AAPM REPORT No. 4

BASIC QUALITY CONTROL IN DIAGNOSTIC RADIOLOGY

American Association of Physicists in Medicine

F O R E W O R D

This document, "Basic Quality Control in Diagnostic Radiology", is the fourth in a series of AAPM reports. This document is designed to enable technologists working with the guidance and supervision of a medical physicist to set up a viable quality assurance program in diagnostic radiology with minimal expense. The AAPM, through its Diagnostic Radiology Committee, plans to issue additional documents detailing physicist/engineer level test methods which utilize more sophisticated equipment. These additional tests will be suitable for installation and acceptance testing and for determining compliance with requirements of the Bureau of Radiological Health and state and local radiation control agencies.

The American Association of Physicists in Medicine is organized, as one of its declared purposes, to prepare and to disseminate technical information in medical physics and related fields. In fulfillment of this purpose, the AAPM through a structure of Task Forces, Committees, and Councils prepares recommendations, policy and state-of-the art reviews in the form of reports. These reports cover topics which may be scientific, educational or professional in nature, and final approval of them is given by that Council of the Association charged with responsibility for the particular concerns of the report.

The Publications Committee of the AAPM hopes that this report will effectively continue the record of published work previously reported by other scientific committees and so ably inaugurated by the previous Publications Committee.

John S. Laughlin, Ph.D.
Chairman, Publications Committee

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Copies of a related monograph, Medical Physics Monograph No. 4: Quality Assurance in Diagnostic Radiology, are also available from the Office of the Executive Secretary at $10.00 prepaid for AAPM Members ($20.00 prepaid for non-members).

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BASIC QUALITY CONTROL IN DIAGNOSTIC RADIOLOGY

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November 1977

Contents - Outline

I. Introduction

A. Description

This document describes a quality assurance protocol for diagnostic x-ray equipment at the radiologic technologist level. A series of tests are described using equipment and test tools designed for that specific purpose. All of the important parameters in diagnostic x-ray quality assurance are described.

B. Origin of Document

This document originated as a charge to Robert Waggener of the Diagnostic Radiology Committee of the American Association of Physicists in Medicine (AAPM) from the President at that time, Jack S. Krohmer. A task force of the Diagnostic Radiology Committee was formed for this purpose with Melvin P. Siedband as Chairman. We recognized early that no one individual, group, or Scientific/Professional Society contains all of the expertise or knowledge in a field as large as Diagnostic Radiology Quality Assurance. For that reason, input was solicited and received from a wide spectrum of individuals working in the area of Diagnostic Radiology Quality Assurance, who were not necessarily members of AAPM. That input is gratefully acknowledged. The value of the document has been immeasurably strengthened by that input.

C. Purpose

This document is designed to offer assistance and guidance to a radiologic technologist implementing and operating a quality assurance program in diagnostic radiology. It is designed for implementation at any level of service from a single unit that is infrequently operated to a large number of units operating at maximum capacity in a large institution. The equipment and test tools described in the protocol are simple, relatively inexpensive and easy to procure from several suppliers.

This document is meant for field use. It is hoped that a large number of institutions will use it and present criticisms and suggestions for further improvement. Since we have had a broad based input to the document from many groups in the field of Diagnostic Radiology, we desire that the protocol be considered as a product of the Radiological Community. We hope that the interested groups in the field of Diagnostic Radiology will endorse it and recommend its use.

D. Personnel and Task Force Meetings

The AAPM Task Force met several times at AAPM and RSNA meetings. The final form of the document was developed at two meetings held at the Rockville, Maryland facilities of the Bureau of Radiological Health (BRH). Individuals contributing to this document were:

Dr. Stephen Balter - Philips Medical
Mr. William Britt - Machlett Labs
Mr. George Deutsch - Picker Corporation

Dr. Richard Dobrin - NYU Medical Center
Mr. Robert Deurkes - El Paso Cancer Center
Mr. Theodore Fields - Fields, Griffith Associates
Mr. Daniel Lawrence - Eastman Kodak
Mr. Pei-Jan Paul Lin - Northwestern University
Dr. Tommie Morgan - BRH
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Mr. Carl Scheid - GE Medical
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and many others whose contributions and suggestions are much appreciated.

E. Acknowledgements

The meetings in Washington for the task group were made possible by support from BRH. This support is gratefully acknowledged as it made possible putting together the final form of the protocol. Publication and dissemination of this document was supported by the Diagnostic Equipment Committee of the American College of Radiology (ACR), Albert Dunn, Chairman. This support is also gratefully acknowledged.

II. Test Equipment

A. Equipment Requirements

Many of the test tools can be made by the user. Such items include test phantoms, mesh patterns, alignment fixtures, and timing tools. Their construction is described in the text. Other test tools, such as the test cassette, require calibration and adjustment which is feasible only when a quantity can be made. Still other test tools are made commercially and are available through the manufacturer or his distributor. The tests have been designed to make repeated use of the same simple test tools.

B. Commercial Test Tools

Several suppliers have tools which meet the requirements of these tests. As an aid to those individuals wishing to initiate a quality assurance testing program a partial listing of manufacturers and/or distributors of equipment is given below. This list is not complete. It is provided for convenience, and no endorsement of any product is intended. In the development of the level one test methods, the AAPM committee has made no attempt to develop testing procedures geared to a specific manufacturer's product or test tool, nor has an effort been made to evaluate test equipment currently commercially available as to its applicability.

Capintec, Inc.
63 E. Sandford Boulevard
Mt. Vernon, New York 10550

Eastman Kodak
QC Apparatus Division
400 Plymouth Avenue, North
Rochester, New York 14650

E.I. DuPont De Nemours and Company
Medical Photo Products Dept.
Chestnut Run
Wilmington, Delaware 19898

General Electric Company
Box 414
Milwaukee, Wisconsin 53201

International Radiographic Supplies Unlimited
1100 Royal Street
New Orleans, Louisiana 70116

Keithley Instruments, Inc.
28775 Aurora Road
Cleveland, Ohio 44139

Macbeth
Color and Photometry Division
Little Britain Road
Draw 950
Newburgh, New York 12550

Machlett Laboratories, Inc.
1063 Hope Street
Stamford, Connecticut 06907

MDH Industries, Inc.
3452 East Foothill Boulevard
Pasadena, California 91107

Minnesota Mining and Manufacturing Company
Photo Products Division
3M Center
St. Paul, Minnesota 55101

Nuclear Associates
100 Voice Road
Carle Place, New York 11514

Philips Medical Systems, Inc.
P.0. Box 848
Shelton, Connecticut 06484

Picker Corporation
595 Miner Road
Cleveland, Ohio 44043

Radiation Measurements, Inc.
P.0. Box 327
Middleton, Wisconsin 53562

Sakura Medical
57 Bushes Lane
Elmwood Park, New Jersey 07407

Sargent-Welch
7300 N. Linder Avenue
Skokie, Illinois 60076

Tobias Associates, Inc.
50 Industrial Drive
North Hampton Industrial Park
Ivyland, Pennsylvania 18974

Victoreen Instruments Division
10101 Woodland Avenue
Cleveland, Ohio 44104

Xonics Medical Systems
515 East Touhy Avenue
Des Plaines, Illinois 60018

III. Quality Assurance Program

A. General Considerations

An adequate diagnostic quality assurance (QA) program involves periodic checks of the components in a diagnostic x-ray imaging system. The optimum QA program for any individual facility will depend on a number of factors which include, but may not necessarily be limited to,

items such as the type of procedures performed, type of equipment utilized, and patient workload. The program should be developed under the guidance and supervision of a medical physicist qualified in this area of expertise by education, training, and experience. The qualified medical physicist should be involved in close consultation during design, initiation, implementation, and evaluation phases of the program. The medical physicist may be a full-time employee or a consultant to the hospital. The important considerations are that he is qualified in this area and is available as needed. Participation, especially as the program matures, may include some on-site responsibility and frequent telephone consultation as problems arise. The medical physicist should be prepared to perform higher level testing as required. A documented QA program should be developed specifically to address the needs of the individual department. This program should identify the items to be monitored and establish the testing intervals. All test results should be recorded and periodic reviews of the results of the testing programs should be carried out to identify needed changes. All tests described in this document were specifically designed to be performed by a qualified technologist as first level tests. The technologist may receive training through formal short courses available in several areas of the country and in-service training by the Medical Physicist.

Note:

This program does not provide means for assuring the radiation safety of staff or patients. A separate radiation safety program is essential in every radiological facility under the direction of a qualified expert in radiation protection as specified by the Joint Commission on Accreditation of Hospitals which requires that the Recommendations of the National Council on Radiation Protection and Measurements be known and adhered to by the hospital.

B. Room Log

An individual equipment log should be maintained on each x-ray unit in a facility. This equipment log must be kept at some convenient location where anyone using the facility (physicians, technologists, physicists, service engineer, etc.) can get ready access. The log should contain;

1. Equipment Data Specifications
   a. Technical specifications, including tube loading charts.
   b. equipment operating instructions.
   C. Detailed identification of major components of the system including name, serial number, and date of installation.
2. An outline of the applicable quality assurance program.
3. A log of the quality assurance test results.
4. A record of service on the equipment including a description of system malfunctions and description of what service was carried out. The service record should also include identification of the individual performing the service and the date.

C. Recording Test Data

All quality assurance test data should be recorded on standardized forms. Examples of such forms are given in the appendix. It is suggested that each institution develop its own forms suitable to its own needs.

1. The use of standardized forms will assure that all of the required data will be obtained.
2. Forms should be filed as part of the room log.
3. The charting of trend data is a recommended procedure which will allow easy identifications of variation with time. This is of particular value in the case of film processors.
4. Where possible, 8in x 10in (20cm x 25cm) film should be used for these tests using film to facilitate storage in standard size notebooks or files.

D. Condition of the X-ray Facility

1. Mechanical integrity: A general observation of the diagnostic system should be made. Key items to look for are the presence of loose or absent screws, bolts, or other structural elements that may have been improperly installed or have worked loose due to use. The functioning of meters, dials, and other indicators should be checked. The operation of pilot lights that are often necessary to observe equipment functions in a darkened examination room should also be checked.

2. Mechanical stability: To obtain a diagnostic quality radiograph it is important to minimize patient motion. Of key importance from the equipment side are the stability and stiffness of the x-ray tube hanger and image receptor, (i.e. table Bucky or wall mounted cassette holder.) The availability and adequacy of patient support devices such as the table or immobilizing devices should also be checked. In addition it is important to check the reproducibility of positioning of the source and image receptor that may be indicated or controlled by physical marks or detents. A check of the accuracy of angulation scale should be made. As part of the check of structural stability an inspection of the electrical and/or mechanical locks on the machine should be carried out.

3. Electrical integrity: The external condition of the high voltage cables should be observed. Check to make sure that the retaining rings at the termination points are tight and that there are no breaks in the insulation. It is important to observe the "lay" of the cables. If they do not hang properly they can interfere with positioning of the tube and may fail prematurely.

4. Electrical safety: The system should be checked by a safety engineer. This involves a physical inspection of the electrical wiring. Key areas where problems often occur include the power cord to light indicators in the beam limitation system, the wires to the exposure hand switch, and other similar power hook ups. Verify that all elements are well grounded (to each other and to the ground).

5. Alignment and SID: Source to image receptor distance (SID) indicators should be checked. The consistency between multiple SID indicators (indicators on the tube support and the collimator) should be verified. The accuracy of these indicators should also be verified with a tape measure. Verification of proper grid installation should be made. This check should also include a verification of the alignment of the x-ray source and the center of the grid. (More specific tests of grids are outlined elsewhere in this report).

E. The Radiograph as a QA Tool

The goal of a diagnostic quality assurance program is to produce radiographs of consistent high quality. Patient radiographs are in turn a quality control check and should be factored into any departmental evaluation program. It also must be kept in mind that the diagnostic radiograph should not be relied on as the only quality control check since acceptable radiographs can be obtained when individual elements in the system (generator, image receptor and processor) are operated outside acceptable limits. For example, compensation for inadequate film development can be corrected by unacceptable increases in exposure.

1. Rejected films: Unacceptable radiographs can result from a variety of factors that include patient motion, positioning error, improper technique selection and equipment related problems. A review of the rejected films should be made on a periodic basis to identify the magnitude of the problem and to determine the cause. The methodology and results of a retake study carried out in two large hospitals has been published by the Bureau of Radiological Health (1).

2. Accepted films: Good practice should always question the adequacy of radiographs of less than optimal quality for their acceptability in making a diagnosis. Repeating a procedure to get a film of optimal quality is often not necessary and should be evaluated in terms of the radiation exposure and cost of the retake. Since one should expect to find films of less than optimal quality in a departmental file, an analytic review of these films should be made on a regular basis. Some of the key indicators that may be a signal for the need for some QA action include static marks, contrast changes and streak marks. Many other items may also be indications of less than adequate system performance. A few examples are given below.

   a. The necessity to change technique factors may indicate changes occurring in the x-ray system or the development stage. In facilities with more than one x-ray unit the source of the problem can often be isolated by seeing if the change is required on all the x-ray systems where the development process would be in question or for a single unit where the generator would be suspected first.
   b. Changes in the appearance of bone or the image contrast in studies where iodine base contrast media is used often indicates a shift in tube potential.

C. Excessive base fog in areas covered by film blockers may indicate improper film handling and/or storage.
d. Asymettry of borders of collimated images

IV. Quality Assurance Tests

The following sections describe the quality assurance tests proposed for use by radiologic technologists. Certain tests should be done daily; e.g., checks of film processing, image focus in a special procedures room. Many tests should be done on a routine or scheduled basis to be certain that changes in performance, not detected in the routine use of the apparatus, are noted so that corrective actions can be taken.

A. Film Processor Monitoring

1. Definition: Variations of chemistry (contamination, oxidation, replenishment), temperature, agitation and other factors will cause variations in the quality of processed film. Many of the variables change slowly so that daily monitoring of processor performance and plotting the results can be used to initiate corrective actions before the radiographs have decreased in diagnostic quality.

Since it is normal for x-ray generators to vary in output as much as 10% from a mean value and since the high contrast of x-ray films amplifies this variation, the use of x-ray test films i.e., wedge films, as a processor testing means is not recommended. Instead, a regulated sensitometer is used to expose a test film in the same area, the film processed at the same time each day and the operating temperatures are recorded. Additional tests are referenced in 2 and 3.

2. Test Equipment Required

a. Regulated sensitometer
b. Densitometer having a regulated self-contained light source.
c. Stainless steel stem dial thermometer readable to within l°F.
d. Reserved box of 8in x 10in (20cm x25cm)x-ray film used in the department

3. Test Procedure: Expose the film in the sensitometer and process with the exposed edge first into the processor. Use the densitometer to read the densities of the grey steps and the clear area along the strip 2 cm past the darkest step. Record the density of the step just below D = 1.0 (use the same step in subsequent tests) as "density" and that of the clear area as "fog". Record the inlet water temperature on the water regulator. Open the processor and use the stem thermometer to read the temperatures of the developer and wash water. Plot on a processor control chart for each month.

When the reserved box is down to 5 films, start a fresh reserved box and obtain overlapping density data for 5 days. Thermometers should be checked by the hospital pathology laboratory. The densitometer should be checked periodically using the density test filter supplied by the manufacturer. Because sensitometers vary, the same sensitometer must be used for all tests.

4. Evaluation of Results: It is assumed that the processor has been recently cleaned and set up using the manufacturer's instructions and has stabilized. Variations of inlet water temperature are of

two types: fast (transient variations of several seconds) and slow (several minutes). The fast variations should be less than ±5°F of the average. The average should be ±2°F of the manufacturer's recommended value. The developer temperature must be ±l°F of the manufacturer's recommended value. The wash temperature should be +0,-5° of the developer temperature. The density variations must not exceed ±0.1 and the fog level must not exceed 0.3 for slightly tinted base, films or 0.25 for other films. Random variations of both density and fog may indicate light leaks. Temperature values shown may be different in certain cases. Check manufacturer's data sheet.

Variations caused by temperature shifts may be compensated by adjustment of the thermostats. Temperature surging may be corrected by adding line pressure regulators, pressure equalizing valves, reserve tanks (i.e. a small 10 gal. hot water heater). Clogged water filters will also affect the operation of the processors. Small variations of the control chart may be compensated by adjustment of replenishment rates. Larger variations outside of acceptance limits should be corrected by dumping, cleaning and recharging the processor since contamination effects are not reversible.

B. Overload Protective Circuit Test

1. Definition: Many x-ray generators have circuits which prevent the operator from exceeding the ratings of the tube. System power capability is determined by setting to the maximum mA for a 0.1 second exposure at 80 kVp. This power may be limited by the tube rating. System power is important since it determines the minimum exposure time for a given mAs. It thus has a direct relation to patient motion. A check of system power also insures proper functioning of the tube protector and assures that the tube will not be damaged by accidental overloading. The set-up of the tube protective circuit involves a trade off between tube life and exposure time. A setting well below the tube power rating will increase exposure time. A longer exposure time results in increased motion unsharpness. This test does not work for falling load generators.

2. Test Equipment Required: Tube rating chart.

3. Test Procedures:
   a. Select a tube-focal spot combination (separate test for each).
   b. Set the timer for 50 ms (l/20 sec.).
   C. In 20 kVp increments, from the minimum kVp to the maximum kVp of the generator, determine the maximum tube current at which an exposure is possible. This is done by increasing the current settings until the "overload" of "exposure lockout" indicator appears. The current setting immediately below the "lockout" condition is the "maximum permitted tube current." Record the value of current.
   d. Reset the timer to 100 ms (l/10 sec.) and repeat step b.
   e. Reset the timer to 1 sec. and repeat step C.

f. Reset the timer to the maximum available time and repeat step C.
g. Select a different tube-focal spot combination and repeat steps b-f.
h. If applicable, select "high speed" rotation and repeat steps a-g.
i. If serial or cine radiography is present, select an appropriate program and repeat steps a-h.

4. Evaluation of Results: From the tube ratings, determine the maximum allowable tube current for each tube, focal spot, kVp and time combination selected above. The "maximum permitted tube current" should not exceed the maximum allowable tube current (obtained from the ratings). Due to the nature of equipment design, the "maximum permitted tube current" may be up to 30% less than the single exposure ratings for single exposure settings, and up to 50% less than the single exposure ratings for serial settings. The "maximum permitted tube current" may be up to 20% less than the serial exposure ratings for serial settings. The actual acceptance current limits must be modified in many cases because most generators have discrete mA settings (eg. 50, 100, 200, 300 . . ..mA see attached data sheet)andcontinuous.adjustments of kVp.

Note: It is possible to have a tube-generator combination in which the low rating of the generator limits exposure techniques.

C. Exposure Time

1. Definition: This test procedure describes the use of a spinning top to determine the accuracy and the reproducibility of the timer settings on single phase, three phase, and constant potential radiographic x-ray units. For the purposes of this test procedure, accuracy will mean the degree of agreement between the measured and indicated time values. Reproducibility will mean the degree of agreement between several measurements of the exposure time at the same indicated time on the x-ray control panel.

The accuracy and reproducibility of the timer stations on diagnostic x-ray equipment are important because they directly affect the mAs and hence the amount of radiation emitted. Poor timer reproducibility will result in erratic radiographic results which may be attributed to other causes. There are three basic types of tops used for determining x-ray exposure time: manually energized tops, manually energized synchronous tops, and synchronous motor-driven tops.

The manually energized top, the classical spinning top, is a metal (usually brass) disk with a hole or slit. If it is spinning while radiographed using a single phase x-ray generator, the resulting radiograph will show a distinct black dot for each l/120 second pulse of the x-ray unit. Counting the number of pulses delivered in the test exposure yields the measured exposure time.

SAMPLE

Tube A Serial 1234 Focus lmm Std Speed

kVp	TIME	MPTC*	MATC**	MPTC/MATC
60	1/20	500	500	1.00
	1/10	500	500	1.00
	1	400	400	1.00
	5	150	180	0.83
80	1/20	500	500	1.00
	1/10	400	450	0.89
	1	300	300	1.00
	5	100	135	0.74 (1)
100	1/20	500	420	1.19 (2)
	1/10	400	360	1.11 (2)
	1	150	180	0.83
	5	100	110	0.91
125	1/20	500	360	1.39 (2)
	1/10	150	275	0.55 (3)
	1	100	200	0.50 (3)
	5	N.A.	90	N.A. (4)

* Maximum permitted tube current (measured)
** Maximum allowable tube current (from ratings)

(1) Low but acceptable due to generator limitation
(2) Too high to be acceptable
(3) Too low to be acceptable
(4) Acceptable due to configuration of generator controls

The manually energized top will not measure exposure time on three phase or constant potential x-ray units since the resulting radiograph of the hole or slit would show a solid arc. However, if the top were rotating at a known speed, then the angle defined by the arc would be directly proportional to the exposure time. A top which rotates at a known speed at the time of exposure and which can be used to measure exposure time on all types of x-ray units is referred to as a synchronous top. The manually energized synchronous top is spun by hand and its rotational speed is known by observing the repetitive pattern on the upper surface of the top. When viewed with fluorescent lighting, a specific pattern will appear to freeze at a specific rotational speed. The motorized synchronous top operates at constant rotational speed.

2. Test Equipment Required
   a. Synchronous top
   b. Lead blocker sheets to permit exposing the cassette one region at a time.
   c. Stepwedge (6 levels of 8mi1(0.2mm) Cu).
   d. Cassette

3. Test Procedure: Using 80 kVp, determine the mAs and distance for your film-screen-processing combination needed to produce a useful radiograph of the synchronous top on the x-ray unit to be tested. Record these on the data sheet for future reference.

   a. For motorized synchronous tops only: Plug top into electrical socket and ascertain that it is functioning.
   b. Place the synchronous top and optional step wedge in region 1 and cover the unused portions of the cassette with the lead blockers.
   C. Select appropriate distance and adjust the collimator so that the beam dimensions just exceed the dimensions of the region in use.
   d. Select the timer setting to be tested and record this time on the data sheet under the column marked "Indicated Time" and across from the number of the region currently in use. Then set 80 kVp and the mA necessary to approximate the previously determined mAs for this unit.
   e. For manually energized synchronous tops only: Place the top on the cassette, cause the synchronous top to commence rotating and observe from the control booth until desired rotational velocity is achieved.
   f. Make the exposure.
   g. Move the top to the next area of the cassette: Repeat the appropriate steps a through f for different time values until all the regions of the cassette have been exposed. If possible, all exposures should be made at the same value of mAs when the step-wedge is used.
   h. Process the exposed film.
   i. On the processed radiograph, immediately record the date and room number, and transfer the indicated times from the data sheet to the corresponding regions on the radiograph.

4. Evaluation of Results (Radiographic Measurement): For single phase x-ray units, count the number of black dots on the radiograph and divide this number by 120. For three phase and constant potential x-ray units, use a protractor to measure the arc.* Divide this number by the product of the rotational speed in revolutions per second (rps) and 360 degrees.

$$\text{Measured exposure time} = \frac{\text{(measured angle)}}{360 \times \text{Rev. per sec.}} \text{ sec}$$

For example: If the measured angle was 18 degrees (l/20 of circle) and the rotational speed for this measurement was one revolution per second, then the measured time in seconds is calculated as follows:

$$\text{measured exposure time} = \frac{18}{360} = 0.05 \text{ sec}$$

Some manufacturers include a transparent template which eliminates this calculation and automatically accounts for rotational speed. Regardless of how the measured exposure time is determined, record it on the data sheet in the appropriate column.

Single phase equipment must operate within the range given below. Step starting of the x-ray contactor or core biasing circuits may generate an additional, low-amplitude pulse which should not be counted. Three phase equipment should operate within the time range indicated. Data may be recorded as "pass-fail" for routine testing of several timing stations. When circuit instabilities are suspected, a number of tests at the same timing station may be made and a statistical analys can be done. If tests at several timing stations are made at the same value of mAs, then the images of the step wedges should appear the same in all exposures if both time and mA settings are correct (see Test IVD).

ACCEPTABLE LIMITS

10	l/120 to l/15 sec	Exact Count of Pulses
	l/10 to l/5 sec	+l pulse
	l/4 to l/2 sec	+2 pulse
	greater than l/2 sec	+5%
30	less than 10 ms	+l ms
	10 ms to below 50 ms	+2 ms
	50 ms to below 100 ms	+4 ms
	100 ms and above	+5%

* Some tops have more than one slit and overlap of the dots or arcs occur. If t is observed, count or measure from the beginning of one overlap (double exposed) region to the end of the next. Subtract the width of the slit when measuring the angle for 3 phase systems; e.g., actual angle of 20°, slit equivalent to 2°, arc

Note: When using the manual tops, an additional tolerance of 5%± 1 ms should be used. Certain generators, while having independent settings for mA and time, actually use mAs timing. Such circuits set an approximate value of mA and terminate the exposure when the required mAs have been delivered. In the above test, time values may thus be outside of the bounds but the step wedge images will appear uniform. If this occurs, check with the equipment manufacturer. For such equipment, measured time values must be within ±25% of indicated values.

D. mAs Reciprocity

1. Definition: If the time values of exposure are correct and if the mA settings are within calibration limits then exposures of the same mAs value should yield the same film densities. If the preceding test confirmed the correctness of the time values then the images of the step wedges should be the same for each exposure. This test may be done concurrently with IVC above by exposing the step wedge with the top. Many test tools incorporate both the top and the wedge in the same assembly.

2. Test Equipment Required

a. Synchronous top with 6 step (8mil- 0.2mm) copper stepwedge.
b. Lead blockers
C. Cassette

3. Test Procedure: Use the procedure of the preceding test (I.V.C.) using constant mAs values for at least three exposures. One exposure should be taken close to the mA value most often used, and one exposure at a lower mA value and longer time to permit reading the actual mA if the generator incorporates a panel meter.

4. Evaluation of Results: Confirm the correctness of time values as in IVC. Compare the density of the middle copper step of each wedge image to the others. Normal variations of density will be less than one step. Thus, if the density of step three of the first exposure exceeds that of step four of the second exposure, one or both of the mA settings of the machine may be out of calibration.

E. Peak Tube Potential - kVp

1. Definition: This test provides a measurement of the peak electrical potential across the x-ray tube when it is operating.

a. The x-ray tube kVp is most critical. A small error of this variable will have a greater effect on the final radiographic or fluoroscopic image than will an equivalent variation in any of the other parameters such as tube current (mA), exposure time, target film distance. The x-ray intensity reaching the image receptor after the beam

passes through the patient varies approximately as the fifth power of kVp. The kVp affects not only the intensity reaching the image receptor but also the subject contrast of the image.

b. Variations between indicated and actual kVp occur for several reasons:

   i. The x-ray generator was not set properly upon installation;
   ii. Excessive power line voltage drop;
   iii. Tube current drifts have changed the voltage drop across the high voltage transformer secondary. The tube voltage has changed even though the primary voltages have remained constant. (Line voltage compensator circuits must be set properly.)
   iv. Component failure.

2. Test Equipment Required: This test uses a modified form of the kVp test cassette described by Ardran and Crooks[4,5,6]. The test cassette first reduces the low energy content of the beam by means of a copper filter. The beam then goes through two columns of holes in a lead mask to an intensifying screen where the light from the screen exposes the test film. In front of one column of holes is placed a copper step wedge. Behind the screen of the second column is placed a 3:l optical attenuator (neutral density filter). Matching the film density of the images of pairs of holes, one of each column, determines the third-value layer of copper attenuation which is used to estimate the effective kVp of the beam. The accuracy is quite high and much better than from that of the "mini-wedge".

   Two types of cassettes are available: one having a single pair of columns (centered at 80 kVp) for routine measurements, another available for four or more pairs of columns centered at various kVp values ranging from low values (mammo) to higher values (chests). These cassettes estimate the effective value of kVp and are calibrated in terms of generator indicated kVp.

3. Test Procedure:

   a. Load the cassette with a fresh film.
   b. Position the cassette in the x-ray field at the recommended distance from the x-ray source.
   C. Set the proper technique on the x-ray control: kVp to be measured, mA station at which measurement is to be made, exposure time necessary to provide manufacturer's recommended mAs. The mAs may be adjusted to obtain proper mean film density from 0.5 to 1.5 without affecting kVp accuracy.
   d. Make the exposure. (Multiple exposures, one for each kVp column).
   e. Process the film.
   f. Examine the film on a view box to determine the copper thickness for which there is a density match. The use of a densitometer is recommended for highest precision, interpolate between steps for accuracy.

g. Routine single tests should be done at 80 kVp at one of the higher mA stations.
h. Record the match step. (Save the test film).
i. Determine the kVp from the calibration curve for the voltage waveform used (single or three phase). Record the kVp measured, and the kVp, mA, sec. and TFD set.

4. Evaluation of Results

a. The measured kVp should be within ±5 kVp of the set value between 65 and 95 kVp, for all mA stations which are used.
b. If the kVp is too high or too low:
   i. Check that the line voltage compensator is set properly.
   ii. Check the mA value with the panel meter on long exposure time (~0.5 sec.). If this has drifted, have it re-set. If not, have the primary voltage re-set to bring the kVp to within acceptable limits by a qualified serviceman using a high voltage divider.

F. X-Ray Output and Beam Quality

1. Definition: The output and beam quality are evaluated using a fixed and reproducible geometry. The output of a system may change as a result of component failure, absence of a required filter, drift from calibrated values or other causes. The beam quality test verifies that the half-value layer is sufficient to reduce patient exposure to low-energy radiation and assures that filters, which may have been removed for mammography or tube inspection, are in place for normal radiography.

2. Equipment Required

a. Radiation detector (low energy), either a direct-reading pocket dosimeter or an ionization chamber with no active area dimension greater than 3 inches and having a suitable means for reading exposure.
b. Distance-measuring device such as common tape measure.
c. Aluminum (1100 alloy) sheets; 5 @ 4in x 4in x .04 (10cm x 10cm x 1 mm).

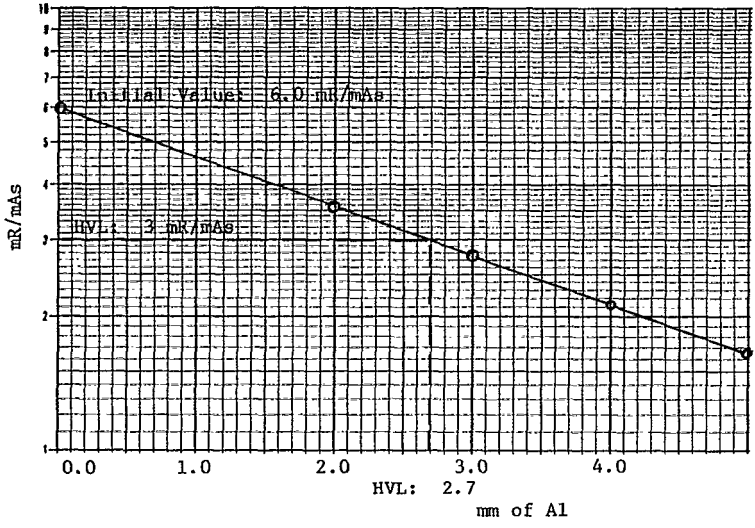
3. Test Procedure

a. Center the x-ray source assembly over the table.
b. Position the tube 100 cm above the table top using the system scales. Verify using the tape measure.
c. Adjust the x-ray field to approximately 6in x 6in (15cm x 15cm tabletop.
d. The radiation detector is zeroed and placed in the center of the x-ray field on the tabletop.

e. At 80 kVp, adjust the mAs to give approximately 2/3 full scale reading on the radiation detector. This may require experimentation to get the required exposure reading. Record the technique factors (mA and time) and mAs.
f. The exposure in mR is read from the detector and recorded. Repeat for a total of three exposures and record the average.
g. Two pieces of aluminum 1.0 mm thick are taped to the face of the collimator to intercept all of the x-ray field.
h. The radiation detector is zeroed and placed in the center of the x-ray field on the tabletop.
i. The radiation detector is exposed (one exposure). The exposure with filter is recorded.
Repeat for a total of three exposures and record the average.
j. Repeat for 3.0 mm total, 4.0 mm total, and 5.0 mm total.

4. Evaluation of Results

a. Output for single phase machines should be about 4.0 ±1.5 mR/mAs (divide dosimeter mR by exposure mAs in step 3f) and about 6.0 ±2 mR/mAs for 3 phase machines. High or low values may indicate too little (see b below) or too much aluminum filtration, a defective tube anode or miscalibration.
b. Plot the results of steps f and j as output in mR/mAs vs thickness of aluminum added. It is required for all systems that 2.3 mm Al reduces the beam by less than 50% at 80 kVp, i.e. the HVL is greater than 2.3 mm Al. In practice, most single phase machines will exceed 2.7 mm Al HVL and three phase machines will exceed 2.9 mm. The results of this test are valid only if test IV-D (kVp) yields acceptable results.



G. Light/X-Ray Field Congruence of Collimators

1. Definition: The purpose of the collimator light field is to allow simulation and visualization of the size, shape, and location of the field. It is important that the light field be approximately congruent to the x-ray field. Light/x-ray field misalignment may be caused by shifts in the relative positions of the light bulb filament and anode focal spot. Such shifts are caused by differences between light bulbs, shifts of mirror position, or shifts of collimator position on the tube head. This test radiographs metal strips or pennies having a known position in the light field.

2. Test Equipment Required

   a. 4 each - l/16in x lin x 3in (1.5mm x 2.5cm x 7.5cm steel strips or 9 pennies or commercial alignment test tool.
   b. 1 loaded 14in x 17in (35m x 43m) film cassette for the initial test and 8in x 10in (20cm x 25cm)for subsequent routine tests.
   C. Common tape measure.

3. Test Procedure - Initial Test

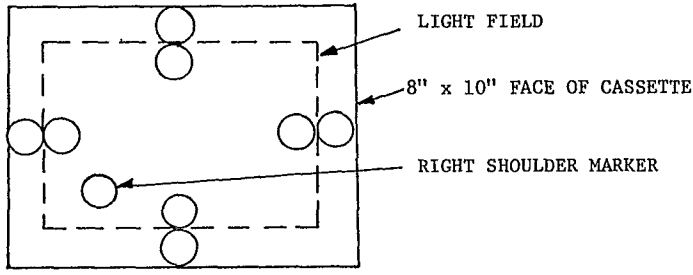
   a. Position the x-ray source over the tabletop so that the indicated distance from the source to the tabletop is 40" (100 cm) and locked in position. Verify using the tape measure.
   b. Adjust the x-ray field size 12in x 15in (30cm x 38cm)field at the tabletop. If the system is automatically collimated, switch to manual mode. Check visually to verify that the collimator face (glass or plastic) is clean and transparent. Some collimators use a plastic filter equivalent to 1.0 to 2.0 mm Al as the faceplate. These filters often turn brown and must be replaced. Other units use thin sheet plastic as dust or safety covers and these must be intact or else replaced.
   c. Turn on the collimator light. If necessary, dim the room light so that the edges of the light field are easily seen.
   d. Place the loaded 14in x 17in cassetteon the tabletop and center it in the light field.
   e. On top of the cassette, in the middle of each side of the light field, position one of the four metal strips so that the outer edge of the 3inside of the strip is parallel to, inside and at the edge of the light field.
   f. A penny is used at the right shoulder position of the cassette to give the orientation of the field on the film.
   g. Make the exposure to give a medium density (D = 1.0, about 60 kVp, 5 mAs).
   h. The film is then developed.
   i. The image is evaluated for misalignment of the x-ray and light fields.

4. Test Procedure - Routine Test

   a. Position the x-ray source over the tabletop so that the distance from source to tabletop is 40in(l00 cm). Inspect the collimator as in 3b.

b. Place the loaded 8in x 10in cassette on the tabletop. Position the 9 pennies, center the cassette, and adjust the collimator so that the light field is as shownbelow.
c. Make the exposure to give a medium density (about 1.0 typ. ex. - 60 kVp, 5 mAs).
d. Develop and inspect the film. Save the film for comparison in future tests.

5. Evaluation of Results: For the initial test, the misalignment (the horizontal misalignment is defined as the sum of the deviation of right and left edges, vertical as the sum of the deviation of the top and bottom edges) must each be less than lin (2.5cm). For the routine tests, the deviations should be less than ±l/2 the diameter of the penny at any edge and must be less than ±1 the diameter of the penny. Commercial alignment fixtures are made with markers indicating pass-fail beam limits



H. Automatic Collimator Field Size

1. Definition: Automatic collimation systems should set the collimator so that the x-ray beam does not significantlv exceed the dimensions of the cassette used. When different cassettes or focus to film distances are used, the automatic system must either set the collimator appropriately or lock out the exposure until the field size has been adjusted to be equal to or less than the cassette size. This test describes a simple test for overhead tube-table bucky systems and which, with simple modifications, may be used to check chest systems as well.

2. Test Equipment Required

a. Loaded 14 in x 17 in (35cm x 43cm) cassette.
b. Empty cassettes, one of each size used in the system.
C. Copper sheet, 6in x 6 in l/16 inch (15cm x 15cm x 1.6 mm).
d. Foam plastic spacers, 2in x 10 in (5 cm x 25cm x25cm) or in largera
e. One penny.

3. Test Procedure: Set the tube so that it is centered and locked 40 in (100 cm) over the cassette tray. Measure or estimate the distance between the tube side of a cassette in the bucky tray and tabletop. Place the loaded 14in x 17in cassette on the tabletop and over the spacers such that its tube side is 4in (10cm) over the surface of the cassette in the tray. Place the penny in the patient right shoulder position. (For certain tomographic units and table systems of larger film tabletop spacing, use 8in (20cm) distance between the front surfaces of the two cassettes.) Use the collimator light field in the manual mode to center and orient the 14in x 17in cassette. Tape the copper place to the face of the collimator and return the system to the automatic mode. Set the generator to 80 kVp and 10 mAs (adjust kVp for central final density of about 1.5 for series of exposures). Without moving the 14in x 17in cassette, make an exposure for each orientation of each empty cassette used in the bucky tray. Use the 14in x 17in cassette in the bucky tray in the orientation as the tabletop cassette. Do not exceed six exposures on any test film; use a second or third test film if required. Develop the test film and repeat if necessary to adjust for visibility of all exposed image formats. Tests may be repeated for different focus-film distances.

4. Evaluation of Results: Because the loaded cassette was 4in above the cassette in the bucky tray, the formats seen in the test film will be 90% (each dimension) of the formats of the actual film (80% in the case of 8 in spacing). Measure each format size and divide each dimension by 0.9 (or 0.8 for 8in spacing) and record. These values should be equal to the cassette dimensions +3/4in (1.9cm) - 1/4in (0.6cm) The center of each of the formats should be +1/2in (1.3cm) of the center of the film.

I. Fluoroscopic Collimator Field Size

1. Definition: This test measures the x-ray field size so that it is not larger than necessary to prevent unnecessary exposure to patients and medical staff. The x-ray field should be restricted so that at any source to image receptor distance, the field does not exceed the useful area of the image receptor by more than a few percent. The field must also be centered to minimize attenuation by the grid.

2. Test Equipment Required

a. 4 each- lin x 3in x 1/16in (2.5cm x 7.5cm x 1.5mm) steel strips.
b. 1 - 8 in x 10 in (20cm x 25cm) or 9in x 9in (23cm x 23cm) loaded cassette
C. Stack of 8 sheets of Masonite 12in x 12in x 1/8in (30cm x 30cm x 3mm) or 2 type 1l00E aluminum plates, 7in x 7in x 3/4in (18cm x 18cm x 1.9cm)
d. One penny.

3. Test Procedure

a. Check the fluoroscopic image receptor to confirm that it is coupled to the under table x-ray source so that movement of the image receptor results in movement of the tube. The

system should prevent an exposure unless it is properly locked.

b. Lower the image receptor to the minimum distance above the tabletop and open the x-ray field collimators to the maximum radiation field size.

c. Place the Masonite stack or aluminum plates on the table and place the metal strips on top in contact with each other to form a "+" sign. The Masonite or aluminum protects the image receptor from excessive exposure.

d. Center the fluoroscopic image receptor over the metal strip array by observing the image on the viewing system and lock in position.

e. Move the individual strips outward (with radiation off) until the inner edge of the metal strip is barely visible on the viewing screen when the radiation is on. Place the penny in the right shoulder position of the field to identify the orientation of the field on the film.

f. Place the loaded cassette on top of the metal strips. This placement must be done carefully so as to not move the metal strips.

g. A fluoroscopic exposure is made on the film by timing for about 5 seconds at 1 to 2 mA at about 80 kVp or in the automatic mode (brightness stabilized). The exposure should product a medium density on the film (density between 0.7 and 1.5). This may require some experimentation on a particular unit to give the desired exposure. This exposure must be done in the fluoroscopic mode (not spot film), because some spot film systems automatically adjust the x-ray field collimator below the tabletop.

h. Process the film.

4. Evaluation of Results: Older systems, using a manual shutter control should limit the field to about +l0-0% of the field diameter of a 9" image intensifier to permit full exposure of a 9 x 9 or 8 x 10 inch spot film. Thus, the radiograph must not show more than l/2 inch of any of the steel strips when the test is done with the image tube as close as possible to the table. Automatic collimating systems should not show more than l/2 in (1.25cm) of any of the steel strips for any vertical position of image intensifier. Better grade systems should also compensate for modes (magnification) of the image intensifier. The images must also be centered to ±1/2 inch to assure proper use of the grid.

   The test may be repeated with the image receptor at the mid-point distance and at the maximum distance of the table top and for the various image intensifier field sizes (4, 6, 9, etc.) to verify tracking of the automatic collimation system.

J. Grid Alignment

1. Definition: The grid uses thin metal strips, usually lead, arranged so that the primary x-ray beam is parallel to the short axis of the strips. Secondary radiation will be intercepted by the strips and the spacer material while the primary; radiation is impeded a lesser amount by the spacer material alone. The grid ratio, the relation between the short axis of the strips and the space between them, ranges from R4 to R16 and determines the degree of alignment necessary. Misalignment

greater than 14° for R4 to 3.6° for R16 grids will result in maximum attenuation of the primary beam. Misalignment of l° in the R16 grid results in unnecessary primary attenuation of about 20%. Similarly, misalignment of 6° in an R4 grid results in an unnecessary loss of 20% in the primary beam. A shift of tube position along the long axis of the strips will have almost no effect on primary attenuation. A careless installation where the x-ray tube is mounted off-center by 2° (only l-3/8in (3.4cm) of the 40in SID) of the Bucky, may raise patient exposure by as much as 30%.

2. Test Equipment Required

a. Stack of 16 Masonite sheets, 12in x 12in x l/8in (30cm x 30cm x 3mm) or copper sheet 6in x 6in x l/l6in (15cm x 15cm x 1.5mm).
b. Plumb bob and line or bulls eye (commercial test tool) or vertical pin test tool. The vertical pin test tool is made by driving a long nail (4in (10cm) or more) into the center of a 12 x 12 x l/8 Masonite sheet. Use a carpenter's square to make sure the nail is at 90° all around.
c. Lead marker or penny.
d. Liquid level (single bubble preferred).
e. Carpenter's square.

3. Test Procedure

a. The basic test method is to take three or more test exposures fixed (not phototimed) of the Masonite stack using the same cassette. Alternatively, the copper sheet may be taped to the collimator face after setting field size to eliminate the Masonite stack.
   i. With the tube at the assumed correct position and 40in (100 cm) from the cassette.
   ii. With the tube 1in (2.5 cm) off axis in one direction at right angles to the grid lines.
   iii. At 1in off axis in the other direction. The three exposures are examined and the central image must be most dense. The exposure factors should be 80 kVp and about 10 mAs (adjust mAs for density of '0.8 to 1.5). It will probably be necessary to temporarily disable the exposure interlock (centering switches), or to operate automatic collimators in the manual mode.

b. Another method to test Bucky grid alignment uses the lead marker or penny taped at the center of the grid (On the centerline marker of the grid) and the testtool. The test tool is placed on the table and positioned so that the pin or nail casts no shadow (exactly centered) when the light beam localizer is used. A radiograph (as before, 20in, 80 kVp, 10 mAs) should show the shadowless image of the pin on the centerline of the grid (draw a line parallel to the film edges through the marker image).
c. If the tabletop can be tilted or slid out of the way, a visual inspection to verify alignment of the table grids may be done using a plumb bob and theliquid level. The plumb bob line may be taped to the circular end of the tube housing, along the vertical diameter and suspended over the grid. The liquid level should be centered. The plumb bob should be on thecenterline when level.

In tomographic systems, the relative motions of tube and grid must always result in the tube remaining aligned with the grid center line marker, check for excessive play in the grid mechanism.

d. Film changers should be checked with a common carpenter's square placed against the grid centerline and sighted along the right angle edge to verify aiming to within 1in (2.5cm) Of the center of the face of the collimator (use plumb line).

K. Bucky Grid Centering

1. Definition: This test provides a means of determining whether the reciprocal motion of the Bucky grid is centered to the film and to the central ray of the x-ray beam. To avoid grid cutoff, evidenced as reduced density and decreased sharpness of detail on one side of a radiograph, it is essential that the cross-table alignment of the x-ray tube, film and Bucky be perpendicular and all components centered to the film. Radiographic evidence of Bucky motion decentering is indicated when a 14 x 17 radiograph of the pelvis shows one hip satisfactorily exposed with good detail and the other underexposed with reduced detail sharpness.

2. Test Equipment Required

a. Stack of 16-12in x 12in x l/8in (30cm x 30cm x 3mm) tempered Masonite phantom, lead markers or coins.

3. Test Procedure

a. Place Masonite phantom on x-ray tabletop and center to simulate the absorption of a pelvis.
b. Place lead markers on the phantom to indicate center and right and left sides.
c. Make a 14in x 17in (35cm x 43cm) radiograph of the phantom using pelvis exposure time and mA but reduce kVP about 10 from usual factors.
d. Process the radiograph.

4. Evaluation of Results

a. When the radiograph is viewed, film density should be uniform on right and left sides of the radiograph. Some small density difference top to bottom of the radiograph should be expected due to heel effect.
b. If gross density differences are seen between the right and left sides, repeat the test making certain that x-ray tube, film and phantom alignment are correct. If gross density differences right and left are seen again, this may indicate that Bucky motion is not symmetric about the central axis of the x-ray tube and film.

5. Additional Diagnostic Test: If asymmetric grid motion is suspected, an additional test may be made. Remove the grid from the bucky, and tape a lead number "1" to the center of the grid with the long axis of the "1" parallel to the long axis of the grid. Replace the grid. Place a lead "0" at the table, center of the beam indicated by the collimator light or table center marker. Make an exposure at the l/2 second time, at kVp and mAs settings such that a medium film density results. The extreme edges of the bucky travel will produce an outline of the lateral movement of the lead number "1". If the cross-table alignment of the central ray is centered to the bucky grid, then the image of the number "1" will be centered to the image of the "0". Lack of cross-table alignment will be apparent.

L. Focal Spot Size

1. Definition: The ratings of an x-ray tube arc limited by the thermal properties of the anode and the geometry of the cathode structure. Generator controls usually limit the single exposure power level while other protective circuits may limit the power to the tube during the multiple exposures of angiography or cineradiography. However, taking two pictures in rapid succession (single exposure ratings) or a jammed film changer may cause the system to operate beyond ratings. Operation at low kVp and high mA or holding the tube in a boosted mode too long may strain the filament. On occasion, tubes may not be identified properly.

   This test is not the same as the pinhole test. This test uses a metal pattern of eleven or more pairs of three bar patterns. The bars are slots in a metal mask and vary in spacing from 0.6 to 3.35 line pairs/mm or more. The bar pattern is used as a radiographic test object and images may he readily correlated to radiographic capability.

2. Test Equipment Required

   a. Focal Spot Test Tool consisting of a suitable bar pattern mounted in a 6in (15 cm) test stand.
   b. Dental Film (Kodak DF 42) or radiographic film in a cardboard cassette, non-screened.
   c. 18in (46cm) scale
   d. Aluminum plate 7in x 7in x 3/4in (l8cm x 18cm x 1.9) 1100 alloy.

3. Test Procedure: Center the focal spot of the tube l8in (45cm) above the bar pattern using the distance tape or measure 18 in (45 cm) from a point l-1/2in (3.8cm) from the center of the tube head cylinder (estimated position of the focal spot). Place the tool over the non-screened film. Use the

collimator light beam to center and confine the field to the top of the tool. Set the factors to 80 kVp and 5 to 10 mAs and expose for both focal spots, moving the film between exposures. For fluoroscopic systems, the test tool (face down) may be viewed on fluoro and shutters adjusted to display only the pattern. Place the aluminum plate on top of the base of the test tool and fluoro at 80 kVp at 1 mA. Then place the non-screened film between the aluminum plate and the base of the test tool. Expose for 5 to 10 sec. (small focus). Use an empty spot film cassette, set to 80 kVp, 5 to 10 mAs, move the film and expose (large focus). Develop the test film.

4. Evaluation of Results: A group of three bars is said to be resolved when exactly three bars can be seen clearly on the film. Both of the right angle groups must be seen clearly to be resolved. The following table lists the number of groups which must be resolved. Smaller focal spots should resolve more groups.

Group	Focal Spot (Nominal) Size mm
1. (0.6 lp/mm)	2.0 (or smaller)
2. (0.7 lp/mm)	2.0 (or smaller)
3. (0.85 lp/mm)	2.0 (or smaller)
4. (1.0 lp/mm)	2.0 (or smaller)
5. (1.15 lp/mm)	1.8 (or smaller)
6. (1.4 lp/mm)	1.5 (or smaller)
7. (1.7 lp/mm)	1.3 (or smaller)
8. (2.0 lp/mm)	1.0 (or smaller)
9. (2.5 lp/mm)	0.8 (or smaller)
10. (2.8 lp/mm)	0.6 (or smaller)
11. (3.35 lp/mm)	0.5 (or smaller)

(Some tools will measure to 0.3 mm. Refer to the suppliers instructions)

Tubes which fail to resolve the minimum number of groups should be retested with the standard pinhole test method.

M. Automatic Exposure Termination

1. Definition: Automatic exposure termination devices include phototiming and limiting circuits which terminate the exposure when a preset quantity of radiation has been detected. When functioning well, these controls will assure consistent radiographic results over a broad range of technique and patient variables. This test verifies the ability of the circuit to adjust exposure time for a standard object as kVp is varied.

2. Test Equipment Required

a. Two aluminum plates, 7 in. x 7 in. x 3/4 in. (18 cm x 18 cm x 1.9 cm) 1100 alloy, and one copper plate, 7 in. x 7 in. x 0.04 in. (18 cm x 18 cm x 1.0 mm).
b. Densitometer having a regulated self-contained light source (ASA diffuse transmission density).
c. Cassette to be used for all exposures.

3. Test Procedure

a. Radiographic system: Set the x-ray tube at 40 in. (100 cm) target film distance and center to the cassette. Position one Al plate and the Cu plate in the center of the light field to 6 in. x 6 in. (15 cm x 15 cm) at the top surface of the stack. Insert a cassette in the tray (film 14 in. x 14 in. or 35 cm x 28 cm) or advance the film (automatic film changers).

b. Chest systems: Set the tube at the standard distance 72 in. (180 cm). Mount or tape one Al plate and the Cu plate to the exit port of the cone or collimator. A cassette is then inserted or the film advanced.

c. Spot Film Systems: Place one Al plate and the Cu plate on the tabletop with a penny on top center. Use the fluoro system to center and lock the system in place. Cone to an inscribed square of the dimensions of the image intensifier. Advance the film cassette and expose after control settings have been made. To save time and film, the 4 on 1 setting may be used.

d. Control Settings and Exposure: Set the control in the phototiming mode (central chamber, preferred), 80 kVp, 200 to 400 mA (mA selection is not possible on falling load generators), normal density setting and make a phototimed exposure. Repeat the above steps for a second exposure at 65 kVp and for a third exposure at 95 kVp. Repeat with two aluminum plates and the Cu plate. Process the six films, measure the central density of each film, mark the density, kVp, room number, date, time, and other data on each film.

e. High kVp Systems: It is difficult to design a phototimer to cover the range of 60 to 150 kVp. High kVp chest systems (125 to 150 kVp) are separately calibrated to account for the special filters and cassettes. A test consists of two exposures using one, then two aluminum plates and the Cu plate mounted at the collimator. The film densities should be within 0.20 of each other and have a mean density of about 1.2 ± 0.2.

4. Evaluation of Results: The densities of the six films for each system must be within 0.3 D of each other. Quality systems will hold the density variations to ±0.20D. Long term variations of the density of the 80 kVp film due to variations of film and processor (it is obvious that the film processor must be controlled for consistent results) should be within 0.30D of each other. Special problems may arise when using rare earth or barium-based screen cassettes on older systems. Usually, the phototiming circuits can be adjusted for differences of energy sensitivity (kV compensation) or for short time exposures which imply thin objects and a different exit energy distribution to the cassette. Because of energy stored in the x-ray tube cables and because many generators operate on integral half-cycles of the power line, three phase phototimers are usually not consistent for times

less than 10 ms or 1 mAs and single phase machines for times less than l/20 sec or 1 mAs. Secondary or grid controlled tubes will respond much faster.

When densities exceed the above limits, the following may be the causes:

a. Improper calibration of the generator.
b. Inadequate kVp compensation of the generator phototimer.
C. Excessive variation between cassettes (cassettes for phototiming should he matched for gain and reserved for use on the same generator).
d. Component failure.
e. Poor design.

N. Optical Systems Focus

1. Definition: Various elements of the fluoroscopic system may shift out of focus causing a decrease of system resolving power. The electron lenses in the image intensifier and the ion pump may derive power from the same voltage divider so a new tube, set while pumping resudual gas, may be out of focus when the gas is finally absorbed. Camera and collimating lenses may be moved relative to their focal planes and TV focus may drift as components age.

2. Test Equipment Required

a. A mesh pattern of copper (or brass) mesh, arranged as eight pie sections, 16, 20, 24, 30, 35, 40, 50, 60 mesh holes/inch (6 to 24/cm), total area of 7in x 7in (17.5cm x 17.5cm). Lead numbers on each section identify the mesh resolution. The use of a radially symmetric pattern permits adjustment of central, general and edge focus.
b. Two aluminum plates 7in x 7in x 3/4in (17.5cm x l7.5cm x l.9cm) 1100 alloy.
C. Small telescope or 7 x 50 monocular.

3. Test Procedure: The mesh pattern is placed close to the face of the image amplifier system and taped in place. The system is then operated at lowest fluoro factors (50 kVp, 1 mA). The plates can be placed on the tabletop and the system operated to obtain images on cine or fluoroscopic films. One plate may be used at the table in fluoro if image saturation ("white out") occurs.

4. Evaluation of Results: The values listed in Table I are minimum acceptable values. Higher quality systems should resolve one higher mesh value except that TV systems are limited by the TV scanning process. Values given for "optical viewer" also refer to the use of the telescope or monocular to view the image intensifier output phosphor through the collimator lens (TV camera removed). Note that 9-l0 in (23-25 cm) tubes in the 5-6 in (13-15 cm) modes and 6in (15cm) tubes perform equally well.

Table I
Resolvable Mesh

	9-10" Center	9-10" Edge	5-6″ Center	5-6″ Edge
Optical Viewer	40	30	40+	35+
Std. TV	20 to 24	20	30 to 35	24 to 30
16mm Cine	35+	30	40	35+
Other Film	40	30	40+	35+

O. Automatic Brightness Control

1. Definition: Automatic brightness controls (ABC) for fluoroscopy usually operate by sensing the light output of the image intensifier and adjusting kVp and/or mA of the x-ray tube. A properly functioning ABC should compensate for variations of pateint thickness, x-ray field size, image intensifier magnification (modes) and other variations of the apparatus (use of grids, drift, distance, etc.). When an iodine based contrast medium is used, fluoroscopic systems perform best over a small kVp range (65 to 80) so that fixed kVp variable mA preset and variable kVp systems (operator checked for operation in the proper kVp range) give good results at low values of patient exposure. Compromise systems which vary kVp to compensate for changes of image brightness but which permit the manual control of mA can be set: high mA/low kVp for imaging contrast media and soft tissues; low mA/high kVp for lower exposures in GI studies.

2. Equipment Required

a. 2 aluminum plates, 1100 alloy, 7in x 7in x 3/4in (17.5cm x 17.5cm x 1.9cm)
b. Aluminum penetrameter plate, 1100 alloy 7in x 7in x 1/32in (0.8mm) having central pairs of holes of 1/16in (1.5mm), l/8in (3mm), 3/16in (4.5mm), 1/4in (6mm)
C. Lead plate, plastic covered, 7in x 7in x 1/16in lead.
d. Radiation detector (low energy) 5R or less either a direct reading pocket dosimeter or ionization chamber with no active area dimension greater than 3 inches (7.5cm) and having a suitable exposure reading means.
e. Shallow support stand suitable for holding test plates 1in (2.5cm) over the table with the radiation detector on the table surface. Wooden rods, 2 1in x 1in x 7in (2.5cm x 2.5cm x 17.5cm) may be used with a pocket dosimeter.
f. Common tape measure.

3. Test Procedure

a. Manual test. Place the two 3/4in (1.9cm) aluminum plates with the penetrameter plate between them on the support stand or rods. Operate the fluoroscopic system at

100 kVp, 1 mA. Set the collimator to define an inscribed square at the input to the image intensifier which is set to 12 inches over the tabletop (measured from base of spot film device or optical system). Record which penetrameter holes are visible. Place dosimeter under the aluminum blocks and expose for a time sufficient to exceed 50% but less than 100% of full scale of the dosimeter at 100 kVp, 1 or 2 mA. Record mA, time, mR. Calculate and record R/min/mAs.

b. Automatic Brightness Control, kVp variable. Set the aluminum plates and collimator as in 3a. Operate the system in the automatic mode and set to low mA (1 mA, if possible). Record the kVp values. Place the dosimeter under the plates, expose as above, record as R/min. Repeat with 3/4in (1.9 cm) plate removed. Repeat both of the above steps for a high mA setting (4 mA, if possible).

c. Automatic Brightness Control, mA Variable. Set the aluminum plates and collimator as in 3a. Operate the system in the automatic mode and set to 80 kVp. Record the mA value. Place the dosimeter under the plates, expose, record as R/min. Repeat with one aluminum plate removed.

d. Radiation Limit Test. Set the aluminum plates and collimator as in 3a. Operate the system in the automatic mode. Place the dosimeter under the plates, place the lead plate over the plates. Expose at max.1 min. automatic factors. Record kVp, mA, R/m. Repeat for the extremes of manual control of the factors. Caution: do not exceed the ratings of the x-ray tube.

4. Evaluation of Results: Because of cable capacity, single phase and three phase fluoroscopic systems are equivalent in performance. For a focus-table distance of 20 inches, the output at the surface of the table should be about 2.0 ± 0.6 R/min/mA for 2.5 mm filtration plus table attenuation at 100 kVp. The system must display the 1/4in and 3/16in penetrameter holes through the noise, better systems should also show the l/8in holes, exceptional systems may show the 1/16in holes. The automatic systems should change factors such that the radiation levels for the reduced phantom (one plate removed) should be less than half that of the full phantom. Month to month stability should cause the systems to repeat within ±5 kVp or ±40% of mA values. With the lead plate, the radiation level must not exceed 10 R/min under any condition. In addition, the ABC must function, the visible density should remain almost constant, and the penetrameter holes should remain visible (except for the 3d).

P. Geometric Tomography

1. Definition; Geometric tomographic systems "se the relative motions of the tube, patient and cassette to blur all image

planes of the object except the plane of interest. In addition to the usual problems of common radiographic apparatus, tomographic systems have the special problems of mechanical motion: bearing wear, grid alignment and generator synchronization. The result of improper motions may be the inability to resolve fine structure or the introduction of image artifacts. For the pluridirectional systems, incorrect grid alignment may result in excessive exposure to x-rays and reduced image contrast. It is assumed for the following tests, that the system has been tested as a conventional radiographic system for kVp, collimation, focal spot, etc.

2. Equipment Required: A tomographic phantom (or set of phantoms) which contains a helix of 12 lead numbers spaced from 1 to 12 from the base, 4 pieces of copper mesh 1 cm x 4 cm, tilted 1 meshes of 8, 12, 16, 20 holes/cm (20, 30, 40, 50 mesh/inch), plastic spacers of 1, 2 and 4cm thickness (optional), 2 aluminum absorbers. 7 in x 7in x 3/4in (17.5cm x 17.5cm x 1.9cm lead or steel sheet approximately 10 cm x 10 cm x 1.5 mm with 3-mm diameter central hole.

3. Test Procedure: Prior to the use of test tools, it is helpful to check for obvious mechanical defects by visual inspection. Operate the unit in the tomographic modes and visually check for smoothness of motion of tube and film and stability of pivot points, i.e., at x-ray tube support, cut level selector and Bucky connection. Mechanical motion defects must be corrected. Check x-ray exposure time for various amplitudes and travel rates with a stop watch and compare with manufacturers specifications for reasonable agreement. Record exposure time measurements for available amplitudes and travel rates. Record all exposure factors and machine settings. For the following tests: (1) it will be necessary to adjust exposure factors to obtain a mean film density of 0.4 to 1.2 (except aperture plate, density of line to 0.6 to 1.3); (2) note the exposure factos actually used; (3) If possible, test under worst case conditions of fastest sweep, retest for other conditions; and (4) stay within tube ratings - avoid equipment damage.

   a. Location of fulcrum: Place the two aluminum absorbers on the tabletop and place the lead number phantom on top. Set the fulcrum control to 47mm. If there is a visual indicator, hold a white card next to the phantom to check indicator beam. Operate the system to produce a large angle, thin section tomograph. The number "7" should be most clear, numbers "4" and "9" should be partially blurred, numbers "1" and "12" should be well blurred. The test may be repeated for small angle tomo - or zonography to demonstrate increased thickness of cut. Acceptable errors are within ±1mm for better circular or pluridirectional devices and ±3mm for simple linear devices measured from fulcrum display. An alternative procedure is to use one aluminum phantom at the tabletop,

the three plastic spacers and the phantom containing the lead helix on top. Set the fulcrum control to 97 mm and do as described above.

b. Mesh Focus: The phantom containing the tilted mesh strips is positioned in place of the lead number helix and the exposure repeated. The length of the strip of mesh in sharp focus will be inversely proportional to sweep angle, about 3 mm length for a thin cut to 10 mm or more for zonography. The 1.6 holes/mm mesh must be resolved clearly over an area of about 3 mm of strip length. Excellent systems may also resolve about 2.5 mm of the 2.0 holes/mm mesh. System5 which fail to resolve the 1.2 holes/mm mesh are of little value in resolving fine anatomical details.

C. Exposure Uniformity: The phantom is removed and the aperture plate is positioned 2 cm over both absorbers using a foam plastic spacer; the film will display the image of the trajectory of the tube and will have a line width sufficient for checking film density. Adjust exposure for line density of 0.6 to 1.3 (medium gray). The line may show less than 0.2 large area density variations but no gross variations. Complete circular, elliptical, hypocyloidal, tri-spiral scans should be seen with overlap within 30° or as specified. Note: single phase generators will generate a series of pulses along the line but may be checked for general uniformity and scan closure.

d. Grid Alignments: A visual inspection of the grid should make certain that the grid axis is the same as the direction of tube swing of pluridirectional systems. For linear systems, the visual inspection should show that the tube trajectory directs the beam through the center of the grid and at right angles to the plane of the grid. A practical test is to compare exposure requirements for the two aluminum absorbers for a tomographic system and a radiographic system at the same distance (FFD).

4. Evaluation of Results: Failure to meet acceptance limits of each section above should trigger corrective action. Interpretation of the test films together with an inspection of the mechanical system is helpful in servicing the apparatus.

Q. Cassettes: Screen Speed and Film/Screen Contact

1. Definition: Cassettes may vary because of screens of different manufacture, age, or front panel materials. Warped cassettes, fatigue of the foam or felt compression material, worn closures, dirt, light leaks, etc., frequently produce unsharp or fogged radiographs to the point where the cassettes of screens should be replaced. Similar problems of poor film/screen contact, dirt, etc., may be present in the film changers or "cassetteless" radiographic systems.

2. Test Equipment Required

a. A 14in x 17in (35cm x 43cm) piece of 1/4in (6mm) galvanized wire mesh, edges taped. A 14in x 14in (35cm x 35cm) or other size pieces may be used, to check film changers. This material is available at most hardware stores as wire cloth and need not be perfectly flat.

b. A l4in x 17in (35cm x 43cm) piece of brass wire mesh, eight mesh per inch, 0.028 in (0.7mm) wire with 1/2in (1.25cm) central hole, edges taped (alternate test mesh to meet ANSI proposed standard PH1-49).

c. A commercial tool of the appropriate size, typically 45 x 45 cm, containing a perforated metal plate to serve the same purposes as the screen or mesh tools.

3. Test Procedure

a. Physical Inspection: It is not unusual after extended use to find labels missing and cassettes and screens of various speeds, age and manufacture in use without compensation, since speed differences may be unknown.

Inventory and sort by intensifying screen type, age and cassette type. Relabel the cassettes to provide clear indication of the type of intensifying screen contained and redistribute the cassettes such that common types are maintained for general and/or special purposes throughout the department. Clean and inspect the intensifying screens. Look for worn areas, stained areas or yellowing due to age. Dirt specks and worn or stained areas produce artifacts on the radiographs. Use only cleaning materials recommended by the screen manufacturer. The frequency of cleaning varies with local conditions. It is helpful to number the intensifving screens with permanent ink in an unobtrusive location and likewise to number the outside of the cassette such that a repeating artifact can be traced to a specific cassette.

b. Cassette-Screen Speed: If there is any doubt or question as to the equality of radiographic speeds among cassettes or screens, the following simple test should he performed.

Place no more than four cassettes, preferably all the same size, on the x-ray table with corners touching; one of the four should be a known standard cassette/screen combination. All cassettes should be loaded with film from the same box. The x-ray tube is centered perpendicular to the intersection of the four cassettes, and an exposure made which will produce a film density between 0.80-1.50.

c. Screen-Film Contract: Lack of intimate screen/film contact within a cassette will cause lack of detail or "blurring". Film/screen contact should be tested initially before acceptance of new cassettes and screens and periodically to determine that film/screen contact is maintained in use. A test exposure of the wire mesh is made with factors of the order of 3-5 mAs, 50 kvP, 40 inch FFD for medium speed

screens and film. Some experimentation may he needed to determine best exposure factors. Wire mesh radiographs should be exposed for a background density of about 1.0.

4. Evaluation of Results

a. For the speed test, compare the resulting densities on the four processed test films close to the central ray. Visual densities should he the same. If a densitometer is used to compare densities, the maximum density variation should be ±0.20.

h. View all mesh test films from a distanceof 6-8feet (2m); areas of poor screen/film contact will appear as dark areas or dark spots. Close inspection of these dark areas will show the wire image blurred. Small areas or poor contact around edges or in corners of the radiograph may have to be ignored.

Cassettes showing poor contact involving large areas either peripherally or centrally often offer poor prospects for repair; consider replacement. Light leaks will be evidenced by fogged edges or corners of the radiograph. This fog can generally be seen both on the screen contact radiograph and on patient radiographs. The cause may be due to faulty latches on the cassette, which may he adjusted or repaired, or due to worn light seals on the cassette or a felt light-seal that is too tight, holding the cover open, particularly on older model cassettes. Discuss indicated repair with vendor. If light leakage is severe, replacement of the cassette is indicated.

R. Radiographic Illuminators

1. Definition: The conditions under which a radiologist, clinician, etc., views radiographs may influence diagnostic accuracy and stamina. Viewing conditions include the brightness of the illuminators as well as the ambient room light level. Undesirable radiographic viewing conditions include:

a. Low intensity illuminators.
b. High ambient room-light levels.
C. Gross mismatch between viewing conditions used by the radiologist and veiwing conditions used by technologists to check films.
d. Illuminators in the same viewing area having grossly mismatched intensities and/or color.

Nonuniformity of radiographic illuminator brightness most commonly occurs when bulbs are replaced without regard for matching their color or intensity, and when output of the lamps change with age.

2. Test Equipment: Photographic light meter.

3. Test Procedure: Visually survey the brightness and color of all illuminators in a given area. A photographic light meter is helpful to compare relative illuminator brightness of different viewing areas in a department of radiology. Be especially careful to avoid gross mismatches in illuminators in the technologist quality control area compared to the "reading rooms".

4. Evaluation of Results: If gross mismatches in brightness and/or color are evident, remove the illuminator front, clean the interior surfaces and note the type of fluorescent tube. Replace all fluorescent tubes which show blackening at the ends. Three types of fluorescent phosphors are in common use : daylight, white, and warm white, which progress in relative apparent color from blue-white to pink-white. If a color mismatch exists, check to see that all lamps in an assembly of illuminators are the same brand and type.

V. Test Schedules and Data Forms

A. General Considerations

It is normal for x-ray apparatus to drift out of calibration with time, use and development of defects. The more complicated systems will require more frequent testing. Some tests can be done in a simple "quick check" way or as a more detailed and painstaking procedure. For example, kVp may be tested once at, say 80 kVp, 300 mA, 0.1 set as a "quick check" or checked at 60, 80, 100, 120 kVp and at 100, 200, 300, 500, etc., mA to verify all conditions of operation. The quick check should prove adequate for monthly testing (unless suspicions are aroused by poor performance) while the detailed test should he done before acceptance of new systems. The tests and their level of care should be based on the requirements of the situation. The tests may be considered as guides for the development of special tests to meet the particular needs of each department and to match the skills of the tester.

The type and frequency of testing should be established by a qualified medical physicist. The medical physicist should also monitor the QA program at frequent intervals to be certain that tests are done correctly and to aid in the interpretation of results.

B. Frequency of Testing

Detailed testing should he done on each system at the start of a department test program to establish baseline data. Ideally, the medical physicist should establish "baseline data" during the initial acceptance testing of new apparatus. To start, it is suggested that rooms should he "quick checked" every month and tested thoroughly every year. Depending on the frequency of detection of faults, the schedule can be adjusted. Rooms should

be tested carefully after repairs and a month after tube replacement to verify calibration stability. Some tests should be incorporated into the user protocol; e.g., a focus test before a cine run.

C. Type of Test Programs

One survey method will use a binder or notebook for each room on each major item (mobile generator, c-arm, etc.). Another method uses a form for recording data on a particular parameter for the entire department (e.g. data on all of the focal spots), so that the department binder contains data sheets for kVp, time, etc. Obviously, the method of testing will dictate the type of test forms. Tine latter method applies to scheduled testing of each parameter in turn.

D. Quick Checks

A simple test form should enable the tester to inspect the room for obvious defects, cables, locks, etc. and check (for pass) or note deviations. The actual tests of a radiographic room may include mR/mAs, timing, kVp (one value), collimator alignment, tomo mesh focus and room inventory. R and F rooms should also include image focus (mesh). Deviations should trigger more detailed testing.

E. Test Forms

Examples of test forms are shown in the following pages.

References

1. Burnett, Bruce M., Mazzaferro, Robert J. and Church, Warren W.: A study of retakes in radiology departments in two large hospitals. DHEW publication (FDA) 76-8016, 1975.

2. Lawrence, D.J., A Simple Method of Processor Control. Medical Radiography and Photography, 49(l), 1973, Eastman Kodak Company, Rochester, N.Y.

3. Gray, J.E., Photographic Quality Assurance in Diagnostic Radiology, Nuclear Medicine and Radiation Therapy, Vol. I., June 1976, HEW Pub. (FDA) 76-8043, Bureau of Radiological Health, Washington, D.C.

4. Ardran, G.M. and Crooks, H.E.: Brit. J. Radiol., 41:193, 1968.

5. Jacobson, A.F., Cameron, J.R., Siedband, M.P., and Wagner, J.: Med. Phys., 3:19, 1976.

6. Manufacturers: 1) Radiation Measurements, Inc.
7617 Donna Drive
Middletown, WI, 53562
2) Nuclear Associates, Inc.
100 Voice Road
Carle Place, NY, 11514

7. NEMA Test Methods for X-Ray Equipment XR5-1974, National Electrical Manufacturing Association, 115 East 44th Street, New York, New York 10017.

Performance Tests

RADIOGRAPHIC-FLUOROSCOPIC ROOM _____

DATE						
TESTER						
INSPECTION						
TABLE TUBE mR/mAs						
Cassette kVp						
OHD TUBE mR/mAs						
Cassette kVp						
Timing						
LAT. TUBE mR/mAs						
Cassette kVp						
IV-TV - FOCUS						
70 MM Focus						
Cine Focus						
INVENTORY						

COMMENTS:

Performance Test

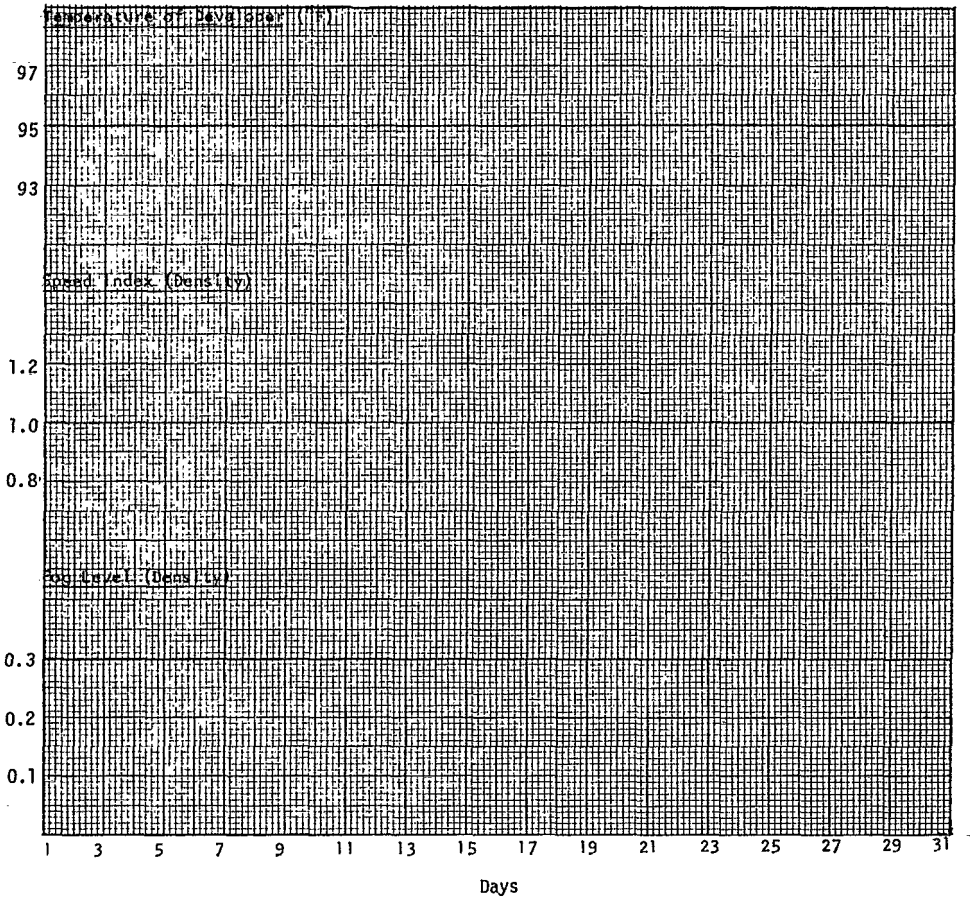
RADIOGRAPHIC ROOM _____

DATE	____	____	____	____	____	____
TESTER	____	____	____	____	____	____
INSPECTION	____	____	____	____	____	____
TUBE mR/mAs	____	____	____	____	____	____
Cassette kVp	____	____	____	____	____	____
Timing	____	____	____	____	____	____
COLLIMATOR	____	____	____	____	____	____
CHEST-PHOTOTIMING	____	____	____	____	____	____
TOMO-FULCRUM	____	____	____	____	____	____
Mesh Focus	____	____	____	____	____	____
INVENTORY	____	____	____	____	____	____

COMMENTS:

FILM PROCESSOR CONTROL CHART

ROOM_____ PROCESSOR TYPE_____ MONTH_____



OVERLOAD PROTECTIVE CIRCUIT TEST

Date:_____

Department:_____ ,Room Number:_____

Generator, Manufacturer:_____ Model Type:_____
Maximum Potential_____ kVp ,Maximum Current_____ mA.

X-ray Tube, Manufacturer:_____ Model Type:_____
Serial #_____, Nominal Focus Size:_____

The Maximum Current (mA) taken from the tube rating charts.

	Small Focal Spot	Large Focal Spot
Normal Speed Rotation		
High Speed Rotation		

Radiographic Technique Factors: 80 kVp, 0.1 Sec. and

Tube Current (mA)	Focal Spot Size		Overload Light		Speed	
	L	S	ON	OFF	N	H
	L	S	ON	OFF	N	H
	L	S	ON	OFF	N	H
	L	S	ON	OFF	N	H
	L	S	ON	OFF	N	H
	L	S	ON	OFF	N	H

The System Power (kW)

	Small Focal Spot	Large Focal Spot
Normal Speed Rotation		
High Speed Rotation		

Note : The System Power (kW) = 0.08 x Maximum System Current (mA)

RECOMMENDATION:

EXPOSURE TIME

Date: _____

Department: _____ , Room number: _____

Generator, Manufacturer: _____ Model Type: _____
Generator Number:(if more than one) _____

Radiographic Technique Factors: 80 kVp , _____ mA
Source-to-film Distance: _____ inches.
Type of film employed: _____

Exposure Time (Sec.)	Measured Angle	Measured Exposure Time
1/120		
1/60		
1/40		
1/30		
1/20		
1/15		
1/10		
1/8		
3/20		
1/5		
1/4		
3/10		
2/5		
1/2		
3/5		
4/5		
1		

*EXPOSURE UNIFORMITY

Date	Motion	Angle	kVp	mA	Sec.	Optical Density						
						1	2	3	4	5	6	Average

PEAK TUBE POTENTIAL (kVp)

Date:________________

Department:__________________, Room Number:________________.
Generator, Manufacturer:________________, Model Type:________________(ϕ), Generator #____________.
X-ray Tube, Manufacturer:________________, Model Type:________________, Serial #____________.
X-ray Tube Number:________________.

Current Station	Dial kVp	50	60	70	80	90	100	110	120					
mA	Measured kVp													
	Match Step													
mA	Measured kVp													
	Match Step													
mA	Measured kVp													
	Match Step													
mA	Measured kVp													
	Match Step													
mA	Measured kVp													
	Match Step													
mA	Measured kVp													
	Match Step													
mA	Measured kVp													
	Match Step													

X-RAY OUTPUT AND BEAM QUALITY

oom _____ Tester _____ Date _____

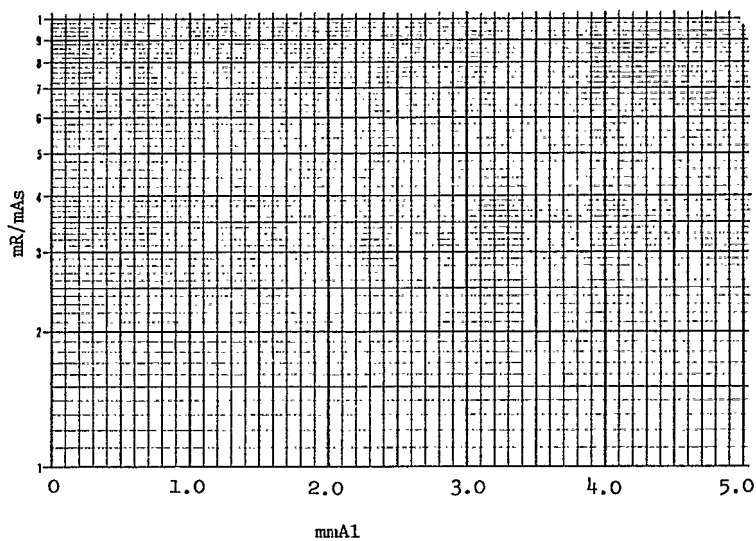
ube 1 (O) _____ mR _____ mAs mR/mAs _____

ube 2 (□) _____ mR _____ mAs mR/mAs _____

ube 3 (△) _____ mR _____ mAs mR/mAs _____

VL Data	1.0mm	2.0mm	3.0mm	4.0mm	5.0mm	HVL
ube 1 (O)	_____ mR	_____ mR	_____ mR	_____ mR	_____ mR	_____ mm
ube 2 (□)	_____ mR	_____ mR	_____ mR	_____ mR	_____ mR	_____ mm
ube 3 (△)	_____ mR	_____ mR	_____ mR	_____ mR	_____ mR	_____ mm

All Measurements at 80 kVp Min. HVL 2.3 mm Al



LIGHT/X-RAY FIELD CONGRUENCE

Department: _____, Room Number: _____.
X-ray Tube, Manufacturer: _____, Model Type: _____,
Serial Number: _____, X-ray Tube Number (if more than one): _____.
Source-to-film Distance: _____ inches, Film Employed: _____.

Date	Direction	Large Field (12" x 15")		Total Deviation	Small Field (6" x 8")		Total Deviation
	Horizontal	left	right		left	right	
	Vertical	top	bottom		top	bottom	
	Horizontal	left	right		left	right	
	Vertical	top	bottom		top	bottom	
	Horizontal	left	right		left	right	
	Vertical	top	bottom		top	bottom	
	Horizontal	left	right		left	right	
	Vertical	top	bottom		top	bottom	
	Horizontal	left	right		left	right	
	Vertical	top	bottom		top	bottom	

FOCAL SPOT SIZE

Department:____________________, Room Number:____________________.
The measurement is for ( )radiographic, ( )fluoroscopic tube.
X-ray Tube, Manufacture:______________,Model:________________.
Serial Number:____.
NOMINAL FOCAL SPOT SIZE: Large______mm, and small ______ mm.
Identify, if more than one x-ray tube:__________________________.

(X-ray Tube Potential : 80 kVp)

Date	Tube Current		RESOLVED BAR GROUP NUMBERS	√
	mA	S or L		
			1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	
			1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	
			1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	
			1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	
			1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	
			1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	
			1, 2, 3, 4, 5, 6, 7, 8, 9, 10,111	
			1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	
			1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	
			1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	
			1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	
			1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	
			1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	
			1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	
			1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	
			1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	
			1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	
			1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	
			1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	
			1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	

AUTOMATIC EXPOSURE TERMINATION

Department:_____ Room Number_____.
Phototimer Tested: ( ) Bucky, ( ) Wall, ( ) Spot Film.
Phototimer Detector, Number of Fields Available:_____.

Date	Measured Optical Density			Phototimer Selection	
	65 kVp	80 kVp	95 kVp	Density	Field

OPTICAL SYSTEM FOCUS

Department:____________________ Room Number:____________________

Image Intensifier, Manufacturer:____________________

Model Type:________________ Serial #________________

Input Phosphor Size:____________________

Identify, if more than one image intensifier:____________________

	RESOLVED MESH					
	Optical View		TV Monitor			
Date	Edge	Center	Edge	Center	Edge	Center

GEOMETRIC TOMOGRAPHY

Department:: ______________, Room Number: ______________.
Generator, Manufacturer: ______________, Model Type: ______________.
X-ray Tube, Manufacturer: ______________, Model Type: ______________.
Serial # ______________, Nominal Focus Size: ______________.
Tomographic Motion Available: ( ) linear, ( ) circular, ( ) elliptical, ( ) spiral, ( ) hypocycloidal.

*LOCATION OF FULCRUM

Date	Motion	Angle	kVp	mA	Sec.	Location of Fulcrum
						1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12.
						1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12.
						1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12.
						1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12.
						1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12.
						1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12.
						1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12.
						1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12.
						1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12.
						1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12.
						1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12.
						1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12.

Circle the numbers clearly shown.
Underline the numbers partially blurred.
Cross out the numbers completely blurred.

FILM-SCREEN CONTACT

For Cassette Size: _____
Department: _____

* UH: Ultra High Speed Screen
H: High Speed Screen
R: Regular or Par Speed Screen
D: Detail Screen

CASSETTE I. D.	DATE INSTALLED	INTENSIFYING SCREEN		CONTACT TEST		
		DESIGNATION	SPEED*	TEST DATE	RESULT	lp/mm

RADIOGRAPHIC ILLUMINATOR

Department: _____

Viewing Box Number	Location or Room Number	Light Value Measurements					Light Bulb			Results
		UL	UR	LR	LL	Date	Make	Type	Date Installed	