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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.

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## **ACR TECHNICAL STANDARD FOR MEDICAL NUCLEAR PHYSICS PERFORMANCE MONITORING OF PET IMAGING 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 positron emission tomography (PET) imaging equipment should be tested on installation and monitored at least annually by a Qualified Medical Physicist to ensure that it is functioning within the manufacturer's specifications and meets accepted performance standards. 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 variations of equipment performance to be monitored, adherence to this standard will maximize image quality and help to ensure the accuracy of quantitative results in clinical procedures. Key points to consider are performance characteristics, patient radiation dose, scanner calibrations, qualifications of personnel, integrity (i.e., correct scaling to standard uptake values [SUV]) of the images presented for physician review, and follow-up procedures.

### **II. GOAL**

The goal is to establish performance standards to promote the production of high-quality diagnostic PET images that are consistent with the clinical use of PET imaging equipment and the clinical objectives of the examination.

### III. QUALIFICATIONS AND RESPONSIBILITIES OF A QUALIFIED MEDICAL PHYSICIST

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 Medical Nuclear 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)

Certification in nuclear medicine physics and instrumentation by the American Board of Science in Nuclear Medicine (ABSNM) is also acceptable.

Regardless of certification, 40 hours of practical clinical experience in PET imaging is required.

The medical physicist must be familiar with the principles of imaging physics and radiation protection; the guidelines of the National Council on Radiation Protection and Measurements (NCRP); laws and regulations pertaining to the use of the equipment being tested; the function, clinical uses, and performance specifications of the imaging equipment; and calibration processes and limitations of the instruments and the techniques used for testing performance.

The medical physicist may be assisted by properly trained individuals in obtaining data. These individuals must be approved by the medical physicist in the techniques of performing 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 is responsible for and should be present during initial and annual surveys and must review, interpret, and approve all data and must provide a signed report of the conclusions.

### IV. PERFORMANCE CHARACTERISTICS TO BE MONITORED

#### A. Performance Evaluation

##### 1. Characteristics to be monitored

The medical physicist must design a quality assurance (QA) program that includes regular testing procedures to insure proper operation on a daily basis. The PET QA program must be reviewed at least annually, preferably semiannually, by a medical physicist.

The procedures should include, as a minimum, those recommended by the manufacturer.

The following characteristics should be evaluated for the equipment to which they apply on at least an annual basis [1-2]:

- a. Spatial resolution (radial, tangential, and axial).
- b. Count rate performance (count rate, versus activity), including count loss correction. Specific measurements of the following may be appropriate:
  - i. Total coincidences.
  - ii. Random coincidences.
  - iii. Scatter coincidences.
  - iv. Net true coincidences.
  - v. Noise equivalent count rate.
- c. Sensitivity (cps/MBq/ml) in two-dimensional (2D) and three-dimensional (3D) modes as applicable.
- d. Image quality, accuracy of attenuation and scatter corrections.
- e. Correct scaling for activity measurements (kBq/ml) and SUV scaling.

#### B. Quality Control Program

A continuous quality control (QC) program must be established for the PET system with the assistance of a medical physicist consistent with the recommendations of the [ACR–SNM Technical Standard for Diagnostic Procedures Using Radiopharmaceuticals](#) [3]. Additional tests to evaluate quantitative parameters should be performed. Testing of standardized uptake values, spatial resolution, contrast detectability, and noise should be performed at least quarterly as part of the QC program. Specific attention should be given to daily QC for attenuation blanks (if applicable), detector operation, and any necessary normalization scans. The medical physicist should determine the frequency of each test and who should perform each test based on the facility and PET usage. An on-site technologist should be identified to be responsible for conducting routine QC.

The results of the QC program must be monitored annually by the medical physicist. If measured values of QC parameters fall outside the control limits, appropriate investigative or corrective actions should be initiated as soon as possible. A 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 upon installation and should be completed before clinical use. This testing should be more comprehensive than periodic performance testing and should be consistent with current acceptance testing practices [1,4-7].

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

The medical physicist or other qualified individual must report the findings to the physician(s), to 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 initiate the required service. Action should be taken immediately by direct verbal communication if there is imminent danger to patients or staff using the equipment due to unsafe conditions. Written survey reports must be provided in a timely manner consistent with the importance of any adverse findings. The medical physicist should confirm that the unit is performing in a safe and acceptable fashion as soon as possible after the required service is performed.

### V. RADIATION SAFETY IN IMAGING

Radiologists, medical physicists, imaging 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 radiation safety officer, should have in place and should adhere to policies and procedures for the safe handling and administration of radiopharmaceuticals, in accordance with ALARA, and must comply with all applicable radiation safety regulations and conditions of licensure imposed by the Nuclear Regulatory Commission (NRC) [8] and by state and/or other regulatory agencies. Quantities of radiopharmaceuticals should be tailored to the individual patient by prescription or protocol.

A table of organ doses must be prepared for all procedures that involve administration of radiopharmaceuticals to patients. The table must specify

the dosage schedule used at the facility. All organs that receive significant doses should be included. Separate values for patient size should be tabulated where applicable. The table must be reviewed at least annually and updated when any of the following occur: addition of new procedures and/or pharmaceuticals, changes in dosage schedules, change in route of administration, and availability of more accurate dosimetry data.

### VI. RADIATION SHIELDING CONSIDERATIONS

Special care must be exercised regarding radiation shielding requirements for PET facility design. Appropriate shielding must be provided for patient injection/uptake rooms, PET imaging suites, and any other areas where PET radiopharmaceuticals are prepared, used, or stored. Due to the high energy of annihilation radiation used in PET, the amount of shielding materials needed to protect adjacent areas is typically much larger than that for conventional CT scanners or other diagnostic imaging modalities. A medical physicist should be consulted early in facility design planning stages so that shielding requirements can be determined and structural design issues arising from the need for large amounts of shielding can be assessed. The American Association of Physicists in Medicine Task Group #108 report “PET and PET-CT Shielding Requirements”[9] should be used as a reference in determining PET shielding requirements.

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