The Aftermath of TG-142

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AAPM Task Group 40 Report "Comprehensive QA for Radiation Oncology"

Med. Phys. 21(4) 1994

- **Performance-based, comprehensive guidelines for preventing correctable systematic errors**
- **Scope:**
  - **Guidelines for administrators**
  - **Cobalt-60 Teletherapy Units**
  - **Brachytherapy**
  - **Conventional Simulators**
  - **CT Scanners**
  - **Measurement Equipment for Dosimetry**
  - **Treatment Planning Computer Systems**
  - **External Beam Treatment Planning Process**
  - **External Beam QA for Individual Patients**
  - **QA of Clinical Aspects**
  - **QA of Medical Electron Accelerators** → **Now TG-142**

In reference to TG-40, TG-142 is a _____.

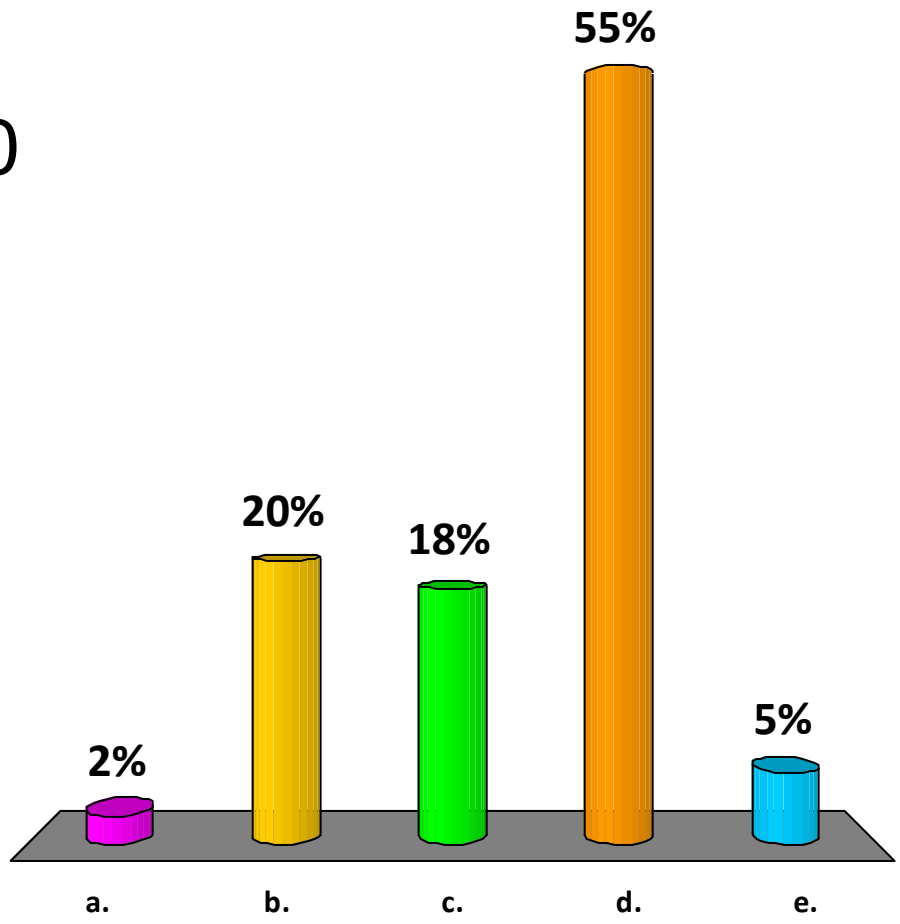
a. outright replacement of TG-40

b. augmentation of TG-40

c. update of TG-40

d. update and augmentation of Table II in TG-40

e. none of the above



- 6. In reference to TG-40, TG-142 is a _____.
- (a) outright replacement of TG-40
- (b) augmentation of TG-40
- (c) update of TG-40
- (d) update and augmentation of Table II in TG-40
- (e) none of the above
-
- Answer: d
-
- Ref: "**Klein EE** et al, AAPM TG-142: Linear Accelerator Quality Assurance, Medical Physics, 36, 4197-4212. August, 2009

Task Group No. 100:

Method for Evaluating QA Needs in Radiation Therapy

- Initially “Replacement for TG-40”
- Radical departure from previous AAPM recommendations and philosophy
- Based on “Failure Modes and Effects Analysis”
- Individual departments responsible for development of unique QA programs
- Based on procedures and resources performed at individual institutions

TG-142: "QA of Medical Accelerators"

Med. Phys. 36(9) 2009

- Fills gap between TG-40 and TG-100
- Gives performance-based recommendations, but incorporates process-oriented concepts and advancements in linacs since 1994

- Scope: (replaces Table II of TG-40)
  - Linac QA: acceptance testing, commissioning, CQI
  - Ancillary treatment devices
    - Asymmetric jaws
    - Dynamic/virtual/universal wedge
    - MLC
    - TBI/TSET
    - Radiographic imaging
    - Respiratory gating

Task Group 142: Philosophy

- The types of treatments delivered with the machine should also have a role in determining the QA program that is appropriate for that treatment machine.
- For example, machines that are used for SRS/SBRT treatments, TBI or IMRT require different tests and/or tolerances.

TG-142 was never intended to be used by Regulators as law

- ***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.***

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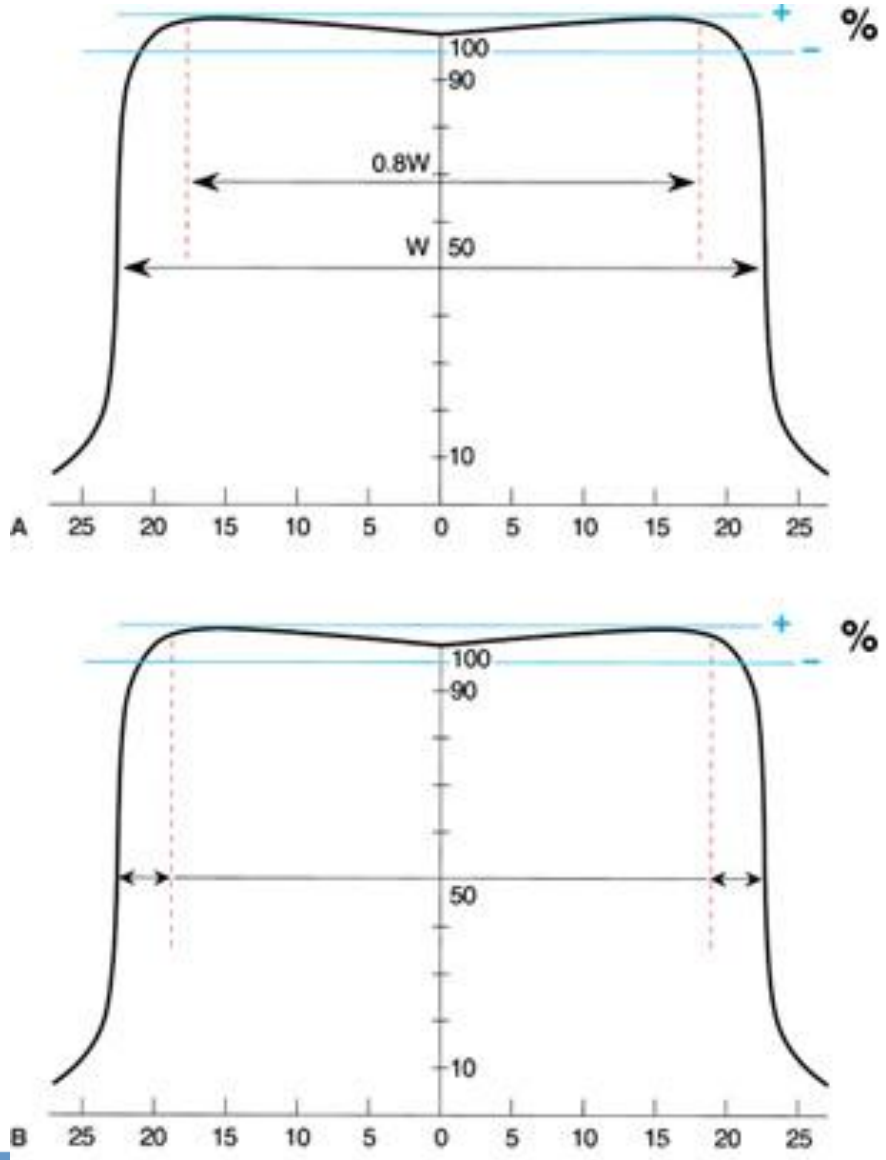
- **But they, the Regulators, did anyway……**

TG-142 vs. TG-40

- TG-40 tests beam flatness/symmetry
  - A +/-3% drift in symmetry, while within TG-40 tolerance, means a 6% change in beam profile
  - New development: beams without flattening filters

- TG-142 recommends:
  - Beam profile measured with a QA device or portal imager
  - Several off-axis locations evaluated
  - Average of multiple points should be within tolerance values

Task Group 142: General



A *Consistent beam profile* is an important quantity for accurate and reproducible dose delivery in radiotherapy.

Task Group 142: General

Chosen O.A. points within core of the field

$$\frac{1}{N}\cdot\sum_{L=1}^{N}\left|\frac{TP_L - BP_L}{BP_L}\right|\cdot 100\% \le Tolerance\ \%$$

- **where: TP_L and BP_L are off-axis ratios at Test and Baseline Points, respectively, at off axis Point L**
- **N is the number of off-axis points**
- **$TP_L = (MP_L/MP_C)$ where *M* represents the measured value, and *C* is the central axis measurement.**
- **Similarly, the baseline points are represented by $BP_L = (MBP_L/MBP_C)$**

TG-142 vs. TG-40

Monthly		
	TG-40	TG-142 changes
Dosimetry		
x-ray central axis dosimetry parameter (PDD, TAR) constancy	2%	Removed
Electron central axis dosimetry parameter constancy (PDD)	2mm	2%/2mm
x-ray beam flatness constancy	2%	***Replaced with 1% constancy of profile***
Electron beam flatness constancy	3%	
x -ray and electron symmetry	3%	
Interlock Checks		
Emergency Off	Functional	Removed
Wedge, "cone"	Functional	
Mechanical		
Light/radiation field coincidence	2 mm or 1%/side	***Only if clinical setups performed***
Field size indicators	2mm	1mm/side
Cross-hair centering	2mm	1mm
Treatment couch position indicators	2 mm/1 deg	Tighter for SRS/SBRT

In regards to beam profiles, TG-142 recommends the following criteria for monthly reviews

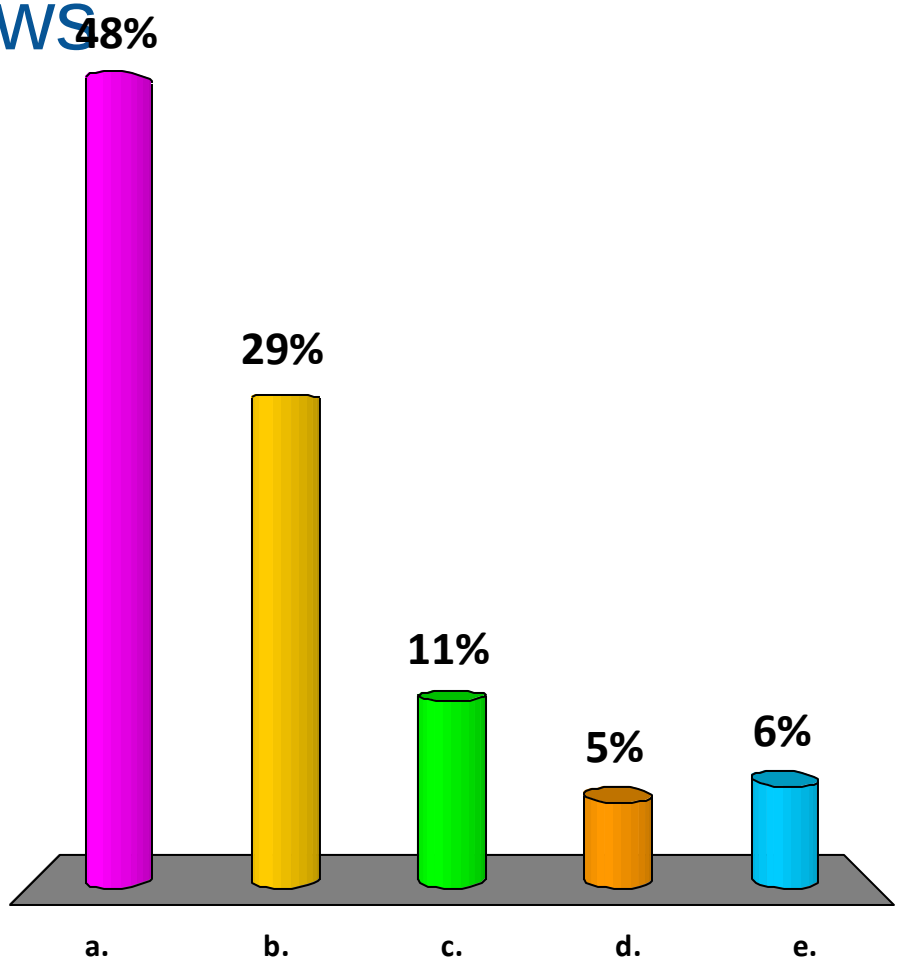
a. Consistent with commissioning profiles to within 1%

b. Consistent with commissioning profiles to within 2%

c. Symmetry of +,- 2%
   Flatness of +,-3%

d. Symmetry of +,- 3%
   Flatness of +,-2%

e. Symmetry of +,- 1%
   Flatness of +,-1%



- 1. In regards to beam profiles, TG-142 recommends the following criteria for monthly reviews:
- (a) Consistent with commissioning profiles to within 1%
- (b) Consistent with commissioning profiles to within 2%
- (c) Symmetry of +,- 2% Flatness of +,-3%
- (d) Symmetry of +,- 3% Flatness of +,-2%
- (e) Symmetry of +,- 1% Flatness of +,-1%

- Answer: a
- Ref: "**Klein EE** et al, AAPM TG-142: Linear Accelerator Quality Assurance, Medical Physics, 36, 4197-4212. August, 2009

Annual

***If PDD_{10}, measured during TG51 calibration deviates >1%, discretion to measure more PDD points**

Procedure	Machine Type Tolerance		
	non-IMRT	IMRT	SRS/SBRT
Dosimetry			
X-ray flatness change from baseline	1%		
X-ray symmetry change from baseline	±1%		
Electron flatness change from baseline	1%		
Electron symmetry change from baseline	±1%		
SRS arc rotation mode (range: 0.5 to 10 MU/deg)	NA	NA	Monitor units set vs. delivered:1.0 MU or 2%
			Gantry arc set vs. delivered: 1.0 deg or 2%
X-ray/electron output calibration (TG-51)	±1%(absolute)		
Spot check of field size dependent output factors for X-ray (2 or more FS)	2% for field size < 4x4 cm^2, 1% ≥4x4 cm^2		
Output factors for electron applicators (spot check of 1 applicator/energy)	±2% from baseline		
X-ray beam quality (PDD_{10} or TMR_{10}^{20}) *	**±1% from baseline**		
Electron beam quality (R_{50})	±1mm		

According to TG-142, for a dual energy machine, PDD must be measured on annual basis for;

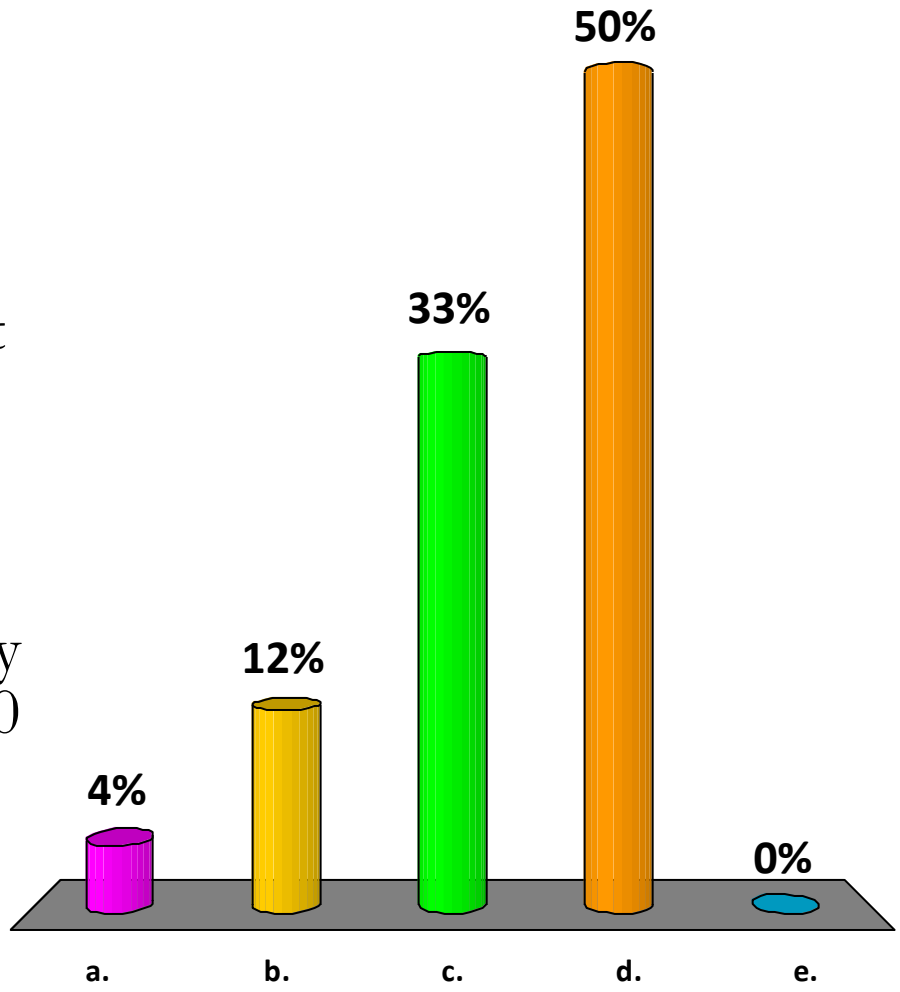
a. All energies, all field sizes in 1cm steps

b. All energies for a sampling of at least 10 different field sizes

c. All energies for a 10x10 field size

d. All energies, but is not necessary if the PDD @ 10cm for a 10x10 field size is within 1%

e. The greater energy for a 10x10 field



- 3. According to TG-142, for a dual energy machine, PDD must be measured on annual basis for;
- (a) All energies, all field sizes in 1cm steps
- (b) All energies for a sampling of at least 10 different field sizes
- (c) All energies for a 10x10 field size
- (d) All energies, but is not necessary if the PDD @ 10cm for a 10x10 field size is within 1%
- (e) The greater energy for a 10x10 field
-
- Answer: d
- Ref: "**Klein EE** et al, AAPM TG-142: Linear Accelerator Quality Assurance, Medical Physics, 36, 4197-4212. August, 2009

Imaging Tests: Daily

[1] Or at a minimum when devices are to be used during treatment day

Procedure	Application Type Tolerance	
	non-SRS/SBRT	SRS/SBRT
Daily[1]		
kV and MV (EPID) imaging		
Collision interlocks	Functional	Functional
Positioning/repositioning	≤ 2 mm	≤ 1 mm
Imaging & Treatment coordinate coincidence (single gantry angle)	≤ 2 mm	≤ 1 mm
Cone-beam CT (kV & MV)		
Collision interlocks	Functional	Functional
Imaging & treatment coordinate coincidence	≤ 2 mm	≤ 1 mm
Positioning/repositioning	≤ 1 mm	≤ 1 mm

Regarding TG-142's recommendation for coincidence of photon beam isocenter and imaging isocenter, the values for non-SRS/SBRT modalities and SRS/SBRT modalities are;

1% a. 0.5mm for either

8% b. 1.0mm for either

89% c. 2mm for non-SRS/SBRT, 1mm for SRS/SBRT

2% d. 1mm for non-SRS/SBRT, 2mm for SRS/SBRT

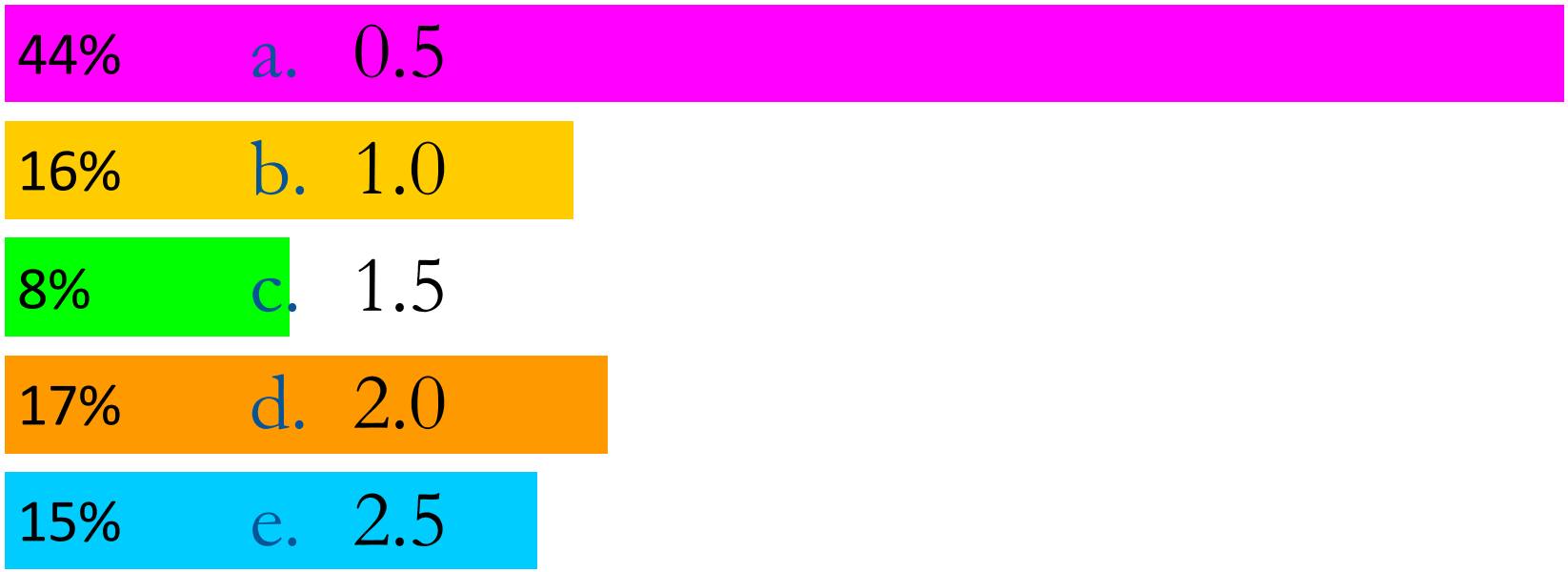
0% e. 2.0mm for either

- 2. Regarding TG-142's recommendation for coincidence of photon beam isocenter and imaging isocenter, the values for non-SRS/SBRT modalities and SRS/SBRT modalities are;
- (a) 0.5mm for either
- (b) 1.0mm for either
- (c) 2mm for non-SRS/SBRT, 1mm for SRS/SBRT
- (d) 1mm for non-SRS/SBRT, 2mm for SRS/SBRT
- (e) 2.0mm for either
-
- Answer: c
-
- Ref: "**Klein EE** et al, AAPM TG-142: Linear Accelerator Quality Assurance, Medical Physics, 36, 4197-4212. August, 2009

What is still confusing/controversial

- What is a consistent profile ?
  - Goes back to commissioning and TP validation
- Laser location accuracy of 1.5mm…measurable?
- "Error" counts for leaf travel
  - Used Varian criteria. All that was out there
- 1mm congruence of photon and imaging isocenters.
  - Thought to be unrealistic considering setup uncertainties
  - Our thoughts – you need to eliminate uncertainties to isolate

TG-142 recommends that MLC leaf motion speed be maintained within ____cm/sec



- 5. TG-142 recommends that MLC leaf motion speed be maintained within _____cm/sec
- (a) 0.5
- (b) 1.0
- (c) 1.5
- (d) 2.0
- (e) 2.5
-
- Answer: a
- Ref: "**Klein EE** et al, AAPM TG-142: Linear Accelerator Quality Assurance, Medical Physics, 36, 4197-4212. August, 2009

RPC WEBPAGE NEWSLETTER

Volume 10, Issue 2 November 2011

The RPC will, as of January 1, 2012, begin to formally evaluate an institution's QA program based on the TG-142 report guidelines and tolerances during their onsite dosimetry review visits to institutions participating in NCI funded clinical trials.

ACR-ASTRO Site Visit Survey Questionnaire

5. QUALITY ASSURANCE

Compliance with AAPM TG-40/TG142

☐ Yes ☐ NA ☐ No _____

Record of daily/monthly output constancy checks as per TG-51

☐ Yes ☐ NA ☐ No _____

Records of machine mechanical quality assurance

☐ Yes ☐ NA ☐ No _____

Evidence that the physicist participates in QA meetings and presents documentation of QA activities

☐ Yes ☐ NA ☐ No _____

Evidence of an equipment evaluation and assessment policy

☐ Yes ☐ NA ☐ No _____

Physics procedure manual or policy book

☐ Yes ☐ NA ☐ No _____

Newer technologies such as on board imaging (OBI, CBCT, and kV imagers), respiratory gating are being monitored for consistent performance

ASTRO Accreditation (APEX)

- Standard 12.1
- The ROP's comprehensive quality management program for each treatment procedure and modality:
- Is consistent with American Association of Physicists in Medicine (AAPM) or equivalent body standards of practice for:
- **External beam radiation therapy dosimetry, mechanical, safety and respiratory management checks.**

What the TG report did NOT intend to cover

- **Rapid Arc, Smart Arc, VMAT, etc.**
- **Specific Modalities being covered otherwise (Tomotherapy (TG-148), CyberKnife (TG-135), etc.**
- FMEA as TG-100 was coming out in 2006

What the TG report did NOT intend to cover

- **Rapid Arc, Smart Arc, VMAT, etc.**
- **Specific Modalities being covered otherwise (Tomotherapy (TG-148), CyberKnife (TG-135), etc.**
- FMEA as TG-100 was coming out in 2006, 2010

What the TG report did NOT intend to cover

- **Rapid Arc, Smart Arc, VMAT, etc.**
- **Specific Modalities being covered otherwise (Tomotherapy (TG-148), CyberKnife (TG-135), etc.**

- FMEA as TG-100 was coming out in 2006, 2010, 2014

What the TG report did NOT intend to cover

- **Rapid Arc, Smart Arc, VMAT, etc.**
- **Specific Modalities being covered otherwise (Tomotherapy (TG-148), CyberKnife (TG-135), etc.**

- FMEA as TG-100 was coming out in 2006, 2010, 2014, 2018 ???
- However, TG-142 – <u>if you read it</u>, strongly recommends the MP be flexible in QA frequency and tolerance depending on machine history.

What the TG report did NOT intend to cover

- Statistical Process Control
- Specific Methods and the commercial products that provide the method

TG-142 recommends _____ for daily output checks

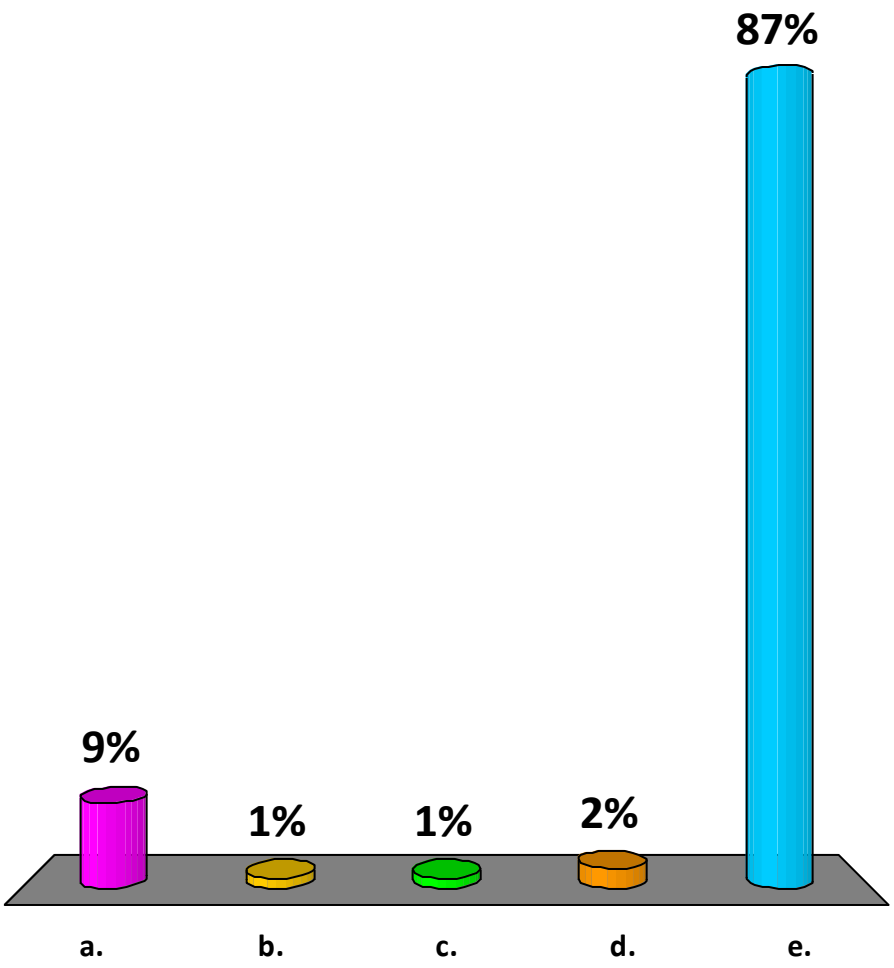
a. A multi-detector array system

b. A solid state diode

c. TLDs

d. A cylindrical ionization chamber in a water phantom

e. No specific detector



- 4. TG-142 recommends _____ for daily output checks
- (a) A multi-detector array system
- (b) A solid state diode
- (c) TLDs
- (d) A cylindrical ionization chamber in a water phantom
- (e) No specific detector
-
- Answer: e
-
- Ref: "**Klein EE** et al, AAPM TG-142: Linear Accelerator Quality Assurance, Medical Physics, 36, 4197-4212. August, 2009

What's Next ?????????

TG-198: An Implementation Guide for TG-142

TG-198: Daily QA

Procedure	Measuring Device	Time Required in minutes (range)
Dosimetry		
Photon & Electron Output Constancy	Ionization chamber, Diode/Mosfet system	10-15
Mechanical		
Laser Location	Front pointer, reference marks	2
Distance Indicator	Front pointer, jig	2
Collimator Size Indicator	Graph paper, ruler, jig	3
Safety		
Door Interlock	NA	1
Door Closing Safety	NA	1
Audiovisual Monitors	NA	1
Stereotactic interlocks	NA	1
Radiation Area Monitors	NA	1
Beam On Indicator	NA	1

TG-198: Daily Imaging QA

Procedure	Measuring Device	Time Required (range)
Daily		
Planar kV and MV (EPID) imaging		
Collision interlocks	NA	5 min.
Positioning/repositioning	phantom containing radiopaque markers.	10-15 min.
Imaging and treatment coordinate coincidence	phantom containing radiopaque markers.	Included above.
Cone-beam CT (kV & MV)		
Collision interlocks	NA	5 min.
Positioning/repositioning	phantom containing radiopaque markers.	10-15 min.
Imaging and treatment coordinate coincidence	phantom containing radiopaque markers.	Included above.

TG-198: Monthly QA

Procedure	Measuring Device	Time Required (range)
Dosimetry		
Photon and Electron Output Constancy per beam	ADCL Calibrated Ionization Chamber/Electrometer, solid phantom or water phantom	45-60 min.
Backup Monitor Chamber Constancy	ADCL Calibrated Ionization Chamber/Electrometer, solid phantom or water phantom	Included above
Typical Dose Rate Output Constancy	ADCL Calibrated Ionization Chamber/Electrometer, solid phantom or water phantom	10-15 min.
Photon and Electron Beam Profile Constancy	Array, film, portal imager	10-60 min.
Electron Beam Energy Constancy	ADCL Calibrated Ionization Chamber/Electrometer, solid phantom or water phantom	20-30 min.
Mechanical		
Light / Radiation Field Coincidence (Symmetric & Asymmetric)	Film or EPID	30 min. (Film) 15 min. (EPID)
Distance Check Device for Lasers Compared with Front Pointer		5 min.
Gantry / Collimator Angle Indicators (@ cardinal angles, digital only)	Level	5 min.
Accessory Trays (i.e. port film graticule tray)	NA	1 min.
Jaw Position Indicators (Symmetric)	Graph paper,	15 min.
Jaw Position Indicators (Asymmetric)	Graph paper,	15 min. (can be done simultaneously with Symmetric)
Cross-Hair Centering (Walkout)	Graph paper,	15 min.
Treatment Couch Position Indicators	Graph paper, ruler	15 min.
Wedge Placement Accuracy	Graph paper, ruler	15 min.
Compensator Placement Accuracy	Graph paper, ruler	15 min.
Latching of Wedges, Blocking Tray	NA	1 min.
Localizing Lasers		30 min. (if adjustment needed)

TG-198: Monthly QA

Procedure	Measuring Device	Time Required (range)
Dosimetry		
Photon and Electron Output Constancy per beam	ADCL Calibrated Ionization Chamber/Electrometer, solid phantom or water phantom ????	45-60 min. ????
Backup Monitor Chamber Constancy	ADCL Calibrated Ionization Chamber/Electrometer, solid phantom or water phantom	Included above
Typical Dose Rate Output Constancy	ADCL Calibrated Ionization Chamber/Electrometer, solid phantom or water phantom	10-15 min.
~~Photon and Electron Beam Profile Constancy~~	~~Array, film, portal imager~~	~~10-60 min.~~
~~Electron Beam Energy Constancy~~	~~ADCL Calibrated Ionization Chamber/Electrometer, solid phantom or water phantom~~	~~20-30 min.~~
Mechanical		
~~Light / Radiation Field Coincidence (Symmetric & Asymmetric)~~	~~Film or EPID~~	~~30 min. (Film)~~ ~~15 min. (EPID)~~
~~Distance Check Device for Lasers Compared with Front Pointer~~		~~5 min.~~
Gantry / Collimator Angle Indicators (@ cardinal angles, digital only)	Level	5 min.
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~~Cross Hair Centering (Walkout)~~	~~Graph paper,~~	~~15 min.~~
Treatment Couch Position Indicators	Graph paper, ruler	15 min.
~~Wedge Placement Accuracy~~	~~Graph paper, ruler~~	~~15 min.~~
~~Compensator Placement Accuracy~~	~~Graph paper, ruler~~	~~15 min.~~
~~Latching of Wedges, Blocking Tray~~	~~NA~~	~~1 min.~~
Localizing Lasers		30 min. (if adjustment needed)

TG-198: Monthly Imaging QA

Procedure	Measuring Device	Time Required (range)
Planar MV imaging (EPID)		
Imaging and treatment coordinate coincidence	phantom containing radiopaque markers.	15-20 min.
Scaling	Object of known dimensions	5 min.
Spatial resolution	Manufacturer supplied test phantom	5-10 min.
Contrast	Manufacturer supplied test phantom	5-10 min.
Uniformity and noise	Manufacturer supplied test phantom	5-10 min.
Planar kV imaging		
Imaging and treatment coordinate coincidence	phantom containing radiopaque markers.	15-20 min.
Scaling	Object of known dimensions	5 min.
Spatial resolution	Manufacturer supplied test phantom	5-10 min.
Contrast	Manufacturer supplied test phantom	5-10 min.
Uniformity and noise	Manufacturer supplied test phantom	5-10 min.
Cone-beam CT (kV & MV)		
Geometric distortion	phantom of known and dimensions	15-20 min.
Spatial resolution	Object of known dimensions	5 min.
Contrast	Manufacturer supplied test phantom	5-10 min.
HU constancy	Manufacturer supplied test phantom	5-10 min.
Uniformity and noise	Manufacturer supplied test phantom	5-10 min.

TG-198: MLC QA

Procedure	Measuring Device	Time Required (range)
Weekly		
Qualitative test - "picket fence"	Array, film, portal imager	1-2
Monthly		
Setting vs radiation field for two patterns (non-IMRT)	Film or EPID and radio-opaque markers if the light field crosshair is used as a surrogate for the radiation isocenter.	Film: 25-35 min EPID: 15-25 min
Backup diaphragm settings (Elekta only)	Film or EPID and radio-opaque markers if the light field crosshair is used as a surrogate for the radiation isocenter.	Film: 25-30 min EPID: 15-20 min
Leaf Travel speed (IMRT)	Log-file analysis software or EPID and corresponding analysis sofware	Log file method: 10-12 min EPID method: 15-20 min
Leaf position accuracy (IMRT)	Films or EPID and software analysis application	Film: 90-120 min EPID: 70-90 min