AFRC

Australian Fenestration Rating Council

AFRC Technical Interpretations

AFRC – AUSTRALIAN FENESTRATION RATING COUNCIL

AFRC – Technical Interpretations E0A1

AFRC,
71 Ridge St,
GORDON NSW 2072
Phone 02 9498 2768 • Fax 02 9498 3816
www.afrc.org.au

Published: 24th January, 2010

Last Updated: 14th September, 2015

Applicable to:
AFRC Protocols and Procedures Manual – v1.0 – 2003
NFRC Simulation Manual

Table of Contents

ATIR-2007-*01* 01/08/2007

AFRC Technical Interpretation

Interpretation Requested:
The Pro's and Con's and feedback and clarification for the 'hash' requirement for IGDB data in the AFRC Protocols and Procedures Manual.

Date Requested:	*Initial Interpretation Date:*	*Final TAC Approval Date:*
01/03/07	17/04/07	26/04/07

Pertinent Document:	
AFRC Technical Protocols and Procedures Manual Version 1.0 – 30.03.07	
Referenced Sections:	*Referenced Pages:*
Chapter 3	Page 4

Interpretation :
The IGDB contains a field which identifies glass data that has been approved by the NFRC. Only NFRC approved glass (identified by a "#" sign) can be used for NFRC simulations. The AFRC has decided that the "#" sign is not necessary for AFRC simulations. Any glass in the IGDB can gain NFRC approval by payment of a licence fee to the NFRC. There are no additional technical requirements over and above those required for inclusion in the IGDB. The "#" mark is a method of raising revenue for the NFRC, and as such does not provide any benefit to the NFRC. There is no advantage to the AFRC to restrict the glass which can be used for simulations.

Technical Committee Revisions to Initial Interpretation:

AFRC Technical Interpretation

Interpretation Requested:
What is the NFRC method and protocol for companies who can prove data submission to the IGDB but do not have the data in the IGDB until the next IGDB upload?

Date Requested:	*Initial Interpretation Date:*	*Final TAC Approval Date:*
01/03/07	26/04/07	30/04/07

Pertinent Document:	
NFRC 302-2004	
Referenced Sections:	*Referenced Pages:*

Interpretation :
NFRC 302 Clause 3.8.1 A states: "No glazing data may be used for NFRC window rating purposes until formally accepted by the NFRC. Acceptance is at the sole discretion of NFRC and is independent of the verification process. All NFRC approved data are encrypted and indicated with a "#" symbol in the WINDOW program." The AFRC requirement is that whilst"#" is not required, the glazing properties shall be validated by being published in the IGDB. NFRC states that IGDB updates are released within 1 day to 2 weeks of the end of the peer review period. Fast tracking of peer review is also available.

Technical Committee Revisions to Initial Interpretation:

ATIR-2007-04

ATIR-2007-*04*
01/08/2007

AFRC Technical Interpretation

Interpretation Requested:
A method for converting IP unit files into SI unit for entry into the Australian system.

Date Requested:	*Initial Interpretation Date:*	*Final TAC Approval Date:*
16/03/07	26/04/07	30/04/07

Pertinent Document:	
NFRC IPSI Policy	
Referenced Sections:	*Referenced Pages:*
Point 5	

Interpretation :
NFRC policy for Metric/Inch-pound reporting states: "For rating purposes, using NFRC-approved simulation software tools, the rounding shall only be performed on the rating after the rating has been determined in metric units and the calculations, including conversions, are complete." It is therefore necessary to go back to the original simulation lab for conversion at the required precision.

Technical Committee Revisions to Initial Interpretation:

AFRC Technical Interpretation

Interpretation Requested:
The interpretation requested is for a definition of "thermally improved aluminium" for AFRC use. This has arisen because of a conflicting, alternative definition that has been used in Australia for a decade by House Energy Rating software and schemes. The frame descriptors "aluminium improved" and "thermally improved aluminium" have been used historically to describe any frame with a U-value ≤ 8 $W/m^2.K$ and/or low-conductivity internal trim (e.g. timber reveals covering some exposed aluminium). Thus the definitions were part performance-based and part material-based. For technical reasons and to preserve consistency with NFRC practice wherever possible, this TI request was initiated to review the permissible definition and use of "thermally improved" in AFRC ratings.

Date Requested:	*Initial Interpretation Date:*	*Final TAC Approval Date:*
16/03/07	30/04/07	03/10/07

Pertinent Document:	
NFRC 100-2004; NFRC Simulation Manual, June 2006.	
Referenced Sections:	*Referenced Pages:*
NFRC 100-2004: Section 3 (Definitions); NFRC Simulation Manual, Sections 2.4.2 and 6.5.1	Pages 7 and 8; Pages 2-4 and 6-25

Interpretation :
The use of the "thermally improved aluminium" is no longer permissible as a frame descriptor for AFRC-rated fenestration products. To eliminate the confusion described above, the term "thermally improved" is only to be used as a descriptor for the purpose of allocating the interior frame boundary condition in THERM5. In this context it is defined in NFRC 100-2004 as:

Interpretation (cont.) :

"Thermally improved (TI) members: system members with a separation ≥ 1.60mm **and < 5.30mm separation** provided by a material [with thermal conductivity ≤ 0.5 W/m.K] or open air space between the interior and exterior surfaces. Such systems include members with exposed interior or exterior trim attached with clips and all skip-debridged systems."

The NFRC Simulation Manual, June 2006, defines the above separation as "splitting the frame components into interior and exterior pieces and use *[of]* a less conductive material to join them".

If the framing member does not conform to the above, but has an integral internal timber trim or reveal, and would have been formerly described as Thermally Improved, then it shall have its interior boundary condition assigned according to the predominant material, per the existing NFRC rules. That is, the method in Section 6.5.1 of the NFRC Simulation Manual shall be followed.

Technical Committee Revisions to Initial Interpretation:

ATIR-2007-*06* 06/02/2009

AFRC Technical Interpretation

Interpretation Requested:

Background

Louvre window systems are widely used in residential applications within Australia. They are commonly used in warmer climates as they can be fully opened to allow maximum ventilation. The closest alignment to a current NFRC product line would be the jal/jal window (jalousie).

A louvre window system consists of a surround frame with a number of operable blades. The number of blades is determined by the overall window height and individual blade heights. A vertical assembly of blades is also known as a gallery. The individual blades are attached to the jamb section via an operating mechanism and are held in place using a blade holder or clip. The material used for the operating mechanism and blade holder may vary as can the blade material. Common operating mechanisms and blade holders are made from a combination of metal and plastic, whilst the blades can be made from glass, aluminium and timber.

A number of challenges are faced when simulating U-value and SHGC for these products due to a number of factors:

- When the blades are in a closed position, each blade is typically a few degrees off vertical (up to 10 degrees)
- Blades overlap when the product is in the closed position
- Clip profiles are rarely uniform along their length.

Interpretation Request

A method for the simulation of louvre windows for U-value, SHGC, VT and CR.

Date Requested:	*Initial Interpretation Date:*	*Final TAC Approval Date:*
20/03/07	03/10/07, revised 25/11/08	23/01/09

Pertinent Document:	
NFRC 100, NFRC 200, Simulation Manual	
Referenced Sections:	*Referenced Pages:*

Interpretation :

A louvre system shall be simulated as per the current NFRC Simulation Manual with the following assumptions and additions.

For simulation purposes, the following assumptions are made:

- Blades are simulated in the fully closed position
- Blade overlap is ignored
- The blade is simulated in the vertical position (90° tilt)

The product size for a louvre system is 600mm wide by 1500mm high.

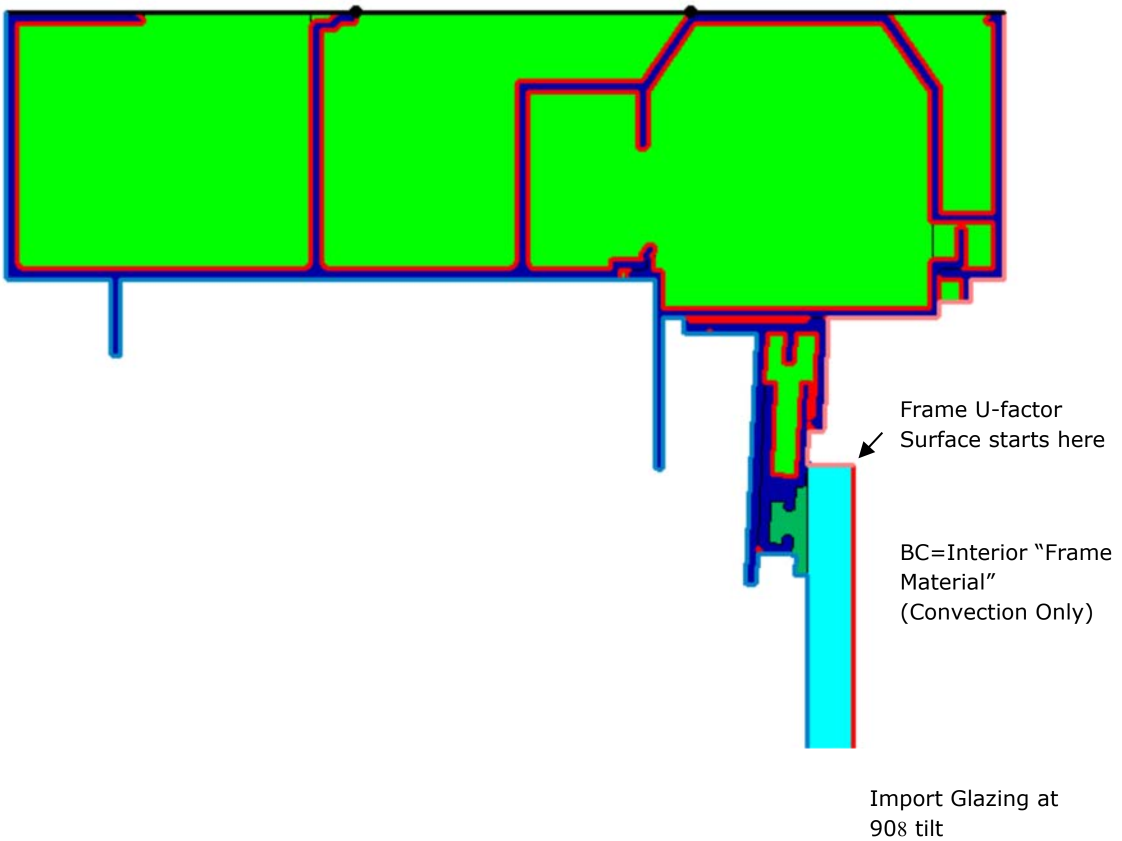
For louvre blade holders that do not have a uniform and consistent profile, the area shall be determined by area-weighting.

Notes:

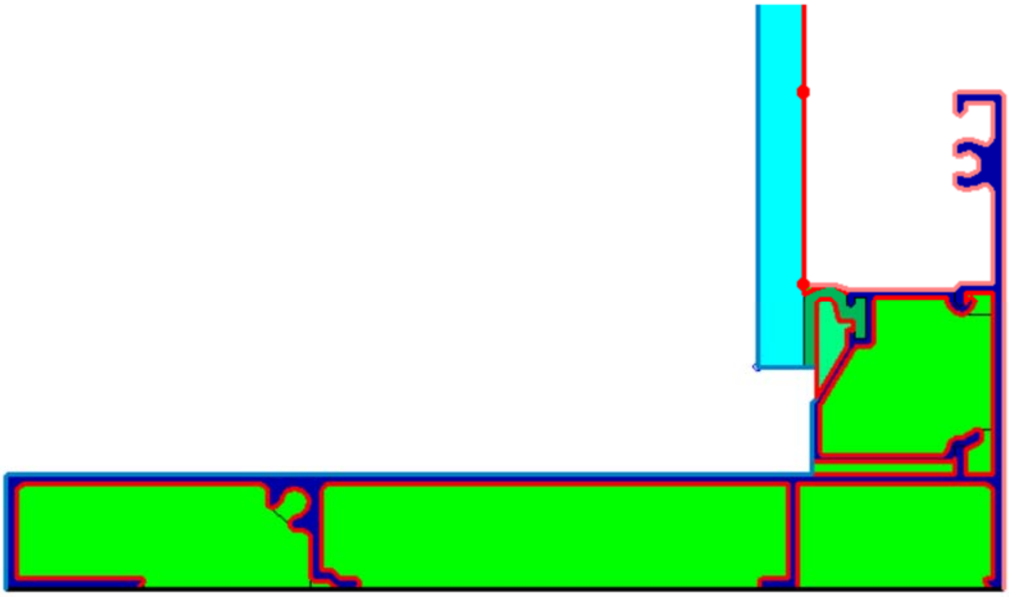
1. An example showing the simulation method for a louvre system is published on the AFRC website (www.afrc.org.au).

Frame Cross-Sections

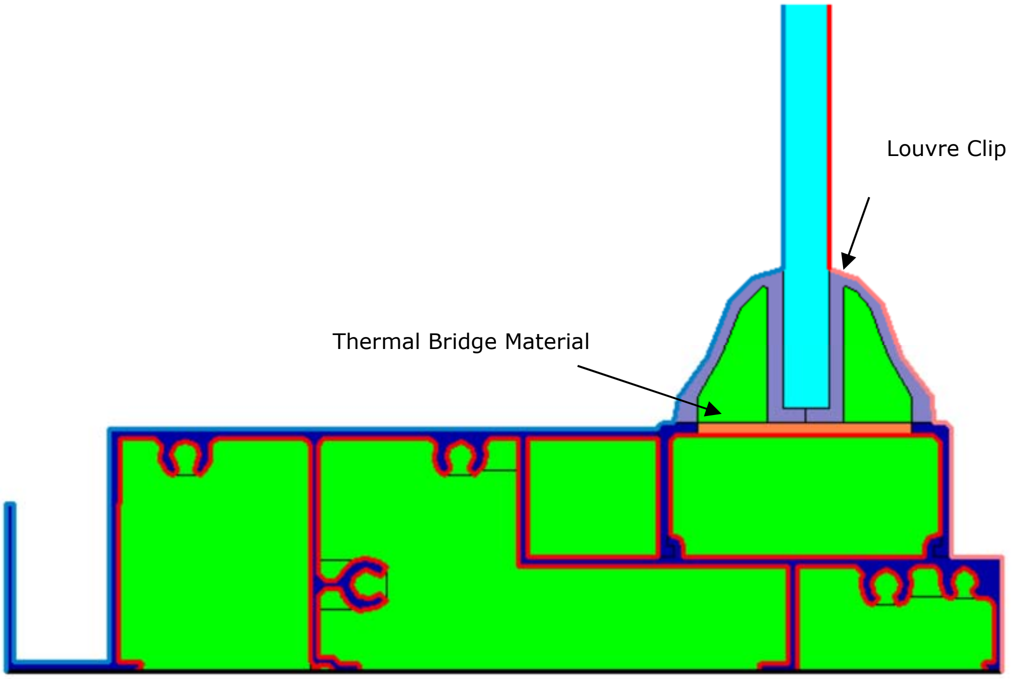
Louvre System Head



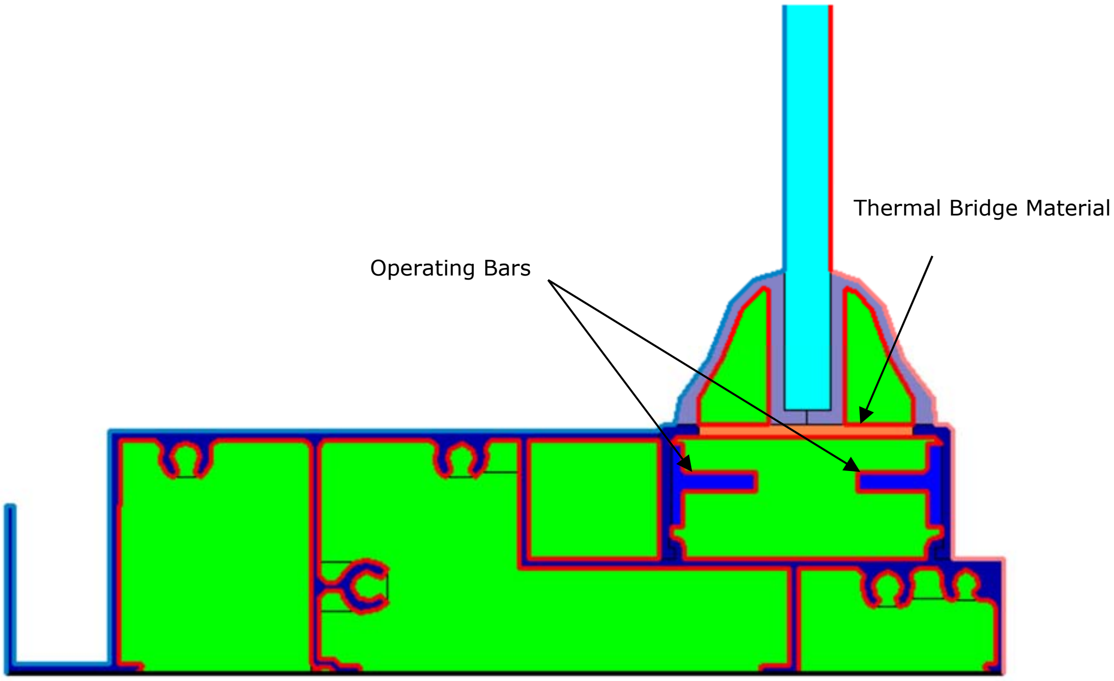
Louvre System Sill



Louvre System Jamb – Non-Operating Mechanism Side



Louvre System Jamb – Operating Mechanism Side



Technical Committee Revisions to Initial Interpretation:

ATIR-2008-*11*
06/02/2009

AFRC Technical Interpretation

Interpretation Requested:
Thermophysical properties for Santoprene™ elastomer.

Date Requested:	*Initial Interpretation Date:*	*Final TAC Approval Date:*
02/06/08	25/11/08	25/11/08

Pertinent Document:	
NFRC 101-2006; Email Correspondence: Re Santoprene question - 2nd response.txt; RE Santoprene question.htm	
Referenced Sections:	*Referenced Pages:*
Appendix B	pp. 17-21

Interpretation :

Background

Santoprene™ is an elastomer commonly used in window fabrication. It is EPDM/polypropylene mixture expected to have a similar conductivity to those constituent polymers, i.e. in the range 0.22 – 0.25 W/m.K. Santoprene™ is not currently listed in the material library of THERM 5.2 nor is it in the appendices of NFRC 101-2006.

Interpretation

Use the material properties of EPDM for Santoprene™

Technical Committee Revisions to Initial Interpretation:

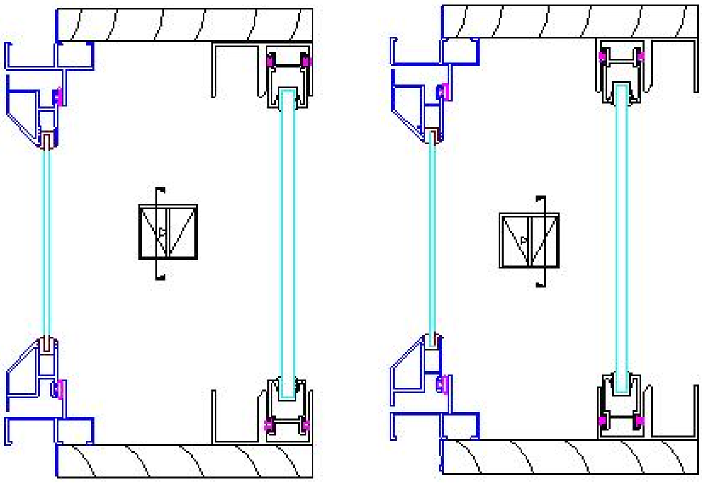
AFRC Technical Interpretation

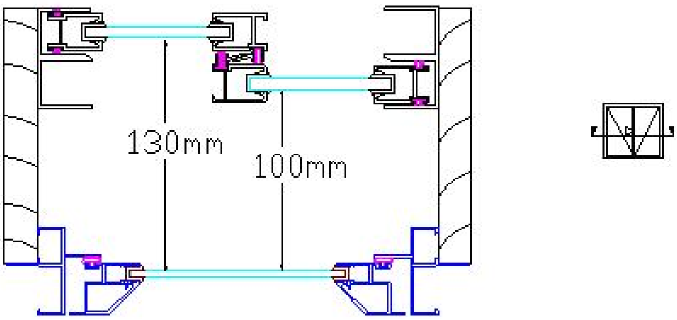
Interpretation Requested:
A method for the simulation for of a 2-Lite sliding window as a secondary glazing option for U-value, SHGC, VT and CR. The primary window is the external window and the secondary window is the internal window.

Background

<u>Sample Configuration</u>

This example is a 2-lite sliding window secondary glazed behind an external awning window.





<u>Simulation Options</u>:

1. Simulate the product as the secondary (internal) window (For this example, simulate as a sliding window with double awnings on the outside (1500mm by 1200mm – width by height))
2. Simulate the product as the primary (external) window with a divider to simulate any internal intermediate frame members. (For this example, simulate as an awning

window and use a divider as the sliding window mullion (1500mm by 600mm – width by height))

3. Simulate the product as a dual custom vision at the primary window rating size. This allows for the option of internal/external intermediate frame members. (For this example, simulate at the awning window size (1500mm by 600mm – width by height))

Issues:

Option 1

Simulation as the secondary window creates an issue when the internal and external windows have different rating sizes. This would skew the results when comparing against existing ratings for the primary window type. (eg. Comparing a sliding window system with other awning windows.) This simulation procedure is also not representative of how the product would be hot box tested.

Option 2

Simulation as the primary window creates an issue when there are intermediate frame members on the internal frame (eg. Mullions, transoms) with differing air gaps between the operable and non-operable member. (eg. For a primary awning window, which is normally simulated as a single lite configuration, with a sliding window as the secondary glazing, the glass would be different distances apart from one side to the other.) To allow for an internal mullion to be simulated, a divider could be used. However, this means different glazing options can't be selected for each side of the internal sliding window (if needed). (I.e. a 2-lite configuration must be used)

Option 3

No issues apparent. Therefore this approach will be taken to simulate a secondary glazed window. The simulation procedures are presented in this interpretation and a full worked example is presented in the AFRC document atir200812eg.

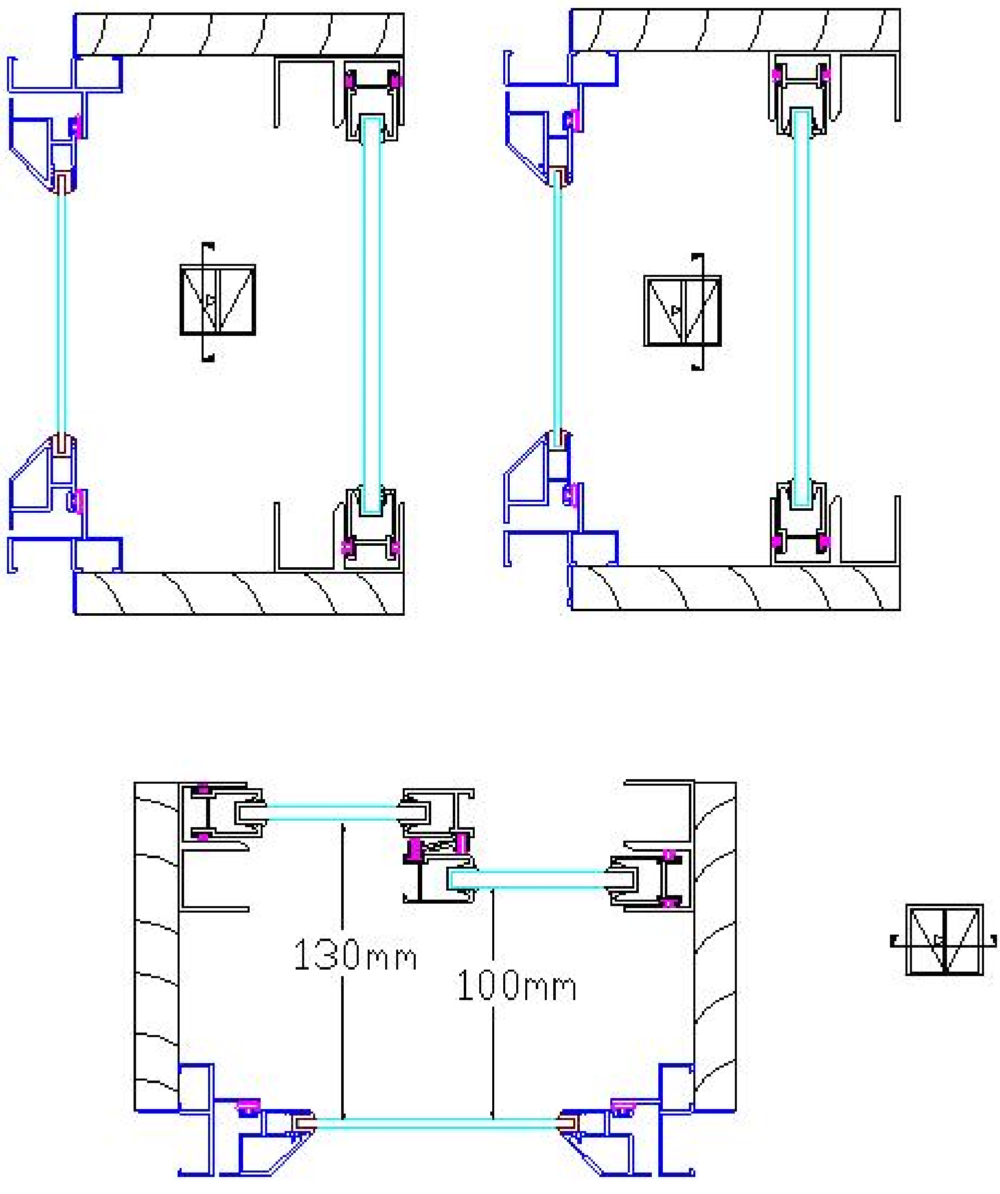
Date Requested:	*Initial Interpretation Date:*	*Final TAC Approval Date:*
22/08/2008	17/06/2010	16/07/2010

Pertinent Document:	
NFRC 100, NFRC 200, Simulation Manual	
Referenced Sections:	*Referenced Pages:*

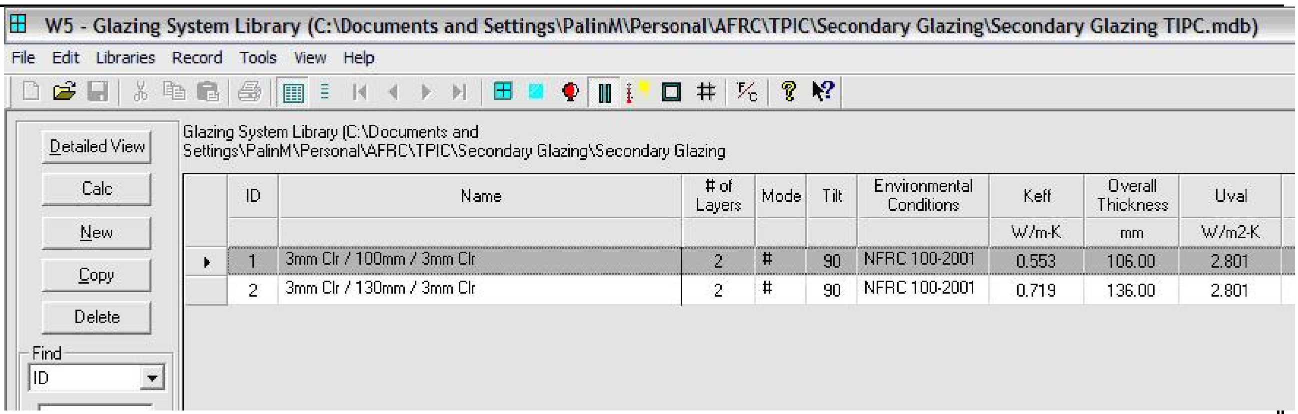
Interpretation :

Simulate the product as a dual custom vision set to the primary window size (external window). The external window is always to be considered as the primary window when setting the size.

<u>Sample Configuration</u>

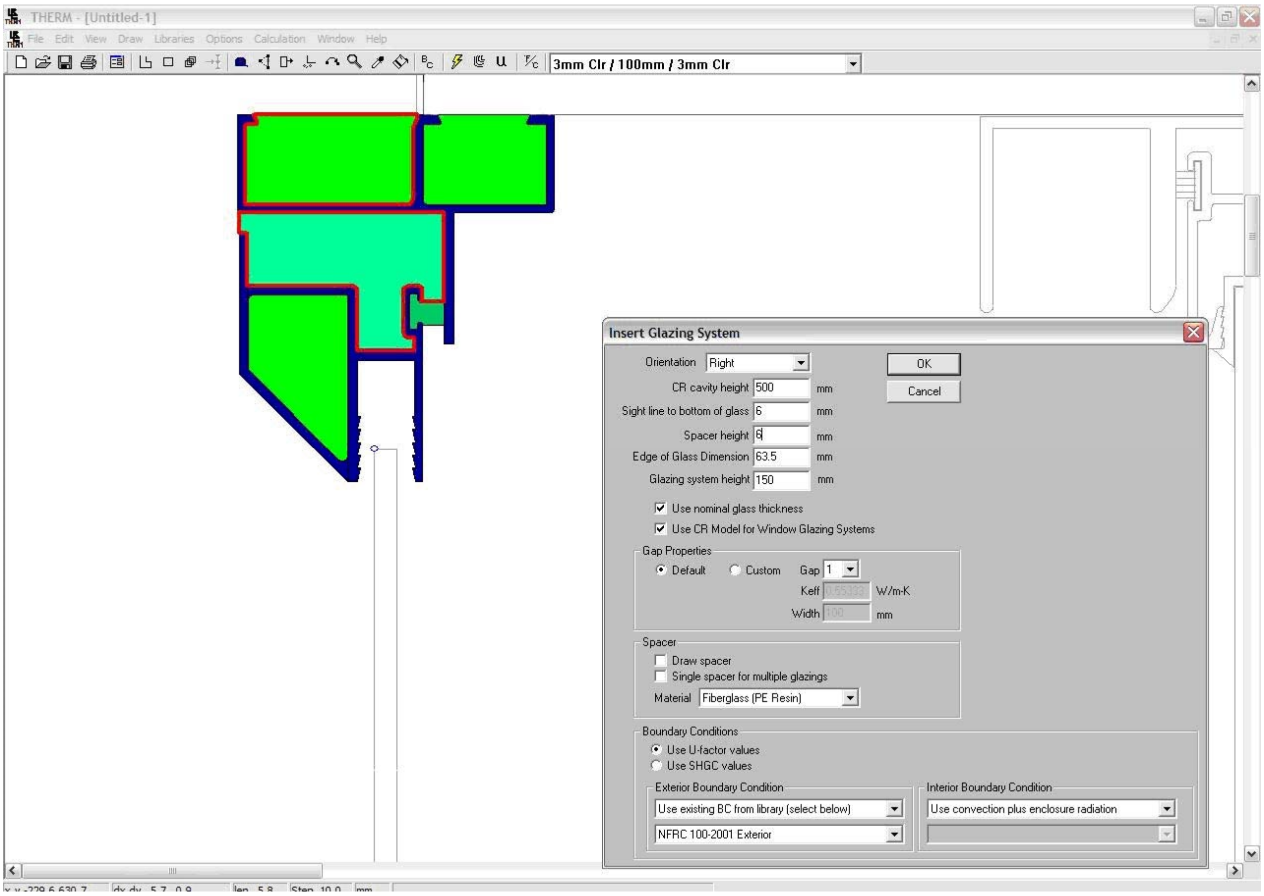


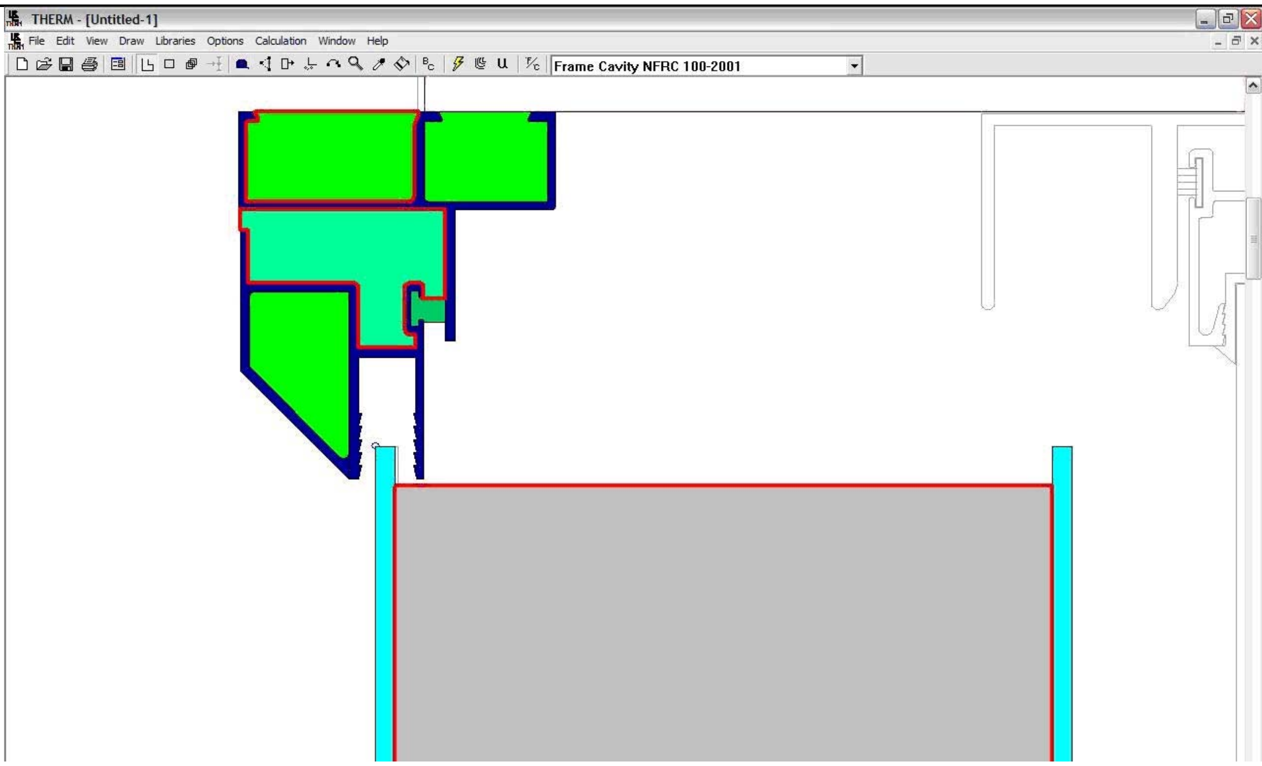
Step 1:
Model two glazing systems in Window 5.2 with different air gaps.



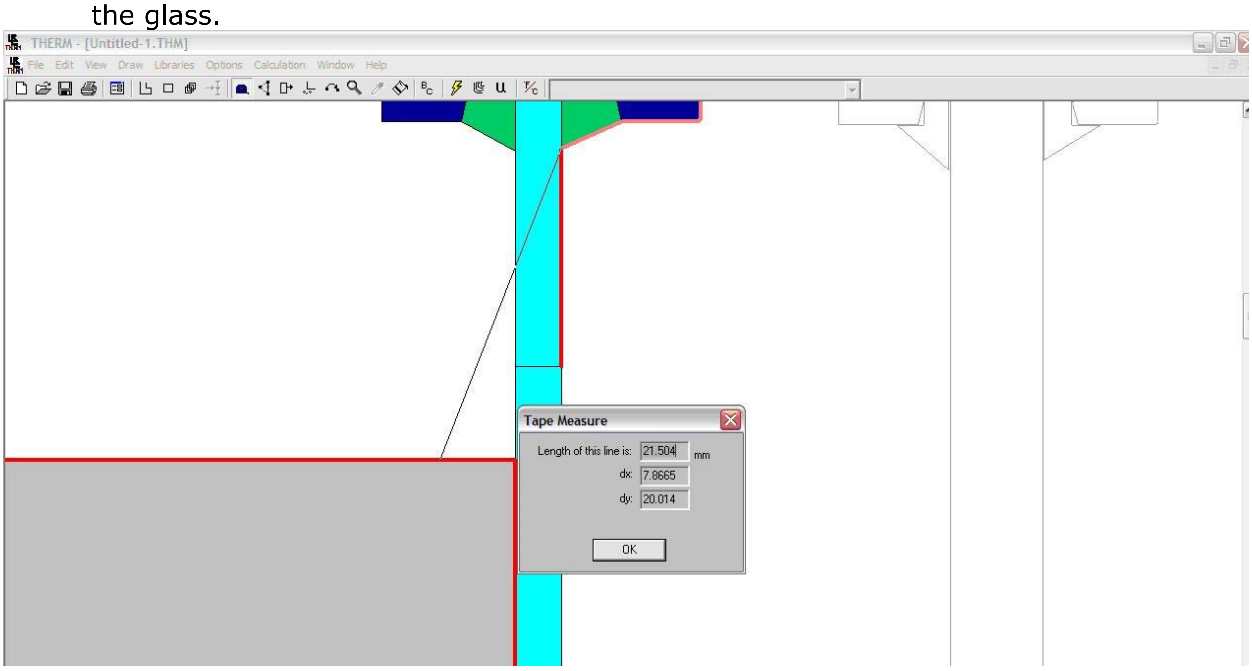
Step 2:

A. Model profiles in Therm5 as per standard NFRC procedures and insert the glazing system.

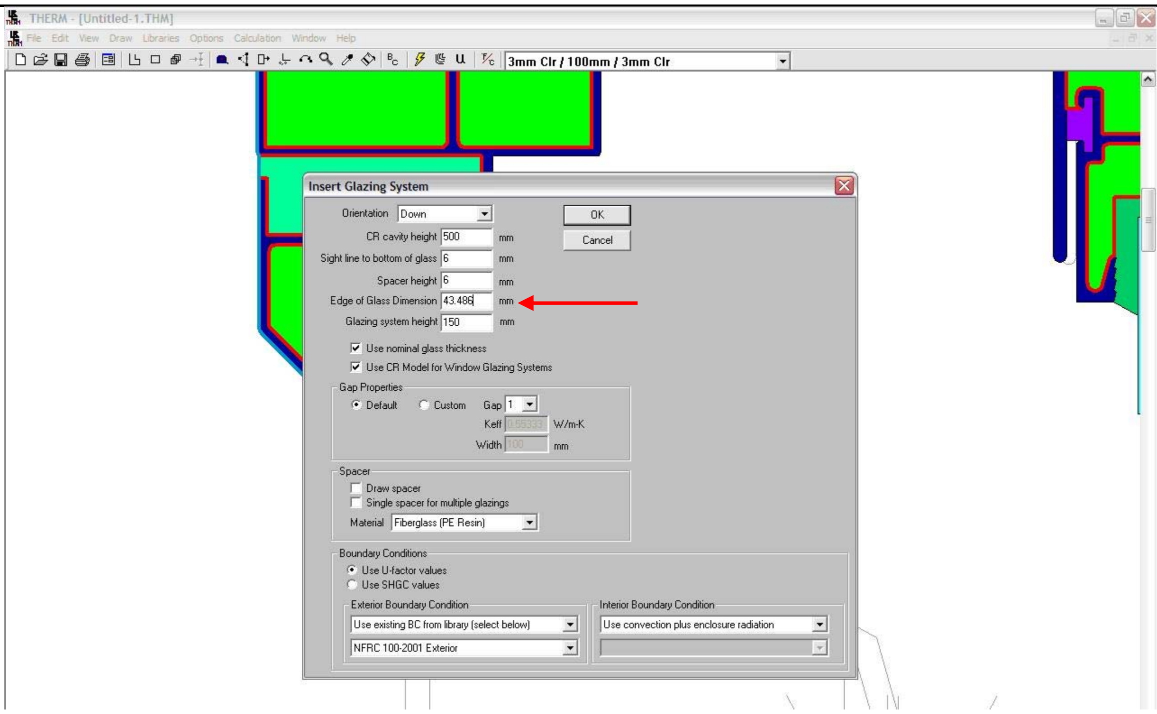




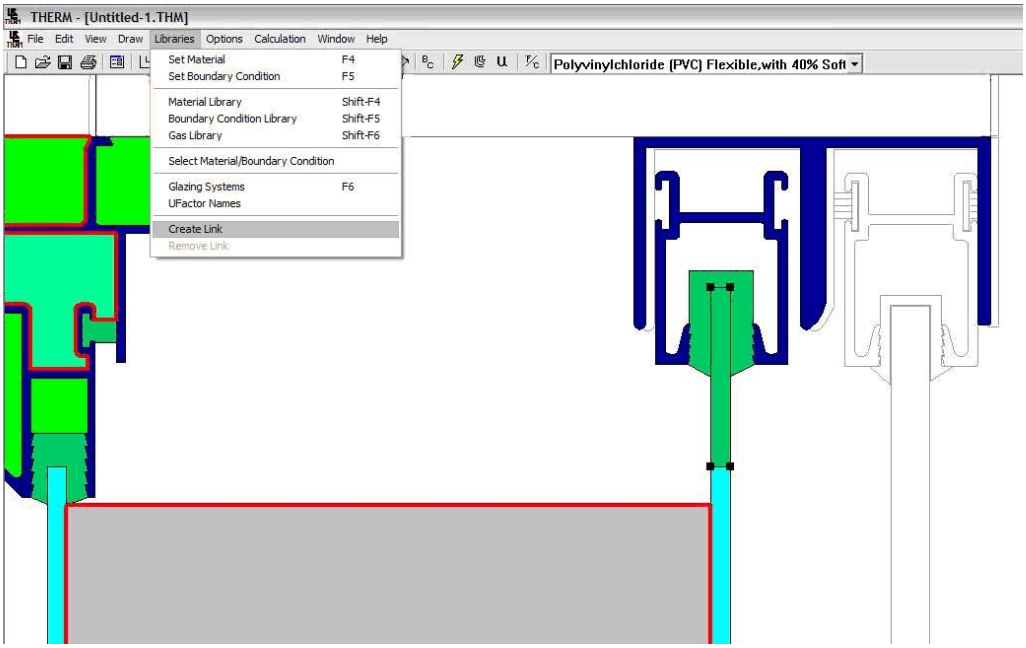
B. If the secondary window (internal window) had a lower PFD than the primary window (external window), draw a rectangle to represent where the glazing should sit and then take the vertical measurement from the internal sightline to the bottom of the air fill of the inserted glass. This is used to adjust the edge of glass when importing the glass.

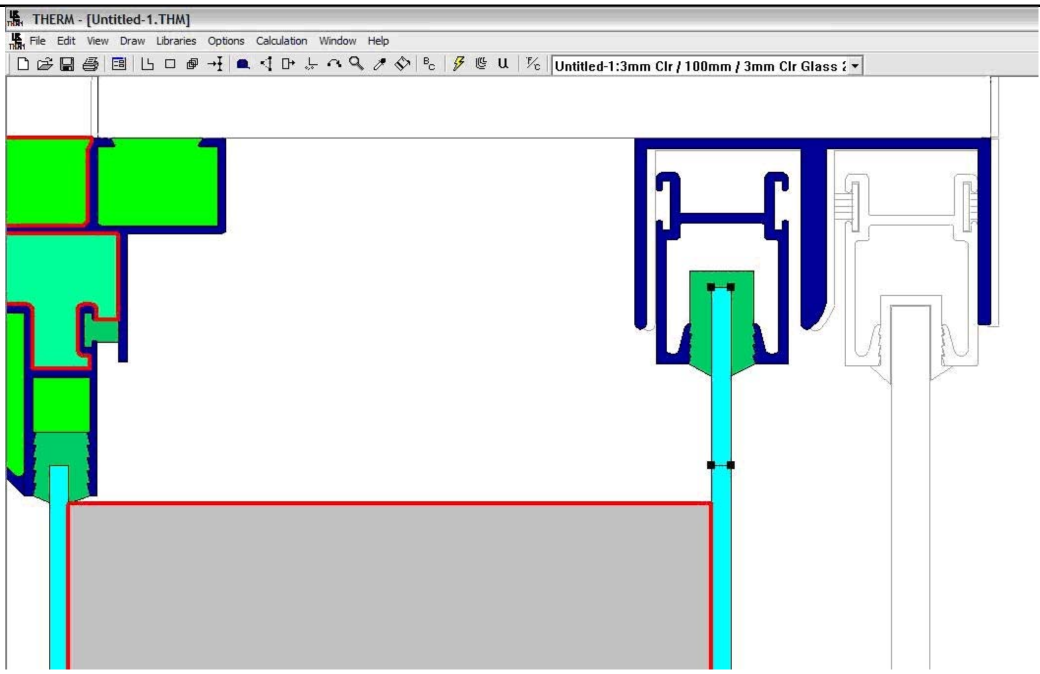


C. Delete the existing glass and re-import using the calculated edge of glass dimension to allow for the lower PFD. (i.e. Subtract the existing glass height from the edge of glass dimension. (Eg: 63.5 – 20.014 = 43.486)

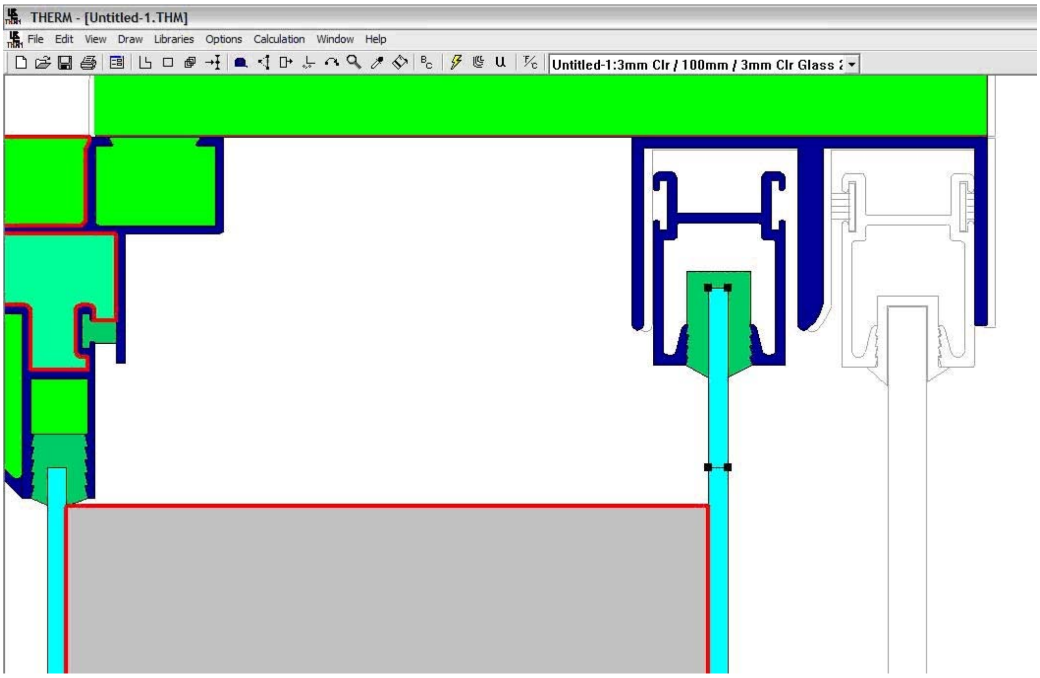


D. Create link between glass and the rectangle drawn in Step B. This will link the two materials and make it a cohesive piece of glass.

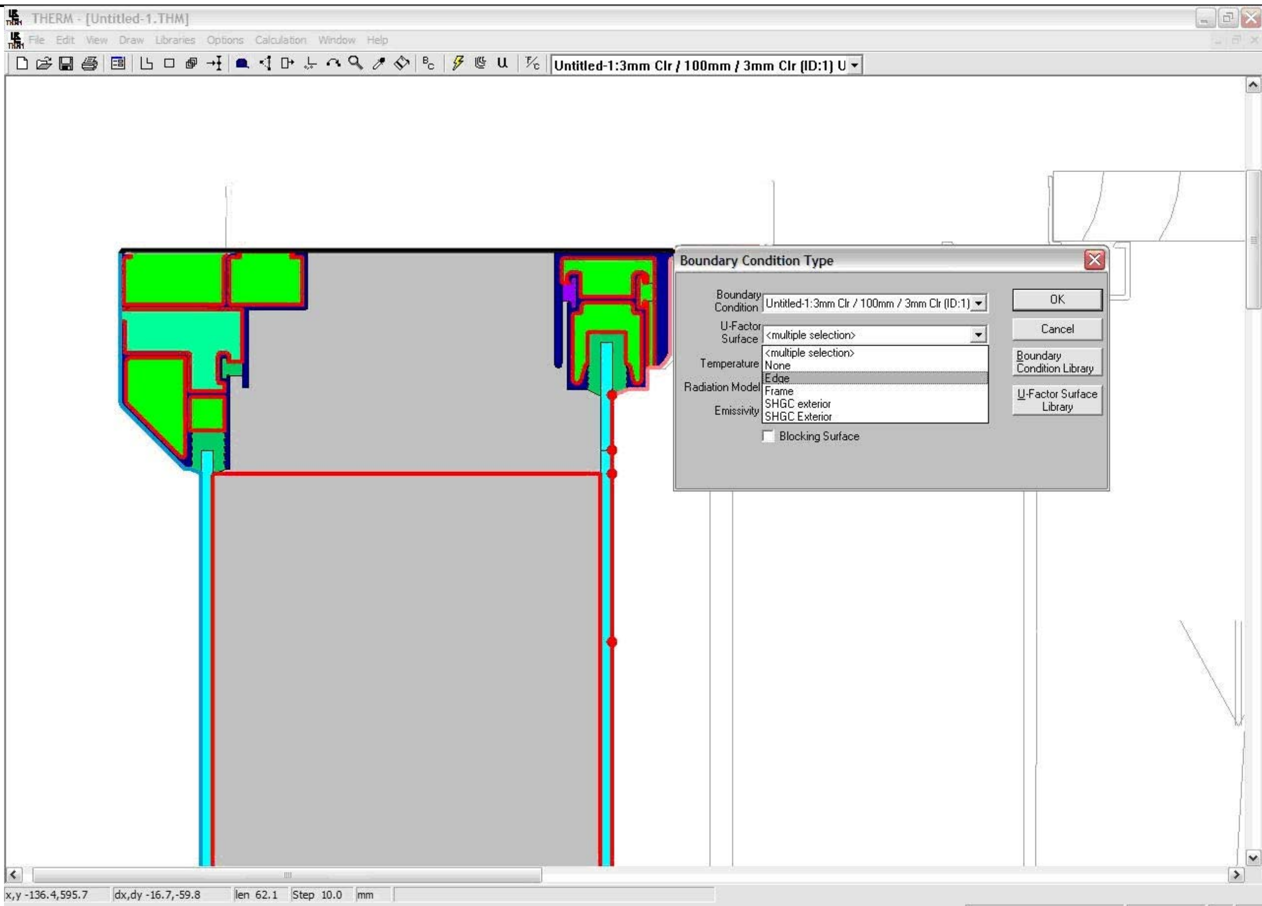




E. Fill the remaining cavity and create link between it and the glazing cavity.

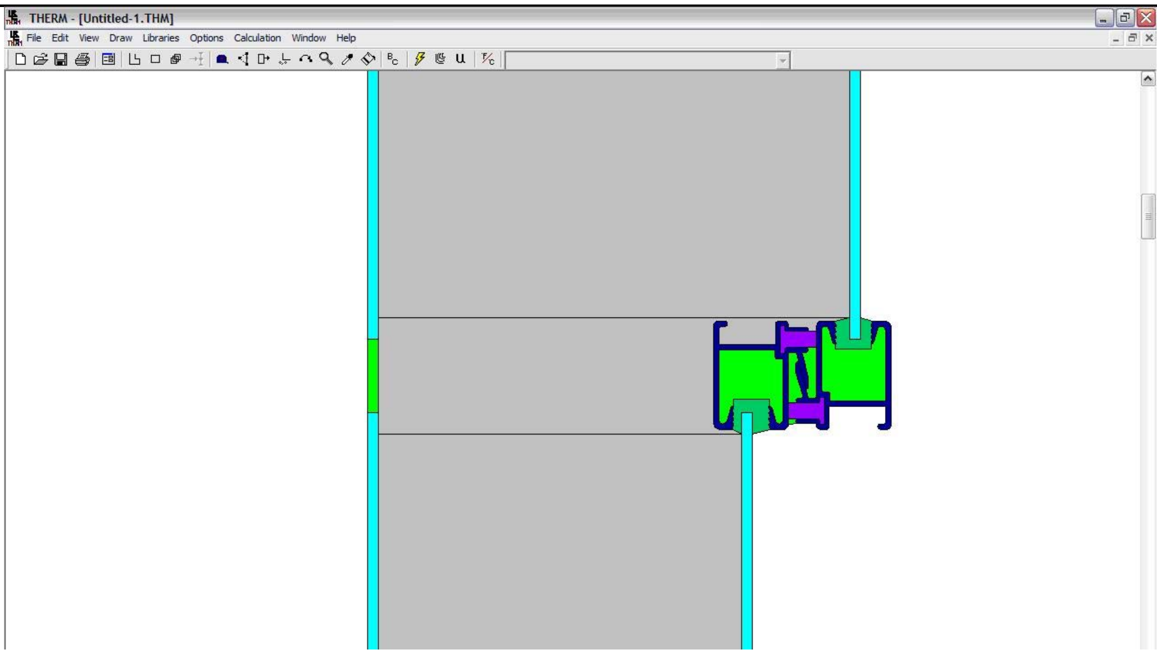


F. When assigning the boundary conditions, THERM will automatically assign a “frame” tag to the linked glass “rectangle” and bottom edge of the glass. Select the 3 tags as shown and change the U-factor Surface to “Edge”. This will give a total edge length of 63.5mm as per NFRC procedures.

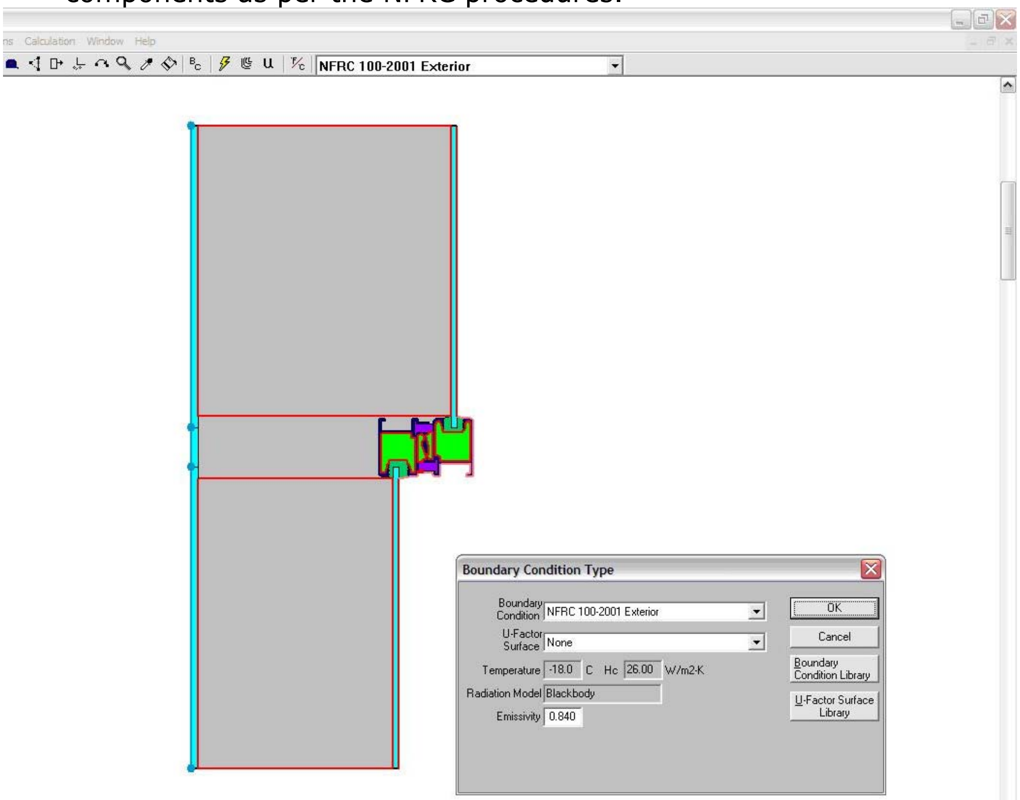


G. Complete this process for the remaining head, sill and jamb sections (i.e. all sections except any intermediate frame sections)

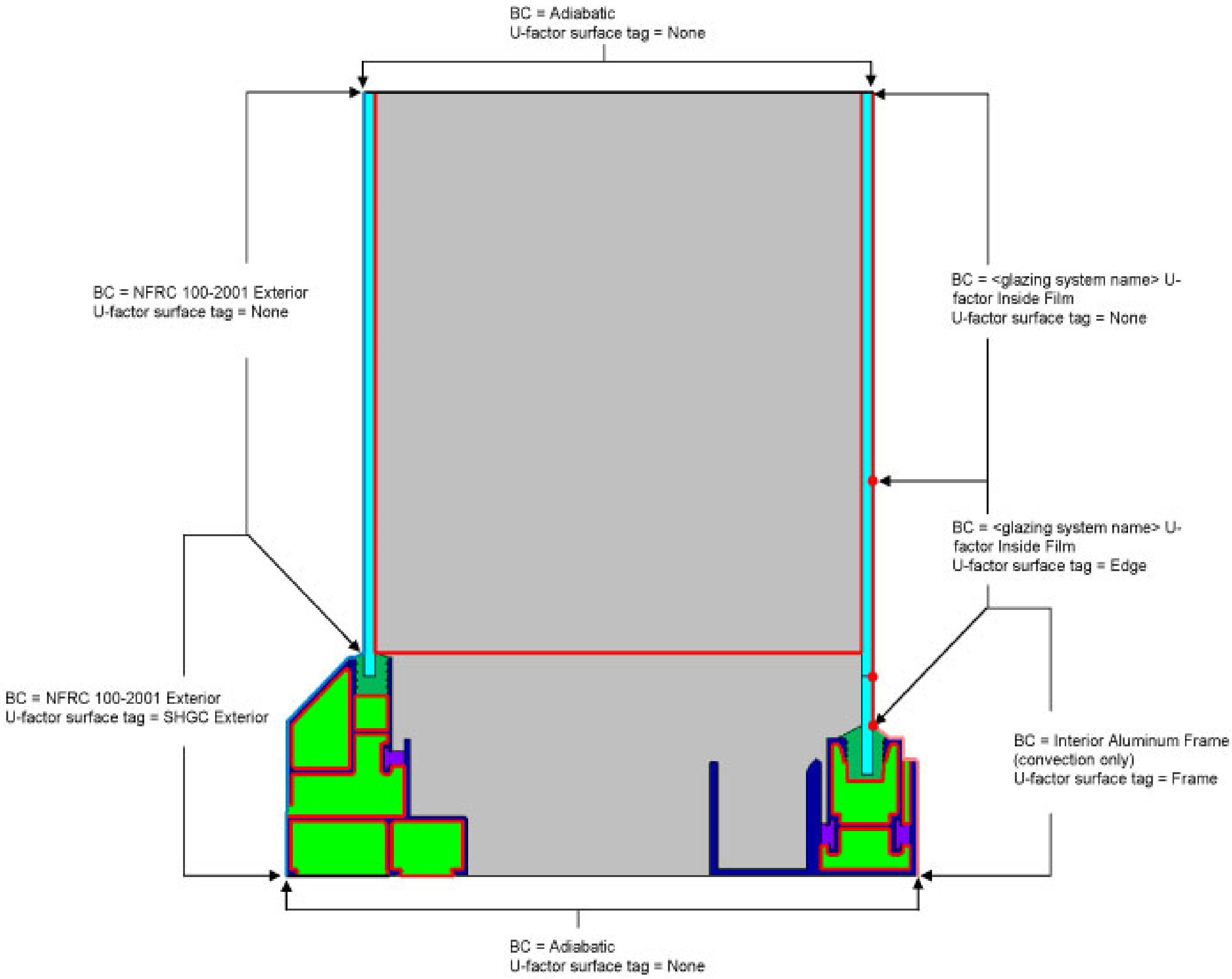
H. THERM modelling of the Intermediate frame section (Mullion/Transom)
   i. Draw the internal intermediate frame section as per NFRC simulation procedures and import the glass.
   ii. Draw a rectangle between the two external glass panes and “create link” with the other external glass panes.



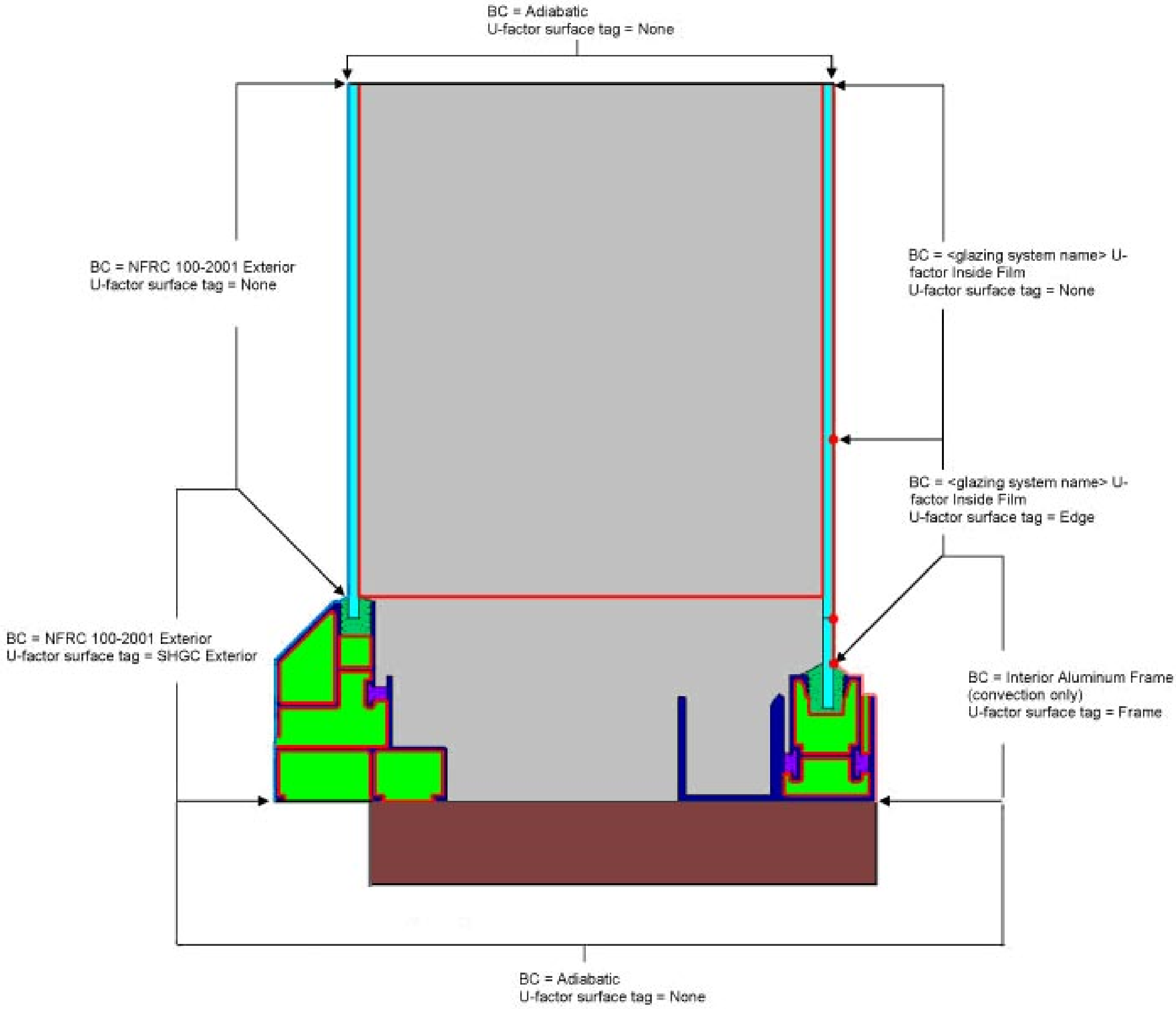
iii. Use the “None” U-factor Surface tag for all external glazing. Tag the internal components as per the NFRC procedures.



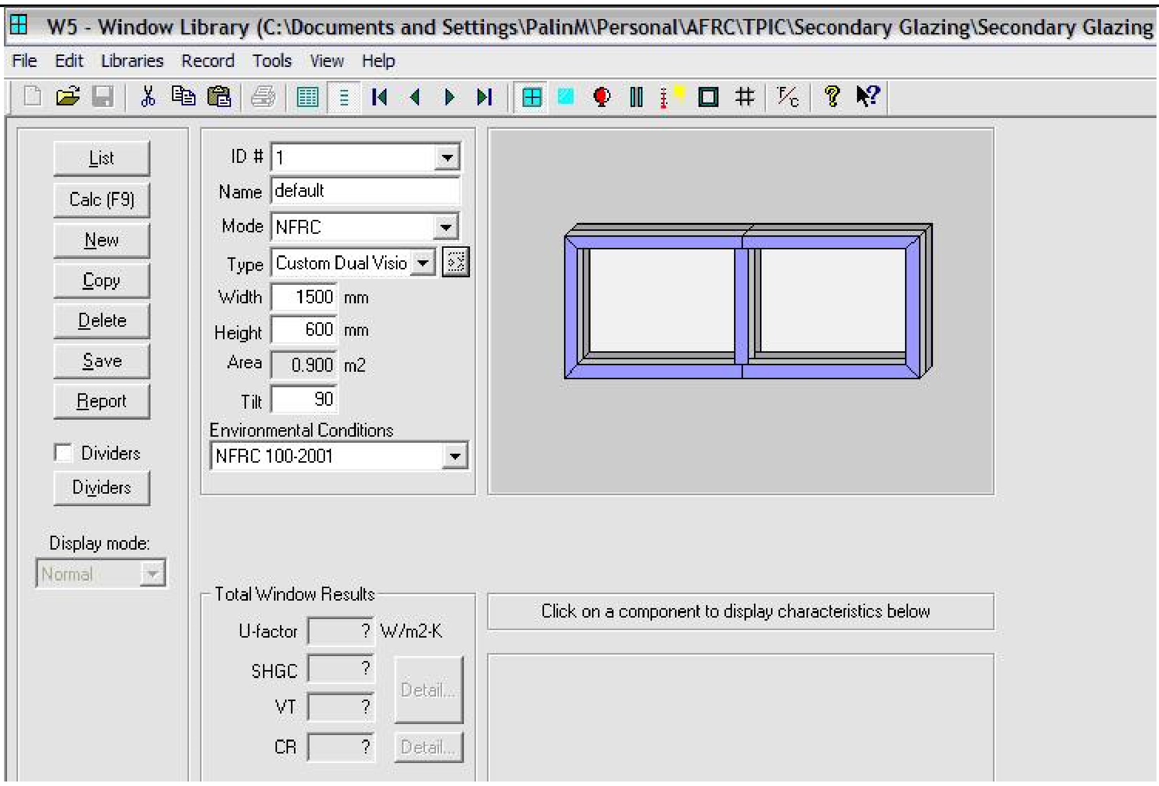
I. Assignment of boundary conditions and U-factor tags. See example below.



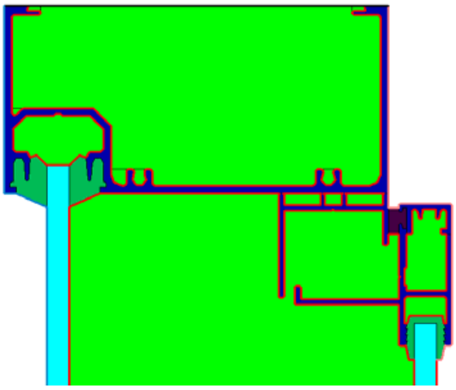
If a reveal is required model as adiabatic tags as below.



iv. Import all THERM files into Window5 and build as a Dual Custom Vision in the Window Library. Set to the size of the primary window (external window). In this example, the awning window is the primary window and the sliding window is the secondary window. Therefore, the Horizontal custom vision window is selected at the size 1500mm by 600mm (width by height).



The method presented in this interpretation can also be applied to a jockey sash configuration where the primary and secondary windows are joined by a framing member. (See Figure below)



Example of a jockey sash configuration

Technical Committee Revisions to Initial Interpretation:

ATIR-2009-*021*
16/07/2010

AFRC Technical Interpretation

Request Form

Interpretation Requested:
How should perimeter frames be taped for simulation?

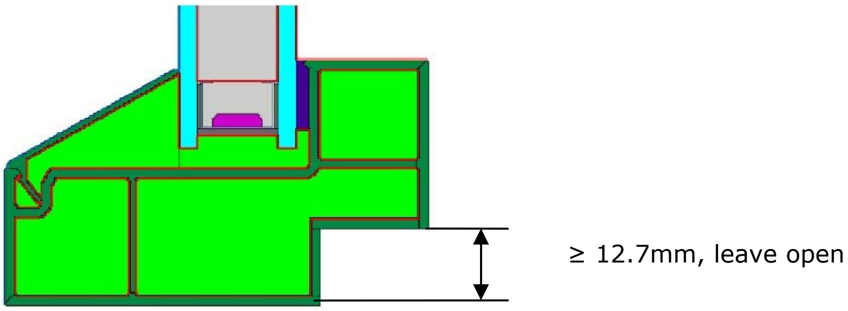
Date Requested:	*Initial Interpretation Date:*	*Final TAC Approval Date:*
24/02/09	24/02/09, revised 28/06/10	16/07/2010

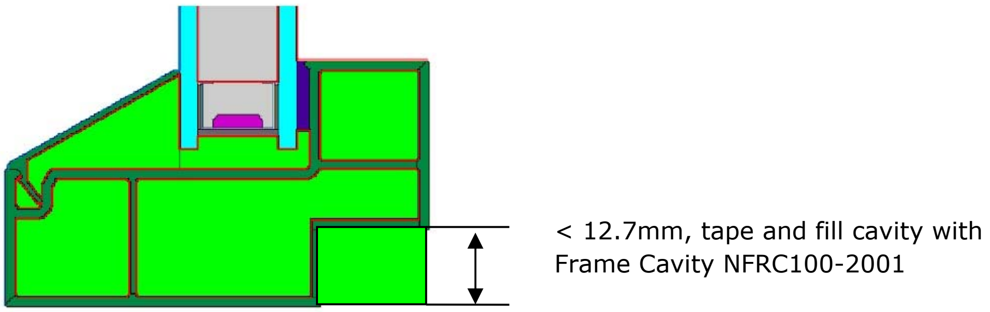
Pertinent Document:	
NFRC 100, NFRC 200, Simulation Manual	
Referenced Sections:	*Referenced Pages:*

Interpretation :

For simulation purposes, a product should be modelled in the same way that it is physically tested. If the manner in which the window would be physically tested is unknown, apply the following interpretation to perimeter taping.

For a frame which has a "step in" at the perimeter, if the distance between the perimeter and the inner leg of the frame is less than or equal to 12.7mm tape from the frame corner perpendicularly to the perimeter.





Technical Committee Revisions to Initial Interpretation:

ATIR-2007-09

ATIR-2007-*09* 16/07/2010

AFRC Technical Interpretation

Interpretation Requested:
How are aluminium windows with timber reveals simulated?

Date Requested:	*Initial Interpretation Date:*	*Final TAC Approval Date:*
26/10/07	26/06/09	16/07/2010

Pertinent Document:	
NFRC 100 - 2004 NFRC 2001 and 2004 Technical Interpretations	
Referenced Sections:	*Referenced Pages:*
Section 4.2.5 (NFRC 100) TI-2005-08 (Technical Interpretations)	Page 18 (NFRC 100) Page 56 (Technical Interpretations)

Interpretation :

Aluminium windows are generally supplied in Australia with reveal linings pre fitted in the factory (See Figure 1).

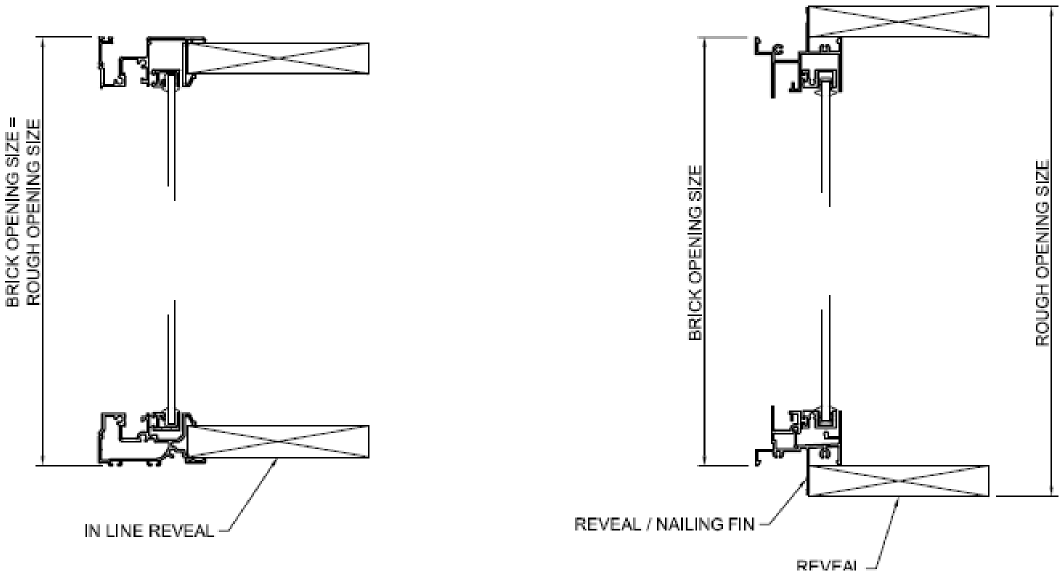


Figure 1: Window as Constructed with a timber reveal (nailing fins)

Reveal fins are described as nailing flanges by NFRC. NFRC 100-2010 4.2.5.A states that:

"*If a nail flange is not removable and is identified as such by the manufacturer, the product shall be simulated and tested with the nail flange covered with a nominal 1 in x 4 in fir trim. If a nail flange is removable, the product shall be simulated and tested without the nail flange*"

The method of simulating non removable nailing flanges is described in NFRC TIPC TI-2005-08. The attached drawing (see Figure 2) shows the NFRC methods of modelling a window with and without fins. There is negligible difference between the results obtained by the two modelling methods. If the window is simulated without the nailing fin, the reveal fin should be removed as per Figure 2 – NFRC Method 1. If the window is simulated with the nailing fin, the fir trim shall be position as per Figure 2 – NFRC Method 2.

If a permanent in-line reveal is present it shall be simulated with the reveal in place.

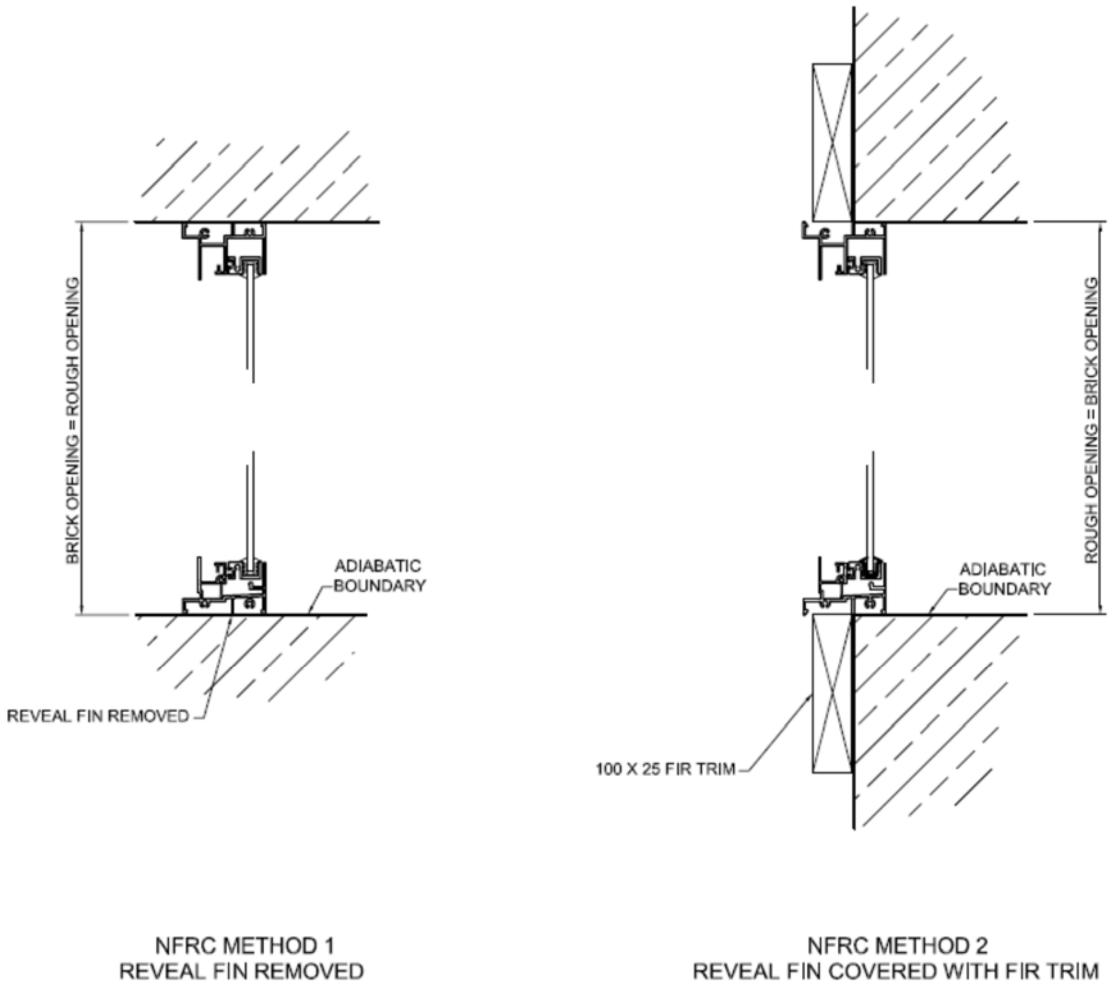


Figure 2: A comparison of the simulation configuration for aluminium frames with a timber reveal (nailing fins)

Additional Information:

If the window is modelled with the reveal attached (See Figure 1 -Window as Constructed), the results are skewed because the effective window size (brick opening size) is smaller than the modelling size (rough opening size). When the window size is removed from the equation and the amount of energy flowing through the window is considered, it can be shown that the reveal does not contribute to the energy performance of the window.

Technical Committee Revisions to Initial Interpretation:

ATIR-2009-01
04/11/2011

AFRC Technical Interpretation

Interpretation Requested:
"Sashless" windows are a type of window commonly used in Australia. They should be more correctly described as frameless sash double hung or sliding windows, where the operating sashes are unframed glass panes. Sealing between the sashes is obtained by overlapping the glass panes and applying a wool pile seal to the leading edge of the inside pane. Where better sealing is required, a second seal is applied to the leading edge of the outside pane. What is the correct procedure to model this type of window?

Date Requested:	*Initial Interpretation Date:*	*Final TAC Approval Date:*
20/03/07	30/06/09	25/10/2011

Pertinent Document:	
Referenced Sections:	*Referenced Pages:*

Interpretation :

Simulation Method.

The following is a simulation technique for sash-less windows under the Australian Fenestration Rating Council.

1. Model all perimeter frame sections (Heads, Jambs and Sills) using standard methods from the Therm6.3/Window6.3 NFRC Simulation Manual.
2. The Vertical/Horizontal meeting rails need to be modelled as per the drawings below in Figure 1.

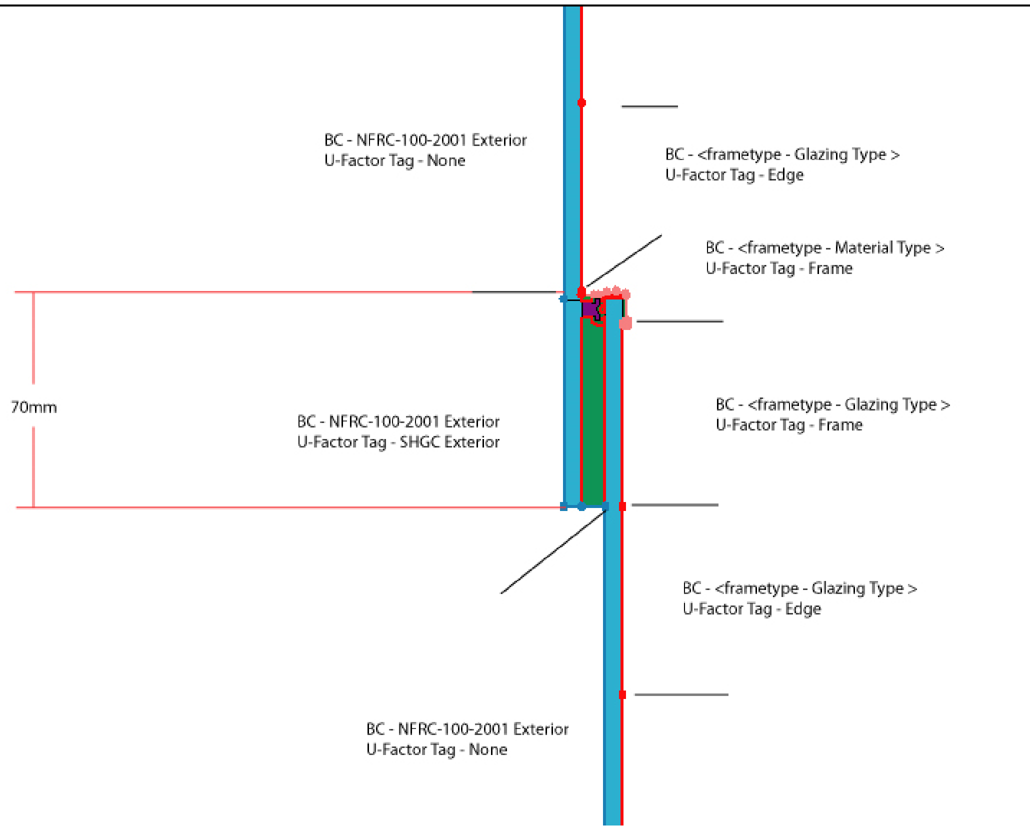


Figure 1 – Meeting Rail example

The simulation procedure requires a default 70mm overlap of the two glazing layers. This is a projected Frame Dimension from the top of the internal sightline to the bottom of the external sightline. This would be the same if the glazing consisted of a double wool pile seal. The edge measurements should be maintained at 63.5mm from the frame area as per the simulation manual. Note: the exterior glazing should be linked between the two polygons creating the glazing layer.

The Therm6 frame sections should then be placed into Window6 as per standard procedures (taken from the NFRC Simulation Manual (Window6/Therm6 Version) and simulated at the product size found in the AFRC Technical Protocols and Procedures Manual (March 2007) in accordance with the specific product type.

ATIR-2011-01
13/04/2012

AFRC Technical Interpretation

Interpretation Requested:
There is some confusion regarding the treatment of Commercial and Shop front window systems. This ATIR seeks clarification of the issues surrounding the modelling of these windows, in particular the modelling of windows with sub sills.

Date Requested:	*Initial Interpretation Date:*	*Final TAC Approval Date:*
31/05/2011	31/05/2011	30/03/2012

Pertinent Document:	
NFRC100-2010; AFRC Protocols and Procedures Manual	
Referenced Sections:	*Referenced Pages:*

Interpretation :

General

Curtain Wall:

Model as per NFRC Simulation Manual May 2011 Section 8.10.2 Figure 8-109.

Window Wall:

NFRC100-2004 Table 4.3, Note 4 was ambiguous as it referred to curtain walls, window walls and glazed walls. It has been AFRC practice to model shop front systems as glazed walls: "*Glazed wall and sloped glazing shall be simulated and tested with standard jamb, head, and sill members*" This definition has been used in the AFRC Protocols and Procedures Manual. Curtain walls and window walls are modelled differently.

However NFRC100-2010 Table 4.3, Note 4 has been changed to remove the reference to glazed walls. There is now only a reference to curtain walls and window walls.

The reason for the change is not known, but the AFRC needs to consider whether we should adopt the change or keep the status quo under an Australian variation.

Sub Sills:

Sub sills are not modelled under NFRC rules as they are considered to be a removable attachment. The AFRC decided to introduce an Australian Variation to include sub sills as 90% of shopfront windows are fitted with sub sills.

NFRC ratings are used for comparison only, whereas AFRC ratings are used in whole of building energy calculations, and as such would be more accurate with the sub sill included.

Unfortunately, this variation has not been documented and there has been a mixture of ratings calculated with and without sub sills. As the designs of shopfront systems are so similar between manufacturers, those rated with a sub sill are disadvantaged over those modelled without.

Recommendations

The AFRC TAC recommends that:

- Shop front windows to be modelled as per the current NFRC modelling rules for Window Walls.
- Shop front windows to be modelled without sub sills as per the current NFRC modelling rules.

Technical Committee Revisions to Initial Interpretation:
The AFRC Protocols and Procedures Manual to be updated to reflect these changes.

ATIR-2013-*01* 14/03/2013

AFRC Technical Interpretation

Interpretation Requested:
This ATIR seeks clarification of the issues surrounding the modelling of non-commercial windows in relation to sub sills

Date Requested:	*Initial Interpretation Date:*	*Final TAC Approval Date:*
06/12/2012	06/12/2012	14/03/2013

Pertinent Document:	
NFRC100; AFRC Protocols and Procedures Manual	
Referenced Sections:	*Referenced Pages:*

Interpretation :
• At the time of writing the ATIR regarding subsill was specifically covering commercial products and did not specifically state any rules for non-commercial products. • AFRC TAC agrees that the same rule should be applied when modelling non-commercial (residential) window products.

Technical Committee Revisions to Initial Interpretation:

ATIR-2013-*02*
16/04/2014

AFRC Technical Interpretation

Interpretation Requested:
How do we model in-line reveal products that may be sold with multiple depths of in-line reveal? Should the shortest in-line reveal that the product is sold with be applied?

Date Requested:	*Initial Interpretation Date:*	*Final TAC Approval Date:*
23/10/2013	23/10/2013	16/04/2014

Pertinent Document:	
Referenced Sections:	*Referenced Pages:*

Interpretation :
The In-line reveal length that is applied in the simulation should be modelled with the shortest in-line reveal depth and the same product with any larger in-line reveal depth will be able to utilise the same performance results.

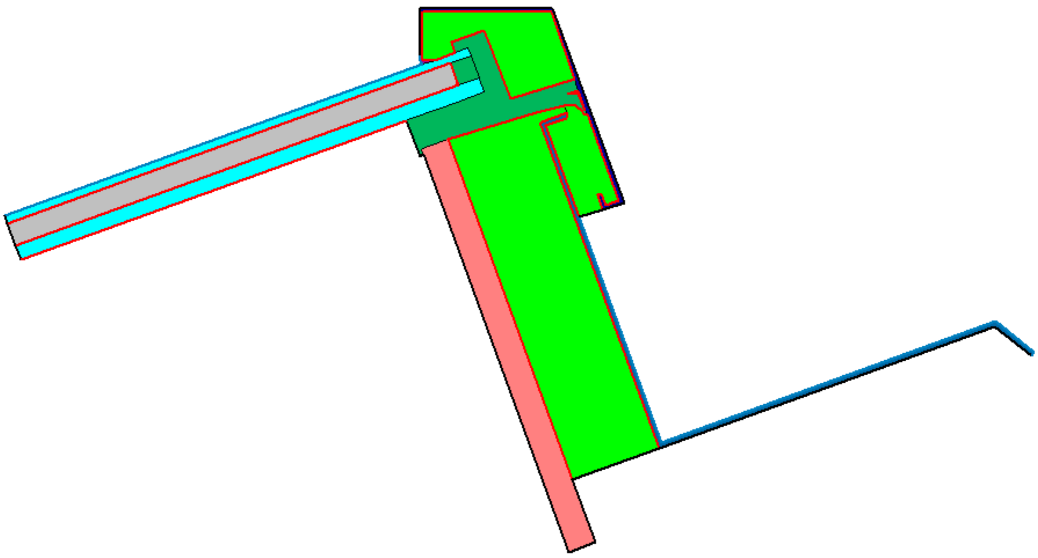
Technical Committee Revisions to Initial Interpretation:

ATIR-2014-02

ATIR-2014-*02*
07/10/2014

AFRC Technical Interpretation

Interpretation Requested:
Are Skylights with internal plasterboard light shaft to be modelled with or without the light shaft included? Many skylight systems incorporate integral plasterboard (or other) material light shafts, which are essential for the performance of the system. While these products are not supplied with the light shaft they are immensely important to the thermal and aesthetic performance of the system. Below is a sample of a system that is sold without a light shaft included but the separation of the internal and external conditions are very reliant on the inclusion of the reveal. Further skylight products are compared to tubular daylight devices (TDD's) which are modelled incorporating their shaft under the AFRC Skylight Simulation Manual. In order to ensure that one product type does not gain an artificial advantage over other products the shaft should be included to ensure consistency. This same example could also be applied with a timber light shaft (or lining).



Date Requested:	*Initial Interpretation Date:*	*Final TAC Approval Date:*
10/09/2014	22/09/14	07/10/2014

Pertinent Document:	
NFRC – 101 AFRC Skylight Simulation Manual	
Referenced Sections:	*Referenced Pages:*

Interpretation :

The light shaft should be simulated with the product as it is an integral part of the system and to install the product in the building fabric the light shaft would needed to be installed to meet the aesthetic requirements of the purchaser.

Care should be taken by the manufacturer and the certifier to ensure that the product is named to specifically include the light shaft that is included.

As an example the Products description for the above product would be

XYZ Series Skylight – Double Glazed – **With Plasterboard Light Shaft**.

This will ensure that the purchaser is informed that in order to meet the performance as specified in the rating the plasterboard light shaft (or lining) is included.

Technical Committee Revisions to Initial Interpretation:

As the light shaft is sometimes not included in the item provided by the manufacturer the product should be modelled in two separate ratings. This will allow users the choice of utilising the product with an internal light shaft or using the result without the internal shaft.

As there are many different materials that can be used to construct the internal light shaft in these products the internal light shaft should be modelled with “Gypsum plasterboard” from NFRC-101, which has a conductivity of 0.25 W/m.K and an emissivity of 0.9. This will be deemed to account for all internal light shaft (or lining) materials.

Each rating shall be conducted with both the with internal light shaft and without the internal light shaft configurations unless the manufacturer does not provide the option of installing without the internal lining option in their installation detail and the light shaft is an integral part of the product.

The products shall be named descriptively to ensure that there is no confusion to energy raters, specifiers, consumers or surveyors. The names should be named as below -

XYZ Series Skylight – Double Glazed – **With Light Shaft.**

XYZ Series Skylight – Double Glazed – **Without Light Shaft.**