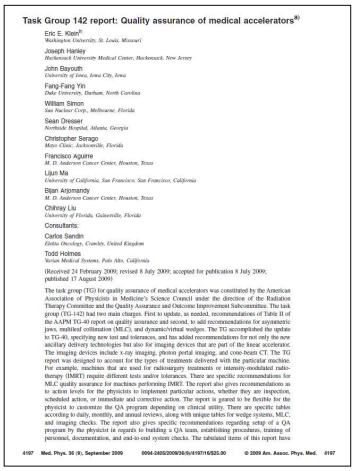
Linac Quality Assurance (*TG-142*)

TG-142: Overview

The Report

- The Task Group 142 protocol was first published in 2009
- It is used for quality assurance of "C-Arm" linear accelerators
  - *Tomotherapy and Cyberknife have separate reports*
- It is used mechanical, dosimetry, and imaging testing
- The TG 142 report (*2009*) replaces the older TG40 QA report (*1994*)



Task Group 142 report: Quality assurance of medical accelerators[a)]

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The task group (TG) for quality assurance of medical accelerators was constituted by the American Association of Physicists in Medicine's Science Council under the direction of the Radiation Therapy Committee and the Quality Assurance and Outcome Improvement Subcommittee. The task group (TG-142) had two main charges. First to update, as needed, recommendations of Table II of the AAPM TG-40 report on quality assurance and second, to add recommendations for asymmetric jaws, multileaf collimation (MLC), and dynamic/virtual wedges. The TG accomplished the update to TG-40, specifying new test and tolerances, and has added recommendations for not only the new ancillary delivery technologies but also for imaging devices that are part of the linear accelerator. The imaging devices include x-ray imaging, photon portal imaging, and cone-beam CT. The TG report was designed to account for the types of treatments delivered with the particular machine. For example, machines that are used for radiosurgery treatments or intensity-modulated radiotherapy (IMRT) require different tests and/or tolerances. There are specific recommendations for MLC quality assurance for machines performing IMRT. The report also gives recommendations as to action levels for the physicists to implement particular actions, whether they are inspection, scheduled action, or immediate and corrective action. The report is geared to be flexible for the physicist to customize the QA program depending on clinical utility. There are specific tables according to daily, monthly, and annual reviews, along with unique tables for wedge systems, MLC, and imaging checks. The report also gives specific recommendations regarding setup of a QA program by the physicist in regards to building a QA team, establishing procedures, training of personnel, documentation, and end-to-end system checks. The tabulated items of this report have

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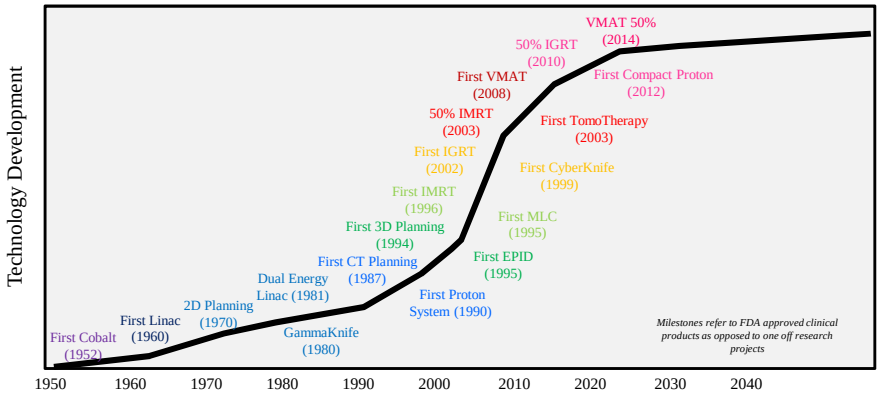
TG-142: Overview

Background

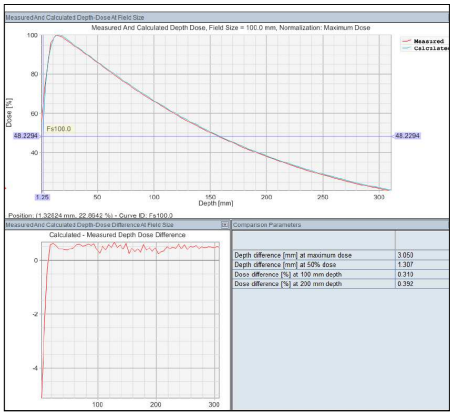
- Several new technologies were developed between 1994 and 2009 not included in TG40



TG-142: Overview

Background

- Baseline dosimetric values entered into treatment planning system 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



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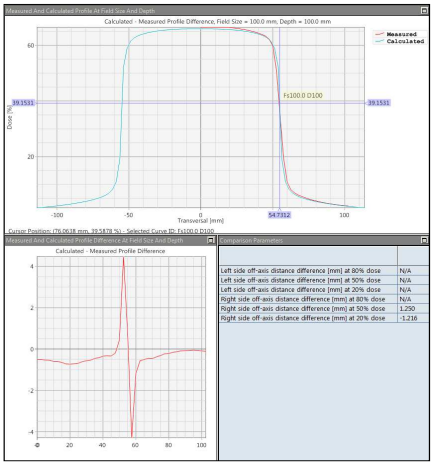

TG-142: Daily Tests

TABLE I. Daily.

Procedure	Machine-type tolerance		
	Non-IMRT	IMRT	SRS/SBRT
Dosimetry			
X-ray output constancy (all energies) Electron output constancy (weekly, except for machines with unique e-monitoring requiring daily)		3%	
Mechanical			
Laser localization	2 mm	1.5 mm	1 mm
Distance indicator (ODI) @ iso	2 mm	2 mm	2 mm
Collimator size indicator	2 mm	2 mm	1 mm
Safety			
Door interlock (beam off)		Functional	
Door closing safety		Functional	
Audiovisual monitor(s)		Functional	
Stereotactic interlocks (lockout)	NA	NA	Functional
Radiation area monitor (if used)		Functional	
Beam on indicator		Functional	

TG-142: Daily Tests

Dosimetry

X-ray output constancy (all energies)
Electron output constancy (weekly, except for machines with unique e-monitoring requiring daily)

Mechanical

Laser localization
Distance indicator (ODI) @ iso
Collimator size indicator

Safety

Door interlock (beam off)
Door closing safety
Audiovisual monitor(s)
Stereotactic interlocks (lockout)
Radiation area monitor (if used)
Beam on indicator

Detector Type:	SunPoint® Diode Detectors Vented Ion Chambers
Detector Spacing: (mm)	Diodes: 5.0
Chamber Active Value: (cm^3)	Electron: 0.6 Photon: 0.3
Field Size: (cm)	20 x 20
Inherent Buildup: (g/cm^2)	Chambers: 1.0 ± 0.1
Inherent Backscatter: (cm)	2.3
Electron Energy Attenuation:	Air, Cu, Al, Fe
Radiation Measured:	Electrons, 4 MeV to 25 MeV Photons, Co-60 to 25 MV
Rf Frequency (rf-Daily QA 3): (GHz)	2.400 to 2.485
Operating System:	Windows XP or Windows 7, any edition (32-64 bit)
Dimensions: L/W/H (cm)	25.6 x 40.8 x 4.6
Weight: (kg)	5.7
Number Of Connection Cables:	Single power / data cable

TG-142: Daily Tests

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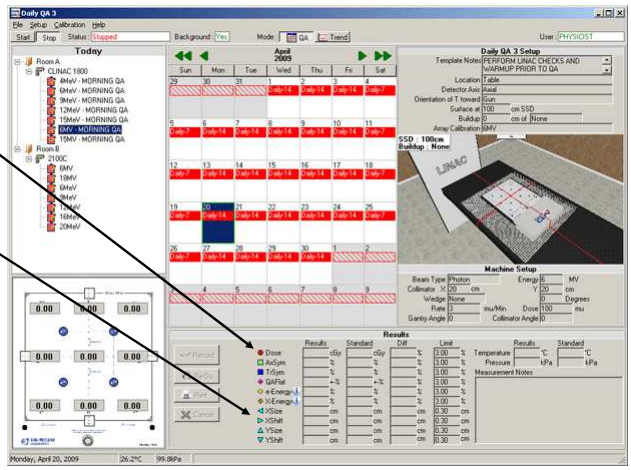

TG-142: Daily Tests

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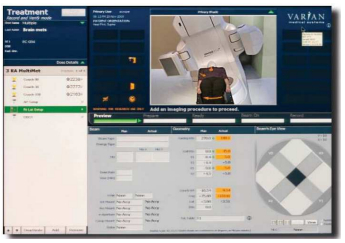


TG-142: Monthly Tests

TABLE II. Monthly.

Procedure	Machine-type tolerance		
	Non-IMRT	IMRT	SRS/SBRT
Dosimetry			
X-ray output constancy Electron output constancy Backup monitor chamber constancy		2%	
Typical dose rate[a] output constancy	NA	2% (@ IMRT dose rate)	2% (@ stereo dose rate, MU)
Photon beam profile constancy		1%	
Electron beam profile constancy		1%	
Electron beam energy constancy		2%/2 mm	

TG-142: Monthly Tests

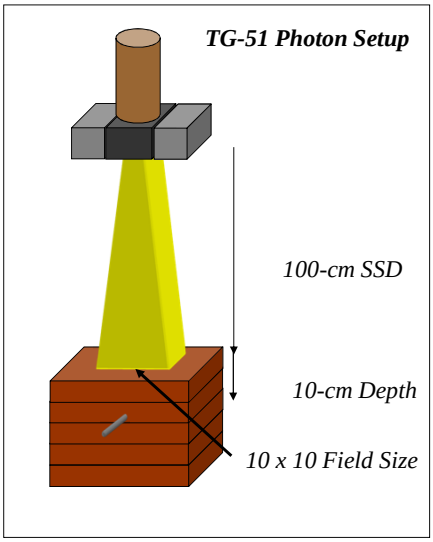
Dosimetry

- TG-51 Calibration in Solid Water covers X-ray and Electron output consistency
- Backup monitor chamber constancy is read off the linac console during TG-51
- Dose rate consistency is measured during TG-51 by taking readings at the Maximum and half max dose rates

Dosimetry

X-ray output constancy
Electron output constancy
Backup monitor chamber constancy
Typical dose rate[a] output constancy

Photon beam profile constancy
Electron beam profile constancy
Electron beam energy constancy



TG-142: Monthly Tests

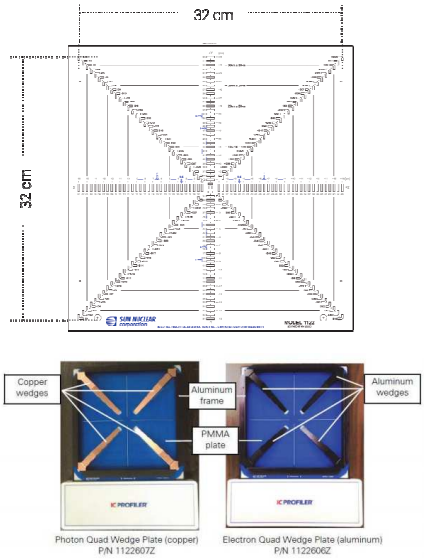
Dosimetry

- Beam profile consistency can be measured with an array device, the EPID imager, a scanning water tank, or an single ionization chamber
- The measured profile is compared against a standard reference profile
- Electron beam energy consistency can be inferred from the profile shape

Dosimetry

X-ray output constancy
Electron output constancy
Backup monitor chamber constancy
Typical dose rate[a] output constancy

Photon beam profile constancy
Electron beam profile constancy
Electron beam energy constancy



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TG-142: Monthly Tests

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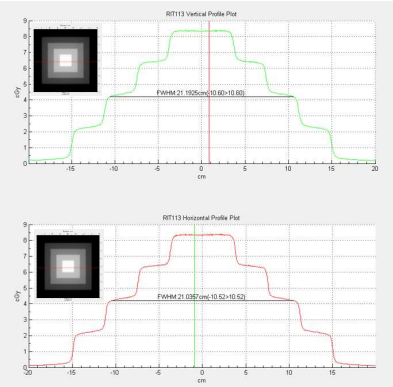


Dosimetry
X-ray output constancy
Electron output constancy
Backup monitor chamber constancy
Typical dose rate[a] output constancy
Photon beam profile constancy
Electron beam profile constancy
Electron beam energy constancy

TG-142: Monthly Tests

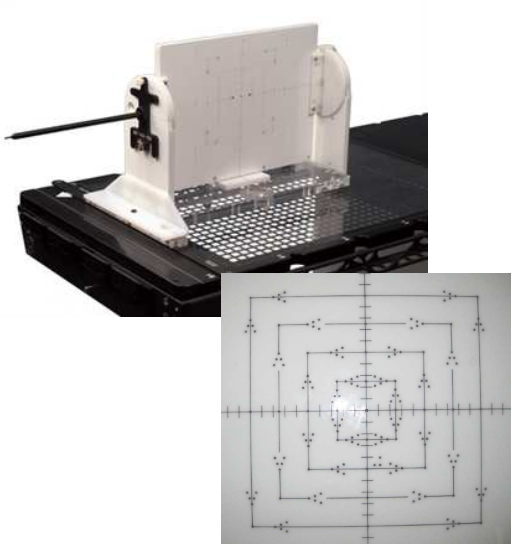
TABLE II. Monthly.

Procedure	Machine-type tolerance		
	Non-IMRT	IMRT	SRS/SBRT
Mechanical			
Light/radiation field coincidence[b]		2 mm or 1% on a side	
Light/radiation field coincidence[b] (asymmetric)		1 mm or 1% on a side	
Distance check device for lasers compared with front pointer		1mm	
Gantry/collimator angle indicators (@ cardinal angles) (digital only)		1.0°	
Accessory trays (i.e., port film graticle tray)		2 mm	
Jaw position indicators (symmetric)[c]		2 mm	
Jaw position indicators (asymmetric)[d]		1 mm	
Cross-hair centering (walkout)		1 mm	
Treatment couch position indicators[e]	2 mm/1°	2 mm/1°	1 mm/0.5°
Wedge placement accuracy		2 mm	
Compensator placement accuracy[f]		1 mm	
Latching of wedges, blocking tray[g]		Functional	
Localizing lasers	±2 mm	±1 mm	< ±1 mm

TG-142: Monthly Tests

Mechanical

- Light/radiation field coincidence[b]
- Light/radiation field coincidence[b] (asymmetric)
- Distance check device for lasers compared with front pointer
- Gantry/collimator angle indicators (@ cardinal angles) (digital only)
- Accessory trays (i.e., port film graticle tray)
- Jaw position indicators (symmetric)[c]
- Jaw position indicators (asymmetric)[d]
- Cross-hair centering (walkout)
- Treatment couch position indicators[e]
- Wedge placement accuracy
- Compensator placement accuracy[f]
- Latching of wedges, blocking tray[g]
- Localizing lasers

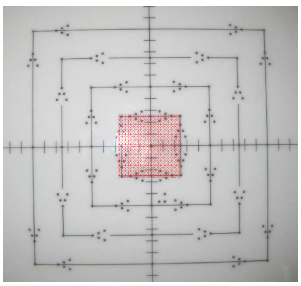


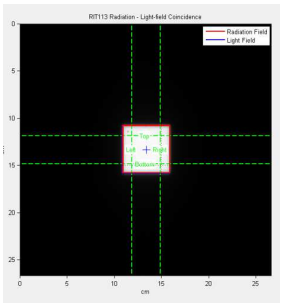
TG-142: Monthly Tests

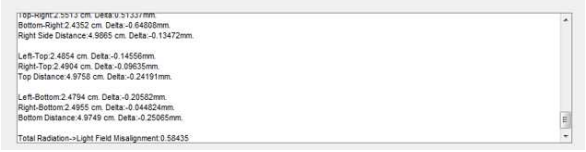
Mechanical

- Light/radiation field coincidence[b]
- Light/radiation field coincidence[b] (asymmetric)
- Distance check device for lasers compared with front pointer
- Gantry/collimator angle indicators (@ cardinal angles) (digital only)
- Accessory trays (i.e., port film graticle tray)
- Jaw position indicators (symmetric)[c]
- Jaw position indicators (asymmetric)[d]
- Cross-hair centering (walkout)
- Treatment couch position indicators[e]
- Wedge placement accuracy
- Compensator placement accuracy[f]
- Latching of wedges, blocking tray[g]
- Localizing lasers

Radiation Light Field 5x5







TG-142: Monthly Tests

Mechanical

- Light/radiation field coincidence[b]
- Light/radiation field coincidence[b] (asymmetric)
- Distance check device for lasers compared with front pointer
- Gantry/collimator angle indicators (@ cardinal angles) (digital only)
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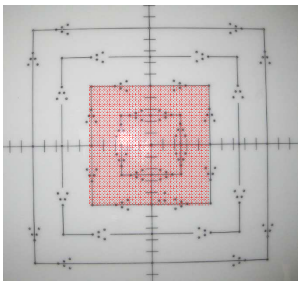
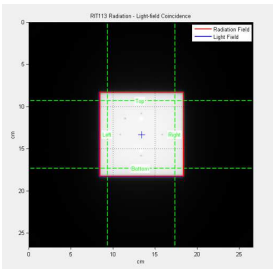
- Cross-hair centering (walkout)
- Treatment couch position indicators[e]
- Wedge placement accuracy
- Compensator placement accuracy[f]
- Latching of wedges, blocking tray[g]
- Localizing lasers

Radiation Light Field 10x10



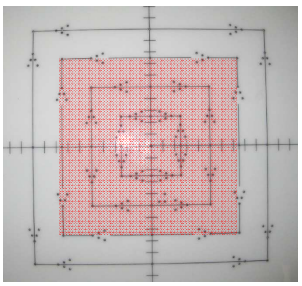


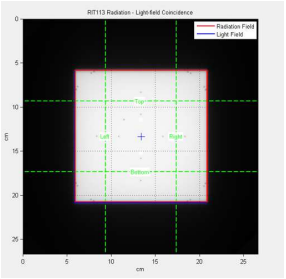
TG-142: Monthly Tests

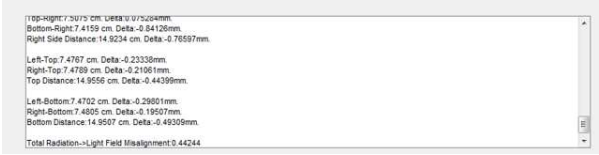
Mechanical

- Light/radiation field coincidence[b]
- Light/radiation field coincidence[b] (asymmetric)
- Distance check device for lasers compared with front pointer
- Gantry/collimator angle indicators (@ cardinal angles) (digital only)
- Accessory trays (i.e., port film graticle tray)
- Jaw position indicators (symmetric)[c]
- Jaw position indicators (asymmetric)[d]
- Cross-hair centering (walkout)
- Treatment couch position indicators[e]
- Wedge placement accuracy
- Compensator placement accuracy[f]
- Latching of wedges, blocking tray[g]
- Localizing lasers

Radiation Light Field 15x15







TG-142: Monthly Tests

Mechanical

- Light/radiation field coincidence[b]
- Light/radiation field coincidence[b] (asymmetric)
- Distance check device for lasers compared with front pointer
- Gantry/collimator angle indicators (@ cardinal angles) (digital only)
- Accessory trays (i.e., port film graticle tray)
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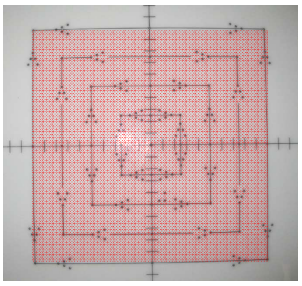
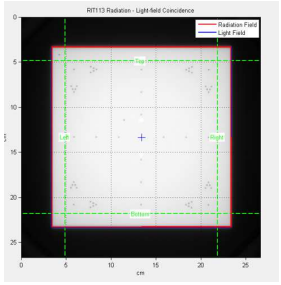
- Latching of wedges, blocking tray[g]
- Localizing lasers

Radiation Light Field 20x20





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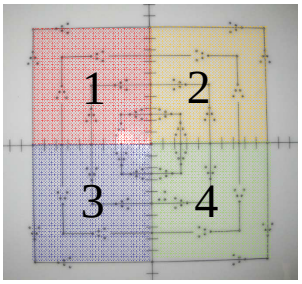
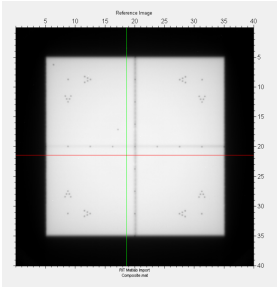
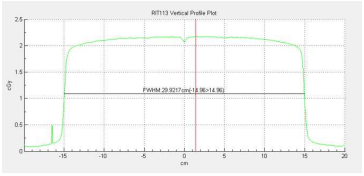
Asymmetric Composite







TG-142: Monthly Tests

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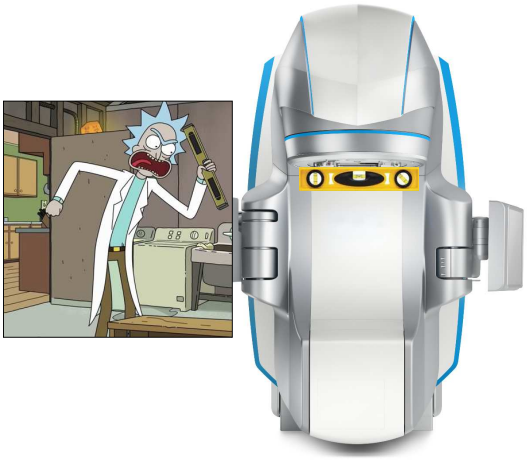

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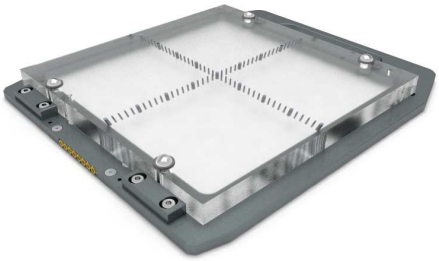

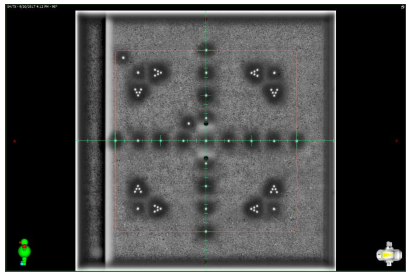

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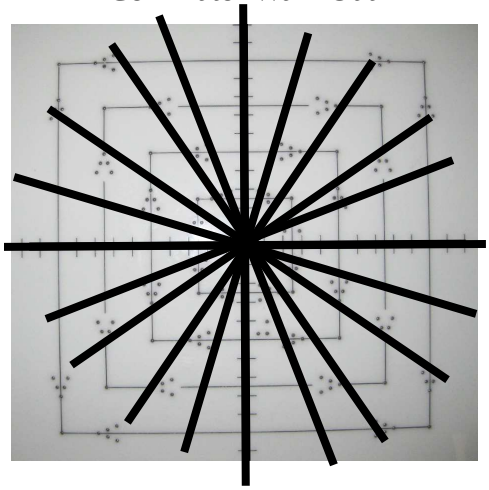
Collimator Walk Out



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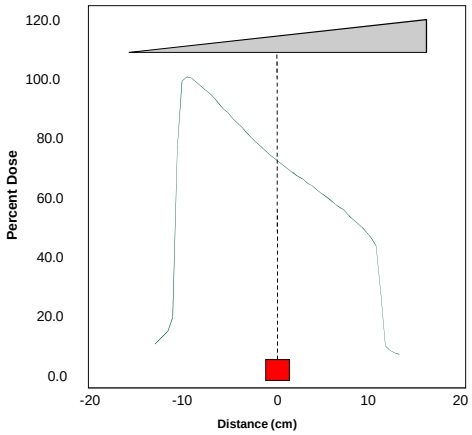
- Compensator placement accuracy[f]
- Latching of wedges, blocking tray[g]
- Localizing lasers

Wedge Placement

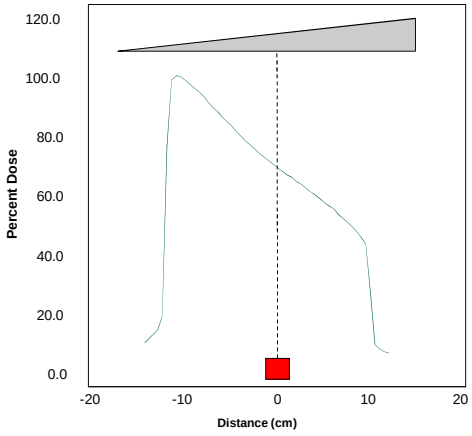


TG-142: Monthly Tests

Mechanical

- Light/radiation field coincidence[b]
- Light/radiation field coincidence[b] (asymmetric)
- Distance check device for lasers compared with front pointer
- Gantry/collimator angle indicators (@ cardinal angles) (digital only)
- Accessory trays (i.e., port film graticle tray)
- Jaw position indicators (symmetric)[c]
- Jaw position indicators (asymmetric)[d]
- Cross-hair centering (walkout)
- Treatment couch position indicators[e]
- Wedge placement accuracy
- Compensator placement accuracy[f]
- Latching of wedges, blocking tray[g]
- Localizing lasers

Wedge Placement



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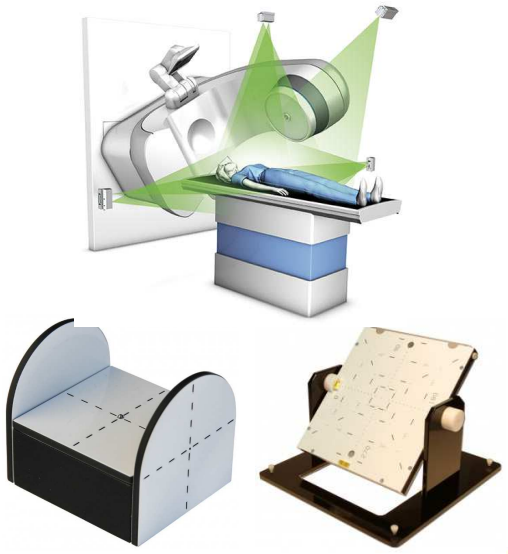
TG-142: Monthly Tests

Mechanical

- Light/radiation field coincidence[b]
- Light/radiation field coincidence[b] (asymmetric)
- Distance check device for lasers compared with front pointer
- Gantry/collimator angle indicators (@ cardinal angles) (digital only)
- Accessory trays (i.e., port film graticle tray)
- Jaw position indicators (symmetric)[c]
- Jaw position indicators (asymmetric)[d]
- Cross-hair centering (walkout)
- Treatment couch position indicators[e]
- Wedge placement accuracy
- Compensator placement accuracy[f]
- Latching of wedges, blocking tray[g]
- Localizing lasers



TG-142: Monthly Tests

TABLE II. Monthly.

Procedure	Machine-type tolerance		
	Non-IMRT	IMRT	SRS/SBRT
Safety			
Laser guard-interlock test		Functional	
Respiratory gating			
Beam output constancy		2%	
Phase, amplitude beam control		Functional	
In-room respiratory monitoring system		Functional	
Gating interlock		Functional	

TG-142: Monthly Tests

Safety

Laser guard-interlock test

Respiratory gating

Beam output constancy
Phase, amplitude beam control
In-room respiratory monitoring system
Gating interlock

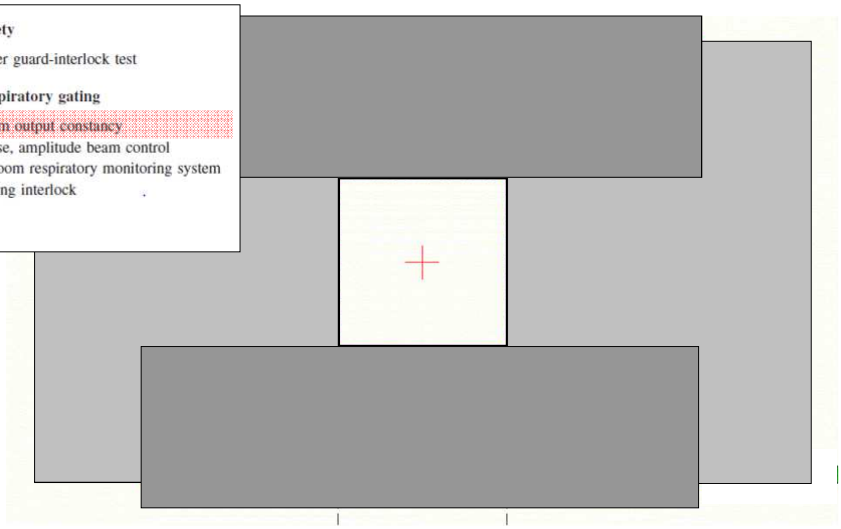
TG-142: Monthly Tests

Safety

Laser guard-interlock test

Respiratory gating

Beam output constancy
Phase, amplitude beam control
In-room respiratory monitoring system
Gating interlock



TG-142: Monthly Tests

Safety

Laser guard-interlock test

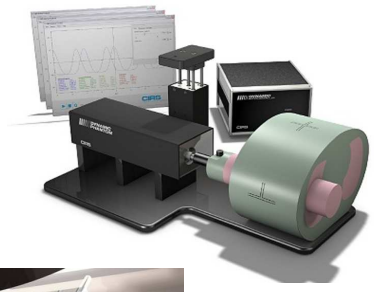
Respiratory gating

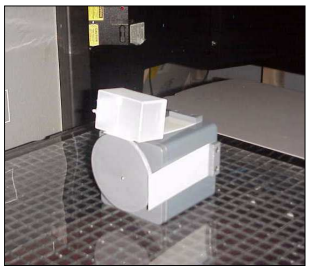
Beam output constancy

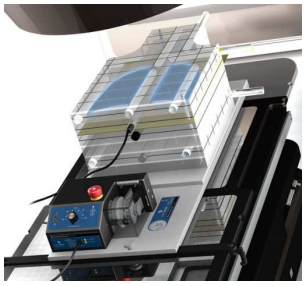
Phase, amplitude beam control

In-room respiratory monitoring system

Gating interlock







TG-142: Annual Tests

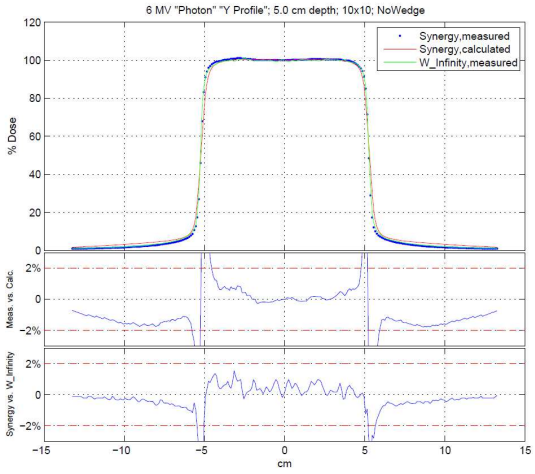
TABLE III. Annual.

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: 0.5–10 MU/deg)	NA	NA	Monitor units set vs delivered: 1.0 MU or 2% (whichever is greater) Gantry arc set vs delivered: 1.0° or 2% (whichever is greater)

TG-142: Annual Tests

Dosimetry

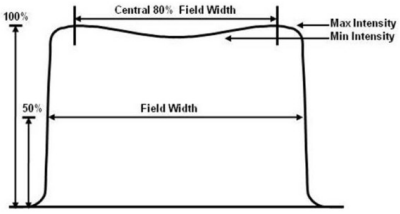
- X-ray flatness change from baseline
- X-ray symmetry change from baseline
- Electron flatness change from baseline
- Electron symmetry change from baseline
- SRS arc rotation mode
  (range: 0.5–10 MU/deg)



TG-142: Annual Tests

Dosimetry

- X-ray flatness change from baseline
- X-ray symmetry change from baseline
- Electron flatness change from baseline
- Electron symmetry change from baseline
- SRS arc rotation mode
  (range: 0.5–10 MU/deg)



The beam flatness F is assessed by finding the maximum D_{max} and minimum D_{min} dose point values on the beam profile within the central 80% of the beam width and then using the relationship:

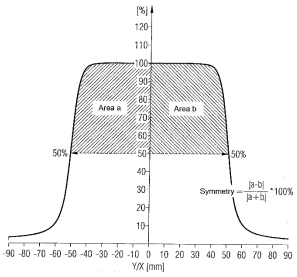
$$F = 100 \times \frac{D_{max} - D_{min}}{D_{max} + D_{min}}$$

TG-142: Annual Tests

Dosimetry

- X-ray flatness change from baseline
- X-ray symmetry change from baseline
- Electron flatness change from baseline
- Electron symmetry change from baseline

SRS arc rotation mode
(range: 0.5–10 MU/deg)



The beam symmetry S is usually determined at z_{max}, which represents the most sensitive depth for assessment of this beam uniformity parameter. A typical symmetry specification is that any two dose points on a beam profile, equidistant from the central axis point, are within 2% of each other. Alternately, areas under the z_{max} beam profile on each side (left and right) of the central axis extending to the 50% dose level (normalized to 100% at the central axis point) are determined and S is then calculated from:

$$S = 100 \times \frac{\text{area}_{\text{left}} - \text{area}_{\text{right}}}{\text{area}_{\text{left}} + \text{area}_{\text{right}}}$$

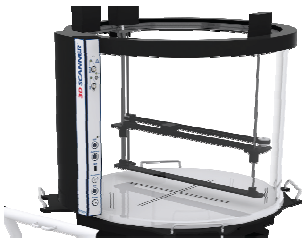
TG-142: Annual Tests

TABLE III. Annual.

Procedure	Machine-type tolerance		
	Non-IMRT	IMRT	SRS/SBRT
X-ray/electron output calibration (TG-51)	±1% (absolute)		
Spot check of field size dependent output factors for x ray (two or more FSs)	2% for field size <4×4 cm², 1% ≥4×4 cm²		
Output factors for electron applicators (spot check of one applicator/energy)	±2% from baseline		
X-ray beam quality (PDD_{10} or TMR_{10}^{20})	±1% from baseline		
Electron beam quality (R_{50})	±1 mm		
Physical wedge transmission factor constancy	±2%		
X-ray monitor unit linearity (output constancy)	±2% ≥5 MU	±5% (2–4 MU), ±2% ≥5 MU	±5% (2–4 MU), ±2% ≥5 MU
Electron monitor unit linearity (output constancy)	±2% ≥5 MU		
X-ray output constancy vs dose rate	±2% from baseline		
X-ray output constancy vs gantry angle	±1% from baseline		
Electron output constancy vs gantry angle	±1% from baseline		
Electron and x-ray off-axis factor constancy vs gantry angle	±1% from baseline		
Arc mode (expected MU, degrees)	±1% from baseline		
TBI/TSET mode	Functional		
PDD or TMR and OAF constancy	1% (TBI) or 1 mm PDD shift (TSET) from baseline		
TBI/TSET output calibration	2% from baseline		
TBI/TSET accessories	2% from baseline		

TG-142: Annual Tests

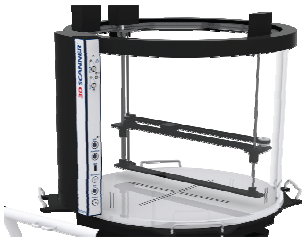
- X-ray/electron output calibration (TG-51)
- Spot check of field size dependent output factors for x ray (two or more FSs)
- Output factors for electron applicators (spot check of one applicator/energy)
- X-ray beam quality (PDD_{10} or TMR_{10}^{20})
- Electron beam quality (R_{50})
- Physical wedge transmission factor constancy
- X-ray monitor unit linearity (output constancy)
- Electron monitor unit linearity (output constancy)
- X-ray output constancy vs dose rate
- X-ray output constancy vs gantry angle
- Electron output constancy vs gantry angle
- Electron and x-ray off-axis factor constancy vs gantry angle
- Arc mode (expected MU, degrees)
- TBI/TSET mode
- PDD or TMR and OAF constancy
- TBI/TSET output calibration
- TBI/TSET accessories



- Must be performed in liquid water using calibrated chambers as described in TG-51 report

TG-142: Annual Tests

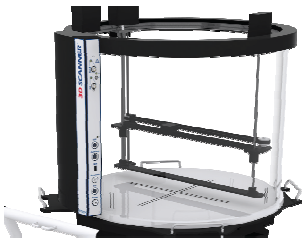
- X-ray/electron output calibration (TG-51)
- Spot check of field size dependent output factors for x ray (two or more FSs)
- Output factors for electron applicators (spot check of one applicator/energy)
- X-ray beam quality (PDD_{10} or TMR_{10}^{20})
- Electron beam quality (R_{50})
- Physical wedge transmission factor constancy
- X-ray monitor unit linearity (output constancy)
- Electron monitor unit linearity (output constancy)
- X-ray output constancy vs dose rate
- X-ray output constancy vs gantry angle
- Electron output constancy vs gantry angle
- Electron and x-ray off-axis factor constancy vs gantry angle
- Arc mode (expected MU, degrees)
- TBI/TSET mode
- PDD or TMR and OAF constancy
- TBI/TSET output calibration
- TBI/TSET accessories



- Doesn't have to be measured in water, but you already have your tank setup
- Measure 5x5, 10x10, 15x15, and 20x20 for each photon mean energy (*typically 2-3 energies*)
- Measure 10x10 and 15x15 cones for each electron energy (*typically 5 energies*)
- Compare to baseline

TG-142: Annual Tests

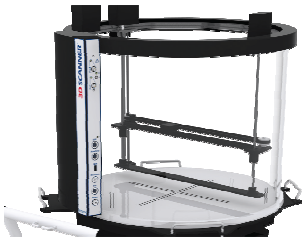
- X-ray/electron output calibration (TG-51)
- Spot check of field size dependent output factors for x ray (two or more FSs)
- Output factors for electron applicators (spot check of one applicator/energy)
- X-ray beam quality (PDD_{10} or TMR_{10}^{20})
- Electron beam quality (R_{50})
- Physical wedge transmission factor constancy
- X-ray monitor unit linearity (output constancy)
- Electron monitor unit linearity (output constancy)
- X-ray output constancy vs dose rate
- X-ray output constancy vs gantry angle
- Electron output constancy vs gantry angle
- Electron and x-ray off-axis factor constancy vs gantry angle
- Arc mode (expected MU, degrees)
- TBI/TSET mode
- PDD or TMR and OAF constancy
- TBI/TSET output calibration
- TBI/TSET accessories



- Doesn't have to be measured in water, but you already have your tank setup
- Measure 10x10 field size for open, 15, 30, 45, and 60 degree wedges for each photon beam energy
- Compare to baseline

TG-142: Annual Tests

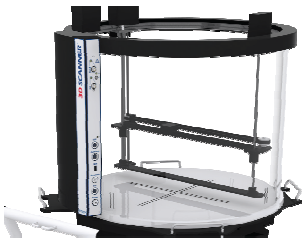
- X-ray/electron output calibration (TG-51)
- Spot check of field size dependent output factors for x ray (two or more FSs)
- Output factors for electron applicators (spot check of one applicator/energy)
- X-ray beam quality (PDD_{10} or TMR_{10}^{20})
- Electron beam quality (R_{50})
- Physical wedge transmission factor constancy
- X-ray monitor unit linearity (output constancy)
- Electron monitor unit linearity (output constancy)
- X-ray output constancy vs dose rate
- X-ray output constancy vs gantry angle
- Electron output constancy vs gantry angle
- Electron and x-ray off-axis factor constancy vs gantry angle
- Arc mode (expected MU, degrees)
- TBI/TSET mode
- PDD or TMR and OAF constancy
- TBI/TSET output calibration
- TBI/TSET accessories



- Doesn't have to be measured in water, but you already have your tank setup
- For a 10x10 field size, take measurements for monitor units of 500, 250, 100, 50, 25, 10, and 3 for each photon and electron beam energy
- Check to see if the dose is linear

TG-142: Annual Tests

- X-ray/electron output calibration (TG-51)
- Spot check of field size dependent output factors for x ray (two or more FSs)
- Output factors for electron applicators (spot check of one applicator/energy)
- X-ray beam quality (PDD_{10} or TMR_{10}^{20})
- Electron beam quality (R_{50})
- Physical wedge transmission factor constancy
- X-ray monitor unit linearity (output constancy)
- Electron monitor unit linearity (output constancy)
- **X-ray output constancy vs dose rate**
- X-ray output constancy vs gantry angle
- Electron output constancy vs gantry angle
- Electron and x-ray off-axis factor constancy vs gantry angle
- Arc mode (expected MU, degrees)
- TBI/TSET mode
- PDD or TMR and OAF constancy
- TBI/TSET output calibration
- TBI/TSET accessories



- Doesn't have to be measured in water, but you already have your tank setup
- For a 10x10 field size, take measurements using 100 monitor unites delivered at multiple dose rates for each photon and electron beam energy
- The readings should be the same

TG-142: Annual Tests

- X-ray/electron output calibration (TG-51)
- Spot check of field size dependent output factors for x ray (two or more FSs)
- Output factors for electron applicators (spot check of one applicator/energy)
- **X-ray beam quality (PDD_{10} or TMR_{10}^{20})**
- Electron beam quality (R_{50})
- Physical wedge transmission factor constancy
- X-ray monitor unit linearity (output constancy)
- Electron monitor unit linearity (output constancy)
- X-ray output constancy vs dose rate
- X-ray output constancy vs gantry angle
- Electron output constancy vs gantry angle
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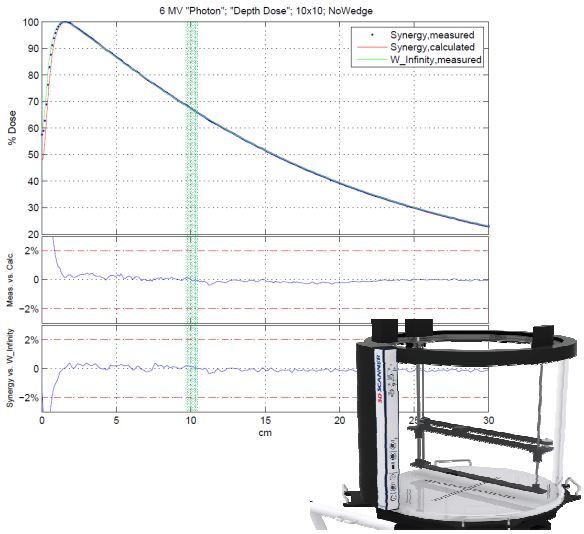
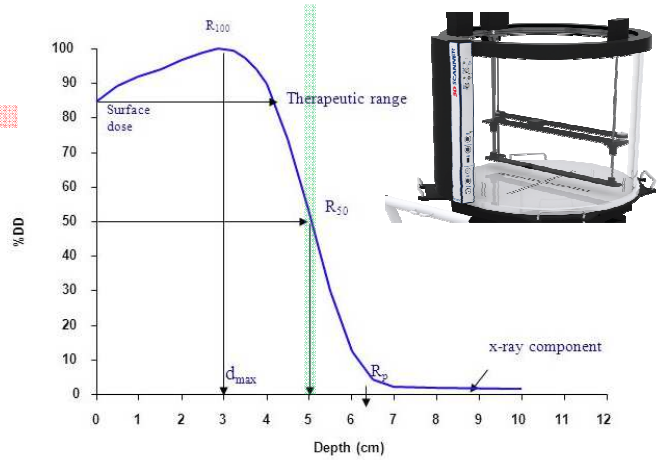
- Arc mode (expected MU, degrees)
- TBI/TSET mode
- PDD or TMR and OAF constancy
- TBI/TSET output calibration
- TBI/TSET accessories



TG-142: Annual Tests

- X-ray/electron output calibration (TG-51)
- Spot check of field size dependent output factors for x ray (two or more FSs)
- Output factors for electron applicators (spot check of one applicator/energy)
- X-ray beam quality (PDD_{10} or TMR_{10}^{20})
- Electron beam quality (R_{50})
- Physical wedge transmission factor constancy
- X-ray monitor unit linearity (output constancy)
- Electron monitor unit linearity (output constancy)
- X-ray output constancy vs dose rate
- X-ray output constancy vs gantry angle
- Electron output constancy vs gantry angle
- Electron and x-ray off-axis factor constancy vs gantry angle
- Arc mode (expected MU, degrees)
- TBI/TSET mode
- PDD or TMR and OAF constancy
- TBI/TSET output calibration
- TBI/TSET accessories



TG-142: Annual Tests

- X-ray/electron output calibration (TG-51)
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- Physical wedge transmission factor constancy
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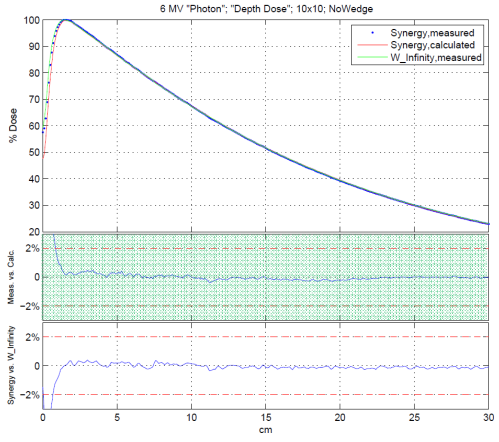
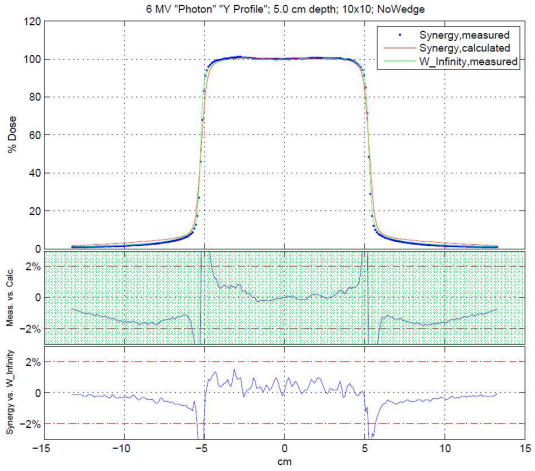
- Electron monitor unit linearity (output constancy)
- X-ray output constancy vs dose rate
- X-ray output constancy vs gantry angle
- Electron output constancy vs gantry angle
- Electron and x-ray off-axis factor constancy vs gantry angle
- Arc mode (expected MU, degrees)
- TBI/TSET mode
- PDD or TMR and OAF constancy
- TBI/TSET output calibration
- TBI/TSET accessories



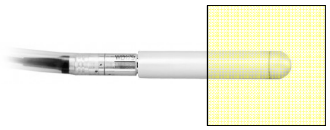
TG-142: Annual Tests

X-ray/electron output calibration (TG-51)
Spot check of field size dependent output factors for x ray (two or more FSs)
Output factors for electron applicators (spot check of one applicator/energy)
X-ray beam quality (PDD_{10} or TMR_{10}^{20})
Electron beam quality (R_{50})
Physical wedge transmission factor constancy
X-ray monitor unit linearity (output constancy)
Electron monitor unit linearity (output constancy)
X-ray output constancy vs dose rate
X-ray output constancy vs gantry angle
Electron output constancy vs gantry angle
Electron and x-ray off-axis factor constancy vs gantry angle
Arc mode (expected MU, degrees)
TBI/TSET mode
PDD or TMR and OAF constancy
TBI/TSET output calibration
TBI/TSET accessories

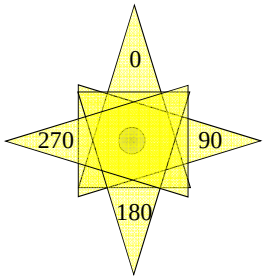


TG-142: Annual Tests

X-ray/electron output calibration (TG-51)
Spot check of field size dependent output factors for x ray (two or more FSs)
Output factors for electron applicators (spot check of one applicator/energy)
X-ray beam quality (PDD_{10} or TMR_{10}^{20})
Electron beam quality (R_{50})
Physical wedge transmission factor constancy
X-ray monitor unit linearity (output constancy)
Electron monitor unit linearity (output constancy)
X-ray output constancy vs dose rate
X-ray output constancy vs gantry angle
Electron output constancy vs gantry angle
Electron and x-ray off-axis factor constancy vs gantry angle
Arc mode (expected MU, degrees)
TBI/TSET mode
PDD or TMR and OAF constancy
TBI/TSET output calibration
TBI/TSET accessories



10x10 with buildup cap



- For a 10x10 field size, take measurements using 100 monitor units delivered at gantry angles of 0, 90, 180, and 270 degrees for each photon beam energy
- Readings should be consistent with 10x10 baseline

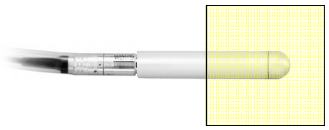
TG-142: Annual Tests

- X-ray/electron output calibration (TG-51)
- Spot check of field size dependent output factors for x ray (two or more FSs)
- Output factors for electron applicators (spot check of one applicator/energy)
- X-ray beam quality (PDD_{10} or TMR_{10}^{20})
- Electron beam quality (R_{50})
- Physical wedge transmission factor constancy
- X-ray monitor unit linearity (output constancy)
- Electron monitor unit linearity (output constancy)
- X-ray output constancy vs dose rate
- X-ray output constancy vs gantry angle
- Electron output constancy vs gantry angle
- Electron and x-ray off-axis factor constancy vs gantry angle
- Arc mode (expected MU, degrees)
- TBI/TSET mode
- PDD or TMR and OAF constancy
- TBI/TSET output calibration
- TBI/TSET accessories

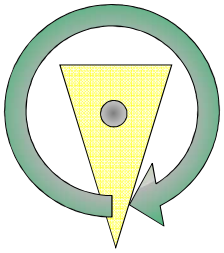
- For a 10x10 field size, take measurements using 100 monitor units delivered at gantry angles of 0, 90, 180, and 270 degrees for each photon beam energy
- Readings should be consistent with 10x10 baseline

TG-142: Annual Tests

- X-ray/electron output calibration (TG-51)
- Spot check of field size dependent output factors for x ray (two or more FSs)
- Output factors for electron applicators (spot check of one applicator/energy)
- X-ray beam quality (PDD_{10} or TMR_{10}^{20})
- Electron beam quality (R_{50})
- Physical wedge transmission factor constancy
- X-ray monitor unit linearity (output constancy)
- Electron monitor unit linearity (output constancy)
- X-ray output constancy vs dose rate
- X-ray output constancy vs gantry angle
- Electron output constancy vs gantry angle
- Electron and x-ray off-axis factor constancy vs gantry angle
- Arc mode (expected MU, degrees)
- TBI/TSET mode
- PDD or TMR and OAF constancy
- TBI/TSET output calibration
- TBI/TSET accessories



10x10 with buildup cap



- For a 10x10 field size, take measurements using 100 monitor units delivered as 360 degree arcs and 180 degree arcs for each photon beam energy
- Readings should be consistent with 10x10 baseline

TG-142: Annual Tests

TABLE III. Annual.

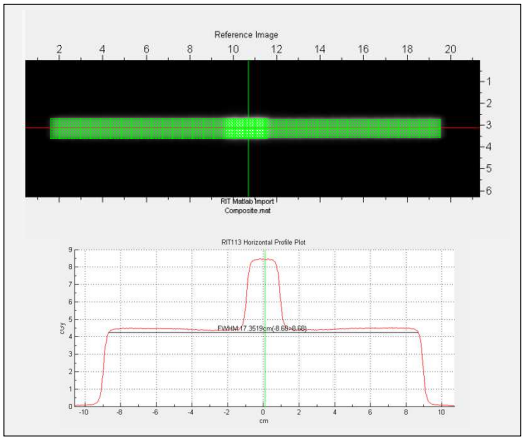
Procedure	Machine-type tolerance		
	Non-IMRT	IMRT	SRS/SBRT
Mechanical			
Collimator rotation isocenter		±1 mm from baseline	
Gantry rotation isocenter		±1 mm from baseline	
Couch rotation isocenter		±1 mm from baseline	
Electron applicator interlocks		Functional	
Coincidence of radiation and mechanical isocenter	±2 mm from baseline	±2 mm from baseline	±1 mm from baseline
Table top sag		2 mm from baseline	
Table angle		1°	
Table travel maximum range movement in all directions		±2 mm	
Stereotactic accessories, lockouts, etc.	NA	NA	Functional
Safety			
Follow manufacturer's test procedures		Functional	
Respiratory gating			
Beam energy constancy		2%	
Temporal accuracy of phase/amplitude gate on		100 ms of expected	
Calibration of surrogate for respiratory phase/amplitude		100 ms of expected	
Interlock testing		Functional	

TG-142: Annual Tests

Mechanical
Collimator rotation isocenter
Gantry rotation isocenter
Couch rotation isocenter
Electron applicator interlocks
Coincidence of radiation and mechanical isocenter
Table top sag
Table angle
Table travel maximum range movement in all directions
Stereotactic accessories, lockouts, etc.

Safety
Follow manufacturer's test procedures

Respiratory gating
Beam energy constancy
Temporal accuracy of phase/amplitude gate on
Calibration of surrogate for respiratory phase/amplitude
Interlock testing



- Using EPID or Film, overlapping fields with lower jaws a collimator angles of 0 and 180-degrees
- Use FWHM to examine the centering of the overlap

TG-142: Annual Tests

Mechanical

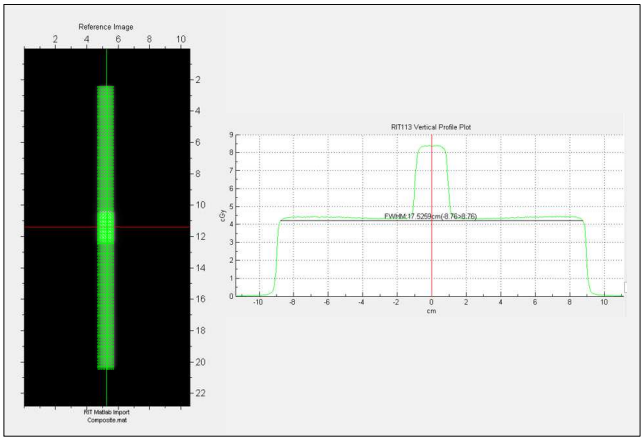
Collimator rotation isocenter
Gantry rotation isocenter
Couch rotation isocenter
Electron applicator interlocks
Coincidence of radiation and mechanical isocenter
Table top sag
Table angle
Table travel maximum range movement in all directions
Stereotactic accessories, lockouts, etc.

Safety

Follow manufacturer's test procedures

Respiratory gating

Beam energy constancy
Temporal accuracy of phase/amplitude gate on
Calibration of surrogate for respiratory phase/amplitude
Interlock testing



- Using EPID or Film, overlapping fields with upper jaws a collimator angles of 0 and 180-degrees
- Use FWHM to examine the centering of the overlap

TG-142: Annual Tests

Mechanical

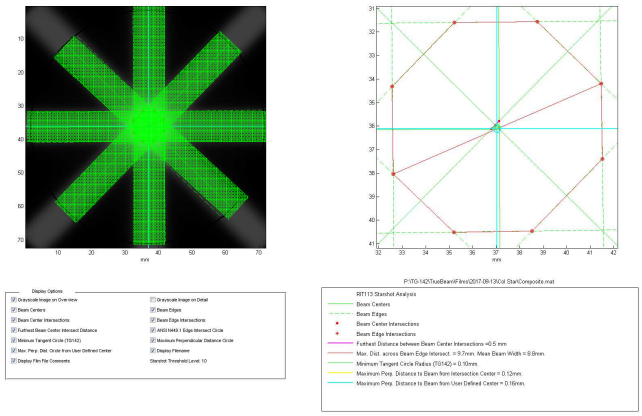
Collimator rotation isocenter
Gantry rotation isocenter
Couch rotation isocenter
Electron applicator interlocks
Coincidence of radiation and mechanical isocenter
Table top sag
Table angle
Table travel maximum range movement in all directions
Stereotactic accessories, lockouts, etc.

Safety

Follow manufacturer's test procedures

Respiratory gating

Beam energy constancy
Temporal accuracy of phase/amplitude gate on
Calibration of surrogate for respiratory phase/amplitude
Interlock testing



- Using EPID or Film, shoot 1-cm wide fields at collimator angles of 0, 45, 90, and 135 degrees
- Use FWHM to find center of "spokes" and look at variation

TG-142: Annual Tests

Mechanical

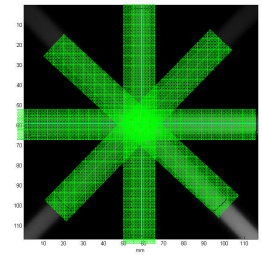
Collimator rotation isocenter
Gantry rotation isocenter
Couch rotation isocenter
Electron applicator interlocks
Coincidence of radiation and mechanical isocenter
Table top sag
Table angle
Table travel maximum range movement in all directions
Stereotactic accessories, lockouts, etc.

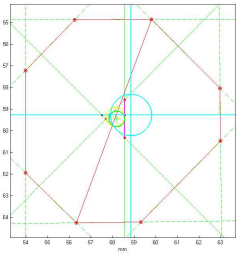
Safety

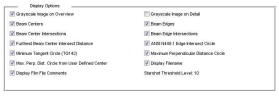
Follow manufacturer's test procedures

Respiratory gating

Beam energy constancy
Temporal accuracy of phase/amplitude gate on
Calibration of surrogate for respiratory phase/amplitude
Interlock testing







- Using Film, shoot 1-cm wide fields at gantry angles of 0, 45, 90, and 135 degrees
- Use FWHM to find center of "spokes" and look at variation

TG-142: Annual Tests

Mechanical

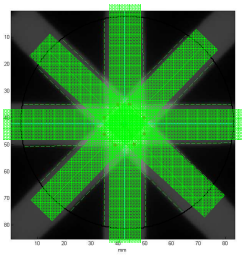
Collimator rotation isocenter
Gantry rotation isocenter
Couch rotation isocenter
Electron applicator interlocks
Coincidence of radiation and mechanical isocenter
Table top sag
Table angle
Table travel maximum range movement in all directions
Stereotactic accessories, lockouts, etc.

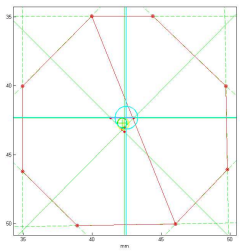
Safety

Follow manufacturer's test procedures

Respiratory gating

Beam energy constancy
Temporal accuracy of phase/amplitude gate on
Calibration of surrogate for respiratory phase/amplitude
Interlock testing





- Using Film, shoot 1-cm wide fields at couch angles of 0, 45, 90, and -45 degrees
- Use FWHM to find center of "spokes" and look at variation

TG-142: Annual Tests

Mechanical

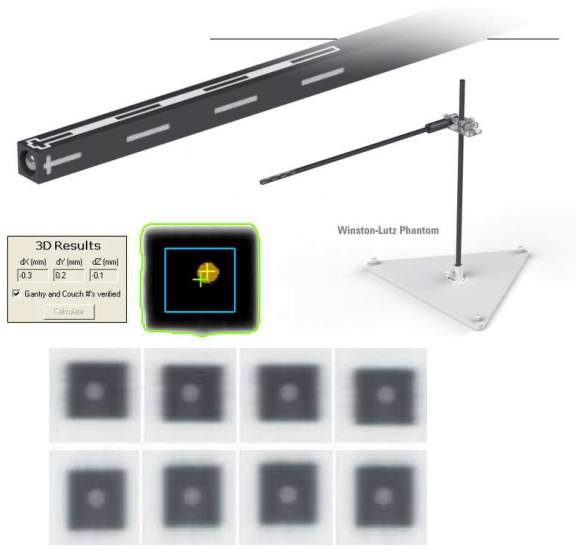
Collimator rotation isocenter
Gantry rotation isocenter
Couch rotation isocenter
Electron applicator interlocks
Coincidence of radiation and mechanical isocenter
Table top sag
Table angle
Table travel maximum range movement in all directions
Stereotactic accessories, lockouts, etc.

Safety

Follow manufacturer's test procedures

Respiratory gating

Beam energy constancy
Temporal accuracy of phase/amplitude gate on
Calibration of surrogate for respiratory phase/amplitude
Interlock testing



TG-142: Annual Tests

Mechanical

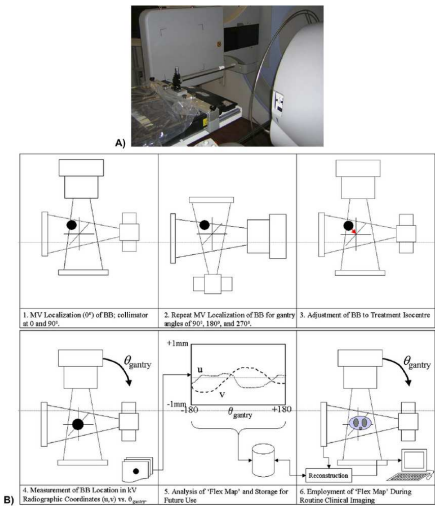
Collimator rotation isocenter
Gantry rotation isocenter
Couch rotation isocenter
Electron applicator interlocks
Coincidence of radiation and mechanical isocenter
Table top sag
Table angle
Table travel maximum range movement in all directions
Stereotactic accessories, lockouts, etc.

Safety

Follow manufacturer's test procedures

Respiratory gating

Beam energy constancy
Temporal accuracy of phase/amplitude gate on
Calibration of surrogate for respiratory phase/amplitude
Interlock testing



- On Elekta linacs, run the flexmap test

TG-142: Annual Tests

Mechanical

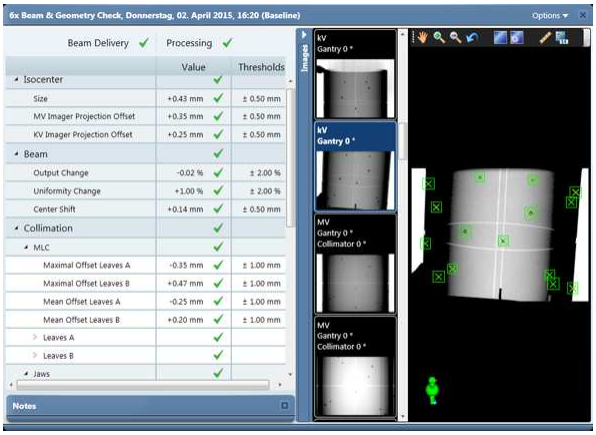
Collimator rotation isocenter
Gantry rotation isocenter
Couch rotation isocenter
Electron applicator interlocks
Coincidence of radiation and mechanical isocenter
Table top sag
Table angle
Table travel maximum range movement in all directions
Stereotactic accessories, lockouts, etc.

Safety

Follow manufacturer's test procedures

Respiratory gating

Beam energy constancy
Temporal accuracy of phase/amplitude gate on
Calibration of surrogate for respiratory phase/amplitude
Interlock testing



- On Varian TrueBeam linacs, run the built-in MPC test

TG-142: Annual Tests

Mechanical

Collimator rotation isocenter
Gantry rotation isocenter
Couch rotation isocenter
Electron applicator interlocks
Coincidence of radiation and mechanical isocenter
Table top sag
Table angle
Table travel maximum range movement in all directions
Stereotactic accessories, lockouts, etc.

Safety

Follow manufacturer's test procedures

Respiratory gating

Beam energy constancy
Temporal accuracy of phase/amplitude gate on
Calibration of surrogate for respiratory phase/amplitude
Interlock testing

- Check to see that linac interlocks will clear only when the selected electron cone is inserted

TG-142: Annual Tests

Mechanical

Collimator rotation isocenter
Gantry rotation isocenter
Couch rotation isocenter
Electron applicator interlocks
Coincidence of radiation and mechanical isocenter
Table top sag
Table angle
Table travel maximum range movement in all directions
Stereotactic accessories, lockouts, etc.

Safety

Follow manufacturer's test procedures

Respiratory gating

Beam energy constancy
Temporal accuracy of phase/amplitude gate on
Calibration of surrogate for respiratory phase/amplitude
Interlock testing

- Check to see that linac interlocks will clear only when the selected stereotactic cone is inserted

TG-142: Annual Tests

Mechanical

Collimator rotation isocenter
Gantry rotation isocenter
Couch rotation isocenter
Electron applicator interlocks
Coincidence of radiation and mechanical isocenter
Table top sag
Table angle
Table travel maximum range movement in all directions
Stereotactic accessories, lockouts, etc.

Safety

Follow manufacturer's test procedures

Respiratory gating

Beam energy constancy
Temporal accuracy of phase/amplitude gate on
Calibration of surrogate for respiratory phase/amplitude
Interlock testing

- Place weight on table and check for sag
- Move table in all directions
- Rotate table and observe for walkout

TG-142: Annual Tests

Mechanical

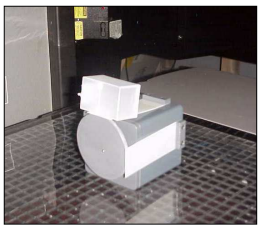
Collimator rotation isocenter
Gantry rotation isocenter
Couch rotation isocenter
Electron applicator interlocks
Coincidence of radiation and mechanical isocenter
Table top sag
Table angle
Table travel maximum range movement in all directions
Stereotactic accessories, lockouts, etc.

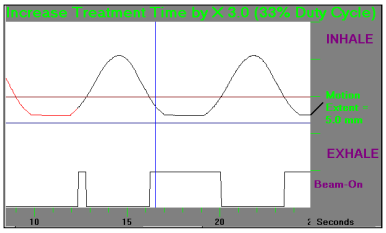
Safety

Follow manufacturer's test procedures

Respiratory gating

Beam energy constancy
Temporal accuracy of phase/amplitude gate on
Calibration of surrogate for respiratory phase/amplitude
Interlock testing





- Using a motion phantom of your choice to trigger the beam on and off
- Observe that the beam is turning on and off at the correct time
- Take measurements with an ionization chamber setup SAD at depths of 10 and 20-cm with the beam gating on and off for each energy
- Compare these readings to non-gated readings

TG-142: Dynamic/Virtual Wedges

TABLE IV. Dynamic/universal/virtual wedges.

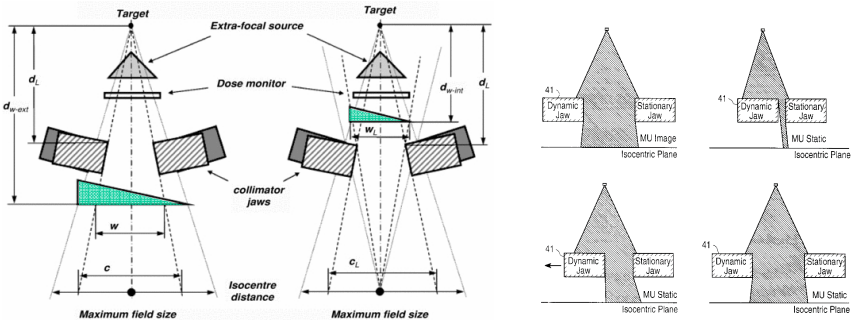
Dynamic-including EDW (Varian), virtual (Siemens), universal (Elekta) wedge quality assurance				
		Tolerance		
Frequency	Procedure	Dynamic	Universal	Virtual
Daily	Morning check-out run for one angle		Functional	
Monthly	Wedge factor for all energies	C.A. axis 45° or 60° WF (within 2%)[a]	C.A. axis 45° or 60° WF (within 2%)[a]	5% from unity, otherwise 2%
Annual	Check of wedge angle for 60°, full field and spot check for intermediate angle, field size	Check of off-center ratios @ 80% field width @ 10 cm to be within 2%		

[a]Recommendation to check 45° if angles other than 60° are used.

TG-142: Dynamic/Virtual Wedges

Daily	Morning check-out run for one angle
Monthly	Wedge factor for all energies
Annual	Check of wedge angle for 60°, full field and spot check for intermediate angle, field size

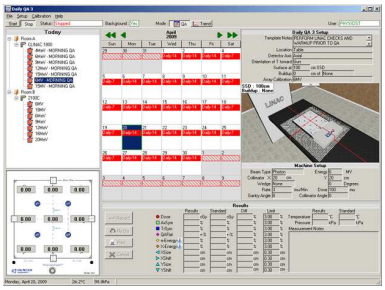
Physical **Virtual/Internal** **Dynamic**



TG-142: Dynamic/Virtual Wedges

Daily	Morning check-out run for one angle
Monthly	Wedge factor for all energies
Annual	Check of wedge angle for 60°, full field and spot check for intermediate angle, field size

- Include a 60-degree wedge angle on the morning QA routine
- Compare to baseline



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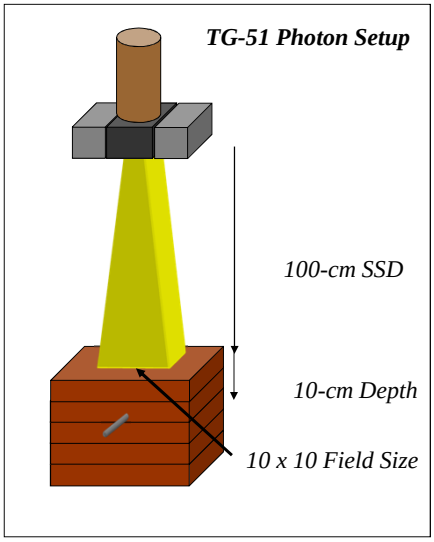
TG-142: Dynamic/Virtual Wedges

Daily	Morning check-out run for one angle
Monthly	Wedge factor for all energies
Annual	Check of wedge angle for 60°, full field and spot check for intermediate angle, field size

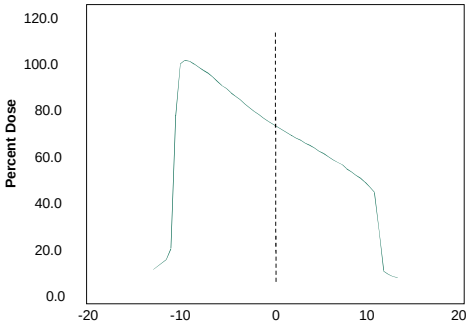
- Include a 60-degree wedge angle in the monthly TG-51 test for each beam energy
- Use the open 10x10 to calculate the wedge factor and compare against baseline



TG-142: Dynamic/Virtual Wedges

Daily	Morning check-out run for one angle
Monthly	Wedge factor for all energies
Annual	Check of wedge angle for 60°, full field and spot check for intermediate angle, field size

- Using a diode array, chamber array, or EPID, measure a 60 degree and a 30 degree wedge angle profile for a 20x20 field size
- Compare against baseline



TG-142: MLC

TABLE V. Multileaf collimation (with differentiation of IMRT vs non-IMRT machines).

Procedure	Tolerance
Weekly (IMRT machines)	
Qualitative test (i.e., matched segments, aka "picket fence")	Visual inspection for discernable deviations such as an increase in interleaf transmission
Monthly	
Setting vs radiation field for two patterns (non-IMRT)	2 mm
Backup diaphragm settings (Elekta only)	2 mm
Travel speed (IMRT)	Loss of leaf speed >0.5 cm/s
Leaf position accuracy (IMRT)	1 mm for leaf positions of an IMRT field for four cardinal gantry angles. (*Picket fence* test may be used, test depends on clinical planning-segment size)
Annually	
MLC transmission (average of leaf and interleaf transmission), all energies	±0.5% from baseline
Leaf position repeatability	±1.0 mm
MLC spoke shot	≤1.0 mm radius
Coincidence of light field and x-ray field (all energies)	±2.0 mm
Segmental IMRT (step and shoot) test	<0.35 cm max. error RMS, 95% of error counts <0.35 cm
Moving window IMRT (four cardinal gantry angles)	<0.35 cm max. error RMS, 95% of error counts <0.35 cm

We will cover these tests in a separate lecture

TG-142: Daily Imaging

TABLE VI. Imaging.

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

TG-142: Daily Imaging

Planar kV and MV (EPID) imaging

Collision interlocks

Positioning/repositioning

Imaging and treatment coordinate coincidence (single gantry angle)

Cone-beam CT (kV and MV)

Collision interlocks

Imaging and treatment coordinate coincidence

Positioning/repositioning

TG-142: Daily Imaging

Planar kV and MV (EPID) imaging

Collision interlocks

Positioning/repositioning

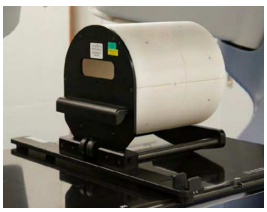
Imaging and treatment coordinate coincidence (single gantry angle)

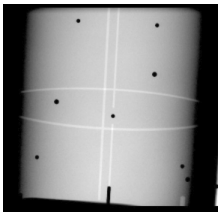
Cone-beam CT (kV and MV)

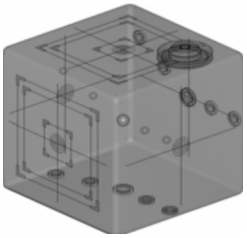
Collision interlocks

Imaging and treatment coordinate coincidence

Positioning/repositioning







TG-142: Monthly Imaging

TABLE VI. Imaging.

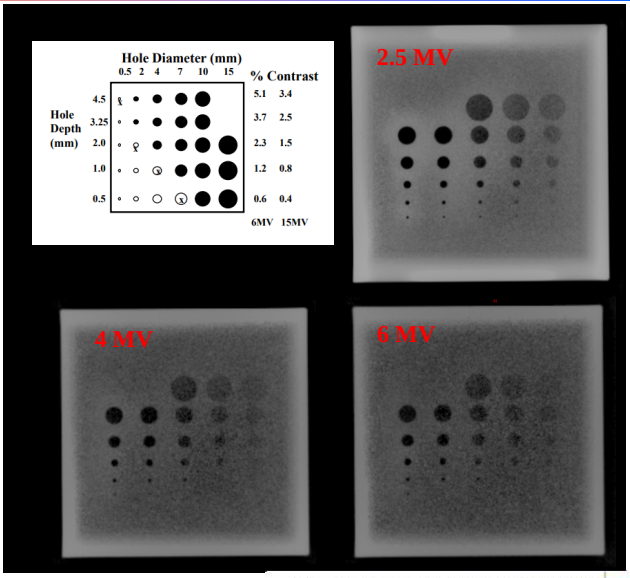
Procedure	Application-type tolerance non-SRS/SBRT	SRS/SBRT
Monthly		
Planar MV imaging (EPID)		
Imaging and treatment coordinate coincidence (four cardinal angles)	≤2 mm	≤1 mm
Scaling[b]	≤2 mm	≤2 mm
Spatial resolution	Baseline[c]	Baseline
Contrast	Baseline	Baseline
Uniformity and noise	Baseline	Baseline
Planar kV imaging[d]		
Imaging and treatment coordinate coincidence (four cardinal angles)	≤2 mm	≤1 mm
Scaling	≤2 mm	≤1 mm
Spatial resolution	Baseline	Baseline
Contrast	Baseline	Baseline
Uniformity and noise	Baseline	Baseline
Cone-beam CT (kV and MV)		
Geometric distortion	≤2 mm	≤1 mm
Spatial resolution	Baseline	Baseline
Contrast	Baseline	Baseline
HU constancy	Baseline	Baseline
Uniformity and noise	Baseline	Baseline

TG-142: Monthly Imaging

Planar MV imaging (EPID)
Imaging and treatment coordinate coincidence (four cardinal angles)
Scaling[b]
Spatial resolution
Contrast
Uniformity and noise

Planar kV imaging[d]
Imaging and treatment coordinate coincidence (four cardinal angles)
Scaling
Spatial resolution
Contrast
Uniformity and noise

Cone-beam CT (kV and MV)
Geometric distortion
Spatial resolution
Contrast
HU constancy
Uniformity and noise



TG-142: Monthly Imaging

Planar MV imaging (EPID)

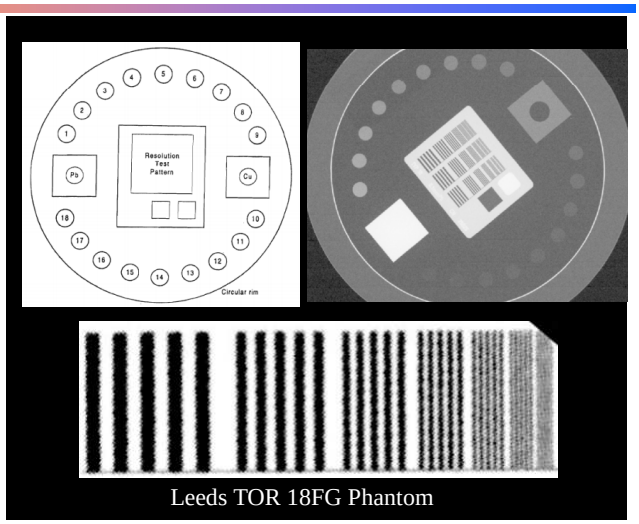
Imaging and treatment coordinate coincidence (four cardinal angles)
Scaling[b]
Spatial resolution
Contrast
Uniformity and noise

Planar kV imaging[d]

Imaging and treatment coordinate coincidence (four cardinal angles)
Scaling
Spatial resolution
Contrast
Uniformity and noise

Cone-beam CT (kV and MV)

Geometric distortion
Spatial resolution
Contrast
HU constancy
Uniformity and noise



Leeds TOR 18FG Phantom

TG-142: Monthly Imaging

Planar MV imaging (EPID)

Imaging and treatment coordinate coincidence (four cardinal angles)
Scaling[b]
Spatial resolution
Contrast
Uniformity and noise

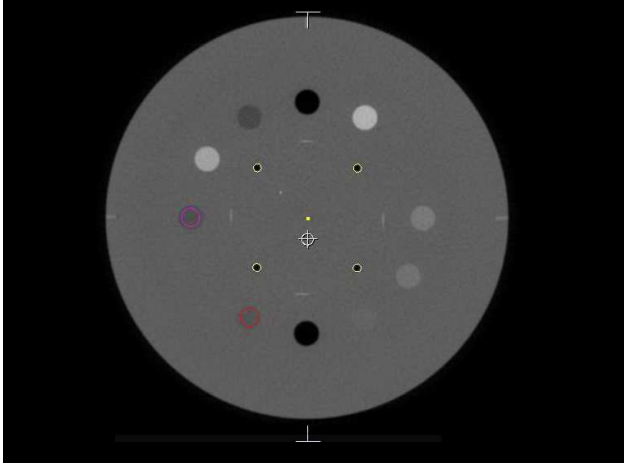
Planar kV imaging[d]

Imaging and treatment coordinate coincidence (four cardinal angles)
Scaling
Spatial resolution
Contrast
Uniformity and noise

Cone-beam CT (kV and MV)

Geometric distortion
Spatial resolution
Contrast
HU constancy
Uniformity and noise

Low Contrast Resolution



TG-142: Monthly Imaging

Planar MV imaging (EPID)

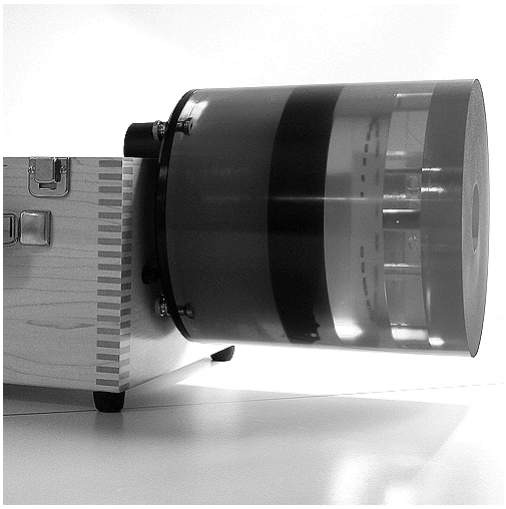
Imaging and treatment coordinate coincidence (four cardinal angles)
Scaling[b]
Spatial resolution
Contrast
Uniformity and noise

Planar kV imaging[d]

Imaging and treatment coordinate coincidence (four cardinal angles)
Scaling
Spatial resolution
Contrast
Uniformity and noise

Cone-beam CT (kV and MV)

Geometric distortion
Spatial resolution
Contrast
HU constancy
Uniformity and noise



TG-142: Monthly Imaging

Planar MV imaging (EPID)

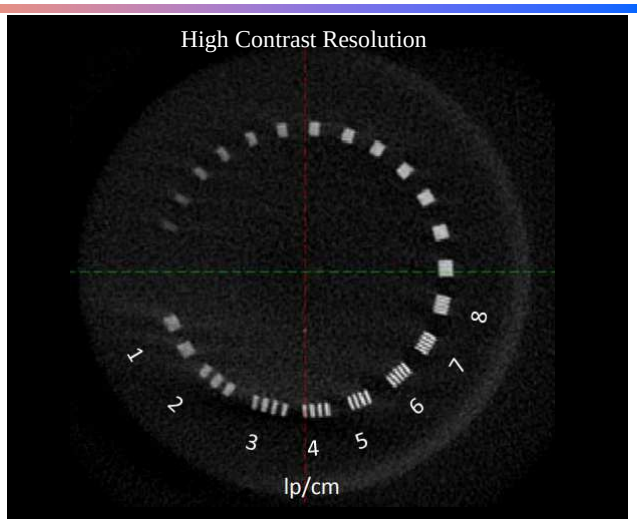
Imaging and treatment coordinate coincidence (four cardinal angles)
Scaling[b]
Spatial resolution
Contrast
Uniformity and noise

Planar kV imaging[d]

Imaging and treatment coordinate coincidence (four cardinal angles)
Scaling
Spatial resolution
Contrast
Uniformity and noise

Cone-beam CT (kV and MV)

Geometric distortion
Spatial resolution
Contrast
HU constancy
Uniformity and noise



TG-142: Monthly Imaging

Planar MV imaging (EPID)

Imaging and treatment coordinate coincidence (four cardinal angles)
Scaling[b]
Spatial resolution
Contrast
Uniformity and noise

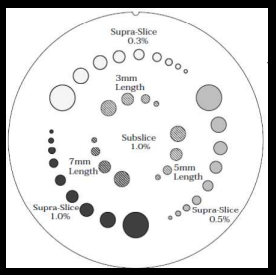
Planar kV imaging[d]

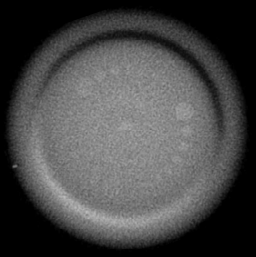
Imaging and treatment coordinate coincidence (four cardinal angles)
Scaling
Spatial resolution
Contrast
Uniformity and noise

Cone-beam CT (kV and MV)

Geometric distortion
Spatial resolution
Contrast
HU constancy
Uniformity and noise

Low Contrast Resolution





TG-142: Monthly Imaging

Planar MV imaging (EPID)

Imaging and treatment coordinate coincidence (four cardinal angles)
Scaling[b]
Spatial resolution
Contrast
Uniformity and noise

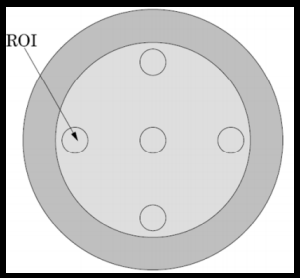
Planar kV imaging[d]

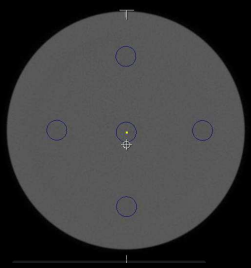
Imaging and treatment coordinate coincidence (four cardinal angles)
Scaling
Spatial resolution
Contrast
Uniformity and noise

Cone-beam CT (kV and MV)

Geometric distortion
Spatial resolution
Contrast
HU constancy
Uniformity and noise

Uniformity and Noise





Spatial Uniformity = (CT#max- CT#min)/10
Noise = (σ * CS * 100) / μw

Questions

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

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TG-142 vs TG-40

Annual		
	TG-40	TG-142 changes
Dosimetry		
x-ray/electron output calibration constancy	2%	+,- 1%
Field size dependence of x-ray output constancy	2%	Spot check 2 or more FS
Output factor constancy for electron applicators	2%	Combination of energies & applicators (i.e.,Varian -5)
Central axis parameter constancy (PDD, TAR)	2%	± 1% for TG-51 purpose
Off-axis factor constancy	2%	± 1% from baseline
Wedge transmission factor constancy	2%	Unique for wedge systems
Monitor chamber linearity	2%	Unique for delivery system
x-ray output constancy vs gantry angle	1%	± 1% from baseline
Electron output constancy vs gantry angle	2%	
Off-axis factor constancy vs gantry angle	2%	

TG-142: Annual Imaging

TABLE VI. Imaging.

Procedure	Application-type tolerance: non-SRS/SBRT	Application-type tolerance: SRS/SBRT
Annual (A)		
Planar MV imaging (EPID)		
Full range of travel SDD	±5 mm	±5 mm
Imaging dose[c]	Baseline	Baseline
Planar kV imaging		
Beam quality/energy	Baseline	Baseline
Imaging dose	Baseline	Baseline
Cone-beam CT (kV and MV)		
Imaging dose	Baseline	Baseline

Questions

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