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Appraise

from August 28, 2019

Client: **EMF Protect**
Kanalstrasse 18½
D-83052 Bruckmühl

Measurement object: **Shielding paint *EMF-Turtal,*** 10µ – 250µ particles applied to 2 primed 5mm poplar wood panels
Pattern 1: 5 m2 /liter, pattern 2: 2.5 m2 /liter

Order: Determination of the shielding attenuation against electromagnetic waves in the frequency range of **500MHz – 40GHz**

Examination basis: ASTM D – 4935-10 and IEEE 299-06

Date d. Measurements: August 28, 2019

Scope: 4 pages of text, 2 measurement protocols as an attachment

Results: The test samples with the ***EMF-Turtal*** shielding paint were examined in the frequency range of 500MHz - 8GHz when measuring according to ASTM with electromagnetic waves with polarization in all directions. The measurement results are also valid for linear vertical and horizontal polarization.
From 10GHz to 40GHz, the measurements were carried out based on IEEE 299 with linear vertical polarization. Here too - due to the homogeneity of the paint application - the results apply equally to waves with horizontal or any oblique polarization.

For sample 1, in which 1 liter of paint was distributed over 5m2, the shielding attenuation values - depending on the measurement frequency - were between 27dB at 500MHz and 57dB at 40GHz.

Sample 2: With a coverage of 2.5m2 per 1 liter (i.e. twice as thick paint application), the shielding attenuation values increased to 32dB at 500 MHz and grew to 64dB at 40GHz.

The detailed values can be found in the attached measurement curves and in the table on page 4.

1. Preliminary remarks

When measuring the attenuation of electromagnetic waves through a shielding material, the test object is usually irradiated with high-frequency energy of a certain power flux density S1 or with a certain power P1 .
Behind the shielding material the penetrating power flux density S2 or
Power P2 measured. The logarithmic quotient according to the following equations gives the shielding attenuation value in decibels (dB):

$$a_{Screen} = 10 \log \frac{S_2}{S_1} = 10 \log \frac{P_2}{P_1} \quad (\text{in } decibels\ dB)$$

For interpreting the measurement curves and their measured values It is helpful to see the following Conversion table to be used.

This table allows the logarithmic dB values to be converted into percentage values, whereby - as in this table - the ***power or power flux density*** penetrating through the shield is usually used to evaluate the shielding effect.

Conversion of attenuation from dB to %			
dB	**Power dB Power Passage in %**		**Passage in %**
0	100.00		
	81.00	21	0.78
1	62.80	22	0.63
2	50.00	23	0.50
3	40.00	24	0.39
4	31.60	25	0.31
5	25.00	26	0.25
6	20.00	27	0.20
7	16.00	28	0.18
8	12.50	29	0.12
9	10.00	30	0.10
10	7.90	31	0.08
11	6.25	32	0.06
12	5.00	33	0.05
13	4.00	34	0.04
14	3.13	35	0.03
15	2.50	36	0.02
16	2, 00	37	0.02
17	1.56	38	0.02
18	1.20	39	0.02
19 20	1.00	40	0.01
		50	0.001
		60	0.0001

Table 1: Conversion of dB values into percentage values

2. Measurement setups for shielding attenuation measurement 2.1 according to ASTM D 4935-2010 from 500 MHz – 8 GHz

For these measurements, 2 coaxial TEM measuring vessels were connected to the network analyzer like a transmitting and receiving antenna. With an S21 –
During calibration, the arrangement was calibrated to "0 dB" without the measurement object, but with a non-shielding replacement object of the same thickness between the measuring heads for the transmission measurement.

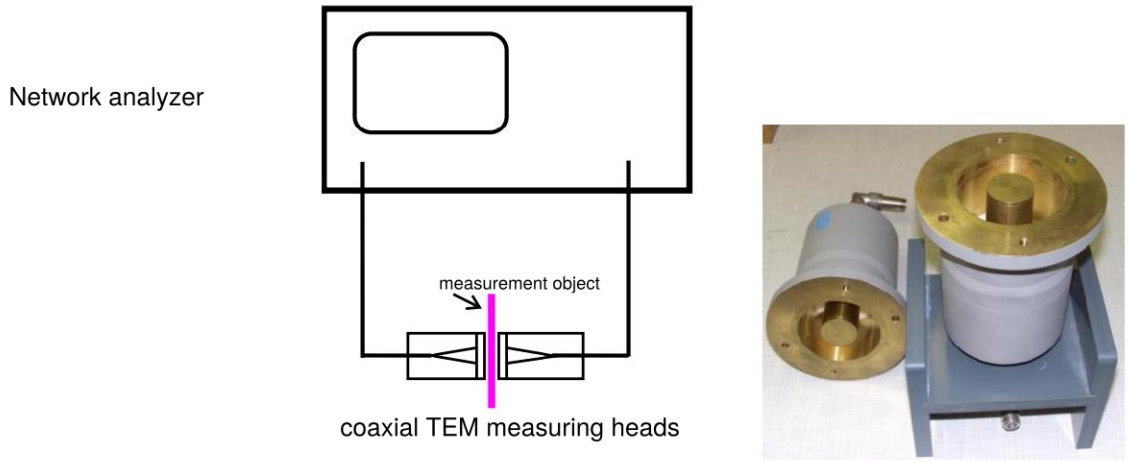


Figure 1 Measuring arrangement for determining the shielding attenuation with TEM measuring heads

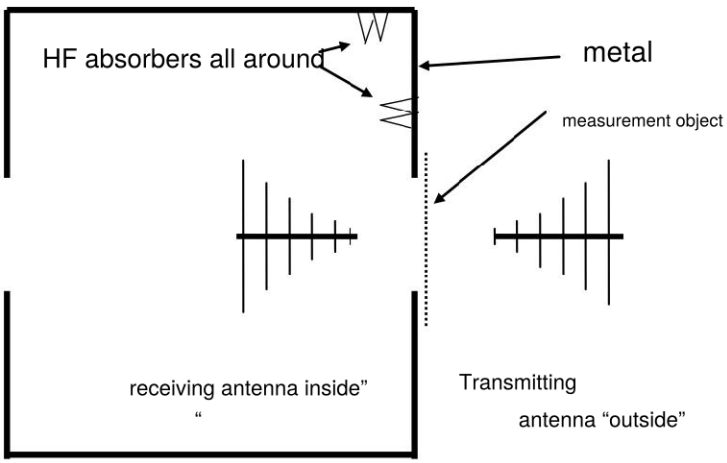
The following measuring devices were used:

Vector network analyzer type ZVRC (30 kHz – 8 GHz) Rohde & Schwarz
Coaxial TEM measuring probes, (1 MHz – 8 GHz), Wandel & Goltermann (see photo)
Documentation: OfficeJet 500, Hewlett & Packard

During this measurement, the electric field strengths in the TEM arrangement - as is usual with coaxial lines - hit the measurement object in all polarization directions.
This means that no discrete statement can be made about the behavior of the measurement object in relation to a specific linear polarization. On the other hand, you get the important information about how the measurement object will behave in relation to polarizations from any direction. **This usually happens in practice, so that the measurement results are very realistic.**

2. 2 Shielding attenuation measurement according to IEEE 299-2006 from 10 GHz to 40 GHz

These measurements were carried out based on the IEEE standard 299-2006 in a measuring room in the radar hall of the UniBw Munich in Neubiberg on August 28, 2019 in the frequency range from 10 GHz to 40 GHz with linearly polarized waves. For this purpose, the test samples - as sketched in the picture below - were placed in front of the 40cm x 40cm opening of a metal wall (area 210cm x 200cm).



picture 2

Measuring arrangement according to IEEE 299-2006

After calibrating the measuring section (without the test specimen to determine the 0 dB transmission value), the shielding attenuation of the test samples was measured.
In order to avoid over-radiation of the measurement signals on the sides of the test samples, it was attached directly between the two measurement antennas.

The following measuring devices and antennas were used:

Microwave signal generator type SMB100A, (9 kHz - 20 GHz), Rohde & Schwarz

Programmable Sweep Generator Type 6668B (10 MHz – 40 GHz), Wiltron

Spectrum analyzer type FSP 30 (9 kHz – 30 GHz), Rohde & Schwarz

EPM Series Power Meter, type 4418B with power sensor 4487D (50MHz – 50GHz) HP

Measuring antennas: 2 double-bar horn antennas (1 GHz – 18 GHz) Rohde & Schwarz

2 HL standard gain horns, 12 GHz – 22 GHz, Narda

2 HL horns 22.5 GHz – 40 GHz, Qpar Angus Ltd.

Documentation: Laser printer Ecosys FS-1020D, Kyocera

3. Summary of results

Measurement curves for the shielding attenuation values between 500MHz and 8GHz are included in the appendix. The screen attenuation values for some important frequencies are printed out numerically in decibels at the top right edge.

The measurements between 10 GHz and 40 GHz were carried out at points every 2.5 GHz. All results are summarized in the table below:

	Shielding attenuation in dB	
Radio service/frequency	***EMF-Turtal*****,** 5m2 /liter	***EMF-Turtal*****,** 2.5m2 /l
C network, TETRA, 450 MHz	**27 dB**	**32dB**
D-Netz, GSM900, 900 MHz	**27 dB**	**32dB**
1GHz	**27 dB**	**32dB**
E-network, GSM1800, 1800 MHz	**27 dB**	**32dB**
Blue tooth, WiFi 2450 MHz	**28 dB**	**33dB**
5G (Sub 6GHz band) 3.4 – 3.8GHz	**30 dB**	**36dB**
New generation WiFi 5.8 GHz	**30 dB**	**38dB**
7.5GHz	**31 dB**	**38dB**
10.0GHz	**31 dB**	**44dB**
12.5GHz	**32 dB**	**44dB**
15.0GHz	**32 dB**	**44dB**
17.5GHz	**37 dB**	**44dB**
20.0GHz	**39 dB**	**49dB**
22.5GHz	**40 dB**	**53dB**
25.0GHz	**45 dB**	**57dB**
27.5GHz	**47 dB**	**59dB**
30.0GHz	**49 dB**	**61dB**
32.5GHz	**50 dB**	**62dB**
35.0GHz	**52 dB**	**63dB**
37.5GHz	**56 dB**	**64dB**
40.0GHz	**57 dB**	**64dB**

Table 2: Shielding attenuation values at different frequencies