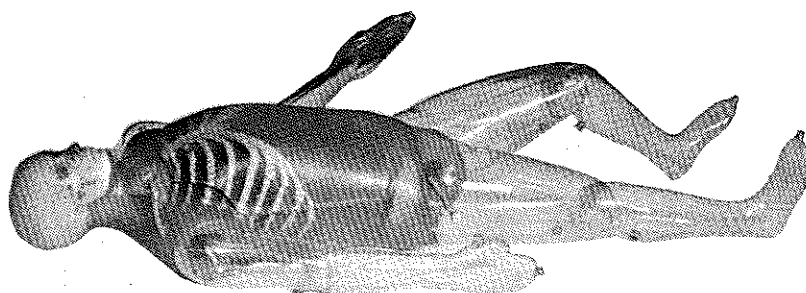
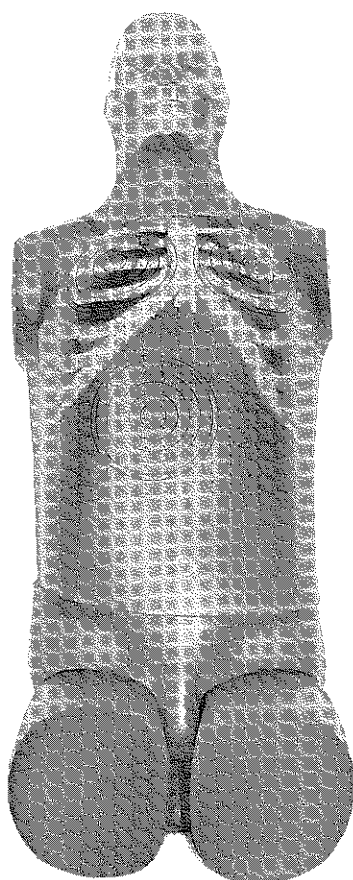


THE FISSION-PRODUCT PHANTOM



FISSION-PRODUCT PHANTOM

This phantom is essentially a modular phantom system affording great flexibility and versatility for many applications. A "sub-set" of features duplicates the Livermore Realistic Phantom for calibration of transuranics in lungs, liver and lymph nodes. Other features are directed toward counting fission products in nuclear power plants, both in chairs and on couches. Still other features permit duplication of atypical body burdens, primarily for research applications.

BODY CONFIGURATION

The Fission-Product Phantom extends the Livermore torso to the entire body. In its basic form, it extends from the head to the crotch, with stub legs articulated at the hip joints to conform stably to various seat pan-seat back angles of counting chairs.

The stub legs are interchangeable with full legs which are also articulated at the knees. Arms, articulated at the shoulders and elbows, may be added.

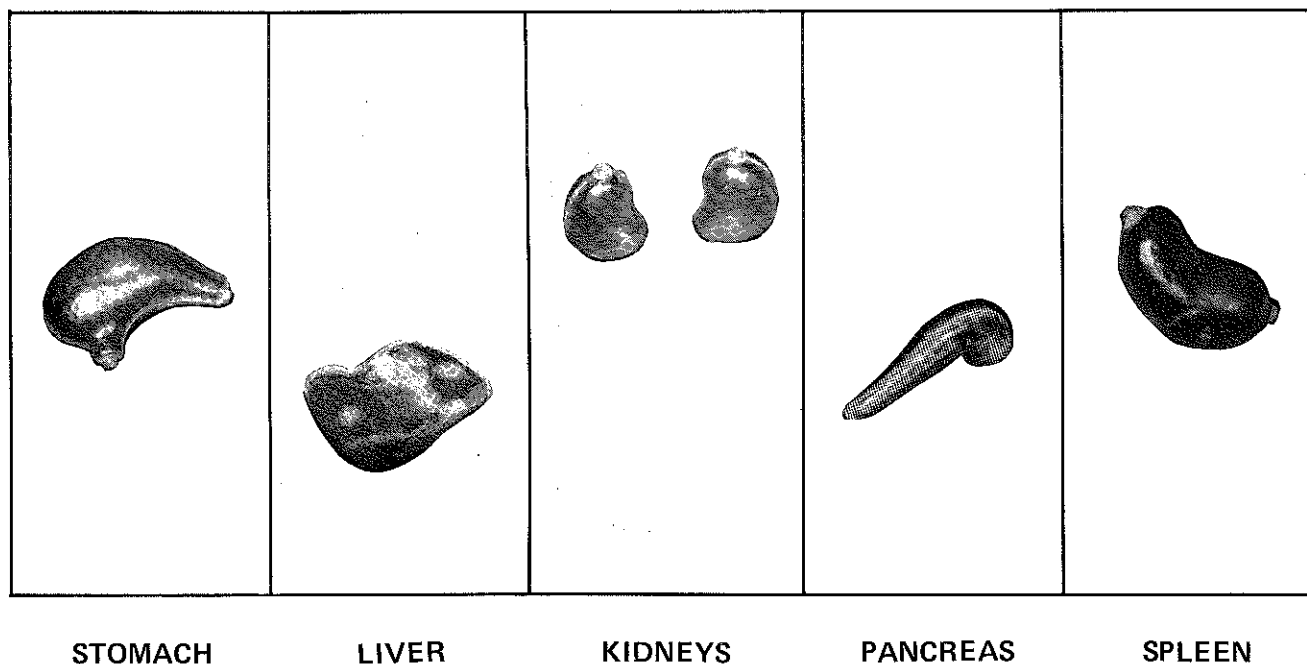
There are slight modifications in the shape of the Fission-Product Phantom as compared with the Realistic Phantom. The latter did not involve the neck or lateral aspects of the shoulders, and the terminations of the phantom in these regions do not conform to a whole-body upright position. To achieve this position, the Fission-Product Phantom has a straight neck and its shoulders terminate in flats for addition of the optional arms. In order that contours of the standard circular-grid counting locations conform to those of the Realistic Phantom, the Livermore shapes have been used at the sterno-clavicular articulations and follow most of the path of the clavicles. Transition to the erect position requires some blending of these shapes, while maintaining normal appearance at the blends. This is not known to have any functional significance.

THE FISSION-PRODUCT PHANTOM

ORGANS

A basic objective of the Fission-Product Phantom design has been to provide for radionuclides of short half-lives, on a flexible basis and with lower costs than involved in furnishing multiple organs, each with a different loading. Two methods are used.

HOLLOW ORGANS



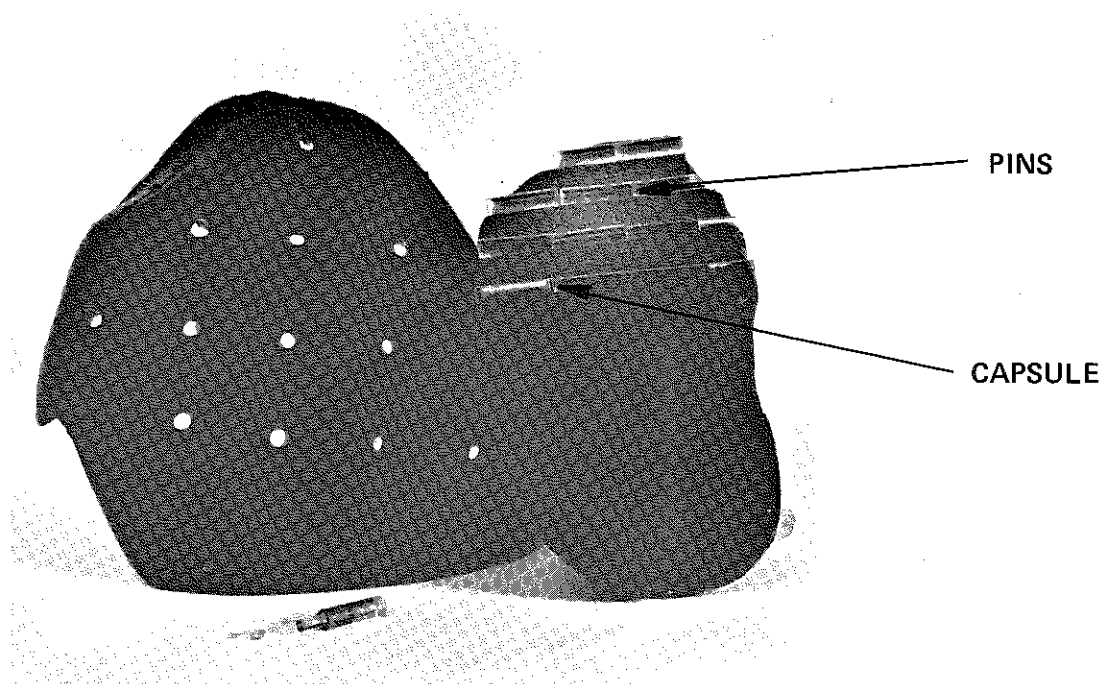
The thyroid, liver, kidneys, pancreas, spleen and stomach are hollow shells, vacuum formed from 1/8th-thick cellulose acetate butyrate sheets and bonded into strong, unitary structures. Each organ is fitted with two ports, sealed with caps and O-rings. These ports permit lengthy flushing between use with different solutions of radionuclides. This system is not recommended for long-term filling with such nuclides as uranium, which are generally dissolved in acids. These would potentially attack the shells over an extended period, although satisfactory for short counting times. The Realistic Phantom solid organs, with integrally-mixed transuranic radionuclides, can be used economically in such cases, in view of the extremely long half-lives which are involved. HUMANOID SYSTEMS will furnish data on request as to the applicability of the hollow-shell organs to any nuclide contemplated for use in solution form.

ORGANS WITH HOLE MATRICES

Certain isotopes may not lend themselves to use in solution form with hollow organs. Other applications may involve discrete source loadings in various parts of the organs, as opposed to uniform dispersion of an isotopic solution within a hollow organ. Such organs are available for the liver, kidneys, spleen, stomach and pancreas.

THE FISSION-PRODUCT PHANTOM

LUNGS WITH HOLE MATRICES



LUNG and LUNG CROSS SECTION SHOWING PINS and CAPSULES

The lungs cannot be based on hollow shells, since they must be lung-equivalent, rather than muscle-equivalent. They are molded to the Livermore shapes and sizes with medial-lateral ducts in a 4-cm x 4-cm grid array.

The ducts are filled with any desired assortment of inert or active plugs, 8 mm in diameter and 28 mm long. The inert plugs are molded solidly in a muscle-equivalent urethane, differing from the Livermore formulation only in increased rigidity. The capsules have central cavities to receive active pins 5 mm in diameter and 26 mm long. The capsules are closed by caps, bonded in place with an adhesive furnished by HUMANOID SYSTEMS (although any commercial urethane adhesive can be used). The assembled capsules preclude skin contact with the active pins.

Selective placement of inert pins and active capsules provides a wide variety of distributions of activity, ranging from essentially uniform to whatever degree of asymmetry is desired. Further flexibility can be provided by specifying different activities in capsules containing the same radionuclides.

Although the user may fill capsules directly, using either solutions or powders, a special process is required to make pins with uniform dispersions of radionuclides within them. These must be ordered from HUMANOID SYSTEMS, but the unique process employed permits such pins to be quite inexpensive.

All phantoms and organs are shipped with all required inert pins in place. On anterior or lateral surfaces, pins are located axially so no part protrudes beyond the surrounding contour. If a complete line of pins in a given hole would cause the posterior or medial pin to protrude, it is eliminated.

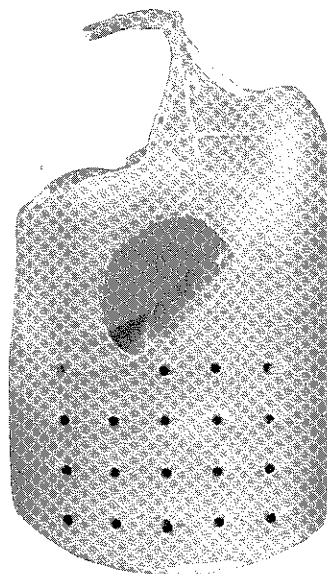
A 50% oversupply of pins is furnished to permit hand cutting for pins to blend with any contours.

THE FISSION-PRODUCT PHANTOM

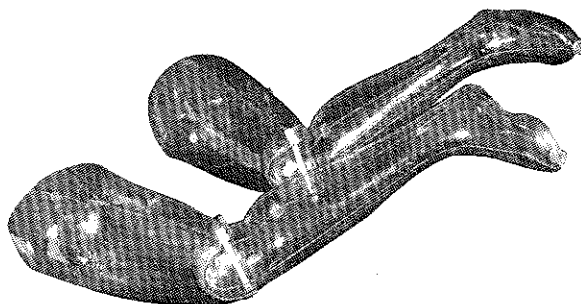
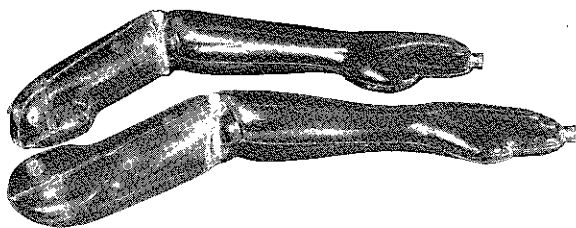
THE INTESTINAL TRACT

A specific intestinal tract is not available in view of the much simpler and less expensive solution provided by the organ matrix principle. The region of the intestinal tract is drilled with an antero posterior 4 cm x 4 cm hole grid, providing for selective and flexible loading. It can be made inert, of course, by filling the holes with inert plugs.

The Intestinal Tract is part of the HS-526 Inert Torso Assembly Spacers. It comes molded as shown, and is included in the HS-550 Basic Fission-Product Phantom.



INTESTINAL TRACT WITH HOLE GRID



ARMS AND LEGS

Arms and legs are fabricated from vacuum-formed cellulose acetate butyrate. Each segment has a double-port system for flushing between usages. The burdens in appendages are usually very small, and solubility problems are of minor concern.

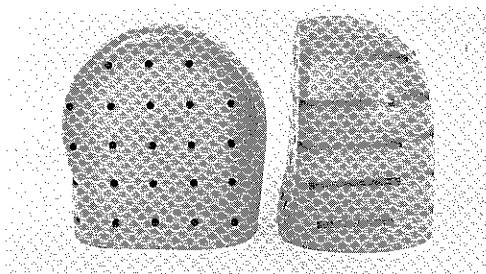
BONE-SEEKING LOADINGS

Provisions can be made in the skeletal members of the torso for hole grids to be loaded with Strontium 90 or other isotopes. These grids are provided on an optional basis only. Natural human bones can be installed in the arms and legs and drilled with grids, also on an optional basis.

THE FISSION-PRODUCT PHANTOM

MUSCLE SEEKING LOADINGS

Although the arms and legs can be filled with solutions containing such isotopes as Cesium 137 and Potassium 40, such an approach is not consistent with the design and use of the torso portion. Instead, hole grids are used in the antero-posterior direction for the shoulder areas and the psoas muscle and in a medial-lateral direction for the stub legs.



STUB LEGS WITH GRID

ORGAN INTERCHANGEABILITY

All organs of the same kind are interchangeable within the Realistic Phantom, regardless of the isotopes used. Similarly, all organs of the same kind are interchangeable within the Fission-Product Phantom.

All lungs, whether solid and active, or inert with hole matrices, and all lymph nodes are interchangeable between the Realistic and Fission-Product Phantoms.

Hollow livers can be used in existing Realistic Phantoms only by drilling blind holes in the posterior side of the cavity to accept the filling and flushing ports. Shaped plastic guides are furnished for drilling if retrofits are to be made. Inert plugs are also furnished to close these holes for use of solid livers which do not have ports.

All new Phantoms, Realistic or Fission-Product, have such holes and are supplied with plugs. The spleen, pancreas, stomach and kidney cavities of the Fission-Product Phantom have similar hole and plug features.

CHEST OVERLAY PLATE INTERCHANGEABILITY

All new Realistic and Fission-Product Phantoms can use the same chest overlay plates. These plates can be used on earlier Realistic Phantoms only by cutting them down in the shoulder areas. This modification will not affect counting locations or results. Generally, this alteration must be done at the factory.

SKELETAL STRUCTURE

In order to locate each organ in its anatomically correct position, and at the same time eliminate air spaces between organs, it has been found necessary to add separator blocks between organs for this purpose. Eight such blocks are included in the basic system of the Fission-Product Phantom.

The skeleton of the Fission-Product Phantom is extended relative to the Lawrence Livermore Realistic Phantom by the use of a full cervical spine, integral with the balance of the spinal column. A natural human skull is used because intercomparisons of head scans are rare and because the HUMANOID SYSTEMS skull inventory is very large and permits a close match to be made between skulls.

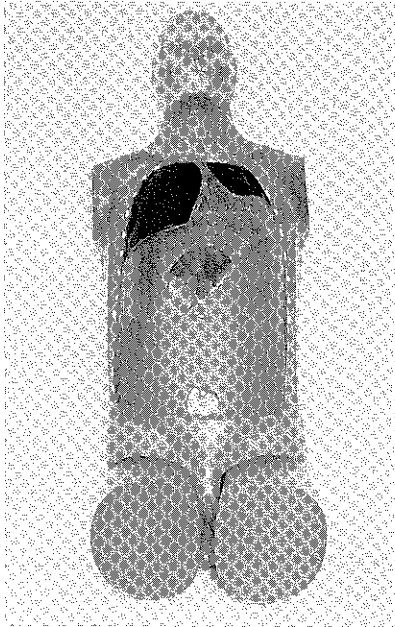
Although full clavicles are incorporated, the scapulae are replaced by polycarbonate inserts, imbedded in the flats at each side of the thorax to give a durable mounting for the optional arms.

The superior portion of the pelvis is included, molded in the Livermore bone material. The inferior portion is replaced by a polycarbonate insert to serve as a rugged attachment for either the stub or the full legs.

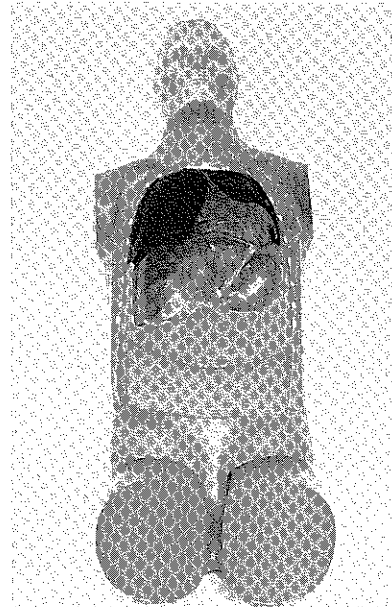
THE FISSION-PRODUCT PHANTOM

SEPARATORS

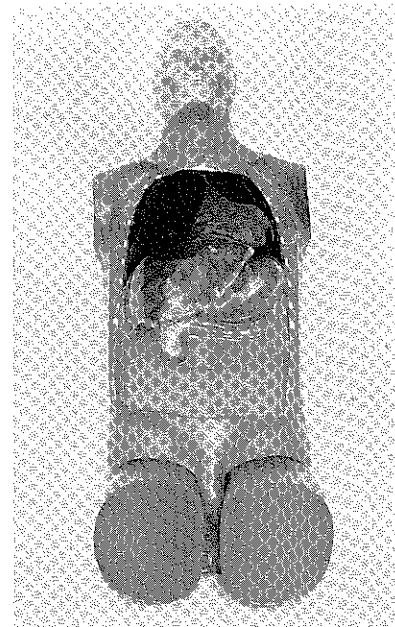
The organs must be separated spatially in the proper anatomic position and, since, organ material and construction will vary, they must be "nested" in inert, tissue-equivalent molded sections to ensure correct assembly. The approach to organ placement and separation is shown below.



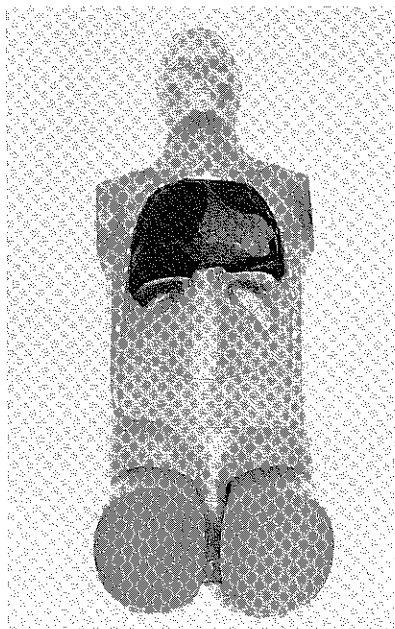
Cover removed to show lungs and anterior aspect of liver.



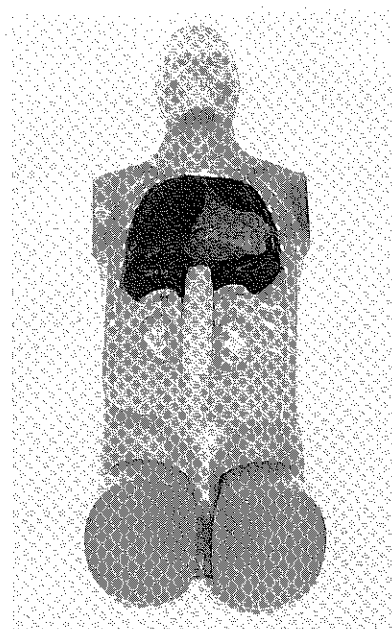
Anterior separator plate removed, showing lungs, heart, liver and stomach.



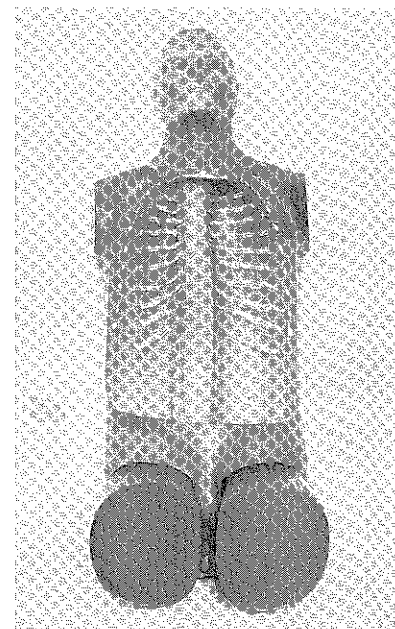
Second separator plate removed, showing lungs, heart, stomach, pancreas and liver.



Third separator plate (and liver) removed showing lungs, heart and spleen.



Fourth separator plate removed, showing lungs, heart and kidneys.



All thoracic structures removed, showing interior of body cavity.