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MPPG 8

LINAC QA From Paper to Practice

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No disclosures

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How did we get here?

AAPM Report No. 13 (1984)

- AAPMs first crack at "Comprehensive quality assurance program"
- 5% dose benchmark

Task Group 40 (1994)

- Specifically supersedes Report No. 13
- ~40 pages; attempts to cover all aspects of radiation oncology
- Not completely superseded by other, newer documents (!)

Task Group 142 (2009)

- Update to TG-40 Table II (technological advances, IMRT, SRS, SBRT)
- Does not supersede the rest of TG-40

MPPG 2, 5, 8 & 9 / TG-100 (2014 – present)

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Why MPPG 8/What's wrong with TG-142?

Anecdotes/Opinions

- Not accessible to the solo/community/rural/??? Physicist
- Made by academics for academics
- Tolerances too tight
- Too many unnecessary tests
- Need too much new equipment
- I heard other physicists complaining about it

The recommendations of this task group are not intended to be used as regulations. These recommendations are guidelines for QMPs to use and appropriately interpret for their individual institution and clinical setting. Each institution may have site-specific or state mandated needs and requirements which may modify their usage of these recommendations.

Reality

- Almost 10 years since TG-142
- Despite disclaimer, is being used as regulation/policy/accreditation
- Did not cover VMAT
- Some tests somewhat ambiguous
- Physicists want a "safety blanket" that definitively defines the critical minimum

MOST IMPORTANT:

■ Fills gap between TG-40 and TG-100

Klein, E, "The Aftermath of TG-142," *Presented at AAPM Annual meeting 2015*

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What is MPPG 8?

- A list of critical performance tests
  - Gives basic reason for each test
  - Basic actions upon failure
  - General description of type of equipment
- Tests (mostly) based off of FMEA (TG-100)
  - Committee members/colleagues scored >> 25 physicists
  - Limited rearranging of test priority do to clinical experience
  - Dramatic departure from previous "expert consensus" approach
- Practical! (getting into personal opinion…)
  - Tests/frequency based on clinical impact of failures
  - "Generic" TG-100 test list
    - TG-100 will take a while to adopt
    - May not be realistic for some clinics

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What is MPPG 8 Not?

- NOT a replacement for TG-142 (but)
  - Different methodology
  - Alternative perspective on what baseline is
- (Still) NOT a cookbook of what tests to perform
  - Does form a more explicit list of critical tests
  - More practical, data driven approach to QA (my opinion)
  - Does go into more detail about each test
- NOT a substitution for performing own analysis
  - Critical tests provide a starting point for all clinics
  - "Safety blanket" for local TG-100 analysis

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XXXXXXX	More stringent tolerance and/or frequency
XXXXXXX	Added test
XXXXXXX	Relaxed tolerance/frequency
	Not included
XXXXXXX	Clarified/expanded existing test to "replace" older test
~~XXXXXXX~~	"replaced" by above
XXXXXXX	Minor expansion/clarification of existing tests

	TG-142		MPPG 8	
Dosimetry Tests	Frequency	Tolerance	Frequency	Tolerance
X-ray output constancy	Daily	3%	Daily	3%
	Monthly	2%	Monthly	2%
	Annual	1%	Annual	1%
Electron Output Constancy	Weekly	3%	Daily	3% (used)
	Monthly	2%	Monthly	2%
	Annual	1%	Annual	1%
Photon profile constancy			Daily	2% (beams used)
	Monthly	1%	Monthly	2%
			Annual	**2% TPS OAFs**
~~**Photon Flatness**~~	~~Annual~~	~~1%~~		
~~**Photon Symmetry**~~	~~Annual~~	~~±1%~~		
Electron beam profile constancy			Daily	2% (beams used)
	Monthly	1%	Monthly	2%
			Annual	**2% TPS OAFs**
~~**Electron flatness**~~	~~Annual~~	~~1%~~		
~~**Electron symmetry**~~	~~Annual~~	~~±1%~~		
Backup chamber constancy	Monthly	2%		
FS output factors	Annual	1%/2% (< 4x4)		
Electron cone factors	Annual	±2%		
Electron beam energy constancy	Monthly	2%/2mm	Monthly	*2 mm*
Photon beam energy constancy			Monthly	1%
Photon beam quality	Annual	±1%	Annual	1%
Electron beam quality	Annual	±1mm	Annual	2 mm
Physical Wedge factors	Annual	±2%		
Photon MU linearity	Annual	±5%(<5 MU)/±2%	Annual	*2%>10 MU/segmented*
Electron MU linearity	Annual	±2%	Annual	2%
Photon constancy vs. dose rate	Monthly	±2% (clinical)		
	Annual	±2% (all)	Annual	2%
Photon constancy vs. gantry angle	Annual	±1%	Annual	2%
Electron constancy vs. gantry angle	Annual	±1%	Annual	2%
Photon & electron OAF vs. gantry angle	Annual	±1%	Annual	2%
Arc Mode MU/deg	Annual	±1%	Annual	2%/ 2 deg
TBI/TSET mode	Annual	Functional	****	****
PDD/TMR and OAF constancy	Annual	1%/1mm	Annual	same as reg.
TBI/TSET output	Annual	2%	Annual	Same as reg.
TBI/TSET accessories	Annual	2%		
Dynamic Delivery			Monthly	3% of open field
Leaf position accuracy			Monthly	1 mm
		****	Assumes functional if other tests performed	

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XXXXXXX	More stringent tolerance and/or frequency
XXXXXXX	Added test
XXXXXXX	Relaxed tolerance/frequency
	Not included
XXXXXXX	Clarified/expanded existing test to "replace" older test
~~XXXXXXX~~	"replaced" by above
XXXXXXX	Minor expansion/clarification of existing tests

	TG-142		MPPG 8	
Mechanical	Frequency	Tolerance	Frequency	Tolerance
Lasers	Daily	1.5mm	Daily	*2 mm*
	Monthly	±1mm	Monthly	1 mm
ODI	Daily	2mm @ iso	Daily	2 mm @ iso
			Monthly	2 mm
Jaw position/jaw			**Daily**	**2 mm/jaw single field**
			Monthly	**2 mm/jaw clinical range**
~~**Jaw position sym**~~	~~Monthly~~	~~2mm~~		
~~**Jaw position asym**~~	~~Monthly~~	~~1mm/1%~~		
Light/rad per jaw			**After service**	**2 mm per jaw**
~~**Light/rad coincidence**~~	~~Monthly~~	~~2mm/1%~~		
~~**light/rad assym**~~	~~Monthly~~	~~1mm/1%~~		
Gantry/coll. Indicators	Monthly	1 deg	Monthly	1 deg
Acc. Tray/graticule	Monthly	2mm	Monthly	2 mm
X-hair walkout	Monthly	1 mm	Monthly	1 mm
Couch position	Monthly	2 mm/1 deg	Monthly	***2mm/ 1 deg; 1 mm over 10 cm, 0.5 deg over 3 deg***
~~**Table travel max range**~~	~~Annual~~	~~±2 mm~~		
Table sag	Annual	2 mm		
Latching	Monthly	Functional	Annual	Functional
Individual iso rotation	Annual	±1 mm	Annual	*2 mm d (acceptable)*
Winston-Lutz			**Annual**	**2 mm d (preferred)**
~~**Rad/mechanical iso**~~	~~Annual~~	~~±2 mm~~		

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~~XXXXXXX~~	"replaced" by above
XXXXXXX	Minor expansion/clarification of existing tests

	TG-142		MPPG 8	
Safety	Frequency	Tolerance	Frequency	Tolerance
Door interlock	Daily	Functional	Daily	Functional
Door closing	Daily	Functional	After service	Functional
Audiovisual	Daily	Functional	Daily	Functional
Stereotactic lockouts	Daily	Functional	Daily	Functional (used)
			Annual	Functional (all)
Radiation area monitor	Daily	Functional		
Beam on indicator	Daily	Functional	Daily	*Functional (console; door)*
			Annual	Functional (all)
Anti-collision test			**Daily**	**Functional (single point)**
			Monthly	**Functional (all)**
~~**Laser Guard**~~	~~Monthly~~	~~Functional~~		
Safety procedures			**QMP**	**Functional**
~~**Manufacterer's tests**~~	~~Annual~~	~~Functional~~		

	TG-142		MPPG 8	
Wedges	Frequency	Tolerance	Frequency	Tolerance
Hard Wedge placement	Monthly	2 mm	Monthly	1 mm
EDW check-run	Daily	Functional	Daily	Functional acceptable
				3% preferred
WF all energies	Monthly	2% for 45 or 60	Monthly	*2% for steepest wedge if not measured daily*
60 deg OCR scan (spot check other angles/fs)	Annual	2% @ 80% field @ 10 cm	Annual	*2% of TPS OAFs*
WF all angles			Annual	2% of TPS

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MPPG 8 Implementation

1. Decide what and when tests are critical for your clinic
   - (Recommend) include all of MPPG 8
   - Increase frequency, as necessary
   - TG-142 tests that were dropped
   - Other tests?

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Tests Modified at SFH:

- Dose rate constancy >>> Monthly

Tests Added at SFH:

- FS dependent output factors
- Electron cone factors
- DLG/leaf-leakage semi-annual*

Table 2 Dosimetry Tests.

Item	Test	Frequency	Tolerance
D1	Photon and electron output constancy	Daily[a]	3% of baseline
		Monthly	2% of baseline
		Annual	1% of TG51
D2	Photon and electron beam profile constancy	Daily[a]	2%
		Monthly	2%
		Annual	2% of TPS OAFs[b]
D3	Electron beam energy	Monthly	2 mm
		Annual	2 mm
D4	Photon beam energy	Monthly	1% of POD/TPR (relative change in value)
		Annual	1% of PDD/TPR at reference depth
D5	Dynamic delivery control	Monthly	3% of open field dose
D6	Photon MU linearity (output constancy)	Annual	2% >10 MU for open field; 2% for segmented field
D7	Electron MU linearity (output constancy)	Annual	2% for clinical range
D8	Photon output vs dose rate	Annual	2%
D9	Photon and electron output vs gantry angle	Annual	2% of IEC gantry 0° output
D10	Photon and electron OAF vs gantry angle	Annual	2% of OAFs at IEC gantry 0°
D11	Arc mode (expected MU, degree)	Annual	2% of MU and 2°
D12	Special procedure mode (TBI/TSET)	Annual	Output: same as regular beam; energy: same as regular beam; profile: same as regular beam

[a]Daily checks should be conducted for the energies used that day.
[b]Tolerance is the same as what was acceptable for TPS model evaluation at the time of commissioning.

Table 3 Mechanical tests.

Item	Test	Frequency	Tolerance
M1	Localizing lasers	Daily	2 mm
		Monthly	1 mm
M2	Optical distance indicator	Daily	2 mm at isocenter
		Monthly	2 mm over clinical range
M3	Jaw position indicators	Daily	2 mm per jaw for single field
		Monthly	2 mm per jaw for clinical range of motion
M4	Light to radiation field coincidence	After Service	2 mm per jaw
M5	Leaf position accuracy	Monthly	1 mm
M6	Gantry/collimator angle indicators	Monthly	1°
M7	Physical graticule (port film graticule)	Monthly	2 mm
M8	Cross-hair centering	Monthly	1 mm
M9	Treatment couch positions (absolute and relative)	Monthly	Abs: 2 mm and 1°; Rel: 1 mm over 10 cm and 0.5° over 3°
M10	Radiation isocentricity (MLC/jaw radiation isocenter with collimator, gantry and couch rotation)	Annual	2 mm diameter[a]
M11	Electron applicator collimator settings/physical inspection/interlocks	Annual	Same as acceptance/TPS
M12	Stereotactic accessories, lockouts, cone coding	Daily	Functional
		Annual	Functional
M13	Accessory latches/interface (all slots)	Annual	Functional

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Tests Modified at SFH:

- Alternate WFs measured monthly

Table 4 Safety tests.

Item	Test	Frequency	Tolerance
S1	Door interlock	Daily	Functional
S2	Door closing safety	After service	Functional
S3	Audio/visual monitors	Daily	Functional
S4	Beam-on indicator	Daily	Functional
		Annual	Functional (all indicators)
S5	Anti-collision test	Daily	Functional (single point for system function)
		Monthly	Functional (all collision interlocks)
S6	Safety procedures	Determined by QMP	Functional

Table 5 Wedge tests.

Item	Test	Frequency	Tolerance
W1	Electronic wedge check	Daily	Internal: functional; collimator shaped wedges: 3%
		Monthly	2%
W2	Physical wedge placement accuracy	Monthly	1 mm
W3	Wedge profile for 60 degree electronic wedges, all energies	Annual	2% of TPS OAFs
W4	Wedge dose for collimator shaped wedges, all angles	Annual	2% of TPS dose

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TABLE 6 Comprehensive review of machine settings.

Item	Test	Frequency	Tolerance
C1	Comprehensive review of machine settings	Annual	Same as acceptance/expected

Tests Modified at SFH:

- DLG
  - Measured at least annually
  - Can change, especially after MLC service (PMI)
- Interleaf Leakage
  - Measured at least annually
  - Can change from MLC wear, over-greasing or multiple leaf replacement

Note on Table 6:

- Review of Machine configuration settings
  - leaf offset (Elekta)
  - DLG (Varian)
  - Leaf leakage/transmission
- Review of Clinical Treatment Parameters
  - Collimator settings for electron cones
  - Default dose rates

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MPPG 8 Implementation

1. Decide what and when tests are critical for your clinic
2. Decide what equipment you have (need) to perform the tests
   - Most equipment you should already have
   - MPPG 8 flexible
   - 10,000 foot or better guidance on ways to perform tests

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TABLE 2 Dosimetry Tests.

Item	Test	Frequency	Tolerance
D1	Photon and electron output constancy	Daily[a]	3% of baseline
		Monthly	2% of baseline
		Annual	1% of TG51
D2	Photon and electron beam profile constancy	Daily[a]	2%
		Monthly	2%
		Annual	2% of TPS OAFs[b]
D3	Electron beam energy	Monthly	2 mm
		Annual	2 mm
D4	Photon beam energy	Monthly	1% of PDD/TPR (relative change in value)
		Annual	1% of PDD/TPR at reference depth
D5	Dynamic delivery control	Monthly	3% of open field dose
D6	Photon MU linearity (output constancy)	Annual	2% >10 MU for open field; 2% for segmented field
D7	Electron MU linearity (output constancy)	Annual	2% for clinical range
D8	Photon output vs dose rate	Annual	2%
D9	Photon and electron output vs gantry angle	Annual	2% of IEC gantry 0° output
D10	Photon and electron OAF vs gantry angle	Annual	2% of OAFs at IEC gantry 0°
D11	Arc mode (expected MU, degree)	Annual	2% of MU and 2°
D12	Special procedure mode (TBI/TSET)	Annual	Output: same as regular beam; energy: same as regular beam; profile: same as regular beam

[a]Daily checks should be conducted for the energies used that day.
[b]Tolerance is the same as what was acceptable for TPS model evaluation at the time of commissioning.

Ionization chamber Water Tank Solid Water

Ionization chamber Water Tank Solid Water — Daily QA device

Ionization chamber Water Tank — Daily QA device *Solid Water*

Flexible — EPID

Ionization chamber Water Tank

Ionization chamber Water Tank

Ionization chamber Solid Water — Gantry mount

Ionization chamber Solid Water — Array Gantry mount

Minimum Equipment

- Calibrated Ionization Chamber
- 2D Water Tank
- Solid Water

Recommended Equipment

- Calibrated Ionization Chamber
- 3D Water Tank
- Solid Water
- Morning QA array
- EPID
- Diode/ion chamber array
- Gantry mount

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TABLE 3 Mechanical tests.

Item	Test	Frequency	Tolerance
M1	Localizing lasers	Daily	2 mm
		Monthly	1 mm
M2	Optical distance indicator	Daily	2 mm at isocenter
		Monthly	2 mm over clinical range
M3	Jaw position indicators	Daily	2 mm per jaw for single field
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M4	Light to radiation field coincidence	After Service	2 mm per jaw
M5	Leaf position accuracy	Monthly	1 mm
M6	Gantry/collimator angle indicators	Monthly	1°
M7	Physical graticule (port film graticule)	Monthly	2 mm
M8	Cross-hair centering	Monthly	1 mm
M9	Treatment couch positions (absolute and relative)	Monthly	Abs: 2 mm and 1°; Rel: 1 mm over 10 cm and 0.5° over 3°
M10	Radiation isocentricity (MLC/jaw radiation isocenter with collimator, gantry and couch rotation)	Annual	2 mm diameter[a]
M11	Electron applicator collimator settings/physical inspection/interlocks	Annual	Same as acceptance/TPS
M12	Stereotactic accessories, lockouts, cone coding	Daily	Functional
		Annual	Functional
M13	Accessory latches/interface (all slots)	Annual	Functional

[a]For SRS-SBRT applications, refer to the relevant AAPM Medical Physics Practice Guideline.

Mech. Front pointer — Jig/Daily QA array

Mech. Front pointer

Graph paper/ruler

Film — Daily QA array

Film — EPID

Level Graph paper/protractor

Eyes

Graph paper

Graph paper/ruler

Film Solid Water — Winston-Lutz phantom EPID

Minimum Equipment

- Graph paper
- Film
- Level
- Ruler
- Solid Water

Recommended Equipment

- Graph Paper
- Level
- Ruler
- Morning QA array
- EPID
- Winston-Lutz phantom/software

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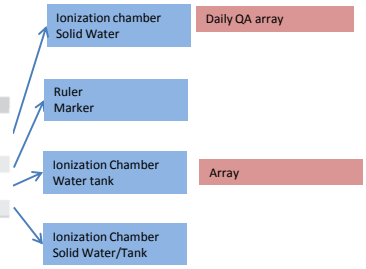
Table 5 Wedge tests.

Item	Test	Frequency	Tolerance
W1	Electronic wedge check	Daily	Internal: functional: collimator shaped wedges: 3%
		Monthly	2%
W2	Physical wedge placement accuracy	Monthly	1 mm
W3	Wedge profile for 60 degree electronic wedges, all energies	Annual	2% of TPS OAFs
W4	Wedge dose for collimator shaped wedges, all angles	Annual	2% of TPS dose



Minimum Equipment

- Ionization Chamber
- Ruler
- 2D Water Tank

***Recommended* Equipment**

- Ionization Chamber
- Ruler
- Daily QA array
- Solid Water
- Ion Chamber/Diode array

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Minimum Equipment

- Calibrated Ionization Chamber
- 2D Water Tank
- Solid Water
- Graph paper
- Film
- Level
- Ruler

***Recommended* Equipment**

- Calibrated Ionization Chamber
- 3D Water Tank
- Solid Water
- Daily QA array
- EPID
- Diode/ion chamber array
- Gantry mount
- Graph Paper
- Level
- Ruler
- Winston-Lutz phantom
- ***Software***

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MPPG 8 Implementation

1. Decide what and when tests are critical for your clinic
2. Decide what equipment you have (need) to perform the tests
3. After assessing equipment, evaluate what tests you *should* perform that is practical with said equipment or any other available equipment
   - What additional (useful) tests can be performed efficiently with my equipment?
   - Cost/benefit

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Examples of additional tests run at SFH:

Daily QA array

- Daily electron energy
- Daily light/rad (rough)

TG-142 software/EPID/Trajectory Files

- Field size/energy
- Picket fence at cardinal angles
- MLC position
- MLC leaf speed

Ion chamber/diode array

- Multiple wedge profiles
- Spot-check open profiles

EPID/portal dosimetry

- Extra MLC checks

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MPPG 8 Implementation

1. Decide what and when tests are critical for your clinic
2. Decide what equipment you have (need) to perform the tests
3. After assessing equipment, evaluate what tests you *should* perform that is practical with said equipment or any other available equipment
4. Reassess all tests and tolerances at _____ interval

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MPPG 8 Implementation Obstacles

- Equipment
  - Typical clinic QA equipment required
  - But: Not efficient
  - The old "I have the minimum equipment needed, but…."
- Rethinking traditional QA
  - "Why have we always done xxxx?"
  - "OMG. MPPG doesn't even include yyyy."
- Deciding what is "Good enough" for your clinic
  - Do I need to add anything?
  - "I can't do a full FMEA analysis!"

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MPPG 8 Implementation Time

Critical Tests Assessment:	2-4 Hours (no FMEA)
Equipment Assessment:	2 Hours
Additional Test Assessment:	Few hours – Few days
Critical Test Implementation:	<Previous QA
Additional Test Implementation:	Some Days
Reassessment:	Ongoing

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Is it worth it?

YES!!

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Why is it "worth it"?

- Fundamentally changes the way we think about QA (in a practical way)
  - "Every-clinic" TG-100 analysis
  - Forces us to ask why we are performing a test
- Gives the closest thing to the "minimum required" list that physicists want
- Eliminates much "over-QAing
  - QA is quicker without feeling like I'm losing information
- Clarifies and streamlines previous tests
- Test guidance is more in depth and clear than previous documents
  - Even clarified a few tests I've done for years
- Practical approach "makes sense" to me

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