

## QUALITY ASSURANCE PROGRAMS FOR DIAGNOSTIC RADIOLOGY FACILITIES

### (a) Applicability

Quality assurance programs as described in paragraph (c) of this section are recommended for all diagnostic radiology facilities.

### (b) Definitions

As used in this section, the following definitions apply:

“Diagnostic radiology facility” means any facility in which an x-ray system(s) is used in any procedure that involves irradiation of any part of the human or animal body for the purpose of diagnosis or visualization. Offices of individual physicians, dentists, podiatrists, chiropractors, and veterinarians as well as mobile laboratories, clinics, and hospitals are examples of diagnostic radiology facilities.

“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” means 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 those 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.

“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.

“X-ray system” means an assemblage of components for the controlled production of diagnostic images with x rays. It includes minimally an x-ray high voltage generator, an x-ray control, a tube-housing assembly, a beam-limiting device, and the necessary supporting structures. Other components that function with the system, such as image receptors, image processors, view boxes, and darkrooms, are also parts of the system.

(c) Elements

A quality assurance program should contain the elements listed in subparagraphs (1) through (10) of this paragraph. The extent to which each element of the quality assurance program is implemented should be determined by an analysis of the facility's objectives and resources conducted by its qualified staff or by qualified outside consultants. Implementation should be based on the requirements of the Department of Health Ionizing Radiation Rules, Chapter 4730. The expected benefits from any additional actions should be evaluated by comparing to the resources required for the program.

(1) Responsibility.

- (i) Responsibility and authority for the overall quality assurance program as well as for monitoring, evaluation, and corrective measures should be specified and recorded in a quality assurance manual.
- (ii) The owner or practitioner in charge of the facility has primary responsibility for implementing and maintaining the quality assurance program.
- (iii) Staff technologists will generally be delegated a basic quality assurance role by the practitioner in charge. Responsibility for specific quality control monitoring and maintenance techniques or quality administration procedures may be assigned, if the staff technologists are qualified by training or experience for these duties. The staff technologists should also be responsible for identifying problems or potential problems requiring actions beyond the level of their training. They should bring these problems to the attention of the practitioner in charge, or his or her representative, so that assistance in solving the problems may be obtained from inside or outside of the facility.
- (iv) In facilities where they are available, physicists, supervisory technologists, or quality control technologists should have a major role in the quality assurance program. Such specialized personnel may be assigned responsibility for day-to-day administration of the program, may carry out monitoring duties beyond the level of training of the staff technologist or, if desired by the facility, may relieve the staff technologists of some or all of their basic monitoring duties. Staff service engineers may also be assigned responsibility for certain preventive or corrective maintenance actions.
- (v) Responsibility for certain quality control techniques and corrective measures may be assigned to personnel qualified by training or experience, such as consultants or industrial representatives, from outside of the facility, provided there is a written agreement clearly specifying these services.
- (vi) In large facilities, responsibility for long-range planning of quality assurance goals and activities should be assigned to a quality assurance committee as described in paragraph (c)(9) of this section.

- (2) Purchase specifications. Before purchasing new equipment, the staff of the diagnostic radiology facility should determine the desired performance specifications for the equipment. The final purchase specifications should be in writing and should include performance specifications. The availability of experienced service personnel should also be taken into consideration in making the final purchase decisions. Any understandings with respect to service personnel should be incorporated into the purchase specifications.

At the time of installation, the vendor should conduct equipment performance evaluations to ensure that the purchase specifications for the equipment meet State regulatory requirements. The equipment should not be formally accepted until the vendor has made any necessary corrections. The purchase specifications and the records of the acceptance testing should be retained through out the life of the equipment for comparison with monitoring results in order to assess continued acceptability of performance.

- (3) Monitoring and maintenance. A routine quality control monitoring and maintenance system incorporating state-of-the-art procedures should be established and conducted on a regular schedule. The purpose of monitoring is to permit evaluation of the performance of the facility's x-ray system(s) in terms of the standards for image quality established by the facility (as described in paragraph (c)(4) of the section) and compliance with applicable Federal and State regulatory requirements.

The maintenance program should include corrective maintenance to eliminate problems revealed by monitoring or other means before they have a serious deleterious impact on patient care. To the extent permitted by the training of the facility staff, the maintenance program should also include preventive maintenance, which could prevent unexpected breakdowns of equipment and disruption of departmental routine.

- (i) The Department of Health Ionizing Radiation Rules, Chapter 4730, includes the parameters that must be monitored. Although the parameters to be monitored may vary somewhat from facility to facility, every diagnostic radiology facility should consider monitoring the following five key components of the x-ray system.

- (a) Film-processing.
- (b) Basic performance characteristics of the x-ray unit.
- (c) Cassettes and grids.
- (d) View boxes.
- (e) Darkroom.

- (ii) Examples of parameters of the above-named components and of more specialized equipment that may be monitored are as follows:

- (a) For film processing:

- An index of speed.
- An index of contrast.
- Base plus fog.

Solution temperatures.  
Film artifact identification.

(b) For basic performance characteristics of the x-ray unit:

(1) For fluoroscopic x-ray units:

Tabletop exposure rates.  
Centering alignment.  
Collimation.  
kVp accuracy and reproducibility.  
mA accuracy and reproducibility.  
Exposure time accuracy and reproducibility.  
Reproducibility of x-ray output.  
Focal spot size consistency.  
Half-value layer.  
Representative entrance skin exposures.

(2) For image-intensified systems:

Resolution.  
Focusing.  
Distortion.  
Glare.  
Low contrast performance.  
Physical alignment of camera and collimating lens.

(3) For radiographic x-ray units:

Reproducibility of x-ray output.  
Linearity and reproducibility of mA stations.  
Reproducibility and accuracy of timer stations.  
Reproducibility and accuracy of kVp stations.  
Accuracy of source-to-film distance indicators.  
Light/x-ray field congruence.  
Half-value layer.  
Focal spot size consistency.  
Representative entrance skin exposures.

(4) For automatic exposure control devices:

Reproducibility.  
kVp compensation.  
Field sensitivity matching.  
Minimum response time.  
Backup timer verification.

- (c) For cassettes and grids:
  - (1) For cassettes:
    - Film/screen contact.
    - Screen condition.
    - Light leaks.
    - Artifact identification.
  - (2) For grids:
    - Alignment and focal distance.
    - Artifact identification.
- (d) For view boxes:
  - Consistency of light output with time.
  - Consistency of light output from one box to another.
  - View box surface conditions.
- (e) For darkroom:
  - Darkroom integrity.
  - Safe light conditions.
- (f) For specialized equipment:
  - (1) For tomographic systems:
    - Accuracy of depth and cut indication.
    - Thickness of cut plane.
    - Exposure angle.
    - Completeness of tomographic motion.
    - Flatness of tomographic field.
    - Resolution.
    - Continuity of exposure.
    - Flatness of cassette.
    - Representative entrance skin exposures.
  - (2) For computerized tomography:
    - Precision (noise).
    - Contrast scale.
    - High and low contrast resolution.
    - Alignment.

Representative entrance skin exposures.

(iii) The maintenance program should include both preventive and corrective aspects.

(a) Preventive maintenance. Preventive maintenance should be performed on a regularly scheduled basis with the goal of preventing breakdowns due to equipment failing without warning signs detectable by monitoring. Such actions have been found cost effective if responsibility is assigned to facility staff members. Possible preventive maintenance procedures are:

- visual inspection of the mechanical and electrical characteristics of the x-ray system covering such things as:
  - checking conditions of cables,
  - watching the tomographic unit for smoothness of motion,
  - assuring cleanliness with respect to spilling of contaminants in the examination room or the darkroom,
  - listening for unusual noises in the moving parts of the system
- following the manufacturer's recommended procedures for cleaning and maintenance of the equipment, and
- regular inspection and replacement of switches and parts that routinely wear out or fail.

The procedures included would depend upon the background of the staff members available. Obviously, a large facility with its own service engineers can do more than an individual practitioner's office.

(b) Corrective maintenance. For maximum effectiveness, the quality assurance program should make provision, as described in paragraph (c)(5) of this section, for ascertaining if potential problems are developing. If potential or actual problems are detected, corrective maintenance should be carried out to eliminate them before they cause a major impact on patient care.

(4) Standards for image quality. Standards of acceptable image quality should be established. Ideally these should be objective, e.g., acceptability limits for the variations of parameter values, but they may be subjective, e.g. the opinions of professional personnel, in cases where adequate objective standards cannot be defined. These standards should be routinely reviewed and redefined as needed as described in paragraph (c)(10) of this paragraph.

(5) Evaluation. The facility quality assurance program should include means for two levels of evaluation.

(i) On the first level, the results of the monitoring procedures should be used to evaluate the performance of the x-ray system(s) to determine whether corrective actions are needed to adjust the equipment so that the image quality consistently meets the standards for image quality. This evaluation should include analysis of trends in the monitoring data as well as the use of the data to determine the need for corrective actions on a day-by-day basis. Comparison of monitoring data with the purchase

specifications and acceptance testing results for the equipment in question is also useful.

- (ii) The facility quality assurance program should also include means for evaluating the effectiveness of the program itself. Possible means include ongoing studies of the retake rate and the causes of the repeated radiographs, examination of equipment repair and replacement costs, subjective evaluation of the radiographs being produced, occurrence and reasons for complaints by radiologists, and analysis of trends in the results of monitoring procedures such as sensitometric studies. Of these, ongoing studies of the retake rate (reject rate) and its causes are often the most useful and may provide information of value in the first level of evaluation. Such studies should be used to evaluate potential for improvement, to make corrections, and to determine whether the corrective actions were effective.

The number of rejects should be recorded daily or weekly, depending on the facility's analysis of its needs. The reasons for the rejection should also be determined and recorded. Should determining these reasons be impossible to perform on a regular basis with the available staff, the analysis should be done for a 2-week period after major changes have occurred in diagnostic procedures or the x-ray system and at least semi-annually.

- (6) Records. The program should include provisions for the keeping of records on the results of the monitoring techniques, any difficulties detected, the corrective measures applied to these difficulties, and the effectiveness of these measures. The extent and form of these records should be consistent with The Department of Health Ionizing Radiation Rules, Chapter 4730. The facility should view these records as a tool for maintaining an effective quality assurance program and not view the data in them as an end in itself but rather as a beginning. For example, the records should be made available to vendors to help them provide better service. More importantly, the data should be the basis for the evaluation and the reviews suggested in paragraphs (c)(5) and (c)(10) in this section.
- (7) Manual. A quality assurance manual should be written in a format permitting convenient revision as needed and should be made readily available to all personnel. The content of the manual should be determined by the facility staff, but the following items are suggested as providing essential information.
  - (i) A list of the individuals responsible for monitoring and maintenance techniques.
  - (ii) A list of the parameters to be monitored and the frequency of monitoring.
  - (iii) A description of the standards, criteria of quality, or limits of acceptability, which have been established for each of the parameters, monitored.
  - (iv) A brief description of the procedures to be used for monitoring each parameter.
  - (v) A description of procedures to be followed when difficulties are detected to call these difficulties to the attention of those responsible for correcting them.

- (vi) A list of the publications in which detailed instructions for monitoring and maintenance procedures can be found. Copies of these publications should also be readily available to the entire staff, but they should be separate from the manual.
  - (vii) A list of the records (including sample forms) that should be kept. The facility staff should also determine and note in the manual the length of time each type of record should be kept before discarding.
  - (viii) A copy of each set of purchase specifications developed for new equipment and the results of the acceptance testing for that equipment.
  - (ix) A list of who to call for answers to quality control questions.
- (8) Training. The program should include provisions for appropriate training for all personnel with quality assurance responsibilities. The training should be specific to the facility and the equipment. This should include both training provided before the quality assurance responsibilities are assumed and continuing education to keep the personnel up-to-date. Practical experience with the techniques conducted under the supervision of experienced instructors, either in the facility or in a special program, is the most desirable type of training. The use of self-teaching materials can be an adequate substitute for supervised instruction, especially in continuing education programs, if supervised instruction is not available.
- (9) Committee. Large facilities such as hospitals should consider the establishment of a quality assurance committee whose primary function would be to maintain lines of communication among all groups with quality assurance and/or image production or interpretation responsibilities. For maximum communication, all departments of the facility with x-ray equipment should be represented. The committee may also be assigned policy-making duties such as some or all of the following: Assign quality assurance responsibilities; maintain acceptable standards of quality; periodically review program effectiveness, etc.

The duties of this committee could be assigned to an already-existing committee such as the Radiation Safety Committee. In smaller facilities, all staff members should participate in the committee's tasks. The Quality Assurance Committee should report directly to the head of the radiology department, or in facilities where more than one department operates x-ray equipment, to the chief medical officer of the facility. The committee should meet on a regular basis.

- (10) Review. The Quality Assurance Committee and/or the practitioner in charge should review the facility's quality assurance program to determine if its effectiveness could be improved. Items suggested for inclusion in the review include:
- (i) The reports of the monitoring and maintenance techniques to ensure that they are being performed on schedule and effectively. These reports should be reviewed at least quarterly.

- (ii) The monitoring and maintenance techniques and their schedules to ensure that they continue to be appropriate and in step with the latest developments in quality assurance. They should be made current at least annually.
- (iii) The standards for image quality to ensure that they too are consistent with the state-of-the-art and the needs and resources of the facility. These standards should be reviewed at least annually.
- (iv) The results of the evaluations of the effectiveness of the quality assurance actions to determine whether changes need to be made. This determination should be made at least annually.
- (v) The quality assurance manual should also be reviewed at least annually to determine whether revision is needed.