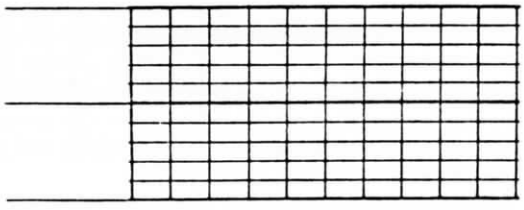


9″ mode

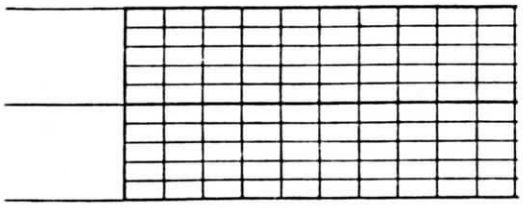


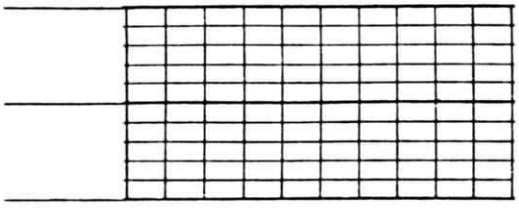
Exit exposure rate (mR/min)



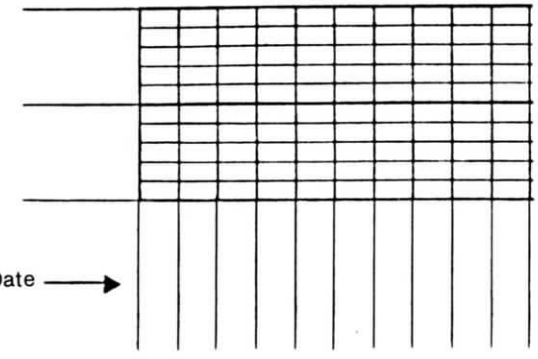


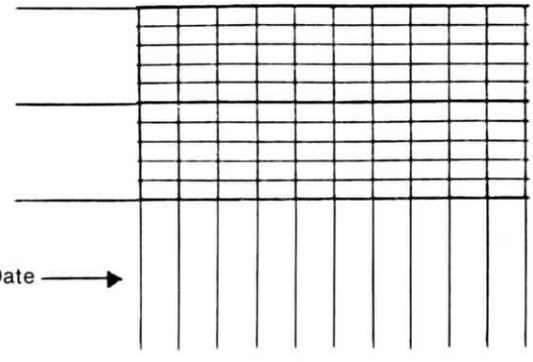
mA





kVp





Maximum Fluoroscopic Exposure Rate

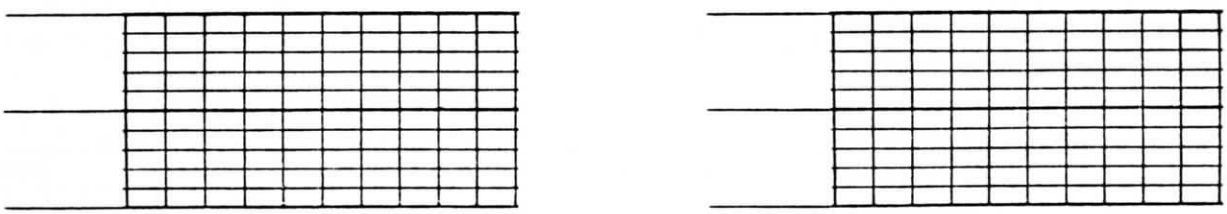
Building _____ Section _____ Room # _____ Tube _____

Tabletop _____ Measurement distance (if other than tabletop) _____

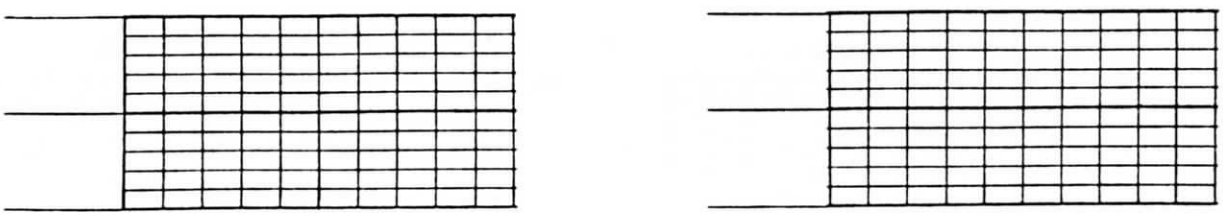
Automatic

Manual

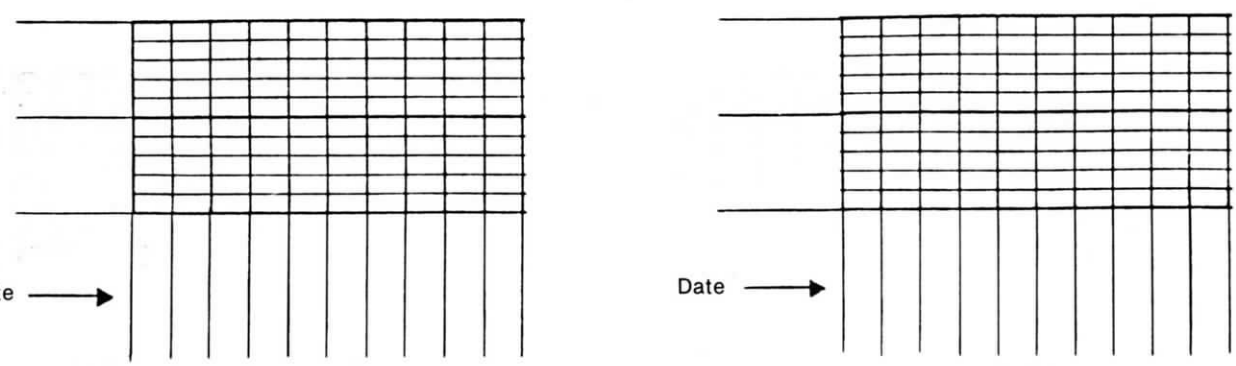
Exposure rate (R/min)



mA



kVp

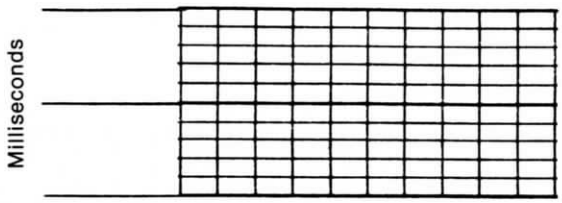


Phototiming

Building _____ Section _____ Room # _____ Tube _____

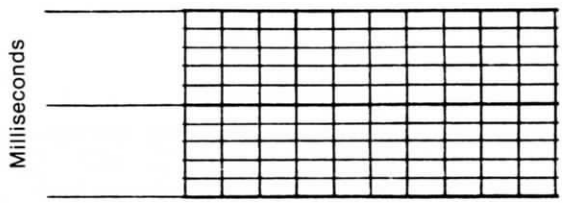
MAXIMUM EXPOSURE TIME:

kVp_____ mA _____ FFD_____



MINIMUM EXPOSURE TIME:

kVp _____ mA _____ FFD _____



PHANTOM RADIOGRAPHS:

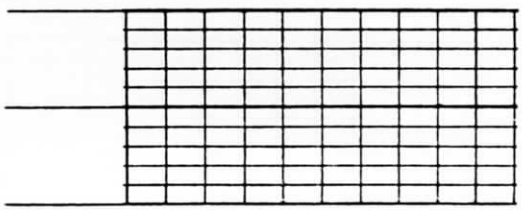
mA _____ FFD _____ Detector: R_____ C_____ L _____

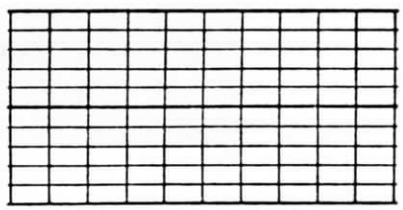
Film density

4-inch acrylic

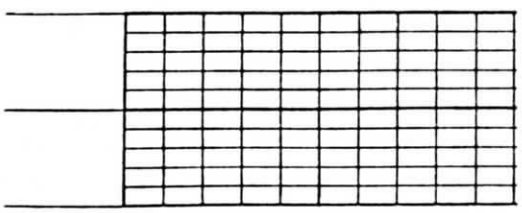
8-inch acrylic

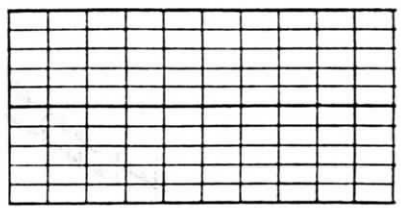
kVp _____



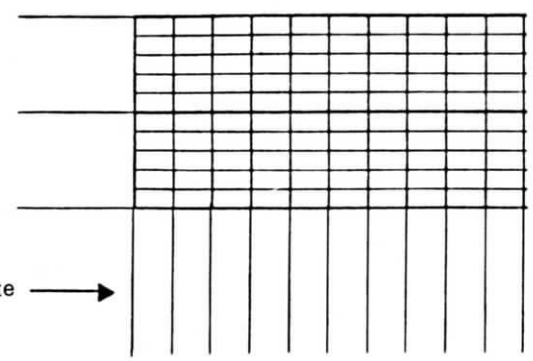


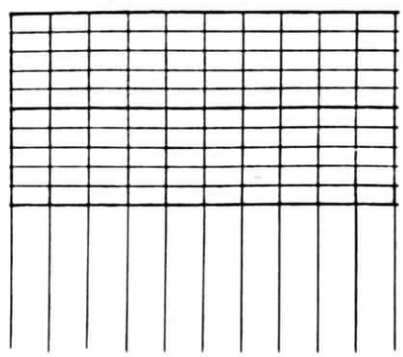
kVp _____





kVp _____





Phantom
Entrance Exposure
and Film Density

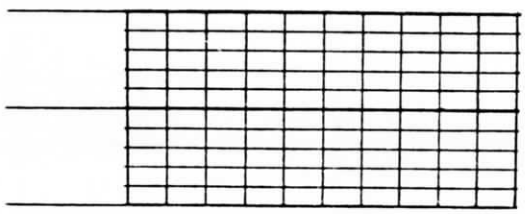
Building _____ Section _____ Room # _____ Tube _____

TECHNIQUE: (21-cm lumbar spine technique from chart)

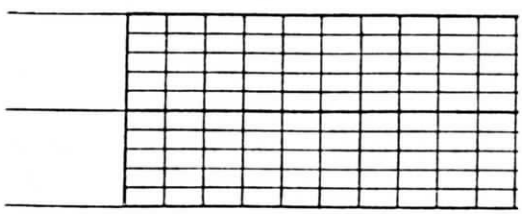
kVp _____ mA _____ time _____

Focal spot _____ FFD _____ phantom _____

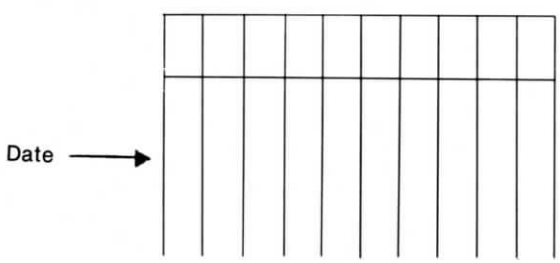
ENTRANCE EXPOSURE (mR) (including backscatter)



FILM DENSITY (read at 1:00 open position on step wedge)



DENSITY UNIFORMITY (Pass/Fail)



Building _____ Section _____ Room # _____

TECHNIQUE: Use charted tomographic factors for a 15-cm lateral skull or AP abdomen

kVp _____ mA _____ Time _____ Focal spot _____

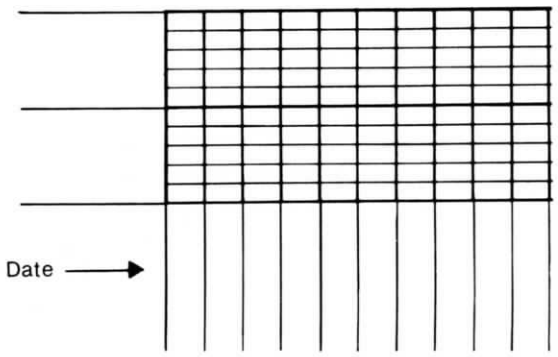
Motion _____ Angle _____

Level _____ Thickness _____

Phantom _____

Date	Resolution	Level	Thickness	Pinhole OK?	Comments

ENTRANCE EXPOSURE (mR)

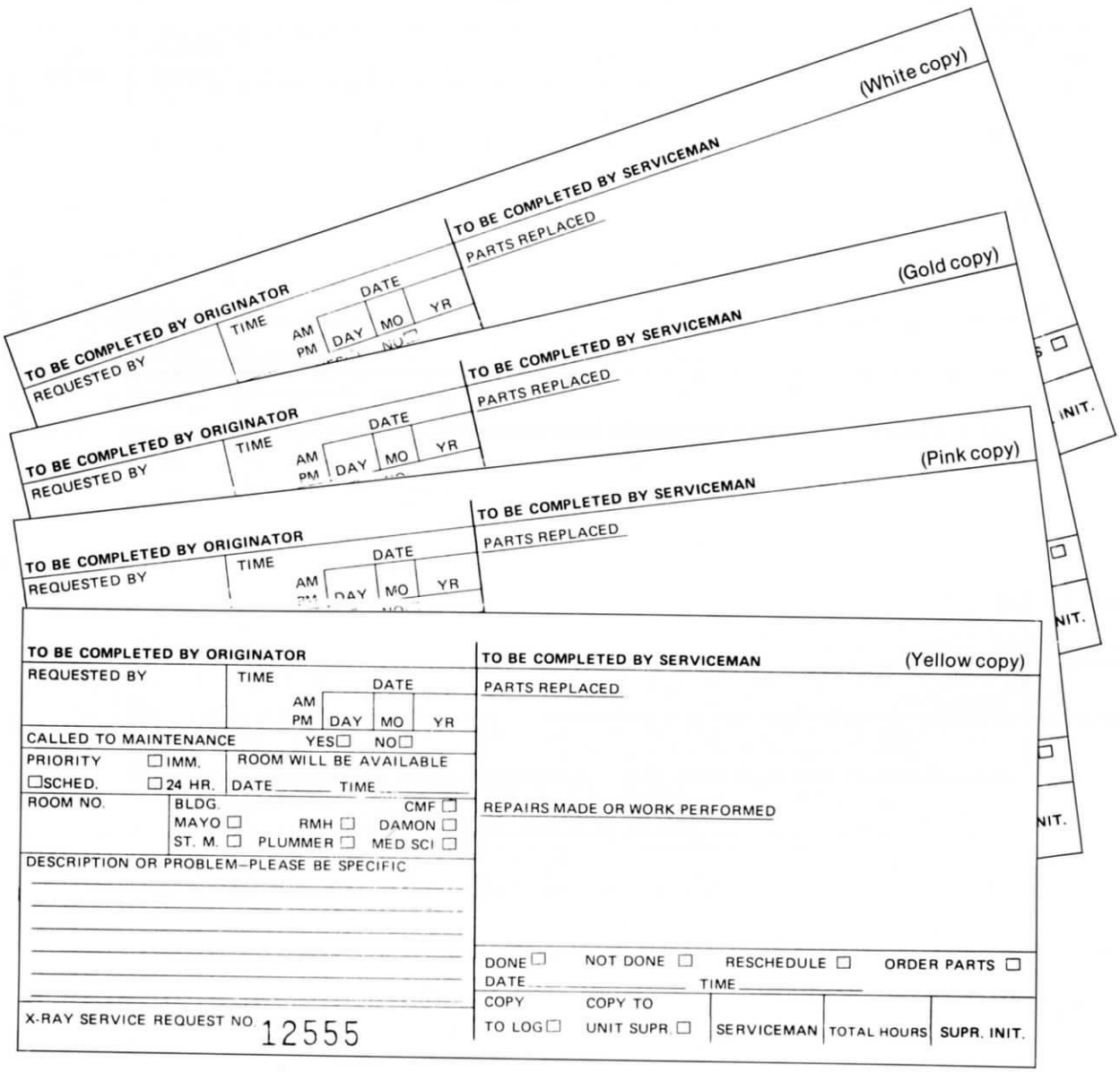


Maintenance Log

Building ______________________ Section ______________________ Room # ______________

Date	Action	Service Hours	QC Hours

X-Ray Service Request Form



(White copy)

TO BE COMPLETED BY ORIGINATOR

REQUESTED BY

TIME AM PM

DATE DAY MO YR

TO BE COMPLETED BY SERVICEMAN

PARTS REPLACED

(Gold copy)

TO BE COMPLETED BY ORIGINATOR

REQUESTED BY

TIME AM PM

DATE DAY MO YR

TO BE COMPLETED BY SERVICEMAN

PARTS REPLACED

(Pink copy)

TO BE COMPLETED BY ORIGINATOR

REQUESTED BY

TIME AM PM

DATE DAY MO YR

TO BE COMPLETED BY SERVICEMAN

PARTS REPLACED

(Yellow copy)

TO BE COMPLETED BY ORIGINATOR

REQUESTED BY

TIME AM PM

DATE DAY MO YR

CALLED TO MAINTENANCE YES☐ NO☐

PRIORITY ☐IMM. ☐SCHED. ☐24 HR.

ROOM WILL BE AVAILABLE DATE_____ TIME_____

ROOM NO.

BLDG. CMF☐ MAYO☐ RMH☐ DAMON☐ ST. M.☐ PLUMMER☐ MED SCI☐

DESCRIPTION OR PROBLEM–PLEASE BE SPECIFIC

X-RAY SERVICE REQUEST NO. 12555

TO BE COMPLETED BY SERVICEMAN

PARTS REPLACED

REPAIRS MADE OR WORK PERFORMED

DONE☐ NOT DONE☐ RESCHEDULE☐ ORDER PARTS☐

DATE_____ TIME_____

COPY TO LOG☐	COPY TO UNIT SUPR.☐	SERVICEMAN	TOTAL HOURS	SUPR. INIT.

EXAMINATION	TIME/SEC	mA	kVp SCALE	TFD	CASSETTE
SKULL					
SKULL, AP, Lateral 0- 3yrs.					
4-7 yrs.					
Adult					
CERVICAL SPINE					
Cervical AP 10°↑				48″	8 x 10 in
Lateral (Cross Table)				48″	24 x 30 cm
¾ (Table Top)				48″	24 x 30 cm
Swimmer's (Grid or Bucky)				48″	24 x 30 cm
Odontoid				30″	8 x 10 in
Piller 30°↓				48″	24 x 30 cm
SHOULDER					
Shoulder AP				48″	24 x 30 cm
Neer View				48″	24 x 30 cm
Transthoracic Lateral				48″	35 x 43 cm
Axillary View (Grid)				48″	24 x 30 cm
Scapula AP & Lateral				48″	24 x 30 cm
Clavical PA				48″	24 x 30 cm
Humerus AP & Lateral				48″	35 x 43 cm
THORACIC					
Dorsal AP (Filter)				48″	35 x 43 cm
Lateral Dorsal (Filter)				48″	35 x 43 cm
EMACIATED ____mA	THIN ____mA	AVERAGE ____mA	PORTLY ____mA	OBESE ____mA	
Dorso-Lumbar Junction 10↓				48″	24 x 30 cm
Dorsal Lower Lateral				48″	24 x 30 cm
Lumbar Upper Lateral				48″	24 x 30 cm
LUMBAR AND ABDOMINAL					
Lumbar AP 5°↑ and Abdomen					
≤18 cm				48″	35 x 43 cm
19-23 cm				48″	35 x 43 cm
≥24 cm				48″	35 x 43 cm
Lumbar ¾, 42° Oblique 5°↑					
≤18 cm				48″	24 x 30 cm
19-23 cm				48″	24 x 30 cm
≥24 cm				48″	24 x 30 cm
Lumbar Lateral Meas L-2				48″	30 x 35 cm
Lumbar Loc lateral meas L-5				48″	6 x 10 in
Lumbar Graft Lateral				48″	24 x 30 cm
Lumbar Flexion & Extension				48″	30 x 35 cm

EXAMINATION	TIME/SEC	mA	kVp SCALE	TFD	CASSETTE
LUMBAR AND ABDOMINAL (cont'd)					
Pancreatic Area (AP (Both 15° Obl) 24 × 30 cm Transverse					
≤ 18 cm				48″	24 x 30 cm
19–23 cm				48″	24 x 30 cm
≥ 24 cm				48″	24 x 30 cm
PELVIC REGION					
Pelvis & Hips AP				48″	35 x 43 cm
Hips Lateral & Oblique 5°↓				48″	24 x 30 cm
Sacrum AP 5°↑				48″	24 x 30 cm
Sacrum Lateral				48″	24 x 30 cm
Coccyx AP 10°↓				48″	24 x 30 cm
Coccyx Lateral				48″	24 x 30 cm
S-1 Joints (R & LPO 20°)				48″	24 x 30 cm
FEMUR, KNEE					
Femur AP				48″	35 x 43 cm
Lateral & Oblique for Vessels				48″	35 x 43 cm
Knee AP, Lateral				48″	24 x 30 cm
Intercondylar Notch				48″	Non-Bucky
Houston View 45°↑				48″	35 x 43 cm
CHEST					
AP Supine, All				48″	35 x 43 cm
Lateral Supine (Bucky)				48″	35 x 43 cm
Lateral Decubitus (Grid)				48″	35 x 43 cm
Lateral Sternum				48″	30 x 35 cm
RIBS					
Ribs Above Diaphragm				48″	24 x 30 cm
EMACIATED _____mA	THIN _____mA	AVERAGE _____mA	PORTLY _____mA	OBESE _____mA	
Ribs Below Diaphram					
≤ 18 cm				48″	24 x 30 cm
19–23 cm				48″	24 x 30 cm
≥ 24 cm				48″	24 x 30 cm
EXTREMITY					
Wrist, Hand, Forearm, Foot—Use Extremity Cassette, 48″					
Extremity— sec, mA—kV from Extremity Cassette Scale as measured					
Wrist & Hand		Small	Medium	Large	
Finger & Toes		kVp	kVp	kVp	
Ankle, Leg, Elbow, Patella, Intercondylar Notch—Use Regular Cassette					
Extremity—Regular Cassette				48″	Non-Bucky

EXAMINATION	TIME	kVp	DIAPHRAGM	ANGLES	REMARKS
SKULL ROUTINE					
Towne					
PA					
Stereo Lateral					
SINUS ROUTINE (Non-Bucky)					
Caldwell					
Waters					
Lateral					
ORBITS (Bucky Sinuses)					
Caldwell					
Waters					
Stereo Lateral					
METASTATIC BONE SURVEY					
Towne					
Lateral (Single)					
Cervical Lateral Bucky					
STEREO BASE					
MASTOIDS					
Towne					
Stenvers					
Laws					
Owens					
FACIAL BONES					
Stereo Caldwell					
Stereo Waters					
Lateral					
SLIT VIEWS					
Orbit (Straight-in-AP)					
Towne					
PLATYBASIA VIEWS					
PA					
Lateral					
OPTIC CANALS					
STYLOID FOR TMJ					
JAW UPRIGHT					
PA					
Lateral					
JUGULAR FORAMEN					
LOCALIZED SELLA					
NASAL BONES					
Orbits (Above)					
Soft Tissue Lateral (Non-Bucky)					
PAROTID AREA					
Towne					
Lateral					
EYE LOCALIZATION					
Orbits (Above)					
Special View (Sweets)					

Kilovoltage versus Measured Centimeter Thickness

SCALE 8	SCALE 4	SCALE 2
49	54	60
50	55	62
51	56	63
52	57	65
53	59	66
54	60	68
55	62	71
56	63	73
57	65	75
59	66	77
60	68	80
62	71	82
63	73	85
65	75	88
66	77	91
68	80	95
71	82	100
73	85	104
75	88	109
77	91	115
80	95	120
82	100	126
85	104	132
88	109	138
91	115	144
100	126	150
104	132	
109	138	
115	144	
120	150	
132		
138		
144		
150		

SCALE 1
60
62
63
65
66
68
71
73
75
77
80
82
85
88
91
95
100
104
109
115
120
126
132
138
144
150

CM	1/2 SCALE	1/4 SCALE	1/8 SCALE
6	54	60	68
7	55	62	71
8	56	63	73
9	57	65	75
10	59	66	77
11	60	68	80
12	62	71	82
13	63	73	85
14	65	75	88
15	66	77	91
16	68	80	95
17	71	82	100
18	73	85	104
19	75	88	109
20	77	91	115
21	80	95	120
22	82	100	126
23	85	104	132
24	88	109	138
25	91	115	144
26	95	120	150
27	100	126	
28	104	132	
29	109	138	
30	115	144	
31	120	150	
32	126		
33	132		
34	138		
35	144		
36	150		
37			
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52			
53			
54			

EXTREMITY CASSETTE

CM	kVp
1	47
2	51
3	54
4	57
5	60
6	63
7	66
8	69
9	72
10	75