GUIDELINE FOR THE TWO-DIMENSIONAL SIMULATION OF SPANDREL PANEL THERMAL PERFORMANCE FOR IMPROVED ACCURACY AND CONSISTENCY

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ABSTRACT

While the approach to thermal simulation of vision glazing areas is well documented by groups such as the National Fenestration Rating Council (NFRC), the approach to simulate opaque spandrel panels is not similarly documented. Furthermore, spandrel assemblies are substantially different from conventional opaque wall assemblies (i.e., concrete, steel stud, wood stud, etc.). To address this industry need, RDH in partnership with the Fenestration Association of BC (FENBC) and funding from BC Housing has developed a procedure to determine spandrel panel U-factors using common industry tools and familiar methods. The methodology includes consideration of various spandrel panel arrangements and builds off the existing NFRC 100 simulation methodology. The objective of this procedure is to document a reasonably accurate and practical approach to determine opaque spandrel area U-values with higher precision and uniformity. This allows for both the accurate representation of these systems with regards to code compliance and energy modelling, as well as the fair comparison of competing products.

BACKGROUND

Many tools and techniques have been developed for determining the effective U-values of most building enclosure assemblies, but there is one important enclosure type for which a standardized evaluation methodology does not yet exist: opaque fenestration assemblies known as spandrels. This lack of a standardized evaluation method has resulted in significant variation in the estimates of spandrel assembly thermal performance, leading to both inaccurate calculation of performance and inequitable comparisons of products. As a result, there is a compelling need to develop a standardized approach that provides realistic values for whole building energy models and allows for fair comparisons of different competing systems.

The tools to perform such evaluations already exist; what has been lacking, is a standardized methodology for how to use them in a way that addresses the unique features of spandrel assemblies. While the standardized approaches described in the widely adopted North American standard NFRC 100 work well for windows, spandrel panels often include more complex geometry that the standard approach does not capture. For example, spandrel panels often feature insulated back pans, which may be interrupted by the concrete slab edge. Additionally, framed walls may be constructed behind the spandrel panel, which can provide additional thermal resistance and further complicate the geometry.

The reference procedure for simulating spandrel U-factors and accompanying user guide are available online at http://www.fen-bc.org/content/view/resources-spandrel.

METHOD

The proposed method involves simulating spandrel panels using two-dimensional (2D) thermal modelling software and area weighting the resultant U-factors, generally following the NFRC 100 procedure with a few modifications. The procedure development team adopted this approach intentionally to leverage the availability of existing product simulation data, industry standard simulation software, and trained technicians and professionals to perform the simulations.

The proposed methodology features two key modifications to the existing NFRC simulation procedure:

1) Three spandrel panel product arrangements (two additional arrangements)
2) Increased edge distance from 63.5 mm (2.5") to 152.4 mm (6")

Arrangements

Spandrel panels, like other fenestration products, are sold in many sizes and configurations. Currently, a single spandrel panel product type and standard model size are recognized in NFRC 100. The standard size is 2,000 mm wide by 1,200 mm high, and the spandrel is simulated with two lites and a vertical mullion. While the use of a single standard model size provides consistency across products, there are potential issues with this approach when applied to spandrel panels.

In practice, spandrel panel areas are often minimized to preserve vision glazing area and are located primarily to conceal opaque interior building elements such as columns and floor slabs. This has resulted in spandrel panels which are significantly smaller, and which are frequently interrupted by floor slabs. These factors have a significant impact on the overall effective thermal performance of the spandrel panel and bring the representativeness of the single standard arrangement into question.

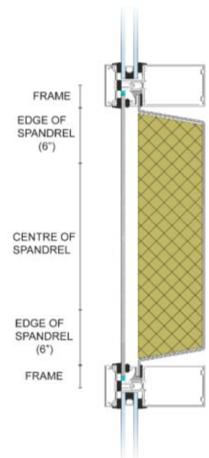
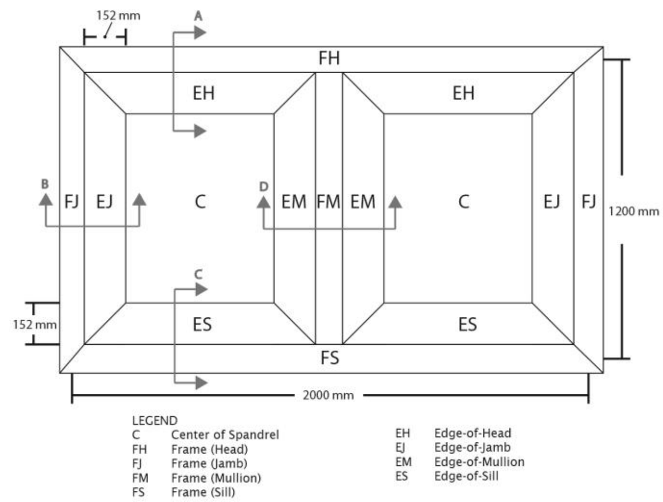
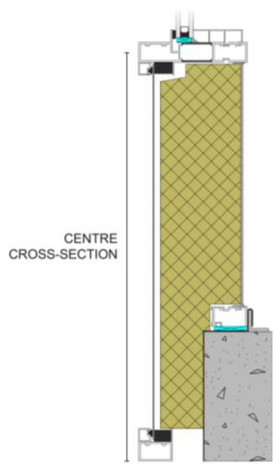
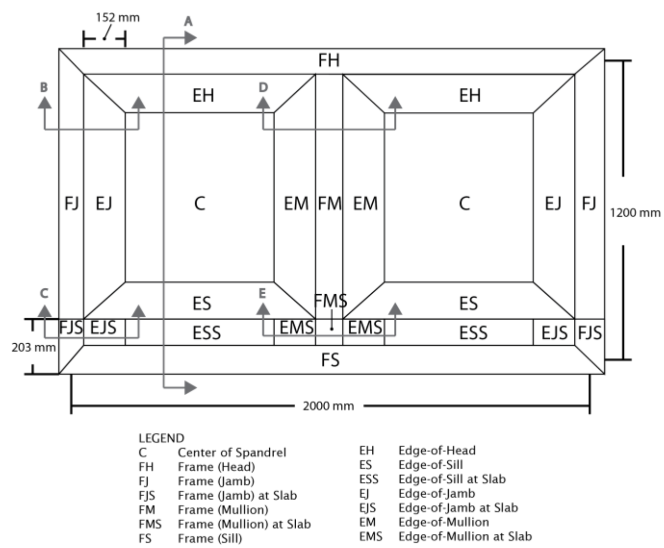
To account for common variations in spandrel panel geometry the procedure proposes a total of three arrangements:

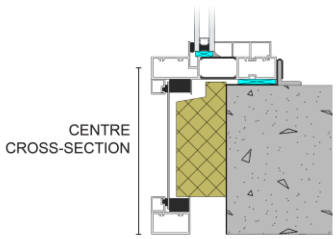
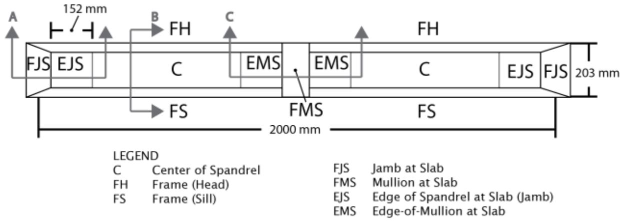
1) Uninterrupted Spandrel
2) Partially Interrupted Spandrel
3) Fully Interrupted Spandrel

Table 1 presents these three arrangements graphically in section view and shows how the arrangements are broken up into U-factor areas, the latter being a key feature of the simulation procedure.

For consistency, the procedure provides a standard model size for each arrangement, which is important for product comparisons and to provide a useful rating of the product's thermal performance. Nevertheless, simulators can determine the thermal performance of spandrels at project specific sizes following the optional procedure in NFRC 100 with a few modifications to account for the additional U-factor areas introduced by the new arrangements. While this step is often considered to be optional for many fenestration products, the opaque nature of spandrel panels means that there is often an energy code requirement to treat spandrels as other opaque wall assemblies. Consequently, it has been more common with spandrels than other fenestration product types to determine U-factors using project specific sizes.

Table 1: Spandrel arrangements, model sizes, and U-factor areas.

Arrangement 1 **Uninterrupted Spandrel**	 	
	2000 mm x 1200 mm (79 in x 47 in)	
Arrangement 2 **Partially Interrupted Spandrel**	 	
	2000 mm x 1200 mm (79 in x 47 in)	

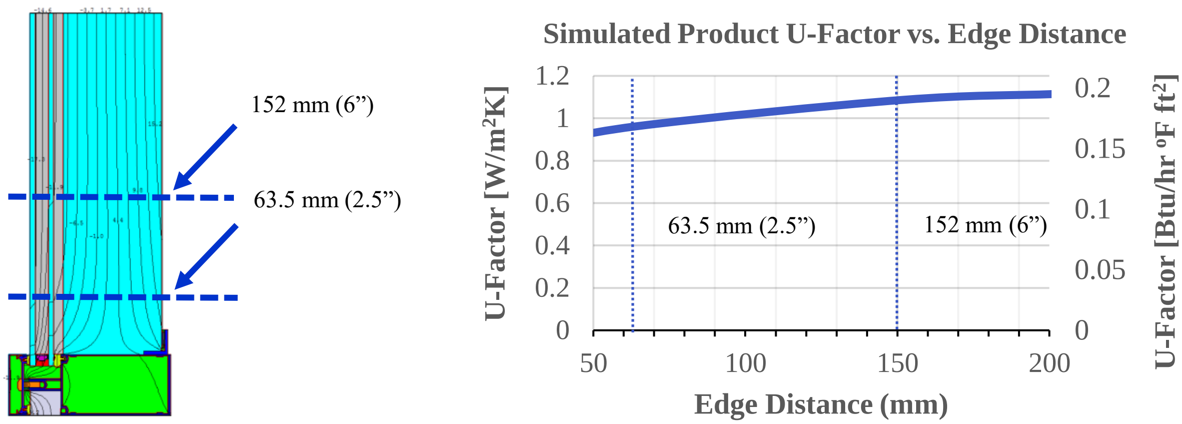
<table>
<tr><td rowspan="2">Arrangement 3
Fully Interrupted Spandrel</td><td>
</td><td>
</td></tr>
<tr><td colspan="2">2000 mm x 203 mm (79 in x 8 in)</td></tr>
</table>

Edge Distance

The second significant modification to the existing NFRC 100 procedure is an increase in the edge distance. Around the perimeter of the frame, heat loss through the panel (or glass) is non-uniform. NFRC 100 captures this effect by defining a separate edge area and associating it with a separate U-factor. The edge area is defined by an edge distance, which is 63.5 mm (2.5”) inwards from the frame for all fenestration products covered by NFRC 100.

Figure 1 (a) shows a standard curtainwall spandrel panel profile with an insulated back-pan. The temperature isotherms illustrate that at the standard edge distance of 63.5 mm (2.5”) away from the frame, heat flow remains non-uniform. In this example, the center of panel performance occurs at a distance of 152 mm (6”). One of the reasons for the increased edge effect is the metal back pan, which acts as a thermal bridge.

Based on several thermal simulations (Figure 1 b), an edge distance of 152 mm (6”) was selected to more accurately capture the two-dimensional heat flow observed in for typical spandrel panels. Furthermore, simulation of typical spandrel panels has shown that using larger edge distances larger has a diminishing impact on the overall simulated product U-factor.



(a) (b)

Figure 1: (a) 2D model of a typical spandrel panel showing temperature isotherms and non-uniform heat flow, 63.5 (2.5”) from the frame. (b) Graph plotting simulated product U-factors vs. edge distance. As the simulated edge distance increases, the change in overall product U-factor decreases.

LIMITATIONS

While an improvement over the current methods, this procedure does not capture the full range of variables that may impact the spandrel panel thermal performance including the impact of adjacent systems, installation details, and modelling tools (i.e., 2D vs. 3D simulation). A discussion of these factors is provided in an accompanying user guide to the procedure. Each design team should consider whether the simulated U-factor meets the needs and expectations of their project.

CONCLUSION

RDH in partnership with FENBC has developed a reference procedure for the simulation of spandrel panel U-factors. The methods largely follow the familiar procedures outlined in NFRC 100 and prioritize consistency, comparability, and ease of use for product rating; while simultaneously allowing for a more accurate assessment of the performance of different spandrel panel arrangements. Significant changes include additional spandrel panel arrangements and an increased edge distance.

REFERENCES

NFRC. 2013. NFRC 100-2014 Procedure for Determining Fenestration Product U-factors. National Fenestration Rating Council Incorporated, Greenbelt, MD.

FENBC. *Unpublished*. Reference Procedure for Simulating Spandrel Panel U-Factors. Fenestration Association of BC, Vancouver, BC.

FENBC. *Unpublished*. User Guide to the Reference Procedure for Simulating Spandrel Panel U-Factors. Fenestration Association of BC, Vancouver, BC.