IMRT dose verification Phantom

- **Simultaneous acquisition of absolute, relative and point dose measurements.**
- **Intuitive, easy set-up and visualization for fast confirmation of TPS.**
- **Easy measurement at multiple points and planes, with layered phantom slabs for 3D patient simulation.**
- **For both IMRT commissioning and routine dose verification, for comprehensive evaluation of the entire IMRT process.**

Gain confidence in the accuracy of treatment plans and help improve patient outcome by 3D evaluation of:

- ▶ High and low dose gradient areas
- ▶ Dose distributions to sensitive regions
- ▶ Inhomogeneity structures

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Please contact Colin Walters
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Features and Benefits

ABSOLUTE DOSE
- Make absolute measurements of dose at various depths in up to 16 positions throughout the phantom with standard thimble ion chambers.

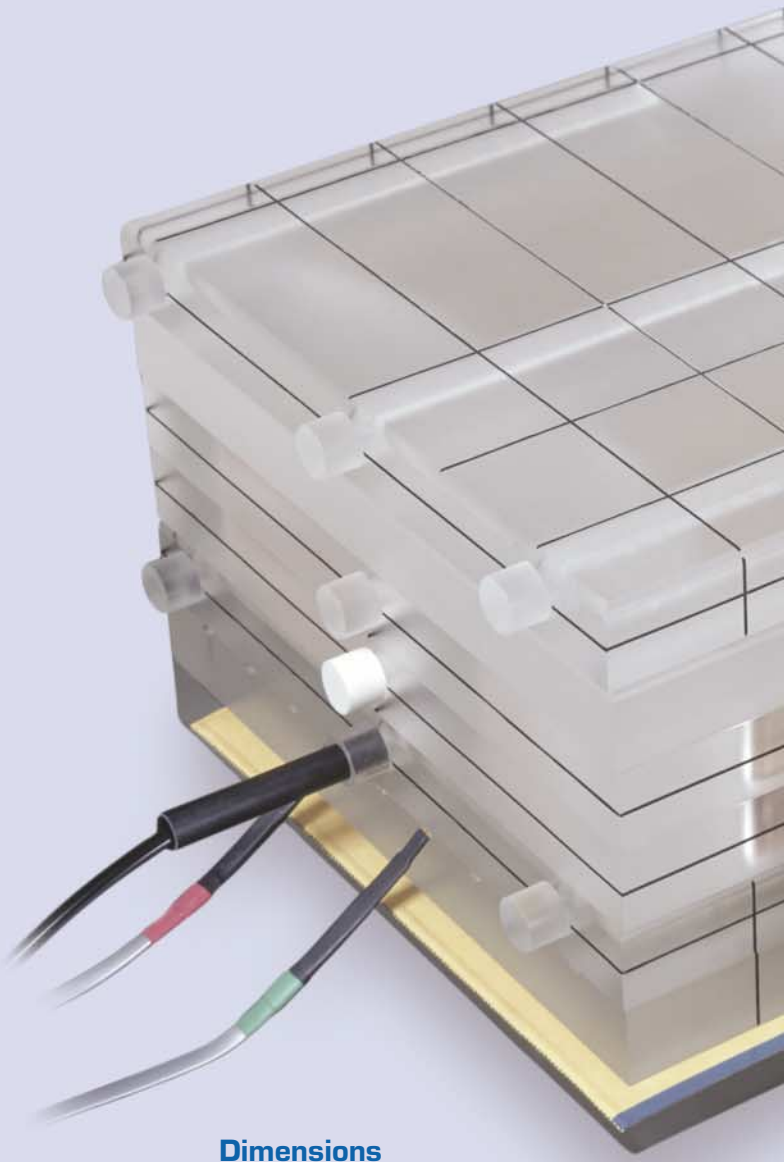
RELATIVE DOSE
- Make relative dose (fluence dose) measurements using ready pack or radiochromic film placed every 3 cm.
- Easily compare film to TPS in 3D using four reference marker points in acrylic Phantom Slab. Reference marker points facilitate orientation of film, digital reconstruction and transfer of multiple coronal film views to 3D sagital and transverse images.

POINT DOSE
- Make point dose measurements in any position in the phantom using MOSFET diodes or TLDs. Point dose measurements are critical when evaluating dose to sensitive structures.

SIMULTANEOUS MEASUREMENT
- Make all three dose measurements simultaneously with one set up and one treatment, saving time.
- Coronal film placement allows simultaneous ion chamber and film use since the planes are parallel.

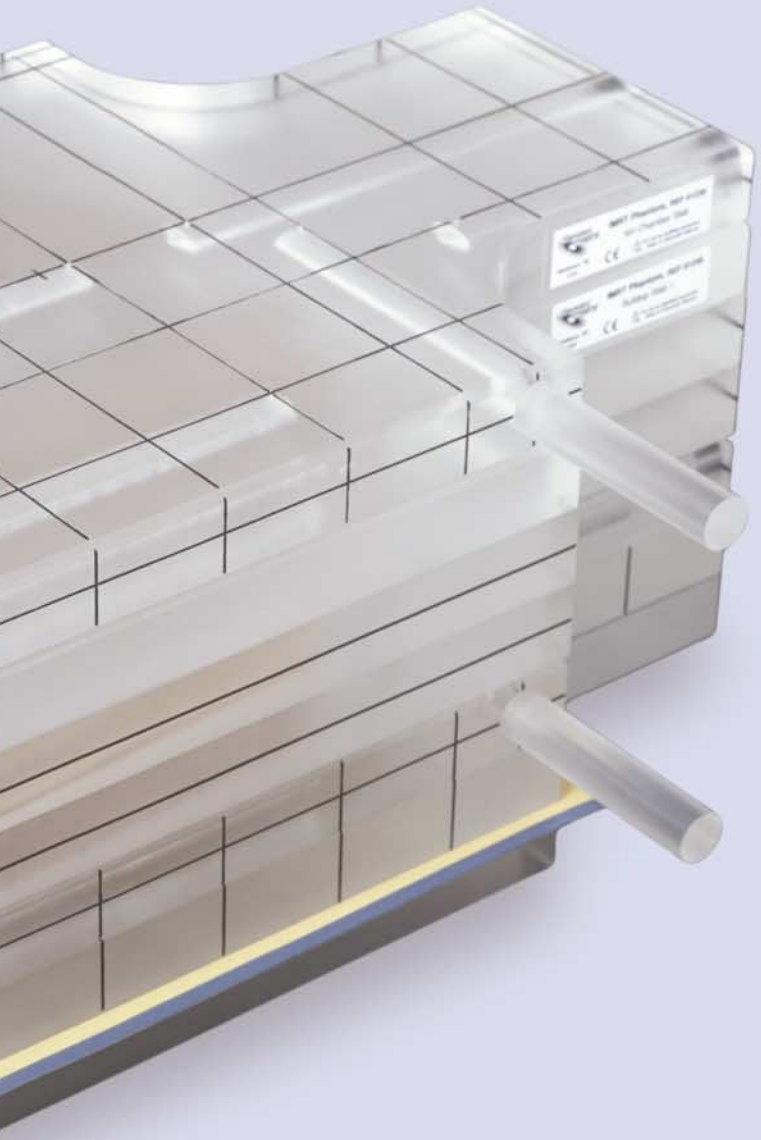
TREATMENT PLANNING INTERFACE
- Interfaces with treatment planning systems as the TPS recognizes the phantom's fiducial system and anthropomorphic shape.

BONE EQUIVALENT PLUG
- Simulates bone for realistic TPS evaluation. Assists with measuring the absolute dose at isocenter near the spine.



Dimensions

Height (six slabs) 18.00 cm (7.09 in)
Width (each slab) 30.00 cm (11.81 in)
Length (each slab) 45.00 cm (17.72 in)
Weight (six slabs) 22.7 kg (50.0 lbs)
Cavity Diameter 1.90 cm (¾ in)



ANTHROPOMORPHIC SHAPE

- Anthropomorphic design provides intuitive, easy set-up for fast confirmation of treatment plan.
- Bone and lung insert fields provide high gradient tissue interfaces to evaluate TPS's ability to manage these interfaces. Uncovers "edge effect" issues related to tissue heterogeneity.
- Accuracy of the prescribed dose is evaluated and confirmed in simulated patient conditions in the body, excluding extremities.
- Effectively evaluates junctioning issues of upper neck and half beam block superclav fields.

FAST SET UP

- Unique, versatile design allows many configurations to simulate individual treatment plans.
- Quick, easy, intuitive set-up. Complete a prostate dose set up and verification in as little as 15 minutes.
- Easily configure and adjust layered phantom slabs for individual 3D patient simulation.
- Fine 1 mm scribed black lines for easy laser alignment positioning of phantom.

TRANSPARENT ACRYLIC CONSTRUCTION

- Operator can visualize the placement of film, chambers and diodes for accurate measurements, thus minimizing registration errors.
- Acrylic is characterized in TG 21 for acrylic to water conversion for high energy photon and electron beams. Water equivalent phantoms are not characterized in this protocol. Some water equivalent phantoms may only be characterized for cobalt to ascertain their equivalence to liquid water. Since exacting measurements are essential when dealing with the small field sizes in IMRT, it is important to know the equivalent properties to liquid water that the TG 21 acrylic to water conversion provides.
- For absolute dosimetry, apply correction factors for acrylic to water which are published in the TG 21 protocol. Standard Imaging combines the required corrections into one table based on depth and energy, allowing the application of only one correction factor.

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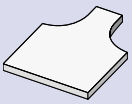
IMRT dose verification Phantom

REF 91230 IMRT Dose Verification Phantom, includes:

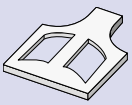
2	Chamber Phantom Slabs with 6 cavities each for ion chamber placement
2	Acrylic Phantom Slabs for build up thickness
2	Lung Phantom Slabs with cavities for simulated lung inserts
16	Solid Acrylic Plugs to fill unused ion chamber cavities
1	Solid Acrylic Plug with cavity drilled for ion chamber of your choice
1	Bone Equivalent Plug
1	Lung Equivalent Set with four (4) inserts for lung phantom voids

Phantom Overview

Chamber Phantom Slab has six cavities for thimble ion chamber measurement. The diameter of each cavity is ¾". Solid acrylic plugs are included to fill the cavities for simulated patient thickness. One solid acrylic plug is drilled for the ion chamber of choice. A bone equivalent plug is included for bone simulation of heterogeneity measurements.

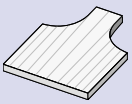


Acrylic Phantom Slab is a solid slab to provide simulated patient build-up material. Four 2 mm steel balls are imbedded in the slab as reference markers for 3D orientation of film on TPS.

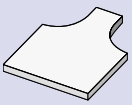


Lung Phantom Slab has two cavities for simulated lung inserts, two cylindrical cavities for thimble ion chamber placement and a set of two cedar lung inserts for lung simulation.

Additional Options



MOSFET Diode/TLD Slab, REF 70608, has nine channels for MOSFET diodes or TLD chips which can be placed at any point in a field for point dose measurements. The small channel size was designed not to perturb other measurements so this slab can also be used as a solid slab for increased patient thickness. MOSFET diodes are isotropic for dose measurements from any angle.



Acrylic Phantom Slab, REF 50062, is a solid slab to provide simulated patient build-up material. Four 2 mm steel balls are provided for use as reference markers for 3D orientation of film on TPS.

Carrying Case, REF 50064, has extendable handles and wheels for transport from room to room. Case also protects phantom during shipping.

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Dose Verification Procedure

STEP A ▶
Create treatment plan based on patient scans.

STEP B ▶
Configure the IMRT Phantom on the CT couch according to the anatomy to be treated.

STEP C ▶
CT scan the phantom with the selected chamber in place.

STEP D ▶
Import phantom scans into the treatment planning system.

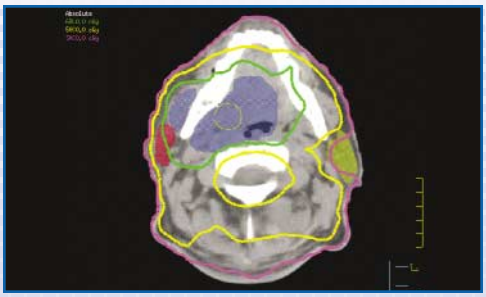
STEP E ▶
Transpose treatment plan onto CT phantom scan.

STEP F ▶
Place the phantom with ion chamber, film and diodes in place on the accelerator treatment couch.

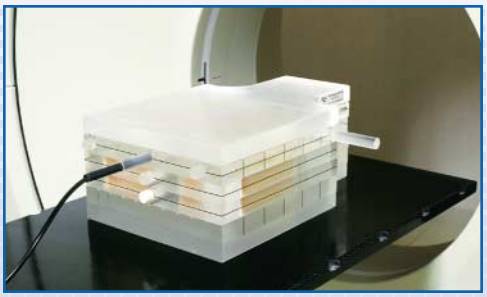
STEP G ▶
Treat the phantom as the treatment plan indicates.

STEP H ▶
Examine the output of the ion chamber (absolute dose), film (relative or fluence dose), Mosfet diodes (point dose) and compare them to the treatment plan.

Head and Neck Treatment Example



Transverse view of a patient scan from treatment planning computer that will be transposed onto the phantom scan.

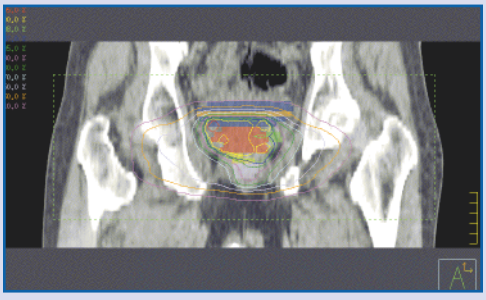


Phantom positioned on the simulator couch ready to be scanned.

Phantom Configuration:
- Solid Slab
- Chamber Slab with chamber at isocenter
- Lung Slab
- Lung Slab with bone equivalent plug
- Diode Slab
- Solid Slab

STEP A ▲▼ **STEPS B & C** ▲▼

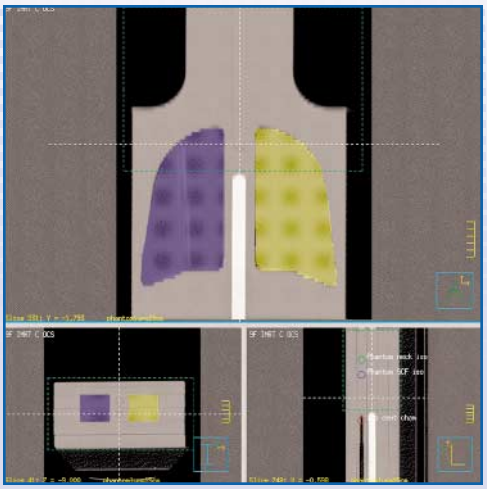
Prostate Treatment Example



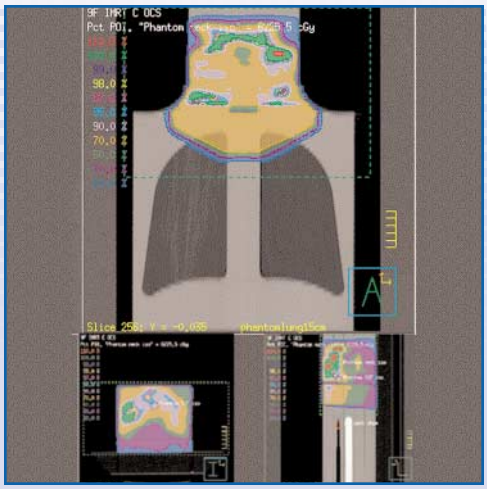
Coronal view of a patient scan from treatment planning computer that will be transposed onto the phantom scan.

Phantom positioned on the simulator couch ready to be scanned.

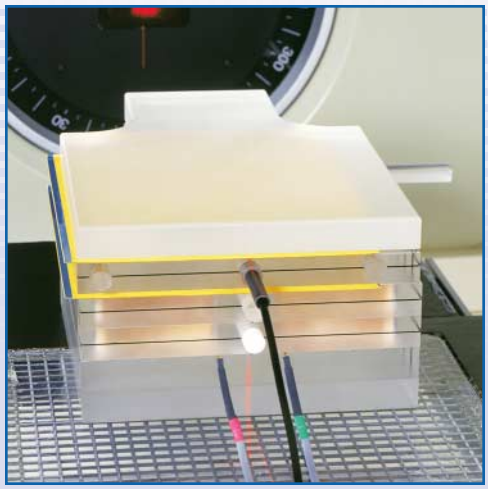
Phantom Configuration:
- Chamber Slab filled with plugs
- Solid Slab
- Chamber Slab with chamber at isocenter
- Diode Slab
- Solid Slab



Three view scan of the phantom in the treatment planning system.



The three view treatment plan is transposed onto the phantom scan.



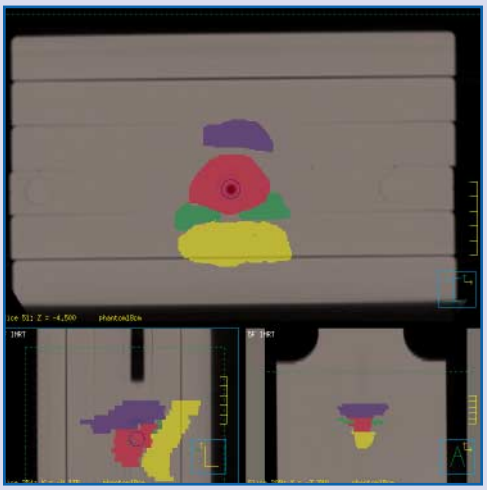
Phantom on accelerator treatment couch ready for treatment.

The bone equivalent plug represents spine. Diodes are offset, left and right, to represent kidneys.

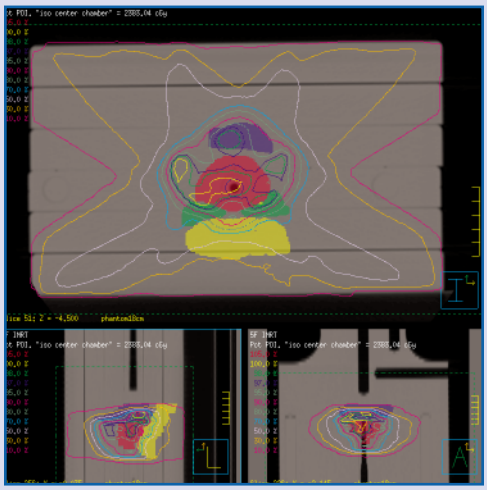
STEP D

STEP E

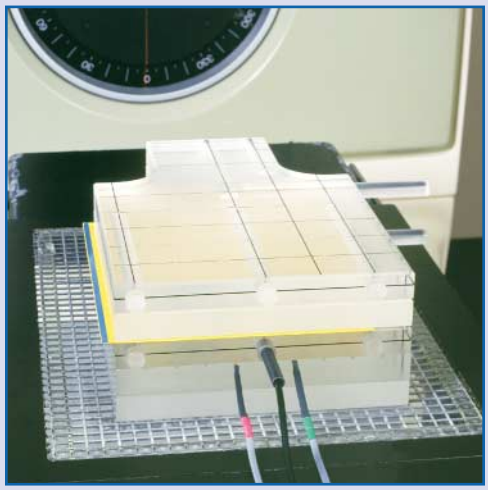
STEPS F & G



Three view scan of the phantom in the treatment planning system.



The three view treatment plan is transposed onto the phantom scan.



Phantom on accelerator treatment couch ready for treatment.

Diodes are offset, left and right, to represent rectal dose.

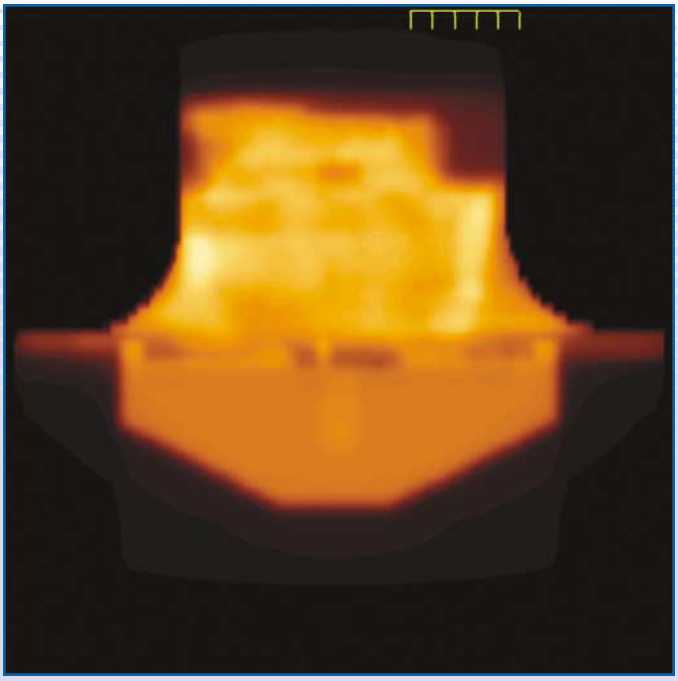
Clinical images courtesy of the regional cancer center at Waukesha and Oconomowoc hospitals

Measure Dose from Each Field to Chamber

Field	Charge Total	Charge per Field
1	1.78	1.78
2	3.54	1.76
3	5.88	2.34
4	7.91	2.03
5	9.23	1.32

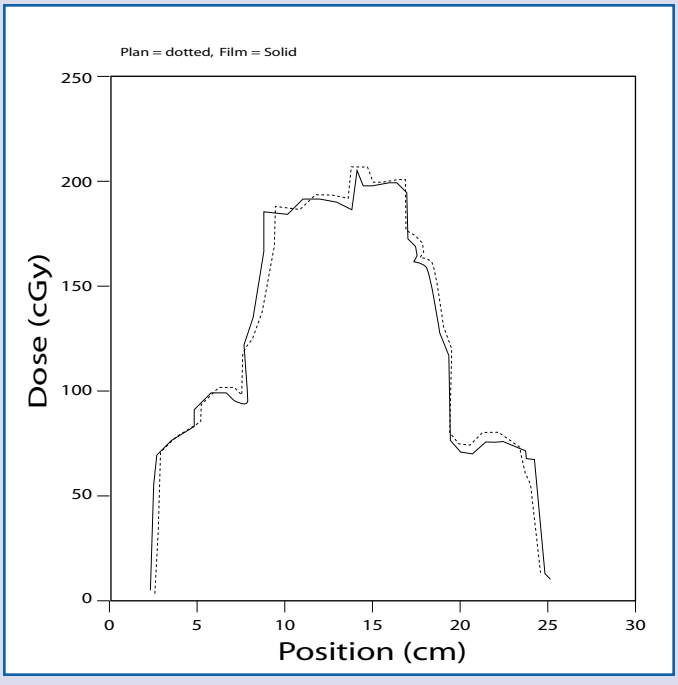
$$Dose_i = Q_i N_{gas} (TPC) \left(\frac{L}{\rho}\right)_i (TMRCF)_i$$

Examine the output of the ion chamber. This table shows typical dose measurements from an ion chamber. In a similar manner point dose measurements from Mosfet diodes can be tabulated and examined.

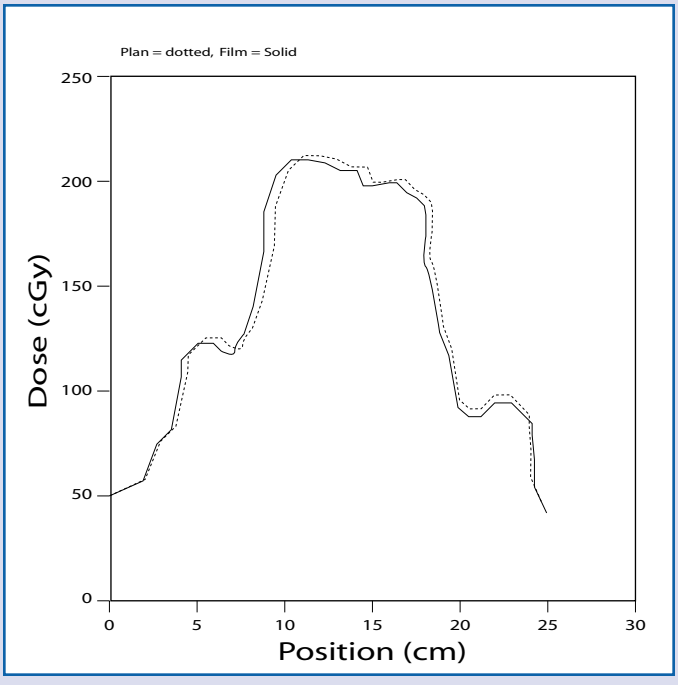


Examine the fluence dose image of a film placed between acrylic slabs of the IMRT Phantom.

AN EXAMPLE ANALYSIS • STEP H



Analysis of a vertical fluence dose profile of the measured film versus the calculated dose on the RTP.



Analysis of a horizontal fluence dose profile of the measured film versus the calculated dose on the RTP.

Frequently Asked Questions

Why was the IMRT Dose Verification Phantom designed?

The IMRT Dose Verification Phantom was designed for TPS verification by 3D evaluation of:

- High and low dose gradient areas
- Dose distributions to sensitive regions
- Inhomogeneity structures

What steps do I take to do QA Testing using the IMRT Phantom?

A. Create treatment plan based on patient scans.
B. Configure the IMRT phantom on the CT couch according to the anatomy to be treated.
C. CT Scan the phantom with the selected chamber in place.
D. Import CT phantom scans into the treatment planning system.
E. Transpose the treatment plan onto the CT Phantom scan.
F. Place phantom, with ion chamber, film and diodes in place, on linear accelerator treatment couch.
G. Treat the phantom as the treatment plan indicates
H. Examine the output of Ion Chamber (absolute dose), Film (relative or fluence dose), MOSFET diodes (point dose) and compare them to the treatment plan.

What agreement should I expect between the planned dose and the measured dose?

This must be determined by the medical facility.

What film do I use and what size do I use?

Film size is limited only by the size of the phantom (30 cm x 45 cm). Either ready pack or radiochromic film can be used. The Kodak® EDR2 film, 10" x 12", is a commonly used ready pack film with a wide response range. GAFCHROMIC® MD-55 and HD-810 are commonly used radiochromic films.

How do I eliminate air gaps using ready pack film with IMRT phantom?

The weight of the IMRT Dose Verification Phantom slabs helps prevent air gaps on film positioned in phantom.

Am I limited to coronal placement of film?

Yes. Coronal film placement provides the advantage of easy irradiation of reference marker points outside of the treated area for accurate comparison with the treatment plan dose. This allows fast comparison of film image with TPS since the reference marker points facilitate orientation of the film. The TPS can reconstruct an image in saggital or transverse planes. Coronal film views provide the best beam's eye view since the patient is positioned A/P or P/A.

Coronal film placement also offers the advantage of simultaneous ion chamber and film use since the planes are parallel. The use of ion chambers in the coronal plane, while film is in the transverse plane, is problematic because the planes are perpendicular.

Isn't solid water more accurate than acrylic?

No. Acrylic delivers same accuracy as water equivalent materials using the established correction factors published in TG 21. Standard Imaging has simplified the conversion by combining TG 21 corrections into one straightforward correction factor which is included with each IMRT Phantom purchase. Acrylic is characterized in TG 21 for acrylic to water conversion for high energy photon and electron beams. Water equivalent phantoms are not characterized in this protocol. Some water equivalent phantoms may only be characterized for cobalt to ascertain their equivalence to liquid water. Since exacting measurements are essential when dealing with the small field sizes in IMRT, it is important to know the true equivalent properties to liquid water that the TG 21 acrylic to water conversion provides.

Additionally, the transparency of the acrylic offers exceptional visualization, leading to more accurate placement of film, chambers, and diodes.

What radiation measuring devices can the phantom accommodate?

Up to six different measuring devices including standard thimble ion chambers, ready pack film, radiochromic film, MOSFET dosimeters, TLD's, and diodes.

Does the phantom eliminate CT imaging artifacts?

Yes, the Chamber Phantom Slabs and the Acrylic Phantom Slabs have radiused corners and edges which are designed to eliminate CT imaging artifacts.