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## **Technical Report:**

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### **DEVELOPMENT OF UPDATED FRAME GROUPING RULES**

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*Report prepared for:*

**National Fenestration Rating Council, Inc.**

6305 Ivy Lane, Suite 140  
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**December 4, 2007**

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## Executive Summary

The purpose of this project was to develop updated frame grouping rules to be used in CMA procedures. The research project consisted of three tasks, (1) Review, documentation and cataloguing of existing frame grouping rules, (2) Collection and cataloguing of major framing types and options in fenestration products and (3) Development of new and updated frame grouping rules.

In task 1 current NFRC frame grouping rules were reviewed. The conclusion drawn based on the Component modeling approach being applicable to all the building types except single family houses and multi family structures of three stories or fewer above grade, which will deploy the standard punched opening products, was that all of the current NFRC frame grouping rules will be applicable to the CMA procedures as well. Therefore, the current NFRC 100 frame grouping rules including the latest addition/modification approved by NFRC membership meeting are recommended for CMA procedures as well. The rules are given in Appendix A.

In Task 2, to identify the listing of all major product types, including the listing and categories of prevalent existing framing cross sections and relevant manufacturers a list of manufacturer from NFRC was requested. Both punched opening and glazing façade manufacturers and products are considered for this project. Various parameters for frame grouping rules were identified for further analysis.

In task 3, based on our own findings and recommended frame grouping rules from the manufactures, a new set of frame grouping rules was developed. The parameters used in the analysis are: Projected Frame Depth (PFD), emissivity (external boundary conditions and internal frame cavity), glazing inset related to exterior, variation in frame width and/or frame height (frame cavity web addition causing cavity split), frame material thickness, changes in internal frame cavities and monotonous changes in the same parameter. The rules, derived from detailed THERM/WINODW modeling, are discussed in detail in the report. Order of priority for frame grouping rules was also established. The main advantage of this approach is that the manufacturers can determine the frame group leaders without performing any simulations as opposed to the current NFRC approach where the frame group leader needs to be determined by simulating all the frame cross sections involved.

One of the subtasks of this project was to recommend the generic frame systems for each of the product types. To achieve this goal, current NFRC certified product database was analyzed to determine the worst case U factors based on framing and operator type. Based on the information and analysis a default frame U factor in each category was developed -. These - values are given in Table 6.

## BACKGROUND

The NFRC has identified frame groupings as the high priority technical issue that need to be resolved in order to successfully and effectively implement CMA.

The NFRC rating and certification process includes a number of grouping rules intended to simplify the process for manufacturers and make the rating process less burdensome. Current NFRC grouping rules are based on the assumption that different options can be grouped around the conservative (worst performing) option, if the overall difference in thermal performance is not large. Frame grouping rules are often intended to simplify the definition of a product line and to reduce number of individual product lines that a manufacturer has to certify. While the current rules in published NFRC 100 may help in reducing the modeling and validation (physical) test requirements, they do not reduce the number of product lines and the number of individual options within a product line. Current NFRC 100 grouping rules were developed with mainly residential products in mind and while many of them can be used for non-residential products, there are issues that are uniquely pertinent to non-residential and were additionally investigated, so that frame grouping rules can be applied to larger number of products. Additionally, the development and ongoing approval process for the component modeling approach (CMA), offers additional grouping and approval opportunities, where frame grouping could be applied first to a frame as a component and then to a more traditional whole product. The new grouping rules will potentially allow a frame manufacturer to have their frame cross-sections be assigned the thermal performance value from that of the matching generic frame cross-section.

The existing frame groupings, used in both residential and current non-residential NFRC procedures, are based on the similarities in framing design with the expectation that the thermal performance of the framing system will not differ significantly if frame groupings are employed. The current grouping procedures were developed over the years as NFRC rating procedures evolved and was fine-tuned during the standards, technical interpretations, and other methodology updates. This procedure is considered to be working well for the residential products and manufactured units where variations among product lines may not be substantial and the number of unique frame cross-sections may be limited. In non-residential products, this number is often described as *infinite* and manufacturers have called for the simplification of this process and for the reduction of unique frame cross-sections that would need to be modeled.

The new frame groupings rules, applicable to wider and more complete line of fenestration products will simplify, enhance and improve NFRC rating system. By providing less cumbersome rating system for non-residential products, which are currently not appropriately considered, NFRC will extend the reach into the non-residential market, which is currently only marginally covered. Also, the updated frame grouping rules will allow the new CMA rating system to be successfully implemented. Without the improved and updated frame grouping rules, CMA will not be able to fully deliver on its promise of simple and effective rating system.

## APPROACH

The objective of the project was to develop additional frame grouping rules, for non-residential products and revisit existing frame grouping rules, so that the new set of frame grouping rules can uniformly be applied to the entire range of fenestration products, whether they are residential or non-residential. In addition to whole product grouping rules, investigate and develop frame grouping rules that are specific to frame component submission in the new CMA, being the basis for the new non-residential NFRC procedure, including the development of generic frame categories that can be used to simplify grouping of frame systems as components in CMA.

### 1.1 Review, Documentation and Cataloguing of Existing Frame Grouping Rules

Current frame grouping rules and language as outlined in NFRC 100 and 200 were reviewed especially in the light of their applicability for non-residential fenestration products. The conclusion drawn based on the Component modeling approach being applicable to all the building types except single family houses and multi family structures of three stories or fewer above grade, which will deploy the standard punched opening products, was that all of the current NFRC frame grouping rules will be applicable to the CMA procedures as well. Therefore, the current NFRC 100 frame grouping rules including the latest addition/modification approved by NFRC membership meeting are recommended for CMA procedures as well. The rules are given in Appendix A.

### 1.2 Collection and Cataloguing of Major Framing Types and Options in Fenestration Products

The number of unique frame cross section for non-residential products is often described as *infinite*; therefore, a simplification process of defining unique cross sections is required for the reduction of unique frame cross-sections that would need to be modeled. The aim was to identify the features such as variation in material thickness, appendages, monotonic variations of the same feature (e.g., depth of the reveal), and sort them out.

As a first step, the listing of all major product types, including the listing and categories of prevalent existing framing cross sections, and relevant manufacturers was identified. Inquiries were sent to selected group of manufacturers asking them to identify their unique framing types and also to indicate their recommendations for grouping rules, as that may be useful in the later part of the project. A list of manufacturer was obtained from NFRC. As current NFRC list did not contain a good representation of Non Residential manufacture, additional manufacturers were solicited from other organizations and personal contacts. The main emphasis was given to the Curtain Walls, Custom windows, Glazed wall/sloped glazing, Store Front and Commercial Skylights manufacturer.

Based on the review of various catalogs the potential parameters for analysis were identified as: Projected frame depth (PFD), emissivity (external boundary conditions and internal frame cavity), glazing inset related to exterior, variation in frame width and/or frame height (frame cavity web addition causing cavity split), frame material

thickness, changes in internal frame cavities and monotonous changes in the same parameter. In consultation with project monitoring task Group, the parameters given in Table 1 were finalized for further study.

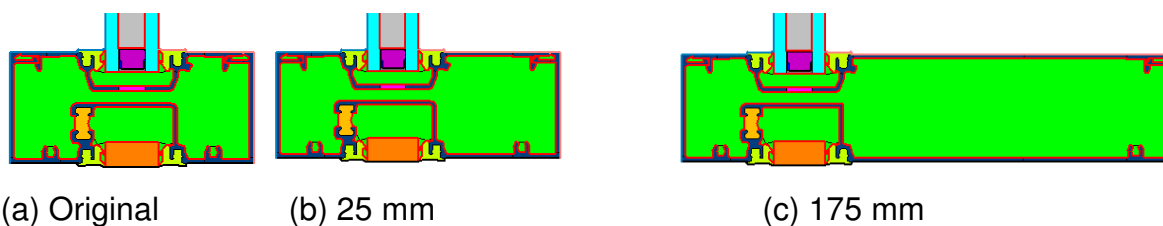
**Table 1.** Various Parameters selected for frame grouping criteria

	Variations
1	Change in length (X direction)
2	Emissivity (0.2, 0.8, 0.9)
3	Glass Location /Position (inward, centered and outward set)
4	Change in PFD
5	Material (wall) Thickness
6	Internal cavity (addition of web)- variations

### 1.3 Development of New and Updated Frame Grouping Rules

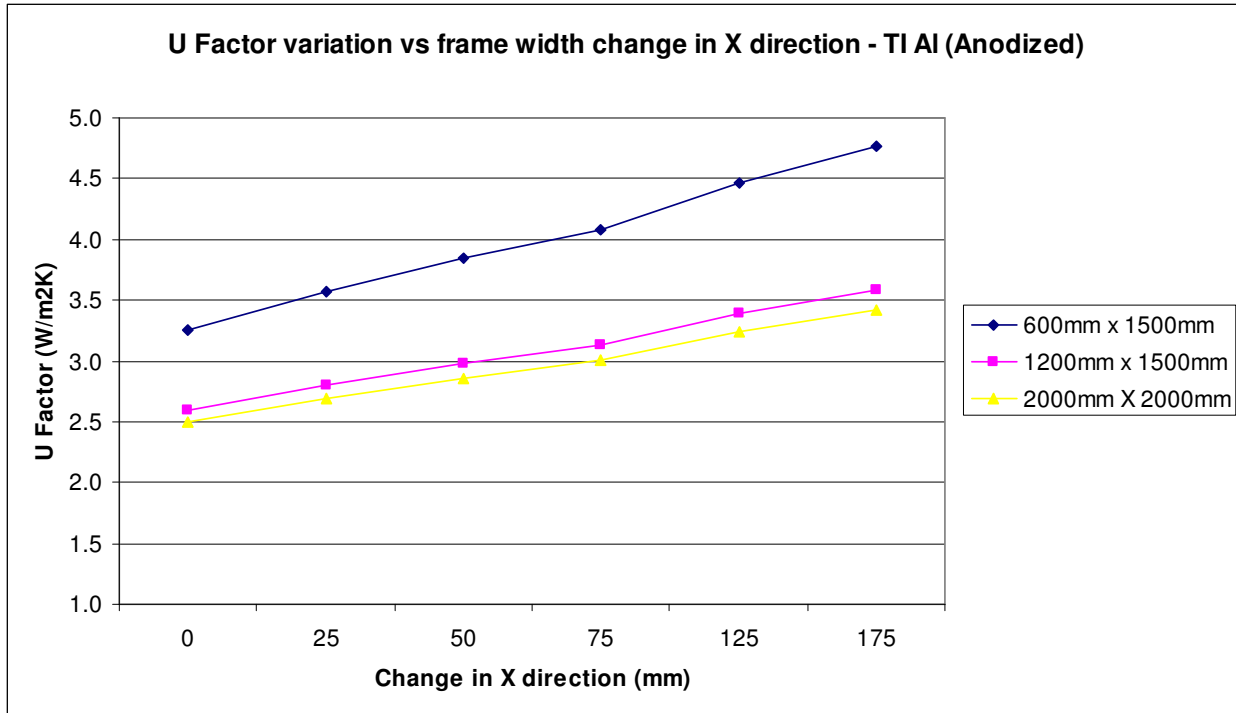
Detailed THERM and WINDOW modeling was performed for various parameters identified in Table 1. The analysis was carried out for different Product sizes and major framing material Aluminum (AL, AL-TI, AL-TB, Wood, Vinyl, and Fiberglass) materials to determine the group leader. A glazing system (clr-Arg-lowE) with c-o-g U factor of  $1.37 \text{ W/m}^2\text{K}$  ( $0.24 \text{ Btu/hr-ft}^2\text{F}$ ) was considered for the analysis. The calculations were performed for 3 product sizes of 600 mm x 1500 mm, 1200mm x 1500m and 2000mm and 200mm, representing casement, fixed and curtain wall/dual vision products.

The methodology is explained here with the help of an example for the parameter 1 (from Table 1). This example shows the effect of change in length in X direction. The cross section length in X direction was varied by 25mm, 50mm, 75mm, 125mm and 175 mm along the X-axis as shown in Figure 1 for the variation of 25 mm and 175 mm. The analysis was done for Aluminum and Thermally Improved (TI) Aluminum product type with emissivity of 0.8 (Anodized Aluminum) and 0.2 (Mill Finish Aluminum).

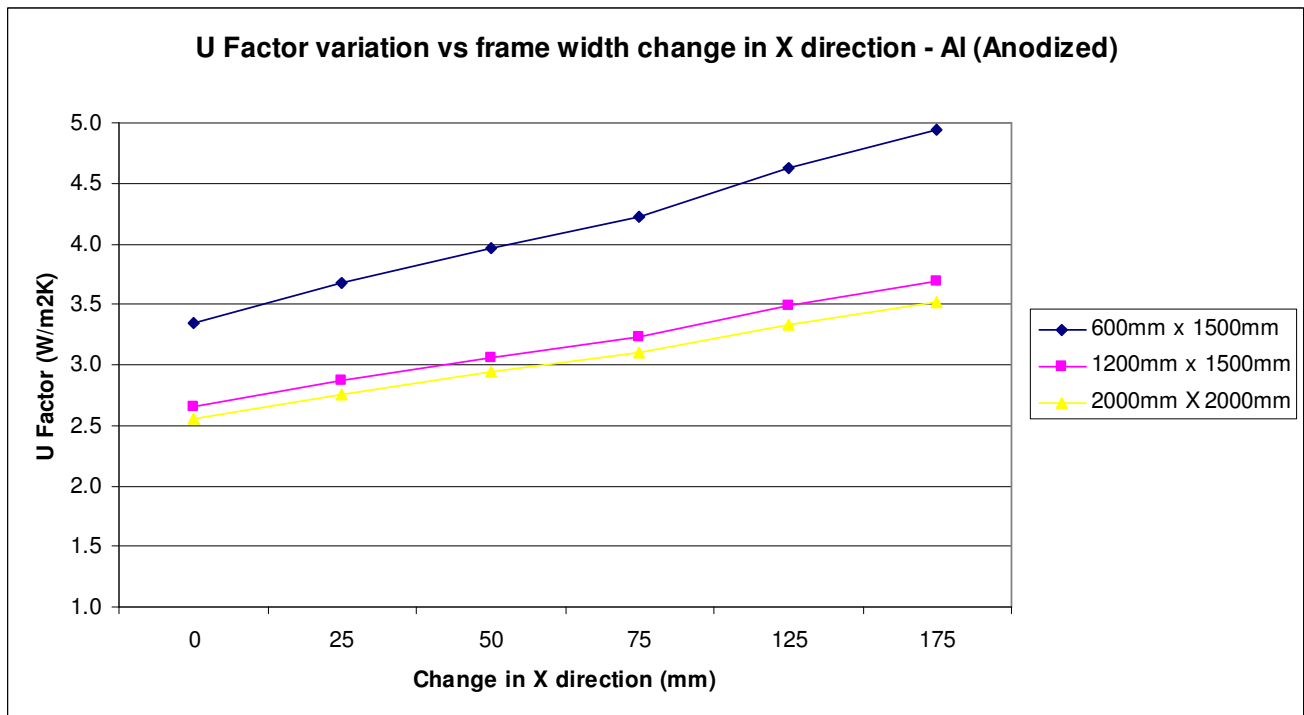


**Figure 1:** Variation of length in X-Axis

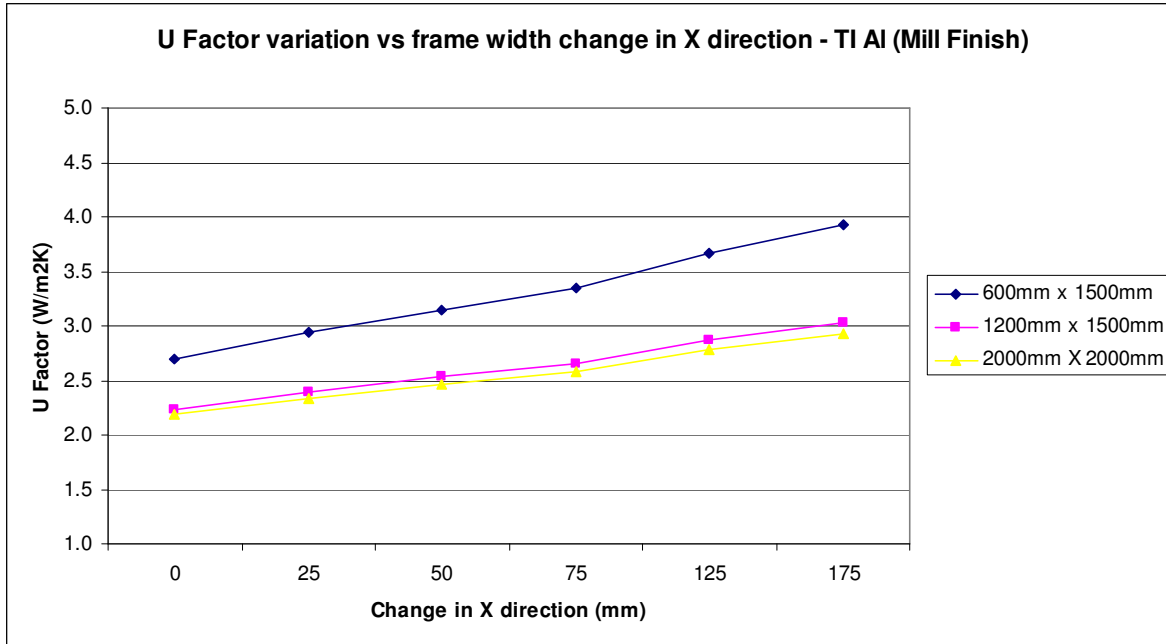
The U factor results are shown in Figures 2 to 6 below.



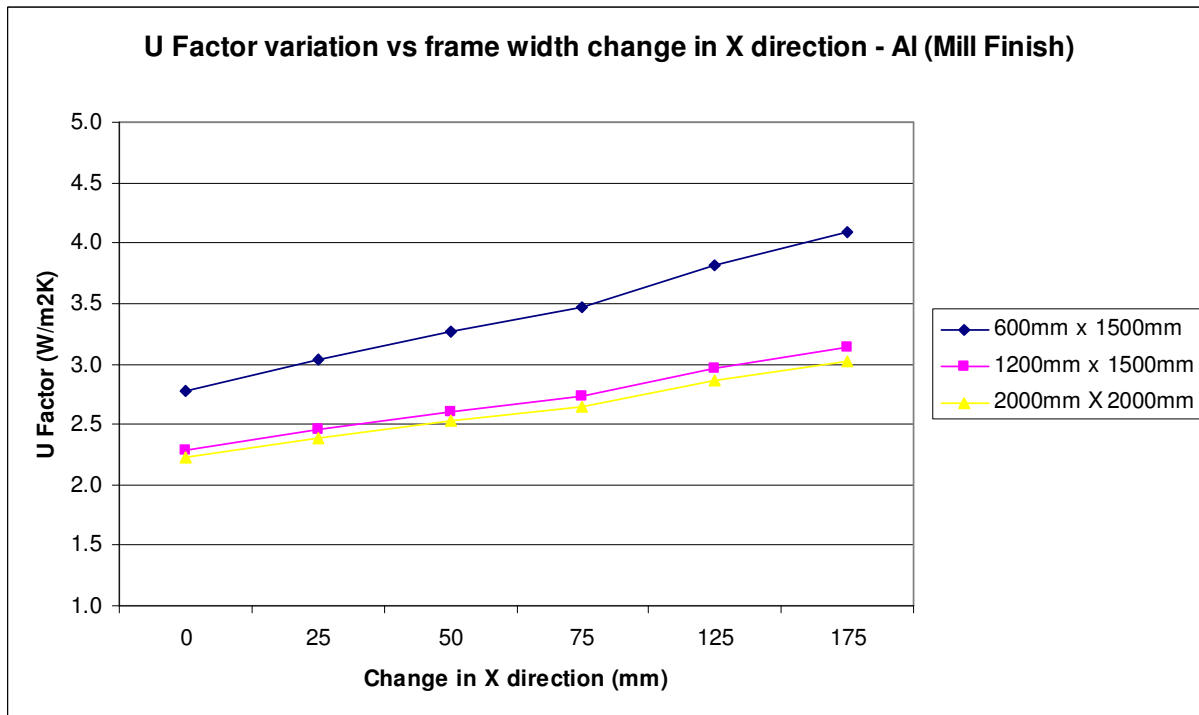
**Figure 2:** U factor variation with change in X direction for Thermally Improved Anodized Aluminum window



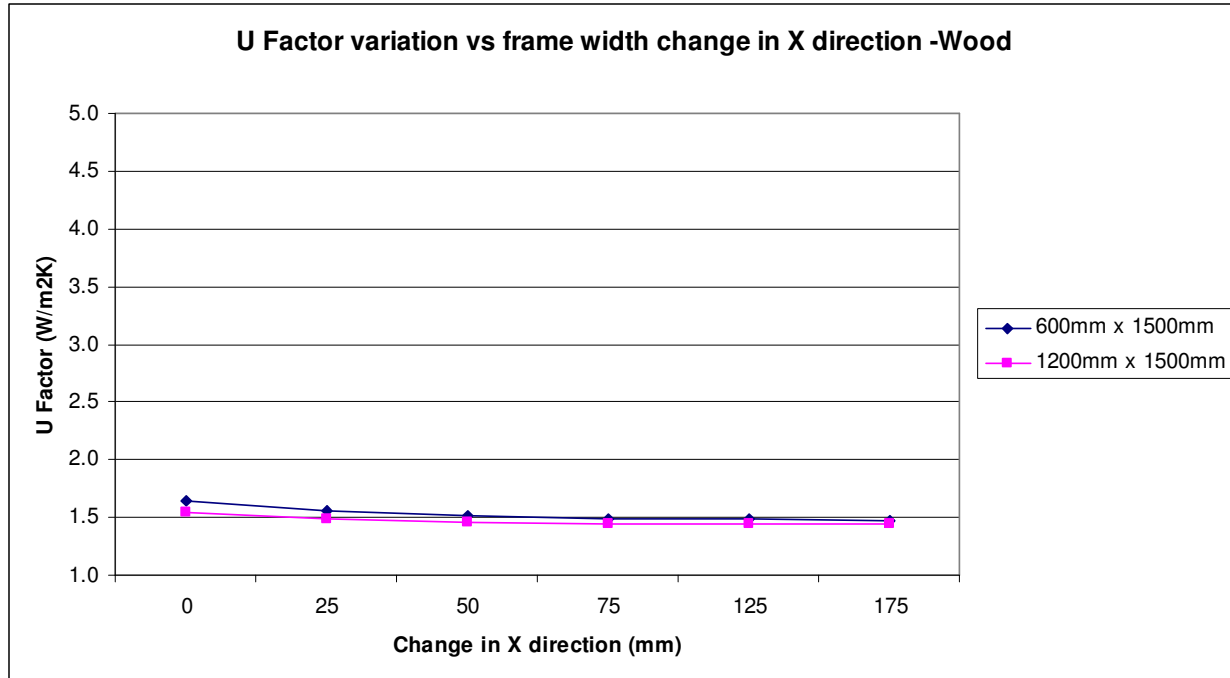
**Figure 3:** U factor variation with change in X direction for Anodized Aluminum window



**Figure 4:** U factor variation with change in X direction for Thermally Improved Mill Finished Aluminum window



**Figure 5:** U factor variation with change in X direction for Mill Finished Aluminum window



**Figure 6:** U factor variation with change in X direction for Wood window

It is evident from Figure 2-5 that U factor increases as the length along X-axis increases. The manufacturer can choose the product having highest frame length in the X-direction as a group leader without simulating the product. The trend is reversed for the wood window, as is evident from Figure 6, though the variation is very small. The graphs for the rest of the parameters are given in Appendix B.

The results are summarized in Table 2 for % U factor and SHGC changes. While frame grouping is important for U-factors, it is inconsequential for SHGC. This is because SHGC of frames is not modeled, but rather estimated from the ratio of wetted to projected area of outdoor frame surfaces. Therefore, the values for SHGC in Table 2 are shown only for reference. Table 2 below shows the maximum change with respect to minimum and maximum values for a particular variation. The main purpose of these results is to establish the order of priority for the variations in case of more than one variation being considered for the frame grouping.

**Table 2.** Change in U factor and SHGC for different frame variations**a. Thermally Broken -Aluminum**

	Variations	Description	% U factor change (min-max /min)*100	% SHGC change
1	Glass Location /Position	Outside, center, inside set	-15	-3
2	Material (wall) Thickness	Increased by 2 , 4mm	-7	0
3	Change in length (X direction)	Increased by 25 mm upto 175 mm	-47	-3
4	Change in PFD	Increased by 10, 20 30 mm	-10	14
5	Emissivity (0.2, 0.8, 0.9)	0.2, 0.8 and 0.9	-25	-1
6	Internal cavity (addition of web)- variations	Addition of 1 and 2 cavities	-1	0

**b. Aluminum**

	Variations	Description	% U factor change (min-max /min)*100	% SHGC change
1	Glass Location /Position	Outside, center, inside set	-19	-3
2	Material (wall) Thickness	Increased by 2 , 4mm	-8	0
3	Change in length (X direction)	Increased by 25 mm upto 175 mm	-48	4
4	Change in PFD	Increased by 10, 20 30 mm	-13	13
5	Emissivity (0.2, 0.8, 0.9)	0.2, 0.8 and 0.9	-25	-1
6	Internal cavity (addition of web)- variations	Addition of 1 and 2 cavities	-2	0

**c. PVC**

	Variations	Description	% U factor change (min-max /min)*100	% SHGC change
1	Glass Location /Position	Outside, center, inside set	-4	0
2	Material (wall) Thickness	Increased by 2 , 4mm	4	0
3	Change in length (X direction)	Increased by 25 mm upto 175 mm	-9	0
4	Change in PFD	Increased by 10, 20 30 mm	-11	15
5	Emissivity (0.2, 0.8, 0.9)	0.2, 0.8 and 0.9		
6	Internal cavity (addition of web)- variations	Addition of 1 and 2 cavities	-3	0

Note: Fiberglass products show similar variations and therefore not considered separately

**d. Wood**

	<b>Variations</b>	<b>Description</b>	<b>% U factor change (min-max /min)*100</b>	<b>% SHGC change</b>
1	Glass Location /Position	Outside, center, inside set	-1.7	0.0
2	Material (wall) Thickness	Increased by 2 , 4mm		
3	Change in length (X direction)	Increased by 25 mm upto 175 mm	1.9	0.0
4	Change in PFD	Increased by 10, 20 30 mm	6.8	19
5	Emissivity (0.2, 0.8, 0.9)	0.2, 0.8 and 0.9		
6	Internal cavity (addition of web)- variations	Addition of 1 and 2 cavities		

Based on the results summarized from above, the following order of priority is established (Table 3).

**Table 3.** Order of priority for frame grouping

	<b>Variations</b>
1	Change in length (X direction)
2	Emissivity (0.2, 0.8, 0.9)
3	Glass Location /Position
4	Change in PFD
5	Material (wall) Thickness
6	Internal cavity (addition of web)- variations

The detailed results are presented in Appendix B. The group leaders for each of the variations are given in Table 4.

**Table 4.** Product Group Leaders**a. Frame types: Aluminum, Thermally Improved Aluminum and Thermally Broken Aluminum**

	<b>Variations</b>	<b>Description</b>	<b>Product Group leader</b>
1	Change in length (X direction)	Increased by 25 mm upto 175 mm	Maximum length in X-direction
2	Emissivity (0.2, 0.8, 0.9)	0.2, 0.8 and 0.9	Hierarchy will be in the descending order of emissivity value, e.g. 0.9 will always be group leader
3	Glass Location /Position	Outside, center, inside set	Outside set is always the group leader (Center set is the group leader for inside and center set variation)
4	Change in PFD	Increased by 10, 20 30 mm	Highest PFD
5	Material (wall) Thickness	Increased by 2 , 4mm	Maximum wall thickness
6	Internal cavity (addition of web)- variations	Addition of 1 and 2 cavities	Maximum number of webs

**b. Frame types: PVC and Fiberglass**

	<b>Variations</b>	<b>Description</b>	<b>Product Group leader</b>
1	Change in length (X direction)	Increased by 25 mm upto 175 mm	Maximum length in X-direction
2	Glass Location /Position	Outside, center, inside set	Outside set (Center set in case of only inside and center set variation)
3	Change in PFD	Increased by 10, 20 30 mm	Highest PFD
4	Material (wall) Thickness	Increased by 2 , 4mm	Minimum wall thickness
5	Internal cavity (addition of web)- variations	Addition of 1 and 2 cavities	Minimum number of webs

**c. Frame type: Wood**

	<b>Variations</b>	<b>Description</b>	<b>Product Group leader</b>
1	Change in length (X direction)	Increased by 25 mm upto 175 mm	Minimum length in X-direction
2	Glass Location /Position	Outside, center, inside set	Outside set (Center set in case of only inside and center set variation)
3	Change in PFD	Increased by 10, 20 30 mm	Lowest PFD

In the current NFRC procedure (NFRC 100), the products are not eligible for frame grouping if PFD of the frame cross sections is different. The argument for not allowing difference in PFD is that if the product with higher PFD comes out to be the group leader, it will reduce the SHGC of the product which is against the intent of the grouping (group leader need to be worst performing and lower SHGC will be considered better especially with respect to cooling load reduction). However, In CMA procedure, the manufactures need to submit all the frame cross sections used for frame grouping and while only group leaders will be modeled for their actual U-factor and that U-factor will be used for all grouped frames; each of these products will be entered in the CMA frame database. Therefore, actual PFD of each grouped frame cross section will be available and will be considered for overall product SHGC calculations.

The trends for various parameters selected were very clear; therefore no building modeling is necessary as was proposed in the original proposal, which was envision for the scenario where the trends could not be established.

#### 1.4 Determination of the Worst Case Frame U-factors:

One of the subtasks of this project was to determine the worst case frame performance for each of the product types to aid in the development of default frame U-factors. The default frame performance was not recommended as a part of this project for two reasons; 1) For several product and operator types, the data was either not available or sample was too small and/or unreliable; 2) there was no consensus what additional penalty in performance should be applied to produce default frame U-factors.

The data from NFRC CPD were utilized to develop the list of worst case frame performance. The data was obtained for clear argon lowE glazing units for all product types listed in the Table 5. The products that are not in NFRC CPD may have had worse performance, but because their data is unpublished this was not possible to determine. The worst case whole product U factors were extracted from current NFRC CPD for each of the product types. To obtain the Frame U Factors, the W5 mdb file for individual products which needed final analysis was requested from the simulation laboratories with the assistance from NFRC staff. The area weighted average frame U factors were extracted from the whole product U factors of the available W5 mdbs. Detailed report for the individual product with worst U factor from W5 MDB was extracted. The frame U factor was obtained by area weighting the frame U factors of various cross sections in that particular product. For example, for a fixed window, the area weighted frame U factor was calculated as follows:

$$U_{Frame} = \frac{A_{LJ} \cdot U_{LJ} + A_{RJ} \cdot U_{RJ} + A_S \cdot U_S + A_H \cdot U_H}{A_{LJ} + A_{RJ} + A_S + A_H}$$

Where, subscript LJ, RJ, S and H are left jam, right jamb, sill and head respectively and A is the area and U is the U Factor.

Data for some of the products were either not available or the data sample was not sufficient in the CPD. The missing products were not assigned any values and were denoted by \*\*. Also, some of the products, which may not be manufactured currently in a specific product type category, were not assigned any values. For example, currently curtain walls are not manufactured with wood and vinyl framing materials and therefore default frame U factors are not assigned for wood and vinyl curtain walls. It is

recommended that these products shall be simulated and cannot use default generic frame U factors. The worst case frame U factors are shown in Table 5 (SI) and Table 6 (IP) . The unassigned categories are denoted by \*\* in. These unassigned categories may be filled in the future once the values are available.

**Table 5. : Worst case frame U factors**

S. No.	Description	Code	Definition	Worst case Frame U factor (W/m <sup>2</sup> K)					
				Aluminum	Aluminum-TI	Aluminum-TB	Wood	Vinyl	FiberGlass
1	Casement	CSDV , CSOX, CSSV*, CSTH,	Double Vent, Vent/Fixed, Single	6.46	5.47	4.81	3.68	2.53	2.75
2	Dual Action	DAOT, DATT	Specify Configuration in Comment Field, Tilt	**	**	**	**	2.02	**
3	Double Door	DDFR	French-style Door (XX or OX)	**	**	**	**	2.10	**
4	Sliding Glass Door	DDSG	Sliding Glass Door (XX or OX)	8.44	7.04	5.00	2.86	2.50	3.28
5	Swinging Door	EDSL	Single Leaf Entrance Door	6.97	**	4.27	**	1.87	**
6	Fixed	FIGS, FIUN, FIXD*, FXEL,	Multiple Geometric, ShapeConfiguration,	6.75	6.19	4.68	*	2.53	2.49
7	Fixed	FXSL	Side-Lite	8.17	**	**	**	2.28	**
8	Fixed	FXTR	Transom	**	**	**	2.30	2.75	**
9	Glazed Wall System	GWCW	Curtain Wall	13.26	9.96	5.45	**	**	**
10	Glazed Wall System	GWSL	Solarium	**	**	5.31	**	**	**
11	Glazed Wall System	GWWW	Window Wall	**	10.10	6.12	**	**	**
12	Horizontal Slider	HSOX*, HSUN, HSXX**	Fixed/Operable, Configuration	8.32	5.69	4.55	2.58	2.15	2.74
13	Projected	PRAW*, PREFIX, PROJ,	Awning, Fixed Over Projected, Vent Only,	6.86	6.56	4.79	**	1.68	2.75
14	Skylight	SKDM, SKFX*, SKOP, SKUN,	Domed, Fixed, Operabl e	**	**	17.18	12.79	12.04	16.64
15	Sloped glazing	SKSL	Sloped Glazing	**	**	11.19	**	**	**
16	Vertical Slider	VSDH, VSSH, VSUN	Double Hung, Single Hung, Configuration	9.16	7.94	5.57	2.48	2.75	2.82

\*\*Sufficient data is not available for this category

**Table 6.** Worst Case frame U factors (IP – Units for reference only)

S. No.	Description	Code	Definition	Worst case U factor (Btu/hr-ft <sup>2</sup> F)					
				Aluminum	Aluminum-TI	Aluminum-TB	Wood	Vinyl	FiberGlass
1	Casement	CSDV, CSOX, CSSV*, CSTH,	Double Vent, Vent/Fixed, Single Specify Configuration in Comment Field, Tilt	1.14	0.96	0.85	0.65	0.45	0.48
2	Dual Action	DAOT, DATT	French-style Door (XX or OX)	**	**	**	**	0.36	**
3	Double Door	DDFR	Sliding Glass Door (XX or OX)	**	**	**	**	0.37	**
4	Sliding Glass Door	DDSG	Single Leaf Entrance Door	1.49	1.24	0.88	0.50	0.44	0.58
5	Swinging Door	EDSL	Multiple Geometric, ShapeConfiguration,	1.23	**	0.75	**	0.33	**
6	Fixed	FIGS, FIUN, FIXD*, FXEL,	Side-Lite	1.19	1.09	0.82	*	0.45	0.44
7	Fixed	FXSL	Transom	1.44	**	**	**	0.40	**
8	Fixed	FXTR	Curtain Wall	**	**	**	0.41	0.49	**
9	Glazed Wall System	GWCW	Solarium	2.34	1.75	0.96	**	**	**
10	Glazed Wall System	GWSL	Window Wall	**	**	0.93	**	**	**
11	Glazed Wall System	GWWW	Fixed/Operable, Configuration	**	1.78	1.08	**	**	**
12	Horizontal Slider	HSOX*, HSUN, HSXX**	Awning, Fixed Over Projected, Vent Only,	1.47	1.00	0.80	0.45	0.38	0.48
13	Projected	PRAW*, PRFX, PROJ,	Domed, Fixed, Operabl e	1.21	1.16	0.84	**	0.30	0.48
14	Skylight	SKDM, SKFX*, SKOP, SKUN,	Sloped Glazing	**	**	3.03	2.25	2.12	2.93
15	Sloped glazing	SKSL	Double Hung, Single Hung, Configuration	**	**	1.97	**	**	**
16	Vertical Slider	VSDH, VSSH, VSUN		1.61	1.40	0.98	0.44	0.49	0.50

\*\*Sufficient data is not available for this category

## Conclusions and recommendations for technical documents:

Current NFRC frame grouping rules were reviewed and recommended to be used in CMA procedures as well. Based on the review of various catalogs the potential parameters for analysis were identified and detailed THERM/WINDOW analysis were carried out to determine the frame group leader for the frame variations. The order of priority was established in case there are more than one variable that is changing in a particular frame cross section. The main advantage of this approach is that manufacturers can determine the frame group leaders without performing any simulations as opposed to the current NFRC approach where the frame group leader needs to be determined by simulating all the frame cross sections involved. As actual PFD will be used there would be no change in VT calculation procedure. .

## Recommendations for the Frame Grouping

The following tables should be included in respective NFRC technical documents.

### NFRC 100 Sections 5.6:

**Table 7.** Recommended Product Group Leaders

#### a. Frame type Aluminum, Thermally Improved Aluminum and Thermally Broken Aluminum

	Variations	Description	Product Group leader
1	Change in length (X direction)	Increased by 25 mm upto 175 mm	Maximum length in X-direction
2	Emissivity (0.2, 0.8, 0.9)	0.2, 0.8 and 0.9	Hierarchy will be in the descending order of emissivity value, e.g. 0.9 will always be group leader
3	Glass Location /Position	Outside, center, inside set	Outside set is always the group leader (Center set is the group leader for inside and center set variation)
4	Change in PFD	Increased by 10, 20 30 mm	Highest PFD
5	Material (wall) Thickness	Increased by 2 , 4mm	Maximum wall thickness
6	Internal cavity (addition of web)- variations	Addition of 1 and 2 cavities	Maximum number of webs

**b. Frame type PVC and Fiberglass**

	<b>Variations</b>	<b>Description</b>	<b>Product Group leader</b>
1	Change in length (X direction)	Increased by 25 mm upto 175 mm	Maximum length in X-direction
2	Glass Location /Position	Outside, center, inside set	Outside set (Center set in case of only inside and center set variation)
3	Change in PFD	Increased by 10, 20 30 mm	Highest PFD
4	Material (wall) Thickness	Increased by 2 , 4mm	Minimum wall thickness
5	Internal cavity (addition of web)- variations	Addition of 1 and 2 cavities	Minimum number of webs

**c. Frame type Wood**

	<b>Variations</b>	<b>Description</b>	<b>Product Group leader</b>
1	Change in length (X direction)	Increased by 25 mm upto 175 mm	Minimum length in X-direction
2	Glass Location /Position	Outside, center, inside set	Outside set (Center set in case of only inside and center set variation)
3	Change in PFD	Increased by 10, 20 30 mm	Lowest PFD

**Table 8.** Order of priority for frame grouping

	<b>Variations</b>
1	Change in length (X direction)
2	Emissivity (0.2, 0.8, 0.9)
3	Glass Location /Position
4	Change in PFD
5	Material (wall) Thickness
6	Internal cavity (addition of web)- variations

## Recommendations for the Default Values

### NFRC 100 - Section 5.6

Two options are recommended for the default frame U-factors. We recommend the following two options:

Option 1: Default frame U-factor for each of the categories in Table 5. Based on PMTG recommendations, 10% penalty was applied to the worst case U factors from Table 5 in order to create default frame U-factors. Results presented in Table 9 and Table 10..

Option 2: Default frame U-factors for three broad-based categories.

- I) Windows/Doors
- II) Curtain Wall/Glazed Wall
- III) Sloped products (i.e., skylights, sloped glazed wall, etc.)

For each of these categories, worst U-factor was chosen from Table 9 (SI) and Table 10 (IP) for appropriate products. The results are shown in Table 11 and Table 12.1

The following table(s) show recommended default U factors for the two options:

**Table 9.** Option 1: Recommended Default frame U factors (SI Units)

S. No.	Description	Code	Definition	Default U factor (Btu/hr-ft <sup>2</sup> F)					
				Aluminum	Aluminum-TI	Aluminum-TB	Wood	Vinyl	FiberGlass
1	Casement	CSDV, CSOX, CSSV*, CSTH,	Double Vent, Vent/Fixed, Single	7.18	6.08	5.34	4.09	2.81	3.06
2	Dual Action	DAOT, DATT	Specify Configuration in Comment Field, Tilt	**	**	**	**	2.25	**
3	Double Door	DDFR	French-style Door (XX or OX)	**	**	**	**	2.33	**
4	Sliding Glass Door	DDSG	Sliding Glass Door (XX or OX)	9.37	7.83	5.56	3.18	2.77	3.64
5	Swinging Door	EDSL	Single Leaf Entrance Door	7.74	**	4.74	**	2.07	**
6	Fixed	FIGS, FIUN, FIXD*, FXEL,	Multiple Geometric, ShapeConfiguration,	7.50	6.88	5.20	*	2.81	2.77
7	Fixed	FXSL	Side-Lite	9.08	**	**	**	2.53	**
8	Fixed	FXTR	Transom	**	**	**	2.56	3.06	**
9	Glazed Wall System	GWCW	Curtain Wall	14.73	11.06	6.05	**	**	**
10	Glazed Wall System	GWSL	Solarium	**	**	5.90	**	**	**
11	Glazed Wall System	GWWW	Window Wall	**	11.22	6.80	**	**	**
12	Horizontal Slider	HSOX*, HSUN, HSXX**	Fixed/Operable, Configuration	9.24	6.32	5.06	2.87	2.39	3.05
13	Projected	PRAW*, PRFX, PROJ,	Awning, Fixed Over Projected, Vent Only,	7.62	7.29	5.32	**	1.87	3.06
14	Skylight	SKDM, SKFX*, SKOP, SKUN,	Domed, Fixed, Operabl e	**	**	19.09	14.21	13.38	18.49
15	Sloped glazing	SKSL	Sloped Glazing	**	**	12.44	**	**	**
16	Vertical Slider	VSDH, VSSH, VSUN	Double Hung, Single Hung, Configuration	10.18	8.82	6.18	2.75	3.06	3.13

\*\* Sufficient data is not available for this category

**Table 10.** Option 1: Recommended Default frame U factors (IP Units – for reference only)

S. No.	Description	Code	Definition	Default U factor (Btu/hr-ft <sup>2</sup> F)					
				Aluminum	Aluminum-TI	Aluminum-TB	Wood	Vinyl	FiberGlass
1	Casement	CSDV , CSOX, CSSV*, CSTH,	Double Vent, Vent/Fixed, Single	1.27	1.07	0.94	0.72	0.50	0.54
2	Dual Action	DAOT, DATT	Specify Configuration in Comment Field, Tilt	**	**	**	**	0.40	**
3	Double Door	DDFR	French-style Door (XX or OX)	**	**	**	**	0.41	**
4	Sliding Glass Door	DDSG	Sliding Glass Door (XX or OX)	1.65	1.38	0.98	0.56	0.49	0.64
5	Swinging Door	EDSL	Single Leaf Entrance Door	1.36	**	0.83	**	0.37	**
6	Fixed	FIGS, FIUN, FIXD*, FXEL,	Multiple Geometric, ShapeConfiguration,	1.32	1.21	0.92	*	0.50	0.49
7	Fixed	FXSL	Side-Lite	1.60	**	**	**	0.45	**
8	Fixed	FXTR	Transom	**	**	**	0.45	0.54	**
9	Glazed Wall System	GWCW	Curtain Wall	2.59	1.95	1.07	**	**	**
10	Glazed Wall System	GWSL	Solarium	**	**	1.04	**	**	**
11	Glazed Wall System	GWWW	Window Wall	**	1.98	1.20	**	**	**
12	Horizontal Slider	HSDV*, HSDN, HSXX**	Fixed/Operable, Configuration	1.63	1.11	0.89	0.50	0.42	0.54
13	Projected	PRAW*, PRFX, PROJ,	Awning, Fixed Over Projected, Vent Only,	1.34	1.28	0.94	**	0.33	0.54
14	Skylight	SKDM, SKFX*, SKOP, SKUN,	Domed, Fixed, Operabl e	**	**	3.36	2.50	2.36	3.26
15	Sloped glazing	SKSL	Sloped Glazing	**	**	2.19	**	**	**
16	Vertical Slider	VSDH, VSSH, VSUN	Double Hung, Single Hung, Configuration	1.79	1.55	1.09	0.49	0.54	0.55

\*\* Sufficient data is not available for this category

**Table 11.** Option 2: Recommended Default frame U factors (SI Units)

Fenestration Type	Default U factor (W/m <sup>2</sup> K)				
	Aluminum	Aluminum-TI	Aluminum-TB	Wood/Vinyl	Fiber Glass
Windows	10.18	8.82	6.18	4.09	3.13
Curtain wall	14.73	11.22	6.80		
Skylights/Sloped glazing	*	*	19.09	14.21	18.49

\*\*Sufficient data is not available for this category

**Table 12.** Option 2: Recommended Default frame U factors (IP Units – for reference only)

Fenestration Type	Default Frame U factor (Btu/hr-ft <sup>2</sup> F)				
	Aluminum	Aluminum-TI	Aluminum-TB	Wood/Vinyl	Fiber Glass
Windows	1.79	1.55	1.09	0.72	0.64
Curtain wall	2.59	1.98	1.20		
Skylights/Sloped glazing	*	*	3.36	2.50	3.26

\*\*Sufficient data is not available for this category

**NFRC 200 – Section 4.7**

Default SHGC will be calculated in accordance with ISO15099 Section 4.2.2. (as referenced in NFRC 200) with the listed assumption below:

$$SHGC_f = \alpha_f \frac{U_f}{\frac{A_s}{A_f} h_{ex}}$$

Where,

SHGC<sub>f</sub> = the frame SHGC

$\alpha_f$  = absorptivity of the frame

$h_{ex}$  = exterior heat transfer coefficient, W/m<sup>2</sup>K (Btu/hr-ft<sup>2</sup>-F)

$U_f$  = frame U factor, for this the default U factor from Table 9 (SI) / Table 10 (IP), or Table 11 (SI) / Table 12 (IP) will be used, W/m<sup>2</sup>K (Btu/hr-ft<sup>2</sup>-F), depending on which Option is adopted.

$A_s$  = the developed (wetted) surface area of the frame, m<sup>2</sup> (ft<sup>2</sup>)

$A_f$  = the projected area of the frame, m<sup>2</sup> (ft<sup>2</sup>)

For default SHGC<sub>f</sub>,  $A_s/A_f$  is assumed to be 1.0. As per current NFRC guidelines  $\alpha_f$  is assumed to be 0.5 for the non-residential products.  $A_s$  will always be greater than  $A_f$  therefore the assumption  $A_s/A_f = 1$  is more conservative because the lower denominator value results in higher value of SHGC<sub>f</sub>.

## References

- Curcija, D.C. 2003. "Component Model Approach In Modeling Non-Residential fenestration Products"
- ISO 15099 (2002) – Thermal Performance of Windows, Doors and Shading Devices - Detailed Calculations
- LBNL. 2003. "THERM5 - A PC Program for Analyzing Window Thermal Performance of Fenestration Products", Berkeley CA: Windows and Daylighting Group, Lawrence Berkeley Laboratory, 2003.
- LBNL 2003, "WINDOW5 - A PC Program for Analyzing Window Thermal Performance of Fenestration Products", Berkeley CA: Windows and Daylighting Group, Lawrence Berkeley Laboratory, 2003.
- NFRC 100-2004. "Procedure for Determining Fenestration Product U-factors". National Fenestration Rating Council. 2004.
- NFRC 200-2004. "Procedure for Determining Fenestration Product Solar Heat Gain Coefficient and Visible Transmittance at Normal Incidence". *National Fenestration Rating Council*. 2004.
- NFRC 101-2004. "Procedure for Determining Thermo-Physical Properties of Materials For Use in NFRC-Approved Software Programs". National Fenestration Rating Council. 2004.
- NFRC 102-2004. "Test Procedure for Measuring the Steady-State Thermal Transmittance of Fenestration Systems". *National Fenestration Rating Council*. 2004.

## Appendix A. Current Frame grouping rules and their applicability to CMA

### Current Frame grouping rules and their applicability to CMA

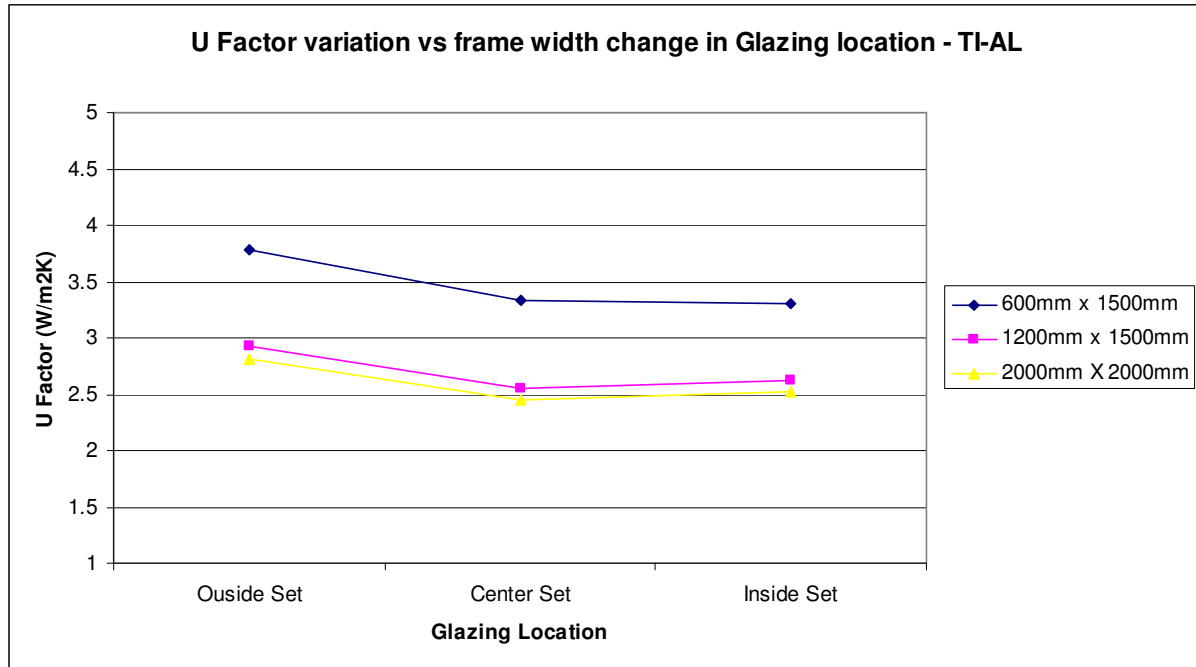
1. Changes to accommodate glazing unit variations. Limited to changes of geometry, number or material type to stops, beads, adhesives or gaskets designed to retain the glazing. Changes to frame and sash profiles are allowed to accommodate glazing unit variations. This provision does not allow for interior and exterior glazed products to be in the same product line. [\[Applicable to all product types\]](#)
2. Frame/sash modifications made to accommodate operating hardware and reinforcement for the purpose of addressing higher/lower loads and stresses. Limited to changes that do not change the exterior perimeter shape of the assembled cross section. [\[Applicable to high rise residential, motels\]](#)
3. Frame or sash changes where one component is replaced by another component of the same physical shape with a thermal conductivity that does not differ by more than ten times the thermal conductivity of the original material. [\[Applicable to high rise residential, motels\]](#)
4. Interior/exterior appendages added to the main web of the frame that is not exposed after product installation, i.e., nailing fins. [\[Applicable to high rise residential, motels\]](#)
5. Changes to the frame profiles to allow for different installations. Limited to the following:
  - i. Any changes to interior/exterior appendages added to the main web of the frame that are removable or not exposed after product installation, i.e., nailing fins
  - ii. Changes in the width (dimension perpendicular to the plane of the glazing) of the main frame or main frame components to allow for installation in different wall thicknesses.
  - iii. Products manufactured in both in-swing and out-swing options.
6. Any sightline changes due to:
  - i. Lengthening or shortening existing walls.
  - ii. Components added or replaced for equal and unequal lite configuration options or;
  - iii. For the installation of an Outside Air Ventilator Assembly (OAVA).

- iv. Changes to the frame profiles to allow for different installations including pocket or sloped sill configuration options and sill height modifications. [\[Applicable to all the products\]](#)
7. Minor revisions made to the profiles for aesthetic purposes. Limited to changes in the size and shape of snap beads, stops, jamb extensions, dividers (including simulated and true divider lites), exterior trim caps on curtain walls, window walls and sloped glazing. Decorative elements such as grooves or beads formed in or applied to the frame or sash are also allowed. [\[Applicable to all the products\]](#)
  8. Any changes to the exterior beyond the plane of the nailing fin, J-channel, or interior most point of exterior accessory groove, i.e. screen tracks, varying shapes of brickmold formed in (integral) or applied to the frame and that do not change the sightline. [\[Applicable to high rise residential, motels\]](#)
  9. Addition, deletion or changes in hardware and reinforcement. [\[Applicable to high rise residential, motels\]](#)
  10. Changes to interior or exterior finishes or coatings [\[Applicable to all products\]](#)
  11. Sealing characteristic variables and elements. Limited to changes in gaskets, sealants, adhesives or weather strips in the same profile. Profile changes to accommodate seal changes shall be allowed. [\[Applicable to all products\]](#)
  12. Products manufactured in both in-swing and out-swing options. [\[Applicable to high rise residential, motels\]](#)
  13. Pocket or sloped sill configuration options. [\[Applicable to high rise residential, motels\]](#)
  14. Equal and unequal lite configuration options. [\[Applicable to all products\]](#)
  15. Vinyl caps attached to the interior. [\[Applicable to high rise residential, motels\]](#)
  16. Any changes to the internal cavities as long as the outside profile geometry does not change. [\[Applicable to all products\]](#)
  17. Application of cladding to an unclad product line. [\[Applicable to high rise residential, motels\]](#)
  18. Changes in the width (dimension perpendicular to the plane of the glazing) of the main frame or main frame components to allow for installation in different wall thicknesses, i.e., lengthening, shortening, and the addition of reinforcing web wall. [\[Applicable to all products\]](#)

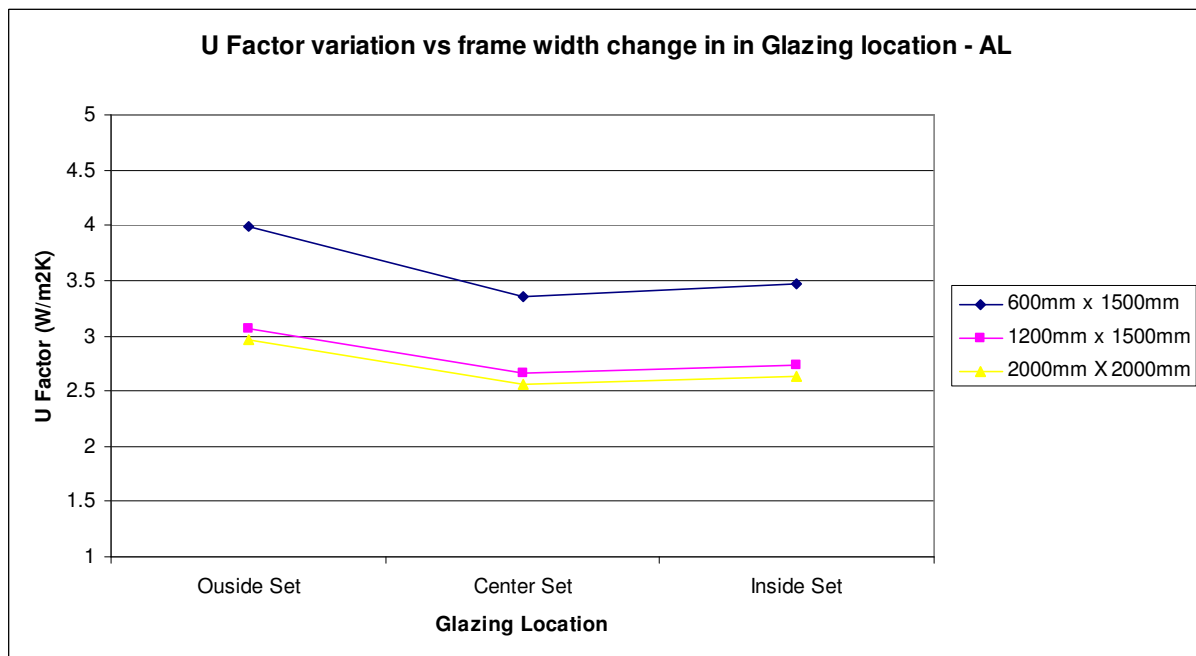
Note: For the purpose of determining U-factors, frame groups shall consist only of frame/sash base profile variations consistent with the changes proposed above. The only allowable exceptions within a frame group are the individual products with different sightlines, simulated as separate individual products.

## Appendix B: U factor variations for Various Parameters selected for frame grouping

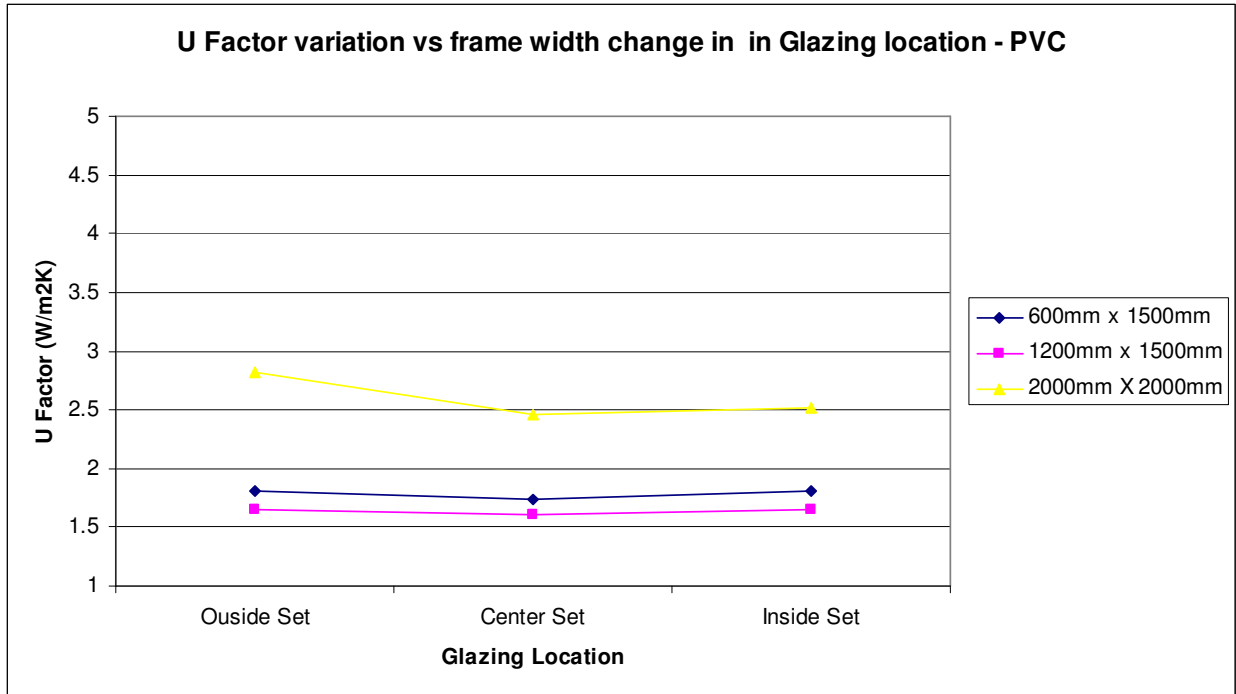
### A. Glazing Location



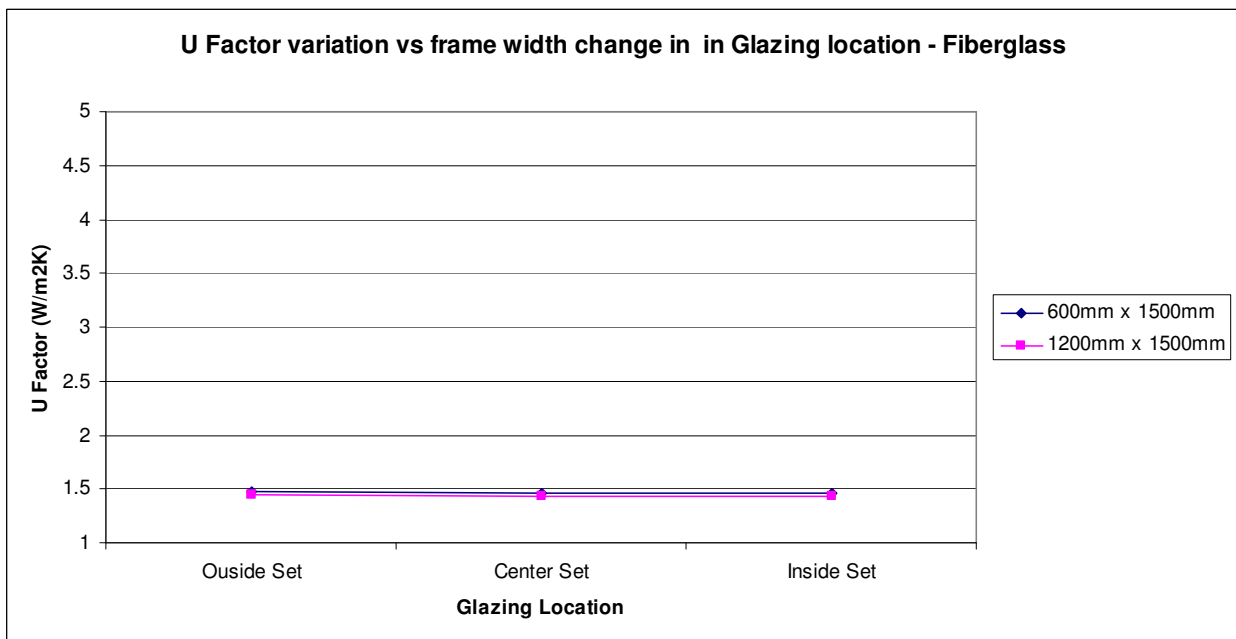
**Figure B.1:** U factor variation with glazing location for Thermally Improved Aluminum window



**Figure B.2:** U factor variation with glazing location for Aluminum window

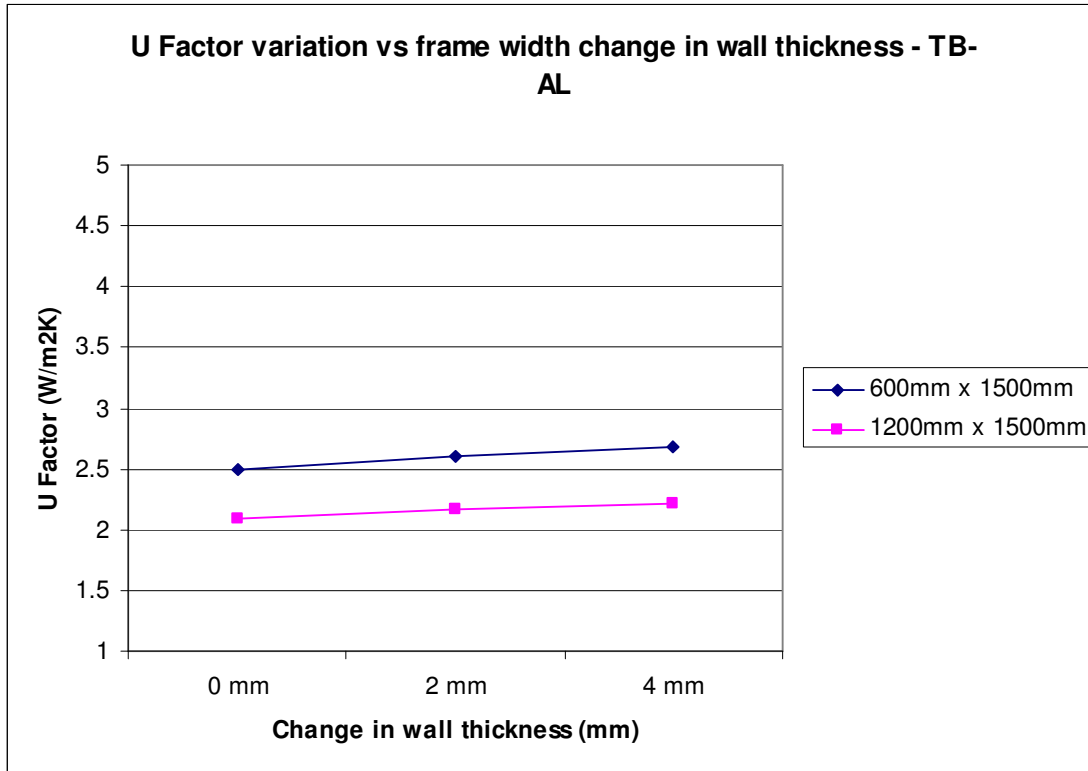


**Figure B.3:** U factor variation with glazing location for PVC window

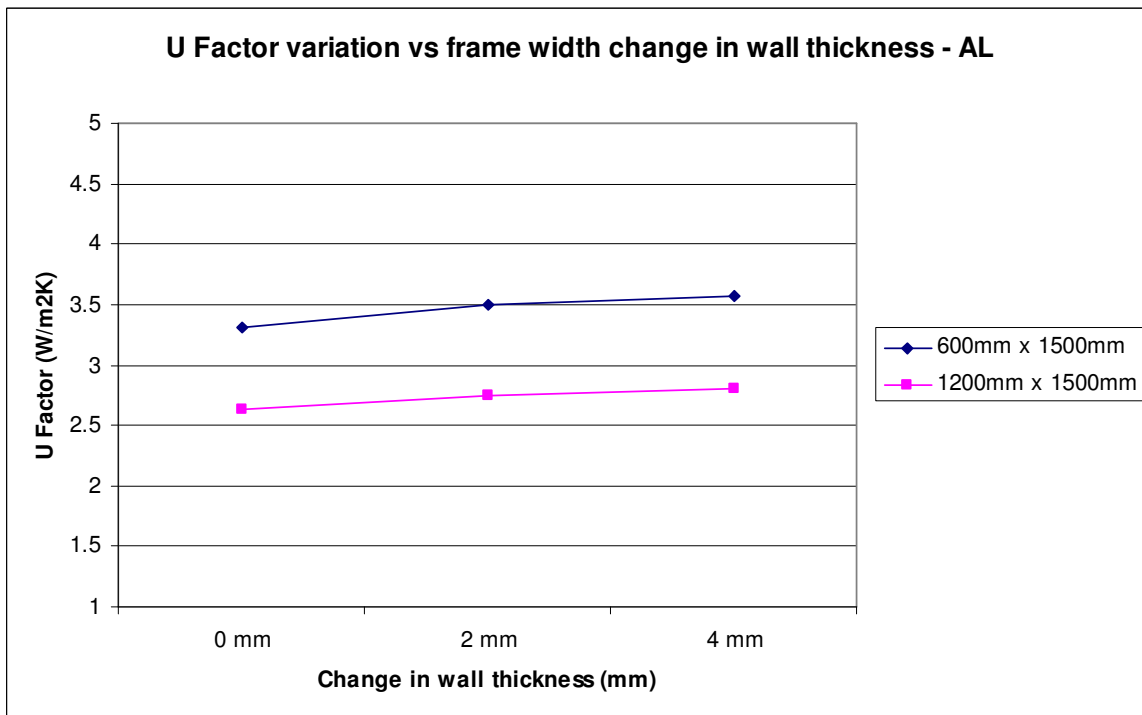


**Figure B.4:** U factor variation with glazing location for Wood window

### B. Change in frame wall thickness



**Figure B.5:** U factor variation with frame wall thickness for Thermally Broken Aluminum Window



**Figure B.6:** U factor variation with frame wall thickness for Aluminum Window

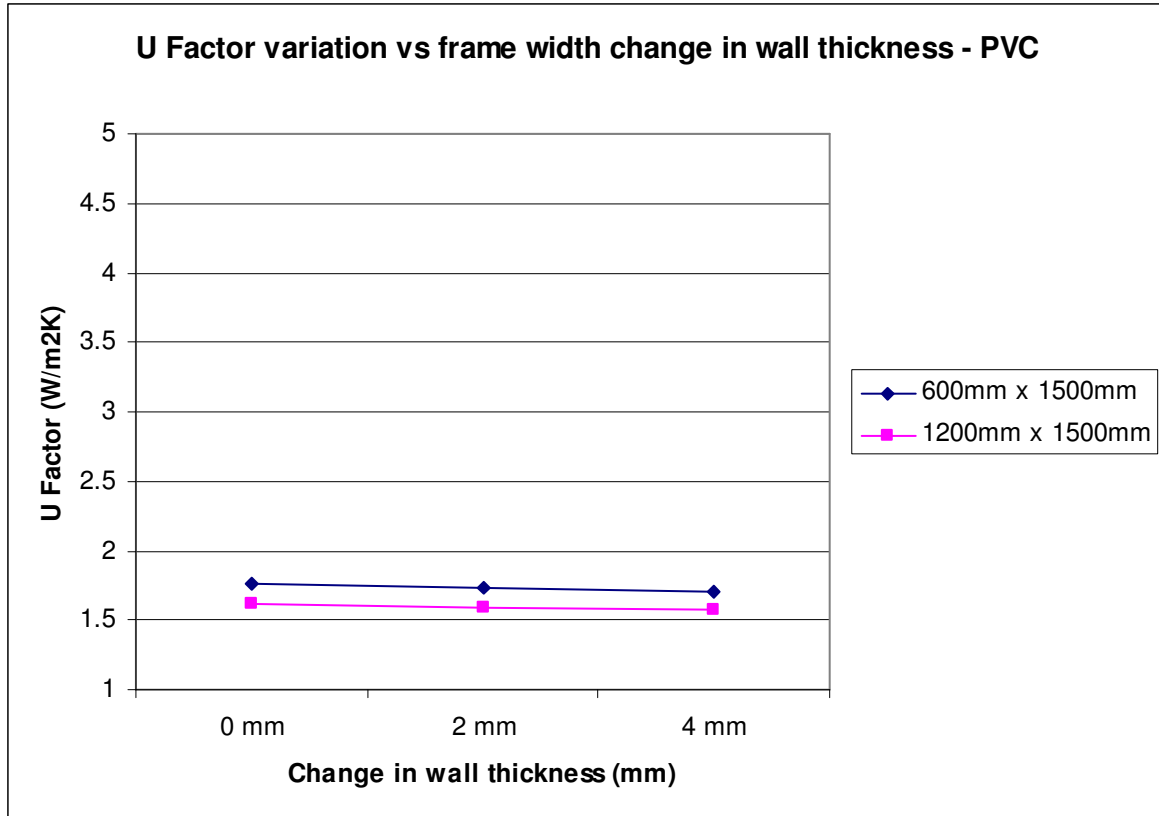


Figure B.7: U factor variation with frame wall thickness for PVC Window

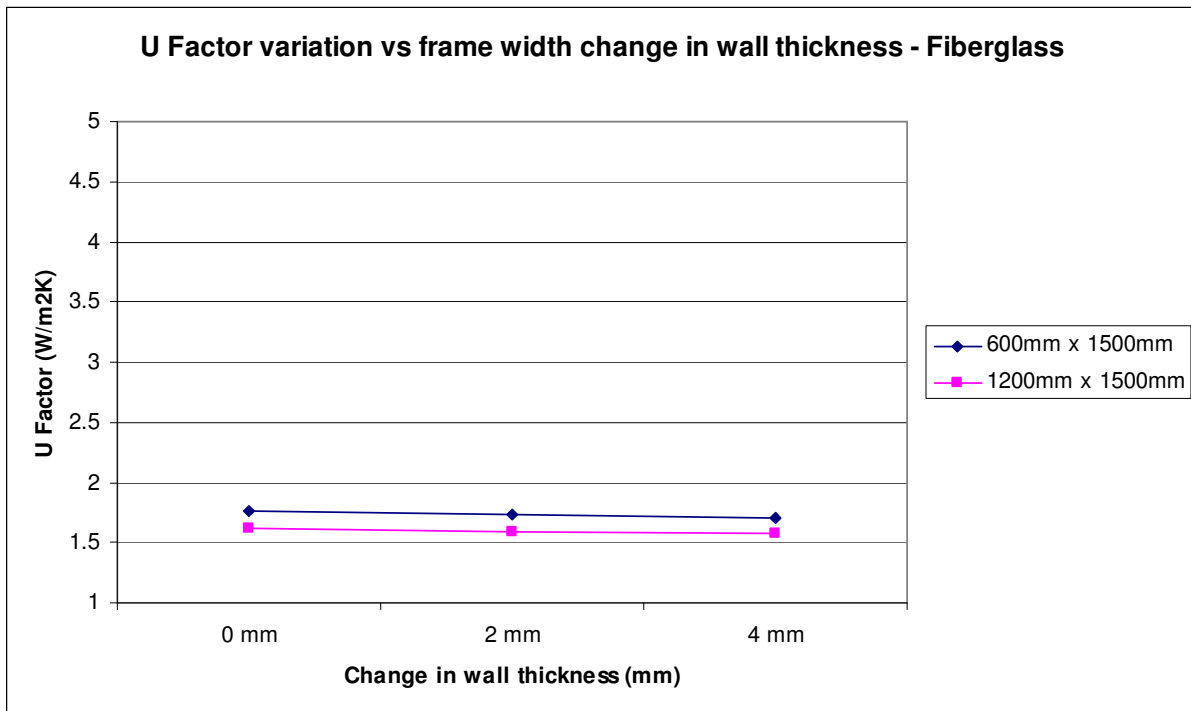
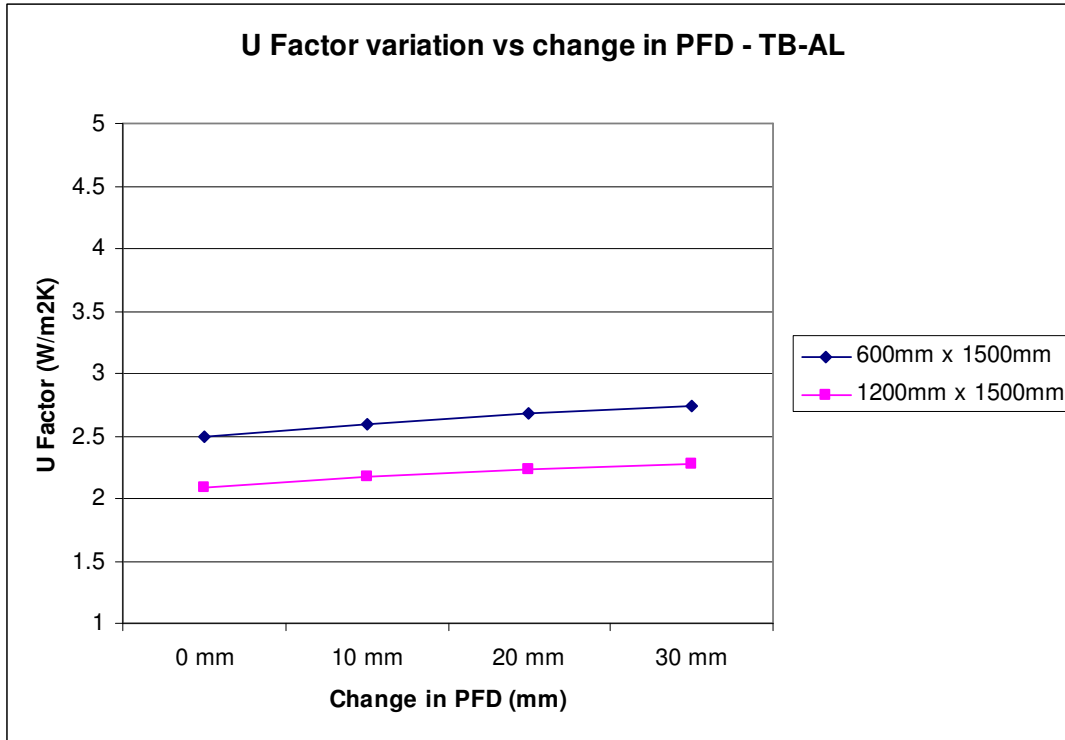
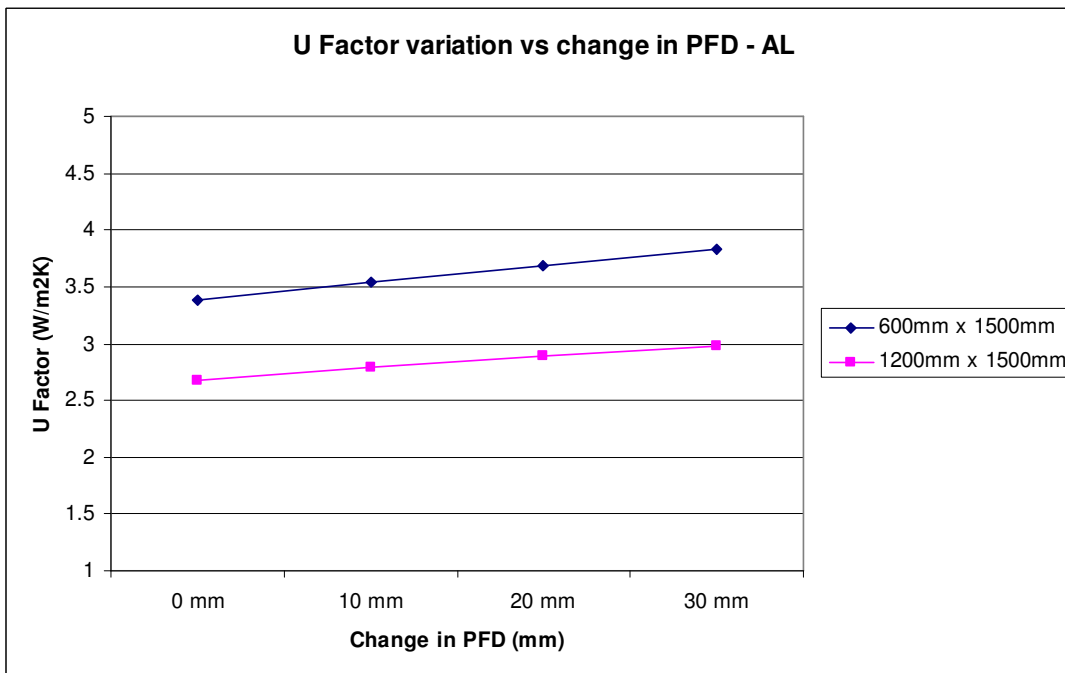


Figure B.8: U factor variation with frame wall thickness for Fiberglass Window

### C. Change in Projected Frame Dimension (PFD)



**Figure B.9:** U factor variation with change in PFD for thermally broken Aluminum window



**Figure B.10:** U factor variation with change in PFD for Aluminum window

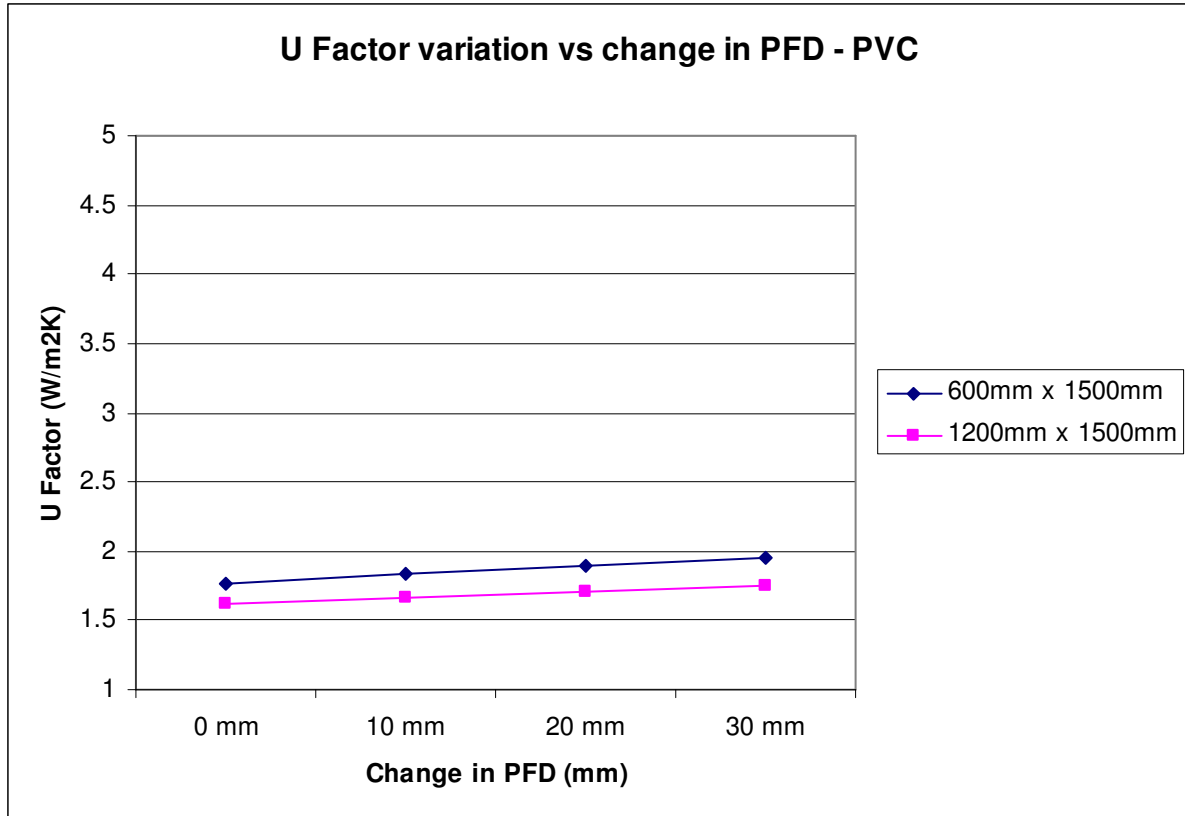


Figure B.11: U factor variation with change in PFD for PVC window

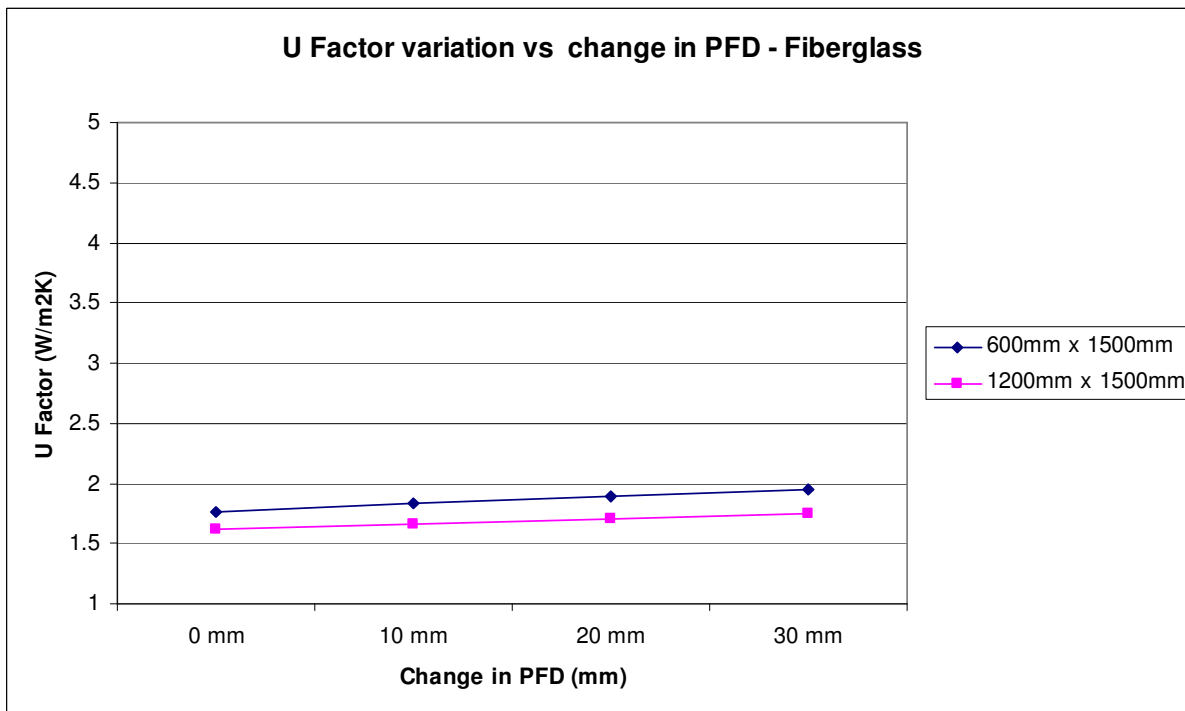
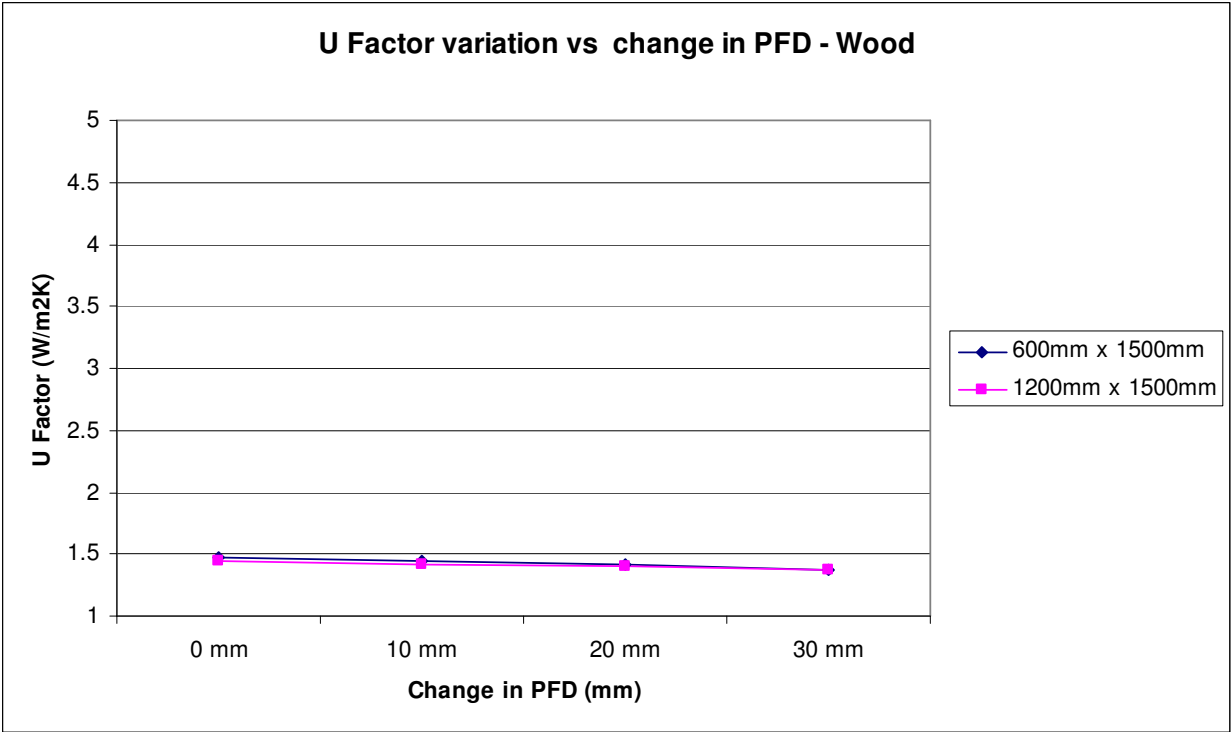
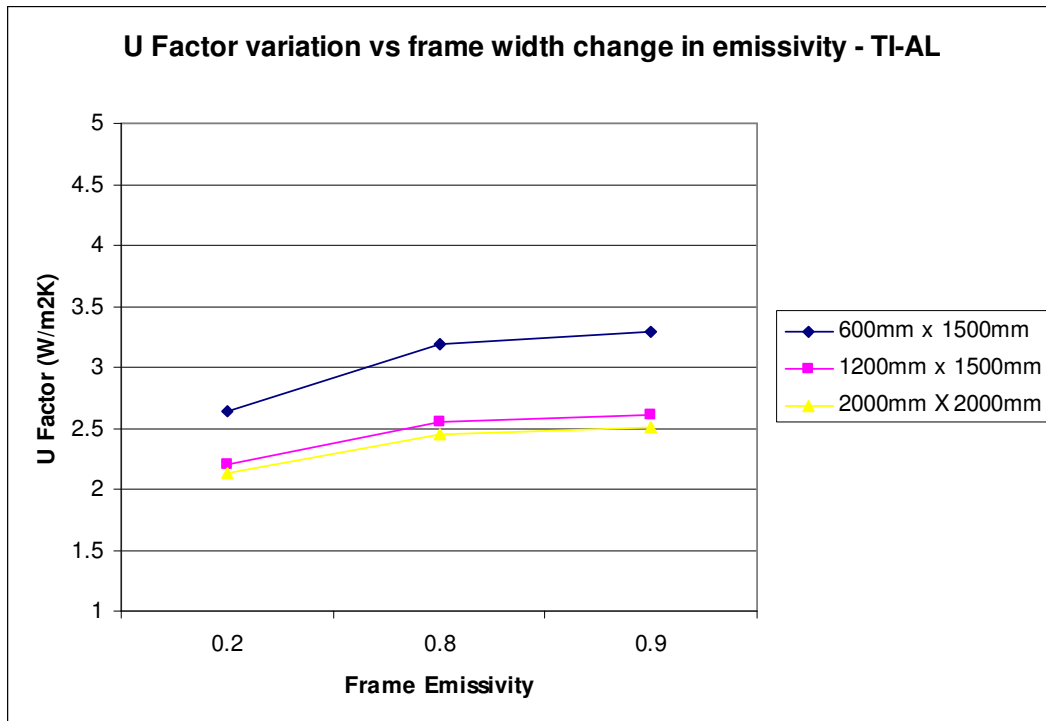


Figure B.12: U factor variation with change in PFD for Fiberglass window

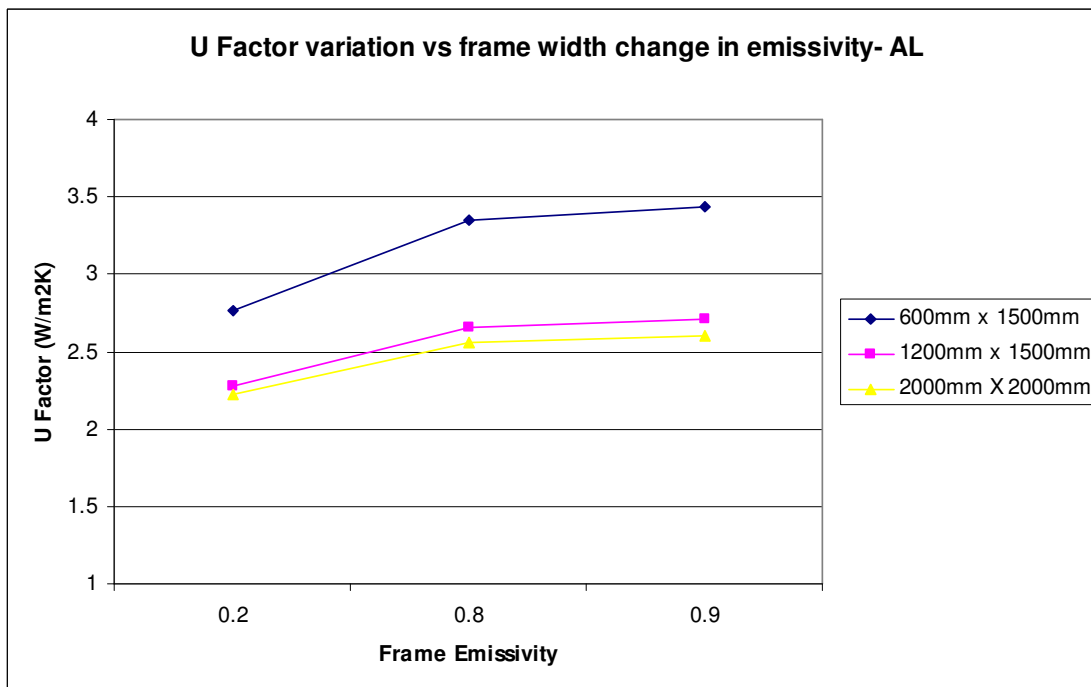


**Figure B.13:** U factor variation with change in PFD for Wood window

**D. Change in frame emissivity**

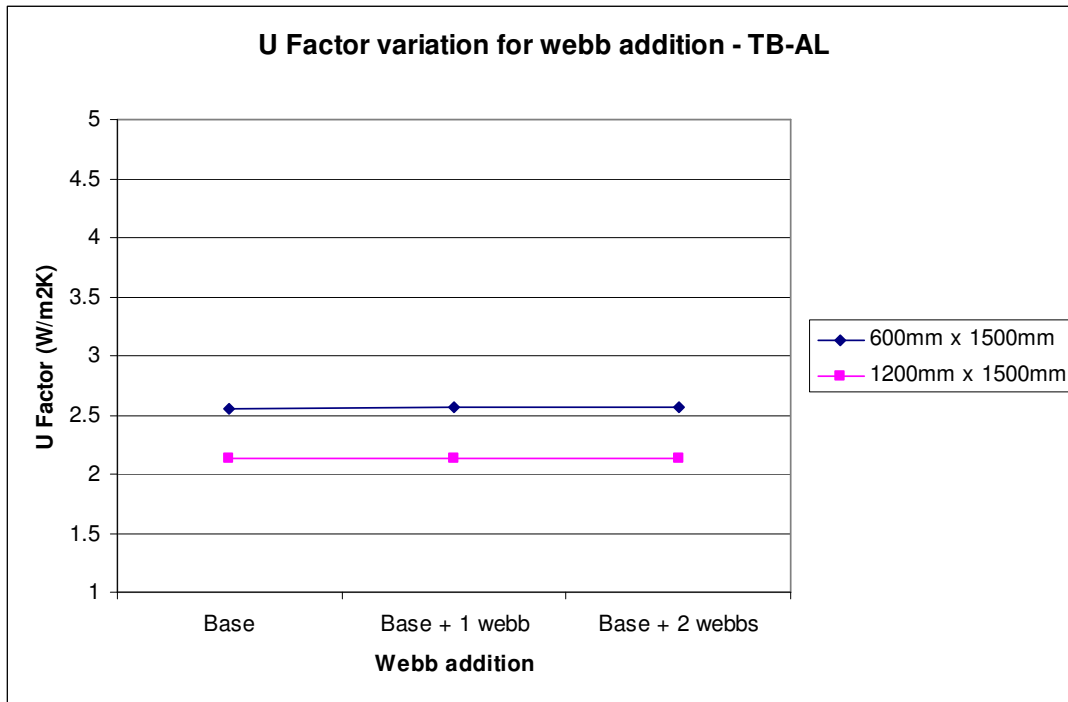


**Figure B.13:** U factor variation with change emissivity for thermally broken Aluminum window

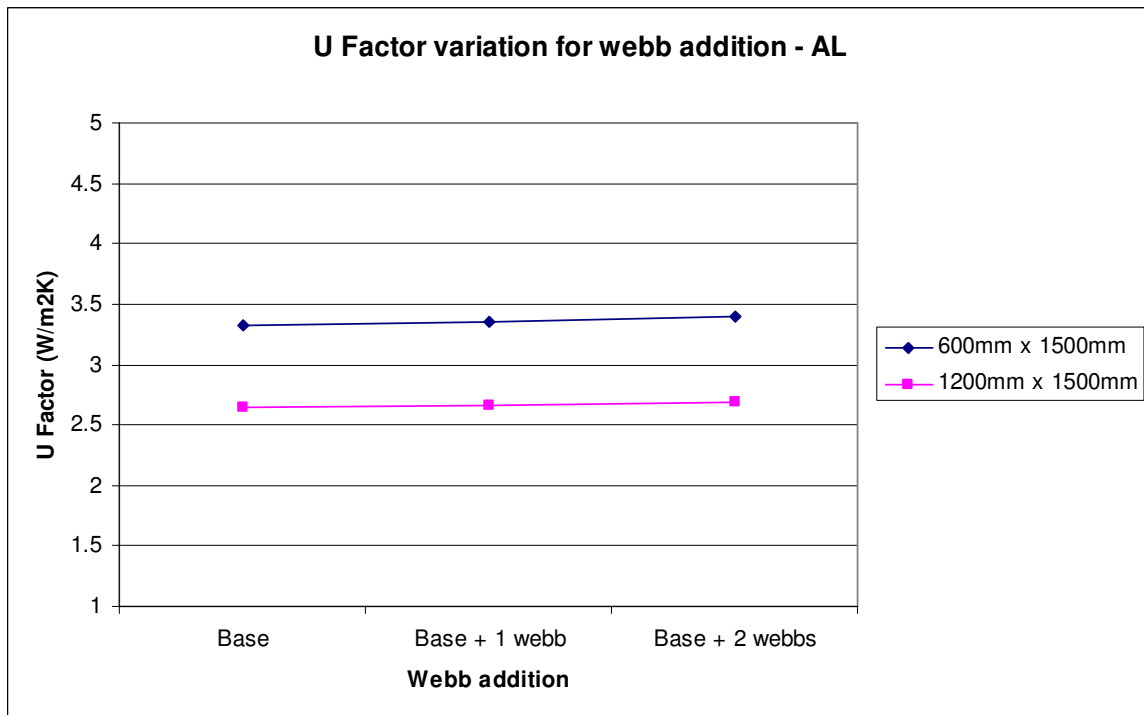


**Figure B.14:** U factor variation with change emissivity for Aluminum window

### E. Webb Addition



**Figure B.15:** U factor variation with variation of webb addition for thermally broken Aluminum window



**Figure B.16:** U factor variation with variation of web addition for Aluminum window

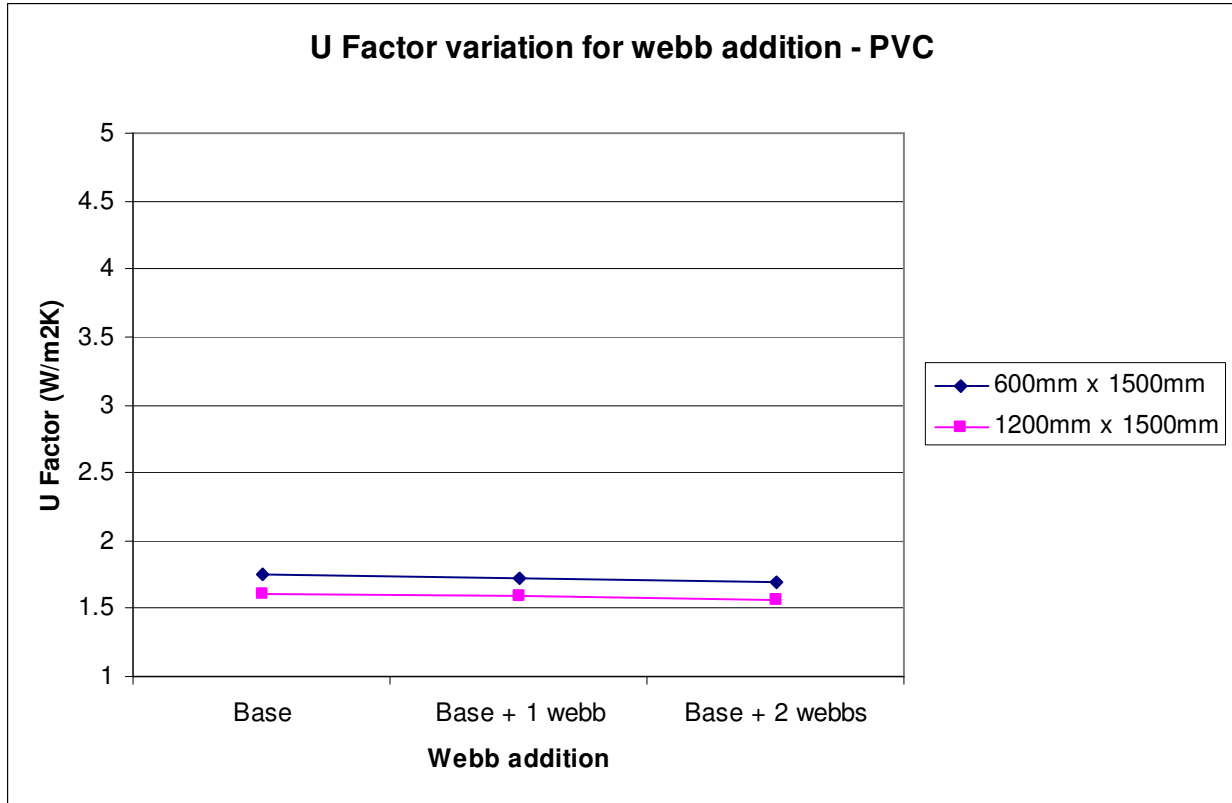


Figure B.17: U factor variation with variation of web addition for PVC window