Date: August 31, 2017

Title: Simulation and Validation of Vacuum Glazing for Ratings & Labeling

Bid Proposal Due Date: October 15, 2017.

All bidders shall submit two copies of all bid proposals and shall be received by the NFRC office on or before the due date 5:00 pm (Eastern Time), at the address mentioned below:

National Fenestration Rating Council
6305 Ivy Lane
Suite 140
Greenbelt, Maryland 20070

All bidders will bid by the NFRC Agreement. If government funding is used for the project then the bidder shall bid by form K requirements.

Title: Simulation and Validation of Vacuum Glazing for Ratings & Labeling

Proponents: D. Charlie Curcija, David Cooper, Bipin Shah

Background: Vacuum Insulating Glass (VIG) is a type of multi-layer insulating glazing system, which is not specifically mentioned in the NFRC rating, simulation or labeling documents. Though construction methods and materials may vary, VIG units on the market today are generally comprised of the following components (See Figure 3);

- Two or more planar glass lites, with each lite of glass separated from the other by a distance typically less than one millimeter.
- An array of pillars or spacers to maintain the void between the lites of glass
- A hermetic edge seal – typically a glass frit, which joins together and encircles the entire perimeter of the VIG unit
- Often a getter material is employed to control residual gas build up
- A hermetically sealable portal, or pump out tube, through which to evacuate residual gas
To attain the most desirable insulating properties, the residual gas between the VIG’s glass lites is evacuated to a level such that “the pressure is low enough that the distance between [molecular] collisions is about the same as the distance over which the gas is contained” (Kocer, 2006). These pressure levels are less than 1 millitorr (less than 0.133 Pa, where standard atmospheric pressure is ~100,000 Pa). Modeling of such systems require new algorithms, since air at such low pressure does not conform to standard convection or conduction models and pillars/standoffs represent three-dimensional thermal bridges that needs to be accounted for in 1-D and 2-D thermal models used in NFRC software tools Berkeley Lab WINDOW and THERM. These models were developed in early 1990s and documented in (Curcija et al., Year). The Berkeley Lab WINDOW software tool incorporates these algorithms and THERM software tool, which is 2-D program imports glazing from WINDOW and then proceeds to model frame and edge of glazing thermal performance as with any other glazing system.

A VIG task group was created in March 2015 with the goal to incorporate rating of windows with VIG into the NFRC documentation and rating procedures and coordinate validation of the Berkeley Lab WINDOW VIG simulation module.

**Objectives:** Develop procedure to determine VIG center of glass thermal conductance and to validate modeling procedure in Berkeley Lab WINDOW and THERM.

**Scope:** Validating VIG modeling algorithms poses unique challenges since two parameters need to be validated, 1) pressure within the VIG and 2) accuracy of algorithms. Determining pressure within VIG is not possible at this time. Pressure can be measured, but in order to access VIG gap, pressure is disturbed. It is similar in difficulty to measuring quantum states, as soon as you observe quantum state, the state itself changes. Also, there is no known method to measure pressure without direct contact to the space (non-disruptive measurement). Considering that we don’t have an option of
measuring pressure, this exercise is more of validating pressure levels using currently accepted algorithms, rather than validating algorithms themselves. Therefore, this research project will focus on methods of measuring conductance of VIG units and through the use of modeling algorithms, calculating resulting pressure. Since most of conductance measuring equipment has size limit of 12” x 12”, these specimens will be smaller than what is typically installed in window products.

Larger specimens will be constructed and fitted into fixed size window (4’ x 5’, or 1,200 mm x 1,500 mm overall window size) and placed in hot box for standard NFRC 102 measurement. Test results, after being corrected to standard NFRC conditions, using NFRC 102 procedures, will be compared to whole product modeling using Berkeley Lab WINDOW (and utilizing calculated pressure from conductance measurements) and THERM programs. The resulting agreement is expected to be within standard 10% tolerance or 0.03 Btu/(hr ft2 F), whichever is greater (NFRC 100). If the tolerance is not achieved, further recommendations will be provided for follow-up research project. If the results are within 10% tolerance, this method of determining VIG gap pressure and modeling in Berkeley Lab WINDOW will be accepted and sent for approval to NFRC BoD.

The following set of samples will be measured and modeled and a IR image of each of the test samples will be provided:
- 2 Frame materials – PVC frame & Metal (Aluminum) frame
- 2 Frame types – fixed (O)
- Glazing: VIG samples from at least 2 manufacturers (some attempt should be made to pick the highest performing product from each manufacturer. Our greatest concern is with these units)
  - 6 samples (per manufacturer) for ASTM C1044 COG thermal conductance measurement (12” x 12” or 24” x 24”, depending on the available apparatus)
  - 2 samples (per manufacturer) to fit 4’ x 5’ fixed window for NFRC 102 hot box measurement

**Deliverables:**
1. Physical testing resulting in U factor for all samples tested.
2. Thermal modeling in LBNL program, providing U factor for all sample constructions tested.
3. Comparison of physical testing to thermal modeling to determine if the program results in similar thermal heat transfer values as tested.
4. Recommended adjustments to the LBNL program to correlate to the physical testing conducted.

**Estimated Duration:** One Year

**Sole Sourcing:** This project need not be sole sourced
TERMS:
Any prospective bidder shall submit a proposal that identifies the total cost of performing all the requirements as documented in this RFP. Any terms of payment shall also be outlined in the proposal. A schedule which outlines all tasks of the RFP shall be included with the bid submittal, including all associated dates and/or times.

References: none

NFRC resources: Staff labor: Not to exceed 25 hours.

Non-NFRC resources: None

NFRC Staff contact:
The NFRC staff contact for the project is below:
Kevin Louder (klouder@nfrc.org) / Jen Padgett (jpadgett@nfrc.org)
National Fenestration Rating Council
6305 Ivy Lane
Suite 140
Greenbelt, Maryland 20770
Phone: (301) 589-1776
Facsimile: (301) 589-3884.

Payment: no greater than 33% payment when the contract is awarded and remainder when the Board of Directors approves the final written report.