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CONFERENCE
& TRADE SHOW
MARCH 26-27
2019
NORFOLK
VA
AIR BARRIER EDUCATION TRACKS FOR
THE CONSTRUCTION INDUSTRY

Non-Visible Energy – Decoding Electromagnetic Energy and Thermodynamics

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Thermographer
SWA Consulting

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EDUCATION

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CONTINUING EDUCATION
AIA

Learning Objectives

- Provide an understanding of thermography and the true science behind the fifth dimension
- Understand the application of thermography in the construction field and for forensic engineering, and factors that result in limitations of the tools and how to overcome some of the factors
- Learn how analyzing imagery can provide useful information to the thermographer not typically available in the field
- Obtain and introduction of nontraditional means of testing which can be successfully conducted with infrared thermography

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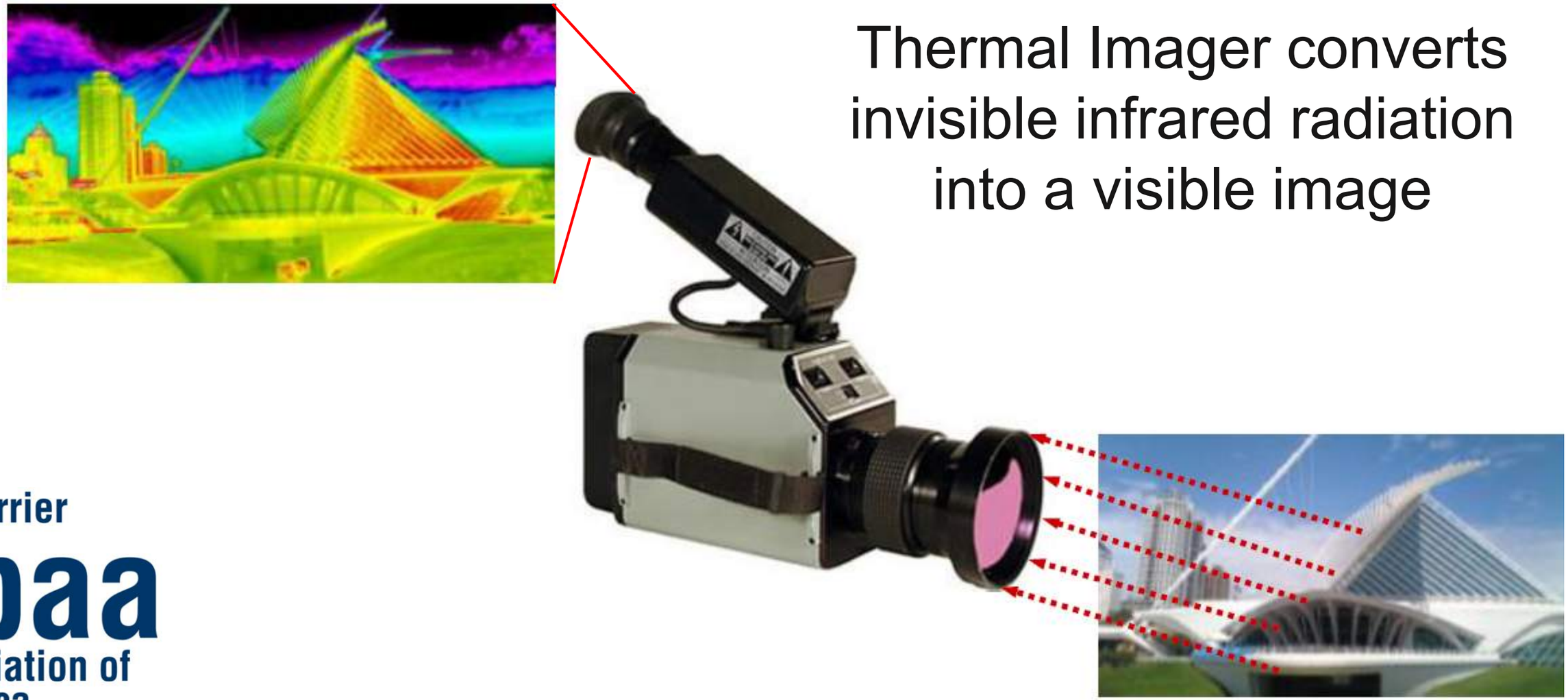
Thermal Imager Principle



Thermal Imager converts invisible infrared radiation into a visible image

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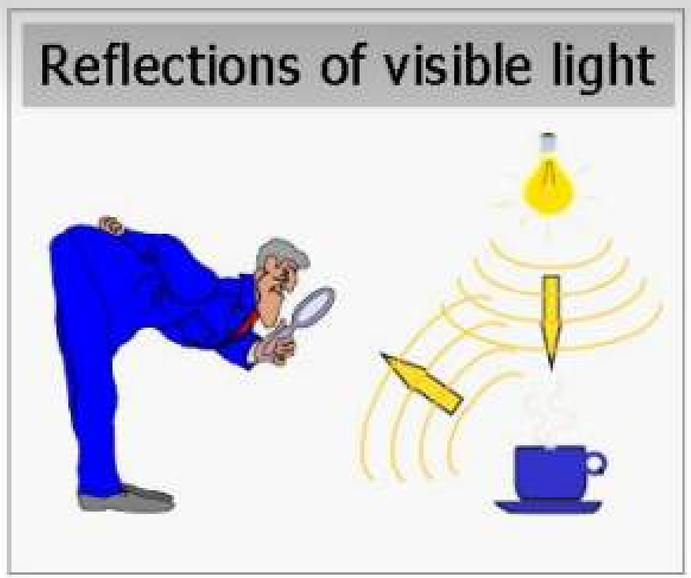
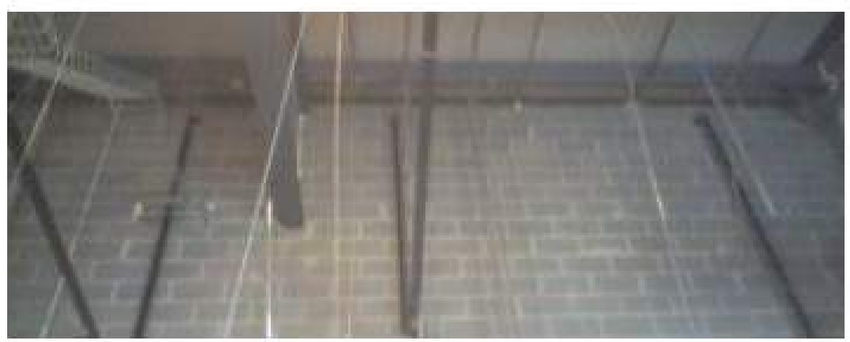
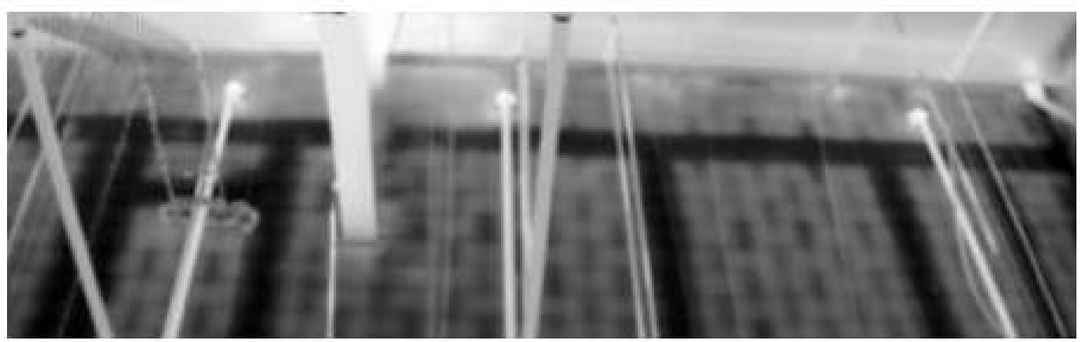
Visual vs. Infrared







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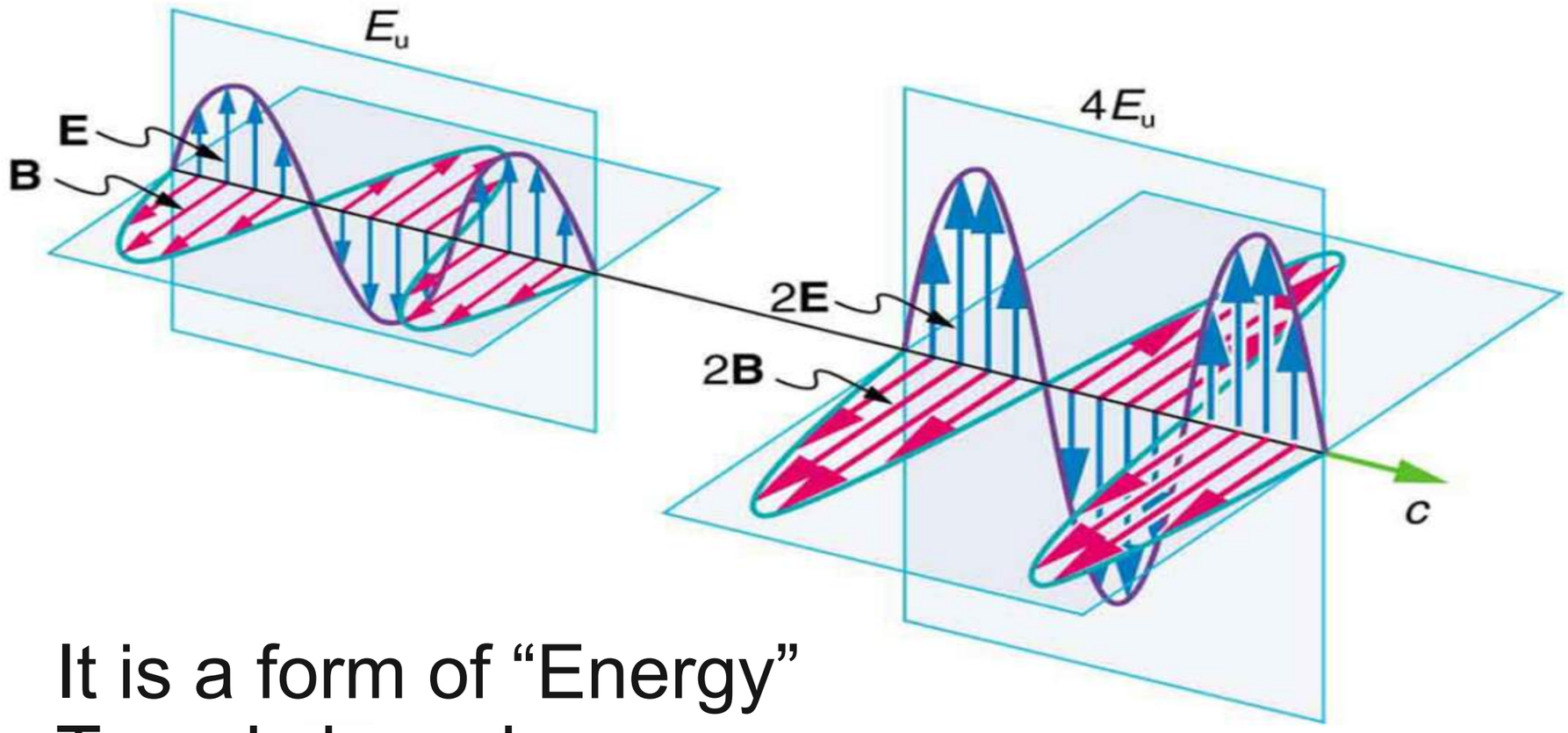
Electromagnetic Energy



- It is a form of “Energy”
- Travels in a sine wave
- The distance from peak to peak define its wave

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Electromagnetic Energy

- It is a form of “Energy”
- Travels in a sine wave
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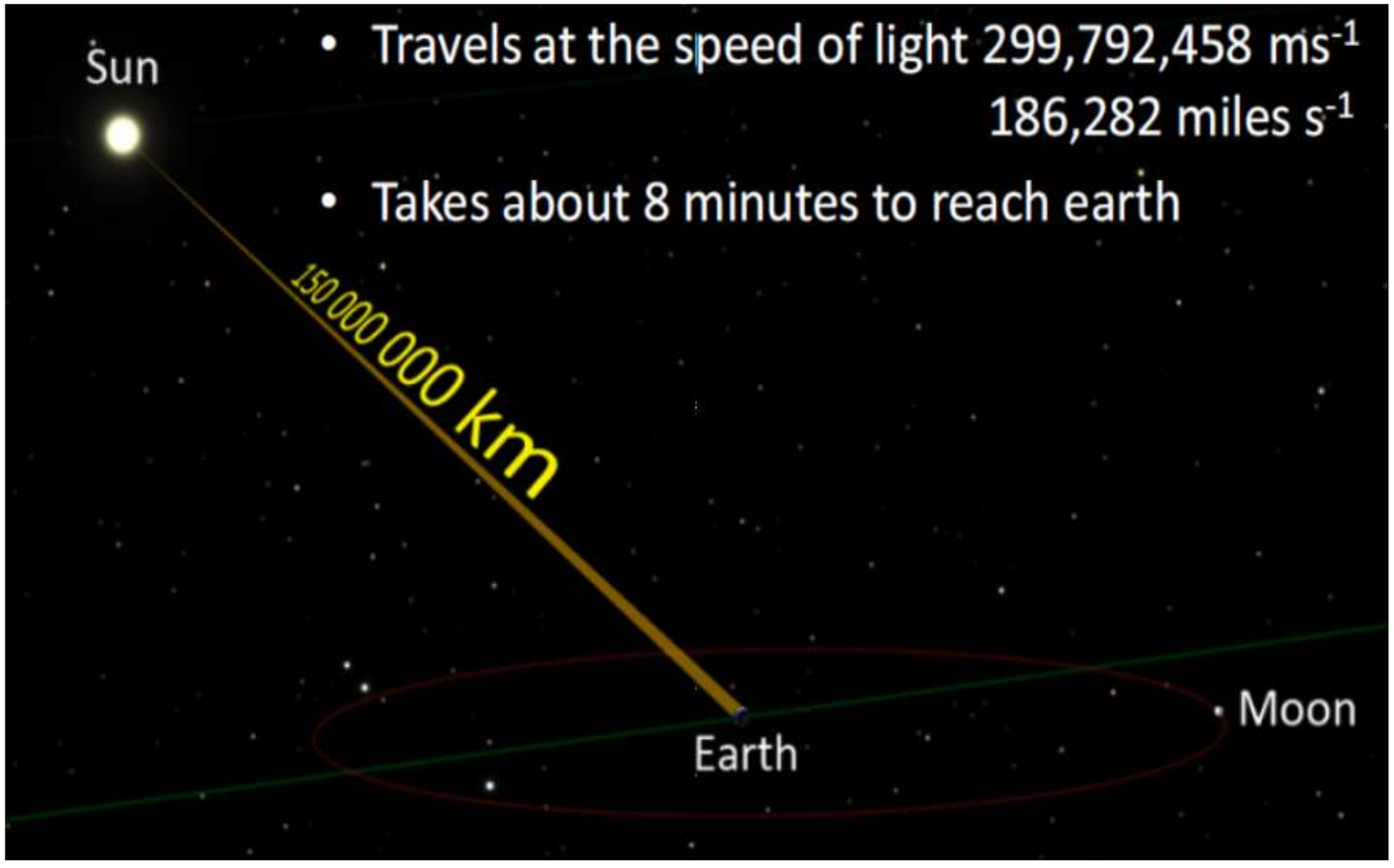

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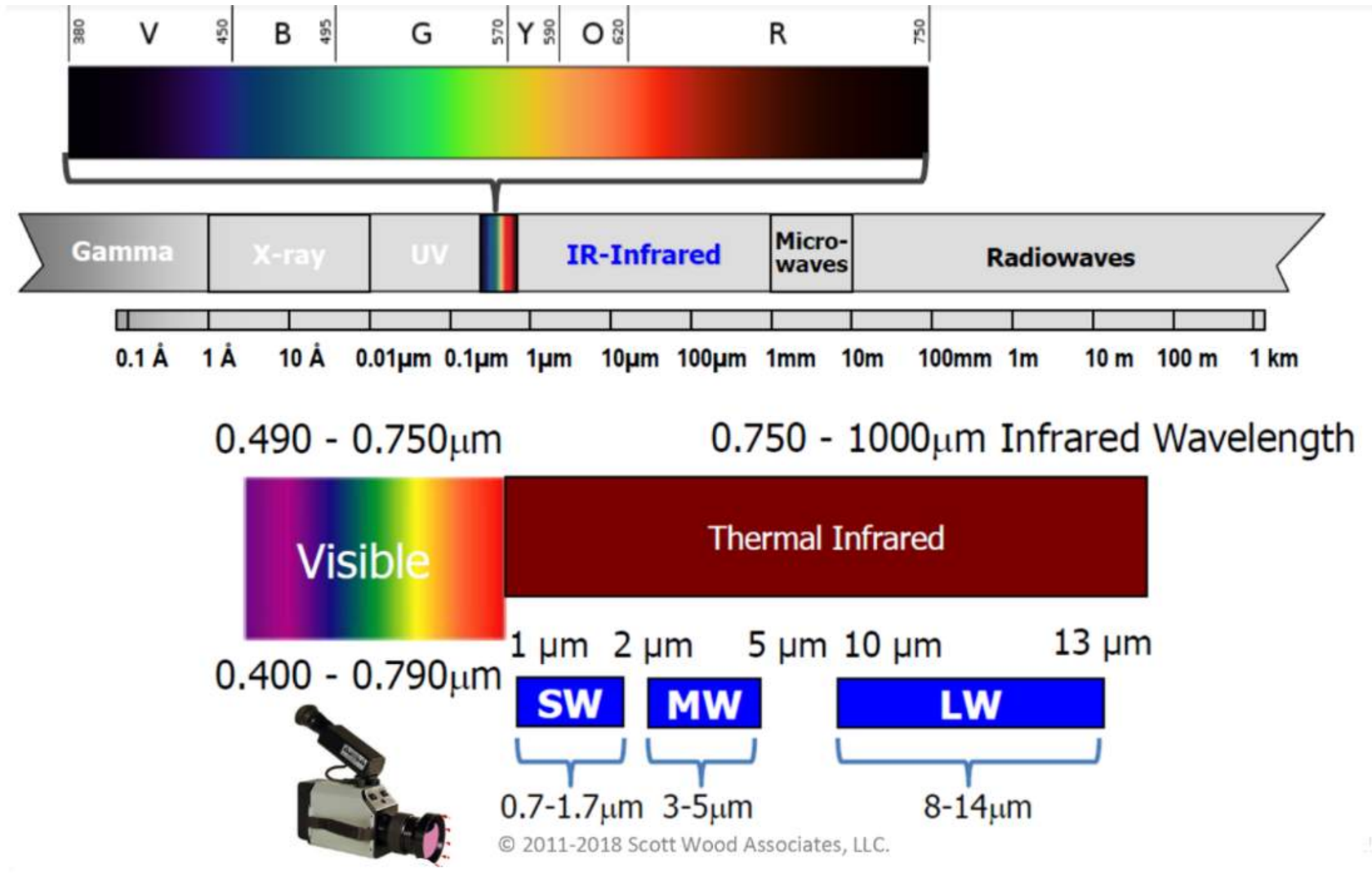
Electromagnetic Spectrum



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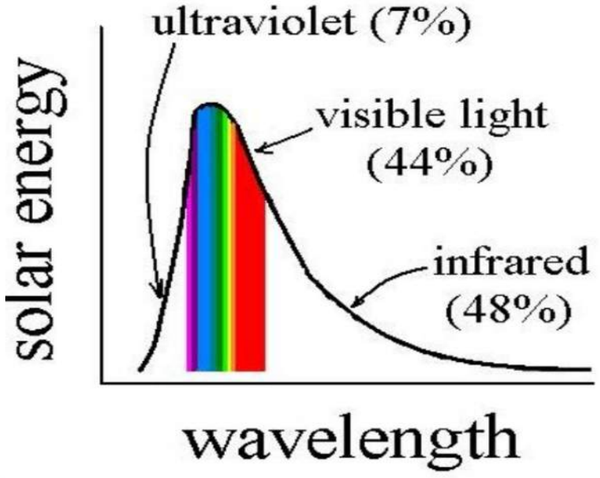
Electromagnetic Spectrum

- Defined by wavelengths
- Different wavelengths have different properties
- Our eyes see only (0.49 – 0.75μm)
- Color is due to different wavelengths
- Infrared energy has no “color”



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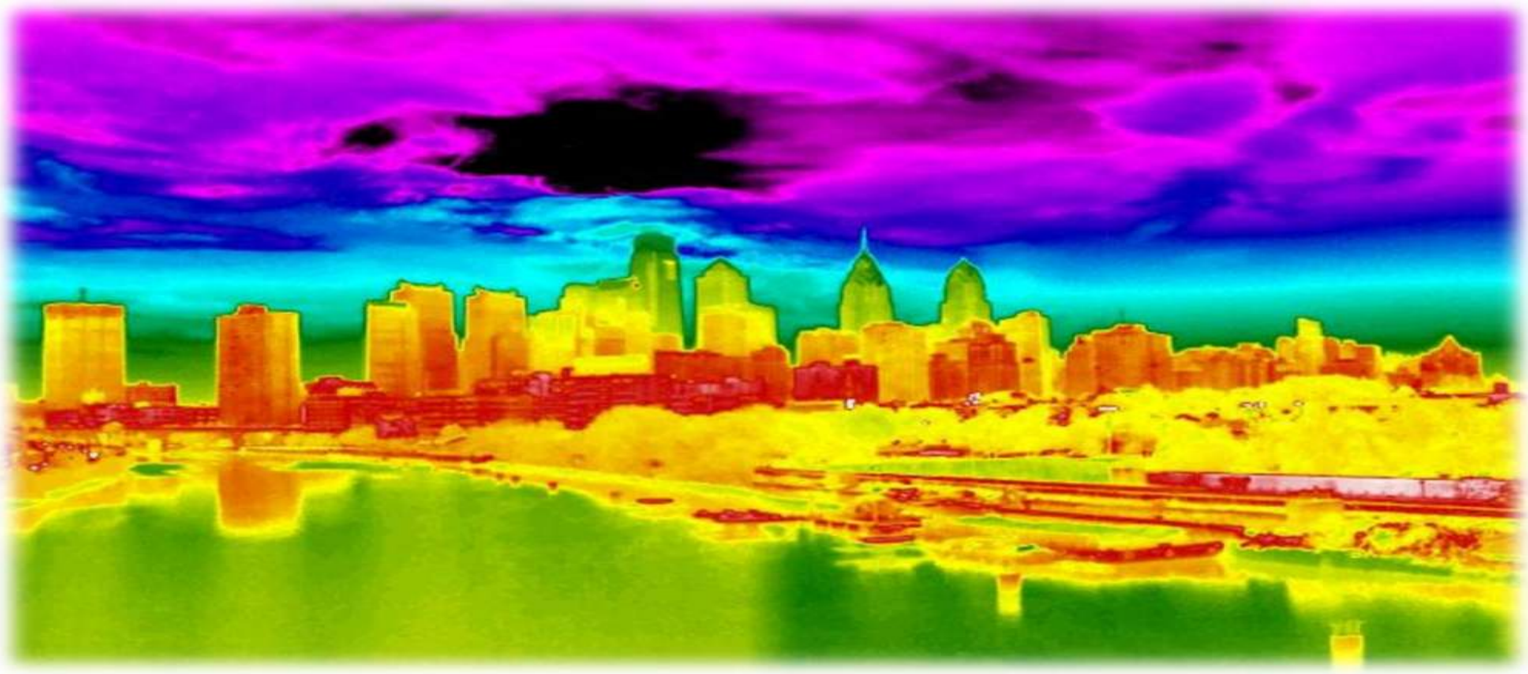

Infrared Imagers

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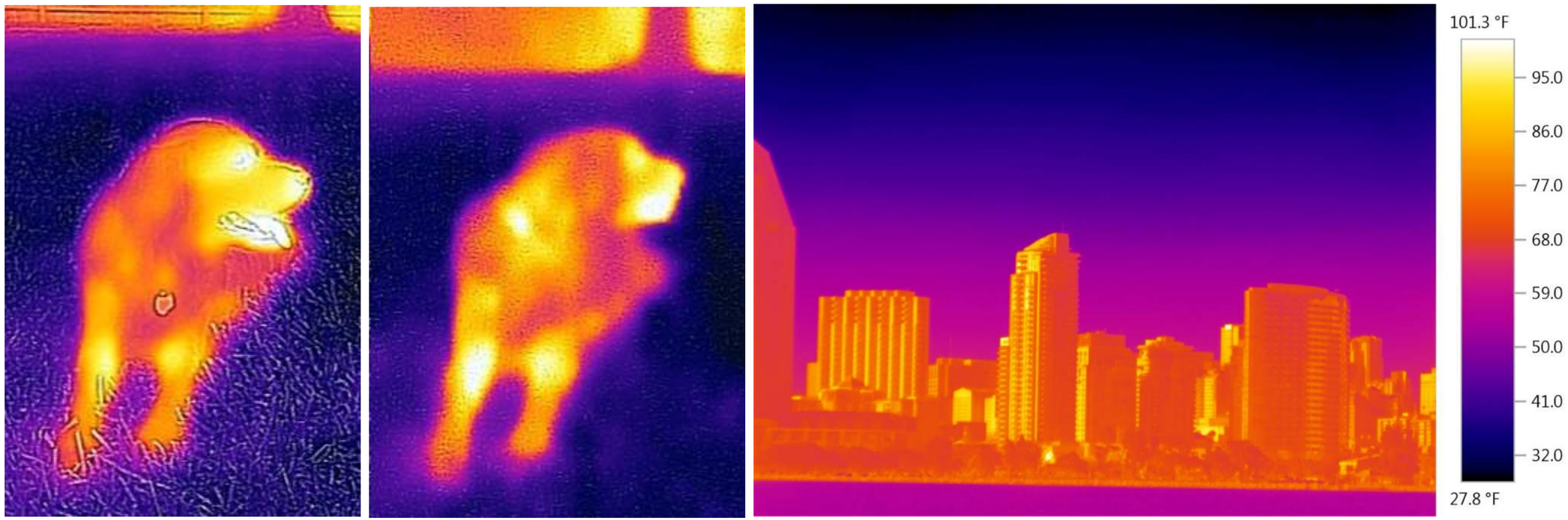
Resolution

Poor - 40x30, 80x60, 100x100, 120x120, 160x160, 320x240, 640x480… - Good



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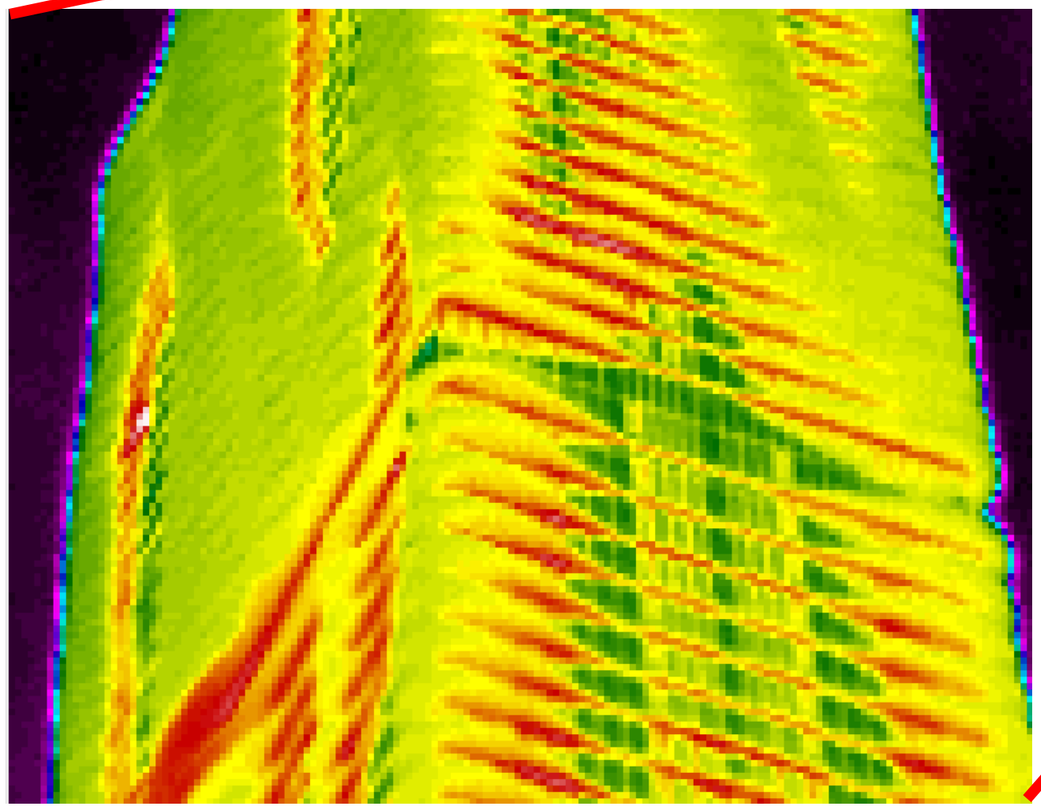
FLIR One:
80x60

Testo T890:
640x480

Thermal Transfer



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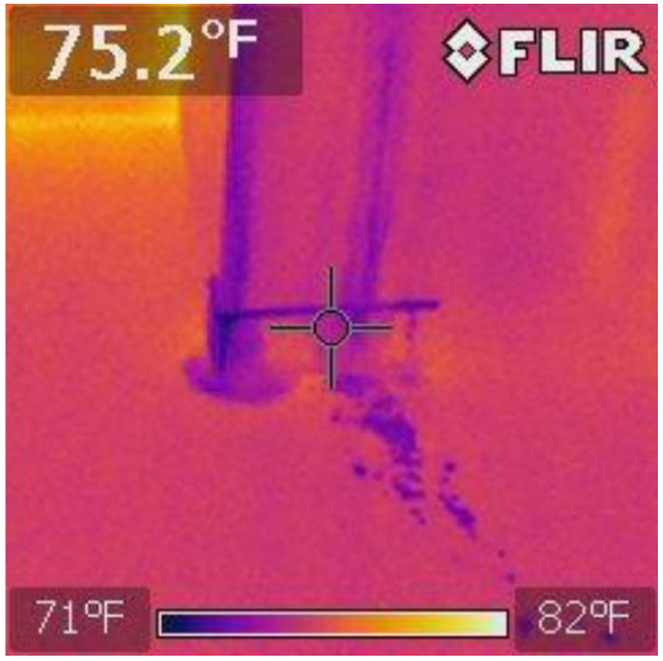
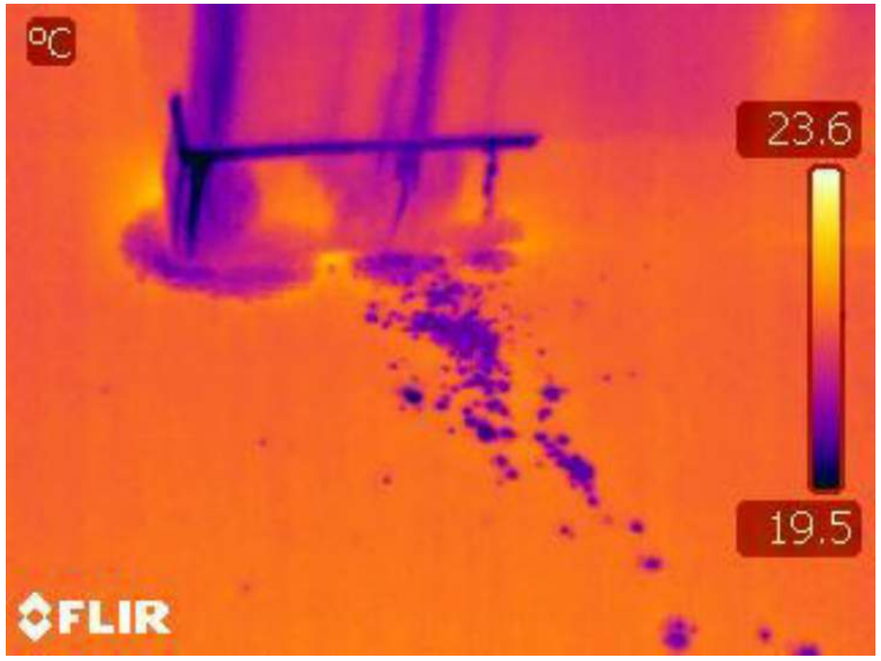
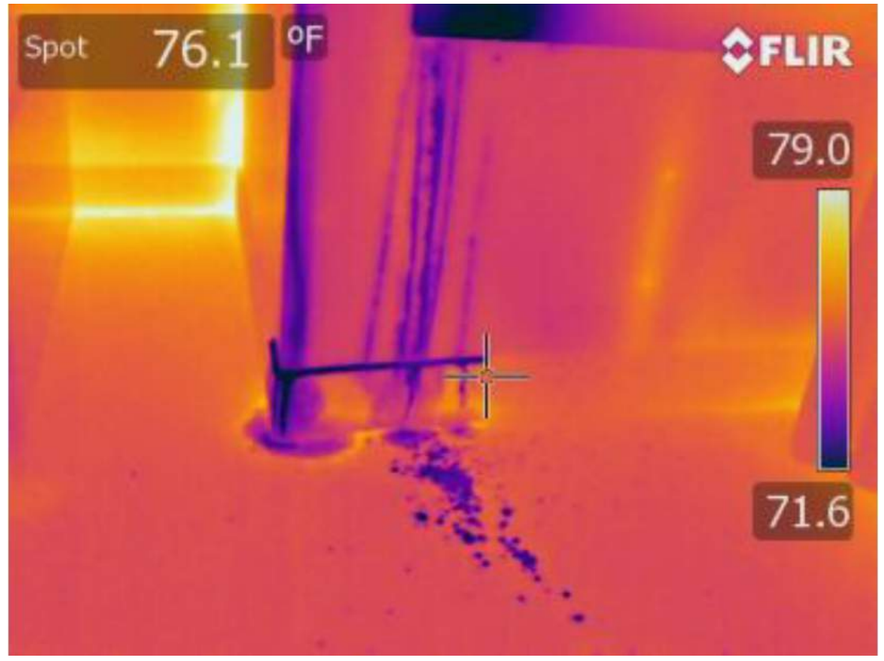
Resolution



Low Resolution
140x140 pixel array
0.0196 MPixels



Medium Resolution
320x240 pixel array
0.0768 MPixels



Higher Resolution
640x480 pixel array
0.3072 MPixels

Testo T890 Super resolution 1280x960

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Emissivity

“The ratio of the radiation emitted from an object as compared to that from a perfect emitter or blackbody.”

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Reflectance (Reflectivity)

The amount of total radiance which can be attributed to reflected energy. Usually expressed as a percentage of total energy.

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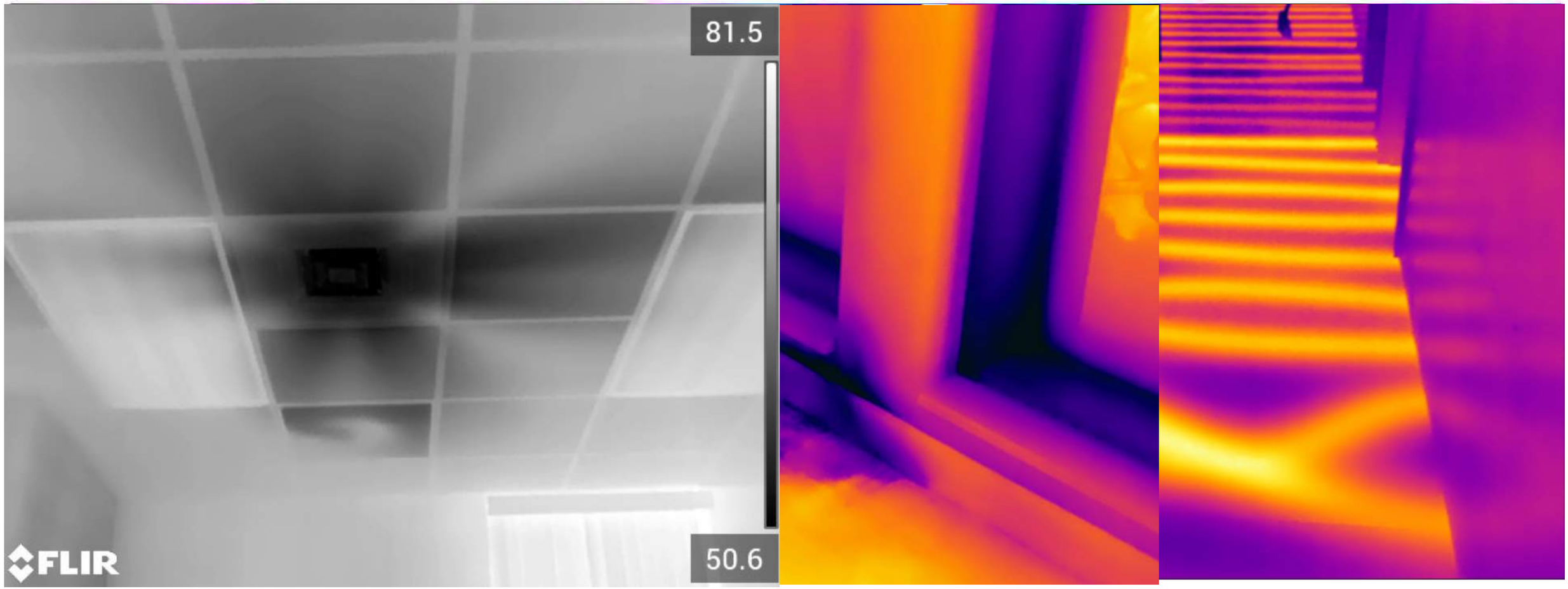

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Heat Flow
Air Flow
Moisture Flow

Industry and Standards

ISO 6781-3:2015

Performance of buildings – Detection of heat, air and moisture irregularities in buildings by infrared methods

Part 3: Qualifications of equipment operators, data analysis and report writers.

(Results for residential and small buildings)

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International Organization for Standardization

Industry and Standards

ASTM C1153 - 10(2015)

Standard Practice for Location of Wet Insulation in Roofing Systems Using Infrared Imaging

ASTM C1060-11a(2015)

Standard Practice For Thermographic Inspection Of Insulation Installations In Envelope Cavities Of Frame Buildings

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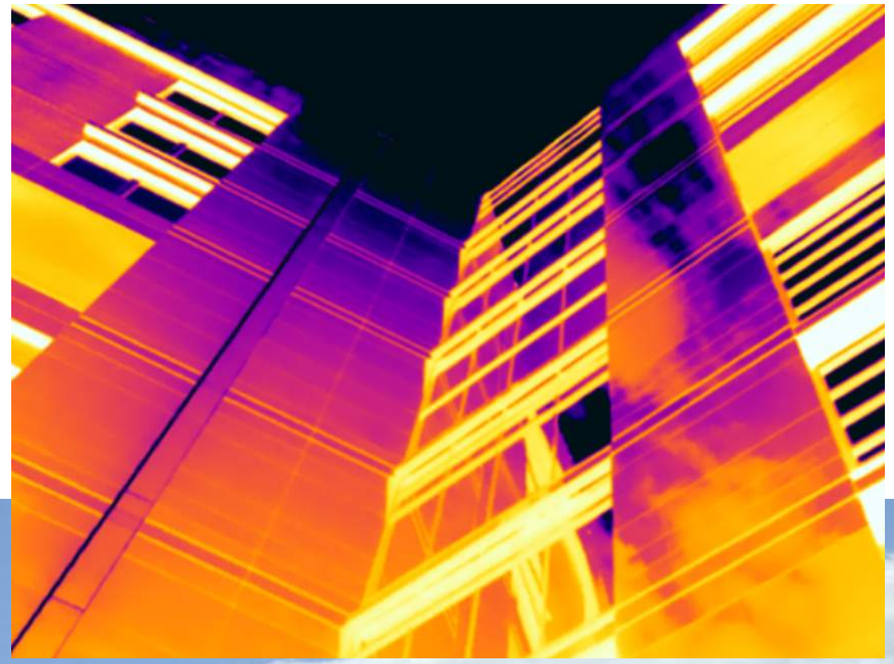
Case Study 1 – CoxHealth Patient Tower Addition



Case Study conducted by:
Miller Engineering, P.C.

Case Study conducted for:
Killian Construction
& CoxHealth

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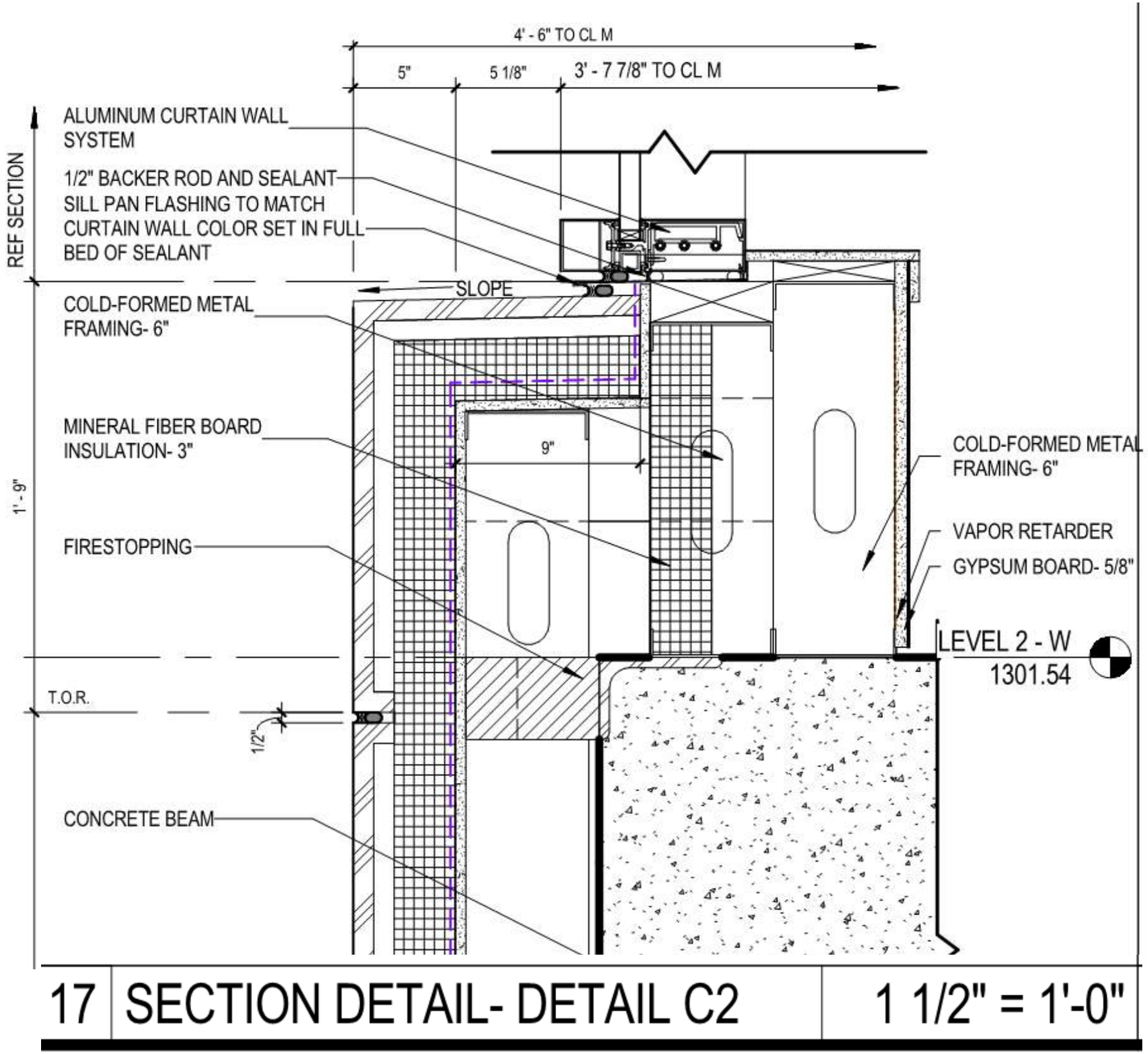
Case Study 1 – CoxHealth Patient Tower Addition

Thermal Performance of Curtain Wall System was studied and reviewed.



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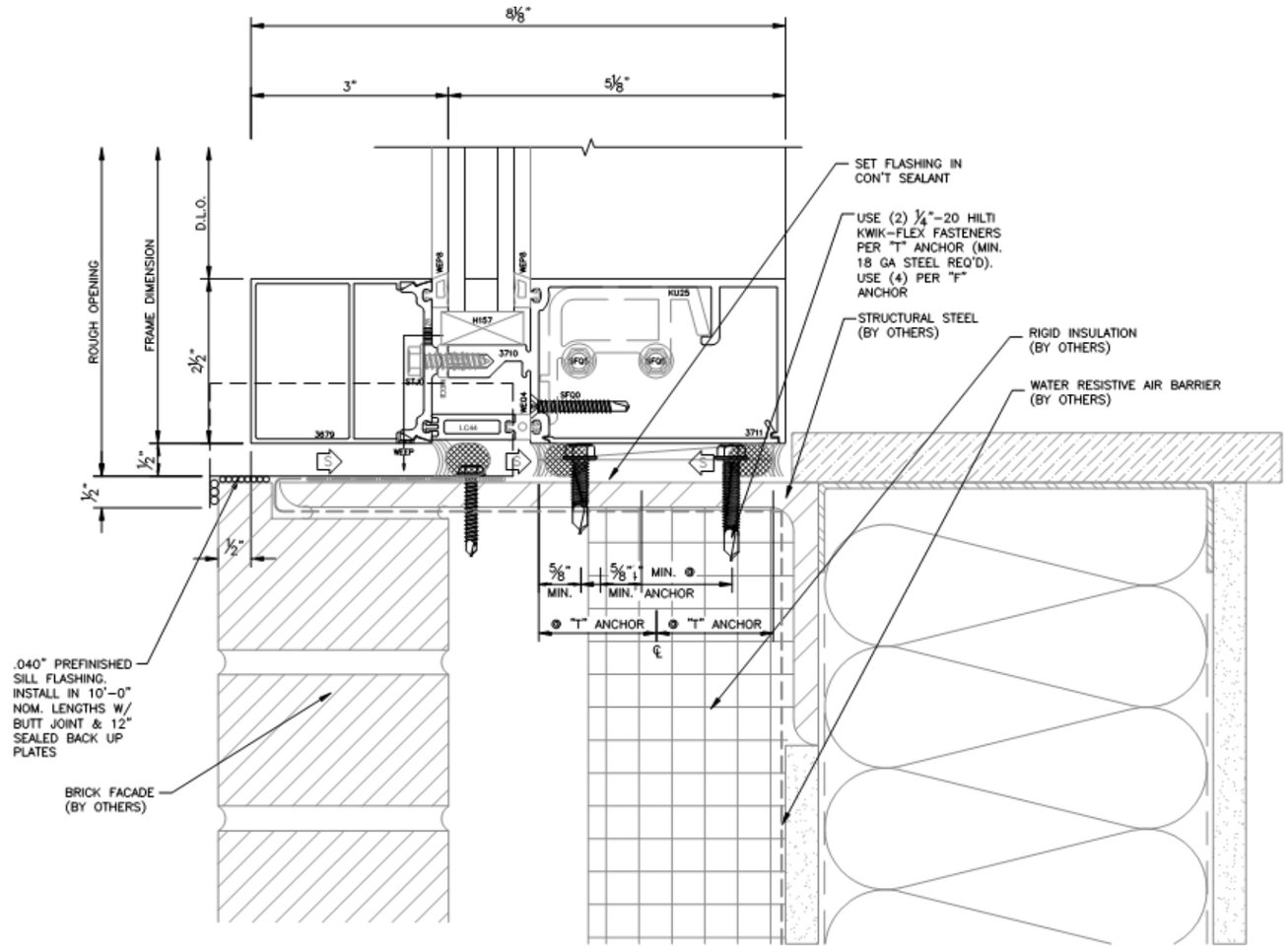
Case Study 1 –
CoxHealth Patient Tower Addition

Shop Drawing Details



82 SILL DETAIL @ BRICK

7.33 SCALE: N.T.S. ARCH. REF.: N/A
EFCO 5900; 2 1/2" X 6"
W/ 2 3/4" DEEP COVERS

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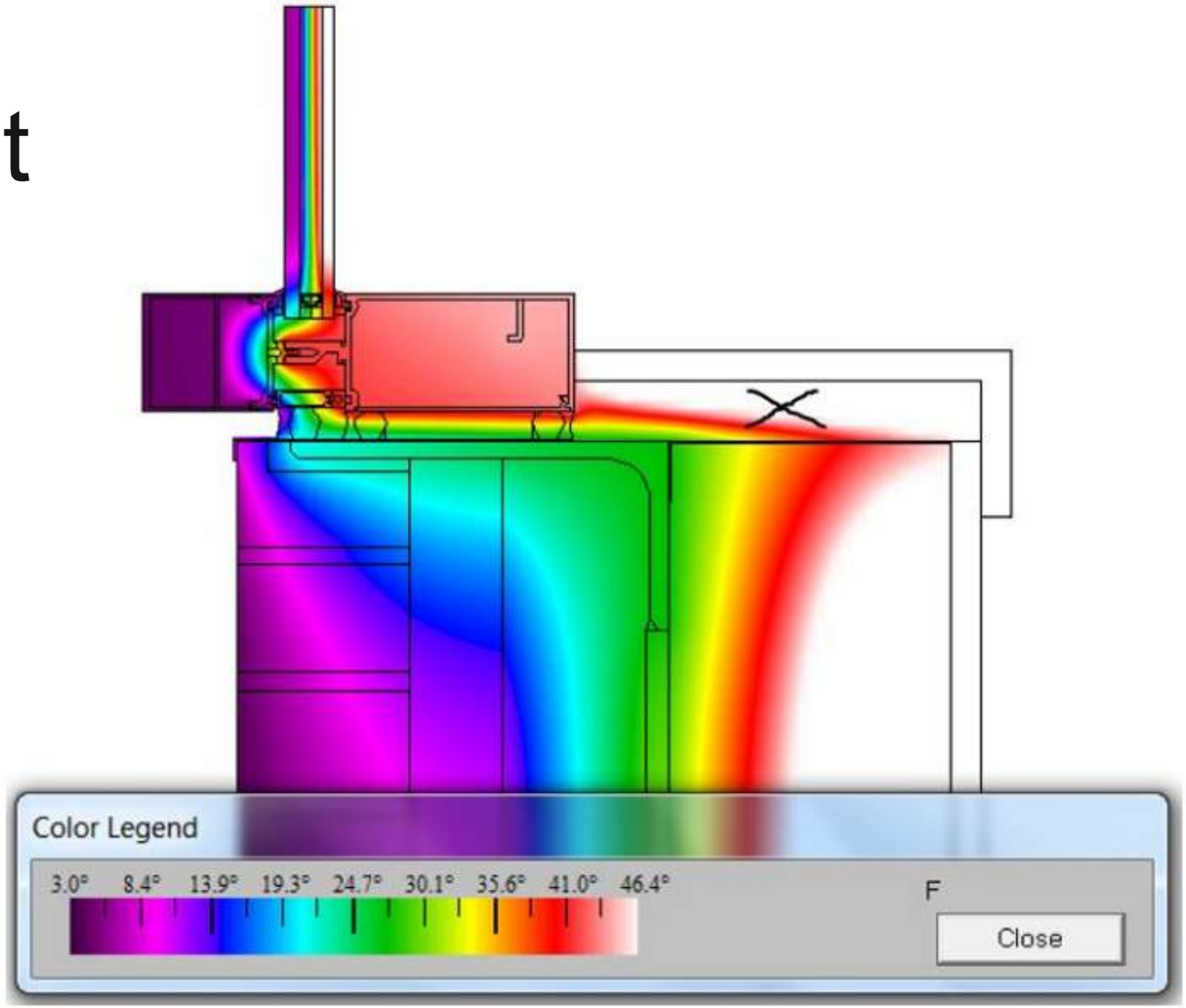
Case Study 1 – CoxHealth Patient Tower Addition



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Predicting surface temperature and condensation of the building enclosure assembly is critical in understanding how components will maintain inside surface temps when thermal bridging in present.

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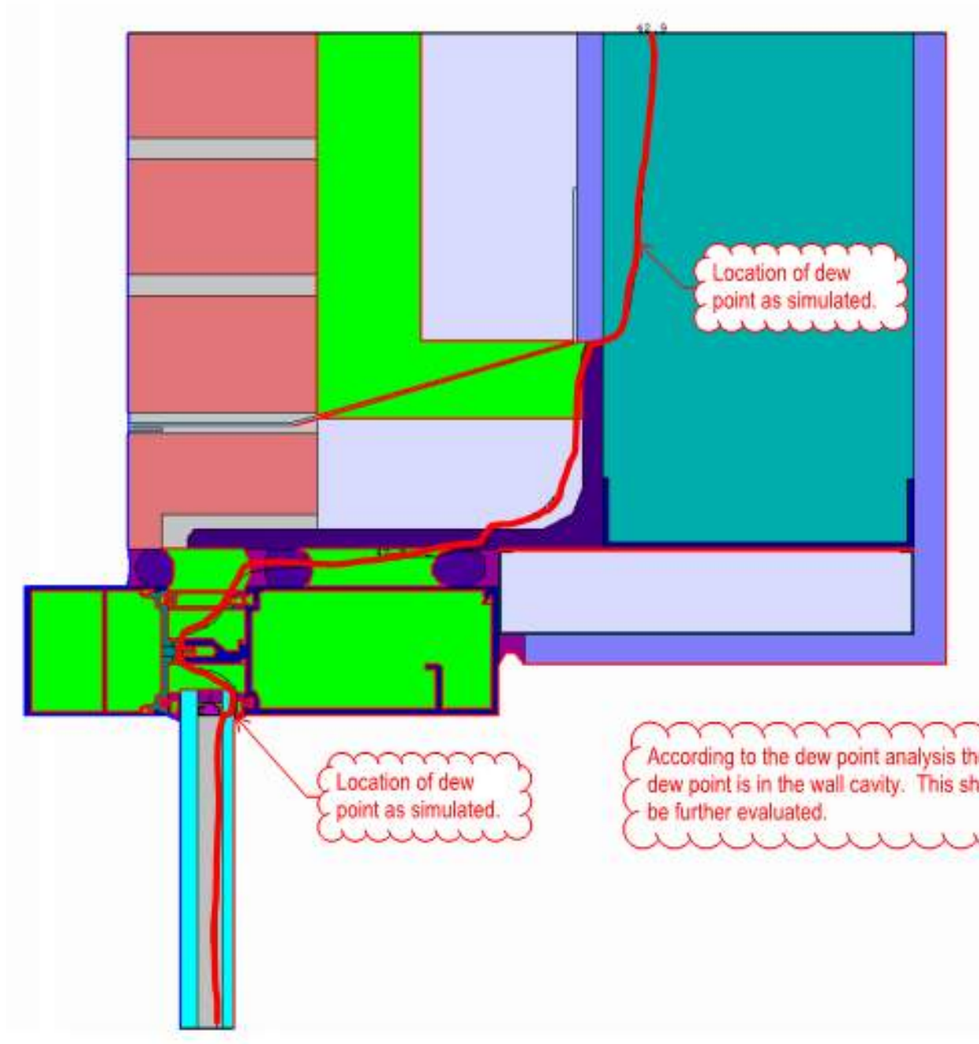
Brick Spandrel Over Vision Head (R.H.=35%) Detail

Color Image of Material Assignments wit Isotherm at Dew Point Temperature



EXTERIOR DESIGN TEMPERATURE	= 3 °F
EXTERIOR WIND SPEED	= 15 mph
INTERIOR TEMPERATURE	= 72 °F
INTERIOR RELATIVE HUMIDITY	= 35 %
INTERIOR DEW POINT TEMPERATURE	= 42.9 °F

SUBJECT: Thermal Simulation JOB NAME: Cox Health Tower

Case Study 1 – CoxHealth Patient Tower Addition

What is the anticipated surface temperature with heating design temperature of 3°F with a 15mph wind?

What about night sky radiation?

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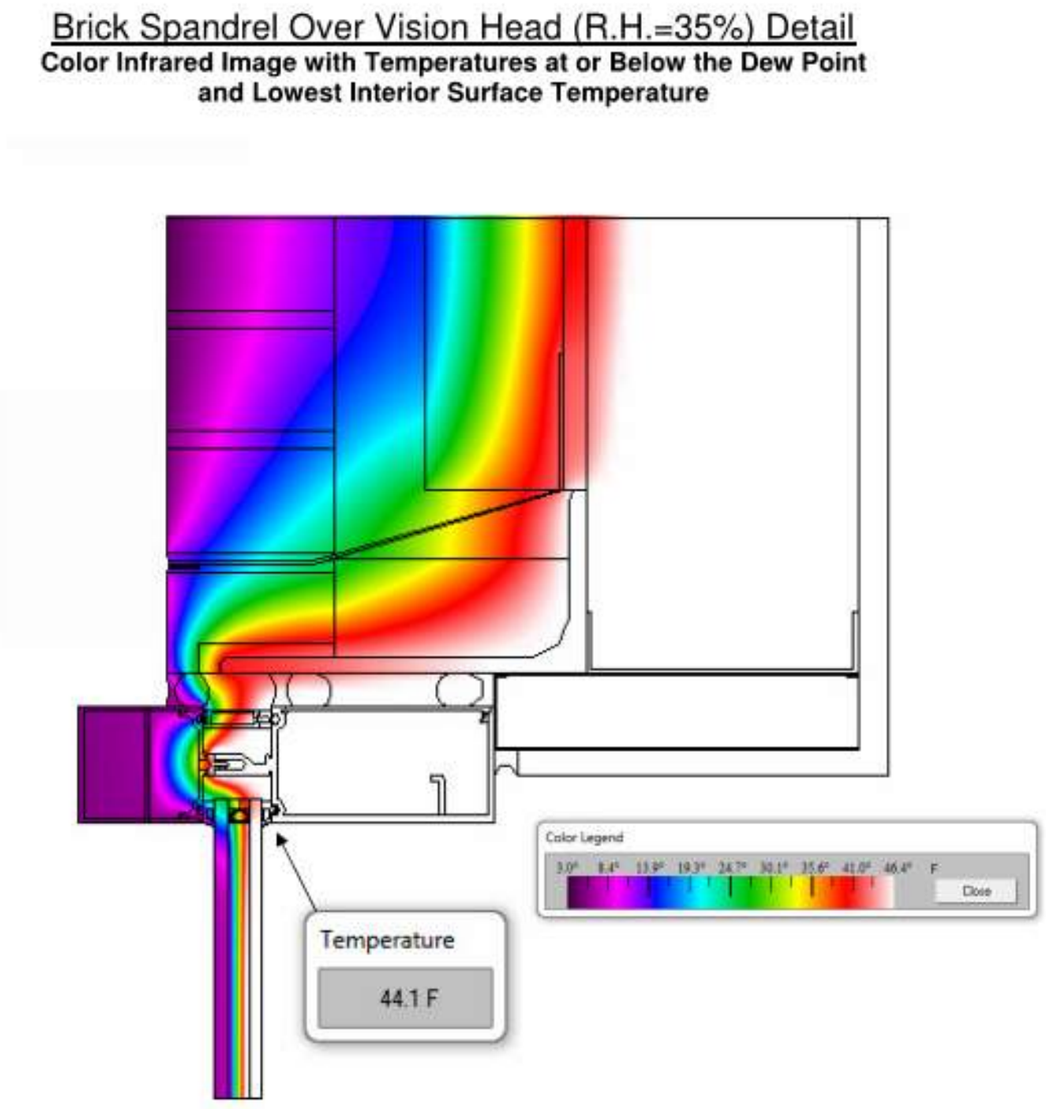

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According to Weather Underground (wunderground.com), weather conditions prior to and at the time of limited assessment were as follows:

CONDITIONS AT THE TIME OF INSPECTION			
Outside ambient temperature	11°F – 25°F	Interior relative humidity	Varies
Interior ambient temperature	Varies	Sky conditions	Clear
Average wind velocity	4.6 mph	Wind chill temperature	2.9°F – 19°F

CONDITIONS 24-HOURS PRIOR & RECENT PRECIPITATION			
Outside ambient temp. (min.)	11°F	Outside ambient temp. (max.)	40°F
Average wind velocity (wind chill)	7 mph	Average rainfall	0.00 in.

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CoxHealth Patient Tower Addition

NICU Room 14 - Average Surface Temperatures on February 2, 2018 at 9:15am

Location	Average Surface Temperature Outside	Average Surface Temperature Inside	ΔT Int/Ext Temperature
Top of sill member - approximately 1/2" from glass	22.5°F	47.6°F	25.1°F
Gasket - surface temperature of gasket material	22.6°F	44.8°F	22.2°F
Glass surface - approximately 1" from sill member	22.7°F	49.9°F	27.2°F

Note: Exterior ambient temperatures were documented at around 18°F at 8:52am and 22°F at 9:52am.

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NICU Room 14 - Estimated Surface Temperatures on February 2, 2018 at 7:00am

Location	Wind Chill at 11°F and 7mph	Ambient Temperature Outside	ΔT Int/Ext Temperature	Projected Surface Temp Inside	Projected Interior Surface Temp with Applied Wind Speed
Top of sill member - approximately 1/2" from glass	±0.2°F	±11°F	25.1°F	36.1°F	25.3°F
Gasket - surface temperature of gasket material	±0.2°F	±11°F	22.2°F	33.2°F	22.4°F
Glass surface - approximately 1" from sill member	±0.2°F	±11°F	27.2°F	38.2°F	27.4°F

Note: According to the design criteria used of: 3°F exterior temp, 72°F interior temp, wind velocity of 15 mph, relative humidity at 35% and dew point temperature of 42.9°F the projected surface temperatures of the frames above would result in surface condensation.

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Condensation Resistance Factor (CRF) was reviewed

AAMA 1503-98 – specifies a warm side temperature of 70°F and a cold side temperature of 0°F with a 15mph exterior wind

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NICU Room #14: Image on left was taken upon arrival at 7:15am on 2/2/18. Image on the right was taken to document the reoccurrence of condensation within 30 minutes of drying glass and tube.

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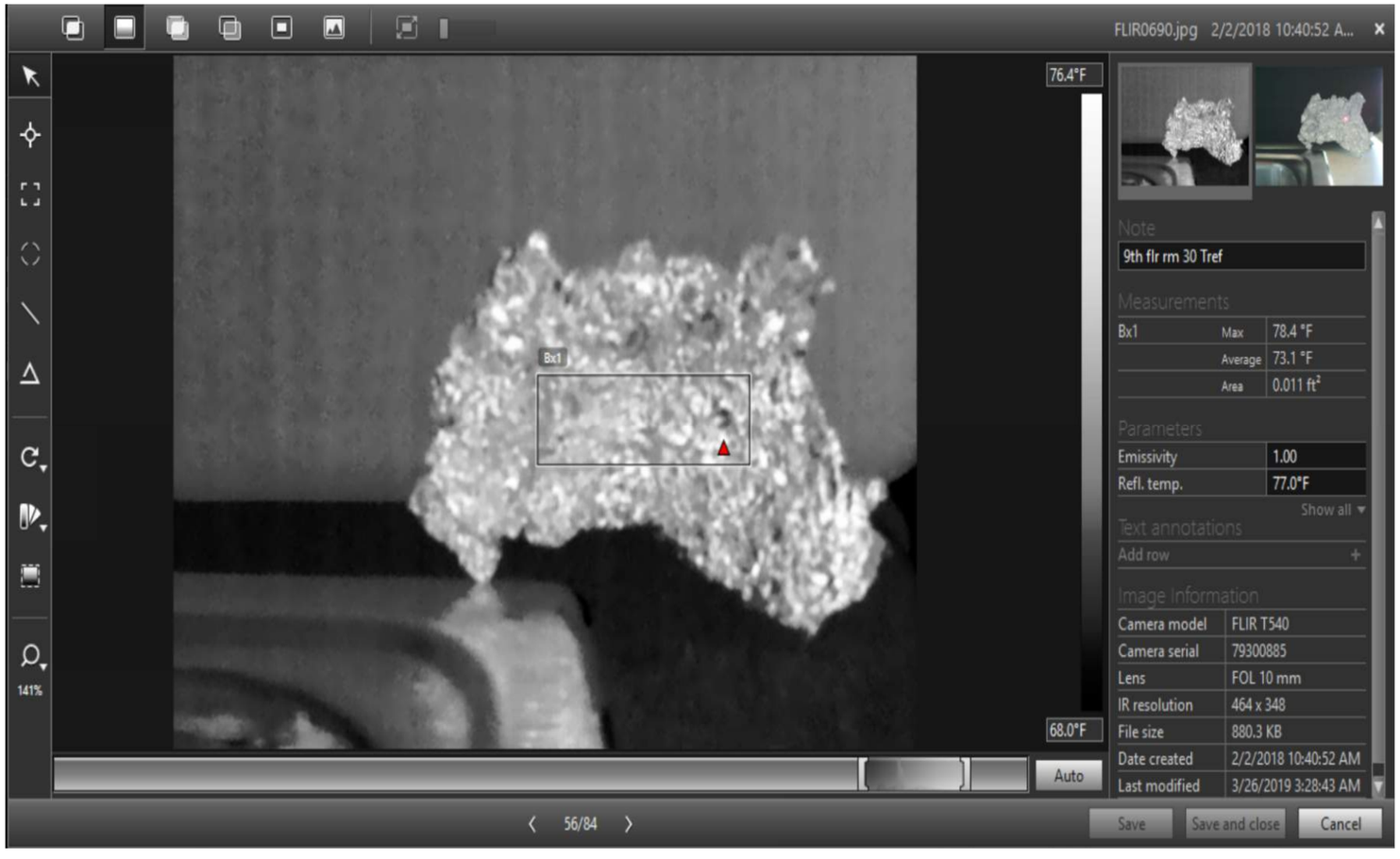

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NICU Room 14 – North Elevation

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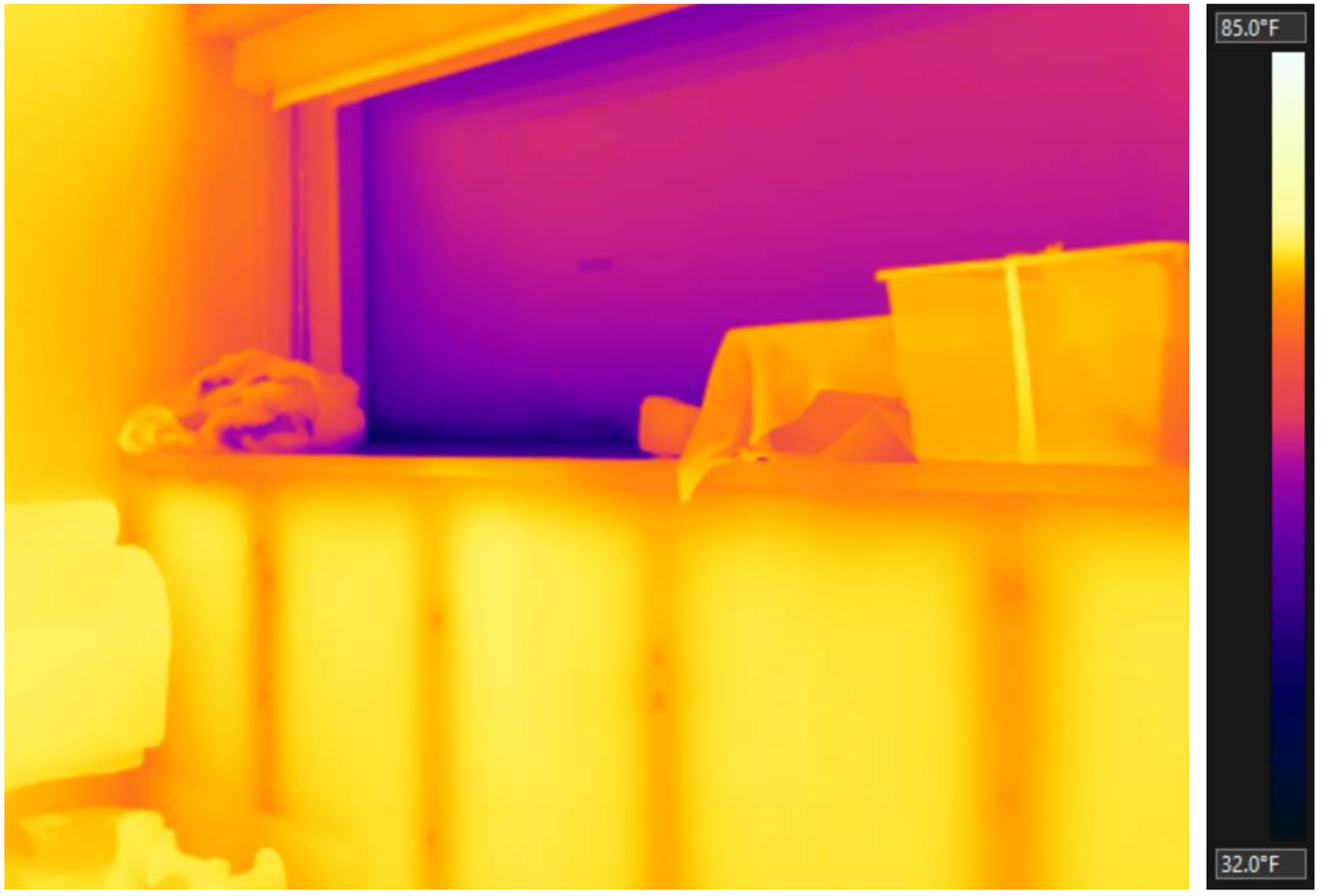

NICU Room 14 – Baseline Reference

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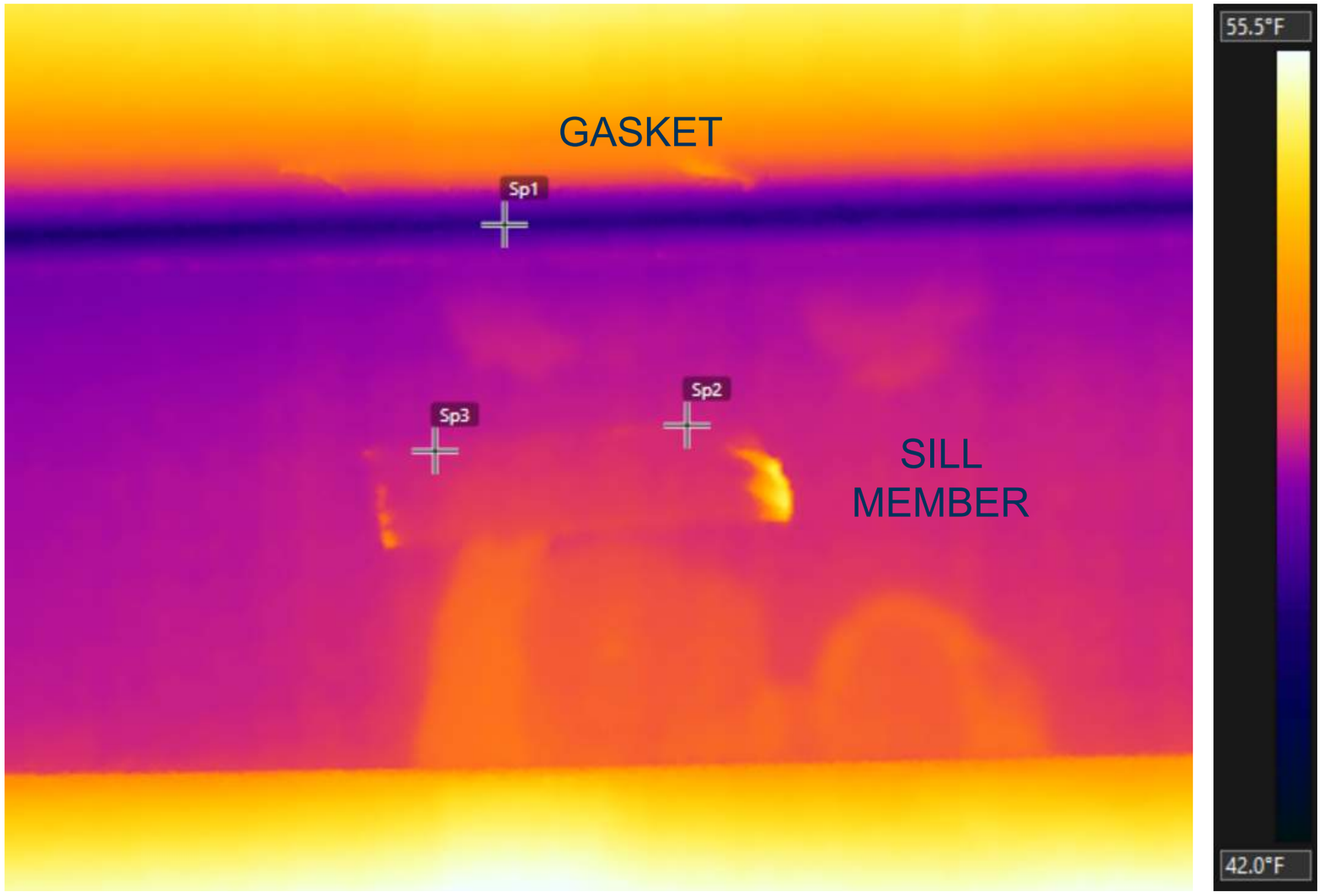
Note	
West light @ sill tube	
Measurements	
Sp1	46.4 °F
Sp2	49.0 °F
Sp3	49.0 °F



NICU Room 14 – Interior at Sill Tube

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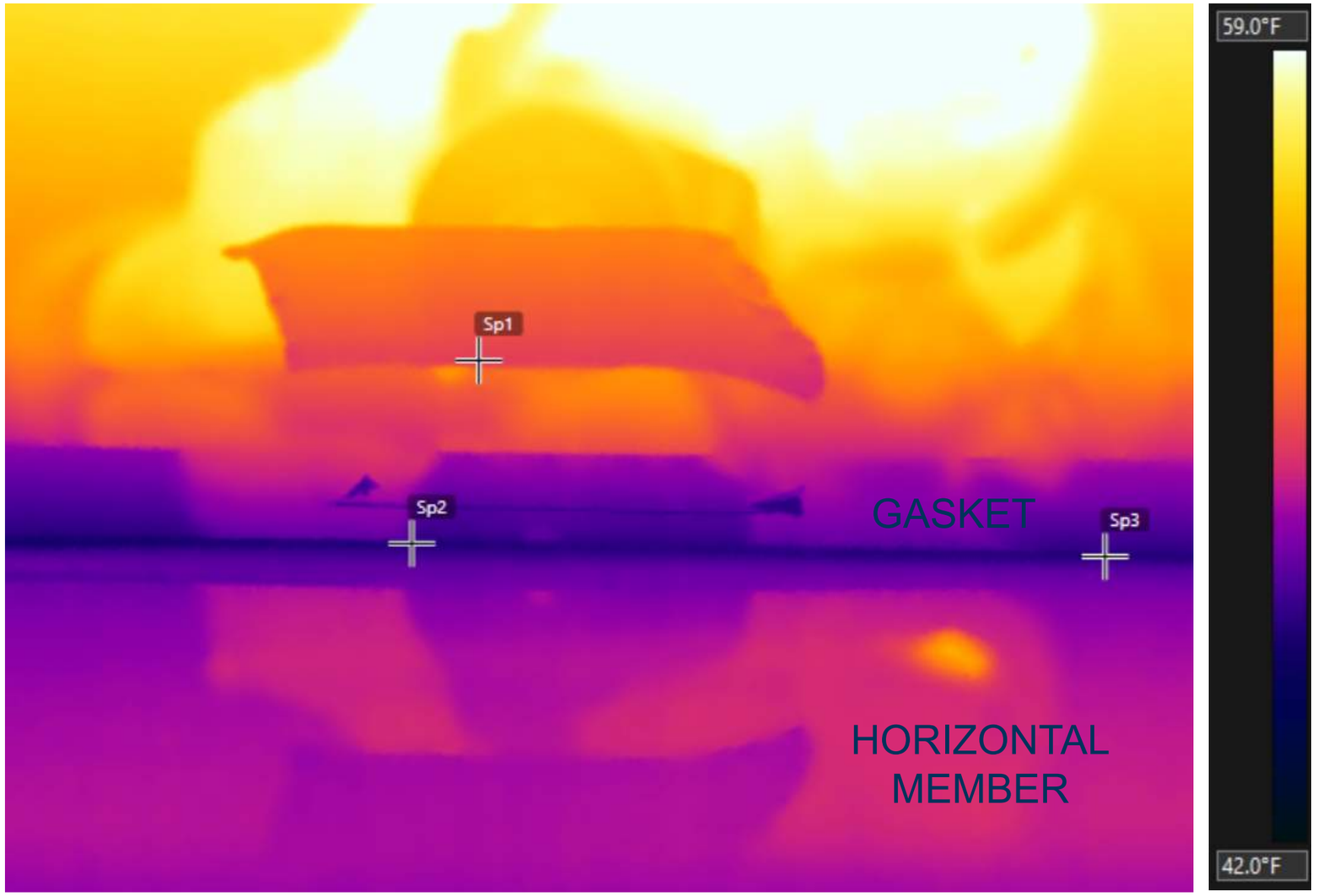
Note

West side mid lite

Measurements

Sp1	50.8 °F
Sp2	46.7 °F
Sp3	46.6 °F



NICU Room 14 – Interior at Middle Tube

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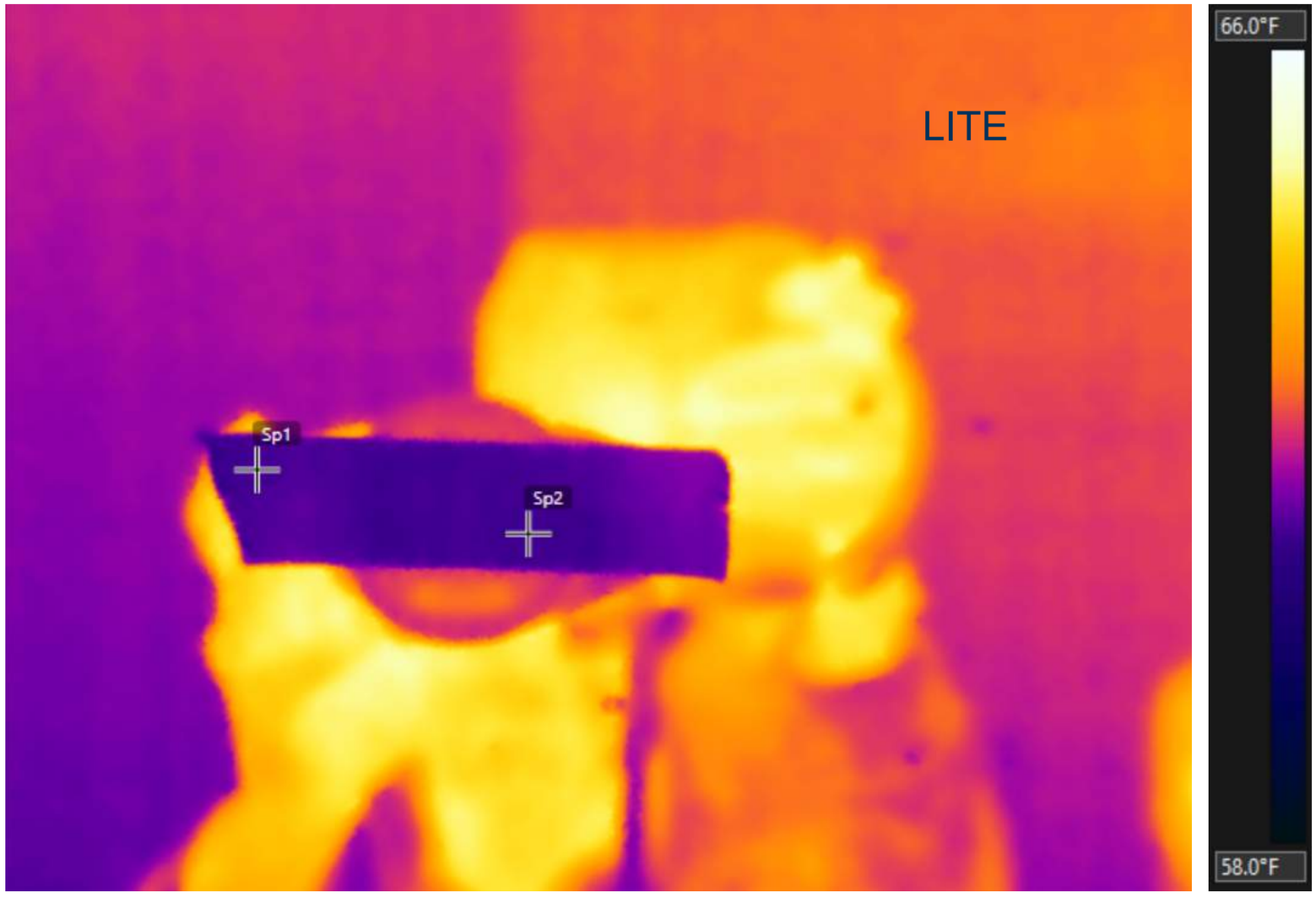
Note

West side mid lite

Measurements

Sp1	61.1 °F
Sp2	61.1 °F



NICU Room 14 – Interior at Middle Lite

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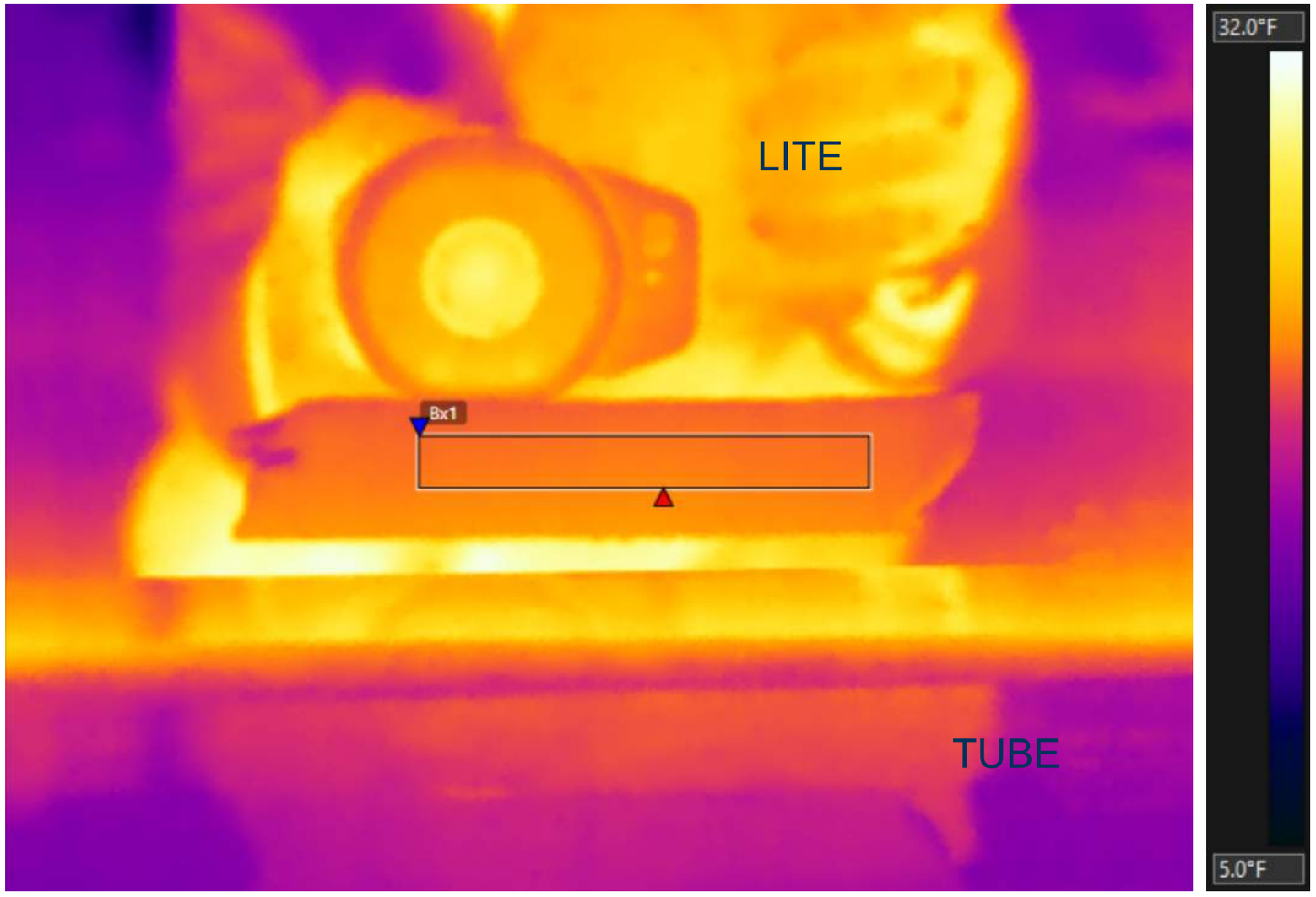
Note

West outside of NICU14

Measurements

Bx1	Max	23.9 °F
	Min	22.3 °F
	Average	23.2 °F



NICU Room 14 – Exterior at Sill Tube

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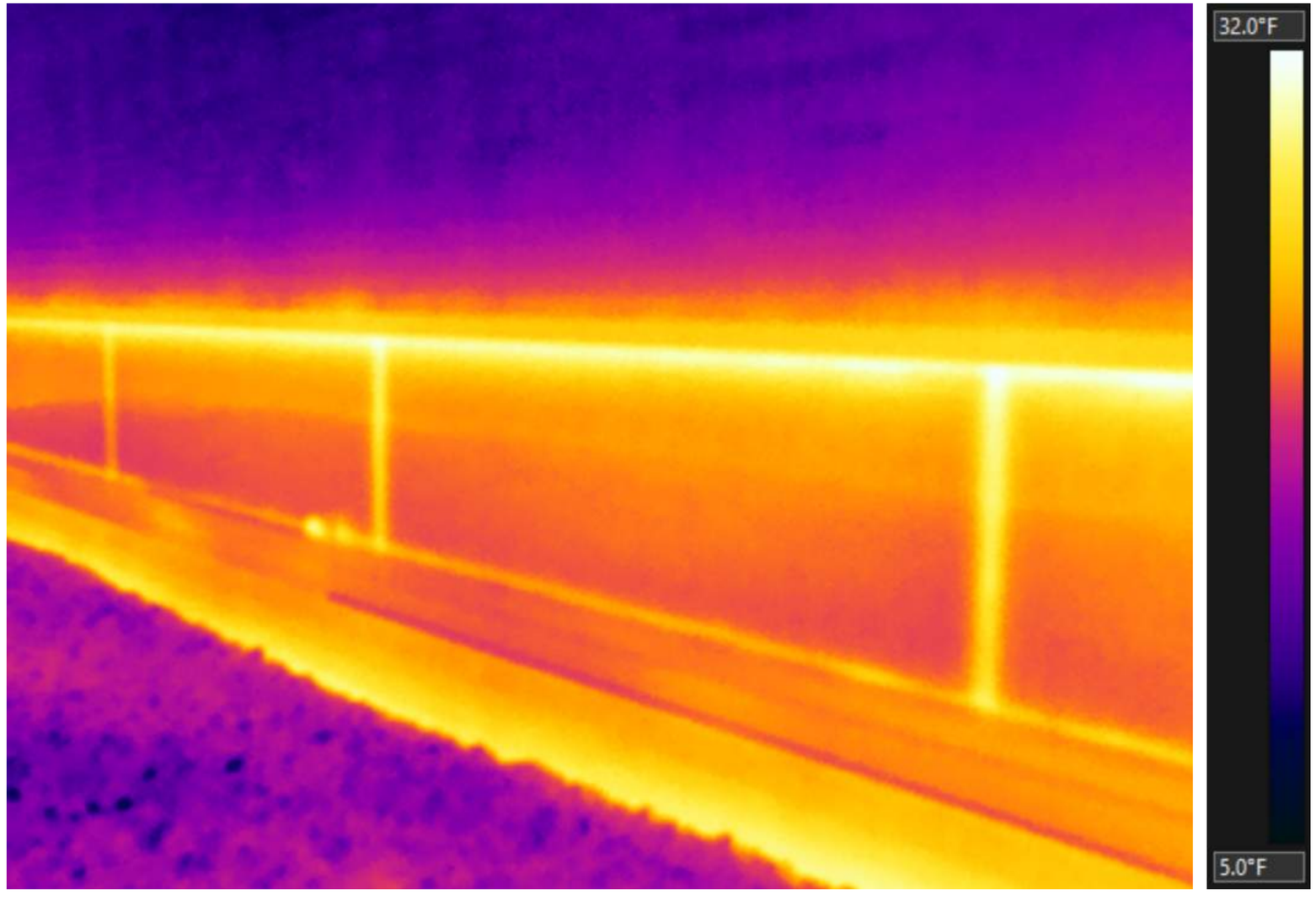

NICU Room 14 – Exterior Baseline

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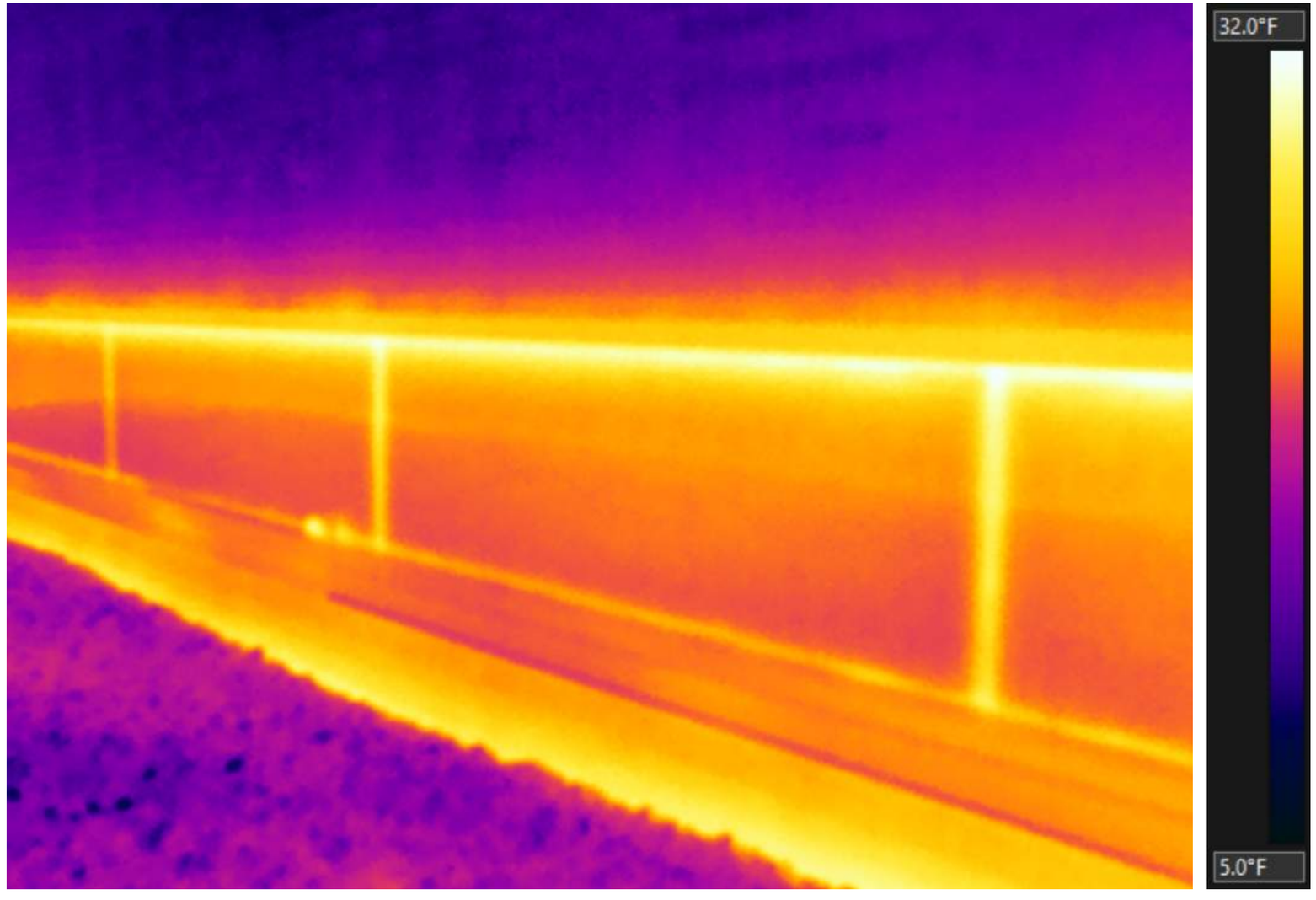
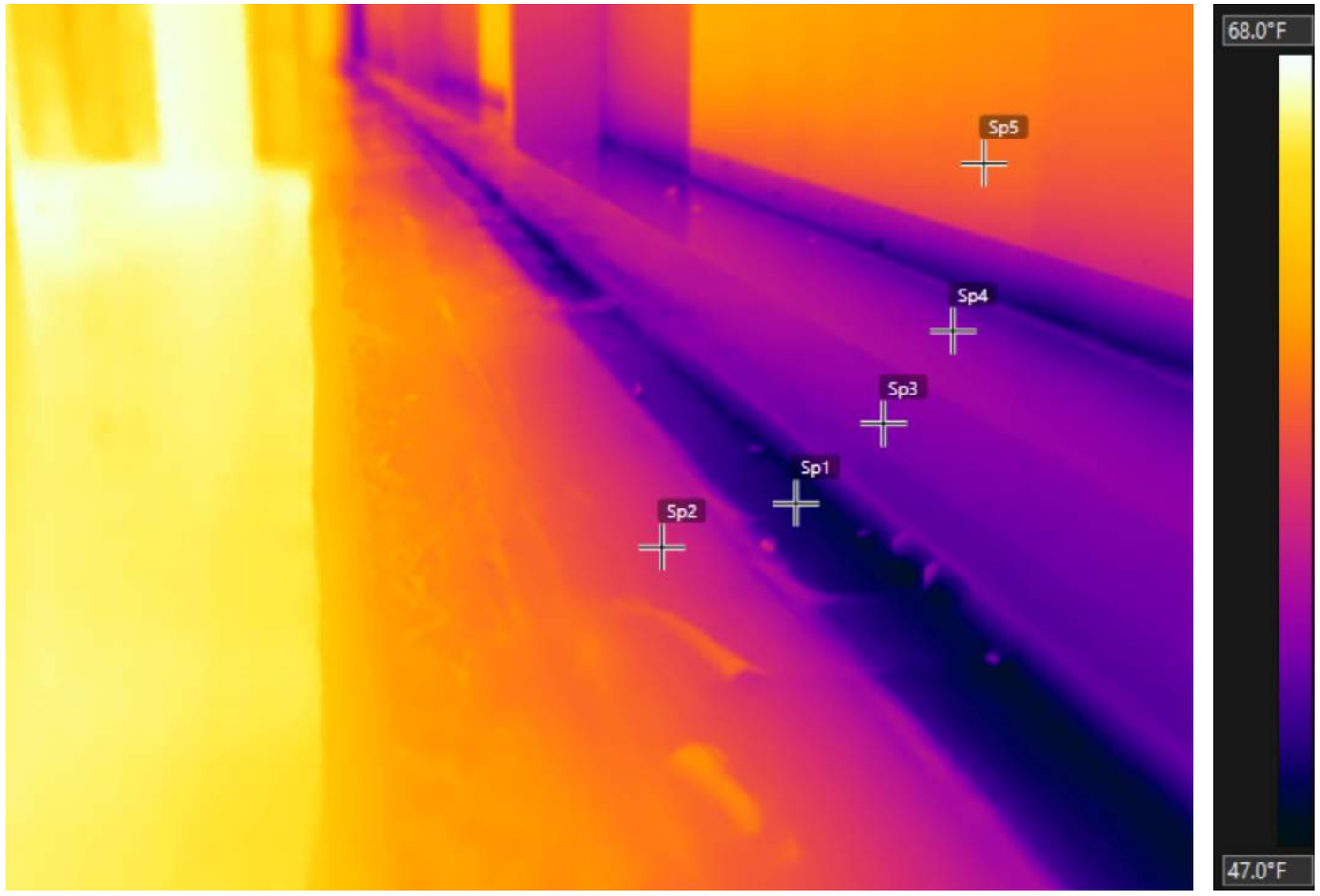


NICU Room 14 – Exterior Baseline

Case Study 1 – CoxHealth Patient Tower Addition



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North wall 5th floor looking north, structural steel temperatures are lower than frame temperatures. This image was taken at 10:00 am when exterior ambient temperatures were approximately 22°F. This image shows the frame sitting on the cold side of the exterior wall, directly onto the steel member. The spot surface temperatures are as follows: Spot1 - 46.7°F, Spot2 - 60.0°F, Spot3 – 51.0°F, Spot4 – 51.0 °F, Spot5 – 51.8°F, Spot6 – 59.8°F.

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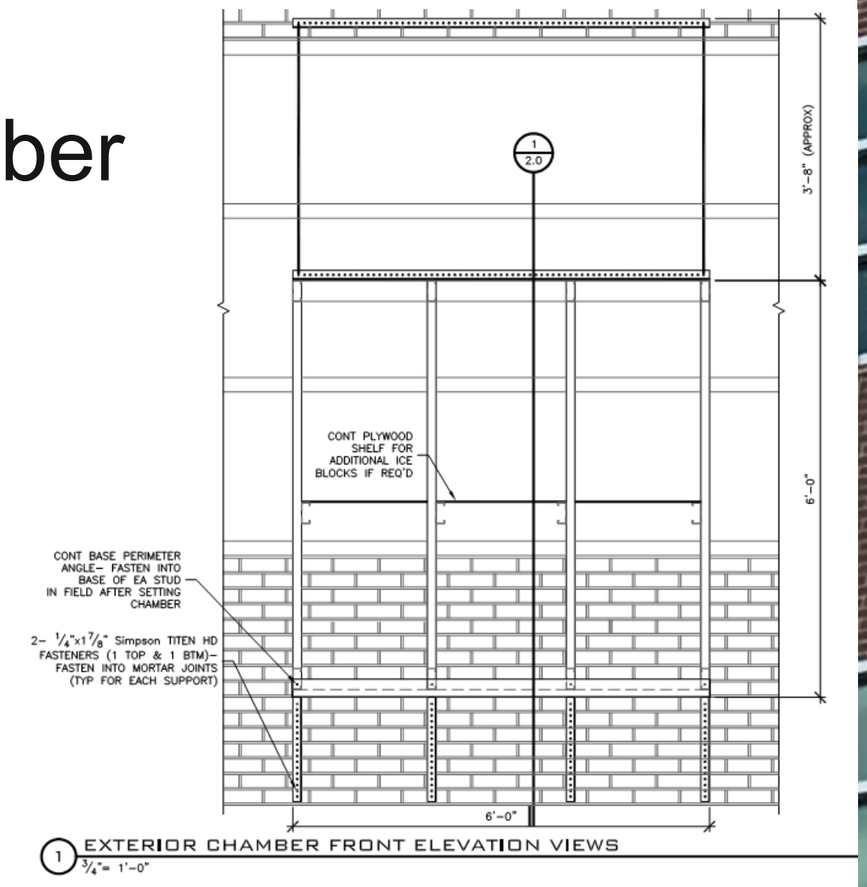
Exterior Chamber designed and installed



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Exterior Chamber filled with dry ice

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200 pounds of dry ice used in 21 hours

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Interior Chamber climate controlled to mechanical system design.

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Interior Chamber climate controlled to mechanical system design.

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Thermocouples installed on interior and exterior at sill, lite, and wall on interior and exterior

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Thermocouples installed on interior and exterior at sill, lite, and wall on interior and exterior

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Thermocouples installed on interior and exterior at sill, lite, and wall on interior and exterior

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Place	Date	Time	Value	Unit	Value	Unit	Value	Unit	Value	Unit
1	5/30/2018	14:00:02	80	T1 KTemp	9999	T2 KTemp	9999	T3 KTemp	9999	T4 KTemp F
2	5/30/2018	14:00:04	80	T1 KTemp	9999	T2 KTemp	9999	T3 KTemp	9999	T4 KTemp F
3	5/30/2018	14:00:05	80	T1 KTemp	9999	T2 KTemp	9999	T3 KTemp	9999	T4 KTemp F
4	5/30/2018	14:00:06	79.9	T1 KTemp	9999	T2 KTemp	9999	T3 KTemp	9999	T4 KTemp F
5	5/30/2018	14:00:07	79.9	T1 KTemp	9999	T2 KTemp	9999	T3 KTemp	9999	T4 KTemp F
1573	6/1/2018	11:05:18	37.5	T1 KTemp	37.2	T2 KTemp	28.6	T3 KTemp	36	T4 KTemp F
1574	6/1/2018	11:06:18	37.7	T1 KTemp	37.2	T2 KTemp	28.7	T3 KTemp	36.1	T4 KTemp F
1575	6/1/2018	11:07:18	37.9	T1 KTemp	37.4	T2 KTemp	28.6	T3 KTemp	36.1	T4 KTemp F
1576	6/1/2018	11:08:18	37.9	T1 KTemp	37.5	T2 KTemp	28.4	T3 KTemp	36.3	T4 KTemp F
1577	6/1/2018	11:09:18	38.1	T1 KTemp	37.7	T2 KTemp	31	T3 KTemp	36.6	T4 KTemp F

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Exterior Thermocouple Readings –
21 hour acclimation

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Place	Date	Time	Value	Unit	Value	Unit	Value	Unit	Value	Unit
1	5/31/2018	9:58:58	71.7	T1 KTemp	71.1	T2 KTemp	72.5	T3 KTemp	75.5	T4 KTemp F
2	5/31/2018	9:59:58	71.7	T1 KTemp	71.2	T2 KTemp	72.3	T3 KTemp	75.3	T4 KTemp F
3	5/31/2018	10:00:58	71.7	T1 KTemp	71.2	T2 KTemp	72.3	T3 KTemp	75.2	T4 KTemp F
4	5/31/2018	10:01:58	71.7	T1 KTemp	71.2	T2 KTemp	72.3	T3 KTemp	75.2	T4 KTemp F
5	5/31/2018	10:02:58	71.7	T1 KTemp	71.4	T2 KTemp	72.3	T3 KTemp	75	T4 KTemp F
1523	6/1/2018	11:20:58	59.9	T1 KTemp	59.1	T2 KTemp	65.8	T3 KTemp	62.2	T4 KTemp F
1524	6/1/2018	11:21:58	60	T1 KTemp	59.4	T2 KTemp	65.8	T3 KTemp	62.1	T4 KTemp F
1525	6/1/2018	11:22:58	60.2	T1 KTemp	59.7	T2 KTemp	66	T3 KTemp	62.2	T4 KTemp F
1526	6/1/2018	11:23:58	60.4	T1 KTemp	59.7	T2 KTemp	66.3	T3 KTemp	62.2	T4 KTemp F
1527	6/1/2018	11:24:58	60.6	T1 KTemp	59.5	T2 KTemp	66.2	T3 KTemp	62	T4 KTemp F

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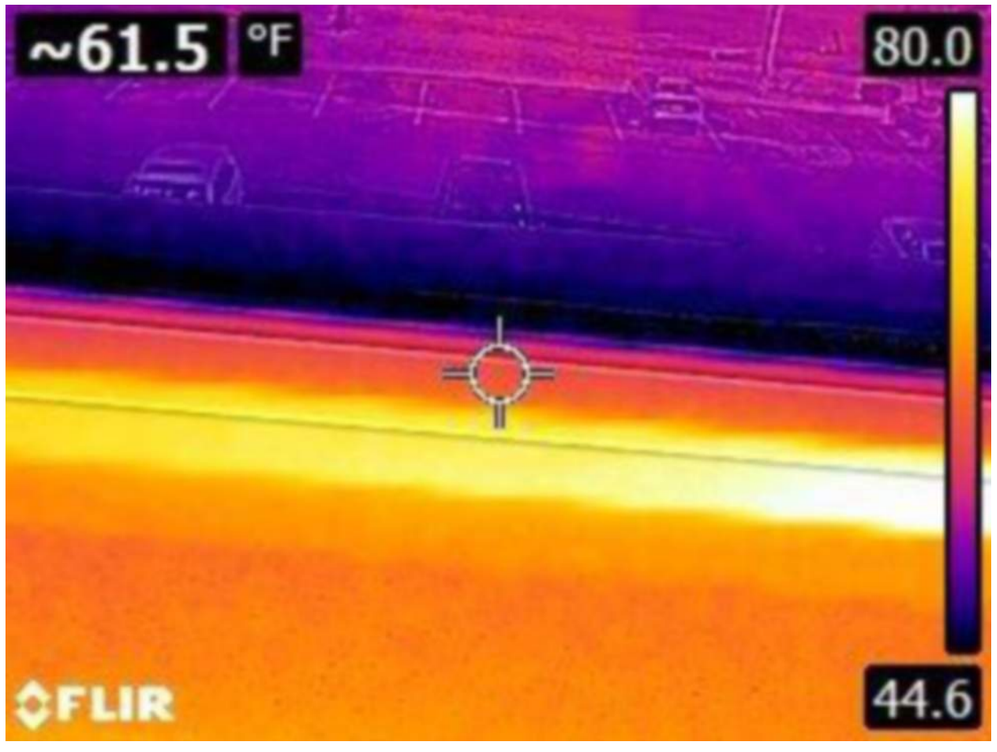
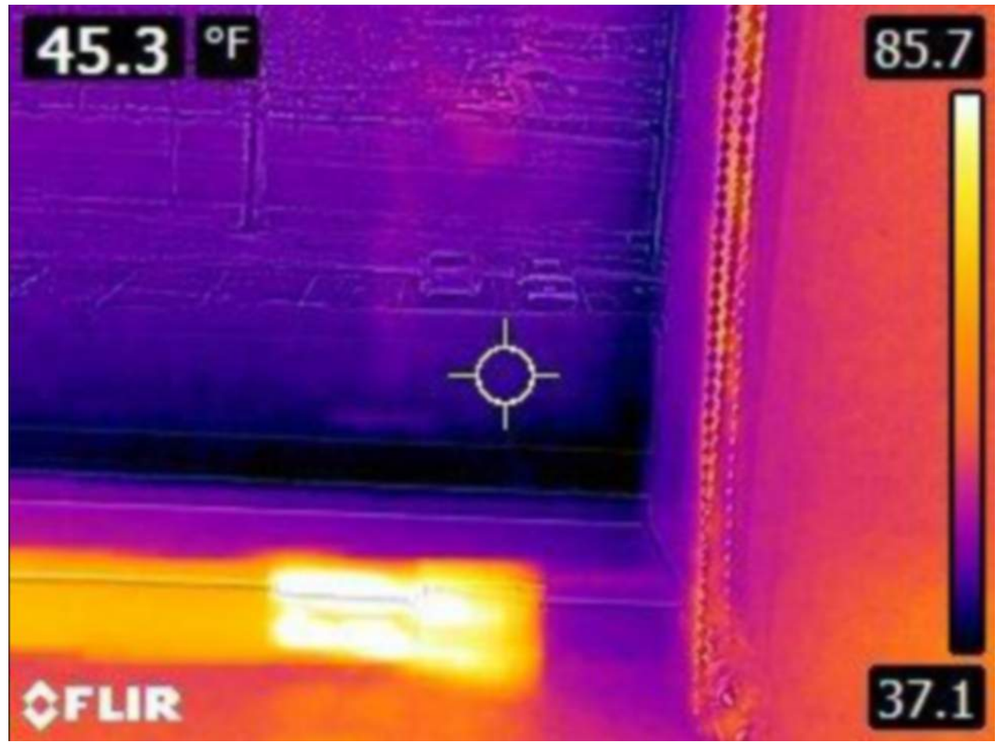
Interior Thermocouple Readings –
21 hour acclimation

Case Study 1 –
CoxHealth Patient Tower Addition





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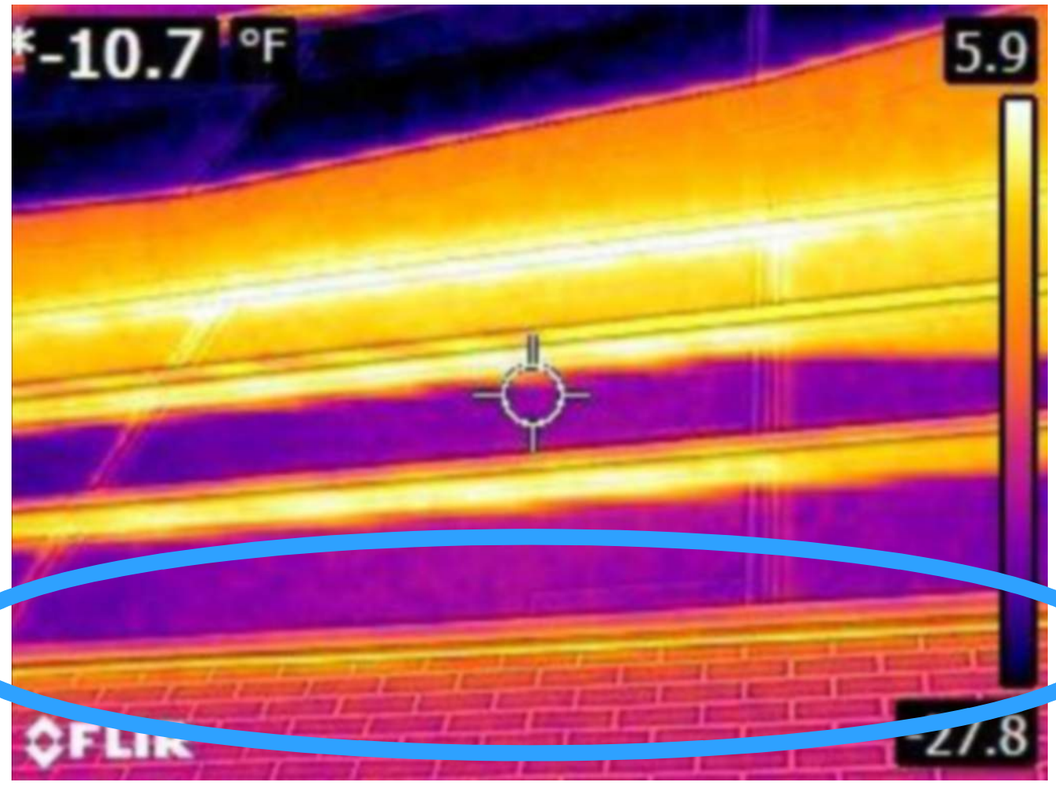
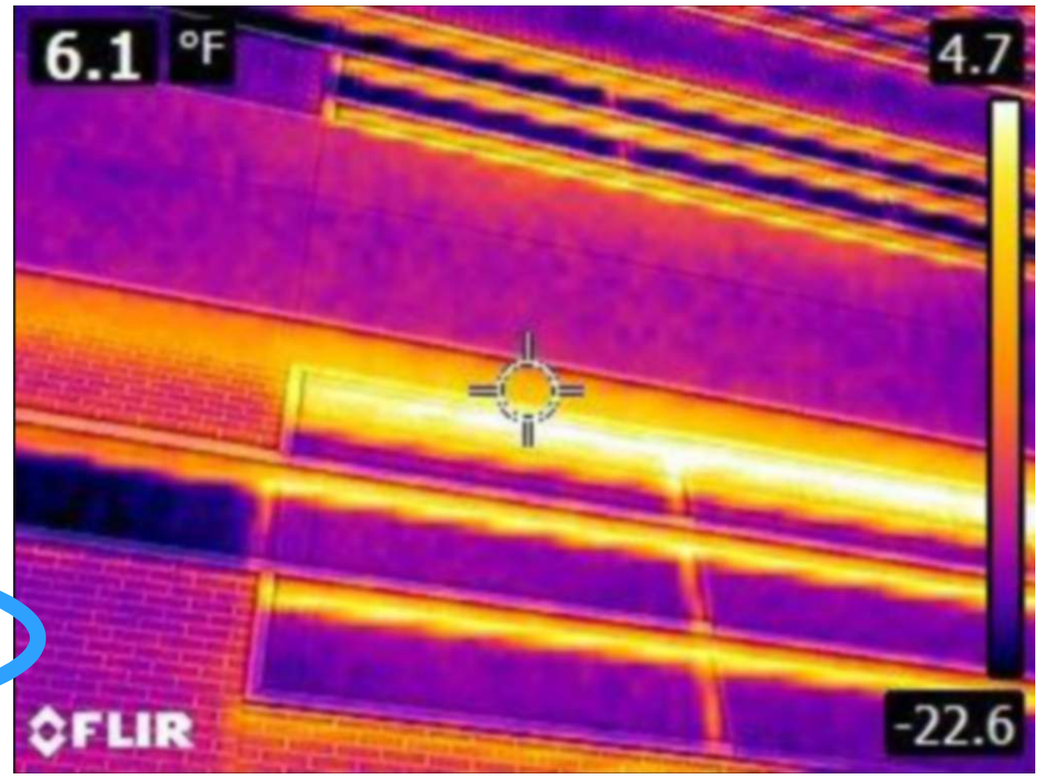
Introduction of Electric Heat strips were added to “warm” the window frame

Case Study 1 –
CoxHealth Patient Tower Addition





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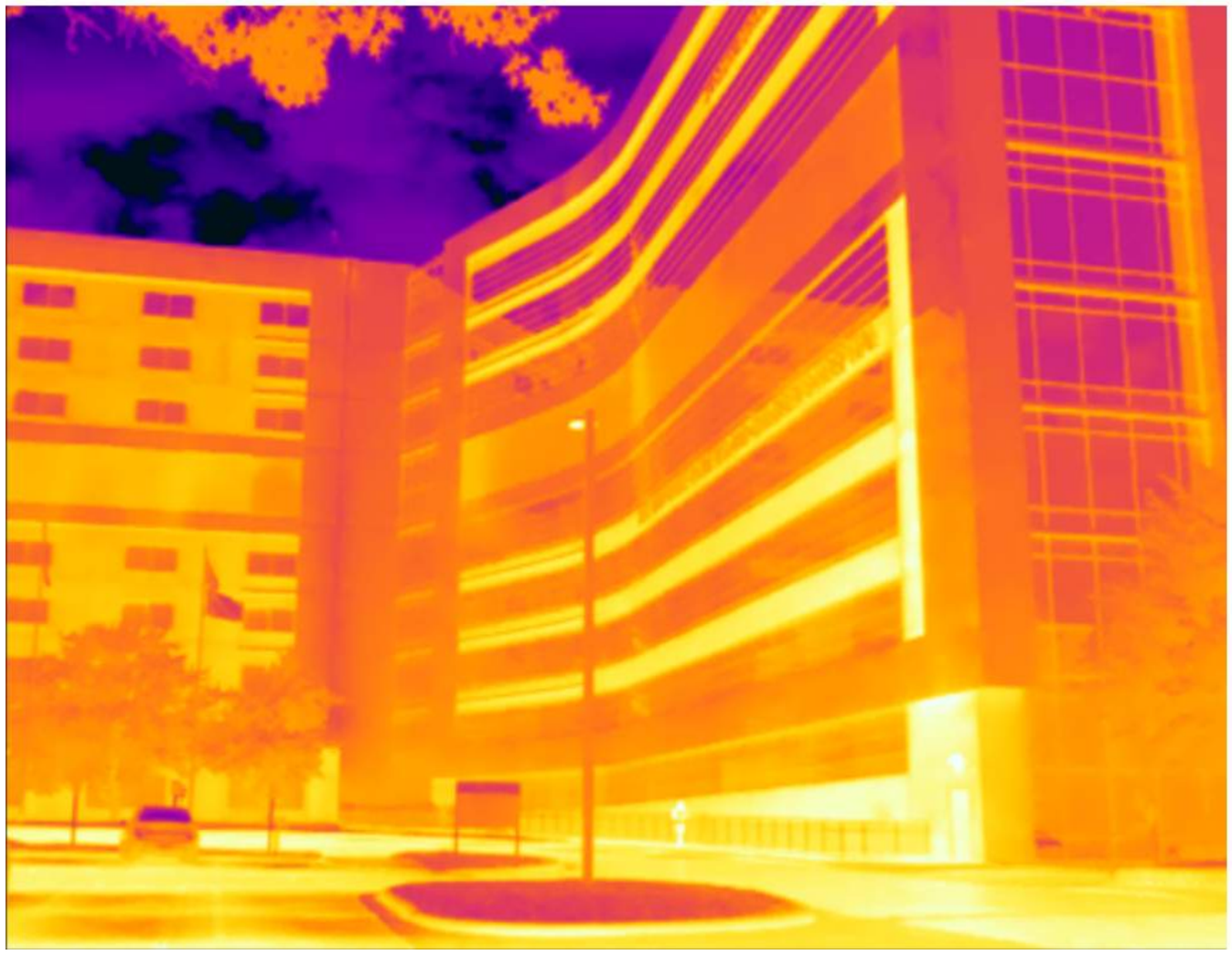
Case Study 1 – CoxHealth Patient Tower Addition



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Case Study 2 – Primatara Mansion

Case Study conducted by:
Miller Engineering, P.C.

Testing conducted for:
Killian Construction
& Robert Low

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Case Study 2 – Primatara Mansion

Leak Point at every window identified at the stainless clips at both the head and jambs.

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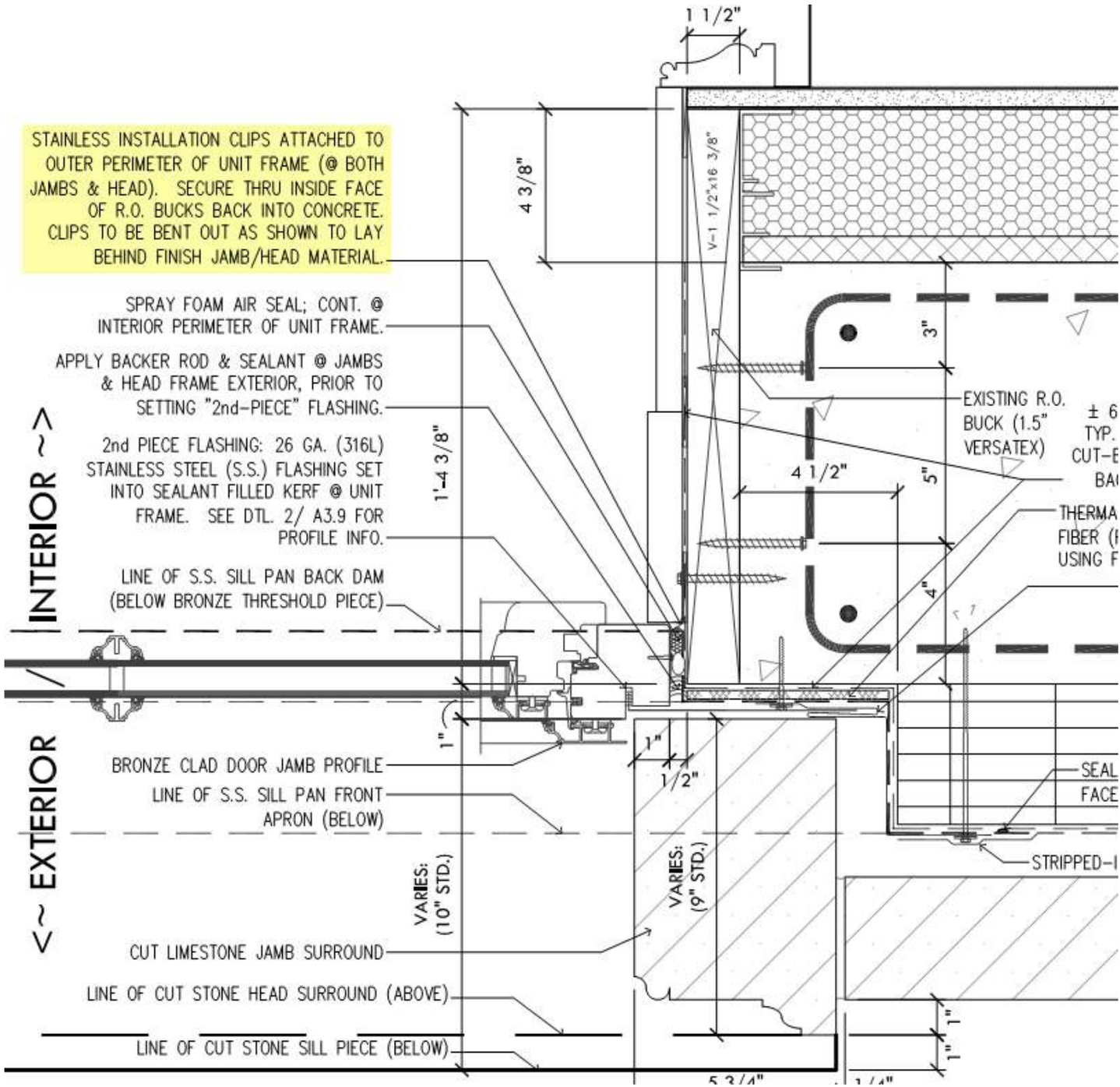

Case Study 2 – Primatara Mansion

Leak Point at every window identified at the stainless clips at both the head and jambs.

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Case Study 2 – Primatara Mansion

Leak Point at every window identified at the stainless clips at both the head and jambs.

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Case Study 2 – Primatara Mansion

Every window and door on the project was to be tested and required to pass with no water infiltration criteria

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Case Study 2 – Primatara Mansion

Modified AAMA 501.2 Water Testing with No-Water Penetration/Infiltration Criteria Conducted

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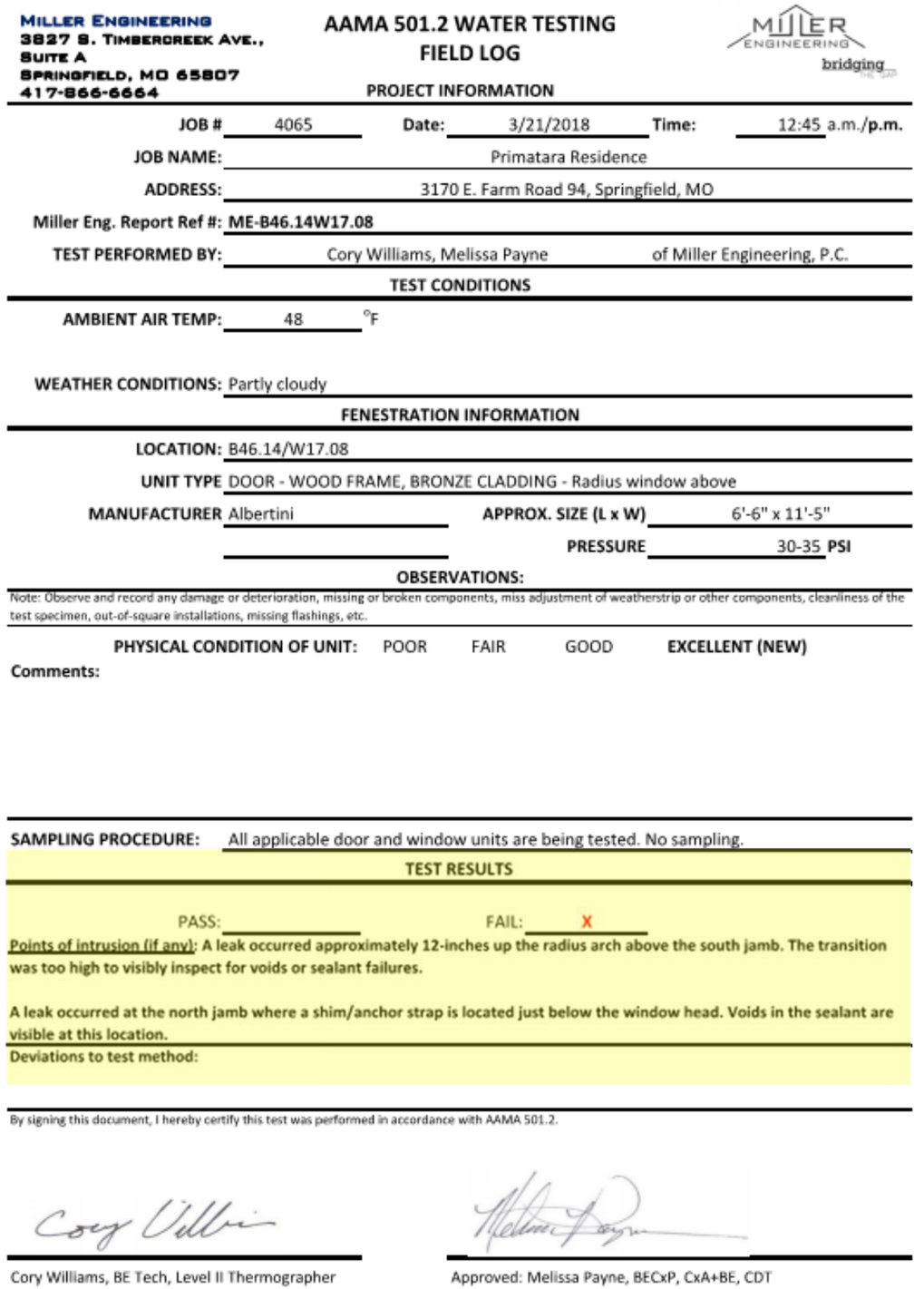
A leak occurred at the north jamb where a shim/anchor strap is located just below the window head.



MILLER ENGINEERING
3827 S. TIMBERCREEK AVE., SUITE A
SPRINGFIELD, MO 65807
417-866-6664

AAMA 501.2 WATER TESTING FIELD LOG

MILLER ENGINEERING bridging

PROJECT INFORMATION

JOB # 4065 Date: 3/21/2018 Time: 12:45 a.m./p.m.

JOB NAME: Primatara Residence

ADDRESS: 3170 E. Farm Road 94, Springfield, MO

Miller Eng. Report Ref #: ME-B46.14W17.08

TEST PERFORMED BY: Cory Williams, Melissa Payne of Miller Engineering, P.C.

TEST CONDITIONS

AMBIENT AIR TEMP: 48 °F

WEATHER CONDITIONS: Partly cloudy

FENESTRATION INFORMATION

LOCATION: B46.14/W17.08

UNIT TYPE DOOR - WOOD FRAME, BRONZE CLADDING - Radius window above

MANUFACTURER Albertini APPROX. SIZE (L x W) 6'-6" x 11'-5"

PRESSURE 30-35 PSI

OBSERVATIONS:

Note: Observe and record any damage or deterioration, missing or broken components, miss adjustment of weatherstrip or other components, cleanliness of the test specimen, out-of-square installations, missing flashings, etc.

PHYSICAL CONDITION OF UNIT: POOR FAIR GOOD EXCELLENT (NEW)

Comments:

SAMPLING PROCEDURE: All applicable door and window units are being tested. No sampling.

TEST RESULTS

PASS: FAIL: X

Points of intrusion (if any): A leak occurred approximately 12-inches up the radius arch above the south jamb. The transition was too high to visibly inspect for voids or sealant failures.

A leak occurred at the north jamb where a shim/anchor strap is located just below the window head. Voids in the sealant are visible at this location.

Deviations to test method:

By signing this document, I hereby certify this test was performed in accordance with AAMA 501.2.

Cory Williams, BE Tech, Level II Thermographer

Approved: Melissa Payne, BECxP, CxA+BE, CDT

Case Study 2 – Primatara Mansion

Unit failure at seals of operable windows.

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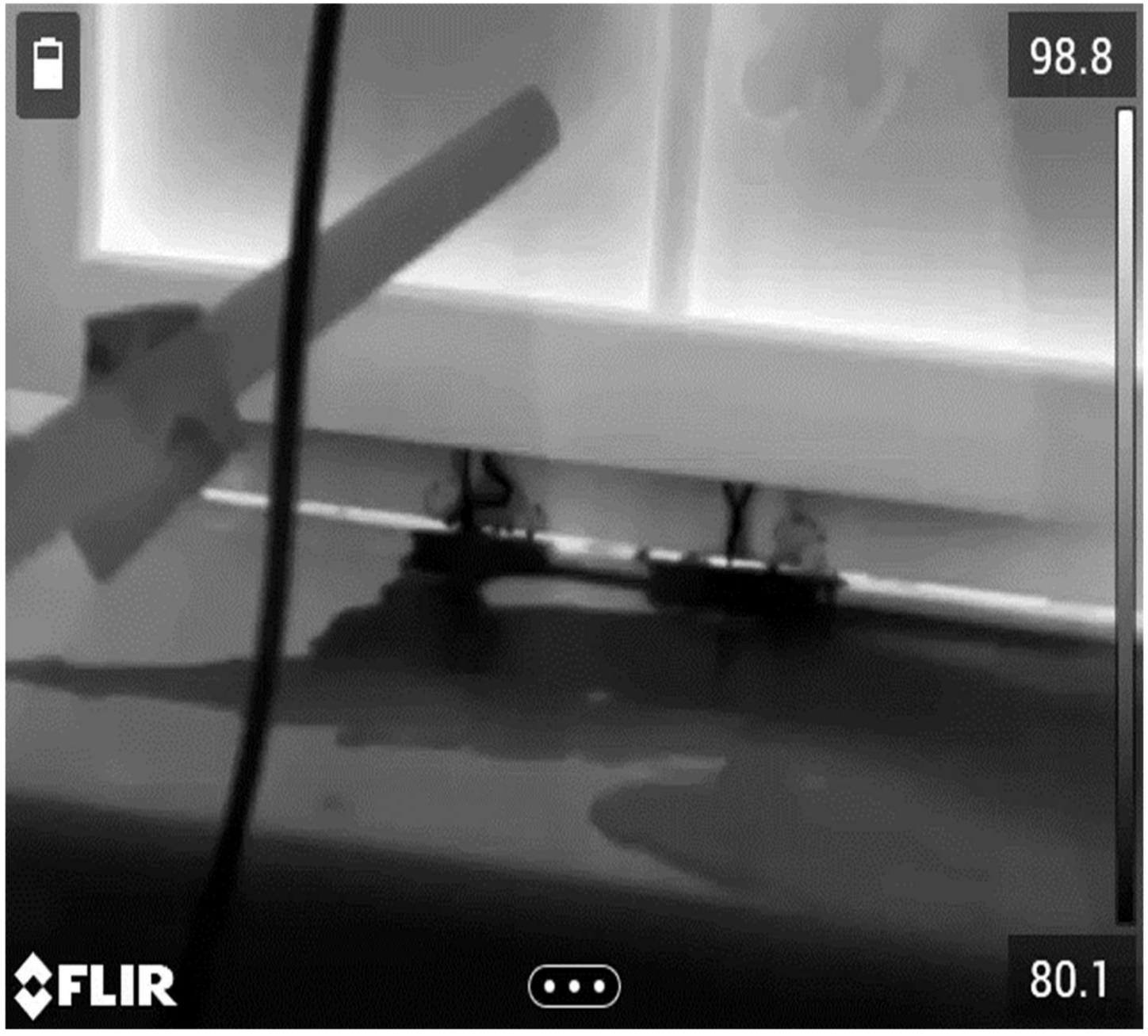

Case Study 2 – Primatara Mansion

Installation failure jamb/sill flashing of windows.

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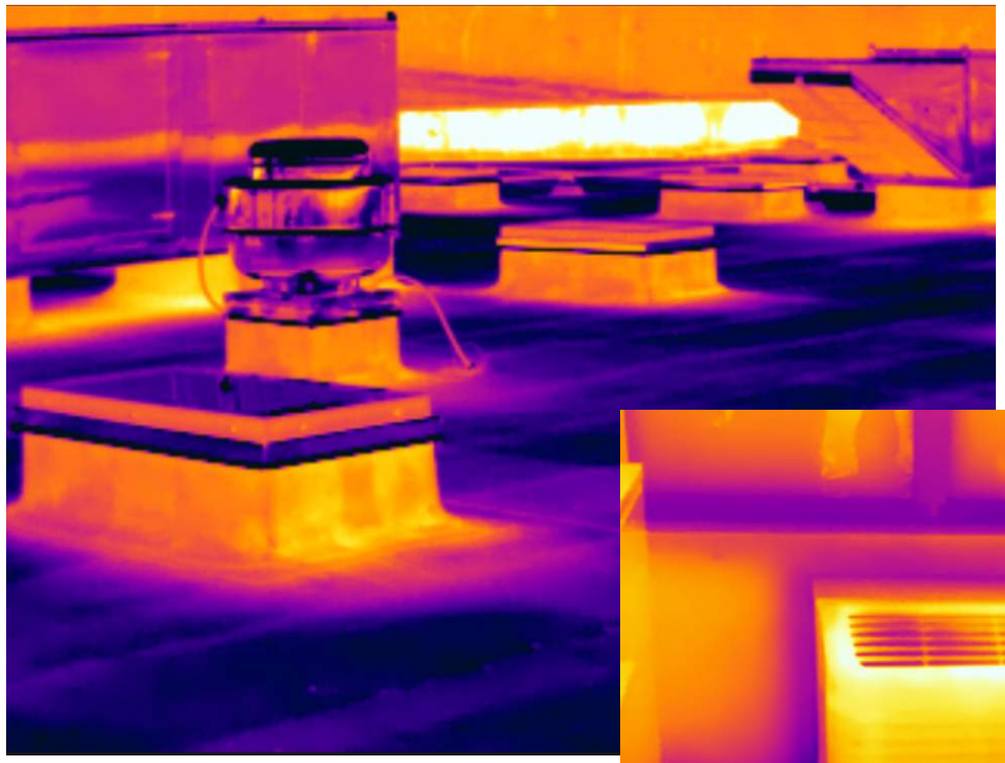
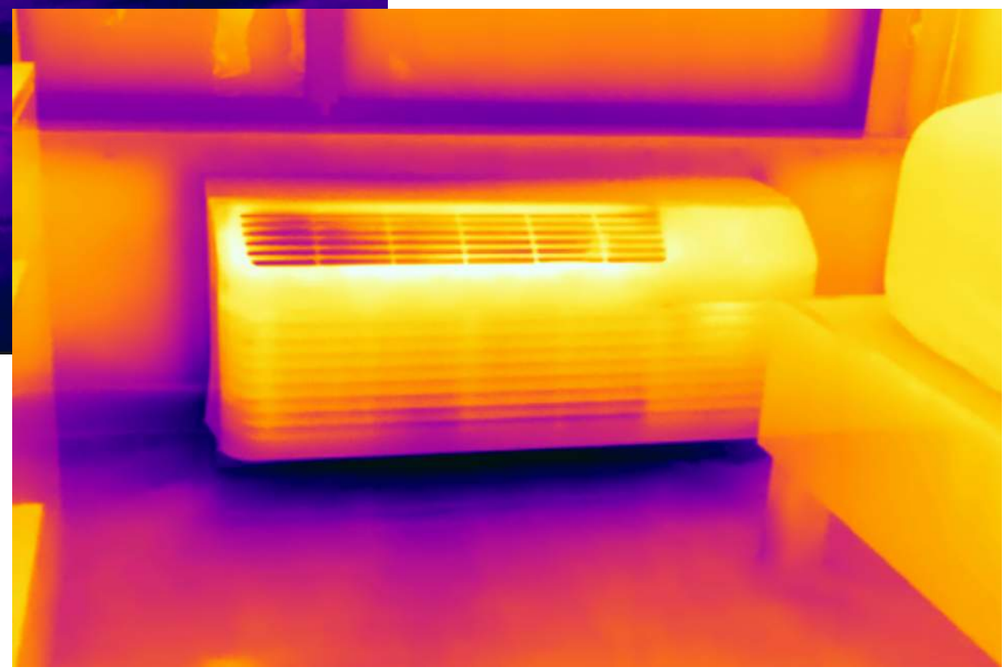
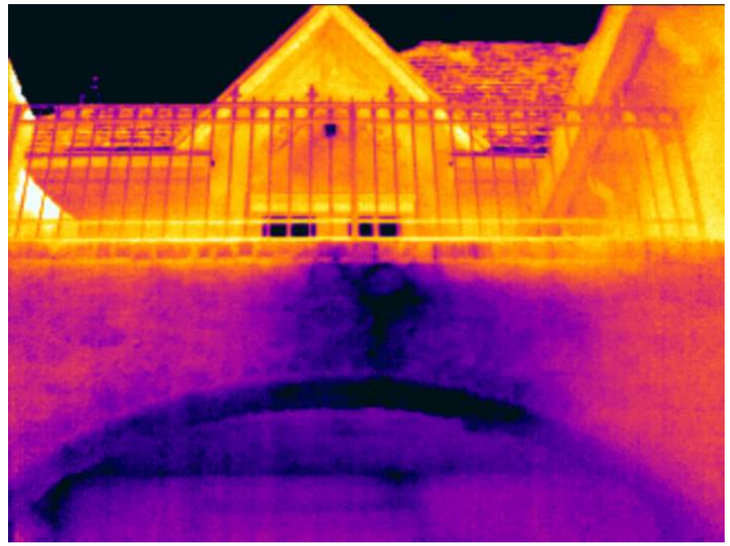
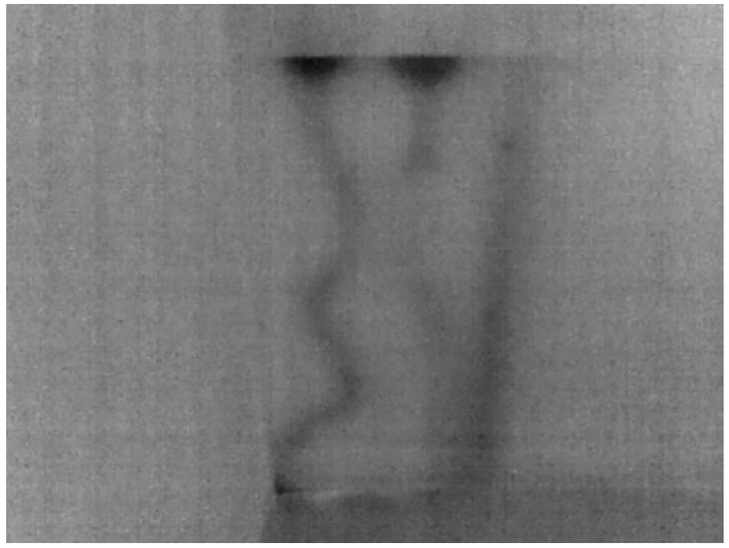
Non-traditional Means of Testing









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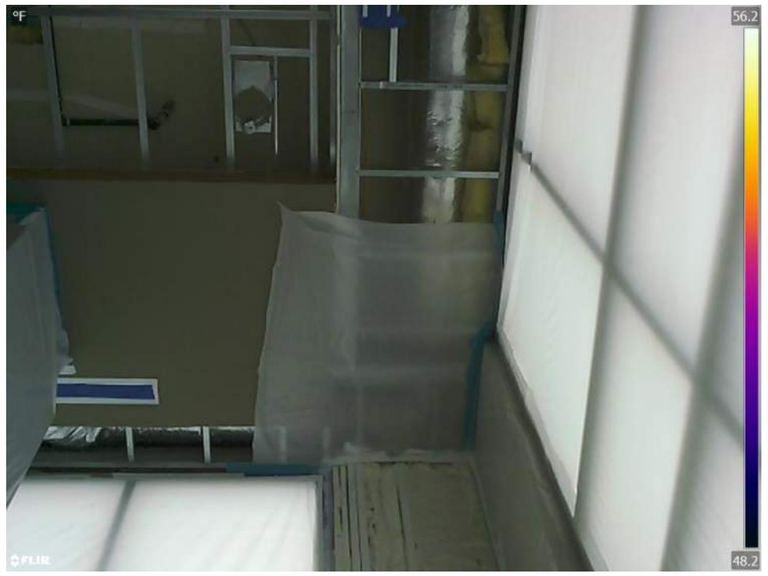
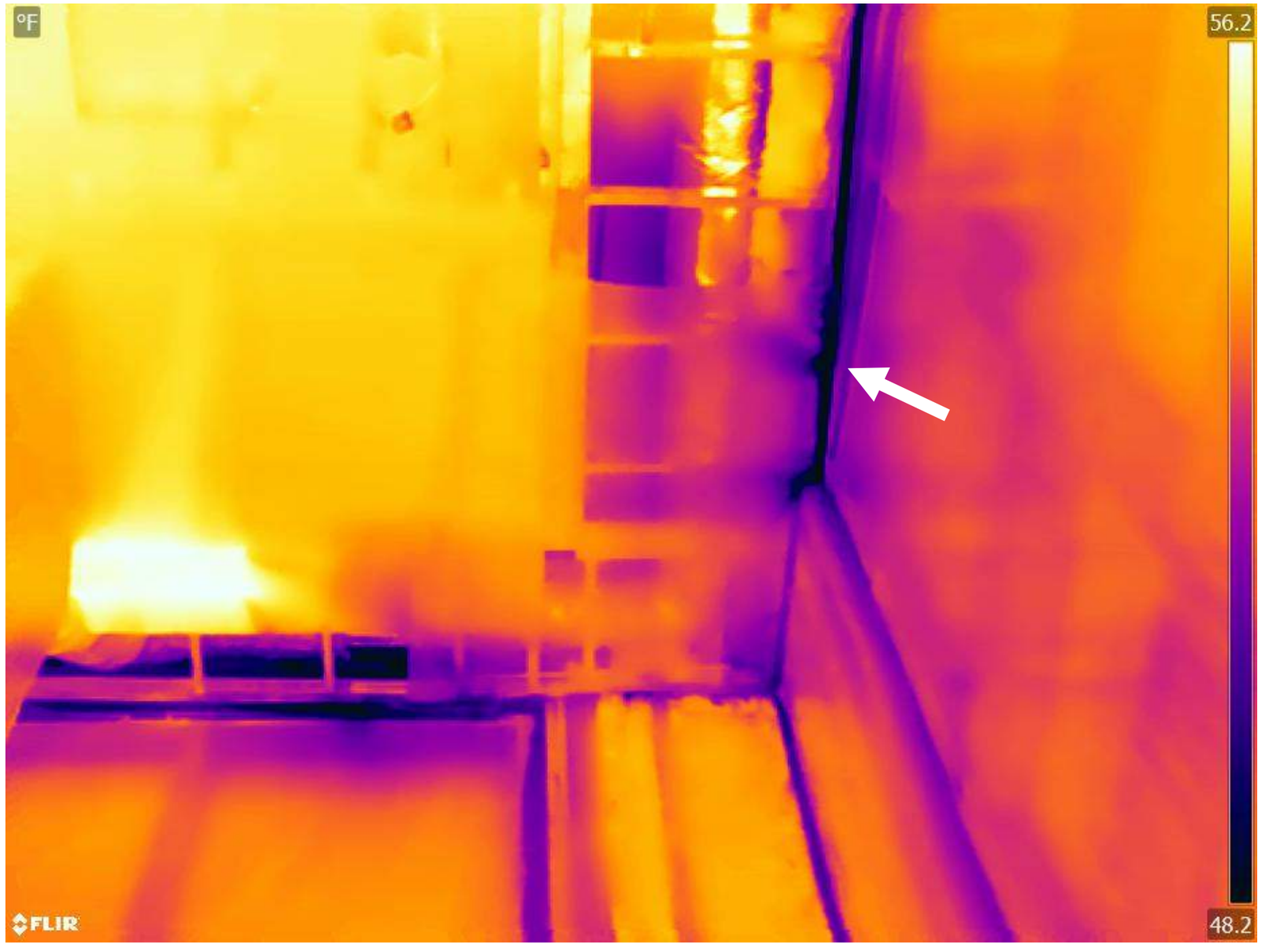
Air Infiltration at Head of Curtain Wall





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Air Infiltration on Exterior Wall in Return Air Plenum

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Air Infiltration and Direct Transfer from Canopy

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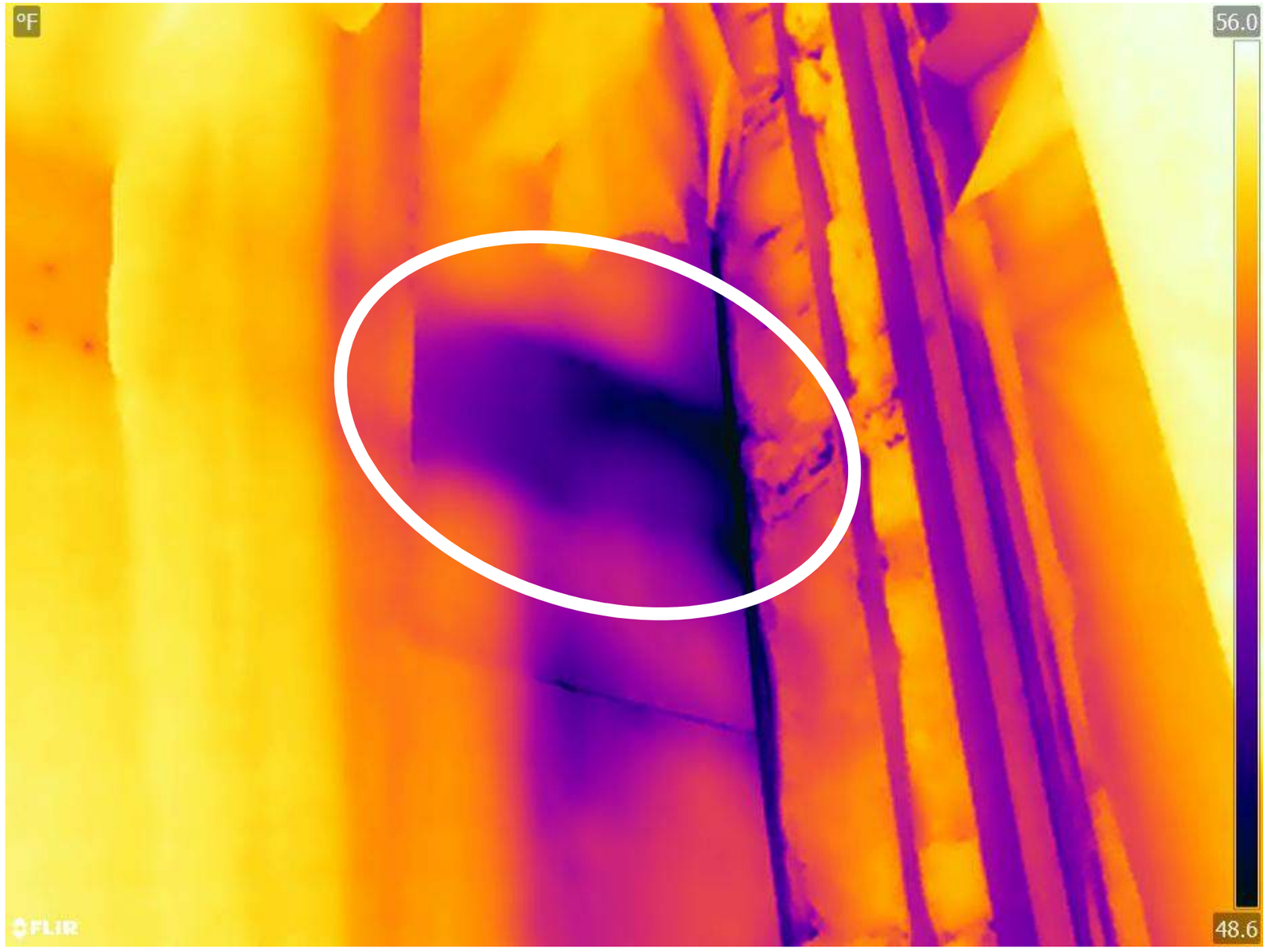

Air Infiltration and Direct Transfer from Canopy

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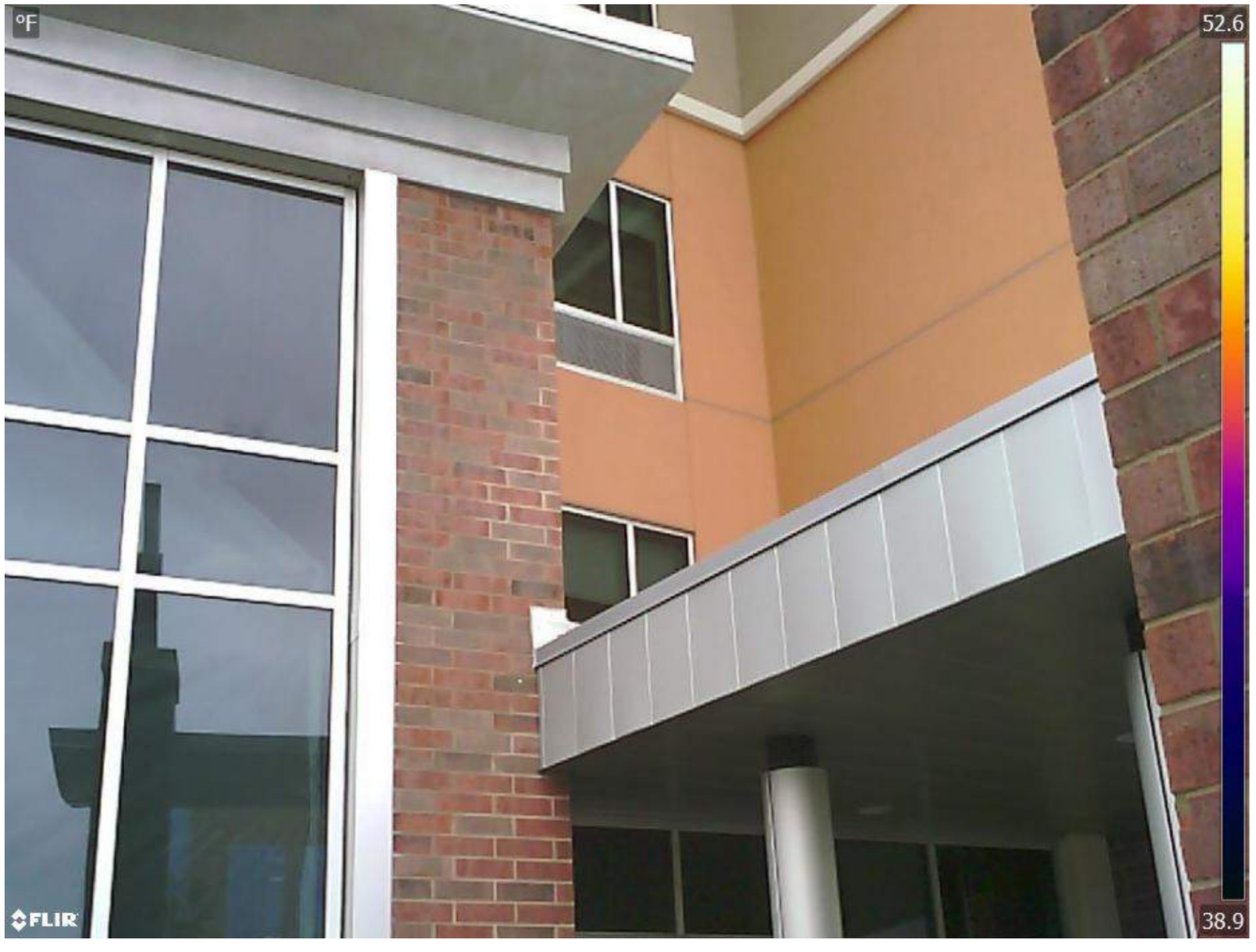
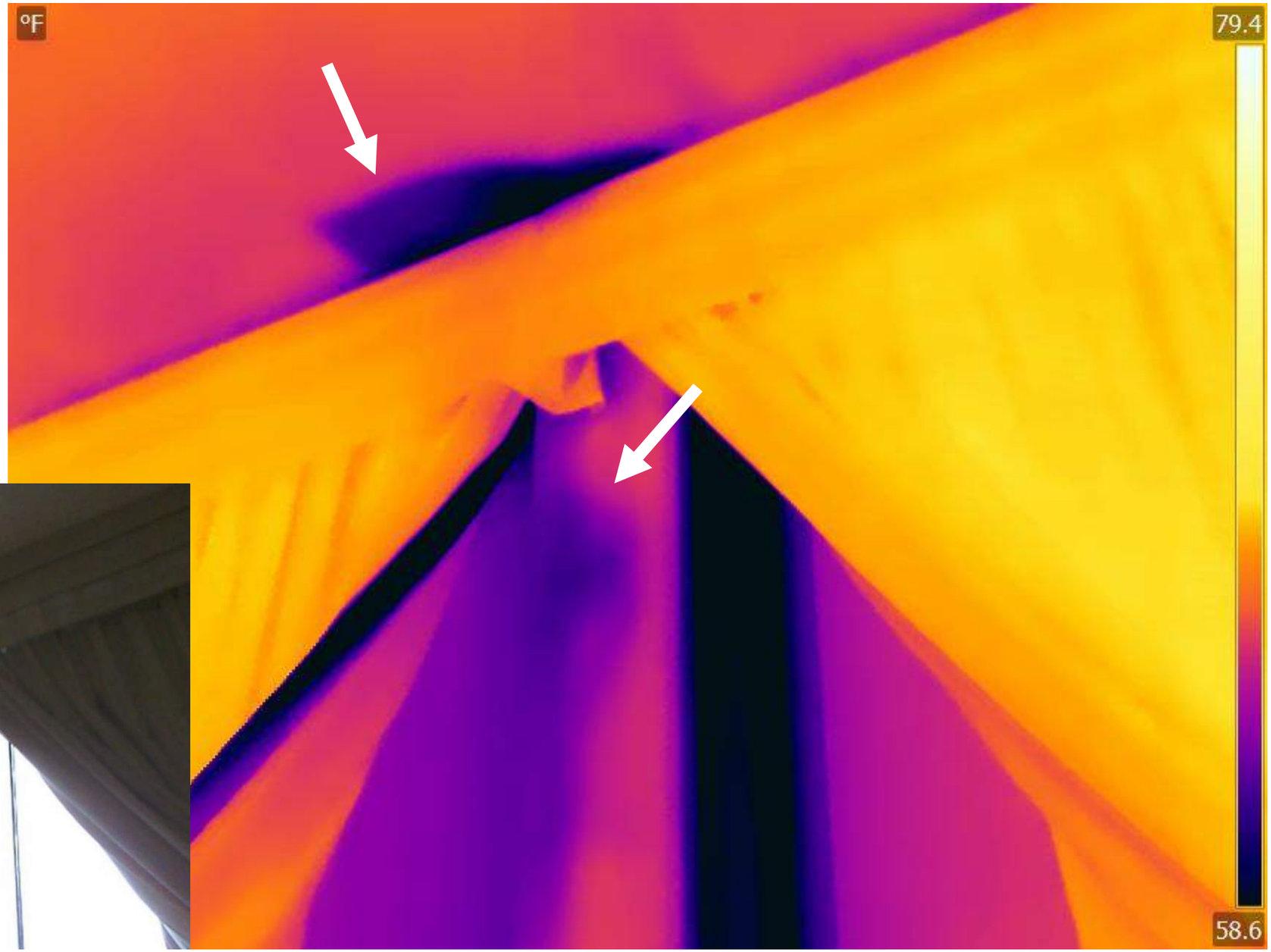


Water Infiltration from Signage Anchoring on Exterior Wall



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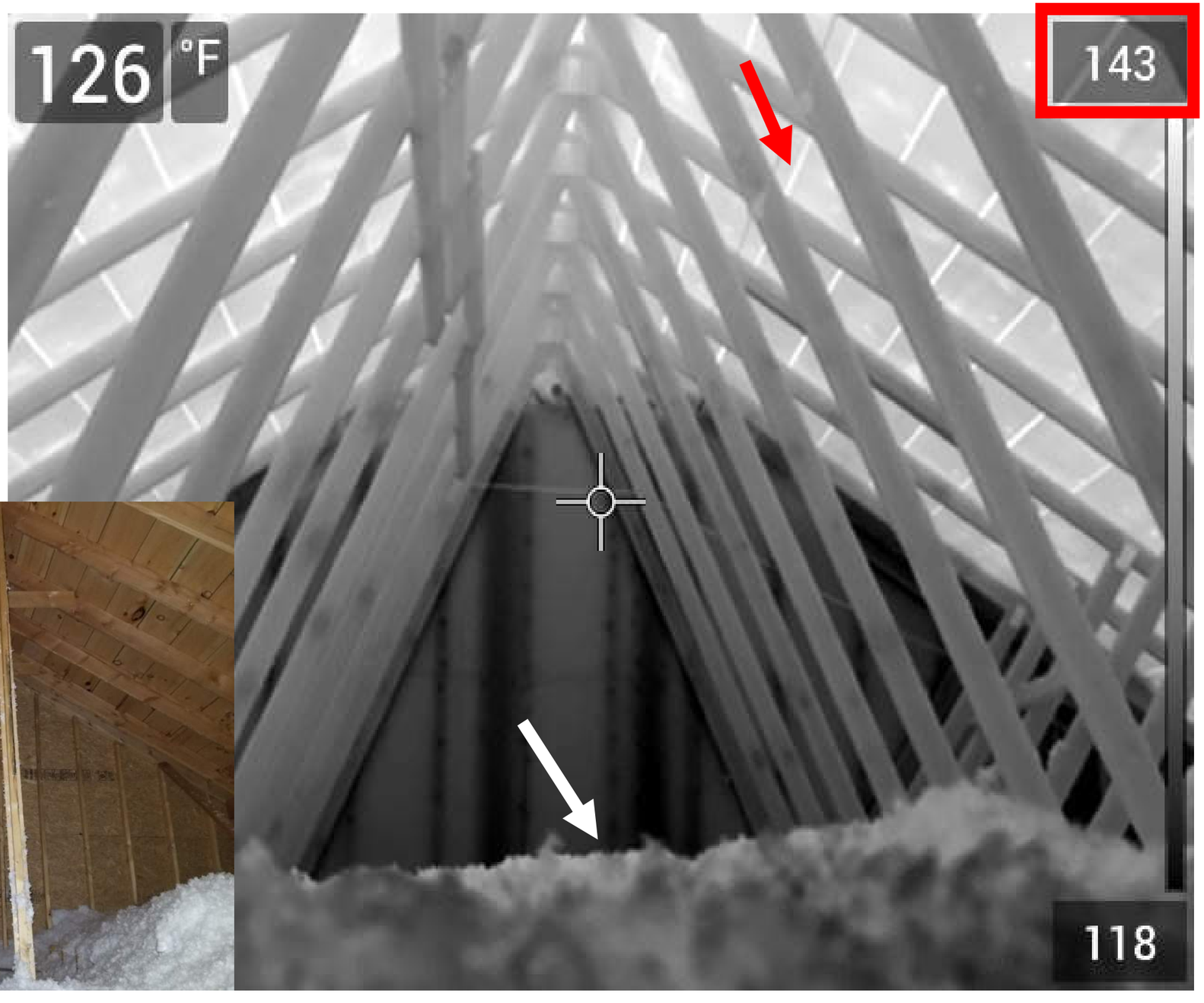
Thermal Capacitance

Mechanical duct temperature drop of 10°F



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Thermal Capacitance

The Roof is Black!

No insulation, and no ventilation

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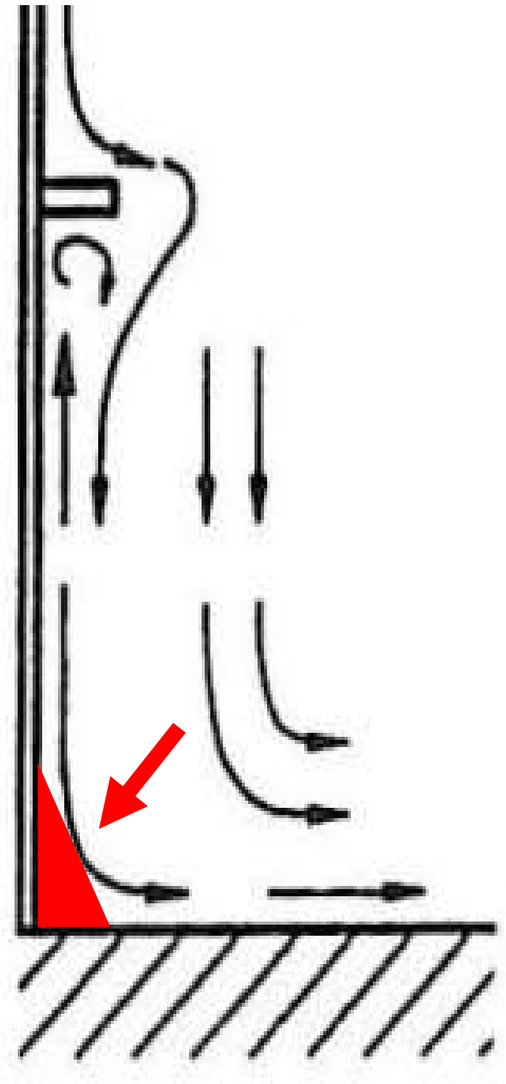
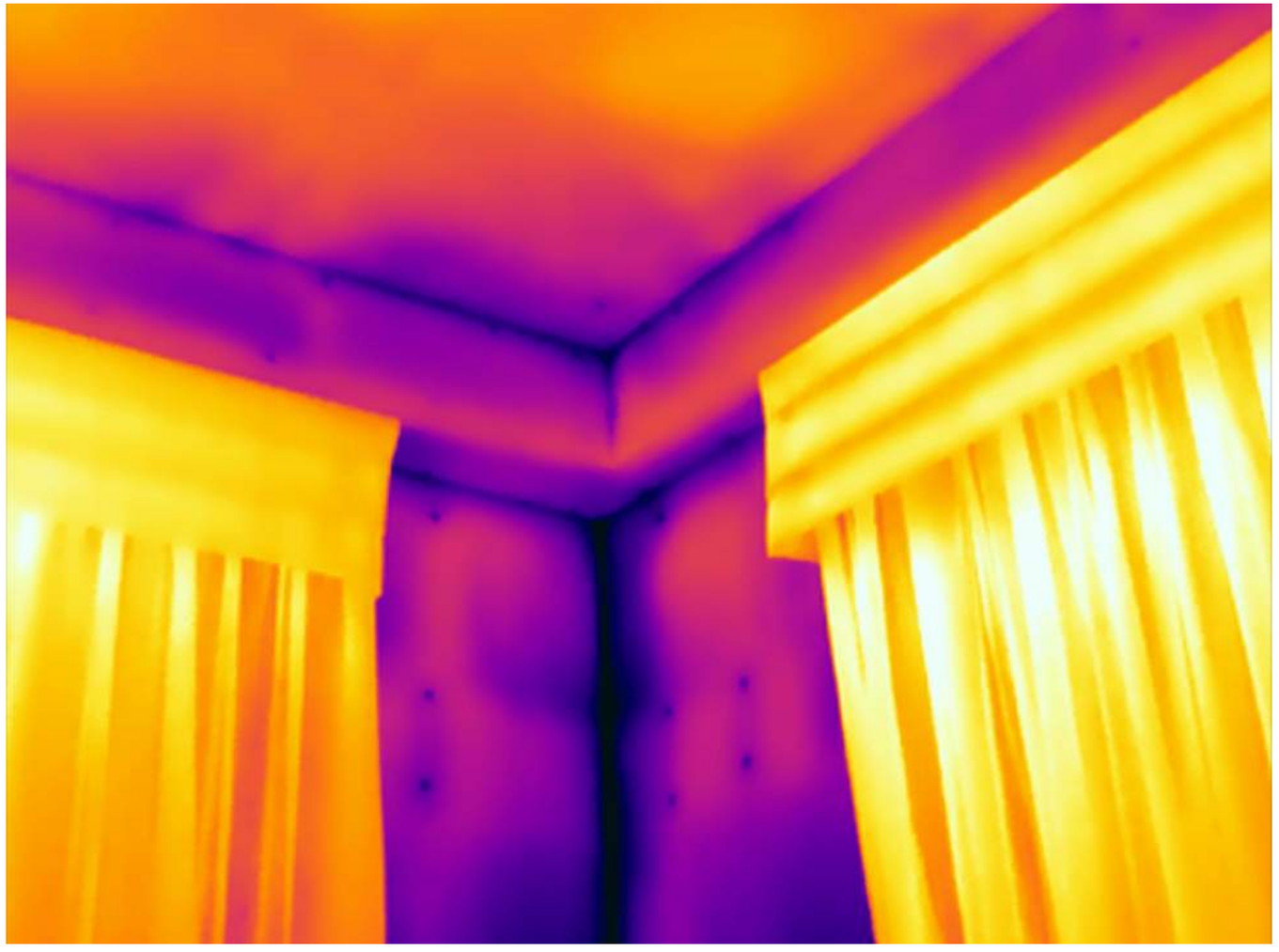
Don’t be Deceived





Cool Spots due to poor air circulation

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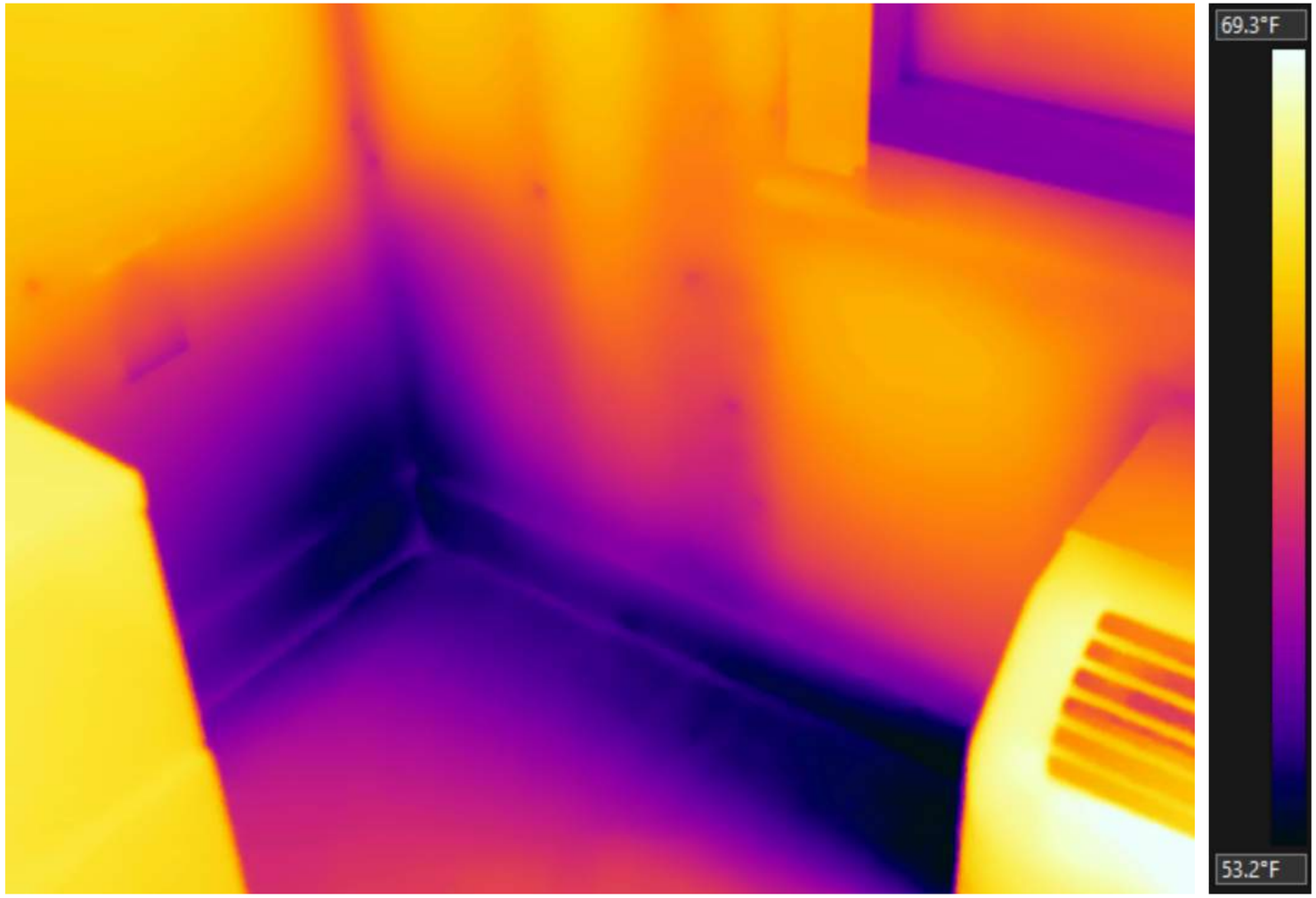
Don’t be Deceived – LEED Gold?



Air Infiltration from PTAC Unit

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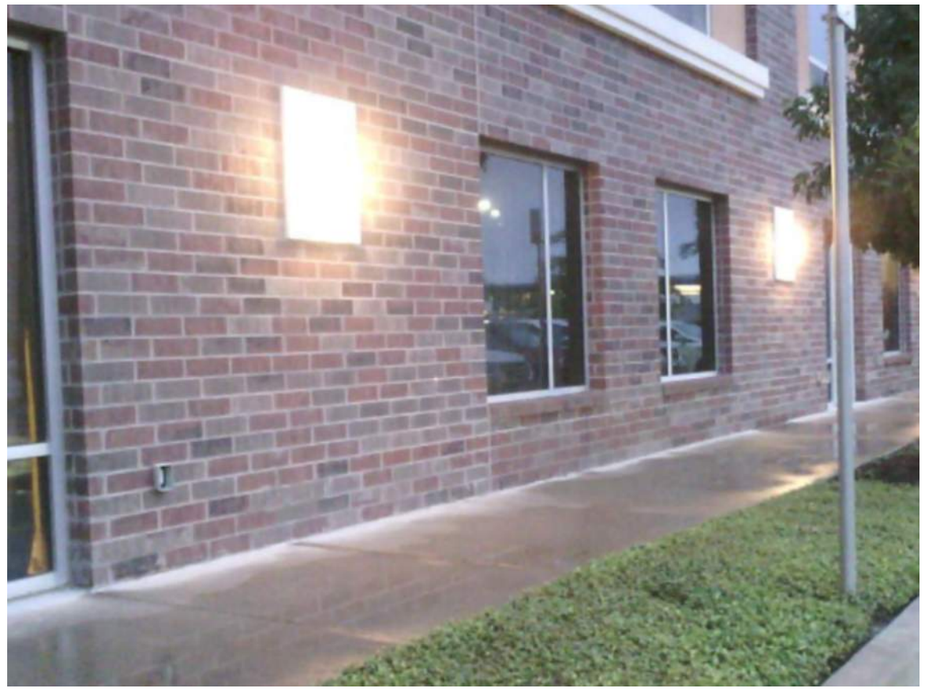
Don’t be Deceived – LEED Gold?



Direct Transfer – Energy Loss

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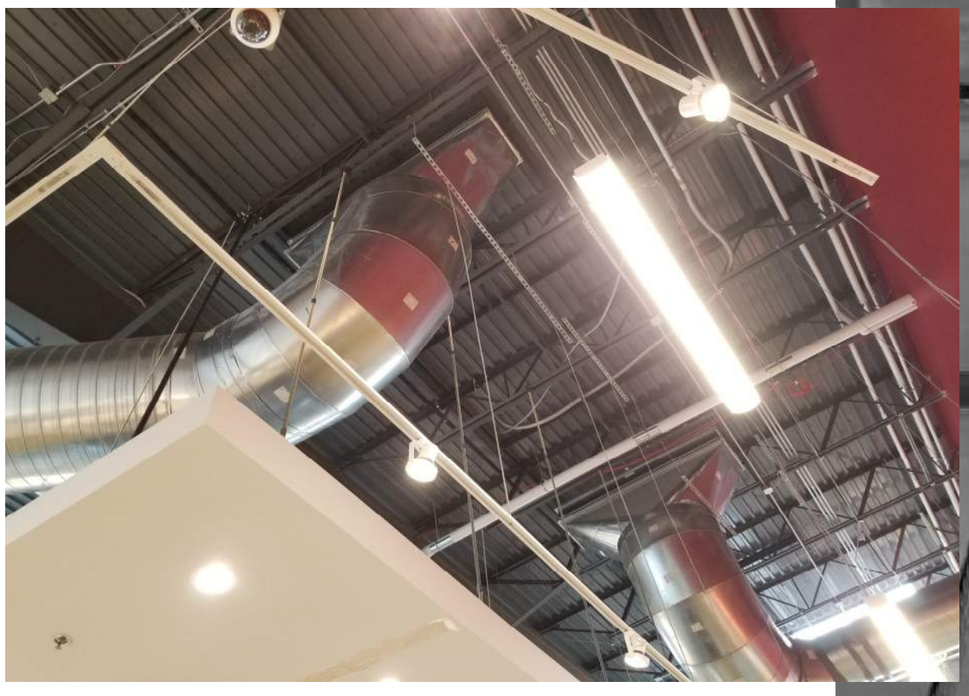
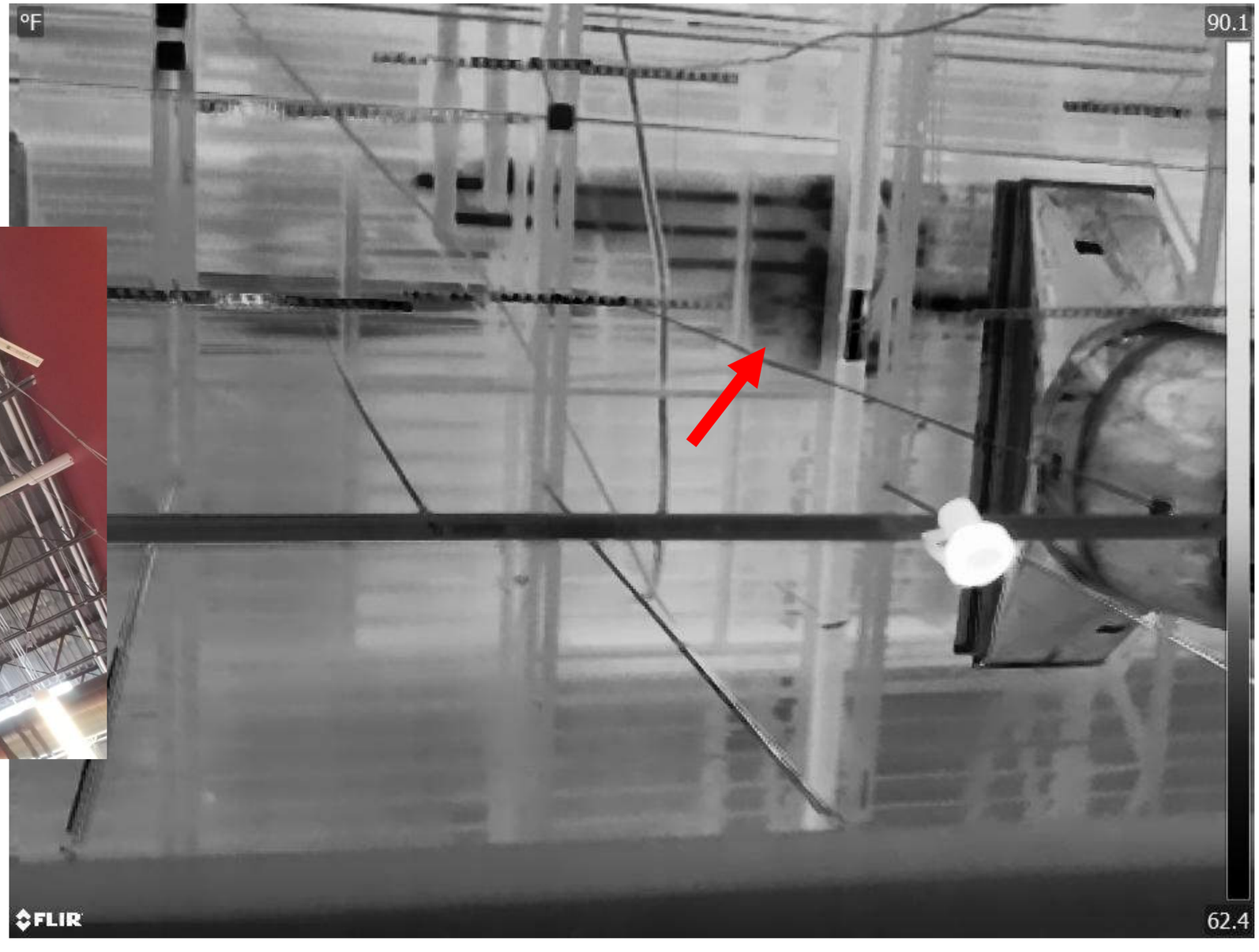
Seeing past the Reflection





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Non-standard Used to Narrow Down Point of Infiltration

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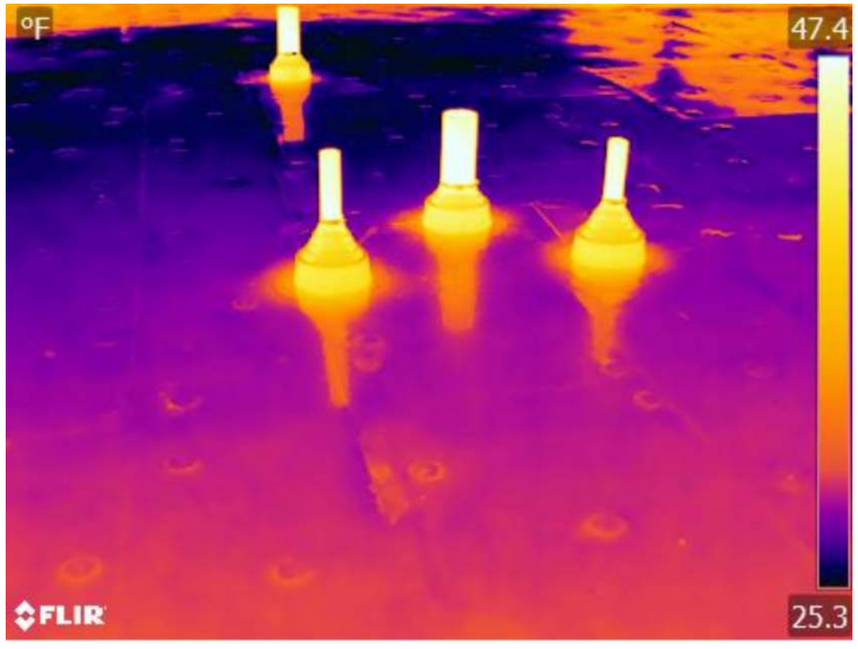
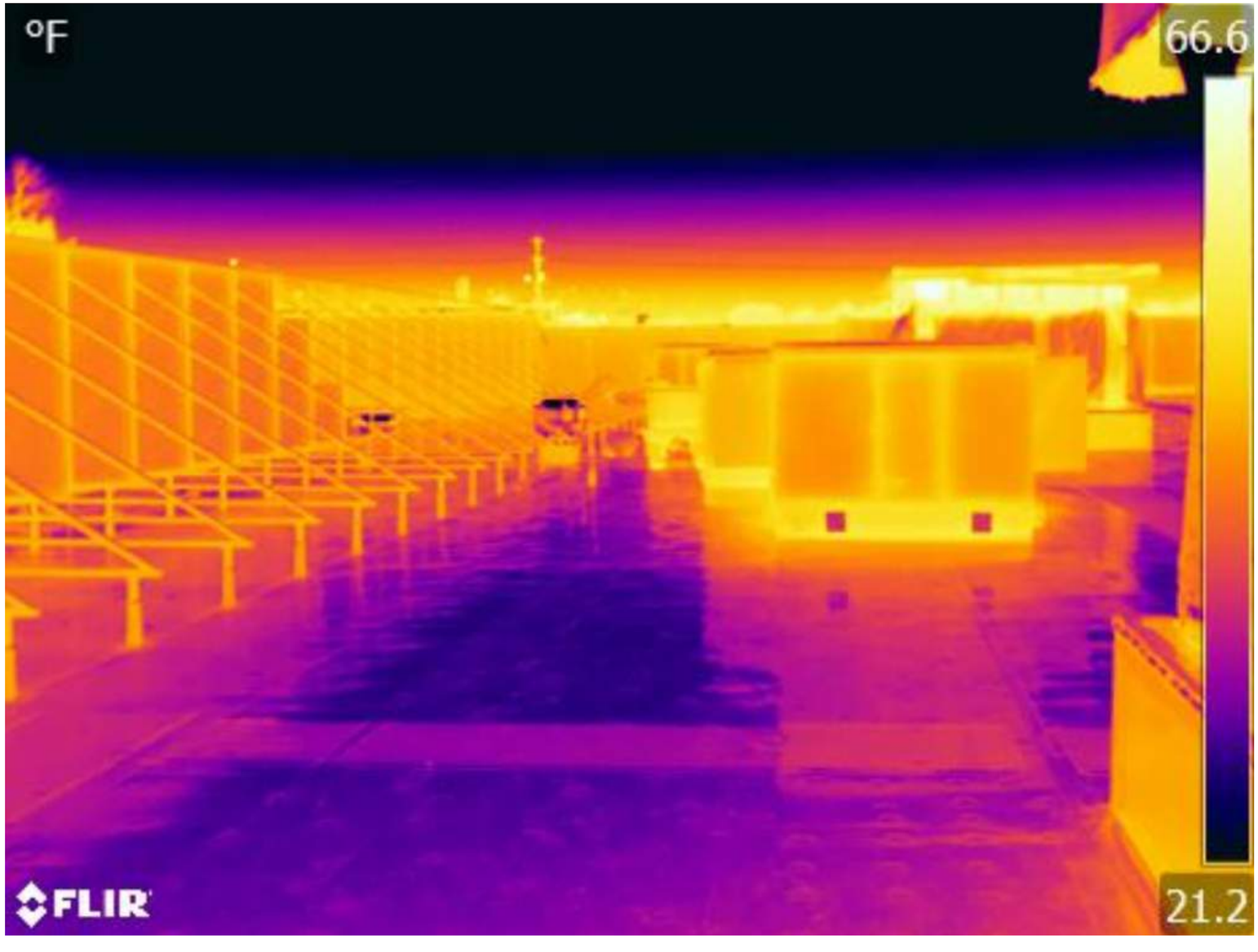
Limitations





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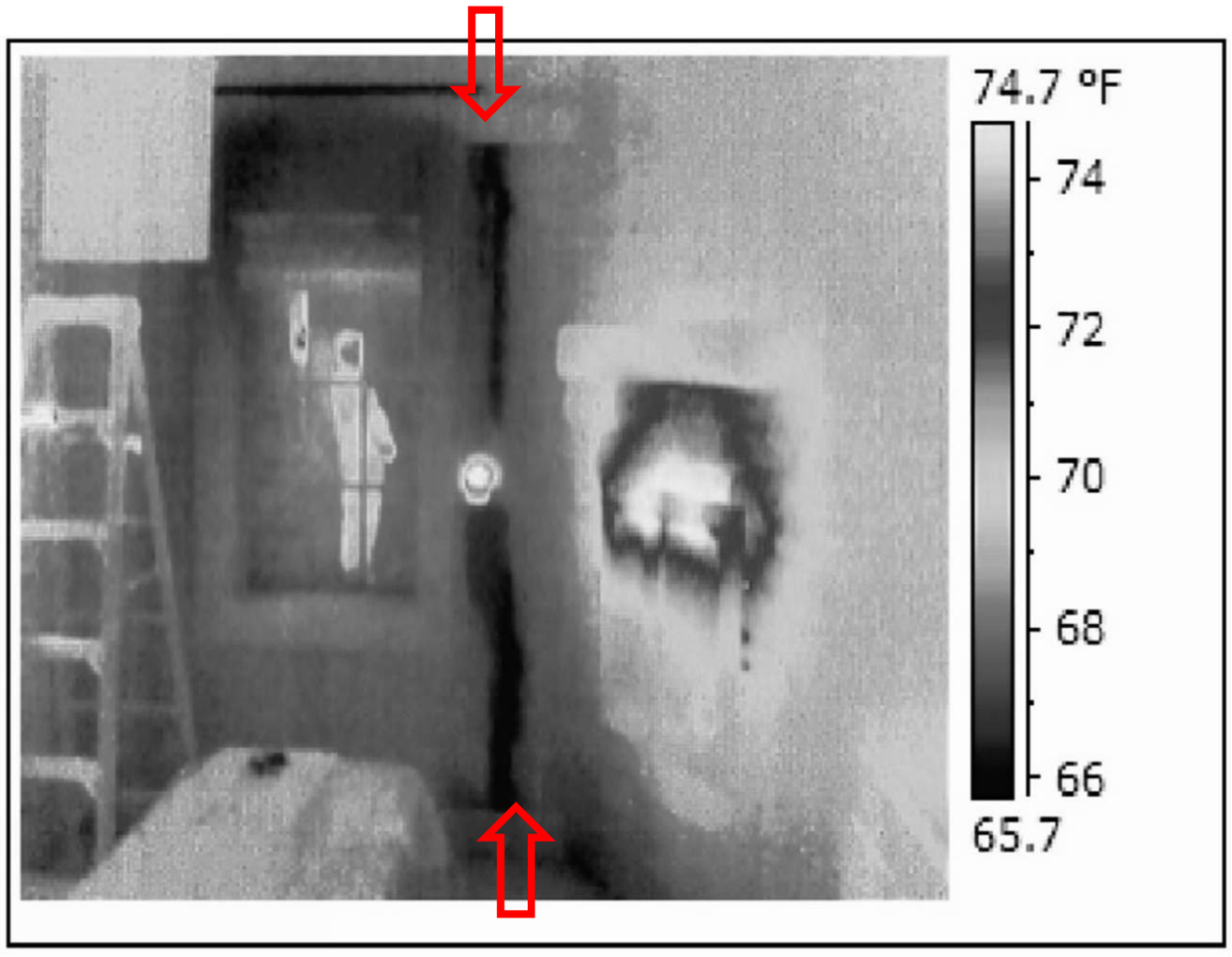
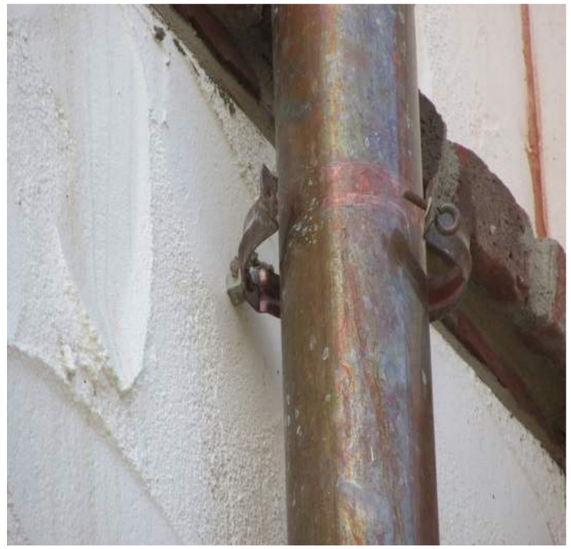
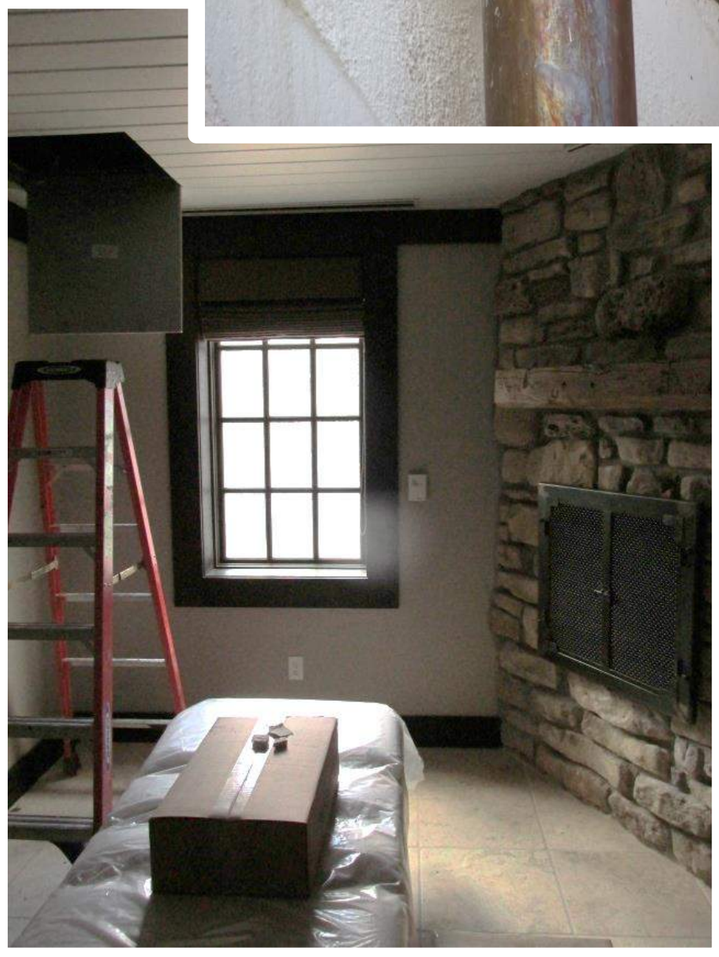
Commissioning Verification of Performance







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Special Thanks to:

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Scott Wood Level III Thermographer
Scott Wood Associates, LLC.

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Melissa Payne, BECxP, CxA+BE,
Level II Building Science Thermographer

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