The American College of Radiology, with more than 30,000 members, is the principal organization of radiologists, radiation oncologists, and clinical medical physicists in the United States. The College is a nonprofit professional society whose primary purposes are to advance the science of radiology, improve radiologic services to the patient, study the socioeconomic aspects of the practice of radiology, and encourage continuing education for radiologists, radiation oncologists, medical physicists, and persons practicing in allied professional fields.

The American College of Radiology will periodically define new practice parameters 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 parameters and technical standards will be reviewed for revision or renewal, as appropriate, on their fifth anniversary or sooner, if indicated.

Each practice parameter 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 and approval. The practice parameters 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 parameter and technical standard by those entities not providing these services is not authorized.

Revised 2012 (Resolution 34)*

ACR–AAPM TECHNICAL STANDARD FOR DIAGNOSTIC MEDICAL PHYSICS PERFORMANCE MONITORING OF COMPUTED TOMOGRAPHY (CT) EQUIPMENT

PREAMBLE

This document is an educational tool designed to assist practitioners in providing appropriate radiologic care for patients. Practice Parameters and Technical Standards 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 and our collaborating medical specialty societies caution against the use of these documents 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 practitioner in light of all the circumstances presented. Thus, an approach that differs from the guidance in this document, 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 this document 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 this document. However, a practitioner who employs an approach substantially different from the guidance in this document 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 the guidance in this document 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 this document is to assist practitioners in achieving this objective.

1 Iowa Medical Society and Iowa Society of Anesthesiologists v. Iowa Board of Nursing, ___ N.W.2d ___ (Iowa 2013) Iowa Supreme Court refuses to find that the ACR Technical Standard for Management of the Use of Radiation in Fluoroscopic Procedures (Revised 2008) sets a national standard for who may perform fluoroscopic procedures in light of the standard’s stated purpose that ACR standards are educational tools and not intended to establish a legal standard of care. See also, Stanley v. McCarver, 63 P.3d 1076 (Ariz. App. 2003) where in a concurring opinion the Court stated that “published standards or guidelines of specialty medical organizations are useful in determining the duty owed or the standard of care applicable in a given situation” even though ACR standards themselves do not establish the standard of care.
I. INTRODUCTION

This technical standard was revised collaboratively by the American College of Radiology (ACR) and the American Association of Physicists in Medicine (AAPM).

All computed tomography (CT) equipment should be evaluated upon installation, and must be subsequently monitored at least annually or more often if required by state or local regulatory agencies, by a Qualified Medical Physicist to ensure that it is functioning properly. Additional or more frequent performance monitoring may be necessary after any service that may change the radiation exposure to patients or personnel, or the image quality.

Although it is not possible to consider all possible variations of equipment performance to be monitored, adherence to this technical standard will assist in optimizing image quality and patient radiation dose [1-5]. Key points to consider are: performance characteristics to be monitored, patient radiation dose, qualifications of personnel, and follow-up procedures.

The goals are to produce optimal quality diagnostic images at an appropriate dose consistent with the clinical use of the equipment and the information requirement of the examination, and to establish performance standards.

II. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

A Qualified Medical Physicist is an individual who is competent to practice independently in one or more of the subfields in medical physics. The American College of Radiology considers certification, continuing education, and experience in the appropriate subfield(s) to demonstrate that an individual is competent to practice in one or more of the subfields in medical physics, and to be a Qualified Medical Physicist. The ACR strongly 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 the American Board of Medical Physics (ABMP).

A Qualified Medical Physicist should meet the ACR Practice Parameter for Continuing Medical Education (CME). (ACR Resolution 17, adopted in 1996 – revised in 2012, Resolution 42)

The appropriate subfield of medical physics for this technical standard is Diagnostic Medical Physics. (Previous medical physics certification categories including Radiological Physics, Diagnostic Radiological Physics, and Diagnostic Imaging Physics are also acceptable.)

The Qualified Medical Physicist must be familiar with:

2. The guidelines of the National Council on Radiation Protection and Measurements (NCRP).
3. Laws and regulations pertaining to the performance of the equipment being tested.
4. The function, clinical uses, and performance specifications of the imaging equipment.
5. Calibration processes and limitations of the instruments used for testing performance.

The Qualified Medical Physicist may be assisted by properly trained individuals in obtaining data. These individuals must be approved by the Qualified Medical Physicist in the techniques of performing tests, the function and limitations of the imaging equipment and test instruments, the reason for the tests, and the importance of the test results. The Qualified Medical Physicist is responsible for and must be present during initial and annual surveys and must review, interpret, and approve all data as well as provide a signed report with conclusions.

III. PERFORMANCE CHARACTERISTICS TO BE MONITORED

The monitoring of performance characteristics of CT equipment [1,5-7] must be evaluated as described below and in accordance with federal, state, or local regulations.
A. Performance Evaluation

1. Equipment performance and patient dosimetry must be evaluated for each CT unit at least annually. This evaluation, at a minimum, must include the following as applicable to the design of the scanner:
   a. Alignment light accuracy.
   b. Image localization from scanned projection radiograph (localization image).
   c. Table incrementation accuracy.
   d. Radiation beam width (collimation).
   e. Reconstructed image thickness.
   f. Image quality.
      i. High-contrast (spatial) resolution.
      ii. Low-contrast sensitivity and resolution.
      iii. Image uniformity.
      iv. Noise.
      v. Artifact evaluation.
   g. CT number accuracy.
   h. Acquisition workstation display.
      i. Dosimetry [6,8].
         i. Radiation output of CT scanner (CT dose index [CTDI\text{vol}] or equivalent).
         ii. Patient radiation dose estimate for representative examinations.
   j. Limited protocol review.
      i. The Qualified Medical Physicist must review a selection of the most commonly used protocols. These should include head and abdomen protocols for adult and pediatric patients as applicable to the facility’s practice. In addition, facility protocols for very high dose procedures (e.g., brain perfusion) should be reviewed [9-11].
      ii. Elements reviewed should include documentation of kVp, mA, rotation time, detector configuration, pitch, reconstructed image thickness, and use of automatic exposure control (including ensuring documentation of reference settings used), and the indicated dose indices (CTDI\text{vol}) resulting from each examination [2,12,13].
   k. Safety evaluation.
      i. Visual inspection.
      ii. Work load assessment.
      iii. Scatter and stray radiation measurements (if work load and other related parameters have changed since acceptance testing).
      iv. Audible/visual signals.
      v. Posting requirements.
   l. Other tests as required by state or local regulations.

2. Monitoring required after replacement or repair of a major component

If a major component is replaced or repaired, a Qualified Medical Physicist should, in a timely manner, evaluate the need for performance testing of the CT scanner. The scope of the evaluation should be determined by the Qualified Medical Physicist based on the type of component that was replaced or repaired.

3. Radiation output and patient radiation dose estimates

A Qualified Medical Physicist must annually compare measured CTDI\text{vol} values to values reported by the scanner, to ensure that the scanner is correctly reporting the values. These comparisons should include both 16 cm and 32 cm dosimetry phantoms, as appropriate for the unit.

Additionally, patient radiation dose estimates for CT equipment must be evaluated at least annually by a Qualified Medical Physicist for selected procedures, comparing them to established reference values when available. Tables of patient radiation absorbed dose for representative examinations (e.g., head,
thorax, abdomen, and pelvis) should be prepared and supplied to the facility. These should include dose estimates to pediatric patients, as applicable to the facility. These results should be compared with appropriate guidelines or recommendations when they are available.

B. Quality Control Program

A continuous quality control (QC) program must be established for all CT units with the assistance of a Qualified Medical Physicist. The Qualified Medical Physicist should determine tolerances, the frequency of each test, and who should perform each test based on the facility and CT usage. An on-site radiologic technologist should be identified to be responsible for conducting routine QC.

The QC program should minimally include the following:
1. CT number accuracy.
2. Noise (CT number standard deviation).
3. Artifact evaluation.
4. Display devices.
   a. Acquisition work station.
   b. Hard-copy display unit(s), if used for patient images.

The results of the QC program must be monitored annually by the Qualified Medical Physicist. If measured values of QC parameters fall outside the established tolerances, the radiologic technologist or the Qualified Medical Physicist should initiate appropriate investigative or corrective actions. A Qualified Medical Physicist should be available to assist in prescribing corrective actions for unresolved problems.

C. Acceptance Testing

Initial performance testing of imaging equipment must be performed by a Qualified Medical Physicist and should be completed before clinical use. This testing 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 Qualified Medical Physicist must provide a written report of the findings of acceptance testing and performance evaluation to the professional(s) in charge of obtaining or providing necessary service to the equipment and, if appropriate, to the responsible physician(s). If appropriate, the Qualified Medical Physicist should notify the facility to initiate the required service. Written reports must be provided in a timely manner consistent with the importance of any adverse findings.

Facilities must complete corrective actions in a timely manner consistent with the importance of any adverse findings.

IV. RADIATION SAFETY IN IMAGING

Radiologists, medical physicists, registered radiologist assistants, radiologic technologists, and all supervising physicians have a responsibility for safety in the workplace by keeping radiation exposure to staff, and to society as a whole, “as low as reasonably achievable” (ALARA) and to assure that radiation doses to individual patients are appropriate, taking into account the possible risk from radiation exposure and the diagnostic image quality necessary to achieve the clinical objective. All personnel that work with ionizing radiation must understand the key principles of occupational and public radiation protection (justification, optimization of protection and application of dose limits) and the principles of proper management of radiation dose to patients (justification, optimization and the use of dose reference levels).

Nationally developed guidelines, such as the ACR’s Appropriateness Criteria®, should be used to help choose the most appropriate imaging procedures to prevent unwarranted radiation exposure.

Facilities should have and adhere to policies and procedures that require varying ionizing radiation examination protocols (plain radiography, fluoroscopy, interventional radiology, CT) to take into account patient body habitus (such as patient dimensions, weight, or body mass index) to optimize the relationship between minimal radiation dose and adequate image quality. Automated dose reduction technologies available on imaging equipment should be used whenever appropriate. If such technology is not available, appropriate manual techniques should be used.

Additional information regarding patient radiation safety in imaging is available at the Image Gently® for children (www.imagegently.org) and Image Wisely® for adults (www.imagewisely.org) websites. These advocacy and awareness campaigns provide free educational materials for all stakeholders involved in imaging (patients, technologists, referring providers, medical physicists, and radiologists).

Radiation exposures or other dose indices should be measured and patient radiation dose estimated for representative examinations and types of patients by a Qualified Medical Physicist in accordance with the applicable ACR Technical Standards. Regular auditing of patient dose indices should be performed by comparing the facility’s dose information with national benchmarks, such as the ACR Dose Index Registry, the NCRP Report No. 172, Reference Levels and Achievable Doses in Medical and Dental Imaging: Recommendations for the United States or the Conference of Radiation Control Program Director’s National Evaluation of X-ray Trends. (ACR Resolution 17 adopted in 2006 – revised in 2009, 2013, Resolution 52).

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REFERENCES


*Practice parameters and technical 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 practice parameters and technical standards published before 1999, the effective date was January 1 following the year in which the practice parameter or technical standard was amended, revised, or approved by the ACR Council.

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