Exova
2395 Speakman Dr.
Mississauga
Ontario
Canada
L5K 1B3

T: +1 (905) 822-4111
F: +1 (905) 823-1446
E: sales@exova.com
W: www.exova.com

Testing. Advising. Assuring.

UNCONTROLLED ELECTRONIC COPY

ASTM E 1354 Caloric Content Determination of "3M 550 FC + AC61"

A Report To: **3M Center**
Industrial and Transportation Division
3M Center, Building 223-1N-14
St, Paul, MN 55144
USA

Phone: (651) 733-8456
Email: hcertain@mmm.com

Attention: Harry Certain

Submitted By: Exova Warringtonfire North America

Report No. 13-002-625(B2)
8 pages + 1 appendix

Date: November 18, 2013

ACCREDITATION To ISO/IEC 17025 for a defined Scope of Testing by the International Accreditation Service

SPECIFICATIONS OF ORDER

Determine Effective Heat of Combustion according to ASTM E 1354 and derive Caloric Content, as per 3M Purchase Order No.USMMMMP4N4 and Exova Warringtonfire North America Quotation No. 13-002-250,923 RV1 dated September 18, 2013.

IDENTIFICATION

Polyurethane adhesive sealant with accelerator, identified as "3M 550 FC + AC61".

(Exova sample identification number 13-002-S0625-2)

SAMPLE PREPARATION

The polyurethane adhesive sealant with accelerator was applied by the client onto 6 mm thick fiberglass reinforced cement substrate using a 3M Two-Component Adhesive Sealant Applicator 400A-2K and 1/32" x 1/32" square notched trowel. The material was applied on October 25, 2013 and allowed to cure prior to testing on November 4, 2013.

SUMMARY OF TEST PROCEDURE

Each specimen is mounted into a holder and placed horizontally below a cone-shaped radiant heat source which has been previously calibrated to emit a predetermined heat flux. Testing can occur with or without a spark ignition source. The test is performed in ambient air conditions, while a load cell continuously monitors specimen weight loss.

Exhaust gas flow rate and oxygen concentration are used to determine the amount of heat release, based on the observation that the net heat of combustion is directly related to the amount of oxygen required for combustion. The relationship is that approximately 13.1×10^3 kJ of heat are released per 1 kg of oxygen consumed.

In addition to rate of heat release, other specified measurements include mass-loss rate, time to sustained flaming and smoke obscuration.

<u>TEST RESULTS</u>

ASTM E 1354-13

Standard Test Method for Heat and Visible Smoke Release Rates
<u>for Materials and Products Using an Oxygen Consumption Calorimeter</u>

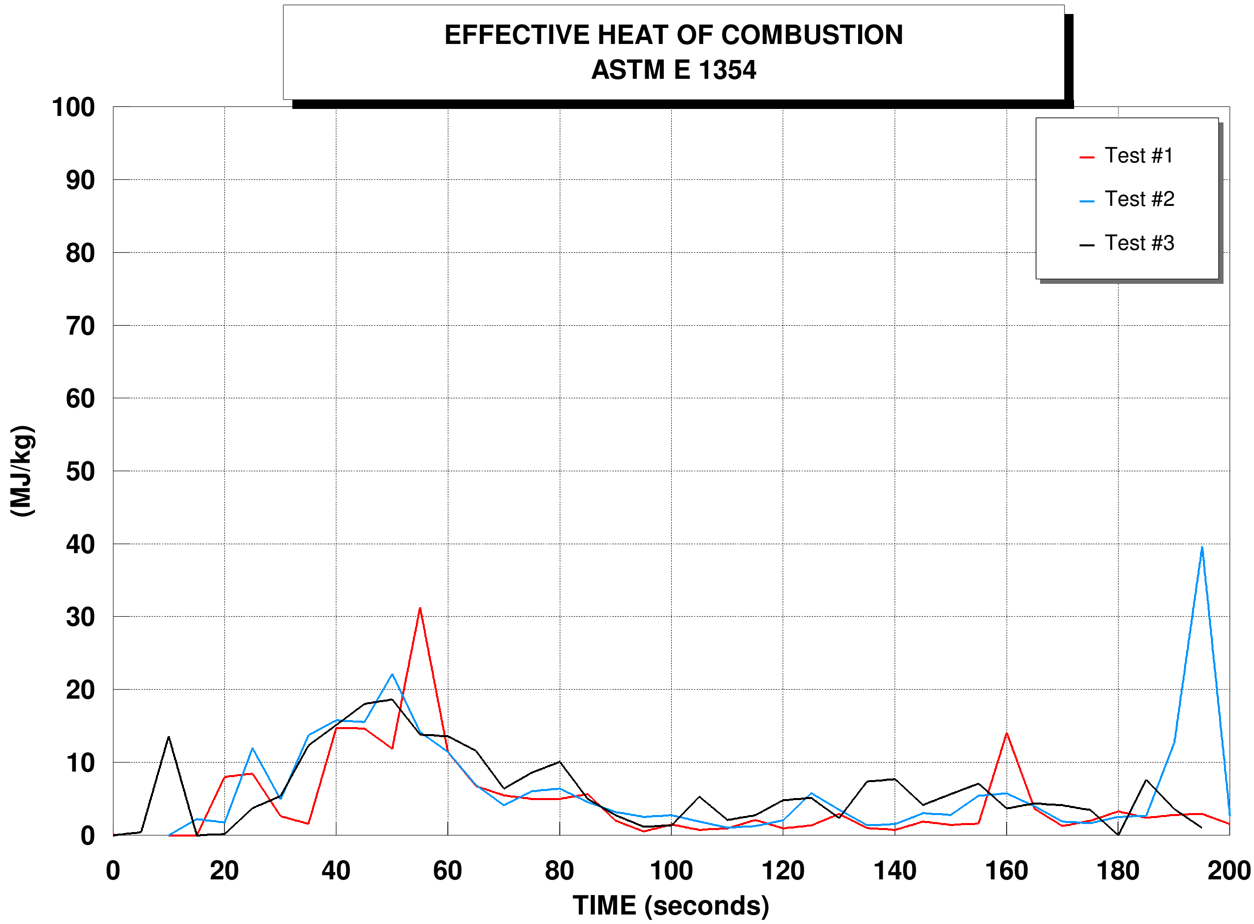
Testing was performed on November 13, 2013 with the sample in the horizontal configuration, utilizing the specimen holder and edge frame and also the specified spark ignition source.

	Test #1	Test #2	Test #3	Average	
Heat Flux (kW/m²)	50	50	50		
Exhaust Flow Rate (l/s)	24	24	24		
Specimen Thickness (mm)	1.0	1.0	1.0		
Initial Mass (g)(including substrate)	90.1	97.0	97.1		
Mass at Sustained Flaming (g)(including substrate)	89.9	96.7	96.9		
Final Mass (g)(including substrate)	81.6	89.1	90.9		
Total Mass Loss (kg/m²)	0.85	0.79	0.62	0.75	
Peak Specific Mass Loss Rate (g/s·m²)	12.42	12.94	12.64	12.67	
Average Mass Loss Rate (g/s·m²)	8.39	5.03	5.13	6.18	
Time to Ignition (s)	32	25	26	28	
Time to Flame-out (s)	86	84	85	85	
Time of Peak Rate of Heat Release (s)	50	40	40	43	
Peak Rate of Heat Release (kW/m²)	147.6	204.8	162.5	171.7	
Average Rate of Heat Release (kW/m²)	69.6	37.2	51.1	52.6	
Total Heat Released (MJ/m²)	3.80	6.13	4.93	4.95	
Average Effective Heat of Combustion (MJ/kg)	9.57	7.22	10.15	**8.98**	*
Average Effective Heat of Combustion (BTU/lb)	4121.3	3111.3	4371.6	**3868**	*
Caloric Content (MJ/kg)	0.37	0.56	0.45	**0.46**	**
Caloric Content (BTU/lb)	160.61	240.68	193.38	**198**	**
Peak Extinction Area (m²/kg)	1685.0	466.2	668.2	939.8	
Average Extinction Area (m²/kg)	108.5	136.9	152.0	132.5	

* Total heat produced per unit mass of material consumed

** Total heat produced per unit mass of material tested

TEST RESULTS (continued)



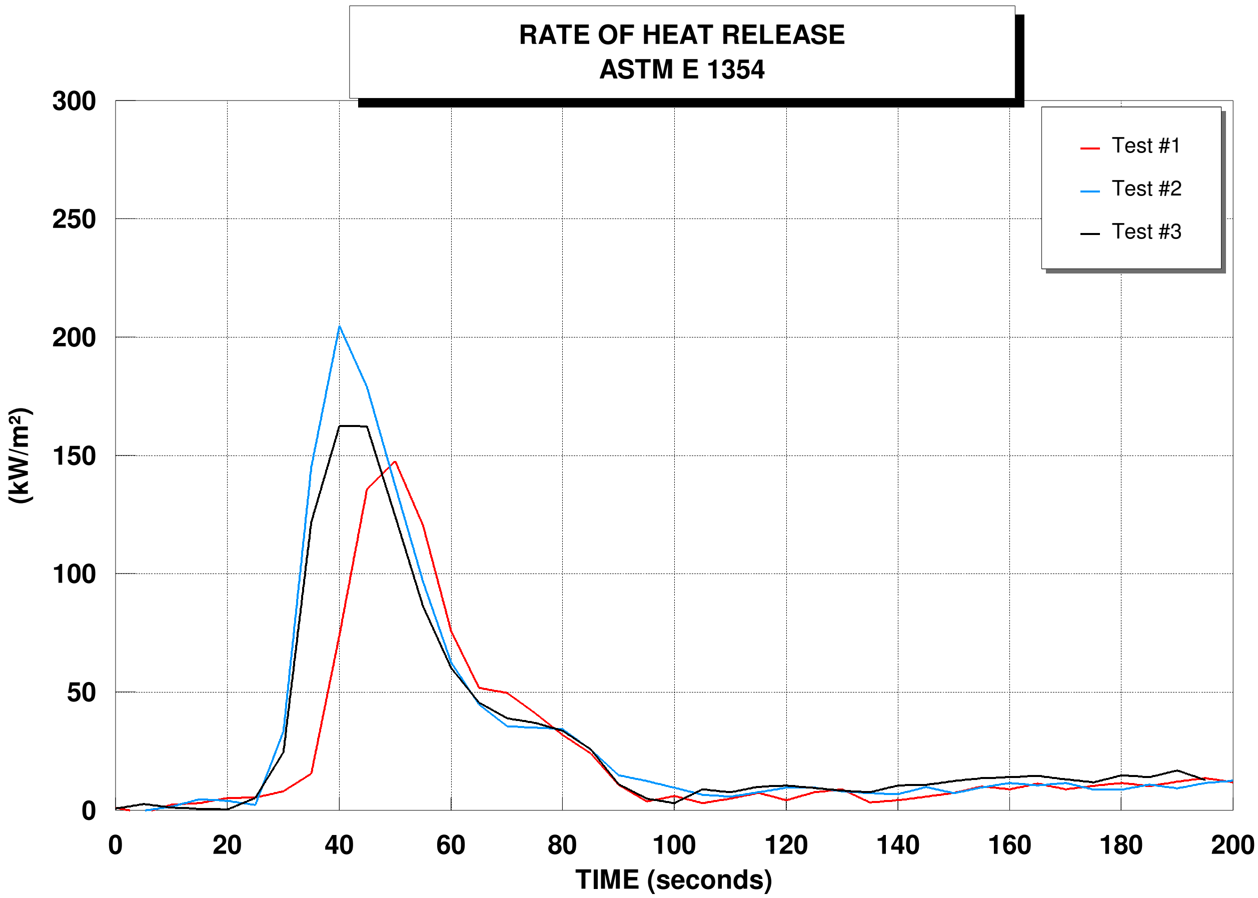
	Test #1	Test #2	Test #3	Average
Average Heat of Combustion (MJ/kg)*	9.57	7.22	10.15	8.98
Heat of Combustion @ 60 s (MJ/kg)**	8.75	11.36	12.14	10.75
Heat of Combustion @ 180 s (MJ/kg)**	0.00	0.00	0.00	0.00
Heat of Combustion @ 300 s (MJ/kg)**	0.00	0.00	0.00	0.00

* Averaged over the period starting when 10% of the ultimate mass loss occurred and ending at the time when 90% of the ultimate mass loss occurred.

** Averages, or projected averages over the 60, 180 or 300 second periods starting when 10% of the ultimate mass loss occurred.

Exova

TEST RESULTS (continued)

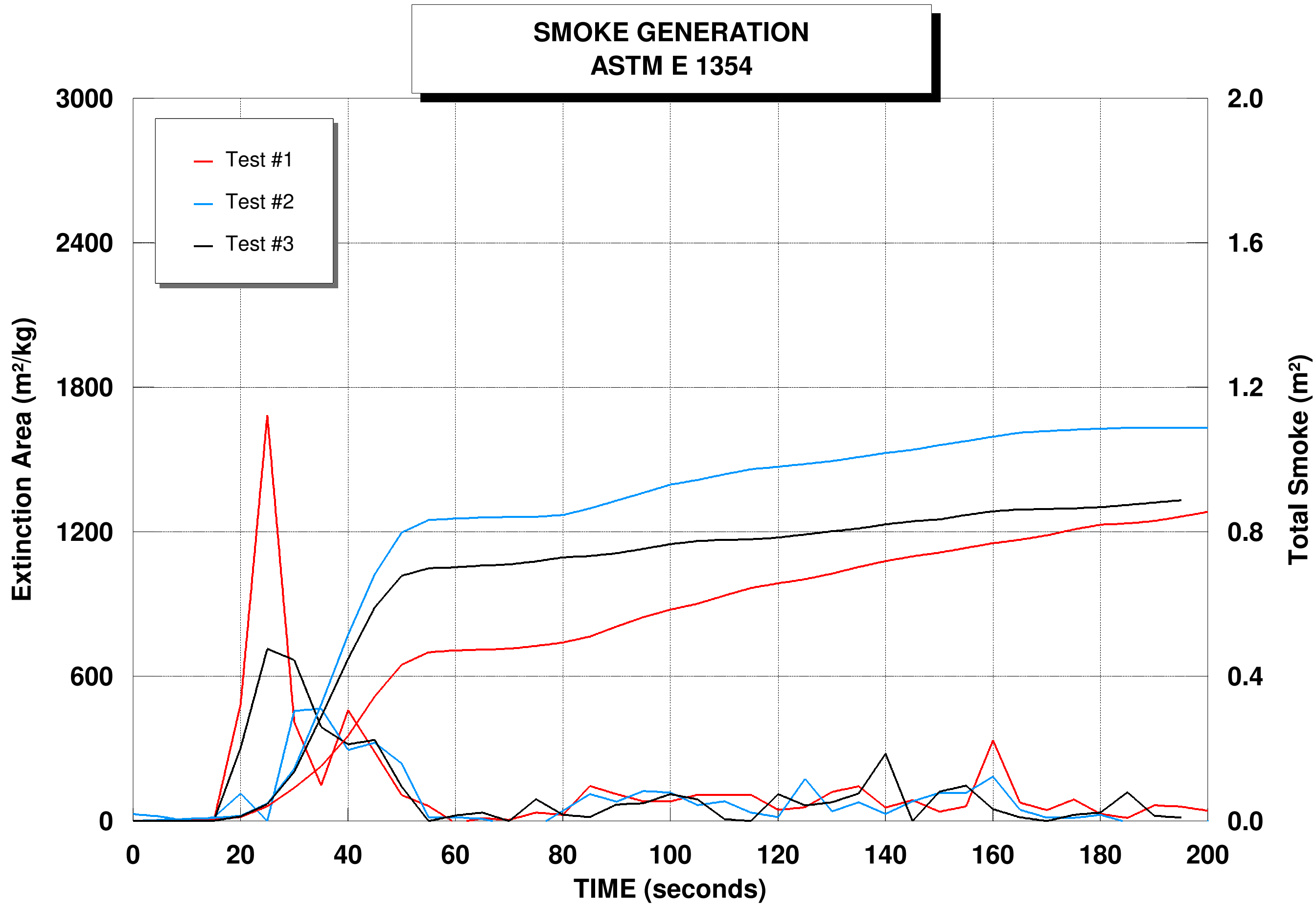


	Test #1	Test #2	Test #3	Average
Peak Rate of Heat Release (kW/m²)	147.6	204.8	162.5	171.7
Average Heat Release Rate (kW/m²)*	69.6	37.2	51.1	52.6
Heat Release Rate @ 60 s (kW/m²)**	64.4	85.2	76.4	75.3
Heat Release Rate @ 180 s (kW/m²)**	0.0	0.0	0.0	0.0
Heat Release Rate @ 300 s (kW/m²)**	0.0	0.0	0.0	0.0

* Averaged over the test period (from ignition to flameout).

** Averages, or projected averages over the first 60, 180 or 300 seconds after ignition.

TEST RESULTS (continued)

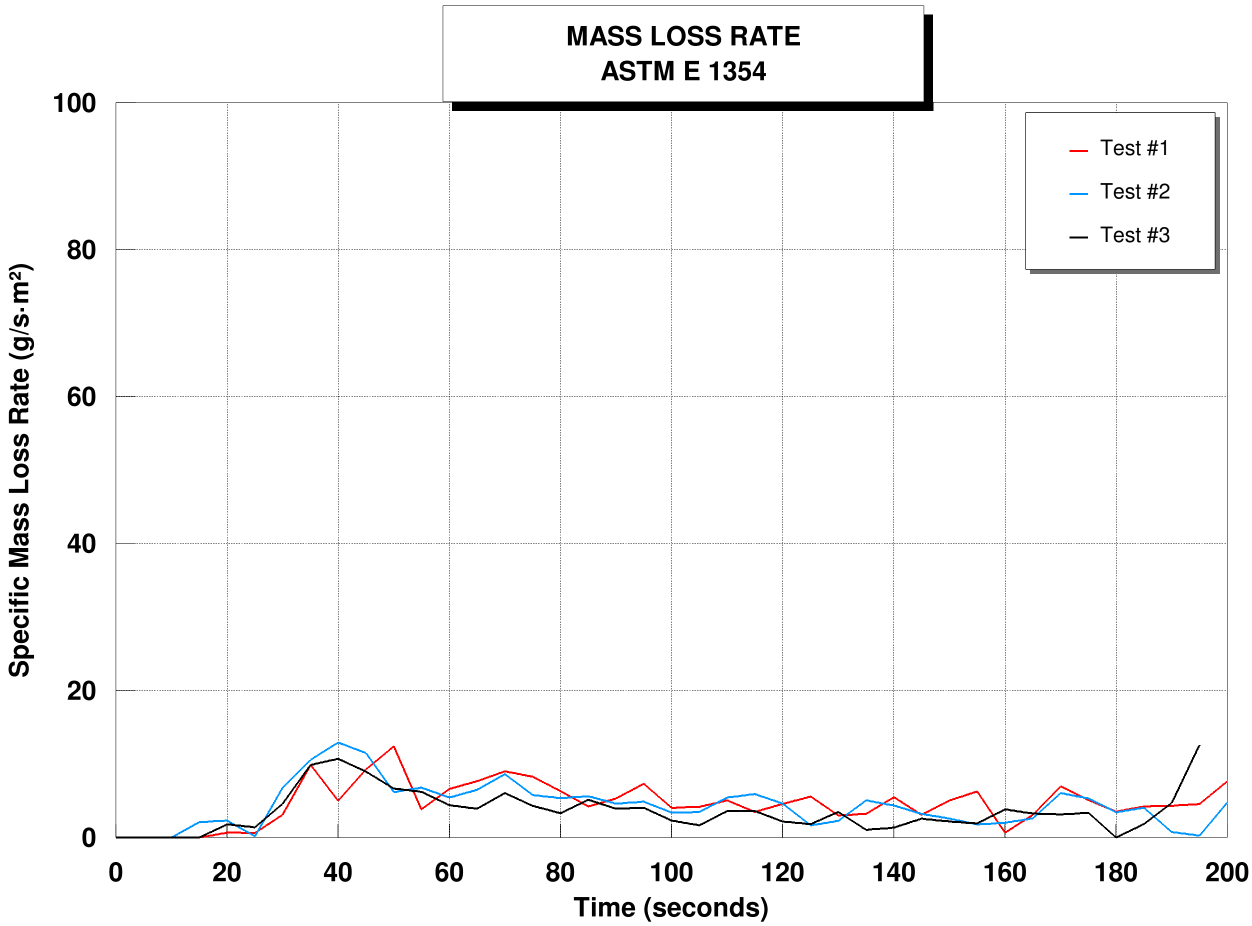


	Test #1	Test #2	Test #3	Average
Peak Extinction Area (m^2/kg)	1685.0	466.2	668.2	939.8
Average Extinction Area (m^2/kg)*	108.5	136.9	152.0	132.5
Extinction Area @ 60 s (m^2/kg)**	105.0	202.4	177.5	161.6
Extinction Area @ 180 s (m^2/kg)**	0.0	0.0	0.0	0.0
Extinction Area @ 300 s (m^2/kg)**	0.0	0.0	0.0	0.0
Total Smoke (m^2)	0.42	1.04	0.75	0.74

* Averaged over the test period (from ignition to flameout).

** Averages, or projected averages over the first 60, 180 or 300 seconds after ignition.

TEST RESULTS (continued)



	Test #1	Test #2	Test #3	Average
Peak Mass Loss Rate (g/s·m²)	12.42	12.94	12.64	12.67
Avg. Specific Mass Loss Rate (g/m²·s)*	8.39	5.03	5.13	6.18
Mass Loss Rate @ 60 s (g/s)**	0.06	0.07	0.05	0.06
Mass Loss Rate @ 180 s (g/s)**	0.00	0.00	0.00	0.00
Mass Loss Rate @ 300 s (g/s)**	0.00	0.00	0.00	0.00

* Averaged over the period starting when 10% of the ultimate mass loss occurred and ending at the time when 90% of the ultimate mass loss occurred.

** Averages, or projected averages over the 60, 180 or 300 second periods starting when 10% of the ultimate mass loss occurred.

CONCLUSIONS

The polyurethane adhesive sealant material, identified in this report, when tested applied onto 6 mm thick fiberglass reinforced cement substrate, affords an average Effective Heat of Combustion of 8.98 MJ/kg (3868 BTU/lb) of consumed material when tested according to ASTM E 1354 at an imposed heat flux of 50 kW/m^2. Based on the initial mass of each specimen, this calculates to an overall average Caloric Content of 0.46 MJ/kg (198 BTU/lb).

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

Mel Garces,
Senior Technologist.

Ian Smith,
Technical Manager.

Note: This report and service are covered under Exova Canada Inc. Standard Terms and Conditions of Contract which may be found on the Exova website (www.exova.com), or by calling 1-866-263-9268.

APPENDIX

(1 Page)

ASTM E 1354 Definitions

Exova

ASTM E 1354 DEFINITIONS

In evaluating the data produced by the oxygen consumption (cone) calorimeter, the following definitions and comments are offered:

Effective Heat of Combustion	This is the measured heat release divided by the mass loss for a specified time period and represents, therefore, the calorific value of the consumed portion only of the tested material. Caloric content under the test conditions can be derived by dividing the total heat released by the original mass of the material under test. It generally differs from the theoretical heat of combustion, since the latter involves complete combustion - a phenomenon which rarely takes place in an actual fire.
Time to Ignition	Also known as ignition delay time, this parameter provides a measure of a material's propensity to ignition as measured by the time to sustained ignition at a given heat flux. It can also be considered to be related to the volatility of the degradation products and the time required to achieve a critical fuel concentration in the vapour phase. This gasification rate is temperature dependent: the higher the imposed heat flux the shorter the time to ignition.
Heat Release Rate (HRR)	HRR is the heat evolved per unit time and is highly dependent on applied heat flux: the higher the flux the greater the HRR. HRR curves can fluctuate significantly with time and it is generally considered that the average HRR can be a better predictor of full-scale fire performance than the peak value.
Total Heat Release	This is the integrated area under the HRR curve over the test period, expressed in MJ/m^3. If one knows the surface area of a material used in a room or transit vehicle, this value is more properly used to estimate "potential heat load" than is the more commonly used "caloric content" based upon the weight of material used.
Mass Loss Rate	This is roughly correlatable with heat release rate because it is the rate at which the test material is degraded to produce combustible fuels. The peak mass loss rate and average mass loss rate are derivative terms generated by the load cell.
Extinction Area	This refers to the "yield" of smoke which is, through mathematical manipulation, expressed as an area per unit mass.

In addition to average values for the test, data averaged to the 60, 180 and 300 second marks after ignition are also typically provided. Where materials burn for different lengths of time, for example, it is more technically sound to compare the average heat release rates over the first 1, 3 or 5 minutes of burning than to compare the test average results which encompass differing time periods.