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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 3)*

ACR TECHNICAL STANDARD FOR DIAGNOSTIC MEDICAL PHYSICS PERFORMANCE MONITORING OF REAL TIME ULTRASOUND EQUIPMENT

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

All ultrasound equipment must be evaluated upon installation (acceptance testing) and routinely thereafter to ensure that it is functioning properly. Acceptance testing and performance evaluations should be performed or supervised by a Qualified Medical Physicist. In addition, regular preventive maintenance should be performed and documented by a qualified equipment service engineer following the recommendations of the equipment vendor. Although it is not possible to consider all possible variations of equipment performance to be monitored, adherence to this standard will maximize image quality. Key points to consider are performance characteristics to be monitored, qualifications of personnel, and follow-up procedures.

II. GOAL

The goal of this document is to establish a standard that will allow production of the highest quality diagnostic images consistent with the clinical use of the equipment and the information requirement of the examination.

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 of medical physics 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)

The medical physicist must be familiar with the principles of ultrasound safety and bioeffects; regulations pertaining to the performance of the equipment being tested; the physics, function, clinical uses, and performance specifications of the imaging equipment; methods and equipment used for testing performance; and analysis and interpretation of test results.

Properly trained individuals may assist the medical physicist in the overall program design and documentation, and in obtaining test data for performance monitoring, as well as other aspects of the program. These individuals should be 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, measurement methods, the reasons for the tests, and the importance of the test results. The medical physicist should periodically review and approve all performance measurements and actions taken to address any specific problems detected by the testing. If it is not possible for a qualified medical physicist to perform the tasks designated for a medical physicist, these tasks may be performed by other appropriately trained personnel with experience. These individuals must be approved by the physician(s) directing the clinical ultrasound practice.

Program documentation must include:

1. Program goals, policies, and responsible personnel.
2. Testing procedures, equipment, frequencies, and performance criteria.

3. Results of all performance measurements.
4. Actions taken to address any specific problems detected by the testing.

IV. PERFORMANCE CHARACTERISTICS TO BE MONITORED

A. Performance Evaluation

Ultrasound system performance evaluations must be performed at least annually, in addition to routine quality control (QC) as described below.

The following performance evaluation tests must be performed at least annually on all machines and transducers:

1. Physical and mechanical inspection.
2. Image uniformity and artifact survey.
3. Geometric accuracy.
4. Contrast resolution.
5. Fidelity of the ultrasound scanner electronic image display(s).
6. System sensitivity.

They may also include, but not be limited to, the following tests (as applicable) [1-3] (see Appendix A):

1. Spatial resolution.
2. Fidelity of the display device(s) used for primary interpretation.
3. Qualitative evaluations of Doppler functionality.

All tests done as part of the routine QC program must also be performed as part of this performance evaluation.

Either subjective visual methods or objective computer-based approaches may be used to make these measurements [1,3-6]. If subjective methods are used, it is recommended that the images used to perform the tests be retained for comparison with subsequent test images.

Image-based performance measurements must be made using an ultrasound phantom. Acceptable phantoms are available from a variety of commercial vendors. Appropriate custom phantoms may also be fabricated by experienced personnel. Other approaches to performance measurement not requiring ultrasound images of phantoms have been reported, e.g., the “paper-clip test” [4] and use of transducer evaluation devices which test the electrical and acoustic characteristics of each individual transducer array element [5]. These approaches may be used for evaluating some performance characteristics if they are appropriately described in the overall program documentation. The topic of display device performance assessment is discussed in the [ACR Technical Standard for Electronic Practice of Medical Imaging](#).

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Appendix A

1. Physical and mechanical inspection – this assures the mechanical integrity of the equipment, and the safety of patient and operator.
2. Image uniformity/artifact survey – this test aims to identify the presence of artifacts, often axial or lateral streaks in scans of uniform sections of a phantom. The use of “in-air” images (i.e., images acquired without the use of gel or phantom) may also be useful in detecting superficial artifacts.
3. Geometric accuracy – tests often involve use of the scanner calipers to measure known distances between phantom test targets in the axial and lateral directions, although other tests of geometric accuracy have been described. The use of a phantom with a sound speed closely matching 1,540 m/s is recommended for determining absolute performance.
4. System sensitivity – visual determination of the maximum depth of visualization of speckle patterns or phantom targets, and quantitative measurements of signal-to-noise ratio (SNR), have both been reported.
5. Spatial resolution – this should be measured in the axial, lateral, and elevational directions. Various approaches have been described for making axial and lateral resolution measurements, including visual interpretation of groups of phantom pin/fiber targets and measurement of pin target dimensions. Similarly, various approaches for making elevational resolution measurements have been discussed, one requiring a

special phantom, and one compatible with multipurpose phantoms [4]. The use of a phantom with a sound speed closely matching 1,540 m/s is recommended for determining absolute performance.

6. Contrast resolution – the use of both anechoic and low contrast echogenic targets has been suggested, as has the use of 2D cylindrical targets and 3D spherical targets. The use of larger 2D targets emphasizes contrast resolution performance, while the use of small targets also tests spatial resolution capabilities.
7. Fidelity of ultrasound scanner electronic image display(s) – when used for diagnostic purposes, the electronic displays on the scanner and any modality workstations should be considered as primary diagnostic devices. This would not necessarily be the case for scanners used exclusively as an aid to guide procedures. Display characteristics that are evaluated may include gray scale response, presence of pixel defects, and overall image quality. These evaluations are typically performed using specialize test pattern images, and may also involve the use of photometric equipment.
8. Fidelity of display device(s) used for primary interpretation – these primary diagnostic displays may be electronic soft-copy displays on a workstation or hard-copy films. Display characteristics that are evaluated may include gray scale response, presence of pixel defects, and overall image quality. These evaluations are typically performed using specialize test pattern images, and may also involve the use of photometric equipment.
9. Qualitative evaluations of Doppler functionality – for spectral Doppler mode, the tests include positioning of the Doppler sampling volume, specification of Doppler angle, Doppler spectral display, directionality of flow, and lack of velocity signal where no flow is present. For color flow imaging mode, the tests include color map and flow direction, and color signal superimposition on the grayscale image. As these are visual, qualitative tests, the use of a phantom is not required.

Development Chronology for this Standard

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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.