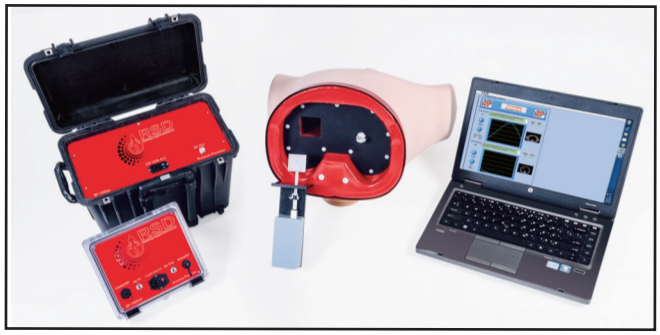
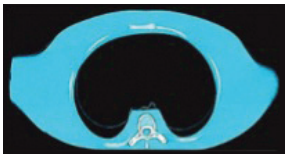
RSD
Radiology Support Devices, Inc.

Dynamic Breathing Phantom





THE ONLY DYNAMIC ANTHROPOMORPHIC THORAX

- **For use in diagnostic radiology, radiation therapy, and routine quality assurance**
- **Faithful simulation of physical form, imaging, and dosimetry properties**
- **Moving target to simulate tumor motion with the lung**
- **Based on the Alderson Radiation Therapy (ART) Phantom**

RSD's newest edition of the Dynamic Breathing Phantom features simplified wiring, an improved control box, optional air supply, pre-designated profiles of patient specific breathing patterns, and the option to integrate simple heart and breast models with the phantom. Plus, the complete system is smaller, lighter, and quieter with revised software for Windows 10 providing a more intuitive interface.

Designed for use in diagnostic radiology settings for the acceptance of diagnostic CT-based scanners and radiation therapy machines, as well as the evaluation of patient radiation therapy delivery and dosimetry, RSD's Dynamic Breathing Phantom achieves realistic anterior ribcage motion by air inflation in realistic breathing patterns. The phantom itself is a simulation of an average adult humanoid torso including lungs, ribcage/chest-wall bone, skin, and sub-dermis. The material properties of the incorporated soft tissue, organs, bones, and joints provide a faithful simulation of the physical thoracic form and of radiological imaging and radiation dosimetry properties.

This unique phantom has a moving target within the lung equivalent lobe to simulate tumor motion inside the lung. The electro-pneumatic motion controller and easy-to-use phantom control software allow users to program different breathing patterns and breathing rates so that they can choose their evaluations to precisely plan dose delivery to any patient. Target motion is controlled independently of the breath motion and may be set to be antithetical or to mimic the recorded motion of a radiation therapy targeted tumor.

The Dynamic Breathing Phantom System includes: The Dynamic Breathing Phantom (thoracic mannequin), electro-pneumatic motion controller, target fixtures for imaging and radiation dosimetry, individual thorax and target motions & rates: sin2, sin4, sin6, 1-sin4, 1-sin6, 5-20 breath/min, Phantom Control Software for Microsoft Windows, and USB control hardware.

Model Numbers

Model No.	Product Description
BF-1500	Dynamic Breathing Phantom with Intergrated Control Module & Air Supply
BF-1500CM	Dynamic Breathing Phantom Control Module (using External Air Supply at 110˜230V AC)
BF-1500AIR	External Air Supply (available in 110˜230V AC)

Materials

See page 30 for more information.

RSD Soft Tissue	RSD Cortical Bone	RSD Trabecular Bone
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Publication References: 1) Ranjbar M, Sabouri P, Repetto C, Sawant A. A novel deformable lung phantom with programmable variable external and internal correlation. Medical Physics, 46: 1995-2005. 2019. DOI: https://doi.org/10.1002/mp.13507. 2) Zhang Y, Deng X, Yin FF, Ren L. Image acquisition optimization of a limited-angle intrafraction verification (LIVE) system for lung radiotherapy. Med Phys. 2018;45(1):340-351. DOI: https://doi.org/10.1002/mp.12647. 3) Cheung Y, Sawant A. An externally and internally deformable, programmable lung motion phantom. Med Phys. 2015 May;42(5):2585-93. DOI: https://doi.org/10.1118/1.4918581. PMID: 25979050; PMCID: PMC4409628.

Applications

Diagnostic CT 4D and linear-accelerator MVCT or CBCT surface motion gated image system acceptance

Moving internal target tracking evaluation for QA of EBRT, SGRT, IGRT, and BgRT, as well as SPECT and PET imaging

Optimization of diagnostic and radiation therapy breathing protocols

Routine quality assurance

Modalities

Intensity-Modulated Radiation Therapy (IMRT)

Stereotactic Body Radiation Therapy (SBRT)

Surface Guided Radiation Therapy (SGRT)

Image-Guided Radiation Therapy (IGRT)

Biology-guided Radiotherapy (BgRT)

Gamma Knife

CyberKnife

CT

Megavoltage CT

Cone Beam CT

X-Ray

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RSD 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. RSD's proprietary moldings allow for continuous production, eliminate the restrictions of human skeleton bones (including limited availability, unethical collection of human bone specimen, variable size, and uncertain chemical composition), and avoid the loss of marrows in dried natural skeletons thereby making RSD skeletons superior to "real bone."

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

ICRU 44: 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.

LINEAR ATTENUATION DATA

1. Monte Carlo simulation was used to calculate linear attenuation coefficients as a function of beam.
2. Monte Carlo results were validated with linear attenuation coefficients derived from Hounsfield Unit measurements at discreet energy levels.
3. RSD Phantom material linear attenuation data was compared to NIST data using ICRU Report 44 compositions of human tissues.
4. NIST data was interpolated when necessary.

MATERIALS	DENSITY (g/cc)
RSD Soft Tissue (Opaque)	1.08
RSD Soft Tissue (Transparent)	1.10
RSD Cortical Bone	1.83
RSD Trabecular Bone	1.17

RSD SOFT TISSUE					
Energy (MeV)	Mean (HU)	Calculated (μ)	μ (ICRU 44)	% Difference	Ratio
00.08	60.30	0.1948	0.1932	0.80%	0.9921
00.10	52.88	0.1797	0.1795	0.15%	0.9985
00.12	57.10	0.1717	0.1709	0.44%	0.9956
00.14	52.95	0.1623	0.1624	0.07%	1.0007
00.20	--	0.1477	0.1439	2.61%	0.9746
00.30	--	0.1245	0.1246	0.04%	1.0004
00.60	--	0.0950	0.0941	1.01%	0.9900
00.80	--	0.0825	0.0826	0.13%	1.0013
01.00	--	0.0744	0.0743	0.18%	0.9982
02.00	--	0.0520	0.0519	0.18%	0.9982
03.00	--	0.0351	0.0357	1.71%	1.0174
06.00	--	0.0288	0.0291	0.88%	1.0088
08.00	--	0.0252	0.0255	0.98%	1.0099
10.00	--	0.0229	0.0232	1.49%	1.0151
15.00	--	0.0203	0.0203	0.15%	0.9985
20.00	--	0.0189	0.0189	0.17%	1.0017

RSD CORTICAL BONE					
Energy (MeV)	Mean (HU)	Calculated (μ)	μ (ICRU 44)	% Difference	Ratio
00.08	1365	0.4345	0.4280	1.51%	0.9851
00.10	1048	0.3496	0.3562	1.84%	1.0188
00.12	0977	0.3211	0.3274	1.91%	1.0195
00.14	0902	0.2932	0.2986	1.80%	1.0184
00.20	--	0.2511	0.2513	0.09%	1.0009
00.30	--	0.2155	0.2137	0.84%	0.9916
00.60	--	0.1596	0.1598	0.11%	1.0011
00.80	--	0.1403	0.1402	0.10%	0.9990
01.00	--	0.1274	0.1261	1.06%	0.9895
02.00	--	0.0883	0.0885	0.17%	1.0017
03.00	--	0.0611	0.0625	2.29%	1.0235
06.00	--	0.0512	0.0525	2.46%	1.0253
08.00	--	0.0468	0.0474	1.20%	1.0121
10.00	--	0.0446	0.0444	0.39%	0.9962
15.00	--	0.0410	0.0409	0.16%	0.9984
20.00	--	0.0393	0.0397	1.02%	1.0103

RSD TRABECULAR BONE (SPONGIOSA)					
Energy (MeV)	Mean (HU)	Calculated (μ)	μ (ICRU 44)	% Difference	Ratio
00.08	551	0.2849	--	--	--
00.10	515	0.2586	--	--	--
00.12	439	0.2337	--	--	--
00.14	318	0.1541	--	--	--