MIL-STD-285 Prediction for TEM-t and H-t SE Measurements

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INTRODUCTION

A well-known technique for characterizing the effectiveness of shielding materials is based on the MIL-STD-285 measuring technique. This technique involves measuring flat samples of the material using a large shielded box with a 1 m x 1 m window. The zero-reference measurement is made with an open, unshielded window; the measurement itself is taken by covering the window with the shielding material. The measuring antennas are placed at a distance of 12" (or about 30 cm) from the samples. This is shown in Figure 1.

Magnetic, electric and plane wave conditions are also measured. Because of the 30-cm distance between the antenna and the sample, the transition of near field to far field is at about 159 MHz. Depending on the antennas used, magnetic or electric field SE is obtained below this frequency.

The disadvantage of this technique is the need for a large sample (about 1 m^2) of the shielding material. Other measuring techniques need only small samples (about 15 cm^2).

This article describes a technique for estimating MIL-STD-285 values using the results obtained from these other SE measuring techniques.

TEM-t AND H-t CELLS

Far field and near field conditions may be simulated using small test cells.[1-3] For far-field conditions, all test methods are based

SE values based on MIL-STD-285 can be predicted using simple test cells and small samples of shielding material.

on the assumption that the ratio of E-field/H-field (wave impedance) is constant. Therefore, all test cells are based on a coaxial transmission line, where the ratio of voltage and current (characteristic impedance) is constant (normally 50 ohms).

In the near field, measurements may be taken in the E-field and the H-field. Test methods have been developed for both field conditions. However, in terms of SE theory, only H-field measurements are relevant.

TEM-t CELL

This technique is based on ASTM-D4935 and takes into account the problems associated with this standard measuring technique. A very simple and easy to use test method has been developed to simulate field conditions. The test cell (Figure 2) is based on a TEM cell with an interrupted inner conductor and a rectangular cross section.

All measurements are taken in a

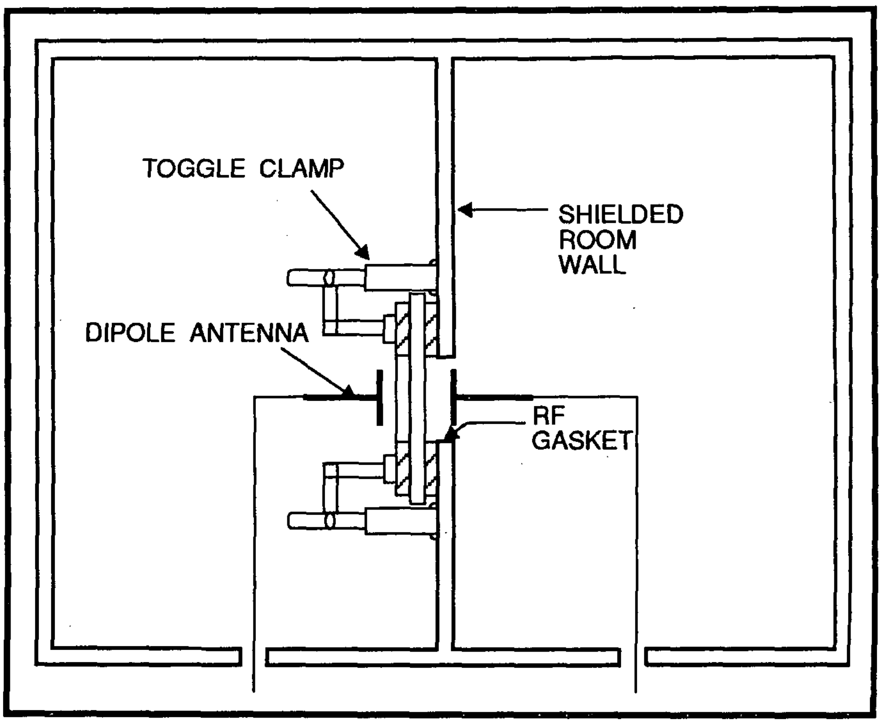

FIGURE 1. Basic Test Setup for MIL-STD-285.

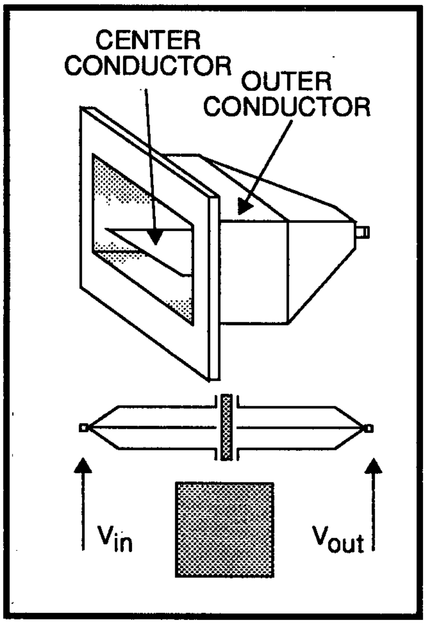

FIGURE 2. *Schematic Figure of TEM-t Cell.*

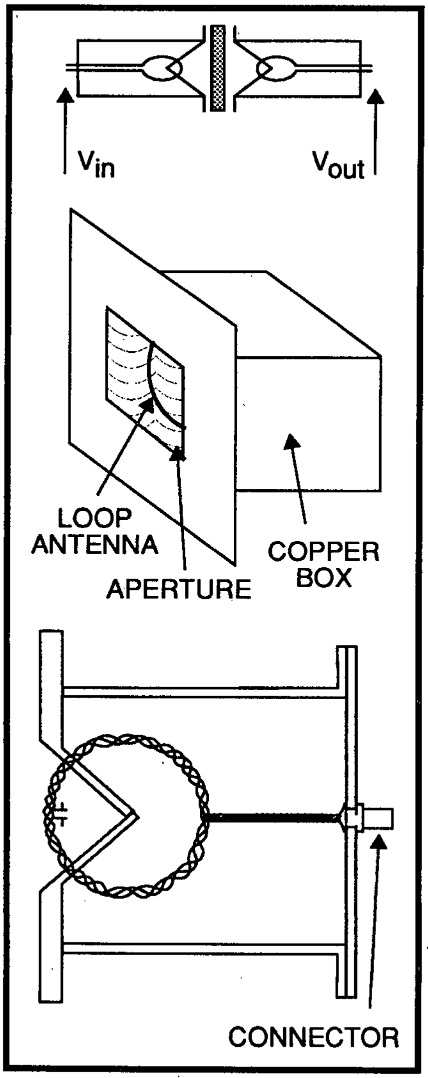

FIGURE 3. *Schematic Figure of H-t Cell.*

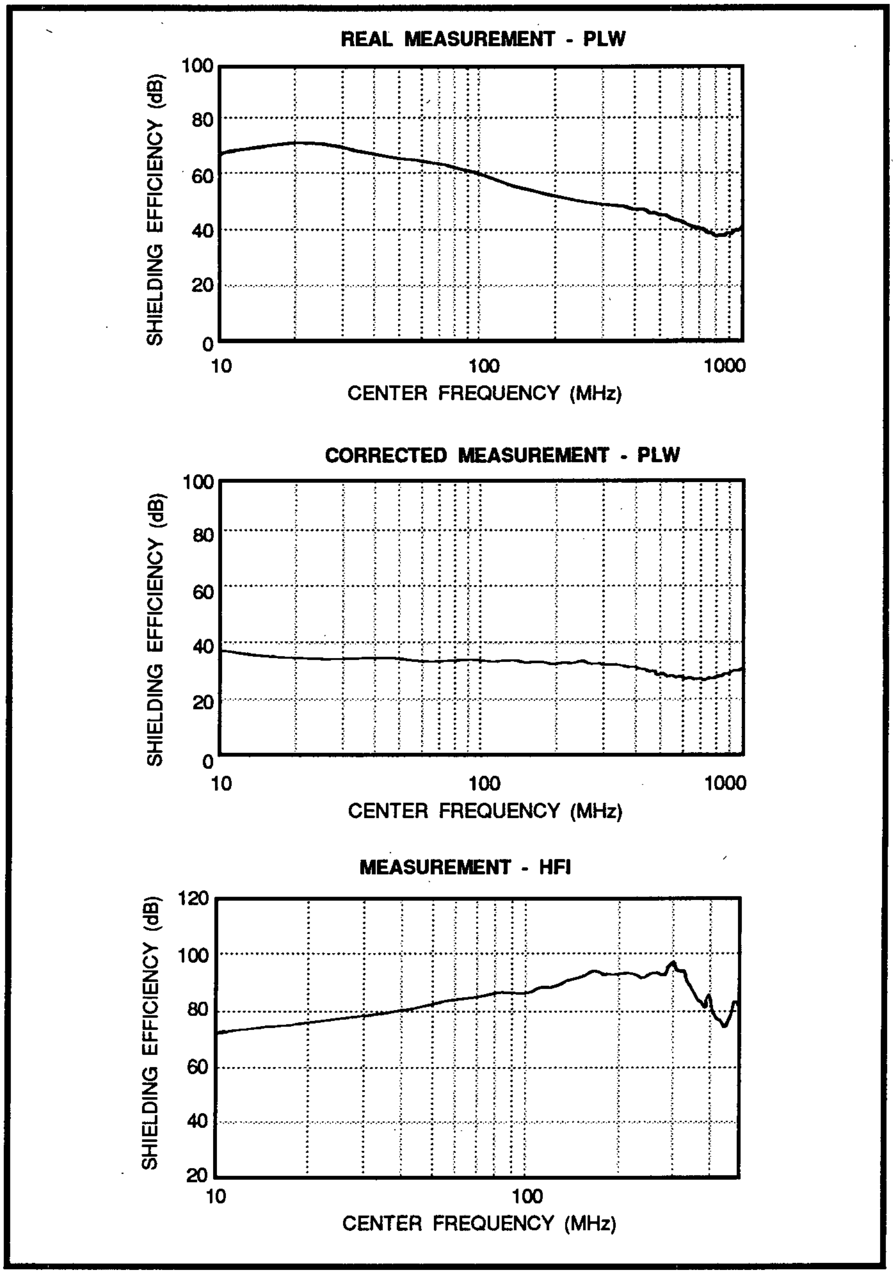

FIGURE 4. *Typical Examples of SE Values Obtained Using TEM-t and H-t Measuring Cells.*

non-contacting, capacitive coupled manner for a variety of materials. Samples must completely cover the outer flanges, but smaller samples may be measured using special sample holders. Even for the reference measurement, no sample preparation is needed. A good correlation is obtained with both theoretical values and measured ASTM-D4935/89 values and by applying a correction factor depending on the cell construction.

This system (Figure 3) uses two electrically shielded loop antennas, each 3 mm from the sample. The system is a closed system, and the loop antennas are coplanar, so that the measurements are taken under the same conditions as the MIL-STD-285 specifications. The system is sample-compatible with the TEM-t; no sample preparation is needed. Typical measurements obtained with both the TEM-t and the H-t cell are given in Figure 4.

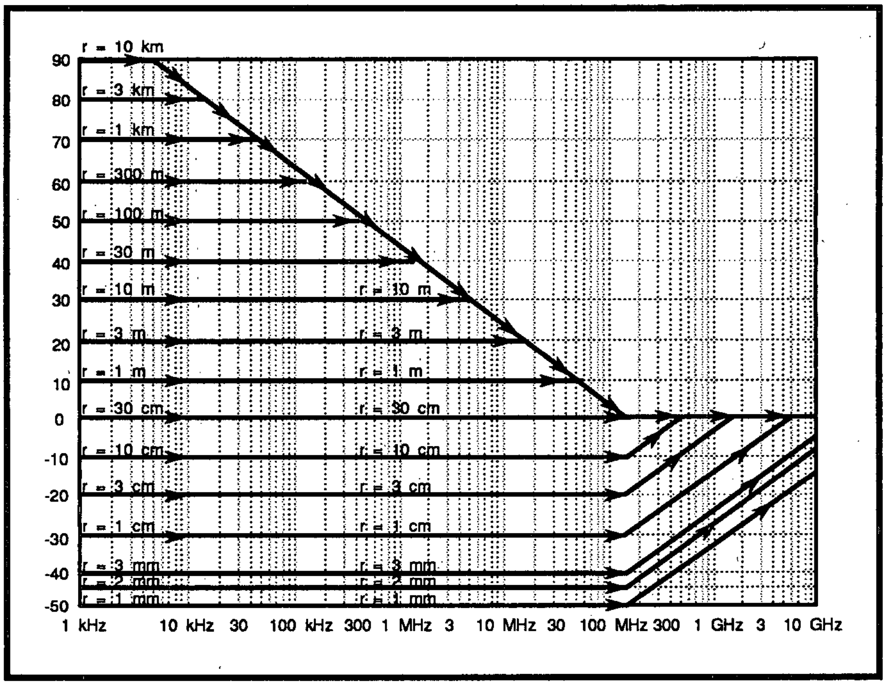

FIGURE 5. *Correction Chart for Other Distances: MIL-STD-285.*[2]

FREQUENCY (MHz)	SUBTRACT (dB)	SUBTRACT FOR MIL-STD-285 (dB)
1000	0	0
900	1	1
700	3	3
500	6	6
400	8	8
300	10	10
250	12	12
200	14	14
150	16	16
100	20	16
70	23	16
50	26	16
40	28	16
30	30	16
20	34	16
10	40	16

TABLE 1. *Correction Factors for a TEM-t Cell.*

TRANSLATION TO MIL-STD-285

Correction charts for the calculation of the MIL-STD-285 values are available in current literature.[2] They give correction factors for SE measurements performed at other distances (Figure 5). The rules given below may be deduced from the characteristics of the TEM-t and the H-t cells.

H-t CELL

The distance from the loop antenna to the sample is 3 mm. The correction graph shows that for frequencies lower than 159 MHz, a correction of 40 dB must be performed or the obtained SE values may be shifted over 2 decades to the lower end. Above 159 MHz, MIL-STD 285 conditions apply to far field conditions, so the results obtained from the TEM-t cell should be used for these far field (called plane wave) conditions.

TEM-t CELL

Figure 4 shows that the direct measurements using the TEM-t cell simulate E-field conditions, because of the resultant slope of 20 dB/decade, before correcting for the cell characteristics. Using these correction factors, far field SE values are obtained. Correction factors are given in Table 1.

For MIL-STD 285 corrections, at frequencies less than 159 MHz, a constant correction factor of 16 dB must be used because MIL-STD-285 conditions below 159 MHz are E-field/near-field conditions.

Samples of shielding material must completely cover the outer flanges, but smaller samples may be measured using special sample holders.

EXAMPLE

TEM-t/H-t and MIL-STD-285 measured SE values are available for two materials, a woven metal plated textile [A] and a sintered material [B]. They are summarized in Table 2.

The procedure for predicting MIL-STD-285 values from TEM-t and H-t measurements is as follows:

1. Shift the H-t values over 2 decades lower in frequency.

2. Add 40 dB to H-t values up to 159 MHz.

3. Correct TEM-t values for far field conditions (above 159 MHz) and for E-field conditions (below 159 MHz) using the correction factors in Table 1.

This procedure yields Table 3. Tables 2 and 3 are summarized in Figures 6a through 6d.

FREQUENCY (MHz)	TEM-t (dB)		H-t (dB)		MIL-STD-285 (dB)	
	A	B	A	B	A	B
200 kHz					21	12
500 kHz					28	19
1 MHz					31.5	28
1.5 MHz					34	36
2.5 MHz					38	39
5 MHz					45	42
10 MHz			13.2	8	50	46
20 MHz			18.6	14.2	56	55
30 MHz			21.2	17.1	61.5	60
40 MHz			23.4	20.3		
50 MHz		98.5	24.6	23.1	63	63
70 MHz	84	98	26.8	28.2		
100 MHz	84.4	97	28.6	33.4	69	72
150 MHz	85.4	100	30.8	38.3	70	78
200 MHz	82	103	32.4	41.3		
250 MHz	82.0	99	33.4	43.2	70.5	84
300 MHz	80.4	98	35	44.5		
400 MHz	80.8	98	36.4	44		
500 MHz	79.2	97	38.8	43.5	72.5	85
700 MHz	76.3	91				
900 MHz	75.8	92				
1000 MHz	72.8	90			73	91

TABLE 2. Measured SE Values for a Woven Metal-plated Textile and a Sintered Material.

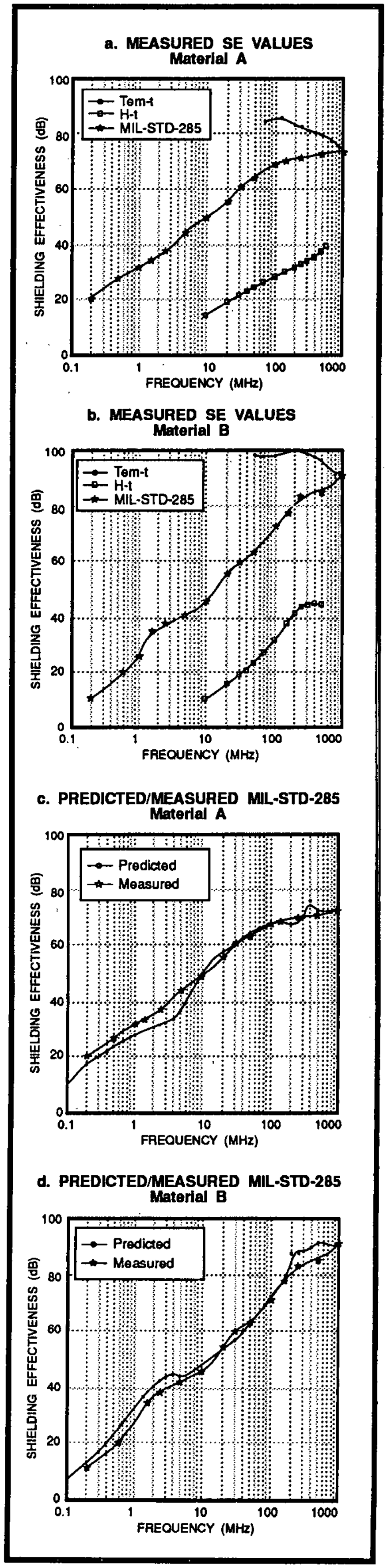

FIGURE 6. Measured SE Values and Predicted MIL-STD-285 SE Values for Materials A and B.

CONCLUSION

A prediction of the SE values in accordance with MIL-STD-285 requirements (material samples approximately 1 m²) is possible using measurements performed on small samples within simple test cells such as the TEM-t and the H-t cells. However, it should be mentioned that, due to the small dimensions of the samples (15 cm²), an average based on more samples may be needed before proceeding to predict MIL-STD-285 values for a 1 m² sample surface area.

REFERENCES

1. Catrysse, J., "Measuring Techniques for SE Values of Samples and Enclosures," Symposium of the IEE on Screening and Shielding, London, 17/1/1992.
2. White, D., "Shielding Materials," Vol. III, ICT, Gainesville, VA.
3. Hariya, E., and Masahiro, V., Instruments for Measuring the Electromagnetic SE," Kansai Electronic Center, Nara, Japan.

FREQUENCY (MHz)	PREDICTED MIL-STD-285 (dB)		MEASURED MIL-STD-285 (dB)	
	A	B	A	B
100 kHz	13.2	8		
200 kHz	18.6	14.2	21	12
300 kHz	21.2	17.1		
400 kHz	23.4	20.3		
500 kHz	24.6	23.1	28	19
700 kHz	26.8	28.2		
1 MHz	28.6	33.4	31.5	28
1.5 MHz	30.8	38.3	34	36
2 MHz	32.4	41.3		
2.5 MHz	33.4	43.2	38	39
3 MHz	35	44.5		
4 MHz	36.4	44		
5 MHz	38.8	43.5	45	42
10 MHz	53.2	48	50	46
20 MHz	58.6	54.2	56	55
30 MHz	61.2	57.1	61.5	60
40 MHz	63.4	60.3		
50 MHz	64.6	63.1	63	63
70 MHz	66.8	68.2		
100 MHz	68.6	73.4	69	72
150 MHz	70.8	78.3	70	78
200 MHz	68	89		
250 MHz	70	87	70.5	84
300 MHz	70.4	88		
400 MHz	72.8	90		
500 MHz	73.2	91	72.5	85
700 MHz	73.3	88		
900 MHz	74.8	91		
1000 MHz	72.8	90	73	91

TABLE 3. *Predicted MIL-STD-285 SE Values.*

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