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SAR Compliance Test Report

Test report no.:	WR449.001	Date of report:	01-Dec-04
Template version:	3	Number of pages:	18
Testing laboratory:	Test & Certification Center (TCC) Dallas Nokia Mobile Phones 6021 Connection Drive Irving, TX 75039, USA Tel. +1 972 894 5000	Client:	Nokia, Inc. 12278 Scripps Summit Dr. San Diego, CA 92131 Tel. +1 858 831 5955 Fax +1 858 831 6500
Responsible test engineer:	Jesse Torres	Product contact person:	Jerry Goertz
Measurements made by:	Cindy Trinh		
Tested device:	RH-66		
FCC ID:	QMNRH-66	IC:	661X-RH66
Supplement reports:	-		

Testing has been carried out in accordance with:

47CFR §2.1093
Radiofrequency Radiation Exposure Evaluation: Portable Devices

FCC OET Bulletin 65 (Edition 97-01), Supplement C (Edition 01-01)
Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields

RSS-102
Evaluation Procedure for Mobile and Portable Radio Transmitters with Respect to Health Canada's Safety Code 6 for Exposure of Humans to Radio Frequency Fields

IEEE 1528 - 2003
IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques

Documentation: The documentation of the testing performed on the tested devices is archived for 15 years at TCC Dallas.

Test results: The tested device complies with the requirements in respect of all parameters subject to the test. The test results and statements relate only to the items tested. The test report shall not be reproduced except in full, without written approval of the laboratory.

Date and signatures: 01-Dec-04

For the contents:

Nerina Walton
Lab Manager

Jesse Torres
Test Engineer

CONTENTS

1. SUMMARY OF SAR TEST REPORT

1.1 Test Details

Period of test	16-Nov-04 to 22-Nov-04
SN, HW and SW numbers of tested device	SN: 044/06108574 HW: S1.2 SW: R100b02.nep
Batteries used in testing	BL-6C
Headsets used in testing	HS-3
Other accessories used in testing	-
State of sample	Prototype unit
Notes	-

1.2 Maximum Results

The maximum measured SAR values for Head configuration and Body Worn configuration are given in section 1.2.1 and 1.2.2 respectively. The device conforms to the requirements of the standard(s) when the maximum measured SAR value is less than or equal to the limit.

1.2.1 Head Configuration

Mode	Ch / *f* (MHz)	Conducted power	Position	SAR limit (1g avg)	Measured SAR value (1g avg)	Result
AMPS	384 / 836.52	25.6 dBm	Left Cheek	1.6 W/kg	1.20 W/kg	PASSED
CDMA800	777 / 848.31	25.1 dBm	Left Cheek	1.6 W/kg	1.20 W/kg	PASSED
CDMA1900	600 / 1880.00	23.4 dBm	Left Tilt	1.6 W/kg	1.12 W/kg	PASSED

1.2.2 Body Worn Configuration

Mode	Ch / *f* (MHz)	Conducted power	Separation distance	SAR limit (1g avg)	Measured SAR value (1g avg)	Result
AMPS	991 / 824.04	25.8 dBm	2.2 cm	1.6 W/kg	1.03 W/kg	PASSED
CDMA800	1013 / 824.70	25.8 dBm	2.2 cm	1.6 W/kg	1.03 W/kg	PASSED
CDMA1900	25 / 1851.25	23.7 dBm	2.2 cm	1.6 W/kg	0.50 W/kg	PASSED

1.2.3 Maximum Drift

Maximum drift during measurements	-0.14 dB

1.2.4 Measurement Uncertainty

Extended Uncertainty (k=2) 95%	± 29.8 %

2. DESCRIPTION OF THE DEVICE UNDER TEST

Device category	Portable
Exposure environment	Uncontrolled exposure

Modes and Bands of Operation	AMPS 800	CDMA 800	CDMA1900
Modulation Mode	FM	QPSK	QPSK
Duty Cycle	1	1	1
Transmitter Frequency Range (MHz)	824.04 - 848.97	824.73 – 848.31	1851.25 – 1908.75

2.1 Picture of the Device

2.2 Description of the Antenna

The device has an internal patch antenna.

3. TEST CONDITIONS

3.1 Temperature and Humidity

Period of measurement:	16-Nov-04 to 22-Nov-04
Ambient temperature (°C):	21.0 to 23.0
Ambient humidity (RH %):	41.0 to 62.0

3.2 Test Signal, Frequencies, and Output Power

The device was put into operation by using call tester. Communication between the device and the call tester was established by air link.

The device output power was set to maximum power level for all tests; a fully charged battery was used for every test sequence.

In all operating bands the measurements were performed on lowest, middle and highest channels.

4. DESCRIPTION OF THE TEST EQUIPMENT

4.1 Measurement System and Components

The measurements were performed using an automated near-field scanning system, DASY4 software version 4.3, manufactured by Schmid & Partner Engineering AG (SPEAG) in Switzerland. The SAR extrapolation algorithm used in all measurements on the device was the 'worst-case extrapolation' algorithm.

The following table lists calibration dates of SPEAG components:

Test Equipment	Serial Number	Calibration interval	Calibration expiry
DASY4 DAE V1	377	12 months	22-Sep-05
E-field Probe ET3DV6	1504	12 months	22-Sep-05
Dipole Validation Kit, D835V2	486	24 months	26-May-05
Dipole Validation Kit, D1900V2	504	24 months	16-Jul-05

Additional test equipment used in testing:

Test Equipment	Model	Serial Number	Calibration interval	Calibration expiry
Amplifier	AR 5S1G2	25583	-	-
Dielectric Probe Kit	Agilent 85070D	US01440005	-	-
Signal Generator	R&S SMT06	100243	12 months	06-Jan-05
Vector Network Analyzer	Agilent 8753ES	US39174932	12 months	19-Feb-05
Power Meter	Boonton 4232A	26001	12 months	08-Jun-05
Power Sensor	Boonton 51015	31143	12 months	08-Jun-05
Power Sensor	Boonton 51015	31144	12 months	08-Jun-05
Call Tester	Anritsu MT8802A	6200027497	12 months	13-Oct-05

4.1.1 Isotropic E-field Probe SN1504

Construction	Symmetrical design with triangular core Built-in optical fiber for surface detection system Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., butyl diglycol)
Calibration	Calibration certificate in Appendix C
Frequency	10 MHz to 3 GHz (dosimetry); Linearity: ± 0.2 dB (30 MHz to 3 GHz)
Optical Surface Detection	± 0.2 mm repeatability in air and clear liquids over diffuse reflecting surfaces
Directivity	± 0.2 dB in HSL (rotation around probe axis) ± 0.4 dB in HSL (rotation normal to probe axis)
Dynamic Range	5 µW/g to > 100 mW/g; Linearity: ± 0.2 dB
Dimensions	Overall length: 330 mm Tip length: 16 mm Body diameter: 12 mm Tip diameter: 6.8 mm Distance from probe tip to dipole centers: 2.7 mm
Application	General dosimetry up to 3 GHz Compliance tests of mobile phones Fast automatic scanning in arbitrary phantoms

4.2 Phantoms

The phantom used for all tests i.e. for both validation testing and device testing, was the twin-headed "SAM Phantom", manufactured by SPEAG. The phantom conforms to the requirements of IEEE 1528 - 2003.

Validation tests were performed using the flat section, whilst Head SAR tests used the left and right head profile sections. Body SAR testing also used the flat section between the head profiles.

The SPEAG device holder (see Section 5.1) was used to position the device in all tests whilst a tripod was used to position the validation dipoles against the flat section of phantom.

4.3 Simulating Liquids

Recommended values for the dielectric parameters of the simulating liquids are given in IEEE 1528 - 2003 and FCC Supplement C to OET Bulletin 65. All tests were carried out using liquids whose dielectric parameters were within ± 5% of the recommended values. All tests were carried out within 24 hours of measuring the dielectric parameters.

The depth of the liquid was 15.0 ± 0.5 cm measured from the ear reference point during validation and device measurements.

4.3.1 Liquid Recipes

The following recipes were used for Head and Body liquids:

800MHz Band

Ingredient	Head (% by weight)	Body (% by weight)
Deionised Water	51.07	65.45
HEC	0.23	-
Sugar	47.31	34.31
Preservative	0.24	0.10
Salt	1.15	0.62

1900MHz Band

Ingredient	Head (% by weight)	Body (% by weight)
Deionised Water	54.88	69.02
Butyl Diglycol	44.91	30.76
Salt	0.21	0.22

4.3.2 Verification of the System

The manufacturer calibrates the probes annually. Dielectric parameters of the simulating liquids were measured every day using the dielectric probe kit and the network analyser. A SAR measurement was made following the determination of the dielectric parameters of the liquids, using the dipole validation kit. A power level of 250 mW was supplied to the dipole antenna, which was placed under the flat section of the twin SAM phantom. The validation results (dielectric parameters and SAR values) are given in the table below.

System verification, head tissue simulant

f [MHz]	Description	SAR [W/kg], 1g	Dielectric Parameters		Temp [°C]
			ε_r	σ [S/m]	
835	Reference result	2.45	42.8	0.89	N/A
	± 10% window	2.21 to 2.70			
	16-Nov-04	2.37	41.5	0.89	21.0
	17-Nov-04	2.39	41.2	0.90	20.8
1900	Reference result	10.2	40.2	1.46	N/A
	± 10% window	9.18 to 11.22			
	18-Nov-04	9.39	38.7	1.46	20.9

System verification, body tissue simulant

f [MHz]	Description	SAR [W/kg], 1g	Dielectric Parameters		Temp [°C]
			ε_r	σ [S/m]	
835	Reference result	2.47	55.0	0.98	N/A
	± 10% window	2.22 to 2.72			
	17-Nov-04	2.51	53.9	0.95	21.3
	19-Nov-04	2.48	53.5	0.94	21.2
1900	Reference result	10.5	50.9	1.60	N/A
	± 10% window	9.45 to 11.55			
	22-Nov-04	9.80	51.2	1.60	19.1

Plots of the Verification scans are given in Appendix A.

4.3.3 Tissue Simulants used in the Measurements

Head tissue simulant measurements

f [MHz]	Description	Dielectric Parameters		Temp
		ε_r	σ [S/m]	[°C]
	Recommended value	41.5	0.90	N/A
	± 5% window	39.4 – 43.6	0.86 – 0.95	
836.5	16-Nov-04	41.5	0.90	21.0
	17-Nov-04	41.2	0.90	20.8
	Recommended value	40.0	1.40	N/A
	± 5% window	38.0 – 42.0	1.33 – 1.47	
1880	18-Nov-04	38.8	1.44	20.9

Body tissue simulant measurements

f [MHz]	Description	Dielectric Parameters		Temp
		ε_r	σ [S/m]	[°C]
	Recommended value	55.2	0.97	N/A
	± 5% window	52.4 – 58.0	0.92 – 1.02	
836.5	17-Nov-04	53.9	0.95	21.3
	19-Nov-04	53.5	0.95	21.2
	Recommended value	53.3	1.52	N/A
	± 5% window	50.6 – 56.0	1.44 – 1.60	
1880	22-Nov-04	51.3	1.58	19.1

5. DESCRIPTION OF THE TEST PROCEDURE

5.1 Device Holder

The device was placed in the device holder (illustrated below) that is supplied by SPEAG as an integral part of the Dasy system.

Device holder supplied by SPEAG

A Nokia designed spacer (illustrated below) was used to position the device within the SPEAG holder. The spacer positions the device so that the holder has minimal effect on the test results but still holds the device securely. The spacer was removed before the tests.

Nokia spacer

5.2 Test Positions

5.2.1 Against Phantom Head

Measurements were made in “cheek” and “tilt” positions on both the left hand and right hand sides of the phantom.

The positions used in the measurements were according to IEEE 1528 - 2003 "IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques”.

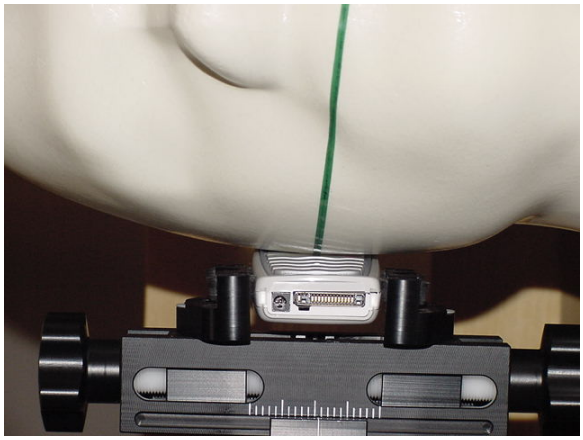

Photo of the device in “cheek” position

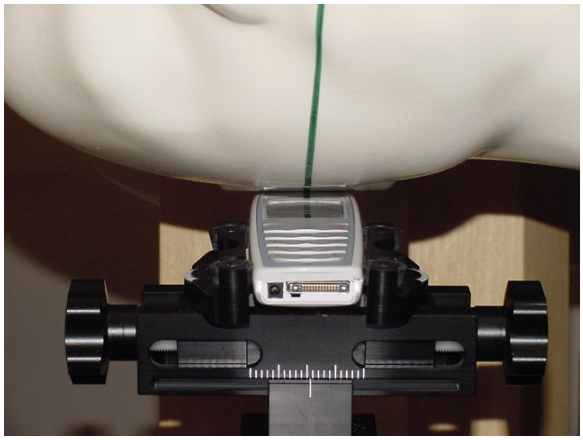

Photo of the device in “tilt” position

5.2.2 Body Worn Configuration

The device was placed in the SPEAG holder using the Nokia spacer and placed below the flat section of the phantom. The distance between the device and the phantom was kept at the separation distance indicated in the photo below using a separate flat spacer that was removed before the start of the measurements. The device was oriented with its antenna facing the phantom since this orientation gave higher results.

Photo of the device positioned for Body SAR measurement.
The spacer was removed for the tests.

5.3 Scan Procedures

First coarse scans were used for determination of the field distribution. Next a cube scan, a minimum of 5x5x7 points covering a volume of at least 32x32x30mm was performed around the highest E-field value to determine the averaged SAR value. Drift was determined by measuring the same point at the start of the coarse scan and again at the end of the cube scan.

5.4 SAR Averaging Methods

The maximum SAR value was averaged over a cube of tissue using interpolation and extrapolation.

The interpolation, extrapolation and maximum search routines within Dasy4 are all based on the modified Quadratic Shepard's method (Robert J. Renka, "Multivariate Interpolation Of Large Sets Of Scattered Data", University of North Texas ACM Transactions on Mathematical Software, vol. 14, no. 2, June 1988, pp. 139-148).

The interpolation scheme combines a least-square fitted function method with a weighted average method. A trivariate 3-D / bivariate 2-D quadratic function is computed for each measurement point and fitted to neighbouring points by a least-square method. For the cube scan, inverse distance weighting is incorporated to fit distant points more accurately. The interpolating function is finally calculated as a weighted average of the quadratics.

In the cube scan, the interpolation function is used to extrapolate the Peak SAR from the deepest measurement points to the inner surface of the phantom.

6. MEASUREMENT UNCERTAINTY

Table 6.1 – Measurement uncertainty evaluation

Uncertainty Component	Section in IEEE 1528	Tol. (%)	Prob Dist	Div	c_i	$c_i . u_i$ (%)	v_i
Measurement System							
Probe Calibration	E2.1	±5.8	N	1	1	±5.8	∞
Axial Isotropy	E2.2	±4.7	R	√3	$(1\text{-}c_p)^{1/2}$	±1.9	∞
Hemispherical Isotropy	E2.2	±9.6	R	√3	$(c_p)^{1/2}$	±3.9	∞
Boundary Effect	E2.3	±8.3	R	√3	1	±4.8	∞
Linearity	E2.4	±4.7	R	√3	1	±2.7	∞
System Detection Limits	E2.5	±1.0	R	√3	1	±0.6	∞
Readout Electronics	E2.6	±1.0	N	1	1	±1.0	∞
Response Time	E2.7	±0.8	R	√3	1	±0.5	∞
Integration Time	E2.8	±2.6	R	√3	1	±1.5	∞
RF Ambient Conditions - Noise	E6.1	±3.0	R	√3	1	±1.7	∞
RF Ambient Conditions - Reflections	E6.1	±3.0	R	√3	1	±1.7	∞
Probe Positioner Mechanical Tolerance	E6.2	±0.4	R	√3	1	±0.2	∞
Probe Positioning with respect to Phantom Shell	E6.3	±2.9	R	√3	1	±1.7	∞
Extrapolation, interpolation and Integration Algorithms for Max. SAR Evaluation	E5.2	±3.9	R	√3	1	±2.3	∞
Test sample Related							
Test Sample Positioning	E4.2.1	±6.0	N	1	1	±6.0	11
Device Holder Uncertainty	E4.1.1	±5.0	N	1	1	±5.0	7
Output Power Variation - SAR drift measurement	6.6.3	±10.0	R	√3	1	±5.8	∞
Phantom and Tissue Parameters							
Phantom Uncertainty (shape and thickness tolerances)	E3.1	±4.0	R	√3	1	±2.3	∞
Liquid Conductivity Target - tolerance	E3.2	±5.0	R	√3	0.64	±1.8	∞
Liquid Conductivity - measurement uncertainty	E3.3	±5.5	N	1	0.64	±3.5	5
Liquid Permittivity Target tolerance	E3.2	±5.0	R	√3	0.6	±1.7	∞
Liquid Permittivity - measurement uncertainty	E3.3	±2.9	N	1	0.6	±1.7	5
Combined Standard Uncertainty			RSS			**±14.9**	206
Coverage Factor for 95%			**k=2**				
Expanded Standard Uncertainty						**±29.8**	

7. RESULTS

The measured Head SAR values for the test device are tabulated below:

AMPS Head SAR results

Position		SAR, averaged over 1g (W/kg)		
		Ch 991 824.04 MHz	Ch 384 836.52 MHz	Ch 799 848.97 MHz
Power level		25.8 dBm	25.6 dBm	25.2 dBm
Left	Cheek	1.09	**1.20**	1.09
	Tilt	0.83	0.90	0.90
Right	Cheek	1.08	1.15	1.10
	Tilt	-	0.69	-

CDMA800 Head SAR results

Position		SAR, averaged over 1g (W/kg)		
		Ch 1013 824.70 MHz	Ch 384 836.52 MHz	Ch 777 848.31 MHz
Power level		25.8 dBm	25.5 dBm	25.1 dBm
Left	Cheek	1.14	1.15	**1.20**
	Tilt	0.82	0.88	0.89
Right	Cheek	1.08	1.17	1.11
	Tilt	-	0.72	-

CDMA1900 Head SAR results

Position		SAR, averaged over 1g (W/kg)		
		Ch 25 1851.25 MHz	Ch 600 1880.00 MHz	Ch 1175 1908.75 MHz
Power level		23.7 dBm	23.4 dBm	23.1 dBm
Left	Cheek	0.90	0.95	0.84
	Tilt	0.90	**1.12**	1.02
Right	Cheek	0.76	0.70	0.61
	Tilt	0.86	0.88	0.77

The measured Body SAR values for the test device are tabulated below

AMPS Body SAR results

Body-worn location setup	SAR, averaged over 1g (W/kg)		
	Ch 991 824.04 MHz	Ch 384 836.52 MHz	Ch 799 848.97 MHz
Power level	**25.8 dBm**	**25.6 dBm**	**25.2 dBm**
Without headset	**1.03**	0.71	0.62
Headset HS-3	-	0.49	-

CDMA800 Body SAR results

Body-worn location setup	SAR, averaged over 1g (W/kg)		
	Ch 1013 824.70 MHz	Ch 384 836.52 MHz	Ch 777 848.31 MHz
Power level	**25.8 dBm**	**25.5 dBm**	**25.1 dBm**
Without headset	**1.03**	0.68	0.62
Headset HS-3	-	0.43	-

CDMA1900 Body SAR results

Body-worn location setup	SAR, averaged over 1g (W/kg)		
	Ch 25 1851.25 MHz	Ch 600 1880.00 MHz	Ch 1175 1908.75 MHz
Power level	**23.7 dBm**	**23.4 dBm**	**23.1 dBm**
Without headset	**0.50**	0.49	0.45
Headset HS-3	-	0.49	-

Plots of the Measurement scans are given in Appendix B.