Surface Condensation Resistance [$f_{Rsi=0.25}$]

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Temperature Factor?

- Surface must be kept free of condensation & mold
- Determined by Water Activity
- $a_w \leq 0.8$ ~ 80% RH
- a_w depends on
  - Climate
  - Assembly U-Value
- Risk is determined by the *Temperature Factor* ($f_{Rsi=0.25}$)

$$f_{Rsi=025} = \frac{T_{surface} - T_{outside}}{T_{inside} - T_{outside}}$$

Climate zone	Hygiene criterion $f_{Rsi=0.25\ m^2K/W} \geq$
1 Arctic	0.80
2 Cold	0.75
3 Cool-temperate	0.70
4 Warm-temperate	0.65

NYC

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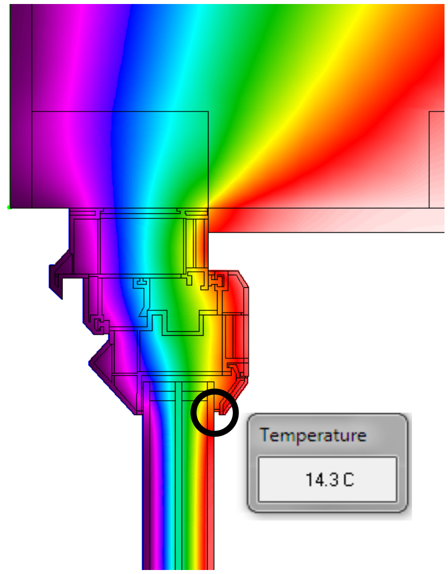
Temperature Factor?

$$f_{Rsi=0.25} = \frac{T_{surface} - T_{outside}}{T_{inside} - T_{outside}}$$

$$f_{Rsi=0.25} = \frac{14.3^{o}C - (-10^{o}C)}{20^{o}C - (-10^{o}C)}$$

$$= 0.81$$



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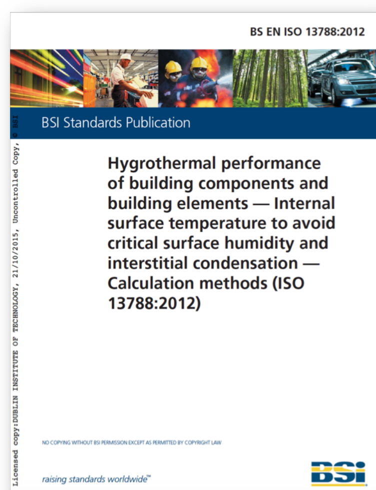
Limitations

- Simplified calculation methods, assume that **moisture transport is by vapor diffusion alone** and use monthly climate data
- If other sources of moisture, such as rain penetration or convection, are negligible, the calculations will normally lead to designs well on the safe side
- does not cover other aspects of moisture, e.g. ground water and ingress of precipitation.


BS EN ISO 13788:2012

BSI Standards Publication

Hygrothermal performance of building components and building elements — Internal surface temperature to avoid critical surface humidity and interstitial condensation — Calculation methods (ISO 13788:2012)

raising standards worldwide™

BSI

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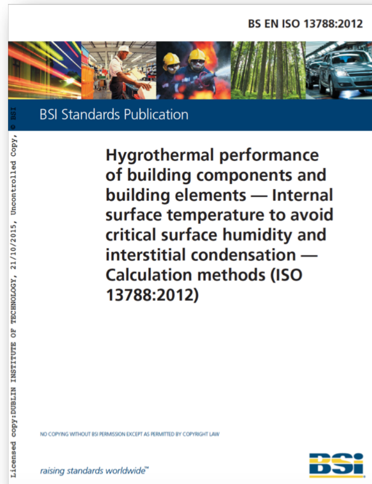
Limitations

In some cases, **airflow** from the interior of the building into the structure is the major mechanism for moisture transport, which can increase the risk of condensation problems very significantly. This International Standard **does not address this issue**; where it is felt to be important, more advanced assessment methods should be considered.



Boundary Conditions?

4.2.3 External temperature

The following temperatures shall be used for the calculations.

a) For calculations of walls exposed to the outside, the external air temperature as specified in 4.2.1 and 4.2.2 shall be used.

b) For calculation of solid ground floors or walls below the ground, incorporate 2 m of soil below the floor in the calculation. The monthly mean temperatures in the ground below this may be estimated with the following steps:

— Take the twelve monthly mean external air temperatures: θ_m

— Average these to give the annual mean external air temperature: θ_{an}

— For each month calculate the average of the θ_m and θ_{an}: $(\theta_{an}+\theta_m)/2$

— Displace the calculated values by one month, so the January value becomes February etc.

— If necessary, more detailed calculation of ground temperature may be carried out with the methods in ISO 13370.

c) For calculations of suspended floors algorithms for the calculation of monthly subfloor temperatures from the internal and external monthly temperatures are given in Annex E of ISO 13370

d) For calculations of roofs the monthly mean equivalent outside temperature, $\overline{\theta_{eq}}$, which takes account of solar gain and cooling by long wave radiation, should be used; $\overline{\theta_{eq}}$ can be calculated using the methodology given in ISO 13790. As a simplified case, $\overline{\theta_{eq}}$ can be taken by subtracting 2 K from every monthly mean external air temperature.

Boundary Conditions: Walls

4.2.1 Location

Unless otherwise specified, the external conditions used shall be representative of the location of the building, taking account of altitude where appropriate.

gee, thanks…

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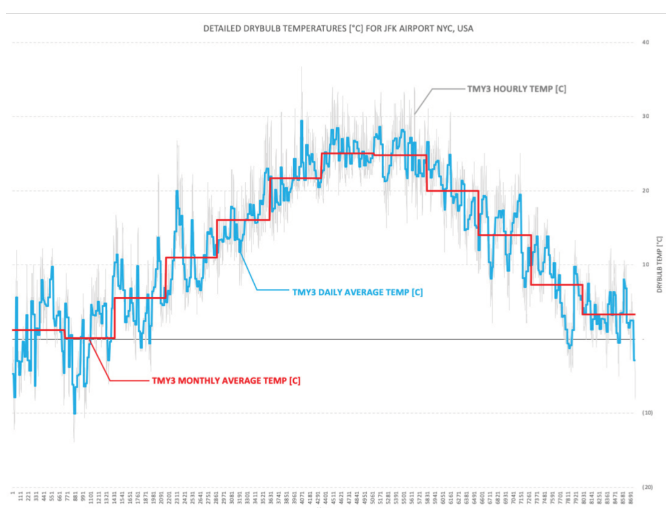
Boundary Conditions: NYC

Month	[°C]	[°F]
Jan	1.2	34.1
Feb	0.1	32.2
Mar	5.5	41.9
Apr	11.0	51.7
May	16.1	60.9
June	21.7	71.1
Jul	25.1	77.1
Aug	24.8	76.6
Sept	20.0	67.9
Oct	14.0	57.3
Nov	7.3	45.1
Dec	3.3	38.0
60d Avg:	**0.65**	**33.2**
90d Avg:	**1.53**	**34.8**



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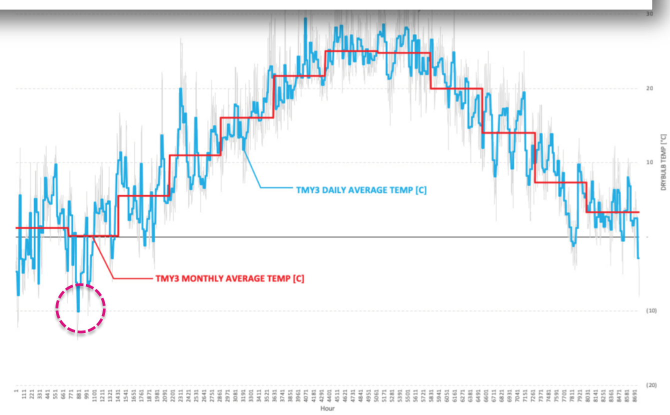
https://www.energyplus.net/weather-download/north_and_central_america_wmo_region_4/USA/NY/USA_NY_New.York-J.F.Kennedy.Intl.AP.744860_TMY3/all

Boundary Conditions: Windows

For calculations of the risk of surface condensation on low thermal inertia elements such as windows and their frames, the average, taken over several years, of the lowest daily mean temperature in each year shall be used in the absence of any national standards.

	[°C]	[°F]
TMY3 Min	-10.1	13.8
ASHRAE 2005 99.6%	-10.5	13.1
ASHRAE 2005 99%	-8.1	17.5



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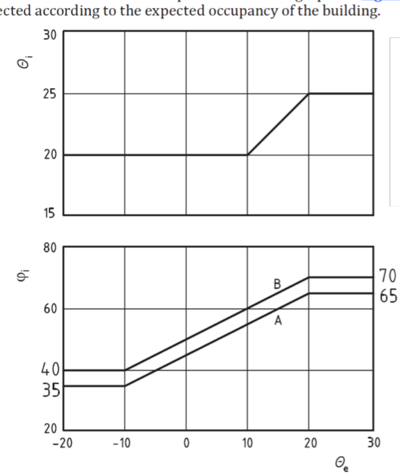
https://www.energyplus.net/weather-download/north_and_central_america_wmo_region_4/USA/NY/USA_NY_New.York-J.F.Kennedy.Intl.AP.744860_TMY3/all

Boundary Conditions: Interior

In the absence of well-defined - controlled, measured or simulated - internal air conditions, a simplified approach to determine the internal temperature and humidity for heated buildings (only dwellings and offices) based on the external air temperature may be used. The internal air conditions are derived from entering the daily mean of the external air temperature into the graphs in Figure A.1. The internal air humidity level is selected according to the expected occupancy of the building.



Key

- θ_i internal temperature, expressed in °C
- φ_i internal relative humidity, expressed in %
- θ_e external temperature, expressed in °C
- A normal occupancy
- B high occupancy

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Boundary Conditions: R_{se}, R_{si}

4.4 Surface resistances

4.4.1 Heat transfer

The value of R_{se} shall be taken as 0,04 m²·K/W.

For condensation or mould growth on opaque surfaces, an internal surface thermal resistance of 0,25 m²·K/W shall be taken to represent the effect of corners, furniture, curtains or suspended ceilings, if there are no national standards.

The values of R_{si} given in Table 2 shall be used for the assessment of interstitial condensation, or surface condensation on windows and doors.

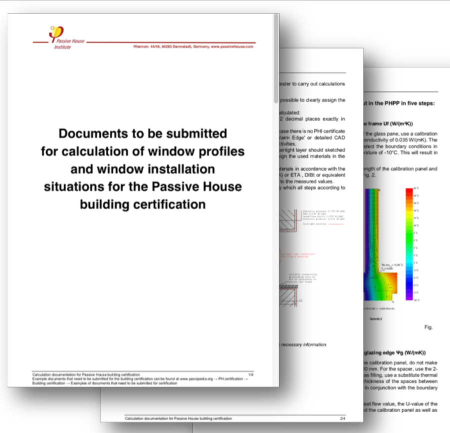
Table 2 — Internal thermal resistances for the assessment of interstitial condensation, or surface condensation on windows and doors

Direction of heat flow	Thermal resistance m2·K/W
Upwards	0,10
Horizontal	0,13
Downwards	0,17

Boundary Conditions: PHI R_{si}

Step 3: Determining the temperature factor f_{Rsi} = 0.25 m²K/W (-)

Use the model in Step 2 and enter a heat transmission resistance of 0.25 m²K/W for the interior boundary condition. Delete all areas that are in contact with indoor air which are not ventilated or are slightly ventilated. Do not make any changes to the model otherwise. The simulation will result in a minimum temperature at the interior surface. Determine f_{Rsi} according to the following formula



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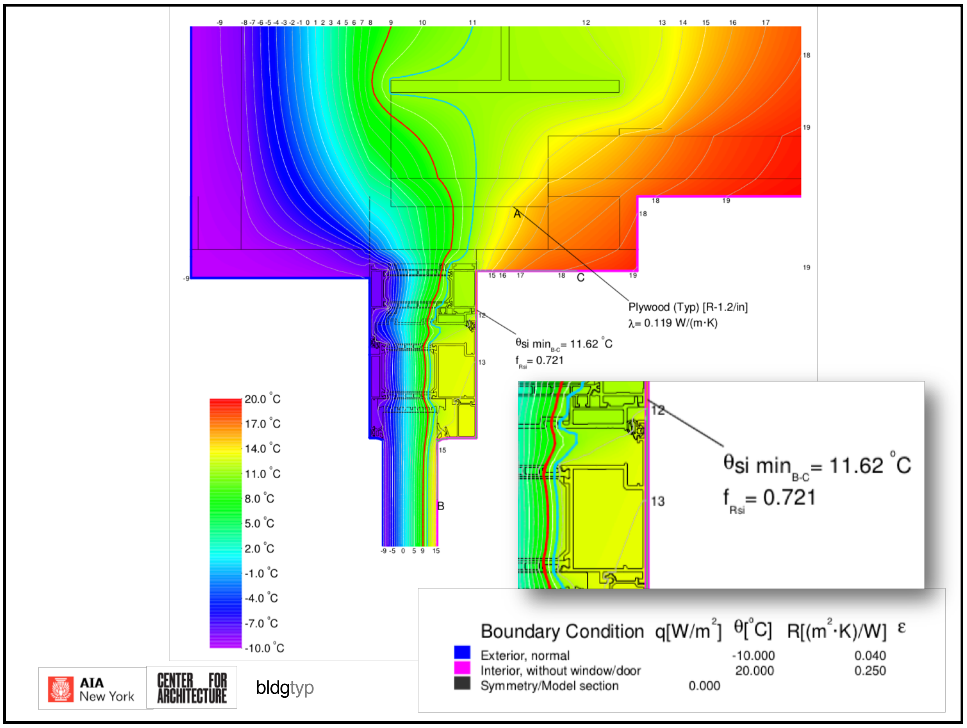
Plywood (Typ) [R-1.2/in]
λ= 0.119 W/(m·K)
θsi min B-C = 11.62 °C
fRsi = 0.721
20.0 °C
17.0 °C
14.0 °C
11.0 °C
8.0 °C
5.0 °C
2.0 °C
-1.0 °C
-4.0 °C
-7.0 °C
-10.0 °C
Boundary Condition q[W/m²] θ[°C] R[(m²·K)/W] ε
Exterior, normal -10.000 0.040
Interior, without window/door 20.000 0.250
Symmetry/Model section 0.000
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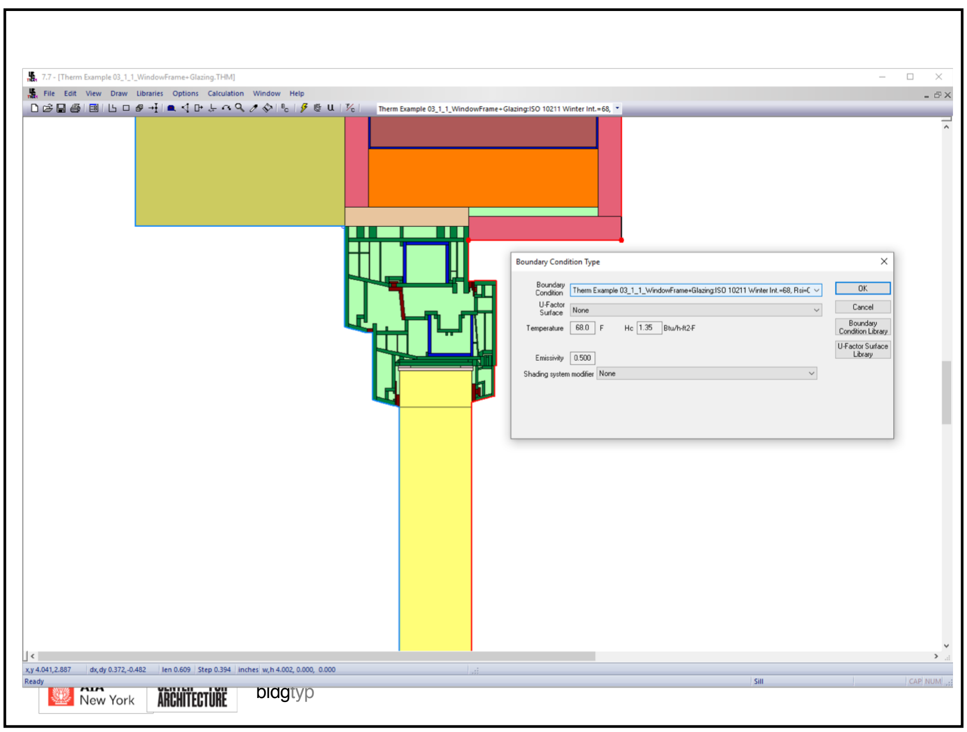
Boundary Condition Type
OK
Cancel
Temperature 68.0 F
Hc 1.35 Btu/h-ft2-F
Emissivity 0.500
Shading system modifier None
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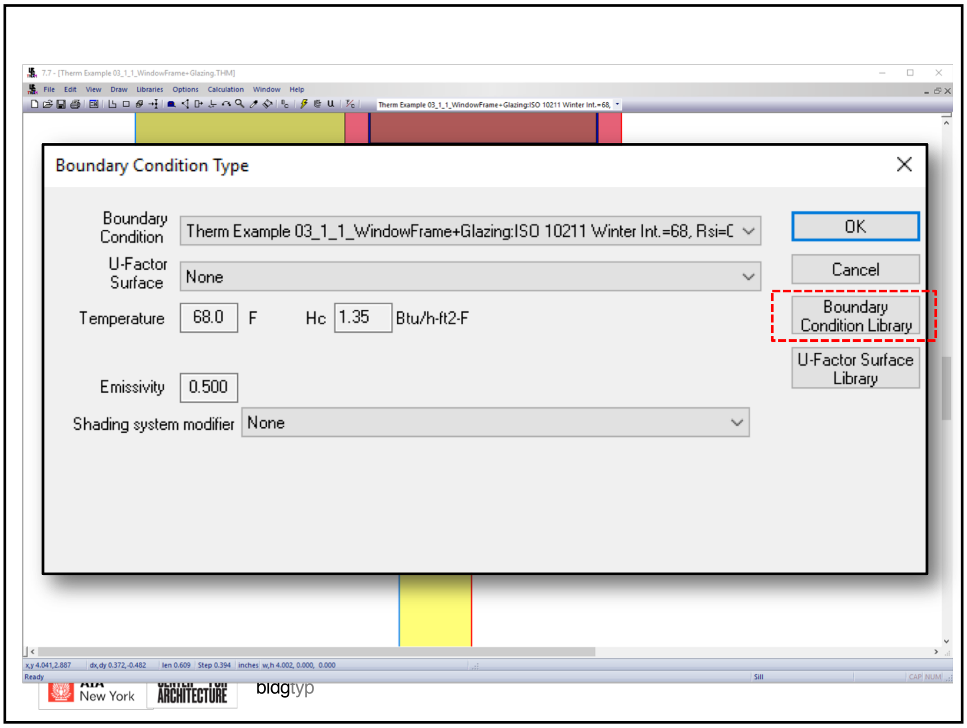
Boundary Condition Type
Boundary Condition
Therm Example 03_1_1_WindowFrame+Glazing:ISO 10211 Winter Int.=68, Rsi=
U-Factor Surface
None
Temperature
68.0
F
Hc
1.35
Btu/h-ft2-F
Emissivity
0.500
Shading system modifier
None
OK
Cancel
Boundary Condition Library
U-Factor Surface Library
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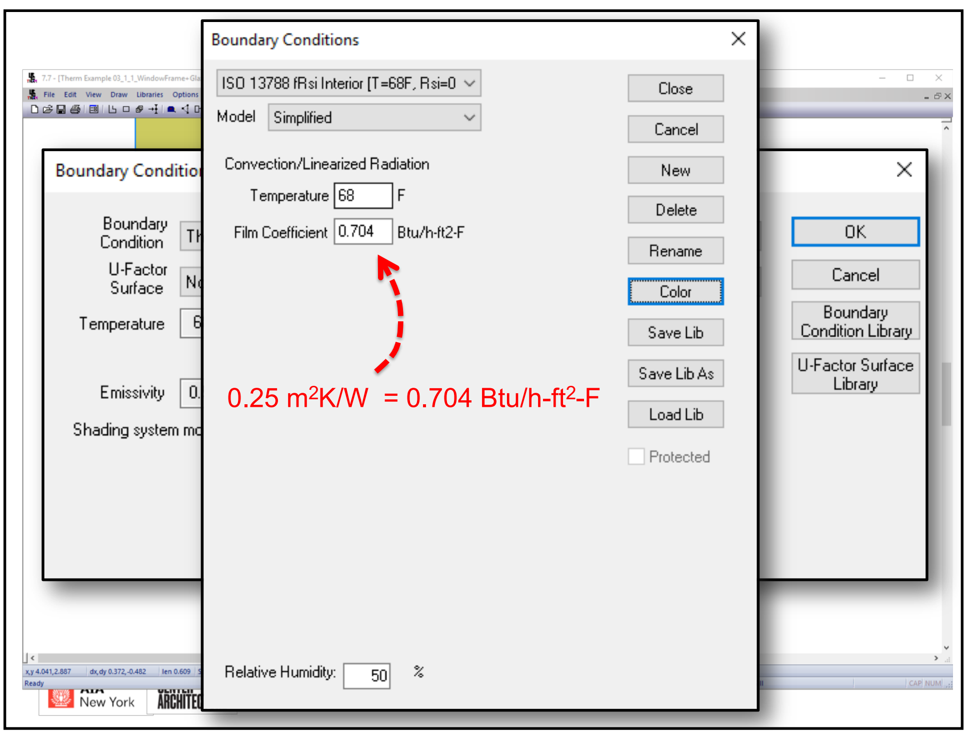
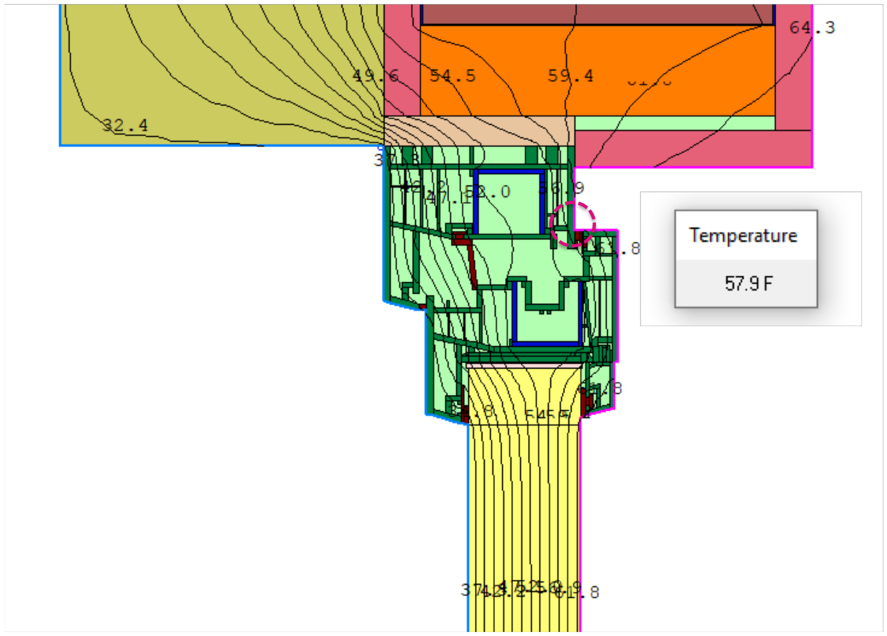

Boundary Conditions
ISO 13788 fRsi Interior [T=68F, Rsi=0
Model
Simplified
Convection/Linearized Radiation
Temperature
68
F
Film Coefficient
0.704
Btu/h-ft2-F
0.25 m2K/W = 0.704 Btu/h-ft2-F
Relative Humidity:
50
%
Close
Cancel
New
Delete
Rename
Color
Save Lib
Save Lib As
Load Lib
Protected
OK
Cancel
Boundary Condition Library
U-Factor Surface Library
Boundary Conditio
Boundary Condition
U-Factor Surface
Temperature
Emissivity
New York



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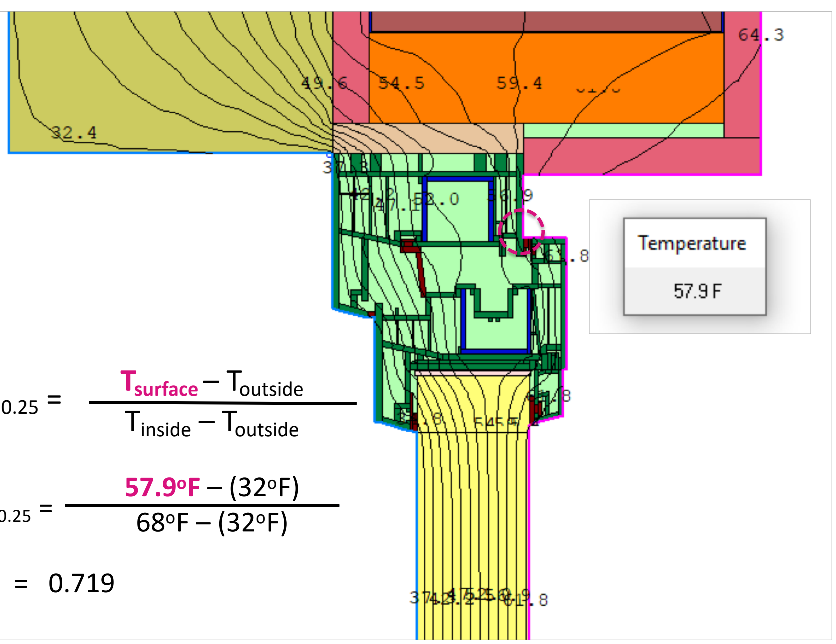

$$f_{Rsi=0.25} = \frac{T_{surface} - T_{outside}}{T_{inside} - T_{outside}}$$

$$f_{Rsi=0.25} = \frac{57.9^{o}F - (32^{o}F)}{68^{o}F - (32^{o}F)}$$

$$= 0.719$$

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