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TEST REPORT

Testing of 50 Hz electric field absorption by
NoEM Electro Protektor shielding coats
(supersedes Test Report version of 12/01/2016)

Customer: **Selena FM S.A.**
ul. Strzegomska 2-4
53-611 Wrocław, Poland

Order: **dated 13/11/2015**

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Test Report authorised by

KIEROWNIK
Pracowni Oddziaływań Środowiskowych
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MANAGER
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Warsaw, 15 January 2016

1. Test objective

The test objective was to evaluate the absorption of a 50 Hz electrical field by the NoEM Electro Protektor shielding coat system, comprising of a paint coat primer and construction-grade plastic material, supplied by Selena FM S.A.

2. Performance method

No regulations or standards currently exist that establish the method for the determination of absorption of 50 Hz electric fields.

The reference know-how was derived from the IEEE Standard 299-2006, Method for Measuring the Effectiveness of Electromagnetic Shielding Enclosures.

This standard applies to the measurement of the effectiveness of absorption exhibited by electromagnetic shielding enclosures within the field frequency range between 9 kHz to 18 GHz (expandable to 50 Hz and 100 GHz).

3. Instruments

The test instruments were an existing test bench for calibration and verification of 50 Hz electric field meters. The test bench comprises of:

- a power supply system, type ABK-63C (an autotransformer with an integrated digital multimeter);
- a reference capacitor.

The instruments are permanently installed in Room 210 of the testing laboratory. The test bench overview is shown in image 1 and fig. 1.

Image 1. Test bench for 50 Hz electric field meters

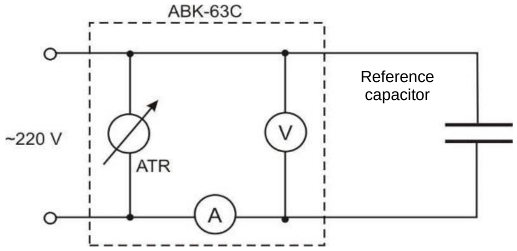


Fig. 1. 50 Hz electrical field test system

The reference capacitor plate to plate distance is d = 0.5 m. The 50 Hz electric field strength on the test bench relative to the capacitor plate voltage is expressed by the following relationship:

$$E\left[\frac{V}{m}\right] = \frac{U[V]}{d[m]}$$

To test the absorption performance of the investigated shielding coats, special cubic structures were built as follows: for test Materials 1 to 4 – cubes of “Botament” boards were made and coated with 2 mm of gypsum plaster; for test Materials 5 to 7 – cubic openwork cages were made.

Inside each cube and cage a Mascheck ESM-100 electric and magnetic field meter was located, the output of which was acquired via PC computer and an optical fibre link.

Image 2. View of the test setup with Maschek ESM-100 meter for testing of electrical field absorption during the test on the tester bench (Test Material 6, cage covered by construction-grade material, interior view)

Table 1. Field meter specifications

Meter:	*ESM-100, P/N 972071-001*
Manufacturer:	*Maschek Elektronik*
Frequency range:	*50 Hz (filter), 5 Hz to 400 kHz*
Measurement range:	*0.1 V/m to 100 kV/m (50 Hz filter) as shown in the meter manual* *0.01 kV/m to 20 kV/m (50 Hz filter) as shown on the calibration certificate*
Calibration certificate:	*Ref. no. 3703.1-M43-4180-458/14* *Issued by the Central Office of Measures, valid through 13/10/2016*

The testing involved a series of strength measurements of a 50 Hz electric field inside a flat capacitor system generating a reference field of a known value and in different variants to account for the shielding coat layers on individual walls of the cube and the cage framework and for the effects of humidity.

The test material absorption was determined by the relationship:

$$S_E = 20\log_{10}\frac{E_1}{E_2}\ [\text{dB}]$$

where:

E_1- Reference strength of the 50 Hz electric field [kV/m] (E_w)
E_2- Measured strength of the 50 Hz electric field [kV/m] (E_p)
The Test Materials are as shown in the table:

Item	Sample code	Material type
1	A	Control, not painted
2	B	NoEM Electro Protektor, 4in1 Electric field shield, White paint coat, Antistatic coat, Priming base coat: 1 layer
3	C	NoEM Electro Protektor, 4in1 Electric field shield, White paint coat, Antistatic coat, Priming base coat: 2 layers
4	D	NoEM Electro Protektor, 4in1 Electric field shield, White paint coat, Antistatic coat, Priming base coat: 1 layer, sealed with an opaque top
5	E	NoEM Electro Protektor, CEAQION TEX: white textile
6	F	NoEM Electro Protektor, 2in1 Electric field shield, Vapour barrier foil: yellow plastic film
7	G	NoEM Electro Protektor, 3in1 Electric field shield, Vapour barrier film, 3-ply foil: green plastic film

4. Environmental conditions

Table 2. Environmental conditions during measurements

Date	*Time*	*Environmental conditions:*	
		Temperature [°C]	*RH [%]*
13/11/2015	12:00 to 14:30	22.2 to 23.6	43 to 62
17/12/2015	9:30 to 11:30	23.1 to 23.4	39 to 61

5. Results

The measurement results are shown in tables below:
The test results are shown as a function of electrical field absorption dependent on:

- test material for the pre-set RH at 40, 50 and 60 %;
- RH for test materials A, B, C, D, E, F and G.

Table 3. 50 Hz electric field absorption for test materials and RH 40%

E_w [V/m]	E_p [V/m]						
	A	B	C	D	E	F	G
400	398.50	41.30	14.50	56.10	0.30	1.70	0.60
1000	998.00	116.70	41.20	144.30	1.10	5.10	1.40
5000	4980.00	530.50	206.50	736.80	6.90	23.60	8.30
10000	9978.00	1067.40	432.10	1577.50	14.50	47.50	16.90
20000	19989.00	2052.00	888.50	3371.00	29.90	96.00	33.90

E_w [V/m]	S_E [%]						
	A	B	C	D	E	F	G
400	0.375	89.675	96.375	85.975	99.925	99.575	99.850
1000	0.200	88.330	95.880	85.570	99.890	99.490	99.860
5000	0.400	89.390	95.870	85.264	99.862	99.528	99.834
10000	0.220	89.326	95.679	84.225	99.855	99.525	99.831
20000	0.055	89.740	95.558	83.145	99.851	99.520	99.831

E_w [V/m]	S_E [dB]						
	A	B	C	D	E	F	G
400	0.033	19.722	28.814	17.062	62.499	47.432	56.478
1000	0.017	18.659	27.702	16.815	59.172	45.849	57.077
5000	0.035	19.486	27.681	16.632	57.202	46.521	55.598
10000	0.019	19.433	27.288	16.041	56.773	46.466	55.442
20000	0.005	19.777	27.047	15.465	56.507	46.375	55.417

Table 4. 50 Hz electric field absorption for test materials and RH 50 %

E_w [V/m]	E_p [V/m]						
	A	B	C	D	E	F	G
400	378.30	22.70	15.20	39.80	0.10	1.50	0.40
1000	935.40	59.00	39.10	89.60	1.00	2.90	1.40
5000	4830.00	275.30	174.10	457.20	5.50	15.40	7.60
10000	9560.00	572.40	346.50	925.70	11.50	31.80	15.80
20000	19988.00	1165.20	644.50	1863.40	23.20	63.30	31.60

E_w [V/m]	S_E [%]						
	A	B	C	D	E	F	G
400	5.425	94.325	96.200	90.050	99.975	99.625	99.900
1000	6.460	94.100	96.090	91.040	99.900	99.710	99.860
5000	3.400	94.494	96.518	90.856	99.890	99.692	99.848
10000	4.400	94.276	96.535	90.743	99.885	99.682	99.842
20000	0.060	94.174	96.778	90.683	99.884	99.684	99.842

E_w [V/m]	S_E [dB]						
	A	B	C	D	E	F	G
400	0.484	24.921	28.404	20.044	72.041	48.519	60.000
1000	0.580	24.583	28.156	20.954	60.000	50.752	57.077

5000	0.300	25.183	29.163	20.777	59.172	50.229	56.363
10000	0.391	24.846	29.206	20.671	58.786	49.951	56.027
20000	0.005	24.693	29.836	20.614	58.711	49.993	56.027

Table 5. 50 Hz electric field absorption for test materials and RH 60%

E_w [V/m]	E_p [V/m]						
	A	B	C	D	E	F	G
400	390.40	2.70	1.00	3.90	0.01	0.90	1.20
1000	973.70	7.60	2.70	11.60	0.50	3.50	2.30
5000	4550.00	37.50	15.10	56.70	3.90	13.90	10.20
10000	9480.00	73.80	34.90	116.10	8.70	28.50	21.00
20000	19986.00	142.50	71.40	240.10	18.30	57.00	40.20

E_w [V/m]	S_E [%]						
	A	B	C	D	E	F	G
400	2.400	99.325	99.750	99.025	99.998	99.775	99.700
1000	2.630	99.240	99.730	98.840	99.950	99.650	99.770
5000	9.000	99.250	99.698	98.866	99.922	99.722	99.796
10000	5.200	99.262	99.651	98.839	99.913	99.715	99.790
20000	0.070	99.288	99.643	98.800	99.909	99.715	99.799

E_w [V/m]	S_E [dB]						
	A	B	C	D	E	F	G
400	0.211	43.414	52.041	40.220	92.041	52.956	50.458
1000	0.231	42.384	51.373	38.711	66.021	49.119	52.765
5000	0.819	42.499	50.400	38.908	62.158	51.119	53.807
10000	0.464	42.639	49.143	38.703	61.210	50.903	53.556
20000	0.006	42.944	48.947	38.413	60.772	50.903	53.936

Table 6. 50 Hz electric field absorption as function of RH for Test Material A

E_w [V/m]	E_p [V/m]			S_E [dB]			S_E [%]		
	40%	50%	60%	40%	50%	60%	40%	50%	60%
400	398.50	378.30	390.40	0.033	0.484	0.211	0.375	5.425	2.400
1000	998.00	935.40	973.70	0.017	0.580	0.231	0.200	6.460	2.630
5000	4980.00	4830.00	4550.00	0.035	0.300	0.819	0.400	3.400	9.000
10000	9978.00	9560.00	9480.00	0.019	0.391	0.464	0.220	4.400	5.200
20000	19989.00	19988.00	19986.00	0.005	0.005	0.006	0.055	0.060	0.070

Table 7. 50 Hz electric field absorption as function of RH for Test Material B

E_w [V/m]	E_p [V/m]			S_E [dB]			S_E [%]		
	40%	50%	60%	40%	50%	60%	40%	50%	60%
400	41.3	22.7	2.7	19.722	24.921	43.414	89.675	94.325	99.325
1000	116.7	59	7.6	18.659	24.583	42.384	88.330	94.100	99.240
5000	530.5	275.3	37.5	19.486	25.183	42.499	89.390	94.494	99.250
10000	1067.4	572.4	73.8	19.433	24.846	42.639	89.326	94.276	99.262
20000	2052	1165.2	142.5	19.777	24.693	42.944	89.740	94.174	99.288

Table 8. 50 Hz electric field absorption as function of RH for Test Material C

E_w [V/m]	E_p [V/m]			S_E [dB]			S_E [%]		
	40%	50%	60%	40%	50%	60%	40%	50%	60%
400	14.50	15.20	1.00	28.814	28.404	52.041	96.375	96.200	99.750
1000	41.20	39.10	2.70	27.702	28.156	51.373	95.880	96.090	99.730
5000	206.50	174.10	15.10	27.681	29.163	50.400	95.870	96.518	99.698
10000	432.10	346.50	34.90	27.288	29.206	49.143	95.679	96.535	99.651
20000	888.50	644.50	71.40	27.047	29.836	48.947	95.558	96.778	99.643

Table 9. 50 Hz electric field absorption as function of RH for Test Material D

E_w [V/m]	E_p [V/m]			S_E [dB]			S_E [%]		
	40%	50%	60%	40%	50%	60%	40%	50%	60%
400	56.1	39.8	3.9	17.062	20.044	40.22	85.975	90.050	99.025
1000	144.3	89.6	11.6	16.815	20.954	38.711	85.570	91.040	98.840
5000	736.8	457.2	56.7	16.632	20.777	38.908	85.264	90.856	98.866
10000	1577.5	925.7	116.1	16.041	20.671	38.703	84.225	90.743	98.839
20000	3371	1863.4	240.1	15.465	20.614	38.413	83.145	90.683	98.800

Table 10. 50 Hz electric field absorption as function of RH for Test Material E

E_w [V/m]	E_p [V/m]			S_E [dB]			S_E [%]		
	40%	50%	60%	40%	50%	60%	40%	50%	60%
400	0.3	0.1	0.01	62.499	72.041	92.041	99.925	99.975	99.998
1000	1.1	1	0.5	59.172	60	66.021	99.890	99.900	99.950
5000	6.9	5.5	3.9	57.202	59.172	62.158	99.862	99.890	99.922
10000	14.5	11.5	8.7	56.773	58.786	61.21	99.855	99.885	99.913
20000	29.9	23.2	18.3	56.507	58.711	60.772	99.851	99.884	99.909

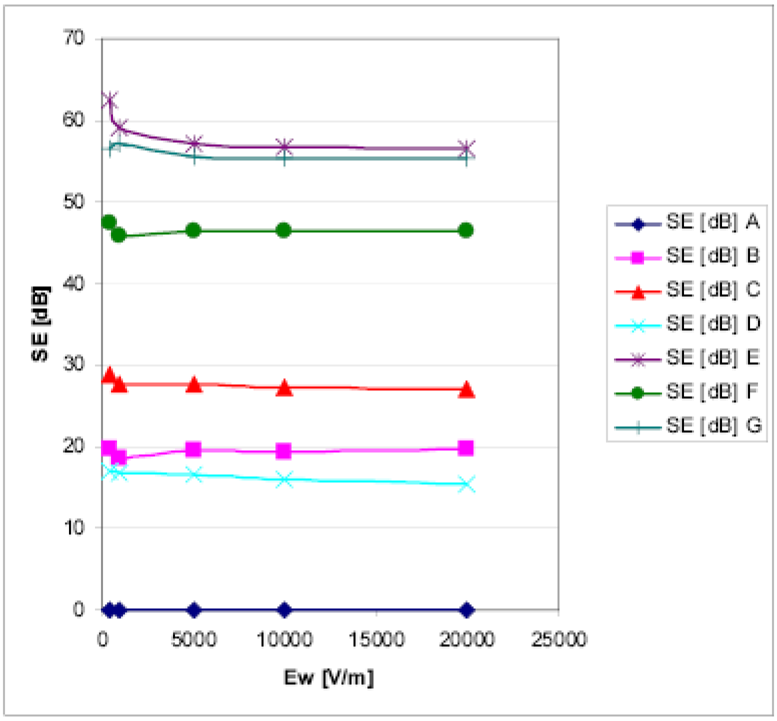
Table 11. 50 Hz electric field absorption as function of RH for Test Material F

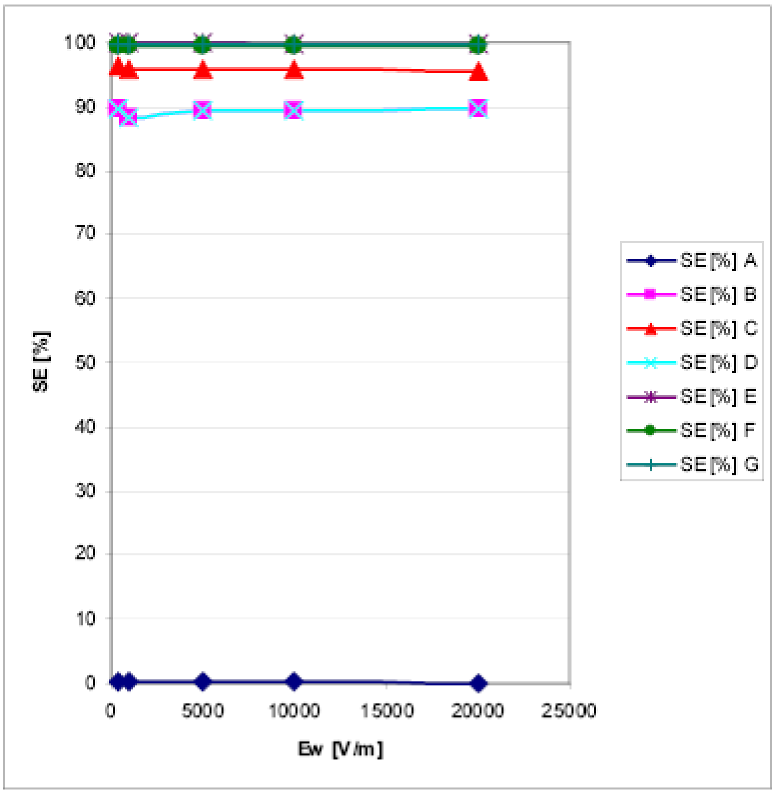
E_w [V/m]	E_p [V/m]			S_E [dB]			S_E [%]		
	40%	50%	60%	40%	50%	60%	40%	50%	60%
400	1.70	1.50	0.90	47.432	48.519	52.956	99.575	99.625	99.775
1000	5.10	2.90	3.50	45.849	50.752	49.119	99.490	99.710	99.650
5000	23.60	15.40	13.90	46.521	50.229	51.119	99.528	99.692	99.722
10000	47.50	31.80	28.50	46.466	49.951	50.903	99.525	99.682	99.715
20000	96.00	63.30	57.00	46.375	49.993	50.903	99.520	99.684	99.715

Table 12. 50 Hz electric field absorption in relation to the RH for Test Material G

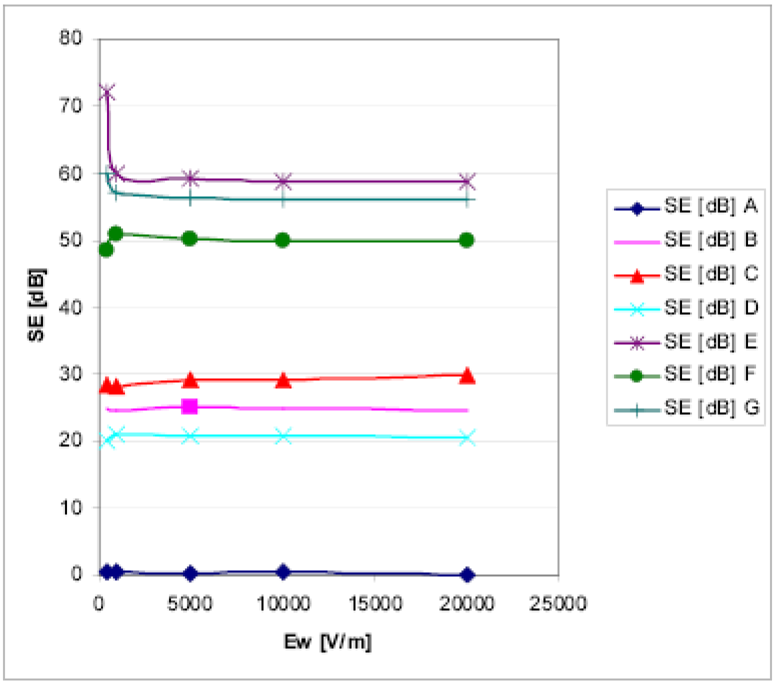
E_w [V/m]	E_p [V/m]			S_E [dB]			S_E [%]		
	40%	50%	60%	40%	50%	60%	40%	50%	60%
400	0.60	0.40	1.20	56.478	60.000	50.458	99.850	99.900	99.700
1000	1.40	1.40	2.30	57.077	57.077	52.765	99.860	99.860	99.770
5000	8.30	7.60	10.20	55.598	56.363	53.807	99.834	99.848	99.796
10000	16.90	15.80	21.00	55.442	56.027	53.556	99.831	99.842	99.790
20000	33.90	31.60	40.20	55.417	56.027	53.936	99.831	99.842	99.799

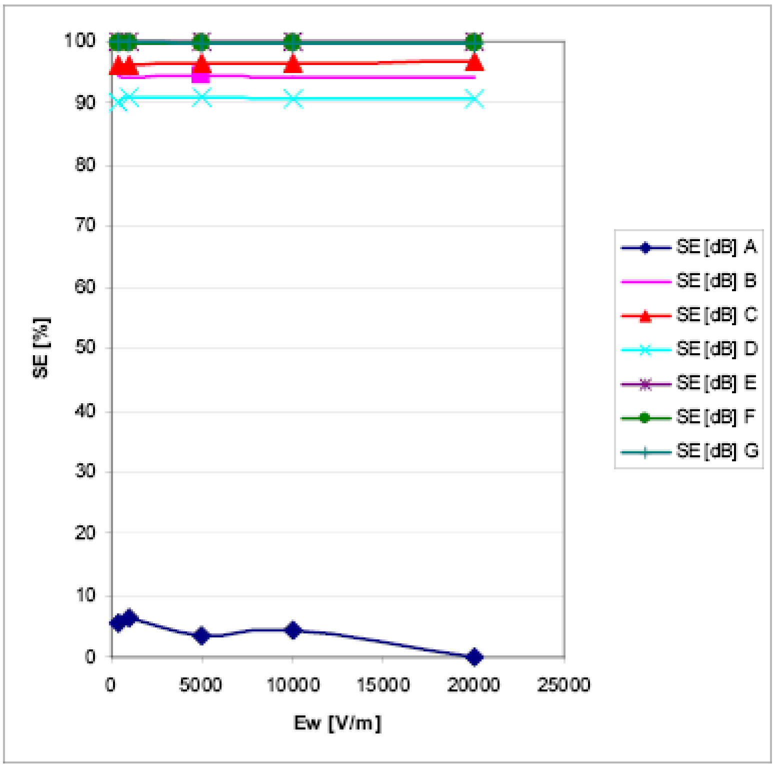
Graph 1. Electric field absorption by insulating materials as function of electric field for RH 40%



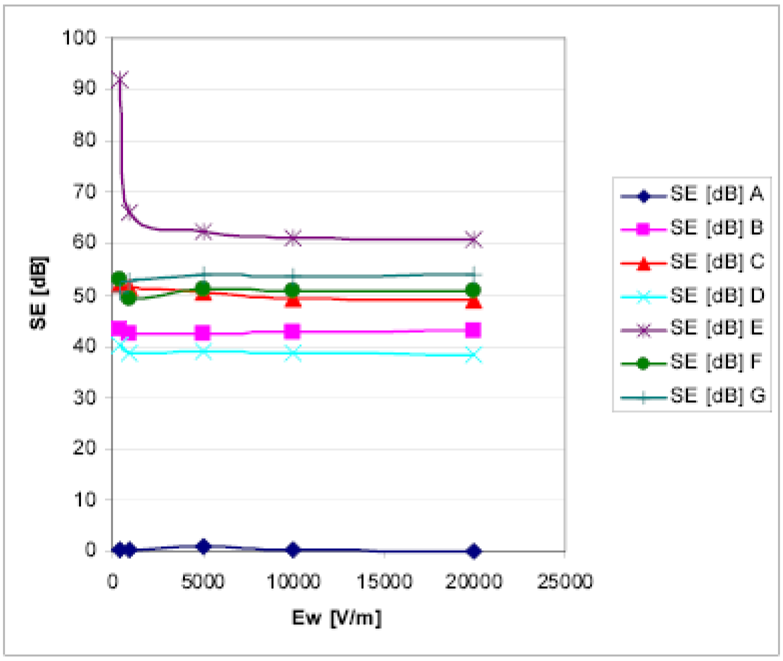


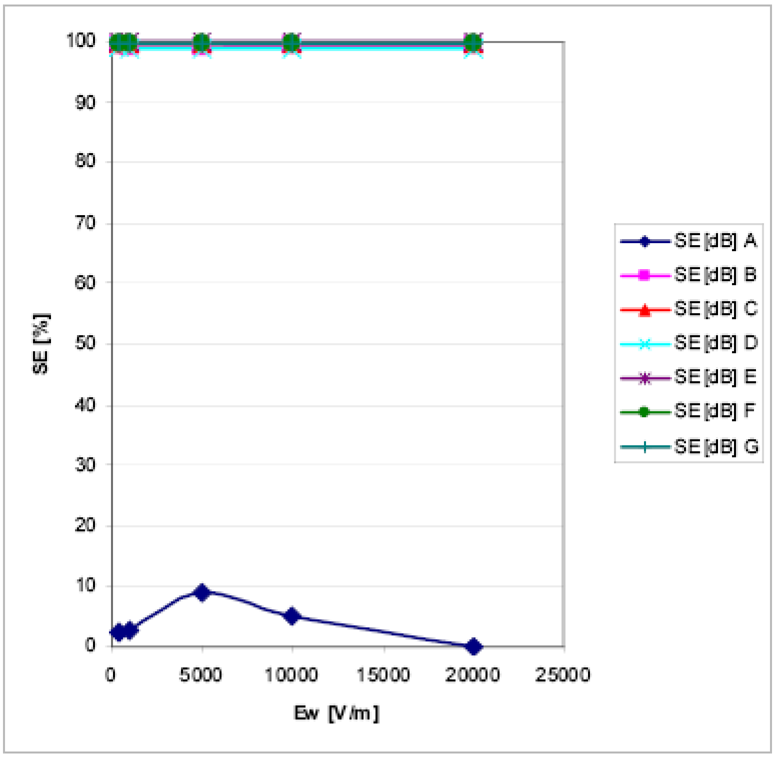
Graph 2. Electric field absorption by insulating materials as function of electric field for RH 50%



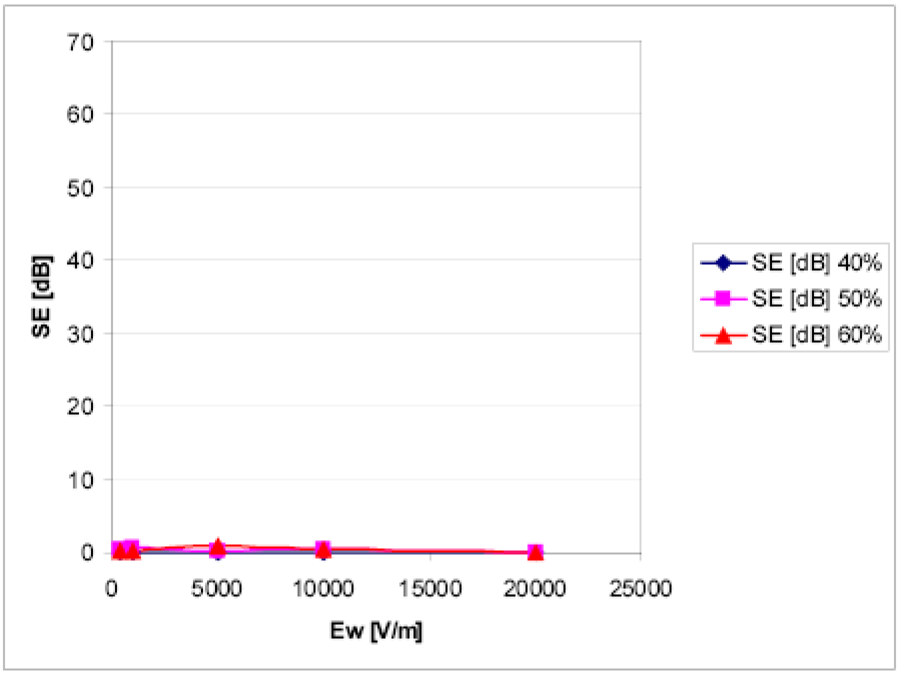


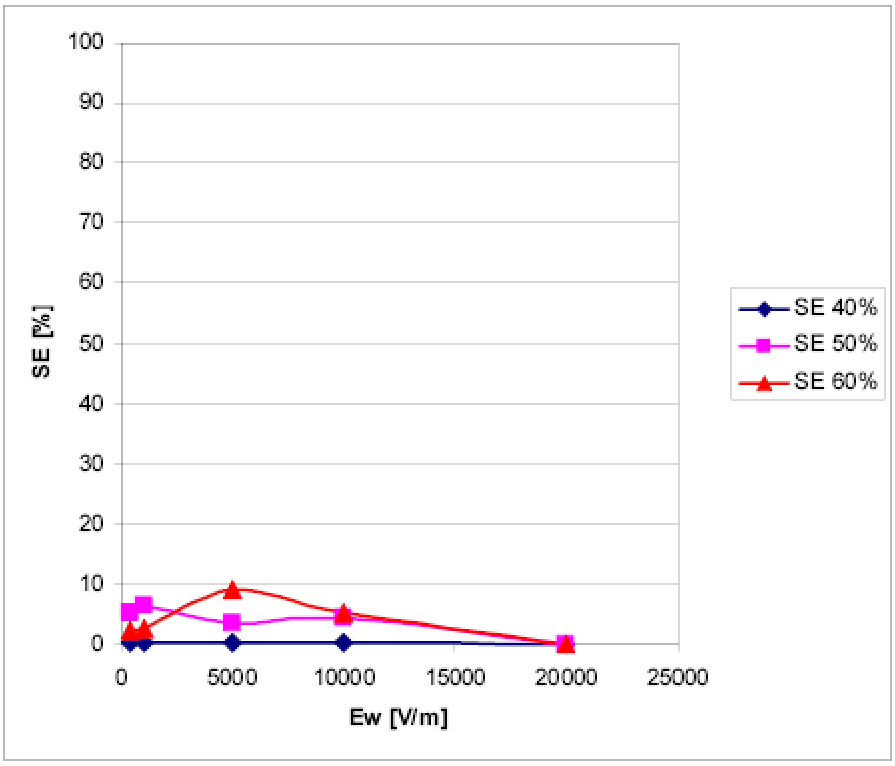
Graph 3. Electric field absorption by insulating materials as function of electric field for RH 60%



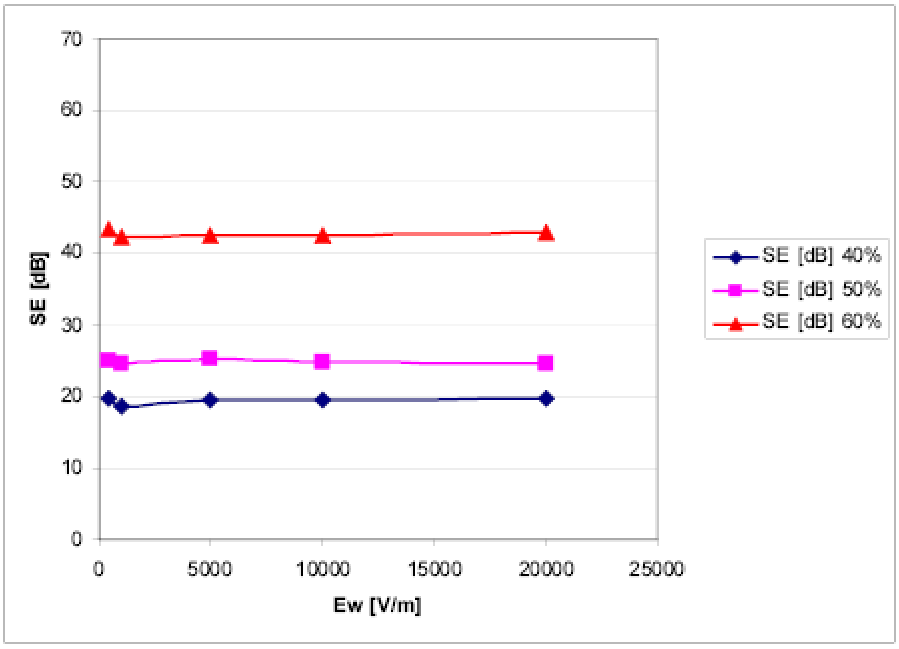


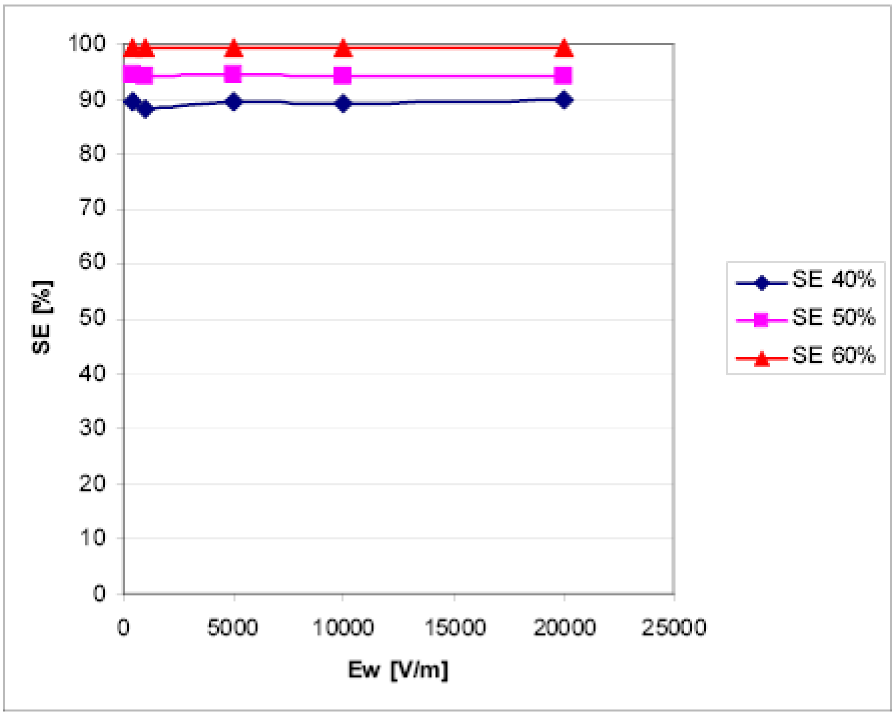
Graph 4. Electric field absorption by insulating materials as function of electric field for RH 40, 50 and 60% for Material A



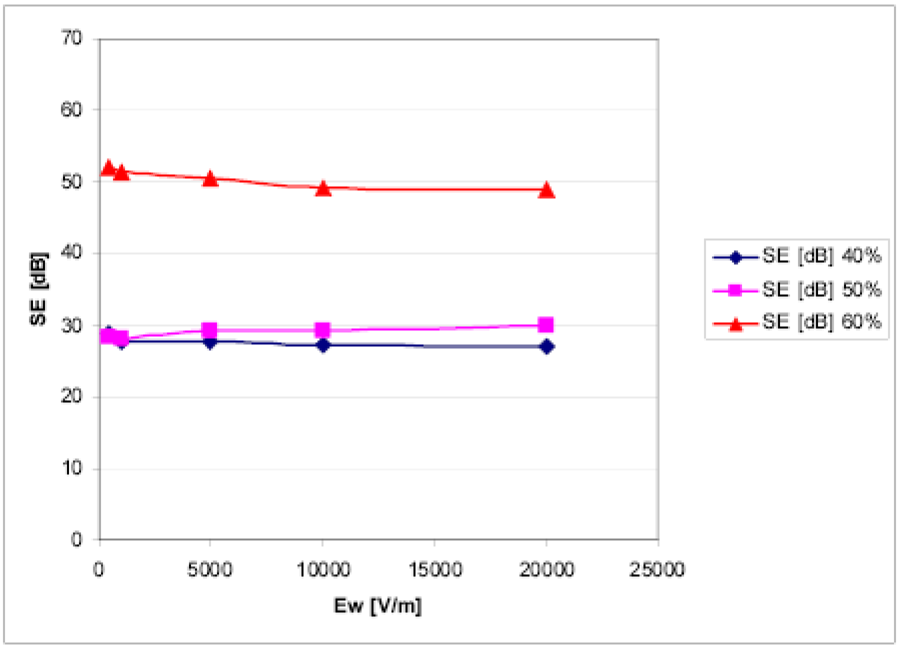


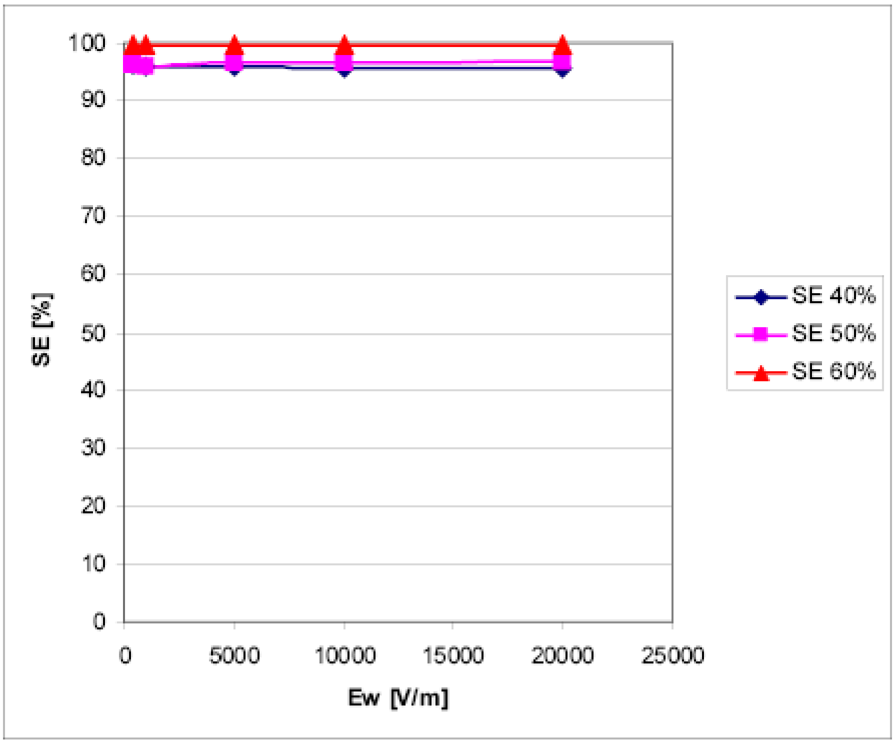
Graph 5. Electric field absorption by insulating materials as function of electric field for RH 40, 50 and 60% for Material B



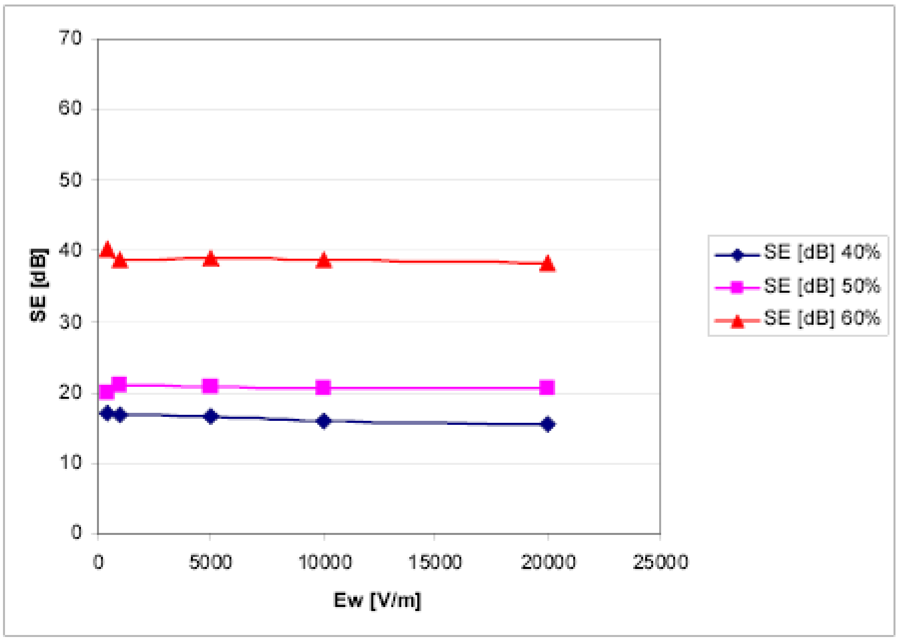


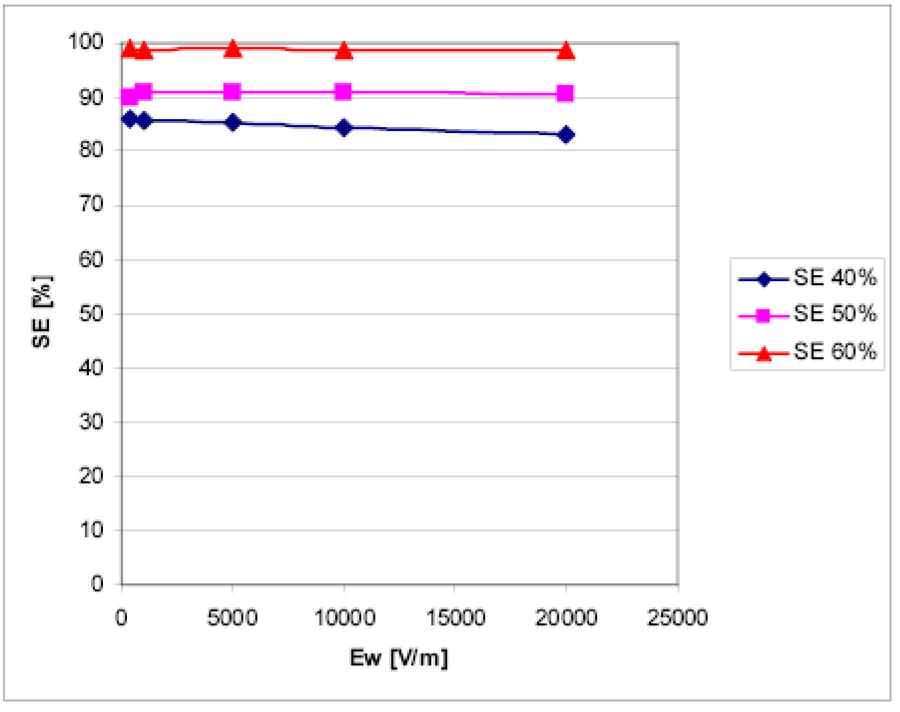
Graph 6. Electric field absorption by insulating materials as function of electric field for RH 40, 50 and 60% for Material C



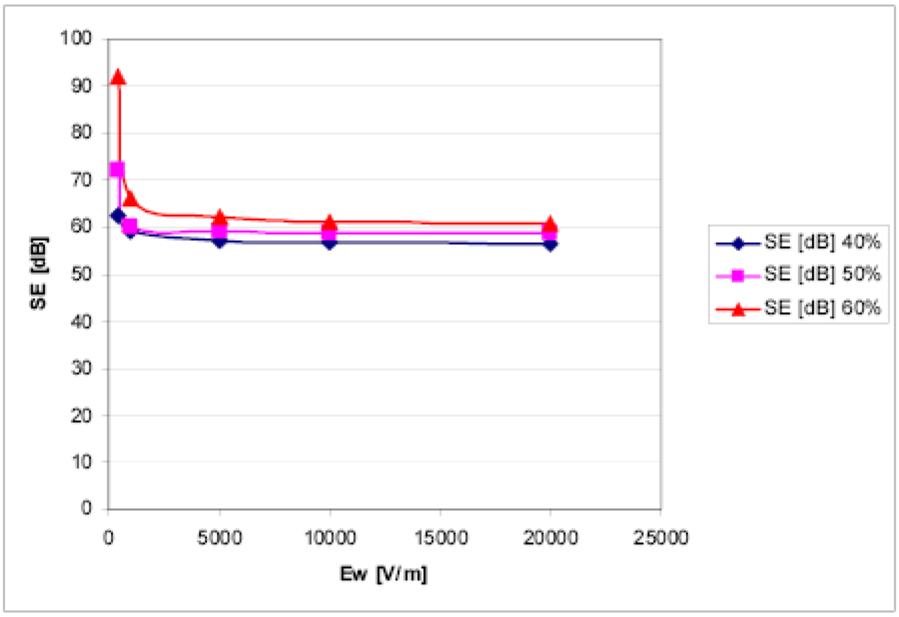


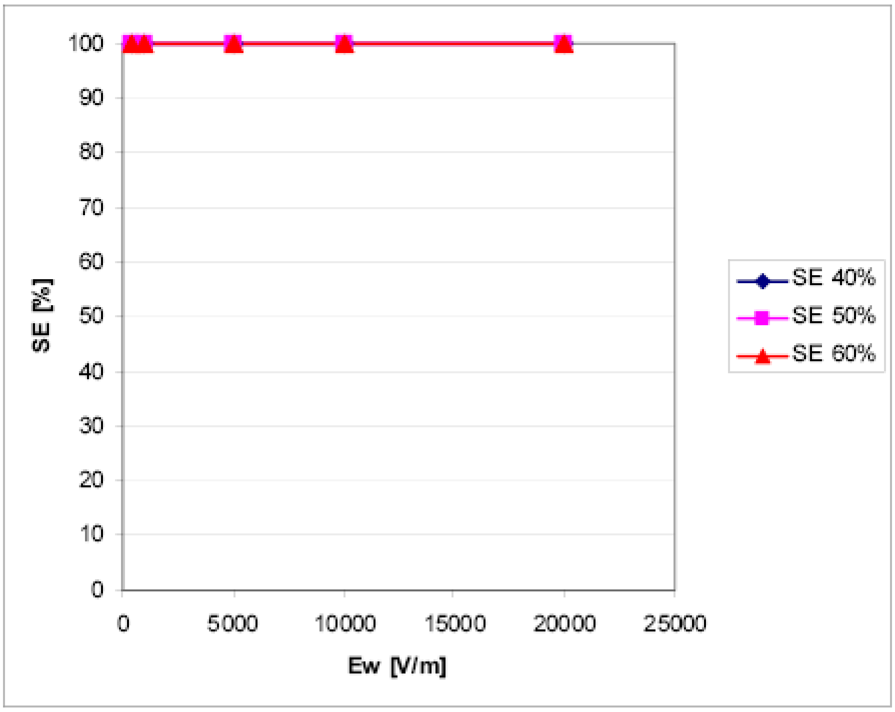
Graph 7. Electric field absorption by insulating materials as function of electric field for RH 40, 50 and 60% for Material D



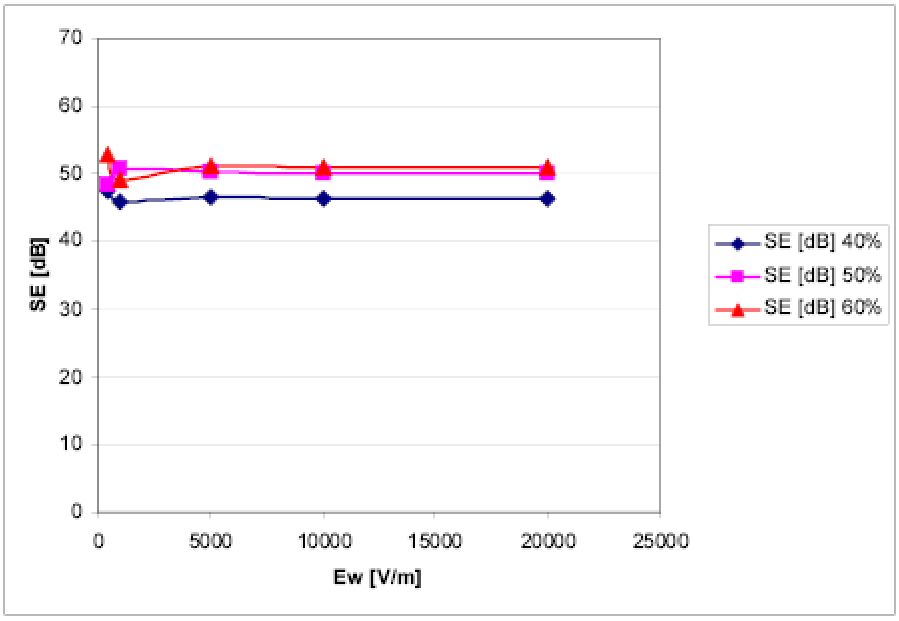


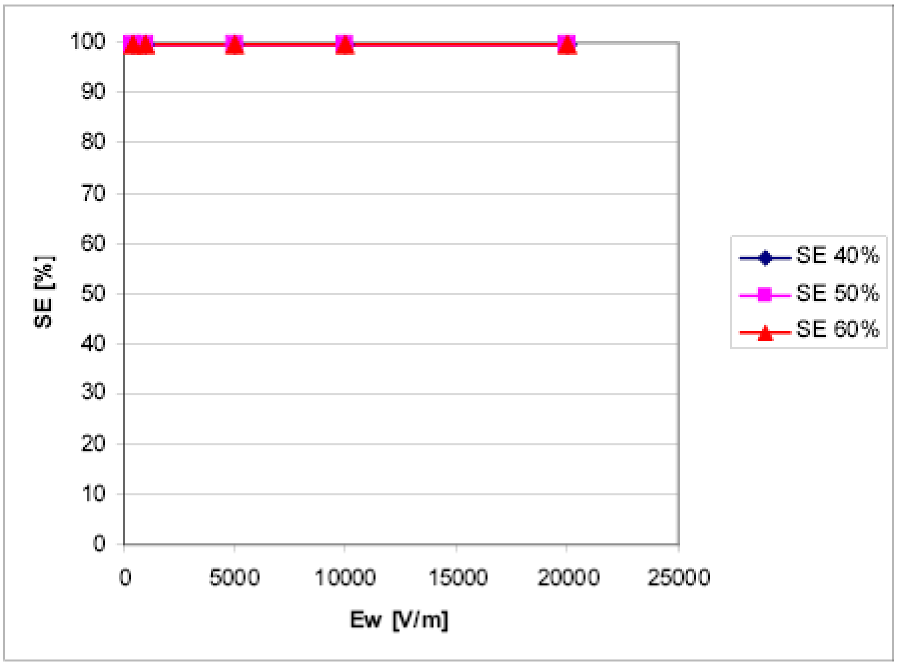
Graph 8. Electric field absorption by insulating materials as function of electric field for RH 40, 50 and 60% for Material E



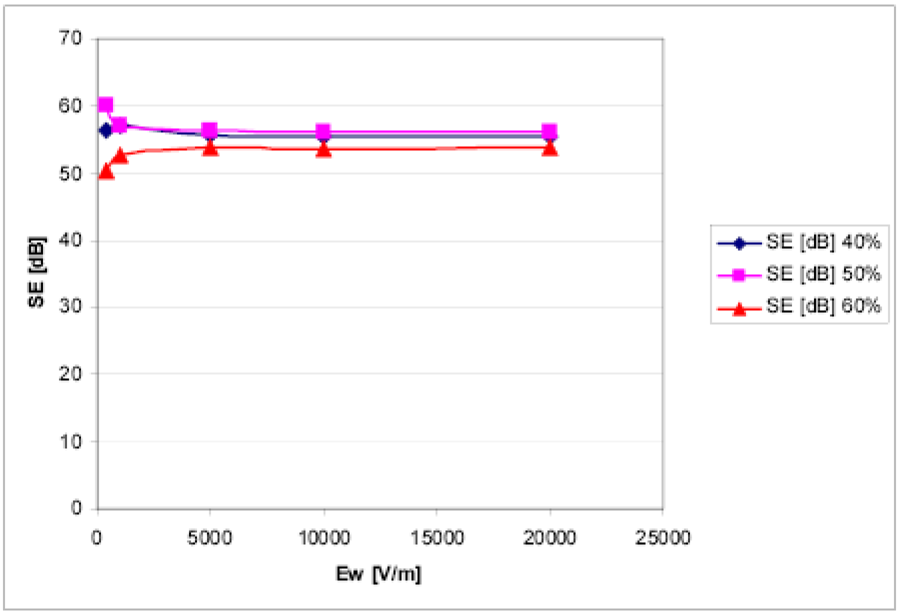


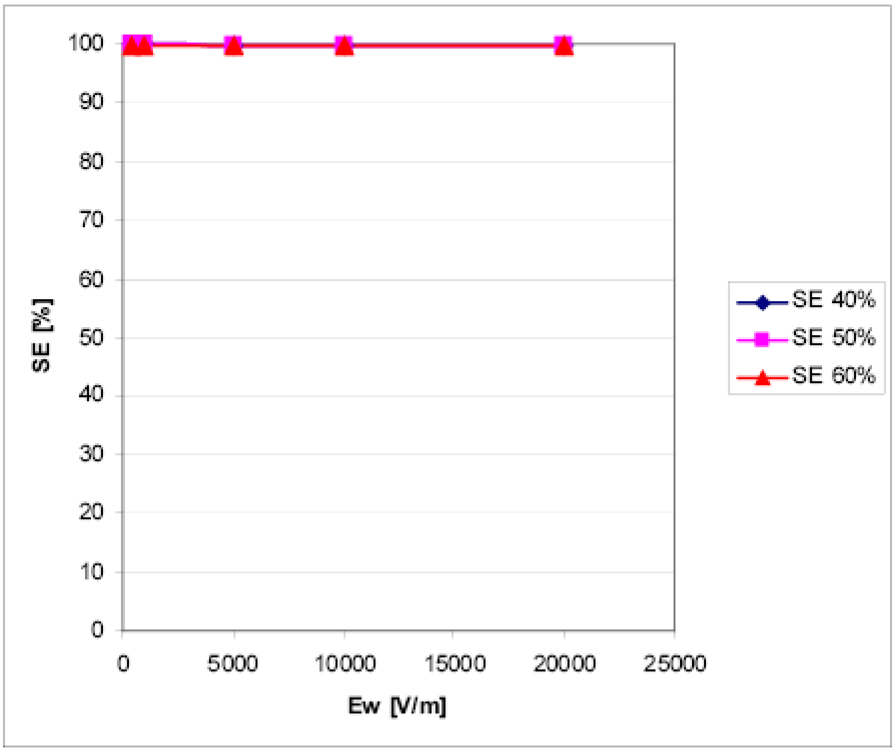
Graph 9. Electric field absorption by insulating materials as function of electric field for RH 40, 50 and 60% for Material F





Graph 10. Electric field absorption by insulating materials as function of electric field for RH 40, 50 and 60% for Material G





6. Evaluation conclusion

Given the results produced by measuring of the 50 Hz electric field strength and the calculated absorption performance of the NoEM Electro Protector materials, it was found that the absorption performance within the tested range of electric field strength is highest for the Test Materials E, F and G and the priming base coat layers in Test Material C.

The absorption performance parameters are better with higher RH, with the exception of the NoEM Electro Protector, 3in1 Electric field shield, Vapour barrier film, 3-ply foil: green plastic foil, which displays virtually constant absorption parameters, since this shielding material is covered with vapour barrier foils on both sides.

For the absorption performance of the NoEM Electro Protector, 2in1 Electric field shield, Vapour barrier foil - yellow plastic foil, absorption effectiveness differs when the exposure to the RH is done from the vapour breathing foil side.

The laminate features the shielding material covered with vapour barrier film on one side and with the vapour breathing film on the other.

The absorption performance of surfaces covered with the priming base coat shows small differences between RH 40% and RH 50%; however, increasing RH to 60% greatly improves the absorption performance.

The tests were made with the electrical field strength above 400 V/m; but take into account, that the absorption performance of the test materials will be comparable or higher at lower electric field strength values.

END OF THE REPORT