aspen aerogels™

Pyrogel XT/XTF Insulation

TECHNICAL GUIDE

(Headings/page#s linked)

Contents

Thermal Conductivity

THERMAL CONDUCTIVITY OF PYROGEL XT ACCORDING TO ASTM C 177

Third-party validation of the thermal conductivity of Pyrogel XT was acquired at temperatures ranging from 0°–650°C (32°–1200°F) under a compressive load of 2 psi. The final report displaying the full thermal conductivity curve is shown in **Appendix A**.

Non-Combustibility and Fire Performance

ASTM E 84 – SURFACE BURNING CHARACTERISTICS

Pyrogel XT was tested in accordance with ASTM E 84, the Standard Test Method for Surface Burning Characteristics of Building Materials, and is given in **Appendix B**. Pyrogel XT exhibited no ignition during testing and thus satisfies the criteria for a Class A rating with a flame spread index: 0, smoke developed index: 5, and fuel contribution: 0.

ASTM E 1354 – STANDARD TEST METHOD FOR HEAT AND VISIBLE SMOKE RELEASE RATES FOR MATERIALS AND PRODUCTS USING AN OXYGEN CONSUMPTION CALORIMETER

Pyrogel XT was tested in accordance with ASTM E 1354 at an incident heat flux equivalent to a cellulosic fire (50 kW/m^2). The testing was performed in triplicate with no signs of ignition for all samples, resulting in a total heat release of zero and effective heat of combustion of 730 J/g. These third-party test results can be found in **Appendix C**.

BS EN 13501-1:2007 – REACTION TO FIRE PERFORMANCE

The reaction to fire performance of Pyrogel XT was evaluated via **BS EN 13501-1:2007**. Pyrogel XT (5-10 mm) achieved a reaction to fire classification of A2-s1, d0 for construction applications and as a suspended ceiling membrane. **EN ISO 1716** and **EN 13823** were carried out as part of this testing, and all results were compliant for Class A2 classification. Third-party test results can be found in **Appendix L**. (Click bolded text to jump to specific section.)

Non-Combustibility and Fire Performance

BSS 7239:88 – TEST METHOD FOR TOXIC GAS GENERATION BY MATERIALS ON COMBUSTION

Quantitative analysis of potential toxic combustion gases was determined for Pyrogel XT via Boeing Support Specification 7239. Specifically, representative production samples were exposed to flaming combustion conditions (25 kW/m^2) as dictated by ASTM E 662. The levels of CO, HF, HCl, NO_X, SO_2 and HCN were determined via Drager colorimetric gas analyses. All of the gases were below the detection limits with the exception of CO and NO_X, which exhibited levels of 100 and 5.0 ppm, respectively. While no specific pass/fail criteria exists for BSS 7239, the measured levels of CO and NO_X are significantly below the accepted transportation industry standards of 3500 and 100 ppm, respectively. The third-party test results for BSS 7239 can be found in **Appendix E**.

ISO 1182:1990 – TEST FOR NON-COMBUSTIBILITY

The non-combustibility of Pyrogel XT was assessed via the methods outlined in ISO 1182. The mean duration of flaming, average specimen temperature and average furnace temperature for a representative sample of Pyrogel XT was 0 sec, 32°C and 27°C (90°F and 81°F), respectively. This performance meets the criteria for non-combustibility as set forth in the 1990 edition of ISO 1182 and is consistent with a Euroclass A2 Fire classification. Third-party ISO 1182 test results can be found in **Appendix D**.

UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL (Pyrogel XTF only)

Testing was conducted on Pyrogel XTF to evaluate its fire resistance. Testing was conducted in accordance with UL 1709-05 Standard for Rapid Rise Fire Tests of Protection Materials for Structural Steel. Results were as follows:

12 mm → 68 min 48 mm → 184 min
30 mm → 132 min 66 mm → >240 min

The third-party test results for UL 17090-05 can be found in **Appendix F**.

Dimensional Stability

ASTM C 356 – LINEAR SHRINKAGE UNDER FULL THERMAL SOAK

The dimensional stability of Pyrogel XT at elevated temperatures was ascertained by testing according to the methods outlined in ASTM C 356. A linear shrinkage of 1.3% and a total mass loss of 1.1% was observed for Pyrogel XT after a 24-hour exposure at 650°C (1200°F). Third-party ASTM C 356 test results can be found in **Appendix H**.

ASTM C 411 – HOT SURFACE PERFORMANCE (FLAT PLATE CONFIGURATION)

The maximum use temperature of Pyrogel XT was confirmed by testing material according to ASTM C 411 in a flat plate configuration. Specifically, a 60 mm stack-up of Pyrogel XT was exposed to a hot surface at 650°C for a period of 96 hours. The maximum midpoint temperature of the stack-up was measured at 463°C with a cold face temperature of 65.6°C, indicating the absence of any unusual exothermic heat rise. After testing, Pyrogel XT retained structural integrity and exhibited no signs of warping, delamination, or cracking. Third-party test results for ASTM C 411 can be found in **Appendix H**.

ASTM C 411/C 447 – ESTIMATION OF MAXIMUM USE TEMPERATURE AND HOT SURFACE PERFORMANCE (PIPE CONFIGURATION)

The maximum use temperature of Pyrogel XT was assessed using the methods outlined in ASTM C 447 using material shrinkage and degradation in thermal performance during ASTM C 411 testing as the main criteria. Specifically, 60 mm of Pyrogel XT was installed on a 3.5” pipe and subjected to heating to 650°C (1200°F) for a period of 96 hours. The average percent shrinkage across the leading edge (i.e. hot face) was measured at 1.77%. Interply thermoucouples located between layers 2-3, 4-5, 6-7, 8-9, and 10-11 were stable throughout the test, indicating the absence of any exothermic heat rise. Third-party ASTM C 411/C 447 test results are found in **Appendix G**.

Water Resistance/Permeability

ASTM C 1104 – WATER VAPOR SORPTION

The amount of water absorbed upon exposure to high humidity conditions was determined via the methods outlined in ASTM C 1104. Specifically, Pyrogel XT exhibits an average weight gain of 2.25% upon exposure to 95% RH at 49°C for 96 hours. Pyrogel XT exceeds the requirements for water vapor sorption as outlined in ASTM C 547, the Standard Specification for Mineral Fiber Pipe Insulation. Third party test results can be found in **Appendix I, Table 2**.

ASTM C 1511 – DETERMINATION OF WATER RETENTION

Water retention test results for Pyrogel XT are given in **Appendix I, Table 3**. The average weight gain for a 10" x 10" sample was 16.3 grams, which translates to a water uptake of 4.2 vol %. It was estimated that a significant majority of this water uptake was attributed to the presence of microscopic water droplets adhered to the surface of the insulation and not solely from bulk absorption. We have thus conducted testing using a modified ASTM C1511 procedure that includes the removal of these surface species via contact with saturated paper towel. The results of this testing indicated that the bulk water uptake of Pyrogel XT was consistently <0.5 vol %.

ASTM C 1559 – WATER WICKING

The propensity for Pyrogel XT to wick water was determined by the methods outlined in ASTM C 1559. Pyrogel XT is hydrophobic and exhibits no water wicking for the duration of the test (168 hours). Third-party test results are shown in **Appendix I, Table 5**.

Other

ASTM C 165 - COMPRESSIVE STRENGTH

The compressive resistance of Pyrogel XT was acquired according to the methods outlined in ASTM C 165. Specifically, the compressive resistance was determined at 10% and 25% strain for Pyrogel XT. The compressive stress at 10% and 25% strain for a single ply of Pyrogel XT was determined to be 102.9 kPa and 182.9 kPa, respectively. Similar results were obtained for a 5-ply specimen, which exhibited a compressive resistance of 103.1 kPa and 217.4 kPa at a 10% and 25% strain, respectively. Third party results are shown in **Appendix I, Table 4**.

ASTM C 592-04 – HEAT AND VIBRATION AGING

The heat and vibration aging characteristics of Pyrogel XT were tested via ASTM C592-04 (Section 11.11, Modified). The specimen was thermally soaked at 400°C for 96 hours and then vibrated horizontally for 6 hours (12 Hz, displacement of 3 mm peak to peak). Pyrogel XT showed a -0.19% mass change after vibration. Third-party test results can be found in **Appendix K**.

ASTM C 795 – CORROSION TEST

This report details the results of a 28-day corrosion test (ASTM C 692) and the pH and chemical testing of water extraction (ASTM C 871) of Pyrogel XT BLKT 1205 as determined by ASTM C 795, standard specification for thermal insulation for use in contact with austenitic stainless steel. Pyrogel XT BLKT 1205 met the chemical requirements of ASTM C 795, falling within the "Acceptable" range of the "Acceptability Curve." Third party results are shown in **Appendix J**.

ASTM D 5034 – TENSILE STRENGTH

The tensile strength of Pyrogel XT was determined for a single ply of 5 mm material according to the methods outlined in ASTM D 5034, Standard Test Method for Breaking Strength and Elongation of Textile Fabrics. The average tensile strength for Pyrogel XT was determined to be 490 N in the machine direction and 370 N in the cross-direction. Third-party test results can be found in **Appendix I, Table 6**.

Appendix A ASTM C 177 – THERMAL CONDUCTIVITY

NETZSCH

Report on the

THERMAL CONDUCTIVITY and
THERMAL RESISTANCE of AEROGEL MAT

Prepared for:

Aspen Aerogels Inc.
30 Forbes Road
Northborough, Massachusetts 01532

Prepared by:

NETZSCH Instruments, Inc.
Testing Services

Report Number: 621001443

Work Performed Under Purchase Order Number: 306132

Submitted By:
Robert C. Campbell
Applications Laboratory Manager

May 2008

Appendix A ASTM C 177 – THERMAL CONDUCTIVITY

NETZSCH

Report on the

Apparent Thermal Conductivity and Thermal Resistance of Aerogel Mat

NETZSCH Instruments was contracted by Aspen Aerogels to evaluate one aerogel mat insulation material for apparent thermal conductivity at nominal mean temperatures of 0, 50, 100, 200, 350, 500 and 600°C by the guarded hot plate method.

The material was identified as given in Table 1 and was submitted as a pair dimensioned approximately 305 mm square by 6 mm thickness. The samples were cut to 200 mm diameter for testing.

The specimens were positioned horizontally with heat flow up and down during the tests. The test results are given in Table 1 after a description of equipment and procedure.

Thermal Conductivity

Thermal conductivity is the material property that determines the amount of heat that will flow through an object when a temperature difference exits across the object. Thermal conductivity is a steady state property; it can only be directly measured under conditions in which the temperature distribution is not changing and all heat flows are steady. The fundamental equation that governs steady-state heat flow in a slab geometry is:

$$Q = (\lambda \times \Delta T \times A) / \Delta x \quad (1)$$

where

Q = the rate of heat flow through the slab (W or Btu/h)

λ = the thermal conductivity of the slab material (W/m K or Btu/h-ft-°F)

ΔT = the temperature difference across the slab (°C or °F)

Δx = the thickness (m or ft)

A = the cross sectional area (m^2 or ft^2)

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Materials that have low values of thermal conductivity allow only a small amount of heat flow and are called thermal insulators. Materials with large values of thermal conductivity allow more heat to flow across the slab with the same temperature difference. Thermal conductivity is a material property and does not depend upon the geometry of the sample. In general, thermal conductivity is a function of the mean sample temperature. The material comprising the slab is often a mixture of materials. It could be a layered composite or a material containing gas cells in which heat can be transferred by convection and radiation as well as by conductivity through the material. In these cases the parameter, λ, defined in Equation (1) is an "effective" or "apparent" thermal conductivity for the heterogeneous material.

Experimental Procedure for Testing by ASTM C 177-97

Testing was performed in accordance with ASTM C 177-97, *Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded Hot Plate Apparatus,* utilizing a Holometrix Model TCFGM guarded hot plate instrument (SN GHP-3). A schematic diagram of the test facility is shown in Figure 1. Two samples sandwiched a heating unit, which consisted of a central metering section and an annular guard section. This composite stack was mounted between two cooling units and surrounded with an environmental heater unit, a fluid-cooled shroud, and edge insulation. The metering section of the heating unit consisted of a metering area heater and metering area surface plates, while the guard section was comprised of a single guard heater and guard surface plates. The cooling units consisted of a cooling plate, a cooling unit heater, and a cooling surface plate. All surface plates were fabricated of 10 mm (0.38 inch) thick steel, were smoothly finished to conform to a true plane to within 0.025 percent, and were treated to have a total hemispherical emittance of 0.82 at 24 °C (75 °F).

The heating unit was fabricated by sandwiching a two-element mica heater unit between two thin sheets of ceramic fiber paper and two surface plates. The overall geometry of the heating unit was 200 mm (8 inches) in diameter, with the metering area being the central 100 mm (4 inch) round section. The unit was bolted together at four points, one being in the metering section. The two sections of the heater unit were separated by a 3 mm (0.125 inch) gap around the perimeter of the metering section. The specific area of the metering section was 8.36 $*10^{-3}$ m^2 (9.00 $*10^{-2}$ ft^2). The area of the gap represented 3.3 percent of the total metering section area. The area of the metering section was determined by measurements to the centers of the gap. A 16-junction differential thermopile was installed between the mica heating unit and the surface plates such that alternate junctions

Reference: Report No. 621001443 2 May 2008

Appendix A ASTM C 177 – THERMAL CONDUCTIVITY

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were in the metering and guard sections respectively and close to the annular gap between the sections. This thermopile was fabricated of 32-gauge Type-K Chromel/Alumel wire. The sensitivity of this thermopile was approximately 0.33 mV/°C (0.18 mV/°F) at 24 °C (75 °F).

The metering area heater was connected to a Sorenson DC Power Supply. A 0.001 Ω precision resistor was connected in series with the heater and the voltage drop across this resistor (0.001 times the current) was monitored. The voltage across the heater was measured directly. The output of the differential thermopile was connected to a differential temperature controller which supplied power to the guard heater such that the thermopile output was minimized.

The cooling units consisted of a 10 mm (0.38 inch) thick copper plate which had a series of interconnected 6 mm (0.25 inch) diameter copper tubes soldered to the plate and foamed in place with a spray urethane foam, a mica electric resistance heater unit, and a surface plate. The plates and heater were similar in cross section to the heating unit. The tubing was connected to a temperature controlled circulating chiller unit and a control thermocouple was attached to the underside of the surface plate and connected to a temperature controller. Temperature control at the surface plates was accomplished by operating the circulating chiller continuously and reheating with the electrical resistance heaters.

The environmental heating unit consisted of a sheathed electric resistance cable heater sandwiched between two tightly fitting passivated stainless steel rings 300 mm (12 inches) in diameter by 100 mm (4 inches) high. The electric resistance heater was connected to a temperature controller. The environmental heating unit and test stack were enclosed by a bell jar. The approximate dimensions of the bell jar were 457mm (18 inches) in diameter by 711mm (28 inches) high. The temperature of the environmental heating unit was controlled and monitored by thermocouples attached to its inner surface. The interspaces between the test stack, environmental heating unit, and bell jar were filled with loose-fill insulation material.

Temperature measurements were performed by utilizing Type-K Chromel/Alumel thermocouples calibrated to the special limits of error specified in ASTM E 230, *Temperature-Electromotive Force (EMF) Tables for Standardized Thermocouples*. All thermocouple sensors were fabricated with #30 AWG wire. The thermocouples were fixed to the surface plates by cementing them into 1.6 mm (0.062 inch) square grooves that had been machine-cut into all the surface plates. A total of two thermocouples were cemented into each working surface; one in the metering section and one in the guard section. The temperature sensors

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were referenced to an Acromag Model 320 Electronic Ice Reference. The setpoint accuracy for the reference is ± 0.5 °C (± 0.9 °F) with a 0.1 °C (0.2 °F) stability over an eight-hour period. The voltage drops, current, and thermopile output were metered with a Hewlett Packard Data Aquisition Unit, Model 3497, having a range of ± 1μV to 300V. The resolution of the meter is 1 microvolt with a maximum error of 0.01 percent of the output and ± 2 microvolts over an eight-hour period.

In operation, a steady temperature equilibrium was established in the test system. The temperatures of the cooling surface plates were set to their required levels. The required temperature difference across each sample was maintained by the adjustment of the power to the metering area heater. If no specific temperature difference was required, a 40 °C (75 °F) difference was used. The temperature of the environmental heating unit was controlled to the mean sample temperature level. The differential output was checked and adjusted such that the thermopile output was maintained between ± 0.01 mV. At equilibrium, established after ensuring that during twenty-one regular sets of ten – one minute readings, the apparent thermal conductivity did not change by more than 0.5 percent and that there was no consistent drift, the power to the metering area heater was measured with the precision resistor network and the temperatures of the working surfaces were evaluated from thermocouple readings.

The apparent thermal conductivity was calculated from

$$\lambda = \frac{Q \times L}{A \times \Delta T}$$

and the thermal resistance was calculated from

$$R = \frac{A \times \Delta T}{Q}$$

where
- λ = apparent thermal conductivity, W/m-K (Btu-in/hr-ft^2-°F)
- Q = power dissipation in the metering heater, W (Btu/hr)
- L = total thickness of both test specimens, m (inches)
- A = the metering surface area taken twice, m^2 (ft^2)
- ΔT = total temperature difference across both specimens, °C (°F)
- R = thermal resistance, m^2-K/W (hr-ft^2-°F/Btu)

Reference: Report No. 621001443 4 May 2008

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The instrument performance was verified using the National Institute of Standards and Technology Standard Reference Material 1450b. The calibration specimen is a high-density fibrous glass material, 25.4 mm (1.00 inch) thick, having a thermal resistance of approximately 0.803 m^2-K/W (4.56 hr-ft^2-°F/Btu) at 24 °C (75 °F). The overall uncertainty of the thermal resistance of the standard is estimated by NIST to be 2 percent. The instrumentation is verified every six months and after any repair or modification.

Reference: Report No. 621001443 5 May 2008

Appendix A ASTM C 177 – THERMAL CONDUCTIVITY

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Test Results

The test results are given in Table 1 and are plotted in Figure 2. The results reported apply only to the specimens that were tested.

A load of approximately 2 PSI was applied to the stack during testing. Prior to testing, the average compression of several extra pieces of the material under a load of 2 PSI was measured with a Satec T500 mechanical tester to be about 6%. Rigid spacers were cut for each sample to a thickness 6% lower than the sample thickness measured with a drop gauge. Under the stack load, the instrument plates made contact with the spacers to ensure a known and uniform plate gap and sample thickness.

The thermal conductivity and resistance results are estimated to be accurate to within ±5%.

Reference: Report No. 621001443 6 May 2008

Appendix A ASTM C 177 – THERMAL CONDUCTIVITY

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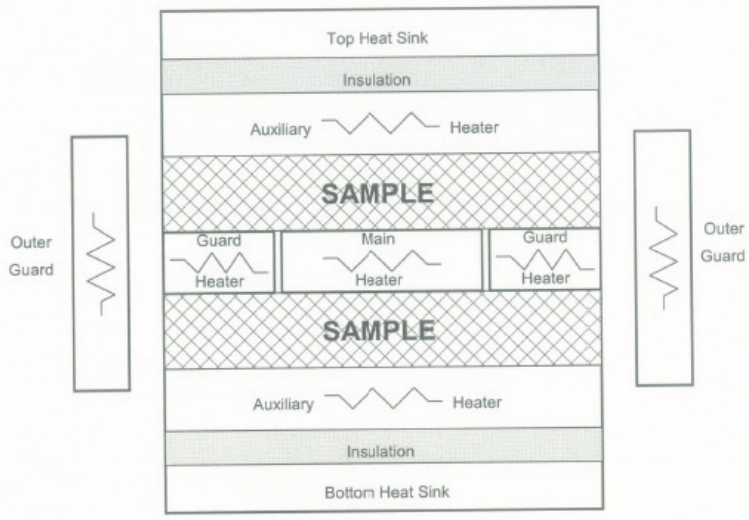

Figure 1. Schematic Diagram of Guarded Hot Plate Instrument

Reference: Report No. 621001443 7 May 2008

Appendix A ASTM C 177 – THERMAL CONDUCTIVITY

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Table 1

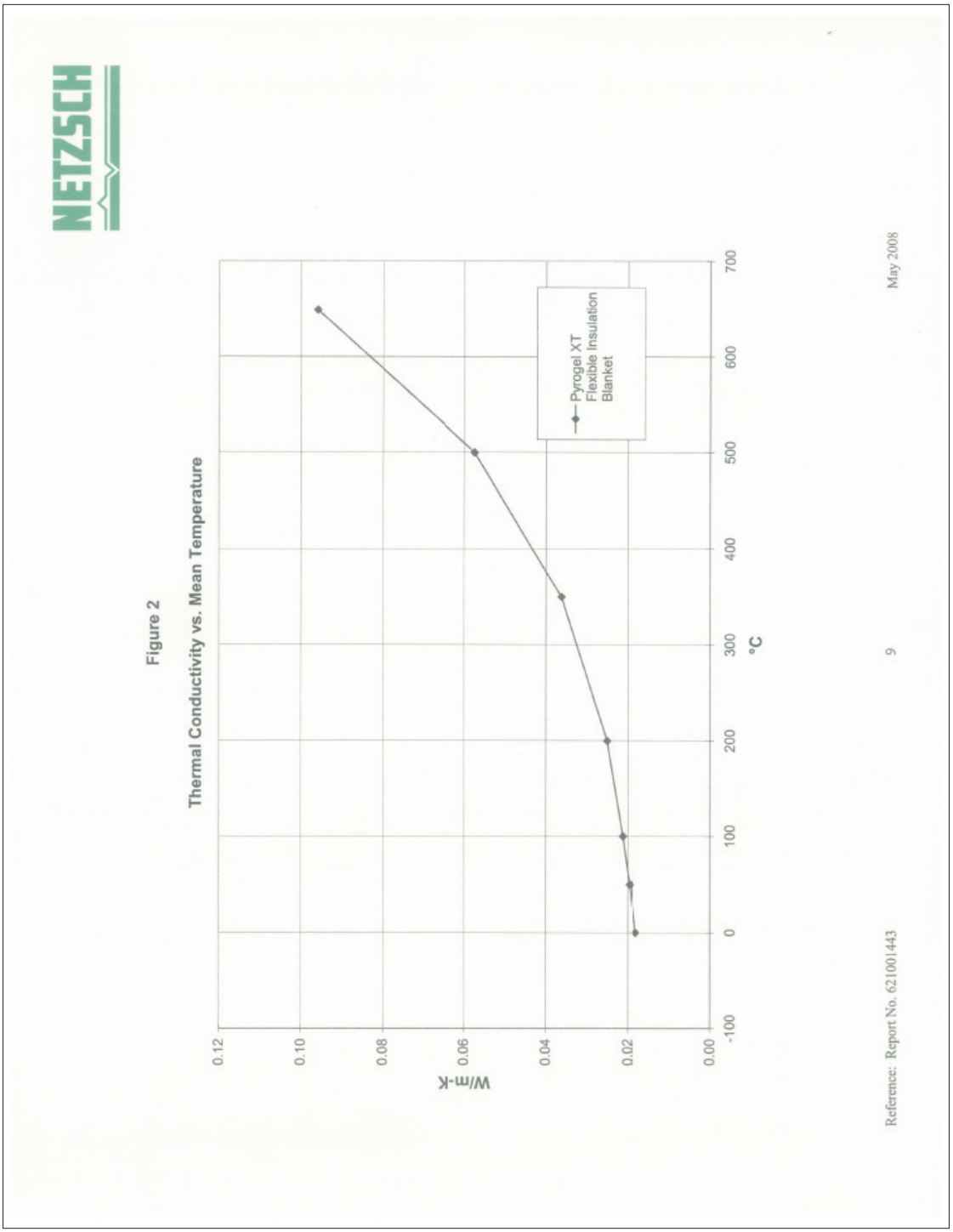
ASTM C177 THERMAL CONDUCTIVITY TEST RESULTS

Specimen	Test Thickness		Test Density		Temperature Mean		Temperature Avg. Delta		Apparent Thermal Conductivity		Thermal Resistance	
	mm	inch	kg/m^3	lbs/ft^3	°C	°F	°C	°F	SI	British	SI	British
Pyrogel XT Flexible Insulation Blanket	5.86	0.231	183	11.4	0	32	40	73	0.0182	0.126	0.322	1.83
					50	122	40	72	0.0195	0.135	0.301	1.71
					100	212	40	72	0.0212	0.147	0.276	1.57
					200	391	41	73	0.0250	0.173	0.234	1.33
					350	661	41	74	0.0362	0.251	0.162	0.919
					500	931	41	73	0.0574	0.398	0.102	0.579
					649	1200	42	76	0.0959	0.665	0.0611	0.347

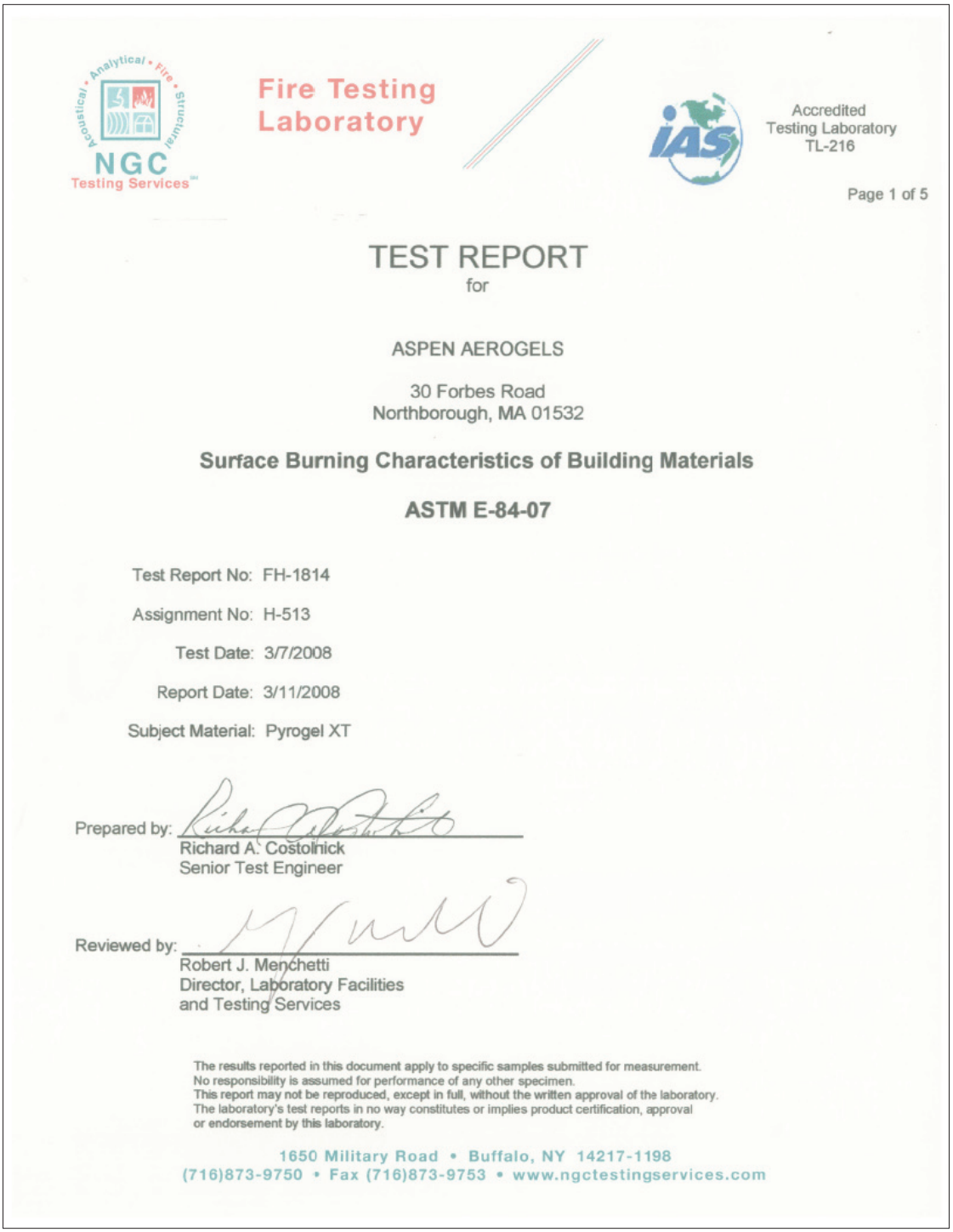
Thermal Conductivity SI Units: W/m-K
Thermal Conductivity British Units: Btu-in/hr-°F-ft^2
Thermal Resistance SI Units: m^2-K/W
Thermal Resistance British Units: hr-°F-ft^2/Btu

Reference: Report No. 621001443 8 May 2008

Appendix A ASTM C 177 – THERMAL CONDUCTIVITY



Appendix B ASTM E 84 – SURFACE BURNING CHARACTERISTICS



Fire Testing Laboratory

NGC Testing Services

Accredited Testing Laboratory TL-216

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TEST REPORT

for

ASPEN AEROGELS

30 Forbes Road
Northborough, MA 01532

Surface Burning Characteristics of Building Materials

ASTM E-84-07

Test Report No: FH-1814

Assignment No: H-513

Test Date: 3/7/2008

Report Date: 3/11/2008

Subject Material: Pyrogel XT

Prepared by:
Richard A. Costolnick
Senior Test Engineer

Reviewed by:
Robert J. Menchetti
Director, Laboratory Facilities
and Testing Services

The results reported in this document apply to specific samples submitted for measurement.
No responsibility is assumed for performance of any other specimen.
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The laboratory's test reports in no way constitutes or implies product certification, approval
or endorsement by this laboratory.

1650 Military Road • Buffalo, NY 14217-1198
(716)873-9750 • Fax (716)873-9753 • www.ngctestingservices.com

Appendix B ASTM E 84 – SURFACE BURNING CHARACTERISTICS

MATERIAL TESTED:

Material submitted by Aspen Aerogels, Northborough, MA, was described by the client as:

PYROGEL XT

Flexible Insulation Blanket

The submitted samples consisted of a single continuous roll, 24 in. wide and cut to the required 24 ft. length.

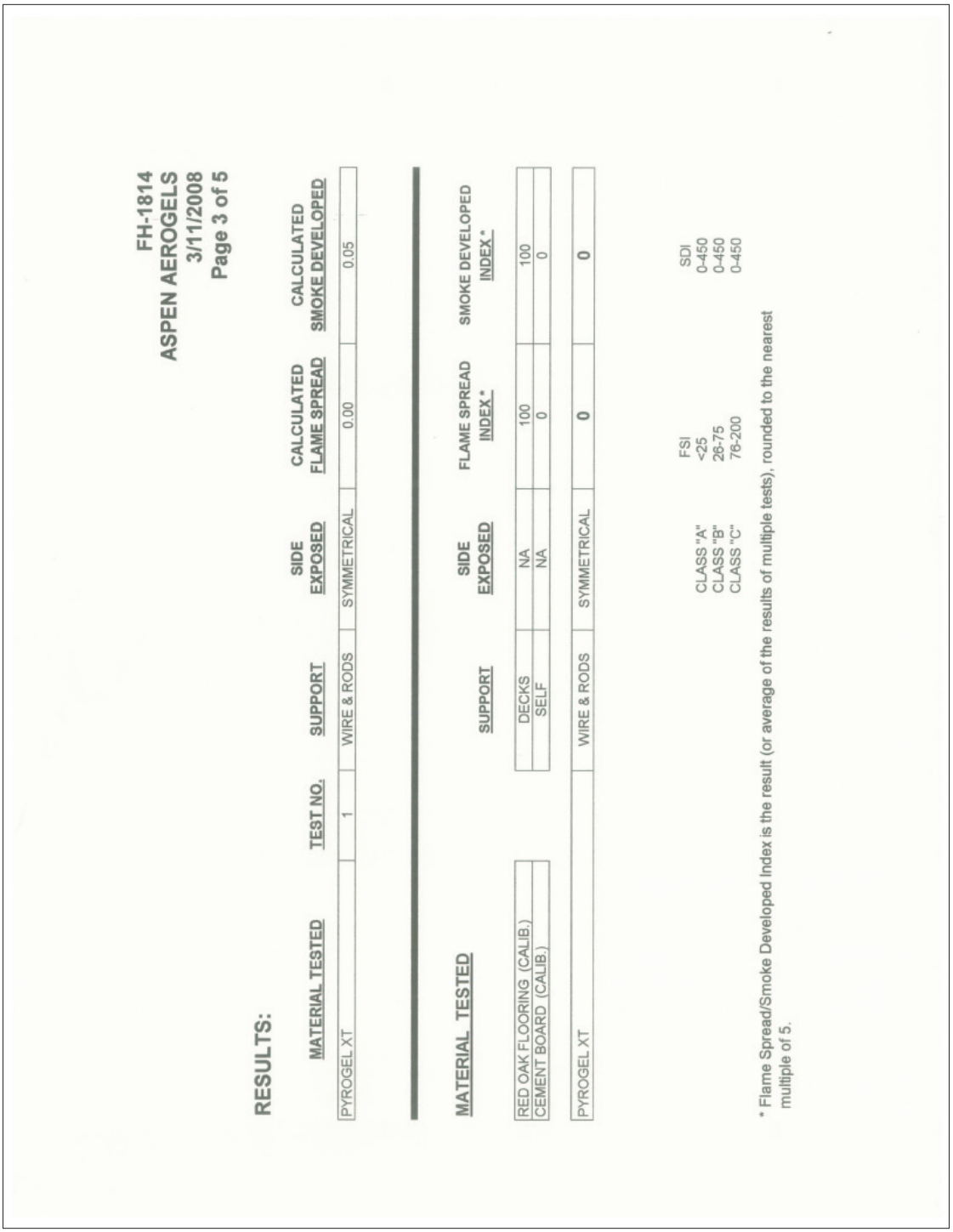
METHOD OF SUPPORT:

The test specimen was supported by 2.0 in. galvanized steel poultry netting, placed over 1/4 in. diameter steel rods spaced 24 in. on center.

RESULTS:

The results can be found on page 3 of this report.

Appendix B ASTM E 84 – SURFACE BURNING CHARACTERISTICS



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ASPEN AEROGELS
3/11/2008
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RESULTS:

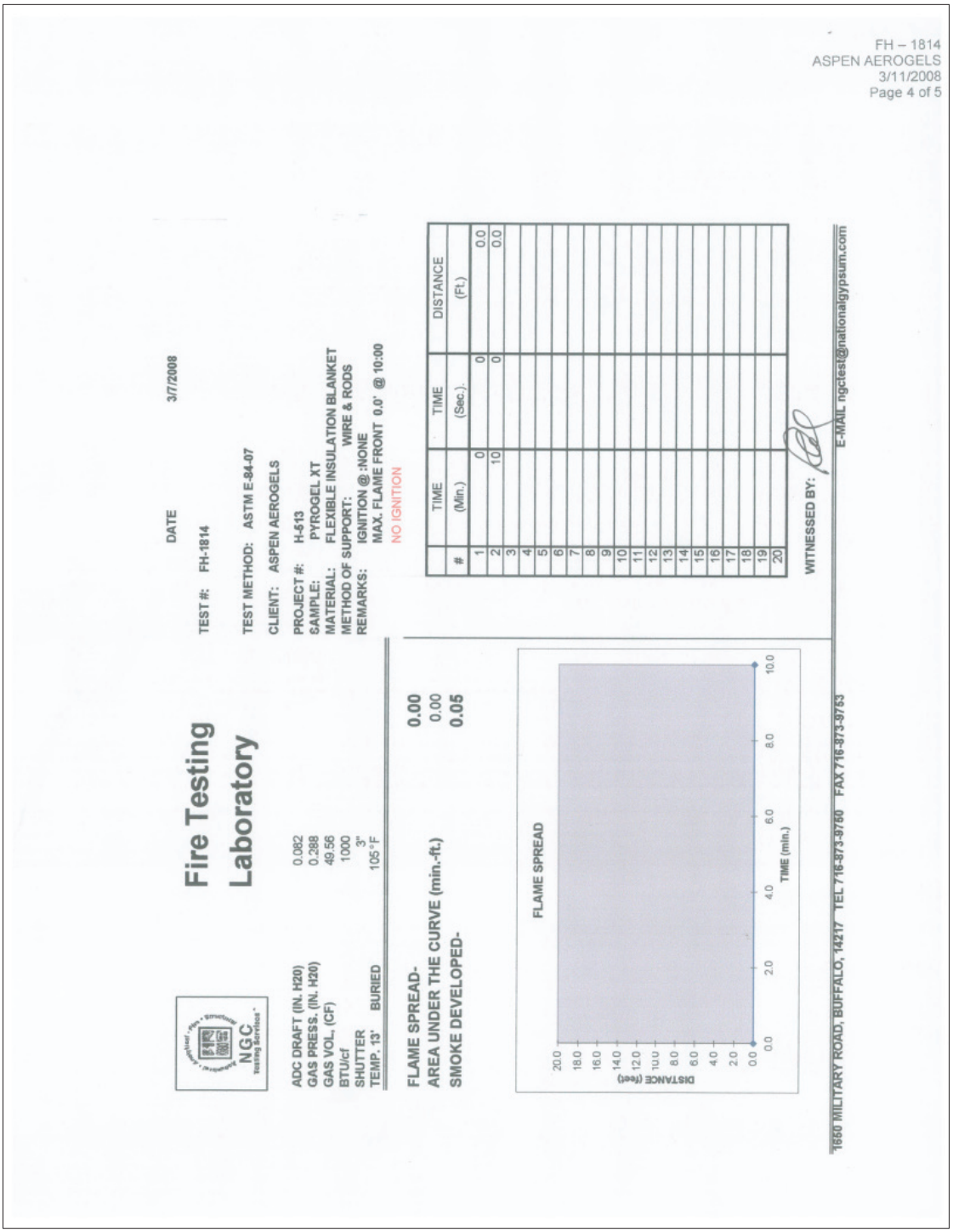
MATERIAL TESTED	TEST NO.	SUPPORT	SIDE EXPOSED	CALCULATED FLAME SPREAD	CALCULATED SMOKE DEVELOPED
PYROGEL XT	1	WIRE & RODS	SYMMETRICAL	0.00	0.05

MATERIAL TESTED	SUPPORT	SIDE EXPOSED	FLAME SPREAD INDEX *	SMOKE DEVELOPED INDEX *
RED OAK FLOORING (CALIB.)	DECKS	NA	100	100
CEMENT BOARD (CALIB.)	SELF	NA	0	0
PYROGEL XT	WIRE & RODS	SYMMETRICAL	0	0

	FSI	SDI
CLASS "A"	<25	0-450
CLASS "B"	26-75	0-450
CLASS "C"	76-200	0-450

* Flame Spread/Smoke Developed Index is the result (or average of the results of multiple tests), rounded to the nearest multiple of 5.

Appendix B ASTM E 84 – SURFACE BURNING CHARACTERISTICS



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3/11/2008
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N.G.C. Testing Services

Fire Testing Laboratory

DATE 3/7/2008
TEST #: FH-1814
TEST METHOD: ASTM E-84-07
CLIENT: ASPEN AEROGELS
PROJECT #: H-613
SAMPLE: PYROGEL XT
MATERIAL: FLEXIBLE INSULATION BLANKET
METHOD OF SUPPORT: WIRE & RODS
REMARKS: IGNITION @ :NONE
MAX. FLAME FRONT 0.0' @ 10:00
NO IGNITION

ADC DRAFT (IN. H20)	0.082
GAS PRESS. (IN. H20)	0.288
GAS VOL. (CF)	49.56
BTU/cf	1000
SHUTTER	3"
TEMP. 13' BURIED	105°F

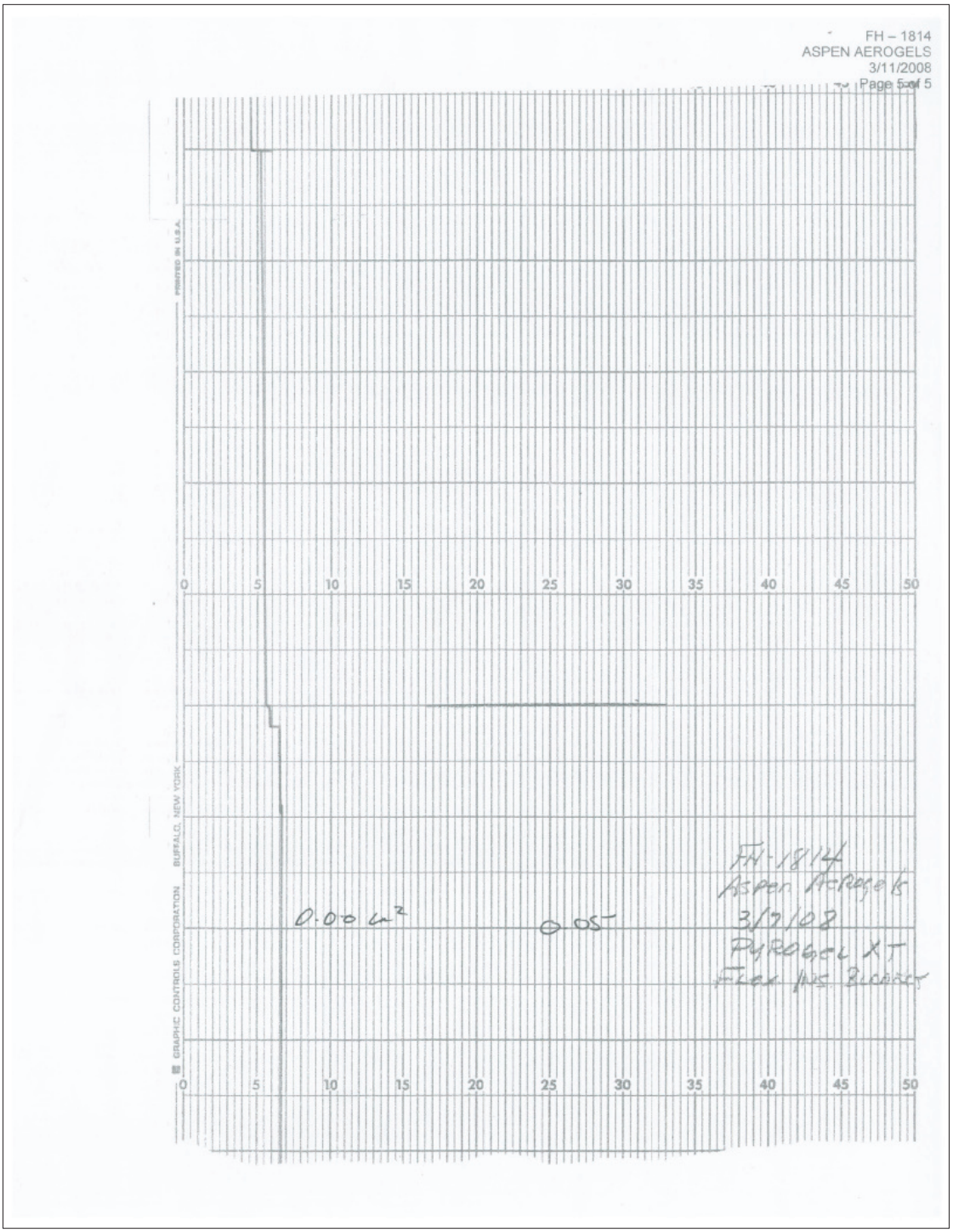
FLAME SPREAD-	0.00
AREA UNDER THE CURVE (min.-ft.)	0.00
SMOKE DEVELOPED-	0.05

#	TIME (Min.)	TIME (Sec.)	DISTANCE (Ft.)
1		0	0.0
2	10	0	0.0
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			

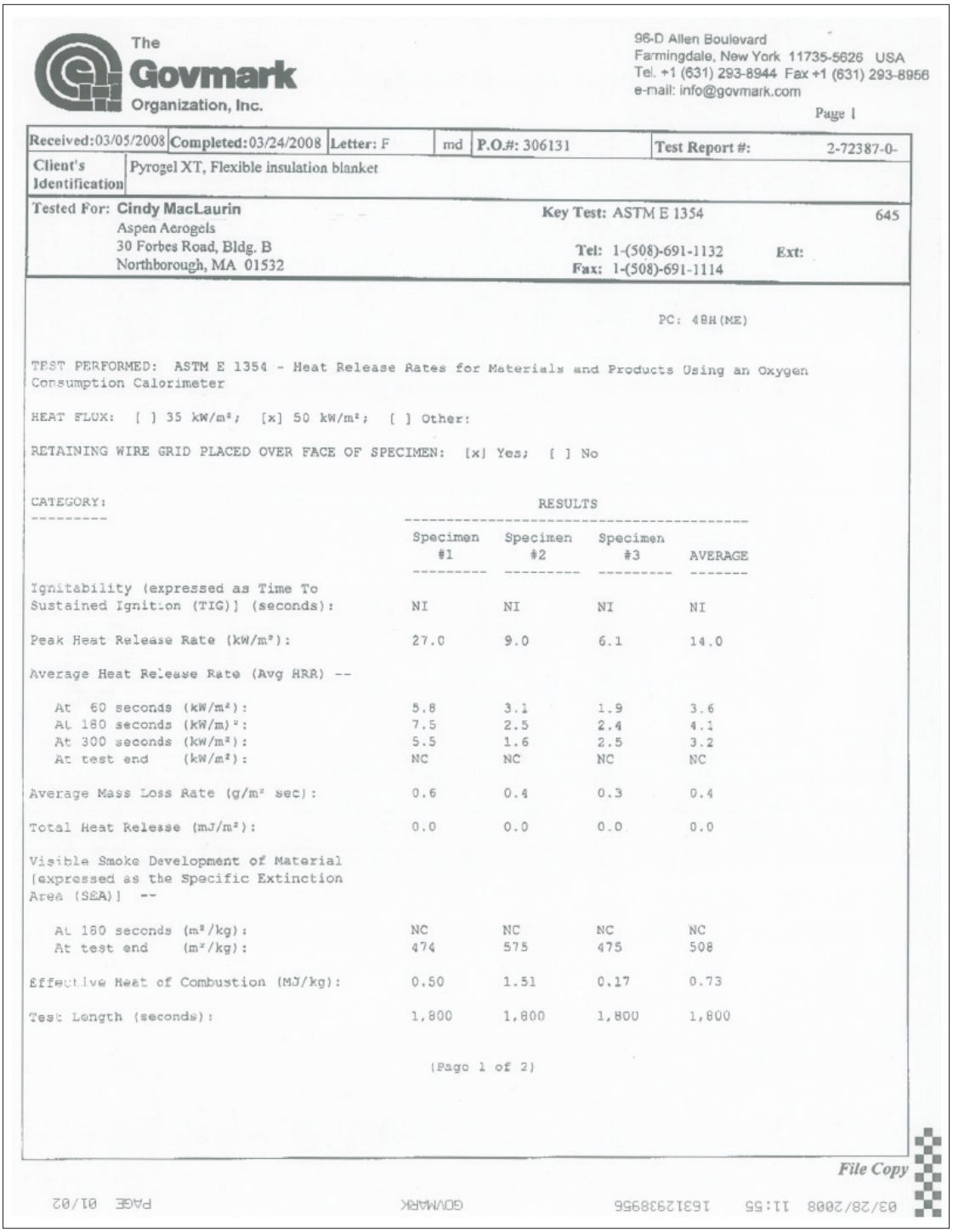
WITNESSED BY:

1650 MILITARY ROAD, BUFFALO, 14217 TEL 716-873-9760 FAX 716-873-9753 E-MAIL ngctest@nationalgypsum.com

Appendix B ASTM E 84 – SURFACE BURNING CHARACTERISTICS



Appendix C ASTM E 1354 – CONE CALORIMETRY



The Govmark Organization, Inc.

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e-mail: info@govmark.com

Page 1

Received:03/05/2008	Completed:03/24/2008	Letter: F	md	P.O.#: 306131	Test Report #:	2-72387-0-
Client's Identification	Pyrogel XT, Flexible insulation blanket					

Tested For: Cindy MacLaurin
Aspen Aerogels
30 Forbes Road, Bldg. B
Northborough, MA 01532

Key Test: ASTM E 1354 645

Tel: 1-(508)-691-1132 Ext:
Fax: 1-(508)-691-1114

PC: 48H(ME)

TEST PERFORMED: ASTM E 1354 - Heat Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter

HEAT FLUX: [ ] 35 kW/m²; [x] 50 kW/m²; [ ] Other:

RETAINING WIRE GRID PLACED OVER FACE OF SPECIMEN: [x] Yes; [ ] No

CATEGORY:	RESULTS			
	Specimen #1	Specimen #2	Specimen #3	AVERAGE
Ignitability (expressed as Time To Sustained Ignition (TIG)] (seconds):	NI	NI	NI	NI
Peak Heat Release Rate (kW/m²):	27.0	9.0	6.1	14.0
Average Heat Release Rate (Avg HRR) --				
At 60 seconds (kW/m²):	5.8	3.1	1.9	3.6
At 180 seconds (kW/m)²:	7.5	2.5	2.4	4.1
At 300 seconds (kW/m²):	5.5	1.6	2.5	3.2
At test end (kW/m²):	NC	NC	NC	NC
Average Mass Loss Rate (g/m² sec):	0.6	0.4	0.3	0.4
Total Heat Release (mJ/m²):	0.0	0.0	0.0	0.0
Visible Smoke Development of Material (expressed as the Specific Extinction Area (SEA)] --				
At 180 seconds (m²/kg):	NC	NC	NC	NC
At test end (m²/kg):	474	575	475	508
Effective Heat of Combustion (MJ/kg):	0.50	1.51	0.17	0.73
Test Length (seconds):	1,800	1,800	1,800	1,800

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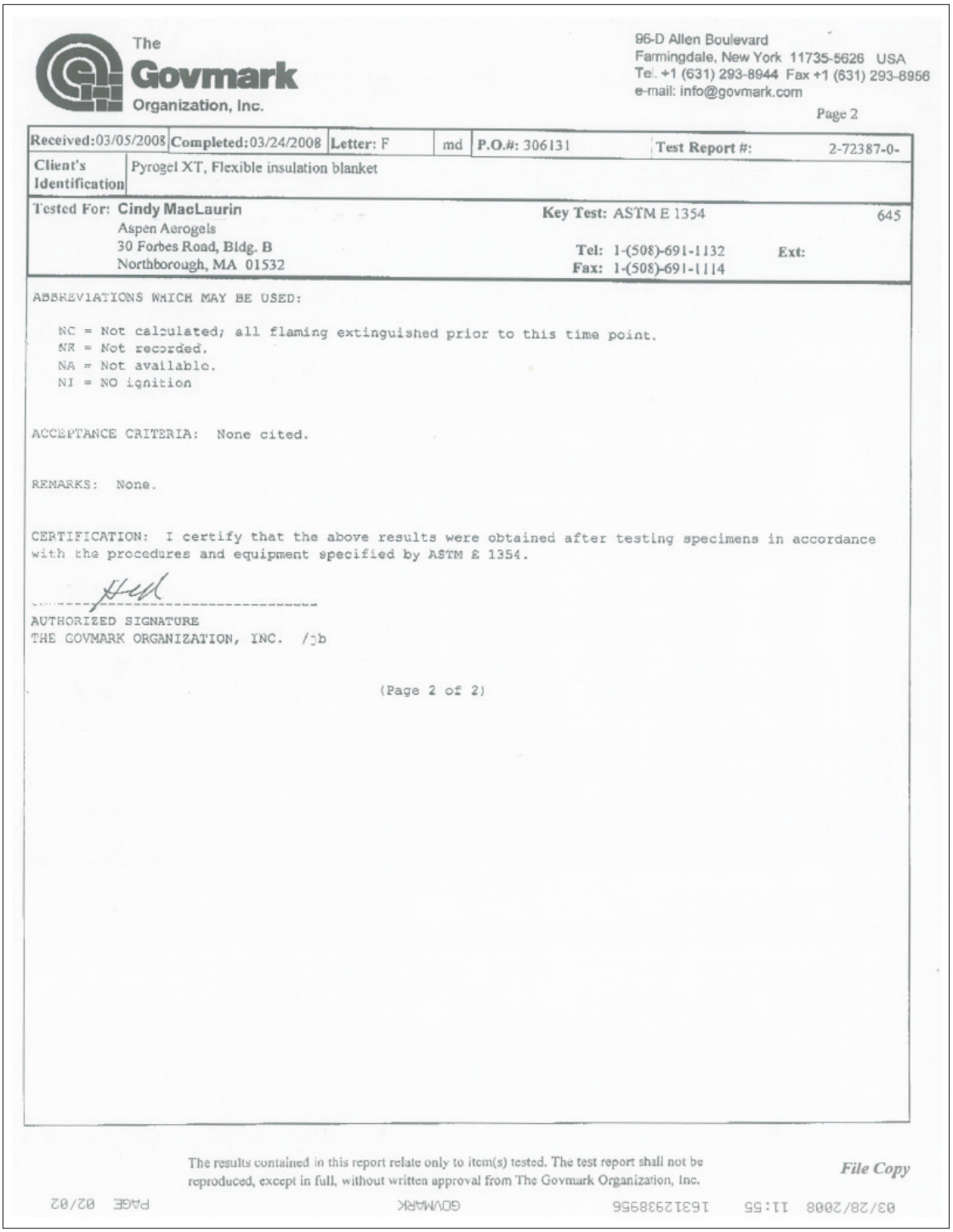
Appendix C ASTM E 1354 – CONE CALORIMETRY



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Page 2

Received:03/05/2008	Completed:03/24/2008	Letter: F	md	P.O.#: 306131	Test Report #:	2-72387-0-
Client's Identification	Pyrogel XT, Flexible insulation blanket					

Tested For: Cindy MacLaurin
Aspen Aerogels
30 Forbes Road, Bldg. B
Northborough, MA 01532

Key Test: ASTM E 1354 645

Tel: 1-(508)-691-1132 Ext:
Fax: 1-(508)-691-1114

ABBREVIATIONS WHICH MAY BE USED:

NC = Not calculated; all flaming extinguished prior to this time point.
NR = Not recorded.
NA = Not available.
NI = NO ignition

ACCEPTANCE CRITERIA: None cited.

REMARKS: None.

CERTIFICATION: I certify that the above results were obtained after testing specimens in accordance with the procedures and equipment specified by ASTM E 1354.

AUTHORIZED SIGNATURE
THE GOVMARK ORGANIZATION, INC. /jb

(Page 2 of 2)

The results contained in this report relate only to item(s) tested. The test report shall not be reproduced, except in full, without written approval from The Govmark Organization, Inc.

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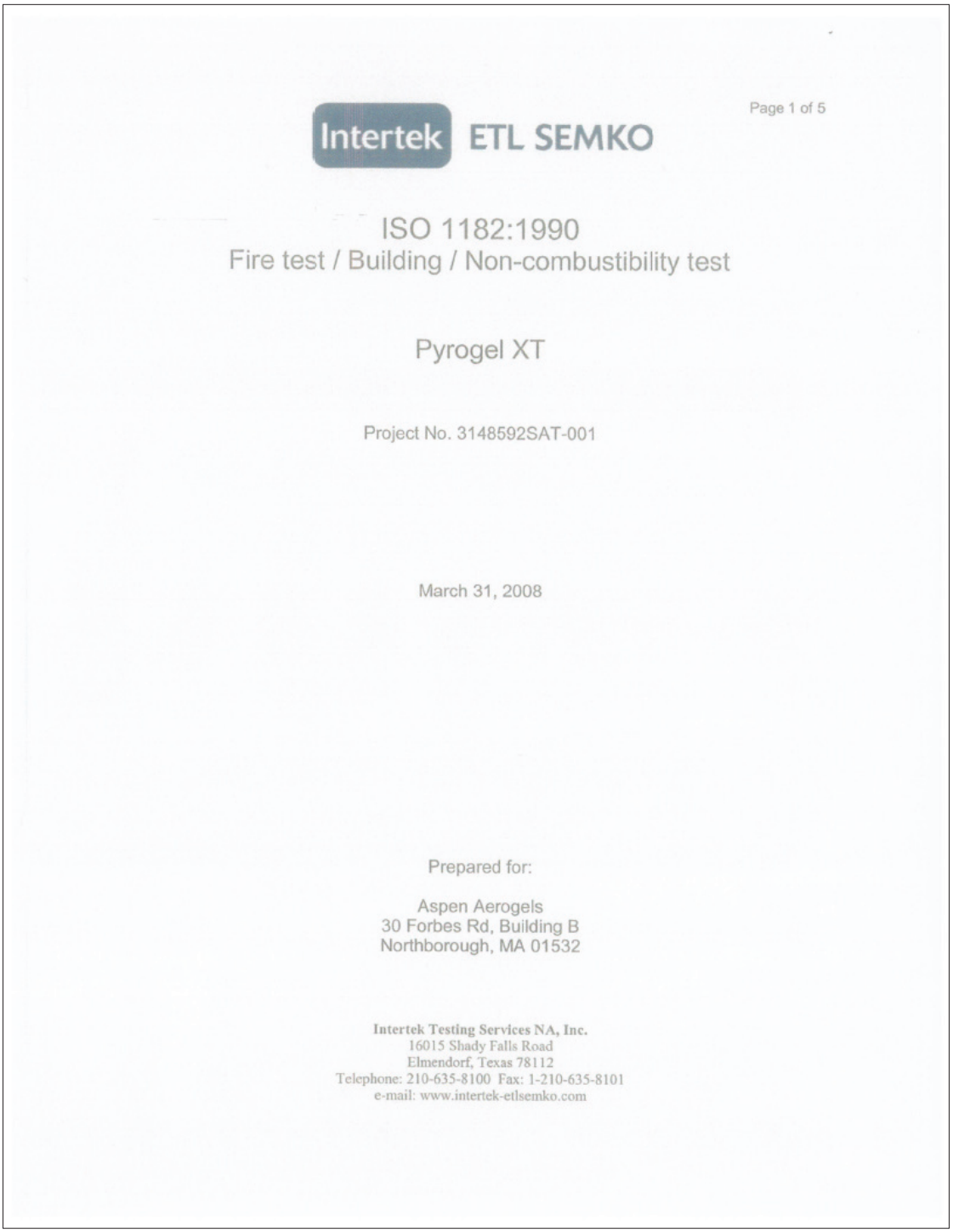
Appendix D ISO 1182:1990 – NON-COMBUSTIBILITY



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Intertek ETL SEMKO

ISO 1182:1990
Fire test / Building / Non-combustibility test

Pyrogel XT

Project No. 3148592SAT-001

March 31, 2008

Prepared for:

Aspen Aerogels
30 Forbes Rd, Building B
Northborough, MA 01532

Intertek Testing Services NA, Inc.
16015 Shady Falls Road
Elmendorf, Texas 78112
Telephone: 210-635-8100 Fax: 1-210-635-8101
e-mail: www.intertek-etlsemko.com

Appendix D ISO 1182:1990 – NON-COMBUSTIBILITY

ABSTRACT

The specimens submitted by Aspen Aerogels and identified as "Pyrogel XT" were tested in accordance with ISO 1182 Non-combustibility test.

This report contains a total of 5 pages.

John Gutierrez
Technician

March 31, 2008

Reviewed and approved:

Servando Romo
Project Manager

March 31, 2008

Intertek ETL SEMKO

Appendix D ISO 1182:1990 – NON-COMBUSTIBILITY

I. INTRODUCTION

This report describes the results of the ISO 1182 Non-combustibility test.
It may be important to ascertain whether a material will or will not contribute directly to fire development and this test has been designed to allow this to be done. Its results will provide information from which regulating authorities will be assisted in deciding whether the material in question may be used without undue hazard in certain locations in buildings. From a technical point of view, the test gives no absolute statement concerning "non-combustibility".
The test results relate only to the behavior of the test specimens of a material under the particular conditions of the test; they are not intended to be the sole criterion for assessing the potential fire hazard of the material in use.

II. PURPOSE

The results of the ISO 1182 test method may be used for the determination of the combustibility performance of a building material under specified conditions. (750°C). The method is intended for the testing of building materials but is not applicable to the testing of products which are coated, faced or laminated.

III. TEST SPECIMENS

Five specimens of materials were tested. The specimens were cylindrical with a diameter of 45 mm and a height of 52 mm. The volume of the specimens was 82.6 cm^3. The specimens consisted of flexible insulation blanket.

Appendix D ISO 1182:1990 – NON-COMBUSTIBILITY

IV. TEST PROCEDURE

Prior to testing, the specimens were conditioned at 60° ± 5°C for twenty-four hours, then stored in a desiccator and cooled to ambient temperature. When the power to the furnace is adjusted so that the average furnace temperature is 750 ± 5°C for at least ten minutes, the samples are placed on the specimen holder and instrumented with thermocouples. The thermocouples are placed on the outer surface at mid-height and the geometric center of the specimen. Once the specimen has been instrumented, the holder (with the specimen) is placed in the furnace and the timing device is started. The furnace and specimen temperatures are recorded during the test. The specimen is kept in the furnace until final temperature equilibrium. The mass of the specimens is recorded before and after testing.

V. RESULTS AND OBSERVATIONS

Specimens submitted by: Aspen Aerogels

Date received: March 26, 2008 (This specimen was received in good condition.)

Date tested: March 28, 2008

Specimen ID: Pyrogel XT

Description of specimen: Flexible Insulation Blanket

Environmental Conditions: 70°F and 63% r.h.

This Test Witnessed by: Owen Evans and Chris Abeles

Appendix D ISO 1182:1990 – NON-COMBUSTIBILITY

The results of these tests are presented in the following tables:

Specimen Number	1	2	3	4	5
Initial Furnace Temp. (°C)	746	748	755	754	751
Mass Before Test (grams)	14.75	15.18	14.16	13.99	14.42
Sustained Flaming (sec.)	None	None	None	None	None
Mass After Test (grams)	14.14	14.59	13.51	13.43	13.91
Percent Mass Loss	4.14	3.89	4.59	4.00	3.54
Average Percent Mass Loss of Five Specimens			4.03		
Mean Duration of Sustained Flaming (sec.)			None		

FURNACE TEMPERATURES

Specimen Number	1	2	3	4	5
Max. Furnace Temperature (°C)	809.9	811.0	819.0	799.9	808.9
Final Furnace Temperature (°C)	775.8	783.0	792.3	777.0	785.3
Furnace Temperature Rise (°C)	34.1	28.0	26.7	22.9	23.6
Average Furnace Temperature Rise of Five Specimens				27.1	

SPECIMEN SURFACE TEMPERATURES

Specimen Number	1	2	3	4	5
Max. Surface Temperature (°C)	828.8	823.7	832.1	826.2	814.6
Final Surface Temperature (°C)	788.2	796.4	801.6	793.2	787.9
Surface Temperature Rise (°C)	40.6	27.3	30.5	33.0	26.7
Average Surface Temperature Rise of Five Specimens				31.6	

SPECIMEN CENTER TEMPERATURES

Specimen Number	1	2	3	4	5
Max. Center Temperature (°C)	922.7	917.7	903.6	901.8	908.3
Final Center Temperature (°C)	762.7	776.0	770.2	761.6	767.3
Center Temperature Rise (°C)	160.0	141.7	133.4	140.2	141.0
Average Center Temperature Rise of Five Specimens				143.3	

Test Notes: (Time in Min : Sec. Top View Only)
Sample #1 had glowing flash spots at 0:59 (min:sec), no flame ignition visible.
Sample #2 had glowing flash spots at 0:58 (min:sec), no flame ignition visible.
Sample #3 had glowing flash spots at 1:01 (min:sec), no flame ignition visible.
Sample #4 had glowing flash spots at 1:22 (min:sec), no flame ignition visible.
Sample #5 had glowing flash spots at 1:15 (min:sec), no flame ignition visible.

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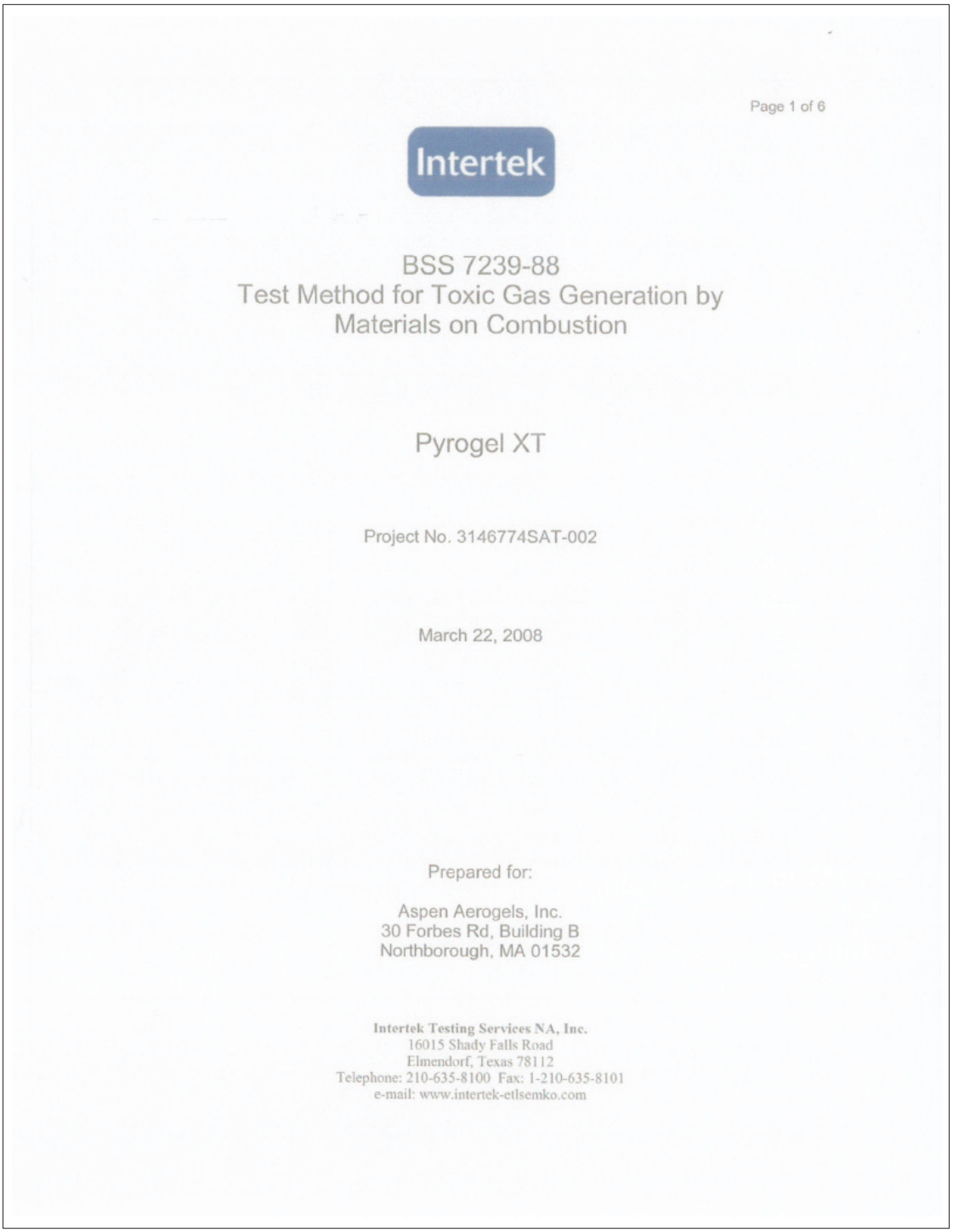
Appendix E BSS 7239 – TOXIC GAS GENERATION



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Intertek

BSS 7239-88
Test Method for Toxic Gas Generation by Materials on Combustion

Pyrogel XT

Project No. 3146774SAT-002

March 22, 2008

Prepared for:

Aspen Aerogels, Inc.
30 Forbes Rd, Building B
Northborough, MA 01532

Intertek Testing Services NA, Inc.
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Elmendorf, Texas 78112
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Appendix E BSS 7239 – TOXIC GAS GENERATION

Abstract

Specimens submitted by Aspen Aerogels, Inc. *and identified as* " Pyrogel XT", *were tested in accordance with BSS 7239-88 by the procedures reported herein. Concentrations of the gases CO, HF, HCl, NO_x, SO_2, and HCN were determined. For results see page 6, table 2*

This report contains a total of 6 pages.

John Gutierrez
Technician

March 22, 2008

Reviewed and approved:

Servando Romo
Project Manager

March 22, 2008

Intertek

Appendix E BSS 7239 – TOXIC GAS GENERATION

INTRODUCTION

The determination of the gaseous products of smoke (often called "fire gases"), including those due to either pyrolysis or combustion, is a difficult problem. The composition of the smoke from most products is affected by the nature of the fire test procedure that created the smoke (i.e., flaming or nonflaming conditions, specimen size and configuration, external applied heat flux, etc.). Gas sampling considerations include the time at which sampling of the atmosphere was initiated and the duration of the sampling (smoke concentrations can change with time); the position of the sampling probe (concentrations can change with location in a chamber); the method of sampling (a major cause of error in fire gas analysis); and the actual method of analysis. Sampling and analysis of fire gases are described in some detail in ASTM E800 ("Standard Guide for Measurement of Gases Present or Generated During Fires"), to which the reader is referred.

One of the common test methods for creating "smoke" is the ASTM E662 smoke chamber (a method fundamentally the same as BSS 7238), which provides for both flaming and nonflaming combustion of 76 mm x 76 mm (3-in. x 3-in.) specimens exposed to an external radiant heat flux of 25 kW/m^2. The smoke is retained within the confines of the 500-L chamber. For this test procedure, analysis of gaseous components is performed starting at four minutes into the test run. Only the flaming exposure is specified. Actual analysis of the gases of interest may be performed directly using Dräger® colorimetric gas analysis tubes; by trapping the gases in solution impingers (bubblers) and subsequently analyzing the anions by ion-selective electrodes, titration or liquid chromatography; or by instruments designed to measure the specific gas(es) of interest (e.g., gas chromatographic methods, NDIR or FTIR analyzers).

The following gases are required to be measured by this test standard:

CO	carbon monoxide
HF	hydrogen fluoride
HCl	hydrogen chloride
NO_x	nitrogen oxides (both NO, nitric oxide, and NO_2, nitrogen dioxide, are detected)
SO_2	sulfur dioxide
HCN	hydrogen cyanide

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Appendix E BSS 7239 – TOXIC GAS GENERATION

In our test procedures, Dräger® colorimetric gas analysis tubes are used. These devices are small glass tubes containing one or more chemical indicators/absorbents that change color when a specific gas reacts with the chemical inside the tube. The length of the coloration is proportional to the concentration of the gas when a fixed volume of the test atmosphere is drawn through the tube (which is accomplished by a hand pump). These tubes have several distinct advantages over other analytical methods for fire gases under the conditions of this test procedure. They are pre-calibrated; they are relatively simple to operate; there is nothing between the gas of interest and the analysis tube; the results are straight-forward and immediate; and this single technique can be used for each of the gases specified (plus several other common gases). Other procedures require more extensive instrumentation with calibration by standard solutions or gases; they introduce additional sampling concerns (which are different for each gas); and no single technique can be used for the six gases specified.

Information is available on each of the Dräger tubes describing the potential interferences for each tube and the range of concentrations over which the tube is calibrated. The stated accuracy of these tubes is in the range of 10-15 percent; however, the combination of sampling errors and analytical uncertainty in other methods could also approach this. In our procedure, we burn several test specimens and take an average of these readings in an effort to minimize the uncertainty in the results.

This standard is intended to measure and describe the properties of materials or products in response to heat and flame under controlled laboratory conditions and is not intended to describe or appraise the fire hazard or fire risk of materials, products, or assemblies under actual fire conditions.

TEST PROCEDURE

Specimens were exposed to flaming conditions in the smoke chamber, in accordance with the procedures in ASTM E662. Gas analyses for the species listed below were performed using Dräger® gas detector tubes. Specimens were exposed to flaming conditions for four minutes; then the igniter was extinguished, the specimen was displaced from the radiant heat flux, any excess pressure within the chamber was released, and the analyses were started within one minute.

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Appendix E BSS 7239 – TOXIC GAS GENERATION

Gas samples were extracted using the gas analysis tubes from points approximately six inches from the top of the chamber and four inches from either side wall. Although this is not the same location as given in BSS 7239

(i.e., 12 in. from the ceiling, in the center of the chamber), our sampling location was determined after considerable reflection on the advantages and disadvantages of various sampling schemes using these tubes. It is our belief that there would be no difference in the two sampling locations using our method of specimen exposure and sampling methodology.

Different tubes were drawn simultaneously from two different locations at opposite sides of the chamber in order to reduce the total time required for sampling. For replicate tests, tubes were drawn by a different operator from the other location. The gases more likely to change concentration due to reaction with moisture or soot in the chamber (i.e., HCl, HCN, HF) are drawn first in order to minimize their residence time in the chamber; while CO is sampled last, since its concentration will not change with time.

Table 1 is a listing of the specific gas detector tubes used in this study

Table 1. Identification of Gas Analysis Tubes used

Gas	Draeger Tube No.	Concentration Range, ppm	Number of Strokes
CO	5/c	10-300	10
HF	1.5/b	1.5 - 15	20
HCl	1/a	1-10	10
NO_x	2/a	5-100	5
SO_2	0.5/a	1 - 25	10
HCN	2/a	2 - 30	5

CRITERIA

In general the airline industry limits (in ppm) are as follows: CO=3500, HF=200, HCl=500, NOx= 100, SO_2 =100 and HCN=150. These limits are not set by the BSS 7239 standard.

Other limits may be required depending on the end use of the product so it is recommended that the proper governing organizations be contacted.

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Appendix E BSS 7239 – TOXIC GAS GENERATION

RESULTS

Specimens submitted by: Aspen Aerogels, Inc.

Date received: March 3, 2008 (This specimen was received in good condition.)

Date tested: March 21, 2008

Specimen ID: Pyrogel XT

Description of specimen: Flexible Insulation Blanket

Environmental conditions: 70°F and 60% r.h.

Specimen preparation and mounting method
The sample was prepared by the client and consisted of a 3 in. x 3 in. x 0.23 in. sheet insulation. The specimen was subjected to the standard conditioning and mounting methods.

Table 2. Test Results with notations
(concentrations in ppm unless otherwise noted)

No.	HCl	HCN	HF	NO_x	SO_2	CO
1 Flaming	<1	N.D.	N.D.	5	N.D.	100
2 Flaming	<1	N.D.	N.D.	5	N.D.	100
Average	NA	N.D.	N.D.	5.00	N.D.	100

NOTES:
N.D. = "none detected"
N/A = Not Available

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Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

TEST REPORT

Intertek

REPORT NUMBER: 3159033
ORIGINAL ISSUE DATE: August 28, 2008
REVISED DATE: N/A

EVALUATION CENTER
16015 Shady Falls Road
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RENDERED TO

Aspen Aerogels, Inc.
30 Forbes Road
Building B
NORTHBOROUGH MA 01532

PRODUCT EVALUATED: Pyrogel® XTF Insulation Material
EVALUATION PROPERTY: Safety Fire Resistance

Report of Testing Pyrogel® XTF Insulation Material for compliance with the applicable requirements of the following criteria: UL 1709-05 Standard for Safety Rapid Rise Fire Tests of Protection Materials for Structural Steel

Page 1 of 95

Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

1 Table of Contents

Intertek

Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

2 Introduction

Intertek Testing Services NA (Intertek) has conducted testing for Aspen Aerogels, Inc. on Pyrogel® XTF Insulation Material, to evaluate its fire resistance. Testing was conducted in accordance with UL 1709-05 Standard for Safety Rapid Rise Fire Tests of Protection Materials for Structural Steel. This evaluation took place on August 21, 2008.

3 Test Samples

3.1. SAMPLE SELECTION

Samples of Pyrogel® XTF were submitted to Intertek directly from the client. Samples were not independently selected for testing. Samples were received at the Evaluation Center on August 18, 2008

3.2. SAMPLE AND ASSEMBLY DESCRIPTION

Intertek technicians installed 14 thermocouples onto the web on each of six W10 X 49 standard columns, 8' long. The thermocouples were installed across 4 zones: A-A, 5; B-B, 3; C-C, 3; and D-D, 3 (see Appendix A).

Representatives from Aspen Aerogels, Inc. installed the Pyrogel® XTF insulation onto the columns. Each of the column web cavities were filled with 19 -21 strips of Pyrogel® XTF (8.9" X 98" X nominal 6mm) to provide a nominal 120mm of insulation on each side of the web. The strips were held in place with 2-3 bands of 0.047" O.D. stainless steel wire (see Appendix C).

Courses (sections) of the Pyrogel® XTF insulation, either 32" or 48" wide and of varying lengths, were wrapped around the web-filled columns in layers (2, 5, 8, 8, 12, 14) alternating the 32" and 48" width insulation to stagger circumferential seams without telescoping. For the thicker, multi-layered columns (P5 – 14) some courses were "double length" and wrapped around twice – 2 layers per course. Some of the columns started with the 32" width and some with the 48" (see configuration table, next page). Each course of insulation overlapped itself by nominally 5", but butted up to the course above and/or below it on the column. If the first course consisted of 32" insulation, the second course was 48" insulation and *visa versa*, staggering the butt joints of the layer beneath it. A 48" course of insulation was the preferred outermost layer on a column to reduce the number of circumferential seams closest to the heat of the furnace. Each course was held in place with 2-3 bands of 0.047" O.D. stainless steel wire, then secured with ½" 0.02 stainless steel bands with ½" stainless steel wing seals, applied 12" o.c. but no closer than 2" from the edge of a seam, tightened with a pistol-grip banding tool (see Appendix A).

The installation process started with the application of a thin film of spray adhesive (3M Hi-Strength 90 Spray Adhesive or Foster Fos-Stik Clear Adhesive Spray 85-45) in a 3 - 4" strip down the leading edge of the section of insulation and the corresponding area of the web-fill strip where the installation would begin. The first course was always installed at the bottom of the column. The leading edge was attached to the edge of the web-fill layers (NOT on the

Intertek

Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

metal beam) and wrapped counterclockwise, overlapping itself to a point half way across the web where it started (approx 5") and was held in place with 0.047" O.D wire. Another course was applied above that one, and one above that (if using 32" widths), butting the seams, completing the first course on the column.

The second course was installed in the same fashion as the first but used the alternate width of insulation to overlap the circumferential seams of the previous layer, and was started at the edge of the web-fill on the opposite side of the column (staggering longitudinal seams). Additional courses followed the same process, alternating the width of insulation used as well as the side of the beam as its starting point. The stainless steel bands were applied after each 2 layers (not courses) of wrapping.

The 96" tall columns were covered with 3 strips of 36" wide, 0.02 stainless steel cladding, each strip overlapping itself 3" and overlapping the one below it by 6". The cladding was installed with a slip-joint when overlapping an adjacent piece and each section was secured with ½" 0.02 stainless steel bands and wing seals, installed 12"o.c. Finally, #42 blind rivets with 2 #8 flat stainless steel washers were installed 6" o.c. down the longitudinal seam and in 4 equidistant places around the overlapping circumferential seams (see Appendix A).

4 Testing and Evaluation Methods

The completed column assemblies were placed in the Laboratory's full scale horizontal furnace in two rows of 3 each. The test was initiated at 10:55 a.m. on Thursday, August 21, 2008. Representatives from Aspen Aerogels, Inc. were in attendance. The ambient temperature and humidity at the time were 84ºF and 76%RH. The outputs of all test specimens and furnace probes were monitored by a 300 channel Yokogawa, Inc., Model Darwin Data Acquisition Unit. The computer was programmed in LabVIEW to send the commands to the data acquisition systems to sample the data input lines and to convert the raw data into a usable format (i.e., degrees Fahrenheit) for display on screen and storage as an ASCII tab-delimited text file. The data was saved at 60-second intervals. Following the test, the files were imported into MS Excel for tabular and graphical display. The maximum allowed temperature for any one thermocouple on a column was 1200ºF and for the TC Average within a section was 1000 ºF.

4.1. TEST STANDARD

Testing was conducted in accordance with UL 1709-05 Standard for Safety Rapid Rise Fire Tests of Protection Materials for Structural Steel.

Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

5 Testing and Evaluation Results

5.1. RESULTS AND OBSERVATIONS

The test was initiated at 10:55 A.M. on August 21, 2008 and ran for 240 minutes. The observations made during the test are listed below:

Time (min:sec)	Observation
0:00	Test initiated
10:00	Smoke from the furnace, around the lid
21:00	Flame from around the samples
72:54	TC #11 from P2 exceeds max allowed temp
152:00	TC #11 from P5 exceeds max allowed temp
205:00	TC #9 from P8A exceeds max allowed temp
209:00	TC #3 from P8B exceeds max allowed temp
241:00	Test terminated

The test results for each column are presented below.

Column P2 (12mm):
Though the first thermocouple to exceed the 1200°F maximum occurred during the 72nd minute of the test (TC #11) the maximum allowable TC average (1000°F) was exceeded at the 68-minute mark.

In accordance with the UL 1709 test standard, a calculation for any correction to the indicated fire resistance period was done. The correction factor was then mathematically added to the indicated fire resistance period, yielding the fire resistance period achieved by this specimen:

ITEM	DESCRIPTION	TEST VALUE
C	correction factor	-0.53 minutes -32 seconds
I	indicated fire-resistance period	68 minutes
A	area under the curve of indicated average furnace temperature for the first three fourths of the indicated period	89134 (°F•min)
As	area under the standard furnace curve for the same part of the indicated period	90188 (°F•min)
	FIRE RESISTANCE PERIOD ACHIEVED BY THIS SPECIMEN ==>	67 minutes

Intertek

Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

Note: The standard specifies that the fire resistance be determined to the nearest integral minute. Consequently, if the correction factor is less than 30 seconds, and the test specimen met the criteria for the full indicated fire resistance period, no correction is deemed necessary.

Column P5 (30mm):
Though the first thermocouple to exceed the 1200°F maximum occurred during the 152nd minute of the test (TC #11), the maximum allowable TC average (1000°F) was exceeded at the 131-minute mark.

In accordance with the UL 1709 test standard, a calculation for any correction to the indicated fire resistance period was done. The correction factor was then mathematically added to the indicated fire resistance period, yielding the fire resistance period achieved by this specimen:

ITEM	DESCRIPTION	TEST VALUE
C	correction factor	-0.47 minutes -28 seconds
I	indicated fire-resistance period	131 minutes
A	area under the curve of indicated average furnace temperature for the first three fourths of the indicated period	176129 (°F•min)
As	area under the standard furnace curve for the same part of the indicated period	177091 (°F•min)
	FIRE RESISTANCE PERIOD ACHIEVED BY THIS SPECIMEN ==>	131 minutes

Note: The standard specifies that the fire resistance be determined to the nearest integral minute. Consequently, if the correction factor is less than 30 seconds, and the test specimen met the criteria for the full indicated fire resistance period, no correction is deemed necessary.

Column P8A (48mm):
Though the first thermocouple to exceed the 1200°F maximum occurred during the 205th minute of the test (TC #9) the maximum allowable TC average (1000°F) was exceeded at the 184-minute mark.

In accordance with the UL 1709 test standard, a calculation for any correction to the indicated fire resistance period was done. The correction factor was then mathematically added to the indicated fire resistance period, yielding the fire resistance period achieved by this specimen:

Intertek

Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

ITEM	DESCRIPTION	TEST VALUE
C	correction factor	-0.37 minutes -22 seconds
I	indicated fire-resistance period	184 minutes
A	area under the curve of indicated average furnace temperature for the first three fourths of the indicated period	250286 (°F•min)
As	area under the standard furnace curve for the same part of the indicated period	251051 (°F•min)
	FIRE RESISTANCE PERIOD ACHIEVED BY THIS SPECIMEN ==>	184 minutes

Note: The standard specifies that the fire resistance be determined to the nearest integral minute. Consequently, if the correction factor is less than 30 seconds, and the test specimen met the criteria for the full indicated fire resistance period, no correction is deemed necessary.

Column P8B (48mm):
Though the first thermocouple to exceed the 1200°F maximum occurred during the 209th minute of the test (TC #3) the maximum allowable TC average (1000°F) was exceeded at the 175-minute mark.

In accordance with the UL 1709 test standard, a calculation for any correction to the indicated fire resistance period was done. The correction factor was then mathematically added to the indicated fire resistance period, yielding the fire resistance period achieved by this specimen:

ITEM	DESCRIPTION	TEST VALUE
C	correction factor	-0.40 minutes -24 seconds
I	indicated fire-resistance period	175 minutes
A	area under the curve of indicated average furnace temperature for the first three fourths of the indicated period	237294 (°F•min)
As	area under the standard furnace curve for the same part of the indicated period	238108 (°F•min)
	FIRE RESISTANCE PERIOD ACHIEVED BY THIS SPECIMEN ==>	175 minutes

Note: The standard specifies that the fire resistance be determined to the nearest integral

Intertek

Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

minute. Consequently, if the correction factor is less than 30 seconds, and the test specimen met the criteria for the full indicated fire resistance period, no correction is deemed necessary.

Column P11 (66mm):
Neither the individual nor the average thermocouple maximums were exceeded during the 240-minute test.

In accordance with the UL 1709 test standard, a calculation for any correction to the indicated fire resistance period was done. The correction factor was then mathematically added to the indicated fire resistance period, yielding the fire resistance period achieved by this specimen:

ITEM	DESCRIPTION	TEST VALUE
C	correction factor	-0.37 minutes -22 seconds
I	indicated fire-resistance period	240 minutes
A	area under the curve of indicated average furnace temperature for the first three fourths of the indicated period	327951 (°F•min)
As	area under the standard furnace curve for the same part of the indicated period	328709 (°F•min)
	FIRE RESISTANCE PERIOD ACHIEVED BY THIS SPECIMEN ==>	240 minutes

Note: The standard specifies that the fire resistance be determined to the nearest integral minute. Consequently, if the correction factor is less than 30 seconds, and the test specimen met the criteria for the full indicated fire resistance period, no correction is deemed necessary.

Column P14 (84mm):
Neither the individual nor the average thermocouple maximums were exceeded during the 240-minute test.

In accordance with the UL 1709 test standard, a calculation for any correction to the indicated fire resistance period was done. The correction factor was then mathematically added to the indicated fire resistance period, yielding the fire resistance period achieved by this specimen:

ITEM	DESCRIPTION	TEST VALUE
C	correction factor	-0.37 minutes -22 seconds
I	indicated fire-resistance period	240 minutes
A	area under the curve of indicated average	

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Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

	furnace temperature for the first three fourths of the indicated period	327951 (°F•min)
As	area under the standard furnace curve for the same part of the indicated period	328709 (°F•min)
	FIRE RESISTANCE PERIOD ACHIEVED BY THIS SPECIMEN ==>	240 minutes

Note: The standard specifies that the fire resistance be determined to the nearest integral minute. Consequently, if the correction factor is less than 30 seconds, and the test specimen met the criteria for the full indicated fire resistance period, no correction is deemed necessary.

Summary of fire resistance achieved by each column:

P2 (12mm).....67 minutes
P5 (30mm) .....131 minutes
P8A (48mm) .....184 minutes
P8B (48mm) .....175 minutes
P11 (66mm) .....240 minutes
P14 (84mm) .....240 minutes

6 Conclusion

Intertek Testing Services NA (Intertek) conducted testing for Aspen Aerogels, Inc., on Pyrogel® XTF Insulation Material, to evaluate its fire resistance. Testing was conducted in accordance with UL 1709-05 Standard for Safety Rapid Rise Fire Tests of Protection Materials for Structural Steel. The P2 (12mm) column received a fire resistance rating of 67 minutes, the P5 (30mm) column received a fire resistance rating of 131 minutes, the P8A (48mm) column received a fire resistance rating of 184 minutes, the P8B (48mm) column received a fire resistance rating of 175 minutes, the P11 (66mm) column received a fire resistance rating of 240 minutes, and the P14 (84mm) column received a fire resistance rating of 240 minutes. This evaluation was completed on August 21, 2008.

The conclusions of this test report may not be used as part of the requirements for Intertek product certification. Authority to Mark must be issued for a product to become certified.

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Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

INTERTEK TESTING SERVICES NA

Reported by: _____
Michael A Brown
Technical Writer

Reviewed by: _____
Mike Dey
Project Manager, Fire Resistance

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Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

APPENDIX A
Assembly Drawings

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Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

Aspen Aerogels, Inc.
Project No. 3159033

28 August, 2008
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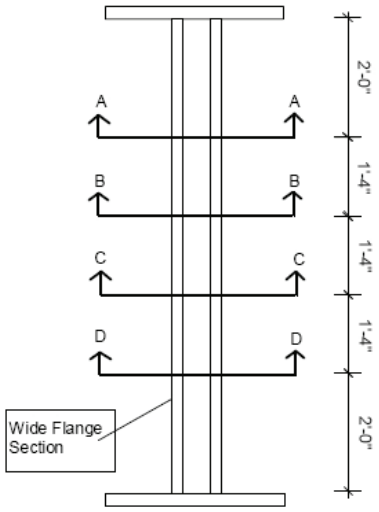
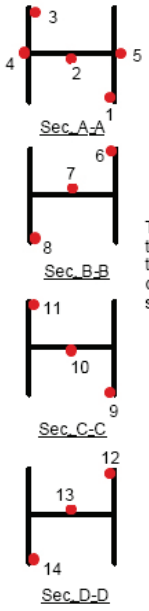


The thermocouples are fabricated from minimum 0.032in. diameter, No. 20 B&S guage, chromel-alumel wires or equivalent having a time constant of 2 seconds or less. The upper and lower levels are 2ft. from the ends of the steel column, and the intermediate levels are to be equally spaced between the upper and lower levels.



Thermocouples are placed to measure significant temperatures of the component elements of the steel column.

The thermocouples are located at the red dots and are numbered accordingly.

INTERTEK TESTING SERVICES NA, INC.
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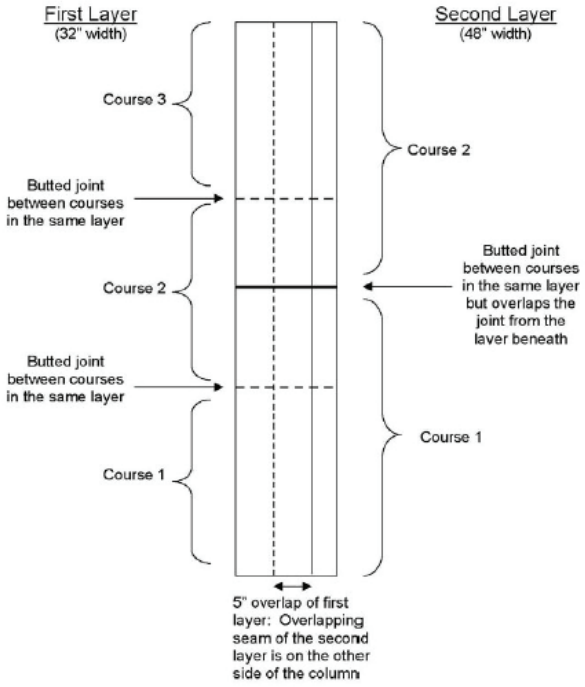
Aspen Aerogels, Inc.

Fig. 1 Thermocouple Layout

Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

Example of the Application of Courses of Insulation:



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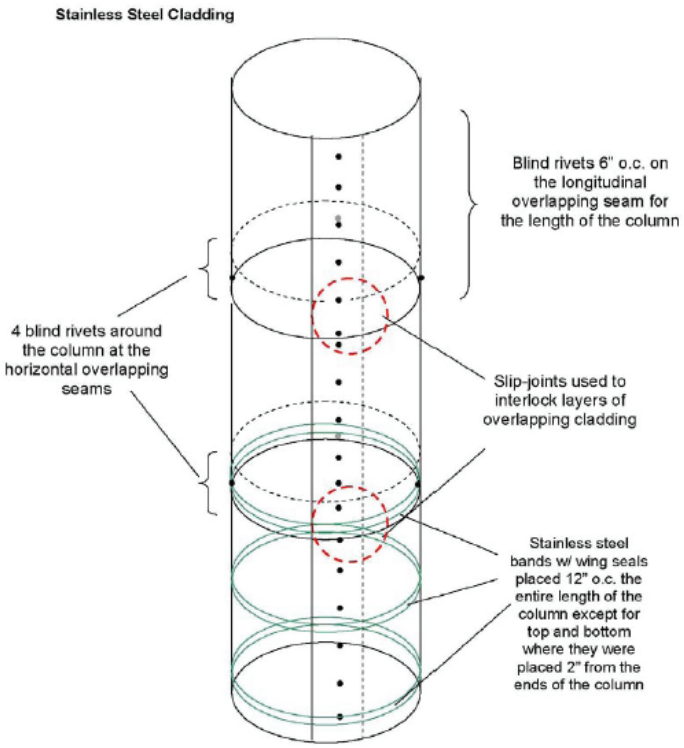
Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL



- Cladding was 36" wide and long enough to enclose the column with a 6" longitudinal overlapping seam
- Using 3 strips of 36" on the 8' high column allowed for 6" circumferential overlapping seams

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Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

APPENDIX B
Temperature Data

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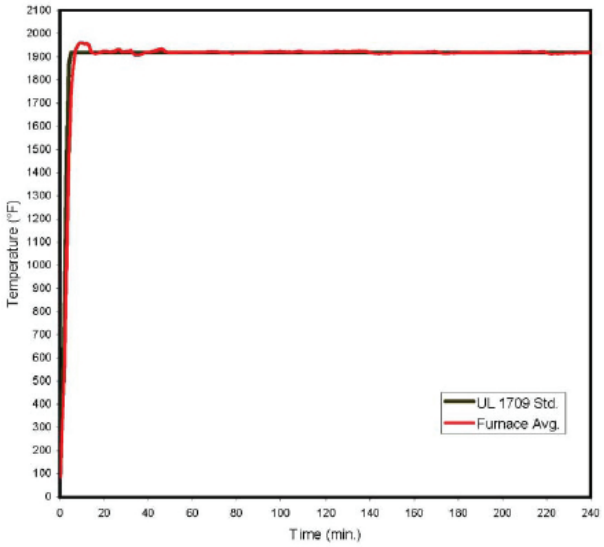
Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

Aspen Aerogels, Inc.
Project No. 3159033
Furnace Interior Temperatures

21 August 2008



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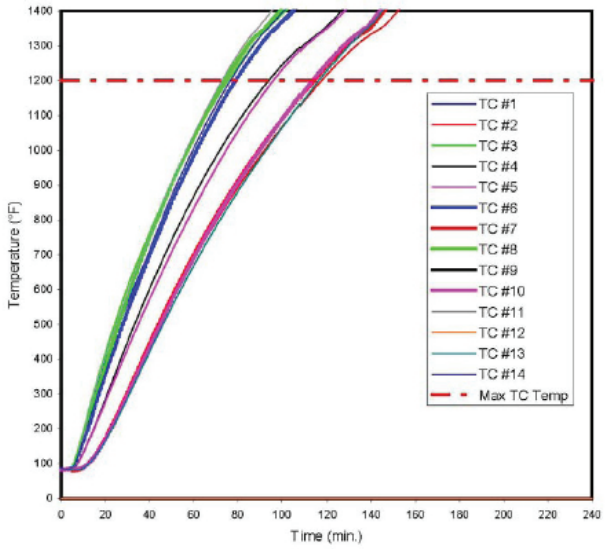
Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

Aspen Aerogels, Inc.
Project No. 3159033
P2 Individual Temperatures

21 August 2008



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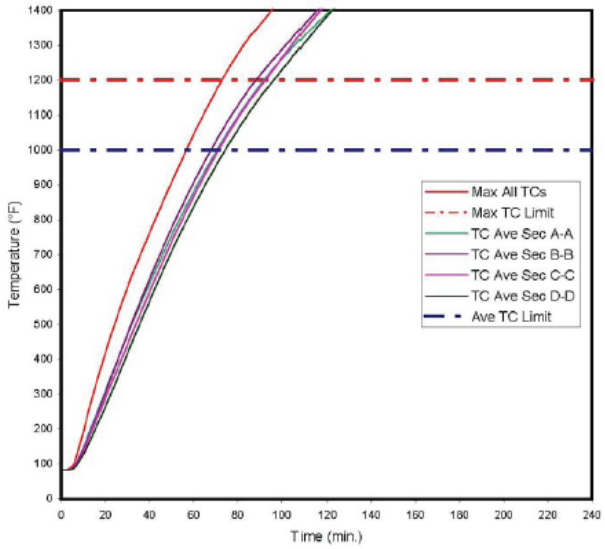
Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

Aspen Aerogels, Inc.
Project No. 3159033
P2 Max and Ave Temperatures

21 August 2008



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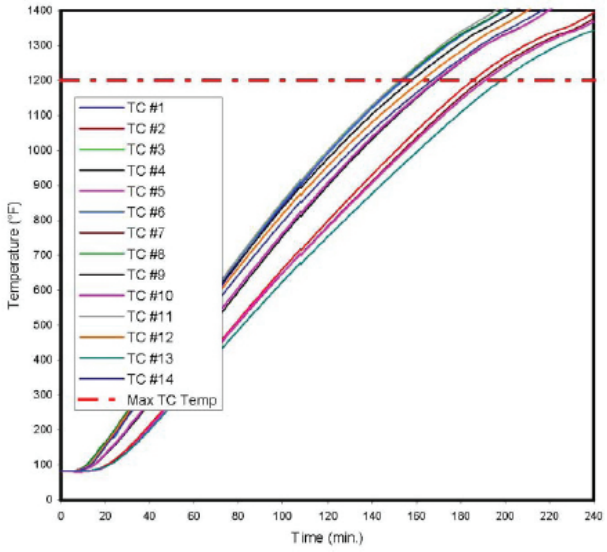
Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

Aspen Aerogels, Inc.
Project No. 3159033
P5 Individual Temperatures

21 August 2008



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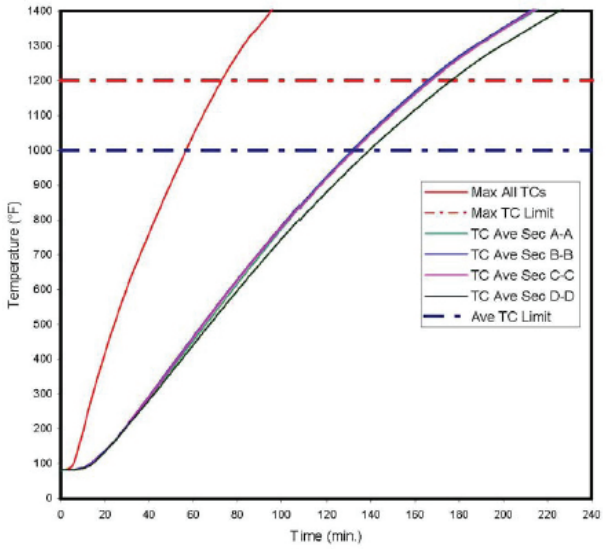
Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

Aspen Aerogels, Inc.
Project No. 3159033
P5 Max and Ave Temperatures

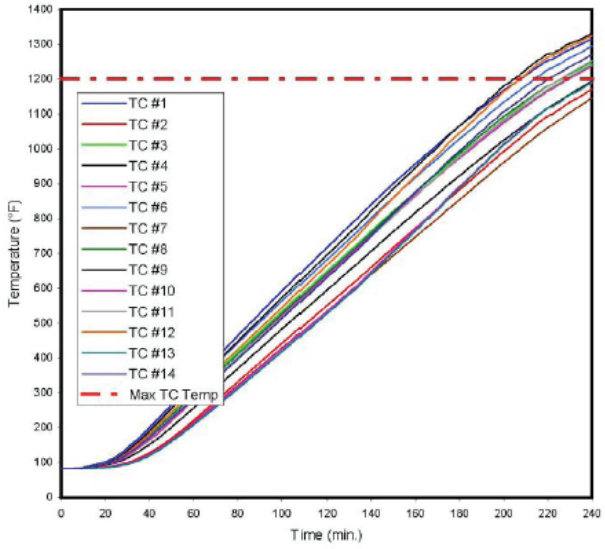
21 August 2008



Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

Aspen Aerogels, Inc.
Project No. 3159033
P8A Individual Temperatures

21 August 2008



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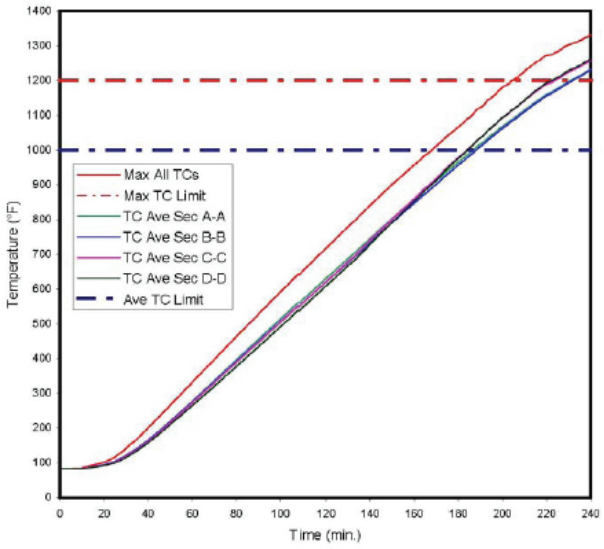
Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

Aspen Aerogels, Inc.
Project No. 3159033
P8A Max and Ave Temperatures

21 August 2008



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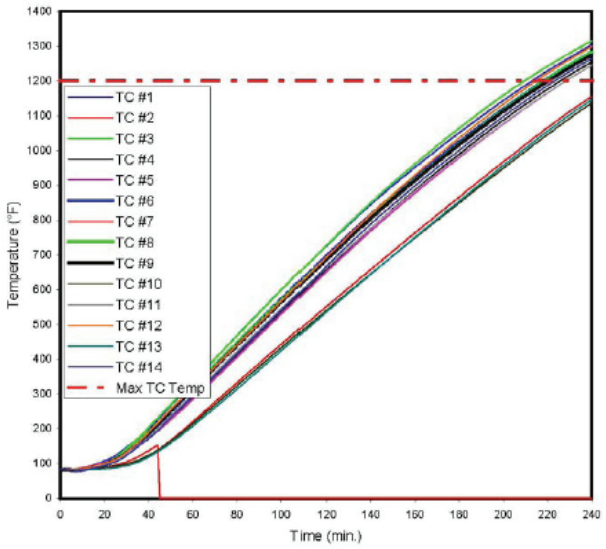
Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

Aspen Aerogels, Inc.
Project No. 3159033
P8B Individual Temperatures

21 August 2008



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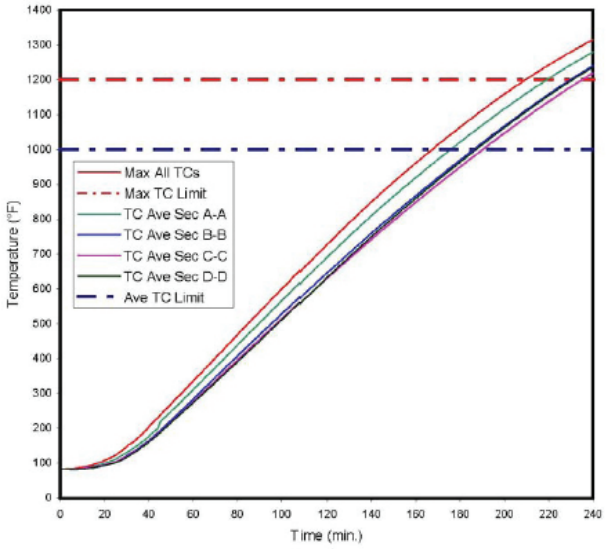
Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

Aspen Aerogels, Inc.
Project No. 3159033
P8B Max and Ave Temperatures

21 August 2008



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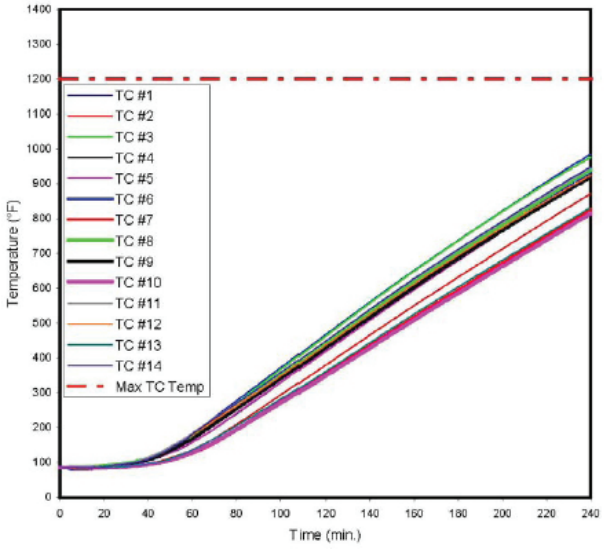
Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

Aspen Aerogels, Inc.
Project No. 3159033
P11 Individual Temperatures

21 August 2008



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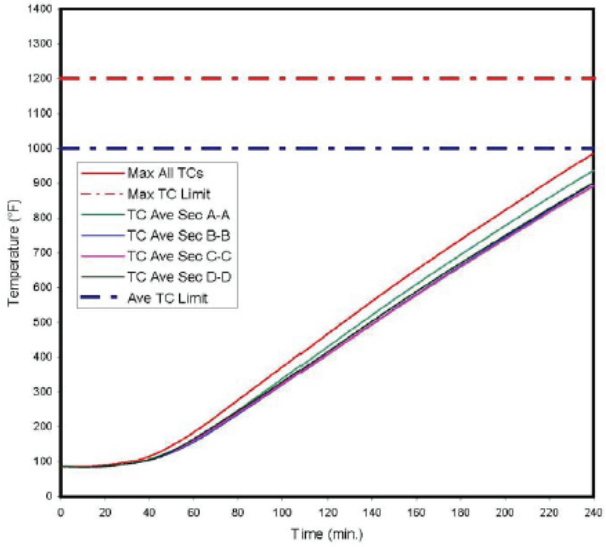
Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

Aspen Aerogels, Inc.
Project No. 3159033
P11 Max and Ave Temperatures

21 August 2008



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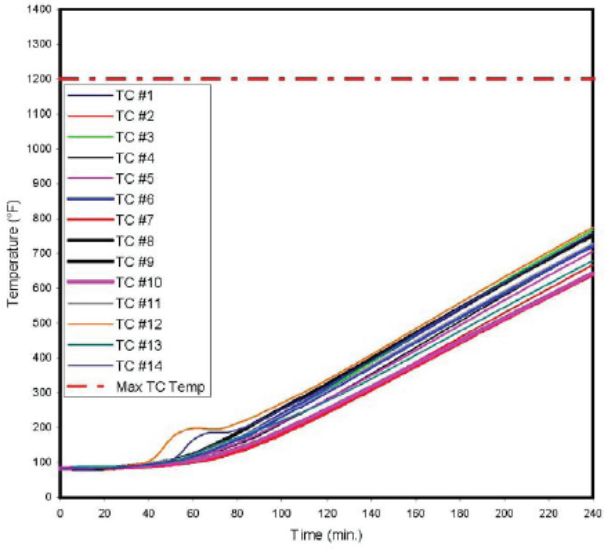
Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

Aspen Aerogels, Inc.
Project No. 3159033
P14 Individual Temperatures

21 August 2008



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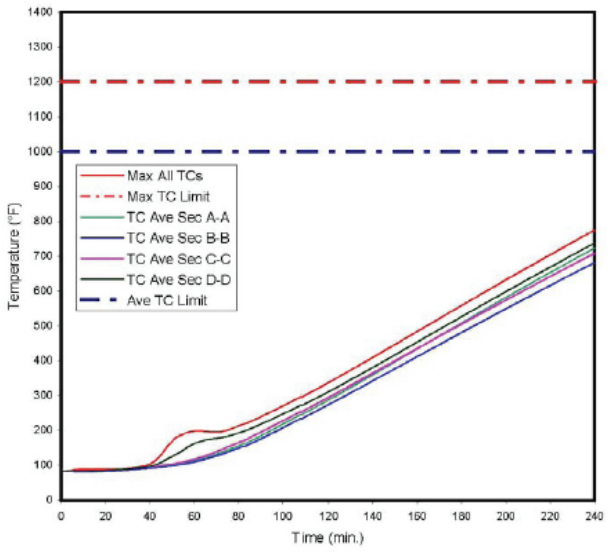
Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

Aspen Aerogels, Inc.
Project No. 3159033
P14 Max and Ave Temperatures

21 August 2008



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Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

21 August 2008

Time (min)	UL 1709 Std Average (°F)	Furnace Average (°F)	Furnace Probe #1 (°F)	Furnace Probe #2 (°F)	Furnace Probe #3 (°F)	Furnace Probe #4 (°F)	Furnace Probe #5 (°F)	Furnace Probe #6 (°F)	Furnace Probe #7 (°F)	Furnace Probe #8 (°F)	Furnace Probe #9 (°F)
0	100	84	84	84	84	84	84	84	bad/probe	84	86
1	400	303	321	488	479	250	312	237	bad/probe	187	189
2	800	531	614	758	688	509	479	481	bad/probe	386	336
3	1400	990	957	1207	1138	998	937	1013	bad/probe	881	791
4	1885	1457	1385	1598	1490	1484	1455	1501	bad/probe	1429	1342
5	1917	1735	1621	1803	1776	1726	1784	1768	bad/probe	1727	1654
6	1917	1853	1771	1893	1899	1842	1904	1867	bad/probe	1856	1820
7	1917	1927	1851	1982	1975	1912	1974	1929	bad/probe	1941	1903
8	1917	1948	1880	1949	1988	1927	1981	1953	bad/probe	1956	1931
9	1917	1960	1897	1959	2007	1943	1994	1963	bad/probe	1972	1943
10	1917	1960	1903	1957	2018	1939	1987	1956	bad/probe	1965	1944
11	1917	1954	1903	1957	1994	1933	1982	1958	bad/probe	1963	1939
12	1917	1957	1904	1962	2002	1935	1984	1957	bad/probe	1967	1942
13	1917	1951	1897	1962	2004	1926	1980	1946	bad/probe	1956	1938
14	1917	1923	1871	1936	1968	1898	1963	1909	bad/probe	1927	1915
15	1917	1916	1861	1928	1969	1888	1950	1907	bad/probe	1919	1904
16	1917	1912	1860	1922	1972	1886	1943	1898	bad/probe	1915	1900
17	1917	1914	1862	1922	1969	1890	1942	1907	bad/probe	1919	1903
18	1917	1917	1864	1924	1977	1893	1946	1905	bad/probe	1921	1905
19	1917	1922	1873	1933	1974	1899	1949	1912	bad/probe	1929	1910
20	1917	1925	1874	1937	1977	1903	1950	1917	bad/probe	1930	1913
21	1917	1925	1881	1936	1958	1905	1951	1918	bad/probe	1935	1915
22	1917	1922	1879	1933	1953	1900	1951	1916	bad/probe	1930	1912
23	1917	1920	1878	1936	1944	1902	1950	1915	bad/probe	1927	1910
24	1917	1923	1879	1940	1968	1900	1947	1914	bad/probe	1930	1911
25	1917	1926	1886	1938	1954	1905	1952	1923	bad/probe	1933	1914
26	1917	1930	1890	1941	1974	1908	1954	1920	bad/probe	1935	1918
27	1917	1930	1894	1943	1950	1912	1959	1928	bad/probe	1937	1920
28	1917	1923	1885	1940	1948	1904	1950	1914	bad/probe	1928	1912
29	1917	1921	1887	1937	1949	1900	1947	1913	bad/probe	1927	1909
30	1917	1924	1888	1939	1947	1903	1955	1921	bad/probe	1928	1910
31	1917	1923	1890	1937	1943	1903	1949	1920	bad/probe	1928	1911
32	1917	1927	1890	1942	1963	1908	1950	1918	bad/probe	1930	1913
33	1917	1916	1887	1927	1943	1896	1940	1909	bad/probe	1920	1905
34	1917	1907	1878	1923	1927	1886	1932	1900	bad/probe	1911	1895
35	1917	1908	1878	1926	1933	1888	1934	1903	bad/probe	1908	1893
36	1917	1908	1879	1924	1932	1889	1936	1901	bad/probe	1908	1893
37	1917	1909	1883	1925	1931	1891	1935	1903	bad/probe	1911	1894
38	1917	1916	1885	1933	1940	1899	1945	1910	bad/probe	1915	1899
39	1917	1919	1892	1933	1952	1898	1944	1916	bad/probe	1919	1901
40	1917	1921	1891	1941	1949	1904	1944	1915	bad/probe	1920	1904
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42	1917	1924	1896	1942	1952	1905	1949	1919	bad/probe	1923	1907
43	1917	1926	1898	1942	1942	1908	1954	1925	bad/probe	1925	1910
44	1917	1928	1900	1947	1952	1910	1953	1922	bad/probe	1926	1911
45	1917	1932	1906	1957	1955	1914	1956	1926	bad/probe	1930	1914
46	1917	1935	1910	1951	1968	1915	1960	1927	bad/probe	1931	1917
47	1917	1928	1904	1944	1950	1911	1954	1923	bad/probe	1925	1913
48	1917	1923	1899	1941	1949	1902	1946	1919	bad/probe	1920	1905
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50	1917	1918	1894	1940	1942	1899	1944	1912	bad/probe	1915	1900
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53	1917	1918	1894	1936	1945	1899	1941	1913	bad/probe	1913	1899
54	1917	1918	1895	1941	1948	1894	1942	1915	bad/probe	1911	1897
55	1917	1921	1897	1942	1953	1898	1943	1919	bad/probe	1913	1898
56	1917	1920	1899	1942	1948	1900	1943	1917	bad/probe	1915	1900
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61	1917	1919	1897	1940	1947	1901	1942	1912	bad/probe	1912	1899
62	1917	1918	1896	1941	1938	1900	1943	1914	bad/probe	1911	1898
63	1917	1919	1898	1942	1941	1901	1942	1917	bad/probe	1915	1899

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Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

21 August 2008

Time (min)	UL 1709 Std Average (°F)	Furnace Average (°F)	Furnace Probe #1 (°F)	Furnace Probe #2 (°F)	Furnace Probe #3 (°F)	Furnace Probe #4 (°F)	Furnace Probe #5 (°F)	Furnace Probe #6 (°F)	Furnace Probe #7 (°F)	Furnace Probe #8 (°F)	Furnace Probe #9 (°F)
64	1917	1921	1900	1944	1950	1902	1943	1912	bad/probe	1914	1899
65	1917	1919	1898	1940	1943	1901	1942	1917	bad/probe	1912	1898
66	1917	1920	1898	1939	1943	1902	1946	1917	bad/probe	1915	1900
67	1917	1922	1900	1942	1950	1903	1945	1920	bad/probe	1915	1901
68	1917	1922	1902	1942	1942	1908	1946	1919	bad/probe	1916	1902
69	1917	1923	1904	1943	1947	1907	1947	1917	bad/probe	1918	1902
70	1917	1923	1902	1941	1950	1906	1947	1916	bad/probe	1916	1905
71	1917	1923	1900	1947	1942	1908	1950	1915	bad/probe	1917	1906
72	1917	1921	1899	1942	1943	1903	1945	1916	bad/probe	1914	1903
73	1917	1918	1899	1941	1941	1901	1942	1909	bad/probe	1911	1899
74	1917	1919	1896	1941	1932	1898	1943	1910	bad/probe	1910	1898
75	1917	1918	1895	1940	1935	1899	1941	1908	bad/probe	1910	1896
76	1917	1917	1897	1937	1937	1899	1942	1917	bad/probe	1910	1897
77	1917	1916	1897	1936	1944	1898	1940	1909	bad/probe	1908	1896
78	1917	1914	1895	1931	1935	1897	1940	1909	bad/probe	1909	1893
79	1917	1915	1893	1936	1942	1898	1939	1909	bad/probe	1908	1893
80	1917	1916	1895	1939	1945	1898	1939	1912	bad/probe	1907	1893
81	1917	1915	1896	1935	1939	1899	1938	1907	bad/probe	1909	1894
82	1917	1917	1894	1938	1945	1899	1940	1914	bad/probe	1909	1894
83	1917	1917	1895	1938	1944	1901	1941	1912	bad/probe	1908	1894
84	1917	1916	1896	1938	1941	1899	1941	1912	bad/probe	1908	1894
85	1917	1916	1892	1940	1942	1898	1941	1915	bad/probe	1907	1894
86	1917	1916	1894	1941	1935	1902	1940	1912	bad/probe	1909	1894
87	1917	1918	1896	1941	1946	1901	1943	1911	bad/probe	1909	1896
88	1917	1919	1898	1942	1947	1901	1942	1911	bad/probe	1912	1896
89	1917	1918	1896	1942	1938	1902	1943	1915	bad/probe	1911	1897
90	1917	1919	1898	1941	1946	1901	1944	1915	bad/probe	1911	1897
91	1917	1918	1898	1939	1945	1902	1942	1912	bad/probe	1911	1897
92	1917	1920	1898	1943	1938	1905	1945	1915	bad/probe	1913	1899
93	1917	1922	1902	1945	1941	1905	1948	1917	bad/probe	1916	1901
94	1917	1923	1902	1944	1946	1907	1949	1917	bad/probe	1915	1901
95	1917	1922	1902	1943	1947	1904	1948	1918	bad/probe	1915	1900
96	1917	1922	1903	1941	1937	1904	1946	1914	bad/probe	1914	1899
97	1917	1922	1903	1940	1945	1906	1948	1921	bad/probe	1915	1900
98	1917	1921	1901	1938	1945	1905	1947	1917	bad/probe	1914	1900
99	1917	1923	1904	1947	1942	1907	1948	1917	bad/probe	1914	1902
100	1917	1924	1905	1944	1954	1905	1947	1919	bad/probe	1915	1901
101	1917	1921	1903	1942	1948	1905	1946	1915	bad/probe	1913	1901
102	1917	1922	1901	1942	1949	1905	1945	1916	bad/probe	1914	1901
103	1917	1920	1899	1944	1947	1904	1944	1912	bad/probe	1912	1900
104	1917	1921	1899	1941	1958	1904	1945	1913	bad/probe	1913	1900
105	1917	1920	1901	1941	1943	1906	1943	1917	bad/probe	1912	1900
106	1917	1921	1901	1941	1945	1905	1944	1917	bad/probe	1913	1900
107	1917	1922	1903	1941	1951	1907	1945	1915	bad/probe	1914	1901
108	1917	1924	1904	1944	1955	1908	1948	1920	bad/probe	1916	1902
109	1917	1923	1904	1943	1948	1907	1950	1916	bad/probe	1916	1903
110	1917	1920	1902	1939	1940	1906	1943	1915	bad/probe	1913	1901
111	1917	1921	1901	1939	1943	1905	1946	1919	bad/probe	1914	1901
112	1917	1921	1901	1943	1941	1905	1944	1918	bad/probe	1913	1900
113	1917	1921	1901	1940	1946	1905	1946	1917	bad/probe	1913	1899
114	1917	1919	1901	1941	1938	1904	1943	1914	bad/probe	1911	1899
115	1917	1918	1900	1938	1938	1903	1942	1911	bad/probe	1911	1898
116	1917	1918	1901	1936	1940	1904	1941	1913	bad/probe	1910	1899
117	1917	1920	1901	1939	1946	1906	1943	1917	bad/probe	1911	1900
118	1917	1920	1900	1939	1944	1903	1944	1917	bad/probe	1913	1899
119	1917	1922	1900	1938	1957	1904	1947	1915	bad/probe	1913	1900
120	1917	1920	1902	1938	1938	1905	1944	1919	bad/probe	1915	1901
121	1917	1921	1904	1938	1947	1908	1945	1914	bad/probe	1913	1901
122	1917	1922	1903	1940	1951	1906	1945	1915	bad/probe	1913	1901
123	1917	1922	1905	1940	1943	1908	1947	1918	bad/probe	1916	1902
124	1917	1924	1904	1942	1949	1909	1947	1919	bad/probe	1916	1903
125	1917	1925	1906	1943	1949	1910	1949	1916	bad/probe	1918	1905
126	1917	1923	1905	1942	1949	1906	1946	1916	bad/probe	1915	1903
127	1917	1921	1903	1939	1943	1907	1946	1915	bad/probe	1916	1902

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Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

21 August 2008

Time (min)	UL 1709 Std Average (°F)	Furnace Average (°F)	Furnace Probe #1 (°F)	Furnace Probe #2 (°F)	Furnace Probe #3 (°F)	Furnace Probe #4 (°F)	Furnace Probe #5 (°F)	Furnace Probe #6 (°F)	Furnace Probe #7 (°F)	Furnace Probe #8 (°F)	Furnace Probe #9 (°F)
128	1917	1924	1905	1940	1958	1906	1947	1918	bad/probe	1915	1903
129	1917	1922	1903	1941	1943	1908	1947	1917	bad/probe	1917	1903
130	1917	1923	1903	1939	1947	1908	1945	1918	bad/probe	1918	1903
131	1917	1923	1904	1939	1947	1907	1946	1918	bad/probe	1916	1903
132	1917	1924	1905	1940	1945	1910	1947	1919	bad/probe	1920	1905
133	1917	1924	1907	1939	1944	1910	1947	1917	bad/probe	1919	1905
134	1917	1924	1907	1937	1945	1909	1947	1920	bad/probe	1919	1905
135	1917	1928	1909	1965	1962	1904	1943	1918	bad/probe	1913	1901
136	1917	1924	1912	1956	1948	1905	1942	1917	bad/probe	1911	1900
137	1917	1924	1914	1953	1947	1902	1942	1914	bad/probe	1912	1898
138	1917	1925	1915	1957	1954	1906	1942	1916	bad/probe	1911	1900
139	1917	1921	1912	1949	1946	1901	1938	1917	bad/probe	1910	1897
140	1917	1918	1910	1954	1938	1897	1935	1909	bad/probe	1906	1893
141	1917	1916	1903	1953	1943	1893	1932	1909	bad/probe	1902	1890
142	1917	1914	1904	1947	1933	1894	1933	1905	bad/probe	1903	1890
143	1917	1914	1901	1958	1931	1893	1932	1906	bad/probe	1900	1889
144	1917	1912	1901	1948	1932	1893	1931	1904	bad/probe	1901	1888
145	1917	1913	1902	1950	1928	1895	1932	1905	bad/probe	1902	1889
146	1917	1915	1903	1953	1935	1893	1934	1906	bad/probe	1903	1891
147	1917	1915	1905	1955	1935	1895	1931	1905	bad/probe	1902	1889
148	1917	1914	1904	1953	1934	1894	1932	1905	bad/probe	1902	1890
149	1917	1913	1901	1957	1933	1893	1930	1904	bad/probe	1900	1889
150	1917	1915	1904	1952	1945	1893	1932	1905	bad/probe	1902	1889
151	1917	1917	1905	1953	1943	1895	1934	1911	bad/probe	1904	1891
152	1917	1918	1906	1959	1945	1895	1934	1910	bad/probe	1903	1891
153	1917	1916	1905	1953	1938	1896	1932	1907	bad/probe	1903	1891
154	1917	1917	1906	1955	1942	1895	1933	1909	bad/probe	1904	1892
155	1917	1917	1907	1959	1935	1896	1935	1910	bad/probe	1903	1891
156	1917	1917	1904	1956	1935	1898	1934	1908	bad/probe	1905	1892
157	1917	1919	1908	1956	1948	1897	1935	1913	bad/probe	1904	1893
158	1917	1917	1906	1957	1941	1898	1934	1907	bad/probe	1904	1892
159	1917	1918	1908	1958	1936	1897	1935	1909	bad/probe	1905	1893
160	1917	1920	1909	1955	1951	1897	1935	1911	bad/probe	1905	1894
161	1917	1920	1907	1965	1946	1899	1936	1910	bad/probe	1906	1894
162	1917	1920	1910	1956	1946	1900	1937	1909	bad/probe	1907	1895
163	1917	1920	1909	1955	1948	1898	1937	1909	bad/probe	1908	1895
164	1917	1919	1912	1946	1946	1899	1937	1912	bad/probe	1907	1896
165	1917	1920	1911	1948	1947	1899	1937	1914	bad/probe	1907	1895
166	1917	1922	1910	1965	1944	1902	1939	1913	bad/probe	1909	1896
167	1917	1920	1908	1957	1942	1899	1938	1911	bad/probe	1907	1896
168	1917	1922	1908	1959	1949	1902	1939	1915	bad/probe	1909	1897
169	1917	1923	1912	1966	1950	1900	1938	1913	bad/probe	1910	1897
170	1917	1923	1912	1965	1945	1902	1939	1913	bad/probe	1910	1899
171	1917	1919	1910	1955	1944	1898	1935	1910	bad/probe	1907	1895
172	1917	1917	1908	1957	1941	1895	1933	1905	bad/probe	1904	1892
173	1917	1914	1904	1954	1940	1893	1929	1901	bad/probe	1901	1889
174	1917	1914	1903	1946	1943	1894	1930	1904	bad/probe	1901	1889
175	1917	1913	1905	1944	1942	1894	1929	1904	bad/probe	1900	1889
176	1917	1915	1905	1958	1936	1891	1931	1903	bad/probe	1903	1889
177	1917	1915	1903	1951	1942	1894	1933	1907	bad/probe	1903	1890
178	1917	1914	1904	1958	1924	1896	1933	1904	bad/probe	1904	1891
179	1917	1917	1905	1955	1942	1896	1932	1907	bad/probe	1904	1891
180	1917	1915	1906	1953	1938	1895	1931	1906	bad/probe	1904	1891
181	1917	1917	1906	1958	1944	1895	1933	1908	bad/probe	1905	1892
182	1917	1917	1907	1950	1944	1898	1933	1906	bad/probe	1905	1894
183	1917	1919	1906	1956	1944	1899	1934	1911	bad/probe	1906	1894
184	1917	1917	1909	1951	1938	1897	1934	1913	bad/probe	1905	1894
185	1917	1919	1908	1959	1940	1899	1937	1912	bad/probe	1907	1895
186	1917	1920	1908	1957	1948	1899	1936	1910	bad/probe	1906	1895
187	1917	1917	1909	1955	1951	1897	1934	1909	bad/probe	1906	1894
188	1917	1916	1907	1939	1941	1899	1934	1908	bad/probe	1907	1894
189	1917	1921	1907	1969	1948	1896	1934	1910	bad/probe	1907	1894
190	1917	1918	1907	1952	1937	1900	1934	1910	bad/probe	1908	1896
191	1917	1919	1910	1947	1945	1901	1935	1913	bad/probe	1908	1896

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Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

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Time (min)	UL 1709 Std Average (°F)	Furnace Average (°F)	Furnace Probe #1 (°F)	Furnace Probe #2 (°F)	Furnace Probe #3 (°F)	Furnace Probe #4 (°F)	Furnace Probe #5 (°F)	Furnace Probe #6 (°F)	Furnace Probe #7 (°F)	Furnace Probe #8 (°F)	Furnace Probe #9 (°F)
192	1917	1918	1911	1926	1948	1899	1935	1908	bad/probe	1907	1896
193	1917	1917	1905	1954	1941	1897	1934	1909	bad/probe	1905	1893
194	1917	1917	1908	1933	1948	1899	1936	1907	bad/probe	1907	1895
195	1917	1915	1912	1910	1938	1900	1934	1925	bad/probe	1907	1896
196	1917	1917	1911	1910	1940	1901	1936	1930	bad/probe	1909	1896
197	1917	1919	1912	1907	1950	1903	1938	1933	bad/probe	1909	1899
198	1917	1918	1912	1908	1945	1902	1936	1933	bad/probe	1909	1899
199	1917	1918	1912	1908	1951	1900	1936	1935	bad/probe	1908	1897
200	1917	1918	1913	1908	1943	1902	1938	1934	bad/probe	1909	1898
201	1917	1918	1913	1908	1943	1903	1938	1936	bad/probe	1909	1899
202	1917	1918	1913	1907	1943	1901	1938	1936	bad/probe	1910	1899
203	1917	1921	1913	1908	1955	1903	1939	1937	bad/probe	1910	1900
204	1917	1920	1913	1907	1950	1902	1939	1937	bad/probe	1910	1900
205	1917	1921	1915	1910	1947	1904	1940	1938	bad/probe	1912	1901
206	1917	1919	1913	1908	1943	1903	1938	1937	bad/probe	1910	1900
207	1917	1922	1916	1908	1954	1905	1940	1939	bad/probe	1911	1901
208	1917	1920	1914	1910	1946	1903	1940	1936	bad/probe	1911	1900
209	1917	1922	1915	1908	1957	1904	1940	1937	bad/probe	1912	1901
210	1917	1922	1916	1909	1948	1906	1942	1939	bad/probe	1913	1902
211	1917	1921	1915	1909	1953	1903	1940	1938	bad/probe	1911	1901
212	1917	1922	1915	1909	1956	1905	1940	1937	bad/probe	1913	1901
213	1917	1921	1915	1909	1949	1903	1939	1938	bad/probe	1912	1901
214	1917	1921	1916	1907	1942	1906	1940	1938	bad/probe	1913	1902
215	1917	1921	1915	1908	1950	1903	1940	1939	bad/probe	1912	1901
216	1917	1921	1915	1909	1949	1903	1941	1938	bad/probe	1912	1901
217	1917	1922	1916	1909	1948	1906	1942	1939	bad/probe	1914	1903
218	1917	1923	1917	1911	1949	1908	1943	1940	bad/probe	1914	1904
219	1917	1923	1917	1908	1950	1907	1942	1940	bad/probe	1913	1904
220	1917	1917	1911	1905	1939	1901	1935	1934	bad/probe	1908	1900
221	1917	1914	1908	1900	1936	1899	1933	1932	bad/probe	1905	1896
222	1917	1912	1906	1899	1937	1895	1931	1930	bad/probe	1902	1893
223	1917	1913	1906	1899	1944	1895	1931	1930	bad/probe	1903	1893
224	1917	1913	1908	1899	1939	1897	1932	1933	bad/probe	1904	1894
225	1917	1912	1906	1901	1935	1896	1932	1929	bad/probe	1904	1894
226	1917	1913	1907	1899	1941	1896	1932	1931	bad/probe	1905	1894
227	1917	1914	1908	1897	1942	1897	1933	1933	bad/probe	1906	1895
228	1917	1914	1909	1901	1939	1898	1934	1932	bad/probe	1906	1896
229	1917	1916	1908	1900	1948	1899	1934	1933	bad/probe	1907	1896
230	1917	1915	1910	1903	1933	1899	1934	1933	bad/probe	1907	1897
231	1917	1915	1910	1902	1942	1899	1934	1933	bad/probe	1907	1896
232	1917	1915	1909	1902	1941	1898	1934	1934	bad/probe	1906	1897
233	1917	1913	1908	1902	1933	1897	1934	1932	bad/probe	1905	1896
234	1917	1916	1911	1902	1948	1898	1934	1934	bad/probe	1906	1896
235	1917	1915	1910	1902	1938	1898	1934	1934	bad/probe	1907	1897
236	1917	1916	1910	1903	1945	1898	1933	1933	bad/probe	1906	1896
237	1917	1917	1911	1904	1944	1899	1937	1936	bad/probe	1909	1898
238	1917	1916	1911	1901	1939	1900	1936	1935	bad/probe	1908	1897
239	1917	1917	1912	1904	1948	1900	1935	1934	bad/probe	1907	1897
240	1917	1917	1911	1904	1944	1900	1936	1934	bad/probe	1907	1897

Max Temp
Max Allowed

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Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

Aspen Aerogels, Inc.
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Time (min)	P2 P2Max (°F)	P2 AAAve (°F)	P2 Sec A-A TC #1 (°F)	P2 Sec A-A TC #2 (°F)	P2 Sec A-A TC #3 (°F)	P2 Sec A-A TC #4 (°F)	P2 Sec A-A TC #5 (°F)	P2 BBAve (°F)	P2 Sec B-B TC #6 (°F)	P2 Sec B-B TC #7 (°F)	P2 Sec B-B TC #8 (°F)	P2 CCAve (°F)	P2 Sec C-C TC #9 (°F)
0	83	83	83	83	83	83	83	82	83	82	82	83	bad/dc
1	83	83	83	83	83	83	83	82	83	82	82	82	bad/dc
2	83	83	83	83	83	83	83	83	83	83	82	83	bad/dc
3	84	83	83	83	84	83	83	83	84	82	82	83	bad/dc
4	87	84	84	83	87	84	83	84	86	83	83	85	bad/dc
5	92	86	88	82	92	86	84	86	89	80	88	86	bad/dc
6	103	92	99	82	103	88	88	92	96	80	99	91	bad/dc
7	122	102	118	82	122	96	95	102	110	81	116	99	bad/dc
8	146	117	140	84	146	107	106	115	126	82	136	110	bad/dc
9	169	131	166	86	169	119	118	129	147	84	157	123	bad/dc
10	191	146	186	89	191	133	131	143	165	88	176	135	bad/dc
11	217	163	214	93	217	147	145	157	182	93	195	149	bad/dc
12	242	180	238	99	242	161	159	170	197	98	216	166	bad/dc
13	266	196	261	106	266	175	172	186	217	105	237	182	bad/dc
14	289	212	283	113	289	188	186	203	238	113	258	197	bad/dc
15	312	228	306	122	312	204	201	220	259	121	280	212	bad/dc
16	333	243	328	130	333	220	218	237	279	131	300	228	bad/dc
17	354	260	347	140	354	236	231	253	298	140	320	242	bad/dc
18	375	278	368	150	375	252	248	269	317	151	340	257	bad/dc
19	398	292	375	161	398	269	261	288	336	162	360	273	bad/dc
20	417	309	393	173	417	285	277	303	355	173	380	288	bad/dc
21	437	325	411	184	437	301	292	320	374	185	401	305	bad/dc
22	458	342	429	197	458	318	308	337	393	197	421	320	bad/dc
23	477	358	446	209	477	334	323	354	411	210	442	336	bad/dc
24	498	374	463	222	498	351	338	371	429	223	461	350	bad/dc
25	515	390	480	235	515	367	353	388	447	236	481	365	bad/dc
26	534	405	496	249	534	384	368	405	465	250	500	380	bad/dc
27	552	422	513	262	552	400	383	422	483	263	519	396	bad/dc
28	570	438	529	276	570	417	398	439	501	277	539	411	bad/dc
29	588	454	545	290	588	433	414	455	518	290	557	426	bad/dc
30	605	469	561	304	605	449	428	472	535	304	577	442	bad/dc
31	622	485	578	318	622	465	443	488	552	318	595	458	bad/dc
32	639	500	592	332	639	481	458	505	569	332	614	473	bad/dc
33	655	515	607	345	655	497	473	521	586	348	632	488	bad/dc
34	671	530	622	359	671	512	487	537	602	360	649	503	bad/dc
35	686	545	636	373	686	527	502	553	618	375	666	518	bad/dc
36	701	559	651	387	701	542	516	568	634	389	682	533	bad/dc
37	718	574	665	400	718	557	530	584	650	403	699	548	bad/dc
38	731	588	679	414	731	572	544	599	665	417	714	563	bad/dc
39	746	602	694	427	746	587	558	614	681	431	731	578	bad/dc
40	761	616	708	440	761	601	572	629	696	445	747	592	bad/dc
41	778	631	722	454	778	616	585	645	712	459	763	607	bad/dc
42	791	645	736	467	791	630	599	659	727	472	779	622	bad/dc
43	808	659	751	480	808	644	613	675	743	486	795	636	bad/dc
44	821	673	765	492	821	658	627	689	758	499	810	651	bad/dc
45	835	686	779	505	835	672	640	704	773	513	826	666	bad/dc
46	850	701	794	518	850	687	654	719	789	526	842	680	bad/dc
47	865	714	808	530	865	700	667	733	804	539	857	694	bad/dc
48	879	728	823	543	879	714	681	748	819	552	872	709	bad/dc
49	893	741	836	555	893	728	694	762	834	565	887	723	bad/dc
50	908	754	850	568	908	741	707	776	848	578	902	737	bad/dc
51	920	767	863	580	920	754	720	789	862	590	916	750	bad/dc
52	934	780	877	592	933	767	733	803	876	603	930	763	bad/dc
53	948	793	890	604	948	780	746	816	890	615	944	777	bad/dc
54	962	806	903	616	959	793	758	830	903	628	958	790	bad/dc
55	976	819	916	628	972	806	771	843	917	640	971	803	bad/dc
56	990	831	929	639	984	818	783	855	930	652	984	816	bad/dc
57	1004	843	941	651	997	831	795	869	944	664	998	828	bad/dc
58	1017	855	954	663	1009	843	808	881	957	676	1011	842	bad/dc
59	1031	867	967	674	1021	855	820	894	970	688	1024	855	bad/dc
60	1044	879	979	685	1033	867	832	906	983	699	1036	867	bad/dc
61	1057	891	992	697	1045	879	844	918	995	711	1049	879	bad/dc
62	1070	903	1004	708	1057	891	856	930	1008	722	1061	892	bad/dc
63	1082	915	1016	719	1068	902	868	943	1020	734	1074	903	bad/dc

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Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

21 August 2008

Time (min)	P2 P2Max (°F)	P2 AAAve (°F)	P2 Sec A-A TC #1 (°F)	P2 Sec A-A TC #2 (°F)	P2 Sec A-A TC #3 (°F)	P2 Sec A-A TC #4 (°F)	P2 Sec A-A TC #5 (°F)	P2 BBAve (°F)	P2 Sec B-B TC #6 (°F)	P2 Sec B-B TC #7 (°F)	P2 Sec B-B TC #8 (°F)	P2 CCAve (°F)	P2 Sec C-C TC #9 (°F)
64	1095	926	1029	730	1080	914	879	954	1033	745	1085	916	bad/tc
65	1107	938	1040	741	1091	925	891	966	1045	756	1097	927	bad/tc
66	1119	949	1052	751	1102	936	903	978	1057	767	1110	939	bad/tc
67	1132	960	1064	762	1113	948	914	989	1069	778	1121	951	bad/tc
68	1143	971	1076	773	1124	959	925	1001	1081	789	1133	962	bad/tc
69	1156	982	1088	783	1134	969	937	1012	1092	800	1144	974	bad/tc
70	1167	993	1100	793	1145	980	948	1023	1104	810	1156	985	bad/tc
71	1179	1004	1111	804	1155	991	959	1035	1116	821	1167	997	bad/tc
72	1190	1015	1123	814	1168	1001	970	1045	1127	831	1178	1007	bad/tc
73	1202	1025	1134	824	1178	1012	981	1056	1138	842	1189	1018	bad/tc
74	1213	1036	1145	834	1188	1022	992	1067	1149	852	1199	1029	bad/tc
75	1223	1046	1156	844	1195	1032	1003	1077	1159	862	1209	1039	bad/tc
76	1234	1056	1167	854	1205	1042	1013	1087	1170	872	1220	1050	bad/tc
77	1245	1066	1177	864	1214	1052	1024	1098	1180	883	1230	1061	bad/tc
78	1255	1076	1188	873	1223	1061	1034	1107	1190	892	1240	1071	bad/tc
79	1265	1086	1198	883	1232	1071	1044	1117	1200	902	1249	1081	bad/tc
80	1275	1095	1208	892	1241	1080	1054	1127	1209	912	1259	1091	bad/tc
81	1284	1105	1218	902	1250	1090	1064	1136	1219	921	1268	1100	bad/tc
82	1294	1114	1228	911	1259	1098	1074	1145	1228	931	1277	1110	bad/tc
83	1303	1124	1238	920	1268	1108	1084	1155	1238	940	1286	1119	bad/tc
84	1312	1132	1247	929	1276	1117	1093	1164	1247	950	1295	1128	bad/tc
85	1321	1141	1256	938	1285	1125	1103	1173	1256	959	1304	1138	bad/tc
86	1329	1150	1266	947	1293	1134	1112	1182	1265	968	1312	1146	bad/tc
87	1336	1159	1274	956	1302	1143	1121	1189	1274	977	1320	1154	bad/tc
88	1343	1168	1283	965	1310	1151	1130	1198	1282	986	1328	1163	bad/tc
89	1350	1177	1292	974	1318	1160	1139	1208	1291	995	1332	1171	bad/tc
90	1357	1185	1301	982	1326	1168	1148	1213	1299	1004	1337	1179	bad/tc
91	1365	1193	1309	991	1333	1176	1157	1221	1308	1013	1342	1187	bad/tc
92	1373	1202	1318	1000	1340	1184	1166	1228	1316	1021	1348	1196	bad/tc
93	1381	1209	1326	1008	1348	1192	1174	1236	1324	1030	1355	1204	bad/tc
94	1389	1217	1333	1016	1352	1199	1183	1244	1331	1038	1362	1212	bad/tc
95	1397	1224	1340	1025	1358	1207	1191	1252	1338	1047	1370	1221	bad/tc
96	1405	1232	1347	1033	1365	1215	1199	1259	1344	1055	1377	1229	bad/tc
97	1413	1239	1353	1042	1371	1222	1207	1268	1349	1064	1384	1238	bad/tc
98	1421	1246	1359	1050	1377	1230	1215	1273	1355	1072	1391	1246	bad/tc
99	1430	1254	1366	1058	1384	1237	1223	1280	1361	1080	1399	1255	bad/tc
100	1438	1260	1372	1066	1390	1244	1230	1287	1367	1088	1406	1263	bad/tc
101	1447	1268	1379	1074	1398	1251	1238	1295	1373	1097	1414	1272	bad/tc
102	1455	1274	1385	1082	1403	1257	1245	1302	1379	1105	1422	1280	bad/tc
103	1463	1281	1391	1090	1409	1264	1253	1309	1385	1113	1430	1289	bad/tc
104	1471	1288	1398	1098	1416	1270	1259	1316	1391	1121	1437	1297	bad/tc
105	1480	1296	1405	1106	1423	1277	1267	1324	1398	1129	1445	1306	bad/tc
106	1488	1302	1412	1114	1429	1283	1273	1332	1405	1137	1453	1314	bad/tc
107	1496	1309	1419	1122	1436	1289	1280	1339	1411	1145	1460	1322	bad/tc
108	1504	1316	1426	1130	1443	1295	1287	1346	1418	1153	1468	1330	bad/tc
109	1512	1322	1433	1137	1450	1300	1292	1354	1425	1161	1476	1339	bad/tc
110	1520	1329	1440	1145	1457	1306	1299	1361	1432	1169	1483	1347	bad/tc
111	1527	1336	1447	1153	1464	1311	1304	1368	1439	1176	1490	1354	bad/tc
112	1535	1342	1454	1160	1470	1316	1310	1376	1447	1184	1498	1362	bad/tc
113	1542	1348	1461	1168	1478	1321	1316	1383	1453	1191	1505	1370	bad/tc
114	1550	1354	1467	1175	1483	1326	1321	1390	1460	1199	1512	1378	bad/tc
115	1557	1361	1474	1183	1489	1331	1326	1397	1467	1207	1518	1385	bad/tc
116	1564	1367	1480	1190	1496	1336	1331	1405	1474	1214	1526	1393	bad/tc
117	1571	1372	1487	1197	1502	1340	1336	1411	1481	1221	1532	1400	bad/tc
118	1578	1379	1494	1204	1508	1346	1341	1418	1487	1228	1539	1407	bad/tc
119	1586	1384	1500	1211	1514	1351	1346	1425	1494	1235	1546	1415	bad/tc
120	1593	1390	1506	1218	1521	1357	1350	1431	1500	1242	1552	1422	bad/tc
121	1601	1397	1513	1225	1527	1364	1358	1438	1507	1249	1559	1429	bad/tc
122	1608	1403	1519	1232	1533	1370	1362	1445	1513	1256	1566	1436	bad/tc
123	1615	1409	1525	1239	1539	1376	1368	1452	1520	1262	1573	1443	bad/tc
124	1623	1416	1531	1246	1545	1383	1375	1459	1526	1269	1581	1451	bad/tc
125	1631	1422	1538	1252	1551	1390	1381	1466	1533	1276	1588	1458	bad/tc
126	1640	1429	1544	1258	1557	1398	1387	1472	1539	1282	1595	1466	bad/tc
127	1647	1435	1550	1264	1563	1405	1395	1479	1545	1289	1603	1473	bad/tc

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Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

21 August 2008

Time (min)	P2 P2Max (°F)	P2 AAAve (°F)	P2 Sec A-A TC #1 (°F)	P2 Sec A-A TC #2 (°F)	P2 Sec A-A TC #3 (°F)	P2 Sec A-A TC #4 (°F)	P2 Sec A-A TC #5 (°F)	P2 BBAve (°F)	P2 Sec B-B TC #6 (°F)	P2 Sec B-B TC #7 (°F)	P2 Sec B-B TC #8 (°F)	P2 CCAve (°F)	P2 Sec C-C TC #9 (°F)
128	1653	1442	1556	1271	1569	1412	1401	1485	1551	1295	1810	1479	badAc
129	1661	1449	1562	1277	1575	1420	1409	1492	1557	1301	1817	1486	badAc
130	1669	1455	1568	1283	1581	1427	1416	1498	1563	1307	1824	1493	badAc
131	1678	1462	1574	1289	1587	1434	1424	1505	1570	1312	1832	1499	badAc
132	1683	1468	1580	1294	1594	1441	1431	1511	1576	1317	1839	1505	badAc
133	1689	1475	1587	1300	1601	1448	1438	1517	1583	1322	1846	1510	badAc
134	1697	1481	1593	1305	1607	1455	1445	1523	1590	1327	1853	1517	badAc
135	1705	1488	1600	1311	1614	1462	1452	1529	1596	1332	1860	1523	badAc
136	1712	1494	1607	1316	1620	1468	1459	1535	1603	1338	1866	1529	badAc
137	1718	1500	1613	1321	1626	1476	1466	1541	1610	1340	1873	1534	badAc
138	1725	1506	1620	1326	1632	1482	1473	1547	1617	1344	1879	1540	badAc
139	1731	1513	1626	1330	1639	1489	1479	1552	1623	1348	1885	1546	badAc
140	1737	1519	1633	1334	1644	1496	1486	1558	1630	1354	1891	1553	badAc
141	1743	1524	1639	1338	1650	1502	1492	1565	1636	1361	1897	1560	badAc
142	1748	1530	1644	1342	1655	1509	1499	1571	1642	1369	1702	1567	badAc
143	1753	1535	1650	1345	1661	1515	1505	1577	1648	1377	1707	1573	badAc
144	1759	1541	1655	1349	1666	1522	1511	1584	1654	1385	1712	1581	badAc
145	1765	1546	1661	1353	1671	1528	1518	1590	1660	1393	1718	1589	badAc
146	1768	1552	1667	1359	1677	1534	1524	1597	1666	1402	1723	1595	badAc
147	1774	1558	1672	1365	1682	1541	1530	1604	1671	1412	1728	1604	badAc
148	1780	1564	1677	1372	1687	1547	1537	1610	1677	1421	1733	1612	badAc
149	1782	1570	1683	1378	1692	1554	1543	1617	1682	1431	1738	1617	badAc
150	1789	1576	1688	1386	1697	1561	1550	1624	1688	1440	1743	1626	badAc
151	1792	1582	1694	1392	1702	1568	1556	1631	1694	1450	1748	1632	badAc
152	1798	1589	1699	1400	1707	1575	1563	1637	1699	1459	1753	1640	badAc
153	1801	1595	1704	1408	1712	1582	1571	1643	1704	1468	1757	1646	badAc
154	1808	1602	1709	1416	1717	1588	1578	1650	1710	1477	1762	1653	badAc
155	1810	1608	1714	1424	1722	1596	1585	1656	1715	1486	1767	1660	badAc
156	1814	1615	1719	1432	1727	1604	1593	1662	1720	1495	1771	1666	badAc
157	1818	1621	1724	1440	1732	1611	1600	1668	1726	1503	1776	1673	badAc
158	1821	1628	1729	1448	1736	1617	1607	1674	1730	1512	1780	1679	badAc
159	1826	1634	1734	1457	1741	1624	1615	1680	1736	1521	1784	1685	badAc
160	1829	1640	1738	1465	1745	1631	1622	1686	1741	1529	1788	1691	badAc
161	1833	1646	1743	1473	1750	1637	1629	1692	1746	1537	1792	1697	badAc
162	1836	1652	1748	1480	1754	1644	1636	1697	1750	1546	1796	1703	badAc
163	1838	1658	1752	1488	1759	1650	1643	1703	1755	1555	1800	1709	badAc
164	1840	1664	1757	1496	1763	1656	1650	1709	1760	1564	1804	1715	badAc
165	1844	1670	1761	1504	1767	1662	1656	1715	1764	1574	1808	1722	badAc
166	1848	1676	1765	1511	1771	1668	1663	1721	1769	1584	1811	1729	badAc
167	1849	1681	1769	1518	1775	1673	1669	1727	1773	1594	1814	1735	badAc
168	1852	1688	1773	1526	1779	1679	1675	1733	1777	1605	1818	1741	badAc
169	1856	1692	1778	1534	1783	1685	1681	1739	1782	1615	1821	1748	badAc
170	1858	1697	1782	1541	1787	1690	1687	1745	1786	1624	1824	1753	badAc
171	1859	1703	1785	1548	1791	1695	1694	1750	1790	1634	1827	1758	badAc
172	1860	1707	1788	1556	1794	1700	1699	1756	1794	1643	1830	1762	badAc
173	1860	1712	1791	1564	1797	1704	1705	1760	1797	1651	1831	1766	badAc
174	1861	1717	1794	1572	1800	1709	1710	1764	1800	1659	1834	1770	badAc
175	1863	1722	1798	1581	1802	1714	1715	1769	1804	1668	1835	1774	badAc
176	1865	1728	1799	1590	1805	1718	1720	1774	1807	1678	1838	1779	badAc
177	1866	1732	1802	1600	1808	1723	1726	1778	1810	1684	1840	1783	badAc
178	1868	1737	1805	1609	1811	1726	1731	1782	1813	1692	1842	1787	badAc
179	1869	1742	1807	1619	1814	1733	1735	1787	1816	1700	1844	1791	badAc
180	1883	1761	1883	1628	1817	1737	1740	1791	1819	1707	1846	1795	badAc
181	1899	1789	1899	1637	1819	1742	1746	1795	1822	1714	1848	1799	badAc
182	1901	1793	1901	1645	1822	1746	1750	1799	1825	1722	1851	1803	badAc
183	1902	1777	1902	1654	1825	1751	1755	1803	1828	1729	1852	1807	badAc
184	1904	1782	1904	1661	1828	1755	1760	1807	1831	1735	1855	1810	badAc
185	1905	1786	1905	1669	1830	1759	1765	1811	1834	1742	1857	1814	badAc
186	1908	1790	1906	1677	1833	1764	1769	1814	1837	1748	1858	1817	badAc
187	1908	1794	1908	1685	1835	1768	1774	1818	1839	1754	1860	1820	badAc
188	1909	1798	1909	1692	1838	1772	1778	1822	1842	1761	1862	1824	badAc
189	1910	1801	1910	1699	1840	1776	1782	1825	1844	1766	1864	1827	badAc
190	1911	1805	1911	1706	1842	1780	1786	1828	1846	1772	1865	1830	badAc
191	1912	1809	1912	1713	1844	1784	1790	1831	1849	1777	1867	1833	badAc

Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

Aspen Aerogels, Inc.
Project No. 3159033

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Time (min)	P2 P2Max (°F)	P2 AAAve (°F)	P2 Sec A-A TC #1 (°F)	P2 Sec A-A TC #2 (°F)	P2 Sec A-A TC #3 (°F)	P2 Sec A-A TC #4 (°F)	P2 Sec A-A TC #5 (°F)	P2 BBAve (°F)	P2 Sec B-B TC #6 (°F)	P2 Sec B-B TC #7 (°F)	P2 Sec B-B TC #8 (°F)	P2 CCAve (°F)	P2 Sec C-C TC #9 (°F)
192	1913	1812	1913	1720	1847	1788	1794	1834	1851	1781	1889	1836	bad/lc
193	1915	1816	1915	1726	1849	1792	1798	1836	1853	1786	1870	1839	bad/lc
194	1915	1819	1915	1732	1850	1795	1802	1839	1855	1790	1871	1842	bad/lc
195	1917	1823	1917	1739	1853	1799	1805	1841	1857	1794	1873	1845	bad/lc
196	1918	1826	1918	1744	1855	1803	1809	1844	1859	1797	1875	1848	bad/lc
197	1919	1829	1919	1750	1857	1807	1813	1846	1861	1800	1876	1851	bad/lc
198	1920	1832	1920	1756	1859	1810	1816	1848	1863	1803	1877	1855	bad/lc
199	1921	1835	1921	1762	1861	1813	1820	1850	1865	1806	1878	1857	bad/lc
200	1922	1839	1922	1767	1863	1817	1824	1852	1866	1809	1880	1860	bad/lc
201	1923	1842	1923	1773	1865	1820	1827	1854	1868	1812	1881	1863	bad/lc
202	1924	1844	1924	1778	1866	1823	1830	1856	1870	1815	1883	1866	bad/lc
203	1925	1847	1925	1783	1868	1826	1833	1857	1871	1817	1884	1868	bad/lc
204	1927	1850	1927	1788	1870	1829	1837	1859	1873	1820	1885	1870	bad/lc
205	1928	1853	1928	1793	1872	1833	1840	1861	1875	1823	1886	1873	bad/lc
206	1928	1856	1928	1798	1874	1836	1843	1863	1876	1825	1887	1875	bad/lc
207	1929	1858	1929	1803	1875	1839	1846	1865	1878	1828	1889	1877	bad/lc
208	1930	1861	1930	1808	1877	1841	1849	1867	1879	1831	1890	1879	bad/lc
209	1931	1864	1931	1812	1879	1844	1852	1868	1880	1833	1891	1881	bad/lc
210	1931	1866	1931	1817	1880	1847	1854	1870	1882	1835	1892	1883	bad/lc
211	1932	1869	1932	1822	1882	1850	1857	1871	1883	1838	1893	1885	bad/lc
212	1933	1871	1933	1827	1884	1853	1860	1873	1884	1840	1894	1887	bad/lc
213	1933	1874	1933	1832	1885	1855	1863	1874	1885	1842	1895	1888	bad/lc
214	1934	1876	1934	1836	1887	1856	1865	1876	1887	1845	1895	1890	bad/lc
215	1934	1878	1934	1841	1888	1860	1866	1877	1888	1847	1896	1892	bad/lc
216	1935	1881	1935	1846	1889	1863	1870	1878	1889	1849	1896	1893	bad/lc
217	1936	1883	1936	1851	1891	1866	1873	1879	1890	1851	1897	1895	bad/lc
218	1936	1885	1936	1856	1892	1868	1875	1881	1891	1853	1898	1896	bad/lc
219	1938	1889	1938	1861	1894	1872	1878	1882	1892	1855	1899	1898	bad/lc
220	1939	1891	1939	1866	1895	1874	1880	1883	1893	1857	1900	1899	bad/lc
221	1940	1893	1940	1871	1897	1877	1881	1884	1893	1859	1900	1900	bad/lc
222	1940	1895	1940	1876	1898	1879	1883	1885	1894	1861	1900	1901	bad/lc
223	1940	1897	1940	1881	1899	1882	1885	1886	1894	1864	1900	1902	bad/lc
224	1941	1900	1941	1886	1900	1885	1887	1887	1895	1866	1900	1903	bad/lc
225	1941	1902	1941	1890	1902	1887	1889	1888	1895	1868	1900	1904	bad/lc
226	1942	1904	1942	1895	1903	1890	1891	1889	1896	1870	1900	1905	bad/lc
227	1942	1906	1942	1899	1904	1892	1892	1890	1896	1872	1901	1906	bad/lc
228	1943	1908	1943	1903	1905	1894	1894	1891	1897	1874	1901	1907	bad/lc
229	1943	1909	1943	1906	1906	1896	1895	1892	1898	1877	1902	1908	bad/lc
230	1943	1910	1943	1908	1907	1897	1897	1893	1899	1879	1902	1908	bad/lc
231	1944	1912	1944	1910	1907	1899	1898	1894	1899	1881	1903	1909	bad/lc
232	1944	1913	1944	1912	1908	1900	1900	1895	1900	1883	1903	1910	bad/lc
233	1945	1914	1945	1913	1909	1901	1901	1896	1900	1884	1903	1911	bad/lc
234	1945	1915	1945	1915	1910	1902	1902	1897	1901	1886	1904	1912	bad/lc
235	1945	1915	1945	1916	1910	1903	1903	1898	1902	1887	1904	1912	bad/lc
236	1946	1916	1946	1917	1911	1904	1904	1898	1902	1888	1904	1912	bad/lc
237	1945	1917	1945	1918	1911	1905	1905	1899	1903	1890	1905	1913	bad/lc
238	1946	1918	1946	1918	1912	1906	1906	1900	1903	1891	1905	1913	bad/lc
239	1946	1918	1946	1919	1912	1907	1907	1901	1904	1892	1906	1914	bad/lc
240	1946	1919	1946	1920	1913	1907	1908	1901	1904	1893	1906	1914	bad/lc
Max T	1946	1919	1946	1920	1913	1907	1908	1901	1904	1893	1906	1914	bad/lc
Max A	1200	1000	1200	1200	1200	1200	1200	1000	1200	1200	1200	1000	1200

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Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

21 August 2008

Time (min)	P2 Sec C-C TC #10 (°F)	P2 Sec C-C TC #11 (°F)	P2 DDAve (°F)	P2 Sec D-D TC #12 (°F)	P2 Sec D-D TC #13 (°F)	P2 Sec D-D TC #14 (°F)	P5 P5fillax (°F)	P5 AAAve (°F)	P5 Sec A-A TC #1 (°F)	P5 Sec A-A TC #2 (°F)	P5 Sec A-A TC #3 (°F)	P5 Sec A-A TC #4 (°F)
0	82	83	83	bad/tc	83	83	82	81	81	81	81	81
1	82	82	83	bad/tc	83	83	82	81	81	81	81	81
2	83	83	83	bad/tc	83	83	82	81	81	81	82	81
3	83	83	83	bad/tc	83	83	82	81	81	81	81	81
4	85	85	84	bad/tc	82	85	82	81	81	81	81	82
5	83	88	85	bad/tc	81	89	83	81	81	81	81	81
6	84	97	88	bad/tc	81	95	83	82	82	81	81	82
7	84	113	98	bad/tc	82	110	85	82	83	81	82	82
8	85	135	108	bad/tc	83	129	87	84	85	81	85	84
9	87	159	117	bad/tc	84	150	90	86	86	82	87	86
10	89	180	126	bad/tc	87	169	93	87	90	81	90	86
11	93	205	139	bad/tc	91	187	97	89	93	82	93	88
12	98	233	152	bad/tc	98	207	103	91	97	85	97	90
13	104	259	166	bad/tc	103	228	110	94	102	83	102	92
14	111	283	180	bad/tc	110	249	118	99	108	84	110	96
15	119	305	194	bad/tc	118	269	126	104	116	86	118	100
16	128	327	208	bad/tc	126	288	134	110	124	87	127	105
17	137	347	221	bad/tc	135	307	143	116	133	89	136	110
18	147	367	235	bad/tc	144	325	151	123	142	92	145	117
19	157	388	249	bad/tc	155	343	158	129	151	94	154	123
20	168	408	263	bad/tc	165	361	165	136	159	98	162	130
21	180	429	278	bad/tc	176	379	172	142	166	101	170	136
22	192	448	293	bad/tc	188	398	181	149	174	105	179	142
23	204	467	309	bad/tc	200	417	190	157	184	110	188	149
24	218	483	323	bad/tc	211	435	199	163	193	114	197	155
25	229	500	339	bad/tc	224	453	208	171	203	119	207	161
26	242	518	354	bad/tc	235	471	217	179	212	124	217	168
27	256	535	370	bad/tc	249	490	227	186	221	129	226	176
28	269	553	385	bad/tc	262	508	236	194	230	135	236	183
29	282	570	401	bad/tc	275	526	245	202	239	141	245	191
30	298	587	416	bad/tc	288	544	254	210	248	147	254	198
31	310	605	432	bad/tc	301	562	264	218	257	153	264	206
32	323	622	447	bad/tc	314	579	273	226	266	159	273	214
33	337	639	462	bad/tc	327	597	282	234	274	166	282	221
34	351	655	478	bad/tc	341	614	291	242	283	172	291	229
35	365	671	492	bad/tc	354	630	300	250	292	179	300	237
36	379	687	507	bad/tc	367	646	309	258	300	186	309	244
37	393	703	522	bad/tc	381	663	318	266	309	193	318	253
38	407	718	537	bad/tc	394	679	327	274	317	200	327	260
39	421	734	551	bad/tc	407	695	335	282	326	207	335	268
40	434	750	566	bad/tc	420	711	344	290	334	214	344	276
41	448	766	581	bad/tc	434	727	352	298	343	221	352	283
42	462	782	596	bad/tc	447	744	361	306	351	228	361	291
43	475	797	610	bad/tc	460	760	370	314	360	236	370	298
44	489	813	625	bad/tc	473	776	379	322	368	243	379	306
45	502	829	639	bad/tc	486	791	388	330	377	250	388	314
46	515	844	653	bad/tc	498	807	396	338	385	258	396	322
47	528	860	667	bad/tc	511	823	405	347	394	265	405	330
48	541	876	682	bad/tc	524	839	415	355	403	273	414	338
49	554	891	695	bad/tc	536	854	424	363	412	280	423	345
50	567	906	709	bad/tc	549	869	433	371	420	287	432	354
51	580	920	722	bad/tc	561	883	441	379	429	295	440	362
52	592	934	736	bad/tc	574	897	450	388	438	302	449	370
53	605	948	749	bad/tc	586	911	459	396	446	310	458	377
54	617	962	762	bad/tc	598	925	468	404	454	317	466	386
55	629	976	775	bad/tc	610	939	477	412	463	325	475	394
56	641	990	787	bad/tc	621	952	485	420	471	332	484	401
57	654	1004	800	bad/tc	633	966	494	428	480	340	492	410
58	666	1017	812	bad/tc	645	979	503	437	489	347	501	418
59	678	1031	825	bad/tc	657	992	511	445	497	355	510	426
60	690	1044	837	bad/tc	668	1005	520	453	505	362	518	434
61	701	1057	849	bad/tc	679	1018	529	461	514	370	527	442
62	713	1070	861	bad/tc	691	1031	538	469	523	377	536	450
63	724	1082	873	bad/tc	702	1043	546	477	531	385	545	458

Intertek

Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

Aspen Aerogels, Inc.
Project No. 3159033

28 August, 2008
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Time (min)	P2 Sec C-C TC #10 (°F)	P2 Sec C-C TC #11 (°F)	P2 DDAve (°F)	P2 Sec D-D TC #12 (°F)	P2 Sec D-D TC #13 (°F)	P2 Sec D-D TC #14 (°F)	P5 PSflax (°F)	P5 AAAve (°F)	P5 Sec A-A TC #1 (°F)	P5 Sec A-A TC #2 (°F)	P5 Sec A-A TC #3 (°F)	P5 Sec A-A TC #4 (°F)
64	738	1095	884	bad/tc	713	1055	555	486	540	393	553	466
65	747	1107	897	bad/tc	725	1068	563	494	548	400	562	474
66	759	1119	908	bad/tc	736	1080	572	502	557	408	571	482
67	770	1132	920	bad/tc	747	1092	581	510	566	415	579	491
68	781	1143	931	bad/tc	757	1104	589	519	574	423	588	499
69	792	1156	942	bad/tc	768	1115	598	527	583	430	597	507
70	803	1167	953	bad/tc	779	1127	607	535	591	438	605	515
71	814	1179	964	bad/tc	790	1138	616	543	600	446	614	523
72	824	1190	975	bad/tc	800	1150	624	551	608	453	622	531
73	834	1202	986	bad/tc	810	1161	633	560	617	461	631	539
74	845	1213	997	bad/tc	821	1172	642	568	626	468	640	547
75	855	1223	1007	bad/tc	831	1182	650	576	634	476	648	556
76	866	1234	1017	bad/tc	841	1193	659	584	643	483	657	563
77	876	1245	1027	bad/tc	851	1203	668	592	651	491	666	572
78	886	1255	1037	bad/tc	861	1213	676	601	660	499	674	580
79	896	1265	1048	bad/tc	871	1224	684	608	668	506	682	588
80	906	1275	1058	bad/tc	881	1234	693	617	677	514	691	596
81	916	1284	1067	bad/tc	891	1243	701	625	685	521	699	604
82	925	1294	1077	bad/tc	900	1253	709	633	694	529	707	612
83	935	1303	1087	bad/tc	910	1263	718	641	702	536	716	620
84	944	1312	1096	bad/tc	919	1272	726	649	710	544	724	628
85	954	1321	1105	bad/tc	929	1281	734	657	718	551	732	636
86	963	1329	1114	bad/tc	938	1290	742	665	727	559	740	644
87	972	1338	1123	bad/tc	947	1299	750	673	735	566	749	652
88	982	1343	1133	bad/tc	957	1308	759	680	743	573	757	659
89	991	1350	1142	bad/tc	966	1317	767	688	751	580	765	667
90	1000	1357	1150	bad/tc	975	1325	775	696	760	588	773	676
91	1009	1365	1159	bad/tc	984	1333	782	704	768	595	781	683
92	1018	1373	1167	bad/tc	993	1340	791	712	776	602	789	691
93	1027	1381	1174	bad/tc	1002	1348	799	720	785	610	798	699
94	1035	1389	1181	bad/tc	1010	1352	807	728	793	617	806	706
95	1044	1397	1189	bad/tc	1019	1359	814	735	801	624	814	714
96	1053	1405	1197	bad/tc	1028	1366	823	743	810	631	822	723
97	1062	1413	1205	bad/tc	1037	1373	831	751	817	638	830	730
98	1070	1421	1213	bad/tc	1046	1380	838	758	825	645	837	737
99	1079	1430	1221	bad/tc	1055	1387	846	766	834	653	845	745
100	1088	1438	1229	bad/tc	1063	1394	854	774	841	660	853	753
101	1098	1447	1237	bad/tc	1072	1401	862	781	849	667	861	761
102	1105	1455	1244	bad/tc	1080	1408	869	789	857	674	869	768
103	1114	1463	1253	bad/tc	1089	1416	877	796	865	681	876	776
104	1122	1471	1261	bad/tc	1098	1423	884	804	873	688	884	783
105	1131	1480	1269	bad/tc	1107	1431	892	812	881	695	892	791
106	1140	1488	1277	bad/tc	1115	1438	900	819	889	702	900	799
107	1148	1496	1285	bad/tc	1124	1446	907	827	896	709	907	806
108	1156	1504	1293	bad/tc	1132	1453	915	834	904	716	914	813
109	1165	1512	1301	bad/tc	1141	1461	922	841	912	723	922	821
110	1173	1520	1309	bad/tc	1149	1468	929	849	919	730	929	828
111	1181	1527	1316	bad/tc	1157	1475	937	856	926	737	937	836
112	1189	1535	1325	bad/tc	1166	1483	944	863	934	744	944	843
113	1197	1542	1332	bad/tc	1174	1490	951	870	941	751	951	850
114	1205	1550	1340	bad/tc	1183	1497	958	878	948	758	958	857
115	1213	1557	1348	bad/tc	1191	1504	966	885	956	765	966	865
116	1221	1564	1355	bad/tc	1199	1511	973	892	964	772	973	872
117	1228	1571	1362	bad/tc	1207	1517	980	899	970	778	980	879
118	1236	1578	1370	bad/tc	1215	1525	987	906	978	785	987	886
119	1243	1586	1377	bad/tc	1222	1532	994	913	985	792	994	893
120	1250	1593	1384	bad/tc	1230	1538	1000	920	992	799	1000	900
121	1257	1601	1391	bad/tc	1237	1544	1007	927	999	806	1007	907
122	1264	1608	1398	bad/tc	1245	1551	1014	933	1006	812	1014	914
123	1271	1615	1404	bad/tc	1251	1556	1021	940	1013	819	1021	921
124	1278	1623	1410	bad/tc	1258	1562	1028	947	1020	826	1028	928
125	1284	1631	1418	bad/tc	1266	1569	1035	954	1027	833	1035	935
126	1292	1640	1426	bad/tc	1274	1578	1041	961	1034	839	1041	941
127	1298	1647	1433	bad/tc	1281	1584	1048	967	1040	846	1048	948

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Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

21 August 2008

Time (min)	P2 Sec C-C TC #10 (°F)	P2 Sec C-C TC #11 (°F)	P2 DDAve (°F)	P2 Sec D-D TC #12 (°F)	P2 Sec D-D TC #13 (°F)	P2 Sec D-D TC #14 (°F)	P5 P5Max (°F)	P5 AAAve (°F)	P5 Sec A-A TC #1 (°F)	P5 Sec A-A TC #2 (°F)	P5 Sec A-A TC #3 (°F)	P5 Sec A-A TC #4 (°F)
128	1304	1653	1439	bad/tc	1287	1590	1055	974	1047	853	1055	955
129	1310	1661	1448	bad/tc	1294	1598	1061	981	1053	859	1061	962
130	1316	1669	1453	bad/tc	1301	1605	1068	987	1060	866	1068	968
131	1321	1676	1461	bad/tc	1308	1613	1074	994	1067	872	1074	975
132	1327	1683	1468	bad/tc	1315	1620	1080	1000	1073	879	1080	981
133	1331	1689	1473	bad/tc	1320	1626	1087	1007	1080	886	1087	988
134	1338	1697	1480	bad/tc	1328	1634	1093	1013	1086	892	1093	994
135	1341	1705	1488	bad/tc	1333	1643	1099	1019	1092	898	1099	1001
136	1345	1712	1495	bad/tc	1339	1651	1106	1026	1099	905	1106	1007
137	1350	1718	1502	bad/tc	1345	1659	1112	1032	1105	911	1112	1014
138	1354	1725	1508	bad/tc	1350	1666	1118	1039	1111	918	1118	1020
139	1361	1731	1515	bad/tc	1355	1674	1124	1045	1117	924	1124	1026
140	1368	1737	1521	bad/tc	1361	1681	1130	1051	1124	931	1130	1032
141	1376	1743	1528	bad/tc	1367	1688	1136	1057	1130	937	1136	1039
142	1385	1748	1535	bad/tc	1375	1694	1142	1094	1136	944	1142	1045
143	1393	1753	1542	bad/tc	1383	1700	1147	1089	1141	950	1147	1051
144	1402	1759	1550	bad/tc	1392	1707	1153	1075	1147	957	1153	1057
145	1412	1765	1557	bad/tc	1400	1714	1159	1081	1153	963	1158	1063
146	1422	1768	1564	bad/tc	1409	1718	1164	1087	1158	969	1164	1069
147	1433	1774	1572	bad/tc	1419	1724	1170	1093	1164	976	1169	1075
148	1443	1780	1581	bad/tc	1429	1732	1176	1099	1170	982	1175	1081
149	1452	1782	1587	bad/tc	1439	1735	1182	1105	1176	988	1180	1087
150	1463	1789	1596	bad/tc	1449	1742	1187	1111	1181	995	1186	1093
151	1472	1792	1603	bad/tc	1459	1747	1193	1116	1187	1001	1191	1099
152	1482	1798	1612	bad/tc	1469	1754	1198	1122	1192	1007	1197	1105
153	1491	1801	1618	bad/tc	1478	1756	1204	1128	1198	1013	1202	1110
154	1500	1809	1626	bad/tc	1488	1764	1209	1134	1203	1020	1208	1116
155	1509	1810	1633	bad/tc	1497	1768	1215	1139	1209	1026	1213	1122
156	1518	1814	1640	bad/tc	1506	1773	1220	1145	1214	1032	1218	1128
157	1527	1818	1647	bad/tc	1515	1778	1226	1150	1219	1038	1223	1133
158	1538	1821	1653	bad/tc	1524	1782	1231	1156	1225	1045	1228	1139
159	1544	1826	1660	bad/tc	1533	1787	1237	1162	1230	1051	1234	1145
160	1553	1829	1666	bad/tc	1541	1791	1242	1167	1235	1057	1239	1150
161	1561	1833	1673	bad/tc	1550	1796	1248	1172	1240	1063	1243	1155
162	1570	1836	1680	bad/tc	1559	1800	1253	1178	1246	1069	1249	1161
163	1579	1838	1684	bad/tc	1566	1801	1258	1183	1251	1075	1254	1166
164	1589	1840	1690	bad/tc	1575	1804	1264	1189	1256	1081	1259	1172
165	1600	1844	1696	bad/tc	1584	1808	1269	1194	1261	1087	1264	1177
166	1610	1848	1703	bad/tc	1593	1813	1274	1199	1266	1093	1268	1182
167	1620	1849	1709	bad/tc	1603	1814	1279	1204	1271	1099	1273	1187
168	1630	1852	1715	bad/tc	1612	1817	1284	1210	1276	1105	1278	1193
169	1639	1856	1722	bad/tc	1622	1821	1289	1215	1280	1111	1283	1198
170	1648	1858	1727	bad/tc	1631	1823	1294	1220	1285	1116	1288	1203
171	1656	1859	1732	bad/tc	1640	1824	1299	1225	1290	1122	1292	1208
172	1664	1860	1736	bad/tc	1648	1824	1304	1230	1295	1128	1297	1214
173	1671	1860	1740	bad/tc	1655	1825	1309	1235	1300	1134	1301	1218
174	1678	1861	1745	bad/tc	1663	1827	1314	1240	1304	1139	1306	1223
175	1685	1863	1749	bad/tc	1670	1828	1318	1244	1308	1145	1310	1228
176	1692	1865	1754	bad/tc	1677	1830	1323	1249	1313	1151	1315	1233
177	1699	1866	1758	bad/tc	1684	1832	1327	1254	1318	1156	1319	1238
178	1705	1868	1763	bad/tc	1691	1834	1332	1259	1322	1162	1323	1243
179	1712	1869	1767	bad/tc	1698	1836	1336	1263	1326	1167	1327	1248
180	1719	1871	1771	bad/tc	1704	1838	1340	1268	1331	1173	1331	1253
181	1725	1873	1776	bad/tc	1711	1840	1344	1273	1335	1178	1335	1257
182	1731	1874	1780	bad/tc	1717	1842	1347	1277	1339	1183	1338	1262
183	1737	1876	1784	bad/tc	1723	1844	1351	1281	1343	1188	1341	1266
184	1742	1878	1787	bad/tc	1728	1846	1354	1285	1346	1193	1344	1271
185	1748	1879	1791	bad/tc	1734	1848	1358	1289	1350	1198	1348	1275
186	1753	1880	1795	bad/tc	1739	1850	1362	1294	1353	1204	1351	1280
187	1758	1881	1798	bad/tc	1744	1851	1366	1298	1356	1208	1355	1284
188	1764	1883	1802	bad/tc	1750	1853	1370	1301	1359	1213	1358	1288
189	1769	1884	1805	bad/tc	1755	1855	1374	1306	1363	1218	1362	1292
190	1774	1885	1809	bad/tc	1760	1857	1377	1310	1367	1223	1366	1297
191	1779	1887	1812	bad/tc	1765	1859	1381	1314	1370	1228	1369	1301

Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

21 August 2008

Time (min)	P2 Sec C-C TC #10 (°F)	P2 Sec C-C TC #11 (°F)	P2 DDAve (°F)	P2 Sec D-D TC #12 (°F)	P2 Sec D-D TC #13 (°F)	P2 Sec D-D TC #14 (°F)	P5 P5Max (°F)	P5 AAAve (°F)	P5 Sec A-A TC #1 (°F)	P5 Sec A-A TC #2 (°F)	P5 Sec A-A TC #3 (°F)	P5 Sec A-A TC #4 (°F)
192	1784	1888	1815	bad/tc	1769	1880	1385	1318	1374	1232	1373	1305
193	1789	1889	1818	bad/tc	1774	1882	1389	1321	1377	1237	1377	1308
194	1794	1890	1821	bad/tc	1778	1884	1393	1325	1381	1241	1380	1312
195	1799	1891	1824	bad/tc	1783	1885	1397	1329	1385	1246	1383	1316
196	1804	1892	1827	bad/tc	1787	1887	1401	1333	1389	1250	1387	1319
197	1809	1893	1830	bad/tc	1791	1888	1405	1336	1392	1254	1391	1323
198	1814	1895	1833	bad/tc	1795	1871	1410	1340	1396	1258	1395	1326
199	1818	1896	1836	bad/tc	1799	1872	1414	1344	1401	1263	1399	1329
200	1823	1897	1838	bad/tc	1802	1874	1418	1348	1405	1267	1403	1332
201	1828	1898	1841	bad/tc	1806	1876	1423	1351	1409	1271	1407	1336
202	1832	1899	1844	bad/tc	1810	1877	1427	1355	1413	1275	1411	1338
203	1835	1900	1846	bad/tc	1813	1879	1432	1358	1418	1279	1415	1341
204	1839	1901	1849	bad/tc	1817	1881	1436	1362	1422	1282	1419	1343
205	1843	1902	1851	bad/tc	1820	1882	1440	1365	1426	1286	1423	1346
206	1846	1903	1854	bad/tc	1823	1884	1445	1369	1431	1289	1427	1349
207	1850	1904	1856	bad/tc	1831	1885	1449	1373	1435	1293	1431	1352
208	1853	1905	1861	bad/tc	1834	1887	1454	1376	1440	1297	1435	1355
209	1856	1906	1863	bad/tc	1837	1888	1458	1380	1444	1300	1439	1359
210	1859	1907	1865	bad/tc	1840	1889	1462	1384	1448	1303	1443	1362
211	1861	1908	1867	bad/tc	1843	1891	1466	1388	1453	1307	1447	1366
212	1864	1909	1869	bad/tc	1846	1892	1471	1391	1457	1310	1451	1370
213	1866	1910	1871	bad/tc	1849	1893	1475	1395	1462	1313	1455	1374
214	1869	1911	1901	bad/tc	1907	1895	1479	1399	1466	1317	1460	1377
215	1871	1912	1911	bad/tc	1926	1896	1483	1403	1470	1320	1463	1381
216	1873	1913	1913	bad/tc	1928	1897	1488	1407	1475	1323	1467	1385
217	1875	1914	1914	bad/tc	1929	1898	1492	1411	1479	1326	1471	1389
218	1877	1915	1915	bad/tc	1930	1899	1496	1415	1483	1329	1475	1393
219	1879	1916	1916	bad/tc	1931	1900	1500	1419	1488	1332	1479	1397
220	1881	1916	1917	bad/tc	1933	1901	1504	1423	1493	1334	1484	1402
221	1883	1917	1918	bad/tc	1934	1901	1508	1427	1497	1337	1487	1406
222	1884	1917	1919	bad/tc	1935	1902	1512	1431	1502	1340	1491	1410
223	1886	1917	1919	bad/tc	1935	1902	1516	1435	1506	1342	1495	1415
224	1888	1918	1920	bad/tc	1936	1903	1520	1438	1510	1344	1499	1419
225	1890	1918	1920	bad/tc	1937	1903	1524	1442	1515	1346	1503	1424
226	1891	1919	1921	bad/tc	1937	1904	1528	1446	1519	1348	1507	1428
227	1893	1919	1921	bad/tc	1938	1904	1531	1450	1523	1350	1511	1432
228	1894	1919	1922	bad/tc	1938	1905	1535	1453	1527	1352	1515	1436
229	1896	1920	1922	bad/tc	1939	1905	1539	1457	1531	1355	1519	1441
230	1898	1920	1923	bad/tc	1939	1906	1543	1461	1536	1358	1523	1445
231	1897	1921	1923	bad/tc	1939	1907	1547	1465	1540	1361	1527	1449
232	1898	1922	1923	bad/tc	1939	1907	1551	1469	1544	1364	1531	1453
233	1899	1922	1924	bad/tc	1939	1908	1554	1473	1548	1368	1535	1457
234	1900	1923	1923	bad/tc	1938	1908	1558	1477	1552	1372	1539	1462
235	1900	1923	1924	bad/tc	1939	1909	1562	1481	1556	1375	1542	1466
236	1901	1923	1924	bad/tc	1938	1909	1566	1485	1560	1379	1546	1470
237	1901	1924	1924	bad/tc	1938	1910	1570	1489	1564	1383	1550	1474
238	1902	1924	1925	bad/tc	1938	1911	1574	1493	1569	1388	1554	1478
239	1902	1925	1925	bad/tc	1938	1911	1578	1497	1573	1390	1558	1482
240	1903	1925	1925	bad/tc	1938	1912	1582	1501	1577	1394	1562	1486
Max T	1903	1925	1925	bad/tc	1939	1912	1582	1501	1577	1394	1562	1486
Max A	1200	1200	1000	1200	1200	1200	1200	1000	1200	1200	1200	1200

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Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

21 August 2008

Time (min)	P5 Sec A-A TC #5 (°F)	P5 BBAve (°F)	P5 Sec B-B TC #6 (°F)	P5 Sec B-B TC #7 (°F)	P5 Sec B-B TC #8 (°F)	P5 CCAve (°F)	P5 Sec C-C TC #9 (°F)	P5 Sec C-C TC #10 (°F)	P5 Sec C-C TC #11 (°F)	P5 DDAve (°F)	P5 Sec D-D TC #12 (°F)	P5 Sec D-D TC #13 (°F)	P5 Sec D-D TC #14 (°F)
0	82	82	82	82	82	82	82	82	82	82	82	82	82
1	81	82	82	82	82	82	82	82	82	82	82	82	82
2	81	82	82	82	82	82	82	82	82	82	82	82	82
3	81	82	82	82	82	82	82	82	82	82	82	82	82
4	81	82	82	82	82	82	82	81	82	82	82	82	82
5	82	82	82	82	82	82	83	81	82	82	82	82	82
6	82	83	83	82	83	82	83	80	83	82	82	81	82
7	83	84	85	82	85	83	85	80	85	83	84	82	83
8	84	85	87	82	87	84	87	80	86	84	85	82	84
9	86	87	89	82	90	86	89	80	88	85	87	82	86
10	87	89	91	82	93	88	91	81	91	88	89	82	88
11	88	91	94	82	97	89	94	81	93	88	92	83	90
12	90	94	97	83	103	92	97	81	97	90	95	83	93
13	93	98	102	83	110	96	102	82	103	94	100	84	97
14	99	103	108	84	118	101	109	83	111	98	106	85	103
15	101	109	115	85	129	106	116	84	119	103	114	86	110
16	108	114	122	86	134	112	124	85	127	109	122	87	118
17	112	120	129	87	143	118	131	87	135	115	131	88	126
18	119	126	138	89	151	123	139	88	142	121	139	90	135
19	125	132	146	92	158	130	148	91	150	128	148	92	144
20	132	138	154	94	165	136	156	94	158	134	157	94	152
21	139	144	162	98	172	143	165	97	166	141	165	97	161
22	146	150	169	101	181	149	173	100	175	148	174	101	169
23	152	157	176	105	190	156	180	104	184	154	182	105	176
24	158	162	179	109	199	162	186	108	192	161	191	108	184
25	166	170	187	114	208	168	195	112	201	168	199	113	193
26	173	178	198	119	217	177	203	117	211	175	208	117	201
27	180	187	209	124	227	185	213	122	220	184	219	122	210
28	188	194	218	129	236	193	223	128	229	191	228	127	219
29	195	202	228	134	245	201	233	133	238	199	237	132	228
30	204	211	238	140	254	210	243	139	247	207	246	138	237
31	212	219	248	146	263	218	252	145	256	214	255	143	245
32	220	228	258	152	273	226	262	151	266	222	264	149	253
33	228	236	267	158	282	234	271	157	275	230	273	155	262
34	235	244	277	164	291	243	280	164	284	237	281	161	270
35	243	252	286	171	300	251	289	170	293	245	290	167	278
36	251	261	296	178	308	259	298	177	302	253	298	174	286
37	259	269	305	185	317	267	307	184	310	260	306	180	294
38	267	277	314	192	326	275	316	191	319	268	314	187	302
39	275	285	324	199	334	284	324	199	328	275	322	193	309
40	283	294	333	206	343	292	333	206	337	283	331	200	317
41	291	303	342	214	352	300	342	213	346	290	339	207	325
42	299	311	351	221	361	309	351	221	355	298	347	214	333
43	306	320	361	228	370	317	359	228	364	306	355	221	341
44	314	328	370	236	378	325	368	235	373	314	364	228	350
45	322	337	379	243	388	334	377	243	382	322	372	235	358
46	330	345	389	251	396	342	386	250	391	330	381	242	366
47	339	354	398	258	405	351	395	258	400	338	390	249	374
48	346	363	407	266	415	360	404	266	409	346	398	256	383
49	355	371	417	273	424	368	413	273	419	354	407	263	391
50	363	380	426	281	433	377	422	281	428	361	415	270	399
51	371	388	436	288	441	386	431	289	437	370	424	278	407
52	379	397	445	296	450	394	440	296	446	378	432	285	416
53	387	405	454	303	459	403	449	304	455	385	440	292	424
54	395	414	463	311	468	411	458	312	464	393	449	299	432
55	403	423	472	318	477	419	466	319	473	401	457	306	440
56	411	431	481	326	485	428	475	327	482	409	466	313	449
57	420	439	490	334	494	437	484	335	491	417	474	320	457
58	428	448	499	341	503	445	492	342	500	425	483	328	465
59	438	456	507	349	511	453	501	350	509	433	491	335	473
60	444	464	516	356	520	462	510	357	518	441	499	342	481
61	452	473	525	364	529	470	518	365	527	449	508	349	490
62	460	481	534	372	538	479	527	373	536	457	516	356	498
63	468	489	542	379	546	487	535	380	545	465	524	364	506

Intertek

Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

21 August 2008

Time (min)	P5 Sec A-A TC #5 (°F)	P5 BBAve (°F)	P5 Sec B-B TC #6 (°F)	P5 Sec B-B TC #7 (°F)	P5 Sec B-B TC #8 (°F)	P5 CCAve (°F)	P5 Sec C-C TC #9 (°F)	P5 Sec C-C TC #10 (°F)	P5 Sec C-C TC #11 (°F)	P5 DDAve (°F)	P5 Sec D-D TC #12 (°F)	P5 Sec D-D TC #13 (°F)	P5 Sec D-D TC #14 (°F)
64	477	498	551	387	555	495	544	388	554	473	533	371	514
65	485	508	560	394	563	504	553	396	563	480	541	378	522
66	493	514	569	402	572	512	561	403	572	488	549	385	530
67	501	523	577	410	581	520	570	411	580	496	557	392	539
68	509	531	586	417	589	529	578	419	589	504	566	399	547
69	517	539	595	425	598	537	587	426	598	512	574	407	555
70	525	547	603	432	607	545	595	434	607	520	582	414	563
71	534	556	612	440	616	554	604	441	616	528	591	421	571
72	542	564	621	447	624	562	612	449	624	535	599	428	579
73	550	572	629	455	633	570	621	457	633	543	607	435	587
74	558	580	638	462	641	578	629	464	642	551	615	442	595
75	566	589	646	470	650	586	637	471	650	559	623	450	603
76	574	598	654	477	658	595	646	479	659	566	631	457	611
77	582	605	663	485	667	603	654	486	668	574	639	464	619
78	590	613	671	492	675	611	662	494	676	582	648	471	627
79	598	620	679	499	683	619	671	501	684	589	656	478	635
80	606	629	688	507	692	627	679	509	693	597	663	485	643
81	614	637	696	514	700	635	687	516	701	604	671	492	650
82	622	644	704	521	708	642	695	523	709	612	679	499	658
83	630	652	712	528	716	651	703	531	718	620	687	507	666
84	638	660	720	536	725	658	711	538	726	627	695	513	674
85	646	668	728	543	733	666	719	545	734	635	703	521	681
86	654	676	737	550	741	674	727	552	742	642	710	528	689
87	661	683	744	557	749	682	735	560	750	650	718	535	697
88	669	691	752	565	757	690	743	567	759	657	726	541	704
89	677	699	760	572	765	697	751	574	767	665	734	548	712
90	685	707	768	579	773	705	758	581	775	672	741	555	720
91	693	714	776	586	781	712	766	588	782	679	749	562	727
92	700	722	784	593	789	720	774	595	791	687	757	569	735
93	708	730	792	600	797	728	782	602	799	694	764	576	742
94	716	737	800	607	805	735	790	609	807	702	772	583	750
95	724	745	808	614	813	742	797	616	814	709	779	590	757
96	731	753	816	621	821	750	805	622	823	716	787	596	765
97	738	760	824	628	829	758	813	629	831	723	794	603	772
98	746	767	831	634	838	765	821	636	838	731	802	610	780
99	754	775	839	642	844	772	828	642	846	738	809	617	787
100	761	782	847	648	852	780	836	649	854	745	817	624	794
101	769	790	855	655	860	787	843	655	862	752	824	630	801
102	776	797	862	662	867	794	850	662	869	759	831	637	809
103	784	805	870	669	875	801	858	669	877	766	839	644	816
104	792	812	878	676	883	808	865	676	884	773	846	651	823
105	800	819	885	683	890	816	873	682	892	780	853	657	831
106	807	827	893	690	898	823	880	689	900	788	861	664	838
107	815	834	900	697	906	830	888	696	907	795	868	671	845
108	822	841	908	703	913	837	894	702	915	801	874	677	852
109	829	849	915	710	921	844	902	709	922	808	882	684	859
110	837	856	922	717	928	851	909	716	929	815	889	690	866
111	844	863	930	724	935	858	916	722	937	822	896	697	873
112	851	870	937	730	942	865	923	729	944	828	902	703	880
113	858	877	944	737	950	872	930	735	951	835	909	709	886
114	865	884	951	744	957	879	937	742	958	842	916	716	893
115	873	891	958	751	964	886	944	749	965	848	923	722	900
116	880	898	965	757	971	893	951	755	972	855	930	729	907
117	887	905	972	764	978	899	957	761	979	861	936	735	913
118	894	911	978	770	985	906	964	768	986	868	943	741	920
119	901	918	985	777	992	913	971	775	993	874	949	748	926
120	908	925	992	784	999	920	978	781	1000	881	956	754	933
121	915	932	999	790	1005	926	984	788	1007	887	962	760	939
122	921	938	1005	797	1013	933	991	794	1014	894	969	766	946
123	928	945	1012	803	1019	939	997	800	1020	900	976	773	952
124	935	952	1019	810	1026	946	1004	807	1027	907	982	779	959
125	942	958	1025	816	1033	953	1011	813	1034	913	989	785	965
126	948	965	1032	823	1039	959	1017	820	1040	919	995	791	972
127	955	971	1039	829	1046	966	1024	826	1047	925	1001	797	978

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Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

21 August 2008

Time (min)	P5 Sec A-A TC #5 (°F)	P5 BBAve (°F)	P5 Sec B-B TC #6 (°F)	P5 Sec B-B TC #7 (°F)	P5 Sec B-B TC #8 (°F)	P5 CCAve (°F)	P5 Sec C-C TC #9 (°F)	P5 Sec C-C TC #10 (°F)	P5 Sec C-C TC #11 (°F)	P5 DDAve (°F)	P5 Sec D-D TC #12 (°F)	P5 Sec D-D TC #13 (°F)	P5 Sec D-D TC #14 (°F)
128	962	978	1045	836	1053	972	1030	832	1054	932	1008	803	984
129	969	984	1052	842	1060	978	1036	839	1060	938	1014	810	991
130	975	991	1058	849	1066	985	1043	845	1067	944	1020	816	997
131	982	997	1065	855	1072	991	1049	851	1073	951	1027	822	1003
132	988	1004	1071	862	1079	998	1055	858	1080	957	1033	828	1009
133	995	1010	1078	868	1085	1004	1061	864	1086	963	1039	834	1015
134	1001	1016	1084	874	1091	1010	1068	870	1092	969	1045	840	1021
135	1007	1023	1090	881	1098	1016	1074	878	1099	975	1051	846	1028
136	1014	1029	1096	887	1104	1023	1080	883	1105	981	1057	853	1033
137	1020	1036	1103	894	1110	1029	1086	889	1111	987	1063	859	1040
138	1026	1042	1109	900	1116	1035	1092	895	1118	993	1069	865	1045
139	1033	1048	1115	906	1122	1041	1098	901	1124	999	1075	871	1051
140	1039	1054	1121	912	1128	1047	1104	908	1130	1005	1081	877	1057
141	1045	1060	1127	919	1134	1053	1110	914	1135	1011	1087	883	1063
142	1051	1066	1133	925	1140	1059	1116	920	1142	1017	1092	889	1069
143	1057	1072	1138	931	1146	1065	1121	926	1147	1022	1098	895	1074
144	1063	1078	1144	938	1152	1071	1127	933	1153	1028	1103	901	1080
145	1069	1084	1150	944	1157	1077	1132	939	1159	1034	1109	907	1085
146	1075	1089	1155	950	1163	1082	1138	945	1164	1039	1114	913	1091
147	1081	1095	1161	957	1168	1088	1143	951	1170	1045	1120	919	1096
148	1087	1101	1167	963	1174	1094	1149	957	1176	1051	1125	925	1102
149	1092	1107	1172	969	1179	1100	1154	963	1182	1056	1130	931	1107
150	1098	1113	1178	976	1185	1105	1160	970	1187	1062	1136	937	1113
151	1104	1118	1183	982	1190	1111	1165	976	1193	1067	1141	943	1118
152	1110	1124	1189	988	1196	1117	1170	982	1198	1073	1147	949	1123
153	1115	1130	1194	994	1201	1123	1176	988	1204	1078	1152	954	1129
154	1121	1136	1200	1001	1207	1128	1181	994	1209	1084	1157	960	1134
155	1126	1141	1205	1008	1212	1134	1186	1000	1215	1089	1162	966	1139
156	1132	1147	1210	1013	1217	1139	1191	1006	1220	1095	1168	972	1144
157	1137	1152	1216	1019	1222	1145	1197	1012	1226	1100	1173	978	1150
158	1143	1158	1221	1025	1228	1150	1202	1018	1231	1106	1178	984	1155
159	1148	1163	1226	1031	1233	1156	1207	1024	1237	1111	1183	990	1160
160	1154	1169	1231	1037	1238	1161	1212	1030	1242	1116	1188	995	1165
161	1159	1174	1236	1043	1243	1167	1217	1036	1248	1121	1193	1001	1170
162	1164	1180	1242	1049	1248	1172	1222	1042	1253	1127	1198	1007	1175
163	1170	1185	1247	1055	1253	1178	1227	1048	1258	1132	1203	1013	1180
164	1175	1190	1252	1061	1258	1183	1232	1054	1264	1138	1209	1019	1186
165	1180	1196	1257	1068	1263	1189	1237	1060	1269	1143	1214	1024	1190
166	1185	1201	1262	1074	1268	1194	1242	1066	1274	1148	1219	1030	1196
167	1191	1206	1267	1079	1273	1199	1247	1071	1279	1153	1224	1036	1200
168	1196	1211	1272	1085	1277	1204	1252	1077	1284	1158	1228	1041	1206
169	1201	1217	1277	1091	1283	1210	1257	1083	1289	1163	1233	1047	1210
170	1206	1222	1282	1097	1287	1215	1262	1089	1294	1169	1238	1053	1215
171	1211	1227	1287	1103	1292	1220	1266	1095	1299	1174	1243	1059	1220
172	1216	1232	1291	1109	1297	1225	1271	1100	1304	1179	1248	1064	1225
173	1221	1237	1296	1114	1301	1230	1276	1106	1309	1184	1252	1070	1230
174	1226	1242	1301	1120	1306	1236	1281	1112	1314	1189	1257	1076	1235
175	1230	1247	1305	1126	1310	1240	1285	1118	1318	1194	1262	1081	1239
176	1235	1252	1310	1132	1315	1245	1290	1123	1323	1199	1266	1087	1244
177	1240	1257	1314	1137	1319	1250	1294	1129	1327	1204	1271	1092	1248
178	1245	1261	1318	1143	1323	1255	1299	1134	1332	1209	1275	1098	1253
179	1249	1265	1323	1148	1328	1260	1303	1140	1336	1213	1279	1103	1257
180	1254	1271	1327	1154	1332	1264	1307	1145	1340	1218	1284	1109	1262
181	1258	1276	1332	1159	1336	1269	1312	1150	1344	1223	1288	1114	1266
182	1263	1280	1336	1164	1340	1273	1316	1156	1347	1228	1292	1120	1271
183	1267	1284	1340	1170	1343	1277	1320	1161	1351	1232	1297	1125	1275
184	1272	1288	1343	1175	1346	1282	1325	1166	1354	1237	1301	1130	1279
185	1276	1292	1347	1180	1349	1286	1329	1171	1358	1241	1305	1135	1284
186	1281	1296	1350	1185	1353	1290	1333	1176	1362	1246	1310	1141	1288
187	1285	1300	1353	1190	1356	1294	1336	1181	1366	1251	1314	1146	1292
188	1289	1304	1357	1195	1360	1299	1340	1186	1370	1255	1318	1151	1297
189	1293	1308	1360	1200	1363	1303	1343	1191	1374	1260	1322	1156	1301
190	1297	1312	1364	1205	1367	1306	1346	1196	1377	1264	1326	1161	1305
191	1301	1316	1367	1209	1371	1311	1350	1201	1381	1268	1330	1166	1309

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Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

21 August 2008

Time (min)	P5 Sec A-A TC #5 (°F)	P5 BBAve (°F)	P5 Sec B-B TC #6 (°F)	P5 Sec B-B TC #7 (°F)	P5 Sec B-B TC #8 (°F)	P5 CCAve (°F)	P5 Sec C-C TC #9 (°F)	P5 Sec C-C TC #10 (°F)	P5 Sec C-C TC #11 (°F)	P5 DDAve (°F)	P5 Sec D-D TC #12 (°F)	P5 Sec D-D TC #13 (°F)	P5 Sec D-D TC #14 (°F)
192	1305	1320	1371	1214	1374	1314	1353	1205	1385	1273	1335	1171	1313
193	1308	1324	1375	1219	1378	1318	1358	1210	1389	1277	1338	1176	1317
194	1312	1328	1379	1223	1381	1323	1360	1215	1393	1281	1342	1181	1321
195	1315	1332	1383	1228	1385	1327	1364	1219	1397	1285	1345	1185	1325
196	1319	1336	1386	1232	1389	1331	1368	1224	1401	1289	1348	1190	1329
197	1322	1340	1390	1237	1393	1335	1371	1228	1405	1293	1351	1195	1332
198	1325	1344	1393	1241	1397	1339	1375	1232	1410	1296	1354	1199	1335
199	1328	1348	1397	1245	1401	1343	1379	1237	1414	1300	1358	1204	1339
200	1331	1352	1401	1250	1405	1347	1382	1241	1418	1304	1362	1208	1342
201	1334	1356	1405	1254	1409	1351	1386	1245	1423	1308	1365	1213	1346
202	1339	1360	1409	1258	1413	1356	1390	1250	1427	1311	1369	1217	1348
203	1339	1364	1413	1262	1417	1360	1394	1254	1432	1316	1373	1222	1352
204	1342	1368	1417	1266	1421	1364	1398	1257	1436	1319	1377	1226	1355
205	1345	1372	1421	1270	1426	1368	1402	1261	1440	1323	1380	1230	1358
206	1348	1376	1425	1273	1429	1372	1405	1265	1445	1327	1384	1234	1362
207	1352	1380	1429	1277	1434	1376	1410	1269	1449	1331	1388	1238	1366
208	1355	1384	1433	1280	1438	1380	1413	1273	1454	1335	1392	1243	1369
209	1358	1388	1437	1284	1442	1384	1418	1276	1458	1338	1395	1247	1373
210	1362	1391	1441	1287	1446	1388	1422	1280	1462	1342	1400	1251	1376
211	1365	1395	1445	1291	1450	1392	1426	1284	1466	1346	1404	1255	1380
212	1369	1399	1449	1294	1455	1396	1430	1287	1471	1350	1408	1259	1383
213	1373	1403	1453	1298	1459	1400	1434	1290	1475	1354	1412	1262	1387
214	1377	1407	1457	1301	1463	1403	1437	1293	1479	1357	1416	1266	1390
215	1381	1411	1461	1304	1467	1407	1442	1297	1483	1361	1420	1270	1394
216	1385	1414	1465	1307	1471	1411	1445	1300	1488	1365	1424	1273	1398
217	1389	1418	1469	1310	1476	1415	1449	1304	1492	1369	1428	1277	1402
218	1393	1422	1473	1313	1479	1419	1453	1307	1496	1373	1433	1280	1406
219	1397	1426	1477	1316	1484	1422	1457	1310	1500	1377	1437	1284	1410
220	1402	1430	1481	1320	1488	1426	1461	1313	1504	1381	1441	1287	1414
221	1408	1433	1485	1322	1492	1430	1465	1316	1508	1385	1445	1291	1418
222	1411	1437	1489	1325	1496	1433	1469	1319	1512	1388	1449	1294	1421
223	1415	1440	1492	1328	1500	1437	1473	1322	1516	1392	1453	1297	1425
224	1420	1444	1496	1331	1504	1440	1476	1325	1520	1395	1457	1300	1429
225	1424	1447	1500	1333	1508	1444	1480	1327	1524	1399	1461	1303	1432
226	1428	1450	1504	1335	1512	1447	1484	1330	1528	1402	1465	1306	1436
227	1432	1453	1507	1337	1516	1450	1487	1332	1531	1406	1469	1309	1440
228	1436	1457	1511	1339	1520	1454	1491	1335	1535	1409	1472	1312	1444
229	1441	1460	1515	1341	1524	1457	1495	1337	1539	1413	1476	1315	1447
230	1445	1463	1518	1343	1527	1460	1499	1339	1543	1416	1480	1318	1451
231	1449	1466	1522	1346	1531	1463	1502	1341	1547	1420	1484	1321	1455
232	1453	1470	1526	1349	1535	1467	1506	1343	1551	1424	1488	1324	1459
233	1457	1474	1530	1352	1539	1470	1510	1346	1554	1427	1492	1326	1463
234	1461	1477	1533	1355	1543	1474	1514	1349	1558	1431	1496	1329	1467
235	1465	1481	1537	1358	1547	1477	1517	1351	1562	1434	1499	1332	1470
236	1469	1484	1541	1362	1550	1481	1521	1355	1566	1437	1503	1335	1474
237	1473	1488	1544	1366	1554	1484	1524	1358	1570	1441	1507	1337	1478
238	1477	1492	1548	1369	1558	1488	1528	1361	1574	1443	1510	1339	1481
239	1481	1495	1551	1373	1562	1492	1532	1365	1578	1447	1514	1341	1485
240	1485	1499	1555	1377	1566	1495	1535	1368	1582	1450	1518	1343	1489
Max T	1485	1499	1555	1377	1566	1495	1535	1368	1582	1450	1518	1343	1489
Max A	1200	1000	1200	1200	1200	1000	1200	1200	1200	1000	1200	1200	1200

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Time (min)	P8A P8AMax (°F)	P8A AAAve (°F)	P8A Sec A-A TC #1 (°F)	P8A Sec A-A TC #2 (°F)	P8A Sec A-A TC #3 (°F)	P8A Sec A-A TC #4 (°F)	P8A Sec A-A TC #5 (°F)	P8A BBAve (°F)	P8A Sec B-B TC #6 (°F)	P8A Sec B-B TC #7 (°F)	P8A Sec B-B TC #8 (°F)	P8A CCAve (°F)
0	83	82	83	82	82	82	82	82	82	82	83	83
1	83	82	83	82	82	82	82	82	82	82	83	83
2	83	82	83	82	82	82	82	83	83	83	82	83
3	83	82	83	83	82	82	82	83	83	83	83	83
4	83	83	83	83	83	82	82	83	83	82	83	83
5	83	83	83	83	83	82	82	83	83	83	83	83
6	84	83	83	83	83	82	83	83	83	83	83	83
7	84	83	83	83	83	82	83	83	83	83	83	83
8	84	83	83	82	83	83	83	83	84	83	83	83
9	84	83	84	82	84	83	84	83	84	83	83	83
10	85	84	85	82	85	84	85	84	85	83	84	84
11	87	85	87	82	86	85	85	85	86	83	85	85
12	88	86	88	83	87	85	88	85	87	83	86	85
13	90	87	90	83	89	86	87	86	89	83	87	86
14	92	88	92	84	90	87	88	87	90	83	89	87
15	93	89	93	84	91	87	89	89	92	84	90	88
16	95	90	95	84	92	88	90	90	93	84	92	89
17	96	91	96	85	94	89	91	90	94	84	93	90
18	98	92	98	86	95	90	92	91	96	84	94	91
19	100	93	100	86	97	91	93	93	98	85	96	92
20	102	95	102	87	98	93	95	95	100	86	98	94
21	104	96	104	88	100	94	96	96	102	86	99	96
22	107	98	107	89	102	95	98	98	104	87	102	97
23	110	100	110	89	104	97	99	100	107	88	104	99
24	113	102	113	91	106	98	101	102	110	89	107	101
25	117	104	117	92	109	100	104	105	114	90	110	103
26	122	107	122	93	112	102	106	107	118	91	113	106
27	126	110	126	94	116	104	109	111	123	92	117	108
28	131	113	131	96	120	107	113	114	128	94	121	112
29	136	117	136	98	124	110	118	117	132	95	125	115
30	142	121	142	99	128	113	121	121	137	97	130	119
31	147	124	147	102	133	116	124	125	142	99	134	123
32	153	129	153	104	138	120	129	129	148	101	139	127
33	158	132	158	109	142	123	133	133	153	103	144	131
34	163	137	163	109	147	127	138	138	158	106	149	135
35	169	141	169	112	152	131	142	142	163	108	154	139
36	175	146	175	115	157	135	147	146	168	111	159	144
37	181	150	181	118	162	139	151	150	174	114	163	148
38	188	155	188	121	166	144	156	155	180	118	168	152
39	194	159	194	124	171	147	160	160	186	121	173	157
40	201	164	201	128	176	152	165	165	192	124	179	162
41	207	169	207	131	180	156	170	170	199	128	184	167
42	213	174	213	135	186	160	174	175	205	131	190	172
43	220	179	220	139	193	165	179	180	211	135	195	177
44	226	185	226	143	199	170	185	186	218	139	201	182
45	233	190	233	147	205	175	191	191	224	143	207	188
46	239	195	239	151	211	180	196	197	230	147	213	193
47	246	201	246	155	218	185	202	202	237	151	219	199
48	252	207	252	160	224	191	208	208	243	156	224	204
49	259	213	259	165	230	196	214	213	250	160	230	210
50	266	218	266	169	236	201	220	219	256	165	236	216
51	272	224	272	174	242	207	226	225	263	169	242	221
52	279	230	279	179	248	212	232	230	269	174	248	227
53	285	236	285	184	254	218	238	236	275	179	254	232
54	292	242	292	189	260	223	244	242	282	184	260	238
55	299	247	299	194	266	229	249	248	288	189	266	244
56	305	253	305	199	272	234	256	253	294	194	271	250
57	312	259	312	204	278	240	262	259	301	199	277	256
58	318	265	318	210	284	245	268	265	307	204	283	261
59	325	271	325	215	290	251	274	270	313	209	289	267
60	332	277	332	220	295	256	280	276	319	214	295	273
61	338	283	338	226	301	262	286	282	325	219	301	279
62	345	288	345	231	307	267	292	288	332	225	306	285
63	352	295	352	237	313	273	298	293	338	230	312	290

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Time (min)	P8A P8AMax (°F)	P8A AAAve (°F)	P8A Sec A-A TC #1 (°F)	P8A Sec A-A TC #2 (°F)	P8A Sec A-A TC #3 (°F)	P8A Sec A-A TC #4 (°F)	P8A Sec A-A TC #5 (°F)	P8A BBAve (°F)	P8A Sec B-B TC #6 (°F)	P8A Sec B-B TC #7 (°F)	P8A Sec B-B TC #8 (°F)	P8A CCAve (°F)
64	358	300	358	242	319	279	304	299	344	235	318	296
65	365	306	365	248	325	284	310	305	350	240	324	302
66	371	312	371	253	331	290	316	311	356	246	330	308
67	378	318	378	259	337	295	322	316	363	251	335	313
68	385	324	385	264	343	301	329	322	369	256	341	319
69	391	330	391	270	349	307	335	328	375	262	347	325
70	398	336	398	275	355	312	341	333	381	267	352	331
71	404	342	404	281	361	318	347	339	387	273	358	337
72	411	348	411	286	367	324	353	345	393	278	364	342
73	418	354	418	292	373	329	359	351	400	283	370	348
74	424	360	424	298	379	335	365	357	406	289	376	354
75	431	366	431	303	385	341	371	363	412	294	382	360
76	437	372	437	309	392	346	377	368	418	300	387	366
77	444	378	444	314	398	352	383	374	424	305	393	372
78	450	384	450	320	404	358	390	380	430	310	399	378
79	457	390	457	325	410	364	396	386	437	316	405	383
80	463	396	463	331	416	369	402	392	443	321	411	389
81	470	402	470	337	422	375	408	397	449	326	417	395
82	476	408	476	342	428	381	414	403	455	332	422	401
83	483	414	483	348	433	386	420	409	461	337	428	407
84	489	420	489	353	439	392	426	415	467	343	434	413
85	496	426	496	359	445	398	432	420	473	348	440	418
86	502	432	502	364	451	403	438	426	479	353	445	424
87	508	438	508	370	457	409	444	432	485	359	451	430
88	515	444	515	375	463	415	450	437	491	364	457	436
89	521	449	521	381	468	420	456	443	497	369	463	441
90	528	455	528	387	474	426	462	449	503	375	469	447
91	534	461	534	392	480	432	468	454	509	380	474	453
92	541	467	541	398	486	437	474	460	515	385	480	459
93	547	473	547	403	492	443	480	466	521	391	486	464
94	553	479	553	409	498	449	486	472	527	396	492	470
95	560	484	560	414	503	454	491	477	533	401	498	476
96	566	490	566	420	509	460	497	483	539	407	504	482
97	572	496	572	425	515	466	503	489	545	412	510	488
98	579	502	579	431	521	471	509	494	551	417	515	493
99	585	508	585	436	527	477	515	500	557	423	521	499
100	591	514	591	441	532	483	521	506	563	428	527	505
101	598	520	598	447	538	488	527	512	569	433	533	511
102	604	526	604	453	544	494	533	518	575	439	539	516
103	610	531	610	458	550	500	539	523	581	444	544	522
104	617	537	617	464	556	505	545	529	587	449	550	528
105	623	543	623	469	562	511	551	535	593	455	556	534
106	630	549	630	475	568	517	557	541	600	460	562	540
107	636	555	636	480	573	522	563	546	605	466	568	545
108	642	560	642	485	579	528	568	552	611	470	574	551
109	648	566	648	491	585	534	574	557	617	476	579	557
110	655	572	655	496	591	539	580	563	623	481	585	563
111	661	578	661	502	596	545	586	569	629	486	591	568
112	667	584	667	507	602	551	592	575	635	492	597	574
113	674	590	674	513	608	556	598	580	641	497	603	580
114	680	596	680	518	614	562	604	586	647	503	609	587
115	686	601	686	524	620	567	610	592	653	508	615	592
116	693	607	693	529	625	573	616	597	659	513	620	598
117	699	613	699	535	631	579	621	603	665	518	626	604
118	705	619	705	540	637	584	627	609	671	524	632	610
119	711	625	711	546	643	590	633	615	677	529	638	615
120	717	630	717	551	648	595	639	620	682	534	644	621
121	724	636	724	556	654	601	644	626	688	540	649	627
122	730	642	730	562	660	606	650	631	694	545	655	632
123	736	647	736	567	666	612	656	637	700	550	661	638
124	742	653	742	573	671	617	662	642	706	555	666	643
125	748	659	748	578	677	623	667	648	712	561	672	649
126	754	664	754	583	683	629	673	654	718	566	678	655
127	761	670	761	589	689	634	679	660	724	571	684	661

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Time (min)	P8A P8AMax (°F)	P8A AAAve (°F)	P8A Sec A-A TC #1 (°F)	P8A Sec A-A TC #2 (°F)	P8A Sec A-A TC #3 (°F)	P8A Sec A-A TC #4 (°F)	P8A Sec A-A TC #5 (°F)	P8A BBAve (°F)	P8A Sec B-B TC #6 (°F)	P8A Sec B-B TC #7 (°F)	P8A Sec B-B TC #8 (°F)	P8A CCAve (°F)
128	787	676	767	594	694	640	685	685	730	576	689	687
129	773	682	773	600	700	646	691	671	735	582	695	672
130	779	688	779	605	706	651	697	676	741	587	701	679
131	785	693	785	610	712	656	702	682	747	592	707	685
132	791	699	791	616	717	662	708	688	753	597	713	690
133	797	704	797	621	723	667	713	693	759	602	718	695
134	803	710	803	629	729	673	719	699	765	608	724	701
135	810	716	810	632	735	679	725	705	771	613	730	707
136	816	722	816	638	740	684	731	710	777	618	736	714
137	822	728	822	643	746	690	737	716	783	624	742	720
138	829	734	829	649	752	695	743	722	789	629	748	726
139	835	740	835	655	758	701	749	728	796	634	754	733
140	841	745	841	660	764	707	755	734	802	640	760	739
141	847	751	847	666	769	712	761	740	808	645	766	746
142	853	757	853	672	775	718	767	746	814	651	772	752
143	859	763	859	678	781	724	772	751	820	656	778	758
144	865	769	865	683	787	730	778	757	826	661	784	764
145	871	774	871	689	793	735	784	763	832	667	790	770
146	877	780	877	695	798	741	790	769	838	672	796	776
147	883	786	883	700	804	746	796	775	844	678	802	782
148	889	791	889	706	809	752	801	780	849	683	807	788
149	895	797	895	711	815	757	807	786	855	689	814	795
150	901	803	901	717	821	763	812	791	861	694	819	800
151	906	808	906	723	826	768	818	797	867	699	825	807
152	912	814	912	728	831	774	824	803	873	704	831	812
153	918	819	918	734	837	779	829	809	879	710	837	818
154	923	825	923	739	843	785	835	814	884	715	842	824
155	929	830	929	745	848	790	840	820	890	721	848	830
156	935	836	935	750	853	796	846	825	896	726	854	836
157	940	841	940	756	859	801	851	830	901	731	859	842
158	946	847	946	761	864	806	857	836	907	737	865	848
159	951	852	951	767	870	812	862	842	912	742	871	854
160	957	858	957	772	875	817	867	847	918	747	876	860
161	962	863	962	778	880	823	873	853	923	753	882	866
162	968	869	968	783	886	828	878	858	929	758	888	872
163	974	874	974	789	891	833	884	864	935	763	894	878
164	980	880	980	795	897	839	889	870	941	769	899	884
165	985	885	985	800	902	844	894	875	948	774	905	890
166	990	890	990	805	907	849	899	880	951	779	910	895
167	995	896	995	811	913	855	905	886	957	784	916	901
168	1001	901	1001	816	918	860	910	891	962	790	921	906
169	1006	906	1006	821	923	865	915	896	967	795	926	912
170	1011	911	1011	826	928	870	920	901	972	800	932	917
171	1017	917	1017	832	934	876	926	907	978	806	938	924
172	1023	922	1023	838	939	881	931	913	984	811	944	931
173	1029	929	1029	845	945	887	937	919	991	817	950	938
174	1035	934	1035	850	950	892	943	925	998	823	956	944
175	1040	930	1040	855	955	898	948	930	1002	828	961	950
176	1045	945	1045	862	961	903	953	936	1007	833	967	956
177	1051	950	1051	867	966	908	959	941	1013	839	972	962
178	1056	955	1056	872	971	913	964	946	1018	844	977	967
179	1062	960	1061	878	976	918	969	952	1023	849	983	973
180	1068	965	1066	883	981	923	974	957	1029	854	988	978
181	1071	970	1071	888	986	928	979	962	1034	860	993	984
182	1077	975	1076	893	991	933	984	968	1039	865	999	988
183	1082	981	1081	899	996	939	989	972	1044	870	1003	995
184	1090	986	1086	905	1001	944	994	978	1050	876	1009	1001
185	1093	991	1091	909	1006	949	999	983	1054	880	1014	1006
186	1099	996	1096	915	1011	954	1004	988	1059	886	1020	1011
187	1106	1001	1102	921	1016	959	1009	994	1065	892	1025	1016
188	1113	1007	1107	927	1021	964	1015	1000	1071	897	1031	1025
189	1119	1012	1113	933	1026	970	1020	1005	1077	903	1036	1031
190	1122	1017	1117	938	1031	974	1025	1010	1081	908	1041	1035
191	1126	1022	1122	942	1036	979	1030	1015	1086	913	1045	1040

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Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

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Time (min)	P8A P8AMax (°F)	P8A AAAve (°F)	P8A Sec A-A TC #1 (°F)	P8A Sec A-A TC #2 (°F)	P8A Sec A-A TC #3 (°F)	P8A Sec A-A TC #4 (°F)	P8A Sec A-A TC #5 (°F)	P8A BBAve (°F)	P8A Sec B-B TC #6 (°F)	P8A Sec B-B TC #7 (°F)	P8A Sec B-B TC #8 (°F)	P8A CCAve (°F)
192	1133	1027	1127	948	1041	984	1035	1020	1092	918	1051	1046
193	1143	1033	1133	956	1046	990	1041	1026	1098	924	1057	1055
194	1145	1038	1138	960	1051	995	1045	1031	1103	929	1062	1058
195	1150	1043	1143	965	1056	1000	1050	1037	1108	935	1067	1064
196	1158	1048	1148	971	1061	1005	1055	1042	1113	940	1072	1070
197	1161	1052	1152	976	1065	1009	1060	1047	1118	945	1077	1074
198	1169	1058	1157	982	1070	1014	1065	1052	1123	950	1083	1081
199	1174	1063	1163	988	1075	1020	1071	1058	1129	956	1088	1087
200	1180	1068	1167	993	1080	1025	1075	1063	1134	961	1093	1093
201	1184	1073	1172	998	1084	1029	1080	1067	1138	966	1097	1097
202	1188	1077	1176	1003	1089	1034	1084	1072	1143	971	1101	1102
203	1191	1081	1180	1007	1093	1038	1089	1076	1147	976	1106	1106
204	1199	1087	1185	1014	1098	1044	1094	1082	1153	982	1111	1113
205	1200	1091	1188	1018	1102	1047	1098	1086	1157	986	1114	1115
206	1208	1096	1194	1024	1107	1053	1103	1091	1162	992	1120	1122
207	1209	1100	1197	1028	1112	1057	1107	1095	1166	996	1124	1126
208	1217	1105	1202	1034	1116	1062	1112	1101	1172	1002	1129	1132
209	1220	1110	1206	1039	1121	1066	1117	1105	1176	1007	1133	1136
210	1226	1114	1211	1044	1125	1071	1121	1110	1181	1012	1137	1142
211	1233	1120	1216	1050	1130	1076	1127	1115	1188	1017	1142	1148
212	1236	1124	1220	1055	1134	1081	1131	1120	1190	1022	1147	1152
213	1242	1129	1225	1060	1139	1085	1136	1125	1195	1027	1151	1156
214	1246	1133	1229	1065	1143	1090	1140	1129	1200	1032	1156	1162
215	1252	1138	1233	1071	1148	1095	1145	1134	1206	1037	1160	1168
216	1256	1143	1238	1076	1152	1099	1149	1138	1209	1042	1164	1172
217	1259	1147	1241	1080	1156	1103	1153	1143	1213	1047	1168	1176
218	1264	1151	1245	1085	1160	1107	1157	1147	1218	1051	1172	1181
219	1269	1156	1250	1090	1164	1112	1162	1152	1223	1056	1177	1186
220	1272	1160	1253	1094	1169	1117	1166	1156	1227	1061	1180	1190
221	1273	1163	1255	1097	1173	1121	1169	1159	1230	1065	1183	1192
222	1273	1166	1257	1099	1176	1125	1172	1162	1232	1069	1186	1193
223	1277	1170	1261	1103	1180	1129	1176	1166	1236	1073	1190	1197
224	1281	1174	1264	1108	1184	1132	1180	1170	1239	1077	1193	1201
225	1283	1177	1267	1111	1187	1136	1184	1174	1242	1082	1197	1204
226	1287	1181	1271	1116	1191	1140	1187	1177	1245	1086	1200	1208
227	1292	1185	1275	1121	1195	1144	1192	1182	1250	1091	1204	1213
228	1295	1190	1279	1126	1199	1148	1196	1186	1254	1095	1208	1217
229	1299	1193	1282	1129	1203	1152	1199	1190	1258	1100	1212	1221
230	1302	1197	1285	1134	1206	1156	1203	1194	1262	1104	1215	1225
231	1304	1200	1288	1137	1210	1160	1207	1197	1264	1108	1219	1227
232	1307	1204	1291	1141	1214	1164	1210	1200	1267	1112	1222	1231
233	1308	1207	1293	1143	1217	1168	1213	1204	1270	1117	1226	1233
234	1311	1210	1296	1147	1221	1171	1216	1207	1273	1120	1229	1236
235	1315	1214	1300	1151	1224	1175	1220	1211	1277	1125	1232	1240
236	1317	1218	1302	1155	1228	1179	1224	1215	1280	1129	1236	1243
237	1322	1222	1306	1160	1232	1183	1228	1219	1285	1133	1240	1248
238	1324	1225	1309	1163	1235	1186	1231	1223	1288	1137	1243	1251
239	1327	1228	1312	1167	1239	1190	1234	1227	1291	1142	1247	1255
240	1331	1232	1316	1171	1242	1194	1238	1230	1294	1146	1250	1258
Max T	1331	1232	1316	1171	1242	1194	1238	1230	1294	1146	1250	1258
Max A	1200	1000	1200	1200	1200	1200	1200	1000	1200	1200	1200	1000

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Time (min)	P8A Sec C-C TC #9 (°F)	P8A Sec C-C TC #10 (°F)	P8A Sec C-C TC #11 (°F)	P8A DDAve (°F)	P8A Sec D-D TC #12 (°F)	P8A Sec D-D TC #13 (°F)	P8A Sec D-D TC #14 (°F)	P8B P8BMax	P8B AAAve	P8B Sec A-A TC #1 (°F)	P8B Sec A-A TC #2 (°F)	P8B Sec A-A TC #3 (°F)
0	83	83	82	82	82	82	82	83	82	83	83	82
1	83	83	82	82	82	82	82	83	82	83	83	82
2	83	83	83	83	83	82	83	83	82	83	83	82
3	83	83	82	82	82	82	83	84	82	83	83	82
4	83	83	82	82	82	82	82	84	82	83	83	82
5	83	83	82	82	82	82	83	84	82	82	82	82
6	83	84	83	83	83	82	83	84	83	83	82	82
7	83	84	83	82	82	82	83	85	83	83	82	82
8	83	83	83	82	82	82	83	86	84	84	83	83
9	84	83	83	83	83	82	83	87	84	85	83	83
10	85	83	84	83	83	82	84	88	85	86	83	84
11	86	83	85	83	84	82	84	89	86	88	83	85
12	87	83	86	84	85	82	86	90	87	90	84	86
13	88	84	87	85	86	82	87	92	88	92	84	88
14	89	84	88	86	87	82	88	93	89	93	84	89
15	91	84	89	87	88	83	89	96	91	96	85	91
16	92	84	91	88	90	83	90	98	92	98	86	92
17	93	85	92	89	91	84	92	100	94	100	86	94
18	94	85	94	90	92	84	93	102	95	102	87	96
19	96	86	95	91	94	84	94	105	97	105	88	98
20	98	86	97	92	95	85	96	108	99	108	89	100
21	100	87	98	93	97	85	97	110	101	110	90	103
22	102	88	100	95	99	86	99	113	104	113	92	106
23	105	89	102	97	102	87	101	116	106	116	93	109
24	108	89	105	98	104	87	103	119	109	119	94	113
25	111	90	107	100	107	88	106	123	112	123	96	117
26	115	91	111	103	111	89	109	127	115	127	97	122
27	119	92	114	106	115	90	112	132	119	132	99	128
28	124	94	118	109	119	92	116	137	122	137	101	133
29	129	95	122	112	123	93	120	142	126	142	103	139
30	134	97	126	115	128	94	124	147	130	147	105	144
31	139	98	131	119	133	96	128	152	134	152	108	149
32	144	100	136	123	138	98	133	156	138	156	110	155
33	150	102	140	127	143	100	137	160	142	160	113	160
34	155	105	145	131	149	103	142	166	147	165	116	166
35	160	107	150	135	154	105	147	172	151	170	119	172
36	166	110	155	140	159	108	152	178	156	175	122	178
37	171	113	159	144	165	111	157	182	161	180	125	182
38	177	116	164	149	171	113	162	190	165	182	130	190
39	183	119	168	153	176	116	166	197	171	188	135	197
40	189	122	174	158	182	120	171	204	177	197	136	204
41	196	126	179	163	188	123	177	210	182	205	141	210
42	202	129	184	168	194	127	182	217	188	212	145	217
43	209	133	190	173	201	131	188	224	194	219	149	224
44	215	137	195	178	207	134	193	230	199	226	153	230
45	222	141	201	183	213	138	199	237	217	233	bad/lc	237
46	228	145	207	188	219	142	204	243	224	240	bad/lc	243
47	235	149	213	194	225	147	210	250	229	246	bad/lc	250
48	242	153	218	199	232	151	215	256	238	253	bad/lc	256
49	248	158	224	205	238	156	221	263	242	260	bad/lc	263
50	255	163	230	210	244	160	227	269	248	267	bad/lc	269
51	261	167	236	216	250	165	232	276	254	274	bad/lc	276
52	268	172	241	221	256	169	238	283	261	280	bad/lc	283
53	274	176	247	227	262	174	244	289	267	287	bad/lc	289
54	281	181	253	232	268	178	249	296	273	294	bad/lc	296
55	287	186	259	237	274	183	255	302	279	300	bad/lc	302
56	294	191	264	243	280	188	260	309	286	307	bad/lc	309
57	301	196	270	248	286	193	266	315	292	314	bad/lc	315
58	307	201	276	254	292	198	272	322	298	320	bad/lc	322
59	313	206	282	260	298	203	278	329	304	327	bad/lc	329
60	320	211	287	265	304	208	283	335	311	334	bad/lc	335
61	326	217	293	271	310	213	289	341	317	341	bad/lc	341
62	333	222	299	276	316	218	294	348	323	347	bad/lc	348
63	339	227	305	282	322	223	300	355	329	354	bad/lc	355

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Time (min)	P8A Sec C-C TC #9 (°F)	P8A Sec C-C TC #10 (°F)	P8A Sec C-C TC #11 (°F)	P8A DDAve (°F)	P8A Sec D-D TC #12 (°F)	P8A Sec D-D TC #13 (°F)	P8A Sec D-D TC #14 (°F)	P8B P8BMax	P8B AAAve	P8B Sec A-A TC #1 (°F)	P8B Sec A-A TC #2 (°F)	P8B Sec A-A TC #3 (°F)
64	345	232	310	287	328	228	305	381	335	380	bad/tc	381
65	352	237	316	293	334	233	311	388	342	387	bad/tc	388
66	358	243	322	298	340	238	317	374	348	374	bad/tc	374
67	364	248	327	304	346	243	322	381	355	381	bad/tc	381
68	371	253	333	309	351	248	328	388	362	388	bad/tc	388
69	377	258	339	314	357	253	333	395	368	394	bad/tc	395
70	384	264	345	321	364	259	339	401	374	401	bad/tc	401
71	390	269	351	326	370	264	345	408	381	408	bad/tc	408
72	397	274	356	331	375	269	350	415	387	415	bad/tc	415
73	403	280	362	337	382	274	356	421	393	421	bad/tc	421
74	409	285	368	343	388	280	362	428	400	428	bad/tc	428
75	416	291	374	349	394	285	368	435	406	435	bad/tc	435
76	422	296	380	354	400	290	373	441	412	441	bad/tc	441
77	429	301	385	360	406	296	379	448	419	448	bad/tc	448
78	435	307	391	366	412	301	385	455	426	455	bad/tc	454
79	441	312	397	372	418	306	391	462	432	462	bad/tc	461
80	448	317	403	377	424	311	397	468	438	468	bad/tc	468
81	454	323	408	383	430	316	402	475	445	475	bad/tc	474
82	460	328	414	389	436	322	408	482	452	482	bad/tc	481
83	467	333	420	394	442	327	414	488	458	488	bad/tc	487
84	473	339	426	400	448	332	420	495	464	495	bad/tc	494
85	479	344	431	406	454	338	426	501	471	501	bad/tc	501
86	486	350	437	411	460	343	431	508	477	508	bad/tc	507
87	492	355	443	417	466	348	437	515	483	515	bad/tc	514
88	498	360	449	423	472	354	443	521	490	521	bad/tc	520
89	504	366	454	429	478	359	449	527	496	527	bad/tc	527
90	510	371	460	434	484	364	454	534	502	534	bad/tc	533
91	516	376	466	440	490	370	460	541	509	541	bad/tc	540
92	523	382	471	446	496	375	466	547	515	547	bad/tc	546
93	529	387	477	451	502	380	472	554	521	554	bad/tc	553
94	535	393	483	457	508	386	478	560	527	560	bad/tc	559
95	541	398	489	463	514	391	483	567	534	567	bad/tc	566
96	548	403	494	468	520	396	489	573	541	573	bad/tc	573
97	554	409	500	474	526	402	495	580	547	580	bad/tc	579
98	560	414	506	480	532	407	501	586	553	586	bad/tc	586
99	566	420	511	486	538	412	507	593	560	593	bad/tc	592
100	572	425	517	492	544	418	513	599	566	599	bad/tc	599
101	579	430	523	497	550	423	519	606	572	606	bad/tc	606
102	585	436	529	504	557	429	525	612	579	612	bad/tc	612
103	591	441	534	509	563	434	531	618	585	618	bad/tc	618
104	597	447	540	515	569	439	536	625	591	625	bad/tc	625
105	604	452	546	521	575	445	543	632	598	631	bad/tc	632
106	610	458	552	527	582	451	549	638	604	638	bad/tc	638
107	616	463	557	533	588	457	555	645	610	644	bad/tc	645
108	622	468	563	538	594	461	560	651	617	651	bad/tc	651
109	628	474	569	544	599	467	566	658	623	657	bad/tc	658
110	634	479	575	550	606	473	572	664	629	664	bad/tc	664
111	640	484	580	556	612	478	578	670	635	670	bad/tc	670
112	647	490	586	562	618	483	584	677	641	676	bad/tc	677
113	653	496	592	568	625	489	590	683	647	682	bad/tc	683
114	660	502	598	574	631	495	596	690	654	689	bad/tc	690
115	666	507	603	580	637	501	602	696	660	695	bad/tc	696
116	672	513	609	586	643	506	608	702	666	701	bad/tc	702
117	678	518	615	591	649	511	613	709	673	708	bad/tc	709
118	684	524	621	597	655	517	620	715	679	714	bad/tc	715
119	690	529	626	603	661	523	625	721	685	720	bad/tc	721
120	696	534	632	609	667	528	631	728	691	726	bad/tc	728
121	702	540	638	614	673	533	637	734	697	732	bad/tc	734
122	708	545	643	620	679	539	643	740	703	739	bad/tc	740
123	714	550	649	626	685	544	648	746	709	745	bad/tc	746
124	720	555	654	631	691	549	654	753	716	751	bad/tc	753
125	726	560	660	637	696	554	660	759	722	757	bad/tc	759
126	733	567	666	643	703	561	666	765	728	763	bad/tc	765
127	739	573	672	650	710	567	672	771	734	769	bad/tc	771

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Time (min)	P8A Sec C-C TC #9 (°F)	P8A Sec C-C TC #10 (°F)	P8A Sec C-C TC #11 (°F)	P8A DDAve (°F)	P8A Sec D-D TC #12 (°F)	P8A Sec D-D TC #13 (°F)	P8A Sec D-D TC #14 (°F)	P8B P8BMax	P8B AAAve	P8B Sec A-A TC #1 (°F)	P8B Sec A-A TC #2 (°F)	P8B Sec A-A TC #3 (°F)
128	745	578	677	655	716	572	678	778	740	775	bad/tc	778
129	751	583	683	661	722	577	684	784	746	781	bad/tc	784
130	758	589	689	667	728	583	690	790	752	787	bad/tc	790
131	764	595	695	673	734	588	696	796	758	793	bad/tc	796
132	769	600	700	678	740	593	701	802	764	799	bad/tc	802
133	775	604	705	684	746	598	707	808	769	805	bad/tc	808
134	782	610	712	690	752	604	713	814	775	811	bad/tc	814
135	788	616	718	696	759	610	719	820	781	817	bad/tc	820
136	795	622	724	703	766	617	726	826	787	823	bad/tc	826
137	802	629	730	709	773	623	732	832	793	828	bad/tc	832
138	808	635	736	716	780	629	738	838	799	834	bad/tc	838
139	815	641	742	722	786	635	745	844	804	840	bad/tc	844
140	822	647	748	729	793	642	751	850	810	845	bad/tc	850
141	829	654	754	736	801	649	758	856	816	851	bad/tc	856
142	835	660	760	742	807	655	764	861	822	857	bad/tc	861
143	841	666	766	748	814	661	770	867	827	862	bad/tc	867
144	848	672	772	755	821	667	777	873	833	868	bad/tc	873
145	854	678	778	761	827	673	783	879	839	873	bad/tc	879
146	860	684	784	767	833	679	789	884	844	878	bad/tc	884
147	867	690	790	774	840	686	796	890	850	884	bad/tc	890
148	873	696	795	780	846	692	802	896	855	890	bad/tc	896
149	880	703	801	786	853	698	808	901	861	895	bad/tc	901
150	885	709	807	792	859	704	814	907	866	900	bad/tc	907
151	892	715	813	798	865	710	820	912	871	905	bad/tc	912
152	898	721	818	805	872	716	826	918	877	910	bad/tc	918
153	904	727	824	811	878	722	833	923	882	916	bad/tc	923
154	910	733	830	817	884	728	838	929	888	921	bad/tc	929
155	916	739	836	823	891	734	844	934	893	926	bad/tc	934
156	922	745	841	829	897	740	851	939	898	931	bad/tc	939
157	928	751	847	835	903	746	857	945	904	936	bad/tc	945
158	934	757	853	842	910	753	863	950	909	942	bad/tc	950
159	940	763	858	848	916	758	869	956	914	947	bad/tc	956
160	946	769	864	854	922	764	875	961	919	952	bad/tc	961
161	952	775	870	860	928	771	881	966	925	957	bad/tc	966
162	958	781	876	865	933	776	886	972	930	962	bad/tc	972
163	965	787	882	872	941	783	893	977	935	967	bad/tc	977
164	971	794	888	879	947	790	900	982	940	972	bad/tc	982
165	977	800	893	885	953	796	905	988	946	978	bad/tc	988
166	982	805	898	889	958	800	910	993	951	982	bad/tc	993
167	988	811	904	896	965	807	917	998	956	988	bad/tc	998
168	993	817	909	902	970	813	922	1003	961	992	bad/tc	1003
169	998	822	915	907	976	818	928	1009	966	997	bad/tc	1009
170	1004	827	920	912	981	823	933	1014	972	1003	bad/tc	1014
171	1012	834	927	919	988	830	940	1019	976	1007	bad/tc	1019
172	1018	841	933	927	995	838	947	1024	982	1013	bad/tc	1024
173	1026	849	939	934	1003	845	954	1029	987	1017	bad/tc	1029
174	1032	855	945	941	1010	852	960	1034	992	1022	bad/tc	1034
175	1038	862	950	947	1017	859	966	1030	997	1027	bad/tc	1039
176	1045	868	956	953	1023	865	972	1044	1002	1032	bad/tc	1044
177	1050	875	962	960	1029	872	978	1049	1007	1037	bad/tc	1049
178	1055	880	967	965	1035	878	983	1054	1011	1041	bad/tc	1054
179	1062	886	972	971	1040	883	989	1059	1016	1046	bad/tc	1059
180	1068	892	977	976	1046	889	994	1064	1021	1051	bad/tc	1064
181	1071	898	983	982	1051	895	1000	1069	1026	1056	bad/tc	1069
182	1077	903	988	987	1058	900	1005	1074	1031	1061	bad/tc	1074
183	1082	909	993	993	1063	906	1011	1079	1036	1065	bad/tc	1079
184	1090	915	999	999	1069	912	1017	1084	1041	1070	bad/tc	1084
185	1093	920	1004	1005	1074	918	1022	1088	1046	1075	bad/tc	1088
186	1099	926	1009	1010	1079	923	1027	1093	1051	1079	bad/tc	1093
187	1108	933	1015	1017	1089	931	1034	1098	1055	1084	bad/tc	1098
188	1113	941	1021	1024	1093	938	1040	1103	1060	1089	bad/tc	1103
189	1119	947	1027	1030	1100	945	1046	1108	1065	1093	bad/tc	1108
190	1122	952	1031	1035	1104	950	1051	1112	1070	1098	bad/tc	1112
191	1126	957	1036	1040	1109	955	1055	1117	1075	1103	bad/tc	1117

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Time (min)	P8A Sec C-C TC #9 (°F)	P8A Sec C-C TC #10 (°F)	P8A Sec C-C TC #11 (°F)	P8A DDAve (°F)	P8A Sec D-D TC #12 (°F)	P8A Sec D-D TC #13 (°F)	P8A Sec D-D TC #14 (°F)	P8B P8BMax	P8B AAAve	P8B Sec A-A TC #1 (°F)	P8B Sec A-A TC #2 (°F)	P8B Sec A-A TC #3 (°F)
192	1133	984	1042	1046	1115	981	1062	1122	1079	1107	bad/tc	1122
193	1143	972	1049	1055	1124	970	1070	1127	1084	1112	bad/tc	1127
194	1145	977	1053	1060	1129	976	1074	1131	1089	1116	bad/tc	1131
195	1150	983	1058	1065	1134	981	1079	1136	1093	1121	bad/tc	1136
196	1156	989	1064	1070	1140	987	1084	1141	1099	1126	bad/tc	1141
197	1161	994	1068	1075	1144	992	1089	1145	1103	1130	bad/tc	1145
198	1169	1001	1074	1082	1151	999	1095	1150	1108	1135	bad/tc	1150
199	1174	1008	1080	1089	1158	1006	1102	1154	1112	1139	bad/tc	1154
200	1180	1014	1085	1094	1164	1012	1108	1159	1117	1144	bad/tc	1159
201	1184	1019	1089	1098	1168	1016	1110	1163	1121	1148	bad/tc	1163
202	1188	1023	1094	1103	1173	1021	1115	1167	1126	1153	bad/tc	1167
203	1191	1028	1098	1107	1177	1026	1119	1172	1130	1157	bad/tc	1172
204	1199	1035	1105	1114	1184	1033	1125	1176	1135	1161	bad/tc	1176
205	1203	1038	1108	1117	1187	1036	1128	1181	1139	1166	bad/tc	1181
206	1208	1045	1114	1124	1194	1043	1134	1185	1144	1170	bad/tc	1185
207	1209	1049	1118	1127	1196	1047	1137	1189	1148	1174	bad/tc	1189
208	1217	1056	1123	1133	1203	1054	1143	1193	1152	1179	bad/tc	1193
209	1220	1061	1128	1138	1208	1058	1147	1198	1157	1183	bad/tc	1198
210	1228	1068	1133	1143	1213	1063	1152	1202	1161	1187	bad/tc	1202
211	1233	1072	1139	1150	1220	1071	1159	1206	1165	1191	bad/tc	1206
212	1238	1078	1143	1155	1225	1076	1163	1210	1170	1196	bad/tc	1210
213	1242	1084	1148	1160	1230	1082	1168	1214	1174	1200	bad/tc	1214
214	1245	1088	1153	1165	1235	1087	1172	1219	1179	1204	bad/tc	1219
215	1252	1094	1158	1171	1241	1093	1178	1222	1182	1208	bad/tc	1222
216	1256	1099	1162	1175	1245	1096	1182	1226	1187	1213	bad/tc	1226
217	1259	1104	1166	1179	1249	1102	1185	1230	1191	1217	bad/tc	1230
218	1264	1108	1171	1183	1253	1107	1190	1235	1195	1221	bad/tc	1235
219	1269	1114	1175	1189	1259	1113	1195	1238	1199	1225	bad/tc	1238
220	1272	1117	1180	1194	1263	1117	1201	1242	1203	1229	bad/tc	1242
221	1273	1120	1183	1197	1266	1120	1204	1246	1207	1233	bad/tc	1246
222	1273	1120	1188	1198	1269	1121	1207	1250	1211	1237	bad/tc	1250
223	1277	1125	1190	1202	1270	1125	1210	1254	1216	1241	bad/tc	1254
224	1281	1129	1194	1205	1273	1129	1214	1256	1220	1245	bad/tc	1256
225	1283	1132	1197	1209	1276	1133	1217	1261	1223	1248	bad/tc	1261
226	1287	1136	1201	1212	1279	1136	1220	1265	1227	1252	bad/tc	1265
227	1292	1142	1205	1216	1284	1141	1224	1269	1231	1256	bad/tc	1269
228	1296	1147	1209	1221	1288	1147	1228	1273	1235	1260	bad/tc	1273
229	1299	1150	1213	1224	1291	1150	1232	1276	1239	1264	bad/tc	1276
230	1302	1155	1217	1229	1295	1155	1236	1280	1243	1267	bad/tc	1280
231	1304	1158	1220	1231	1297	1158	1239	1283	1247	1271	bad/tc	1283
232	1307	1161	1224	1234	1300	1161	1242	1287	1251	1275	bad/tc	1287
233	1308	1163	1227	1237	1301	1163	1246	1290	1254	1278	bad/tc	1290
234	1311	1167	1231	1239	1304	1166	1248	1294	1258	1282	bad/tc	1294
235	1315	1171	1235	1244	1308	1171	1252	1297	1261	1286	bad/tc	1297
236	1317	1174	1238	1247	1311	1174	1256	1301	1265	1289	bad/tc	1301
237	1322	1180	1242	1252	1316	1180	1260	1305	1269	1293	bad/tc	1305
238	1324	1183	1246	1255	1318	1183	1263	1308	1272	1296	bad/tc	1308
239	1327	1187	1250	1258	1321	1186	1267	1311	1276	1300	bad/tc	1311
240	1331	1191	1253	1262	1325	1190	1270	1315	1280	1304	bad/tc	1315
Max T	1331	1191	1253	1262	1325	1190	1270	1315	1280	1304	bad/tc	1315
Max A	1200	1200	1200	1000	1200	1200	1200	1200	1000	1200	1200	1200

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Time (min)	P8B Sec A-A TC #4 (°F)	P8B Sec A-A TC #5 (°F)	P8B BBAve	P8B Sec B-B TC #6 (°F)	P8B Sec B-B TC #7 (°F)	P8B Sec B-B TC #8 (°F)	P8B CCAve	P8B Sec C-C TC #9 (°F)	P8B Sec C-C TC #10 (°F)	P8B Sec C-C TC #11 (°F)	P8B DDAve	P8B Sec D-D TC #12 (°F)	P8B Sec D-D TC #13 (°F)
0	82	82	82	82	82	82	83	82	83	83	82	83	82
1	82	82	82	82	82	82	83	82	83	83	82	83	82
2	82	82	82	82	82	82	83	83	83	83	82	83	82
3	82	82	82	82	82	82	83	83	83	83	83	84	82
4	82	82	82	82	82	82	83	83	83	83	83	84	82
5	82	83	82	81	82	82	83	82	83	83	82	84	81
6	82	84	82	81	82	82	83	81	84	83	82	84	81
7	82	85	81	80	82	82	83	81	84	83	82	84	81
8	83	86	82	81	82	83	83	82	85	83	82	85	82
9	83	87	82	81	82	83	84	83	85	84	83	85	82
10	84	88	83	82	82	84	84	84	85	84	83	86	81
11	84	89	83	83	82	84	85	85	85	85	83	86	82
12	85	90	84	84	82	86	86	86	86	86	84	87	82
13	86	91	85	86	82	87	87	87	86	87	85	89	82
14	87	93	86	87	82	88	87	88	86	88	86	90	82
15	88	94	86	88	82	89	88	90	86	89	87	92	82
16	89	96	88	90	82	91	90	92	87	91	88	94	82
17	91	98	89	91	83	93	91	93	87	92	89	95	83
18	92	100	90	93	83	95	92	95	88	93	90	97	83
19	94	102	92	94	84	97	93	96	89	95	92	98	84
20	96	104	93	96	84	98	94	98	89	96	93	100	84
21	98	106	95	98	85	101	96	100	90	98	94	102	85
22	100	108	96	100	86	103	98	102	91	100	96	104	86
23	103	110	98	102	87	106	100	105	92	102	97	106	86
24	105	112	100	105	87	109	102	108	92	105	99	109	87
25	108	114	103	108	89	113	104	111	93	108	102	112	88
26	111	117	106	112	90	116	106	114	94	111	104	115	89
27	115	120	109	116	91	121	109	118	95	115	107	119	90
28	118	123	113	121	92	126	113	122	97	119	110	123	91
29	122	126	117	126	94	131	116	126	98	123	113	128	92
30	126	129	121	131	96	136	119	131	99	127	117	133	94
31	130	133	125	137	98	141	123	136	101	132	120	138	95
32	134	137	129	142	100	146	127	141	103	137	124	143	97
33	139	140	133	146	103	150	131	146	105	141	129	149	99
34	143	144	137	150	105	155	135	151	107	146	133	154	101
35	148	148	141	154	108	161	139	156	109	151	138	160	104
36	153	153	145	159	111	166	143	161	112	156	141	165	106
37	159	158	150	165	114	172	148	167	115	161	147	171	110
38	163	162	155	170	117	177	152	172	118	165	151	177	112
39	169	167	160	175	120	184	156	178	121	170	155	183	116
40	174	172	165	181	124	189	162	185	124	176	160	190	119
41	179	177	170	187	127	196	167	191	127	182	165	197	122
42	184	182	175	194	131	201	172	198	131	188	171	204	126
43	190	188	181	201	135	208	178	204	134	195	176	210	130
44	195	193	187	207	139	214	183	211	138	201	182	217	134
45	201	198	192	214	143	220	189	217	142	207	187	223	138
46	207	204	199	221	148	227	194	224	146	213	193	230	142
47	212	209	204	227	152	233	200	230	150	219	199	237	146
48	218	215	210	234	157	239	206	237	155	225	204	243	150
49	224	221	216	240	162	246	211	243	159	231	210	249	155
50	230	226	222	247	167	252	217	250	164	238	216	256	159
51	235	232	228	254	172	259	223	256	169	244	222	262	164
52	241	238	234	260	177	265	229	263	174	250	227	268	169
53	247	244	240	267	182	272	235	269	179	256	233	275	173
54	253	249	246	273	188	278	240	275	184	262	239	281	178
55	259	255	253	280	193	285	246	282	189	268	245	287	183
56	265	261	259	286	198	292	252	288	194	274	250	293	188
57	271	267	265	293	204	298	258	295	199	280	256	299	193
58	277	273	271	299	209	305	264	301	204	287	262	305	198
59	282	279	277	306	215	311	270	307	210	293	267	311	203
60	288	285	283	312	220	318	276	314	215	299	273	317	208
61	294	290	290	319	226	324	282	320	220	305	279	323	213
62	301	297	296	325	231	331	288	327	226	311	285	330	219
63	306	302	302	332	237	337	294	333	231	317	291	336	224

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Time (min)	P8B Sec A-A TC #4 (°F)	P8B Sec A-A TC #5 (°F)	P8B BBAve	P8B Sec B-B TC #6 (°F)	P8B Sec B-B TC #7 (°F)	P8B Sec B-B TC #8 (°F)	P8B CCAve	P8B Sec C-C TC #9 (°F)	P8B Sec C-C TC #10 (°F)	P8B Sec C-C TC #11 (°F)	P8B DDAve	P8B Sec D-D TC #12 (°F)	P8B Sec D-D TC #13 (°F)
64	312	308	308	338	242	344	299	339	236	323	296	342	229
65	319	314	315	345	248	351	306	346	242	330	302	348	234
66	325	320	321	351	254	357	311	351	247	335	308	354	240
67	331	327	327	358	259	363	318	358	253	342	314	360	245
68	337	333	333	365	265	370	323	364	258	348	319	366	250
69	343	339	339	371	271	376	329	370	263	354	325	372	256
70	349	345	346	378	277	383	335	377	269	360	332	379	261
71	355	351	352	385	282	389	341	383	274	366	337	385	266
72	362	357	358	391	288	396	348	390	280	373	343	391	271
73	368	363	364	398	293	402	353	396	285	379	349	397	277
74	374	369	370	404	299	408	359	402	291	385	355	403	282
75	380	375	377	411	304	415	366	409	296	392	361	410	287
76	388	381	383	417	310	421	371	415	301	398	367	416	293
77	393	388	389	424	315	427	377	421	307	404	373	423	298
78	399	394	395	431	321	433	383	427	312	410	379	429	303
79	405	400	401	437	327	439	389	433	318	416	385	435	309
80	411	406	407	444	332	446	395	440	323	423	391	441	314
81	418	412	414	451	338	452	401	446	329	429	397	447	320
82	424	419	419	457	343	458	407	452	335	435	403	454	325
83	430	425	426	464	349	464	413	458	340	441	409	460	331
84	436	431	432	470	355	471	420	465	346	448	415	466	336
85	443	437	438	476	360	477	425	471	351	454	421	472	342
86	449	443	444	483	365	483	431	477	356	460	427	479	347
87	455	449	450	489	371	489	437	483	362	466	433	485	353
88	461	456	456	496	377	495	443	490	367	472	438	491	358
89	467	462	462	502	382	501	449	495	373	478	444	497	363
90	474	468	468	509	388	507	455	502	378	484	451	504	369
91	480	474	474	515	393	513	461	508	384	491	457	510	375
92	486	480	480	521	399	520	467	514	389	497	463	517	380
93	492	486	486	528	405	526	473	521	395	503	469	523	386
94	498	492	492	534	410	532	478	528	400	509	475	529	391
95	505	499	498	540	416	538	485	533	406	515	481	536	397
96	511	505	504	547	421	544	490	539	411	521	487	542	403
97	517	511	510	553	426	550	496	545	417	527	493	548	408
98	523	517	516	559	432	556	502	552	422	533	499	555	413
99	529	524	522	566	437	562	508	558	428	539	505	561	419
100	535	530	528	572	443	568	514	564	433	545	511	567	425
101	542	536	534	578	449	575	520	570	439	551	517	574	430
102	548	542	539	584	454	580	526	577	444	557	523	580	436
103	554	548	546	591	459	587	532	583	450	563	529	586	441
104	560	554	552	597	465	593	538	589	455	569	535	593	447
105	567	560	558	604	470	599	544	595	461	575	542	599	453
106	573	567	564	610	476	605	550	602	466	581	547	605	458
107	579	573	569	616	481	611	555	608	471	587	554	612	464
108	585	579	575	622	487	617	561	614	477	593	560	618	470
109	591	585	581	629	492	623	567	620	482	599	566	625	475
110	597	591	588	635	498	630	573	626	488	605	572	631	481
111	603	597	593	641	503	635	579	632	493	611	578	637	486
112	609	603	599	647	509	642	584	638	498	617	584	644	492
113	615	609	605	653	514	648	590	644	504	622	590	650	497
114	622	616	611	659	520	654	596	651	509	628	596	656	503
115	628	622	617	666	525	660	602	657	515	634	602	662	508
116	634	628	623	672	531	666	608	663	520	640	608	669	514
117	640	634	629	678	536	672	613	669	525	646	614	675	520
118	646	640	634	684	541	678	619	675	530	652	620	681	525
119	652	646	640	690	547	684	625	681	536	658	627	687	531
120	658	652	646	696	552	690	630	687	541	663	633	694	536
121	664	658	652	702	557	696	636	693	546	669	639	700	542
122	670	664	658	708	563	702	642	699	552	675	645	706	547
123	676	670	663	714	568	708	648	705	557	681	651	712	553
124	682	676	669	720	573	714	653	711	563	686	657	719	558
125	688	682	675	726	579	719	659	717	568	692	663	725	564
126	694	688	680	732	584	725	665	723	573	698	669	731	569
127	700	694	686	738	589	731	670	729	578	704	674	737	574

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Time (min)	P8B Sec A-A TC #4 (°F)	P8B Sec A-A TC #5 (°F)	P8B BBAve	P8B Sec B-B TC #6 (°F)	P8B Sec B-B TC #7 (°F)	P8B Sec B-B TC #8 (°F)	P8B CCAve	P8B Sec C-C TC #9 (°F)	P8B Sec C-C TC #10 (°F)	P8B Sec C-C TC #11 (°F)	P8B DDAve	P8B Sec D-D TC #12 (°F)	P8B Sec D-D TC #13 (°F)
128	708	700	692	744	595	737	676	735	583	709	680	743	580
129	712	705	698	750	600	743	682	741	589	715	686	749	585
130	718	711	703	756	605	749	687	747	594	721	692	756	591
131	724	717	709	762	610	755	693	753	599	727	698	762	596
132	730	723	715	768	616	761	698	759	604	732	704	768	602
133	735	729	721	774	621	767	704	765	609	738	710	774	607
134	741	735	726	779	626	773	709	770	615	743	715	780	612
135	747	741	732	785	632	778	715	776	620	749	721	786	618
136	753	746	737	791	637	784	721	782	625	755	727	792	623
137	759	752	743	797	642	790	726	788	630	760	732	798	628
138	764	758	749	803	647	796	731	793	635	766	738	804	633
139	770	763	754	808	653	802	737	799	640	771	744	810	639
140	776	769	760	814	658	807	742	805	645	777	750	816	644
141	782	775	765	820	663	813	748	811	651	782	756	822	650
142	788	780	771	825	669	819	753	816	656	788	761	828	655
143	793	786	776	831	674	824	759	822	661	793	767	834	660
144	799	792	782	837	679	830	764	828	666	799	773	840	666
145	805	797	787	842	684	835	769	833	671	804	778	845	671
146	810	803	793	848	690	841	775	839	677	809	783	851	676
147	816	808	798	853	695	846	780	844	682	815	789	857	682
148	821	814	804	859	700	852	786	850	687	821	795	863	687
149	827	819	809	864	705	857	791	855	692	826	800	868	692
150	833	825	814	869	711	863	796	861	697	831	806	874	698
151	838	830	820	875	716	868	801	866	702	836	811	880	703
152	843	836	825	880	721	873	807	871	708	841	816	885	708
153	849	841	830	885	727	878	812	877	713	847	822	891	714
154	854	847	836	891	732	884	817	882	718	852	827	897	719
155	859	852	841	896	737	889	822	887	723	857	833	902	724
156	865	857	846	901	742	895	828	893	728	862	838	907	729
157	871	862	852	907	748	900	833	898	734	868	844	913	735
158	876	868	857	912	753	906	839	904	739	873	849	919	740
159	881	873	862	917	758	911	844	909	744	878	854	924	745
160	886	878	867	922	763	916	849	914	749	883	860	930	751
161	892	883	872	928	768	921	854	919	754	888	865	935	756
162	897	889	878	933	774	926	859	925	759	894	870	941	761
163	902	894	883	938	779	932	864	930	764	898	875	946	766
164	908	899	888	943	784	937	869	935	769	904	881	952	772
165	913	904	893	948	789	942	875	941	774	909	886	957	777
166	918	910	898	953	794	947	880	946	779	914	891	962	782
167	924	915	904	959	799	953	885	951	785	919	897	968	787
168	929	920	909	964	805	958	890	956	790	924	902	973	792
169	934	925	914	969	810	963	895	961	794	929	908	979	798
170	939	930	919	974	815	968	900	967	800	934	913	984	803
171	944	935	924	979	820	973	905	972	804	939	918	989	808
172	950	941	929	984	825	979	910	977	810	944	923	995	813
173	955	945	934	989	830	984	915	982	814	949	928	1000	818
174	960	950	939	994	835	989	920	987	819	954	933	1005	824
175	965	955	945	999	841	994	925	992	824	959	938	1010	829
176	970	960	950	1004	846	999	930	997	829	964	943	1015	834
177	975	965	955	1009	851	1004	935	1002	835	969	949	1021	839
178	980	970	960	1014	856	1009	940	1007	839	973	954	1026	844
179	985	975	965	1019	861	1014	945	1012	845	978	959	1031	849
180	990	980	970	1024	866	1019	950	1017	850	983	964	1036	854
181	995	985	974	1028	871	1024	955	1022	854	988	969	1041	860
182	1000	990	980	1033	877	1029	960	1027	860	993	974	1046	865
183	1005	995	985	1038	882	1034	965	1031	865	998	979	1051	870
184	1010	1000	990	1043	887	1039	970	1037	870	1002	984	1056	875
185	1015	1005	995	1048	892	1044	974	1041	875	1007	989	1061	880
186	1020	1010	999	1053	897	1048	979	1046	880	1012	994	1066	886
187	1025	1014	1004	1057	902	1053	984	1051	885	1017	999	1071	891
188	1030	1019	1009	1062	907	1058	989	1056	890	1021	1004	1076	896
189	1035	1024	1014	1067	912	1063	994	1061	895	1026	1009	1081	901
190	1040	1029	1019	1072	917	1068	999	1066	900	1031	1014	1086	906
191	1045	1034	1024	1076	922	1073	1004	1070	905	1036	1019	1090	911

Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

21 August 2008

Time (min)	P8B Sec A-A TC #4 (°F)	P8B Sec A-A TC #5 (°F)	P8B BBAve	P8B Sec B-B TC #6 (°F)	P8B Sec B-B TC #7 (°F)	P8B Sec B-B TC #8 (°F)	P8B CCAve	P8B Sec C-C TC #9 (°F)	P8B Sec C-C TC #10 (°F)	P8B Sec C-C TC #11 (°F)	P8B DDAve	P8B Sec D-D TC #12 (°F)	P8B Sec D-D TC #13 (°F)
192	1049	1039	1029	1081	927	1078	1008	1075	910	1040	1024	1095	916
193	1054	1043	1034	1086	933	1082	1013	1080	915	1045	1029	1100	921
194	1059	1048	1038	1090	938	1087	1018	1085	920	1050	1033	1105	926
195	1064	1052	1043	1095	943	1092	1023	1089	925	1054	1038	1110	931
196	1069	1058	1048	1100	948	1097	1028	1094	930	1059	1044	1115	937
197	1073	1062	1052	1104	952	1101	1032	1099	934	1064	1048	1119	942
198	1078	1067	1057	1109	957	1106	1037	1103	939	1068	1053	1124	947
199	1083	1072	1062	1114	962	1111	1042	1108	944	1073	1058	1129	952
200	1087	1076	1067	1118	966	1115	1047	1113	949	1078	1063	1133	957
201	1092	1081	1072	1123	973	1120	1051	1117	954	1082	1068	1138	962
202	1097	1085	1076	1127	977	1125	1056	1122	959	1087	1072	1143	967
203	1101	1090	1081	1132	982	1129	1061	1126	964	1092	1077	1147	972
204	1106	1095	1086	1136	987	1134	1065	1131	969	1096	1082	1152	977
205	1111	1099	1090	1141	992	1138	1070	1135	974	1101	1087	1157	982
206	1115	1104	1095	1145	997	1143	1075	1140	979	1105	1091	1161	987
207	1120	1108	1100	1150	1002	1148	1079	1144	984	1110	1096	1166	992
208	1124	1113	1104	1154	1007	1152	1084	1149	989	1114	1100	1170	997
209	1129	1118	1109	1159	1012	1157	1088	1153	993	1118	1105	1174	1002
210	1133	1122	1114	1163	1017	1161	1093	1157	998	1123	1109	1179	1006
211	1137	1126	1118	1167	1022	1165	1097	1161	1003	1127	1114	1183	1011
212	1142	1131	1123	1172	1027	1170	1102	1166	1008	1132	1119	1188	1016
213	1146	1135	1127	1176	1032	1174	1106	1170	1013	1136	1124	1192	1022
214	1151	1140	1132	1181	1037	1178	1111	1174	1018	1141	1128	1197	1026
215	1155	1144	1136	1185	1041	1183	1115	1178	1022	1145	1132	1201	1031
216	1159	1148	1141	1189	1046	1187	1120	1183	1027	1149	1137	1205	1036
217	1164	1153	1145	1193	1051	1191	1124	1187	1032	1153	1141	1209	1041
218	1168	1157	1150	1197	1056	1196	1129	1191	1037	1158	1146	1214	1046
219	1172	1161	1154	1201	1061	1200	1133	1195	1041	1162	1150	1218	1051
220	1176	1166	1159	1206	1066	1204	1137	1199	1046	1166	1155	1222	1056
221	1180	1170	1163	1210	1070	1208	1141	1203	1051	1170	1159	1226	1060
222	1184	1174	1167	1214	1075	1212	1145	1207	1055	1174	1163	1230	1065
223	1189	1178	1172	1218	1080	1217	1150	1211	1060	1179	1168	1234	1070
224	1193	1182	1176	1222	1084	1221	1154	1215	1065	1183	1172	1238	1074
225	1197	1187	1180	1226	1089	1225	1159	1219	1070	1187	1176	1242	1079
226	1201	1191	1184	1230	1094	1229	1163	1223	1074	1191	1180	1246	1084
227	1205	1195	1188	1234	1098	1233	1167	1227	1079	1195	1185	1250	1089
228	1209	1199	1192	1237	1103	1236	1171	1231	1083	1199	1189	1254	1093
229	1213	1203	1196	1241	1107	1240	1175	1235	1088	1203	1193	1258	1098
230	1217	1207	1200	1245	1112	1244	1179	1238	1092	1207	1197	1261	1102
231	1221	1211	1204	1249	1116	1248	1183	1242	1097	1211	1201	1265	1107
232	1225	1215	1209	1253	1121	1252	1188	1246	1102	1215	1205	1269	1111
233	1228	1219	1213	1257	1125	1256	1191	1250	1106	1218	1209	1273	1116
234	1232	1222	1216	1260	1129	1260	1195	1254	1110	1222	1213	1277	1120
235	1236	1226	1220	1264	1134	1263	1199	1257	1115	1226	1217	1280	1124
236	1240	1230	1224	1268	1138	1267	1203	1261	1119	1230	1221	1284	1129
237	1243	1234	1228	1272	1142	1271	1207	1264	1124	1234	1225	1288	1133
238	1247	1238	1232	1275	1147	1275	1211	1268	1128	1238	1228	1291	1137
239	1251	1241	1236	1279	1151	1278	1215	1272	1132	1242	1233	1295	1142
240	1255	1245	1240	1283	1155	1283	1219	1276	1136	1246	1237	1299	1146
Max T	1255	1245	1240	1283	1155	1283	1219	1276	1136	1246	1237	1299	1146
Max A	1200	1200	1000	1200	1200	1200	1000	1200	1200	1200	1000	1200	1200

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Time (min)	P8B Sec D-D TC #14 (°F)	P11 P11Max	P11 AAAve	P11 Sec A-A TC #1 (°F)	P11 Sec A-A TC #2 (°F)	P11 Sec A-A TC #3 (°F)	P11 Sec A-A TC #4 (°F)	P11 Sec A-A TC #5 (°F)	P11 BBAve	P11 Sec B-B TC #6 (°F)	P11 Sec B-B TC #7 (°F)	P11 Sec B-B TC #8 (°F)
0	82	86	85	85	85	85	85	84	85	85	85	85
1	82	86	85	85	85	85	85	85	85	85	85	85
2	82	86	85	85	85	85	85	84	85	85	85	85
3	82	86	85	85	85	85	85	85	85	85	85	85
4	82	86	85	85	85	85	85	85	85	84	85	85
5	81	86	84	83	84	85	85	84	85	83	85	86
6	81	86	84	83	83	85	84	83	84	82	85	86
7	80	86	84	83	83	85	84	83	84	82	85	86
8	80	86	83	83	83	85	83	83	84	82	85	86
9	81	86	83	83	83	85	83	83	85	83	85	86
10	81	86	83	83	83	85	83	83	85	83	85	86
11	82	86	83	83	83	85	83	83	85	83	85	86
12	84	86	83	83	83	85	83	83	84	83	84	86
13	84	86	83	83	83	85	83	83	84	83	84	86
14	86	86	84	84	83	85	83	83	85	83	85	86
15	87	87	84	84	83	86	84	83	85	84	85	87
16	88	87	84	84	83	86	84	83	85	84	85	87
17	90	88	84	85	83	86	84	84	86	84	85	88
18	91	88	85	86	83	87	84	84	86	85	85	88
19	93	89	85	86	83	87	85	84	86	85	85	89
20	94	90	86	87	83	88	85	85	87	86	85	90
21	96	90	86	88	83	89	86	85	87	87	85	90
22	98	91	87	89	84	90	87	86	88	87	85	91
23	100	92	88	90	84	91	87	87	88	88	85	92
24	102	93	88	91	84	92	88	87	89	89	85	93
25	105	93	89	92	85	93	89	88	90	90	86	93
26	108	95	90	93	85	94	89	89	90	91	86	94
27	111	96	91	94	86	95	90	90	91	92	87	95
28	115	97	92	95	86	96	91	90	92	92	87	96
29	119	98	93	96	87	97	92	91	92	93	87	97
30	124	99	93	97	87	98	93	92	93	94	88	98
31	128	100	95	99	88	99	94	93	94	95	88	99
32	133	101	96	100	89	101	95	94	95	96	89	100
33	138	102	97	101	90	102	96	95	96	97	89	101
34	143	103	98	103	91	103	97	96	97	98	90	102
35	149	105	99	104	92	105	98	98	98	100	90	104
36	153	107	101	106	93	106	100	99	99	101	91	105
37	159	108	102	108	94	108	101	100	100	102	92	107
38	163	111	104	110	94	110	103	102	102	104	93	108
39	169	113	105	112	96	112	104	103	103	106	93	110
40	172	115	107	114	97	114	106	105	105	108	94	112
41	177	118	109	116	98	116	107	107	107	110	95	116
42	183	120	111	119	100	118	109	109	108	112	96	117
43	188	123	113	122	101	121	111	111	110	114	97	119
44	194	126	115	125	102	124	113	113	112	117	98	122
45	200	129	118	128	104	126	115	115	114	119	99	124
46	207	132	120	131	105	130	118	117	116	122	100	127
47	214	135	123	134	107	133	120	120	119	125	102	130
48	220	139	125	137	109	136	122	122	121	128	103	133
49	226	142	128	141	111	139	125	125	124	131	105	136
50	233	146	131	144	113	143	128	128	126	134	106	139
51	239	149	134	147	115	146	130	130	129	137	108	142
52	245	153	137	151	117	149	133	133	132	141	110	145
53	251	156	139	154	119	152	135	136	135	144	112	149
54	259	160	142	158	121	156	138	139	138	147	114	152
55	264	164	146	162	124	159	141	142	141	151	116	156
56	270	168	149	166	126	162	144	146	144	154	118	159
57	276	171	152	169	129	166	147	149	147	158	120	162
58	282	176	155	173	131	168	151	152	150	161	123	166
59	288	180	158	177	134	171	154	155	153	164	125	169
60	294	184	162	181	137	176	158	158	156	168	128	173
61	300	189	166	185	139	181	162	162	160	172	130	177
62	306	193	170	189	143	186	165	166	163	176	133	181
63	312	197	174	194	146	191	169	169	167	180	136	185

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Time (min)	P8B Sec D-D TC #14 (°F)	P11 P11Max	P11 AAAve	P11 Sec A-A TC #1 (°F)	P11 Sec A-A TC #2 (°F)	P11 Sec A-A TC #3 (°F)	P11 Sec A-A TC #4 (°F)	P11 Sec A-A TC #5 (°F)	P11 BBAve	P11 Sec B-B TC #6 (°F)	P11 Sec B-B TC #7 (°F)	P11 Sec B-B TC #8 (°F)
64	318	202	178	199	149	198	173	173	171	185	138	190
65	324	208	182	204	152	200	177	177	175	189	141	194
66	330	210	186	209	156	205	180	180	179	194	144	198
67	338	214	190	214	159	210	184	185	182	198	147	202
68	342	219	195	219	162	215	188	189	187	203	150	207
69	348	224	199	224	166	220	192	193	191	208	154	211
70	355	229	203	229	169	224	197	197	195	212	157	216
71	361	234	208	234	173	229	201	202	199	217	160	220
72	367	239	212	239	177	234	205	206	203	221	164	224
73	373	244	216	244	181	238	209	210	207	226	168	228
74	379	248	221	248	185	243	214	215	211	230	171	233
75	385	253	225	253	189	248	218	219	216	235	175	237
76	392	258	230	258	193	252	222	223	220	239	179	241
77	398	263	234	263	197	257	227	228	224	244	182	245
78	404	267	239	267	201	262	231	232	228	248	186	250
79	410	272	243	272	205	266	235	237	232	253	190	254
80	417	277	247	277	209	271	239	241	236	257	194	258
81	423	282	252	282	213	276	244	246	241	262	197	263
82	429	286	256	286	217	281	248	250	245	266	201	267
83	436	291	261	291	221	286	253	254	249	271	205	271
84	442	296	265	296	225	290	257	259	253	275	209	276
85	448	301	270	301	229	295	262	263	257	279	213	280
86	454	305	275	305	234	300	266	268	262	284	217	285
87	460	310	279	310	238	305	271	272	266	288	221	289
88	468	315	284	315	242	309	275	277	270	293	225	293
89	473	320	288	320	246	314	280	281	275	297	229	298
90	479	324	293	324	251	319	284	286	279	301	233	302
91	485	329	297	329	255	323	288	290	283	306	237	307
92	491	334	302	334	259	328	293	294	287	310	241	311
93	498	338	306	338	264	333	297	299	292	315	245	315
94	504	343	311	343	268	338	302	303	296	319	249	320
95	510	348	315	348	272	343	306	307	300	323	253	324
96	516	353	320	353	276	347	311	312	305	328	257	329
97	523	357	324	357	281	352	316	316	309	332	261	333
98	529	362	329	362	285	357	320	321	313	336	265	338
99	535	367	334	367	289	362	325	325	317	341	269	342
100	541	372	338	372	294	367	329	330	322	345	273	347
101	548	378	343	376	298	371	334	334	326	349	277	351
102	554	381	347	381	302	376	338	339	330	354	281	356
103	560	386	352	386	307	381	343	343	334	358	285	360
104	566	391	357	391	311	386	348	347	339	363	289	365
105	573	396	361	396	316	391	352	352	343	367	293	369
106	579	401	366	401	319	396	357	356	348	372	297	374
107	585	405	371	405	324	401	362	361	352	376	301	379
108	591	410	375	410	328	405	366	365	356	380	305	383
109	598	415	380	415	332	410	371	370	361	385	309	388
110	604	420	384	420	337	415	375	374	365	389	313	392
111	610	424	389	424	341	420	380	379	369	394	317	396
112	617	429	393	429	345	425	385	383	373	398	321	401
113	623	434	398	434	350	430	389	388	378	403	325	406
114	629	439	403	439	354	435	394	393	382	407	329	410
115	635	444	407	444	358	439	399	397	387	412	333	415
116	641	448	412	448	362	444	403	401	391	416	337	419
117	647	453	417	453	367	449	408	406	395	420	341	424
118	654	458	421	458	371	454	412	410	399	425	345	428
119	662	463	426	463	376	458	417	415	404	429	349	433
120	668	467	430	467	380	463	422	419	408	434	353	437
121	675	472	435	472	384	468	426	424	413	438	358	442
122	681	477	439	477	388	473	431	428	417	443	362	447
123	687	481	444	481	393	478	436	433	421	447	366	451
124	694	486	448	486	397	482	440	437	426	452	370	456
125	700	491	453	491	402	487	445	442	430	456	374	460
126	706	496	458	496	406	492	450	446	434	460	378	465
127	712	500	462	500	410	497	454	451	439	465	382	469

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Time (min)	P8B Sec D-D TC #14 (°F)	P11Max	P11 AAAve	P11 Sec A-A TC #1 (°F)	P11 Sec A-A TC #2 (°F)	P11 Sec A-A TC #3 (°F)	P11 Sec A-A TC #4 (°F)	P11 Sec A-A TC #5 (°F)	P11 BBAve	P11 Sec B-B TC #6 (°F)	P11 Sec B-B TC #7 (°F)	P11 Sec B-B TC #8 (°F)
128	718	505	467	505	415	501	459	455	443	489	386	474
129	724	510	472	510	419	508	463	460	447	474	390	478
130	730	514	476	514	423	511	468	464	452	478	394	483
131	738	519	481	519	427	516	472	469	456	483	398	487
132	742	524	485	524	432	520	477	473	461	487	403	492
133	748	528	489	528	436	525	481	477	464	491	406	496
134	754	533	494	533	440	530	486	482	469	496	411	501
135	760	538	499	538	445	535	491	486	473	500	415	505
136	765	542	503	542	449	539	495	491	478	505	419	510
137	771	547	508	547	453	544	500	495	482	509	423	515
138	777	552	512	552	457	549	504	500	487	514	427	519
139	783	556	517	556	462	553	509	504	491	518	431	523
140	789	561	521	561	466	558	513	509	495	522	435	528
141	795	565	526	565	470	563	518	513	499	527	439	532
142	800	570	531	570	475	568	522	518	504	531	443	537
143	808	575	535	575	479	572	527	522	508	536	447	542
144	812	579	539	579	483	577	531	526	512	540	451	546
145	817	584	544	584	487	581	536	531	516	544	455	550
146	823	588	548	588	491	586	540	535	521	549	459	555
147	828	593	553	593	496	590	545	540	525	553	463	559
148	834	596	557	598	500	595	549	544	529	557	467	564
149	839	602	562	602	504	600	554	548	534	562	472	568
150	845	607	566	607	509	604	558	553	538	566	475	572
151	850	611	571	611	513	609	563	557	542	570	480	577
152	855	616	575	616	517	613	567	561	547	575	484	581
153	861	620	579	620	521	618	571	566	551	579	488	586
154	866	624	583	624	525	622	576	570	555	583	492	590
155	872	629	588	629	529	627	580	574	559	588	496	594
156	877	633	592	633	534	631	584	579	564	592	500	599
157	883	638	597	638	538	636	589	583	568	596	504	603
158	888	642	601	642	542	640	593	587	572	601	508	607
159	893	647	605	647	546	645	597	591	576	605	512	611
160	899	651	610	651	550	649	602	596	580	609	516	616
161	904	655	614	655	555	653	606	600	584	613	520	620
162	909	660	618	660	559	658	610	604	589	618	524	624
163	914	664	622	664	563	662	615	608	593	622	528	629
164	920	669	627	669	567	667	619	613	597	626	532	633
165	925	673	631	673	571	671	623	617	601	630	536	637
166	930	677	635	677	575	676	628	621	605	634	540	642
167	935	682	640	682	579	680	632	625	610	639	544	646
168	940	686	644	686	583	684	636	629	613	643	547	650
169	946	690	648	690	587	689	641	634	618	647	552	654
170	951	695	652	695	591	693	645	638	622	651	555	659
171	956	699	656	699	595	697	649	642	626	656	559	663
172	961	703	661	703	599	702	653	646	630	660	563	667
173	966	708	665	708	603	706	658	650	634	664	567	671
174	971	712	670	712	608	711	662	655	638	668	571	676
175	976	716	673	716	611	715	666	659	643	673	575	680
176	981	721	678	721	616	719	670	663	647	677	579	684
177	986	725	682	725	620	724	675	667	650	681	582	688
178	991	729	686	729	624	728	679	671	655	685	586	693
179	996	733	690	733	628	732	683	676	659	689	590	697
180	1001	738	695	738	632	736	687	680	663	693	594	701
181	1006	742	699	742	636	741	691	684	667	697	598	705
182	1011	746	703	746	640	745	696	688	671	701	602	709
183	1016	751	707	751	644	749	700	692	675	706	605	713
184	1021	755	711	755	648	753	704	696	679	710	609	717
185	1026	759	715	759	652	758	708	700	683	714	613	722
186	1031	763	719	763	656	762	712	704	687	718	617	726
187	1035	767	724	767	660	766	716	709	691	722	621	730
188	1041	771	728	771	664	770	721	713	695	726	625	734
189	1045	776	732	776	668	775	725	717	699	730	629	738
190	1050	780	736	780	672	779	729	721	703	734	633	742
191	1055	784	740	784	676	783	733	725	707	738	637	746

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Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

21 August 2008

Time (min)	P8B Sec D-D TC #14 (°F)	P11Max	P11 AAAve	P11 Sec A-A TC #1 (°F)	P11 Sec A-A TC #2 (°F)	P11 Sec A-A TC #3 (°F)	P11 Sec A-A TC #4 (°F)	P11 Sec A-A TC #5 (°F)	P11 BBAve	P11 Sec B-B TC #6 (°F)	P11 Sec B-B TC #7 (°F)	P11 Sec B-B TC #8 (°F)
192	1060	788	744	788	680	787	737	729	711	742	640	751
193	1065	792	748	792	684	791	741	733	715	747	644	755
194	1069	797	753	797	686	795	745	737	719	751	648	758
195	1074	801	757	801	692	799	749	742	723	755	652	763
196	1079	805	761	805	697	804	754	746	727	759	656	767
197	1084	809	765	809	701	808	758	750	731	763	660	771
198	1088	813	769	813	704	812	762	754	735	767	663	775
199	1093	817	773	817	709	816	766	758	739	771	667	779
200	1098	822	777	822	713	820	770	762	743	775	671	783
201	1103	826	781	826	717	824	774	766	747	779	675	787
202	1107	830	785	830	721	828	778	770	751	783	679	791
203	1112	834	790	834	725	833	782	774	755	787	683	795
204	1118	838	794	838	729	837	786	778	759	791	687	799
205	1121	843	798	843	733	841	790	783	763	795	691	803
206	1125	847	802	847	737	845	794	787	767	799	695	807
207	1130	851	806	851	741	849	798	791	771	804	698	811
208	1134	855	810	855	745	853	803	795	775	808	702	815
209	1138	859	814	859	749	857	806	799	779	812	706	819
210	1143	864	818	864	753	861	810	803	783	816	710	823
211	1148	868	822	868	757	865	814	807	787	820	714	827
212	1152	872	826	872	761	869	818	811	791	824	718	831
213	1157	876	830	876	765	874	822	815	795	828	721	835
214	1161	880	834	880	769	877	826	819	799	832	725	839
215	1165	885	838	885	773	881	830	823	803	837	729	843
216	1170	889	842	889	777	885	834	827	807	841	733	847
217	1174	893	847	893	781	889	838	832	811	845	737	851
218	1178	897	851	897	785	893	842	836	815	849	741	855
219	1182	901	855	901	789	897	846	840	819	853	745	859
220	1187	905	859	905	793	901	850	844	823	857	748	863
221	1191	909	863	909	797	905	854	848	827	861	752	867
222	1195	914	867	914	801	909	857	852	831	865	756	871
223	1199	918	871	918	805	913	861	856	835	869	760	875
224	1203	922	875	922	809	917	865	860	839	873	764	879
225	1207	926	878	926	813	920	869	864	843	877	768	883
226	1211	930	882	930	817	924	873	868	847	881	772	887
227	1215	934	886	934	821	928	877	872	850	885	776	890
228	1219	938	890	938	824	932	880	876	854	889	780	894
229	1223	942	894	942	828	936	884	880	858	893	783	898
230	1227	946	898	946	833	939	888	884	862	897	787	902
231	1231	950	902	950	836	943	892	888	866	901	791	906
232	1235	954	906	954	840	947	896	892	870	905	795	910
233	1238	958	909	958	844	950	899	896	874	909	799	913
234	1242	962	913	962	848	954	903	900	877	912	803	917
235	1246	965	917	965	852	958	907	904	881	916	806	921
236	1250	969	921	969	856	962	911	908	885	920	810	924
237	1253	973	925	973	860	965	914	912	889	924	814	928
238	1257	977	929	977	864	969	918	916	893	928	818	932
239	1261	981	933	981	868	973	922	920	897	932	822	936
240	1265	985	936	985	872	976	925	924	900	936	826	939
Max T	1265	985	936	985	872	976	925	924	900	936	826	939
Max A	1200	1200	1000	1200	1200	1200	1200	1200	1000	1200	1200	1200

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Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

21 August 2008

Time (min)	P11 CCAve	P11 Sec C-C TC #9 (°F)	P11 Sec C-C TC #10 (°F)	P11 Sec C-C TC #11 (°F)	P11 DDAve	P11 Sec D-D TC #12 (°F)	P11 Sec D-D TC #13 (°F)	P11 Sec D-D TC #14 (°F)	P14 Max	P14 AAAve	P14 Sec A-A TC #1 (°F)	P14 Sec A-A TC #2 (°F)
0	85	85	85	85	85	85	85	88	84	82	82	82
1	85	85	85	85	88	86	86	88	83	82	82	82
2	85	85	85	85	85	86	85	86	83	82	82	82
3	85	85	85	85	88	85	86	88	84	82	82	82
4	85	85	85	85	85	85	86	85	84	82	82	82
5	85	85	85	85	85	84	86	85	85	82	82	82
6	85	84	85	85	84	83	85	85	87	82	82	82
7	84	83	84	84	84	83	85	85	87	82	82	82
8	84	83	84	84	84	83	85	84	88	82	82	82
9	84	83	84	84	84	83	85	84	88	82	82	81
10	84	83	84	84	84	83	85	84	88	82	82	81
11	84	83	84	84	84	83	85	84	88	82	82	81
12	84	83	84	84	84	83	85	84	88	82	82	81
13	84	83	84	85	84	83	85	84	88	82	82	81
14	84	83	84	85	84	84	85	84	88	81	82	81
15	85	84	84	86	85	84	85	85	88	81	82	81
16	85	84	84	86	85	84	85	85	88	81	82	81
17	85	84	84	87	85	85	85	86	88	81	82	81
18	85	85	84	87	86	86	85	86	88	81	82	81
19	86	86	84	88	86	86	85	87	88	82	83	82
20	86	86	84	89	87	87	85	88	88	82	83	82
21	87	87	84	90	87	88	85	89	88	82	83	82
22	88	88	85	91	88	89	86	89	88	83	84	82
23	89	89	85	92	88	89	86	90	88	83	84	82
24	89	90	85	93	89	90	86	91	88	83	85	82
25	90	91	85	93	90	91	86	92	88	84	85	82
26	91	92	86	95	91	92	87	93	89	84	86	82
27	92	93	86	96	91	93	87	93	89	85	86	83
28	92	93	86	97	92	94	88	94	89	85	87	83
29	93	94	87	98	93	95	88	95	90	86	88	83
30	94	95	87	99	94	96	89	96	91	86	88	83
31	95	96	88	100	94	97	89	97	92	87	89	84
32	96	97	89	101	95	98	90	98	92	87	90	84
33	98	98	89	102	96	99	91	99	93	88	91	84
34	97	99	90	103	97	100	91	100	94	89	92	85
35	99	101	90	105	99	102	92	102	95	89	92	85
36	100	102	91	107	100	103	93	103	96	89	93	86
37	101	103	92	108	101	105	93	105	97	90	94	86
38	103	105	93	111	102	107	94	106	98	91	94	86
39	104	106	93	113	104	108	95	108	101	92	95	87
40	106	108	94	115	105	110	96	110	103	92	96	87
41	108	110	95	118	106	113	97	113	107	93	97	88
42	109	112	96	120	109	115	98	115	111	94	98	88
43	112	115	97	123	111	117	99	117	116	95	99	89
44	114	117	98	126	113	120	100	120	123	95	100	89
45	116	120	99	129	116	123	102	123	130	96	100	90
46	118	122	100	132	119	126	103	127	138	97	101	91
47	121	125	102	135	121	129	105	130	146	98	102	91
48	123	128	103	139	124	133	107	133	155	99	103	92
49	126	131	105	142	127	137	108	137	162	100	104	93
50	129	134	107	146	130	140	110	140	168	101	105	94
51	131	137	108	149	133	144	112	144	175	102	107	94
52	134	140	110	153	137	147	115	148	180	103	108	95
53	137	143	112	156	140	151	117	151	183	104	109	96
54	140	147	114	160	143	155	120	155	186	105	110	97
55	143	150	116	164	147	159	122	159	189	106	112	98
56	147	153	119	168	150	163	125	162	192	107	113	99
57	150	157	121	171	153	167	127	166	194	109	115	100
58	153	160	123	176	157	170	130	170	196	110	117	101
59	156	163	126	180	161	174	133	177	197	111	118	101
60	160	167	129	184	165	178	136	181	198	113	120	103
61	164	171	131	189	169	182	139	186	198	114	122	104
62	168	176	134	193	173	187	142	190	198	116	124	105
63	171	180	137	197	177	191	145	195	198	118	127	106

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Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

21 August 2008

Time (min)	P11 CCAve	P11 Sec C-C TC #9 (°F)	P11 Sec C-C TC #10 (°F)	P11 Sec C-C TC #11 (°F)	P11 DDAve	P11 Sec D-D TC #12 (°F)	P11 Sec D-D TC #13 (°F)	P11 Sec D-D TC #14 (°F)	P14 P14 Max	P14 AAAve	P14 Sec A-A TC #1 (°F)	P14 Sec A-A TC #2 (°F)
64	175	184	139	202	181	195	148	199	198	120	129	107
65	179	189	142	208	185	199	151	204	197	122	131	109
66	183	193	146	210	189	203	155	208	197	124	134	110
67	187	197	149	214	193	207	158	213	196	126	136	111
68	191	202	152	219	197	212	162	217	196	128	138	113
69	195	206	155	223	201	216	165	222	196	130	141	115
70	199	211	158	227	205	220	168	226	195	132	144	116
71	203	215	162	232	209	224	172	230	195	134	146	118
72	207	219	165	236	213	228	175	235	196	137	149	120
73	211	224	169	240	217	233	179	239	196	139	152	121
74	215	228	172	245	221	237	183	243	199	141	155	123
75	219	232	176	249	225	241	186	248	201	143	157	125
76	223	237	179	253	229	245	190	252	203	146	160	127
77	227	241	183	258	233	249	194	256	205	148	163	129
78	231	245	187	262	237	254	197	261	208	151	166	131
79	235	250	190	266	241	258	201	265	210	153	168	133
80	240	254	194	271	245	262	205	269	213	156	171	135
81	244	259	198	275	250	266	209	274	215	158	174	138
82	248	263	202	279	254	271	212	278	217	160	176	140
83	252	267	206	284	258	275	216	282	219	163	179	142
84	256	271	209	288	262	279	220	286	221	165	182	144
85	260	276	213	292	266	283	224	291	224	168	185	146
86	264	280	217	296	270	287	228	295	227	171	189	149
87	269	284	221	301	274	292	231	300	230	174	193	151
88	273	289	224	305	278	296	235	304	233	177	197	154
89	277	293	228	309	282	300	239	308	235	180	200	156
90	281	297	232	314	287	305	243	313	239	184	204	159
91	285	301	236	318	291	309	247	317	242	188	208	162
92	289	306	240	322	295	313	251	322	245	191	212	164
93	294	310	244	327	299	318	254	326	248	194	215	167
94	298	314	248	331	303	322	258	330	251	198	219	170
95	302	319	251	335	308	326	262	335	254	201	223	173
96	306	323	255	340	312	331	266	339	257	204	226	176
97	310	327	259	344	316	335	270	344	260	208	230	178
98	315	332	263	349	320	339	274	348	264	211	234	182
99	319	336	267	353	325	344	278	353	267	214	237	184
100	323	340	271	358	329	348	282	357	270	218	241	187
101	327	344	274	362	333	352	286	362	273	221	244	190
102	331	349	278	367	337	357	289	366	278	225	248	194
103	335	353	282	371	342	361	293	371	280	228	252	197
104	340	358	286	376	346	366	297	375	283	232	256	200
105	344	362	290	380	350	370	301	380	286	235	259	203
106	349	367	294	385	355	375	305	385	289	239	263	206
107	353	371	298	389	359	379	309	389	293	242	266	209
108	357	375	302	394	363	383	313	393	296	246	270	213
109	362	380	306	399	368	388	317	398	299	249	273	216
110	366	384	310	403	372	392	321	403	303	252	277	219
111	370	389	313	407	376	397	325	407	306	256	281	222
112	374	393	317	412	381	401	329	412	310	260	284	226
113	379	398	322	417	385	406	333	417	313	263	288	229
114	383	402	325	421	389	410	337	421	316	266	291	232
115	387	406	329	426	394	415	341	426	320	270	295	235
116	391	411	333	430	398	419	345	430	323	273	299	238
117	396	415	337	435	403	424	349	435	327	277	302	242
118	400	420	341	439	407	428	353	439	330	280	306	245
119	404	424	345	444	411	433	357	444	334	284	310	248
120	408	428	349	448	416	437	361	449	337	288	313	252
121	413	433	353	453	420	442	366	453	341	291	317	255
122	417	437	357	457	425	446	370	458	344	295	321	258
123	421	441	361	462	429	451	374	462	348	298	324	262
124	426	446	365	466	433	455	378	467	351	302	328	265
125	430	450	369	471	437	459	382	471	355	305	332	268
126	434	455	373	475	442	464	386	476	359	309	335	271
127	439	459	377	480	446	468	390	481	362	313	339	275

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Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

Aspen Aerogels, Inc.
Project No. 3159033

28 August, 2008
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Time (min)	P11 CCAve	P11 Sec C-C TC #9 (°F)	P11 Sec C-C TC #10 (°F)	P11 Sec C-C TC #11 (°F)	P11 DDAve	P11 Sec D-D TC #12 (°F)	P11 Sec D-D TC #13 (°F)	P11 Sec D-D TC #14 (°F)	P14 Max	P14 AAAve	P14 Sec A-A TC #1 (°F)	P14 Sec A-A TC #2 (°F)
128	443	484	381	484	451	473	394	485	366	316	343	278
129	447	488	385	489	456	478	399	490	369	320	346	281
130	451	472	389	493	460	482	403	494	373	323	350	285
131	458	477	393	498	464	486	407	499	377	327	354	288
132	460	481	397	502	468	491	411	503	380	330	357	291
133	464	485	401	507	473	495	415	508	384	334	361	295
134	469	490	405	511	477	500	419	512	388	338	365	298
135	473	494	409	516	481	504	423	517	391	341	369	301
136	477	499	413	520	486	509	427	522	395	345	372	305
137	482	503	417	525	490	513	432	526	399	348	376	308
138	486	507	421	529	495	518	436	531	402	352	380	311
139	490	512	425	533	499	522	440	535	406	356	384	315
140	494	516	429	538	503	526	444	540	409	359	387	318
141	498	520	433	542	508	531	448	544	413	363	391	322
142	503	525	437	547	512	535	452	549	417	367	395	325
143	507	529	441	551	516	540	456	553	421	371	399	329
144	512	534	446	556	521	544	460	558	424	375	403	332
145	516	538	450	560	525	549	465	562	428	378	406	336
146	520	542	454	564	530	553	469	567	432	382	410	339
147	525	547	458	569	534	557	473	571	436	386	414	342
148	529	551	462	573	538	561	477	576	439	390	418	346
149	533	555	466	577	542	566	481	580	443	393	422	349
150	537	560	470	582	546	570	485	584	447	397	425	353
151	541	564	473	586	551	574	489	589	450	401	429	356
152	545	568	478	590	555	579	493	593	454	404	433	360
153	549	572	481	595	559	583	497	597	458	408	437	364
154	554	577	485	599	563	587	501	602	462	412	441	367
155	558	581	489	603	568	591	506	606	465	415	444	370
156	562	585	493	607	572	596	510	610	469	419	448	374
157	566	589	497	612	576	600	514	615	473	423	452	377
158	570	594	501	616	580	604	518	619	478	427	456	381
159	574	598	505	620	585	608	522	624	480	430	459	385
160	578	602	509	624	589	612	526	628	484	434	463	388
161	583	607	513	629	593	617	530	632	488	438	467	392
162	587	611	517	633	597	621	534	636	491	442	471	395
163	591	615	521	637	601	625	538	640	495	445	474	399
164	595	619	525	641	605	629	542	645	499	449	478	402
165	599	623	529	645	609	633	546	649	502	453	482	406
166	603	627	533	650	613	637	550	653	506	457	486	409
167	607	632	536	654	618	642	554	658	510	460	489	413
168	611	636	540	658	622	646	557	662	514	464	493	417
169	615	640	544	662	626	650	561	666	517	467	497	420
170	619	644	548	666	630	654	565	670	521	472	501	424
171	624	648	552	671	634	658	569	674	525	475	504	427
172	628	653	556	675	638	662	573	679	529	479	508	431
173	632	657	560	679	642	666	577	683	532	482	512	434
174	636	661	564	683	646	671	581	687	536	486	516	438
175	640	665	567	687	650	675	585	691	540	490	519	441
176	644	669	571	691	654	679	589	695	543	493	523	445
177	648	673	575	695	658	683	593	699	547	497	527	448
178	652	677	579	700	662	687	596	704	551	501	530	452
179	656	681	582	704	666	691	600	708	555	504	534	455
180	660	685	586	708	670	695	604	712	558	508	538	459
181	664	690	590	712	674	699	608	716	562	512	542	463
182	668	694	594	716	678	703	612	720	566	516	545	466
183	672	698	597	720	682	707	616	724	569	519	549	470
184	676	702	601	724	686	711	619	728	573	523	553	473
185	680	706	605	728	690	715	623	732	577	527	556	477
186	684	710	609	732	694	719	627	736	580	530	560	480
187	688	714	613	736	698	723	631	740	584	534	564	484
188	692	718	617	740	702	727	635	744	588	538	567	487
189	696	722	621	744	706	731	639	748	592	541	571	491
190	699	726	624	748	710	735	642	752	595	545	575	494
191	703	730	628	752	714	739	646	756	599	549	579	498

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Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

21 August 2008

Time (min)	P11 CCAve	P11 Sec C-C TC #9 (°F)	P11 Sec C-C TC #10 (°F)	P11 Sec C-C TC #11 (°F)	P11 DDAve	P11 Sec D-D TC #12 (°F)	P11 Sec D-D TC #13 (°F)	P11 Sec D-D TC #14 (°F)	P14 Max	P14 AAAve	P14 Sec A-A TC #1 (°F)	P14 Sec A-A TC #2 (°F)
192	707	734	632	756	718	743	650	760	602	552	582	502
193	711	738	636	760	722	747	654	764	606	556	586	505
194	715	742	640	764	726	751	658	768	610	559	589	508
195	719	746	644	768	729	755	661	772	613	563	593	512
196	723	750	647	772	733	759	665	776	617	567	597	515
197	727	754	651	776	737	762	669	780	621	571	601	519
198	731	758	655	780	741	766	673	784	624	574	604	522
199	735	762	659	784	745	770	677	788	628	578	608	526
200	739	766	663	788	749	774	681	792	632	581	611	529
201	743	770	666	792	753	778	684	796	636	585	615	533
202	747	774	670	796	757	782	688	800	639	588	619	536
203	751	778	674	800	761	786	692	804	643	592	622	540
204	755	782	678	804	765	790	696	808	646	596	626	543
205	758	785	682	808	769	794	700	812	650	599	630	547
206	762	790	685	812	772	797	703	816	654	603	633	550
207	766	793	689	816	776	801	707	820	657	607	637	554
208	770	797	693	820	780	805	711	824	661	610	641	557
209	774	801	697	823	784	809	715	828	664	614	644	560
210	778	805	701	827	788	813	718	832	668	617	648	564
211	781	809	704	831	792	817	722	836	672	621	651	567
212	785	813	708	835	796	821	726	840	675	625	655	571
213	789	817	712	839	799	824	730	844	679	628	658	574
214	793	820	716	843	803	828	733	848	682	632	662	578
215	797	824	720	847	807	832	737	852	686	635	665	581
216	801	828	723	851	811	836	741	856	690	639	669	585
217	805	832	727	855	815	840	745	860	693	642	673	588
218	809	836	731	859	819	843	749	864	697	646	676	592
219	813	840	735	863	822	847	752	868	700	650	680	595
220	817	844	739	867	826	851	756	872	704	653	684	598
221	821	848	743	871	830	855	760	876	707	657	687	602
222	824	852	746	875	834	859	764	880	711	660	691	605
223	828	855	750	878	838	863	768	884	715	664	694	608
224	832	859	754	882	842	866	771	888	718	667	698	612
225	836	863	758	886	846	870	775	892	722	671	701	615
226	840	867	762	890	850	874	779	896	725	674	705	619
227	843	871	765	894	853	877	783	899	729	678	708	622
228	847	874	769	898	857	881	786	903	733	681	712	626
229	851	878	773	901	861	885	790	907	736	685	716	629
230	855	882	777	905	864	888	794	911	740	688	719	633
231	859	886	780	909	868	892	798	915	743	692	722	636
232	862	889	784	913	871	895	801	918	748	696	726	640
233	866	893	788	916	875	899	805	922	750	699	730	643
234	870	897	792	920	879	903	809	926	754	702	733	646
235	873	900	796	924	882	906	812	929	757	706	737	650
236	877	904	799	927	886	910	816	933	760	709	740	653
237	881	908	803	931	890	913	820	937	764	713	743	657
238	884	911	807	935	894	917	824	941	767	716	747	660
239	888	915	811	939	897	920	827	944	771	720	751	664
240	892	919	815	942	901	924	831	948	774	723	754	667
Max T	892	919	815	942	901	924	831	948	774	723	754	667
Max A	1000	1200	1200	1200	1000	1200	1200	1200	1200	1000	1200	1200

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Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

21 August 2008

Time (min)	P14 Sec A-A TC #3 (°F)	P14 Sec A-A TC #4 (°F)	P14 Sec A-A TC #5 (°F)	P14 BBAve	P14 Sec B-B TC #6 (°F)	P14 Sec B-B TC #7 (°F)	P14 Sec B-B TC #8 (°F)
0	82	82	82	82	82	82	badtc
1	82	82	82	82	82	82	badtc
2	82	82	82	82	82	82	badtc
3	82	82	82	83	82	83	badtc
4	83	82	82	83	82	83	badtc
5	83	82	82	83	82	83	badtc
6	82	82	82	82	81	82	badtc
7	81	82	82	82	81	82	badtc
8	81	82	82	82	81	82	badtc
9	81	82	82	82	81	82	badtc
10	81	82	82	82	81	82	badtc
11	81	82	82	82	81	82	badtc
12	81	82	82	82	81	82	badtc
13	81	82	82	82	81	82	badtc
14	80	82	82	82	81	82	badtc
15	80	82	82	82	81	82	badtc
16	80	82	82	82	81	83	badtc
17	80	82	82	82	81	83	badtc
18	80	82	82	82	81	83	badtc
19	81	82	82	82	81	83	badtc
20	81	82	82	83	82	83	badtc
21	81	82	83	83	82	83	badtc
22	82	83	83	83	82	83	badtc
23	82	83	83	83	83	83	badtc
24	82	83	83	84	83	84	badtc
25	83	84	84	84	84	84	badtc
26	84	84	84	85	85	84	badtc
27	85	85	84	85	85	84	badtc
28	85	85	85	85	86	84	badtc
29	86	86	85	86	86	85	badtc
30	87	86	86	86	87	85	badtc
31	87	87	86	87	88	85	badtc
32	88	87	87	87	89	85	badtc
33	89	88	87	88	89	86	badtc
34	90	88	88	88	90	86	badtc
35	90	89	89	89	91	86	badtc
36	91	89	89	90	92	87	badtc
37	92	90	90	90	92	87	badtc
38	93	91	90	90	93	87	badtc
39	94	92	91	91	94	88	badtc
40	95	92	92	92	95	88	badtc
41	95	93	93	92	95	89	badtc
42	96	94	93	93	96	89	badtc
43	97	94	94	94	97	90	badtc
44	98	95	95	94	98	90	badtc
45	99	96	95	95	99	91	badtc
46	100	97	96	95	99	91	badtc
47	101	98	97	96	100	92	badtc
48	102	99	98	97	101	92	badtc
49	103	100	99	98	102	93	badtc
50	104	101	100	98	103	93	badtc
51	105	102	101	99	104	94	badtc
52	106	103	102	100	105	95	badtc
53	108	104	103	101	107	95	badtc
54	109	105	104	102	108	96	badtc
55	110	106	105	103	109	97	badtc
56	111	107	106	105	111	98	badtc
57	113	108	107	106	113	98	badtc
58	114	109	109	107	114	99	badtc
59	116	111	110	108	116	100	badtc
60	118	112	112	110	118	101	badtc
61	119	113	113	111	120	102	badtc
62	121	115	115	113	122	103	badtc
63	123	117	117	114	124	104	badtc

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Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

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Time (min)	P14 Sec A-A TC #3 (°F)	P14 Sec A-A TC #4 (°F)	P14 Sec A-A TC #5 (°F)	P14 BBAvs	P14 Sec B-B TC #6 (°F)	P14 Sec B-B TC #7 (°F)	P14 Sec B-B TC #8 (°F)
64	125	118	119	116	126	105	badtc
65	127	120	121	117	128	106	badtc
66	129	122	123	119	130	107	badtc
67	132	124	125	121	133	109	badtc
68	134	126	127	123	135	110	badtc
69	137	128	129	125	138	112	badtc
70	139	130	131	127	140	113	badtc
71	142	132	134	129	143	115	badtc
72	144	134	136	131	145	117	badtc
73	147	136	138	133	148	118	badtc
74	149	138	141	136	151	120	badtc
75	152	140	143	138	153	122	badtc
76	155	143	146	140	156	124	badtc
77	157	145	148	143	159	126	badtc
78	160	147	150	145	161	128	badtc
79	162	150	153	147	164	130	badtc
80	165	152	155	149	166	132	badtc
81	167	155	158	152	169	134	badtc
82	169	158	161	154	172	135	badtc
83	171	158	163	156	173	137	badtc
84	173	161	165	158	176	140	badtc
85	176	164	168	160	178	142	badtc
86	179	167	171	164	182	145	badtc
87	183	169	174	167	186	147	badtc
88	187	172	177	170	189	150	badtc
89	191	175	180	173	193	152	badtc
90	196	178	183	176	196	155	badtc
91	200	182	186	179	200	157	badtc
92	204	185	190	182	204	160	badtc
93	208	188	193	185	208	162	badtc
94	212	191	196	188	211	165	badtc
95	216	195	199	192	215	168	badtc
96	220	198	202	195	218	171	badtc
97	223	201	206	198	222	173	badtc
98	227	205	209	201	226	176	badtc
99	231	208	212	204	229	179	badtc
100	235	212	215	208	233	182	badtc
101	238	215	218	211	236	185	badtc
102	242	219	222	214	240	188	badtc
103	246	222	225	218	244	191	badtc
104	250	225	228	221	247	194	badtc
105	254	229	232	224	251	197	badtc
106	257	232	235	227	254	200	badtc
107	261	236	238	231	258	203	badtc
108	265	239	241	234	261	206	badtc
109	269	243	245	237	265	209	badtc
110	272	246	248	241	268	213	badtc
111	276	250	251	244	272	216	badtc
112	280	253	255	247	275	219	badtc
113	284	257	258	251	279	222	badtc
114	287	260	261	254	282	225	badtc
115	291	264	265	257	286	228	badtc
116	295	267	268	261	290	232	badtc
117	299	271	271	264	293	235	badtc
118	302	274	274	268	297	238	badtc
119	306	278	278	271	300	241	badtc
120	310	282	281	274	304	244	badtc
121	314	285	285	278	307	248	badtc
122	318	289	288	281	311	251	badtc
123	322	292	291	284	314	254	badtc
124	325	296	295	288	318	257	badtc
125	329	299	298	291	321	260	badtc
126	333	303	302	295	325	264	badtc
127	337	307	305	298	329	267	badtc

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Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

21 August 2008

Time (min)	P14 Sec A-A TC #3 (°F)	P14 Sec A-A TC #4 (°F)	P14 Sec A-A TC #5 (°F)	P14 BBAvs	P14 Sec B-B TC #6 (°F)	P14 Sec B-B TC #7 (°F)	P14 Sec B-B TC #8 (°F)
128	341	310	308	301	332	270	badtc
129	345	314	312	305	336	274	badtc
130	348	318	315	308	339	277	badtc
131	352	321	319	312	343	280	badtc
132	356	325	322	315	346	284	badtc
133	360	329	326	319	350	287	badtc
134	364	332	329	322	353	290	badtc
135	368	336	333	325	357	293	badtc
136	372	339	336	328	360	296	badtc
137	376	343	340	332	364	300	badtc
138	380	347	343	336	368	303	badtc
139	384	351	346	339	371	306	badtc
140	388	354	350	343	375	310	badtc
141	392	358	354	346	379	313	badtc
142	396	362	357	350	382	317	badtc
143	400	366	361	353	386	320	badtc
144	404	370	364	357	390	323	badtc
145	408	373	368	360	393	326	badtc
146	412	377	372	364	397	330	badtc
147	416	381	375	367	400	333	badtc
148	420	385	379	370	404	336	badtc
149	424	388	382	374	407	340	badtc
150	428	392	386	377	411	343	badtc
151	432	396	390	381	415	346	badtc
152	436	400	393	384	418	350	badtc
153	440	404	397	388	422	353	badtc
154	444	407	400	391	425	356	badtc
155	448	411	404	395	429	360	badtc
156	452	415	407	398	433	363	badtc
157	455	419	411	402	436	367	badtc
158	459	422	415	405	440	370	badtc
159	463	426	418	408	443	373	badtc
160	467	430	422	412	447	377	badtc
161	471	434	426	415	450	380	badtc
162	475	438	429	419	454	383	badtc
163	479	441	433	422	457	387	badtc
164	483	445	436	426	461	390	badtc
165	487	449	440	429	465	393	badtc
166	491	453	444	433	468	397	badtc
167	495	457	447	436	472	400	badtc
168	499	460	451	439	475	403	badtc
169	502	464	454	443	479	407	badtc
170	507	468	458	446	482	410	badtc
171	510	472	462	450	486	414	badtc
172	514	475	465	454	490	417	badtc
173	518	479	469	457	493	420	badtc
174	522	483	472	461	497	424	badtc
175	526	487	476	464	500	427	badtc
176	530	490	479	467	503	430	badtc
177	534	494	483	471	507	434	badtc
178	537	498	487	474	511	437	badtc
179	541	501	490	477	514	440	badtc
180	545	505	494	481	518	444	badtc
181	549	509	498	484	521	447	badtc
182	553	513	501	488	525	451	badtc
183	557	516	505	491	528	454	badtc
184	560	520	508	495	532	457	badtc
185	564	524	512	498	535	461	badtc
186	568	528	516	502	539	464	badtc
187	572	532	519	505	542	467	badtc
188	576	535	523	509	546	471	badtc
189	580	539	526	512	549	474	badtc
190	583	542	530	515	553	477	badtc
191	587	546	534	519	556	481	badtc

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Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

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Time (min)	P14 Sec A-A TC #3 (°F)	P14 Sec A-A TC #4 (°F)	P14 Sec A-A TC #5 (°F)	P14 BBAvs	P14 Sec B-B TC #6 (°F)	P14 Sec B-B TC #7 (°F)	P14 Sec B-B TC #8 (°F)
192	591	550	537	522	560	484	badtc
193	595	554	541	525	563	487	badtc
194	599	557	544	529	567	490	badtc
195	602	561	548	532	570	494	badtc
196	606	565	551	536	574	497	badtc
197	610	568	555	539	577	500	badtc
198	614	572	559	543	581	504	badtc
199	617	576	562	546	584	507	badtc
200	621	579	566	549	588	510	badtc
201	625	583	569	553	591	514	badtc
202	629	587	573	556	595	517	badtc
203	632	590	576	559	598	520	badtc
204	636	594	580	563	602	523	badtc
205	640	597	583	566	605	527	badtc
206	644	601	587	569	608	530	badtc
207	647	605	590	573	612	533	badtc
208	651	608	594	576	615	536	badtc
209	655	612	597	580	619	540	badtc
210	658	616	601	583	622	543	badtc
211	662	619	605	586	625	546	badtc
212	666	623	608	590	629	550	badtc
213	670	627	612	593	632	553	badtc
214	673	630	615	596	636	556	badtc
215	677	634	619	599	639	559	badtc
216	681	637	622	603	643	562	badtc
217	684	641	626	606	646	566	badtc
218	688	645	629	609	649	569	badtc
219	692	648	633	613	653	572	badtc
220	695	652	636	616	656	575	badtc
221	699	655	640	620	660	579	badtc
222	702	659	643	623	663	582	badtc
223	706	663	647	626	666	585	badtc
224	710	666	650	629	670	588	badtc
225	713	670	654	633	673	592	badtc
226	717	673	657	636	676	595	badtc
227	721	677	661	639	680	598	badtc
228	724	680	664	642	683	601	badtc
229	728	684	668	645	686	604	badtc
230	731	687	671	649	690	608	badtc
231	735	691	674	652	693	611	badtc
232	739	695	678	655	696	614	badtc
233	742	698	681	659	700	617	badtc
234	746	702	685	662	703	621	badtc
235	749	705	689	665	706	624	badtc
236	753	709	692	669	710	627	badtc
237	756	712	695	672	713	630	badtc
238	760	716	699	675	716	633	badtc
239	764	719	702	679	720	637	badtc
240	767	723	706	682	723	640	badtc
Max T	767	723	706	682	723	640	badtc
Max A	1200	1200	1200	1000	1200	1200	1200

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Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

APPENDIX C
Photographs

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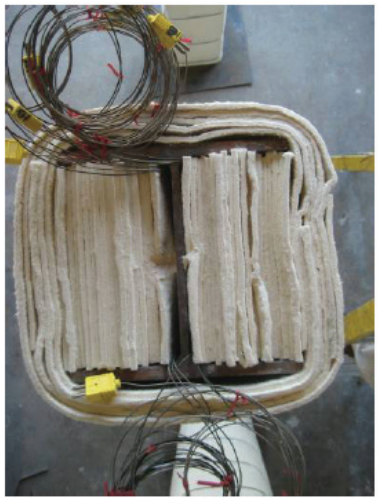
Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL



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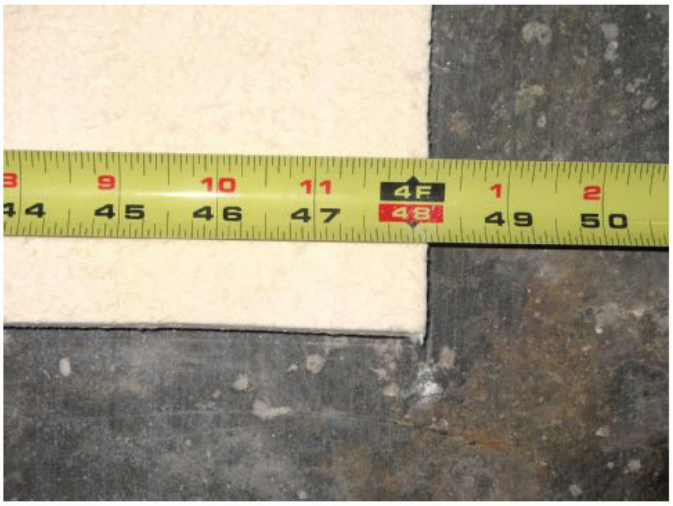

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Appendix F UL 1709 – RAPID RISE FIRE TESTS OF PROTECTION MATERIALS FOR STRUCTURAL STEEL

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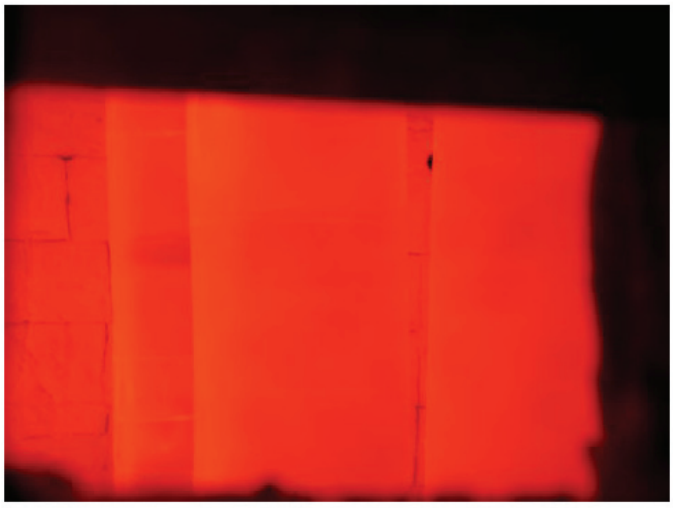

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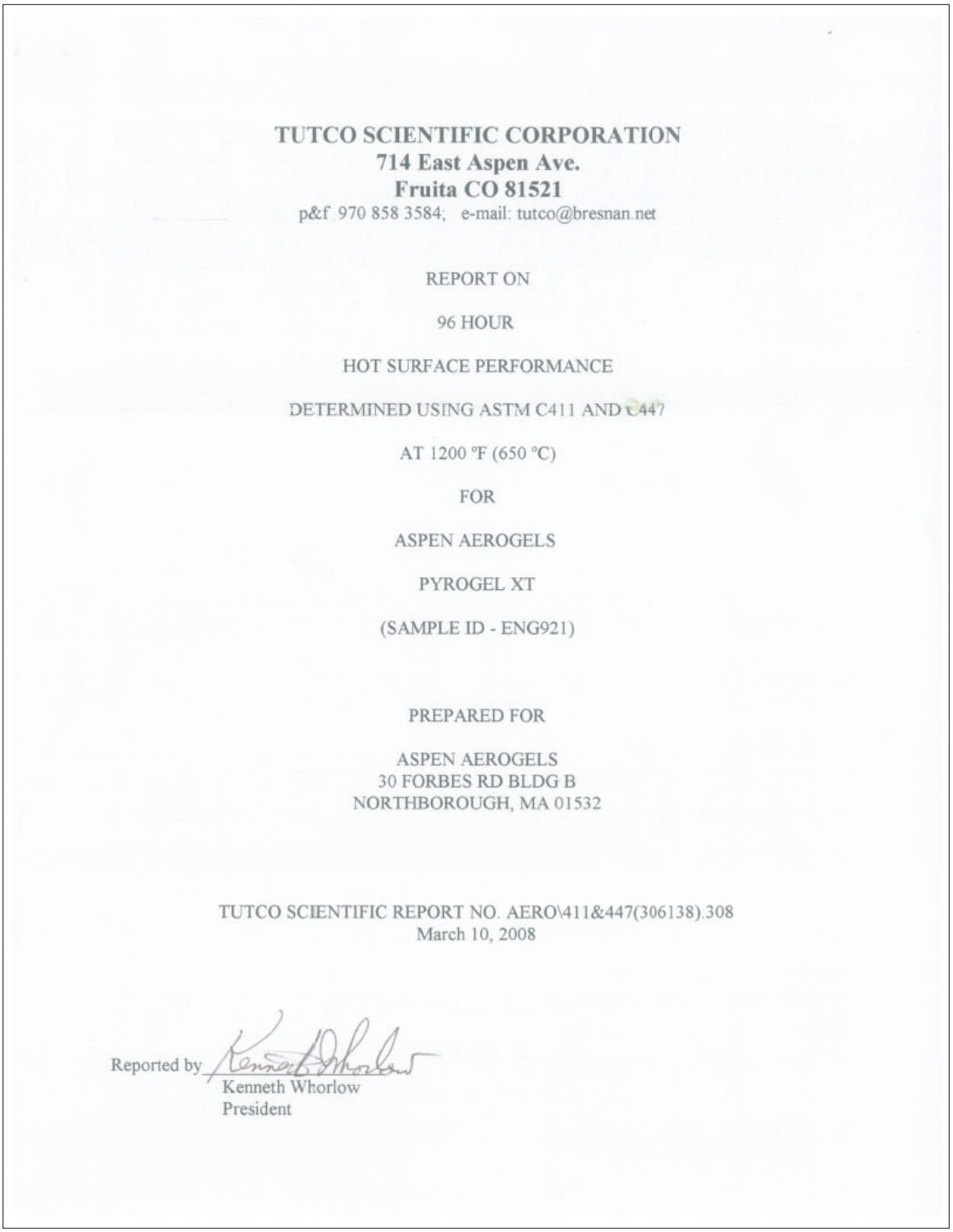
REVISION SUMMARY

DATE	SUMMARY
<Insert date of revision>	<Insert Summary of revision>

Intertek

Appendix G ASTM C 411/C 447 – HOT SURFACE PERFORMANCE



TUTCO SCIENTIFIC CORPORATION
714 East Aspen Ave.
Fruita CO 81521
p&f 970 858 3584; e-mail: tutco@bresnan.net

REPORT ON

96 HOUR

HOT SURFACE PERFORMANCE

DETERMINED USING ASTM C411 AND C447

AT 1200 °F (650 °C)

FOR

ASPEN AEROGELS

PYROGEL XT

(SAMPLE ID - ENG921)

PREPARED FOR

ASPEN AEROGELS
30 FORBES RD BLDG B
NORTHBOROUGH, MA 01532

TUTCO SCIENTIFIC REPORT NO. AERO\411&447(306138).308
March 10, 2008

Reported by
Kenneth Whorlow
President

Appendix G ASTM C 411/C 447 – HOT SURFACE PERFORMANCE

AERO\411&447(306138).308
PAGE 2

Project: Determine the hot surface performance and the interior temperature rise of one sample of Flexible Insulation Blanket received from Aspen Aerogels. The testing was conducted by request of Cindy MacLaurin by letter for purchase order 306138.

Samples: The sample was identified as Pyrogel XT, Sample ID ENG921

Test Method: ASTM C 411 (Hot Surface Performance of High-Temperature Thermal Insulation - Pipe Insulation Method) continuing the test for 4 days as required by C 411. The test was conducted at 1200 °F (650 °C) hot surface temperature. In addition, during the heat up, the interior temperature rise at layers 2, 4, 6, 8, and 10 were recorded in accord with C447 section 8.1.6. Shrinkage across the 36" length and around the first and part of the second wrap was determined as described in the procedure section.

Procedure: The temperature was targeted to be 1200 °F (650 °C) and the temperature of the hot pipe surface was within +/- 25 °F as required by ASTM C411. The material was installed on the pipe as a continuous 11 ply installation with 4 inches overlapping the outside seam. Sheathed thermocouples were placed between layers 2-3, 4-5, 6-7, 8-9, 10-11. The data was recorded by a data logger 4 times a minute during the heating of the pipe (approximately 400 minutes). An aluminum jacket was installed over the insulation. The hot surface temperature of the pipe was controlled to a maximum of 1200 °F (650 °C) and monitored with thermocouples on the surface of the hot pipe and guards. The test was continued for 96 hours at the 1200 °F (650 °C) hot surface temperature.

The leading edge of the insulation material was started on the pipe using wire. A 0.06 inch wire was wrapped around the pipe and twisted tight. One lead was clipped and the other formed into a small hook. The wires were used in the center and 2 inches from each end. The leading edge of the material was pushed onto the hook, and then the wire hook was tapped flat. The insulation material was then wrapped around the affixed leading edge. The 11 layers of material were wrapped tight and were held in place on the pipe using fiberglass reinforced tape wrapped around the outer layer of insulation. The tape was positioned approximately 2 inches from each end and at 10 inch intervals. The aluminum jacket was installed on the test pipe using wire at the center and 6 inches in from each end. The circumference of the insulation was 30.75 inches and the circumference with the aluminum jacket installed was 31 inches.

Shrinkage across the 36" length of the leading edge and 10 cm back from the leading edge was measured. Circumferential shrinkage around the first wrap and part of the second wrap were determined at 10 cm intervals. The shrinkage was determined by imbedding small staples along the edges and up the center of the blanket. The distance between the staples was measured to 0.1 cm accuracy using a tape measure before and after exposure. The percentage changes for the measurements are provided.

Observations and Results: After 4-days exposure at 1200 °F (650 °C)

Figure 1 is a graph of the thermocouple temperatures at the layers and cold surface during heat-up and continuing for the first 400 minutes of the test. None of the layers indicated an exothermic heat rise.

Appendix G ASTM C 411/C 447 – HOT SURFACE PERFORMANCE

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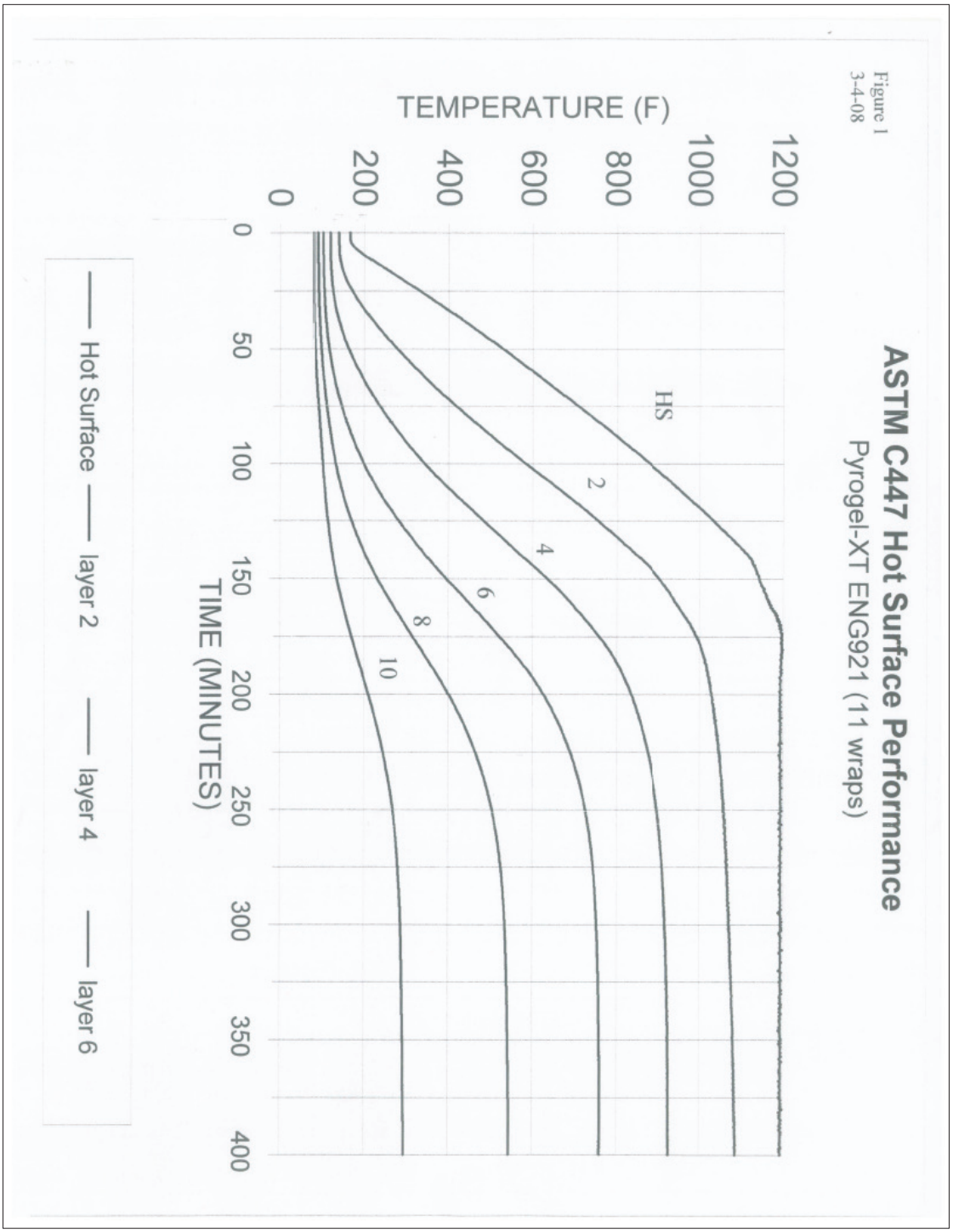
Observations and Results: (continued)
There were no observed changes of the installed material during the test or at the conclusion of the 96 hour heating period. After the test equipment had cooled, the material was removed from the pipe and remained intact.
1. Visual examination during the test period was limited because of the exterior metal jacket.
2. There was no apparent flaming, glowing, smoldering, or smoking at any time during the test that could be seen at the exposed ends of the jacketed material.
3. There was some odor during the heating.
4. None of the layers indicated an exothermic heat rise.
5. Visual examination of the exterior of the installed material at the conclusion of the test, after the pipe had cooled and the jacket was removed, showed no apparent sagging, surface cracking, warpage, de-lamination or shrinkage.
6. After disassembly, all layers of the 11 ply pipe insulation showed no apparent sagging, surface cracking, warpage, de-lamination or shrinkage. The material remained flexible.
7. The was no evidence of flaming, glowing, smoldering, or smoking on the inner layers.

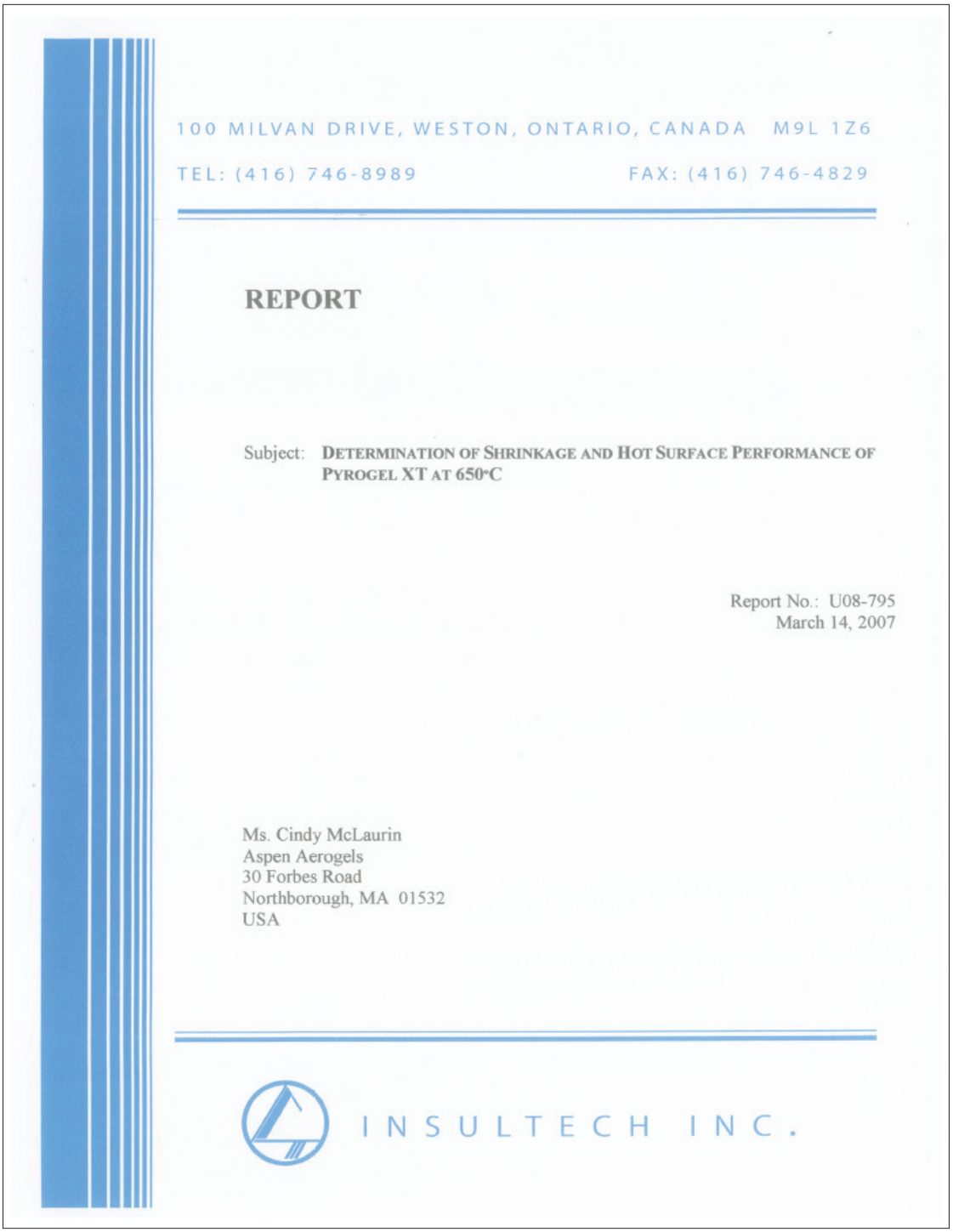
Results of the Shrinkage Measurements during C411 Hot Surface Performance test

1. Across the 36 inch length of the leading edge the percentage shrinkage was 0.9%.
2. Across the 36 inch length approximately 10 cm back from the leading edge the percentage shrinkage was 0.8%.
3. The circumferential shrinkage was measured along both sides and in the center of the blanket, along the leading edge and at approximately 10 cm positions back from the leading edge. The average percentage shrinkage at the leading edge was 1.77%. The average percentage shrinkage at the next four positions were: 1.65%, 2.66%, 2.02%, 2.65%
4. The measured circumferential shrinkage around the sample was greater than across the width. This is probably due to the added condition of permanent wrinkles caused by compression of the measured surface of the blanket as it is wrapped around the pipe. The wrinkles are not an indication of shrinkage of the blanket fibers.

Appendix G ASTM C 411/C 447 – HOT SURFACE PERFORMANCE



Appendix H ASTM C 356 & C 411 – LINEAR SHRINKAGE AND HOT SURFACE PERFORMANCE



100 MILVAN DRIVE, WESTON, ONTARIO, CANADA M9L 1Z6

TEL: (416) 746-8989 FAX: (416) 746-4829

REPORT

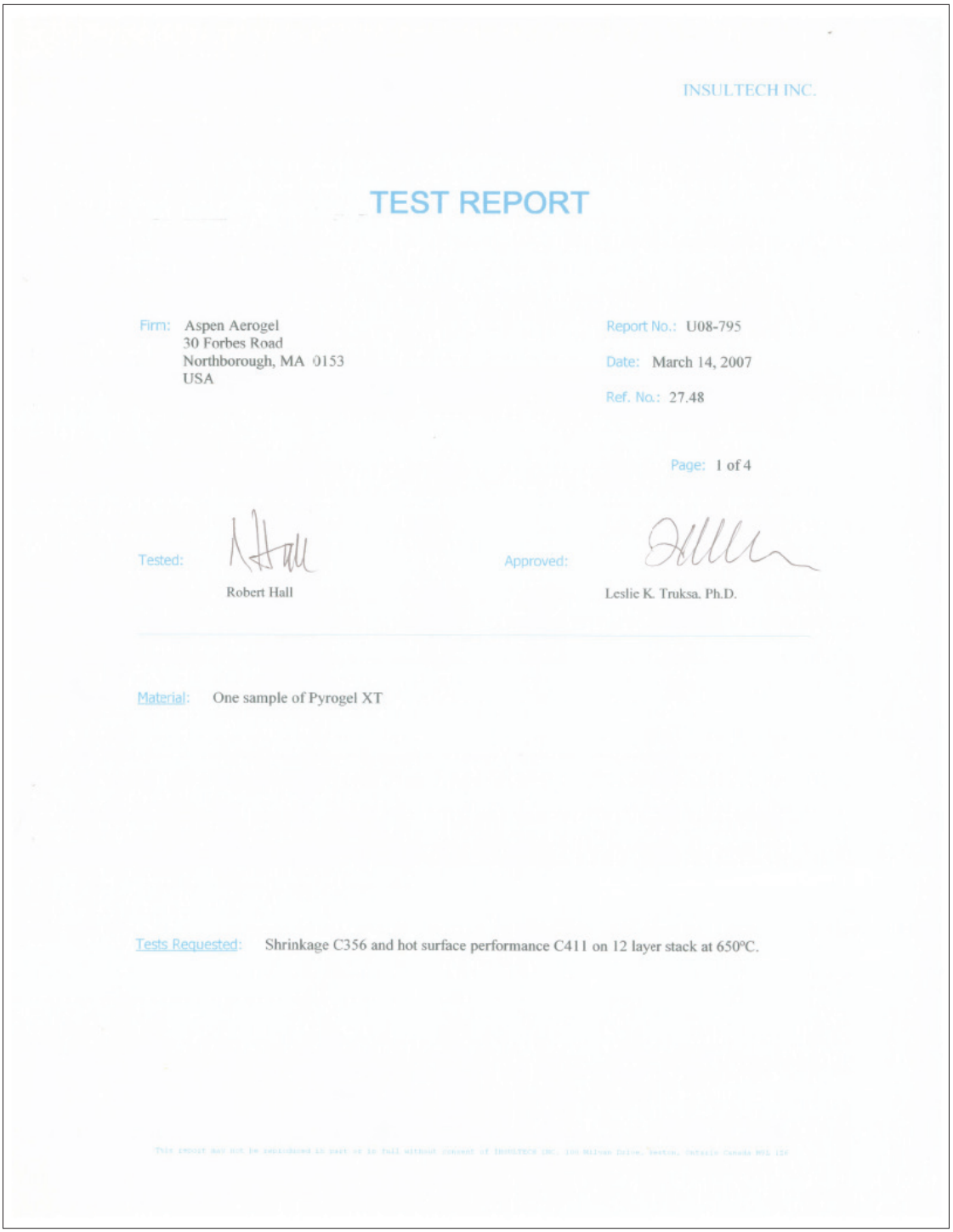
Subject: **DETERMINATION OF SHRINKAGE AND HOT SURFACE PERFORMANCE OF PYROGEL XT AT 650°C**

Report No.: U08-795
March 14, 2007

Ms. Cindy McLaurin
Aspen Aerogels
30 Forbes Road
Northborough, MA 01532
USA

INSULTECH INC.

Appendix H ASTM C 356 & C 411 – LINEAR SHRINKAGE AND HOT SURFACE PERFORMANCE



INSULTECH INC.

TEST REPORT

Firm: Aspen Aerogel
30 Forbes Road
Northborough, MA 0153
USA

Report No.: U08-795
Date: March 14, 2007
Ref. No.: 27.48

Page: 1 of 4

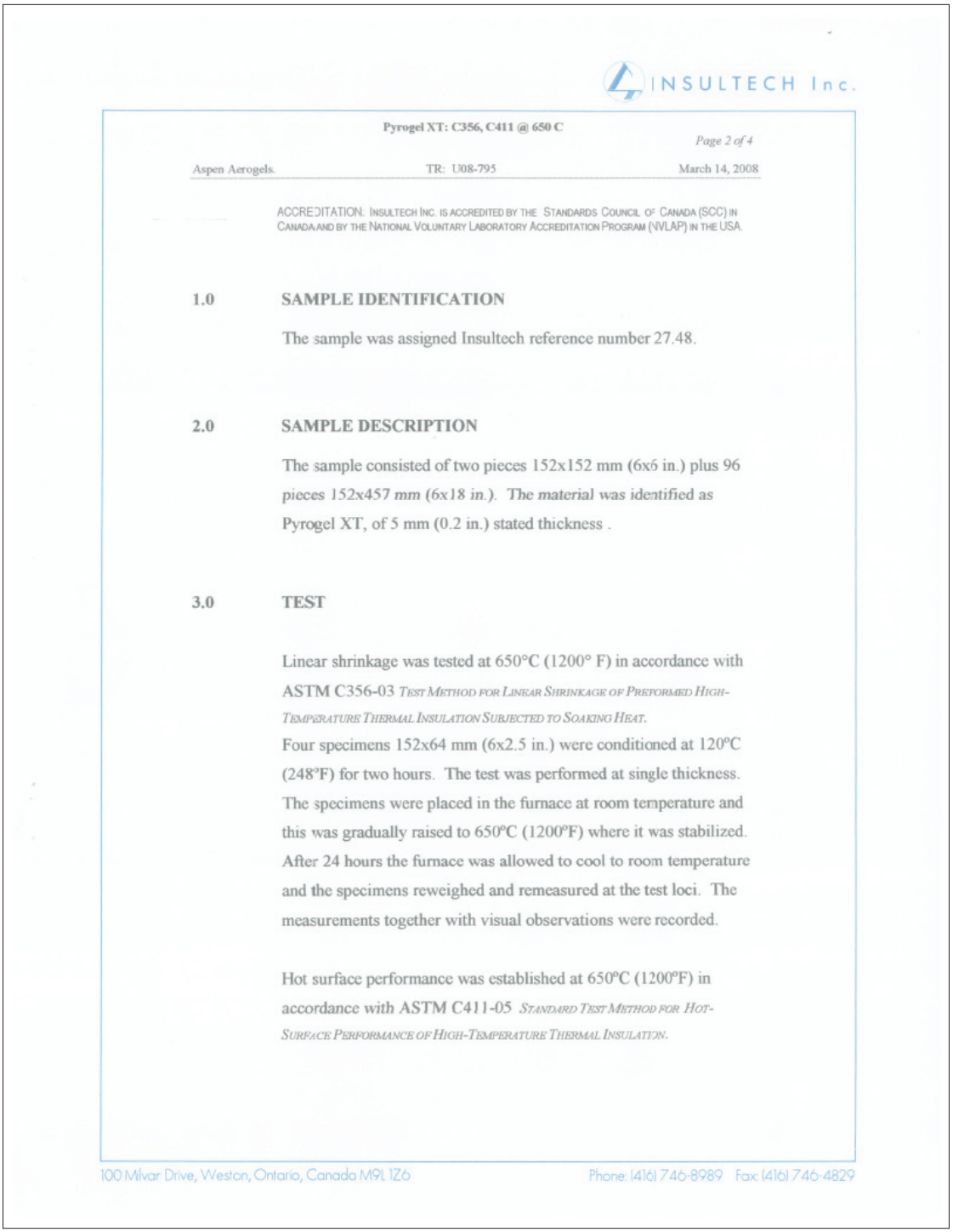
Tested: Robert Hall

Approved: Leslie K. Truksa, Ph.D.

Material: One sample of Pyrogel XT

Tests Requested: Shrinkage C356 and hot surface performance C411 on 12 layer stack at 650°C.

Appendix H ASTM C 356 & C 411 – LINEAR SHRINKAGE AND HOT SURFACE PERFORMANCE



INSULTECH Inc.

Pyrogel XT: C356, C411 @ 650 C

Page 2 of 4

Aspen Aerogels. TR: U08-795 March 14, 2008

ACCREDITATION: INSULTECH INC. IS ACCREDITED BY THE STANDARDS COUNCIL OF CANADA (SCC) IN CANADA AND BY THE NATIONAL VOLUNTARY LABORATORY ACCREDITATION PROGRAM (NVLAP) IN THE USA.

1.0 SAMPLE IDENTIFICATION

The sample was assigned Insultech reference number 27.48.

2.0 SAMPLE DESCRIPTION

The sample consisted of two pieces 152x152 mm (6x6 in.) plus 96 pieces 152x457 mm (6x18 in.). The material was identified as Pyrogel XT, of 5 mm (0.2 in.) stated thickness .

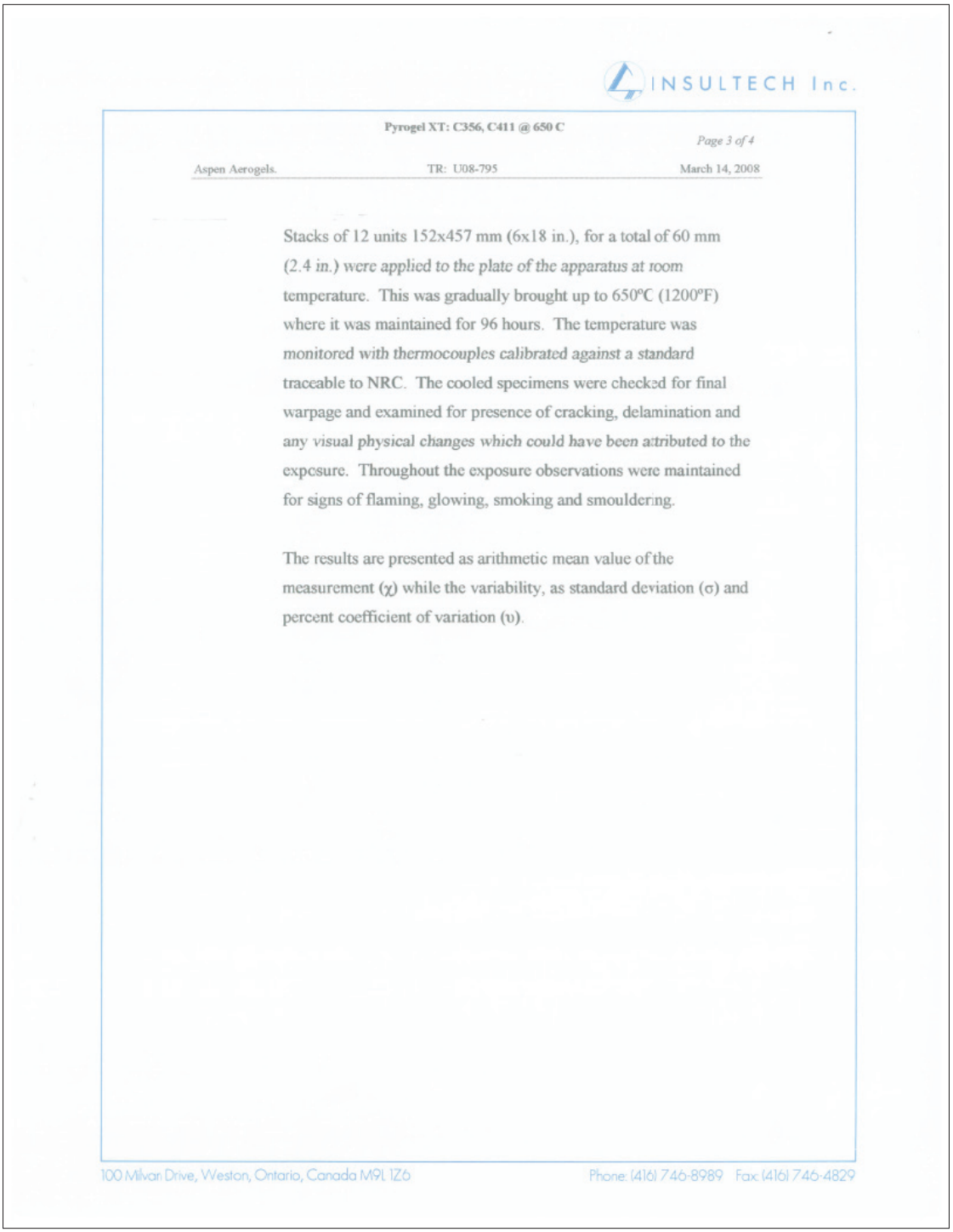
3.0 TEST

Linear shrinkage was tested at 650°C (1200° F) in accordance with ASTM C356-03 *Test Method for Linear Shrinkage of Preformed High-Temperature Thermal Insulation Subjected to Soaking Heat.* Four specimens 152x64 mm (6x2.5 in.) were conditioned at 120°C (248°F) for two hours. The test was performed at single thickness. The specimens were placed in the furnace at room temperature and this was gradually raised to 650°C (1200°F) where it was stabilized. After 24 hours the furnace was allowed to cool to room temperature and the specimens reweighed and remeasured at the test loci. The measurements together with visual observations were recorded.

Hot surface performance was established at 650°C (1200°F) in accordance with ASTM C411-05 *Standard Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation.*

100 Milvar Drive, Weston, Ontario, Canada M9L 1Z6 Phone: (416) 746-8989 Fax: (416) 746-4829

Appendix H ASTM C 356 & C 411 – LINEAR SHRINKAGE AND HOT SURFACE PERFORMANCE



INSULTECH Inc.

Pyrogel XT: C356, C411 @ 650 C

Aspen Aerogels. TR: U08-795 March 14, 2008

Stacks of 12 units 152x457 mm (6x18 in.), for a total of 60 mm (2.4 in.) were applied to the plate of the apparatus at room temperature. This was gradually brought up to 650°C (1200°F) where it was maintained for 96 hours. The temperature was monitored with thermocouples calibrated against a standard traceable to NRC. The cooled specimens were checked for final warpage and examined for presence of cracking, delamination and any visual physical changes which could have been attributed to the exposure. Throughout the exposure observations were maintained for signs of flaming, glowing, smoking and smouldering.

The results are presented as arithmetic mean value of the measurement (χ) while the variability, as standard deviation (σ) and percent coefficient of variation (υ).

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Appendix H ASTM C 356 & C 411 – LINEAR SHRINKAGE AND HOT SURFACE PERFORMANCE

INSULTECH Inc.

Pyrogel XT: C356, C411 @ 650 C

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Aspen Aerogels. TR: U08-795 March 14, 2008

4.0 RESULTS

.1 Linear shrinkage

	χ	(n=4) σ/υ
Mass loss on drying, %	0.26	0.087/32.97
Mass loss on test, %	1.05	0.185/17.61
Shrinkage, %	1.28	0.307.24.00
Visual observations: No significant change from the original.		

.2 **Hot surface performance**

Initial warpage: zero
Final warpage: zero

No cracking, delamination or change of state were observed.
All specimens appeared unchanged and retained good structural integrity.
Mid point maximum temperature was 463°C (865°F)
Maximum surface temperature recorded was 65.6 °C (150 °F).
There was no indication of glowing, smoking, smouldering or flaming.
There was no evidence of sustained exotherm.

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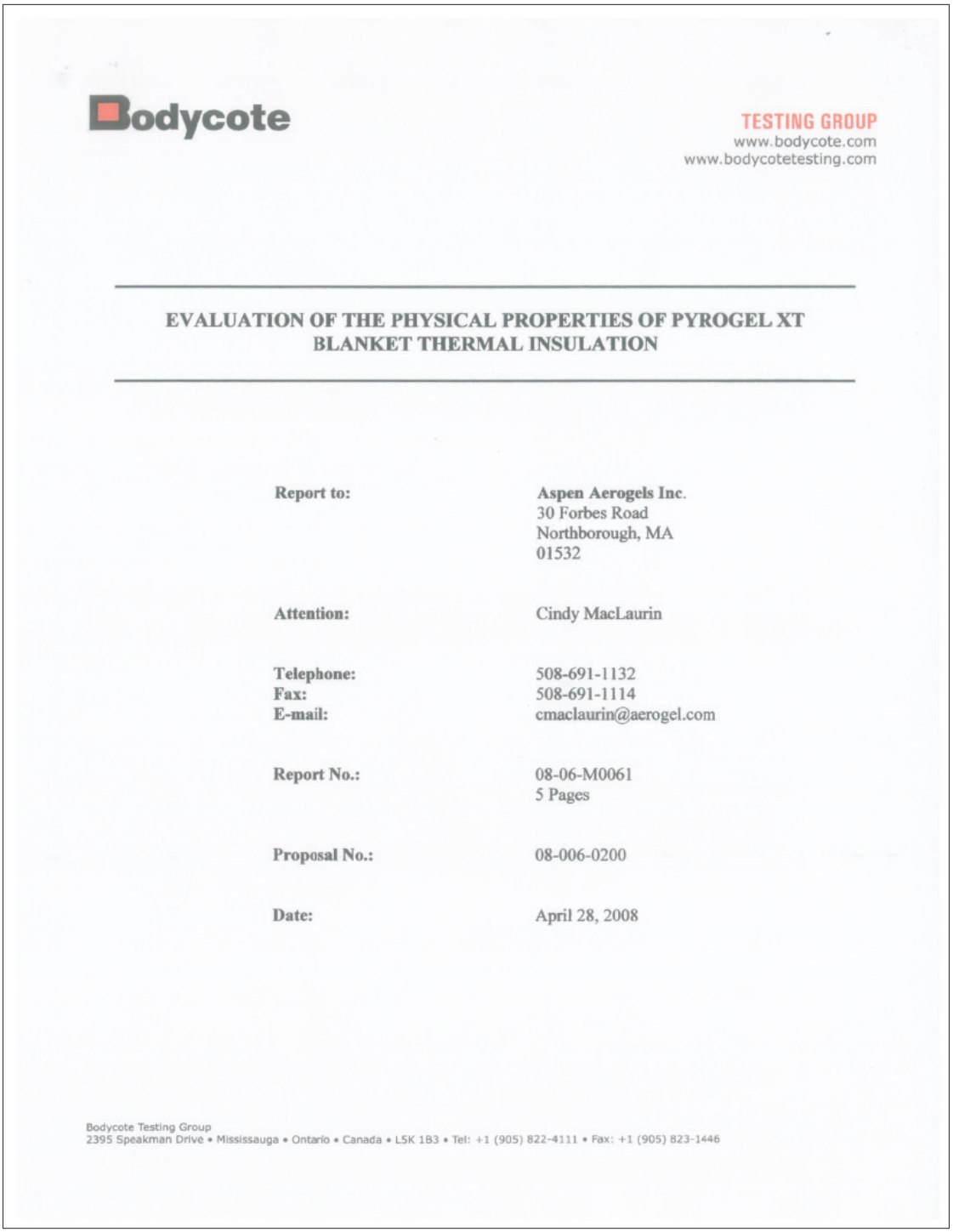
Appendix I MECHANICAL RESILIENCE AND WATER RESISTANCE



Bodycote

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

EVALUATION OF THE PHYSICAL PROPERTIES OF PYROGEL XT BLANKET THERMAL INSULATION

Report to:	**Aspen Aerogels Inc.** 30 Forbes Road Northborough, MA 01532
Attention:	Cindy MacLaurin
Telephone: **Fax:** **E-mail:**	508-691-1132 508-691-1114 cmaclaurin@aerogel.com
Report No.:	08-06-M0061 5 Pages
Proposal No.:	08-006-0200
Date:	April 28, 2008

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

Appendix I MECHANICAL RESILIENCE AND WATER RESISTANCE

1.0 INTRODUCTION

At the request of Aspen Aerogels Inc., Bodycote Testing Group was retained to evaluate several physical properties of a sample of thermal insulation material.

Upon receipt, the sample was assigned the following Bodycote Sample No.

Client Sample Description	Bodycote Sample No.
PYROGEL XT	08-06-M0061

2.0 PROCEDURE

The sample was evaluated according to the following standard test methods:

Test Description	Test Method
Standard Test Method for Determining the Water Vapor Sorption of Unfaced Mineral Fibre Insulation	ASTM C 1104 - 00
Standard Test Method for Determining the Water Retention (Repellency) Characterisitics of Glass Fibre Insulation	ASTM C 1511 - 04
Standard Test Method for Measuring Compressive Properties of Thermal Insulation	ASTM C 165 - 07
Standard Test Method for Determining Wicking of Glass Fibre Blanket Insulation	ASTM C 1559
Standard Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test)	ASTM D 5034 –95(2001)

Appendix I MECHANICAL RESILIENCE AND WATER RESISTANCE

3.0 RESULTS

A summary of all data is provided in table 1. Detailed results are provided in tables 2 through 6.

Table 1 – Summary of Results
Bodycote Sample No. 08-06-M0061

Description	Result
Water Vapor Sorption (ASTM C 1104)	
Mass Gain, %	2.25
Water Retention (Repellency) (ASTM C 1511)	
Water Repellency, g	16.3
Mass Gain, %	16.4
Volume of Water, %	4.2
Compressive Properties (ASTM C 165)	
5 layers, 30.2mm thickness	
Compressive Stress @ 10% Compression, kPa	103.1
Compressive Stress @ 25% Compression, kPa	217.4
Wicking (ASTM C 1559)	
As Received; 20°C; 168 hours, mm	0
As Received; 50°C; 168 hours, mm	0
336 hr Aged; 20°C; 168 hours, mm	0
336 hr Aged; 50°C; 168 hours, mm	2
Leached; 20°C; 168 hours, mm	0
Leached; 50°C; 168 hours, mm	1
Grab Test (ASTM D 5034)	
Maximum Load, Machine Direction, N	490
Maximum Load, Cross Direction, N	370

Table 2 – Water Vapor Sorption (ASTM C 1104)
Bodycote Sample No. 08-06-M0061

Specimen	Initial Mass, g	Final Mass, g
1	24.73	25.28
2	24.07	24.65
3	25.07	25.60
Average	**24.62**	**25.18**
	Mass Gain:	**2.25%**

Appendix I MECHANICAL RESILIENCE AND WATER RESISTANCE

Table 3 – Water Retention (ASTM C 1511)
Bodycote Sample No. 08-06-M0061

Specimen	Initial Mass, g	Final Mass, g
1	101.43	118.70
2	100.08	114.34
3	96.83	114.32
Average	**99.44**	**115.78**
	Water Repellency:	**16.3 g**
	Mass Gain:	**16.4 %**
	Volume of Water:	**4.2 %**

Table 4 – Compressive Strength (ASTM C 165)
Bodycote Sample No. 08-06-M0061

Specimen	Stress at 10% Compression, kPa	Stress at 25% Compression, kPa
1	103.1	214.4
2	108.1	217.4
3	112.7	172.1
Average	**108.0**	**201.3**

Table 5 – Wicking (ASTM C 1559)
Bodycote Sample No. 08-06-M0061

Duration, hrs	Max Height, mm		Max Height, mm		Max Height, mm	
	As Received		Heat Aged		Leached	
	20°C	50°C	20°C	50°C	20°C	50°C
24	0	0	0	1	0	0
48	0	0	0	1	0	0
72	0	0	0	1	0	1
96	0	0	0	1	0	1
168	0	0	0	2	0	1

Appendix I MECHANICAL RESILIENCE AND WATER RESISTANCE

Bodycote Testing Group

Evaluation of Physical Properties of Pyrogel XT for Aspen Aerogels Inc.

Page 5 of 5
Report No. 08-06-M0061

Table 6 – Grab Test (ASTM D 5034)
Bodycote Sample No. 08-06-M0061

Specimen	Maximum Load Machine Direction, N	Maximum Load Cross Direction, N
1	420	340
2	340	380
3	550	400
4	530	390
5	610	330
Average	490	370

Reported by:

David Beauchamp, B.Sc., Ext. 228
Scientist, Building Performance Centre
Product Testing Group

Reviewed by:

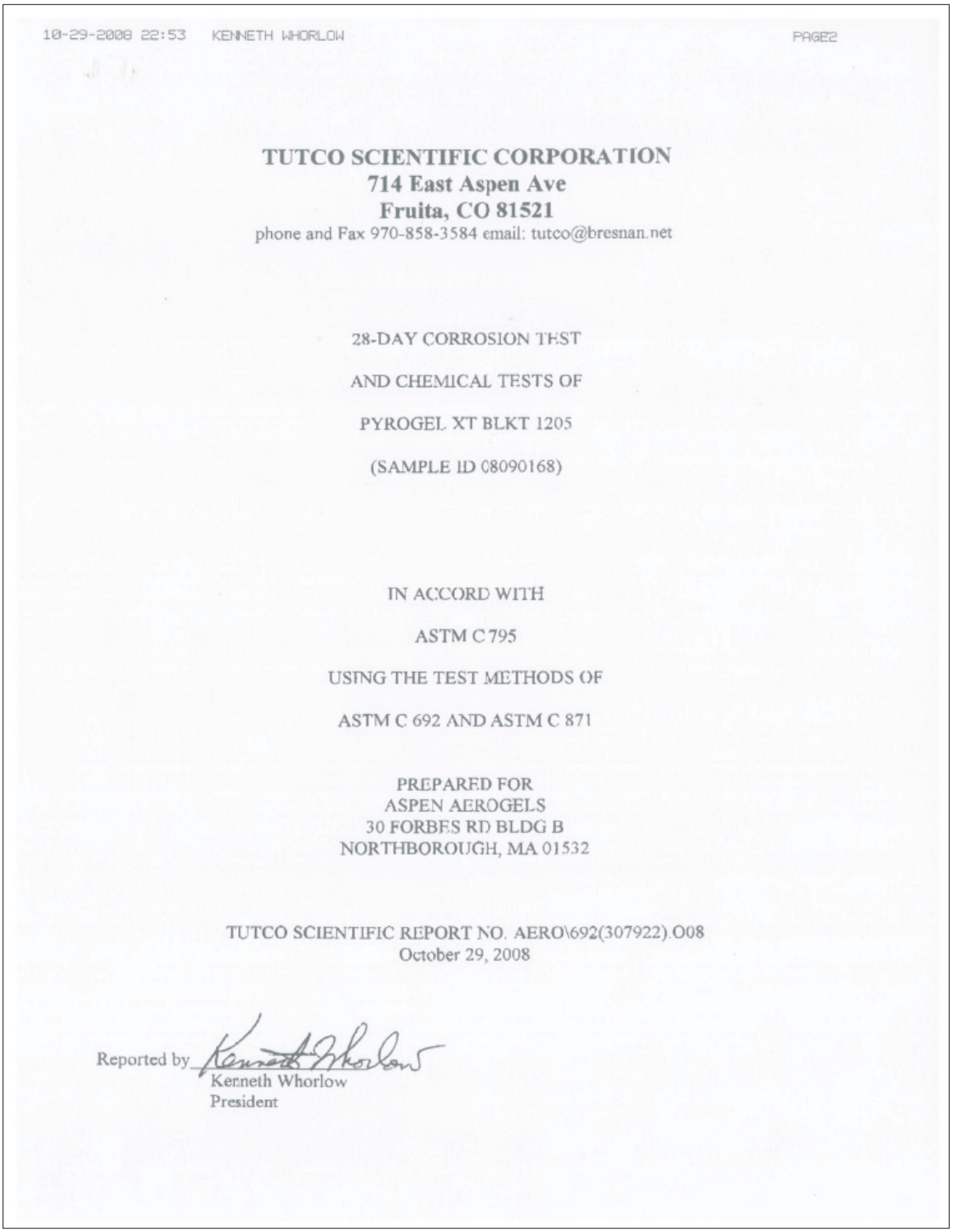
Franz C. Bauer, Ext. 403
Manager, Building Performance Centre
Product Testing Group

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

This report refers only to the particular samples, units, material, instrument, or other subject used and referred to in it, and is limited by the tests and/or analyses performed. Similar articles may not be of like quality, and other testing and/or analysis programs might be desirable and might give different results.

Please note that unless otherwise notified by the Client, the sample(s) will be disposed of 30 days following issue of the final report. The Client is responsible for any costs associated with returning the sample.

Appendix J ASTM C 795 – CORROSION TEST



10-29-2008 22:53 KENNETH WHORLOW PAGE2

TUTCO SCIENTIFIC CORPORATION
714 East Aspen Ave
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28-DAY CORROSION TEST

AND CHEMICAL TESTS OF

PYROGEL XT BLKT 1205

(SAMPLE ID 08090168)

IN ACCORD WITH

ASTM C 795

USING THE TEST METHODS OF

ASTM C 692 AND ASTM C 871

PREPARED FOR
ASPEN AEROGELS
30 FORBES RD BLDG B
NORTHBOROUGH, MA 01532

TUTCO SCIENTIFIC REPORT NO. AERO\692(307922).O08
October 29, 2008

Reported by Kenneth Whorlow
Kenneth Whorlow
President

Appendix J ASTM C 795 – CORROSION TEST

AERO\692(307922).O08
Page 2

Subject: This report covers ASTM C871 Chemical Tests (Standard Test Method for Chemical Analysis of Thermal Insulation Materials for Leachable Chloride, Fluoride, Silicate, and Sodium Ions) and ASTM C 692 28-Day (Pre-Production) Corrosion Tests (Standard Test Method for Evaluating the Influence of Thermal Insulations on the External Stress Corrosion Cracking Tendency of Stainless Austenitic Steel). The material tested was Pyrogel XT Blkt 1205, Sample ID 08090168 received from Aspen Aerogels on PO # 307922, dated 23-Sep-08.

The results may be used to determine the qualification of the insulation to the requirements of ASTM C 795 (Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel).

Samples: The samples were identified as
#1 Name: Pyrogel XT Blkt 1205, Sample ID, 8090168

CHEMICAL TESTS

Sample Preparation: Samples were cut from the submitted specimen such that the test samples were representative of the entire cross section of the material. Samples weighing 20.0 grams were prepared for the duplicate extractions.

Each weighed sample was put in a blender jar containing 500 ml of demineralized water, ground and crushed into small pieces and quantitatively transferred to a one-liter stainless steel beaker. The sample slurry was heated to boiling and maintained at temperature for 30 minutes. The liquid was cooled, the weight was brought to 500 grams, and then strained and then filtered to produce the extraction solution for chemical tests.

Chemical Test Procedures: All test procedures were conducted in accord with ASTM C871. The tests used were as follows: Chloride - Amperometric-coulometric titrator; Silicate - Molydisilicic acid; Sodium - Ion Selective Electrode; Fluoride - Ion Selective Electrode; pH - Standard pH probe and meter.

Test Results: Given in parts per million (mg/kg).

Sample	Sodium	Silicate	Chloride	Fluoride	pH
1A	41	7349	33	9	8.8
1B	40	7230	32	9	8.8

Chemical Test Conclusions: The sample identified as Pyrogel XT Blkt 1205, Sample ID 08090168 met the chemical requirements of ASTM C 795, falling within the "acceptable" range of the "acceptability curve".

Appendix J ASTM C 795 – CORROSION TEST

AERO\692(307922).O08
Page 3

28-DAY CORROSION TEST

Corrosion Test Procedures: The 28-Day Corrosion Test was run in accord with ASTM C692, using the Drip Test Procedure. The metal used to fabricate the test coupons had a 0.051 carbon content. The coupons were sensitized by heating at 1200°F in an air atmosphere for 3 hours. They were then prepared in accord with ASTM C692. The lot of sensitized steel was qualified by three-day exposure to a 1500 ppm chloride solution - all specimens cracked, and 28-day exposure to de-ionized water - none cracked.

Sample Preparation: Test samples were fabricated from the blanket insulation to form approximately 1.5" thick, 4" wide, 3.5" tall sections using 4 layers of the material held together with rubber bands. Four specimens were prepared and each fitted with a u-bend coupon. The test coupons and specimens were set up on the C692 drip test apparatus, which was brought to operating temperature and the flow of de-ionized water from the peristaltic pump was started. The material is hydrophobic and does not readily wet, therefore 1/4 inch channels were cut in the center pieces of the insulation. Water dripped into the channel percolated down to the coupon surface. The flow rate was set at 250 ml/day on each test specimen.

After 28-days the coupons and contact area of the materials were examined and the materials were wet at the contact surface of the coupons. All of samples was slightly adhered to the coupons in small spots.

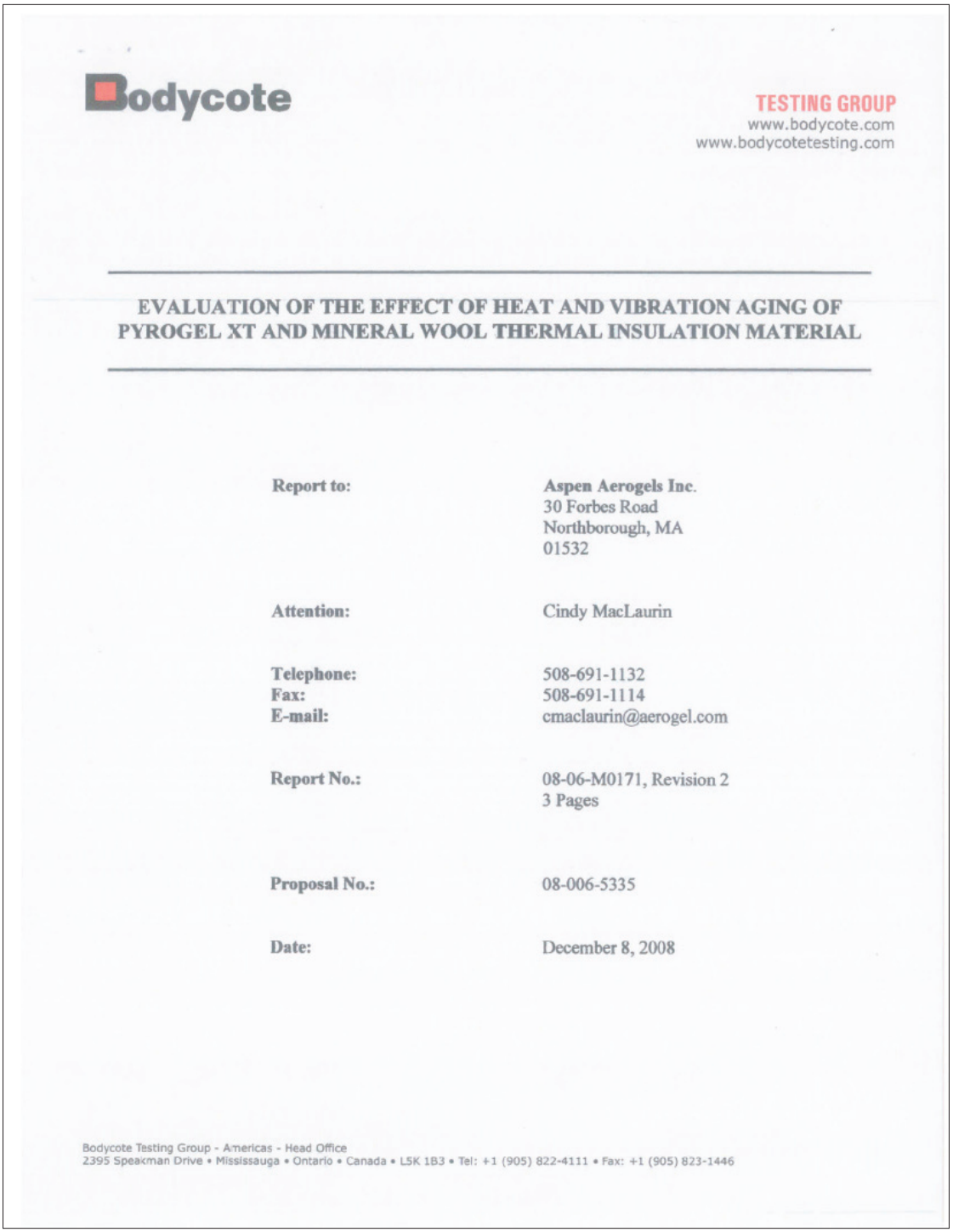
Corrosion Test Results: At the conclusion of 28-days from the start of the test the coupons were removed, flattened, cleaned, re-bent, and inspected. No obvious cracks were found. The required inspection using dye penetrant and developer was done to add greater confidence that all cracks are found. No cracks were found on any of the coupons. The coupons were determined to be free of cracks.

# of Coupons tested	# of Coupons Cracked
4	0

Corrosion Test Conclusion:

The sample identified as Pyrogel XT Blkt 1205, Sample ID 08090168, produced none of the four coupons tested having any cracks.

Appendix K ASTM C 592-04 – HEAT AND VIBRATION AGING



Bodycote

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www.bodycote.com
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EVALUATION OF THE EFFECT OF HEAT AND VIBRATION AGING OF PYROGEL XT AND MINERAL WOOL THERMAL INSULATION MATERIAL

Report to:	**Aspen Aerogels Inc.** 30 Forbes Road Northborough, MA 01532
Attention:	Cindy MacLaurin
Telephone: **Fax:** **E-mail:**	508-691-1132 508-691-1114 cmaclaurin@aerogel.com
Report No.:	08-06-M0171, Revision 2 3 Pages
Proposal No.:	08-006-5335
Date:	December 8, 2008

Bodycote Testing Group - Americas - Head Office
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Appendix K ASTM C 592-04 – HEAT AND VIBRATION AGING

1.0 INTRODUCTION

At the request of Aspen Aerogels Inc., Bodycote Testing Group was retained to evaluate the mass and physical appearance effects of heat and vibration aging of two samples of thermal insulation material.

Upon receipt, the sample was assigned the following Bodycote Sample No.:

Client Sample Description	Bodycote Sample No.
Pyrogel XT	08-06-M0171 – A
Mineral Wool	08-06-M0171 – B

2.0 PROCEDURE

The sample was evaluated according to the following standard test methods:

Test Description	Test Method
Standard Specification for Mineral Fibre Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type) - Resistance to Vibration	ASTM C 592 – 04 *Section 11.11 Modified*

ASTM C 592 Section 11.11 Resistance to Vibration - Modified
Testing to this method was conducted in accordance with section 11.11 of ASTM C 592. The following testing specifics apply, and where appropriate are deviations from the method.

Each sample was initially weighed at ambient laboratory conditions (nominally 23^{0}C and 60% relative humidity). The weights were recorded to an accuracy of 0.1 grams. Immediately after weighing, the sample was heated on a hot plate apparatus to 400^{0}C for greater than 96 hours with a temperature gradient through the sample from 400^{0}C at the hot plate surface to ambient laboratory conditions on the opposite face. After at least 96 hours had elapsed the samples were removed from the hot plate, allowed to cool to room temperature and weighed.

The sample was then transferred to the vibration fixture, comprised of 6 equally spaced rods on which the sample was impaled. The sample was held horizontally on the vibration table for 6 hours, being vibrated at a frequency of 12 Hz, with a displacement of 3 mm (peak to peak). Vibration was conducted in an ambient lab environment. The sample was then carefully removed from the table and a final weight taken.

Appendix K ASTM C 592-04 – HEAT AND VIBRATION AGING

Bodycote Testing Group

Evaluation of the Effect of Heat and Vibration Aging on Thermal Insulation for Aspen Aerogels Inc. — *Page 3 of 3, Report No. 08-06-M0171, Revision 2*

3.0 RESULTS

Table 1 – Heat & Vibration Aging of Thermal Insulating Material ASTM C 592 §11.11 Modified
Bodycote Sample No. 08-06-M0171-A (Pyrogel XT)

Change in Mass after Vibration (heat aged sample)	Observations
- 0.19 %	*Blackening around edges of sample on mid thickness plies.*

Initial mass of specimen	3523.0 g
Specimen mass after 96 hrs at 400°C	3449.6 g
Specimen mass after 96 hrs at 400°C and 6 hours vibration	3442.9 g

Table 2 – Heat & Vibration Aging of Thermal Insulating Material ASTM C 592 §11.11 Modified
Bodycote Sample No. 08-06-M0171-B (Mineral Wool)

Change in Mass after Vibration (heat aged sample)	Observations
- 0.51 %	*No change observed.*

Initial mass of specimen	3211.0 g
Specimen mass after 96 hrs at 400°C	3215.4 g
Specimen mass after 96 hrs at 400°C and 6 hours vibration	3199.0 g

Reported by:

David Beauchamp, B.Sc., Ext. 228
Scientist, Building Performance Centre
Product Testing Group

Reviewed by:

Franz C. Bauer, Ext. 403
Manager, Building Performance Centre
Product Testing Group

This report refers only to the particular samples, units, material, instrument, or other subject used and referred to in it, and is limited by the tests and/or analyses performed. Similar articles may not be of like quality, and other testing and/or analysis programs might be desirable and might give different results.

Appendix L BS EN 13501-1:2007 – REACTION TO FIRE PERFORMANCE

classification report

Bodycote

Title:

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

Notified Body No:

0833

Product Name:

Pyrogel XT

Report No:

180079

Issue No:

2

Prepared for:

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

Date:

20th January 2009

business partner
LABC

warringtonfire
global safety
TESTING

Appendix L BS EN 13501-1:2007 – REACTION TO FIRE PERFORMANCE

1. Introduction

This classification report defines the classification assigned to "Pyrogel XT", a batting insulation, in line with the procedures given in EN 13501-1:2007

2. Details of classified product

2.1 General

The product, "Pyrogel XT", a batting insulation, is deemed as being suitable for construction applications, excluding flooring and linear pipe thermal insulation in building and construction.

2.2 Product description

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

General description		A batting insulation mounted onto a calcium silicate based substrate utilising screws
Batting	Product reference	"Pyrogel XT"
	Detailed description / composition details	Silica based aerogel insulation batting
	Name of manufacturer	Aspen Aerogels, Inc.
	Density	0.18 g/cm³ (stated by sponsor) 0.19 g/cm³ (Determined by **Bodycote warringtonfire**)
	Weight per unit area	896g/m² (Determined by **Bodycote warringtonfire**)
	Thickness	5-10mm (stated by sponsor) 4.73 - 9.86mm (determined by **Bodycote warringtonfire**)
	Colour	Beige
	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	870kg/m³
	Flame retardant details	The substrate is inherently flame retardant
Mounting and fixing details		The specimen was mechanically fixed to the calcium silicate substrate utilising 16mm long screws. The screws were located around the perimeter of each wall and were positioned in the corners and at approximately 350mm intervals.
Brief description of manufacturing process		Aspen Aerogels produces nanoporous insulating materials, the process involves casting of the aerogels into fibrous battings.

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Appendix L BS EN 13501-1:2007 – REACTION TO FIRE PERFORMANCE

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.

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 178244 WF 178245	EN 13823
Bodycote warringtonfire	Aspen Aerogels Inc	WF 178243	EN ISO 1716

3.2 Test results

Test method & test number	Parameter	No. tests	Results	
			Continuous parameter - mean (m)	Compliance parameters
EN 13823	$FIGRA_{0.2MJ}$	4	0	Compliant
	THR_{600s}		0.49, 0.56, 0.13, 0.37	Compliant
	LSF		No	Compliant
	SMOGRA		0, 0, 0, 0	Compliant
	TSP_{600s}		42, 36, 36, 34	Compliant
EN ISO 1716	PCS ≤ 2,0 MJ/kg (1) PCS ≤ 2,0 MJ/ kg (2)(2a) PCS ≤ 1,4 MJ/m² (3) PCS ≤ 2,0 MJ/kg (4) Total	3	2.1 MJ/kg	Compliant

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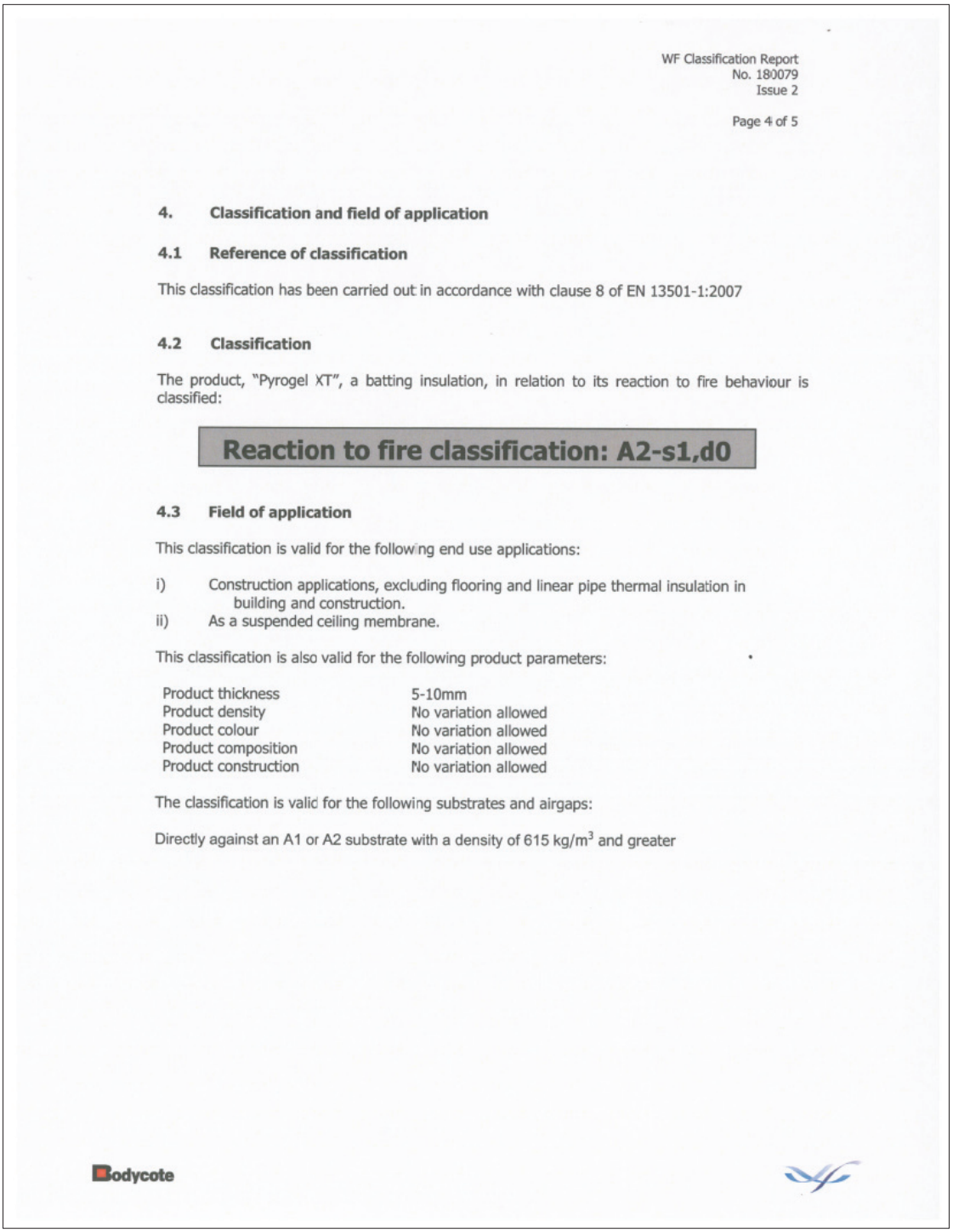
Appendix L BS EN 13501-1:2007 – REACTION TO FIRE PERFORMANCE



WF Classification Report
No. 180079
Issue 2

Page 4 of 5

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, "Pyrogel XT", a batting insulation, in relation to its reaction to fire behaviour is classified:

Reaction to fire classification: A2-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 in building and construction.
ii) As a suspended ceiling membrane.

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

Bodycote

Appendix L BS EN 13501-1:2007 – REACTION TO FIRE PERFORMANCE

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 L BS EN 13501-1:2007 – REACTION TO FIRE PERFORMANCE

test report

Bodycote

BS EN ISO 1716:2002

Determination Of The Heat Of Combustion For Building Products

WF Report Number

178243 (Issue 2)

Date of Original:

12th January 2009

Date of Issue 2:

21st January 2009

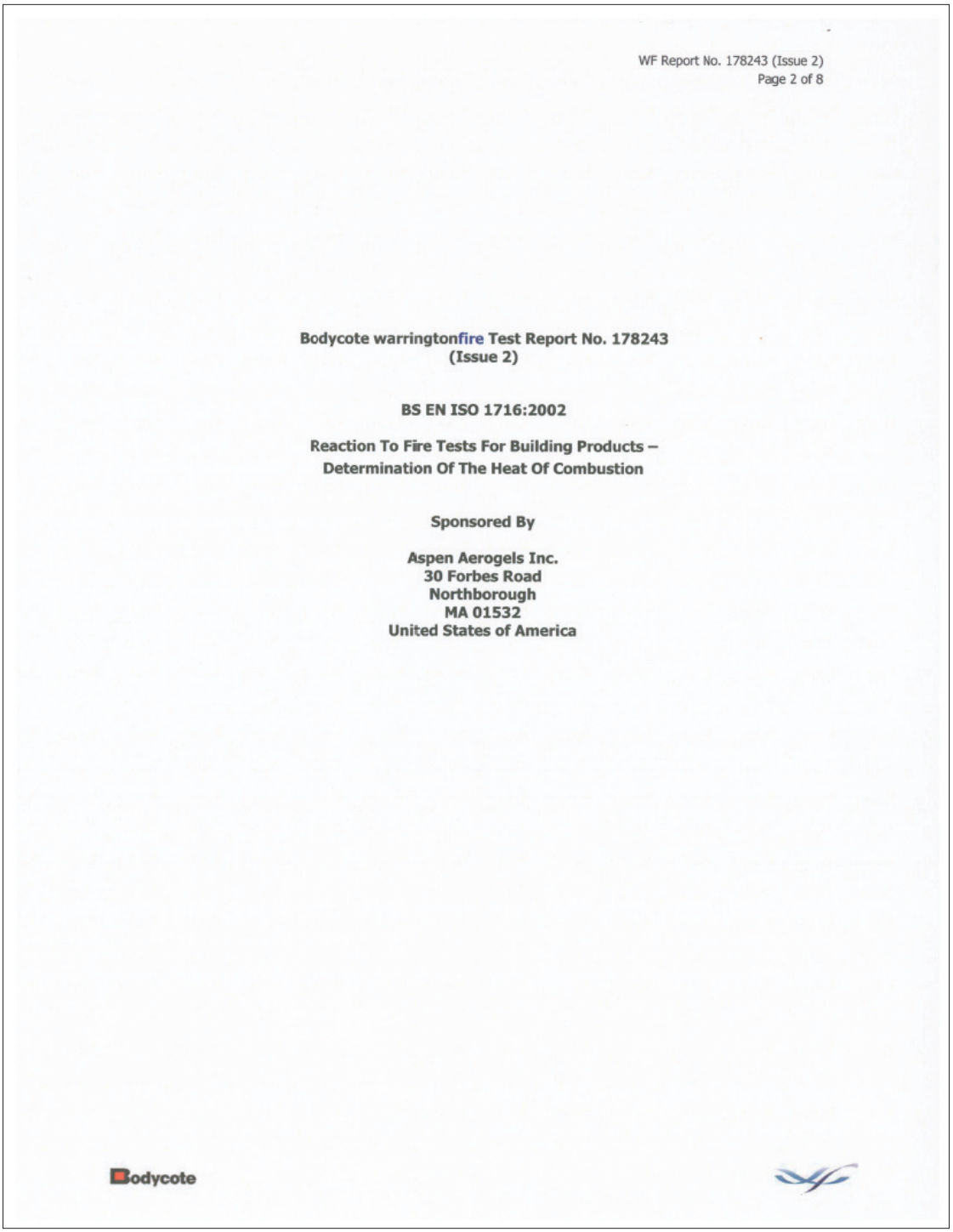
Test Sponsor:

Aspen Aerogels Inc.

warringtonfire global safety TESTING

UKAS TESTING 0249

Appendix L BS EN 13501-1:2007 – REACTION TO FIRE PERFORMANCE



Bodycote warringtonfire Test Report No. 178243
(Issue 2)

BS EN ISO 1716:2002

Reaction To Fire Tests For Building Products –
Determination Of The Heat Of Combustion

Sponsored By

Aspen Aerogels Inc.
30 Forbes Road
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United States of America

Bodycote

Appendix L BS EN 13501-1:2007 – REACTION TO FIRE PERFORMANCE

CONTENTS PAGE NO.

Bodycote

Appendix L BS EN 13501-1:2007 – REACTION TO FIRE PERFORMANCE

Test Details

Purpose of test	To determine the calorific potential of a building material during combustion when it is tested in accordance with the test specified in BS EN ISO 1716:2002 "Reaction To Fire Tests For Building Products – Determination Of The Heat Of Combustion". The test was performed in accordance with the procedure specified in BS EN ISO 1716:2002 and this test report should be read in conjunction with that European Standard.
Scope of test	BS EN ISO 1716 specifies a method of test for determining the heat of combustion of building materials at constant volume in a bomb calorimeter. Results are reported as individual values which may be interpreted by reference to other documents; e.g. EN 13501-1:2002 "Fire Classification of Construction Products and Building Elements Part 1 Classification using Test Data from Reaction to Fire Tests. The test is intended for materials or products whether composite products or coated products.
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 has 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.
Instruction to test	The test was conducted on the 17th December 2008 at the request of Aspen Aerogels Inc., the sponsor of the test.
Provision of test specimens	The specimens were supplied by the sponsor of the test. **Bodycote warringtonfire** was not involved in any selection or sampling procedure.
Conditioning of specimens	The specimens were received on the 10th November 2008. Prior to test the prepared specimens were conditioned for at least 48 hours at a temperature of 23 ± 2°C and a relative humidity of 55 ± 5%, in accordance with BS EN 13238:2001
Test procedure	The specimens were tested using an additional combustible substance of known and high calorific value which for this test was paraffin oil. The specimens were tested using the crucible method in an isoperibol bomb calorimeter. The water equivalent (E) of the bomb calorimeter was 0.01012 MJ/K

Appendix L BS EN 13501-1:2007 – REACTION TO FIRE PERFORMANCE

Description of Test Specimens

The description of the specimens given below has been prepared from information provided by the sponsor of the test. All values quoted are nominal, unless tolerances are given.

General description	Insulation
Product reference	"Pyrogel XT"
Detailed description / composition details	Silica based aerogel insulation batting
Name of manufacturer	Aspen Aerogels, Inc.
Density	0.18 g/cm³ (stated by sponsor)
Weight per unit area	896g/m² (Determined by **Bodycote warringtonfire**)
Thickness	5mm (stated by sponsor) 4.7mm (determined by **Bodycote warringtonfire**)
Colour	Beige
Flame retardant details	**See Note 1**
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 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.

Specimen preparation The specimens were homogeneous and were prepared by selecting portions of the material from the sample submitted for test to give a total mass of 50g. These were then ground and reduced to a fine powder prior to conditioning for test.

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Appendix L BS EN 13501-1:2007 – REACTION TO FIRE PERFORMANCE

Test Results

Results of test

The results are detailed in Table 1.

The test results relate only to the specimens of the product in the form in which they were tested. Small differences in the composition of the product may significantly affect the performance during the test and may therefore invalidate the test results. Care should be taken to ensure that any product which is supplied or used is fully represented by the specimens which were tested.

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

For the product tested, the following results relating to the gross calorific potential were obtained.

Gross Calorific Value per Unit Mass MJ/Kg	Gross Calorific Value per Unit Area MJ/m^2
2.0789	--

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. 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.

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Appendix L BS EN 13501-1:2007 – REACTION TO FIRE PERFORMANCE

Signatories

Responsible Officer
D. J. Owen *

Approved
M. Dale *
Deputy Operations Manager

Authorised
C. Dean *
Operations Manager

* For and on behalf of **Bodycote warringtonfire**.

Report Issued: 12th January 2009

Issue 2: 21st January 2009

Bodycote

Appendix L BS EN 13501-1:2007 – REACTION TO FIRE PERFORMANCE

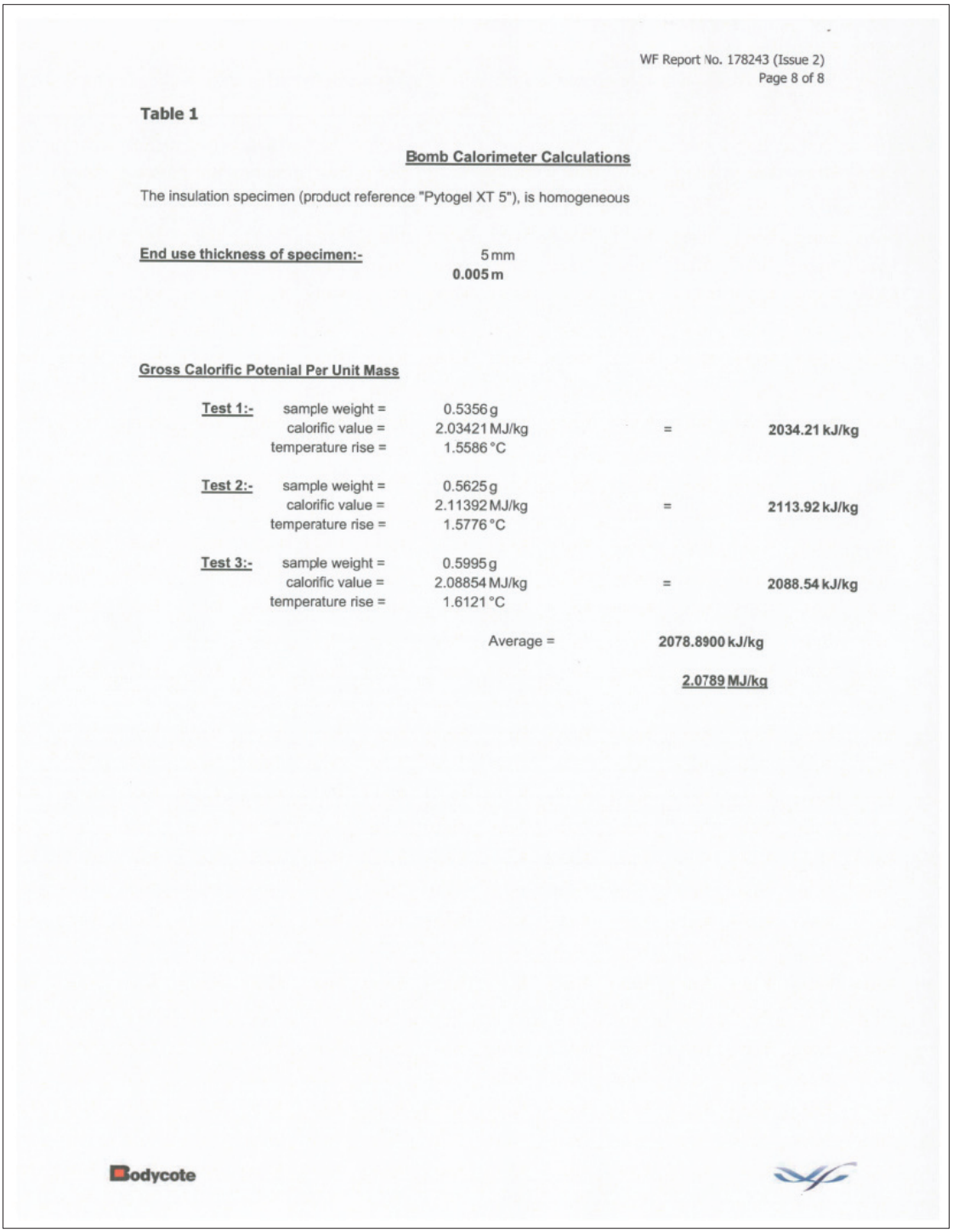

Table 1

Bomb Calorimeter Calculations

The insulation specimen (product reference "Pytogel XT 5"), is homogeneous

End use thickness of specimen:- 5 mm
0.005 m

Gross Calorific Potenial Per Unit Mass

Test 1:-	sample weight =	0.5356 g		
	calorific value =	2.03421 MJ/kg	=	**2034.21 kJ/kg**
	temperature rise =	1.5586 °C		
Test 2:-	sample weight =	0.5625 g		
	calorific value =	2.11392 MJ/kg	=	**2113.92 kJ/kg**
	temperature rise =	1.5776 °C		
Test 3:-	sample weight =	0.5995 g		
	calorific value =	2.08854 MJ/kg	=	**2088.54 kJ/kg**
	temperature rise =	1.6121 °C		

Average = **2078.8900 kJ/kg**

2.0789 MJ/kg

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Appendix L BS EN 13501-1:2007 – REACTION TO FIRE PERFORMANCE

test report

Bodycote

BS EN 13823: 2002

Reaction to Fire Tests for Building Products Exposed to the Thermal Attack by a Single Burning Item

WF Report Number

178244

Date:

16th January 2009

Test Sponsor:

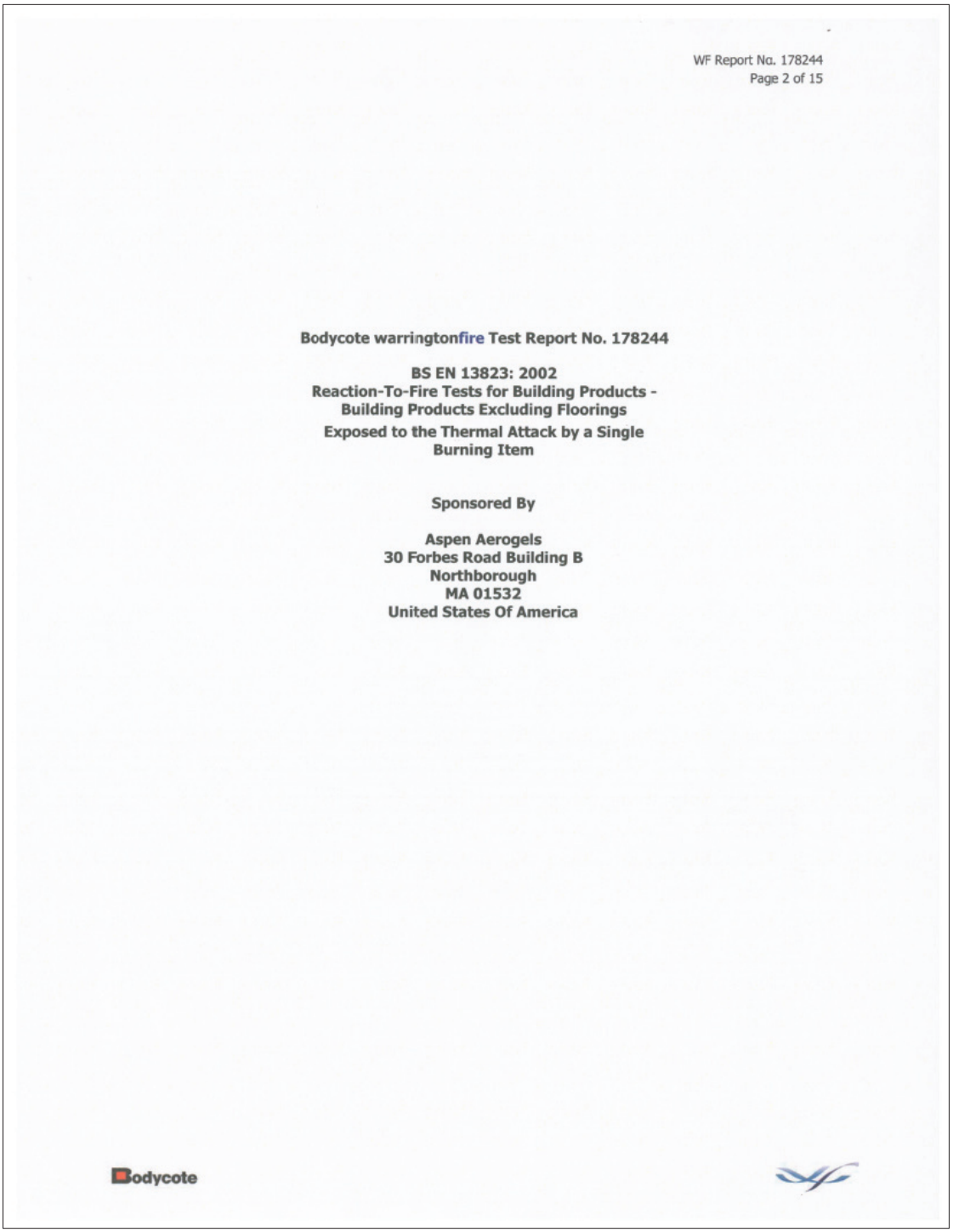
Aspen Aerogels

business partner LABC

warringtonfire global safety TESTING

UKAS TESTING 0249

Appendix L BS EN 13501-1:2007 – REACTION TO FIRE PERFORMANCE



Bodycote warringtonfire Test Report No. 178244

BS EN 13823: 2002
Reaction-To-Fire Tests for Building Products - Building Products Excluding Floorings Exposed to the Thermal Attack by a Single Burning Item

Sponsored By

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Bodycote

Appendix L BS EN 13501-1:2007 – REACTION TO FIRE PERFORMANCE

CONTENTS PAGE NO.

Bodycote

Appendix L BS EN 13501-1:2007 – REACTION TO FIRE PERFORMANCE

Test Details

Purpose of test	To provide data which, in conjunction with data from other test methods, will enable building products excluding floorings, to be classified in accordance with the Classification requirements specified in BS EN 13501-1: 2007. The test was performed in accordance with the procedure specified in BS EN 13823: 2002 and this report should be read in conjunction with that standard.
Scope of test	To determine the reaction-to-fire performance of construction products, excluding floorings and excluding products which are indicated in the EC Decision 2000/147/EC, when exposed to thermal attack by a single burning item (SBI) utilising the test procedures defined in BS EN 13823: 2002. There were no deviations from the defined procedures.
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 has 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.
Instruction to test	The test was conducted on the 16th and the 18th of December 2008 at the request of Aspen Aerogels, the sponsor of the test.
Provision of test specimens	The specimens of batting were supplied by the sponsor of the test. **Bodycote warringtonfire** was not involved in any selection or sampling procedure. **Bodycote warringtonfire** supplied the substrate and attached the batting onto the substrate.
Conditioning of specimens	The specimens were received on the 10th November 2008 and were conditioned to constant mass at a temperature of 23 ± 2°C and a relative humidity of 50 ± 5% prior to testing.
Intended application	Thermal Insulation
Test facility	The SBI test facility at **Bodycote warringtonfire** is constructed in accordance with the specifications detailed in BS EN 13823: 2002.
Exposed face	The batting face of the specimens was exposed to the heating conditions of the test when the specimens were mounted in the test position.

Appendix L BS EN 13501-1:2007 – REACTION TO FIRE PERFORMANCE

Description of Test Specimens

Test specimens

The description of the specimens given below has been prepared from information provided by the sponsor of the test. All values quoted are nominal, unless tolerances are given.

The test specimen comprised two walls (or wings) mounted into an aperture in a specimen trolley such that they formed a vertical 90° corner. The dimensions of the walls were as follows:

Short wall - 495 ± 5 mm long x 1500 ± 5 mm high
Long wall - 1000 ± 5 mm long x 1500 ± 5 mm high

Each wall (or wing) consisted of the following product:

General description		A batting insulation mounted onto a calcium silicate based substrate utilising screws
Batting	Product reference	"Pyrogel XT"
	Detailed description / composition details	Silica based aerogel insulation batting
	Name of manufacturer	Aspen Aerogels, Inc.
	Density	0.18 g/cm³ (stated by sponsor) 0.19 g/cm³ (Determined by **Bodycote warringtonfire**)
	Weight per unit area	896g/m² (Determined by **Bodycote warringtonfire**)
	Thickness	5mm (stated by sponsor) 4.73mm (determined by **Bodycote warringtonfire**)
	Colour	Beige
	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	870kg/m³
	Flame retardant details	The substrate is inherently flame retardant
Mounting and fixing details		The specimen was mechanically fixed to the calcium silicate substrate utilising 16mm long screws. The screws were located around the perimeter of each wall and were positioned in the corners and at approximately 350mm intervals.
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 provided this information but at the specific request of the sponsor, this information has been omitted from the test report and is instead held on our confidential file relating to this investigation.

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Appendix L BS EN 13501-1:2007 – REACTION TO FIRE PERFORMANCE

The specimen walls (or wings) were placed in the trolley in accordance with the requirements of section 5.3 of the Standard.

Photographs of the installed product are appended as Plates 1 and 2 of this report.

Each wing was retained in the trolley using mechanical clamps which pushed the wing against a lip at the top and bottom of the aperture in the trolley.

The trolley incorporated a triangular propane sand burner of side length 250mm, which was positioned in the base of the corner formed by the two wings of the test specimen, with a horizontal separation of 40mm between the edge of the burner and the lower edges of the wings. The burner is referred to as the primary burner and has an output of 30kW. A secondary propane sand burner was attached to the fixed frame, beneath the hood but at the furthest possible distance from the specimen when the trolley was in place. The purpose of this burner is to obtain base line data without affecting the assembled specimen. The trolley incorporated a grill in its base and this was the sole source of ventilation for the test enclosure whilst the test was in progress. A plan view of the SBI apparatus is shown in Figure 1. A schematic illustration of the specimen housing and the exhaust system is shown in Figure 2.

Appendix L BS EN 13501-1:2007 – REACTION TO FIRE PERFORMANCE

Test Results

Results and observations

The test results relate to the behaviour of the test specimens of a product under the particular conditions of the test; they are not intended to be the sole criterion for assessing the potential fire 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 may therefore invalidate the test results. Care should be taken to ensure that any product which is supplied or used is fully represented by the specimens which were tested.

Observations made during the test and comments on any difficulties encountered during the test are given in Table 1.

A total of three specimens were tested. The following data, relevant to Euroclassification of Building Products was obtained:

Parameter	Result			
	Specimen 1	Specimen 2	Specimen 3	Mean
FIGRA (W/s) (*THR(t) threshold of 0.2MJ*)	0.00	0.00	0.00	0.00
FIGRA (W/S) *(THR(t) threshold of 0.4MJ)*	0.00	0.00	0.00	0.00
THR 600s (MJ)	0.49	0.56	0.13	0.40
SMOGRA (m^2/s^2)	0.00	0.00	0.00	0.00
TSP 600s (m^2)	42.03	36.39	35.71	38.04
Lateral Flame Spread to End of Specimen?	None	None	None	-
Fall of Flaming Drop/Particle?	None	None	None	-
Flaming of Fallen Particle Exceeding 10s?	None	None	None	-

Curves of time averaged rate of heat release contribution of the specimen (HRRav(t)), cumulative heat release (THR(t)), and Fire Growth Rate (FIGRA) are appended as figures 3 to 5. Curves of time averaged rate of smoke production (SPRav(t)), cumulative smoke production (TSP(t)) and smoke growth rate (SMOGRA) are appended as figures 6 to 8.

Interpretation of the test results given above in the context of Euroclassification of building products should be carried out using BS EN 13501 – 1: 2007.

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Appendix L BS EN 13501-1:2007 – REACTION TO FIRE PERFORMANCE

Table 1

Time		Observation
min	Sec	
05	12	In the case of all three specimens, discolouration of the surface of the product occurred.
06	00	In the case of all three specimens, flaming in the region of the burner began to occur.
26	00	End of test conditions. In the case of all three specimens, all flaming ceased.

Note: Impingement of the burner flame onto the specimen commenced at 5 minutes.

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. 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.

Bodycote

Appendix L BS EN 13501-1:2007 – REACTION TO FIRE PERFORMANCE

Signatories

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M. Dale *
Deputy Operations Manager

Authorised
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Operations Manager

* For and on behalf of **Bodycote warringtonfire**.

Report Issued: 16th January 2009

Bodycote

Appendix L BS EN 13501-1:2007 – REACTION TO FIRE PERFORMANCE

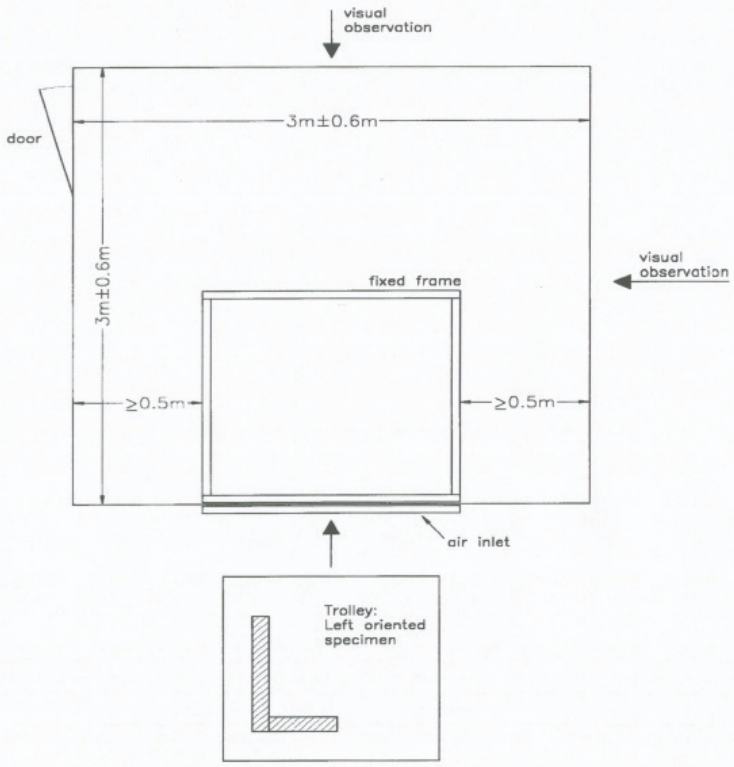
Annex 1:
Test apparatus and installation Figures and Plates

Plate 1: Total View of the exposed surface of the long wing.

Plate 2: Close up view of the vertical outer edge of the long wing at a height of 500mm

Appendix L BS EN 13501-1:2007 – REACTION TO FIRE PERFORMANCE

Figure 1 - Plan View of SBI Apparatus



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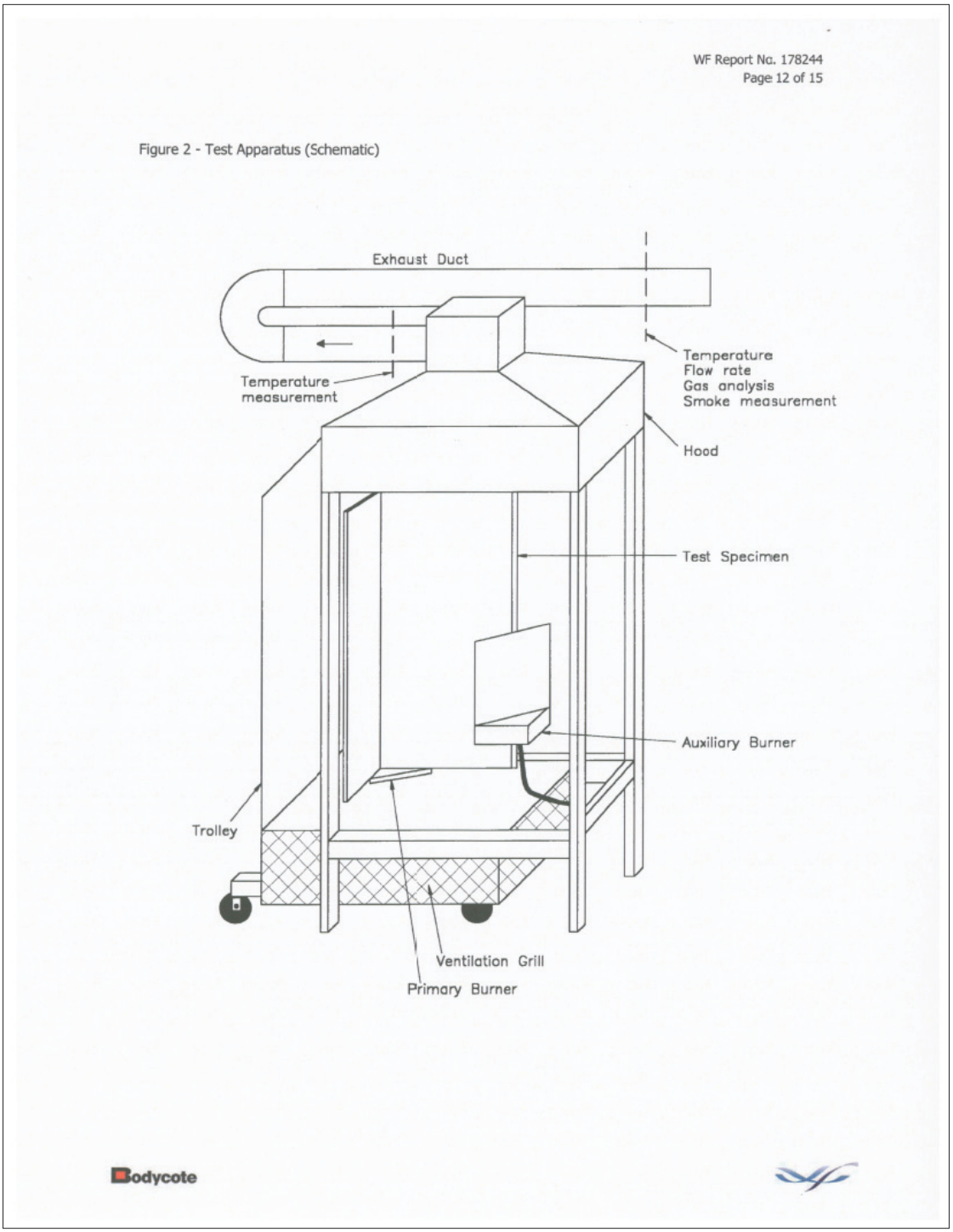


Appendix L BS EN 13501-1:2007 – REACTION TO FIRE PERFORMANCE

Annex 2: Graphs

Figure 3. $HRR_{av}(t)$ (kW)

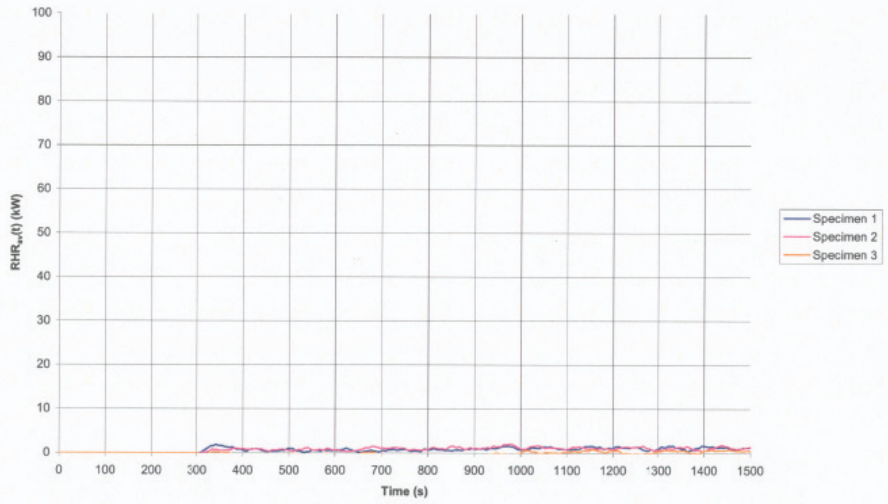
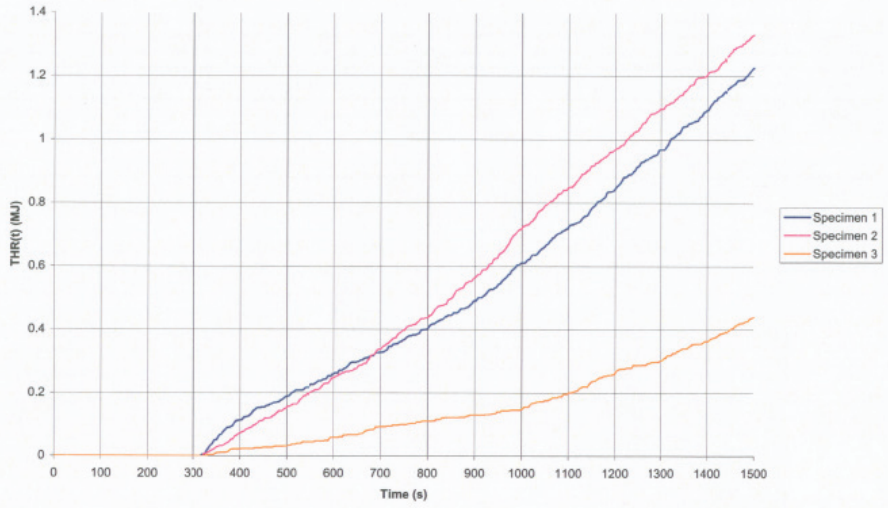


Figure 4. THR(t) (MJ)



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Appendix L BS EN 13501-1:2007 – REACTION TO FIRE PERFORMANCE

Figure 5. FIGRA

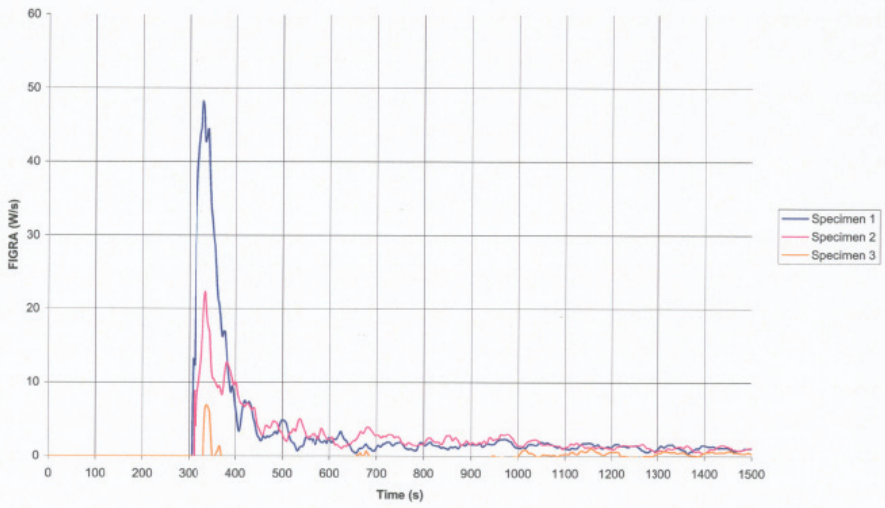

Figure 6. $SPR_{av}(t)$ (m^2/s)

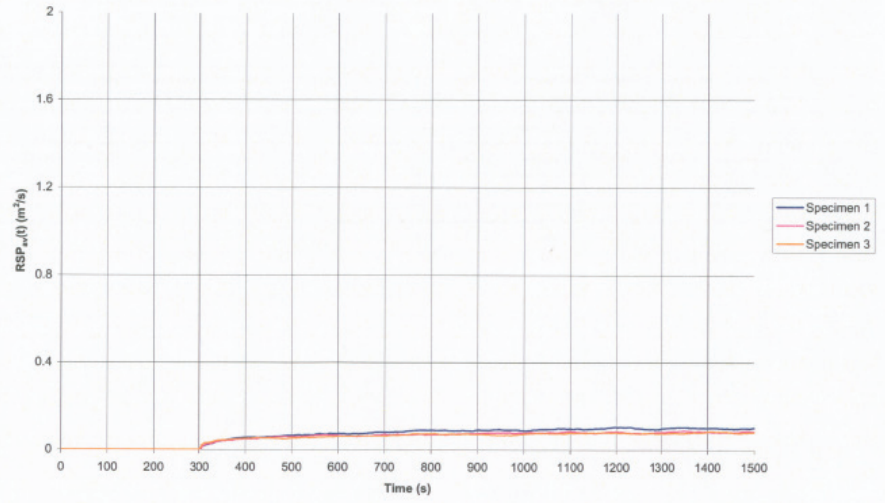

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Figure 7. TSP(t) (m^2)

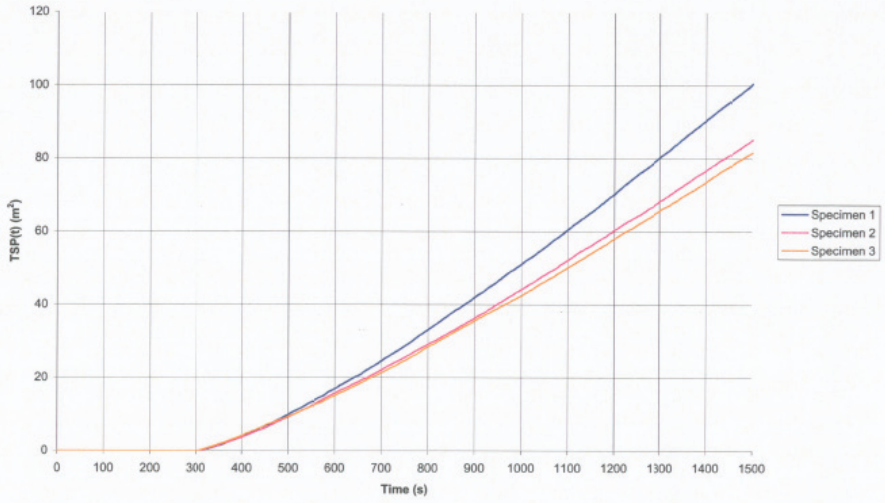
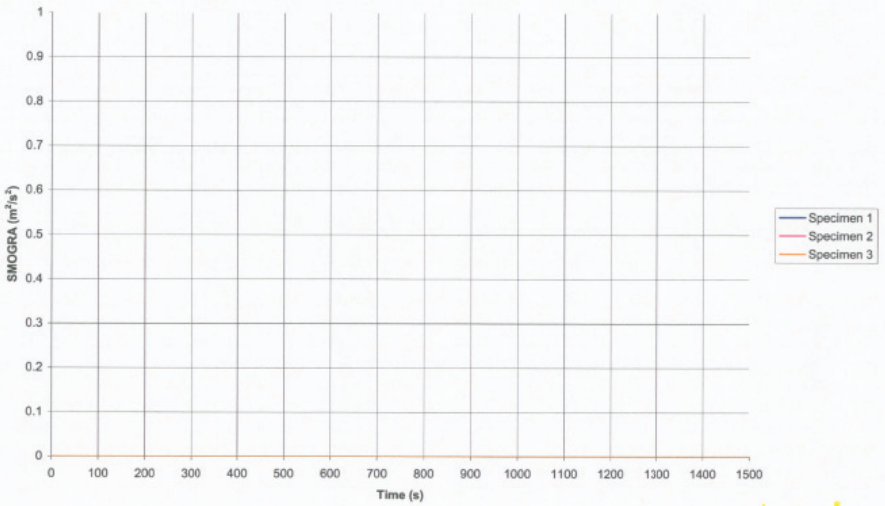


Figure 8. SMOGRA Graph.



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