IMRT Thorax Phantom User Guide

Model 002LFC

SUN NUCLEAR
A MIRION MEDICAL COMPANY

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1 Introduction

Description

The 002LFC IMRT Thorax Phantom is 30 cm wide x 30 cm long x 20 cm tall and includes lung and cylindrical spine. It allows measurements in mediastinum, lungs, and spine, and up to 12 Ready-Pack™ or Gafchromic™ films can be positioned in the phantom.

The following are features of the IMRT Thorax Phantom:

- Is made from proprietary tissue-equivalent epoxy materials. Linear attenuations of the simulated tissues are within 1% of actual attenuation from 50 keV to 15 MeV. This allows for very accurate simulation from CT planning to treatment delivery. The phantoms are elliptical in shape and measure 20 cm in height to properly represent average patient size and proportion. The uniformity of shape also enhances accuracy of depth measurements.
- Accommodates Ready-Pack or Gafchromic Film in a transverse orientation (other orientations available upon request).
- Incorporates a unique interchangeable rod design that enables chambers, diodes, MOSFETs, and TLDs to be positioned in the same locations within the phantom for intercomparison of detectors. Depending on the model selected, your phantom may allow measurements to be taken inside or adjacent to semi-anthropomorphic lung and bone structures.
- Enables acquisition through planning process to treatment delivery.
- Includes CT-to-film fiducial markers allowing easy film registration supported by RIT 113.
- Includes an alignment base and holding device that enables quick and easy setup of multiple phantom sections while still allowing easy access and relocation of detectors.

Parts

After unpacking, identify the following parts.

Table 1-1. Model 002LFC Parts Included

Part Number	Qty	Description
-	1	15 cm thick thorax section drilled to accommodate rod inserts
-	12	1 cm thorax sections
-	1	3 cm end section
002RW-S	5	Water-equivalent solid rod inserts
002RB-S	1	Bone-equivalent solid rod insert
002RL-S	4	Lung-equivalent solid rod inserts
-	1	Set of CT-to-film fiducial markers (installed)

Table 1-1. Model 002LFC Parts Included (Continued)

Part Number	Qty	Description
-	1	Alignment base
-	1	Holding device
-	1	Fiducial protector

Options and Accessories

Note: *Customers must complete their order with the purchase of at least one (1) insert option listed below. For best results, the full set is recommended. Refer to separate CIRS cavity and plug code list for available chamber cavities.*

Table 1-2. Insert Options

Part Number	Description
002RW CVXX-XX	Water-equivalent rod inserts with ion chamber cavity
002RB CVXX-XX	Bone-equivalent rod insert with ion chamber cavity
002RL CVXX-XX	Lung-equivalent rod insert with ion chamber cavity

Table 1-3. Additional Options

Part Number	Description
002BR-2PK	Breast attachment - 2 pack
002FC	Film stack for small volume 3D image reconstruction
002HCV	Homogeneous section that accommodates 002FC film cassette
002LCV	Thorax region section that accommodates 002FC film cassette
002SPH	Water-equivalent rods for TLDs (set of 5 rods length 5 cm)
002ED	Electron density reference plugs, set of 4 (lung, bone core in water, muscle, adipose)
9501	Case for IMRT Phantoms (002H9K, 002LFC, 002PRA) when ordered with corresponding Cavity Slab (002HCV, 002LCV, 002PCV)
9502	Case for IMRT Phantoms (002H9K, 002LFC, 002PRA)
158200-09	Precision Cut EBT3 Film Kit for Model 002FC, 038-05, 038-21 (Set of 25 inserts plus 6 calibration strips)

As described in Report of the Coordinated Research Project on Development of Procedures for Quality Assurance of Dosimetry Calculations in Radiotherapy - International Atomic Energy Agency (IAEA-TECDOC-1583)

Model 002ED

The materials used to construct your phantom may be used for electron density calibration. See *Material Specifications* on page 15 for electron density data. Additional reference plugs are available. They measure 2.5 cm in diameter x 5 cm in length and can be positioned in any phantom hole.

Figure 1-1. Electron Density Reference Plugs

Model 002BR-2PK

Breasts attachments are available as an optional accessory. The attachments are made from breast-equivalent material that mimics 50% glandular and 50% adipose breast tissue reference. They approximate an average breast size (350 cc) and shape, and are drilled to accommodate TLD arrays in 30 mm grid spacing. Breast attachments are sold in pairs only. They can be specially manufactured to accommodate other detectors upon customer request.
IMPORTANT: Do not over tighten the nylon screws. Too much torque may result in damage to the threaded holes in the phantom. If damage occurs, the phantom may need to be returned to Sun Nuclear for repair.

Figure 1-2. Breast Attachments (for Shape Reference Only)

2 Phantom Assembly

Assemble the Phantom

1. Please inspect your shipping carton before unpacking. If there are any signs of damage to the carton do not accept the shipment. If the shipment has already been received, contact Sun Nuclear or your distributor immediately for instructions. A claim will most likely need to be filed with the shipping company, and all evidence of carton damage will need to be retained for proof of claim.
2. A holding device is provided with the phantom to enable quick setup, adequate compression of the films, and easy transport during testing. For your convenience, your phantom is shipped in the assembled holding device.

Figure 2-1. Phantom With Holding Device

3. Carefully unpack, visually inspect, and inventory all items. Check your pack list to ensure you have accounted for all items in the shipment. Contact Sun Nuclear or your distributor immediately if any items are missing or damaged.
4. **IMPORTANT!** Your phantom may contain steel CT fiducial markers. Handle with care. They protrude from the phantom and they are sharp in order to produce a clean series of holes in your film which can later be referenced to your CT plan. They will damage the surface of other phantom sections with which they come in contact. When using your phantom for dosimetry, remember to remove the fiducial protector plate and position film into the interface or leave the interface empty. When storing your phantom, place back the fiducial protector plate to protect the phantom surfaces.

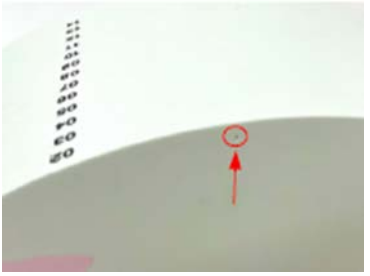

Figure 2-2. CT Fiducial Marker

5 Always use the alignment base to assemble the phantom. This will ensure that the fiducials contact phantom surfaces in the same location every time. You can store your phantom with the spacers provided or a spare ready-pack envelope to protect the fiducials. Place the alignment base plate on a level surface. The two parallel male ridges are to be facing upwards. Then place the sections of your phantom onto the base plate, aligning the grooves with the ridges as shown.

Figure 2-3. Phantom on Alignment Base Plate

6 Position the holding device over the phantom as shown.

Figure 2-4. Position Holding Device

7 Tighten the knobs in equal turns until the end plates meet the phantom. Visually inspect to ensure the recessed edges of the end plates are aligned

with the outside contours of the phantom on both ends. Continue to tighten each knob in equal turns until hand tight. The phantom should be secure, but never overtightened while in use.

Figure 2-5. Tighten Knobs

8 The phantom can now be removed from the alignment base for scanning and treatment delivery. The end plates allow for easy access to the interchangeable rods so that detectors can be added or rearranged in the phantom without having to take it apart. When removing the films, however, it is recommended that the phantom be returned to the alignment base before loosening the knobs.

Figure 2-6. Final Setup

9 It is recommended to use the alignment base while imaging. After the phantom is positioned using the lasers, it may be taped in place for easy alignment and reproducible readings for the next study.

10 All IMRT phantoms are clearly marked on the top, ends, and sides with laser alignment guides to enable reproducible and accurate positioning of the phantom for CT scanning and treatment planning system verification. Crosshairs are also present at the top and side of the phantom for proper alignment with ISO center if the detectors are placed therein.

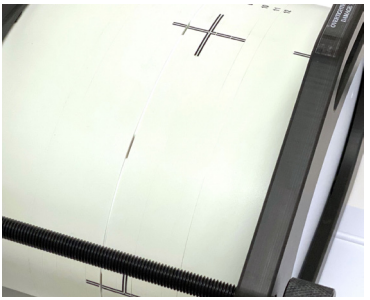

Figure 2-7. Laser Alignment Guides

3 Use of Film and Dosimeters

Model 002LFC was designed to accommodate a wide variety of dosimeters in the areas of greatest challenge for IMRT. When possible, the dosimeter holders have been made interchangeable to allow for inter-comparison of detectors and cost effective upgrades as new detectors become available. As with all CIRS phantoms, custom modifications to detector position or orientation can be made upon request. For a complete listing of optional accessories and model numbers, refer to *Options and Accessories* on page 2.

1 Ready-Pack or Gafchromic films can be positioned in transverse orientation within the phantom. The IMRT 002LFC can accommodate at least 1 and up to 12 films spaced 1 cm apart.

Note: *Interchangeable rods are designed to allow for close positioning to at least one film plane. This enables a combination of the ion chamber and film measurement in one irradiation session affording time savings and film calibration.*

Figure 3-1. Ready-Pack Film Positioning

Option 2 below requires the purchase of Model 002HCV or 002LCV cavity slab:

2 Gafchromic film can be used with the film stack for small volume dose mapping (Model 002FC). Film can be cut by hand, or Gafchromic Precision Cut films can be purchased from CIRS. The film stack measures 2.5x2.5x2.5" (63.5x63.5x63.5 mm) and accommodates 13 layers of film with 4 mm thick water-equivalent spacers in between each film. Place 1 film between each spacer and assemble the stack. Use a fine-point tip marker to mark the edges of the film using the grooves along the side of the stack. This enables x, y, and z orientation when viewing individual films. Place the film stack inside the cavity slab in the desired orientation.

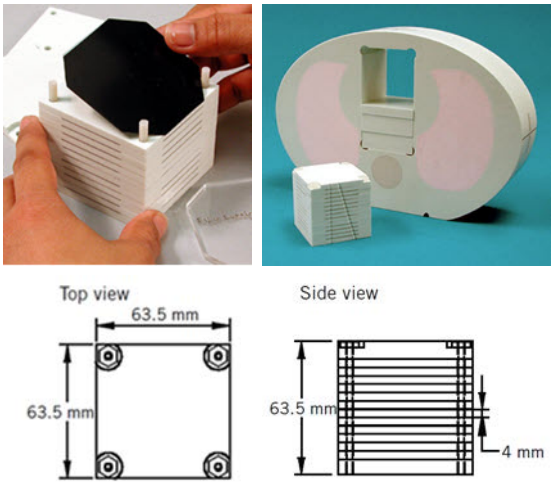

Figure 3-2. Gafchromic Film Placement

3 The interchangeable rods measure 1" in diameter and 16 cm in length. They are available in lung-, bone-, and water-equivalent material. Detector cavities are manufactured to allow the sensitive volume of the detector to be positioned 16 mm to the film plane and aligned with laser marks on the phantom body. This allows detector and film measurements to be taken in one irradiation session.

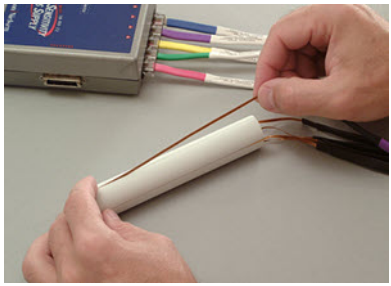

Figure 3-3. Interchangeable Rods

Cavity rods can be ordered to accommodate thimble chambers, diodes, MOSFET arrays, or TLDs (refer to *Options and Accessories* on page 2). Solid rods of the same tissue are provided to fill phantom cavities not in use.

Figure 3-4. Cavity Rods

4 Use of The Phantom

IMRT System QA

Most any IMRT phantom QA process will include scanning the phantom on CT, importing the resulting scan data to the Treatment Planning System, creating a treatment plan for phantom scans, treating the phantom, and examining the resultant output data. However, IMRT QA and dose verification is a complicated process. There are many different opinions regarding the choice of detectors, QA processes, and interpretation of results. Engineers and physicists at CIRS are available to answer specific questions regarding the materials, design, and technical specifications of the phantom. Specific questions regarding various detectors and IMRT QA issues should be directed toward the appropriate manufacturers of those detectors and experts in the field.

Commissioning of Radiotherapy Treatment Planning Systems: Testing for Typical External Beam Treatment Techniques

The following are IAEA clinical test cases recommended during commissioning, using the IMRT phantom Model 002LFC (refer to the IAEA-TECDOC-1583 for instructions):

- **Case 1:** Verification of digitized contour – non-dosimetric test
- **Case 2:** Verification/determination of CT numbers to relative electron density conversion in the RTPS

5 Support and Maintenance

Hardware Maintenance

Inspection

Periodically inspect your phantom and accessories for damage. If damage is visible or errors are suspected, discontinue use and contact Sun Nuclear Support. See *Contacting Sun Nuclear Support* below.

Lung tissue-equivalent materials that are used in the IMRT 002LFC mimics the inhale (low density) state of the human lung reference. Lung material is manufactured from a CIRS-proprietary, epoxy-based material. This material may have some small visual defects, color variation, or minor density variations on CT scans. These variations will not affect use of your phantom. If you have questions or comments, please feel free to contact Sun Nuclear Support.

Repair

The phantom and the parts provided with the phantom cannot be repaired by the user. Most phantoms can be easily repaired, and if damaged contact Sun Nuclear Support.

Storage

Your phantom is manufactured from epoxy resin. It is designed for use in a typical medical imaging facility or similar conditioned environment such as a laboratory. It is strongly recommended that when not in use, the phantom be stored in a dark, fully climatized storage area.

Epoxy is quite durable, but can still be damaged if it is dropped on a hard surface so handle with care. The phantom should be stored on the holder without any tension from the front and back panels.

Disposal and Recycling

Do not discard unit as waste. Recycle the components in accordance with local regulations.

Contacting Sun Nuclear Support

You may request support in two ways:

- Submit a support request using our online form. See *Support Website* below.
- Contact the Sun Nuclear Support team by telephone:
  - U.S.A.: +1 321-259-6862, Option 3
  - Netherlands: +31 20 399 90 41, Option 1
  - Germany: +49 61 02 50 49 500, Option 2

Support Website

1. Open an internet browser and navigate to sunnuclear.com/support.
2. Enter your email address and password and then click **Login**.
   - To download product information, click **Products and Devices**, select the product, and then select the download type.
   - To open a Support request, click **Open New Case**, complete the form, and then click **Create Case**.

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Appendix A: Material Specifications

Tissue Simulation of IMRT Materials[1,2]

Linear attenuation coefficients to reference tissues

Table A-1. Ratios of IMRT Materials

En, MeV	Plastic Water-DT to H_2O Ratio, %	Average Bone to Ref[1] Ratio, %	Lung (inhale) to Ref[2] Ratio, %
0.05	100.8	100.00	100.3
0.06	100.5	99.96	101.1
0.08	100.3	99.91	101.9
0.10	100.2	99.88	102.2
0.15	100.1	99.86	102.5
0.20	100.1	99.84	102.5
0.40	100.1	99.84	102.7
0.60	100.1	99.83	102.6
0.80	100.1	99.84	102.7
1.00	100.1	99.83	102.7
1.50	100.1	99.84	102.7
2.00	100.1	99.84	102.6
4.00	100.0	99.87	102.1
6.00	99.8	99.93	101.6
8.00	99.7	99.95	101.2
10.0	99.6	100.03	100.7
15.0	99.2	100.06	100.0
20.0	99.1	100.13	102.7
El. density	100.1	99.83	102.7
Density	1.039 g/cm^3	1.60 g/cm^3	0.21 g/cm^3

1. ICRP 23, Report of the Task Group on Reference Man (1975).
2. Woodard, H.Q., White, D.R., The Composition of Body Tissues, The British Journal of Radiology (1986) 59: 1209-1219.

Electron Density Reference Inserts

Table A-2. Electron Density Reference Inserts

Composition	Density	Electron Density per cc x 10 ^ 23	Electron Density Relative to H_2O
Lung	0.21	0.69	0.207
Bone core in water	1.60	5.03	1.506
Muscle	1.06	3.48	1.042
Adipose	0.96	3.17	0.949

Appendix B: Regulatory Supplement

In addition to the regulatory information contained in the body of this manual, the following supplemental regulatory information is provided.

Sun Nuclear Corporation Symbols

The following symbols are used in this guide and in Sun Nuclear Corporation's product labels.

WARNING: This symbol indicates a hazard that could result in major injury or equipment damage. (EN ISO 7010, W001)

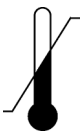
CAUTION: This symbol indicates a potential hazard that could result in minor injury or equipment damage. (EN ISO 15223-1, 5.4.4)

CAUTION: This symbol indicates a pinch hazard. (EN ISO 7010, W024)

Note: *Important or supporting information.*

Manufacturer's Identification (name and address). (EN ISO 15223-1, 5.1.1)

Date of Manufacture. (EN ISO 15223-1, 5.1.3)



Temperature limitation. (EN ISO 15223-1, 5.3.7)

Humidity limitation. (EN ISO 15223-1, 5.3.8)

Atmospheric pressure limitation. (EN ISO 15223-1, 5.3.9)

Serial Number. (EN ISO 15223-1, 5.1.7)

Catalog Number. (EN ISO 15223-1, 5.1.6)

Consult instructions for use. This equipment must be used in accordance with the instructions in this manual. Read all instructions and safety labels before use. (EN ISO 15223-1, 5.4.3)

Do not throw in trash; dispose of in an environmentally friendly way. (EN 50419)

Operator Responsibility

The instructions in this manual are intended for trained clinical personnel. The operator is solely responsible for the accurate setup and use of the phantom.

Reporting Health or Safety Related Issues or Concerns

Any serious incident that has occurred in relation to the device should be reported to the manufacturer and the competent authority of the Member State in which the user and/or patient is established.

To report any safety or health related issues or concerns regarding the use of Sun Nuclear products, contact Sun Nuclear directly.

Modifications to Equipment

Any changes or modifications to the device that are not expressly approved by Sun Nuclear Corporation could void your warranty.

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