



National Fenestration
Rating Council®

National Fenestration Rating Council Incorporated

NFRC 102-200410

Procedure for
Measuring the Steady-State Thermal Transmittance
of Fenestration Systems

© ~~2004~~ 2010 NATIONAL FENESTRATION RATING COUNCIL, INC.

~~Published June 2004~~
~~First Edition~~

PREPARED BY:

National Fenestration Rating Council
6305 Ivy Lane, Suite 140
Greenbelt, MD 20770
Voice: (301) 589-1776
Fax: (301) 589-3884
Email: info@nfr.org
Website: www.nfr.org



FOREWORD

~~This NFRC procedure is for use by the NFRC Accredited Testing Laboratories and laboratory inspector(s). It is intended to be a companion document to ASTM C1199-009, specifying specific NFRC requirements and deviations. It is also intended to eliminate the necessity to interpret vague or general statements from all other referenced test documents.~~

~~This NFRC procedure is a compilation of information from ASTM C1199, data from hundreds of thermal performance tests by technicians and engineers, NFRC round robin data, and technical interpretations by NFRC.~~

~~This procedure incorporates or references many aspects of ASTM C1199 and ASTM C1363, with modifications adopted by NFRC. NFRC is working cooperatively with ASTM and the ISO with the goal of having a single unified test procedure. It is the intention of NFRC to adopt a harmonized standard when established.~~

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

~~National Fenestration Rating Council
8484 Georgia Avenue, Suite 320
Silver Spring, MD 20910
Voice: (301) 589-1776
Fax: (301) 589-3884
Email: info@nfre.org
Website: www.nfre.org~~



Table of Contents

Table of Contents	iii
1. Scope.....	1
2. Referenced Documents	1
3. Terminology.....	2
4. Significance and Use	3
5. Apparatus	3
6. Calibration.....	4
7. Experimental Procedure	7
8. Calculation of Thermal Transmittance	11
9. Calculation of Standardized Thermal Transmittance.....	12
10. Report.....	13
11. Precision and Bias	14
Annexes (Mandatory Information)	15
ANNEX A3. STANDARD TEST METHOD FOR DETERMINING THE THERMAL TRANSMITTANCE OF TUBULAR DAYLIGHTING DEVICES	15
Figure A3.1 TDD Hot Box for Testing in the Insulation at Ceiling Configuration	16
Figure A3.2 TDD Hot Box for Testing in the Insulation at Roof Configuration	17
Figure A3.3 Metering Chamber Calibration Transfer Standard	19
Figure A3.4 Climatic Chamber Calibration Transfer Standard	20
Figure A3.5 Attic Chamber Calibration Transfer Standard	21
Figure A3.6 Climatic Chamber CTS Installation	24
Figure A3.7 Attic Chamber CTS Installation	25
Figure A3.8 Metering Chamber CTS Installation.....	26
ANNEX A4. GARAGE PANEL AND ROLLING DOOR INSTALLATION.....	27
ANNEX A5. TABLES AND FIGURES	28
Table A5-1: Product Types and Model Sizes	28

Figure A5-1: Thermocouple Location Two-Lite Curtain Wall, Patio Door ..	29
Figure A5-2: Thermocouple Location Casement, Projected (Awning).....	30
Figure A5-3: Thermocouple Location Fixed	31
Figure A5-4: Thermocouple Location Horizontal Slider.....	32
Figure A5-5: Thermocouple Location Vertical Slider.....	33
Figure A5-6: Thermocouple Location Entrance Door.....	34
Figure A5-7: Thermocouple Location Divider	35
Figure A5-8: Example of Method to Determine Interior and Exterior Wetted 2-D Surface Areas.....	36
Figure A5-9: Garage Door Installation	37
Figure A5-10: Thermocouple Location Four Panel Garage Door	38
Figure A5-11: Rolling Door Installation.....	39
Figure A5-12: Thermocouple Locations for Garage Doors.....	40
Bibliography	41
Index	42

1. SCOPE

The following parts of Section 1: Scope of ASTM C1199-09 are valid for this procedure:

~~1.1~~ ~~Note 1~~ ~~Note 2~~ ~~1.3~~
~~1.5~~ ~~1.6~~ ~~1.7~~ All

~~The following parts of Section 1: Scope of ASTM C1199-00 are amended for this procedure:~~

~~1.2 is replaced with the following:~~

~~1.2(A) This test method refers to the thermal transmittance, U , of a fenestration system installed vertically in the absence of solar and air leakage effects.~~

~~1.4(A) For rating purposes, this test method describes how to calculate a standardized thermal transmittance, U_{ST} . Two standardization methods are described, the Calibration Transfer Standard (CTS) method and the area weighting (AW) method. The method used shall be in accordance with section 8.2(A).~~

2. REFERENCED DOCUMENTS

The following parts of Section 2: Referenced Documents of ASTM C1199-09 are valid for this procedure:

~~2.2~~ ~~2.3~~ All

~~The following parts of Section 2: Referenced Documents of ASTM C1199-00 are amended for this procedure:~~

~~2.1 is amended as follows:~~

~~2.1(A) ASTM Standards: The references to C236 and C976 are invalid in the context of the NFRC Test Procedure. Any references to these documents should refer to the appropriate section of ASTM C1363.~~

3. TERMINOLOGY

The following parts of Section 3: Terminology of ASTM C1199-00~~9~~ are valid for this procedure:

~~3.1~~ ~~3.2.1~~ ~~3.2.2~~ ~~3.2.3.1~~
~~3.2.4~~ ~~3.2.5~~ ~~3.2.5.1~~ ~~3.2.5.2~~
~~3.2.6~~ ~~3.2.7~~ ~~3.2.8~~All

The following parts of Section 3: Terminology of ASTM C1199-00 are amended for this procedure:

~~3.2 is valid in its entirety with the following addition:~~

~~3.2(A) The following additional definitions are valid for this procedure:~~

~~**Test specimen**—effective thermal conductance, C —The time rate of heat flow through a unit area of a test specimen (fenestration system), induced by a unit temperature difference between the test specimen surfaces. It is calculated as follows:~~

$$C_s = \frac{1}{(1/U_s - 1/h_h - 1/h_c)} \quad (1A)$$

~~**View Factor**—The portion of the metering box "viewed" by the test specimen that is exchanging radiation with the interior test specimen surface. This area of the metering box would be comprised of the baffle surface and any portion of any perimeter metering box wall that the test specimen is exchanging radiation with at a 90° incident angle. For most test specimens using this method, the metering box baffle would be the only surface exchanging radiation with the test specimen.~~

~~**Projecting Products**—A non-planar product where the glazing projects outward past the cold-side surround panel surface plane (i.e. skylights, garden windows).~~

~~3.2.3 is valid in its entirety with the following addition:~~

~~3.2.3(A) —The following equation may be used as an alternate.~~

$$U_{ST} = \frac{1}{\left[\left(\frac{1}{h_{STh}} \right) + \left(\frac{1}{C_s} \right) + \left(\frac{1}{h_{STc}} \right) \right]} \quad (2A)$$

~~3.3 is valid in its entirety with the following addition:~~

~~3.3(A) The following definitions are valid for this procedure:~~

~~C_s = thermal conductance of test specimen (surface to surface), $W/m^2 \cdot C$ $Btu-in/hr \cdot ft^2 \cdot ^\circ F$~~

~~t_{spL} = area-weighted room side surround panel surface temperature, $^\circ C$ ($^\circ F$)~~

t_{sp2} = ~~area-weighted weather-side surround panel surface temperature, °C (°F)~~

4. SIGNIFICANCE AND USE

~~The following parts of Section 4: Significance and Use of ASTM C1199-09 is to be considered non-mandatory information are valid for this procedure:~~

~~4.1 — 4.3 — 4.3.2 — 4.3.3~~

~~Note 3~~

~~The following parts of Section 4: Significance and Use of ASTM C1199-00 are amended for this procedure:~~

~~4.2 is replaced with the following:~~

5. APPARATUS

~~The following parts of Section 5: Apparatus of ASTM C1199-09 are valid for this procedure:~~

~~All, with additions noted below~~

~~The following parts of Section 5: Apparatus of ASTM C1199-09 are amended for this procedure:~~

~~5.1.3.2 is valid in its entirety with the following addition:~~

~~For garage and rolling doors, specimens shall be sealed so as to anticipate movement of the specimen due to thermal stresses. These specimens shall be sealed at both the interior and exterior surfaces.~~

~~4.2(A) 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 thermal transmittance of fenestration systems are specified below.~~

~~NFRC Test Conditions:~~

- ~~1. — Interior ambient temperature of 21.1°C (70.0°F) $\pm 0.3^{\circ}\text{C}$ (0.5°F).~~
 - ~~2. — Exterior ambient temperature of -18°C (0°F) $\pm 0.3^{\circ}\text{C}$ (0.5°F).~~
 - ~~3. — The interior relative humidity shall be maintained at or below 15%.~~
-

4. ~~An interior measured film coefficient during CTS panel(s) calibration testing of 7.67 W/(m²AEC) (1.35 Btu/hAft²AEF) (± 5%).~~
5. ~~An exterior measured film coefficient during CTS panel(s) calibration testing of 30.0 W/(m²AEC) (5.28 Btu/hAft²AEF) (± 10%).~~
6. ~~A combined film coefficient during CTS panel(s) calibration testing of 6.108 W/(m²AEC) (1.076 Btu/hAft²AEF) (± 5%).~~

~~4.3.1 is valid in its entirety except for a typographical error.~~

~~In the first sentence, a reference to "h_i and h_e" should be "h_i and h_e".~~

~~4.4 is replaced with the following:~~

~~4.4(A) The thermal transmittance of a test specimen is affected by its size and three-dimensional geometry. Therefore, it is mandatory that fenestration systems be tested at the sizes specified in Table 1 of the current version of NFRC 100.~~

5.6. CALIBRATION

The following parts of Section ~~65~~: Calibration of ASTM C1199-09~~0~~ are valid for this procedure:

All, with additions noted below	5.1	5.1.1	5.1.2	5.1.2.2
Note 4	Note 5	5.1.4	5.1.4.1	
Note 6	5.2	5.2.1	5.2.1.1	
Note 7	5.2.1.2	5.2.2	5.2.2.1	
5.2.3	5.2.3.1	5.2.4	5.2.4.1	
5.2.4.3	Note 8	5.2.4.4	5.2.4.5	
5.2.4.6	Note 9	5.2.4.7	Note 10	
5.2.4.7(2)	Note 11	5.2.4.7(3)	Note 12	
5.3	5.3.1	5.3.2	5.3.3	
Note 13	5.3.4	Note 14		

The following parts of Section ~~65~~: Calibration of ASTM C1199-09~~0~~ are amended for this procedure:

~~5.1.2.1 is valid with the following change:~~

~~5.1.2.1(A) A surround panel, consisting of a stable homogeneous thermal insulation material with a thermal conductivity at 24°C (75°F) not in excess of 0.03 W/(mAK) (0.02 Btu/hAft²AEF) and having a very low gas permeance, shall be provided for mounting the test specimen (see Figure 1). For structural integrity, the homogeneous insulation core may be sandwiched~~

between two sheets of a support material having a very low gas (air and water vapor) permeance and stable thermal and dimensional properties. The surface of the surround panel shall have an emissivity greater than 0.8. The opening in the central homogeneous insulation board core may be covered with a nonreflecting tape to minimize surface damage. The thickness of the homogeneous insulation core of the surround panel (see Figure 2) shall be at least the maximum thickness of the test specimen (usually one part of the test specimen frame) and shall be in no circumstances less than 100 mm (4 in.). The maximum thickness of the homogeneous insulation core of the surround panel shall be no more than 25 mm (1 in.) greater than the maximum thickness of the test specimen. That is, for test specimen maximum thicknesses less than or equal to 100 mm (4 in.), the surround panel core thickness shall be 100 mm (4 in.). For test specimen maximum thicknesses greater than 100 mm (4 in.) and up to 125 mm (5 in.), the surround panel core thickness shall be 125 mm (5 in.). For test specimen maximum thicknesses greater than 125 mm (5 in.) and up to 150 mm (6 in.), the surround panel core thickness shall be 150 mm (6 in.) and so on for larger test specimens. Unless specifically required for test specimen mounting purposes (very high mass test specimens like patio doors or large curtain walls), no thermal anomalies (that is, thermal bridges like wood or metal) shall exist in the surround panel. In those specific situations where the surround panel is not homogeneous, a detailed drawing describing the surround panel and the thermal anomaly materials and the modified surround panel construction, along with the measured thermal conductance (using Test Methods C 177 or C 518) of all materials used shall be included with the test report. It is required that the thermal conductance (C_{sp} , surface to surface including facing and core materials) of a sample of the surround panel be measured in a guarded hot plate (Test Method C177) or a heat flow meter (Test Method C518) at a 1.5°C (35 °F) mean (moderate winter @ 21.1°C ± 18°C (70.0°F/0°F)). It is also recommended that thermal conductance be measured at two additional temperatures that cover conditions experienced during testing.

5.1.3 is valid with the following change:

5.1.3(A) — The projected area of the Calibration Transfer Standard shall cover the same range as the test specimen model size and tolerances as specified in the current version of NFRC 100. Two Calibration Transfer Standards shall be used; one approximately the largest model size to be tested and one approximately the smallest model size to be tested.

~~The CTS Panel values used shall be those closest to the representative size of the test specimen in relation to the appropriate CTS Panel size.~~

~~5.1.4.2 is replaced with the following:~~

~~5.1.4.2(A) — *Air temperatures* — The air temperature sensors shall be located 75 mm (3 in.) from the surface of the surround panel. The air temperature sensors shall be arranged in a vertical grid network, with a minimum density of two sensors per square meter of metering area, but not less than nine. The rows and columns closest to the metering box walls shall be located at a minimum distance of 150 mm (6 in.) from each meter box wall. Parallel averaging of air temperatures shall be allowed on vertical elevations (horizontal rows) only.~~

~~This equation shall also apply to the radiating surface temperatures, surround panel surfaces, and each meter box wall individual surface. Locations are to be evenly distributed to properly characterize each individual surface area.~~

~~5.1.5 is replaced with the following:~~

~~5.1.5(A) — *Air leakage* — All fenestration product types shall be sealed at the warm side surface. A specimen with a primary/secondary (storm window) application shall be sealed at the warm side of each application. Weep holes/slots located on the cold side shall be sealed on the cold side. In addition, all requirements of ASTM E1423, Section 7.1.3 and Note 4, should be followed, except where in conflict with the above language.~~

~~65.12.32.2 is valid in its entirety replaced with the following addition:~~

~~5.2.3.2(A) — NFRC Criteria for NFRC SS steady State conditions may also be determined as follows:~~

1. Determining steady-state involves two separate evaluations. First, a series of four hourly sets of data are compared to the group mean to determine if steady state has been achieved. Second, two additional consecutive two-hour test periods are individually compared to the average initial four-hour period and each other to verify steady-state conditions are maintained. The following tests are applied to both assessments.
2. The average room and weather side air temperatures and all other surface temperatures shall not vary by more than $\pm 0.3^{\circ}\text{C}$ ($\pm 0.5^{\circ}\text{F}$) over the entire eight (8) hour steady state period. (See ASTM C1363 requirements.)

3. The total heat input into the metering box, Q (including Q_{mb} , Q_{fl} , and warm room heater and circulating fan power) shall be used to determine steady state. The mean of the four one-hour steady state periods shall agree within $\pm 1\%$ of the mean of each of the two hour test periods and each of the two (2) two-hour test periods must be within $\pm 1\%$ of one another.
4. As an alternative, steady-state conditions and time constant may be determined per ASTM C1363.

~~65.21.43.2~~ is valid in its entirety with the following addition:

~~5.2.4.2(A)~~—As a secondary check on Q_s , the following equation is required:

$$Q_s = Q - Q_{sp} - Q_{fl} \quad (14A,2A)$$

This equation shall produce the same result as the ~~equation (1) or (2)primary equation~~ within $\pm 10\%$

~~5.2.4.7(1) is valid in its entirety with the following addition:~~

~~5.2.4.7(1) (A) The baffle to surround panel interior surface spacing may be adjustable to serve as one means of adjusting the air flow velocity. For the purpose of maintaining a characterized air flow, a minimum spacing of 140.0 mm (5.5 in.) to a maximum of 200 mm (8 in.) is required. (Reference to ASTM C1363; Section 6.8.9.2.)~~

~~5.2.4.7(4), 5.2.4.7(5), and 5.2.4.7(6) are replaced with the following:~~

~~5.2.4.7(A)—Weather side surface heat transfer coefficient, h_c~~

$$h_c = \frac{Q_s}{[A_s (t_2 - t_c)]} \quad (5A)$$

~~Where t_2 is calculated according to equation (17)~~

~~The following parts of Section 5: Calibration of ASTM C1199-00 are invalid for this procedure:~~

~~5.1.4.2 5.2.3.2 5.2.4.7(4) 5.2.4.7(5)
5.2.4.7(6)~~

6.7. EXPERIMENTAL PROCEDURE

The following parts of Section ~~67~~: Experimental Procedure of ASTM C1199-~~009~~ are valid for this procedure:

~~All except 7.5.2.1, 7.5.2.2, 7.5.4, and 7.5.4.16.1~~ ~~6.2~~ ~~6.3~~
~~6.3.1~~
~~6.4~~ ~~6.5~~ ~~6.5.1~~ ~~6.5.2~~
~~6.5.2.3~~ ~~6.5.3~~ ~~6.5.4.2~~

The following parts of Section 6: Experimental Procedure of ASTM C1199-009 are amended for this procedure:

~~6.2.1 is valid in its entirety with the following addition:~~

- ~~6.2.1(A) Skylights shall be tested in a configuration that is as close to the actual installation as possible (without flashing) with the following conditions:~~
- ~~1. Curb Mounted skylights that do not have an integral curb attached shall be simulated and tested installed on a nominal 40mm by 90 mm (1 1/2 in by 3 1/2 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 NFRC 100 is based on a center of the rafter to 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 product 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.~~

~~6.4.1 is replaced with the following:~~

- ~~6.4.1(A) Establish, as per the procedure in section 5.2.3.2(A), steady-state temperature and power conditions for which the test specimen is to be tested and record measurements of power,~~

~~temperatures, and velocity at no greater than five minute intervals throughout the steady state test period.~~

76.5.2.1 is replaced with the following:

76.5.2.1(A) Additional temperature measurements shall be made on the surround panel wall. There shall be a minimum of eight temperature sensors, with four at positions bisecting the four lines from the corners of the surround panel aperture to the corresponding corners of the metering area, and four at the positions bisecting the sides of the rectangle having the first four thermocouples at its corners.

76.5.2.2 is replaced with the following:

76.5.2.2(A) When using the CTS Method, the attachment of interior and exterior surface thermocouples to the test specimen shall be voluntary. For the Area-weighted Method it is a requirement to make temperature measurements on the fenestration system frame, glazing (center and near edges) and on any other test specimen surfaces (sills, muntins, etc.), in order to provide a representative area weighted value of the fenestration system surface to surface temperature difference. It must be recognized that there is a wide range of fenestration system designs, therefore it is not possible to specify the locations of the test specimen temperature sensors to provide a correct area weighted determination of the various surface temperatures for all configurations. Area-weighting surface temperature measurements are obtained by placing each predetermined individual temperature sensor in the center of surface area that represents the average temperature of those areas. Consequently, thermocouples may be placed on both horizontal and vertical surfaces depending on the geometry of the test sample. The cross sections in Figure 1 to Figure 7 show typical interior and exterior specimen surface temperature locations. Additional thermocouples may be needed to adequately capture the average temperatures and areas of the test specimen. Each glazing corner edge thermocouple shall be placed at a point 13 mm (1/2 in.) from the adjacent framing. The temperature sensors used shall be at a minimum, special limit (premium) thermocouples 30 gage [0.25476 mm (0.01003 in.)], for surface temperature measurements. Placement shall be as such to minimize the disturbance of the air flows on the surfaces of the test specimen.

~~6.5.2.2(A).a The attachment of thermocouples shall be performed by using a nominal 25 mm (1 in.) wide by 100 mm (4 in.) long 3M 425 aluminum tape with the 100 mm (4 in.) dimension parallel to the thermocouple wire. The surface emissivity of the tape shall~~

be similar (± 0.1) to the surface emissivity of the sample.
(Refer to NFRC 101 for guidance.)

~~76.5.4, 76.5.4.1, 6.5.4.3~~ are replaced with the following:

~~76.5.4(A)~~ Wind Speed Measurements -The exterior applied dynamic wind (perpendicular or parallel) shall produce an exterior film coefficient of $30.0 \text{ W}/(\text{m}^2\text{AEC})$ ($5.28 \text{ Btu}/\text{hAft}^2\text{AEF}$) $\pm 10\%$ during calibration testing of a CTS Panel. The weather side wind speed shall be measured in the free stream condition. One such method for perpendicular weather side wind would be to have the exterior wind speed measured at the mid-point area of the exit aperture of the discharge plenum. The sensor shall be located a maximum distance of 150 mm (6 in.) toward the wind generator from the vertical plane of the exit aperture. Note that the center of the exit aperture and the center of the test specimen should be in the same plane as noted in Section 5.1.4.

For parallel flow patterns, this location shall be in the free air stream such that the wind speed sensor is not in the test specimen surface boundary layers or wakes. A distance of 75 mm (3 in.) out from the exterior surface of the surround panel, at the center point, is required.

~~76.5.4.1(A)~~ Periodic traversing of the weather side air flow field, to determine the air velocity distribution, is required during annual CTS Panel calibration testing. For the exterior wind flow, 20 equidistant measurements shall be made, with a grid of 4 rows in height and 5 columns in width, to determine the uniformity of the exterior wind velocity.

~~6.5.5 is replaced with the following:~~

~~6.5.5(A) — 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 may 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_{gs} , and the thermal transmittance, U_{gs} , 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:~~

- ~~(1) — Differences in the barometric pressure due to a difference in the elevations of the fenestration manufacturing facility and the testing facility.~~
- ~~(2) — Changes in barometric pressure at the testing facility due to local weather variations.~~

- ~~(3) — Changes in the mean temperature of the glazing unit enclosed airspace during testing.~~

~~Recognizing that glass deflection can cause a change in the thermal conductance, C , and the thermal transmittance, U , an estimation of the gap spacing between the glass sheets 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 measuring the deflection profile of each glass plate and then subtracting the thickness of the individual plates. 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 glazing deflection measurements shall be performed on both sides of the fenestration system and shall be included in the test report. The glazing deflection measurements shall be performed:~~

- ~~(1) — Just before the test commences, and~~
~~(2) — 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.~~

~~The following parts of Section 6: Experimental Procedure of ASTM C1199-00 are invalid for this procedure:~~

~~6.4.1 ————— 6.5.2.1 ————— 6.5.2.2 ————— 6.5.4
6.5.4.1 ————— 6.5.4.2 ————— 6.5.4.3 ————— 6.5.5~~

7.8. CALCULATION OF THERMAL TRANSMITTANCE

The following parts of Section 7.8: Calculation of Thermal Transmittance of ASTM C1199-090 are valid for this procedure:

All

~~7.1 ————— 7.1.1 ————— 7.1.2 ————— 7.1.3
7.1.4~~

$$U_{ST-CTS} = \frac{1}{\left[\left(\frac{1}{h_{STh}} \right) + \left(\frac{1}{C_s} \right) + \left(\frac{1}{h_{STc}} \right) \right]} \quad (8A)$$

~~8.2.8 is valid in its entirety with the following typographical correction:~~

~~8.2.8(A) — Equation (41) should read:~~

$$U_{st[aw]} = \frac{1.0}{\left[\left(\frac{1}{U_s} \right) + \left(\frac{A_s}{A_h} \right) \left(\frac{1}{h_{STh}} - \frac{1}{h_h} \right) + \left(\frac{A_s}{A_c} \right) \left(\frac{1}{h_{STh}} - \frac{1}{h_c} \right) \right]} \quad (9A)$$

~~A_h and A_c shall be determined in accordance with Figure 8.~~

98.2.9.1 is replaced with the following:

98.2.9.1(A) The standardized surface heat transfer coefficients are as specified below:

$$h_{STh} \left(W/m^2 \cdot ^\circ K \right) = 1.46 \left[\frac{(t_h - t_1)}{H} \right]^{0.25} + \sigma e1 \left[\frac{(t_h + 273.16)^4 - (t_1 + 273.16)^4}{(t_h - t_1)} \right]$$

or

$$h_{STh} \left(Btu/h \cdot ft^2 \cdot ^\circ F \right) = 0.30 \left[\frac{(t_h - t_1)}{H} \right]^{0.25} + \sigma e1 \left[\frac{(t_h + 459.67)^4 - (t_1 + 459.67)^4}{(t_h - t_1)} \right]$$

Where

$$\begin{aligned} H &= \text{total height of production m (ft)} \\ h_{STc} &= 30.0 \text{ W/m}^2 \cdot \text{K} \text{ (5.28 Btu-in/hr}\cdot\text{ft}^2 \cdot \text{^\circ F)} \end{aligned}$$

The following parts of Section 98: Calculation of Standardized Thermal Transmittance of ASTM C1199-~~00-09~~ are invalid for this procedure:

9.2 ~~89.2.9.1~~

9.10. REPORT

The following parts of Section 910: Report of ASTM C1199-09 are valid for this procedure:

~~All 9.1.1 — 9.1.2 — 9.1.3 — 9.1.4~~
~~9.1.5 — 9.1.6 — 9.1.7 — 9.1.8~~

9.1.9	9.1.10	9.1.11	9.1.11.1
9.1.11.2	9.1.11.3	9.1.12	9.1.12.1
9.1.12.2	9.1.13	9.1.14	9.1.15
9.2	9.2.1	Note 17	

The following parts of Section 9: Report of ASTM C1199-00 are amended for this procedure:

9.1 is valid in its entirety with the following addition:

9.1(A) The report shall include all of the information required by the NFRC LAP and subsequent NFRC LAP Bulletins. If the test specimen size is non-standard (more than ± 13 mm ($\pm 1/2$ in.) in width and/or height different than the model size referenced in Table 1 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 (example: "1150 mm by 1700 mm — non-standard size"). If the test conditions are non-standard then the text "non-standard test conditions" shall be inserted immediately following the name of the procedure everywhere the test procedure is listed both in the full report and in any summary (example "NFRC Test Procedure — non-standard test conditions").

The following parts of Section 9: Report of ASTM C1199-00 are invalid for this procedure:

None

10.11. _____ PRECISION AND BIAS

The following parts of Section ~~10~~11: Precision and Bias ~~of ASTM C1199-00~~ of ASTM C1199-09 are valid for this procedure:

All

10.1	10.1.1	10.1.1.1	10.1.1.2
10.1.1.3	10.1.1.4	10.1.2	10.1.2.1
10.1.2.2	10.1.2.3	10.1.2.4	10.1.2.5
10.1.2.6	10.1.2.7	10.1.3	10.1.4

The following parts of Section 10: Precision and Bias of ASTM C1199-00 are amended for this procedure:

None

The following parts of Section 10: Precision and Bias of ASTM C1199-00 are invalid for this procedure:

None

~~11.~~ ANNEXES/APPENDICES (MANDATORY INFORMATION)

The following parts of ~~Annex A1 and Annex A2 Section 11 Appendices (Mandatory Information)~~ of ASTM C1199-09~~0~~ are valid for this procedure:

~~A1.1 A1.2 A1.2.1 A2.1
A2.2 A2.2.1 A2.2.2 A2.2.3
A2.2.4 A2.2.5 A2.3 A2.3.1~~

~~The following parts of Appendices (Mandatory Information) of ASTM C1199-00 are amended for this procedure:~~

~~None~~

~~The following parts of Section 11: Appendices (Mandatory Information) of ASTM C1199-00 are invalid for this procedure:~~

~~All/None~~

Annex A3. Standard Test Method for Determining the Thermal Transmittance of Tubular Daylighting Devices

A3.1 Scope

A3.1.1 This appendix covers requirements and guidelines and specifies calibration procedures required for the measurement of the steady-state thermal transmittance of Tubular Daylighting Devices (TDDs). This appendix covers two distinct apparatus setups which are intended to rate the two primary installation methods utilized with these products.

A3.1.2 The general requirements of testing shall be as defined in NFRC 102, ASTM C1199, and ASTM C1363. This appendix will describe the unique apparatus and testing modifications required to accurately test a TDD. Requirements in this appendix shall supersede the requirements in any other documents.

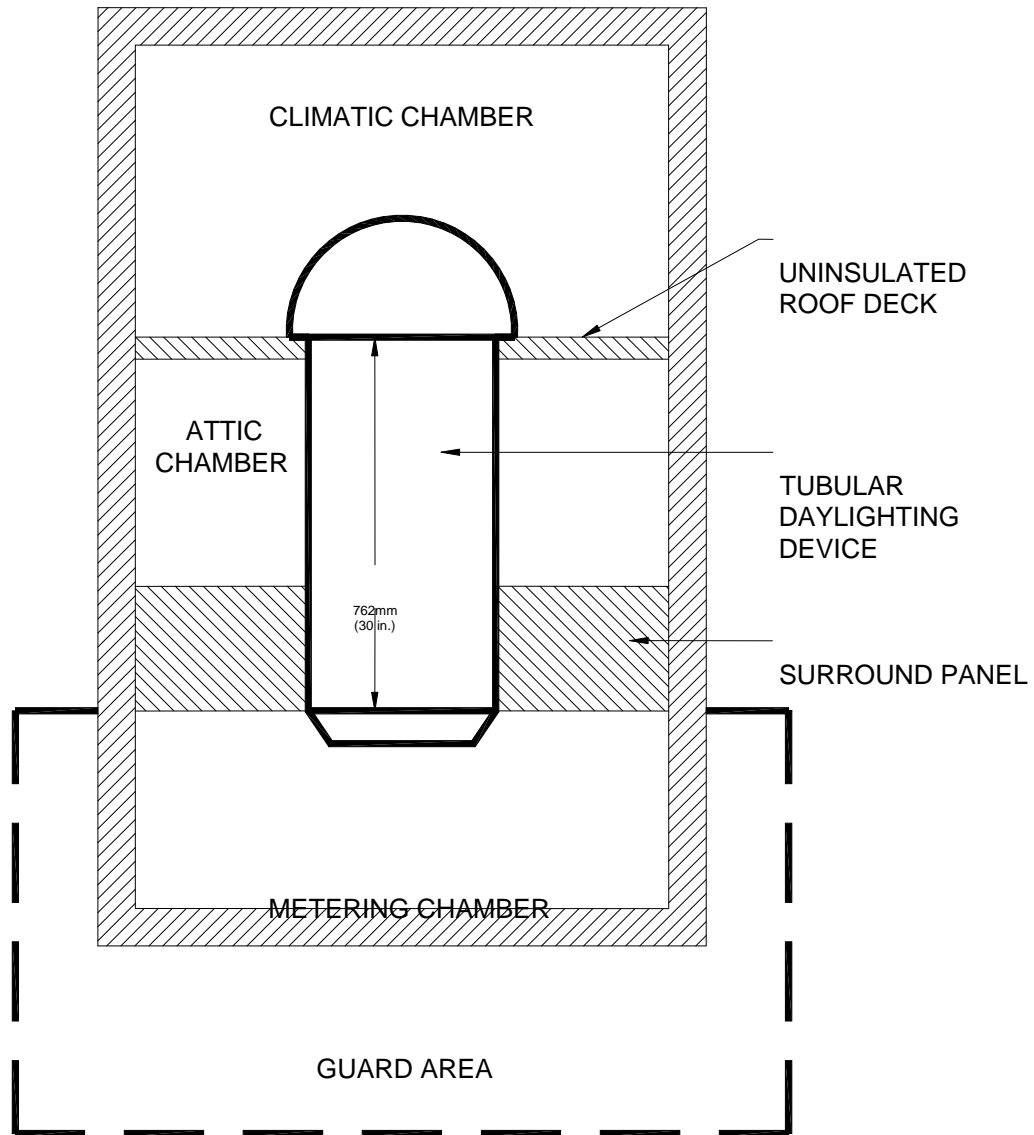
A3.1.3 The primary modifications have been made to accommodate the unique product configuration, small product area, and the requirement for three distinct environmental chambers. Unlike other tests using NFRC 102 and ASTM C1199, the hot box apparatus is configured for a test with heat flow in the vertical direction.

A3.2 Apparatus

A3.2.1 The general concepts and construction specified in ASTM C1363 are applicable to this standard, with some unique modifications. Unlike the standard C1363 apparatus, the TDD hot box apparatus requires three distinct environmental chambers. These chambers are the

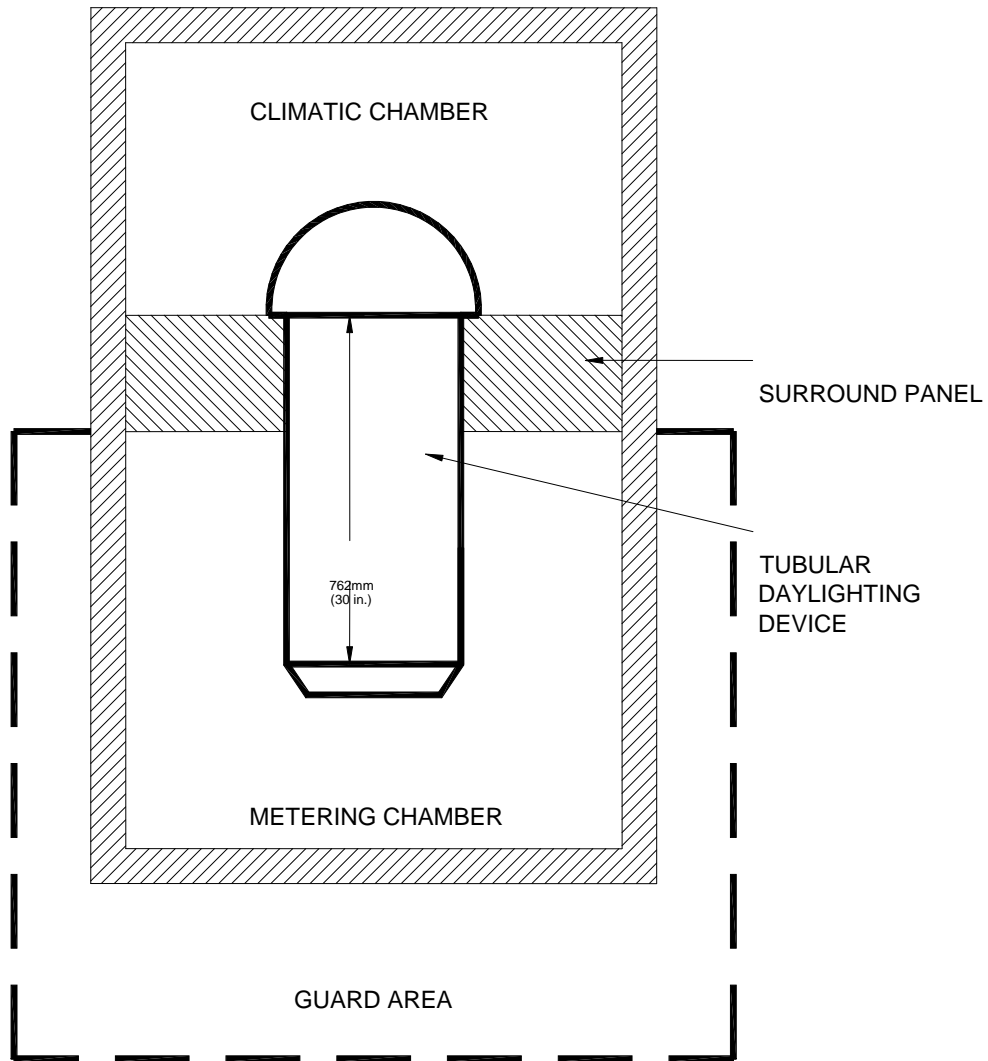
metering chamber, the attic chamber, and the climatic chamber. The chambers are arranged as shown in Figures A3.1 and A3.2. The same apparatus can be utilized for testing in both configurations and this should be considered during design and construction.

Figure A3.1 TDD Hot Box for Testing in the Insulation at Ceiling Configuration



**Figure A3.1 – TDD Hot Box for Testing
in the Insulation at Ceiling
Configuration**

Figure A3.2 TDD Hot Box for Testing in the Insulation at Roof Configuration



**Figure A3.2 – TDD Hot Box for Testing
in the Insulation at Roof Configuration**

A3.2.2 The metering chamber shall comply with standard practices for hot box construction as per ASTM C1363, with the following cautions. Due to the very small size and low heat flow of the specimen being tested, the chamber shall be sized to allow for the maximum ratio of heat flow through the specimen to total heat flow. The metering chamber guard area shall be designed and controlled to minimize wall losses. Minimizing the heat flows through the walls and surround panel are critical to achieving acceptable accuracy with this test method.

A3.2.3 The weather side chamber shall comply with standard practices for hot box construction as per ASTM C1363.

A3.2.4 The attic chamber shall comply with all the standard practices for hot box construction as per ASTM C1363 guidelines for the metering chamber.

A3.3 NFRC Test Conditions

A3.3.1 Metering Chamber Conditions

- (1) Interior ambient temperature of $21.0^{\circ}\text{C}\pm 0.3^{\circ}\text{C}$ ($69.8^{\circ}\text{F}\pm 0.5^{\circ}\text{F}$).
- (2) An interior measured film coefficient during CTS panel calibration testing of $7.67\text{ W/m}^2\text{-}^{\circ}\text{C}$ ($1.35\text{ Btu/hr-ft}^2\text{-}^{\circ}\text{F}$) $\pm 5\%$.

A3.3.2 Climatic Chamber Conditions

- (1) Exterior ambient temperature of $-18.0^{\circ}\text{C}\pm 0.3^{\circ}\text{C}$ ($-0.4^{\circ}\text{F}\pm 0.5^{\circ}\text{F}$).
- (2) An exterior measured film coefficient during CTS panel calibration testing of $30.0\text{ W/m}^2\text{-}^{\circ}\text{C}$ ($5.28\text{ Btu/hr-ft}^2\text{-}^{\circ}\text{F}$) $\pm 10\%$.

A3.3.3 Attic Chamber Conditions

- (1) Attic ambient temperature of $-18.0^{\circ}\text{C}\pm 0.1^{\circ}\text{C}$ ($-0.4^{\circ}\text{F}\pm 0.2^{\circ}\text{F}$).
- (2) An attic measured film coefficient during CTS panel calibration testing of $12.5\text{ W/m}^2\text{-}^{\circ}\text{C}$ ($2.20\text{ Btu/hr-ft}^2\text{-}^{\circ}\text{F}$) $\pm 5\%$.

A3.4 Calibration

A3.4.1 Calibration Transfer Standards – The unique geometry of TDDs requires the use of a very unique CTS panel. The CTS is constructed of three sections as detailed below and in Figures A3.3, A3.4, and A3.5. All panels shall be constructed using a 12.7mm (0.5in) thick core material and 3mm (0.125in) facing material. All thermocouples shall be mounted on the exterior of the facing materials. The thermal conductance of the CTS core, C_{ts} , and the CTS assembly, $C_{ts[assembly]}$, shall be measured as specified in Annex A.1 of ASTM C 1199.

A3.4.1.1 Metering Chamber CTS – This panel is shown in Figure A3.3 and is the most standard of the three required CTS constructions, representing the interior diffuser of the TDD. The panel shall be 343mm x 343mm (13.5in x 13.5in). and shall be instrumented with nine thermocouples. It shall be mounted inset in the surround panel so that the face of the CTS in the metering room is flush with the face of the surround panel.

Figure A3.3 Metering Chamber Calibration Transfer Standard

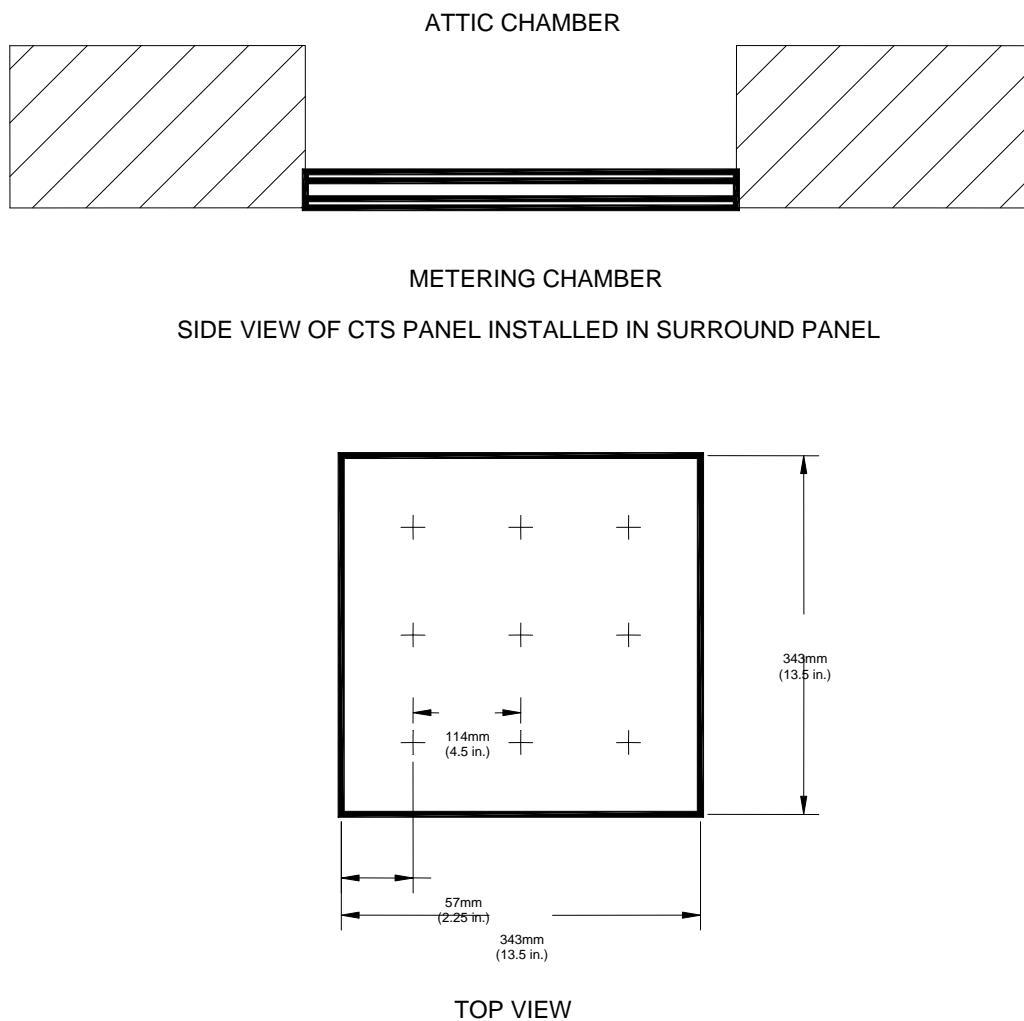
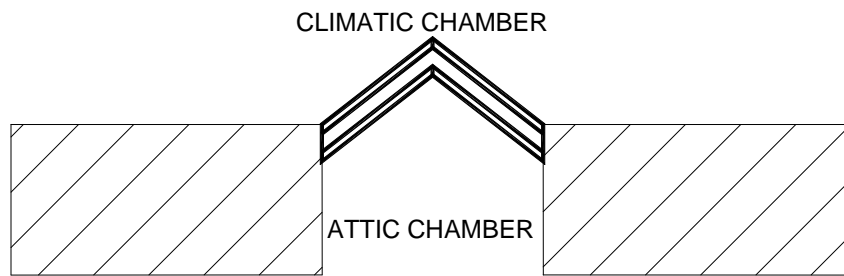


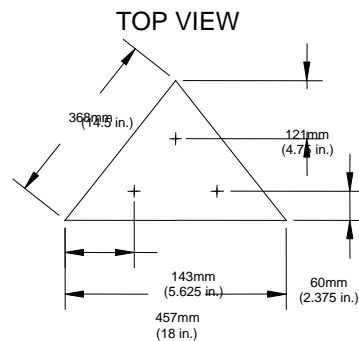
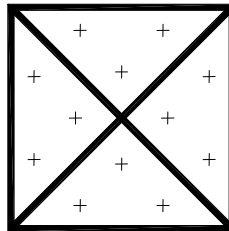
Figure A3.3 – Metering Chamber Calibration Transfer Standard

A3.4.1.2 Climatic Chamber CTS – This panel is shown in Figure A3.4 and is the most unique of the three required CTS constructions, representing the exterior dome of the TDD. This panel is pyramidal in shape, with four equal triangular sides. It shall be 203mm (8in) in height, when assembled, with a 457mm x 457mm (18in x 18in) base and shall be instrumented with twelve thermocouples, three on each face.

Figure A3.4 Climatic Chamber Calibration Transfer Standard



SIDE VIEW OF CTS PANEL INSTALLED IN SURROUND PANEL

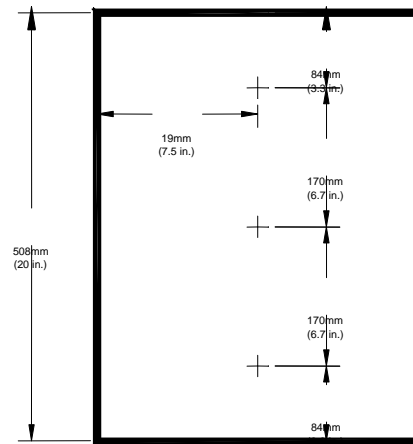


PANEL LAYOUT

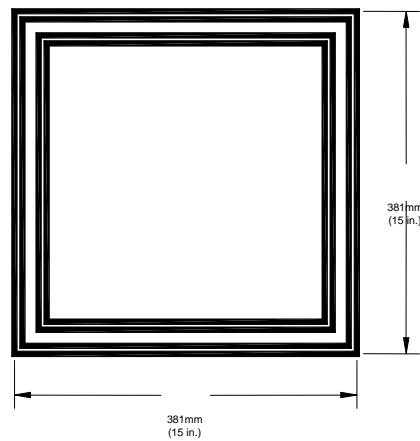
Figure A3.4 – Climatic Chamber Calibration Transfer Standard

A3.4.1.3 Attic Chamber CTS – This panel is shown in Figure A3.5 and is like four standard CTS joined into a tube, representing the tube of the TDD. The panel shall be 38.1mm x 38.1mm (15in x 15in). and shall be instrumented with twelve thermocouples.

Figure A3.5 Attic Chamber Calibration Transfer Standard



SIDE VIEW



TOP VIEW

Figure A3.5 – Attic Chamber Calibration Transfer Standard

A3.4.2 Calibration Tests – There are two distinct testing configurations required for TDDs. The metering box wall characterization shall be performed as specified in ASTM C1363 for both testing configurations. Three distinct surface heat transfer coefficients representing the climate, attic and metering chambers shall also be determined for each testing configuration.

Full characterization will require the following tests:

- (1) Metering Box Wall and Flanking Loss Calibration as specified in ASTM C1363, three tests covering a full range of expected EMF, in the Insulation at Ceiling Configuration
- (2) Metering Box Wall and Flanking Loss Calibration as specified in ASTM C1363, three tests covering a full range of expected EMF, in the Insulation at Roof Configuration
- (3) Climatic Chamber CTS Surface Heat Transfer Verification at the conditions specified in section A3.3
- (4) Attic Chamber CTS Surface Heat Transfer Verification at the conditions specified in section A3.3.
- (5) Metering Chamber CTS Surface Heat Transfer Verification at the conditions specified in section A3.3.

The CTS calibration setups are shown in Figures A3.6, A3.7, and A3.8. Metering Box Wall and Flanking Loss shall be calculated as described in ASTM C1363. The surface heat transfer coefficients shall be calculated as described in the following sections. The CTS calibration is an iterative process, which may require adjustment of each individual chamber. The final surface heat transfer coefficients shall be determined and reported for all three panels, after all adjustments have been made.

A3.4.2.1 *Room side surface heat transfer coefficient, h_h* is calculated as follows:

$$h_h = Q_{sm} / (A_{sm} \cdot (t_h - t_{1m})) \quad (\text{A3.1})$$

Where:

Q_{sm} = Metering Chamber CTS heat flow, calculated from:

$$Q_{sm} = C_{ts[\text{assembly}]} \cdot A_{sm} \cdot (t_{1m} - t_{2m}) \quad (\text{A3.2})$$

A_{sm} = Area of the exposed cold side of the Metering Chamber CTS

t_{1m} = Area weighted average temperature of the warm side of the Metering Chamber CTS

t_{2m} = Area weighted average temperature of the cold side of the Metering Chamber CTS

A3.4.2.2 *Weather side surface heat transfer coefficient, h_c* is calculated as follows:

$$h_c = Q_{sc} / (A_{sc} \cdot (t_{2c} - t_c)) \quad (\text{A3.3})$$

Where:

Q_{sc} = Climatic Chamber CTS heat flow, calculated from:

$$Q_{sc} = C_{ts[\text{assembly}]} \cdot A_{sc} \cdot (t_{1c} - t_{2c}) \quad (\text{A3.4})$$

A_{sc} = Area of the warm side of the Climatic Chamber CTS panel

t_{1c} = Area weighted average temperature of the warm side of the Climatic Chamber CTS

t_{2c} = Area weighted average temperature of the cold side of the Climatic Chamber CTS

A3.4.2.3 *Attic side surface heat transfer coefficient, h_a* is calculated as follows:

$$h_a = Q_{sa} / (A_{sa} \cdot (t_{2a} - t_a)) \quad (\text{A3.5})$$

Where:

Q_{sa} = Attic Chamber CTS heat flow, calculated

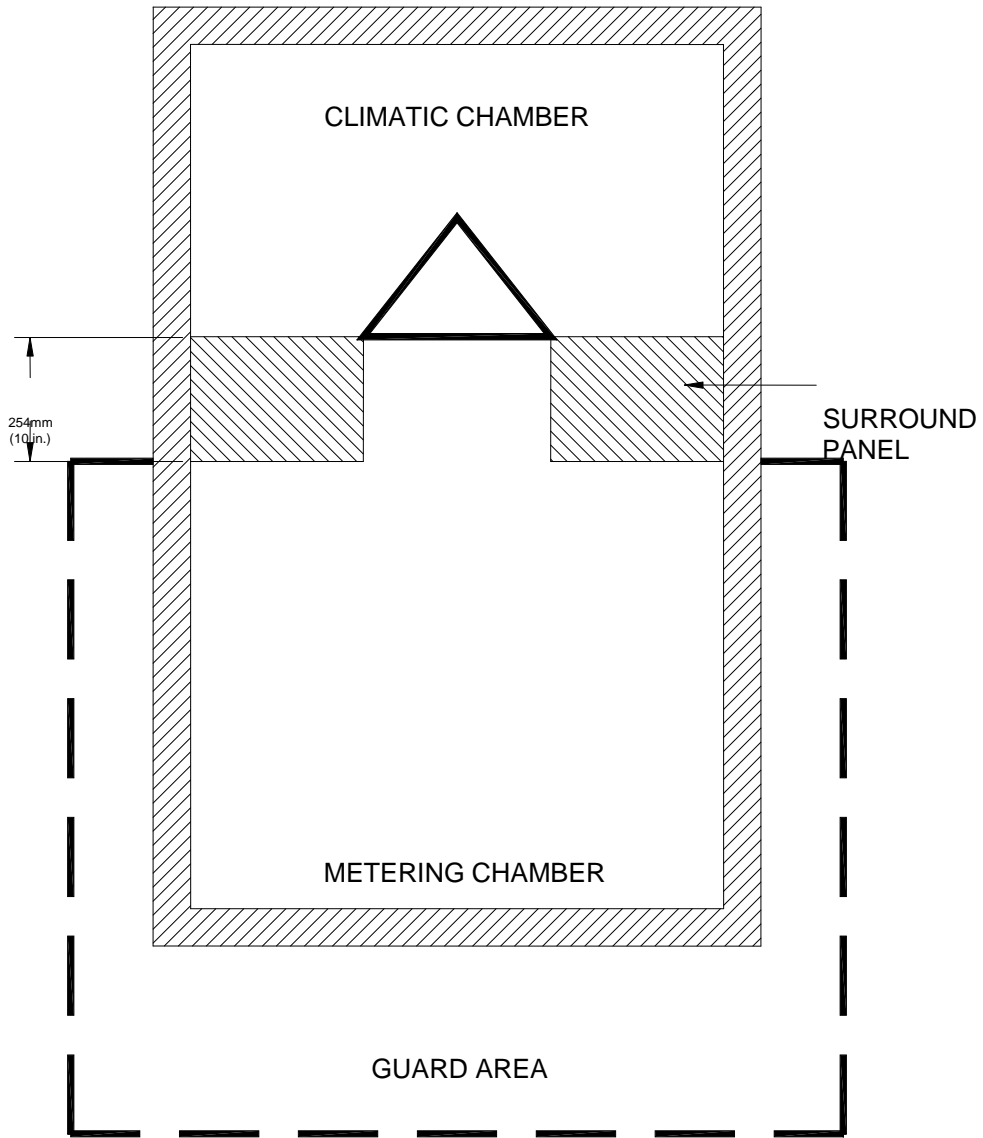
$$Q_{sa} = C_{ts[\text{assembly}]} \cdot A_{sa} \cdot (t_{1a} - t_{2a}) \quad (\text{A3.6})$$

A_{sa} = Area of the warm side of the Attic Chamber CTS panel

t_{1a} = Equal area weighted average temperature of the warm side of the Attic Chamber CTS

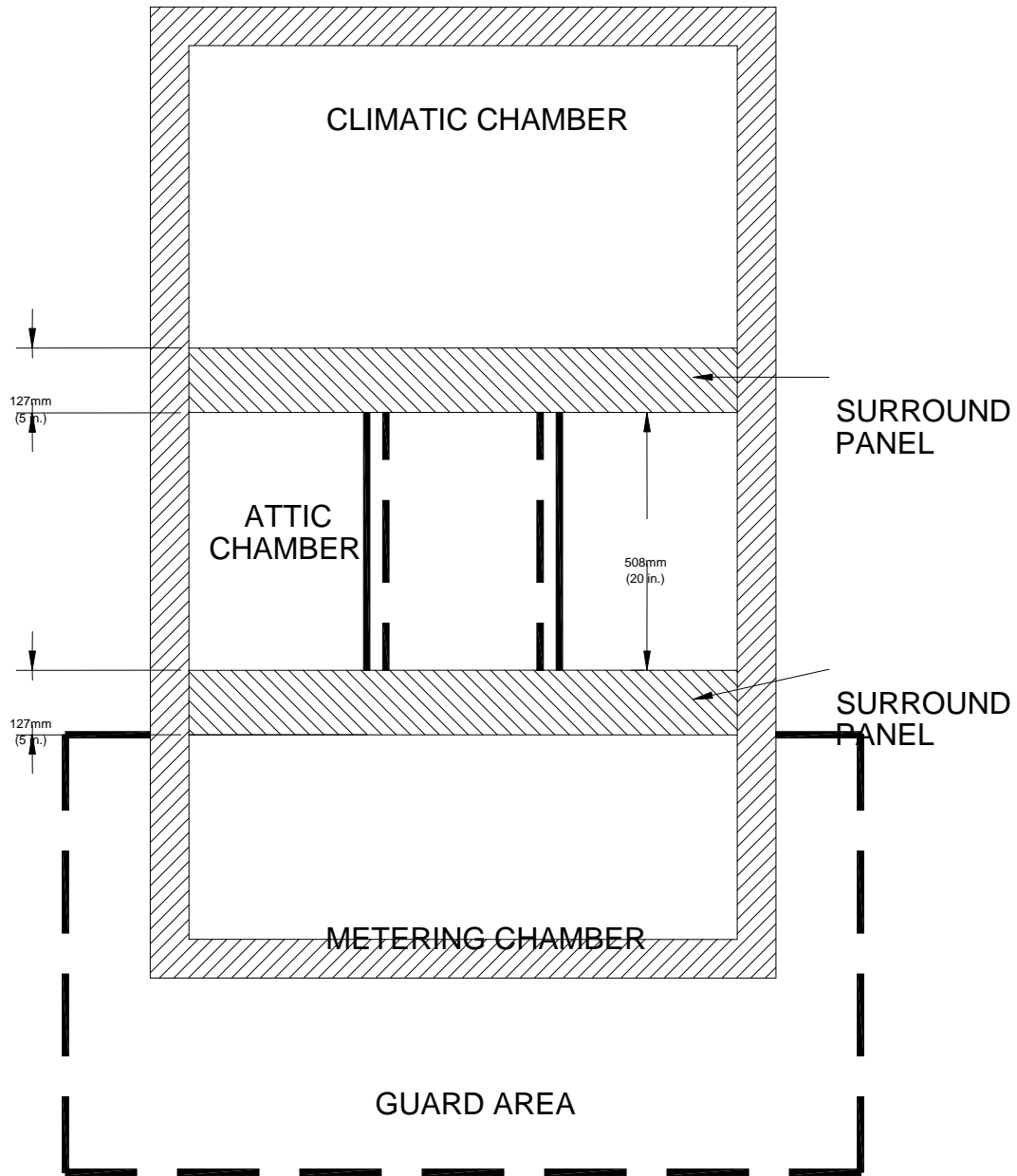
t_{2a} = Equal area weighted average temperature of the cold side of the Attic Chamber CTS

**Figure A3.6 Climatic Chamber CTS
Installation**



**Figure A3.6 – Climatic Chamber
CTS Installation**

Figure A3.7 Attic Chamber CTS Installation



**Figure A3.7 - Attic Chamber
CTS Installation**

Figure A3.8 Metering Chamber CTS Installation

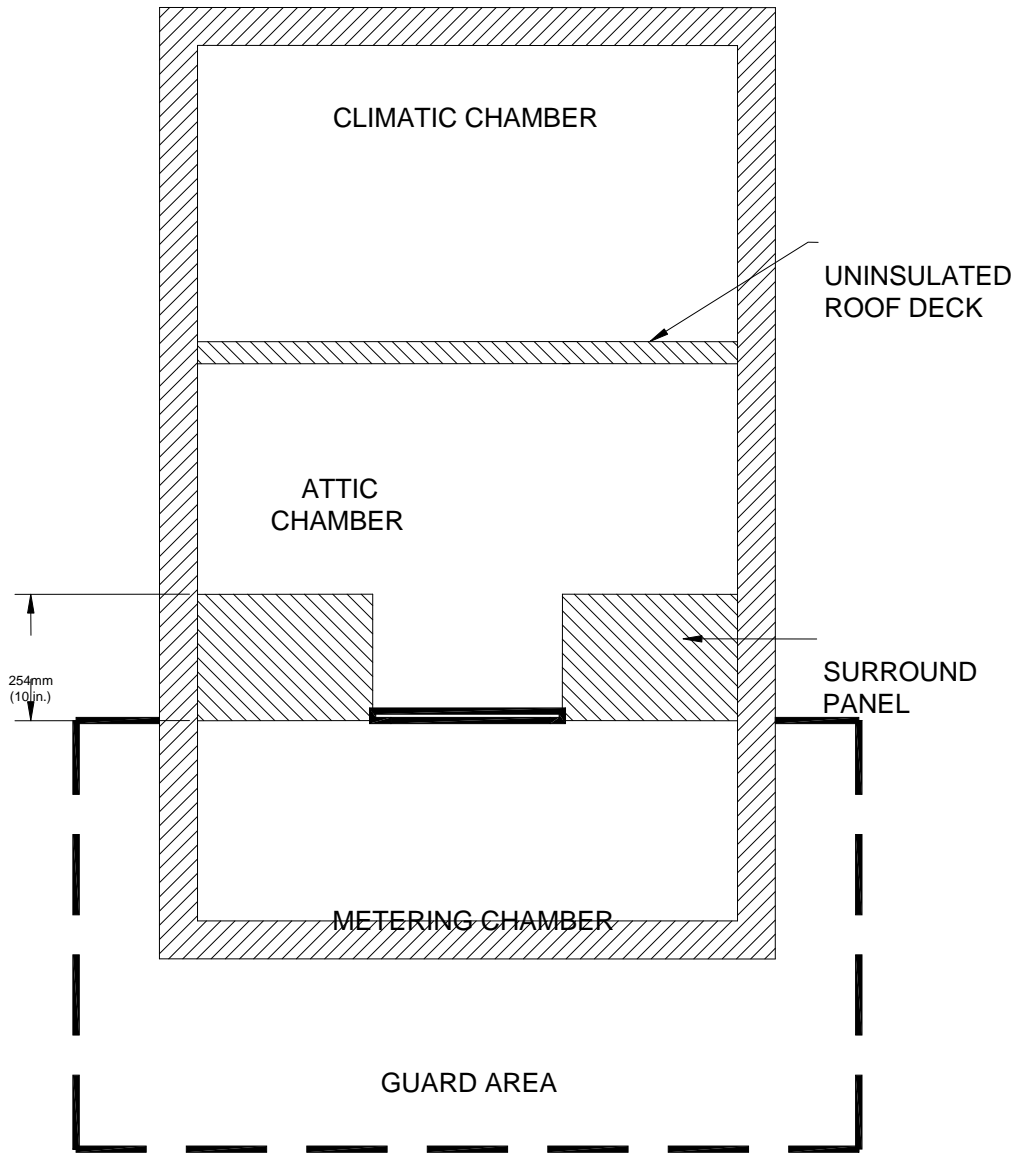


Figure A3.8- Metering Chamber CTS Installation

A3.5 Calculation of Thermal Transmittance

A3.5.1 *Test Specimen Thermal Transmittance*, U_s , is calculated as follows:

$$U_s = Q_s / (A_t \cdot (t_h - t_c)) \quad (\text{A3.7})$$

Where:

A_t = Projected TDD Tube Area, based on outside tube diameter

A3.5.2 A Test Specimen Standardized Thermal Transmittance, U_{st} , cannot be calculated for this product.

Annex A4. Garage Panel and Rolling Door Installation

~~*Garage Panel and Rolling Door Installation*~~—The door will be secured to a nominal 2 x 4 side and top wood framing, and supported on the bottom by a nominal 2 x 6 wood sill. These wood framing components are installed within the aperture of the surround panel in an ASTM C 1363 and ASTM C 1199 thermal chamber. The warm side surface of the top and side wood framing is placed so that it is flush with the warm side surface of the surround panel.

NOTE: Not only are these wood framing components intended to increase the structural rigidity of the 100 mm (4 in.) thick surround panel, but they also provide a means to secure the top and the sides of the test specimen. The garage door can be attached to the top and side wood framing using fasteners placed at regular intervals that pass through the edge of the garage door test specimen into the wood framing. Ensure that the door is placed so that the bottom weather-stripping of the door creates a seal on the nominal 2 x 6 wood sill. Additional sealing can be performed by taping or caulking the edges and gaps on the warm side.

Annex A5. Tables and Figures

Table HA5-1: Product Types and Model Sizes

Product Type	Opening (X) Non-operating (O)	Model Size (width by height)
		SI (IP)
Casement – Double ¹	XX , XO , OO	1200 mm by 1500 mm (47 in. by 59 in.)
Casement – Single	X ²	600 mm by 1500 mm (24 in. by 59 in.)
Dual Action	X	1200mm by 1500 mm (47 in. by 59 in.)
Fixed (includes non-standard shapes)	O	1200 mm by 1500 mm (47 in. by 59 in.)
Garage(Vehicular Access)/Rolling Door	X	2134 mm by 2134 mm (84 in. by 84 in.)
Greenhouse/Garden ²	X	1500 mm by 1200 mm (59 in. by 41 in.)
Hinged Escape	X	1500 mm by 1200 mm (59 in. by 47 in.)
Horizontal Slider	XO or XX	1500 mm by 1200 mm (59 in. by 47 in.)
Hybrid Tubular Daylighting Device	O	530 mm Dia. (21 in. Dia.)
Jal/Jal Awning	X	1200 mm by 1500 mm (47 in. by 59 in.)
Pivoted	X	1200 mm by 1500 mm (47 in. by 59 in.)
Projecting (Awning, Dual)	XX	1500 mm by 1200 mm (59 in. by 47 in.)
Projecting (Awning – Single)	X	1500 mm by 600 mm (59 in. by 24 in.)
Door Sidelite ^{2,3}	XX or O	600 mm by 2000 mm (24 in. by 79 in.)
Skylight/ Roof Window	X ^{3,4}	1200 mm by 1200 mm (47 in. by 47 in.)
Sliding Patio Door with Frame	XO or XX	2000 mm by 2000 mm (79 in. by 79 in.)
Glazed Wall/Sloped Glazing	OO ⁴	2000 mm by 2000 mm (79 in. by 79 in.)
Swinging Door with Frame	O, X, XO or XX ⁵	1000-960 mm by 2000 mm (37 3/4 in. by 82 3/8 in.) or 1920 mm by 2090 mm (75 1/2 in. by 79 3/8 in.)
Door Transom ^{2,6,8}	XO	2000 mm by 600 mm (79 in. by 24 in.)
Tropical Awning	X	1500 mm by 1200 mm (59 in. by 47 in.)
Tubular Daylighting Device	O	350 mm Dia. (14 in. Dia.)
Vertical Slider	XO or XX	1200 mm by 1500 mm (47 in. by 59 in.)

¹ Double Casements and Dual Awning are to be rated only in the case where single units casement is are not manufactured.

² If not manufactured, use O (fixed unit).

³ Fits over or in a 1180 mm by 1180 mm (46.5 in. by 46.5 in.) opening.

⁴ Two lites with one vertical mullion. Curtain walls shall be simulated and tested with intermediate verticals as jambs and intermediate horizontals as head/sill frame members. Window walls shall be simulated and tested with intermediate verticals as jambs and standard head and sill members. For rating of curtain walls and window walls, area weight intermediate members based on centerline dimensions. Glazed wall and sloped glazing shall be simulated and tested with standard jamb, head, and sill members (see Section 5.5).

⁵ The single door shall be used to represent all door assemblies (single, double, multiple) unless the manufacturer does not produce a single door, in that case the double door shall be used to represent double and multiple door assemblies.

⁶ Sidelites greater than 700mm wide and transoms greater than 700mm high shall be rated as fixed windows. Slab sidelites greater than 700mm wide shall be rated as Swinging Doors. Operable Sidelites are rated as the appropriate operator type.

⁷ Non-operating versions (O) of this type may be included in the same product line as the operable version as long as the changes to render the product non-operable comply with Section 4.2. If there is no operable version of the product, it is classified as a fixed window.

⁸ Operable transoms are rated as the appropriate operator type.

Figure 4A5-1: Thermocouple Location Two-Lite Curtain Wall, Patio Door

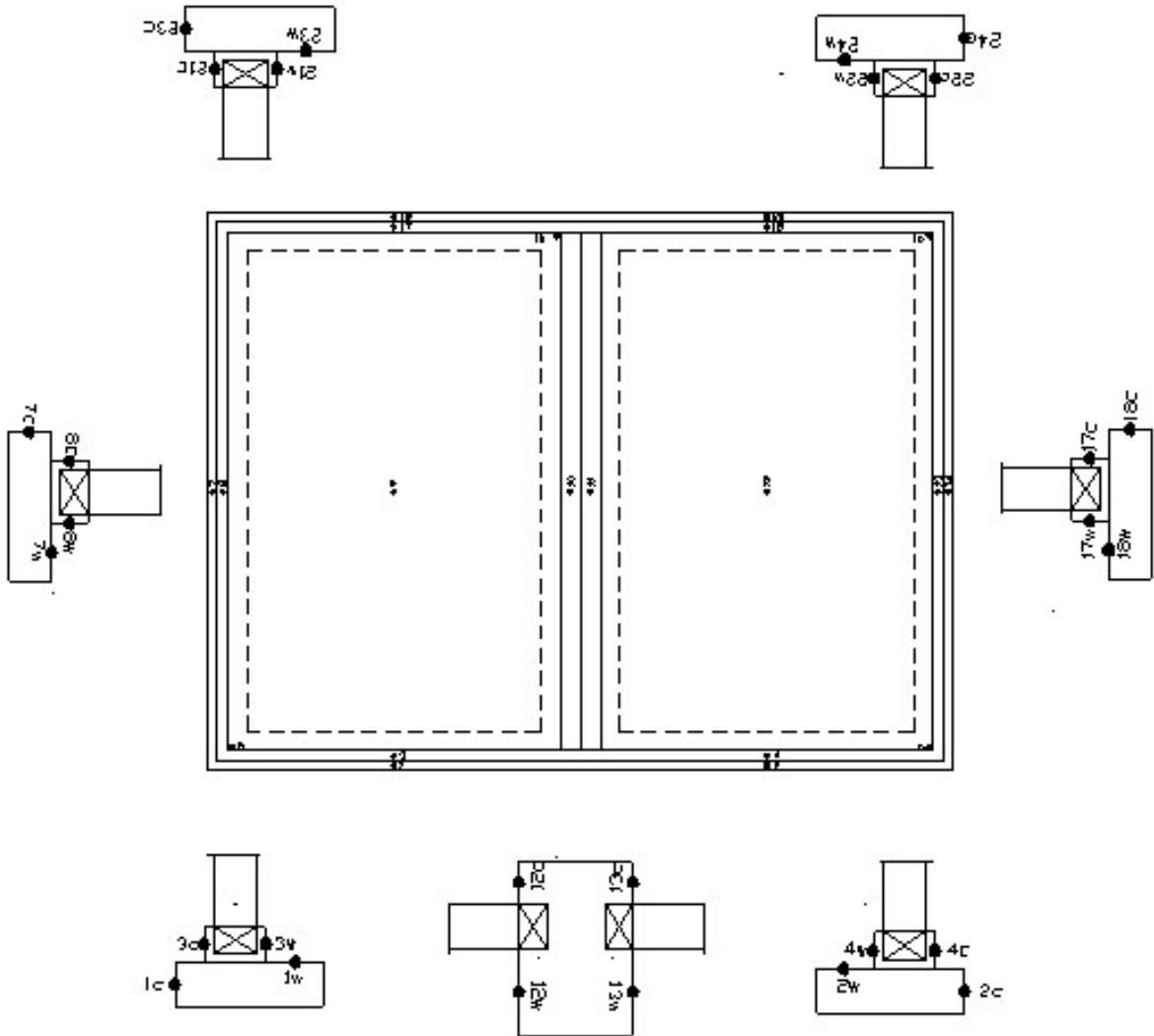


Figure 4A5-2: Thermocouple Location Casement, Projected (Awning)

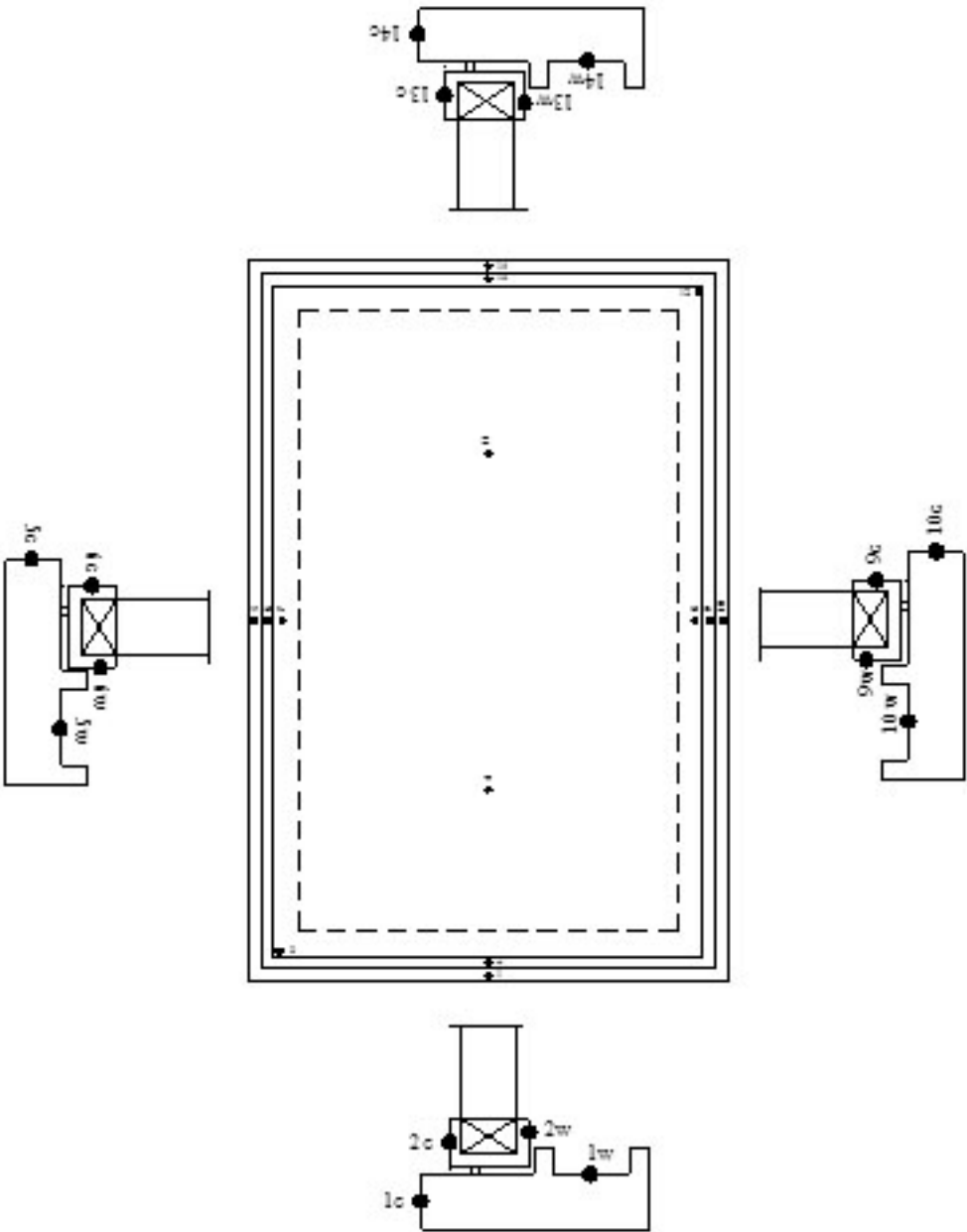


Figure 4A5-3: Thermocouple Location Fixed

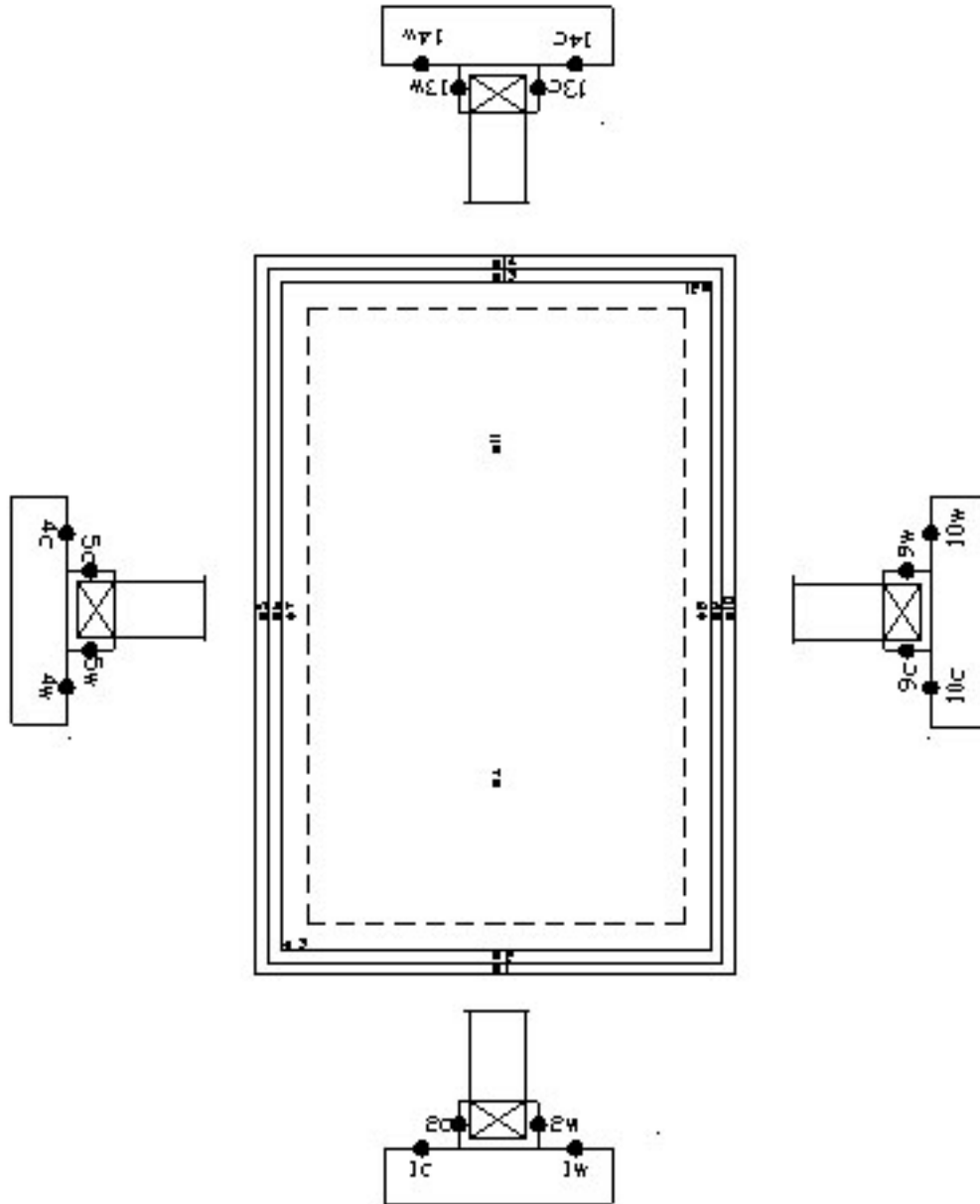


Figure 4A5-4: Thermocouple Location Horizontal Slider

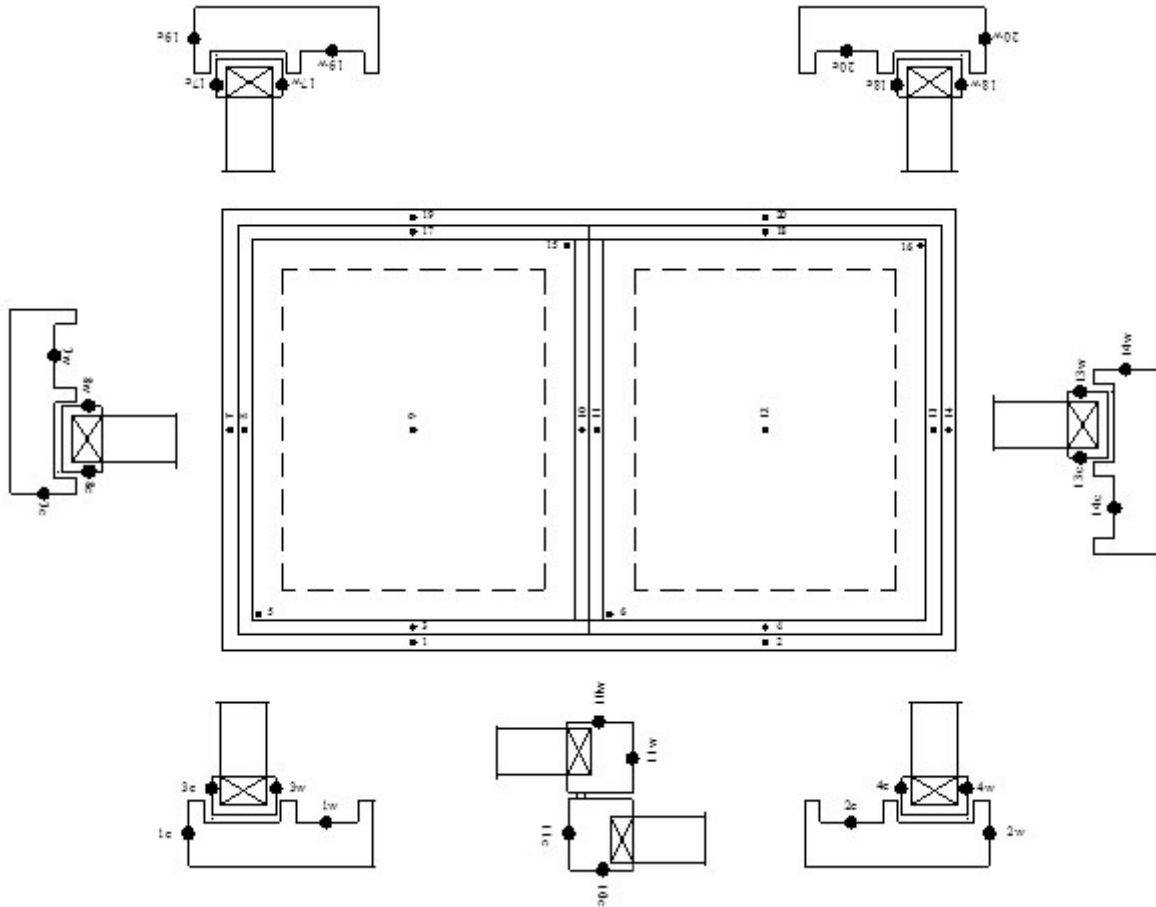


Figure 4A5-5: Thermocouple Location Vertical Slider

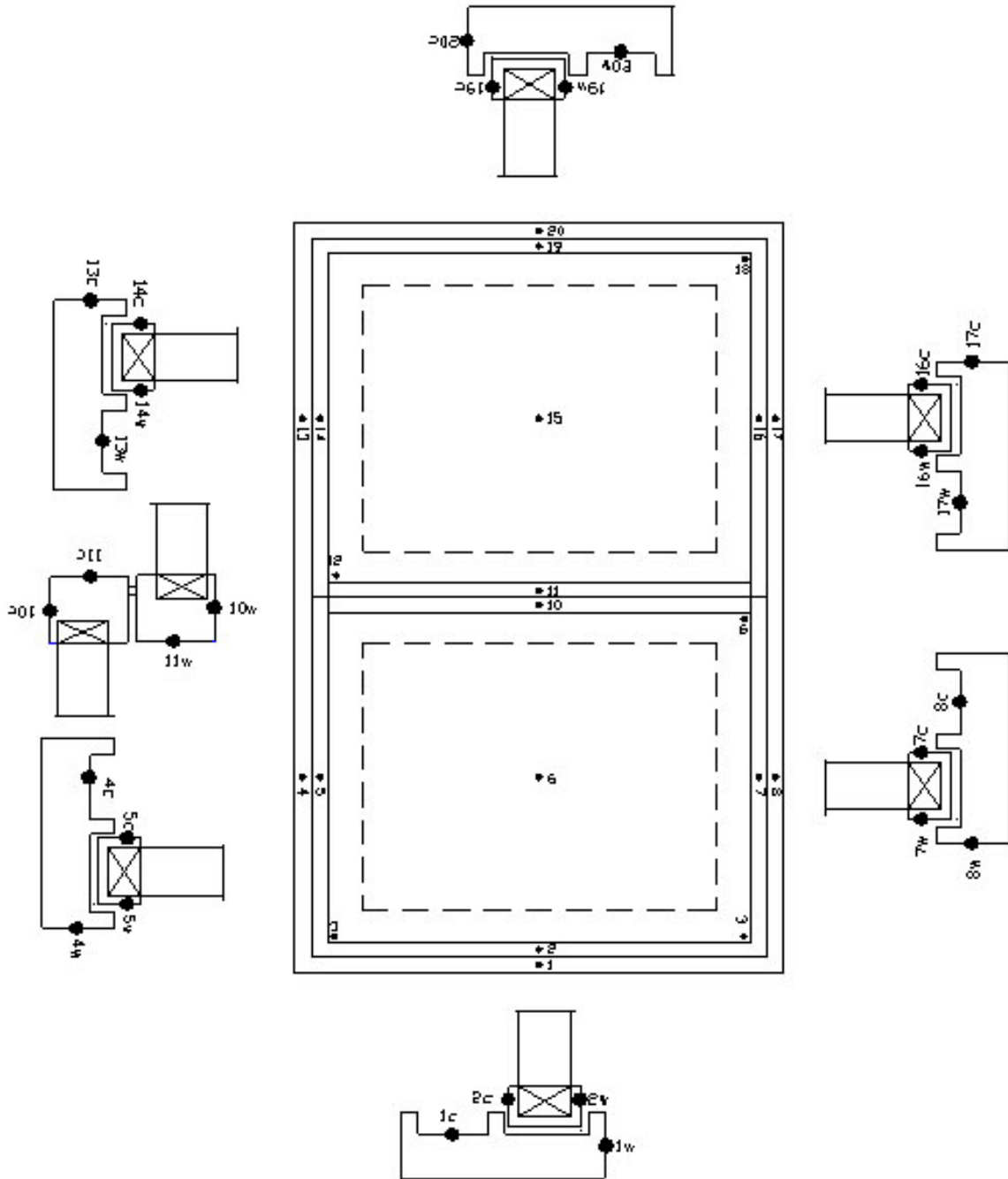


Figure 4A5-6: Thermocouple Location Entrance Door

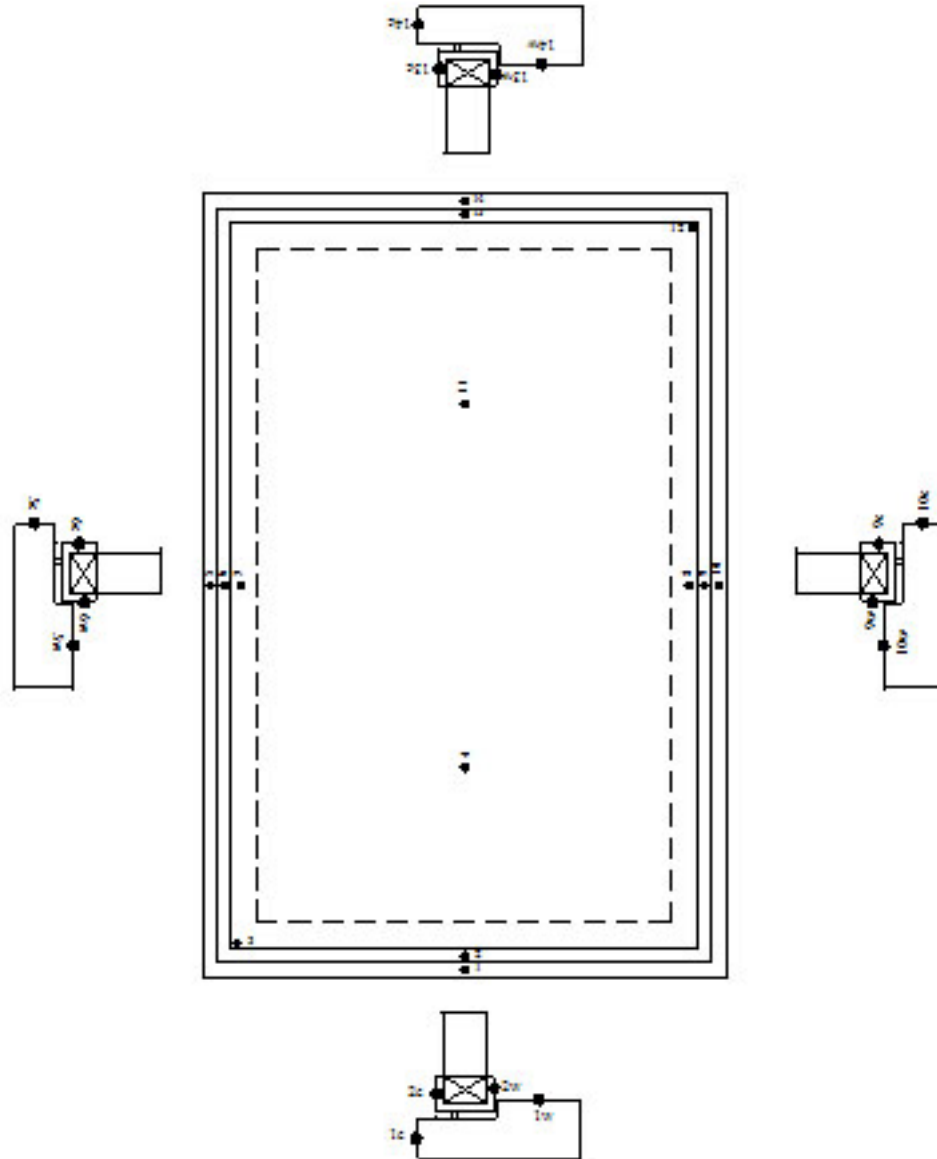


Figure [4A5-7](#): Thermocouple Location Divider

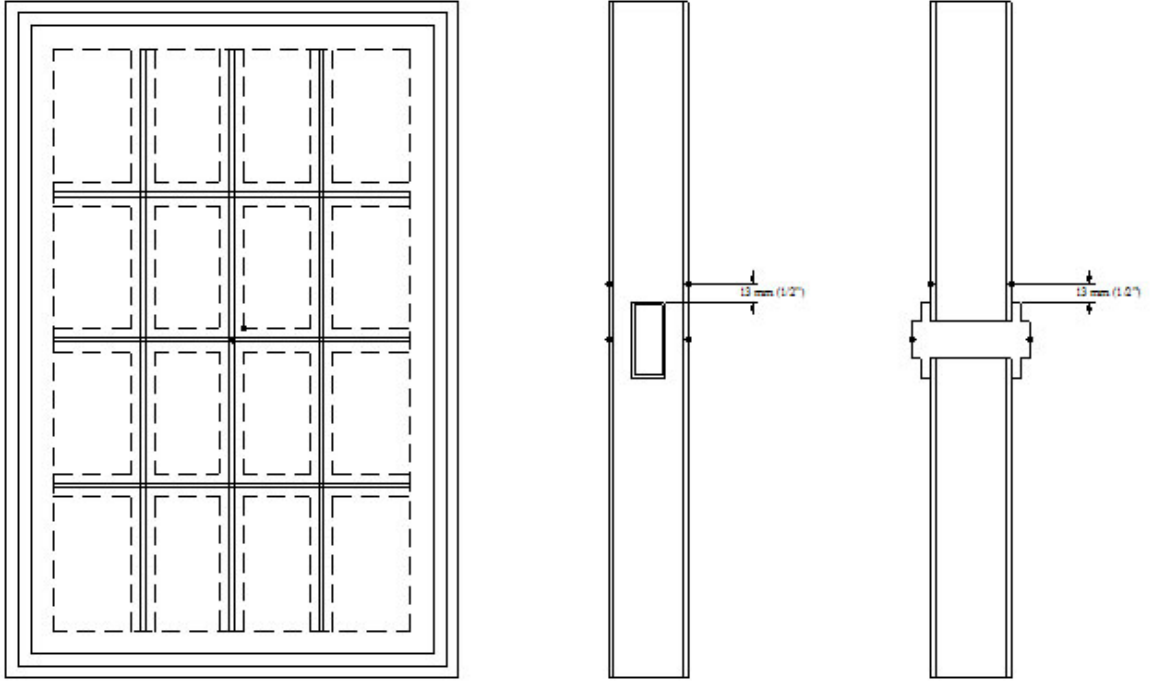
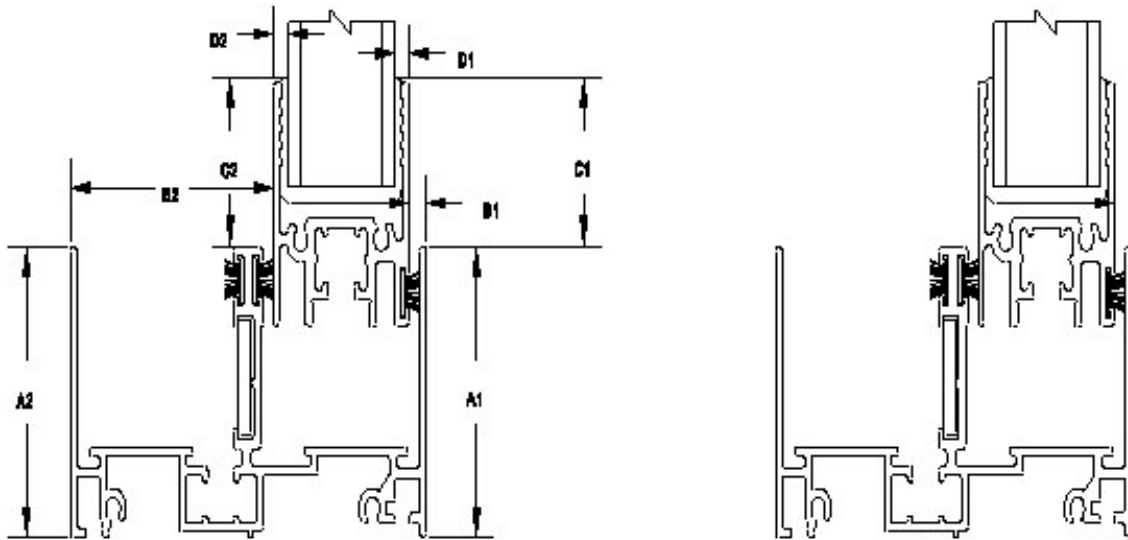


Figure 4A5-8: Example of Method to Determine Interior and Exterior Wetted 2-D Surface Areas



Area for the frame shall be calculated as
[projected height (A*) + projected depth (B*)] × assigned length of the section

Area for the sash shall be calculated as
[projected height (C*) + projected depth (D*)] × assigned length of the section

A1" designates as interior projected profile

A2" designates as exterior projected profile

Figure 11A5-9: Garage Door Installation

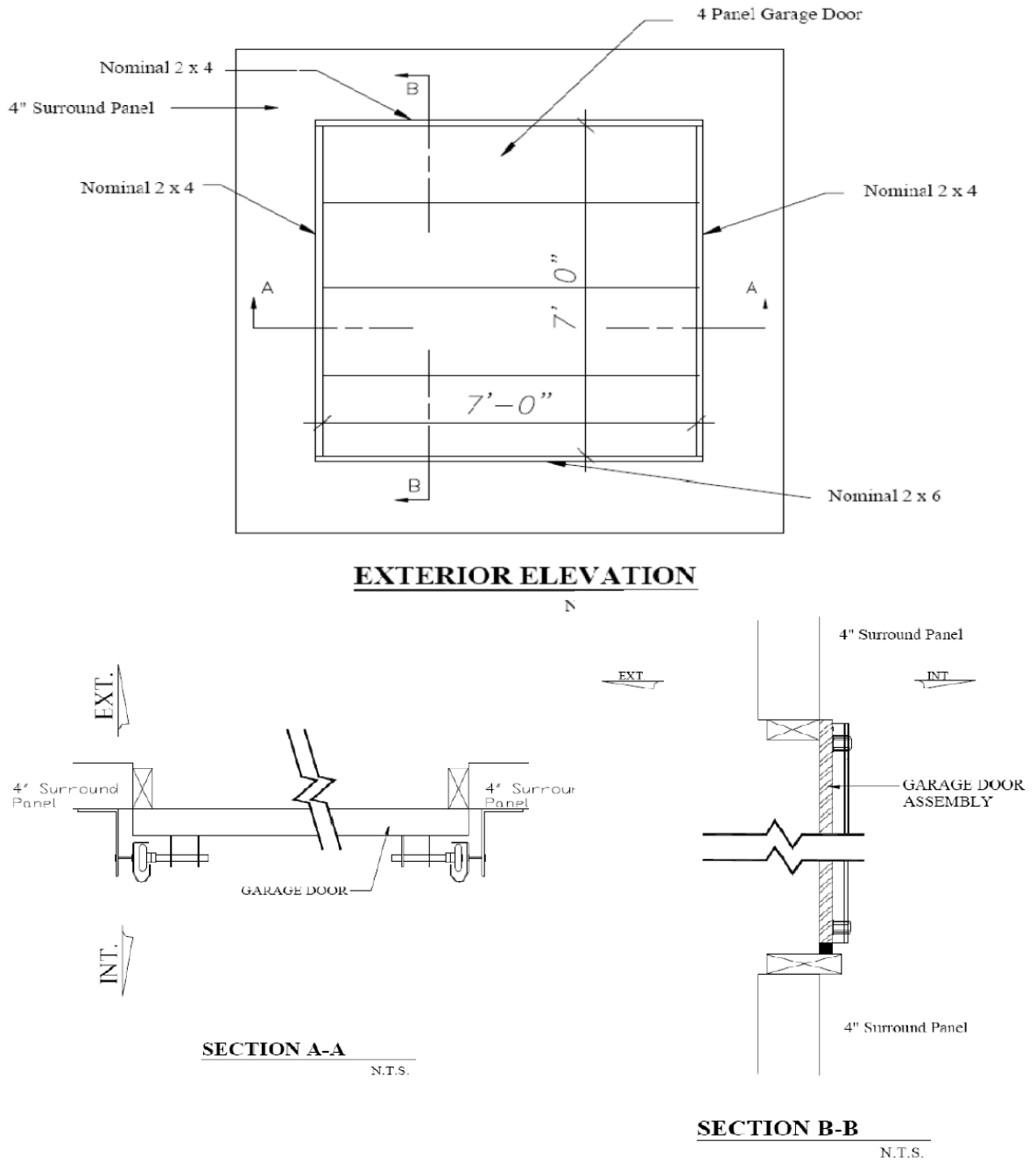
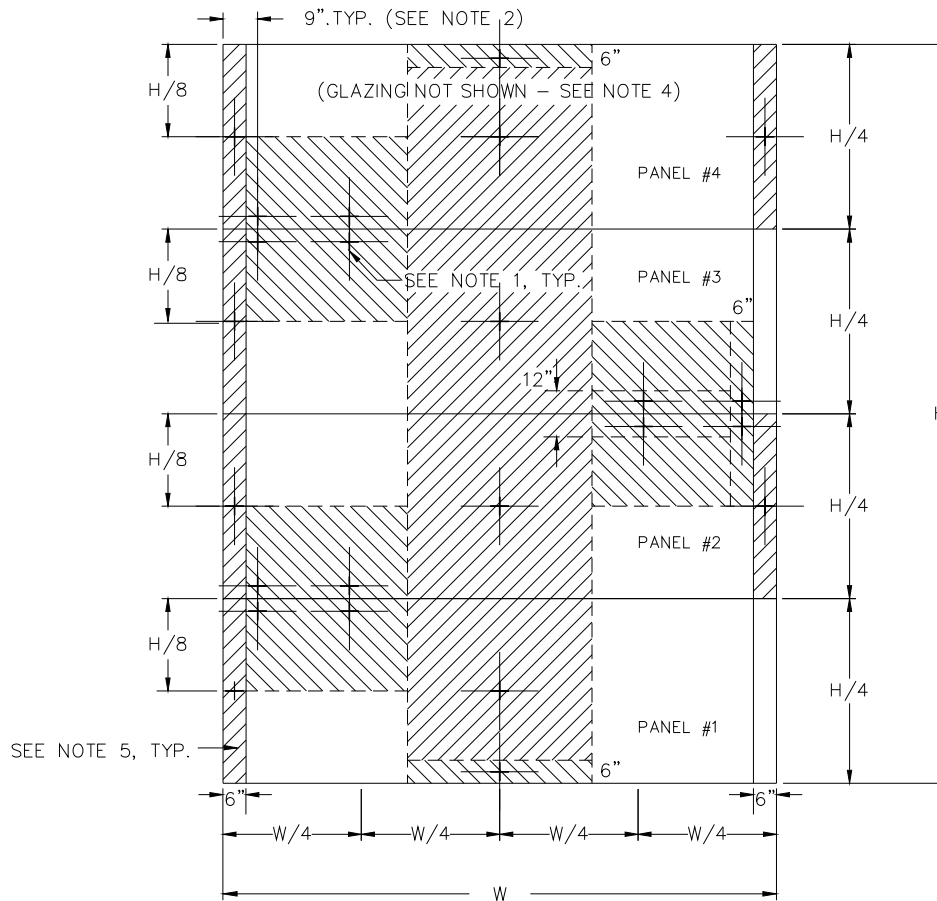


Figure 11A5-10: Thermocouple Location Four Panel Garage Door



NOTE:

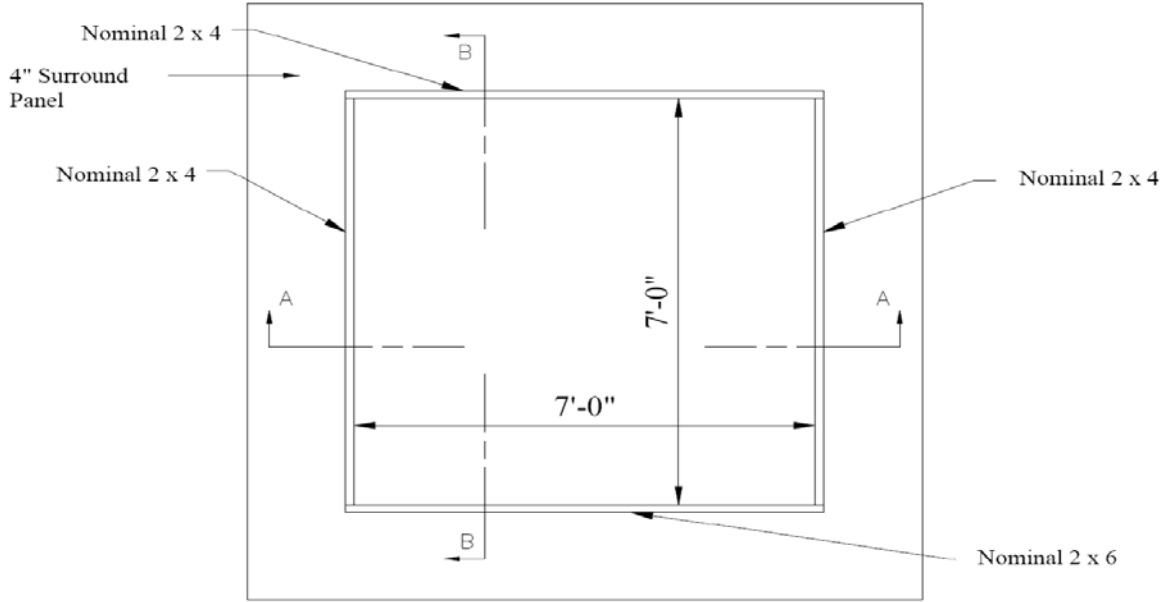
1. PANEL PERIMETER THERMOCOUPLES SHALL BE LOCATED 3" FROM PANEL EDGES UNLESS OTHERWISE NOTED.
2. THERMOCOUPLES NEAR JAMB LOCATIONS SHALL BE PLACED ON PANEL SKIN MATERIAL AT THE THINNEST DOOR SECTION.
3. NUMBER AND LOCATION OF THERMOCOUPLES MAY VARY, DEPENDENT UPON THE DESIGN OF THE GARAGE DOOR.
4. WHEN GLAZING IS USED, THERMOCOUPLES FOR EACH LIGHT SHALL INCLUDE ONE IN THE CENTER AND TWO AT THE EDGES. ONE OF THE TWO AT THE EDGE SHALL BE LOCATED AT $\frac{1}{2}$ " FROM A LOWER CORNER AND THE SECOND SHALL BE LOCATED $\frac{1}{2}$ " FROM THE OPPOSITE UPPER CORNER.
5. TRIBUTARY AREAS INDICATE REPRESENTATIVE AREAS ASSOCIATED WITH THERMOCOUPLES IN SUCH AREAS, USED IN AREA-WEIGHTING CALCULATIONS.

INTERIOR ELEVATION VIEW

Perimeter edge TC locations are 32 mm (1 1/4 in.)

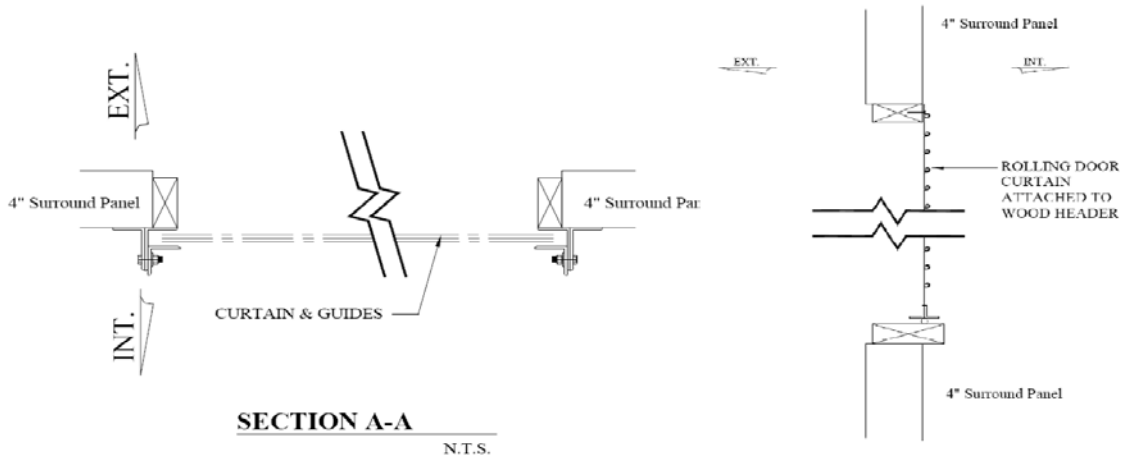
Not all thermocouple locations may be necessary dependent upon the design of the garage door. Glazing TCs shall have 2 edge and 1 center.

Figure HA5-11: Rolling Door Installation



EXTERIOR ELEVATION

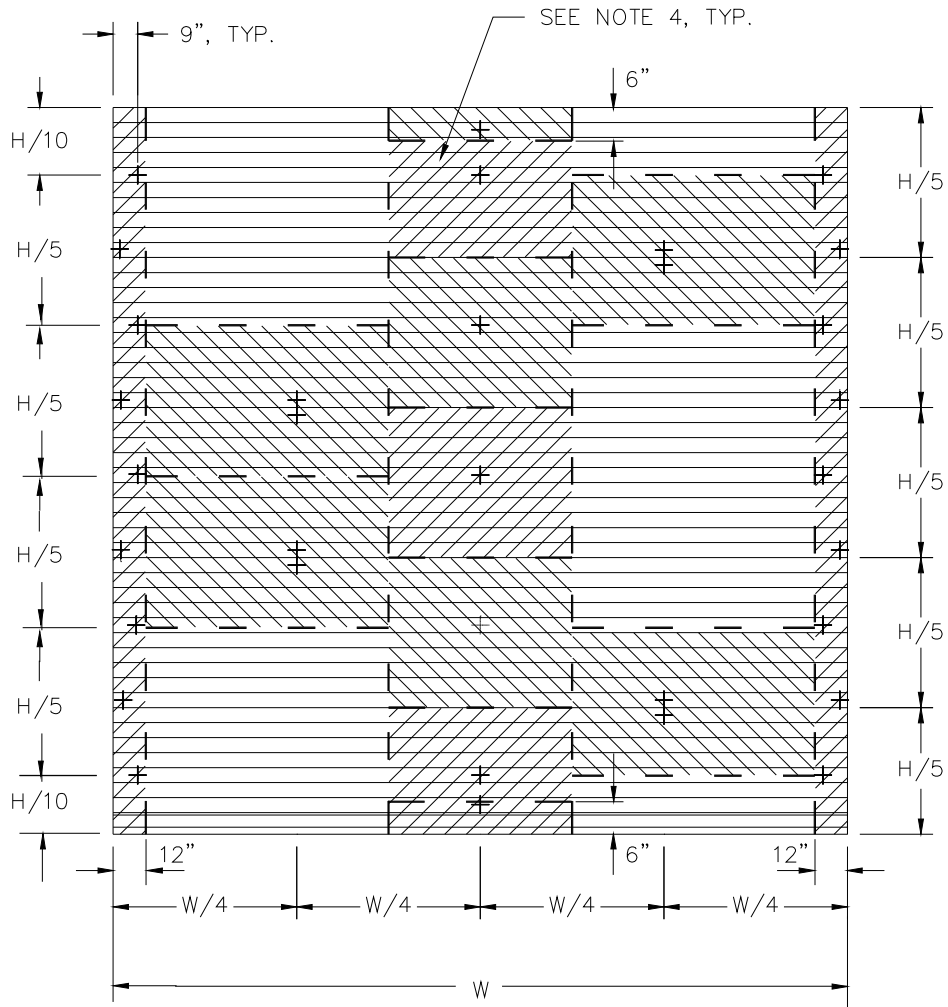
Door not shown N.T.S.



SECTION B-B

N.T.S.

Figure 4A5-12: Thermocouple Locations for Garage Doors



NOTE:

1. DOOR PERIMETER THERMOCOUPLES SHALL BE LOCATED 3" FROM EDGES OF CLEAR OPENING UNLESS OTHERWISE NOTED.
2. DOOR THERMOCOUPLES SHALL BE CENTERED VERTICALLY ON EACH DOOR SLAT.
3. NUMBER AND LOCATION OF THERMOCOUPLE LOCATIONS MAY VARY, DEPENDENT UPON THE DESIGN OF THE ROLLING DOOR.
4. TRIBUTARY AREAS INDICATE REPRESENTATIVE AREAS ASSOCIATED WITH THERMOCOUPLES IN SUCH AREAS, USED IN AREA-WEIGHTING CALCULATIONS.

INTERIOR ELEVATION VIEW

BIBLIOGRAPHY

All Bibliography references of ASTM C1199-0~~90~~ are valid for this procedure. The following references are in addition to those listed in ASTM C1199-0~~90~~.

~~ASHRAE Handbook, Fundamentals Volume, American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc.~~

~~Bowen, R.P. and K.R. Solvason, "A Calorimeter for Determining Heat Transmission Characteristics of Windows", Submitted to ASTM for publication, 1985.~~

~~BS874: Part 3: Section 3.1: 1987, British Standard Methods for Determining thermal insulation properties, Part 3. Tests for thermal transmittance and conductance, Section 3.1 Guarded hot box method, British Standards Institution, British Standards House, 2 Park Street, London W1A 2BS, England.~~

~~ISO 8990, Thermal Insulation—Determination of Steady-State Thermal Transmission Properties—Calibrated and Guarded Hot Box, International Standards Organization.~~

INDEX

Air leakage	8	NFRC 101	12
Air temperatures.....	8	Projecting Products	5
area-weighting.....	4	skylight size	10
ASTM C1363.....	ii, 4, 9	skylights	5, 10
AW	4	Skylights	10
Calibration Transfer Standard.....	4, 8	surround panel.....	5, 7, 8, 9, 10, 11, 12
Calibration Transfer Standard (CTS).....	4	test specimen... 4, 5, 6, 7, 8, 11, 12, 13, 14,	15
Curb Mounted	10	Test specimen.....	4
enclosed air space	12, 13	U-factor	10
glazing unit.....	12, 13	View Factor.....	5
homogeneous insulation.....	7	Weep holes/slots	8
NFRC 100	6, 8, 10, 15		