Certification Report on

Specific Absorption Rate (SAR) Experimental Analysis on Body

Standard Telecom Co., Ltd.

NXC-3200

Test Date: 5 July, 2000

AIRB-Standard Telecom NXC 3200-3490

51 Spectrum Way Nepean ON K2R 1E6
Tel: (613) 820-2730 Fax: (613) 820-4161
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CERTIFICATION REPORT

Subject: **Specific Absorption Rate (SAR) Experimental Analysis on Body**

Product: Dual Mode Single Band Cellular Handset

Model: NXC-3200

Client: Standard Telecom Co., Ltd.

Address: 926 Kwanyang 2-Dongan-Ku
Anyang-City, Kyunggi-Do
Korea 431-062

Project #: AIRB-Standard Telecom NXC 3200-3490

Telecommunications Approval Board - Spectrum Sciences Institute - SAR Certified APREL Laboratories A071-NXC-3200

Prepared by: APREL Laboratories
51 Spectrum Way
Nepean, Ontario
K2R 1E6

Tested by ______ Date: July 14, 2000
Delia M. Zapata, BSEE

Submitted by ______ Date: 19 July 00
Dr. Paul G. Cardinal
Director, Laboratories

Approved by ______ Date: July 19/2000
Dr. Jacek J. Wojcik, P. Eng.

REGISTERED PROFESSIONAL ENGINEER J. J. Wojcik PROVINCE OF ONTARIO

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FCC ID:
Applicant: Standard Telecom Co., Ltd.
Equipment: Dual Mode Single Band Cellular Handset
Model: NXC-3200
Standard: FCC 96 –326, Guidelines for Evaluating the Environmental Effects of Radio-Frequency Radiation

ENGINEERING SUMMARY

This report contains the results of the engineering evaluation performed on a Standard Telecom model NXC-3200 Dual Mode Single Band Cellular Handset when using a hands-free kit which includes a holster and belt clip (for SAR in the vicinity of the head see report AIRB-Standard Telecom NXC 3200-3489). The measurements were carried out in accordance with FCC 96-326. The cellular handset was evaluated at its maximum nominal power level.

The cellular handset was tested operating at maximum output power in AMPS (27dBm) and CDMA (25dBm) modes on low, middle and high channels, with the antenna extended and retracted, with the two types of battery offered. The cellular handset was configured with the headset attached and with the handset inside its holster. The testing was conducted with the holster belt clip against the phantom and the headset touching the phantom.

The maximum SAR was found to coincide with the peak performance RF output power operating in AMPS mode, on the middle channel (383, 836.49 MHz), with the antenna retracted and using the standard battery. Test data and graphs are presented in this report.

Based on the test results for this device, and as it will be marketed and used with a warning in the manual that the hands-free kit only be used with the phone placed in its holster, it is certified that the product meets the requirements as set forth in the above specifications, for partial body exposure in an uncontrolled RF exposure environment.

The results presented in this report relate only to the sample tested.

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1. INTRODUCTION

Tests were conducted to determine the Specific Absorption Rate (SAR) of a sample of a Standard Telecom model NXC-3200 Dual Mode Single Band Cellular Handset. These tests were conducted at APREL Laboratories' facility located at 51 Spectrum Way, Nepean, Ontario, Canada. A view of the SAR measurement setup can be seen in Appendix A Figure 1. This report describes the results obtained.

2. APPLICABLE DOCUMENTS

The following documents are applicable to the work performed:

1) FCC 96-326, Guidelines for Evaluating the Environmental Effects of Radio-Frequency Radiation

2) ANSI/IEEE C95.1-1992, IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz.

3) ANSI/IEEE C95.3-1992, IEEE Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields – RF and Microwave.

4) OET Bulletin 65 (Edition 97-01) Supplement C (Edition 97-01), "Evaluating Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields".

3. EQUIPMENT UNDER TEST

- Standard Telecom model NXC-3200 Dual Mode Single Band Cellular Handset, S/N 22, received on 4 July 2000.

The cellular handset will be called DUT (Device Under Test) in the following.

The DUT is a cellular headset that can operate at two different modes: AMPS and CDMA. Table 1 presents the corresponding output power for each mode, and the transmission frequency associated with each channel.

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MODE	Output Power	Channel		
		L/M/H	#	Frequency
AMPS	27 dBm / 501 mW	L	991	824.04
		M	383	836.49
		H	799	849.97
CDMA	25 dBm / 316 mW	L	1011	824.64
		M	383	836.49
		H	779	848.37

Table 1. DUT transmission characteristics

The DUT antenna is located at the top ride side of the device when viewed from the keyboard side. The antenna is an Avantego ¼ λ retractable whip over a ¼ λ fixed helix stub. Its typical gain is –2.2 dBd when the whip is retracted and –1 dBd when extended.

A photograph of the DUT, antenna and battery types can be found in Appendix B. See the manufacturer's submission documentation for drawings and more design details.

4. TEST EQUIPMENT

- APREL Triangular Dosimetric Probe Model E-009, s/n 115, Asset # 301420
- CRS Robotics A255 articulated robot arm, s/n RA2750, Asset # 301335
- CRS Robotics C500 robotic system controller, s/n RC584, Asset # 301334
- APREL F-1, flat manikin, s/n 001
- Tissue Recipe and Calibration Requirements, APREL procedure SSI/DRB-TP-D01-033
- Anritsu MS2661C Spectrum Analyzer (9KHz - 3GHz)

5. TEST METHODOLOGY

1. The test methodology utilised in the certification of the DUT complies with the requirements of FCC 96-326 and ANSI/IEEE C95.3-1992.

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2. The E-field is measured with a small isotropic probe (output voltage proportional to E^2).

3. The probe is moved precisely from one point to the next using the robot (10 mm increments for wide area scanning, 5 mm increments for zoom scanning, and 2.5 mm increments for the final depth profile measurement).

4. The probe travels in the homogeneous liquid simulating human tissue. Appendix D contains information about the recipe and properties of the simulated tissue used for these measurements.

5. The liquid is contained in a manikin simulating a portion of the human body.

6. The DUT, inside its holster, is positioned with the holster's belt clip parallel to and touching the bottom of the phantom.

7. All tests were performed with the highest power available from the sample DUT in the AMPS and CDMA modes, with high, middle and low channels under transmit conditions.

More detailed descriptions of the test method is given in Section 6 when appropriate.

6. TEST RESULTS

6.1. TRANSMITTER CHARACTERISTICS

The battery-powered DUT will consume energy from its batteries, which may affect the DUT's transmission characteristics. In order to gage this effect the output of the transmitter is sampled before and after each SAR run. In the case of this DUT, the conducted power was sampled. A power meter was connected to the antenna feed point. The following table shows the conducted RF power sampled before and after each of the six sets of data used for the worst case SAR in this report.

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Scan		Conducted Power Readings (dBm)		D (dB)	Battery #
Type	**Height (mm)**	**Before**	**After**		
Area	2.5	27.0	27.2	0.2	Standard 6
Area	12.5	27.0	27.0	0.0	Standard 4
Zoom	2.5	27.0	-	-	Standard 5
Zoom	7.5	-	-	-	Standard 5
Zoom	12.5	-	26.9	-0.1	Standard 5
Depth	2.5 – 22.5	27.0	26.85	-0.15	Standard

6.2. SAR MEASUREMENTS

1) RF exposure is expressed as a Specific Absorption Rate (SAR). SAR is calculated from the E-field, measured in a grid of test points as shown in Appendix A Figure 2. SAR is expressed as RF power per kilogram of mass, averaged in 10 grams of tissue for the extremities and 1 gram of tissue elsewhere.

2) The DUT was put into test mode for the SAR measurements by using manufacturer supplied keyboard commands to control the mode, channel of operation and the maximum operating power (nominally 27dBm in AMPS mode and 25dBm in CDMA mode).

3) Figure 3 in Appendix A shows a contour plot of the SAR measurements for the DUT (AMPS mode, middle channel, 383, 836.49 MHz) with the holster and clip, standard battery and with the antenna retracted). The presented values were taken 2.5 mm into the simulated tissue from the flat phantom's solid inner surface. Figures 1 and 2 in Appendix A show the phantom used in the measurements. A grid is shown inside of the phantom indicating the orientation of the x-y grid used, with the co-ordinates (0,0) on the top left (orange dot). The y-axis is positive towards the right and the x-axis is positive towards the bottom. In this position the antenna is aligned with y=11, and the bottom of the device, with x=40.

   A different presentation of the same data is shown in Appendix A Figure 4. This is

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a surface plot, where the measured SAR values provide the vertical dimension, which is useful as a visualisation aid.

Similar data was obtained 12.5 mm into the simulated tissue. These measurements are presented as a contour plot in Appendix A Figure 5 and surface plot in Figure 6.

Figure 10 in Appendix A shows an overlay of the DUT's outlines, superimposed onto a contour plot similar to that shown as Figure 3, and which includes the head set and cable draped across the bottom of the phantom.

Figures 3 through 6 in Appendix A show that there is a dominant peak, in the contour plots, that diminishes in magnitude with depth into the tissue simulation.

4) Wide area scans were performed operating at maximum output power (27 dBm / 501 mW), in AMPS mode with standard and large type batteries, the antenna extended and retracted for the low (991, 824.04 MHz), middle (383, 836.49 MHz) and high (799, 849.97 MHz) channels.

Wide areas scans were then performed in CDMA mode (25 dBm / 316 mW), for the worst case: DUT with the antenna retracted and using a standard battery while operating on the high, middle and low channels. The peak single point SAR for the scans were:

MODE	**Battery type**	**Antenna position**	**Channel**			**Highest SAR [W/kg]**
			L/M/H	**#**	**Frequency (MHz)**	
AMPS	Standard	retracted	L	991	824.04	0.48
AMPS	**Standard**	**retracted**	**M**	**383**	**836.49**	**0.51**
AMPS	Standard	retracted	H	799	849.97	0.33
AMPS	Standard	extracted	L	991	824.04	0.36
AMPS	Standard	extracted	M	383	836.49	0.45
AMPS	Standard	extracted	H	799	849.97	0.31
AMPS	Large	retracted	L	991	824.04	0.43
AMPS	Large	retracted	M	383	836.49	0.50
AMPS	Large	retracted	H	799	849.97	0.30
AMPS	Large	extracted	M	383	836.49	0.36
CDMA	Standard	retracted	L	1011	824.64	0.38
CDMA	Standard	retracted	M	383	836.49	0.40
CDMA	Standard	retracted	H	779	848.37	0.25
DUT w/o holster and belt clip, placed with battery side of worst case configuration against bottom of phantom						
AMPS	**Standard**	**retracted**	**M**	**383**	**836.49**	**1.65**

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All subsequent testing was performed with the DUT operating in AMPS mode (nominally 27 dBm output power), using a standard battery, with the antenna retracted and transmitting on the middle channel (383, 836.49 MHz).

5) The DUT was then explored on a refined 5 mm grid in three dimensions. Figures 7, 8 and 9 show the measurements made at 2.5, 7.5 and 12.5 mm respectively. The SAR value averaged over 1 gram was determined from these measurements by averaging the 27 points (3x3x3) comprising a 1 cm cube. The maximum SAR value measured averaged over 1 gram was determined from these measurements to be 0.336 W/kg.

6) To extrapolate the maximum SAR value averaged over 1 gram to the inner surface of the phantom a series of measurements were made at a few (x,y) co-ordinates within the refined grid as a function of depth, with 2.5 mm spacing. Figure 11 in Appendix A shows the data gathered and the exponential curves fit to them. The average exponential coefficient was determined to be
(-0.0549 ± 0.0013) / mm.

7) The distance from the probe tip to the inner surface of the phantom for the lowest point is 2.5 mm. The distance from the probe tip to the tip of the measuring dipole within the APREL Triangular Dosimetric Probe Model E-009 is 2.3 mm. The total extrapolation distance is 4.8 mm, the sum of these two.

Applying the exponential coefficient over the 4.8 mm to the maximum SAR value averaged over 1 gram that was determined previously, we obtain the maximum SAR value at the surface averaged over 1 gram, **0.437 W/kg.**

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Nepean, Ontario, K2R 1E6
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7. CONCLUSIONS

The maximum Specific Absorption Rate (SAR) averaged over 1 g, determined at 836.49 MHz (383, 27 dBm, 501 mW) of a Standard Telecom model NXC-3200 Dual Mode Single Band Cellular Handset when used with the Standard Telecom hands-free kit, including the holster, is 0.437 W/kg. The overall margin of uncertainty for this measurement is ± 11.9 % (Appendix C).

Only one SAR peak was observed and it was situated over the handset. No SAR of any significance with respect to health and safety guidelines was measured on the headset or its cord.

The SAR limit given in the FCC 96-326 safety guideline is 1.6 W/kg for partial body exposure in an uncontrolled RF exposure environment. Considering the above, this unit as tested, and as it will be marketed and used with a warning in the manual that the hands-free kit only be used with the phone placed in its holster, is found to be compliant with this requirement.

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APPENDIX A. Measurement Setup and SAR Graphs


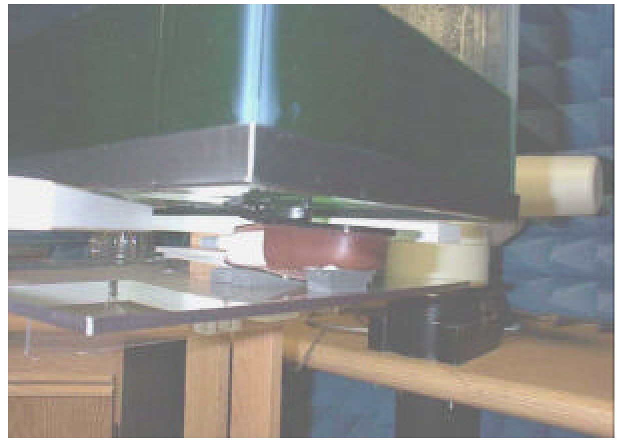

Figure 1. Setup and Close up of Setup

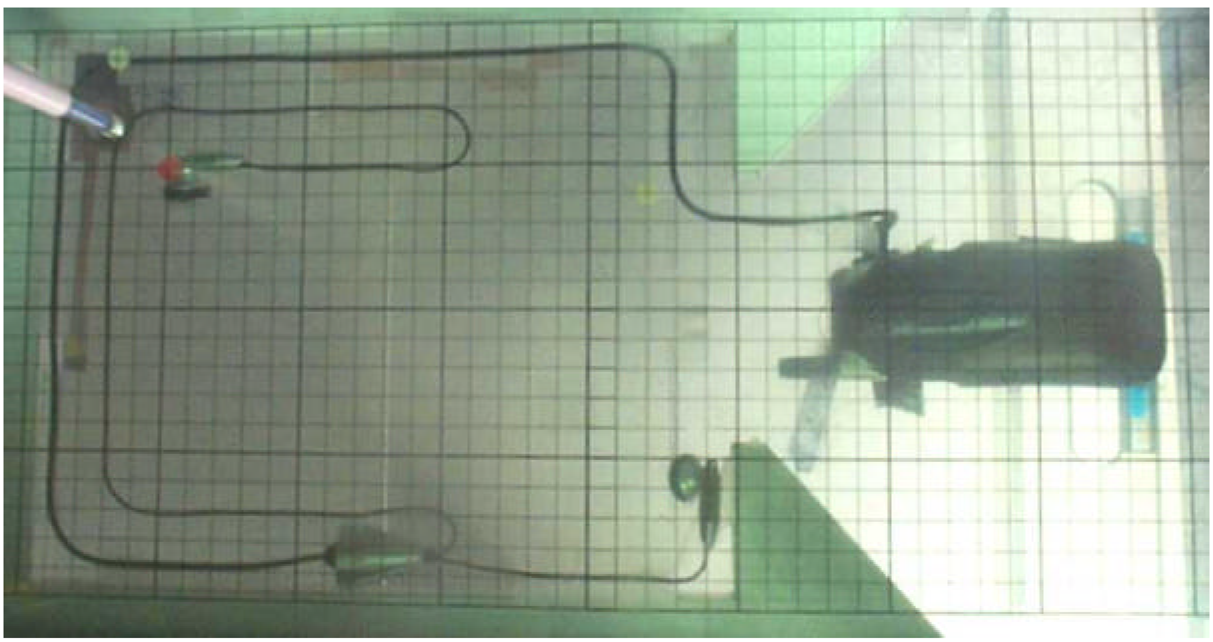

Figure 2. Grid inside the Phantom

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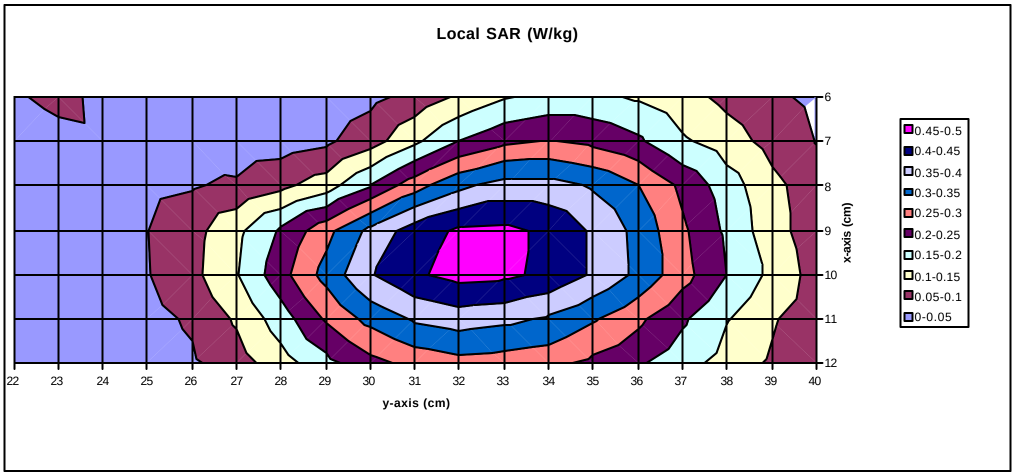

Figure 3. Contour Plot of the Area Scan 2.5mm Above Phantom Surface

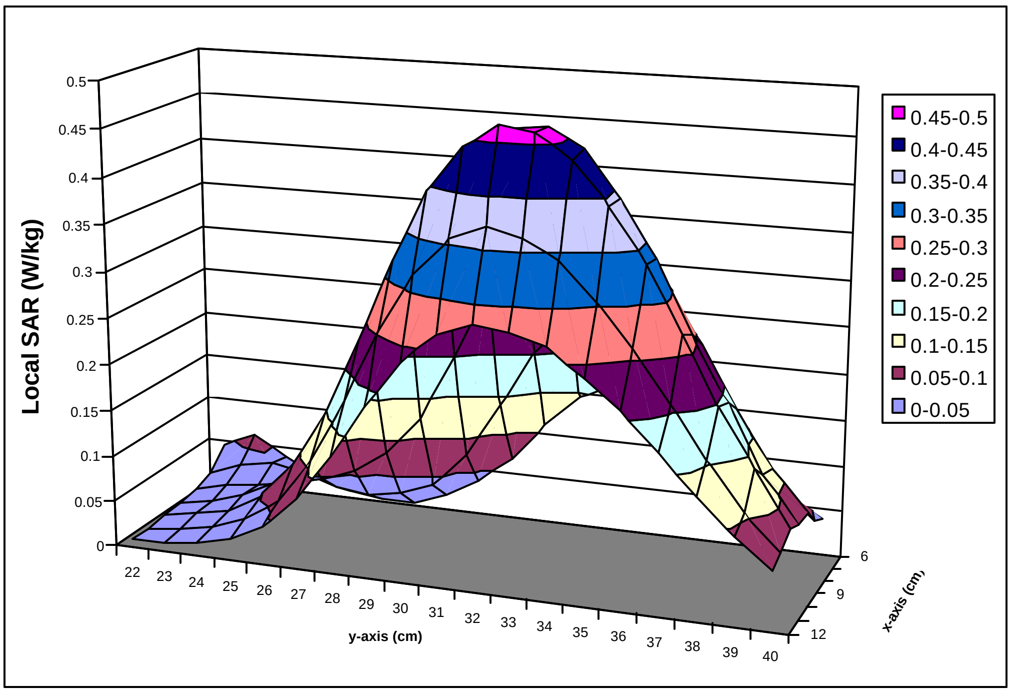

Figure 4. Surface Plot of the Area Scan 2.5mm Above Phantom Surface

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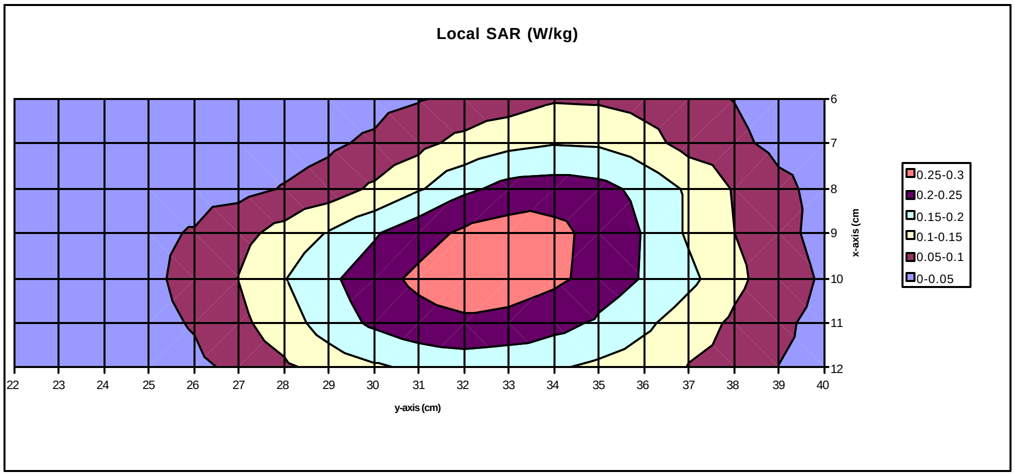

Figure 5. Contour Plot of the Area Scan 12.5mm Above Phantom Surface

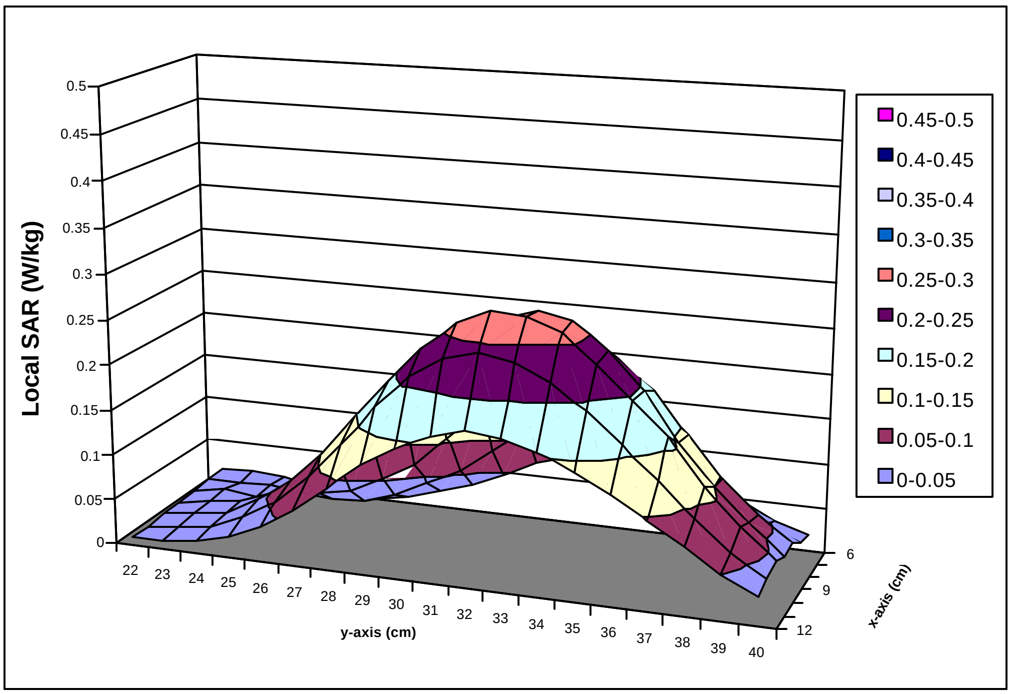

Figure 6. Surface Plot of the Area Scan 12.5mm Above Phantom Surface

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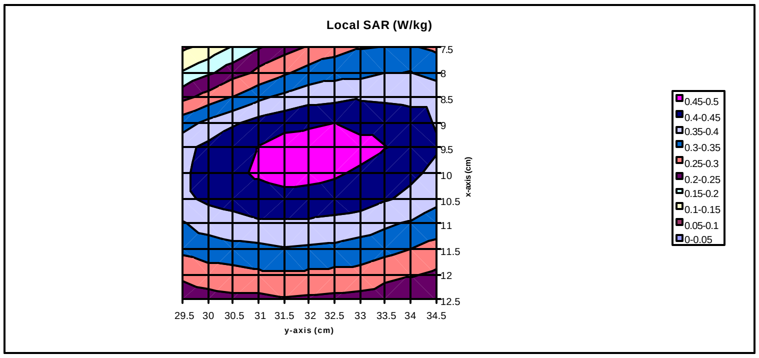

Figure 7. Zoom Scan 2.5mm Above Phantom Surface

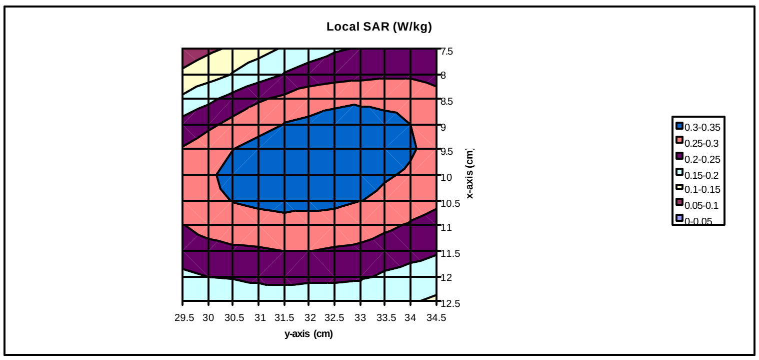

Figure 8. Zoom Scan 7.5mm Above Phantom Surface

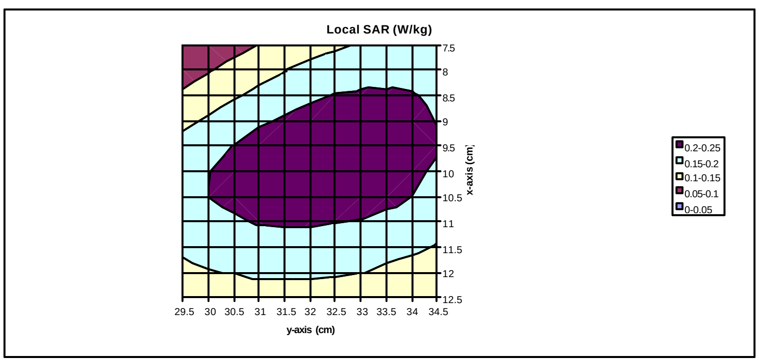

Figure 9. Zoom Scan 12.5mm Above Phantom Surface

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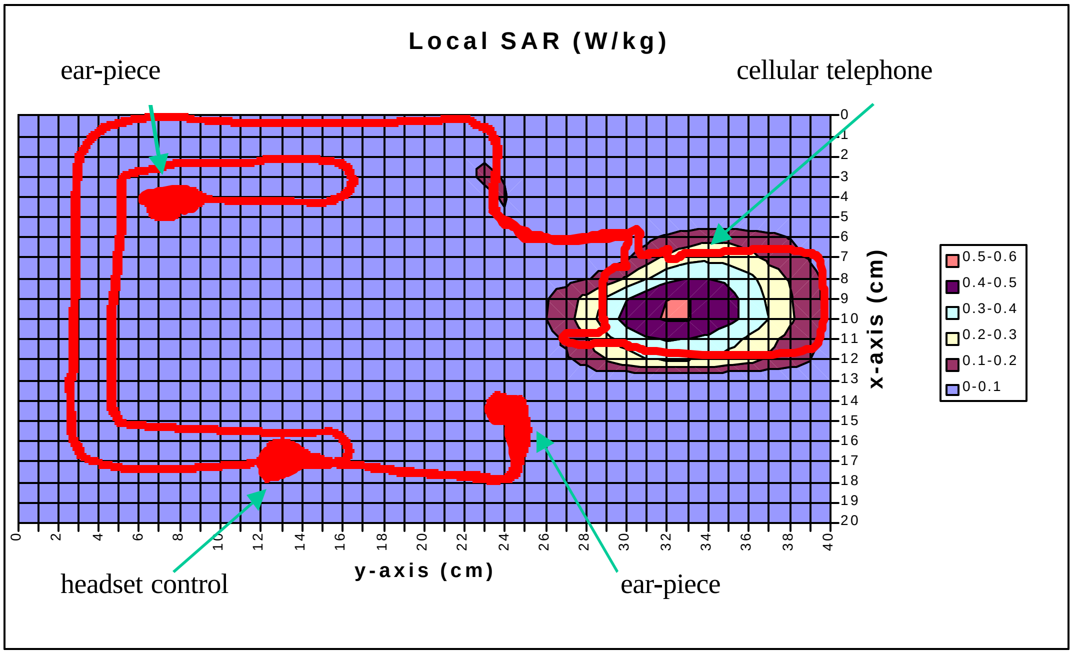
Figure 10. Overlay of the DUT's Outlines Superimposed onto the Area Scan



Contour

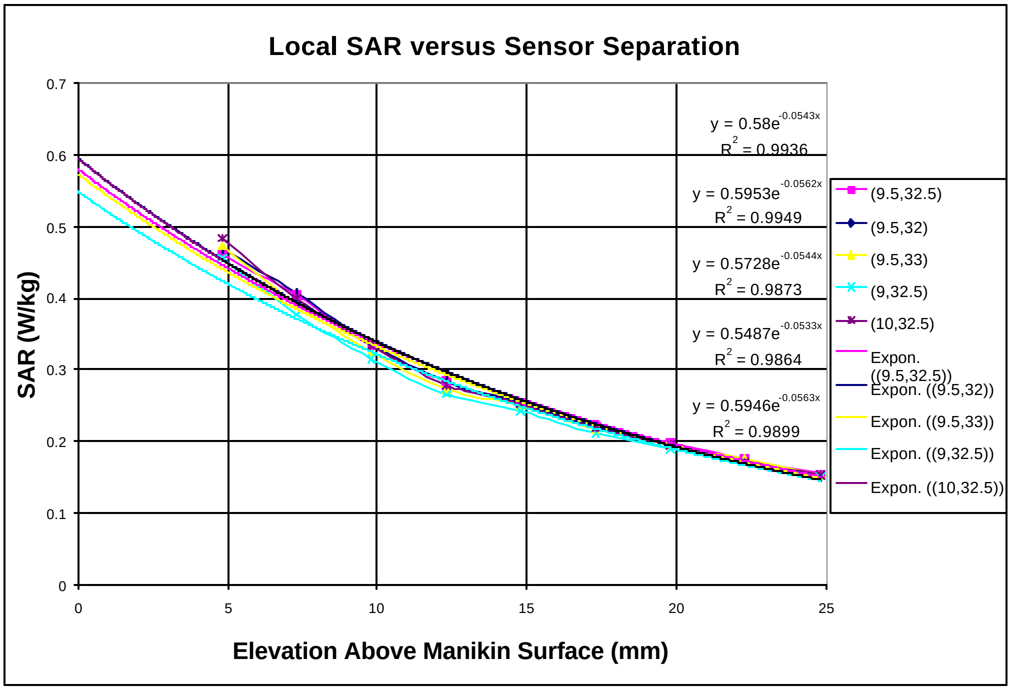


Figure 11. Local SAR versus Sensor Separation

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APPENDIX B. Manufacturer's Specifications

ANTENNA
Fixed helix antenna with retractable whip and not defined gain.

BATTERY TYPES

Standard battery, NB-320S (left)
Large battery, NB-320L (right)

(See manufacturer's submission documentation for drawings and more design details)

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APPENDIX C. Uncertainty Budget

Uncertainties Contributing to the Overall Uncertainty

Type of Uncertainty	Specific to	Uncertainty
Power variation due to battery condition	phone	2.3%
Extrapolation due to curve fit of SAR vs depth	phone	4.8%
Extrapolation due to depth measurement	setup	2.7%
Conductivity	setup	6.0%
Density	setup	2.6%
Tissue enhancement factor	setup	7.0%
Voltage measurement	setup	1.0%
Probe sensitivity factor	setup	3.5%
		11.9% RSS

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APPENDIX D. Simulated Muscle Tissue Material and Calibration Technique

The mixture used was based on that presented SSI/DRB-TP-D01-033, “Tissue Recipe and Calibration Requirements”.

De-ionised water	52.8 %
Sugar	45.3 %
Salt	1.5 %
HEC	0.3 %
Bactericide	0.1 %

Mass density, ρ 1.30 g/ml

(The density used to determine SAR from the measurements was the recommended 1040 kg/m^3 found in Appendix C of Supplement C to OET Bulletin 65, Edition 97-01).

Dielectric parameters of the simulated tissue material were determined using a Hewlett Packard 8510 Network Analyser, a Hewlett Packard 809B Slotted Line Carriage, and an APREL SLP-001 Slotted Line Probe.

The dielectric properties at 835 MHz are:

	APREL	OET 65 Supplement	Δ / % (OET)
Dielectric constant, ε_r	57.0	56.11	1.6%
Conductivity, σ/ [S/m]	1.06	0.946	12.2%
Tissue Conversion Factor, γ	8.52	-	-

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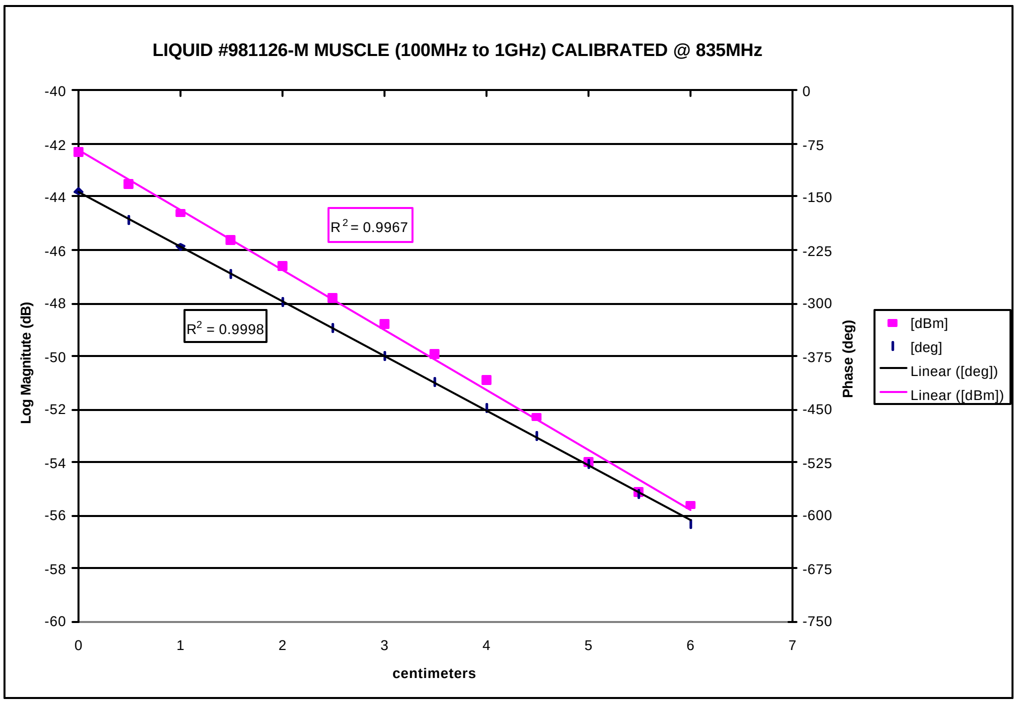
SIMULATION FLUID #	**981126-M**
CALIBRATION DATE	**4-Jul-00**
CALIBRATED BY	**Ken O'Donnell**
Frequency Range	**100MHz-1GHz**
Frequency Calibrated	**835 MHz**
Tissue Type	**Muscle**

Position [cm]	Amplitude [dBm]	Phase [deg]	[deg]
0	-42.3	-141.6	-141.6
0.5	-43.5	178.6	-181.4
1	-44.6	139.6	-220.4
1.5	-45.6	101.2	-258.8
2	-46.6	61.8	-298.2
2.5	-47.8	24.4	-335.6
3	-48.8	-13.7	-373.7
3.5	-49.9	-52.6	-412.6
4	-50.9	-89.1	-449.1
4.5	-52.3	-127	-487
5	-54	-167.3	-527.3
5.5	-55.1	150.9	-569.1
6	-55.6	108.8	-611.2

ΔdB_1	-6.5	Δdeg_1	-232.1
ΔdB_2	-6.4	Δdeg_2	-231.2
ΔdB_3	-6.3	Δdeg_3	-228.7
ΔdB_4	-6.7	Δdeg_4	-228.2
ΔdB_5	-7.4	Δdeg_5	-229.1
ΔdB_6	-7.3	Δdeg_6	-233.5
ΔdB_7	-6.8	Δdeg_7	-237.5
ΔdB_{AVG} [dB]	-6.77	Δdeg_{AVG} [deg]	-231.47
dB_{AVG} (α_{AVG}) [dB/cm]	-2.26	deg_{AVG} (β_{AVG}) [deg/cm]	-77.157
(α_{AVG}) [NP/cm]	-0.260	(β_{AVG}) [rad/cm]	-1.3466
f [Hz]	8.35E+08		
μ [H/cm]	1.25664E-08		
ε_o [F/cm]	8.854E-14		
			D
ε_r	**57.0**		1.6%
$\sigma_{effective}$	**1.06**	**S/m**	12.2%



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835 MHz Data (Heike & Tony) Muscle with E-115

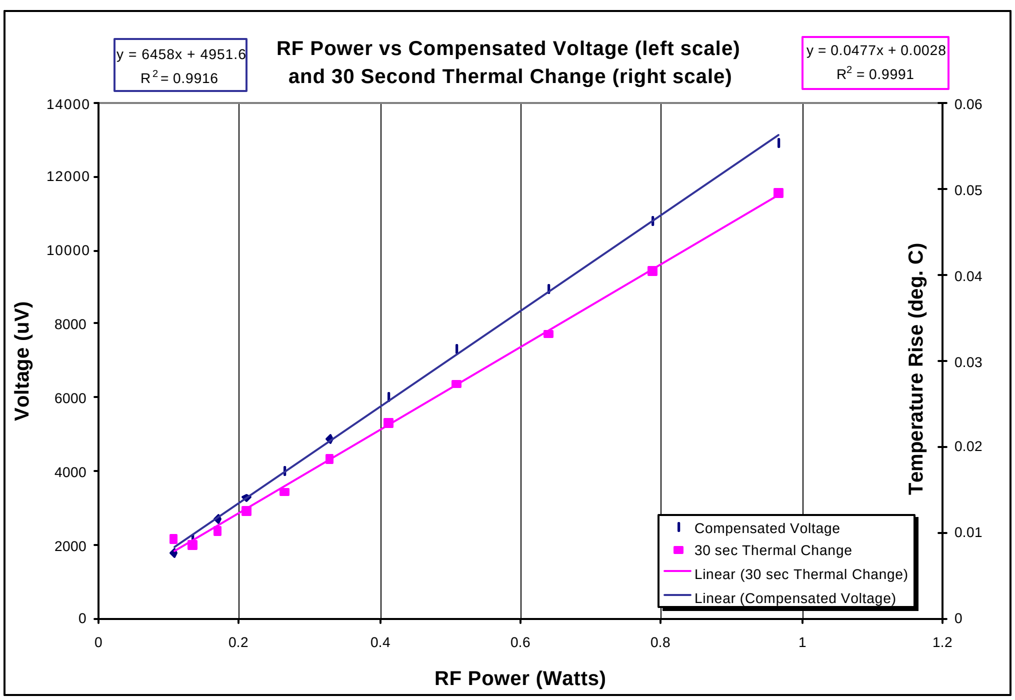
						delta T	Sum		Thermal
	RF Power		Ch0	Ch1	Ch2	(30 sec)	Vi/Ei		SAR
W	dBm	R&S	uV	uV	uV	deg. C			W/kg
0.10666	20.28	-25.61	391	1196	2954	0.0093	1793		0.86
0.133352	21.25	-24.64	439	1440	3638	0.0086	2178		0.80
0.169044	22.28	-23.61	513	1782	4517	0.0102	2689		0.94
0.210863	23.24	-22.65	586	2173	5542	0.0125	3277		1.16
0.263027	24.2	-21.69	684	2661	6787	0.0147	3999		1.36
0.328095	25.16	-20.73	830	3247	8276	0.0185	4876		1.71
0.412098	26.15	-19.74	1001	4028	10205	0.0227	6012		2.10
0.509331	27.07	-18.82	1196	4932	12402	0.0273	7313		2.53
0.639735	28.06	-17.83	1440	6079	15137	0.0331	8941		3.06
0.787046	28.96	-16.93	1733	7397	18188	0.0405	####		3.75
0.966051	29.85	-16.04	2100	8960	21680	0.0495	####		4.58

Directional Coupler factor 25.9 dB (Asset 100251 cal file data)
Additional inline attenuation 20 dB

Sensitivity (e) 1.66 1.72 1.68 - Sensor Sensitivity in mV/ (mW/cm^2): 835 MHz cal
n = 1.50 e 2.49 2.58 2.52

Density	1.3	g/cm^3	1300	kg/m^3	
Conductivity	10.8	mS/cm	1.08	S/m	
Heat Capacity (c)	2.78	J/C/g	2775	J/C/kg	
Exposure Time	30	seconds	30	econds	
Slope of Measure Voltage (m_V)	####	uV/W	0.013	V/W	
- standard error or m_V	124	uV/W	0.0001	V/W	1.0%
Slope of Measure Temp Change (m_T)	0.05	C/W	0.0482	C/W	
- standard error or m_T	0	C/W	0.0007	C/W	1.5%

Tissue Conversion Factor (g) 8.52



51 Spectrum Way
Nepean, Ontario, K2R 1E6
Tel. (613) 820-2730
Fax (613) 820 4161
e-mail: info@aprel.com

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APPENDIX E. Validation Scans on a Flat Phantom

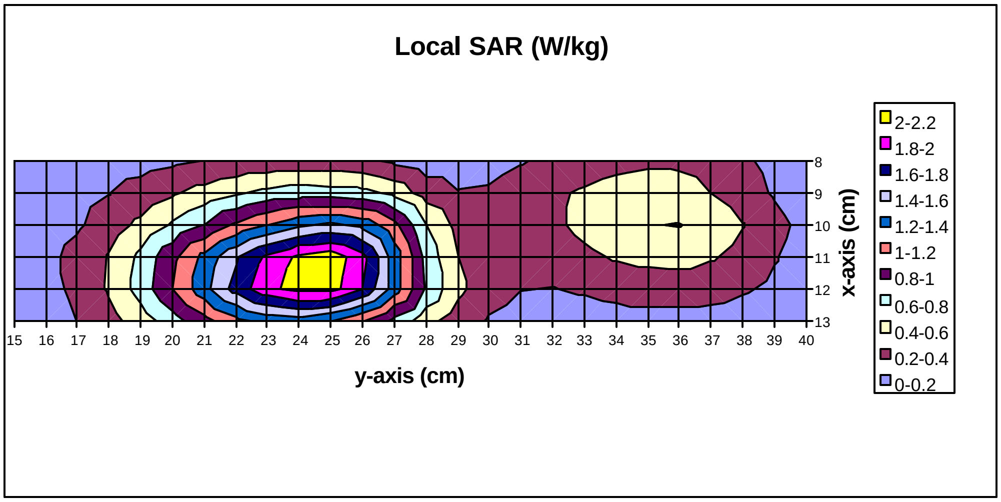

Figure 12. Contour Plot of the Reference Area Scan 2.5mm Above Phantom Surface

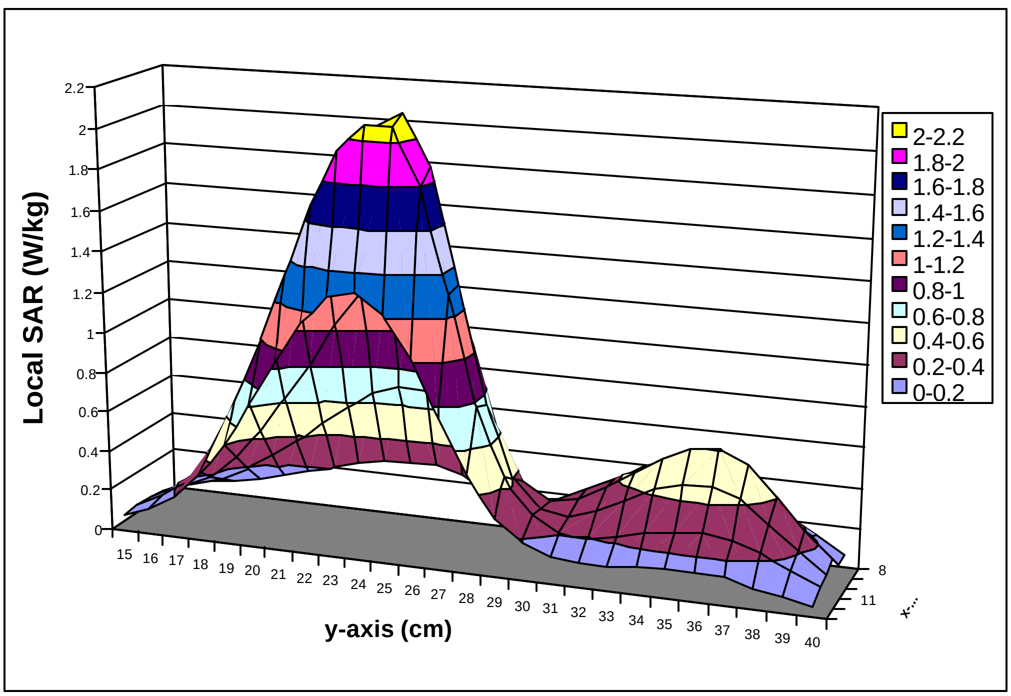

Figure 13. Surface Plot of the Reference Area Scan 2.5mm Above Phantom Surface

51 Spectrum Way
Nepean, Ontario, K2R 1E6
Tel. (613) 820-2730
Fax (613) 820 4161
e-mail: info@aprel.com
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