Revised 2014 (Resolution 34)*

ACR–AAPM TECHNICAL STANDARD FOR DIAGNOSTIC MEDICAL PHYSICS PERFORMANCE MONITORING OF MAGNETIC RESONANCE IMAGING (MRI) 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[1]. 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).

The performance of all magnetic resonance imaging (MRI) units should be evaluated upon installation and at least annually to ensure proper functioning [1]. Additional or more frequent performance monitoring may be necessary in certain situations (eg, after major equipment repairs or upgrades). Although it is not possible to consider all possible variations of equipment to be monitored, adherence to this technical standard will promote high image quality.

The goal is to establish performance standards to promote production of high-quality diagnostic magnetic resonance (MR) images that are consistent with the clinical use of MRI equipment and with the clinical objectives of examinations.

II. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

The personnel qualified to carry out acceptance testing and monitoring of MRI equipment for the purposes of this technical standard include a Qualified Medical Physicist or a Qualified MR Scientist.

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, 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 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 by 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, 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.)

Certification by the American Board of Medical Physics (ABMP) or the Canadian College of Physics in Medicine (CCPM) in Magnetic Resonance Imaging Physics is also acceptable.

A Qualified MR Scientist is an individual who is not board certified in an appropriate subfield of medical physics but has obtained a graduate degree in a physical science involving nuclear MR magnetic resonance (NMR) or MRI and has at least 3 years of documented experience in a clinical MRI environment. In addition, he or she must have completed formal coursework in the biological sciences with at least one course in biology or radiation biology and one course in anatomy, physiology, or similar topics related to the practice of medical physics [2].

Regardless of certification status, to be considered a Qualified Medical Physicist or MR Scientist one should have performed evaluations of at least 3 MRI systems in accordance with the ACR MRI Quality Control Manual under the direction of a Qualified Medical Physicist or MR Scientist. Additional guidance on the initial qualifications, as well as continuing experience and education for the Qualified Medical Physicist or MR Scientist, is provided in the current document "ACR CT, MRI, Nuclear Medicine and PET Accreditation Program Requirements for Medical Physicists/MR Scientists," which can be found at http://www.acr.org/Quality-Safety/Accreditation.

The Qualified Medical Physicist or MR Scientist must be familiar with the principles of MRI safety for patients, personnel, and the public [3]; the Food and Drug Administration guidance for MRI diagnostic devices; and other

regulations pertaining to the performance of the equipment being monitored. The Qualified Medical Physicist or MR Scientist must be knowledgeable in the field of nuclear MR physics and familiar with MRI technology, including the function, clinical uses, and performance specifications of MRI equipment, as well as calibration processes and limitations of the performance testing hardware, procedures, and algorithms. The Qualified Medical Physicist or MR Scientist must have a working understanding of clinical imaging protocols and methods of their optimization. This proficiency should be maintained by participation in continuing education programs of sufficient frequency to ensure familiarity with current concepts, equipment, and procedures.

The Qualified Medical Physicist or MR Scientist must be present during surveys and may be assisted in obtaining test data for performance monitoring by other properly trained individuals. These individuals must be properly trained and approved by the Qualified Medical Physicist or MR Scientist in the techniques of performing the tests, the function and limitations of the imaging equipment and test instruments, the reason for the tests, and the importance of the test results. Supervision of these individuals should be in accordance with current AAPM Professional Policy 18-A [4]. The Qualified Medical Physicist or MR Scientist must review and approve all measurements.

III. PERFORMANCE CHARACTERISTICS TO BE MONITORED

A. Performance Evaluation

The performance of each MRI unit must be evaluated at least annually [5]. At a minimum this evaluation should include the following items or their equivalents:

1. Magnetic field homogeneity
2. Slice position accuracy
3. Slice thickness accuracy [6]
4. Performance testing for coils used clinically
    a. Coil physical visual inspection
    b. Transmitter gain/attenuator verification
    c. Image signal-to-noise ratio (SNR) [7-9].
    d. Image artifact assessment
    e. Image intensity uniformity for all volume coils [10]
    f. Year-to-year variations of each of the above parameters should be compared and/or tracked
5. Geometric accuracy (gradient calibration) [11]
6. High-contrast spatial resolution
7. Low-contrast detectability
8. Acquisition workstation monitor performance
9. Inspection of the physical and mechanical integrity of the system
10. Evaluation of technologist quality control (QC) program
11. Assessment of the MRI safety program [3]

B. Quality Control Program

A continuous QC program must be implemented for all MRI units. The program should be established with the assistance of a Qualified Medical Physicist or MR Scientist. The Qualified Medical Physicist or MR Scientist should identify the person responsible for performing the tests and may recommend increasing the frequency of testing based on the facility and MRI usage. The minimum number of tests and testing frequency are specified in the ACR MRI Quality Control Manual [5]. At a minimum the QC program should include the following items or their equivalents:

1. Setup and positioning accuracy (mechanical inspection)
2. Central frequency
3. Transmitter gain or attenuation (head coil RF calibration)

4. Geometric accuracy along each of the 3 major axes (gradient calibration)
5. High-contrast spatial resolution.
6. Low-contrast detectability (eg, signal-to-noise ratio)
7. Image artifact assessment
8. Film printer fidelity when used for primary interpretation
9. Acquisition workstation monitor quality control
10. Visual checklist

For those systems performing magnetic resonance spectroscopy (MRS) an MRS quality control program should be established [12]. Water and metabolic peak areas, full width at half maximum, baseline noise, and volume-of-interest accuracy should be assessed.

If any monitored QC parameter falls outside of the control limits, corrective action should be taken. A Qualified Medical Physicist or MR Scientist should assist in prescribing corrective actions for unresolved problems.

C. Acceptance Testing

Initial performance testing should be performed upon installation of the MRI scanner and after major upgrades. This testing or oversight of testing should be more comprehensive than periodic performance testing and should be consistent with current acceptance testing practices [1,3]. The acceptance testing protocol should include an evaluation of all coils. All new or replacement coils should be evaluated prior to clinical use.

D. Written Survey Reports and Follow-up Procedures

The Qualified Medical Physicist or MR Scientist 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 or MR Scientist 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.

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