

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 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.

1999 (Res. 18)
Revised 2004 (Res. 17c)
Amended 2006 (Res. 16g)
Effective 10/01/04

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 radiologic 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 on 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 should be evaluated upon installation and subsequently monitored at least annually to ensure that it is functioning properly. Additional or more frequent performance monitoring may be necessary in certain situations (e.g., after major equipment maintenance). 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 is to produce the highest quality diagnostic image consistent with the clinical use of the equipment

and the information requirement of the examination and to establish 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 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) 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.

The continuing education of a Qualified Medical Physicist should be in accordance with the [ACR Practice Guideline for Continuing Medical Education \(CME\)](#). (2006 - ACR Resolution 16g)

The monitoring medical physicist must be familiar with the principles of ultrasound safety and bioeffects; 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 physicist shall participate in continuing education programs of sufficient frequency to be familiar with current concepts, equipment, and procedures.

The medical physicist 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 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 medical physicist must review and approve all data measurements.

IV. PERFORMANCE CHARACTERISTICS TO BE MONITORED

The performance of each ultrasound unit should be evaluated at least annually. This evaluation should include, but not be limited to, the following tests:

1. Physical and mechanical inspection.
2. Fidelity of display and/or work station monitor.

3. Caliper distance accuracy:
 - a. Vertical
 - b. Horizontal
4. Depth of penetration/visualization.
5. Dead-zone depth.
6. Image uniformity.
7. Axial resolution.
8. Lateral resolution.
9. Elevation resolution.
10. Anechoic object imaging.
11. Film processor quality control (QC).
12. Hardcopy fidelity.
13. Softcopy fidelity.

For those systems with Doppler and color-flow imaging capabilities, the operational characteristics should be qualitatively evaluated to verify proper function, including positioning accuracy of the Doppler sampling volume, Doppler angle between the transducer and vessel axis, Doppler spectral display, directionality of flow, signal aliasing, and lack of signal where no flow is present. For color flow imaging, appropriate color mapping corresponding to flow direction and proper superimposition on the grayscale image should be assessed. Assessment of quantitative accuracy of Doppler velocity estimates and corresponding flow requires the use of calibrated ultrasound Doppler flow phantoms, which is beyond the scope of typical system evaluation tests. For those systems with tissue harmonic imaging capabilities, image resolution, contrast, and noise in this mode should also be assessed.

V. QUALITY CONTROL PROGRAM

There shall be a continuous quality control (QC) program for all ultrasound units. The medical physicist should assist in the establishment of this program. The medical physicist should determine the frequency of testing and who should perform the testing based on the facility and ultrasound usage. The QC program should include, but need not be limited to, the following:

1. Physical and mechanical inspection.
2. Fidelity of display and/or workstation monitor.
3. Image uniformity.
4. Film processor QC.
5. Depth of penetration/visualization.
6. Caliper distance accuracy.

The medical physicist should monitor the results of the QC program annually. If the test results fall outside of the control limits, corrective action should be taken. A medical physicist should be available to assist in prescribing corrective actions for unresolved problems.

VI. ACCEPTANCE TESTING

Initial performance testing should be performed upon installation. This testing should be more comprehensive than periodic performance and compliance testing and shall be consistent with current acceptance testing practices. Any acceptance testing protocol should include the evaluation of all transducers.

VII. FOLLOW-UP PROCEDURES AND WRITTEN SURVEY REPORTS

The medical physicist shall report the findings to the physician(s), the responsible professional(s) in charge of obtaining or providing necessary service to the equipment, and, in the case of the consulting physicist(s), to the representative of the hiring party. If appropriate, the medical physicist should also initiate the required service. Action shall be taken immediately by verbal communication if there is imminent danger to patients or staff using the equipment due to unsafe conditions. Written survey reports shall be provided in a timely manner consistent with the importance of any adverse findings.

ACKNOWLEDGEMENTS

This standard was revised according to the process described in the ACR Practice Guidelines and Technical Standards book by the Guidelines and Standards Committee of the Commission on Medical Physics.

Guidelines and Standards Committee

Nicholas A. Detorie, PhD, Chair
Robert L. Dixon, PhD
Laurie E.W. Gaspar, MD
Richard A. Geise, PhD
Michael T. Gillin, PhD
John S. Kent, MS
Tariq A. Mian, PhD
James T. Norweck, MS
Alan H. Rowberg, MD
James A. Seibert, PhD
Guy H. Simmons, PhD

Richard L. Morin, PhD, Chair, Commission

REFERENCES

1. *A Guide to Continuous Quality Improvement in Medical Imaging*. Reston, Va: American College of Radiology; 1996.
2. Goodsett MM. Real-time B-mode ultrasound quality control test procedures. Report of AAPM Ultrasound Task Group No. 1. *Med Phys* 1998;25:1385-1406.
3. Gray JE, Lisk KG, Haddick DH, et al. Test pattern for video displays and hard-copy cameras. *Radiology* 1985;154:519-527.

4. Kofler JM, Groth DS. *Ultrasound Quality Control: Basic Tests*. Rochester, Minn: Mayo Clinic and Foundation; 1996.
5. Lopez H. *Methods for Measuring Performance of Pulse-Echo Ultrasound Equipment, Part II: Digital Methods (stage I)*. Laurel, Md: American Institute of Ultrasound in Medicine; 1995.
6. Madsen E. *Quality Assurance Manual for GrayScale Ultrasound Scanners (Stage 2)*. Laurel, Md: American Institute of Ultrasound in Medicine; 1995.
7. Papp J. *Quality Management in the Imaging Sciences*. St. Louis, Mo: Mosby; 1998.
8. Siegel EL, Templeton AW, Cook LT, et al. Image calibration of laser digitizers, printers, and grayscale displays. *RadioGraphics* 1992;12:329-335.
9. *Specification, Acceptance Testing and Quality Control of Diagnostic X-ray Imaging Equipment*. College Park Md: American Association of Physicists in Medicine; AAPM Monograph 20; 1991.
10. van Wijk MC, Thijssen JM. Performance testing of medical ultrasound equipment: fundamental vs. harmonic mode. *Ultrasonics* 2002;40:585-591.