QA/QC in the Digital Radiography Environment (part 1)

P.C. Berry, PhD, LANL
Hans Snyder, PhD, N-2 LANL
P. Heintz, PhD, Department of Radiology University of New Mexico

3 Rivers Technical Conference
18-19 August 2009
WHY THIS TOPIC?

• 1. Received a call from an engineer wanting to know how to measure the dose rate on his LINAC, and he believes that the energy is changing but does not know how to measure it. Is there a QA/QC process that I know of and what instrumentation is needed.


“The existing practice of quality assurance in medical imaging is problematic because of the subjective manner in which it is performed, the lack of community and industry-wide QA standards, a paucity of supporting technology, and an overall lack of accountability. QA is usually performed by the same tech who performed the image acquisition.”
WHY THIS TOPIC?

• 3. The Society for Imaging Informatics in Medicine, July 2009. “Ask the experts: Monitor characteristics, and general monitor questions.”


DISCLAIMER

REMEMBER,

- VERY LITTLE
- MATH!!!
OBJECTIVES

- Define QA/QC
- Define the DR Environment
- High energy machines
- Equipment
- Tests and one sample
- Questions
WHAT IS QA/QC?

• QUALITY ASSURANCE (QA):

   All plans and systematic actions necessary to provide adequate confidence that a structure, system, or component will perform satisfactorily in service. (International Organization for Standardization-ISO 1995)

• QUALITY CONTROL:

   The regulatory process through which the actual quality performance is measured, compared with existing standards and finally the actions necessary to keep or regain confidence with the standard. (International Organization for Standardization-ISO 1995)

   The normal radiation safety checks are not part of the quality control.
WHAT IS CQI?

• CONTINUOUS QUALITY IMPROVEMENT:
  
  Documentation of the results of the quality assurance program.

• Actions taken whenever the results are outside of the stated tolerance.
OLD IMAGING ENVIRONMENT

X-Ray Source

FILM
one shot only

VIEWBOX
IMAGING ENVIRONMENT

X-Ray Source

PART 1

“BLACK HOLE”

DETECTORS reused

PART 2

IMAGE PROCESSING

PART 3

DISPLAY MONITORS

PARTS 1&2
BLACK HOLE - DETECTORS

• TYPES:
  CR
  DR
    DIRECT
    INDIRECT
  CCD
  CMOS
  DIGITIZED X-RAY FILM
IMAGING ENVIRONMENT

X-Ray Source

PART 1

“BLACK HOLE”

DETECTORS

PART 2

IMAGE PROCESSING

PART 3

DISPLAY MONITORS

PARTS 1&2
WHY A SECTION ON IMAGE PROCESSING?

"Your x-ray showed a broken rib, but we fixed it with Photoshop."
Requirements of a Quality System

- Clear definition of responsibilities
- Documented procedures
- Accurate record keeping
- Control of system failures
- Internal audit procedures
- Training needs
WHY ARE WE DOING THE LINAC?

STARTING POINT FOR THE IMAGING PROCESS

LAST CHANCE TO INSURE THAT YOU HAVE THE BEST POSSIBLE PHYSICS PARAMETERS FROM THE LINAC INTERACTING WITH THE PART BEFORE ENTERING THE VIRTUAL WORLD.
WHY ARE WE DOING THE LI NAC?

Dose rate of the LI NAC can be between 250-15,000 rad/ min@ 1 meter.

Major contribution of dose is to the object, only 1 -3% exits the object.

Panel is reused thereby receiving a dose

Energy response of the detector is different from film (changing spectrum)

Need to monitor x-ray uniformity and flatness to insure image quality
WHO PERFORMS THE TESTS?

(Each subset may have different personnel)
WHO PERFORMS THE TESTS ON THE HIGH ENERGY MACHINES?
ASNT LEVEL I or LEVEL II
(RADIOGRAPHER)
ASNT LEVEL III (RADIOGRAPHER)
RADI OLOGI CAL PHYSICI ST

- Where is the water phantom?
- Here comes Dr. Berry, QUICK, hide the water phantom!!
HIGH ENERGY X-RAY SOURCES

BRIEF TUTORIAL ON LINEAR ACCELERATORS, MICROTRON and BETATRON
DIFFERENCE BETWEEN A LOW ENERGY AND HIGH ENERGY SOURCE
DIFFERENCE BETWEEN A LOW ENERGY AND HIGH ENERGY SOURCE
LINEAR ACCELERATOR

Source of electrons

Means of accelerating the electrons

Means of focusing on the target

TARGET

X-RAYS
Diagram of Linear Accelerator

- Electron Gun
- Modulator
- Power Supply
- Magnetron or Klystron
- Wave Guide System
- Accelerator Tube
- Bending Magnet
- Treatment Head (Straight Beam)
- Treatment Head (Bent Beam)
LINEAR ACCELERATOR

- Courtesy of Varian Medical System
MICROTRON

Source of electrons

Means of accelerating the electrons

Means of focusing on the target

TARGET

X-RAYS
MICROTRON
MICROTRON

- View from target towards electron exiting position
MICROTRON

- View from magnet looking towards the target
MICROTROTON

- Front view of the microtron

COLLIMATOR
BETATRON
TESTS TO BE PERFORMED

ACCEPTANCE: Baseline

Manufacturer and customer perform the tests jointly

QUALITY CONTROL (specific frequency)

Performed by the User

Testing Interval: semi-annual unless a major component has to be replaced or a software updating.

Diagnosis of change in performance before radiologically apparent

Verification of corrective action
ACCEPTANCE TESTS

- Radiation output (dose calibrated at a specific distance and collimator setting or cone size)
- Beam flatness and symmetry
- Machine ion chamber linearity
- X-ray beam spectrum
- Beam stability
- Focal spot size
- Beam energy verification
QC tests

- **NOTE: These are our recommendations.**

- Radiation output

- Ion chamber uniformity

- Flatness and symmetry

- Energy check
QC tests

Why these tests:

1. In the digital environment we will need to know the dose to the digital panel so that degradation and a “dead panel” statistics can be gathered.
   At what approximate dose did your panel die?

2. Some components in an object are radiosensitive so that the dose has to be tracked.

3. To perform calculations, we have to know that what is read out is really what was given.

4. A stable and uniform beam is preferred to doing “software” manipulations.

5. A method of monitoring the internal components.
EQUIPMENT FOR THE LINEAR ACCELERATOR TESTS
- Can be used for flatness/symmetry measurement
High Energy Panel

- Can be used for flatness/symmetry measurement
EQUIPMENT (TLDs and Ion Chambers)

- Ion chamber with various build-up caps
EQUIPMENT (ELECTROMETER)

- ELECTROMETER used with the various Ion chambers and build-up caps
  Used for any quantitative measurement
EQUIPMENT (ION CHAMBER w/ Electrometer)

- RADCAL 9015 can be used for output checks
The Profiler can be used for flatness/symmetry measurements.
EQUIPMENT (WATER PHANTOM)
EXAMPLE: OUTPUT CHECK

- **EQUIPMENT:** ion chamber with appropriate build-up cap, and electrometer, barometer, thermometer

- **Procedure:**
  1. Choose collimator setting to define output (10cm X 10 cm, 2 degree cone etc.)
  2. Set the source to detector distance (100 cm to the front of the build-up cap)
  3. Record the pressure and temperature
  4. Attach the ion chamber to the electrometer and allow it to warm-up.
  5. Once it is warmed-up zero the electrometer.
  6. Either set an appropriate time (1 minute) or number of rads (200 rads)
  7. Turn on the radiation and obtain three readings.
OUTPUT CHECK

8. Average the three readings and record the time.

9. If the electrometer reads (nC), take the average reading multiply it by the calibration factor (for both the ion chamber and electrometer), and the temperature-pressure correction factor and divide it by the time.

10. This will give rads/ min or rads/ sec depending on the units for time.
OUTPUT CHECK (SAMPLE FORM)

Temp__ °C + 273 = _____ K (a)
Pressure = _____ mmHg (b) H (t-p) = (a/295)* (760/b) (c)

Instrumentation Used
Chamber__________  SN__________  N=__________
Electrometer__________ SN_________ Bias Voltage
Field size (Cone)=__________ cm x __________ cm
Source Surface Distance ________________ cm
Time (min):
   AVERAGE (d)

__________________  ____________________  ________________  ________________  

Electrometer (nC)  AVERAGE (e)
__________________  ____________________  

NOTE: N is the ion chamber and electrometer calibration factor
OUTPUT CHECK (SAMPLE FORM)

OUTPUT rad/ min) = (e/ d)* ( c ) * N

REMEMBER: This is only for the field size calibrated
DISPLAY QA/ QC
DISPLAY
The American Association of Physicists in Medicine (AAPM) has done a lot of research in this area.

**TASK GROUPS HAVE BEEN CHARTERED TO PROVIDE GUIDELINES**

The American College of Radiology is updating the guidelines.

The Society for Imaging Informatics in Medicine continues to publish articles in the "Ask the Expert" section.
DISPLAY QA/ QC

http://deckard.duhs.duke.edu/~samei/tg18.htm (This has the procedures and images that are needed)


e-mail me (pberry@lanl.gov) for power point presentation from Argentina conference and additional articles on the subject.
MONITOR ISSUES: QUESTIONS ASKED

- CRT vs. LCD
- How many Mpx
- What about the contrast ratio?
- How many bits 8, 10, or 16?
- Monochrome LCD or color LCD?
- Consumer grade or medical grade display
- What about PDAs?
- What about ambient conditions
- Do displays need testing?

Courtesy of E. Samei
GREAT NEWS

RSNA 2009 will showcase: READING ROOM OF THE FUTURE

NOT A PRODUCT PROMOTION BUT WILL SHOWCASE PRODUCTS THAT INTEGRATE QUANTITATIVE ANALYSIS INTO THE IMAGE INTERPRETATION PROCESS.
Well, that’s all that there is for QA/QC part 1. ANY QUESTIONS?
“I need someone well versed in the art of torture—do you know PowerPoint?”