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**QUALITY CONTROL RECOMMENDATIONS
FOR
DIAGNOSTIC RADIOGRAPHY**

**VOLUME 2
PODIATRIC FACILITIES**

July 2001

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Conference of Radiation Control Program Directors, Inc.

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**QUALITY CONTROL RECOMMENDATIONS
FOR DIAGNOSTIC RADIOGRAPHY
VOLUME 2: PODIATRIC FACILITIES**

**Prepared by CRCPD's
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ABSTRACT

Committee on Quality Assurance in Diagnostic X-Ray, *Quality Control Recommendations for Diagnostic Radiography, Volume 2: Podiatric Facilities*, CRCPD Publication 01-5 (July 2001) (49 pp).

This publication presents a template of a Quality Control Program for facilities with podiatry facilities. The procedures included in this manual are one way to perform these tests. Applicable forms and additional instructions have been included in appendices.

The information contained in this document is for guidance. The implementation and use of the information and recommendations contained in this document are at the discretion of the user. The implications from the use of this document are solely the responsibility of the user.

This document has been developed by a working group of the Conference of Radiation Control Program Directors, Inc. (CRCPD) and accepted by the Board of Directors for publication. The contents contained herein, however, may not necessarily represent the views of the entire membership of the CRCPD or any federal agency supporting the work contained in this document. The mention of commercial products, their sources, or their use in connection with material reported herein is not to be construed as either an actual or implied endorsement of such products by the CRCPD or any federal agency.

FOREWORD

The Conference of Radiation Control Program Directors, Inc. (CRCPD) is an organization made up of the radiation control programs in each of the 50 states (except Wyoming, which has no radiation control program), the District of Columbia, and Puerto Rico, and of individuals, regardless of employer affiliation, with an interest in radiation protection. The primary purpose and goal of CRCPD is to assist its members in their efforts to protect the public, radiation worker, and patient from unnecessary radiation exposure. CRCPD also provides a forum for centralized communication on radiation protection matters between the states and the federal government, and between individual states.

One method of providing assistance to the states, as well as to other interested parties, is through technical and administrative publications. Most technical publications of CRCPD are written by various committees, task forces, or special working groups. Most administrative publications are written by the staff of the Office of Executive Director (OED).

This specific publication, *Quality Control Recommendations for Diagnostic Radiography, Volume 2: Podiatric Facilities*, is a guidance document for use by state x-ray inspectors and podiatric facilities with x-ray machines. No conclusions are included, and the implementation and use of the information contained in this document are solely the responsibility of the user.

Paul L. Schmidt

Chairperson
Conference of Radiation Control
Program Directors, Inc.

Dedicated in the memory of Debra Jackson and Joyce Zeisler.

PREFACE

The Conference of Radiation Control Program Directors, Inc. Committee on Quality Assurance in Diagnostic X-ray has compiled this manual to suggest a standard in quality control within a podiatry facility that uses radiation-producing machines for medical diagnosis. Separate manuals are available for dental facilities and facilities using radiography or fluoroscopy for other diagnostic purposes. State radiation control personnel are encouraged to share applicable information with facilities in need of establishing or improving their quality control program.

All state radiation control personnel are encouraged to promote quality assurance as a proven means to reduce exposure, increase and maintain diagnostic image quality, and limit health care costs. In many instances, state radiation control personnel are the primary source of such information and should offer assistance as necessary.



John P. Winston, Chairperson
Committee on Quality Assurance
in Diagnostic X-ray

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QUALITY CONTROL RECOMMENDATIONS FOR DIAGNOSTIC RADIOGRAPHY VOLUME 2: PODIATRIC FACILITIES

INTRODUCTION

The Conference of Radiation Control Program Directors, Inc. Committee on Quality Assurance in Diagnostic X-ray has compiled this manual to suggest a standard in quality control within each podiatric facility that uses radiation-producing machines for medical diagnosis. A **Quality Control (QC) Program** allows a facility with limited resources and personnel to monitor the basic components of the imaging process at a low cost through the use of simple, inexpensive tools and minimal staff time.

The **Quality Assurance (QA) Program** is a program designed by management to assure quality of a product or service. Such a program can have wide-ranging aspects, including customer feedback, employee empowerment, and quality control. **Quality control** involves specific actions designed to keep measurable aspects of the process involved in manufacturing a product or providing a service within specified limits. These actions typically involve measurement of a process variable, checking the measured value against a limit, and performing corrective action if the limit is exceeded. This document suggests such variables, methods for measurement, control limits, and in some cases corrective actions typically applied to control equipment performance in radiological imaging.

All medical facilities using x-ray equipment, from a simple intraoral dental unit to an image intensified special procedures system, will benefit from adopting a quality assurance program. An established program will monitor the imaging process from start to finish and reveal potential problems that may otherwise go unrecognized. The following concepts and procedures are what the Committee believes will provide a standard in program monitoring and may not meet the requirements of some state or federal regulations. Quality assurance in medical imaging is a rapidly evolving concept and each facility is encouraged to continually pursue ways to improve and expand its program.

This volume of Quality Control Recommendations has been written for facilities with podiatric x-ray machines. **Separate volumes are available for dental facilities and facilities using radiography or fluoroscopy for other diagnostic purposes.**

GETTING STARTED

The following sections present the basic test procedures and a suggested schedule for performing the tests. Each section is arranged with an objective for the test, suggested performance criteria, the frequency at which each test should be performed, equipment required to perform the test, instructions for performing each test, how to evaluate the results, and when corrective action should be taken. Several of the tests mention forms to be completed with test results. These forms are found in Appendix A. Alternative forms may be available from your film representative, service engineer, physicist, or other qualified expert. Appendix B includes detailed instructions on how to perform processor sensitometry. Appendix C contains the glossary, or definitions of terms used throughout this manual.

It is essential that one person at a given facility, the QA Coordinator, be in charge of maintaining the QA program and be allotted the time, equipment, and space necessary to carry out the duties that are required. The facility's **QA Coordinator** may choose to assign specific duties to other personnel, but should maintain oversight and realize that consistency is compromised when several people share the responsibility of carrying out these tasks. The QA Coordinator must ensure all the tasks are performed in a timely manner regardless of assigned staff availability (e.g., vacation or illness).

After each link (x-ray unit, developing system, screen-film combination, darkroom, etc.) in the imaging chain is optimized, a working QA program will flag the Coordinator when something goes awry. The Coordinator should review test results daily. If any test results fall outside established tolerances, **repeat the test to validate the results, then take corrective action**. The Coordinator must be capable of identifying problems and be allowed enough time to resolve them as they arise, or the QC program will not operate as designed.

Getting off to a good start is imperative. The QC program is based on planning and purchasing the proper equipment, then establishing a high standard of quality and maintaining it. The information provided should enable the Coordinator to set up and monitor the entire program. If a facility protocol is not available for a specific type of equipment (e.g., digital imaging systems), the manufacturer's recommendations should be followed. Establishing an open line of **communication** with representatives from the State Radiation Control Program and other technical experts will make it much easier to set a standard of which the facility can be proud.

In order to perform the QC tests outlined in this manual, an initial outlay of about \$1,500 will be necessary. Minimal annual costs can be expected to keep your QA and QC programs running.

- Sensitometer (21 Step), approximately \$700
- Densitometer, approximately \$700
- Box of film (clinically used)
- Aluminum step wedge, approximately \$70
- Brass or copper mesh screens (1/8 inch or 3 mm spacing) large enough to cover largest cassette in use at facility, approximately \$10

- Measuring tape
- Non-mercury thermometer, approximately \$10
- Cleaning equipment for screens, cassettes and darkroom

This equipment may be purchased through your film, x-ray, or health physics equipment vendors.

Once you have become proficient at performing the tests the time spent will be minimal. Daily tests should take about 5 minutes to perform and should be done prior to the first patient image of the day. Monthly tests will add an additional 10 minutes to the daily tests. Quarterly tests will take about 45 minutes to perform. The semiannual test for darkroom fog should take no more than 5 minutes to perform and analyze. The annual tests and biennial tests completed by the qualified expert will probably take 1 to 2 hours to perform.

There are several sources from which a facility may locate a “qualified expert.” The first place to contact is the Radiation Control Program in your state. Many state programs have an approval process for this type of individual and will provide lists of qualified experts in your area. If your state does not have such a list, a large, JCAHO approved hospital would have a “consultant” that they use who meets the suggested qualifications.

QUALITY CONTROL MANUAL

A **QC Manual** should be created and reviewed at least annually. The manual should include the facility’s objectives, QC instructions, QC results, and personnel responsibility. Items that should be included in a **QC Manual** are:

- A list of the tests to be performed and the frequency for each test, including acceptable test limits, test procedures, maintenance, and service records.
- A list of equipment to be used for testing.
- Policy and procedures for QC tests as well as for the facility.
- Sample forms.

Questions asked during a review might include:

- Is image quality maintained at the desired level?
- Is the x-ray technique chart up-to-date?
- Is the screen-film combination used still the best suited for our facility?
- Do all personnel meet required or established qualifications?
- Does any equipment need to be replaced?
- Do any QC procedures need to be changed or updated?
- Are personnel adequately performing assigned tasks?
- Is patient and personnel radiation exposure as low as reasonably achievable?
- Are all documents up-to-date and accurate?

RECOMMENDED QUALITY CONTROL TESTS FOR PODIATRIC FACILITIES

Test	Frequency	Procedure
Processor QC	Daily, Prior to Developing Films and After Service	1
Darkroom QC	Daily and Weekly	2
System Constancy Check	Monthly and After Service	3A, 3B
Viewboxes	Monthly	4
Visual Checklist	Quarterly and After Service	5
Repeat Analysis	Quarterly	6
Film and Chemical Storage	Quarterly	7
Artifact Evaluation	Quarterly	8
Cassettes and Screens	Quarterly or Semiannually (As Needed)	9
Darkroom Fog	Semiannually*	10
Screen-Film Contact	Annually and As Needed	11
Collimation Tests	Annually	12
SID Indication	Annually	13
Lead Apron Check	Annually	14
Program Review	Annually	Form 6
Radiation Safety Survey	Two Years	Form 4

*Darkroom fog should be evaluated every time you change the filter, bulb, or film type, and at least every 6 months.

PROCESSOR QC (SENSITOMETRY)

(Procedure 1)

OBJECTIVE:

To determine if processor is working optimally.

SUGGESTED PERFORMANCE CRITERIA:

± 0.15 optical density of the mid-density step
± 0.15 optical density of the density difference
+ 0.03 optical density of the base + fog level

FREQUENCY:

Daily, prior to processing patient films

REQUIRED EQUIPMENT:

1. Sensitometer*
2. Dedicated box of control film
3. Densitometer

STEPS:**

1. Expose the control film with the sensitometer.
2. Develop the film.
3. Determine the average optical density of the **mid-density** step and record on **Form B1** in Appendix B.
4. Determine the average optical **density difference** and record.
5. Measure the background optical density (base + fog) and record.
6. Verify that the measured values are within the suggested performance criteria.

CORRECTIVE ACTION:

The tests should be repeated if the values are outside the performance criteria. If, after repeating, the results are still out of limits, look for processing problems and contact the processor service supplier.

* If asymmetric film is being used, a dual-sided sensitometer is necessary.

** For detailed instructions, chart and example, please see **Appendix B**.

Note: The sensitometer and densitometer must be maintained and calibrated according to manufacturer's recommendations.

DAILY AND WEEKLY DARKROOM QC (Procedure 2)

OBJECTIVE:

Keep the darkroom clean and processing optimized.

FREQUENCY:

- Daily - Check developer temperature
- Daily - Check developer, rinse, fixer levels
- Daily - Clean processor feed tray, counter tops
- Weekly - Clean darkroom

REQUIRED EQUIPMENT:

1. Non-mercury thermometer
2. Mop
3. Non-abrasive, liquid cleaning solutions
4. Damp, lint-free cloths

STEPS:

Daily: If manual processing, developer temperature must be measured with non-mercury thermometer for correlation with the time-temperature chart.

If auto processing, measure the temperature with a non-mercury thermometer to verify that the developer is operating within the temperature range established by the manufacturer, and that the display, if applicable, is accurate. It may not be necessary to physically measure the temperature daily if the processor passes the daily QC test (Procedure 1).

Daily: If manual processing, replenish following the chemistry manufacturer guidelines. Replace rinse water.

If auto processing, follow the processor manufacturer recommendations regarding replenishment.

Daily: Clean processor feed tray and counter top.

Weekly: Damp mop darkroom floor. Clean counters, cabinets, and anywhere else dust may accumulate. Clean film hangers.

CORRECTIVE ACTION:

If automatic processor can not be maintained at its optimal operating temperature, call processor service supplier.

INITIAL SETUP PROCEDURE FOR CONSTANCY TEST (Procedure 3A)

The Initial Setup Process must be completed in order to establish the baseline values necessary for comparison with monthly results. The “comparison film,” acquired after completing the following steps, represents an image derived from an optimized imaging chain. Whenever there is a change in the imaging chain (different **type** of film or intensifying screen, type of chemistry, new processor or x-ray unit), a new baseline must be established by repeating the Initial Setup Procedure.

1. Thoroughly clean the film processor or processing tanks. Add fresh developer and starter solutions, and fixer, following the manufacturer’s instructions.
2. Load a sheet of x-ray film into a clean, dry cassette.
Note: One cassette should be designated and marked as the QC cassette and used for all QC tests. It may also still be used for clinical imaging.
3. Position the x-ray tube at the source-to-image distance (SID) normally used, and confirm the tube is perpendicular to the cassette.
4. Place the step wedge on the cassette and center the x-ray beam to the step wedge. If variable collimation is available, collimate the light field to the edges of the step wedge.
5. Set the x-ray technique factors to those used clinically.
6. Make an exposure of the step wedge.
7. Process the film in the usual manner.
8. Using a densitometer, measure the optical density of the steps on the step wedge image. The optical density of Step 5 should be approximately 1.20. If it is not, adjust the x-ray technique factors accordingly and repeat the exposure.
9. The film should be marked as the “Comparison Film.” This will be used to compare with the monthly film.
Note: The image of the step wedge on the comparison film should range from slightly darker than the unexposed area to nearly opaque (See **Figure 1**). If your image does not look like this, adjust the technique factors accordingly and repeat until an acceptable image is acquired. DO NOT vary the film developing techniques from what is recommended by the manufacturer in order to get a satisfactory step wedge.
10. Record the date, technique factors used for the film, SID, and the optical density of Steps 4 through 8.

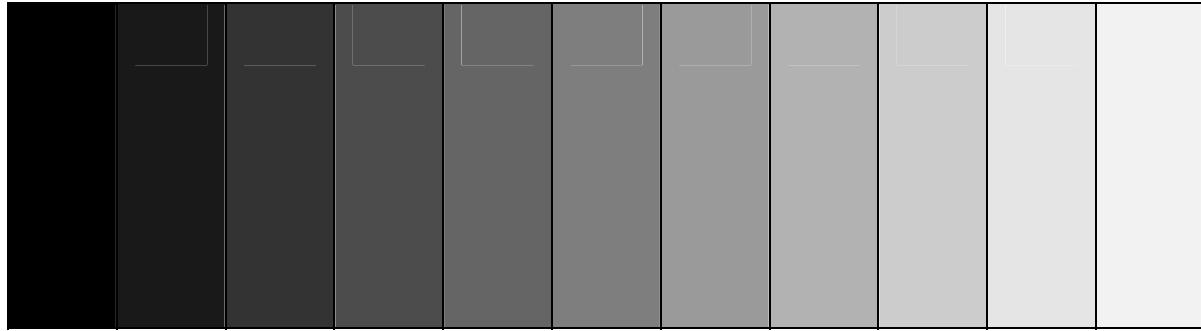


Figure 1. Constancy Test Comparison Film Example.

Figure 1 is an example of what the “comparison film” should look like. As stated in Step 9 of the Initial Setup Procedure, the goal is to create an image of the step wedge that has an optical density range beginning with a step that is slightly darker than the surrounding unexposed film to a step that is nearly opaque. It is the inner four or five steps that are most important since they depict the contrast one would like to see on clinical images.

Steps 4 through 8 of the step wedge film created during the constancy test should be compared to the same steps (using the viewbox and mask) on the comparison film. If the densities have shifted by more than 1 step, constancy has not been maintained.

SYSTEM CONSTANCY TEST (Procedure 3B)

OBJECTIVE:

To assure the radiographic system is operating consistently.

SUGGESTED PERFORMANCE CRITERIA:

Optical density on test film within 1 step of comparison film.

FREQUENCY:

1. Monthly*
2. After service of the equipment

REQUIRED EQUIPMENT:

1. Aluminum step wedge
2. QC cassette
3. Film
4. Densitometer
5. Comparison film from Procedure 3A

STEPS:

1. Set the x-ray unit to the technique factors and source-to-image distance used for the Initial Setup Procedure (3A) for the Constancy Test.
2. Place the step wedge on the loaded QC cassette on the table top and center the x-ray beam to the step wedge.
3. Collimate to the edges of the step wedge.
4. Make an exposure of the step wedge and process normally.
5. Using the densitometer, compare the optical densities for Steps 4 through 8 with the comparison film.
6. Record your results on the **Monthly QC Checklist (Form 3)**.

EVALUATION:

Compare the current film with the comparison film. If the densities are not within 1 step of the comparison film, constancy has not been maintained and clinical images should not be taken until the problem has been identified and corrected.

CORRECTIVE ACTION:

Repeat the test to confirm results. Verify that the processor is in control. Contact your x-ray and processor service engineers.

*This test may be substituted for daily sensitometry until a facility is able to obtain such equipment.

VIEWBOXES (Procedure 4)

OBJECTIVE:

To ensure viewboxes are clean and light levels are kept consistent throughout. A difference in luminance can create confusion and may effect accurate interpretations.

SUGGESTED PERFORMANCE CRITERIA:

Viewbox lights are the same “color” and luminance, and viewbox surfaces are kept clean.

FREQUENCY:

Monthly

REQUIRED EQUIPMENT:

Glass cleaning supplies

STEPS:

1. Clean surface of viewbox.
2. If a bulb or tube fails, it is best to replace all of them.
3. Record results on the **Monthly QC Checklist (Form 3)**.

VISUAL CHECKLIST (Procedure 5)

OBJECTIVE:

To assure that all components of the radiographic x-ray system indicator lights, displays, and mechanical locks and detents are working properly and that the mechanical rigidity and stability of the equipment is optimum.

SUGGESTED PERFORMANCE CRITERIA:

Each of the items listed in the **QC Visual Checklist (Form 2)** should pass or receive a check mark. Items not passing the visual check should be replaced or corrected as soon as possible.

FREQUENCY:

1. Quarterly
2. After service or maintenance on the x-ray system.

STEPS:

1. Collimator light brightness and cleanliness.
Determine if light is functioning and is clearly defined under normal operating conditions, without visible dust or foreign matter shadows.
2. Collimator beam limiting devices (BLDs) available and used.
If unit provides variable collimation, determine that they are functioning correctly and smoothly. If manual beam limiting devices are being used, assure they are sufficient for confining the x-ray beam to the area of clinical interest. Assure that both types are being used correctly.
3. Locks and detents operable.
Check to make sure all locks and detents are functioning as intended. Assure that the x-ray tube maintains its position at the clinically used angles.
4. Boom smoothness of motion.
Determine if boom moves easily without catches or interruptions.
5. Grid condition and operation.
If grids are being used, check that grid lines, grid cutoff, or grid damage is not visible on films. Assure that grid is properly positioned, centered to central ray and if a focused grid is being utilized that the correct focal distance is being used.
6. Condition of cables.
Inspect all cables for frayed coverings, kinks, and determine that cables are free from friction from other objects.
7. Tube or generator oil leakage.
Visually inspect areas around x-ray tube and generator for oil or abnormal collection of dust attaching to oil leaks.
8. Cassettes and screens condition.

Cassettes and screens should be cleaned regularly. Check screen condition for dust particles, scratches, and areas of discoloration. Assure screens are properly fitted and attached to cassettes. Check cassette latches to make sure they are functioning properly and are not broken. Cassettes and screens should be replaced if necessary.

9. Loaded cassette storage.

Determine that loaded cassettes are stored in an area that is properly shielded from radiation to prevent exposure. They should be stored off the ground and kept free from dust.

10. Control panel indicators.

Assure all control panel switches, lights, and meters are functioning correctly.

11. Technique chart.

Make sure a technique chart is available, current, and appropriate for all procedures normally performed.

12. Patient viewability.

Determine that means are provided to permit continuous observation of the patient during the x-ray exposure.

13. Exposure switch placement.

Assure the exposure switch is mounted in such a way that exposure can only be made with the operator in a protected area during the entire exposure. If unit is portable or mobile without a portable protective barrier, assure cable on exposure switch provides means for the operator to be at least nine feet from the tube housing during the exposure.

14. Lead aprons, gloves, collars, etc.

Assure proper items are available and stored correctly without bends or folds. If abnormal areas are found, complete Procedure 14.

CORRECTIVE ACTION:

Missing items from the room should be replaced as soon as possible. Malfunctioning equipment should be reported to the x-ray service engineer for repair or replacement as soon as possible.

***Note:** Some of the items on the visual checklist are operator convenience features. However, many of the items are essential for patient safety and high quality diagnostic images. It may be necessary to add additional items to the list that are specific to particular equipment or procedures. These should be included on the checklist and in each evaluation.

REPEAT ANALYSIS (Procedure 6)

OBJECTIVE:

To identify ways to minimize patient exposure and reduce costs by addressing higher than normal repeat rates.

SUGGESTED PERFORMANCE CRITERIA:

The criteria associated with repeating a film is subjective. There is no good way to determine what the repeat rate should be. Each facility should decide on its own, but should strive for a repeat rate of no greater than 5 to 7%.

FREQUENCY:

1. *Ongoing* tracking of films
2. Quarterly data analysis

STEPS:

1. Determine the reason for film repeat as compared to the categories listed on the data sheet.
2. Record these numbers on the **Repeat Analysis Form (Form 5)**.
3. Determine the total number of repeated films and the total number of films exposed. The overall repeat rate is the total of repeated films divided by the total number of films exposed during the test period.
4. By dividing the number of repeats per category by the total number of repeated films, a facility can determine the repeat rate per category.

CORRECTIVE ACTION:

The percentage of repeats should guide the facility to focus their efforts to those areas needing the most attention. For example, films that are too light or too dark may be due to processing problems, equipment problems that require repair or re-calibration, or technique charts may need updating.

FILM AND CHEMICAL STORAGE (Procedure 7)

OBJECTIVE:

To assure film and chemistry quality is maintained and inventory is rotated on a first in, first out basis.

FREQUENCY:

Quarterly

STEPS:

1. Maintain inventory so first in is first out.
2. Maintain the temperature and humidity to manufacturer recommendations.
3. Follow the chemistry manufacturer guidelines for replacement and disposal.
4. Record results on the **Quarterly QC Checklist (Form 3)**.

CORRECTIVE ACTION:

If storage conditions exceed manufacturer's recommendations, take the necessary steps to resolve the problem.

Note: Premixed replenisher should not be stored in the replenisher tanks for more than 2 weeks due to oxidation.

ARTIFACT EVALUATION (Procedure 8)

OBJECTIVE:

To identify and minimize artifacts that may obscure clinical findings on the radiographs.

SUGGESTED PERFORMANCE CRITERIA:

No roller marks or artifacts

FREQUENCY:

1. Quarterly
2. When artifacts are noted

REQUIRED EQUIPMENT:

1. Cassette and film
2. Marking Pen
3. Viewbox

STEPS:

1. Place the loaded cassette in the bucky or cassette holder. Expose the film to obtain an optical density of about 1.00 (5-10 mAs, 60 kVp)
2. After unloading the cassette in the darkroom, mark the direction of the film transport with a pencil and develop as usual.
3. Using the same cassette, repeat Steps 1 and 2, but this time mark and run the film perpendicular to the previous one.
4. Using a viewbox, compare the films, comparing any artifacts seen on them to their direction of travel through the processor.
5. Record results on the **Quarterly QC Checklist (Form 3)**.

ANALYSIS:

If artifacts are present, compare the artifacts with respect to the direction of film transport. If the artifacts run parallel on both films with respect to transport direction, they are from the processor. If they are perpendicular to each other when viewed with respect to transport direction, they are from somewhere else in the imaging chain.

CORRECTIVE ACTION:

Find, identify, and correct the source of artifacts

INTENSIFYING SCREEN CLEANING PROCEDURE (Procedure 9)

OBJECTIVE:

To assure that screens and cassettes are free of dust and dirt particles that may degrade image quality.

SUGGESTED PERFORMANCE CRITERIA:

Minimize artifacts on films from screens or cassettes.

FREQUENCY:

1. Quarterly or semiannually (depending on workload and amount of dust in the environment)
2. When a problem is noticed

REQUIRED EQUIPMENT:

1. Screen cleaner (as recommended by manufacturer)
2. Lint-free gauze pad or cloth, or camel's hair brush.
3. Canned air* (available from photographic supply store)

STEPS:

1. Visually inspect the condition of the intensifying screen.
2. Dust the screen with the camel's hair brush and canned air.*
3. If foreign material (e.g. dirt, developer solution) cannot be readily removed with the camel's hair brush, use liquid screen cleaner.
4. After cleaning with manufacturer approved cleaners, screens should be allowed to air-dry, standing vertically, before returning the cassette to use.
5. Record results on the **Quarterly QC Checklist (Form 3)**.

CORRECTIVE ACTION:

If the screen shows signs of cracking, fading, or discoloration it should be evaluated for replacement.

*Assure that the canned air used to clean the screens is "clean" air. If the air contains moisture, oil, or other contaminants, you may be introducing artifacts or damaging the screen.

Note: Lack of humidity in the darkroom can lead to excessive dust in the cassettes and static artifacts on film. To remedy this situation, install a humidifier in the darkroom.

DARKROOM INTEGRITY OR FOG TEST (Procedure 10)

OBJECTIVE:

To determine and minimize the amount of darkroom fog.

SUGGESTED PERFORMANCE CRITERIA:

An optical density increase of 0.05 or less.

FREQUENCY:

1. Semiannually, with each type of film used clinically
2. After bulb or filter replacement
3. After changing or adding types of film

REQUIRED EQUIPMENT:

1. Opaque material (manila folder)
2. Watch or timer
3. Attenuation block (aluminum step wedge, phantom, acrylic block) to create a medium optical density of about 1.0 on the film.
4. Densitometer

STEPS:

1. Load a cassette with film and place on a flat surface.
2. Center the attenuation block and expose the film using an x-ray technique that will result in an optical density of about 1.0 after the film is processed.
3. With the safelights on, place the exposed film on the work area in the darkroom. Cover half the film with opaque material, bisecting the latent image parallel to the long axis of the film.
4. Leave exposed film on the counter for 2 minutes, then process as usual.
5. While waiting 2 minutes for darkroom fog test, look for any sources of extraneous light. Any light leaks identified should be repaired as soon as possible.
6. Inspect the processed film. If there is no discernible delineation between the shielded and unshielded sides of the film, there is no fog problem.
7. If a line is evident, measure the optical densities of both sides of the line with the densitometer. If the density difference is greater than 0.05, corrective action should be taken.
8. Record results on the **Semiannual QC Checklist (Form 3)**.

CORRECTIVE ACTION:

Repeat the test with the safelight off. If the results remain the same, the problem may be caused by a light leak or extraneous light. If the fog level disappears, the fog was due to the safelight and remedial action must be taken to correct the problem.

POSSIBLE SOURCES OF DARKROOM FOG:

- Safelight filters (old or compromised)
- Safelight housing
- Safelight too close to work area
- Light bulb of incorrect wattage or type
- Ancillary indicator lights on processor
- Timers
- Radios
- Fluorescent light afterglow
- Light leaks
- Suspended ceilings
- Any place there is a hole cut in the wall
- Excessive ambient light through the tinted viewing windows of daylight loading systems

SCREEN-FILM CONTACT TEST (Procedure 11)

OBJECTIVE:

To assure that optimum contact is maintained between the screen(s) and film in each cassette.

SUGGESTED PERFORMANCE CRITERIA:

No large areas (> 2 cm in diameter) of poor contact.

FREQUENCY:

1. Acceptance testing for new cassettes
2. Annually
3. As needed, if reduced image sharpness is suspected

REQUIRED EQUIPMENT:

1. Brass or copper mesh screens (1/8 inch or 3 mm spacing). The mesh should be as large as the largest cassette to be tested. The mesh can be placed between two thin sheets of acrylic or cardboard to protect it.
2. Densitometer

STEPS:

1. Load cassettes to be tested and let rest for approximately 15 minutes to allow trapped air to escape.
2. Place the cassette on the table and collimate the beam to the cassette size.
3. Place the wire mesh on top of the cassette and expose the cassette. (Suggested technique factors are: 5-10 mAs, 50 kVp; 2 mAs, 70 kVp; or 3-5 mAs, 60 kVp).
4. Process the film. The optical density of the area between the wires of the mesh on the film should be between 1.5 and 2.0.
5. View the film on a viewbox in a room with low ambient lighting. Stand 6 to 8 feet away from the viewbox to evaluate the film.
6. Areas of poor contact will appear as dark areas on the film.
7. Record results on the **Annual QC Checklist (Form 4)**.

CORRECTIVE ACTION:

Large areas (>2 cm in diameter) of poor contact may indicate the need for corrective action. Clean the cassettes and retest. Areas of poor contact around the periphery of the cassette may indicate faulty latches or worn seals on the cassettes. If the area of poor contact is not eliminated by cleaning, consider replacing the cassette.

COLLIMATION TESTS (Procedure 12)

OBJECTIVE:

To assure that the light field accurately defines the x-ray field.

SUGGESTED PERFORMANCE CRITERIA:

The light and x-ray field misalignment does not exceed 2% of the source-to-image distance (SID) in either the length or the width of the film.

FREQUENCY:

1. Annually
2. After service or maintenance on the x-ray system (e.g., changing the light bulb)

REQUIRED EQUIPMENT:

1. 8 coins
2. Measuring tape

STEPS:

1. Place a 10 x 12 inch (24 x 30 cm) loaded cassette at a known SID (e.g., 28 inches).
2. If possible, adjust the field size to 6 x 8 inches (15 x 20 cm). The field must be smaller than the film. If your system is not equipped with a variable collimator, attach a beam limiting device (BLD) that provides a field size smaller than the cassette.
3. Place the coins as shown in the **Figure 2**.
4. Expose (65 kVp, 4 mAs) and develop the film. If field edges are not well defined, adjust techniques accordingly and repeat this step.
5. **Measure** the distances between the light (where the coins touch) and x-ray fields for all coin locations (see **Figure 3**).
6. Add differences for each set of coins along and across the film, and divide each set of differences by the SID (Example: (1.5" along table / 28")(100) = 5.38% and (0.5" across table / 28")(100) = 1.79%).
7. Percentage differences greater than 2.0% in either direction should be corrected as soon as possible.
8. Using the same exposed film, determine the center of the x-ray field (darkened portion of film) using a straight edge (see **Figure 4**).
9. In the same manner, determine the center of the film.
10. **Measure** distance between the two centers and calculate the difference as a percentage of the SID. If the percentage difference is greater than 2.0%, corrective action is necessary.
11. **Measure** the dimensions of the x-ray field on the film. If the difference between the indicated and measured field size exceeds 2% of the SID, corrective action is required.

12. Record on the **Annual QC Checklist (Form 4)**.

CORRECTIVE ACTION:

Malfunctioning equipment should be reported to the x-ray service engineer to correct the problem.

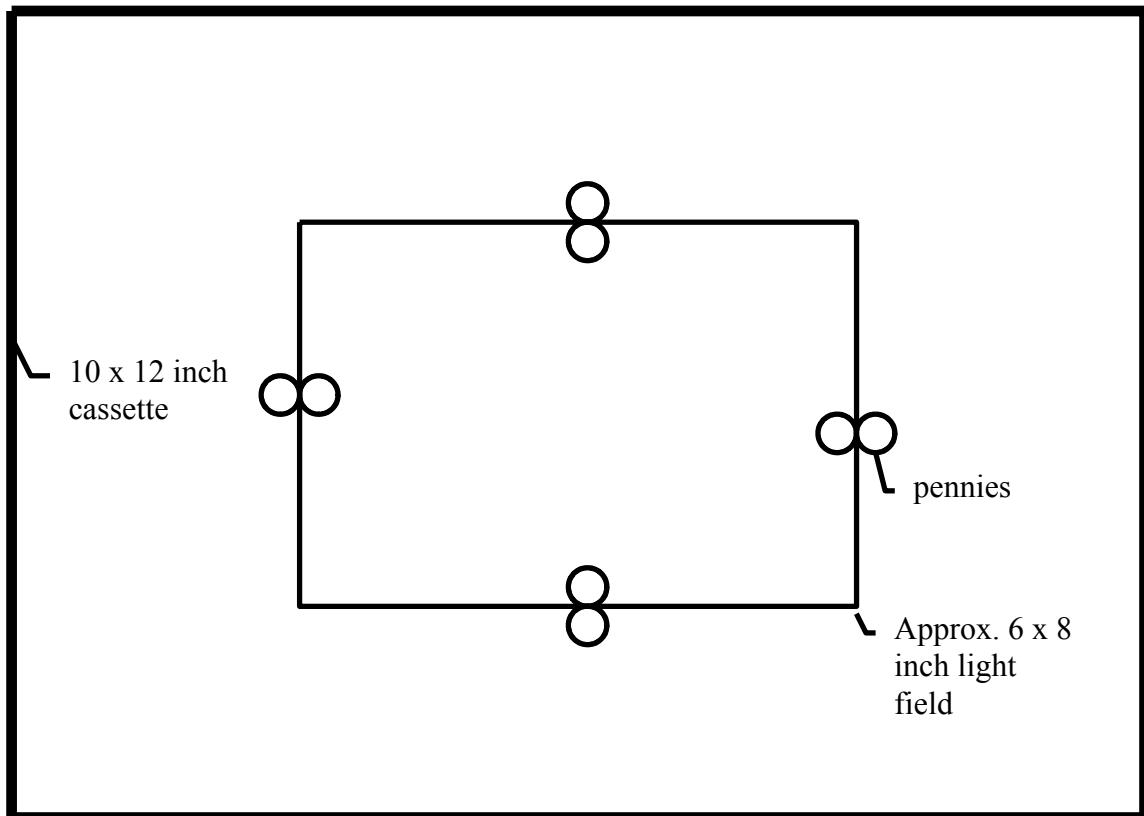
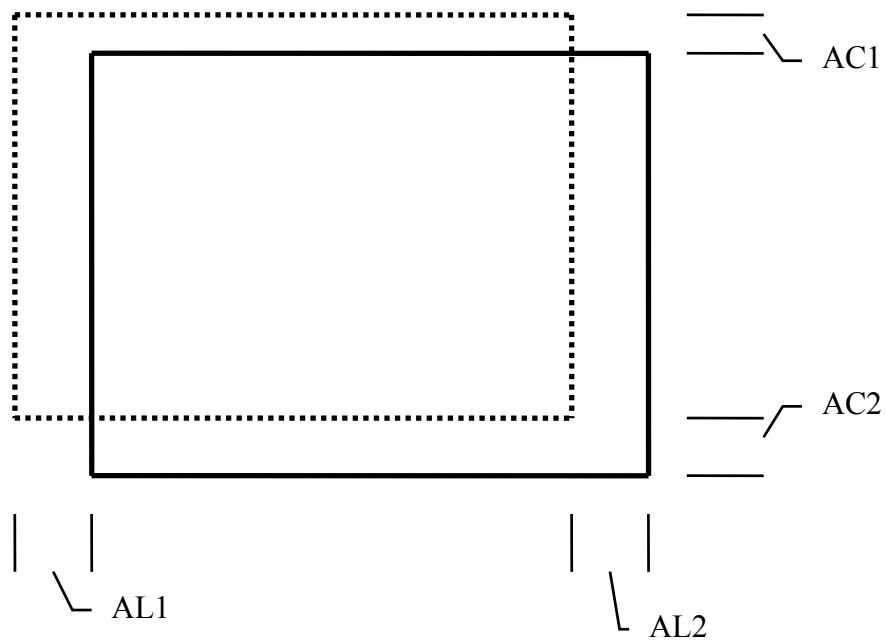


Figure 2. Setup for Collimator Accuracy Test.



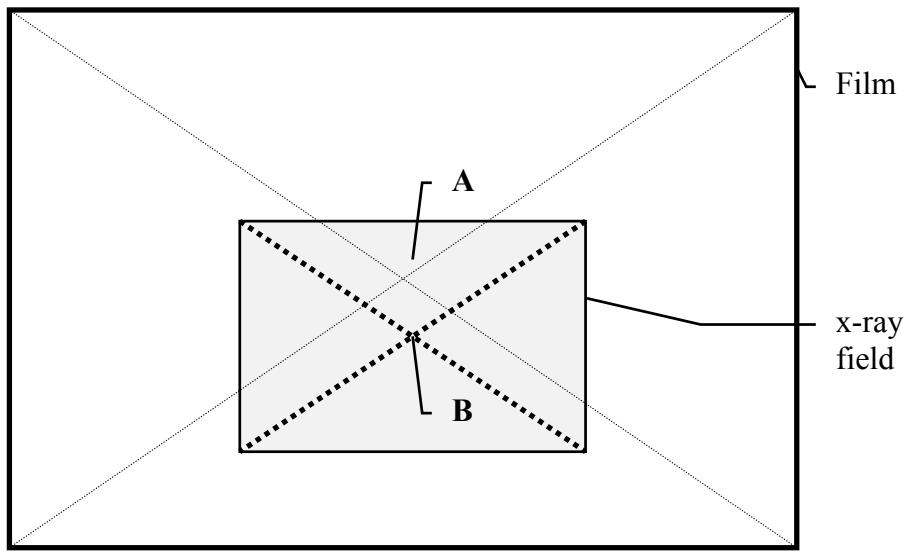
Where: is the edge of the light field (where the coins touch)
 —— is the edge of the x-ray field

Then: $AL1 + AL2 = \text{TotAL}$ (Total along table misalignment in inches)
 $AC1 + AC2 = \text{TotAC}$ (Total across table misalignment in inches)

$(\text{TotAL} / 28")100 = \%$ misalignment of light vs. x-ray field along table
 $(\text{TotAC} / 28")100 = \%$ misalignment of light vs. x-ray field across table

If either of the above is greater than 2%, corrective action is necessary.

Figure 3. Determining the Total Misalignment of the Light Field and the X-ray Field.



IF: **CtrMis** is the distance in inches between **A** and **B**.

THEN: $(\text{CtrMis} / 28")100 =$ % misalignment of the center of the film in the cassette holder and the center of the x-ray field at an SID of 28 inches.

If the above is greater than 2%, corrective action is necessary.

Figure 4. Determining Alignment of X-ray Field to Cassette Holder.

SOURCE-TO-IMAGE DISTANCE INDICATION (Procedure 13)

OBJECTIVE:

To assure that the source-to-image distance (SID) is indicated accurately.

SUGGESTED PERFORMANCE CRITERIA:

The actual SID is within 2% of the indicated SID.

FREQUENCY:

1. Annually
2. After service or maintenance on the x-ray system

REQUIRED EQUIPMENT:

Measuring Tape

STEPS:

1. Note the indicated SID from the distance indicator. This should be done for each clinically used SID.
2. Measure the distance from the focal spot to the cassette. If the focal spot is not indicated on the tube housing, contact the x-ray service engineer or consult the operators manual.
3. This distance should be within 2% of the indicated SID.
4. Record results on the **Annual QC Checklist (Form 4)**.

CALCULATIONS:

Calculate 2% of the SID. Example: $(100\text{cm})(.02) = 2\text{ cm}$

CORRECTIVE ACTION:

Malfunctioning equipment should be reported to the x-ray service engineer for repair or replacement as soon as possible.

Note: If the x-ray machine is not equipped with variable SID (e.g., *Excel* podiatry units), this test need not be completed.

LEAD APRON, GLOVE, GONADAL, AND THYROID SHIELD INTEGRITY CHECK (Procedure 14)

OBJECTIVE:

To assure that the lead aprons, gloves, gonadal shields, and thyroid collars provide optimal protection when positioned appropriately.

SUGGESTED PERFORMANCE CRITERIA:

No breaks in lead lining of protective garments.

FREQUENCY:

Annually

REQUIRED EQUIPMENT:

Lead aprons, gloves, gonadal, and thyroid shields

STEPS:

Option 1: If an image intensified fluoroscopy unit is available, this is the preferred way to inspect the aprons, gloves, and collars.

1. Lay out the item to be checked on the table.
2. Examine the entire item using the fluoroscope.
3. Record results on the **Annual QC Checklist (Form 4)**.

Option 2: If an image intensified fluoroscopy unit is not available:

1. Closely inspect each item for kinks and irregularities.
2. Take a radiograph of suspect areas.
3. Process the film and look for breaks in the lead lining.
4. Record results on the **Annual QC Checklist (Form 4)**.

CORRECTIVE ACTION:

Any item displaying breaks in the lead lining should be replaced.

Note: Lead aprons should never be folded. Cracks in the lead lining can develop at the fold, reducing the useful life of the apron.

BIBLIOGRAPHY

Quality Assurance in Dental Radiography by Kodak (1990).

Exposure and Processing in Dental Radiography by Kodak (1990).

Checklist for Establishing a Diagnostic Quality Assurance Program by USDPHHS/PHS/FDA/CDRH (1980).

Data Record for HHS Field Tests by General Electric Medical Systems (1985).

X-ray Processor Quality Assurance Program by the Coast Guard.

21 CFR 1000.55 Recommendation for Quality Assurance Programs in Diagnostic Radiology Facilities (1979).

Quality Assurance Manual by CRCPD H-7 Committee (1980).

Update of 2/99 “QA Collectible” on darkroom fog by CRCPD H-7 Committee.

Suleiman OH, Showalter CK, Gross RE, Bunge RE. *Radiographic Film Fog in the Darkroom*. Radiology 1984; 151:237-238.

Conway BL, Suleiman OH, Rueter FG, Antonsen RG, Slayton RJ. *National Survey of Mammography Facilities in 1985, 1988, and 1992*. Radiology 1994; 191:323-330.

American College of Radiology. *Mammography Quality Control Manual*. Reston, VA: American College of Radiology; 1999.

American College of Radiology. *Barium Enema Quality Control Manual*. Reston, VA: American College of Radiology; 1998.

NCRP #100, PP.34-37.

Gray JE, Winkler NT, Stears JG, Frank ED, *Technical Aspect of Screen-Film Radiography Film Processing & Quality Control*, Maryland: 1983 Aspen Systems, Inc., Rockville, MD.

AAPM Report No. 4, Basic Quality Control in Diagnostic Radiology, 1978.

Kodak Image Insight 3, Screen Imaging, The Film-Screen Combination: Fundamentals; 1976.

Guidelines for a Radiology Department, August 1984, Ontario Medical Association and Ontario Hospital Association.

Wilson RL, *Chiropractic Radiography and Quality Assurance Handbook*, 1999, CRC Press, Fla.

APPENDIX A

FORMS AND CHECKLISTS

The following forms and checklists may be reproduced as necessary to aid in maintaining your quality control program:

- ✓ *Quality Control Program Contact Sheet*
A form designed to be completed, posted in the QC work area, and used as a quick reference.
- ✓ *Daily Quality Control Checklist (Podiatric Form 1)*
Is a daily checklist to ensure that Procedures 1 and 2 are completed.
- ✓ *Quarterly Quality Control Visual Checklist (Podiatric Form 2)*
This checklist should be completed every calendar quarter as described in Procedure 5.
- ✓ *Monthly, Quarterly, and Semiannually Quality Control Checklist (Podiatric Form 3)*
Is a checklist for Procedures 3, 4, 6, 7, 8, 9, and 10.
- ✓ *Annually and Biennially Quality Control Checklist (Podiatric Form 4)*
Is a checklist for Procedures 11, 12, 13, and 14, and the routine survey by the qualified expert.
- ✓ *Repeat Analysis Form (Podiatric Form 5)*
Is used for the ongoing tracking of repeat films and to calculate the repeat rate, following Procedure 6. An example form is included.
- ✓ *Annual Quality Control Review Form (Podiatric Form 6)*
Is designed to be used as an aid during the annual review of the QA program.

Note: In addition to the forms in Appendix A, there are two forms in Appendix B:

X-Ray Processing Control Chart (*Form B-1*)
Cross-over Worksheet (*Form B-2*)

QUALITY CONTROL PROGRAM CONTACT SHEET

	<u>NAME AND ADDRESS</u>	<u>PHONE</u>
Doctor Responsible for QA	_____	_____
QA Coordinator	_____	_____
State Radiation Control Program	_____	_____
Medical Physicist or Qualified Expert	_____	_____
X-ray Machine(s) Technical Representative	_____	_____
Film Processor Technical Representative	_____	_____
X-ray Film and Intensifying Screens Technical Representative	_____	_____
Service Engineer	_____	_____
Radiation Safety Officer	_____	_____

Current as of: _____

DAILY
QUALITY CONTROL CHECKLIST
(Podiatric Form 1)

Facility: _____

Month: _____

Year: _____

Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Initials																															
Processor QC																															
Darkroom Cleanlines																															

Comments (Date problems noted and identified, corrective action taken):

Pass = P Fail = F Does Not Apply = NA

**QUARTERLY
QUALITY CONTROL VISUAL CHECKLIST
(Podiatric Form 2)**

Year(s): _____

Facility: _____

Calendar Quarter (1 st , 2 nd , 3 rd , 4 th)						
Date						
Initials						
1. Collimator Light Brightness and Cleanliness						
2. Collimator BLDs Available and Used						
3. Locks and Detents Operable						
4. Boom Smoothness of Motion						
5. Grid Condition and Operation						
6. Condition of Cables						
7. Tube or Generator Oil Leakage						
8. Cassettes and Screens Condition						
9. Loaded Cassette Storage						
10. Control Panel Indicators						
11. Technique Chart						
12. Patient Viewability						
13. Exposure Switch Placement						
14. Lead Aprons, Gloves, Collars, Etc.						

Each radiographic unit should be evaluated and any failures noted above should be described in detail in the Remarks section.

Remarks (Date problems noted and identified, corrective action taken):

Pass = T Fail = F Does Not Apply = NA

**MONTHLY, QUARTERLY, AND SEMIANNUALLY
QUALITY CONTROL CHECKLIST
(Podiatric Form 3)**

Year: _____ Facility: _____

Date										
Initials										
System Constancy										
Viewboxes										
Repeat Analysis										
Artifact Evaluation										
Film and Chemistry Storage										
Screen and Cassette Cleanliness										
Darkroom Fog										

Remarks (Explain problems identified and corrective action taken):

Pass = P Fail = F Does Not Apply = NA

ANNUALLY AND BIENNIALLY
QUALITY CONTROL CHECKLIST
(Podiatric Form 4)

Date		<i>Qualified Expert Survey Date</i>	
		Half-value Layer	
Light and X-ray Field Alignment		Focal Spot and Resolution	
Field Size Indicator Accuracy		Timer Accuracy and Reproducibility	
SID Indication		kVp Accuracy and Reproducibility	
Lead Aprons, Gloves, Collars, Etc.		mA Linearity	
Screen-film Contact		Exposure Reproducibility	
		ESE Evaluation	
		Technique Chart Evaluation	

Remarks (Explain problems identified and corrective action taken):

The qualified expert report for each unit, as well as documentation on the corrective action taken on identified problems, should be maintained along with this checklist.

Pass = P Fail = F Does Not Apply = NA

REPEAT ANALYSIS FORM
(Podiatric Form 5)

From: _____ To: _____

Facility: _____

Cause	Number of Films	Percentage of Repeats
1. Positioning		
2. Patient Motion		
3. Light Films		
4. Dark Films		
5. Black Films		
6. Static		
7. Fog		
8. Incorrect Patient ID		
9. Double Exposure		
10. Miscellaneous (?)		
11. Good Films (No Apparent Problem)		
12. Clear Film		

Total

Repeats (1-12)		%
----------------	--	---

Total Film Used _____

EXAMPLE REPEAT ANALYSIS FORM

From: 1/1/99 To: 3/31/99

Facility: Hometown Podiatry

CAUSE	Number of Films	Percentage of Repeats
1. Positioning 1111111	7	19%
2. Patient Motion 111111111	9	24%
3. Light Films 111	3	8%
4. Dark Films 111111111111	13	35%
5. Black Films	-	-
6. Static 1	1	2.7%
7. Fog 11	2	5.4%
8. Incorrect Patient ID 11	2	5.4%
9. Double Exposure	-	-
10. Miscellaneous (?)	-	-
11. Good Films (No Apparent Problem)	-	-
12. Clear Film	-	-

Repeats (1-12)	Total	5.3%
37	37	37

Total Film Used 694

*37 total repeats / 694 total film used = 0.053 or 5.3%
 7 total positioning problems / 37 total repeats = 0.19 or 19%.*

ANNUAL QUALITY CONTROL REVIEW FORM (Podiatric Form 6)

Facility Name: _____ QC Coordinator: _____

Date of Review: _____ Year Reviewed: _____

Attendees: _____

- < Is image quality being maintained at the desired level?
- < What is the facility repeat rate? Are changes addressed when necessary?
- < Is the x-ray technique chart up-to-date?
- < Is the screen-film combination still the best for the facility? Are the screens over 15 years old? If so, consider replacing them.
- < Do all personnel meet required or established qualifications?
- < Based on QC trends (variations or inconsistencies on QC charts), do any procedures, practices, or equipment need to be modified?
- < Do any QC procedures need to be changed or updated?
- < Are personnel adequately performing assigned tasks?
- < Is patient and personnel radiation exposure as low as reasonably achievable as compared to national data?

APPENDIX B

PROCESSOR QUALITY CONTROL

(Reprinted from the 1998 *ACR Barium Enema Quality Control Manual* with permission of the American College of Radiology, Reston, Virginia. No other representation of this material is authorized without express, written permission from the American College of Radiology.)

OBJECTIVE:

To confirm and verify that the film processor-chemical system is working in a consistent manner according to pre-established specifications (manufacturer's specifications).

FREQUENCY:

Daily, prior to processing patient films.

REQUIRED EQUIPMENT:

1. Sensitometer
2. Densitometer
3. Fresh box of control film
4. Control chart
5. Non-mercury clinical digital fever thermometer, accurate to at least $\pm 0.5^{\circ}$ F.

PROCEDURES:

A. Establishment of Processor Quality Control Operating Levels

This procedure is carried out when the quality control program is initiated or when a significant change is made in imaging procedures, i.e., different film, chemicals, or processing conditions.

B. Daily Processor Quality Control

This procedure is carried out daily at the beginning of the work day before processing any patient films but after processor warm-up. This procedure ensures consistent film quality through consistent film processing.

C. Control Film Cross-Over

This procedure is carried out whenever a new box of film is opened for QC purposes. Radiographic film is produced in batches and it may be necessary to adjust baselines based on slight variations in film between batches.

Procedure A: Establishment of Processor Quality Control Operating Levels

1. Select a fresh box of film of the same type used clinically, and reserve this box for QC purposes only. (Note emulsion number on quality control chart.)
2. Drain the chemicals from the processor and thoroughly flush the racks and tanks with water.
3. Drain the replenisher tanks and refill with fresh replenisher.
4. Fill the fixer tank with fixer solution.
5. Once again flush the developer tank with water.

6. Fill the developer tank about one-half full with developer solution and add the specified amount of developer starter solution. Add sufficient developer solution to fill developer tank.
7. Set the solution temperature controls at the temperatures specified in the film manufacturer's written literature.
8. Set the developer and fixer replenishment rates as specified by the film manufacturer.
9. After the developer temperature has stabilized, check the temperature of the developer solution with a clinical fever thermometer and assure that the processor is operating at the temperature specified by the film manufacturer. Clean the thermometer stem of developer solution after each use.
10. Using a sensitometer, expose and process a sensitometric strip. Repeat this exposure and processing once each day for 5 consecutive days.

Note: Before processing sensitometric strips, be sure that the:

- Developer temperature is correct;
- Sensitometric strip is processed with the less-exposed end being fed into the processor first;
- Sensitometric strip is processed on the same side of the processor, and it is inserted on the same side of the processor feed tray each time;
- Sensitometric strip is processed with the emulsion in the same orientation (for single emulsion films); and
- Delay between exposure and processing is similar each day to avoid any latent image changes that may occur with time.

11. Read and record the densities of each step of the sensitometric strip using the densitometer, including an area of processed film that has not been exposed. Measure the densities of the steps in the center of each step.
12. Determine the average of the densities for each step using the densities from the same step of the 5 strips done on 5 consecutive days.
13. Determine which step has an average density closest to 1.20. Record this optical density and corresponding step number as the mid-density (MD) step on the control chart (Form B-1). (This step is often referred to as the speed point, speed index, or speed step.) The mid-density is a measure of how dark the films will be. Underprocessing will produce films that are too light.
14. Determine which step has a density closest to, but less than, 2.20 and record this step number as the high-density (HD) step on the control chart (**Form B-1**). Next, determine which step has a density closest to but not less than 0.45 and record this step number as the low-density (LD) step on the control chart. The difference in densities between these two steps (HD minus LD) should be designated as the density difference (DD). The density difference is a measure of the contrast provided on the film that can be affected by processing conditions. Underprocessing can reduce contrast.

Note: The density difference determined by this method is to be used only to assess consistency of film and processing. It is not appropriate for comparing different film types or for comparing film types processed at different facilities.

15. Determine the average of the densities from the unexposed area of the 5 strips. This density will be recorded on the control chart (Form B-1) as the base-plus-fog level (B+F) of the film.
16. Confirm that the numerical values of the MD, DD, and B+F you recorded on the center line of the appropriate areas of the control chart are correct. See **Figure B-1** and the following section entitled “Suggested Performance Criteria” for examples and further information.

Procedure B: Daily Processor Quality Control

1. Expose and immediately process a sensitometric strip. Before processing sensitometric strips be sure that the:
 - Developer temperature is correct,
 - Sensitometric strip is processed with the less-exposed end fed into the processor first,
 - Sensitometric strip is processed on the same side of the processor, i.e., it is inserted on the same side of the processor feed tray each time, and
 - Delay between exposure and processing is similar each day to avoid any latent image changes that may occur with time.
2. Read the densities of the three indicated steps and the base-plus-fog.
3. Plot the mid-density (MD), the density difference (DD), and the base-plus-fog (B+F) level on the control chart.
4. Determine if any of the data points exceed the control limits.
5. Circle the out-of-control data points, correct the cause of the problem and repeat the test, note the cause of the problem in the “Remarks” section of the control chart, and plot the in-control data point(s).
6. Determine if there are any trends (3 or more data points moving in the same direction) in the MD, DD or B+F. If trends are present but the data points have not yet exceeded the control limits, patient films may be processed. However, it will be necessary to determine the cause of the trend and to monitor the processor closely to assure that the control limits are not exceeded.

Procedure C: Control Film Cross-Over

1. While you still have at least 5 sheets of the old QC film remaining, select a new box of film for processor quality control.
2. Assure that the processor is in control.
3. Expose and immediately process 5 sensitometric strips each from the old and new boxes of film.
4. Determine the average of the steps previously identified for processor quality control for MD, DD, and B+F from the 5 films from the old box and from the 5 films from the new box. **See Form B-2.**
5. Determine the difference in the average values between the new and old boxes of film, as shown in the example in **Figure B-2.**
6. Adjust the old operating levels for MD, DD, and B+F by this difference to establish the new operating levels. This is accomplished by adding the difference (new-old), including

the sign, to the old operating level. If the difference (new-old) is positive, the new operating level is increased. If the difference (new-old) is negative, the new operating level is decreased.

7. Record the new operating levels with their new control limits on a new control chart. Record the complete emulsion number of the new box of film on the new processor control chart. If the new box of film produces step densities that are so different from the old that the monitored steps are no longer the best choices, then new operating levels need to be established. (The best choices are the step with densities greater than or equal to 0.45 for the low-density step, closest to 1.20 for the mid-density step, and closest to but less than 2.20 for the high-density step.)
8. Make a notation on the control chart in the remarks section of the date that a cross-over was performed.

PRECAUTIONS:

It is desirable that sensitometric strips be exposed and processed and the data evaluated before clinical films are processed each day. If problems are detected, corrective action must be taken before clinical films are processed under less than optimal conditions.

The use of sensitometric strips exposed more than an hour or two before use is not acceptable because these strips may be less sensitive to changes in the processor than freshly exposed strips. In addition, as noted above, the sensitometric strip must be evaluated before clinical films are processed. Reading of the sensitometric strips and evaluating the results hours or days after the strip has been processed do not provide adequate quality control. Many clinical films may be improperly processed before the results are available. In order to maintain good QC of the processor, it is essential to read the densities of the sensitometric control strips with a calibrated densitometer. Visual comparison of the steps of the control strips is not adequate.

As indicated above, each sensitometric strip must be processed on the same side of the processor and fed into the processor with the less-exposed (low density) end of the strip leading. This reduces variation in the results and avoids development artifacts.

Radiographic film is produced in batches. Consequently, there may be slight variations in the characteristics of film between batches. In addition, film aging and storage conditions can affect the sensitometric characteristics of the film. Whenever a new box of film is opened for QC purposes, it is necessary to perform a "cross-over" with the old film. That is, the purpose of running the daily sensitometric strip is to test the processing and not the film, so if the new batch of film is darker (a higher optical density) under exactly the same processing conditions, then one must adjust the operating levels (MD and DD) to the values measured for the new film. The "cross-over" should be carried out only with a processor with seasoned chemistry. Expose and process, at the same time, 5 sensitometric strips each from the old and new boxes of film. Determine the average of each of the 3 indicated steps and of the base-plus-fog for the old film and for the new film. The operating level on the control chart should be adjusted to the new levels for MD and DD. For example, if the MD operating level for the old film was 1.30 and the new film has an optical density 0.1 higher

than the old film, simply change the number on the control chart from 1.30 to 1.40. If the B+F of the new film exceeds the B+F of the old film by more than 0.02, the cause for this increase should be investigated.

It is essential to assure that developer temperature is within $\pm 0.5^{\circ}\text{F}$ of the temperature specified by the film manufacturer. Quality control must also be performed on the densitometer, sensitometer, and thermometer themselves, to ensure their proper calibration. Manufacturer recommendations for quality control on these instruments should be followed, where available.

Do not use previously-processed film as “clean-up” film for the processor, since this can contaminate the developer.

SUGGESTED PERFORMANCE CRITERIA AND CORRECTIVE ACTION:

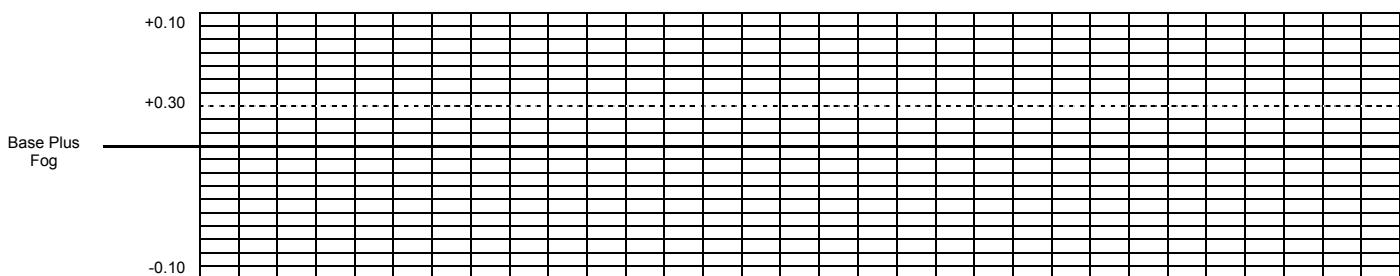
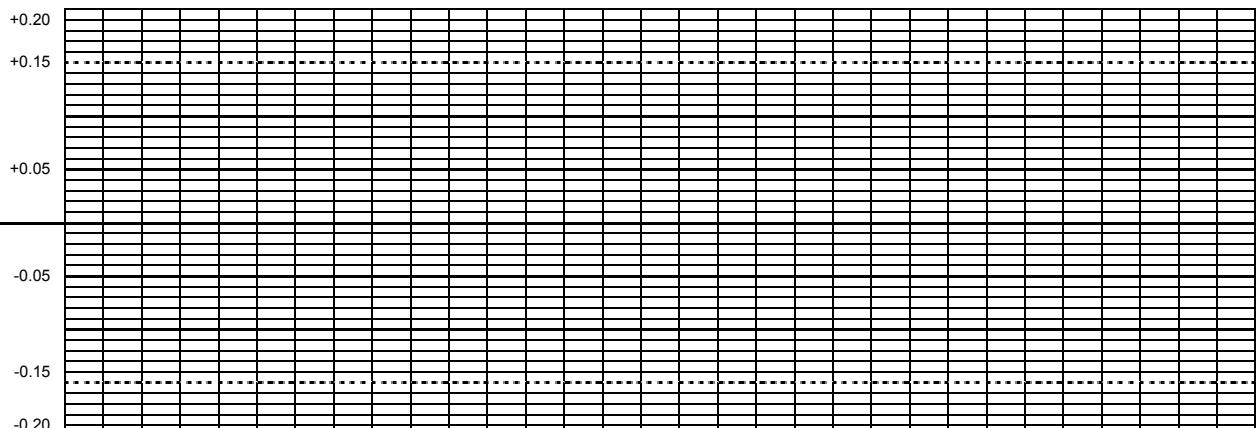
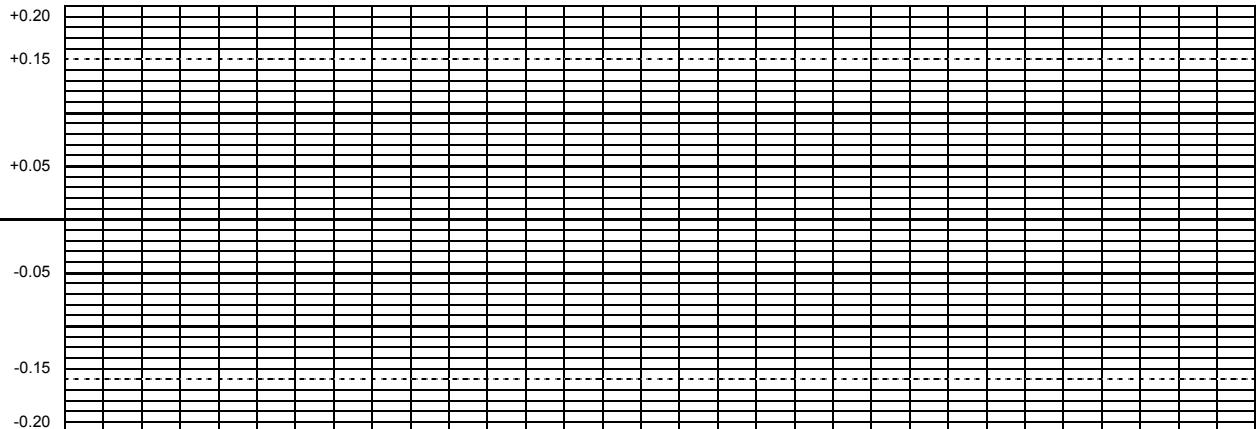
If the MD and DD are within ± 0.15 of their respective operating levels, and the B+F is within ± 0.03 of its operating level, the processor is in control, and no further action is required. If the MD or DD exceeds the control limit of ± 0.15 , the source of the problem should be determined and corrected before clinical films are processed. Likewise, if the B+F exceeds $+0.05$, corrective action should be taken before clinical films are processed.

If a change in the mid-density, density difference, or base-plus-fog exceeds the suggested performance criteria, it will be necessary to determine the source or sources of this change (temperature, chemistry, replenishment, etc.) and the problem(s) should be corrected. In addition, the out-of-control data point should be circled, the cause of the problem noted in the “Remarks” section of the control chart, and the in-control data point plotted. See **Figure B-1**.

X-RAY PROCESSING CONTROL CHART
FORM B-1

Processor: _____ Film: _____
 Emulsion # _____ Month _____ Yr. _____

Month:												
Date:												
Initials:												



REPLENISHMENT RATE

Date	Developer	Fixer

TEMPERATURE

Date	Developer	Wash

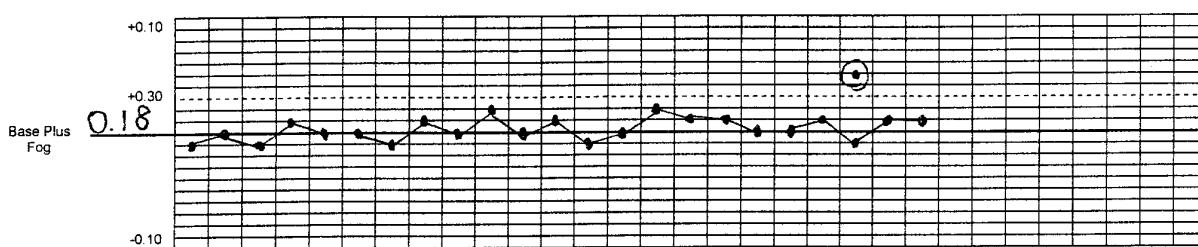
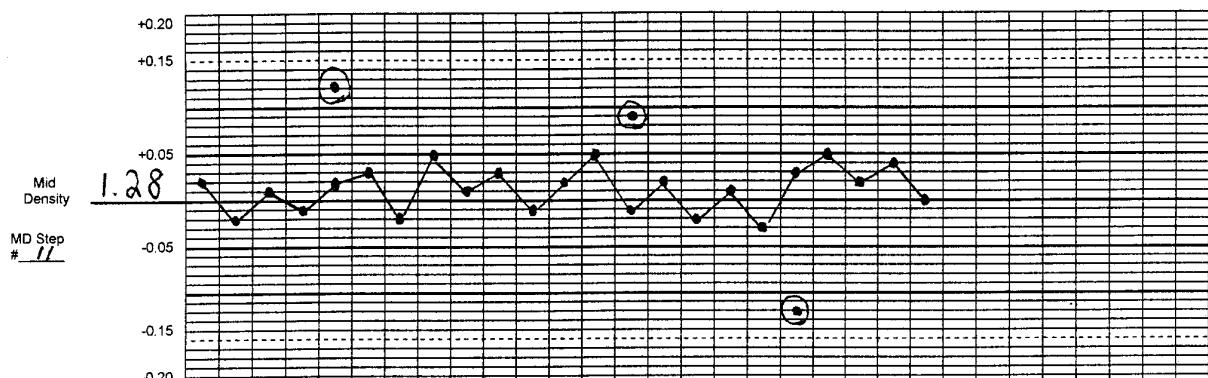
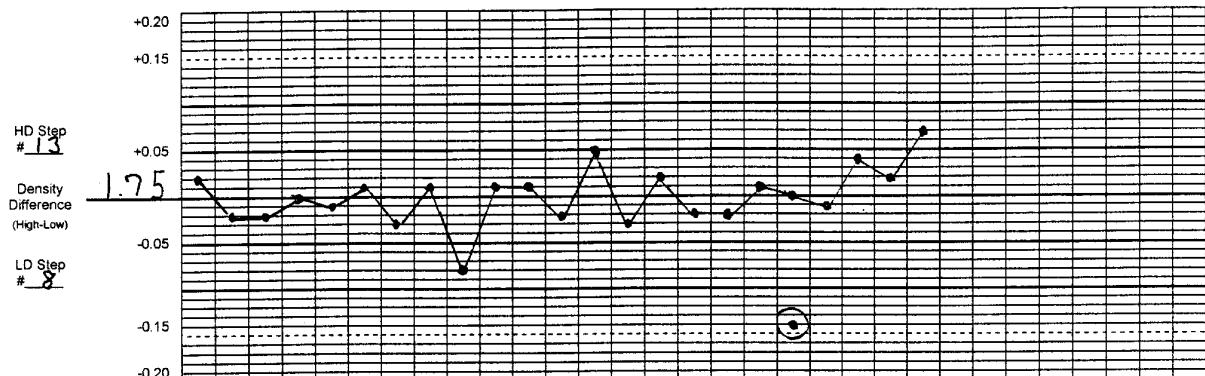
REMARKS

Date	Action

Date	Action

X-RAY PROCESSING CONTROL CHART

Processor: MAIN Film: ABC
Emulsion #: 234567 Month APRIL Yr. 1999



REPLENISHMENT RATE		
Date	Developer	Fixer
4/19	70	90
5/5	60	90
5/12	70	90

TEMPERATURE		
Date	Developer	Wash
4/19	95°	68°
4/23	75°	71°

Date	Action	REMARKS
4/23	Temp high - lowered to 95°	
5/5	NOTED TREND lowered	
	reptile rate	
5/12	increased	
	reptile rate	

Date	Action
5/14	Fixed light + leak

Figure B1. X-ray Processing Control Chart Example.

CROSS-OVER WORKSHEET
FORM B-2

New Emulsion #					Old Emulsion #				
Film #	Low Density (LD) Step#	Mid Density (MD) Step#	High Density (HD) Step#	B + F	Film #	Low Density (LD) Step#	Mid Density (MD) Step#	High Density (HD) Step#	B + F
1					1				
2					2				
3					3				
4					4				
5					5				
Average					Average				
Average Density Difference (DD = HD - LD)					Average Density Difference (DD = HD - LD)				

MD difference between old and new film (New MD - Old MD)	
DD difference between old and new film (New DD - Old DD)	
B+F difference between old and new film (New - Old)	

	MD	DD	B + F
Old operating levels			
Difference between new and old film			
New operating levels			

New Emulsion #		24578			Old Emulsion #		23456		
Film #	Low Density (LD) Step#10	Mid Density (MD) Step#11	High Density (HD) Step#13	B + F	Film #	Low Density (LD) Step#10	Mid Density (MD) Step#11	High Density (HD) Step#13	B + F
1	0.49	1.25	2.39	0.18	1	0.46	1.27	2.33	0.17
2	0.50	1.23	2.43	0.18	2	0.48	1.30	2.30	0.17
3	0.49	1.26	2.40	0.17	3	0.46	1.27	2.28	0.18
4	0.53	1.28	2.41	0.18	4	0.48	1.28	2.32	0.17
5	0.49	1.28	2.43	0.18	5	0.47	1.31	2.35	0.18
Average	0.50	1.26	2.41	0.18	Average	0.47	1.29	2.31	0.17
Average Density Difference (DD = HD - LD)					Average Density Difference (DD = HD - LD)				

MD difference between old and new film (New MD - Old MD)	-0.03
DD difference between old and new film (New DD - Old DD)	+0.07
B+F difference between old and new film (New - Old)	+0.01

	MD	DD	B + F
Old operating levels	1.34	1.9	0.17
Difference between new and old film	-0.03	+0.07	+0.01
New operating levels	1.31	1.97	0.18

Figure B-2. Cross-over Worksheet Example.

APPENDIX C

GLOSSARY

Aluminum equivalent means material affording the same attenuation as a thickness of aluminum (type 1100 alloy).

Automatic exposure control (AEC), also called a phototimer, means a device that automatically controls one or more technique factors to deliver a required quantity of radiation.

Beam-limiting device, also called a collimator, diaphragm or cone, means a device that provides a means to restrict the dimensions of the useful x-ray field.

Beam quality. See half-value layer (HVL).

Cassette holder, sometimes called a “Bucky,” means a device, other than a spot-film device, that positions an x-ray film cassette during an x-ray exposure.

Control panel means that part of the x-ray control upon which are mounted the switches, knobs, push buttons, and other hardware necessary for manually setting the technique factors.

Collimator. See beam-limiting device.

Dose means the absorbed dose as defined by the International Commission on Radiation Units and Measurements.

Exposure is the amount of ionizing radiation (in air) produced by the x-ray machine.

Exposure reproducibility is a measure of the x-ray machine’s ability to have a consistent output at a preselected technique.

Focal spot is the source of the x-rays on the anode in the x-ray tube.

Half-value layer (HVL), also referred to as beam quality, means the thickness of specified material that attenuates the intensity of the radiation beam to one-half of its original value.

Image receptor means any device, such as a fluorescent screen, radiographic film, solid-state detector, which transforms incident x-ray photons either into a visible image or into another form that can be made into a visible image by further transformations. In those cases where means are provided to preselect a portion of the image receptor, term “image receptor” shall mean the preselected portion of the device (e.g., spot film devices).

Image receptor support means that part of the x-ray system designed to support the image receptor during an examination.

kVp is the peak kilovoltage applied to the x-ray tube.

Light field is produced by a light source in the collimator (or beam limiting device) and indicates the location and size of the x-ray field.

Phototimer. See automatic exposure control.

Primary protective barrier is the material, excluding filters, placed in the primary beam to reduce the radiation exposure for protection purposes.

Qualified expert is an individual having the knowledge, training, and experience to measure ionizing radiation, evaluate safety techniques, and advise regarding radiation protection needs and medical quality assurance programs. A *qualified medical physicist* will meet the requirements of a *qualified expert*.

Qualified medical physicist is an individual who is competent to practice independently. This individual demonstrates competence through certification in radiological or diagnostic radiological physics and continuing education in relevant areas.

Quality administration procedures are those management actions intended to guarantee that monitoring techniques are properly performed and evaluated and that necessary corrective measures are taken in response to monitoring results. These procedures provide the organizational framework for the quality assurance program.

Quality assurance means the planned and systematic actions that provide adequate confidence that a diagnostic x-ray facility will produce consistently high quality images with minimum exposure of the patients and healing arts personnel. The determination of what constitutes high quality will be made by the facility producing the images. Quality assurance actions include both "quality control" techniques and "quality administration" procedures.

Quality assurance program is an organized entity designed to provide "quality assurance" for a diagnostic radiology facility. The nature and extent of this program will vary with the size and type of the facility, the type of examinations conducted, and other factors.

Quality control techniques are techniques used in the monitoring or testing and maintenance of the components of an x-ray system. The quality control techniques thus are concerned directly with the equipment.

Repeat films are those patient films that had to be repeated and resulted in additional exposure to the patient.

Source is the focal spot of the x-ray tube.

Source-to-Image-Distance (SID) means the distance from the source to the image receptor.

Technique factor(s) means kilovoltage (kVp), time (seconds or pulses), current (mA), or the product of time and current (mAs).

Useful beam means the radiation that passes through the tube housing port and the aperture of the beam-limiting device when the exposure switch or timer is activated.

Variable-aperture beam-limiting device, also called an adjustable collimator, is a beam-limiting device that has the capacity for adjustment of the x-ray field size at a given SID.

X-ray control is a device that controls input power to the x-ray high voltage generator and/or the x-ray tube. It includes equipment such as timers, phototimers, automatic brightness stabilizers, and similar devices that control the technique factors of an x-ray exposure.

X-ray field. See useful beam.

X-ray service engineer is a person whose knowledge, training, and experience qualify them to repair x-ray equipment.

X-ray tube is any electron tube that is designed for the conversion of electrical energy into x-ray energy.

CRCPD'S MISSION: A PARTNERSHIP DEDICATED TO RADIATION PROTECTION.

The Conference of Radiation Control Program Directors, Inc. (CRCPD) is a nonprofit organization made up of individuals in state and local government who regulate and control the use of radiation sources, and of individuals, regardless of employer affiliation, who have expressed an interest in radiation protection. CRCPD was formed in 1968.

The objectives and purposes of the organization are: to promote radiological health in all aspects and phases, to encourage and promote cooperative enforcement programs with federal agencies and between related enforcement agencies within each state, to encourage the interchange of experience among radiation control programs, to collect and make accessible to the membership of the CRCPD such information and data as might be of assistance to them in the proper fulfillment of their duties, to promote and foster uniformity of radiation control laws and regulation, to encourage and support programs that will contribute to radiation control for all, to assist the membership in their technical work and development, and to exercise leadership with radiation control professionals and consumers in radiation control development and action.

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