Comparison of WINDOW 5 / THERM 5 and WINDOW 6 / THERM 6 Results for Specular Glazing Systems

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1. Overview

The WINDOW software program is used extensively in the fenestration industry to calculate the thermal and optical properties of glazing systems and whole window products. The version of WINDOW that is currently certified for the NFRC Ratings Program is WINDOW 5.2.17a. LBNL has developed the next version of WINDOW, currently WINDOW 6.3, which has the added capabilities of modeling complex glazing and shading systems (such as venetian blinds, woven shades and fritted glass).

However, the basic calculation method for non-complex glazing products, also known as specular glazings, has not changed significantly between WINDOW 5.2.17a and WINDOW 6.3. The only difference between the two versions for the specular glazing calculations are the following changes:

- Solar Heat Gain Coefficient Correction: This was a minor correction which resulted in a change of no more than one percent (1%) between the two programs. Calculations are now in accordance with equation 14 in Section 4.2.2 of ISO 15099

- U-factor Correction for Vertical Cross Section (Jambs and Vertical Meeting Rails): Two different fixes were made which affect the U-factor.

    - The Lv (vertical length) and Lh (horizontal length) dimenions in equation 93 in section 6.6.5 of ISO 15099 were not clearly defined for cavities in vertical cross sections. Research in an accepted (but not published) paper comparing THERM with CFD showed discrepancies, which caused a review of the ISO 15099 algorithms. This resulted in a change to the algorithms such that the frame cavity dimensions are now correct for radiation calculations for cavities in vertical cross sections.

    - A frame cavity emissivity bug was fixed which very slightly changed the U-factor for some cross sections. See the detailed description under the Whole Products section of this report.

- CR Correction: Reference temperatures for CR calculations are now in exact accordance with NFRC 500. Temperature differences with W5/T5 CR calculations are less than 0.09 ^{o}C. In addition, the CR results are affected by the change in U-value for vertical cross sections (see above).

Therefore, if WINDOW 6.3 and THERM 6.3 are used only for modeling whole products with specular glazing systems, in comparison to WINDOW 5.2 and THERM 5.2, the results for winter U-value will be within 0.5%, the results for Visible Transmission (Tvis) will be identical, the results for Solar Heat Gain Coefficient (SHGC) will be within 1%, and the results for CI will be within 1.2%.

The first section in this report is a comparison of glazing systems only (not whole products), and the second section is a comparison of whole products.

2. Glazing System Comparison

In order to confirm that WINDOW 5.2.17a and WINDOW 6.3 produce the same results for glazing system calculations, a matrix of 101 glazing systems was calculated in both programs.

2.1. Glazing System Comparison

The matrix of 101 glazing systems was run with both WINDOW 5.2.17a and WINDOW 6.3.1. The results for the glazing system comparisons are shown in Table 1.

2.1.1. U-factor

The percentage difference for U-factor is 0.00% in all cases.

2.1.2. Tvis

The percentage difference for Tvis is 0.00% in all cases.

2.1.3. SHGC

The SHGC calculation method changed very slightly between the two versions of WINDOW; WINDOW 6 contains a fix to the SHGC calculation from WINDOW 5, that results in a very slight difference in results. The maximum difference in the values is 0.002, or 0.59%, i.e., less than one percent.

Table 1. Comparison of WINDOW 5 and WINDOW 6 for calculating glazing system U-factor, SHGC, VT in SI units

ID	# Glazing Layers	Glazing				U-factor (W/m^2-K)				SHGC (-)				VT (-)			
		Glass	emiss.	Glass / Gap / Glass (mm)	Gas	W5	W6	DIFF	DIFF (%)	W5	W6	DIFF	DIFF (%)	W5	W6	DIFF	DIFF (%)
1	Single Glazing	Un-Coated	0.84	N/A	N/A	5.878	5.878	0.000	0.00%	0.866	0.868	0.0013	0.15%	0.899	0.899	0.000	0.00%
2	Double Glazing	Un-Coated	0.84	4/6/4	Air	3.148	3.148	0.000	0.00%	0.770	0.772	0.0016	0.21%	0.813	0.813	0.000	0.00%
					Argon	2.902	2.902	0.000	0.00%	0.771	0.772	0.0015	0.20%	0.813	0.813	0.000	0.00%
					Krypton	2.595	2.595	0.000	0.00%	0.772	0.773	0.0015	0.19%	0.813	0.813	0.000	0.00%
					Xenon	2.454	2.454	0.000	0.00%	0.772	0.774	0.0015	0.19%	0.813	0.813	0.000	0.00%
3				4/12/4	Air	2.729	2.729	0.000	0.00%	0.772	0.773	0.0015	0.19%	0.813	0.813	0.000	0.00%
					Argon	2.575	2.575	0.000	0.00%	0.772	0.774	0.0015	0.19%	0.813	0.813	0.000	0.00%
					Krypton	2.525	2.525	0.000	0.00%	0.773	0.774	0.0014	0.18%	0.813	0.813	0.000	0.00%
					Xenon	2.505	2.505	0.000	0.00%	0.773	0.774	0.0013	0.17%	0.813	0.813	0.000	0.00%
4				4/20/4	Air	2.750	2.750	0.000	0.00%	0.772	0.774	0.0014	0.19%	0.813	0.813	0.000	0.00%
					Argon	2.614	2.614	0.000	0.00%	0.773	0.774	0.0014	0.18%	0.813	0.813	0.000	0.00%
					Krypton	2.556	2.556	0.000	0.00%	0.773	0.774	0.0011	0.15%	0.813	0.813	0.000	0.00%
					Xenon	2.505	2.505	0.000	0.00%	0.773	0.774	0.0011	0.14%	0.813	0.813	0.000	0.00%
5		One Pane Coated (Surface # 2)	0.2	4/6/4	Air	2.595	2.595	0.000	0.00%	0.649	0.650	0.0015	0.24%	0.748	0.748	0.000	0.00%
					Argon	2.222	2.222	0.000	0.00%	0.647	0.648	0.0014	0.21%	0.748	0.748	0.000	0.00%
					Krypton	1.736	1.736	0.000	0.00%	0.644	0.645	0.0011	0.18%	0.748	0.748	0.000	0.00%
					Xenon	1.537	1.537	0.000	0.00%	0.643	0.644	0.0010	0.16%	0.748	0.748	0.000	0.00%
6				4/12/4	Air	1.980	1.980	0.000	0.00%	0.645	0.646	0.0012	0.19%	0.748	0.748	0.000	0.00%
					Argon	1.740	1.740	0.000	0.00%	0.644	0.645	0.0011	0.17%	0.748	0.748	0.000	0.00%

ID	# Glazing Layers	Glazing				U-factor (W/m^2-K)				SHGC (-)				VT (-)			
		Glass	emiss.	Glass / Gap / Glass (mm)	Gas	W5	W6	DIFF	DIFF (%)	W5	W6	DIFF	DIFF (%)	W5	W6	DIFF	DIFF (%)
7					Krypton	1.675	1.675	0.000	0.00%	0.642	0.643	0.0011	0.16%	0.748	0.748	0.000	0.00%
					Xenon	1.629	1.629	0.000	0.00%	0.642	0.643	0.0013	0.21%	0.748	0.748	0.000	0.00%
				4/20/4	Air	2.054	2.054	0.000	0.00%	0.643	0.645	0.0012	0.19%	0.748	0.748	0.000	0.00%
					Argon	1.827	1.827	0.000	0.00%	0.643	0.644	0.0012	0.18%	0.748	0.748	0.000	0.00%
					Krypton	1.716	1.716	0.000	0.00%	0.642	0.644	0.0014	0.22%	0.748	0.748	0.000	0.00%
					Xenon	1.629	1.629	0.000	0.00%	0.642	0.644	0.0014	0.22%	0.748	0.748	0.000	0.00%
8		One Pane Coated (Surface # 2)	0.1	4/6/4	Air	2.473	2.473	0.000	0.00%	0.623	0.625	0.0013	0.21%	0.747	0.747	0.000	0.00%
					Argon	2.067	2.067	0.000	0.00%	0.622	0.623	0.0011	0.17%	0.747	0.747	0.000	0.00%
					Krypton	1.533	1.533	0.000	0.00%	0.619	0.620	0.0008	0.13%	0.747	0.747	0.000	0.00%
					Xenon	1.322	1.322	0.000	0.00%	0.618	0.618	0.0007	0.11%	0.747	0.747	0.000	0.00%
9				4/12/4	Air	1.810	1.810	0.000	0.00%	0.620	0.621	0.0009	0.15%	0.747	0.747	0.000	0.00%
					Argon	1.549	1.549	0.000	0.00%	0.619	0.620	0.0008	0.13%	0.747	0.747	0.000	0.00%
					Krypton	1.477	1.477	0.000	0.00%	0.617	0.618	0.0007	0.12%	0.747	0.747	0.000	0.00%
					Xenon	1.423	1.423	0.000	0.00%	0.617	0.618	0.0010	0.17%	0.747	0.747	0.000	0.00%
10				4/20/4	Air	1.899	1.899	0.000	0.00%	0.618	0.619	0.0009	0.15%	0.747	0.747	0.000	0.00%
					Argon	1.648	1.648	0.000	0.00%	0.618	0.618	0.0009	0.14%	0.747	0.747	0.000	0.00%
					Krypton	1.521	1.521	0.000	0.00%	0.617	0.618	0.0011	0.18%	0.747	0.747	0.000	0.00%
					Xenon	1.423	1.423	0.000	0.00%	0.617	0.618	0.0011	0.18%	0.747	0.747	0.000	0.00%
11		One Pane Coated (Surface # 2)	0.04	4/6/4	Air	2.374	2.374	0.000	0.00%	0.377	0.378	0.0011	0.30%	0.691	0.691	0.000	0.00%
					Argon	1.940	1.940	0.000	0.00%	0.372	0.373	0.0009	0.23%	0.691	0.691	0.000	0.00%
					Krypton	1.365	1.365	0.000	0.00%	0.364	0.365	0.0006	0.16%	0.691	0.691	0.000	0.00%

ID	# Glazing Layers	Glazing				U-factor (W/m^2-K)				SHGC (-)				VT (-)			
		Glass	emiss.	Glass / Gap / Glass (mm)	Gas	W5	W6	DIFF	DIFF (%)	W5	W6	DIFF	DIFF (%)	W5	W6	DIFF	DIFF (%)
					Xenon	1.146	1.146	0.000	0.00%	0.360	0.360	0.0000	0.00%	0.691	0.691	0.000	0.00%
12				4/12/4	Air	1.672	1.672	0.000	0.00%	0.367	0.367	0.0007	0.19%	0.691	0.691	0.000	0.00%
					Argon	1.392	1.392	0.000	0.00%	0.363	0.363	0.0006	0.16%	0.691	0.691	0.000	0.00%
					Krypton	1.315	1.315	0.000	0.00%	0.358	0.359	0.0010	0.28%	0.691	0.691	0.000	0.00%
					Xenon	1.254	1.254	0.000	0.00%	0.358	0.360	0.0019	0.53%	0.691	0.691	0.000	0.00%
13				4/20/4	Air	1.773	1.773	0.000	0.00%	0.363	0.364	0.0016	0.45%	0.691	0.691	0.000	0.00%
					Argon	1.501	1.501	0.000	0.00%	0.360	0.362	0.0018	0.49%	0.691	0.691	0.000	0.00%
					Krypton	1.361	1.361	0.000	0.00%	0.359	0.361	0.0021	0.59%	0.691	0.691	0.000	0.00%
					Xenon	1.254	1.254	0.000	0.00%	0.359	0.360	0.0018	0.51%	0.691	0.691	0.000	0.00%
14	Triple Glazing			4/6/4/6/4	Air	2.169	2.169	0.000	0.00%	0.693	0.695	0.0016	0.24%	0.739	0.739	0.000	0.00%
					Argon	1.947	1.947	0.000	0.00%	0.694	0.696	0.0016	0.23%	0.739	0.739	0.000	0.00%
					Krypton	1.684	1.684	0.000	0.00%	0.695	0.697	0.0015	0.22%	0.739	0.739	0.000	0.00%
					Xenon	1.552	1.552	0.000	0.00%	0.696	0.698	0.0015	0.22%	0.739	0.739	0.000	0.00%
15		Un-Coated	0.84	4/9/4/9/4	Air	1.914	1.914	0.000	0.00%	0.694	0.696	0.0016	0.23%	0.739	0.739	0.000	0.00%
					Argon	1.747	1.747	0.000	0.00%	0.695	0.697	0.0016	0.22%	0.739	0.739	0.000	0.00%
					Krypton	1.573	1.573	0.000	0.00%	0.696	0.698	0.0015	0.22%	0.739	0.739	0.000	0.00%
					Xenon	1.539	1.539	0.000	0.00%	0.696	0.698	0.0015	0.22%	0.739	0.739	0.000	0.00%
16				4/12/4/12/4	Air	1.780	1.780	0.000	0.00%	0.695	0.697	0.0016	0.22%	0.739	0.739	0.000	0.00%
					Argon	1.648	1.648	0.000	0.00%	0.696	0.697	0.0015	0.22%	0.739	0.739	0.000	0.00%
					Krypton	1.570	1.570	0.000	0.00%	0.696	0.698	0.0015	0.22%	0.739	0.739	0.000	0.00%
					Xenon	1.557	1.557	0.000	0.00%	0.697	0.698	0.0016	0.23%	0.739	0.739	0.000	0.00%

ID	# Glazing Layers	Glazing				U-factor (W/m^2-K)				SHGC (-)				VT (-)			
		Glass	emiss.	Glass / Gap / Glass (mm)	Gas	W5	W6	DIFF	DIFF (%)	W5	W6	DIFF	DIFF (%)	W5	W6	DIFF	DIFF (%)
17		Two Panes Coated (Surface # 2 and # 5)	0.2	4/6/4/6/4	Air	1.678	1.678	0.000	0.00%	0.558	0.559	0.0016	0.28%	0.626	0.626	0.000	0.00%
					Argon	1.382	1.382	0.000	0.00%	0.559	0.560	0.0014	0.25%	0.626	0.626	0.000	0.00%
					Krypton	1.021	1.021	0.000	0.00%	0.560	0.561	0.0012	0.22%	0.626	0.626	0.000	0.00%
					Xenon	0.842	0.842	0.000	0.00%	0.560	0.561	0.0011	0.20%	0.626	0.626	0.000	0.00%
18				4/9/4/9/4	Air	1.338	1.338	0.000	0.00%	0.559	0.560	0.0014	0.24%	0.626	0.626	0.000	0.00%
					Argon	1.109	1.109	0.000	0.00%	0.559	0.561	0.0012	0.22%	0.626	0.626	0.000	0.00%
					Krypton	0.875	0.875	0.000	0.00%	0.560	0.561	0.0011	0.20%	0.626	0.626	0.000	0.00%
					Xenon	0.838	0.838	0.000	0.00%	0.561	0.562	0.0012	0.22%	0.626	0.626	0.000	0.00%
19				4/12/4/12/4	Air	1.159	1.159	0.000	0.00%	0.559	0.561	0.0013	0.23%	0.626	0.626	0.000	0.00%
					Argon	0.977	0.977	0.000	0.00%	0.560	0.561	0.0012	0.21%	0.626	0.626	0.000	0.00%
					Krypton	0.884	0.884	0.000	0.00%	0.561	0.562	0.0012	0.21%	0.626	0.626	0.000	0.00%
					Xenon	0.865	0.865	0.000	0.00%	0.562	0.563	0.0016	0.28%	0.626	0.626	0.000	0.00%
20		Two Panes Coated (Surface # 2 and # 5)	0.1	4/6/4/6/4	Air	1.577	1.577	0.000	0.00%	0.530	0.531	0.0013	0.24%	0.624	0.624	0.000	0.00%
					Argon	1.263	1.263	0.000	0.00%	0.530	0.532	0.0011	0.20%	0.624	0.624	0.000	0.00%
					Krypton	0.880	0.880	0.000	0.00%	0.531	0.532	0.0009	0.16%	0.624	0.624	0.000	0.00%
					Xenon	0.689	0.689	0.000	0.00%	0.532	0.533	0.0008	0.15%	0.624	0.624	0.000	0.00%
21				4/9/4/9/4	Air	1.217	1.217	0.000	0.00%	0.531	0.532	0.0010	0.20%	0.624	0.624	0.000	0.00%
					Argon	0.974	0.974	0.000	0.00%	0.531	0.532	0.0009	0.17%	0.624	0.624	0.000	0.00%
					Krypton	0.727	0.727	0.000	0.00%	0.532	0.533	0.0008	0.15%	0.624	0.624	0.000	0.00%
					Xenon	0.689	0.689	0.000	0.00%	0.533	0.534	0.0010	0.19%	0.624	0.624	0.000	0.00%
22				4/12/4/12/4	Air	1.028	1.028	0.000	0.00%	0.531	0.532	0.0009	0.18%	0.624	0.624	0.000	0.00%

ID	# Glazing Layers	Glazing				U-factor (W/m^2-K)				SHGC (-)				VT (-)			
		Glass	emiss.	Glass / Gap / Glass (mm)	Gas	W5	W6	DIFF	DIFF (%)	W5	W6	DIFF	DIFF (%)	W5	W6	DIFF	DIFF (%)
					Argon	0.834	0.834	0.000	0.00%	0.532	0.532	0.0008	0.16%	0.624	0.624	0.000	0.00%
					Krypton	0.739	0.739	0.000	0.00%	0.532	0.533	0.0010	0.19%	0.624	0.624	0.000	0.00%
					Xenon	0.718	0.718	0.000	0.00%	0.533	0.535	0.0017	0.32%	0.624	0.624	0.000	0.00%
23		Two Panes Coated (Surface # 2 and # 5)	0.04	4/6/4/6/4	Air	1.497	1.497	0.000	0.00%	0.309	0.310	0.0010	0.33%	0.533	0.533	0.000	0.00%
					Argon	1.170	1.170	0.000	0.00%	0.308	0.308	0.0008	0.26%	0.533	0.533	0.000	0.00%
					Krypton	0.768	0.768	0.000	0.00%	0.305	0.306	0.0006	0.18%	0.533	0.533	0.000	0.00%
					Xenon	0.568	0.568	0.000	0.00%	0.304	0.305	0.0000	0.00%	0.533	0.533	0.000	0.00%
24				4/9/4/9/4	Air	1.121	1.121	0.000	0.00%	0.307	0.308	0.0008	0.25%	0.533	0.533	0.000	0.00%
					Argon	0.866	0.866	0.000	0.00%	0.306	0.306	0.0006	0.20%	0.533	0.533	0.000	0.00%
					Krypton	0.608	0.608	0.000	0.00%	0.304	0.305	0.0000	0.00%	0.533	0.533	0.000	0.00%
					Xenon	0.570	0.570	0.000	0.00%	0.304	0.305	0.0006	0.20%	0.533	0.533	0.000	0.00%
25				4/12/4/12/4	Air	0.924	0.924	0.000	0.00%	0.306	0.307	0.0006	0.21%	0.533	0.533	0.000	0.00%
					Argon	0.720	0.720	0.000	0.00%	0.305	0.305	0.0005	0.17%	0.533	0.533	0.000	0.00%
					Krypton	0.622	0.622	0.000	0.00%	0.304	0.305	0.0006	0.19%	0.533	0.533	0.000	0.00%
					Xenon	0.600	0.600	0.000	0.00%	0.305	0.306	0.0009	0.30%	0.533	0.533	0.000	0.00%
26	Quadruple Glazing	Two Panes Coated (Surface # 2 and # 5)	0.04	4/12/4/12/4/12/4	Air	0.788	0.788	0.000	0.00%	0.283	0.284	0.0007	0.25%	0.485	0.485	0.000	0.00%
					Argon	0.625	0.625	0.000	0.00%	0.284	0.284	0.0006	0.21%	0.485	0.485	0.000	0.00%
					Krypton	0.534	0.534	0.000	0.00%	0.285	0.286	0.0006	0.20%	0.485	0.485	0.000	0.00%
					Xenon	0.514	0.514	0.000	0.00%	0.286	0.287	0.0010	0.35%	0.485	0.485	0.000	0.00%
	Max. Diff.							**0.00**	**0.00%**			**0.002**	**0.59%**			**0.00**	**0.00%**

3. Whole Product Comparison

In order to evaluate the difference in results between WINDOW 5.2.17a and WINDOW 6.3 produce the same results for whole product calculations, nine different products were calculated in both programs. WINDOW 6.3.1 and THERM 6.3.1 were used for these comparisons.

3.1. Description of Products

The nine products that were compared were:

1. Kawneer 1600 S1 Curtain Wall (thermally improved aluminum frame, aluminum spacer)
2. CW3 Curtain Wall (thermally improved aluminum frame, aluminum spacer)
3. Fiberglass Casement Window (fiberglas frame, aluminum spacer)
4. PFM Casement Window (wood frame, aluminum spacer)
5. PVC Casement Window (PVC frame, aluminum swiggle spacer)
6. Velux FS87 Skylight (aluminum clad wood frame, SST spacer)
7. NFRC Test Round Robin 2001 (TRR01)
   Fixed Window (thermally broken aluminum frame, aluminum spacer)
8. NFRC Test Round Robin 1997 (TRR97)
   Fixed Window (aluminum clad wood frame, galvanized steel spacer)
9. NFRC Test Round Robin 1999 (TRR 99)
   Horizontal Slider Window (aluminum frame, galvanized steel spacer)

3.2. Whole Product Results

The whole product results, compared between WINDOW5 / THERM 5 and WINDOW 6 / THERM 6, are summarized below and detailed in Table 2. Differences in results smaller than 0.0005 were disregarded.

3.2.1. U-factor

The U-factor change due to the frame cavity emissivity bug fix was analyzed before the vertical jamb cavity change was implemented, and resulted in U-factor changes of less than 0.01. See Table 3 for the frame cross section results.

When the vertical cavity change was implemented in THERM 6, the maximum change to the whole product U-factors was 0.040, or 1.98% difference from the WINDOW 5 / THERM 5 values.

3.2.2. Tvis

The percentage difference for Tvis is 0% in all cases.

3.2.3. SHGC

The SHGC change resulted in a very slight difference in results between WINDOW 5/ THERM 5 and WINDOW 6 / THERM 6. The maximum difference in the values is 0.005, or 1.38%.

3.2.4. CR

The CR calculation method resulted in a maximum difference between WINDOW 5/ THERM 5 and WINDOW 6 / THERM 6 of 0.217, or 1.18%.

Table 2. Comparison of WINDOW 5 and WINDOW 6 for whole product U-factor, SHGC, VT in SI Units

Product Ref.	Product Type	Material: Frame / Spacer	Glazing System	Size		U-factor (W/m^2-K)				SHGC				VT				CR			
				Width (mm)	Height (mm)	T5/ W5	T6/ W6	DIFF	DIFF (%)	T5/ W5	T6/ W6	DIFF	DIFF (%)	T5/ W5	T6/ W6	DIFF	DIFF (%)	T5/ W5	T6/ W6	DIFF	DIFF (%)
Kawneer 1600 S1	Curtain Wall	TI AL / AL	Clr-6_Air_Clr-6	2032	2032	3.482	3.482	0.000	0.00%	0.607	0.609	0.002	0.32%	0.664	0.664	0.000	0.00	30.068	30.136	0.068	0.23%
CW3	Curtain Wall	TI AL (e=0.2) / AL	Clr-6_Air_Clr-6	2032	2032	3.126	3.127	0.000	0.00%	0.612	0.614	0.004	0.65%	0.676	0.676	0.000	0.00	15.847	16.013	0.166	1.05%
		TI AL (e=0.9) / AL		2032	2032	3.440	3.439	-0.001	-0.04%	0.616	0.618	0.002	0.33%	0.676	0.676	0.000	0.00	21.530	21.741	0.212	0.98%
Fiberglass	Casement	Fiberglass / AL	Clr-6_Air_LowE 272-6	600	1500	2.032	1.992	-0.040	-1.98%	0.338	0.333	-0.005	-1.38%	0.483	0.483	0.000	0.00	49.941	50.021	0.081	0.16%
PFM	Casement	Wood / AL	Clr-5-Air-Clr-5	914.4	1219.2	2.685	2.683	-0.002	-0.07%	0.627	0.629	0.002	0.26%	0.682	0.682	0.000	0.00	39.681	39.785	0.105	0.26%
			Lowe179-5_Air_Clr5	914.4	1219.2	2.019	2.018	-0.002	-0.09%	0.529	0.530	0.001	0.15%	0.654	0.654	0.000	0.00	46.758	46.927	0.169	0.36%
PVC	Casement	PVC / AL Swiggle	LowE_037-Air-Clr	609.6	1219.2	1.830	1.801	-0.029	-1.59%	0.256	0.256	0.000	0.00%	0.384	0.384	0.000	0.00	56.099	56.151	0.052	0.09%
Velux - FS87	Skylight	AL Clad Wood / SST	Lowe270-3_Ar_Clr-3	547.878	1314.45	3.111	3.111	0.000	0.00%	0.352	0.352	0.001	0.17%	0.665	0.665	0.000	0.00	49.239	49.235	-0.003	-0.01%
TRR01	Fixed	TB AL / AL	CmftE2-3_Air_HMSC75_Air_CmftE2-3	1016	1016	1.899	1.894	-0.005	-0.26%	0.274	0.275	0.001	0.33%	0.414	0.414	0.000	0.00	40.002	40.219	0.217	0.54%
TRR97	Fixed	AL Clad Wood / Galv. Steel	LowE272-5_Air_Clr-5	1219.2	1219.2	1.956	1.956	0.000	0.00%	0.346	0.346	0.001	0.21%	0.596	0.596	0.000	0.00	47.023	47.227	0.204	0.43%
TRR99	Hor. Slider	AL / Galv. Steel	Clr-3_Air_HMSC75_Air_S500CL-3	1524	914.4	2.760	2.760	0.000	0.00%	0.313	0.315	0.001	0.40%	0.500	0.500	0.000	0.00	14.393	14.564	0.170	1.18%
Max Diff								**0.040**	**1.98%**			**0.005**	**1.38%**			**0.000**	**0.00**			**0.217**	**1.18%**

3.3. Frame Cross Sections

Table 3. Comparison of WINDOW 5 and WINDOW 6 for Frame Cross Section U-factor in SI Units

		U-factor Frame (W/m^2-K)				U-factor Edge (W/m^2-K)			
ID	**Name**	**W5/T5**	**W6/T6**	**DIFF**	**DIFF %**	**W5 /T5**	**W6/T6**	**DIFF**	**DIFF %**
11	Kawneer 1600 head (1600S1_hd.thm)	7.227	7.227	0.000	0.00%	2.861	2.861	0.000	0.00%
12	Kawneer 1600 jamb (1600S1_jb.thm)	7.219	7.218	-0.001	-0.02%	2.858	2.858	0.000	0.00%
13	Kawneer 1600 meeting rail (1600S1_mr.thm)	9.813	9.808	-0.005	-0.05%	2.792	2.792	0.000	0.00%
14	Kawneer 1600 sill (1600S1_si.thm)	7.206	7.206	0.000	0.00%	2.860	2.860	0.000	0.00%
21	CW3 head (CW3_hd_02.thm)	5.301	5.301	0.000	0.00%	3.116	3.116	0.000	0.00%
22	CW3 jamb (CW3_jb_02.thm)	5.284	5.283	-0.001	-0.02%	3.110	3.110	0.000	0.00%
23	CW3 meeting rail (CW3_mr_02.thm)	7.119	7.119	0.000	0.00%	3.111	3.111	0.000	0.00%
24	CW3 sill (CW3_si_02.thm)	5.268	5.268	0.000	0.00%	3.097	3.097	0.000	0.00%
25	C CW3 head (W3_hd_09.thm)	7.646	7.646	0.000	0.00%	2.917	2.917	0.000	0.00%
26	CW3 jamb (CW3_jb_09.thm)	7.659	7.628	-0.031	-0.41%	2.919	2.918	-0.001	-0.02%
27	CW3 meeting rail (CW3_mr_09.thm)	9.927	9.925	-0.002	-0.02%	2.928	2.929	0.001	0.02%
28	CW3 sill (CW3_si_09.thm)	7.628	7.628	0.000	0.00%	2.906	2.906	0.000	0.00%
31	Fiberglass Casement head (Fiberglass_hd.thm)	2.109	2.109	0.000	0.00%	2.454	2.454	0.000	0.00%
32	Fiberglass Casement jabm (Fiberglass_jb.thm)	2.310	2.132	-0.178	-7.71%	2.450	2.448	-0.002	-0.08%
33	Fiberglass Casement sill (Fiberglass_si.thm)	2.109	2.109	0.000	0.00%	2.454	2.454	0.000	0.00%
41	PFM Casement head (PFM01_hd.thm)	2.207	2.207	0.000	0.00%	3.014	3.014	0.000	0.00%
42	PFM Casement jamb (PFM01_jb.thm)	2.223	2.203	-0.020	-0.90%	3.014	3.013	-0.001	-0.03%
43	PFM Casement sill (PFM01_si.thm)	2.206	2.206	0.000	0.00%	3.013	3.013	0.000	0.00%
44	PFM Casement head (PFM02_hd.thm)	2.184	2.184	0.000	0.00%	2.420	2.420	0.000	0.00%
45	PFM Casement jamb (PFM02_jb.thm)	2.200	2.180	-0.020	-0.92%	2.421	2.420	-0.001	-0.03%
46	PFM Casement sill (PFM02_si.thm)	2.184	2.184	0.000	0.00%	2.420	2.420	0.000	0.00%
51	PVC Casement head (PVC_hd.thm)	1.780	1.780	0.000	0.00%	2.032	2.032	0.000	0.00%
52	PVC Casement jamb (PVC_jb.thm)	1.826	1.728	-0.098	-5.36%	2.050	2.038	-0.012	-0.61%
53	PVC Casement sill (PVC_si.thm)	1.777	1.777	0.000	0.00%	2.031	2.031	0.000	0.00%
61	Velux FS95 Skylight head (FS95_hd_75_c_20.thm)	24.803	24.803	0.000	0.00%	2.416	2.416	0.000	0.00%
62	Velux FS95 Skylight jamb (FS95_jb_75_c_20.thm)	24.838	24.838	0.000	0.00%	2.415	2.415	0.000	0.00%
63	Velux FS95 Skylight sill (FS95_si_75_c_20.thm)	11.301	11.301	0.000	0.00%	2.132	2.132	0.000	0.00%
71	Round Robin 2001 head (TRR01_hd.thm)	3.604	3.592	-0.012	-0.33%	1.753	1.747	-0.006	-0.32%

		U-factor Frame (W/m^2-K)				U-factor Edge (W/m^2-K)			
ID	**Name**	**W5/T5**	**W6/T6**	**DIFF**	**DIFF %**	**W5 /T5**	**W6/T6**	**DIFF**	**DIFF %**
72	Round Robin 2001 jamb (TRR01_jb.thm	3.660	3.640	-0.020	-0.53%	1.754	1.749	-0.005	-0.30%
73	Round Robin 2001 sill (TRR01_si.thm)	3.603	3.591	-0.012	-0.32%	1.753	1.747	-0.006	-0.32%
81	Round Robin 1997 head (TRR97_hd.thm)	2.501	2.501	0.000	0.00%	2.361	2.361	0.000	0.00%
82	Round Robin 1997 jamb (TRR97_jb.thm)	2.522	2.519	-0.003	-0.12%	2.367	2.366	-0.001	-0.02%
83	Round Robin 1997 sill (TRR97_si.thm)	2.503	2.503	0.000	0.00%	2.361	2.362	0.001	0.02%
91	Round Robin 1999 head fixed (TRR99_hf.thm)	9.377	9.378	0.001	0.01%	2.144	2.145	0.001	0.07%
92	Round Robin 1999 head vented (TRR99_hv.thm)	4.549	4.551	0.002	0.04%	2.544	2.547	0.003	0.12%
93	Round Robin 1999 jamb fixed (TRR99_jf.thm)	10.218	10.213	-0.005	-0.05%	2.129	2.129	0.000	0.00%
94	Round Robin 1999 jamb vented (TRR99_jv.thm)	4.437	4.440	0.003	0.06%	2.560	2.565	0.005	0.20%
95	Round Robin 1999 meeting rail (TRR99_mr.thm)	9.718	9.714	-0.004	-0.04%	2.343	2.342	-0.001	-0.04%
96	Round Robin 1999 sill fixed (TRR99_sf.thm)	12.593	12.600	0.007	0.05%	2.238	2.240	0.002	0.07%
97	Round Robin 1999 sill vented (TRR99_sv.thm)	4.543	4.554	0.011	0.25%	2.548	2.555	0.007	0.28%
	Max			**0.178**	**7.71%**			**0.012**	**0.61%**

The figures below show the frame cross sections for each of the whole products.

3.3.1. Kawneer 1600 S1 Curtain Wall

This is a thermally improved aluminum frame with an aluminum spacer

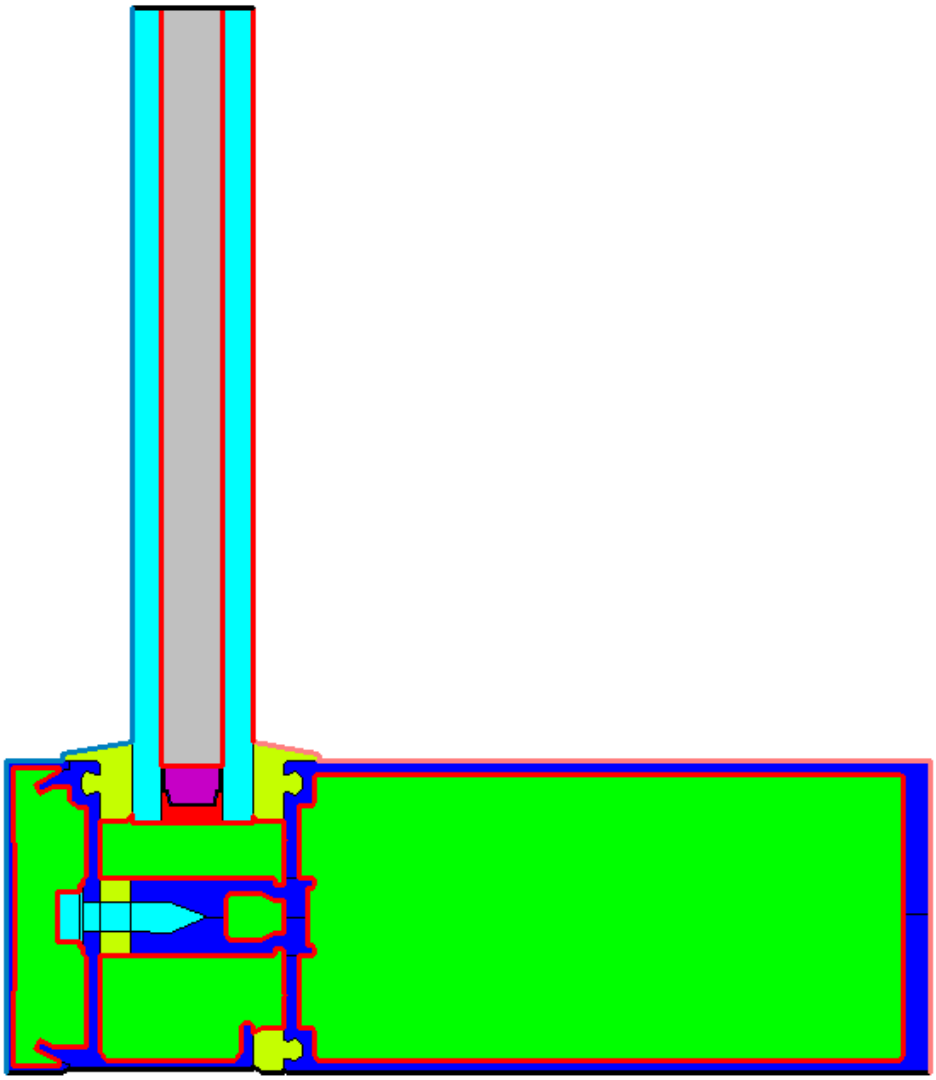


Figure 1. Kawneer 1600 S1 Frame cross-section.

3.3.2. CW3 Curtain Wall

This is a thermally improved aluminum frame with an aluminum spacer

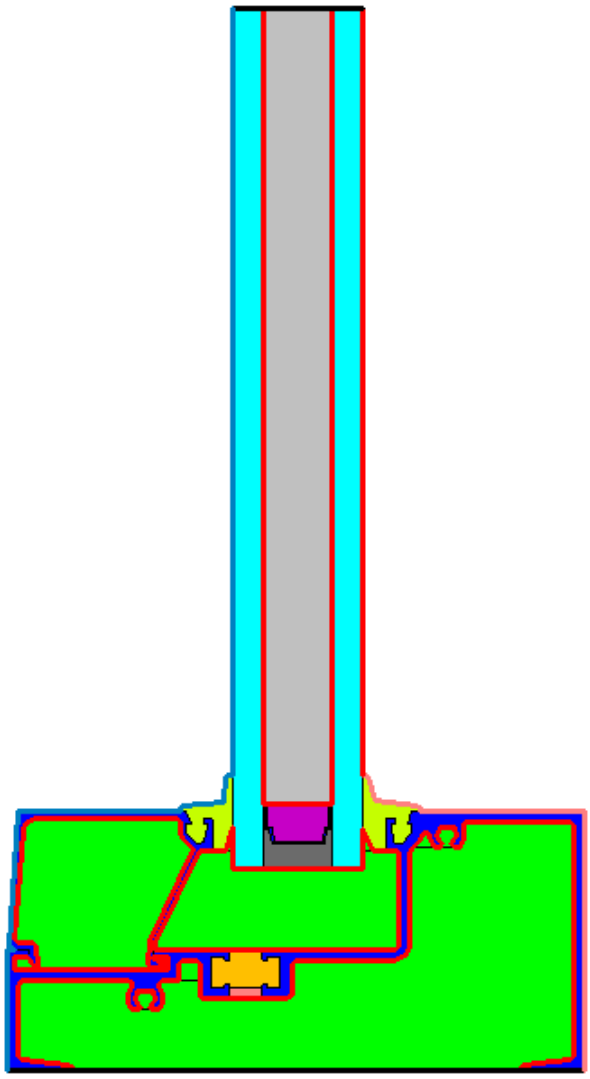


Figure 2. CW3 Curtain Wall Frame cross-section

3.3.3. Fiberglass Casement Window

This is a fiberglas frame with an aluminum spacer

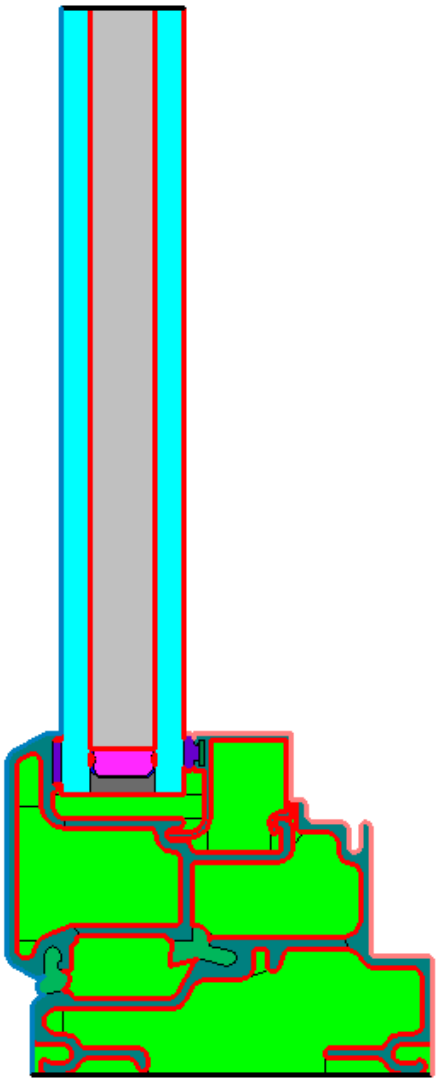


Figure 3. Fiberglass Casement Window frame cross-section

3.3.4. PFM Casement Window

This is a wood frame with an aluminum spacer

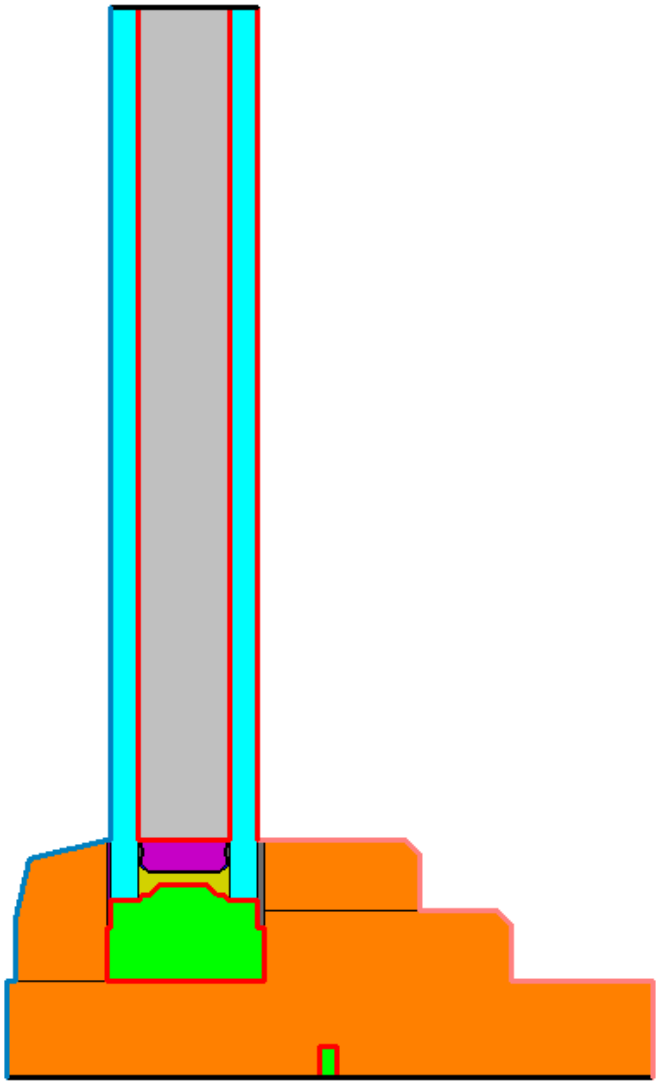


Figure 4. PFM Casement Window Frame cross-section

3.3.5. PVC Casement Window

This is a PVC (vinyl) frame with an aluminum Swiggle spacer

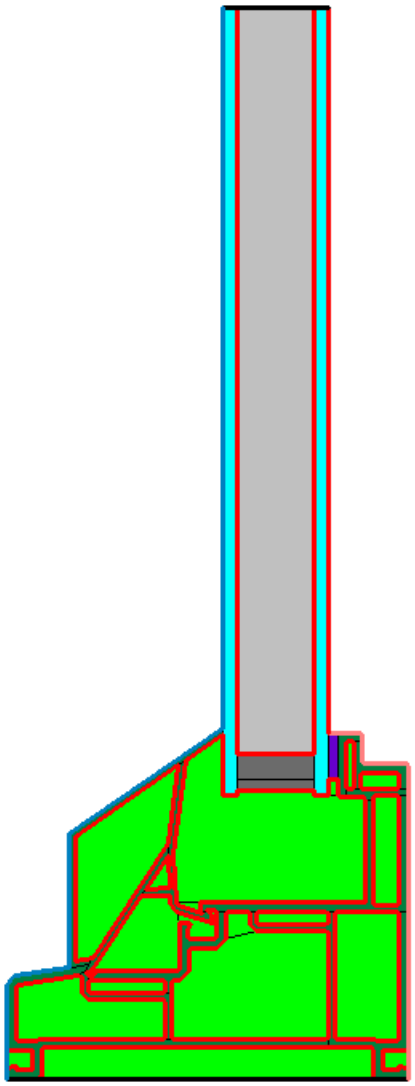


Figure 5. PVC Casement Window Frame cross-section

3.3.6. Velux FS87 Skylight

This is an aluminum clad wood frame with an SST spacer

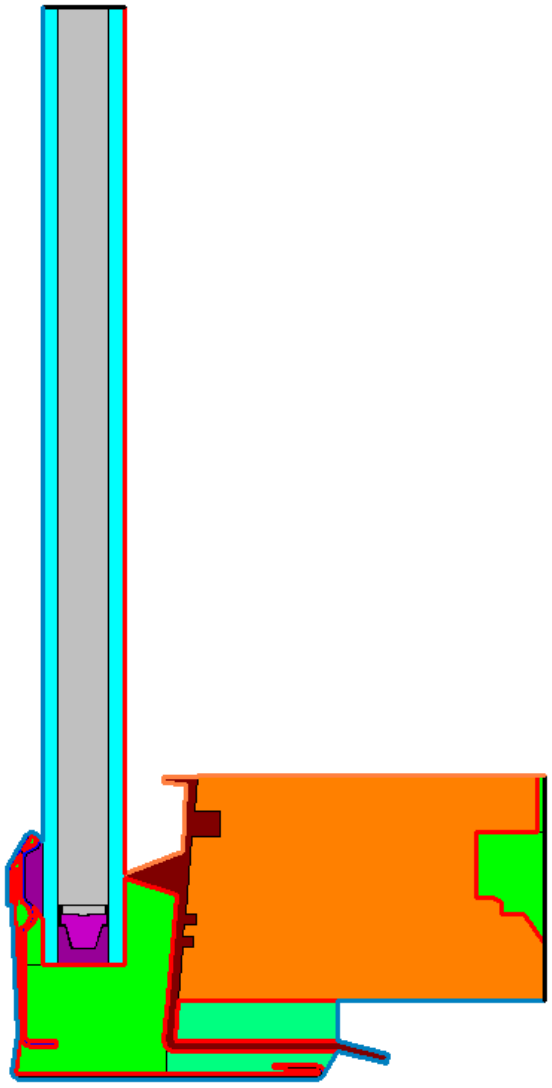


Figure 6.Velux FS87 Skylight Frame cross-section

3.3.7. TRR01 Fixed Window

This is a thermally broken aluminum frame with an aluminum spacer

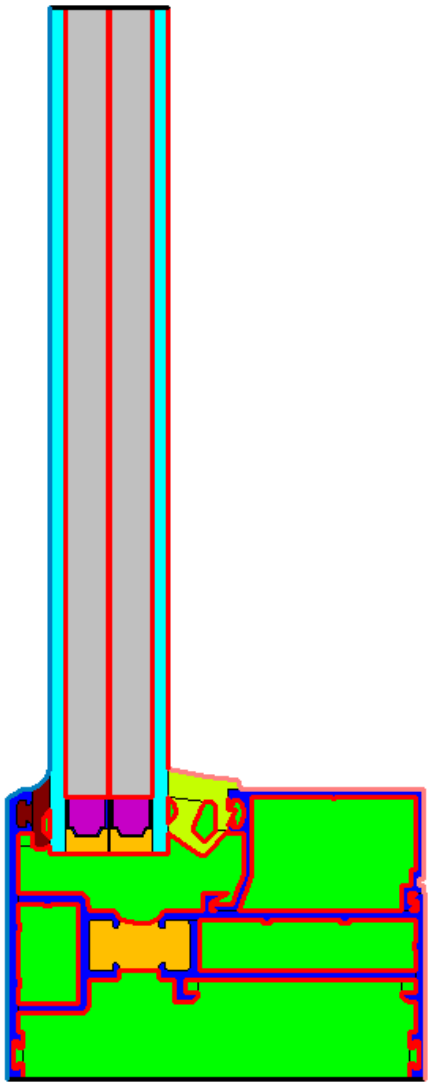


Figure 7. TRR01 Fixed Window Frame cross-section

3.3.8. TRR97 Fixed Window

This is an aluminum clad wood frame with a galvanized steel spacer

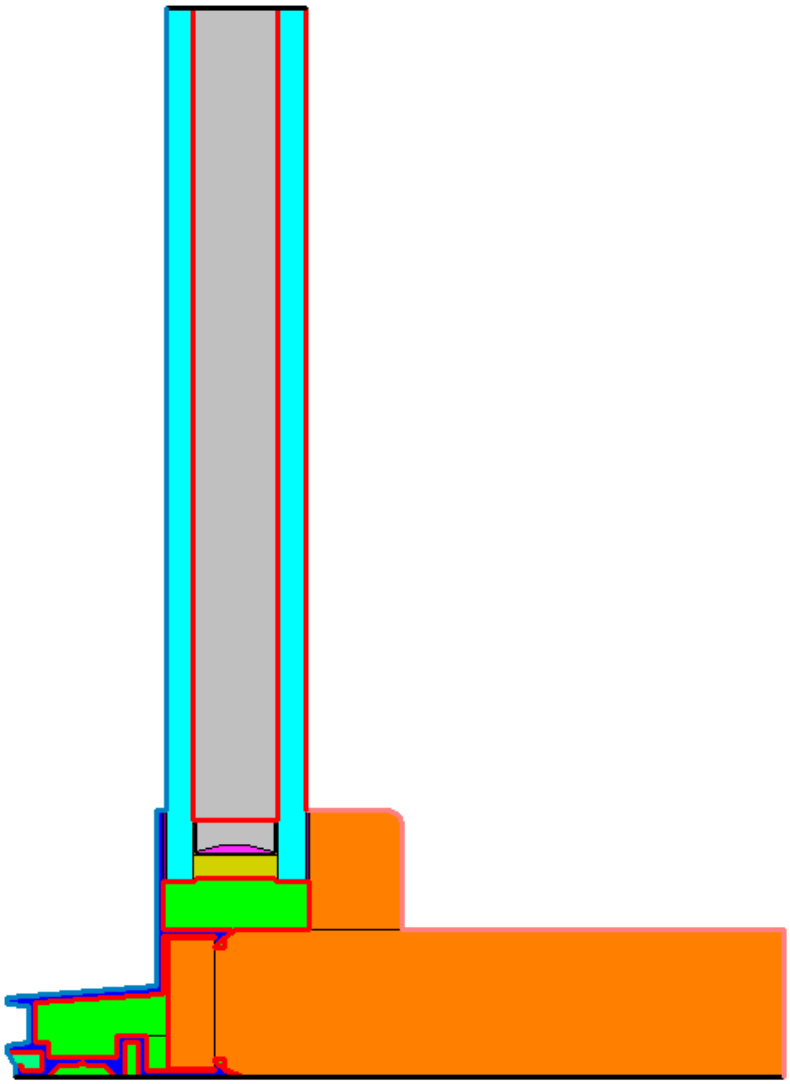


Figure 8. TRR97 Fixed Window Frame cross-section

3.3.9. TRR99 Horizontal Slider Window

This is an aluminum frame with a galvanized steel spacer

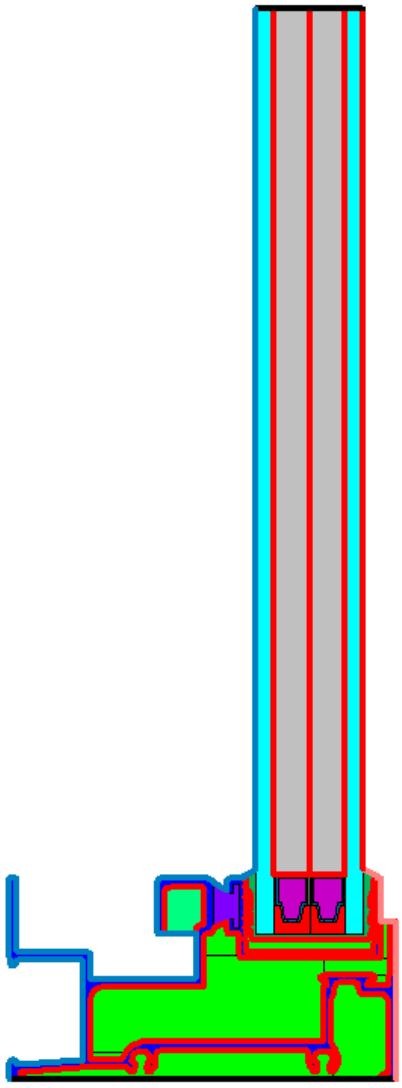


Figure 9. TRR99 Horizontal Slider Frame cross-section

3.4. Glazing System Descriptions

The following table describes the glazing systems used in the whole product calculations. The results for U-factor, SHGC, and VT are from WINDOW 6 calculations.

Table 4. Glazing Systems used in the whole product calculations

No	Name		Thick (mm)	U-factor (W/m^2-K)	SHGC	VT	Tsol	Rout sol	Rin sol	Rout vis	Rin vis	Tuv
1	**Clr-6_Air_Clr-6**		24.700	2.684	0.703	0.791	0.6071	0.1174	0.1183	0.1524	0.1520	0.5011
	5012	CLEAR_6.PPG										
		Air										
	5012	CLEAR_6.PPG										
2	**Clr-6_Air_Clr-6**		25.401	2.677	0.704	0.786	0.6069	0.1137	0.1140	0.1436	0.1436	0.4626
	103	CLEAR_6.DAT										
		Air										
	103	CLEAR_6.DAT										
3	**Clr-6_Air_LowE272-6**		25.401	1.829	0.475	0.699	0.3479	0.2216	0.4380	0.0918	0.1250	0.1418
	2004	Clr-6.CIG										
		Air										
	2014	LoE272-6.CIG										
4	**Clr-5-Air-Clr-5**		26.510	2.710	0.742	0.810	0.6672	0.1208	0.1208	0.1451	0.1451	0.5107
	2003	Clr-5.CIG										
		Air										
	2003	Clr-5.CIG										
5	**Lowe179-5_Air_Clr5**		26.510	1.851	0.625	0.776	0.5530	0.1717	0.1802	0.1319	0.1400	0.2198
	2186	LoE179-5.CIG										
		Air										
	2003	Clr-5.CIG										
6	**LowE_037-Air-Clr**		21.875	1.724	0.398	0.614	0.3615	0.4095	0.3904	0.2376	0.2873	0.2928
	917	CMFTIAC3.AFG										
		Air										
	102	CLEAR_3.DAT										
7	**Lowe270-3_Ar_Clr-3**		15.901	2.014	0.370	0.702	0.3386	0.3864	0.4074	0.1269	0.1216	0.1443
	2026	LoE270-3.CIG										
		Argon										
	2001	Clr-3.CIG										
8	**CmftE2-3_Air_HMSC75_Air_CmftE2-3**		15.901	2.014	0.370	0.702	0.3386	0.3864	0.4074	0.1269	0.1216	0.1443
	907	CMFTE2_3.AFG										
		Air										
	1510	HMSC75.SWT										
		Air										
	907	CMFTE2_3.AFG										

No	Name		Thick (mm)	U-factor (W/m^2-K)	SHGC	VT	Tsol	Rout sol	Rin sol	Rout vis	Rin vis	Tuv
9	**LowE272-5_Air_Clr-5**		25.875	1.719	0.407	0.707	0.3614	0.3082	0.3290	0.1143	0.1048	0.1491
	2013	LoE272-5.CIG										
		Air										
	2003	Clr-5.CIG										
10	**Clr-3_Air_HMSC75_Air_S500CL-3**		18.497	1.734	0.356	0.582	0.2730	0.4061	0.3268	0.2193	0.2450	0.0092
	5009	CLEAR_3.PPG										
		Air										
	1510	HMSC75.SWT										
		Air										
	5242	S500CL_3.PPG										

3.5. Glass Layer Descriptions

The table below describes the glass layers that were used in the glazing systems for the comparison analysis.

Table 5. Description of the glass layers used in the glazing system definitions for the calculated products

No	ID	Name	Thick (mm)	Tsol	Rsol1	Rsol2	Tvis	Rvis1	Rvis2	emis1	emis2	Manufacturer	Product Name
1	102	CLEAR_3.DAT	3.048	0.834	0.075	0.075	0.899	0.083	0.083	0.840	0.840	Generic	Generic Clear Glass
2	103	CLEAR_6.DAT	5.715	0.771	0.070	0.070	0.884	0.080	0.080	0.840	0.840	Generic	Generic Clear Glass
3	907	CMFTE2_3.AFG	3.099	0.695	0.115	0.101	0.830	0.096	0.087	0.204	0.840	AFG Industries	Comfort E² on Clear
4	917	CMFTIAC3.AFG	3.150	0.411	0.457	0.391	0.672	0.189	0.249	0.037	0.840	AFG Industries	Comfort Ti-AC LowE on Clear
5	1510	HMSC75.SWT	0.076	0.375	0.460	0.460	0.756	0.128	0.107	0.755	0.055	Southwall Technologies, Inc.	Heat Mirror™ Solar Control 75 Suspended Film
6	2001	Clr-3.CIG	2.970	0.848	0.076	0.076	0.904	0.082	0.082	0.840	0.840	Cardinal Glass Industries	Float Glass - 3mm
7	2003	Clr-5.CIG	4.750	0.811	0.072	0.072	0.897	0.080	0.080	0.840	0.840	Cardinal Glass Industries	Float Glass - 5mm
8	2004	Clr-6.CIG	5.660	0.786	0.071	0.071	0.890	0.081	0.081	0.840	0.840	Cardinal Glass Industries	Float Glass - 6mm
9	2013	LoE272-5.CIG	4.750	0.417	0.287	0.417	0.786	0.055	0.042	0.840	0.042	Cardinal Glass Industries	LoE² 272 on 5 mm Clear
10	2014	LoE272-6.CIG	5.700	0.409	0.264	0.417	0.781	0.055	0.042	0.840	0.042	Cardinal Glass Industries	LoE² 272 on 6 mm Clear
11	2026	LoE270-3.CIG	3.000	0.379	0.367	0.467	0.772	0.072	0.054	0.840	0.037	Cardinal Glass Industries	LoE² 270 on 3mm Clear
12	2186	LoE179-5.CIG	4.750	0.665	0.135	0.167	0.861	0.080	0.064	0.840	0.110	Cardinal Glass Industries	LoE 179 on 5mm Clear
13	5009	CLEAR_3.PPG	3.277	0.827	0.076	0.077	0.898	0.086	0.086	0.840	0.840	PPG Industries	Clear Glass
14	5012	CLEAR_6.PPG	5.664	0.771	0.072	0.073	0.886	0.085	0.085	0.840	0.840	PPG Industries	Clear Glass
15	5242	S500CL_3.PPG	3.277	0.705	0.126	0.108	0.833	0.113	0.109	0.215	0.840	PPG Industries	Sungate® 500 on Clear

3.6. Spacer Descriptions

Table 6. Description of the spacers used for the comparison calculations in SI Units

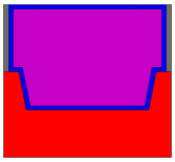
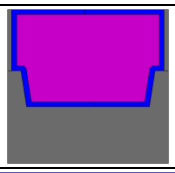
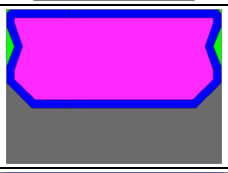
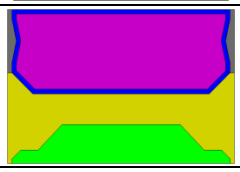
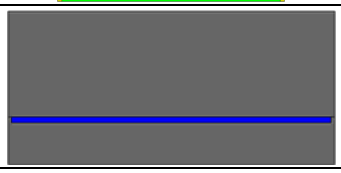
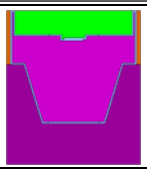
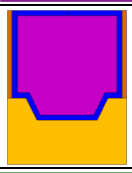
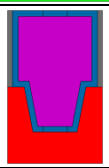
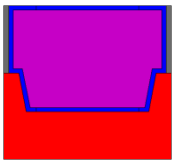
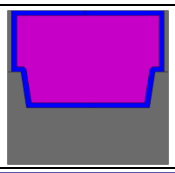
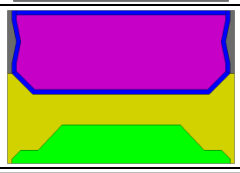
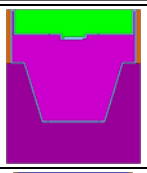
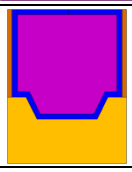
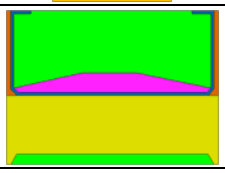
No	Spacer Type	Manufacturer	Keff (W/m-K)	Applied in Product	
1	Standard Aluminum	Allmetal	1.530	Kawneer 1600 S1	
2	Standard Aluminum	Allmetal	0.999	CW3	
3	LPD Aluminum		1.013	Fiberglass	
4	LPD Aluminum		0.889	PFM	
5	Swiggle Aluminum	TruSeal	0.815	PVC	
6	Stanless Steel	Cardinal	0.372	Skylight	
7	250P Aluminum	Allmetal	0.565	TRR01	
8	Intercept Galvanized Steel	PPG	0.670	TRR97	
9	Standard Black Steel	Allmetal	1.002	TRR99	

Table 7. Description of the spacers used for the comparison calculations in IP Units

No	Spacer Type	Manufacturer	Keff (Btu/hr-ft-F)	Applied in Product	
1	Standard Aluminum	Allmetal	0.884	Kawneer 1600 S1	
2	Standard Aluminum	Allmetal	0.577	CW3	
3	LPD Aluminum		0.585	Fiberglass	
4	LPD Aluminum		0.514	PFM	
5	Swiggle Aluminum	TruSeal	0.471	PVC	
6	Stanless Steel	Cardinal	0.215	Skylight	
7	250P Aluminum	Allmetal	0.327	TRR01	
8	Intercept Galvanized Steel	PPG	0.387	TRR97	
9	Standard Black Steel	Allmetal	0.579	TRR99