

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

# Surface Flammability, Smoke and Toxic Gas Generation of "3M™ Polyurethane Adhesive Sealant 550 Fast Cure"

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: hccertain@mmm.com

Attention: Harry Certain

Submitted By: Exova Warringtonfire North America

Report No. 13-002-625(A1)  
5 pages + 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 surface flammability in accordance with ASTM E 162, rate of smoke generation according to ASTM E 662 and toxic gas production in accordance with Bombardier SMP 800-C and Boeing BSS 7239, 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, identified as "3M™ Polyurethane Adhesive Sealant 550 Fast Cure".

(Exova sample identification number 13-002-S0625-1)

### **SAMPLE PREPARATION**

The polyurethane adhesive sealant was applied by the client onto 6 mm thick fiberglass reinforced cement substrate using a 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.

### **TEST RESULTS**

#### **ASTM E 162-13**

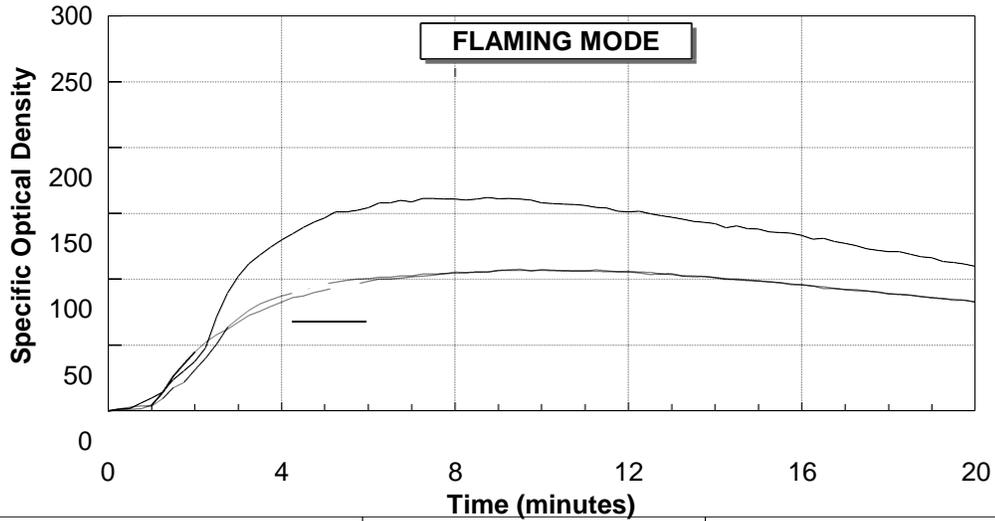
Surface Flammability of Materials Using a Radiant  
Heat Energy Source. (Is = Flame Spread Index).

	<u>F<sub>s</sub></u>	<u>Q</u>	<u>I<sub>s</sub></u>	<u>Observations</u>
1:	2.7	2.7	7	Maximum flame front propagation to a distance of 12 inches.
2:	2.6	2.9	7	Surface venting observed.
3:	2.3	1.7	4	No flaming running and flaming dripping observed.
4:	2.5	2.3	<u>6</u>	
Rounded Average:			5	
Specified Maximum:			35	No flaming running or flaming dripping allowed

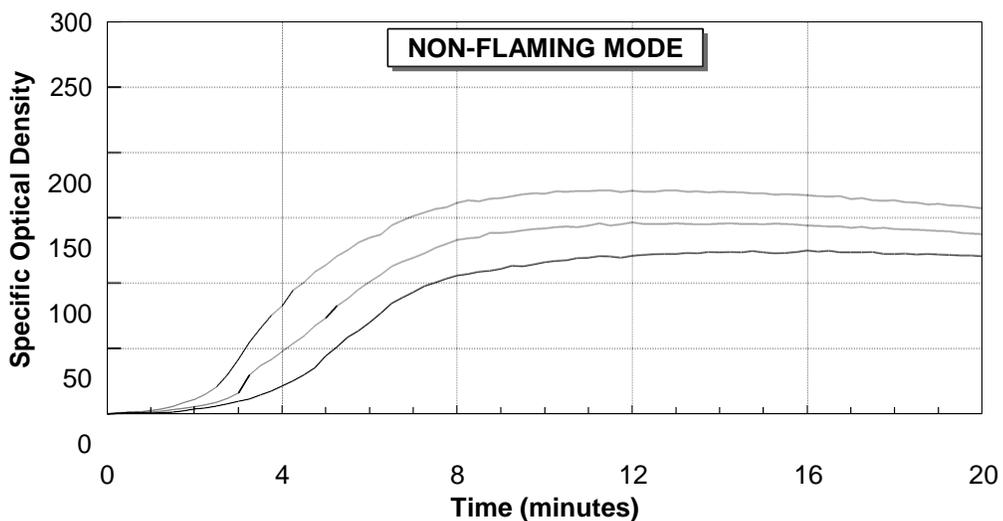
**TEST RESULTS (continued)**

**ASTM E 662-13d**

Specific Optical Density of Smoke Generated by Solid Materials



Relative Room Humidity: 28%		Test Duration: 20 min.			Chamber Wall Temp: 35°C		
Flaming Mode		Test	#1	#2	#3	Average	Specified Maxima
Specific Optical Density at 1.5 minutes			26	18	24	23	100
Specific Optical Density at 4.0 minutes			83	88	130	100	200
Maximum Specific Optical Density			108	107	162	126	-
Maximum Corrected Optical Density			105	104	159	123	-



Relative Room Humidity: 28%		Test Duration: 20 min.			Chamber Wall Temp: 35°C		
Non-Flaming Mode		Test	#1	#2	#3	Average	Specified Maxima
Specific Optical Density at 1.5 minutes			3	6	1	3	100
Specific Optical Density at 4.0 minutes			48	83	21	51	200

---

Maximum Specific Optical Density	147	171	125	148	-
Maximum Corrected Optical Density	145	168	123	146	-

**TEST RESULTS (continued)****ASTM E 662 Observations**

In the flaming mode, ignition was initially observed at the point of pilot flame impingement followed by visible smoke and charring. In the non-flaming mode, visible smoke production was observed within 30 seconds followed by charring.

**Bombardier SMP 800-C (Rev. 6 2009-08-31)**  
Toxic Gas Generation from Material Combustion

	<u>Flaming</u> <u>Mode</u>	<u>Non-Flaming</u> <u>Mode</u>	<u>Specified</u> <u>Maxima</u>
Carbon Monoxide (CO ppm)			
at 1.5 minutes	6	<1	-
at 4.0 minutes	157	<1	-
at maximum	1042	452	3500
Carbon Dioxide (CO2 ppm)			
at 1.5 minutes	30	<1	-
at 4.0 minutes	3617	30	-
at maximum	13881	1629	90000
Nitrogen Oxides (as NO2 ppm)	2	<1	100
Sulfur Dioxide (SO2 ppm)	50	19	100
Hydrogen Chloride (HCl ppm)	33	94	500
Hydrogen Fluoride (HF ppm)	2	<2	100
Hydrogen Bromide (HBr ppm)	4	2	100
Hydrogen Cyanide (HCN ppm)	6	6	100
Original Weight (g)(including substrate)	50.88	47.63	-
Final Weight (g)	<u>Not determinable</u>	<u>Not determinable</u>	-
Weight Loss (g)	-	-	-
Weight Loss (%)	-	-	-
Time to Ignition (s)	3	Did not ignite	-
Burning Duration (s)	100	-	-

**TEST RESULTS (continued)****Boeing BSS 7239 (Rev.: A 1-18-88)**Toxic Gas Generation

		Flaming <u>Mode</u>	Non-Flaming <u>Mode</u>	Typical Specified <u>Maxima</u>
Carbon Monoxide (CO ppm)	at 1.5 minutes	10	<1	-
	at 4.0 minutes	150	<1	-
	at maximum	980	370	3500
Nitrogen Oxides (as NO <sub>2</sub> ppm)		<1	<1	100
Sulfur Dioxide (SO <sub>2</sub> ppm)		32	11	100
Hydrogen Chloride (HCl ppm)		100	170	500
Hydrogen Fluoride (HF ppm)		<12	<12	200
Hydrogen Cyanide (HCN ppm)		5	5	150
Original Weight (g)(including substrate)		49.00	50.62	-
Final Weight (g)		<u>Not determinable</u>	<u>Not determinable</u>	-
Weight Loss (g)		-	-	-
Weight Loss (%)		-	-	-
Time to Ignition (s)		5.0	Did not ignite	-
Burning Duration (s)		60.0	-	-

**CONCLUSIONS AND COMMENTS**

There are currently no specific performance criteria cited by the Federal Railroad Administration for adhesive sealant materials. However, the adhesive identified in this report, when tested applied onto 6 mm thick fiberglass reinforced cement substrate, would meet all of the current requirements (for all specified categories) as they pertain to surface flammability (ASTM E 162) and rate of smoke generation (ASTM E 662).

The polyurethane adhesive sealant also meets Bombardier requirements as they pertain to toxic gas production (Bombardier SMP 800-C).

Boeing BSS 7239 is solely a test procedure and as such, has no specific pass/fail criteria of its own. The reference criteria cited are typical for the transportation industry and are listed for reference purposes only. They may or may not apply to this specific product.

The polyurethane adhesive sealant identified in this report meets the M-7 Technical Specification requirements as they pertain to toxic gas generation (Boeing BSS 7239).

**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.

---

*may be found on the Exova website ([www.exova.com](http://www.exova.com)), or by calling 1-866-263-9268.*

**APPENDIX**

(4 pages)

**Summaries of Test Procedures**

**ASTM E 162-13**Surface Flammability of Materials Using a Radiant Energy Source.

As specified, four specimens, 6 x 18 inches in size, are pre-dried for 24 hours at 60°C. Section 10.1 of ASTM E 162-13 states to then condition the specimens to "equilibrium (constant weight)" but does not specify a definition or procedure with respect to establishing the "constant weight". Therefore, prior to testing, the specimens are then conditioned for a minimum period of 24 hours at 50 ± 5% relative humidity and 23 ± 3°C.

Each specimen is mounted into a holder and inclined at 30° from the vertical in front of a 12 x 18 inch gas-fired radiant panel. The orientation of the specimen is such that ignition is forced near its upper edge by a pilot flame, and the flame front progresses downwards.

A factor derived from the rate of progress of the flame-front and the rate of heat liberation by the material under test is calculated as follows and then reported after rounding the average of the tests to the nearest multiple of 5:

$$I_s = F_s \cdot Q$$

Where:  $I_s$  is the flame spread index

$F_s$  is the flame spread factor

$Q$  is the heat evolution factor

Transit authorities generally specify a maximum  $I_s$  acceptance criterion of 35 for general applications, and 100 for light diffusers, windows and transparent plastic windscreens.

**ASTM E 662-13d**Standard Test Method for the Specific Optical Density of Smoke Generated by Solid Materials

This method of test covers a procedure for measuring the smoke generated by solid materials and assemblies in thickness up to and including 1 inch (25.4 mm). Measurement is made of the attenuation of a light beam by smoke (suspended solid or liquid particles) accumulating within a closed chamber due to nonflaming pyrolytic decomposition and flaming combustion. Results are expressed in terms of specific optical density (Ds), which is derived from a geometrical factor and the measured optical density (absorbance).

As specified, the test samples are pre-dried for 24 hours at 60°C. Section 9.1 of ASTM E 662-13d states to then condition the specimens to "equilibrium (constant weight)" but does not specify a definition or procedure with respect to establishing the "constant weight". Therefore, prior to testing, the specimens are then conditioned for a minimum period of 24 hours at  $50 \pm 5\%$  relative humidity and  $23 \pm 3^\circ\text{C}$ .

Three specimens, 3" square, are exposed to each mode of combustion. Prior to test initiation, the chamber wall temperature is established in the range of 33 to 37°C. The % light transmittance during the course of the combustion is recorded. These data are used to express the quantity of smoke in the form of Specific Optical Density based on the following formula, which assumes the applicability of Bouguer's law:

$$D_s = (V/AL) \cdot \log(100/T) = G \cdot \log(100/T) = 132 \cdot \log(100/T)$$

Where:  $D_s$  = Specific Optical Density

$T$  = % Transmittance

$V$  = Chamber Volume (18 ft<sup>3</sup>)

$A$  = Exposed Area of the Sample (0.0456 ft<sup>2</sup>)

$L$  = Length of Light Path in Chamber (3.0 ft)

$G$  = Geometric Factor

Among the parameters normally reported are:

$D_s$		
1.5	- specific optical density after 1.5 minutes	
$D_s$		
4.0	- specific optical density after 4.0 minutes	
$D_m$	- maximum specific optical density at any time during the 20 minute test	
$D_m$		
(corr)	- $D_m$ corrected for incidental deposits on the optical surfaces	

Transit authorities generally specify a maximum  $D_s$  1.5 of 100 and a maximum  $D_s$  4.0 of 200 in either flaming or non-flaming test mode.

**Bombardier SMP 800-C (Rev. 6 2009-08-31)**Toxic Gas Sampling and Analytical ProceduresToxic Gas Generation

Gases produced for analysis are generated in a specified, calibrated smoke chamber during standard rate of smoke generation testing (typically ASTM E 662), in both flaming combustion and non-flaming pyrolytic decomposition test modes.

Carbon Monoxide (CO) and Carbon Dioxide (CO<sub>2</sub>)

CO and CO<sub>2</sub> are monitored continuously during the 20 minute test using a non-dispersive infrared (NDIR) analyzer. Data are reported in ppm by volume at 1.5 and 4.0 minutes and at maximum concentration.

Acid Gas Sampling

HCN, HF, HCl, HBr, NO<sub>x</sub> and SO<sub>2</sub> are sampled by drawing 6 litres of the chamber atmosphere through two midget impingers, each containing 10 ml of 0.25N NaOH, at a rate of 375 ml per minute. The 16-minute sampling period is commenced at the 4 minute mark. All determinations are performed in both the flaming and non-flaming modes and all data are reported in parts per million (ppm) by volume in air.

Analysis of Impingers for Hydrogen Cyanide (HCN)

Cyanide in the NaOH impinger, as NaCN, is converted to CNCl by reaction with chloramine-T at pH greater than 8 without hydrolyzing to CNO<sup>-</sup>. After the reaction is complete, CNCl forms a red-blue colour on addition of a pyridine-barbituric acid reagent. Cyanide is quantified by spectrometric measurement of the increase in colour 578 nm.

Reference: In-house SOP 00-13-SP-1216 based on ASTM Method D 2036-91

Analysis of Impingers for Hydrogen Fluoride (HF)

Fluoride, as NaF, in the NaOH impinger is determined using SPADNS colorimetry.

Reference: In-house SOP 01-13-SP-1295

Analysis of Impingers for Hydrogen Chloride (HCl) and Hydrogen Bromide (HBr)

Alkali halides (chloride and bromide) formed in the NaOH solution are measured using ion chromatography and conductivity detection.

Reference: In-house SOP 02-13-SP-1402

Analysis of Impingers for Nitrogen Oxides (NO<sub>x</sub>)

Nitrite and nitrate formed in the alkaline solution are determined using ion chromatography and conductivity detection. The nitrite and nitrate results are combined and the total expressed as nitrogen dioxide (NO<sub>2</sub>).

Reference: In-house SOP 02-13-SP-1402

Analysis of Impingers for Sulfur Dioxide (SO<sub>2</sub>)

SO<sub>2</sub> is trapped in the NaOH impinger as sulfite and sulfate (SO<sub>3</sub><sup>-2</sup> and SO<sub>4</sub><sup>-2</sup>). Hydrogen peroxide is added to convert SO<sub>3</sub><sup>-2</sup> to SO<sub>4</sub><sup>-2</sup>. Resulting sulfate is determined using ion chromatography and conductivity detection.

Reference: In-house SOP 02-13-SP-1402

**Boeing BSS 7239 (Rev.: A 1-18-88)**  
Toxic Gas Sampling and Analytical Procedures

Toxic Gas Generation

Gases produced for analysis are generated in a specified, calibrated smoke chamber during standard rate of smoke generation testing (ASTM E 662), in both flaming combustion and non-flaming pyrolytic decomposition test modes.

Carbon Monoxide (CO)

CO is monitored continuously during the 20 minute test using a non-dispersive infrared (NDIR) analyzer. Data are reported in ppm by volume at 1.5 and 4.0 minutes and at maximum concentrations.

Acid Gas Sampling

HCN, HF, HCl, HBr, NO<sub>x</sub> and SO<sub>2</sub> are sampled by drawing 1 litre of the chamber atmosphere through two midjet impingers, each containing 10 ml of 0.25N NaOH, at a rate of 400 ml per minute. The 2½ minute sampling period is commenced at the 4 minute mark. Determinations are performed in both the flaming and non-flaming modes and data are reported in parts per million (ppm) by volume in air.

Analysis of Impingers for Hydrogen Cyanide (HCN)

Cyanide in the NaOH impinger, as NaCN, is converted to CNCl by reaction with chloramine-T at pH greater than 8 without hydrolyzing to CNO<sup>-</sup>. After the reaction is complete, CNCl forms a red-blue colour on addition of a pyridine-barbituric acid reagent. Cyanide is quantified by spectrometric measurement of the increase in colour 578 nm.

Reference: In-house SOP 00-13-SP-1216 based on ASTM Method D 2036-91

Analysis of Impingers for Hydrogen Fluoride (HF)

Fluoride, as NaF, in the NaOH impinger is determined using SPADNS colorimetry.

Reference: In-house SOP 01-13-SP-1295

Analysis of Impingers for Hydrogen Chloride (HCl)

Alkali halides (chloride) formed in the NaOH solution are measured using ion chromatography and conductivity detection.

Reference: In-house SOP 02-13-SP-1402

Analysis of Impingers for Nitrogen Oxides (NO<sub>x</sub>)

Nitrite and nitrate formed in the alkaline solution are determined using ion chromatography and conductivity detection. The nitrite and nitrate results are combined and the total expressed as nitrogen dioxide (NO<sub>2</sub>).

Reference: In-house SOP 02-13-SP-1402

Analysis of Impingers for Sulfur Dioxide (SO<sub>2</sub>)

SO<sub>2</sub> is trapped in the NaOH impinger as sulfite and sulfate (SO<sub>3</sub><sup>-2</sup> and SO<sub>4</sub><sup>-2</sup>). Hydrogen peroxide is added to convert SO<sub>3</sub><sup>-2</sup> to SO<sub>4</sub><sup>-2</sup>. Resulting sulfate is determined using ion chromatography and conductivity detection.

Reference: In-house SOP 02-13-SP-1402