Designation: E1423 – 14

# Standard Practice for Determining Steady State Thermal Transmittance of Fenestration Systems[1]

This standard is issued under the fixed designation E1423; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This practice covers standard test specimen sizes and test conditions as well as the calculation and presentation of the thermal transmittance and conductance data measured in accordance with Test Method C1199. The standard sizes and conditions are to be used for fenestration product comparison purposes. The specifier may choose other sizes and conditions for product development or research purposes.

1.2 This practice deals with the determination of the thermal properties of a fenestration system installed vertically without the influences of solar heat gain and air leakage effects.

NOTE 1—To determine air leakage effects of fenestration systems, Test Method E283 or E1424 should be referenced.

NOTE 2—See Appendix Appendix X1 regarding garage doors and rolling doors.

1.3 This practice specifies the procedure for determining the standardized thermal transmittance of a fenestration test specimen using specified values of the room-side and weather-side surface heat transfer coefficients, $h_h$ and $h_c$, respectively.

1.4 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

## 2. Referenced Documents

2.1 *ASTM Standards:*[2]

C168 Terminology Relating to Thermal Insulation

C1199 Test Method for Measuring the Steady-State Thermal Transmittance of Fenestration Systems Using Hot Box Methods

C1363 Test Method for Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus

E283 Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen

E631 Terminology of Building Constructions

E783 Test Method for Field Measurement of Air Leakage Through Installed Exterior Windows and Doors

E1424 Test Method for Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure and Temperature Differences Across the Specimen

2.2 *Other Documents:*

ANSI/DASMA 105-1998[3]

NFRC 102-2002[4]

## 3. Terminology

3.1 *Definitions*—Definitions and terms are in accordance with Terminology E631 and C168, from which the following have been selected and modified to apply specifically to fenestration systems. See Fig. 1 and Fig. 2 for variable identification. (For further information on definitions and procedures, see Appendix X2 or Test Method C1199.)

3.1.1 *surface heat transfer coefficient, h* (sometimes called *surface conductance* or *film coefficient)*—the time rate of heat flow from a unit area of a surface to its surroundings, induced by a unit temperature difference between the surface and the environment. Subscripts are used to differentiate between room-side ($_1$ or $_h$) and weather-side ($_2$ or $_c$) surface heat transfer coefficients (see Figs. 1 and 2).

3.1.2 *thermal transmittance $U_s$* (sometimes called *overall coefficient of heat transfer)*—the heat transfer in unit time

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[4] Available from National Fenestration Rating Council (NFRC), 6305 Ivy Lane, Suite 140, Greenbelt, MD 20770, http://www.nfrc.org.

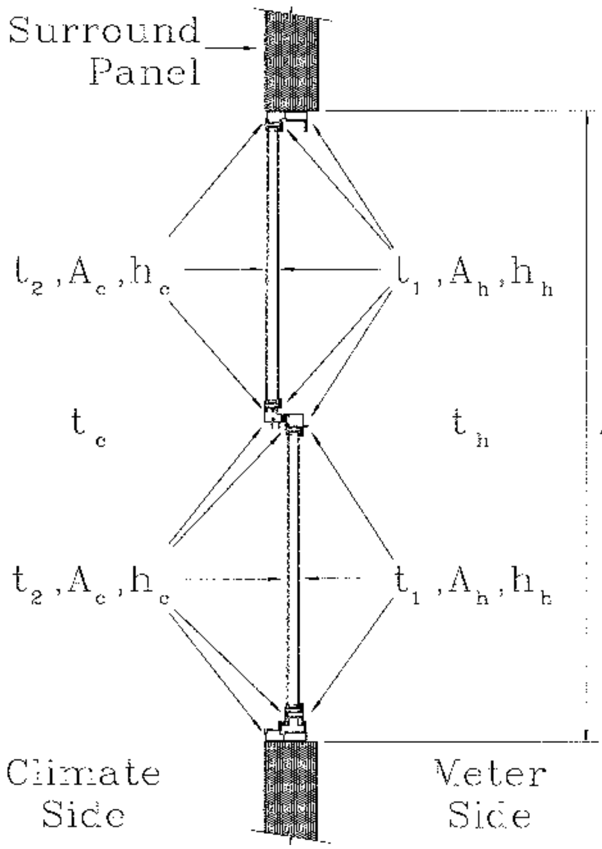


**FIG. 1 Window Mounted Flush with Climate Side of Surround Panel**

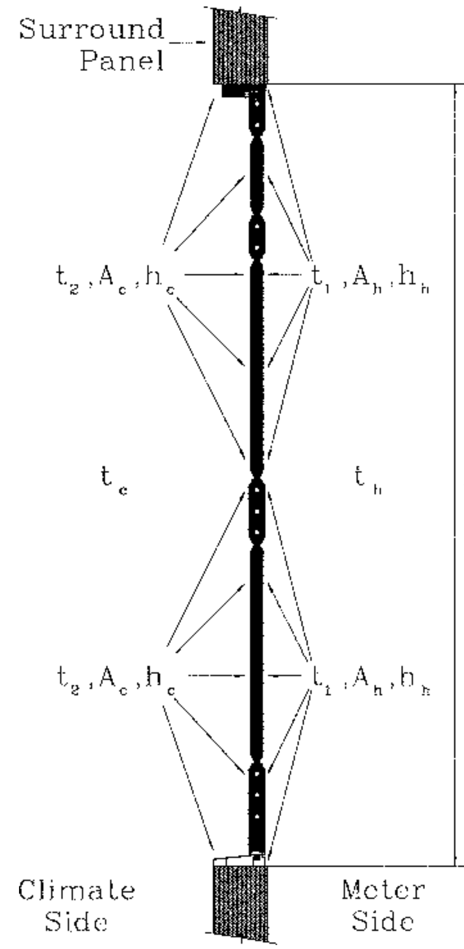


**FIG. 2 Door Mounted Flush with Climate Side of Surround Panel**

through unit area of a test specimen and its boundary air films, induced by unit temperature difference between the environments on each side.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *standardized thermal transmittance, $U_{ST}$*—the heat transfer in unit time through unit area of a specimen (using standardized surface heat transfer coefficients) induced by unit temperature difference between the environments on each side. **Test Method C1199**

3.2.2 *surround panel* (sometimes called the *mask, mask wall,* or *homogeneous wall)*—a panel with a homogeneous core that may be faced with paint, plywood, or plastic in which the test specimen is mounted.

3.2.3 *test specimen*—the fenestration system or product being tested.

3.2.4 *thermal resistance, $R_S$*—the temperature difference between the environments on the two sides of a body or assembly when a unit heat flow per unit time per unit area is established through the body or assembly under steady-state conditions. It is defined as follows:

$$R_S = \frac{1}{U_S} \tag{1}$$

where:

$R_S$ = overall thermal resistance of specimen (air to air under test conditions), $(m^2 \cdot K)/W$ $((ft^2 \cdot hr \cdot °F)/Btu)$.

3.3 *Symbols*—The symbols, terms, and units used in this test method are as follows:

$A_c$ total heat transfer surface area of test specimen on weather side, $m^2$

$A_h$ total heat transfer surface area of test specimen on room side, $m^2$

$A_s$ projected area of test specimen, (same as open area in surround panel), $m^2$

$h_c$ surface heat transfer coefficient, weather side, $W/(m^2 \cdot K)$

$h_h$ surface heat transfer coefficient, room side, $W/(m^2 \cdot K)$

$h_{h+c}$ surface heat transfer coefficient, combined room and weather side, $W/(m^2 \cdot K)$

$h_{STc}$ standardized surface heat transfer coefficient, weather side, $W/(m^2 \cdot K)$

$h_{STh}$ standardized surface heat transfer coefficient, room side, $W/(m^2 \cdot K)$

$R_S$ overall thermal resistance of test specimen (air to air under test conditions), $(m^2 \cdot K)/W$

$t_c$ average temperature of weather side air, °C

$t_h$ average temperature of room side air, °C

$t_1$ average temperature of test specimen, room side surface, $K$ or $°C$

$t_2$ average temperature of test specimen, weather side surface, $K$ or $°C$

$U_S$ thermal transmittance of test specimen (air to air under test conditions), $W/(m^2 \cdot K)$

$U_{ST}$ standardized thermal transmittance of test specimen, $W/(m^2 \cdot K)$

## 4. Significance and Use

4.1 This practice details the test specimen sizes and test conditions, namely, the room-side and weather-side air temperatures, and the surface heat transfer coefficients for both sides of the test specimen, when testing fenestration products in accordance with Test Method C1199.

4.2 The thermal transmittance and conductance of a specimen are affected by its size and three-dimensional geometry. Tests should therefore be conducted using the specimen sizes recommended in 5.1. Should the specimen size differ from those given in 5.1, the actual size shall be reported in the test report.

4.3 Many factors can affect the thermal performance of a fenestration system, including deflections of sealed glazing units. Care should be exercised to maintain the original physical condition of the fenestration system and while installing it in the surround panel.

4.4 The thermal transmittance and conductance results obtained do not, and are not intended, to reflect performances expected from field installations since they do not account for solar radiation and air leakage effects. The thermal transmittance and conductance results are taken from specified laboratory conditions and are to be used only for fenestration product comparisons and as input to thermal performance analyses that also include solar and air leakage effects.

## 5. Test Specimen

5.1 *Specimen Sizes*—The specimen sizes given in Table 1 for different types of fenestration systems shall be used when testing fenestration products. For test specimens not manufactured at the exact sizes given in Table 1, choose the product with dimensions that produces the smallest value of deviation, $D$, calculated by Eq 2. For non-rectangular products, choose the product with an area closest to the area of the product in Table 1.

$$D = \sqrt{[(W_p - W_m)^2 + (H_p - H_m)^2]} \quad (2)$$

where:

$D$ = deviation, mm (in.)
$W_p$, $H_p$ = width and height of production size, mm (in.)
$W_m$, $H_m$ = width and height of model size, mm (in.)

## 6. Test Conditions

6.1 *General*—A single set of test conditions does not necessarily define the thermal characteristics of a fenestration system. However, a single set of test conditions is specified to permit comparison of the thermal transmittance of different fenestration products. Thermal transmittance values obtained under this set of test conditions have been shown to be valid for the range of weather conditions typical of the North American climate [weather-side temperatures between 43 and −30°C (110 and −22°F) and wind speeds up to 6.7 m/s (15 mph)].

6.2 *Test Conditions for U-Values for Comparison Purposes*—The test specimen shall be tested in accordance with Test Method C1199. For comparison purposes, the following set of conditions shall be used (see Fig. 1):

**TABLE 1 Specimen Size Dimensions**[A]

| Window Type | Configuration | Test Specimen Model Size, mm. (in.)[B] |
|---|---|---|
| | **I - Window Assemblies** | |
| Vertical slider | XO or XX | 1200 × 1500 (47 × 59) |
| Horizontal slider | XO or XX | 1500 × 1200 (59 × 47) |
| Casement - Double | XX | 1200 × 1550 (47 × 59) |
| Casement - Single | X | 1200 × 1500 (47 × 59) |
| Projecting (Awning - Double) | XX | 1500 × 1200 (59 × 47) |
| Projected (Awning - Single) | X | 1500 × 600 (59 × 24) |
| Fixed (includes non-standard shapes) | O | 1200 × 1500 (47 × 59) |
| Sloped Glazing | OO | 2000 × 2000 (79 × 79) |
| Skylights/roof window | X | 1200 × 1200 (47 × 47) |
| Greenhouse/Garden | X | 1500 × 1200 (59 × 47) |
| Dual Action | X | 1200 × 1500 (47 × 59) |
| Pivoted | X | 1200 × 1500 (47 × 59) |
| Sidelites | X | 600 × 1200 (24 × 79) |
| Transoms | X | 1200 × 600 (79 × 24) |
| Basement | O | Rated at the appropriate product type |
| Bay or Bow | | Rated at the appropriate product type |
| Composite - Fixed beside operable | | 1200 × 1500 (47 × 59) |
| Composite - Fixed over operable | | 1200 × 1500 (47 × 59) |
| Hinged Escape | X | 1500 × 1200 (59 × 47) |
| Jal/Jal Awning | X | 1200 × 1500 (47 × 59) |
| Tropical Awning | X | 1500 × 1200 (59 × 47) |
| | **II - Door Assemblies** | |
| Swinging door(s) with frame | X, OX or XX | 1000 × 2000 (39 × 82)[B] or 2000 × 2000 (79 × 79)[C] |
| Sliding Patio doors with frame | XO or XX | 2000 × 2000 (79 × 79) |

[A] Select size type based on the manufacturer's average standard size and intended use of the product.
[B] Typical of a single door.
[C] Typical of a double door.

$$t_h = 21.0°C \pm 0.3°C \ (69.8°F \pm 0.5°F) \quad (3)$$

$$t_c = -18.0°C \pm 0.3°C \ (-0.40°F \pm 0.5°F) \quad (4)$$

6.2.1 *Room Side (Natural Convection)*—The air velocity should be less than 0.3 m/s (60 ft/min). For comparison purposes, the standard surface heat transfer coefficient measured on the room side of each calibration transfer standard (CTS) during calibration shall be:

$$h_{STc} = 7.67 \text{ W/m}^2\cdot\text{K} \pm 5\% \ (1.35 \text{ Btu/hr}\cdot\text{ft}^2\cdot°\text{F} \pm 5\%) \quad (5)$$

[Allowed CTS calibration range of:
7.29 to 8.05 W/m²·K (1.28 to 1.42 Btu/hr·ft²·°F)]

Since this is the natural convection lower limit of the indoor side overall surface heat transfer coefficient, a ±5 % variation in this value is allowed to accommodate some forced convection due to small room side air circulation fans that provide a more uniform flow distribution on the indoor side of the CTS.

NOTE 3—Using the 1997 American Society for Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) Fundamentals Handbook (1),[5] Fenestration Chapter 29, Table 3, the indoor side of the overall combined natural convection, radiation heat transfer coefficient for a 1.22-m (4-ft) high, 13-mm (0.5-in.) wide cavity, double glazed, low emittance glazing unit is 6.98 W/($m^2$·K) (1.23 Btu/(hr·$ft^2$·°F)). For a 1.22-m (4-ft) high, 12.7-mm (0.5-in.) thick high density expanded polystyrene (EPS) foam core CTS with two 4-mm (0.16-in.) glass faces, the indoor side calculated overall combined natural convection, radiation heat transfer coefficient is 7.02 W/($m^2$·K) (1.24 Btu/(hr·$ft^2$·°F)), using the same methods and equations that were used to obtain the ASHRAE Chapter 27, Table 3 results. Rounding off these two results gives a nominal standardized surface heat transfer coefficient of 7.0 W/($m^2$·K) (1.23 Btu/(hr·$ft^2$·°F)), which is the below the limit for natural convection for this size of CTS.

6.2.2 *Weather-side*—For comparison purposes, the standard surface heat transfer coefficient measured on the weather side of each CTS shall be (perpendicular or parallel):

$$h_{STc} = 30.0 \text{ W/m}^2\cdot\text{K} \pm 10\% \ (5.28 \text{ Btu/hr}\cdot\text{ft}^2\cdot°\text{F} \pm 10\%) \quad (6)$$

[Allowed CTS calibration range of:
27.0 to 33.0 W/m²·K (4.75 to 5.81 Btu/hr·ft²·°F)]

NOTE 4—Again, referring to the 1997 ASHRAE Fundamentals Handbook (1), Fenestration Chapter 29, the recommended design value for the weather side overall combined forced convection, radiation heat transfer coefficient for a nominal 24 km/h (15 mph) wind speed is $h_c$ = 29.0 W/($m^2$·K) (5.1 Btu/(hr·$ft^2$·°F)).

6.2.3 *Combined Room and Weather Side*—For comparison purposes, the combined standard surface heat transfer coefficient measured simultaneously on both the room and weather side of each calibration transfer standard (CTS) during calibration shall be:

$$h_{h+c} = 6.11 \text{W/m}^2\cdot\text{K} \pm 5\% \ (1.08 \text{ Btu/hr}\cdot\text{ft}^2\cdot°\text{F} \pm 5\%) \quad (7)$$

[Allowed CTS calibration range of:
5.80 to 6.72 W/m²·K (1.03 to 1.13 Btu/hr·ft²·°F)]

where:

$h_{h+c}$ = $1/(1/h_h + 1/h_c)$

[5] Available from American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE), 1791 Tullie Circle, NE, Atlanta, GA 30329, http://www.ashrae.org.

6.2.4 *Relative Humidity on the Warm Side*—Condensation on the test specimen may influence the temperature measurements of the surface and shall be avoided. The relative humidity in the metering chamber shall be maintained at or below 15 %.

## 7. Test Specimen Installation and Instrumentation

7.1 *Test Specimen Installation:*

7.1.1 *Surround Panel*—A surround panel shall be provided for installation of the test specimen similar to that shown in Figs. 1 and 2 (see the description in Test Methods C1199 and C1363).

7.1.2 *Test Specimen*—The fenestration system to be tested shall be installed in the surround panel as shown in Figs. 1 and 2 for windows and doors. That is, the complete assembly, including all frame elements and operating hardware, shall be in place during the test. Accessory interior or exterior devices, such as trim or insect screens, shall be removed before testing. The test specimen shall be mounted so that it is centered in the metering area of the surround panel, and the frame on the cold side of the fenestration product shall be flush with the weather side of the surround panel. The specimen shall be fixed securely in a plane parallel to the surround panel surfaces, suitable for any wind loads experienced during testing. The installation shall also allow space to accommodate all sash or operating members, or both. If the fenestration system does not fill the opening in the surround panel completely, the space between the surround panel and the fenestration system shall be filled with material of similar thermal conductance and thickness to that of the surround panel. Perimeter joints between the specimen and the surround panel shall be sealed on both sides of the wall. In no case shall the tape or caulk cover more than 13 mm (0.50 in.) of the test specimen frame or edge.

7.1.2.1 *Projecting Fenestration Products*—Skylights shall be tested in a configuration that is as close to the actual installation as possible (without integral flashing) with the following conditions:

*(1)* Curb-mounted skylights that do not have an integral curb attached shall be installed on a nominal 40 mm × 90 mm (1½ in. × 3½ in.) wood curb made from Douglas fir with no knots.

*(2)* Skylights shall be tested and reported in the vertical orientation.

*(3)* Skylights installed inside the rafter opening that have the bottom of the curb touching the finish facing material may extend the surround panel material to the inside of the curb, or the inside of the finished opening material, whichever comes first. The surround panel material shall not extend beyond the inside of the skylight curb.

*(4)* The skylight size listed in Table 1 is based on a center of the rafter to the center of the rafter dimension. Thereby, the standard size references a median size between a skylight mounted between the rafters and a skylight mounted on top of the rafters.

*(5)* The U-factor for skylights is based on the projected fenestration area. For skylights installed between the rafters, the outside dimension of the curb is considered to be the

projected area. For skylights installed on top of the rafters, the inside dimension of the curb is considered to be the projected area.

7.1.3 *Air Leakage*—All potential air leakage sites on the test specimen, on the surround panel, and at the interface between the surround panel and the test specimen must be sealed with nonmetallic tape or caulking, or both, as close to the warm side as possible to minimize or eliminate air leakage between the room side and weather side chambers. The thermal performance can be affected by the method and placement of the test specimen air seal. Therefore, the test specimen is to be sealed at the warm side of the test specimen with tape, caulking, or other material of similar surface emissivity (±0.1) to that of the adhering surface. Minimize the use of tape or caulking, as excessive application of these materials can affect the thermal performance of the test specimen.

7.1.3.1 A test specimen with primary and secondary components (such as a storm window) shall be sealed at the warm side of each component.

7.1.3.2 Weep holes/slots located on the cold side shall be sealed on the cold side.

7.1.3.3 Perimeter joints between the test specimen and the surround panel shall be sealed on both sides of the wall. In no case shall the tape or caulk cover more than 13 mm (0.50 in.) of the test specimen frame or edge.

7.1.3.4 As an additional precaution to minimize the potential for leakage of air through and around the sealed test specimen, means may be provided to measure and equalize the pressure difference across the test specimen. For hot boxes that have a perpendicular (to the test specimen weather side surface) wind direction, this is accomplished by balancing the weather side total pressure with the room side static pressure to 0 ± 10 Pa (0 ± 0.21 $Lbf/ft^2$). For hot boxes that have a parallel (to the test specimen weather side surface) wind direction, this is accomplished by balancing the weather side static pressure with the room side static pressure to 0 ± 10 Pa (0 ± 0.21 $Lbf/ft^2$).

7.1.3.5 Good laboratory practice would include periodic assessment of the quality of the sealing methods used by monitoring closely the fenestration test specimen heat flux and temperature measurements during the duration of the thermal tests to ensure that there are no changes in the thermal performance due to losses in the seal integrity.

7.1.3.6 As an alternative method to determine whether or not air leakage exists, the following technique currently in use by one laboratory has been found to be useful. Place a sheet of 0.1 mm (4 mil) polyethylene over the CTS or fenestration test specimen (metered specimen) on the room side and seal it with tape to the surround panel at least 12 cm (4.7 in.) outside the perimeter of the specimen. Balance the pressure between the room side and weather side chambers as indicated above, and monitor the pressure difference. If the polyethylene sheet has not moved appreciably, it can be assumed that no net air leakage exists and the polyethylene sheet can be removed.

7.2 *Test Specimen Instrumentation:*

7.2.1 *Temperature Sensors*—If additional temperature sensors are to be mounted on the fenestration system frame and glazing surfaces to determine an average surface temperature for both the weather side and room sides of the test specimen, Figs. 3-16 shows the preferred locations based on experience with fenestration product testing. If there is further interest in attempting to determine edge (spacer) heat transfer effects, additional temperature sensors should be mounted in the region of the glazing near the frame, especially in the glazing/frame corners. Paragraph 6.10 of Test Method C1363 provides the requirements for the temperature sensor accuracy, which is presumed to be met by using Type T thermocouples with diameters no larger than 0.51 mm (No. 24 AWG). Alternative arrangements may be used if comparative measurements or calculations reveal that the basic requirements are met.

NOTE 5—Figs. 3-16 indicates the temperature sensor locations for a limited sample of window types as an alternative to calculation of the window surface temperatures. The following guidelines are recommended for other window types, doors, glazed curtain walls, glass block walls, and so forth: (*1*) a minimum of 20 temperature sensors should be used per side, with a minimum of 6 being placed on the glazing and a minimum of 14 placed on the sash/frame components of the test specimen; (*2*) additional temperature sensors should be added for thermal bridges or other frame elements with high thermal conductance; and (*3*) the temperature sensors are to be placed in locations as close as possible to those found in Figs. 3-16.

7.2.2 *Temperature Sensor Attachment*—Surface temperature sensors shall be applied to the test specimen as described in 6.10.1 of Test Method C1363. If thermocouples are used to measure the surface temperature, a minimum of 100 mm (4 in.) of thermocouple wire must be adhered to the surface. The

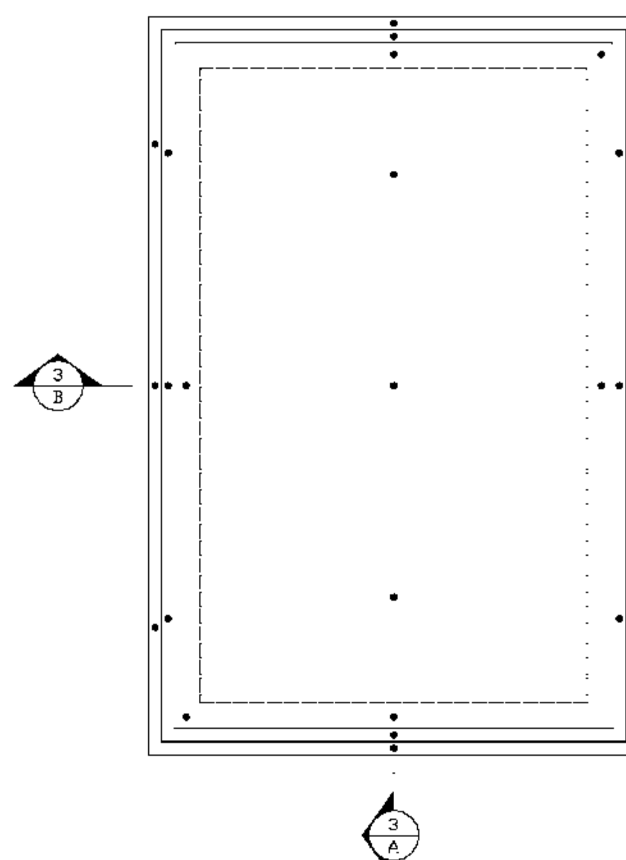


**FIG. 3 Casement Awning Temperature Sensor Placement**

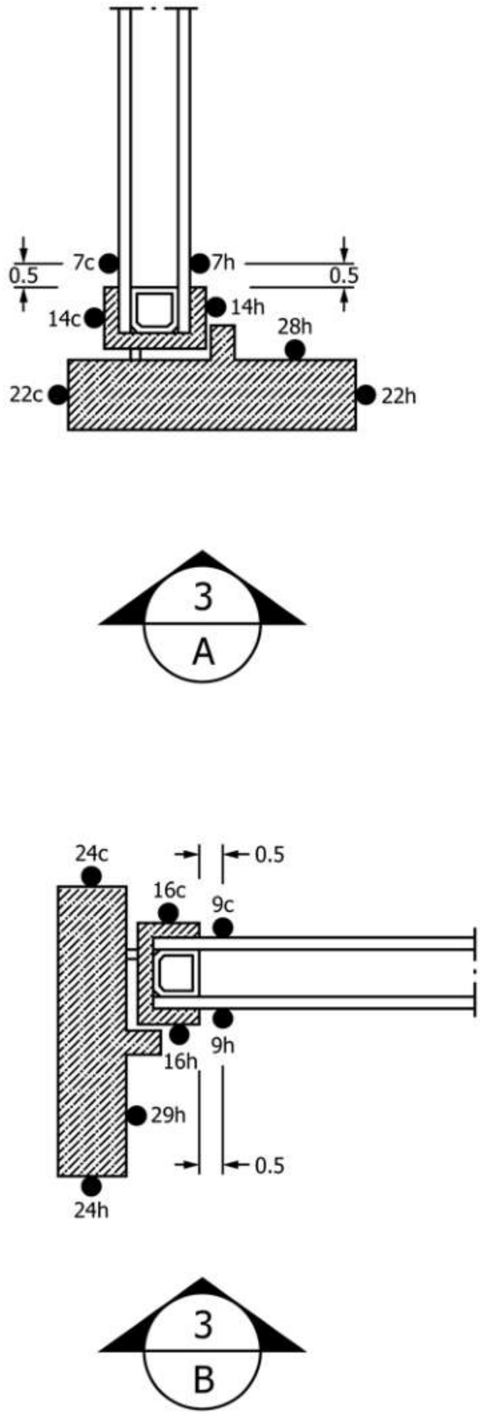


FIG. 4 Cross-sections of Casement and Awning Temperature Sensor Placement

emittance of the tape or sealant used to adhere the temperature sensor bead and lead wire should closely match (±0.05) the emittance of the surface to which it is being attached. Care should be taken to avoid having the temperature sensor cause any significant disturbance to the local air flow and the test specimen heat transfer. To avoid thermal shunting, route temperature sensor lead wires so that they do not bridge areas of expected large temperature difference.

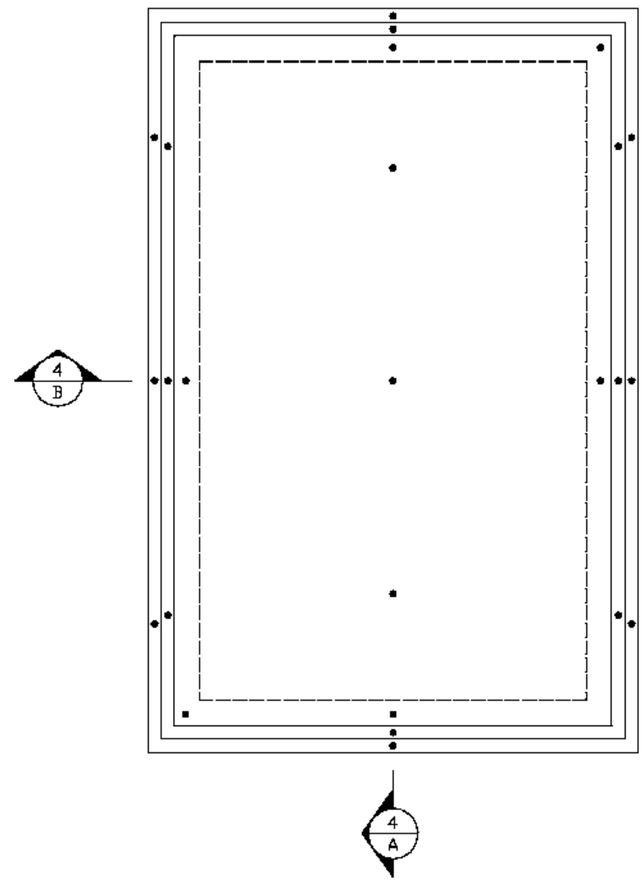


FIG. 5 Sidelite and Transoms Temperature Sensor Placement (Transoms - Rotate 90°)

7.2.3 *Average Area Weighted Surface Temperatures of Test Specimen*—The individual surface temperature measurements of the test specimen shall be area weighted to determine the average surface temperature of the room side of the test specimen, $t_1$, and the average surface temperature of the weather side of the test specimen, $t_2$. Proper measurement of the average surface temperature of each side of the fenestration test specimen requires that (*1*) the surface area of the test specimen be accurately measured and (*2*) the individual temperature sensors be attached to the test specimen surface at locations representing areas of minimal surface temperature gradient. The individual temperature sensors shall be located in the center of surface areas, which represents the average temperature of that surface area (see Fig. 3 and Fig. 4). Consequently, temperature sensors may be placed on both horizontal and vertical surfaces depending on the geometry of the test specimen.

7.2.3.1 *Surface Area Measurement*—The total surface area of each side of the test specimen must be determined. The sum of the individual surface areas on the room side and the weather side of the test specimen must equal the total measured surface areas of the room side, $A_h$, and weather side, $A_c$, respectively. See Fig. 1 for guidance on measuring areas of extruded frame members with exposed flanges and fins.

NOTE 6—When using the CTS method in Test Method C1199, the surface area of the test specimen can be estimated using the projected

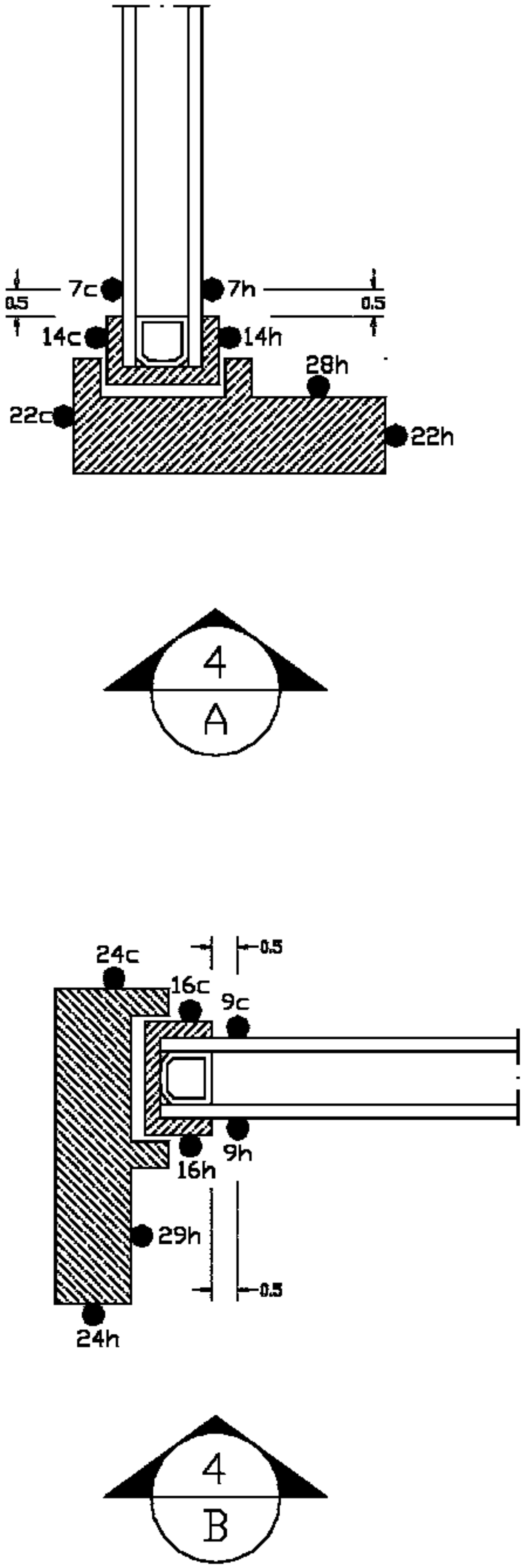


FIG. 6 Cross-sections of Sidelite and Transoms Temperature Sensor Placement

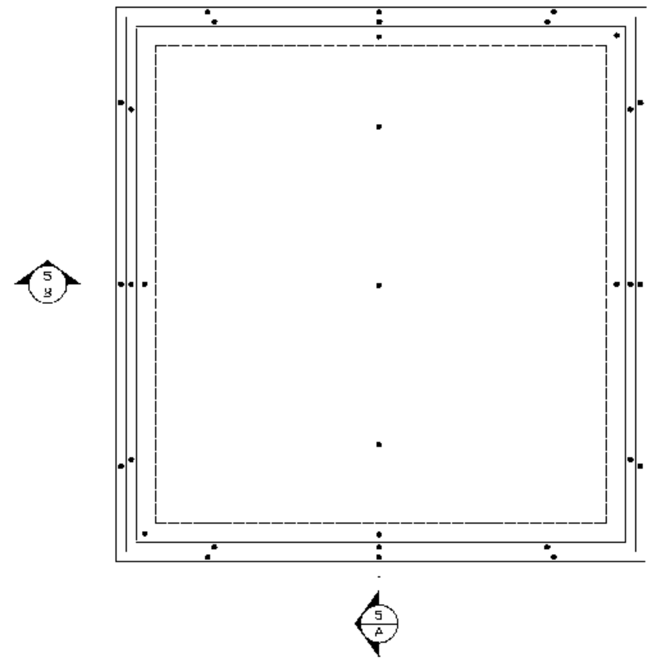

FIG. 7 Fixed Window Temperature Sensor Placement

height and depth of the frame and sash components. When using the area weighting method in Test Method C1199, more careful measurement of the "wetted" surface area of the test specimen may be necessary, including the surface areas of finger holds, fins, channels, and convoluted moldings on the frame or sash. Construction drawings of cross sections of the test specimen frame can assist in determining the total surface area of the test specimen, provided that the distance measurements can be made to the proper scale. If construction drawings of the test specimen are not available, it is possible to measure the length of a convoluted surface on a frame in one direction with tape. Place a piece of masking tape on the convoluted frame surface that you want to measure. After marking the edges of each individual area on the tape with a pen, remove the tape and place it on a ruler in such a way as to measure the distance between the marks.

7.2.3.2 *Surface Temperature Sensor Location*—Surface temperature sensors shall be placed in the center of isothermal areas as shown in Figs. 3-16. If surface temperature sensors are placed in locations other than shown in Figs. 3-16, those locations must be identified in the test report. On frames containing elements of high thermal conductance, extra temperature sensors may be needed to measure the temperature of those elements and their surrounding area. Each glazing corner edge temperature sensor shall be placed at a point 13 mm (0.5 in.) from the adjacent framing.

NOTE 7—Because there is such a large variety of shapes and configurations in frame and sash profiles on modern fenestration products, it is impossible to give guidance on where to properly locate every surface temperature sensor on the frame and sash. Typically, the surface temperature of surfaces on appendages or elements that protrude, such as channel fins and hand rails, have less of an influence on the overall thermal transmittance of the fenestration product than the temperature of surfaces connected to the body of the frame or sash. In those frames that have internal air cavities (that is, vinyl or aluminum extrusions), it is more important to measure the surface temperature of elements that bound internal air cavities than to measure the surface temperature of thin, protruding elements that do not bound internal air cavities. Ultimately, proper surface temperature sensor placement will depend on the experience and judgment of the test laboratory operator.

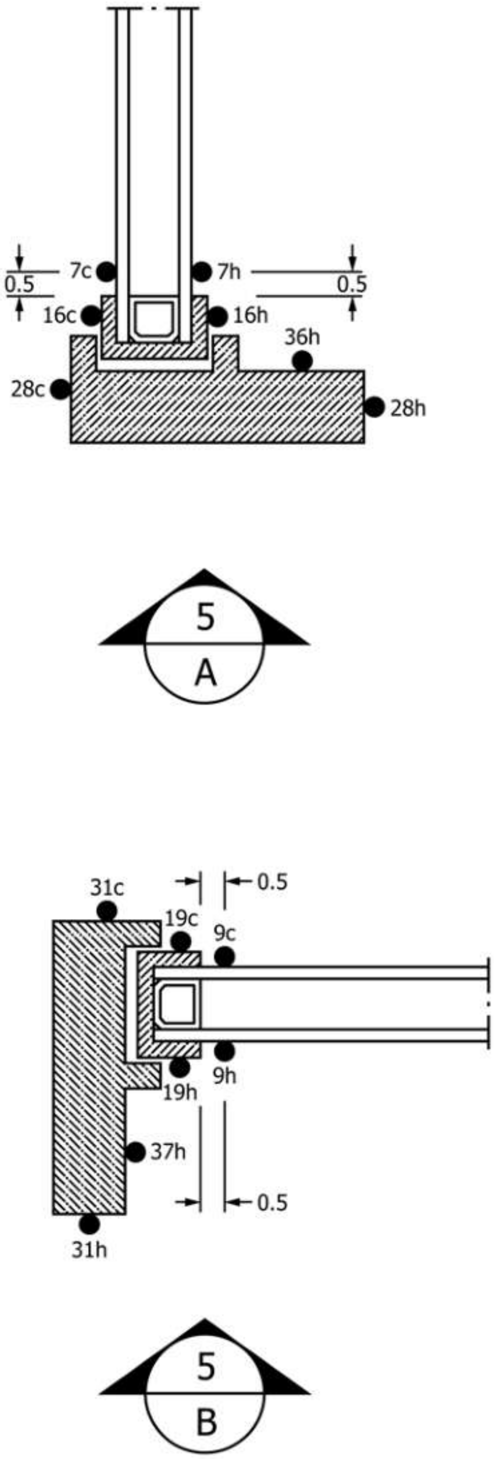


FIG. 8 Cross-sections of Fixed Window Temperature Sensor Placement

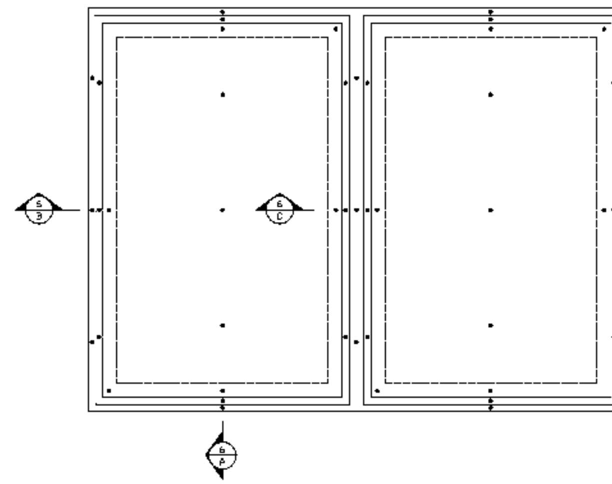

FIG. 9 Glazed Walls and Sloped Glazing Temperature Sensor Placement

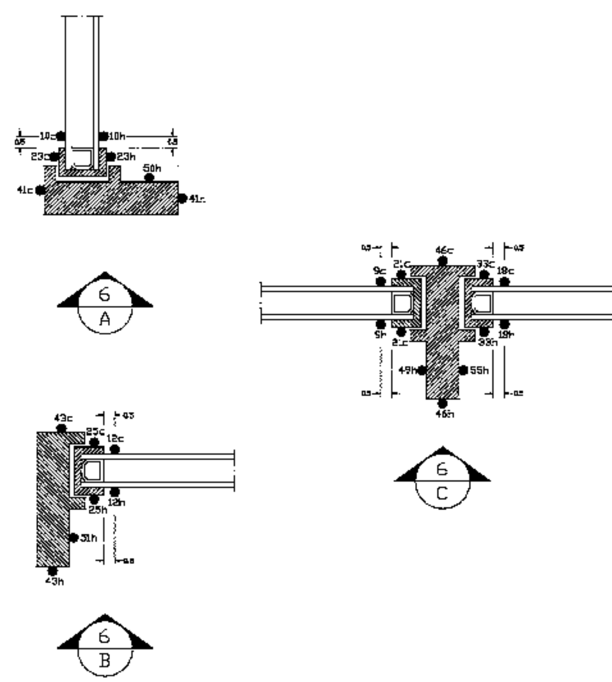


FIG. 10 Cross-sections of Glazed Wall and Sloped Glazing Temperature Sensor Placement

## 8. Glazing Deflection

8.1 Variations in the pressure in the space between the panes of glass in sealed glazing units may cause deflections in the glass. In extreme cold weather cases, the glass surfaces can bow and come into contact with each other at their center points. This change in the enclosed space dimensions can significantly affect the thermal conductance, $C_s$, and the thermal transmittance, $U_S$, of the test specimen. Some of the factors, which can cause a pressure unbalance between the glazing unit enclosed air space and the surrounding environment are:

8.1.1 Differences in the barometric pressure due to a difference in the elevations of the fenestration system manufacturing facility and the testing facility.

8.1.2 Changes in barometric pressure at the testing facility due to local weather conditions.

8.1.3 Changes in the mean temperature of the glazing unit enclosed airspace during testing.

8.2 Recognizing that glass deflection can cause a change in the thermal conductance, $C_S$, and the thermal transmittance, $U_S$,

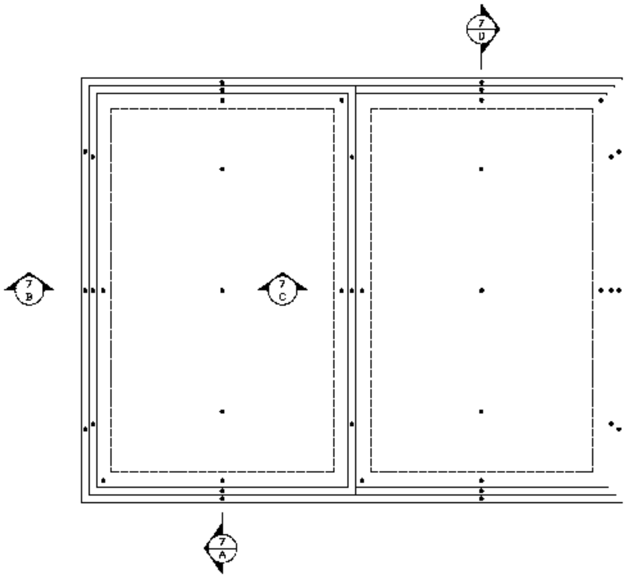

FIG. 11 Horizontal Slider and Sliding Patio Door Temperature Sensor Placement

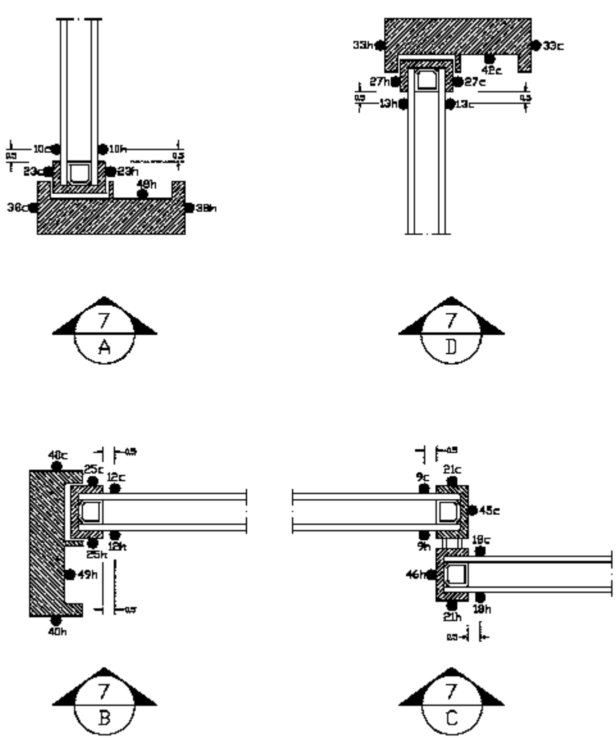

FIG. 12 Cross-sections of Horizontal Slider and Sliding Patio Door Temperature Sensor Placement

an estimation of the gap spacing between the glass panes is required immediately before and after the test. The initial gap thickness can be estimated by either measuring the overall glazing thickness at the center, or by measuring the deflection profile of each glass pane and then subtracting the thickness of the individual panes. Gap thickness during the test can be estimated from the initial thickness measurements minus the change in glass deflections, which occur during the test. The

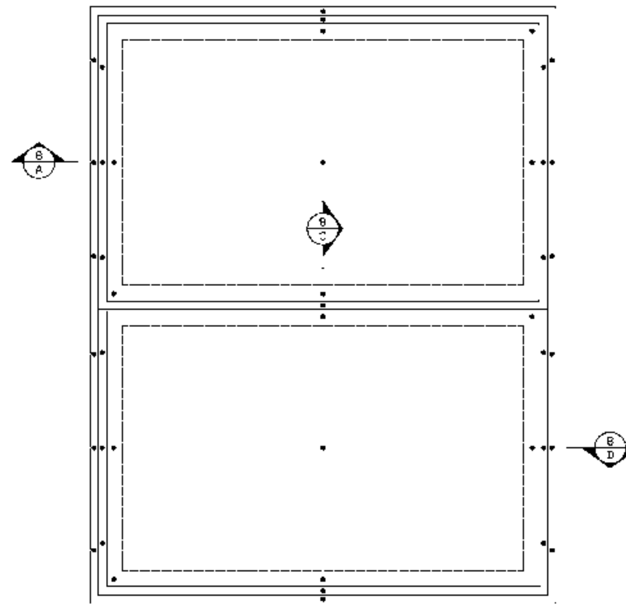

FIG. 13 Vertical Slider Temperature Sensor Placement

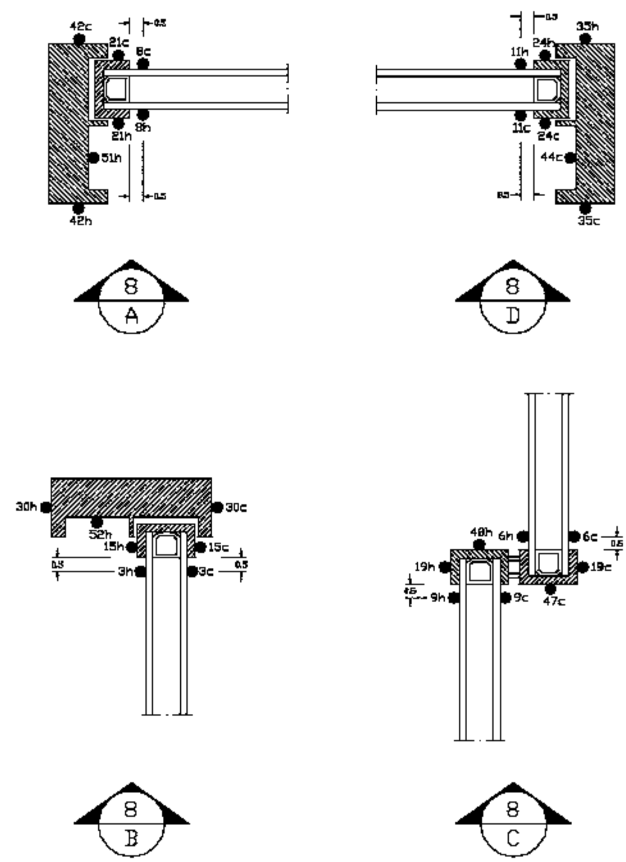

FIG. 14 Cross-sections of Vertical Slider Temperature Sensor Placement

glazing deflection measurements shall be performed on both sides of the fenestration system and shall be included in the test report.

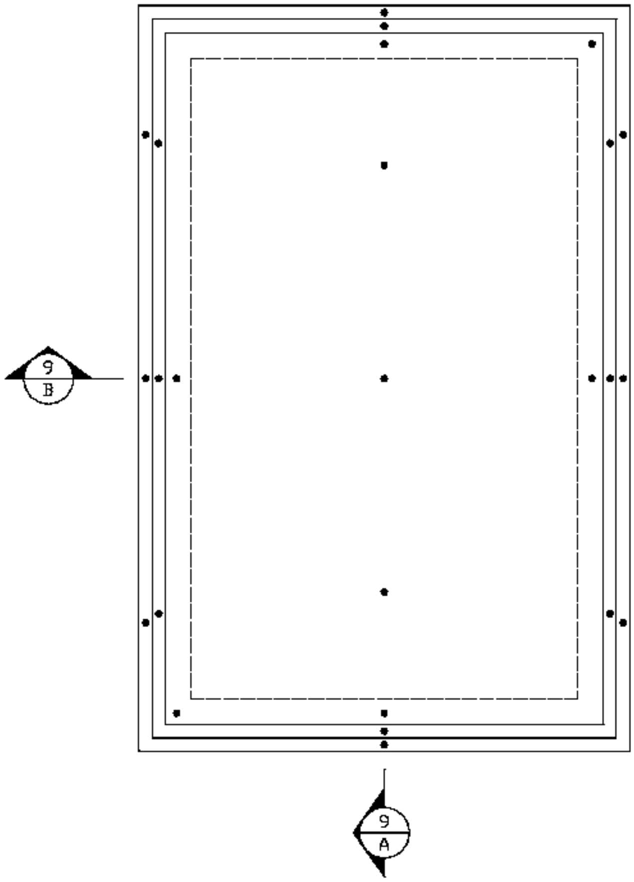


FIG. 15 Single-Glazed Door Temperature Sensor Placement

8.2.1 After the fenestration system has been delivered to the testing laboratory and has come to equilibrium in the laboratory.

8.2.2 Just before the test commences, and

8.2.3 Immediately after the test is completed and while the test specimen enclosed air space mean temperature is close to that which existed during the test.

## 9. Report

9.1 Report all of the information specified in Section 9 of Test Method C1199.

9.2 Report the standardized thermal transmittance, $U_{ST}$, and specify its estimated uncertainty. If the test specimen size and configuration are different than those specified in 5.1, include the nonstandard size and configuration in the report.

9.3 Include the test conditions used, such as room-side and weather-side air and surface temperatures, wind speed, and direction, in the report.

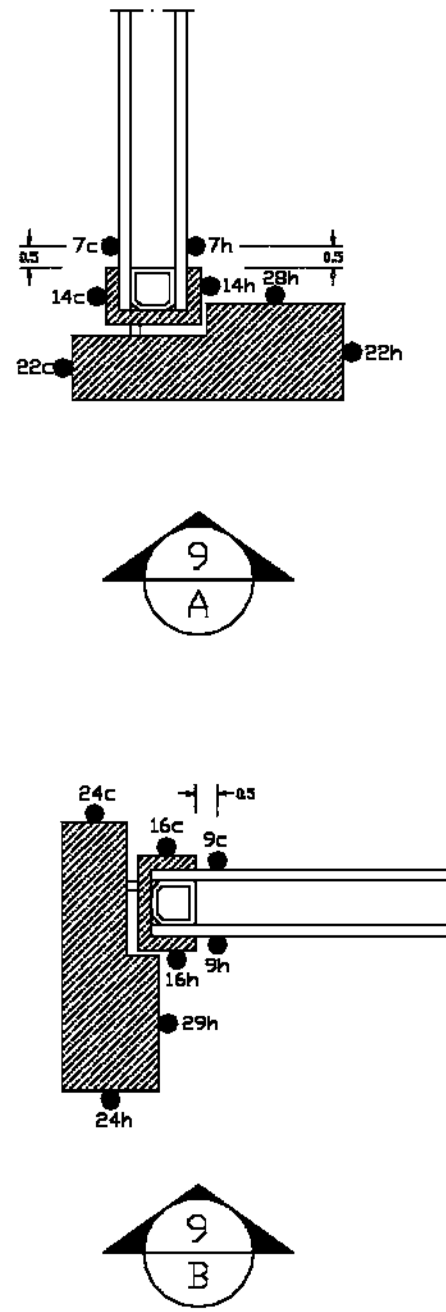


FIG. 16 Single-Glazed Door Temperature Sensor Placement

## 10. Keywords

10.1 doors; fenestration; heat; heat transfer; hot box; skylight; steady state; surround panel; thermal performance; transmittance; U-factorwindows

# APPENDIXES

## (Nonmandatory Information)

## X1. GARAGE DOORS AND ROLLING DOORS

X1.1 Garage doors and rolling doors are excluded from this standard, pending work being undertaken by an NFRC garage door/rolling door U-factor task group. The task group is composed of garage door manufacturers and rolling door manufacturers belonging to the Door & Access Systems Manufacturers Association (DASMA) along with interested parties experienced with U-factor testing of other fenestration products. The task group has been charged with developing and recommending the most suitable and repeatable provisions for testing and simulating U-factors for garage doors and rolling doors.

X1.2 Work is also being undertaken via an ASHRAE research project intending to validate methods of determining U-factor values for garage doors and rolling doors. The work is expected to be forwarded to the NFRC garage door/rolling door U-factor task group upon successful completion of the project.

X1.3 In the meantime, two documents currently exist addressing U-factor testing for such doors. DASMA has developed and published ANSI/DASMA 105-1998. The document can be used to determine $U_s$, which is the U-factor based on measured surface coefficients. Separately, NFRC has developed and published NFRC 102-2002. The document can be used to determine either $U_s$ or $U_{st}$ which is the U-factor based on standardized surface coefficients. $U_{st}$ can be determined using either the Area-Weighted method or the Calibrated Transfer Standard method. Potential users are encouraged to contact either DASMA or NFRC for further information on their respective standards, or for updates on the status of the NFRC task group work.

## X2. RELATED PUBLISHED MATERIAL


AAMA Standard 1503-98 Voluntary Test Method for Thermal Transmittance and Condensation Resistance of Windows, Doors and Glazed Wall Sections.[6]

ASHRAE Handbook, 1997 Fundamentals Volume[5] American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc.

Bowen, R. P., and Solvason, K. R., "A Colarimeter for Determining Heat Transmission Characteristics of Windows," Thermal Insulated Materials and Systems, *ASTM STP 922*, ASTM.

BS 874 Part 3: Section 3.1: 1987 Methods for Determining Thermal Insulation Properties, Part 3 Tests for Thermal Transmittance and Conductance, Section 3.1 Guarded Hot Box Method.[5]

BS 874 Part 3: Section 3.2: 1990, Methods for Determining Thermal Insulation Properties, Part 3. Tests for Thermal Transmittance and Conductance, Section 3.2 Calibrated Hot Box Method.[5]

BS 874: Methods for Determining Thermal Insulation Properties with Definitions of Thermal Insulating Terms.[5]

C177 Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.[2]

C518 Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.[2]

C1045 Practice for Calculating Thermal Transmission Properties Under Steady-State Conditions.[2]

C1114 Test Method for Steady-State Thermal Transmission Properties by Means of the Thin-Heater Apparatus.[2]

C1363 Test Method for Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus.

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Houghton, F. C., and McDermott, P., "Wind Velocity Gradients Near a Surface and Their Effect on Film Conductance," ASHVE Transactions, Vol 37, pp. 201-322.

ISO 8990 Thermal Insulation-Determination of Steady-State Thermal Transmission Properties-Calibrated and Guarded Hot Box.[5]


[6] Available from American Architectural Manufacturers Association (AAMA), 1827 Waldron Office Square, Suite 550, Schaumburg, IL 60173–4268, http://www.aamanet.org.

[7] Available from National Institute of Building Sciences (NIBS), 1090 Vermont Avenue, NW, Suite 700, Washington, DC 20005, http://www.nibs.org.

ISO/DIS 12567 Thermal Insulation - Determination of Thermal Resistance of Components - Hot Box Method for Windows and Doors.[5]

Lowinski, J. F., "Thermal Performance of Wood Windows and Doors," ASHRAE Transaction, Vol 85, Part 1, 1979.

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NFRC 100-97 Procedure for Determining Fenestration Product Thermal U-factors.[4]

Parmelee, G. V., "Heat Transmission Through Glass: Part II - Solar Heat Transmission by Windows and Glass Panels," ASHVE Research Bulletin, Vol 53, No. 1, July 1947, pp. 89-158.

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