

## Test report n° SB-08-080

### Evaluation of VOC and formaldehyde emissions from two 25 µm polyester pre-coated galvanized steel products according to the ECA, AgBB and AFSSET schemes

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**Request by :**

**European Coil Coating Association  
European Profiles and Panels Producers Association  
Rue du Luxembourg 19-21, 1000 Bruxelles  
Belgique**

## OBJECTIVE

The objective of this test is the evaluation of VOC and formaldehyde emissions from two 25 µm polyester pre-coated galvanized steel products according to the ECA, AgBB and AFSSET evaluation schemes.

## FRAMEWORK

According to CSTB quotation n° 26013939.

## TEST SAMPLES

Origin : Pre-coated galvanized steel products, sampled and shipped for testing at CSTB by EPPF/ECCA.

## REFERENCES

- EN ISO 16000-9 : Indoor air – Part 9 : Determination of the emission of volatile organic compounds from building products and furnishing – Emission test chamber method (ISO, 2006).
- EN ISO 16000-11 : Indoor air – Part 11 : Determination of the emission of volatile organic compounds from building products and furnishing – Sampling, storage of samples and preparation of test specimen (ISO, 2006).
- ISO 16000-6 : Indoor air – Part 6 : Determination of volatile organic compounds in indoor and test chamber air by active sampling on Tenax TA sorbent, thermal desorption and gas chromatography using MS/FID (ISO, 2004).
- ISO 16000-3 : Indoor air – Part 3 : Determination of formaldehyde and other carbonyl compounds – Active sampling method (ISO, 2001).

Marne-la-Vallée, November 25, 2008

Engineer,  
in charge of testing

Technician,  
in charge of testing

François MAUPETIT

Céline CANNIER

## 1. Description of test samples

This test report is concerning two 25 µm polyester pre-coated galvanized steel products delivered by EPPF/ECCA:

- ✓ **NOIR PMT normal** sample: 25 µm polyester paint system with a 80/20 polyester/melamine ratio.
- ✓ **BLANC PMT normal** sample: 25 µm polyester paint system with a 85/15 polyester/melamine ratio.

Sample	Reception at CSTB	Test start		Test end
		Test specimen preparation	Introduction in test chamber	
<b>NOIR PMT normal</b>	20/05/2008	10/06/2008; 13h15	10/06/2008; 13h30	08/07/2008; 15h40
<b>BLANC PMT normal</b>	20/05/2008	10/06/2008; 10h30	10/06/2008; 10h55	08/07/2008; 14h30

**Table 1 :** Description of test samples

## 2. Preparation of test specimens

For each tested product, CSTB used the six test portions delivered. Dimensions each test portion was: 0.235 m x 0.17 m. Test portions were fixed back to back using with a low emission adhesive. The effective emitting surface of each test portion was 0.21 m x 0.15 m (0.0315 m<sup>2</sup>). Therefore, the total emitting surface of the test specimen was 0.19 m<sup>2</sup>. The test portions were placed on a stainless steel stand and introduced in the emission test chamber just after preparation.

## 3. Emission test chamber conditions

Just after preparation, test specimens have been introduced in a glass emission test chamber. Testing parameters are presented in Table 2.

Test parameters	Test chamber conditions
Emission test chamber type	CLIMPAQ (glass)
Emission test chamber volume	0.0509 m <sup>3</sup>
Temperature	23 ± 2 °C
Relative humidity	50 ± 5 %
Test specimen surface	0.19 m <sup>2</sup>
Air flow rate	0.24 m <sup>3</sup> .h <sup>-1</sup>
Air exchange rate	4.72 h <sup>-1</sup>
Product loading factor	3.73 m <sup>2</sup> .m <sup>-3</sup>
Area specific air flow rate (q <sub>test</sub> )	1.25 m <sup>3</sup> .m <sup>-2</sup> .h <sup>-1</sup>
Test duration	28 days

**Table 2 :** Testing conditions

#### 4. VOC and aldehydes sampling conditions

VOC and aldehydes active sampling were performed in duplicate by pumping air through respective sorbents just before beginning of the test (day 0), then after  $24 \pm 2$  hours (day 1),  $72 \pm 2$  hours (day 3) and  $28 \pm 2$  days (day 28) after introduction of the test specimen in the emission test chamber. Sampling conditions are presented in Table 3.

Sampling conditions	VOC	Aldehydes
Number of sampled tubes	2	2
Sorbent type	Tenax TA	DNPH
Sampling duration	60 min.	60 min.
Sampling air flow rate	80 ml.min <sup>-1</sup>	750 ml.min <sup>-1</sup>
Sampled air volume	4.8 l	45 l

Table 3 : Sampling conditions

#### 5. VOC and aldehydes measurement method

Sampling and measurements of VOC are performed according to ISO 16000-6. Parameters selected for VOC analyses at CSTB are presented in Table 4.

VOC are identified by mass spectrometry (MS) and quantified by flame ionization detector (FID) using their specific response factor when available or using the toluene response factor (concentrations expressed in toluene equivalent). The total VOC concentration (TVOC) is calculated as the sum of concentrations of all volatile organic compounds eluting between n-hexane and n-hexadecane (included) quantified using the toluene response factor. The TVOC concentration is expressed in toluene equivalent.

Parameters	Analytical conditions
Thermo desorber	Perkin Elmer ATD 400
Desorption temperature	260 °C
Nitrogen flow rate	50 ml.min <sup>-1</sup>
Desorption duration	15 min.
Secondary trap temperature	280 °C
Gas chromatograph / Mass spectrometer	VARIAN GC 3800 / MS Saturn 2000
Temperature cycle	40 °C during 5 min. 2.5 °C / min. up to 170 °C 7.5 °C / min. up to 250 °C 250 °C during 13 min.
Capillary column	DB-5 ms (length : 60 m, internal diameter : 0.25 mm, phase thickness : 1 µm)
FID temperature	270 °C
Mass spectrometer parameters	Trap (MS Saturn 2000) 70 eV 33-425 amu

Table 4 : Analytical conditions for VOC analyses

Sampling and measurements of formaldehyde are performed according to ISO 16000-3. Parameters for their analysis at CSTB are presented in Table 5.

Sampling is performed by pumping on cartridges filled with silica gel coated with 2,4-dinitrophenylhydrazine (DNPH). After sampling, cartridges are eluted in 5 ml acetonitrile. Two 20 µl injections of this elution solution are analyzed by high performance liquid chromatography (HPLC) on a WATERS Alliance system.

Aldehydes are identified and quantified using specific calibration.

Parameters	Analytical conditions
HPLC system	WATERS Alliance
Detection	UV (wave length : 360 nm)
Capillary column	WATERS Novapack C18 (length : 150 mm, internal diameter : 3.9 mm, phase thickness : 4 µm, pore diameter : 60 Å)
Elution flow rate	1.5 ml.mn <sup>-1</sup>
Column temperature	35 °C

**Table 5 :** Analytical conditions for formaldehyde and other carbonyl compounds analyses

## 6. Test results

Test results presented in this report are the arithmetic means of the 2 sampled and analysed samples. Results are corrected from the chamber blank value measured before introduction of the test specimen in the emission test chamber.

Test results are expressed as area specific emission rates ( $SE_{R_a}$ , in  $\mu\text{g}\cdot\text{m}^{-2}\cdot\text{h}^{-1}$ ), calculated according to EN ISO 16000-9:

$$SE_{R_a} = C_{\text{meas}} \cdot q_{\text{test}}$$

where  $C_{\text{meas}}$  are the measured formaldehyde concentrations ( $\mu\text{g}\cdot\text{m}^{-3}$ ) and  $q_{\text{test}}$  the area specific air flow rate during the test (Table 2).

**6.1 NOIR PMT normal sample**

VOC GC	day 1	day 3	day 28
toluene	< 0,4	0,7	< 0,4
m-xylene	0,6	< 0,4	0,3
cyclohexanone	6,5	1,4	< 0,4
2,2,4,6,6-pentamethylheptane	1,4	0,9	< 0,4
2-ethylhexanol	1,3	0,9	0,4
nonanal	1,4	1,1	0,6
decanal	1,1	1,1	0,5
TVOC	17,9	7,4	< 0,4
sum VOC eluting after hexadecane	1,9	2,0	0,6

**Table 6.1.a :** VOC area specific emission rates for the NOIR PMT normal test sample ( $\mu\text{g}\cdot\text{m}^{-2}\cdot\text{h}^{-1}$ )

aldehydes HPLC	day 1	day 3	day 28
formaldehyde	19,3	9,9	6,5
propionaldehyde	< 0,4	0,4	4,4

**Table 6.1.b :** Aldehyde area specific emission rates for the NOIR PMT normal test sample ( $\mu\text{g}\cdot\text{m}^{-2}\cdot\text{h}^{-1}$ )

**6.2 BLANC PMT normal sample**

VOC GC	day 1	day 3	day 28
toluene	< 0,4	< 0,4	3,4
2-butoxyethanol	2,9	4,6	1,1
2,2,4,6,6-pentamethylheptane	1,6	0,8	< 0,4
nonanal	0,7	< 0,4	< 0,4
décanal	0,3	< 0,4	< 0,4
TVOC	8,0	5,0	5,4
sum VOC eluting after hexadecane	< 0,4	< 0,4	< 0,4

**Table 6.2.a :** VOC area specific emission rates for the BLANC PMT normal test sample ( $\mu\text{g}\cdot\text{m}^{-2}\cdot\text{h}^{-1}$ )

aldehydes HPLC	day 1	day 3	day 28
formaldehyde	22,5	16,0	9,6
propionaldehyde	< 0,4	< 0,4	6,1
pentanal (valeraldehyde)	< 0,4	0,5	1,0

**Table 6.2.b :** Aldehyde area specific emission rates for the BLANC PMT normal test sample ( $\mu\text{g}\cdot\text{m}^{-2}\cdot\text{h}^{-1}$ )

## 7. Health-related evaluation of VOC and formaldehyde emissions

For the health-related evaluation of VOC and formaldehyde emissions from building products according to the ECA, AgBB and AFSSET protocols, exposure concentrations in a model room ( $C_{exp}$ ) are calculated from area specific emission rates:

$$C_{exp} = SER_a / q_{scenario}$$

where  $SER_a$  are the area specific emission rates ( $\mu\text{g}\cdot\text{m}^{-2}\cdot\text{h}^{-1}$ ) and  $q_{scenario}$  the area specific air flow rate for the selected conventional evaluation scenario in the model room described in EN ISO 16000-9 (here, "ceiling / flooring" scenario:  $q_{scenario} = 1.25 \text{ m}^3\cdot\text{m}^{-2}\cdot\text{h}^{-1}$ ).

### 7.1 NOIR PMT normal sample

VOC GC	day 1	day 3	day 28
toluene	< 0,3	0,6	< 0,3
m-xylene	0,5	< 0,3	0,3
cyclohexanone	5,2	1,2	< 0,3
2,2,4,6,6-pentamethylheptane	1,1	0,7	< 0,3
2-ethylhexanol	1,1	0,8	0,4
nonanal	1,1	0,9	0,5
decanal	0,9	0,9	0,4
TVOC	14,3	5,9	< 0,3
sum VOC eluting after hexadecane	1,5	1,6	0,5

**Table 7.1.a :** VOC exposure concentrations in the model room for the NOIR PMT normal test sample ( $\mu\text{g}\cdot\text{m}^{-3}$ )

aldehydes HPLC	day 1	day 3	day 28
formaldehyde	15,4	7,9	5,2
propionaldehyde	> 0,3	0,3	3,5

**Table 7.1.b :** Aldehyde exposure concentrations in the model room for the NOIR PMT normal test sample ( $\mu\text{g}\cdot\text{m}^{-3}$ )

**7.1.1 Evaluation according to the ECA-IAQ protocol (1997)**

Days	Parameters	Limit values	Exposure concentrations	Compliance
day 1	Sum C1	25	not detected	Yes
day 3	TVOC	5000	5.9	Yes
day 28	TVOC	200	< 0.3	Yes
day 28	Sum C1	2,5	not detected	Yes
day 28	Ci > 5	LCI		
	formaldehyde	10	5.2	
day 28	R = Ci / LCI	1	0.52	Yes
day 28	Sum Cni > 5	20	0	Yes
<b>Compliance with ECA protocol</b>				<b>Yes</b>

**Table 7.1.1 :** Evaluation of NOIR PMT normal emissions according to the ECA-IAQ protocol

VOC and formaldehyde emissions from the NOIR PMT normal comply with requirements of the ECA-IAQ protocol (1997).

**7.1.2 Evaluation according to the AgBB protocol (2008)**

Days	Parameters	Limit values	Exposure concentrations	Compliance
day 3	TVOC	10000	5.9	Yes
day 3	Sum C1, C2	10	not detected	Yes
day 28	TVOC	1000	< 0.3	Yes
day 28	Sum C1, C2	1	not detected	Yes
day 28	Ci > 5	LCI		
day 28	R = Ci / LCI	1	0	Yes
day 28	Sum Cni > 5	100	0	Yes
<b>Compliance with AgBB protocol</b>				<b>Yes</b>

**Table 7.1.2 :** Evaluation of NOIR PMT normal emissions according to the AgBB protocol

VOC and formaldehyde emissions from the NOIR PMT normal comply with requirements of the AgBB protocol (2008).



**7.1.3 Evaluation according to the AFSSET protocol (2006)**

Days	Parameters	Limit values	Exposure concentrations	Compliance
day 3	TVOC	10000	5.9	Yes
day 3	Sum C1, C2	10	not detected	Yes
day 28	TVOC	1000	< 0.3	Yes
day 28	Sum C1, C2	1	not detected	Yes
day 28	Ci > 5	LCI		
	formaldehyde	10	5.2	
day 28	R = Ci / LCI	1	0.52	Yes
day 28	Sum Cni > 5	100	0	Yes
<b>Compliance with AFSSET protocol</b>				<b>Yes</b>

**Table 7.1.3 :** Evaluation of NOIR PMT normal emissions according to the AFSSET protocol

VOC and formaldehyde emissions from the NOIR PMT normal comply with requirements of the AFSSET protocol (2006).

**7.2 BLANC PMT normal sample**

VOC GC	day 1	day 3	day 28
toluene	< 0,3	< 0,3	2,8
2-butoxyethanol	2,3	3,7	0,9
2,2,4,6,6-pentamethylheptane	1,3	0,6	< 0,3
nonanal	0,6	< 0,3	< 0,3
décanal	0,3	< 0,3	< 0,3
TVOC	6,4	4,0	4,3
sum VOC eluting after hexadecane	< 0,3	< 0,3	< 0,3

**Table 7.2.a :** VOC exposure concentrations in the model room for the BLANC PMT normal test sample ( $\mu\text{g.m}^{-3}$ )

aldehydes HPLC	day 1	day 3	day 28
formaldehyde	18,0	12,8	7,7
propionaldehyde	< 0,3	< 0,3	4,9
pentanal (valeraldehyde)	< 0,3	0,4	0,8

**Table 7.2.b :** Aldehyde exposure concentrations in the model room for the BLANC PMT normal test sample ( $\mu\text{g.m}^{-3}$ )

**7.2.1 Evaluation according to the ECA-IAQ protocol (1997)**

Days	Parameters	Limit values	Exposure concentrations	Compliance
day 1	Sum C1	25	not detected	Yes
day 3	TVOC	5000	4.0	Yes
day 28	TVOC	200	4.3	Yes
day 28	Sum C1	2,5	not detected	Yes
day 28	Ci > 5	LCI		
	formaldehyde	10	7.7	
day 28	R = Ci / LCI	1	0.77	Yes
day 28	Sum Cni > 5	20	0	Yes
<b>Compliance with ECA protocol</b>				<b>Yes</b>

**Table 7.2.1 :** Evaluation of BLANC PMT normal emissions according to the ECA-IAQ protocol

VOC and formaldehyde emissions from the BLANC PMT normal comply with requirements of the ECA-IAQ protocol (1997).

**7.2.2 Evaluation according to the AgBB protocol (2008)**

Days	Parameters	Limit values	Exposure concentrations	Compliance
day 3	TVOC	10000	4.0	Yes
day 3	Sum C1, C2	10	not detected	Yes
day 28	TVOC	1000	4.3	Yes
day 28	Sum C1, C2	1	not detected	Yes
day 28	Ci > 5	LCI		
day 28	R = Ci / LCI	1	0	Yes
day 28	Sum Cni > 5	100	0	Yes
<b>Compliance with AgBB protocol</b>				<b>Yes</b>

**Table 7.2.2 :** Evaluation of BLANC PMT normal emissions according to the AgBB protocol

VOC and formaldehyde emissions from the BLANC PMT normal comply with requirements of the AgBB protocol (2008).

**7.2.3 Evaluation according to the AFSSET protocol (2006)**

Days	Parameters	Limit values	Exposure concentrations	Compliance
day 3	TVOC	10000	4.0	Yes
day 3	Sum C1, C2	10	not detected	Yes
day 28	TVOC	1000	4.3	Yes
day 28	Sum C1, C2	1	not detected	Yes
day 28	Ci > 5	LCI		
	formaldehyde	10	7.7	
day 28	R = Ci / LCI	1	0.77	Yes
day 28	Sum Cni > 5	100	0	Yes
<b>Compliance with AFSSET protocol</b>				<b>Yes</b>

**Table 7.2.3 :** Evaluation of BLANC PMT normal emissions according to the AFSSET protocol

VOC and formaldehyde emissions from the BLANC PMT normal comply with requirements of the AFSSET protocol (2006).