
Spectrum Sciences Institute RF Dosimetry Research Board



Attention: all comments, suggestions, and inquiries should be addressed to
Dr. Jack J. Wojcik or Dr. Paul G. Cardinal
51 Spectrum Way, Nepean, Ontario, K2R 1E6, Canada. tel.:(613)820-2730, fax:(613)820-4161
e-mail: inform@spectrum-sciences.org

Phantom Design Requirements

SSI/DRB-TP-D01-031



PART of SAR Measurements Requirements

SSI/DRB-TP-D01-030

DRAFT

Prepared jointly with:

APREL
Laboratories

Near Field Measurements Laboratory

March 1998

- NOTICE -

This draft was prepared to assist the Dosimetry Research Board of SPECTRUM SCIENCES INSTITUTE and specifically the Working Group on SAR Measurements. It is submitted as a basis for discussion only, and is not binding on APREL Inc. Subsequent study may lead to revisions of the document, both in numerical values and/or form, and after continuing study and analysis, APREL Inc. specifically reserves the right to add to, or amend the content of this contribution.



TABLE OF CONTENTS

1.0	Introduction	3
1.1	Purpose And Scope Of The Standard	3
1.2	Test Facilities	3
1.3	Test Personnel	3
1.4	Standard Environmental Conditions	3
2.0	Background	4
3.0	References	5
4.0	Definitions	6
5.0	Phantoms	6
5.1	Universal Head-Arm (Unihead) Phantom	6
5.1.1	Head Simulator	6
5.1.2	Arm And Hand Simulator	10
5.1.3	Materials	10
5.2	Flat Phantom	13
5.3	Insulated Flat Phantom	13
6.0	Sar Laboratory Setup	13
7.0	Test configurations using the Uni-Head	15



1.0 INTRODUCTION

1.1 Purpose and Scope of the Standard

The purpose of this document is to standardize the phantom(s) required for Specific Absorption Rate (SAR) testing associated with SAR measuring systems. This document defines the parts and dimensions of the phantom, in accordance with industry standards and practices.

This Standard defines:

- the methodology and procedures used to define a reproducible representation of the human head, hand and arm
- the dimensions on the canonical shapes used, and the materials required
- the hardware required and the proper setup

This Standard is part of a Certification Program Methodology as described in a separate document entitled "SSI/DBR TP-D01-030, Specific Absorption Rate (SAR) Standard For Portable Telecommunications Devices, March 1998". SSI/DBR TP-D01-031 contains specific criteria that must be met for SAR certification.

1.2 Test Facilities

All calibration work as described in this Standard shall be performed at an ISO/IEC Guide 25 accredited laboratory.

1.3 Test Personnel

Personnel performing the calibration will be experienced in relevant measurements (e.g. physical properties or RF characteristics) and supervised by a person proficient in SAR measurements.

1.4 Standard Environmental Conditions

All measurements and calibration should be performed under normal laboratory conditions for physical properties and electrical characteristics as stipulated by ISO/IEC Guide 25. The nominal temperature for physical property measurements and for electrical characterization are 20°C and 23°C, respectively.



2.0 BACKGROUND

Portable communication devices used by consumers typically operate over the range of several watts to a milliwatt, or less, using either analog or digital modulation techniques. Most portable telephones have antennas that radiate within a few centimeters of the user's head. The field strength and field distribution near the antenna are highly dependent on the location, orientation and electromagnetic characteristics of adjacent objects. The head and hand are normally in the reactive near-field region of the antenna where the electromagnetic field is non-propagating. The energy absorbed in the head and hand is mainly due to electric fields induced by the magnetic fields generated by currents flowing through the feedpoint, along the antenna and body of the portable device. The RF energy is scattered and attenuated as it propagates through the tissues of the head, and maximum energy absorption is expected in the more absorptive high water-content tissues near the surface of the head or hand. To account for near-field effects portable devices are evaluated with realistic head models called a phantom.

A phantom is a device that simulates the size, contours, and electrical characteristics of human tissue at normal body temperature. It is composed of a manikin (solid shell) and a tissue-equivalent synthetic material solution (see SSI/DRB-TP-D01-033).

The solid manikin shell is made of a dielectric material, which is transparent to RF energy (i.e. has very low RF absorption), and is as thin as possible while maintaining the strength necessary to hold the mass of simulated tissue.

Current phantoms in use are:

- Universal Head-arm (UniHead) Phantom for ear independent evaluation of the RF exposure in the head of users by telephone-type devices, as well as RF exposure in the head of users of hand held radios positioned in front of the face, and in the hand of users of hand held portable devices
- Flat Phantom for evaluating the RF exposure of other parts of the user body by wireless devices that are not normally used in the vicinity of the head and cannot be accommodated by the UniHead, as well as for experimental investigations. (Such devices would include wireless LAN PCMCIA cards installed in laptop personal computers)
- Insulated Flat Phantom used for the determination of the enhancement factor of synthetic tissue in the calibration of the miniature isotropic electric field (E-field) probes



3.0 REFERENCES

- Considerations for Human Exposure to EMFs from Mobile Telecommunication Equipment (MTE) in the frequency range 30 MHz – 6GHz, 1997, CENELEC European Committee for Electrotechnical Standardization, Secretariat SC211/B, WGMTE.
- "Numerical and Experimental Near Field Evaluation of a DCS 1800 Mobile Phone", A.Bahr, R.Kastle, S.G.Pan, T.Schmid, T.Becks, and N.Kuster, 1997, part of: "Suggestions Prepared Following the CENELEC Document", N. Kuster et al, Attachment 9, Minutes IEEE Standards Coordinating Committee –34, Subcommittee – 2, May 2, 1997 meeting.
- "Electromagnetic Energy Exposure of Simulated Users of Portable Cellular Telephones", Q. Balzano, O. Garay, T.J. Manning, Jr, 1995, IEEE Transactions on Vehicular Technology, 44:390-403.
- "EM Absorption in the Human Head and Neck for Mobile Telephones at 835 and 1900MHz", O. Gandhi, G. Lazzi, and C. Furse, 1996, IEEE Transactions on Microwave Theory and Techniques, 44:1884-1897.
- "The Dependence of EM Energy Absorption Upon Human Head Modeling at 900 MHz.", V.Hombach, K.Meier, M.Burkhardt, E.Kuhn, and N.Kuster, 1996, IEEE Transactions on Microwave Theory and Techniques, 44:1865 – 1873.
- "Dosimetric Evaluation of Handheld Mobile Communications Equipment with Known Precision", N.Kuster, R.Kastle, and T.Schmid, 1997, IEICE Transactions. E80-A:1 – 8.
- "Soft and Dry Phantom Modeling Material Using Silicone Rubber with Carbon Fiber", Y. Nikawa, M. Chino, and K. Kikuchi, 1996, IEEE Transactions on Microwave Theory and Techniques, 44:1949 – 1953.
- Fields of a Portable Radio Handset Near the Human Head – Phase I, C.W. Trueman, S.J. Kubina, and M. Danesh, 1996, TN-EMC-96-01 Final Report, EMC Laboratory, Department of Electrical and Computer Engineering, Concordia University, Montreal, Quebec, Canada, 70–99.
- Provisional Head and Torso Simulator for Acoustic Measurements of Air Conduction Hearing Aids, International Electrotechnical Commission 60959 TR0 Ed. 1.0 (7 July 1989)



4.0 DEFINITIONS

manikin: an RF transparent shell for the phantom

phantom: a device that simulates the size, contours, and electrical characteristics of human tissue

5.0 PHANTOMS

5.1 Universal Head-Arm (UniHead) Phantom

IEC 60959 (TR0 Ed.1.0, 1989, Provisional Head and Torso Simulator for Acoustic Measurements of Air Conduction Hearing Aids) tabulates standard ergonomic data for the human head and torso. A manikin generated from these measurements represents the 95th percentile of the population.

5.1.1 Head Simulator

The principle dimensions of the head and torso simulator are shown in Figures 5.1 and 5.2 are listed in Table 5.1.

Table 5.1

A	HEAD BREADTH	152 mm
B	HEAD HEIGHT	141 mm
C	BITRAGON DIAMETER	110 mm
D	NECK DIAMETER	103 mm
E	SHOULDER BREADTH	440 mm
F	CHEST BREADTH	279 mm
G	HEAD LENGTH	199 mm
H	TRAGON TO WALL	97 mm
I	CHIN-VERTEX LENGTH	243 mm
J	TRAGON TO SHOULDER	165 mm
K	SHOULDER DEPTH	116 mm
L	CHEST DEPTH	225 mm
M	SHOULDER POSITION	125 mm

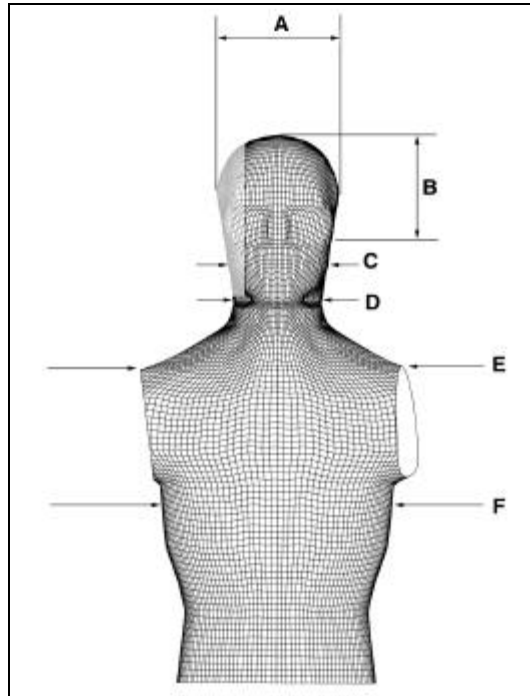


Figure 5.1

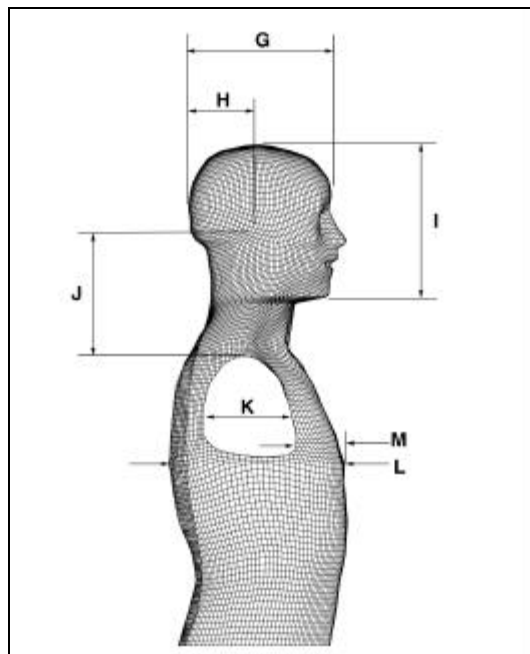


Figure 5.2

Comments and inquiries should be addressed to:

RF Dosimetry Research Board (DRB)
Spectrum Sciences Institute
51 Spectrum Way, Nepean, Ontario, Canada K2R 1E6
Tel. (613) 820-6471 Fax (613) 820-4161
e-mail: inform@spectrum-sciences.org

Ref: Project U404-7-0016 -1997



An engineering approximation for a human head simulator can be made from this ergonomic data using basic canonical shapes. If we define one cylinder with the diameter of the head's breadth (A) and a second with the diameter of the chin's diameter (C) and join the two cylinder with a plane tangent to both cylinders and with a contact separation of $(I - (A+C)/2)$ we have the basic shape of the head simulator shown in Figure 5.3. This plane defines the "cheek" of the head simulator. The width of the head simulator can be defined by the length of the head (G).

The head simulator is therefore defined by two quarter cylinders, the plane joining these two sections, for an overall length of 243 mm, and limited to a width of 199 mm.

Figure 5.4 shows an alignment aid for positioning a portable communication device. This applique is defined by the positions of the ears and the eyes within the head. By recognizing that both ears are in the center of their respective sides of the head and that the tip of the pinna of the compressed ear coincides with the beginning of the roll-off of the skull cylinder section, we can define a symmetric, ear independent, reference point at (0,0). This is the tip of the composite pinna. Furthermore, the two shaded spots at (0,-7 cm) and (0,+7 cm) correspond to the positions of the humans eyes relative to the ears.

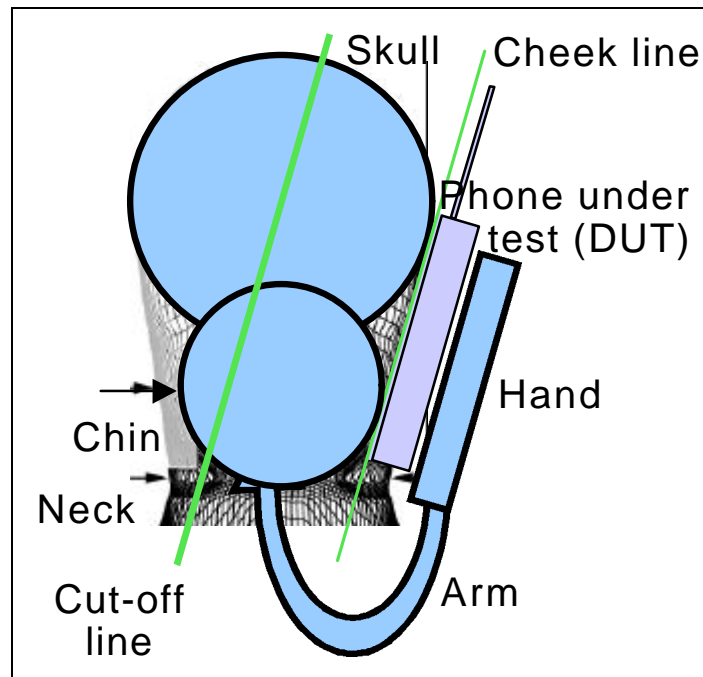


Figure 5.3

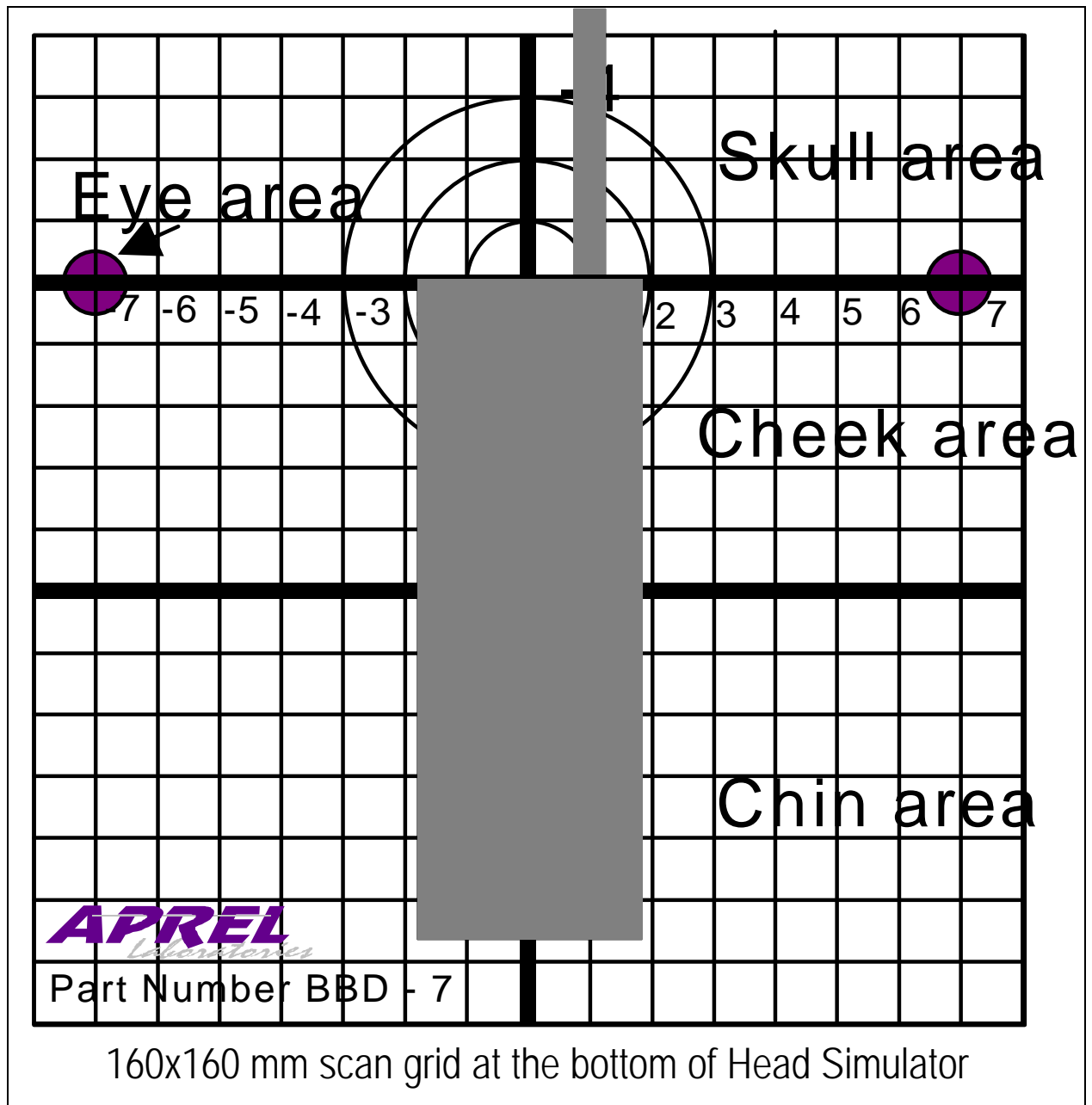


Figure 5.4

Comments and inquiries should be addressed to:

RF Dosimetry Research Board (DRB)
Spectrum Sciences Institute
51 Spectrum Way, Nepean, Ontario, Canada K2R 1E6
Tel. (613) 820-6471 Fax (613) 820-4161
e-mail: inform@spectrum-sciences.org

Ref: Project U404-7-0016 -1997



5.1.2 Arm and Hand Simulator

The principal dimensions of the arm and hand are listed in Table 5.2. The hand is represented with a parallelepipedic volume having the dimensions 36x90x110mm. The hand simulator is attached to the head simulator by means of a flexible arm that is attached to a valved nipple. This can provide a continuous conducting link between the liquid in the head where the measurements are taking place and the hand where the handset is being held. Alternatively, with the valve shut, muscle simulating synthetic tissue can be placed in the hand and arm simulator, at the expense of the continuous conducting link.

Table 5.2

	SHOULDER –ELBOW LENGTH	365 mm
	FOREARM-HAND LENGTH	440 mm
	HAND THICKNESS	36 mm
	HAND LENGTH	200 mm
	HAND BREADTH AT THUMB	112 mm
	HAND BREADTH AT METACARPAL	90 mm

Figure 5.5 shows an alignment aid for positioning a portable communication device. This applique is symmetric with respect to the center of the hand simulator. The upper surface of the hand simulator is longer than the defined parallelepipedic volume in order for a dielectric alignment pin to be screwed in to act as a stop for positioning the phone on the hand. In addition, the upper surface is also wider to allow notches to be placed on either side to which an elastic restraint can be attached to hold the portable device in place.

5.1.3 Materials

The materials used for the fabrication of the Universal Head–arm (UH-a) are non-metallic. The support platform and base are constructed of laminated wood for easy cleaning (see Figure 5.6 and Table 5.3). The vertical guides are constructed of hard wood giving precision of vertical movement to the measuring gauge and the hand guide. The head- and hand-simulating volumes are made of Plexiglas. The head simulation has the top edge raised above the platform for easy wrapping and removal for storage when containing tissue-simulating liquid. This allows a substitution of phantoms representing different frequencies. Tissue-simulating liquid contained in the hand volume is connected to tissue simulating liquid contained in the head volume by a flexible arm that can be detached for cleaning and storage. The Plexiglas volume of head is formed and terminally stabilized to its exact characteristics. Plexiglas does not include additives for reinforcement. The manufacturing process for the Universal Head-arm allows precise duplication of

Comments and inquiries should be addressed to:

RF Dosimetry Research Board (DRB)
Spectrum Sciences Institute
51 Spectrum Way, Nepean, Ontario, Canada K2R 1E6
Tel. (613) 820-6471 Fax (613) 820-4161
e-mail: inform@spectrum-sciences.org

Ref: Project U404-7-0016 -1997



geometrical and dielectric properties of the setup. Bonding with adhesives and solvents is used. Nylon screws are used to secure some elements. Clear gloss materials and appropriate grids allow verification of proper location and function of the phone under test.

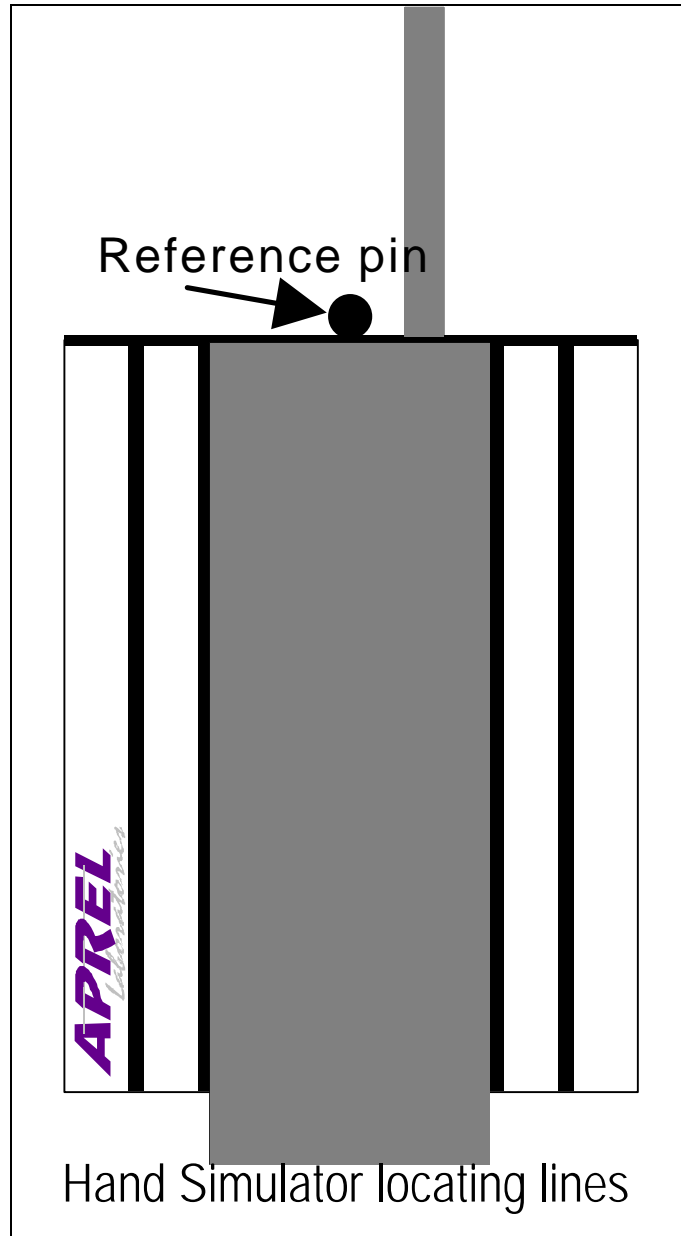


Figure 5.5

Comments and inquiries should be addressed to:

RF Dosimetry Research Board (DRB)
Spectrum Sciences Institute
51 Spectrum Way, Nepean, Ontario, Canada K2R 1E6
Tel. (613) 820-6471 Fax (613) 820-4161
e-mail: inform@spectrum-sciences.org

Ref: Project U404-7-0016 -1997

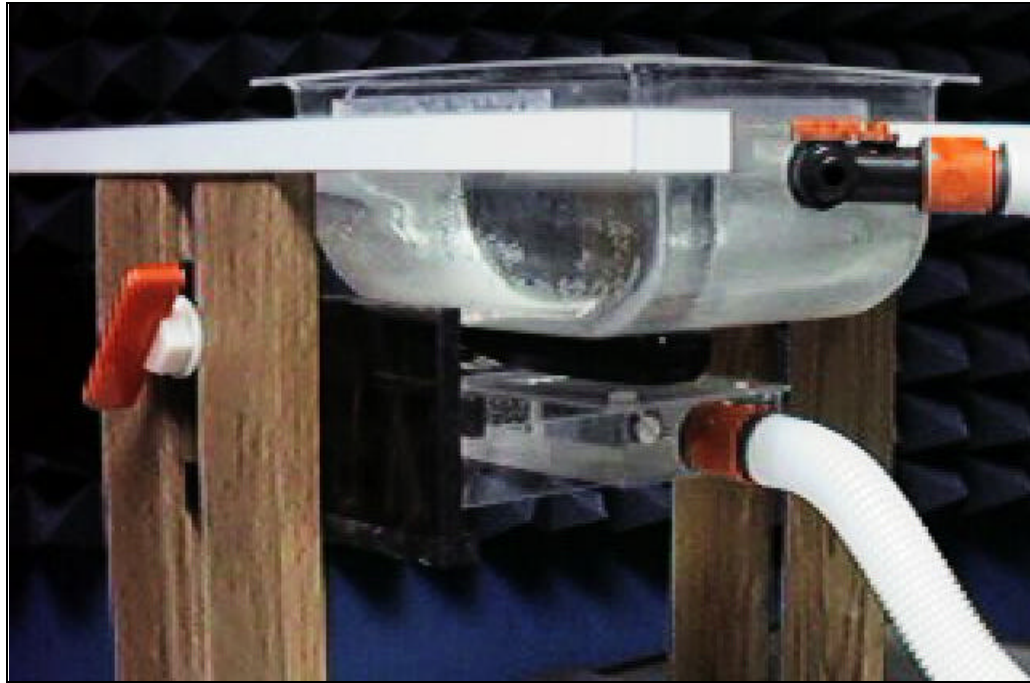


Figure 5.6

Table 5.3

Specifications	
Model	UH-1
Frequency	tissue dependant
Head cut-off section	190 mm x 240 mm
Hand surface	95 mm x 115 mm
Basic scan area	160 mm x 160 mm
Hand position	self-locking
Head-arm-hand connections	fast release type
Dimensions	
-height	410 mm
-length	580 mm
-width	500 mm
Weight	approx. 12 kg

Comments and inquiries should be addressed to:

RF Dosimetry Research Board (DRB)
Spectrum Sciences Institute
51 Spectrum Way, Nepean, Ontario, Canada K2R 1E6
Tel. (613) 820-6471 Fax (613) 820-4161
e-mail: inform@spectrum-sciences.org

Ref: Project U404-7-0016 -1997



5.2 Flat Phantom

An acrylic flat phantom with a parallelepipedic volume of 47mm x 14mm x 7mm is used for evaluating the RF exposure of other parts of the user body by wireless devices that are not normally used in the vicinity of the head and cannot be accommodated by the UniHead. (Such devices would include wireless LAN PCMCIA cards installed in laptop personal computers). It can also be suitable for experiment where a larger flat surface is desired that is provided by the UniHead phantom.

Insulated Flat Phantom

A styrofoam flat phantom with a parallelepipedic volume of 32mm x 21mm x 18 mm is used for the determination of the enhancement factor of synthetic tissue in the calibration of the miniature isotropic electric field (E-field) probes.

6.0 SAR LABORATORY SETUP

The phantom is typically setup in relation to the other SAR measurement system equipment as shown in Figure 6.1. The major pieces of equipment for this setup are shown in the Table 6.1.

The articulated robot arm is usually located at one edge or corner of the laboratory space, situated in an RF anechoically damped area. The miniature isotropic E-field probe is attached to the end of the robot arm by means of a dielectric holder which serves the purpose of displacing the probe from the metal of the robot arm that could perturb the RF fields from the portable communication device under test. The phantom is placed in front of the robot arm, on the phantom support fixture, at a distance as far as possible from the robot, but close enough that the E-field probe can explore the entire interior region of the phantom. Again, this is to minimize the perturbations of the RF fields from the portable communication device under test in the vicinity of the robot arm.

The E-field probe is connected to a data acquisition card inside a computer by means of shielded cables. The computer controls the SAR measurement system by controlling the movement of the robot by communicating with its controller, and recording data from the data acquisition card.

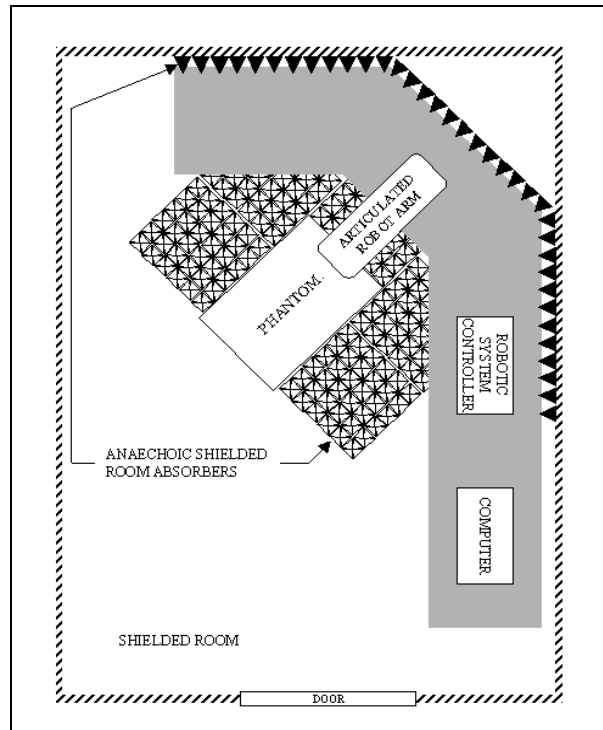


Figure 6.1

Table 6.1

Description	Manufacturer	Model
Articulated Robot Arm	CRS Robotics	A255
Robotic System Controller	CRS Robotics	C500
Phantom	APREL	various
Phantom support fixture	APREL	various
Synthetic Tissue Mixture	APREL	SSI/DRB-TP-D01-033
Miniature E-field probe	Narda	8021B
Probe support fixture	APREL	N/A
Computer	Northern Micro	Pentium 75
Software	Microsoft	Office 97 Pro
Software	APREL	SAR Measurement
Data acquisition card	ComputerBoards	CIO-DAS08-PGH
Miscellaneous Cables	N/A	N/A

Comments and inquiries should be addressed to:

RF Dosimetry Research Board (DRB)
Spectrum Sciences Institute
51 Spectrum Way, Nepean, Ontario, Canada K2R 1E6
Tel. (613) 820-6471 Fax (613) 820-4161
e-mail: inform@spectrum-sciences.org

Ref: Project U404-7-0016 -1997



7.0 TEST CONFIGURATIONS USING THE UNI-HEAD

The Universal Head (Uni-Head) had been originally designed by APREL Laboratories for studies of antenna structures and for optimization of radiating characteristics of handsets. In addition of being a design tool, the Uni-Head may be used for most of measurements required in dosimetry. The figure 7.1 below illustrates some typical scenarios using the Uni-head for various devices under test (DUT).

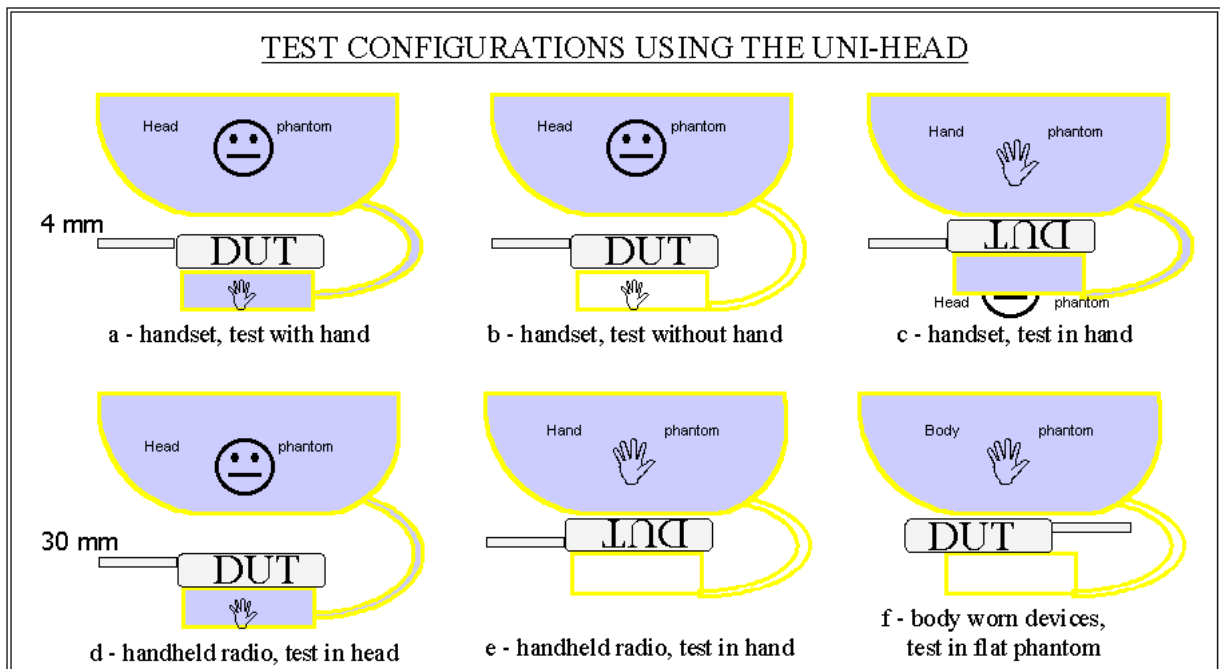


Figure 7.1 (not to scale)