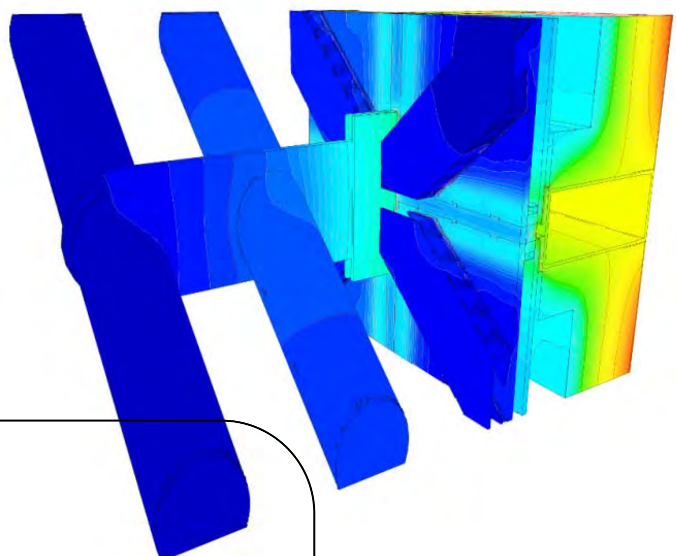
ABRIDGED FINAL REPORT - REV. 1

Thermal Performance Computer Simulations

for

[redacted]



Presented to:

[redacted]

[redacted]

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Executive Summary

On basis of shop drawings, we modeled two details of the curtain wall system, and simulated the thermal transmittance of these details in 3D FEA software. As a result of our analyses, we found the risk of condensation is low.

Remarks

This document has been prepared to assist you in the assessment of condensation risk of two curtain wall details, in accordance to the our accepted proposal dated [redacted] and later scope expansions.

We reserve the right to alter or amend our comments regarding these items if new circumstances associated with the condition and requirements of the primary and delegated designs, project site, or materials are brought to light by further investigations at a later date. If you have any questions regarding these observations or our general conclusions, please contact me at your earliest convenience at (305) 600 0516.

We thank you for your confidence in Building Enclosure Consulting LLC.

Karol Kazmierczak ASHRAE, CDT, LEED-AP, NCARB
Senior Building Science Architect

APPENDIX A:
Specifications -Thermal Requirements

Mr. [redacted] of [redacted] emailed the following environmental conditions on [redacted]:

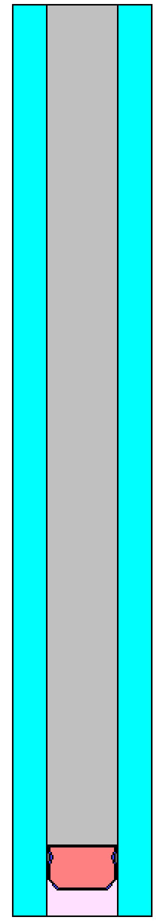
Exterior 0°F / interior 70°F/ wind/ 15 mph wind velocity.

The interior condensation criteria were set at:
70°F / 30% RH (Dew Point 37.1°F).

No architectural specifications were provided for our review on this project.

APPENDIX B:
Glazing Options

Glazing Name GL-1 :



The project was modeled with one glazing option: 1" insulating glass: 1/4" HS Azuria tint, SB60 Low E coating on #2, 1/2" air space, 1/4" HS. (COG U factor 0.29 Btu/ft^2 x hr x F), and regular aluminum box spacer. Detailed glazing data are listed below:

Glass Description at the Shop Drawings:

GLASS DESCRIPTION	
MARK	DESCRIPTION
GL-1	1" INSULATING GLASS EXT GLASS- 1/4" LOW E SB60 AZURLA #2 HS, 1/2" SPACER, INT. 1/4" CLEAR HS (BY R.A.K.)

The shop drawings showed the regular aluminum spacer.

Data retrieved from LBNL Windows 6.3.90 for this glass makeup:

Tilt : 90.0
Glazings: 2
KEFF : 0.0175
Width : 0.948
Uvalue : 0.29
SHGCc : 0.28
SCc : 0.32
Vtc : 0.54
RHG : 67.60

```
Layer Data for Glazing System '9

ID     Name            D( ")  Tsol  1 Rsol 2 Tvis  1 Rvis 2  Tir  1 Emis 2 Keff
------ --------------- ----- ---- ---- ---- ---- ---- ---- ---- ---- ---- ----
Outside
  5269 SB60  Azuria_6.#0.223 .236 .054 .449 .607 .052 .036 .000 .843 .035 .578
       1 Air          0.500                                              .017
   103 CLEAR_6.DAT    #0.225 .771 .070 .070 .884 .080 .080 .000 .840 .840 .578
Inside
```

APPENDIX C:
Shop Drawings

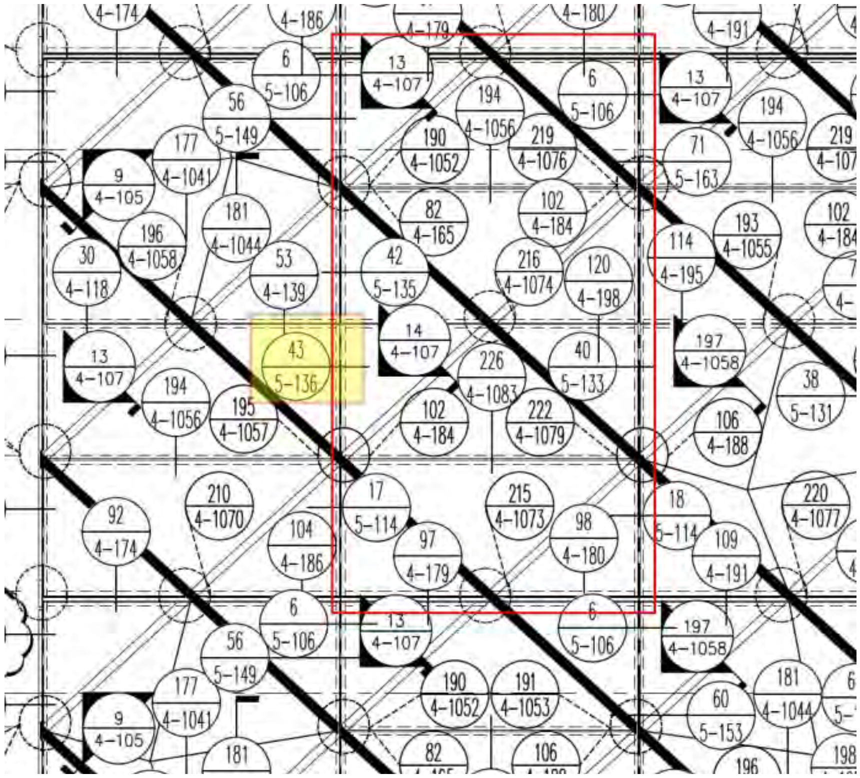


Figure 1. Detail #1. The analyzed fragment of the facade - Drawing 3-114.

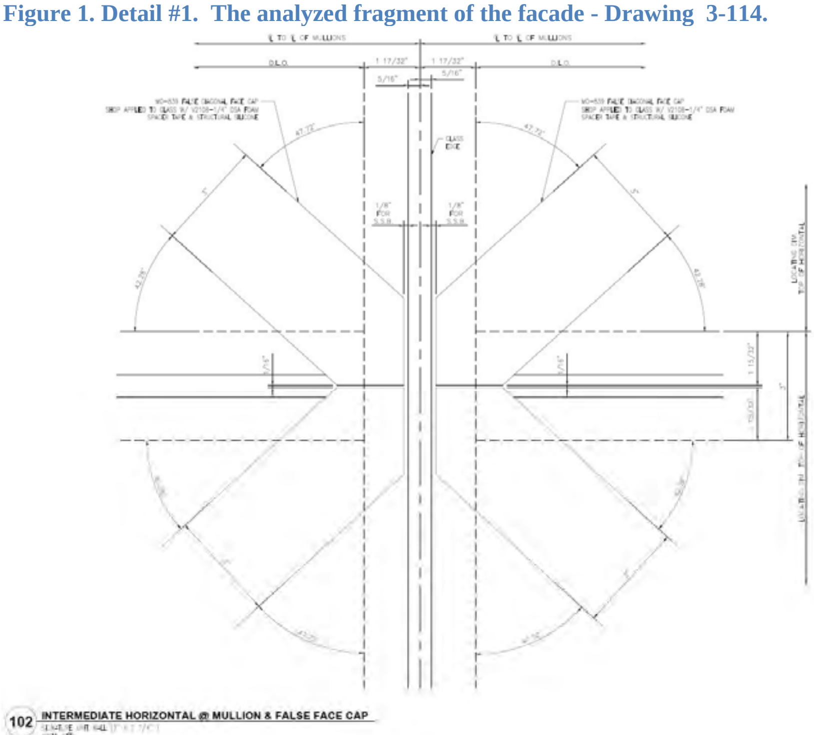


Figure 2. Detail #1. Elevation of the analyzed detail without shades. Drawing 4-184.

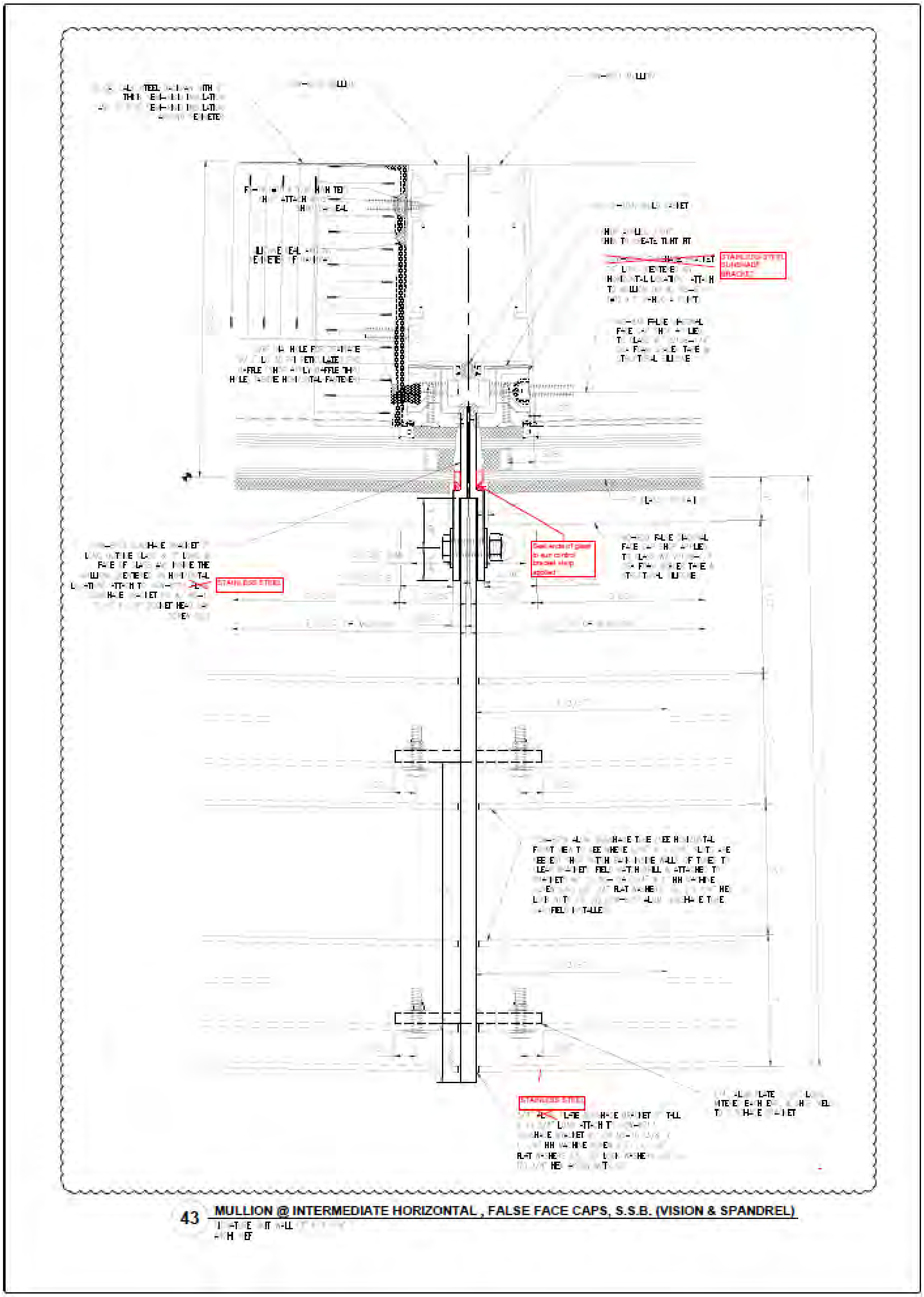


Figure 3. Detail #1. Horizontal section above the analyzed detail. Drawing 3-156.

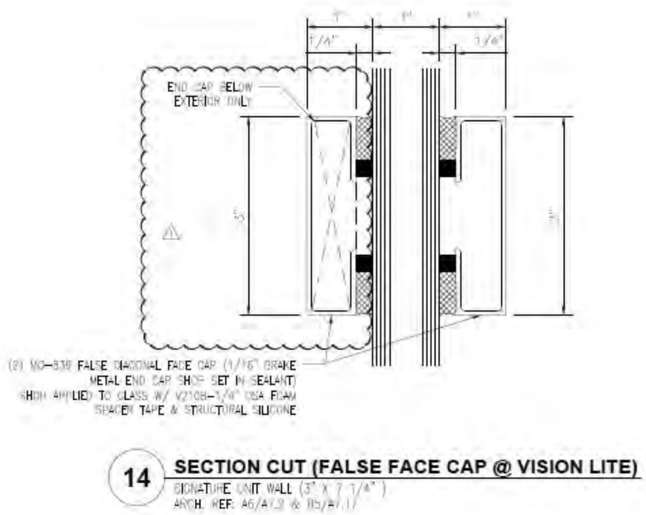


Figure 4. Detail #1. Diagonal section of the false cap detail. Drawing 4-107.

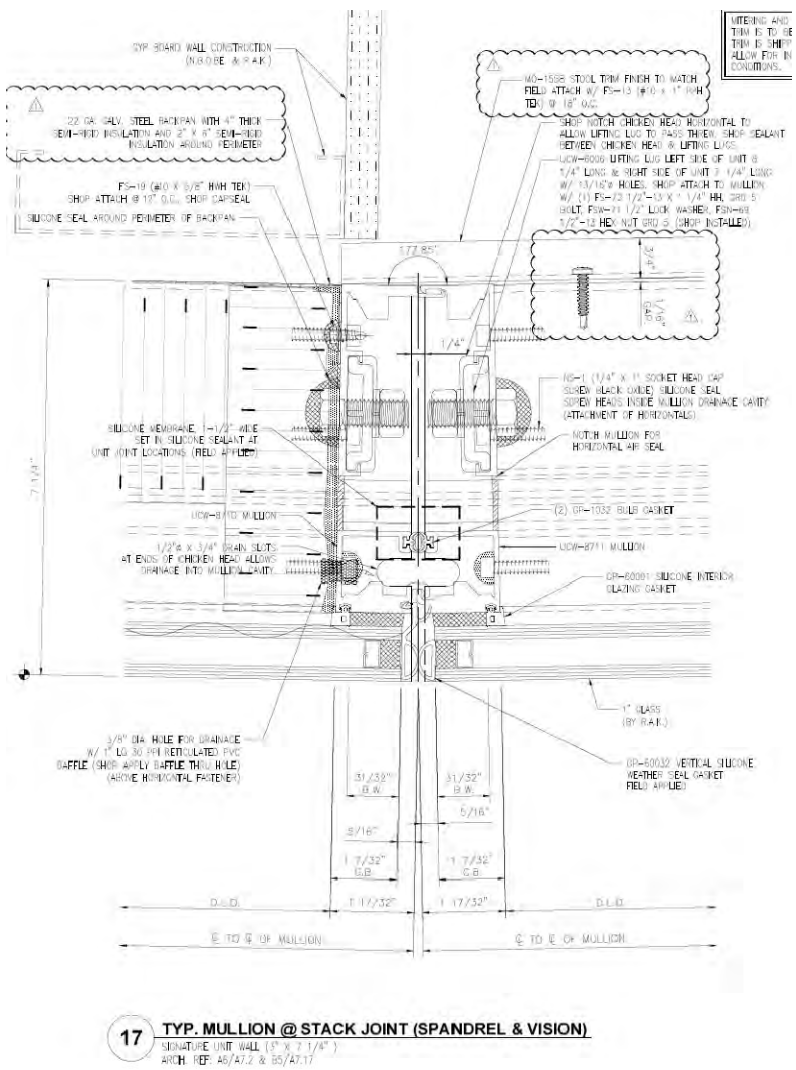


Figure 5. Detail #1. Horizontal section below the analyzed detail. Drawing 3-114.

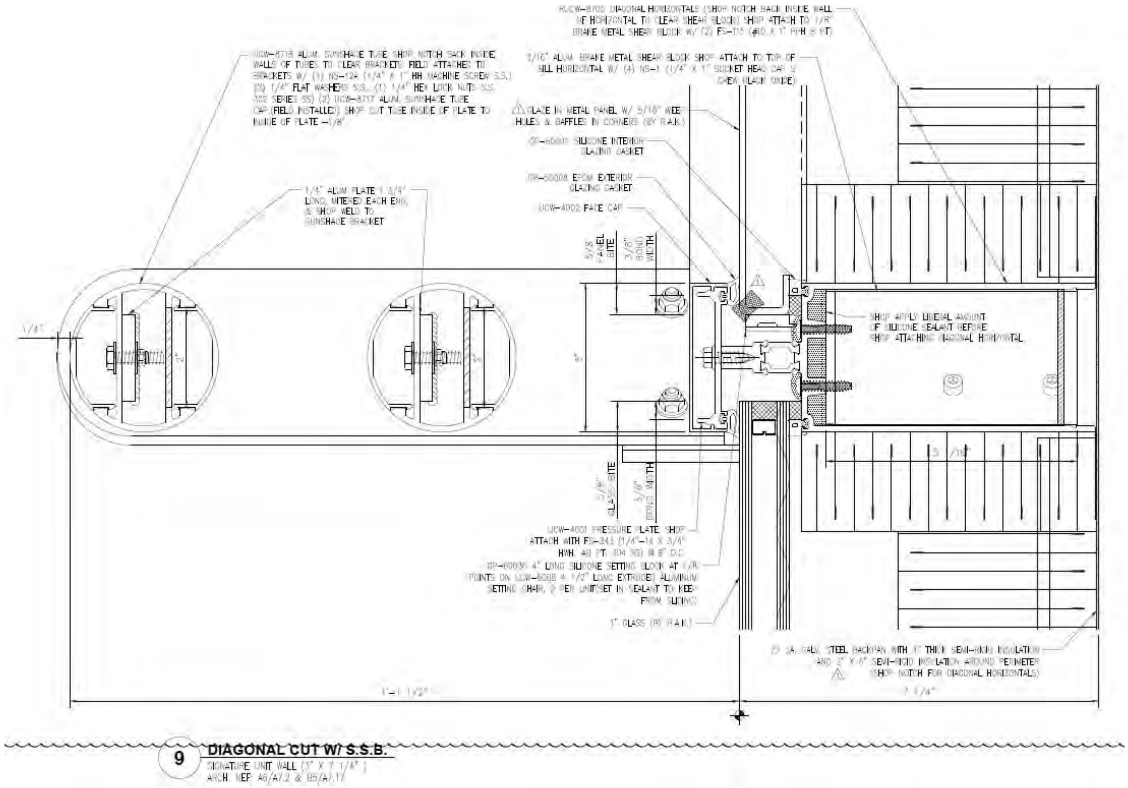


Figure 6. Detail #1. Section of the analyzed shade profiles. Drawing 4-105. Aluminum bracket was substituted by stainless steel per the revised detail 5-136 (Fig. 3)

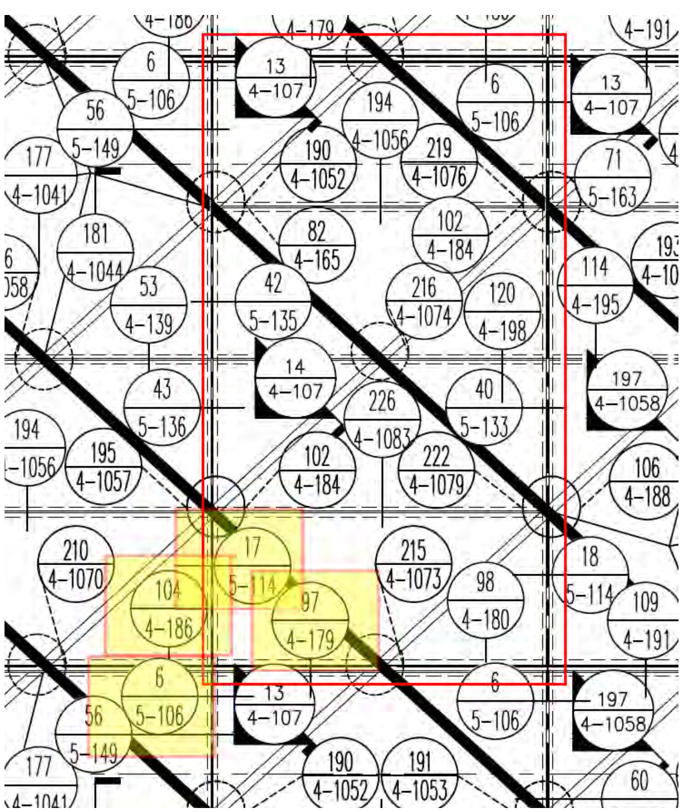


Figure 7. Detail #2. Elevation with the location of the second detail indicated.

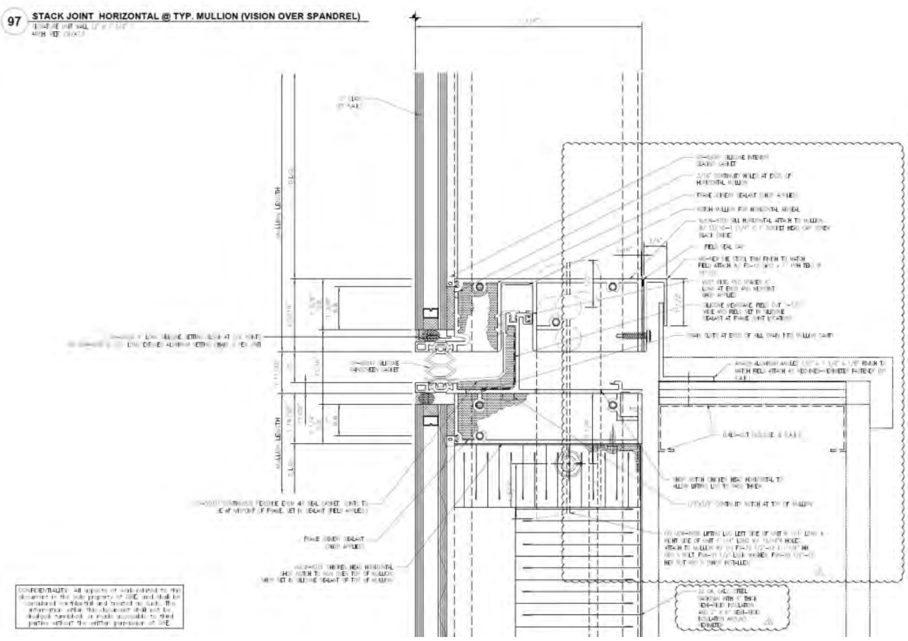


Figure 8. Detail #2. Section of the analyzed stack joint. Drawing 4-179.

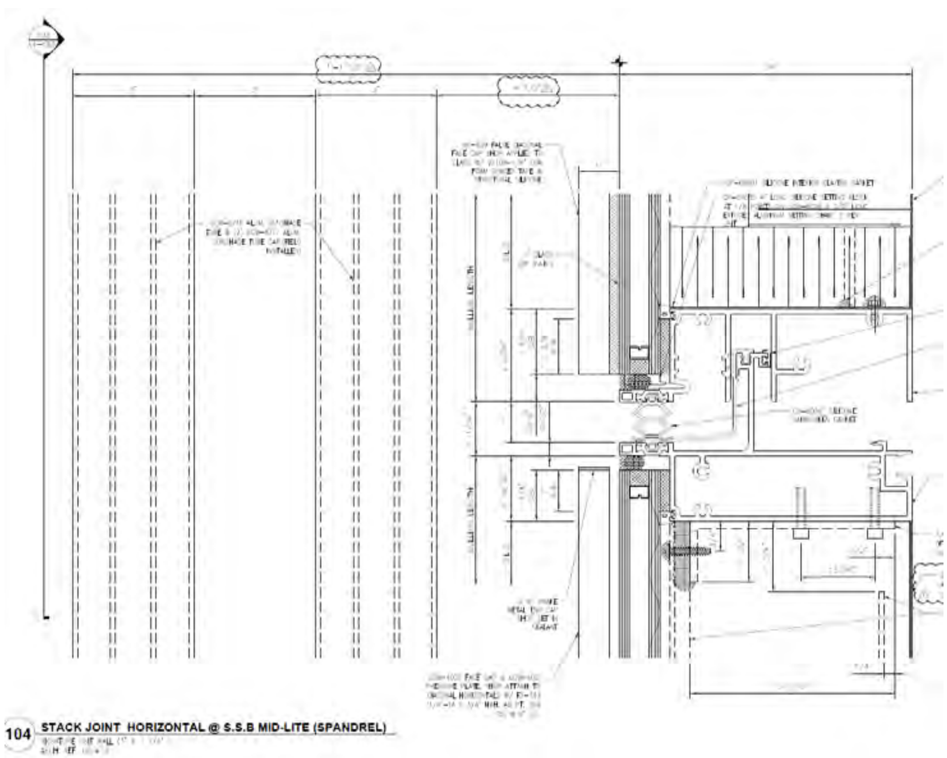


Figure 9. Detail #2. Section of the analyzed stack joint. Drawing 4-186.

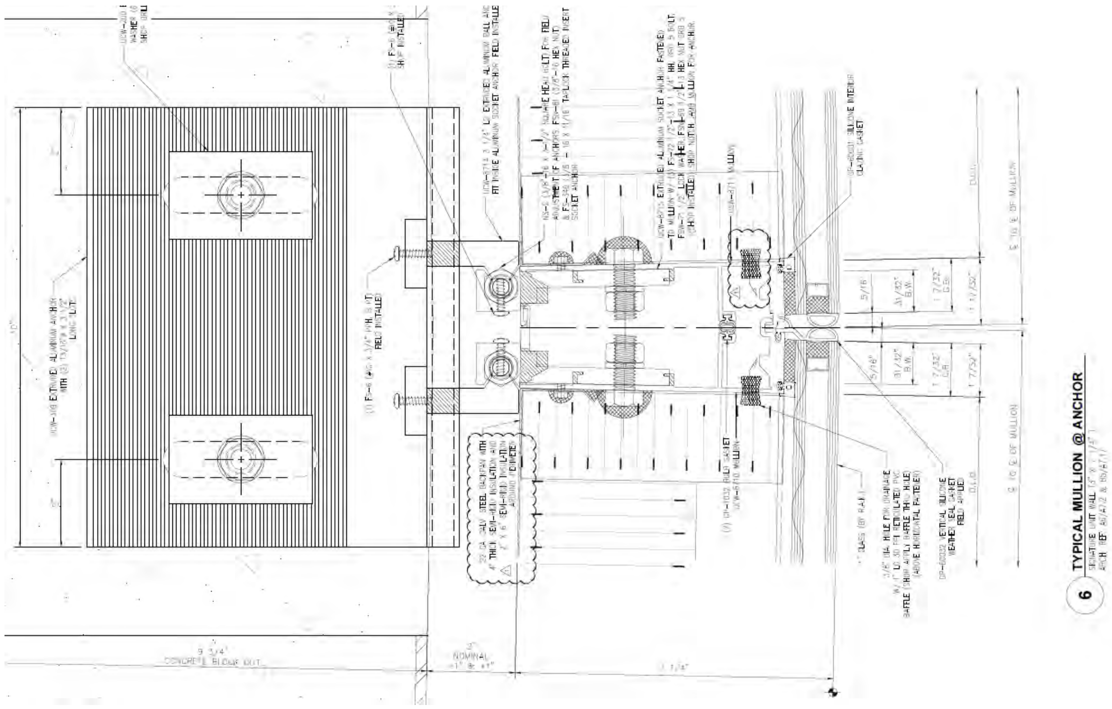


Figure 10. Detail #2. Section of the analyzed split mullion. Drawing 5-106.

APPENDIX D:
Physical Properties of Materials

Solid Materials

The properties of materials are based on the standard EN12524 " Building Materials and Products - Hygrothermal Properties - Tabulated Design Values," referenced by NFRC. The project-based boundary conditions were used in order to model convective air film coefficients. Conductivities of air cavities were calculated based on CEN (European Committee for Standardisation) rules (EN ISO 6946 and EN ISO 10077-2. The materials used in the simulations of this project are listed below:

Name	Conductivity W/mK
Aluminum	160.00
Steel - Galvanized	62.00
Steel - Stainless	17.00
Glass Lime -Soda	1.00
Silicone Filled	0.50
Ethylene Propylene Diene Monomer (EPDM)	0.25
Mineral Wool Batt (assumed CW90)	0.035
Polyethylene Foam	0.034
Polyamide Nylon	0.25

Air Cavities	Calculated per CEN rule.
Glass Air Cavity	Calculated per the App.B

Assignment of Materials:

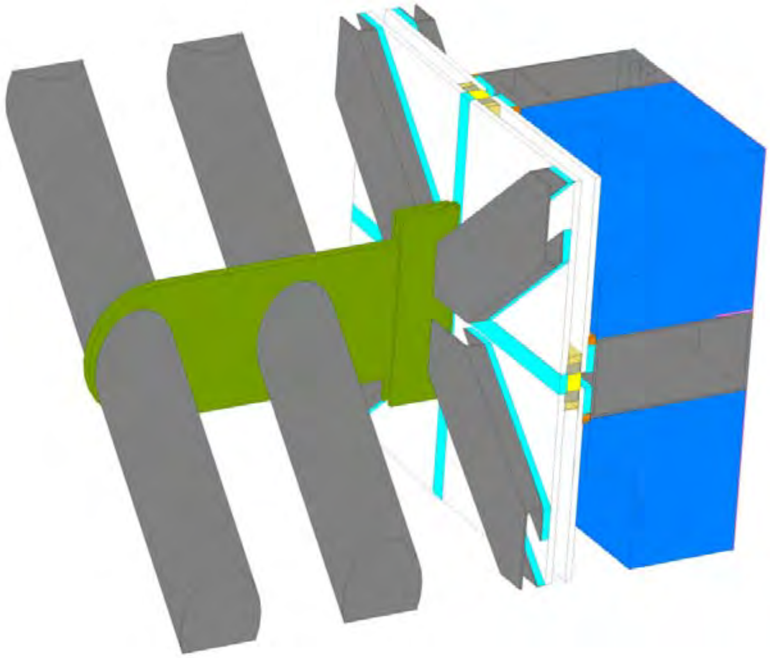


Figure 1. Detail #1. Assignment of materials by thermal conductivity.

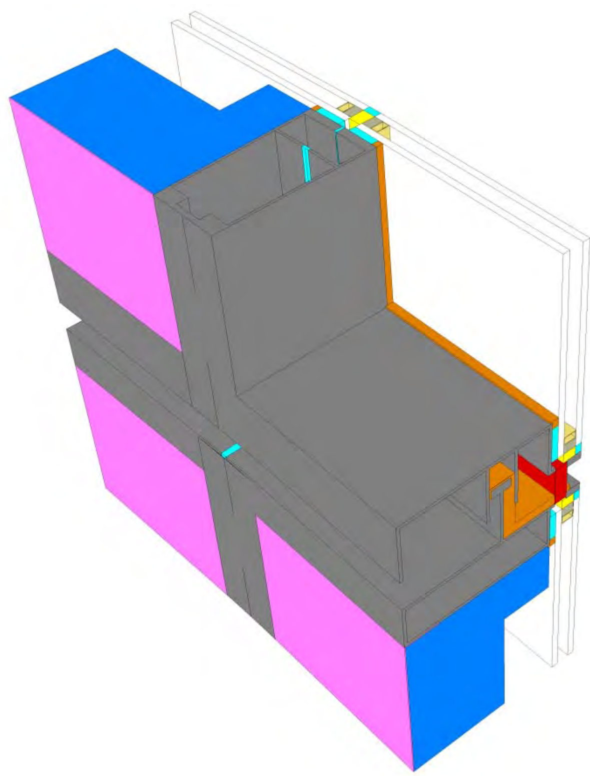


Figure 2. Detail #2. Assignment of materials by thermal conductivity.

APPENDIX E:
Temperature Maps

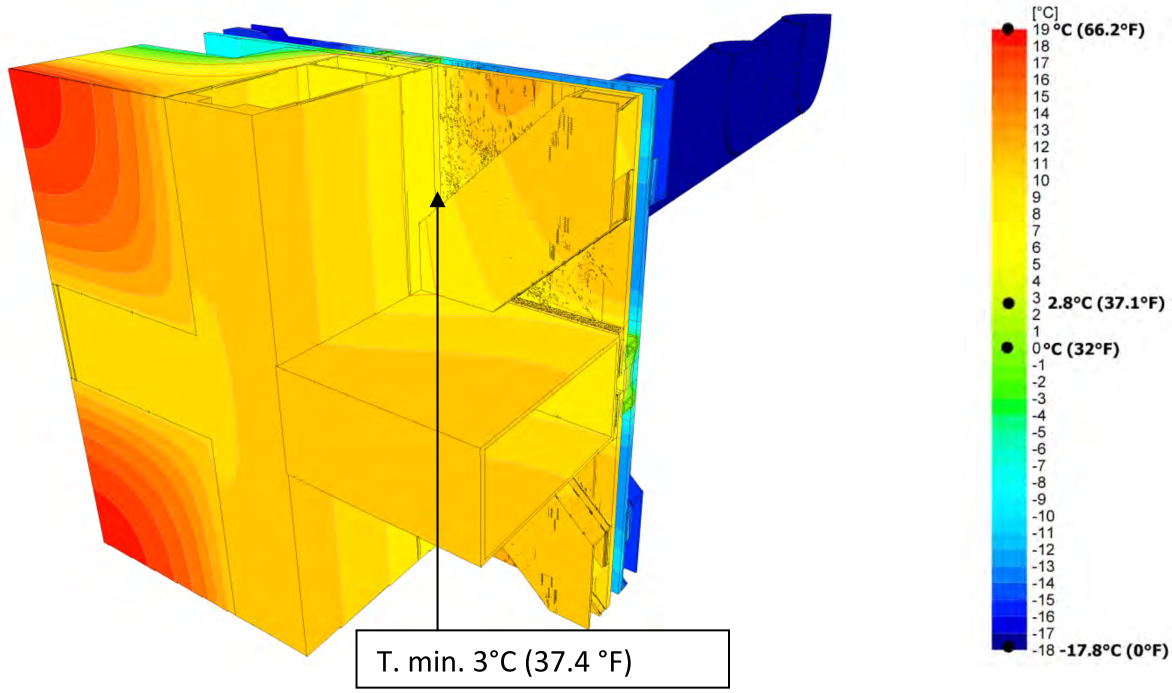


Figure 1. Detail #1. Interior view at the vision panel's jamb. Full temperature scale.

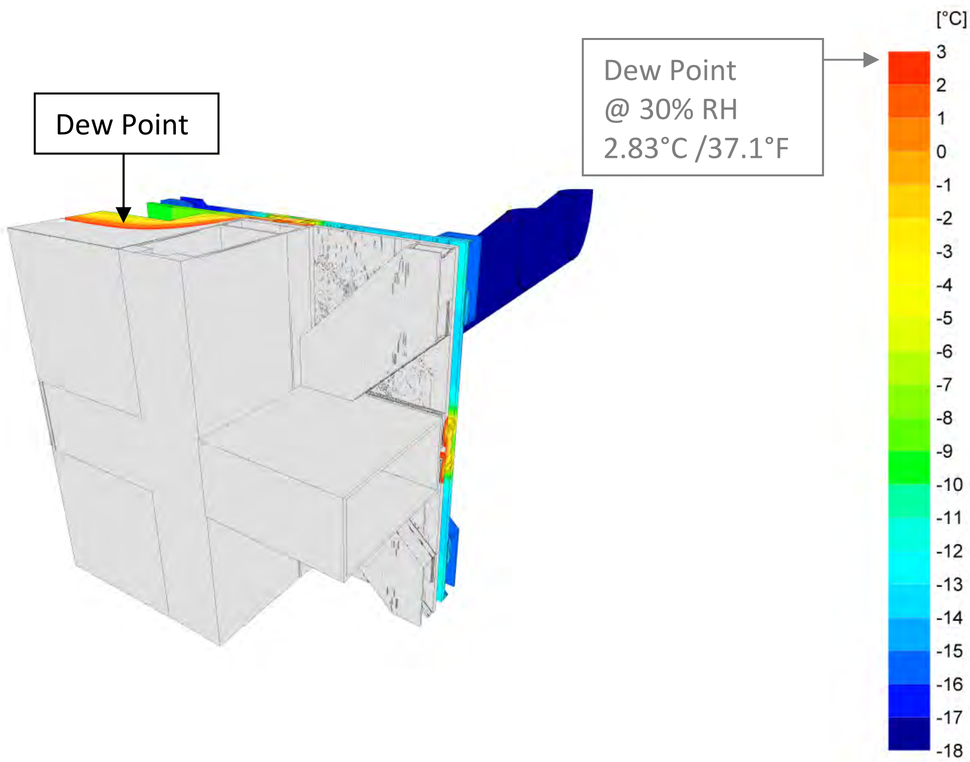


Figure 2. Detail #1. Same view with a different scale, for the better Dew Point illustration.

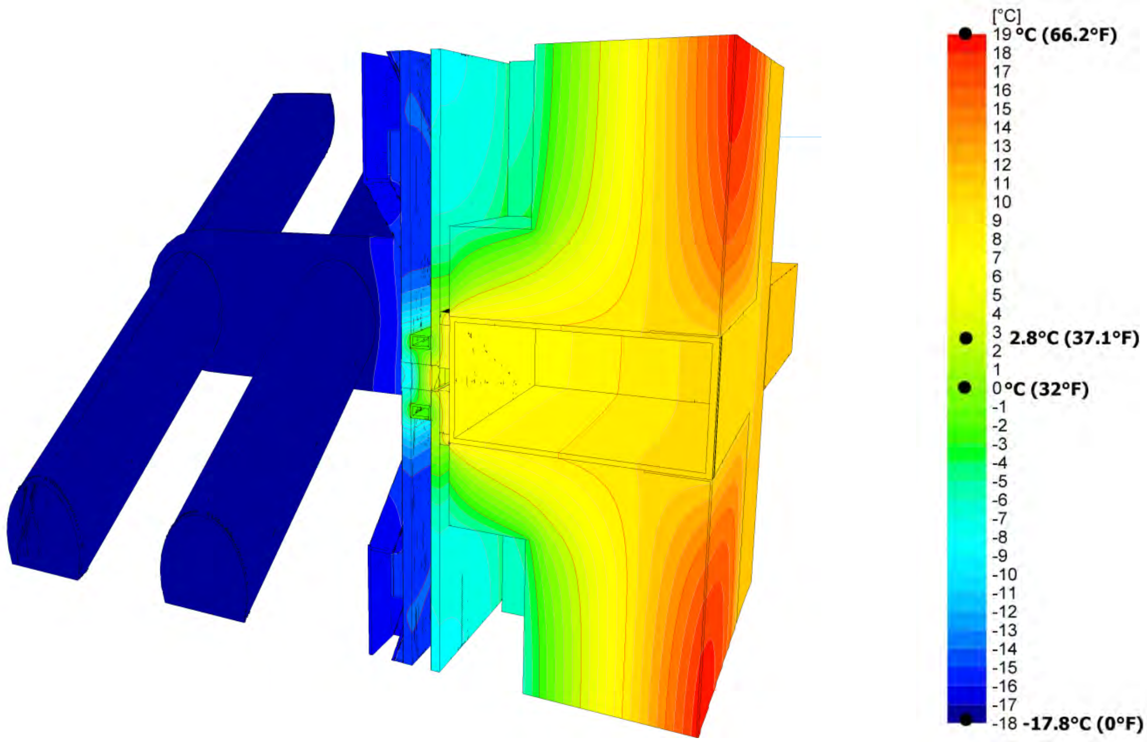


Figure 3. Detail #1. Interior view at the shadow box.. Full temperature scale.

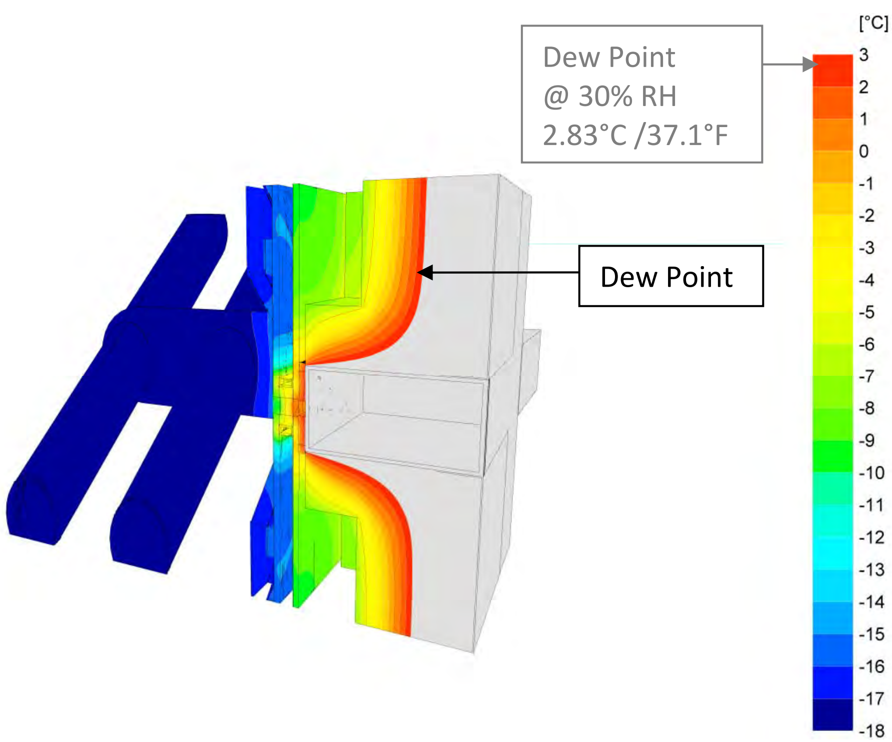


Figure 4. Detail #1. Interior view at the shadow box.. Different scale, for better Dew Point illustration.

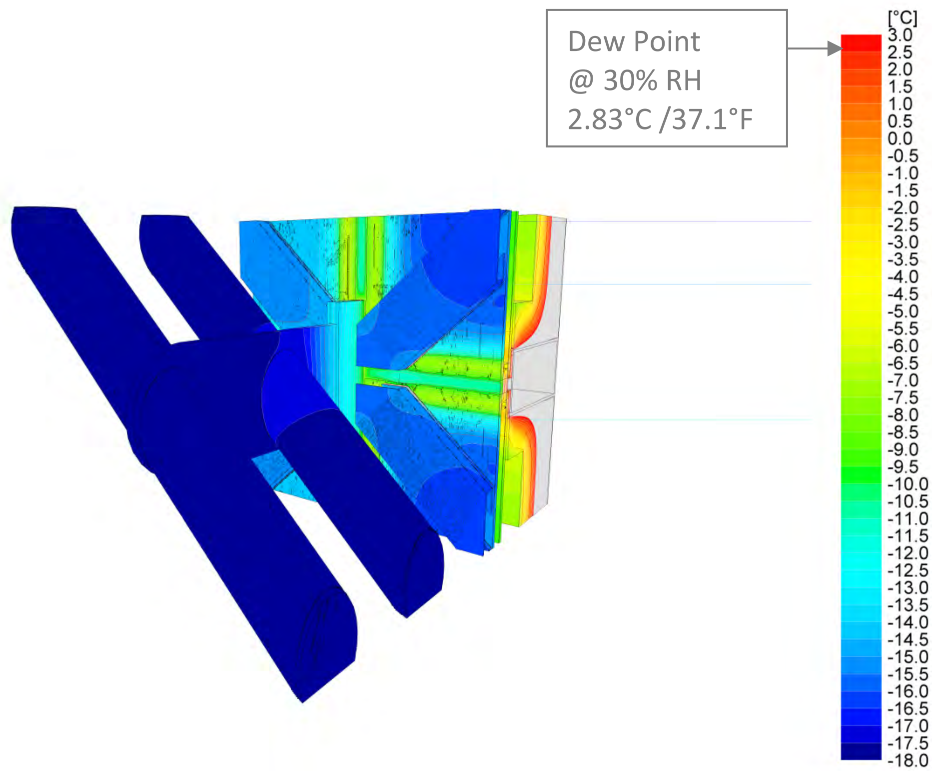


Figure 5. Detail #1. Exterior view.

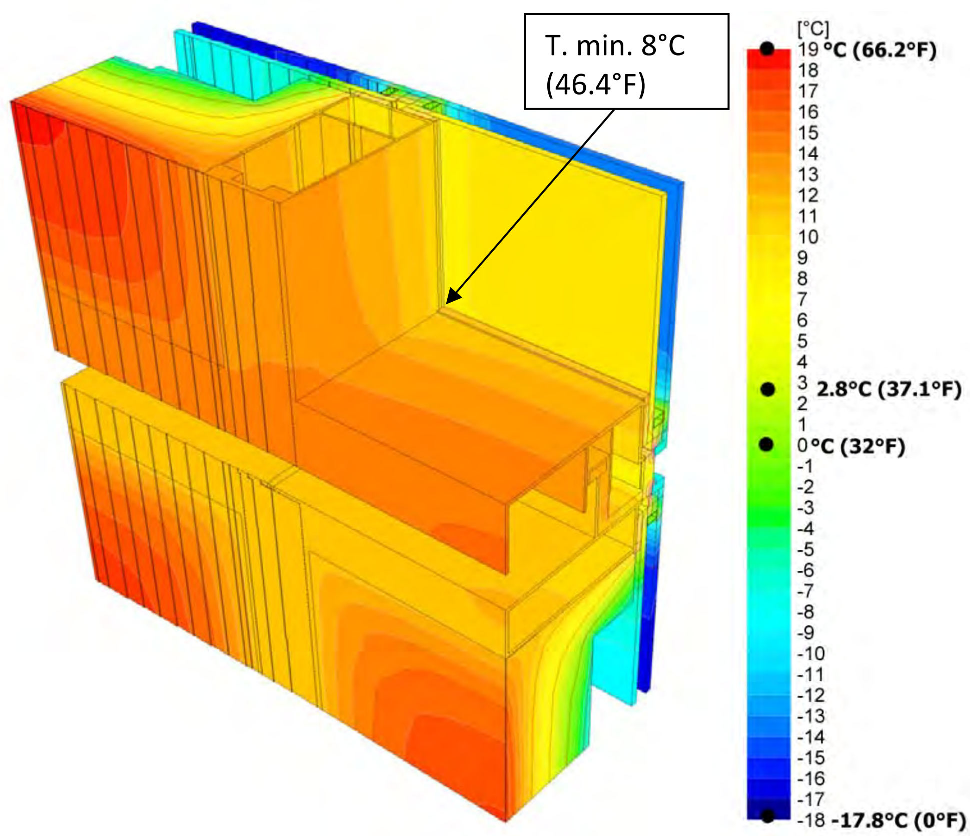


Figure 6. Detail #2. Interior view at the vision panel's jamb/sill corner. Full temperature scale.

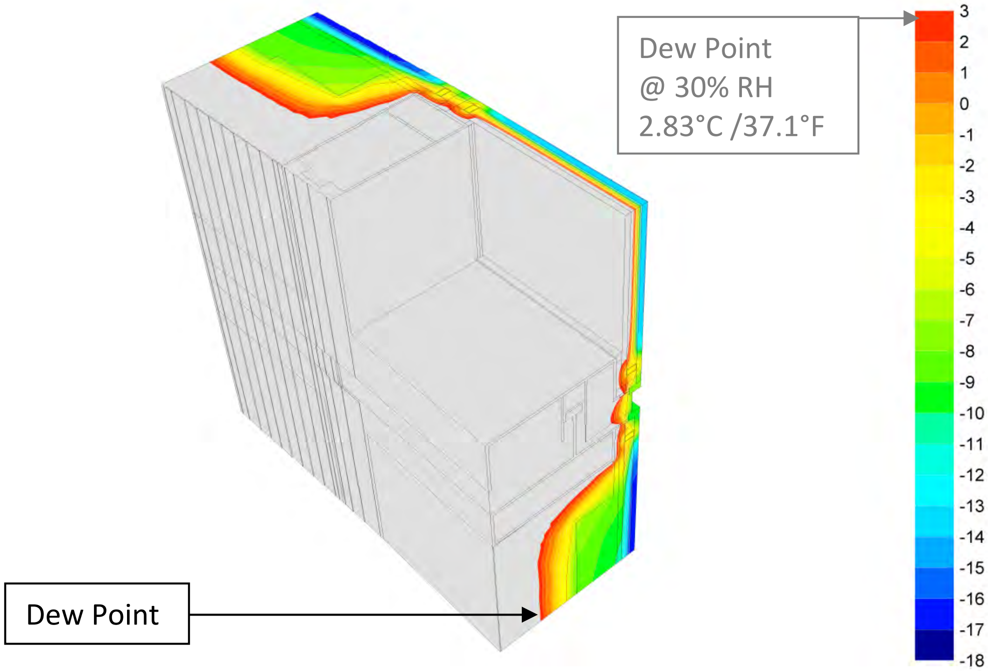


Figure 7. Detail #2. Interior view at the vision panel's jamb/sill corner. Different scale, for the better Dew Point illustration.

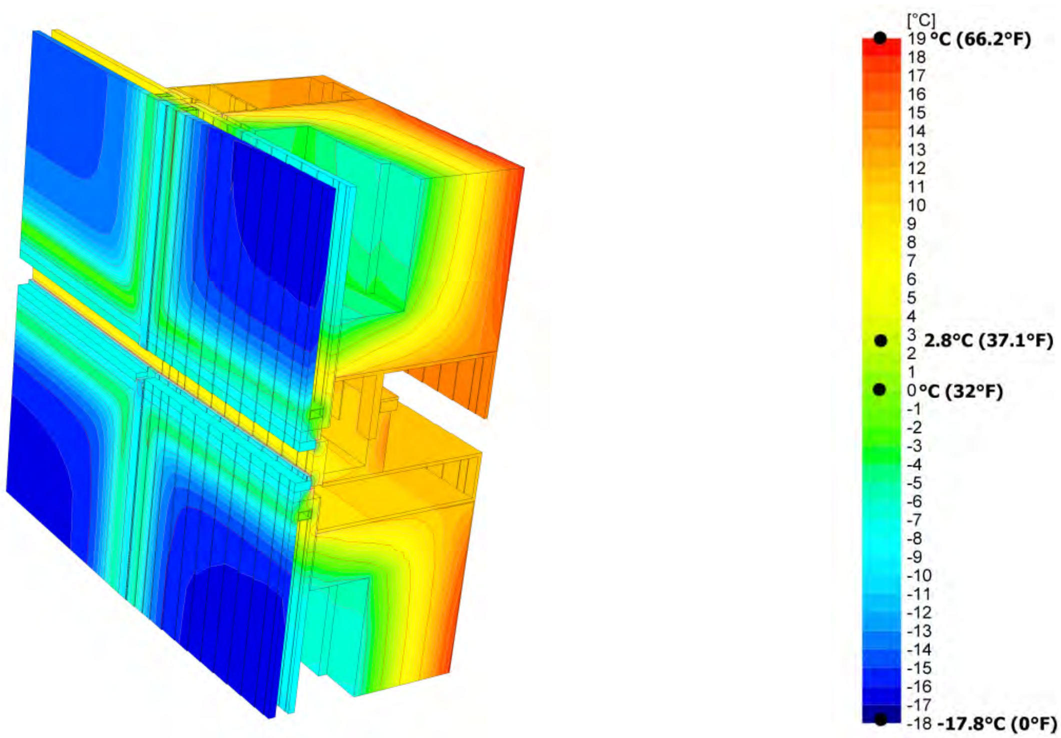


Figure 8. Detail #2. Exterior view. Full temperature scale.

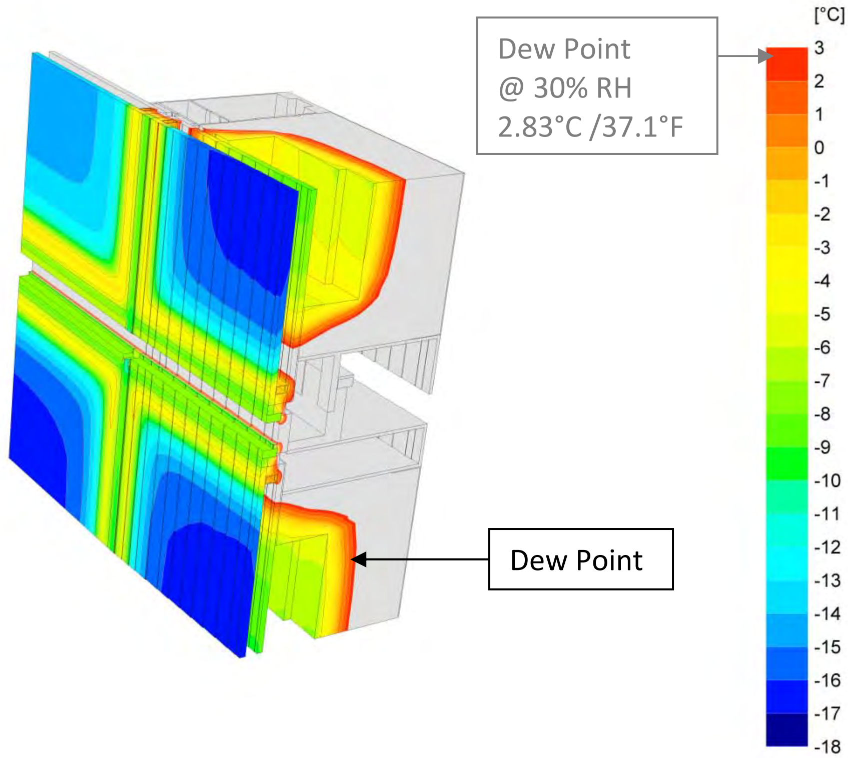


Figure 9. Detail #2. Exterior view. Different scale, for the better Dew Point illustration.

APPENDIX F:
Condensation Risk Assessment

Based on our review of the submitted documentation, and the three-dimensional thermal finite element analyses we conducted, as indicated on the temperature maps reproduced in the Appendix E, we came to the following conclusions:

Detail #1. (The window jamb detail featuring the sunshade penetration.)

The condensation was found to be limited to the areas designated as wet. Therefore, the risk of condensation of the detail #1 was found to be low.

Detail #2. (The bottom corner of the window, featuring the stack joint of the curtain wall.)

The condensation was found to be limited to the areas designated as wet. Therefore, the risk of condensation of the detail #2 was found to be low.

What does the low condensation risk mean?

Limitations of the Condensation Assessment. A low risk of condensation does not mean that condensation will never form during the life of the building. The average specified design or benchmark conditions are not necessarily maintained in the center of their range in a real life. Some conditions that alone, or in combination with others, may lead to condensation are:

- External temperatures falling below the design temperature.
- High wind, exceeding the design velocity, in conjunction with, at, or near design temperature.
- Variations of interior temperature and increase of humidity caused by human activities (i.e. washing, cooking, etc.)
- Upper and lower bound combinations of interior temperature and humidity ranges, within a mechanical adjustment tolerance.
- Upper and lower bound combinations of interior temperature and humidity ranges, outside a mechanical adjustment tolerance (i.e. malfunctioning thermostat.)
- A true detail is almost always different from an idealized computer model. There are many variables, such as construction tolerances, original characteristics of used materials, their characteristics in use (i.e. cleanliness of surfaces), psychometric conditions inside and outside a building enclosure.

Limitations of Location. A basic analysis of a detail is conducted by comparison of its temperature map with the calculated dew point temperature. However; there are two exceptions:

- Per most building codes, a zone cooler than the Dew Point is acceptable, providing it is either protected by a vapor retarder, safely drained outside or both.

We assume that a vapor retarder complies with requirements set by ASHRAE "Handbook of Fundamentals." A deficient or damaged element performing the function of a vapor barrier may contribute to the condensation.

- Even though we may model the entire detail including adjacent assemblies, they are modeled and simulated only as an aid in assessment of the main object of our simulation. We do not assess the risk of condensation in the assemblies that are beyond the scope of our investigation.

<u>Limitations of the Simulation Method.</u> Although the steady-state conduction simulation is well established and approved by NFRC and AAMA for fenestration analysis, we recognize the three main limitations listed below:

1) <u>Wind-Chill Factor</u>. We assumed certain fixed boundary conditions, such as convection coefficients, as opposed to the computational fluid dynamics (CFD) which would identify the true convection.

2) <u>Heat Transfer Delay</u>. We performed steady-state simulation, which assumed that environmental conditions and material characteristics are held steady, as opposed to transient simulations which would consider their fluctuations.

3) <u>Radiation</u>. The simulation relies on simplified radiation coefficient as opposed to the actual radiation simulation.