TTI-P-G 158

Report

Dosimetric Assessment of the Siemens M46 (FCC ID: PWX-M46) According to the FCC Requirements

April 19, 2002

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Executive Summary

The M46 is a new mobile phone from Siemens operating in the 1900 MHz frequency range. The device has an integrated antenna. The system concept used is the PCS 1900 standard.

The objective of the measurements done by IMST was the dosimetric assessment of one device in the PCS 1900 standard. The examinations have been carried out with the dosimetric assessment system „DASY3“.

The measurements were made according to the Supplement C to OET Bulletin 65 of the Federal Communications Commission (FCC) Guidelines [FCC 2001] for evaluating compliance of mobile and portable devices with FCC limits for human exposure (general population) to radiofrequency emissions.

The Siemens M46 mobile phone (FCC ID: PWX-M46) is in compliance with the Federal Communications Commission (FCC) Guidelines [FCC 2001] for uncontrolled exposure. The phone was tested in the Body Worn configurations with the following accessories and combinations: “Belt Clip” with “Headset” and “Belt Clip” with “MP3 Player”.

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1 Subject of Investigation

The M46 is a new mobile phone from Siemens operating in the 1900 MHz frequency range. The device has an integrated antenna. The system concept used is the PCS 1900 standard.

Fig. 1: Picture of the device under test.

The objective of the measurements done by IMST was the dosimetric assessment of one device in the PCS 1900 standard. The examinations have been carried out with the dosimetric assessment system „DASY3“ described below.

2 The IEEE Standard C95.1 and the FCC Exposure Criteria

In the USA the recent FCC exposure criteria [FCC 2001] are based upon the IEEE Standard C95.1 [IEEE 1999]. The IEEE standard C95.1 sets limits for human exposure to radio frequency electromagnetic fields in the frequency range 3 kHz to 300 GHz.

2.1 Distinction Between Exposed Population, Duration of Exposure and Frequencies

The American Standard [IEEE 1999] distinguishes between controlled and uncontrolled environment. Controlled environments are locations where there is exposure that may be incurred by persons who are aware of the potential for exposure as a concomitant of employment or by other cognizant persons. Uncontrolled environments are locations where there is the exposure of individuals who have no knowledge or control of their exposure. The exposures may occur in living quarters or workplaces. For exposure in controlled environments higher field strengths are admissible. In addition the duration of exposure is considered.

Due to the influence of frequency on important parameters, as the penetration depth of the electromagnetic fields into the human body and the absorption capability of different tissues, the limits in general vary with frequency.

2.2 Distinction between Maximum Permissible Exposure and SAR Limits

The biological relevant parameter describing the effects of electromagnetic fields in the frequency range of interest is the specific absorption rate SAR (dimension: power/mass). It is a measure of the power absorbed per unit mass. The SAR may be spatially averaged over the total mass of an exposed body or its parts. The SAR is calculated from the r.m.s. electric field strength E inside the human body, the conductivity σ and the mass density ρ of the biological tissue:

$$SAR = \sigma \frac{E^2}{\rho} = c \left. \frac{\partial T}{\partial t} \right|_{t \to 0+} \quad . \tag{1}$$

The specific absorption rate describes the initial rate of temperature rise $\partial T / \partial t$ as a function of the specific heat capacity c of the tissue. A limitation of the specific absorption rate prevents an excessive heating of the human body by electromagnetic energy.

As it is sometimes difficult to determine the SAR directly by measurement (e.g. whole body averaged SAR), the standard specifies more readily measurable maximum permissible exposures in terms of external electric E and magnetic field strength H and power density S, derived from the SAR limits. The limits for E, H and S have been fixed so that even under worst case conditions, the limits for the specific absorption rate SAR are not exceeded.

For the relevant frequency range the maximum permissible exposure may be exceeded if the exposure can be shown by appropriate techniques to produce SAR values below the corresponding limits.

2.3 SAR Limit

In this report the comparison between the American exposure limits and the measured data is made using the spatial peak SAR; the power level of the device under test guarantees that the whole body averaged SAR is not exceeded.

Having in mind a worst case consideration, the SAR limit is valid for uncontrolled environment and mobile respectively portable transmitters. According to Table 1 the SAR values have to be averaged over a mass of 1 g (SAR_{1g}) with the shape of a cube.

Standard	Status	SAR limit [W/kg]
IEEE C95.1	In force	1.6

Table 1: Relevant spatial peak SAR limit averaged over a mass of 1 g.

3 The FCC Measurement Procedure

The Federal Communications Commission (FCC) has published a report and order on the 1st of August 1996 [FCC 1996], which requires routine dosimetric assessment of mobile telecommunications devices, either by laboratory measurement techniques or by computational modeling, prior to equipment authorization or use. In 2001 the Commission's Office of Engineering and Technology has released Edition 01-01 of Supplement C to OET Bulletin 65. This revised edition, which replaces Edition 97-01, provides additional guidance and information for evaluating compliance of mobile and portable devices with FCC limits for human exposure to radiofrequency emissions [FCC 2001].

3.1 General Requirements

The test shall be performed in a laboratory with an environment which avoids influence on SAR measurements by ambient EM sources and any reflection from the environment itself. The ambient temperature shall be in the range of 20°C to 26°C and 30-70% humidity.

3.2 Device Operating Next to a Person's Ear

3.2.1 Phantom Requirements

The phantom is a simplified representation of the human anatomy and comprised of material with electrical properties similar to the corresponding tissues. The physical characteristics of the phantom model shall resemble the head and the neck of a user since the shape is a dominant parameter for exposure.

3.2.2 Test Positions

As it cannot be expected that the user will hold the mobile phone exactly in one well defined position, different operational conditions shall be tested. The Supplement C to OET Bulletin 65 requires two test positions. For an exact description helpful geometrical definitions are introduced and shown in Fig. 2 - 3.

There are two imaginary lines on the mobile, the vertical centerline and the horizontal line. The vertical centerline passes through two points on the front side of the handset: the midpoint of the width w_t of the handset at the level of the acoustic output (point A on Fig. 2), and the midpoint of the width w_b of the bottom of the handset (point B). The horizontal line is perpendicular to the vertical centerline and passes through the center of the acoustic output (see Fig. 2). The two lines intersect at point A.

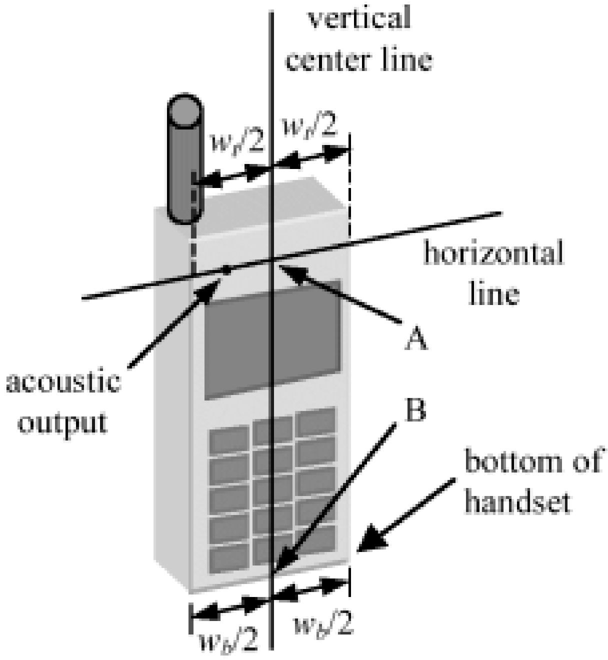

Fig. 2: Handset vertical and horizontal reference lines.

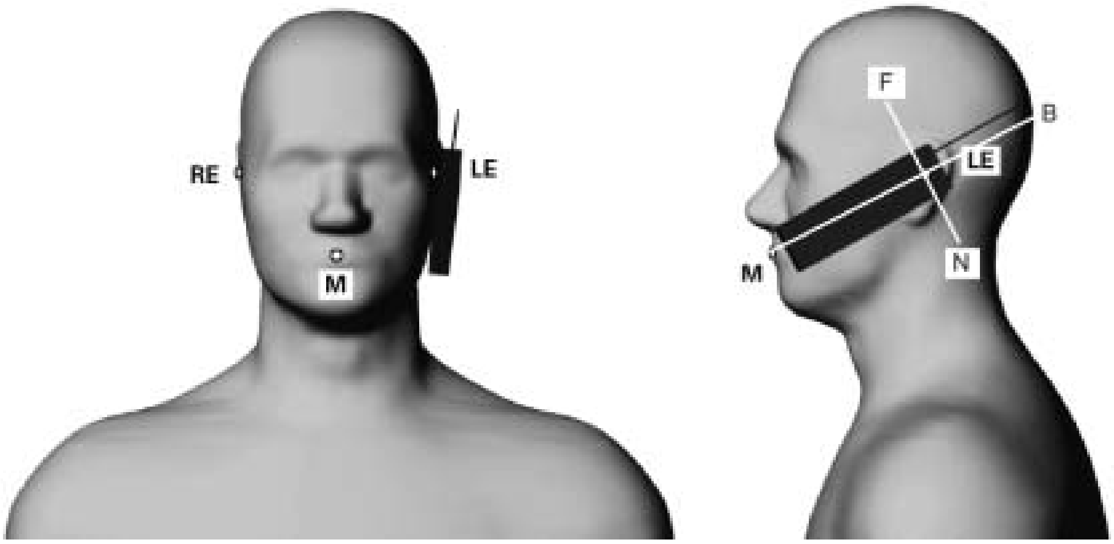

Fig. 3: Phantom reference points.

According to Fig. 3 the human head position is given by means of the following three reference points: auditory canal opening of both ears (RE and LE) and the center of the closed mouth (M). The ear reference points are 15-17 mm above the entrance to the ear canal along the BM line (back-mouth), as shown in Fig. 3. The plane passing through the two ear canals and M is defined as the reference plane. The line NF (Neck-Front) perpendicular to the reference plane and passing through the RE (or LE) is called the reference pivoting line. Line BM is perpendicular to the NF line. With this definitions the test positions are given by

- **Cheek position (see Fig. 4):**

Position the handset close to the surface of the phantom such that point A is on the (virtual) extension of the line passing through points RE and LE on the phantom (see Fig. 3), such that the plane defined by the vertical center line and the horizontal line of the phone is approximately parallel to the sagittal plane of the phantom. Translate the handset towards the phantom along the line passing through RE and LE until the handset touches the ear. While maintaining the handset in this plane, rotate it around the LE-RE line until the vertical centerline is in the plane normal to MB-NF including the line MB (called the reference plane). Rotate the phone around the vertical centerline until the phone (horizontal line) is symmetrical with respect to the line NF. While maintaining the vertical centerline in the reference plane, keeping point A on the line passing through RE and LE, and maintaining the phone contact with the ear, rotate the handset about the line NF until any point on the handset is in contact with a phantom point below the ear.

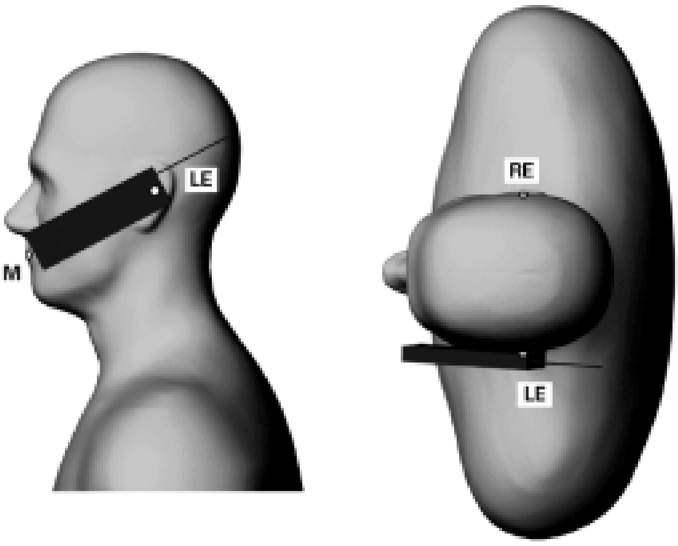

Fig. 4: The cheek position.

- **Tilted position (see Fig. 5):**

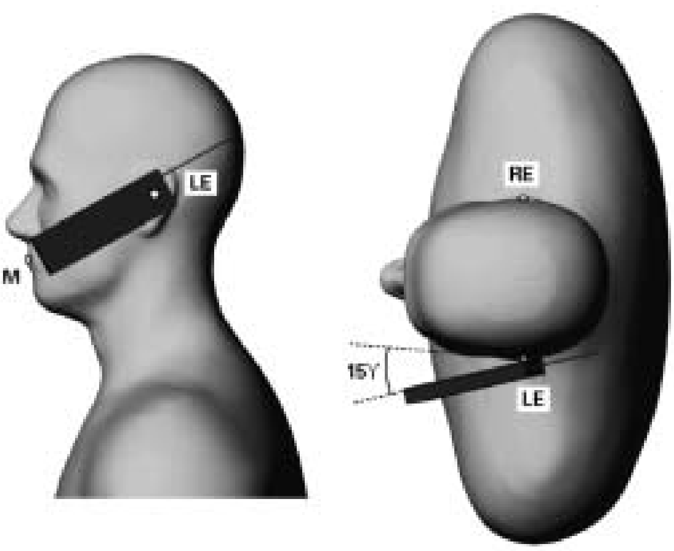

Fig. 5: The tilted position.

While maintaining the orientation of the phone retract the phone parallel to the reference plane far enough to enable a rotation of the phone by 15°. Rotate the phone around the horizontal line by 15°. While maintaining the orientation of the phone, move the phone parallel to the reference plane until any part of the phone touches the head. In this position, point A will be located on the line RE-LE.

3.2.3 Test to be Performed

The SAR test shall be performed with both phone positions described above, on the left and right side of the phantom. The device shall be measured for all modes operating when the device is next to the ear, even if the different modes operate in the same frequency band.

For devices with retractable antenna the SAR test shall be performed with the antenna fully extended and fully retracted. Other factors that may affect the exposure shall also be tested. For example, optional antennas or optional battery packs which may significantly change the volume, lengths, flip open/closed, etc. of the device, or any other accessories which might have the potential to considerably increase the peak spatial-average SAR value.

The SAR test shall be performed at the high, middle and low frequency channels of each operating mode. If the SAR measured at the middle channel for each test configuration is at least 2.0 dB lower than the SAR limit, testing at the high and low channels is optional.

3.3 Body-worn and Other Configurations

3.3.1 Phantom Requirements

For body-worn and other configurations a flat phantom shall be used which is comprised of material with electrical properties similar to the corresponding tissues.

3.3.2 Test Position

The body-worn configurations shall be tested with the supplied accessories (belt-clips, holsters, etc.) attached to the device in normal use configuration. Devices with a headset output shall be tested with a connected headset.

3.3.3 Test to be Performed

For purpose of determining test requirements, accessories may be divided into two categories: those that do not contain metallic components and those that do. For multiple accessories that do not contain metallic components, the device may be tested only with that accessory which provides the closest spacing to the body.

For multiple accessories that contain metallic components, the device must be tested with each accessory that contains a unique metallic component. If multiple accessories share an identical metallic component, only the accessory that provides the closest spacing to the body must be tested.

If the manufacturer provides none body-worn accessories a separation distance of 1.5 cm between the back of the device and the flat phantom is recommended. Other separation distances may be used, but they shall not exceed 2.5 cm. In these cases, the device may use body-worn accessories that provide a separation distance greater than that tested for the device provided however that the accessory contains no metallic components.

For devices with retractable antenna the SAR test shall be performed with the antenna fully extended and fully retracted. Other factors that may affect the exposure shall also be tested. For example, optional antennas or optional battery packs which may significantly change the volume, lengths, flip open/closed, etc. of the device, or any other accessories which might have the potential to considerably increase the peak spatial-average SAR value.

The SAR test shall be performed at the high, middle and low frequency channels of each operating mode. If the SAR measured at the middle channel for each test configuration is at least 2.0 dB lower than the SAR limit, testing at the high and low channels is optional.

4 The Measurement System

DASY is an abbreviation of „Dosimetric Assessment System“ and describes a system that is able to determine the SAR distribution inside a phantom of a human being according to different standards. It consists of a robot, several field probes calibrated for use in liquids, a shell phantom, tissue simulating liquid and software. The software controls the robot and processes the measured data to compare them with safety levels with respect to human exposure to radio frequency electromagnetic fields. Fig. 6 shows the equipment, similar to the installations in other laboratories [DASY 1995].

Fig. 6: The measurement set-up with two phantoms containing tissue simulating liquid.

The mobile phone operating at the maximum power level is placed by a non metallic device holder in the above described positions at a shell phantom of a human being. The distribution of the electric field strength *E* is measured in the tissue simulating liquid within the shell phantom. For this miniaturised field probes with high sensitivity and low field disturbance are used. Afterwards the corresponding SAR values are calculated with the known electrical conductivity σ and the mass density ρ of the tissue. The system software is able to determine the averaged SAR values (averaging region 1 g or 10 g) for compliance testing.

This is done by two scans: first a coarse scan determines the region of the maximum SAR, afterwards the 1 g or 10 g averaged SAR is measured in a second fine scan. The measurement time takes about 20 minutes.

For the measurements the Specific Anthropomorphic Mannequin (SAM) is used. The phantom is a fibreglass shell integrated in a wooden table. The thickness of the phantom amounts to 2 mm ± 0.1 mm. It enables the dosimetric evaluation of left and right hand phone usage and includes an additional flat phantom part. The phantom set-up includes a coverage (polyethylene), which prevents the evaporation of the liquid.

4.1 Measurement Procedure

The following steps are used for each test position:

- Measurement of the local SAR value at a fixed location (P1). This value serves as a reference value for calculating a possible power drift.
- Measurement of the SAR distribution with a grid spacing of 15 mm x 15 mm and a constant distance to the inner surface of the phantom. With interpolation of these values, the area of the maximum SAR is calculated.
- Around this point, a cube of 30 mm x 30 mm x 30 mm is assessed by measuring 7 x 7 x 7 points. With these data, the peak spatial-average SAR value is calculated (additionally all peaks within 2.0 dB of the highest peak identified during the grid scan are assessed by a cube).
- Repetition of the SAR measurement at the fixed location (P1) and repetition of the whole procedure if the two results differ by more than ± 5%.

4.2 Uncertainty Assessment

Table 2 includes the uncertainty budget suggested by the [IEEE 200x] and determined by Schmid & Partner Engineering AG. The expanded uncertainty (K=2) is assessed to be ± 27.1%.

Error Sources	Uncertainty Value	Probability Distribution	Divisor	c_i	Standard Uncertainty	v_i^2 or v_{eff}
Measurement System						
Probe calibration	± 4.4 %	Normal	1	1	± 4.4 %	∞
Axial isotropy	± 4.7 %	Rectangular	√3	$(1\text{-cp})^{1/2}$	± 1.9 %	∞
Spherical isotropy	± 9.6 %	Rectangular	√3	$(\text{cp})^{1/2}$	± 3.9 %	∞
Spatial resolution	± 0.0 %	Rectangular	√3	1	± 0.0 %	∞
Boundary effects	± 5.5 %	Rectangular	√3	1	± 3.2 %	∞
Probe linearity	± 4.7 %	Rectangular	√3	1	± 2.7 %	∞
Detection limit	± 1.0 %	Rectangular	√3	1	± 0.6 %	∞
Readout electronics	± 1.0 %	Normal	1	1	± 1.0 %	∞
Response time	± 0.8 %	Rectangular	√3	1	± 0.5 %	∞
Integration time	± 1.4 %	Rectangular	√3	1	± 0.8 %	∞
RF ambient conditions	± 3.0 %	Rectangular	√3	1	± 1.7 %	∞
Mech. robot constraints	± 0.4 %	Rectangular	√3	1	± 0.2 %	∞
Probe positioning	± 2.9 %	Rectangular	√3	1	± 1.7 %	∞
Extrapolation & integration	± 3.9 %	Rectangular	√3	1	± 2.3 %	∞
Test Sample Related						
Device positioning	± 6.0 %	Normal	0.89	1	± 6.7 %	12
Device holder uncertainty	± 5.0 %	Normal	0.84	1	± 5.9 %	8
Power drift	± 5.0 %	Rectangular	√3	1	± 2.9 %	∞
Phantom and Set-up						
Phantom uncertainty	± 4.0 %	Rectangular	√3	1	± 2.3 %	∞
Liquid conductivity (target)	± 5.0 %	Rectangular	√3	0.6	± 1.7 %	∞
Liquid conductivity (meas.)	± 10.0 %	Rectangular	√3	0.6	± 3.5 %	∞
Liquid permittivity (target)	± 5.0 %	Rectangular	√3	0.6	± 1.7 %	∞
Liquid permittivity (meas.)	± 5.0 %	Rectangular	√3	0.6	± 1.7 %	∞
Combined Uncertainty					± 13.6 %	

Table 2: Uncertainty budget of DASY3.

5 SAR Results

The Tables below contain the measured SAR values averaged over a mass of 1 g.

Phantom Side (Liquid depth = 16.4 cm)	Test Position	SAR_{1g} [W/kg] (Drift[dB])			Temperature	
		Channel 512 1850.20 MHz 29.9 dBm	Channel 661 1880.00 MHz 29.8 dBm	Channel 810 1909.80 MHz 29.8 dBm	Ambient [° C]	Liquid [° C]
Left Head	Cheek		0.616* (-0.03)		21.5	20.5
	Tilted		0.644 (-0.08)		21.5	20.5
Right Head	Cheek		0.686* (0.02)		21.6	20.5
	Tilted	0.711 (0.06)	0.705 (0.03)	0.644 (0.00)	21.6/21.6/21.6	20.5/20.6/20.6

Table 3: Measured head SAR results for PCS 1900 for the Siemens M46 (*Cube 1)

Accessory (Liquid depth = 15.4 cm)	SAR_{1g} [W/kg] (Drift[dB])			Temperature	
	Channel 512 1850.20 MHz 29.9 dBm	Channel 661 1880.00 MHz 29.8 dBm	Channel 810 1909.80 MHz 29.8 dBm	Ambient [° C]	Liquid [° C]
M46 with Belt Clip and Headset	0.275 (-0.04)	0.262 (-0.02)	0.237 (0.02)	22.1/22.1/22.1	21.1/21.1/21.1
M46 with Belt Clip and MP3 player	0.246* (0.00)	0.238* (0.01)	0.215* (-0.04)	22.2/22.2/22.3	21.2/21.3/21.3

Table 4: Measured SAR results in body-worn configuration for PCS 1900 for the Siemens M46 (* Cube 1).

The “Cube 1” labeling indicates that during the grid scanning an additionally peak was found which was within 2.0 dB of the highest peak. The value of the highest cube can be found in the above tables, the value from the second assessed cube can be found in the SAR distribution plot.

The above mentioned power values are conducted measured values. The power output was measured in the IMST GmbH.

Before the measurements the test side ambient conditions were checked performing SAR measurements with the phone powered off. The highest noise level was 0.0007 W/kg (1g cube) for the head positions and 0.0008 W/kg (1g cube) for the body positions.

6 Evaluation

In Fig. 7 the head phantom SAR results for PCS 1900 given in Table 3 are summarized and compared to the limit. In Fig. 8 the SAR results in body-worn configuration for PCS 1900 given in Table 4 are summarized and compared to the limit.

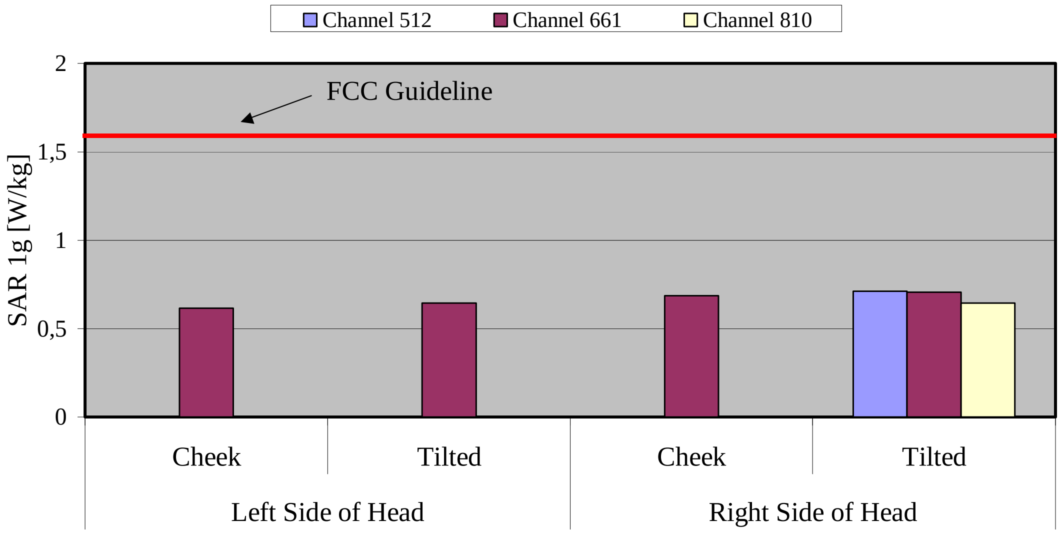

Fig. 7: The measured head phantom SAR values for the Siemens M46 for PCS 1900 in comparison to the FCC exposure limit.

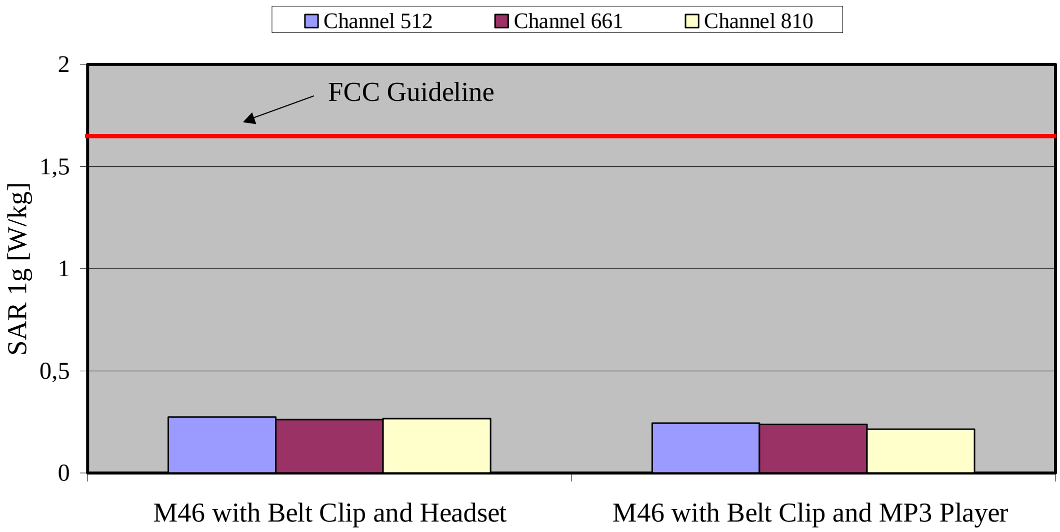

Fig. 8: The measured SAR values in body-worn configuration with headset and MP3 player for the Siemens M46 for PCS 1900 in comparison to the FCC exposure limit.

The Siemens M46 mobile phone (FCC ID: PWX-M46) is in compliance with the Federal Communications Commission (FCC) Guidelines [FCC 2001] for uncontrolled exposure. The phone was tested in the Body Worn configurations with the following accessories and combinations: “Belt Clip” with “Headset” and “Belt Clip” with “MP3 Player ”.

7 Appendix

7.1 Administrative Data

Date of validation:	1900 MHz, Head: April 15, 2002
	1900 MHz, Body: April 16, 2002
Date of measurement:	PCS 1900, Head: April 15, 2002
	PCS 1900, Body: April 16, 2002
Data stored:	Siemens_6575_235

7.2 Device under Test and Test Conditions

MTE:	Siemens M46, Production Line Unit	
Date of receipt:	April 12, 2002	
IMEI:	099999001234561	
FCC ID:	PWX-M46	
Equipment class:	Portable device	
Power Class (PCS 1900):	1, tested with power level 0	
RF exposure environment:	General Population/Uncontrolled	
Power supply:	Internal battery type 4.2V	
Antenna:	Antenna type: integrated	
Measured Standards:	PCS 1900 (Basestation Simualtor)	
Modulation:	GMSK	
Crest Factor:	PCS 1900: 8	
TX range:	PCS 1900 :	1850.2 MHz – 1909.8 MHz
RX range:	PCS 1900 :	1930.2 MHz – 1989.8 MHz
Used TX Channels:	PCS 1900:	low: ch. 512, center: ch. 661, high: ch. 810

7.3 Tissue Recipes

The following recipes are provided in percentage by weight.

1900 MHz, Head:	45.65%	Diethylenglykol-monobutylether
	54.00%	De-Ionized Water
	0.35%	Salt
1900 MHz, Body:	29.68%	Diethylenglykol-monobutylether
	70.00%	De-Ionized Water
	0.32%	Salt

7.4 Material Parameters

Frequency		ε_r	σ [S/m]	Temperature Ambient [° C]	Temperature Liquid [° C]
1900 MHz (Head)	Recommended Value	40.00 ± 2.00	1.40 ± 0.07	20.0 - 26.0	-
	Measured Value	38.40 ± 1.90	1.46 ± 0.15	21.20	20.30
1900 MHz (Body)	Recommended Value	53.30 ± 2.67	1.52 ± 0.08	20.0 - 26.0	-
	Measured Value	51.10 ± 2.60	1.53 ± 0.16	21.40	21.10

Table 5: Parameters of the tissue simulating liquids.

7.5 Simplified Performance Checking

The simplified performance check was realized using the dipole validation kits. The input power of the dipole antennas were 250 mW and they were placed under the flat part of the SAM phantom. The results are listed in the Table 6 and shown in Fig. 9-10

Frequency		SAR_{1g} [W/kg]	ε_r	σ [S/m]	Temperature Ambient [° C]	Temperature Liquid [° C]
1900 MHz (Head)	Target Value	10.8	39.20	1.47	20.0 - 26.0	-
	Measured Value	11.2	38.40	1.46	21.50	20.50
1900 MHz (Body)	Target Value	10.2	53.50	1.46	20.0 - 26.0	-
	Measured Value	10.5	51.10	1.53	22.10	21.10

Table 6: Validation results, 1900 MHz.

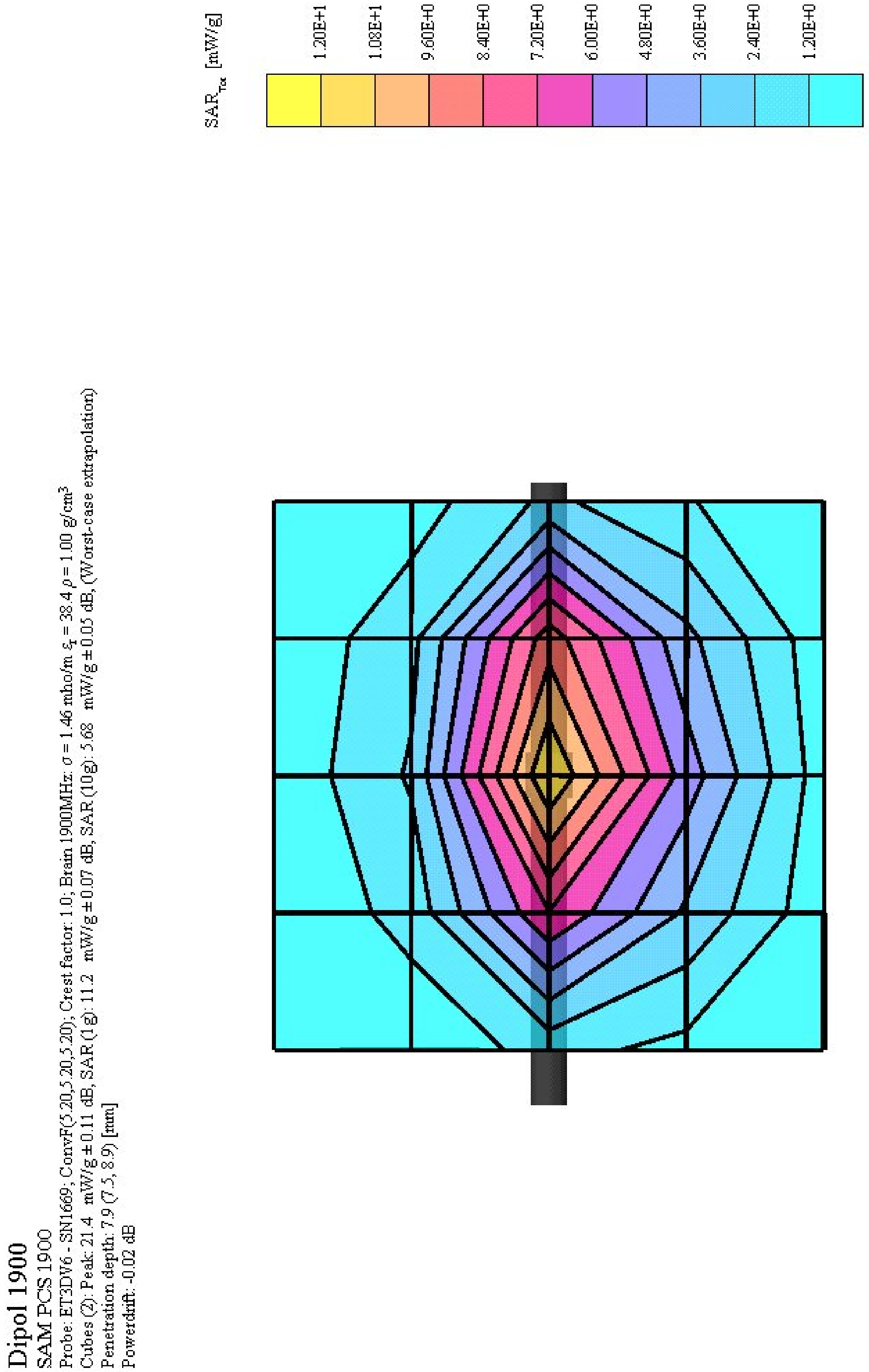

Fig. 9: Validation measurement 1900 MHz head, coarse grid.

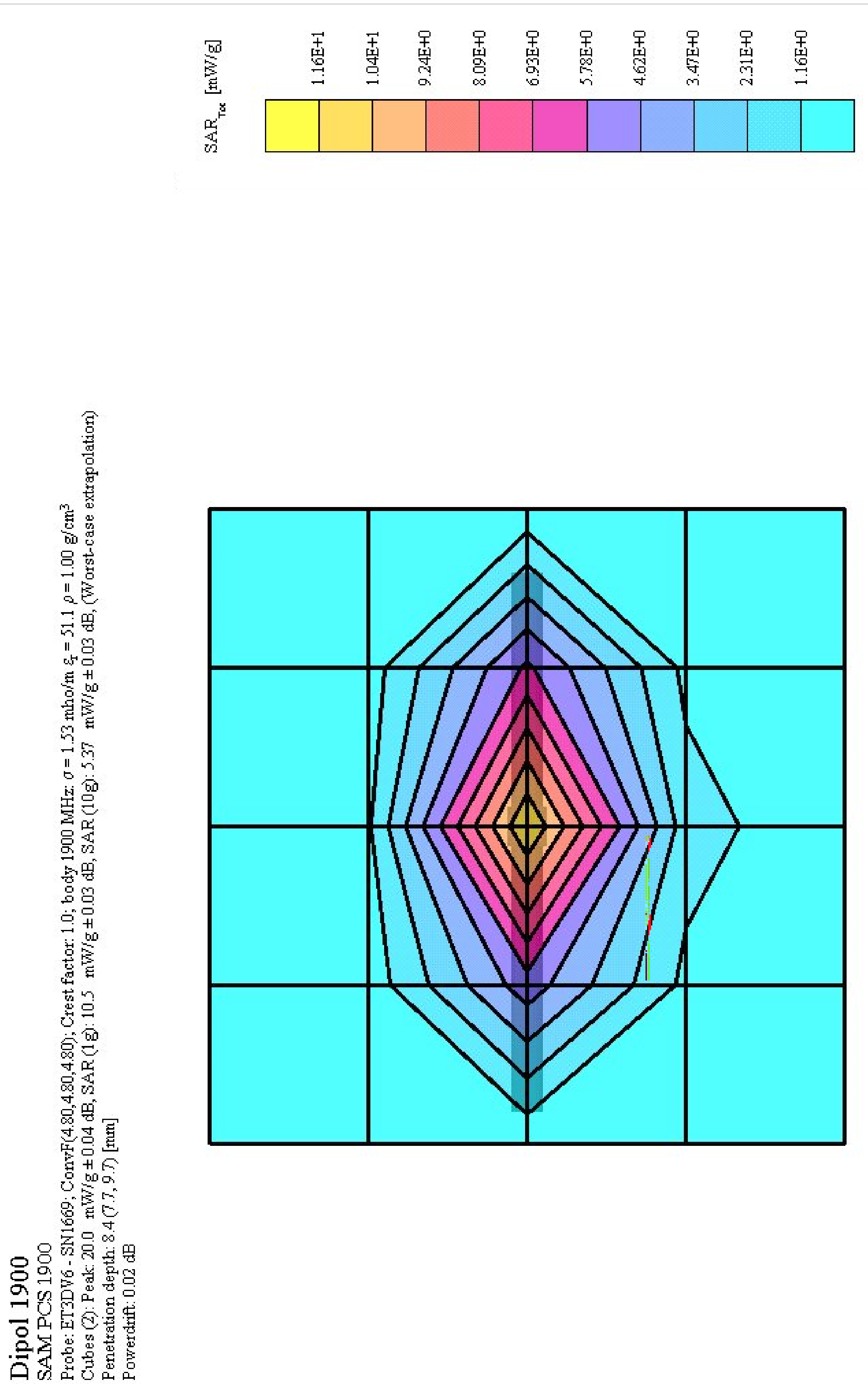

Fig. 10: Validation measurement 1900 body, coarse grid.

7.6 Environment

Humidity: 38% ± 5 %

7.7 Test Equipment

Test Equipment	Model	Serial Number	Last Calibration	Next Calibration
DASY3 System				
Software Version	V3.1D	N/A	N/A	N/A
Dosimetric E-Field Probe	ET3DV6	1669	03/2002	03/2003
Data Acquisition Electronics	DAE3 V1	335	05/2001	05/2002
Phantom	SAM	1073	N/A	N/A
Performance Checking				
System Validation Dipole, Head	D1900V2	535	04/2001	04/2003
System Validation Dipole, Body	D1900V2	535	08/2001	04/2003
Power Meter, Agilent	E4426A	GB41050414	12/2001	12/2002
Power Sensor, Agilent	E9301H	U40010212	12/2001	12/2002
Power Meter, Gigatronics	8541B	1830892	12/2001	12/2002
Power Sensor, Gigatronics	80401A	1829437	01/2002	12/2002
RF Source (Network Analyzer)	HP8753D	3410A06555	12/2001	12/2002
RF Amplifier, Mini-Circuits	ZHL-42	D012296	N/A	N/A
Material Measurement				
Network Analyzer	HP8753D	3410A06555	12/2001	12/2002
Dielectric Probe Kit	HP85070B	US33020263	N/A	N/A
General				
Base Station Simulator, Wavetek	4032	1388073	N/A	N/A
Radio Tester, Rohde & Schwarz	CMU200	835305/050	01/2002	01/2003

Table 7: Test equipment.

7.8 Pictures of the device under test

Fig. 11 – 15 show the device under test and the used accessories.

Fig. 11: Front and back view of the device.

Fig. 12: Side views of the device.

Fig. 13: Phone with used Belt Clip.

Fig. 14: Used Headset.

Fig. 15: Used MP3 Player .

7.9 Test Positions for the Device under Test

Fig. 16 – Fig. 21 shown the test positions for the SAR measurements.

Fig. 16: Cheek position, left side.

Fig. 17: Tilted position, left side.

Fig. 18: Cheek position, right side.

Fig. 19: Tilted position, right side.

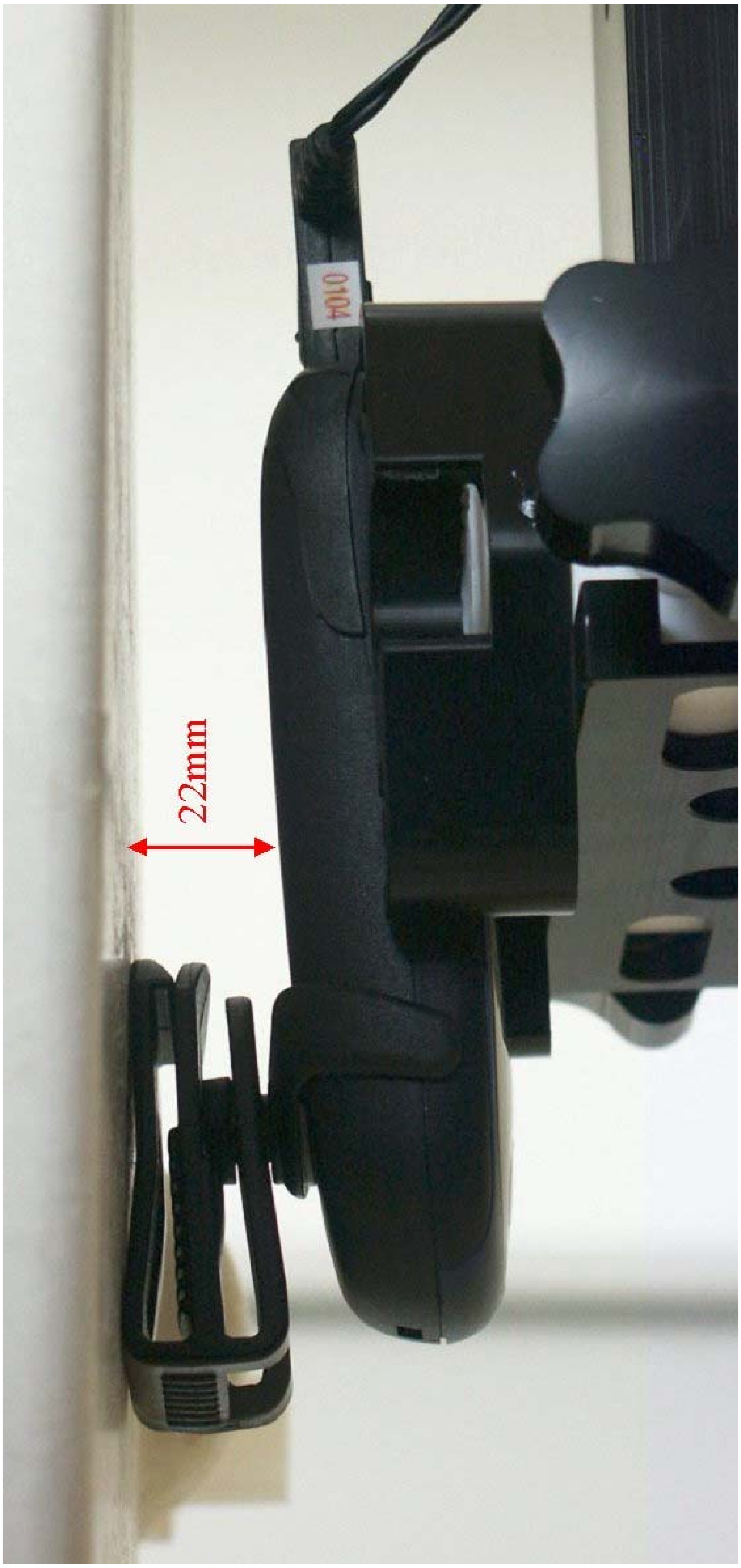

Fig. 20: Body worn configuration, Belt Clip with Headset.

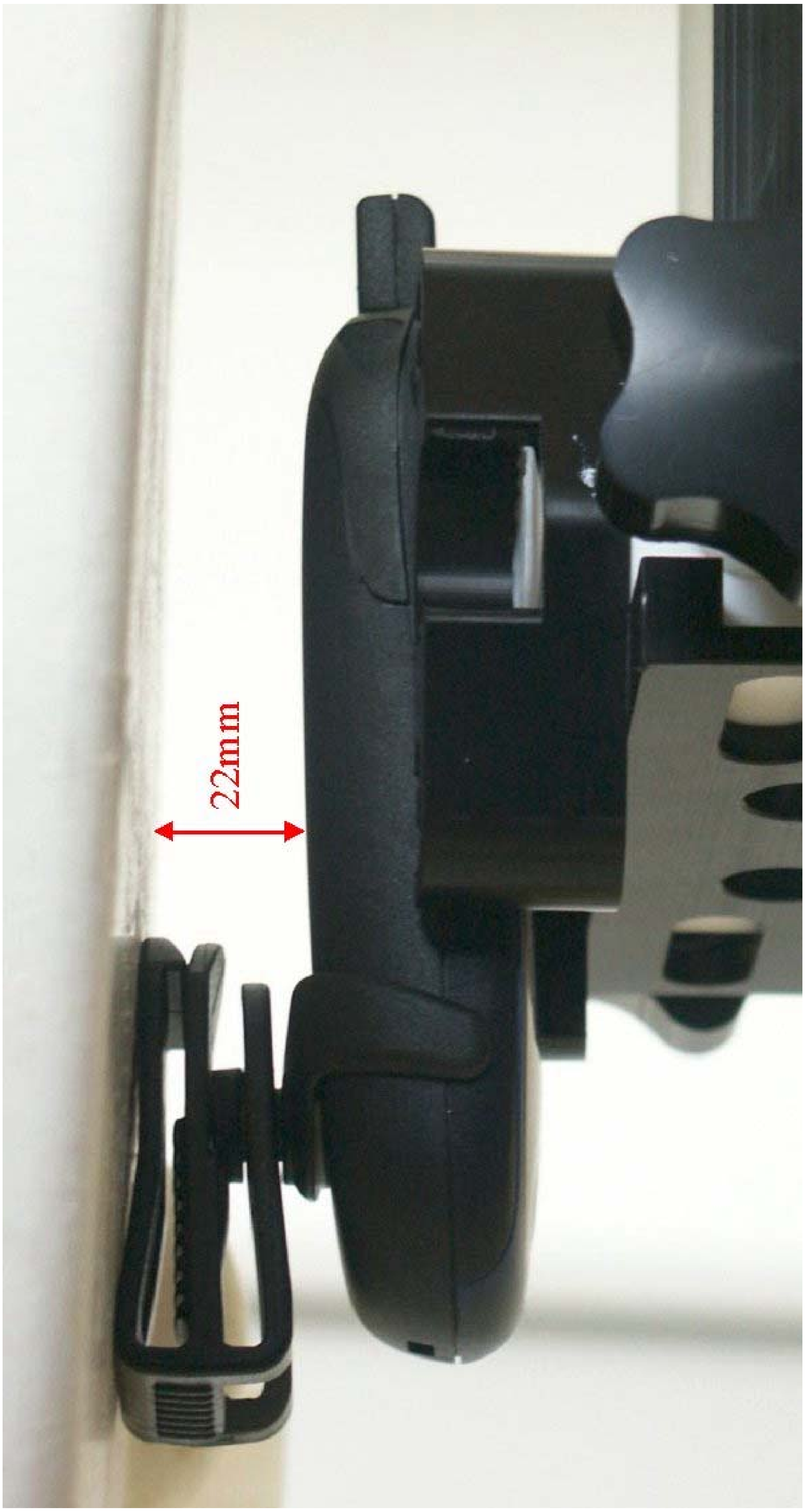

Fig. 21: Body worn configuration, Belt Clip with MP3 Player.

7.10 Pictures to demonstrate the required liquid depth

Fig. 22 show the liquid depth in the used SAM phantoms.

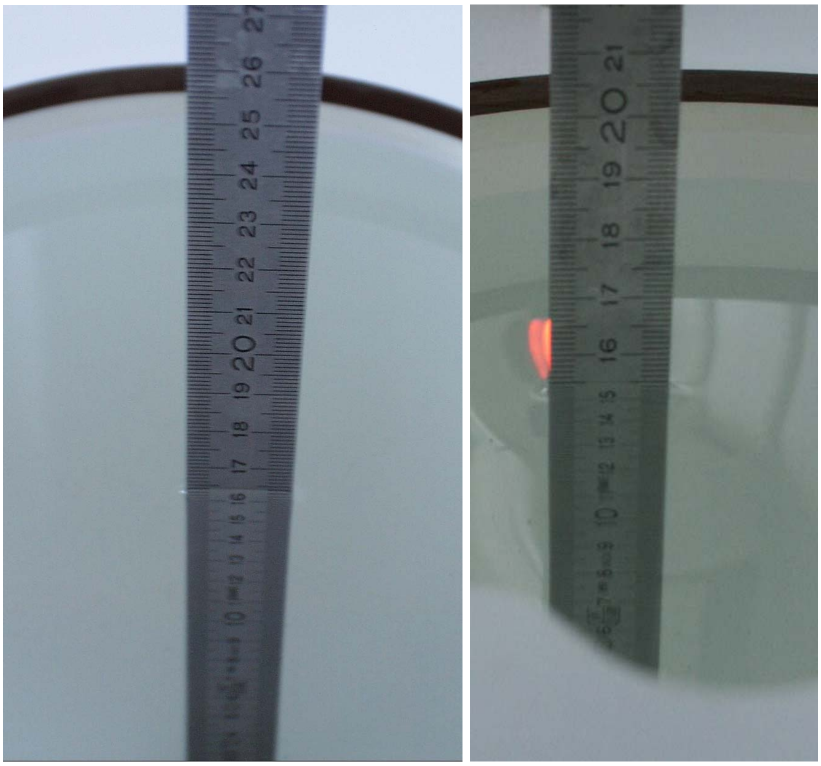

Fig. 22: Liquid depth for PCS 1900 head (left) and body (right) measurements.

8 References

[DASY 1995] Referenzliste des Herstellers, der Fa. Schmid & Partner Engineering AG, über installierte DASY-Systeme mit RX90 Robotern: Deutsche Telekom, Forschungs- und Technologiezentrum; Motorola Cellular - MRO; Motorola; Ericsson Mobile Communications AB; Nokia Mobile Phones LTD; IMST GmbH, 1995.

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