



Resolution A.653 (16) 1989
RECOMMENDATION ON IMPROVED FIRE TEST PROCEDURES FOR
SURFACE FLAMMABILITY OF BULKHEAD, CEILING AND DECK
FINISH MATERIALS
(supersedes resolutions A.516(13) and A.564(14))

Pyrogel XT

Project No. 3194946SAT-001B

December 23, 2009

Prepared for:

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ABSTRACT

The specimens submitted by Aspen Aerogels and identified as "Pyrogel XT" were tested in accordance with IMO Resolution A.653(16) adopted October 1989. A total of three specimens were tested.

SUMMARY OF TEST RESULTS

Flammability Performance		Average Results
Time to Ignition	(min:sec)	0:10*
Distance of Extinguishment	mm	120
Time to Extinguishment	(min:sec)	2:24*
Heat for Ignition (Qig)	MJ/m ²	1.21*
Surface Flammability Criteria		
Critical Flux at Extinguished (CFE)	kW/m ²	41.1
Average Heat for Sustained Burning (Qsb)	MJ/m ²	1.53*
Total Heat Released (Qt)	MJ	0.00
Peak Heat Release Rate (Qp)	kW	0.03
Did specimens meet the floor covering criteria? (Y/N)		Yes
Did specimens meet the wall and ceiling criteria? (Y/N)		Yes

Note: Pass/ fail criteria is based on the average result.

* This is the result for sample #3 since samples 1 & 2 did not ignite.

This report contains a total of 19 pages.



Darrell R. Gonzales
Technician

December 23, 2009

Reviewed and approved:



Servando Romo
Project Manager

December 23, 2009

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SCOPE

This Recommendation specified a procedure for measuring fire characteristics of bulkhead, ceiling and deck finish materials as a basis for characterizing their flammability and thus their suitability for use in marine construction.

The test results relate only to the behavior 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.

PRINCIPLE OF THE TEST

This test provides methods for evaluating flammability characteristics of 155 mm x 800 mm specimens in vertical orientation. The specimens are exposed to a graded radiant flux field supplied by a gas-fired radiant panel. Means are provided for observing the times to ignition, spread and extinguishment of flame along the length of the specimen as well as for measuring the compensated millivolt signal of the stack gas thermocouples as the burning progresses. Experimental results are reported in terms of: heat for ignition, heat for sustained burning, critical flux at extinguishment and heat release of specimen during burning.



Photo notes: Radiant panel with reverberatory wires (left side of the photo) – Directly in front of the radiant panel is the specimen holder with the calibration dummy specimen – Above the specimen holder is the fume stack – Below the specimen holder are the viewing rakes used for timing flame front.

DEFINITIONS

Certain terms used in this Recommendation require definition for clarity. Other fire characteristic terms are also used; these are defined hereunder but relate only to the results of measurements by this specific test method.

Compensating thermocouple

A thermocouple for the purpose of generating an electrical signal representing long-term changes in stack metal temperatures. A fraction of the signal generated is subtracted from the signal developed by the stack gas thermocouples.

Critical flux at extinguishment

A flux level at the specimen surface corresponding to the distance of farthest advance and subsequent self-extinguishment of the flame on the centerline of a burning specimen. The flux reported is based on calibration tests with a dummy specimen.

Dummy specimen

A specimen used for standardizing the operating condition of the equipment; it should be roughly 20 mm thickness, $800 \pm 100 \text{ kg/m}^3$ density and should meet the requirements of resolution A.472(XII) as non-combustible.

Special calibration dummy specimen

A dummy specimen intended only for use in calibration of heat flux gradient.

Fume stack

A box-like duct with thermocouples and baffles through which flames and hot fumes from a burning specimen pass. Its purpose is to permit measurement of the heat release from the burning specimen.

Heat for ignition

The product of the time from initial specimen exposure until the flame front reaches the 150 mm position and the flux level at this position; this latter obtained in prior calibration of the apparatus.

Heat release of specimen

The observed heat release under the variable flux field imposed on the specimen and measured as defined by the test method.

Heat for sustained burning

The product of time from initial specimen exposure until arrival of the flame front and the incident flux level at the same location as measured with a dummy specimen during calibration. The longest time used in this calculation should correspond to flame arrival at a station at least 30 mm prior to the position of the furthest flame propagation on the centerline of the specimen.

Reverberatory wires

A wire mesh located in front of, but close to, the radiating surface of the panel heat source. This serves to enhance the combustion efficiency and increase the radiance of the panel.

Viewing rakes

A set of bars with wires spaced at 50mm intervals for the purpose of increasing the precision of timing flame front progress along the specimen.

CLASSIFICATION

Materials giving average values for all of the surface flammability criteria not exceeding those listed in the following table, are considered to meet the requirement for low flame spread in compliance with regulations II-2/3.8, II-2/34 and II-2/49 of SOLAS 1974, as amended

SURFACE FLAMMABILITY CRITERIA

Bulkhead, Wall and Ceiling Linings				Floor Coverings			
CFE (kW/m ²)	Q _{sb} (MJ/m ²)	Q _t (MJ)	q _p (kw)	CFE (kW/m ²)	Q _{sb} (MJ/m ²)	Q _t (MJ)	q _p (kw)
≥20.0	≥1.5	≤0.7	≤4.0	≥7.0	≥0.25	≤2.0*	≤10.0

*According to the FTP Code in Annex 1 part 5, the value for floor coverings (≤1.5 MJ) given in section 10 of the annex to resolution A.653 (16) is replaced by ≤2.0 MJ.

Where CFE = Critical flux at extinguishment

Q_{sb} = Heat for sustained burning

Q_t = Total heat release

q_p = Peak heat release rate

Total heat release

The total heat release is given by integration of the positive part of the heat release rate during the test period.

Peak heat release rate

The peak heat release rate is the maximum of the heat release rate during the test period.

SIZE OF TEST SPECIMENS

Three specimens are determined for each type of surface. The specimens should be between 150 to 155 mm wide and by 795 to 800 mm long. The thickness should not be greater than 50 mm. If the material is greater than 50 mm, the sample is reduced to 50 mm by cutting away the unexposed face. Specimens are conditioned at a temperature of 23 ± 2°C and a relative humidity of 50 ± 10%.

TEST PROCEDURE

The test method involves mounting the conditioned specimen in a well-defined flux field and measuring the time of ignition, spread of flame, its final extinguishment together with a stack thermocouple signal as an indication of heat release by the specimen during burning.

The conditioned specimen was placed in cool holder away from the heat of the radiant panel. Prior to insertion in the specimen holder, the back and edges of the specimen were wrapped in a single sheet of aluminum foil. After inserting the specimen into the holder, it was backed by a cool 10 ± 2 mm board of non-combustible refractory insulating material.

The dummy specimen in a specimen holder is mounted in position facing the radiant panel with the fume exhaust system and the acetylene-air pilot flame ready for testing.

The test starts when the radiant panel and stack signals have attained equilibrium. After equilibrium was achieved, the dummy specimen was removed and the specimen inserted into position.

The time of ignition and arrival of the flame front at each 50 mm position along the specimen was recorded. Also recorded were the time and the position on the specimen at which the progress of flaming combustion ceased. The millivolt signal from the stack thermocouples was recorded with a computer and then converted into heat release by using the data from the fume stack calibration (*data provided in appendix A*), which correlates the heat input to millivolt output.

Duration of Test

The test should be terminated, the specimen removed, and the dummy specimen in its holder reinserted when any one of the following is applicable.

- 1.) The specimen fails to ignite after a 10 min exposure;
- 2.) 3 min have passed since all flaming from the specimen ceased;
- 3.) Flaming reaches the end of the specimen or self-extinguishes and thus ceases progress along the specimen. This criterion should only be used when heat release measurements are not being made.

TEST RESULTS

Date received: December 3, 2009

Date tested: 12/16/09

Specimen ID: Pyrogel XT

Description of specimen

Fibrous pad

Individual Results

Flammability Performance Individual Specimen Results		Specimen 1	Specimen 2	Specimen 3
Time to Ignition	(min:sec)	No ignition	No ignition	0:10
Distance of Extinguishment	mm	0	0	360
Time to Extinguishment	(min:sec)	n/a	n/a	2:24
Heat for Ignition (Qig)	MJ/m ²	n/a*	n/a*	1.21
Surface Flammability Criteria				
Critical Flux at Extinguishment (CFE)	kW/m ²	50.4	50.4	22.5
Average Heat for Sustained Burning (Qsb)	MJ/m ²	n/a*	n/a*	1.53
Total Heat Released (Qt)	MJ	0.001	0.000	0.000
Peak Heat Release Rate (Qp)	kW	0.08	0.00	0.00

***Note:** This calculation cannot be made because the flames did not reach the 150-mm station as required and as defined in section 3.6 for the (Qig) *Heat for Ignition* and sections 3.8 and 9.3 for the (Qsb) *Heat for Sustained Burning* of the IMO Resolution A.653(16) test standard.

Additional notes: Sample #3 ignited but the flames were very small, so the flames did not produced enough heat to increase heat values.

Average Results

Flammability Performance		Average Results
Time to Ignition	(min:sec)	0:10*
Distance of Extinguishment	mm	120
Time to Extinguishment	(min:sec)	2:24*
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Critical Flux at Extinguished (CFE)	kW/m ²	41.1
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Did specimens meet the floor covering criteria? (Y/N)		Yes
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Note: Pass/ fail criteria is based on the average result.

* This is the result for sample 3 since samples 1 & 2 did not ignite.

CONCLUSION

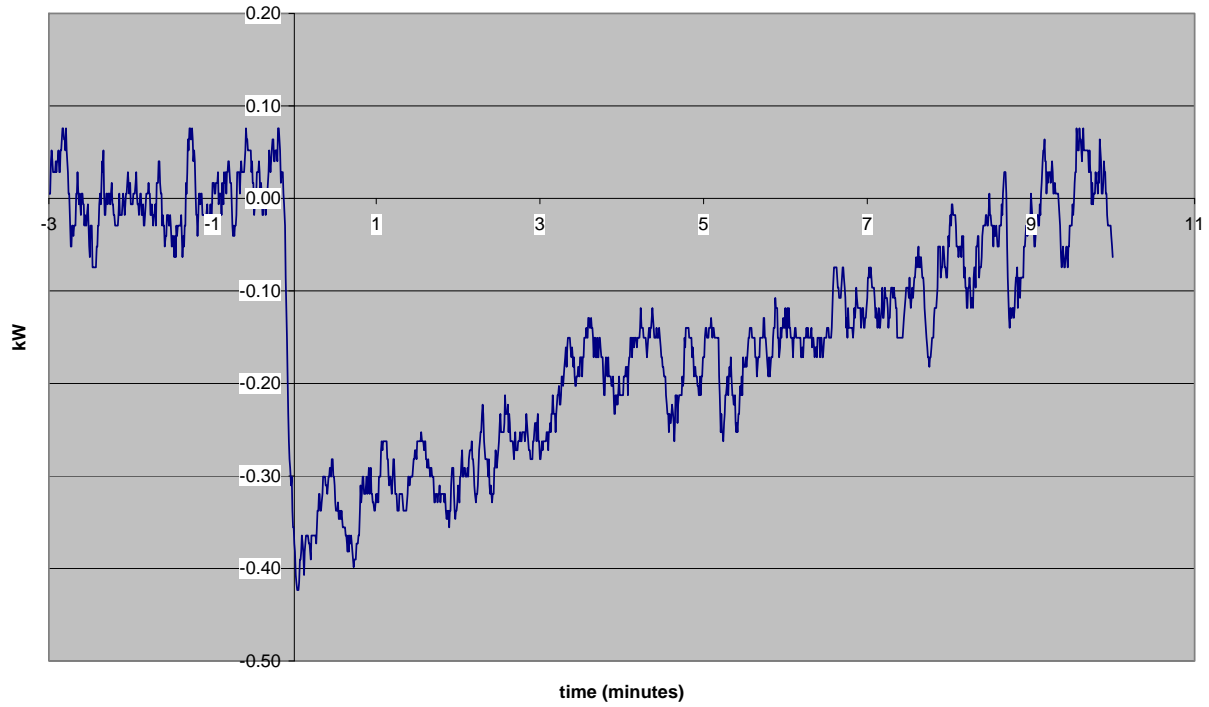
This specimen meets the floor covering criteria and the Bulkhead, Wall and Ceiling Linings criteria.

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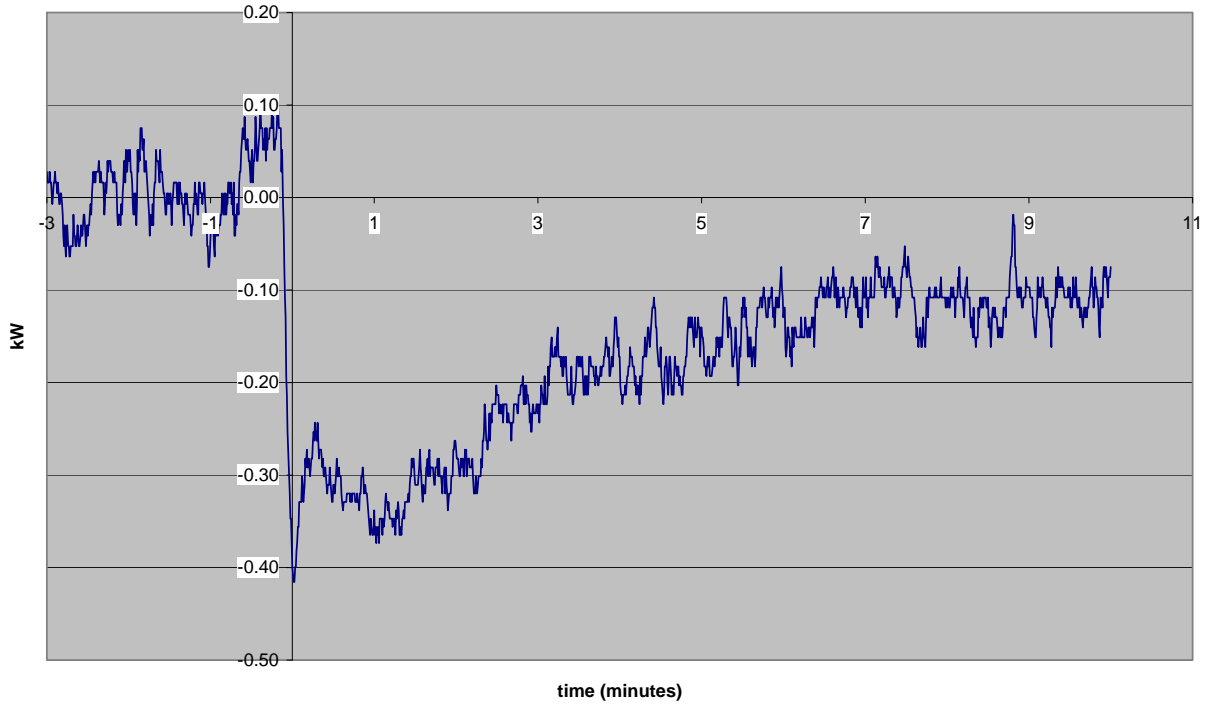
Graphs of the specimen's heat release are provided in the following pages and calibration data is included in appendix A. Post photo is located in appendix B.



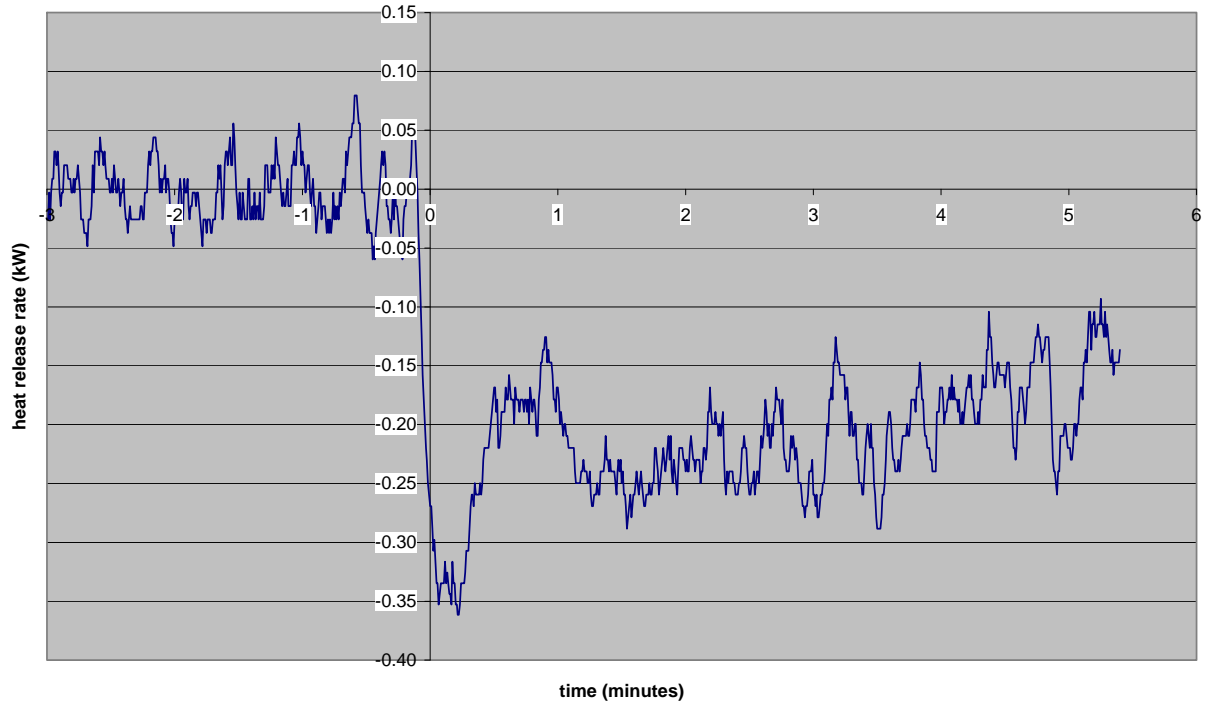
3194946SAT-001B
Specimen 1



3194946SAT-001B
Specimen 2



3194946SAT-001B
Specimen 3



APPENDIX B CALIBRATION DATA

Radiant Panel Heat Flux Calibration

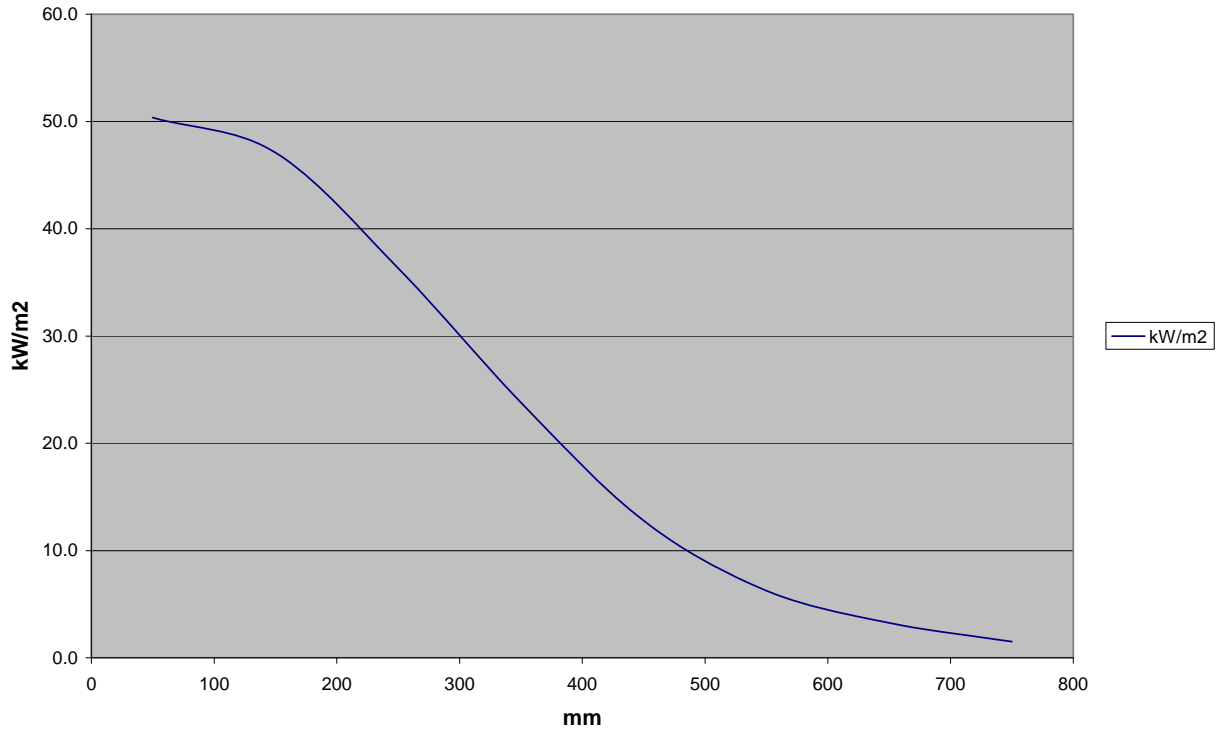
Distance From Zero Point (mm)	Actual Calibration Readings (kW/m²)	Standard Requirements (kW/m²)	% Error
50	50.4	50.5	-0.30
150	47.1	47.1	-0.01
250	36.3	37.8	-3.91
350	23.8	23.9	-0.43
450	12.8	13.2	-3.22
550	6.3	6.2	1.01
650	3.3	3.1	5.05
750	1.5	1.5	0.20

Fume Stack Calibration Data

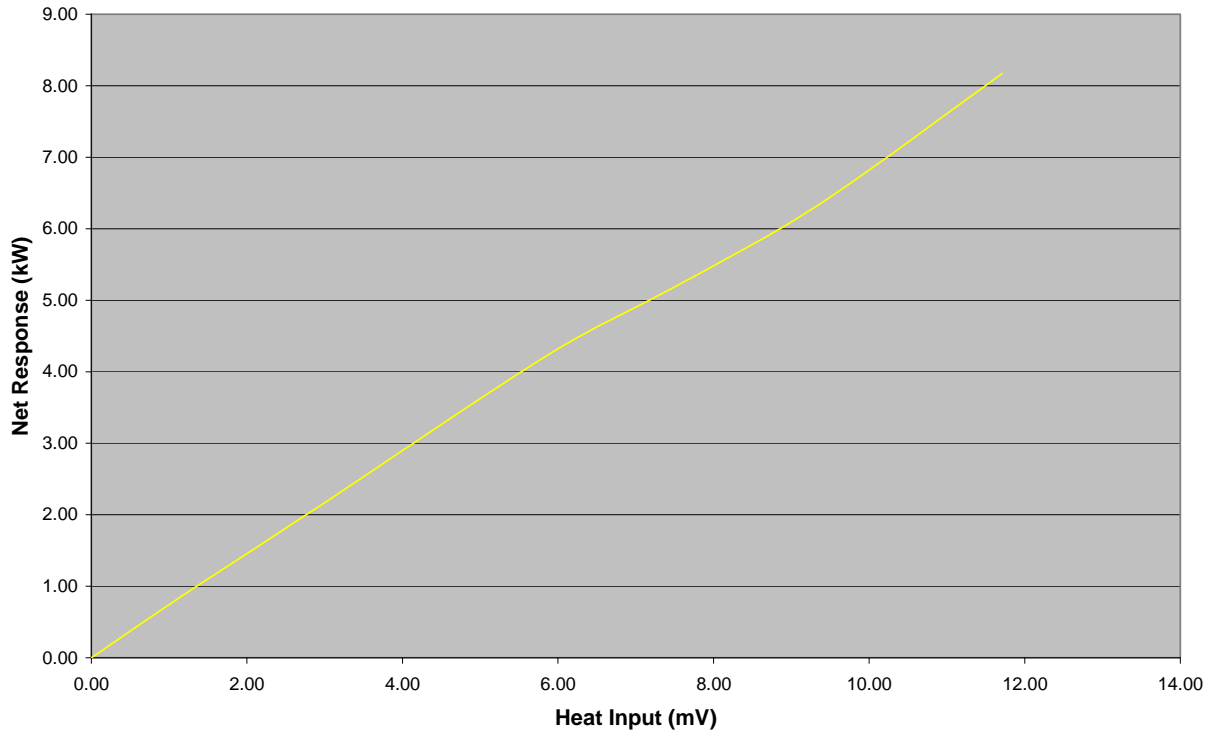
Heat Input (kW)	Net Response (mV)
0.00	0.00
1.17	0.87
2.93	2.12
5.85	4.22
7.61	5.25
9.37	6.35
11.71	8.17

A graphical representation of this data is provided in the following pages.

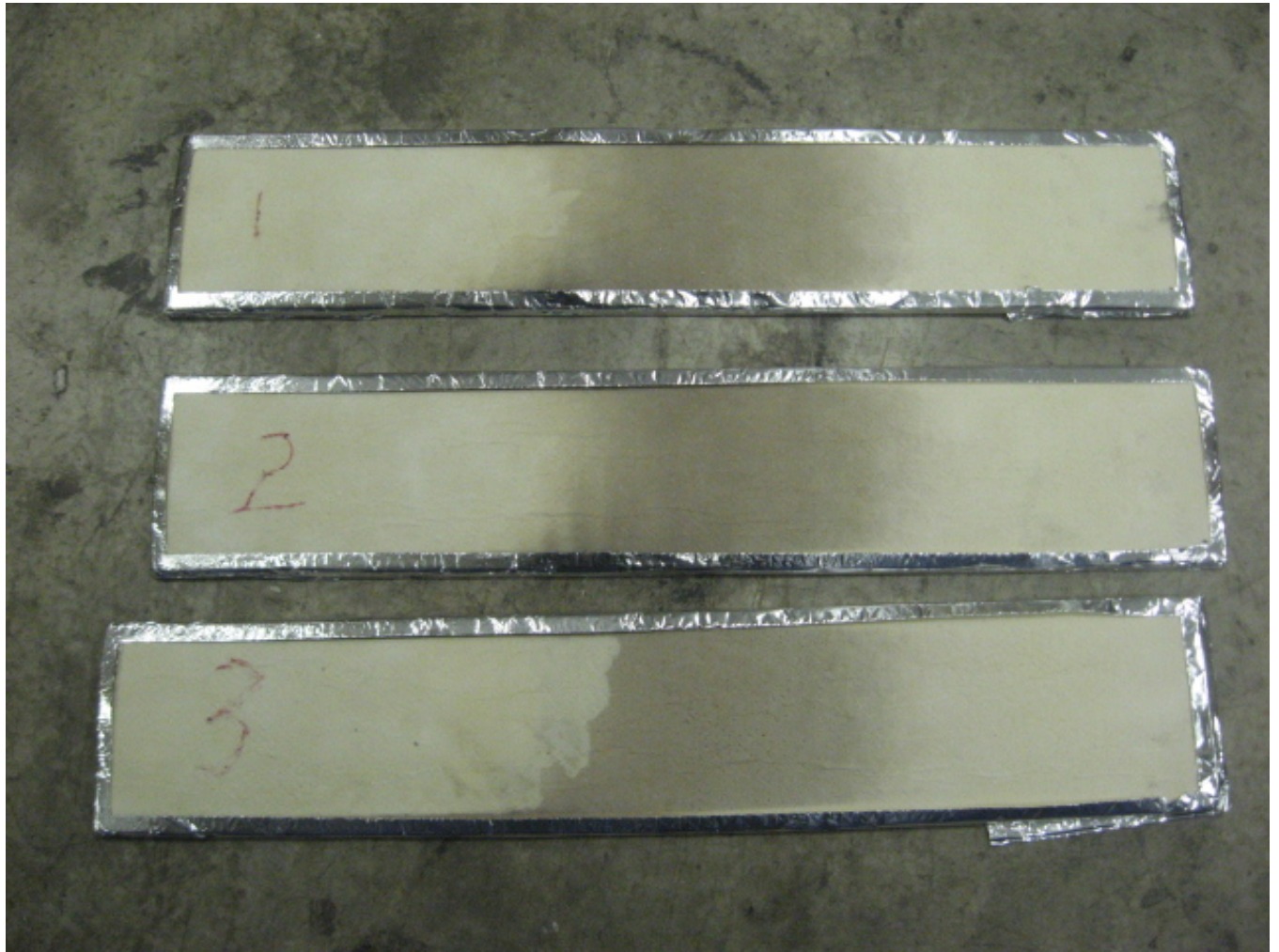
Radiant Panel Calibration



Fume Stack Calibration



APPENDIX B PHOTOS



Specimens after being tested.