Optimizing Energy Performance in Building Renovations

New York University - 370 Jay Street Case Study
BCxA Northeast Chapter Commissioning Summit, Session 2
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Speakers

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- *John Runkle, P.E., heads consulting services for Intertek's Building and Construction Group, with an emphasis on building enclosures, fire/life-safety , and acoustical systems. He is a past board member of the BCxA's National Capital Chapter and a current member of the BCxA's International Board.*

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- Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Course Description

370 Jay Street / The Center for Urban Science and Progress (CUSP) is a 14-story building of approximately 560,000 square feet, constructed in 1951. The $80 million gut renovation project, completed in 2017, created a new home for the applied science arm of New York University's academic initiative on cities and for multiple programs focused on digital technology and digital media. LEED Platinum (Core and Shell) was recently awarded.

The HVAC design incorporates dedicated outdoor air system (DOAS) units through which all latent energy is removed from the outside air stream. Only sensible cooling is provided at the indoor terminal units. To support this engineering strategy, very stringent design criteria had to be applied to glazing and enclosure upgrades. The existing limestone façade was retained, making it even more challenging to create a sustainable envelope that truly separated the interior and exterior environments.

The commissioning team tested both the existing structure and newly created air barrier on the interior of the exterior walls to help the construction team learn how to install the new windows and interior-applied barriers so they would meet the design criteria. This project realized maximum savings by setting and meeting aggressive air leakage targets and working with the designers to ensure that HVAC equipment was right-sized for both initial and annual energy savings.

The presentation will cover the benefits of this commissioning effort and corresponding testing, as well as lessons learned regarding the DOAS units coupled with sensible-only HVAC systems. Useful information related to the commissioning of ice thermal storage systems will also be provided.

Learning Objectives

1. Understand how enclosure commissioning can be effectively applied to existing buildings.
2. Learn how to get the best value out of your enclosure testing and how to negotiate through typical project challenges with testing.
3. Discuss how to maximize energy savings through fully implementing full building commissioning.

Building Transformation

370 Jay Street: from “a state of disrepair” into the Center for Urban Science and Progress: a vibrant hub where engineering, media, tech and the arts can co-exist and collaborate

The transformation presents many design challenges including the synergy between the HVAC & building envelope design

Source: Brownstoner

Source: Mitchell Giurgola

Existing Conditions

Existing Conditions

HVAC Design Criteria

"we have assumed winter infiltration of 0.10 CFM/SF of envelope area in winter and **0.04 CFM/SF in summer**. Load calculations were then performed to determine the amount of primary air (desiccated DOAS supply) required to combat the latent load from occupants and infiltration using the following:

- Summer OA Dehum = 81.0 DB / 76.1 WB = 128.5 GR/LB (this includes DOAS intake as well as the infiltration component)
- Summer SA = 63.1 DB / 53.1 WB = 44.1 GR/LB
- Summer Room = 75.0 DB / 45% RH = 58.1 GR/LB

Given that the vapor-permeable air barrier is designed to reduce infiltration to 0.01 CFM/SF, we felt comfortable proceeding with this design, despite the fact that the existing exterior envelope had not been leak tested. We have stressed that the **interface of air-barrier-to-window and air-barrier-to-floor/column will be critical to ensuring a tight envelope and proper humidity control**."

HVAC Design Criteria

(4) Headered Dedicated Outside Air Systems (DOAS) units: 30,000 CFM each to serve the majority of the building

HVAC Design Criteria

Each with: Enthalpy Recovery Wheel, Pre-Cooling Coil, Active Desiccant Wheel, Dual Temperature (Switchover) Coil, Supply Fans, Regeneration Coil, Relief Fans and Exhaust Fans

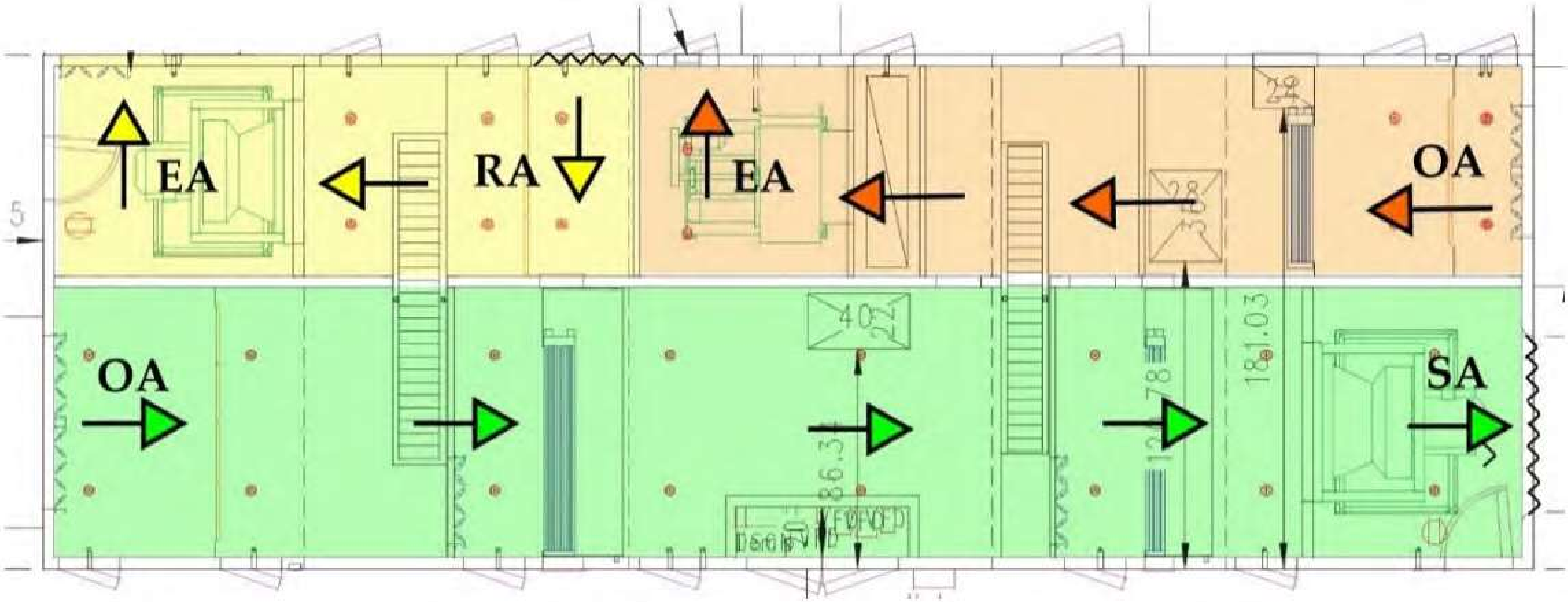
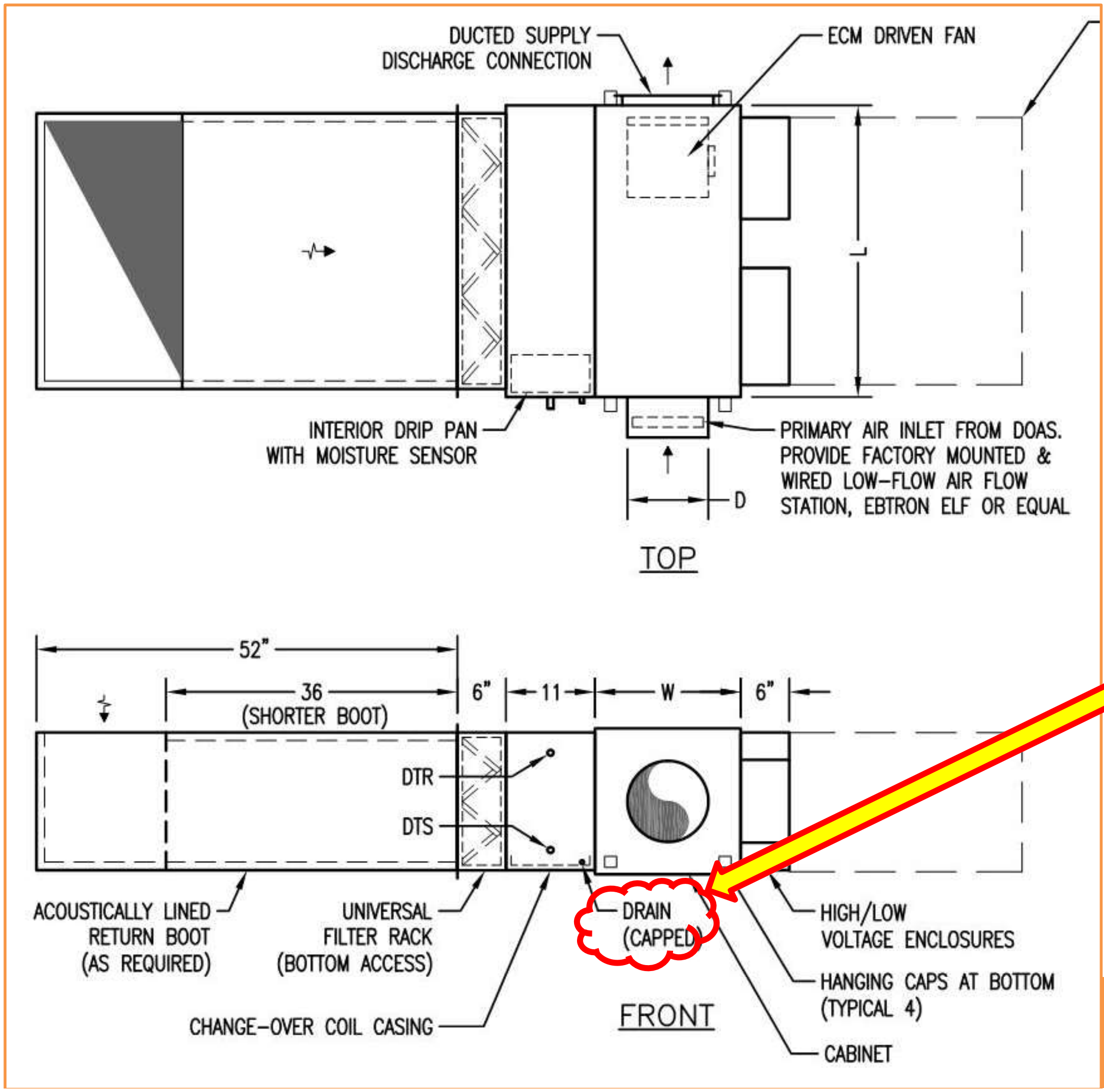


Figure 3.2: DOAS Unit Layout (Top View)

HVAC Design Criteria

- ALL latent cooling to happen in the DOAS units
- **ONLY Sensible cooling in the space fan powered boxes**



Drain pans were "capped"

OPR

Owners Project Requirements Documentation
Written and submitted by: Intertek/Architectural Testing, Inc.

Project: New York University at 370 Jay Street, Brooklyn, NY Date: 1/6/15

The following is a series of questions and answers that summarizes our understanding of the Owners Project Requirements. The answers are based on discussions with the various stakeholders involved in the planning/construction of the project. Should any of these parameters not reflect the Owner's desires, kindly notify the author immediately.

1. Are you utilizing specific programs or tools to measure energy conservation issues such as LEED or ASHRAE 90.1?

   The design is based on LEED 2009/version 3 Core and Shell and ASHRAE 90.1-2007 standard. Atelier 10 is performing a full building energy simulation to demonstrate compliance and LEED EA credits. They predict that the project will achieve all available LEED 2009 C&S credits for reducing overall energy costs.

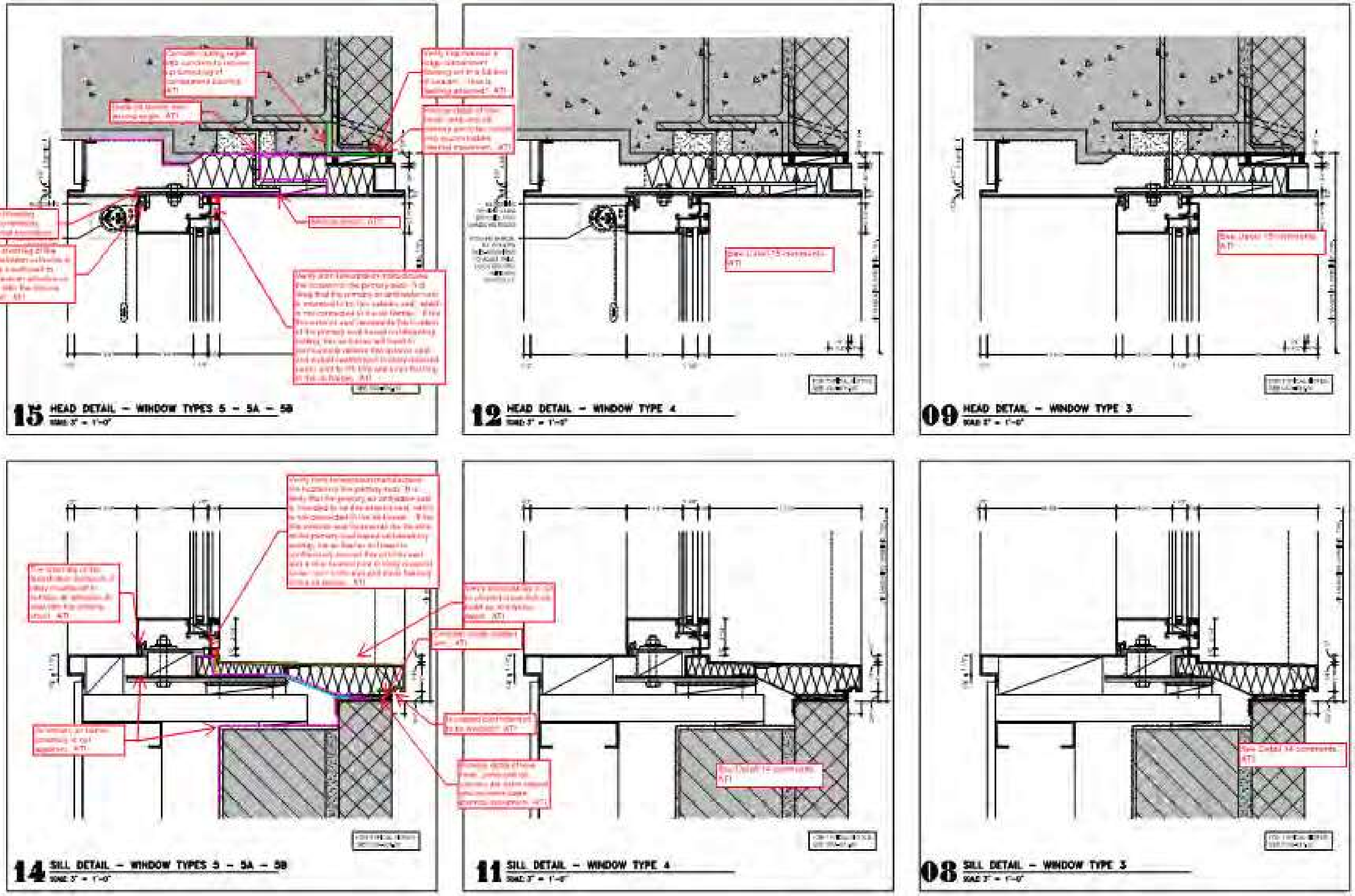
Energy Modeling

- Solar Heat Gain

- U-Factor

- Air Leakage

Design Review



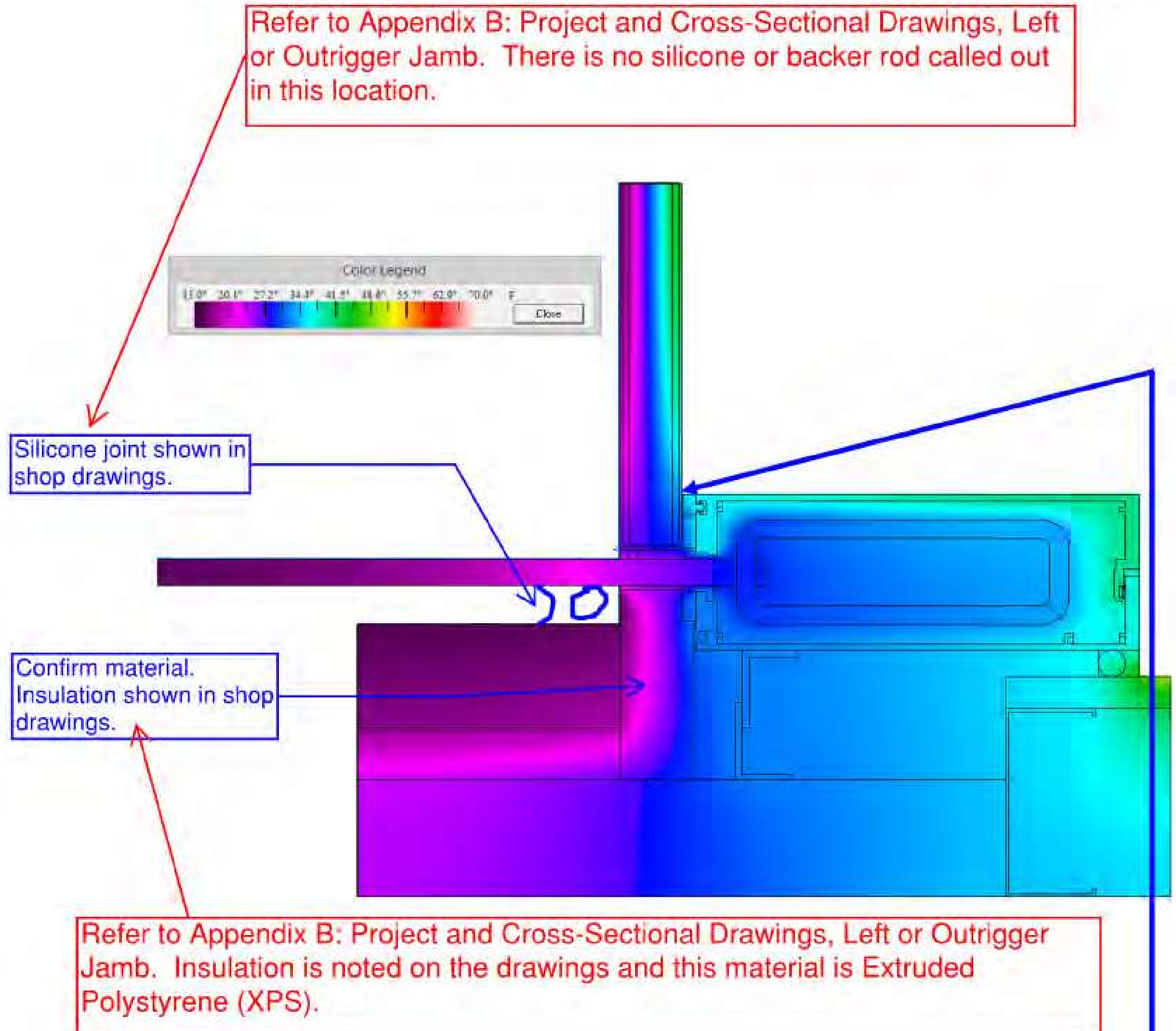
Dewpoint Analysis

Cross Section: D1.15 - Jamb

Environmental Conditions:

70.0 °F Interior Ambient Air Temperature with 30% Relative Humidity

13.0 °F Exterior Ambient Air Temperature with an applied 17mph wind condition



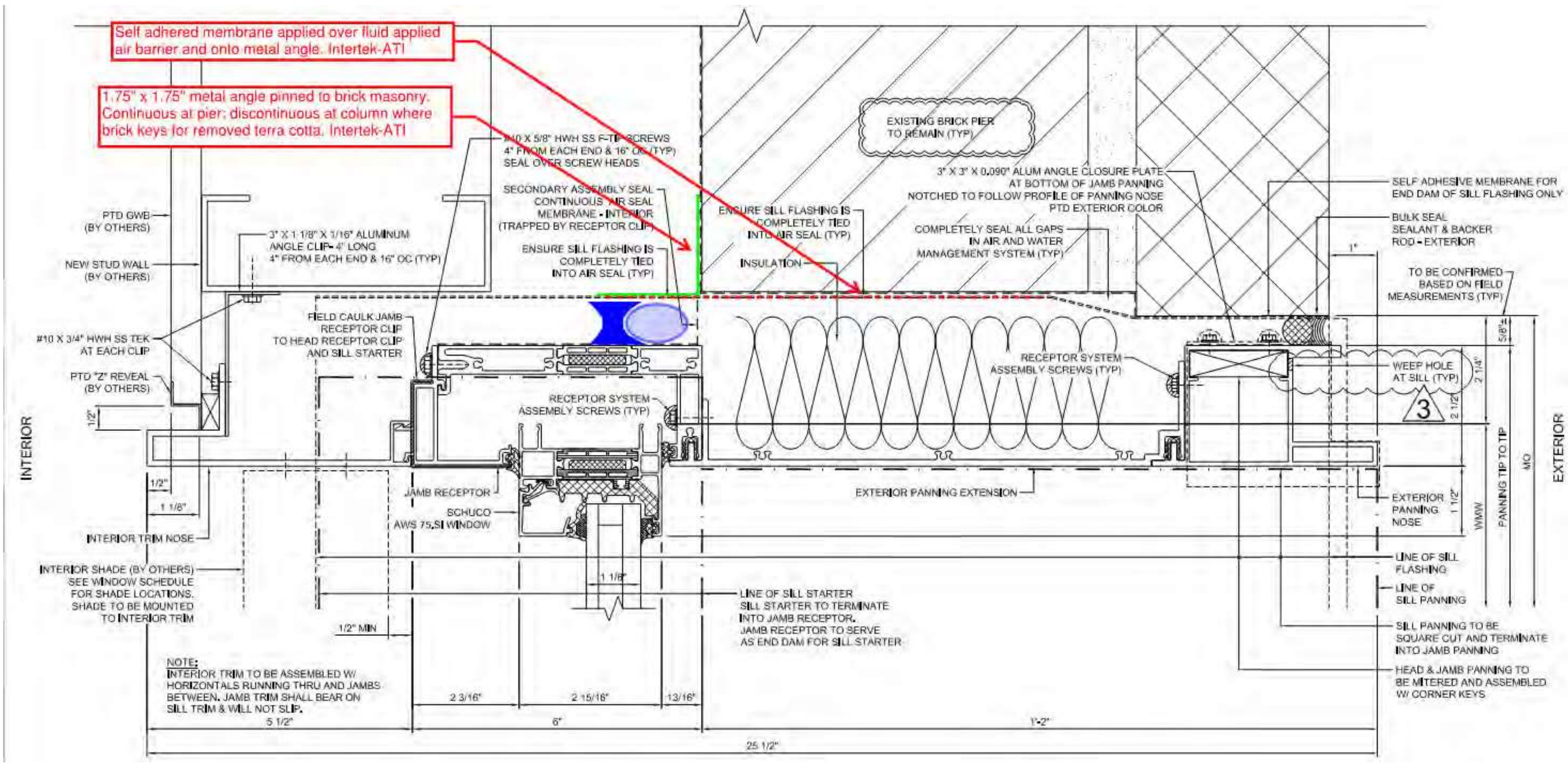
Dewpoint Temperature: 37.2 °F

Coldest Interior Frame Temperature: 33.0 °F

Edge of Glass Temperature: N/A

Coldest Interior Temperature: 33.0 °F

Shop Drawing Reviews



Enclosure Testing Options

NYU

NYU

OPTIONS FOR INVESTIGATIVE
AIR LEAKAGE TESTING
OF THE OPAQUE WALL

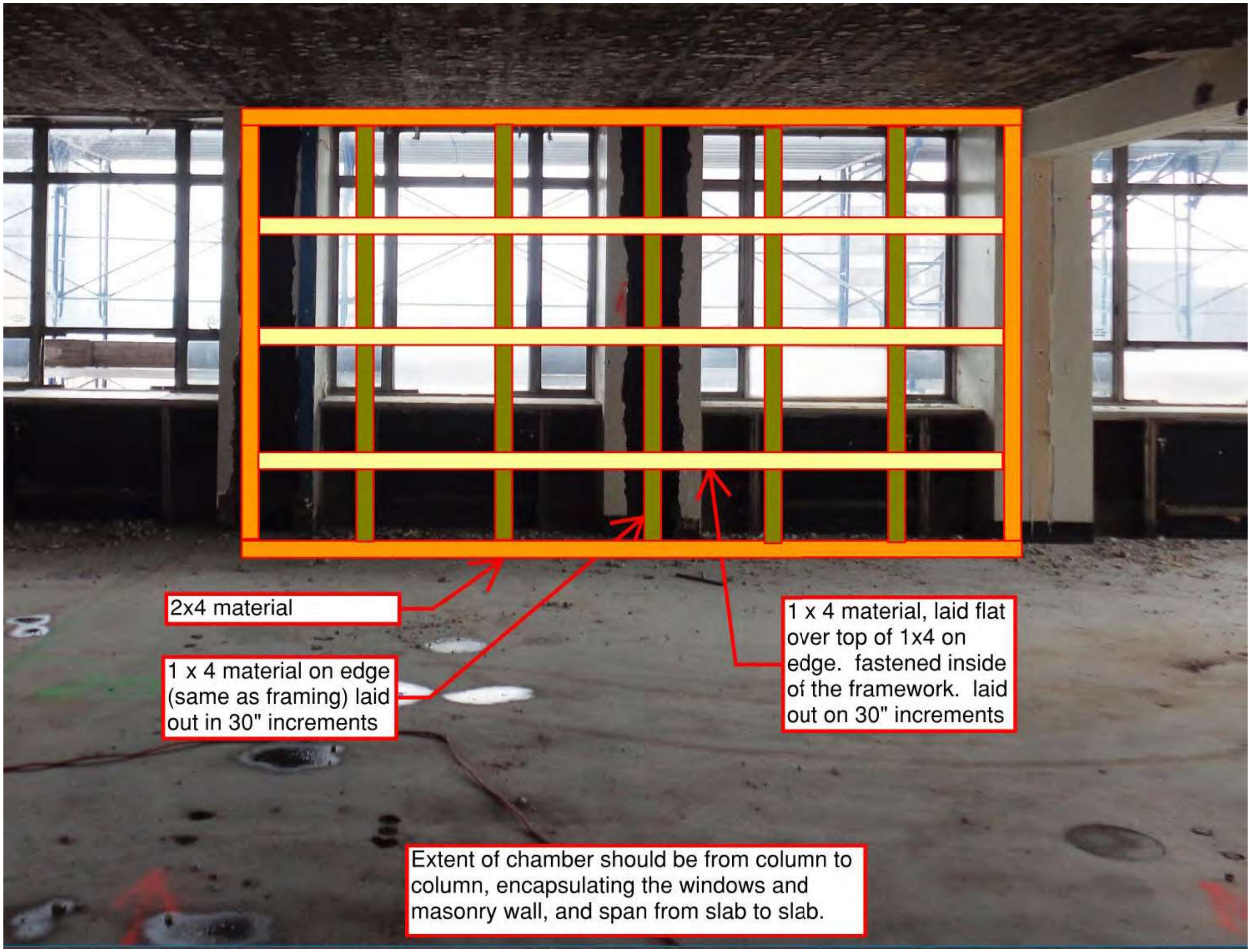
Enclosure Testing Options

#	Option	Pro	Con	Cost*
1	**Whole Building Air Testing** Top 2 and bottom 2 floors; Smoke Tracer and IR testing	• Provide worst case scenario results due to potentially heavy weighting of the roof-to-wall condition. • Provide a quantitative result	• Includes windows that are to be removed • Does not include the air barrier to be installed • Isolation installation required • Two separate tests • Most costly	$25-$35k
2	**Smoke Tracer and Infrared Test** Top 2 and bottom 2 floors	• Identification and stratification of air leakage at non window conditions • Ability to include other conditions in the design to control air leakage • Only simple chambers and isolation required	• Not Quantative	$5-$8k
3	**2 Bay Chamber Test** As-built condition at column	• Quantative result • Quantify current leakage at window perimeter and opaque wall • Identification of air leakage at column which is currently unknown	• Anticipated leakage from window perimeter and opaque wall is already accounted for in the design calculations • Substantial chamber construction involved	$8-$12k

BECx Testing Specification

Component	Performance Criteria – Air	Performance Criteria – Water
Curtain Wall/ Fenestrations/ Skylights	ASTM E 1186 (4.2.7) – No major air leaks. A major leak is defined as air and smoke are visible and easily detectable by hand within one inch of the leak location(s)	AAMA 501.1/ ASTM E 1105 - No uncontrolled water leakage when tested under a pressure difference equivalent to the greater of 20% of the maximum positive pressure in zone 5 of the ASCE 07 wind load calculations or 20% of the positive wind tunnel recorded pressure but not less than 10 psf
	ASTM E 783 – Maximum air leakage of 0.06 cfm/ft at an air pressure differential of 6.24 psf	
Air Barrier Assemblies	ASTM E 1186 (4.2.6) – Pass/fail criteria shall be no bubbles observed in the leak detection liquid.	AAMA 501.1/ ASTM E 1105 - No uncontrolled water leakage when tested under a pressure as defined in fenestrations above, but not less than 10 psf.
	ASTM E 783 – Maximum air leakage of 0.04 cfm/ft at an air pressure differential of 1.57 psf	
	ASTM E 1186 (4.2.7) – No major air leaks. A major leak is defined as air and smoke are visible and easily detectable by hand within one inch of the leak location(s)	
Roofing Systems	ASTM E 1186 (4.2.6) – Pass/fail criteria shall be no bubbles observed in the leak detection liquid.	ASTM D5957 – No leaks through membrane/roof deck after 48 hours of 2.5" ponded water or. Electronic Leak Detection (ELD) may be provided in lieu of flood testing in the field and details of the membrane; supplemental flood testing may be required at drain bodies and other penetrations that are difficult to test with ELD.

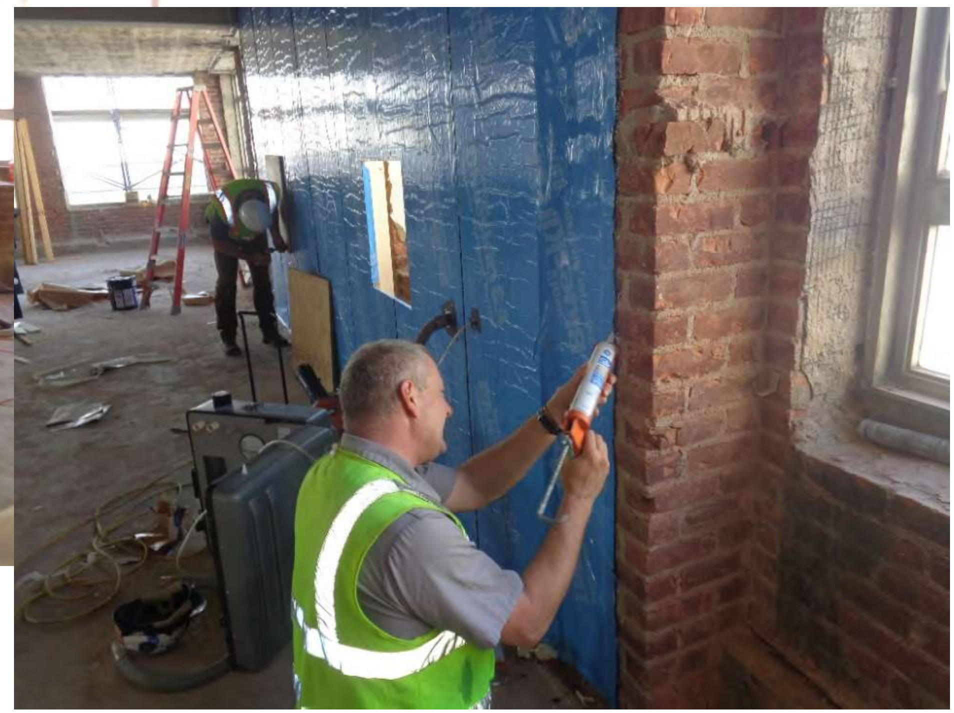
Baseline Testing



Baseline Testing

Baseline Testing

Baseline Testing



Baseline Testing Results

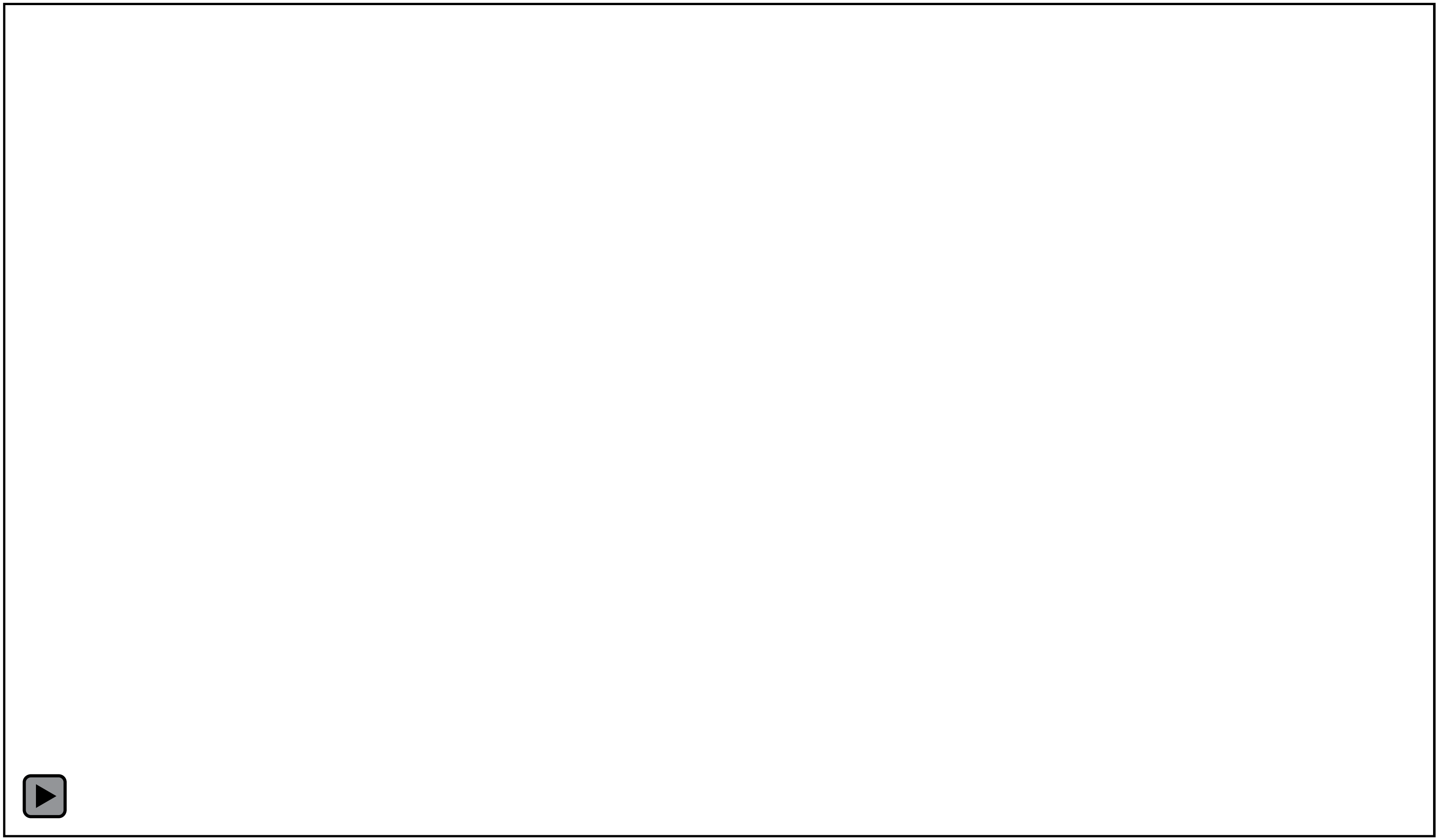
General Note: Due to excessive air leakage through the specimen, the target air pressure differential of 1.57 psf could not be achieved. The following results were recorded at a lower air pressure. Had the target pressure been achieved, higher air flow through the specimen would have occurred.

<u>**Title of Test**</u>	<u>**Test Results**</u>	<u>**Allowable**</u>
Air Infiltration @ 1.00 psf	0.77 cfm/ft^2	Report Only

Air Barrier Challenges

Enhanced Sealing

Window Installation



Mock-up Air Barrier Installation

Mock-up Air Barrier Installation

New Installation Water Testing

New Installation Testing Results

General Note: The following test was conducted on the brick wall. The windows were isolated with plastic sheeting.

Initial results were only 2x better than baseline

Title of Test	Test Results	Allowable
Air Infiltration @ 1.57 psf	0.30 cfm/ft^2	0.05 cfm/ft^2

General Note: The isolation material was removed and the following test was conducted on the fixed windows.

Title of Test	Test Results	Allowable
Air Infiltration @ 6.24 psf		
Left window	0.05 cfm/ft^2	0.06 cfm/ft^2
Right window	0.02 cfm/ft^2	0.06 cfm/ft^2

New Installation Testing Results

Discontinuous Air seal

Qualitative Air Barrier Testing

Qualitative Air Barrier Testing

Additional Water Testing

Additional Water Testing

New Window Removal

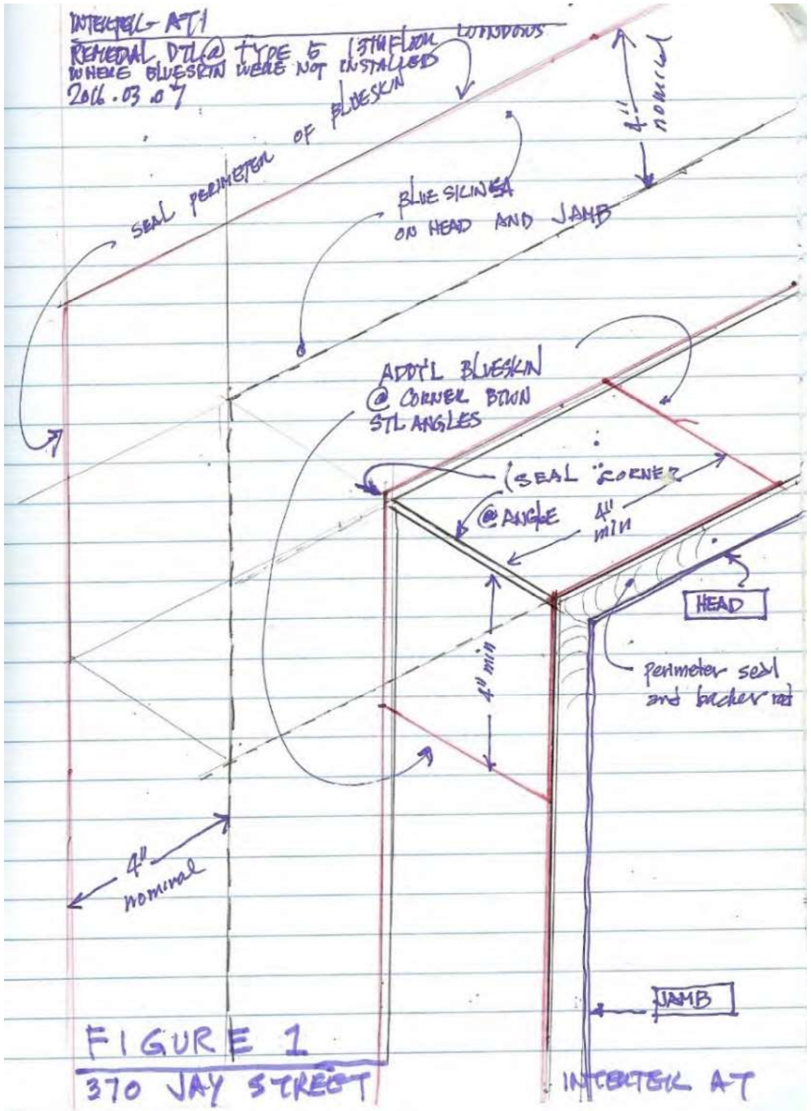
New Window Removal

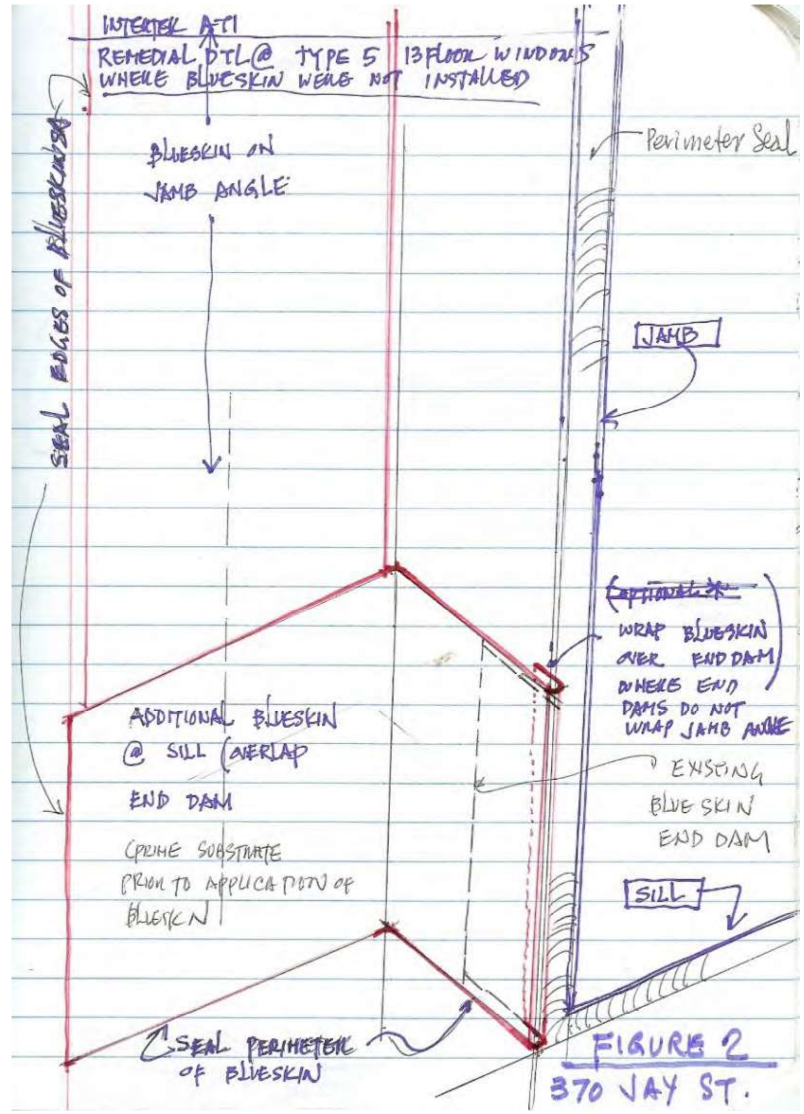
New Installation - Retesting

Retesting Results

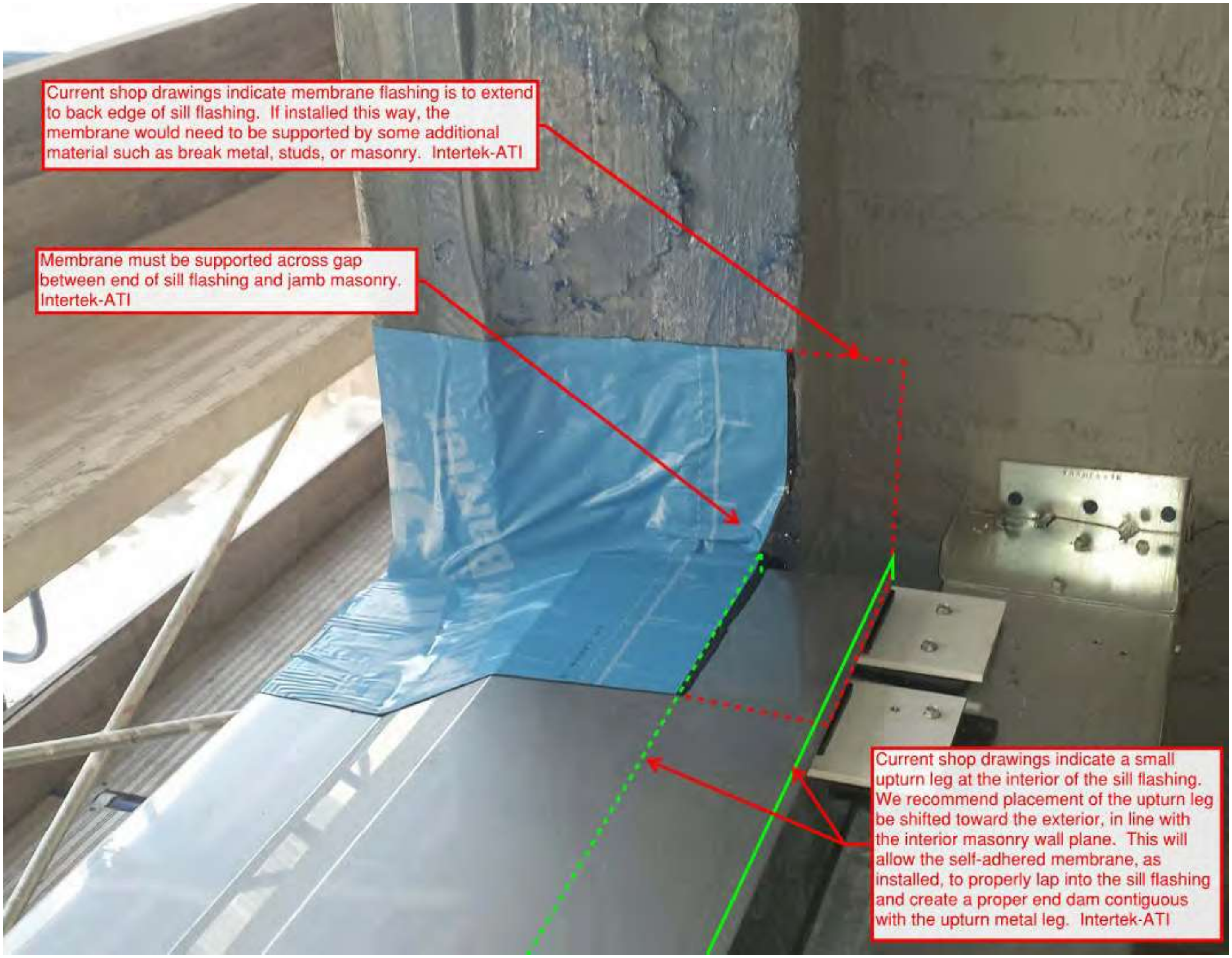
Discontinuity in Air Seal

Flashing Changes

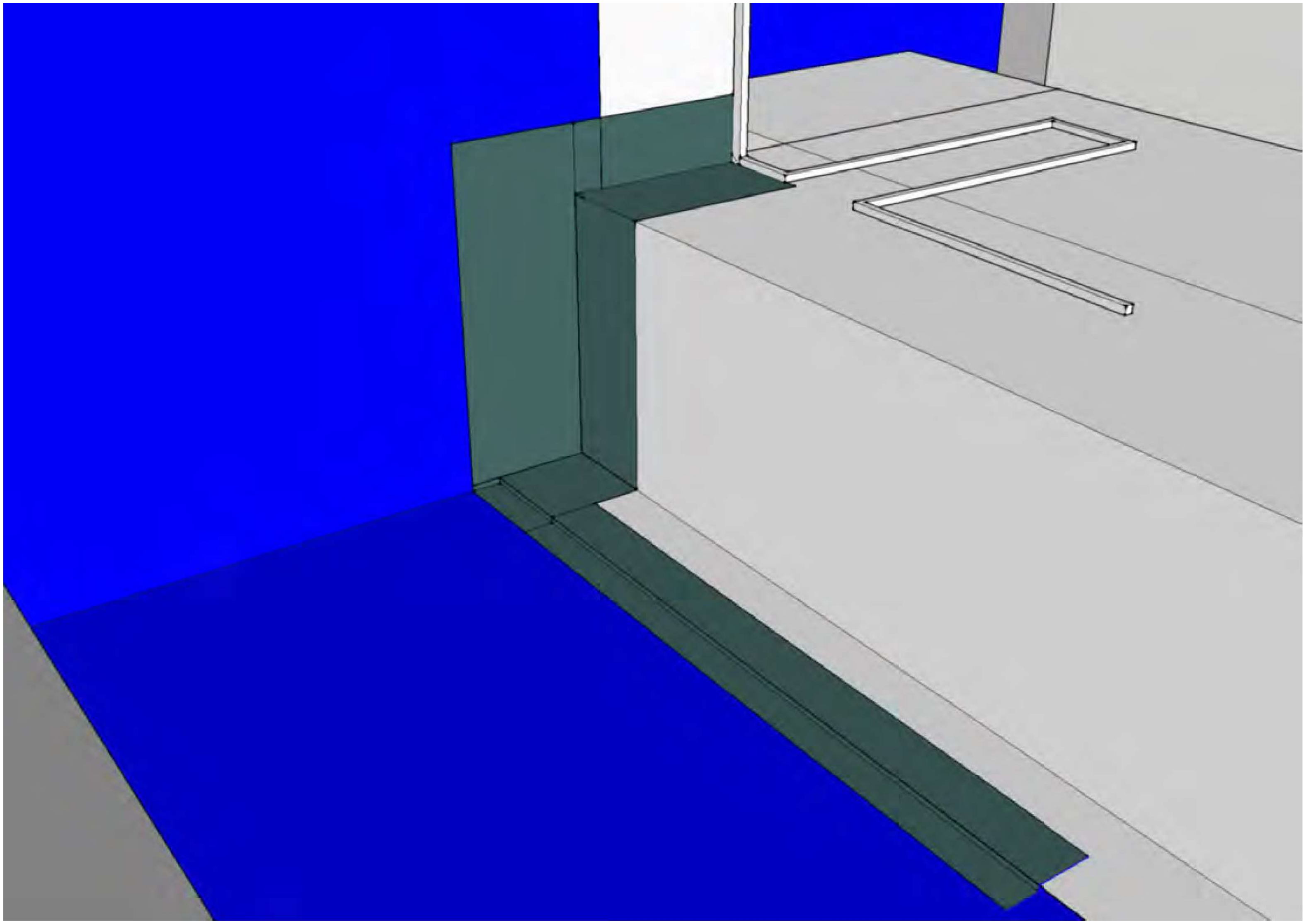




Sill Flashing Detail



Flashing Changes



Revised Flashing Detail

Final Air Testing Results

Overall Size: 18' 7" wide by 10' 0" high
Location: West elevation, 11th floor, Between Columns 2 and 3

General Note: The following test was conducted on the brick wall. The windows remained isolated as described in the Test Procedure Section.

Final results were 10x better than baseline

Title of Test	Test Results	Allowable
Air Infiltration @ 1.57 psf Brick Wall and Chamber	13.80 cfm	N/A

General Note: The interior tare bags were removed from both windows. The portion of the window frames located within the rough opening were evaluated.

Title of Test	Test Results	Allowable
Air Infiltration @ 1.57 psf Both Window Frames	0.80 cfm	N/A

Full Scale - Air Barrier Installation

Construction Happens

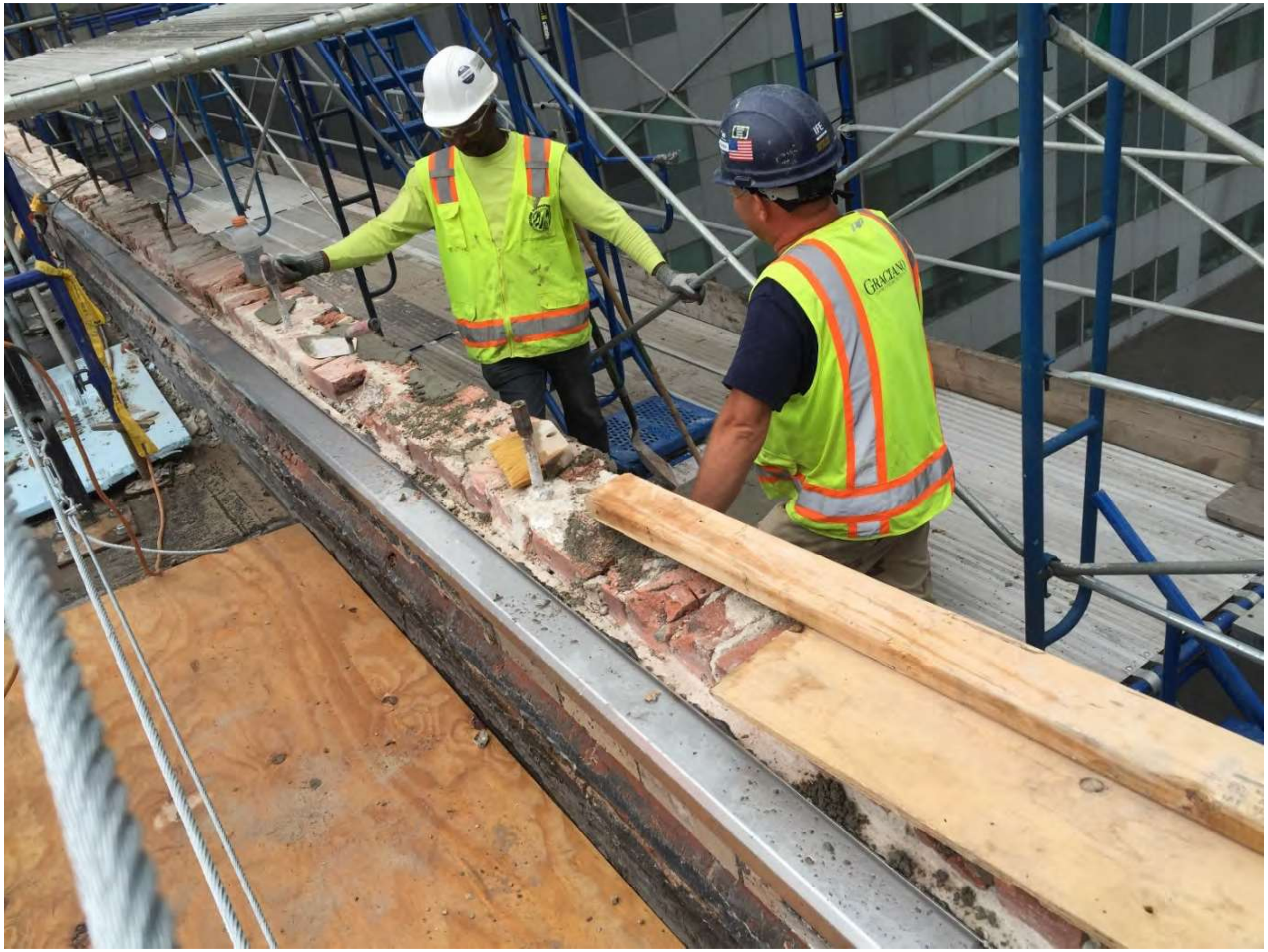
Construction Happens

Construction Happens

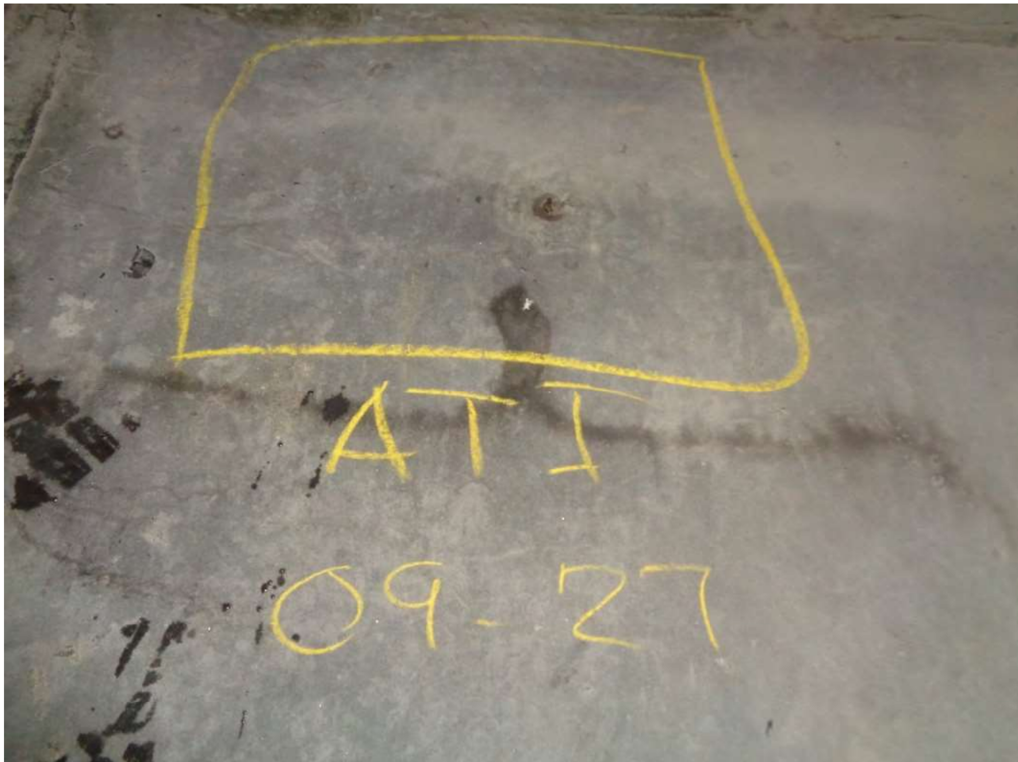
Window Modifications

Water Testing Eventually Passed

Roofing and Parapets

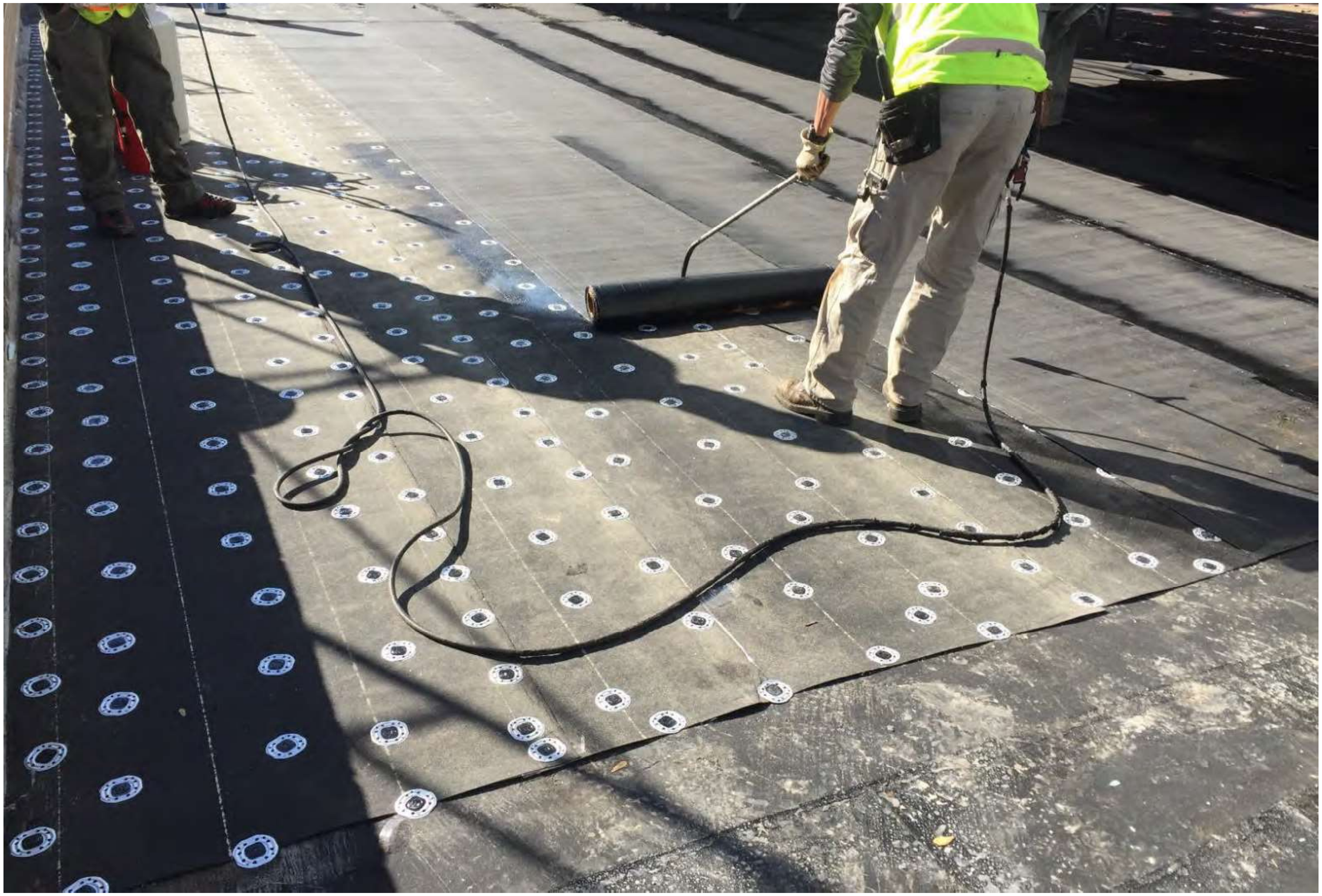


Roofing and Parapets



Roofing and Parapets

Roofing and Parapets

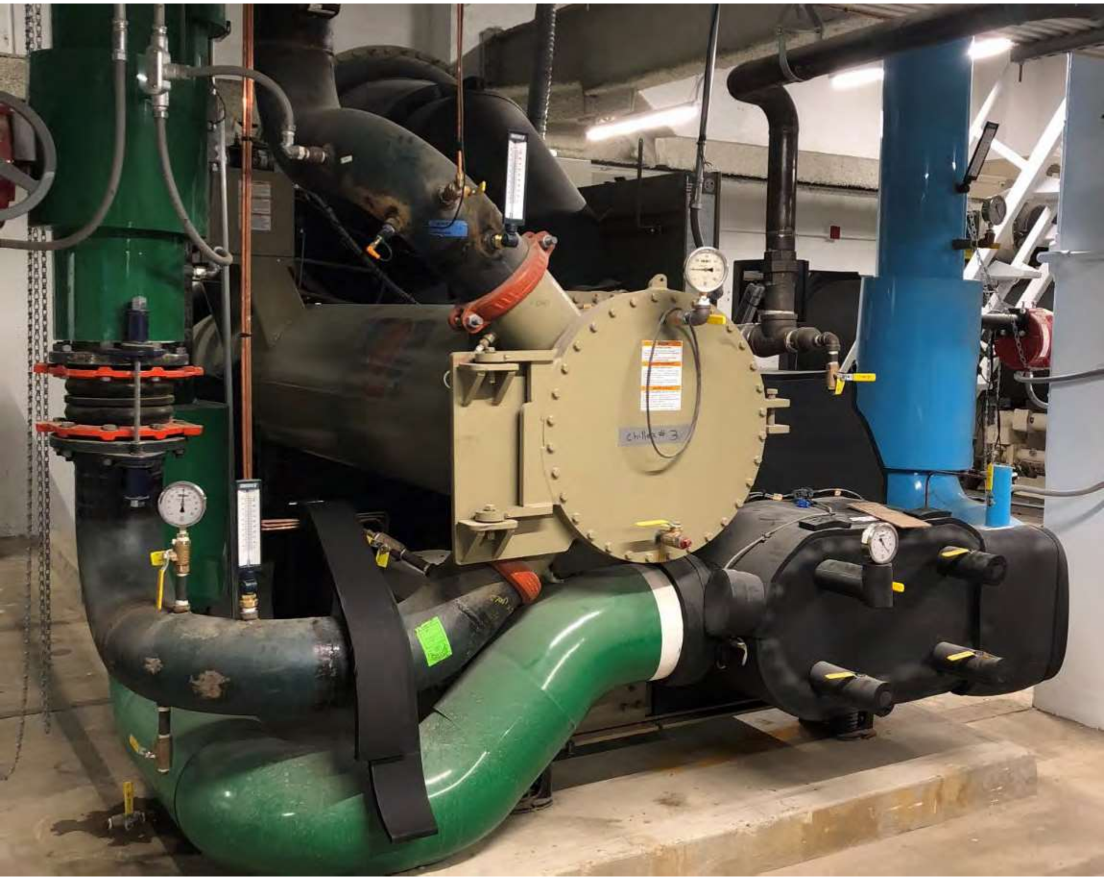


Roofing and Parapets

Ice Thermal Storage System Overview

- Ice thermal storage was installed with a goal of providing 2,500 ton-hours of thermal storage.
- 12 ice tanks make 500 tons of ice available for a period of 5 hours.
- Use of ice storage reduces the total installed tonnage required.
- A 500 ton ice-making chiller is installed to build ice overnight when utility costs are lower.
- Piping system is filled with ice/glycol mix (25% ethylene glycol) to allow distribution of 22.5°F liquid to ice tanks.
- System extracts heat from chilled water via plate & frame heat exchanger.
- Chilled water supply temperature of 54°F allows for more effective use of ice.
- Ice-making chiller can be used in back-up mode to directly cool chilled water

Ice Storage Cx Concerns



System required a large amount of optimization with the rest of chiller plant.

- Staging on/off use of ice tanks
- Utilizing back-up mode upon no ice available and primary chiller failure.
- Interaction of ice-build mode and chiller plant free-cool.

System initially utilized ice tank volume sensors to determine available ice storage.

- This proved to be inaccurate and unreliable.
- The team moved to utilize system BTU meters to determine available ton-hours.

MEP Cx Lessons Learned

- Extremely complex designs coupled with phased occupancy make commissioning extremely challenging due to very light space loads. Plan ahead and discuss with the team what can and can't be done
- Interaction of chiller plant, ice storage, and DOAS units present a very fine balance between all systems. Expect multiple retests and for Cx to play a critical role in pulling together all the details with the manufacturers, contractors and engineer
- Owner building operations and engineering is critical to support the building operations during phased turnover, when systems are half commissioned.

BECx Lessons Learned

- You won't get optimized efficiency without pushing your comfort level. ***Efficiency is the opposite of factor of safety.***
- A failed mock-up test does not mean it's a failed mock-up.
- Past testing may not be indicative of future results.
- It takes teamwork to resolve problems.
- BECx can be extremely valuable on an existing building even when claddings remain.

Questions & Thank you!

Ice Storage System Flow Diagram