



Carli, Inc.

18 Tanglewood Rd.
Amherst, MA 01002

TEL: (413) 256-4647
FAX: (413) 256-4823

home@fenestration.com
<http://www.fenestration.com>

Technical Report:

TREATMENT OF DOUBLE-SASH, SLOPED, SINGLE-GLAZED, AND STRUCTURAL GLAZING FENESTRATION PRODUCTS IN CMA METHODOLOGY

Report prepared for:

National Fenestration Rating Council, Inc.

6305 Ivy Lane, Suite 140
Greenbelt, MD 20770

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EXECUTIVE SUMMARY

The objective of this project is to simulate a selected group of non-standard products, namely, Single Glazing, Structural glazing, Sloped Glazing (slope of 20° or less, IG incorporating a laminate layer and Double Sash Configurations, using both standard THERM/WINDOW and CMA methodologies to confirm that these products can be confidently simulated with the CMA methodology.

In Task 1, typical single glazing, structural glazing, sloped glazing, IG incorporating a laminated layer and double-sash fenestration products were identified and all necessary information required for simulation was collected. A matrix of glazing and spacer options to be modeled with these fenestration products was proposed and sent to PMTG for review. Based on the suggestions from the PMTG, the matrix was modified and finalized. The matrix is given in Appendix 1.

In Task 2, the fenestration products from the finalize matrix, were modeled in THERM and WINDOW with all of the selected configurations, including all glazing options. Simulated thermal and solar optical performance for each product and associated options were tabulated.

In Task 3, the THERM models from Task 2 were modified and modeled using the CMA methodology (i.e., Best/Worst options). The modeling data was entered into the FENSIZ, which incorporates the CMA methodology. After the CMA based simulations were completed, the values for the same matrix of options and products were tabulated and the results compared with conventional modeling results obtained in Task 2.

The results from the both conventional (THERM/WINDOW) and CMA based simulations were compared. All of the U Factor results are within the expected discrepancies (i.e., less than 0.02 Btu/(hr-ft²-F), with the majority being below 0.01. SHGC results are all within 0.01 while VT results are identical in both the procedures. The results are summarized in Table 1.

From the results, it can be concluded that current CMA procedure can be confidently used for all the non standard products identified in this project and no further investigation is necessary.

BACKGROUND

The NFRC CMA methodology (NFRC 2004, Curcija 2004) covers a majority of fenestration products. This procedure is being developed with a focus on typical non-residential products with a target implementation date of early 2009. It is believed that this methodology applies equally well to a smaller number of non-standard systems; however this has not been proven yet. It is important that as many fenestration products as possible are covered by this procedure to minimize exceptions and special cases. These systems have been identified by a Technical Issues Task Group as potentially problematic and solutions have been sought. The aim of this project is to investigate if the non standard products proposed here can be satisfactorily handled by current CMA methodology or not.

The objective of this project is to simulate a selected group of non-standard products (listed below) using both standard THERM/WINDOW and CMA methodologies to confirm that these products can be confidently simulated with the CMA methodology. If the CMA methodology does not produce satisfactory results for some or all of these products, the proposed alternate course(s) of action will be suggested and recommendations for further research to resolve any discrepancies will be provided.

The products considered in this project include:

- Single Glazing
 - This is to take into account products with a low emissivity coating on the interior glazing surface as well as glass / polycarbonate composite products with low conductivity.
- Structural glazing
 - These applications can utilize deep sightlines on the glazing as well as deep structural joints.
- Sloped Glazing (slope of 20° or less)
 - By code, laminated glass is required for single glazing or the interior pane of an IG.
- IG incorporating a laminate layer
 - One or both panes may be laminated due to security/acoustic considerations.
- Double Sash Configuration
 - This must consider installations with IG or single glazed exterior, a wide airspace, and single glazed interior pane (including interior/exterior storms and standard triple glazing). Any of these panes may be laminated/lowE.

APPROACH

Based on the specific requirements in the bid document, this research project will be divided into the following 4 tasks:

1. Identification of typical fenestration products
2. THERM and WINDOW modeling of typical fenestration products
3. Modeling of typical fenestration products using CMA methodology
4. Conclusions and final report

Identification of representative fenestration products

Typical single glazing, structural glazing, sloped glazing, IG incorporating a laminated layer and double-sash fenestration products were identified and all necessary information required for simulation was collected. A matrix of glazing and spacer options to be modeled with these fenestration products was proposed and sent to PMTG for review. Based on the suggestions from the PMTG, the matrix was modified and finalized. The matrix is given in Appendix 1.

THERM and WINDOW modeling of fenestration products

The fenestration products from the finalize matrix, were modeled in THERM and WINDOW with all of the selected configurations, including all glazing options. Simulated thermal and solar optical performance for each product and associated options were tabulated.

Modeling of fenestration products using CMA methodology

The THERM models from Task 2 were modified and modeled using the CMA methodology (i.e., Best/Worst options). The modeling data was entered into the FENSIZ, which incorporates the CMA methodology. During the investigation we found out that for calculating the total product U factor, the current CMA procedure was not using actual product height for the center of glass U factor calculations instead nominal height was being used for this calculation. This was causing differences in results, mainly for the single glazed products. The results, shown in Table 1, using CMA methodology were recalculated using the actual product height. It is therefore recommended to use actual product height for center of glass calculations during the product U-factor calculation in CMA. After the CMA based simulations were completed, the values for the same matrix of options and products were tabulated and the results compared with conventional modeling results obtained in Task 2.

Conclusions

The results from the both conventional (THERM/WINDOW) and CMA based simulations were compared. All of the U Factor results are within the expected discrepancies (i.e., less than 0.02 Btu/(hr-ft²-F), with the majority being below 0.01 Btu/(hr-ft²-F). SHGC results are all within 0.01 while VT results are identical in both procedures. The results are summarized in Table 1.

From the results, it can be concluded that current CMA procedure can be confidently used for all the non standard products identified in this project and no further investigation is necessary.

Recommendations

As the results are within the expected discrepancies for all the non-standard products considered in this project, no changes in the NFRC standard documents are necessary. However, it is recommended to use actual product height for the center of glass calculations during the whole product U Factor calculations in CMA and this may need to be clarified in NFRC 100, section 5.6, if needed. .

Table 1: Comparison of Results

Product Ref.	Product Type	Material: Frame / Spacer	Glazing System	Size		U (Btu/h-ft ² -F)				SHGC (-)				VT (-)			
				Width (in)	Height (in)	T5/W5	CMA	DIFF	DIFF (%)	T5/W5	CMA	DIFF	DIFF (%)	T5/W5	CMA	DIFF	DIFF (%)
P1	Single Glazed	AL / N/A	G1-103(clear)	78.740	78.740	1.110	1.099	-0.011	-0.99	0.750	0.749	0.000	-0.01	0.787	0.787	0.000	0.00
			G2-910(HClowE)			0.801	0.803	0.002	0.23	0.650	0.649	-0.001	-0.20	0.731	0.731	0.000	0.00
			G3-6162(Laminate)			0.748	0.760	0.012	1.63	0.441	0.441	0.000	0.06	0.618	0.618	0.000	0.00
			G4-30001(Film)			0.888	0.886	-0.002	-0.17	0.214	0.215	0.001	0.35	0.155	0.155	0.000	0.00
P2	Laminate Glazing	TI AL / AL 1/2"	G5-103-Arg-6162	78.740	78.740	0.456	0.454	-0.002	-0.37	0.451	0.450	-0.001	-0.25	0.518	0.518	0.000	0.00
			G6-103-Arg-6162-Flipped			0.436	0.433	-0.003	-0.67	0.550	0.550	0.000	-0.04	0.518	0.518	0.000	0.00
		TI AL / AL 7/32"	G7-Laminate-Air-Laminate			0.597	0.598	0.001	0.18	0.500	0.500	0.000	-0.04	0.607	0.607	0.000	0.00
P2	Sloped Orientation	TI AL / AL 1/2"	G8-103-Air-103	78.740	78.740	0.816	0.812	-0.003	-0.39	0.681	0.681	0.000	-0.03	0.753	0.753	0.000	0.00
			G9-103-Arg-5284(SClowE)			0.632	0.638	0.006	0.99	0.437	0.437	0.000	-0.03	0.672	0.672	0.000	0.00
P3	Structural Glazed	AL / AL 1/2"	G10-103-Air-103	78.740	78.740	0.516	0.505	-0.011	-2.14	0.695	0.690	-0.005	-0.69	0.728	0.728	0.000	0.00
			G11-103-Argon-5284(SClowE)			0.322	0.307	-0.015	-4.52	0.459	0.454	-0.005	-1.14	0.650	0.650	0.000	0.00
P4	Structural Glazed	AL / AL 1/2"	G10-103-Air-103	78.740	78.740	0.536	0.524	-0.011	-2.14	0.688	0.682	-0.005	-0.77	0.706	0.706	0.000	0.00
			G11-103-Argon-5284(SClowE)			0.344	0.330	-0.015	-4.26	0.459	0.453	-0.006	-1.21	0.630	0.630	0.000	0.00
P5	Double Sash	TB AL / AL 1/4"	G12-103-Air-103-Air-103-Air-103	47.244	59.055	0.340	0.336	-0.004	-1.05	0.431	0.431	0.000	0.01	0.493	0.493	0.000	0.00
			G13-5284-Arg-103-Air-5284-Arg-103			0.264	0.254	-0.010	-3.79	0.227	0.227	0.000	-0.11	0.390	0.390	0.000	0.00
P6	Double Sash	TB AL / N/A	G14-103-Air-103	59.055	47.244	0.678	0.678	0.001	0.09	0.445	0.445	0.001	0.11	0.469	0.469	0.000	0.00
			G15-910-Air-103			0.600	0.600	0.000	0.02	0.395	0.396	0.001	0.24	0.436	0.436	0.000	0.00

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- Curcija, D.C.; Manteghi, M.; Bhandari, M.S.; and Shah, B.V. 2004. "Component Modeling Methodology for Predicting Thermal Performance of Non-Residential Fenestration Systems". *Thermal Performance of Building Envelopes IX Conference*. Clearwater Beach, FL. December 2004.
- DBS. 2006. "FENSIZ: A Windows Based PC Program for Rapid Calculation of Thermal Performance of Fenestration Products in Accordance with Component Modeling Procedure". *User's Manual and Program Description*. DesignBuilder Software. 2006.
- NFRC. 2004. "NFRC 100, Section 5.6: 5.6 Non Residential and High Rise Residential Building Fenestration Products". *National Fenestration Rating Council*. 2004.

APPENDIX A. CONFIGURATIONS USED IN THE MODELING

Table A1. Glazing and spacer Systems

Glazing Systems to be Used		Glazing ID					
Single Glazing							
G1 – Single: clear - 6mm	103						
G2 – Single: Low-e (HC) - 6mm	910						
G3 –Single: Laminate	6162						
G4 –Single clear with applied film	103	2598 (aplied film)					
		[30001]					
IG Incorporating Laminates							
G5 – Double: Laminate Air Clear	103	Air (0.5")	6162				
G6 – Double: Clear Air Laminate	103	Air (0.5")	6162	Flipped (lowe on interior surface)			
G7 – Double: Laminate Air Laminate	laminata	Air (0.25")	laminata				
Laminata: 3mm clr - SGP 90 mil - 3mm clr (Total thickness - 0.4328 in)	30002		3002				
Sloped glazing (20 degeee tilt)							
G8 - Double: Clear Air Clear	103		103	20 degree			
G9 - Double: Clear- Argon Low-e (SC)	103	Argon	5284	20 degree			
Structured glazing							
G10 - Double: Clear Air Clear	103		103				
G11 - Double: Clear- Argon Low-e (SC)	103	Argon	5284				
Double sash							
G12 - Double/Double: Clear Air Clear	103		103	Air	103		103
G13 - Double/Double: Clear- Argon Low-e (SC)	5284	Argon	103	Air	5284	Argon	103
G14 - Single/Single: Clear- AIR-clear	103	AIR	103				
G15 - Single/Single: LowE- AIR-clear	910	AIR	103				
Spacer							
S1 – Standard Aluminum bar single seal							

Table A2. Optical properties of glasses

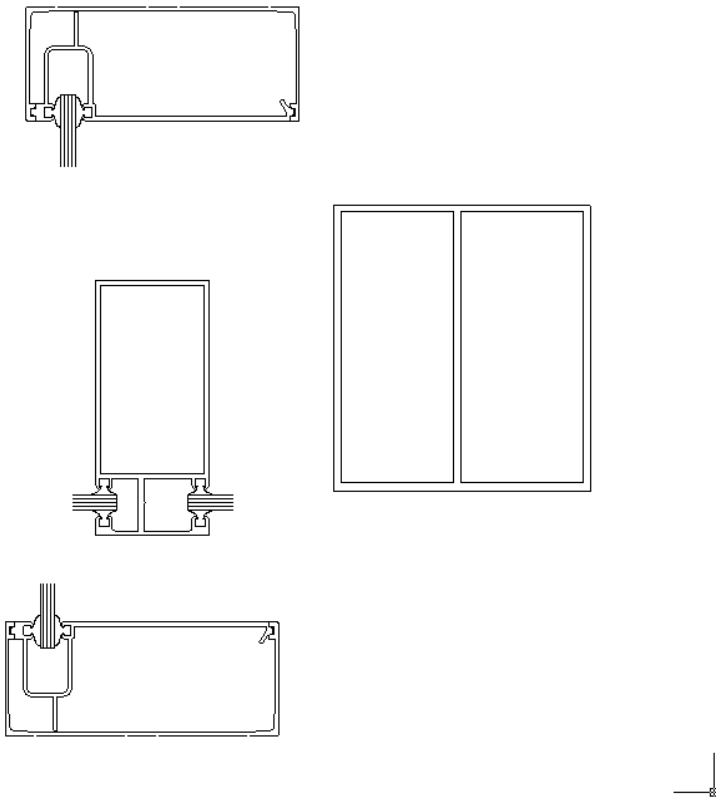
Glass ID	Name	Product Description	Thick in.	Tsol	Rsol1	Rsol2	Tvis	Rvis1	Rvis2	emis1	emis2
103	CLEAR_6.DAT	Generic Clear Glass	0.2250	0.771	0.070	0.070	0.884	0.080	0.080	0.840	0.840
724	C120.AFG	Copper on Clear	0.2220	0.112	0.623	0.474	0.224	0.327	0.354	0.026	0.840
910	CMFTE2_6.AFG	Comfort E ² on Clear	0.2220	0.662	0.107	0.092	0.821	0.097	0.086	0.202	0.840
5000	SB70XL Strph-6.PPG	Solarban® 70XL on Starphire®	0.2230	0.281	0.513	0.562	0.720	0.077	0.059	0.841	0.018
5284	SB60 Clear-6.PPG	Solarban 60® on Clear	0.2230	0.386	0.272	0.455	0.790	0.059	0.049	0.840	0.035
6162	BGLE-lam.vir	Blue Green LowE laminated	0.5059	0.368	0.055	0.091	0.694	0.077	0.088	0.840	0.154
30001	2598-On-103.usr	Generic Applied Film	0.2262	0.122	0.430	0.625	0.174	0.537	0.589	0.840	0.371
30002	102/90SGP6/102.usr	Generic Laminate	0.4328	0.616	0.062	0.062	0.848	0.078	0.078	0.840	0.840

Table A3. Thermal and Optical properties of glazing systems (At Nominal Height)

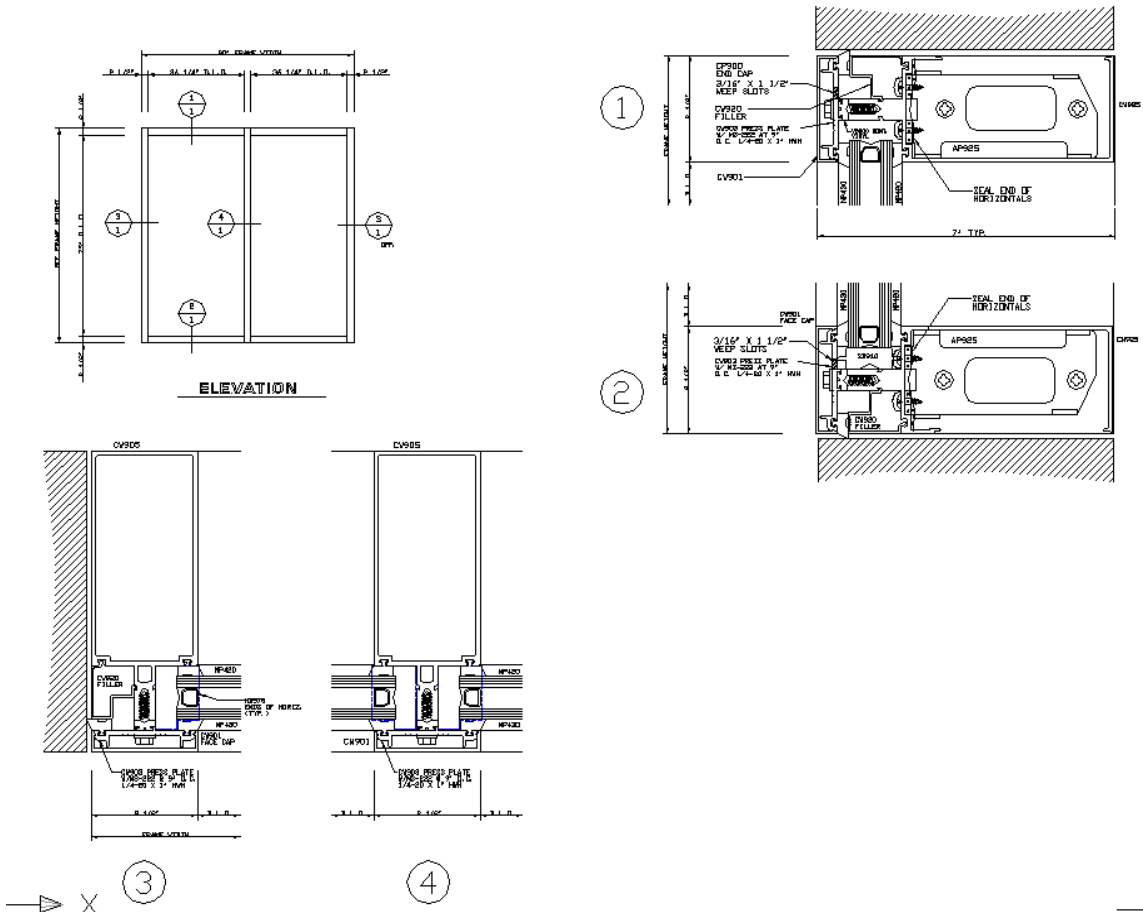
W5 ID	Reference - Name	# of layers	Thick in.	U Btu/h-ft ² -F	SHGC	Tvis
1	G1-103(clear)	1	0.236	1.023	0.816	0.884
2	G2-910(HClowE)	1	0.236	0.670	0.704	0.821
3	G3-6162(Laminate)	1	0.472	0.612	0.477	0.694
4	G4-30001(Film)	1	0.236	0.769	0.218	0.174
11	G5-103-ARG-6162	2	1.229	0.325	0.527	0.618
12	G6-103-ARG-6162-Flip	2	1.229	0.283	0.636	0.618
13	G7-Laminate-AIR-Lami	2	1.116	0.499	0.576	0.724
21	G8-103-Air-103 (20 degree)	2	0.992	0.558	0.705	0.786
22	G9-103-Argon-5284(SC) (20 degree)	2	0.992	0.355	0.450	0.701
25	G10-103-Air-103	2	0.992	0.472	0.702	0.786
26	G11-103-Argon-5284(SC)	2	0.992	0.246	0.449	0.701
31	G12-103-Air-103-AIR-103-Air-103	4	4.185	0.255	0.544	0.632
32	G13-5284-Arg-103-AIR-5284-Arg-103	4	4.185	0.149	0.282	0.499
33	G14-103-AIR-103	2	1.292	0.480	0.703	0.786
33	G15-910-AIR-103	2	1.292	0.359	0.620	0.731
41	Low Glazing - IGU	2	0.972	0.080	0.184	0.165
42	High Glazing - IGU	2	0.972	0.473	0.702	0.786
43	Low Glazing - Single	1	0.236	0.561	0.170	0.224
44	High Glazing - Single	1	0.236	1.023	0.816	0.884

Table A4. Product Configurations used in the modeling

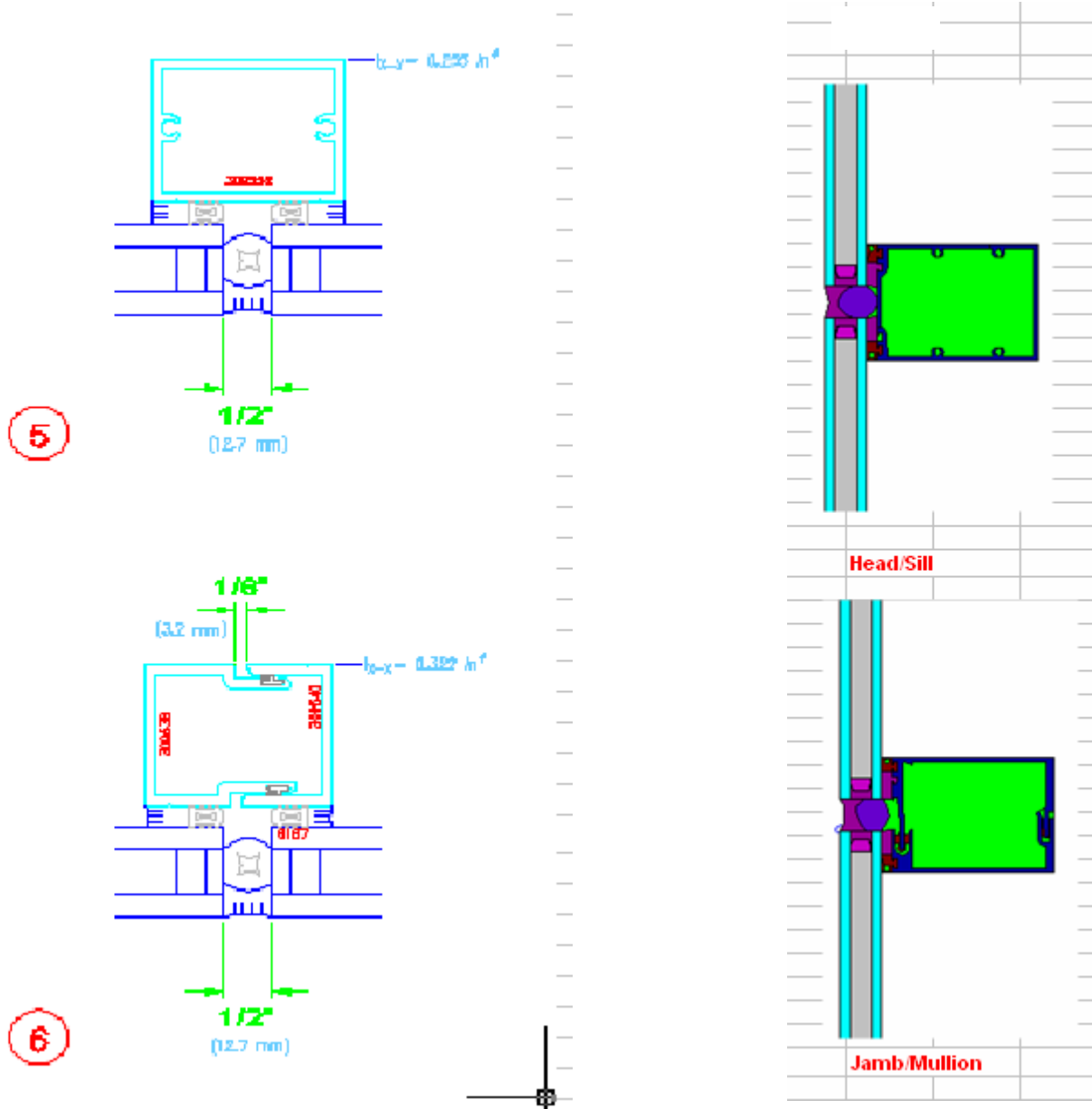
1. Product Details [Window Wall] – Single glazing option [P1]



2. Product Details [Window Wall] – Laminate and sloped glazing options [P2]



3. Product Details [Curtain Wall] – Structural glazed options [P3, P4]



Note: Cross section 5 would be used as Head and Sill and 6 would be used for Jamb and mullion

P3

P4

