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Issue Date: *14h July 2004*

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TEST REPORT

TSL No. R17895

Fire testing of "Interpon D36 Polyester Powder Coating", in accordance with the London Underground Limited Engineering Standard 2-01001-002: Issue A1: December 2003.

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CONDITIONS OF ISSUE OF REPORTS.

QUERIES OR FURTHER INFORMATION.

ANY QUERIES OR REQUESTS FOR ADDITIONAL INFORMATION ON THE SUBJECT OF THIS REPORT SHOULD BE ADDRESSED TO THE AUTHOR WHO MAY BE CONTACTED AT THE ADDRESS GIVEN ON THE TITLE PAGE.

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Fire testing of "Interpon D36 Polyester Powder Coating", in accordance with the London Underground Limited Engineering Standard 2-01001-002: Issue A1: December 2003.

1. INTRODUCTION

Sample panels of aluminium coated with polyester powder coating were submitted on 4th May 2004, by Mr A Moseley of Akzo Nobel Powder Coatings Limited, for smoke emission, toxic fume emission and flammability testing, in accordance with London Underground Limited Engineering Standard 2-01001-002: Issue A1: December 2003.

2. MATERIAL DESCRIPTION

1mm thick, aluminium panels, coated with 'SA210E Interpon D36 Polyester Powder coating', supplied by Akzo Nobel Powder Coatings Limited.

No additional information was submitted by the client.

Laboratory sample reference is TSL0108.

3. TEST METHOD

3.1 SMOKE EMISSION

The above specimen was tested for smoke emission on 12th May 2004, in accordance with BS6853: 1999: D8.6 – "Code of Practice for Fire Precautions in the design and construction of passenger carrying trains".

3.2 TOXIC FUME EMISSION

3.2.1 QUALITATIVE ANALYSIS

The above specimen was tested on 18th May 2004 for qualitative analysis using scanning electron microscopy and energy dispersive X-Rays.

3.2.2 QUANTITATIVE ANALYSIS

The above specimen was tested on 18th May 2004, for quantitative determination of Nitrogen, Carbon and Sulphur using Carlo Erba EA1108 Elemental analyser'.

3.3 FLAMMABILITY

3.3.1 FIRE PROPAGATION

The above specimen boards were tested to determine the fire propagation index of specimens of a product when tested in accordance with BS476: Part 6: 1989 "Fire tests on building materials and structures, method of test for fire propagation for products".

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3.3.2 SURFACE SPREAD OF FLAME

The above specimen boards were tested to determine the classification of specimens of a product when tested in accordance with BS476: Part 7: 1997 "Fire tests on building materials and structures, method of test to determine the classification of the surface spread of flame of products".

4. RESULTS

The tests relate to the behaviour of test specimens of the products under particular conditions of test; they are not intended to be the sole criterion for assessing the potential fire hazard of the product in use. In particular, differences in the thickness, orientation or design may significantly affect fire performance and care should be taken to ensure that any differences between the test conditions and application conditions are not adversely significant.

4.1 SMOKE EMISSION

The measured absorbance A_m is calculated in accordance with the Beer-Lambert Law as follows:

$$A_m = \log_{10} (I_o / I_t)$$

Where: I_o = Initial Luminous intensity
I_t = transmitted Luminous intensity

A_m is converted to Standard absorbance A_o (Figures 1-3; Page 11-12), using the equation:

$$A_o = (A_m \times V) / (n \times L)$$

Where: V = volume of the cube ($27m^3$)
L = optical path length (3m)
N = is the number of units comprising the specimen.

The calculated results are as follows:

Sample Reference	Test	Result Ao abs (m^2/burn area)	
		Ao(ON)	Ao(OFF)
TSL0108	1	0.538	0.698
	2	0.445	0.651
	Average	0.492	0.675
	S.D.	0.0658	0.0332

REQUIREMENTS:

The requirements for smoke emission as stated in the London Underground Limited Engineering Standard 2-01001-002: Issue A1: December 2003 for category ST/SU/v & p "Station/Surface/vertical & prone is:

A_o(ON) < 3.6 m^2/burn area & A_o(OFF) < 5.4 m^2/burn area

The test data show that the referenced specimen meets the smoke emission criterion for category ST/SU/v & p application.

4.2 TOXIC FUME EMISSION

4.2.1 QUALITATIVE ANALYSIS

The qualitative analysis of the sample shows the following elements (Figure 4; Page 14)

Sample reference	Elements detected
TSL0108	Carbon, Oxygen, Silicon, Aluminium, Titanium, Sulphur.

4.2.2 QUANTITATIVE ANALYSIS

Sample reference	% Nitrogen	% Carbon	% Sulphur
TSL0108	0.19	36.02	1.88

The above results are expressed as a percentage wt/wt.

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REQUIREMENTS

The Engineering Standard states that "For unrestricted use of a material, covered by Standard 2-01001-002: Issue A1: December 2003, neither it nor its constituents shall have deliberately incorporated by selection, addition or modification any significant amounts of organically bound halogens, nitrogen, sulphur or phosphorus; typical chemical groups proscribed are:-

C-X (where X = Halogen)
C-N
C-P
C-O-P
C-S
C-O-S

Trace levels of such chemical groups are acceptable – the criterion for "trace level" shall be that the summation of the weight for weight percentage of the chemical group divided by the atomic weight for the group shall not exceed 0.015".

Thus, applying the 'Trace level' i.e.

$$\sum \frac{w/w\%\ of\ Chemical\ Group}{Atomic\ weight\ of\ Group} \leq 0.015$$

The calculated value for the specimen gives a value of 0.0723, based on 0.19% Nitrogen and 1.88% Sulphur content.

Hence, the specimen material under this category fails to meet the London Underground Limited Engineering Standard 2-01001-002: Issue A1: December 2003, due to the presence of nitrogen and sulphur above the required limit.

However, considering that the respective standard calls for keeping the concentrations of any toxic gases below the relevant IDLH levels (Immediately Dangerous to Life or Health), it is therefore possible to calculate the potential toxic hazard presented by this material. Such calculations would need to assume that the *dispersal volume in which the product is installed is 700m^3 for Stations.*

Following assumptions would also need to be made:

The single material is the sole contributor to the fire atmosphere.

All of the Nitrogen and sulphur in the material would convert to Hydrogen cyanide, i.e. 100% conversion of nitrogen to hydrogen cyanide.

Size of Fire region is 1.25m^{2}fixed locations (stations).

The specific density of the material is 1.68g/cm^3

Hence, the expected concentrations of hydrogen cyanide and sulphur dioxide is calculated, according to "Users Guide to the LUL Code of Practice - Fire Safety of Materials Used in the Underground - Issue 1; 1994", which gives the following expected concentration of Hydrogen cyanide.

Sample	Expected concentration (ppm)	Location (ST/SU/v & p)
TSL0108	HCN	0.78
	SO2	7.73

The total expected toxicity, $T_{x,}$ is given by the equation:

$$T_{Total} = \sum \frac{C_N}{H_N}$$

Where, C_N = Concentration of any one toxic species, and
H_N = IDLH for value for that toxic species.

The calculated values and the requirements are:

Sample	Total expected toxicity, $T_{x.}$	Requirements
TSL0108	0.09	<1.0

4.3 FLAMMABILITY

4.3.1 FIRE PROPAGATION

Sample reference	Fire propagation index, I	Subindex, i_1	subindex, i_2	Subindex, i_3
TSL0108	0	0	0	0

See Appendix A for full results.

4.3.2 SURFACE SPREAD OF FLAME

Sample reference	Result
TSL0108	Class 1

See Appendix A for full results

REQUIREMENTS:

Requirements for Category:	Fire Propagation (BS476: Part 6: 1989)	Surface Spread of Flame (BS476: Part 7: 1997)
ST/SU/v&p (Station/Surface/vertical & prone	I <12; i_1 <6	Class 1

The material, therefore, meet the flammability requirements for LUL Engineering Standard 2-01001-002: Issue A1: December 2003

5. CONCLUSION

The material described in Section 2.0 of this report meets the smoke emission, toxic fume emission and flammability requirements for Category ST/SU/v&p *"Station/Surface/vertical & prone"* of the London Underground Limited Engineering Standard 2-01001-002: Issue A1: December 2003.

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OBSERVATIONS

SAMPLE REFERENCE TSL0108

TEST: BS6853: 1999: APPENDIX D8.6

TEST 1.

Time (min.sec)	Observations
0.00 - 40.00	Nothing significant.

TEST 2.

Time (min.sec)	Observations
0.00 - 40.00	Nothing significant.

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Figure 1: Variation of Absorbance (Ao) with two specimens (Specimen No.2)

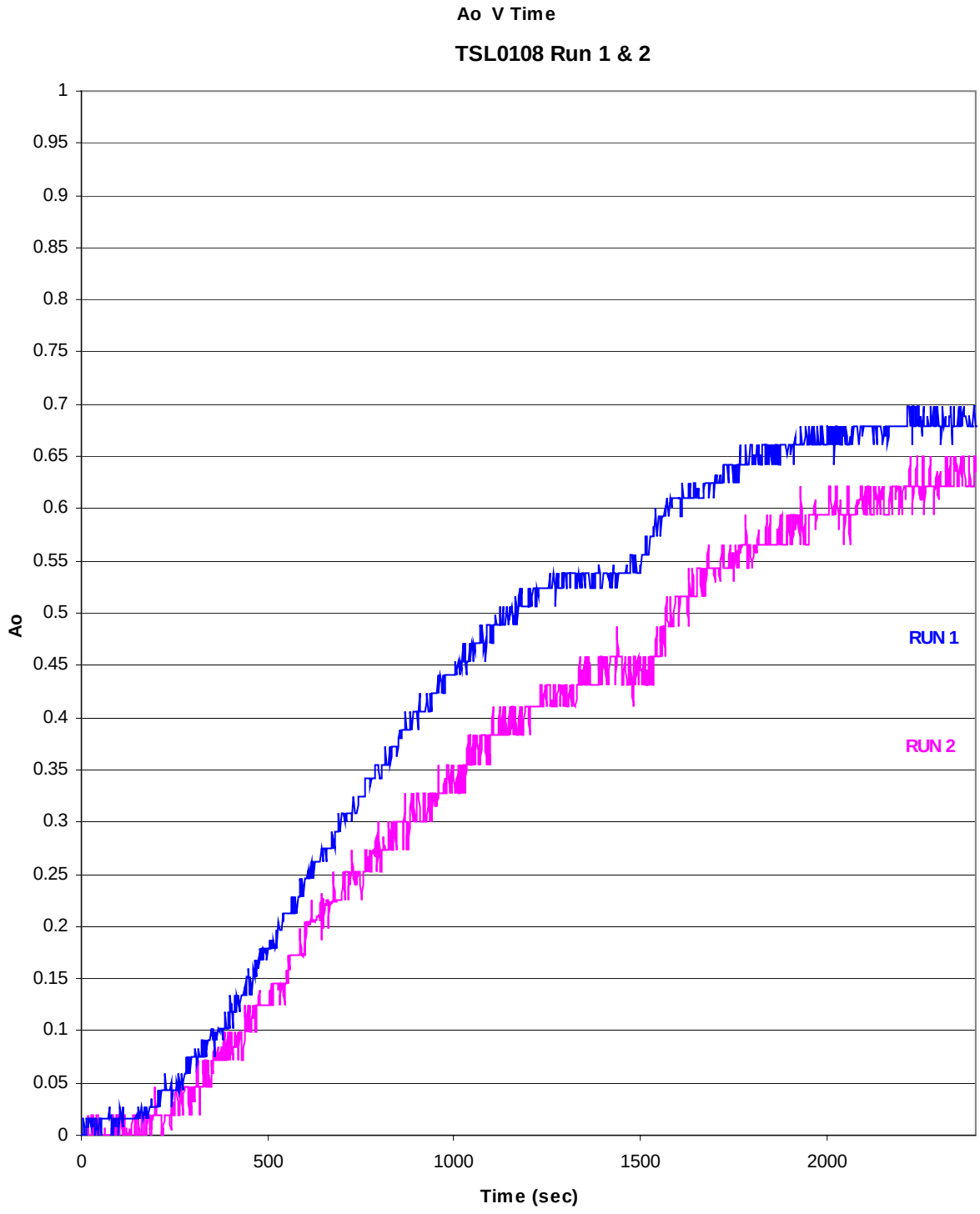

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Figure 2: Variation of Absorbance (Ao) with time (specimen No: 2)

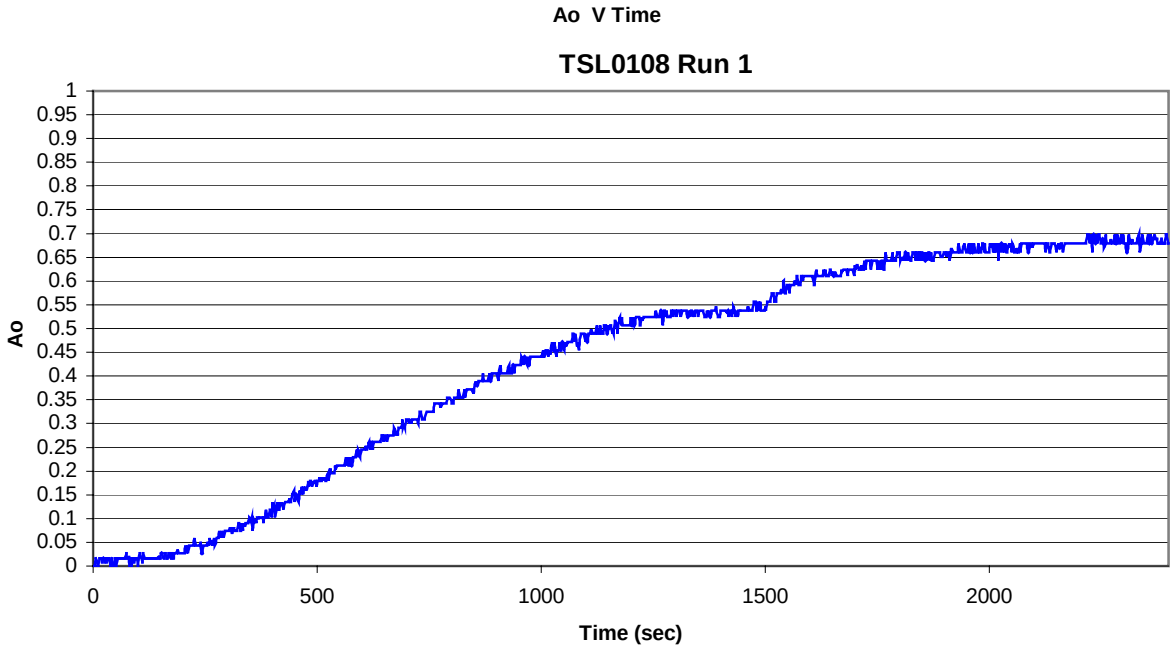

Figure 3: Variation of Absorbance (Ao) with time (specimen No: 2)

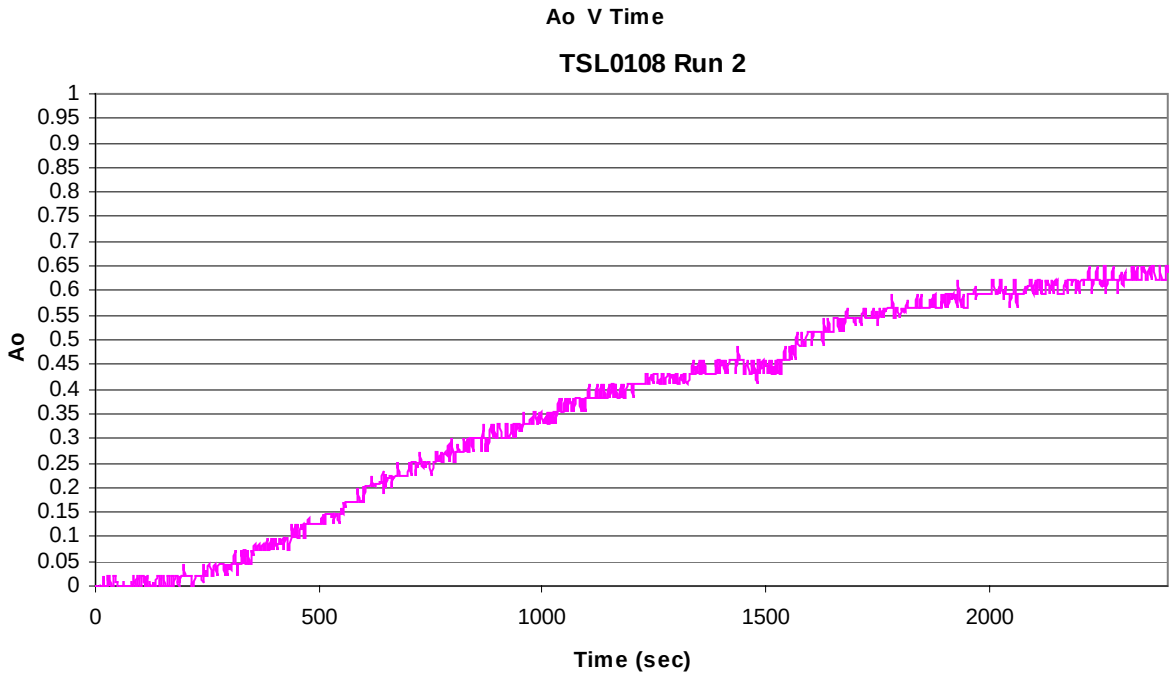

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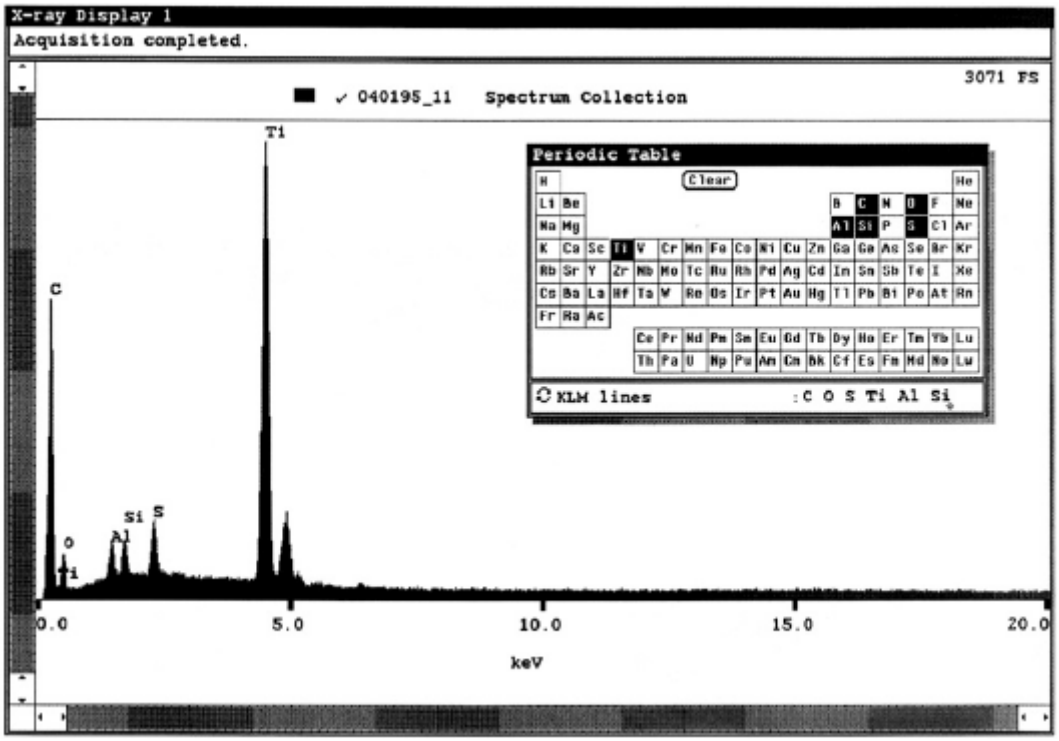
Figure 4: X-ray spectrum for 'Interpon D36 Polyester Powder Coating'.

Laboratory sample reference TSL0108



Appendix A

Test Data

(BS476: Part 6 : 1987 and BS476: Part 7: 1997)

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TEST DATA

FIRE PROPAGATION TEST – BS476: PART 6: 1989

SPECIMEN No. 1

TIME/MINS INDEX OF PEFORMANCE	SPECIMEN	CALIBRATION TEMPERATURE	TEMPERATURE	SUB
(t)	DEG C Θ_S	Deg C Θ_C	$\Theta s-\Theta c/10t$	
0.50	12.1	13.9	-0.4	
1.00	17.6	19.9	-0.2	
1.50	22.2	26.1	-0.3	
2.00	27.4	30.8	-0.2	
2.50	30.6	34.7	-0.2	
3.00	34.4	38.1	-0.1	**S1 = 0**
4.00	54.6	61.0	-0.2	
5.00	82.4	90.9	-0.2	
6.00	105.2	114.0	-0.1	
7.00	126.1	136.2	-0.1	
8.00	143.3	154.6	-0.1	**S2 = 0**
9.00	156.8	169.4	-0.1	
10.00	172.9	180.5	-0.1	
12.00	193.8	201.4	-0.1	
14.00	209.8	212.5	0.0	
16.00	215.9	221.1	0.0	
18.00	224.5	227.2	0.0	
20.00	228.2	232.2	0.0	**S3 = 0**
				S =0

SUB INDEX S1 = 0
SUB INDEX S2 = 0
SUB INDEX S3 = 0

INDEX OF PERFORMANCE = 3.14

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TEST DATA

FIRE PROPAGATION TEST – BS476: PART 6: 1989

SPECIMEN No. 2

TIME/MINS INDEX OF PEFORMANCE	SPECIMEN	CALIBRATION TEMPERATURE	TEMPERATURE	SUB
(t)	DEG C Θ_S	Deg C Θ_C	$\Theta s-\Theta c/10t$	
0.50	12.6	13.9	-0.3	
1.00	17.7	19.9	-0.2	
1.50	23.0	26.1	-0.2	
2.00	27.4	30.8	-0.2	
2.50	31.6	34.7	-0.1	
3.00	34.2	38.1	-0.1	**S1 = 0**
4.00	54.9	61.0	-0.2	
5.00	82.1	90.9	-0.2	
6.00	105.4	114.0	-0.1	
7.00	127.5	136.2	-0.1	
8.00	146.0	154.6	-0.1	**S2 = 0**
9.00	162.0	169.4	-0.1	
10.00	175.6	180.5	0.0	
12.00	197.7	201.4	0.0	
14.00	210.0	212.5	0.0	
16.00	217.4	221.1	0.0	
18.00	222.3	227.2	0.0	
20.00	228.5	232.2	0.0	**S3 = 0**
				S =0

SUB INDEX S1 = 0
SUB INDEX S2 = 0
SUB INDEX S3 = 0

INDEX OF PERFORMANCE = 0

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TEST DATA

FIRE PROPAGATION TEST – BS476: PART 6: 1989

SPECIMEN No. 3

TIME/MINS INDEX OF PEFORMANCE	SPECIMEN	CALIBRATION TEMPERATURE	TEMPERATURE	SUB
(t)	DEG C Θ_S	Deg C Θ_C	$\Theta s-\Theta c/10t$	
0.50	12.2	13.9	-0.3	
1.00	17.2	19.9	-0.3	
1.50	22.3	26.1	-0.3	
2.00	26.7	30.8	-0.2	
2.50	29.9	34.7	-0.2	
3.00	33.8	38.1	-0.1	**S1 = 0**
4.00	55.7	61.0	-0.1	
5.00	85.0	90.9	-0.1	
6.00	107.9	114.0	-0.1	
7.00	128.8	136.2	-0.1	
8.00	147.2	154.6	-0.1	**S2 = 0**
9.00	163.2	169.4	-0.1	
10.00	171.9	180.5	-0.1	
12.00	202.6	201.4	0.0	
14.00	212.5	212.5	0.0	
16.00	216.2	221.1	0.0	
18.00	221.1	227.2	0.0	
20.00	228.5	232.2	0.0	**S3 = 0**
				S =0

SUB INDEX S1 = 0
SUB INDEX S2 = 0
SUB INDEX S3 = 0

INDEX OF PERFORMANCE = 0

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TEST DATA

SURFACE SPREAD OF FLAME TEST – BS476: PART 7: 1997

Specimen No.	1	2	3	4	5	6
Maximum distance at 1.5 minutes (mm)	0	0	0	0	0	0
Distance (mm)	Time to travel to indicated distance (minutes, seconds)					
75						
165						
190						
215						
240						
265						
290						
375						
455						
500						
525						
600						
675						
710						
750						
785						
825						
900						
Maximum distance travelled in 10 minutes (mm)	0	0	0	0	0	0

Observations made during test and comments on any difficulties encountered during the test.

No ignition was observed.