

T h e P h a n t o m L a b o r a t o r y

RSVP Phantom™ Manual

Radiosurgery Verification Phantom

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WARRANTY

THE PHANTOM LABORATORY INCORPORATED ("Seller") warrants that this product shall remain in good working order and free of all material defects for a period of one (1) year following the date of purchase. If, prior to the expiration of the one (1) year warranty period, the product becomes defective, Buyer shall return the product to the Seller at:

The Phantom Laboratory Incorporated
2727 State Route 29
Greenwich, NY 12834
or
PO Box 511
Salem, NY 12865-0511

Seller shall, at Seller's sole option, repair or replace the defective product. The Warranty does not cover damage to the product resulting from accident or misuse.

IF THE PRODUCT IS NOT IN GOOD WORKING ORDER AS WARRANTED, THE SOLE AND EXCLUSIVE REMEDY SHALL BE REPAIR OR REPLACEMENT, AT SELLER'S OPTION. IN NO EVENT SHALL SELLER BE LIABLE FOR ANY DAMAGES IN EXCESS OF THE PURCHASE PRICE OF THE PRODUCT. THIS LIMITATION APPLIES TO DAMAGES OF ANY KIND, INCLUDING, BUT NOT LIMITED TO, DIRECT OR INDIRECT DAMAGES, LOST PROFITS, OR OTHER SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER FOR BREACH OF CONTRACT, TORT OR OTHERWISE, OR WHETHER ARISING OUT OF THE USE OF OR INABILITY TO USE THE PRODUCT. ALL OTHER EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTY OF MERCHANT ABILITY AND FITNESS FOR PARTICULAR PURPOSE, ARE HEREBY DISCLAIMED.

WARNING

This product has an FH3-4 mm/min flame rating and is considered to be flammable. It is advised not to expose this product to open flame or high temperature (over 125° Celsius or 250° Fahrenheit) heating elements.

12/6/99

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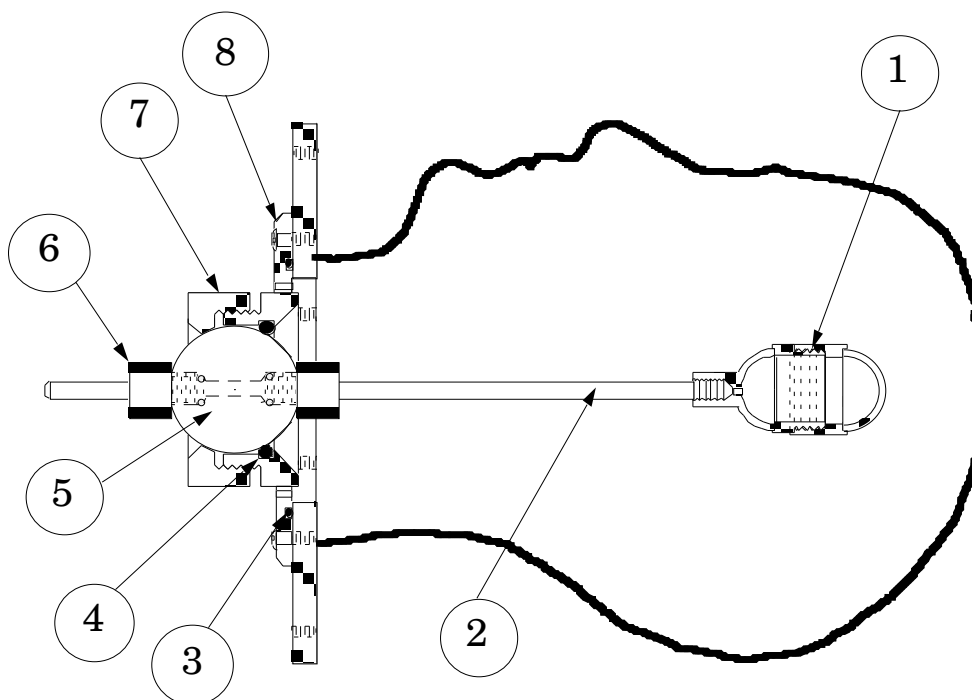


Figure 1
Components of the RSVP Phantom™

1. Tumor vessel 2. Position rod 3. Cover plate O-ring 4. Rotation ball O-ring
5. Rotation ball 6. Lock bolts for position rod 7. Lock nut for rotation ball
8. Cover plate

Introduction

The Phantom Laboratory, Incorporated and physicist Charles W. Coffey, II, Ph.D. have developed the RSVP Phantom™ to provide stereotactic localization and dose verification for radiosurgery machines. The phantom is positioned in the radiosurgery head frame to allow accurate simulation of patient imaging and dose procedures. The alignment of the phantom's X, Y, and Z axes are verified by filling the tumor vessel with a radiation-sensitive ferrous agarose gel and then simulating a patient alignment and dose sequence. The portion of the gel that exhibits a color change corresponds to the site of maximum exposure.

A variety of techniques may be used to measure the radiation dose delivered to the tumor vessel. The optional TLP211 RANDO® plug holder, which is mounted into the tumor vessel, may be used to hold 5mm plugs for thermoluminescent dosimetry (TLD) chips, powder, or rods. Quantitative dose measurements may also be obtained by using commercially available probes and ionization chambers. Another option is the use of film dosimetry techniques to acquire relative dose data for beam profiles and planar isodose distributions. The optional TLP212 and TLP213 film holders, which are mounted into the tumor vessel, may be used to hold the film securely in place for dosimetry measurements.

Because each medical facility has its own unique set of requirements we do not make specific recommendations on the frequency and expected results of evaluations. Review the local governing regulations, the needs of your radiologists, oncologists, physicists, and your system manufacturer's recommendations, when developing your measurement protocols.

If you have questions about the operation of the RSVP Phantom™ or the optional equipment that is available for the phantom, please contact The Phantom Laboratory at the following address:

The Phantom Laboratory, Incorporated
PO Box 511, Salem NY 12865 USA
Phone: 800-525-1190 or 518-692-1190
Fax: 518-692-3329

Care for the Phantom

The shell of the RSVP Phantom™ is composed of 0.125-inch-thick cellulose acetate butyrate (CAB), a transparent plastic chosen for its strength and low water absorption. The shell is mounted on a durable polycarbonate end plate, which is attached to a cover plate and an assembly that allows the tumor port to be rotated. The head frame of your radiosurgery system may be screwed directly into the CAB plastic. To avoid unnecessary wear on the phantom shell, be careful not to overtighten the head frame screws. Note that, in normal use, the screws may cause small dimples to form in the CAB plastic.

The RSVP Phantom™ is designed to be filled with water. You should never allow a filled phantom to freeze. If water is left in the phantom for an extended period of time, bacteria and other microorganisms may begin to grow and cause the water to become cloudy. If clouding occurs, the phantom should be emptied and washed with a mild detergent and water. Before storing the phantom, empty all water from it.

The tumor rotation ball assembly is located on the base of the phantom. The ball assembly may be extracted from the phantom by simply removing its lock nut and then lifting the ball out of the assembly. The O-ring that lies under the rotation ball should sit evenly on the lip surrounding the opening that leads into the main body of the phantom. The application of a small amount of petroleum jelly to the O-ring will help insure that the rotation ball forms a tight seal on the ring. Be careful not to apply too much jelly to the O-ring, because excessive lubrication may cause the ring to slip out of position when the lock nut is tightened. Always remember to loosen the rotation ball lock nut before rotating the tumor ball. If the rotation ball is turned when the nut is tight, the O-ring will be twisted out of position, thereby preventing a proper seal.

Removing the Tumor Vessel and Filling the Phantom

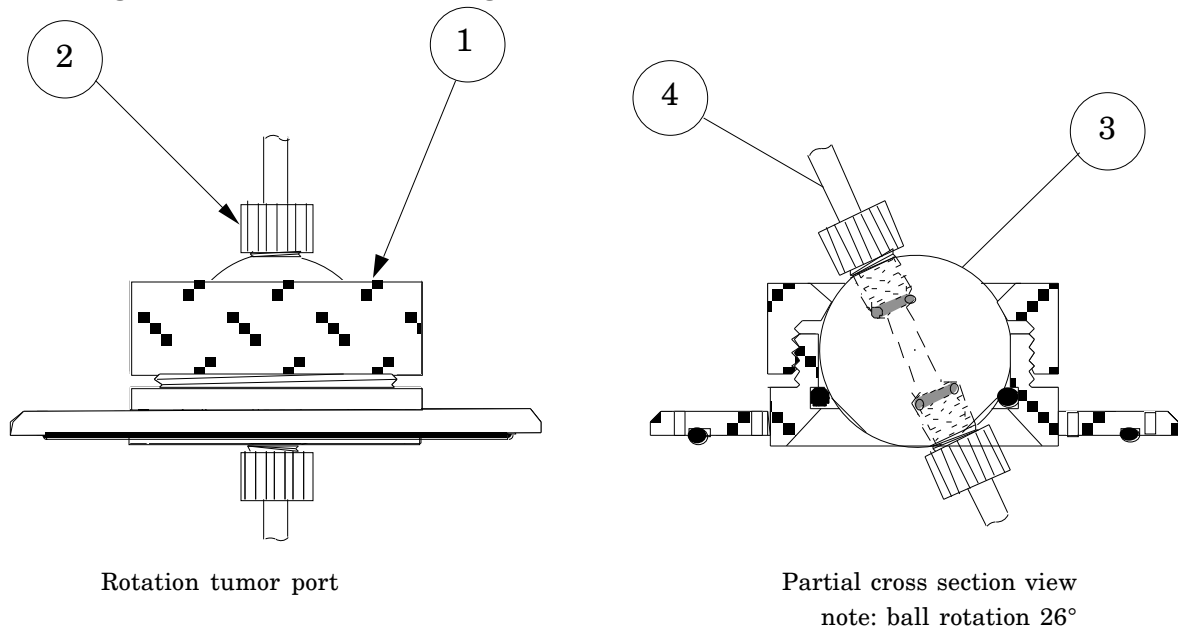


Figure 2

The rotation ball port

1. Lock nut for rotation ball 2. Lock bolt for position rod 3. Rotation ball 4. Position rod

Tumor removal

To remove the tumor vessel, the phantom's case should be used to secure the phantom in an inverted position. Begin by removing the rotation ball lock nut. Once this is accomplished, the rotation ball, position rod, and tumor vessel can be lifted out of the phantom as a complete assembly.

Tumor positioning and filling the head

The following steps are used to place the rotation ball, position rod and tumor vessel into the empty head form. First, position the rotation ball assembly and tumor vessel (or dosimeter) within the head form. Next, loosen the lock bolts on the position rod to insert it through the rotation ball until the rod extends the desired distance into the head form. Tighten the lock bolts when the rod is in the proper position.

Once you have completed the necessary adjustments to the ball, rod, and tumor vessel, remove the intact assembly from the head form and fill the phantom with water. Next, insert the assembly back into the head form and fit the rotation ball lock nut loosely onto the phantom. Rotate the ball until the tumor vessel (or dosimeter) is in the desired position, and tighten the rotation ball lock nut.

Check for leaks, place the phantom in the face-up position shown in Figure 1. Small leaks can generally be stopped by tightening the rotation ball lock nut and position rod lock bolt. If you are unable to stop leakage from the rotation ball port, it may be necessary to disassemble the port and check the O-rings to ensure that they are properly seated.

Once the assembly is in the proper position and the phantom is leak-free, you may attach the head frame to the phantom in preparation for scanning.

Using the Head Frame

During use of the RSVP Phantom™ and radiosurgery head frame, the phantom should be secured in an upright position. The case can serve as a support as shown in Figure 3 below.

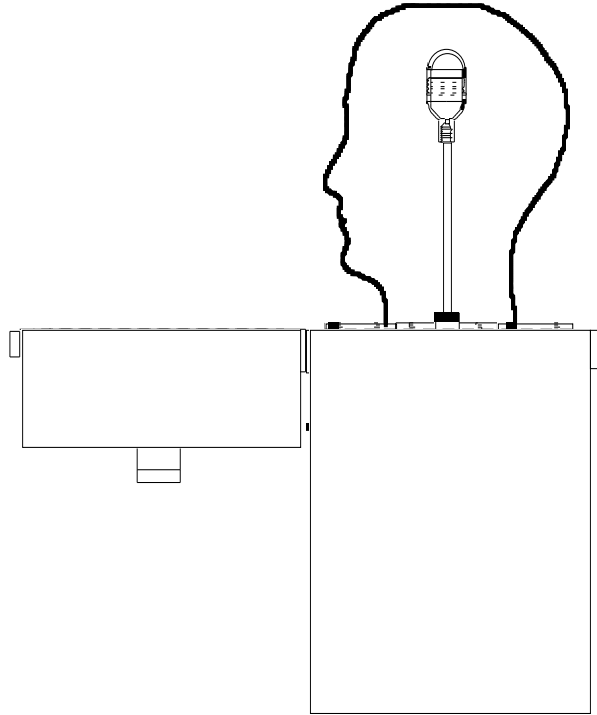


Figure 3
The RSVP Phantom™ secured in an upright position.

The head frame of your radiosurgery system should be positioned on the phantom's outer shell just as the frame would be on the patient's head during a radiosurgical procedure. The immobilization screws, on the head frame, may be tightened directly into the CAB plastic. Small dimples may form in the plastic when the screws are tightened, these dimples should have no effect on the structural integrity of your phantom. If you have difficulty mounting your radiosurgery head frame to your phantom, please contact The Phantom Laboratory for technical support.

Once the radiosurgery head frame is secured in place, the imaging localization device for computed tomography (CT), magnetic resonance imaging (MRI), or angiography should be attached to the head frame. Please note that in positioning the head frame and attached localization device, you must be careful to ensure that the imaged target (tumor) is within the spatial range-- the X, Y, and Z limits--of the localization device.

The phantom, head frame, and localization device may now be placed on the imaging table for a scanning procedure. You may find it necessary to use some site-dependent support system to position and secure the phantom, head frame and localization device on your imaging table.

Filling the Tumor Vessel

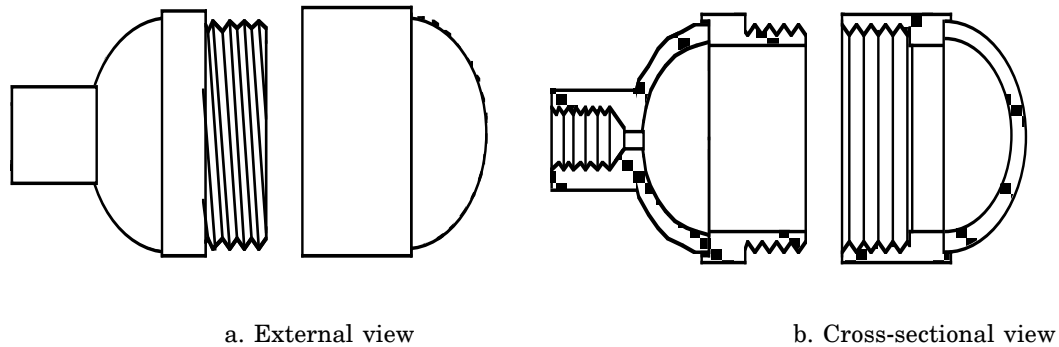


Figure 4
The tumor vessel.

Filling tumor vessel with low viscosity liquids

As shown in Figure 4b, the tumor vessel has a small port at the base of the position rod connector. Therefore, you must remove the position rod before adding or removing materials through the port. To fill the tumor vessel with a low-viscosity liquid, you may use a syringe to inject the fluid directly through the port into the tumor vessel. Once the vessel is full, simply rethread the position rod into the connector to close the port.

Filling the tumor vessels with high viscosity materials

A different procedure is used for filling the tumor vessel with high-viscosity materials that cannot be readily injected through the port. In such cases, it is necessary to unthread the two halves of the tumor vessel and then place the desired material in each half. While the half of the tumor vessel with male threads should be filled completely with material, the female-threaded half should be filled only to the beginning of the first thread nearest the rounded end. The two halves of the tumor vessel may then be threaded together. Please note that you may set a tumor-simulation mark by inserting a catheter section into the gel before threading the two halves together.

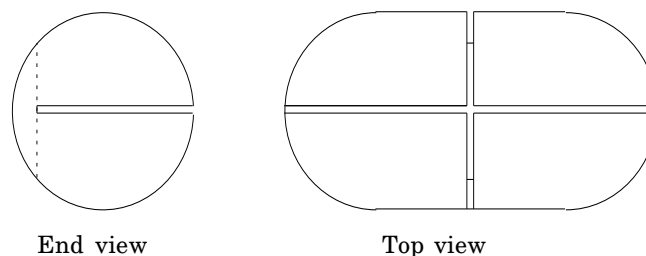


Figure 5
TLP211 5mm plug holder

Film Alignment Verification

The TLP227 insert may be used instead of gel for alignment verification. The insert holds film in two axes enabling simultaneous recording of the dose distribution in two plains. For alignment verification use a non light sensitive film like the Gafchromic Dosimetry Media.

Preparing the Ferrous Agarose Gel

You may use the following seven-step "recipe" to prepare 50ml of ferrous agarose gel:

WARNING; Beware of any impurities, for example dirt, et cetera. Impurities will cause the gel to change color prior to irradiation.

- (1) Bring 45ml of triply de-ionized water to a boil.
- (2) Measure 1 gram of agar.
- (3) Add the agar to the boiling water and heat the mixture while stirring continuously for 4 to 5 minutes.
- (4) Remove the mixture from heat, and continue stirring for 3 to 4 minutes.
- (5) While the agar mixture is being stirred (step 4), combine 5ml of a ferrous ammonium sulfate solution and 5ml of xylenol orange solution. Directions for preparing these solutions are provided below.
- (6) Once the stirring in Step 4 is completed, add the ferrous ammonium sulfate xylenol orange solution to the agar mixture and stir for an additional 8 to 10 minutes.
- (7) Pour the resulting gel into the two halves of the tumor vessel.

Original Chemicals Needed:

2 x 10⁻⁴M Ferrous Ions (Fe⁺⁺)
 1.5 x 10⁻⁴M Xylenol Orange
 5 x 10⁻²N Sulfuric Acid (H₂SO₄)
 1.0% Agar

Preparing Stock Solutions:

Xylenol Orange

- (1) Measure 0.124 grams of xylenol orange.
- (2) Add 100ml of triply de-ionized H₂O.

Ferrous Ammonium Sulfate

- (1) Measure .0784 grams of Fe⁺⁺.
- (2) Add 25ml of H₂SO₄ (5x 10⁻² Normal).
- (3) Add 75ml of triply de-ionized water.

Chemical Supply Source:

Fisher Scientific Headquarters, 711 Forbes Avenue, Pittsburgh, PA 15219
 412-562-8300

Ferrous Ammonium Sulfate crystal [Fe(NH₄)₂(SO₄)₂•6H₂O] (Cat.# I77-500)
 Xylenol Orange Tetrasodium Salt (Cat.# X15-5)

Sigma Chemical Co., St. Louis, MO
 314-771-5750

Purified Agar (Stock# A-7049)

Ferrous Ammonium Sulfate [Fe(NH₄)₂(SO₄)₂•6H₂O]

Xylenol Orange (Stock# X-3500 Tetrasodium Salt)

Dose evaluations

Several types of devices may be used to obtain quantitative measurements of the radiation dose delivered to the phantom's tumor vessel. These include TLD chips and radiation-sensitive films, as well as a number of commercially available probes and ionization chambers.

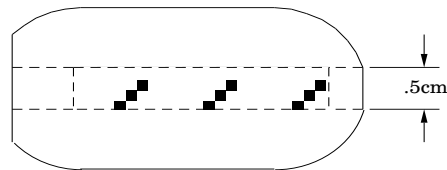


Figure 6

TLP211 5mm plug holder

Note that a standard TLD plug 2.5cm long and 0.5cm diameter (shaded area) has been inserted into the holder.

Thermoluminescent dosimetry (TLD)

For TLD measurement, the RSVP Phantom™ may be fitted with the optional TLP211 plug holder, which is designed to hold the standard 25mm by 5mm diameter plugs and capsules used in the RANDO® Phantom. To eliminate air gaps in the holder, at either end of the standard plug, the Mix D plugs RAN235 can be cut to length with a sharp knife. Once the plugs with TLD have been inserted, the TLP211 plug holder may be placed into the tumor vessel for positioning.

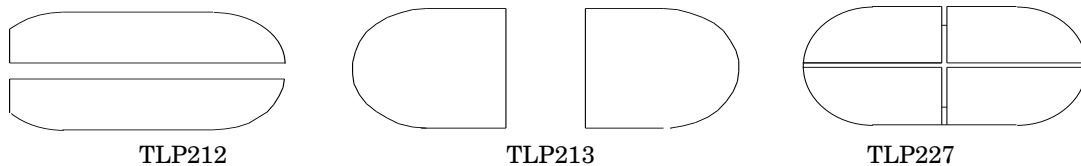


Figure 7

Film holders

Film Dosimetry

The TLP212, TLP213 and TLP227 film holders allow dosimetry film to be placed within the tumor vessel. The TLP212 is specifically designed for sagittal and coronal measurements, while the TLP213 is designed for cross-sectional (transverse) measurements. The TLP227 enables measurements of sagittal or coronal and cross-sectional measurements. Unlike the TLP212 and TLP213, which can be pressed against the two sides of the film, the TLP227 insert has 1mm machined slots which hold the film. These slots are not airtight. Physicists concerned about the affect of air on the film dosimetry should use caution when using this insert.

Relative dose measurements may be obtained to evaluate beam profiles and planar isodose distributions. A high-quality dosimetry film, such as Gafchromic Dosimetry Media, should be used for film dosimetry measurements. The film must be cut to the proper size and placed in the film holder. The holder is then installed and positioned within the tumor vessel.

Radiation Chambers and Probes

Chambers capable of making direct radiation measurements within the phantom are manufactured by the companies listed below. These devices will come with long rods capable of passing through the phantom's rotation ball for positioning. Due to variables with the rod diameters, some modifications to the rotation ball may be required.

Exradin, Inc.
1950 University Lane
Lisle, IL 60532
Phone: 708-968-5666 Fax: 708-968-6565

Exradin can adapt any of the models 1, 2, 12 and 14 chambers for use in the RSVP. The modified chambers come with a 13" Lexan stem mounted in a rotation ball.

PTW-Freiburg
Lörracher Str. 7
D-79115 Freiburg
Germany
Phone: 0761-49055-0 Fax: 0761-49055-70

The PTW-Freiburg has introduced a small volume chamber. They may be able to modify this chamber for use with the RSVP phantom.

Other manufacturers have expressed interest in making probes that are compatible to the RSVP Phantom™. For current information contact The Phantom Laboratory.

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