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SAR test report for the NSM Technology DECT phone

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Apparatus Description:	NSM Technology Bluetooth/DECT Phone
Customer name:	Ian De Monte
Customer address:	ITS Testing and Certification ITS House Cleeve Road Leatherhead Surrey KT22 7SB

C-MAC References:

JOB Number 50483SAR2001-31

SAR Test Procedure document number EMP042.doc Issue Number 2

1. Summary

The highest SAR levels measured were 0.0298 mW/g for left hand usage and 0.0331 mW/g for right hand usage averaged over 10g measured at the intended use position. The FCC limit is 1.6mW/g averaged over 10g. The NSM Technology phone clearly meets the FCC requirements.

2. Distribution

Name	Location	Number of Copies
Ian de Monte	ITS - UK	1
Bjorn Rosenquist	ITS - Sweden	2
File	Harlow	2

3. Contents

4. Introduction

This report summarises a Specific Absorption Rate (SAR) test conducted on an NSM Teschnology Bluetooth/DECT phone at the Harlow Laboratories of C-MAC Engineering. The Handset part number OEBCA00172 was measured in accordance with the requirements for compliance testing defined in the Final Draft of the report 'Considerations for Human Exposure to Electromagnetic Fields from Mobile Telephone Equipment (MTE) in the Frequency Range of 30MHz up to 6GHz" prepared by the working Group for Mobile Telecommunications Equipment (WGMTE) of CENELEC TC211 on the mandate of DGXIII of December 1997[1].

The results are compared with the North American standard [3] for maximum permitted exposure for uncontrolled use. The American standard (ANSI) has been widely used as the basis of the TTC/MPT standard used in Japan and the Far East (see [2] for details). The results presented in this report for the FCC standard are equally valid for both markets.

It should be noted that SAR is frequency dependent, and the results presented are only valid for 2400 MHz. Production of handportable variations for other frequency bands will require further testing.

5. SAR Dosimetric Assessment Equipment

5.1. Measurement Apparatus

For the evaluation, the dosimetric assessment system used was the automated near-field scanning system DASY3 from Schmidt & Partner Engineering AG (SPEAG).
The system employs a robotic arm which scans an E-field probe within a generic phantom filled with brain-simulated tissue.

The high precision robot (working range greater than 0.9m) positions the probes with a positional repeatability of better than ±0.02mm. Special E field probes have been developed for measurements close to material discontinuity, the sensors of which are directly loaded with a Schottky diode and connected via highly resistive lines (length ≈ 300mm) to the data acquisition unit. The system is described in detail in [2].

The SAR measurements were conducted with the dosimetric probe ET3DV5 SN1319 (manufactured by SPEAG), designed in the classical triangular configuration [2] and optimised for dosimetric evaluation. The probe has been calibrated according to the procedure described in [5] with an accuracy of better than ±10%. The spherical anisotropy was evaluated with the procedure described in [6] and found better than ±0.25dB. The probe had been calibrated in the last twelve months and test certificates, traceable to national standards are available for inspection as required.

The phantom used was the ‘Generic Twin Phantom’ described in [3]. A photograph of the measurement kit is shown in Figures 1, 2 and 3

Appendix 4 gives a list of test equipment used and the calibration due dates.

5.2. Brain Simulation Fluid

Measurement of the SAR of a handset requires the preparation of a homogeneous fluid representative of the R.F. characteristics of the human brain.

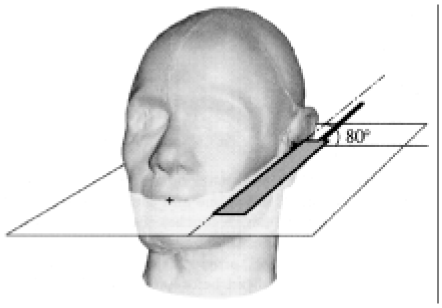
For the measurements included in this report, a sugar solution was made to represent the brain dielectric properties at 2400MHz, as reported by Gabriel [5] and recommended by the FCC [6]. Tests were done with a simulating fluid whose measured properties are shown in the table below.

Tissue	**Dielectric Constant**	**Conductivity S/m**
Brain (2400MHz)	42.6+/-5%	1.48+/-4%

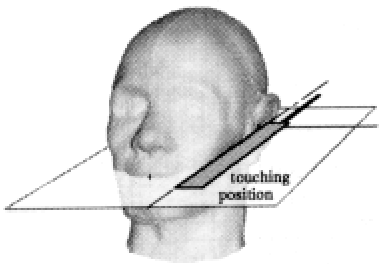
The fluid represents a comparatively low conductance fluid that represents the mean values of human brain,
The dielectric properties were confirmed by measurements with a HP85070B dielectric probe kit connected to a HP8753D network analyser. The parameters were re-tested regularly during the measurement to check for liquid ageing.

5.3. Measurement Procedures

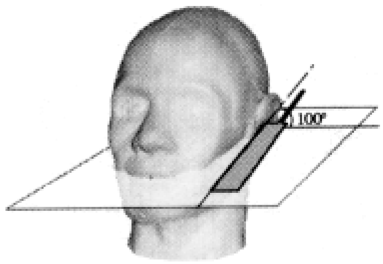
The requirements and necessary procedures are defined in detail in the draft report, [1] "Safety Considerations for Human Exposure to Electromagnetic Fields from Mobile Telephone Equipment (MTE) in the Frequency Range of 30MHz up to 6GHz". This is a detailed report and defines well the apparatus and procedures necessary to provide compliance testing. This report has been prepared by a working group of CENELEC, the European standard committee, and as such provides limits necessary to comply with accepted European Standard levels. SAR figures must be within the limits in 4 characteristic positions:



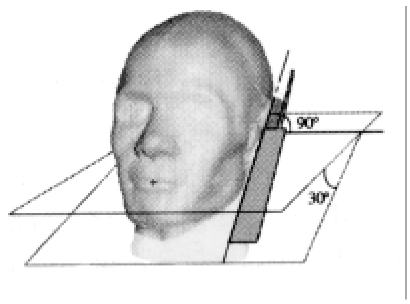
Intended Use



Touch Position



100° Position



30° Tilted

CENELEC characteristic positions

The NSM Technology handset will be distributed to the American market and as such is required to comply with the FCC limits. The FCC (ANSI standards committee) limit for a 'controlled environment' is 8 mW/g and for an 'uncontrolled environment' is 1.6mW/g. Note that these limits are the same as those set by the TTC/MPT (Japanese standard committee). The standard states that the handportable should exhibit compliance while in the 'standard' operating position. The 'standard' position is not defined thus the CENELEC positions will be used for measurements.

To show compliance to both standards it was necessary to perform measurements

- with the handportable in four CENELEC positions.
- on both the left and right hand side of the head.

5.4. Estimation of Measurement Uncertainties

The probes used were calibrated with an accuracy of better than ±10%. The worst-case uncertainty of the HP85070B dielectric probe kit for measurement of the dielectric constant and for the measurement of the conductivity is ±10%. The total uncertainty for the determination of the peak SAR values averaged over 10g for the system is estimated to be ±26%. This uncertainty includes probe, calibration, positioning and evaluation errors, and errors when assessing the correct dielectric parameters for the brain simulating liquid as well as errors in estimating the output power. However it does not include the errors of modelling the general population using a homogenous phantom. Generally a 95% confidence level is quoted (that is there is only 1 in 20 chance that a person will have a SAR different to that calculated) in which case the errors are expected to increase to ±36% (95% confidence level). A full error analysis is included as **Appendix 2** of this report.

The measurement uncertainties have been recalculated to allow for the higher level of conductivity at 2400MHz. But the overall measurement uncertainty has changed from +/-36% to +/- 37%.

6. Test Results

The following table shows the SAR levels for the NSM Technology Handset

Handset Position	Units in mW/g 1g		Units in mW/g 10g	
		Limit		Limit
CEN 100º, left hand usage	0.0521	8	0.0223	1.6
CEN intended, left hand usage	0.0615	8	0.0298	1.6
CEN touch, left hand usage	0.0643	8	0.0247	1.6
CEN 30º tilted, left hand usage	0.0578	8	0.0259	1.6
CEN 100º, right hand usage	0.0524	8	0.0274	1.6
CEN intended, right hand usage	0.0702	8	0.0331	1.6
CEN touch, right hand usage	0.0425	8	0.0189	1.6
CEN 30º tilted, right hand usage	0.0420	8	0.0216	1.6

7. Appendix 1: List of Figures

8. Appendix 2: Measurement Uncertainty

The following error budget is based on a full study by T. Schmid, K. Pokovic and N. Kuster entitled 'Uncertainty Budget for Compliance Testing with Safety Limits' available on request from Schmid & Partner Engineering AG (SPEAG), Zurich, Switzerland. This document includes the full assumptions of the error model and related references to experimental work. The work is based on the Ph.D. thesis of K. Pokovic, which is also available on request from ETH, Zurich.

The error budget has been adapted to reflect the circumstances of the equipment in use at Nortel. These include the use of the flat body phantom and the uncertainty of the average body tissue parameters in the upper torso. Notes show the alterations made.

The total error is made up of three types of uncertainty:

a. The assessment uncertainty of the field intensity
b. The uncertainty of Device positioning
c. The uncertainty of modelling the body torso using the phantom

Each of these is considered in **Tables A2.1 to A2.3**. All uncertainties are added up in quadrature. The offsets are added linearly and represent the observed over-estimation of using a homogenous phantom to measure SAR (see note 1).

Two forms of error are then calculated by quadrature addition of the respective uncertainities and linear addition of the offsets. **Table A2.4** shows the repeatability error in the phantom which is the error that the results can be reproduced in the same equipment elsewhere. This will also be the error when a CENELEC approved homogenous measurement phantom is agreed for the standard.

Currently, the standards require that the SAR is shown to be lower in the general population. Hence, in addition to these errors, there is the uncertainty that the phantom represents accurately the human torso. **Table A2.5** shows the error when this is included. Note that, although not a standard requirement, a 95% confidence limit (K=2) is conventionally used to indicate the tolerable error.

Uncertainty Description	Error	Distribution	Weight	Standard Deviation	Offset
Probe Uncertainty					
-Axial Isotropy	±0.2dB	U-shape	0.5	±2.4%	
-Spherical Isotropy	±0.4dB	U-shape	0.5	±4.8%	
-Isotropy from Gradient	±0.5dB	U-shape	0	±0.0%	
-Spatial Resolution	±0.5%	Normal	1	±0.5%	
-Linearity Error	±0.2dB	Rectangular	1	±2.7%	
-Calibration Error	±3.6%	Normal	1	±3.6%	
Evaluation Uncertainty					
-Data Acquisition Error	±1%	Rectangular	1	±0.6%	
-ELF and RF Disturbances	±0.25%	Normal	1	±0.25%	
-Dielectric Parameters	±13%	Rectangular	1	±7.8%	
Spatial Peak SAR Evaluation Uncertainty					
-Extrapolation	±3%	Normal	1	±3%	
-Probe Positioning Error	±0.1mm	Normal	1	±1%	
Cube/ Orientation/Integration	±3%	Normal	1	±3%	
Cube Shape Inaccuracies	±2%	Rectangular	1	±1.2%	
Total Measurement Uncertainty				±11.4%	

Table A2.1 Assessment Uncertainty

Uncertainty Description	Error	Distribution	Weight	Standard Deviation	Offset
-Device Positioning	±6%	Normal	1	±6%	
-Device Output Power	±0.1dB	Normal	1	±5%	
-Laboratory Set-up	±3%	Normal	1	±3%	
Total Source Uncertainty				±8.4%	

Table A2.2 Source Uncertainty

Uncertainty Description	Error	Distribution	Weight	Standard Deviation	Offset
-Internal Anatomy (note 1)			1	±10%	+10%
-Shape (note 2)			1	±7%	+10%
-Other Influences			1	±0%	≥0%
Total Phantom Uncertainty				±12.2%	+20%

Table A2.3 Phantom Uncertainty (80% User Group Coverage)

Uncertainty Description	Uncertainty	Offset
-Total Assessment Uncertainty	±11.4%	
-Total Source Uncertainty	±8.4%	
Combined Uncertainty (K=1)	**±14.1%**	
Combined Uncertainty (95% conf.)	**±28%**	

Table A2.4 Total Uncertainty of measurement

Uncertainty Description	Uncertainty	Offset
-Total Assessment Uncertainty	±11.4%	
-Total Source Uncertainty	±8.4%	
-Total Phantom Uncertainty	±12.2%	+20%
Combined Uncertainty (K=1)	**±18.7%**	**+20%**
Combined Uncertainty (95% conf.)	**±37%**	**+20%**

Table A2.5 Total Population Uncertainty (80% User Group Coverage)

Notes:

1. Whereas a large number of electromagnetic computer modelling studies have been performed to compare the homogenous phantom with that expected from a inhomogeneous head, less have been performed on the torso. As a result, this uncertainty has been increased from 7% to 10%. Tests that have been done suggest the homogenous phantom over-estimates the SAR by 10%. See N.Kuster, R. Kastle and T. Schmid “Dosemetric Evaluation of Mobile Communications Equipment With Known Precision”, *IEICE Transactions on Communications*, vol E80-B, no 5, pp645-652, May 1997.

2. Studies performed by SPEAG (see reference in note 1 above) suggest that the SPEAG phantom, when used at the head position, over-estimates SAR by 5% due to the shape of the phantom head.

9. Appendix 3: List of References

[1] WGMTE of CENELEC TC211/B Third draft, 'Safety considerations for human exposure to electromagnetic fields from mobile telecommunication equipment (MTE) in the frequency range 30MHz - 6GHz', CENELEC, Brussels Apr. 1996

[2] N. Kuster, Q. Balzano, J.C. Lin, 'Mobile Communication Safety', 1997, Chapman and Hall

[3] Federal Communications Commission, 'Report and order: Guidelines for evaluation the environmental effects of radio frequency radiation', Tech. Rep. FCC 96-326, FCC, Washington D.C. 20554, 1996

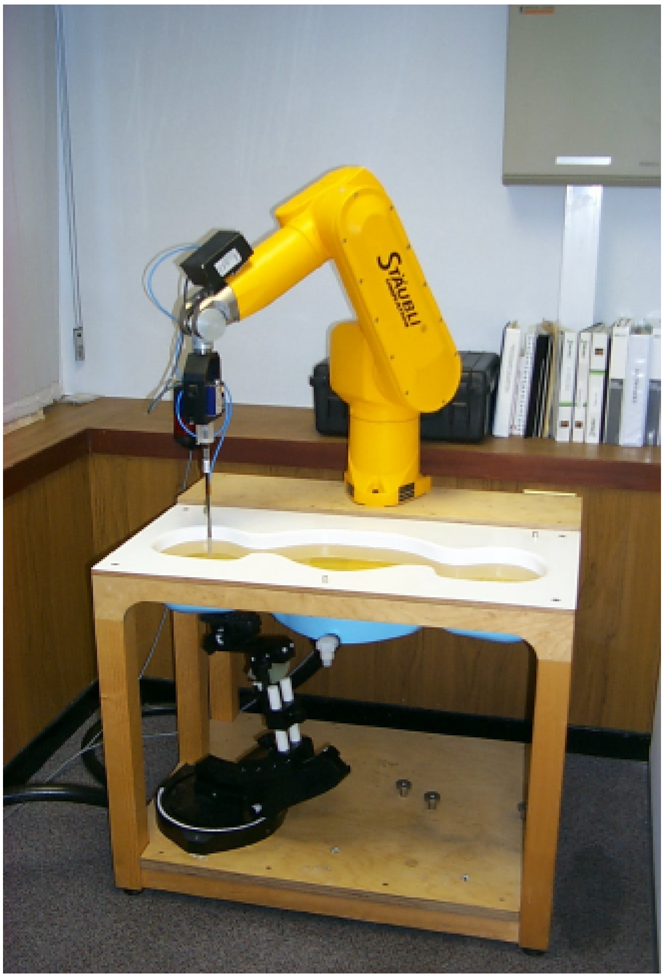
[4] Thomas Schmid, Oliver Eggar, Niels Kuster, 'Automated E-field scanning system for dosimetric assessments', IEEE Transactions on Microwave Theory and Techniques, vol. 44 pp. 105-113, Jan 1996

[5] C. Gabriel, S. Gabriel, E Corthout, 'The dielectric properties of biological tissues: Literature survey', Phys. Med. Biol., vol. 41, pp2231-2249, 1996

[6] For recommended values see http://www.fcc.gov/fcc-bin/dielec.sh

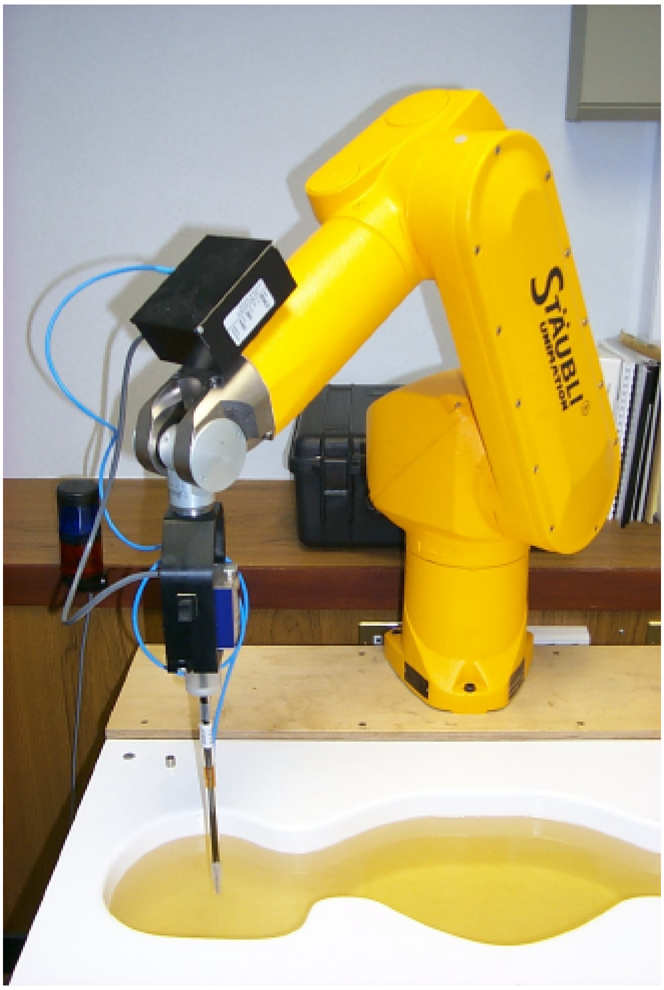
10. Appendix 4: Equipment List

Description	Serial Number	Cal Due Date
HP8753D Network Analyser	3410A07727	June 2001
8120-6192 Dielectric Probe	1077614	June 2001
ET3DV5 SAR Probe	1319	24 May 2002
DAE3 Data Acquisition Unit	314	24 May 2002



Dasy 3 Measurement system

Figure 1.



Dasy 3 Probe in Brain Tissue Medium

Figure 2.

Handset clamped into RH position

Figure 3.

NSM Technology Handset

Figure 4.