AAPM Medical Physics Practice Guidelines (Update On Therapy MPPGs)

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Outline

MPPGs to Discuss

1. **MPPG 2.b: Commissioning and quality assurance of X-ray-based image-guided radiotherapy systems**
2. **MPPG 5.a: Commissioning and QA of Treatment Planning Dose Calculations — Megavoltage Photon and Electron Beams**
3. **MPPG 11.a: Plan and chart review in external beam radiotherapy and brachytherapy**
4. **MPPG 13.a: HDR Brachytherapy (NOT yet published but is approved by EXCOM)**
5. **MPPG 15.a: Peer Review in Clinical Physics (NOT yet approved by EXCOM)**

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AAPM MEDICAL PHYSICS PRACTICE GUIDELINE 2.b.: Commissioning and quality assurance of X-ray-based image-guided radiotherapy systems

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This report is the first revision of MPPG 2 first published in 2014.

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Motivation

1. Many clinical practice environments now utilize treatment delivery systems with one or more IGRT systems that fall under the responsibility of the QMP.

2. A variety of guidance documents and task group reports have been issued that include additional recommendations for commissioning and quality assurance of IGRT or planning CT systems. However, these reports do not clearly delineate *best* practice from *minimum* practice standards.

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Relevant Prior Publications

1. Herman MG, Balter JM, Jaffray DA, et al. Clinical use of electronic portal imaging: Report of AAPM Radiation Therapy Committee **Task Group 58**. *Med Phys*. **2001.**
2. Mutic S, Palta JR, Butker EK, et al. Quality assurance for computed-tomography simulators and the computed-tomography-simulation process: report of the AAPM Radiation Therapy Committee **Task Group No. 66**. *Med Phys*. **2003.**
3. Murphy MJ, Balter J, Balter S, et al. The management of imaging dose during image-guided radiotherapy: report of the **AAPM Task Group 75**. *Med Phys*. **2007.**
4. Klein EE, Hanley J, Bayouth J, et al. **Task Group 142 report**: quality assurance of medical accelerators. *Med Phys*. **2009**.
5. The role of in-room kV X-ray imaging for patient setup and target localization. ***AAPM TG-104***. Madison (WI): Medical Physics Publishing; **2009**.
6. Langen KM, Papanikolaou N, Balog J, et al. QA for helical tomotherapy: report of the **AAPM Task Group 148**. *Med Phys*. **2010**.
7. Comprehensive methodology for the evaluation of radiation dose in X-ray computed tomography. ***AAPM TG-111***. Medical Physics Publishing; **2010**.
8. Dieterich S, Cavedon C, Chuang CF, et al. Report of **AAPM TG 135**: quality assurance for robotic radiosurgery. *Med Phys*. **2011**.
9. Bissonnette J-P, et al. Quality assurance for image-guided radiation therapy utilizing CT-based technologies: a report of the **AAPM TG-179**. *Med Phys*. **2012**.

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Covered Technologies

1. Gantry-mounted 2D and 3D MV imaging systems

2. Gantry-mounted 2D and 3D kV imaging systems

3. Room-mounted 2D and 3D kV imaging systems

STAFF QUALIFICATIONS AND RESPONSIBILITIES

Medical physicist:

Responsibilities of the qualified medical physicist in an IGRT program include:

1. Acceptance testing and commissioning.
2. Implementing and managing a quality assurance program.
3. Developing and implementing standard operating procedures (including imaging protocols and repositioning thresholds).

<u>Others Described:</u>

1. Radiation Oncologist
2. Medical dosimetrist
3. Radiation therapist
4. Information technology specialist

Minimum Required Resources and Equipment

At a minimum, quality assurance tools must be capable of assessing the following IGRT characteristics:

1. Image quality (i.e., contrast, Resolution, Uniformity).
2. Spatial accuracy (scaling).
3. Congruence of imaging and treatment isocenters.
4. Accuracy of registration/table movements.
5. Imaging dose.

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Time Estimates

1. Two-dimensional MV imaging systems.
   a. Acceptance/Commissioning/Documentation: 8–12 hours.
   b. Ongoing support: 8–16 hours annually.
2. Three-dimensional MV imaging systems.
   a. Acceptance/Commissioning/Documentation: 8–20 hours.
   b. Ongoing support: 8–16 hours annually.
3. Two-dimensional kV imaging systems.
   a. Acceptance/Commissioning/Documentation: 8–12 hours.
   b. Ongoing support: 8–16 hours annually.

4. Three-dimensional kV imaging systems.
   a. Acceptance/Commissioning/Documentation: 8–20 hours.
   b. Ongoing support: 8–16 hours annually.

Staff training

1. Training for the operation of the IGRT system must be provided. The IGRT system vendor typically provides on-site training to the physicist and therapists for use of the equipment.

2. Prior to the initial use of IGRT, the treatment team should meet to discuss staff responsibilities, clinical goals, and process workflows. The physicist should also review the image acquisition procedures with the therapists and radiation oncologists.

3. Consultation with a QMP certified in diagnostic imaging to develop optimized data acquisition and image formation protocols is advantageous and recommended.

4. In addition to initial training, it is important that each facility develop a periodic training review program to ensure competency on current systems and augment with training for system upgrades/changes. Formal training of new staff not present at initial training should be conducted.

Minimum Practices for Commissioning and QA

Acceptance testing and commissioning	
Procedure	
Customer acceptance procedures	
TPS integration	
OIS integration	
Establish routine QA baselines	
QA documentation	
Routine quality assurance	
Daily or day of special procedure	
Procedure	Tolerance
Safety/interlocks	Functional
Imaging-treatment isocenter coincidence and table positioning composite (SRS only)	1 mm
Imaging-treatment isocenter coincidence (lasers as treatment reference)	2 mm
Table positioning/repositioning	2 mm
Monthly	
Procedure	Tolerance
Imaging-treatment isocenter coincidence (MV image as reference)	2 mm
Semi-annually	
Procedure	Tolerance
Image scaling	2 mm
Annually	
Procedure	Tolerance
Gating Interlock	Functional
Imaging dose	
2D MV	± 1 cGy of the baseline value
2D kV (static imaging mode)	± 3 mGy of the baseline value
2D kV (fluoroscopy mode)	± 1 cGy/min of the baseline value
All 3D imaging modes	± 1 cGy of the baseline value
Image quality	
2D (spatial resolution, contrast)	At least baseline value
3D (uniformity, spatial resolution, contrast)	At least baseline value
Upgrade/Repair/Service	
Manufacturer recommended testing	As recommended
Verify / Reestablish QA baselines (as appropriate)	As needed post-change

SRS, stereotactic radiosurgery; SBRT, stereotactic body radiation therapy.

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Conclusions

1. IGRT is a powerful and increasingly essential component of clinical radiation oncology practice.

2. Proper use and quality assurance of clinical IGRT systems are of critical importance to maximizing the benefits and minimizing the risks of the technology.

3. The minimum technical requirements for managing a clinical IGRT program stated in this document will help to achieve a more uniform standard of practice that improves the safety and quality of care of patients for whom IGRT is needed.

AAPM Medical Physics Practice Guideline 5.a.: Commissioning and QA of Treatment Planning Dose Calculations — Megavoltage Photon and Electron Beams

Medical Physics Practice Guideline: Jennifer B. Smilowitz, Chair, Indra J. Das, Vladimir Feygelman, Benedick A. Fraass, Stephen F. Kry, Ingrid R. Marshall, Dimitris N. Mihailidis, Zoubir Ouhib, Timothy Ritter, Michael G. Snyder, Lynne Fairobent, AAPM Staff

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The intended user of this document is the QMP. Hospital and clinic administration are also encouraged to use this report as a reference for an explanation of process, time, and resource requirements.

Prior Related Task Group Reports

1. Fraass B, Doppke K, Hunt M, et al. American Association of Physicists in Medicine Radiation Therapy Committee **Task Group 53**: Quality assurance for clinical radiotherapy treatment planning. Med Phys. **1998**.

2. International Atomic Energy Agency. Commissioning and quality assurance of computerized planning systems for radiation treatment of cancer. **TRS 430**. Vienna: International Atomic Energy Agency; **2004**.

3. Das IJ, Cheng CW, Watts RJ, et al. Accelerator beam data commissioning equipment and procedures: **Report of the TG-106** of the Therapy Physics Committee of the AAPM. Med Phys. 2008.

4. Langen KM, Papanikolaou N, Balot J, et al. QA for helical tomotherapy: Report of **AAPM Task Group 148**. Med Phys. 2010.

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Motivation

1. The treatment planning system (TPS) is an essential component of external beam radiation therapy.

2. The accuracy of the dose calculations is paramount for safe and efficacious treatment delivery. A substantial (but not exclusive) part of commissioning a TPS is ensuring that the radiation beam parameters, and other data affecting the accuracy of the dose calculation, are adequately modeled in the system and are properly validated.

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Goals of the Report

1. Clearly identify and reference applicable portions of existing AAPM reports and peer-reviewed articles for established commissioning components.

2. Provide updated guidelines on technologies that have emerged since the publication of previous reports.

3. Provide guidance on validation tests for dose accuracy and constancy.

4. Provide guidance on tolerance values and evaluation criteria for clinical implementation.

5. Provide a checklist for commissioning processes and associated documentation.

Evaluation Criteria

Modeling the commissioning data in the TPS is an iterative process that includes compromises in accuracy over the range of clinical scenarios that could be encountered. The tolerance values and evaluation criteria in this MPPG represent a compromise between a number of factors:

1. Avoiding values that are too "tight" and may be unreasonable or unachievable over the investigated range of field sizes, depths, off-axis positions, test setups, and beam modifiers.

2. Avoiding values that are too "loose" and could, therefore, result in approval of a sub-optimal model.

3. The need for a simple, generic set of evaluation criteria, as opposed to a complex matrix of test scenarios and tolerances for different parts of the model which could potentially lead to confusion.

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SCOPE

The scope of this report is limited to the commissioning and QA of the beam modeling and calculation portion of a TPS where:

i. External photon and electron treatment beams are delivered at typical source-to-surface distance (SSDs) using a gantry-mounted radiation source including conventional and smaller fields used in IMRT, VMAT, and helical tomotherapy delivery.

ii. Modern dose algorithms are utilized, including corrections for tissue heterogeneity.

iii. The multileaf collimator (MLC) is used as the primary method of shaping the beam aperture or modulating the fluence for treatments.

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Outside SCOPE

1. Noncommercial planning systems, small static shaped fields less than 2× 2 cm^2 such as those used in stereotactic radiosurgery (SRS),

2. Secondary monitor unit validation and other such ancillary software,

3. Optimization and leaf sequencing algorithms,

4. Methods involving biological modeling (including tumor control and normal tissue complication probability),

5. And all nondosimetric components of the planning system which include (but are not limited to) dataset management and presentation, coordinate systems, image generation, image registration, anatomical structures, and functions dependent on anatomy (e.g., dose-volume histograms, beam's eye view displays).

Recommendations

If the TPS is being commissioned in parallel with the commissioning of a new linear accelerator, then a full set of new modeling data is required.

If a new TPS and/or new algorithm are being commissioned on an existing linear accelerator, then existing data could be used, provided they are verified and meet vendor requirements. However, additional data may also be required.

It may be useful to acquire data that will be used for verification at the same time commissioning data are collected.

Time Estimate: For one algorithm, two to four weeks for a single energy photon beam and six to eight weeks for two photon energies and five electron energies. This will depend strongly on how much commissioning data need to be collected and the availability and experience of the QMP(s) involved, the adequacy and availability of the equipment used, and the access to the accelerator.

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Measurement Equipment

TABLE 1. Detectors suitable for TPS commissioning and validation of photon and electron beams.

Detector	*Use*	*Comments*	*Reference*
Scanning ion chambers	Beam scanning for photons and electrons	Typical scanning chambers have an air cavity of 4–6 mm diameter, (minimum of 2 chambers for measurement and reference)	TG-106 (Das et al.[5])
Electron diodes and film	Beam scanning for electrons, output factors (film)	QMP must confirm the effective point of measurement	TG-25 (Khan et al.[45]), TG-70 (Gerbi et al.[46])
Small field detectors	• Small field scanning & output factors[a], • IMRT/VMAT point measurement • MLC intraleaf measurement & penumbra	Carefully select the detector type and size to fit the application. When scanning for penumbra, diodes are recommended.	TG-106 (Das et al.[5]), TG-120 (Low et al.[18]) Yunice, et al.[16]
Large ion chamber	Aggregate MLC transmission factors	Interleaf transmission	LoSasso et al.[20]
Film and/or array detector	2D dose distributions, including dynamic/virtual wedge and planar fluence maps, intraleaf measurements[b]	• Absolute dosimetry preferred; relative dosimetry adequate. • Desirable if the device can be mounted on the gantry and/or in a phantom at different geometries	TG-106 (Das et al.[5]), TG-120 (Low et al.[18]), IAEA TRS-430[7]

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Other Equipment

TABLE 2. Equipment required for TPS commissioning of photon and electron beams.

Equipment	*Use*	*Comments*	*Reference*
3D water phantom	Beam scanning	Must have sufficient scanning range and lateral/depth scatter	TG-106 (Das et al.[5]), TG-70 (Gerbi et al.[46])
Electrometers and cables	Beam scanning, output calibration, relative and absolute dosimetry	ADCL calibration, low noise and leakage with wide dynamic range and linear response	TG-106 (Das et al.[5])
Buildup cap or miniphantom	In-air output factor measurement	Measurements required for some planning systems, most second check systems	Yunice, et al.[16]
Water-equivalent phantom material in slab form	Buildup and backscatter for measurements	> 20 cm of total thickness in varying increments, width and length ≥ 30 cm, cavity for detector(s)	TG-106 (Das et al.[5]), TG-120 (Low et al.[18]), IAEA TRS-430[7]
CT density phantom	CT number to electron or mass density calibration	Should include tissue-equivalent materials spanning the clinical range of low-density lung to high-density bone.	TG-66 (Mutic et al.[13])
Heterogeneity phantom with lung-equivalent material	End-to-end testing	Include cavities for detectors, useful for annual QA reference test	TG-65 (Papanikolaou & Stathakis[26]), IAEA TRS-430[7]
Anthropomorphic phantom	Anatomic model testing, end-to-end testing, use testing	Include cavities for detectors	IAEA TRS-430[7]
Software for data processing	Processing, comparing, and analyzing profiles, depth-dose curves, and other beam data	May be included with the 3D water tank scanning software	TG-106 (Das et al.[5])
IMRT/VMAT or arc therapy phantom	VMAT or arc therapy	Options include a solid phantom holding a planar array, 3D detector arrays, film inside a phantom, other	TG-120 (Low et al.[18])

CT Calibration

The QMP must consider the range of clinically relevant densities and scan parameters (kVp) as important components of the dose algorithm commissioning process. Materials used for CT number mapping must range from air (~ 0.001 g/cm3) to high-density material (~ 2 g/ cm3), including densities to mimic lung (~ 0.3 g/ cm3) and dense bone (~ 1.4–1.9 g/ cm3).

A separate CT density curve should be developed and validated for the image guidance system if those CT datasets will be used for dose calculation.

It is recommended that scanner-specific calibration curves be obtained.

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Data acquisition for IMRT/VMAT delivery

1. Even if not specified by the TPS vendor, the QMP should measure percent depth dose (PDD) and output factors with a small-volume detector down to a field size of 2×2 cm or smaller for comparison with dose calculation.

2. MLC intraleaf and interleaf transmission and leaf gap

3. Leaf-end penumbra should be obtained with a small detector (such as a diode or microchamber) to avoid volume-averaging effects.

4. Leaf timing for binary MLC systems should be verified using film or exit detector measurements.

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PHOTON BEAMS: BASIC DOSE ALGORITHM VALIDATION

While it is good practice to use field configurations for validation that were not used for modeling for the majority of the tests, it is efficient to collect the validation data at the same time as the modeling data are acquired.

TABLE 3. TPS model comparison tests and tolerances.

Test	*Comparison*	*Description*	*Tolerance*
5.1	Dose distributions in planning module vs. modeling (physics) module	Comparison of dose distribution for large (> 30×30cm^2) field.	Identical[a]
5.2	Dose in test plan vs. clinical calibration condition[b]	Reference calibration condition check	0.5%
5.3	Dose distribution calculated in planning system vs. commissioning data	PDD and off axis output factors for a large and a small field size	2%

[a] Identical to within the expected statistical uncertainty (considering noise and calculation grid size).
[b] TPS absolute dose at reference point.

TABLE 4. Basic photon beam validation tests summary[a].

Test	*Description*	*Sample tests from literature*[7]
5.4	Small MLC-shaped field (non SRS)	Photon Test 1
5.5	Large MLC-shaped field with extensive blocking (e.g., mantle)	Photon Test 3
5.6	Off-axis MLC shaped field, with maximum allowed leaf over travel	Photon Test 2
5.7	Asymmetric field at minimal anticipated SSD	Photon Test 6
5.8	10×10 cm^2 field at oblique incidence (at least 20°)	Photon Test 10
5.9	Large (> 15 cm) field for each nonphysical wedge angle[b]	–

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Photon Beam Model Evaluation

TABLE 5. Basic TPS photon beam evaluation methods and tolerances.

Region	*Evaluation Method*	*Tolerance*[a] *(consistent with IROC Houston)*
High dose	Relative dose with one parameter change from reference conditions	2%
	Relative dose with multiple parameter changes[b]	5%
Penumbra	Distance to agreement	3 mm
Low-dose tail	Up to 5 cm from field edge	3% of maximum field dose

[a] Tolerances are relative to local dose unless otherwise noted.

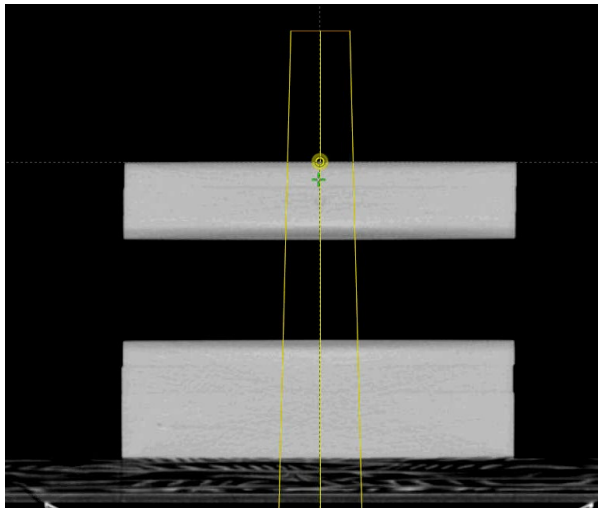
PHOTON BEAMS: HETEROGENEITY CORRECTION VALIDATION

TABLE 6. Heterogeneous TPS photon beam validation tests.

Test	*Objective*	*Description*	*Tolerances*[a]	*Reference*
6.1	Validate planning system reported electron (or mass) densities against known values	CT-density calibration for air, lung, water, dense bone, and possibly additional tissue types	–	TG 65,[26] IAEA TRS-430[7]
6.2	Heterogeneity correction distal to lung tissue	5×5 cm^2, measure and calculate dose ratio above and below heterogeneity, outside of the buildup region	3%	IAEA TRS-430,[7] Carrasco et al.[28]

[a] Tolerances are relative to local dose unless otherwise noted.

For 6.2: use a 5 cm slab of water-equivalent plastic stacked upon a 13 cm slab of low-density material, upon a 10 cm slab of water-equivalent plastic. For lung-equivalent material, any type of low-density material, such as low-density wood or styrofoam can be used, as long as the thickness is sufficient to result in a dose correction greater than 10% compared to a homogeneous phantom.



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PHOTON BEAMS: IMRT/VMAT DOSE VALIDATION

TABLE 7. VMAT/IMRT test summary.

Test	*Objective*	*Description (example)*	*Detector*	*Ref*
7.1	Verify small field PDD	≤ 2×2 cm^2 MLC shaped field, with PDD acquired at a clinically relevant SSD	Diode or plastic scintillator	Yunice et al.[16]
7.2	Verify output for small MLC-defined fields	Use small square and rectangular MLC-defined segments, measuring output at a clinically relevant depth for each[a]	Diode, plastic scintillator, minichamber or microion chamber	Cadman et al.[58]
7.3	TG-119 tests	Plan, measure, and compare planning and QA results to the TG119 report for both the Head and Neck and C-shape cases	Ion chamber, film and/or array	TG-119 (Ezzell et al.[37])
7.4	Clinical tests	Choose at least 2 relevant clinical cases; plan, measure, and perform an in-depth analysis of the results	Ion chamber, film and/or array	Nelms et al.[42]
7.5	External review	Simulate, plan, and treat an anthropomorphic phantom with embedded dosimeters.	Various options exist[b]	Kry et al.[39]

TABLE 8. VMAT/IMRT evaluation methods and tolerances.

Measurement Method	*Region*	*Tolerance*
Ion Chamber	Low-gradient target region	2% of prescribed dose
	OAR region	3% of prescribed dose
Planar/Volumetric Array	All regions	2%/2 mm[a], no pass rate tolerance, but areas that do not pass need to be investigated
End-to-End	Low-gradient target region	5% of prescribed dose

[a] Application of a 2%/2 mm gamma criterion can result in the discovery of easily correctable problems with IMRT commissioning that may be hidden in the higher (and ubiquitous) 3%/3 mm passing rates.[39]

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ELECTRON BEAM VALIDATION

TABLE 9. Basic TPS validation tests for electron beams and minimum tolerance values.

Test	*Objective*	*Description*	*Tolerance*
8.1	Basic model verification with shaped fields	Custom cutouts at standard and extended SSDs	3%/3 mm
8.2	Surface irregularities obliquity	Oblique incidence using reference cone and nominal clinical SSD	5%
8.3	Inhomogeneity test	Reference cone and nominal clinical SSD	7%

Clinically used nonroutine electron setups (e.g., abutting electron/electron fields, electron/photon fields, and small fields that results in a loss of lateral electron equilibrium) will require additional dosimetric verification to understand the limits of the electron dose model.

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ESTABLISHING ROUTINE QA

A. Recommendations

i. Reference plans should be selected at the time of commissioning and then recalculated for routine QA comparison.

ii. For photons, representative plans for each configured beam should be chosen from Table 4 for static and wedge beams and Table 7 for IMRT/VMAT.

iii. For electrons, sample plans should be calculated for each energy using a heterogeneous dataset with reasonable surface curvature. It is also recommended to include extended distance and bolus verification in the sample plans.

iv. Optionally, an additional thorax dataset with contours and suggested static beam parameters is included with the downloadable IMRT/VMAT sample datasets (http://www.aapm.org/pubs/tg244/). The curvature and inhomogeneity conditions of this dataset are applicable for TPS dose algorithm testing of wedged fields, dynamic arc, and/or electron plans.

v. All routine QA recalculations should agree with the reference dose calculation to within 1%/1 mm. A partial or complete recommissioning (including validation) may be required if more significant deviations are observed.

Other Recommendations

1. Through the entire commissioning process, maintain clear and thorough documentation of the tests performed, equipment used, results, and findings, compiled into a final commissioning report by the QMP, and appended with future TPS modification or recommissioning documentation.

2. The QMP should understand why any Vendor stated accuracy limitations exist and use them as a guide when evaluating the accuracy of their beam model.

3. Get Peer review of the TPS model parameters, agreement to measured data, and validation procedure/results.

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DOSE ALGORITHM COMMISSIONING CHECKLIST

MPPG Section	*MPPG Item for Each Beam Model*	*Commissioning Report Pages*
1	QMP understands algorithms and has received proper training.	
3	Manufacturer's guidance for data acquisition was consulted and followed.	
3.B	Appropriate CT calibration data acquired.	
3.D	Review of raw data (compare with published data, check for error, confirm import into TPS).	
4	Beam modeling process completed according to manufacturer's instructions.	
4	Beam models evaluated qualitatively and quantitatively using metrics within the modeling software.	
5	Basic photon beam validation: Tests 5.1–5.8 (5.9 for nonphysical wedge).	
6	Heterogeneity correction validation for photon beams: Tests 6.1–6.2	
7	IMRT/VMAT validation: Tests 7.1–7.4	
7	IMRT/VMAT End-to-End test with external review: Test 7.5	
7	Understand and document limitations of IMRT/VMAT modeling and dose algorithms.	
8	Electron validation: Tests 8.1–8.3	
9	Baseline QA plan(s) (for model constancy) identified for each configured beam and routine QA established.	

Medical Physics Practice Guideline (MPPG) 11.a: Plan and chart review in external beam radiotherapy and brachytherapy

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The recommendations of this MPPG have been reviewed and endorsed by the American Society of Radiologic Technologists and the American Association of Medical Dosimetrists.

This MPPG is a follow-on to AAPM Task group report TG 275.

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Table of Contents

Scope and Charges

1. To define the roles of dosimetrists, radiation therapists, medical physicists, and qualified medical physicists as they pertain to the treatment plan/chart review process for external beam radiotherapy (EBRT) and brachytherapy.
2. To define a minimum level of practice support for initial, weekly, and end of treatment (EOT) plan/chart reviews organized in the form of lists.
3. To make recommendations on the timing of the initial, weekly, and EOT plan/chart review.

To maintain diversity and represent the widest range of practices, the MPPG task group included members from academic and community practices using different RO-EMR (record and verify) systems and treatment planning systems.

Simulation Checklist

TABLE 2 Example checklist items for simulation therapists

Verify Patient name, MRN, and DOB
Verify patient pregnancy status, Implanted electronic device (IED)
Verify Informed consent completed and presence of signatures
Verify treatment site and laterality consistent with informed consent form
Verify presence of diagnosis document that state diagnosis, stage, treatment site, treatment intent, clinical protocol, etc.
Simulation order completed

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Plan Check Checklist

TABLE 5 Example planner checklist items for EBRT plans

	Recommended	Optional
Planning	Patient identification and correct planning data set Isocenter or reference origin agree with simulation document Treatment site, laterality, and intended dose regimen in Rx agree with simulation or other documents. CT image adequate (eg, FOV) Couch setting correct (eg, removal/insert table model) Density overrides in contours reasonable Normal/critical structure contours reasonable PTV and ITV are logical (without stray voxels) Dose grid size include all critical contours Bolus documented following local convention (if applicable) Field name/ID correct and following local convention Warning /error messages addressed	Calculation algorithm/resolutions set correctly, particularly for a structure with small volume in SRS Necessary new calculation/reference point added (if applicable) Composite plan if multiple CTs, sequential treatments, or retreatment Use the scheduled treatment machine
Plan document	Planned Rx matched with Rx in RO-EMR Isodose distributions DVHs Scorecard/DVH metrics meet clinical requirements or clinical protocols (if applicable) Electron/bolus skin renders (if applicable) DRRs with beam shapes are appropriate (3D plan only) Collision check (gantry, couch, and patient body)	Include an Isocenter image slice Display beam configuration in 3D view Follow local documentation standard
RO-EMR Preparation	Document Isocenter shifts and bolus Additional patient setup instruction following local convention Image guidance/motion management (KVCBCT, MVCBCT, DIBH, etc.) documented Rx approved by physician in RO-EMR or in Plan Reference CT (isocenter/structures) for CBCT sent (for third party image guidance system) Block/accessory code (eg, electron code) checked Dose tracking parameter set Field parameters set and completed (table vertical, tolerance table, or default table position, SID) Treatment delivery pattern/schedule set correctly DRR associated and set to Tx (for third party RO-EMR system) SSDs documented	Check number limits of contours/CT slices on IGRT systems Backup timer check

Abbreviations: DIBH, deep inspiration breath hold; DRR, digitally reconstructed radiograph; KVCBCT, Kilo-voltage cone beam CT; MVCBCT, Mega-voltage cone beam CT; Rx, prescription; SID, source-imager distance; SSD, source-skin distance; Tx, treatment.

For a solo QMP who also acts as the planner, they recommend that a certified medical dosimetrist conducts the initial plan check by independently reviewing the plan, provided the QMP reviews and approves the final documentation, and performs a secondary MU/dose calculation using a secondary method other than the TPS.

Plan Report "Controversy"

- Upon completion of the plan, a plan report is typically created, which is ideally stored in a file format, such as PDF, that cannot be easily modified after creation.
- Each institution should establish a local standardized format for the treatment plan report.
- Treatment plan documentation should be easily accessible and serves as an efficient means of communicating with outside institutions upon request.
- The plan report should provide a durable record of the plan, independent of the planning system, in the event the planning system and/or record and verify data become inaccessible and groups such as radiation therapists who may be less familiar with all of the features of a TPS can still review it.
- The treatment plan report can also be used as the document of prior treatment(s) in the re-irradiation setting.
- **However, it is recognized that there may be alternative approaches without creating a plan report, specifically, as technology changes or in the circumstances not considered by the MPPG members as a part of this review.**

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EBRT Plan Report Elements

TABLE 6 Example EBRT plan report elements

Section	Recommended	Optional
General	Hospital/location Print date or date of service Planning system (version)	Page numbers Plan creation/revision date Planner/staff
Demographics	Patient name/MRN	Date of birth/gender
Prescription/Written directive on plan document	Target Anatomic Site Dose Fractionation Prescription method/plan normalization method	Course/diagnosis identifier Planner/physician approval/ date
Plan Summary	Machine identifier Energy, photon/electron Beam names/IDs Gantry angles Collimator angles and sizes RX and normalization MUs per beam Couch angles	
Additional Plan info	Isocenter location Patient or couch shifts Planning CT date/scanner ID Patient orientation (head first/ supine) Ref. points/points of interest with location/dose/type	Name of CT density table Import log Plan UID Composite plan information IEC convention
Dose calculation	Method (eg, convolution, AAA, Monte Carlo, etc.) Normalization method Heterogeneity corrections (Y/N) Grid resolution/size Tissue density override Warning messages	
DRRs/Beams eye views (For 3D treatment fields)	Wedge direction in graphical display Patient orientation Beam ID and direction Beam shapes (jaw and MLC) with scale Target contours Critical OAR contour(s) Bolus placement with skin render	
Images with Isodose	Absolute isodose lines with selected target and OARs contours Prescription isodose level(s) Isocenter point or its location Location of Maximum dose or hot spots Patient orientation Slice number	
DVHs (when appropriate)	Structure names Defined dose goal to each structure (Volume, minimum dose, maximum dose, mean dose, etc.) DVHs	

Plan Report "Controversy"

JOURNAL OF APPLIED CLINICAL
MEDICAL PHYSICS

PARALLEL OPPOSED EDITORIAL | Open Access

Creating a treatment plan report should be mandated as a minimum standard practice for patient care and QA documentation

Ping Xia, Arthur Olch, Yi Rong

First published: 26 October 2020 | https://doi.org/10.1002/acm2.13072

Take a look at this debate article, I was on the "Con" side of this proposition!

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Initial plan/chart review for medical physicists (also one for RTTs)

TABLE 8 Example initial EBRT treatment plan/chart check items for medical physicists

Sections	Recommended	Optional
Plan integrity check		
	Patient name/MRN/DOB	
	Isocenter/initial reference point matched with simulation doc	Dose calculation algorithm (per institutional policy)
	Isocenter/initial reference point matched with the patient skin marks	
	Isocenter shift documented	
	Rx dose in plan matched with Rx in RO-EMR	
	Field parameters (MUs, dose, field size, collimator, gantry, and MLC positions) reasonable or following local policy	
	Calculation dose grid included all critical contours	
	Beams associated with appropriate isocenter	
	If multiple isocenters are used, clearly labeling of each isocenter	
	3D field shapes appropriate for physician intent (3D plans only)	
	Plan quality and dose metrics reasonable (if applicable)	
	Beam name following institutional convention	
	Beam modification (bolus) noted and documented	
	Check Beam clearance (potential collision)	
	Correct CT dataset used	
	ROI density override appropriate	
	Deliverability of beams (minimum MU for EDW, and maximum MU allowed for high dose, or high dose box checked, errors and warning messages addressed)	
	Couch included/excluded correctly	
	Implanted electronic device dose documented (if applicable)	
	Prior treatment dose added and plan sum appropriate (if applicable)	
	Report conformal index (SRS/SBRT plan only)	
	Secondary dose calculation difference <5%	
Preparation in RO-EMR		
	Rx in RO-EMR in accordance with Table 3	Setup beams associated with the same treatment isocenter
	Rx approved by physician	Image fusion/registration completed and documented
	Plan approved by physician and physicist (or in plan document)	Patient-specific QA reviewed
	All field parameters input (or associated) correctly and approved (if using third party system)	Special physics consult documented (if applicable)
	Site setup instruction (treatment positions, bolus, motion management, etc) are set correctly	Planned for a scheduled treatment machine
	Reference CT input with correct isocenter and include relevant targets and ROIs	Immobilization appropriate
	DRRs associated and approved (if use a third party system)	Dose tracking point (volume) matched Rx in RO-EMR
	Tolerance table set correctly	Created QCL/task for therapy check
	CBCT/IGRT alignment instruction presence	
	Treatment schedule (eg, daily, BID) is in agreement with Rx	
	Dose tracking set correctly (if applicable)	
	Special instructions as needed (eg, surface guided imaging parameters, breath-hold threshold)	

Weekly and end of treatment chart review for EBRT

TABLE 10 Example weekly chart review items for EBRT plans

Recommended	Optional
Rx site	Daily prior treatment timeout documented
Rx changed or field modified since last check (updated document or added comment)	CBCT and portal images approved
Dose delivered to date	
Number of fractions delivered	Correct tolerance table applied
Plan quality reasonable (applied to the first weekly check for each plan)	Bolus fields are indicated in setup note
IMRT QA done and approved (applied to the first weekly check)	
Image frequency and modality agree with Rx	Treatment calendar is correct
Dose tracking correct	Review rejected IGRT images
Overrides with proper comments	
In-vivo measured required and results documented	
Review journal entries/patient notes	
Treatment breaks documented	
Special device or medical condition (pacemakers, etc.)	
Secondary setup verification documented and within limits where applicable (eg, SSDs, SGRT, separation)	
Couch parameters and IGRT shifts within limits or have a note	

TABLE 11 Example end of treatment chart review items

Recommended	Optional
Treatment Site	
Total dose delivered	Are all weekly checks done and appropriate
Number of fractions delivered	All verification images reviewed
Total dose delivered agrees with Rx (if not, proper documentation in the medical record)	
All documents signed (except for completion note)	

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COMPUTER- AIDED and AUTOMATED PLAN CHECK

1. These programs are effective in checking logistic requirements and numerical consistency. For example, a computer program can check whether a prescription or portal image is approved by the radiation oncologist or whether radiation treatment parameters agree with the planned parameters.

2. Due to significant variations in workflow among different practices, these programs cannot completely replace the function of a medical physicist in the process of the plan and chart review.

3. With the increasing use of artificial intelligence and sophisticated machine learning tools, more solutions are expected to be available clinically soon.

4. The combination of computer-aided and human plan/chart review can significantly improve the effectiveness and efficiency of the plan/chart review process while improving the safety and quality of patient care.

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SUMMARY

1. This MPPG provides recommendations for medical physicists and other clinical staff for plan and chart review that meet a minimum standard for quality of care.

2. The report also provides key elements that should be considered in plan/chart documentation, minimum professional qualifications for those conducting plan/ chart review, and appropriate timelines for completing plan/chart reviews.

MPPG 13.a

MPPG 13.1: HDR Brachytherapy (Part A)

Susan Richardson, PhD, Chair

Members:
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This MPPG has not yet been published but is approved by EXCOM

Scope

This report has been divided into two parts:

Part A describes the infrastructure and program design in creation of an afterloader-based HDR brachytherapy program.

Part B (a separate, subsequent publication) describes the clinical treatment processes including imaging, planning, and treatment delivery.

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Recognizing Regulatory Environment

Regulation	References	Topics covered
RAM Licensing	10 CFR § 30 10 CFR § 33	The process by which an organization or individual may receive a license entitling them to receive, possess, use, transfer, or deliver RAM
Personnel Monitoring	10 CFR § 20 IAEA Safety Standards No. GSR Part 3[4] NCRP Report No. 116[5]	Standards of protection for the public against exposure to radiation and the limits of exposure for radiation workers
Shielding	NCRP report No. 49[6] IPEM report 75[7] IAEA Safety Report Series 47[8]	Guidance on shielding design
Security	10 CFR § 37	Specifies the requirements for physical protection of large quantities of radioactive material
	10 CFR § 20.1801 IAEA Nuclear Security Series No. 11-G[9]	Specifies security of stored materials
	10 CFR §35.610	Specifies security of HDR hardware and computers
	49 CFR § 173	General transportation requirements for RAM
Transportation and Handling	IAEA Safety Standards No. SSR-6 (Rev. 1)[10]	
	10 CFR § 71	Packaging, shipment, and transport of RAM
	10 CFR § 20.1906	Receiving and opening of RAM
	49 CFR § 172	Receiving or packaging RAM
Records	10 CFR § 30.51 10 CFR § 40.61	Receipt, inventory, acquisition, transfer, and disposal
Periodic Spot Checks	10 CFR § 35.643 ICRP Publication 97[11]	Periodic Spot Checks for Remote Afterloader Units
Training	10 CFR § 19 ICRP Publication 97	Notices, instructions, and reports by licensees and regulated entities to RAM workers
Patient Treatment	10 CFR § 35.615	AMP presence during treatment
	10 CFR § 35.604	Radiation surveys
	10 CFR § 35.610 ICRP Publication 97	Emergency Procedures

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Table of Contents

Previous Guidance Documents

It has been over 20 years since quantitative QA performance benchmark recommendations were defined by the AAPM for brachytherapy.

Table 2: Guidance documents on clinical implementation of HDR from multiple societies

Topic	Reference	Year published
General HDR QA/QC/QM programs	AAPM report 41[14]	1993
	AAPM report 46[15]	1994
	AAPM report 59[16]	1997
	AAPM report 61[17]	1998
	ASTRO/PRO special article[18]	2014
	IAEA 2D to 3D[19]	2015
	COMP/CPQR quality guidlines (Frenière)[20]	2018
	NCS (Nederlandse Commissie voor Stralingsdosimetrie) Code of Practice[21]	2018
	ACR/ABS/ASTRO practice parameter[22]	2020
	ACR/AAPM Technical Standard[23]	2020
Dosimetric Formalisms and Consensus data	AAPM and ESTRO report 229[24]	2012
Uncertainties in Brachytherapy	AAPM/GEC-ESTRO report 138[25]	2011
	GEC-ESTRO/AAPM review[26]	2014
Treatment Planning	AAPM report 62[27]	1998
	CPQR Quality Guidelines (Villarreal-Barajas)	2018
Model Based Dose Calculation	AAPM report 186[29]	2012
Surface Brachytherapy	AAPM/GEC ESTRO report 253[30]	2020
Safety and Risk Analysis Methodology	ICRP Prevention of Accidents[31]	2005
	AAPM report 283[32]	2016
	ASTRO Safety is no Accident[33]	2012 and 2019

Facility

A summary table of advantages and challenges of various facility types with optional imaging devices is shown in the Table 3 below:

Table 3: Summary of facility types for HDR treatments

Location	Advantage	Challenge	Imaging Devices
Linac or Simulator Vault	Existing shielding and space, minimization of	Storage, patient scheduling, hardware interlocks	CT CBCT kV imaging
	patient transport after imaging		ultrasound
Dedicated Suite (brachy only)	Access, storage, patient timing	Shielding cost, space limitations Patient transportation if no in-room imaging	CT Portable CT CT on rails CBCT MR kV imaging ultrasound
Operating Room	Access	Shielding, storage, multiple interlocks,	variable

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Afterloader QA

Table 4: Afterloader HDR QA with periodicity and tolerance

Periodic Test Description	Frequency	Tolerance Recommended (Required)
Source strength measurement	SE	+/- 3% (5%)
Source positioning accuracy[i]	SE, D	+/- 1 (2) mm
Source retraction with backup battery upon power failure	SE	Functional
Timer accuracy[ii]	SE, D	1 second or 1% whichever is greater
Timer linearity[iii]	PMI	1% (3%)
Electrical Interlocks at room entrance (door interlock(s))	SE, D	Functional
Emergency retraction button	SE, D	Functional
"Last Man" Out button (if present)	SE, D	Functional
Treatment interrupt button	SE, D	Functional
Source out indicators on the unit, console, and facility	SE, D	Functional
Audio/visual systems	D	Functional
Emergency response kit complete	D	Functional
Independent radiation room monitor & remote display	D	Functional
Calibrated Survey meter present	D	Functional
Console computer date and time accuracy	SE, D, Daylight time changes	+/- 1 h
Decayed source strength (or activity) in console (compared to decay chart)	SE, D	+/-1%
Catheter misconnect/channel/ turret check	D	Functional
TPS to console software communication	SE	Functional

Frequency: SE= source exchange; D=Daily (on patient treatment day) PMI=preventative maintenance inspection

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Software

Table 6: TPS Imaging and Tool Validation tests

Test Description	Tolerance Recommended (Required)	Required
Image Transfer and Reconstruction	Pass/Fail	✓
Patient Orientation	Pass/Fail	✓
Labelling	Pass/Fail	✓
Geometric Accuracy	Modality dependent (see text)	✓
Image Registration	Modality dependent (see text)	
Contouring	Functional	
Source, Point, and Line Delineation	1mm (2mm)	
External Device Interfaces (e.g. steppers)	Functional	

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TPS Source Validation

Table 7: TPS source validation and dose calculation tests

Test Description	Frequency	Tolerance Recommended (Required)	Required Test
Source Model Data	C, A*	Exact	✓
Source Decay (if possible)	C, SE	1%	✓
Plan Normalization/Weighting/Scaling	C	Functional	✓
Dose Calculation Grid	C	Functional	
Point Dose Calculation (single source)	C, A*	2% (3%)	✓
Point Dose Calculation (multi source)	C	3% (5%)	
Dose Display (absolute and relative)	C	Functional	
DVH Calculation	C	Functional	✓

Frequency: C=commissioning, A= Annual; SE= Source Exchange. * = perform either test.

Misc. TPS Commissioning Tests

Table 8: Various TPS commissioning tests

Treatment Planning Test Description	Test Specifics	Tolerance Recommended (Required)	Required Test
Optimization Validation	Manual dwell time/weight	Functional	
	Dose shaper/graphical optimization	Functional	
	Geometric optimization	Functional	
	Inverse planning	Functional	
TPS Output Validation	Printer or pdf function	Functional	
	Data transfer integrity	Functional	✓
Applicators and Catheters	Solid applicator geometry	+/- 1 mm (2mm)	✓
	Source position	+/-2mm (3mm) Depends on applicator and modality	✓
	Shielding	Functional	
Independent Calculation†	Dose calculation	Functional	
End to End Validation	End to end testing	Functional	✓

†optional test.

MPPG 15.a

AAPM Medical Physics Practice Guideline 15.a: Peer Review in Clinical Physics

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This MPPG has not been approved by EXCOM, is under AAPM membership review so recommendations can not be shared yet.

Prior Related Reports

- Halvorsen PH, Das IJ, Fraser M, et al. AAPM **Task Group 103** report on peer review in clinical radiation oncology physics. *J Appl Clin Med Phys* 2005;6(4):50-54.
- Skourou C, Sherouse GW, Bahar N, et al. Code of Ethics for the American Association of Physicists in Medicine (Revised): Report of **Task Group 109**. *Med Phys* 2019;46(4):e79-e93.
- American College of Radiology. https://www.acr.org/Practice-Management-Quality-Informatics/Peer-Learning-Resources.

Scope

1. Though therapeutic medical physics has a deeper history of peer review than does diagnostic medical physics, peer review can be of great benefit to all aspects of clinical medical physics.

2. It will cover the process of conducting a peer review, from the initial contact to the final report. Specific applications for both therapy and diagnostic physicists will be presented.

3. The document was developed with external peer reviewers as the primary focus.

Motivation

1. Approximately 14% of medical physicists work solo (according to the 2019 AAPM Professional Survey Report). Working alone, it is easy to become blinded to deficiencies in one's own work product.

2. Standards of practice evolve.

3. Peer review is one approach to meeting Part IV: Assessment of Performance in Practice for the Maintenance of Certification (MOC) program for the American Board of Radiology (ABR), and this applies to both therapy and diagnostic medical physics.

Motivation

1. The focus is on **practice improvement**, helping the incumbent to be more effective in their role.

2. Peer review should comprise not only a review of professional practice, but should also be a critical assessment of the practice setting: Is there sufficient institutional support? Are appropriate tools and resources available? Is the workload appropriate for thoughtful and thorough work?

3. Is there a "Just Culture" in which errors and near-miss events are evaluated in a deliberately nonpunitive framework, avoiding a culture of blame and responsibility and focusing instead on error prevention and fostering a culture of continuous quality improvement.

Type of Recommendations

1. The primary focus of these recommendations is to ensure that the peer review is constructive for the incumbent physicist and disconnected from unrelated matters such as personnel decisions (eg, annual performance evaluations).

2. We provide recommendations for the frequency of review, the initiation of the review process, criteria for reviewer selection, the conduct of the peer review, reporting the findings of the review, and follow up.

Peer Review Process

1. Frequency of the review
2. Initiation of the review
3. Reviewer compensation
4. Selection of reviewer including relationship to incumbent, qualifications, and approach
5. Preparation for the review-Administrators and staff should contribute to an environment where peer review is supportive and considered a part of routine good practice. The incumbent should be afforded appropriate time to prepare for the review, and the day of the on-site review should be considered a professional development day without other scheduled tasks.
6. Topics to cover during the review, QA documentation, physicist skills, program safety culture, incumbent supervision skills, professionalism, career development.
7. Assessment methodology
8. Oral exit summary
9. Written report including recommendations
10. Follow-up

Supplemental Templates Provided

1. Sample letter to the Medical Director explaining the high level results of the review
2. Sample letter to the Incumbent explaining the detailed results of the review
3. Sample Site data form
4. Sample Facility Resources Overview form including clinical services, Equipment and Instrumentation, and Program checklist
5. Chart review checklist for a selection of charts
6. Programmatic questions

These are presented in a few variations with different findings, ie. only minor recommendations, vs major recommendations. Including recommendations for focused remedial attention.

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Questions?