Mini-Phantom & In-Air Comparison Jig

REF 72194, 72195 & 72193

Distributed by SeeDOS Ltd
Please contact Colin Walters at
cwalters@seedos.com

DOC #80396-00

Standard Imaging®

General Precautions

WARNING:
Follow manufacturer's recommended safety procedures for radioactive sources.

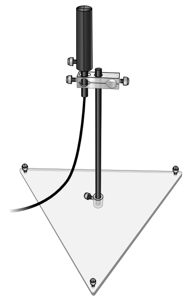
CAUTION:
Do not drop or mishandle unit.

CAUTION:
Proper use of this device depends on careful reading of all instructions and labels.

Warnings and Cautions alert users to dangerous conditions that can occur if instructions in the manual are not obeyed. Warnings are conditions that can cause injury to the operator, while Cautions can cause damage to the equipment.

Table of Contents

PAGE



SeeDOS Ltd

Overview of the Mini-Phantom

All of the common dosimetry systems, TAR[1], TMR[2], TPR[3] require that dose to a point in a phantom be separated into a primary component arising from the photon and electron fluence from the head of the accelerator and a secondary component arising from scatter in the phantom. More current dose calculation algorithms[4-7] model energy fluence from different parts of the accelerator head and also require input data that describes the change in accelerator output with collimator settings.

The basic method for separating these components of dose involves the measurement of total scatter correction factor in a full phantom, $S_{h,p}$, and the head scatter correction factor, S_h[2,8]. The phantom scatter correction factor can be calculated as follows: $S_p = S_{h,p}/S_h$.

The measurement of S_h is usually done with an ion chamber covered with a cylindrical build-up cap, which is irradiated perpendicular to its cylindrical axis (see Figure 1). The build-up cap serves two functions: it provides enough charged particles to give a large signal (provides build-up) and it reduces the number of contaminating electrons that reach the detector. Commonly, the wall thickness of the build-up cap is d_{max}, the depth of maximum dose in a water phantom. This type of build-up cap has the disadvantage of becoming very large for high energy x-rays, which have large d_{max}.

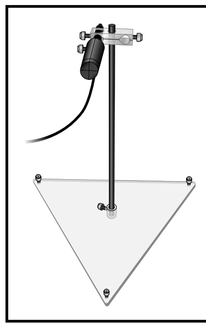


Figure 1

The large buildup cap prevents the measurement of S_h for small field sizes since the build-up cap must fully irradiated at all field sizes[8]. It is also known that contamination electrons can penetrate to depths beyond d_{max}[9-13] and this can effect the measurement of S_h.

Another type of build-up cap, the columnar mini-phantom, is in the shape of a square[14,15] or cylindrical[13,16-19] column, which is irradiated parallel to its long axis (see Figure 2). Generally the ion chamber

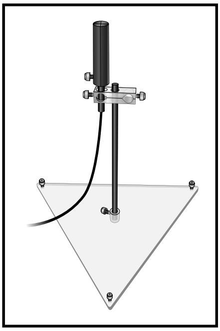


Figure 2

is mounted at 5 to 10 cm below the surface of the column, depending on the energy of the x-ray beam that is measured[16]. The 5 to 10 cm depths in the columnar miniphantom provides buildup and are deep enough to stop all contamination electrons that travel along its long axis.

The wall thickness of the columnar miniphantom must be adequate to stop contamination electrons from passing through the sides of the mini-phantom to the detector. The needed thickness increases with photon energy[13,19]. Measurements have shown[19] that a wall thickness of 1.2 g/cm^2 is adequate for measuring accelerator x-ray beams as energetic as 18 MV. The measurement of head scatter is not affected by the orientation of the axis of the cylindrical ion chamber[20]. However, placement of the ion chamber's cylindrical axis parallel with the columnar mini-phantom long axis will gives the smallest cross section with respect to the beam. With a 0.7-cm diameter ion chamber and 1.15 cm thick walls the columnar mini-phantom has a diameter of 3.0cm. This allows one to measure field sizes as small as 3 cm x 3 cm.

The mini-phantom must be fully enclosed by the irradiating field to measure head scatter correctly. In order to measure fields smaller than 3 cm x 3 cm one may propose fabricating mini-phantoms out of higher atomic number materials. The wall thickness will be thinner when these materials are used, so that the mini-phantom has a smaller diameter. However, use of high atomic number materials is a controversial idea. A number of reports[19-22] have indicated that the measured S_h depends on the atomic number of the fabrication material, whereas others[13,23,24] have reported that there is no significant effect of mini-phantom material. In view of these differing results it seems prudent to use a mini-phantom constructed of material that has an effective atomic number close to that of water*.

***Standard Imaging's Mini-Phantom is made of water equivalent plastic.**

Use of the Mini-Phantom to measure, S_h, head-scatter factor

The miniphantom should be kept away from any large objects that would scatter x-rays. This can be accomplished by supporting the miniphantom with the plastic rod stand as shown in Figure 2. A cylindrical ion chamber can be used as a detector and is secured in the hole of the miniphantom with the thumbscrew. The barrel of the cylindrical ion chamber is secured in the plastic clamp with the thumbscrew. The long axis of the miniphantom is aligned parallel with the central axis of the x-ray field. The scribed lines on the top surface of the miniphantom can be used to position it in the center of the field. The center of the active volume of the ion chamber is set at a source-axis-distance, SAD, usually 100 cm. The scribed line on the lateral surface of the miniphantom identifies the centroid of volume of the ion chamber.

Measurements:

The cumulative charge is measured for 100 MU irradiation's for various field sizes.

$S_h(w) = M_L / M_{10}$, where M_L is the measured signal for a square field of side length L cm, and M_{10} is the measured signal for a square field of a side length of 10 cm. Figure 3 shows $S_h(w)$,● ● ●, for a 6 MV beam of a Siemens MD2 linear accelerator.

Care must be taken so that the cross section of the miniphantom is fully irradiated by the smallest field measured. For the setup geometry described above the center of the ion chamber is at SAD = 100 cm but the top of the miniphantom is a distance of 90 cm from the source. Since the miniphantom has a diameter of 3 cm the smallest field that can be measured is 3 cm x 3 cm at 90 cm from the source. This field side length is 3 x 100/90 = 3.3 cm at SAD 100 cm. So, the smallest field size that can be measured is 3.3 cm x 3.3 cm with the 3.3 cm collimator size being defined at SAD = 100 cm.

Measurements of $S_{h,p}(w)$,■ ■ ■, for a 6 MV beam of a Siemens MD2 linear accelerator are shown in Figure 3. These data were measured in a Wellhofer water scanning-tank with the detector at 10 cm depth and SAD = 100 cm.

$S_p(w) = S_{h,p}(w)/S_h(w)$,▲ ▲, was calculated and is also plotted in Figure 3.

These data are measured at 10-cm depth and do not hold for any other depth. These data a typical of what one may measure and every clinic should measure data for its own equipment.

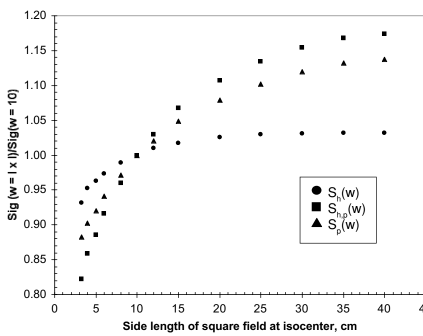


Figure 3

In-Air Comparison Jig Overview

The In air Comparison Jig shown in Figure 4 is designed to hold one or two chambers for a comparison of calibration factors or for a quality assurance check of radiation output, using the appropriate build-up caps. Figure 4 shows the setup for two chambers. The quality assurance measurement would be done with only one of the two chambers mounted on the in-air comparison jig.

Using the In-Air Comparison Jig

A. Simultaneous Comparison of Ionization Chambers

The In air Comparison jig is used for simultaneous comparison of ionization chambers response by the following steps:

1. Set the radiation source, Co-60 or accelerator for a 10 cm x 10 cm field.

2. Set the center of this field to the center of the two ionization chambers by aligning the cross hairs with the center of the marker on the jig rod.

3. Mount the ionization chambers as shown in Figure 4 with the centers of the longitudinal axis of the thimble or ionization cavities aligned. The centers of the active length of the cylindrical axis must be at the same SSD.

4. Add the appropriate buildup cap for the energy to be tested to each chamber.

5. Make sure the chambers are connected to the appropriate electrometers using the appropriate scales and are at the temperature of the radiation vault.

6. Take 3 or 4 readings for each chamber.

7. The average of the ratio of the responses of the chambers for each setup should be equal to the calibration ratio of the two chambers, assuming the radiation field is flat or the same on each side of the center line. The following equation can be used.

$$\mathbf{F = (F_R/X_R) * X}$$

Where:
F = Calculated Calibration Factor
$\mathbf{F_R}$ = Referenced Calibration Factor
X = Uncalibrated Chamber Collected Charge
$\mathbf{X_R}$ = Referenced Chamber Collected Charge

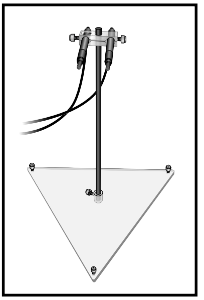


Figure 4

B. Quality Assurance of In air output of radiation

1. Mount a single ionization chamber, in the jig (See Figure 4), so the center of the active volume of the chamber is in the center of the field and at the appropriate SSD or SAD for d_{max}.

2. Measure the temperature and pressure.

3. Follow steps A4 through A6.

4. Correcting for temperature and pressure and using other correction factors as necessary, determine the output in air.

5. Use as a Quality Assurance means of uniformity of output.

Bibliography

[1]H.E. Johns and J.R. Cunningham, *The Physiology of Radiology*, 4th ed. (Charles C. Thomas, Springfield, 1983), pp. 336-381.

[2]J.G. Holt, J.S. Laughlin, and J.P. Moroney, “The extension of the concept of tissue-air ratios (TAR) to high energy x-ray beams,” Radiology **96**, 437-446 (1970).

[3]C.J. Karzmark, A. deubert, and R. Loevinger, “Tissue-phantom ratios – An aid to treatment planning,” Brit. J. Radiol. **38**, 158-159 (1965).

[4]T.R. Mackie, J.W. Scrimger, and J.J. Battista, “A convolution method of calculating dose for 15-MV x-rays,” Med. Phys. **12**, 188-196 (1985).

[5]A. Boyer and E. Mok, “A photon dose distribution model employing convolution calculations,” Med. Phys. **12**, 169-177 (1985).

[6]R. Mohan, C. Chui, and L. Lidofsky, “Differential pencil beam dose computation model for photons,” Med. Phys. **13**, 64-73 (1986).

[7] A. Ahnesjö, P. Andreo, and A. Brahme, “Calculation and application of point spread function for treatment planning with high energy photon beams,” Acta. Oncol. **26**, 49-56 (1987).

[8]F.M. Khan, W. Sewchand, J. Lee, and J.F. Williamson, “Revision of tissue-maximum ratio and scatter-maximum ratio concepts for cobalt 60 and higher energy x-ray beams,” Med. Phys. **7**, 230-237 (1980).

[9]T.N. Padikal and J.A. Deye, “Electron contamination of a high-energy x-ray beam,” Phys. Med. Biol. **23**, 1086-1092 (1978).

[10]P.J.Biggs and C.C. Ling, “Electrons as the cause of the observed d_{max} shift with field size in high energy photon beams,” Med. Phys. **6**, 291-295 (1979).

[11]B.R. Thomadsen, S. Kubsad, B.R. Paliwal, S. Shahabi, and T.R. Mackie, “On the cause of the variation in tissue-maximum ratio values with source-to-detector distance,” Med. Phys. **20**, 723-727 (1993).

[12]D.M. Frye, B.R. Paliwal, B.R. Thomadsen, and P. Jursinic, “Intercomparison of normalized head-scatter factor measurement techniques,” Med. Phys. **22**, 249-253 (1995).

[13]X.A. Li, M. Soubra, and L.H. Gerig,“Lateral electron equilibrium and electron contamination in measurements of head-scatter factors using miniphantoms and brass caps,” Med. Phys. **22**, 1167-1170 (1995).

[14]G. Krithivas and S.N. Rao, “Dosimetry of 24-MV x-rays from a linear accelerator,” Med. Phys. **14**, 274-281 (1987).

[15]M. Tatcher and B.E. Bjärngard, “Head-scatter factors in rectangular photon fields,” Med. Phys. **20**, 205-206 (1993).

[16]J.J.M. van Gasteren, S. Heukelom, H.J. van Kleffens, R. van der Laarse, J.L.M. Venselaar, and C.F. Westermann, “The determination of phantom and collimator scatter components of the output of megavoltage photon beams: measurements of the collimator scatter part with a beam-coaxial narrow cylindrical phantom,” Radiotherapy and Oncol. **20**, 250-257 (1991).

[17]A.L. McKenzie and P.H. Stevens, “Twenty-five years of MTRP - a theoretical and experimental analysis,” Phys. Med. Biol. **40**, 17-29 (1995).

[18]A. Dutreix, B.E. Bjärngard, A. Bridier, B. Mijnheer, J.E. Shaw, and H. Svensson, *Monitor Unit Calculation for High Energy Photon Beams,* (ESTRO and Garant Publishers, N.V., The Netherlands, 1997).

[19]P.A. Jursinic and B.R. Thomadsen, “Measurements of head-scatter factors with cylindrical build-up caps and columnar miniphantoms,” Med. Phys. **26**, 512-517 (1999).

[20]L. Weber, P. Nilsson, and A. Ahnesjö, “Build-up cap materials for measurements of photon head-scatter factors,” Phys. Med. Biol. **42**, 1875-1886 (1997).

[21]J. Spicka, D. Herron, and C. Orton, “Separationg output factor into collimator factor and phantom scatter factor for megavoltage photon calculations,” Med. Dos. **13**, 23-24 (1984).

[22]S. Heukelom, J.H. Lanson, and B.J. Mijnheer, “Differences in wedge factor determination in air using a PMMA mini-phantom or a brass build-up cap,” Med. Phys. **24**, 1986-1991 (1994).

[23]T.C. Zhu and B.E. Bjärngard, “The head-scatter factor for small field sizes,” Med. Phys. **21**, 65-68 (1994).

[24]A.R., Hounsell and J.M. Wilkinson, “Head scatter modelling for irregular field shaping and beam intensity modulation,” Phys. Med. Biol. **42**, 1737-1749 (1997).

Maintenance

Exterior cleaning of the device can be done with a soft brush and a cloth. Gently brush all surfaces to remove dirt and dust. Remove any remaining dirt with a cloth slightly dampened with a solution of mild detergent and water or a liquid disinfecting agent.

If assistance is desired in the proper disposal of this product (including accessories and components), after its useful life, please return to Standard Imaging.

Service

There are no serviceable parts on the Mini-Phantom or In-Air Comparison Jig.

Parts and Accessories List

REF	Description
80396	Instruction Manual
72193	In-Air Comparison Jig / Mini Phantom Stand
72194	Mini-Phantom for Exradin A12
72195	Mini-Phantom for Exradin A12 w/stand (REF 72194 + REF 72193)

Customer Responsibility

WARNING:

Federal law in the U.S.A. and Canada restricts the sale, distribution or use of this device to, by or on the order of a licensed medical practitioner. The use of this device should be restricted to the supervision of a qualified medical physicist. Handling of radioactive sources is potentially hazardous and should be performed by qualified personnel. Should repair or replacement of this device become necessary after the warranty period, the customer should seek advice from Standard Imaging Inc. prior to such repair or replacement. If this device is in need of repair, it should not be used until all repairs have been made and the product is functioning properly and ready for use. The owner of this device has sole responsibility for any malfunction resulting from abuse, improper use or maintenance, or repair by anyone other than Standard Imaging Inc. The information in this manual is subject to change without notice. No part of this manual may be copied or reproduced in any form, or by any means, without prior written consent of Standard Imaging Inc.

Features and Specifications

Mini-Phantom

Dimensions	
Diameter	3 cm (1.18 in)
Length	20 cm (7.87 in)
Centroid of chamber volume	10 cm from end of phantom
Material	Water equivalent plastic
Fiducial marks denote chamber centroid of volume	

In-Air Comparison Jig

Chamber clamp size accomodations	From 1/4” to 1/2” diameter for In-Air Comparisons
Dimensions	
Center Rod Height	40 cm (15.75 in)
Chamber Holder	
Height	2.22 cm (1 in)
Length	2.22 cm (1 in)
Width	6.35 cm (2.50 in)
Base	33.02 cm (13 in) equilateral triangle
Materials	
Center Rod	Carbon fiber
Chamber Holder	Polycarbonate
Base	Acrylic
Screws	Nylon
Fiducial marks on clamp assist in laser alignment	

Warranty

Standard Imaging, Inc. sells this product under the warranty herein set forth. The warranty is extended only to the buyer purchasing the product directly from Standard Imaging, Inc. or as a new product from an authorized dealer or distributor of Standard Imaging, Inc.

For a period of twenty-four (24) months for well chambers and twelve (12) months for all other Standard Imaging, Inc. products from the date of original delivery to the purchaser or a distributor, this product is warranted against functional defects in materials and workmanship, provided it is properly operated under conditions of normal use, and that repairs and replacements are made in accordance herewith. The foregoing warranty shall not apply if the product has been disassembled, altered or repaired other than by Standard Imaging, Inc. or if the product has been subject to abuse, misuse, negligence or accident.

Standard Imaging's sole and exclusive obligation and the purchaser's sole and exclusive remedy under the above warranties are limited to repairing or replacing free of charge, at Standard Imaging's option, a product: (1) which contains a defect covered by the above warranties; (2) which are reported to Standard Imaging, Inc. not later than seven (7) days after the expiration date of the 12 or 24 month warranty period; (3) which are returned to Standard Imaging promptly after discovery of the defect; and (4) which are found to be defective upon Standard Imaging's examination. Transportation charges are the buyer's responsibility. This warranty extends to every part of the product except fuses, batteries, or glass breakage. Standard Imaging, Inc. shall not be otherwise liable for any damages, including but not limited to, incidental damages, consequential damages, or special damages. Repaired or replaced products are warranted for the balance of the original warranty period, or at least 90 days.

This warranty is in lieu of all other warranties, express or implied, whether statutory or otherwise, including any implied warranty of fitness for a particular purpose. In no event shall Standard Imaging, Inc. be liable for any incidental or consequential damages resulting from the use, misuse or abuse of the product or caused by any defect, failure or malfunction of the product, whether a claim of such damages is based upon the warranty, contract, negligence, or otherwise.