Quast Consulting & Testing Inc.

WELCOME

September 11, 2020

Specifying Thermal Analysis

Commercial Building Envelope - Fenestration

- Presenters
  - Brian Sasman P.E. (President)
  - Jeff Zibton (Project Manager)

Learning Objectives

- Understand standardized vs project specific energy transmittance ratings.
- Define key points to consider when specifying energy transmittance ratings.
- Understand commonly referenced standardized condensation ratings vs project specific condensation risk evaluation.
- Define key points to consider when specifying condensation resistance performance.
- Review the benefits of pairing simulations with performance mock-up test data.

Thermal Analysis

Energy Transmittance

Condensation Resistance

Thermal Analysis

Energy Transmittance

- U-factor
- SHGC (Solar Heat Gain Coefficient)

Condensation Resistance

Quantifying rate of energy loss or gain

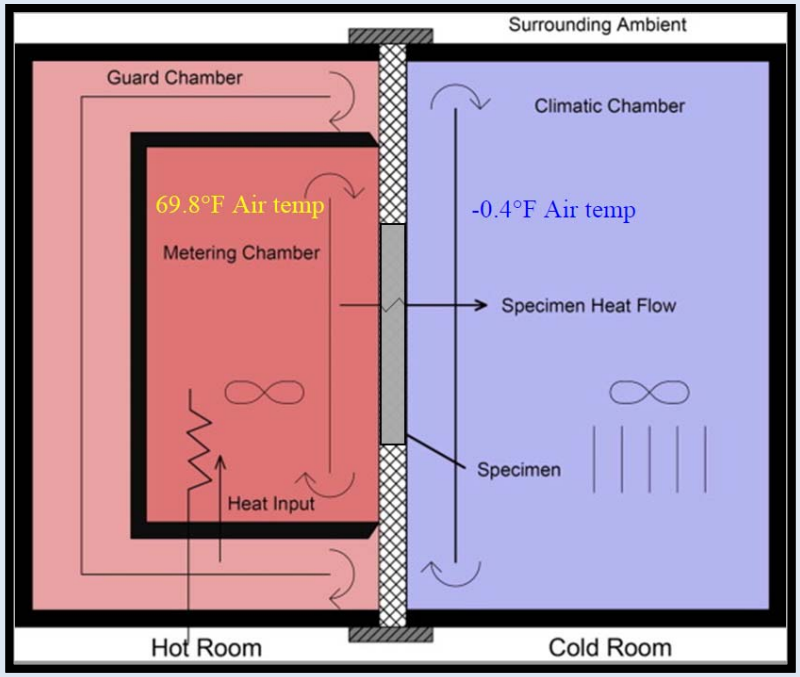
U-factor= Energy lost via conductive transmittance:
Night-time steady state conditions

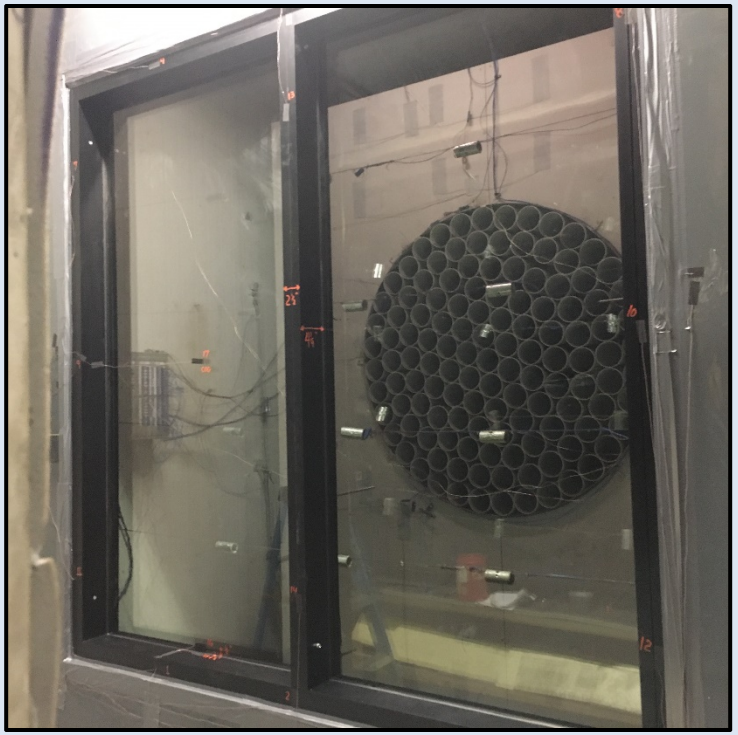
SHGC=Solar Energy gained via solar radiation at 0° incidence

U-factor and SHGC performance can be measured by physical testing, however Ratings are produced through finite element modeling using LBNLs THERM and WINDOW software tools.

Measured Energy Transmittance

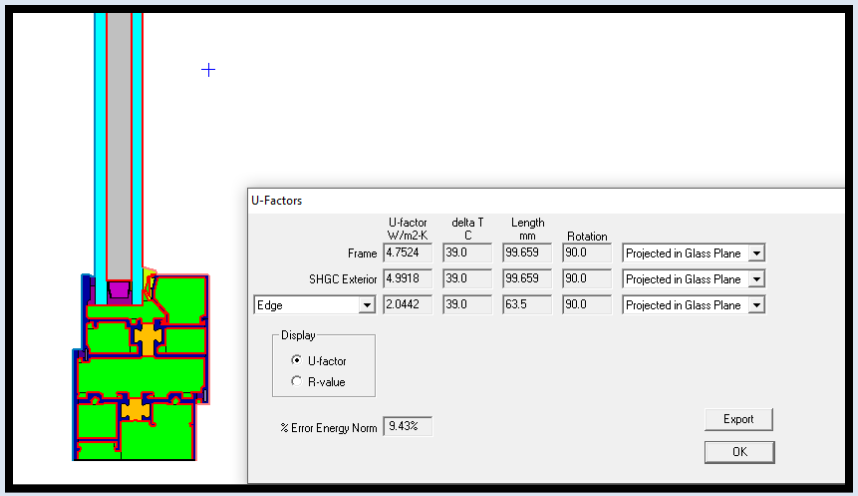
NFRC 102, *Physical U-factor test*





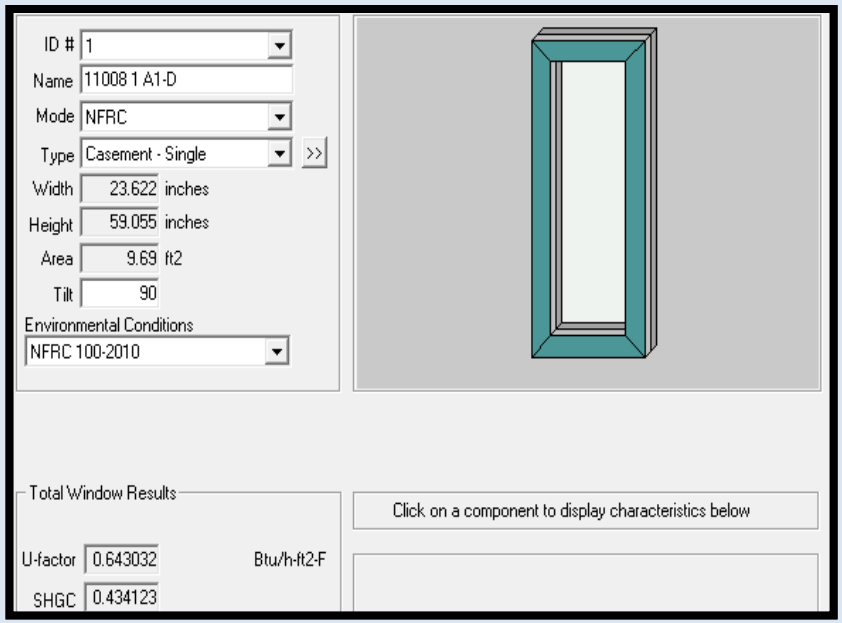
Guarded hot box chamber

Finite Element Analysis
Thermal Modeling

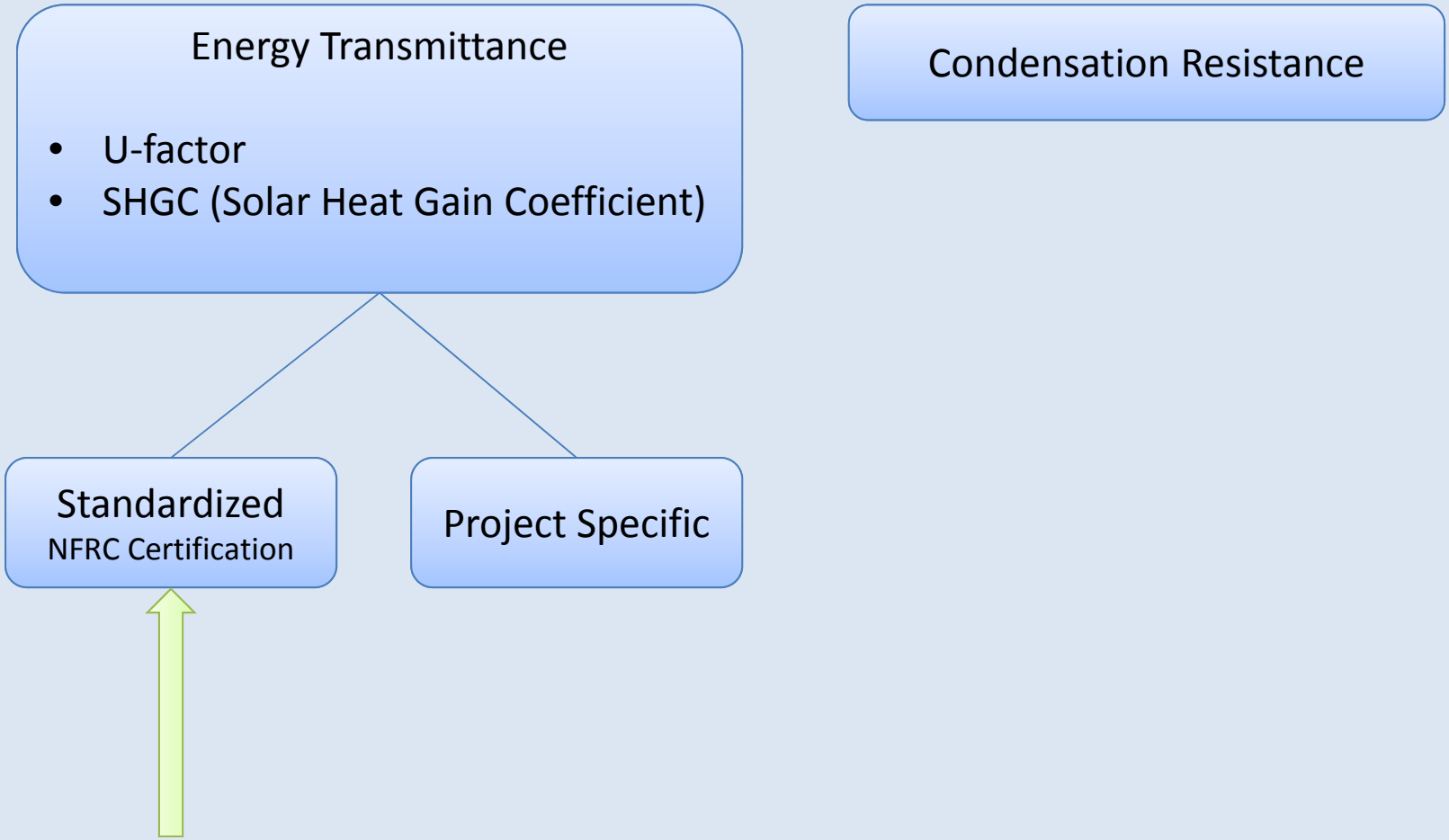


NFRC 100, *Simulated U-factor*
NFRC 200, *Simulated Solar Heat Gain Coefficient*

2-Dimensional modeling software
THERM 7.4
WINDOW 7.4



Thermal Analysis



Standardized Energy Transmittance

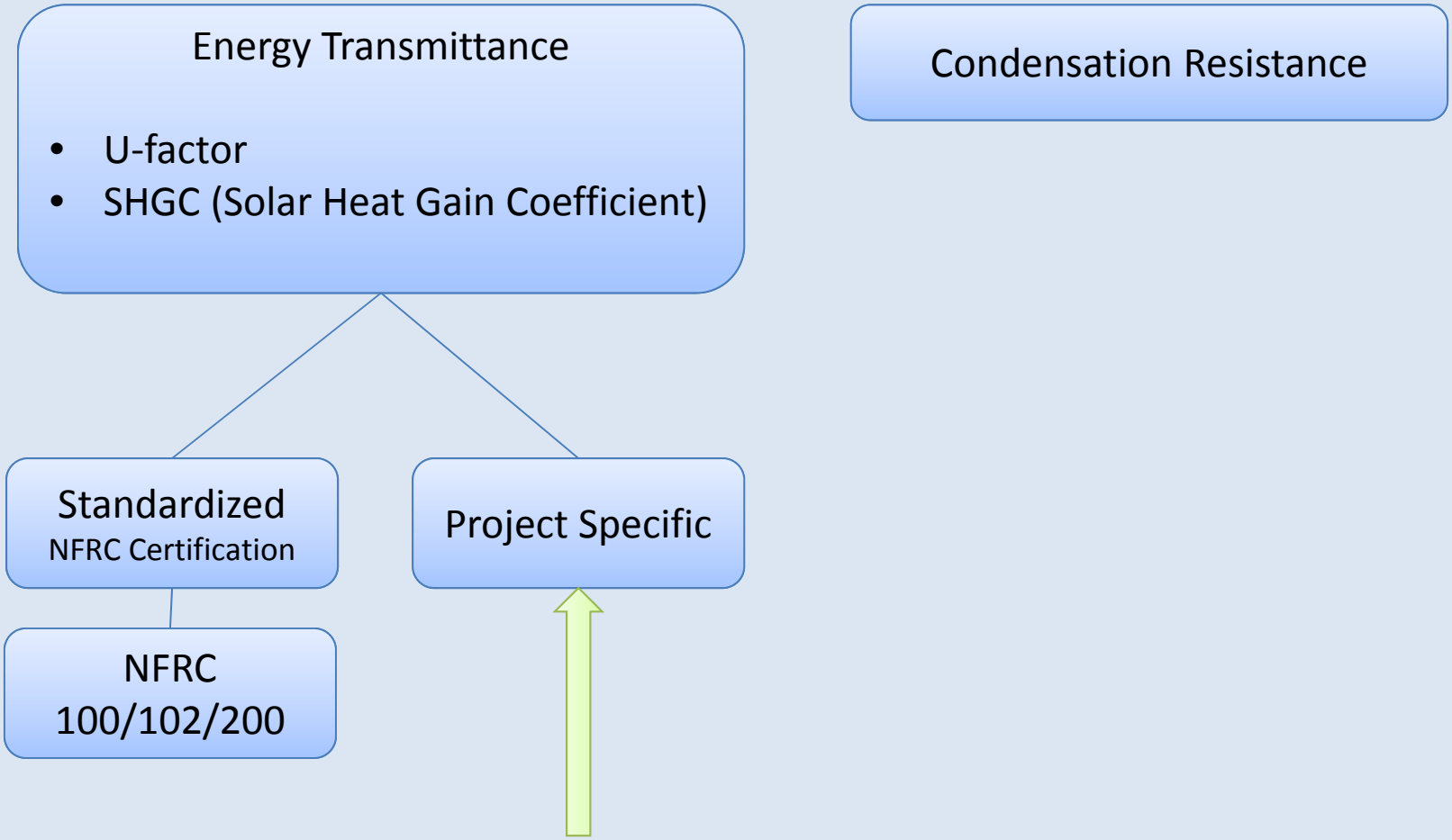
Benefits:

- Product to product comparison
- “Certifiable” Values
- Compliance with energy code requirements
- Compliance with energy efficiency incentive programs (LEED)
- Existing product data may be available

Drawbacks:

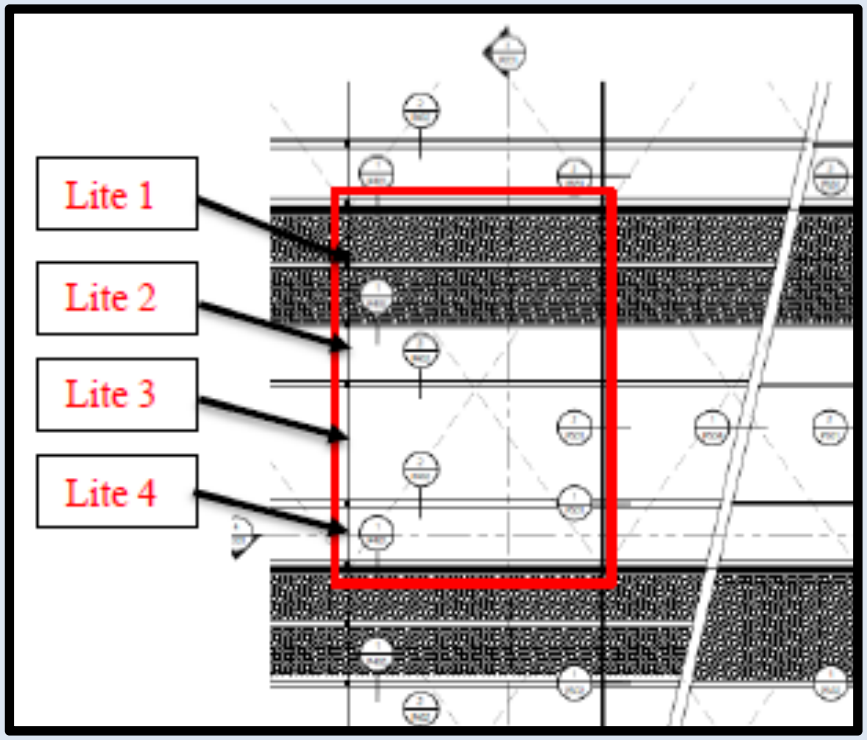
- Typically uses standard product profiles
- Uses standardized sizes and configurations
- Does not include opaque lites
- Does not include the influence of adjacent construction
- Full product certification may up to a few months to complete

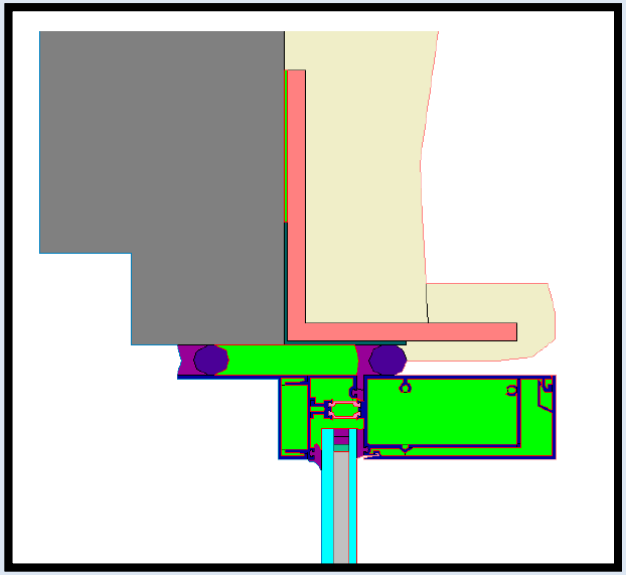
Thermal Analysis

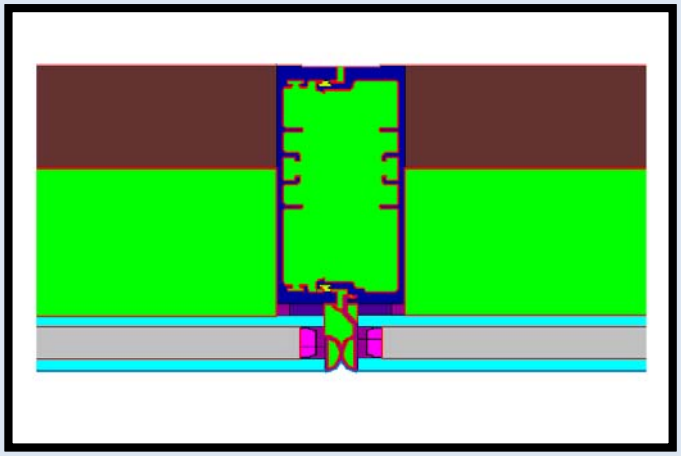


Project Specific Energy Transmittance

NFRC 100 modeling and calculation principals expanded to larger complex areas







Elevation A w/additonal Horizontal Bars		
Lite	U-factor (Btu/Hr· Ft^2· °F)	Area (Ft^2)
1	0.113	44.32
2	0.407	23.32
3	0.323	46.68
4	0.521	25.68
Vison Total	0.397	95.68
Spandrel Total	0.113	44.32
Overall Total	0.307	140.00

Project Specific Energy Transmittance

Benefits:

- Accurate estimates of project performance
- Can be performed early in the design process
- Custom profiles included in calculations
- Project size lites and configurations
- Opaque lites can be included in analysis
- Adjacent construction can be considered
- Can be useful for consideration in mechanical system sizing, etc.

Drawbacks:

- Can be more costly than standardized product calculations
- Does not qualify as “certification” or “label”
- Can be overanalyzed
  - Selecting and calculating typical repeating project modules can provide a reasonably accurate estimation
  - Specifying extensive modeling including atypical conditions can result in substantially higher costs with relatively small changes in estimated performance.

Key points for specifying energy transmittance analysis

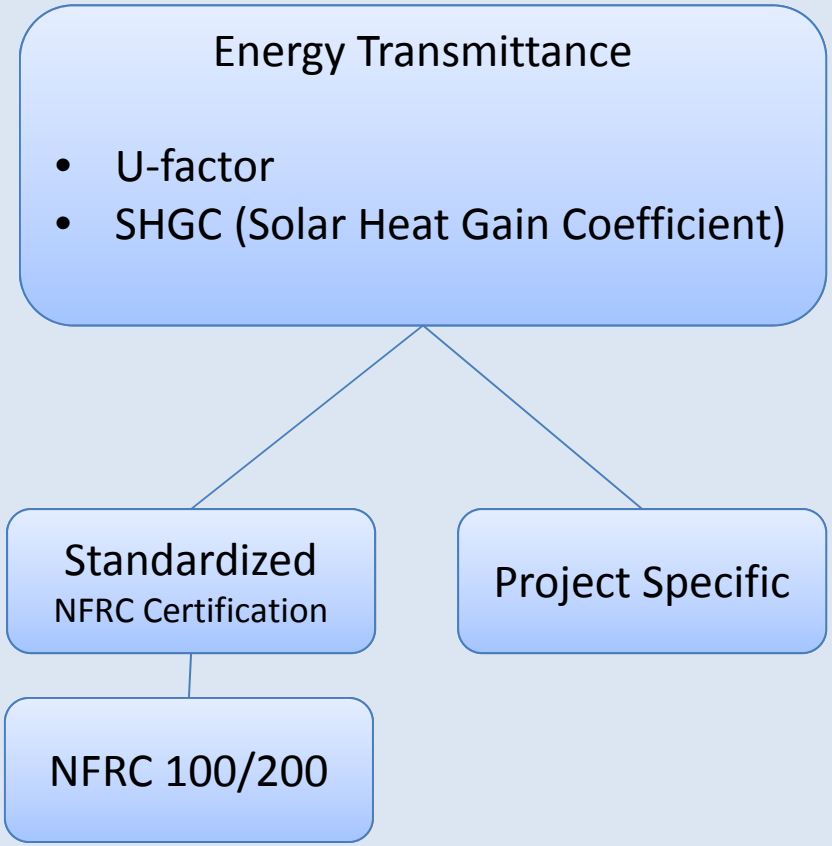
Standard product rating

- U-factor in accordance with NFRC 100
- SHGC in accordance with NFRC 200
- Clearly state if product certification or labeling is required:
  - NFRC 700 site built certification, NFRC 700 certified product, or NFRC 705 Label Certificate

Project specific energy transmittance

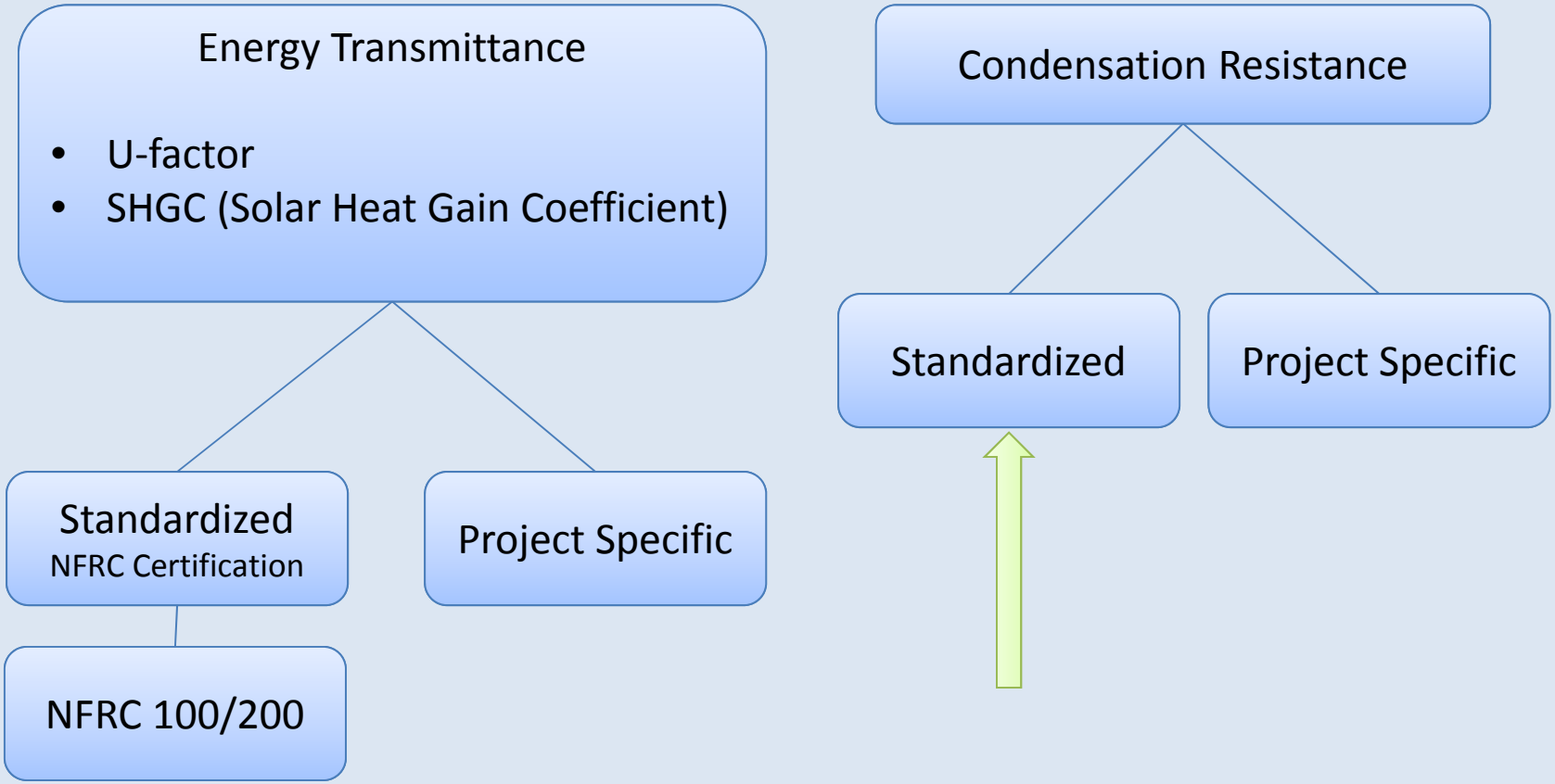
- U-factor (SHGC) in general accordance with NFRC 100 (200) performed at project size and configuration, and to include adjacent construction.
- A detailed description of extents of analysis should be included in the contract documents.
  - Project specification
  - Architectural drawings

Thermal Analysis



Questions?

Thermal Analysis



Standardized Condensation Rating

NFRC 500 “CR” Rating

- Computer modeling
- Part of NFRC standard product rating
- Scale of 0-100
- Based off of simulated surface temperatures and compared to three different interior dewpoint temperatures

AAMA 1503 “CRF” Rating

- Physical Test
- Origins date back to 1970’s
- Scale of 0-100
- Measures 14 predetermined frame locations, 6 predetermined glass locations
- Additionally 10 frame temperature measurements located at lab discretion
- Performed at one set of environmental conditions, 0^{o}F Outside / 70^{o}F Inside

Common Mistake in Specifying Standard Condensation Rating

Example: Aluminum thermally broken fixed window with insulated glass (Argon 90% and LowE coating)

NFRC 500 CR rating= 44
AAMA 1503 CRF rating= 58

Standardized Condensation Rating

NFRC 500, *"CR" rating*
AAMA 1503, *"CRF" rating*

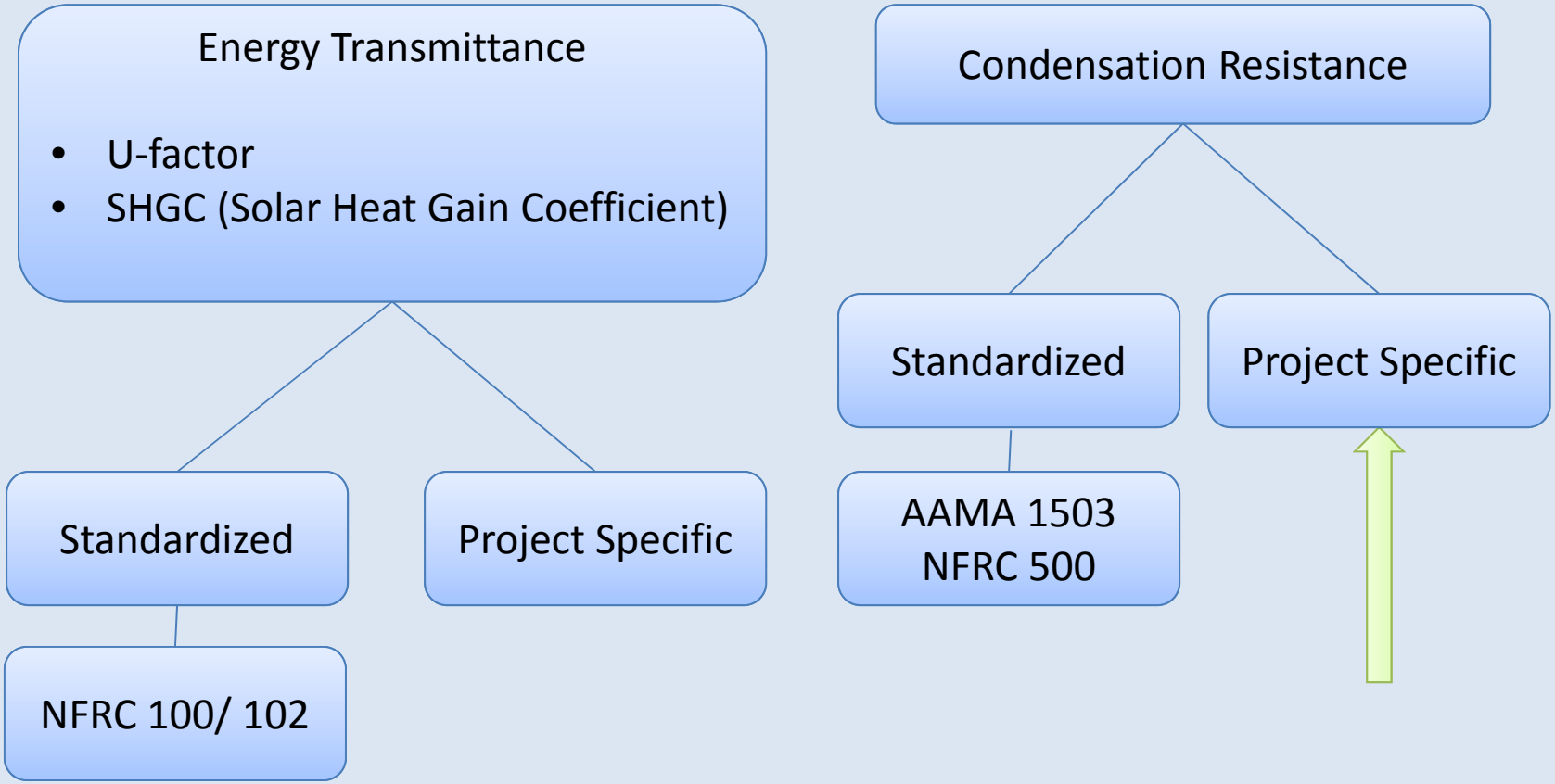
Benefits:

- System comparisons
- Compare System A to System B with all variables equal

Drawbacks:

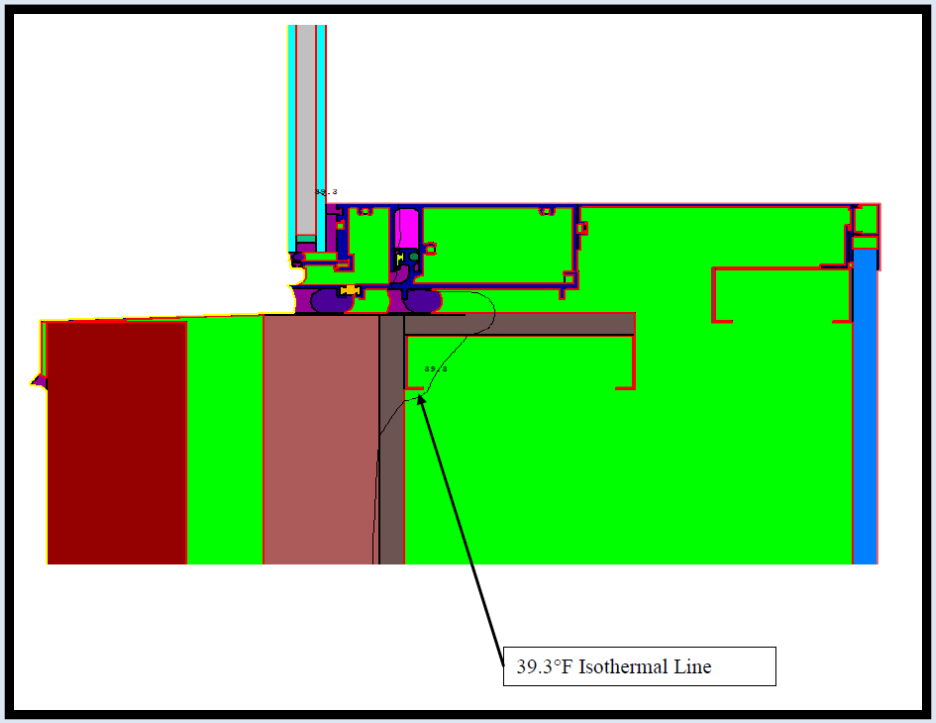
- Standard product profiles
- Standard product size and configuration
- Uses standardized environmental conditions
- Does not include the influence of adjacent construction
- Results do not illustrate specific areas of risk within the system
- "CR" and "CRF" Ratings often mistakenly interchanged

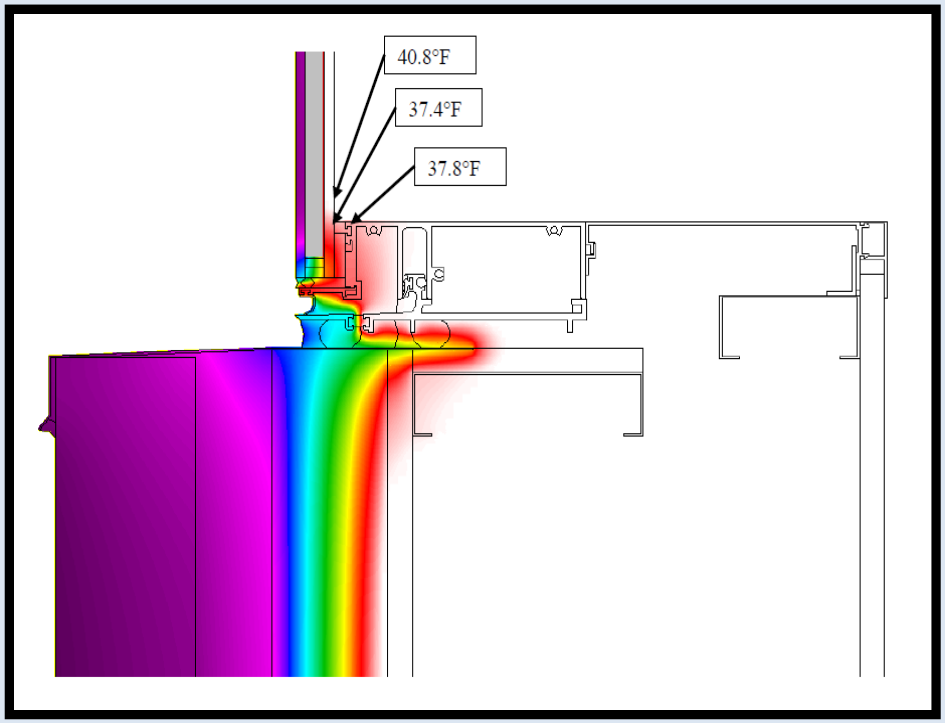
Thermal Analysis



Project Specific Condensation Risk Analysis

2D Finite Element Analysis using LBNL THERM Software



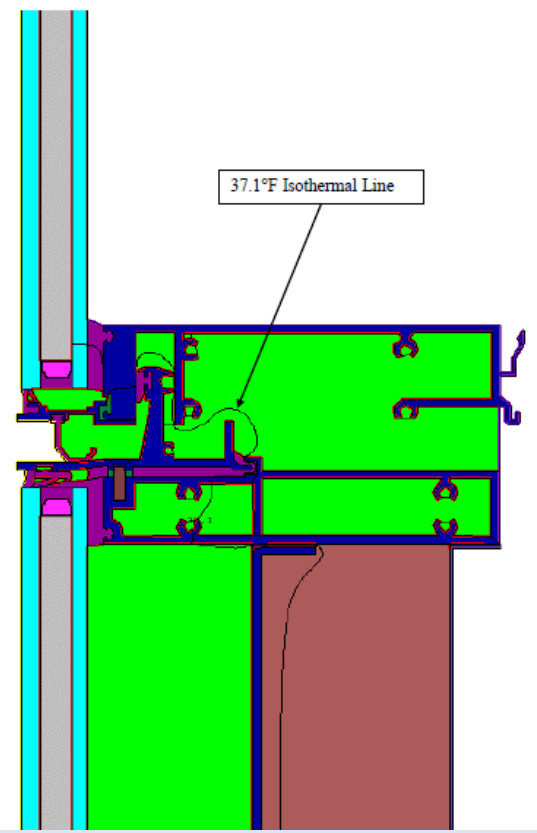


Project Specific Condensation Risk Analysis

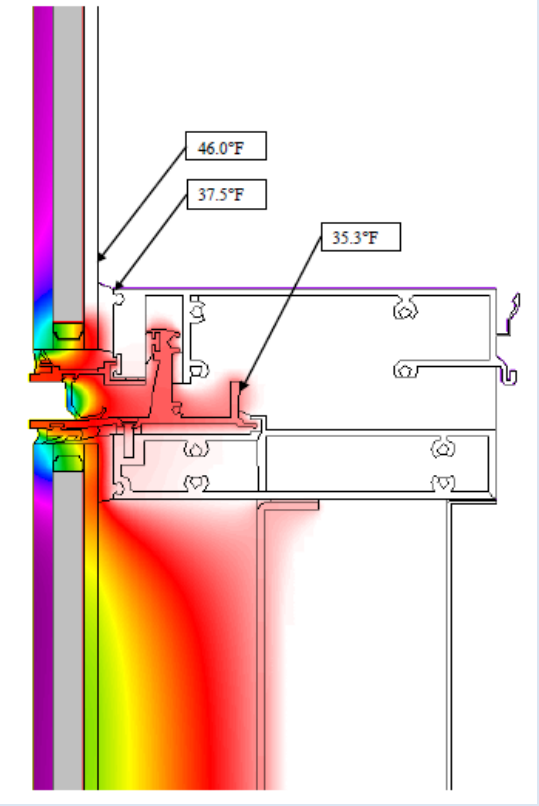
Create models tailored to project specific environmental conditions

- Exterior Air Temperature
- Exterior Wind Speed
- Interior Air Temperature

Compare interior surface temperatures to design dew point temperature to identify areas with the potential to form condensation.



- Interior Air Temperature = 70°F
- Interior RH% = 30%
- Dew Point Temperature = 37.1°F



Project Specific Condensation Risk Analysis

Benefits:

- Includes adjacent building construction
  - Major factor in performance
- Opaque lites included
- Project specific environmental conditions
  - ASHRAE design temperature exterior
  - Project specified interior temperature and humidity
- Visual and quantitative results
  - Shows specific areas of risk at each modeled detail
  - Great tool to head off issues early in the design process

Drawbacks:

- Should be approached carefully to avoid adding unnecessary costs by repeatedly modeling details during development
- Limitations to details influenced heavily by three dimensional energy flow
  - Anchors
  - Spandrel intersections
  - Parapets
- Results should not be reviewed with some level of interpretation
- Somewhat lacking industry standards until recent (AAMA 515)

Key points for specifying condensation risk analysis

Standard product comparison

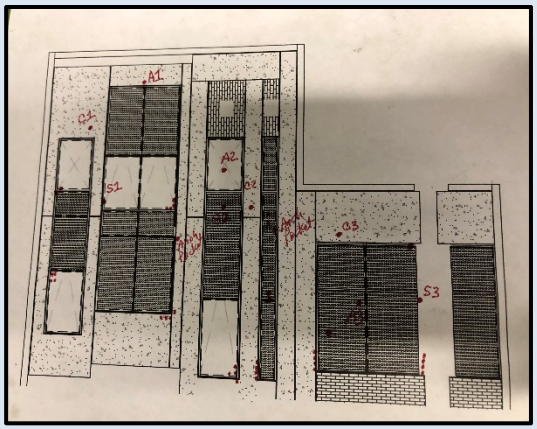
- CR rating in accordance with NFRC 500
- CRF rating in accordance with AAMA 1503

Project specific condensation risk analysis

- Condensation risk analysis using two dimensional finite element modeling software (THERM / WINDOW)
- Adjacent construction shall be included
- Statement as to whether any level of condensation formation is expectable in simulations (i.e. condensation formation shall not exceed 5% of any detail)
- A description of number of details required
  - Typical details
  - Atypical details
- Environmental conditions
  - Winter design interior temperatures
  - Winter design interior humidity
  - Exterior temperature
    - ASHRAE climatic design temperatures 99% or 99.6% typical
  - Exterior windspeed
    - 15 mph typical

Project Specific Condensation Test

AAMA 501.5 *Test method for thermal cycling of exterior walls*
AAMA 501.9 *Surface temperature assessment for condensation resistance of exterior wall systems*



Validation of Project Specific Simulations

Benefits:

- Helps to understand level of accuracy of finite element models
- Increases data and knowledge regarding 3-D conditions
  - Parapets
  - Sunshade brackets
  - Anchors
  - Vision/ spandrel transitions
- Typically included as a step in performance mock-up tests

Drawbacks:

- Performed late in the design process and may be costly to make design changes

Questions?

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