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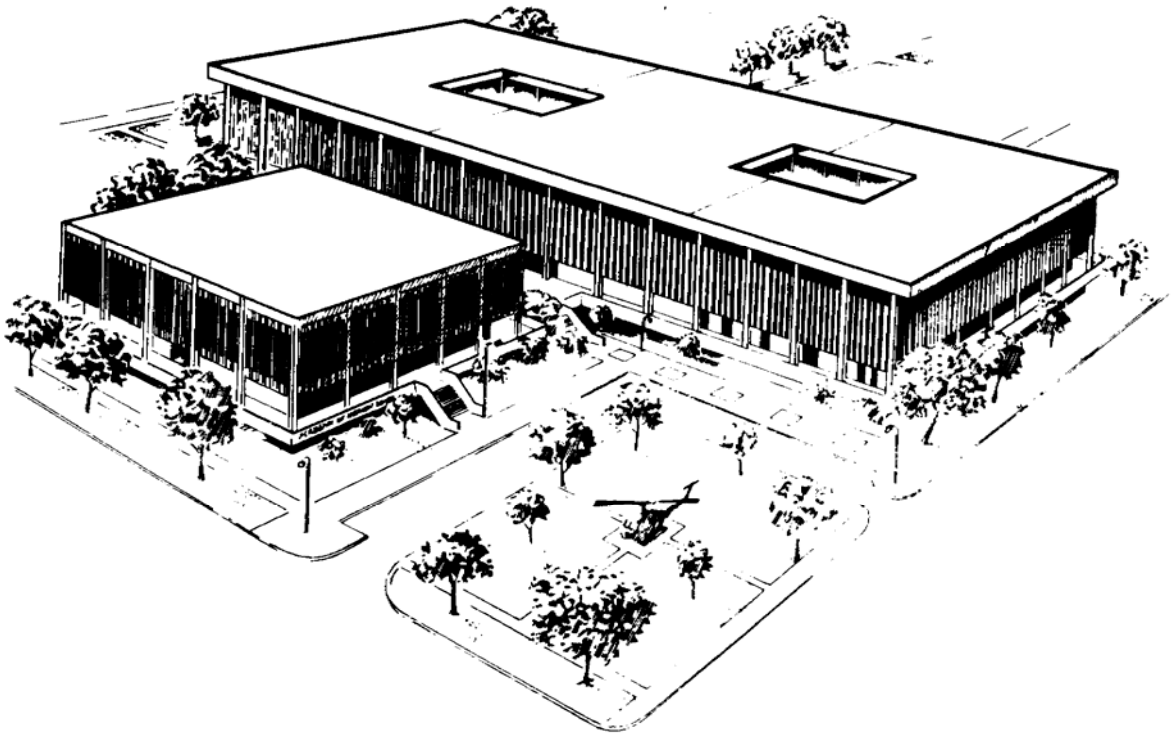

INTRODUCTION TO QUALITY ASSURANCE

SUBCOURSE MD0062 EDITION 200

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The subject matter experts responsible for content accuracy of this edition were from the Department of Clinical Support Services, Academy of Health Science, ATTN: MCCS-HC, Fort Sam Houston, Texas 78234-6100.

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TABLE OF CONTENTS

TABLE OF CONTENTS (completed)

CORRESPONDENCE COURSE OF THE
U.S. ARMY MEDICAL DEPARTMENT CENTER AND SCHOOL

SUBCOURSE MD0062

INTRODUCTION TO QUALITY ASSURANCE

INTRODUCTION

Quality assurance and quality control programs have only recently become familiar terms in the radiology field. You may be interested to know that in the early 1970's most radiology departments did not even know the concepts of a quality assurance or quality control program nor did they know how to initiate such programs. Today, radiology departments are acutely aware of the benefits of a good quality assurance program. Such a program requires testing of the radiology equipment to ensure proper performance. In this subcourse, you will find information about the purpose of each of the various tests for the radiology equipment, the equipment necessary for the testing, the procedures for testing, how to evaluate and interpret test results, and how to accomplish preventive and corrective maintenance.

Subcourse Components:

This subcourse consists of 12 lessons. The lessons are as follows:

Lesson l. Quality Assurance and Quality Control.
Lesson 2. Federal and Military Regulations.
Lesson 3. Quality Assurance/Quality Control Monitoring and Maintenance.
Lesson 4. Radiographic Unit Quality Control Tests.
Lesson 5. Fluoroscopic Unit Quality Control Tests.
Lesson 6. Tomographic Unit Quality Control Tests.
Lesson 7. Processors/Darkrooms Quality Control Tests.
Lesson 8. Illuminators Quality Control Test.
Lesson 9. Cassettes/Intensifying Screens Quality Control Tests.
Lesson 10. Grid Alignment Quality Control Test.
Lesson 11. Protective Devices Quality Control Tests.
Lesson 12. Retake Analysis Program.

Study Suggestions:

Here are some suggestions that may be helpful to you in completing this subcourse:

Complete the subcourse lesson by lesson

Read and study each lesson carefully.

After completing each lesson, work the exercises at the end of the lesson, marking your answers in the lesson.

After completing each set of lesson exercises, compare your answers with those on the solution sheet which follows the exercises. If you have answered an exercise incorrectly, check the reference cited after the answer on the solution sheet to determine why your response was not the correct one.

As you successfully complete each lesson, go on to the next. When you have completed all of the lessons, complete the examination if you have enrolled in the correspondence course of subcourse. Mark your answers in the examination booklet; then transfer your responses to the examination answer sheet using a #2 pencil.

Mail the solution sheet to the Academy (along with the Student Comment Sheet if you have comments concerning the subcourse or examination) in the envelope provided with the examination booklet. Be sure that your name, rank, social security number, and return address are on all correspondence sent to the Academy. You will be notified by return mail of the examination results. Your grade on the exam will be your rating for the subcourse.

Credit Awarded:

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You can enroll by going to the web site http://atrrs.army.mil and enrolling under "Self Development" (School Code 555).

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LESSON ASSIGNMENT

LESSON 1	Quality Assurance and Quality Control.
TEXT ASSIGNMENT	Paragraphs 1-1 through 1-7.
LESSON OBJECTIVES	After completing this lesson, you should be able to:

1-1. Identify key terms and/or definitions of quality assurance and quality control.

1-2. Identify the benefits of a quality assurance program.

1-3. Identify the four elements of a quality assurance program.

1-4. Identify the key terms and/or functions of equipment used in quality control testing and the major aspects of a quality control system.

SUGGESTION After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you achieve the lesson objectives.

LESSON 1

QUALITY ASSURANCE AND QUALITY CONTROL

1-1. PURPOSE

In brief, quality control (QC) is a system of specific activities that ensures proper functioning of equipment and services in the radiology department. Quality assurance (QA) is a system of checks and balances that ensures proper management and effectiveness of the quality control system. Quality assurance includes many facets of activities, such as quality control, preventive maintenance, equipment calibration, in-service education of the technologists and darkroom personnel, specification and acceptance testing of new equipment, and evaluation of new products.

a. **Quality Control**. This is a system of specific activities that:

(1) Ensures quality products and services that meet the user's need.

(2) Provides for adequate, dependable, and economic quality.

b. **Quality Assurance.** This is a management system that:

(1) Ensures an effective overall quality system.

(2) Evaluates the adequacy and effectiveness of the overall quality control program.

(3) Initiates corrective measures where they are necessary.

1-2. BENEFITS OF QUALITY CONTROL AND QUALITY ASSURANCE FOR PATIENTS AND DEPARTMENTS

a. **Patients.** The reduction in radiation exposure to the patient is the most important benefit of a quality assurance program. Because the equipment is in excellent working condition, there are fewer retakes and the personnel can minimize the dose to the patient so that the potential benefits outweigh the risk of the examination. Improving the quality of the image (which a QA program does) naturally improves the diagnostic information. This is what you, as an X-ray Specialist, will always strive for: OPTIMAL diagnostic radiographs.

b. **Departments.** Not only the patients benefit from a quality assurance program. The radiology departments also benefit from the program in two specific ways: consistency in production and cost effectiveness.

(1) Optimal radiographs. A quality assurance program results in consistency in the production of quality diagnostic images. There are very few retakes caused by machine failure because the machines are kept in proper adjustment. Actually, most retakes are due to the radiology specialist's error of improper patient positioning or improper machine settings.

(2) Cost effectiveness. There are many reports proving that the initiation of a quality assurance program can save the radiology department a lot of money and reduce the need for films and chemicals. One program announced an annual savings of $27,000 for these items. Another clinic had a 20 percent decrease in film purchases even though the number of examinations increased by three percent. Other statistics indicate that a 12-room department could realize annual savings of between $33,000 and $51,000.

NOTE: The cost effectiveness of a quality assurance program is wonderful for business, but always remember that the most important benefit of the program is the reduced radiation exposure to the patient.

1-3. ELEMENTS

There are four elements in a quality assurance program. When they are accomplished, you can be sure that the program is working well.

a. **Standard for Quality**. Each facility (department) must set its own standard. This is because departments vary in their equipment, personnel, and patient load. For example, a small department with limited equipment cannot produce as much as a large department with a lot of equipment. Therefore, those who set the standards should be as objective as possible. In addition, the quality of the radiographs should have a variation allowance in film density. Usually, it will be plus or minus ten percent.

b. **Communications.** The lines of communication must be open between the staff and the quality assurance personnel. The entire staff must cooperate to assure the success of the program.

c. **Quality Assurance Manual.** Such a manual will familiarize the staff with the proper quality assurance procedures and guide the staff in the application of these procedures.

d. **Responsibilities/Administration.** The facility administrators should have a list of the personnel who are responsible for overseeing the program, performing the tests, and ensuring that reports are accomplished. Of course, the quality assurance personnel will always respect the local standing operating procedures (SOP).

1-4. QUALITY CONTROL SYSTEM

The following is a list of the test equipment used to determine the accuracy of the radiology machinery.

a. **Sensitometer**. Checks out the processor by producing a series of controlled exposures on a sheet of X-ray film (see figures 1-1 and 1-2).

b. **Densitometer**. Measures the density of film blackening on a selected area of an X-ray film (see figure 1-3).

c. **Thermometer (Metal Stem)**. See figure 1-4.

d. **Wisconsin Kilovolt Peak Measurement Device**. Measures accurately (plus or minus 4) the Wisconsin Kilovolt Peak (kVp) being produced (see figure 1-5).

e. **Collimator and Beam Alignment Test Tools**. Ensure that a proper conefield is produced (see figure 1-6).

f. **Dosimeter.** Determines how well the generator is calibrated and measures the maximum standard fluoroscopic exposure rates (see figure 1-7).

Figure 1-1. Sensitometer.

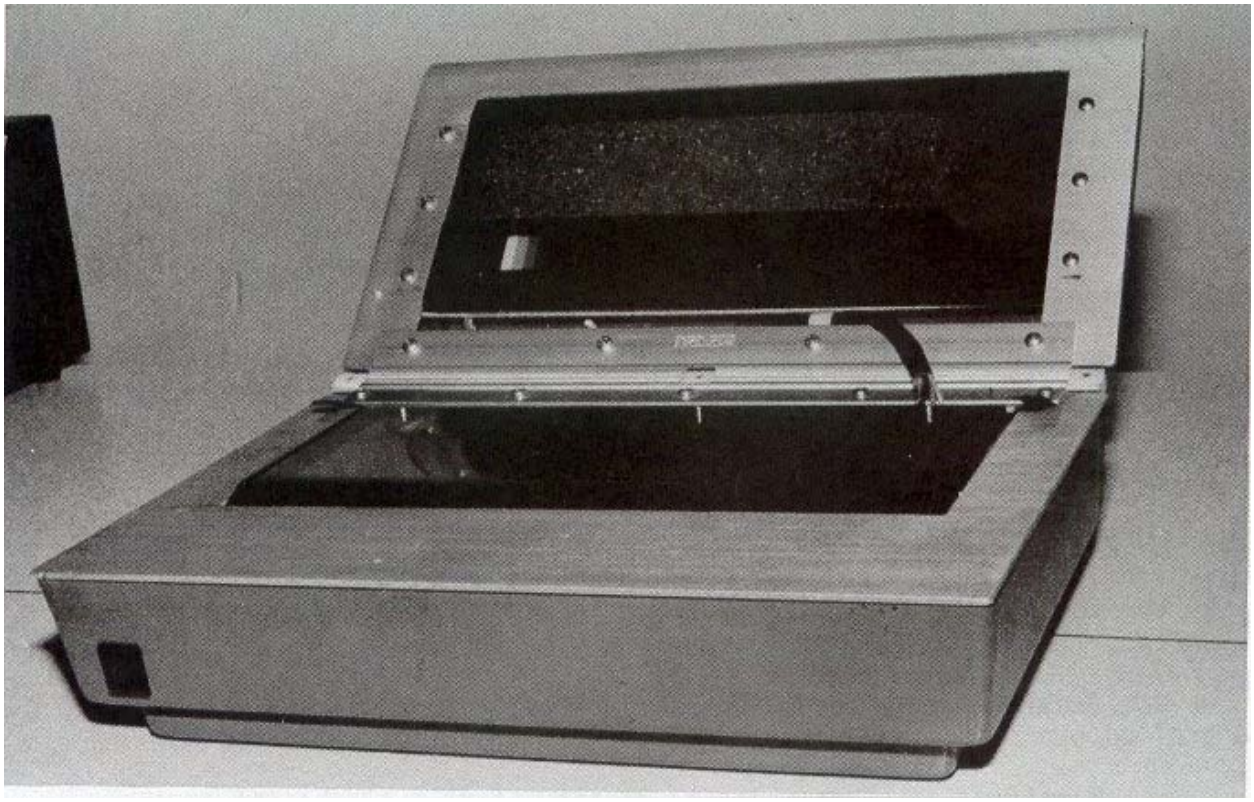

Figure 1-2. Sensitometer opened.

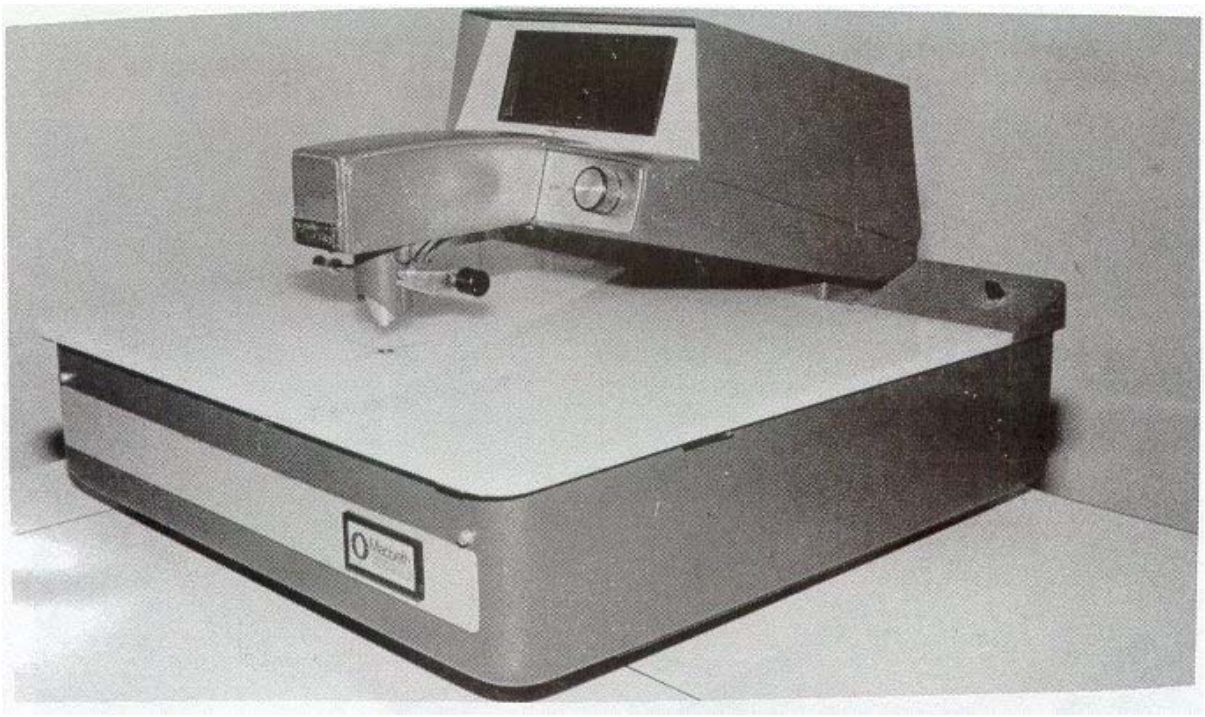

Figure 1-3. Densitometer.

Figure 1-4. Thermometer.

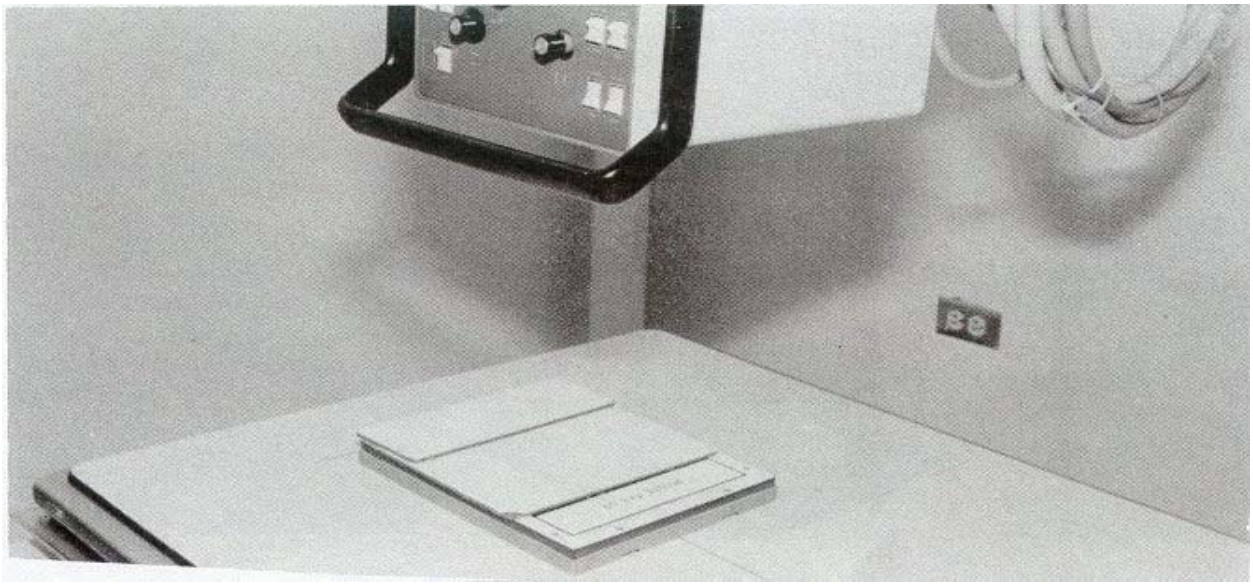

Figure 1-5. Wisconsin kVp measurement device in use.

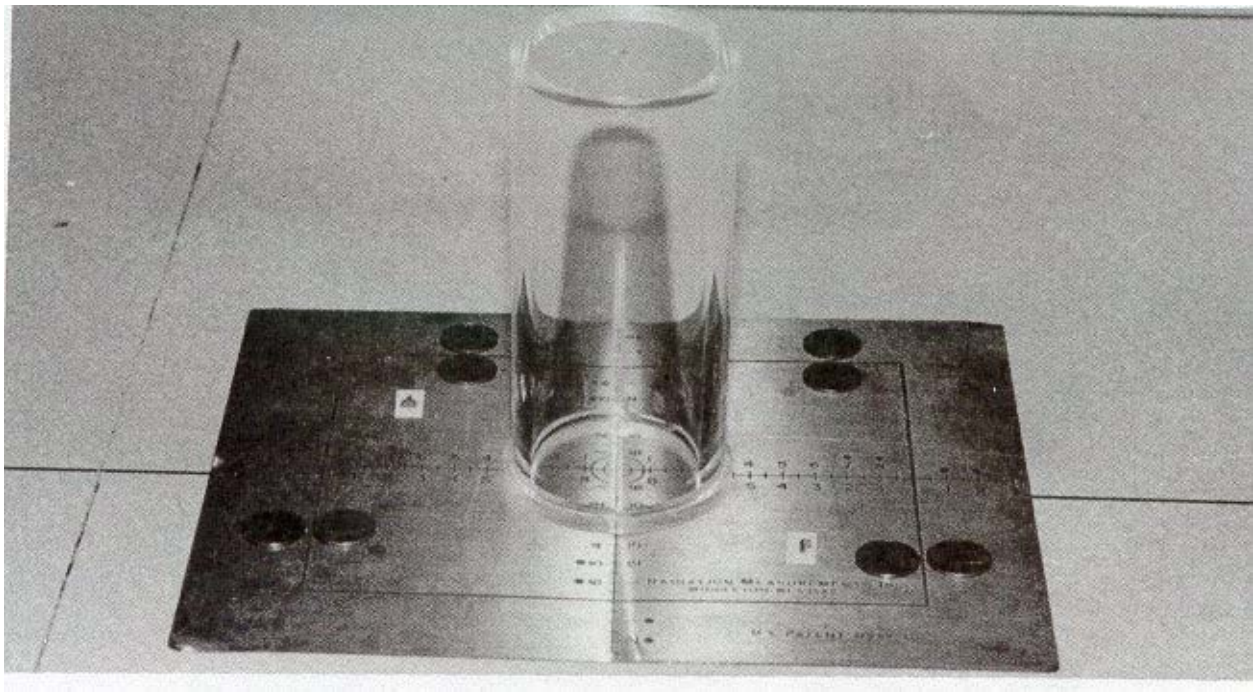

Figure 1-6. Collimator and Beam Alignment Test Tools.

Figure 1-7. Dosimeter.

g. **Half-Value Layer Aluminum**. Use pieces of aluminum of different thicknesses to help determine the half-value layer (HVL) of a unit.

h. **Star Focal Spot Test Tool**. Helps determine the focal spot size (there are only two sizes, large and small) (see figure 1-8).

i. **Tomographic Phantoms**. Made of Plexiglas, aluminum and other special objects (see figure 1-9).

j. **Synchronous or Electronic Milliamperage Timer**. Helps determine the accuracy of the timer by checking the milliamperage (mA) and timing. The manual spin top test is only good on single phase units (see figure 1-10).

k. **Phantom.** - A model of a body or one of its parts.

l. **Screen-Film Contact Mesh.** Helps determine the film-screen contact. You are looking for clear resolution (detail) (see figure 1-11).

Figure 1-8. Star focal spot test tool.

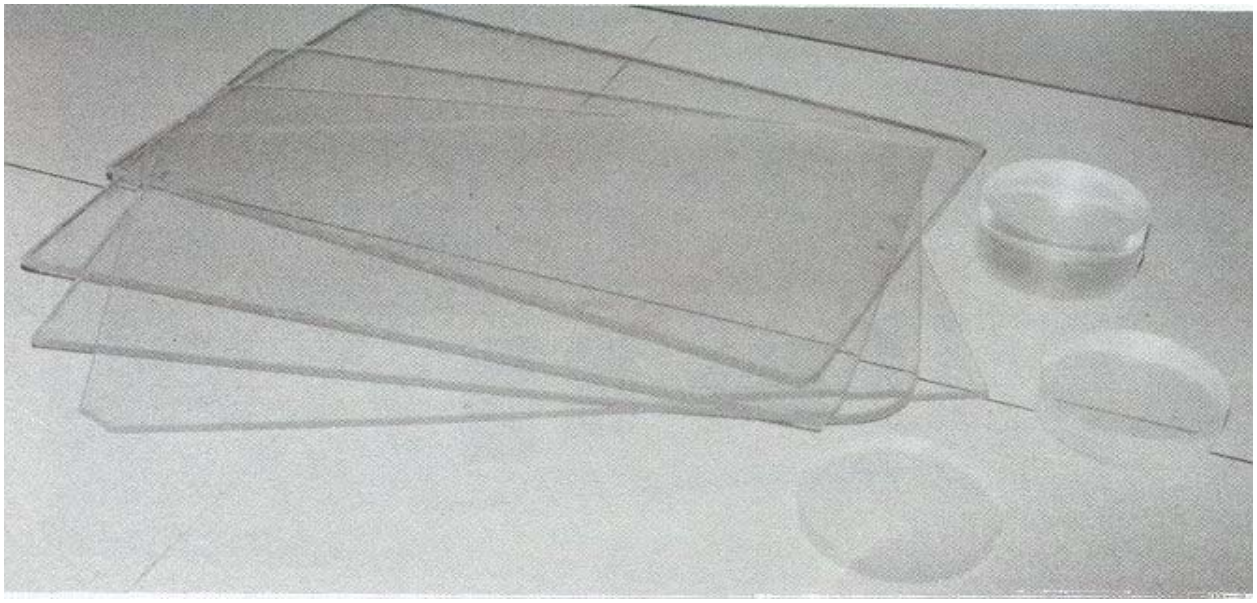

Figure 1-9. Tomographic phantoms.

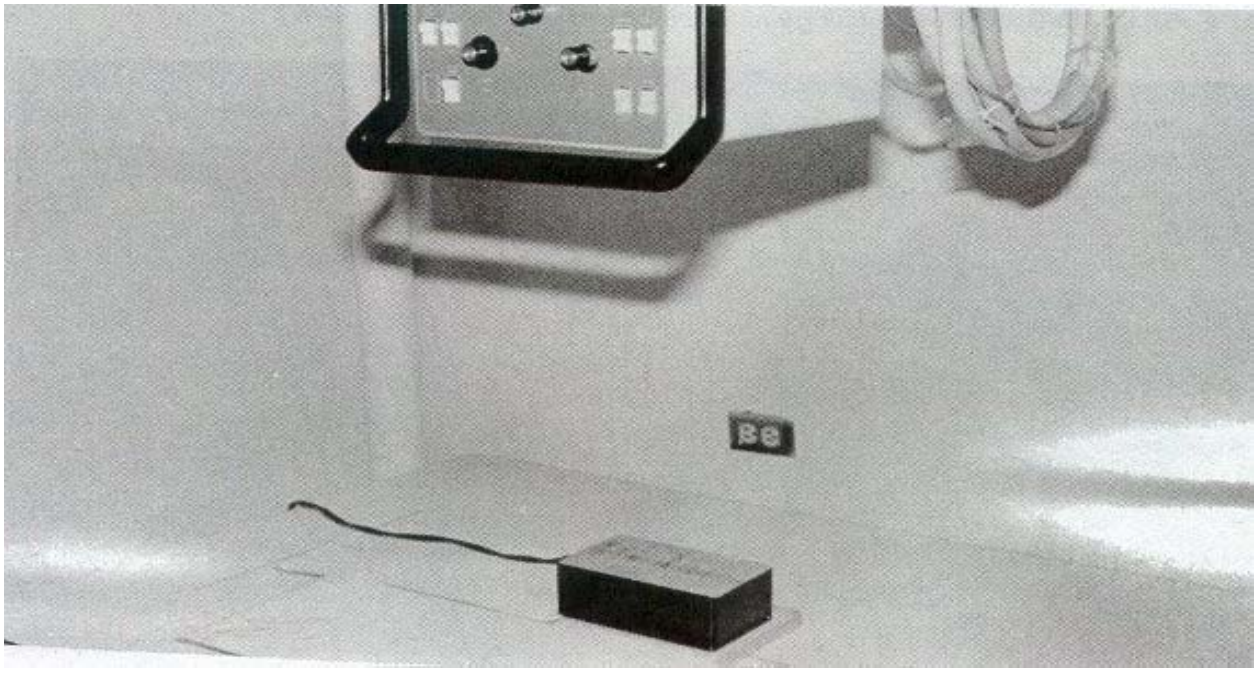

Figure 1-10. Synchronous or electronic mA timer.

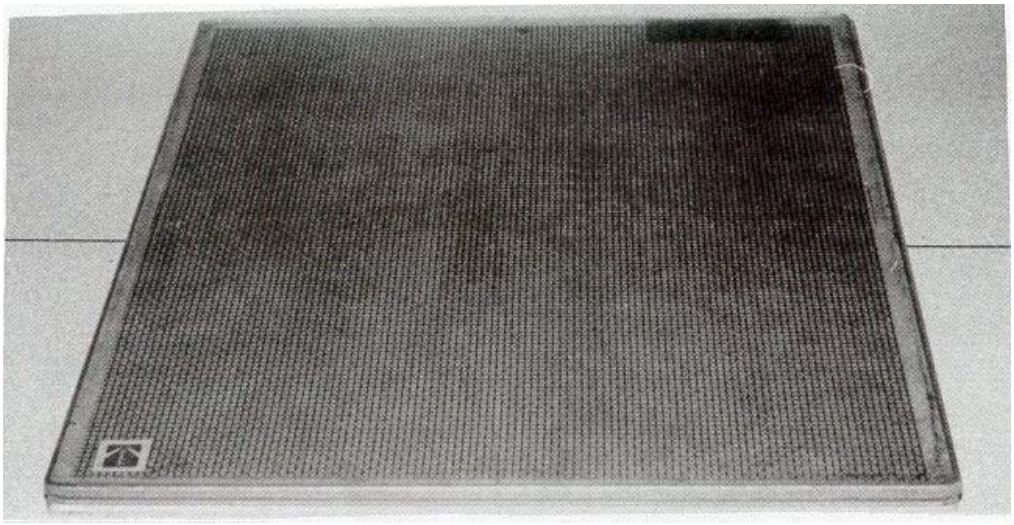

Figure 1-11. Screen-film contact mesh.

1-5. RECORD KEEPING

This is a must! Every time a piece of equipment is tested, results must be documented. There are some standard forms available. Most are locally devised and produced. This information is necessary to prove that you have made the test, to show the repairman what your test results have been, and to establish a historical log of both your activities and the performance of the equipment.

1-6. TEST REVIEW

Anytime a test indicates problems with the equipment, a retest for verification is necessary before you call for a biomedical repairperson or a contracted service representative. After the machine has been repaired, you must test it again.

1-7. EVALUATION

This is one of the first activities you will want to establish in a quality assurance program.

a. The results of the evaluation provide a "baseline" (minimum) performance level for the equipment.

b. An evaluation identifies problems that may exist with the equipment performance.

c. The evaluators then decide which actions to take to improve the situation.

Continue with Exercises

EXERCISES, LESSON 1

INSTRUCTIONS: Answer the following exercises by marking the lettered response that best answers the exercise or best completes the incomplete statement or by writing the answer in the space provided.

After you have completed all of these exercises, turn to "Solutions to Exercises" at the end of the lesson and check your answers. For each exercise answered incorrectly, reread the material referenced with the solution.

1. Which of the following phrases is descriptive of quality assurance?

   a. A management system.

   b. A system of specific activities.

2. Two benefits of a quality assurance program are reduced radiation to the patient and consistency in production. List one more.

   _____

3. List the four elements of a quality assurance program.

   _____

   _____

   _____

   _____

4. A sensitometer:

   a. Measures the density of film blackening.

   b. Indicates degree of heat or cold.

   c. Checks out the processor by producing a series of controlled exposures on a sheet of x-ray film.

   d. Ensures that a proper conefield is produced.

5. A collimator:

   a. Measures the density of film blackening.

   b. Indicates degree of heat or cold.

   c. Checks out the processor by producing a series of controlled exposures on a sheet of x-ray film.

   d. Ensures that a proper conefield is produced.

6. The quality of radiographs should have a variation allowance in film density.

   a. True.

   b. False.

7. "Resolution" in radiology means _____ .

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES, LESSON 1

1. a (para 1-1b)

2. Cost effectiveness (para 1-2b)

3. Standard for quality
   Communications
   QA manual
   Responsibilities/administration (para 1-3)

4. c (para 1-4a)

5. d (para 1-4e)

6. a (para 1-3a)

7. Detail (para 1-4l)

End of Lesson 1

LESSON ASSIGNMENT

LESSON 2	Federal and Military Regulations.
TEXT ASSIGNMENT	Paragraphs 2-1 through 2-3.
LESSON OBJECTIVES	After completing this lesson, you should be able to:
	2-1. Identify the federal regulation, which applies to all diagnostic radiology facilities and the different elements of a quality assurance program covered by that regulation.
	2-2. Identify the military regulation that covers ionizing radiation.
SUGGESTION	After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you to achieve the lesson objectives.

LESSON 2

FEDERAL AND MILITARY REGULATIONS

2-1. PURPOSE

How can we know when we have an excellent quality assurance program? We follow some guidelines in order to standardize the established limits. How such a program can be implemented has been outlined in detail in several regulations and, by looking at these regulations, we can gain a better insight into the program. The federal government has published recommendations for quality assurance programs in diagnostic imaging facilities. In addition, most of the professional societies are endorsing quality control and are publishing guidelines for quality assurance programs. The Federal Title 21 presents guidelines that apply to all diagnostic radiology facilities, but the regulation has no enforcement power. So, the Army incorporates the Title 21 guidelines into its Technical Bulletin (TB) MED 521, which does have enforcement powers. We can see how both of these documents are important influences in all the military quality assurance programs.

2-2. TITLE 21, CODE OF FEDERAL REGULATIONS

a. **Title 21 Guidelines.** Title 21, Code of Federal Regulations (CFR) guidelines are applicable to all diagnostic radiology facilities.

b. **Definitions Representative of the Title 21, Code of Federal Regulations.**

(1) Diagnostic radiology facility uses an x-ray system in any procedure involving irradiation of any part of the human body for diagnosis or visualization.

(2) Quality assurance means planned and systematic actions to certify that the diagnostic radiology facility will produce consistently high quality images with minimum exposure to patients and personnel.

(3) A quality assurance program is organized and designed to provide quality assurance for the diagnostic radiology facility.

(4) Quality control techniques are used to monitor (or test) and maintain components of the x-ray system (concerned directly with the equipment).

(5) Quality assurance administration procedures are intended to guarantee that:

(a) Monitoring techniques are properly performed and evaluated.

(b) Necessary corrective measures are taken in response to the monitoring results.

(6) The x-ray system is an assemblage of components for controlled production of diagnostic images with x-ray.

c. **Elements of a Quality Assurance Program According to Title 21 Code Of Federal Regulations**.

(1) Responsibility. The facility owner or the practitioner in charge has the primary responsibility for the program. He may, however, delegate some basic quality assurance roles to staff technologists. These responsibilities should be specified in a quality assurance manual that would include monitoring, evaluating, and providing corrective measures for the overall program.

(2) Purchase specification procedures. The facility personnel must determine their desired performance specifications for equipment and define these specifications in writing before the final purchase of any equipment. Once the equipment is installed, the designated person must conduct a testing program to ensure that the specifications are met. If any adjustments or corrections are necessary, the facility will not accept the equipment until the vendor has made the corrections.

(3) Monitoring and maintenance procedures. The goal is that the facility will incorporate and establish state of the art procedures on a regular schedule. This can be done by proper monitoring and by taking the initiative toward preventive and corrective maintenance.

(a) The following items/facilities should be monitored:

1 Film processing.

2 Basic performance character.

3 Cassettes and grids.

4 View boxes (illuminators).

5 Darkroom.

(b) Initiative maintenance includes the following procedures.

1 "Preventive maintenance" means to inspect and test the equipment carefully and in a timely manner.

2 "Corrective maintenance" means to call the service engineer or the manufacturer's representative at the earliest signs of trouble or malfunction. After going through the lower levels of repair personnel, go to the highest, if necessary.

(4) Standards for image quality.

(a) "Objective standards" are the factual (ideal) acceptability limits for the variation of parameter values.

(b) "Subjective standards" are the opinions of the professional personnel. These can be very important because the people who work with the equipment daily are usually the first to sense that something is wrong. Then, after testing and retesting, corrective action can be taken before the trouble becomes severe.

(5) Evaluation procedures.

(a) On level one, personnel qualified to test the equipment evaluate the performance of the x-ray system to determine whether corrective actions are needed. This regular testing, and if necessary, corrective action ensure that the image quality consistently meet the set standards.

(b) On level two, the person in charge of the quality assurance program initiates an ongoing study of the retake rate and the causes of repeated radiographs. This study enables him to evaluate the effectiveness of the program itself.

(6) Records.

(a) Whoever tests the system must always record the results of the monitoring techniques and the difficulties detected.

(b) He must record which corrective measures were applied to the difficulties and how effective the measures were.

(7) Quality assurance manual.

(a) This is usually a locally produced handbook written in a format that permits convenient revisions as they are needed.

(b) This book must be readily available to all radiology personnel.

(8) Training. The facility provides for appropriate training for all personnel.

(9) Committee. In large facilities, there is usually a quality assurance committee that maintains the lines of necessary communication among all the groups.

(10) Review. To determine the needed improvements is the responsibility of the committee or the practitioner in charge of the radiology department.

d. **Enforcement Procedures**. There are no enforcement procedures in the Title 21 regulation, BUT the Joint Commission on the Accreditation of Hospital Organizations (JCAHO) will not accredit a hospital without a quality assurance program. (Would you like to be x-rayed in a nonaccredited hospital?) Consequently, no Army hospital wants to be without such a program.

e. **Information and Consultation Services**. If none of the hospital personnel is qualified to propose the type of equipment to be bought, to prepare the aims of the program, or to identify problem areas, an outside consultation service can be contracted to do those things. It will probably be a civilian agency that will send a representative to confer with the practitioner and/or the committee and help make the decisions.

f. **Other Responsible Agencies**.

(1) Health and Human Services (HHS) is a top government agency that deals with problems concerning the general public.

(2) The Food and Drug Administration (FDA) is a subagency of HHS and deals with problems concerning food, drugs, and other products. This includes control of ionizing radiation.

2-3. MILITARY REGULATIONS: TECHNICAL BULLETIN MEDICAL 521

a. The Inspector General (IG) appoints a team for periodic inspections using Technical Bulletin (TB) Medical (MED) 521 for guidelines (see figure 2-1).

b. If a radiology department does not comply with the requirements of TB MED 521, the IG files a formal written complaint to the commanding general. All complaints must be answered in writing stating that the unsatisfactory conditions have been corrected. Then, the IG will probably return in thirty days to see if the department is up to specifications.

c. While the TB MED 521 outlines the how, where, and who of ionizing radiation for the military, a consultation service may be hired occasionally. This is done to be sure of compliance with any changes in Title 21 CFR because the TB incorporates the Federal regulations into its bulletin.

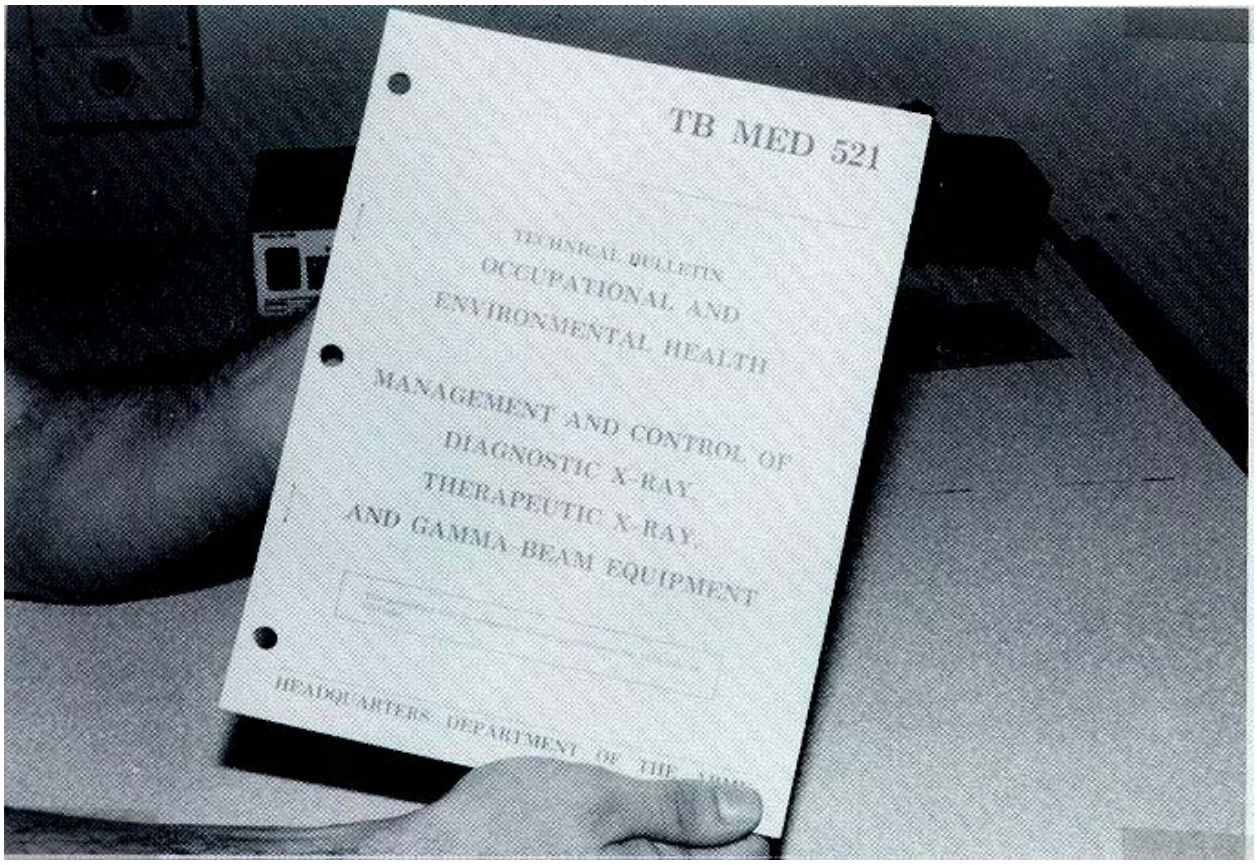

Figure 2-1. Technical Bulletin (TB) MED 521.

Continue with Exercises

EXERCISES, LESSON 2

INSTRUCTIONS: Answer the following exercises by marking the lettered response that best answers the exercise or best completes the incomplete statement or by writing the answer in the space provided.

After you have completed all of these exercises, turn to "Solutions to Exercises" at the end of the lesson and check your answers. For each exercise answered incorrectly, reread the material referenced with the solution.

1. The federal regulation that applies to all diagnostic radiology facilities is

   _____.

2. The Army regulation that provides guidance for quality assurance programs is

   _____.

3. The committee or the practitioner in charge of the radiology department determines the needed improvements.

   a. True.

   b. False.

4. JCAHO means _____.

5. Which of the following items should be monitored on a regular schedule?

   a. Darkroom.

   b. Cassettes and grids.

   c. Viewboxes.

   d. All of the above.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES, LESSON 2

1. Title 21 CFR (para 2-2a)
2. TB MED 521 (para 2-1)
3. a (para 2-2c(10))
4. Joint Commission on the Accreditation of Hospitals Organizations (para 2-2d)
5. d (paras 2-2c(3)(a)3, 4, 5)

End of Lesson 2

LESSON ASSIGNMENT

LESSON 3	Quality Assurance/Quality Control Monitoring and Maintenance.
TEXT ASSIGNMENT	Paragraphs 3-1 through 3-2.
LESSON OBJECTIVES	After completing this lesson, you should be able to:

3-1. Identify the definitions and responsibilities of each of the following personnel in a QA program:

- Staff radiographer.
- Student radiographer.
- Darkroom personnel.
- Quality assurance/quality control technician.
- Physicist.
- Service engineer.
- Radiologist.

SUGGESTION After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you achieve the lesson objectives.

LESSON 3

QUALITY ASSURANCE/QUALITY CONTROL MONITORING AND MAINTENANCE

3-1. PURPOSE

It is important to recognize that all radiology department personnel must cooperate and communicate to ensure a successful quality assurance program. Each person must not only perform the duties, but also effectively interact with all other personnel. The key word is "teamwork." Without it, there would be a below standard or ineffective quality assurance program.

3-2. PERSONNEL

a. **Staff Radiographer**. A full-time radiographer is called a staff radiographer. His responsibilities are to:

(1) Perform and analyze quality control tests IF he has been properly trained.

(2) Aid the quality assurance technician to perform noninvasive quality control tests on assigned equipment.

(3) Report possible problems to the appropriate personnel. (No one knows the equipment better than the person who works with it all day.)

b. **Student Radiographer**. An individual enrolled in an accredited radiology school. His responsibilities are to:

(1) Perform quality control tests as part of his training.

(2) Perform only under the direct supervision of a qualified staff radiographer.

c. **Darkroom Personnel**. Any individual that is permanently assigned to the darkroom that may or may not be a radiographer. His responsibilities are to:

(1) Aid the quality assurance technician in performing tests, but only if he is properly trained.

(2) Expose sensitometric strips.

(3) Check for safelight fog.

(4) Monitor replenishment levels.

(5) Monitor temperatures of the film processor.

d. **QA/QC Technician**. Individual who manages the quality assurance program. He may be the chief radiographer or a staff radiographer. His responsibilities are to:

(1) Monitor the radiographic equipment and the film processors.

(2) Analyze the quality of all radiographs.

(3) Troubleshoot the problems.

(4) Establish the standards for film quality and technical factors.

(5) Keep the program records.

(6) Verify that problems have been solved.

(7) Develop purchase specifications for new equipment.

(8) Audit the quality of service to the patients and referring physicians.

e. **Physicist**. A radiation scientist, an engineer, or a physician, who is concerned with research, teaching, or operational aspects of radiation safety. Occasionally, he may be an outside (civilian) consultant. His responsibilities are to:

(1) Perform additional testing that was outlined in a written contract.

(2) Perform corrective action when requested to do so.

f. **Service Engineer**. A biomedical repairperson from the manufacturer (while the equipment is still under warranty), or he may be part of the medical maintenance section in the hospital. He acts as an outside consultant. His responsibilities are to:

(1) Perform maintenance service that was outlined in a written contract.

(2) Perform corrective action when requested.

g. **Radiologist**. The chief radiologist's responsibilities are to:

(1) Oversee the quality assurance program.

(2) Delegate responsibility of the daily operation of the program.

(3) Be responsible for the entire program.

Continue with Exercises

EXERCISES, LESSON 3

INSTRUCTIONS: After you have completed all of these exercises, turn to "Solutions to Exercises" at the end of the lesson and check your answers. For each exercise answered incorrectly, reread the material referenced with the solution.

1. One duty of the service engineer is to:

   a. Perform corrective action when requested to do so.

   b. Perform quality control tests as part of his training.

   c. Analyze the quality of all radiographs.

   d. Monitor replenishment levels.

2. A _____ may be a radiation scientist, an engineer, or a physician.

   a. Physicist.

   b. Radiologist.

   c. Service engineer.

   d. Staff radiographer.

3. Who has the overall authority in the QA/QC program?

   _____.

4. Who performs and analyzes quality control tests, aids the quality assurance technician to perform noninvasive quality control tests, and reports possible problems to the appropriate personnel?

   a. Staff radiographer.

   b. Darkroom personnel.

   c. Physicist.

   d. Service engineer.

5. Who checks for the safelight fog?

   a. Student radiographer.

   b. Darkroom personnel.

   c. QA/QC technician.

   d. Service engineer.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES, LESSON 3

1. a (para 3-2f(2))
2. a (para 3-2e)
3. Radiologist (para 3-2g)
4. a (paras 3-2a(1), (2), (3))
5. b (para 3-2c(3))

End of Lesson 3

LESSON ASSIGNMENT

LESSON 4 Radiographic Unit Quality Control Tests.

TEXT ASSIGNMENT Paragraphs 4-1 through 4-41.

LESSON OBJECTIVES After completing this lesson, you should be able to:

4-1. Select the equipment, procedures, evaluations, and maintenance that apply to the kVp quality control test.

4-2. Select the equipment, procedures, evaluations, and maintenance that apply to the mAs quality control test.

4-3. Select the equipment, procedures, evaluations, and maintenance that apply to the focal spot quality control test.

4-4. Select the equipment, procedures, evaluations, and maintenance, which apply to the collimator quality control test.

4-5. Select the equipment, procedures, evaluations, and maintenance that apply to the automatic exposure timer system quality control test.

SUGGESTION After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you achieve the lesson objectives.

LESSON 4

RADIOGRAPHIC UNIT QUALITY CONTROL TESTS

Section I. WISCONSIN KILOVOLT PEAK QUALITY CONTROL TEST

4-1. PURPOSE

The purpose of the kVp quality control test is to assure that the x-ray generator is producing the same kVp that the control panel indicates. You, as a radiographer, can readily understand why you need to know these different types of quality control tests. You could be called upon to run these tests on a piece of equipment that could be malfunctioning. Remember, in a small clinic the radiographer is the chief radiographer, the staff radiographer, and the quality assurance technologist.

4-2. EQUIPMENT/MATERIAL

a. Wisconsin x-ray test cassette (see figure 4-1).

b. Two small lead sheets.

c. Densitometer.

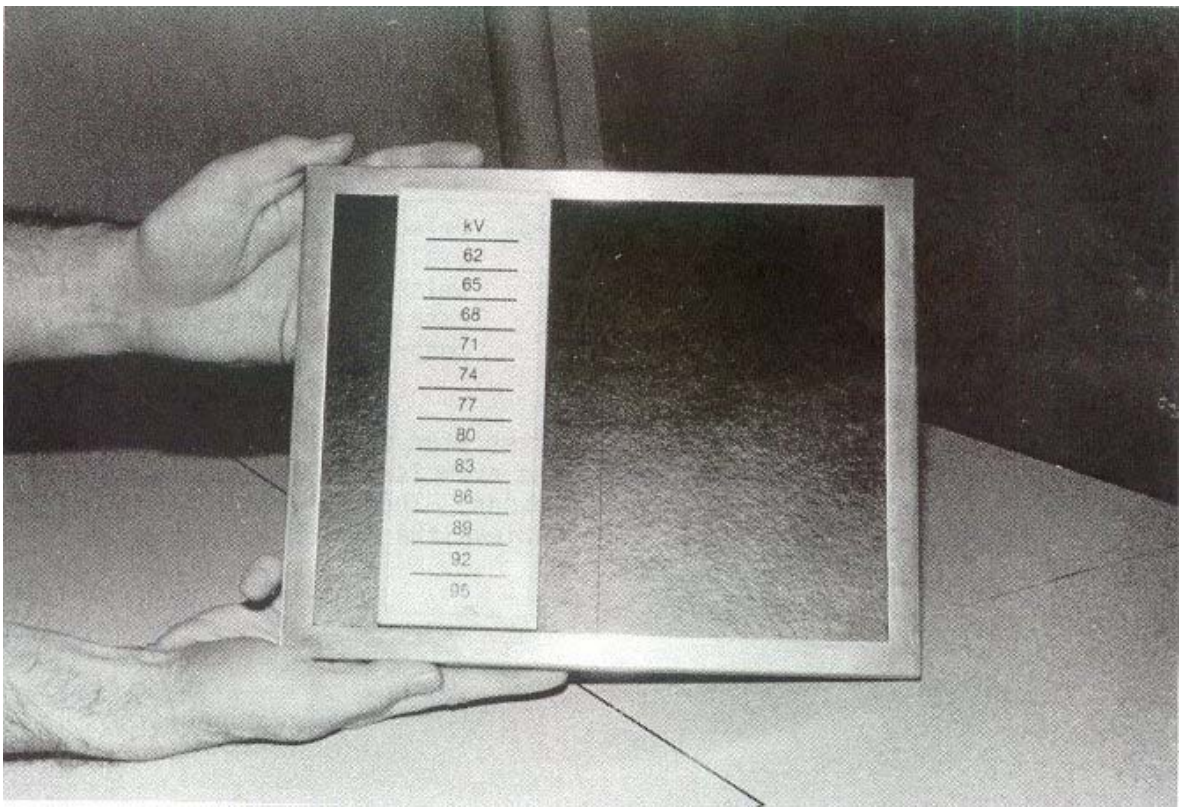

Figure 4-1. Old kVp test cassette.

4-3. PROCEDURE

a. Perform a line check. The incoming voltage must be on-line for the output kVp to be accurate.

b. Place the long axis of the Wisconsin test cassette parallel to the cathode-anode axis of the x-ray tube.

c. Place the lead sheets on the cassette leaving the 60 kVp region exposed.

d. Center the 60 kVp region under the x-ray tube (see figure 4-2).

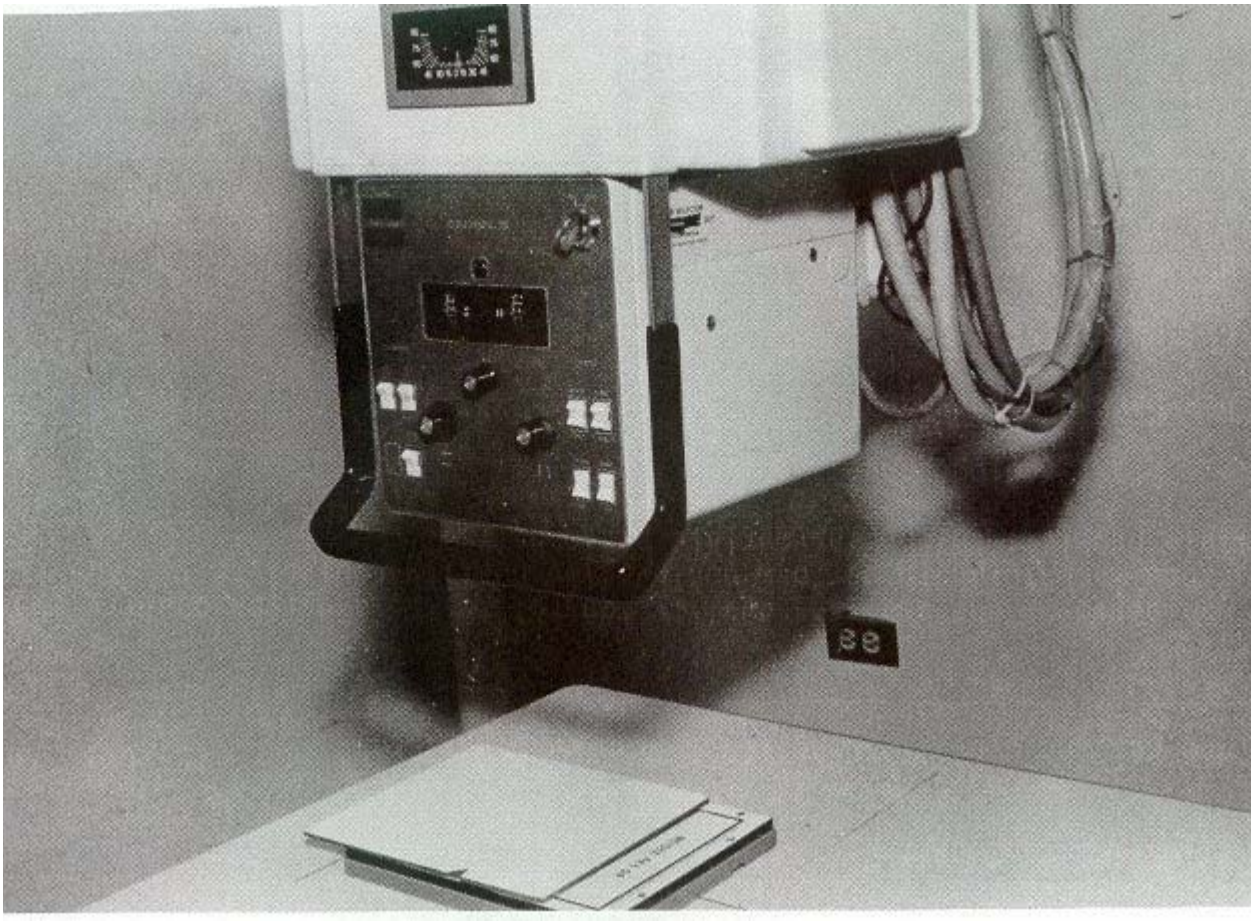

Figure 4-2. Testing the 60 kVp region.

e. Collimate the x-ray beam to the 60 kVp region.

f. Set the source to image detector distance (SID) to 20 inches.

NOTE: A 20-inch SID is used ONLY on the 60 kVp region. A 40-inch SID will be used on the other kVp regions on the cassette.

g. Set the control panel.

(1) Milliampere (mA) at which kVp values are being checked.

NOTE: Milliampere will NOT be changed for each exposure. Take all exposures with the same mA.

(2) 60 kVp and time with mA to produce 150 mAs.

h. Make the exposure.

i. Collimate the x-ray beam to the 80 kVp region (see figure 4-3).

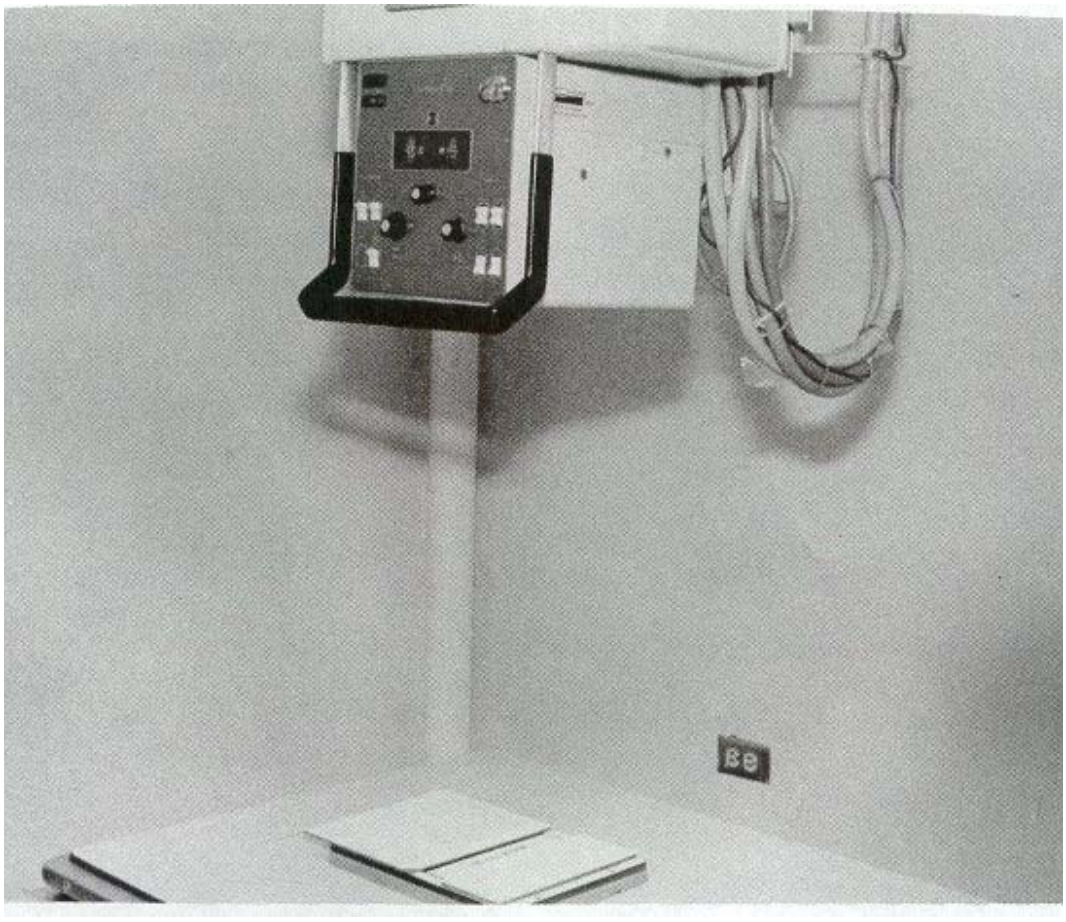

Figure 4-3. Testing 80 kVp region.

j. Use the lead sheets to block off the surrounding regions.

k. Set the SID at 40 inches.

l. Set the control panel.

   (1) 80 kVp.

   (2) 75 mAs.

m. Make the exposure.

n. Collimate the x-ray beam to the 100 kVp region (see figure 4-4).

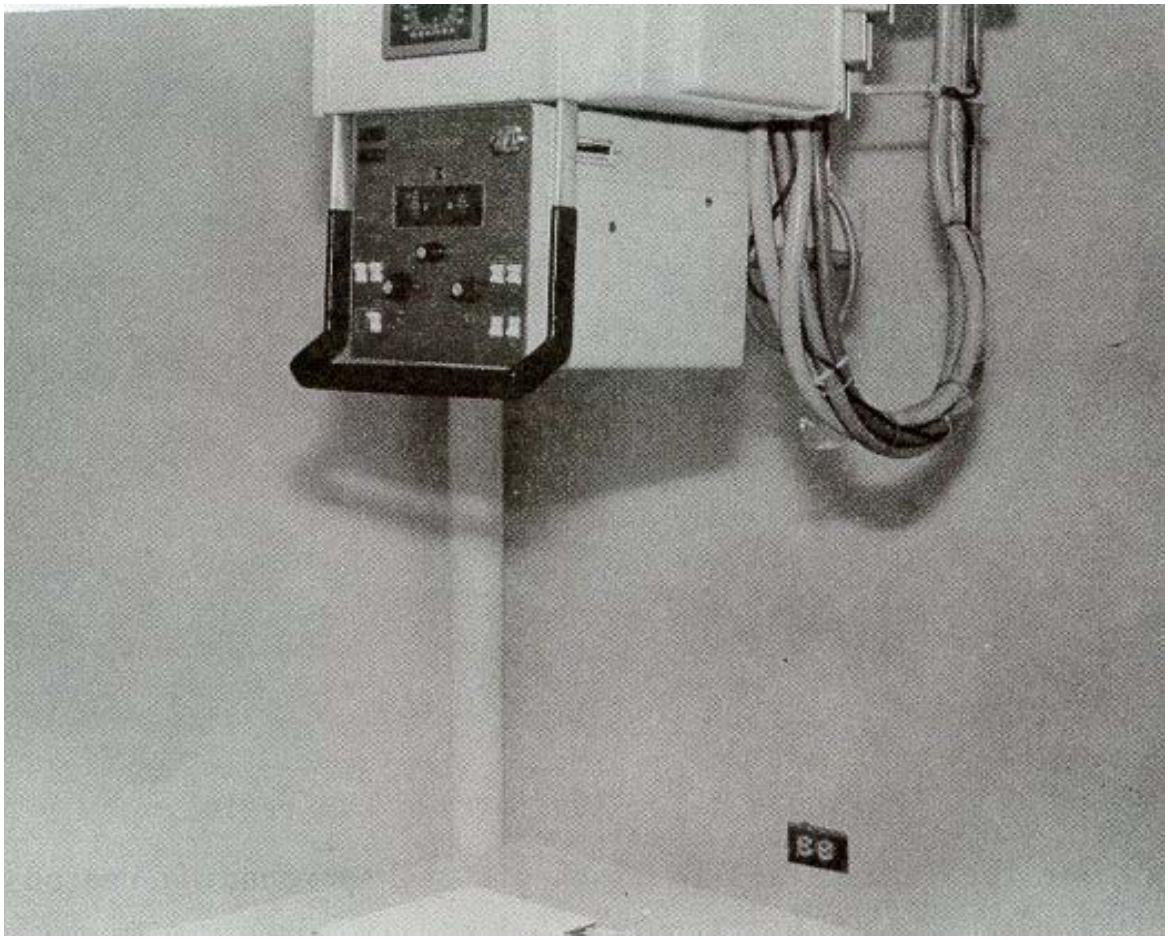

Figure 4-4. Testing 100 kVp region.

o. Use the lead sheets to block off the surrounding regions.

p. Set the SID at 40 inches.

q. Set the control panel.

   (1) 100 kVp.

   (2) 15 mAs.

r. Make the exposure.

s. Collimate the x-ray beam to the 120 kVp region (see figure 4-5).

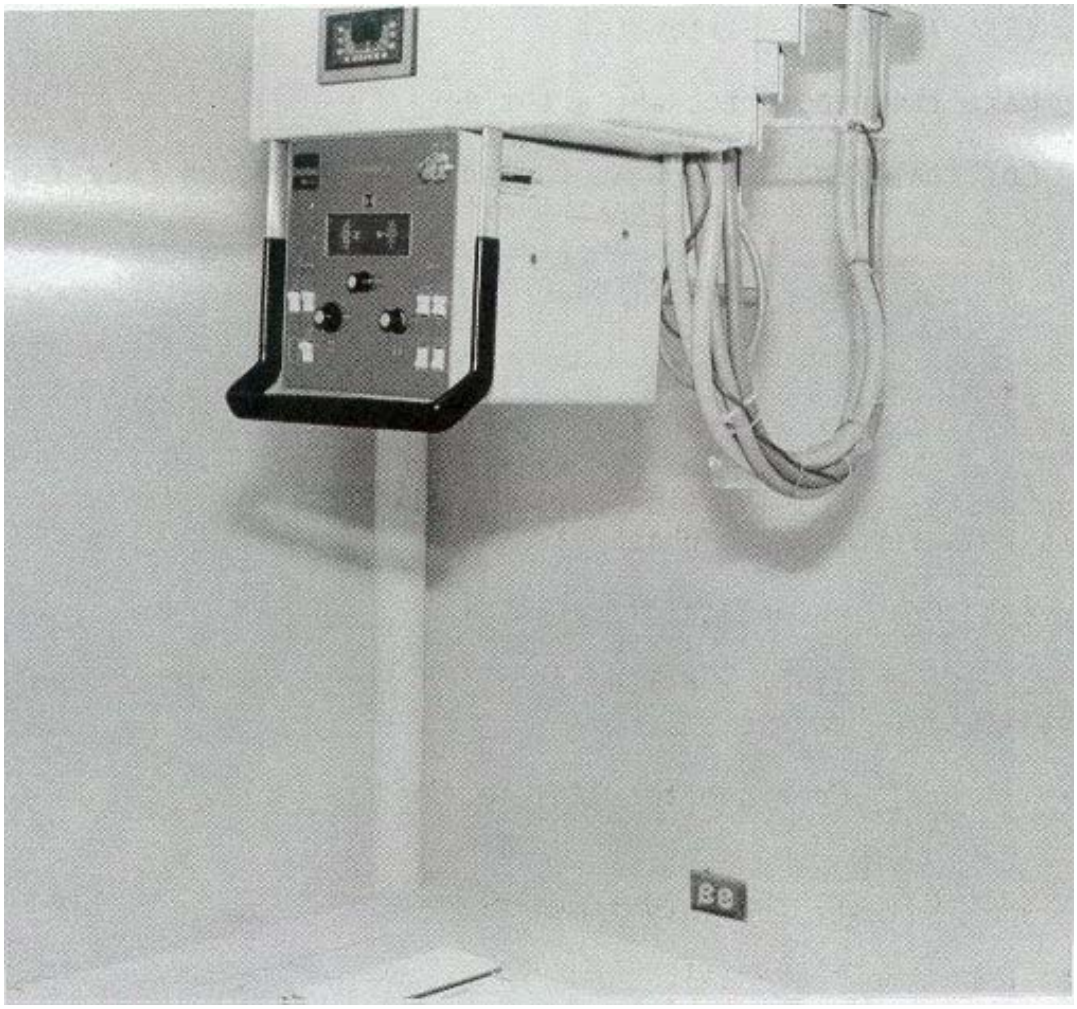

Figure 4-5. Testing 120 kVp region.

t. Use the lead sheets to block off the surrounding regions.

u. Set the SID at 40 inches.

v. Set the control panel.

(1) 120 kVp.

(2) 12 mAs.

w. Make the exposure.

NOTE: For three-phase machines, the mAs should be decreased by approximately 30 percent.

x. Process the film.

4-4. EVALUATION AND INTERPRETATION

a. Determine the "match" step in each region.

(1) Use the densitometer.

(2) Find the point where the density in the left column most closely matches the density in the right column.

b. Use the calibration chart provided by the manufacturer.

(1) Read up the vertical axis of the chart to the appropriate step number.

(2) Draw a horizontal line from the appropriate step number. The line intersects with the calibration curves on the chart.

NOTE: There are two calibration curves. One is for a single phase, and the other is for a three-phase machine.

(3) Draw a vertical line.

(a) Start the line from the point where the horizontal line intersects with the curves.

(b) Continue the line to the kVp readings at the bottom of the chart.

(4) Compare the actual kVp reading with the indicated kVp reading.

NOTE: The Department of HS recommends a standard of plus or minus 4 kVp to the indicated kVp reading.

4-5. PREVENTIVE MAINTENANCE

Perform preventive maintenance tests routinely at three-month intervals as well as any time service work is done on the machine. That would be any work that would affect the system calibration and any time an x-ray tube is replaced. Be sure to check that more testing was done before the service person leaves.

4-6. CORRECTIVE MAINTENANCE

Corrective maintenance should be done, when the measured kVp is more than plus or minus 4 kVp difference than the indicated kVp.

Section II. ELECTRONIC X-RAY TIMING AND MILLIAMPERES TEST

4-7. PURPOSE

The electronic x-ray timing and mAs test is to assure that the exposure time and the mAs set on the radiographic equipment are correct.

NOTE: A manual spin-top test may be used to check the timing system of single-phase equipment ONLY. A spin top cannot be used on three-phase equipment, but an electronic timer can be used on BOTH types of units (see figure 4-6)

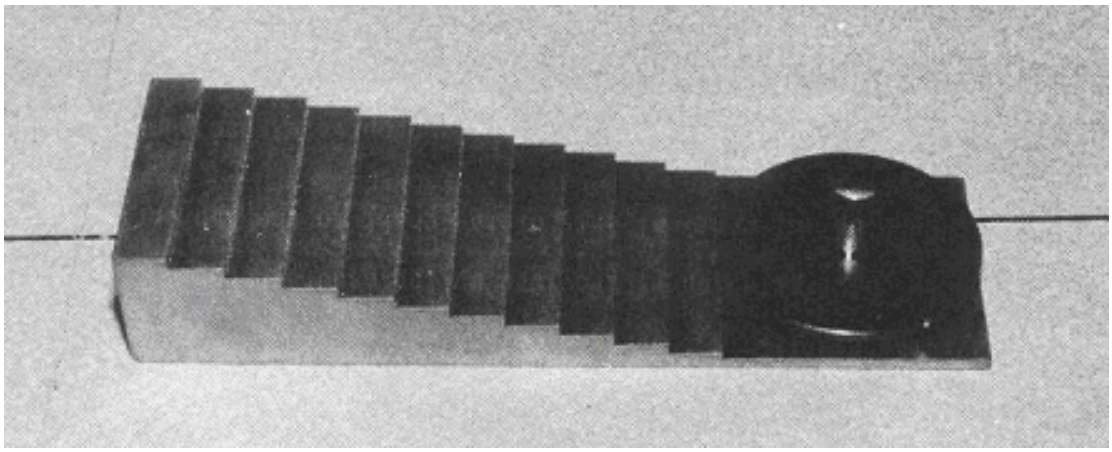

Figure 4-6. Spin top test tool.

4-8. EQUIPMENT/MATERIAL

a. Motorized synchronous top (mAs-timer test tool).

b. Lead blockers.

c. Timer protractor.

d. Extension cord.

e. A 10- by 12-inch cassette.

f. Lead numbers.

4-9. PROCEDURE

a. Plug the timing tool into 110 volt outlet.

NOTE: If needed, use an extension cord to ensure that the test tool can be easily placed on the x-ray table.

b. Place the cassette on the x-ray table.

c. Place a lead blocker over three-fourths of the cassette, leaving one-fourth exposed. Four different exposures are made on one cassette.

d. Place the timing tool on the unleaded portion of the cassette.

e. Collimate the x-ray beam to the test tool.

f. Set the SID at 40 inches.

g. Calculate the given mAs.

(1) Use four different times and mA.

(2) Examples:

(a) 50 mA at 1/5 second (see figure 4-7).

(b) 100 mA at 1/10 second (see figure 4-8).

(c) 200 mA at 1/20 second (see figure 4-9).

(d) 300 mA at 1/30 second (see figure 4-10).

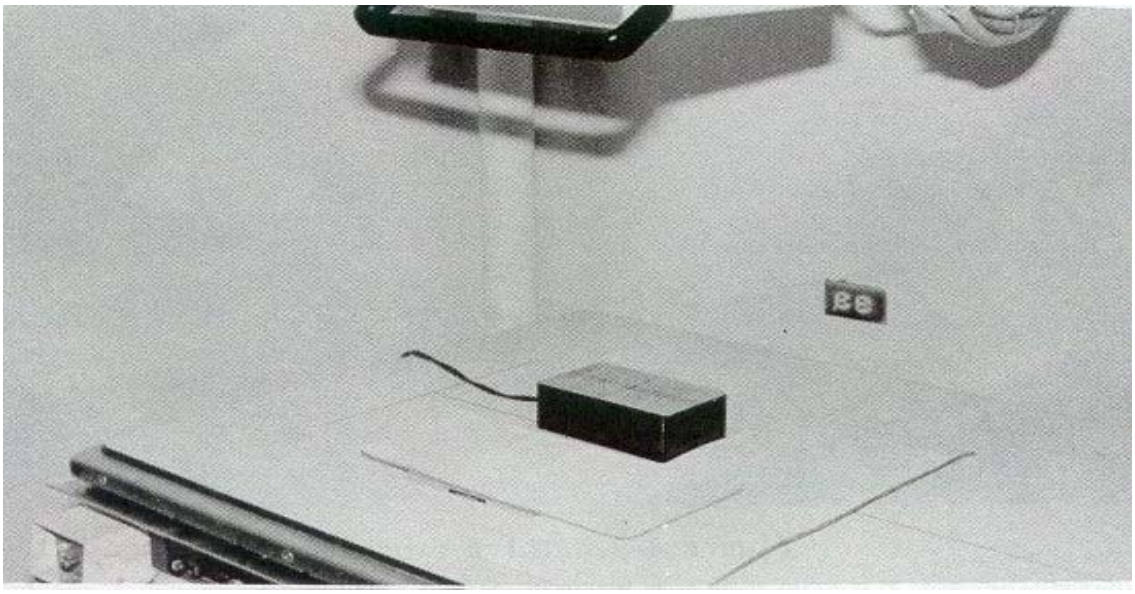

Figure 4-7. First of four exposures on the film being tested at 50 mA at 1/5 second.

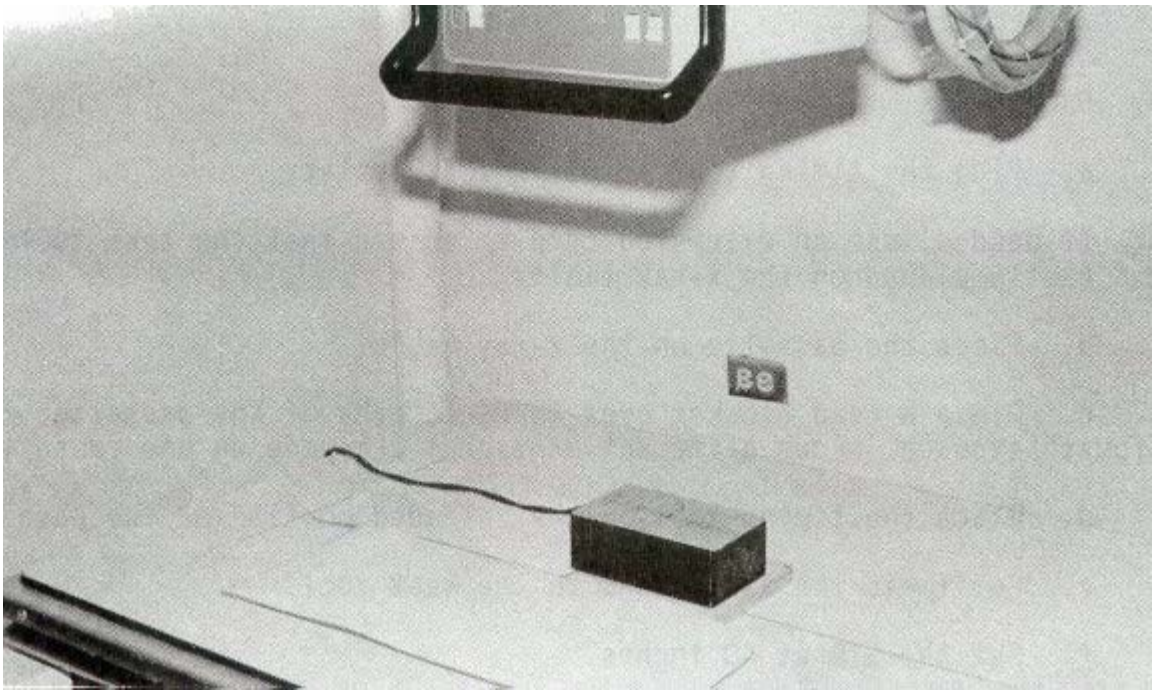

Figure 4-8. Second exposure.

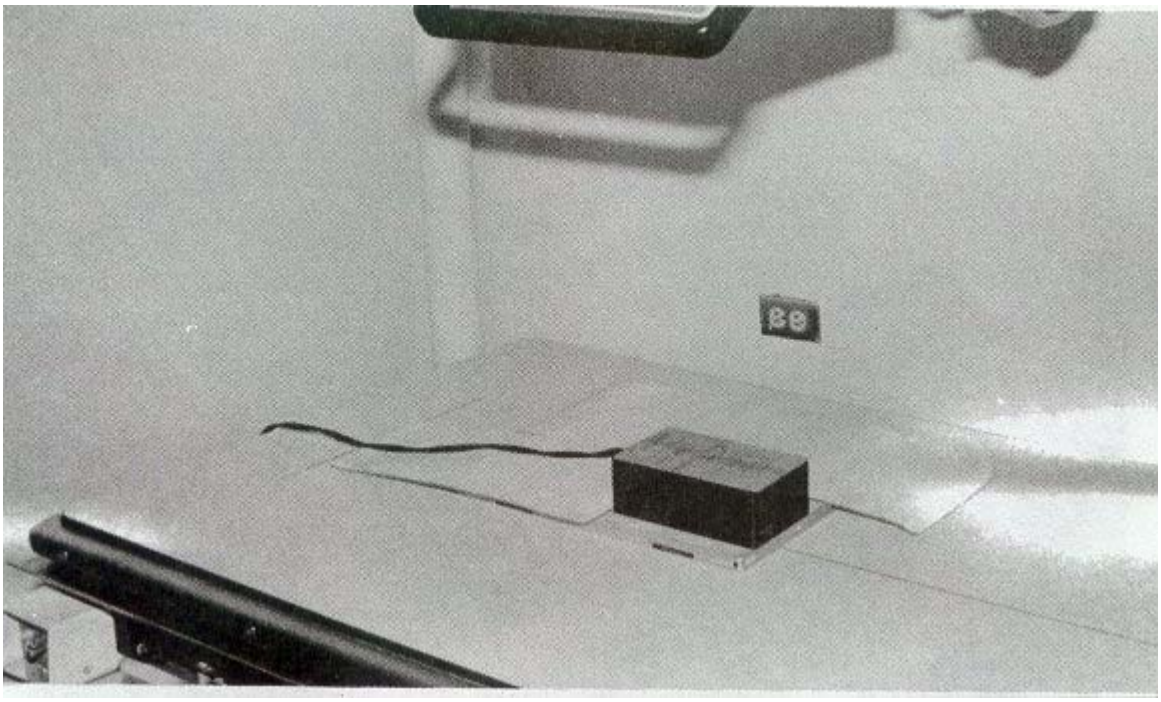

Figure 4-9. Third exposure.

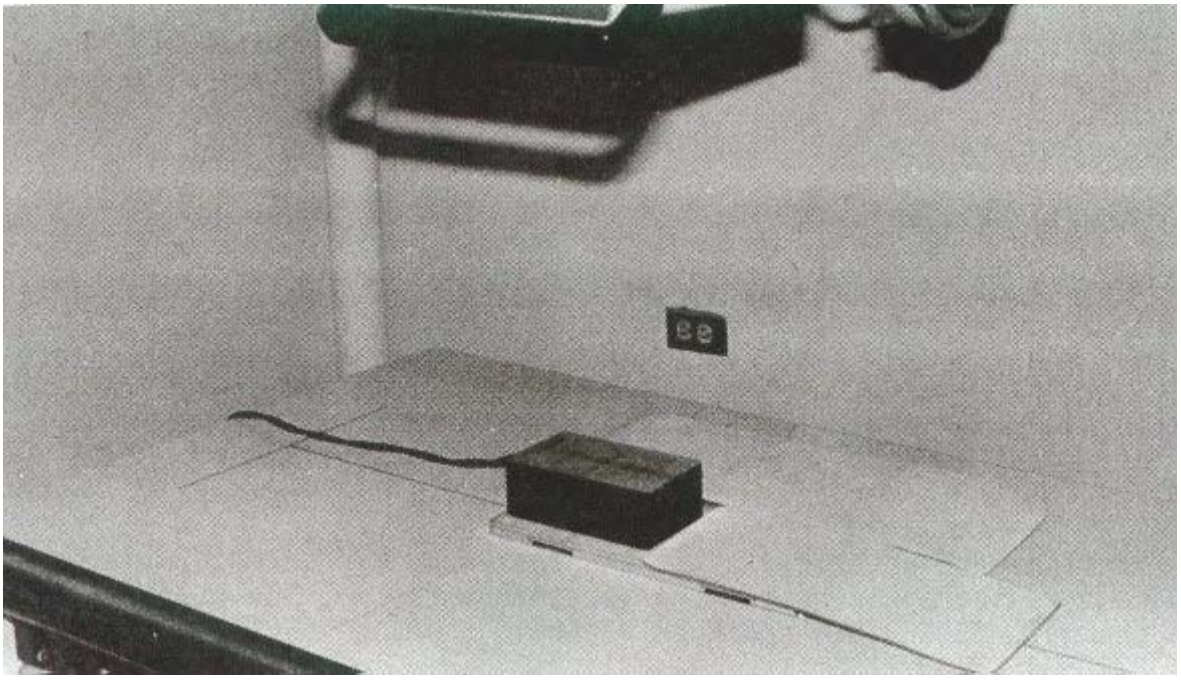

Figure 4-10. Final exposure.

h. Set the proper kVp.

(1) Seventy kVp on a three-phase machine.

(2) Eighty kVp on a single-phase machine.

i. Use a lead number to mark the unleaded section of the cassette with the appropriate mA and time.

j. Make the exposure.

k. Rearrange the lead blocker.

(1) Cover the exposed area.

(2) Uncover another fourth of the cassette.

l. Repeat steps h through k until four exposures have been made.

NOTE: Each exposure will have a different mA and time, but will produce the same mAs.

4-10. EVALUATION AND INTERPRETATION

a. Place the processed film on the illuminator.

b. Use the timer protractor to measure the angle of darkened area of the moving slit.

NOTE: An extra impulse of a low brightness level is permitted at the beginning arc. This is caused by a step-start effect of premagnetizing.

c. Compare the four different step wedges.

(1) Use the same kVp and mAs on all four exposures.

(2) The density should be the same on all four step wedges.

d. Use the densitometer to check the densities of the step wedges.

NOTE: If the timer proves to be accurate, and the four exposures have different amounts of density, consider the milliamperage (mA) inaccurate.

NOTE: You can make an error if you use the wrong kVp or mA. Remember, on some radiographic units when you change the mA, the kVp will also change. BE CERTAIN THE MACHINE FACTORS ARE CORRECT BEFORE MAKING AN EXPOSURE.

e. Ensure that timer errors (as allowed by the Bureau of Radiological Health) do not exceed the following guidelines:

(1) Up to 10 percent.

(2) One "step" between corresponding steps on the step wedge.

4-11. PREVENTIVE MAINTENANCE

Perform the electronic x-ray timing and mAs test routinely at six-month intervals. Also test following any service work which could affect the calibration of the x-ray generator timing or the mAs and, of course, if the radiographic equipment is not performing correctly.

4-12. CORRECTIVE MAINTENANCE

If the timing system errors are greater than 10 percent, or if the densities vary more than one step between the corresponding steps on the wedge, call a qualified service representative or engineer after you retest the machinery (to ensure you did not make a mistake in your testing).

Section III. FOCAL SPOT QUALITY CONTROL TEST

4-13. PURPOSE

The purpose is twofold: the focal spot test determines the approximate focal spot size and tracks age deterioration.

4-14. EQUIPMENT/MATERIAL

a. Wisconsin focal spot test tool.

b. One loaded cardboard (10 x 12) film holder.

c. Two small lead sheets.

d. Lead markers.

4-15. PROCEDURE

a. Place the cardboard film holder on the x-ray table.

(1) Use two lead sheets.

(2) Expose one-fourth of the film holder.

b. Place the test tool on the exposed portion of the film holder.

c. Place the "bar" patterns facing the x-ray tube.

d. Align the printing on the test tool parallel to the cathode-anode axis of the table.

e. Set the SID at 24 inches.

f. Collimate the x-ray beam to the exposed fourth of the film holder.

NOTE: Four exposures will be made on the film: two of a small focal spot and two of a large focal spot.

g. Use the lead markers to designate whether small or large focal spots are being used.

h. Set the machine factors.

(1) 80 kVp.

(2) 10 mAs.

(3) Small focal spot (see figure 4-11).

NOTE: Select a mA station with a small focal spot that is commonly used.

i. Make the exposure.

j. Repeat the above procedure using another small focal spot (see figure 4-12.).

NOTE: Make sure that a different mA station is used; then, a different small focal spot will be used.

k. Repeat the procedure using two different large focal spots (see figure 4-13).

Figure 4-11. First exposure with small focal spot.
Note "S" marker on top of test tool.

Figure 4-12. Second exposure using another small focal spot.
Again, note "S" marker on test tool.

Figure 4-13. Both exposures of test tool using large focal spots. Note "B" marker is used for large focal spot test.

4-16. EVALUATION AND INTERPRETATION

a. Examine the imaged bar patterns using a magnifying glass, if necessary.

b. Find the smallest group in which all three bars can be seen clearly.

c. Note the number by the set of bars.

d. Determine the dimension of the effective focal spot.

(1) Use the chart provided by the manufacturer.

(2) Find the number by the set of bars most clearly seen.

(3) Read to the right of the chart to find the dimension.

(4) Measure the distance between the set screws imaged on either side of the test pattern.

(5) Measure the hole separation at 40 millimeters.

NOTE: A discrepancy of measurement could indicate that the SID indicator is in error. More measurements should be taken to confirm this indication.

4-17. PREVENTIVE MAINTENANCE

You should perform the focal spot test routinely at three-month intervals and when an x-ray tube is replaced.

4-18. CORRECTIVE MAINTENANCE

The focal spot test is used only to indicate approximate focal spot sizes and to subjectively indicate the gradual erosion of a focal spot. The Department of Health and Human Services Bureau of Radiological Health maintains that a given nominal focal spot size should be able to resolve the same number of groups over its useful life to within plus or minus one group. If a great change in focal spot resolution occurs, replace the x-ray tube.

Section IV. COLLIMATOR QUALITY CONTROL TEST

4-19. PURPOSE

This collimator test verifies the centering alignment of the beam restriction system, the accuracy of the numerically indicated field size, and the congruence of the light and radiation fields. There are several tests used to check the collimator, and this is one of the simpler ones.

4-20. EQUIPMENT/MATERIAL

a. One 10- x 12-inch cassette.

b. Nine pennies.

c. Lead markers "A" and "F" may be used rather than the ninth penny.

d. Lead letters for the room number and date.

4-21. PROCEDURE

a. Place the cassette on the x-ray table with the cassette's long dimension parallel to the table's long dimension.

b. Place the light field to the center of the cassette at 40 SID.

c. Collimate the x-ray beam at 6- by 8-inch field size.

d. Place two pennies in the center of each margin of the light field.

(1) One penny inside the light field.

(2) One penny outside the light field.

e. Mark the film with the "A" and "F" markers because they will help designate the anode and front of the table in case the collimator is inaccurate. You can then determine which way the collimator needs adjustment. Place the lead markers and letters as indicated below:

(1) "A" at the anode end of the x-ray tube.

(2) "F" marks the front of the x-ray table (see figure 4-14).

(3) The lead letters go well inside the light field in order to identify the room number and date (see figure 4-15).

f. Make the exposure using 60 kVp at 5 mAs.

g. Process the film.

NOTE: Commercially made collimator test tools can be used in lieu of pennies.

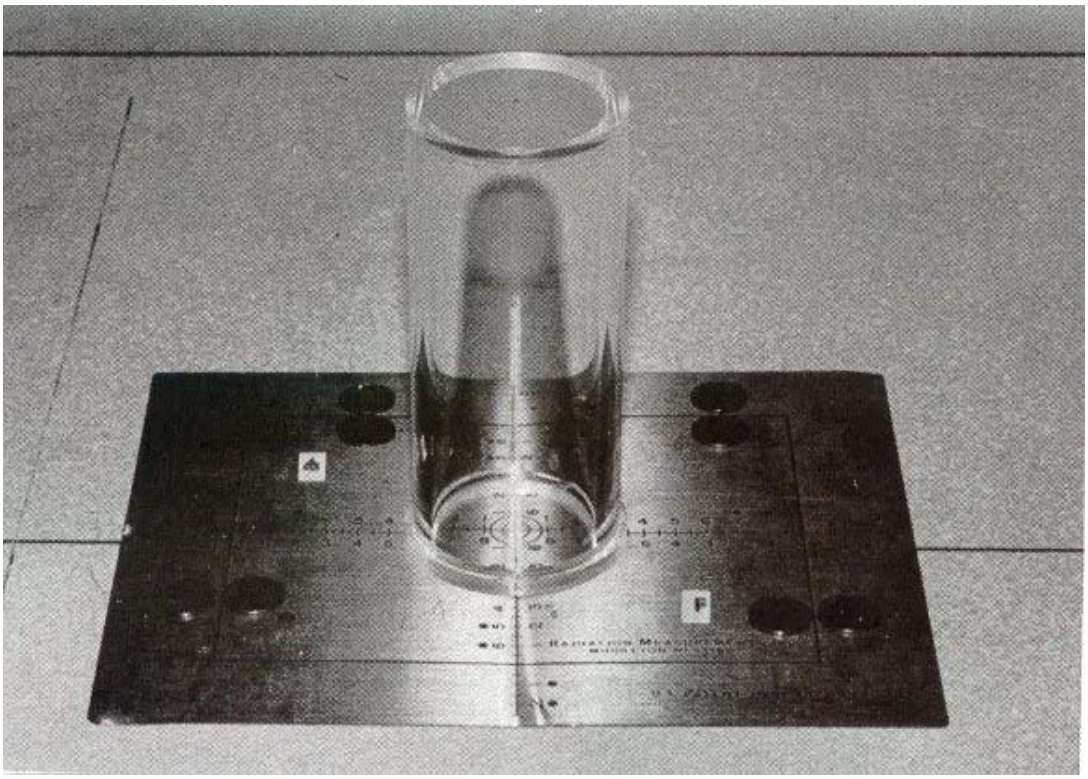

Figure 4-14. Collimator test tool with "A" and "F" markers.

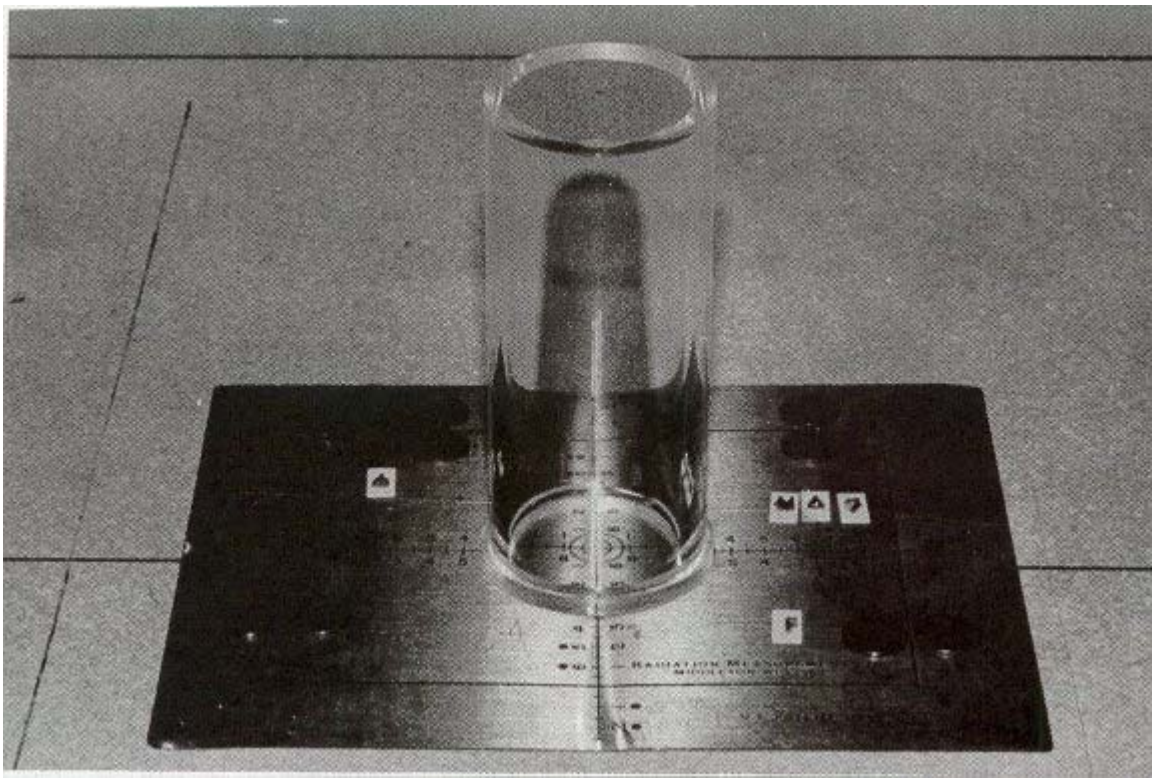

Figure 4-15. Collimator test tool with room number included.
Note that date can be flashed on card when film runs.

4-22. EVALUATION AND INTERPRETATION

a. The lead markers designate the:

(1) Room number.

(2) Date.

(3) Anode.

(4) Front of the table.

b. The results depend on where the x-ray field falls.

(1) If it falls within half a penny's distance from the center line, the results are ideal.

(2) If it exceeds the proper location by more than one penny's distance, the results are unacceptable.

4-23. PREVENTIVE MAINTENANCE

Perform the collimator test routinely at two-month intervals and any time service work is done on the beam limitation system. This includes collimator bulb replacement.

4-24. CORRECTIVE MAINTENANCE

Call the service representative or engineer to adjust the collimator when the test results show that the x-ray field exceeds the proper location by more than one penny.

Section V. AUTOMATIC EXPOSURE TIMER (AET) QUALITY CONTROL TEST

4-25. PURPOSE

The purpose of the following test procedures is to ensure that the AET control system functions properly. Performing quality control tests on the AET (phototiming) system is a time-consuming and detailed project. There are six areas that must be tested.

4-26. EQUIPMENT/MATERIAL

a. Evaluation phantom (pieces of Plexiglas).

b. Direct readout dosimeter (digital timer).

c. Ringstand and clamp.

d. Densitometer.

e. Lead number for test film identification.

f. Two sheets of 1/8-inch lead, 11 x 14 inches.

g. Cassettes with the same screen speed and film from same box.

h. Forms for recording information.

NOTE: The following procedure should be used for each area with minor alterations for the area of interest.

4-27. PROCEDURE

a. Set the radiographic equipment in the phototimer mode.

b. Set the x-ray tube:

(1) Longitudinally and transversely centered.

(2) Vertically with the usual SID.

c. Position the base section of the phantom on the tabletop in the center of projected light.

d. Place the reference marker in the upper right quadrant.

e. Collimate to the phantom.

f. Place the dosimeter chamber or the digital timer contained in the light field with a ringstand for support.

g. Place the chamber readout so it is visible to the control booth.

4-28. REPRODUCIBILITY TEST

a. Add two more pieces of Plexiglas to the base phantom for a total thickness of six inches (see figure 4-16).

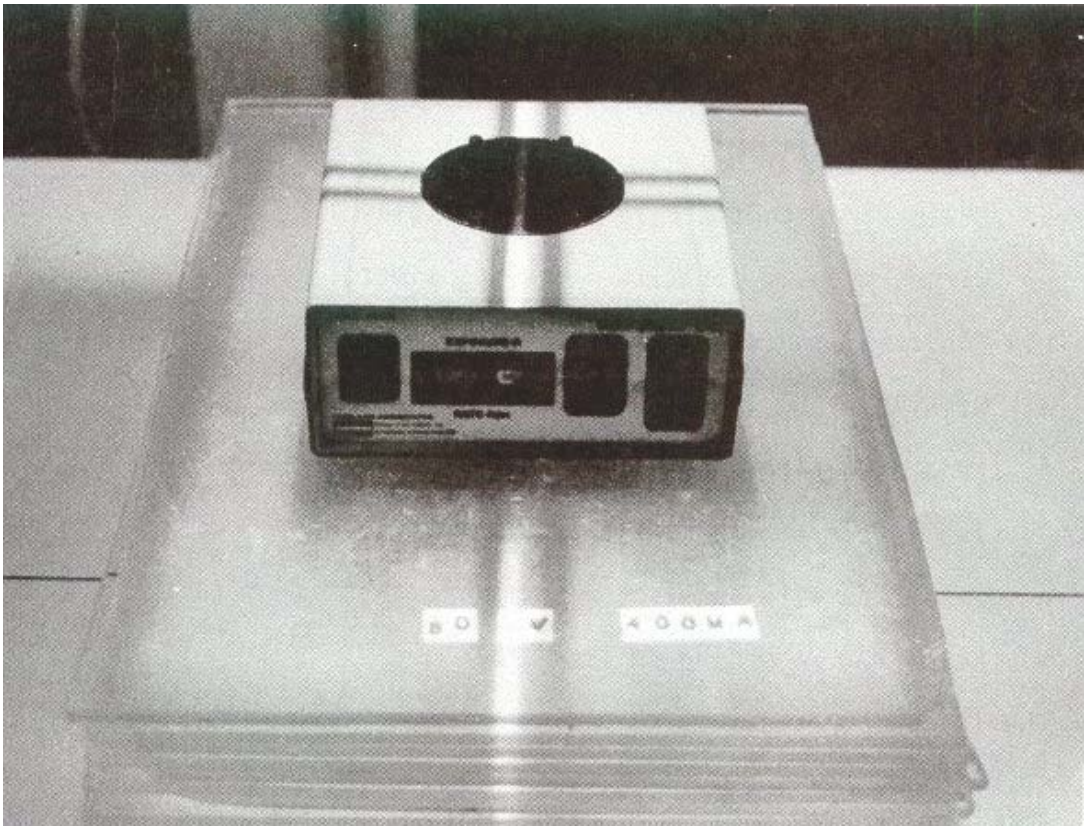

Figure 4-16. Set up for first exposure from example 4-28, a through c.

b. Insert a cassette into the Bucky tray and close the Bucky tray.

c. Set the machine factors:

(1) 80 kVp.

(2) Any mA station commonly used on an AET, for example, 400 mA (see figure 4-17).

d. Place the density control on normal (see figure 4-18).

e. Select an imaging sensor that provides the largest averaging area, for example, on a tri-field system select all three, if possible.

f. Place the lead identification numbers on the phantom and record the technical factors used (see figure 4-19).

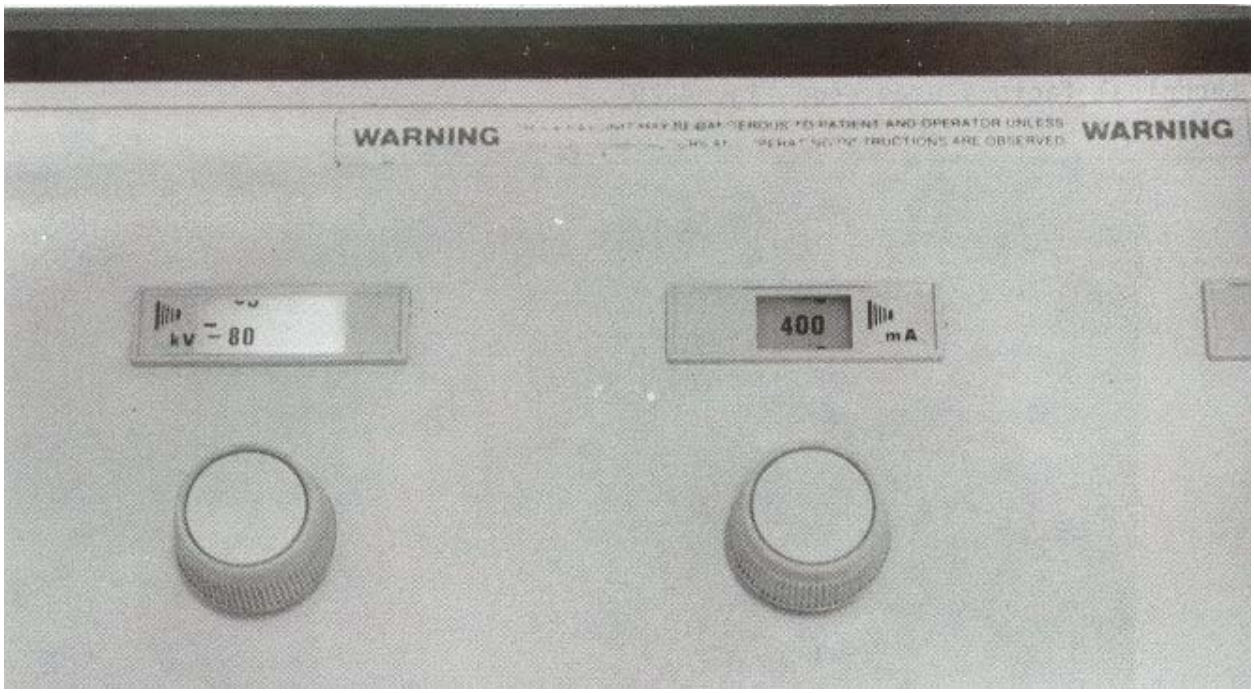

Figure 4-17. Machine factors are set.

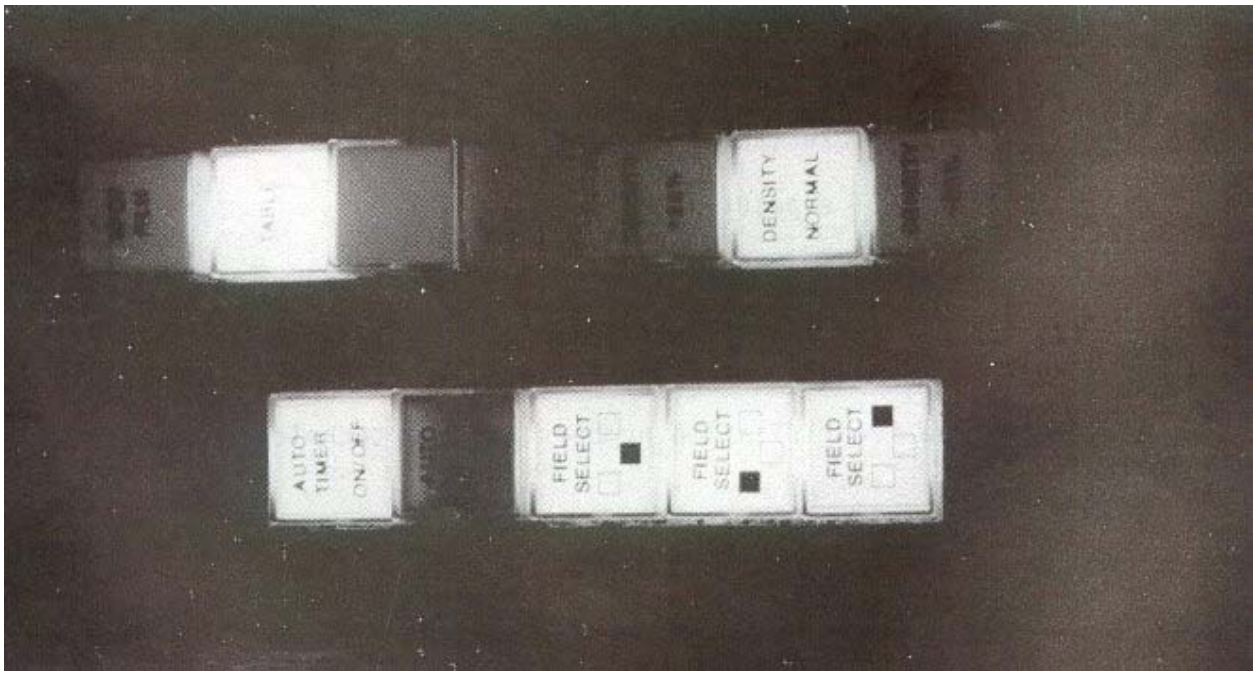

Figure 4-18. Machine set on normal density.

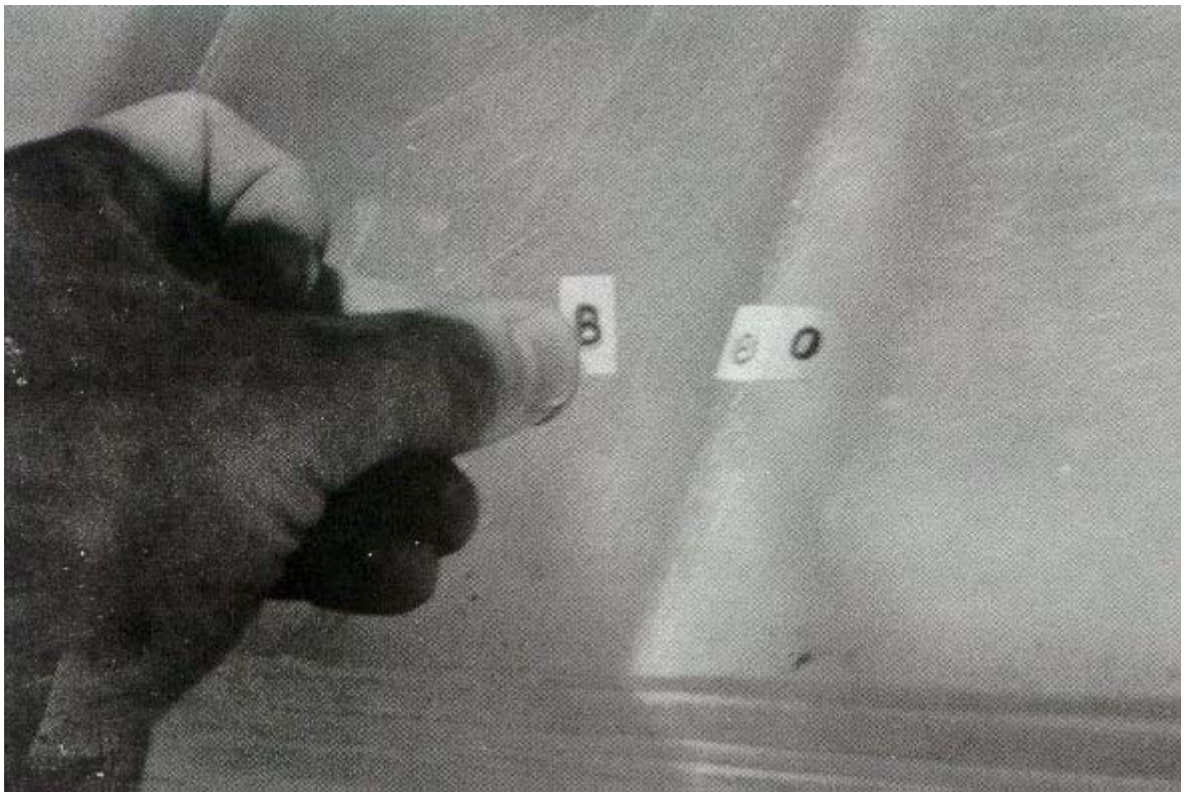

Figure 4-19. Technologist changes identification number before taking another AET exposure.

g. Make three AET exposures.

(1) Change the film between each exposure.

(2) Change the lead identification numbers factor on each film because you want to know which film was first, and so forth

h. Record the identification numbers and the technical factors after each exposure.

i. Process all three films (see figure 4-20).

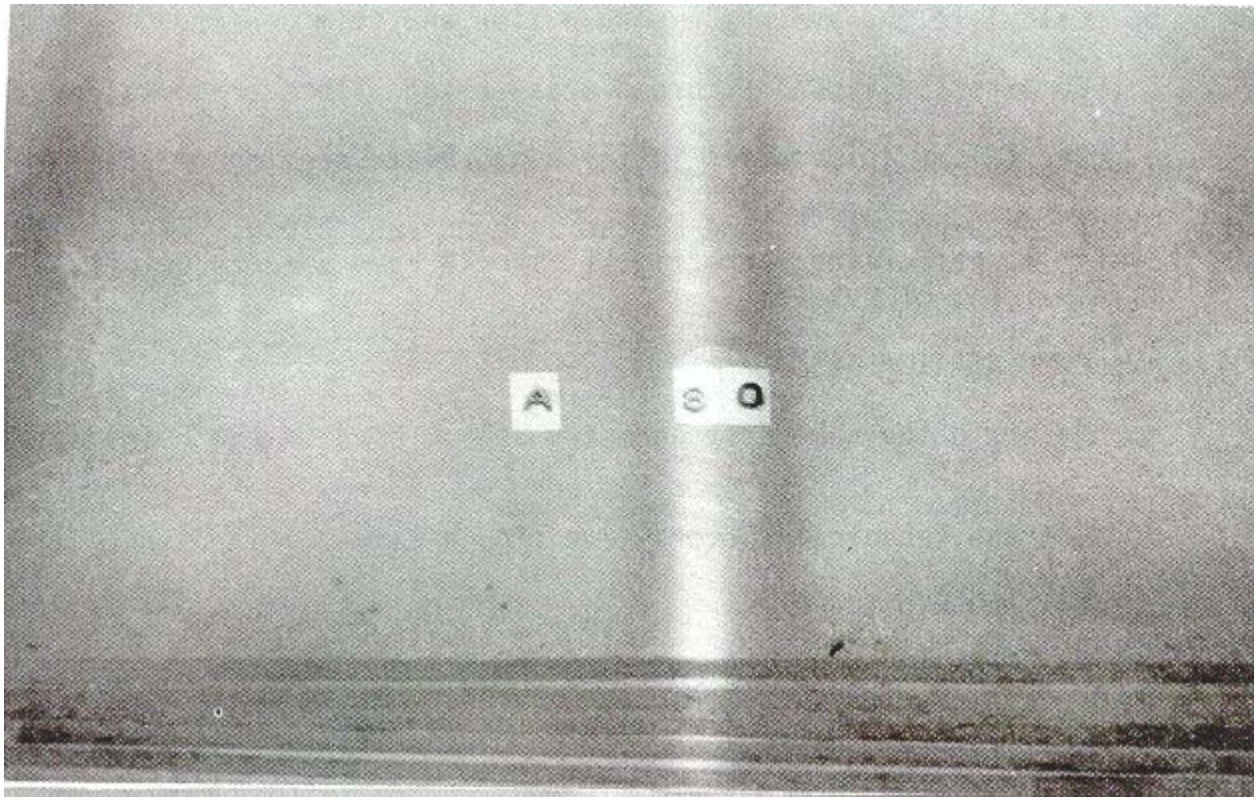

Figure 4-20 (continued). Examples of set up for remaining exposures.

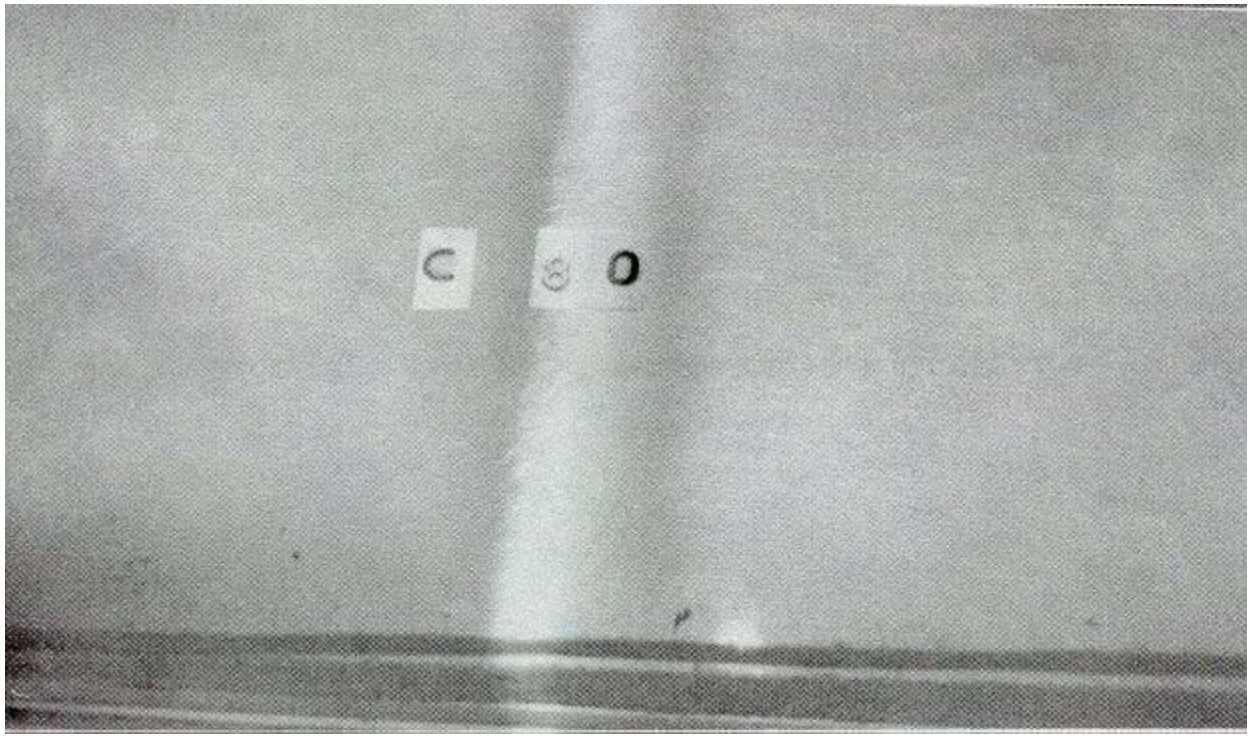

Figure 4-20 (concluded). Examples of set up for remaining exposures. Dosimeter chamber not set; however, it remains centered during all three exposures.

4-29. EVALUATION AND INTERPRETATION

a. Use the densitometer to measure the density at the reference marker.

b. Calculate the average exposure time and film density.

c. Compare individual recorded measurement with average values.

d. Record the information in the appropriate section of the form.

NOTE: All three exposures should be the same or very close. If the AET system is performing correctly, it should have reproducibility within five percent or better.

4-30. kVp COMPENSATION TEST

a. Maintain the same test geometry as you used in the reproducibility test.

b. Set the technical factors (see figure 4-21).

(1) 60 kVp.

(2) For example, 400 mA.

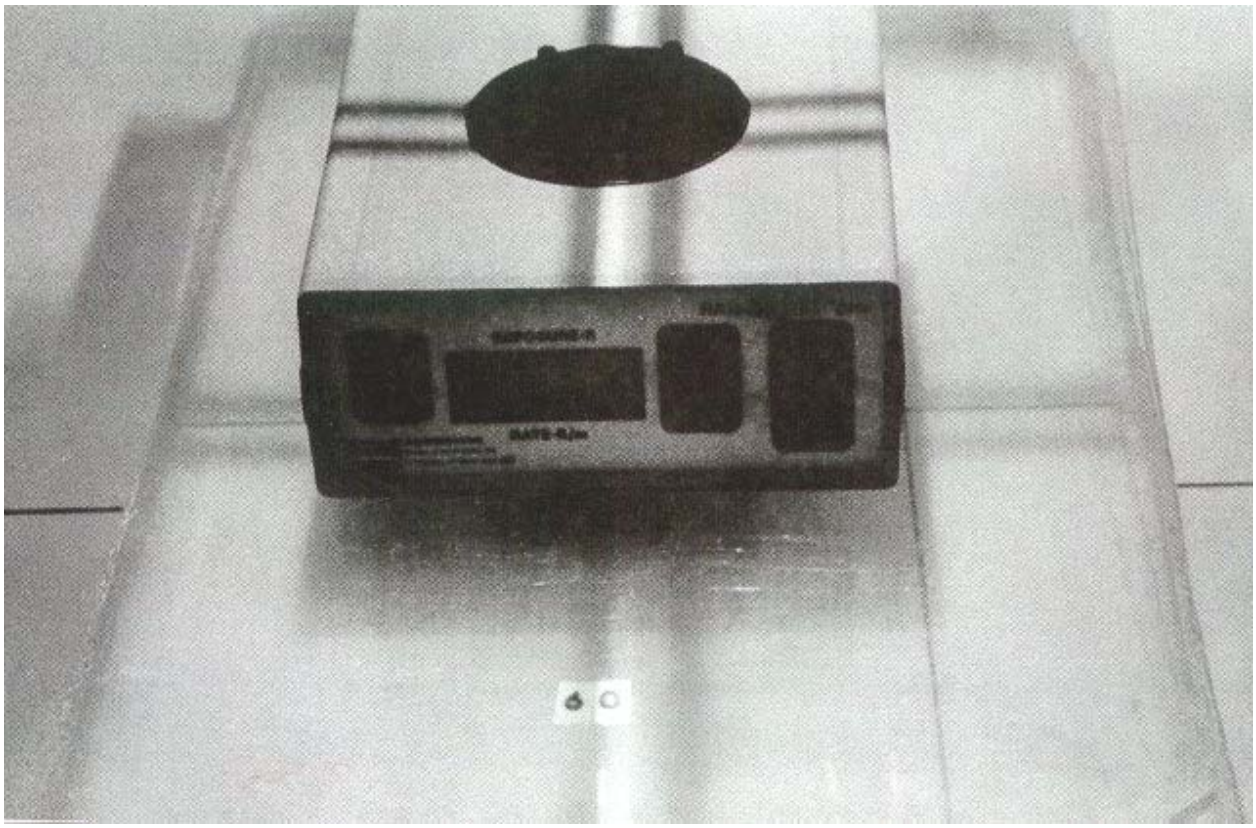

Figure 4-21. Same set up as the reproducibility test.

c. Place the lead identification number "60" on the top surface of the phantom (see figure 4-22).

d. Insert a cassette in the Bucky tray and close the Bucky tray.

e. Make the AET exposure.

f. Record the information in the appropriate section of the form.

g. Repeat steps a--f using 80, 100, and 120 kVp.

NOTE: Be sure to change the cassette and lead identification numbers when changing kVp's (see figure 4-23).

h. Process four films.

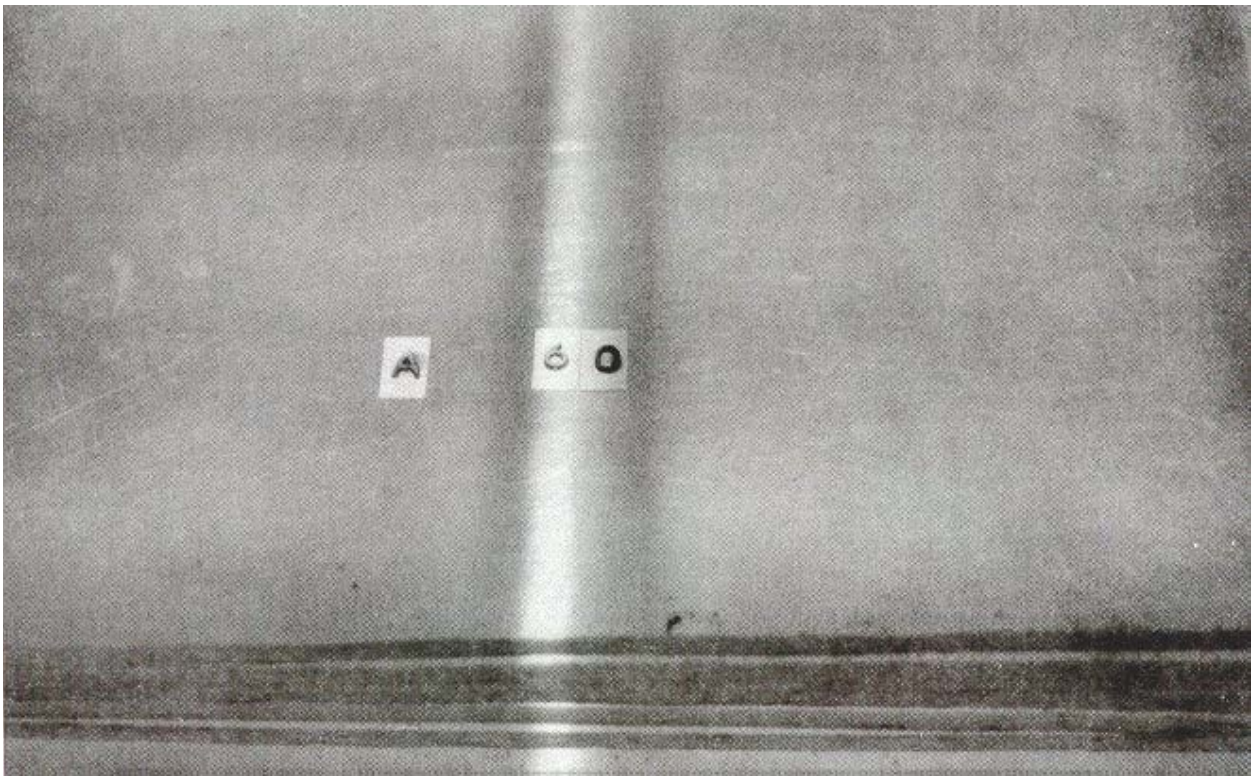

Figure 4-22. Note the "A" identification marker placed on the phantom prior to the first exposure.

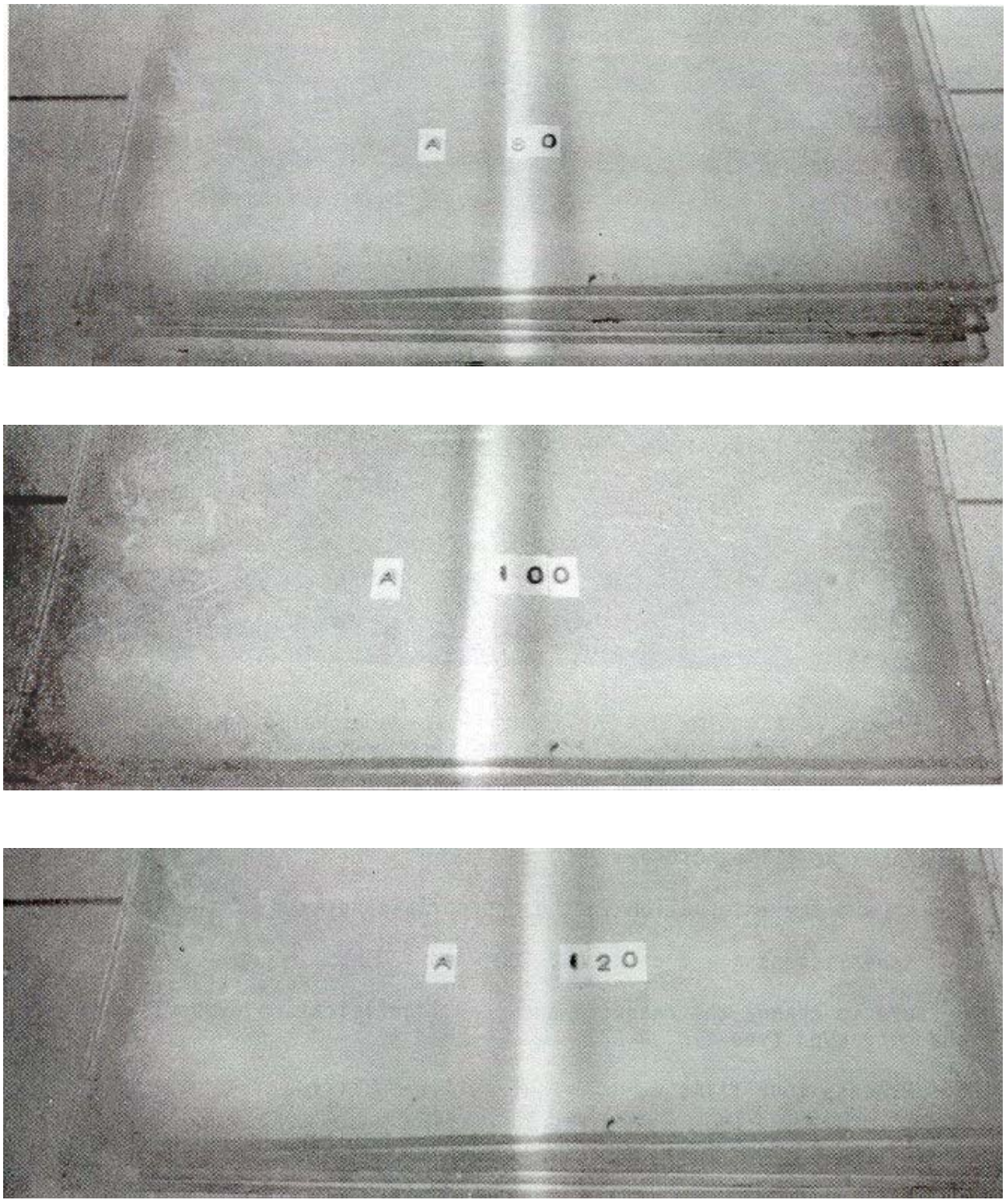

Figure 4-23. Set up with markers for 80 through 120.

4-31. EVALUATION AND INTERPRETATION

a. Measure the density at the reference marker.

b. Record the measurement in the appropriate area of the form.

c. Increasing the kVp should decrease the exposure time; the density should remain about the same.

NOTE: If the exposure time fails to decrease or the radiographic film density increases dramatically, the machine could be malfunctioning.

4-32. FIELD SENSITIVITY MATCHING TEST

a. Maintain the same geometry and set up as in the reproducibility test (see figure 4-24).

b. Select 80 kVp.

c. Select sensing fields or a combination of fields.

d. Insert a cassette into the Bucky tray and close the Bucky tray.

e. Place a lead number on the phantom to identify the film.

f. Record the necessary data on the appropriate section of the form.

g. Make the exposure.

h. Repeat steps a through g until all three sensing fields have been tested (see figure 4-25).

i. Process all radiographs.

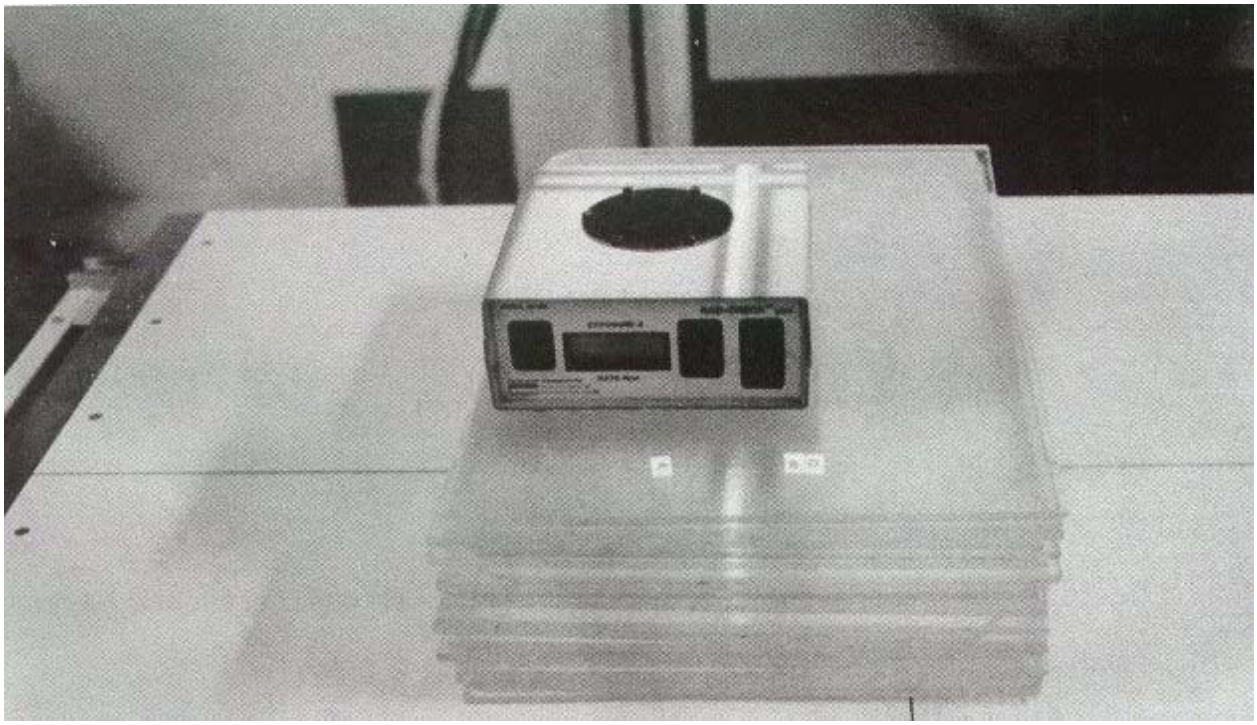

Figure 4-24. Set up remains the same as in reproducibility test.

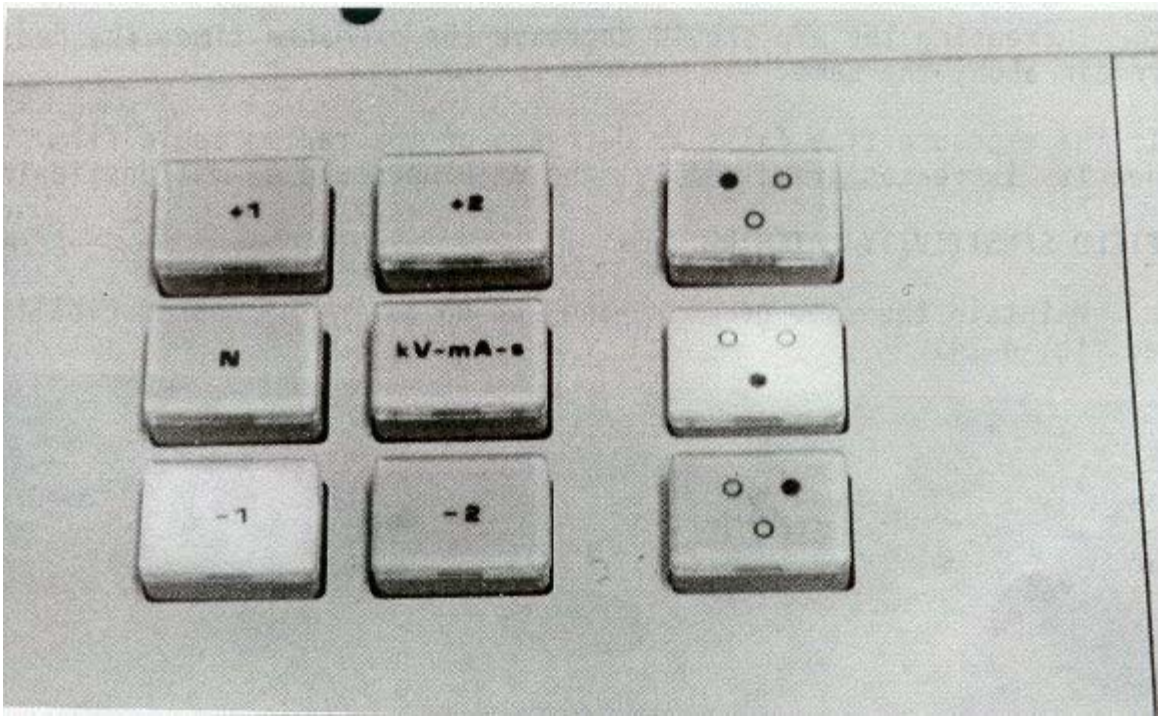

Figure 4-25. Note one of the many fields that must be tested:
-1 center cell, -1 upper right cell, and so forth.

4-33. EVALUATION AND INTERPRETATION

a. Measure the density of all the test films at the reference marker.

b. Record the density readings on the form.

c. Calculate the average exposure time for each field test.

d. Record the calculations on the appropriate section of the form.

e. Compare the results on individual field measurements. They should be within ten percent of the average measurements.

4-34. DENSITY CONTROL FUNCTION TEST

a. Maintain the same geometry and set up as in the reproducibility test (see figure 4-26).

b. Select the sensing fields that you used in the reproducibility test.

c. Insert a cassette into the Bucky tray and close the Bucky tray.

d. Place a lead number on the phantom for identification.

e. Select a density control station (plus or minus one or plus or minus two) (see figure 4-27).

f. Record the appropriate data on the proper section of the form.

g. Make the exposure (see figure 4-28).

h. Repeat steps a through g until all the density control stations have been tested.

i. Process the films.

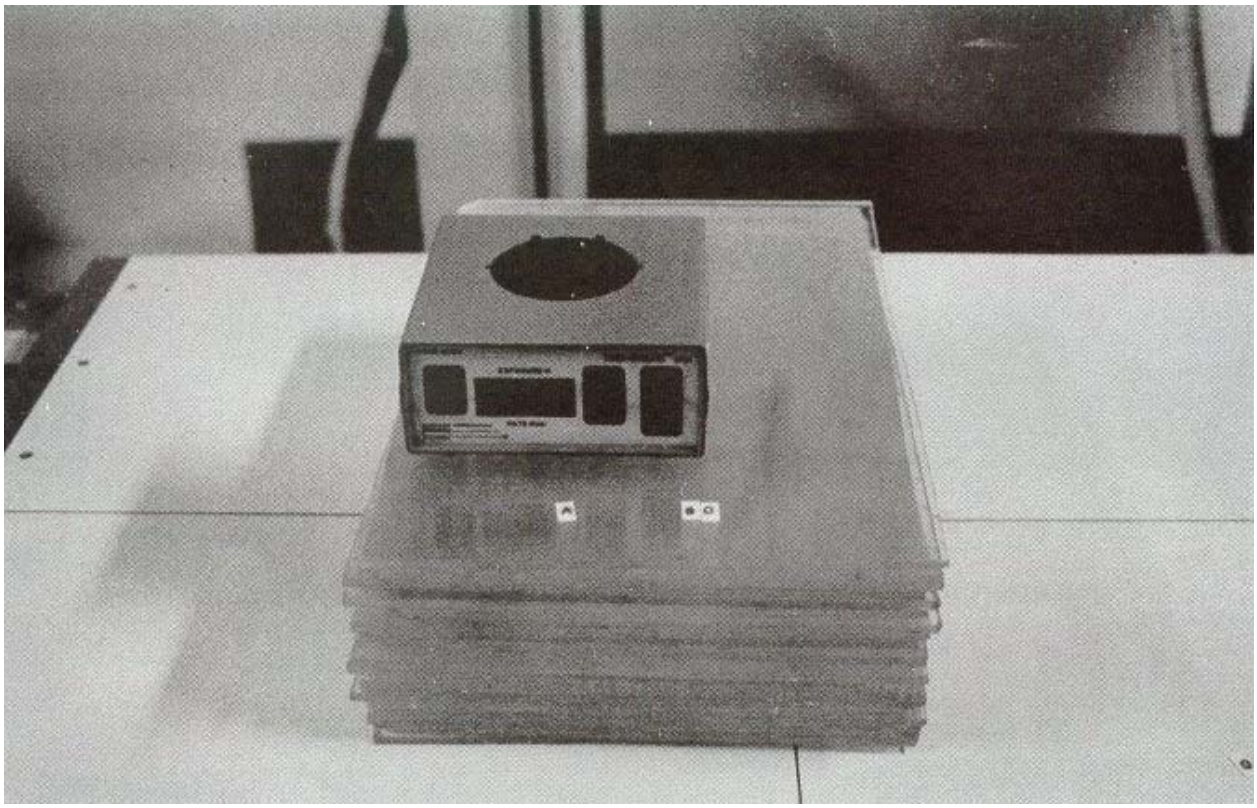

Figure 4-26. Geometry the same as in the reproducibility test.

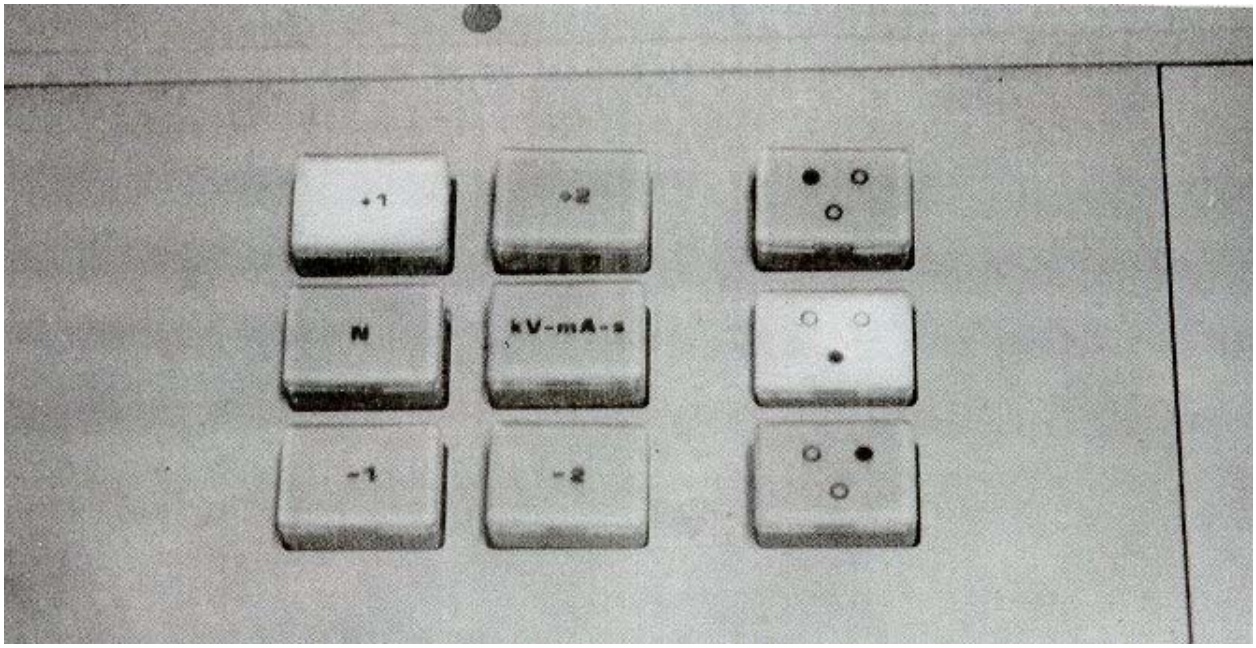

Figure 4-27. Density control station plus one (+1) being tested.

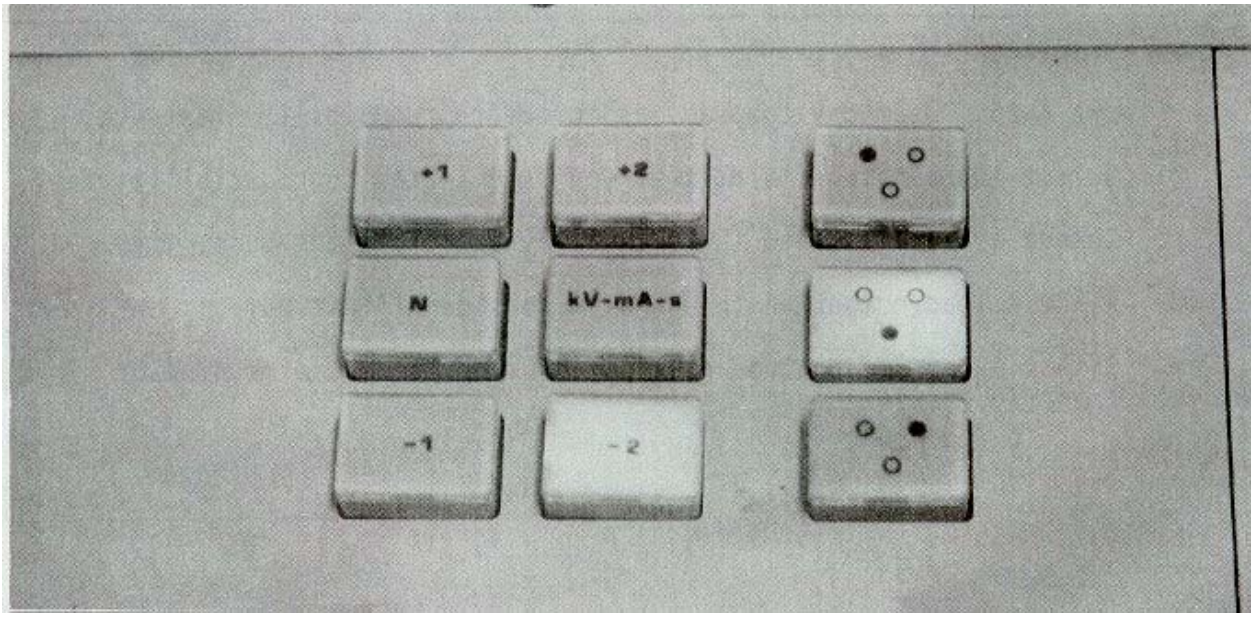

Figure 4-28. Density control station minus two (-2) being tested.

4-35. EVALUATION AND INTERPRETATION

a. Measure each film at the reference point.

b. Record the data on the appropriate area of the form.

c. If the kVp is constant, the exposure time should increase with the increased phantom thickness.

d. If the phantom thickness is the same, the exposure time should decrease with the increased kVp.

NOTE: Densities should be in the range of 0.4 optical density over the kVp for phantom thickness above 4 inches.

4-36. RESPONSE CAPABILITY TEST

This test ensures that the automatic exposure control responds to different patient thicknesses with both exposure time and an increase or decrease of kVp.

a. Maintain basic setup for reproducibility test.

b. Remove two sections of the phantom; only the base section of two inches remains (see figure 4-29).

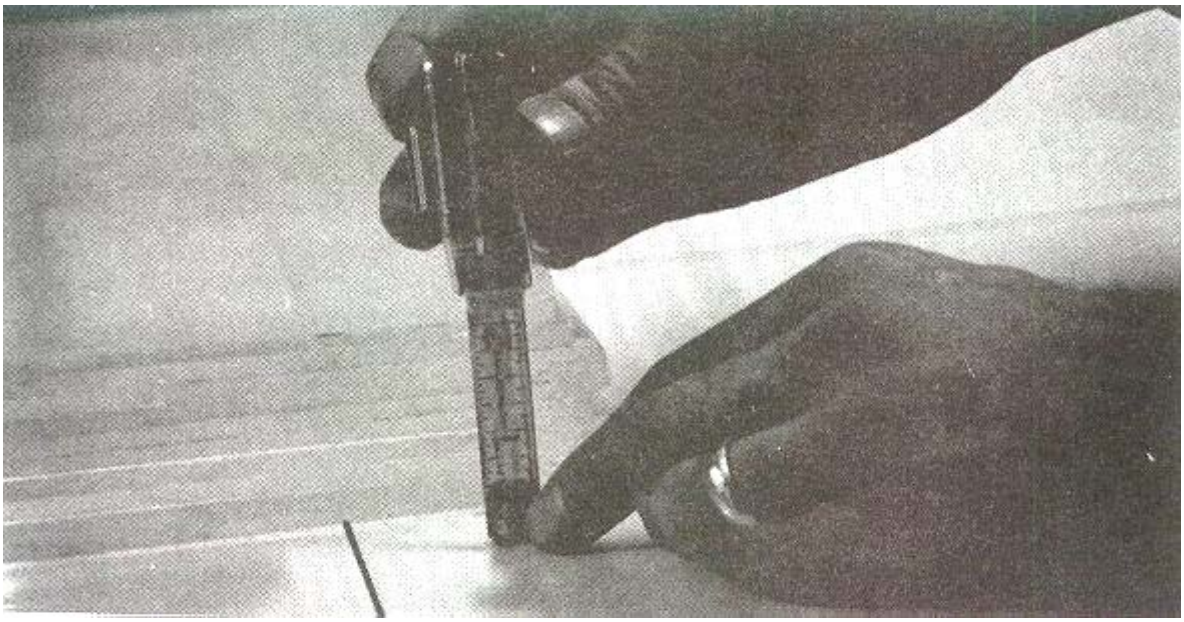

Figure 4-29. Base section measures only two inches.

c. Set mA the same as on the reproducibility test.

NOTE: Make sure that the largest sensing field is used, and the density control is on normal.

d. Select 60 kVp.

e. Place the cassette in the Bucky tray.

f. Place the lead numbers and identify the kVp and different thickness of the phantom on top of phantom.

g. Record the data on the appropriate section of the form.

h. Make the exposure.

i. Record the exposure indicated on the digital timer display.

j. Repeat steps d through i for phantom thicknesses of four, six, eight, and ten inches, using kVps of 80, 100, and 120 (see figure 4-30).

k. Process all films.

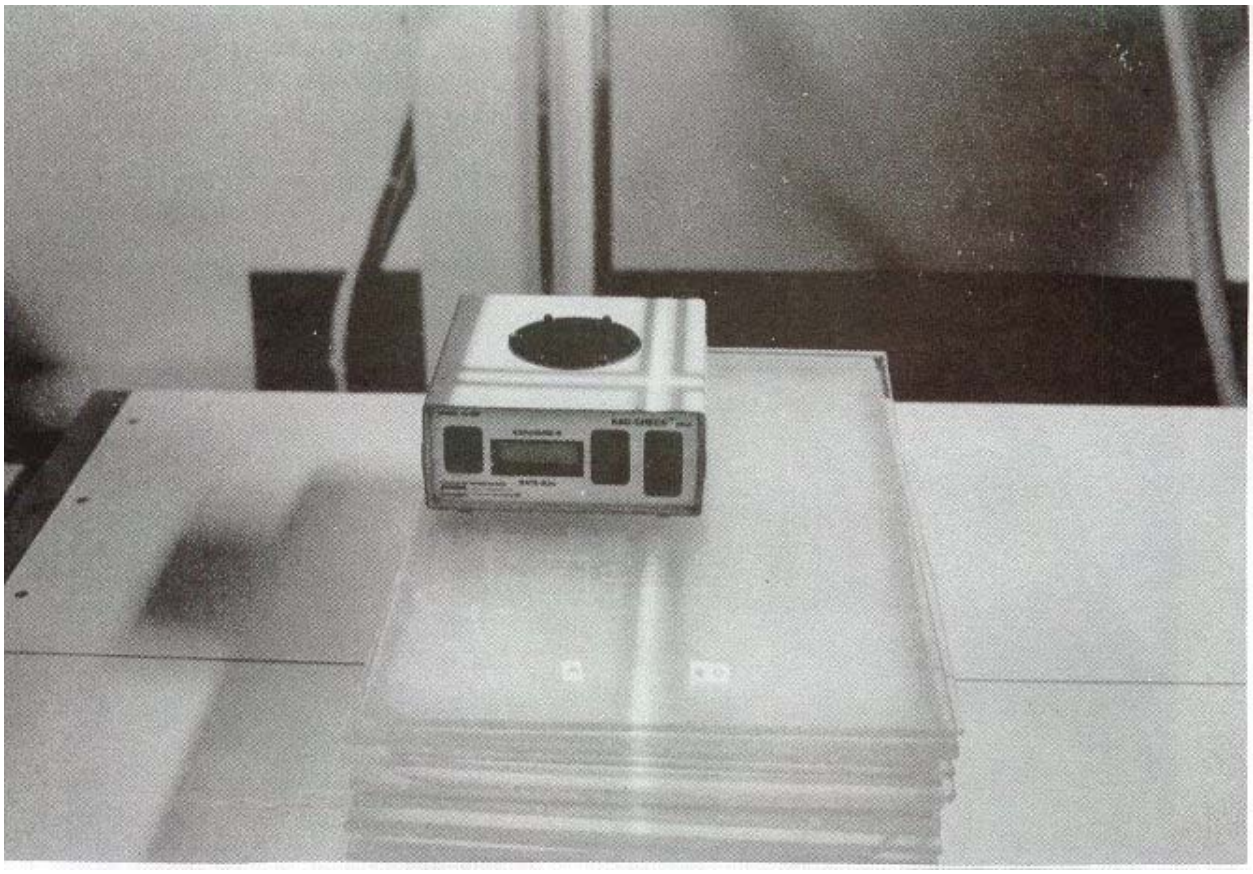

Figure 4-30. Set up for 80 kVp (base at six inches).

4-37. EVALUATION AND INTERPRETATION

a. Measure each film at a reference point.

b. Record the data on the appropriate area of the form.

c. If the kVp is constant, the exposure time should increase with the increased phantom thickness.

d. If the phantom thickness remains the same, the exposure time should decrease with the increased kVp.

NOTE: Densities should be in the range of 0.4 optical density over the kVp for a phantom thickness above four inches.

4-38. BACKUP TIMER TEST

a. Reset the phantom, machine factors, and AET used in the reproducibility test (see figure 4-31).

b. Position the 1/8-inch ll- x 14-inch lead beam stop on top of the phantom to block sensitive areas of AET. The beam will not penetrate the lead (see figure 4-32).

c. Make the exposure.

d. Record the measured time on the appropriate section of the form.

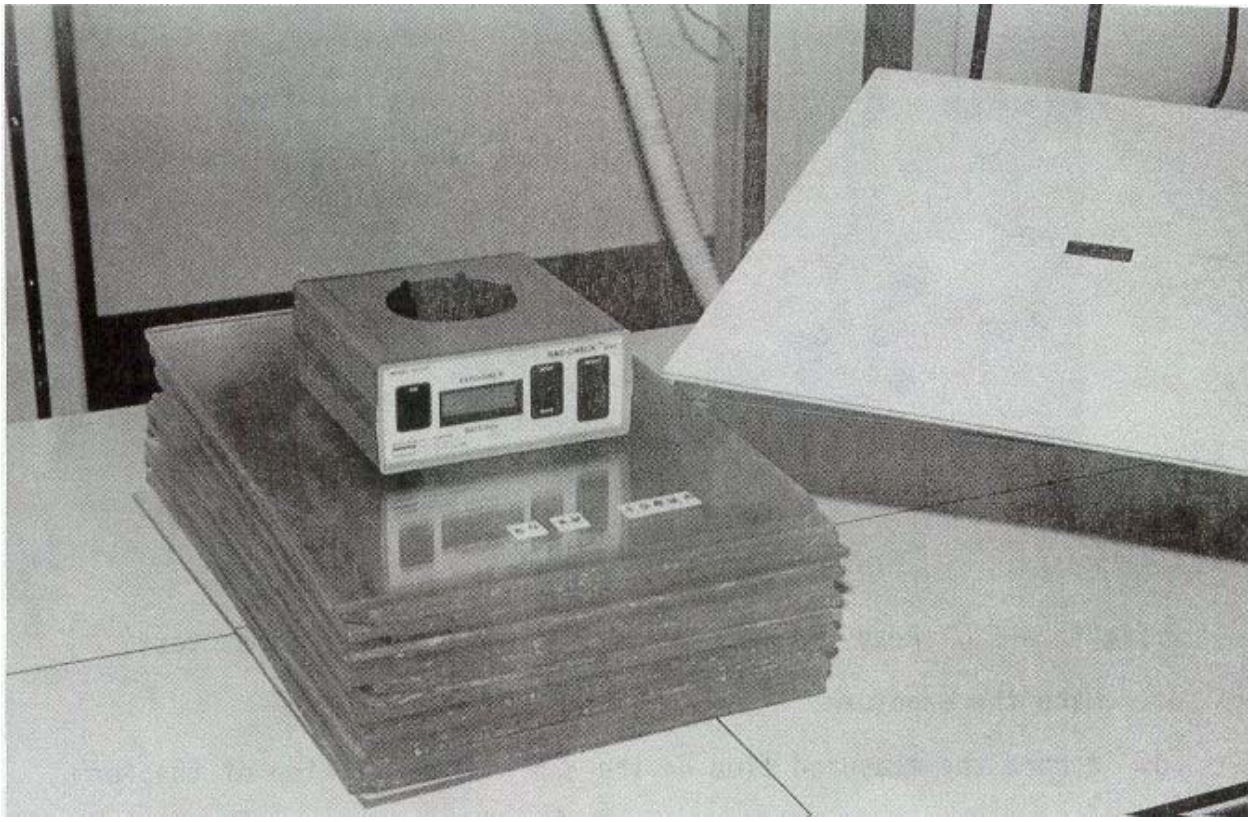

Figure 4-31. Reset to reproducibility test set up preparing to place lead blocker over the dosimeter.

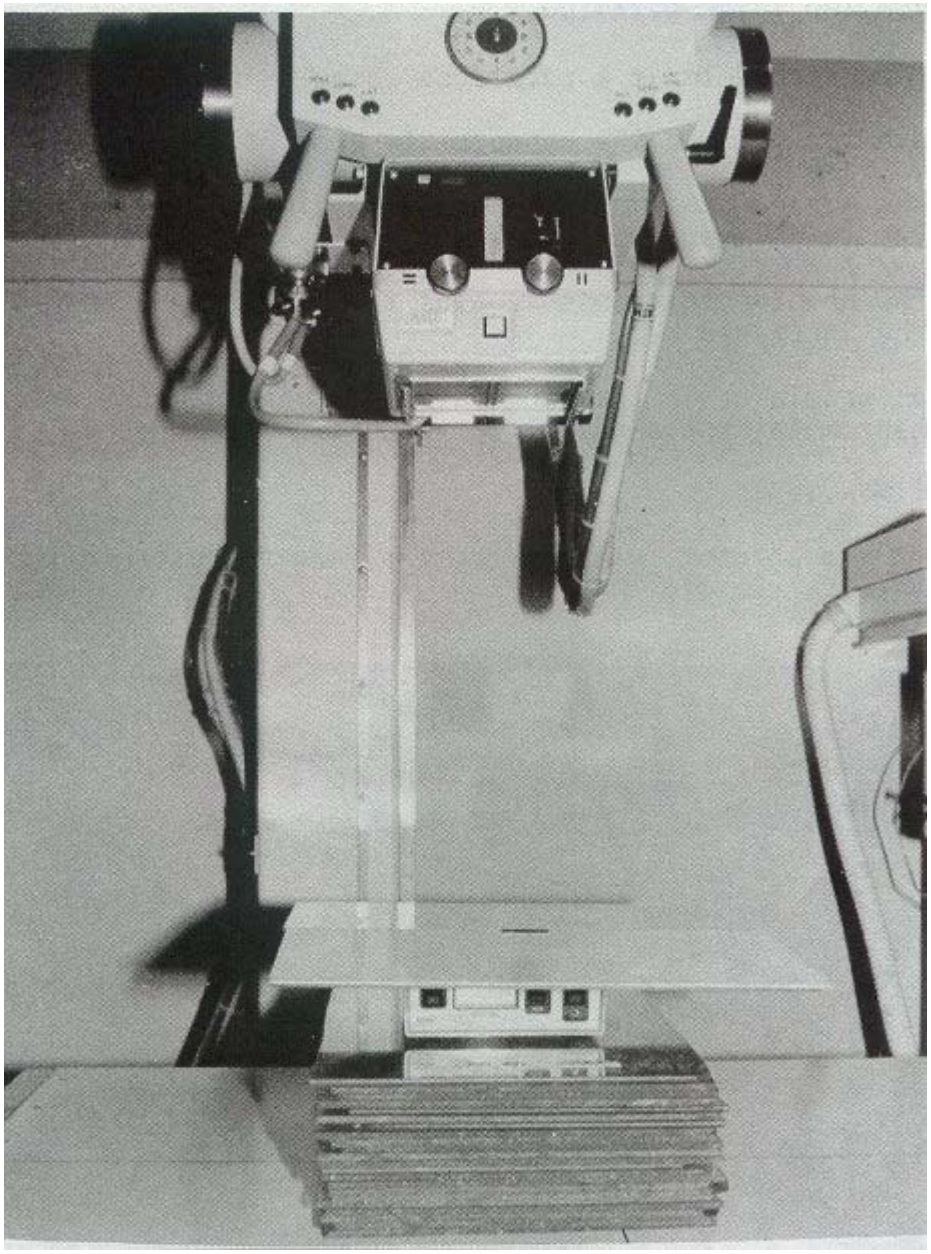

Figure 4-32. Ready to take AET exposure for backup timer test.

4-39. EVALUATION AND INTERPRETATION

To calculate the mAs produced by the exposure, multiply the mA used by the measured exposure time.

4-40. PREVENTIVE MAINTENANCE

The automatic exposure timer system should be checked routinely every six months, following any service repair work on the AET system, and when suspected problems exist.

4-41. CORRECTIVE MAINTENANCE

Contact a service representative or engineer if one or more than one of the standards are not met.

Continue with Exercises

EXERCISES, LESSON 4

INSTRUCTIONS: Answer the following exercises by marking the lettered response that best answers the exercise or best completes the incomplete statement or by writing the answer in the space provided.

After you have completed all of these exercises, turn to "Solutions to Exercises" at the end of the lesson and check your answers. For each exercise answered incorrectly, reread the material referenced with the solution.

Exercises 1 through 5 pertain to the **kVp test.**

1. You need three pieces of equipment to perform the kVp quality control test. They are:

   _____.

   _____.

   _____.

2. List the first five procedural steps to perform the test.

   _____.

   _____.

   _____.

   _____.

   _____.

3. To determine the "match" step in each region, you try to find the point where the density in the left column most closely matches the density in the _____.

4. On a routine basis, the kVp test should be performed every _____ months.

5. If an x-ray tube is replaced, what kind of preventive maintenance should be done? _____.

Exercises 6 through 10 pertain to the **electronic x-ray timing and mAs test.**

6. The following equipment/material is required to perform the test. What other equipment/material is also required?

   mAs timer.
   Lead blockers.
   Timer protractor.

   _____.

   _____.

   _____.

7. On what portion of the cassette do you place the timing tool to perform the test?

   _____.

8. How do you calculate the given mAs?

   _____.

   _____.

   _____.

   _____.

   _____.

9. If the timer proves to be correct and the exposures have different amounts of density, you consider the mA to be:

   a. Accurate

   b. Inaccurate

10. The Bureau of Radiological Health allows timer errors up to _____ percent.

Exercises 11 through 15 pertain to the **focal spot quality control test.**

11. What is the purpose of the focal spot test in addition to determining the approximate focal spot size?

_____.

12. What size film holder do you need for the focal spot test?

_____.

13. Do you place the "bar" patterns facing or facing away from the x-ray tube when preparing to perform the focal spot test?

_____.

14. A discrepancy of measurement could indicate that the SID indicator is in error. If this happens, what should you do?

_____.

15. If a great change in focal spot resolution occurs, what should you do?

_____.

Exercises 16 through 20 pertain to the **collimator quality control test.**

16. Why do you need lead numbers for the collimator test?

_____.

17. What can you use as a collimator test tool instead of nine pennies?

_____.

18. Where does the "A" go in relation to the x-ray tube when you are preparing to perform the collimator test?

_____.

19. Routinely, how often should the collimator test be done?

_____.

20. If the collimator test results show that the x-ray field exceeds the proper location according to the standard, what should you do?

_____.

Exercises 21 through 32 pertain to the **automatic exposure timer quality control test.**

21. How many tests must be performed on the AET? _____.

22. Which of the following tests is/are part of the AET test?

    a. Density control.

    b. Reproducibility test.

    c. kVp compensation test.

    d. All of the above are part of the AET test.

23. How many AET exposures do you make for the reproducibility test? _____.

24. What do you compare the individual recorded measurement with to get the reproducibility percent for the reproducibility test?

_____.

25. Which kVp numbers do you use for the kVp compensation test?

_____.

26. Where do you measure the density for the kVp compensation test?

_____.

27. For the field sensitivity matching test, you maintain the same geometry and set up as in the _____ test.

28. For the field sensitivity-matching test, the results on individual field measurements should be within _____ percent of the average measurements.

29. Why do you place a lead number on the phantom for the density control function test?

_____ .

30. For the density control function test, if the kVp is constant, the exposure time should _____ with increased phantom thickness.

31. Where do you position the lead beam for the backup timer test?

_____.

32. For the backup timer test, routinely, how often should the timer system be checked?

_____.

33. On which test is a line check necessary?

    a. Focal spot test.

    b. mAs test.

    c. kVp test.

    d. Collimator test.

34. A densitometer is needed to perform the kVp test.

    a. True.

    b. False.

35. On which test is a motorized synchronous top necessary?

    a. Focal spot test.

    b. mAs timer test.

    c. kVp test.

    d. Collimator test.

36. Where do you set the SID for the mAs test?

    a. 20 inches.

    b. 40 inches.

    c. 60 inches.

    d. 80 inches.

37. In the focal spot test, the set screws separation measurement should be _____.

38. The focal spot test should be performed routinely at:

    a. Three-month intervals.

    b. Six-month intervals.

    c. Nine-month intervals.

    d. Twelve-month intervals.

39. Which test do you perform that requires nine pennies (or equivalents)?

    a. Focal spot test.

    b. mAs test.

    c. kVp test.

    d. Collimator test.

40. In the collimator test, the lead letters are important because they give:

    a. The accuracy of numerically indicated field size.

    b. Congruence of light and radiation fields.

    c. The room number and date.

    d. Alignment of the beam restriction system.

41. For the AET test, you need a ringstand and clamp.

    a. True.

    b. False.

42. In the kVp compensation test of the AET, if you increase the kVp, the exposure time should _____.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES, LESSON 4

1. Wisconsin x-ray test cassette
   two small lead sheets
   densitometer (para 4-2a, b, c)

2. Perform a line check.
   Place the long axis of the test cassette parallel to the cathode-anode axis of the x-ray tube.
   Place the lead sheets on the cassette leaving the 60 kVp region exposed.
   Center the 60 kVp region under the x-ray tube.
   Collimate the x-ray beam to the 60 kVp region. (para 4-3a, b, c, d, e)

3. Right column (para 4-4a(2))

4. Three (para 4-5)

5. Perform the kVp test (para 4-5)

6. Extension cord
   10- by 12-inch cassette
   Lead numbers (para 4-8d, e, f)

7. The unleaded portion (para 4-9d)

8. Use four different times and mA.
   50 mA at 1/5 second
   100 mA at 1/10 second
   200 mA at 1/20 second
   300 mA at 1/30 second (Para 4-9g(2))

9. b (para 4-10 2nd NOTE)

10. Ten (para 4-10e(1))

11. To track age deterioration (para 4-13)

12. 10 by 12 (para 4-14b)

13. Facing (para 4-15c)

14. Take more measurements para 4-16, NOTE)

15. Replace the x-ray tube (para 4-18)

16. For the room number and date (para 4-23d)

17. Commercially made test tool (para 4-24 NOTE)

18. At the anode end (para 4-24e(1))

19. Two-month intervals (para 4-26)

20. Call the service representative or engineer. (para 4-27)

21. Six (para 4-25)

22. d (para 4-28, 4-30, 4-34)

23. Three (para 28g)

24. Average values (4-29c)

25. 60, 80, 100, 120 (paras 4-30b(1), g)

26. At the reference marker (para 4-31a)

27. Reproducibility (para 4-32a)

28. Ten (para 4-33e)

29. For identification (4-34d)

30. Increase (para 4-35c)

31. On top of the phantom (para 4-38b)

32. Six months (para 4-40)

33. c (para 4-1a)

34. a (para 4-2c)

35. b (para 4-8a)

36. b (para 4-9f)

37. Forty millimeters (para 4-16d(5))

38. a (para 4-17a)

39. d (para 4-20b)

40. c (para 4-20d)

41. a (para 4-26c)

42. Decrease (para 4-31c)

End of Lesson 4

LESSON ASSIGNMENT

LESSON 5 Fluoroscopic Unit Quality Control Tests.

TEXT ASSIGNMENT Paragraphs 5-1 through 5-24.

LESSON OBJECTIVES After completing this lesson, you should be able to:

5-1. Select the correct equipment, order of procedure, evaluation and interpretation, and preventive or corrective maintenance for the:

a. Minimum source to tabletop distance test.

b. Beam restriction adequacy test.

c. Imaging system focusing and resolution test.

d. Exposure rate test.

SUGGESTION After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you achieve the lesson objectives.

LESSON 5

FLUOROSCOPIC UNIT QUALITY CONTROL TESTS

Section I. MINIMUM SOURCE TO TABLETOP DISTANCE TEST

5-1. PURPOSE

The fluoroscope is the device, which enables you to see the shadows of x-rays passing through the body. In other words, you can see on a screen exactly what you are x-raying. Fluoroscopic procedures usually produce higher total exposure rates to patients and medical personnel than conventional radiographic procedures. Yet, fluoroscope units are often overlooked in a quality assurance program since it does require more time and effort to perform the four necessary tests. Nevertheless, installations with fluoroscopic capability should be concerned that these units are operating correctly to avoid excessive exposure rates. Because radiation levels vary at a rate inversely proportional to the squares of the distances in accordance with the inverse square law, it is important that the minimum source to tabletop distance be adequate. The shorter the source to tabletop distance, the greater the amount of radiation the patient will receive. This test will enable you to find the proper minimum distance from the fluoroscopic source to the tabletop. If this distance is out of the prescribed range, the fluoroscope machine is out of adjustment.

5-2. EQUIPMENT/MATERIAL

a. One metallic object--3 inches long.

b. One metallic object--6 inches long.

NOTE: Any lengths of metal strips will work as long as the length ratios are exactly 1:2. Another example would be one quarter and two quarters. Just be sure to keep the ratios 1:2. The smaller one goes on the table; the larger object goes on the imaging assembly (see figure 5-1).

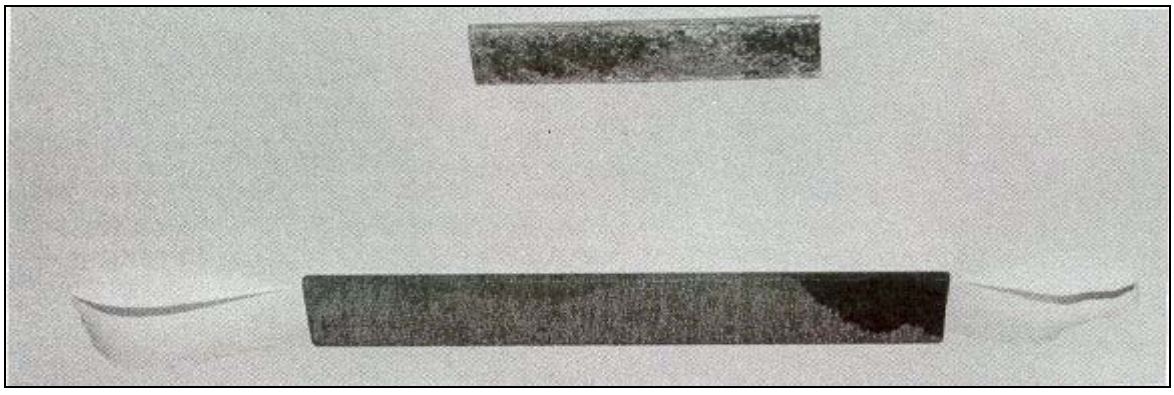

Figure 5-1. Both objects used in minimum source to tabletop distance test.

c. Masking tape. (Do not use white hospital tape because it can leave a residue that causes an artifact in the fluoroscopic image.)

d. Measuring tape.

e. Recording form.

5-3. PROCEDURE

a. Adjust the system to the minimum distance obtainable.

b. Next, place the 3-inch metal object on the table (see figure 5-2).

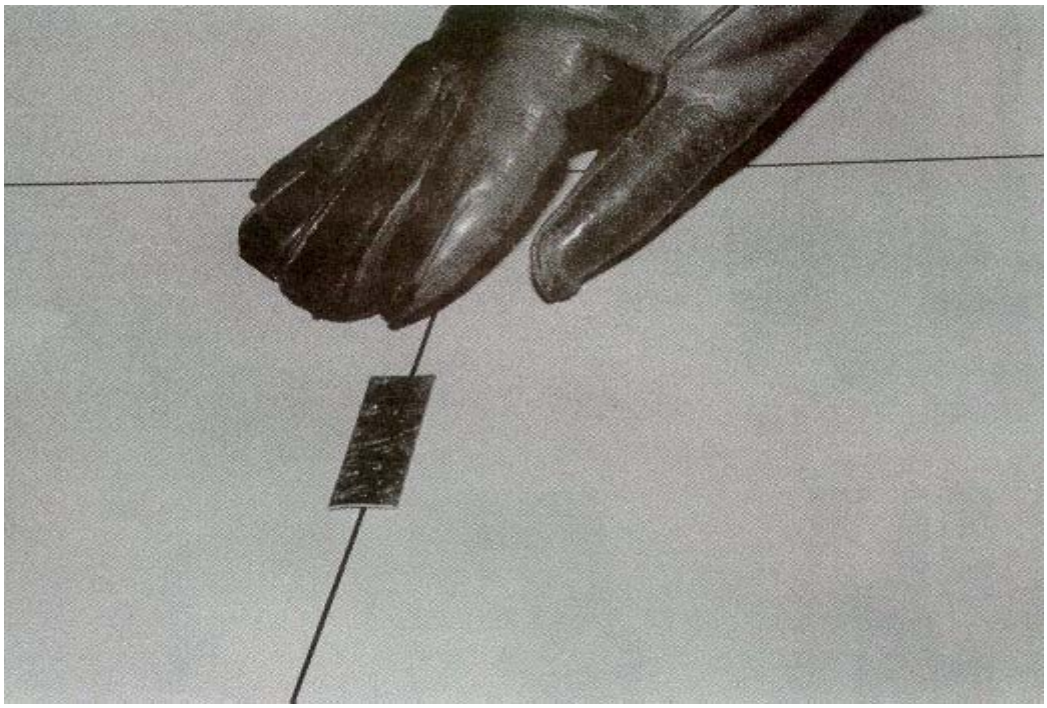

Figure 5-2. Place three-inch metal object on table.

c. Tape the 6-inch object to the anterior-most (front) surface of the fluoroscopic imaging assembly.

d. Put on your lead apron (see figure 5-3).

e. Use the fluoroscopy and observe the image. Keep adjusting the distance between the tabletop and the radiation source until the two metal objects are seen to be exactly the same size on the viewing screen (see figure 5-4).

f. Lock the assembly in place.

Figure 5-3. Be sure to put on your lead apron.

Figure 5-4. Observe the image.

5-4. EVALUATION AND INTERPRETATION

a. After locking the assembly in place, you must measure the distance between the two metal objects (the metal strips, quarters, or whatever you used). This distance equals the distance between the source and the tabletop.

b. The minimum range, usually, is 17 to 20 inches with a one-inch leeway. In other words, 16 inches would be all right, but 15 inches or less would not be acceptable. In such a case, the patient would receive too much radiation. If the distance is greater than 21 inches, the patient would produce a less than optimal exam or study (see figure 5-5).

NOTE: A distance of 12 inches is acceptable for portable units.

c. Record your findings on a data sheet.

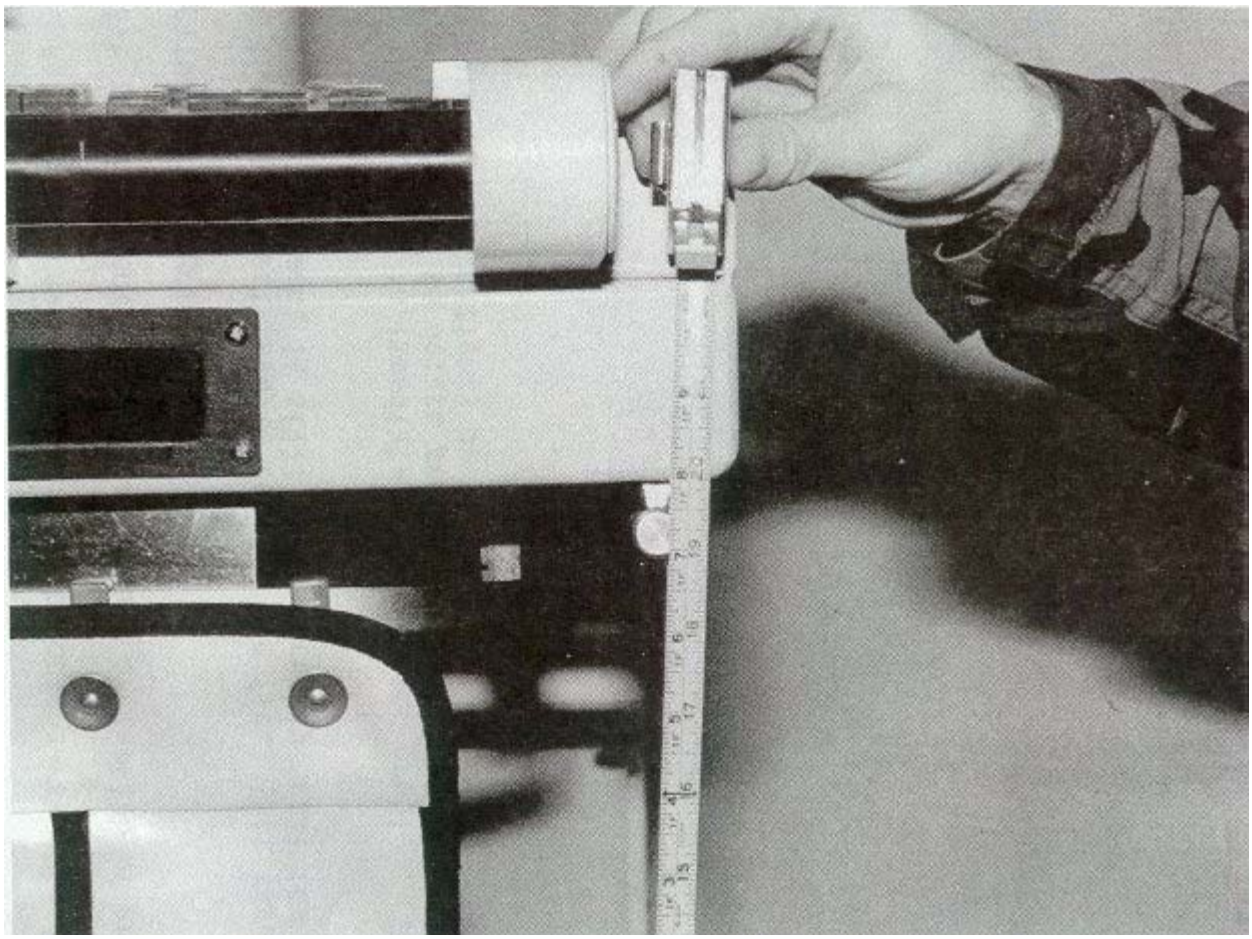

Figure 5-5. Measure the acceptable distance of 20 inches.

d. Repeat the test if the distance is outside the prescribed range. Always repeat a test that gives inferior results. Perhaps the equipment needs adjustment, or perhaps you made an error in performing the test. Anyway, before you call a service engineer or a manufacturer's representative, you want to be sure that the repeat test results are the same as the first test results.

5-5. PREVENTIVE MAINTENANCE

a. Perform this test when a quality assurance program is begun.

b. Test the machinery when it is newly installed.

c. Repeat the test every time a fluoroscopic x-ray tube is replaced.

d. Test the equipment after every repair or service of any kind.

5-6. CORRECTIVE MAINTENANCE

a. If the repeat test results confirm the first test results, call the engineer or, if the equipment is still under warranty, call the manufacturer's representative.

b. Do this at once to immediately correct the problem. Remember, the reason for the testing is to detect problems before they can cause considerable harm to your patients or to you.

Section II. BEAM RESTRICTION ADEQUACY TEST

5-7. PURPOSE

When the radiologist collimates to a given area of the body, he needs to be sure that what he sees on the TV screen or the mirror optic is what is being exposed to radiation. This beam restriction adequacy test will allow for the determination of the exact area being imaged and allow the quality control technologist to assure that all fluoroscopic systems in the department are producing images of a similar size. Beam restriction ensures that the patients are not receiving excessive doses of radiation, and it minimizes the amount of secondary (scatter) radiation that the technologist and radiologist are exposed to in the examining room.

5-8. EQUIPMENT/MATERIAL

a. A fluoroscopic beam restriction test tool.

b. Lead numbers and letters for identification.

c. Cardboard holder loaded with ready pack film.

d. A 12-inch ruler graduated by 1/32.

e. Three-fourth inch aluminum block.

5-9. PROCEDURE

a. Put on a lead apron.

b. Place the three-fourth inch attenuator block on the tabletop to intercept the radiation going to the image intensifier.

c. Select a clinically useful image intensifier or tower height such as a ten-inch height and lock the assembly in place.

d. Set the technical factors to low values.

e. Place the three-fourths inch aluminum block on the tabletop, place the test tool on top of the attenuator, and use the fluoroscopic control.

(1) Align the orientation marker "R" in the upper quadrant of the viewed image.

(2) Locate the test tool control dot at the approximate center of the viewed fluoroscopic image (see figure 5-6).

Figure 5-6. Technologist locating the control dot under the fluoroscope.

f. Use the fluoroscopic unit, the manual mode, to accomplish the following actions:

(1) Achieve the final centering.

(2) Reduce the field in transverse (cross) dimension until the visual field equals the row of dots in the test tool. Be sure to align the row of dots in the visual field.

g. Repeat the above procedure in the longitudinal (lengthwise) dimension.

NOTE: Center the test tool properly with respect to the imaging assembly.

NOTE: Use the image chain to decrease the amount of radiation received while moving the test tool and to prevent damage to the components.

h. Tape the test tool to the table top to minimize the possibility of any movement.

i. Perform the beam restriction test in the fluoroscopic mode.

(1) Start the fluoroscopic exposure.

(2) Observe the test tool image.

(3) Carefully insert the brass slides into the test tool channels with the ends of the slides just visible at the edges of the viewed image on the fluoroscope or mirror optics.

NOTE: The ends of the slides define the visual field of the image intensifier system.

(4) Discontinue the fluoroscopic exposure.

(5) Place an 8- x 10-inch cardboard with ready pack film on top of the test tool.

(6) Again, start the fluoroscopy and set the controls for automatic brightness control of the generator.

NOTE: If this is not possible, set the fluoroscopic technique factor to low values (which may be increased later, if necessary) to prevent damage to the components in the image chain.

(7) Adjust the technique and time so that the proper film density will result.

NOTE: If using a screenless cassette, place a one-eighth inch sheet of lead over the cassette to prevent exposure to the image intensifier.

NOTE: By using maximum mA and higher kVp you will decrease the needed exposure time.

(8) Test for all field size modes, for the small and the large focal spot in both manual and automatic modes.

(9) Examine the fluoroscopic image and ensure that each of the collimator edges (assuming a rectangular collimator system is present) is visible just within the edges of the visual field as seen on the fluoroscopic television or the mirror optics.

(10) Process the test film.

(11) Identify the test film.

(12) Record your results on the data forms and film (i.e., the spot film format, manual or automatic mode, and large or small focal spot).

NOTE: If the density is insufficient to define the test tool, repeat the test with higher mAs to obtain a test film of greater density.

5-10. EVALUATION AND INTERPRETATION

Since this test involves the analysis of several test radiographs, you must identify each film as it is taken and record the identifying data on the data form.

a. From each of the radiographs, measure the total amount by which the radiation field exceeds the visual field by both length and width.

(1) The clear area demonstrates the tips of the brass strips. Remember, the brass strips represent the area that the radiated field should NOT exceed.

(2) The dark area is the region actually exposed to radiation.

b. The sum of the lengths for one pair of opposing strips will give the excess width. The sum of the other strips will be the excess length.

NOTE: In the radiographic light field x-ray test, any misalignment is measured. In this test we will measure only the differences representing excess radiation (that is, where the radiation field exceeds the correct area). If the radiation is within the visual field by any amount, it is not included.

c. Calculate the sum of excesses, that is, width plus length.

d. Record results of all films on the data forms.

e. For an image intensified system, the excess width and length should not exceed 3% of the source (or focal spot) to table top distance (STD). The sum of excess width plus length should not exceed 4%.

5-11. PREVENTIVE MAINTENANCE

Keeping the fluoroscopic beam to a minimum is vital to protect the patient from excessive radiation. When you, as a radiologist, collimate to a given area of the body, you need to be sure that what you see on the screen is exactly what is being exposed to radiation and no more than that. Bearing this in mind, be sure to test the beam restriction adequacy (or see that someone does) following each of the times or situations listed below.

a. Implementation of a quality assurance program.

b. Installation of new equipment.

c. Service work has been performed on fluoroscopic beam restriction.

d. Replacement of the fluoroscopic x-ray tube.

e. Routinely at six-month intervals.

5-12. CORRECTIVE MAINTENANCE

If your test results exceed the established standards, you must do the following.

a. Verify your first test results by retesting. If the second test shows the beam restriction accuracy to be all right, possibly you made an error in performing the first test. If the retest results match the first test results, you may be sure that something needs adjustment.

b. Call the manufacturer's representative or the service engineer.

Section III. FOCUSING AND RESOLUTION OF THE IMAGING SYSTEM

5-13. PURPOSE

This focusing and resolution of the imaging system test ensures that the fluoroscopic unit has acceptable focusing and resolution (detail).

5-14. EQUIPMENT/MATERIAL

a. Image intensifier resolution test pattern.

b. Twelve-inch spacer assembly (can be plexiglas cylinder 12 inches high or may be sponges).

c. Aluminum attenuated (attenuation is the proportion of radiation that is absorbed by the item being measured) block that is 8 x 8 x 0.5 inches (see figure 5-7).

5-15. PROCEDURE

a. Place fluoroscopic imaging assembly at maximum height above the tabletop.

b. Place attenuated block on the tabletop.

c. Place 12-inch spacer on top of the attenuated block.

d. Place the test pattern on top of the spacer.

e. Center these items (approximately) in the center of the visual field on the tabletop (see figure 5-8).

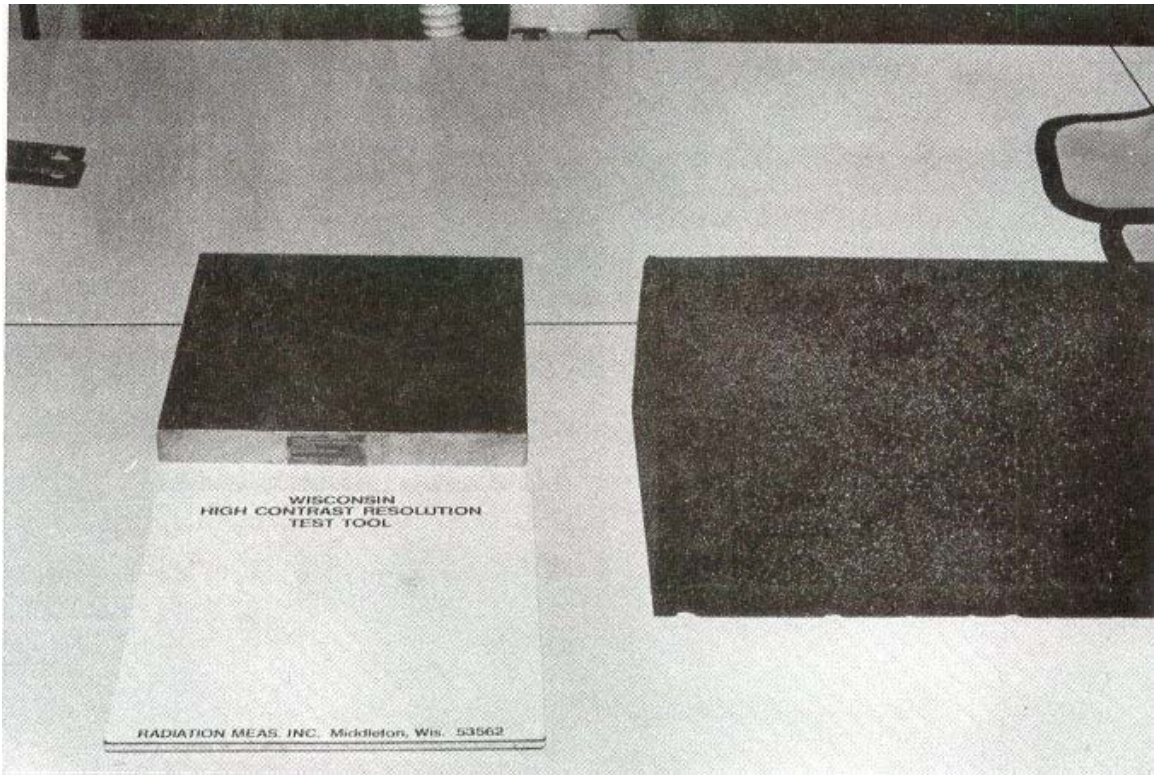

Figure 5-7. Equipment for focusing and resolution test.

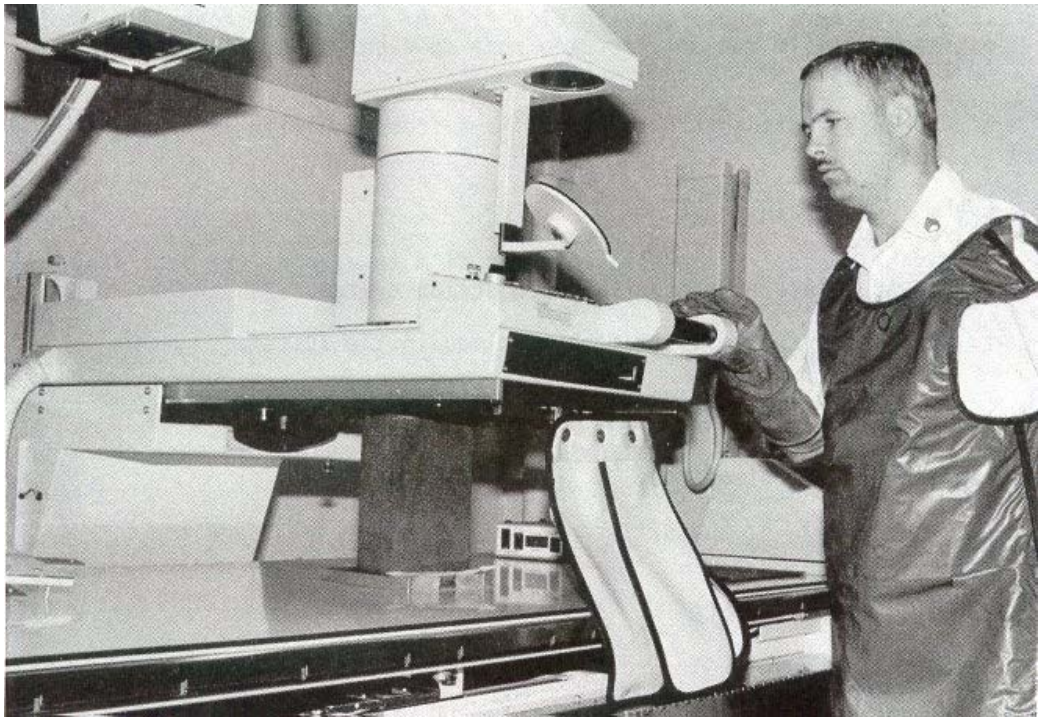

Figure 5-8. Technologist centering test items to visual field.

f. Lock the fluoroscopic assembly in place both transversely and longitudinally.

g. Lower the fluoroscope assembly to just touch the test pattern.

h. Put on your lead apron.

i. Select 60 kVp fluoroscopic technique for this test.

j. Begin the fluoroscopic exposure.

k. Observe the image of the resolution test pattern.

l. Note the number of the wire mesh that you can clearly see in the viewed image.

m. Record the number value on the data form under the correct mode and image intensifier field size.

n. If your unit has a magnification mode, repeat the above process.

o. Record the number value in the appropriate section of the data form.

NOTE: If the system is equipped with cine film or photospot capability, make a test film run of recording mode in each intensifier mode. Use 60 kVp and the small focal spot.

p. Process and identify the test films from each film recording system tested.

5-16. EVALUATION AND INTERPRETATION

It may be necessary with small format film to examine the test films with a magnifying glass or appropriate projection system.

a. Determine the smallest mesh resolved in the system.

b. Record the results on the data form.

c. Compare the test results with the minimum resolvable mesh chart or the established clinic standards.

d. Make a note of any difference between the results and the established standards.

5-17. PREVENTIVE MAINTENANCE

Resolution should be tested following the situations below.

a. Implementation of a quality assurance program.

b. The installation of new equipment.

c. Any service or repair work on the image intensifier.

d. The connection of any viewing and recording systems.

e. Routinely at 6-month intervals.

5-18. CORRECTIVE MAINTENANCE

If your test results exceed the established levels, you must do the following things.

a. Verify your test results by retesting.

b. Confirm the first results with the second test.

c. If necessary, call the service engineer or the manufacturer's representative.

Section IV. THE EXPOSURE RATE TEST

5-19. PURPOSE

The exposure rate test measures the existing radiation levels of a fluoroscopic unit. Such tests allow you to compare patient exposure from room to room for consistency. The exposures should be within fairly close levels if the rooms have similar equipment.

5-20. EQUIPMENT/MATERIAL

a. A direct readout dosimeter.

b. A 12-inch ruler.

c. Two 1/8-inch lead sheets.

d. Supports to hold the lead above the ionization chamber.

5-21. PROCEDURE

a. Set the fluoroscope machine controls to automatic brightness.

b. Turn the mA and kVp controls to maximum, if possible.

c. Adjust the height of the fluoroscope tower to 12 inches above the tabletop.

d. Place the dosimeter chamber in the center of the radiation field fluoroscopically (see figure 5-9).

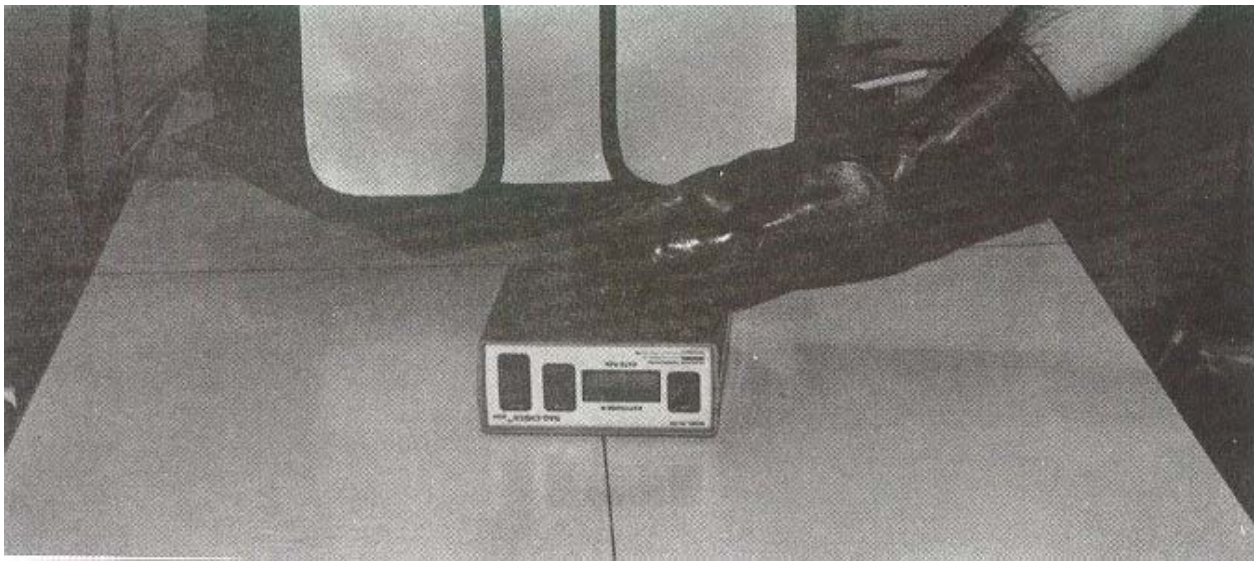

Figure 5-9. Centering the dosimeter chamber to center of radiation field.

e. Adjust the fluoroscope shutter so that it is just visible on the edges of the image, and it should not cover any active volume of the chamber.

f. Turn the dosimeter to the exposure rate mode.

g. Place the supports around the probe.

h. Place the lead sheets on the supports.

i. Put on your lead apron.

j. Turn on the fluoroscope long enough to stabilize the automatic brightness controls.

k. Ensure that the beam is completely attenuated (absorbed) by the lead. There should be no light seen on the monitor.

l. Read and record the exposure rate maximum under the automatic mode.

m. Record kVp and mA for future reference.

n. Place the fluoroscope machine controls in the manual mode.

o. Set the kVp and mA controls to maximum settings.

p. Read and record the exposure rate to the maximum under the manual mode.

q. Be sure to record the temperature and barometric pressure by calling the local weather station.

5-22. EVALUATION AND INTERPRETATION

a. In the automatic mode the exposure rate must not exceed 10 R/min.

b. In the manual mode the exposure rate must not exceed 5 R/min.

NOTE: The Bureau of Radiological Health determined these exposure rates.

5-23. PREVENTIVE MAINTENANCE

The exposure rate should be measured in the following situations:

a. On the implementation of a quality assurance program.

b. When new equipment is installed.

c. Following the replacement of an x-ray tube or an image intensifier tube.

d. Following any service or repair work on the image intensifier system.

e. Routinely at 6-month intervals.

5-24. CORRECTIVE MAINTENANCE

a. Always retest to confirm the results of the first test.

b. Call a qualified service engineer or the manufacturer's representative when the exposure rate exceeds the maximum levels.

Continue with Exercises

EXERCISES, LESSON 5

INSTRUCTIONS: Answer the following exercises by marking the lettered response that best answers the exercise, by completing the incomplete statement, or by writing the answer in the space provided at the end of the exercise.

After you have completed all of these exercises, turn to "Solutions to Exercises" at the end of the lesson and check your answers. For each exercise answered incorrectly, reread the material referenced with the solution.

Exercises 1 through 5 pertain to the **minimum source to tabletop distance test.**

1. What is the proper ratio for the metal pieces in this minimum source to tabletop distance test?

   _____.

2. You must wear a lead apron while performing the minimum source to tabletop distance test.

   a. True.

   b. False.

3. Fifteen inches would usually be acceptable for the minimum source to tabletop distance range.

   a True.

   b False.

4. What must you do if the minimum source to tabletop distance test results shows a distance outside the prescribed range?

   _____.

5. What must you do after every repair or service of any kind to the equipment?

   _____.

Exercises 6 through 10 pertain to the **beam restriction adequacy test.**

6 List three pieces of equipment needed to perform the beam restriction adequacy test.

_____.

_____.

_____.

7. Why do you place the 3/4-inch attenuator block on the tabletop?

_____.

8. By using maximum mA and high kVp you will _____the needed exposure time.

9. The _____ area is the region actually exposed to radiation.

   a. clear.

   b. dark.

10. Routinely, this beam restriction adequacy test must be repeated every _____ months.

Exercises 11 through 15 pertain to the **focusing and resolution of the imaging system.**

11. First, you place the fluoroscopic imaging assembly at _____ height above the tabletop.

    a. maximum

    b. minimum

12. Select_____ kVp fluoroscopic technique for the focusing and resolution of the imaging system test.

13. If your unit has a magnification mode, what must you do?

_____.

14. To evaluate your results of the focusing and resolution test, you determine the (largest/smallest) mesh resolved in the system. Circle one.

    a. largest

    b. smallest.

15. If any viewing and recording systems have been connected, what must you do?

_____.

Exercises 16 through 20 pertain to the **exposure rate test.**

16. The purpose of this exposure rate test is to measure _____.

17 A direct readout dosimeter is required to perform the exposure rate test.

    a. True

    b. False

18 In the automatic mode, the mA and kVp controls are turned to:

    a. maximum

    b. minimum

19. How do you record the temperature and barometric pressure?

_____.

20. In the automatic mode, the exposure rate must not exceed _____ R/min.

21. For the minimum source to tabletop distance test, white hospital tape may _____ be used.

    a. Seldom.

    b. Often.

    c. Always.

    d. Never.

22. In performing this minimum source to tabletop test, you adjust the distance between the tabletop and the radiation source until:

    a. The smaller image looks larger than the other one.

    b. The larger image grows even larger than the other one.

    c. The two images are the same size.

    d. The two images disappear.

23. A minimum distance of _____inches is acceptable for portable units.

    a. Ten.

    b. Twelve.

    c. Fourteen.

    d. Sixteen.

24. To do the beam restriction adequacy test, you adjust the system to:

    a. The minimum distance obtainable.

    b. The maximum distance obtainable.

    c. Thirteen inches.

    d. Fifteen inches.

25. What is secondary radiation?

    a. A controlled narrow beam.

    b. A controlled wide beam.

    c. An insufficient dosage.

    d. Scatter.

26. If the density is too weak to define the test tool, you repeat the test with:

    a. Lower mAs.

    b. Higher mAs.

    c. One hundred kVp.

    d. One hundred-twenty kVp.

27. Where do you place the 12-inch spacer during the focusing and resolution test in relationship to the attenuated block?

    a. Beside it.

    b. Underneath it.

    c. On top of it.

    d. None of the above.

28. Which kVp in the text example given do you select for the focusing and resolution test?

    a. Forty.

    b. Sixty.

    c. Eighty.

    d. One hundred.

29. How close do you put the fluoroscopic assembly to the test pattern?

    a. Raise the assembly to the maximum.

    b. Raise the assembly to 15 inches from the test pattern.

    c. Lower the assembly to 12 inches from the test pattern.

    d. Lower the assembly to just touch the test pattern.

30. Which of the following items is used to perform the exposure rate test?

    a. Lead numbers for identification.

    b. Sponges or a 12-inch spacer.

    c. One metallic object 3 inches long.

    d. A direct readout dosimeter.

31. Where do you place the answer to exercise 10?

    a. On the upper right quadrant of the image.

    b. On the lower right quadrant of the image.

    c. In the center of the radiation field.

    d. Outside the radiation field.

32. The exposure rate should be measured:

    a. Upon the implementation of a quality assurance program.

    b. When new equipment is installed.

    c. Routinely at 6-month intervals.

    d. All of the above.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES, LESSON 5.

1. 1:2 (para 5-2 NOTE)

2. a (para 5-3d)

3. b (para 5-4b)

4. Repeat test (para 5-4d)

5. Test the equipment (para 5-5d)

6. Any three of the following:
   Fluoroscopic beam restriction test tool.
   Lead numbers and letters for identification.
   Cardboard holder loaded with ready pack film.
   Twelve-inch ruler graduated by 1/32.
   3/4-inch aluminum block. (para 5-8a, b, c, d, e)

7. To intercept the radiation going to the image intensifier (para 5-9b)

8. decrease (para 5-19, 6th NOTE)

9. dark (para 5-10a(2))

10. six (para 5-11e)
11. a (para 5-15a)

12. Sixty (para 5-15i)

13. Retest (para 5-15n)

14. b (para 5-16a)

15. Retest (para 5-17d)

16. Existing radiation levels of a fluoroscopic unit (para 5-19)

17. a (para 5-20a)

18. a (para 5-21b)

19 Call the local weather station (para 5-21q)

20 Ten (para 5-22a)

21. d (para 5-2c)

22. c (para 5-3e)

23. b (para 5-4, NOTE)

24. a (para 5-9a)

25. d (para 5-7)

26. b (para 5-9)

27. c (para 5-13c)

28. b (para 5-13i)

29. d (para 5-14g)

30. d (para 5-20a)

31. c (para 5-21d)

32. d (para 5-23a, b, e)

End of Lesson 5

LESSON ASSIGNMENT

LESSON 6 Tomographic Units Quality Control Tests.

TEXT ASSIGNMENT Paragraphs 6-1 through 6-36.

LESSON OBJECTIVES After completing this lesson, you should be able to:

6-1. Select one or more of the following: correct equipment, order of procedure, evaluation and interpretation, preventive maintenance, or corrective maintenance for the:

Cut level indicator test.

Exposure angle test.

Exposure uniformity test.

Cut thickness test.

Plane flatness test.

Resolution test.

SUGGESTION After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you achieve the lesson objectives.

LESSON 6

TOMOGRAPHIC UNITS QUALITY CONTROL TESTS

Section I. CUT LEVEL INDICATOR TEST

6-1. PURPOSE

The cut level indicator test is performed to determine the accuracy of the cut level indicator (the exposure angle). This is one of several areas that must be checked on a timely basis to ensure that the best radiograph is being produced. By routinely checking the six variables on the tomographic unit, you can usually detect early problems and take corrective action before the imaging is seriously impaired.

6-2. EQUIPMENT/MATERIAL

a. A 45 degree tomographic wedge with a centimeter scale.

b. Three quarter-inch thick Plexiglas attenuator blocks.

c. A 10- x 12-inch cassette.

d. Recording form.

6-3. PROCEDURE

a. Prepare the equipment to be tested (see figure 6-1).

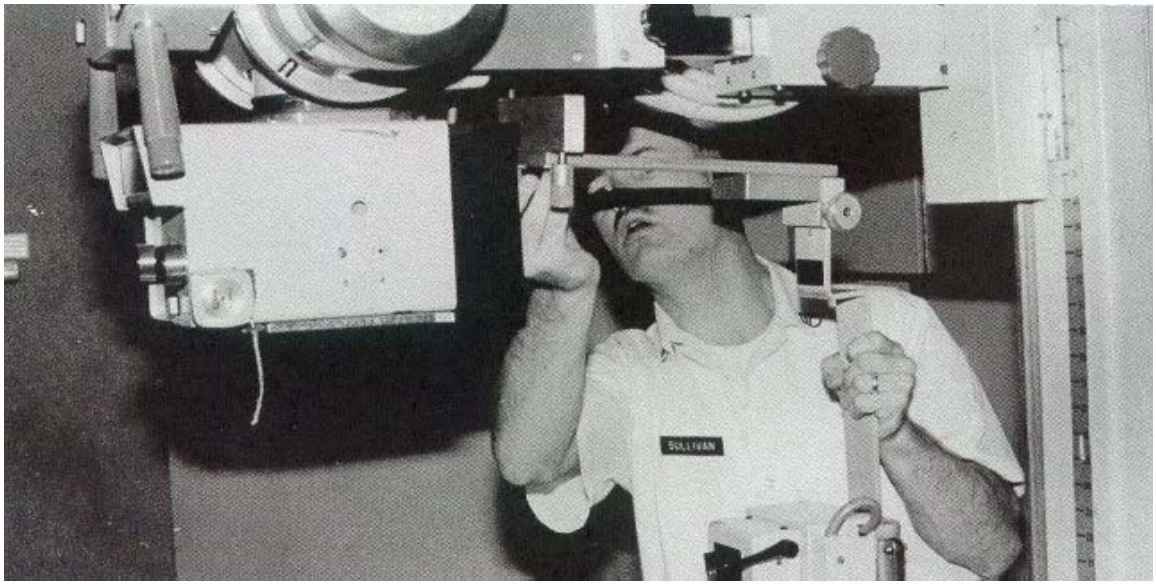

Figure 6-1. Technologist preparing machine to be tested.

b. Select the most commonly used tomographic motion, exposure angle, and sweep speed.

c. Place the x-ray tube perpendicular to the table.

d. Position the tomographic test wedge in the center of the field.

(1) You want a 15-centimeter (cm) scale aligned with the central ray.

(2) For even density, position the Plexiglas attenuators on both sides of the test tool.

NOTE: For linear systems, position the test wedge so that the number scale is perpendicular to the direction of motion.

e. Place the 10- x 12-inch cassette lengthwise in the Bucky tray and lock the Bucky tray (see figure 6-2).

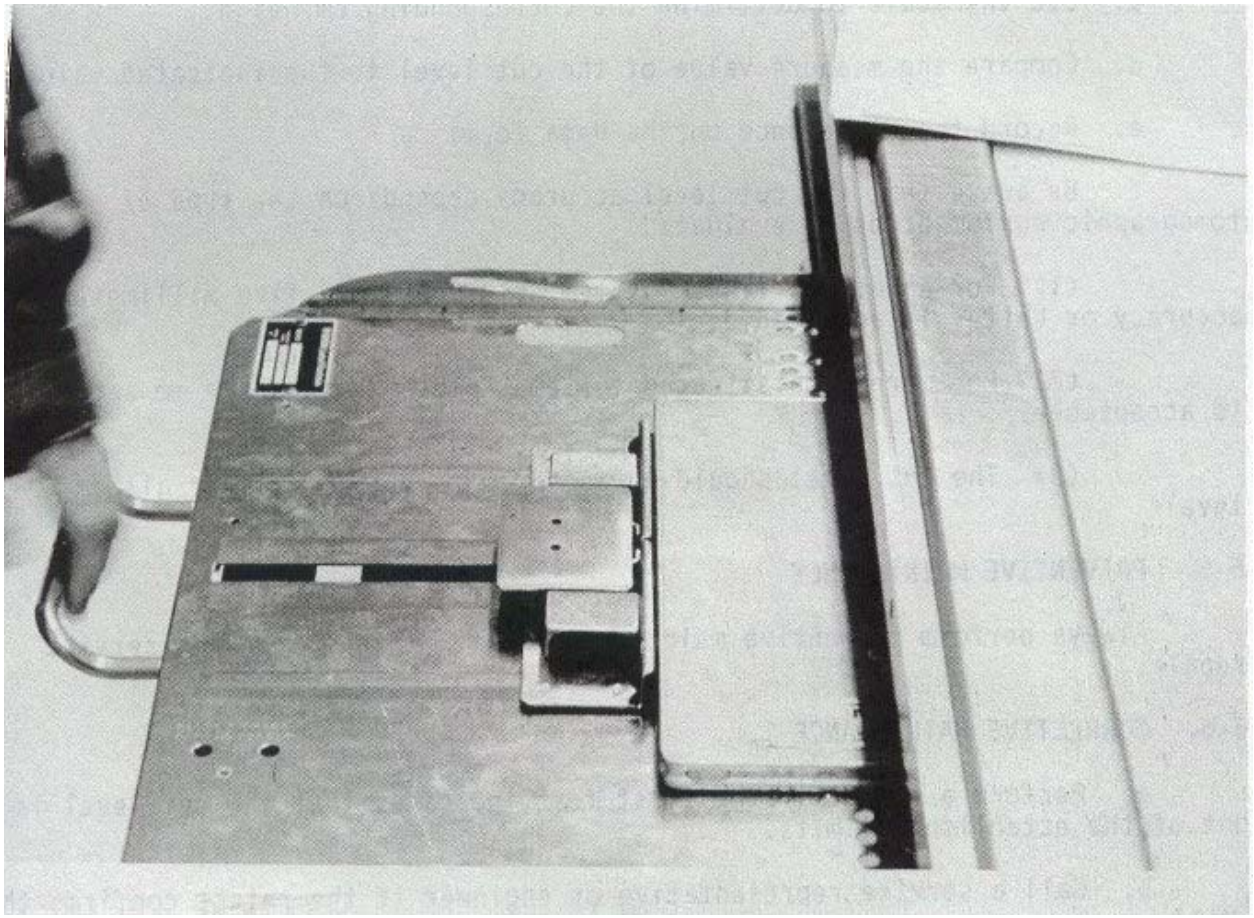

Figure 6-2. Placing the cassette in the Bucky tray.

f. Select the tomographic technical factors at 60 kVp and approximately 50 mAs.

g. Select the cut level at 15 cm above the table.

h. Make the exposure.

i. Process the film.

j. Record the technical factors used and the tomographic parameters on the data form and the radiograph.

k. Repeat the procedure for other cut levels of 5, 10, and 20 cm.

6-4. EVALUATION AND INTERPRETATION

a. Place the test film on the illuminator.

b. Determine which wire is in the sharpest focus.

c. Use the scale to determine the corresponding cm height.

d. Compare the measure value of the cut level to the indicated value.

e. Record the difference on the data form.

f. Be aware that the cut level accuracy depends on the type of tomographic equipment being evaluated.

(1) For an add-on linear system, plus or minus five millimeter (mm) accuracy or better is acceptable.

(2) For more sophisticated systems, plus or minus one mm accuracy is acceptable.

(3) The cut level should be approximately the same for all cm levels.

6-5. PREVENTIVE MAINTENANCE

Always perform preventive maintenance by retesting after any service repair.

6-6. CORRECTIVE MAINTENANCE

a. Perform a retest if the first test indicates that the cut level is out of the established limits.

b. Call a service representative or engineer if the retest confirms the problem.

Section II. EXPOSURE ANGLE TEST

6-7. PURPOSE

The exposure angle test determines the exposure angle during a tomographic exposure compared with the indicated exposure angle.

6-8. EQUIPMENT/MATERIAL

a. Forty-five degree tomographic wedge with a centimeter angle test tool.

b. Three-fourth-inch Plexiglas attenuator blocks.

c. Data forms.

6-9. PROCEDURE

a. Prepare equipment to be tested.

b. Select the most commonly used tomographic motion, exposure angle, and sweep speed.

c. Place the x-ray tube at a perpendicular angle to the table.

d. Use the equipment centering light.

(1) Position the tomographic test wedge in the center of the field.

(2) Align the 12.5 cm scale marker to coincide with the central ray.

NOTE: For linear systems, orient the wedge so the scale is perpendicular to the direction of the tube motion.

e. Place the Plexiglas attenuator blocks on the sides of the wedge.

f. Place a 10- x 12-inch cassette in the Bucky tray with the long axis perpendicular to the long axis of the tabletop. (The 10- x 12-inch cassette will be crosswise in the Bucky tray.

g. Select tomographic technique factors:

(1) 60 kVp.

(2) 50 mAs, approximately.

h. Select the cut level of 12.5 cm (see figure 6-3).

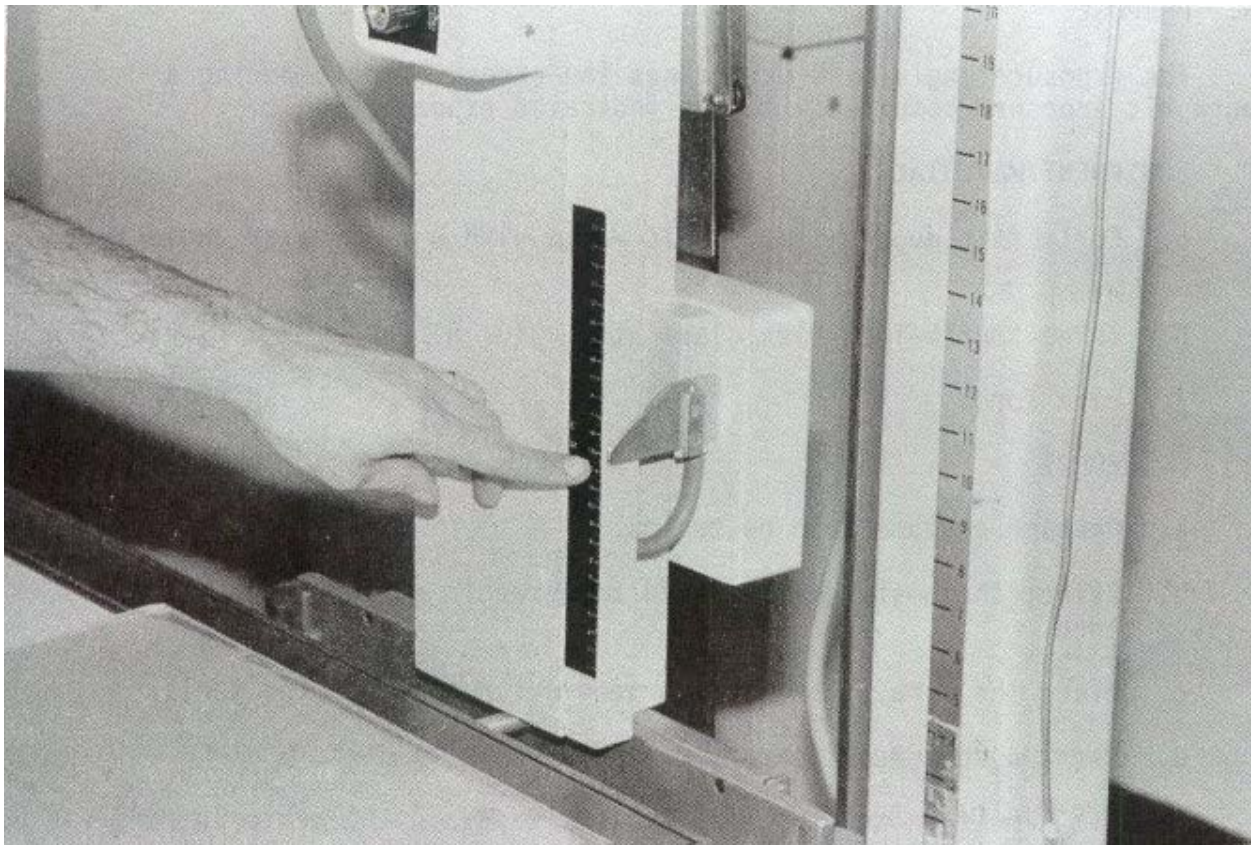

Figure 6-3. Select the cut level of 12.5 cm.

i. Make the exposure.

j. Process the test film.

k. Record the technique factors used and the tomographic parameters on the data form and the film.

l. Repeat the procedure for other exposure angles and tomographic motion.

6-10. EVALUATION AND INTERPRETATION

a. Place the radiographic film on the illuminator.

NOTE: In the tomogram, the image on the long diagonal wire will appear as two blurred triangles. The apex of each triangle will appear in sharp focus at the level of cut.

b. Reconstruct the outline of the triangles on the film using a marking pencil and ruler.

c. Select one triangle.

d. Draw a baseline to the triangle using the reference scale as a guide.

e. Determine the distance from the apex of the triangle to the drawn base using scale markings.

f. Record the information on the data form.

g. Measure the width of the reconstructed triangle at the drawn baseline using a centimeter ruler.

h. Record the information on the data form.

i. Call the distance from the apex to baseline, b. Call the baseline width, c.

j. Calculate the tomographic exposure angle using the appropriate formula and chart.

NOTE: The tomographic exposure angle, A, is then given by the relationship A = 2 tan (c/2b). Calculate the quantity (c/2b) and with the aid of the figure below determine the value tan (c/2b) that corresponds to this quantity. Tan (c/2b) corresponds to 1/2 the tomographic exposure angle A when the value of C is used in the calculation and to the tomographic half angles A and A where C and C are used in the calculation respectively.

The exposure angle should also be evaluated for symmetry about the midline of the exposure. This may be done by constructing a perpendicular line for the baseline of the reconstructed triangle through the apex of the triangle and calculating the exposure half angles as:

$$A = 2 \tan (c /2b) \text{ and } A = 2 \tan (C /2b)$$

where C and C are defined on the film.

The relationship between the quantity (C/2b) and tan (c/2b) used to determine the tomographic exposure angle A and tomographic exposure half angles A and A. To use this graph, calculate the value of the quantity (C/2b) and find its position along the x-axis. Then determine the tan (C/2b) value along the y-axis, which would correspond to this.

NOTE: The exposure angle measured by using this technique should agree with the indicated exposure angle to within plus or minus 4 degrees. The symmetry of the exposure angle, about midline, should be within plus or minus 2 degrees. On the test results, the image of the long diagonal wire will appear as two blurred triangles. The apex of each triangle will appear in sharp focus at the level of the cut. In the above example the apex will appear sharp at 12.5 cm.

6-11. PREVENTIVE MAINTENANCE

As with the other tests, preventive maintenance is extremely important in order to spot trouble, if there is any, before overexposure to your patients and yourself can occur.

a. Perform routinely at six-month intervals.

b. Perform after any service work has been done involving the mechanical aspects of the drive systems.

6-12. CORRECTIVE MAINTENANCE

a. Always perform a retest to confirm or deny the first test results.

b. Call a qualified service representative or engineer if the retest confirms the problem.

Section III. UNIFORMITY OF TOMOGRAPHIC EXPOSURE TEST

6-13. PURPOSE

The uniformity exposure test determines the uniformity of the exposures.

6-14. EQUIPMENT/MATERIAL

a. Plexiglas spacer block 5 cm thick.

b. Lead aperture plate with a hole in the middle (see figure 6-4).

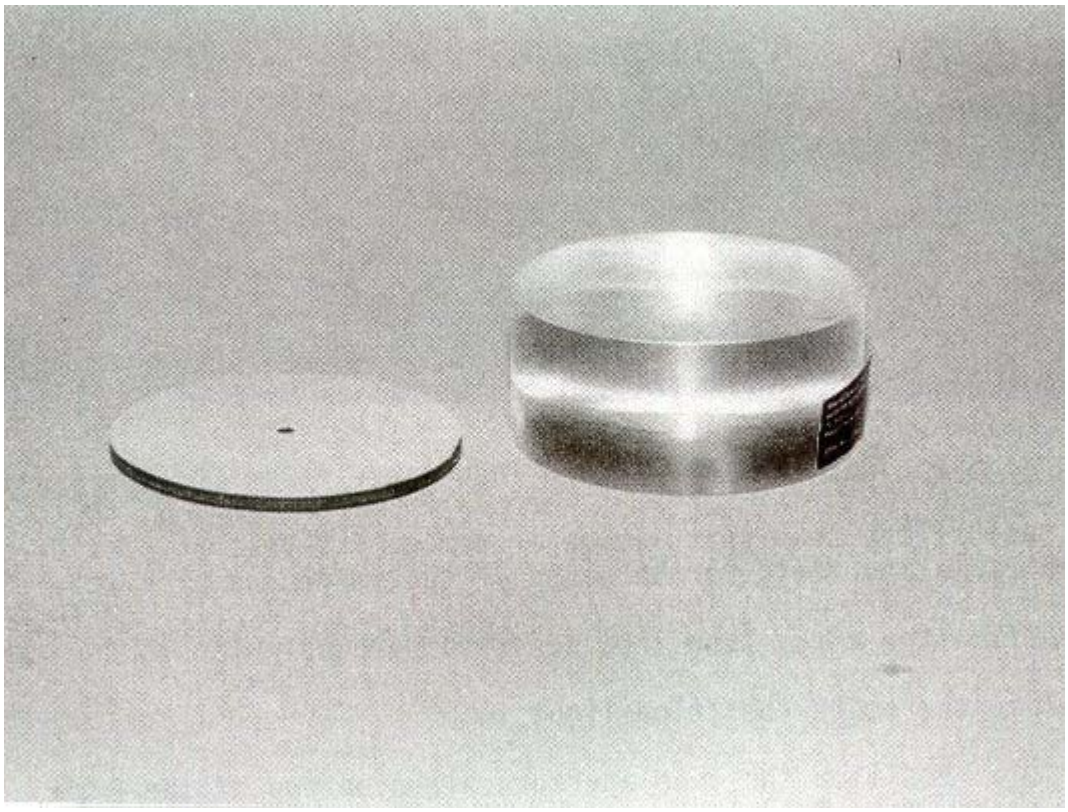

Figure 6-4. Plexiglas spacer block 5 cm thick and lead aperture plate with a hole in the middle.

c. Densitometer.

d. Recording data form.

6-15. PROCEDURE

a. Prepare the equipment to be tested.

b. Position an 8- x 10-inch cassette in the Bucky tray (see figure 6-5).

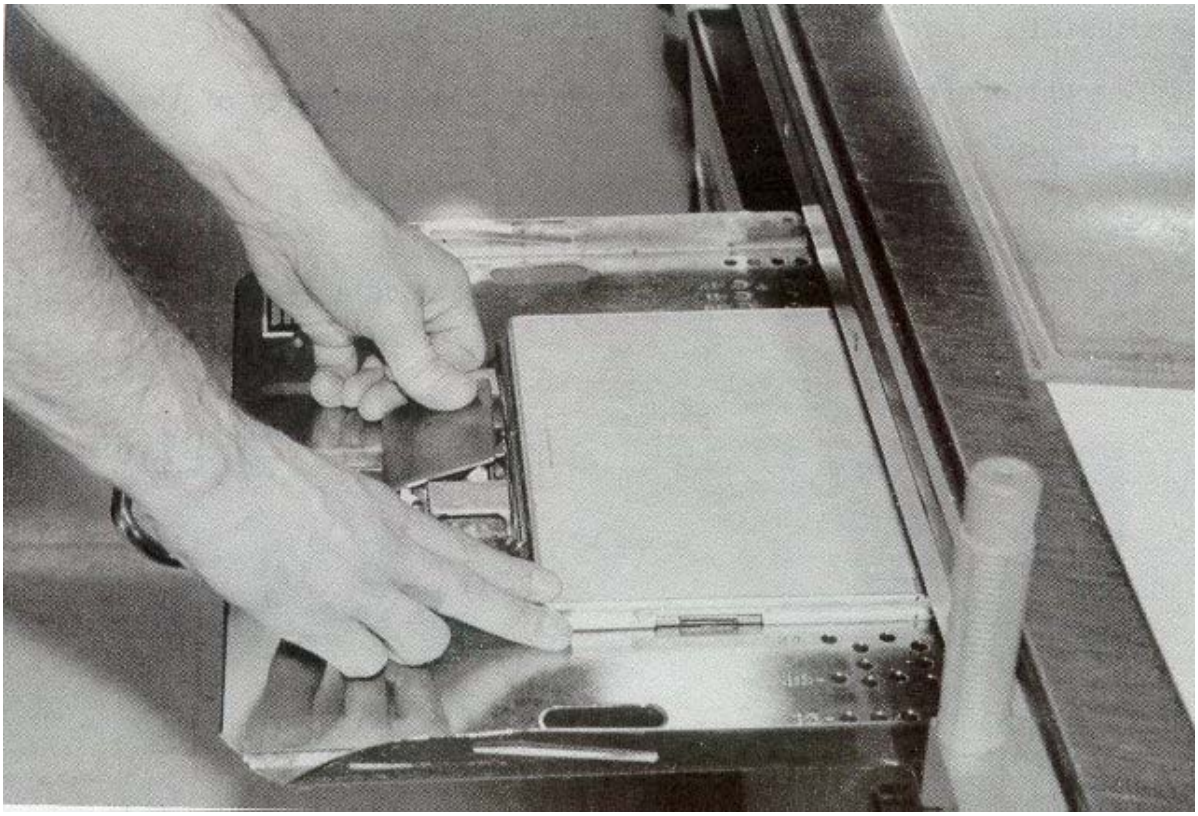

Figure 6-5. Position an 8- x 10-inch cassette in the Bucky tray.

c. Adjust the beam restriction system on the unit to provide a 3- x 3-inch radiation field in the plane of the image receptor to minimize fog.

d. Place the x-ray tube in a position perpendicular to the table.

e. Use the center position light to:

(1) Position the lead aperture plate on top of the 5 cm Plexiglas spacer (see figure 6-6).

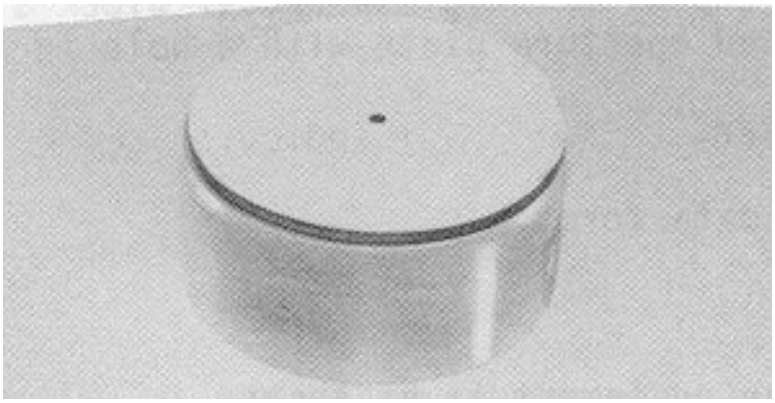

Figure 6-6. Lead aperture plate and 5 cm. Plexiglas spacer positioned on the table.

(2) Position the hole in the plate to be coincident with the central ray.

f. Select the most commonly used:

(1) Tomographic motion.

(2) Exposure angle.

(3) Sweep speed.

g. Record the information on the data form.

h. Select an indicator level of 12 cm (see figure 6-7).

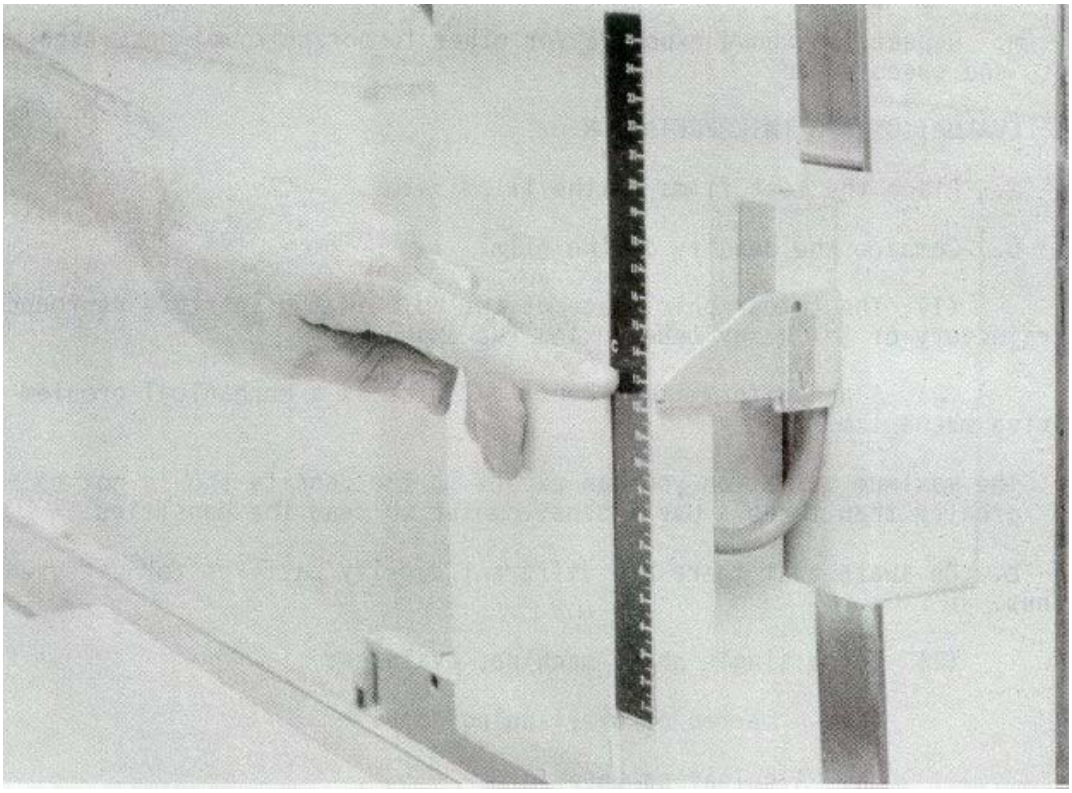

Figure 6-7. Cut level indicator set at 12 cm.

i. Set the control panel:

(1) 60 kVp.

(2) 100 mAs approximately.

j. Record the information on the data form.

NOTE: It may be necessary to alter the technique factors to obtain an image that has a density in the range of 1.0 to 1.5 in the areas of the aperture image.

k. Make the tomographic exposure.

l. Process the test film.

m. Repeat the above exposure for other tomographic motions, exposure angles, and sweep speed.

6-16. EVALUATION AND INTERPRETATION

a. Place the test films on the illuminator.

b. Compare the density on the film.

(1) The tomographic image of the hole in the aperture reproduces the trajectory of the x-ray tube during the exposure.

(2) A non-uniform image density indicates a mechanical problem in the drive mechanism.

NOTE: The maximum variation you can expect in the density should not be greater than three. Use a densitometer to read the densities.

c. Be aware that there are different density patterns for different machines.

(1) For a single phase machine, evaluate:

(a) A series of overlapping dots.

(b) A pulsating waveform.

NOTE: You can expect a series of overlapping dots and a pulsating waveform because of the pulsating nature of the associated high voltage waveform.

(2) For a linear system, evaluate the tube motion:

(a) The uniform density.

(b) A straight-line pattern, not wobbly.

(3) For a pluri-directional system, evaluate:

(a) The completeness of motion.

(b) The degree of exposure overlap.

(c) Motions should be closed (no open gaps).

(d) Any overlap should not exceed 20 degrees.

d. Record the information on the data form.

6-17. PREVENTIVE MAINTENANCE

The uniformity of exposure test should be performed:

a. At six-month intervals.

b. After any service performed on the tomographic drive mechanism.

c. If a mechanical problem is suspected.

6-18. CORRECTIVE MAINTENANCE

a. Perform a retest before proceeding with corrective maintenance.

b. Call a service representative or engineer if the retest reveals:

(1) Large non-uniformities of density.

(2) Waviness of trace.

(3) Incomplete closures.

(4) Excessive overlaps.

Section IV. CUT THICKNESS TEST

6-19. PURPOSE

The cut thickness test determines the thickness of the tomographic cut.

6-20. EQUIPMENT/MATERIAL

a. A 45 degree tomographic wedge with a centimeter scale.

b. Plexiglas attenuator blocks 3/4-inch thick.

c. Recording data form.

d. A 10- x 12-inch cassette.

6-21. PROCEDURE

a. Prepare the system to be tested.

b. Insert the 10- x 12-inch cassette into the Bucky tray.

c. Place the x-ray tube in a position perpendicular to the tabletop.

d. Use the system's centering light to:

(1) Position the tomographic test tool.

(2) Align the 12.5 cm mark on the scale to be coincident with the central ray.

NOTE: For linear systems, the test tool should be oriented so that the scale is parallel to the direction of the tube travel (see figure 6-8).

e. Select the most commonly used:

(1) Tomographic motion.

(2) Sweep speed.

(3) Exposure angle.

f. Select a cut level of 12.5 cm.

g. Record the information on the data form.

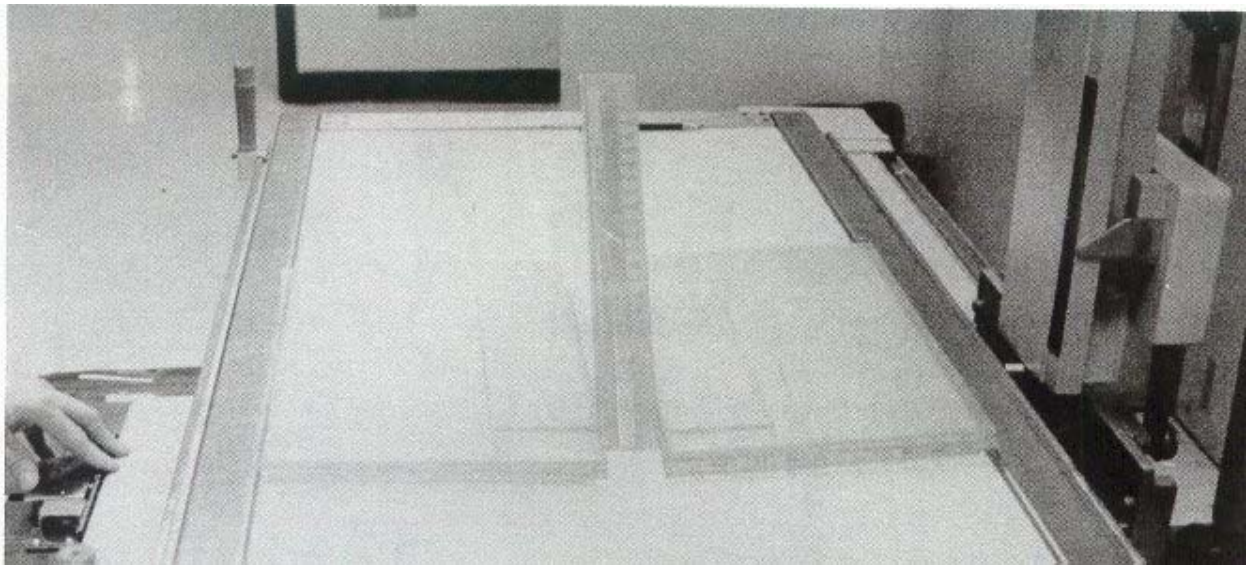

Figure 6-8. Tomographic wedge parallel to the direction of the tube travel.

h. Set the control panel:

(1) 60 kVp.

(2) 30 mAs approximately.

i. Make the tomographic exposure.

j. Process the test film.

k. Repeat the test for other tomographic motion sweeps.

l. Process the films.

6-22. EVALUATION AND INTERPRETATION

a. Ensure that the radiographs and the recording form include the following information:

(1) Tomographic motion.

(2) Sweep speed.

(3) Exposure angle.

(4) Cut level.

b. Place the test films on the illuminator.

c. Look for the images of wires on the tomographic scale to show varying degrees of focus. The focus will decrease on either side.

d. Determine the distance to both sides of the cut plane where the wire images remain in reasonable focus.

NOTE: This is the thickness of the cut plane (see figure 6-9).

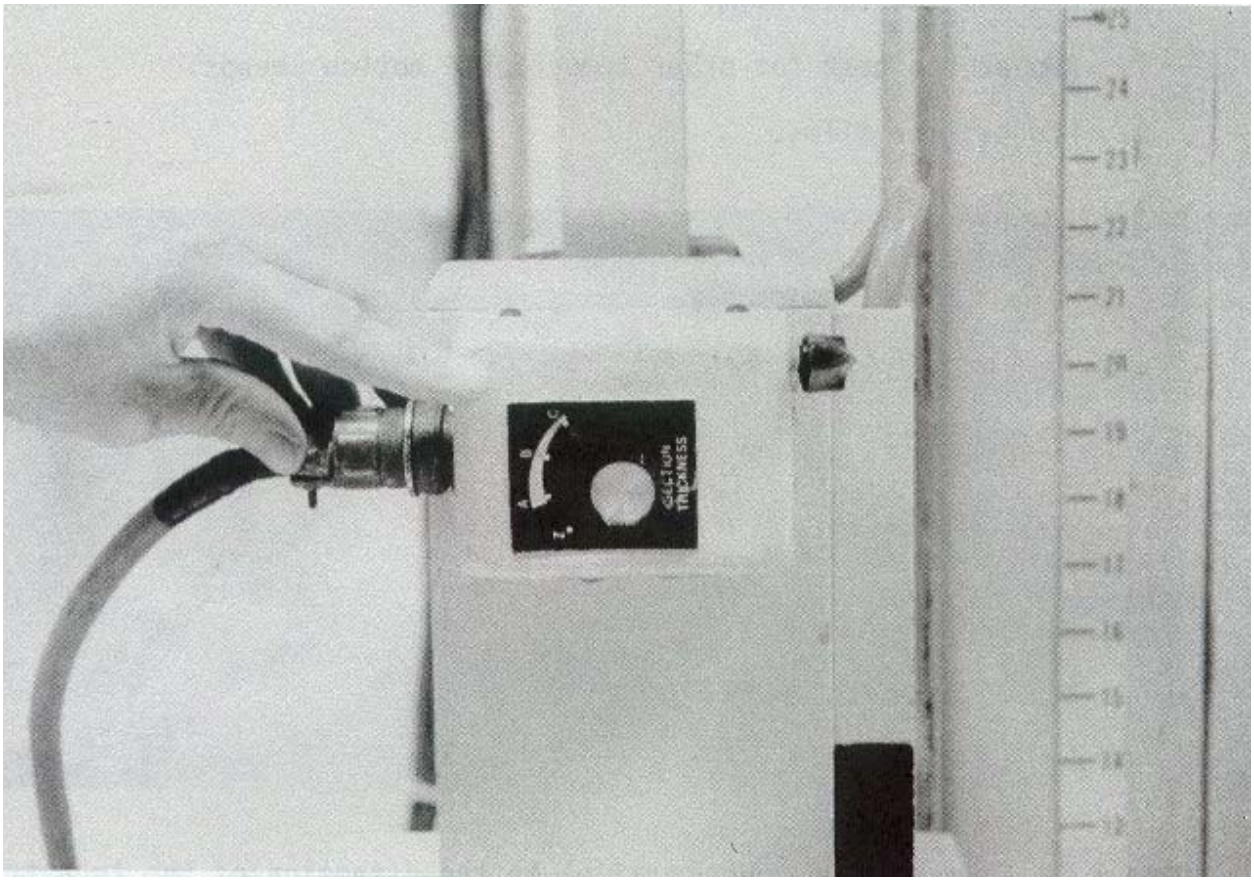

Figure 6-9. Test for all section thickness selections (example of 4 here).

e. Record the value on the data form.

f. Perform this subjective test. Since it is difficult to set specific limits on the thickness of the cut plane, refer to the equipment manufacturer's specifications and compare your results with them. One thing you can rely on is that as the exposure angle increases, the thickness of the cut plane should decrease.

6-23. PREVENTIVE MAINTENANCE

The cut thickness test should be performed:

a. At six-month intervals.

b. After any service work on the tomographic drive mechanism.

c. When you need to know the thickness of the tomographic cut.

6-24. CORRECTIVE MAINTENANCE

a. Call the equipment manufacturer.

b. Discuss questions about the thickness of the cut plane with the equipment manufacturer.

Section V. FLATNESS OF PLANE

6-25. PURPOSE

This test determines the flatness of the tomographic plane.

6-26. EQUIPMENT/MATERIAL

a. One 45 degree tomographic wedge with a centimeter scale.

b. Plexiglas attenuator blocks, 3/4 inch.

c. One 14- x 17-inch cassette.

d. Recording data forms.

6-27. PROCEDURE

a. Prepare the equipment to be tested.

b. Place the 14- x 17-inch cassette lengthwise in the Bucky tray (see figure 6-10).

c. Place the x-ray beam perpendicular to the tabletop and adjust the beam restriction system to provide a 14- x 17-inch radiation field (see figure 6-11).

d. Position the 45 degree test wedge in the center (approximately) of the upper left quadrant of the light field with 12 cm point of scale (see figure 6-12.

Figure 6-10. Cassette is lengthwise in the Bucky tray.

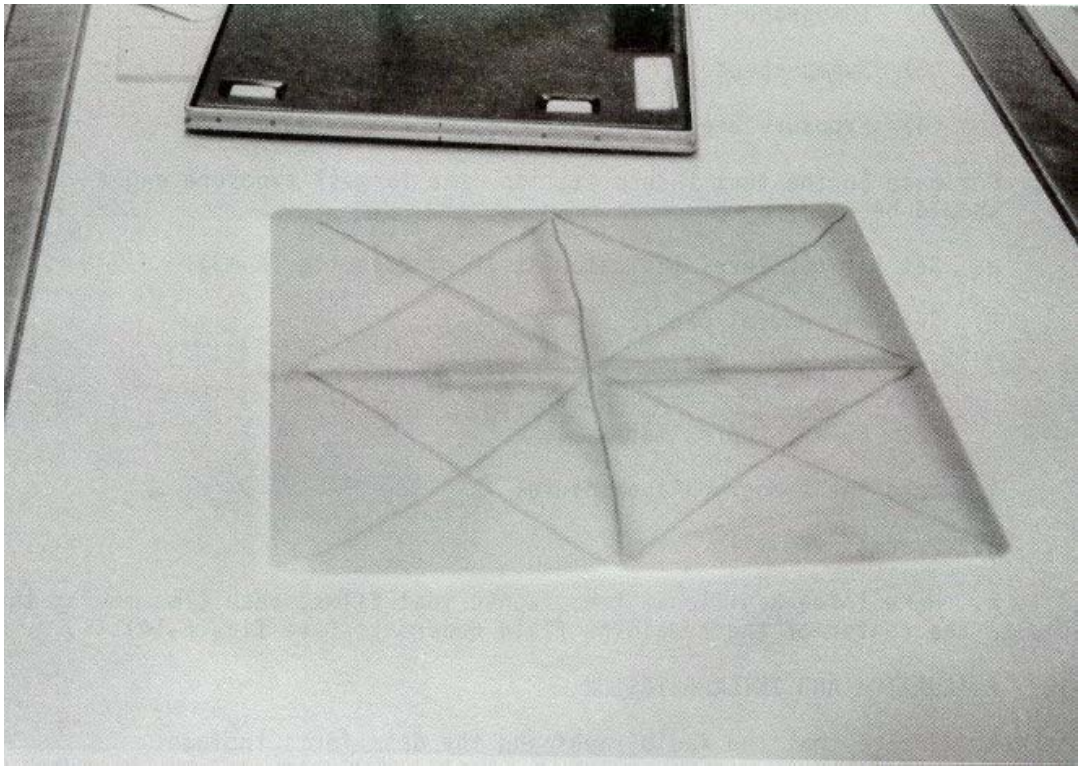

Figure 6-11. A clear piece of film divided into quadrants is very helpful.

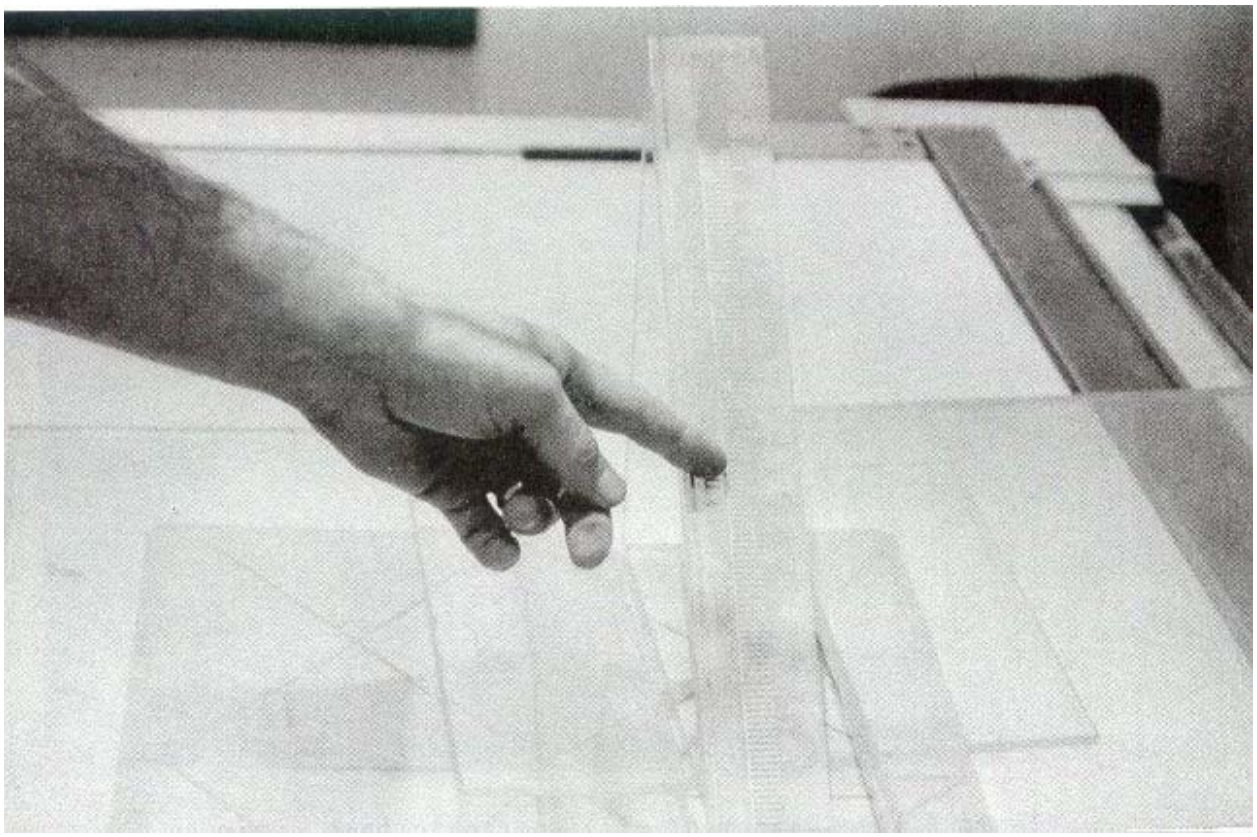

Figure 6-12. Test wedge is to center of upper left quadrant.

NOTE: For linear systems, the wedge scale should be parallel to the direction of the tube travel.

e. Place the Plexiglas attenuator blocks on the sides of the wedge.

f. Select:

(1) Tomographic motion.

(2) Sweep speed.

(3) Exposure angle.

NOTE: For ease in the test interpretation, the largest exposure angle should be used.

g. Set the cut level indicator at 12 cm (see figure 6-13).

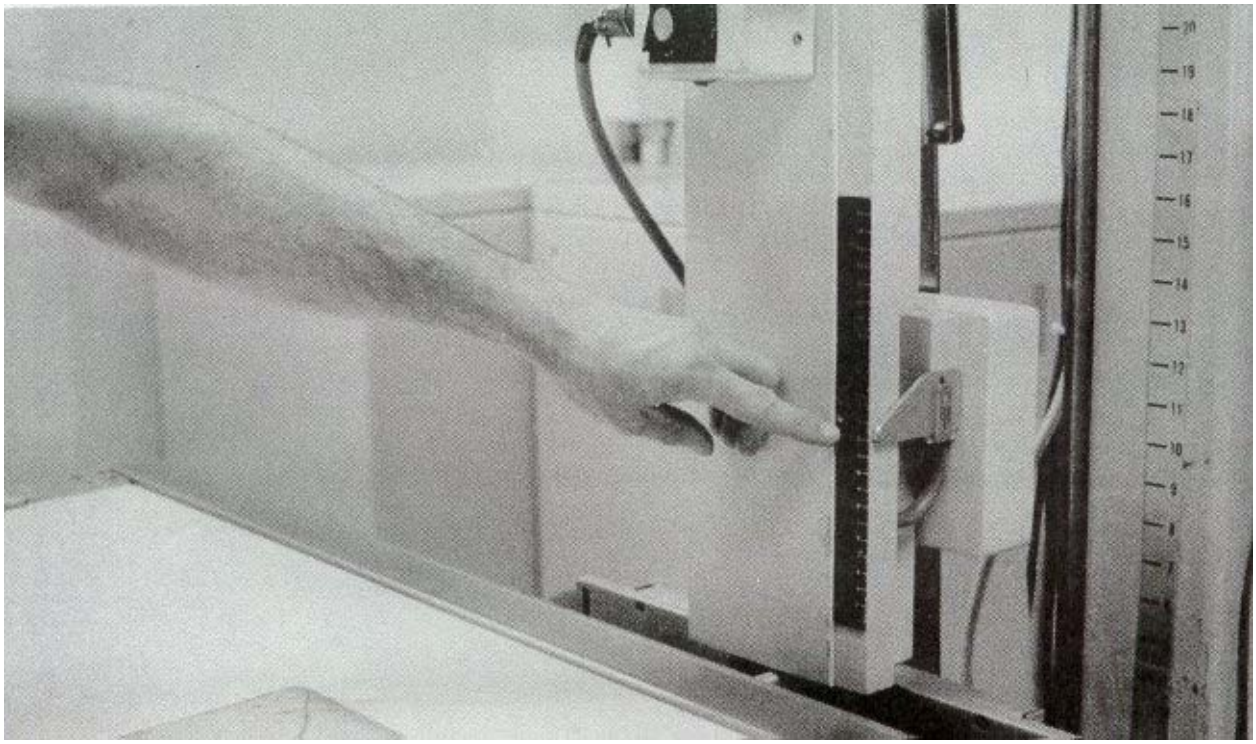

Figure 6-13. Cut level indicator set at 12 cm.

h. Set the control panel:

(1) 60 kVp.

(2) 50 mAs approximately.

i. Make the tomographic exposure.

Process the film.

k. Make three additional tomographic test films, each time moving the wedge to the center of the remaining field quadrants (see figure 6-14).

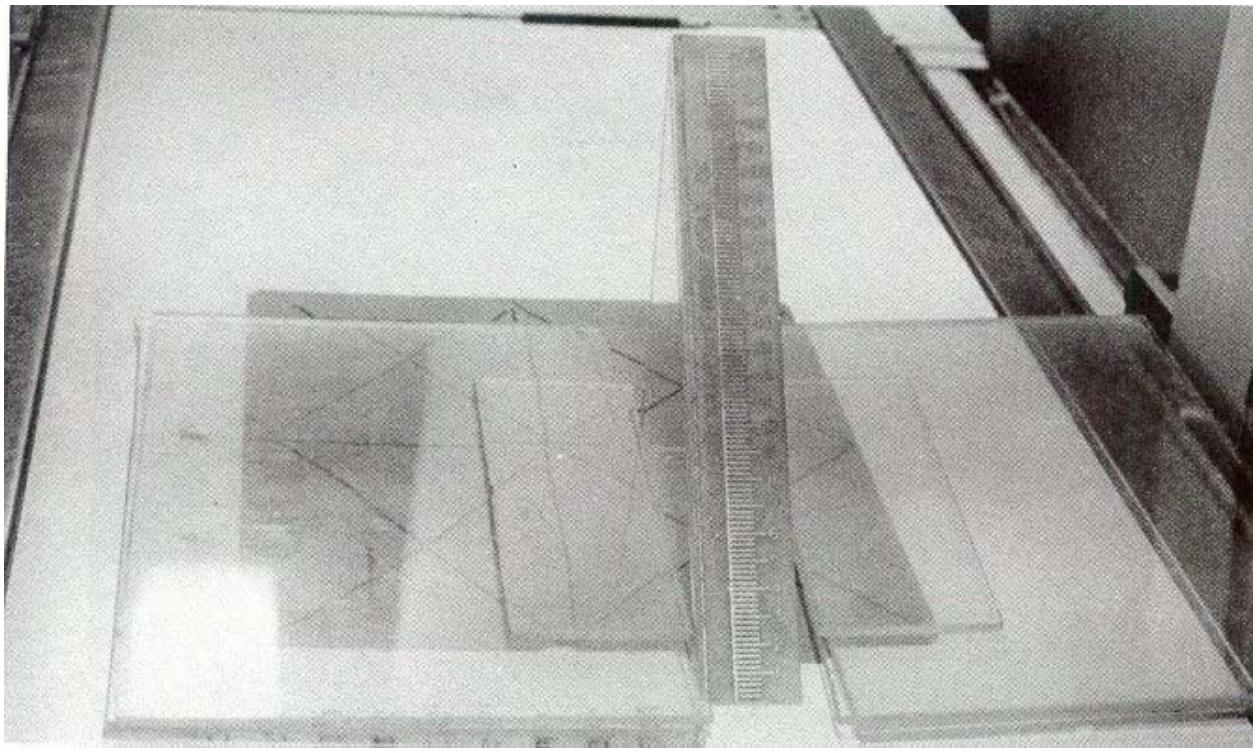

Figure 6-14. Placement of tomographic test wedge
for remaining field quadrants (continued).

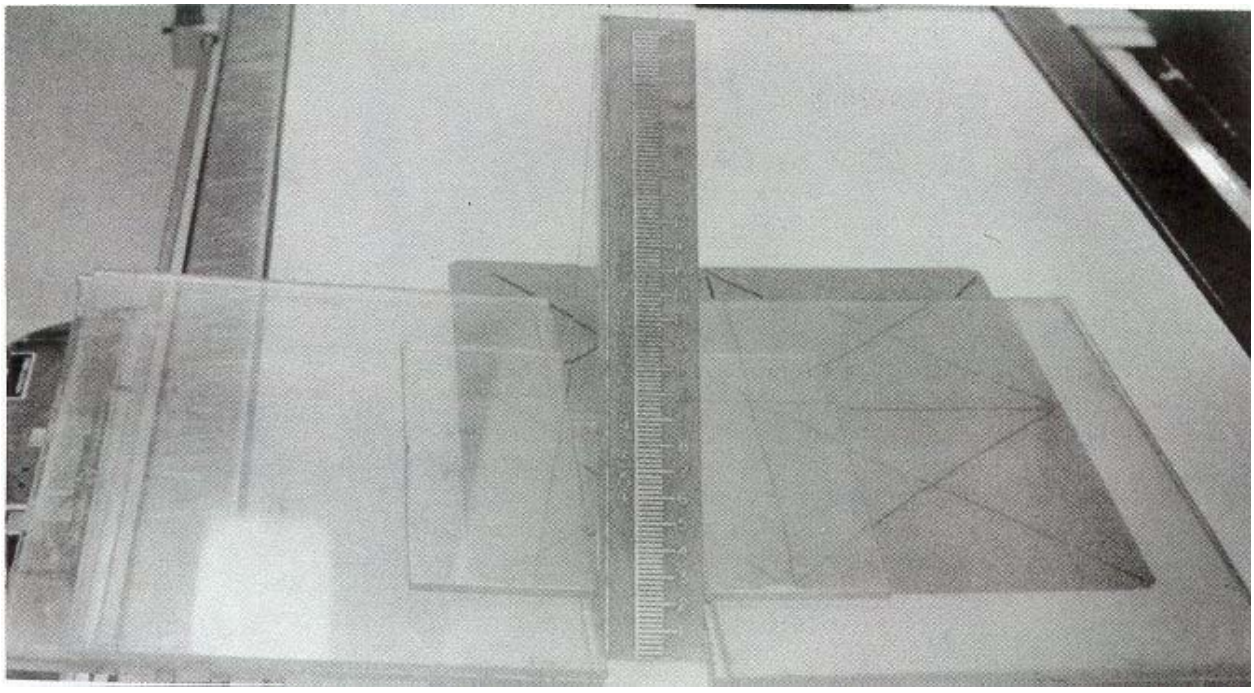

Figure 6-14. Placement of tomographic test wedge
for remaining field quadrants (continued).

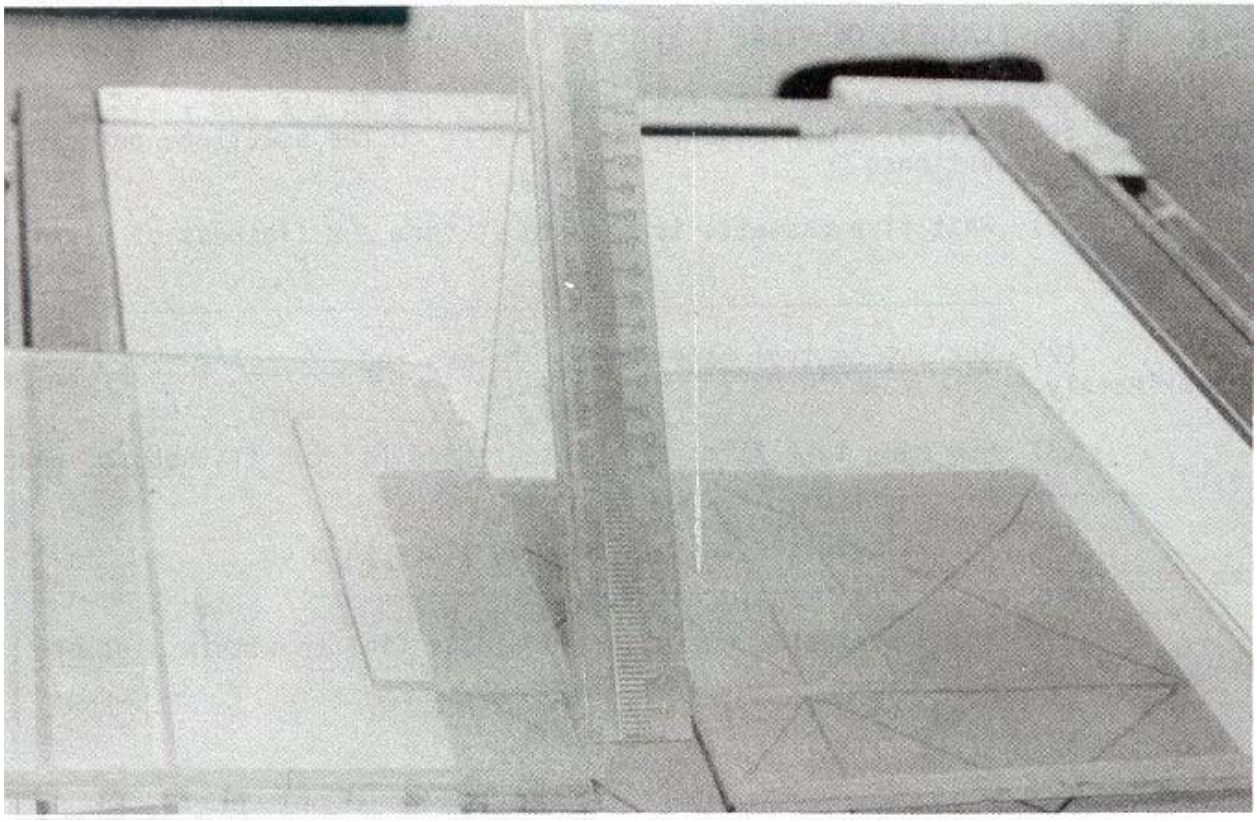

Figure 6-14. Placement of tomographic test wedge for remaining field quadrants (concluded).

6-28. EVALUATION AND INTERPRETATION

a. Ensure that the radiographs and the data forms include:

(1) Tomographic motion.

(2) Sweep speed.

(3) Exposure angle.

(4) Technical factors.

b. Place the test films on the illuminator.

c. Determine the scale marker with maximum focus (cut level).

d. Record the information on the data form.

NOTE: The point of the scale that is in sharpest focus should be the same regardless of the quadrant in which the test device was imaged. The tomographic cut plane should be flat to within plus or minus 2 mm. For linear equipment, this tolerance may have to be expanded to plus or minus 3 mm.

6-29. PREVENTIVE MAINTENANCE

This test should be performed:

a. At six-month intervals

b. After any service has been performed on the tomographic drive mechanism.

6-30. CORRECTIVE MAINTENANCE

Any non-uniformity in the cut plane flatness requires correction. Call a service representative or engineer for system adjustment.

Section VI. RESOLUTION TEST

6-31. PURPOSE

The resolution test determines the resolution (detail) capability of the system in the plane of cut.

6-32. EQUIPMENT/MATERIAL

a. Tomographic resolution test object.

b. Plexiglas spacers 5 cm thick and attenuator blocks.

c. One 8- x 10-inch cassette.

d. Record data form.

6-33. PROCEDURE

a. Prepare the system for the operation.

b. Select the most commonly used:

(1) Tomographic motion.

(2) Sweep speed.

(3) Exposure angle.

c. Center (with respect to the tomographic field) two spacer blocks with the resolution test object on top of them on the tabletop.

NOTE: For linear systems, orient the resolution test object so that the slope of the wire mesh patterns is perpendicular to the direction of the tube travel.

d. Select the cut level of 10.5 cm (see figure 6-15).

e. Set the control panel to 60 kVp and 20 mAs approximately.

f. Insert the 8- x 10-inch cassette into the Bucky tray (see figure 6-16).

g. Adjust the beam restriction system to an 8 x 10 field.

h. Make the tomographic exposure.

i. Process the test film.

j. Repeat the test procedure for other tomographic motion, sweep speed, and exposure angles.

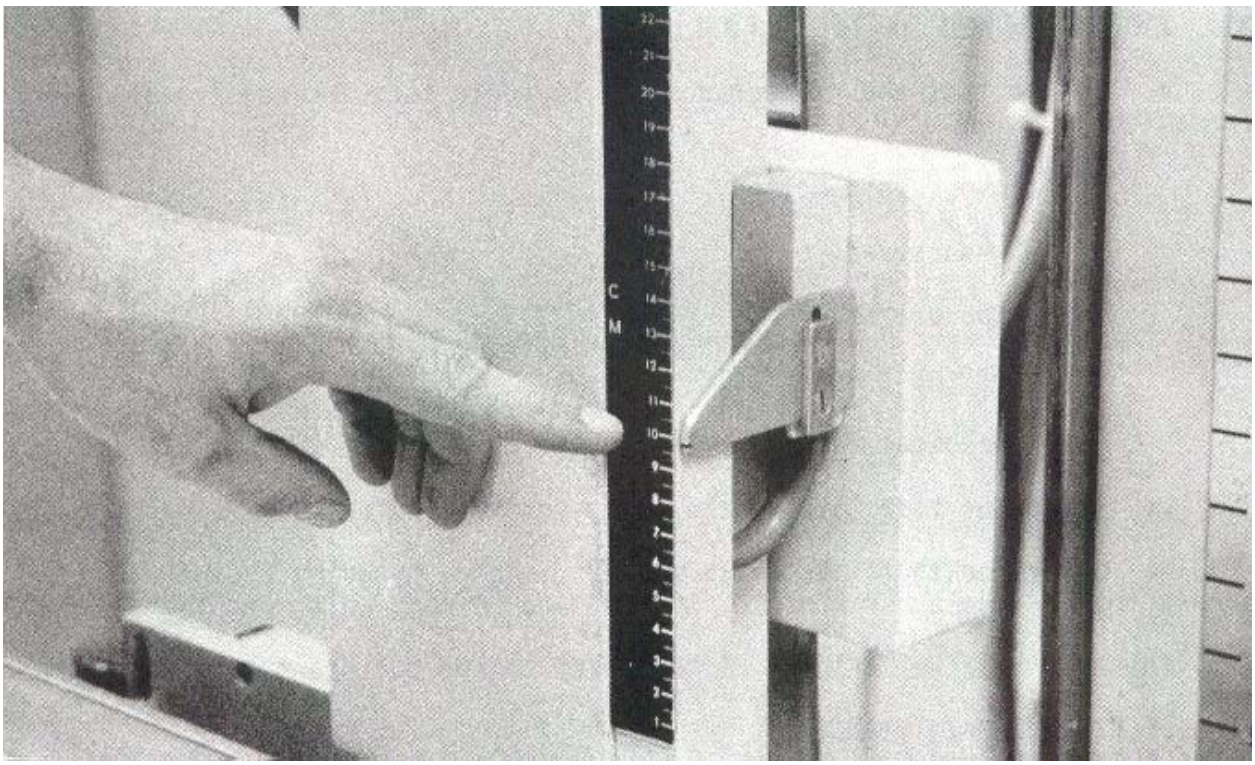

Figure 6-15. Selecting cut level moving up to 10.5 cm.

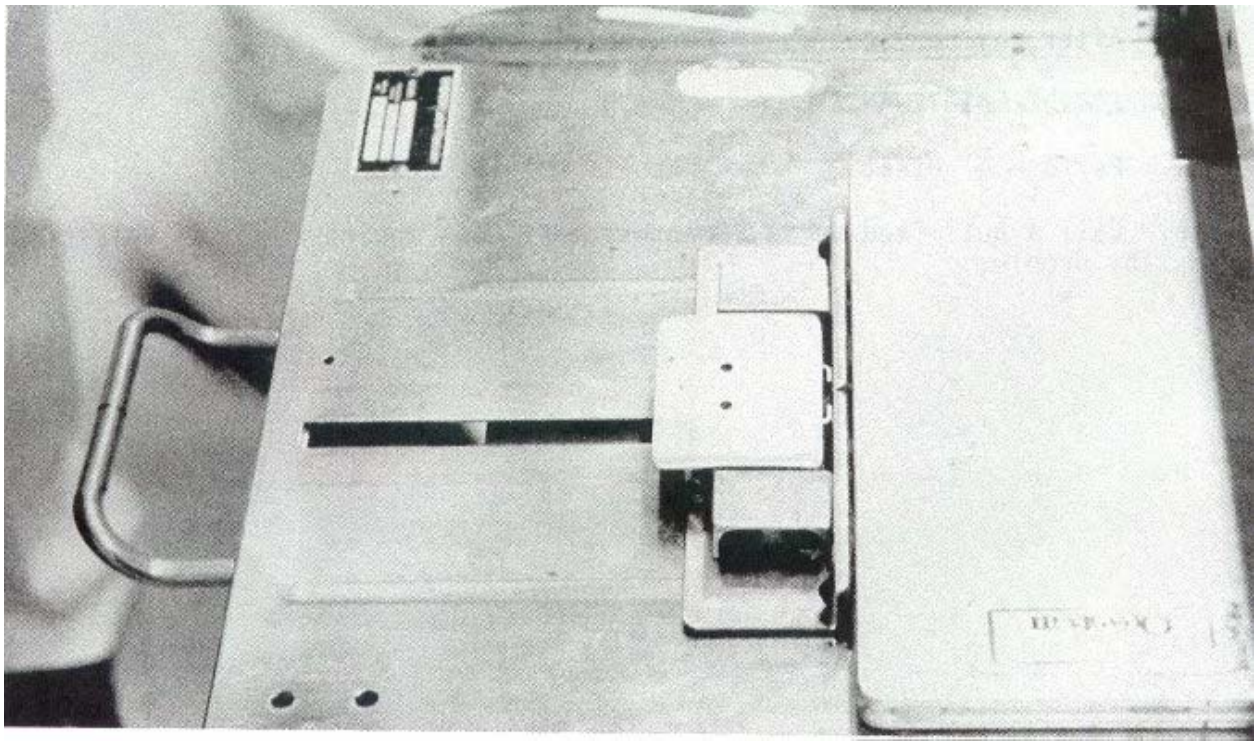

Figure 6-16. Inserting 8- x 10-inch cassette in Bucky tray.

6-34. EVALUATION AND INTERPRETATION

a. Ensure that the radiographs and the data form include the following information.

(1) Tomographic motion.

(2) Sweep speed.

(3) Exposure angle.

(4) Set cut level.

(5) Technical factors.

b. Place the test film on the illuminator for viewing.

c. Determine the finest mesh pattern imaged, by going from the coarsest to the finest, such as 20, 30, 40, and 50 mesh holes per inch.

NOTE: The mesh will be in focus at the level of the cut plane.

6-35. PREVENTIVE MAINTENANCE

The resolution test should be performed:

a. At six-month intervals.

b. After any service repair work on the equipment.

6-36. CORRECTIVE MAINTENANCE

a. Perform a retest.

b. Call a qualified service representative or engineer if the retest confirms any problem.

Continue with Exercises

EXERCISES, LESSON 6

INSTRUCTIONS: Answer the following exercises by marking the lettered response that best answers the exercise, by completing the incomplete statement, or by writing the answer in the space provided.

After you have completed all of these exercises, turn to "Solutions to Exercises" at the end of the lesson and check your answers. For each exercise answered incorrectly, reread the material referenced with the solution.

Exercises 1 through 4 pertain to the **cut level indicator test.**

1. The cut level test determines the accuracy of the cut level _____.

2. For this test, how thick should the Plexiglas attenuator blocks be?

   a. 1/4 inch.

   b. 1/2 inch.

   c. 3/4 inch.

   d. One inch.

3. The 10- x 12-inch cassette goes crosswise in the Bucky tray.

   a. True.

   (b. False.

4. To evaluate the results of the test, you compare the measure value of the cut level with the:

   a. Centimeter height.

   b. Recorded difference.

   c. Wire in sharpest focus.

   d. Indicated value.

Exercises 5 through 9 pertain to the **exposure angle test**.

5. The exposure angle test determines the exposure angle during a tomographic exposure compared with the _____exposure angle.

6. Place the x-ray tube at a perpendicular angle to the table when preparing to perform the exposure angle test.

   a. True.

   b. False.

7. Where do you place the Plexiglas attenuator blocks?

   _____.

8. The technique factors used and the tomographic parameters are recorded on the data form and the _____.

9. The symmetry of the exposure angle, about midline, should be within plus or minus _____degrees.

Exercises 10 through 14 pertain to the **uniformity of tomographic exposure test**

10. For the uniformity of tomographic exposure test, you need a Plexiglas spacer block, a lead aperture plate with a hole in the middle, a recording data form, and a _____.

11. Position the hole in the plate to be coincident with the _____.

12. You select the most commonly used tomographic motion, exposure angle, and _____.

13. A non-uniform image density indicates what kind of problem?

    _____.

14. You would call a service representative or engineer if the retest reveals:

    _____.

    _____.

    _____.

    _____.

Exercises 15 through 19 pertain to the **cut thickness test**.

15. To perform the cut thickness test you need a 45-degree tomographic wedge with a _____ _____.

16. Select the most commonly used tomographic motion, sweep speed, and _____ _____.

17. Select a cut level of _____.

18. As the exposure angle increases, the thickness of the cut plane should _____.

19. The cut thickness test should be performed every _____months.

Exercises 20 through 24 pertain to the **flatness of plane test**.

20. What size cassette is used to perform the flatness of plane test? _____.

21. Set the control panel at _____kVp and _____mAs approximately.

22. How many test films are photographed for the flatness of plane test? _____

23. To evaluate the test films, you place them on the _____.

24. The tomographic cut plane should be flat to within plus or minus _____mm.

Exercises 25 through 29 pertain to the **resolution test**.

25. Select the cut level of _____cm to perform the resolution test.

26. Set the control panel at _____kVp and _____mAs approximately to perform the resolution test..

27. In addition to the tomographic motion, sweep speed, and exposure angle, the data form should include: (List two)

    _____.

    _____.

28. The mesh will be in focus at the level of the cut plane.

    a. True.

    b. False.

29. The resolution test should be performed every _____months.

30. Concerning the cut level test, what is another phrase for "cut level?"

    _____.

31. The attenuator blocks in the cut level test are made of _____.

32. To interpret the film in the exposure angle test, where do you place the film?

    _____.

33. The exposure angle test must be performed every _____months.

34. The uniformity of tomographic exposure test requires a lead plate with a _____ in the middle.

35. In the uniformity test, there are different _____patterns for different machines.

36. The thickness test requires what size cassette?

    a. 10 x 12 inch.

    b. 10 x 14 inch.

    c. 14 x 17 inch.

37. For the cut thickness test, using the system's centering light, you align the 12.5 cm mark to coincide with the central ray, and you position the (three words) _____.

38. Add two more pieces of equipment to the list below that the flatness of plane test requires.

    a. One 14- x 17-inch cassette.

    b. Recording data forms.

    c. _____.

    d. _____.

39. For the flatness of plane test, you adjust the beam restriction system to provide a _____ (size) radiation field.

40. What size cassette do you need to perform the resolution test?

    _____.

41. Where do you place the test object in the resolution test?

    _____.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES, LESSON 6

1. Cut level indicator (para 6-1)
2. c (para 6-2b)
3. b (para 6-3e)
4. d (para 6-4d)
5. Indicated (para 6-7)
6. a (para 6-9c)
7. On the sides of the wedge (para 6-9e)
8. Film (para 6-9k)
9. Two (para 6-10 3rd NOTE)
10. Densitometer (para 6-14c)
11. Central ray (para 6-15e(2))
12. Sweep speed (para 6-15f(3))
13. Mechanical (para 6-16b(2))
14. Large non-uniformities of density
    Waviness of trace
    Incomplete closures
    Excessive overlaps (para 6-18b(1) through (4))
15. Centimeter scale (para 6-20)
16. Exposure angle (para 6-21e(3))
17. 12.5 cm (para 6-21f)
18. Decrease (para 6-22f)
19. Six (para 6-23a)
20. 14 x 17 inch (para 6-26c)

21. 60 kVp and 50 mAs (para 6-327h(2))

22. Four (para 6-27k)

23. Illuminator (para 6-28b)

24. Two (para 6-28 NOTE)

25. 10.5 (para 6-33d)

26. 60 kVp and 20 mAs approximately (para 6-33e)

27. Set cut level and technical factors (para 6-34a(4)(5))

28. a (para 6-34 NOTE)

29. Six (para 6-35a)

30. Exposure angle (para 6-1)

31. Plexiglas (para 6-2b)

32. On the illuminator (para 6-10a)

33. Six (para 6-11a)

34. Hole (para 6-14b)

35. Density (para 6-16c)

36. a (para 6-20d)

37. Tomographic test tool (para 6-21d(1))

38. A 45-degree tomographic wedge and Plexiglas attenuator blocks, 3/4-inch (paras 6-26a, b)

39. 14 x 17 (para 6-27c)

40. 8 x 10 (para 6032c)

41. On top of the spacer blocks (para 6-33c)

End of Lesson 6

LESSON ASSIGNMENT

LESSON 7	Processors/Darkrooms Quality Control Tests.
TEXT ASSIGNMENT	Paragraphs 7-1 through 7-23.
LESSON OBJECTIVES	7-1. Select the correct equipment, order of procedure, evaluation and interpretation, and (when appropriate) preventive or corrective maintenance for the: Automatic processor accuracy test for establishing the norms. Automatic processor accuracy test for daily maintenance. Safelight test. Darkroom assurance light leak test.
SUGGESTION	--After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you achieve the lesson objectives.

LESSON 7

PROCESSORS/DARKROOMS QUALITY CONTROL TESTS

Section I. AUTOMATIC PROCESSOR ACCURACY TEST

7-1. PURPOSE

Where does the radiographic process really begin and end? In the darkroom! The way the radiographic film is handled from the beginning (opening of the film cartons) to the final step (dropping the film into the processor film bin) determines the quality of the finished radiograph. No wonder that extreme care needs to be taken when working in the darkroom and with processors. This lesson will cover the critical areas in the handling of radiographic film. The first test is for automatic processor accuracy.

7-2. ESTABLISHING NORMS

a. The automatic processor accuracy test establishes the normal operating level of the automatic processor, and the normal level means the optimum level. When you know this level you have a standard for daily quality control.

b. The automatic processor accuracy test should be performed:

(1) At or prior to the start of a quality assurance program.

(2) After major repairs.

(3) After major cleaning, which is when, all the tanks and lines are emptied and flushed. This is not a daily or weekly cleaning.

(4) In accordance with your clinic standing operating procedure (S0P) which may be quarterly, biannually, or annually.

7-3. EQUIPMENT/MATERIAL

a. A sensitometer, which puts densities on the film (see figure 7-1).

b. A densitometer, which reads the densities (see figure 7-2).

Figure 7-1. Sensitometer.

Figure 7-2. Densitometer.

c. A digital thermometer is recommended although a metal stem is an acceptable alternative. Do not use a mercury and iodine glass thermometer because of possible breakage that could result in contamination of the entire system developer (see figure 7-3).

Figure 7-3. Digital thermometer with metal stem.

d. A secure 3-month supply (100 in a box) of control film that was produced with emulsion from the same batch. Store it carefully to prevent deterioration so that the last piece of film will have the same properties as the first.

e. You will need the recording forms and charts.

7-4. PROCEDURE

a. Clean the entire processor very thoroughly, but do not use system cleaner at this time. Minute traces of system cleaner can contaminate the chemistry and invalidate the initial setup controls.

(1) Replace the developer and recirculation filter.

(2) Ensure that the processor is functioning correctly.

(3) Dispose of all replenishing solutions.

(4) Clean the replenishing tanks thoroughly.

(5) Mix the replenishing solution according to manufacturer's recommendations.

(6) Flush the processor fixer tank with water.

(7) Replace the fixer rack.

(8) Flush the developer tank with water.

(9) Fill the developer tank with fresh developer.

(10) Add the proper amount of starter to the developer according to the manufacturer's recommendations.

b. Run the processor approximately 30 minutes.

c. Check the temperature of the fixer, developer, and wash. Use a thermometer, not the gauges on the processor.

d. Check the replenishing rates of chemicals (see figure 7-4).

e. Check the water flow rate.

f. Check the processing time from when the leading edge of the film enters the processor until it exits the dryer.

g. Process enough films (about 30) using one gallon of developer to equalize the chemistry.

h. Expose three pieces of double emulsion film with the sensitometer. Be sure to expose both sides (see fig 7-5).

i. Wait at least 30 minutes before processing films. This will reduce the inherent variability from strip to strip.

j. Process the exposed films within 4 hours. This reduces latent image decay.

k. Process the strips.

Figure 7-4. Radiology NCO checking replenishing rates of chemicals.

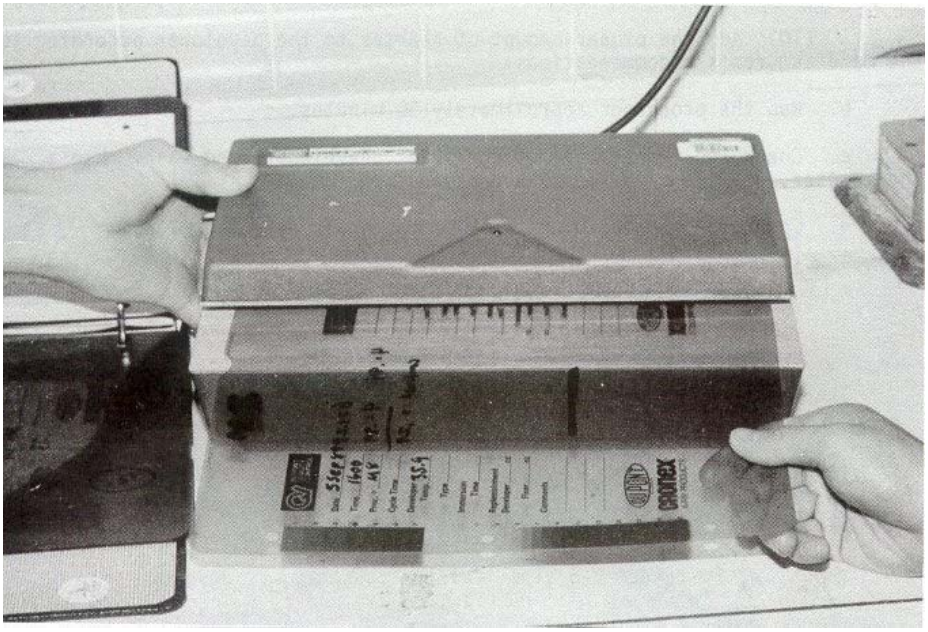

Figure 7-5. Exposed film showing how to use the sensitometer.

7-5. EVALUATION AND INTERPRETATION

a. Use the densitometer to perform several density readings and to determine the amount of density on the strip. Do not read the margins of the film.

b. Ensure that the densitometer is properly calibrated.

c. Zero the densitometer.

d. Select four unexposed areas on the film; check for fogging.

NOTE: The term "base-plus-fog" is used to describe the density on this unexposed area.

e. Measure the density in four unexposed areas. Add all four densities and divide by four to get the average density.

f. Record the average base-plus-fog density on the film.

g. Plot this number on the appropriate area of the chart (gross fog).

h. Select step on sensitometric strip and measure approximately 1.0 to 1.3 density.

i. Read the density on the opposite side of the sensitometric strip at the same step.

(1) If one on side step five has 1.0 density, read the density on step five of the opposite side of the film.

(2) If the density differs, average the density values. This determines the "speed" of the film.

j. Mark the measurement of density on the film.

NOTE: Remember paragraph 7-5 step i(2) that was used to determine the "speed." This step will be used as a reference point for each day's sensitometric strip.

k. Plot the density reading on the appropriate area of the chart.

l. Use four steps darker if the speed has 21 steps. Use two steps darker if the speed has 11 steps.

NOTE: Remember to read both sides of the film and average the density values.

m. Subtract the speed-reading from the higher reading. The difference between the two readings is the "contrast." For example, the density at step 9 is 1.82, and the density at step 5 is 1.0. The difference is .82, which represents the contrast.

n. Plot this reading on the appropriate area of the chart.

o. Chart the temperature of the developer.

Section II. AUTOMATIC PROCESSOR ACCURACY TEST--DAILY MAINTENANCE

7-6. PURPOSE

The automatic processor accuracy test - daily maintenance assures that the daily operation of the processor is at an optimum level for consistent quality radiographs.

7-7. EQUIPMENT

a. Sensitometer.

b. Densitometer.

c. Digital thermometer of metal stem.

d. Control film used for densitometer or sensitometer strip.

7-8. PROCEDURE

a. Follow the start-up procedures recommended by the manufacturer.

b. Assure that the processor's chemicals are stabilized.

c. Run several clean up films through to check the processor's operation. Do not use the control film.

d. Expose proper number of sensitometric strips. Expose only enough for one day.

e. Wait at least 30 minutes (to stabilize) but no longer than four hours (so film won't deteriorate).

7-9. EVALUATION AND INTERPRETATION

a. Zero and calibrate the densitometer.

b. Read the sensitometric strips for speed, contrast, and base-to-fog using the same step on the strip used in establishing the norms.

c. Plot your readings on the chart in the appropriate areas.

d. Draw a straight line from the established norm number to today's number.

e. If today's number is outside the established limits, circle it.

f. Repeat the procedure in areas of speed, contrast, fog, and developer temperature.

g. Determine the points outside the established limits.

h. Run several more sensitometric strips to verify first reading if it was outside the norm.

7-10. PREVENTIVE MAINTENANCE

a. Perform this test daily.

b. Plot the data correctly on the chart.

c. Diagnose any possible mechanical problems.

7-11. CORRECTIVE MAINTENANCE

Call the service engineer or the manufacturer's representative.

Section III. SAFELIGHT TEST

7-12. PURPOSE

The safelight test is performed to find any potential source of "unsafe" light in the darkroom. Once found, the "unsafe" light can be eliminated.

7-13. EQUIPMENT/MATERIAL

a. A 10- x 12-inch cassette, unloaded.

b. Opaque material (cardboard for example).

c. Clock with a second hand.

7-14. PROCEDURE

a. Turn off all white and safelights in the darkroom.

b. Load the 10 x 12-inch cassette.

c. Place the cassette on the x-ray table.

d. Calculate the exposure to produce a density of approximately 0.5 (1 mAs, 45 kVp, 40" SID, rare earth; 45 kVp, 2.5 mAs, 40" SID hi plus).

e. Center the x-ray tube to the cassette.

f. Make the exposure.

g. Return the cassette to the darkroom.

h. Turn off all safelights and white lights.

i. Remove the film from the cassette.

j. Place the film on the workbench in the safelight area.

k. Cover one-half of film with opaque material (such as cardboard) and keep it covered throughout the entire test.

l. Place another opaque sheet (cardboard) on top of the entire film.

m. Uncover one-fourth of the film.

n. Expose the film to the safelight for 30 seconds.

o. Slide the cardboard down on the film and expose another quarter of the film.

p. Expose the film for 30 seconds more to the safelight.

q. Repeat steps o and p until the last quarter of the film has been exposed for 30 seconds.

r. Process the film.

NOTE: Repeat the above procedure for all the loading benches and feed trays.

7-15. EVALUATION AND INTERPRETATION

a. Place the film on the illuminator.

b. Compare, visually, if the borders between each area were covered with the strip of opaque material.

c. Use the densitometer to determine the difference of densities.

d. Record the different values on the film.

NOTE: The density differences between the fogged and unfogged areas on the radiographic film should not exceed .05 for a two-minute exposure.

7-16. PREVENTIVE MAINTENANCE

a. This is a constant project that should be performed at six-month intervals.

b. This test should be performed when fog becomes a problem in the darkroom area.

7-17. CORRECTIVE MAINTENANCE

a. Replace the defective safelight as soon as possible.

b. Replace the light bulb with proper wattage light bulb. The darkroom technologist can do this.

Section IV. DARKROOM ASSURANCE LIGHT LEAK TEST

7-18. PURPOSE

This test is performed to check the darkroom area for light leaks because they could fog the radiographic films.

7-19. EQUIPMENT

None.

7-20. PROCEDURE

a. Turn off all the safelights and white lights.

b. Accustom your eyes to the dark (about 15 minutes).

c. Look for evidence of light penetrating the darkroom.

(1) Check the seals on the door entrance.

(2) Check the seals on the processor.

(3) Check the light on the silver recovery system.

(4) Check the seal on the passboxes.

(5) Check the ceiling tiles. If the ceiling is suspended, light can leak in from the surrounding rooms.

(6) Check the position of the heating duct. Ensure that loaded cassettes are not placed near the ducts because that will cause fog on the film.

7-21. EVALUATION AND INTERPRETATION

a. Make a note of the areas where there are light leaks.

b. Eliminate the light leaks from the darkroom.

7-22. PREVENTIVE MAINTENANCE

a. Perform this test every six months.

b. Perform this test when fog interferes with image quality.

7-23. CORRECTIVE MAINTENANCE

Initiate work orders to correct any light leaks in the darkroom.

Continue with Exercises

EXERCISES, LESSON 7

INSTRUCTIONS: Answer the following exercises by marking the lettered response that best answers the exercise, by completing the incomplete statement, or by writing the answer in the space provided at the end of the exercise.

After you have completed all of these exercises, turn to "Solutions to Exercises" at the end of the lesson and check your answers. For each exercise answered incorrectly, reread the material referenced with the solution.

Exercises 1 through 5 pertain to the **automatic processor accuracy test**.

1. The automatic processor accuracy test establishes the _____ operating level of the automatic processor.

2. The automatic processor accuracy test should be performed IAW your clinic SOP which may be _____, biannually, or annually.

3. What kind of thermometer is not permitted during the automatic processor accuracy test?
   _____.

4. First, you replace the developer and the _____. (Two words)

5. If the speed has 21 steps, use _____steps darker.

Exercises 6 through 10 pertain to the **automatic processor accuracy test - daily maintenance**.

6. Before running test film through the processor, wait at least 30 minutes but no longer than _____hours.

7. To evaluate, you draw a straight line from the _____norm number to today's number.

8. If today's number is outside the established limits, what do you do?

   _____.

9. Repeat the procedure in areas of speed, contrast, fog, and _____ _____.

10. How often should you perform this test?

    _____.

Exercises 11 through 15 pertain to the **safelight test.**

11. The purpose of the safelight test is to eliminate any potential source of _____in the darkroom.

12. To perform the safelight test you need a 10- x 12-inch cassette, unloaded, some opaque material, and _____. (one more item)

13. After turning off all white and safelights in the darkroom, what do you do next?

    _____.

14. How many times do you expose the film to the safelight?

    _____.

15. The density differences between the fogged and unfogged areas on the radiographic film should not exceed 0.5 for a _____ (time) exposure.

Exercises 16 through 20 pertain to the **darkroom assurance light leak test.**

16. You check the darkroom area for light leaks because they could _____ the radiographic films.

17. What equipment do you need to perform the darkroom assurance light leak test?

_____.

18. You must accustom your eyes to the dark for about how long?

_____.

19. Next, what do you do?

_____.

20. How often should the darkroom assurance light leak test be performed?

_____.

21. Establishing norms provides a standard for daily _____ _____.

22. The test for establishing norms should be performed before major cleaning.

    a. True.

    b. False.

23. For the norms test, how long do you run the processor before entering the film?

    a. Fifteen minutes.

    b. Thirty minutes.

    c. Forty-five minutes.

    d. Sixty minutes.

24. During the test for norms, you record the average base-plus-fog density on the _____.

25. How often should you test the processor for optimum daily maintenance?

    a. Daily.

    b. Weekly.

    c. Every three months.

    d. Every six months.

26. Which of the items below is necessary for the safelight test?

    a. Sensitometer.

    b. Densitometer.

    c. Opaque material.

    d. Digital thermometer.

27. In the safelight test, you expose the film to the safelight for _____ seconds.

28. In evaluating the safelight test, the density differences between the fogged and unfogged areas on the film should not exceed what number for a two-minute exposure?

    a. .1

    b. .01

    c. .5

    d. .05

29. When fog becomes a problem in the darkroom area, which test should you perform?

    a. The test for establishing norms.

    b. The daily maintenance test.

    c. The safelight test.

    d. The darkroom assurance test.

30. The darkroom assurance test should be performed:

    a. Daily.

    b. Weekly.

    c. Every 3 months.

    d. Every 6 months.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES, LESSON 7

1. Normal (para 7-2a)
2. Quarterly (para 7-2b(4))
3. Mercury (para 7-3c)
4. Recirculation filter (para 7-4a(1))
5. Four (para 7-5l)
6. Four (para 7-8e)
7. Established (para 7-9d)
8. Circle it (para 7-9e)
9. Developer temperature (para 7-9f)
10. Daily (para 7-10a)
11. "Unsafe" light (para 7-12)
12. Clock with a second hand (para 7-13c)
13. Load the cassette (para 7-14b)
14. Four (para 7-14q)
15. Two-minute (para 7-15, NOTE)
16. Fog (para 7-18)
17. None (para 7-19)
18. Fifteen minutes (para 7-20b)
19. Look for evidence of light penetrating the darkroom (para 7-20c)
20. Every six months (para 7-22a)
21. Quality control (para 7-2a)

22. b (para 7-2b(3))

23. b (para 7-4b)

24. Film (para 7-5f)

25. a (para 7-10a)

26. c (para 7-13b)

27. Thirty (para 7-14n)

28. d (para 7-15, NOTE)

29. c (para 7-16b)

30. d (para 7-22a)

End of Lesson 7

LESSON ASSIGNMENT

LESSON 8	Illuminators Quality Control Test.
TEXT ASSIGNMENT	Paragraphs 8-1 through 8-6.
LESSON OBJECTIVES	After completing this lesson, you should be able to:

8-1. Identify the purpose for performing the illuminator quality control test.

8-2. Select the proper order of procedure for performing a quality control test on illuminators.

8-3. Select the test results that are out of or within the established standards for illuminators.

SUGGESTION After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you achieve the lesson objectives.

LESSON 8

ILLUMINATORS QUALITY CONTROL TEST

8-1. PURPOSE

The illuminators quality control test determines the uniformity of the radiographic illuminators that are used for viewing radiographs. Misdiagnosis could occur with poor lighting, and that is why performing a quality control test on illuminators is an important step in the quality assurance program.

8-2. EQUIPMENT/MATERIAL

a. Radiographic illuminator measuring mask. This can be made from cardboard or exposed radiographic film.

b. Photographic light meter (reads in candles).

c. Recording data forms.

8-3. PROCEDURE

a. Remove the Plexiglas front of the illuminator and check for burned out bulbs or bulbs with blackened ends.

b. Replace the bulbs with the same brand and type being removed.

c. Replace any bulbs that cause gross mismatch due to age or tone differences.

d. Clean the interior of the viewbox including bulbs and both sides of the plexiglas. Use a screen cleaner.

e. Replace the Plexiglas front.

f. Turn on the illuminators at least 2 minutes before performing the test. During these 2 minutes the lights of the illuminator should stabilize and give full brightness.

g. Place the mask on the illuminator (viewbox).

NOTE: The mask has a series of positioning guides for the light meter.

h. Start with the first quadrant (upper left corner) and place the meter in contact with the viewbox (see figure 8-1).

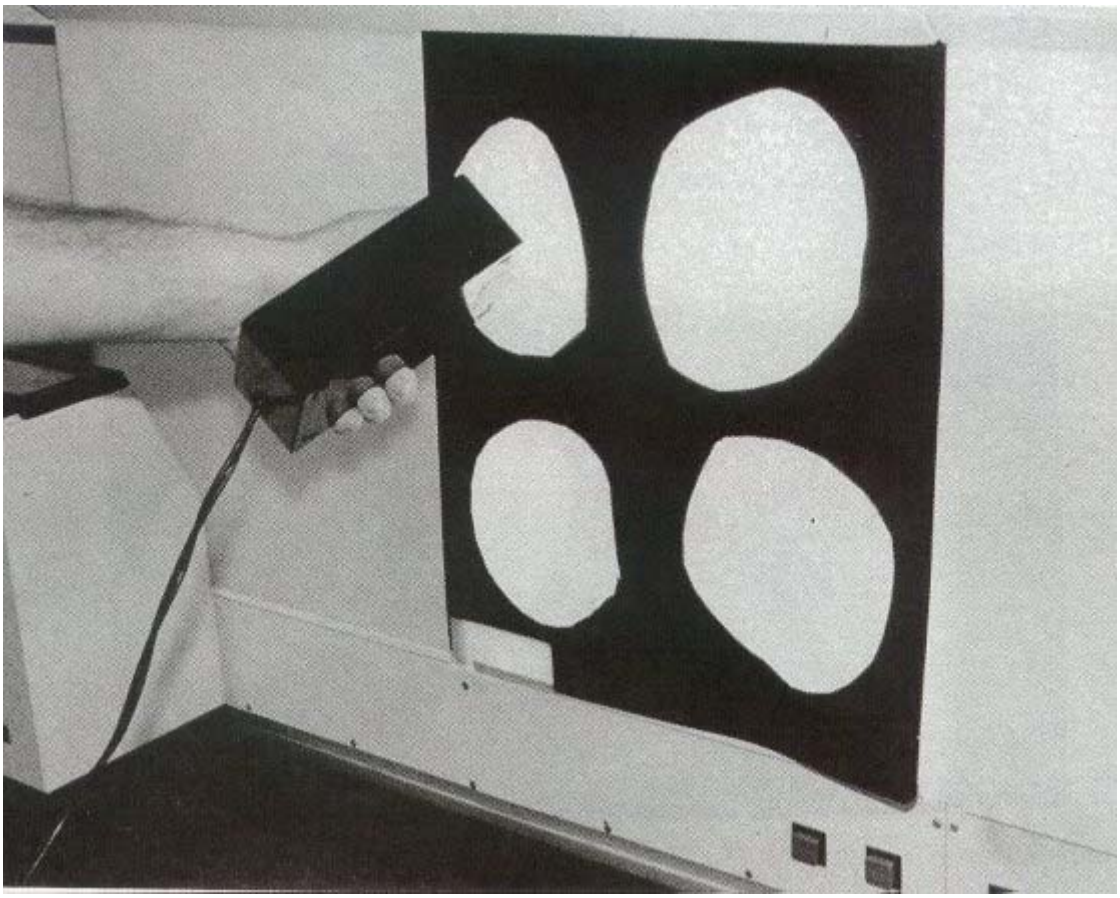

Figure 8-1. First quadrant.

i. Note the reading on the scale of the light meter.

j. Record the data on the form.

k. Repeat the procedure for the remaining quadrants.

l. Repeat steps a through k for all the other viewboxes (see figures 8-2 through 8-4).

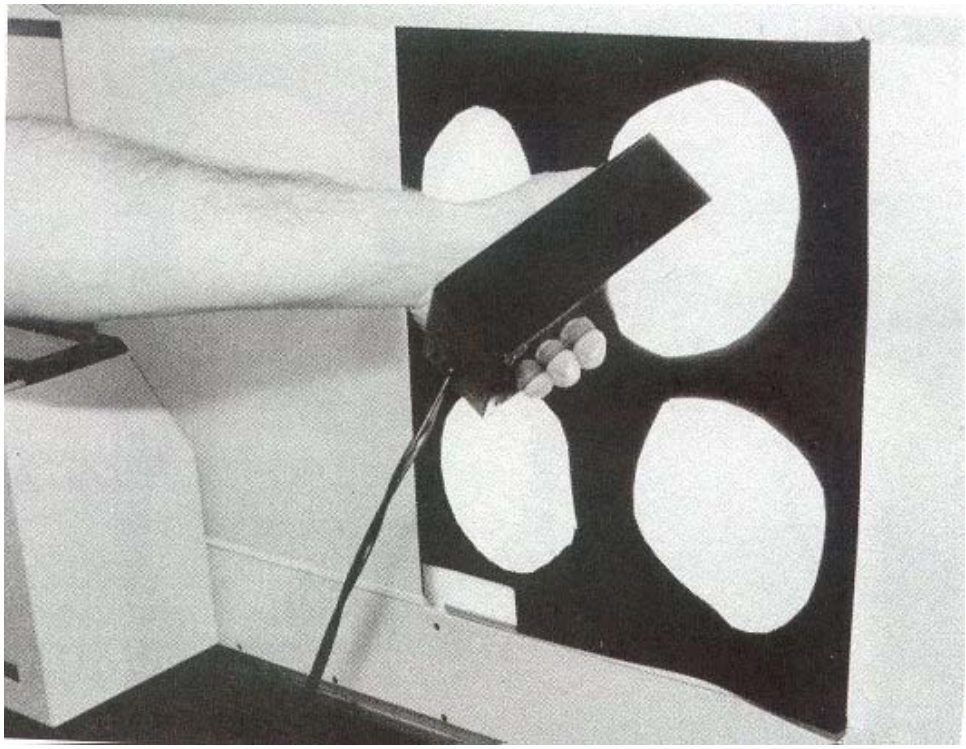

Figure 8-2. Second quadrant.

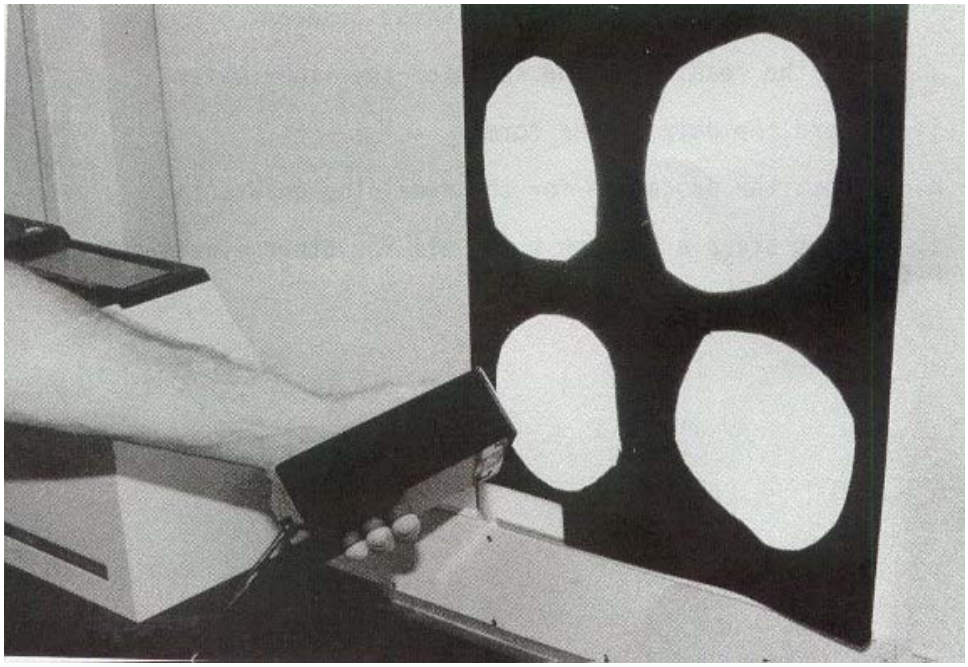

Figure 8-3. Third quadrant.

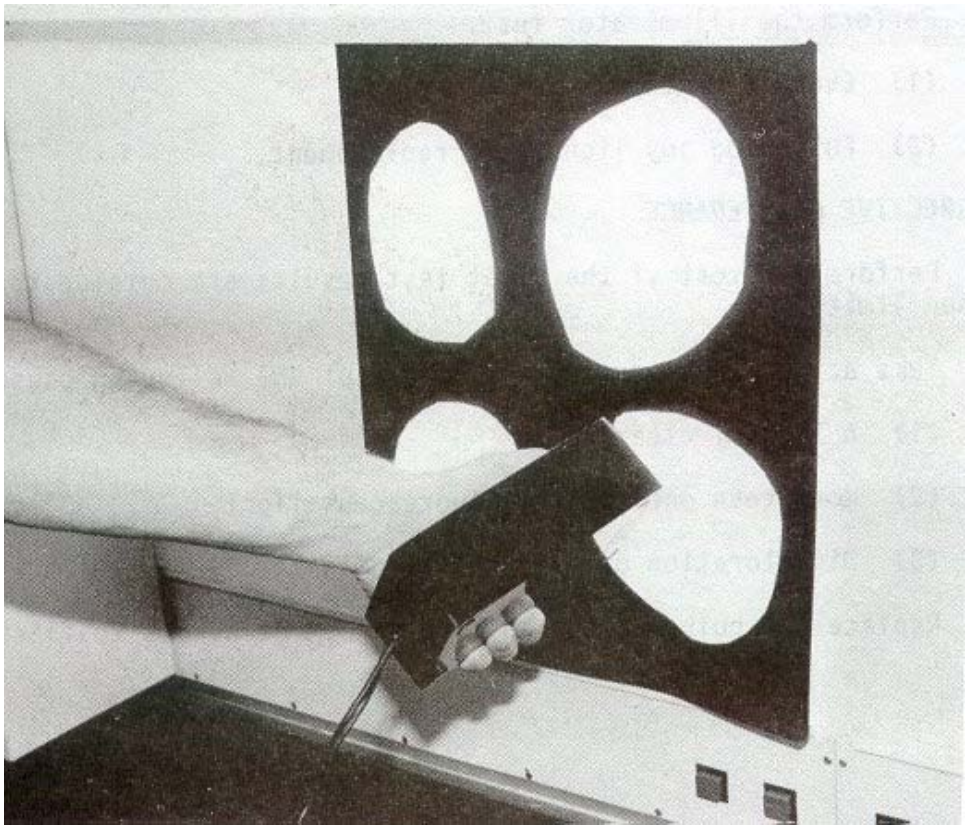

Figure 8-4. Fourth quadrant.

8-4. EVALUATION AND INTERPRETATION

a. Determine the average illumination level for each viewbox (all readings should be the same).

b. Do not accept a variation of illumination between individual quadrants if it exceeds:

(1) Ten percent.

(2) Fifteen percent in five groups of viewboxes.

(3) Twenty percent in group-to-group variations.

8-5. PREVENTIVE MAINTENANCE

a. Replace illuminator lamps:

(1) Every year if used 8 hours per day.

(2) More frequently if used more than 8 hours per day.

b. Perform the illuminator test.

(1) Every 6 months.

(2) Following any light bulb replacement.

8-6. CORRECTIVE MAINTENANCE

a. Perform a retest if the first test results are outside the established limits.

b. Take action to determine any or all of the following causes.

(1) A lack of cleaning.

(2) More than one type of fluorescent light.

(3) Discoloration of external illuminator surface with age.

c. Replace all bulbs if one bulb burns out or starts to flicker.

Continue with Exercises

EXERCISES, LESSON 8

INSTRUCTIONS: Answer the following exercises by marking the lettered response that best answers the exercise, by completing the incomplete statement, or by writing the answer in the space provided at the end of the exercise.

After you have completed all of these exercises, turn to "Solutions to Exercises" at the end of the lesson and check your answers. For each exercise answered incorrectly, reread the material referenced with the solution.

1. Which of the following items should be used to perform the illuminator test?

   a. Densitometer.

   b. Sensitometer.

   c. Photographic light meter.

   d. Phantom.

2. How long should the illuminators be turned on before performing the test?

   a. One minute.

   b. Two minutes.

   c. Three minutes.

   d. Four minutes.

3. What is the maximum acceptable variation of illumination between individual quadrants?

   a. Ten percent.

   b. Fifteen percent.

   c. Twenty percent.

   d. Twenty-five percent.

4. How often must you replace the illuminator lamps if they are used 8 hours per day?

   a. Every three months.

   b. Every six months.

   c. Every nine months.

   d. Every twelve months.

5. If test results are outside the established limits, you should retest.

   a. True.

   b. False.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES, LESSON 8

1. c (para 8-2b)

2. b (para 8-3f)

3. c (para 8-4b(2))

4. d (para 8-5a(1))

5. a (para 8-6a)

End of Lesson 8

LESSON ASSIGNMENT

LESSON 9 Cassettes/Intensifying Screens Quality Control Tests.

TEXT ASSIGNMENT Paragraphs 9-1 through 9-12.

LESSON OBJECTIVES After completing this lesson, you should be able to:

9-1. Select the correct equipment, order of procedure, evaluation and interpretation, and preventive or corrective maintenance for the:

Film-screen combination quality control test.

Film-screen contact quality control test.

SUGGESTION After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you achieve the lesson objectives.

LESSON 9

CASSETTES/INTENSIFYING SCREENS QUALITY CONTROL TESTS

Section I. FILM-SCREEN COMBINATION QUALITY-CONTROL TEST

9-1. PURPOSE

Two areas that must not be overlooked when considering the amount of density on a radiograph are the film-screen combination and the film-screen contact. The film-screen combination test is to assure that the film-screen combination (image receptors) used in a department may be used without altering exposure factors (that they are all the same speed). You, as a radiographer, must always bear in mind the importance of the film-screen combination and film-screen contact tests. When there is a problem with different densities on the radiograph, remember that these two quality control tests help make up the total quality assurance program.

9-2. EQUIPMENT/MATERIAL

a. Calibrated penetrometer (step wedge).

b. Densitometer.

c. Lead numbers for identification markers.

9-3. PROCEDURE

a. Use the same exposure room and processor. Avoid as many variations as possible.

b. Select standard SID--40 inches.

c. Set the control panel:

(1) Select the technique to produce a density of one (1.0) near the middle of the penetrometer.

(2) Eighty kVp.

(3) Two mAs.

d. Select the size of the film holder to be tested.

e. Test all the same size receptors and during the same time period.

f. Collimate to the penetrometer size.

NOTE: Do not change the size of the conefield during testing.

g. Make the radiographic exposure.

h. Process the films.

i. Collect all the films.

j. Select, randomly, density on the penetrometer closest to a density of 1.0.

NOTE: Step j will be known as a guide (master) for the remaining test films.

k. Use the densitometer for density readings (see figure 9-1).

l. Follow step j above for the rest of the test films.

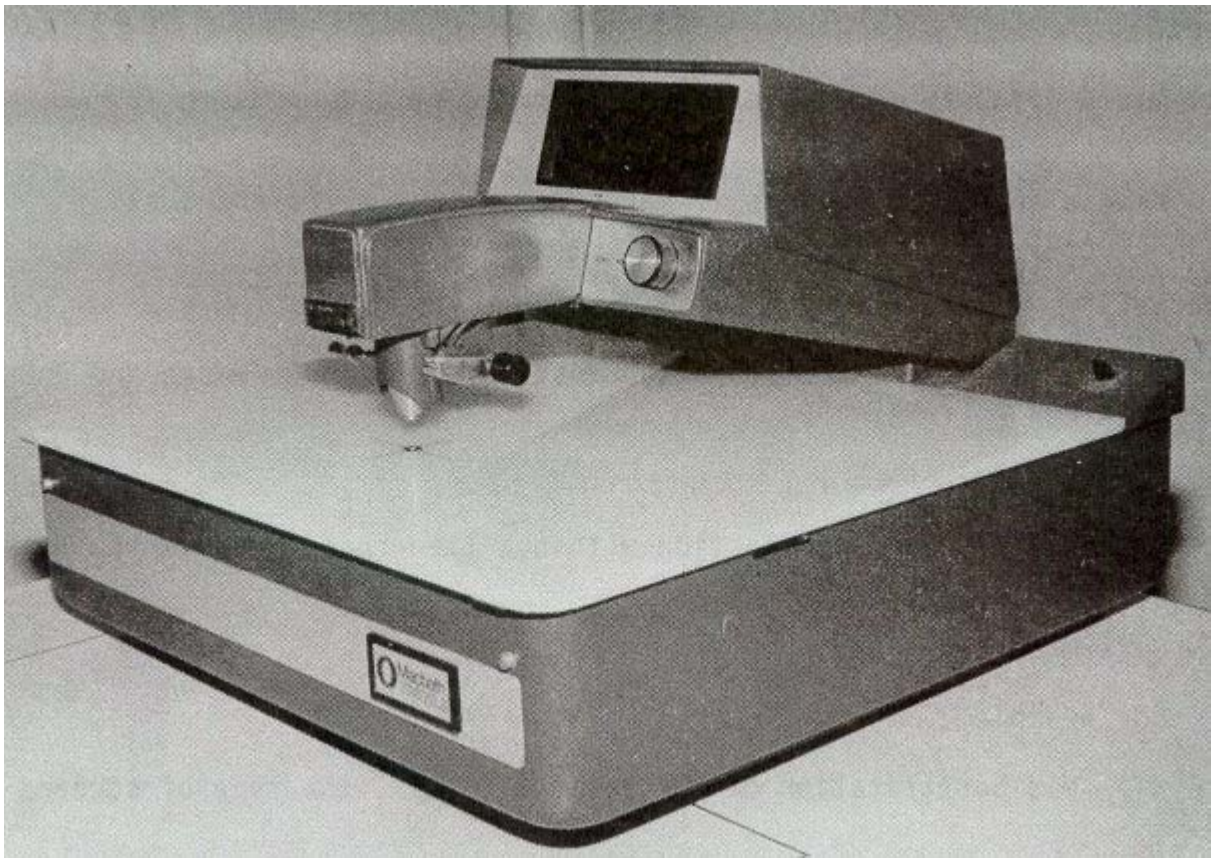

Figure 9-1. Densitometer used in making density readings.

9-4. EVALUATION AND INTERPRETATION

a. Count the number of step differences.

(1) Between the master film and the test films.

(2) For example:

(a) On the master film, step 7 has a density of 1.0. Test film number two, step three has a density of .97.

(b) The difference of steps would be the master film, step 7 minus the test film number 2, step 3 = 4 minus the step difference.

b. Divide this number:

(1) Into 0.3 (the factor required to double-film density).

(2) For example: 0.3/4 = .075 (the log exposure change between each step).

NOTE: It would normally require a step difference of 2 to equal a 15 percent change.

c. Make a change of screens if more than 2 step differences exist between the master and the test film.

9-5. PREVENTIVE MAINTENANCE

Perform the film-screen combination test on a quarterly basis and upon acquisition of new screens.

9-6. CORRECTIVE MAINTENANCE

a. Check film-screen combination within a five-speed group, which does not meet the above criteria.

b. Determine the cause.

c. For example:

(1) Misidentification of the cassette, that is, the type of screens it contains.

(2) Screens with the same speed that were made by different manufacturers.

(3) Poor screen contact.

d. Replace the cassette/screen in question if you cannot make a determination for the density variation.

Section II. FILM-SCREEN CONTACT TEST

9-7. PURPOSE

The film-screen contact test determines the adequacy of the film-screen contact of the radiographic cassettes. In doing so, it locates those cassettes with poor film-screen contact.

9-8. EQUIPMENT

a. Wire-mesh test pattern (see figure 9-2).

b. Paper clips if no wire mesh is available.

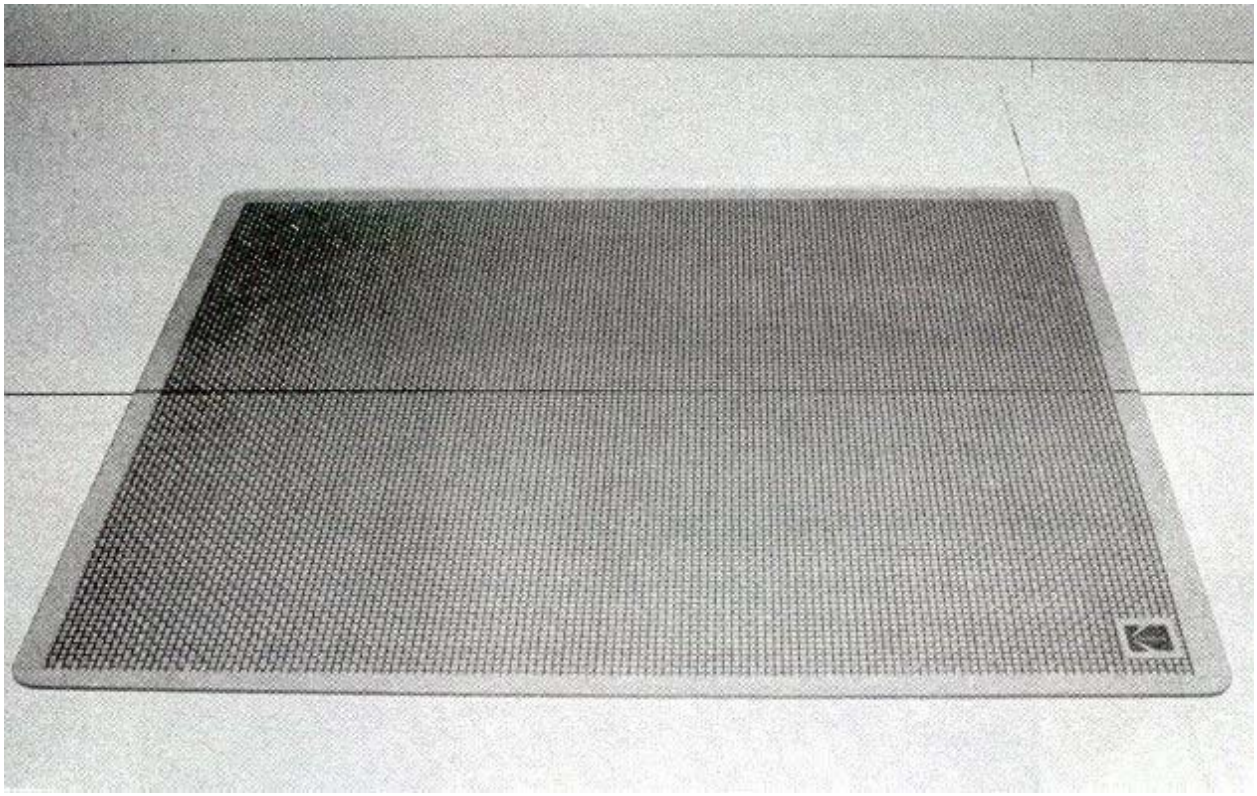

Figure 9-2. Wire mesh test pattern.

9-9. PROCEDURE

a. Place the wire-mesh test tool pattern and the cassette to be tested on the radiographic table with the long axis of the cassette perpendicular to the anode-cathode axis of the x-ray tube.

b. Position the x-ray tube to the center of the cassette.

c. Adjust the focal film distance to 40 inches.

d. Collimate the x-ray beam to the cassette (see figure 9-3).

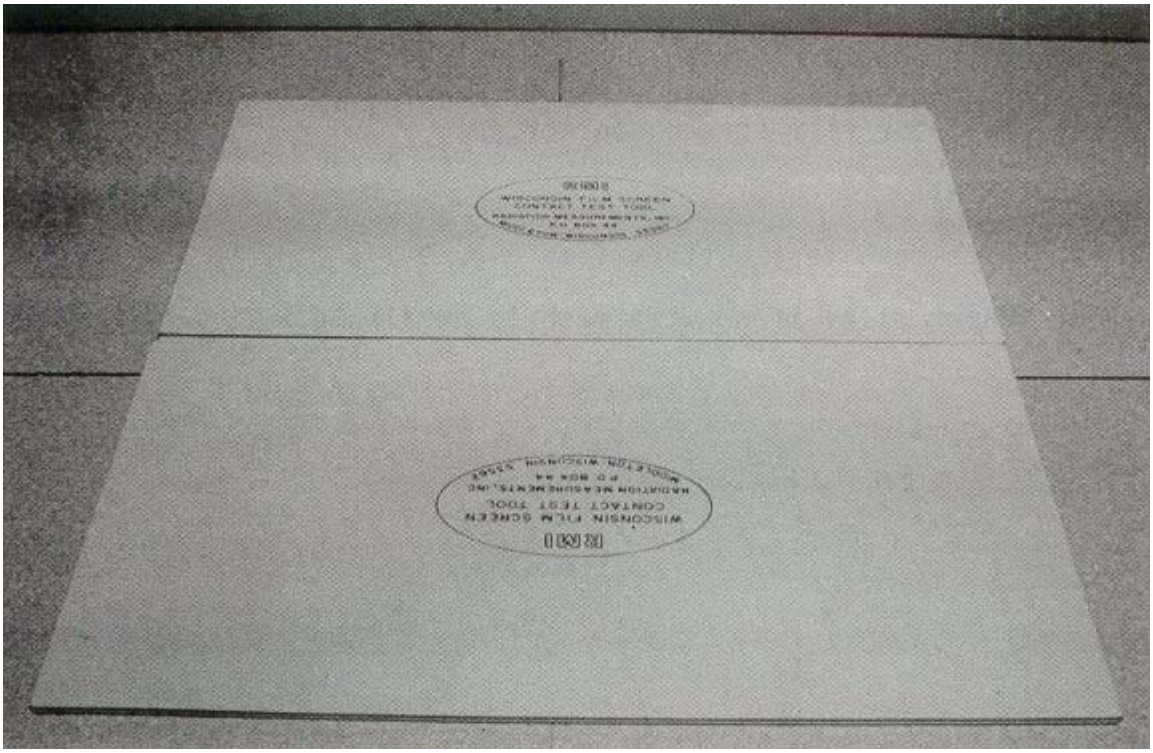

Figure 9-3. Wire mesh patterns that are interchangeable for 8- x 10-, 10- x 12 and 11- x 14-inch cassettes.

e. Place the screen-film test pattern on the cassette.

NOTE: If using paper clips, place the paper clips on the cassette front surface, evenly distributed (see figure 9-4).

f. Use machine factors to produce optical density between 2.5 - 3.8 (60 kVp, small focal spot and approximately 5 mAs) for the radiograph wire mesh.

g. Repeat the above procedure on all cassettes to be tested.

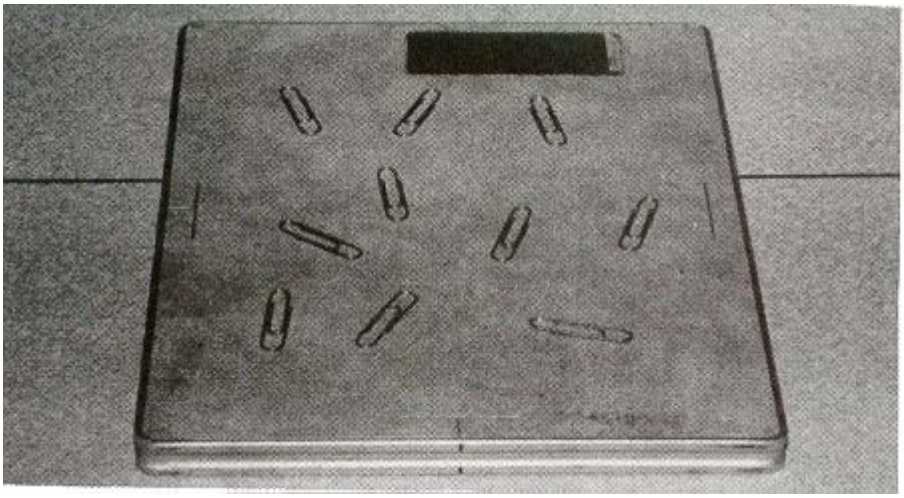

Figure 9-4. Cassette being tested with paper clips.

9-10. EVALUATION AND INTERPRETATION

a. Place the processed film on the illuminator.

b. View the films from a distance of 6 feet or more.

c. Look for fuzzy or blurry areas on the wire.

d. Make notes on the appropriate form of the cassettes demonstrating poor film-screen contact.

NOTE: There are no federal regulations governing the film-screen contact test. Usually, if there is poor screen-film contact on the edges of the film, the cassette is permitted to remain in service because the part under examination is usually in the middle of the radiograph.

9-11. PREVENTIVE MAINTENANCE

Perform the test routinely:

a. Every 6 months.

b. Upon acquisition of new cassettes.

c. Following repairs of damaged cassettes.

9-12. CORRECTIVE MAINTENANCE

Check cassettes that are exhibiting poor film-screen contact for:

a. Air trapped in the cassette between the screen and the film (after loading the cassette, wait 10-15 minutes before performing the test).

b. Damaged cassette frame.

c. Damaged latches.

d. Foreign objects on the screen.

e. Improperly mounted screens.

Continue with Exercises

EXERCISES, LESSON 9

INSTRUCTIONS: Answer the following exercises by marking the lettered response that best answers the exercise, by completing the incomplete statement, or by writing the answer in the space provided at the end of the exercise.

After you have completed all of these exercises, turn to "Solutions to Exercises" at the end of the lesson and check your answers. For each exercise answered incorrectly, reread the material referenced with the solution.

Exercises 1 through 5 pertain to the **film-screen combination test.**

1. List the equipment/material required to perform this test.

   _____.

   _____.

   _____.

2. In the procedure, you select the standard SID, which is _____inches.

3. You set the control panel to produce a density of one near the middle of the penetrometer. You set at _____kVp and _____mAs.

4. Count the number of step differences between the master film and the _____ film.

5. You perform this test on a quarterly basis and upon acquisition of new _____.

Exercises 6 through 10 pertain to the **film-screen contact test.**

6. If no wire mesh is available, what can you use for equipment to perform this test?

   _____.

7. Proceeding with the test, where do you place the screen-film test pattern?

_____.

8. At what distance do you view the film after placing the processed film on the illuminator?

_____.

9 . Upon acquisition of new cassettes, what should you do?

_____.

10. Damaged latches can cause poor screen-film contact.

    a. True.

    b. False.

11. You will need identification markers for the film-screen combination test.

    a. True.

    b. False.

12. A density of _____should is produced in the film screen.

    a. .05.

    b. .5.

    c. 1.0.

    d. 1.5.

13. In the film-screen combination test, how large a step difference would be required to equal a 15 percent change?

    a. 1.

    b. 2.

    c. 3.

    d. 4.

14. How often should the film-screen combination test be performed?

    a. Every year.

    b. Every nine months.

    c. Every six months.

    d. Every three months.

15. For the film-screen contact test, you may use paper clips.

    a. True.

    b. False.

16. Adjust the focal film distance to _____ inches for the film-screen contact test.

17. What, if any, regulations govern the film-screen contact test?

    a. Title 21 CFR.

    b. There are none.

    c. JCAHO.

    d. TB MED 521.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES, LESSON 9

1. Calibrated penetrometer or step wedge
   Densitometer
   Lead numbers for identification markers (para 9-2a, b, and c)

2. Forty (para 9-3b)

3. Eighty kVp and two mAs (para 9-3c(2)(3))

4. Test (para 9-4a(1))

5. Screens (para 9-5b)

6. Paper clips (para 9-8b)

7. On the cassette (para 9-8e)

8. Six feet (para 9-10b)

9 Perform the test (para 9-11b)

10 a (para 9-12c)

11. a (para 9-2c)

12. c (para 9-3c(1))

13. b (para 9-4, NOTE)

14. d (para 9-5)

15. a (para 9-8b)

16. 40 (para 9-9c)

17. b (para 9-10, NOTE)

End of Lesson 9

LESSON ASSIGNMENT

LESSON 10 Grid Alignment Quality Control Test.

TEXT ASSIGNMENT Paragraphs 10-1 through 10-6.

LESSON OBJECTIVES After completing this lesson, you should be able to:

10-1. Identify the purpose for performing the grid quality control test.

10-2. Select the appropriate equipment to perform the quality control test of grids.

10-3. Select the proper order of procedure for performing a quality control test on grids.

10-4. Given a list of quality control test results, select the results that are out of or within the established standards for grids.

SUGGESTION After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you achieve the lesson objectives.

LESSON 10

GRID ALIGNMENT QUALITY CONTROL TEST

10-1. PURPOSE

The grid alignment test reveals the alignment or misalignment of the radiographic grid to the center of the image receptor and to the x-ray tube central ray. It is a simple test, but just as important as any other because a misalignment of the grid can cause uneven densities on the final radiograph.

10-2. EQUIPMENT/MATERIAL

a. Grid test tool.

b. Loaded 8- x 10-inch film holder.

c. Densitometer.

d. Data form.

10-3. PROCEDURE

a. Set the SID.

(1) Adjust the tube perpendicularly (crosswise) to the table.

(2) Use the proper SID for that table's grid (usually 40, but not always).

b. Center the x-ray tube, first longitudinally, then transversely (crosswise) and lock in place. If the tube has a transverse lock mechanism, use it.

c. Place an 8- x 10-inch film holder in the tray with the long axis of the film perpendicular to the long axis of the table. Be sure that the cassette tray is completely inserted.

d. Lock the bucky tray.

e. Position the grid alignment test tool on the tabletop with the tool in a perpendicular position to the long dimension of the x-ray tube. Then center the zero position of the test tool to the optical cross hairs of the beam restriction system. Ensure that the orientation arrow is toward the front of the x-ray table (see figure 10-1).

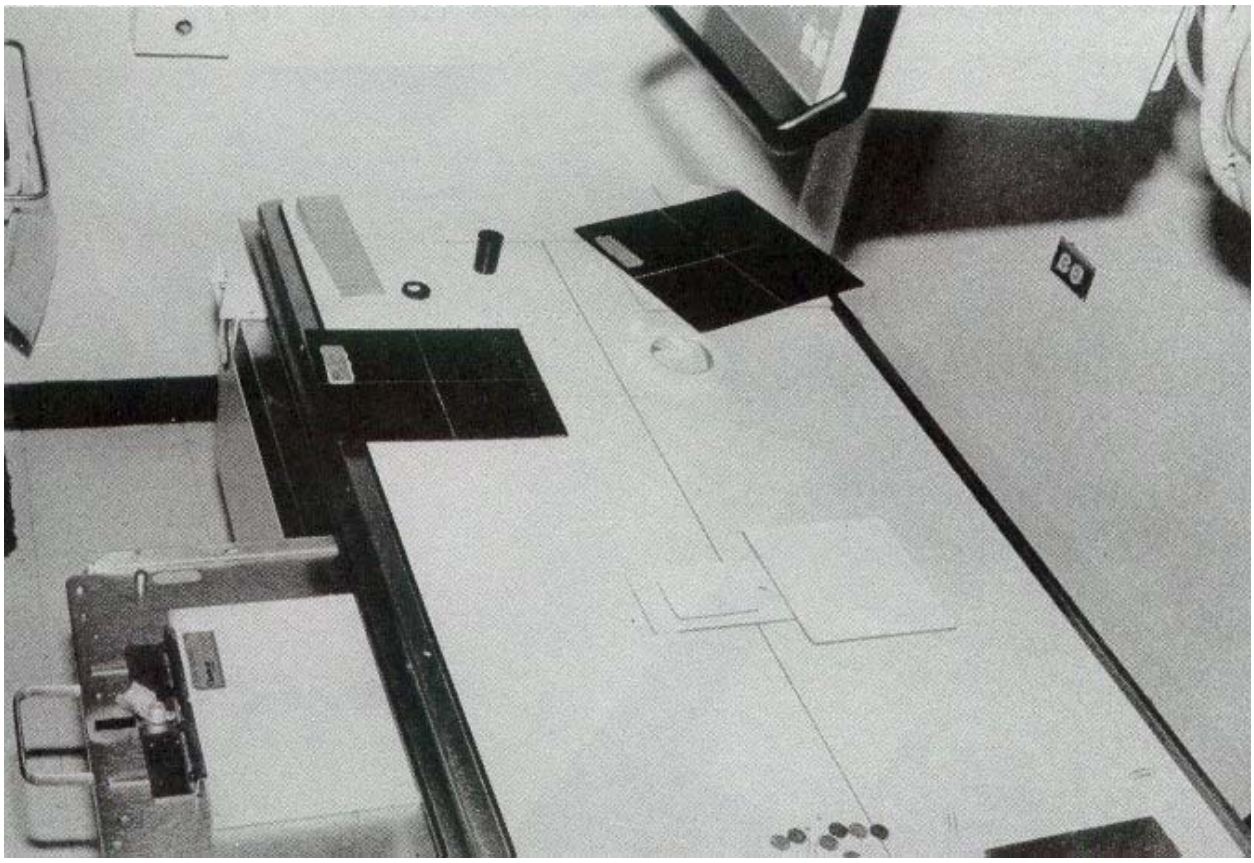

Figure 10-1. Grid alignment test tool at zero position centered.

f. Adjust the conefield to the following limits:

(1) The width of the test tool.

(2) Be sure only the center of the tool will be radiated.

g. Insert plugs in the other holes (other than the center one) or place lead shields over them if there are no plugs (see figure 10-2).

h. Set the technical exposure of 5 mAs at 60 kVp. (Set the mAs first because they will change the kVp).

i. Make the exposure.

j. Make additional exposures of each hole. Plug the ones that are not being irradiated. When you make an exposure of the hole next to the arrow, include the arrow. Be sure not to move the test tool until after all the exposures have been completed.

k. Process the film.

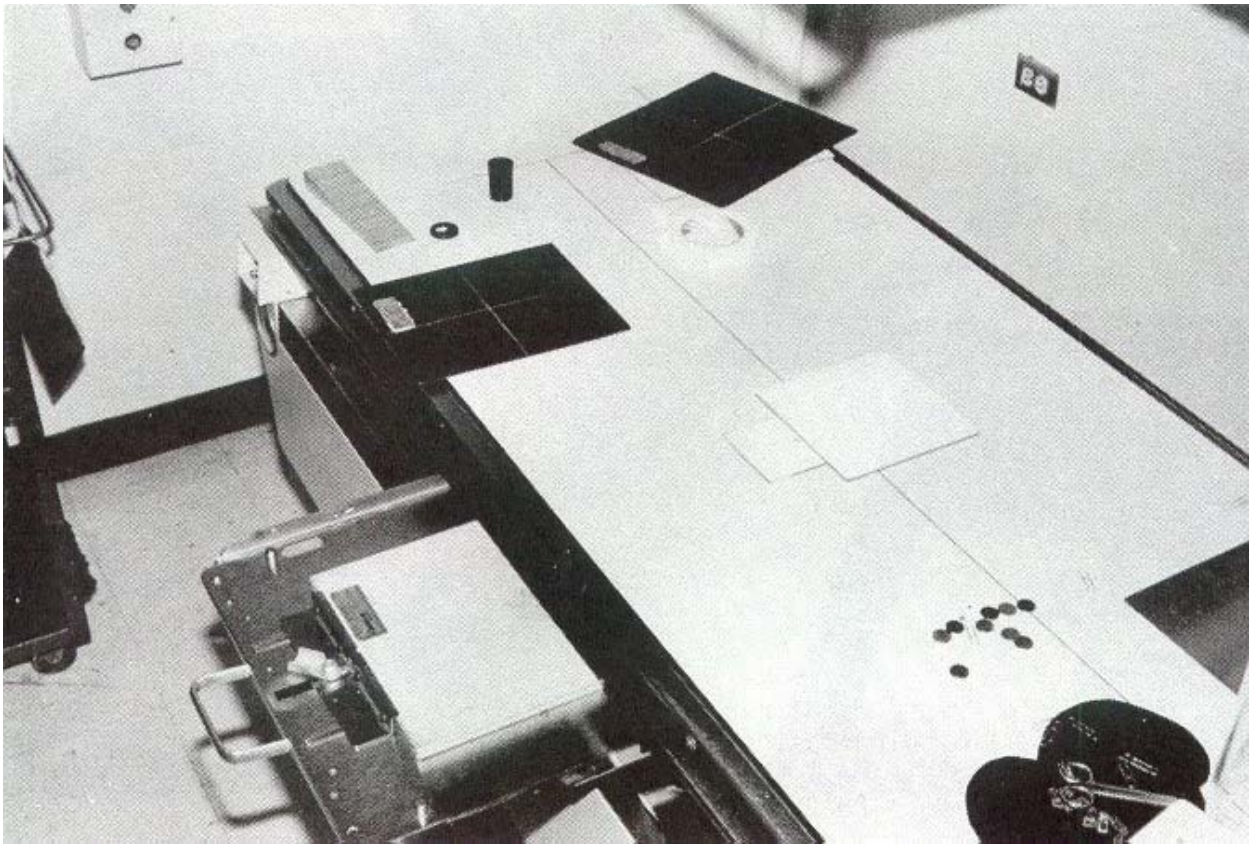

Figure 10-2. Lead shield over center hole exposing outer hole on test tool.

NOTE: The density measurement of the central hole should be in the range of 1.5 to 2.5. As you repeat the filming, adjust the mAs until this reading is obtained. The central hole should be densest because the beam defrays at an angle.

10-4. EVALUATION AND INTERPRETATION

a. In order to evaluate, you must measure and record:

(1) The density of each hole image.

(2) The required information on the data form.

b. A properly aligned grid's central hole will display the maximum density.

(1) An acceptable tolerance is .5 inch from the central hole.

(2) An unacceptable tolerance will display a maximum density at 1 inch or greater from the central hole.

c. If tests are unacceptable, repeat them to determine if you need corrective maintenance.

10-5. PREVENTIVE MAINTENANCE

Grid should be tested at the following times:

a. Every 6 months.

b. After every maintenance, which could affect the x-ray tube, the grid, and the film holder alignment.

10-6. CORRECTIVE MAINTENANCE

Contact the service engineer or the manufacturer's representative, if necessary.

a. For corrective action.

b. If misalignment problem occurs.

Continue with Exercises

EXERCISES, LESSON 10

INSTRUCTIONS: Answer the following exercises by marking the lettered response that best answers the exercise, by completing the incomplete statement, or by writing the answer in the space provided at the end of the exercise.

After you have completed all of these exercises, turn to "Solutions to Exercises" at the end of the lesson and check your answers. For each exercise answered incorrectly, reread the material referenced with the solution.

1. You need a densitometer to perform the grid alignment test.

   a. True.

   b. False.

2. The orientation arrow is toward the (front/back) of the x-ray table. Circle one.

3. The SID is set at 40 for the grid test.

   a. True.

   b. False.

4. The grid should be tested every _____months.

5. An acceptable density tolerance from the central hole is:

   a. .5 inch.

   b. 1.0 inch.

   c. 1.5 inch.

   d. 2.0 inch.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES, LESSON 10

1. a (para 10-2c)
2. Front (para 10-3e)
3. a (para 10-3a(2))
4. Six (para 10-5a)
5. a (para 10-4b(1))

End of Lesson 10

LESSON ASSIGNMENT

LESSON 11	Protective Devices Quality Control Tests.
TEXT ASSIGNMENT	Paragraphs 11-1 through 11-13.
LESSON OBJECTIVES	After completing this lesson, you should be able to

11-1. Identify the appropriate equipment and order of procedures required to perform the:

X-ray tube protective circuitry quality control test.

Quality control tests on protective devices.

SUGGESTION After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you achieve the lesson objectives.

LESSON 11

PROTECTIVE DEVICES QUALITY CONTROL TESTS

Section I. X-RAY TUBE PROTECTIVE CIRCUITRY TEST

11-1. PURPOSE

The x-ray tube protective circuitry test is to verify that the x-ray tube protective circuitry is performing properly. The x-ray tube protective circuitry test is essential to the quality assurance program. You, as a radiographer, need to be sure that this protective device is functioning correctly at all times.

11-2. EQUIPMENT/MATERIAL

a. Tube rating chart.

b. Recording data forms.

11-3. PROCEDURE

a. Set the control panel to select.

(1) 90 kVp, x-ray generator control.

(2) Maximum mA allowed from the tube rating chart.

NOTE: Ensure the tube rating is for a small focal spot.

(3) Maximum time allowed for kVp/mA from the tube rating chart.

(4) Time, the closest time, not exceeding it.

b. Activate the x-ray tube protective circuitry.

(1) Do not make an exposure.

(2) Check the technique overload indicator.

c. Record the data on the form.

d. Select the next highest time.

(1) Determine if the overload indicator activates on first time station.

(2) Record the results of the overload indicator on the form.

e. Select the next lower time.

(1) Determine if the overload indicator activates on the first time station.

(2) Decrease the time until the overload indicator deactivates.

(3) Record the results on the form.

f. Repeat steps a through e with a large focal spot.

g. Repeat large and small focal spots at 60 and 120 kVp.

11-4. EVALUATION AND INTERPRETATION

a. Compare:

(1) Exposure time settings of the activating overload indicator.

(2) Maximum exposure time on the tube rating chart.

b. Ensure that the exposure time is within the maximum allowed.

11-5. PREVENTIVE MAINTENANCE

Perform the x-ray tube protective circuitry test:

a. At the beginning of a quality assurance program.

b. At six-month intervals.

c. Following the installation of a new x-ray tube.

11-6. CORRECTIVE MAINTENANCE

a. Test the tube protector.

b. Call the service representative immediately to readjust the unit if the tube protector allows exposure in excess of maximum.

Section II. PROTECTIVE DEVICES QUALITY CONTROL TEST

11-7. PURPOSE

The protective devices test is to ensure that the lead gloves and aprons you wear in the radiology room, the x-ray room, or the fluoroscopic exam room are safe for you to use. They must not have any cracks or holes in them, and, if they do, the items will not protect you properly and must be repaired or replaced.

11-8. EQUIPMENT/MATERIAL

a. Calibrated test object.

b. Radiographic or fluoroscopic unit.

NOTE: The protective device can be checked with either the overhead tube or the fluoroscopic unit.

11-9. FLUOROSCOPE PROCEDURE

a. Check the gloves, aprons, and gonad shields for cracks and tears.

b. Set the control panel for fluoroscopy.

c. Place the items on the radiographic table.

d. Smooth the items as flat as possible.

e. Place the calibrated test object on the table for a comparison.

NOTE: The test object standard should be a small piece of lead or lead equivalent material that has been measured to correspond with the desired attenuating properties for protective apparel.

NOTE: Before proceeding, be sure to put on a lead apron.

f. Use the TV monitor or mirror optics to view the test items and compare the densities of the test item with the test object.

NOTE: The density of the test item should be equivalent to the density of the test object.

11-10. OVERHEAD TUBE PROCEDURE

a. Adjust the technical factors on a three-phase machine.

   (1) 80 kVp.

   (2) 5 mAs.

b. Place the test object on one corner of the film (see figure 11-1).

c. Make the exposure for each item (see figure 11-2).

d. Process the films.

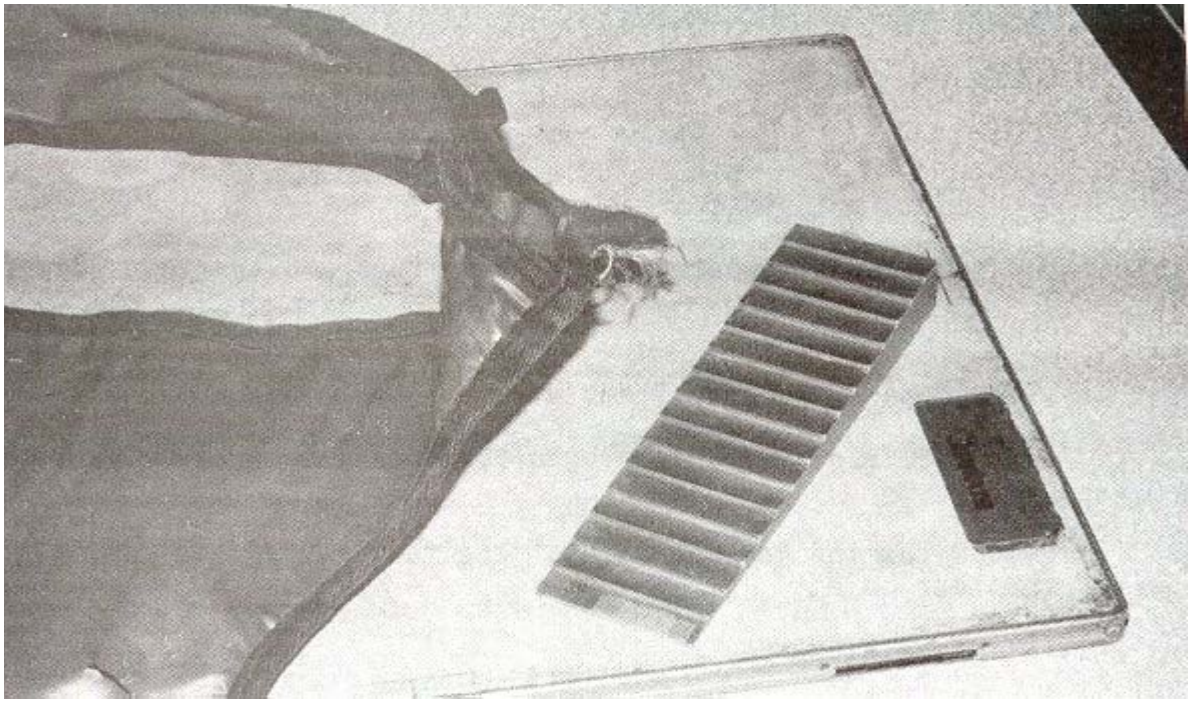

Figure 11-1. Test object in the corner while testing lead apron.

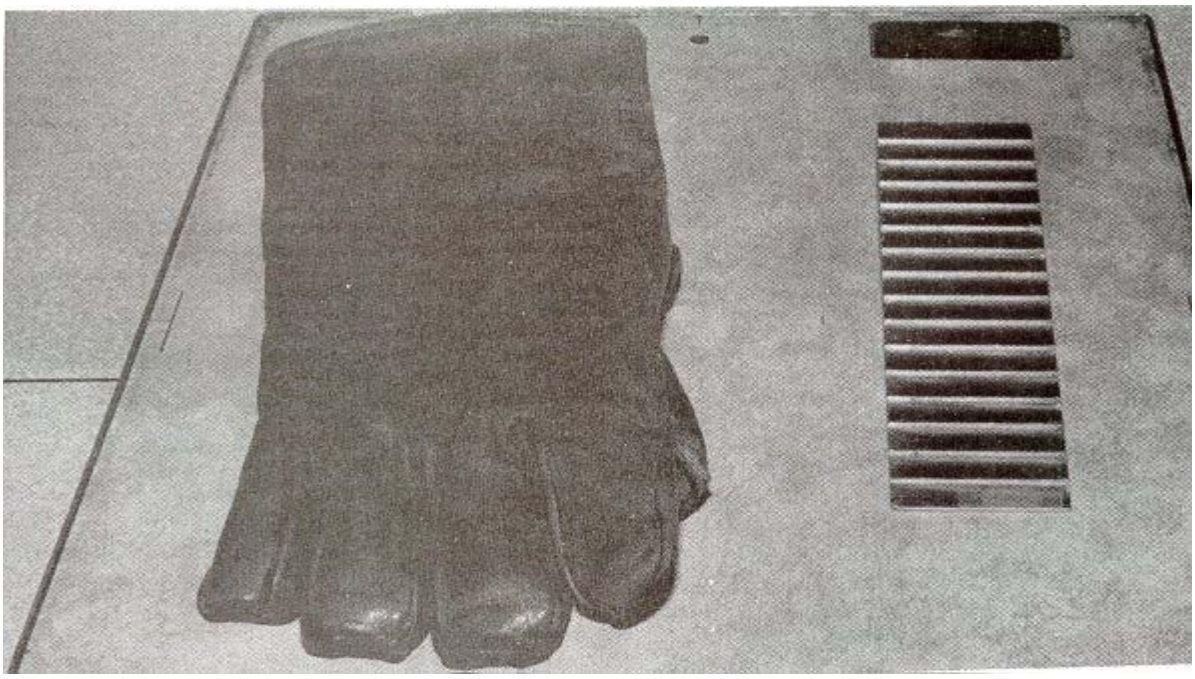

Figure 11-2. Test being made of one glove from a pair.

11-11. EVALUATION AND INTERPRETATION

a. Check the fluoroscopy.

(1) Look for light cracks.

(2) Look for bright areas.

NOTE: You want equal density between the test items and the test object.

b. Check the overhead.

(1) Compare the test items with the test object.

(2) Determine the shielding effectiveness. Does it meet the minimum requirements?

(3) Determine the densities. The test items should be lighter or the same as the test object.

11-12. PREVENTIVE MAINTENANCE

a. Inspect all your protective apparel:

(1) When it's new and before it's put into use.

(2) At regular intervals during use.

(3) As a result of reported problems.

b. Mark and save your radiographs of the items.

11-13. CORRECTIVE MAINTENANCE

Repair or replace the damaged or defective items immediately.

Continue with Exercises

EXERCISES, LESSON 11

INSTRUCTIONS: Answer the following exercises by marking the lettered response that best answers the exercise, by completing the incomplete statement, or by writing the answer in the space provided at the end of the exercise.

After you have completed all of these exercises, turn to "Solutions to Exercises" at the end of the lesson and check your answers. For each exercise answered incorrectly, reread the material referenced with the solution.

Exercises 1 through 5 pertain to the **x-ray tube protective circuitry test.**

1. What is the purpose of the x-ray tube protective circuitry test?

   _____.

2. At the first testing, you must ensure that the tube rating is for a _____ focal spot.

   a. Small.

   b. Large.

3. You keep decreasing the time until the overload indicator deactivates.

   a. True.

   b. False.

4. How often should the x-ray tube protective circuitry test be performed?

   _____.

5. If the tube protector allows exposure in excess of maximum, what must you do?

   _____.

Exercises 6 through 10 pertain to the **protective devices test.**

6. What should you do with lead gloves and aprons that have cracks or holes in them?

   _____.

7. What equipment do you need for the protective devices test?

   _____.

8. During the test procedure, where do you place the test object?

   _____.

9. The density of the test item should be equivalent to the density of the _____.

10. When you do the fluoroscopy check, what do you look for?

    _____

11. What is the second procedural step in performing the x-ray tube protective circuitry test?

    a. Select the next highest time.

    b. Set the control panel.

    c. Repeat large and small focal spots.

    d. Activate.

12. For the x-ray tube protective circuitry test, you decrease the time until the overload indicator _____.

13. The x-ray tube protective circuitry test should be performed:

    a. At the beginning of a quality assurance program.

    b. At six-month intervals.

    c. Following the installation of a new x-ray tube.

    d. All of the above.

14. _____is needed to perform the protective devices quality control test.

    a. Calibrated test object.

    b. Tube rating chart.

    c. Phantom.

    d. Measuring tape.

15. To perform the protective devices quality control test, you also need a radiographic or _____unit.

16. If you perform the protective devices test with a radiographic unit, the density of the test item should be _____or the same as that of the test object.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES, LESSON 11

1. To verify that the x-ray tube protective circuitry is performing properly. (para 11-1)

2. a (para 11-3 NOTE)

3. a (para 11-3e(2))

4. Every six months (para 11-5b)

5. Call a service representative (para 11-6b(2))

6. Repair or replace them (para 11-7)

7. Calibrated test object and a radiographic or fluoroscopic unit (paras 11-8a, b)

8. On the table with the gloves and aprons (para 11-9e)

9. Test object (para 11-9, 3rd NOTE)

10. Light cracks and bright areas (para 11-11a(1),(2))

11. d (para 11-3b)

12. Deactivates (para 11-3e(2))

13. d (para 11-5a-c)

14. a (para 11-8a)

15. Fluoroscopic (para 11-8b)

16. Lighter (para 11-11b(3))

End of Lesson 11

LESSON ASSIGNMENT

LESSON 12	Retake Analysis Program.
TEXT ASSIGNMENT	Paragraphs 12-1 through 12-5.
LESSON OBJECTIVES	After completing this lesson, you should be able to

12-1. Identify the definition of retake analysis.

12-2. Identify the objectives of the retake analysis program.

12-3. Identify the methods of selection for implementing a retake analysis program.

12-4. Identify the procedure for implementing a retake analysis program.

12-5. Identify the retake analysis program evaluation.

12-6. Identify the follow-up procedure for the retake analysis program.

SUGGESTION After studying the assignment, complete the exercises at the end of this lesson. These exercises will help you achieve the lesson objectives.

LESSON 12

RETAKE ANALYSIS PROGRAM

12-1. PURPOSE

a. Retake analysis is a systematic procedure to analyze the radiographs found to be unacceptable by the quality control technician or radiologist. The program determines the quantity of and reasons for rejected films. The retake analysis provides a systematic approach to determine departmental patterns. It also helps a radiographic department realize an increase in film quality and a decrease in film costs. Such analysis is important to the quality assurance program for the reasons just mentioned, but its overall importance is that it furnishes the only method by which you can tell just how effectively your quality assurance program is working.

b. Specific objectives of the program are to:

(1) Determine the total number of acceptable radiographs.

(2) Alert the supervisors of the number of repeat examinations and non-diagnostic radiographs.

(3) Classify the rejects in two ways:

(a) Find the reason for the error. Radiographers should always admit the error.

(b) Find out what type of examination was performed. As you know, some positions are more difficult to radiograph well than others, as are some people (very obese, for example). Also, some patients move.

(4) Allow supervisors to analyze causes.

(5) Identify:

(a) Cost of the waste in the departments.

(b) Unnecessary radiation exposure to patients and personnel.

(6) Evaluate the overall effectiveness of the quality assurance program.

NOTE: A retake analysis program should be implemented before starting the quality control testing.

12-2. VARIOUS METHODS OF PROCEDURAL SELECTION

a. Record each unacceptable radiograph according to one of the following reasons:

(1) Poor position.

(2) Incorrect amount of density.

(3) Type of examination.

b. File the rejects in a film jacket or box according to the error type or the body part.

c. Record the rejects on an analysis form.

d. Put all the rejected films in a designated place.

e. Analyze and record the radiographs every week or two.

NOTE: The last two methods make it difficult to pinpoint problems.

12-3. PROCEDURE

a. Select a method of implementation for the retake analysis program.

b. Clean out all the rejected film bins.

c. Establish a method to count all the radiographic film consumed. You should:

(1) Record the number of boxes of film used daily.

(2) Use a counter attached to the processor. The disadvantage of a counter is that if two films are run side-by-side, only one film will be counted. Record the count every 24 hours and reset the counter. (For example, an 8 x 10 plus a warm-up film and a feed film for the fluoroscope.)

d. Determine the total number of examinations performed.

e. Determine the number of films used per procedure.

f. Multiply the total number of examinations performed by the number of films used per procedure.

g. Add the number of rejected films.

h. Count the full boxes of film used during the study.

i. Collect all the rejected radiographs after 1,000 films have been processed.

j. Record the reject numbers on a tally sheet.

k. Analyze the rejected films as either too light or too dark and list the possible causes: machine, processor, or technician.

l. Determine the repetition rate of total repeated films and total films used. For example:

(1) 1225 films processed.

(2) 153 films repeated.

(3) 153 divided by 1,225 equals 12 percent repeated.

NOTE: Repeat rate is different from rejection rate.

m. Determine the rejection rate of total rejected films, total films used, and total films wasted (green and clear). For example:

(1) 1,225 films processed plus 250 films wasted equals 1,475 films used.

(2) l53 films rejected.

(3) 153 divided by 1,475 equals 10 percent rejected.

n. Determine the percent of rejection according to categories. For example, if 153 films were rejected and 49 of them were too dark, the dark film repeat rate is 32 percent (49 divided by 153). The categories for rejection are listed below:

(1) Films too dark.

(2) Films too light.

(3) Positioning.

(4) Processing.

(5) Artifacts.

(6) Positioning of the same body parts reoccurs (skull, abdomen, etc.).

12-4. EVALUATION AND INTERPRETATION

a. Determine how much money is wasted on film cost. To do this, you figure the average cost per piece of radiographic film and multiply that by the number of rejects. For example:

(1) $3.00 is the average cost of radiographic film.

(2) There were 750 rejected films.

(3) $3.00 times 750 equals $2,250. This is the dollar value of the rejected films.

b. Determine the monthly total and enter it into a log book. Add the monthly totals for the yearly total.

NOTE: This dollar figure should decrease after the implementation of a quality assurance program. This will help demonstrate the cost saving of the program.

c. Determine the departmental problems. For example:

(1) 50 percent errors--density problems.

(2) 60 percent errors--density problems due to excessive density.

(3) 80 percent overexposed rejects done in the same room.

CONCLUSION: A problem exists with the equipment or the technician or both. If the problem is with the equipment, several quality control tests can be run to pinpoint the malfunction.

d. A normal, acceptable rejection rate is from 5 to 15 percent in a radiology department with a quality assurance program.

(1) The largest number of retakes will be caused by density and positioning errors.

(2) Clear films cause a large number of rejects. These are due to the unused loaded cassettes not being returned to the unexposed passbox. Also, a spot film may have been left in the image intensification device.

NOTE: Don't ever use suspected exposed film on trauma patients or babies.

NOTE: Always return the loaded cassettes to their designated areas and remove the spot film when the last fluoroscopy is finished.

12-5. FOLLOW-UP

a. Review all acceptable radiographs periodically.

b. Determine the number of good as well as minimally acceptable radiographs.

NOTE: If the quality control program is working, the number of minimally acceptable radiographs should decrease and the number of good quality radiographs should increase.

c. Perform your retake analysis 3 or 4 times a year.

d. Compare the subsequent retake analysis with the first retake analysis.

Continue with Exercises

EXERCISES, LESSON 12

INSTRUCTIONS: Answer the following exercises by marking the lettered response that best answers the exercise, by completing the incomplete statement, or by writing the answer in the space provided at the end of the exercise.

After you have completed all of these exercises, turn to "Solutions to Exercises" at the end of the lesson and check your answers. For each exercise answered incorrectly, reread the material referenced with the solution.

1. Retake analysis evaluates the overall effectiveness of the _____ _____program.

2. A repeat rate is different from a rejection rate.

   a. True.

   b. False.

3. Possible causes for rejected films could be:

   a. Machine.

   b. Processor.

   c. Technician.

   d. All of the above.

4. If you have 1,225 films processed and 153 films repeated, what is the repetition rate?

   a. 10 percent.

   b. 12 percent.

   c. 14 percent.

   d. 16 percent.

5. If an artifact appears on the radiograph, you reject the film.

   a. True.

   b. False.

6. The acceptable rejection rate in a radiology department that has a quality assurance program is between _____and _____.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES, LESSON 12

1. quality assurance (para 12-1b(6))
2. a (para 12-3, NOTE)
3. d (para 12-3k)
4. b (para 12-3l,(3)
5. a (para 12-3n(5))
6. 5--15 percent (para 12-4d)

End of Lesson 12