MINI PHANTOM

& In-Air Comparison Jig
REF 72193, 72208-C07, 72208-C10
General Precautions

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

CAUTION:
Do not drop or mishandle the MiniPhantom or In-Air Comparison Jig.

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.
Overview of the MiniPhantom

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, \(S_{h}\). 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. 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 \(d_{\text{max}}\) 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 \(d_{\text{max}}\).

The large buildup cap prevents the measurement of \(S_h\) for small field sizes since the build-up cap must be fully irradiated at all field sizes\(^8\). It is also known that contamination electrons can penetrate to depths beyond \(d_{\text{max}}\)\(^9\)\(^-\)\(^1\)\(^3\) and this can effect the measurement of \(S_h\).

Another type of build-up cap, the columnar MiniPhantom, is in the shape of a square\(^1\)\(^4\),\(^1\)\(^5\) or cylindrical\(^1\)\(^3\),\(^1\)\(^6\)\(^-\)\(^1\)\(^9\) column, which is irradiated parallel to its long axis (see Figure 1). The ion chamber is mounted 10 cm below the surface of the column. The 10 cm depth in the columnar MiniPhantom provides buildup and is 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 MiniPhantom to the detector. The
needed thickness increases with photon energy\textsuperscript{13,19}. Measurements have shown\textsuperscript{19} that a wall thickness of 1.2 g/cm\textsuperscript{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\textsuperscript{20}. However, placement of the ion chamber’s cylindrical axis parallel with the columnar MiniPhantom long axis will give 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 MiniPhantom has a diameter of 3.0 cm. This allows one to measure field sizes as small as 3 cm x 3 cm.

The MiniPhantom 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 MiniPhantoms out of higher atomic number materials. The wall thickness will be thinner when these materials are used, so that the MiniPhantom has a smaller diameter. However, use of high atomic number materials is a controversial idea. A number of reports\textsuperscript{19-22} have indicated that the measured $S_h$ depends on the atomic number of the fabrication material, whereas others\textsuperscript{13,23,24} have reported that there is no significant effect of MiniPhantom material. In view of these differing results it seems prudent to use a MiniPhantom constructed of material that has an effective atomic number close to that of water\textsuperscript{*}.

Head-scatter Factor ($S_h$) Measurement Setup

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 In-Air Comparison Jig as shown in Figure 1. 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.

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\textsuperscript{*}Standard Imaging’s MiniPhantom is made of water equivalent plastic.
Using the MiniPhantom - Calculations

Measurements:

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

\[ S_h(w) = \frac{M_1}{M_{10}}, \]

where \( M_1 \) 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 2 shows \( S_{h,p}(w) \), 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 \( 3 \times 100/90 = 3.3 \) 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 2. These data were measured in a water scanning-tank with the detector at 10 cm depth and SAD = 100 cm.

\[ S_p(w) = \frac{S_{h,p}(w)}{S_h(w)}, \]

was calculated and is also plotted in Figure 2.

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

The In-air Comparison Jig shown in Figure 3 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 3 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 3 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.

\[ F = \left( \frac{F_R}{X_R} \right) \times X \]

Where:

- \( F \) = Calculated Calibration Factor
- \( F_R \) = Referenced Calibration Factor
- \( X \) = Uncalibrated Chamber Collected Charge
- \( X_R \) = Referenced Chamber Collected Charge

B. Quality Assurance of In-air output of radiation

1. Mount a single ionization chamber, in the jig (See Figure 3), 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


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.

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

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

Parts and Accessories List

<table>
<thead>
<tr>
<th>REF</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>80396</td>
<td>Instruction Manual</td>
</tr>
<tr>
<td>72193</td>
<td>In-Air Comparison Jig</td>
</tr>
<tr>
<td>72208-C07</td>
<td>MiniPhantom for Model A12 Exradin Farmer-type Chamber</td>
</tr>
<tr>
<td>72208-C10</td>
<td>MiniPhantom for Model A19 Exradin Classic Farmer-type Chamber</td>
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</table>
## Features and Specifications

### MiniPhantom

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dimensions</strong></td>
<td></td>
</tr>
<tr>
<td>Diameter</td>
<td>3 cm (1.18 in)</td>
</tr>
<tr>
<td>Length</td>
<td>20 cm (7.87 in)</td>
</tr>
<tr>
<td><strong>Centroid of chamber volume</strong></td>
<td>10 cm from end of phantom</td>
</tr>
<tr>
<td><strong>Material</strong></td>
<td>Water equivalent plastic</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td>Fiducial marks denote chamber centroid of volume</td>
</tr>
</tbody>
</table>

### In-Air Comparison Jig

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chamber clamp size accommodations</strong></td>
<td>From 1/4” to 1/2” diameter for In-Air Comparisons</td>
</tr>
<tr>
<td><strong>Dimensions</strong></td>
<td></td>
</tr>
<tr>
<td>Center Rod Height</td>
<td>40 cm (15.75 in)</td>
</tr>
<tr>
<td>Chamber Holder Height</td>
<td>2.22 cm (1 in)</td>
</tr>
<tr>
<td>Chamber Holder Length</td>
<td>2.22 cm (1 in)</td>
</tr>
<tr>
<td>Chamber Holder Width</td>
<td>6.35 cm (2.50 in)</td>
</tr>
<tr>
<td>Base</td>
<td>33.02 cm (13 in) equilateral triangle</td>
</tr>
<tr>
<td><strong>Materials</strong></td>
<td></td>
</tr>
<tr>
<td>Center Rod</td>
<td>Carbon fiber</td>
</tr>
<tr>
<td>Chamber Holder</td>
<td>Polycarbonate</td>
</tr>
<tr>
<td>Base</td>
<td>Acrylic</td>
</tr>
<tr>
<td>Screws</td>
<td>Nylon</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td>Fiducial marks on clamp to assist in laser alignment</td>
</tr>
</tbody>
</table>

*Specifications are subject to change without notice.*
Service Policy

If service, including recalibration, is required, please contact Standard Imaging’s Customer Service department by phone or email prior to shipping the product. Standard Imaging’s Customer Service and Technical Service staff will attempt to address the product issue via phone or email. If unable to address the issue, a return material authorization (RMA) number will be issued. With the RMA number, the product can be returned to Standard Imaging. It is the responsibility of the customer to properly package, insure and ship the product, with the RMA number clearly identified on the outside of the package. The customer must immediately file a claim with their carrier for any shipping damage or lost shipments. Return shipping and insurance is to be pre-paid or billed to the customer, and the customer may request a specific shipper. Items found to be out of warranty are subject to a minimum service fee of 1 hour labor (excluding recalibrations) for diagnostic efforts and require a purchase order (PO) before service is performed. With concurrence from customer, the product may be replaced if it is unserviceable or if the required service is cost prohibitive. Products incurring service charges may be held for payment. Standard Imaging does not provide loaner products. See the Standard Imaging Warranty and Customer Responsibility for additional information.

Serialization Information

Standard Imaging products that are serialized contain coded logic in the serial number which indicates the product, day and year of manufacture, and a sequential unit number for identification:

A YY DDD X

A  Unique product ID
YY  Last two digits of the year
    (e.g. 1999 = 99, 2000 = 00)
DDD  Day of the year (1 ≤ DDD ≤ 365)
X  Unique unit ID Number (1 ≤ X ≤ 9)

Customer Responsibility

This product and its components will perform properly and reliably only when operated and maintained in accordance with the instructions contained in this manual and accompanying labels. A defective device should not be used. Parts which may be broken or missing or are clearly worn, distorted or contaminated should be replaced immediately with genuine replacement parts manufactured by or made available from Standard Imaging Inc.

⚠️ CAUTION: Federal law in the U.S.A. and Canadian law restrict the sale, distribution, or use of this product to, by, or on the order of a licensed medical practitioner. The use of this product should be restricted to the supervision of a qualified medical physicist. Measurement of high activity radioactive sources is potentially hazardous and should be performed by qualified personnel.

Should repair or replacement of this product become necessary after the warranty period, the customer should seek advice from Standard Imaging Inc. prior to such repair or replacement. If this product 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. After repair, the product may need to be calibrated. The owner of this product 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.
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 provided in the table below from the date of original delivery to the purchaser or a distributor, this Standard Imaging, Inc. product, provided in the table is warranted against functional defects in design, 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 altered, disassembled or repaired other than by Standard Imaging, Inc. or if the product has been subject to abuse, misuse, negligence or accident.

<table>
<thead>
<tr>
<th>Product</th>
<th>Warranty Period</th>
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<tr>
<td>Standard Imaging Ionization Chambers</td>
<td>2 years</td>
</tr>
<tr>
<td>Standard Imaging Well Chambers</td>
<td>2 years</td>
</tr>
<tr>
<td>Standard Imaging Electrometers</td>
<td>2 years</td>
</tr>
<tr>
<td>Standard Imaging BeamChecker Products</td>
<td>2 years</td>
</tr>
<tr>
<td>Standard Imaging Software Products</td>
<td>1 year</td>
</tr>
<tr>
<td>All Other Standard Imaging Products</td>
<td>1 year</td>
</tr>
<tr>
<td>Standard Imaging Custom Products</td>
<td>90 days</td>
</tr>
<tr>
<td>Consumables</td>
<td>90 days</td>
</tr>
<tr>
<td>Serviced Product</td>
<td>90 days</td>
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<tr>
<td>Resale Products</td>
<td>As defined by the Original Equipment Manufacturer</td>
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<tr>
<td>ADCL Product Calibration</td>
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<tr>
<td>(Standard Imaging uses the UW-ADCL for recalibrations required under warranty)</td>
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<tr>
<td>0 - 90 days = 100% of ADCL Calibration Costs</td>
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<td>91 - 182 days = 75% of ADCL Calibration Costs</td>
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<tr>
<td>183 – 365 days = 50% of ADCL Calibration Costs</td>
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<tr>
<td>366 – 639 days = 25% of ADCL Calibration Costs</td>
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Standard Imaging’s sole and exclusive obligation and the purchaser’s sole and exclusive remedy under the above warranties are, at Standard Imaging’s option, limited to repairing, replacing free of charge or revising labeling and manual content on, 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 warranty period in the table; (3) which are returned to Standard Imaging, Inc. promptly after discovery of the defect; and (4) which are found to be defective upon examination by Standard Imaging Inc. Transportation related charges, (including, but not limited to shipping, customs, tariffs, taxes, and brokerage fees) to Standard imaging are the buyer’s responsibility. This warranty extends to every part of the product except consumables (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.

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