aspen aerogels™

Spaceloft Insulation

TECHNICAL GUIDE

Contents

Introduction

Spaceloft is a flexible, nanoporous aerogel blanket insulation that reduces energy loss while conserving interior space in residential and commercial building applications. Spaceloft's unique properties – extremely low thermal conductivity, superior flexibility, compression resistance, hydrophobicity, and ease of use – make it essential for those seeking the ultimate in thermal protection. Using patented nanotechnology, Spaceloft insulation combines a silica aerogel with reinforcing fibers to deliver industry-leading thermal performance in an easy-to-handle and environmentally safe product. Spaceloft is a proven, effective insulator in building applications, providing the highest R-value of any insulation material for maximum energy efficiency in walls, floors, roofs, framing, and windows.

Spaceloft Advantages

- Superior Thermal Performance – 2 to 4 times better than competing insulation products
- Reduced Thickness and Profile – Equal thermal resistance at a fraction of the thickness
- Less Time and Labor to Install – Easily cut and conformed to complex shapes, tight curvatures, and spaces with restricted access
- Physically Robust – Soft and flexible but with excellent springback, Spaceloft recovers its thermal performance even after compression events as high as 50 psi
- Shipping and Warehousing Savings – Reduced material volume, high packing density, and low scrap rates can reduce logistics costs by a factor of five or more compared to other insulations
- Simplified Inventory – The same Spaceloft blanket can be kitted to fit any shape or design
- Hydrophobic Yet Breathable – Spaceloft repels liquid water but allows vapor to pass through
- Environmentally Safe – Landfill disposable, shot-free, with no respirable fiber content

Specification Compliance and Performance

Test Procedure	Property	Results
ASTM C 177	Thermal Conductivity via Guarded Hot Plate	13.1 mW/m*K @ 10°C
EN 12667	Thermal Conductivity via Guarded Hot Plate	13.1 mW/m*K @ 10°C
ASTM E 84	Flame and Smoke Spread	Class A: FSI <5, SDI 20
EN 13501-1: 2007	Reaction to Fire Performance	Passed Euroclass C-s1,d0
ASTM C 165	Compressive Stress / Strain	8.0 psi @ 10% strain, 30.5 psi @ 25% strain
Specific Heat	Specific Heat	1.000 J/g*K @ 40°C
ASTM E 96	Water Vapor Transmission Rate	1877 ng/Pa*s*m^2 (dry cup method)
ASTM E 228	Linear Coefficient of Thermal Expansion (@ 10°C)	x: 1.06 x 10^{-5} K^{-1}, y: 1.90 x 10^{-5} K^{-1}
ASTM C 1104	Water Vapor Sorption	Mass Gain = 1.08%

(Click below to jump to Appendices.)

Non-Combustibility & Fire Performance

EN 13501-1 – REACTION TO FIRE CLASSIFICATION (BODYCOTE, WARRINGTON FIRE)

The reaction to fire performance of Spaceloft was evaluated via BS EN 13501-1:2007. Spaceloft (5-10 mm) achieved a reaction to fire classification of C-s1, d0 for construction applications as a suspended ceiling membrane. EN 13823 and ISO EN 11925-2 were carried out as part of this testing and all results were compliant for Class C classification. See **Appendix A**.

ASTM E 84 – SURFACE BURNING CHARACTERISTICS (BODYCOTE TESTING GROUP)

Spaceloft was tested in accordance with ASTM E 84, the Standard Test Method for Surface Burning Characteristics of Building Materials. Spaceloft satisfies the criteria for a Class A rating with a flame spread index of <5 and a smoke developed index of 20. See **Appendix B**.

Mechanical and Dimensional Stability

ASTM C 165 – COMPRESSIVE RESISTANCE (ASPEN AEROGELS, INC.)

Compressive stress was measured at both 10% and 25% compressive strain. The average compressive stress was 8.0 psi @ 10% strain and 30.5 psi @ 25% strain. **Report pending**.

ASTM C 1101 – FLEXIBILITY AT AMBIENT TEMPERATURE (BODYCOTE TESTING GROUP)

Spaceloft was classified as flexible at room temperature according to ASTM C 1101 test results. **Report pending**.

ASTM E 228 – LINEAR COEFFICIENT OF THERMAL EXPANSION (NETZSCH)

The coefficient of thermal expansion of Spaceloft was tested via ASTM E 228 from -170°C to 100°C with a reference temperature of 20°C. The results at 10°C are: $x = 1.06 \times 10^{-5}\ K^{-1}$, $y = 1.90 \times 10^{-5}\ K^{-1}$. See **Appendix C**.

DIN 52275-2 – DETERMINATION OF LINEAR DIMENSIONS AND DENSITY (FRAUENHOFER INSTITUTE)

A series of tests was conducted at the Frauenhofer Institute to demonstrate the application suitability of Spaceloft in external thermal insulation composite systems. These tests include DIN 52275-2, EN ISO 15148, EN ISO 12571, EN ISO 12572, and DIN 52103. See **Appendix D**.

Thermal Measurements

ASTM C 177 – THERMAL CONDUCTIVITY VIA GUARDED HOT PLATE, FULL CURVE (NETZSCH)

Third-party validation of the thermal conductivity of Spaceloft was acquired at mean temperatures ranging from -160° to 150°C (-256° to 302°F) under a compressive load of 2 psi. See **Appendix E**.

ASTM C 177 – THERMAL CONDUCTIVITY VIA GUARDED HOT PLATE, 10°C (FIW MÜNCHEN)

Third-party validation of the thermal conductivity of Spaceloft was acquired at a mean temperature of 10°C under a compressive load of 2 psi. See **Appendix F**.

EN 12667 – THERMAL CONDUCTIVITY VIA GUARDED HOT PLATE, 10°C (FIW MÜNCHEN)

Third-party validation of the thermal conductivity of Spaceloft was acquired at a mean temperature of 10°C under a compressive load of 2 psi. See **Appendix G**.

SPECIFIC HEAT – (TPRL)

The specific heat of Spaceloft was measured from -60°C to 150°C. See **Appendix H**.

EN ISO 8497 – DECLARATION OF CONFORMITY

The values declared ($\lambda_{90,90}$) and reported on the product's labels are determined according to the rule ISO 10456 and represent 90% of the production and with 90% of reliability. $\lambda_{90,90}$ = 0.014 W/m*K. See **Appendix I**.

Water Resistance

ASTM C 1104 – WATER VAPOR SORPTION (BODYCOTE TESTING GROUP)

The average weight gained during the ASTM C 1104 testing was 1.08%. **Report pending**.

ASTM C 1511 – WATER RETENTION, REPELLENCY (BODYCOTE TESTING GROUP)

The average weight gained during the ASTM C 1511 testing was 3.9%. **Report pending**.

ASTM E 96 – WATER VAPOR TRANSMISSION RATE (BODYCOTE TESTING GROUP)

Both water and desiccant method were tested via ASTM E 96. The results for Spaceloft are 2319 ng/Pa*s*m^2 (water method), 1877 ng/Pa*s*m^2 (desiccant method). **Report pending**.

EN ISO 15148 – DETERMINATION OF WATER ABSORPTION COEFFICIENT BY PARTIAL IMMERSION (FRAUENHOFER INSTITUTE)

A series of tests was conducted at the Frauenhofer Institute to demonstrate the application suitability of Spaceloft in external thermal insulation composite systems. These tests include DIN 52275-2, EN ISO 15148, EN ISO 12571, EN ISO 12572, and DIN 52103. See **Appendix D**.

EN ISO 15148 – DETERMINATION OF WATER ABSORPTION COEFFICIENT BY PARTIAL IMMERSION (GLASGOW CALDONIAN UNIVERSITY)

The water absorption coefficient measured for Spaceloft is 0.0072 kg/m^2*$h^{0.5}$. Spacetherm is a UK trade name of Spaceloft. See **Appendix J**.

EN ISO 12571 – DETERMINATION OF HYGROSCOPIC SORPTION PROPERTIES (FRAUENHOFER INSTITUTE)

A series of tests was conducted at the Frauenhofer Institute to demonstrate the application suitability of Spaceloft in external thermal insulation composite systems. These tests include DIN 52275-2, EN ISO 15148, EN ISO 12571, EN ISO 12572, and DIN 52103. See **Appendix D**.

EN ISO 12571 – DETERMINATION OF HYGROSCOPIC SORPTION PROPERTIES (GLASGOW CALDONIAN UNIVERSITY)

Saturated salt solutions were prepared to give conditions of 33.0%, 53.0%, 79.5%, and 94.0% RH. The moisture content of the Spaceloft was measured at each humidity condition. Spacetherm is a UK trade name of Spaceloft. See **Appendix K**.

Water Resistance

EN ISO 12572 – DETERMINATION OF WATER VAPOUR TRANSMISSION PROPERTIES (FRAUENHOFER INSTITUTE)

A series of tests was conducted at the Frauenhofer Institute to demonstrate the application suitability of Spaceloft in external thermal insulation composite systems. These tests include DIN 52275-2, EN ISO 15148, EN ISO 12571, EN ISO 12572, and DIN 52103. See **Appendix D**.

EN ISO 12572 – DETERMINATION OF WATER VAPOUR TRANSMISSION PROPERTIES (GLASGOW CALDONIAN UNIVERSITY)

Two methods were used to determine the water vapor transmission properties of Spaceloft. The average dry cup and wet cup; results were 0.337 MNs/g and 0.275 MNs/g respectively. Spacetherm is a UK trade name of Spaceloft. See **Appendix L**.

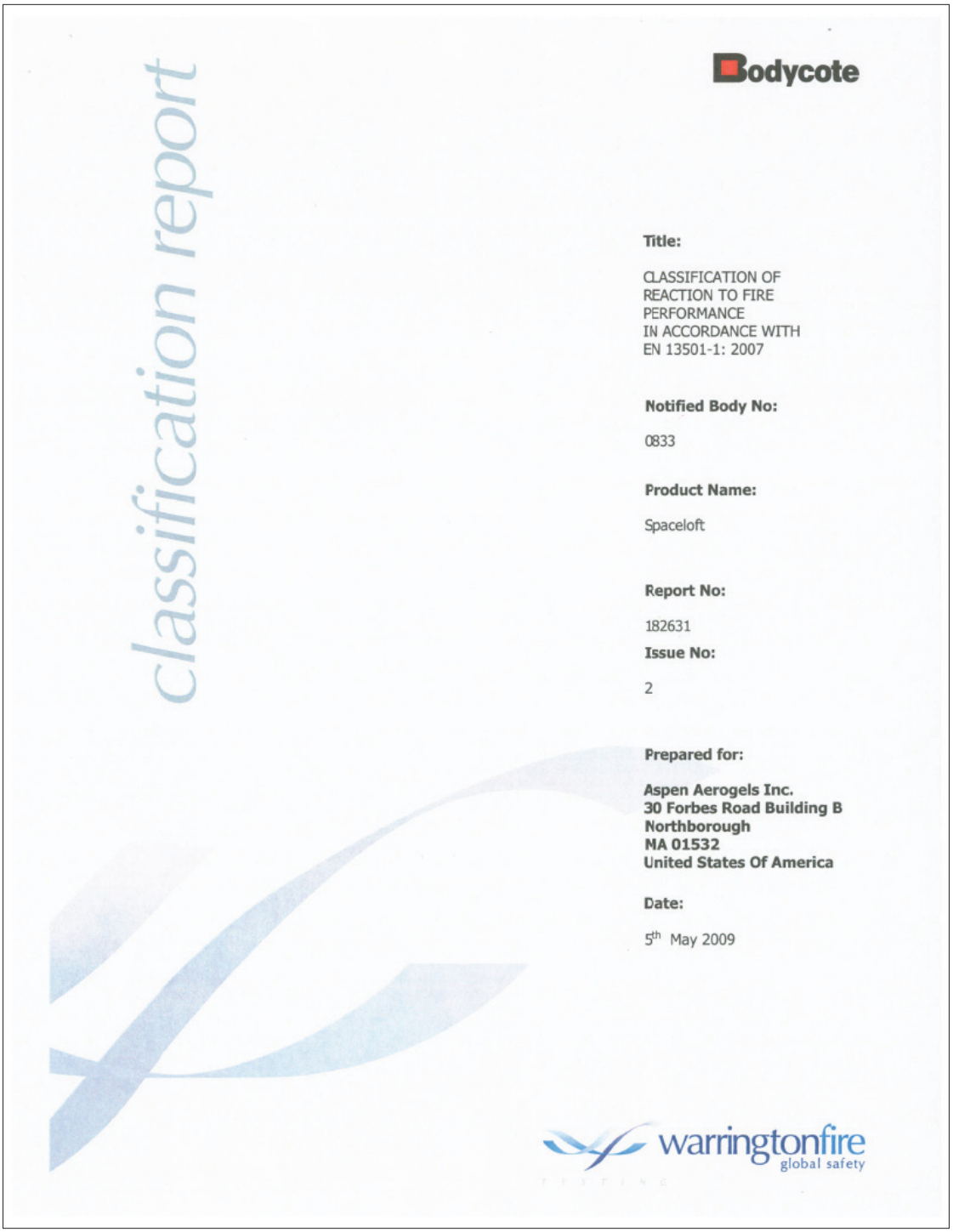
DIN 52103 – DETERMINATION OF WATER ADSORPTION AND SATURATION COEFFICIENT OF NATURAL STONE AND MINERAL AGGREGATES (FRAUENHOFER INSTITUTE)

A series of tests was conducted at the Frauenhofer Institute to demonstrate the application suitability of Spaceloft in external thermal insulation composite systems. These tests include DIN 52275-2, EN ISO 15148, EN ISO 12571, EN ISO 12572, and DIN 52103. See **Appendix D**.

EN ISO 12087 – LONG TERM WATER ABSORPTION BY TOTAL IMMERSION (GLASGOW CALDONIAN UNIVERSITY)

The long term water absorption by total immersion is determined by measuring the change in mass of the test specimen, totally immersed in water, over a period of 28 days. The excess water adhering to the surface, not absorbed by the test specimen, is removed by drainage. The Spaceloft achieved an average water absorption by volume of 6.3% during this test. Spacetherm is a UK trade name of Spaceloft. See **Appendix M**.

Appendix A EN 13501-1 – REACTION TO FIRE CLASSIFICATION (BODYCOTE, WARINGTON FIRE)



classification report

Bodycote

Title:

CLASSIFICATION OF
REACTION TO FIRE
PERFORMANCE
IN ACCORDANCE WITH
EN 13501-1: 2007

Notified Body No:

0833

Product Name:

Spaceloft

Report No:

182631

Issue No:

2

Prepared for:

Aspen Aerogels Inc.
30 Forbes Road Building B
Northborough
MA 01532
United States Of America

Date:

5th May 2009

warringtonfire
global safety

Appendix A EN 13501-1 – REACTION TO FIRE CLASSIFICATION (BODYCOTE, WARINGTON FIRE)

1. Introduction

This classification report defines the classification assigned to "Spaceloft", a silica based, aerogel insulation batting, in line with the procedures given in EN 13501-1:2007

2. Details of classified product

2.1 General

The product, "Spaceloft", a silica based, aerogel insulation batting, is deemed as being suitable for construction applications, excluding flooring and linear pipe thermal insulation.

2.2 Product description

The product, "Spaceloft", a silica based, aerogel insulation batting, is fully described below and in the test reports provided in support of classification listed in Clause 3.1.

General description		An insulation material backed by a calcium silicate substrate
Batting	Product reference	"Spaceloft"
	Detailed description / composition details	Silica based, aerogel insulation batting
	Name of manufacturer	Aspen Aerogels, Inc.
	Density	0.15 g/cm³
	Weight per unit area	0.745 – 1.56 kg kg/m²
	Thickness	5 - 10mm
	Colour	White
	Flame retardant details	**See Note 1**
Substrate	Product reference	"Promat – Brandschultzbauplatten; Promatect-H"
	Generic type	Calcium Silicate based board
	Name of manufacturer	Promat
	Thickness	12mm
	Density	870 kg/m³
	Flame retardant details	The substrate is inherently flame retardant
Mounting and fixing details		The specimens were tested clipped to a calcium silicate substrate with bull dog clips.
Brief description of manufacturing process		Aspen Aerogels produces nanoporous insulating materials, the process involves casting of the aerogels into fibrous battings.

Note 1 - The sponsor of the test has confirmed that no flame retardant additives were utilized in the production of the product / component

Bodycote

Appendix A EN 13501-1 – REACTION TO FIRE CLASSIFICATION (BODYCOTE, WARINGTON FIRE)

3. Test reports/extended application reports & test results in support of classification

3.1 Test reports/extended application reports

Name of Laboratory	Name of sponsor	Test reports/extended application report Nos.	Test method / extended application rules & date
Bodycote warringtonfire	Aspen Aerogels Inc	WF 181535 WF 181536	EN 13823
Bodycote warringtonfire	Aspen Aerogels Inc	WF 181537	EN ISO 11925-2
Bodycote warringtonfire	Aspen Aerogels Inc	WF 182633	EN 15117

3.2 Test results

Test method & test number	Parameter	No. tests	Results	
			Continuous parameter - mean (m)	Compliance parameters
EN 13823	FIGRA $_{0.2MJ}$	4	145.21, 137.28	Compliant
	THR $_{600s}$		1.16, 1.55	Compliant
	LSF		No	Compliant
	SMOGRA		0	Compliant
	TSP$_{600s}$		39.8, 38.72	Compliant
EN ISO 11925-2 (30s exposure – surface)	F_s	6	0	Compliant
EN ISO 11925-2 (30s exposure – edge)	F_s	6	0	Compliant

Bodycote

Appendix A EN 13501-1 – REACTION TO FIRE CLASSIFICATION (BODYCOTE, WARINGTON FIRE)

4. Classification and field of application

4.1 Reference of classification

This classification has been carried out in accordance with clause 8 of EN 13501-1:2007

4.2 Classification

The product, "Spaceloft", a silica based, aerogel insulation batting, in relation to its reaction to fire behaviour is classified:

Reaction to fire classification: C-s1,d0

4.3 Field of application

This classification is valid for the following end use applications:

i) Construction applications, excluding flooring and linear pipe thermal insulation

This classification is also valid for the following product parameters:

Product thickness	5-10mm
Product density	No variation allowed
Product colour	No variation allowed
Product composition	No variation allowed
Product construction	No variation allowed

The classification is valid for the following substrates and airgaps:

Directly against an A1 or A2 substrate with a density of 615 kg/m^3 and greater

5. Limitations

This classification report does not represent type approval or certification of the product.

SIGNED

L S Hill

.....

Leigh Hill
Technical Consultant
Technical Department

APPROVED

Janet Murrell

.....

Janet Murrell
Technical Manager
Technical Department
on behalf of:
Bodycote warringtonfire

Bodycote

Appendix B ASTM E 84 – SURFACE BURNING CHARACTERISTICS (BODYCOTE TESTING GROUP)

Bodycote

TESTING GROUP
www.bodycote.com
www.bodycotetesting.com

ELECTRONIC DRAFT COPY

ASTM E 84 Surface Burning Characteristics of "Spaceloft" Blanket Insulation

A Report To:	**Aspen Aerogels Inc.** 30 Forbes Road, Building B Northborough, MA 01532 USA
Phone: Email:	(508) 691-1132 cmaclaurin@aerogel.com
Attention:	Cindy MacLaurin
Submitted by:	Fire Testing
Report No.	08-002-884(A) 4 Pages
Date:	November 21, 2008

Bodycote Testing Group
2395 Speakman Drive • Mississauga • Ontario • Canada • L5K 1B3 • Tel: +1 (905) 822-4111 • Fax: +1 (905) 823-1446

Appendix B ASTM E 84 – SURFACE BURNING CHARACTERISTICS (BODYCOTE TESTING GROUP)

Bodycote Testing Group

ASTM E 84 Surface Burning Characteristics of "Spaceloft" Blanket Insulation *Page 2 of 4*

For: Aspen Aerogels Inc. *Report No. 08-002-884(A)*

REGISTRATION ISO 9001:2000, registered by QMI, Registration #001109.

SPECIFICATIONS OF ORDER

Determine the Flame Spread and Smoke Developed Indices based upon a single test conducted in accordance with ASTM E 84-08a as per your P.O. #308224 and our Quotation No. 08-002-10214 accepted October 27, 2008.

SAMPLE IDENTIFICATION (Bodycote sample identification number 08-002-S0884)

Blanket insulation material identified as: "P/N S100087; Lot BLKT 253".

TEST PROCEDURE

The method, designated as ASTM E 84-08a, "Standard Method of Test for Surface Burning Characteristics of Building Materials", is designed to determine the relative surface burning characteristics of materials under specific test conditions. Results are expressed in terms of Flame Spread Index (FSI) and Smoke Developed (SD).

Although the procedure is applicable to materials, products and assemblies used in building construction for development of comparative surface spread of flame data, the test results may not reflect the relative surface burning characteristics of tested materials under all building fire conditions.

SAMPLE PREPARATION

The sample, which consisted of one continuous section approximately 24 feet in length by 21 inches in width by 0.4 inches in thickness, was conditioned at a temperature of 73 ± 3°F and a relative humidity of 50 ± 5% prior to testing. During testing the sample was supported over its entire length by 2" hexagonal wire mesh and was further supported by ¼" steel rods spaced nominally at two-foot intervals.

The testing was performed on: 2008-11-12

SUMMARY OF TEST PROCEDURE

The tunnel is preheated to 150°F, as measured by the floor-embedded thermocouple located 23.25 feet downstream of the burner ports, and allowed to cool to 105°F, as measured by the floor-embedded thermocouple located 13 feet from the burners. At this time the tunnel lid is raised and the test sample is placed along the ledges of the tunnel so as to form a continuous ceiling 24 feet long, 12 inches above the floor. The lid is then lowered into place.

Appendix B ASTM E 84 – SURFACE BURNING CHARACTERISTICS (BODYCOTE TESTING GROUP)

Bodycote Testing Group

ASTM E 84 Surface Burning Characteristics of "Spaceloft" Blanket Insulation *Page 3 of 4*

For: Aspen Aerogels Inc. *Report No. 08-002-884(A)*

SUMMARY OF TEST PROCEDURE (continued)

Upon ignition of the gas burners, the flame spread distance is observed and recorded every 15 seconds. Flame spread distance versus time is plotted ignoring any flame front recessions. If the area under the curve (A) is less than or equal to 97.5 min·ft, FSI = 0.515·A; if greater, FSI = 4900/(195-A). Smoke Developed is determined by comparing the area under the obscuration curve for the test sample to that of inorganic reinforced cement board and red oak, arbitrarily established as 0 and 100, respectively.

TEST RESULTS

SAMPLE	FSI	SD
"Spaceloft" Blanket Insulation	<5	20

Observations of Burning Characteristics

- The sample began to propagate flame approximately 0.5 minutes after exposure to the test flame.
- The flame front propagated to a maximum distance of 0.5 feet at approximately 0.5 minutes and receded to the baseline by approximately 2.5 minutes.
- Smoke Developed was recorded during the test (see accompanying chart).

Authorities having jurisdiction usually refer to these categories:

	Flame-Spread Index	Smoke Development
Class 1 or A	0 - 25	450 Maximum
Class 2 or B	26 - 75	450 Maximum
Class 3 or C	76 - 200	450 Maximum

Note: This is an electronic copy of the report. Signatures are on file with the original report.

Robert A. Carleton,
Fire Testing.

Ian Smith,
Fire Testing.

Note: This report consists of 4 pages, including the cover page, that comprise the report "body". It should be considered incomplete if all pages are not present.

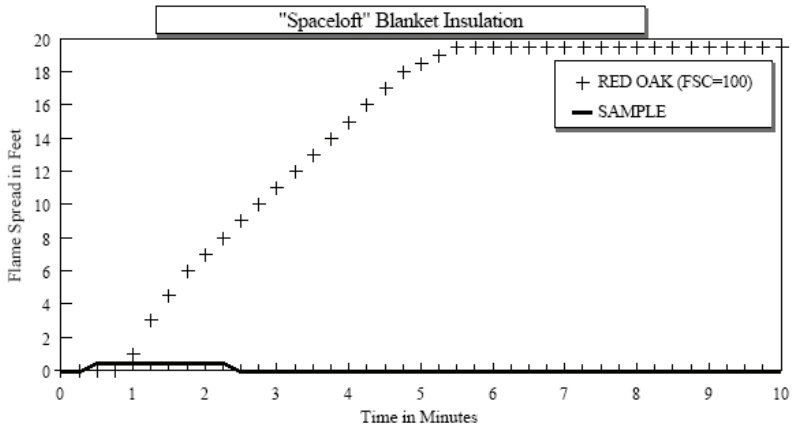
Appendix B ASTM E 84 – SURFACE BURNING CHARACTERISTICS (BODYCOTE TESTING GROUP)

Bodycote Testing Group

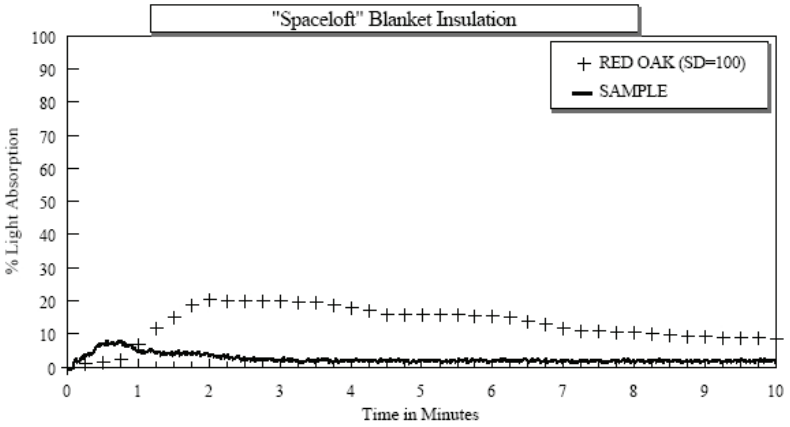
ASTM E 84 Surface Burning Characteristics of "Spaceloft" Blanket Insulation *Page 4 of 4*

For: Aspen Aerogels Inc. *Report No. 08-002-884(A)*

FLAME SPREAD INDEX



SMOKE DEVELOPED



FSI	SD
<5	20

Appendix C ASTM E 228 – LINEAR COEFFICIENT OF THERMAL EXPANSION (NETZSCH)

NETZSCH

Applications Laboratory
Thermophysical Properties Section

Thermal Expansion of Spaceloft

621001667

Prepared for:

Aspen Aerogels Inc.
30 Forbes Road
Northborough, Massachusetts 01532

Prepared by

Michael Manuelian
NETZSCH Instruments, Inc.

February 2009

Appendix C ASTM E 228 – LINEAR COEFFICIENT OF THERMAL EXPANSION (NETZSCH)

NETZSCH

Thermal Expansion of Spaceloft

Introduction

The Thermophysical Property Section of the NETZSCH Instruments Testing Laboratory, Burlington, MA, received one spaceloft sample from Aspen Aerogel for measurement of thermal expansion. The sample was submitted as a sheet, from which test samples approximately 25mm in length were cut from both the X and Y direction.

The thermal expansion was measured in accordance with ASTM E288 using a NETZSCH model 402C pushrod dilatometer, as shown in Figure 1. This dilatometer was equipped with a low temperature furnace capable of operation between -175 and 450°C. The system is vacuum tight, allowing measurements to be carried out in pure inert or oxidizing atmospheres, as well as under vacuum. A set of primary standards, including fused silica, sapphire, platinum, tungsten, etc., is available for the system calibration. The expected expansion of the specimen and the temperature range of the measurement normally dictate which standard is used. Data acquisition and evaluation, as well as instrument control, are accomplished with a MS®-Windows™ Thermal Analysis software package. The software includes semi-automatic routines for correction of the sample holder expansion, as well as computation of the expansion coefficients, onset and peak temperatures, inflection points, rate of expansion, etc.

Reference: 621001667 1 February 2009

Appendix C ASTM E 228 – LINEAR COEFFICIENT OF THERMAL EXPANSION (NETZSCH)

NETZSCH

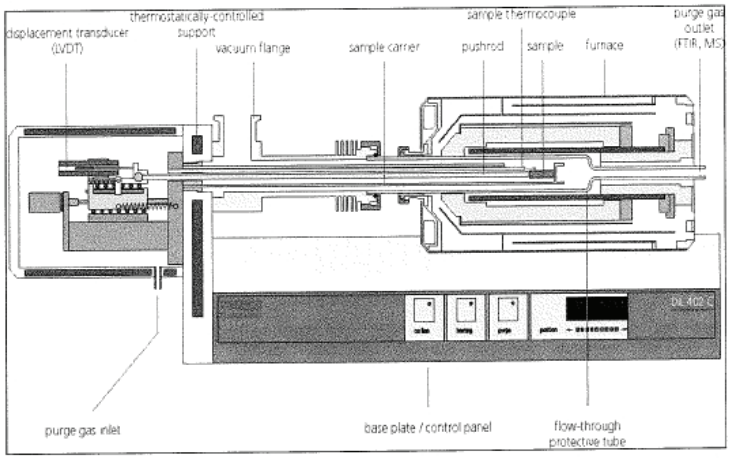


Figure 1

Test Parameters:

Temperature program	-170°C – 100°C, 3K/min
Atmosphere	He
Sample holder	Fused Silica
Contact force of pushrod	30 cN
Sample length	X 28.07 mm Y 24.82mm

Reference: 621001667 2 February 2009