SAR COMPLIANCE TESTING OF TELSON MODEL TDC 8020

WIRELESS TELEPHONE

FINAL TECHNICAL REPORT

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I. Introduction

The U.S. Federal Communications Commission (FCC) has adopted limits of human exposure to RF emissions from mobile and portable devices that are regulated by the FCC [1]. The FCC has also issued Supplement C (Edition 97-01) to OET Bulletin 65 defining both the measurement and the computational procedures that should be followed for evaluating compliance of mobile and portable devices with FCC limits for human exposure to radiofrequency emissions [2].

The Telson Model TDC 8020 shown in Fig. 1 is a dual-mode wireless telephone that operates in the frequency band 825.03 MHz (Channel 001) to 848.97 MHz (Channel 799) for transmit frequencies. It operates in both the AMPS mode with a maximum ERP of 0.417 W (26.2 dBm) and the CDMA mode with a maximum ERP of 0.257 W (24.1 dBm). In the transmit mode, the telephone may be set to the maximum ERP by means of AGC control. Since the power output is higher for the AMPS mode, the SARs were determined for this higher radiated power mode. For SAR compliance testing, we have used the tissue-simulant model of the human head described in [3]. As recommended in [2], the Telson Model TDC 8020 was placed against the left ear with the antenna located towards the front of the head as shown in Fig. 2. This allows the antenna to be in close proximity to the model of the head resulting in higher SARs allowing, thereby, the worst case determination of absorbed energy in the user's head [4]. Also as recommended in [2], the SAR distributions were measured without the model of a hand to determine the worst case SARs.

The SAR distributions were measured at the low-frequency end (825.03 MHz - Channel 001), at the midband (836.49 MHz - Channel 383) and at the high-frequency end (848.97 MHz - Channel 799), both for antenna pulled out or left retracted, respectively.

II. The Tissue-Simulant Model

For measurements of the SAR distributions, we have used the Utah Experimental Model that is described in detail in [3]. This model uses a lossy outer shell of the following approximate dimensions:

Axial length from chin to top of the head = 26 cm
Distance from location of the ear canal to top of the head = 14.7 cm
Width from side to side = 16.5 cm

These dimensions are typical for adult human beings. The shell thickness of the head and neck model is approximately 4-7 mm, which is typical of the human skull thickness. The thickness for the ear region is, however, considerably less and is only about 3 mm.

This experimental model shown in Fig. 2 has, in the past, been used for comparison of the measured peak 1-g SARs with those obtained with the Utah FDTD Code for ten wireless telephones, five at 835 MHz and five for PCS (1900 MHz) frequencies [see Table 1]. The numerical SARs were obtained using the anatomically-based, 15-tissue Utah model of the head and neck with a resolution of $1.974 \times 1.974 \times 3.0$ mm that has been described in the scientific literature through numerous publications (see e.g. references 4, 5). The measured and calculated 1-g SARs for these ten telephones, including some research test samples from diverse manufacturers using a variety of radiating antennas for different source-based time-averaged powers are compared in Table 1 [3]. Even though widely different peak 1-g SARs from 0.13 to 5.41 W/kg are obtained because of the variety of antennas and handsets, agreement between the calculated and the measured data is excellent and generally within ± 25 percent.

These tests validate the Utah Experimental Phantom Model as being capable of giving peak 1-g SARs that are in good agreement with the SARs obtained with the realistic, anatomically-based model of the human head and neck both at 835 and 1900 MHz.

The head and neck and the upper part of the torso of the model are filled with a liquid with measured electrical properties (dielectric constant and conductivity) close to the average properties of the brain for white and gray matters in the frequency band 825-849 MHz. This corresponds to $\varepsilon_r = 43.5$ and $\sigma = 0.9$ S/m. For a composition of 40.5% water, 56.0% sugar, 2.5% salt (NaCℓ) and 1.0% HEC, we have measured the values of $\varepsilon_r = 41.1 \pm 1.4$ and $\sigma = 1.06 \pm 0.05$ S/m at the center band frequency of 836.5 MHz using the HP Model 85070 B Dielectric Probe in conjunction with HP Model 8720 C Network Analyzer (50 MHz - 20 GHz). Since these values are very close to the desired values for ε_r and σ, this composition was, therefore, used as the biological phantom material to fill the model shown in Fig. 2.

The SAR distributions were measured using the automated 3-D stepper-motor driven SAR measurement system described in [3].

III. The Measured SAR Distributions for Telson Model TDC 8020 Wireless Telephone

As suggested in Supplement C (Edition 97-01) to the FCC OET Bulletin 65 [2], the SAR measurements have been conducted with the Telson Model TDC 8020 Wireless Telephone pressed against the model of the head shown in Fig. 2 such that the speaker is aligned against the location of the ear canal. Furthermore, the handset is oriented such that the center line of the body of the handset is in the plane passing through the two ear canals and the tip of the mouth.

The highest SAR regions for each of the frequencies (low end Channel 001, midband Channel 383, and highest-frequency Channel 799) were determined in the first instance by using coarser sampling with a step size of 8.0 mm over three overlapping scan areas for a total scan area of 8.0×9.6 cm. After identifying the regions of the highest SAR for each of the frequencies, the SAR distributions were measured with a resolution of 2 mm in order to obtain the peak 1 cm^3 or 1-g SAR.

The measured SAR distributions for the Telson Model TDC 8020 Wireless Telephone for the low end, midband, and highest frequencies with antennas pulled out or left retracted are given in Tables 2-7, respectively. The peak 1-g SARs thus determined are summarized in Table 8. The measured peak 1-g SARs vary from 0.924-1.445 W/kg. As given in [3], we estimate the measurement error to be less than ± 10 percent. This measurement error was established by comparing the measured peak 1-g SARs with those calculated using the FDTD computational method for planar and spherical phantoms for three different spacings of dipole radiators at 835 and 1900 MHz. As given in Tables IV and V of [3], agreement between measured and calculated peak 1-g SARs was generally within ± 10 percent.

IV. Comparison of the Data With FCC 96-326 Guidelines

According to the FCC 96-326 Guidelines [1], the peak 1-g SAR for any 1-g of tissue should not exceed 1.6 W/kg. For a maximum ERP of 0.417 W (26.2 dBm) in the AMPS mode, we measure SARs on the order of 0.924-1.445 W/kg (see Table 8) depending on frequency (low band, midband, or high band) and whether the antenna is pulled out or left retracted in the handset. All of the measured SARs are lower than 1.6 W/kg suggested in the FCC 96-326 Guidelines [1].

REFERENCES

1. Federal Communications Commission, "Guidelines for Evaluating the Environmental Effects of Radiofrequency Radiation," FCC 96-326, August 1, 1996.

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3. O. P. Gandhi, G. Lazzi and C. M. Furse, "Electromagnetic Absorption in the Human Head and Neck for Mobile Telephones at 835 and 1900 MHz," *IEEE Transactions on Microwave Theory and Techniques,* Vol. 44, pp. 1884-1897, 1996.

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Table 1. Comparison of the experimentally measured and FDTD-calculated peak 1-g SARs for ten wireless telephones, five each at 835 and 1900 MHz, respectively [3].

	Time-Averaged Radiated Power mW	Using Experimental Model W/kg	Numerical Method W/kg
Cellular Telephones at 835 MHz			
Telephone A	600	4.02	3.90
Telephone B	600	5.41	4.55
Telephone C	600	4.48	3.52
Telephone D	600	3.21	2.80
Telephone E	600	0.54	0.53
PCS Telephones at 1900 MHz			
Telephone A	125	1.48	1.47
Telephone B	125	0.13	0.15
Telephone C	125	0.65	0.81
Telephone D	125	1.32	1.56
Telephone E	99.3	1.41	1.25

Table 2. **Antenna pulled out. The SARs measured for the Telson Model TDC 8020 Wireless Telephone radiating the maximum possible time-averaged power of 0.417 W (26.2 dBm) for Channel 001 (825.03 MHz) in the AMPS mode.** The SARs in W/kg are measured with a step size of 2 mm for the highest SAR region of the model.

1-g SAR = 1.264 W/kg

a. At depth of 1 mm

1.716	1.849	1.822	1.731	1.665
1.770	1.863	1.820	1.783	1.679
1.767	1.812	1.771	1.748	1.663
1.686	1.723	1.703	1.680	1.628
1.595	1.591	1.619	1.581	1.549

b. At depth of 3 mm

1.440	1.535	1.520	1.452	1.408
1.487	1.552	1.530	1.497	1.426
1.482	1.520	1.495	1.474	1.415
1.434	1.466	1.449	1.434	1.393
1.373	1.379	1.394	1.371	1.337

c. At depth of 5 mm

1.206	1.272	1.265	1.216	1.189
1.245	1.289	1.282	1.254	1.209
1.241	1.273	1.259	1.240	1.202
1.217	1.245	1.232	1.222	1.191
1.182	1.192	1.199	1.188	1.154

d. At depth of 7 mm

1.014	1.058	1.056	1.024	1.008
1.046	1.075	1.076	1.054	1.027
1.042	1.069	1.062	1.047	1.024
1.036	1.059	1.049	1.044	1.021
1.020	1.032	1.034	1.030	1.000

e. At depth of 9 mm

0.862	0.894	0.895	0.874	0.865
0.889	0.909	0.912	0.898	0.881

0.886	0.908	0.905	0.894	0.881
0.891	0.909	0.902	0.899	0.883
0.889	0.899	0.899	0.897	0.874

Table 3. **Antenna left retracted. The SARs measured for the Telson Model TDC 8020 Wireless Telephone radiating the maximum possible time-averaged power of 0.417 W (26.2 dBm) for Channel 001 (825.03 MHz) in the AMPS mode.** The SARs in W/kg are measured with a step size of 2 mm for the highest SAR region of the model.

1-g SAR =1.039 W/kg

a. At depth of 1 mm

1.438	1.539	1.501	1.416	1.364
1.473	1.528	1.513	1.471	1.382
1.451	1.484	1.470	1.441	1.381
1.401	1.421	1.402	1.368	1.335
1.311	1.314	1.315	1.282	1.252

b. At depth of 3 mm

1.207	1.281	1.259	1.196	1.159
1.237	1.281	1.270	1.236	1.174
1.223	1.254	1.241	1.219	1.170
1.186	1.208	1.191	1.170	1.137
1.125	1.131	1.130	1.109	1.076

c. At depth of 5 mm

1.011	1.063	1.053	1.006	0.983
1.036	1.070	1.063	1.035	0.995
1.028	1.055	1.044	1.027	0.989
1.003	1.023	1.008	0.997	0.967
0.964	0.970	0.969	0.955	0.924

d. At depth of 7 mm

0.848	0.884	0.882	0.849	0.835
0.870	0.895	0.890	0.868	0.844
0.866	0.888	0.879	0.866	0.837
0.851	0.867	0.854	0.849	0.824
0.826	0.833	0.831	0.823	0.795

e. At depth of 9 mm

0.720	0.745	0.746	0.723	0.715
0.738	0.756	0.753	0.737	0.721

0.736	0.752	0.746	0.734	0.715
0.729	0.739	0.729	0.726	0.707
0.713	0.717	0.716	0.711	0.689

Table 4. **Antenna pulled out. The SARs measured for the Telson Model TDC 8020 Wireless Telephone radiating the maximum possible time-averaged power of 0.417 W (26.2 dBm) for Channel 383 (836.49 MHz) in the AMPS mode.** The SARs in W/kg are measured with a step size of 2 mm for the highest SAR region of the model.

1-g SAR = 1.445 W/kg

a. At depth of 1 mm

0.981	1.119	1.484	1.657	1.781
2.069	2.296	2.368	2.367	2.174
2.190	2.297	2.265	2.196	2.085
2.071	2.148	2.120	2.100	2.008
1.925	1.968	1.978	1.950	1.871

b. At depth of 3 mm

0.739	0.959	1.253	1.398	1.503
1.735	1.910	1.971	1.965	1.817
1.838	1.913	1.889	1.839	1.756
1.759	1.813	1.791	1.776	1.709
1.655	1.687	1.695	1.675	1.610

c. At depth of 5 mm

0.556	0.823	1.057	1.177	1.268
1.451	1.584	1.634	1.623	1.513
1.536	1.587	1.568	1.534	1.475
1.490	1.526	1.509	1.497	1.449
1.421	1.443	1.449	1.434	1.383

d. At depth of 7 mm

0.432	0.711	0.896	0.996	1.074
1.217	1.316	1.358	1.342	1.262
1.286	1.318	1.304	1.282	1.240
1.264	1.286	1.272	1.264	1.231
1.221	1.236	1.240	1.230	1.190

e. At depth of 9 mm

0.368	0.623	0.771	0.855	0.922
1.033	1.108	1.141	1.121	1.065

1.086	1.107	1.095	1.082	1.054
1.081	1.093	1.082	1.077	1.052
1.057	1.065	1.067	1.061	1.031

Table 5. **Antenna left retracted. The SARs measured for the Telson Model TDC 8020 Wireless Telephone radiating the maximum possible time-averaged power of 0.417 W (26.2 dBm) for Channel 383 (836.49 MHz) in the AMPS mode.** The SARs in W/kg are measured with a step size of 2 mm for the highest SAR region of the model.

1-g SAR = 1.372 W/kg

a. At depth of 1 mm

1.775	1.944	1.959	1.849	1.798
1.832	1.941	1.960	1.908	1.804
1.806	1.938	1.941	1.906	1.821
1.782	1.862	1.885	1.859	1.793
1.725	1.776	1.799	1.796	1.741

b. At depth of 3 mm

1.505	1.629	1.640	1.561	1.521
1.552	1.634	1.647	1.607	1.532
1.544	1.640	1.643	1.612	1.551
1.532	1.594	1.601	1.585	1.535
1.495	1.532	1.548	1.545	1.497

c. At depth of 5 mm

1.275	1.363	1.370	1.316	1.286
1.313	1.373	1.381	1.351	1.300
1.318	1.384	1.386	1.360	1.318
1.315	1.362	1.356	1.349	1.311
1.293	1.318	1.329	1.326	1.284

d. At depth of 7 mm

1.085	1.145	1.150	1.115	1.094
1.115	1.157	1.162	1.139	1.107
1.127	1.171	1.172	1.152	1.123
1.130	1.164	1.151	1.149	1.122
1.119	1.134	1.141	1.138	1.104

e. At depth of 9 mm

0.936	0.976	0.979	0.956	0.943
0.957	0.986	0.989	0.972	0.953

0.971	1.001	0.999	0.987	0.967
0.977	1.000	0.987	0.987	0.968
0.972	0.980	0.984	0.982	0.956

Table 6. **Antenna pulled out. The SARs measured for the Telson Model TDC 8020 Wireless Telephone radiating the maximum possible time-averaged power of 0.417 W (26.2 dBm) for Channel 799 (848.97 MHz) in the AMPS mode.** The SARs in W/kg are measured with a step size of 2 mm for the highest SAR region of the model.

1-g SAR = 1.080 W/kg

a. At depth of 1 mm

1.550	1.668	1.653	1.506	1.447
1.568	1.634	1.642	1.533	1.453
1.523	1.600	1.601	1.524	1.455
1.456	1.504	1.472	1.459	1.394
1.352	1.375	1.373	1.365	1.297

b. At depth of 3 mm

1.282	1.367	1.355	1.249	1.206
1.299	1.350	1.346	1.274	1.213
1.275	1.333	1.323	1.273	1.219
1.233	1.269	1.242	1.230	1.182
1.163	1.176	1.176	1.167	1.116

c. At depth of 5 mm

1.056	1.115	1.104	1.032	1.002
1.072	1.109	1.098	1.053	1.009
1.063	1.106	1.088	1.058	1.018
1.041	1.065	1.044	1.034	0.998
0.997	1.002	1.004	0.996	0.958

d. At depth of 7 mm

0.871	0.910	0.900	0.854	0.834
0.885	0.912	0.897	0.871	0.840
0.887	0.917	0.896	0.880	0.851
0.879	0.894	0.878	0.869	0.844
0.854	0.855	0.858	0.850	0.821

e. At depth of 9 mm

0.727	0.753	0.744	0.715	0.703
0.740	0.758	0.743	0.728	0.708

0.747	0.767	0.747	0.738	0.718
0.748	0.755	0.743	0.736	0.719
0.736	0.734	0.736	0.730	0.707

Table 7. **Antenna left retracted. The SARs measured for the Telson Model TDC 8020 Wireless Telephone radiating the maximum possible time-averaged power of 0.417 W (26.2 dBm) for Channel 799 (848.97 MHz) in the AMPS mode.** The SARs in W/kg are measured with a step size of 2 mm for the highest SAR region of the model.

1-g SAR = 0.924 W/kg

a. At depth of 1 mm

1.232	1.349	1.355	1.288	1.201
1.294	1.406	1.378	1.278	1.218
1.309	1.388	1.366	1.313	1.222
1.285	1.352	1.330	1.287	1.214
1.228	1.263	1.249	1.228	1.173

b. At depth of 3 mm

1.030	1.112	1.116	1.069	1.003
1.080	1.159	1.137	1.062	1.019
1.095	1.150	1.134	1.089	1.022
1.080	1.129	1.111	1.076	1.020
1.040	1.067	1.053	1.036	0.992

c. At depth of 5 mm

0.857	0.911	0.914	0.883	0.836
0.897	0.949	0.933	0.878	0.848
0.912	0.946	0.936	0.898	0.852
0.903	0.937	0.924	0.896	0.853
0.877	0.897	0.883	0.870	0.835

d. At depth of 7 mm

0.714	0.748	0.750	0.730	0.698
0.744	0.776	0.764	0.726	0.706
0.758	0.779	0.771	0.741	0.710
0.754	0.777	0.766	0.745	0.713
0.739	0.753	0.740	0.729	0.703

e. At depth of 9 mm

0.601	0.622	0.623	0.611	0.590
0.623	0.642	0.633	0.606	0.594

0.634	0.646	0.639	0.617	0.597
0.634	0.649	0.639	0.624	0.600
0.626	0.634	0.623	0.615	0.596

Table 8. Summary of the measured peak 1-g SAR for the Telson Model TDC 8020 Wireless Telephone.

Frequency MHz	1-g SAR (W/kg)	
	Antenna Pulled Out	Antenna Left Retracted
825.03 (Channel 001)	1.264	1.039
836.49 (Channel 383)	1.445	1.372
848.97 (Channel 799)	1.080	0.924

Fig. 1. Photograph of the Telson Model TDC 8020 Wireless Telephone.

Fig. 2. The Telson Model TDC 8020 Wireless Telephone held against the phantom model used for measurement of the SAR distribution.