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ACR–AAPM TECHNICAL STANDARD FOR THE PERFORMANCE OF RADIATION ONCOLOGY PHYSICS FOR EXTERNAL BEAM THERAPY

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 success of radiation oncology depends on the **delivery** accuracy of ~~delivery of specified~~ absorbed doses to selected targets, in both tumors and normal tissues. ~~This standard was revised by the American College of Radiology (ACR) with assistance from the American Association of Physicists in medicine (AAPM) to assist the medical physicist in ensuring the accurate and safe delivery of external beam radiation therapy~~ Since the practice of radiation oncology physics occurs in a variety of settings, the judgment of the **Qualified M**edical **P**hysicist should be used to apply these standards to individual practices.

II. QUALIFICATIONS OF PERSONNEL

A. Qualified Medical Physicist ~~Qualifications~~

> 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 subfields 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 Guideline for Continuing Medical Education (CME). (ACR Resolution 17, 1996 – revised in 2012, Resolution 42) [1]

The appropriate subfield of medical physics for this standard is Therapeutic Medical Physics (including medical physics certification categories of Radiological Physics, Therapeutic Radiological Physics and Radiation Oncology Physics).

In addition, the Qualified Medical Physicist must meet any qualifications imposed by the state and/or local radiation control agency to practice radiation oncology physics and/or to provide oversight of the establishment and conduct of the physics quality management program.

B. Credentialing

The qualifications of a medical physicist and subsequent delineation of clinical privileges must be set forth either in a job description or through the medical staff membership process in the appropriate category. **Depending on the bylaws of the relevant hospital/institution the credentials and delineated privileges for the Qualified Medical Physicist should be confirmed through the medical staff membership process in the appropriate category since clinical radiation oncology physics involves direct contact with patients and their hospital records.**

C. Professional Relationships

1. Accountability

> The Qualified Medical Physicist ~~must~~ **should** be accountable directly to the medical director of radiation oncology. Where **Qualified M**edical **P**hysicists are employed in a setting that precludes direct reporting

to the medical director on administrative matters, the **Qualified M**edical **P**hysicist should also be accountable to the appropriate senior institutional administrator with oversight responsibility for radiation oncology.

2. Authority

A Qualified Medical Physicist must direct the radiation oncology physics program. In most settings, this will include direction of medical dosimetrists, junior/resident physicists, therapy equipment service engineers; other physics support staff personnel**,** and radiation therapists in their physics-related responsibilities. Responsibilities and reporting status of support staff must be clearly defined by the **Qualified M**edical **P**hysicist. In departments with more than one **Qualified M**edical **P**hysicist, delegation of responsibility and lines of communication must be clearly established.

D. Professional Development

The Qualified Medical Physicist is expected to remain current with technical developments, standards of practice, professional issues, and changes in regulatory requirements by attending national and regional meetings, conferences, ~~and~~ symposia ~~and~~ **or** through access to current journals and books.

E. Professional Arrangements

~~This~~ **The** technical standard**s set forth in this document apply** ~~applies~~ to any arrangement by which medical physics services are provided: by contract with ~~the~~ **an** individual, by contract with a medical physics private practice group, by contract with a physician **practice** group employing physicists, or by direct employment.

III. RESPONSIBILITIES OF PERSONNEL ~~SPECIFICS~~

A. Responsibilities

Qualified Medical **P**hysicists are primarily ~~and professionally~~ engaged in the design, optimization, technical evaluation, and ~~precise and accurate~~ delivery of **radiotherapy** treatment plans. **Qualified Medical Physicists are the only individuals qualified to perform and oversee the calibration of therapeutic radiation delivery systems eg, linear accelerators.** They are also responsible for radiation protection of patients and staff. Their role may include clinical, research, educational, and administrative duties. The responsibilities of the **Qualified M**edical **P**hysicist must be ~~clearly defined~~ **recognized and supported** by the medical director **and as per AAPM Professional Policy 17 [2].**

The Qualified Medical Physicist must participate in the specification, selection, acceptance, and commissioning of radiation-producing machines, accessories, and computerized treatment planning systems. The physics staff should also supervise arrangements for proper maintenance of this equipment. The Qualified Medical Physicist will periodically evaluate all equipment for continued utility, appropriateness, reliable performance, age, and condition and make recommendations on a practical life span, obsolescence, and replacement.

~~B. Equipment Needs~~

~~The Qualified Medical Physicist must determine the need for, specify, and have access to dosimetric and treatment planning equipment, including but not limited to the following:~~

~~1. Measurement instruments to calibrate all treatment equipment and patient monitoring devices. Such instruments must include ionization chambers/electrometers used as local standards ionization~~

~~chambers/electrometers used as field instruments, readout devices, constancy check instruments, and plastic and water filled dosimetric phantoms.~~

~~2. A three-dimensional computerized treatment planning system.~~

~~3. Computerized water phantom systems with appropriate ionization chambers or diodes.~~

~~4. Film densitometry systems or solid-state detector array systems.~~

~~5. In vivo patient dose measuring systems, eg, diodes, metal oxide silicon field effect transistors (MOSFETs) thermoluminescence dosimeters (TLDs), or optically stimulated luminescence (OSL) dosimeters.~~

~~6. Radiation protection measurement devices.~~

~~7. Appropriate quality assurance test tools for radiation therapy equipment.~~

~~8. Equipment to support special external beam techniques (such as those listed in section III.C).~~

~~The Qualified Medical Physicist must participate in the specification, selection, acceptance, and commissioning of radiation-producing machines, accessories, and computerized treatment planning systems. The physics staff should also supervise arrangements for proper maintenance of this equipment. The medical physicist will periodically evaluate all equipment for continued utility, appropriateness, reliable performance, age, and condition and make recommendations on a practical life span, obsolescence, and replacement.~~

B. Personnel Requirements

A Qualified Medical Physicist must be available for each institution that uses therapeutic equipment. The numbers of **Qualified M**edical **P**hysicists and support personnel must be appropriate for the types, the levels of complexity, and the volume of the external beam services offered [3,4]. External beam physics services generally include calibration of the radiation beams, safe and appropriate operation of the treatment units, continuing quality assurance, and support of the radiation oncologist's dose prescription. This clinical support includes patient-specific dose measurements (if requested), monitoring of the custom block fabrication process or appropriate use of multileaf collimation (MLC), and responsibility for the technical accuracy of the computerized treatment plans, including patient data acquisition and calculation and dose delivery verification as necessary. ~~A medical physicist must be available for each institution that uses therapeutic equipment~~ Special external beam treatment techniques — eg, stereotactic techniques **(SRS, SBRT, SABR)**, intensity modulated radiation therapy (IMRT) including volumetric modulated arc therapy (VMAT), total-body irradiation (TBI), image-guided radiation therapy (IGRT), total skin electron treatment (TSET) — require additional physics support at a level higher than that required for routine external beam therapy. **It is recommended that end-to-end testing procedures be designed and implemented for the purpose of systematic and random error reduction. The end-to-end test procedures should include use of anthropomorphic phantoms from the Radiological Physics Center (RPC) at MD Anderson Cancer Center. These phantoms enable a test of entire patient treatment procedures including imaging, treatment planning, plan export from the planning system to the treatment unit and finally the treatment delivery. The dose delivery is independently verified by the RPC.**

Staffing requirements are in addition to those required to provide services outside the scope of this standard, including brachytherapy, radiation safety, research, administration, and education and training programs [5,6]. Trainees with medical physics responsibilities must be supervised and their work reviewed by a **Qualified M**edical **P**hysicist or his/her designee.

Commissioning of modern therapy systems is a critically important, time-consuming process. The technological complexity of modern systems requires a well-designed and carefully implemented series of steps for data collection, analysis, computer modeling, and validation on the specific system as installed. ~~Such a large and important task requires appropriate focus by a physicist directly accountable for the accuracy of the system's clinical use. In many cases, the services of a consultant hysicist with expertise in such commissioning processes may be an acceptable approach. Regardless of the approach chosen by the practice~~ **T**he Qualified Medical Physicist ~~responsible for the site should~~ **must** determine the scope of work to be performed consistent with the clinical scope of service in the practice, and the appropriate timeline for the work to ensure that all quality and

safety aspects are afforded sufficient focus. The Qualified Medical Physicist ~~should~~ **must** review the final results of the commissioning process and independently repeat a subset of the measurements. The Qualified Medical Physicist determines when the therapy system can commence clinical use and communicates **to all clinical and administrative groups** any possible limitations on the scope of use.

Physics support staff should be appropriately trained. Medical dosimetrists should be certified by the Medical Dosimetry Certification Board. **In clinics where it is not always possible at least one Certified Medical Dosimetrist (CMD) should be available to supervise pre-certified dosimetrists.** In-house therapy equipment service engineers should participate in the manufacturer's training program. **Radiation therapists should be certified in radiation therapy by the American Registry of Radiologic Technologists (ARRT), or be eligible for such certification.**

Prior to the introduction of a new modality, such as IMRT including VMAT, TBI, intraoperative radiation therapy, stereotactic techniques, TSET, and dedicated special purpose treatment units, the administrator and the medical director should consult the **Qualified M**edical **P**hysicist so that adjustments to staffing can be made for specialized procedures. Issues related to several complex treatment techniques are dealt with in other technical standards and practice parameters [7-10].

IV. EQUIPMENT

The Qualified Medical Physicist must determine the need for, specify the requirements of, and have access to dosimetric and treatment planning equipment, including but not limited to the following:

1. **Measurement instruments to calibrate all treatment equipment include, but not limited to the following:**
   - **Instruments must include ionization chambers/electrometers used as local standards and/or used as field instruments.**
   - **constancy check instruments, and plastic**
   - **water filled dosimetric phantoms**
   - **other appropriate dosimetry equipment**
2. **Computerized water scanning systems with appropriate ionization chambers, diodes and other measuring tools.**
3. **Dosimetry QA hardware and software such as film densitometry systems or detector array systems.**
4. **In vivo patient dose measuring systems, eg, diodes, metal oxide silicon field effect transistors (MOSFETs), thermoluminescence dosimeters (TLDs), or optically stimulated luminescence (OSL) dosimeters.**
5. **Radiation protection measurement devices, such as appropriate survey meters and area monitors.**
6. **Appropriate quality assurance test tools for radiation therapy equipment such as mechanical alignment tools, thermo add examples from offline.**
7. **Imaging equipment quality assurance tools [11,12].**
8. **Equipment to support special external beam techniques (such as those listed in section III.B).**

V. QUALITY MANAGEMENT PROGRAM

A. Introduction

Quality management (QM) in radiation oncology may be defined as those procedures that ensure a consistent and safe fulfillment of the dose prescription. The **Qualified M**edical **P**hysicist is responsible for designing and implementing those aspects of the QM program that involve the use of the external beam radiotherapy equipment.

The **Qualified M**edical **P**hysicist is also responsible for reviewing and approving the procedures followed by the radiation therapy and dosimetry staff in planning and delivering the prescribed dose.

Quality management of radiation therapy equipment is primarily an ongoing evaluation of functional performance characteristics. Accordingly, the **Qualified M**edical **P**hysicist must develop, implement, supervise, and review the policies and procedures that encompass **the quality assurance (QA)** radiation therapy equipment. **The policy and procedure review may include the use of risk based tools such as Failure Modes and Effects Analysis (FMEA) or Systems-Theoretic Accident Model and Processes (STAMP) [13-16].**

B. General Protocol Outline

The goal of the QM program for external beam radiation therapy equipment is to ensure that the performance characteristics defined by physical parameters and established during commissioning of the equipment remain within acceptable limits. **Policies and p**rocedures must be established **by the Qualified Medical Physicist** to verify that all equipment meets the manufacturer's specifications and to establish baseline performance values for new or refurbished equipment or for equipment following major repair. Once a baseline standard has been established, a protocol for periodic ~~QM~~ **QA** tests must be developed for monitoring the baseline performance values. The protocol for ~~QM~~ **QA** tests should recommend the equipment to be used, the frequency of measurement, techniques to be followed, suggested performance criteria, action levels, and routes of notification. ~~QM~~ **QA** test procedures should be able to measure parameter changes smaller than tolerance or action levels.

~~The effectiveness of the QM program should be evaluated annually. Such evaluations help to maintain a uniform standard dose among different treatment facilities, ensuring more accurate dissemination of treatment regimens and results in the literature~~ A written summary of physics activities along with the results of the evaluation should be ~~reviewed with and approved by~~ **should be documented and presented to** the medical director and senior institutional administrator annually. This written summary should be incorporated into the institution's overall QM program.

C. Specific Protocols

1. Measurement equipment

   A program must be in place to ensure the accuracy and precision of measurement equipment used for calibration and constancy checks of treatment machines and instruments used for patient dosimetry. The program must have documented procedures for instrument calibration to ensure traceability to accredited calibration facilities and to affirm instrument precision and accuracy. Redundancy in dose calibration equipment is recommended to ensure that instruments are holding their calibration. **This can be achieved by cross calibrations or the use of the appropriate long-lived radioactive source.** ~~A check system can be established by comparing the response of the measurement equipment with an appropriate long-lived radioactive source. If access to an appropriate check source is unavailable~~ **I**t is recommended that both a local standard and a field dosimetry system be maintained and routinely compared.

2. ~~Calibration of~~ **T**reatment machines ~~and independent verification of output~~

   Protocols for calibrating treatment machines must follow those protocols currently published by the American Association of Physicists in Medicine and adhere to state and federal guidelines.

   An independent ~~check~~ **verification** of the output of each beam must be performed annually to verify that the treatment unit calibration is consistent with national standards. The independent check ~~should~~ **must** be performed by either:

a. A **Qualified M**edical **P**hysicist who did not perform the annual output calibration, using a dosimetry system other than the one that was used during the annual calibration (this dosimetry system must also have calibration factors traceable to an accredited dosimetry calibration laboratory); or
b. Using an independent ~~TLD~~ **dosimetry** service that is designed to measure doses within an uncertainty of 5%.

3. Radiotherapy simulators, imaging equipment, and treatment devices

Procedures for establishing and maintaining the imaging equipment used in planning radiation therapy treatment planning (eg, computed tomography (CT), ~~and~~ magnetic resonance (MR), ~~scanners~~ **positron emission tomography (PET), PET/CT scanners, and other** radiography equipment), should be an integral part of a QM program. The **Qualified M**edical **P**hysicist must be aware of the factors that affect image quality as well as the effect of image distortions on treatment planning. The medical physicist should ensure that those elements of imaging equipment quality control directly relevant to radiation oncology planning are carried out at an appropriate frequency [17].

Every effort should be made to acquire patient data through digital imaging techniques. If deemed appropriate by the radiation oncologist, manual techniques may be used. All data used in the dose-distribution calculation and implementation process should be reviewed by a member of the physics staff for appropriateness prior to its use in computation. The spatial linearity (in 3 dimensions) of CT or other digital images used for planning should be verified by test imaging of appropriate phantoms having fixed fiducials and/or known external dimensions.

4. **External beam dose distributions and associated coordinate systems**

Independent systems involved in the treatment simulation, planning and delivery process may have different image characteristics and coordinate systems. Faithful data transfer and coordinate translation must be achieved, and this process must be routinely tested. One method to test the data chain is via an "end-to-end" test, which may contain some or all of the following components:

a. Simulation, including CT scanning of a dosimetry phantom.
b. Phantom image data transfer to the treatment planning system.
c. Creation of a treatment plan with variables such as independent jaws, wedging, blocking, noncoplanar beams, or other techniques at the discretion of the medical physicist.
d. Calculation, monitor unit verification and transfer of the plan to the record and verify system or treatment unit, in the custom of the clinic.
e. Treatment of to the dosimetry phantom with dosimeter(s) in place.
f. Analysis of dose measured compared to that predicted by the planning system.
g. In each of the imaging systems (simulation and planning), a check of spatial fidelity, Hounsfield unit (HU) value, and beam geometry (size, source skin distance [SSD], etc) against nominal values.

Alternative methods of completely testing the image/data chain may be devised by the medical physicist.

5. Treatment planning computer systems

The treatment planning computer model must be verified using ~~actual~~ beam data measured ~~by~~ **under the supervision of** the Qualified Medical Physicist on the same treatment unit for which the model will be applied for patient planning. **Reference beam data provided by the manufacturer may be used if it is within acceptable agreement with the measured data set as determined by the Qualified Medical**

Physicist. Treatment planning computer systems must undergo rigorous acceptance tests and commissioning to ensure that the calculated output satisfactorily agrees with measured beam data for a series of test cases and to ensure that the hardware and software were installed properly. (See the ACR–ASTRO Practice Parameter for 3-D External Beam Radiation Planning and Conformal Therapy [18].

All users must receive ~~proper~~ **documented** training **by the Qualified Medical Physicist or manufacturer**. **In addition, d**ocumented training should be given to **all** new users. ~~and following major~~ **S**oftware releases **should be reviewed and documented by all users**.

~~Graphical~~ **Treatment** planning systems must be tested to ensure that they meet the published specifications of the system. All features of the system that are used ~~by the~~ **in clinical** practice must be tested. Both central-axis and off-axis beam characteristics at specific points should be tested for various field sizes to confirm the spatial accuracy of the dose display. ~~A study must be performed for open fields, blocked fields, and wedged fields.~~ **Studies must be performed to test all types of external beam planning used at the site.** ~~The calculated data must be compared with measured data. Suggested standards of agreement have been published.~~ The limitations**/uncertainties** of the dose-calculation~~al~~ algorithm(s) must be **reviewed, documented** ~~established~~ and **available to all clinical personnel** ~~presented to the radiation oncologists~~ **at the time of commissioning**.

If the ~~graphica~~ **treatment** planning system is used to define beam apertures, then this function should be tested along with margin tools used to define the planning target volume.

In many ~~graphical~~ **treatment** planning systems, the dose can be displayed in terms of absolute dose or relative dose. The exact method of dose display must be consistent with the treatment planning approach that is used clinically. The user must confirm that the relative dose distribution is as described in the system manual. The absolute dose calculation must be confirmed by measurements under normal conditions in radiation fields of various sizes [19].

If dose-volume histograms are used in the analysis of the plan, their validity must be checked. Various dose distributions can be calculated whose characteristics are known. The dose and volume results from the dose-volume histogram can be checked against the known values.

Periodic tests (eg, standard plans) must be performed routinely and after any major service or software change to ensure the accuracy of monitor unit and/or dose-calculation algorithms, to ensure that any software changes (including editing of beam data files) were implemented correctly and have not corrupted the beam data, to ensure that any hardware changes were installed properly, and to verify that the system performance is consistent with its initial commissioning.

6. Electrical, mechanical, and radiation safety

A documented program must be implemented to assess potential safety hazards and to check the integrity of mechanical and electrical patient care devices. This program should include**, but not limited to the following:**

- Periodic inspections of patient dose-monitoring devices
- Treatment machines (**including the proper operation of linac vault doors and interlock safety devices such as door pressure sensors or motion detectors).**
- Simulators (including the patient support assembly)
- Accessories to these machines, including MLC systems, treatment couches, imaging systems, immobilization devices, and beam attenuators [20].

The radiation protection program must be designed to cover all treatment and imaging equipment and be consistent with state and federal regulations. ~~and the as-low-as-reasonably-achievable (ALARA) concept~~

VI. CLINICAL PRACTICE

A. Availability

The **A Qualified M**edical **P**hysicist must be available for continuing medical physics consultation for patients, consultation with the radiation oncologist and to provide advice or direction to staff when patient treatment is being planned or conducted. Procedures must be established to meet clinic needs for periods when a **Qualified M**edical **P**hysicist is not immediately available on site, including standard procedures and covering physicists.

The Qualified Medical Physicist should be present to review and/or supervise complicated simulations as well as treatment setups and communicate specific requirements directly.

The **Qualified M**edical **P**hysicist must review, as soon as possible, all dosimetric and physics activities that occurred during his/her absence. Authority to perform specific clinical **medical** physics duties must be delegated by the **Qualified M**edical **P**hysicist to each member of the physics staff in accordance with their training and competence. The radiation oncologist must be informed of the clinical activities authorized for each member and/or the locum tenens **Qualified Medical P**hysicist. Daily on-site availability is preferable. Practices without a full-time **Qualified M**edical **P**hysicist must have regular on-site physics support during hours of clinical activity at least 2 days a week and provide 0.4 full time equivalents (FTE) coverage. In addition, state or local regulatory requirements must be met.

B. Calculation Procedures and Protocols

~~1. Patient data~~

~~Patient data may be acquired through digital or manual techniques. All data used in the dose distribution calculation and implementation process should be reviewed by a member of the physics staff for reasonableness prior to its use in computation. The spatial linearity (in 3 dimensions) of CT or other digital images used for planning should be verified by test imaging of appropriate phantoms having fixed fiducials and/or known external dimensions~~

1. Monitor units or treatment time

Each practice must have a written procedure that defines how to calculate the monitor units or treatment time for all routine treatments. Such calculations should be based on measured dosimetric parameters. Tables of these dosimetric parameters **in either paper form or electronic** must be compiled **and be readily accessible to the physics and physician staff.**

All **treatment planning system** calculations of monitor units or treatment time must be verified by a**n independent monitor unit calculation** system**.** ~~for independent checking by another person or method~~ **This independent calculation is to be performed by a member of the physics team and checked by the Qualified Medical Physicist** before the first treatment if the total number of fractions is five or fewer or otherwise before the third fraction. Verification must begin with a review of the written dose prescription. IMRT has different requirements (See the ACR–ASTRO Practice Parameter for Intensity Modulated Radiation Therapy [IMRT] [9].) Documentation of this review and verification must be inserted in the patient's treatment record.

2. External beam dose distributions

External beam dose distributions must be generated as requested by the radiation oncologist. Cumulative dose distributions should be generated as appropriate. The **Qualified M**edical **P**hysicist must review all dose distributions. The physics review must include a review of the dose prescription and the patient's treatment ~~record~~ **plan parameters** to ensure that the graphical dose distribution is consistent with the dose prescription and the treatment record. **Documentation of this review must be inserted in the patient's treatment record.**

3. Treatment plan beam parameters

The **Qualified M**edical **P**hysicist must review and verify the parameters that are used to describe the radiation beam or beams used in the treatment plan. They include the target**/source**-to-patient **skin** distance **(SSD or TSD)**, ~~the~~ **gantry angle** collimator rotation ~~and opening~~ **field size,** a description of the beam aperture or MLC pattern(s) when shaped fields are used, the identification of wedges or compensator if such are used, the relative beam weight or normalization, and all ~~gantry and~~ treatment couch parameters.

~~4. External beam dose distributions and associated coordinate systems~~

~~Independent systems involved in the treatment simulation, planning and delivery process may have different image characteristics and coordinate systems. Faithful data transfer and coordinate translation must be achieved, and this process must be routinely tested. One method to test the data chain is via an "end-to-end" test, which may contain some or all of the following components:~~

~~h. Simulation, including CT scanning of a dosimetry phantom.~~

~~i. Phantom image data transfer to the treatment planning system.~~

~~j. Creation of a treatment plan with variables such as independent jaws, wedging, blocking, noncoplanar beams, or other techniques at the discretion of the medical physicist.~~

~~k. Calculation, monitor unit verification and transfer of the plan to the record and verify system or treatment unit, in the custom of the clinic.~~

~~l. Treatment of to the dosimetry phantom with dosimeter(s) in place.~~

~~m. Analysis of dose measured compared to that predicted by the planning system.~~

~~n. In each of the imaging systems (simulation and planning), a check of spatial fidelity, Hounsfield unit (HU) value, and beam geometry (size, source skin distance [SSD], etc) against nominal values.~~

~~Alternative methods of completely testing the image/data chain may be devised by the medical physicist.~~

C. Clinical Quality Management

1. Plan implementation

Appropriate implementation of the dose prescription is critical for safe and effective radiotherapy treatment. ~~Routine review of~~ **A**ll patient treatment plans must be ~~performed~~ **reviewed** by ~~the~~ **a Qualified M**edical **P**hysicist and must include **a** review of patient and dosimetric data as well as beam and machine parameters. ~~and their faithful transfer from simulation to planning to treatment unit~~

~~2. System overview~~

~~The medical physicist must review all of the technical aspects of the treatment delivery system on an established schedule. This review must be presented to the medical director and administration on a documented, periodic basis.~~

2. Chart rounds

   The **Qualified M**edical **P**hysicist ~~should~~ **must** participate in weekly department-wide chart rounds to ensure the fulfillment of the prescription and review any changes in dose, patient setup(s), and simulation and port films.

   ~~The medical physicist should be present to review and/or supervise complicated simulations as well as treatment setups and communicate specific requirements directly.~~

3. Medical physics chart review protocol

   The **Qualified M**edical **P**hysicist must develop a chart review protocol for reviewing treatment records. This protocol should **include a** review **of** new or modified treatment fields, treatment prescription, simulation instructions, isodose distributions, special dose calculations and measurements, monitor units (time) calculations, in vivo measurements, daily treatment records, and cumulative doses. The review must assess accuracy of information as well as completeness and clarity of the record. If verify and record systems are used, the physics chart check protocol must include reviewing all treatment related data recorded therein. **Documentation of this review must be part of the patient's treatment record.**

   a. Physicist's continuing chart review
      The **Qualified M**edical **P**hysicist must review each patient's chart to ensure accuracy of calculation, appropriateness of charting data, and fulfillment of the physicians' written prescription. Any deviation from the radiotherapy prescription should be reported in a timely manner to the responsible radiation oncologists so that corrective action can be taken. The physics chart review must be conducted at least weekly. **Documentation of this review must be part of the patient's treatment record. If the site employs more than one Qualified Medical Physicist this review should be rotated amongst the physicists so that more than one Qualified Medical Physicist reviews the chart.**
   b. Completion of treatment chart review
      At the completion (end) of treatment (EOT), the **Qualified M**edical **P**hysicist must review the entire chart to affirm the fulfillment of the initial and/or revised prescribed dose. This review must be performed within 1 week of EOT and documented in the treatment record. Any deviations from the physician treatment plan or radiotherapy prescription must be documented and promptly brought to the attention of the attending radiation oncologist.

VII. NEW PROCEDURES

The practice of radiation oncology often involves the implementation of new procedures and technologies. When these are being considered, the **Qualified M**edical **P**hysicist ~~should~~ **must** participate along with team members of the medical and administrative areas. The **Qualified M**edical **P**hysicist should undertake a systematic literature review, make site visits, confer with colleagues familiar with the new procedure or equipment, and otherwise obtain factual information for use in planning, acquisition, and implementation. Such information may include clinical application, impacts on workflows, equipment, staffing, and space utilization.

Prior to implementation of any procedure, technique, system, or accessory, they must be received **(accepted)**, commissioned, and released for clinical use by the **Qualified M**edical **P**hysicist. In the case of a product (hardware, software, or accessory) the commissioning must include safety testing and verification that the system or device meets the manufacturer's performance standards. Commissioning will also include institution of a ~~quality assurance (~~QA~~)~~ program to demonstrate the consistent safety and performance of the system or device.

Documentation of the acceptance, commissioning and QA program development must be on-site and available for review.

The ~~quality improvement~~ **QA** program associated with any new procedure should be periodically reviewed and updated.

For more information on image-guided radiation therapy, see the ACR–AAPM Technical Standard for Medical Physics Performance Monitoring of Image-Guided Radiation Therapy (IGRT) and the ACR–ASTRO Practice Parameter for Image-Guided Radiation Therapy (IGRT) [11,21].

VIII. DOCUMENTATION

The **Qualified M**edical **P**hysicist is responsible for documenting the following:

1. Procedures for instrument calibration and periodic instrument constancy checks.
2. Procedures to verify the manufacturer's specifications and to establish baseline performance values for radiation therapy equipment.
3. Quality management programs for radiation therapy equipment, simulators, treatment planning systems, and monitor unit calculation algorithms.
4. Monitor units (time) calculation procedures and protocols.
5. Physics chart check protocol for reviewing treatment delivery.
6. Procedures for checking the mechanical and electrical integrity of patient care devices.
7. Radiation protection program as it pertains to radiation oncology.
8. Calculations related to patient dosimetry and/or physics measurements when such needs arise or per clinicians' requests.
9. Consultations requested by the radiation oncologist.
10. Commissioning of new systems and/or equipment introduced into the clinic.
11. **Response to vendor safety notices**
12. **Equipment repair log and QA prior to returning to service.**

IX. PEER REVIEW

The **Qualified M**edical **P**hysicist should engage in a formalized peer review on a regular basis [22,23].

Physicists engaged in solo practice (being the only **Q**ualified **M**edical **P**hysicist at a facility, or serving as consultant providing the only **Qualified M**edical **P**hysicist service to the facility) should follow published AAPM recommendations, including peer review recommendations [23].

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~~Suggested Reading~~ ~~(Additional articles that are not cited in the document but that the committee recommends for further reading on this topic)~~

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