

LSUHSC-Shreveport  
Radiation Oncology  
Proc.19.9

# **THE EQUIPMENT CONTROL PROGRAM**

Louisiana State University Health Science Center  
Shreveport, LA  
Department of Radiation Oncology 2006

Prepared by:  
John Chang, Ph.D., Medical Physicist  
Barbara Nikfar, RT(R)(T) CMD

TABLE OF CONTENTS

Introduction .....	3
Quality Assurance, A Team Effort .....	4
Role of personnel Involved in the QA Program .....	5
Performance Evaluation of Treatment Equipment.....	6
Quality Assurance Tests .....	8
Notes on Different QA Tests .....	10
References	

## **Introduction**

The treatment of cancer patients is a multidisciplinary effort involving surgery, chemotherapy, immunotherapy, cryosurgery, hyperthermia therapy, and radiation. In the Radiation Oncology Department, certain quantity of radiation is given either once or over a period of time in several fractions. Precisely administered radiation treatments are a basic requisite to achieving an optimum balance between the maximum probability of cure and an accepted level of complications.

In view of this, an effective quality assurance (QA) program in Radiation Oncology is essential. Such a program establishes criteria for optimum machine performance, monitors adherence to established criteria, ensures accuracy of dose delivered, enhances communication between Radiation Oncologists, Surgeons, Physicists, Dosimetrists, Therapist and Technologists, and minimizes machine down time. A formal quality assurance program has been in effect at the LSUHSC in Shreveport, LA.

This department has one linear accelerator (Elekta 6 & 18 MV), Philips CT Simulator, Gamma Knife, HDR and brachytherapy sources (Cs-137).

### **QUALITY ASSURANCE, A TEAM EFFORT**

In the Radiation Oncology Department, the task of treating patients with radiation is carried out by a team consisting of:

- Radiation Oncologists
- Medical Physicist
- Dosimetrist
- Radiation Therapist
- Radiology Technologist
- Nurses
- Maintenance Technicians
- And sometimes surgeons

**ROLE OF PERSONNEL INVOLVED IN THE QA PROGRAM**

The Radiation Oncologist in charge of a patient conducts the examination, prescribes an optimal radiation regimen, supervises planning and delivery of dose, watches the progress of the patient during therapy and the effects that any modification of treatment regimen maybe warranted , and the conclusion of the course, reviews the efficacy of therapy through follow-up examination(s). Following the therapist's prescription of a treatment regimen, the physicist and dosimetrist proceeds to explore and work out a therapy plan that is optimal for treating the patient. After a proper treatment plan is approved by the Radiation Oncologist, the physicist and dosimetrist will send the machine parameters to the Record and Verify system (R&V). The accuracy of the patient set-up is confirmed by the Radiation Oncologist, Physicist and Therapist at the time before the first treatment of a new treatment field or modification of a field being treated. The Radiology Technologist is responsible for operation of CT simulation under the supervision of the Radiation Oncologist and also assist therapist with other related duties. The nurse also may assist the patient during transfer and assist the Radiation Oncologist during physical examinations. The service engineer has the job of assuring proper operation of radiation machines, preventive maintenance inspections and testing of equipment after service. The calibration of output and quality control of all the different radiation beams, under various conditions of use, is provided by the Medical Physicist. The Medical Physicist is responsible for standardizing equipment protocols according to State Regulations.

1. Performance Evaluation of Treatment Equipment

i) Elekta 6 & 18 MV Linear Accelerator

- a. Proper working condition of the machine and general safety checks are done by the technologist daily during warm up period. Beam constancy check at a reference point is done by the technologist daily at the end of warm up (tolerance 3%).
- b. Out-put check is done by ion chamber in water phantom once a month by the physicist (tolerance of dose/m.u. - +2%). In addition, laser beam alignment (tolerance 2 mm). Verification of optical distance indicator, emergency switch operation, door interlock, isocenter movements of the machine are checked by the physicists.
- c. X-ray and light beam coincidence are checked by the physicist once a month using x-ray film or Electron Portal Imaging Device (EPID). Tolerance: within 2 mm for a 10 cm x 10 cm field.
- d. symmetry and flatness will be checked using either water phantom, film, profiler, mapcheck, Thebs, etc.
- e. Detail dosimetry and performance evaluation is done by the physicist as listed or after any major part replacement in the machine.

Safety Check

-Performance and safety check are done by the technologist once a day during warm-up period. If suspect of any mechanical and/or electrical failure, maintenance contract engineer of the linear accelerator is contacted.

-Detail electrical and mechanical safety checks are done by the Accelerator Service Engineer as needed and not to exceed 3 months in their quarterly PMI.

CT Simulator

-Daily warm up procedures are performed along with a CT phantom. The technologist records daily values specified on warm-up sheet.

-Mechanical and Electrical Safety checks are done by the manufacturer's engineer as needed basis and at least once a year.

- Reproduction of patient Coordinate system as referenced in simulator and transferred to the treatment room. Tolerance 2 mm.

-Simulator system needs good image quality. The quality of the image is checked by the vendor technician as needed basis and at least quarterly.

Brachytherapy Sources

-Physical inventory of all brachytherapy services are done by the physicist every three months.

-Leak test of all sources are done by the physicist every six months.

-Each time any source is taken out from the safe for treatment and returned to the safe after treatments are logged by the nurse in charge with the supervision of the physicist. Inventory is again done.

-If radioactive seeds are used for treatment, the inventory is kept and the disposal information is logged by the nurse in charge and supervised by the physicist.

LSUHSC-Shreveport

Radiation Oncology

Proc.19.9

Storage Room

Storage room is surveyed biannually.

Radiation Safety

-Area survey of all radiation machines are done once a year by the physicist.

-Area survey of the radioactive material safe is done once a year by the physicist.

-Leak test of all radioactive materials are done once in every six months by the physicist.

-Personnel monitors (film badge) are provided by the safety office and permanent records are maintained in that office. A copy of monthly dose report for this department is also kept in Radiation Oncology and reviewed by the physicist once a month.

-Calibrations of survey meters are done by the safety office once in six months and records are kept in that office.

Radiation safety is done as per:

1. Louisiana Radiation Regulations, Department of Environmental Quality
2. NCRP Report 102: "Medical x-ray and gamma-ray protection for energies up to 10 MeV-Equipment design and use: (19 )
3. NCRP Report 40: "Protection against radiation from brachytherapy sources" (1972)
4. NCRP Report 49: "Structural shielding design and evaluation for medical use of x-rays and gamma rays of energies up to 10 MeV" (1976)
5. NCRP Report 51: "Radiation protection design guidelines for 0.1-100 MeV" (1976)
6. NCRP Report 59: "Operational radiation safety program" (1978)
7. NCRP Report 71: "Operational radiation safety-training"(1983)

**Quality Assurance Test**  
**Linear Accelerator**

<b>Frequency</b>	<b>Procedure</b>	<b>Tolerance</b>
<b>Daily</b>	Dosimetry	
	X-ray output constancy	3%
	Electron output constancy <sup>b</sup>	3%
	Mechanical	
	Localizing lasers	2mm
	Distance indicator (ODI)	2mm
	Collimator reading to optical light field dimension optical light field	2mm Isocenter of 2mm
	Safety	
	Door interlock	Functional
	Audiovisual monitor	Functional
	Radiation Detection Monitors	Functional
	Beam interrupt	Functional
	Treatment table PSA	Functional
	Warm-up procedures	Functional
<b>Monthly</b>	Dosimetry	
	X-ray output constancy <sup>c</sup>	2%
	Electron output constancy <sup>c</sup>	2%
	Backup monitor constancy	2%
	X-ray central axis dosimetry parameter (PDD,TAR) constancy	2%
	Electron central axis dosimetry parameter Constancy (PDD)	2mm therapeutic depth
	X-ray beam flatness constancy	2%
	Electron beam flatness constancy	3%
	X-ray and electron symmetry	3%
	Safety Interlocks	
	Emergency off switches	Functional
	Wedge, electron cone interlocks	Functional
	Collision interlocks on collimator, electron cone	Functional
	Mechanical checks	
	Light/radiation field coincidence	2mm or 1% on a side <sup>d</sup>
	Gantry/collimator angle indicators	1 degree
	Wedge position	2mm (or 2% change In transmission factor)
Tray Position	2mm	



LSUHSC-Shreveport  
 Radiation Oncology  
 Proc.19.9

Applicator position	2mm
Field size indicators	2mm
Cross-hair centering	2mm diameter
Treatment couch position indicators	2mm/1 degree
Latching of wedges, blocking tray	Functional
Jaw symmetry <sup>e</sup>	2mm
Field light intensity	Functional

**Annually**

Dosimetry

X-ray/electron output calibration constancy	2%
Field size dependency of x-ray output constancy	2%
Output factor constancy for electron applicators	2%
Central axis parameter constancy (PDD, TAR)	2%
Off-axis factor constancy	2%
Transmission factor constancy for all treatment accessories	2%
Wedge transmission factor constancy <sup>f</sup>	2%
Monitor chamber linearity	1%
X-ray output constancy vs gantry angle	2%
Electron output constancy vs gantry angle	2%
Arc mode	Mfrs. Specs

Safety Interlocks

Follow manufacturers test procedures	Functional
--------------------------------------	------------

Mechanical checks

Collimator rotation isocenter	2mm diameter
Gantry rotation isocenter	2mm diameter
Couch rotation isocenter	2mm diameter
Coincidence of collimetry, gantry, couch axes with isocenter	2mm diameter
Coincidence of radiation and mechanical isocenter	2mm diameter
Table top sag	2mm
Vertical travel of table	2mm
Opposing field displacement	2mm

<sup>b</sup> All electron energies need not be checked daily, but all electron energies are to be checked at least twice weekly

<sup>c</sup> A constancy check with a field instrument using temperature/pressure corrections.

<sup>d</sup> Which ever is greater, should also be check after change in light field source.

<sup>e</sup> Jaw symmetry is defined as difference in distance of each jaw from the isocenter

<sup>f</sup> Most wedges transmission factors are field size and depth dependent

**CT Simulator**

**Daily**

Localizing lasers	2mm
Distance indicator ( )	

## **Treatment Planning System**

Dose calculation of the treatment planning computer at the normalization point, be it isocenter or specific normalization point for every single field is double checked with a second calculation method; using either a hand calculation or another independent computer, for example: MUcheck. The agreement must be within specific number set in MUcheck. The result is printed out and included in the patient treatment chart.

### **NOTES ON DIFFERENT QA TESTS**

1. Audio Visual Equipment:  
Turn on the intercom and television equipment. Any variation in sound and view may indicate problems with movement of different parts during the test that follow. Proper operation of the audio-visual equipment is necessary for communicating with and watching the patient during treatment.
2. Start up:  
Follow the manufacturer's instructions for starting up each machine. Each of the steps in the warm-up sequence checks the functional status of some vital part of the complex circuitry in the machine. A regular review of these readings will help identify trends of performance of different part and may even alert the operator of developing malfunctions. A serious problem will have to be looked into and resolved by the physicist and/or service engineer.
3. Control Panel on Treatment Table:  
The couch, machine head and gantry are operated through an enable switch on the treatment table and independent pendent. These mechanisms combine the convenience of manipulation with the assurance that no movement of these three parts occurs accidentally. One has to be on guard against failure of the enable switch. Check the rotational movement of the gantry. Note if the motion is irregular. Also, similarly test the motion of the collimator rotation with proper pushbuttons to select the collimator rotation and using the lever on the machine head to rotate.
4. Accessories:  
An examination of accessories-filters, wedges, cones, shielding blocks, trays, adaptors, mounts, and cut-outs, etc. will reveal any dents, cracks and potential malfunctions.
5. Timer Shut Off:  
Termination of exposure at the end of MU settings proper operation of the MU1 and MU2 interlock. Next check the timer interlock, programmed another field with more MU than the time to deliver all the MU, see if the machine stops the treatment at the end of the time with some MU left un-deliver.
6. On/Off Indicator:

The ON/OFF indicator works properly and is luminated.

7. Laser:

There are three positioning lights; three laser beams on the walls. Ideally, these three beams intersect in a point that is used as the reference point (at SSD) during the patient set-up. This point should coincide with the point of intersection of the axes of rotation of the machine head and gantry. Also, the isocenters of both the light and radiation fields should coincide with this reference point. The diameter of the sphere of intersection of positioning lights should be no more than 4 mm.

8. 100 cm SSD Light:

It will be checked every day to ensure that the range light is illuminated and properly set-ups at 100 cm.

9. Collimator dial Reading 10 cm x 10; The Measured Field Size Dimension at 100 cm SSD:

The accuracy of collimator dial settings assures correct field dimensions. Both sides of the field at SSD should be measured, for a set field size. For daily check up the collimator setting will by 10 cm x 10 cm and SSD dial setting will be 100 cm. The deviation of 2 mm may be tolerated for each dimension.

10. Beam Interrupt:

To assure their proper operation, the “beam interrupt” on the machine should be checked individually. After the beam interrupt is activated, the machine can be restarted by a restart pushbutton. This test can be done during the warm-up testing, but it must be done at least quarterly.

11. Operation of Patient Table:

Check all movements of the patient table – upward and downward motion, left and right displacements, inward and outward movement of the table, and rotation of the carriage. Also, with the distance light on, mark a dot or a cross along the cross hair on a sheet of paper to represent the isocenter when the table top is at a 100 cm distance from the source. Then move the table vertically for 20-30 cm –downand and up, noting any displacement of the shadow of the cross hair from the mark. A displacement of more than 2 mm indicate that vertical movement of the carriage needs adjustment.

12. Isocenter of Radiation Field:

The position of isocenter of the radiation field can be checked by the “star pattern” radiograph method. A localization film is set upright to define a vertical plane through the isocenter. Collimators are closed to define a narrow beam. A sequence of a few rads exposure is made with the gantry oriented at 45, 90, 135, 180, 225, 270 and 315 degrees. On developing the film a star pattern appears with a small “circle” at the center. The film can be process in the VIDAR and RIT system. The analysis can be printed out for the record.

13. Isocenter of Optical Field:

The position of the optical field isocenter during rotation of gantry will be

checked with a small plate in which two mutually perpendicular axes are marked.

14. Radiation and Light Field Coincidence:

All patient set-ups are done with the help of the light field, which itself is assumed to be exactly coincident with the radiation field. However, because light fixture and mirror are not rigid and permanently fixed, this coincidence needs to be checked every now and then. With light field at 100 cm SSD, the center and boundary of the field can be delimited on the cover of a localization film with small pieces of thin metal wire, with fine pin point or drawing with a ball point pen. Depends on the film used, an exposure of a few MU for L film to 100 MU for V film is needed to yield the boundary of the radiation field. This can also be done with EPID and a few coins at the beam edges. A deviation of more than 2 mm at any point along either dimension will require adjustment.

15. Beam Output:

The rate of radiation exposure is another important number. Its constancy can be checked by measuring (a) the reading of an ionization chamber exposed within a Lucite block, in air, or in water and (b) the room temperature and pressure. A deviation of less than two percent may be tolerated.

16. Energy Check:

The energy check involved the measurements of the central axis depth dose in a phantom or water. The measurement involves taking ionization readings at two depths. For a photon beam, 10 and 20 cm depths are the recommended readings. A square field of side 10x10 cm is normally used for these measurements. The phantom may be a stack of Lucite slabs or a water tank. A variation in the output by more than three percent required a readjustment. It is necessary to keep a log of the energy response factor for the ion chamber used for calibration.

17. Field Symmetry:

The symmetry and flatness of a beam profile is a crucial characteristic. Film, water scanner, profiler, EPID, etc. can be used for a particular field size and beam profile will be drawn to evaluate symmetry and flatness. It is useful to conduct this test with a Linac engineer, so that symmetry adjustment can be done immediately. Beam flatness cannot be adjusted with this method, refer to #16 above to adjust the energy to adjust the flatness.

Written: Jan 2007

Reviewed: December 2008