

# BRE Global Test Report

## EN 45545-2: 2013 specific tests for requirement set R7 on Graphene Enhanced Top Coat MT on Fibreboard

**Prepared for:** Blocksil Ltd  
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## 1 Objective

To evaluate the sample described in Section 2 when subjected to the tests required in Table 5 – Requirement Set R1 of EN 45545-2: 2013 Railway applications – Fire protection on railway vehicles – Part 2: Requirements for the fire behaviour of materials and components<sup>(1)</sup>.

## 2 Sample

### 2.1 Traceability

The test samples were supplied by the test sponsor. BRE Global was not involved in the sample selection process and therefore cannot comment upon the relationship between samples supplied for test and the product supplied to market. The test results apply to the sample as received.

### 2.2 Sample Details

Unless otherwise stated all measurements are nominal.

Test Sponsor	Blocksil Ltd, Cathedral House, 5 Beacon Street, Lichfield, WS13 7AA, UK
Manufacturer of sample	This information has been provided and is held on file in confidence at the request of the test sponsor.
Sample name/reference	Graphene Enhanced Top Coat MT
Sample description (as provided by test sponsor/manufacturer)	Graphene enhanced hybrid polymer roof coating The test sponsor's product description is reproduced in Appendix A. Further product description details have been provided and have been held on file in confidence at the request of the test sponsor.
Description of specimens (as received)	Grey coating on calcium silicate board
Mean thickness (mm)	12.2
Mean weight per unit area (kg/m <sup>2</sup> )	12.9
Test face	Coated face
Sample receipt date	01 July 2020(BRE Sample Ref E12896/7/8)

## 3 Conditioning

The specimens were conditioned as required by the standards.



## 4 ISO 5658-2 Spread of flame test

### 4.1 Objective

To determine the lateral spread of flame characteristics of the sample described in Section 2, in accordance with the test method defined in ISO 5658-2<sup>(2)</sup> as specified in EN 45545-2 test ref. T02.

### 4.2 Details of test

Test Date	23 July 2020
Test format	No Air Gap

### 4.3 Results

#### 4.3.1 Flame spread data

Observed ignition time, extinction time, duration of test, final spread of flame for each specimen and time to reach each reference point.

Flame spread distance (mm)	Flame spread times:					
	Test 1		Test 2		Test 3	
	minutes	seconds	minutes	seconds	minutes	seconds
50	0	27	0	40	0	25
100	1	27	1	33	1	29
150	1	54	1	58	2	19
200	2	24	2	37	3	06
250	3	10	3	32	4	02
300			4	35	6	08
350						
Maximum flame spread (mm)	260		310		300	
Time to ignition (minutes : seconds)	0	27	0	40	0	25
Flaming ceased (minutes : seconds)	05	10	05	38	06	32
Test stopped (minutes : seconds)	15	15	15	45	16	40



### 4.3.2 Observations

Run 1 –	No significant observations
Run 2 –	No significant observations
Run 3 –	No significant observations

### 4.4 Derived fire characteristics

Derived fire characteristics for each specimen as defined in the objective.

Criteria	Specimen			
	1	2	3	Average
<b>Critical Flux at Extinguishment (kW/m<sup>2</sup>)</b> <i>CFE</i>	<b>36.42</b>	<b>30.01</b>	<b>31.31</b>	<b>32.58</b>
Average Heat for sustained burning (MJ/m <sup>2</sup> ) <i>Qsb</i>	6.262	7.245	8.817	7.441

NOTE – If the heat of sustained burning is undefined for all three specimens, *Qsb* is undefined and the criterion of *Qsb* is deemed to have been met



## 5 ISO 5660-1 Heat release rate (cone calorimeter method) test

### 5.1 Objective

To assess the performance of the sample described in Section 2 when subjected to the heat release rate (cone calorimeter method) test specified in ISO 5660-1<sup>(3)</sup> as specified in EN 45545-2 test ref. T03.01.

### 5.2 Details of test

Test Date	13 July 2020
Specimen preparation	The sample was prepared in accordance with the test standard.
Description of substrate and fixing:	None
Jointing details	None

### 5.3 Results

#### 5.3.1 Ambient laboratory conditions

Run number	BREG specimen No.	Relative humidity (%)	Ambient temperature (°C)
1	E12897-1	43.9	22.6
2	E12897-2	38.7	24.7
3	E12897-3	40.4	25.1

#### 5.3.2 Tabulated data

Face subjected to test: Coated face

Wire grid used: No

Test orientation: Horizontal

Retainer frame used: Yes

Exposed specimen area: 0.008836m<sup>2</sup>

Exhaust system flow rate (Nominal): 0.024 m<sup>3</sup>/s

Frequency of measurement: 2s

Orifice constant, C: 0.037212 m<sup>1/2</sup>.g<sup>1/2</sup>.K<sup>1/2</sup>

Operator: M J Walford

Distance between the bottom surface of the cone heater and the top of the specimen: 25 mm

Any special mounting procedures: None

Deviations from the test standard: None

Difficulties encountered in testing: None

**Table 1: Irradiance 50 kW/m<sup>2</sup> (3 test runs)**

Specimen number	Thickness  (mm)	Time to ignition  $t_{ig}$  (s)	Time to end of test  (s)	Test Duration  (s)	Total HRR  $Q_{A,tot}$  (MJ/m <sup>2</sup> )	MARHE  (kW/m <sup>2</sup> )
1	12.2	113	1200	1087	5.6	14.75
2	12.1	111	1200	1089	6.3	14.93
3	12.1	108	1200	1092	5.8	16.75
<b>Mean Value</b>	<b>12.1</b>	<b>111</b>	<b>1200</b>	<b>1089</b>	<b>5.9</b>	<b>15.48</b>

Specimen number	60s mean  $\dot{q}_{A,60}$  (kW/m <sup>2</sup> )	180s mean HRR  $\dot{q}_{A,180}$  (kW/m <sup>2</sup> )	300s mean HRR  $\dot{q}_{A,300}$  (kW/m <sup>2</sup> )	Maximum HRR  $\dot{q}_{A,max}$  (kW/m <sup>2</sup> )	Average  $\Delta h_{c,eff}$  (MJ/kg)	Average MLR between 10 and 90 % mass loss  $\dot{m}_{A,10-90}$  (g/m <sup>2</sup> s)
1	41.14	15.51	10.17	66.44	3.19	1.83
2	38.90	15.95	11.25	63.01	3.63	1.77
3	42.64	17.88	12.41	70.66	3.44	1.70
<b>Mean value</b>	<b>40.89</b>	<b>16.45</b>	<b>11.28</b>	<b>66.70</b>	<b>3.42</b>	<b>1.77</b>

Specimen number	Initial Mass  $m$  (g)	Mass at sustained flaming  $m_s$  (g)	Final Mass  $m_f$  (g)	Total mass Loss  $\Delta m$  (g/m <sup>2</sup> )	Average rate of mass loss  $\dot{m}$  (g/m <sup>2</sup> s)	Total of Mass Pyrolysed  (%)
1	124.20	123.00	107.64	1739	1.59	13
2	124.72	123.70	108.49	1721	1.57	13
3	124.97	124.00	108.97	1701	1.57	13
<b>Mean value</b>	<b>124.63</b>	<b>123.57</b>	<b>108.37</b>	<b>1720</b>	<b>1.58</b>	<b>13</b>

**MAHRE = 15.5 kW/m<sup>2</sup>**





## Key to symbols

- $t_{ig}$  Time to ignition (onset of sustained flaming), expressed in seconds.
- $Q_{A,tot}$  Total heat released per unit area during the entire test, expressed in mega joules per square metre.
- ARHE The average rate of heat emission at time  $t$ , expressed in kilowatts per unit area. Calculated as the cumulative heat emission from  $t = 0$  to  $t = t$  divided by  $t$  and given by the following equation (reference EN 45545-2 Clause 5).

$$ARHE(t_n) = \frac{\sum_{n=2}^n (t_n - t_{n-1}) \times \frac{\dot{q}_n + \dot{q}_{n-1}}{2}}{t_n - t_{n-1}}$$

Where  $\dot{q}$  is the heat release per unit area and  $t$  is the time.

MARHE The maximum value of ARHE, expressed in kilowatts per unit area.

$\dot{q}_{A,60}$ ,  $\dot{q}_{A,180}$  and  $\dot{q}_{A,300}$  Average heat release rate per unit area over a period starting at  $t_{ig}$  and ending 60 s, 180 s or 300 s later respectively, expressed in kilowatts per square metre.

$\dot{q}_{A,max}$  Maximum value of the heat release rate per unit area, expressed in kilowatts per square metre.

$\Delta h_{c,eff}$  Effective net heat of combustion expressed in mega joules per kilogram.

$\dot{m}_{A,10-90}$  Average mass loss rate per unit area between 10 % and 90 % of mass loss, expressed in grams per square metre seconds.

$m_s$  Mass at sustained flaming, expressed in grams.

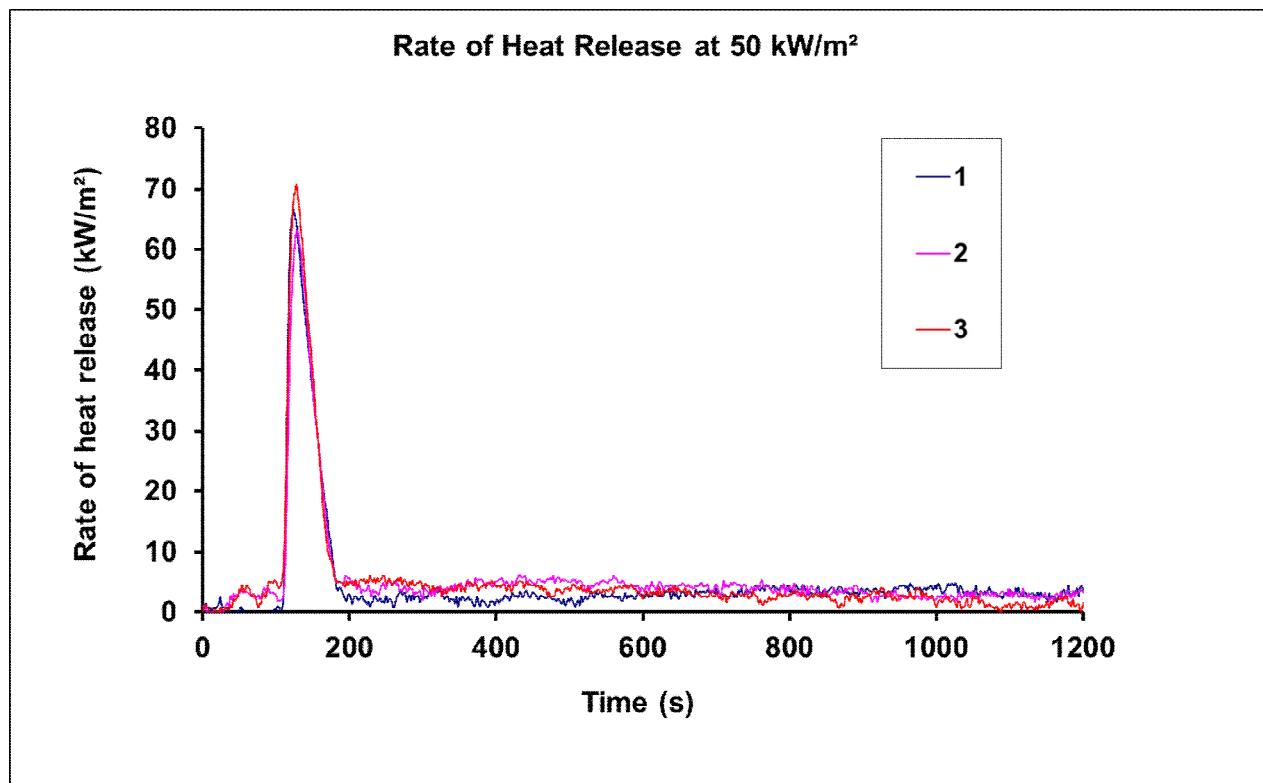
$m_r$  Mass remaining after the test, expressed in grams.

$\Delta m$  Sample mass loss, expressed in grams per square metre.

$\dot{m}$  Average rate of specimen mass loss calculated between  $t_{ig}$  and the end of the test, expressed in grams per square metre seconds.



### 5.3.3 Graphical data



### 5.3.4 Observations

Specimen No.	Additional observations
1-3	8-10s – Smoke produced 72-85s – Surface starts to bubble 108-113s – Specimen ignites. Flaming all over surface 137-141s – Flaming starts to reduce 158-160s – Flaming at edges only



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## 6 EN ISO 5659-2 Smoke and Toxicity Tests

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### 6.1 Objective

To assess the performance of the sample described in Section 2 when subjected to smoke and toxicity test specified in EN 45545-2 Annex C Method 1 and EN ISO 5659-2<sup>(4)</sup>.

### 6.2 Details of test

The test was conducted in accordance with the procedures specified in EN 45545-2: Annex C Method 1 and EN ISO 5659-2 as specified in EN 45545-2 test refs T10.04 and T11.01.

All gas concentrations were determined by an FTIR system, as described in Annex C of EN 45545 2.

One sample measuring 75mm x 75mm was tested at irradiance 50kW/m<sup>2</sup> in non-flaming mode only. The sampling of the evolved gases was undertaken at 4 minutes and 8 minutes.

Test Date	10 July 2020
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### 6.3 Equipment identification

Smoke Chamber IN3714, FT-IR Omnic and TQ Analyst Software



## 6.4 Results

### Condition: 50kW/m<sup>2</sup> no flame

#### 6.4.1 Toxicity results at 4 minutes (EN 45545-2 Annex C Method 1)

Gases	Measured <sup>[1]</sup> Conc. (µL/L)	Calculated <sup>[2]</sup> C <sub>n</sub> (kg/m <sup>3</sup> )	Ref. Conc. <sup>[3]</sup> C <sub>i</sub> (mg/m <sup>3</sup> )	Individual* CIT <sub>G</sub>
HCl	41	0.0000507	75	0.054
HCN	0	0.0000000	55	0.000
HBr	0	0.0000000	99	0.000
HF	0	0.0000000	25	0.000
SO <sub>2</sub>	0	0.0000000	262	0.000
NO <sub>x</sub> <sup>[4]</sup>	0	0.0000000	38	0.000
CO	97	0.0000924	1380	0.005
CO <sub>2</sub>	183	0.0002736	72000	0.000
<b>CIT<sub>G</sub> =</b>				<b>0.06</b>

#### 6.4.2 Toxicity results at 8 minutes (EN 45545-2 Annex C Method 1)

Gases	Measured <sup>[1]</sup> Conc. (µL/L)	Calculated <sup>[2]</sup> C <sub>n</sub> (kg/m <sup>3</sup> )	Ref. Conc. <sup>[3]</sup> C <sub>i</sub> (mg/m <sup>3</sup> )	Individual* CIT <sub>G</sub>
HCl	58	0.0000721	75	0.077
HCN	0	0.0000000	55	0.000
HBr	0	0.0000000	99	0.000
HF	0	0.0000000	25	0.000
SO <sub>2</sub>	0	0.0000000	262	0.000
NO <sub>x</sub> <sup>[4]</sup>	0	0.0000000	38	0.000
CO	274	0.0002603	1380	0.015
CO <sub>2</sub>	327	0.0004861	72000	0.001
<b>CIT<sub>G</sub> =</b>				<b>0.09</b>

[1] Concentration measured in the EN ISO 5659-2 chamber at 4 minutes

[2] Concentration adjusted for pressure/temperature, calculated in accordance with EN 45545-2 Clause C.9 used to calculate CIT<sub>G</sub> in Clause C.16.2

[3] Reference concentrations given in EN 45545-2 Table C.1

[4] NO<sub>x</sub> includes both NO<sub>2</sub> and NO quoted as NO<sub>2</sub>

The Limit of Quantification (LOQ) for CO<sub>2</sub> = 150 PPM

The Limit of Quantification (LOQ) for CO = 20 PPM

The Limit of Quantification (LOQ) for HF and SO<sub>2</sub> = 5 PPM

The Limit of Quantification (LOQ) for HBr and NO = 15 PPM

The Limit of Quantification (LOQ) for HCN and HCl = 10 PPM

The Limit of Quantification (LOQ) for NO<sub>2</sub> = 10 PPM



### 6.4.3 Smoke results at 50kW/m<sup>2</sup> no pilot flame (EN ISO 5659-2)

Test	<i>D<sub>s</sub>max</i>	<i>D<sub>s</sub>(1)</i>	<i>D<sub>s</sub>(2)</i>	<i>D<sub>s</sub>(3)</i>	<i>D<sub>s</sub>(4)</i>	<i>VOF<sub>4</sub></i>
1	<b>166.65</b>	4.742	33.23	113.9	144.00	223.872
2	<b>173.28</b>	6.449	37.93	123.4	153.19	244.374
3	<b>180.39</b>	4.799	28.87	110.2	148.19	217.964
Average	<b>173.4</b>				148.5	228.7

### 6.4.4 Observations during Test

Test	Initial specimen mass (g)	Observations
1	71.6585	The specimen did not ignite
2	72.4926	The specimen did not ignite
3	71.4994	The specimen did not ignite

	Test 1	Test 2	Test 3
<b>Initial mass of the specimen</b>	71.6585	72.4926	71.4994
<b>Mass of foil</b>	0.4955	0.4883	0.5013
<b>Mass of burnt specimen in foil</b>	64.6528	65.3187	64.7779
<b>Mass lost</b>	7.5012	7.6622	7.2228
<b>Final mass of specimen</b>	64.1573	64.8304	64.2766



## 7 Criteria

The specification given in of Table 5 of EN 45545-2 for Material Requirement Set R7 are:

Test method (EN 45545-2 Test ref.)	Parameter and unit	Maximum or minimum	HL1	HL2	HL3
ISO 5658-2 (T02)	CFE kWm <sup>-2</sup>	Minimum	20	20	20
ISO 5660-1 50kW/m <sup>2</sup> (T03.01)	MARHE kWm <sup>-2</sup>	Maximum	-	90	60
EN ISO 5659-2 50kW/m <sup>2</sup> (T10.01)	D <sub>smax</sub> dimensionless	Maximum	-	600	300
EN ISO 5659-2 50kW/m <sup>2</sup> (T11.01)	CIT <sub>G</sub> dimensionless	Maximum	-	1.8	1.5

## 8 Conclusion

The sample described in Section 2 of this report, when subjected to the tests required for Material Requirement Set R7 as given in of Table 5 of EN 45545-2: 2013 satisfied the criteria for:

### Hazard Level HL3

## 9 Validity

The test results relate only to the behaviour of the test specimens of the product under the particular conditions of these tests; they are not intended to be the sole criterion for assessing the potential fire hazard of the product in use.

The information in section 2.2 and Appendix A of this report, other than that indicated otherwise, has been supplied by the test sponsor and has not been independently verified by BRE Global. The validity of the results is conditional on the accuracy of that data.



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## 10 References

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- 1 EN 45545-2: 2013 Railway applications - Fire protection of railway vehicles - Part 2: Requirements for fire behaviour of materials and components. CEN Avenue Marnix 17, B-1000 Brussels, Belgium.
- 2 ISO 5658-2: 2006. Reaction to fire tests - Spread of flame - Part 2: Lateral spread on building and transport products in vertical configuration. ISO, Geneva, Switzerland.
- 3 ISO 5660-1: 2015. Reaction to fire tests – Heat release, smoke production and mass loss rate – Part 1: Heat release rate (cone calorimeter method). ISO, Geneva, Switzerland.
- 4 EN ISO 5659-2: 2012 (Incorporating corrigendum March 2013) Plastics - Smoke generation: Part 2: Determination of optical density by a single-chamber test. CEN Avenue Marnix 17, B-1000 Brussels, Belgium.



## 11 Appendix A

Test sponsor (Company name and address): Blocksil Limited	
Parameter	Details (if applicable)
Trade name	Graphene Enhanced Top Coat MT
General description	Graphene enhanced hybrid polymer roof coating
Name and address of manufacturer of product	Note 1
Place of manufacture	Note 1
Product reference/number	Graphene Enhanced Top Coat MT
Thickness	Approx. 11.3mm
Density	950kg per cubic metre fibreboard & 1.25kg per litre coating
Mass per unit area	Approx. 10.86 kg per square metre
Generic type of product	Roof Coating
Flame retardant treatment added or organic content limited during production (yes/no), if yes give details	Yes.12% Aluminium Trihydrate
Harmonised EN product standard, and AVCP System No. if applicable	N/A
Industry/in-house product standard, if applicable	N/A
Interior facing 1 (test face) <ul style="list-style-type: none"> <li>- Generic type</li> <li>- Product reference</li> <li>- Manufacturer</li> <li>- Thickness</li> <li>- Mass per unit area/ density</li> <li>- Colour reference</li> <li>- Trade name flame retardant</li> <li>- Generic type flame retardant</li> <li>- Amount flame retardant</li> </ul>	Roof Coating Graphene Enhanced Top Coat MT Note 1 250 to 300 microns Approx. 0.42kg per square metre of coating Goosewing Grey N/A Aluminium Trihydrate 12%
Substrate (if applicable) <ul style="list-style-type: none"> <li>- Generic type</li> <li>- Product standard</li> <li>- Product name/reference</li> <li>- Manufacturer</li> <li>- Thickness</li> <li>- Density or mass per unit area</li> <li>- Class (EN 13501-1)</li> </ul>	Fibreboard Tested to BS476-4 and EN3501-1 SUPALUX Promat UK Limited Approx. 11mm 950 kg per cubic metre A1
Face to be tested	Coated face, goosewing grey in colour
Orientation aspects	N/A
Sampling Identification Reference	N/A
Additional information:	Coated face has a tactile, silicone feel

Note 1 - This information has been provided and is held on file in confidence at the request of the test sponsor.