

New Test Method

ASTM Cxxxx

Second Draft

October 21, 2003

STANDARD TEST PROCEDURE AND COMPUTER MODELING METHOD TO
DETERMINE THE CONDENSATION RESISTANCE OF FENESTRATION PRODUCTS

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This method is under jurisdiction of ASTM committee C-16 on Thermal Insulation and is the direct responsibility of Subcommittee C16.30 on Thermal Measurements

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1 SCOPE

- 1.1 This standard test method provides requirements and guidelines required for the determination of Condensation Resistance of fenestration systems installed vertically.
- 1.2 The test part of this standard method provides requirements and guidelines, and specifies calibration procedures required for the measurement of the Condensation Resistance. The standard specifies the necessary measurements to be made using measurement systems conforming to the ASTM Test Procedure C1199-97 for determination of fenestration system thermal transmittance.
- 1.3 The computer modeling part of this standard method provides requirements and guidelines for determining the Condensation Resistance using software tools.
- 1.4 This procedure is limited to evaluating and rating the Condensation Resistance of, where applicable, residential and commercial windows, doors, curtain wall systems, site-built products, skylights and other related fenestration products.
- 1.5 This standard method refers to the Condensation Resistance, CI, of a fenestration system in the absence of solar and air leakage effects.
- 1.6 This standard method does not cover the following:
 - 1.6.1 Exterior glazing condensation or between glazing layer condensation
 - 1.6.2 Thermal performance changes of a fenestration product over the course of time, i.e., long term energy performance
 - 1.6.3 The impact of air leakage and degradation in performance of fenestration products
 - 1.6.4 Condensation Resistance of products with attachments
- 1.7 The Condensation Resistance is determined for a single set of environmental conditions. Based on the comparative rating of the CR value, the potential for evaluating condensation formation on the interior surfaces of a product under other environmental conditions (ambient temperature conditions and indoor relative humidity) can be assessed.

2 REFERENCED DOCUMENTS

- 2.1 ASTM Standards:
 - C 1199 Standard Test Method for Measuring the Steady State Thermal Transmittance of Fenestration Systems Using Hot Box Methods
 - C 1363 Method of Test for the Thermal Performance of Building Assemblies by Means of a Hot Box Apparatus
- 2.2 Other:
 - NFRC Test Procedure for Measuring the Steady-State Thermal Transmittance of

Fenestration Systems (April 1997)

NFRC 100: Procedures for Determining Fenestration Product U-factors (April 1997)

NFRC 500: Procedure for Determining Fenestration Product Condensation Resistance Values (April 1997)

AAMA 1503-98 Voluntary Test Method for Thermal Transmittance and Condensation Resistance of Windows, Doors and Glazed Wall Sections

ASHRAE SPC142P “Standard Method for Determining and Expressing the Heat Transfer and Total Optical Properties of Fenestration Products”. American Society for Heating Refrigerating and Air-Conditioning Engineers, Inc. Draft Standard.

ISO 15099 “Thermal Performance of Windows, Doors and Shading Devices — Detailed Calculations”. International Organization for Standardization.

3 TERMINOLOGY

3.1 *Definitions* – For definitions of terms and symbols used in this test method, refer to Terminology in C1199-97, and C1363 and the following subsections.

3.1.1 **Condensation Resistance (CR):** is a relative indicator of a fenestration product's ability to resist the formation of condensation. The higher the CR value the greater the resistance to the formation of condensation.

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

3.1.3 **Glazing Condensation Resistance (CR_g):** the Condensation Resistance for the glazing portion of the fenestration product.

3.1.4 **Product Condensation Resistance (CR):** the lower of the CR_f and the CR_g.

3.2 *Symbols and Units* -- 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.

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

$t_{dp,1} = 2.9^{\circ}\text{C} (37.3^{\circ}\text{F})$ @ RH = 30%

$t_{dp,2} = 10.3^{\circ}\text{C} (50.6^{\circ}\text{F})$ @ RH = 50%

$t_{dp,3} = 15.4^{\circ}\text{C} (59.8^{\circ}\text{F})$ @ RH = 70%

t_{dpp} = Dew point temperatures corrected by adding 0.3°C (0.5°F), $t_{dpp} = t_{dp} + 0.3^{\circ}\text{C}$ ($t_{dpp} = t_{dp} + 0.5^{\circ}\text{F}$)

$t_{dpp,1} = 3.2^{\circ}\text{C} (37.8^{\circ}\text{F})$

$t_{dpp,2} = 10.6^{\circ}\text{C} (51.1^{\circ}\text{F})$

$t_{dpp,3} = 15.7^{\circ}\text{C} (60.3^{\circ}\text{F})$

t_{f_i} = average temperature of the frame segments, subdivided as per 4.2.2,

t_{eog_i} = average temperature of the edge-of-glass segments, subdivided as per 4.2.2,

t_{cog} = average temperature of the center-of-glass area
 t_{g_i} = individual glazing (center-of-glass plus edge-of-glass) thermocouple temperatures.
 ΔL_{f_i} = length of subdivided segments on each modeled frame cross-section
 ΔL_{eog_i} = length of subdivided segments on each modeled edge-of-glass cross-section
 L_{f_i} = total (wetted) length of each modeled frame cross-section i ,
 L_{eog_i} = total length of each modeled edge-of-glass cross-section i ,
 A_{cog} = total center-of-glass area,
 A_{f_k} = projected frame area of each modeled section on the interior surface
 A_{eog_k} = edge-of-glass area of each modeled cross-section on the interior surface
 A_{d_k} = divider area of each modeled divider cross-section on the interior surface
 A_{deog_k} = divider-edge area of each modeled divider section on the interior surface
 A_f = Total projected area of the frame on the interior surface
 A_g = Total area of the glazing (center-of-glass plus edge-of-glass plus divider and divider-edge areas) 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-glass or frame sections (i.e. jamb, sill, head, meeting rail, etc.)
 CI_f = Condensation Resistance of the frame
 CI_g = Condensation Resistance of the glazing, including edge, divider, and divider-edge
 CR = Condensation Resistance of the Specimen

4 SIGNIFICANCE AND USE

- 4.1 This standard method specifies the procedure to determine Condensation Resistance (CR) at standard conditions for the whole fenestration product.
- 4.2 This standard details both simulation and testing procedures for determining CI.
- 4.3 The primary method for determining CR is simulation method.
- 4.4 The validation of simulation results is done through the comparison of simulated and measured U-factors. If the results agree to within 10%, the simulation result is considered validated for both U-factors and CI.
- 4.5 For products, which do not validate, testing procedure specified in chapter 5 is used.

- 4.6 The test method references the calibration and testing procedures as defined in ASTM C1199, and necessary additional temperature instrumentation required in order to apply Test Procedure to measure the Condensation Resistance of vertical fenestration systems.
- 4.7 Since both temperature and surface air film conditions affect results, use of recommended conditions will assist in reducing confusion caused by comparing results of tests performed under dissimilar conditions. **Standardized test conditions** for determining the Condensation Index for rating purposes of fenestration systems are specified below.
- 4.7.1 Interior ambient temperature of 21.1 °C (± 0.25 °C), 70 °F (± 0.5 °F).
- 4.7.2 Exterior ambient temperature of -17.8 °C ± 0.25 °C), 0 °F (± 0.5 °F).
- 4.7.3 The test sample shall not exhibit any form of condensation on its surfaces during testing.
- 4.7.4 An interior measured film coefficient during CTS panel calibration testing of 8.29 W/m²C (1.35 Btu/hr-ft²-F) ($\pm 5\%$).
- 4.7.5 An exterior measured film coefficient during CTS panel calibration testing of 28.97 W/m²C (5.1 Btu/hr-ft²-F) ($\pm 10\%$).

Note: The environmental test conditions stipulated above are for the purpose of comparative ratings between products. This test method may be used at different ambient temperature conditions for the purpose of determining a Condensation Resistance for specified climatic conditions other than those stipulated above.

- 4.8 The Condensation Resistance of a test specimen may be affected by its size and three-dimensional geometry. Therefore, it is recommended that fenestration systems be tested at standard sizes (i.e., as specified in the NFRC 100).
- 4.9 This simulation method shall consist of 2-D heat transfer simulation of the same cross-sections used for U-factor determination.
- 4.10 Since both temperature and surface air film conditions affect results, this test procedure requires the use of standardized environmental conditions. The standardized test conditions for determining the Condensation Resistance of vertical fenestration systems are specified below.
- 4.10.1 Interior ambient temperature of 21°C (70°F).
- 4.10.2 Exterior ambient temperature of -18°C (0°F).
- 4.10.3 Relative Humidities of 30%, 50%, and 70% RH providing dew point temperatures of approximately 2.9°C (37.3°F), 10.3°C (50.6°F) and 15.4°C (59.8°F)
- 4.10.4 Wind speed of 7 m/s (15 mph)
- 4.10.5 Sky condition of 100% cloud cover

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

5 SIMULATION METHOD

- 5.1 **Product Simulation Requirements:** The fenestration system is to be simulated in accordance with a software tool that includes a detailed gray-body diffuse radiation model and detailed convection modeling inside all glazing cavities.
- 5.2 **Determination of Surface Segments:** The total exposed surface area shall not be calculated for the simulation procedure. Instead, for each 2-D cross-section, the indoor surface needs to be subdivided into smaller segments, no larger than the size of mesh or grid used by the simulation program. These segments will 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.
- 5.3 **Condensation Resistance rating:** The Condensation Resistance (CR) shall be determined for the total fenestration product from the lower of the condensation indices for the frame, CI_f , and glazing, CI_g .
- 5.4 **Condensation Resistance Calculations:** The following section defines the method of calculating the Condensation Resistance from simulation data.
- 5.4.1 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 criteria listed in Section 4.10.
- 5.4.2 The Condensation Resistance using this procedure shall be determined as follows (see also Equations 1 and 2).
- 5.5 **Determine Condensation Resistance of the frame, CI_f :** Temperatures of the frame sections shall be determined for each subdivided segment (see Section 4.2.2), as an average for that segment, using the approved 2-D simulation program. For each dew 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 and the difference between the corrected dewpoint temperature and the outside temperature ($t_{dpp}-t_o$) and calculated for the three relative humidities (i.e., dew point temperatures) for each cross-section. The final CI_f for each relative humidity shall be calculated by area weighting these non-dimensional numbers for the whole frame area as given in Equation 1.

$$CI_f = \left\{ 1 - \left\{ \frac{\sum_k SS_{f_k} * A_{f_k}}{A_f} \right\}^{1/3} \right\} * 100 \quad (1)$$

$k = \text{frame section}$

where for each frame cross-section, k :

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

where for each relative humidity:

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

$i =$ subdivided element

$^+ =$ positive values only

5.6 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-glass and the center-of-glass. The center-of-glass Condensation Resistance also includes the divider and divider-edge areas, if applicable.

5.6.1 **Center-of-Glass:** Determine if the interior glass surface of the center-of-glass 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-glass area for $A_{cog,j}$. If the interior glass surface temperature is above the condensation reference point temperature then use 0 for $A_{cog,j}$.

5.6.1.1 **Dividers:** True divided lites, simulated divided lites and between glass dividers are included in the center-of-glass 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 divider-edge values shall be calculated. Temperatures of the divider and divider-edge sections shall be determined for each subdivided segment (see Section 5.2), as an average for that segment. 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 divider-edge 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.

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

$$CR_c = \left\{ 1 - \left\{ \frac{\sum_k SS_{d_k} * A_{d_k} + \sum_k SS_{deog_k} * A_{deog_k} + \sum_k SS_{cog_k} * A_{cog_k}}{\sum_k A_{d_k} + \sum_k A_{deog_k} + \sum_k A_{cog_k}} \right\}^{1/3} \right\} * 100 \quad (2)$$

$k =$ center – of – glass, divider, divider – edge sections, respectively

where for each cross-section, k :

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

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

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

where for each relative humidity, j :

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

$i =$ subdivided element

$^+ =$ positive values only

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

$i =$ subdivided element

$^+ =$ positive values only

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

$i =$ subdivided element

$^+ =$ positive values only

- 5.6.2 **Edge-of-Glass:** Temperatures of the edge-of-glass sections shall be determined for each subdivided segment (see Section 5.2), 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-glass 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.
- 5.6.3 The final CR_e shall be calculated by area weighting these non-dimensional numbers for the edge-of-glass areas as given in Equation 3.

$$CR_e = \left\{ 1 - \left\{ \frac{\sum_k SS_{eog_k} * A_{eog_k}}{\sum_k A_{eog_k}} \right\}^{1/3} \right\} * 100 \quad (3)$$

k = edge – of – glass sections, respectively

where for each cross-section, k :

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

where for each relative humidity, j :

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

i = subdivided element

$+$ = positive values only

- 5.6.4 Determine Condensation Resistance of the Total Product, CR . *Condensation Resistance* = Lower of the CR_f , CR_c , and CR_e

5.6.5 Condensation Resistance Variables

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

$t_{dp,1} = 2.9^\circ\text{C} (37.3^\circ\text{F})$ @ RH = 30%

$$t_{dp,2} = 10.3^{\circ}\text{C} (50.6^{\circ}\text{F}) \quad @ \text{ RH} = 50\%$$

$$t_{dp,3} = 15.4^{\circ}\text{C} (59.8^{\circ}\text{F}) \quad @ \text{ RH} = 70\%$$

$$t_{dpp} = \text{condensation reference point temperatures, } t_{dpp} = t_{dp} + 0.3^{\circ}\text{C} \\ (\text{ } t_{dpp} = t_{dp} + 0.5^{\circ}\text{F})$$

$$t_{dpp,1} = 3.2^{\circ}\text{C} (37.8^{\circ}\text{F})$$

$$t_{dpp,2} = 10.6^{\circ}\text{C} (51.1^{\circ}\text{F})$$

$$t_{dpp,3} = 15.7^{\circ}\text{C} (60.3^{\circ}\text{F})$$

$$t_o = \text{exterior ambient temperature } -18^{\circ}\text{C} (0^{\circ}\text{F})$$

$$t_{fi} = \text{average temperature of the frame segments } i, \text{ subdivided as per 4.2.2,}$$

$$t_{eog_i} = \text{average temperature of the edge-of-glass segments } i, \text{ subdivided as per} \\ \text{4.2.2,}$$

$$t_{cog_i} = \text{average temperature of the center-of-glass area } i,$$

$$t_{deog_i} = \text{average temperature of the divider-edge area } i,$$

$$t_{di} = \text{average temperature of the divider area } i,$$

$$L_{fi} = \text{length of subdivided segments on each modeled frame cross-section}$$

$$L_{eog_i} = \text{length of subdivided segments on each modeled edge-of-glass cross-} \\ \text{section}$$

$$L_{deog_i} = \text{length of subdivided segments on each modeled divider-edge cross-} \\ \text{section}$$

$$L_{di} = \text{length of subdivided segments on each modeled divider cross-section}$$

$$L_f = \text{total (wetted) length of each modeled frame cross-section,}$$

$$L_{eog} = \text{total length of each modeled edge-of-glass cross-section,}$$

$$L_{deog} = \text{total length of each modeled divider-edge cross-section,}$$

$$L_d = \text{total length of each modeled divider cross-section, } A_{cog_k} = \text{center-} \\ \text{of-glass area of section } k,$$

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

$$A_{eog_k} = \text{edge-of-glass area of each modeled cross-section on the interior} \\ \text{surface}$$

$$A_{cog_k} = \text{center-of-glass area of each modeled center-of-glass section on the} \\ \text{interior surface}$$

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

- A_{deog_k} = divider-edge 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-glass, frame (i.e. jamb, sill, head, meeting rail, etc.), or center-of-glass sections
- CR_f = Condensation Resistance of the frame
- CR_c = Condensation Resistance of the center-of-glass area, including, divider, and divider-edge
- CR_e = Condensation Resistance of the edge-of-glass area
- CR = Condensation Resistance of the Specimen

6 TEST METHOD

- 6.1 **Test Specimen Testing Requirements:** The fenestration system is to be tested in accordance with C1199 Test Procedure for Measuring the Steady-State Thermal Transmittance of Fenestration Systems with the additional thermocouples applied to the interior surface of the product as defined in Appendix B of this procedure.
- 6.2 **Determination of Total Exposed Surface Area:** The fenestration total wetted surface area shall be used.
- 6.3 **Temperature Measurement:** The fenestration system is to be instrumented in accordance with C1199 Test Procedure for Measuring the Steady-State Thermal Transmittance of Fenestration Systems.
- 6.3.1 All measurements specified in ASTM C 1363 shall be made.
- 6.3.2 The attachment of thermocouples shall be performed using a nominal 25mm (1 in.) wide by 100mm (4 in.) long adhesive-backed flat-white, or equal emittance, aluminum foil tape with the 100mm (4 in.) dimension parallel to the thermocouple wire.
- 6.4 Test Procedure Calculations
- 6.4.1 **General Calculations:** This section defines the method of calculating the Condensation Resistance from test data.
- 6.4.1.1 Determination of the resistance of the window unit to the formation of condensation in any form, referred to as the Condensation Resistance, shall be accomplished using the criteria listed in Section 4.7.

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

i = frame thermocouples

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

i = edge – of – glass thermocouples

$$CR_c = \left\{ 1 - \left[\frac{\sum_{j=1}^3 \left[\frac{\sum_i (t_{dpp,j} - t_{g_i})^+ * A_{c_i}}{(t_{dpp,j} - t_o) * A_c} \right]_{j=RH@30\%,50\%,70\%}}{3} \right]^{1/3} \right\} * 100$$

i = center – of – glass, divider, and divider – edge thermocouples

6.4.1.2 The Condensation Resistance Index using this procedure shall be determined as follow.

6.4.1.2.1 Record interior surface temperature for each individual thermocouple location.

6.4.1.2.2 Calculate the wetted area assigned to each individual surface thermocouple sensor as described in Section 6.2.

6.4.1.2.3 Calculate the total interior wetted area of frame and glass.

6.4.1.2.4 Determine Condensation Resistance of the frame, CR_f , and of the center of glazing, CR_c , and edge of glass, CR_e using the following formulas:

6.4.1.2.5 Calculate CR as a lower of CR_c, CR_e and CR_f

6.4.1.2.6 **Condensation Resistance Variables**

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

$t_{dp,1} = 2.9^{\circ}\text{C}$ (37.3°F) @ RH = 30%

$t_{dp,2} = 10.3^{\circ}\text{C}$ (50.6°F) @ RH = 50%

$t_{dp,3} = 15.4^{\circ}\text{C}$ (59.8°F) @ RH = 70%

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

$t_{dpp} =$

$t_{dp} + 0.3^{\circ}\text{C}$ ($t_{dpp} = t_{dp} + 0.5^{\circ}\text{F}$)

$t_{dpp,1} = 3.2^{\circ}\text{C}$ (37.8°F)

$t_{dpp,2} = 10.6^{\circ}\text{C}$ (51.1°F)

$t_{dpp,3} = 15.7^{\circ}\text{C}$ (60.3°F)

t_o = exterior ambient temperature (-18°C)

t_{f_i} = individual frame thermocouple temperatures.

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

t_{eog_i} = individual edge-of-glass thermocouple temperatures.

A_{f_i} = wetted interior area represented by the frame thermocouples

A_{c_i} = interior area represented by the central part of glazing (i.e., center-of-glass, divider, and divider-edge) thermocouples

A_{eog_i} = interior area represented by the edge-of-glass 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-glass, divider, and divider-edge) on the interior surface

A_{eog} = Total area of the edge-of-glass 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-glass area, including divider
and divider-edge

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

CR = Condensation Resistance of the Specimen

APPENDIX A: Background on the Condensation Resistance (CR) Determination

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 significant damage to building materials. Water contact with insulating glass sealants 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 fall below the interior dew point temperature. The interior dew point temperature is a function of the relative humidity of the air. 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 Condensation Resistance (CR) scale is 1-100, with a higher number being better. The CR is determined based on outside conditions of approximately -18°C (0°F) with a 7m/s (15mph) wind, and inside conditions of approximately 21°C (70°F) with relative humidities of 30%, 50%, and 70%. The CR 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 CR is based on the lower of the frame or glazing value.

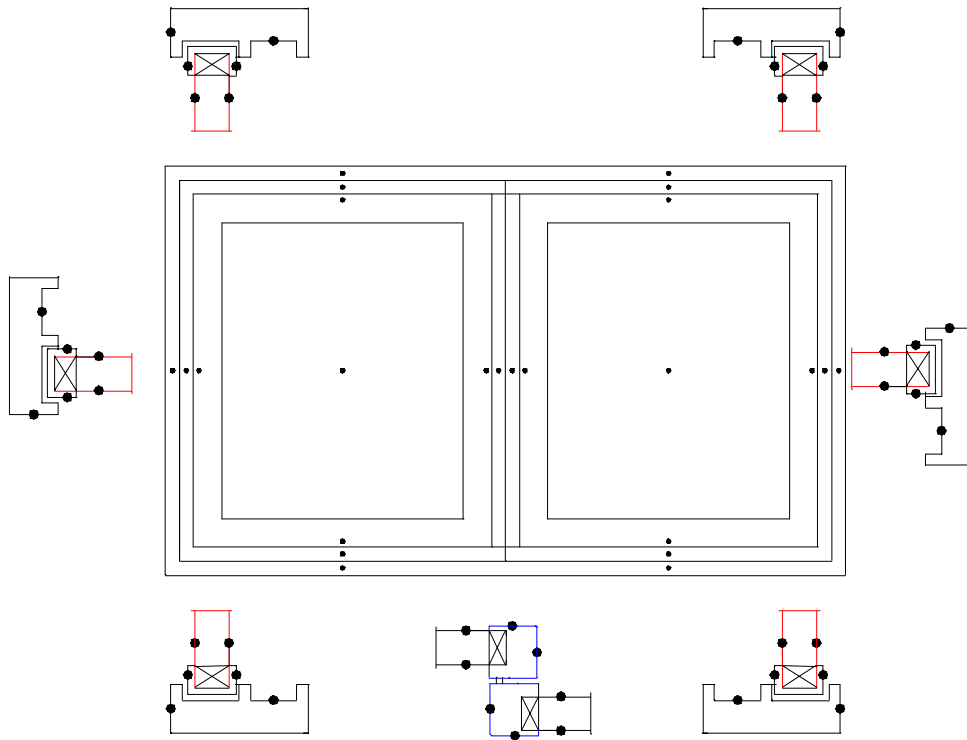
The Condensation Resistance is determined for very specific conditions. When installed in a building, there are numerous uncontrolled, site specific factors that may affect the condensation formation on the fenestration product, including installation details, site geometry, wind speed and direction, air circulation and fenestration product coverings, to name a few. In this procedure, the Condensation Resistance 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.

8 APPENDIX B: Predetermined Temperature Measurement Locations

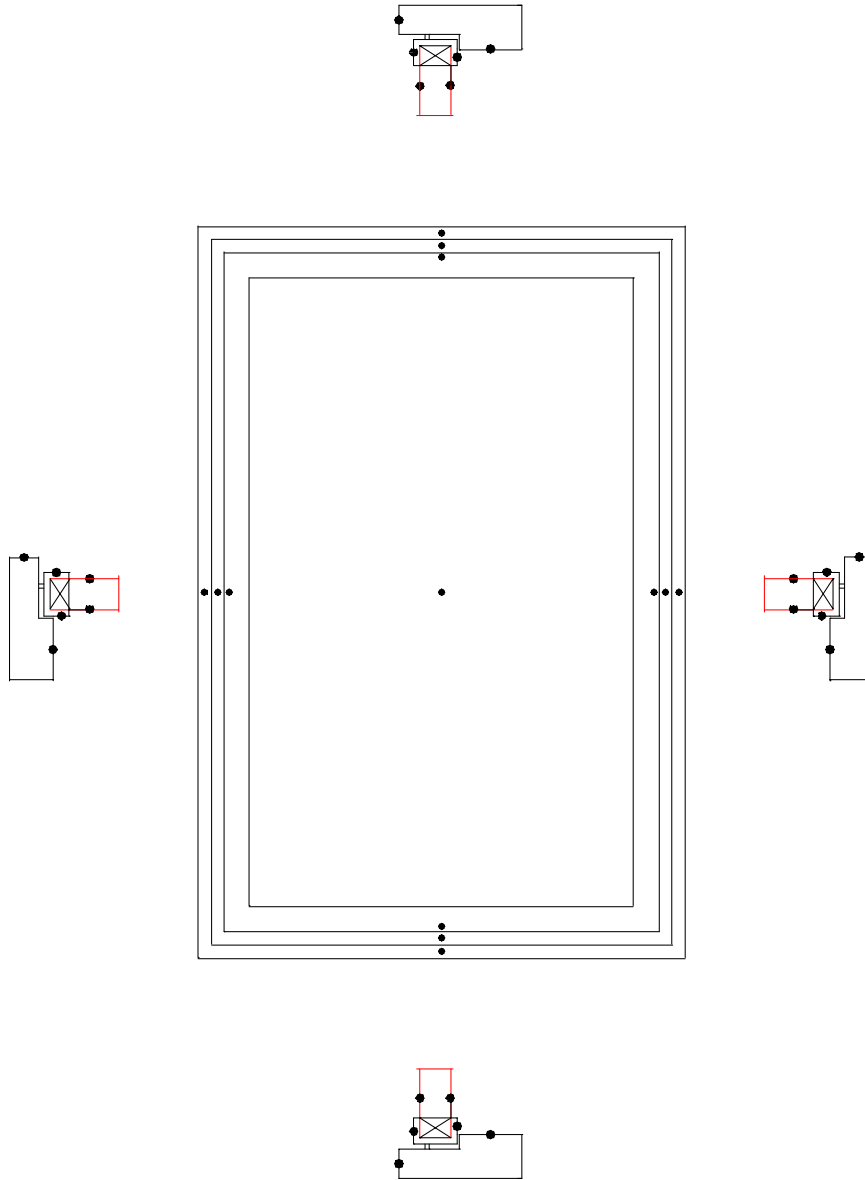
Horizontal Slider, Vertical Slider and Sliding Patio Door

Thermocouple Placement

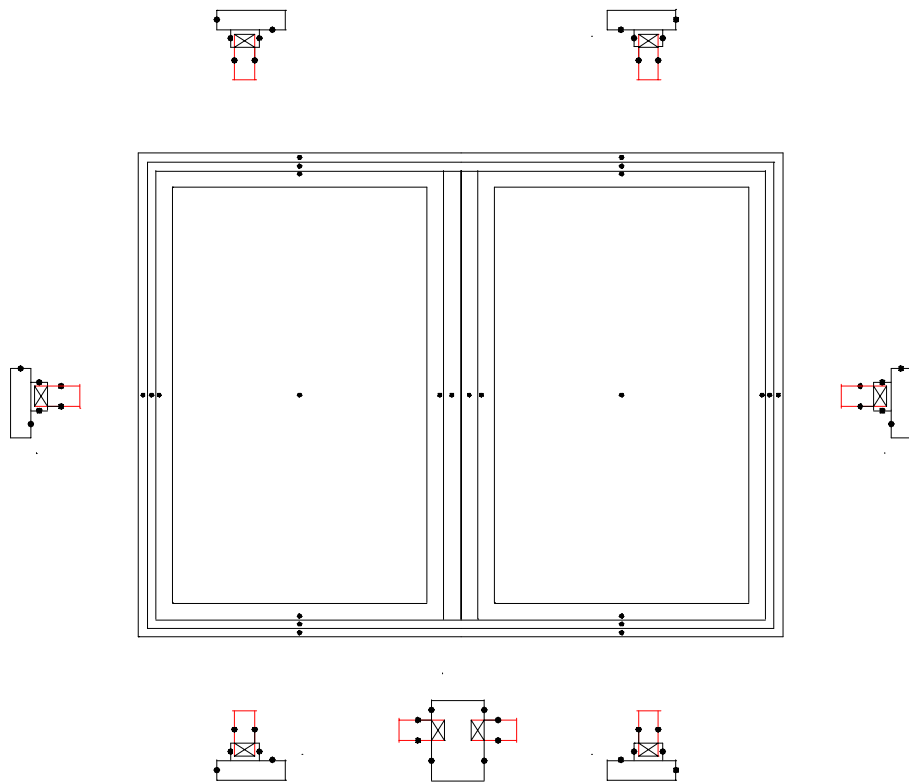
(Vertical Slider - rotate 90 degrees)



Swinging Patio Door Thermocouple Placement

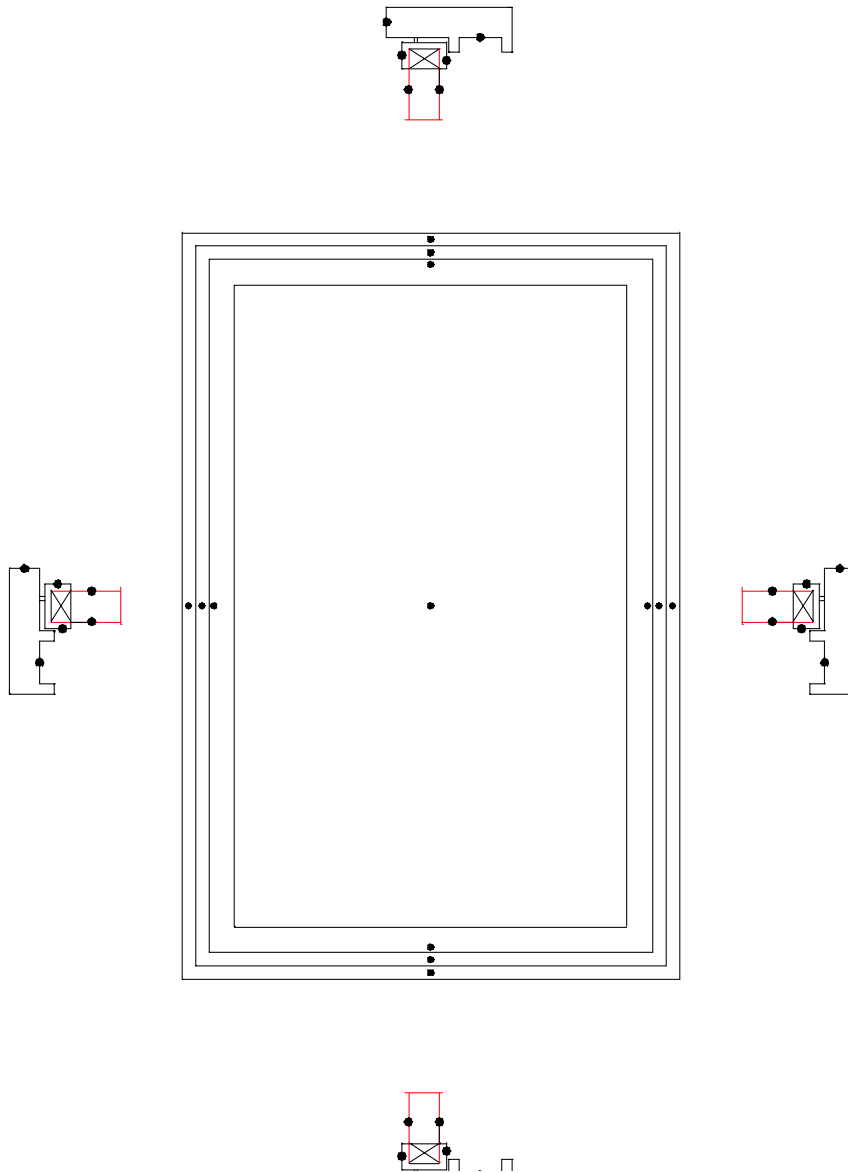


Glazed Wall and Sloped Glazing Thermocouple Placement

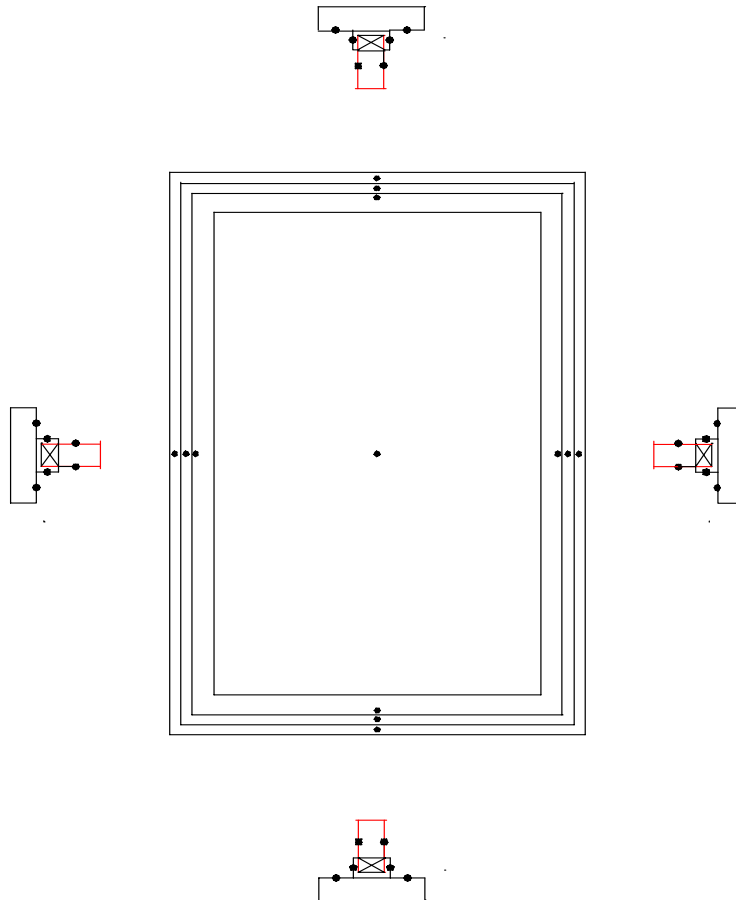


Casement and Awning Thermocouple Placement

(Awning - rotate 90 degrees)



Fixed, Sidelite and Transom Thermocouple Placement



Divider Thermocouple Placement

