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The American College of Radiology will periodically define new practice guidelines and technical standards for radiologic practice to help advance the science of radiology and to improve the quality of service to patients throughout the United States. Existing practice guidelines and technical standards will be reviewed for revision or renewal, as appropriate, on their fifth anniversary or sooner, if indicated.

Each practice guideline and technical standard, representing a policy statement by the College, has undergone a thorough consensus process in which it has been subjected to extensive review, requiring the approval of the Commission on Quality and Safety as well as the ACR Board of Chancellors, the ACR Council Steering Committee, and the ACR Council. The practice guidelines and technical standards recognize that the safe and effective use of diagnostic and therapeutic radiology requires specific training, skills, and techniques, as described in each document. Reproduction or modification of the published practice guideline and technical standard by those entities not providing these services is not authorized.

Revised 2011 (Resolution 4)\*

## **ACR TECHNICAL STANDARD FOR DIAGNOSTIC MEDICAL PHYSICS PERFORMANCE MONITORING OF RADIOGRAPHIC AND FLUOROSCOPIC EQUIPMENT**

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### **PREAMBLE**

These guidelines are an educational tool designed to assist practitioners in providing appropriate radiation oncology care for patients. They are not inflexible rules or requirements of practice and are not intended, nor should they be used, to establish a legal standard of care. For these reasons and those set forth below, the American College of Radiology cautions against the use of these guidelines in litigation in which the clinical decisions of a practitioner are called into question.

The ultimate judgment regarding the propriety of any specific procedure or course of action must be made by the physician or medical physicist in light of all the circumstances presented. Thus, an approach that differs from the guidelines, standing alone, does not necessarily imply that the approach was below the standard of care. To the contrary, a conscientious practitioner may responsibly adopt a course of action different from that set forth in the guidelines when, in the reasonable judgment of the practitioner, such course of action is indicated by the condition of the patient, limitations of available resources, or advances in knowledge or technology subsequent to publication of the guidelines. However, a practitioner who employs an approach substantially different from these guidelines is advised to document in the patient record information sufficient to explain the approach taken.

The practice of medicine involves not only the science, but also the art of dealing with the prevention, diagnosis, alleviation, and treatment of disease. The variety and complexity of human conditions make it impossible to always reach the most appropriate diagnosis or to predict with certainty a particular response to treatment.

Therefore, it should be recognized that adherence to these guidelines will not assure an accurate diagnosis or a successful outcome. All that should be expected is that the practitioner will follow a reasonable course of action based on current knowledge, available resources, and the needs of the patient to deliver effective and safe medical care. The sole purpose of these guidelines is to assist practitioners in achieving this objective.

### **I. INTRODUCTION**

This standard was revised by the American College of Radiology (ACR) with assistance from the American Association of Physicists in Medicine (AAPM).

The performance of all radiographic and fluoroscopic equipment must be evaluated upon installation and monitored at least annually by a Qualified Medical Physicist to ensure that the equipment is functioning properly and that patients are not exposed to unnecessary doses of radiation. Additional or more frequent monitoring may be necessary after repairs that might change the radiation exposure to patients or personnel or the imaging performance of the equipment. Although it is not possible to consider all possible variations of equipment performance to be monitored, adherence to this standard will assist in maximizing image quality and in reducing patient radiation doses.

### **II. GOAL**

The goals are to produce the highest quality diagnostic image at the lowest reasonable radiation dose consistent with the clinical use of the equipment and the information

requirement of the examination and to establish and maintain performance standards.

### **III. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL**

A Qualified Medical Physicist is an individual who is competent to practice independently one or more of the subfields in medical physics. The American College of Radiology (ACR) considers certification and continuing education and experience in the appropriate subfield(s) to demonstrate that an individual is competent to practice one or more of the subfields in medical physics, and to be a Qualified Medical Physicist. The ACR recommends that the individual be certified in the appropriate subfield(s) by the American Board of Radiology (ABR), the Canadian College of Physics in Medicine, or for MRI, by the American Board of Medical Physics (ABMP) in magnetic resonance imaging physics.

The appropriate subfields for this standard are Diagnostic Radiological Physics and Radiological Physics.

A Qualified Medical Physicist should meet the [ACR Practice Guideline for Continuing Medical Education \(CME\)](#). (ACR Resolution 17, 1996 – revised in 2008, Resolution 7)

Understanding of the relationship between image quality and patient radiation dose is essential for proper monitoring of equipment performance. The medical physicist must be familiar with the principles of imaging physics and radiation protection; the current guidelines of the National Council on Radiation Protection and Measurements (NCRP); federal and local laws and regulations pertaining to the performance of the equipment being tested; the function, clinical uses, and performance specifications of the imaging equipment; and calibration processes and limitations of the instruments used for testing performance.

The medical physicist may be assisted by other properly trained individuals in obtaining test data for performance monitoring. These individuals must be properly trained and approved by the medical physicist in the techniques of performing the tests, the function and limitations of the imaging equipment and test instruments, the reasons for the tests, and the importance of the test results. The tests will be performed by or under the general supervision of the medical physicist, who is responsible for and must review, interpret, and approve all data and provide a signed report.

### **IV. PERFORMANCE CHARACTERISTICS TO BE MONITORED**

#### **A. Performance Evaluation**

The performance of each radiographic and fluoroscopic unit must be evaluated at least annually. This evaluation should include, but not be limited to, the following tests (as applicable):

1. Integrity of unit assembly.
2. Collimation and radiation beam alignment.
3. Fluoroscopic system resolution.
4. Automatic exposure control system performance.
5. Fluoroscopic automatic brightness control performance (high-dose-rate, pulsed modes, field-of-view [FOV] variation).
6. Image artifacts.
7. Fluoroscopic phantom image quality.
8. kVp accuracy and reproducibility.
9. Linearity of exposure versus mA or mAs.
10. Exposure reproducibility.
11. Timer accuracy.
12. Beam quality assessment (half-value layer).
13. Fluoroscopic entrance exposure rates.
14. Image receptor entrance exposure.
15. Equipment radiation safety functions.
16. Patient dose monitoring system calibration
17. Video and digital monitor performance.
18. Digital image receptor performance.

For further information on computed radiography [CR] and digital radiography [DR] systems please see the [ACR–AAPM–SIIM Practice Guideline for Digital Radiography](#) [1].

#### **B. Quality Control Program**

A continuous quality control (QC) program must be implemented for all radiographic and fluoroscopic units. The program should be established with the assistance of the medical physicist. The medical physicist should identify the person responsible for performing the tests and may choose to modify the frequency of testing based on the system's usage and performance. The QC program should include, but not be limited to, the following tests (as applicable):

1. Appropriateness of technique factors.
2. Visual equipment checklists.
3. Phantom images.
4. Repeat analysis.
5. Viewboxes, image monitors, and viewing conditions.
6. Laser film printer quality control.
7. Darkroom and screen cleanliness.
8. Processor quality control.
9. Screen film speed matching.
10. Analysis of fixer retention.
11. Darkroom fog.
12. Screen-film contact.
13. CR and DR system performance.

### C. Acceptance Testing

Initial performance testing of imaging equipment must be performed upon installation and before clinical use. This testing must be more comprehensive than periodic performance and must be consistent with current acceptance testing practices. Electrical safety of the equipment must also be tested by appropriate personnel prior to its initial clinical use.

### D. Written Survey Reports and Follow-Up Procedures

The medical physicist must provide a written report of the findings of acceptance testing and performance evaluation to the responsible physician(s), if appropriate, and to the professional(s) in charge of obtaining or providing necessary service to the equipment. If appropriate, the medical physicist should initiate the required service. Written reports must be provided in a timely manner consistent with the importance of any adverse findings.

If use of the equipment would pose imminent danger to patients or staff, the medical physicist must take immediate action to prevent its use.

## V. RADIATION SAFETY IN IMAGING

Radiologists, medical physicists, radiologic technologists, and all supervising physicians have a responsibility to minimize radiation dose to individual patients, to staff, and to society as a whole, while maintaining the necessary diagnostic image quality. This concept is known as “as low as reasonably achievable (ALARA).”

Facilities, in consultation with the medical physicist, should have in place and should adhere to policies and procedures, in accordance with ALARA, to vary examination protocols to take into account patient body habitus, such as height and/or weight, body mass index or lateral width. The dose reduction devices that are available on imaging equipment should be active; if not, manual techniques should be used to moderate the exposure while maintaining the necessary diagnostic image quality. Periodically, radiation exposures should be measured and patient radiation doses estimated by a medical physicist in accordance with the appropriate ACR Technical Standard. (ACR Resolution 17, adopted in 2006 – revised in 2009, Resolution 11)

Patient radiation dose must be estimated for radiographic and fluoroscopic equipment at least annually. Tables of patient radiation exposure for representative examinations must be prepared and supplied to the facility. These tables must be prepared using measured radiation output data and imaging techniques provided by the facility. These results must be compared with appropriate guidelines or recommendations when they are available [2-3]. The

medical physicist should assist facilities in understanding and developing policies and procedures to evaluate risks to patients, personnel, and physicians from studies and interventions requiring prolonged radiation exposure [3-13].

## ACKNOWLEDGEMENTS

This standard was revised according to the process described under the heading *The Process for Developing ACR Practice Guidelines and Technical Standards* on the ACR web site (<http://www.acr.org/guidelines>) by the Guideline and Standards Committee of the ACR Commission on Medical Physics with assistance from the AAPM.

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## REFERENCES

1. American College of Radiology. Practice guideline for digital radiography. [http://www.acr.org/SecondaryMainMenuCategories/quality\\_safety/guidelines/dx/digital\\_radiography.aspx](http://www.acr.org/SecondaryMainMenuCategories/quality_safety/guidelines/dx/digital_radiography.aspx). Accessed May 24, 2011.
2. American College of Radiology. Practice guideline for diagnostic reference levels in medical x-ray imaging. [http://www.acr.org/SecondaryMainMenuCategories/quality\\_safety/guidelines/med\\_phys/reference\\_levels.aspx](http://www.acr.org/SecondaryMainMenuCategories/quality_safety/guidelines/med_phys/reference_levels.aspx). Accessed May 24, 2011.
3. *Public Health Advisory: Avoidance of Serious X-Ray Induced Skin Injuries to Patients During Fluoroscopically-Guided Procedures*. Rockville, Md: Food and Drug Administration; 1994.
4. *Specification and Acceptance Testing and Quality Assurance of Diagnostic X-Ray Imaging Equipment*.

- College Park, Md: American Association of Physicists in Medicine; 1994. AAPM Monograph 20.
5. *Managing the Use of Fluoroscopy in Medical Institutions*. College Park, Md: American Association of Physicists in Medicine; 1998. AAPM Report 58.
  6. *Cardiac Catheterization Equipment Performance*. College Park, Md: American Association of Physicists in Medicine; 2001. AAPM Report 70.
  7. *Structural Shielding Design for Medical X-Ray Imaging Facilities*. Bethesda, Md: National Council on Radiation Protection and Measurements; 2004. NCRP Report 147.
  8. *Performance Standards for Diagnostic X-Ray Systems and their Major Components*: Federal Register; June 10, 2005. Final Rule 21 CFR Part 1020.30-1020.32.
  9. Balter S, Hopewell JW, Miller DL, Wagner LK, Zelefsky MJ. Fluoroscopically guided interventional procedures: a review of radiation effects on patients' skin and hair. *Radiology* 2010;254:326-341.
  10. Mahesh M. Fluoroscopy: patient radiation exposure issues. *Radiographics* 2001;21:1033-1045.
  11. Miller DL, Balter S, Wagner LK, et al. Quality improvement guidelines for recording patient radiation dose in the medical record. *J Vasc Interv Radiol* 2009;20:S200-207.
  12. Seibert JA, Filipow L, Andriole K, ed. *Practical Digital Imaging and PACS*. Madison, Wisc: Medical Physics Publishing; AAPM Monograph 25; 1999.
  13. Stecker MS, Balter S, Towbin RB, et al. Guidelines for patient radiation dose management. *J Vasc Interv Radiol* 2009;20:S263-273.

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\*Guidelines and standards are published annually with an effective date of October 1 in the year in which amended, revised or approved by the ACR Council. For guidelines and standards published before 1999, the effective date was January 1 following the year in which the guideline or standard was amended, revised, or approved by the ACR Council.

#### Development Chronology for this Standard

1992 (Resolution 11)  
Amended (Resolution 13)  
Revised 1997 (Resolution 17)  
Revised 2001 (Resolution 18)  
Revised 2006 (Resolution 29, 16g, 17)  
Amended 2009 (Resolution 11)  
Revised 2011 (Resolution 4)