# RSD RADIOLOGY SUPPORT DEVICES ALDERSON I PHANTOMS



Founder, Samuel W. Alderson



#### **ABOUT OUR FOUNDER**

Radiology Support Devices (RSD) and its predecessor companies owe their specialty of duplicating the human body to the fact that a former wife of the founder of these companies, Samuel W. Alderson, was always late for appointments. One evening, late in World War II, one of her friends came over for dinner, and Mr. Alderson chatted with her pending the arrival of his wife. The friend was depressed by working in an amputee center, and she bemoaned the poor arm prostheses being fitted to the amputees.

At that time Mr. Alderson was working at the Bell Telephone Laboratories on the first missile-guidance system, which contained powerful, miniature permanent-magnet motors. He wondered why such motors could not be used to power improved arm prostheses. He began to explore this possibility at the same time that IBM, which had promised to President Roosevelt that they would turn their technology to the improvement of artificial arms, was looking around for a project engineer for this task. Mr. Alderson was recommended to IBM for this post and was hired by IBM to head a special laboratory to pursue this development.

By 1952 Mr. Alderson had developed an arm with which an amputee with no stump could perform many tasks, using toe controls. He then went on to controls using the skin currents that accompany the contraction of muscles which had previously powered lost arms. Unfortunately, the electronics could not be miniaturized enough at that time, so the project was put on hold until technology caught up with its requirements. IBM then helped Mr. Alderson establish his own company to bring the electric arm to a plateau until such time as further development could be undertaken.

As a result of this experience in duplicating the human body, his new company entered this field more broadly, pioneering dummies for testing military-aircraft ejection-seats. His company then received a contract from a major aircraft company to develop special dummies to test the survivability of the Command Module of Project Apollo. The contract became more complicated when it was found that the Command Module could not be relied upon to survive a ground landing, and its work statement had to be changed to permit a splash-down landing. The complications caused by this program led to insolvency of the company. Mr. Alderson then moved to California, where he had grown up, and started Humanetics Inc., devoted to the further development and manufacture of crash-test dummies for auto safety and to a phantom (a medical term for a dummy) which was the first such device to guide radiation treatments for cancer by measuring the dose that would be delivered to a patient, as determined in a corresponding phantom. The Alderson RANDO phantom, and its successor the Alderson ART phantom, have become worldwide standards and are used in nearly every radiation therapy clinic in the world.

Humanetics was sold to a British company, but Mr. Alderson bought back the radiation part of the business and proceeded to develop PIXY, which is virtually an American standard for training radiologic technologists in taking x-rays. The new company, Radiology Support Devices (RSD), took over from the Lawrence Livermore National Laboratories the production of a phantom to calibrate in-vivo counters to determine the amount and nature of radioactive particles absorbed in the bodies of nuclear workers. Today RSD is known as the world leader in the development of phantoms for Diagnostic Radiology, Radiation Therapy, Nuclear Medicine, and Health Physics.

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Male ART and Female ART

# THE ALDERSON RADIATION THERAPY PHANTOM (ART)

### The Worldwide Standard for Quality Assurance for Radiation Therapy

The Alderson Radiation Therapy phantom (ART) and its earlier version, the Alderson RANDO phantom, have been in use for over 30 years. The ART has been refined and improved in both design and materials. These phantoms are indispensable quality-assurance tools; about 10,000 are in use all over the world. They provide integrated tests of the entire chain of treatment planning and delivery.

ART phantoms are molded of tissue-equivalent material; they are designed within highly sophisticated technological constraints and follow ICRU-44 standards. They are also designed for accuracy and ease of use.

#### ANATOMY

The male ART represents a 175 cm (5 ft. 9 in.) tall, 73.5 kg (162 lb.) male, and the female ART represents a 155 cm (5 ft. I in.) tall, 50 kg (II0 lb.) female.

The ART phantom is transected-horizontally into 2.5 cm thick slices. Each slice has holes which are plugged with bone-equivalent, soft-tissue-equivalent or lung tissueequivalent pins which can be replaced by TLD holder pins. The holder pins are ordered separately.

Soft-tissue-equivalent coatings produce slices with glasssmooth interfaces. These coatings are cut away over the air spaces of the oronasal pharynges, trachea and stem bronchi.

Dosimetry holes are drilled in grids 3 cm x 3 cm or 1.5 cm x 1.5 cm in 5 and 7 mm diameters. These afford detailed measurements of dose distributions.



### **BREAST ATTACHMENTS**

There is poor correlation between clothing brassiere sizes and breast volumes. Breasts are specified according to this table:

Volume	Approximate Clothing Size
200 ml	A
400 ml	В
600 ml	С
900 ml	D
l 200 ml	DD

Breasts are available in various sizes. They can be sliced in frontal planes (drilled or undrilled for film dosimetry). Slices can receive any of the pins listed below. Breasts of male and female ART phantoms are contoured to blend realistically with the thoraxes. They are attached to the thorax with nylon screws. The male chest with breasts attached serves as a large female.

#### MATERIALS

Soft Tissues: There are unlimited, small variations in density and absorption throughout the human body. Phantom soft tissue is closely controlled to have the average density of these tissues.

Skeletons: RSD skeletons are highly-detailed polymer moldings which reproduce the shape, mass density and attenuation coefficients of cortical bone and spongiosa. They allow continuous production of phantoms, instead of the sporadic production required by the limited availability, variable size and uncertain chemical composition of human skeletons. These problems, plus loss of marrows in dried natural skeletons, make RSD skeletons superior to "real bone".

Molds for the RSD cortical bone and spongiosa were made from human skeletons consistent with the sizes of the softtissue molds.

RSD skeletons conform closely to the standards established by the International Commission on Radiation Units and Measurements (ICRU Report No. 44); mass density is reduced slightly to take into account a small decrease in calcium content for older patients.

Lungs: Lungs are molded from syntactic foam, with a specific gravity of 0.30 g/cc.





### **TLD DOSIMETERS AND FITTINGS**

Phantoms are shipped with all dosimetry holes filled with blank pins. Pins for TLD chips have recesses at one end 3.2  $\times$  3.2  $\times$  0.9 mm. Pins for TLD rods have I mm-diameter holes cross-drilled at the centers of the pins. All pins are 2.50 cm long unless otherwise specified.

### TLD DOSIMETERS AND HOLDERS

TLD Chip Holders – 5 mm or 7 m	Catalog No. ART-10
TLD Rod Holders I mm diameter x 3 mm long – 5 mm or 7	ART-12 mm
TLD Rod Holders I mm diameter x 6 mm long – 7 mm only	ART-15
Blank Pins – 5 mm diameter	ART-20-S, L, B
Blank Pins – 7 mm diameter	ART-21-S, L, B
S = Soft Tissue Equivalent L = Lung Tissue Equivalent B = Bone Tissue Equivalent	

Note: ART-10 and ART-12 are interchangeable in ART phantoms.

### ASSEMBLY

ART phantom slices are held between aluminum plates by nylon tie rods. Knobs at the end of the rods clamp the slices tightly in proper alignment.

Both internal and external assembly devices are included. The external assembly facilitates film dosimetry, while the internal assembly is used generally with TLDs or ionchamber dosimetry.



Head and Neck Phantom

# MODEL NUMBERS

	UNDRILLED	3 CM X 3 CM GRID HOLE SPACING	I.5 CM X I.5 CM GRID HOLE SPACIING
Male ART Phantom (Sections 0-35)	ART-200X	ART-200	ART-200A
Male ART Head and Neck Phantom (Sections 0-9)	ART-210X	ART-210	ART-210A
Male ART Chest Phantom (Sections 10-25)	ART-211X	ART-211	ART-211A
Male ART Pelvis Phantom (Sections 26-35)	ART-212X	ART-212	ART-212A
Female ART Phantom (Sections 0-32)	ART-300X	ART-300	ART-300A
Female ART Head and Neck Phantom (Sections 0-9)	ART-310X	ART-310	ART-310A
Female ART Chest Phantom (Sections 10-23)	ART-311X	ART-311	ART-311A
Female ART Pelvis Phantom (Sections 24-32)	ART-312X	ART-312	ART-3 I 2A

Female Breast Attachments

### **BREAST ATTACHMENTS**

Male Breasts- Female Breasts- Volume: 200, 400, 600, 900, 1200 ml	ART-250-A-B-C-D-E ART-350-A-B-C-D-E A = 2, 4, 6, 9, or 12	EXAMPLE: ART-250-4-S-3.0-7-P = Male Breast - 400 ml - sliced - 3 x 3 grid - 7 mm diameter-pair
Sliced or unsliced:	B = S  or  U	
Hold Grid	C = 1.5, 3.0  or  0	
1.5 x 1.5 or 3.0 x 3.0 cm or none		
Hole Size	D = 5  or  7	
5 or 7 mm diameters or N/A		
Side — Left, right or pair	E-L,R or $P$	



# THE TREATMENT BRASSIERE

### Immediately Improves Most Breast Treatments

- Reshapes the ipsilateral breast more favorably for radiation treatments
- Eliminates inframammary folds
- Reduces dose to the lungs, heart and ribs
- Both shape and position are accurately repeatable, treatment after treatment





Cross Section of Phantom With Unconfined Breast Shapes

- More uniform dose
- Simplifies the application of IMRT to breast treatments
- Reshapes the contralateral breast to move it away from the beams
- Full Brassiere Library of 40 cups in portable "caddy" for convenient, organized fitting of nearly all patients



Breasts Reshaped by Treatment Brassiere



Cross Section of Phantom with Breast Reshaped by Treatment Brassiere

Data on increased skin dose due to the ipsilateral cup were submitted to the FDA. These data provided a comparison of skin dose increased by the Treatment Brassiere with the increase found for various thermoplastic positioning devices on the market. The skin dose due to the cup material (0.50 mm thick for small cups to about 0.63 mm thick for very large cups) was found to be substantially less than for other positioning devices. The FDA has issued a 510 (k) Marketing Clearance for the Treatment Brassiere.





### CUP SELECTION

Cups are divided into four groups corresponding to small thoraxes (chest breadths from 27 to 32 cm), medium thoraxes (32 to 36 cm), large thoraxes (36 to 42 cm), and extra large thoraxes (over 42 cm).

Cup selection begins by measuring a patient's chest breadth when supine and wearing her clothing brassiere. This indicates the group containing the right cup for her. The cups of the group (five each for left or right) are removed from the Treatment Brassiere Caddy and the cup making the best fit is selected. (Clothing Brassiere sizes cannot be used for cup selection because of poor correlation between clothing brassiere sizes and breast volumes.)

Clothing Cup Size*	Observed Volume (ml)
Α	94 to 225
В	146 to 458
С	267 to 835
D	499 to 1120
DD	988 to 1427+
DDD	2765 to 3176

(These data are based on 75 models. Some cup volumes shown are altered from other cups as required for continuous gradation.) \*As reported by models

# **ABDS MODEL NUMBERS**

#### **TREATMENT BRASSIERES**

BR-100-TBC	Basic Brassiere Libra 40 different cups	ry with Caddy,
BR-100	Basic Brassiere Libra 40 different cups	ry without Caddy, <u>Chest Breadths</u>
BR-100S	Small Group	(27-32 cm)
BR-100M	Medium Group	(32-36 cm)
BR-100L	Large Group	(36-42 cm)
BR-100XL	Extra Large Group	(over 42 cm)

Small Group		<u>Volume (ml)</u>	
BR-100SL-	(Left Brassiere)	200	
BR-100SR-	(Right Brassiere)	300	
		400	
		500	
		600	

_				-
	Medium Group		Volume (ml)	
	BR-100ML-	(Left Brassiere)	250	
	BR-100MR-	(Right Brassiere)	500	
			750	
			1000	
			1250	

			_
Large Group		<u>Volume (ml)</u>	
BR-100LL-	(Left Brassiere)	500	
BR-100LR-	(Right Brassiere)	750	
		1000	
		1250	
		1500	

Extra Large Group BR-100XLL-BR-100XLR-

Volume (ml) (Left Brassiere) 1000 (Right Brassiere) 1500 2000 2500 3000 L,R = Left, Right **BR=Brassiere Assembly** 

S,M,L,XL= Size Group 200 to 3000 = Breast Volume

Example: BR-100ML-250

Brassiere Assembly Medium Group, Left Breast, Volume 250 ml

# PHANTOMS FOR LINAC RADIOSURGERY AND THE GAMMA KNIFE



Spherical Phantom in Stereotactic Frame

# SPHERICAL PHANTOM to Check Mechanical and Dosimetric Parameters of Treatment Units

- · Homogenous dry water phantom with precise spherical shape - 16 cm diameter
- Displacement of maximum dose from center of sphere shows degree of accuracy and stability of the system
- Checks the dose-calculation algorithm for a homogenous sphere

# DOSIMETRY IN THE SPHERICAL PHANTOM

When the center of the sphere is used as the target for testing the treatment unit, it must indicate the relationship between the point of maximum dose and the target. These should closely coincide for an accurate system.

A three-dimensional dosimetry cylinder at the center of the sphere measures both the deviation of the maximum dose from the target and the gradient of the dose along the three orthogonal axes of the sphere.



Dosimetric

The TLD dosimetric cylinder is a stack of dry-water disks of 44 mm in diameter. Seven of the disks have concentric rings of holes for TLD rods, I mm in diameter and 3 mm long. Disk #4 is in the central plane of the cylinder. A smaller target disk is at the center of this disk. It has a Hounsfield number of about 130 for visibility in a CT scan.

The disks are assembled tightly by two nylon rods and round, blind nuts, which locate the cylinder precisely, linearly and angularly, in both sphere and head.

### THE FILM DOSIMETRIC CYLINDER

This is an optional cylinder, interchangeable with the TLD cylinder. It is built up of 11 film disks and 12 dry-water disks with the same nylon assembly rods and blind nuts.

A simple fixture is supplied so the user can punch the film disks from film sheets.



The Film Dosimetric Cylinder

### STANDARD CONE

This is a dry-water cone, which fits precisely in a recess in the sphere. It accepts the dosimetric cylinder (TLD or film). It houses the dosimetric cylinder at the center of the sphere.



Spherical Phantom with Cone and Adaptor for Inspection of Dosimetric Cylinder

# **HEAD PHANTOM to Check Accuracy of** the Treatment



Head Phantom for Stereotactic Radiosurgery

- Total System Quality Assurance
- Checks the dose calculation algorithm with and without correction for tissue heterogeneities
- Measures the dose delivered to intracranial lesions

The Sphere was designed in conjunction with Timothy D. Solberg, Ph.D.



# OPTIONAL CONE

This is molded to locate the measuring volume of an ion chamber at the center of the sphere. This cone is custom-molded to suit the particular ion chamber specified by the customer.

# DOSIMETRY IN THE HEAD PHANTOM

Provisions are made for installation of the dosimetric cylinder at two locations in the cranium. One is on the CC axis of the head close to the apex. The other is near one side of the head at about ear level. Both cylinders are perpendicular to the transverse planes of the head.

Since the dose at only one location is to be measured at a time, the other location is filled with a dry-water cylinder with no dosimetric provisions. The target can be located uniquely by an initial CT scan.



Disk with TLD Rods



![](_page_8_Figure_9.jpeg)

### CATALOG NUMBERS

### ST-1100A SPHERICAL PHANTOM SYSTEM

Includes the following:

- ST-1101 Sphere with Standard Recess for Truncated Cones
- ST-1102 Truncated Cone for TLD and Film Dosimetry
- ST-1103 TLD Dosimetric Cylinder
- ST-1104 Adaptor for Dosimetric Cylinder
- Includes 4 Spare Nylon Assembly Rods and 8 Spare Blind Nylon Nuts.

#### **OPTIONS**

- ST-1106 Truncated Cone for Ion Chamber (includes molding or machining to install ion chamber at center of sphere to user's specification)
- ST-1116 Film Dosimetric Cylinder

NOTE: If both the sphere and head are purchased, only one dosimetric cylinder is needed.

### ST-1150A HEAD PHANTOM

#### Includes:

Includes one TLD Dosimetric Cylinder and one One-Piece, Dry-Water Cylinder to Fill Other Cavity.

Includes 4 Spare Nylon Assembly Rods and 8 Spare Blind Nylon Nuts.

#### **OPTIONS**

ST-1115 Punch for film ST-1116 Film Dosimetric Cylinder

![](_page_9_Picture_1.jpeg)

# "KIP" (Kohrman Injection Phantom)

- Always Available for Teaching/Training
- Always Available to Maintain Skills
- Checks Out Fluoroscopy System
- No Biohazards Which Are Associated With Cadavers

![](_page_9_Picture_7.jpeg)

KIP has been designed to provide realistic functions, while avoiding complications not essential to its use. Proper fluoroscopic needle placement techniques can be taught or practiced without fear of biological contamination hazards associated with fresh or frozen cadavers.

![](_page_9_Picture_9.jpeg)

Fluoroscopically, the look and feel of the anatomical landmarks is important and can be demonstrated with the use of KIP. Needle placement for caudals, epidurals, selective nerve and root blocks, medial branch blocks, facet injections and sympathetic blocks can all be demonstrated. Practice RF needle-placement along with disc needle-placement plus injection techniques for shoulder, hip and symphysis pubis, all in the convenience and safety of your own particular laboratory or teaching facility. There is now no need to deal with local, state, and federal regulations regarding biohazards associated with cadavers.

You can keep KIP in the closet and take it out whenever needed.

![](_page_9_Picture_12.jpeg)

![](_page_10_Picture_1.jpeg)

KIP has been developed to help one learn and to hone skills for proper needle placement for a variety of interventional techniques. It was not practicable to design the phantom with a capability of demonstrating

![](_page_10_Picture_3.jpeg)

realistic flow patterns associated with diagnostic dyes, so it is not designed for actual injections. However, the all important fluoroscopic guidance and needle-placement are realistic in KIP.

Further simplifications are the elimination of skeletal articulations that permit joint or spinal motions and the elimination of rib numbers 2 to 9; the rigid flesh makes these superfluous. Positioning of KIP as a single unit provides complete and realistic positioning capabilities.

KIP has the capability for injections not only in the spine, but also at one shoulder, one hip, and at the pubis symphysis.

![](_page_10_Picture_7.jpeg)

KIP has skeletal structures covered with a soft gel and a latex skin, supported by a hard, synthetic material.

KIP has been tested to determine the probable effective life of injection sites; a gel/skin section was used for a trial and six hundred injections were made in a dime-sized area. There was no perceptible degradation of the latex skin or of the gel itself. Considering the far greater area available in KIP, it is unlikely that repairs or refurbishments will be needed for a very long time.

The gel-filled injectable parts of KIP are completely encased in a latex skin. Many lattices are known allergens, but the latex skin of KIP is made of the same material that is used in the RSD PIXY phantom. Hundreds of these phantoms are in use, but no user has ever complained of allergic reactions. The RSD technicians, who have worked for years with this latex, have also never had such reactions. Allergic reactions are not expected to be a concern for the vast majority of users. The materials and design processes in KIP are made not only to simplify the overall process, but also to keep it as realistic as possible.

#### KIP (Injection Phantom) Catalog No. - RS-1300

![](_page_11_Picture_1.jpeg)

# ANTHROPOMORPHIC PHANTOMS

For Teaching/Training in Diagnostic Radiology

![](_page_11_Picture_4.jpeg)

![](_page_11_Picture_5.jpeg)

# ANTHROPOMORPHIC PHANTOMS ARE IDEAL SUBSTITUTE PATIENTS FOR TEACHING/TRAINING RADIOLOGIC TECHNOLOGISTS

- Permit unlimited repetition of most views...patients cannot be used for this
- Demonstrate effects of changing technical factors
- Provide valid feedback to evaluate trainee performance
- Because the same phantom can be used year after year, performance norms can be derived to guide training procedures

# HUMAN SKELETAL ARCHITECTURE IS DUPLICATED MORE REALISTICALLY WITH RSD SKELETONS THAN WITH CADAVERIC SKELETONS

- Soft-tissue molds and skeleton molds are matched for anatomic fidelity
- RSD skeletons meet radiation interaction properties of both cortical bone and spongiosa as standardized by the International Commission on Radiation Units and Measurements...many cadaveric human skeletons DO NOT—especially when dried out for their preparation

![](_page_11_Picture_14.jpeg)

Which skull is natural and which is made by RSD?

Answer at bottom of page

![](_page_11_Picture_17.jpeg)

![](_page_11_Picture_18.jpeg)

# PIXY

# The Anthropomorphic Training/Teaching Phantom

- An anatomically and radiologically correct female
- Small size and low weight simplify positioning
- Can be positioned for most views
- Permits evaluation of student performance
- Organs accept contrast media
- Opaque or transparent

PIXY<sup>®</sup> was designed specifically for training radiologic technologists. PIXY is 5 ft. 1 in. (156 cm) tall and weighs 105 lbs (48 kg). She is repeatable, virtually indestructible and a convenient substitute for patients.

![](_page_12_Picture_10.jpeg)

PIXY is made of tissue-equivalent materials and has life-like articulations. Students have no difficulty in maneuvering PIXY into most desired positions.

PIXY is used to demonstrate anatomy and evaluate positioning and imaging techniques, including kVp, mAs, contrast, optical density, OFD and TFD. Radiographs of PIXY are optically equivalent in density and contrast to human patients.

PIXY permits unlimited exposures and tolerates trainee errors.

### PIXY ANATOMY

PIXY shoulders have ball and socket joints; elbows and knees flex 90° to 100°. Hips flex 130° with 30° hyperextension.

A "frog position" is made possible by lateral flexion at the hips. The right hand is molded with fingers positioned for an AP view, while the left hand is in an oblique-lateral position. The left foot is in full plantar flexion; the right foot is in a neutral position.

C1, C2, C6 and C7 were converted to mechanical nylon joints because educators in the field prefer full positioning capabilities for the head. The design permits the remaining neck vertebrae to be fixed in a normal position, while assuring a full range of head motion.

![](_page_12_Picture_18.jpeg)

PIXY contains abdominal and pelvic organs: stomach, gall bladder, urinary bladder, kidneys, rectum and sigmoid flexure. These are air-filled, but accept water or contrast media and can be easily flushed after use. Custom fractures and custom pathologies are optional.

# PIXY MATERIALS

#### Skeletons

The matching of skeletons and soft-tissues permits external and bony landmarks to coincide. The position of bones within the soft tissues is anatomically correct.

The detail cast into RSD skeletons is considered a triumph of the sculptural moldmaker's craft. The skull, for example, has frontal

### **PIXY MODEL NUMBERS**

**RS-102** Opaque PIXY Phantom with stomach, gall bladder, urinary bladder, kidneys, rectum and sigmoid flexure. Permanent shipping/storage case.

**RS-102T** Same a RS-102 but transparent

RS-157\* Animal Lungs

**RS-102SP\*** Custom Fractures and Pathologies. Depressed skull fracture at any desired location. Hairline fracture of the scaphoid bone of the wrist (with no fragment separation). Fracture of the superior pubic ramus. Rib fracture at the mid-axillary line. Unseparated fracture of the patella. Stress fracture of the 5th tarsal bone of the extended foot. Pathologies based on user's requirements.

**RS-102R** Standard PIXY Refurbishment.

\* Must be ordered with Phantom (cannot be retrofitted).

and sphenoidal sinuses, ethmoidal and mastoid air cells and the auditory ossicles. Bone sutures are radiographically visible.

#### Soft tissues

PIXY is available in opaque or transparent tissue-equivalent materials. The transparent PIXY has visible organs and skeleton except at the hips, knees, and elbows, which are opaque because, as on the opaque PIXY, latex coverings are needed to retain tissue-equivalent gels for soft tissue continuity at these articulations. Two-ply coverings protect against gel leakage.

#### Lungs

Standard PIXY lungs are molded of tissue-equivalent foam with the mass density of inflated human lungs (0.30 g/cc). They are connected to the oro-nasal cavity by the stem bronchi and trachea. The oro-nasal pharynx is filled with a nearly air-equivalent foam.

Optional animal lungs, which duplicate the intricate detail of the vascular trees, are available. These lungs are fixed in the inflated state and molded to conform to the pleural cavities of the phantom. The pulmonary arteries are injected with a blood-equivalent plastic. In addition, low, medium or high contrast material may be selected by the user.

### REFURBISHMENT

RSD offers a PIXY refurbishment service which, after wear and tear from usage over an extended period of time, restores PIXY to its original condition. This service includes repair of minor bone fractures of hands and feet. Quotes are furnished upon request for more extensive damage.

\*Highly detailed polymer skeletons which reproduce the shape, mass density and attenuation coefficients of the cortical bone and spongiosa, allow continuous production of phantoms instead of sporadic production due to limited availability, variable size and uncertain chemical composition of human skeletons.

![](_page_13_Picture_21.jpeg)

# SECTIONAL PHANTOMS

# Anthropomorphic Body Sections with Applications Throughout the Field Of Radiography

Sectional phantoms, with the anatomic and radio-fidelity of PIXY, are used widely in teaching/training, with many other applications. They represent an average male 5 ft. 9 in. tall (175 cm), with a weight of 162 lbs (74 kg). They are rugged, easily transported and shatter-proof.

Sectional phantoms do not replace simple geometric phantoms that are used to evaluate individual characteristics of an imaging system. They provide comprehensive evaluation of the imaging system and imaging techniques under realistic conditions. Typical applications are the same as PIXY.

![](_page_14_Picture_5.jpeg)

### SECTIONAL MODEL NUMBERS

RS-10	8 OR RS-108T	Head with Cervical Spine (C1-C7)	RS-118 or RS-118T	Knee (natural position), right or left
RS-10	9 or <b>RS-109T</b>	Head without Cervical Spine	RS-119 or RS-119T	Knee (90° flexion), left only
RS-11	l or RS-IIIT	Thorax	RS-120 or RS-120T	Elbow (natural position), right or left
RS-11	3 or RS-113T	Pelvis	RS-121 or RS-121T	Elbow (90° flexion), left only
RS-11	4 or RS-II4T	Hand/Wrist (natural position), right or left	RS-122 or RS-122T	Complete Arm/Shoulder (natural position),
RS-11	5 or <b>RS-115T</b>	Hand/Wrist (oblique position), left only		right only
RS-11	6 or RS-116T	Foot/Ankle (natural position), right or left	RS-123 or RS-123T	Complete Leg/Hip (natural position),
RS-11	7 or <b>RS-117T</b>	Foot/Ankle (extended position), left only		right only

All Sectional phantoms are available in either opaque or transparent material (suffix T)

![](_page_15_Picture_1.jpeg)

# MAMMO II PHANTOM A Mammography Teaching/Training Phantom

- Teaches positioning for craniocaudal and mediolateral oblique views
- Teaches spot-compression procedures
- Sensitivity training for patient comfort
- Helpful in training male students (no more loaded vests to simulate breasts)

MAMMO II is a patient substitute that allows instructors to teach mammography positioning.

MAMMO II mammograms, taken within the range of standard technical factors, provide realistic images with high contrast.

MAMMO II simplifies classroom procedures, allowing trainees to take as many exposures as are needed to develop expertise.

![](_page_15_Picture_10.jpeg)

A molded gel provides realistic compressibility. Mammograms are taken at a breast thickness of 5-cm, using normal technical factors.

The breast is mounted on a post with adjustments for height and the angles needed for various views.

![](_page_15_Picture_13.jpeg)

![](_page_15_Picture_14.jpeg)

A small indicator box is placed next to the breast to signal when the 5-cm breast thickness is reached. An "ouch" is represented by a red warning light which informs the trainee that a patient's pain level can be reached at about this compression. The light is actuated 5-mms before the dead stop produced by the box. This procedure emphasizes the care needed for patients when the pain zone is reached.

![](_page_16_Picture_2.jpeg)

![](_page_16_Picture_3.jpeg)

![](_page_16_Picture_4.jpeg)

#### Indicator Box

#### MODEL NUMBER

RS-750 MAMMO II Phantom complete with stand and carrying/storage case

Our thanks to Dr. Carolyn Kimme-Smith for her invaluable help in developing MAMMO II.

# WOUNDED WILLY AND DAMAGED DEBBIE

Anthropomorphic Phantoms for Military Training in Radiology

- 60 TRAUMAS AND PATHOLOGIES DIVIDED
  BETWEEN WILLY AND DEBBIE
- CAN BE POSITIONED REALISTICALLY

![](_page_17_Picture_5.jpeg)

Wounded Willy

![](_page_17_Picture_7.jpeg)

Damaged Debbie

- HUMAN TECHNICAL FACTORS
- UNLIMITED REPETITION OF VIEWS
  WITHOUT HUMAN EXPOSURE
- RADIOGRAPHS THAT PERMIT
  EVALUATION OF TRAINEE PERFORMANCE
- TEACHING/TRAINING FOR CIVILIAN HOSPITAL EMERGENCY ROOMS

![](_page_17_Picture_13.jpeg)

# DESIGN PRINCIPLES FOR RADIOGRAPHIC TEACHING/TRAINING PHANTOMS

It is a universally-accepted fact of life that people cannot be subjected to diagnostic radiography for other than medicallynecessary purposes. Observance of this principle rules out the use of patients for basic training in these procedures (but permitting the use of patients for advanced, supervised training).

The re-creation of the human body, in all of its immense complexity, represents overkill for radiographic training. One example of a widely-accepted divergence from precise reproduction of the human is the use of transparent phantoms to combine the teaching of radiography with that of anatomy.

Whichever philosophy is pursued, the basic qualifiers of human substitutes are phantoms that yield radiographs resembling

those of the human, taken with human technical factors, articulated to enable basic views to be presented, and with an appropriate level of human anatomy.

A phantom is a "trade-off" between acceptable anatomic detail and unacceptable impact of artifacts on the image. WILLY and DEBBIE are based on several decades of experience with "trade-offs", variously driven toward one extreme or another. They yield human-like images, with human technical factors and with limited artifacts, (which are presented clearly as artifacts, not as anatomic detail). They are well-balanced patient substitutes for basic training of radiologic technologists, particularly in military or emergency room environments.

![](_page_17_Picture_20.jpeg)

The concept of grouping a large number of casualties in two teaching/training phantoms was originated by the Fleet Hospital & Operations Training Center, Camp Pendleton, California. WOUNDED WILLY and DAMAGED DEBBIE were designed and constructed by Radiology Support Devices, Inc. of Long Beach, California.

### WILLY AND DEBBIE TEACHING/TRAINING CAPABILITIES

They demonstrate and evaluate positioning and imaging techniques, including kVp, mAs, contrast, optical density, OFD and TFD. Their radiographs are optically equivalent to humans in density and contrast.

#### WILLY AND DEBBIE DIFFERENCES

The most obvious difference between them is in the complement of traumas and pathologies assigned to each.

Another difference is that DEBBIE has female breasts, while WILLY has natural male chest contours. DEBBIE is fitted with a wig, while WILLY is bald. They are dressed in camos for military training and in jumpsuits for civilian training.

### **REALISM OF TRAUMAS AND PATHOLOGIES**

There is no single, unique description of any of their traumas and pathologies. Rather, there are limitless variations among a broad range of casualties. The most meaningful judgments of the realism of trauma and pathologies are those based on long radiographic experience across the spectrum of casualties.

Patrick Hale, Senior Radiologic Technologist at the UCLA Emergency Room and an RSD consultant, made those judgments with respect to WILLY AND DEBBIE.

#### DIMENSIONS

The size and weight of PIXY are also used for WILLY and DEBBIE. They are small adults. Since technologists must learn to work with patients of all sizes and weights, a smaller phantom is as valid for training as a larger phantom, and position is facilitated. Each is 5 ft. 1 in. tall (156 cm) and weights 105 lbs (48 kg).

#### ANATOMY

WILLY and DEBBIE are articulated at the neck, shoulders, elbows, hips and knees. Fractures of the left shoulder and left hip are located in DEBBIE. To minimize handling problems, all other traumas of the arms and legs are located in WILLY and on the right side of DEBBIE. The articulations provide a broad range of positioning of capabilities, even the "frog position".

#### LUNGS

Lungs are molded of durable materials with radiodensities matched to humans in a median respiratory state. Animal lungs matching the human in size and blood vessels are available, but they are oriented towards research rather than training.

#### **SOFT TISSUES**

WILLY and DEBBIE have solid "soft tissues" that are hard and rigid. They cannot be palpated to locate traumas. However, radiological technologists are generally informed by the physician as to the views to be taken. The instruction manual provides this information to instructors.

#### **SKELETONS**

RSD-manufactured skeletons are used rather than natural human skeletons. The latter are generally unavailable and usually consist of an assortment of bones ranging from children to adults of ages for which osteoporosis becomes a factor.

RSD skeletons are not to be confused with plastic skeletons for teaching anatomy. RSD skeletons are made to fit the soft-tissue molds precisely. They have spongiosa moldings within marrow cavities and outer, cortical bone. Both constituents meet the internationally-accepted standards for radiodensity and specific gravity.

![](_page_19_Picture_1.jpeg)

Number 7: Fracture of Zygomatic Arch

Head Mounted on Anatomic Neck

### LEGEND

Traumas and pathologies are listed below. External markings are: N (none), O (open wound), S (swelling), H (bullet or foreign body hole), B (bruise), Side (R.L.), E (WILLY or DEBBIE).

# HEAD

Number	WILLY/ DEBBIE	Description	Side	External Marking
I	WILLY	Metallic fragment in orbit	R	N
2	WILLY	Multiple fragments lower face	N/A	Ν
3	WILLY	Step deformity of intraorbital rim	L	В
4	WILLY	Separated fracture of frontal zygomatic suture	L	S
5	WILLY	Metallic foreign body over skull	N/A	Ν
6	WILLY	Mandible fracture with missing bone	N/A	0
7	DEBBIE	Depressed comminuted fracture of zygomatic arch	L	S
8	DEBBIE	Mandibular fractures	R	S, B
9	DEBBIE	Cloudy maxillary sinus	L	Ν
10	DEBBIE	Fracture of nasal bones with mild displacement	N/A	Н

Note: An axial duct is seen above. It is filled by a polycarbonate rod to assemble the head and neck to TI. When assembled, the duct artifact is barely visible.

Anatomic and mechanical necks are interchangeable between WILLY and DEBBIE

Heads are interchangeable between WILLY and DEBBIE

![](_page_19_Picture_11.jpeg)

![](_page_20_Picture_1.jpeg)

Traumas and pathologies are listed below. External markings are: N (none), O (open wound), S (swelling), H (bullet or foreign body hole), B (bruise), Side (R.L.), E (WILLY or DEBBIE).

# HEAD

Number	WILLY/ DEBBIE	Description	Side	External Marking
11,12	WILLY	Displacement fracture of mandibular condyle	L&R	S

![](_page_21_Picture_1.jpeg)

![](_page_21_Picture_2.jpeg)

Anatomic Neck

Among the "trade-offs" required in these phantoms is that anatomic fidelity and the ability to move the head into a broad range of views is required in radiography. No mechanism can be designed for intervertebral motion without artifacts obliterating the radiographs.

This problem has been solved by the use of two necks. One is a multi-articulated polycarbonate assembly which provides for nearly all commonly used views. There is no attempt at radiographic realism in this neck. An alternate, fully-realistic neck is interchangeable with the mechanical neck. The cervical spine of this neck contains traumas.

### LEGEND

Traumas and pathologies are listed below. External markings are: N (none), O (open wound), S (swelling), H (bullet or foreign body hole), B (bruise), Side (R.L.), E (WILLY or DEBBIE).

# NECK

Number	WILLY/ DEBBIE	Description	Side	External Marking
13	E	C4, C5 Compression fracture	N/A	N
14	E	C7 Fractured by bullet	N/A	Н
15	E	C-spine bullet anterior to trachea shadow	N/A	Н

![](_page_21_Picture_10.jpeg)

Numbers 13 and 14-AP

![](_page_21_Picture_12.jpeg)

Numbers 13 and 14-Lateral

![](_page_21_Picture_14.jpeg)

![](_page_22_Picture_1.jpeg)

Traumas and pathologies are listed below. External markings are: N (none), O (open wound), S (swelling), H (bullet or foreign body hole), B (bruise), Side (R.L.), E (WILLY or DEBBIE).

# THORAX

Number	WILLY/ DEBBIE	Description	Side	External Marking
16	WILLY	Fracture of lateral ribs 6 & 7	R	N
17	WILLY	Mediolateral fracture of ribs 8 & 9	L	N
18	WILLY	Multiple rib fractures, four metallic fragments visible	R	Ν
19	WILLY	12th rib fracture	R	Ν
20	WILLY	Bullet in hemothorax overlaying 8th rib	L	Н
21	WILLY	Bullet overlying heart shadow	N/A	Н
22	WILLY	2 cm metallic fragment in mid-chest	R	Ν
23	WILLY	Bullet visible below costal margin under 11th rib	L	Н
24	WILLY	2 bullets in LUQ	L	Н
25, 26	WILLY	Shattered distal scapula	L&R	Н

![](_page_23_Picture_1.jpeg)

Numbers 27 and 29

![](_page_23_Picture_3.jpeg)

Traumas and pathologies are listed below. External markings are: N (none), O (open wound), S (swelling), H (bullet or foreign body hole), B (bruise), Side (R.L.), E (WILLY or DEBBIE).

# THORAX

Number	WILLY/	Description	Side	External
	DEBBIE			Marking
27	DEBBIE	Widened mediastinum and pleural effusion	N/A	N
28	DEBBIE	Chest tube, lung inflated	L	Tube
29	DEBBIE	Infiltrate	N/A	Ν

![](_page_23_Picture_8.jpeg)

![](_page_24_Picture_1.jpeg)

Traumas and pathologies are listed below. External markings are: N (none), O (open wound), S (swelling), H (bullet or foreign body hole), B (bruise), Side (R.L.), E (WILLY or DEBBIE).

# ABDOMEN

Number	WILLY/ DEBBIE	Description	Side	External Marking
30	DEBBIE	Bullet in mid-abdomen	N/A	Н
31	WILLY	Unstable fracture of LI	N/A	Ν
32	WILLY	Compression fracture of L5	N/A	Ν
33	DEBBIE	Metallic foreign body lateral to PSOAS	R	Ν
34	DEBBIE	Compression fracture of L4	N/A	Ν
35	DEBBIE	Metallic fragments – 2 mid-abdomen,		
		I each in RLQ and LLQ	N/A	Ν
36	DEBBIE	Bullet in mid-abdomen	N/A	Н
37	DEBBIE	Metallic fragments – 2 mid-abdomen		
		I each: RLQ and LLQ	N/A	Ν
38	WILLY	ILIAC crest comminuted fracture with metallic fragments	R	В

![](_page_25_Picture_1.jpeg)

Numbers 39, 40, 41, 43 and 44

![](_page_25_Picture_3.jpeg)

Numbers 41 and 45

Traumas and pathologies are listed below. External markings are: N (none), O (open wound), S (swelling), H (bullet or foreign body hole), B (bruise), Side (R.L.), E (WILLY or DEBBIE).

# **PELVIS**

Number	WILLY/ DEBBIE	Description	Side	External Marking
39	DEBBIE	Displaced fracture of pubic ramus	L	N
40	DEBBIE	Sacroiliac disruption, acetabular fracture	L	Ν
41	DEBBIE	Foreign body lateral to PSOAS	R	Ν
42	WILLY	Non-displaced pubic ramus fracture	N/A	Ν
43	WILLY	Superior and inferior pubic ramus fracture	R	Ν
44	WILLY	Pelvis fracture with symphysis diastasis and	NI/A	NI
45	WILLY	Bullet in sacrum	N/A	N

![](_page_25_Picture_9.jpeg)

![](_page_26_Picture_1.jpeg)

NOTE CIRCULAR ARTIFACT ... THIS IS FILLING PLUG FOR JOINT GEL

Traumas and pathologies are listed below. External markings are: N (none), O (open wound), S (swelling), H (bullet or foreign body hole), B (bruise), Side (R.L.), E (WILLY or DEBBIE).

# HIP JOINTS AND THIGHS

Number	WILLY/ DEBBIE	Description	Side	External Marking
46	WILLY	Shattered acetabulum	L	Latex "shorts"
47	WILLY	Shattered femoral head	L	Latex "shorts"
48	WILLY	Comminuted mid-shaft fracture	L	S
49	WILLY	Left femur comminuted fracture 12 cm above knee	L	S

![](_page_27_Picture_1.jpeg)

Traumas and pathologies are listed below. External markings are: N (none), O (open wound), S (swelling), H (bullet or foreign body hole), B (bruise), Side (R.L.), E (WILLY or DEBBIE).

# KNEES, LOWER LEGS, FEET

Number	WILLY/ DEBBIE	Description	Side	External Marking
50	DEBBIE	Proximal tibia fracture	L	S
51	WILLY	Comminuted fracture of tibia and fibula	R	S
52	WILLY	Displaced ankle fracture	R	S
53	DEBBIE	Minimally displaced distal tibia fracture	R	S
54	DEBBIE	Displaced fracture of calcaneus bone	R	Ν

![](_page_27_Picture_6.jpeg)

Knee Joint

![](_page_27_Picture_8.jpeg)

Number 51

![](_page_27_Picture_10.jpeg)

![](_page_28_Picture_0.jpeg)

Traumas and pathologies are listed below. External markings are: N (none), O (open wound), S (swelling), H (bullet or foreign body hole), B (bruise), Side (R.L.), E (WILLY or DEBBIE).

# SHOULDER AND ELBOW JOINTS

![](_page_28_Picture_4.jpeg)

NOTE: GROOVES TO RECEIVE LATEX SLEEVE

![](_page_29_Picture_1.jpeg)

Traumas and pathologies are listed below. External markings are: N (none), O (open wound), S (swelling), H (bullet or foreign body hole), B (bruise), Side (R.L.), E (WILLY or DEBBIE).

# FOREARMS

Number	WILLY/ DEBBIE	Description	Side	External Marking
55	WILLY	Displaced fracture of radius and ulna	L	
56	DEBBIE	Volar angulated distal radius and ulna fracture	L	
57	WILLY	Angulated comminuted fracture of midshaft radius and ulna	R	
58	DEBBIE	Minimally displaced distal radius fracture not involving wrist, offset bone ends		

# HANDS

Number	WILLY/ DEBBIE	Description	Side	External Marking
59	DEBBIE	3rd and 4th metacarpals shattered	L	Thickened,
				back of hand

![](_page_29_Picture_8.jpeg)

Number 59

![](_page_29_Picture_10.jpeg)

# ORDERING INFORMATION

# **RS-600 TEACHING/TRAINING PHANTOM SYSTEM**

#### Includes:

- RS-601 WOUNDED WILLY
- RS-602 DAMAGED DEBBIE
- RS-603 ANATOMIC NECK
- RS-604 MECHANICAL NECK WITH FOAM FLESH NECK/I EA FOR WILLY & DEBBIE
- RS-605 TRAUMAS AND PATHOLOGIES (-01 TO -59)

### **RS-610 CUSTOM ITEMS**

Traumas and pathologies are divided between WILLY and DEBBIE in a way that minimizes interference between them. Some changes can be made in locations of each, or additional traumas and/or pathologies can be added or substituted for others.

Ask about special requirements and pricing of changes. Changes cannot usually be retrofitted.

![](_page_30_Picture_12.jpeg)

# ANGIOGRAPHIC HEAD PHANTOMS

# The Anthropomorphic Quality Assurance Phantom

- 3-dimensional high-contrast vascular pattern
- Full or half-head
- Tissue equivalent materials
- Step wedge and resolution test patterns
- Opaque or transparent

Alderson ANGIOGRAPHIC HEAD PHANTOMS bridge the gap between physical and anatomical information requirements. Molded in tissue equivalent material, an accurate male skull contains a 3-dimensional, high-contrast vascular simulation to facilitate correlation of the radiologist's subjective evaluation of angiographic image quality with actual measurements of resolution and contrast under the same exposure conditions.

Each ANGIOGRAPHIC HEAD PHANTOM contains a 5-step wedge. A 2-10 line pair/mm test pattern is optional. Other patterns or test objects and custom pathologies are available on special order.

![](_page_31_Picture_10.jpeg)

![](_page_31_Picture_11.jpeg)

![](_page_32_Picture_1.jpeg)

The ANGIOGRAPHIC HEAD PHANTOM provides a "dry run" to completely check out angiographic equipment and ensure that is operating satisfactorily in all significant details before subjecting patients to radiological procedures. If the imaging system malfunctions, the phantom also plays a critically important role in isolating and verifying correction of the problems. The ANGIOGRAPHIC HEAD PHANTOM confines the variables to components and technique and is an invaluable service and teaching tool.

Unique RSD soft-tissue equivalent material is used for the skin tissue and neck and is adjusted to brain density in the cranium. This material closely duplicates brain tissues in radioabsorptive and scatter properties. The phantom is virtually shatterproof.

A high contrast 3-dimensional vascular pattern is placed in the median plane. The pattern closely resembles an internal carotid arteriogram in its early phase. The radio-density of the angiographic pattern has been adjusted to represent a 75% contrast-media. The phantom can be used omnidirectionally.

The ANGIOGRAPHIC HEAD PHANTOM is available as either a full or half head. The full head has the advantage of representing the full scatter properties and subject contrast of a human head. The half-head model is well suited to non-grid techniques. It has the advantages of lighter weight, lower cost and smaller size, easily fitting into a briefcase.

The combination of the simulated vascular pattern, resolution chart, and stepwedge enables the user to correlate physical parameters (such as resolution, contrast and speed) with the subjective evaluation of the skull markings and the vascular detail.

The ANGIOGRAPHIC HEAD PHANTOM is available in either transparent or opaque models.

### **MODEL NUMBERS**

#### **RS-230**

Opaque Full Angiographic Head with stepwedge **RS-230T** 

Transparent Full Angiographic Head with stepwedge **RS-235** 

Opaque Full Angiographic Head with resolution test pattern (2-10 1p/mm) and stepwedge **RS-235T** 

Transparent Full Angiographic Head with resolution test pattern (2-10 Ip/mm) and stepwedge

#### **RS-240**

Opaque Half Angiographic Head with stepwedge RS-240T

Transparent Half Angiographic Head with stepwedge **RS-245** 

Opaque Half Angiographic Head with resolution test pattern (2-10 Ip/mm) and stepwedge **RS-245T** 

Transparent Half Angiographic Head with resolution test pattern (2-10 1p/mm) and stepwedge

![](_page_33_Picture_1.jpeg)

LUNG/CHEST PHANTOMS

# The Next Best Thing to Human Lungs for Radiographic Studies

- Extensive Vascular Detail
- Different Degrees of Vascular Contrast Available
- Interchangeable Normal and Pathological Lungs

Developed in conjunction with the University at California, Irvine's Department of Radiological Sciences, the Alderson Lung/Chest Phantom is a specialized phantom, providing a high degree of realism in chest radiography.

The Alderson Lung/Chest Phantom extends from the neck to below the diaphragm. It is molded around a male skeleton, corresponding to the external body size of a patient, 5 feet, 9 inches (175 cm) tall and weighing 162 lbs (73.5 kg). RSD materials are equivalent to natural bone and soft tissues.

Animal lungs are selected to match the size of an adult male. Lungs are fixed in the inflated-state and are molded to conform to the pleural cavities of the phantom. The pulmonary arteries are injected with a blood equivalent plastic.

The Lung/Chest Phantom with simulated left coronary artery reveals several areas of coronary artery irregularity and narrowing.

#### To demonstrate different pathological conditions, five standard pathologies are incorporated:\*

- Two contiguous 0.5 cm nodules at the tip of the first left rib
- A 0.6 cm nodule superimposed with large vessel in the left lower lobe
- A 1.5 cm nodule, left mediastinal shadow
- A 0.6 cm nodule blending in with the right pulmonary artery
- Pneumonia in the right lower lobe

### Custom Pathologies Are Available Upon Request

The Lung/Chest Phantom is available either with the diaphragm permanently sealed to the interior of the phantom, fixing the lungs in place, or with a removeable diaphragm, which permits the interchange of lungs, and provides an unlimited number of configurations and disease simulations.

Custom pathologies are available as wrap around sheets on either or both lungs.

All models are available with blood-equivalent pulmonary arteries, or with low or high contrast media added.

\*Bullet points are optional items.

![](_page_33_Picture_22.jpeg)

No Added Contrast

![](_page_33_Picture_24.jpeg)

Low Contrast

![](_page_33_Picture_26.jpeg)

High Contrast

### **MODEL NUMBERS**

#### RS-310

Lung/Chest Phantom with permanently sealed diaphragm **RS-315** 

Lung/Chest Phantom with permanently sealed diaphragm and left coronary artery

#### **RS-320**

Lung/Chest Phantom with removeable diaphragm lung pair insert without coronary artery **RS-330** 

Lung/Chest Phantom with removeable diaphragm lung pair insert with coronary artery

#### **RS-**340

Lung/Pair insert without coronary artery

#### **RS-**345

Lung/Pair insert with coronary artery

![](_page_33_Picture_39.jpeg)

# COMPUTED TOMOGRAPHY HEAD PHANTOMS

### Computed Tomography Head Phantom

Model Number RS-250

- Anthropomorphic
- Molded Around Skull
- Checks Important Physical Parameters
- Provides Realistic System Check
- Ideal For Training
- Polycarbonate Base Dimensioned For Scans Parallel or Perpendicular to Longitudinal Axis

![](_page_34_Picture_10.jpeg)

SECTION A: Aluminum plates, 0.4 mm thick, set at a  $45^{\circ}$  angle, measure beam width and slice thickness.

SECTION B: The dosimetry section provides patient-exposure controls, and checks on abnormal internal doses before actual patient scans. Customization to accommodate TLD with rods or chips is available.

SECTION C: Cylindrical tumors of graded sizes and radiodensities establish high and low-contrast resolution and demonstrate partial beam-averaging effects.

SECTION D: The anthropomorphic section provides actual auditory ossicles in an air-contrast inner ear and a fractured petrous bone. Small tumors in the posterior fossa are placed in an area which most scanners image with difficulty.

SECTION E: 1/4-in. diameter aluminum rod on the phantom's longitudinal axis, checks general alignment, and "Dry Water" gives a realistic "noise check".

![](_page_34_Picture_16.jpeg)

![](_page_34_Picture_17.jpeg)

![](_page_34_Picture_18.jpeg)

![](_page_34_Picture_19.jpeg)

![](_page_34_Picture_20.jpeg)

![](_page_35_Picture_1.jpeg)

# ANTHROPOMORPHIC PHANTOMS FOR NUCLEAR MEDICINE

Realistic Test Subjects for Applications Where Patients Cannot Serve or Should Not Serve

• Radiation Equivalent and Anatomically Correct

They test reconstruction techniques, non-uniform attenuation and scatter correction methods using different radionuclides under realistic conditions

The Heart/Thorax Phantom is ideal for evaluation of detectability, extent and severity of myocardial infarcts in patients. This Phantom also provides valid assessment of mammoscintigraphy techniques. The Striatal Phantom optimizes quantitative imaging in patients, using PET or SPECT.

![](_page_35_Picture_7.jpeg)

#### REFERENCES

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![](_page_35_Picture_15.jpeg)

# HEART/THORAX FOR CARDIAC SPECT/PET AND MAMMOSCINTIGRAPHY

Applications of Anthropomorphic Phantoms\*

- Receptor Quantification as a Function of Uptake Ratio(s)
- Partial Volume Effects
- Scatter and Attenuation Correction Schemes
- Threshold for Changes in Uptake(s)

Myocardial perfusion SPECT is a widely-used, non-invasive method for the diagnosis and management of patients with coronary disease. However, non-uniform photon attenuation, Compton scatter, limited and depth-dependent spatial resolution, as well as image noise, limit the ability of SPECT to obtain images that reliably represent the true tracer distribution. The non-uniform attenuation of the thorax is the most significant factor limiting the diagnostic efficacy of myocardial SPECT.

The currently used attenuation, scatter and resolution correction methods are suboptimal, since they do not provide improvement in the 25% false-negative findings in a group of about 100 patients with luminal diameter stenoses of at least 50%(1). Furthermore, the ability to detect multivessel disease was 70% without and 47% with corrections. This finding implies that myocardial SPECT can seriously underestimate the extent

\*Applicable to both Heart/Thorax(h) and Striatal(s) Phantoms unless otherwise indicated.

![](_page_36_Picture_10.jpeg)

- Comparison of Different Acquisition Modes, e.g. 2D vs. 3D Pet(s)
- Design of Different Reconstruction Strategies
- Testing and Validation of Image Registration Techniques
- Design of Imaging Protocol for Patients

**Disassembled Phantom** 

of disease in high-risk patients. On the other hand, the falsepositive findings in the group with a low probability of coronary disease were reduced from 14% without corrections to 3% with corrections.

Obviously, further improvements in both hardware and software for myocardial SPECT are necessary before this important diagnostic technique can realize its full potential. These improvements must be carefully evaluated on realistic, anthropomorphic phantoms to improve results in clinical practice.

### **MODEL NUMBERS**

Catalog Nos	. Description
RS-800T	Heart/Thorax Phantom (Includes all items listed below)
RS-801	Thoracic Cavity with bottom plate
RS-803	Perfusable Lungs (Pair)
RS-804	Heart (With two hollow defects in myocardial wall.
	Standard sizes or to customer specifications).
RS-805	Liver shell
RS-806	Chest overlay
RS-807	Removeable Breast with set of 5 tumors
RS-809	Set of 10 threaded nylon tumor support rods
RS-810	Set of 5 fillable markers
RS-811	Tumor only, with rods sizes – 3, 6, 9, 12 and 15m

PET images of the Heart Phantom filled with 0.5 mCi of F-18 FDG placed in the Thorax Phantom were acquired on a Siemens/CTI ECAT EXACT HR+ PET system in 3-D mode (septa out) at the University of California at Los Angeles (UCLA), by courtesy of Magnus Dahlbom, PhD. The emission scan contained 25M counts and were reconstructed using a Hanning filter, resulting in a final image resolution of approximately 5.5 mm FWHM. The data were corrected for scatter and attenuation prior to reconstruction.

![](_page_37_Picture_1.jpeg)

Disassembled Heart with Standard Defects

### **BASIC THORAX**

The thorax is molded of polyurethane, modified for tissueequivalence, with a mass density of 1.10 g/cc. The narrow beam linear attenuation coefficient measured at 140 keV (Tc-99m) is 0.160 cm - 1.

The skeleton, embedded in the soft tissue, extends from the suprasternal notch down to L2. The RSD materials closely meet the standards of the International Commission on Radiation Units and Measurement (ICRU) Report No. 44 (Tissue Substitutes in Radiation Dosimetry and Measurement, 1989) for both the cortical and spongiosa components of the human skeleton. The mass densities are 1.88 g/cc for cortical bone and 1.16 g/cc for spongiosa. The narrow beam linear attenuation coefficient for the cortical component, measured at 140 keV, is 0.280 cm-1.

The volume of the thoracic cavity, when all organs (heart, lungs, and liver) are inserted, is about 8,200 ml. It is filled from the top, with either an inert or a radioactive solution, to simulate the thoracic background.

A valve is installed at the base for conveniently draining the phantom. The residue on the walls of the cavity can be easily flushed with the fittings provided at the top of the phantom. A second, smaller fitting is also provided as an air-bleed during filling.

#### HEART

An accurately anatomic heart model is based on vacuum-formed shells. It was designed using high resolution, contrast-enhanced, ultrafast CT data from a normal patient, slightly modified to facilitate its use.

The left and right chambers are connected at the atrium region to make a single compartment which can be filled and flushed independently using two ports labeled HC (heart chambers). The right ventricle is slightly modified to allow air to escape during filling. The myocardial wall (MW) has two ports, flushing and independent filling. The volume of the heart chambers is 284 ml, while the volume of the myocardial wall is 238 ml, without inserted defects.

The standard model includes three defects with volumes of 8.9, 13.5, and 41.7 ml, respectively. Each of the defects can be filled separately.

Defects of different dimensions can be ordered at no added cost. A disassembled heart is sent on request, so that dimensions of a special set can be established. Note that different defects cannot be retrofitted in the assembled heart.

### LUNGS

Perfusable lungs are molded in hollow, vacuum-formed shells, filled with styofoam beads. The final mass density of 0.40 g/cc is attained by adding an inert or radioactive solution through a filling port at the top of each lung shell. Extra sets of lungs can also be furnished for work continuity. The volumes of the left and right lung shells are 907 ml and 1,134 ml, respectively.

#### LIVER

A liver with a volume of 980 ml is included to evaluate the effect of its uptake on quantitative myocardial imaging. It is a vacuumformed shell, mounted on acrylic tubes to minimize artifacts. The liver can be filled with an inert or radioactive solution.

#### FILLABLE EXTERNAL MARKERS

A set of fillable capsules is provided to serve as external markers. Capsules can be filled with a radioactive solution and attached to the external surface of the phantom. The phantom can then be imaged, using SPECT or PET modalities to compare imageregistration techniques.

### THORAX OVERLAY, REMOVEABLE BREASTS AND BREAST TUMORS

The thoracic phantom without the overlay simulates an average male patient. The overlay, with or without breasts, simulates a large female or a still larger male patient, respectively. It is then possible to evaluate the effect of additional attenuation and scatter on quantitative myocardial imaging.

The volume of each vacuum-formed breast is 972 ml. A tumor, filled with a radioactive solution can be inserted to evaluate the planar and tomographic imaging techniques used for mammoscintigraphy-(2). A set of breast tumors (3, 6, 9, 12 and 15 mm diameters) is included. They are supported by thin, threaded nylon rods which pass through ports and are sealed by O-rings. They can be bent by hand to reach any part of a breast.

The thorax is mounted on a base plate with an O-ring seal. Four rubber feet provide space under the phantom for drain fittings the base plate is removed readily to provide access to the interior of the phantom.

A knob at the top of the neck secures a rod which passes through to the heart/lung subassembly for disassembly.

![](_page_37_Picture_24.jpeg)

# STRIATAL PHANTOMS FOR SPECT/PET

### THE HEAD

The Head Phantom is based upon a standard RSD head with a calvarial cut to insert or remove the brain shell easily. The nasal cavity and maxillary sinuses are filled with foam with a mass density of 0.23 g/cc.

#### BRAIN SHELL

The brain shell has five compartments which can be filled separately: left and right nucleus caudate, left and right putamen, and the remainder of the brain. This allows different nucleus caudate to putamen ratios as well as different striatal to background ratios to be obtained; this also permits differences between left and right striatal activity to be examined.

The volume of the brain shell is about 1,260 ml. The volumes of the nucleus caudate and putamen are 5.4 ml and 6.0 ml respectively.

#### FILLABLE EXTERNAL MARKERS

A set of fillable capsules is provided to serve as external markers. Capsules can be filled with a radioactive solution and attached to the external surface of the phantom. The phantom can then be imaged, using SPECT or PET modalities to compare image-registration techniques.

Quantification of striatal uptake is not straightforward because it depends on a number of factors:

Type of radionuclide used (Tc-99m, I-123 or F-18) Imaging factors such as: collimator type, amount of scatter and attenuation.

Image processing parameters such as: scatter and attenuationcorrection techniques, type of reconstruction filter, slice thickness, region-of-interest size and its location.

![](_page_38_Picture_12.jpeg)

Striatal Head Phantom

# **MODEL NUMBERS**

Catalog Nos	5. Description
RS-900T	Head with transparent Brain Shell containing Striatum.
	(Includes a set of fillable markers.)
RS-901T	Transparent Brain Shell containing Striatum.

In normal subjects, the putamen and head of the nucleus caudate are small structures with typical dimensions of 7-15 mm in the axial plane (that is comparable to the system resolution). Since partial volume effects are more important for objects with dimensions less than twice the system resolution, the selection of imaging and reconstruction parameters is critically important in calculating the striatal-to-occipital ratio used to measure the relative striatal uptake in the brain.

![](_page_38_Picture_18.jpeg)

PET Images of the Striatal Phantom filled with 0.8 mCi of FDG were acquired on a Siemens/CTI ECAT EXACT HR PET system in 2-D mode at the University of California at Los Angeles (UCLA) by courtesy of David Stout. The emission scan contained 43 million counts and was corrected for attenuation and reconstructed with a Hann filter resulting in a final image resolution of approximately 7.6 mm FWHM.

![](_page_38_Picture_20.jpeg)

View of the Brain Shell Alone

![](_page_39_Picture_1.jpeg)

# THE LAWRENCE LIVERMORE **REALISTIC PHANTOM**

A Worldwide Reference Standard for In-vivo Counting

 And Alderson Fission-Product and Thyroid Phantoms

The Lawrence Livermore Realistic Phantom was developed under the direction of the U.S. Department of Energy, primarily as a reference standard for the in-vivo counting of emissions from low-energy transuranic nuclides.

The organs of interest are the lungs, liver, and lymph nodes. Each of these may be radioactive or inert. These organs are accommodated in a male thorax generally similar to average adult males.

The Livermore phantom contains a synthetic bone skeleton molded within a soft-tissue-equivalent material. The organs are located in an internal cavity with a separate torso cover that closes the phantom. Anterior sections of ribs and the sternum are molded into this cover.

Soft-tissue-equivalent blocks are used to position the organs and fill significant air spaces, providing continuity of the soft tissues throughout the phantom. The phantom is shipped assembled with inert organs. Any or all of these organs can be replaced with radioactive organs, which are shipped in separate packages.

### ORGANS

All organs are made of soft-tissue-equivalent materials. Lungs are available with nuclides uniformly dispersed throughout the lung molding material. Optional organs (developed by RSD and not part of the original DOE specifications) are inert, but have holes in 2 cm<sup>2</sup> grids. These either can be filled with inert plugs or with active capsules to establish any desired distribution within the lungs.

The liver has the same loading flexibility, but another option is

![](_page_39_Picture_12.jpeg)

Lungs

![](_page_39_Picture_14.jpeg)

**Chest Overlay Plates** 

available, designed for use with solutions having relatively short half-lives. This liver is a hollow shell with a fill/drain port.

If the liver is not required, it may be replaced with the Abdominal Contents, which are also available with a hole matrix, or active.

Lymph nodes are available as hollow shells or as active packets. Two are 8 mm in diameter by 17 mm long. A third is 13 mm in diameter by 25 mm long. They are positioned in recesses molded in a lymph node block.

#### CHEST OVERLAY PLATES

Transuranic emissions from individuals with varying amounts of muscle and/or adipose tissue may be so attenuated as to be undetectable. Chest overlay plates were developed to ensure the validity of in-vivo counting of such individuals.

There are three sets of plates, each in four graded thicknesses. One set is equivalent to 87% adipose and 13% muscle, another is equivalent to 50% adipose and 50% muscle, and the third is equivalent to 100% muscle. Plates of each material and/or each thickness are available separately.

### TARGETS

Three sets of concentric circles are drawn in permanent black ink over the torso cover and over each chest overlay plate. They range in 1 in. increments from 1 in. to 5 in. in diameter, with a 5.5 in. diameter outer circle. One set of circles is placed over each lung region, with the outer circle tangent to the inferior aspect of the clavicle and protruding over the sternum. The third set is placed over the liver.

> A 2 cm<sup>2</sup> grid is projected in red ink over most of the chest surface by the same technique that is used for the circles. All targets are consistent among all phantoms.

![](_page_39_Picture_25.jpeg)

![](_page_40_Picture_1.jpeg)

# THE FISSION-PRODUCT PHANTOM

The Fission-Product Phantom is partially modeled after the Lawrence Livermore Realistic Phantom. It was developed by RSD to meet the needs of nuclear power stations and other facilities where more organs are needed than are provided by the Lawrence Livermore Realistic Phantom.

This phantom may be used on a couch, in a chair or standing. It includes the head and neck, the complete torso and stub legs articulated at the hips (which are also needed for the sitting position). The same access to the torso cavity is provided as in the Livermore Phantom.

The materials of construction are RSD multi-energetic formulations. The skeleton has been extended to include the head and full torso. The RSD "Superhuman Skeleton," which is multienergetic, is used. RSD materials closely meet the standards of the International Commission on Radiation Units and Measurements (ICRU) Report No. 44 (Tissue Substitutes in Radiation Dosimetry and Measurement, 1989).

#### ORGANS

The organs of the Lawrence Livermore Realistic Phantom fit exactly into the Fission-Product Phantom, but RSD has modified the internal construction to accommodate additional organs: thyroid, kidneys, stomach, spleen, pancreas, and small and large intestines.

The Fission-Product Phantom system is shipped with inert organs. Any or all organs can be replaced by radioactive organs, which are shipped in separate packages.

The same choices of nuclide loadings are available for active organs as for the liver of the Livermore Phantom (uniformly dispersed in the molding materials, hollow shells or with hold grids).

### CHEST OVERLAY PLATES

These are fitted specifically to the Fission-Product Phantom and are not interchangeable with the Livermore Phantom.

### THE THYROID PHANTOM

The Thyroid Phantom is an integral part of the Fission-Product Phantom, but it can also be supplied separately (with or without a head). This phantom has the same contours as in the full Fission-Product Phantom.

The Thyroid Phantom contains a neck with corresponding "Superhuman Skeleton" vertebrae, a hollow-shell thyroid with filling and flushing ports, and a front cover of tissue-equivalent phantom material.

This assembly has been designed for rapid removal of the cover plate and thyroid, a quick fill with an isotope solution and an equally rapid reassembly. This permits work with iodines of very short half-lives. A portion of the clavicles and sternum are included to further enhance the realism of the phantom.

### RADIONUCLIDES

RSD routinely manufactures active organs with isotopes to suit users' needs. Active capsules to fit into the gridded holes are available, or empty capsules can be supplied to be filled by the user.

RSD usually supplies the required isotopes, but users may furnish them if so desired.

Isotopes are most often received as calibrated solutions, traceable to the NIST. Organ loading is controlled by micropipetting aliquots from the calibrated solutions. Uraniums and plutoniums are traceable to the NIST by mass. Other isotopes are usually traceable by activity.

Some isotopes are manufactured only at intervals throughout the

year, so delivery is subject to availability. In some cases, calibration costs from governmental sources are subject to wide fluctuations.

![](_page_40_Picture_22.jpeg)

Thyroid Phantom

![](_page_41_Picture_1.jpeg)

![](_page_41_Picture_2.jpeg)

# LIVERMORE ORGANS

Organs	Inert, Hole Matrix	Solid, Active	lnert, Hollow
Lungs	N/A	RS-503A	N/A
Lymph Nodes (set of 3)	N/A	RS-506A	RS-506S
Liver and Liver Envelope	RS-507H	RS-508A (Liver only)	RS-519S (Liver only)
Abdominal Contents*	RS-510H	RS-511A	N/A

\*Replaces Liver and Liver Envelope

# **FISSION-PRODUCT ORGANS**

Organs	Inert, Hole Matrix	Solid, Active	lnert, Hollow
Lungs	RS-502H	RS-503A	N/A
Lymph Nodes (set of 3)	N/A	RS-506A	RS-506S
Thyroid	N/A	RS-543A	RS-543S
Liver	RS-507H	RS-508A	RS-519S
Kidneys (pair)	RS-530H	RS-531A	RS-532S
Stomach	RS-533H	RS-534A	RS-535S
Pancreas	RS-536H	RS-537A	RS-538S
Spleen	RS-539H	RS-540A	RS-541S
Small Intestive	RS-544H	N/A	N/A
Large Intestine	RS-546H	N/A	N/A

#### CHEST OVERLAY PLATES

RS-513	Chest Overlay Plate (Any of 4 thicknesses)
(1, 2, 3, 4)	#1 – thinnest, #4 – thickest
(A, B, C)	A) 87% adipose – 13% muscle
	B) 50% adipose – 50% muscle
	C) 100% muscle
RS-514	Chest Overlay Plates
(A, B, C)	Set of 4, in materials A, B, or C

RSD RADIOLOGY SUPPORT DEVICES ALDERSON | PHANTOMS

#### MODEL NUMBER RS-500

Lawrence Livermore Realistic Phantom System includes: torso and gridded torso cover, inert heart, lungs, lymph nodes, liver and liver envelope or abdominal contents. All blocks needed for organ location and soft tissue continuity within torso. Documentation. Permanent shipping and storage case.

# MODEL NUMBER

#### RS-550

Fission-Product Phantom System, includes: head, neck, neck cover plate for thyroid access, complete torso and gridded torso cover, inert heart, lungs, lymph nodes, thyroid, liver, kidneys, stomach, pancreas, spleen, small and large intestines. Stub legs with pivot bolts. Documentation. Permanent shipping and storage case.

#### CAPSULES

#### **RS-520**

Active Capsule (isotope and activity to be specified) **RS-521** 

Inert Capsule with sealing cap, to be filled by user

#### THYROID PHANTOM

#### **RS-542**

Thyroid Phantom without head; consists of neck, hollow thyroid, thyroid cover, a portion of the cervical spine, sternum and clavicles

#### RS-545

Thyroid Phantom with head; (same as RS-542 but with head and full cervical spine)

### RS-543A

Thyroid, solid, active **RS-534S** 

Thyroid, hollow, inert

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![](_page_42_Picture_1.jpeg)