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Surface Flammability, Smoke and Toxic Gas Generation of "3M™ Polyurethane Adhesive Sealant 550 Fast Cure + AC63"

A Report To:

3M Center
Industrial and Transportation Division
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Attention: Harry Certain

Submitted By: Exova Warringtonfire North America

Report No. 13-002-625(B1)
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 with accelerator, identified as "*3M™ Polyurethane Adhesive Sealant 550 Fast Cure + AC63*".

(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.

TEST RESULTS

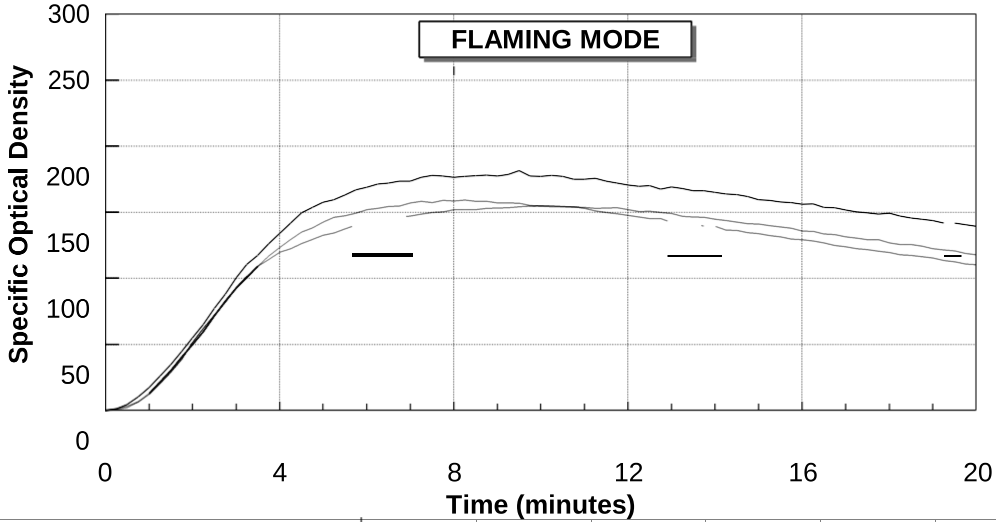
ASTM E 162-13

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

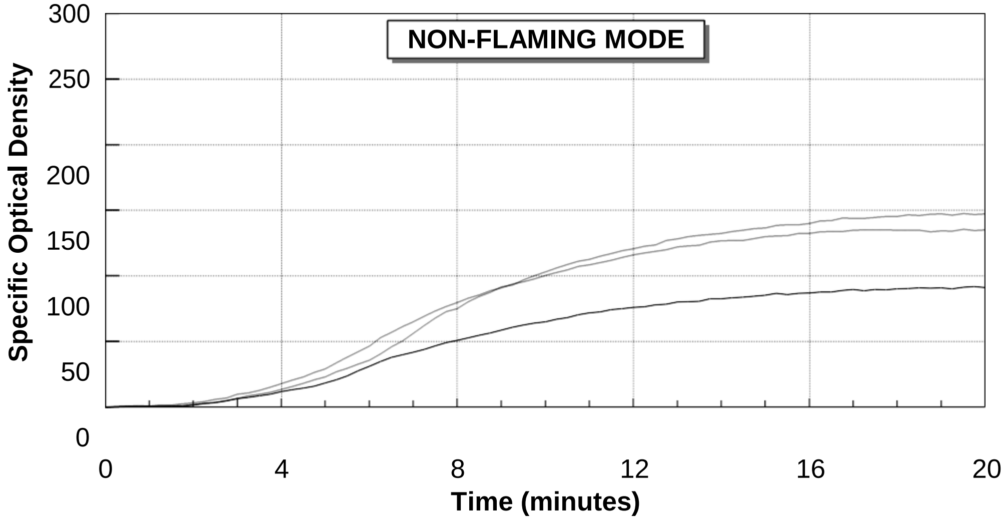
	Fs	Q	Is	Observations
1:	1.3	2.8	4	Flashing flame front propagation to a distance of 8 inches.
2:	1.4	1.6	2	Surface venting observed.
3:	1.6	4.6	7	No Flaming running and flaming dripping observed.
4:	1.6	3.4	5	
Rounded Average:			5	
Specified Maximum:			35	No flaming running or flaming dripping allowed

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		30	29	35	31	100
Specific Optical Density at 4.0 minutes		120	124	134	126	200
Maximum Specific Optical Density		155	159	181	165	-
Maximum Corrected Optical Density		153	157	179	163	-



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		1	2	1	1	100
Specific Optical Density at 4.0 minutes		14	18	12	14	200

Maximum Specific Optical Density	148	136	92	125	-
Maximum Corrected Optical Density	147	136	91	125	-

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

		Flaming Mode	Non-Flaming Mode	Specified Maxima
Carbon Monoxide (CO ppm)				
	at 1.5 minutes	<1	<1	-
	at 4.0 minutes	85	<1	-
	at maximum	923	273	3500
Carbon Dioxide (CO2 ppm)				
	at 1.5 minutes	<1	51	-
	at 4.0 minutes	772	163	-
	at maximum	11508	1011	90000
Nitrogen Oxides (as NO2 ppm)		<1	<1	100
Sulfur Dioxide (SO2 ppm)		<1	5	100
Hydrogen Chloride (HCl ppm)		21	59	500
Hydrogen Fluoride (HF ppm)		<2	<2	100
Hydrogen Bromide (HBr ppm)		3	<1	100
Hydrogen Cyanide (HCN ppm)		3	1	100
Original Weight (g)(including substrate)		49.63	51.31	-
Final Weight (g)		Not determinable	Not determinable	-
Weight Loss (g)		-	-	-
Weight Loss (%)		-	-	-
Time to Ignition (s)		3	Did not ignite	-
Burning Duration (s)		60	-	-

TEST RESULTS (continued)

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

Toxic Gas Generation

		Flaming Mode	Non-Flaming Mode	Typical Specified Maxima
Carbon Monoxide (CO ppm)	at 1.5 minutes	<1	<1	-
	at 4.0 minutes	139	<1	-
	at maximum	998	276	3500
Nitrogen Oxides (as NO2 ppm)		<1	<1	100
Sulfur Dioxide (SO2 ppm)		11	<3	100
Hydrogen Chloride (HCl ppm)		94	150	500
Hydrogen Fluoride (HF ppm)		<12	<12	200
Hydrogen Cyanide (HCN ppm)		2	<1	150
Original Weight (g)(including substrate)		47.18	46.52	-
Final Weight (g)		Not determinable	Not determinable	-
Weight Loss (g)		-	-	-
Weight Loss (%)		-	-	-
Time to Ignition (s)		3	Did not ignite	-
Burning Duration (s)		60	-	-

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), 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:

$$\mathrm{Is} = \mathrm{Fs} \cdot \mathrm{Q}$$

Where: Is is the flame spread index

Fs is the flame spread factor

Q is the heat evolution factor

Transit authorities generally specify a maximum Is 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 ± 5% relative humidity and 23 ± 3°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: Ds = Specific Optical Density
T = % Transmittance
V = Chamber Volume (18 ft^3)
A = Exposed Area of the Sample (0.0456 ft^2)
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 Procedures

Toxic 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, NOx 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 (NOX)

Nitrite and nitrate formed in the alkaline solution are determined using ion chromatography and conductivity detection. The nitrite and nitrite 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 (SO3^{-2} and SO4^{-2}). Hydrogen peroxide is added to convert SO3^{-2} to SO4^{-2}. 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, NOx and SO2 are sampled by drawing 1 litre of the chamber atmosphere through two midget 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. Reference: In-house SOP 00-13-SP-1216 based on ASTM Method D 2036-91

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Alkali halides (chloride) formed in the NaOH solution are measured using ion chromatography and conductivity detection. Reference: In-house SOP 02-13-SP-1402

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Nitrite and nitrate formed in the alkaline solution are determined using ion chromatography and conductivity detection. The nitrite and nitrite 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 ($SO3^{-2}$ and $SO4^{-2}$). Hydrogen peroxide is added to convert $SO3^{-2}$ to $SO4^{-2}$. Resulting sulfate is determined using ion chromatography and conductivity detection. Reference: In-house SOP 02-13-SP-1402