# APPENDIX D: SAR TISSUE SPECIFICATIONS

## Measurement Procedure for Tissue verification:

1) The network analyzer and probe system was configured and calibrated.
2) The probe was immersed in the tissue. The tissue was placed in a nonmetallic container. Trapped air bubbles beneath the flange were minimized by placing the probe at a slight angle.
3) The complex admittance with respect to the probe aperture was measured
4) The complex relative permittivity $\varepsilon_r^{'}$ can be calculated from the below equation (Pournaropoulos and Misra):

$$Y = \frac{j2\omega\varepsilon_r\varepsilon_0}{\left[\ln(b/a)\right]^2}\int_a^b\int_a^b\int_0^\pi \cos\phi' \frac{\exp\left[-j\omega r(\mu_0\varepsilon_r^{'}\varepsilon_0)^{1/2}\right]}{r} d\phi' d\rho' d\rho$$

where $Y$ is the admittance of the probe in contact with the sample, the primed and unprimed coordinates refer to source and observation points, respectively, $r^2 = \rho^2 + \rho'^2 - 2\rho\rho'\cos\phi'$, $\omega$ is the angular frequency, and $j = \sqrt{-1}$.

**3 Composition / Information on ingredients**

**3.2 Mixtures**
**Description:** Aqueous solution with surfactants and inhibitors
**Declarable, or hazardous components:**

| | | |
|---|---|---|
| CAS: 107-21-1<br>EINECS: 203-473-3<br>Reg.nr.: 01-2119456816-28-0000 | **Ethanediol**<br>STOT RE 2, H373;<br>Acute Tox. 4, H302 | >1.0-4.9% |
| CAS: 68608-26-4<br>EINECS: 271-781-5<br>Reg.nr.: 01-2119527859-22-0000 | **Sodium petroleum sulfonate**<br>Eye Irrit. 2, H319 | < 2.9% |
| CAS: 107-41-5<br>EINECS: 203-489-0<br>Reg.nr.: 01-2119539582-35-0000 | **Hexylene Glycol / 2-Methyl-pentane-2,4-diol**<br>Skin Irrit. 2, H315; Eye Irrit. 2, H319 | < 2.9% |
| CAS: 68920-66-1<br>NLP: 500-236-9<br>Reg.nr.: 01-2119489407-26-0000 | **Alkoxylated alcohol, > $C_{16}$**<br>Aquatic Chronic 2, H411;<br>Skin Irrit. 2, H315; Eye Irrit. 2, H319 | < 2.0% |

**Additional information:**
For the wording of the listed risk phrases refer to section 16.
Not mentioned CAS-, EINECS- or registration numbers are to be regarded as Proprietary/Confidential.
The specific chemical identity and/or exact percentage concentration of proprietary components is withheld as a trade secret.

**Figure D-1**

Note: Liquid recipes are proprietary SPEAG. Since the composition is approximate to the actual liquids utilized, the manufacturer tissue-equivalent liquid data sheets are provided below.

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**Measurement Certificate / Material Test**

| | |
|---|---|
| Item Name | **Body Tissue Simulating Liquid (MBBL600-6000V6)** |
| Product No. | SL AAM U16 BC (Batch: 210621-3) |
| Manufacturer | SPEAG |

**Measurement Method**

TSL dielectric parameters measured using calibrated DAK probe.

**Target Parameters**

Target parameters as defined in the KDB 865664 compliance standard.

**Test Condition**

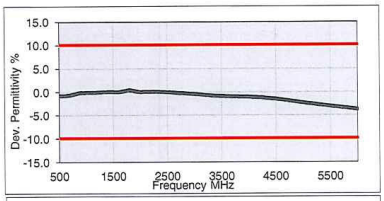
| | |
|---|---|
| Ambient Condition | 22°C ; 30% humidity |
| TSL Temperature | 22°C |
| Test Date | 23-Jun-21 |
| Operator | WM |

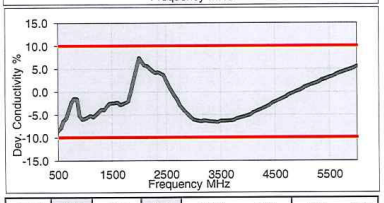
**Additional Information**

TSL Density
TSL Heat-capacity

**Results**

| | Measured | | | Target | | Diff.to Target [%] | |
|---|---|---|---|---|---|---|---|
| f [MHz] | e' | e'' | sigma | eps | sigma | Δ-eps | Δ-sigma |
| 600 | 55.7 | 26.7 | 0.89 | 56.1 | 0.95 | -0.7 | -6.3 |
| 750 | 55.3 | 22.5 | 0.94 | 55.5 | 0.96 | -0.4 | -2.1 |
| 800 | 55.1 | 21.5 | 0.96 | 55.3 | 0.97 | -0.4 | -1.0 |
| 825 | 55.1 | 21.1 | 0.97 | 55.2 | 0.98 | -0.3 | -1.0 |
| 835 | 55.1 | 20.8 | 0.97 | 55.1 | 0.99 | 0.0 | -1.5 |
| 850 | 55.0 | 20.6 | 0.97 | 55.2 | 0.99 | -0.3 | -2.0 |
| 900 | 54.9 | 19.9 | 0.99 | 55.0 | 1.05 | -0.2 | -5.7 |
| 1400 | 54.1 | 15.9 | 1.24 | 54.1 | 1.28 | 0.0 | -3.1 |
| 1450 | 54.0 | 15.7 | 1.27 | 54.0 | 1.30 | 0.0 | -2.3 |
| 1600 | 53.8 | 15.3 | 1.36 | 53.8 | 1.39 | 0.0 | -2.2 |
| 1625 | 53.8 | 15.2 | 1.38 | 53.8 | 1.41 | 0.1 | -2.1 |
| 1640 | 53.8 | 15.2 | 1.39 | 53.7 | 1.42 | 0.1 | -2.1 |
| 1650 | 53.7 | 15.1 | 1.39 | 53.7 | 1.43 | 0.0 | -2.8 |
| 1700 | 53.7 | 15.0 | 1.42 | 53.6 | 1.46 | 0.3 | -2.7 |
| 1750 | 53.6 | 14.9 | 1.45 | 53.4 | 1.49 | 0.3 | -2.7 |
| 1800 | 53.5 | 14.9 | 1.49 | 53.3 | 1.52 | 0.4 | -2.0 |
| 1810 | 53.5 | 14.9 | 1.50 | 53.3 | 1.52 | 0.4 | -1.3 |
| 1825 | 53.5 | 14.8 | 1.51 | 53.3 | 1.52 | 0.4 | -0.7 |
| 1850 | 53.5 | 14.8 | 1.52 | 53.3 | 1.52 | 0.4 | 0.0 |
| 1900 | 53.4 | 14.8 | 1.56 | 53.3 | 1.52 | 0.2 | 2.6 |
| 1950 | 53.4 | 14.7 | 1.60 | 53.3 | 1.52 | 0.2 | 5.3 |
| 2000 | 53.3 | 14.7 | 1.63 | 53.3 | 1.52 | 0.0 | 7.2 |
| 2050 | 53.3 | 14.7 | 1.67 | 53.2 | 1.57 | 0.1 | 6.4 |
| 2100 | 53.2 | 14.7 | 1.71 | 53.2 | 1.62 | 0.1 | 5.6 |
| 2150 | 53.1 | 14.7 | 1.75 | 53.1 | 1.66 | 0.0 | 5.4 |
| 2200 | 53.1 | 14.7 | 1.80 | 53.0 | 1.71 | 0.1 | 5.3 |
| 2250 | 53.0 | 14.7 | 1.84 | 53.0 | 1.76 | 0.1 | 4.5 |
| 2300 | 52.9 | 14.7 | 1.88 | 52.9 | 1.81 | 0.0 | 3.9 |
| 2350 | 52.9 | 14.8 | 1.93 | 52.8 | 1.85 | 0.1 | 4.3 |
| 2400 | 52.8 | 14.8 | 1.98 | 52.8 | 1.90 | 0.1 | 4.2 |
| 2450 | 52.7 | 14.8 | 2.02 | 52.7 | 1.95 | 0.0 | 3.6 |
| 2500 | 52.6 | 14.9 | 2.07 | 52.6 | 2.02 | -0.1 | 2.5 |
| 2550 | 52.5 | 14.9 | 2.12 | 52.6 | 2.09 | -0.1 | 1.4 |
| 2600 | 52.5 | 15.0 | 2.16 | 52.5 | 2.16 | 0.0 | 0.0 |




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3500 | 50.9 | 15.9 | 3.10 | 51.3 | 3.31 | -0.9 | -6.3 |
| 3700 | 50.6 | 16.2 | 3.33 | 51.1 | 3.55 | -1.0 | -6.2 |
| 5200 | 47.7 | 18.6 | 5.39 | 49.0 | 5.30 | -2.6 | 1.7 |
| 5250 | 47.6 | 18.7 | 5.46 | 49.0 | 5.36 | -2.7 | 1.9 |
| 5300 | 47.5 | 18.8 | 5.54 | 48.9 | 5.42 | -2.8 | 2.2 |
| 5500 | 47.1 | 19.1 | 5.83 | 48.6 | 5.65 | -3.0 | 3.2 |
| 5600 | 46.9 | 19.2 | 5.98 | 48.5 | 5.77 | -3.2 | 3.6 |
| 5700 | 46.7 | 19.3 | 6.13 | 48.3 | 5.88 | -3.3 | 4.2 |
| 5800 | 46.5 | 19.4 | 6.27 | 48.2 | 6.00 | -3.5 | 4.6 |
| 6000 | 46.1 | 19.7 | 6.57 | 47.9 | 6.23 | -3.7 | 5.5 |
| 6500 | | | | | | | |
| 7000 | | | | | | | |
| 7500 | | | | | | | |
| 8000 | | | | | | | |
| 8500 | | | | | | | |
| 9000 | | | | | | | |
| 9500 | | | | | | | |
| 10000 | | | | | | | |

**Figure D-2**
**600 – 6000 MHz Body Tissue Equivalent Matter**

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**Measurement Certificate / Material Test**

| | |
|---|---|
| Item Name | **Head Tissue Simulating Liquid (HBBL600-10000V6)** |
| Product No. | SL AAH U16 BC (Batch: 210629-3) |
| Manufacturer | SPEAG |

**Measurement Method**

TSL dielectric parameters measured using calibrated DAK probe.

**Target Parameters**

Target parameters as defined in the IEEE 1528 and IEC 62209 compliance standards.

**Test Condition**

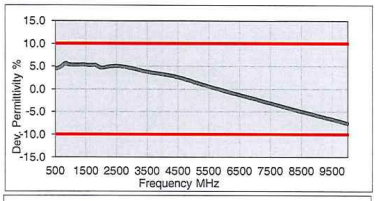
| | |
|---|---|
| Ambient Condition | 22°C ; 30% humidity |
| TSL Temperature | 22°C |
| Test Date | 1-Jul-21 |
| Operator | WM |

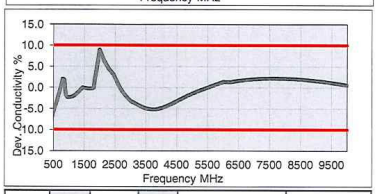
**Additional Information**

TSL Density
TSL Heat-capacity

**Results**

| | Measured | | | Target | | Diff.to Target [%] | |
|---|---|---|---|---|---|---|---|
| f [MHz] | e' | e'' | sigma | eps | sigma | Δ-eps | Δ-sigma |
| 600 | 44.7 | 25.5 | 0.85 | 42.7 | 0.88 | 4.6 | -3.6 |
| 750 | 44.1 | 21.6 | 0.90 | 41.9 | 0.89 | 5.1 | 0.7 |
| 800 | 44.0 | 20.6 | 0.92 | 41.7 | 0.90 | 5.6 | 2.5 |
| 825 | 44.0 | 20.2 | 0.93 | 41.6 | 0.91 | 5.8 | 2.6 |
| 835 | 44.0 | 20.0 | 0.93 | 41.5 | 0.91 | 5.9 | 2.0 |
| 850 | 43.9 | 19.8 | 0.93 | 41.5 | 0.92 | 5.8 | 1.5 |
| 900 | 43.8 | 19.0 | 0.95 | 41.5 | 0.97 | 5.5 | -2.1 |
| 1400 | 42.8 | 15.1 | 1.18 | 40.6 | 1.18 | 5.4 | 0.0 |
| 1450 | 42.7 | 14.9 | 1.20 | 40.5 | 1.20 | 5.4 | 0.0 |
| 1600 | 42.4 | 14.4 | 1.28 | 40.3 | 1.28 | 5.2 | -0.3 |
| 1625 | 42.4 | 14.3 | 1.30 | 40.3 | 1.30 | 5.3 | 0.1 |
| 1640 | 42.4 | 14.3 | 1.31 | 40.3 | 1.31 | 5.3 | 0.3 |
| 1650 | 42.3 | 14.3 | 1.31 | 40.2 | 1.31 | 5.1 | -0.2 |
| 1700 | 42.3 | 14.2 | 1.34 | 40.2 | 1.34 | 5.3 | -0.2 |
| 1750 | 42.2 | 14.1 | 1.37 | 40.1 | 1.37 | 5.3 | -0.1 |
| 1800 | 42.1 | 14.0 | 1.40 | 40.0 | 1.40 | 5.3 | 0.0 |
| 1810 | 42.1 | 13.9 | 1.41 | 40.0 | 1.40 | 5.3 | 0.7 |
| 1825 | 42.1 | 13.9 | 1.42 | 40.0 | 1.40 | 5.3 | 1.4 |
| 1850 | 42.0 | 13.9 | 1.43 | 40.0 | 1.40 | 5.0 | 2.1 |
| 1900 | 42.0 | 13.8 | 1.46 | 40.0 | 1.40 | 5.0 | 4.3 |
| 1950 | 41.9 | 13.8 | 1.49 | 40.0 | 1.40 | 4.7 | 6.4 |
| 2000 | 41.8 | 13.7 | 1.53 | 40.0 | 1.40 | 4.5 | 9.3 |
| 2050 | 41.8 | 13.7 | 1.56 | 39.9 | 1.44 | 4.7 | 8.0 |
| 2100 | 41.7 | 13.7 | 1.59 | 39.8 | 1.49 | 4.7 | 6.8 |
| 2150 | 41.6 | 13.6 | 1.63 | 39.7 | 1.53 | 4.7 | 6.3 |
| 2200 | 41.6 | 13.6 | 1.67 | 39.6 | 1.58 | 4.9 | 5.8 |
| 2250 | 41.5 | 13.6 | 1.70 | 39.6 | 1.62 | 4.9 | 4.8 |
| 2300 | 41.4 | 13.6 | 1.74 | 39.5 | 1.67 | 4.9 | 4.4 |
| 2350 | 41.3 | 13.6 | 1.78 | 39.4 | 1.71 | 4.9 | 4.0 |
| 2400 | 41.3 | 13.6 | 1.82 | 39.3 | 1.76 | 5.1 | 3.7 |
| 2450 | 41.2 | 13.6 | 1.86 | 39.2 | 1.80 | 5.1 | 3.3 |
| 2500 | 41.1 | 13.6 | 1.90 | 39.1 | 1.85 | 5.0 | 2.5 |
| 2550 | 41.0 | 13.7 | 1.94 | 39.1 | 1.91 | 4.9 | 1.6 |
| 2600 | 41.0 | 13.7 | 1.98 | 39.0 | 1.96 | 5.1 | 0.8 |




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3500 | 39.4 | 14.2 | 2.77 | 37.9 | 2.91 | 3.8 | -4.9 |
| 3700 | 39.0 | 14.4 | 2.96 | 37.7 | 3.12 | 3.6 | -5.2 |
| 5200 | 36.4 | 16.0 | 4.62 | 36.0 | 4.66 | 1.2 | -0.8 |
| 5250 | 36.3 | 16.0 | 4.68 | 35.9 | 4.71 | 1.1 | -0.7 |
| 5300 | 36.2 | 16.1 | 4.73 | 35.9 | 4.76 | 1.0 | -0.5 |
| 5500 | 35.9 | 16.2 | 4.96 | 35.6 | 4.96 | 0.6 | 0.0 |
| 5600 | 35.7 | 16.3 | 5.08 | 35.5 | 5.07 | 0.4 | 0.3 |
| 5700 | 35.5 | 16.4 | 5.20 | 35.4 | 5.17 | 0.2 | 0.6 |
| 5800 | 35.3 | 16.5 | 5.31 | 35.3 | 5.27 | 0.0 | 0.8 |
| 6000 | 34.9 | 16.6 | 5.55 | 35.1 | 5.48 | -0.4 | 1.4 |
| 6500 | 34.0 | 17.1 | 6.17 | 34.5 | 6.07 | -1.3 | 1.6 |
| 7000 | 33.1 | 17.4 | 6.78 | 33.9 | 6.65 | -2.2 | 2.0 |
| 7500 | 32.3 | 17.7 | 7.40 | 33.3 | 7.24 | -3.1 | 2.2 |
| 8000 | 31.4 | 18.0 | 8.01 | 32.7 | 7.84 | -4.1 | 2.1 |
| 8500 | 30.5 | 18.2 | 8.62 | 32.1 | 8.45 | -5.0 | 2.0 |
| 9000 | 29.7 | 18.4 | 9.22 | 31.5 | 9.08 | -5.9 | 1.6 |
| 9500 | 28.9 | 18.6 | 9.82 | 31.0 | 9.71 | -6.7 | 1.2 |
| 10000 | 28.1 | 18.7 | 10.42 | 30.4 | 10.36 | -7.6 | 0.6 |

**Figure D-3**
**600 – 10000 MHz Head Tissue Equivalent Matter**

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**Measurement Certificate / Material Test**

| | |
|---|---|
| Item Name | **Head Tissue Simulating Liquid (HBBL4-250V3)** |
| Product No. | SL AAH 005 AD (Batch: 210601-1) |
| Manufacturer | SPEAG |

**Measurement Method**

TSL dielectric parameters measured using calibrated DAK probe.

**Setup Validation**

Validation results were within ± 2.5% towards the target values of Methanol.

**Target Parameters**

Target parameters as defined in the IEEE 1528 and IEC 62209 compliance standards.

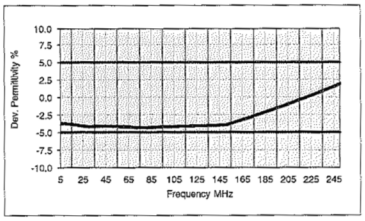
**Test Condition**

| | |
|---|---|
| Ambient | Environment temperatur (22 ± 3)°C and humidity < 70%. |
| TSL Temperature | 22°C |
| Test Date | 3-Jun-21 |
| Operator | WM |

**Additional Information**

| | |
|---|---|
| TSL Density | 1.042 g/cm3 |
| TSL Heat-capacity | 3.574 kJ/(kg*K) |

| | Measured | | | Target | | Diff.to Target [%] | |
|---|---|---|---|---|---|---|---|
| f [MHz] | ε' | ε'' | sigma | eps | sigma | Δ-eps | Δ-sigma |
| 5 | 53.0 | 2603.50 | 0.72 | 55.0 | 0.75 | -3.6 | -4.0 |
| 10 | 52.9 | 1301.62 | 0.72 | 55.0 | 0.75 | -3.8 | -4.0 |
| 15 | 52.9 | 868.41 | 0.72 | 55.0 | 0.75 | -3.8 | -4.0 |
| 20 | 52.8 | 651.83 | 0.73 | 55.0 | 0.75 | -4.0 | -2.7 |
| 25 | 52.8 | 521.90 | 0.73 | 55.0 | 0.75 | -4.0 | -2.7 |
| 30 | 52.7 | 435.32 | 0.73 | 55.0 | 0.75 | -4.2 | -2.7 |
| 35 | 52.6 | 373.51 | 0.73 | 54.9 | 0.75 | -4.2 | -2.7 |
| 40 | 52.5 | 327.19 | 0.73 | 54.8 | 0.75 | -4.2 | -2.7 |
| 45 | 52.4 | 291.20 | 0.73 | 54.7 | 0.75 | -4.1 | -2.7 |
| 50 | 52.3 | 262.44 | 0.73 | 54.6 | 0.75 | -4.1 | -2.7 |
| 55 | 52.2 | 238.95 | 0.73 | 54.4 | 0.75 | -4.1 | -2.8 |
| 60 | 52.1 | 219.39 | 0.73 | 54.3 | 0.75 | -4.1 | -2.9 |
| 65 | 51.9 | 202.87 | 0.73 | 54.2 | 0.75 | -4.3 | -2.9 |
| 70 | 51.8 | 188.72 | 0.73 | 54.1 | 0.75 | -4.3 | -3.0 |
| 75 | 51.6 | 176.48 | 0.74 | 54.0 | 0.75 | -4.4 | -1.7 |
| 80 | 51.5 | 165.78 | 0.74 | 53.9 | 0.75 | -4.4 | -1.7 |
| 85 | 51.5 | 156.34 | 0.74 | 53.8 | 0.75 | -4.2 | -1.8 |
| 90 | 51.4 | 147.97 | 0.74 | 53.7 | 0.75 | -4.2 | -1.9 |
| 95 | 51.3 | 140.49 | 0.74 | 53.5 | 0.75 | -4.2 | -1.9 |
| 100 | 51.2 | 133.76 | 0.74 | 53.4 | 0.75 | -4.2 | -2.0 |
| 105 | 51.1 | 127.68 | 0.75 | 53.3 | 0.76 | -4.1 | -0.7 |
| 110 | 51.0 | 122.16 | 0.75 | 53.2 | 0.76 | -4.1 | -0.7 |
| 115 | 50.9 | 117.13 | 0.75 | 53.1 | 0.76 | -4.1 | -0.8 |
| 120 | 50.8 | 112.52 | 0.75 | 53.0 | 0.76 | -4.1 | -0.9 |
| 125 | 50.7 | 108.28 | 0.75 | 52.9 | 0.76 | -4.1 | -0.9 |
| 130 | 50.6 | 104.37 | 0.75 | 52.8 | 0.76 | -4.1 | -1.0 |
| 135 | 50.5 | 100.76 | 0.76 | 52.6 | 0.76 | -4.1 | 0.3 |
| 140 | 50.4 | 97.41 | 0.76 | 52.5 | 0.76 | -4.1 | 0.2 |
| 145 | 50.3 | 94.30 | 0.76 | 52.4 | 0.76 | -4.0 | 0.2 |
| 150 | 50.2 | 91.39 | 0.76 | 52.3 | 0.76 | -4.0 | 0.1 |
| 155 | 50.1 | 88.68 | 0.76 | 52.1 | 0.76 | -3.8 | -0.3 |
| 160 | 50.0 | 86.14 | 0.77 | 51.8 | 0.77 | -3.5 | 0.5 |
| 165 | 50.0 | 83.75 | 0.77 | 51.6 | 0.77 | -3.1 | 0.0 |
| 170 | 49.9 | 81.51 | 0.77 | 51.4 | 0.77 | -2.9 | -0.5 |
| 175 | 49.8 | 79.40 | 0.77 | 51.1 | 0.78 | -2.6 | -0.9 |
| 180 | 49.7 | 77.41 | 0.78 | 50.9 | 0.78 | -2.4 | -0.1 |
| 185 | 49.6 | 75.52 | 0.78 | 50.7 | 0.78 | -2.1 | -0.6 |
| 190 | 49.5 | 73.74 | 0.78 | 50.4 | 0.79 | -1.8 | -1.0 |
| 195 | 49.4 | 72.06 | 0.78 | 50.2 | 0.79 | -1.6 | -1.5 |
| 200 | 49.3 | 70.46 | 0.78 | 50.0 | 0.80 | -1.3 | -2.0 |
| 205 | 49.2 | 68.94 | 0.79 | 49.7 | 0.80 | -1.1 | -1.2 |
| 210 | 49.2 | 67.49 | 0.79 | 49.5 | 0.80 | -0.6 | -1.6 |
| 215 | 49.1 | 66.11 | 0.79 | 49.3 | 0.81 | -0.3 | -2.1 |
| 220 | 49.0 | 64.80 | 0.79 | 49.0 | 0.81 | -0.1 | -2.5 |
| 225 | 48.9 | 63.55 | 0.80 | 48.8 | 0.81 | 0.2 | -1.7 |
| 230 | 48.8 | 62.35 | 0.80 | 48.6 | 0.82 | 0.5 | -2.1 |
| 235 | 48.8 | 61.20 | 0.80 | 48.3 | 0.82 | 1.0 | -2.6 |
| 240 | 48.7 | 60.11 | 0.80 | 48.1 | 0.82 | 1.2 | -3.0 |
| 245 | 48.6 | 59.05 | 0.80 | 47.9 | 0.83 | 1.5 | -3.4 |
| 250 | 48.5 | 58.05 | 0.81 | 47.6 | 0.83 | 1.8 | -2.7 |



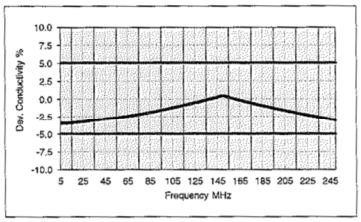




**Figure D-4**
**5 – 250 MHz Head Tissue Equivalent Matter**