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Surface Flammability, Smoke and Toxic Gas Generation of "3M™ Polyurethane Adhesive Sealant 560"

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

Phone: (651) 733-8456
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Attention: Harry Certain

Submitted By: Fire Testing

Report No. 11-002-639(B1)
5 pages + appendix

Date: October 18, 2011

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 your Purchase Order No. USMMM8U18T and our Quote No. 11-006-08170 RV1 dated September 21, 2011.

IDENTIFICATION (Exova sample identification number 11-002-S0639-2)

Polyurethane adhesive sealant, identified as "3M™ Polyurethane Adhesive Sealant 560".

SAMPLE PREPARATION

The coating material was applied onto 6 mm thick fiberglass reinforced cement substrate using a 1/32 x 1/32" square notched trowel and was allowed to dry 48 hours prior to testing.

TEST RESULTS

ASTM E 162-11a

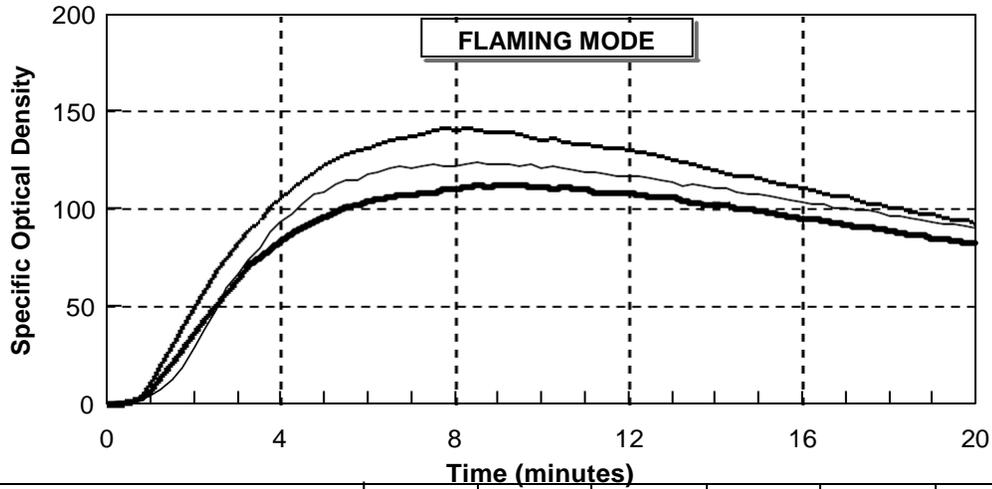
Surface Flammability of Materials Using a Radiant Heat Energy Source. (Is = Flame Spread Index).

	<u>F_s</u>	<u>Q</u>	<u>I_s</u>	<u>Observations</u>
1:	4.1	6.7	27	Maximum flame front propagation to a distance of 17 inches.
2:	4.1	5.7	23	No flaming running or flaming dripping observed.
3:	4.0	5.9	24	
4:	4.1	5.7	<u>24</u>	
Rounded Average:			25	
Specified Maximum:			35	No flaming running or flaming dripping allowed

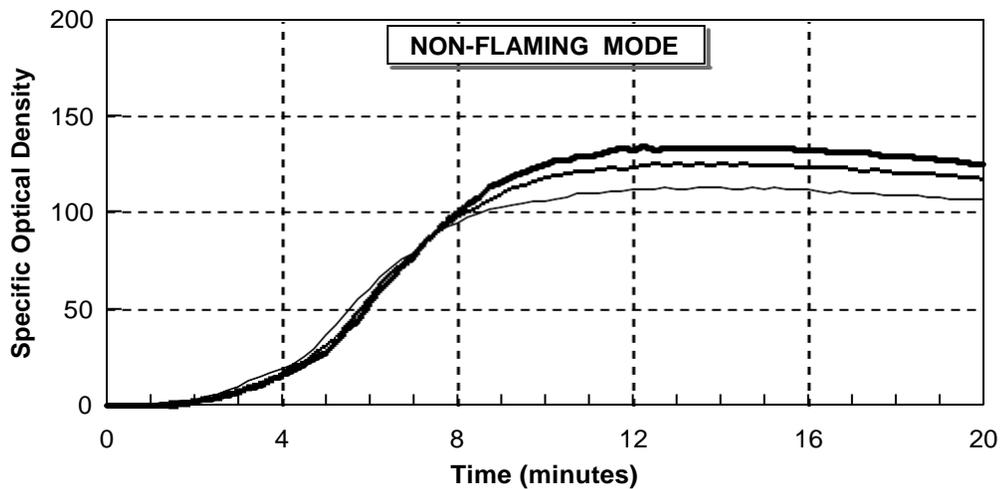
TEST RESULTS (continued)

ASTM E 662-09

Specific Optical Density of Smoke Generated by Solid Materials



Relative Room Humidity: 29%		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			21	31	11	21	100
Specific Optical Density at 4.0 minutes			84	107	93	94	200
Maximum Specific Optical Density			112	142	124	126	-
Maximum Corrected Optical Density			109	139	120	123	-



Relative Room Humidity: 29%		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			1	1	1	1	100
Specific Optical Density at 4.0 minutes			16	18	19	18	200
Maximum Specific Optical Density			134	127	113	125	-
Maximum Corrected Optical Density			133	124	112	123	-

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

In the flaming mode, ignition was initially observed at the point of pilot flame impingement. Surface charring and visible smoke production were also observed. In the non-flaming mode, visible smoke production was observed within 40 seconds followed by surface 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	33	<10	-
at 4.0 minutes	195	<10	-
at maximum	990	603	3500
Carbon Dioxide (CO2 ppm)			
at 1.5 minutes	300	100	-
at 4.0 minutes	1650	150	-
at maximum	12750	1650	90000
Nitrogen Oxides (as NO2 ppm)	2	2	100
Sulfur Dioxide (SO2 ppm)	12	6	100
Hydrogen Chloride (HCl ppm)	17	54	500
Hydrogen Fluoride (HF ppm)	5	4	100
Hydrogen Bromide (HBr ppm)	1	1	100
Hydrogen Cyanide (HCN ppm)	5	5	100
Original Weight (g)	43.4	43.6	-
Final Weight (g)	<u>Not determinable</u>	<u>Not determinable</u>	-
Weight Loss (g)	-	-	-
Weight Loss (%)	-	-	-
Time to Ignition (s)	5	Did not ignite	-
Burning Duration (s)	60	-	-

TEST RESULTS (continued)

Boeing BSS 7239 (Rev.: A 1-18-88)

Toxic Gas Generation

		Flaming <u>Mode</u>	Non-Flaming <u>Mode</u>	M-7 Technical Specification <u>Maxima</u>
Carbon Monoxide (CO ppm)	at 1.5 minutes	53	<10	-
	at 4.0 minutes	230	13	-
	at maximum	1053	638	3500
Nitrogen Oxides (asNO2 ppm)		<1	<1	100
Sulfur Dioxide (SO2 ppm)		17	<6	100
Hydrogen Chloride (HCl ppm)		53	110	500
Hydrogen Fluoride (HF ppm)		21	19	200
Hydrogen Bromide (HBr ppm)		<3	<3	-
Hydrogen Cyanide (HCN ppm)		4	<1	150
Original Weight (g)		43.7	49.8	-
Final Weight (g)		<u>Not determinable</u>	<u>Not determinable</u>	-
Weight Loss (g)		-	-	-
Weight Loss (%)		-	-	-
Time to Ignition (s)		5	Did not ignite	-
Burning Duration (s)		60	-	-

CONCLUSIONS AND COMMENTS

The polyurethane adhesive sealant identified in this report, when tested at applied onto 6 mm thick fiberglass reinforced cement substrate, meets The Federal Railroad Administration requirements 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 SMP800-C).

Boeing BSS 7239 is solely a test procedure and, as such, has no specific pass/fail criteria of its own. The M-7 Technical Specification criteria are cited for reference purposes only, and 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,
Fire Testing.

Ian Smith,
Fire Testing.

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

(4 pages)

Summaries of Test Procedures

ASTM E 162-11aSurface Flammability of Materials Using a Radiant Energy Source.

Four specimens, 6 x 18 inches in size, are pre-dried for 24 hours at 60°C and conditioned to equilibrium at 50 ± 5% relative humidity and 23 ± 3°C before testing.

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 662-09

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).

Specimens are dried for 24 hours at 60°C and conditioned to equilibrium at 50% RH and 23°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:

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

Where: Ds = Specific Optical Density

T = % Transmittance

V = Chamber Volume (18 ft³)

A = Exposed Area of the Sample (0.0456 ft²)

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

G = Geometric Factor

Among the parameters normally reported are:

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

Transit authorities generally specify a maximum Ds 1.5 of 100 and a maximum Ds 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 (CO₂)

CO and CO₂ 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_x and SO₂ 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⁻. 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_x)

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 (NO₂).

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

Analysis of Impingers for Sulfur Dioxide (SO₂)

SO₂ is trapped in the NaOH impinger as sulfite and sulfate (SO₃²⁻ and SO₄²⁻). Hydrogen peroxide is added to convert SO₃²⁻ to SO₄²⁻. 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_x and SO₂ 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⁻. 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.

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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 (NO₂).

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SO₂ is trapped in the NaOH impinger as sulfite and sulfate (SO₃²⁻ and SO₄²⁻). Hydrogen peroxide is added to convert SO₃²⁻ to SO₄²⁻. Resulting sulfate is determined using ion chromatography and conductivity detection.

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