Spectrum Sciences Institute
RF Dosimetry Research Board

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Positioning and Scanning Requirements

SSI/DRB-TP-D01-034

PART of SAR Measurements Requirements

SSI/DRB-TP-D01-030

DRAFT

Prepared jointly with:

APREL Laboratories

Near Field Measurements Laboratory

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- NOTICE -

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1.0 INTRODUCTION

1.1 Purpose and Scope of the Standard

The purpose of this document is to standardize the portable transmitter positioning and E-field scanning inside the phantom that simulates parts of the human body for Specific Absorption Rate (SAR) measurements.

This Standard defines:

- the methodology and procedures to be followed in the laboratory to setup the portable handset
- the procedure to define the E-field area scanning
- the procedure to determine zoom scan to derive the 1 or 10 gram average SAR.

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-D01-034 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 (eg physical properties or RF characteristics) and supervised by a person proficient in SAR measurements.

1.4 Test Equipment

The required test equipment, hardware and software, is identified is each individual procedure. Equipment may be substituted or updated from time to time. Should this

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occur, such change shall be noted in the test report. Equipment shall be calibrated to standards traceable to International Standards.

1.5 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

2.1 Positioning of the Device Under Test (DUT)

In positioning a portable communication device with respect to the simulated human body, we are interested in obtaining the worst coupling between the device and the head while ensuring that such a position is a reasonable approximation of a common usage position.

SAR inside the head is predominantly attributable to the H-fields produced by the currents inside the handset or along its antenna. These H-fields cause currents in the boundary of the phantom, which in turn induce E-fields within the simulated tissue. These E-fields give rise to the measured SAR within the portion of the simulated human body being exposed.

The exact sources of the highest H-fields within the phone are not usually known. However, the antenna feedpoint area is normally the prime suspect. The coupling of a high current producing area with the simulated tissue causes deposition of energy into the simulated tissue as well as modifications to characteristics of the transmitting source itself.

If a large plastic case, with various internal components, is coupled to simulated tissue, and the coupled area does not carry current, or the current carrying area is remote (in relative terms), there will be no significant SAR deposited in the tissue, nor will there be any significant change of the source.

The purpose of various standards (e.g. CENELEC), or industry practices, is to position the handset with respect to an arbitrary shape of the head in such a way that the coupling between the tissue and the current source is the strongest.

The Universal Head-arm (UniHead) is engineered in such a way that the maximum coupling can be found without maneuvering the handset through various positions. This is

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achieved by placing the handset at a constant position and a constant displacement relative to the phantom. Thus the SAR generating area, wherever it is in the handset, will always couple to the simulated tissue. This makes maneuvering of the handset (3 angles, left-right ear, 3 point contact, etc.) redundant.

The commonly accepted distance between the tissue boundary and the handset is 6 mm (2 mm shell + 4 mm for the compressed human ear).

In the practice of measuring SAR a plastic layer forms part of the space between the tissue boundary and the phone. The dielectric and conductive characteristics of this layer of plastic are relatively close to those of air in comparison to those of the simulated tissue. It is believed in today's practice that this layer does not have any other role that creating a distance between the device surface and the tissue boundary. However, an investigation of the measuring uncertainty produced by the presence of plastic are not very complete. In the UniHead, for the sake of precision and repeatability, the only layer which is introduced is the one that is needed to contain the tissue simulation and no additional arbitrarily shaped space is introduced.

In the research carried out by APREL Laboratories for Spectrum Sciences Institute, much of which was witnessed by industry, it was demonstrated that when the current was flowing in the parts of the phone closer to the head than the hand simulation, there was essentially no impact on the SAR distribution or the peak SAR value (< 10% difference). However, in instances when the current carrying components are closer to the hand than to the head, the impact on the handset performance and peak SAR value is significant, and should not be neglected.

In the instances where there is a requirement for measurement without the hand, the Universal Head is engineered in such a way that the simulated tissue can be easily removed from the hand simulation and thus becomes a positioning bracket with marginal quantities of plastic with a marginal impact on the radiated fields.

2.2 Area Scanning

A head model is usually placed on its side, which allows a handset to be placed underneath the head to facilitate field measurements. The field probe is inserted into the liquid from above and measurements can then be made on the inside surface of the head next to the phone. SAR measurements usually start with a coarse measurement at 1-2 cm resolution where the electric field probe is scanned throughout the entire region of tissues next to the handset and its antenna. This provides a SAR distribution near the surface of the phantom, closest to the phone, where the approximate location of the peak SAR can be identified.

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2.3 Zoom Scanning and 1g or 10g Averaging

A smaller region centered on the peak SAR location is then scanned with a 1-5 mm finer resolution to determine the one-gram average SAR. The measurements obtained from this fine resolution scan are averaged over a 1-cm^3 volume in the shape of a cube to determine the one-gram average SAR. A 10-cm^3 volume for a ten-gram average SAR is appropriate for the extremities in North America, or for all requirements in Europe or Japan. The average density of most high water-content tissues is about 1020-1040 kg/m^3, which requires the tissue volume to be about 1 cm long on each side. For a 10-gram average SAR a tissue volume of 2 cm long on each side can be used produce a conservative overestimate of the SAR value (the actual side length should be 2.125 cm). The number of measurement points required in the fine scan to provide accurate one-gram average SAR is dependent on the field gradients at the peak SAR location. In smooth gradients, the one-gram average SAR can be correctly predicted with only a few measurement points. When steep field gradients exist, many measurement points evenly distributed within a cubic centimeter of the tissue material may be required to correctly predict the one-gram average SAR. To overcome this problem, a curve-fitting process may be applied to the measured data to allow more points to be used in the average.

The measurements provided by electric field probe normally do not correspond to the location at the tip of a probe because the detectors are located behind the tip. For homogeneous phantoms, the peak field values are at the surface of the phantom, but the detectors of the probe are generally 2.5-7.0 mm behind the tip of the probe. Therefore the field measurements must be extrapolated to the surface of the phantom to compensate for field attenuation introduced by this offset distance. This can be done by taking a number of measurement points in a straight line perpendicular to the phantom surface at the peak SAR location and applying a curve-fitting process for the extrapolation.

If measurements in the immediate vicinity of the phantom surface are included in the extrapolation routine, the boundary effect of the probe must be considered. The boundary effect results in an increased sensitivity of the probe and is caused by the interaction of the field disturbance around the probe with the boundary. The strength of the overestimation depends on the probe dimensions, the probe distance from the surface, the boundary curvature, the probe angle to the surface and the field decay in the solution. If the boundary effect is not completely compensated for in the software, a positive error offset (overestimation) of the spatial peak SAR will occur. An alternative approach is to dismiss all measurements near the surface and extrapolate over a longer distance. This will eliminate the offset error, but largely increase the error due to extrapolation uncertainty.

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The actually assessed cube is a surface adapted "cube" as opposed to a geometrical cube. This is partially due to the missing definition of the cube placement and partially due to the mechanics of the data acquisition systems which operate is a Cartesian coordinate system.

3.0 REFERENCES

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4.0 DEVICE UNDER TEST (DUT) POSITIONING PROCEDURES

4.1 DUTs Held Against the Ear

1. Select the simulated tissue appropriate for the type of tissue being tested, and the operating frequency of the DUT, and fill the Universal Head-arm (UniHead) with it.
2. Allow sufficient time for all air bubbles to escape before performing a scan.
3. Lift up the measurement slide (see Figure 4.1) and place the DUT face-up under it. Lower the measurement slide so that it rests on the DUT and record the height on the scale to the left of the slide using the lower edge of the slide as reference.
4. Add 4 mm to this height to account for the spacing provided by a compressed human ear and record the value.

Figure 4.1

5. Put the DUT into test mode at the highest rated power, and operating on either the maximum performance frequency or one of the low, middle and high channels.
6. Loosen the bolt (on the right side of the UniHead stand) holding the hand simulator support, using the orange finger tab, and lower whole structure. Pull out the sliding support, using its orange finger tab (Figure 4.2), so that the DUT simulator is easily accessible.
7. Position the DUT on top of the hand simulator, butting the top of it up against the reference pin, and centered within the locating lines (see Figure 4.3).

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8. Use a rubber band (elastic) to hold the DUT in place making use of the two notches on either side of the hand simulator (see Figure 4.2).

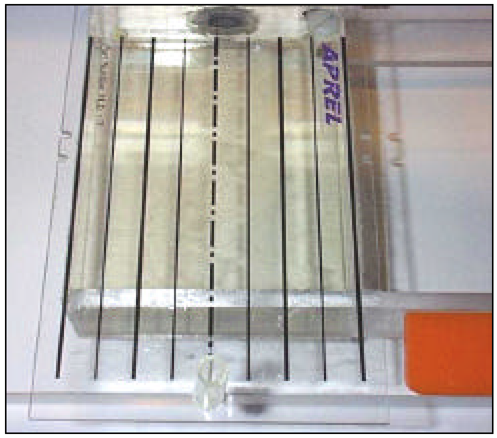
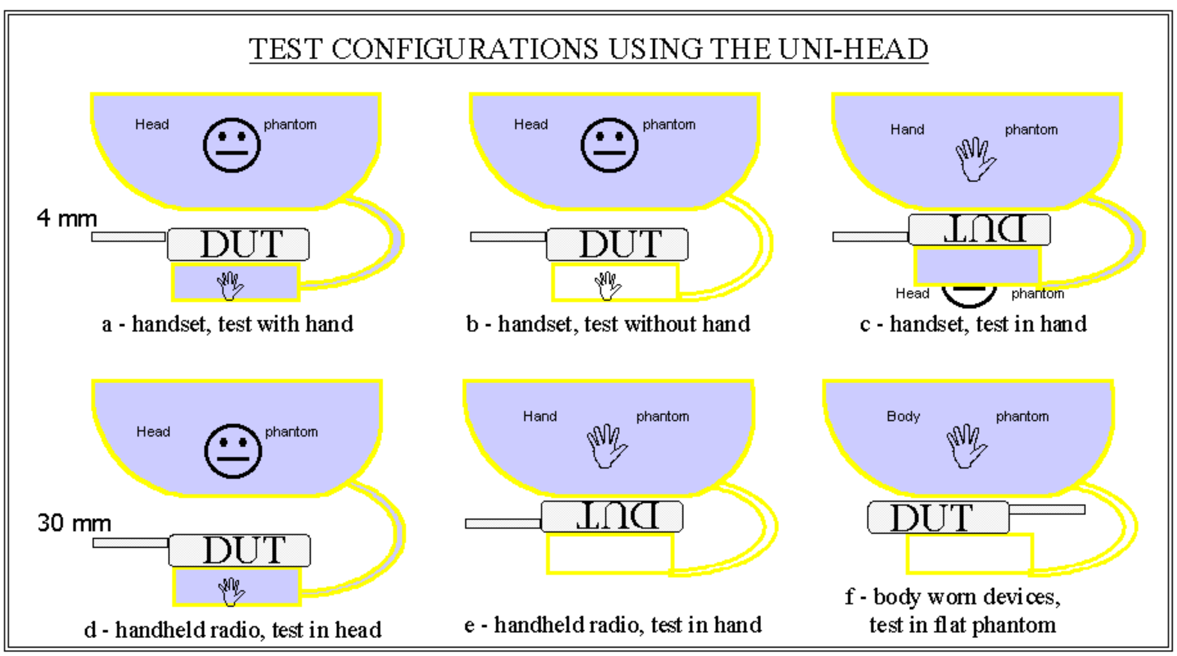


Figure 4.2

9. Slide the hand simulator back under the UniHead until it stops against the mechanical stop. This will locate the device properly in a horizontal plane in relation to the head simulator.
10. Slide the hand simulator support up until the top or the support lines up with the height determined in step 4 above.
11. Looking from above the device should be lined up as shown in Figure 4.4



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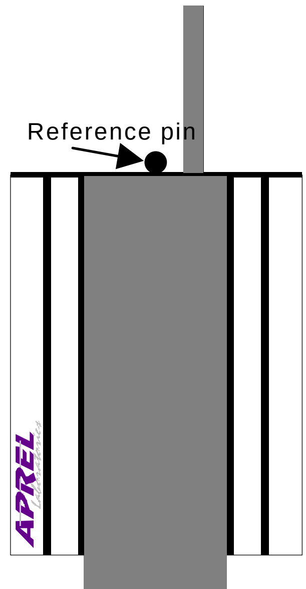
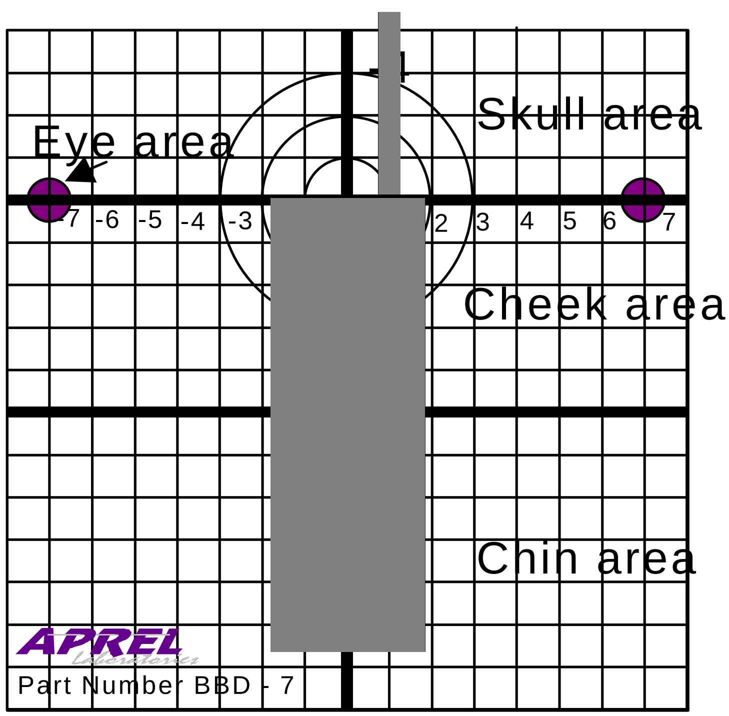


Hand Simulator locating lines

Figure 4.3



160x160 mm scan grid at the bottom of Head Simulator

Figure 4.4

4.2 DUTs Held In Front of the Mouth (e.g. PPT radio like handset)

1. Perform steps 1 through 9 as in Section 4.1.
2. Lower the device by 30 mm to account for the spacing provided by a human nose.
3. Looking from above the device should be lined up as shown in Figure 4.4

4.3 DUTs Used in the Hand Away from the Body (e.g. point of sale device)

The head simulator can be used as a substitute for the hand when performing a SAR evaluation for a device that is normally held in the hand but is not used in the vicinity of the head or the body. In this case the hand simulator should be empty (i.e. it will not contain simulated tissue) and will act strictly as a support to hold the DUT. The hand substitute (i.e. the head simulator) should be filled with simulated muscle tissue.

1. Close the valve between the head simulator and the hand simulator. This will ensure that the hand simulator remains empty and will serve only as a support for the DUT (if the hand is full of simulated tissue from a previous procedure, disconnect and empty it).
2. Select the simulated tissue appropriate for the type of tissue being tested, and the operating frequency of the DUT, and fill the head simulator portion of the UniHead with it.
3. Allow sufficient time for all air bubbles to escape before performing a scan.
4. Lift up the measurement slide (see Figure 4.1) and place the DUT face-up under it. Lower the measurement slide so that it rests on the DUT and record the height on the scale to the left of the slide using the lower edge of the slide as reference.
5. Add 30 mm to this height to account for the spacing provided by a human nose and record the value.
6. Put the DUT into test mode at the highest rated power, and operating on either the maximum performance frequency or one of the low, middle and high channels.
7. Loosen the bolt (on the right side of the UniHead stand) holding the hand simulator support, using the orange finger tab, and lower whole structure. Pull out the sliding support, using its orange finger tab (Figure 4.2), so that the DUT simulator is easily accessible.
8. Position the DUT upside-down on top of the hand simulator, butting the top of it up against the reference pin, and centered within the locating lines (see Figure 4.3).
9. Use a rubber band (elastic) to hold the DUT in place making use of the two notches on either side of the hand simulator (see Figure 4.2).
10. Slide the hand simulator back under the UniHead until it stops against the mechanical stop. This will locate the device properly in a horizontal plane in relation to the head simulator.

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11. Slide the hand simulator support up until the top or the support lines up with the height determined in step 5 above.
12. Looking from above the device should be lined up as shown in Figure 4.4

4.4 DUTs Carried Next to the Body

The head simulator can be used as a substitute for the body, or thighs, when performing a SAR evaluation for a device that is normally positioned against the body. These devices include backpack, shoulder strap or belt mounted portable communication gear as well as those installed into laptop computers. In this case the hand simulator should be empty (i.e. it will not contain simulated tissue) and will act strictly as a support to hold the DUT. The body or thigh substitute (i.e. the head simulator) should be filled with simulated muscle tissue.

1 Close the valve between the head simulator and the hand simulator. This will ensure that the hand simulator remains empty and will serve only as a support for the DUT (if the hand is full of simulated tissue from a previous procedure, disconnect and empty it).
2 Select the simulated tissue appropriate for the type of tissue being tested, and the operating frequency of the DUT, and fill the head simulator portion of the UniHead with it.
3 Allow sufficient time for all air bubbles to escape before performing a scan.
4 Lift up the measurement slide (see Figure 4.1) and place the DUT face-up under it. Lower the measurement slide so that it rests on the DUT and record the height on the scale to the left of the slide using the lower edge of the slide as reference.
5 Add 30 mm to this height to account for the spacing provided by a human nose and record the value.
6 Put the DUT into test mode at the highest rated power, and operating on either the maximum performance frequency or one of the low, middle and high channels.
7 Loosen the bolt (on the right side of the UniHead stand) holding the hand simulator support, using the orange finger tab, and lower whole structure. Pull out the sliding support, using its orange finger tab (Figure 4.2), so that the DUT simulator is easily accessible.
8 Position the DUT upside-down on top of the hand simulator, butting the top of it up against the reference pin, and centered within the locating lines (see Figure 4.3).
9 Use a rubber band (elastic) to hold the DUT in place making use of the two notches on either side of the hand simulator (see Figure 4.2).
10 Slide the hand simulator back under the UniHead until it stops against the mechanical stop. This will locate the device properly in a horizontal plane in relation to the head simulator.

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11 Slide the hand simulator support up until the top or the support lines up with the height determined in step 5 above.

12 Looking from above the device should be lined up as shown in Figure 4.4

5.0 AREA SCANNING PROCEDURE

Once the DUT is properly positioned with respect to the UniHead, a coarse scan of the electric field generated by the DUT can be made using a miniature isotropic E-field probe, throughout the entire region of tissues next to the handset and its antenna. This provides a SAR distribution near the surface of the phantom, closest to the phone, where the approximate location of the peak SAR can be identified.

5.1 Definition

area scan: measurement of the electric field inside the simulated tissue, over an array of positions following the inside surface of the phantom, and covering the entire region. The resolution of the scan is usually 1-3 cm.

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