National Fenestration Rating Council Incorporated

NFRC 500-2010[E0A1]

Procedure for
Determining Fenestration Product Condensation Resistance Values

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FOREWORD

The National Fenestration Rating Council, Incorporated ("NFRC") has developed and operates a uniform rating system for energy and energy-related performance of fenestration products. The Rating System determines the U-factor, Solar Heat Gain Coefficient (SHGC), and Visible Transmittance (VT) of a product, which are mandatory ratings for labeling NFRC certified products and are mandatory ratings for inclusion on label certificates, and are supplemented by procedures for voluntary ratings of products for Air Leakage (AL), and Condensation Resistance. Together, these rating procedures, as set forth in documents published by NFRC, are known as the NFRC Rating System.

The Rating System employs computer simulation and physical testing by NFRC-accredited laboratories to establish energy and related performance ratings for fenestration product types. The Rating System is reinforced by a certification program under which NFRC-licensed responsible parties claiming NFRC product certification shall label and certify fenestration products to indicate those energy and related performance ratings, provided the ratings are authorized for certification by an NFRC-licensed certification and Inspection Agency (IA).

The requirements of the rating, certification, and labeling program (the "Certification Program") are set forth in the most recent versions of the following as amended, updated or interpreted from time to time:

- NFRC 700 Product Certification Program (the "PCP")
- NFRC 705 Component Modeling Approach ("CMA") Product Certification Program (the "CMA-PCP").

Through the Certification Programs and the most recent versions of its companion programs as amended, updated or interpreted from time to time:

- The laboratory accreditation program (the "Accreditation Program"), set forth in the NFRC 701 Laboratory Accreditation Program (the "LAP")
- The IA licensing program (the "IA Program"), set forth in NFRC 702 Certification Agency Program (the "CAP")
- The CMA Approved Calculation Entity ("ACE") licensing program (the “ACE Program”) as set forth in the NFRC 708 Calculation Entity Approval Program (the "CEAP"),

NFRC intends to ensure the integrity and uniformity of NFRC ratings, certification, and labeling by ensuring that responsible parties, testing and simulation laboratories, and IAs adhere to strict NFRC requirements.

In order to participate in the Certification Programs, a manufacturer / responsible party shall rate a product whose energy and energy-related performance characteristics are to be certified in accordance with mandatory NFRC rating procedures. At present, a manufacturer/responsible party may elect to rate products for U-factor, SHGC, VT, Air Leakage, Condensation Resistance, or any other procedure adopted by NFRC, and to include those ratings on the NFRC temporary label affixed to its products, or on the NFRC Label Certificate. U-factor, SHGC and VT, AL, and Condensation Resistance rating reports shall be obtained from a laboratory, which has been accredited by NFRC in accordance with the requirements of the NFRC 701.

The rating shall then be reviewed by an IA which has been licensed by NFRC in accordance with the requirements of the NFRC 702. NFRC-licensed IAs also review label format and content, conduct in-plant inspections for quality assurance in accordance with the requirements of the NFRC 702, and issue a product Certification Authorization Report (CAR), or approve for issuance an NFRC Label Certificate for site-built or CMA products and attachment products. The IA is also responsible for the investigation of potential violations (prohibited activities) as set forth in the NFRC 707 Compliance and Monitoring Program.

Ratings for products that are labeled with the NFRC Temporary and Permanent Label, or products that are listed on an NFRC Label Certificate, in accordance with NFRC requirements, are considered to be NFRC-certified. NFRC maintains a Certified Products Directory (CPD), listing product lines and individual products selected by the manufacturer/responsible party for which certification authorization has been granted.

NFRC manages the Rating System and regulates the Product Certification Program (PCP), Laboratory Accreditation Program (LAP) and Certification Agency Program (CAP) in accordance with the NFRC 700 (PCP), the NFRC 701 (LAP), the NFRC 702 (CAP), the NFRC 705 (CMA-PCP), and the NFRC 708 (CEAP) procedures, and conducts compliance activities under all these programs as well as the NFRC 707 Compliance and Monitoring Program (CAMP). NFRC continues to develop the Rating System and each of the programs.

NFRC owns all rights in and to each of the NFRC 700, NFRC 701, NFRC 702, NFRC 705, NFRC 707, NFRC 708 and each procedure, which is a component of the Rating System, as well as each of its registration marks, trade names, and other intellectual property.

The structure of the NFRC program and relationships among participants are shown in Figure 1, Figure 2, and Figure 3. For additional information on the roles of the IAs and laboratories and operation of the IA Program and Accreditation Program, see the NFRC 700 (PCP), NFRC 701 (LAP), and NFRC 702 (CAP) respectively.

Figure 1

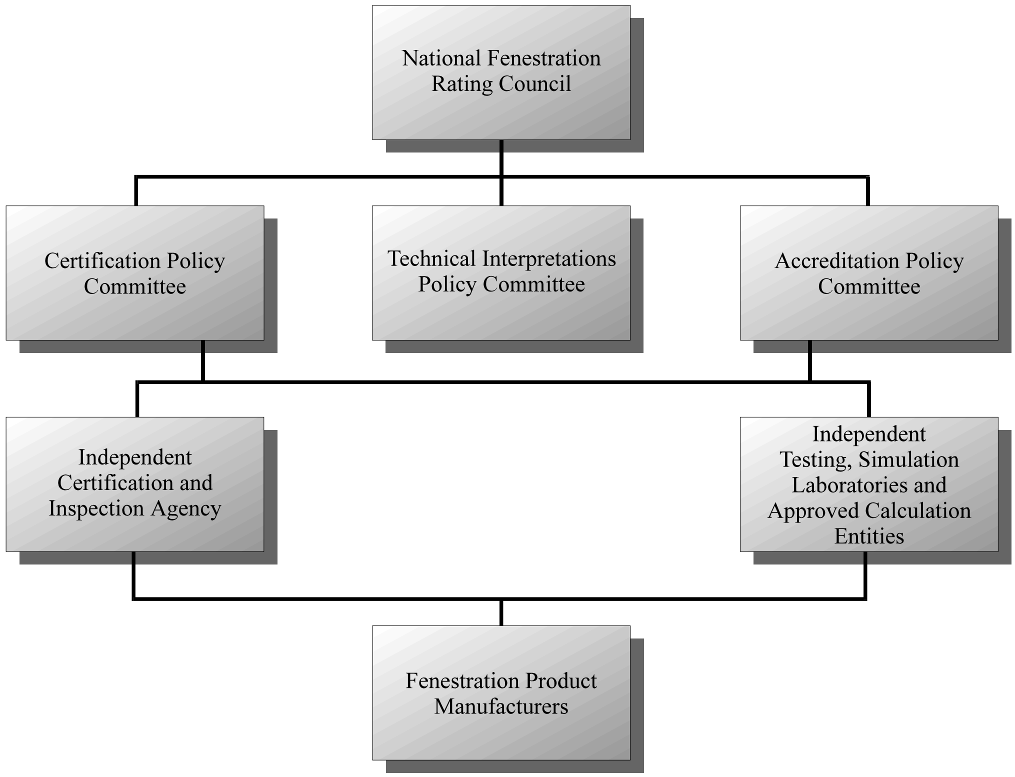


Figure 2

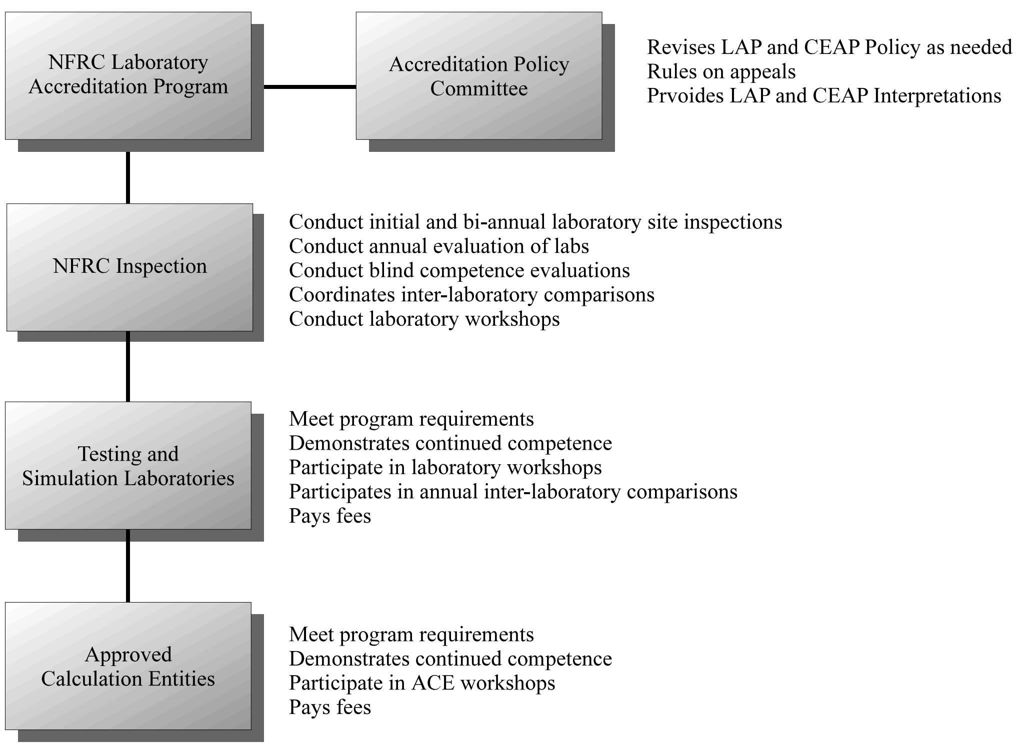
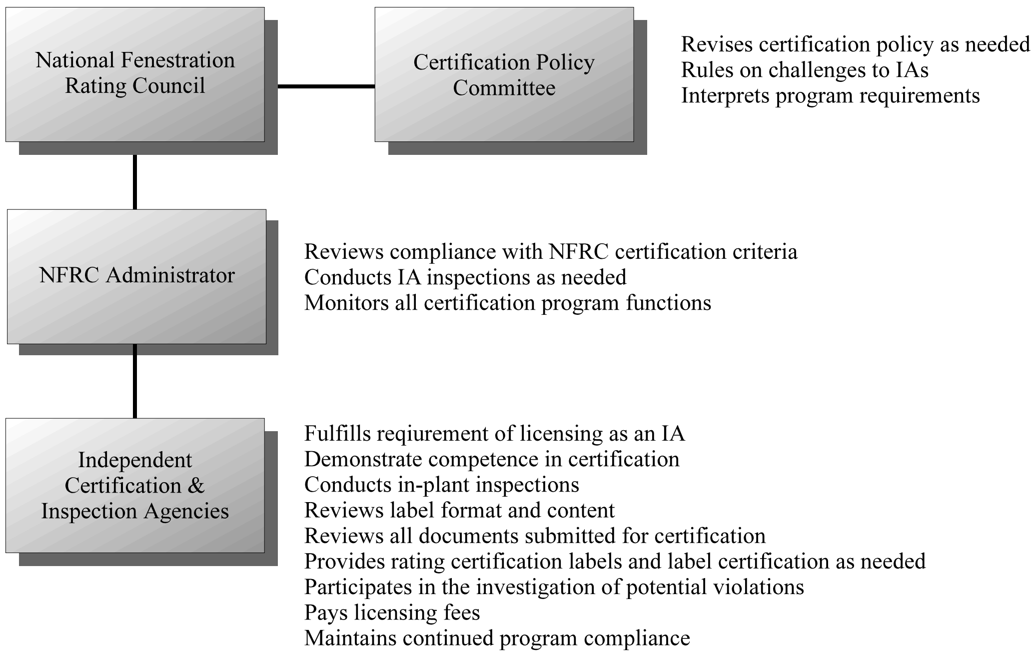


Figure 3



Questions on the use of this procedure should be addressed to:

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DISCLAIMER

NFRC certification is the authorized act of a manufacturer/responsible party in: (a) labeling a fenestration or related attachment product with an NFRC Permanent Label and NFRC Temporary Label, or (b) generating a site built or CMA label certificate, either of which bears one or more energy performance ratings reported by NFRC-accredited simulation and testing laboratories and authorized for certification by an NFRC-licensed IA. Each of these participants acts independently to report, authorize certification, and certify the energy-related ratings of fenestration and related attachment products.

NFRC does not certify a product and certification does not constitute a warranty of NFRC regarding any characteristic of a fenestration or fenestration-related attachment product. Certification is not an endorsement of or recommendation for any product or product line or any attribute of a product or product line. NFRC is not a merchant in the business of selling fenestration products or fenestration-related products, and therefore cannot warrant products as to their merchantability or fitness for a particular use.

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NFRC program participants are required to indemnify NFRC from and against such liability.

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1. PREFACE

This edition of the NFRC Condensation Resistance procedure includes information from ASTM C 1199, ASTM E 1423, NFRC round robin testing data, and technical interpretations by NFRC. The Condensation Resistance procedure includes a Simulation Method and a Test Method.

The NFRC Simulation Method is presented in Section 4. The Simulation Method is based upon the NFRC-approved software tools and is to be used in conjunction with NFRC 100 and the NFRC Simulation Manual.

The Test Method references NFRC 102 which contains many aspect of ASTM C 1199, as well as modifications adopted by NFRC.

The Test Method has been developed to be a supplement to the Simulation Method. Those products that cannot be simulated for Condensation Resistance shall use the test procedure to determine a Condensation Resistance rating. The Test Method replicates, as closely as possible, the Simulation Method for Condensation Resistance, but simulated and tested Condensation Resistance values may not be identical. The simulations are being validated with tested U-Factors, as obtained using the NFRC 100 procedure and not with tested Condensation Resistance values.

This procedure may involve hazardous materials, operations and equipment. This procedure does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this procedure to establish appropriate health and safety practices and to determine the applicability of any regulatory limitations prior to use.

The values stated in metric (SI) units are to be regarded as the standard. The inch-pound (IP) units shown in parenthesis are for reference only.

2. SCOPE

2.1 Fenestration Products Covered by NFRC 500

The following products and effects are within the scope of the NFRC 500 and shall be permitted to be rated in accordance with this procedure.

A. This procedure provides a Condensation Resistance rating for windows, fully glazed doors, curtain wall systems, site-built products, sloped glazing systems, skylights, Dynamic Glazing Products, and other fenestration products.

i. Dynamic Glazing Products that utilize a shading system between glazing layers can only be rated for Condensation Resistance by using the test method specified in Section 5;

~~i.~~ii. Fenestration products containing fritted glazing, etched glazing, or sandblasted glazing shall be rated by computer simulation.

B. This procedure refers to the Condensation Resistance rating of a fenestration system installed vertically in the absence of solar and air leakage effects.

C. The Condensation Resistance rating is determined for a single set of environmental conditions. The Condensation Resistance value is a comparative rating that indicates a product's ability to resist the formation of condensation. Since the Condensation Resistance rating is a comparative rating, it may not be appropriate for the determination of the actual occurrence of condensation under a given set of environmental conditions.

2.2 Fenestration Products and Effects Not Covered by NFRC 500

The following products and effects are beyond the scope of NFRC 500 and shall not be rated in accordance with this procedure.

A. Fenestration products with shading or diffusing systems other than those listed in Section 2.1;

~~A.~~B. Exterior glazing condensation or between glazing layer condensation;~~.~~

~~B.~~C. Thermal performance changes of a fenestration product over the course of time, i.e., long term energy performance;~~.~~

~~C.~~D. The impact of air leakage and degradation in performance of fenestration products; and

~~D.~~E. Condensation Resistance of non-fully glazed doors and products with attachments.

3. TERMINOLOGY

Condensation Resistance (CR): a relative indicator of a fenestration product's ability to resist the formation of condensation at a specific set of environmental conditions. The higher the Condensation Resistance value the greater the resistance to the formation of condensation.

Center-of-glazing Condensation Resistance (CR_c): the Condensation Resistance for the central portion of the glazing (i.e., part of glazing where 1-D heat transfer effects dominate). The CR_c also includes divider and edge-of-divider portions of the product.

Condensation reference point temperature (t_{dpp}): the dew point temperature plus 0.3ºC (0.5ºF).

Dew point temperature (t_{dp}): temperature at which water vapor condenses to liquid water at a given relative humidity (RH).

Edge-of-glazing Condensation Resistance (CR_e): the Condensation Resistance for the edge portion of the glazing (i.e., part of glazing where 2-D heat transfer effects dominate).

Frame Condensation Resistance (CR_f): the Condensation Resistance for the frame portion of the fenestration product.

Product Condensation Resistance (CR): the lower of the CR_f, CR_c, and CR_e.

> [*Note 1*: The term 'CR' is being used as an abbreviation for Condensation Resistance for simplification purposes in equations and reference to specific terms, and shall only be used in its abbreviated form in this document and in test and simulation reports. The term 'CR' shall not be used as an acronym for the Condensation Resistance rating for certification and labeling purposes.]

4. SIMULATION METHOD FOR DETERMINING FENESTRATION PRODUCT CONDENSATION RESISTANCE VALUES

4.1 Significance and Use

A. This simulation method shall consist of 2-D heat transfer simulation of the same cross-sections used for U-Factor determination as specified by NFRC 100, or the latest applicable procedures.

B. Since both temperature and surface air film conditions affect results, this simulation method requires the use of standardized environmental conditions. The standardized NFRC simulation conditions for determining the Condensation Resistance of vertical fenestration systems are specified below.

   i. Interior ambient temperature of 21ºC (69.8ºF).

   ii. Exterior ambient temperature of –18ºC (-0.4ºF).

   iii. Relative humidities of 30 percent, 50 percent, and 70 percent RH providing condensation reference point temperatures of approximately 2.9ºC, 10.3ºC and 15.4ºC (37.3ºF, 50.6ºF and 59.8ºF)

   iv. Wind speed of 5.5 m/s (12.3 mph)

   v. Mean radiant temperature equal to the exterior ambient air temperature.

   [*Note 2*: The environmental simulation conditions stipulated above are for the purpose of comparative ratings between products.]

C. The Condensation Resistance of a specimen shall be determined at the sizes specified in Table 4-3 of NFRC 100.

D. This simulation method shall be used to determine the Condensation Resistance, provided the simulations have been validated under NFRC 100. If the product has been deemed a test only product under NFRC 100, Section 5 shall be used to determine the Condensation Resistance.

E. If any grouping has been done under NFRC 100 to simplify the number of individual products in a product line, the same grouping shall be used to simplify the number of individual products for Condensation Resistance.

4.2 Simulation Method

4.2.1 Product Simulation Requirements

The fenestration system shall be simulated in accordance with NFRC-approved software tools that include a detailed gray-body diffuse radiation model and detailed convection modeling inside all glazing cavities.

4.2.2 Determination of Surface Segments

For each 2-D cross-section, the developed boundary at the interior surface shall be subdivided into smaller segments, no larger than the size of mesh or grid used by the simulation program. These segments shall be used to compute the product of segment lengths and temperature difference used in the Condensation Resistance rating calculations. In addition, the total length for each 2-D cross-section shall be calculated.

4.2.3 Condensation Resistance Rating

The Condensation Resistance (CR) shall be determined for the total fenestration product from the lower of the Condensation Resistance rating for the frame (CR_f), edge-of-glazing (CR_e) and center-of-glazing (CR_c).

4.3 Condensation Resistance Calculations

The following section defines the method of calculating the Condensation Resistance from simulation data.

A. Determination of the resistance of the fenestration product to the formation of condensation in any form, referred to as the Condensation Resistance, shall be accomplished using the conditions listed in Section 4.1.B.

B. The Condensation Resistance using this procedure shall be determined using Equation 4-1, Equation 4-2 and Equation 4-3.

4.3.1 Determine Condensation Resistance of the Frame, CR_f

Temperatures of the frame sections shall be determined for each subdivided segment (see Section 0.05.2.1), as an average for that segment, using the approved 2-D simulation program. For each condensation reference point temperature, the product of each segment length and the temperature difference (t_{dpp}-t_f), shall be determined and summed for all positive values. This sum shall be divided by the product of total frame segment lengths, L_f and the difference between the condensation reference point temperature and the outside temperature (t_{dpp}-t_o) and calculated for the three relative humidities (i.e., condensation reference point temperatures) for each cross-section. The final CR_f for each relative humidity shall be calculated by area weighting these non-dimensional numbers for the whole frame area as given in Equation 4-1.

$$CR_f = \left\{ 1 - \left\{ \frac{\sum_k SS_{f_k} A_{f_k}}{A_f} \right\}^{1/3} \right\} \times 100$$

k=frame section

Equation 4-1

Where for each frame cross-section, k:

$$SS_{f_k} = \frac{\sum_j \left(S_f \right)_{j=RH\,@30\%,50\%,70\%}}{3}$$

Where for each relative humidity:

$$S_f = \frac{\sum_i \left(t_{dpp} - t_{f_i} \right)^{+} \Delta L_{f_i}}{\left(t_{dpp} - t_o \right) L_f}$$

i=subdivided element

$^{+}$*=positive values only*

4.3.2 Determine Condensation Resistance of the Glazing Portion, CR_c and CR_e.

The glazing Condensation Resistance shall be split into two components: the edge-of-glazing and the center-of-glazing. The center-of-glazing Condensation Resistance also includes the divider and edge-of-divider areas, if applicable.

4.3.2.1 Center-of-Glazing

Determine if the interior glass surface of the center-of-glazing area is above or below the three prescribed condensation reference point temperatures at 30% (j=1), 50% (j=2) and 70% (j=3) relative humidity. If the interior glass surface is at or below the condensation reference point temperature, use the entire center-of-glazing area for $A_{cog,j}$. If the interior glass surface temperature is above the condensation reference point temperature then use 0 for $A_{cog,j}$.

4.3.2.2 Dividers

True divided lites, simulated divided lites and between glass dividers are included in the center-of-glazing Condensation Resistance, CR_c. If the glazing system contains between glass dividers, and the space between the divider and glass is less than 3 mm (1/8 in.), divider and edge-of-divider values shall be calculated. Temperatures of the divider and edge-of-divider sections shall be determined for each subdivided segment (see Section 0.05.2.1), as an average for that segment, using the approved 2-D simulation program. For each condensation reference point temperature, the product of segment length, ΔL and the temperature difference (t_{dpp}-t_d) and (t_{dpp}-t_{deog}) shall be determined and summed for all positive values. This sum shall be divided by the product of the divider width, L_d or edge-of-divider width, L_{deog} (i.e., 63.5 mm [2.5 in.]) and difference between the condensation reference point temperature and the outside temperature (t_{dpp}-t_o). These calculated quantities shall be reported for the three relative humidities (i.e., condensation reference point temperatures) for each unique divider cross-section.

The final CR_c shall be calculated by area weighting these non-dimensional numbers for the center-of-glazing, divider, and edge-of-divider areas as given in Equation 4-2.

$$CR_c = \left\{ 1 - \left\{ \frac{\sum_k SS_{d_k} A_{d_k} + \sum_k SS_{deog_k} A_{deog_k} + \sum_k SS_{cog_k} A_{cog_k}}{\sum_k A_{d_k} + \sum_k A_{deog_k} + \sum_k A_{cog_k}} \right\}^{1/3} \right\} \times 100$$

Equation 4-2

k=center-of-glazing, divider, edge-of-divider sections, respectively

Where for each frame cross-section, k:

$$SS_{d_k} = \frac{\sum_j \left(S_d\right)_{j=RH@30\%,50\%,70\%}}{3}$$

$$SS_{doeg_k} = \frac{\sum_j \left(S_{deog}\right)_{j=RH@30\%,50\%,70\%}}{3}$$

$$SS_{cog_k} = \frac{\sum_j \left(S_{cog}\right)_{j=RH@30\%,50\%,70\%}}{3}$$

where for each relative humidity, j

$$S_d = \frac{\sum_i \left(t_{dpp} - t_{d_i}\right)^+ \cdot \Delta L_{d_i}}{\left(t_{dpp} - t_o\right) L_d}$$

i=subdivided element

+=positive values only

$$S_{deog} = \frac{\sum_i \left(t_{dpp} - t_{deog_i}\right)^+ \cdot \Delta L_{deog_i}}{\left(t_{dpp} - t_o\right) L_{deog}}$$

i=subdivided element

+=positive values only

$$S_{cog} = \frac{\sum_i \left(t_{dpp} - t_{cog_i}\right)^+}{\left(t_{dpp} - t_o\right)}$$

i=subdivided element

+=positive values only

4.3.2.3 Edge-of-Glazing

Temperatures of the edge-of-glazing sections shall be determined for each subdivided segment (see Section 0.05.2.1), as an average for that segment, using the approved 2-D simulation program. For each condensation reference point temperature, the product of segment length and temperature difference (t_{dpp}-t_{eog}) shall be determined and summed for all positive values. This sum shall be divided by the product of total edge-of-glazing length (i.e., 63.5 mm [2.5 in.]) and difference between the condensation reference point temperature and the outside temperature (t_{dpp}-t_o) and calculated for three relative humidities (i.e., condensation reference point temperatures) for each cross-section.

The final CR_e shall be calculated by area weighting these non-dimensional numbers for the edge-of-glazing areas as given in Equation 4-3.

$$CR_e = \left\{ 1 - \left\{ \frac{\sum_k SS_{eog_k} A_{eog_k}}{\sum_k A_{eog_k}} \right\}^{1/3} \right\} \times 100 \qquad \text{Equation 4-3}$$

k=edge-of-glazing sections, respectively

Where for each cross-section, k:

$$SS_{eog_k} = \frac{\sum_j \left(S_{eog}\right)_{j=RH@30\%,50\%,70\%}}{3}$$

where for each relative humidity, j

$$S_{eog} = \frac{\sum_i \left(t_{dpp} - t_{eog_i}\right)^{+} \cdot \Delta L_{eog_i}}{\left(t_{dpp} - t_o\right) L_{eog}}$$

i=subdivided element

+=positive values only

4.3.3 Determine Condensation Resistance of the Total Product, CR.

Condensation Resistance = Lower of the CR_f, CR_c, and CR_e

4.3.4 Condensation Resistance Variables

t_{dp} = Dew point temperatures at the given relative humidity (RH);

$t_{dp,1}$	=	2.9ºC (37.3ºF)	@ RH = 30%
$t_{dp,2}$	=	10.3ºC (50.6ºF)	@ RH = 50%
$t_{dp,3}$	=	15.4ºC (59.8ºF)	@ RH = 70%

t_{dpp} = condensation reference point temperatures

t_{dpp}	=	t_{dp}+0.3ºC ($t_{dpp} = t_{dp}$+0.5ºF)
$t_{dpp,1}$	=	3.2ºC (37.8ºF)
$t_{dpp,2}$	=	10.6ºC (51.1ºF)
$t_{dpp,3}$		15.7ºC (60.3ºF)

t_o = exterior ambient temperature –18ºC(0ºF)

t_{fi} = average temperature of the frame segments i, subdivided as per Section 0.05.2.1

t_{eogi} = average temperature of the edge-of-glazing segments i, subdivided as per Section 0.05.2.1

t_{cogi} = average temperature of the center-of-glazing area i

t_{deogi} = average temperature of the edge-of-divider area i

t_{di} = average temperature of the divider area i

ΔL_{fi} = length of subdivided segments on each modeled frame cross-section

ΔL_{eogi} = length of subdivided segments on each modeled edge-of-glazing cross-section

ΔL_{deogi} = length of subdivided segments on each modeled edge-of-divider cross-section

ΔL_{di} = length of subdivided segments on each modeled divider cross-section

L_f = total (wetted) length of each modeled frame cross-section

L_{eog} = total length of each modeled edge-of-glazing cross-section

L_{deog} = total length of each modeled edge-of-divider cross-section

L_d = total length of each modeled divider cross-section

A_{cogk} = center-of-glazing area of section, k

A_{fk} = projected frame area of each modeled section on the interior surface

A_{eogk} = edge-of-glazing area of each modeled cross-section on the interior surface

A_{cogk} = center-of-glazing area of each modeled center-of-glazing section on the interior surface

A_{dk} = divider area of each modeled divider cross-section on the interior surface

A_{deogk} = edge-of-divider area of each modeled divider section on the interior surface

A_f = Total projected area of the frame on the interior surface

i = Index denoting divided sub-segments on indoor boundary

j = Index denoting relative humidity considered

j = 1; RH=30%

j = 2; RH=50%

j = 3; RH=70%

k = Index denoting edge-of-glazing, frame (i.e. jamb, sill, head, meeting rail, etc.), or center-of-glazing sections

CR_f = Condensation Resistance of the frame

CR_c = Condensation Resistance of the center-of-glazing area, including divider and edge-of-divider

CR_e = Condensation Resistance of the edge-of-glazing area

CR = Condensation Resistance of the specimen

4.4 Simulation Report

The simulation report shall include all of the information specified in the NFRC LAP and subsequent NFRC LAP Bulletins.

The report shall include the total product Condensation Resistance rating value, CR.

The following statement shall be included in the simulation report directly after the above results are reported:

The Condensation Resistance results obtained from this procedure are for controlled laboratory conditions and do not include the effects of air movement through the specimen, solar radiation, and the thermal bridging that may occur due to the specific design and construction of the fenestration system opening.

5. Test Method for Determining Fenestration Product Condensation Resistance Values

5.1 Significance and Use

A. This test method references the calibration and testing procedures as defined in the NFRC 102 and necessary additional temperature instrumentation required for the NFRC test procedure to measure the Condensation Resistance of vertical fenestration systems.

B. Since both temperature and surface air film conditions affect results, this test method requires the use of standardized environmental conditions. The test conditions for the NFRC test procedure to measure Condensation Resistance shall be identical to those used in the NFRC 102.

C. This test method does not include procedures to measure the Condensation Resistance due to either air movement through the test specimen or solar radiation effects.

D. The Condensation Resistance of a test specimen may be affected by its size and three-dimensional geometry. If the test specimen size is non-standard [± 12.7 mm (0.5 in)] in width and/or height from the model size referenced in Table 4-3 of NFRC 100, then the text "non-standard size" shall be indicated in the final report as per Section 5.4.

E. This test method shall only be used when the product cannot have the Condensation Resistance simulated using an NFRC Condensation Resistance Simulation Method per Section 4 of this procedure.

5.2 Test Method

5.2.1 Test Specimen Testing Requirements

The fenestration system shall be tested in accordance with Section 6 of the NFRC 102 with the additional thermocouples applied to the interior surface of the product as defined in Appendix B of this procedure.

5.2.2 Determination of Total Exposed Surface Area

The fenestration total wetted surface area shall be used. The wetted surface area shall be the same as that used in NFRC 102.

5.2.3 Temperature Measurement

The fenestration system ~~is~~ shall be instrumented in accordance with Section 6 of NFRC 102.

A. All measurements specified in NFRC 102 shall be made.

B. The attachment of thermocouples shall be performed using a nominal 25 mm wide by 100 mm long (4 in. by 1 in.) adhesive-backed aluminum foil tape, with a surface emittance equal to that of the base surface (± 0.1). The 100 mm (4 in.) dimension parallel to the thermocouple wire.

~~B.~~C. For Dynamic Glazing Products that utilize a shading or diffusing system, thermocouples shall be applied to the most indoor glazing surface. They shall not be applied to any shade or blind component which may be present on the indoor side of the product.

5.3 Test Procedure Calculations

General Calculations

This section defines the method of calculating the Condensation Resistance from test data.

A. Determination of the resistance of the fenestration product to the formation of condensation in any form, referred to as the Condensation Resistance, shall be accomplished using the conditions listed in Section 5.1.B.

B. The Condensation Resistance using this procedure shall be determined as follows.

i. Record interior surface temperature for each individual thermocouple location.

ii. Calculate the wetted area assigned to each individual surface thermocouple sensor.

iii. Calculate the total interior wetted area of frame and glazing.

iv. Determine Condensation Resistance of the frame, CR_f, center-of-glazing, CR_c, and of the edge-of-glazing, CR_e, using Equation 5-1, Equation 5-2 and Equation 5-3:

$$CR_f = \left\{ 1 - \left\{ \frac{\sum_{j=1}^{3} \left[\frac{\sum_i \left(t_{dpp,j} - t_{f_i} \right)^+ \cdot A_{f_i}}{\left(t_{dpp,j} - t_o \right) A_f} \right]_{j=RH@30\%,50\%,70\%}}{3} \right\}^{1/3} \right\} \times 100 \qquad \text{Equation 5-1}$$

i=frame thermocouples

$$CR_e = \left\{ 1 - \left\{ \frac{\sum_{j=1}^{3} \left[\frac{\sum_i \left(t_{dpp,j} - t_{eog_i} \right)^{+} \cdot A_{eog_i}}{\left(t_{dpp,j} - t_o \right) A_{eog}} \right]_{j=RH@30\%,50\%,70\%}}{3} \right\}^{1/3} \right\} \times 100$$

Equation 5-2

i=center-of-glazing, divider and edge-of-divider thermocouples

$$CR_e = \left\{ 1 - \left\{ \frac{\sum_{j=1}^{3} \left[\frac{\sum_i \left(t_{dpp,j} - t_{eog_i} \right)^{+} \cdot A_{eog_i}}{\left(t_{dpp,j} - t_o \right) A_{eog}} \right]_{j=RH@30\%,50\%,70\%}}{3} \right\}^{1/3} \right\} \times 100$$

Equation 5-3

i= edge-of-glazing thermocouples

5.3.1 Determine Condensation Resistance of the Total Product, CR.

Condensation Resistance = Lower of the CR_f, CR_c, and CR_e

5.3.2 Condensation Resistance Variables

$t_{dp,jv}$ = Dew point temperatures at the given relative humidity (RH);

- $t_{dp,1}$ = 2.9ºC (37.3ºF) @ RH = 30%
- $t_{dp,2}$ = 10.3ºC (50.6ºF) @ RH = 50%
- $t_{dp,3}$ = 15.4ºC (59.8ºF) @ RH = 70%

$t_{dpp,j}$ = condensation reference point temperatures

- t_{dpp} = t_{dp}+0.3ºC (t_{dpp} = t_{dp}+0.5ºF)
- $t_{dpp,1}$ = 3.2ºC (37.8ºF)
- $t_{dpp,2}$ = 10.6ºC (51.1ºF)
- $t_{dpp,3}$ = 15.7ºC (60.3ºF)

t_o = exterior ambient temperature [-18ºC (-0.4ºF)]

t_{fi} = individual frame thermocouple temperatures.

t_{gi} = individual glazing (center-of-glazing, divider, and edge-of-divider) thermocouple temperatures.

t_{eogi}	=	individual edge-of-glazing thermocouple temperatures.
A_{fi}	=	wetted interior area represented by the frame thermocouples
A_{ci}	=	interior area represented by the central part of glazing (i.e., center-of-glazing, divider, and edge-of-divider) thermocouples
A_{eogi}	=	interior area represented by the edge-of-glazing thermocouples
A_f	=	Total (wetted) area of the frame on the interior surface
A_c	=	Total area of the central part of glazing (i.e., center-of-glazing, divider, and edge-of-divider) on the interior surface
A_{eog}	=	Total area of the edge-of-glazing on the interior surface
i	=	Index denoting frame, or glazing thermocouple section
j	=	Index denoting relative humidity considered j = 1; RH=30% j = 2; RH=50% j = 3; RH=70%
CR_f	=	Condensation Resistance of the frame
CR_c	=	Condensation Resistance of the center-of-glazing area, including divider and edge-of-divider
CR_e	=	Condensation Resistance of the edge-of-glazing area
CR	=	Condensation Resistance of the Specimen

5.4 Test Report

The report shall include all of the information specified in NFRC 102, and the NFRC LAP and subsequent NFRC LAP Bulletins. The test specimen size and design shall also be reported. If the test specimen size is non-standard [± 12.7 mm (0.5 in.)] in width and/or height from the model size referenced in Table 4-3 of NFRC 100, then the text "non-standard size" shall be inserted immediately following the size everywhere the size is listed, both in the full report and in any summary.

The report shall include the total product Condensation Resistance rating value, CR; the frame Condensation Resistance, CR_f; the center-of-glazing Condensation Resistance, CR_c and the edge-of-glazing Condensation Resistance, CR_e, as determined using this test procedure. In addition, the report shall include, if applicable, information required in the Section 9 of NFRC 102.

The following statement shall be included in the test report directly after the above results are reported:

> The Condensation Resistance results obtained from this procedure are for controlled laboratory conditions and do not include the effects of air movement through the specimen, solar radiation, and the thermal bridging that may occur due to the specific design and construction of the fenestration system opening.

6. Referenced Documents

6.1 NFRC Documents

NFRC 100-2010	Procedures for Determining Fenestration Product U-Factors.
NFRC 102-2010	Procedure for Measuring the Steady-State Thermal Transmittance of Fenestration Systems

6.2 ASTM Standards

C 1199	Standard Test Method for Measuring the Steady State Thermal Transmittance of Fenestration Systems Using Hot Box Methods
C 1363	Standard Method of Test for the Thermal Performance of Building Assemblies by Means of a Hot Box Apparatus
E 1423	Standard Practice for Determining the Steady-State Thermal Transmittance of Fenestration Systems

Appendix A Background on the NFRC Condensation Resistance Rating

Reducing or eliminating condensation is one of many fenestration product selection criteria, but an especially important one in cold climates. In addition to the aesthetic issue of reduced visibility or window view, condensation can cause damage to curtains, carpets and wall finishes, cause mold and wood rot, lift paint and plaster, and eventually result in damage to building materials. Water contact with insulating glass sealant may result in premature failure of the edge seals.

The formation of condensation on the interior surfaces of fenestration products is dependent on a number of factors including the outdoor temperature, and the relative humidity inside the building. As the outside temperature falls, the indoor surface temperature of the fenestration product may fall below the interior dew point temperature. The interior dew point temperature is a function of the relative humidity of the interior air; such that, the higher the relative humidity the higher the dew point temperature. This means that with the same fenestration product surface temperature conditions, condensation will occur sooner in a space with a higher indoor relative humidity. Measured winter relative humidity levels in buildings vary between 20 and 70 percent.

The NFRC Condensation Resistance scale is 1-100, with a higher number being better. The Condensation Resistance rating is determined based on outside conditions of -18ºC (-0.4ºF) with a 5.5 m/s (12.3 mph) wind and inside conditions of 21ºC (69.8ºF) with indoor relative humidities of 30 percent, 50 percent, and 70 percent. The Condensation Resistance rating is a value that considers the relative area of condensation at the three humidities and the degree to which the surface temperatures are below the dew point for the frame and for the glazing. The Condensation Resistance rating specified in the NFRC rating is based on the lower of the frame, edge-of-glazing or center-of-glazing values.

The Condensation Resistance rating is determined for very specific conditions. When installed in a building, there are numerous uncontrolled, site specific factors that may affect the condensation formation on the fenestration product, including installation details, site geometry, wind speed and direction, air circulation and fenestration product coverings, to name a few. In this procedure, the Condensation Resistance rating is meant to apply only to interior fenestration product surfaces under cold winter conditions. The procedure does not address the issue of condensation on the exterior fenestration product surface as can occur during seasons other than winter.

APPENDIX B PREDETERMINED TEMPERATURE MEASUREMENT LOCATIONS

This appendix indicates the correct placement of thermocouples when testing for Condensation Resistance rating in accordance with Section 5. All thermocouples intended to measure center-of-glazing temperature shall be placed at the center-of-glazing of each unit in the fenestration product. All thermocouples intended to measure edge-of-glazing temperature shall be placed 12.7 mm (0.5 in.) from the sightline of the frame along the centerline of the fenestration product. All thermocouples intended to measure frame temperatures shall be placed along the centerline of the fenestration product at a location that will be representative of the area weighted average temperature of the frame segment represented by the thermocouple. There are many different kinds of fenestration products covered by this procedure, including many different frame materials and designs. The exact placement of frame thermocouples will require the operator to make some judgment in the position of the thermocouples.

Figure 6-1 Casement and Awning Thermocouple Placement
(Awning - rotate 90 degrees)

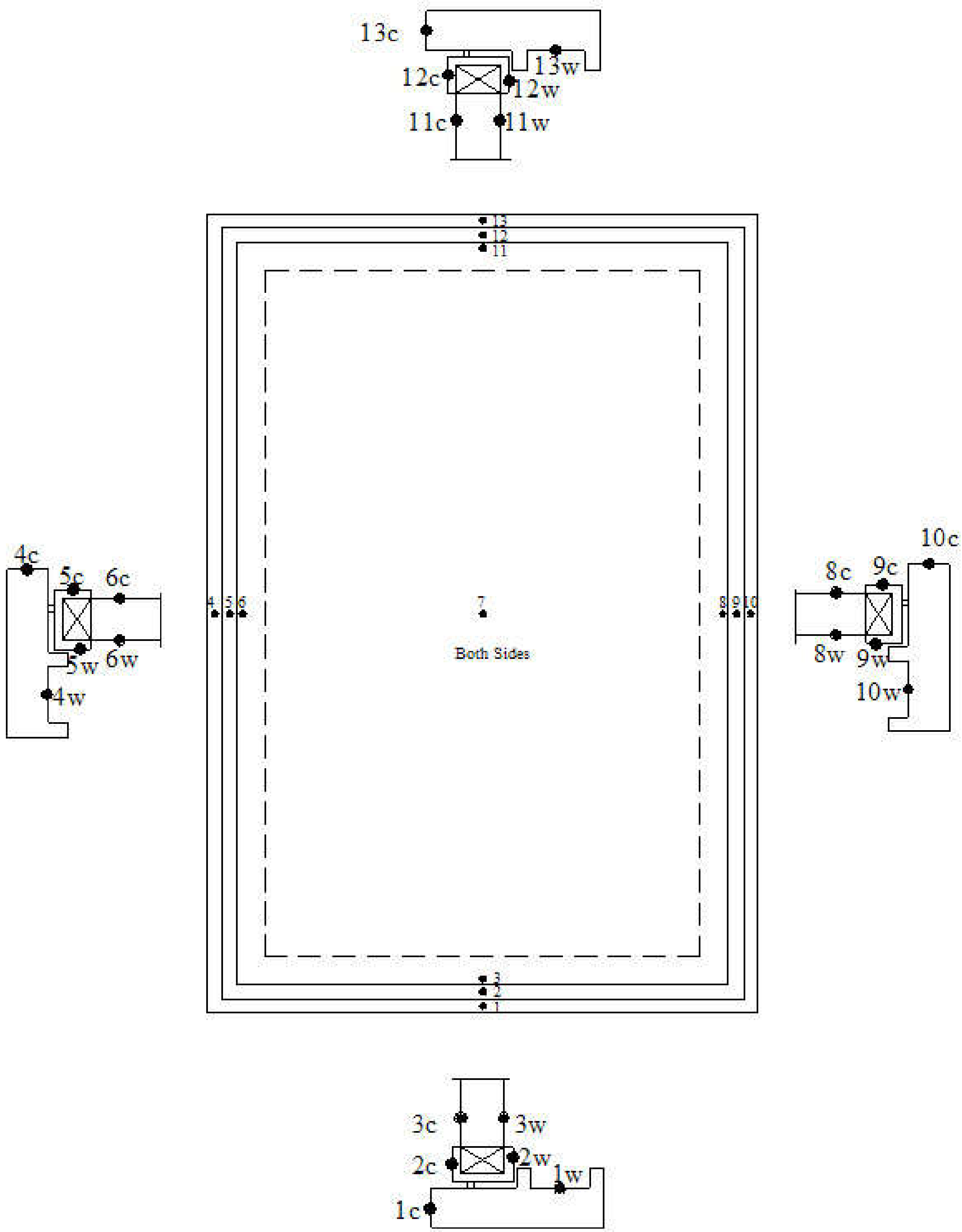


Figure 6-2 Fixed Window, Sidelite, and Transom Thermocouple Placement

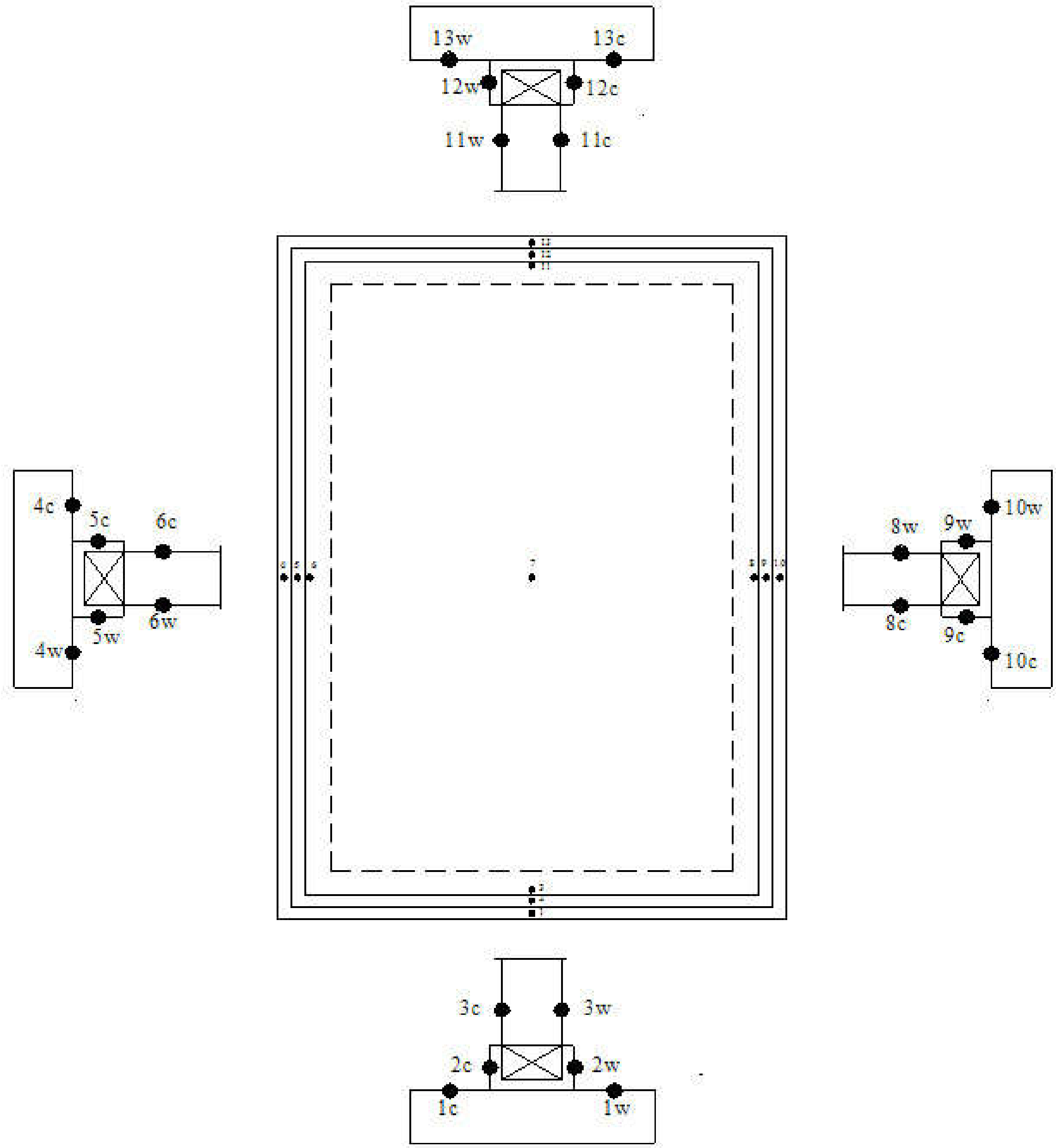


Figure 6-3 Swinging Patio Door Thermocouple Placement

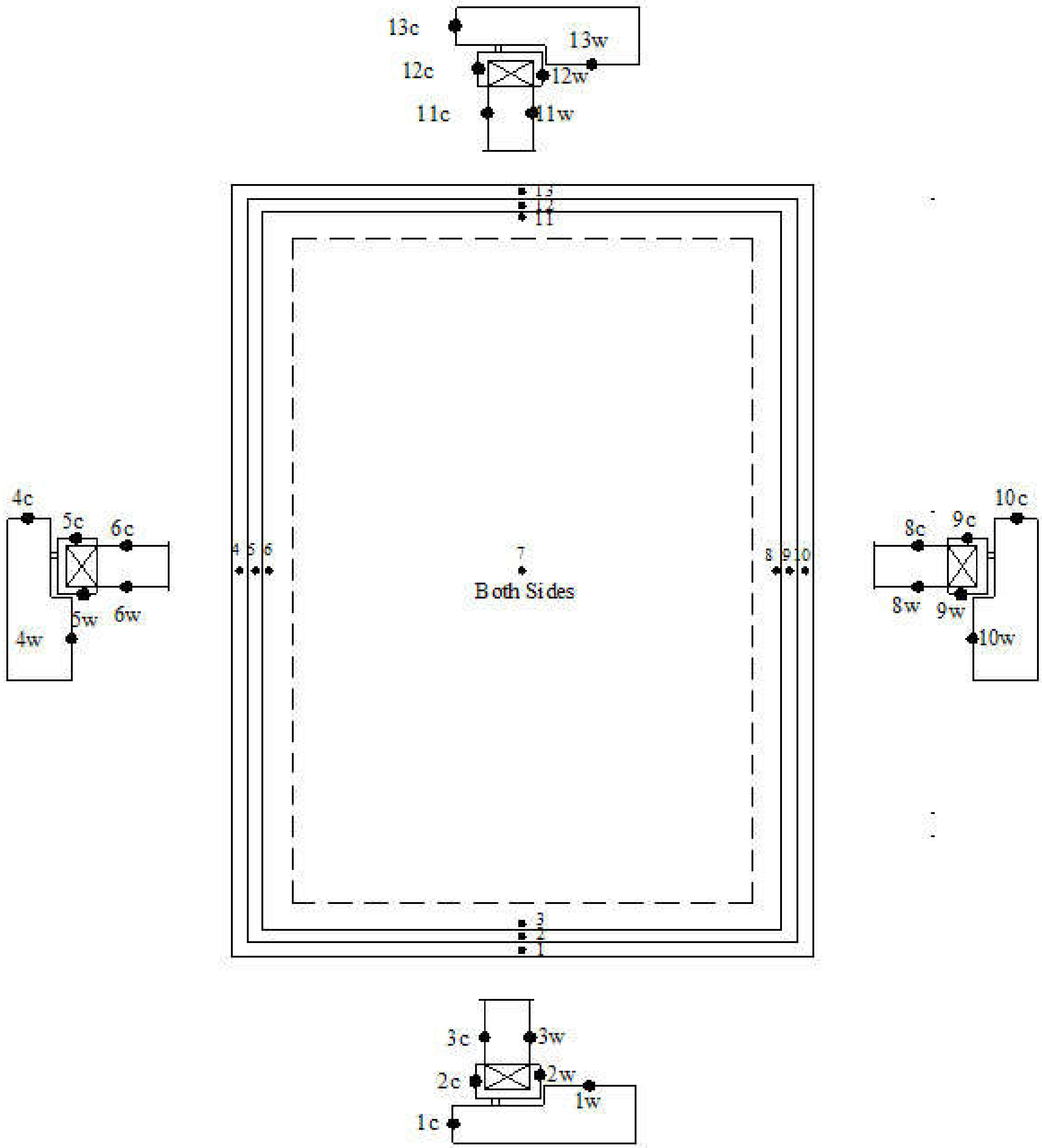


Figure 6-4 Horizontal Slider, Vertical Slider, and Sliding Patio Door Thermocouple Placement (Vertical Slider – rotate 90 degrees)

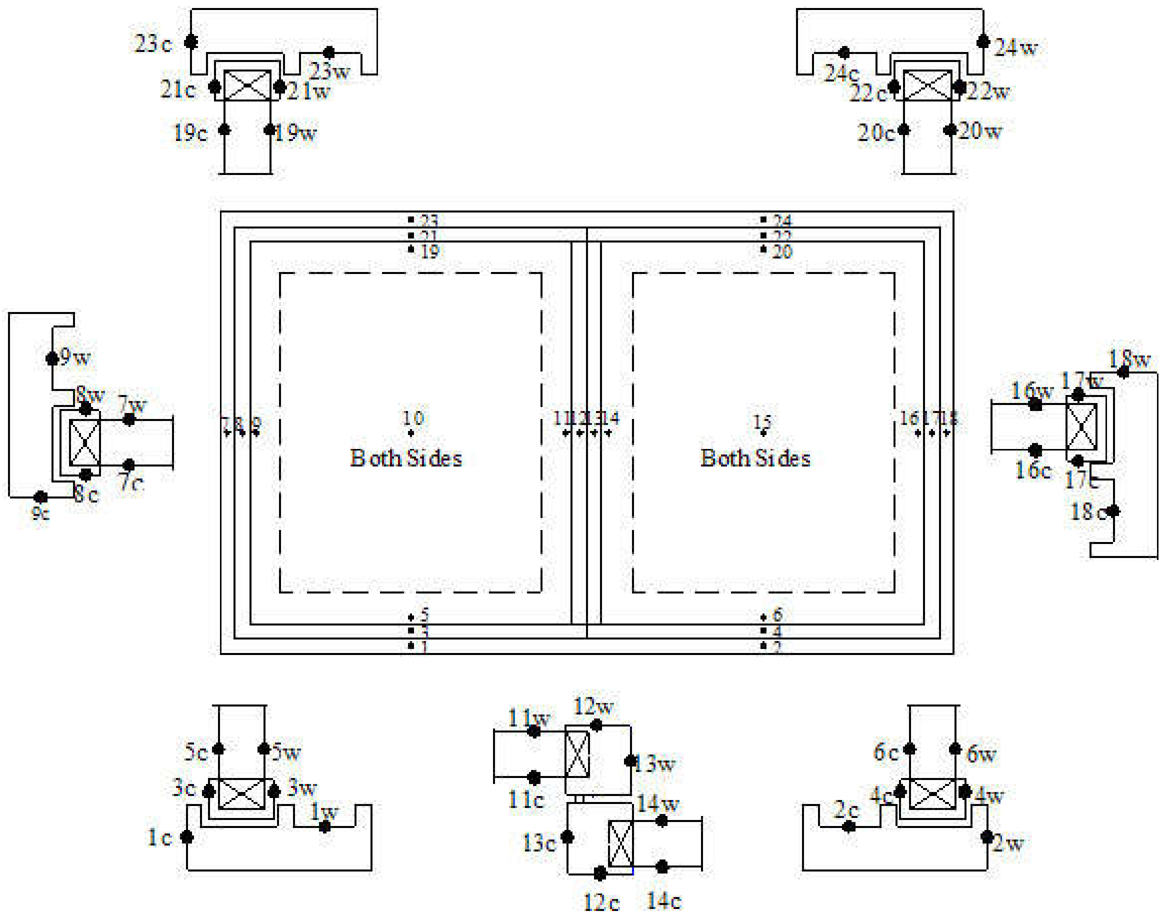


Figure 6-5 Glazed Wall and Sloped Glazing Thermocouple Placement

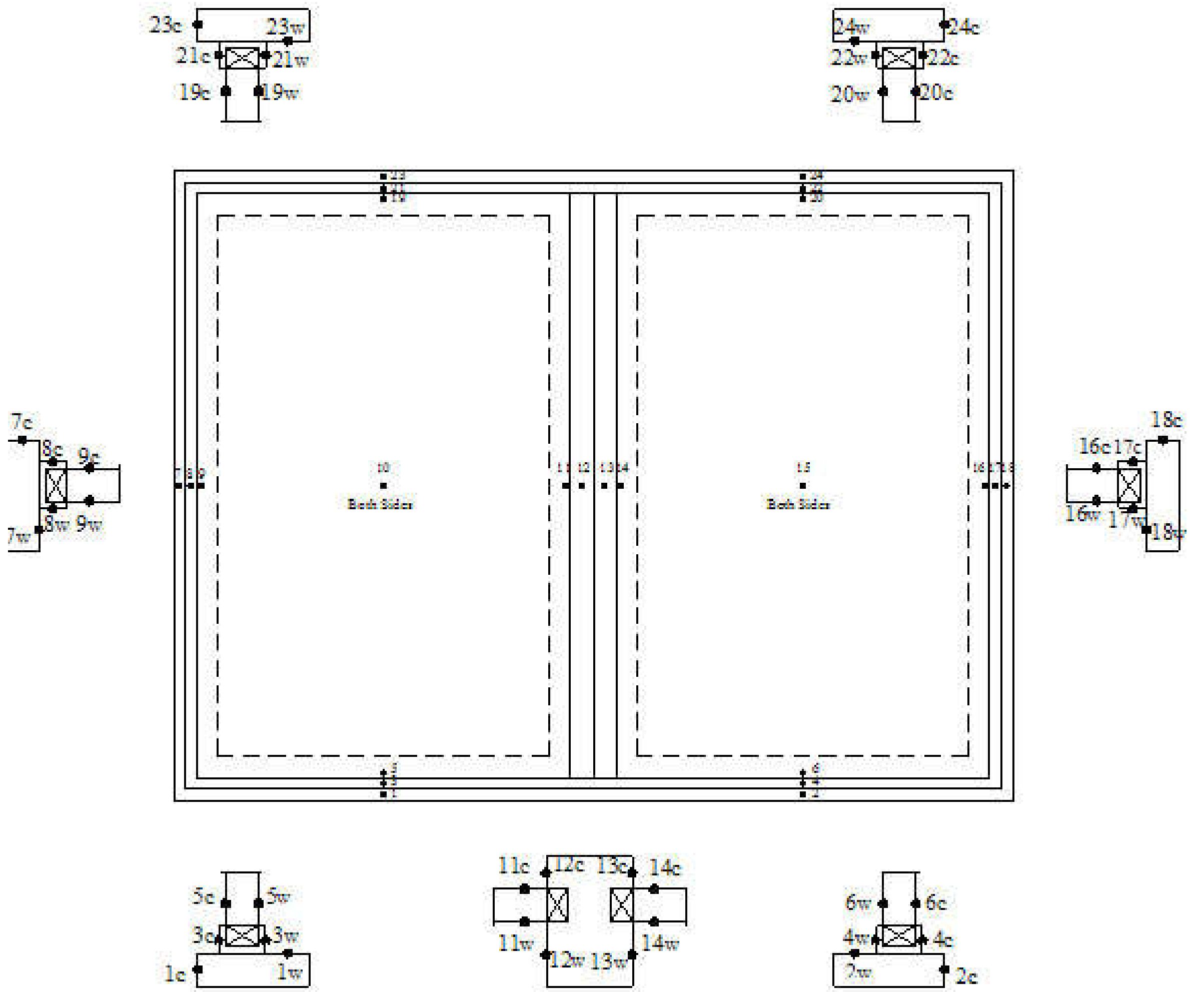
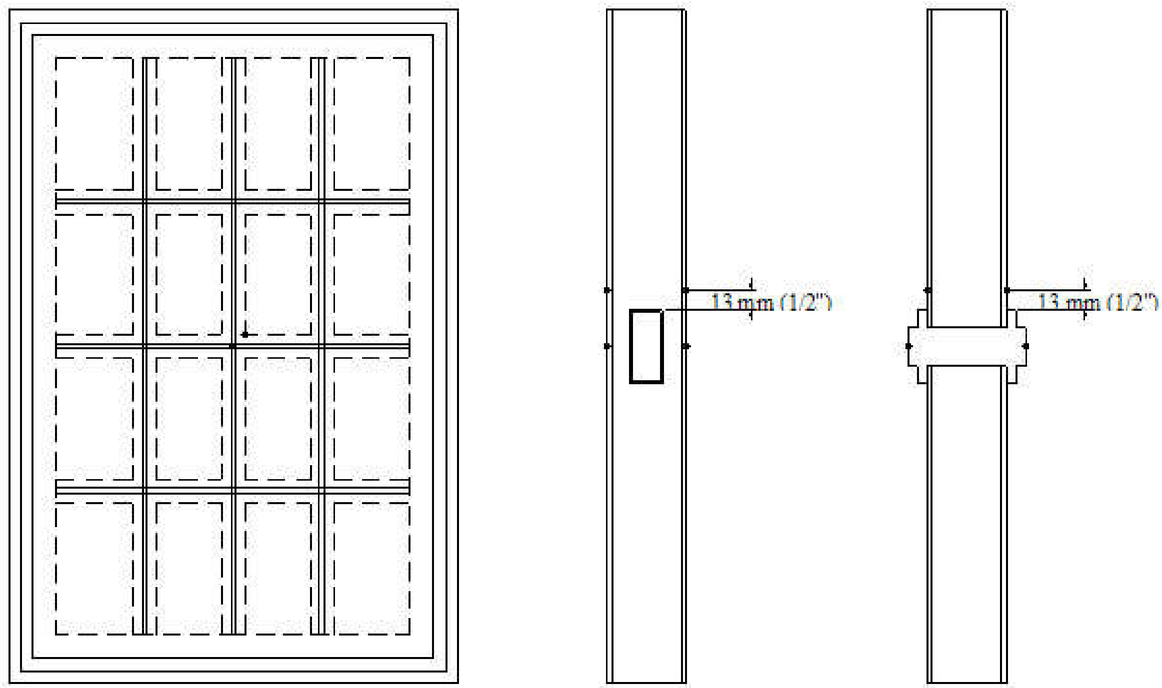


Figure 6-6 Divider Thermocouple Placement



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