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COMPARATIVE U-FACTOR, SHGC & VT STUDY OF VARIOUS INSULATED GLASS UNIT CONFIGURATIONS WITH AND WITHOUT THE “WINDOW INSULATORS ACRYLIC PANEL SYSTEM” IN ACCORDANCE WITH CSA A440.2-09

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1.0 INTRODUCTION

At the request of Window Insulators Ltd., Exova was retained to conduct a U-factor, Solar Heat Gain Coefficient (SHGC) and Visible Transmittance (VT) computer model comparison study of various insulated glass units (IGU's) installed within a wood fixed window unit without and with the "Window Insulators Acrylic Panel System."

Window Insulators System Description:

The Window Insulators Ltd. window system is a "lightweight and clear flexible acrylic panel that seals magnetically and fits over your existing windows." The acrylic panel is a nominal 3 mm thick clear sheet that sits within a rigid PVC perimeter clip and has an adhered magnetic strip. The magnetic strip and clip adapt magnetically to a painted steel angle measuring 0.650" (l) x 0.750" (h) 0.010" (t) that is installed using silicone to the interior side of a window frame.

The simulations outlined in this report were conducted in accordance with CSA A440.2-09 (*Fenestration Energy Performance*). CSA A440.2-09 is a nationally recognized standard used in Canada for the evaluation of fenestration products and is referenced in the following codes:

- 2011 National Energy Code of Canada – Division B – Part 3 – Building Envelope: Section 3.1.1.5
- 2010 National Building Code of Canada – Division B – Part 9 – Housing and Small Buildings: Section 9.7.3.3
- 2006 Ontario Building Code Supplementary Standard SB-12 – Energy Efficiency for Housing (*January 1, 2012 Update*): Section 2.1.1.8(2)(a)

The comparative insulated glass units outlined in this study were modelled with and without the presence of the "Window Insulators System" for comparative purposes.

As the acrylic glazing used in the "Window Insulators System" was not located in the certified International Glazing Database (IGDB), spectral measurements (*between 300 – 2500 μm , T, RF, RB*) and emissivities were acquired by Professor Michael Collins of The University of Waterloo using a CARY 500 spectrometer and Gier Dunkel DB-100.

Upon acquiring the spectral measurements and surface emissivities, the raw data results for the acrylic layer were sent to Exova to for review/formatting and characterization within the Optics 5 software program. The glazing layer analysis for the acrylic was then exported from Optics 5 and imported into the Window 6.3 software program. Each glazing layer was positioned within the prescribed convectional IGU configuration and the results were calculated using the "NFRC 100-2010" boundary conditions at a tilt angle of 90° in accordance with NFRC 100-2010, 200-2010 (*standards referenced by CSA A440.2-09*).

For the purposes of the study, the centre-of-glass results were simulated (*that is, calculated*) for the following IGU configurations:

- Configuration #1: 3 mm Generic Clear Glass / 12.7 mm Argon Gas Gap / 3 mm Generic Clear Glass
- Configuration #2: 3 mm Generic Clear Glass / 12.7 mm Argon Gas Gap / 3 mm Cardinal LoE180 [3]
- Configuration #3: 3 mm Generic Clear Glass / 12.7 mm Argon Gas Gap / 3 mm Generic Clear Glass / 76 mm Air Gas Gap Window Insulators Acrylic Panel
- Configuration #4: 3 mm Generic Clear Glass / 12.7 mm Argon Gas Gap / 3 mm Cardinal LoE180 [3] / 76 mm Air Gas Gap Window Insulators Acrylic Panel

Note: Square brackets, [#], denote LowE coated surface.

In addition to the centre-of-glass results, the above insulated glass unit configurations with and without the “Window Insulators System” were simulated within a representative fixed wood window frame for a comparative evaluation of a complete window unit.

Representative Window Unit Details:

Exova Simulation No.: 14-06-M0236-3
Window Type: Fixed Picture
Series Model: Dummy Fixed Picture Window
Simulation Window Size: 1200 mm (wide) x 1500 mm (high)
Simulation CR Cavity Height: 1400 mm
Frame Material / Finish: WD (*wood*)
Reinforcement Material: No Reinforcements
Operator Type: FIXD (*4-sided*)

Glazing Layers Created in Optics5: Yes

Glazing Information:

Glazing Method: Wet Glazed, Silicone on Interior / Exterior
Gas Fill (Argon): 90 % Argon / 10% Air (used in insulated glass unit, IGU)
Gas Fill (Air): 100% Air (*used between IGU and acrylic panel*)

Spacer Type for Glazing Options:

S2, Width: 0.5"
Type: ZF-D
Primary Sealant: Butyl Hot Melt
Secondary Sealant: Silicone
Desiccant: No

Requested Grid Options (Using CSA/NFRC Standard Grid Pattern): No

Weatherstripping Configuration:

<u>Type:</u>	<u>Quantity Installed:</u>	<u>Location:</u>
Silicone	1 Bead	Exterior Glass Stop / IGU
Silicone	1 Bead	Interior Frame / IGU

Note: Detail drawings for the above simulated window units (*with and without “Window Insulators System”*) have been included in Appendix A.

2.0 PROCEDURE

The Building Performance Centre at Exova evaluated the above window configurations in accordance with the procedures of the CSA A440.2-09, “Energy Performance of Windows & Other Fenestration Systems” test Standard.

Software Employed:

- International Glazing Database Version: 32.0
- Frame and Edge Modelling Software: Therm Version: 6.3.46
- Glazing Layers Created: Optics Version: 5.1 (*Maintenance Pack 2*)
- Centre of Glass Calculation Software: Window Version: 6.3.74
- Total Window Unit Calculation Software: Window Version: 6.3.74

Simulation Notes:

- Simulation Date: September 14, 2014
- Continuous Hardware Modelled: No
- Any model additions and removals: “Window Insulators System” added when applicable.
- The solar absorptance of dividers and frames is 0.3 for SHGC calculation, unless otherwise stated.
- The exterior boundary condition used unless otherwise stated was NFRC 100-2010.
- Grouping Details of Products: No
- The thermal conductivity of all “glass” glazing layers was assumed to be 1.000 W/m-K. However, the 3 mm thick acrylic panel was modelled using a thermal conductivity of 0.200 W/m-K as per NFRC 101-2014, Plexiglas (PMMA) / Lucite.
- The average hemispheric emittance was measured to be 0.86 as used for both sides of the acrylic surface when modelled.
- For the calculation of ER (*Energy Rating*), the “fixed” air leakage value of 0.2 L/s·m² as outlined in NAFS – AAMA/WDMA/CSA/1.S.2/A440-08, Table 9 was used for comparative purposes.

3.0 RESULTS

Table 1 – Summary of Centre-of-Glass Results (<u>Only</u>)									
IGU Configuration	No. of Layers	Overall Thickness (mm)	Glazing 1 Thickness (mm)	Glazing 2 Thickness (mm)	Glazing 3 Thickness (mm)	Keff (W/m-K)	U-Value (W/m ² -K)	SHGC	Visible Transmission
1	2	18.7	3.0	3.0	-	0.060	2.58	0.76	0.81
2	2	18.7	3.0	3.0	-	0.026	1.48	0.67	0.79
3	3	97.7	3.0	3.0	3.0	0.225	1.67	0.69	0.76
4	3	97.7	3.0	3.0	3.0	0.128	1.10	0.62	0.72

IGU Configuration Langed:

1. 3 mm Generic Clear Glass / 12.7 mm Argon Gas Gap / 3 mm Generic Clear Glass
2. 3 mm Generic Clear Glass / 12.7 mm Argon Gas Gap / 3 mm Cardinal LoE180 [3]
3. 3 mm Generic Clear Glass / 12.7 mm Argon Gas Gap / 3 mm Generic Clear Glass / 76 mm Air Gas Gap Window Insulators Acrylic Panel
4. 3 mm Generic Clear Glass / 12.7 mm Argon Gas Gap / 3 mm Cardinal LoE180 [3] / 76 mm Air Gas Gap Window Insulators Acrylic Panel

TABLE 2 – COMPARISON SUMMARY A WOOD FIXED WINDOW UNIT WITHOUT AND WITH THE “WINDOW INSULATORS ACRYLIC PANEL SYSTEM”:

Product Code	Grouping ID Number	Total IGU Thickness (in)	Glazing Option Number	Glazing #1 Thickness (in)	Glazing #2 Thickness (in)	Glazing #3 Thickness (in)	Gap Space 1 (in)	Gap Space 2 (in)	Gas Information			Emissivity					Spacer Type	Tint	C-O-G U-Factor (W/m ² ·K)	C-O-G SHGC	C-O-G VT	Grid Type	Grid Size (in)	Total Product U-Factor (W/m ² ·K)	SHGC NO GRID	SHGC GRID < 1"	SHGC GRID > 1"	VT NO GRID	VT GRID < 1"	VT GRID > 1"	ER NO GRID	ER GRID < 1"	ER GRID > 1"		
									Gas Fill 1	Gas Fill 2	% of Gas Fill 1	% of Gas Fill 2	Surface 1	Surface 2	Surface 3	Surface 4																		Surface 5	Surface 6
1		0.736	1	0.118	0.118		0.500		ARG	90					ZF-D	CL	2.58	0.76	0.81	N	N/A	2.47	0.67	N/A	N/A	24	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2		0.736	2	0.118	0.118		0.500		ARG	90		0.068			ZF-D	CL	1.48	0.67	0.79	N	N/A	1.55	0.59	N/A	N/A	40	N/A	N/A	N/A	40	N/A	N/A	N/A	N/A	N/A
3		3.846	3*	0.118	0.118	0.118	0.500	3.000	ARG	AFR	90				ZF-D	CL	1.67	0.69	0.76	N	N/A	1.62	0.61	N/A	N/A	40	N/A	N/A	N/A	40	N/A	N/A	N/A	N/A	N/A
4		3.846	4*	0.118	0.118	0.118	0.500	3.000	ARG	AFR	90	0.068			ZF-D	CL	1.10	0.82	0.74	N	N/A	1.12	0.55	N/A	N/A	47	N/A	N/A	N/A	47	N/A	N/A	N/A	N/A	N/A



Operator Type: Fixed
Simulation Window Size: 1500 Height (mm) 1200 Width (mm)
Frame Type: WD
Sash Type: WD
Thermal Break Type: N
Simulation Laboratory Code: SEVA

Physical Air Leakage Value: 0.20 L/s.m²
Manufacturer: Window Insulators
Exova Report Number: 14-06-M0236-3
Product Series / Model: Dummy Fixed Window
Window 6.3 File Name: 14-06-M0236 Thermal Simulations.mdb
Date: 14-Sep-14
Simulation Revision No.: Original

Glazing Options:
1 3 mm Generic Clear Glass / 12.7 mm Argon Gas Gap / 3 mm Generic Clear Glass
2 3 mm Generic Clear Glass / 12.7 mm Argon Gas Gap / 3 mm Cardinal LoE180 [3]
3 3 mm Generic Clear Glass / 12.7 mm Argon Gas Gap / 3 mm Generic Clear Glass / 76 mm Air Gas Gap Window Insulators Acrylic Panel
4 3 mm Generic Clear Glass / 12.7 mm Argon Gas Gap / 3 mm Cardinal LoE180 [3] / 76 mm Air Gas Gap Window Insulators Acrylic Panel

Options:
* Window Insulators System Applied to Window

4.0 CONCLUSION

Based on the results shown in Tables 1 & 2, the “Window Insulators System” when used in conjunction with the conventional fixed window configuration as described, significantly reduced the thermal conductivity. The summarized comparative thermal performance results are shown below in Table 3:

Table 3 – Summarized Thermal Performance Results							
Configuration Number	Specimen Description	SI Units		British Units			
		U-Factor	Thermal Conductivity	U-Factor	Thermal Conductivity	U-Factor	Thermal Conductivity
1	3 mm Clear / 12.7 mm Argon / 3 mm Clear	2.47	W/m ² -K	0.44	BTU/h.ft ² .°F	2.27	°F. ft ² .h/BTU
3	3 mm Clear / 12.7 mm Argon / 3 mm Clear + Window Insulators Systems	1.62	W/m ² -K	0.29	BTU/h.ft ² .°F	3.45	°F. ft ² .h/BTU
2	3 mm Clear / 12.7 mm Argon / 3 mm LoE 180 [3]	1.55	W/m ² -K	0.27	BTU/h.ft ² .°F	3.70	°F. ft ² .h/BTU
4	3 mm Clear / 12.7 mm Argon / 3 mm LoE 180 [3] + Window Insulators Systems	1.12	W/m ² -K	0.20	BTU/h.ft ² .°F	5.00	°F. ft ² .h/BTU

* SI units were the primary units of measure / calculation. Conversion: 1 BTU/h.ft².°F = 5.678 W/m².K

5.0 TERMS AND CONDITIONS

This report is related only to the fenestration product simulated and shall not be reproduced, except in full, without the approval of Exova Canada Inc. This report is not intended as a comprehensive evaluation of the system regarding performance and application to specific buildings and/or configurations.


The values stated in this reported were rounded as per the CSA A440.2-09 unit and measurement requirements.

6.0 REPORT REVISION SUMMARY

Revision No: Original	Date (yyyy-mm-dd): 2014-09-15	Description of Revisions: Original Document
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Reported by:

Reviewed & Authorized by:

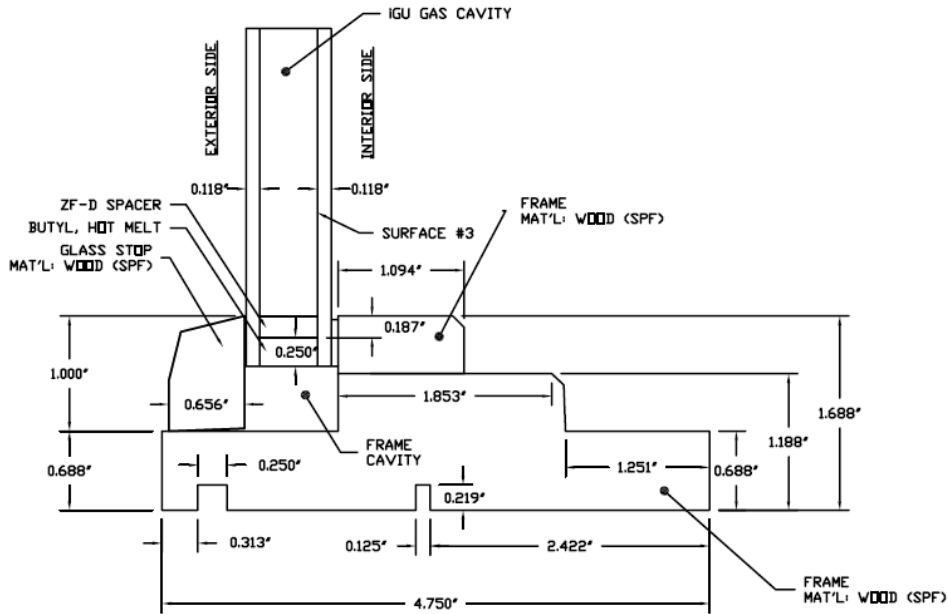

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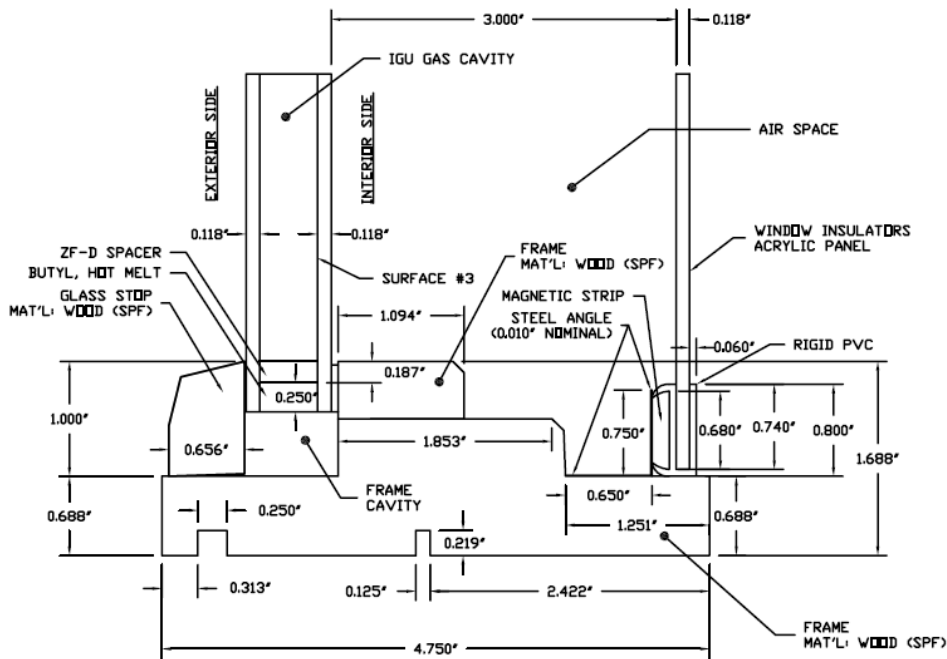
APPENDIX A

*Simulation Profile Detail for Dummy Fixed Picture Window
(Without and With Window Insulator System) & Product Picture*

(2 Pages)



SIMULATED WINDOW SYSTEM PROFILE WITHOUT "WINDOW INSULATORS" INSTALLED



SIMULATED WINDOW SYSTEM PROFILE WITH "WINDOW INSULATORS" INSTALLED

NOTE: ALL DIMENSIONS PRESENTED IN INCHES



Figure A1 – Window Insulators Panel & Steel Angle



Figure A2 – Window Insulators Panel Magnetized to Steel Angle