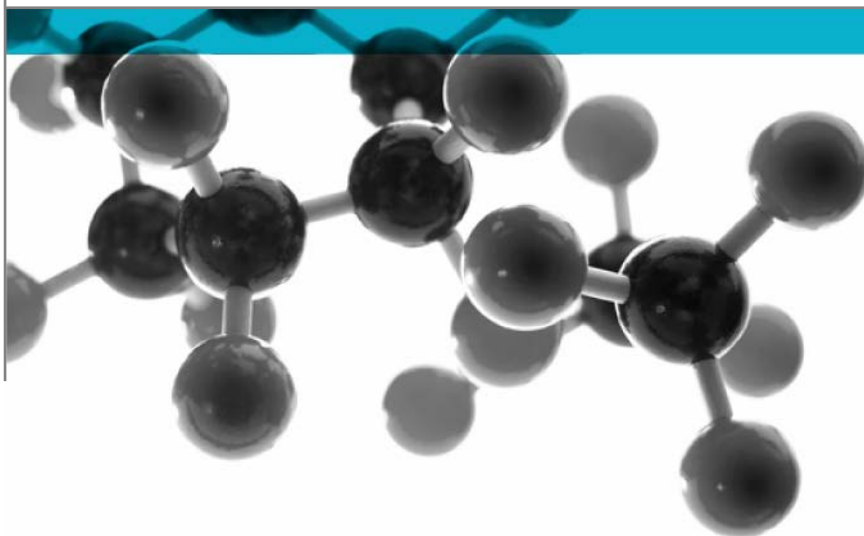


BS EN 45545-2:2013+A1:2015 – Test Methods T10.01, T10.02, T10.04 & T11.01



Smoke and Toxicity Assessment

Test Method References “T10.01” / “T10.02”/ “T10.04” (ISO 5659-2: 2017; Plastics – Smoke Generation. Part 2 Determination of Optical Density by a Single Chamber Method) and “T11.01” (Gas Analysis in the Smoke Box EN ISO 5659-2, using FTIR Technique)

A Report To: Kingspan Insulation LLC

Document Reference: 523627

Date: 24th March 2023

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Page 1



Executive Summary

Objective To determine the toxic fume and optical density produced from the following product when tested in accordance with methods T10.01, T10.02, T10.04 and T11.01 as defined in BS EN 45545-2:2013+A1:2015 at an irradiance level of 50kW/m² without a pilot flame.

Generic Description	Product reference	Thickness	Density
Aluminium faced and backed polyisocyanurate foam insulation	"PalDuct PIR – Product Code: 1010"	20mm	45kg/m ²
Individual components used to manufacture composite:			
Aluminium foil	Confidential	Confidential	Confidential
Polyisocyanurate foam insulation	"PalDuct PIR foam"	20mm	35kg/m ²
Aluminium foil	Confidential	Confidential	Confidential
Please see page 7 of this test report for the full description of the product tested			

Test Sponsor Kingspan Insulation LLC, Dubai Investment Park 2, PO Box 113826, Dubai, United Arab Emirates.

Summary of Test Results: The average $D_s(4)$ value determined was 10.

The average VOF4 value determined was 6.

The average D_{smax} value determined within 10 minutes was 125.

The average D_{smax} value determined within 20 minutes was 125.

The average CIT value at four minutes was 0.01.

The average CIT value at eight minutes was 0.01.

Date of Test 20th and 21st October 2022

Reason for Revision This document replaces Issue 1 (dated 9th March 2023) of the same number which has been withdrawn. Subsequent to the report being issue, the sponsor confirmed that the product reference was incomplete and the complete product reference has been issued and detailed in this Issue 2 report.

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Issue Date: 24th March 2023

Client: Kingspan Insulation LLC

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Signatories

	
Responsible Officer K. Deluce * Testing Officer	Authorised T. Deluce * Technical Lead

* For and on behalf of [Warringtonfire](#).

Report Issued: 24th March 2023

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Author: K. Deluce
Client: Kingspan Insulation LLC

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Test Details

Introduction

Warringtonfire was commissioned to carry out an area based smoke and toxicity test in accordance with the method recommended in BS EN 45545-2: 2013+A1:2015. This standard recommends that the test is carried out using the apparatus and procedures detailed in ISO 5659-2: 2017. The standard provides equations which should be calculated in relation to the smoke density. In addition to this the quantitative determination of the gases emitted should be carried out in accordance with the procedure specified in EN 45545 Annex C, Method 1 (Smoke Chamber).

The test was performed in accordance with the procedures specified in EN 45545 and EN ISO 5659-2 and this report should be read in conjunction with these and other related standards.

Test method

The principle of the test methods referenced "T10.01", "T10.02", "T10.04" and "T11.01" is to expose a material to specified thermal conditions of pyrolysis and combustion in a continuous procedure.

The test was conducted in an "ISO 5659-2 Smoke Chamber" supplied by Concept (operated with "Concept" software), in combination with an "IGS FTIR Analyser" supplied by Thermo Scientific (operated with Thermo "Result" software).

Specimens were tested in the non-flaming mode in a horizontal position by exposure to the heating arrangement specified in ISO 5659-2. The heat flux was 50kW/m^2 . The change in optical density of the smoke produced when dispersed within a fixed volume of air is recorded throughout the period of test utilising the Concept software in order to determine information relating to the smoke density.

Quantitative determination of toxic gases emitted is carried out using Fourier Transform Infra Red (FT-IR) analysis and the TQ Analyst software. The FT-IR has been calibrated, the calibration spectra were produced by the FTIR supplier (Thermo) using bottled gases and library spectrum, plus Warringtonfire using bottles gases and calibrated solutions via an evaporator.

In all cases, the sample gases are taken from 300mm from the centre of the top of the chamber with sample lines being kept as short as possible to minimise sample losses.

The test method provides a means for the comparative assessment of products, however, it does not model a real fire situation and the results cannot therefore be used to describe the fire hazard of materials under actual fire conditions.

Fire test study group/EGOLF

Certain aspects of some fire test specifications are open to different interpretations. The Fire Test Study Group and EGOLF have identified a number of such areas and have agreed Resolutions which define common agreement of interpretations between fire test laboratories which are members of the Groups. Where such Resolutions are applicable to this test they have been followed.

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Instruction to test The test was conducted on the 20th and 21st October 2022 at the request of Kingspan Insulation LLC, the sponsor of the test.

Provision of test specimens The specimens were supplied by the sponsor of the test. **Warringtonfire** was not involved in any selection or sampling procedure. The results stated in this report apply to the sample as received.

Test face The nominated face of the specimens was exposed to the heating conditions.

Condition of specimen edges Layered product, with no layer covering the edges.

Photograph of specimen



Conditioning of specimens The specimens were received on the 29th September 2022.
The specimens were conditioned at temperatures of $23 \pm 2^{\circ}\text{C}$ and a relative humidity of $50 \pm 5\%$ RH, for a minimum period of 24 hours prior to testing.

Description of Test Specimens

The description of the system given below has been prepared from information provided by the sponsor of the test. This information has not been independently verified by Warringtonfire. All values quoted are nominal, unless tolerances are given.

General description		Aluminium faced and backed polyisocyanurate foam insulation
Product reference of overall composite		"PalDuct PIR – Product Code: 1010"
Name of manufacturer of overall composite		Kingspan Insulation LLC
Thickness of overall composite		20mm (stated by sponsor) 20.33mm (determined by Warringtonfire)
Density of overall composite		45kg/m ³ (stated by sponsor) 46.32kg/m ³ (determined by Warringtonfire)
Foil	Generic type	Aluminium foil
	Product reference	See Note 1 below
	Name of manufacturer	See Note 1 below
	Thickness	See Note 1 below
	Density	See Note 1 below
	Colour	Silver
	Flame retardant details	See Note 2 below
Insulation	Generic type	Polyisocyanurate foam insulation
	Product reference	"PalDuct PIR foam"
	Name of manufacturer	Kingspan Insulation LLC
	Colour	White
	Thickness	20mm
	Weight per unit area	35kg/m ³
	Flame retardant details	See Note 2 below
Foil	Generic type	Aluminium foil
	Product reference	See Note 1 below
	Name of manufacturer	See Note 1 below
	Thickness	See Note 1 below
	Density	See Note 1 below
	Colour	Silver
	Flame retardant details	See Note 2 below
Brief description of manufacturing process		See Note 1 below

Note 1: The sponsor of the test has provided this information but at the specific request of the sponsor, these details have been omitted from the report and are instead held on the confidential file relating to this investigation.

Note 2: The sponsor of the test has confirmed that no flame retardant additives were utilised in the production of the component.

Test Results

Applicability of test results

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

The test results relate only to the specimens of the product in the form in which they were tested. Small differences in the composition or thickness of the product may significantly affect the performance during the test and will therefore invalidate the test results. It is the responsibility of the supplier of the product to ensure that the product which is supplied is identical with the specimens which were tested.

Smoke Density

Test method referenced "T10.01" requires the $D_s(4)$ to be calculated. That is the specific optical density at 4 minutes test duration.

Test method referenced "T10.02" requires the VOF4 to be calculated. That is the area under the D_s vs. time curve during the period zero minutes to four minutes. This is calculated utilising the trapezium rule equation (assuming a finite element (t) of one minute):

$$VOF_4 = D_1 + D_2 + D_3 + \frac{D_4}{2}$$

Test method referenced "T10.04" requires the D_{smax} to be calculated. That is the maximum specific optical density within the first 10 minutes test duration.

The maximum specific optical density within the complete 20 minute test duration is also reported in case this is required by an alternative specification.

	Specimen 1	Specimen 2	Specimen 3	Mean Average
$D_s(4)$	7	15	9	10
VOF4	4	9	5	6
D_{smax} within 10 minutes	98	114	164	125
D_{smax} within 20 minutes	98	114	164	125

Toxic Gas Emission

Test method referenced "T11.01" required the CIT to be calculated. That is the conventional index of toxicity, a summation term from the analysis of gases taken at four minutes and eight minutes test duration.

	Specimen 1	Specimen 2	Specimen 3	Mean Average
CIT (4 minutes)	0.01	0.01	0.01	0.01
CIT (8 minutes)	0.01	0.01	0.00	0.01

Additional Test Data

Additional test data relating to the smoke & toxicity performance of the product is detailed in Appendix I of this report.

A graph of the results obtained is illustrated in Appendix II.

Summary of results The average $D_s(4)$ value determined was 10.

The average VOF4 value determined was 6.

The average D_s max value determined within 10 minutes was 125.

The average D_s max value determined within 20 minutes was 125.

The average CIT value at four minutes was 0.01.

The average CIT value at eight minutes was 0.01.

Validity

The specification and interpretation of fire test methods are the subject of ongoing development and refinement. Changes in associated legislation may also occur. For these reasons it is recommended that the relevance of test reports over five years old should be considered by the user. Where this report is used to confirm compliance for use on European rolling stock as per the Technical Specification for Interoperability (LOC&PAS TSI (Commission Regulation (EU) No. 1302/2014)), all tests must have been conducted within the last 5 years or the test reports must have been reviewed within the last five years. The laboratory that issued the report will be able to offer, on behalf of the legal owner, a review of the procedures adopted for a particular test to ensure that they are consistent with current practices, and if required may endorse the test report.

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

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Appendix I

Gas Concentration At Four Minutes:

The concentration of each gas species for which analysis was conducted for at the four minute sampling point (expressed in ppm and kg/m³) is provided in the below table:

Gas	Specimen 1		Specimen 2		Specimen 3		Mean Average	
	ppm	kg/m ³	ppm	kg/m ³	ppm	kg/m ³	ppm	kg/m ³
Carbon Monoxide	2	0.0000	2	0.0000	3	0.0000	2	0.0000
Carbon Dioxide	195	0.0003	168	0.0003	229	0.0004	197	0.0003
Sulphur Dioxide	ND	ND	ND	ND	ND	ND	ND	ND
Hydrogen Chloride	ND	ND	ND	ND	ND	ND	ND	ND
Hydrogen Bromide	ND	ND	ND	ND	ND	ND	ND	ND
Hydrogen Fluoride	ND	ND	ND	ND	ND	ND	ND	ND
Hydrogen cyanide	ND	ND	ND	ND	ND	ND	ND	ND
Nitrogen Oxides	2	0.0000	2	0.0000	3	0.0000	2	0.0000

Where ND indicates None Detected

Gas Concentration At Eight Minutes:

The concentration of each gas species for which analysis was conducted for at the eight minute sampling point (expressed in ppm and kg/m³) is provided in the below table:

Gas	Specimen 1		Specimen 2		Specimen 3		Mean Average	
	ppm	kg/m ³	ppm	kg/m ³	ppm	kg/m ³	ppm	kg/m ³
Carbon Monoxide	17	0.0000	20	0.0000	27	0.0000	21	0.0000
Carbon Dioxide	806	0.0013	766	0.0012	877	0.0014	816	0.0013
Sulphur Dioxide	ND	ND	ND	ND	ND	ND	ND	ND
Hydrogen Chloride	ND	ND	ND	ND	ND	ND	ND	ND
Hydrogen Bromide	ND	ND	ND	ND	ND	ND	ND	ND
Hydrogen Fluoride	ND	ND	ND	ND	ND	ND	ND	ND
Hydrogen cyanide	ND	ND	ND	ND	ND	ND	ND	ND
Nitrogen Oxides	2	0.0000	2	0.0000	0	0.0000	1	0.0000

Where ND indicates None Detected

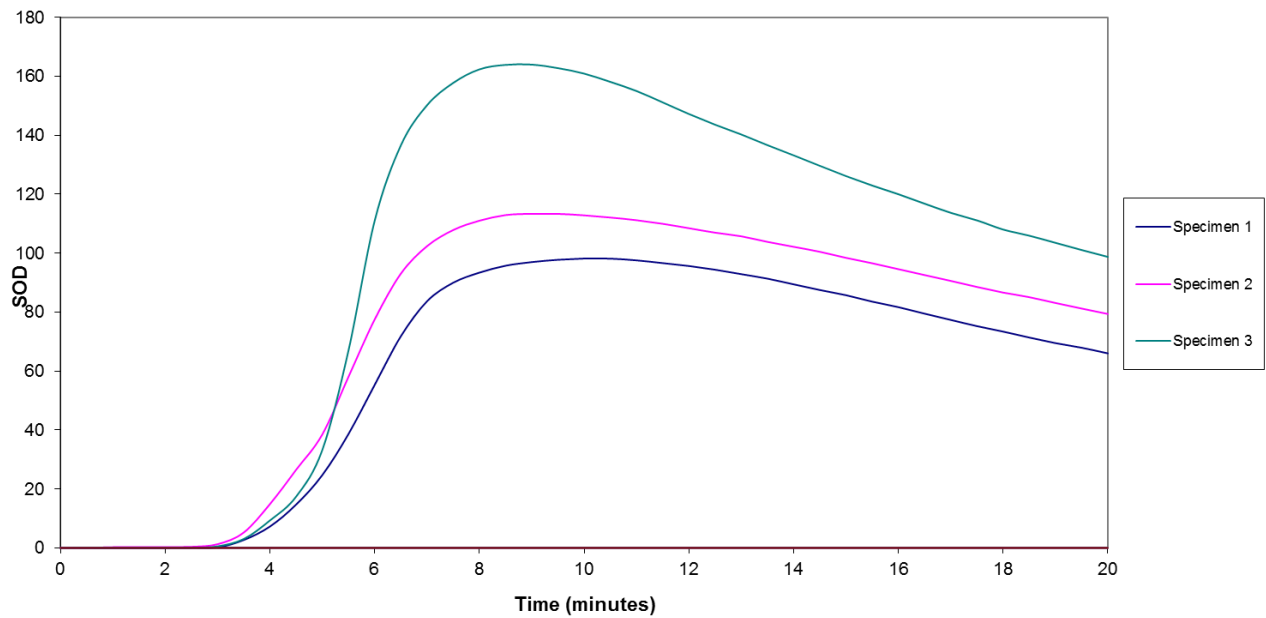
	SPECIMEN NUMBER			Mean
	1	2	3	
Clear Beam Correction Factor (D_c)	4	5	7	
Specific Optical Density at 10 minutes (D_{s10})	98	113	161	124
Specimen thickness	20.27	20.42	20.40	20.36
Initial specimen weight (g)	5.27	5.37	5.27	5.30
Final specimen weight (g)	3.27	3.27	3.67	3.40
Mass Loss (g)	2.00	2.10	1.60	1.90
Wire Grid	N/A	N/A	N/A	N/A
Neutral-density correction factor (C_f)	N/A	N/A	N/A	N/A
Test Duration (s)	1200	1200	1200	1200
Chamber back wall temperature	52	54	53	
Test Operator	A. Saunders			N/A

Observations:

	50kW/m ² In The Absence Of A Pilot Flame		
Specimen No.	1	2	3
Colour of smoke produced	Light	Light	Light
Expansion distance towards heater (mm)	5	5	N/A
Type of expansion	Lifting only	Lifting only	N/A
Heater to specimen distance (mm)	25	25	25
Ignition time in seconds	N/A	N/A	N/A
Extinction time in seconds	N/A	N/A	N/A
Unusual or unexpected behavior	No	No	No
Difficulties experienced during test	No	No	No
N/A = Not Applicable			

Appendix II

50kW/m² in the absence of a pilot flame



Revision History

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Revised By: K. Deluce	Approved By: T. Kinder
Reason for Revision: This document replaces Issue 1 (dated 9th March 2023) of the same number which has been withdrawn. Subsequent to the report being issue, the sponsor confirmed that the product reference was incomplete and the complete product reference has been issued and detailed in this Issue 2 report.	

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