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Testing, calibrating, advising.

**EVALUATION OF "FLORASEAL 50"
LIGHT DENSITY OPEN CELL SPRAY APPLIED SEMI-RIGID POLYURETHANE
FOAM IN ACCORDANCE WITH CAN/ULC-S712.1-17**

For:	Genyk 1701, 3e Avenue Grand-Mere, QC G9T 2W6
Attention:	Yves Rondeau.
Cell Phone: Email:	819-619-5010 yvesrondeau@genyk.com
Proposal No.:	18-006-545143 & 18-006-580688-RV1 (for HHRA)
Report No.:	18-06-P0045 4 pages, 9 appendices
Date:	January 7, 2019

1.0 INTRODUCTION

At the request of the Genyk, Exova was retained to evaluate a semi rigid foam material, identified as “FLORASEAL 50,” in accordance with CAN/ULC-S712.1-17, “Standard Specification for Thermal Insulation – Light Density, Open Cell Spray Applied Semi-Rigid Polyurethane Foam - Material Specification.”

1.1 Sampling Information

On April 30, 2018, samples were selected at Genyk’s facility in Grand-Mere, QC under witness by a third party representative. The sample selection letter is attached in **Appendix A** and a representative photograph of the sample is shown in **Appendix B**.

On August 21, 2018, the same material was sprayed from the earlier selected drums at Genyk’s facility in Grand-Mere, QC under the witness by the same third party representative. The 2nd sample selection letter is shown in the Volatile Organic Component (VOC) report in **Appendix H**. Upon selection, the sample was shipped to Exova, Mississauga for testing.

1.2 Sample Preparation & Identification

Sample preparation was performed in compliance with Clause 5.2 and 5.3 of the CAN/ULC-S712.1-17 Standard. The test sample was assigned the following Exova Sample No.:

Client Sample Identification	Exova Sample No.
“FLORASEAL 50”	18-06-P0045

2.0 PROCEDURE

The test sample was evaluated in accordance with CAN/ULC-S712.1-17 for the following:

CAN/ULC-S712.1-17 Clause	Test Description	Test Method
5.5.1	Air Permeance	ASTM E2178
5.5.2	Apparent Core Density	ASTM D1622
5.5.3	Dimensional Stability	ASTM D2126
5.5.4	Fungi Resistance	ASTM C1338
5.5.5	Open Cell Content	ASTM D6226
5.5.6	Surface Burning Characteristics	CAN/ULC-S102
5.5.7	Thermal Resistance	ASTM C518
5.5.8	Time to Occupancy	CAN/ULC-S774
5.5.9	Water Absorption	ASTM D2842, Procedure A
5.5.10	Water Vapor Permeance	ASTM E96, Procedure A

3.0 RESULTS

A summary of the test results is presented below in Table 1.

TABLE 1

Physical Property	Unit	Requirement CAN/ULC-S710.1-11		Results / Comments
		Min.	Max.	
Air Permeance at 75 Pa pressure difference at 100 mm thickness	L/(m ² ·s)	-	Declare	≤ 0.01 Passed See Appendix C
Open Cell Content	%	80	-	98.5 Passed See Appendix D
Apparent Core Density	kg/m ³	6.8	-	8.87, Passed See Appendix E1
Dimensional Stability , Volume Change at: -20 °C 80°C 70 °C, 97 ± 3%RH	%	-	-1 / +10 -15 / +10 -15 / +14	+0.6 Passed -2.2 Passed +0.4 Passed See Appendix E2
Thermal Resistance (at 50 mm thickness)	(m ² ·K)/W	1.20	-	1.28 Passed Appendix E3
Water Absorption , by volume	%	-	50	48 Passed (WVP ≤1400≥400 See Appendix E4
Water Vapor Permeance at 50mm	Ng/Pa.s. m ²	400	1400	1296, Passed See Appendix E5
Surface Burning Characteristics , -Flame Spread Rating (FSR) -Smoke developed Classification (SDC) -Flame Spread Value (FSV) CAN/ULC S127			500 - -	65, Passed 230 353 Appendix F
Fungi Resistance		No Growth	-	None, Passed See Appendix G
Volatile Organic Compounds (Time to occupancy)	d	1	-	Meets the time to occupancy requirement. See Appendix H (VOC report) and Appendix I (Toxicologist analysis of VOC for Human Health Risk Assessment (HHRA))

4.0 CONCLUSION

As shown in Table 1, the sample of "FLORASEAL 50 Foam" meets with all the physical requirements of CAN/ULC-S712.1-17 "Standard Specification for Thermal Insulation – Light Density, Open Cell Spray Applied Semi-Rigid Polyurethane Foam - Material Specification."

5.0 REVISION(S)

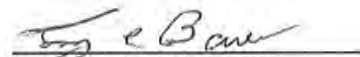
Date	Revision No.	Description
2019-01-08	0	Original Report.

Reported by:



Rubaiyat Khondker, M.A.Sc., P.Eng. Ext. 11662
Supervisor, Building Performance Centre,
Products Division

Approved by:



Franz Bauer., Ext 11403
Tech. Manager, Building Performance Centre
Products Testing Group

ACCREDITATION

Unless otherwise specified, Exova Canada Inc. is ISO 17025 accredited to perform the testing described in this report. Accreditation is verified by International Accreditation Service (TL-407). Full scope listed online at iasonline.org/testing_laboratories

Tested for CCMC evaluation purposes. This report and service are covered under Exova Canada Inc.'s Standard Terms and Conditions of Contract which may be found on the company website www.exova.com, or by calling 1-866-263-9268. This report refers only to the particular samples, units, material, instrument, or other subject used and referred to in it, and is limited by the tests and/or analyses performed. Similar articles may not be of like quality, and other testing and/or analysis programs might be desirable and might give different results.

APPENDIX A

Sample Selection Letter

(3 pages)

Polyurethane Spray Foam System Sample Preparation Report

Genyk
1701, 3e Ave..
Grand-Mere, QC
G9T 2W6, Canada

Proposal No.: MESAR 17633
Date: April 30, 2018

Attn: Yves Rondeau

On April 30, 2018, samples of spray-applied polyurethane thermal insulating foam were prepared for testing purposes at Genyks' facility in Grand-Mere, QC under witness by a third party representative. The details of the application and conditions are provided below.

Liquid Raw Materials

	Lot/Batch Number	Material Description	Storage Conditions
A-Component	GE017845	ISO A-2732	Warehouse
B-Component	L-8105	FLORASEAL 50	Warehouse

Spray Application Equipment

Equipment	Temperature, °F	Pressure, psi	Equipment	Details
A-Side at Pump	135	Approx. 1200	Gun Model	Fusion AP
B-Side at Pump	135	Approx. 1200	Mix Chamber	01(52/52)
Hose	135	1050	Mix Ratio	1:1
--	--	--	Proportioner	Graco E30

Applicator & Conditions

Foam Application Conditions			
Ambient Temperature, °C	23	Hose-End Temperature, °F	135
Ambient Relative Humidity, %	32	Hose Length, ft	60

Qualified Applicator Information	
Licensed Company Name	Genyk InHouse
Qualified Applicator Name	David Lievin

Specimen Details

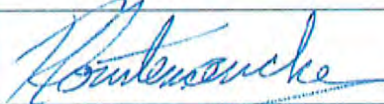
Specimen Set 1 – Detailed Preparation Information						
Exova Sample ID.: 18-006-545143						
Intended Testing		CAN/ULC-S712.1:2017 Section 5.2.1				
Date & Time of Application		2018-04-30 8h30	No. of Pieces		7	
Substrate Information		Foam Details				
Material	Plywood with 2"x4" wood box	Pass Thickness	1 st pass	4"	No. of passes	1
Temp.	20 °C		2 nd pass	--	Total thickness	4"
Dim.	78"x 24"		3 rd pass	--	Time between passes	--
Thick.	4" deep		4 th pass	--	Substrate orientation	Vertical

Specimen Set 2 – Detailed Preparation Information						
Exova Sample ID.: 18-006-545143						
Intended Testing		CAN/ULC-S102				
Date & Time of Application		2018-04-30 9h30	No. of Pieces		9	
Substrate Information		Foam Details				
Material	Type X drywall	Pass Thickness	1 st pass	2"	No. of passes	1
Temp.	20.8 °C		2 nd pass	--	Total thickness	2"
Dim.	96"x 21"		3 rd pass	--	Time between passes	--
Thick.	5 / 8"		4 th pass	--	Substrate orientation	Vertical

Specimen Set 3 – Detailed Preparation Information						
Exova Sample ID.: 18-006-545143						
Intended Testing		CAN/ULC-S127				
Date & Time of Application		2018-04-30 11h00	No. of Pieces		11	
Substrate Information		Foam Details				
Material	Type X drywall	Pass Thickness	1 st pass	2"	No. of passes	1
Temp.	18.6 °C		2 nd pass	--	Total thickness	2"
Dim.	96"x 48"		3 rd pass	--	Time between passes	--
Thick.	5 / 8"		4 th pass	--	Substrate orientation	Horizontal

Specimen Set 4 – Detailed Preparation Information						
Exova Sample ID.: 18-006-545143						
Intended Testing		CAN/ULC-S712.1:2017 Section 5.2.2				
Date & Time of Application		2018-04-30 13h00		No. of Pieces	8	
Substrate Information		Foam Details				
Material	Plywood with 2"x6" wood sides	Pass Thickness	1 st pass	5 1/2"	No. of passes	1
Temp.	19.3 °C		2 nd pass	--	Total thickness	5 1/2"
Dim.	84"x 24"		3 rd pass	--	Time between passes	--
Thick.	5 1/2" deep		4 th pass	--	Substrate orientation	Vertical

Exova Witness

Witnessing Information	
Location of preparation	Genyk 1701, 3e Ave. Grand-Mere, G9T 2W6, Canada
Technical representative	Roland Courtemanche, P. Eng. Project Manager Consultants Mesar Inc.
Signature	



APPENDIX B

Photographs of the Test Sample

(1 page)

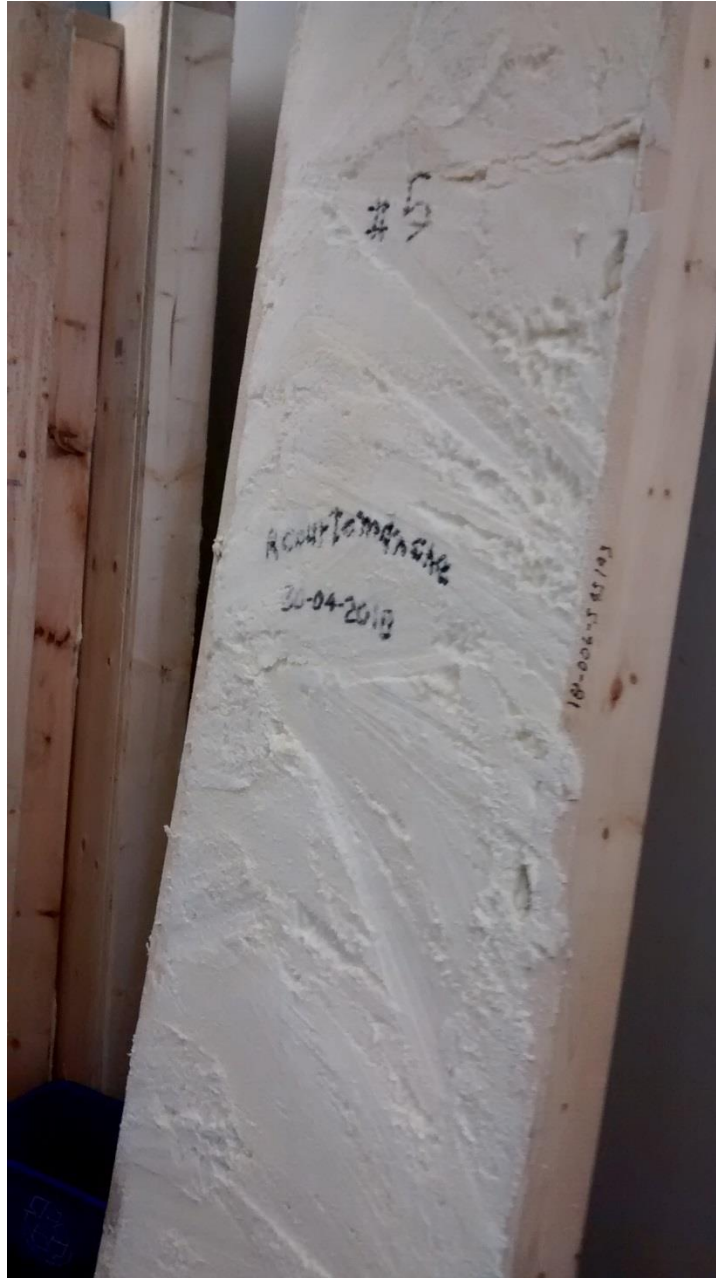


Photo B1: Photo of the prepared sample

APPENDIX C

Air Permeance Test Report
Report #: 18-006-545143

(23 pages)



Testing. Advising. Assuring.

FILE COPY

**EVALUATION OF THE AIR PERMEANCE PROPERTIES OF
THERMAL INSULATION – LIGHT DENSITY, OPEN
CELL SPRAY APPLIED SEMI-RIGID POLYURETHANE FOAM FOR**

**GENYK
“FLORASEAL 50”**

**IN ACCORDANCE WITH CAN/ULC S712.1-2017 STANDARD,
REFERENCING ASTM E2178-13**

Report to:	Yves Rondeau 1701, 3e Avenue Grand-Mere, QC G9T 2W6
Attention:	Mr. Yves Rondeau
Telephone:	819-691-5010
Email:	YvesRondeau@Genyk.com
Report No.:	18-06-P0045-S 7 Pages, 3 Appendices
Proposal No.:	18-006-545143
Date:	July 21, 2018

1.0 INTRODUCTION

At the request of Genyk, Exova was retained to evaluate a light density, open cell spray applied semi rigid polyurethane thermal insulation foam identified as "Floraseal 50" in accordance with CAN/ULC S712.1:2017 standard as outlined in Exova Proposal Number: 18-006-545143.

Upon receipt of the product, the sample was assigned the following Exova Sample Number:

Client Sample Description:
Floraseal 50

Exova Specimen No.:
18-06-P0045-S1 to S5

A sample preparation report has been attached to Appendix C.

2.0 PROCEDURE

The sample was evaluated for the following test:

Test Description	Test Method
Air Permeance	CAN/ULC-S712.1-17, Section 5.5.1, <i>Referencing ASTM E2178-13 (Using Wood Substrate)</i>

Note: SI units are the primary units of measure.

Air Permeance Specimen Preparation:

As per CAN/ULC-S712.1-17, Section 5.5.1, "The air permeance shall be determined in accordance with ASTM E2178-13 using five specimens 100 mm (3.94") thick. The specimens shall be prepared by constructing a rectangular frame within an inside dimensions of 0.6 m x 2.0 m (23.62 x 78.74") made from wood with a height of 100 mm (3.94"). Wood fiberboard or other similar material is to be attached to one side. The light density, open cell spray applied semi-rigid polyurethane foam material shall be sprayed into the frame and shall have a height greater than the frame. The material above the open top of the frame shall be cut flush with the frame. The wood fiberboard shall be cut from the material and removed. A wire mesh shall be installed on both sides of the wood frame, holding the material in place. The corners of the wood frame shall be sealed. The specimen shall be installed into the testing apparatus outlined in ASTM E2178 and the air permeance test shall be run with both a positive pressure and a negative pressure as per CAN/ULC S712.1-17, Section 5.5.1"

The sample material was conditioned for a minimum of seven days at 21 ± 1°C (70°F) and 40 ± 5% RH, after which specimens were prepared for testing.

Prior to testing, each specimen's excess insulation material on the exterior side was cut flush to the frame height which was controlled height of 100 mm (3.94"). Each specimen was then sealed within the air leakage test chamber as prescribed by ASTM E2178-13 (Figure 1). Air was exhausted from the chamber at rates required to maintain the following test pressure differences: 25, 50, 75, 100, 150, and 300 Pa (0.52, 1.04, 1.57, 2.09, 3.13 and 6.27 psf). At each successive pressure, the air leakage through the specimen was measured and the specimen monitored for any physical changes. The air leakage of the specimen was then re-measured at pressure differentials of 100, 75 and 50 Pa (2.09, 1.57, 1.04 psf), as required by the test procedure.

3.0 PROCEDURE (CONTINUED)

Equipment Used for Air Flow Measurements:

Manometer:	MII B06794
Mass Flow Meter:	MII A09200
Multimeter:	MII B11547
Condition Room	MII-B09680
Air Permeance Test Chamber	CAN/ULC-S712.1:2017, Section 5.5.1 Apparatus

Testing for each specimen was conducted on the following dates:

Infiltration Direction:

<u>Test Specimen:</u>	<u>Test Date:</u>
18-06-P0045-S1	July 11 ,2018
18-06-P0045-S2	July 14 ,2018
18-06-P0045-S3	July 12 ,2018
18-06-P0045-S4	July 13 ,2018
18-06-P0045-S5	July 16 ,2018

Exfiltration Direction:

<u>Test Specimen:</u>	<u>Test Date:</u>
18-06-P0045-S1	July 11 ,2018
18-06-P0045-S2	July 14 ,2018
18-06-P0045-S3	July 12 ,2018
18-06-P0045-S4	July 13 ,2018
18-06-P0045-S5	July 16 ,2018

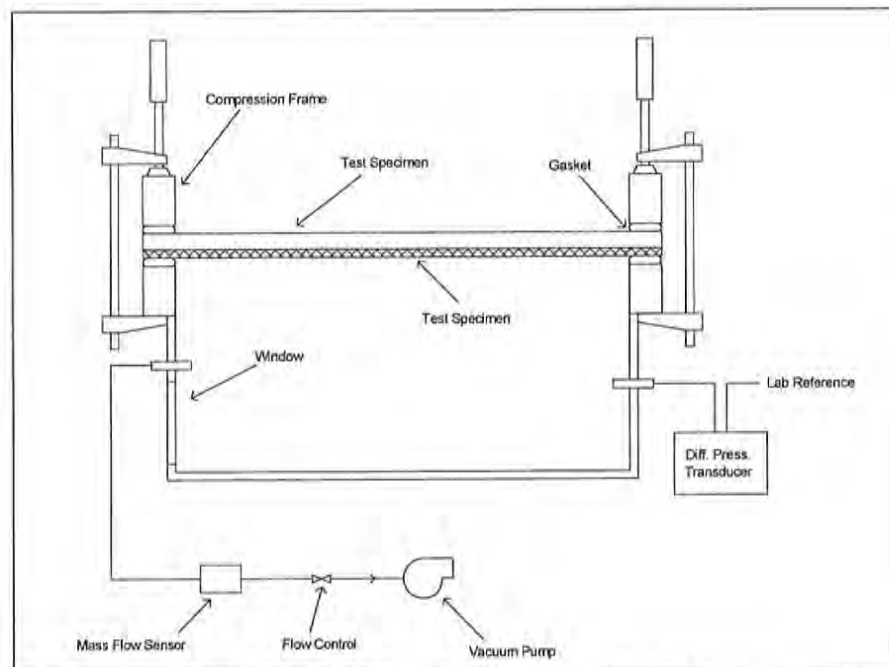


Figure 1 – Test Setup (Referenced from ASTM E2178)

4.0 RESULTS

The summarized test results are shown below in Tables 1 & 2. The logarithmic graphs and located in Appendix A & B.

Table 1 - Summarized Test Results in Accordance with CAN/ULC-S712.1-17, Section 5.5.1, Referencing ASTM E2178-13 Positive / Infiltration Pressure Exova Specimen No. 18-06-P0045-S1 to S5							
Negative Pressure (Pa)	Calculated Flow (L/(m ² s))						Requirement
	18-06-P0045-S1	18-06-P0045-S2	18-06-P0045-S3	18-06-P0045-S4	18-06-P0045-S5	Average	
25	0.0080	0.0093	0.0039	0.0111	0.0086	0.0082	Declare Air Permeance at 75 Pa
50	0.0145	0.0169	0.0073	0.0187	0.0154	0.0146	
75	0.0205	0.0240	0.0105	0.0255	0.0215	0.0204	
100	0.0262	0.0307	0.0136	0.0317	0.0274	0.0259	
150	0.0370	0.0435	0.0196	0.0432	0.0384	0.0363	
300	0.0668	0.0788	0.0367	0.0731	0.0683	0.0648	
100	0.0263	0.0345	0.0135	0.0342	0.0270	0.0271	
75	0.0202	0.0259	0.0104	0.0271	0.0213	0.0210	
50	0.0139	0.0173	0.0072	0.0195	0.0152	0.0146	

Table 2 - Summarized Test Results in Accordance with CAN/ULC-S712.1-17, Section 5.5.1, Referencing ASTM E2178-13 Negative / Exfiltration Pressure Exova Specimen No. 18-06-P0045-S1 to S5							
Negative Pressure (Pa)	Calculated Flow (L/(m ² s))						Requirement
	18-06-P0045-S1	18-06-P0045-S2	18-06-P0045-S3	18-06-P0045-S4	18-06-P0045-S5	Average	
25	0.0083	0.0088	0.0040	0.0111	0.0089	0.0082	Declare Air Permeance at 75 Pa
50	0.0149	0.0162	0.0074	0.0189	0.0157	0.0146	
75	0.0209	0.0232	0.0106	0.0258	0.0219	0.0205	
100	0.0267	0.0298	0.0137	0.0322	0.0278	0.0260	
150	0.0376	0.0426	0.0197	0.0439	0.0388	0.0365	
300	0.0676	0.0785	0.0366	0.0748	0.0687	0.0652	
100	0.0267	0.0329	0.0136	0.0347	0.0277	0.0271	
75	0.0207	0.0243	0.0103	0.0274	0.0217	0.0209	
50	0.0145	0.0159	0.0070	0.0196	0.0153	0.0145	

Table 3 - Summarized Test Results in Accordance with CAN/ULC-S712.1-17, Section 5.5.1, Referencing ASTM E2178-13 Positive / Infiltration Pressure Exova Specimen No. 18-06-P0045-S1 to S5							
Negative Pressure (lbs/ft ²)	Calculated Flow (cft/ft ²)						Requirement
	18-06-P0045-S1	18-06-P0045-S2	18-06-P0045-S3	18-06-P0045-S4	18-06-P0045-S5	Average	
0.52	0.0016	0.0019	0.0008	0.0022	0.0017	0.0016	Declare Air Permeance at 1.57 lbs/ft ²
1.05	0.0029	0.0034	0.0015	0.0038	0.0031	0.0029	
1.57	0.0041	0.0048	0.0021	0.0051	0.0043	0.0041	
2.09	0.0053	0.0062	0.0027	0.0064	0.0055	0.0052	
3.14	0.0074	0.0087	0.0039	0.0087	0.0077	0.0073	
6.27	0.0134	0.0158	0.0074	0.0147	0.0137	0.0130	
2.09	0.0053	0.0069	0.0027	0.0069	0.0054	0.0054	
1.57	0.0041	0.0052	0.0021	0.0054	0.0043	0.0042	
1.05	0.0028	0.0035	0.0014	0.0039	0.0030	0.0029	

Table 4 - Summarized Test Results in Accordance with CAN/ULC-S712.1-17, Section 5.5.1, Referencing ASTM E2178-13 Negative / Exfiltration Pressure Exova Specimen No. 18-06-P0045-S1 to S5							
Negative Pressure (lbs/ft ²)	Calculated Flow (cft/ft ²)						Requirement
	18-06-P0045-S1	18-06-P0045-S2	18-06-P0045-S3	18-06-P0045-S4	18-06-P0045-S5	Average	
0.52	0.0017	0.0018	0.0008	0.0022	0.0018	0.0016	Declare Air Permeance at 1.57 lbs/ft ²
1.05	0.0030	0.0033	0.0015	0.0038	0.0032	0.0029	
1.57	0.0042	0.0047	0.0021	0.0052	0.0044	0.0041	
2.09	0.0054	0.0060	0.0028	0.0065	0.0056	0.0052	
3.14	0.0076	0.0086	0.0040	0.0088	0.0078	0.0073	
6.27	0.0136	0.0158	0.0073	0.0150	0.0138	0.0131	
2.09	0.0054	0.0066	0.0027	0.0070	0.0056	0.0055	
1.57	0.0042	0.0049	0.0021	0.0055	0.0044	0.0042	
1.05	0.0029	0.0032	0.0014	0.0039	0.0031	0.0029	

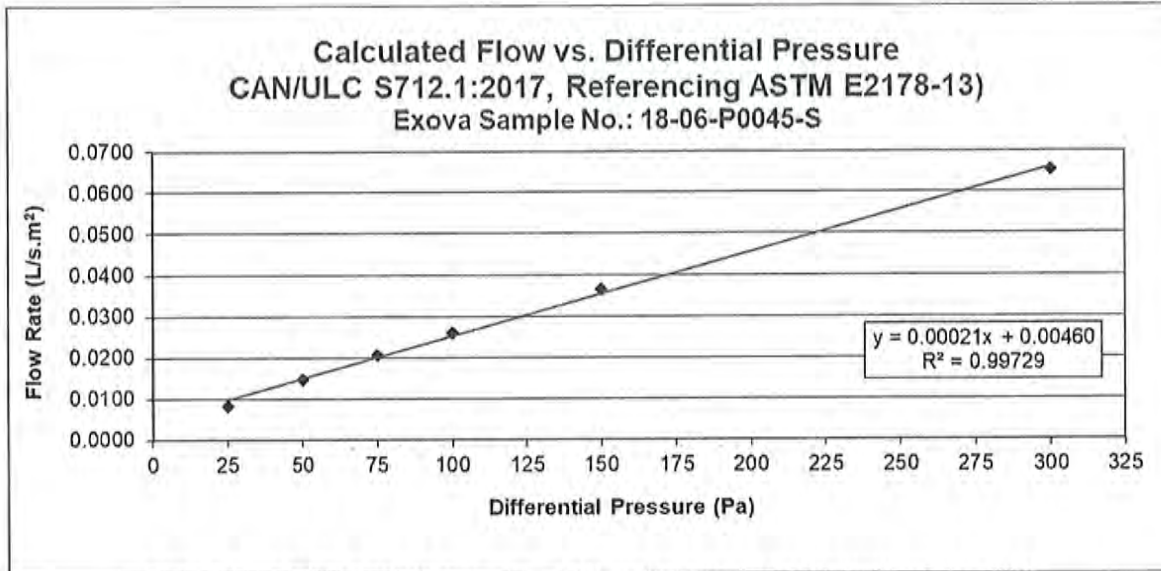


Figure 1 – Calculated Air Flow vs., Differential Pressure (Negative Pressure)

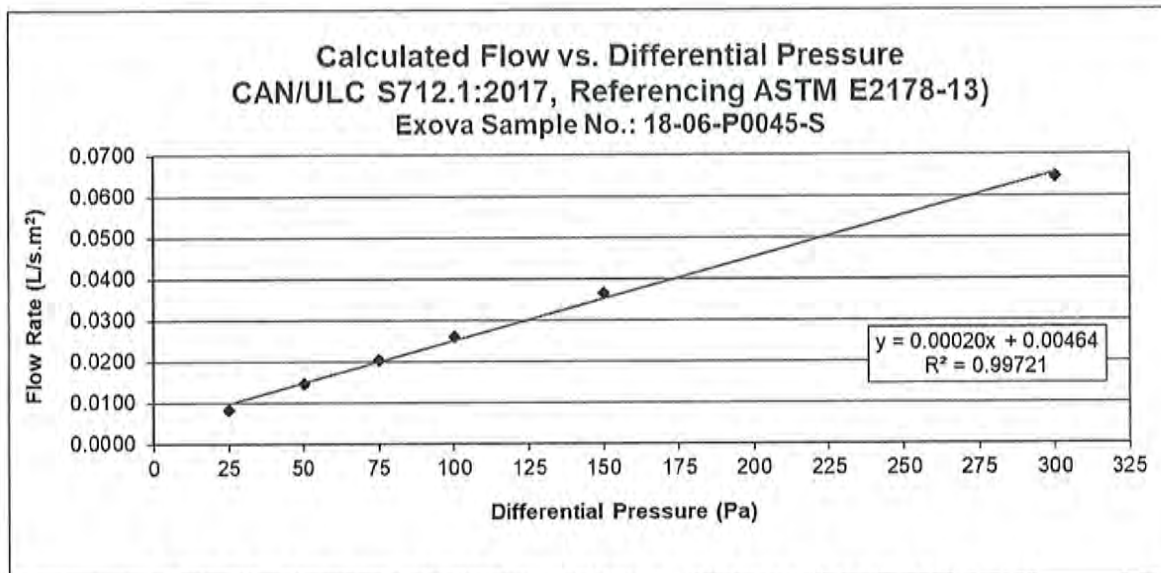


Figure 2 – Calculated Air Flow vs., Differential Pressure (Positive Pressure)

5.0 CONCLUSION

As per CAN/ULC-S712.1:2017, the air permeance values of the test specimens at 100 mm (3.94") thick shall be declared at 75 Pa (1.57 lb/ft²) pressure differential. Based on the summarized testing results located in Tables 1 -4, the average air permeance values at 75 Pa (1.57 lb/ft²) for Exova Sample No.: 18-06-P0045-S are as follow:

Average Position Pressure: 0.020 L/(s·m²) @ 75 Pa (0.0041 cfm/ft² @ 1.57 lbs/ft²)
Average Negative Pressure: 0.021 L/(s·m²) @ 75 Pa (0.0041 cfm/ft² @ 1.57 lbs/ft²)

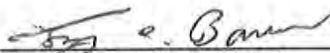
6.0 REPORT REVISION SUMMARY

<u>Revision No:</u>	<u>Date:</u>	<u>Description of Revisions:</u>
Original	2018-July 21	Original Document

Reported & Authorized by:

Reviewed by:


Sunny Ling, C.E.T., Ext. 11412
Assistant Operations Manager
Technical Development, Building Systems
Products Testing Division


Franz Bauer, Ext. 11403
Technical Manager, Building Products
Products Testing Division

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APPENDIX A

Air Flow Versus Pressure Differential (log/log) Graphs

Infiltration Direction

(5 Pages)

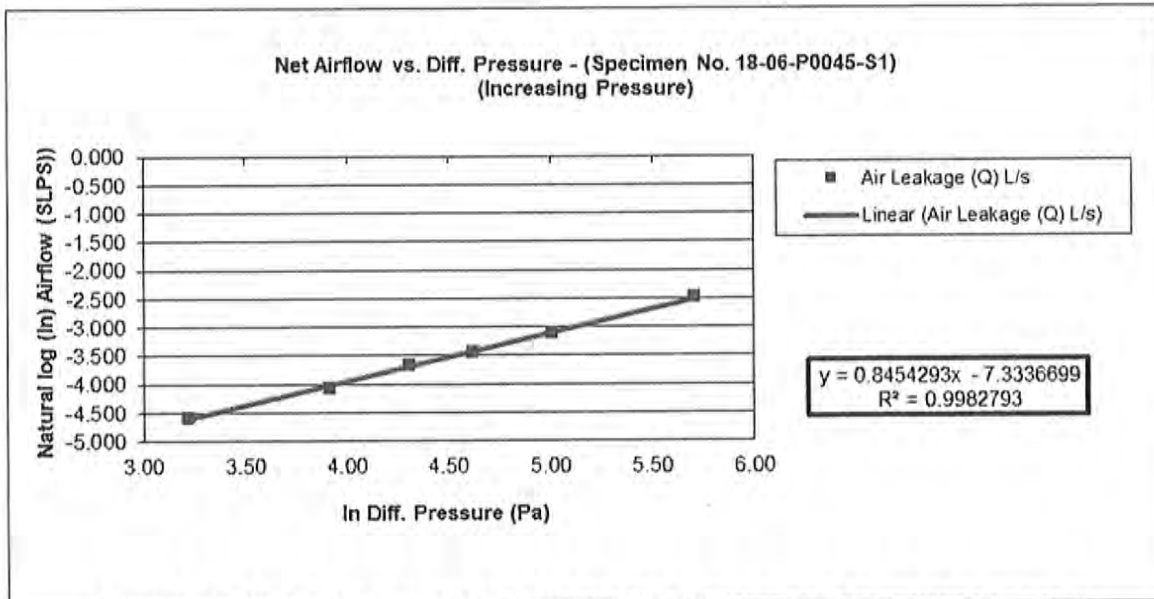


Figure A-1 – Exova Specimen No: 18-06-P0045-S1 Increasing Air Flow vs. Pressure
Direction of Air Flow: Infiltration

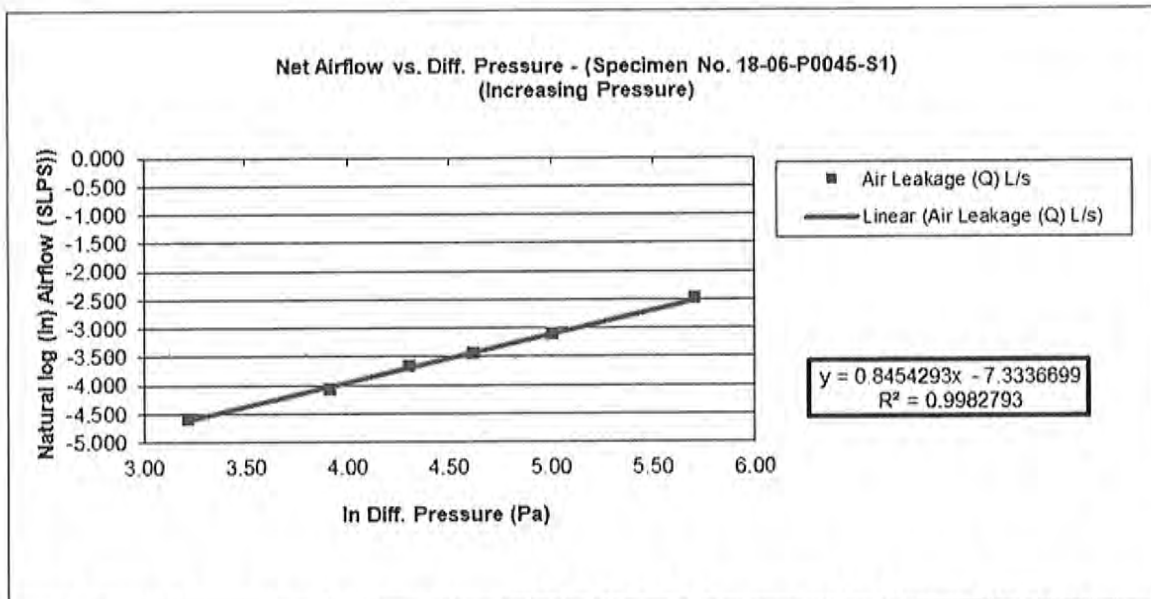


Figure A-2 – Exova Specimen No.: 18-06-P0045-S1 Decreasing Air Flow vs. Pressure
Direction of Air Flow: Infiltration

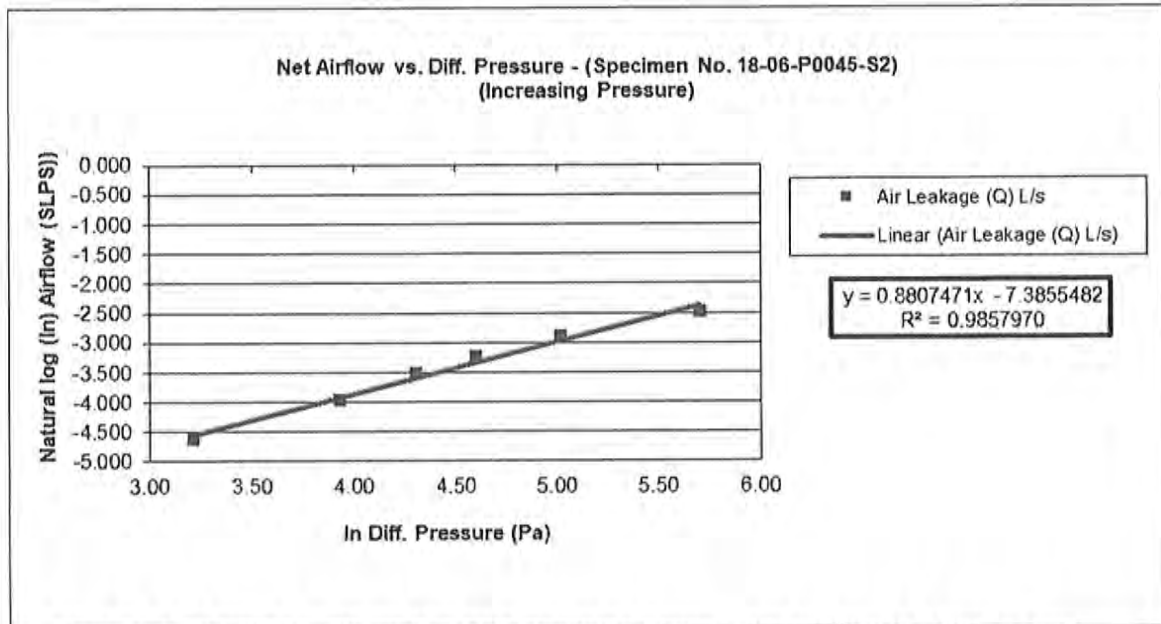


Figure A-5 – Exova Specimen No: 18-06-P0045-S2 Increasing Air Flow vs. Pressure
Direction of Air Flow: Infiltration

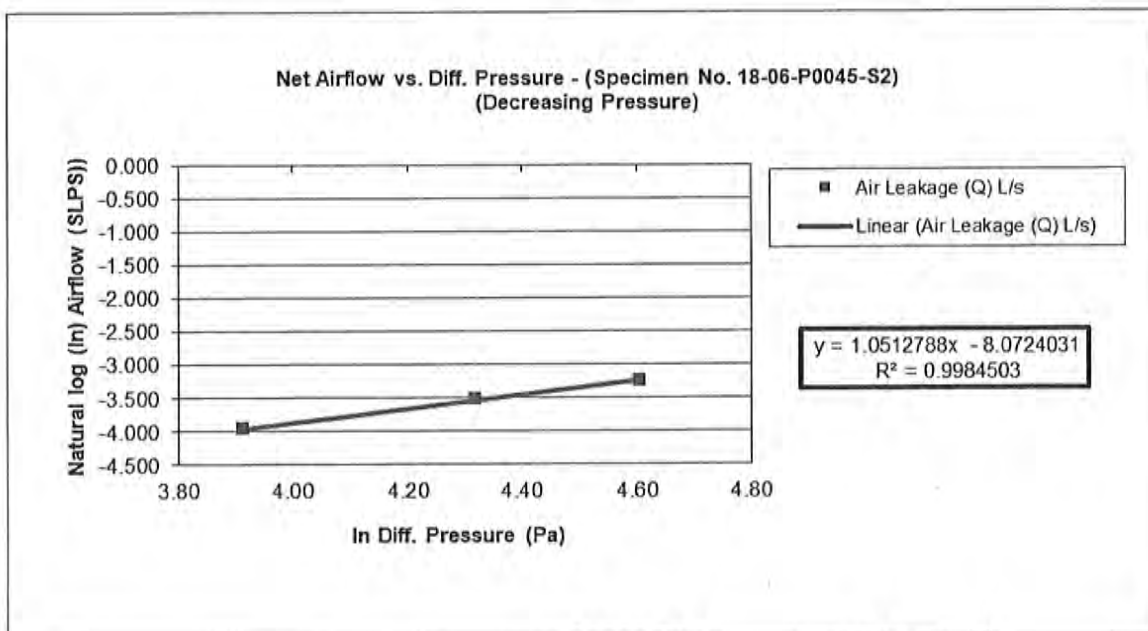


Figure A-6 – Exova Specimen No.: 18-06-P0045-S2 Decreasing Air Flow vs. Pressure
Direction of Air Flow: Infiltration

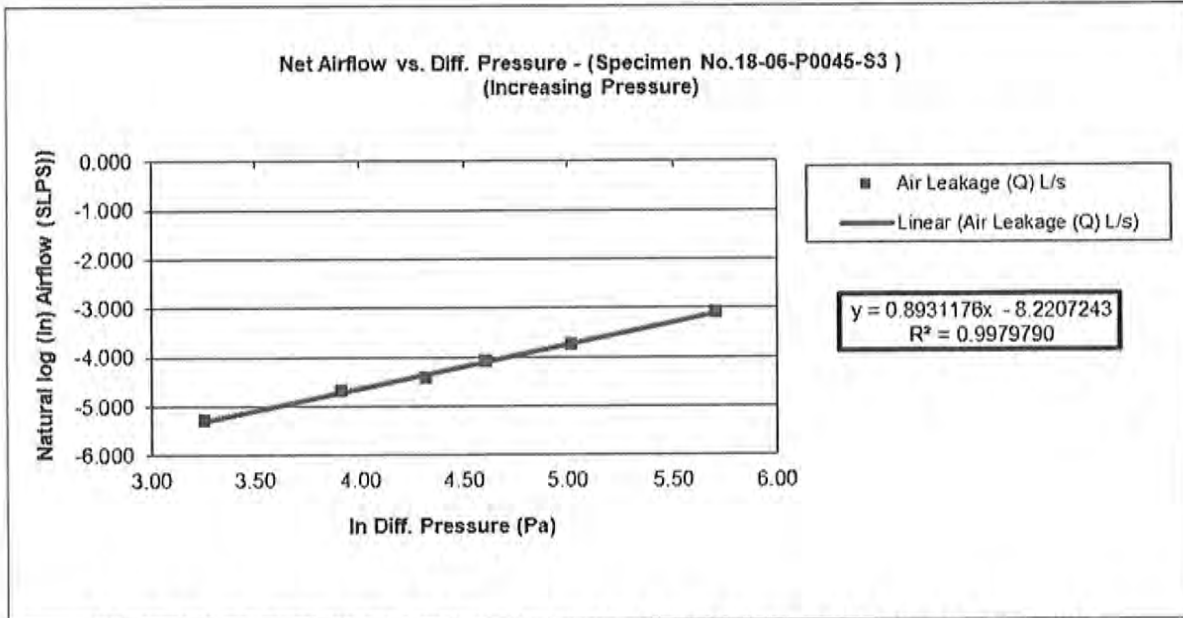


Figure A-9 – Exova Specimen No.: 18-06-P0045-S3 Increasing Air Flow vs. Pressure
Direction of Air Flow: Infiltration

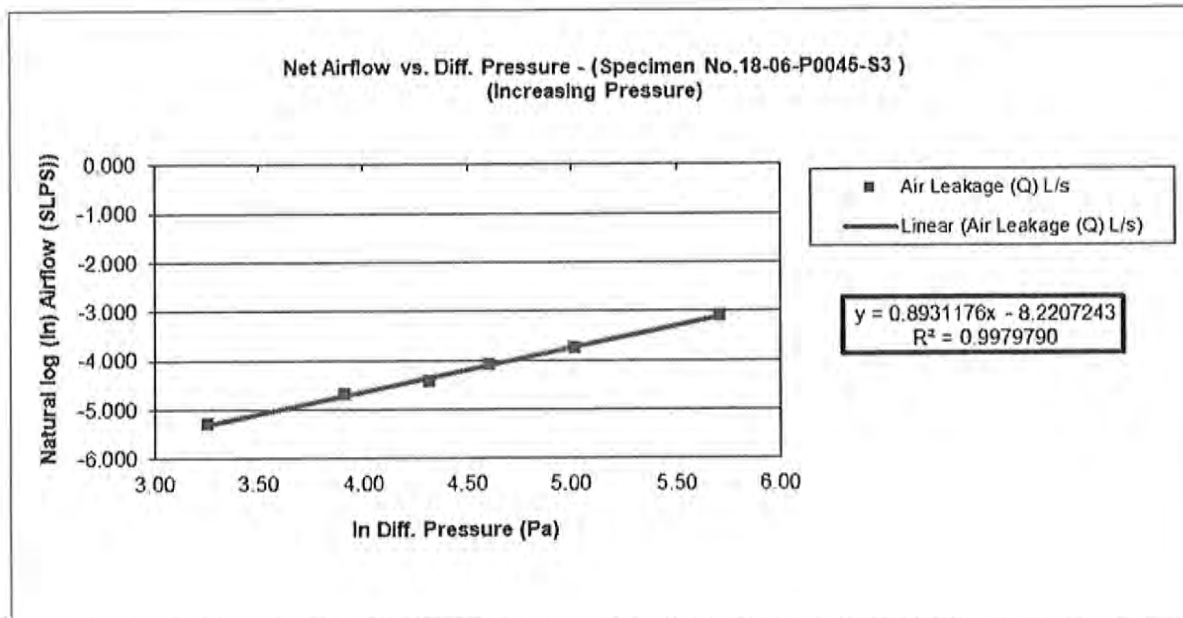


Figure A-10 – Exova Specimen No.: 18-06-P0045-S3 Decreasing Air Flow vs. Pressure
Direction of Air Flow: Infiltration

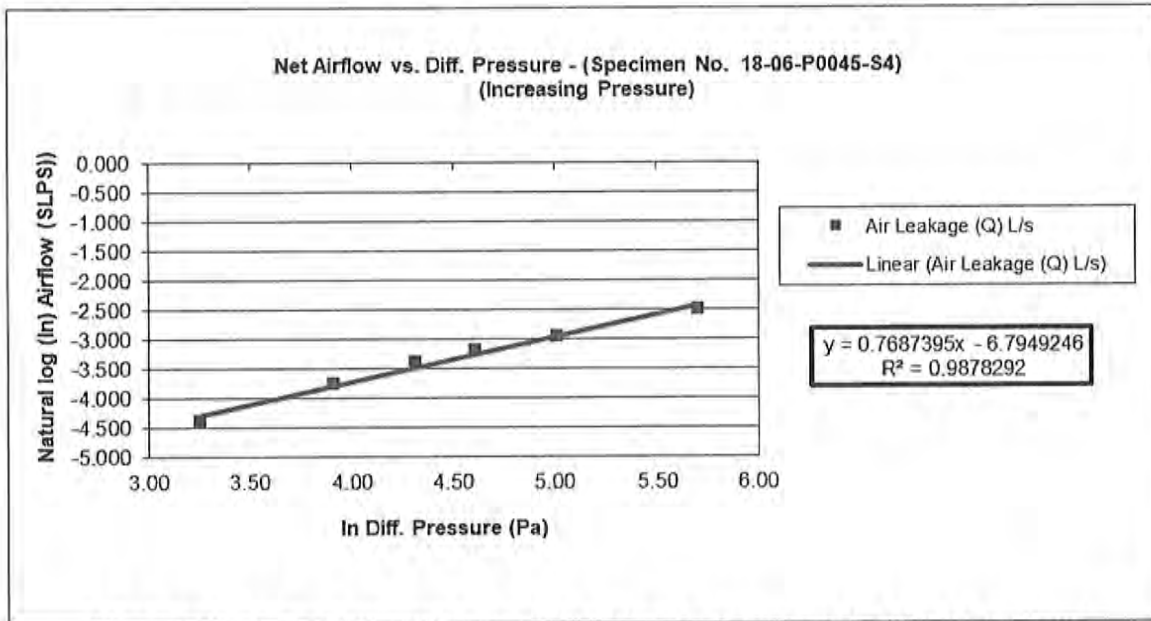


Figure A-13 – Exova Specimen No: 18-06-P0045-S4 Increasing Air Flow vs. Pressure
Direction of Air Flow: Infiltration

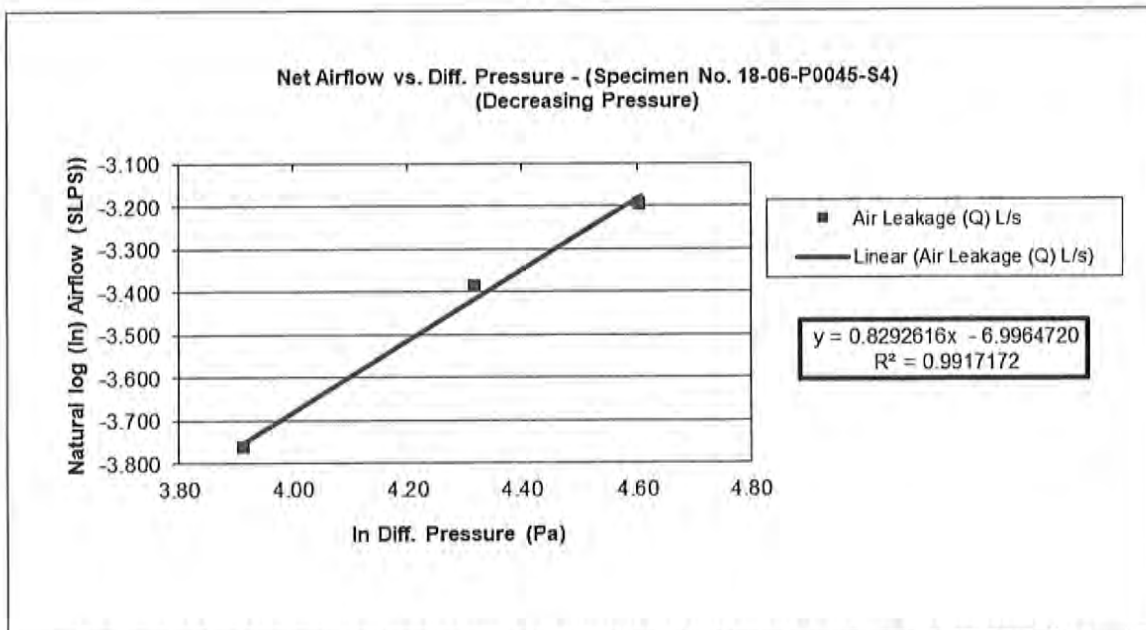


Figure A-14 – Exova Specimen No.: 18-06-P0045-S4 Decreasing Air Flow vs. Pressure
Direction of Air Flow: Infiltration

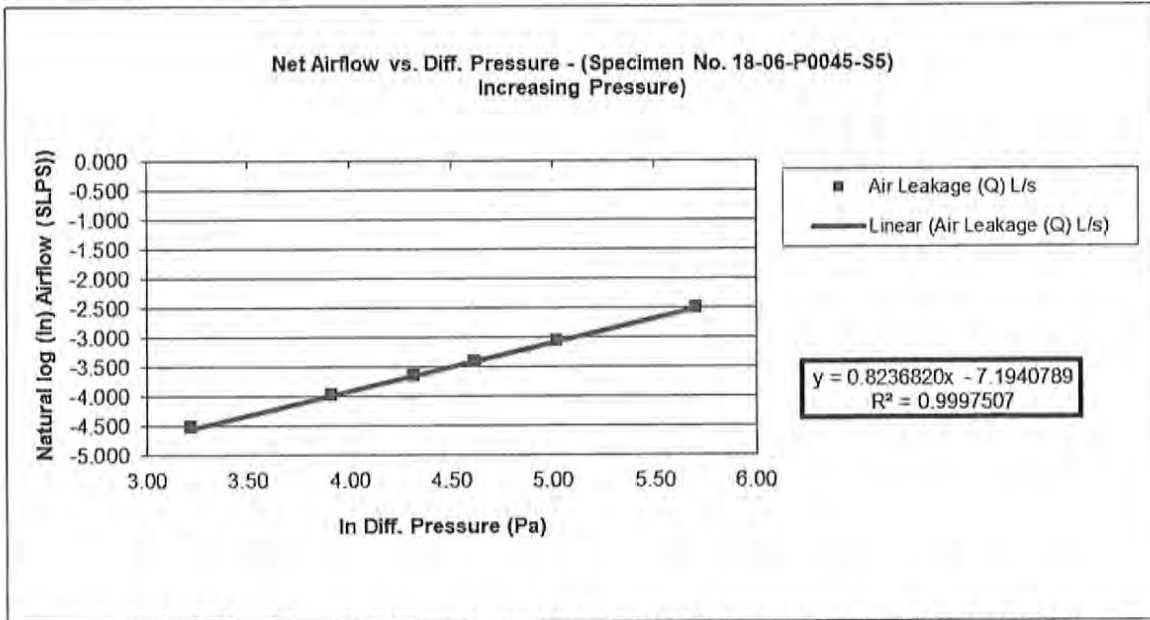


Figure A-17 – Exova Specimen No: 18-06-P0045-S5 Increasing Air Flow vs. Pressure
Direction of Air Flow: Infiltration

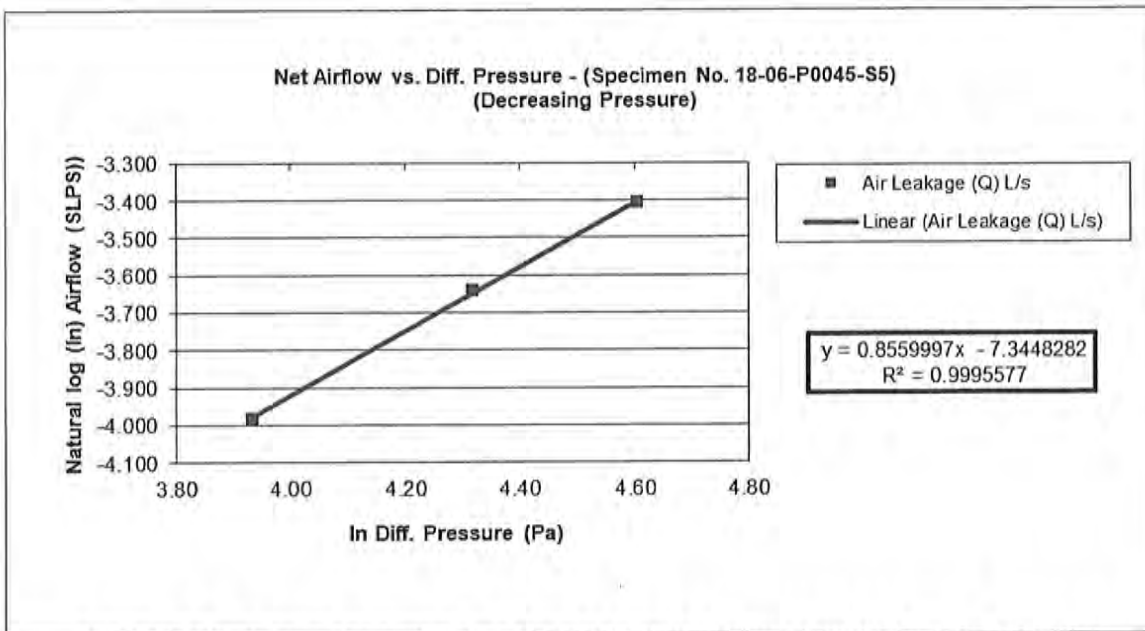


Figure A-18 – Exova Specimen No.: 18-06-P0045-S5 Decreasing Air Flow vs. Pressure
Direction of Air Flow: Infiltration

APPENDIX B

Air Flow Versus Pressure Differential (log/log) Graphs

Exfiltration Direction

(5 Pages)

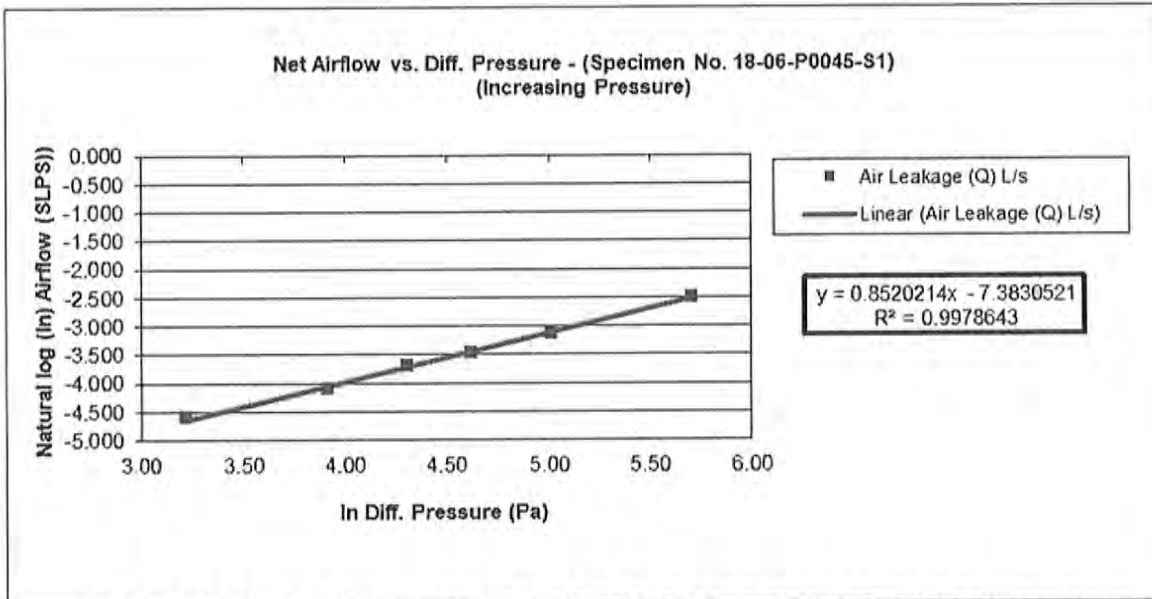


Figure B-1 – Exova Specimen No: 18-06-P0045-S1 Increasing Air Flow vs. Pressure
Direction of Air Flow: Exfiltration

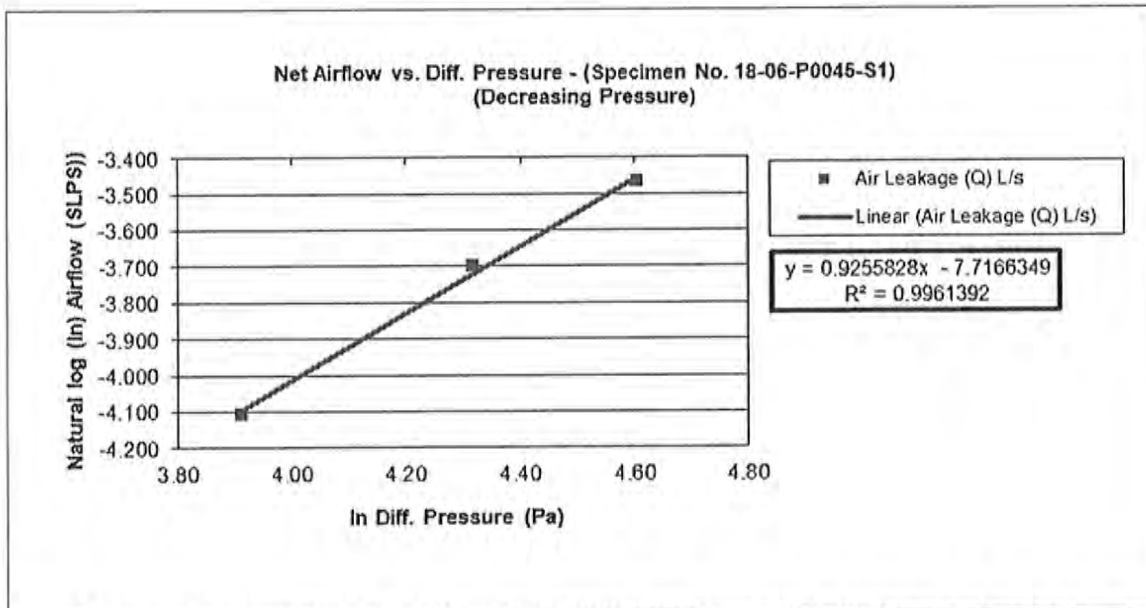


Figure B-2 – Exova Specimen No.: 18-06-P0045-S1 Decreasing Air Flow vs. Pressure
Direction of Air Flow: Exfiltration

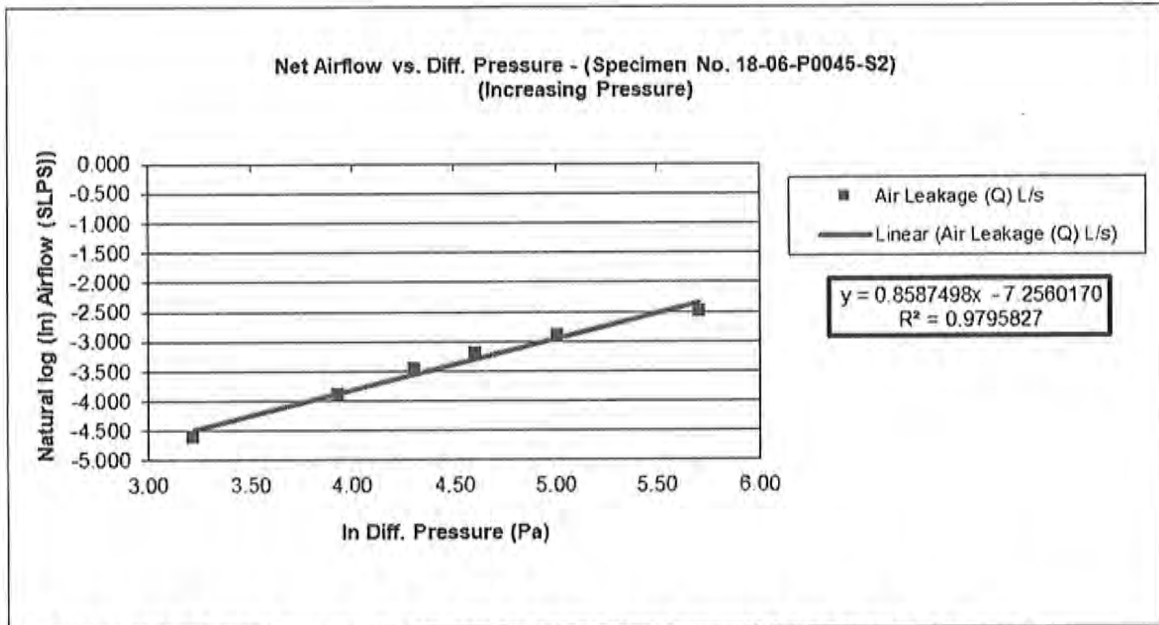


Figure B-5 – Exova Specimen No: 18-06-P0045-S2 Increasing Air Flow vs. Pressure
Direction of Air Flow: Exfiltration

*Note: Regression of ≥ 0.99 cannot be met as per ASTM E2178. The air tightness of the test sample is declare only.

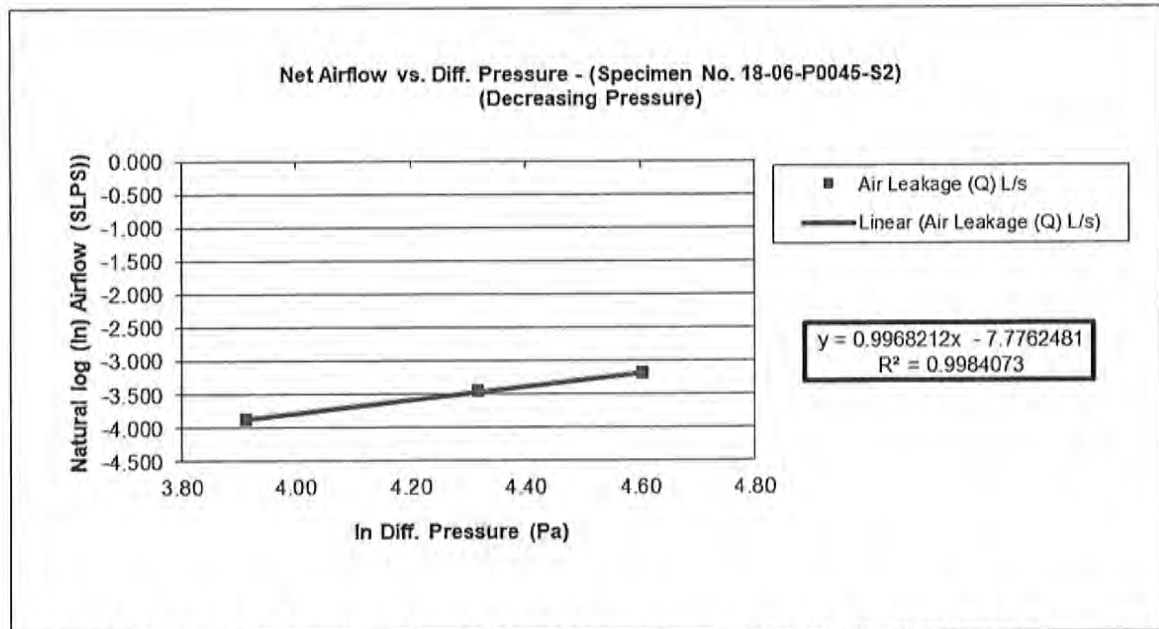


Figure B-6 – Exova Specimen No.: 18-06-P0045-S2 Decreasing Air Flow vs. Pressure
Direction of Air Flow: Exfiltration

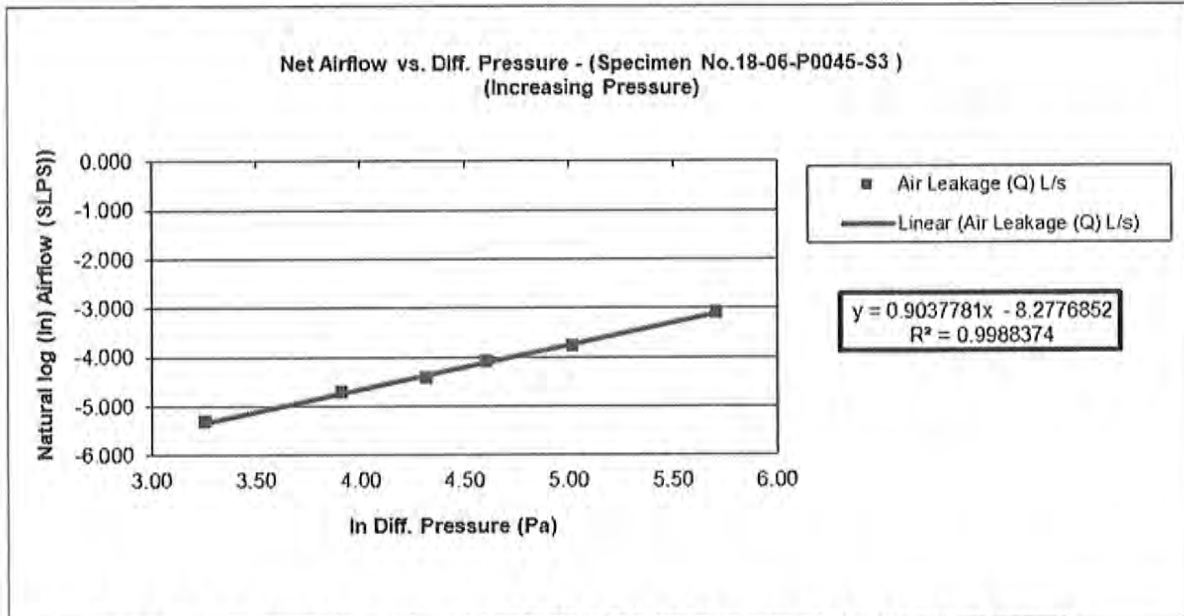


Figure B-9 – Exova Specimen No.: 18-06-P0045-S3 Increasing Air Flow vs. Pressure
Direction of Air Flow: Exfiltration

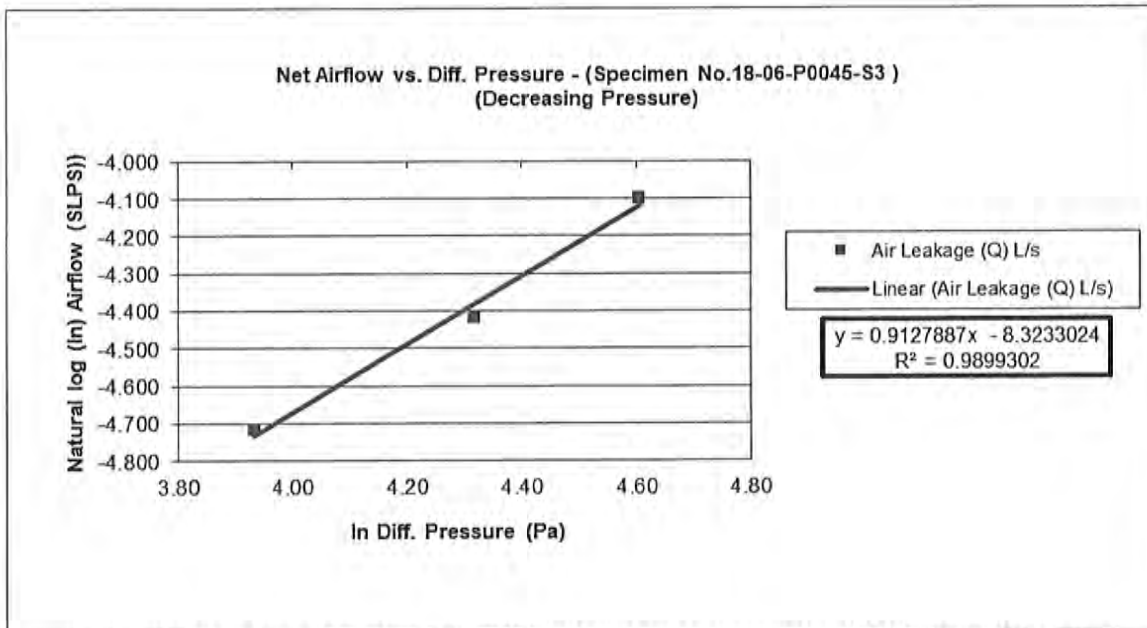


Figure B-10 – Exova Specimen No.: 18-06-P0045-S3 Decreasing Air Flow vs. Pressure
Direction of Air Flow: Exfiltration

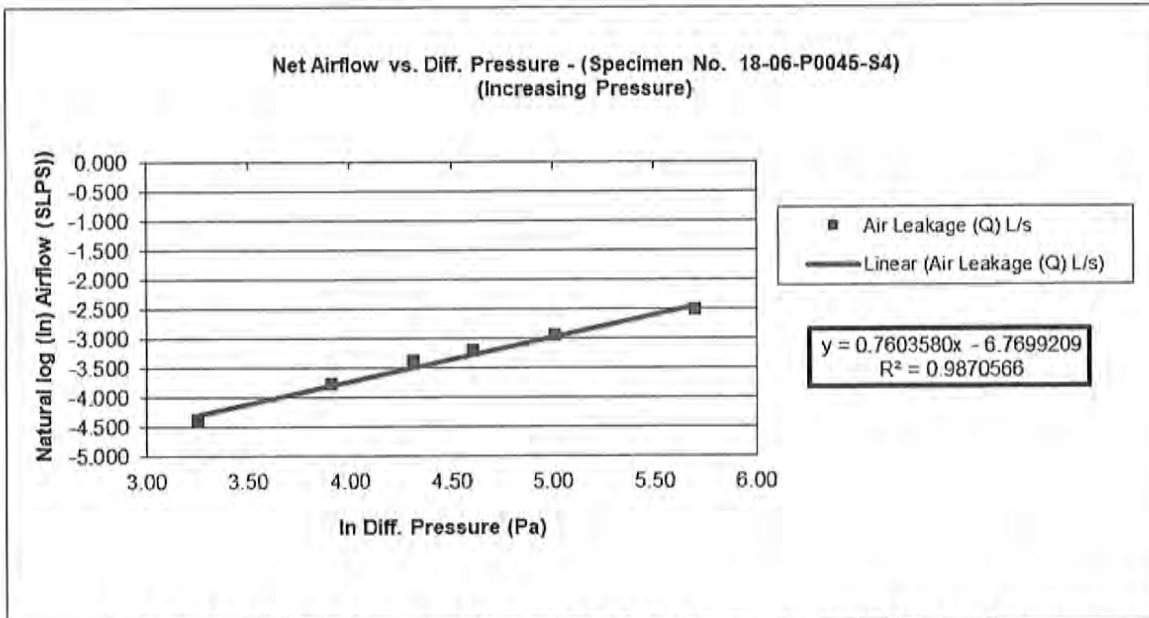


Figure B-13 – Exova Specimen No: 18-06-P0045-S4 Increasing Air Flow vs. Pressure
Direction of Air Flow: Exfiltration

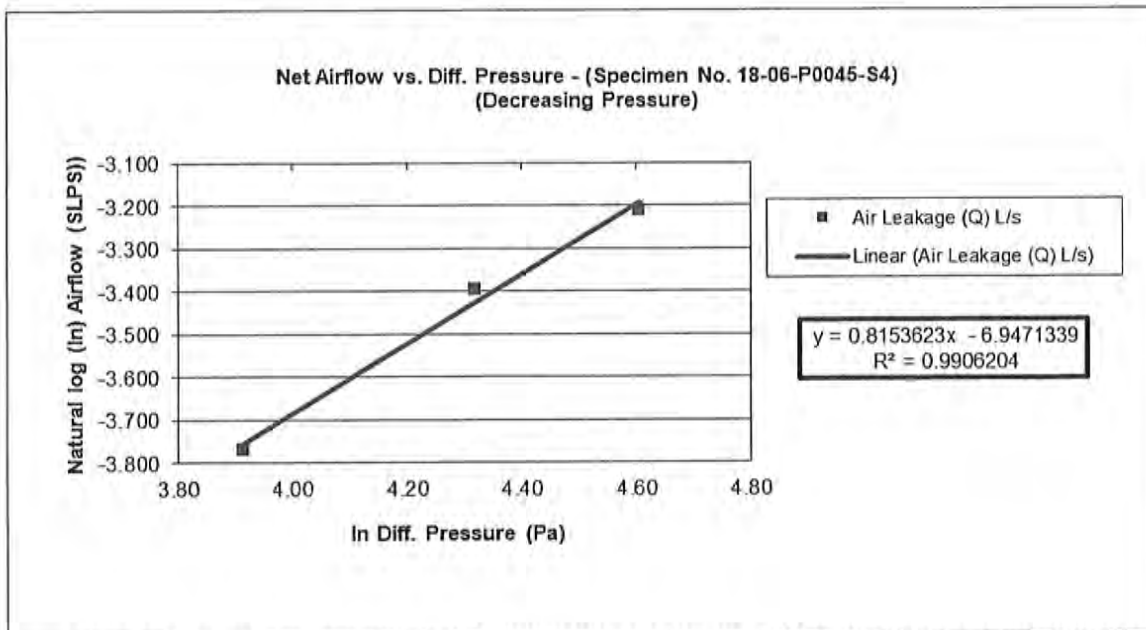


Figure B-14 – Exova Specimen No.: 18-06-P0045-S4 Decreasing Air Flow vs. Pressure
Direction of Air Flow: Exfiltration

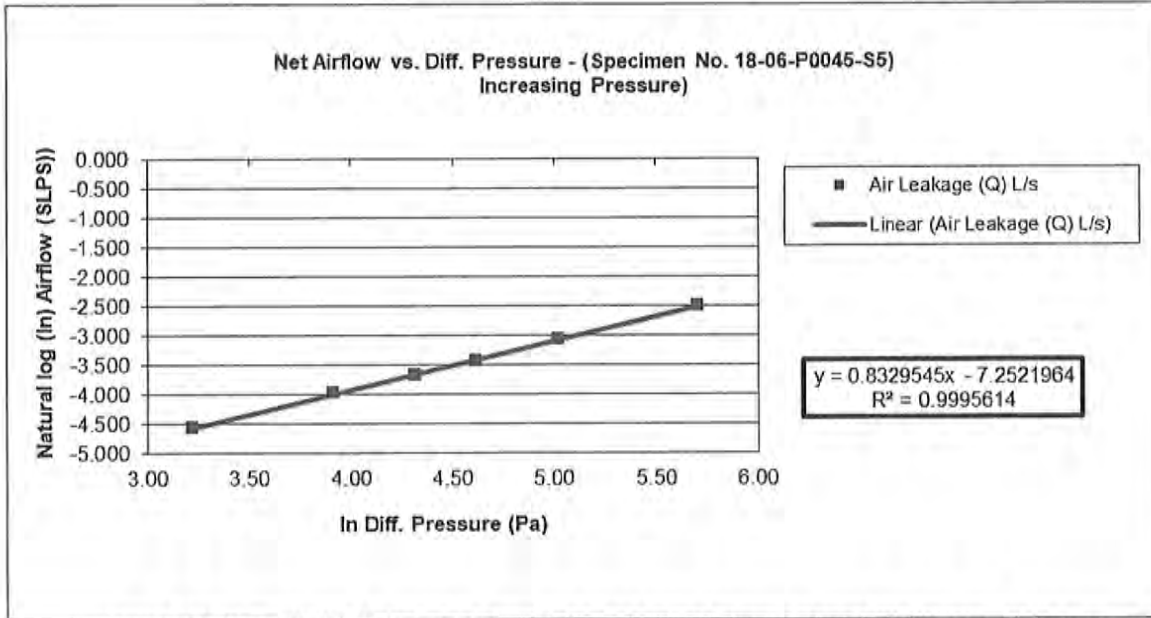


Figure B-17 – Exova Specimen No: 18-06-P0045-S5 Increasing Air Flow vs. Pressure
Direction of Air Flow: Exfiltration

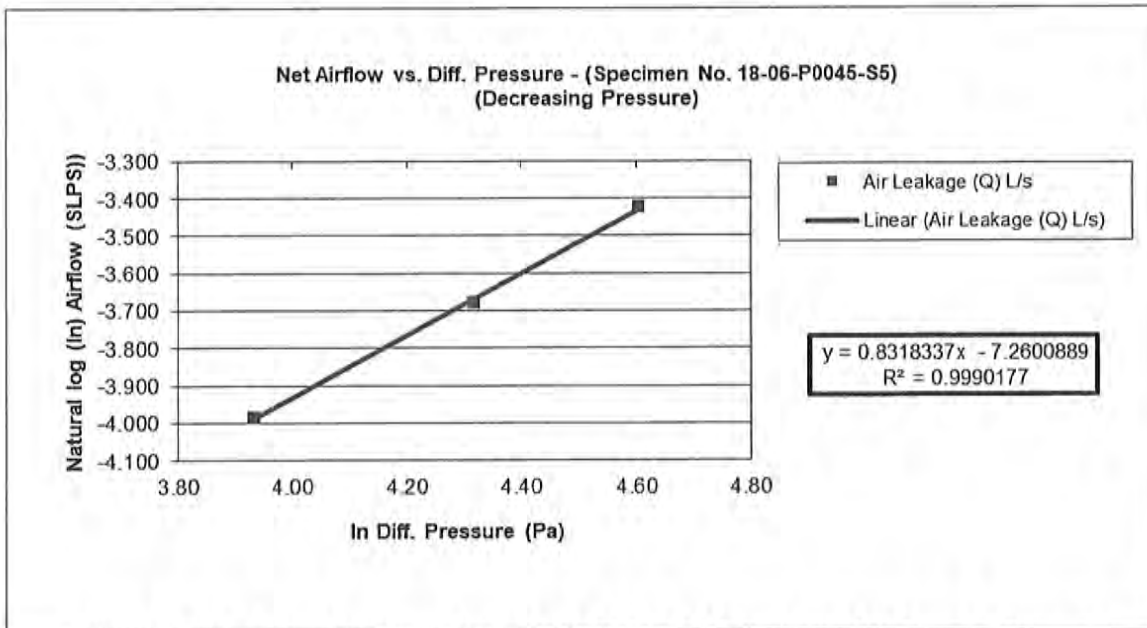


Figure B-18 – Exova Specimen No.: 18-06-P0045-S5 Decreasing Air Flow vs. Pressure
Direction of Air Flow: Exfiltration

APPENDIX C

Sample Preparation Report

(3 Pages)

Polyurethane Spray Foam System Sample Preparation Report

Genyk
1701, 3e Ave..
Grand-Mere, QC
G9T 2W6, Canada

Proposal No.: MESAR 17633
Date: April 30, 2018

Attn: Yves Rondeau

On April 30, 2018, samples of spray-applied polyurethane thermal insulating foam were prepared for testing purposes at Genyks' facility in Grand-Mere, QC under witness by a third party representative. The details of the application and conditions are provided below.

Liquid Raw Materials

	Lot/Batch Number	Material Description	Storage Conditions
A-Component	GE017845	ISO A-2732	Warehouse
B-Component	L-8105	FLORASEAL 50	Warehouse

Spray Application Equipment

Equipment	Temperature, °F	Pressure, psi	Equipment	Details
A-Side at Pump	135	Approx. 1200	Gun Model	Fusion AP
B-Side at Pump	135	Approx. 1200	Mix Chamber	01(52/52)
Hose	135	1050	Mix Ratio	1:1
--	--	--	Proportioner	Graco E30

Applicator & Conditions

Foam Application Conditions			
Ambient Temperature, °C	23	Hose-End Temperature, °F	135
Ambient Relative Humidity, %	32	Hose Length, ft	60

Qualified Applicator Information	
Licensed Company Name	Genyk InHouse
Qualified Applicator Name	David Lievin

Specimen Details

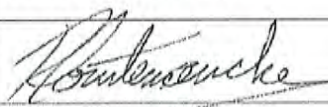
Specimen Set 1 – Detailed Preparation Information Exova Sample ID.: 18-006-545143						
Intended Testing		CAN/ULC-S712.1:2017 Section 5.2.1				
Date & Time of Application		2018-04-30 8h30		No. of Pieces		7
Substrate Information		Foam Details				
Material	Plywood with 2"x4" wood box	Pass Thickness	1 st pass	4"	No. of passes	1
Temp.	20 °C		2 nd pass	--	Total thickness	4"
Dim.	78"x 24"		3 rd pass	--	Time between passes	--
Thick.	4" deep		4 th pass	--	Substrate orientation	Vertical

Specimen Set 2 – Detailed Preparation Information Exova Sample ID.: 18-006-545143						
Intended Testing		CAN/ULC-S102				
Date & Time of Application		2018-04-30 9h30		No. of Pieces		9
Substrate Information		Foam Details				
Material	Type X drywall	Pass Thickness	1 st pass	2"	No. of passes	1
Temp.	20.8 °C		2 nd pass	--	Total thickness	2"
Dim.	96"x 21"		3 rd pass	--	Time between passes	--
Thick.	5/8"		4 th pass	--	Substrate orientation	Vertical

Specimen Set 3 – Detailed Preparation Information Exova Sample ID.: 18-006-545143						
Intended Testing		CAN/ULC-S127				
Date & Time of Application		2018-04-30 11h00		No. of Pieces		11
Substrate Information		Foam Details				
Material	Type X drywall	Pass Thickness	1 st pass	2"	No. of passes	1
Temp.	18.6 °C		2 nd pass	--	Total thickness	2"
Dim.	96"x 48"		3 rd pass	--	Time between passes	--
Thick.	5/8"		4 th pass	--	Substrate orientation	Horizontal

Specimen Set 4 – Detailed Preparation Information Exova Sample ID.: 18-006-545143						
Intended Testing		CAN/ULC-S712.1:2017 Section 5.2.2				
Date & Time of Application		2018-04-30 13h00		No. of Pieces	8	
Substrate Information		Foam Details				
Material	Plywood with 2"x6" wood sides	Pass Thickness	1 st pass	5 1/2"	No. of passes	1
Temp.	19.3 °C		2 nd pass	--	Total thickness	5 1/2"
Dim.	84"x 24"		3 rd pass	--	Time between passes	--
Thick.	5 1/2" deep		4 th pass	--	Substrate orientation	Vertical

Exova Witness

Witnessing Information	
Location of preparation	Genyk 1701, 3e Ave. Grand-Mere, G9T 2W6, Canada
Technical representative	Roland Courtemanche, P. Eng. Project Manager Consultants Mesar Inc.
Signature	



APPENDIX D

Open Cell Content

Certificate of Analysis No. 18-73974

(2 pages)



Testing, calibrating, advising

Certificate of Analysis

Request Number: 18-73974

Date Received: June 4, 2018
Date Certificate Issued: November 14, 2018
Certificate Version: 2

- Official Certificate of Analysis
 Preliminary Certificate of Analysis

Exova (BPC-06)

2395 Speakman Drive
Mississauga, Ontario, Canada
L5K1B3

Tel.: (905) 822-4111

Fax:

Email:

Client P.O.	Client Contact
WO# 541771	Rubaiyat Khondker

Comments

The Certificate was revised to add additional information regarding the Results.

Results Note:

An accurate Open Cell content could not be determined as the pressure readings were drifting during the measurements.

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This version replaces and cancels all earlier version

ND : Not detected

NA : Information not available

NMT: No More Than

NLT: Not Less Than

Certificate no. 48935 - Version 2 - Page 1 of 2

This certificate must not be reproduced, except in its entirety, without written consent from the laboratory. The above-mentioned samples will be retained for a period of 30 days following the issue of this certificate with the exception of microbiology samples or as instructed by the client. Results pertain only to the samples submitted for analysis.

APPENDIX E

Detailed Test Results

Density, Dimensional Stability, Thermal Resistance, Water Absorption and Water Vapor Permeance

(8 pages)

E1 APPARENT CORE DENSITY

Ten (10) specimens were cut from the prepared material. No forming skins were included.

Specimen Size: 100 mm × 100 mm × 100 mm (nominal)

Equipment: Digital calipers, MII# B02703
Digital balance, MII# B10938

Test Date: 2018-06-02

Table E1.1 – Apparent Core Density
ASTM D1622
Exova Sample No.: 18-06-P0045

Specimen	Dimensions, mm			Mass, g	Density
	Length, mm	Width, mm	Thick., mm		
1	101	100	102	9.19	8.92
2	102	100	102	9.21	8.85
3	100	100	101	8.70	8.61
4	100	101	99	8.65	8.49
5	99	102	101	9.01	8.83
6	101	99	101	8.62	8.58
7	99	101	101	8.90	8.77
8	99	100	101	9.59	9.59
9	99	100	99	8.91	9.05
10	100	101	99	9.02	9.00
Average	100.32	100.35	100.60	8.98	8.87
Standard Deviation	1.16	0.88	1.20	0.30	0.31

E2 DIMENSIONAL STABILITY

Three (3) specimens were tested per exposure condition.

Specimen Size: 100 mm × 100 mm × 50 mm (nominal)

Preconditioning: 14 days; 23 ± 2°C; 50 ± 5% RH
Environmental controller, MII# B14944

Test Duration: 28 days

Equipment: Digital calipers, MII# B13123
Digital balance, MII# B10938
Thermocouple, MII# B10864

Exposure Condition 1: -20°C; Ambient humidity
BPC Freezer, Ref# A11200

Exposure Condition 2: 70°C; 97 ± 3% RH
BPC chamber, Ref# A14220

Exposure Condition 3: 80°C; Ambient Humidity
BPC oven, MII# A02754

Date: 2018-06-04 to 2018-07-02

Table E2.1 – Dimensional Stability (-20°C; Ambient humidity)

ASTM D2126

Exova Sample No.: 18-06-P0045

Specimen	Length, mm		% Δ	Width, mm		% Δ	Thickness, mm		% Δ	Volume, cm ³		% Δ
	Initial	Final		Initial	Final		Initial	Final		Initial	Final	
1	103.99	104.05	0.06	103.25	104.21	0.93	52.56	52.31	-0.48	0.0	0.0	0.5
2	104.09	104.67	0.56	104.19	104.51	0.31	53.16	52.97	-0.36	0.0	0.0	0.5
3	104.97	105.32	0.33	104.56	105.29	0.70	52.37	52.29	-0.15	0.0	0.0	0.9
Average	104.35	104.68	0.32	104.00	104.67	0.65	52.70	52.52	-0.33	0.0	0.0	0.6
Std. Dev.	0.54	0.64	0.25	0.68	0.56	0.31	0.41	0.39	0.16	0.0	0.0	0.2

Table E2.2 – Dimensional Stability (70°C; 97 ± 3% RH)

ASTM D2126

Exova Sample No.: 18-06-P0045

Specimen	Length, mm		% Δ	Width, mm		% Δ	Thickness, mm		% Δ	Volume, cm ³		% Δ
	Initial	Final		Initial	Final		Initial	Final		Initial	Final	
1	103.66	104.15	0.47	104.55	103.36	-1.14	51.60	52.19	1.14	0.0	0.0	0.5
2	103.09	103.40	0.30	104.06	102.71	-1.30	51.47	52.51	2.02	0.0	0.0	1.0
3	103.84	103.85	0.01	104.41	102.53	-1.80	51.98	52.86	1.69	0.0	0.0	-0.1
Average	103.53	103.80	0.26	104.34	102.87	-1.41	51.68	52.52	1.62	0.0	0.0	0.4
Std. Dev.	0.39	0.38	0.23	0.25	0.44	0.35	0.27	0.34	0.44	0.0	0.0	0.6

Table E2.3 – Dimensional Stability (80°C; Ambient humidity)

ASTM D2126

Exova Sample No.: 18-06-P0045

Specimen	Length, mm		% Δ	Width, mm		% Δ	Thickness, mm		% Δ	Volume, cm ³		% Δ
	Initial	Final		Initial	Final		Initial	Final		Initial	Final	
1	105.63	103.71	-1.82	104.18	103.42	-0.73	52.70	52.39	-0.59	0.0	0.0	-3.1
2	104.78	103.80	-0.94	103.77	103.19	-0.56	51.97	52.24	0.52	0.0	0.0	-1.0
3	103.06	102.76	-0.29	104.74	102.87	-1.79	52.45	52.21	-0.46	0.0	0.0	-2.5
Average	104.49	103.42	-1.01	104.23	103.16	-1.02	52.37	52.28	-0.18	0.0	0.0	-2.2
Std. Dev.	1.31	0.58	0.77	0.49	0.28	0.66	0.37	0.10	0.61	0.0	0.0	1.1

E3 THERMAL RESISTANCE:

Specimen Dimensions: 300 x 300 x 50 mm (nominal)

No of Samples: 5 (five)

Equipment: LaserComp FOX314 Heat Flow Meter, MII# B13096 / A14505

Calibration File: NIST Calibration 1450C-4 2011-08-25 modified

Measurement: Mitutoyo Digital Calipers, MII# B10643
Digital Balance, MII# B12518
Environmental Controller, MII# B14944
Tape, MII# B13813

Conditioning: 40+ hours at 23°C; 50% RH

Test Conditions: Mean Temperature 23°C
ΔT = 22°C

Sample Orientation: Horizontal

Test Date: 2018-05-11 to 2018-05-14

Table E3.1 – Thermal Transmission Properties
Applicable standard: ASTM C518 – 17
Exova Sample No.: 18-06-P0045-1

Description	Results			
	Value	SI Units	Value	Imperial Units
Measured Length	305.00	mm	12.008	in
Measured Width	305.12	mm	12.013	in
Test Thickness	44.361	mm	1.747	in
Measured Mass	41.23	g	0.091	lb
Density	9.99	kg/m ³	0.623	lb/ft ³
Upper Surface Temperature	13.02	°C	55.44	°F
Lower Surface Temperature	35.02	°C	95.04	°F
Temperature Differential	22.00	°C	39.60	°F
Mean Temperature	24.02	°C	75.24	°F
Rate of Heat Flux	18.59	W/m ²	5.89	BTU/h·ft ²
Thermal Conductance	0.85	W/m ² ·K	0.15	BTU/h·ft ² ·°F
Thermal Resistance	1.18	K·m ² /W	6.72	°F·ft ² ·h/BTU
Thermal Conductivity	0.03749	W/m·K	0.260	BTU·in/h·ft ² ·°F
Thermal Resistivity	26.674	K·m/W	3.847	°F·ft ² ·h/BTU·in

Table E3.2 – Thermal Transmission Properties Applicable standard: ASTM C518 – 17 Exova Sample No.: 18-06-P0045-2				
Description	Results			
	Value	SI Units	Value	Imperial Units
Measured Length	306.01	mm	12.048	in
Measured Width	304.12	mm	11.973	in
Test Thickness	50.950	mm	2.006	in
Measured Mass	41.68	g	0.092	lb
Density	8.79	kg/m ³	0.549	lb/ft ³
Upper Surface Temperature	13.02	°C	55.44	°F
Lower Surface Temperature	35.02	°C	95.04	°F
Temperature Differential	22.00	°C	39.60	°F
Mean Temperature	24.02	°C	75.24	°F
Rate of Heat Flux	16.63	W/m ²	5.27	BTU/h·ft ²
Thermal Conductance	0.76	W/m ² ·K	0.13	BTU/h·ft ² ·°F
Thermal Resistance	1.32	K·m ² /W	7.51	°F·ft ² ·h/BTU
Thermal Conductivity	0.03852	W/m·K	0.267	BTU·in/h·ft ² ·°F
Thermal Resistivity	25.961	K·m/W	3.744	°F·ft ² ·h/BTU·in

Table E3.3 – Thermal Transmission Properties Applicable standard: ASTM C518 – 17 Exova Sample No.: 18-06-P0045-3				
Description	Results			
	Value	SI Units	Value	Imperial Units
Measured Length	305.01	mm	12.008	in
Measured Width	305.21	mm	12.016	in
Test Thickness	51.118	mm	2.013	in
Measured Mass	44.03	g	0.097	lb
Density	9.25	kg/m ³	0.578	lb/ft ³
Upper Surface Temperature	13.02	°C	55.44	°F
Lower Surface Temperature	35.02	°C	95.04	°F
Temperature Differential	22.00	°C	39.60	°F
Mean Temperature	24.02	°C	75.24	°F
Rate of Heat Flux	16.78	W/m ²	5.32	BTU/h·ft ²
Thermal Conductance	0.76	W/m ² ·K	0.13	BTU/h·ft ² ·°F
Thermal Resistance	1.31	K·m ² /W	7.45	°F·ft ² ·h/BTU
Thermal Conductivity	0.03898	W/m·K	0.270	BTU·in/h·ft ² ·°F
Thermal Resistivity	25.654	K·m/W	3.700	°F·ft ² ·h/BTU·in

Table E3.4 – Thermal Transmission Properties

Applicable standard: ASTM C518 – 17
Exova Sample No.: 18-06-P0045 - 4

Description	Results			
	Value	SI Units	Value	Imperial Units
Measured Length	305.14	mm	12.013	in
Measured Width	304.99	mm	12.007	in
Test Thickness	51.050	mm	2.010	in
Measured Mass	42.57	g	0.094	lb
Density	8.96	kg/m ³	0.559	lb/ft ³
Upper Surface Temperature	13.02	°C	55.44	°F
Lower Surface Temperature	35.02	°C	95.04	°F
Temperature Differential	22.00	°C	39.60	°F
Mean Temperature	24.02	°C	75.24	°F
Rate of Heat Flux	17.37	W/m ²	5.51	BTU/h·ft ²
Thermal Conductance	0.79	W/m ² ·K	0.14	BTU/h·ft ² ·°F
Thermal Resistance	1.27	K·m ² /W	7.19	°F·ft ² ·h/BTU
Thermal Conductivity	0.04031	W/m·K	0.280	BTU·in/h·ft ² ·°F
Thermal Resistivity	24.808	K·m/W	3.578	°F·ft ² ·h/BTU·in

Table E3.5 – Thermal Transmission Properties

Applicable standard: ASTM C518 – 17
Exova Sample No.: 18-06-P0045 - 5

Description	Results			
	Value	SI Units	Value	Imperial Units
Measured Length	305.01	mm	12.008	in
Measured Width	305.21	mm	12.016	in
Test Thickness	48.700	mm	1.917	in
Measured Mass	44.22	g	0.097	lb
Density	9.75	kg/m ³	0.609	lb/ft ³
Upper Surface Temperature	13.02	°C	55.44	°F
Lower Surface Temperature	35.02	°C	95.04	°F
Temperature Differential	22.00	°C	39.60	°F
Mean Temperature	24.02	°C	75.24	°F
Rate of Heat Flux	17.94	W/m ²	5.69	BTU/h·ft ²
Thermal Conductance	0.82	W/m ² ·K	0.14	BTU/h·ft ² ·°F
Thermal Resistance	1.23	K·m ² /W	6.96	°F·ft ² ·h/BTU
Thermal Conductivity	0.03971	W/m·K	0.275	BTU·in/h·ft ² ·°F
Thermal Resistivity	25.183	K·m/W	3.632	°F·ft ² ·h/BTU·in

Table E3.6 – Thermal Transmission Properties Applicable standard: ASTM C518 – 17 Exova Sample No.: 18-06-P0045 - Average				
Description	Results			
	Value	SI Units	Value	Imperial Units
Measured Length	305.23	mm	12.017	in
Measured Width	304.93	mm	12.005	in
Test Thickness	49.236	mm	1.938	in
Measured Mass	42.75	g	0.094	lb
Density	9.35	kg/m ³	0.584	lb/ft ³
Upper Surface Temperature	13.02	°C	55.44	°F
Lower Surface Temperature	35.02	°C	95.04	°F
Temperature Differential	22.00	°C	39.60	°F
Mean Temperature	24.02	°C	75.24	°F
Rate of Heat Flux	17.46	W/m ²	5.53	BTU/h·ft ²
Thermal Conductance	0.79	W/m ² ·K	0.14	BTU/h·ft ² ·°F
Thermal Resistance	1.26	K·m ² /W	7.17	°F·ft ² ·h/BTU
Thermal Conductivity	0.03900	W/m·K	0.270	BTU·in/h·ft ² ·°F
Thermal Resistivity	25.66	K·m/W	3.701	°F·ft ² ·h/BTU·in
Thermal Resistance @ 50 mm	1.283	K·m ² /W	7.286	°F·ft ² ·h/BTU

E4 WATER ABSORPTION

Procedure	A	
Specimen Dimensions	200 mm × 200 mm × 100 mm (nominal)	
No. of Specimens	4 (four)	
Conditioning	24 hours at 50°C	
Exposure	96 hours under 51 cm head of water; Water temperature 21-23°C	
Measurement Equipment	Mitutoyo® digital callipers	MII# B13123
	Digital balance	MII# B10938 / B10731
	Thermocouple	MII# B10864
	Timer	MII#B10672
Test Date	2018-05-10 to 2018-05-14	

Table E4 – Water Absorption ASTM D2842, Procedure A Exova Sample No.: 18-06-P0045								
No.	Specimen Dimensions before 96 hr Immersion				Volume, cm ³	Empty Jig, g	Final Buoyancy, g	Water Absorption %
	Length, mm	Width, mm	Thick., mm	Mass, g				
1	202.73	201.70	102.85	39.22	4205.60	5454	3296	47.75
2	200.30	200.02	102.03	39.48	4087.73	5454	3425	49.40
3	201.63	202.95	102.41	38.30	4190.70	5454	3150	44.11
4	203.74	202.95	101.72	39.27	4172.81	5454	3407	50.40
Avg.								47.91
Std. Dev.								2.78

E5 WATER VAPOR PERMEANCE

Procedure: A (Desiccant)
 No. of Specimens Tested: 3 specimens with 1 dummy
 Sealant: Type 1 GE Silicone (100% silicone)
 Test Area: 0.0645 m² (254 mm x 254 mm square)
 Container Design: Stainless Steel Tray
 Conditions: 23 ± 2°C; 50 ± 2% Relative Humidity
 Equipment: Digital balance (0.01g resolution), MII# A13646
 Mitutoyo digital callipers, MII# A11312
 Environmental controller, MII# B14944
 Thickness: 50.46 mm
 Vapor Flow: from free rise side to bottom flat side
 Test Dates: 2018-06-18 to 2018-06-21

Table E5 – Water Vapour Permeance					
ASTM E 96/ E96M-16, Desiccant method					
Exova Sample No.: 18-06-P0045					
No.	Mass, g			Water Vapour Permeance	
	Initial	Final	Change	ng/Pa·s·m ²	US Perms
1	3272.15	3284.71	12.56	1343	23
2	2891.83	2907.72	15.89	1278	22
3	3532.67	3552.02	19.35	1267	22
Avg.	3232.22	3552.02	15.93	1296	23

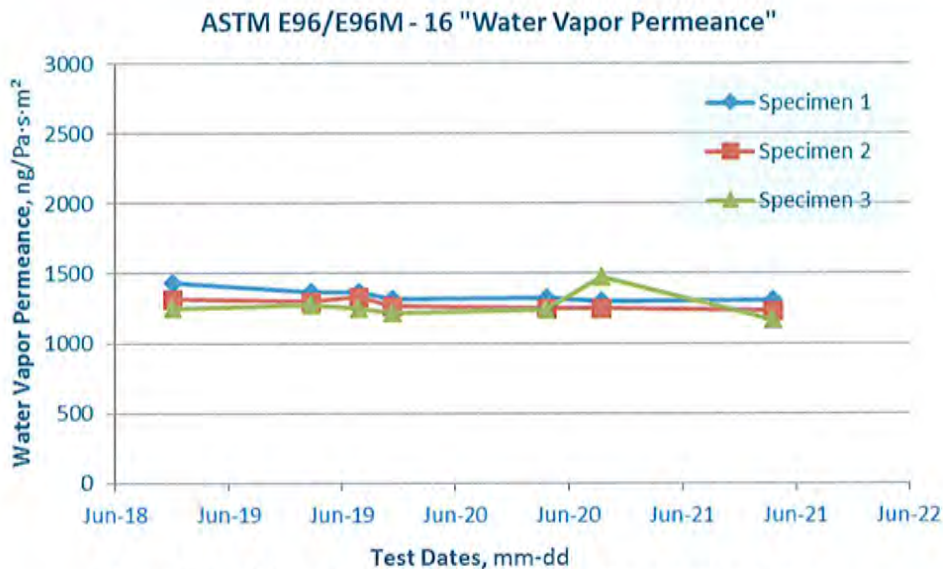


Figure B6 – Water Vapour Permeance (ng/Pa·s·m²) vs. Time

APPENDIX F

Surface Burning Characteristics

Exova Report No.: 18-002-284

(10 pages)

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Testing, calibrating, advising

CAN/ULC-S102 Surface Burning Characteristics of "FLORASEAL 50" Foam Insulation

A Report To:	Genyk 1701, 3e Avenue Grand-Mere, QC, Canada G9T 2W6
Phone:	+1 819-691-5010
Attention:	Yves Rondeau
E-mail:	yvesrondeau@genyk.com
Submitted by:	Exova Warringtonfire North America
Report No.	18-002-284 5 Pages + Appendix
Date:	May 28, 2018

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

SPECIFICATIONS OF ORDER

Determine the Flame Spread and Smoke Developed Classifications based upon triplicate testing conducted in accordance with CAN/ULC-S102-10 and a single screening test conducted in accordance with CAN/ULC-S127-14, as per Exova Building Science Project No. 18-06-P0045, Exova Work Order No. 541769, and Exova Proposal No. 18-006-545143.

SAMPLE IDENTIFICATION (Exova sample identification number 18-06-P0045)

Foam Insulation material, applied to a gypsum board substrate, described as, "Thermal Insulation / light density, Open Cell Spray Applied Semi Rigid Polyurethane Foam", identified as: "FLORASEAL 50"

TEST PROCEDURE

Although the procedure is applicable to materials, products and assemblies used in building construction for development of comparative surface spread of flame data, the test results may not reflect the relative surface burning characteristics of tested materials under all building fire conditions.

The method, designated as CAN/ULC-S102-10, "Standard Method of Test for Surface Burning Characteristics of Building Materials and Assemblies", is designed to determine the relative surface burning characteristics of materials under specific test conditions. Results of less than three identical specimens are expressed in terms of Flame Spread Value (FSV) and Smoke Developed Value (SDV). Results of three or more replicate tests on identical samples produce average values expressed as Flame Spread Rating (FSR) and Smoke Developed Classification (SDC).

CAN/ULC-S102 acknowledges that a specific phenomenon can occur during testing of certain low thermal inertia products (i.e. some foamed plastic materials), that suggests that calculated Flame Spread Values are lower than what would be expected during actual fire conditions. The anomalous behaviour is described as:

"The flame front initially progressing rapidly but then slowing down or failing to advance further and not reaching the end of the test chamber during the test period".

If these conditions occur, the standard attempts to employ a correction by allowing the formula $FSV = 92.5 d/t$ to be used, where "t" is the time in minutes for the flame front to propagate an observed distance ("d"), in metres. However, in many instances where "d" or "t" cannot be accurately determined, CAN/ULC-S102 mandates that the material should then also be tested to determine FSR using the CAN/ULC-S127-14 *Standard Corner Wall Method of Test for Flammability Characteristics of Non-Melting Foam Plastic Building Materials*.

Also for CAN/ULC-S127 testing, results of less than three identical specimens are expressed in terms of Flame Spread Value (FSV). Results of three or more replicate tests on identical samples produces an average value expressed as Flame Spread Rating (FSR).

The intent is to report the highest Flame Spread Rating (worse case) from all respective calculations and tests.

SUMMARIES OF TEST PROCEDURES

CAN/ULC-S102

The tunnel is preheated to 85°C, as measured by the backwall-embedded thermocouple located 7090 mm downstream of the burner ports, and allowed to cool to 40°C, as measured by the backwall-embedded thermocouple located 4000 mm from the burners. At this time the tunnel lid is raised and the test sample is placed along the ledges of the tunnel so as to form a continuous ceiling 7315 mm long, 305 mm above the floor. The lid is then lowered into place.

Upon ignition of the gas burners, the flame spread distance is observed and recorded every second. Flame spread distance versus time is plotted. Calculations ignore all flame front recessions and the Flame Spread Values (FSV) are determined by calculating the total area under the curve for each test sample. If the total area under the curve (AT) is less than or equal to 29.7 m·min, then $FSV = 1.85 \cdot AT$. If greater than 29.7 m·min, then $FSV = 1640 / (59.4 - AT)$.

Smoke Developed Values (SDV) are determined by comparing the area under the obscuration curve for each test sample to that of inorganic reinforced cement board and red oak, established as 0 and 100, respectively. Each Smoke Developed Value is determined by dividing the total area under the obscuration curve by that of red oak and then multiplying by 100.

CAN/ULC-S127

The inside surfaces of the CAN/ULC-S127-14 Corner Wall Test Apparatus (walls and ceiling) are lined with the test material and the burner is positioned so as to be in tangential contact with the two adjacent, interior exposed walls of the apparatus.

The burner is ignited and observations are made to determine the time of issuance of flame from beneath the canopy, fracture of the cotton thread, or recession of the flame front.

The Flame Spread Value (FSV) for each test is calculated using the following equation:

$$FSV = 51.47(t)^{-1.215} \text{ for } 0.15 \leq t \leq 3.0$$

Where "t" is the time in minutes.

SAMPLE PREPARATION

The insulation material was supplied, pre-applied to a gypsum board substrate, at a nominal thickness of 76 mm. For CAN/ULC-S102 testing, each test specimen consisted of a total of three sections, each approximately 533 mm in width by 2438 mm in length. The sections were butted together during testing to form the requisite specimen length. Prior to testing, the specimens were conditioned to constant mass at a temperature of $23 \pm 3^\circ\text{C}$ and a relative humidity of $50 \pm 5\%$. At the initiation of testing, each specimen was self-supporting.

Testing was performed on: Test #1: 2018-05-24 Test #2: 2018-05-24 Test #3: 2018-05-24

For the single CAN/ULC-S127 test, sections were cut and fitted to the test apparatus from supplied sheets of material (approximately 1219 mm x 2438 mm). The specimen sections were then conditioned at a temperature of 23°C and a relative humidity of 50% prior to final assembly on the test frame.

Testing was performed on: 2018-05-28

TEST RESULTS**CAN/ULC-S102-10**Standard Method of Test for Surface Burning
Characteristics of Building Materials and Assemblies

SAMPLE: "FLORASEAL 50"

Test	Approx. Time to Ignition (s)	Maximum Flame Front Distance (m)	Time to Maximum Flame Front (s)	Maximum Air Temperature (°C)	Flame Spread Value (FSV)	"Corrected" Flame Spread Value (FSV)	Smoke Developed Value (SDV)
1	3	2.15	272	319	33	44	269
2	3	2.77	275	335	39	56	231
3	3	1.43	87	216	25	91	190
Average:					32	64	230
Rounded Average Flame Spread Rating (FSR):					30	65	-
Rounded Average Smoke Developed Classification (SDC):					-	-	230

Observations of Burning Characteristics (CAN/ULC-S102-10)

Each of the specimens ignited approximately 3 seconds after exposure to the test flame. Some charred material (chunks) was observed to fall from the specimens.

CAN/ULC-S127-14Standard Corner Wall Method of Test for
Non-Melting Foam Plastic Building Materials

Trial	Category* (A, B, or C)	Time (s) to Observed Flame (average of all timing devices)	Time (t) in Minutes	Calculated Flame Spread Value (FSV)
Test #1	A	12.3	0.205	353

- * A Issuance of flame beneath the canopy
 B Fracture of the cotton thread where it is difficult to assess the time "t" in A
 C Recession of the flame front (this may occur instead of the events covered by A and B)

Observations of Burning Characteristics (CAN/ULC-S127-14)

The sample ignited almost immediately after exposure to the test flame. The flame was observed to issue from beneath the canopy (category A) and the test was forcibly extinguished at that time.

COMMENTS

The anomalous behavior that is possible for low density materials (i.e. foamed plastics), is discussed in Appendix C of CAN/ULC-S102-10. It is stated that CAN/ULC-S127 testing is required to be performed (in addition to CAN/ULC-S102) if the following phenomenon occurs: "...the flame front initially progressing rapidly but then slowing down or failing to advance further, and not reaching the end of the test chamber during the test period."

All three test specimens tested in CAN/ULC-S102 exhibited a rapid initial flame front, that did not advance to the end of the test chamber.

By request, only a single trial was performed to the CAN/ULC-S127 test procedure. Triplicate testing would be required for many Code compliance purposes.

SUMMARY

The Smoke Developed Classification (SDC) determined during CAN/ULC-S102-10 testing was determined to be 230.


The "regular" Flame Spread Rating (FSR) determined during CAN/ULC-S102-10 testing was 30.

The "corrected" (92.5 x d/t) Flame Spread Rating (FSR) for CAN/ULC-S102-10 testing was determined to be 65.

The Flame Spread Value (FSV) determined for a single CAN/ULC-S127 test was 353.

Results Interpretation

CAN/ULC-S102 and CAN/ULC-S127 contain no performance criteria. The National Building Code of Canada (NBCC) or other jurisdictional or industry documentation should be referenced to determine the FSR and/or SDC performance criteria that is most-applicable to the product under test, for the intended application.


Francis Williams,
Technician.


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

(4 Pages)

Charts 1 through 9, **Representative Curves for CAN/ULC-S102**

Figure 1. **Example Schematic of Test Compartment for CAN/ULC-S127**

Test 1 of 3

Sample:	"FLORASEAL 50"
---------	----------------

Chart 1. FLAME SPREAD (Specimen #1)

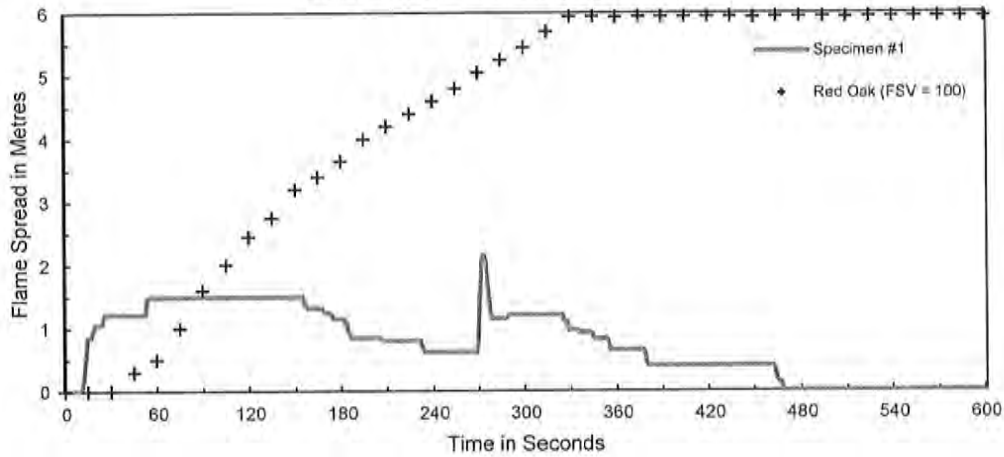


Chart 2. SMOKE DEVELOPED (Specimen #1)

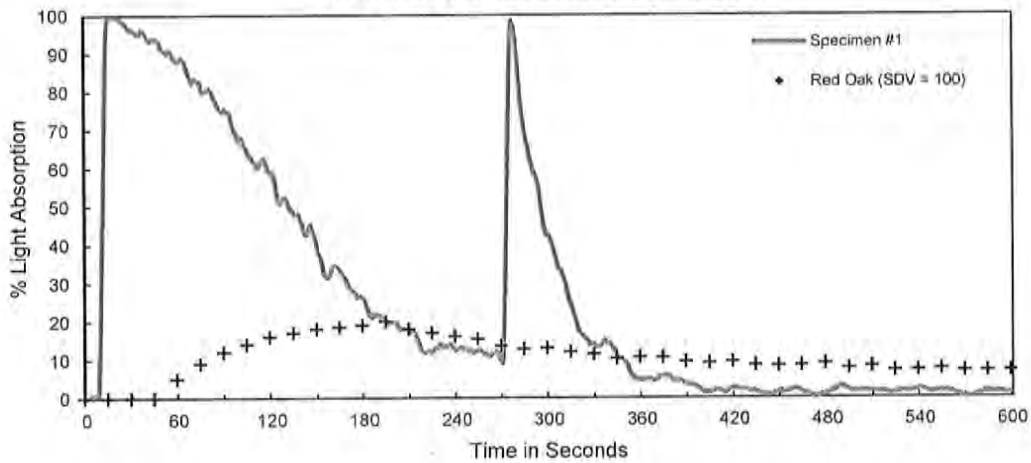
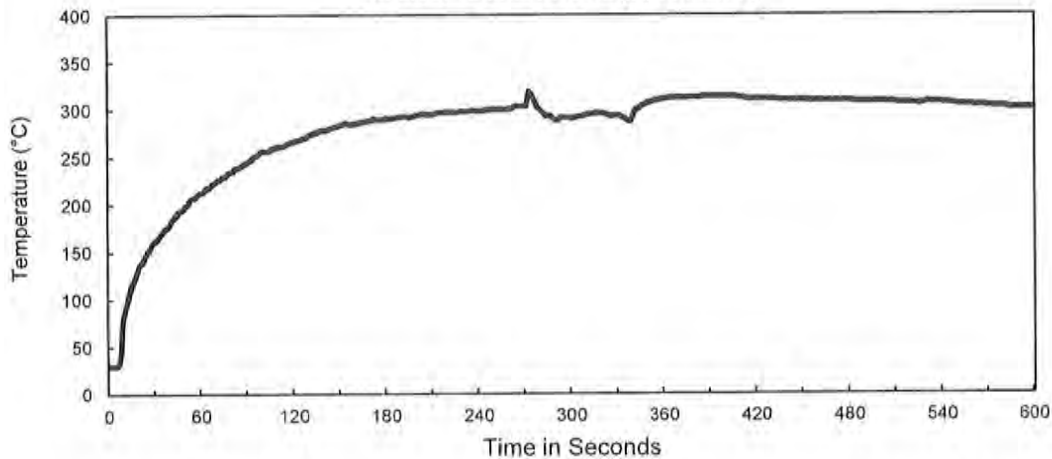


Chart 3. TEMPERATURE (Specimen #1)



Flame Spread
Value (FSV)
33

Smoke Developed
Value (SDV)
269

Maximum Air
Temperature (°C)
319

Test 2 of 3

Sample: "FLORASEAL 50"

Chart 4. FLAME SPREAD (Specimen #2)

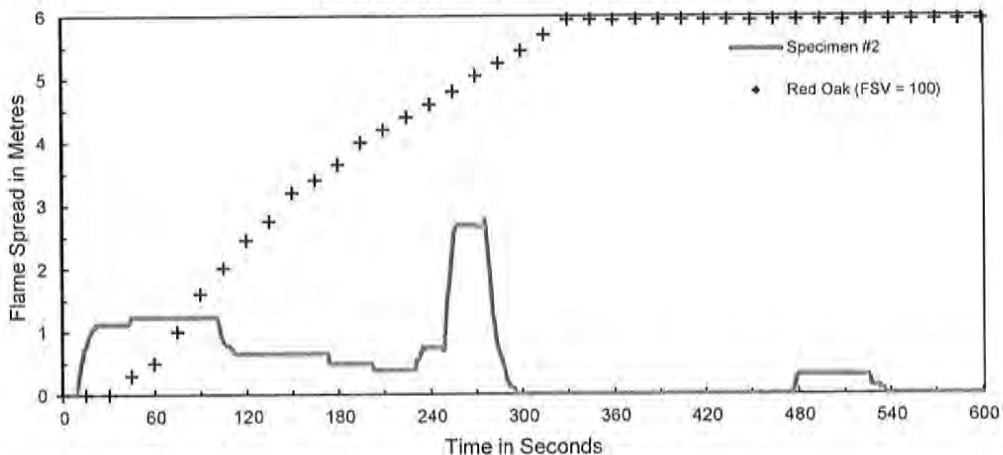


Chart 5. SMOKE DEVELOPED (Specimen #2)

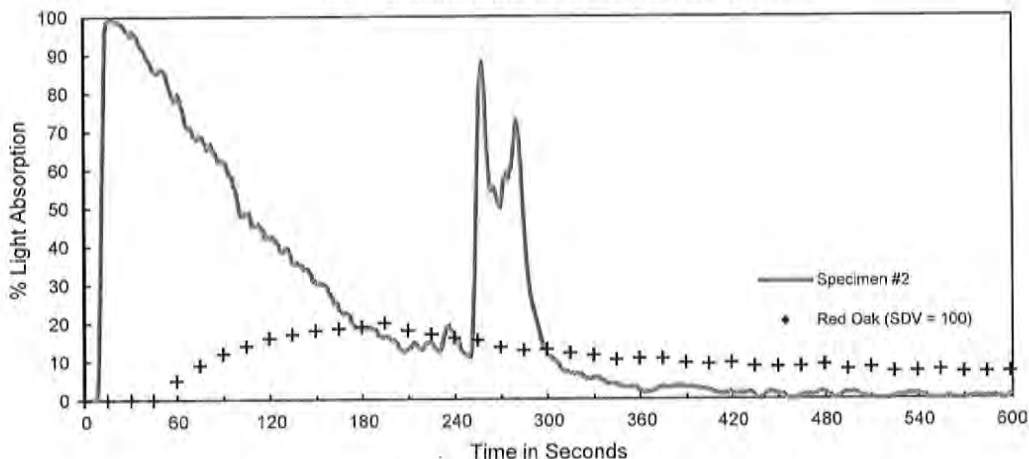
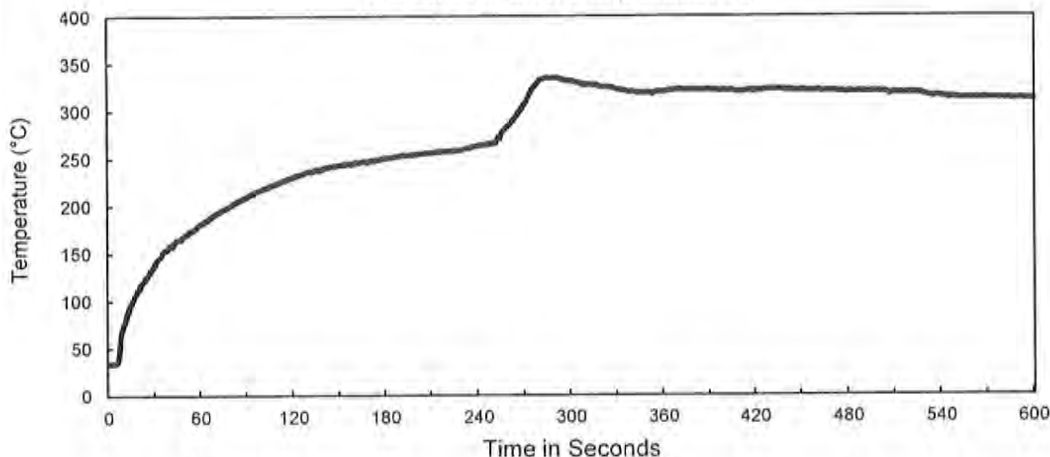


Chart 6. TEMPERATURE (Specimen #2)



Flame Spread
Value (FSV)
39

Smoke Developed
Value (SDV)
231

Maximum Air
Temperature (°C)
335

Test 3 of 3

Sample: "FLORASEAL 50"

Chart 7. FLAME SPREAD (Specimen #3)

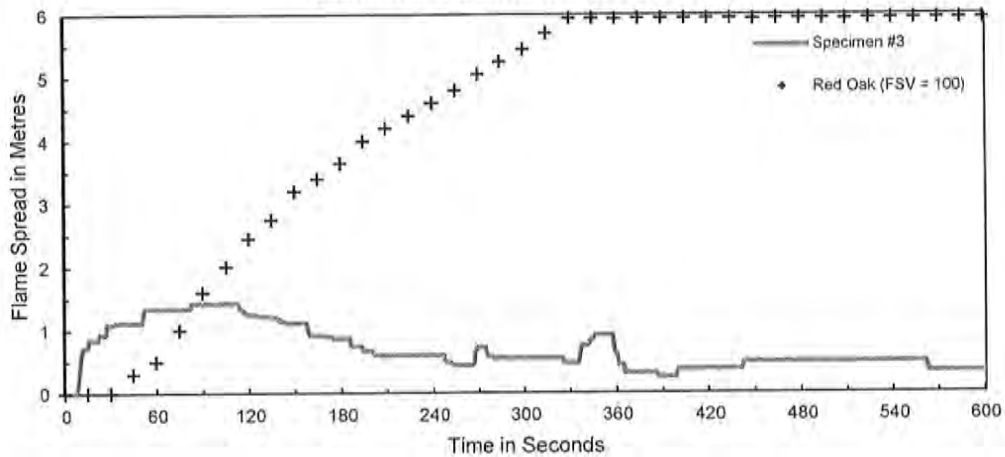


Chart 8. SMOKE DEVELOPED (Specimen #3)

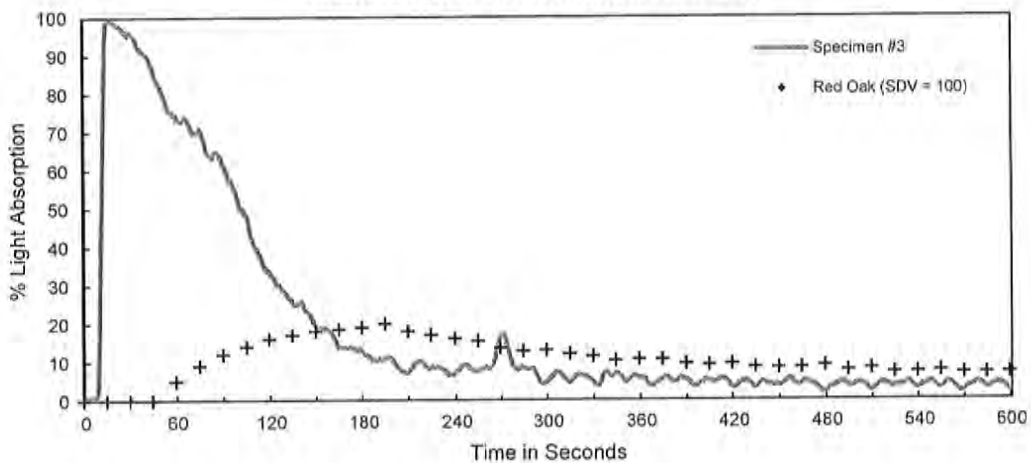
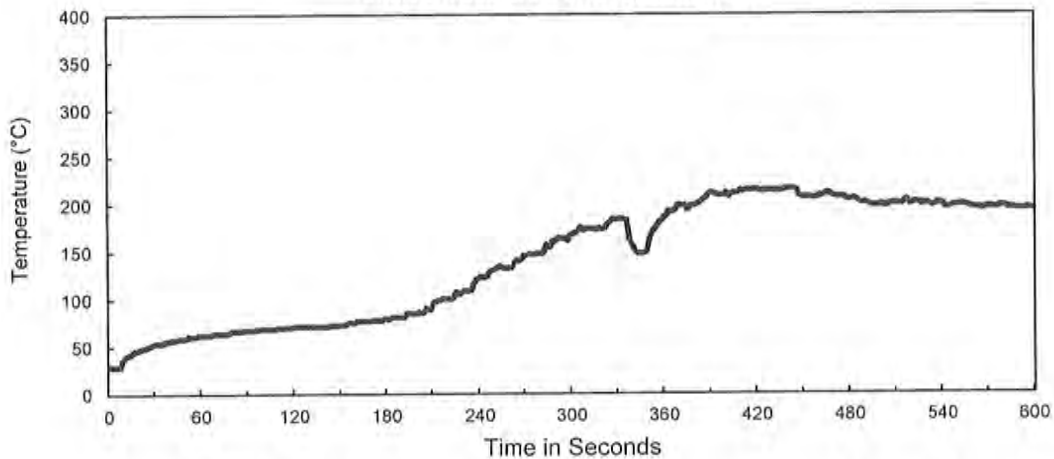


Chart 9. TEMPERATURE (Specimen #3)

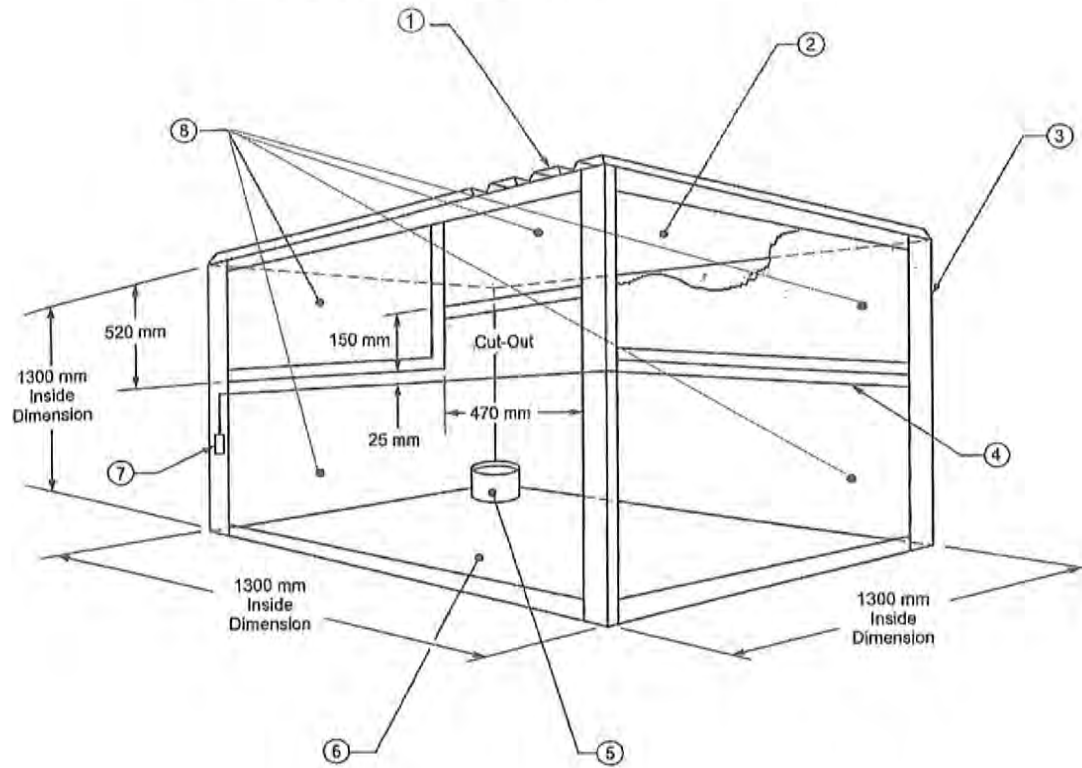


Flame Spread
Value (FSV)
25

Smoke Developed
Value (SDV)
190

Maximum Air
Temperature (°C)
216

Figure 1. Corner Wall Test Compartment



- Legend:
- 1 Steel cellular decking
 - 2 Reinforced inorganic cement board mounted to frame
 - 3 40 mm x 65 mm Angle Iron Frame
 - 4 Cotton thread
 - 5 Ignition burner (ignition source)
 - 6 Floor
 - 7 Mass (attached to cotton thread)
 - 8 Specimen position (also forms the interior ceiling of the mock-up)

<< End of Report >>

APPENDIX G

Fungi Resistance

Report Number R2018-326

(3 pages)

ASTM C 1338-14

*Standard Test Method for Determining Fungi Resistance of
Insulation Materials and Facings*

FINAL REPORT: R2018-326

Prepared for:
Exova
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Accredited Testing Provided by:



130 Erick Street
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TESTING CERT: #2832.01

Testing Initiated: June 7, 2018
Testing Completed: July 5, 2018
Report Issued: July 10, 2018

Performed By: Agata Shulfer
Title: Senior Staff Scientist

Approved By: Debbie Koester
Title: Quality Manager



Objective:

To determine the relative ability of one sample to resist fungal growth as seen in the ASTM C1338 – 14 fungal resistance test.

Test Sample Identification:

1. BPC Project No. # 18-06-P0045

Test Procedure Summary:

Test pieces are sprayed with a mixed spore suspension of five fungal strains. Inoculated samples were then placed into a chamber maintained at $30 \pm 2^\circ\text{C}$ and $95 \pm 4\%$ relative humidity for 28 days. At the end of the incubation period, samples were examined at 40X magnification.

Test Variables

Test Organisms:	<i>Aspergillus brasiliensis</i> ¹	ATCC 9642
	<i>Talaromyces pinophilus</i> ²	ATCC 11797
	<i>Chaetomium globosum</i>	ATCC 6205
	<i>Aspergillus flavus</i>	ATCC 9643
	<i>Aspergillus versicolor</i>	ATCC 11730
<hr/>		
Sample Description:	Test as received, 6" x 6" x 1" pieces	
<hr/>		
Number of Replicates per Sample:	Three	
<hr/>		
Positive Growth Control:	Sterile Filter Paper White birch tongue depressor	
<hr/>		
Environmental Conditions:	$30 \pm 2^\circ\text{C}$; $95 \pm 4\%$ relative humidity	
<hr/>		
Incubation Duration:	28 days	
<hr/>		
Pass/Fail Criteria:	Growth or No Growth	
<hr/>		
Deviations from Standard Test Method:	None, testing performed per ASTM C1338 without deviation.	

¹ *Aspergillus brasiliensis* formerly classified as *Aspergillus niger*

² *Talaromyces pinophilus* formerly identified as *Penicillium funiculosum*



Results:

The results for the test pieces can be found in the data table below. Temperature and relative humidity were maintained for the duration of testing. The control test pieces performed as expected, confirming the validity of the test. These results pertain only to the samples tested.

The criterion used to determine Pass/Fail for this test was growth/no growth.

Sample	Rep	Results
BPC Project No. # 18-06-0045	1	Pass - No growth present - Confirmed at 40x magnification
	2	Pass - No growth present - Confirmed at 40x magnification
	3	Pass - No growth present - Confirmed at 40x magnification

Sample after removal from the test chamber



No fungal growth was confirmed at 40x magnification.

APPENDIX H

Volatile Organic Compounds

Report Number 033761

(29 pages)



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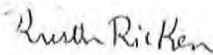
REPORT NUMBER: 033761

Exova
2395 Speakman Drive
Mississauga, Ontario L5K 1B3
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Date: November 5, 2018
Purchase Order: POC112520
Customer Reference: 18-006-545143

his project shall be governed exclusively by the General Terms and Conditions of Sale and Performance of Testing Services by Element Materials Technology. In no event shall Element Materials Technology be liable for any consequential, special or indirect loss or any damages above the cost of the work. It is our policy to retain components and sample remnants for a minimum of 30 days from the report date, after which time they may be discarded. The data herein represents only the item(s) tested. This report shall not be reproduced, except in full, without prior permission of Element Materials Technology.

REPORTED / APPROVED BY:

Prepared By: 
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PURPOSE

The purpose of this test report is to present the test results obtained during the performance of a test program. This report includes a brief description of the samples presented for test, a list of the documents presented as test instructions, and a summary of the testing performed and the results obtained. Applicable requirements and conclusions are based on the criteria provided by our client, or as specified in the reference document(s). All results relate only to the items tested, as listed within this report.

WORK REQUESTED / REFERENCE DOCUMENT

CAN/ULC S774-09

1. PRODUCT DESCRIPTION

TYPE OF MATERIAL: The product tested was identified as spray applied polyurethane thermal insulating foam. The sample material was generated from A-side lot GE017845 and B-side lot L-8105 to produce Exova Canada sample #18-006-545143.

SAMPLE RECEIVED: The sample was created on 21 August, 2018 at Genyk Inc.'s facility in Shawinigan, QC under the supervision of Roland Courtemanche of Exova. The sample was subsequently sealed and overnight couriered to the Element Warren testing facilities in Warren, Michigan.

2. TEST OBJECTIVE

The testing objective was to identify and quantify volatile organic compound (VOC) emissions using Procedure 'B' of the Underwriters Laboratories of Canada CAN/ULC-S774-09 testing standard.

3. METHODOLOGY

3.1 Storage and Pre-conditioning of Product

The storage conditions of the drums containing components "A" and "B" of the two-part spray-applied polyurethane foam were stored at warehouse. Storage conditions were not documented.

3.2 Preparation of Test Chambers

Prior to receiving the foam sample, and following the assembly of the test chambers and associated equipment, all systems were run-up to test conditions.

3.3 Mixing and Spraying the Polyurethane Foam

Components were sprayed at 14:15 hrs, Eastern Standard Time (EST), Tuesday, 21 August, 2018 at GENYK Inc. in Shawinigan, QC. Roland Courtemanche of Exova acted as the independent witness for the spraying session, confirming product identification and documenting conditions. Refer to Appendix B.

3.4 Preparation of the Foam Test Panel

The product was sprayed upon a sheet of aluminum foil to create a panel. The sample piece was sealed in a Tedlar® bag provided by Exova. The bag was secured in a locked transport case and transported via overnight courier to the Element testing facility in Warren, MI.

3.5 Preparation of Test Specimens

On 22 August, 2018 the sample piece was removed from its packing and cut into three specimens for introduction into the chambers. The specimens were freshly cut on all six sides. The dynamic-chamber specimens were cut into two (2) thicknesses of 25mm and installed into stainless steel specimen holders. The exposed surface area provided a chamber loading ratio of $0.5\text{m}^2/\text{m}^3$ (square meters per cubic meter). One specimen was introduced to the 51.2 liter stainless steel dynamic chamber (specimen #1) while the other specimen (specimen #2) was retained in an airtight vessel. The headspace-chamber portion of the sample (specimen #3) was introduced to the headspace chamber – refer to section 3.6. Introduction of the specimen to the dynamic chamber occurred at 14:15hrs EST; exactly 24 hours and 0 minutes after manufacture. This is in accordance with the testing standards stipulation for the test to commence 24 hours after the sample's manufacture (CAN/ULC-S774-09; section 6.1.2).

3.6 Headspace Analysis

A test specimen was cut from the sample piece and installed in the headspace chamber (0.60 liter volume) to occupy greater than 50% of the 0.60 liter volume. The chamber was then sealed and maintained at 40°C for 24 hours at zero air flow. Twenty four hours later an air sample was drawn from the headspace chamber for analysis. The headspace analysis is useful when concentration levels of compounds in the 1 and 12 hour tests are too low for identification by mass spectral library. The headspace apparatus often generates higher concentrations of compounds that volatilize quickly. In most situations, the headspace analysis is not required since the concentrations are of sufficient strength during the subsequent chamber tests.

3.7 Dynamic Chamber Analysis (Procedure B)

The dynamic test chamber was operated in an environmentally-controlled enclosure with the air sampling apparatus mounted externally. Air samples to determine chamber emission concentrations were taken at the specified time intervals as prescribed in the CAN/ULC-S744-09 standard; air samples were drawn at 1, 12, 24, and 48 hours and on days 4, 7, 14, and 30 (refer to section 7.3). The air samples were then analyzed as described in *section 4 and Appendix A – Analytical Method*.

4 ANALYTICAL TECHNIQUES

Carbotrap™ 400 absorbent tubes, in conjunction with gas chromatograph/mass selective detector (GC/MSD) analysis, were utilized for all air sampling sessions to identify and quantify volatile organic compound emissions from the sample.

4.1 Carbotrap™ Samples

The Carbotrap™ 400 absorbent tubes were thermally desorbed using a CDS thermal desorption unit at 300°C for three minutes. Any volatilized compounds are directed into the GC/MSD for compound identification and quantification. The quantification of the compounds may be achieved by several protocols:

- 1) Using toluene response factor for semi-quantitative estimate of compound concentration,
- 2) Using response factor of a compound in the same family as the detected compound, for a more accurate semi-quantitative estimate, or
- 3) Using response factor for the pure standard of the detected compound for a quantitative measurement.

The normal protocol that is used for quantization is number (1) and it is that protocol that was utilized to generate the profile contained herein. Protocol (2) is significantly more costly due to several pure compounds (if available) would be required to be purchased and much more time is required to perform the calibrations. Protocol (3) is the most costly since each detected compound needs to be purchased as a pure standard (often they are not readily available) and time is required to prepare each calibration standard. Protocols (2) and (3) require re-test coordination and preparation.

4.2 Calibration of Analytical Equipment

Appendix A details the Quality Control Procedures and calibration methods.

5 FACILITIES AND EQUIPMENT

5.1 Analytical Instrumentation

The following equipment was used to capture and analyze the air samples:

Supelco Carbotrap™ 400 tubes

Dynatherm 9300 Thermal Desorption Unit (TDU)

Gas Chromatography:

- Agilent model 7890A Gas Chromatograph
- Agilent model 5975C inert XL Mass Selective Detector
- Restek model Rxi-5ms column (60m x 0.25mm x 0.25um)
- Windows ChemStation Data System
- NIST98 and Wiley275 Mass Spectral Databases

5.2 Test Chambers

The test chambers used in the testing consisted of:

Dynamic chamber: 51.2 liter stainless steel chamber

Headspace chamber: 0.60 liter stainless steel chamber

5.3 High Purity Supply Air System

The high purity air system providing VOC –free supply air consists of:

Parker model UHP-35ZA-S zero air generator

Swagelok stainless steel distribution tubing

Swagelok stainless steel fittings and valves

Humidification and temperature are controlled to test condition set-points prior to introduction into the chambers.

6 DESCRIPTION OF SAMPLE PANEL AND TEST SPECIMENS

Description of sample piece provided to Element:

Dimensions: 160mm x 110mm x 60mm thick – nominal
160mm x 110mm x 50mm thick – nominal
160mm x 110mm x 60mm thick - nominal

Number of pieces: Three

Description of dynamic chamber test specimen:

Dimensions: 160mm x 160mm x 25mm thick
Chamber loading factor 0.5m²/m³

7 DESCRIPTION OF TEST CONDITIONS

7.1 Sample Preparation

CHEMICAL PRECONDITIONING

Storage Temperature	20-25°C
Storage Relative Humidity	Not documented

SAMPLE PANEL CURING

CURING START – DATE / TIME	21 August, 2018/ 14:15 hrs EST
Room temperature	Unmonitored; in transit
Room relative humidity	Unmonitored; in transit
Air exchange rate	Zero: A.C.H.; sealed air-tight
Cure duration	24 hours

TEST SPECIMENS

TEST START DATE / TIME	22 August, 2018 / 14:15 hrs
Laboratory room temperature	23°C ± 2°C
Laboratory relative humidity	50% ± 5%
Duration of test	30 days

7.2 Headspace Chamber Air Sampling

7.2.1 Headspace Chamber Background Measurement

CHAMBER	
Chamber temperature	40°C
Chamber relative humidity	Uncontrolled
Chamber volume	0.6 Liters
Duration of pre-test air purge	> 72 hours
Air flow rate	200 ml/min ± 5%
Air flow source	High Purity Air System
COLLECTION MEDIA	
Sorbent tube	Supelco Carbotrap™ 400
Sampling duration	60 minutes
Sampling air flow rate	200 ml/min ± 5%

7.2.2 Headspace Chamber VOC Identification Measurement

CHAMBER	
Chamber temperature	40°C ± 2°C
Chamber relative humidity	Uncontrolled
Chamber volume	0.6 Liters
Duration of pre-test air purge	> 48 hours
Air flow rate	200 ml/min ±5%
Air flow source	High Purity Air System
COLLECTION MEDIA	
Sorbent tube	Supelco Carbotrap™ 400
Sampling duration	15 minutes
Sampling air flow rate	200 ml/min ± 5%

7.3 Dynamic Chamber Air Sampling

7.3.1 Dynamic Chamber Background Measurement

CHAMBER	
Chamber temperature	40°C ± 2°C
Chamber relative humidity	50% ± 5%
Chamber volume	51.2 liters
Duration of pre-test air purge	> 72 hours
Air flow rate	256 ml/min ±5%
Air flow source	High Purity Air System
COLLECTION MEDIA	
Sorbent tube	Supelco Carbotrap™ 400
Sampling duration	60 minutes
Sampling air flow rate	200 ml/min ± 5%

7.3.2 Test Specimen VOC Measurement #1 – (hour-1 test)

CHAMBER	
Test Start – Date / Time	22 August, 2018 / 15:15 hrs
Chamber temperature	40°C ± 2°C
Chamber relative humidity	35.1-36.5% (chamber acclimating towards set pt)
Chamber volume	51.2 liters
Air flow rate	256 ml/min ±5%
Air flow source	High Purity Air System
COLLECTION MEDIA	
Sorbent tube	Supelco Carbotrap™ 400
Sampling duration	60 minutes
Sampling air flow rate	200 ml/min ± 5%
Sampling interval	Hour 1 of 30 days

7.3.3 Test Specimen VOC Measurement #2 – (Hour-12 test)

CHAMBER	
Test Start – Date / Time	23 August, 2018 / 2:15 hrs
Chamber temperature	40°C ± 2°C
Chamber relative humidity	50% ± 5%
Chamber volume	51.2 liters
Air flow rate	256 ml/min ±5%
Air flow source	High Purity Air System
COLLECTION MEDIA	
Sorbent tube	Supelco Carbotrap™ 400
Sampling duration	60 minutes
Sampling air flow rate	200 ml/min ± 5%
Sampling interval	Hour 12 of 30 days

7.3.4 Test Specimen VOC Measurement #3 – (Hour-24 test)

CHAMBER	
Test Start – Date / Time	23 August, 2018 / 14:15 hrs
Chamber temperature	40°C ± 2°C
Chamber relative humidity	50% ± 5%
Chamber volume	51.2 liters
Air flow rate	256 ml/min ±5%
Air flow source	High Purity Air System
COLLECTION MEDIA	
Sorbent tube	Supelco Carbotrap™ 400
Sampling duration	60 minutes
Sampling air flow rate	200 ml/min ± 5%
Sampling interval	Day 1 of 30 days

7.3.5 Test Specimen VOC Measurement #4 – (Day-2 test)

CHAMBER	
Test Start – Date / Time	24 August, 2018 / 14:15 hrs
Chamber temperature	40°C ± 2°C
Chamber relative humidity	50% ± 5%
Chamber volume	51.2 liters
Air flow rate	256 ml/min ±5%
Air flow source	High Purity Air System
COLLECTION MEDIA	
Sorbent tube	Supelco Carbotrap™ 400
Sampling duration	60 minutes
Sampling air flow rate	200 ml/min ± 5%
Sampling interval	Day 2 of 30 days

7.3.6 Test Specimen VOC Measurement #5 – (Day-4 test)

CHAMBER	
Test Start – Date / Time	26 August, 2018 / 14:15 hrs
Chamber temperature	40°C ± 2°C
Chamber relative humidity	50% ± 5%
Chamber volume	51.2 liters
Air flow rate	256 ml/min ±5%
Air flow source	High Purity Air System
COLLECTION MEDIA	
Sorbent tube	Supelco Carbotrap™ 400
Sampling duration	60 minutes
Sampling air flow rate	200 ml/min ± 5%
Sampling interval	Day 4 of 30 days

7.3.7 Test Specimen VOC Measurement #6 – (Day-7 test)

CHAMBER	
Test Start – Date / Time	29 August, 2018 / 14:15 hrs
Chamber temperature	40°C ± 2°C
Chamber relative humidity	50% ± 5%
Chamber volume	51.2 liters
Air flow rate	256 ml/min ±5%
Air flow source	High Purity Air System
COLLECTION MEDIA	
Sorbent tube	Supelco Carbotrap™ 400
Sampling duration	60 minutes
Sampling air flow rate	200 ml/min ± 5%
Sampling interval	Day 7 of 30 days

7.3.8 Test Specimen VOC Measurement #7 – (Day-14 test)

CHAMBER	
Test Start – Date / Time	5 September, 2018 / 14:15 hrs
Chamber temperature	40°C ± 2°C
Chamber relative humidity	50% ± 5%
Chamber volume	51.2 liters
Air flow rate	256 ml/min ±5%
Air flow source	High Purity Air System
COLLECTION MEDIA	
Sorbent tube	Supelco Carbotrap™ 400
Sampling duration	60 minutes
Sampling air flow rate	200 ml/min ± 5%
Sampling interval	Day 14 of 30 days

7.3.9 Test Specimen VOC Measurement #8 – (Day-30 test)

CHAMBER	
Test Start – Date / Time	21 September, 2018 / 14:15 hrs
Chamber temperature	40°C ± 2°C
Chamber relative humidity	50% ± 5%
Chamber volume	51.2 liters
Air flow rate	256 ml/min ±5%
Air flow source	High Purity Air System
COLLECTION MEDIA	
Sorbent tube	Supelco Carbotrap™ 400
Sampling duration	60 minutes
Sampling air flow rate	200 ml/min ± 5%
Sampling interval	Day 30 of 30 days

8 TEST RESULTS

8.1 Background Measurement – Headspace Chamber

Iden: EX3-2

Table 8.1

Compound Identified	Confidence of I.D. ¹	Amount Detected (µg)	Air concentration (mg/m ³)
Clean	-	-	-
Detection Limit		0.05	0.004
Total Volume of Air Sample		12.0 liters	

 Note¹ - Confidence of Identification – Refer forward to Section 8.5

µg = microgram {one millionth of a gram}

 mg/m³ = milligram {one thousandth of a gram}

ND = not detected

Iden = sample identification number

8.2 Test Specimen VOC Identification – Headspace Chamber

Iden: EX3-6

Table 8.2

Compound Identified (synonym)	Confidence of I.D. ¹	Amount Detected (µg)	Air Concentration (mg/m ³)
Ethane, 1,1,1-trifluoro-	4	0.03	0.011
Methane, trifluoro-	5	5.50	1.834
Propane, 2,2-difluoro-	5	0.77	0.256
Propene, 2-chloro-3,3,3-trifluoro-	4	1.99	0.664
Tetrazolo[1,5-b]pyridazine	5	0.06	0.020
Formamide, N,N-diethyl-	5	0.75	0.251
1-Propene, 1-chloro-	1	0.41	0.137
Methylene Chloride	2	0.10	0.033
Ethene, 1,2-dichloro-, (E)-	3	11.37	3.790
2-Propanone, 1-(pentylthio)-	5	0.14	0.045
Heptamethyltrisiloxane	3	0.06	0.021
.alpha.-D-Xylofuranoside, methyl 3-O-methyl-	4	0.09	0.029
Diisopropyl ether	3	0.11	0.038
Propane, 1,2-dichloro-	1	0.86	0.287
1,4-Dioxane	3	0.75	0.249
1,3,6-Trioxocane, 2-methyl-	4	0.56	0.188
Toluene	1	0.85	0.283
1-methyl-1-indanol	4	0.27	0.091
(2-Methyl-[1,3]dithian-2-yl)phenylmethanol	4	0.14	0.048

Table 8.2 continued			
Compound Identified (synonym)	Confidence of I.D.¹	Amount Detected (µg)	Air Concentration (mg/m³)
1,4-Dioxane, 2,5-dimethyl-	1	0.13	0.043
Cyclotrisiloxane, hexamethyl-	1	1.59	0.530
2-Pentenal, 2-methyl-	1	0.23	0.075
2-Propanol, 1-propoxy-	3	0.05	0.017
2-Propanol, 1-(2-propenyloxy)-	2	0.05	0.017
Benzene, chloro-	1	0.76	0.253
p-Xylene	1	0.05	0.017
Cyclohexanone	2	0.06	0.020
1,3-Propanediamine, N,N,N',N'-tetramethyl-	1	0.13	0.043
2,4-Cyclohexadien-1-one, 3,5-bis(1,1-dimethylethyl)-4-hydroxy-	4	0.11	0.036
Benzene, 1,3,5-trimethyl-	3	0.04	0.014
Cyclotetrasiloxane, octamethyl-	1	0.47	0.157
Benzene, 1-ethyl-3-methyl-	4	0.05	0.017
Benzene, 1,2-dichloro	1	0.07	0.022
2-Propanol, 1,1'-oxybis-	4	0.09	0.031
2-Pentanone, 5-methoxy-	4	0.34	0.112
Benzene, cyclopropyl-	3	0.11	0.037
Benzene, 1-ethynyl-4-methyl-	3	0.14	0.045
Propane, 1,1'-oxybis[3-chloro-	1	0.09	0.032
Nonane, 2,2,4,4,6,8,8-heptamethyl-	4	0.05	0.017
S-[2-[N,N-Dimethylamino]ethyl]morpholine-N-carbonylthiocarbohydroximate	3	0.20	0.066
Benzoic acid, 2-[(trimethylsilyl)oxy]-, trimethylsilyl ester	2	0.85	0.284
Propanedioic acid, bis(trimethylsilyl) ester	4	0.46	0.154
Ethanedioic acid, bis(trimethylsilyl) ester	3	0.46	0.153
3,6-Dioxa-2,4,5,7-tetrasilaoctane, 2,2,4,4,5,5,7,7-octamethyl-	3	0.17	0.057
Detection Limit		0.05	0.017
Total Volume of Air Sample		3.0 liters	

Refer to table 8.1 for table notes.

8.3 Background Measurement – Dynamic Chamber
Table 8.3

Iden: EX3-1

Compound Identified	Confidence of I.D. ¹	Amount Detected (µg)	Air concentration (mg/m ³)
Clean	-	-	-
Detection Limit		0.05	0.004
Total Volume of Air Sample		12.0 liters	

Refer to table 8.1 for table notes.

8.4 VOC Measurements - Dynamic Chamber (30- day test period)
8.4.1 VOC Decay Measurement #1 – Hour-1
Table 8.4.1

Iden: EX3-3

Compound Identified (synonym)	Confidence of I.D. ¹	Amount Detected (µg)	Air Concentration (mg/m ³)
1-Propene, 3-bromo-3,3-difluoro-	5	0.07	0.006
Ethyl Chloride	5	0.06	0.005
Propene, 1-chloro-3,3,3-trifluoro-	4	0.29	0.024
Trichloromonofluoromethane	2	0.68	0.057
Ethene, 1,2-dichloro-, (E)-	1	8.89	0.741
Hexane, 3-methyl-	3	0.08	0.006
Propane, 1,2-dichloro	1	0.58	0.048
1,3,6-Trioxocane, 2-methyl-	4	0.23	0.019
Toluene	1	2.44	0.203
Benzene, (isothiocyanatomethyl)-	4	0.23	0.019
Benzene, [(methoxymethoxy)methyl]-	4	0.08	0.007
Cyclotrisiloxane, hexamethyl-	2	0.16	0.013
2-Pentenal, 2-methyl-	1	0.08	0.007
Benzene, chloro-	1	0.26	0.022
p-Xylene	1	0.09	0.007
Benzene, 1-ethynyl-4-methyl-	3	0.06	0.005
Benzoic acid, 2-[(trimethylsilyl)oxy]-, trimethylsilyl ester	2	0.23	0.019
Cyclotetrasiloxane, octamethyl-	4	0.08	0.006
Ethanedioic acid, bis(trimethylsilyl) ester	3	0.11	0.009
Detection Limit		0.05	0.004
Total Volume of Air Sample		12.0 liters	

Refer to Table 8.1 for table notes.

8.4.2 VOC Decay Measurement #2 – Hour-12

Iden: EX3-4

Table 8.4.2

Compound Identified (synonym)	Confidence of I.D. ¹	Amount Detected (µg)	Air Concentration (mg/m ³)
Ethene, 1,2-dichloro-, (E)-	1	0.32	0.027
Toluene	1	0.21	0.017
Cyclotrisiloxane, hexamethyl-	1	0.11	0.009
Detection Limit		0.05	0.004
Total Volume of Air Sample		12.0 liters	

Refer to Table 8.1 for table notes.

8.4.3 VOC Decay Measurement #3 – Hour-24

Iden: EX3-5

Table 8.4.3

Compound Identified (synonym)	Confidence of I.D. ¹	Amount Detected (µg)	Air Concentration (mg/m ³)
Toluene	1	0.12	0.010
Cyclotrisiloxane, hexamethyl-	2	0.24	0.020
Cyclotetrasiloxane, octamethyl-	1	0.06	0.005
2-Propanol, 1,1'-oxybis-	4	0.09	0.008
Propane, 1-chloro-3-[2-(2-methoxyethoxy)ethoxy]-	3	0.10	0.008
Tris(3-chloropropyl) phosphate	5	0.09	0.008
Detection Limit		0.05	0.004
Total Volume of Air Sample		12.0 liters	

Refer to Table 8.1 for table notes

8.4.4 VOC Decay Measurement #4 – Day-2

Iden: EX3-7

Table 8.4.4

Compound Identified (synonym)	Confidence of I.D. ¹	Amount Detected (µg)	Air Concentration (mg/m ³)
Trimethylphosphine oxide	5	0.06	0.005
Propane, 2-chloro-2-nitro-	5	0.06	0.005
Toluene	1	0.54	0.045
Cyclotrisiloxane, hexamethyl-	2	0.25	0.021
Cyclotetrasiloxane, octamethyl-	2	0.06	0.005
Propane, 1-chloro-3-[2-(2-methoxyethoxy)ethoxy]-	4	0.10	0.008
Tris(3-chloropropyl) phosphate	5	0.16	0.013
Detection Limit		0.05	0.004
Total Volume of Air Sample		12.0 liters	

Refer to Table 8.1 for table notes

8.4.5 VOC Decay Measurement #5 – Day-4

Iden: EX3-8

Table 8.4.5

Compound Identified (synonym)	Confidence of I.D. ¹	Amount Detected (µg)	Air Concentration (mg/m ³)
Trimethylphosphine oxide	5	0.07	0.006
Propane, 2-chloro-2-nitro-	5	0.06	0.005
Toluene	1	0.33	0.028
Tetrachloroethylene	1	0.09	0.008
Cyclotrisiloxane, hexamethyl-	3	0.27	0.022
Cyclotetrasiloxane, octamethyl-	1	0.05	0.004
Tris(3-chloropropyl) phosphate	5	0.40	0.033
Detection Limit		0.05	0.004
Total Volume of Air Sample		12.0 liters	

Refer to Table 8.1 for table notes

8.4.6 VOC Decay Measurement #6 – Day-7

Iden: EX3-9

Table 8.4.6

Compound Identified (synonym)	Confidence of I.D. ¹	Amount Detected (µg)	Air Concentration (mg/m ³)
Toluene	1	0.26	0.021
Cyclotrisiloxane, hexamethyl-	4	0.14	0.012
Tris(3-chloropropyl) phosphate	5	0.31	0.026
Detection Limit		0.05	0.004
Total Volume of Air Sample		12.0 liters	

Refer to Table 8.1 for table notes

8.4.7 VOC Decay Measurement #7 – Day-14

Iden: EX3-10

Table 8.4.7

Compound Identified (synonym)	Confidence of I.D. ¹	Amount Detected (µg)	Air Concentration (mg/m ³)
Toluene	1	0.24	0.020
Cyclotrisiloxane, hexamethyl-	1	0.06	0.005
Tris(3-chloropropyl) phosphate	5	0.26	0.022
Detection Limit		0.05	0.004
Total Volume of Air Sample		12.0 liters	

Refer to Table 8.1 for table notes

8.4.8 VOC Decay Measurement #8 – Day-30

Iden: EX3-11

Table 8.4.8

Compound Identified (synonym)	Confidence of I.D. ¹	Amount Detected (µg)	Air Concentration (mg/m ³)
Tris(3-chloropropyl) phosphate	4	0.22	0.018
Detection Limit		0.05	0.004
Total Volume of Air Sample	12.0 liters		

Refer to Table 8.1 for table notes

8.5 Table of Confidence of Identification – GC/MSD

Table 8.5

ASSIGNED VALUE	DESCRIPTION
1	High confidence; clean spectra, excellent match with library spectrum. (>90)
2	Mass spectrum has small spectral differences from library match. A good comparison. Reference compound required for positive identification. (75-89%)
3	Possible compound or similar structural type. Spectrum is contaminated with other features. Reference compound required for positive identification. (50-74%)
4	Evidence of possible structure and possibly molecular weight range. Compound is poor identification. (20-49%)
5	Unable to identify. (<20%)

9 ANALYSIS OF TEST RESULTS

- The test conducted on hour-1 identified nineteen (19) compounds.
- The test conducted on hour-12 identified three (3) compounds.
- The test conducted on hour-24 identified six (6) compounds.
- The test conducted on hour-48 identified seven (7) compounds.
- The test conducted on day-4 identified seven (7) compounds
- The test conducted on day-7 identified three (3) compounds.
- The test conducted on day-14 identified three (3) compounds.
- The test conducted on day-30 identified one (1) compound.
- The Headspace chamber test yielded the detection of forty four (44) volatile organic compounds, thirteen (13) of which were detected in subsequent testing.

Permissible concentrations in indoor air are calculated using the time weighted average (TWA) exposure value found in the American Conference of Government Industrial Hygienists (ACGIH) - The Threshold Limit Values Handbook (2018) to calculate the compound's *threshold limit value* (TLV.)

Determining threshold limit values (TLVs) in milligrams per cubic meter (mg/m³) is done by taking the TWA values presented in the reference literature in parts-per-million (ppm) and multiplying that value by the compounds molecular weight (MW) then dividing the product by the constant 24.45.

$$\text{TLV \{mg/m}^3\} = \frac{\text{TWA \{ppm\} x MW of compound}}{24.45} \dots\dots\dots (\text{Eq.1})$$

These values are further divided by 100 to yield a value of 1% of the listed *occupational exposure* (8 hours per day – 40 hours per week) levels. This is industry protocol for establishing figures suitable for *residential exposure* (24 hours per day -7 days per week) levels and is in accordance with Section 9.4 of the testing standard.

Five (5) compounds detected during dynamic chamber testing are not present in the reference literature to provide TWA values for calculation. The compound (marked “Note 2” in Table 9.3) will require the services of a toxicologist for further evaluation, per section 9.3 of the testing standard.

9.1 Table of Identified Compounds

Table 9.1 (Headspace concentration values are not included in this table)

	Compound Identified (synonym)	CAS Number	Confidence of I.D. ① (refer to Table 8.5)
1	1-Propene, 3-bromo-3,3-difluoro-	000420-90-6	5
2	Ethyl Chloride	000075-00-3	5
3	Propene, 1-chloro-3,3,3-trifluoro-	002730-43-0	4
4	Trichloromonofluoromethane	000075-69-4	2
5	Ethene, 1,2-dichloro-, (E)-	000156-60-5	1
6	Hexane, 3-methyl-	000589-34-4	3
7	Propane, 1,2-dichloro	000078-87-5	1
8	1,3,6-Trioxocane, 2-methyl-	002781-01-3	4
9	Toluene	000108-88-3	1
10	Benzene, (isothiocyanatomethyl)-	000622-78-6	4
11	Benzene, [(methoxymethoxy)methyl]-	031600-55-2	4
12	Cyclotrisiloxane, hexamethyl-	000541-05-9	1
13	2-Pentenal, 2-methyl-	000623-36-9	1
14	Benzene, chloro-	000108-90-7	1
15	p-Xylene	000106-42-3	1
16	Benzene, 1-ethynyl-4-methyl-	000766-97-2	3
17	Benzoic acid, 2-[(trimethylsilyl)oxy]-, trimethylsilyl ester	003789-85-3	2
18	Cyclotetrasiloxane, octamethyl-	000556-67-2	1
19	Ethanedioic acid, bis(trimethylsilyl) ester	018294-04-7	3
20	2-Propanol, 1,1'-oxybis-	000110-98-5	4
21	Propane, 1-chloro-3-[2-(2-methoxyethoxy)ethoxy]-	100688-50-4	3
22	Propane, 2-chloro-2-nitro-	000594-71-8	5
23	Tetrachloroethylene	000127-18-4	1
24	Trimethylphosphine oxide	000676-96-0	5
25	Tris(3-chloropropyl) phosphate	000000-00-0	4

① - Confidence of ID values may vary from test to test; these values reflect the highest confidence achieved during testing.

The measured compounds, relative to their respective compound number assigned in table 9.1 and their concentrations detected during the 30-day series of tests are presented in table 9.2 to demonstrate the decay pattern observed.

9.2 Table of Rate of Compound Decay
Table 9.2 (all values expressed in milligrams per cubic meter (mg/m³))

	Compound (synonym)	Hour 1	Hour 12	Hour 24	Day 2	Day 4	Day 7	Day 14	Day 30
1	1-Propene, 3-bromo-3,3-difluoro-	0.006	--	--	--	--	--	--	--
2	Ethyl Chloride	0.005	--	--	--	--	--	--	--
3	Propene, 1-chloro-3,3,3-trifluoro-	0.024	--	--	--	--	--	--	--
4	Trichloromonofluoromethane	0.057	--	--	--	--	--	--	--
5	Ethene, 1,2-dichloro-, (E)-	0.741	0.027	--	--	--	--	--	--
6	Hexane, 3-methyl-	0.006	--	--	--	--	--	--	--
7	Propane, 1,2-dichloro	0.048	--	--	--	--	--	--	--
8	1,3,6-Trioxocane, 2-methyl-	0.019	--	--	--	--	--	--	--
9	Toluene	0.203	0.017	0.010	0.045	0.028	0.021	0.020	--
10	Benzene, (isothiocyanatomethyl)-	0.019	--	--	--	--	--	--	--
11	Benzene, [(methoxymethoxy)methyl]-	0.007	--	--	--	--	--	--	--
12	Cyclotrisiloxane, hexamethyl-	0.013	0.009	0.020	0.021	0.022	0.012	0.005	--
13	2-Pentenal, 2-methyl-	0.007	--	--	--	--	--	--	--
14	Benzene, chloro-	0.022	--	--	--	--	--	--	--
15	p-Xylene	0.007	--	--	--	--	--	--	--
16	Benzene, 1-ethynyl-4-methyl-	0.005	--	--	--	--	--	--	--
17	Benzoic acid, 2-[(trimethylsilyloxy)-, trimethylsilyl ester	0.019	--	--	--	--	--	--	--
18	Cyclotetrasiloxane, octamethyl-	0.006	--	0.005	0.005	0.004	--	--	--
19	Ethanedioic acid, bis(trimethylsilyl) ester	0.009	--	--	--	--	--	--	--
20	2-Propanol, 1,1'-oxybis-	--	--	0.008	--	--	--	--	--
21	Propane, 1-chloro-3-[2-(2-methoxyethoxy)ethoxy]-	--	--	0.008	0.008	--	--	--	--
22	Propane, 2-chloro-2-nitro-	--	--	--	0.005	0.005	--	--	--
23	Tetrachloroethylene	--	--	--	--	0.008	--	--	--
24	Trimethylphosphine oxide	--	--	--	0.005	0.006	--	--	--
25	Tris(3-chloropropyl) phosphate	--	--	0.008	0.013	0.033	0.026	0.022	0.018

*Bold values indicates the test with the highest observed concentration for each respective compound

9.3 Table of Identified Compounds with Maximum Concentration

Table 9.3 (Only those compounds with confidence of I.D. levels of 1 and 2 are listed)

	Compound (synonym)	CAS Number	Confidence of I.D. ① (refer to Table 8.5)	Threshold limit value/100 (mg/m ³)	Maximum measured concentration (mg/m ³)
4	Trichloromonofluoromethane	000075-69-4	2	②	0.057
5	Ethene, 1,2-dichloro-, (E)-	000156-60-5	1	7.93	0.741
7	Propane, 1,2-dichloro	000078-87-5	1	0.46	0.048
9	Toluene	000108-88-3	1	0.75	0.203
12	Cyclotrisiloxane, hexamethyl-	000541-05-9	2	②	0.013
13	2-Pentenal, 2-methyl-	000623-36-9	1	②	0.007
14	Benzene, chloro-	000108-90-7	1	0.46	0.022
15	p-Xylene	000106-42-3	1	4.34	0.007
17	Benzoic acid, 2-[(trimethylsilyloxy)-, trimethylsilyl ester	003789-85-3	2	②	0.019
18	Cyclotetrasiloxane, octamethyl-	000556-67-2	1	②	0.006
23	Tetrachloroethylene	000127-18-4	1	1.70	0.008

① - Confidence of ID values may vary from test to test; these values reflect the highest confidence achieved during testing.

② - The identified compound is not listed in the reference literature to provide TWA values for TLV calculation.

10 SUMMARY

There were twenty five (25) detectable VOC emissions from the spray applied polyurethanes thermal insulating foam product for the entire 30 day test. Eleven (11) compounds have a confidence of I.D. level of 1 or 2 that are reported in table 9.3. Five (5) of the eleven (11) compounds detected during the chamber testing with a confidence of I.D. level of 1 or 2 are not listed in the ACGIH 2018 TLV Handbook to provide values for TLV calculation. Therefore, a toxicological review and assessment of the testing data is required to complete the examination of this product, per Section 9.3 of the testing standard.

11 CONCLUSIONS

1. Dynamic chamber testing performed in accordance with Procedure B of the CAN/ULC-S774-09 testing standard produced an emissions profile containing twenty five (25) unique volatile organic compounds. The stipulated reference literature (ACGIH 2018 TLV Handbook) does not contain information relating to five of these compounds. Therefore, testing results for the product are deemed inconclusive, pending further assessment by a toxicologist.
2. In accordance with prior arrangements a copy of this report shall be furnished to Dr. Bharadwaj directly if seeking further information regarding her toxicological assessment of this product.

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TEST EQUIPMENT

All test instruments were calibrated and are traceable to the International System of Units (SI) through a National Measurement Institute such as the National Institute of Standards and Technology (NIST) or through consensus standards. The Element Warren calibration system meets the requirements of ISO 17025:2005.

ID	Description	Manufacturer	Model	Calibration Due
B13324	GC/MSD	Agilent	7890A/5975C	CBU
B14346	Flowmeter	BIOS	DC-Lite	04/04/2019
B13930	Flowmeter	Brooks	4800	01/29/2019
B16177	VOC Chamber	Element	51 Liter	10/23/2018

NCR – No Calibration Required, ICO – Initial Calibration Only, CBU – Calibrate Before Use

REVISION HISTORY

Rev. #	Description/Changes	Date
0	Initial Release	11/05/18

Appendix A – Analytical Method ANALYTICAL METHOD

Calibration Procedure:

The initial calibration of the thermal desorption system is performed by using the TDU in the preparation mode, where a known concentration of the calibration standard (normally toluene, but other compounds may be substituted by prior approval) is loaded into a clean tube. The tube is then desorbed in the operating mode into the GC/MSD system. This calibration check is performed regularly during the analysis of the sample tubes as a quality control check. The linearity of response of the calibration compound is checked by loading high levels of the compound onto the Carbotraps™ until non-linearity occurs. A low level loading is also done to check on the lower limit of detection. The sample tubes are desorbed in the TDU at 300°C for 3 minutes. The desorption chamber is linked to the capillary column in the GC and any volatilized compounds are recorded on the total ion chromatogram (TIC). Library matches are inspected by the operator to check for quality of the matches. The software also calculates a quality factor from 0-100%. Any compound with >90% quality are considered excellent. For compounds whose mass spectra do not give an excellent match, a code is assigned which indicates the level of confidence of identification (the codes range from 1-5). These codes were previously described in Section 8.5. The best library matches occur when there are no interfering co-eluting peaks and there is a high signal to noise ratio for the compound GC peak. For the same compound during the time of study, the quality factor may degrade when the signal gets very small.

Appendix B – Witness Report Sample Preparation Report

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Testing. Advancing. Assuring.

Components of a Polyurethane Spray Foam System Sample Preparation Report

Company Name
Genyk Inc
1701 3rd Avenue
Shawinigan (QC), G9T2W6

Date: August 21th, 2018
Proposal No.: 18-006-545143

Attn:

On August 21, 2018 a sample of spray-applied polyurethane thermal insulating foam was prepared for testing purposes CAN/ULC S-774. The details of the application and conditions are provided below.

Liquid Raw Materials

	Lot/Batch Number	Material Description	Storage Conditions
A-Component	GE017845	ISO A-2732	Warehouse
B-Component	L-8105	FLORASEAL 50	Warehouse

Spray Application Equipment

Equipment	Temperature, °F	Pressure, psi	Equipment	Details
A-Side at Pump	135	Approx. 1200	Gun Model	Fusion AP
B-Side at Pump	135	Approx. 1200	Proportioner	Graco E30
Hose	135	1050	Mix Ratio	1 : 1

Applicator & Conditions

Foam Application Conditions			
Ambient Temperature, °C	28°C	Hose-End Temperature, °F	135
Ambient Relative Humidity, %	50%	Hose Length, ft	60

Qualified Applicator Information	
Licensed Company Name	Genyk Int'l house
Qualified Applicator Name	David Lievin

EXOVA

Specimen Details

Specimen Set 1 – Detailed Preparation Information Exova Sample ID.: 18-006-545143					
Intended Testing		CAN/ULC S-774			
Date & Time of Application		August 21th, 2018 - 2:15 pm	No. of Pieces		3
Substrate Information		Foam Details			
Material	Aluminum Foil	Pass Thickness	1 st pass	No. of passes	1
Temp.	23°C		2 nd pass	Total thickness	2" 00
Dim.	18" x 40"		3 rd pass	Time between passes	N/A
Thick.	N/A		4 th pass	Substrate orientation	Horizontal

Exova Witness

Witnessing Information	
Location of preparation	GENYK Inc. 1701 3 rd Avenue Shawinigan (QC) G9T 2W6
Exova technical representative	Roland Courtamanche, p. Eng Project Manager Consultants Mesar Inc.
Exova signature	

APPENDIX I

Human Health Risk Assessment Analysis

Prepared by Dr. Lalita Bharadwaj

(Toxicologist)

(31 pages)

**HUMAN HEALTH RISK ASSESSMENT OF VOLATILE ORGANIC
COMPOUND EMISSIONS FROM A SPRAY APPLIED
POLYURETHANE INSULATING FOAM
FOR CANADA VOC**

Submitted to:

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EXECUTIVE SUMMARY

Lalita Bharadwaj, Ph.D. undertook a Human Health Risk Assessment for a spray-applied polyurethane thermal insulating foam developed by Canada VOC. Exova Warren Testing Facilities in Warren, Michigan performed emissions testing of a test specimen (foam sample) of a spray-applied polyurethane foam, identified here in this report as "*Canada VOC polyurethane foam*". Emission testing was conducted in accordance with 'Procedure B' of the Underwriters Laboratories of Canada, CAN/ULC-S774-09 Testing Standard. Headspace and dynamic chamber analyses were performed on a test specimen of "*Canada VOC polyurethane foam*" and volatile organic compound (VOC) emissions were characterized by gas chromatography-mass spectroscopy.

The purpose of the risk assessment was two-fold: 1) to determine whether volatile organic compound (VOC) emissions from the foam sample pose a health risk, and 2) to determine an acceptable residential occupancy time for the polyurethane insulating foam. The health risk assessment was undertaken using guidelines, protocols and methodologies proposed and readily accepted by Health Canada and the Canadian Construction Materials Centre. These guiding principles of risk assessment were utilized to predict the human health risk associated with potential exposure to VOC emissions identified and measured from a test specimen of "*Canada VOC polyurethane foam*".

Careful consideration of all relevant chemical and toxicity data was given to the assessment to determine the potential for health risk. The assessment accounted for the potential for human exposure to maximum indoor air concentrations of each VOC emission product identified through dynamic chamber analysis of the spray-applied polyurethane insulating foam. The assessment took into consideration the chemical nature and toxicity information of the VOC emissions, potential for human exposures, the magnitude, frequency and duration of human exposure to each VOC product, and their individual decay patterns over a 30-day period of dynamic chamber analysis. The assessment also included comparisons (including stringent safety margins) between potential exposure to maximum possible levels and the toxicological profiles of the VOC products emitted.

The decay pattern of the VOC products (up to 30 days), indicate the concentration of individual airborne VOC and the total VOC (TVOC) decrease rapidly over time. Maximum airborne emission concentrations of each individual VOC emission product measured through the process of dynamic chamber analysis was found to be below airborne exposure concentrations considered safe for human exposure.

Considering that VOC emission products were classified as having a low order inhalational toxicity following short term low-level exposures and the maximum emission concentrations were well below the safety standards applied in this risk assessment, it was concluded that airborne concentrations of VOC or TVOC emitted from "Canada VOC polyurethane foam" would be considered safe for human exposure.

With the proviso that the 24-hour curing period is respected post-application (mixing and spraying), "Canada VOC polyurethane foam" will not pose a significant human health risk to individuals residing in homes where this material is applied. The VOC emissions from "Canada VOC polyurethane foam" will not pose a health risk to individuals residing in homes or buildings where the Canada VOC spray-applied polyurethane foam is applied.

The present analysis indicates a low risk for adverse inhalational exposures and thus a low potential for residential health risk. Following the post-application curing period, estimated VOC concentrations from "Canada VOC polyurethane foam" were determined to remain within an acceptable range for human exposure. With the expressed provision that the 24-hour curing period (mixing and spraying) is maintained after application, it is suggested that a residential occupancy time of 1 hour be considered for "Canada VOC polyurethane foam".

1.0 INTRODUCTION

Initiated in December 2018, Dr. Lalita Bharadwaj undertook a human health risk assessment to evaluate the potential impacts on human health from exposure to Volatile Organic Compound (VOC) products emitted from a spray-applied polyurethane insulating foam sample identified as "Canada VOC polyurethane foam".

Volatile organic compounds (VOCs) are chemicals that contain carbon and hydrogen. Typically, VOCs have high vapour pressures, easily vaporize at normal temperature and pressure and have boiling points that range from 50-250°C. Several thousand compounds both natural and synthetic are classified as VOC. Volatile organic compounds include a wide range of organic compounds with different functional groups (Yu and Crump, 1998 [18]). These include carbon-based molecules such as; aldehydes, ketones, alcohols, amines, aliphatic and aromatic hydrocarbons, some of which are halogenated. Many of these volatile organic compounds are ubiquitously present, at low levels in various indoor air environments (office, home and workplaces). Volatile organic compounds can be emitted into indoor air from a variety of sources. These include and are not limited to the following: cigarette smoke, furnishings, vehicle exhaust, and various building materials such as paint, varnish and glues and household products such as air fresheners (1).

The World Health Organization (WHO) (WHO, 1989, [17]) has classified indoor VOC pollutants into three groups. These include the following: (i) very volatile organic compounds (VVOCs) which have boiling points ranging from <0°C to 50-100 °C, (ii) volatile organic compounds (VOCs) with boiling points ranging from 50-100°C to 240-260°C, and vapour pressures > 10⁻² kPa, and (iii) semi-volatile organic compounds (SVOCs) with boiling points ranging from 240-260°C to 380-400°C and vapour pressures of 10⁻² to 10⁻⁸ kPa.

Standard approaches of risk assessment were utilized to characterize the potential human health risks associated with exposures to VOC emitted from the spray-applied polyurethane insulating foam sample. In this case the risk assessment was based on maximum likely exposures to VOC emission products. It was assumed that individuals would be exposed repeatedly long-term to

maximum concentrations of VOC emission products as determined by dynamic chamber analysis of the foam sample "*Canada VOC polyurethane foam*".

Spray-applied polyurethane foams are commonly utilized in commercial, institutional and residential construction. Currently, there is an incomplete source of toxicity data evaluating the potential human health effects associated with exposures to PU spray foams or to its volatile organic compound (VOC) emission products under conditions other than those associated with occupational exposures. The potential short or long-term health effects associated with exposure to this material in the general population are fundamentally unknown. Due to the lack of detailed toxicity information, the human health risks associated with short and/or long-term exposures to PU spray foams and their emission products are predicted by the application of human health risk assessment protocols (2,3).

Spray-applied PU foam products manufactured and developed for use in residential or commercial buildings must undergo standardized VOC emissions testing before commercialization and approval by the Canadian Construction Materials Centre (4). For polyurethane formulations intended for use in residential spaces, VOC emissions are to be tested in accordance with appropriate methods outlined in the Underwriters Laboratories of Canada, *CAN/ULC-S774-09; Standard Laboratory Guide for the Determination of Volatile Organic Compound Emissions from Polyurethane Foam*. These include both Headspace (HS) and dynamic chamber analysis (DCA [Procedure B]) methods. These are briefly described below.

Headspace and dynamic chamber analyses involve the measurements of VOC emissions from test specimens generated from sample panels of polyurethane foam that have been aged for approximately 20 to 24 hours. The test specimen, utilized for headspace and dynamic chamber analyses, is cut from the sample panel. A strict process is followed for the generation of both the sample panel and the test specimens. This process can be reviewed in the client report entitled; "*033761 Canada VOC*" and prepared by Exova (5). Within the body of this report, a brief description of the Headspace and Dynamic chamber analyses conducted on the PU foam sample are outlined below.

A sample panel is produced in accordance with Section 6.1.3 of the testing standard. The thermal insulation panel is produced by spraying the product onto a sheet of high density polyethylene (HDPE) covered aluminum foil. Once created it is sealed in air-tight packaging and then transported via overnight courier to the Exova Testing Facility in Warren, Michigan. The sample panel is removed from its air-tight packaging and is subsequently cut into appropriately sized and shaped pieces to create the test specimen (foam sample). The resulting foam sample is then placed into test chambers for headspace and dynamic chamber analyses. In this case, the sample was created on August 21, 2018 and a test specimen (foam sample) was cut from the sample and produced on August 22, 2018 (exactly 24 hours and 0 minutes following the creation of the sample) and installed into the test chambers (5).

Headspace analysis involves an initial screening of VOC emissions from the test specimen (foam sample). Headspace analysis is advantageous when concentration levels of VOCs, in the 1 and 12 hour testing intervals, are too low for identification by mass spectral library. The Headspace apparatus is known to generate higher concentrations of compounds that volatilize quickly. In situations where emission concentrations are of sufficient strength during subsequent DCA testing of products, headspace analysis is not required in the majority of testing situations. VOC emissions, solely detected in these exaggerated conditions of headspace analysis are considered non-typical and are not considered further in the analyses procedures.

Procedure B of the Underwriters Laboratories of Canada, dynamic chamber analysis, determines polyurethane VOC emission profiles over a 30-day period. In accordance with the testing standard, DCA commences 24 hours after the manufacture of the sample panel (CAN/ULC-S774-09; Section 6.1.2). In general, DCA is a procedure used to identify, quantify, and determine emission rates of VOC(s) released from commercial formulations of spray PU foams once foams have cured over an initial 24-hour period. The results obtained by dynamic chamber analysis of PU test specimen (foam sample) are used to predict potential indoor air concentrations of VOC emission products that could occur in a typical residential or workplace building where spray PU insulating foams are applied. These data provide a quantitative estimate of the potential levels of human exposure to PU-derived VOC emission products and are vital for determining the degree

of human health risk associated with exposure to these chemicals in the household, workplace or other inhabited structures.

1.1 Headspace and Dynamic Chamber Analysis

Headspace and dynamic chamber analyses were performed to characterize VOC emissions from the test specimen of the spray applied polyurethane insulating foam "*Canada VOC polyurethane foam*". Analysis was completed by the Exova Building Products Laboratory using procedures outlined in CAN/UCL-S774-09 [Standard Laboratory Guide for the Determination of Volatile Organic Compound Emissions from Polyurethane Foam] (5). Head Space analysis was performed on the test specimen. Using Carbotrap™ 400 absorbent tubes, in conjunction with gas chromatography-mass selective detector analysis; the number, chemical nature and the relative concentrations of VOC products emitted from the test specimen of the spray-applied PU foam was determined.

1.2 Headspace Analysis

Headspace analysis of test specimen "*Canada VOC polyurethane foam*" revealed that forty-four (44) VOC products were emitted from the "*Canada VOC polyurethane foam*" test specimen. The compounds emitted and their respective concentrations are summarized in Section 8.0, Test Results, Table 8.2, Pages 15-16, of the Exova emissions report (5).

Emission products identified through the process of headspace analysis were generally classified as hydrocarbon based compounds. In general terms, a mix of compounds were identified and these included compounds such as: halogenated aliphatic hydrocarbons and aromatic hydrocarbons, siloxanes and a few benzene related compounds. Volatile organic compound emission concentrations range from the lowest airborne concentration of 0.014 mg/m³ (Benzene, 1,3,5-trimethyl) to the highest airborne concentration 3.790 mg/m³ (Ethene, 1,2-dichloro (E)-). These emission levels were considered low.

Appropriate and comparable exposure limits, when available and assigned to individual VOCs identified through headspace analysis of the “Canada VOC polyurethane foam” specimen were reviewed and utilized as a comparative guideline to gauge potential health risks associated with exposures to the airborne concentrations identified by the headspace analysis. Through this review it was found that the airborne emission concentrations were low and would be considered safe under an occupational exposure scenario.

Occupational exposures refer to those exposures that are generally consistent over a work period, are generally higher than the exposures experienced by the general population and occur over a regular work week of 8 hours per day 5 days a week. Under these conditions, exposure limits are established for the protection of human health. The emission concentrations measured through headspace analysis are below occupational exposure limit where they have been established for the various VOCs identified. This suggests that airborne levels measured during headspace analysis are low and should not accumulate to concentrations that would likely pose a risk to human health.

1.3 Dynamic Chamber Analysis

Subsequent to headspace analyses, discrete dynamic chamber analysis was performed on the spray-applied polyurethane foam test specimen “Canada VOC polyurethane foam” (5). VOC emission products, identified through DCA, were measured in air samples collected at specified time intervals (1, 12, 24, 48 hours and 4, 7, 14, and 30 days) as prescribed by Section 7.3 of the CAN/UCL-S774-09 Standard. Dynamic chamber analysis was utilized to screen for VOCs emission products derived from the “Canada VOC polyurethane foam” test specimen. These emissions can be reviewed in Section 8.4, Tables 8.4.1-8.4.8, pages 17 to 20, of the Exova emissions report (5). The VOC emissions from “Canada VOC polyurethane foam” were determined over a 30-day period of testing.

The results obtained by dynamic chamber analysis are summarized below and were utilized as a quantitative estimate of the potential levels of human exposure to “Canada VOC polyurethane

foam"-derived VOC emission products. These data were applied to the risk assessment process to determine the degree of human health risk associated with potential exposures to these specific VOC emissions derived from the spray-applied polyurethane insulating foam (referred to as "Canada VOC polyurethane foam").

1.3.1 Unique VOC Emission Products

A total of twenty-five (25) unique VOC emission products were identified through the dynamic chamber analysis of "Canada VOC polyurethane foam". Headspace analysis yielded forty-four (44) VOC emission products. Table 1 provides a summary of the twenty-five (25) unique VOC emission products identified through the process of DCA. Data can also be reviewed in the VOC emissions profiling report generated by Exova in Table 9.1 page 22 (5).

Table 1: Unique VOC Emissions Products Identified Through DCA

Number (#)	Unique VOC Emission Product
1	1-Propene, 3-bromo-3,3-difluoro
2	Ethyl Chloride
3	Propene, 1-chloro-3,3,3-trifluoro
4	Trichloromonofluoromethane
5	Ethene, 1,2-dichloro (E)-
6	Hexane, 3-methyl
7	Propane, 1,2-dichloro
8	1,3,6-trioxocane, 2-methyl
9	Toluene
10	Benzene, (isothiocyanatomethyl)-
11	Benzene, [(methoxymethoxy)methyl]-
12	Cyclotrisiloxane, hexamethyl-
13	2-Pentenal, 2-methyl
14	Benzene, chloro
15	p-Xylene
16	Benzene, 1-ethnyl-4-methyl-
17	Benzoic acid, 2-[(trimethylsilyl)oxy]-trimethylsilyl ester
18	Cyclotetrasiloxane, octamethyl-
19	Ethanoic acid, bis(trimethylsilyl)ester
20	2-Propanol, 1,1'-oxybis-
21	Propane, 1-chloro-3[2-(2-methoxyethoxy)ethoxy]-
22	Propane, 2-chloro-2-nitro
23	Tetrachloroethylene
24	Trimethylphosphine oxide
25	Tri(3-chloropropyl)

Dynamic chamber analysis demonstrated that twenty-five (25) unique VOCs were emitted from "Canada VOC polyurethane foam". A summary of the DCA analysis is provided on page 26 of the Exova emissions report (5). An analysis of DCA test results outlining the number of compounds identified at each testing interval is provided on page 21 Section 9 and tabulated in Table 9.2 "Table of Rate of Compound Decay", on page 23, of the Exova publication (5). A brief summary of the DCA results is provided below.

In summary, twenty-five (25) unique VOCs were identified as emission products of "Canada VOC polyurethane foam". Maximum airborne concentrations of eighteen (18) of the twenty-five (25) unique VOC products (#s 1-11 and 13-19), as numbered above in Table 1 of this report, were detected at the 1 hour DCA testing interval. The maximum emitted airborne concentrations of these 18 unique VOCs and measured at the 1 hour testing interval, ranged in concentration from 0.005 mg/m³ to 0.741 mg/m³. These emissions concentrations are considered to be low.

Reported personal exposure levels of polyurethane applicators have been found to range in concentration from 0.120 mg/m³ to 0.570 mg/m³ (7-9). Maximum emission concentrations of one (1) of the 18 unique VOCs (#5 or Ethene, 1,2-dichloro-(E)) measured at the 1-hour DCA testing interval was measured at a concentration slightly above (0.741 mg/m³) the reported personal exposure levels of polyurethane applicators. The maximum concentration for this VOC (#5 or Ethene, 1,2-dichloro-(E)) dropped well below reported personal exposure levels within the next, 12-hour, DCA testing interval. Furthermore, Ethene, 1,2-dichloro-(E) emissions dropped to undetectable at the 24 hour DCA testing interval. These data suggest that although Ethene, 1,2-dichloro-(E) emissions were initially exaggerated at the 1-hour interval, the emissions rapidly dropped to zero within a 24 hour period. These data suggest that these emissions are not sustained over the 30-day period of DCA testing and would not accumulate to levels that would pose significant risk to individuals residing in homes where the spray-applied polyurethane foam would be applied. These data also suggest that 72% of the maximum emission concentrations measured for the Unique VOCs over the 30-day DCA identified from "Canada VOC polyurethane foam", were emitted within the 1-hour DCA testing period. Emission concentrations measured at intervals

subsequent to the 1-hour testing interval were well below the highest emission level of 0.741 mg/m³. None of the maximum emissions concentrations were sustained over the testing period.

Emissions of three (3) of the 25 VOCs measured during DCA were measured at the 12-hour testing interval. Emission concentrations of these three (3) VOCs ranged in concentration from 0.009 mg/m³ to 0.027 mg/m³ and were well below maximum levels observed at the 1-hour testing interval, identified within this 12-hour DCA interval.

Six (6) unique VOC emission products were identified at the 24-hour DCA testing interval. Maximum emission concentrations of two (2) of the 25 unique compounds were measured at the 24-hour interval. The maximum emission concentrations were similar and were measured as 0.008 mg/m³. This maximum emission concentration observed at the 24-hour time interval falls well within, and at the lower range, of personal exposure levels of polyurethane applicators suggesting that emissions are not exaggerated, typical for polyurethane applications and are relatively low.

The DCA at 2-days revealed that seven (7) of 25 unique VOCs were emitted. At the 2-day testing interval there was one (1) maximum measured emission concentration identified. The maximum airborne concentrations measured at the 2-day interval was observed at a concentration of 0.005 mg/m³. This maximum emission concentration was well within personal exposure levels of applicators.

Dynamic chamber analysis at testing intervals of 4-day, 7-day, 14-day and 30-day yielded 7, 3, 3 and 1 unique VOCs respectively. Maximum emission concentrations of three (3) VOCs were emitted at the 4-day DCA testing interval. However, levels were very low in magnitude and did not persist. In fact, there was a steady decline in the number of VOCs emitted as well as the concentrations measured over the 30-day testing period. These data suggest that VOC emissions, at the maximum levels, generally occur immediately within the first hour of DCA and dissipate to levels well below maximum over the 30-day testing period.

In summary the DCA data suggest that 25 unique VOCs are emitted from “Canada VOC polyurethane foam”. Emission concentrations measured within 1 hour of DCA are very low. DCA

analysis reveal that VOC emissions from “Canada VOC polyurethane foam” very quickly dissipate from maximum measured concentrations to zero or levels well below the highest observed concentrations. The total number of VOC (TVOC) measured and identified at the 1 hour DCA period, is never exceeded and the TVOCs drop over time. These data suggest that maximum VOC concentrations are emitted early following the initiation of DCA (within an 1 hour), maximum emission concentrations are not persistent and these dissipate to undetectable or levels well below respective maximum concentration levels. DCA analysis indicates that VOC emission concentrations are very low and are within an acceptable range for personal exposure.

Maximum VOC emission concentrations of each unique VOC emission product identified through DCA are outlined in Table 2 below. The time within the period of DCA where maximum VOC emission concentration for each of the 25 emission products is summarized in Table 2.

In summary, twenty-five (25) unique VOC compounds were identified as emission products. Dynamic chamber analysis data suggest that VOCs derived from “Canada VOC polyurethane foam” are transiently emitted and rapidly fall to zero within the 30-day DCA period of testing. The maximum VOC emission concentrations identified for each VOC identified is considered low in magnitude.

Table 2: provides a summary of the VOCs identified through DCA of “Canada VOC polyurethane foam” their maximum airborne concentration and the time in which the maximum emission levels were detected.

Table 2: Maximum Airborne Concentrations of VOC Emissions from “Canada VOC polyurethane foam” and Time of Detection.

VOC #	VOC Emission Identified	Maximum Airborne Concentration (mg/m ³)	Time of Detection (hours)
1	1-Propene, 3-bromo-3,3-difluoro	0.006	1
2	Ethyl Chloride	0.005	1
3	Propene, 1-chloro-3,3,3-trifluoro	0.024	1
4	Trichloromonofluoromethane	0.057	1
5	Ethene, 1,2-dichloro-, (E)-	0.741	1
6	Hexane, 3-methyl	0.006	1
7	Propane, 1,2-dichloro	0.048	1
8	1,3,6-Trioxocane, 2-methyl	0.019	1
9	Toluene	0.203	1
10	Benzene, (isothiocyanatomethyl)	0.019	1
11	Benzene, [(methoxymethoxy)methyl]-	0.007	1
12	Cyclotrisiloxane, hexamethyl	0.022	4-days
13	2-Pentenal, 2-methyl	0.007	1
14	Benzene, chloro	0.022	1
15	p-Xylene	0.007	1
16	Benzene, 1-ethynyl-4-methyl-	0.005	1
17	Benzoic acid, 2-[trimethylsilyloxy]-trimethylsilyl ester	0.019	1
18	Cyclotetrasiloxane, octamethyl	0.006	1
19	Ethanedioic acid, bis(trimethylsilyl)ester	0.009	1
20	2-Propanol, 1,1'-oxybis-	0.008	24
21	Propane, 1-chloro-3-[2-methoxyethoxy)ethoxy]-	0.008	24
22	Propane, 2-chloro-2-nitro-	0.005	4-days
23	Tetrachloroethylene	0.008	4-days

24	Trimethylphosphine oxide	0.006	4-days
25	Tris(3-chloropropyl) phosphate	0.033	4-days

Review of DCA indicates that the majority of the maximum measured emission concentrations for these unique VOCs were detected within 1 hour of DCA. Through review of DCA testing, it is evident that 25 VOC compounds are emitted from “Canada VOC polyurethane foam”, the majority (72% or 18/25) of the highest observed concentration for each respective compound is emitted within the first 1 hour of DCA. The chemical nature of the VOCs identified varied as well as airborne emission concentrations. Maximum VOC emissions were not maintained over the 30-day period of DCA. Additionally, overtime there was a rapid decline in the total number of VOC emissions detected over the 30-day period. In general, airborne concentrations of VOCs measured and emitted from “Canada VOC polyurethane foam”, are very low and not persistent.

In summary, DCA data suggests the following: the total number of VOCs emitted from “Canada VOC polyurethane foam” is 25. Maximum emission concentrations are very low, generally measured within 1-hour of testing and not maintained throughout the 30-day period of testing. Emissions fluctuate rapidly from detectable to non-detectable. There was only one VOC emitted at the end of the DCA testing (30-day interval) and this concentration is considered very low. Review of the DCA data for “Canada VOC polyurethane foam” also indicate that peak concentrations of VOC emission products would likely be reached within 25 hours following the mixing, spraying and direct application of this foam.

The maximum indoor air concentrations, summarized above in Table 2, and determined through DCA analysis, represent the highest estimated level of human exposure to VOC products emitted from “Canada VOC polyurethane foam”. The time in which maximum VOC concentrations were detected specifies the point in time when maximum concentrations would be reached in a residence following the 24-period when the components of the spray-applied PU foam were mixed, sprayed and applied (ie. it is assumed that individuals residing in homes would be exposed to these emission levels within 25 hours after the products application). The maximum measured concentrations of each VOC emission product were utilized in the process of a human health risk assessment to evaluate the potential human health risks that may be associated with exposures to

maximum airborne VOC emissions derived from the "Canada VOC polyurethane foam" polyurethane insulating foam.

The toxicity of each VOC emission product was addressed in the assessment. The human health risk assessment was conducted using conservative assumptions that would lead to an overestimation of potential exposure and risk. Thus in this case, a "worst case scenario" was applied to the assessment. In this scenario it was assumed that human exposure levels are equal to the maximum measured airborne VOC concentrations detected by DCA of the "Canada VOC polyurethane foam" test specimen.

Few experimental assessments have been conducted to evaluate exposure levels to VOC emissions during the spraying and application process of spray-applied polyurethane foam insulations. Of the studies conducted to date, personal exposure levels to VOC emissions have been evaluated for spray-gun operators and their helpers during the application of PU foams to houses and office buildings (6). Recorded personal VOC exposures reported in exposure assessment studies were found to be in the range of 0.120 mg/m³ to 0.570 mg/m³ (7-9). These personal exposure levels are within the range of maximum measured airborne concentrations (0.005 mg/m³ to 0.741 mg/m³) identified through the process of DCA of the spray-applied PU foam sample.

The personal exposure data reported in these studies provide an indication of the range of VOC concentrations occupants may typically be exposed to following the application of a spray-applied PU insulating foam to a residential structure. A lower range of VOC concentrations may be experienced by residents with the application of a foam considering the process of, and primary purpose of the application, timing of application as well as occupancy related factors. The personal exposure data observed in previous studies provide an indication of the range of concentrations that could typically be experienced by polyurethane applicators and the helpers of those applicators or even by-standers in the home. These exposure levels represent typical occupational exposures and provide guidance towards evaluating health risk in this case. Furthermore, the occupational exposure levels provide some support towards the utilization of maximum measured airborne emissions in the application of the risk assessment process that is aimed primarily at evaluating

health risk in a worst case scenario. Although, DCA reveal that maximum levels are not maintained in air for extended periods, the assumption that human exposures are equal to maximum measured airborne concentrations provides an ample margin of safety to assess risk to human health. These assumptions were utilized in the assessment of human health risk. The following questions were addressed in this particular risk assessment process.

- 1) Will exposure to maximum indoor air concentrations of VOC emission products from "*Canada VOC polyurethane foam*" (outlined in Table 2) pose a significant human health risk to applicators or residents of homes or buildings where this construction material is applied?
- 2) What is the limiting residential occupancy time for "*Canada VOC polyurethane foam*"? (ie. When is it safe for individuals to reside or re-enter buildings following the application of "*Canada VOC polyurethane foam*"?).

2.0 RISK ASSESSMENT

Risk assessment is a process that involves the characterization of the probability of adverse human health effects that may be associated with exposure to environmental chemicals (2,3,6). This process was used here to predict the potential for human health risk associated with an exposure to VOC products emitted from the polyurethane product "*Canada VOC polyurethane foam*". A risk assessment evaluates a product's potential to produce adverse human health effects. Emission data obtained from environmental chamber testing is used to predict human exposure concentrations of contaminants, and these concentrations are assessed for their potential to produce cancer and non-cancer risks. The data is reviewed according to standards and guidelines available from occupational exposure limits. These limits are available from numerous governmental organizations. The EPA and Health Canada's carcinogenic and non- carcinogenic risk levels, and sensory irritation and odorant limits are also considered in the risk assessment process. Risk assessment is an obligation for those manufacturers who want to understand potential health risks associated with use of their products. The risk assessment process is divided into four major steps; hazard identification, dose-response assessment, exposure assessment and risk characterization and each step is briefly outlined below.

The first step, hazard identification, involves the identification of Contaminants of Potential Concern (COPC). In this step of the risk assessment process, VOC emission products were evaluated for their safety through review of available toxicity data. The maximum measured concentration of each VOC emission product was compared to levels of exposure that have been accepted as “safe” for industrial workers. Accepted levels of exposure signify Threshold Limit Values (TLV) and/or Occupational Exposure Limits (OEL). These values of exposure are assigned by governing occupational agencies such as the American Conference of Industrial Hygienists [ACGIH] (10), National Institute for Occupational Safety and Health [NIOSH] (11) and the Occupational Safety and Health Administration [OSHA] (12). However, there are cases in which TLV values have not yet been assigned to chemicals. For example, chemicals that may be identified as VOC emission products. Thus in this case where an exposure guideline has not been developed, maximum indoor air concentrations, of the VOC emission product identified, were compared to a no observed adverse effect levels (NOAEL) derived from animal/human toxicity data (2,3,6) or a TLV value assigned to the parent compound or a compound similar in chemical nature to the identified VOC product.

In addition to the identification of COPC, the first step of the risk assessment process involves the review of pertinent toxicity data (which may include inhalational, reproductive, developmental, carcinogenic, mutagenic and/or genotoxic information), and the chemical characteristics and occupational exposure limits of each VOC emission product identified.

In the second step of the risk assessment process the dose-response relationship is evaluated for the COPC identified. Generally, adverse health effects will only occur when an agent is absorbed by a human receptor and distributed to target organs/tissues at concentrations and for durations of exposure sufficient to elicit toxicity. Therefore, the nature of the relationship between the received dose and the probability of an adverse biological response is evaluated in the dose-response step of the risk assessment. In this step the relationship between the magnitude of the received dose and the occurrence of an adverse health response is characterized (2,3,6). The dose-response assessment considers whether exposure to maximum measured concentrations of airborne COPC would result in an absorbed dose likely to pose a risk to human health.

The third step in the risk assessment process involves defining the type of human exposure to VOC emission products identified as COPC. This step includes [1] describing the magnitude, frequency and duration of exposure to VOC(s) emissions and [2] identifying the possible exposure routes. In the case of emission products from "Canada VOC polyurethane foam" [1] the magnitude, frequency and duration of exposure were classified as a short term continuous low-level exposure and [2] the main route of exposure was via the respiratory tract. Dermal and oral exposure routes are considered insignificant in this case.

The potential for human health risk is characterized in the fourth and final step of the risk assessment process. The likelihood that humans may experience toxicological effects under the actual conditions of exposure is determined here. In this case, it was determined whether individuals are at risk of experiencing adverse health effects by residing in buildings where the spray applied polyurethane foam product is applied.

3.0 HAZARD IDENTIFICATION

This section summarizes the contaminants of potential concern that were selected for this assessment. A review of the DCA analysis of "Canada VOC polyurethane foam" indicated that there were twenty-five (25) VOCs emitted from the spray polyurethane insulating foam sample. The maximum measured concentrations of each VOC emitted, as identified through DCA of "Canada VOC polyurethane foam" were summarized above in Table 2.

3.1 Selection of Contaminants of Potential Concern (COPC)

Based on human health considerations, a selection process was performed to identify contaminants of potential concern (COPC) from the list of VOC products emitted from "Canada VOC polyurethane foam". The procedure followed for selection of COPC is described below.

Firstly, contaminants of potential concern were identified by comparing maximum measured concentrations of each VOC to 1% of the American Conference of Government Industrial

Hygienists (ACGIH) 2010 Threshold limit values established for these chemicals. The ACGIH TLV-TWA divided by 100 is industry protocol for establishing chronic human exposure levels suitable for residential scenarios (24 hours per day, 7 days per week). Maximum measured concentrations of VOC emission products at concentrations exceeding the above referenced guideline were considered COPC. In other words, these VOC emission products were considered to demonstrate a potential to cause adverse health outcomes under prolonged or repeated exposure. Maximum concentrations of volatile organic compounds emitted at levels at or below referenced guidelines were considered safe for human exposure.

Exposure levels that are considered to be acceptable (“safe”) for human exposure such as the TLV-TWA® are usually allocated to various chemicals by the American Conference of Governmental Industrial Hygienists [ACGIH], however other agencies such as the National Institute for Occupational Safety and Health [NIOSH], Occupational Safety and Health Administration [OSHA] and other governing bodies of occupational and industrial hygiene assign exposure limits to chemicals. As a further step in the risk assessment process, maximum measured airborne concentrations of COPC were compared to occupational exposure limits assigned by agencies other than the ACGIH. Occupational exposure limits do not represent a fine line between safe and dangerous concentrations, nor are they a relative index of toxicity. For the purposes of this risk assessment occupational exposure limits were used to facilitate the risk assessment process and help to predict the potential for human health risk associated with an exposure to VOC emission products. It is not generally recommended that occupational exposure limits be used as standards for indoor air quality in the home and for this reason the occupational exposure limits were reduced by a suitable safety factor to err on the side of caution when assessing the potential human health risks associated with this particular case. The magnitude of this safety factor depends primarily on the number, the toxicity and the relative quantity of VOC emission products and other contaminants ordinarily present in the home (2,3,6,10).

In summary, if no TLV-TWA® guideline is established or available for an individual VOC emission product, then maximum airborne concentrations were compared to either a TLV-TWA® ÷ 100 derived for the parent compound, a chemically similar compound, a guideline value

established by another governing agency other than the ACGIH, and/or an inhalational No Observed Effect Levels \div 100 [(NOEL)- an airborne concentration that produced no observed adverse effects in exposed animals] derived from animal toxicity studies. If measured concentrations were found to be below the NOEL \div 100 value then the VOC emission product was dropped for further consideration. VOC emission products measured at concentrations exceeding the above guidelines or derived levels (NOEL \div 100; when no TLV-TWA[®] guidelines were available) were selected for further consideration and deemed COPC.

Table 3, summarizes the VOC emission products, their maximum measured concentrations and their respective ACGIH TLV-TWA[®] (or regulatory limits) values divided by 100.

Table 3: Maximum Indoor Airborne Concentrations of VOC Emission Products from "Canada VOC polyurethane foam" and ACGIH TLV-TWA[®] (regulatory limit) \div 100.

VOC Emission Product Identified	Maximum Indoor Air Concentration (mg/m ³)	ACGIH TLV-TWA [®] (regulatory limit) \div 100
1-Propene, 3-bromo-3,3-difluoro	0.006	^a 1.00
Ethyl Chloride	0.005	2.63
Propene, 1-chloro-3,3,3-trifluoro	0.024	^b 42.53
Trichloromonofluoromethane	0.057	56.0
Ethene, 1,2-dichloro-, (E)-	0.741	7.93
Hexane, 3-methyl	0.006	^c 1.80
Propane, 1,2-dichloro	0.048	0.46
1,3,6-Trioxocane, 2-methyl	0.019	^d NA
Toluene	0.203	0.75
Benzene, (isothiocyanatomethyl)-	0.019	^e 3.20
Benzene, [methoxymethoxy)methyl]-	0.007	^e 3.20
Cyclotrisiloxane, hexamethyl	0.022	^f 1.21
2-Pentenal, 2-methyl	0.007	^g 1.75
Benzene, chloro	0.022	0.46
p-Xylene	0.007	4.35
Benzene, 1-ethynyl-4-methyl	0.005	^e 3.20

Benzoic acid, 2-[(trimethylsilyl)oxy]-trimethylsilyl ester	0.019	^h NA
Cyclotetrasiloxane, octamethyl	0.006	^f 1.21
Ethanedioic acid, bis(trimethylsilyl) ester	0.009	ⁱ 0.01
2-Propanol, 1,1'-oxybis	0.008	^j 2.45
Propane, 1-chloro-3-[2-(2-methoxyethoxy)ethoxy]	0.008	^k 1.49
Propane, 2-chloro-2-nitro	0.005	^l 0.10
Tetrachloroethylene	0.008	1.70
Trimethylphosphine oxide	0.006	^m 0.004
Tris(3-chloropropyl) phosphate	0.033	ⁿ NA

Note:

NA- Unavailable

Maximum Indoor Air Concentration Exceeds Exposure Limit⁺ 100

Unless specified in the notes below, regulatory limits utilized in the above table have been derived by the ACGIH and are representative of the ACGIH-TLV-TWA® for each specific compound listed in the table. For those chemicals with guideline values that are not available a surrogate level was utilized and an explaining note on the toxicity was provided.

^a100 mg/m³ Canada/Alberta Occupational Exposure Limit for Allyl Bromide <http://datasheets.scbt.com/sc-280596.pdf>

^bWEEL 800 ppm (42.53 mg/m³) <https://www.tera.org/OARS/WEELS/I233zdE%20HCFO%20OARS%20WEEL%20FINAL.pdf>

^cNIOSH Recommended Exposure Limit of 180 mg/m³

^dNA Methyltrioxocane is classified as an irritant. An irritant is defined by the OSHA as a chemical which is not corrosive, but which causes a reversible inflammatory effect on living tissue by chemical action at the site of contact. A more general definition of an irritant is a substance which on immediate, prolonged or repeated contact with normal living tissue will induce local inflammatory reactions. Skin contact may cause skin irritation with discomfort or rash. Eye contact may cause eye irritation with discomfort, tearing, or blurring of vision. Inhalation may cause irritation of the upper respiratory passages, with coughing and discomfort. In general, irritation to mucous membranes typically involves high levels of exposure. Animal studies suggest that toxicity of irritants is associated with repeated exposures to very high airborne concentrations. Concentrations that are significantly above the reported maximum emission concentration measured in this case. Taking into consideration the classification of methyltrioxocane, the concentrations and exposure scenarios known to elicit toxicity, this VOC product was not considered COPC in this case or further in the risk assessment process.

^eOSHA- maximum time-weighted average (TWA) exposure limit is 1 part of benzene vapor per million parts of air (1 ppm) for an 8-hour workday or 3.20 mg/m³

^fCyclotrisiloxane, hexamethyl: A Workplace Environmental Exposure Limit has been derived for cyclic siloxane chemicals at the following exposure limit 10 ppm <http://www.tera.org/OARS/D4%20OARS%20WEEL%20FINAL.pdf>

^gRecommended Exposure Limit: NIOSH- for Pentanal- 10 Hr Time-Weighted Avg: 50 ppm (175 mg/cu m).

^hNA No exposure limit for benzoic acid has been established. However, benzoic acid as it exists in a white powder may cause irritation to the eyes, skin and respiratory tract on contact and in the event of a short-term exposure. Additionally there is no data to provide an accurate estimation of the rate in which a harmful concentration in air is reached on evaporation of benzoic acid at 20°C. Considering benzoic acids boiling point of 240°C and vapour density of 4.2 (air =1) it does not appear to be readily volatile and the vapour if produced is denser than air suggesting vapour is heavier than air and would not be maintained within the breathing zone of an individual in a standing position.

ⁱACGIH TLV-TWA Ethanedioic acid.

^jACGIH TLV-TWA Propanol

^kACGIH TLV-TWA 1-Chloro-1-Nitropropane

^mACGIH TLV-TWA for phosphine. Note that trimethylphosphine was only emitted on days 2 and 4 of DCA testing. The emissions were low and transient and were not maintained for extended periods. The occupational exposure level is extremely stringent and exposure scenarios in a residence would not be similar to those under occupational exposure conditions. Although the maximum emission concentration of trimethylphosphine is slightly above the TLV-TWA value divided by 100, the emission is not considered significant in the context of human health risk under a residential exposure scenario.

ⁿNA Tris(1-chloro-2-propyl) phosphate (TCPP) is a colourless liquid used as a flame retardant, mainly in polyurethane foams. It is not volatile. TCPP is classified as having a low to moderate acute toxicity by the oral (LD50 in rats = 1017–4200 mg/kg body weight), dermal (LD50 in rats and rabbits is > 5000 mg/kg body weight) and inhalation routes (LC50 in rats is > 4.6 mg/litre) suggesting that under conditions of low levels short term exposures it is unlikely to produce adverse effects in exposed

individuals. TCPP has been demonstrated to be very mildly irritating in rabbit eye and skin irritancy tests and does not produce skin sensitization. http://www.who.int/ipcs/publications/chc/who_chc_209.pdf

As summarized above in Table 3, the VOC emission products emitted from “*Canada VOC polyurethane foam*” have available ACGIH TLV-TWA® and/or other suitable exposure limits to be applied as comparative levels for the identification of COPC and for the assessment of their potential human health risks.

Based on the industry protocol for establishing chronic human exposure levels suitable for residential scenarios (ie. by application of a safety factor of 100 to the ACGIH TLV-TWA®, or the exposure limits accepted in this case, the assessment of toxicity data and the qualitative characterization of risk) the maximum emission concentrations, measured for the VOCs identified as emissions from the “*Canada VOC polyurethane foam*” test foam are considered safe. Thus, the VOC emission products were not considered as COPC for the purpose of this risk assessment.

4.0 DOSE-RESPONSE ASSESSMENT

The relationship between the potential received dose and the probability of adverse health effects is evaluated in the dose-response step of the risk assessment process. The intention of this risk assessment is to determine the relationship between exposure to maximum indoor air VOC concentrations and the potential for an adverse human health effect. Possible durations of exposure will be considered below.

4.1 Threshold Limit Values and Dose Response Assessment

In order to determine whether the maximum indoor air concentrations of VOC emission products pose a significant health risk to an individual residing in a home where “*Canada VOC polyurethane foam*” is applied, a comparison of this value was made with an exposure level that is considered acceptable (“safe”) for human exposure. This “safe” level represents the ACGIH-Threshold Limit Value-Time Weighted Average® ÷ 100 (TLV-TWA® ÷ 100), a NOEL ÷ 100 or an exposure limit derived from another regulatory body such as NIOSH, or OSHA. The safe levels for human exposure were determined in the hazard identification step of the risk assessment

process. A safety factor of 100, applied to the TLV-TWA® or other derived exposure limits provides an ample margin of safety in this case. Thus, it is assumed here that a repeated long-term to levels of the TLV-TWA®, or other relevant and appropriate exposure limit divided by (\div) 100 would not pose a significant health risk to occupants of a home where “*Canada VOC polyurethane foam*” is applied. In addition and for those compounds where an exposure limit was not available a qualitative assessment of risk was made. The qualitative assessment of those chemicals that had no established “safe level” considered available toxicity information to characterize risk. Considering the toxicity data, the low emission levels and the transient nature of the maximum airborne VOC emissions of all VOC observed through DCA of “*Canada VOC polyurethane foam*”; an acute, subacute, sub-chronic or chronic exposure to these VOC is unlikely to occur and result in any appreciable risk to human health.

There are several factors supporting the use of a relevant exposure limit, such as the TLV-TWA® \div 100, and NOEL, NOAEL or other relevant quantitative and qualitative toxicological information as a reasonable comparative value for the current assessment of “*Canada VOC polyurethane foam*”. Occupational exposures in the work environment are generally higher than exposures that occur in a home environment. They are also considered continuous exposures that occur more frequently and for longer duration. In addition, exposures in a work environment are generally more consistent and tend to occur over an 8-hour work shift over a 5-day work week. Exposures to chemicals in the home may be more random, intermittent and sporadic. Through the hazard assessment step of the risk assessment it was determined that “*Canada VOC polyurethane foam*”-derived VOC emissions will not pose significant inhalational toxicity under conditions where individuals would be exposed to low airborne concentrations (inhalation being considered the primary route of exposure since the emission products are expected to exist primarily in the vapour phase). The emission concentrations are not likely to produce significant adverse systemic injury, and animal toxicity data indicate the risk of significant adverse effects following acute, sub-chronic or chronic exposure to low-levels of “*Canada VOC polyurethane foam*”-derived VOC emissions is insignificant.

A review of relevant human and animal studies indicated that toxicity is associated with repeated exposures to extremely high airborne concentrations. The dynamic chamber analysis demonstrates emission levels are very low and maximum levels are not persistent. Therefore, the potential for exposures to concentrations and for durations of exposure that are likely to be associated with adverse effects are improbable in this case. In any scenario, potential exposure is likely to be of a short term duration, to low levels, rapid high levels of absorption into the human body is not likely, the accumulation to acute toxic concentrations in the ambient air, and/or in the body following absorption, is also very low, and exposure should not lead to a chronic or an acute adverse outcome.

Overall, exposure to maximum measured concentrations of VOC emissions derived from "Canada VOC polyurethane foam" are not likely to result in a received human dose that would result in adverse human health effects.

5.0 EXPOSURE ASSESSMENT

A chemical agent will not produce adverse effects in biological systems unless the agent (or agent's metabolite) reaches appropriate sites in the body at a concentration and for a length of time sufficient to produce the adverse effect. Thus, whether a toxic response occurs is not only dependent on dose, but is also dependent on the chemical and physical properties of the agent, the exposure situation and the susceptibility of the subject. Thus to characterize fully the potential hazard associated with exposure to the emission products from "Canada VOC polyurethane foam", information on the exposure situation is also required. In the following section of this risk assessment the exposure to VOC emission products in general, will be addressed. This step of the risk assessment process is designed to describe and characterize the likelihood, the extent, the magnitude, the duration and the route of exposure to the VOC emission products identified in Section 1.0.

The likelihood and the extent of human exposure to VOC emissions from "Canada VOC polyurethane foam" or polyurethane material in general, depend on several factors and these include: [1] the chemical nature of the VOC products, [2] the characteristics of the residential

structure (size and air-tightness of the house) and [3] the activity patterns of the residents, or time spent indoors, [4] the susceptibility of the exposed individuals and [5] the purpose and intended use of the polyurethane product (6). These factors will be considered here to assess the degree of exposure to VOC products emitted from "*Canada VOC polyurethane foam*".

Generally, VOC products when released into the indoor environment of a residence are expected to exist solely as vapours (3,5). Thus, the respiratory system constitutes the primary route of exposure to each of the VOC emission products identified through emissions testing. VOC vapours within the ambient atmosphere are likely to be degraded quickly (6). For example, many VOC are degraded in the atmosphere by reaction with photo-chemically produced hydroxyl radicals. Typically, the estimated half-life for VOC vapours range between a few minutes to several hours or even days in some cases (eg. benzene). Therefore, it is expected that in a home, these VOC emissions will be degraded, their ambient levels will decrease over time and accumulation to a potentially toxic level in the ambient air of a residential building is not likely. Therefore, in this case, the duration of exposure to low-level emission products is relatively short and repeated exposure to maximum emission levels would not be maintained and extended for long periods of time. Additionally, acute exposures to low-levels are not associated with adverse health impacts.

It is important to note that in general the majority of maximum emission concentrations of VOCs were measured within the 1-hour testing interval and were measured at levels well below the safety guidelines applied to evaluate health risk in this case, suggesting that concentrations emitted should not reach a significant concentration in indoor air and pose a risk to health.

Fluctuations in the number (profile) and concentration of VOCs measured through the DCA analysis may be related to the curing process of the polyurethane foam. Curing of spray polyurethane foams (SPF) essentially means that the chemicals used and mixed to formulate the product react to generate the foam intended for subsequent spraying. SPF may appear hardened or "tack-free" within a range of a few seconds to a few minutes after application to a residential space. During this range of time the SPF may still emit VOCs. Following the curing process however, SPF is considered to be relatively inert in terms of volatility. The DCA takes this issue into account

because the chemical components of the SPF ("*Canada VOC polyurethane foam*") are mixed and sprayed to produce a foam test panel 24-hours prior to analysis. The foam test panel is subsequently cut immediately prior to installation into the dynamic chambers exposing the interior surface of the SPF product. Exposure to the interior surface of a SPF is not likely to occur following its application to a residence suggesting that the profile and concentrations of VOCs emitted from the foam test panel in DCA are much higher than those experienced in practical application.

In some practical application scenarios (installation of wiring, maintenance work, building renovations, demolition etc.) potentially involving cutting and heating of material, it is conceivable that interior surfaces of cured foam are exposed and may emit VOCs. Depending on the level and duration of such work, exposure and risk mitigation measures should be considered, including personal protective equipment for occupational workers, adequate cleaning and ventilation, securement of work areas, and in some cases temporary removal of residents.

In the worst-case scenario, the maximum potential level of human exposure to VOCs emitted from "*Canada VOC polyurethane foam*" could be as high as the maximum indoor air concentrations determined by dynamic chamber analysis and outlined in Tables 1 and 2. The maximum indoor air concentrations of VOC products emitted from "*Canada VOC polyurethane foam*" are predicted based on a 500 m³ house with a ventilation rate of 0.3 air exchanges/ hour (4). By applying this low estimate for air exchange rate, the dynamic chamber analysis provides a very conservative estimate for maximum indoor air concentrations of the VOC products. Thus, even immediately after application of the polyurethane foam, the actual maximum indoor air concentrations in most structures would likely be lower than those predicted through DCA and outlined above in Tables 2 and 3. Individuals would likely be exposed intermittently, for a short period of time in the case of a residential environment. It can safely be assumed that the actual level of human exposure "*Canada VOC polyurethane foam*"-derived VOC emission products would be considerably lower than the maximum indoor air concentrations applied in the process of this risk assessment. The combined factors of low levels of VOC emission relative to safe levels, short duration of VOC emissions and the low potential for repeated chronic exposure by occupants, to levels associated

with toxicity, suggest a low risk for adverse health effects posed by exposure to airborne emission products of "Canada VOC polyurethane foam".

6.0 RISK CHARACTERIZATION

Risk characterization is the final step in the risk assessment process. It involves integrating all information developed through hazard identification, dose response assessment and exposure assessment (toxicity, measured air concentrations, exposure pathway information, inhalation route), for the purpose of estimating risk to humans. Throughout this assessment, procedures have been used to err on the side of caution in estimating the potential health risk associated with "Canada VOC polyurethane foam" -derived VOC emission products.

This analysis has revealed that VOC products emitted from "Canada VOC polyurethane foam" should not pose a health risk to individuals residing in buildings insulated with this material.

A number of factors support this conclusion:

[1] All maximum airborne concentrations of VOC emission products were below the very conservative safety guidelines applied in the risk assessment process (100 x below the occupational safety standard). Airborne concentrations were measured at levels well below those concentrations associated with any reported health risk. The majority of the maximum measured airborne concentrations of each VOC were detected within the 1-hour DCA testing interval and emission concentrations subsequent to this sample period never exceeded the maximum. The VOCs, where maximum emission levels were measured at days subsequent to 1 hour were significantly below the safety guidelines applied in this risk assessment.

[2] In general VOC emission products from "Canada VOC polyurethane foam" at concentrations determined through DCA, are of low order toxicity under conditions of low-level intermittent exposures, possess a low inhalational toxicity at low level airborne concentrations and have not been demonstrated to pose a significant carcinogenic risk to the general population at intermittent low levels of exposure. Acute high levels of exposure, well above the maximum emission

concentrations observed through DCA, have been associated with adverse health effects. In addition, repeated high levels for long-term durations have been associated with adverse health effects, a scenario of exposure not likely to occur under the conditions of application or within a residential exposure scenario.

[3] Based on the decay pattern of the VOC emission products (up to 30 days), ambient indoor VOC air concentrations decrease very rapidly over time and should not accumulate to a toxic concentration in the home or in any other residential building. Although, it was observed that three VOCs were emitted and detected in air samples collected at testing intervals beyond 4 days, these levels were well below safety guidelines applied in the process of this risk assessment. Acute exposures to low-levels are not associated with adverse impacts to human health.

[4] Exposure to maximum potential indoor air concentrations of VOC emission products was demonstrated through the risk assessment process to possess a low potential for human health risk under the conditions of exposure outlined in the Exposure Assessment Section of the document.

[5] Short-term low-level exposures to VOC products emitted from “*Canada VOC polyurethane foam*” are not associated with acute or chronic adverse health effects.

Presently there are no Canadian or U.S. human exposure standards for total volatile organic compounds (TVOC), however a target of 1 mg/m³ and 5 mg/m³ respectively, are being discussed for indoor office environments. The European Community has prepared a target guideline value for TVOC of 0.3 mg/m³ for office environments. TVOC concentrations (calculated based on maximum emission concentrations of 25 unique VOCs identified) are below the recommended guideline for Canadian and U. S. office environments.

Exposure to potential VOCs and consideration of re-occupancy time following the application of spray applied polyurethane foam is also dependent on a factors, including SPF formulation, the amount of foam applied per volume of space, temperature, humidity, the degree of ventilation and other variables. Dynamic chamber analysis of “*Canada VOC polyurethane foam*” provides a VOC

emissions profile under a case scenario where there are exposed interior surfaces of SPF, relatively high temperature (40°C), uncontrolled humidity low and low air flow rates. It is likely that the profile and concentrations of VOCs emitted from the foam test panel in DCA are much higher than those experienced in practical application.

Overall, the concentrations of airborne VOC and TVOC decrease rapidly over time and are not likely to accumulate in ambient air to toxic concentrations. Thus in this case, exposure to maximum airborne concentrations of VOC or TVOC, will not pose a significant human health risk. Following the post-application curing period, estimated VOC concentrations from “Canada VOC polyurethane foam” were determined to remain within an acceptable range for human exposure. Based on the integration of all information presented in the steps of the risk assessment process.

The DCA provides VOC emission concentrations following a 24 hour period after which the spray foam is applied (a 24 hour period following the mixing and spraying of the product). Considering DCA and the results thereof, *it is suggested that a residential occupancy time of 1 hour be considered for “Canada VOC polyurethane foam” with the expressed provision that the 24-hour curing period (mixing and spraying) is maintained after application.*

7.0 RECOMMENDATIONS

Indoor exposures to VOCs from building materials are of obvious concern. The potential for off-gassing of volatile chemicals from spray polyurethane foam is not fully understood and is an area where more research is needed. Since there are numerous sources of VOC in building material and home furnishings, it is clear that regulatory improvements to indoor VOC standards in residential buildings will not be achieved by singling out individual products, but rather through an assessment of all potential components of such residences. Significant improvements in the indoor air of individual VOC could be achieved by establishing an overall limit in the amount of total VOC contributed by all housing materials used in the construction of new buildings. This limit could then be maintained through adequate ventilation.

In some practical application scenarios (installation of wiring, maintenance work, building renovations, demolition etc.) potentially involving cutting and heating of material, it is conceivable that interior surfaces of cured foam are exposed and may emit VOCs. Depending on the level and duration of such work, exposure and risk mitigation measures should be considered, including personal protective equipment for occupational workers, adequate cleaning and ventilation, securement of work areas, and in some cases temporary removal of residents.


The current risk assessment indicates that there is a low human health risk associated with exposure to VOC emission products from "*Canada VOC polyurethane foam*". Since no significant threat to health can be associated with an exposure to low-levels of these emission products, maximum levels are transient and do not persist at levels exceeding safety limits over the 30-day period of dynamic chamber analysis, it is suggested that *a residential occupancy time of 1 hour be considered for "Canada VOC polyurethane foam" with the expressed provision that the 24-hour curing period (mixing and spraying) is maintained after application.*

8.0 CLOSURE

A Human Health Risk Assessment (HHRA) has been completed as authorized. This report has been prepared for the exclusive use of Canada VOC and its agents for specific application to the polyurethane spray foam "*Canada VOC polyurethane foam*". It has been prepared in accordance with generally accepted toxicological practices and no other warranty, expressed or implied, is made. Any use, which a Third Party makes of this report, or any reliance on decisions to be made based on it, is the responsibility of such Third Parties. Dr. L. Bharadwaj accepts no responsibility for damages, if any, suffered by any Third Party as a result of decisions made or actions based on this report.

I trust that this report fulfils your requirements for this project. Should you require additional information, please contact Dr. Lalita Bharadwaj.

Yours very truly,

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	<p>Date: December 21, 2018</p>

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