



## Applications

Calibration standard for the quantitation of in vivo radioactivity

Detector calibration for photons deposited in human organs

In vivo counting of emissions from various isotopes

Organ bioassays for various isotopes

## MADE FOR NUCLEAR POWER STATIONS WITH MORE ORGANS THAN THE LAWRENCE LIVERMORE REALISTIC 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 that require more organs than 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 Lawrence Livermore Realistic Phantom.



Fission-Product Phantom system includes head, neck, and 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; and permanent shipping and storage case.

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

**Thyroid Phantom:** See page 27 for more information.

**Isotopes:** 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. 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.

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.

## Model Numbers

Model No.	Product Description
RS-550	The Fission-Product Phantom

## Specifications

Packing Size	Packing Weight
107W x 51D x 46H cm	75 kg
42W x 20D x 18H in	165 lb.

**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 ( $\mu$ )	$\mu$ (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 ( $\mu$ )	$\mu$ (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 ( $\mu$ )	$\mu$ (ICRU 44)	% Difference	Ratio
00.08	551	0.2849	--	--	--
00.10	515	0.2586	--	--	--
00.12	439	0.2337	--	--	--
00.14	318	0.1541	--	--	--