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## What is Missing in Current TG142 Guidance?

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Chair, TG-142

Professor of Radiation Oncology  
Washington University  
St. Louis, MO

**AAPM Spring Clinical Meeting  
March 09, 2015**

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## First....

## What is in report and why did we need it?

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## Establishing Guidelines

- *Ideal world: a full set of QA procedures leading to complete error elimination*
  - real-time monitoring and correction of errors
  - perfect predictions of all outcomes
- *Real world: limited resources*
  - Evaluate the entire process from consultation to end of treatment
  - Identify potential errors
  - Create a feasible plan for minimizing occurrence of error

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### The Resource Problem

- Lack of adequate guidance for resource allocation
- Lack of qualified personnel
- Rapid implementation of new technology
  - More sophisticated equipment
  - More resources
  - Clinics are under pressure to implement new technology
- Lack of timely guidelines

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### QA Methodology

- Performance-based:
  - Evaluates quality of machines and processes by a mechanical comparison of a proscribed test's results with expected results established by historical specifications and intent
  - Emphasis on rigid testing ignores the evolution of machine functionality and modes of utilization
- Process-based:
  - Evaluates the performance of the process of evaluation itself, which provides feedback for ever-evolving, ever more accurate evaluations, which in turn increases quality.

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### Prospective and Performance Analysis: More Related than One May Think

- How does one project a Process Review for a New Technology?
  - By relying on knowledge and prior related history
- Do we still need to perform QA tests for equipment that has proven itself over time
  - Yes !! There is still value for performance based testing provided we prioritize and use proper tools.

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**AAPM**

- Establishes standards of practice
- Issues guidelines and recommendations for a comprehensive list of radiation therapy processes
- Continually pursues research in order to establish relevant guidelines for emerging technologies
- Members intimately familiar with QA issues

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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**

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From: Colin Orton <mailto:ortonc@comcast.net>  
 To: Eric Klein <mailto:eklein@radonc.wustl.edu>; amolsh@MSKCC.ORG <mailto:amolsh@MSKCC.ORG>  
 Sent: Saturday, March 12, 2011 11:12 AM  
 Subject: Re: Point/Counterpoint debate

Dear Howard and Eric:

Thank you both for agreeing to debate the Proposition  
**"QA procedures in radiation therapy are hopelessly outdated and are causing an increase rather than a decrease in error rates"**  
 for the Medical Physics Point/Counterpoint series.  
 I have attached a formal letter of invitation along with the Instructions for Authors. Please note that your Opening Statements are due by May 1st.

Regards, **QA procedures in radiation therapy are outdated and negatively impact the reduction of errors**

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**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

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**Medical Electron Accelerators**

- TG-40 Concerns:
  - Output constancy
  - Beam symmetry, flatness
  - Rotation isocenter accuracy
  - Wedge and tray factors
- Recommendations:
  - A page-long table of specific component tests
  - QA procedures for emerging systems beyond the scope of TG-40 should be established by the manufacturers
- Current concerns:
  - Many new technologies since 1994:
    - MLC, IMRT, EPID, Tomotherapy, AlignRT, breathing motion management systems, asymmetric wedges, SmartArc, IGR...
  - Many ways to combine modalities
  - Many, many new ways to have errors!

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**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

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### Task Group 142: QA of Medical Accelerators

**Members**

- Chair: Eric E. Klein, Ph.D., Washington University
- Joseph Hanley, Ph.D., Hackensack Univ Medical Center
- John Bayouth, Ph.D., University of Iowa
- Fang-Fang Yin, Ph.D., Duke University
- William Simon, M.S., Sun Nuclear Corp.
- Sean Dresser, M.S., Northside Hospital
- Christopher Serago, Ph.D., Mayo Clinic, Jacksonville
- Francisco Aguirre, M.S., M.D. Anderson Cancer Center
- Lijun Ma, Ph.D., University of California, San Francisco
- Bijan Arjomandy, Ph.D., M.D. Anderson Cancer Center
- Chihray Liu, Ph.D., University of Florida
- Consultants: Carlos Sandin (Elekta), Todd Holmes (Varian Medical Systems)

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### 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.

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### BACKGROUND

- Baseline dosimetric values entered into TPS to characterize and/or model the treatment machine directly affect calculated plans
- Values can deviate from their baseline as a result of;
  - Machine malfunction
  - Mechanical breakdown
  - Physical accidents
  - Component failure
  - Major component replacement
  - Gradual changes as a result of aging
- These patterns of failure must be considered when establishing a periodic QA program

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### 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.....**

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### 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

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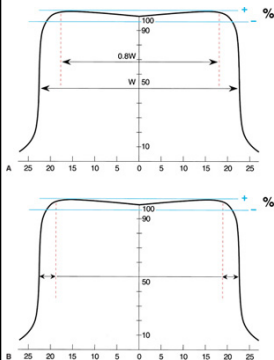
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### Task Group 142: General



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

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### Task Group 142: General

**Chosen O.A. points within core of the field**

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

- 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
- $TP_L = (MP_L/IMP_C)$  where M represents the measured value, and C is the central axis measurement.
- Similarly, the baseline points are represented by  $BP_L = (MBP_L/MBP_C)$

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### TG-142 vs. TG-40

■ Spirit and intent of TG-40 maintained but clarified:

- Action levels
  - Level 1: inspection action
    - investigate a sudden change in a usually non-varying parameter even if still within tolerance
  - Level 2: scheduled action
    - if a parameter is consistently close to failing, or failed once by a small margin, schedule an investigation within 1 or 2 days of event
  - Level 3: immediate action
    - stop treatment and investigate in cases of, e.g., safety interlock failure, or significant dosimetric error

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

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Procedure	Machine Type Tolerance		
	non-IMRT	IMRT	SRS/SBRT
<b>Annual</b> <span style="color: red;">*If PDD<sub>100</sub> measured during TG51 calibration deviates &gt;1%, discretion to measure more PDD points</span>			
<b>Dosimetry</b>			
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 <sup>2</sup> , 1% ≥4x4 cm <sup>2</sup>	
Output factors for electron applicators (spot check of 1 applicator/energy)		±2% from baseline	
<b>X-ray beam quality (PDD<sub>10</sub> or TMR<sub>10</sub><sup>20</sup>)*</b>		<b>±1% from baseline</b>	
Electron beam quality (R <sub>50</sub> )		±1mm	

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Procedure	Application Type Tolerance	
	non-SRS/SBRT	SRS/SBRT
<b>Imaging Tests: Daily</b> <span style="color: blue;">Or at a minimum when devices are to be used during treatment day</span>		
<b>Daily<sup>1)</sup></b>		
<b>kV and MV (EPID) imaging</b>		
<b>Collision interlocks</b>	<b>Functional</b>	<b>Functional</b>
<b>Positioning/repositioning</b>	<b>≤ 2 mm</b>	<b>≤ 1 mm</b>
<b>Imaging &amp; Treatment coordinate coincidence (single gantry angle)</b>	<b>≤ 2 mm</b>	<b>≤ 1 mm</b>
<b>Cone-beam CT (kV &amp; MV)</b>		
<b>Collision interlocks</b>	<b>Functional</b>	<b>Functional</b>
<b>Imaging &amp; treatment coordinate coincidence</b>	<b>≤ 2 mm</b>	<b>≤ 1 mm</b>
<b>Positioning/repositioning</b>	<b>≤ 1 mm</b>	<b>≤ 1 mm</b>

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## 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

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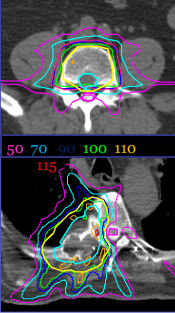
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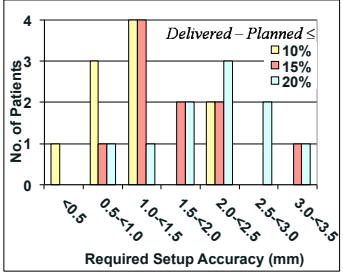
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## Why is Imaging QA Important?





Required Setup Accuracy (mm)	10%	15%	20%
<0.5	1	1	1
0.5-1.0	3	1	1
1.0-1.5	4	1	1
1.5-2.0	2	2	1
2.0-2.5	3	2	1
2.5-3.0	2	1	1
3.0-3.5	1	1	1

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## SUMMARY OF RECOMMENDATIONS/ IMPLEMENTATION SCHEME

- **QA team led by the QMP supports all QA activities & policies and procedures.**
- **The 1<sup>st</sup> step is to establish institution-specific baseline and absolute reference values.**
- **Daily QA tasks may be carried out by a RTT using a cross-calibrated dosimetry system that is robust and easy-to-setup.**
- **There is overlap of tests for daily, monthly, and annual that can achieve independence with independent measurement devices.**

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

## TG-198: An Implementation Guide for TG-142

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**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.



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**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 \_\_\_\_\_

Physicist 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

## ACR-ASTRO Site Visit Survey Questionnaire

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**5. QUALITY ASSURANCE**

Compliance with AAPM TG-40/TG147  
 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 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

**I DIDN'T SHOW THIS SLIDE**

**ACR/ASTRO Site Visit Survey Questionnaire**

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**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.**

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**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

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### 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

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### 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

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### 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 – if you read it, strongly recommends the MP be flexible in QA frequency and tolerance depending on machine history.

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### What the TG report did NOT intend to cover

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

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### What the TG report did NOT intend to cover

- Statistical Process Control
- Along with FMEA to be covered by Dr. O'Daniel
- Specific Methods and the commercial products that provide the method
- To be discussed by Dr. Heintz

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