HACKETTSTOWN REGIONAL MEDICAL CENTER
JOAN KNECHEL CANCER CENTER
ANNUAL QA – LINEAR ACCELERATOR

==========

Effective Date: August 2006	**Policy No: ROC QA 02**
Cross Referenced:	**Origin: Radiation Oncology**
Reviewed Date: 5/09, 12/11, 11/12, 6/14	**Authority: Medical Physicist**
Revised Date: 5/09, 6/14	**Page: 1of 8**

==========

SCOPE:
Department of Radiation Oncology, Medical Physics

DEFINITIONS:

Qualified Medical Physicist - A board certified medical physicist who is qualified to perform QA procedures for linear accelerators and treatment simulators and is registered as such in New Jersey State.
Isocenter – a point of intersection of the collimator axis and the gantry axis of rotation.

Monitor Unit (MU) – a unit of measurement of machine output of a linear accelerator.

PURPOSE

To meet all State, Federal regulatory and accrediting agencies' accuracy and safety requirements.

POLICY

Qualified Medical Physicist is responsible for determining corrective action necessary, performing such corrective action and documenting corrective action. If an outside consultant performs the annual calibration, the Qualified Medical Physicist is responsible for addressing all findings of the annual report that are out of tolerance. Tolerances quoted are as per AAPM TG40, Values in parentheses represent action levels at HRMC. All data for the mechanical & safety checks are summarized in the Treatment Machine QA report.

PROCEDURE

1. The Qualified Medical Physicist to perform tests annually and report findings on appropriate form.
2. Any items out of tolerance are to be noted and the Director of the Cancer Center is to be notified as soon as possible.

REPORTING FORMS
"Annual Calibration Test Results 200# Machine Name"

A. Mechanical Tests

1. Mechanical Isocenter Variation with Rotation

Procedure:
Collimator: the projection of the crosshairs is marked at collimator angles of 0°, 90°, and 270° at 100cm or on the floor. Record the diameter of the smallest circle, which includes all the crosshair projections de-magnified to the isocenter.

Gantry: The movement of the mechanical isocenter is determined by attaching the front pointer assembly and shimming the assembly to obtain the least movement when rotating the collimator through 180°. Then mark the position of the end of the pointer every 45° on graph paper secured to the table top. Record the diameter of the smallest circle, which includes all the pointer positions.

Couch: Setup IsoAlign device at 100cm. Center crosshairs on scribed crosshairs on device. Rotate couch 90 in either direction about zero using scribed marks on IsoAlign. Record digital couch reading

Tolerance: 2mm diameter

Corrective Action:
Qualified Medical Physicist to call service to recalibrate prior to any patient treatment.

2. Light Field Alignment and Symmetric Jaw Readout Calibration

Procedure:
Align graph paper or IsoAlign with Crosshairs at collimator angle = 0°, 100cm from the source. Adjust the collimators to match several field sizes covering the clinical range. Record the digital readout. Do this for the upper and lower jaws.

Tolerance: 2mm

Corrective Action: Qualified Medical Physicist to recalibrate field size, or call service engineer to recalibrate prior to any patient treatment.

3. Collimator Readout Calibration

Procedure:
Rotate the gantry to 90° or 270°. Place a level on the interface mount or on the accessory mount and obtain the true collimator angle. Check the digital and mechanical readout for the indicated collimator angles.

Tolerance: 1.0°

Corrective Action:
Qualified Medical Physicist to recalibrate collimator angle, or call service to recalibrate prior to any patient treatment.

4. Gantry Angle Indicator

Procedure:
Place a level on the interface mount or on the accessory mount and obtain the true angle for the four orthogonal gantry angles. Check the digital readout.

Note: For machines that treat patients at extended distances, e.g. 130 cm, a 0.5° gantry misalignment will appear as a 0.26cm translation of the isocenter (30cm x tan 0.5°). The calibration of the gantry angel at 0° and 180° should be more stringent, when possible, for these machines.

Tolerance: 1.0°

Corrective Action: Qualified Medical Physicist to recalibrate gantry angle, or call service to recalibrate prior to any patient treatment.

5. Patient Treatment Couch Mechanical Motions

Procedure: Setup IsoAlign device at 100cm. Device should be set up with the rotation axis along the long axis off couch (aligned in radial direction). Known displacements are made in the lateral, longitudinal and vertical directions using the scribed makers on the IsoAlign device. The digital readout is noted. Alternatively check the whole range of travel against an independent tape measure.
Tolerance: 2mm
Corrective Action: Qualified Medical Physicist to recalibrate couch along that particular axis or call service engineer to recalibrate prior to any patient treatment.

6. ODI

Procedure: With IsoAlign still in place, turn on ODI take reading at surface for 100 SSD. Position IsoAlign block on surface of device, read ODI on top surface of block for 90 SSD reading. Remove block, rotate IsoAlign surface out of the way and place block into lower spot. Read ODI on block surface for 110 SSD reading. Reading at 95cm and 105cm can also be performed with the block.
Tolerance: 2mm
Corrective Action: Qualified Medical Physicist to recalibrate ODI, or call service to recalibrate prior to any patient treatment.

7. Light Field and Radiation Field Coincidence

Procedure: Place film at 100cm SFD on leveled surface. Set fields using specified collimator settings. Score the 50% edge and crosshairs. Insert graticule tray. Record deviation of light field from radiation field for each jaw at 10 and 20 cm setting.
Tolerance: greater of 2mm or 1%
Corrective Action: Qualified Medical Physicist to call service engineer to recalibrate prior to any patient treatment.

B. Radiation Isocenter Test.

1. Collimator Rotation Checks

Procedure: Attach the front pointer and mark with a pin the mechanical isocenter on a sheet of ready pack film. A "star" pattern exposure is created on the film by repeatedly irradiating a film perpendicular to the central axis of the beam using a slit radiation field (0.4 cm wide). The collimator is rotated 30 degrees between each of the six exposures. Draw the centerlines of these fields. Measure the diameter of the smallest circle that intersects all the centerlines. Record the deviation of the radiation and mechanical isocenters, i.e., the center of the circle with respect to the pinhole.
Tolerance: 2mm diameter
Corrective Action: Qualified Medical Physicist to call service engineer to recalibrate prior to any patient treatment.

2. Gantry Rotation Checks

Procedure: Attach the front pointer and mark with a pin the mechanical isocenter on a sheet of ready pack film. A "star" pattern exposure is created on the film by repeatedly irradiating a film perpendicular to the central axis of the beam using a slit radiation field (0.4 cm wide). The collimator is rotated 30 degrees between each of the six exposures. Draw the centerlines of these fields. Measure the diameter of the smallest circle that intersects all the centerlines. Record the deviation of the radiation and mechanical isocenters, i.e., the center of the circle with respect to the pinhole.
Tolerance: 2mm diameter
Corrective Action: Qualified Medical Physicist to call service engineer to recalibrate prior to any patient treatment.

3. Table Rotation Checks

Procedure: Attach the front pointer and mark with a pin the mechanical isocenter on a sheet of ready pack film. A "star" pattern exposure is created on the film by repeatedly irradiating a film perpendicular to the central axis of the beam using a slit radiation field (0.4 cm wide). The couch is rotated 30-45 degrees between each of 5-6 exposures. Draw the centerlines of these fields. Measure the diameter of the smallest circle that intersects all the centerlines. Record the deviation of the radiation and mechanical isocenters, i.e., the center of the circle with respect to the pinhole.
Tolerance: 2mm diameter
Corrective Action: Qualified Medical Physicist to call service engineer to recalibrate prior to any patient treatment.

C. Photon & Electron Beam Performance.

Note: All tests in Section C were performed using a Scanditronix Wellhofer or other water phantom scanning system.

1. Field Flatness Constancy

Procedure:
Beam flatness photons & electrons can be measured with any of the following methods:

1) With an ion chamber in a water tank
2) With film
3) With the Profiler (diode array)

Record the average flatness (use Wellhofer Protocol 1). Plot all curves. Compare with clinical data from commissioning.

Tolerance: 2% Photons 3% Electrons

Corrective Action: Qualified Medical Physicist to call service engineer to recalibrate prior to any patient treatment.

2. Field Symmetry

Procedure:
Beam Symmetry for photons and electrons can be measured with any of the following methods:

1) With an ion chamber in a watery tank
2) With film
3) With the Profiler (diode array)

Record the average symmetry (use Wellhofer Protocol 1). Plot all curves. Compare with clinical data from commissioning.

Tolerance: 3%

Corrective Action:
Qualified Medical Physicist to call service engineer to recalibrate prior to any patient treatment.

3. Beam energy/ Central axis Parameter

Procedure:
Measure doses with an ion chamber on the central axis in a water phantom for photons & electrons. Record the depth of d_{max} and d_{10}. Compare with clinical data from commissioning.

Tolerance: 2%

Corrective Action: Qualified Medical Physicist to call service engineer to recalibrate prior to any patient treatment.

4. Relative Output Factors Constancy

Tolerance: 2%

Corrective Action:
Qualified Medical Physicist to call service engineer to recalibrate prior to any patient

treatment.

5. Accessory Transmission Factors

Procedure: Measure doses with an ion chamber at depth on the central axis in a water phantom for all wedges and blocking tray. Normalize data to a 10x10 field size. Compare with clinical data from commissioning.
Tolerance: 2%
Corrective Action: Qualified Medical Physicist to inspect accessory and recheck measurements. If still out of tolerance Qualified Medical Physicists to call service engineer to check accessory prior to any patient treatment.

D. Dosimetry

1. Short Term Reproducibility with MU Setting

Procedure: Measure doses with an ion chamber at depth on the central axis in a water phantom (or in Solid Water) for photons & electrons. Record the readings for 100MU for all energies. Repeat measurements > 2 hours later. Compare values. Alternatively, the reproducibility of the monitor system is assessed by determining the coefficient of variation (relative standard deviation) of measured output for four sequential 100 MU runs.
Tolerance: 2%
Corrective Action: Qualified Medical Physicist to call service engineer to retune beams. Qualified Medical Physicist to recheck prior to any patient treatment.

2. Reproducibility with Rep Rate

Procedure: Measure doses with an ion chamber at depth on the central axis in a water phantom (or in Poly) for photons & electrons. Record the readings for 100MU for all energies. Repeat measurements for clinically used range of Rep rates. Normalize to readings at default clinical Rep rate and compare values.
Tolerance: 3%
Corrective Action: Qualified Medical Physicist to call service engineer to retune beams. Qualified Medical Physicist to recheck prior to any patient treatment.

3. Reproducibility with Gantry Angle

Procedure: With Gantry at 0°, measure doses with an ion chamber on the central axis in a water phantom for photons & electrons for 100 MU given. Repeat at 90°, 270° and 180°. Compare with data at 0°.
Tolerance: 2%
Corrective Action: Qualified Medical Physicist to call service engineer to retune beams. Qualified Medical Physicist to recheck prior to any patient treatment.

4. Dose Linearity/MU setting

Procedure: The linearity of the monitor system is assessed using an ion chamber in full phantom on the central axis of a 10x10 field for a representative clinical range of MU settings. The results normalized to the number of monitor unites used for routine calibration, 100 MU, are calculated and compared.
Tolerance: 2%
Corrective Action: Qualified Medical Physicist to call service engineer to retune beams. Qualified Medical Physicist to recheck prior to any patient treatment.

5. Arc Mode

Procedure:
Tolerance: Greater of 3% or 1MU, arcs 45 ° to 89° Greater of 2% or 1MU, arcs $\geq$ 90° Dose 2% of the static dose meas. At 0°
Corrective Action: Qualified Medical Physicist to call service engineer to recalibrate beams. Qualified Medical Physicist to recheck prior to any patient treatment.

6. Off-axis Factor Constancy vs. Gantry Angle.

Procedure: For photons, irradiate Kodak-V films at 90°, 0°, 180°, and 270° gantry angles. Setup source to Axis Distance 100 SAD, Field size 25x 25 cm, Collimator Angle 0°, Depth Dmax. Compare asymmetry at all angles. Alternatively, mount the Profiler to the head of the machine.
Tolerance: 2 %
Corrective Action: Qualified Medical Physicist to call service engineer to recalibrate beams. Qualified Medical Physicist to recheck prior to any patient treatment.

E. TG51 Calibration K_{SW} determination and Annual Calibration of Daily QA device.

1. TG51 Calibration

Procedure: Follow TG51 procedures to measure doses with a waterproofed ion chamber at depth on the central axis in water phantom for photons & electrons. Determine beam quality k_q (Photons) or k_{ecal} k'_{R50} (electrons), Temp/pressure correction P_{TP}, Polarity Correction P_{pol}, Ionization Correction P_{ion}, Gradient correction P^{Q}_{gr} (electrons only), and finally Dose/MU at d_{max}.
Tolerance: N/A
Corrective Action: none

2. K_{SW} determination

Procedure: Immediately after TG51 Calibration in water, measure doses with the same ion chamber at depth on central axis in a solid water phantom for photons & electrons. Record the readings for 100MU for all energies. Calculate the value of K_{SW} using the known output in water from TG51 calibration. New values of K_{SW} to be entered into Monthly calibration spreadsheets.
*Tolerance:*2% deviation from previous year
Corrective Action: Two Qualified Medical Physicists to check all parameters and repeat measurements.

3. Annual Calibration of Daily QA device

Procedure: Immediately after K_{SW} determination perform annual calibration of Daily QA device for that machine. For Daily QA_2 device follow procedure "Daily QA2 Morning Check Device Recalibrate QA Field Procedure".
Tolerance : N/A
Corrective Action: none

REFERENCES:

TG51 - AAPM "Protocol for Clinical Dosimetry of High-Energy Photon and Electron Beams", Medical Physics, Vol.26, Issue 9, 1999