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Technical Report:

Verification of CMAST

Report prepared for:

National Fenestration Rating Council, Inc.

1300 Spring Street, Suite 500
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August 21, 2009

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EXECUTIVE SUMMARY

This technical report provides results of the verification of calculations done by CMAST 1.0. Verification is done for a number of specimens covering broad range of typical fenestration products. Each unique frame assembly is verified with the number of typical glazing and spacer options, covering the range of glazing and spacer options currently available. Prior to this verification of the CMAST calculation, separate verification of the WINDOW and THERM programs was done and documented in a separate report (LBNL 2009).

Twelve unique frame assemblies were considered, each paired with 21 glazing/spacer options and one of those at two different angles of inclination (20° and 90°), for a total of 273 products. For each of the products comparison was made between CMAST results, spreadsheet generated results, W6/T6 generated results and test results, where available.

Results of the verification were judged by the level of differences between CMAST and spreadsheet, while T6/W6 and test results were provided as reference points. Differences between CMAST and spreadsheet initially revealed differences, which helped debug CMAST calculation module. There were two rounds of comparison that produced differences, after which changes were made to CMAST to fix bugs and incorrect implementation of the procedure, before the final results were produced. This final report is the summary of the comparison after all bugs and issues were addressed and so it shows no differences for all of the products analyzed, this completing verification process and assuring the CMAST algorithms are faithful implementation of the CMA procedure (NFRC 2009, Curcija et al. 2005).

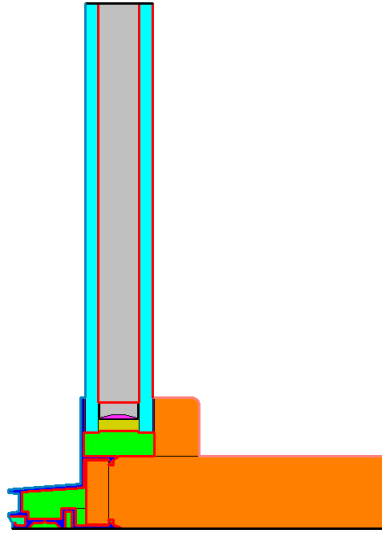
Comparison between T6/W6 and CMAST produced differences that were in line with the level of disagreement reported at the time CMA procedure was published (Curcija et al. 2005). These differences are for vast majority of products, particularly at NFRC size, less than 0.01 for all indices (i.e., U, SHGC, VT) and for few products at sizes other than NFRC, differences in U-factor reach 0.02, while for SHGC and VT they consistently remain below 0.01.

SELECTION OF SPECIMENS:

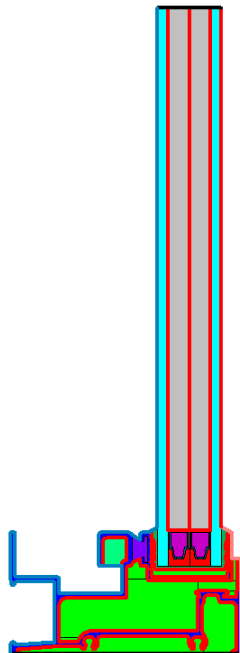
Twelve unique frame assemblies were considered, each paired with 21 glazing/spacer options and one of those at two different angles of inclination (20° and 90°), for a total of 273 products. For each of the products comparison was made between CMAST results, spreadsheet generated results, W6/T6 generated results and test results, where available.

The following unique frame assemblies were considered (images show one typical cross-section for each product):

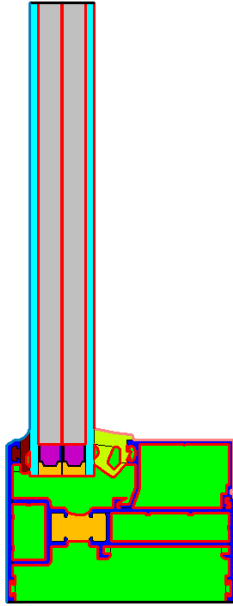
- 1) TRR-97 – Aluminum-Clad fixed Wood window (NFRC Test Round Robin 1997)



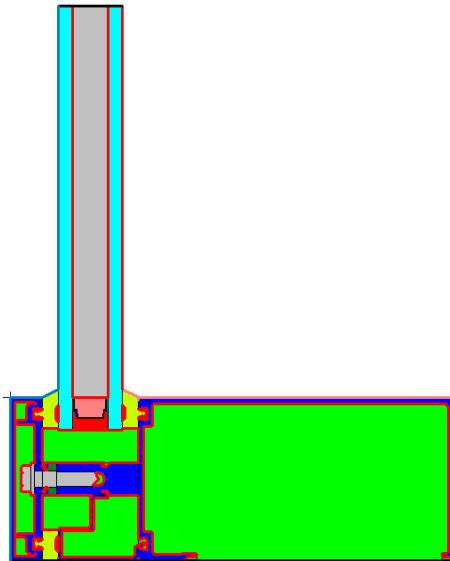
- 2) TRR-99 – Aluminum non-thermal horizontal slider window (NFRC Test Round Robin 1999)



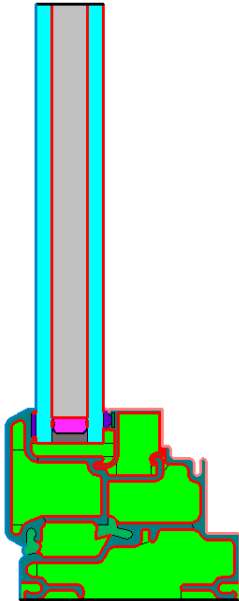
- 3) TRR-01 – Thermally-Broken Aluminum fixed window (NFRC Test Round Robin 2001)



- 4) TRR-02 – Thermally-broken Aluminum curtain wall (NFRC Test Round Robin 2002)



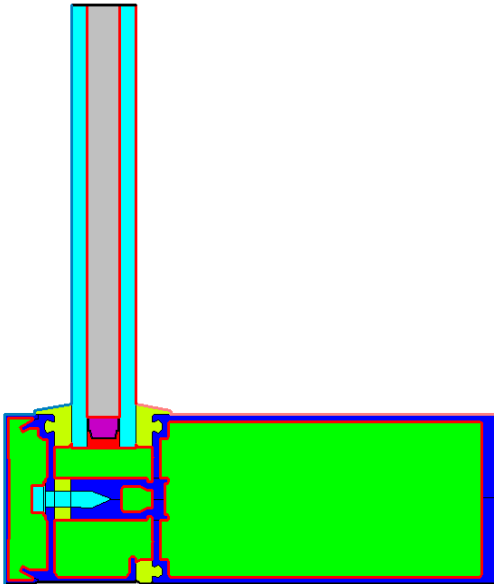
5) GF-6800 – Fiberglass casement window



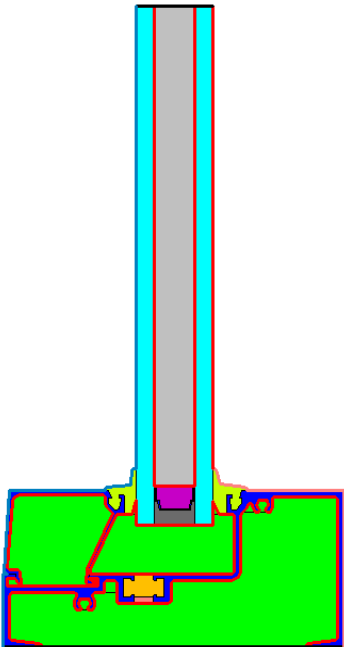
6) TR-4600 – PVC casement window



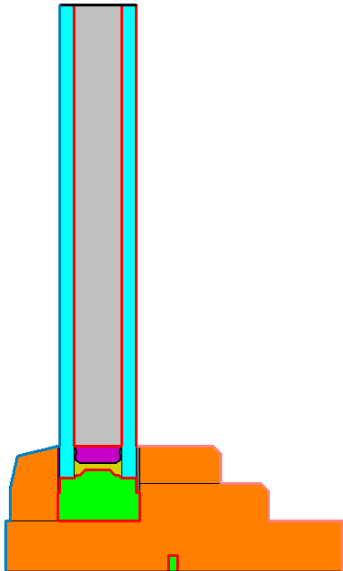
7) K1600-S1 – Thermally-Improved Aluminum curtain wall



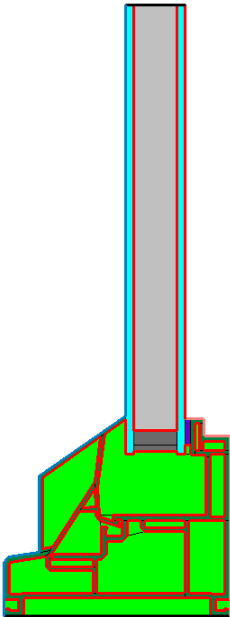
8) CW3 – Thermally-Broken Aluminum curtain wall



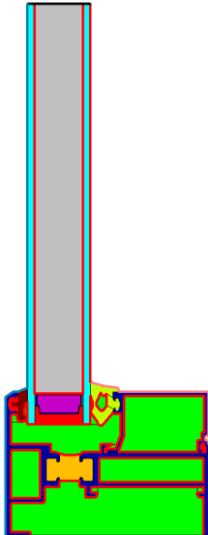
9) PFM – Wood fixed window (THERM sample window)



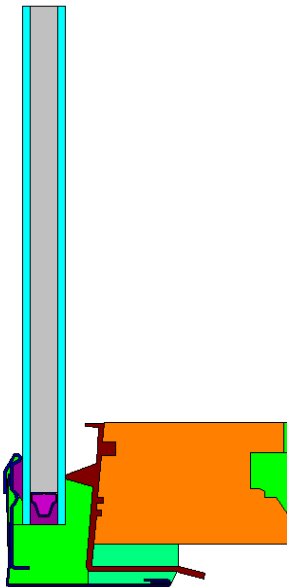
10) PVC – PVC casement window



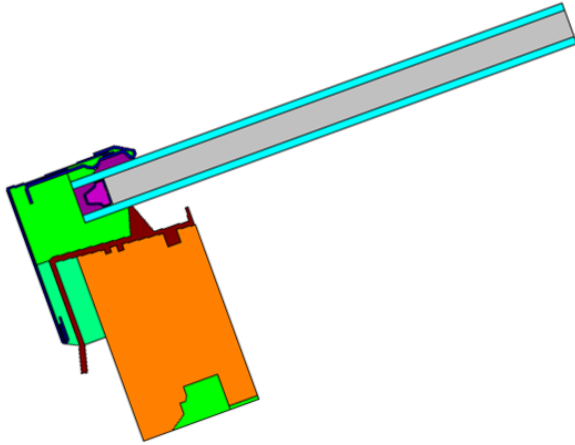
11) TR-3800 – Thermally-broken Aluminum fixed window



12) FS87 – Aluminum-clad Wood skylight (vertical)



13) FS87 – Aluminum-clad Wood skylight (20°)



The following glazing options were considered:

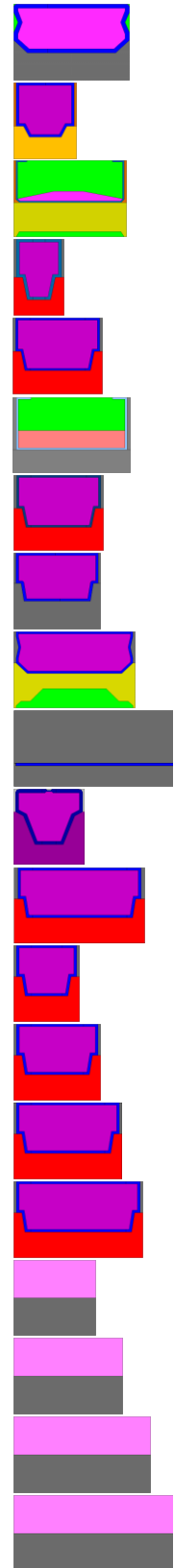
No	Name	ID 1	Gas Fill 1	ID 2	Gas Fill 2	ID 3
1	clr/arg/clr (5/8")	102	Argon	102		
2	clr/arg/clr (5/8") - 20 deg	102	Argon	102		
3	clr/arg/clr (3/4")	102	Argon	102		
4	clr/arg/clr (7/8")	102	Argon	102		
5	clr/arg/clr (1")	102	Argon	102		
6	CMFTi-R/arg/clr (5/8")	925	Argon	102		
7	CMFTi-R/arg/clr (5/8") - 20 deg	925	Argon	102		
8	CMFTi-R/arg/clr (3/4")	925	Argon	102		
9	CMFTi-R/arg/clr (7/8")	925	Argon	102		
10	CMFTi-R/arg/clr (1")	925	Argon	102		
11	LowE272-5_Air_Clr-5	2013	Air	2003		
12	Clr-3_Air_HMSC75_Air_S500CL-3	5009	Air	1510	Air	5242
13	CmftE2-3_Air_HMSC75_Air_CmftE2-3	907	Air	1510	Air	907
14	Clr-6_Air_Clr-6	103	Air	103		
15	Clr-6_Air_LowE272-6	2004	Air	2014		
16	Clr-3-Air-Clr-3	102	Air	102		
17	Clr-6_Air_Clr-6	5012	Air	5012		
18	Clr-6_Air_Clr-6	103	Air	103		
19	Clr-5-Air-Clr-5	2003	Air	2003		
20	LowE179-5_Air_Clr-5	2186	Air	2003		
21	LowE_037-Air-Clr	917	Air	102		
22	LowE270-3_Ar_Clr-3	2026	Argon	2001		
23	LowE270-3_Ar_Clr-3 - 20 deg	2026	Argon	2001		
24	CmftE2-3_Air_Clr-3	907	Air	102		

Glass Data:

No	ID	Name	Thick	Tsol	Rsol1	Rsol2	Tvis	Rvis1	Rvis2	emis1	emis2
1	102	CLEAR_3.DAT	0.120	0.834	0.075	0.075	0.899	0.083	0.083	0.840	0.840
2	103	CLEAR_6.DAT	0.225	0.771	0.070	0.070	0.884	0.080	0.080	0.840	0.840
3	907	CMFTE2_3.AFG	0.122	0.695	0.115	0.101	0.830	0.096	0.087	0.204	0.840
4	917	CMFTIAC3.AFG	0.124	0.411	0.457	0.391	0.672	0.189	0.249	0.037	0.840
5	925	CMFTIR_3.AFG	0.124	0.496	0.395	0.331	0.780	0.126	0.158	0.033	0.840
6	1510	HMSC75.SWT	0.003	0.375	0.460	0.460	0.756	0.128	0.107	0.755	0.055
7	2001	Clr-3.CIG	0.117	0.848	0.076	0.076	0.904	0.082	0.082	0.840	0.840
8	2003	Clr-5.CIG	0.187	0.811	0.072	0.072	0.897	0.080	0.080	0.840	0.840
9	2004	Clr-6.CIG	0.223	0.786	0.071	0.071	0.890	0.081	0.081	0.840	0.840
10	2013	LoE272-5.CIG	0.187	0.417	0.287	0.417	0.786	0.055	0.042	0.840	0.042
11	2014	LoE272-6.CIG	0.224	0.409	0.264	0.417	0.781	0.055	0.042	0.840	0.042
12	2026	LoE270-3.CIG	0.118	0.379	0.367	0.467	0.772	0.072	0.054	0.840	0.037
13	2186	LoE179-5.CIG	0.187	0.665	0.135	0.167	0.861	0.080	0.064	0.840	0.110
14	5009	CLEAR_3.PPG	0.129	0.827	0.076	0.077	0.898	0.086	0.086	0.840	0.840
15	5012	CLEAR_6.PPG	0.223	0.771	0.072	0.073	0.886	0.085	0.085	0.840	0.840
16	5242	S500CL_3.PPG	0.129	0.705	0.126	0.108	0.833	0.113	0.109	0.215	0.840

The following spacer options were considered:

No	Manufacturer	Model	Spacer Type	Width (in)	U (Btu/hr-ft ² -F)	Keff (Btu/hr-ft-F)	Applied in Product
1	Allmetal	LPD	Aluminum Single Seal	0.528	104.3658	5.206	Graham GF-6800
2	Allmetal	250P	Aluminum Dual Seal	0.338	29.4724	0.859	TRR01
3	PPG	Intercept LP	Galvanized Steel Dual Seal	0.625	9.7137	0.512	TRR97
4	Allmetal	Standard Black Steel	Black Steel Dual Seal	0.245	32.7526	0.693	TRR99
5	Allmetal	Standard Al	Aluminum Dual Seal	0.550	24.4873	1.154	TRR02
6	GED	Intercept	Stainless Steel Dual Seal	0.625	4.6014	0.241	TRACO TR-4600
7	Allmetal	Standard Al	Aluminum Dual Seal	0.500	26.9442	1.158	Kawneer 1600 S1
8	Allmetal	Standard Al	Aluminum Dual Seal	0.528	24.4730	1.107	CW3
9	Allmetal	LPD	Aluminum Dual Seal	0.650	21.0351	1.167	Marvin PFM
10	TruSeal	Swiggle Strip	Butyl with Aluminum substrate no seal	0.625	14.1834	0.751	PVC
11	Cardinal	XLA 12-098	Aluminum Dual Seal	0.390	13.1508	0.434	Velux FS87
12	Allmetal	Standard Al	Aluminum Dual Seal	0.764	20.2137	1.317	TRACO TR-3800
13	Allmetal	Standard Al	Aluminum Dual Seal	0.375	28.1699	0.909	Velux FS87
14	Allmetal	Standard Al	Aluminum Dual Seal	0.500	26.8035	1.152	TRR-99
15	Allmetal	Standard Al	Aluminum Dual Seal	0.625	25.6482	1.376	TRR-97; TR-4600; PVC
16	Allmetal	Standard Al	Aluminum Dual Seal	0.750	24.6154	1.583	TRR-01; TRR-02; GF-6800; 1600 S1, CW3; PFM; TR-3800
17	Edgetech	SuperSpacer Premium	Silicone Foam Single Seal	0.375	3.6726	0.115	Velux FS87
18	Edgetech	SuperSpacer Premium	Silicone Foam Single Seal	0.500	2.7574	0.115	TRR-99
19	Edgetech	SuperSpacer Premium	Silicone Foam Single Seal	0.625	2.2074	0.115	TRR-97; TR-4600; PVC
20	Edgetech	SuperSpacer Premium	Silicone Foam Single Seal	0.750	1.8403	0.115	TRR-01; TRR-02; GF-6800; 1600 S1, CW3; PFM; TR-3800



RESULTS

Results of the verification were judged by the level of differences between CMAST and spreadsheet, while T6/W6 and test results were provided as reference points. Differences between CMAST and spreadsheet initially revealed differences, which helped debug CMAST calculation module. There were two rounds of comparison that produced differences, after which changes were made to CMAST to fix bugs and incorrect implementation of the procedure, before the final results were produced. This final report is the summary of the comparison after all bugs and issues were addressed and so it shows no differences for all of the products analyzed, this completing verification process and assuring the CMAST algorithms are faithful implementation of the CMA procedure (NFRC 2009, Curcija et al. 2005).

Comparison between T6/W6 and CMAST produced differences that were in line with the level of disagreement reported at the time CMA procedure was published (Curcija et al. 2005). These differences are for vast majority of products, particularly at NFRC size, less than 0.01 for all indices (i.e., U, SHGC, VT) and for few products at sizes other than NFRC, differences in U-factor reach 0.02, while for SHGC and VT they consistently remain below 0.01.

Tables with comparison are shown on the next 13 pages. Yellow highlighted rows indicate NFRC standard size.

The column DIFF indicates absolute difference from CMAST to THERM6/WINODW6 (T6/W6). Negative numbers indicate that CMAST gives lower numbers, while positive number indicate that CMAST gives higher numbers. The difference between CMAST and spreadsheet is always 0, so there is no separate column that shows this difference.

TRR-97

Model	Product Type	Framing	Glazing System	Spacer	Size		U (Btu/hr-ft ² -F)					SHGC (-)				VT (-)					
					Width (in)	Height (in)	Spread sheet	CMAST	T6/W6	Test	DIFF	Spread sheet	CMAST	T6/W6	DIFF	Spread sheet	CMAST	T6/W6	DIFF		
TRR-97	Fixed	Aluminum-Clad Wood	clr/arg/clr (7/8")	Allmetal Standard Aluminum (5/8")	36	24	0.488	0.488	0.491		-0.003	0.573	0.573	0.575	-0.002	0.606	0.606	0.606	0.000		
					48	36	0.478	0.478	0.481		-0.003	0.628	0.628	0.629	-0.001	0.666	0.666	0.666	0.000		
					47.244	59.055	0.468	0.468	0.471		-0.003	0.655	0.655	0.656	-0.001	0.697	0.697	0.697	0.000		
					72	54	0.467	0.467	0.47		-0.003	0.671	0.671	0.672	-0.001	0.714	0.714	0.714	0.000		
					96	72	0.460	0.460	0.462		-0.002	0.693	0.693	0.694	-0.001	0.738	0.738	0.738	0.000		
					36	24	0.465	0.465	0.451		0.014	0.573	0.573	0.574	-0.001	0.606	0.606	0.606	0.000		
				Edgetech SuperSpacer Premium (5/8")	48	36	0.460	0.460	0.451		0.009	0.627	0.627	0.628	-0.001	0.666	0.666	0.666	0.000		
					47.244	59.055	0.454	0.454	0.448		0.006	0.655	0.655	0.656	-0.001	0.697	0.697	0.697	0.000		
					72	54	0.455	0.455	0.449		0.006	0.671	0.671	0.671	0.000	0.714	0.714	0.714	0.000		
					96	72	0.451	0.451	0.447		0.004	0.693	0.693	0.693	0.000	0.738	0.738	0.738	0.000		
					36	24	0.351	0.351	0.354		-0.003	0.355	0.355	0.357	-0.002	0.527	0.527	0.527	0.000		
					48	36	0.324	0.324	0.327		-0.003	0.388	0.388	0.390	-0.002	0.579	0.579	0.579	0.000		
			CMFTi-R/arg/clr (7/8")	Allmetal Standard Aluminum (5/8")	47.244	59.055	0.309	0.309	0.311		-0.002	0.405	0.405	0.406	-0.001	0.606	0.606	0.606	0.000		
					72	54	0.301	0.301	0.303		-0.002	0.415	0.415	0.416	-0.001	0.621	0.621	0.621	0.000		
					96	72	0.289	0.289	0.29		-0.001	0.428	0.428	0.429	-0.001	0.642	0.642	0.642	0.000		
					36	24	0.321	0.321	0.304		0.017	0.355	0.355	0.356	-0.001	0.527	0.527	0.527	0.000		
					48	36	0.303	0.303	0.29		0.013	0.388	0.388	0.389	-0.001	0.579	0.579	0.579	0.000		
					47.244	59.055	0.291	0.291	0.281		0.010	0.405	0.405	0.406	-0.001	0.606	0.606	0.606	0.000		
				Edgetech SuperSpacer Premium (5/8")	72	54	0.286	0.286	0.277		0.009	0.415	0.415	0.415	0.000	0.621	0.621	0.621	0.000		
					96	72	0.277	0.277	0.271		0.006	0.428	0.428	0.429	-0.001	0.642	0.642	0.642	0.000		
					LowE272-5 Air Clr-5	GED Intercept Galv Steel	48.00	48.00	0.344	0.344	0.344	0.330	0.000	0.345	0.345	0.346	-0.001	0.596	0.596	0.596	0.000

TRR-99

Model	Product Type	Framing	Glazing System	Spacer	Size		U (Btu/hr-ft ² -F)					SHGC (-)				VT (-)					
					Width (in)	Height (in)	Spread sheet	CMAST	T6/W6	Test	DIFF	Spread sheet	CMAST	T6/W6	DIFF	Spread sheet	CMAST	T6/W6	DIFF		
TRR-99	Horizontal Slider	Aluminum Non-Thermal	clr/arg/clr (3/4")	Allmetal Standard Aluminum (1/2")	36	24	0.789	0.789	0.783	0.55	0.006	0.611	0.611	0.616	-0.005	0.637	0.637	0.637	0.000		
					48	36	0.694	0.694	0.691		0.003	0.653	0.653	0.657	-0.004	0.687	0.687	0.687	0.000		
					59.055	47.244	0.643	0.643	0.641		0.002	0.676	0.676	0.679	-0.003	0.713	0.713	0.713	0.000		
					72	54	0.613	0.613	0.611		0.002	0.688	0.688	0.691	-0.003	0.728	0.728	0.728	0.000		
					96	72	0.569	0.569	0.569		0.000	0.706	0.706	0.708	-0.002	0.749	0.749	0.749	0.000		
					36	24	0.782	0.782	0.769		0.013	0.610	0.610	0.616	-0.006	0.637	0.637	0.637	0.000		
				Edgetech SuperSpacer Premium (1/2")	48	36	0.689	0.689	0.680		0.009	0.653	0.653	0.657	-0.004	0.687	0.687	0.687	0.000		
					59.055	47.244	0.638	0.638	0.632		0.006	0.676	0.676	0.679	-0.003	0.713	0.713	0.713	0.000		
					72	54	0.609	0.609	0.604		0.005	0.688	0.688	0.691	-0.003	0.728	0.728	0.728	0.000		
					96	72	0.566	0.566	0.563		0.003	0.706	0.706	0.708	-0.002	0.749	0.749	0.749	0.000		
					CMFTi-R/arg/clr (3/4")	Allmetal Standard Aluminum (1/2")	36	24	0.648		0.648	0.641	0.007	0.382	0.382	0.387	-0.005	0.554	0.554	0.554	0.000
							48	36	0.538		0.538	0.533	0.005	0.407	0.407	0.411	-0.004	0.598	0.598	0.598	0.000
			59.055	47.244			0.479	0.479	0.474		0.005	0.420	0.420	0.423	-0.003	0.620	0.620	0.620	0.000		
			72	54		0.444	0.444	0.440	0.004		0.428	0.428	0.431	-0.003	0.633	0.633	0.633	0.000			
			96	72		0.395	0.395	0.392	0.003		0.439	0.439	0.441	-0.002	0.652	0.652	0.652	0.000			
			Edgetech SuperSpacer Premium (1/2")	36		24	0.638	0.638	0.623		0.015	0.382	0.382	0.387	-0.005	0.554	0.554	0.554	0.000		
				48	36	0.531	0.531	0.519	0.012		0.407	0.407	0.411	-0.004	0.598	0.598	0.598	0.000			
				59.055	47.244	0.473	0.473	0.463	0.010		0.420	0.420	0.423	-0.003	0.620	0.620	0.620	0.000			
			72	54	0.439	0.439	0.430	0.009	0.428		0.428	0.430	-0.002	0.633	0.633	0.633	0.000				
			96	72	0.391	0.391	0.384	0.007	0.439		0.439	0.440	-0.001	0.652	0.652	0.652	0.000				
			Clr 3-Air-HMSC75-Air-S500CL_3	Allmetal Standard Black Steel	60.00	36.00	0.554	0.554	0.545		0.55	0.009	0.314	0.314	0.317	-0.003	0.500	0.500	0.500	0.000	

TRR-01

Model	Product Type	Framing	Glazing System	Spacer	Size		U (Btu/hr-ft ² -F)				SHGC (-)				VT (-)						
					Width (in)	Height (in)	Spread sheet	CMAST	T6/W6	Test	DIFF	Spread sheet	CMAST	T6/W6	DIFF	Spread sheet	CMAST	T6/W6	DIFF		
TRR-01	Fixed	Thermally Broken Aluminum	clr/arg/cir (1")	Allmetal Standard Aluminum (3/4")	36	24	0.622	0.622	0.620		0.002	0.546	0.546	0.552	-0.006	0.564	0.564	0.564	0.000		
					48	36	0.575	0.575	0.575		0.000	0.607	0.607	0.612	-0.005	0.635	0.635	0.635	0.000		
					47.244	59.055	0.548	0.548	0.548		0.000	0.639	0.639	0.643	-0.004	0.672	0.672	0.672	0.000		
					72	54	0.534	0.534	0.534		0.000	0.657	0.657	0.660	-0.003	0.692	0.692	0.692	0.000		
					96	72	0.512	0.512	0.512		0.000	0.682	0.682	0.685	-0.003	0.722	0.722	0.722	0.000		
					36	24	0.606	0.606	0.593		0.013	0.545	0.545	0.551	-0.006	0.564	0.564	0.564	0.000		
				Edgetech SuperSpacer Premium (3/4")	48	36	0.563	0.563	0.555		0.008	0.607	0.607	0.611	-0.004	0.635	0.635	0.635	0.000		
					47.244	59.055	0.538	0.538	0.532		0.006	0.639	0.639	0.642	-0.003	0.672	0.672	0.672	0.000		
					72	54	0.526	0.526	0.521		0.005	0.657	0.657	0.659	-0.002	0.692	0.692	0.692	0.000		
					96	72	0.505	0.505	0.502		0.003	0.682	0.682	0.684	-0.002	0.722	0.722	0.722	0.000		
					36	24	0.498	0.498	0.491		0.007	0.342	0.342	0.349	-0.007	0.491	0.491	0.491	0.000		
					48	36	0.432	0.432	0.427		0.005	0.378	0.378	0.383	-0.005	0.552	0.552	0.552	0.000		
			CMFTi-R/arg/cir (1")	Allmetal Standard Aluminum (3/4")	47.244	59.055	0.397	0.397	0.393		0.004	0.398	0.398	0.401	-0.003	0.585	0.585	0.585	0.000		
					72	54	0.377	0.377	0.373		0.004	0.408	0.408	0.411	-0.003	0.602	0.602	0.602	0.000		
					96	72	0.347	0.347	0.345		0.002	0.423	0.423	0.426	-0.003	0.628	0.628	0.628	0.000		
					36	24	0.477	0.477	0.457		0.020	0.341	0.341	0.347	-0.006	0.491	0.491	0.491	0.000		
					48	36	0.417	0.417	0.403		0.014	0.378	0.378	0.382	-0.004	0.552	0.552	0.552	0.000		
					47.244	59.055	0.385	0.385	0.374		0.011	0.397	0.397	0.400	-0.003	0.585	0.585	0.585	0.000		
				Edgetech SuperSpacer Premium (3/4")	72	54	0.366	0.366	0.356		0.010	0.408	0.408	0.410	-0.002	0.602	0.602	0.602	0.000		
					96	72	0.339	0.339	0.332		0.007	0.423	0.423	0.425	-0.002	0.628	0.628	0.628	0.000		
					CmftE2_3-Air-HMSC75-Air-CmftE2_3	Allmetal Aluminum 250	40.00	40.00	0.405	0.405	0.399	0.40	0.006	0.275	0.275	0.280	-0.005	0.414	0.414	0.414	0.000

TRR-02

Model	Product Type	Framing	Glazing System	Spacer	Size		U (Btu/hr-ft ² -F)				SHGC (-)				VT (-)					
					Width (in)	Height (in)	Spread sheet	CMAST	T6/W6	Test	DIFF	Spread sheet	CMAST	T6/W6	DIFF	Spread sheet	CMAST	T6/W6	DIFF	
TRR-02	Curtain Wall	Thermally Broken Aluminum	clr/arg/clr (1")	Allmetal Standard Aluminum (3/4")	36	24	0.744	0.744	0.740		0.004	0.485	0.485	0.494	-0.009	0.495	0.495	0.495	0.000	
					48	36	0.670	0.670	0.668		0.002	0.559	0.559	0.565	-0.006	0.580	0.580	0.580	0.000	
					72	54	0.601	0.601	0.600		0.001	0.623	0.623	0.627	-0.004	0.653	0.653	0.653	0.000	
					78.74	78.74	0.572	0.572	0.572		0.000	0.648	0.648	0.652	-0.004	0.683	0.683	0.683	0.000	
					96	72	0.563	0.563	0.563		0.000	0.656	0.656	0.660	-0.004	0.692	0.692	0.692	0.000	
					36	24	0.726	0.726	0.712		0.014	0.485	0.485	0.492	-0.007	0.495	0.495	0.495	0.000	
				Edgetech SuperSpacer Premium (3/4")	48	36	0.656	0.656	0.646		0.010	0.559	0.559	0.564	-0.005	0.580	0.580	0.580	0.000	
					72	54	0.591	0.591	0.584		0.007	0.623	0.623	0.627	-0.004	0.653	0.653	0.653	0.000	
					78.74	78.74	0.563	0.563	0.559		0.004	0.648	0.648	0.651	-0.003	0.683	0.683	0.683	0.000	
					96	72	0.555	0.555	0.551		0.004	0.656	0.656	0.659	-0.003	0.692	0.692	0.692	0.000	
					36	24	0.640	0.640	0.630		0.010	0.307	0.307	0.315	-0.008	0.430	0.430	0.430	0.000	
					48	36	0.544	0.544	0.536		0.008	0.350	0.350	0.356	-0.006	0.504	0.504	0.504	0.000	
			CMFTi-R/arg/clr (1")	Allmetal Standard Aluminum (3/4")	72	54	0.456	0.456	0.450		0.006	0.388	0.388	0.392	-0.004	0.568	0.568	0.568	0.000	
					78.74	78.74	0.421	0.421	0.417		0.004	0.403	0.403	0.407	-0.004	0.594	0.594	0.594	0.000	
					96	72	0.408	0.408	0.404		0.004	0.408	0.408	0.411	-0.003	0.602	0.602	0.602	0.000	
					36	24	0.618	0.618	0.596		0.022	0.306	0.306	0.313	-0.007	0.430	0.430	0.430	0.000	
					Edgetech SuperSpacer Premium (3/4")	48	36	0.527	0.527	0.510		0.017	0.350	0.350	0.355	-0.005	0.504	0.504	0.504	0.000
						72	54	0.443	0.443	0.431		0.012	0.388	0.388	0.392	-0.004	0.568	0.568	0.568	0.000
				78.74		78.74	0.411	0.411	0.401		0.010	0.403	0.403	0.406	-0.003	0.594	0.594	0.594	0.000	
				96	72	0.399	0.399	0.390		0.009	0.408	0.408	0.410	-0.002	0.602	0.602	0.602	0.000		
				Clr 6-Air-Clr 6	Allmetal Standard Aluminum	80.00	80.00	0.576	0.576	0.575		0.001	0.599	0.599	0.602	-0.003	0.661	0.661	0.661	0.000

TR-4600

Model	Product Type	Framing	Glazing System	Spacer	Size		U (Btu/hr-ft ² -F)				SHGC (-)					VT (-)			
					Width (in)	Height (in)	Spread sheet	CMAST	T6/W6	Test	DIFF	Spread sheet	CMAST	T6/W6	DIFF	Spread sheet	CMAST	T6/W6	DIFF
TRACO TR-4600	Casement	PVC	clr/arg/cir (7/8")	Allmetal Standard Aluminum (5/8")	36	24	0.475	0.475	0.475		0.000	0.471	0.471	0.473	-0.002	0.496	0.496	0.496	0.000
					48	36	0.469	0.469	0.470		-0.001	0.552	0.552	0.554	-0.002	0.584	0.584	0.584	0.000
					47.244	59.055	0.460	0.460	0.462		-0.002	0.596	0.596	0.597	-0.001	0.632	0.632	0.632	0.000
					72	54	0.463	0.463	0.464		-0.001	0.618	0.618	0.619	-0.001	0.657	0.657	0.657	0.000
					96	72	0.457	0.457	0.458		-0.001	0.653	0.653	0.654	-0.001	0.695	0.695	0.695	0.000
					36	24	0.449	0.449	0.435		0.014	0.471	0.471	0.472	-0.001	0.496	0.496	0.496	0.000
				Edgetech SuperSpacer Premium (5/8")	48	36	0.450	0.450	0.440		0.010	0.552	0.552	0.553	-0.001	0.584	0.584	0.584	0.000
					47.244	59.055	0.446	0.446	0.440		0.006	0.596	0.596	0.596	0.000	0.632	0.632	0.632	0.000
					72	54	0.449	0.449	0.443		0.006	0.618	0.618	0.619	-0.001	0.657	0.657	0.657	0.000
					96	72	0.446	0.446	0.442		0.004	0.653	0.653	0.653	0.000	0.695	0.695	0.695	0.000
					36	24	0.372	0.372	0.367		0.005	0.292	0.292	0.295	-0.003	0.431	0.431	0.431	0.000
					48	36	0.342	0.342	0.337		0.005	0.342	0.342	0.343	-0.001	0.508	0.508	0.508	0.000
			CMFTi-R/arg/cir (7/8")	Allmetal Standard Aluminum (5/8")	47.244	59.055	0.320	0.320	0.316		0.004	0.369	0.369	0.370	-0.001	0.550	0.550	0.550	0.000
					72	54	0.315	0.315	0.312		0.003	0.383	0.383	0.384	-0.001	0.572	0.572	0.572	0.000
					96	72	0.300	0.300	0.297		0.003	0.404	0.404	0.405	-0.001	0.604	0.604	0.604	0.000
					36	24	0.339	0.339	0.316		0.023	0.292	0.292	0.294	-0.002	0.431	0.431	0.431	0.000
					48	36	0.317	0.317	0.299		0.018	0.342	0.342	0.343	-0.001	0.508	0.508	0.508	0.000
					47.244	59.055	0.301	0.301	0.288		0.013	0.369	0.369	0.369	0.000	0.550	0.550	0.550	0.000
				Edgetech SuperSpacer Premium (5/8")	72	54	0.297	0.297	0.285		0.012	0.382	0.382	0.383	-0.001	0.572	0.572	0.572	0.000
					96	72	0.286	0.286	0.277		0.009	0.404	0.404	0.404	0.000	0.604	0.604	0.604	0.000
					Clr 3-Air-Clr 3	GED Intercept Stainless Steel	47.24	59.06	0.467	0.467	0.464		0.003	0.595	0.595	0.596	-0.001	0.632	0.632

K1600-S1

Model	Product Type	Framing	Glazing System	Spacer	Size		U (Btu/hr-ft ² -F)				SHGC (-)				VT (-)						
					Width (in)	Height (in)	Spread sheet	CMAST	T6/W6	Test	DIFF	Spread sheet	CMAST	T6/W6	DIFF	Spread sheet	CMAST	T6/W6	DIFF		
Kawneer 1600 S1	Curtain Wall	Thermally Improved Aluminum	clr/arg/clr (1")	Allmetal Standard Aluminum (3/4")	36	24	0.977	0.977	0.972		0.005	0.491	0.491	0.503	-0.012	0.491	0.491	0.491	0.000		
					48	36	0.841	0.841	0.838		0.003	0.563	0.563	0.572	-0.009	0.577	0.577	0.577	0.000		
					72	54	0.718	0.718	0.716		0.002	0.626	0.626	0.632	-0.006	0.652	0.652	0.652	0.000		
					78.74	78.74	0.668	0.668	0.667		0.001	0.650	0.650	0.655	-0.005	0.681	0.681	0.681	0.000		
					96	72	0.652	0.652	0.651		0.001	0.658	0.658	0.663	-0.005	0.691	0.691	0.691	0.000		
					36	24	0.961	0.961	0.947		0.014	0.490	0.490	0.502	-0.012	0.491	0.491	0.491	0.000		
				Edgetech SuperSpacer Premium (3/4")	48	36	0.829	0.829	0.818		0.011	0.563	0.563	0.571	-0.008	0.577	0.577	0.577	0.000		
					72	54	0.709	0.709	0.702		0.007	0.626	0.626	0.631	-0.005	0.652	0.652	0.652	0.000		
					78.74	78.74	0.660	0.660	0.655		0.005	0.650	0.650	0.655	-0.005	0.681	0.681	0.681	0.000		
					96	72	0.645	0.645	0.640		0.005	0.658	0.658	0.663	-0.005	0.691	0.691	0.691	0.000		
					36	24	0.878	0.878	0.868		0.010	0.314	0.314	0.325	-0.011	0.428	0.428	0.428	0.000		
					48	36	0.719	0.719	0.711		0.008	0.355	0.355	0.364	-0.009	0.502	0.502	0.502	0.000		
			CMFTi-R/arg/clr (1")	Allmetal Standard Aluminum (3/4")	72	54	0.575	0.575	0.569		0.006	0.392	0.392	0.398	-0.006	0.567	0.567	0.567	0.000		
					78.74	78.74	0.519	0.519	0.514		0.005	0.406	0.406	0.411	-0.005	0.593	0.593	0.593	0.000		
					96	72	0.499	0.499	0.495		0.004	0.411	0.411	0.415	-0.004	0.601	0.601	0.601	0.000		
					36	24	0.859	0.859	0.838		0.021	0.313	0.313	0.324	-0.011	0.428	0.428	0.428	0.000		
					48	36	0.704	0.704	0.687		0.017	0.355	0.355	0.363	-0.008	0.502	0.502	0.502	0.000		
					72	54	0.564	0.564	0.553		0.011	0.391	0.391	0.397	-0.006	0.567	0.567	0.567	0.000		
				Edgetech SuperSpacer Premium (3/4")	78.74	78.74	0.510	0.510	0.500		0.010	0.406	0.406	0.410	-0.004	0.593	0.593	0.593	0.000		
					96	72	0.491	0.491	0.482		0.009	0.410	0.410	0.415	-0.005	0.601	0.601	0.601	0.000		
					Clr 6-Air-Clr 6	Allmetal Standard Aluminum (1/2")	80.00	80.00	0.671	0.671	0.673	0.64	-0.002	0.600	0.600	0.605	-0.005	0.664	0.664	0.664	0.000

CW3

Model	Product Type	Framing	Glazing System	Spacer	Size		U (Btu/hr-ft ² -F)				SHGC (-)				VT (-)						
					Width (in)	Height (in)	Spread sheet	CMAST	T6/W6	Test	DIFF	Spread sheet	CMAST	T6/W6	DIFF	Spread sheet	CMAST	T6/W6	DIFF		
CW3	Curtain Wall	Thermally Broken Aluminum	clr/arg/clr (1")	Allmetal Standard Aluminum (3/4")	36	24	0.814	0.814	0.810		0.004	0.514	0.514	0.520	-0.006	0.530	0.530	0.530	0.000		
					48	36	0.720	0.720	0.718		0.002	0.580	0.580	0.585	-0.005	0.606	0.606	0.606	0.000		
					72	54	0.634	0.634	0.634		0.000	0.638	0.638	0.642	-0.004	0.672	0.672	0.672	0.000		
					78.74	78.74	0.599	0.599	0.599		0.000	0.661	0.661	0.663	-0.002	0.698	0.698	0.698	0.000		
					96	72	0.588	0.588	0.588		0.000	0.668	0.668	0.671	-0.003	0.706	0.706	0.706	0.000		
					36	24	0.803	0.803	0.791		0.012	0.513	0.513	0.520	-0.007	0.530	0.530	0.530	0.000		
				Edgetech SuperSpacer Premium (3/4")	48	36	0.712	0.712	0.704		0.008	0.580	0.580	0.585	-0.005	0.606	0.606	0.606	0.000		
					72	54	0.628	0.628	0.623		0.005	0.638	0.638	0.641	-0.003	0.672	0.672	0.672	0.000		
					78.74	78.74	0.594	0.594	0.591		0.003	0.660	0.660	0.663	-0.003	0.698	0.698	0.698	0.000		
					96	72	0.583	0.583	0.580		0.003	0.668	0.668	0.670	-0.002	0.706	0.706	0.706	0.000		
					36	24	0.704	0.704	0.696		0.008	0.322	0.322	0.329	-0.007	0.461	0.461	0.461	0.000		
					48	36	0.589	0.589	0.583		0.006	0.362	0.362	0.367	-0.005	0.527	0.527	0.527	0.000		
			CMFTi-R/arg/clr (1")	Allmetal Standard Aluminum (3/4")	72	54	0.486	0.486	0.481		0.005	0.397	0.397	0.400	-0.003	0.585	0.585	0.585	0.000		
					78.74	78.74	0.446	0.446	0.442		0.004	0.410	0.410	0.413	-0.003	0.607	0.607	0.607	0.000		
					96	72	0.431	0.431	0.427		0.004	0.414	0.414	0.417	-0.003	0.615	0.615	0.615	0.000		
					36	24	0.690	0.690	0.673		0.017	0.322	0.322	0.329	-0.007	0.461	0.461	0.461	0.000		
					48	36	0.578	0.578	0.566		0.012	0.362	0.362	0.367	-0.005	0.527	0.527	0.527	0.000		
					72	54	0.478	0.478	0.469		0.009	0.397	0.397	0.400	-0.003	0.585	0.585	0.585	0.000		
				Edgetech SuperSpacer Premium (3/4")	78.74	78.74	0.439	0.439	0.432		0.007	0.410	0.410	0.413	-0.003	0.607	0.607	0.607	0.000		
					96	72	0.425	0.425	0.418		0.007	0.414	0.414	0.417	-0.003	0.615	0.615	0.615	0.000		
					Clr 6-Air-Clr 6	Allmetal Standard Al_0.528	80.00	80.00	0.603	0.603	0.605		-0.002	0.610	0.610	0.612	-0.002	0.676	0.676	0.676	0.000

PFM

Model	Product Type	Framing	Glazing System	Spacer	Size		U (Btu/hr-ft ² -F)				SHGC (-)				VT (-)						
					Width (in)	Height (in)	Spread sheet	CMAST	T6/W6	Test	DIFF	Spread sheet	CMAST	T6/W6	DIFF	Spread sheet	CMAST	T6/W6	DIFF		
Marvin PFM	Fixed	Wood	clr/arg/cir (1")	Allmetal Standard Aluminum (3/4")	36	24	0.467	0.467	0.471		-0.004	0.600	0.600	0.601	-0.001	0.634	0.634	0.634	0.000		
					48	36	0.463	0.463	0.467		-0.004	0.647	0.647	0.648	-0.001	0.686	0.686	0.686	0.000		
					47.244	59.055	0.457	0.457	0.460		-0.003	0.671	0.671	0.672	-0.001	0.713	0.713	0.713	0.000		
					72	54	0.458	0.458	0.461		-0.003	0.684	0.684	0.685	-0.001	0.728	0.728	0.728	0.000		
					96	72	0.454	0.454	0.456		-0.002	0.703	0.703	0.704	-0.001	0.749	0.749	0.749	0.000		
					36	24	0.448	0.448	0.435		0.013	0.599	0.599	0.600	-0.001	0.634	0.634	0.634	0.000		
				Edgetech SuperSpacer Premium (3/4")	48	36	0.449	0.449	0.441		0.008	0.646	0.646	0.647	-0.001	0.686	0.686	0.686	0.000		
					47.244	59.055	0.445	0.445	0.440		0.005	0.670	0.670	0.671	-0.001	0.713	0.713	0.713	0.000		
					72	54	0.448	0.448	0.443		0.005	0.684	0.684	0.684	0.000	0.728	0.728	0.728	0.000		
					96	72	0.446	0.446	0.443		0.003	0.703	0.703	0.703	0.000	0.749	0.749	0.749	0.000		
					36	24	0.324	0.324	0.326		-0.002	0.371	0.371	0.373	-0.002	0.552	0.552	0.552	0.000		
					48	36	0.307	0.307	0.308		-0.001	0.400	0.400	0.401	-0.001	0.597	0.597	0.597	0.000		
			CMFTi-R/arg/cir (1")	Allmetal Standard Aluminum (3/4")	47.244	59.055	0.296	0.296	0.297		-0.001	0.414	0.414	0.415	-0.001	0.620	0.620	0.620	0.000		
					72	54	0.291	0.291	0.292		-0.001	0.423	0.423	0.424	-0.001	0.633	0.633	0.633	0.000		
					96	72	0.283	0.283	0.284		-0.001	0.434	0.434	0.435	-0.001	0.651	0.651	0.651	0.000		
					36	24	0.299	0.299	0.282		0.017	0.370	0.370	0.371	-0.001	0.552	0.552	0.552	0.000		
					48	36	0.288	0.288	0.276		0.012	0.399	0.399	0.400	-0.001	0.597	0.597	0.597	0.000		
					47.244	59.055	0.281	0.281	0.272		0.009	0.414	0.414	0.415	-0.001	0.620	0.620	0.620	0.000		
				Edgetech SuperSpacer Premium (3/4")	72	54	0.279	0.279	0.270		0.009	0.422	0.422	0.423	-0.001	0.633	0.633	0.633	0.000		
					96	72	0.273	0.273	0.267		0.006	0.434	0.434	0.435	-0.001	0.651	0.651	0.651	0.000		
					Clr-5-Air-Clr-5	Allmetal Aluminum LPD	24.00	36.00	0.471	0.471	0.474	0.48	-0.003	0.582	0.582	0.584	-0.002	0.630	0.630	0.630	0.000
							LowE179-5 Air_Clr5	Allmetal Aluminum LPD	24.00	36.00	0.365	0.365	0.368	0.37	-0.003	0.490	0.490	0.492	-0.002	0.605	0.605

PVC

Model	Product Type	Framing	Glazing System	Spacer	Size		U (Btu/hr-ft ² -F)				SHGC (-)				VT (-)				
					Width (in)	Height (in)	Spread sheet	CMAST	T6/W6	Test	DIFF	Spread sheet	CMAST	T6/W6	DIFF	Spread sheet	CMAST	T6/W6	DIFF
PVC	Casement	PVC	clr/arg/clr (7/8")	Allmetal Standard Aluminum (5/8")	36	24	0.434	0.434	0.432		0.002	0.477	0.477	0.480	-0.003	0.502	0.502	0.502	0.000
					23.622	59.055	0.427	0.427	0.428		-0.001	0.492	0.492	0.494	-0.002	0.518	0.518	0.518	0.000
					48	36	0.439	0.439	0.438		0.001	0.555	0.555	0.557	-0.002	0.587	0.587	0.587	0.000
					72	54	0.441	0.441	0.441		0.000	0.620	0.620	0.622	-0.002	0.659	0.659	0.659	0.000
					96	72	0.440	0.440	0.441		-0.001	0.654	0.654	0.655	-0.001	0.696	0.696	0.696	0.000
					36	24	0.417	0.417	0.404		0.013	0.477	0.477	0.479	-0.002	0.502	0.502	0.502	0.000
				23.622	59.055	0.412	0.412	0.403		0.009	0.491	0.491	0.493	-0.002	0.518	0.518	0.518	0.000	
				48	36	0.426	0.426	0.418		0.008	0.555	0.555	0.556	-0.001	0.587	0.587	0.587	0.000	
				72	54	0.432	0.432	0.427		0.005	0.620	0.620	0.621	-0.001	0.659	0.659	0.659	0.000	
				96	72	0.433	0.433	0.430		0.003	0.654	0.654	0.655	-0.001	0.696	0.696	0.696	0.000	
				36	24	0.318	0.318	0.313		0.005	0.296	0.296	0.299	-0.003	0.437	0.437	0.437	0.000	
				23.622	59.055	0.313	0.313	0.310		0.003	0.306	0.306	0.308	-0.002	0.451	0.451	0.451	0.000	
				48	36	0.302	0.302	0.298		0.004	0.344	0.344	0.346	-0.002	0.511	0.511	0.511	0.000	
				72	54	0.287	0.287	0.284		0.003	0.384	0.384	0.385	-0.001	0.573	0.573	0.573	0.000	
			96	72	0.278	0.278	0.276		0.002	0.405	0.405	0.406	-0.001	0.605	0.605	0.605	0.000		
			36	24	0.296	0.296	0.278		0.018	0.296	0.296	0.298	-0.002	0.437	0.437	0.437	0.000		
			23.622	59.055	0.293	0.293	0.278		0.015	0.305	0.305	0.307	-0.002	0.451	0.451	0.451	0.000		
			48	36	0.286	0.286	0.272		0.014	0.344	0.344	0.345	-0.001	0.511	0.511	0.511	0.000		
			72	54	0.275	0.275	0.266		0.009	0.384	0.384	0.385	-0.001	0.573	0.573	0.573	0.000		
			96	72	0.269	0.269	0.262		0.007	0.405	0.405	0.405	0.000	0.605	0.605	0.605	0.000		
			LowE_037-Air-Clr	TrueSeal Swiggle Strip	24.00	48.00	0.337	0.337	0.321	0.31	0.016	0.254	0.254	0.256	-0.002	0.384	0.384	0.384	0.000

TR-3800

Model	Product Type	Framing	Glazing System	Spacer	Size		U (Btu/hr-ft ² -F)				SHGC (-)				VT (-)						
					Width (in)	Height (in)	Spread sheet	CMAST	T6/W6	Test	DIFF	Spread sheet	CMAST	T6/W6	DIFF	Spread sheet	CMAST	T6/W6	DIFF		
TRACO TR-3800	Fixed	Thermally Broken Aluminum	clr/arg/cir (1")	Allmetal Standard Aluminum (3/4")	36	24	0.620	0.620	0.618		0.002	0.545	0.545	0.552	-0.007	0.564	0.564	0.564	0.000		
					48	36	0.573	0.573	0.573		0.000	0.607	0.607	0.612	-0.005	0.634	0.634	0.634	0.000		
					47.244	59.055	0.546	0.546	0.546		0.000	0.639	0.639	0.643	-0.004	0.672	0.672	0.672	0.000		
					72	54	0.533	0.533	0.533		0.000	0.657	0.657	0.660	-0.003	0.692	0.692	0.692	0.000		
					96	72	0.511	0.511	0.511		0.000	0.682	0.682	0.685	-0.003	0.722	0.722	0.722	0.000		
					36	24	0.603	0.603	0.591		0.012	0.545	0.545	0.550	-0.005	0.564	0.564	0.564	0.000		
				Edgetech SuperSpacer Premium (3/4")	48	36	0.561	0.561	0.553		0.008	0.606	0.606	0.611	-0.005	0.634	0.634	0.634	0.000		
					47.244	59.055	0.536	0.536	0.531		0.005	0.638	0.638	0.642	-0.004	0.672	0.672	0.672	0.000		
					72	54	0.524	0.524	0.520		0.004	0.656	0.656	0.659	-0.003	0.692	0.692	0.692	0.000		
					96	72	0.504	0.504	0.501		0.003	0.682	0.682	0.684	-0.002	0.722	0.722	0.722	0.000		
					36	24	0.493	0.493	0.488		0.005	0.342	0.342	0.348	-0.006	0.490	0.490	0.490	0.000		
					48	36	0.428	0.428	0.425		0.003	0.378	0.378	0.383	-0.005	0.552	0.552	0.552	0.000		
			CMFTi-R/arg/cir (1")	Allmetal Standard Aluminum (3/4")	47.244	59.055	0.394	0.394	0.391		0.003	0.397	0.397	0.401	-0.004	0.584	0.584	0.584	0.000		
					72	54	0.374	0.374	0.372		0.002	0.408	0.408	0.411	-0.003	0.602	0.602	0.602	0.000		
					96	72	0.346	0.346	0.344		0.002	0.423	0.423	0.426	-0.003	0.628	0.628	0.628	0.000		
					36	24	0.471	0.471	0.455		0.016	0.341	0.341	0.347	-0.006	0.490	0.490	0.490	0.000		
					48	36	0.413	0.413	0.401		0.012	0.378	0.378	0.382	-0.004	0.552	0.552	0.552	0.000		
					47.244	59.055	0.381	0.381	0.372		0.009	0.397	0.397	0.400	-0.003	0.584	0.584	0.584	0.000		
				Edgetech SuperSpacer Premium (3/4")	72	54	0.363	0.363	0.355		0.008	0.408	0.408	0.410	-0.002	0.602	0.602	0.602	0.000		
					96	72	0.337	0.337	0.331		0.006	0.423	0.423	0.425	-0.002	0.628	0.628	0.628	0.000		
					CmftE2-3 Air Clr-3	Allmetal Aluminum 250	47.24	59.06	0.470	0.470	0.467		0.003	0.547	0.547	0.551	-0.004	0.620	0.620	0.620	0.000

FS87 - Vertical

Model	Product Type	Framing	Glazing System	Spacer	Size		U (Btu/hr-ft ² -F)				SHGC (-)				VT (-)						
					Width (in)	Height (in)	Spread sheet	CMAST	T6/W6	Test	DIFF	Spread sheet	CMAST	T6/W6	DIFF	Spread sheet	CMAST	T6/W6	DIFF		
Velux FS87	Skylight	Aluminum Clad Wood	clr/arg/clr (5/8")	Allmetal Standard Aluminum (3/8")	36	24	0.655	0.655	0.655		0.000	0.717	0.718	-0.001	0.763	0.763	0.763	0.000			
					48	36	0.596	0.596	0.597		-0.001	0.730	0.730	0.731	-0.001	0.778	0.778	0.778	0.000		
					47.244	47.244	0.577	0.577	0.578		-0.001	0.735	0.735	0.735	0.000	0.784	0.784	0.784	0.000		
					72	54	0.549	0.549	0.550		-0.001	0.741	0.741	0.741	0.000	0.790	0.790	0.790	0.000		
					96	72	0.523	0.523	0.524		-0.001	0.746	0.746	0.746	0.000	0.796	0.796	0.796	0.000		
					36	24	0.643	0.643	0.634		0.009	0.716	0.716	0.717	-0.001	0.763	0.763	0.763	0.000		
				Edgetech SuperSpacer Premium (3/8")	48	36	0.588	0.588	0.583		0.005	0.730	0.730	0.731	-0.001	0.778	0.778	0.778	0.000		
					47.244	47.244	0.569	0.569	0.566		0.003	0.735	0.735	0.735	0.000	0.784	0.784	0.784	0.000		
					72	54	0.543	0.543	0.540		0.003	0.741	0.741	0.741	0.000	0.790	0.790	0.790	0.000		
					96	72	0.519	0.519	0.517		0.002	0.746	0.746	0.746	0.000	0.796	0.796	0.796	0.000		
					36	24	0.470	0.470	0.469		0.001	0.444	0.444	0.445	-0.001	0.664	0.664	0.664	0.000		
					48	36	0.408	0.408	0.407		0.001	0.453	0.453	0.453	0.000	0.677	0.677	0.677	0.000		
			CMFTi-R/arg/clr (5/8")	Allmetal Standard Aluminum (3/8")	47.244	47.244	0.389	0.389	0.388		0.001	0.456	0.456	0.456	0.000	0.682	0.682	0.682	0.000		
					72	54	0.357	0.357	0.357		0.000	0.460	0.460	0.460	0.000	0.688	0.688	0.688	0.000		
					96	72	0.331	0.331	0.331		0.000	0.463	0.463	0.463	0.000	0.693	0.693	0.693	0.000		
					36	24	0.455	0.455	0.443		0.012	0.444	0.444	0.445	-0.001	0.664	0.664	0.664	0.000		
					48	36	0.397	0.397	0.388		0.009	0.453	0.453	0.453	0.000	0.677	0.677	0.677	0.000		
					47.244	47.244	0.379	0.379	0.371		0.008	0.456	0.456	0.456	0.000	0.682	0.682	0.682	0.000		
				Edgetech SuperSpacer Premium (3/8")	72	54	0.350	0.350	0.344		0.006	0.460	0.460	0.460	0.000	0.688	0.688	0.688	0.000		
					96	72	0.326	0.326	0.322		0.004	0.463	0.463	0.463	0.000	0.693	0.693	0.693	0.000		
					LowE270-3_Ar_Clr-3	Cardinal Aluminum	21.57	51.75	0.451	0.451	0.448	0.50	0.003	0.351	0.351	0.352	-0.001	0.665	0.665	0.665	0.000

FS87 - 20°

Model	Product Type	Framing	Glazing System	Spacer	Size		U (Btu/hr-ft ² -F)				SHGC (-)				VT (-)						
					Width (in)	Height (in)	Spread sheet	CMAST	T6/W6	Test	DIFF	Spread sheet	CMAST	T6/W6	DIFF	Spread sheet	CMAST	T6/W6	DIFF		
Velux FS87	Skylight	Aluminum Clad Wood	clr/arg/clr (5/8") - 20 deg	Allmetal Standard Aluminum (3/8")	36	24	0.712	0.712	0.724		-0.012	0.718	0.718	0.718	0.000	0.763	0.763	0.763	0.000		
					48	36	0.658	0.658	0.667		-0.009	0.732	0.732	0.733	-0.001	0.778	0.778	0.778	0.000		
					47.244	47.244	0.643	0.643	0.651		-0.008	0.737	0.737	0.738	-0.001	0.784	0.784	0.784	0.000		
					72	54	0.616	0.616	0.622		-0.006	0.743	0.743	0.743	0.000	0.790	0.790	0.790	0.000		
					96	72	0.595	0.595	0.599		-0.004	0.749	0.749	0.749	0.000	0.796	0.796	0.796	0.000		
					36	24	0.700	0.700	0.701		-0.001	0.718	0.718	0.718	0.000	0.763	0.763	0.763	0.000		
				Edgetech SuperSpacer Premium (3/8")	48	36	0.650	0.650	0.651		-0.001	0.732	0.732	0.732	0.000	0.778	0.778	0.778	0.000		
					47.244	47.244	0.635	0.635	0.636		-0.001	0.737	0.737	0.738	-0.001	0.784	0.784	0.784	0.000		
					72	54	0.610	0.610	0.611		-0.001	0.743	0.743	0.743	0.000	0.790	0.790	0.790	0.000		
					96	72	0.590	0.590	0.591		-0.001	0.749	0.749	0.749	0.000	0.796	0.796	0.796	0.000		
					36	24	0.564	0.564	0.571		-0.007	0.445	0.445	0.445	0.000	0.664	0.664	0.664	0.000		
					48	36	0.504	0.504	0.508		-0.004	0.454	0.454	0.454	0.000	0.677	0.677	0.677	0.000		
			CMFTi-R/arg/clr (5/8") - 20 deg	Allmetal Standard Aluminum (3/8")	47.244	47.244	0.486	0.486	0.490		-0.004	0.457	0.457	0.457	0.000	0.682	0.682	0.682	0.000		
					72	54	0.455	0.455	0.458		-0.003	0.460	0.460	0.461	-0.001	0.688	0.688	0.688	0.000		
					96	72	0.431	0.431	0.433		-0.002	0.464	0.464	0.464	0.000	0.693	0.693	0.693	0.000		
					36	24	0.550	0.550	0.543		0.007	0.445	0.445	0.445	0.000	0.664	0.664	0.664	0.000		
					48	36	0.493	0.493	0.488		0.005	0.454	0.454	0.454	0.000	0.677	0.677	0.677	0.000		
					47.244	47.244	0.476	0.476	0.472		0.004	0.457	0.457	0.457	0.000	0.682	0.682	0.682	0.000		
				Edgetech SuperSpacer Premium (3/8")	72	54	0.448	0.448	0.445		0.003	0.460	0.460	0.460	0.000	0.688	0.688	0.688	0.000		
					96	72	0.426	0.426	0.423		0.003	0.464	0.464	0.464	0.000	0.693	0.693	0.693	0.000		
					LowE270-3 Ar Clr-3 - 20 deg	Cardinal Aluminum	21.57	51.75	0.553	0.553	0.558		-0.005	0.352	0.352	0.352	0.000	0.665	0.665	0.665	0.000

APPENDIX A: GLAZING SYSTEMS DETAILS

No	Name	ID 1	Gas Fill 1	ID 2	Gas Fill 2	ID 3	Thick (in)	Tsol (-)	Routsol (-)	Rinsol (-)	Routvis (-)	Rinvis (-)	Tuv (-)	U-Factor (Btu/hr-ft ² -F)	SHGC (-)	VT (-)
1	clr/arg/clr (5/8")	102	Argon	102			0.611	0.703	0.128	0.128	0.150	0.150	0.564	0.469	0.763	0.814
2	clr/arg/clr (5/8") - 20 deg	102	Argon	102			0.611	0.703	0.128	0.128	0.150	0.150	0.564	0.528	0.765	0.814
3	clr/arg/clr (3/4")	102	Argon	102			0.736	0.703	0.128	0.128	0.150	0.150	0.564	0.446	0.763	0.814
4	clr/arg/clr (7/8")	102	Argon	102			0.861	0.703	0.128	0.128	0.150	0.150	0.564	0.449	0.763	0.814
5	clr/arg/clr (1")	102	Argon	102			0.986	0.703	0.128	0.128	0.150	0.150	0.564	0.452	0.763	0.814
6	CMFTi-R/arg/clr (5/8")	925	Argon	102			0.611	0.433	0.356	0.345	0.209	0.185	0.294	0.259	0.473	0.708
7	CMFTi-R/arg/clr (5/8") - 20 deg	925	Argon	102			0.611	0.433	0.356	0.345	0.209	0.185	0.294	0.356	0.474	0.708
8	CMFTi-R/arg/clr (3/4")	925	Argon	102			0.736	0.433	0.356	0.345	0.185	0.209	0.294	0.244	0.472	0.708
9	CMFTi-R/arg/clr (7/8")	925	Argon	102			0.861	0.433	0.356	0.345	0.185	0.209	0.294	0.252	0.471	0.708
10	CMFTi-R/arg/clr (1")	925	Argon	102			0.986	0.433	0.356	0.345	0.185	0.209	0.294	0.259	0.471	0.708
11	LowE272-5_Air_Clr-5	2013	Air	2003			1.019	0.361	0.308	0.329	0.114	0.105	0.149	0.303	0.407	0.707
12	Clr-3_Air_HMSC75_Air_S500CL-3	5009	Air	1510	Air	5242	0.728	0.273	0.406	0.327	0.219	0.245	0.009	0.305	0.356	0.582
13	CmftE2-3_Air_HMSC75_Air_CmftE2-3	907	Air	1510	Air	907	0.915	0.247	0.322	0.314	0.201	0.216	0.007	0.223	0.341	0.535
14	Clr-6_Air_Clr-6	103	Air	103			1.022	0.607	0.114	0.114	0.144	0.144	0.463	0.471	0.704	0.786
15	Clr-6_Air_LowE272-6	2004	Air	2014			1.000	0.348	0.222	0.438	0.092	0.125	0.142	0.322	0.475	0.699
16	Clr-3-Air-Clr-3	102	Air	102			0.861	0.703	0.128	0.128	0.150	0.150	0.564	0.482	0.764	0.814
17	Clr-6_Air_Clr-6	5012	Air	5012			0.972	0.607	0.117	0.118	0.152	0.152	0.501	0.473	0.703	0.791
18	Clr-6_Air_Clr-6	103	Air	103			1.000	0.607	0.114	0.114	0.144	0.144	0.463	0.472	0.704	0.786
19	Clr-5-Air-Clr-5	2003	Air	2003			1.044	0.667	0.121	0.121	0.145	0.145	0.511	0.477	0.742	0.810
20	LowE179-5_Air_Clr-5	2186	Air	2003			1.044	0.553	0.172	0.180	0.140	0.132	0.220	0.326	0.625	0.776
21	LowE_037-Air-Clr	917	Air	102			0.861	0.362	0.410	0.390	0.287	0.238	0.293	0.304	0.398	0.614
22	LowE270-3_Ar_Clr-3	2026	Argon	2001			0.626	0.339	0.386	0.407	0.122	0.127	0.144	0.252	0.370	0.702
23	LowE270-3_Ar_Clr-3 - 20 deg	2026	Argon	2001			0.626	0.339	0.386	0.407	0.122	0.127	0.144	0.355	0.370	0.702
24	CmftE2-3_Air_Clr-3	907	Air	102			1.000	0.588	0.140	0.158	0.145	0.161	0.437	0.362	0.653	0.752

Argon in glazing systems No 1-10 is 10% Air / 90% Argon mixture

Argon in glazing systems No 22 and 23 is 5% Air / 95% Argon mixture