SMT
Structure Monitoring Technology


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# . . . From a kick to TPMS

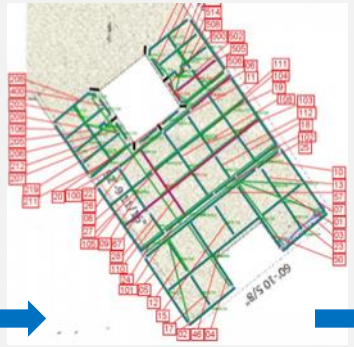
# . . . To The Internet of Things

# Life Cycle Monitoring

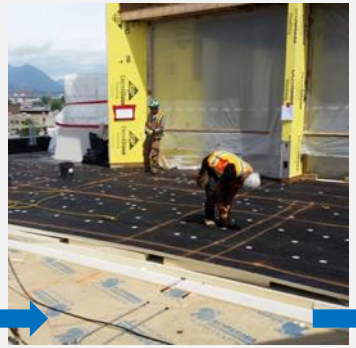
Monitoring technologies are available to track products and materials through:

Manufacturing

Transportation



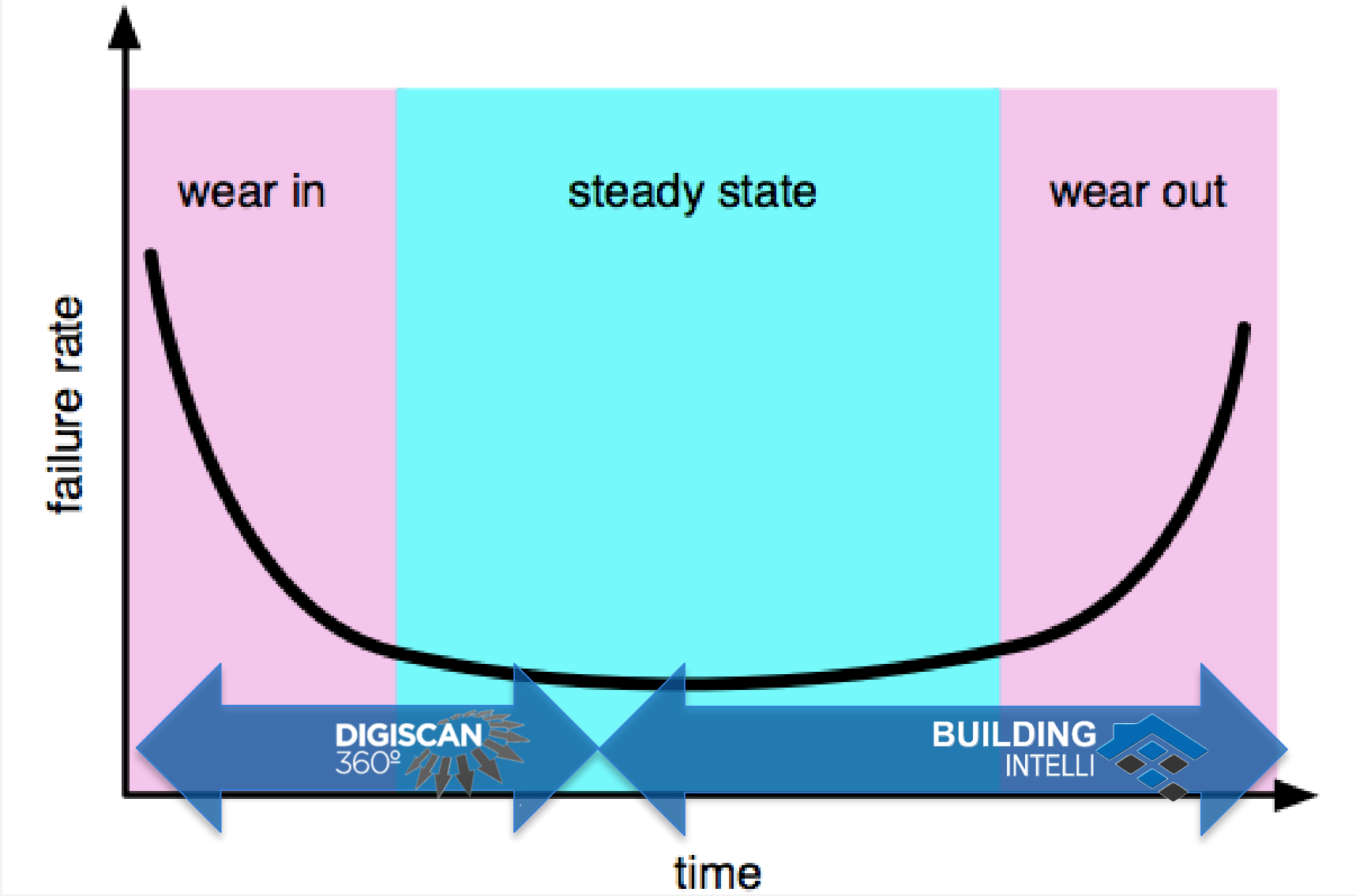
Installation



Service life

Renewal

# Material Service Lifetime



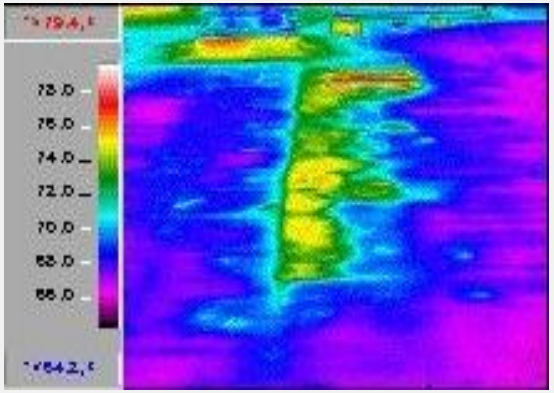
# Visual Inspection

Quality Assurance Are all membranes Exposed

# Point in Time Measurements

Capacitance Scan

Infra-Red Thermography

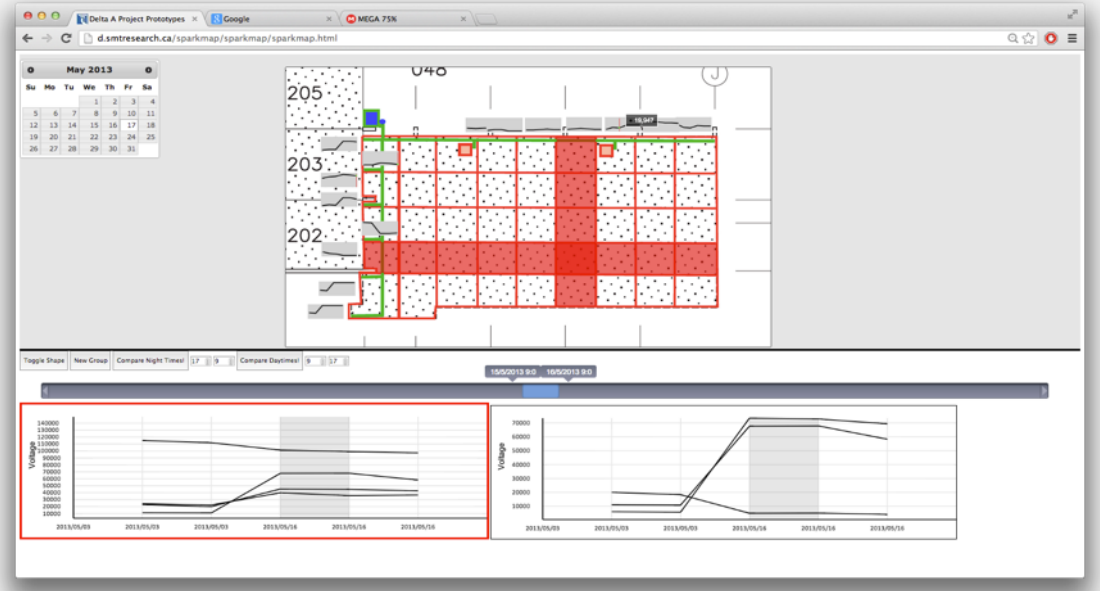


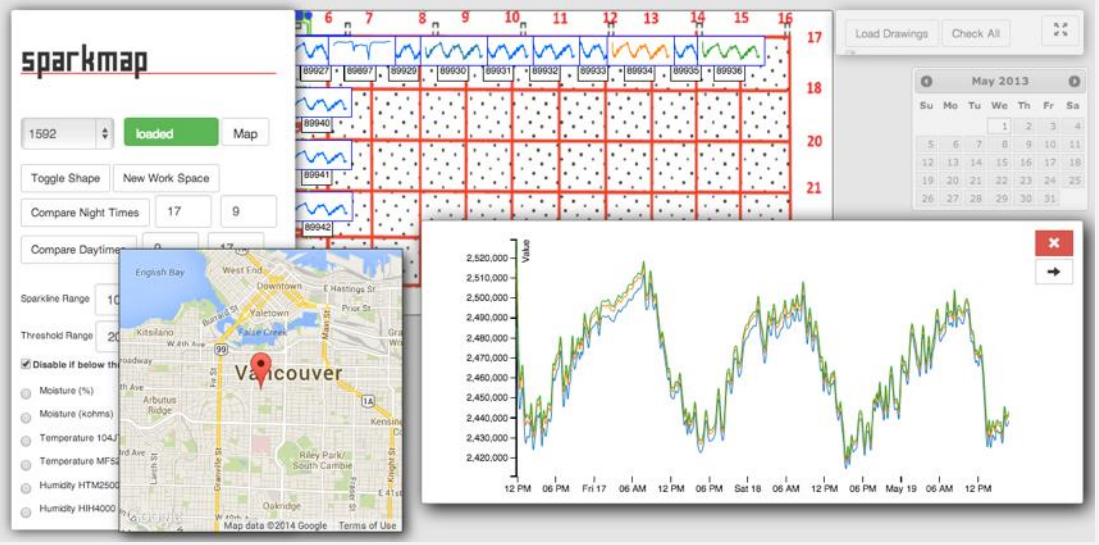

Low Voltage Scan

High Voltage Dry Scan

The inspection is obsolete the moment you walk off the site.


Car Info
01:08
35 psi
28 ℃
35 psi
28 ℃
35 psi
28 ℃
35 psi
28 ℃
35 psi
28 ℃

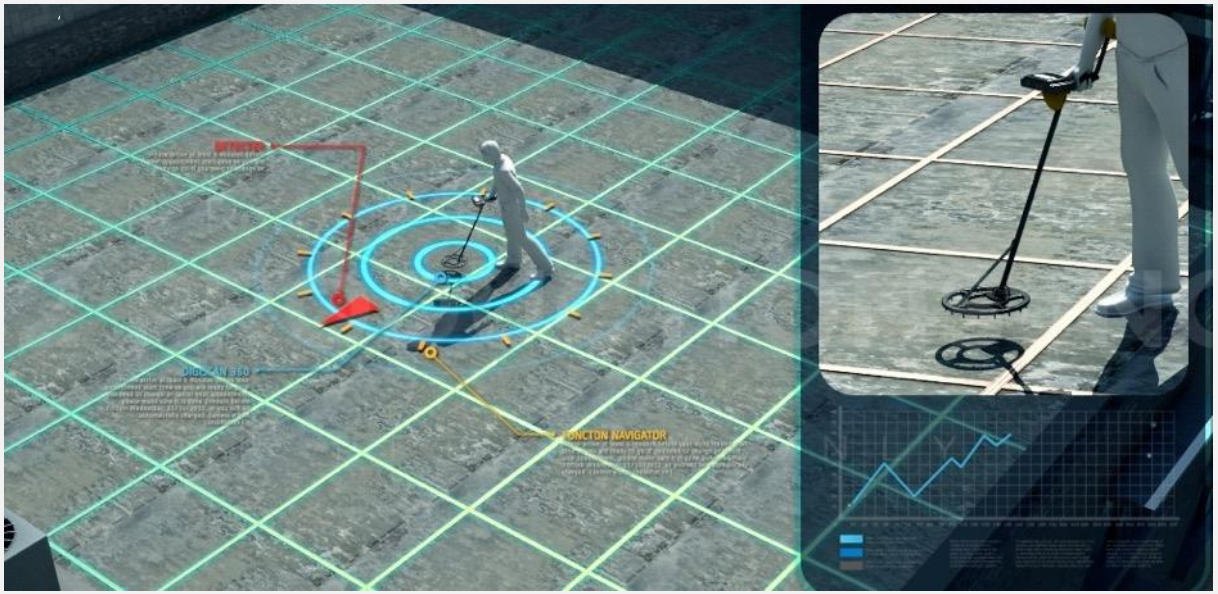

d.smtresearch.ca/sparkmap/sparkmap.html
May 2013
205
203
202

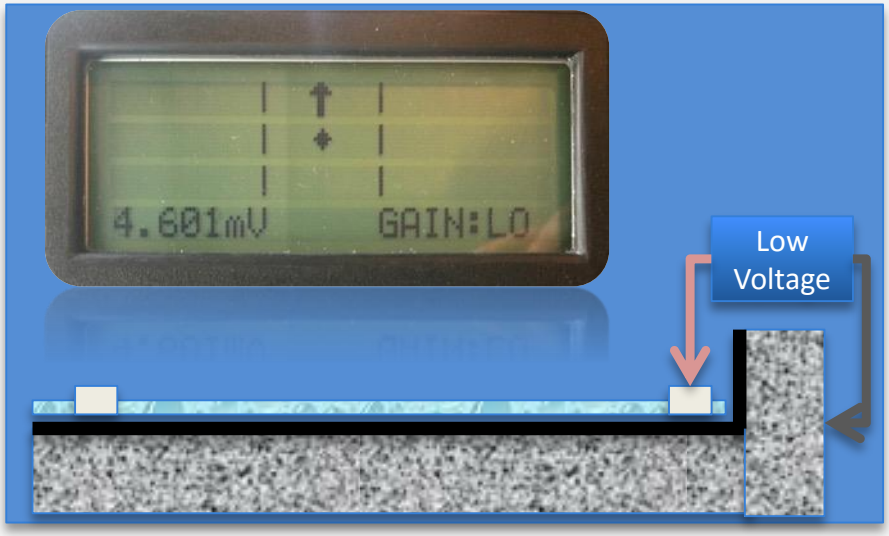

sparkmap
1592
loaded
Map
Toggle Shape
New Work Space
Compare Night Times
17
9
Compare Daytimes
Sparkline Range
Threshold Range
Moisture (%)
Moisture (kohms)
Temperature 104J
Temperature MF52
Humidity HTM2500
Humidity HIH4000
Vancouver
Map data ©2014 Google
Terms of Use
Load Drawings
Check All
May 2013
Value
2,520,000
2,510,000
2,500,000
2,490,000
2,480,000
2,470,000
2,460,000
2,450,000
2,440,000
2,430,000
2,420,000
12 PM
06 PM
Fri 17
06 AM
12 PM
06 PM
Sat 18
06 AM
12 PM
06 PM
May 19
06 AM
12 PM

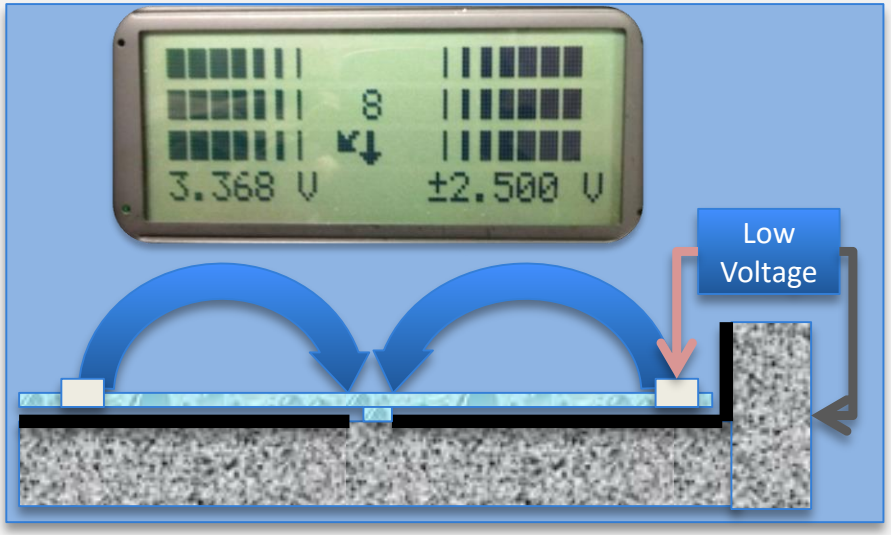


**DigiSCAN**

A manual procedure in which we evaluate typical inverted roof decks to pin-point leaks.

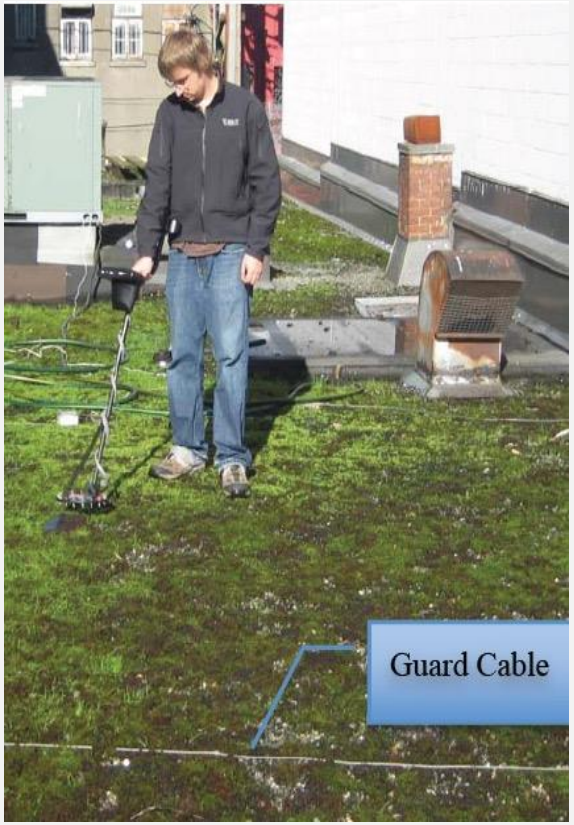



4.601mV
GAIN:LO
Low
Voltage


8
3.368 V
±2.500 V
Low
Voltage

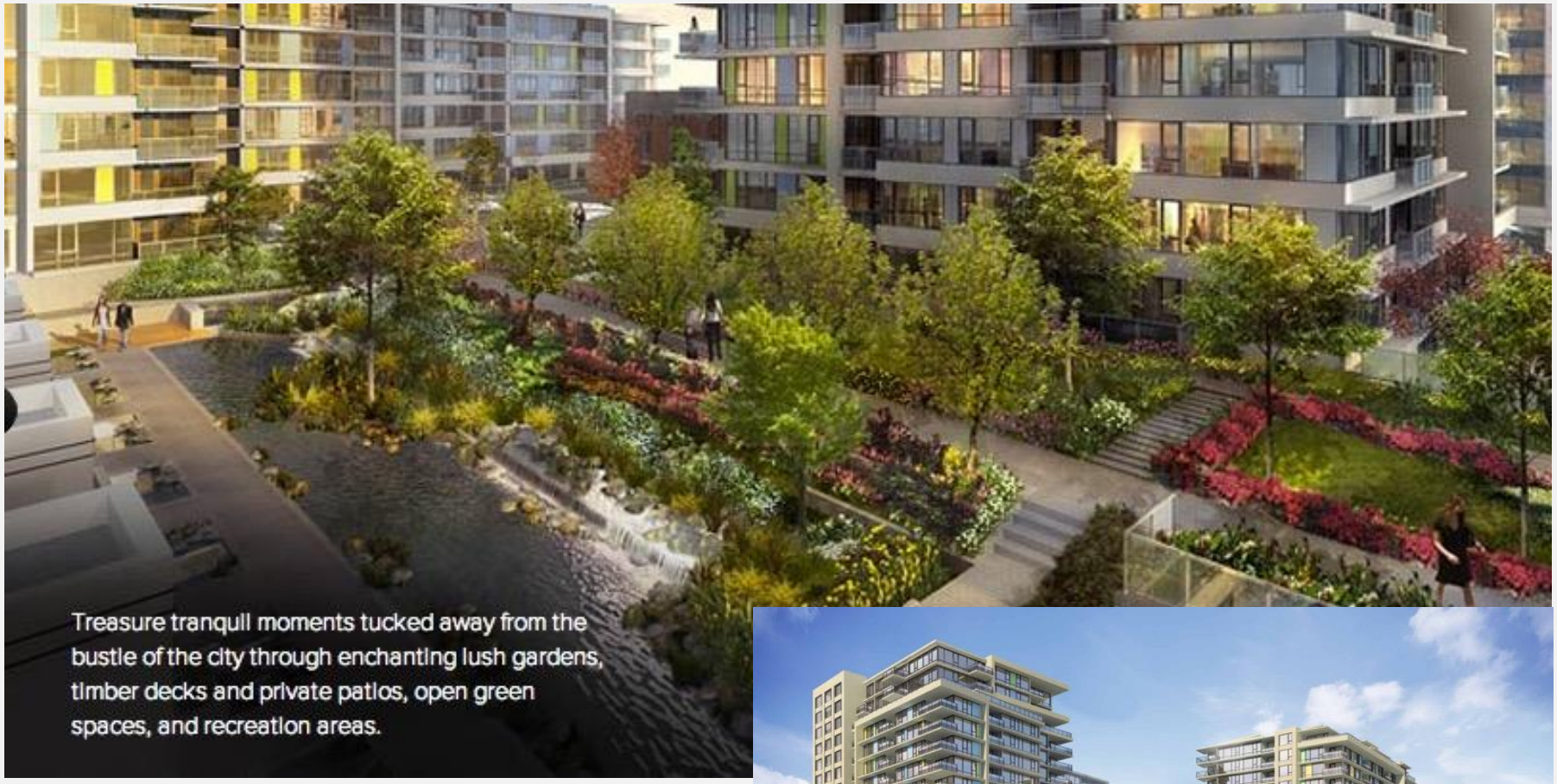
Immediately after membrane installed.

Prior to covering with overburden.



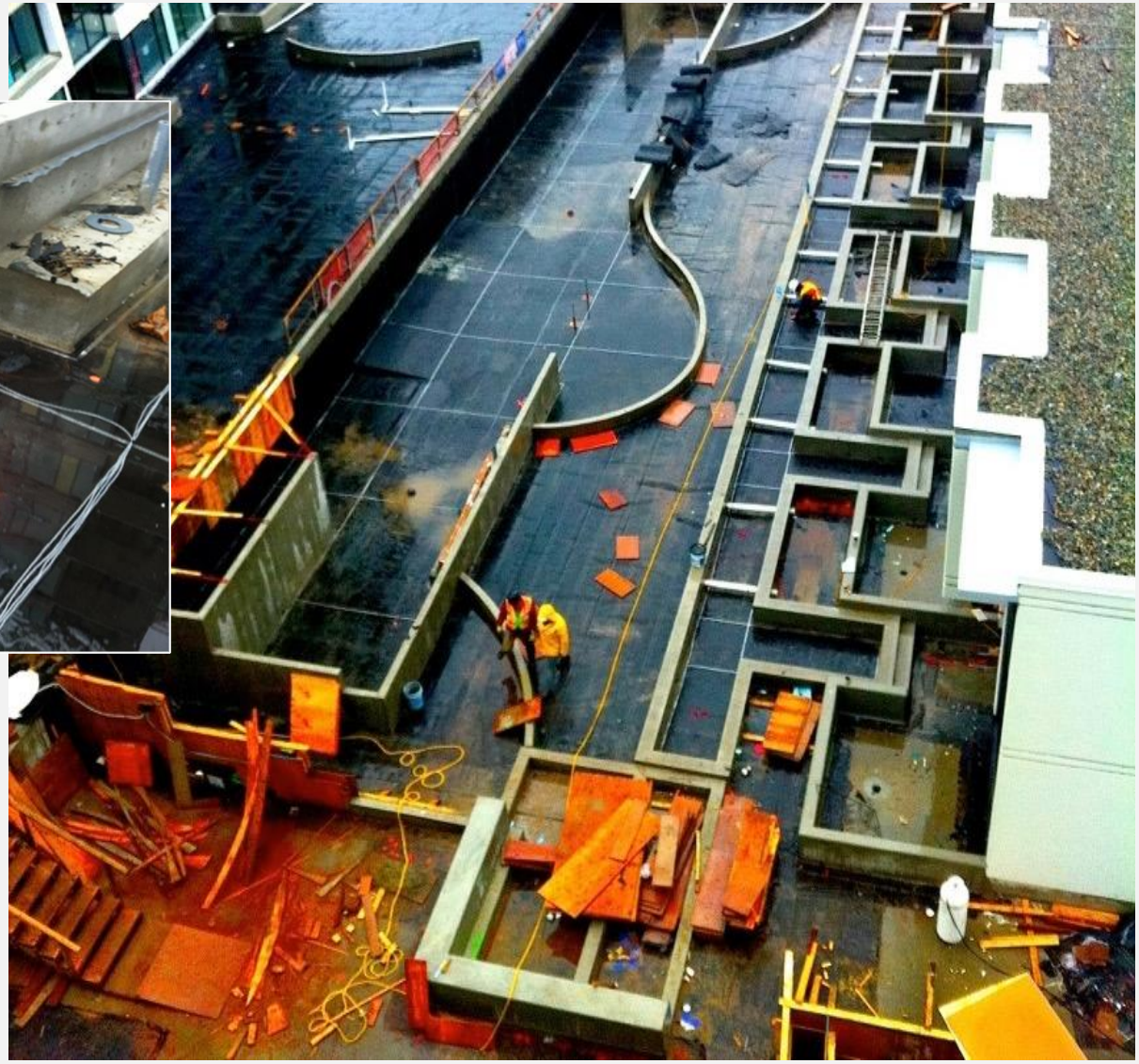

With overburden in place.

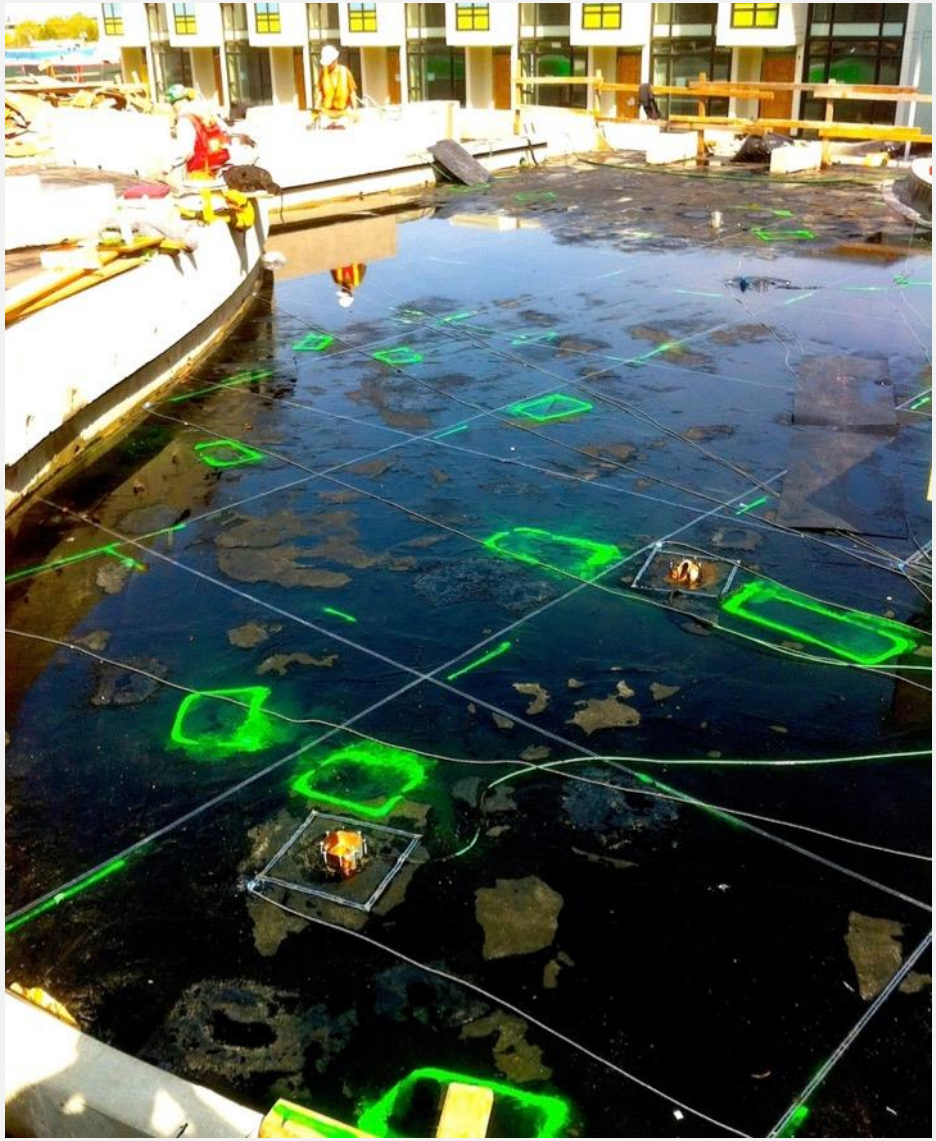

DIGISCAN
360°
Vancouver, BC




Renderings by TMU

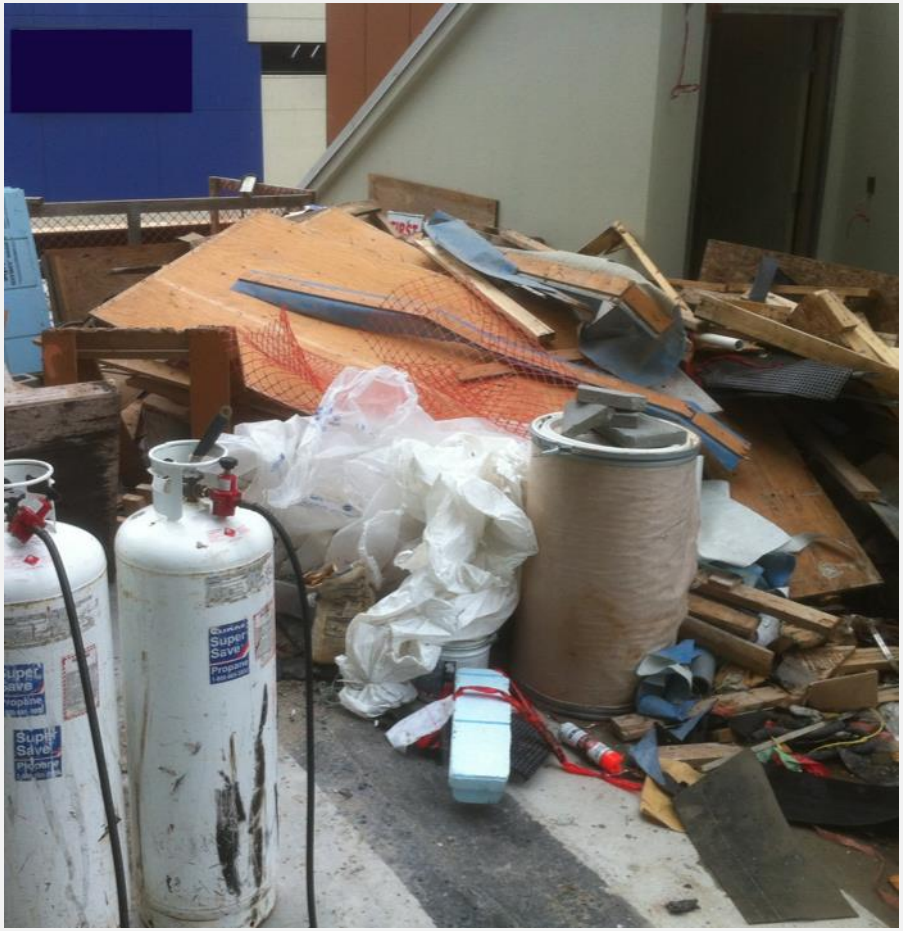

L4





# Damage “by others”

# Damage “by others”

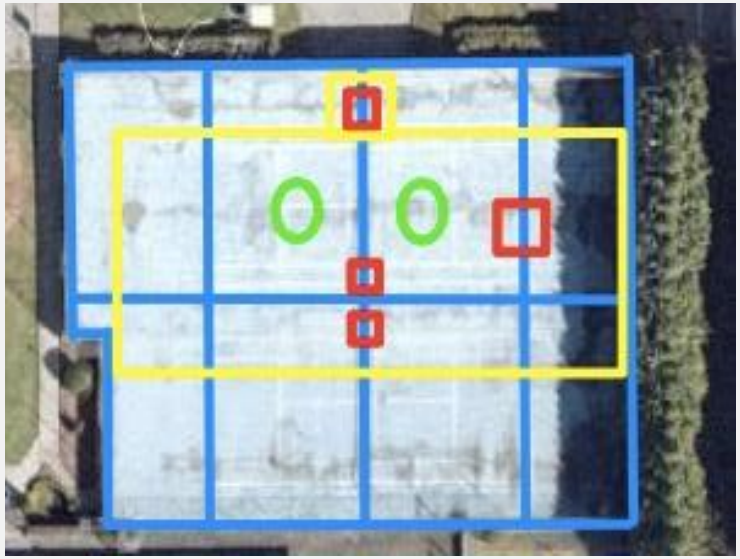


# Damage “by others”

# Damage “by others”

# Damage “by others”

# Existing Parkade Decks

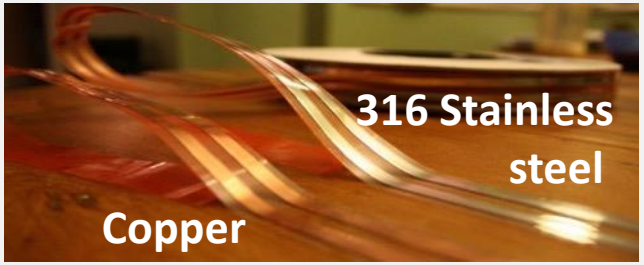


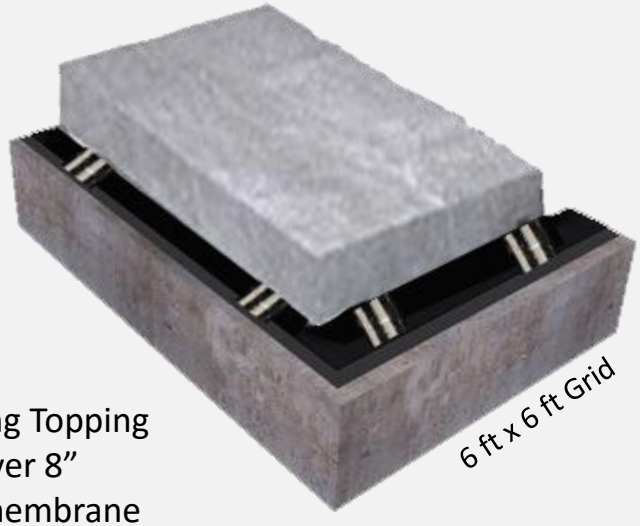
# Water Features


8
715.8mV
±2.500 V
SMT
Structure Monitoring Technology


4.06

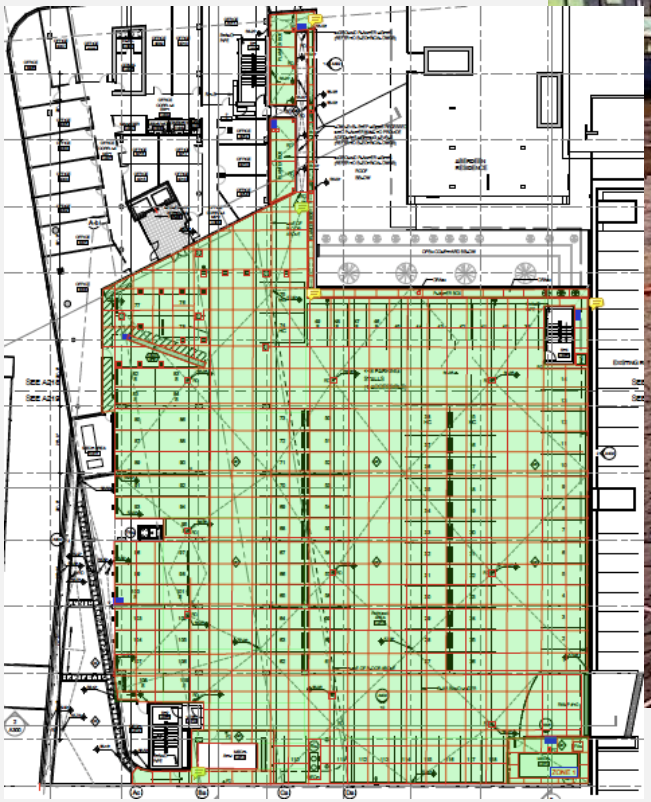
# Inverted Roof Monitoring



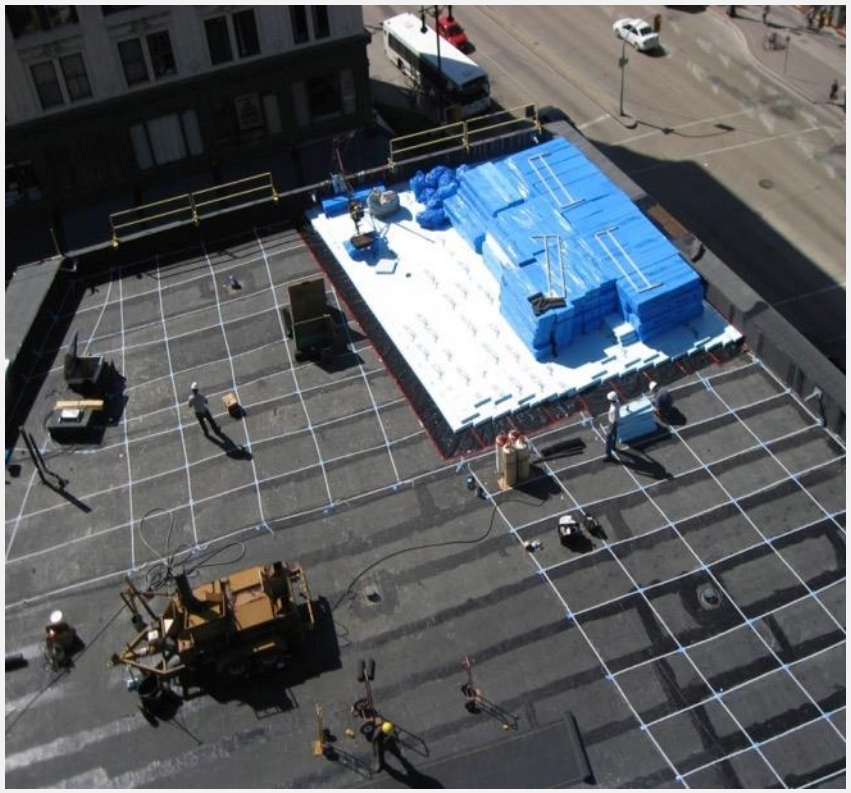




Concrete / Paving Topping or Green roof over 8”
To inspect the membrane you need a jackhammer to get into it.


Green Roof Overburden under 8” of soil
To Inspect the membrane you would need a shovel and knife.



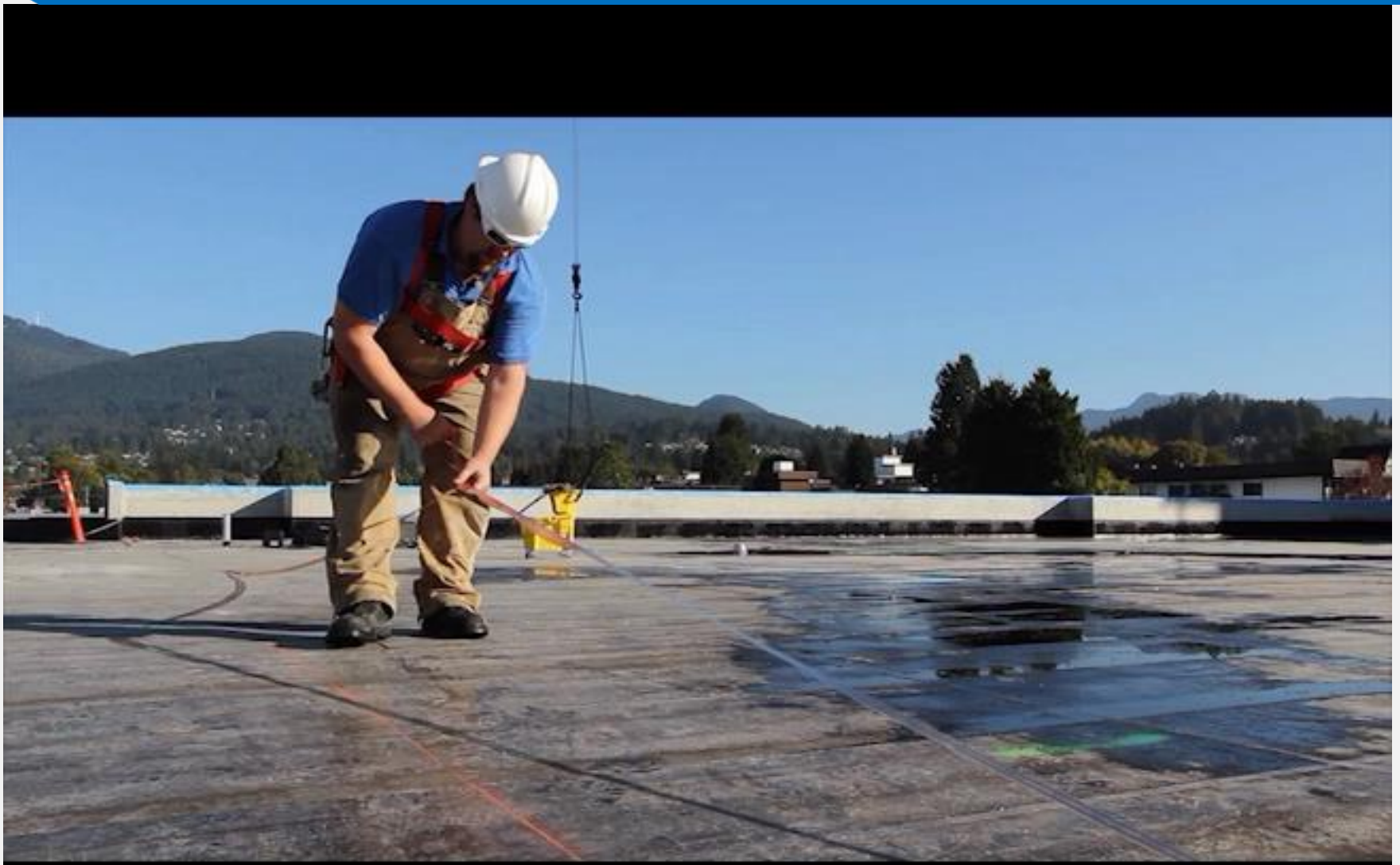
BUILDING INTELLI



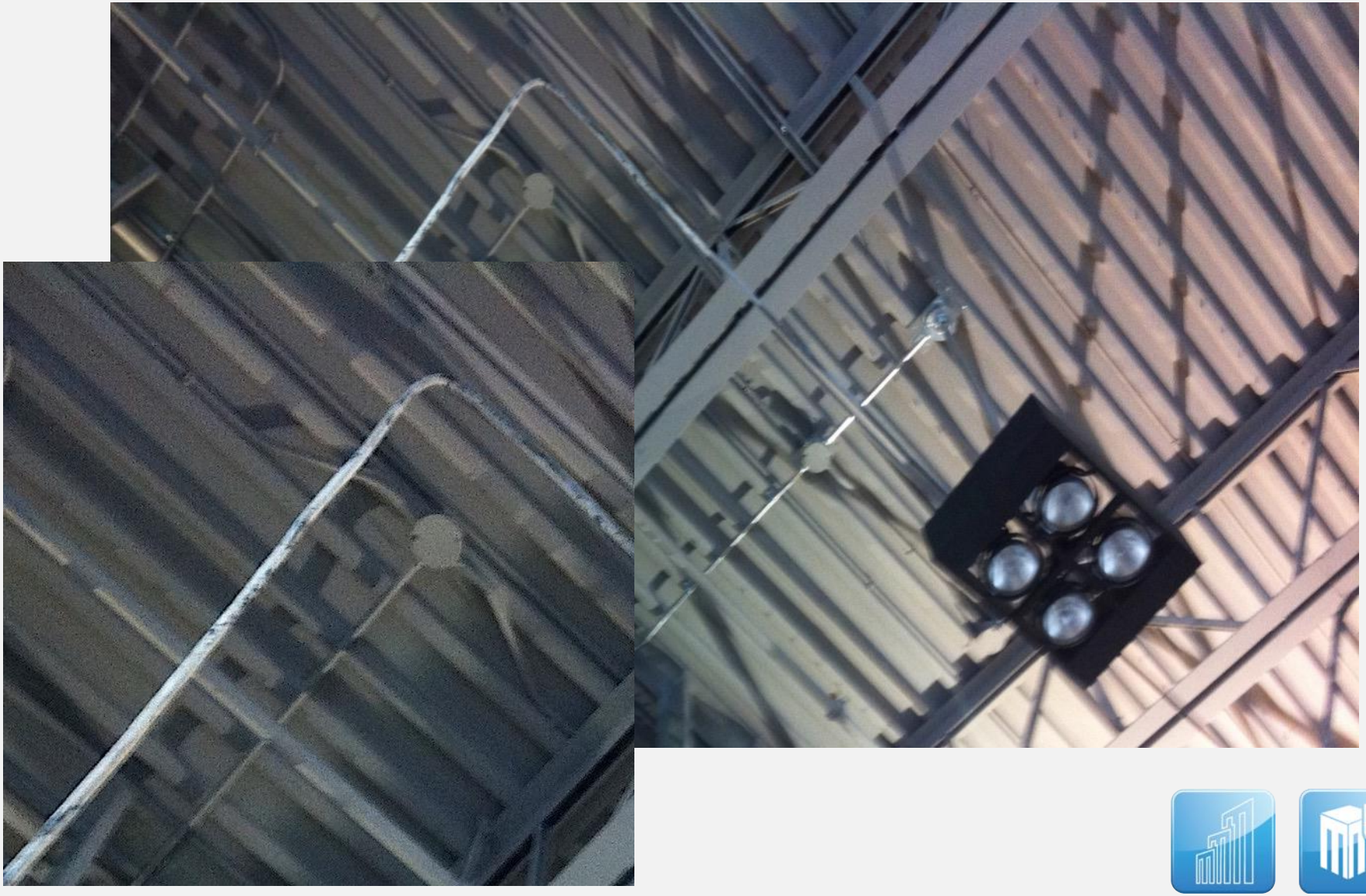
Project: MB Hydro head quarters. Winnipeg, Manitoba
36,000 sq ft Green Roof  completed 2009
LEED Platinum, Most Energy Efficient Building in North America

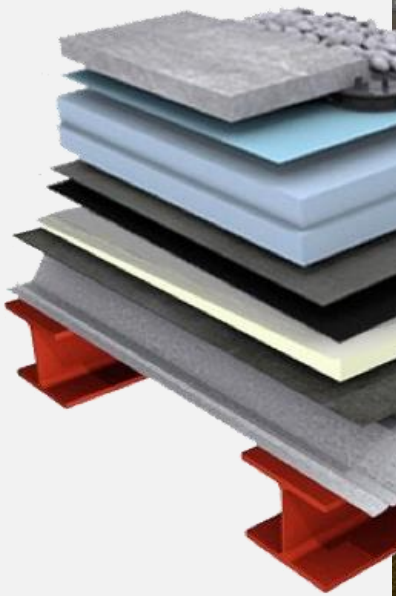
Moisture Detection Tape installed AFTER membrane Installed
Installation coordinated with roofing and green roof contractors.

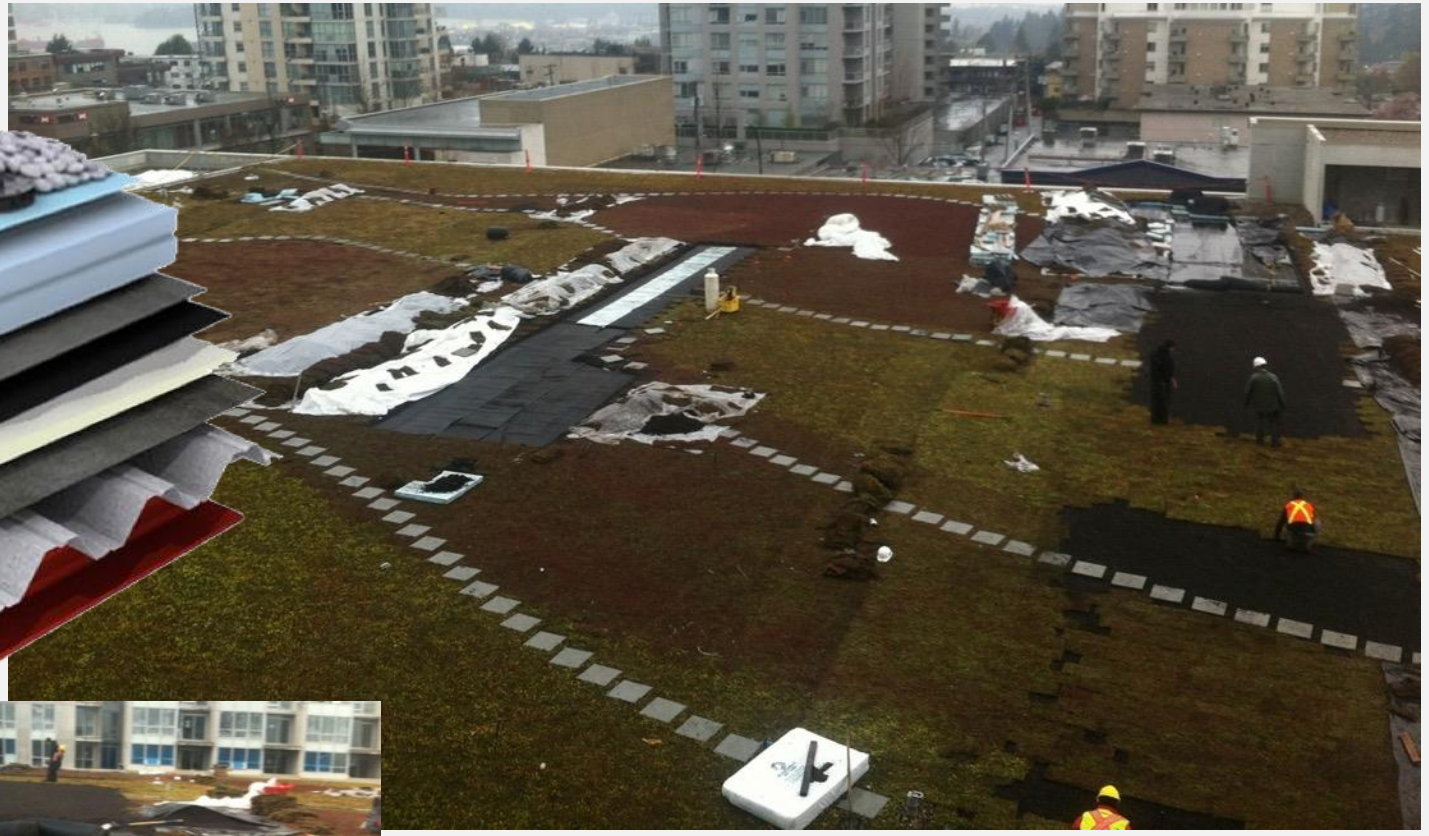
VIDEO: BuildingIntelli MDS Install

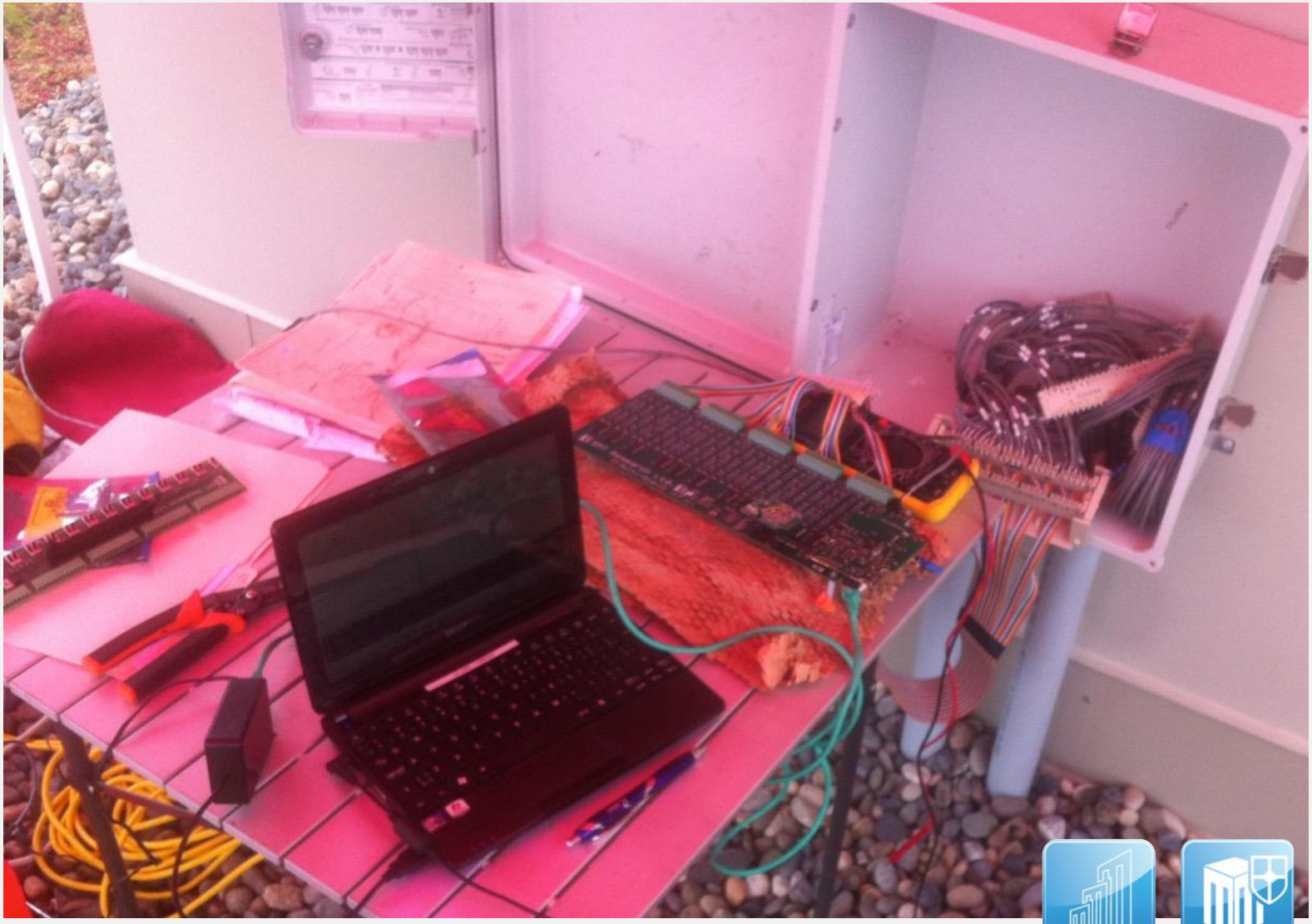


BUILDING INTELLI

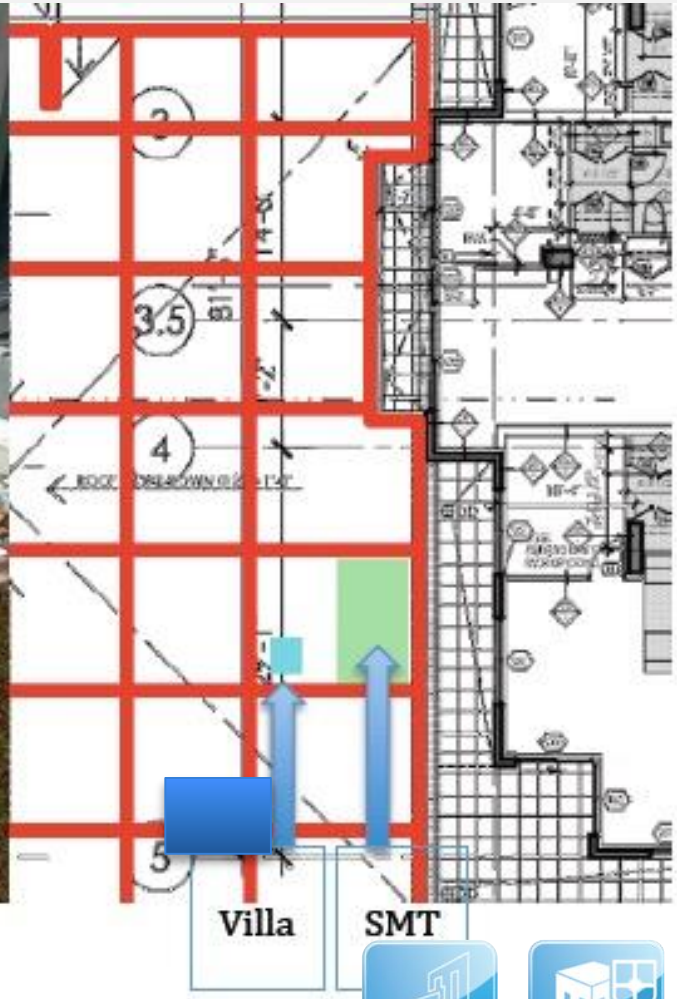


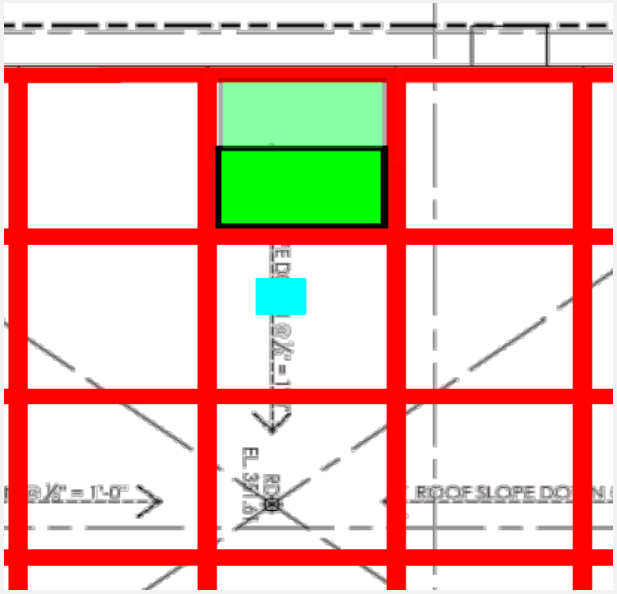


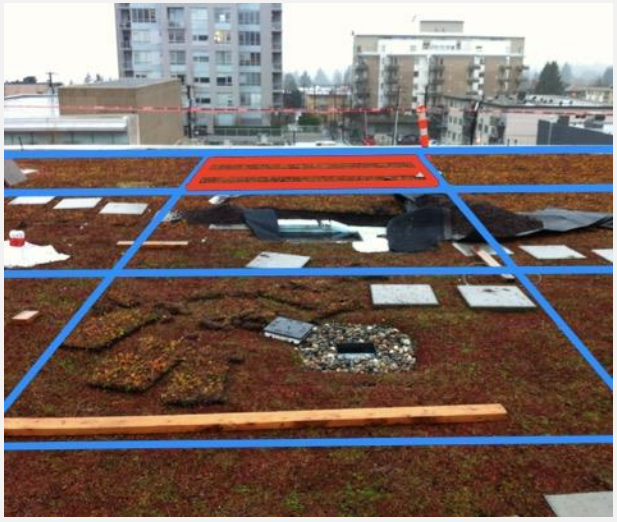


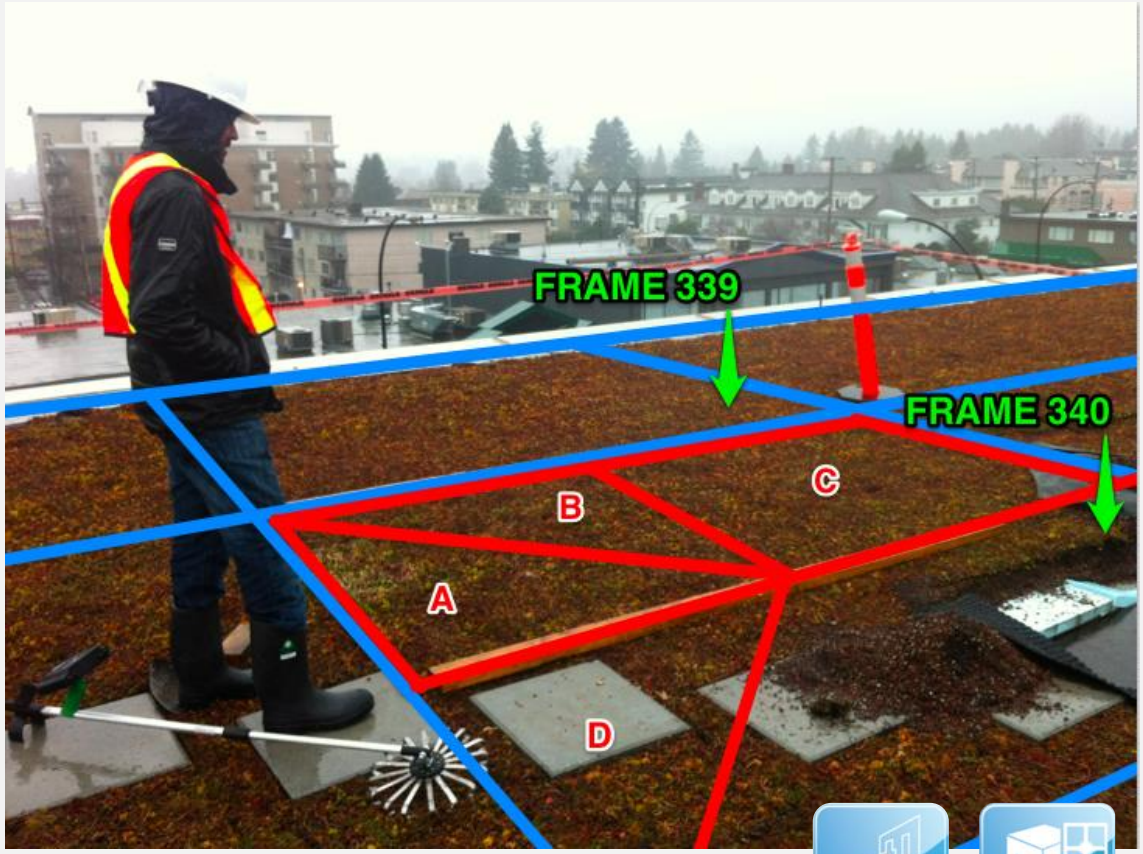


BUILDING INTELLI

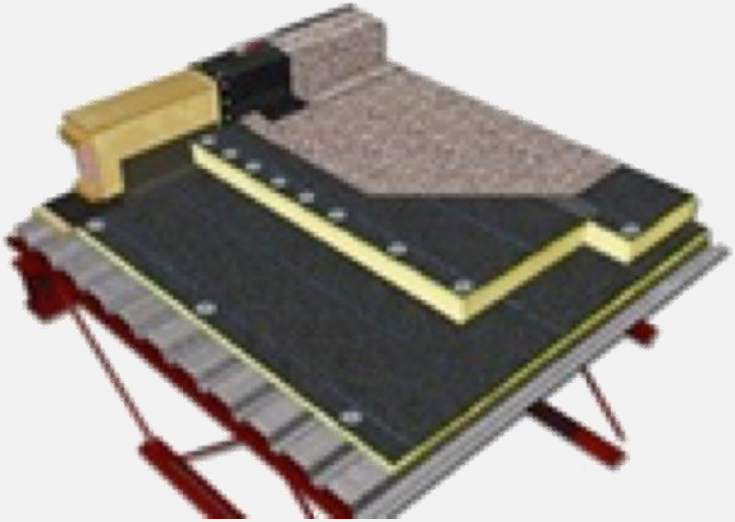


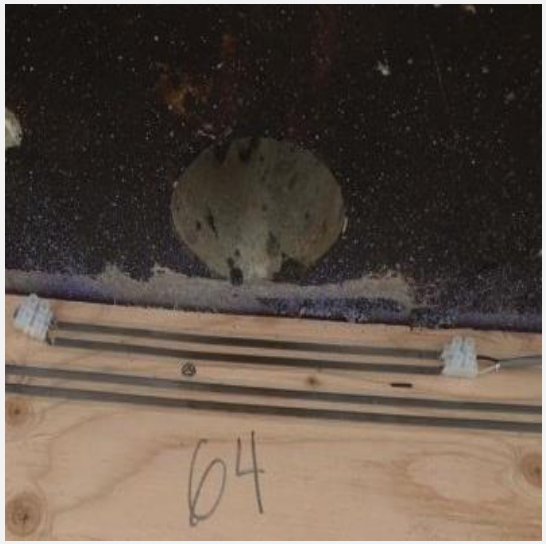





FRAME 339
FRAME 340
A
B
C
D

# Conventional Roof Monitoring




64

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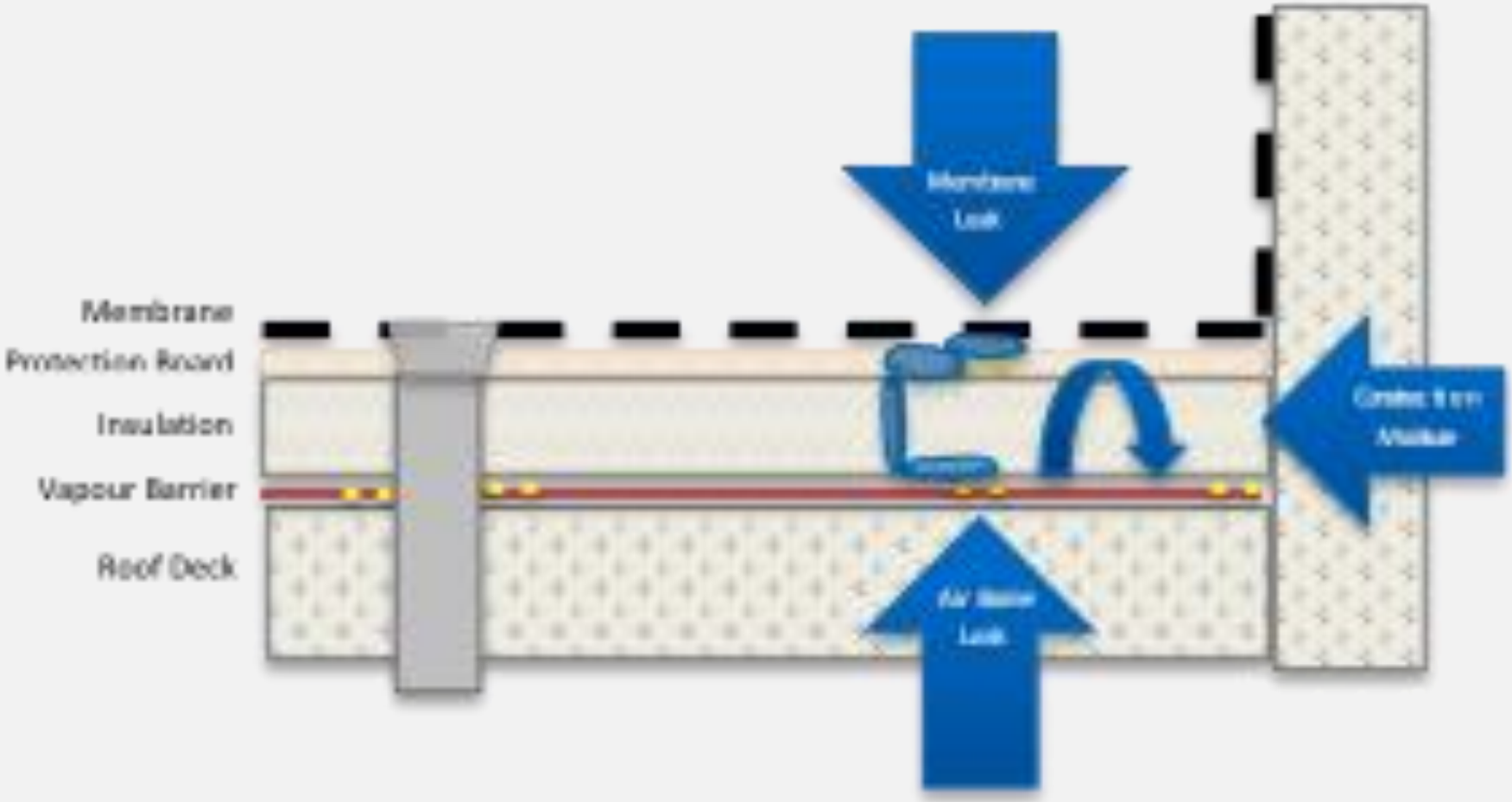
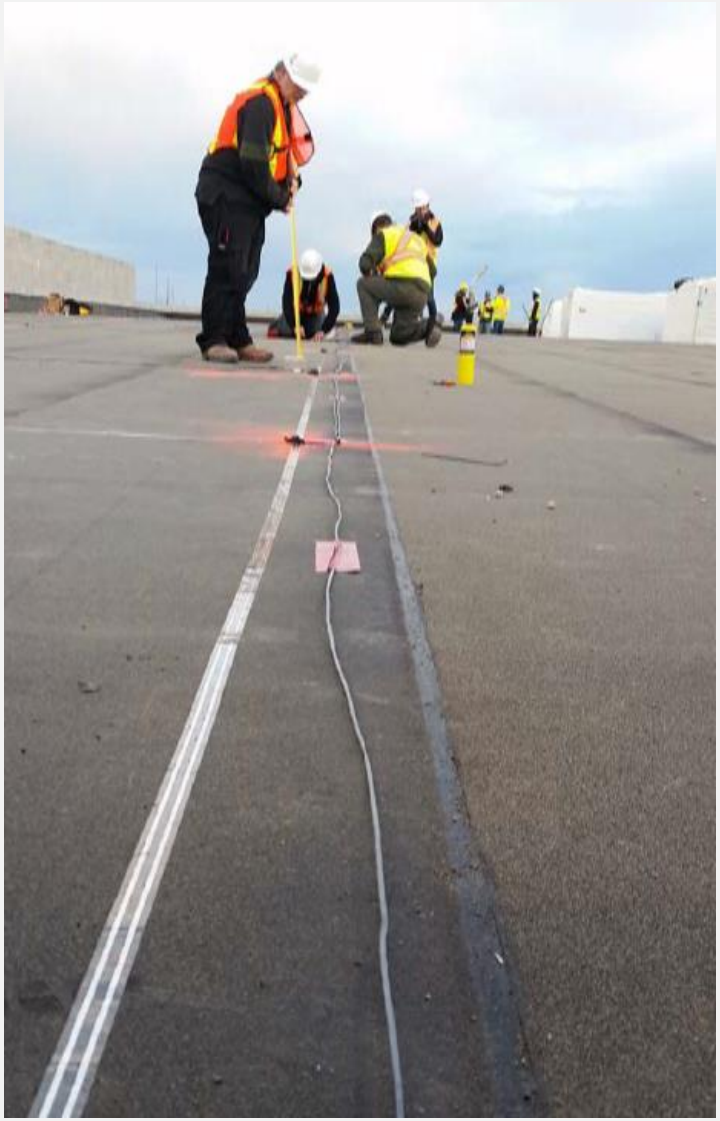

Membrane
Protection Board
Insulation
Vapour Barrier
Roof Deck

# titel

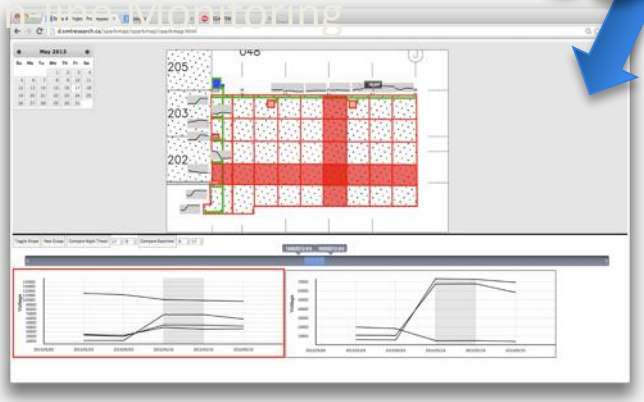
# titel






SMT Local Electronics


SMT Relay Interface
4 NO/NC outputs


Reports, Trends, and Analysis
Event Email, Text, SMS, Pager

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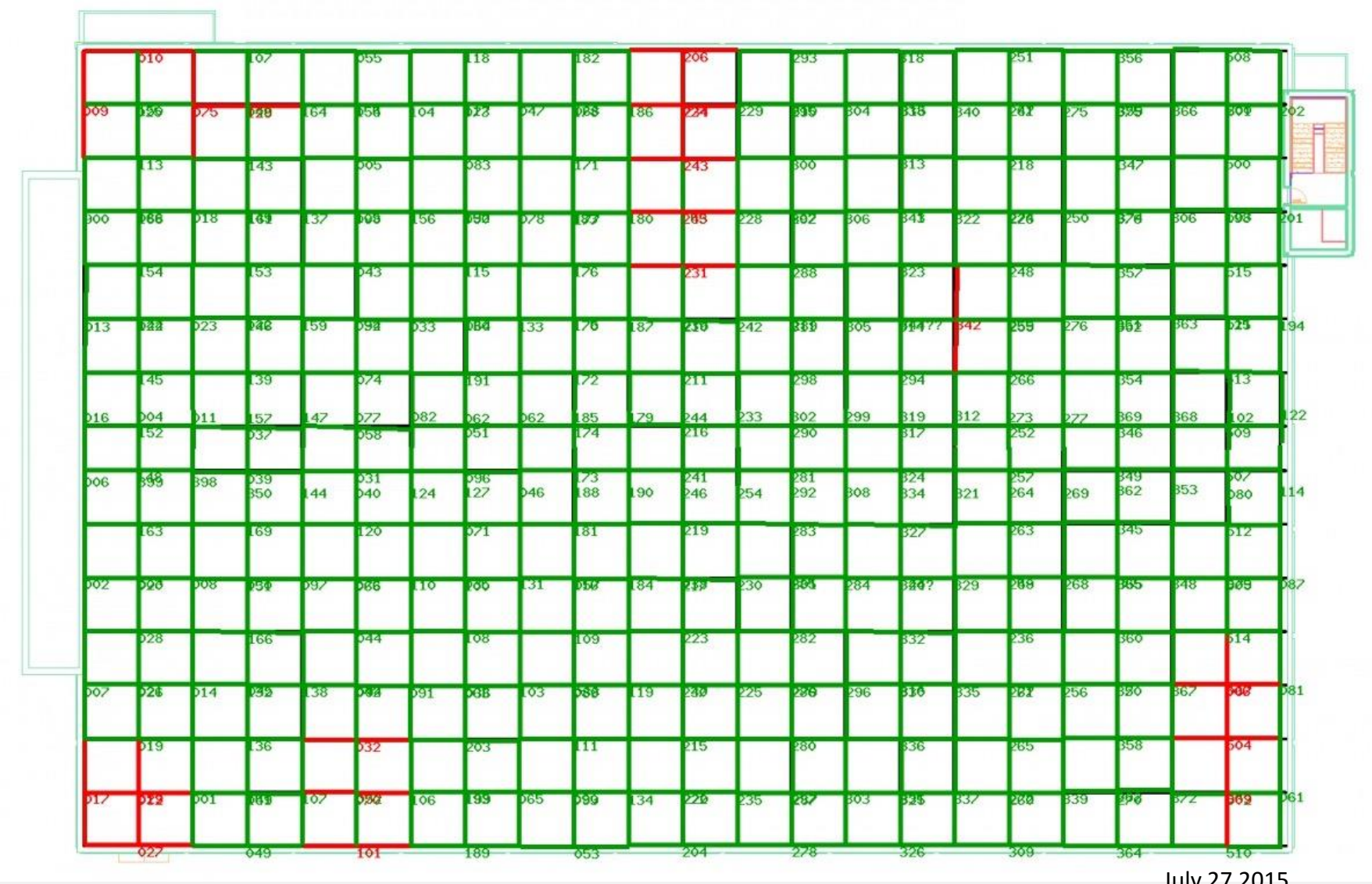

July 27 2015

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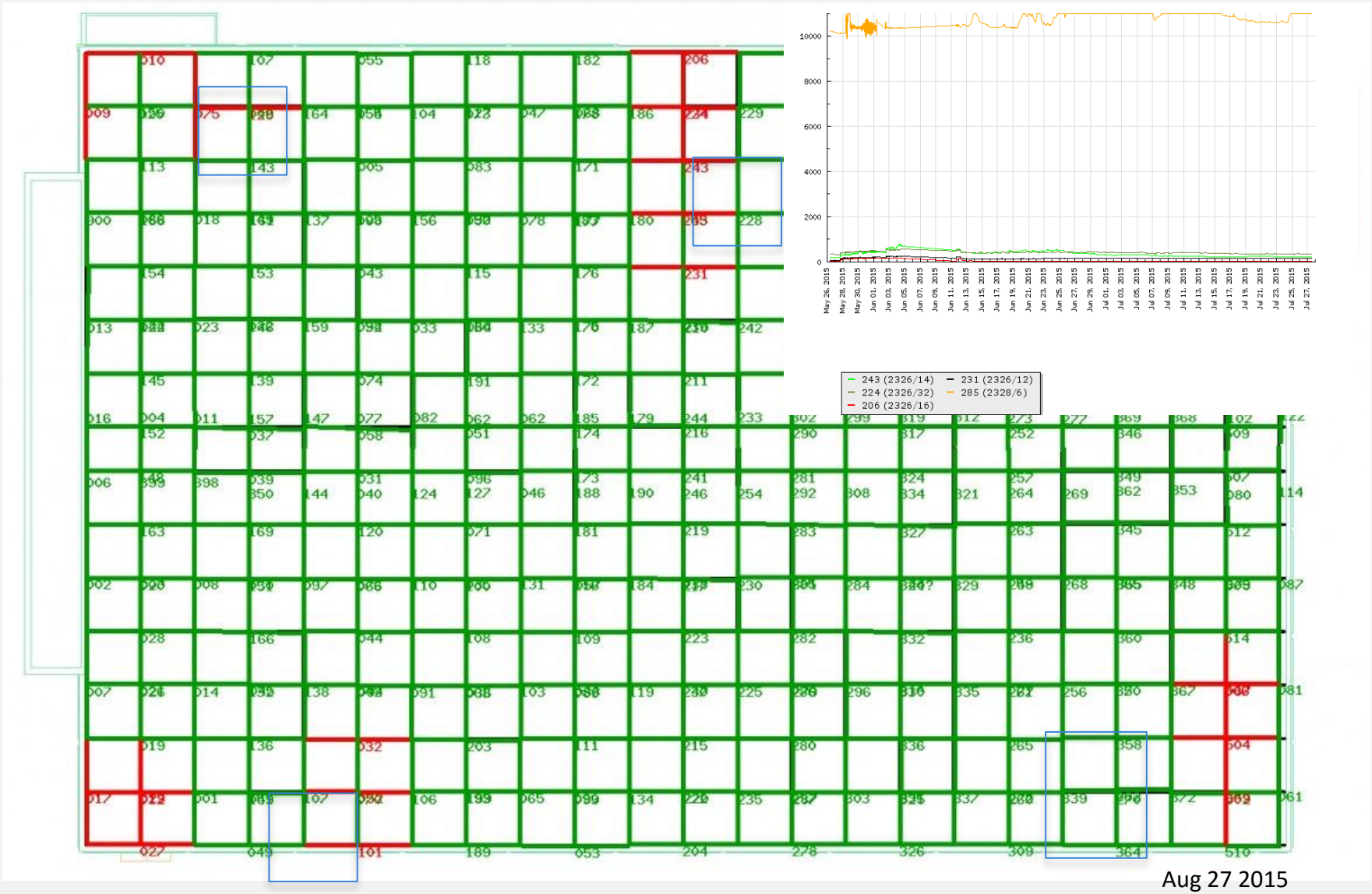


Aug 27 2015

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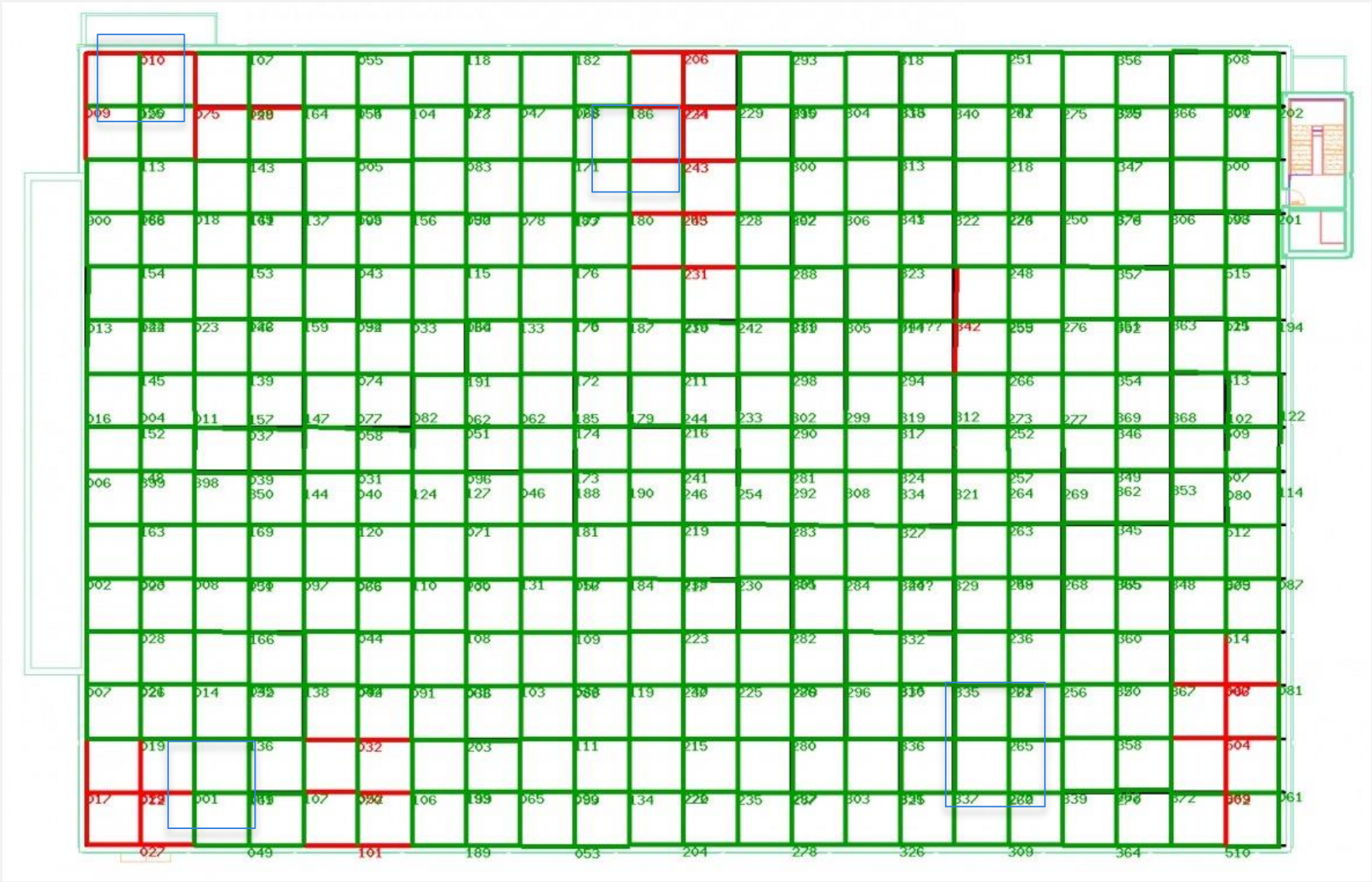

# ROOF INVESTIGATION

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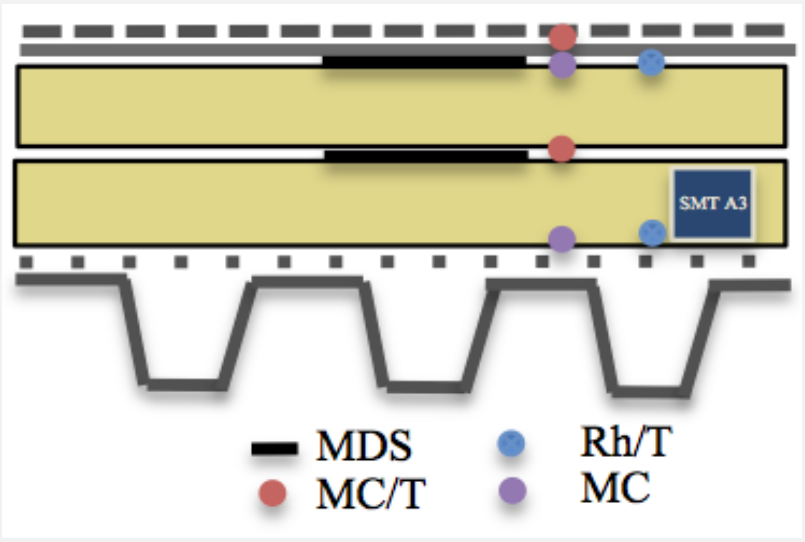
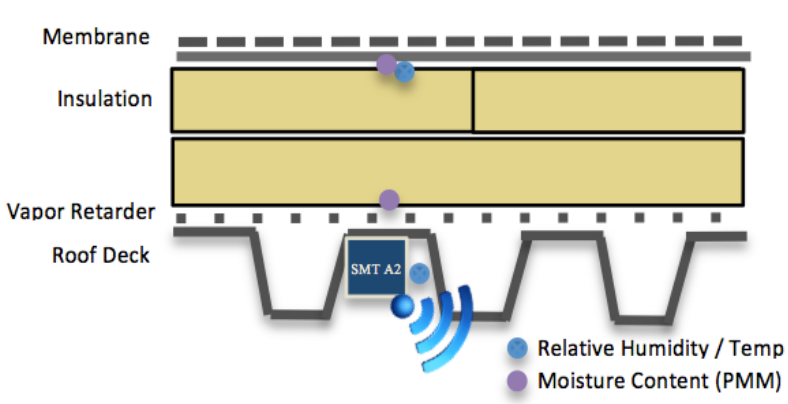
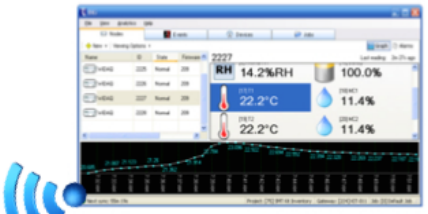



# ROOF INVESTIGATION



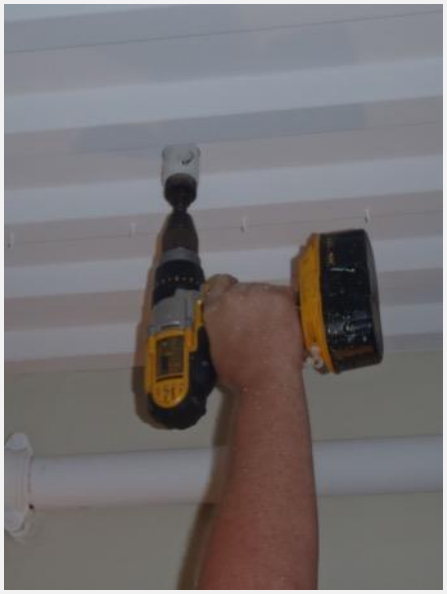

**Gateway - BiG Laptop**




SMT A3 Wireless data-logger sends data in real-time with a permanent installed Building Intelligence Gateway(BiG) and View Data remotely over the internet

OR

Collect Data on your next site visit, using your laptop.



# WOOD CONSTRUCTION

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# Case Studies


High Rise Moisture Monitoring

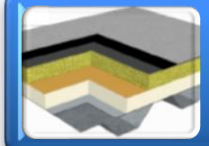

Air Barrier Monitoring


Low Slope Unvented Roof Deck Spray Foam


Window Replacement Monitoring Under Sill


Wall Remediation Monitoring

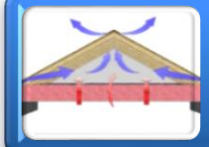

Sensor Types


Conventional Roof Hybrid Insulation Comparisons


PolyIso Shrinkage Monitoring


Window Study Occupant Comfort


Differential Pressure Monitoring Projects


Attics in Marine Climates


Pedestrian Tunnel

# The Future

## DigiSCAN Drone

Photo: ubc.ca

## AR App

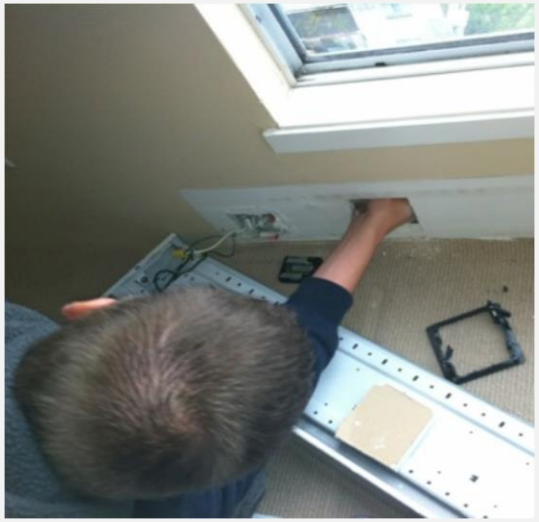
## Insurance Risk Mitigation

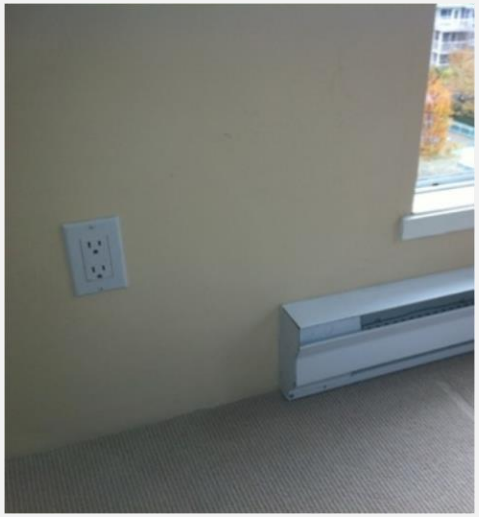
## Concrete Sensors

# INTERIOR INSTALLATIONS

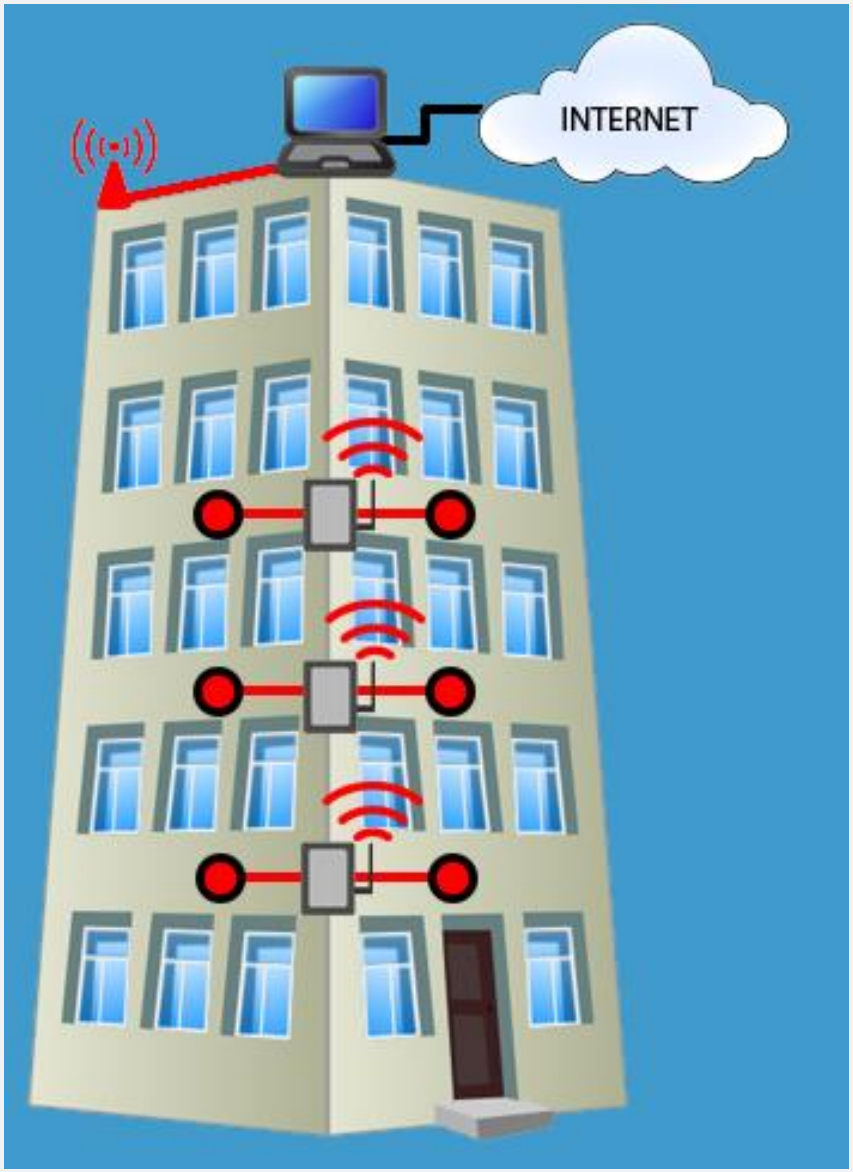


# INTERIOR INSTALLATIONS






# INTERIOR INSTALLATIONS



# WALL INVESTIGATIONS

Sheathing within exterior bathroom walls were previously deteriorated from air exfiltration.

Sheathing replaced as part of a larger full enclosure rehabilitation. Bathrooms all fully rehabilitated.

# WALL INVESTIGATIONS

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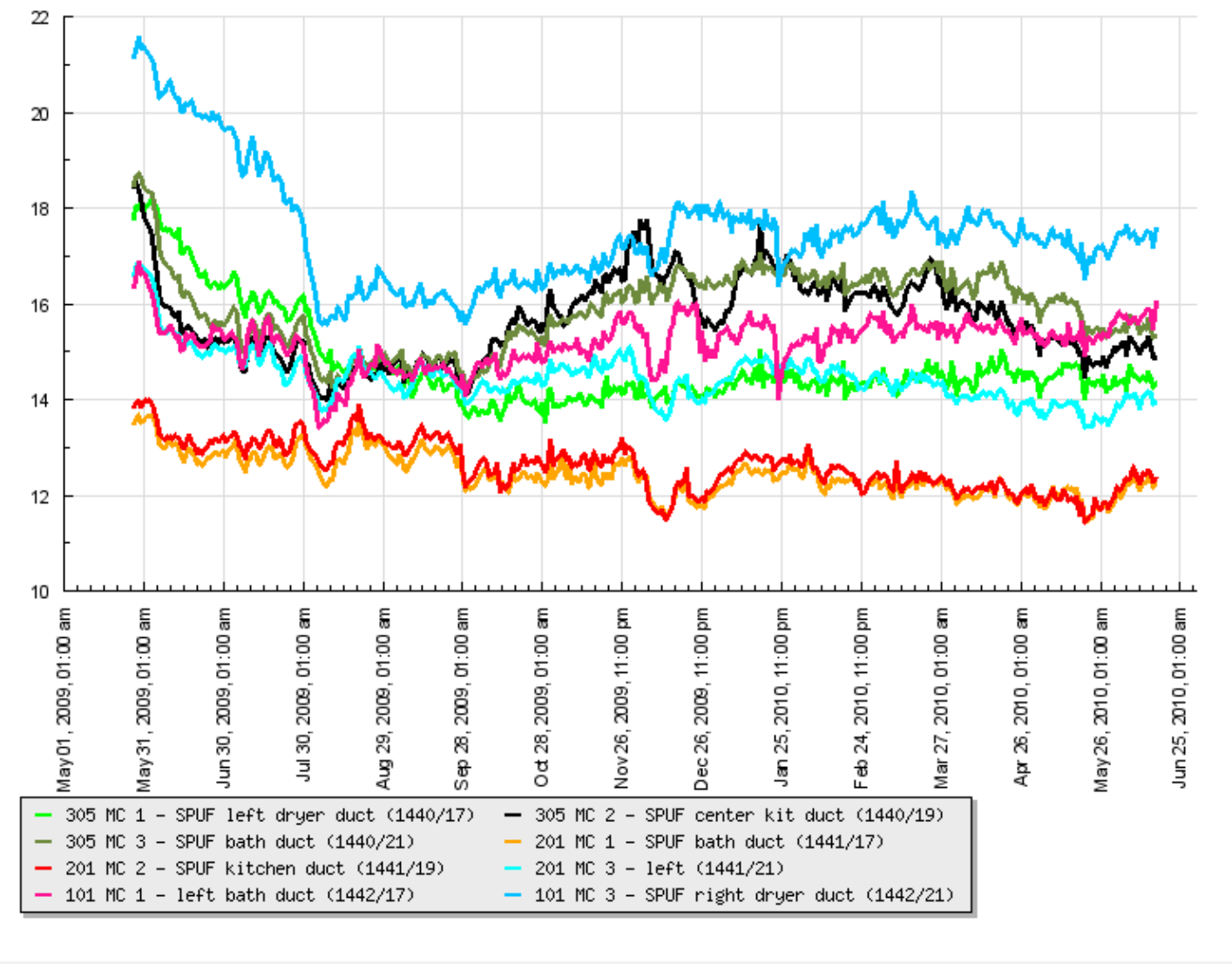
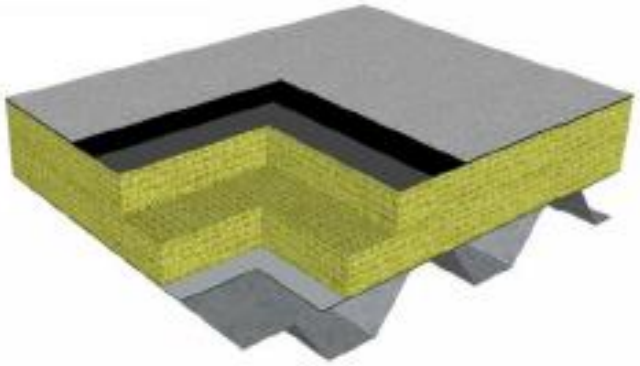


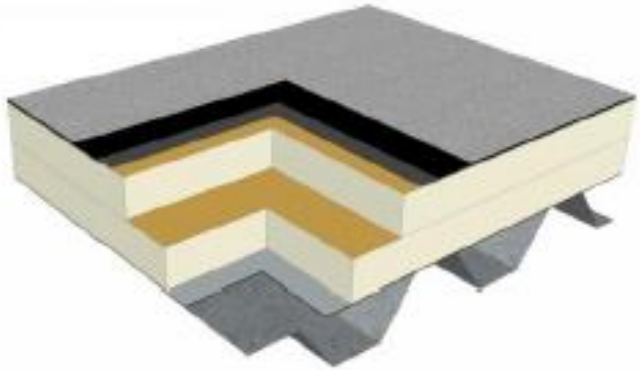

- Plywood dries down behind sprayfoam on inside and self-adhered membrane & metal flashing detailing on exterior

- Air leakage addressed, Moisture levels following normal seasonal trends

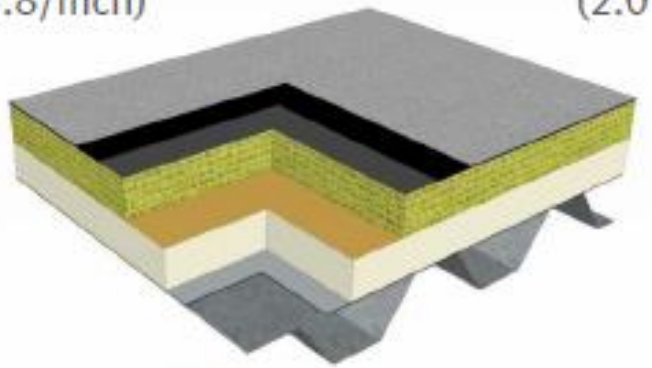
## → 3 different insulation assemblies



Soprarock DD+ - R-21.9
(2.5" + 3.25" R-3.8/inch)
(DD)



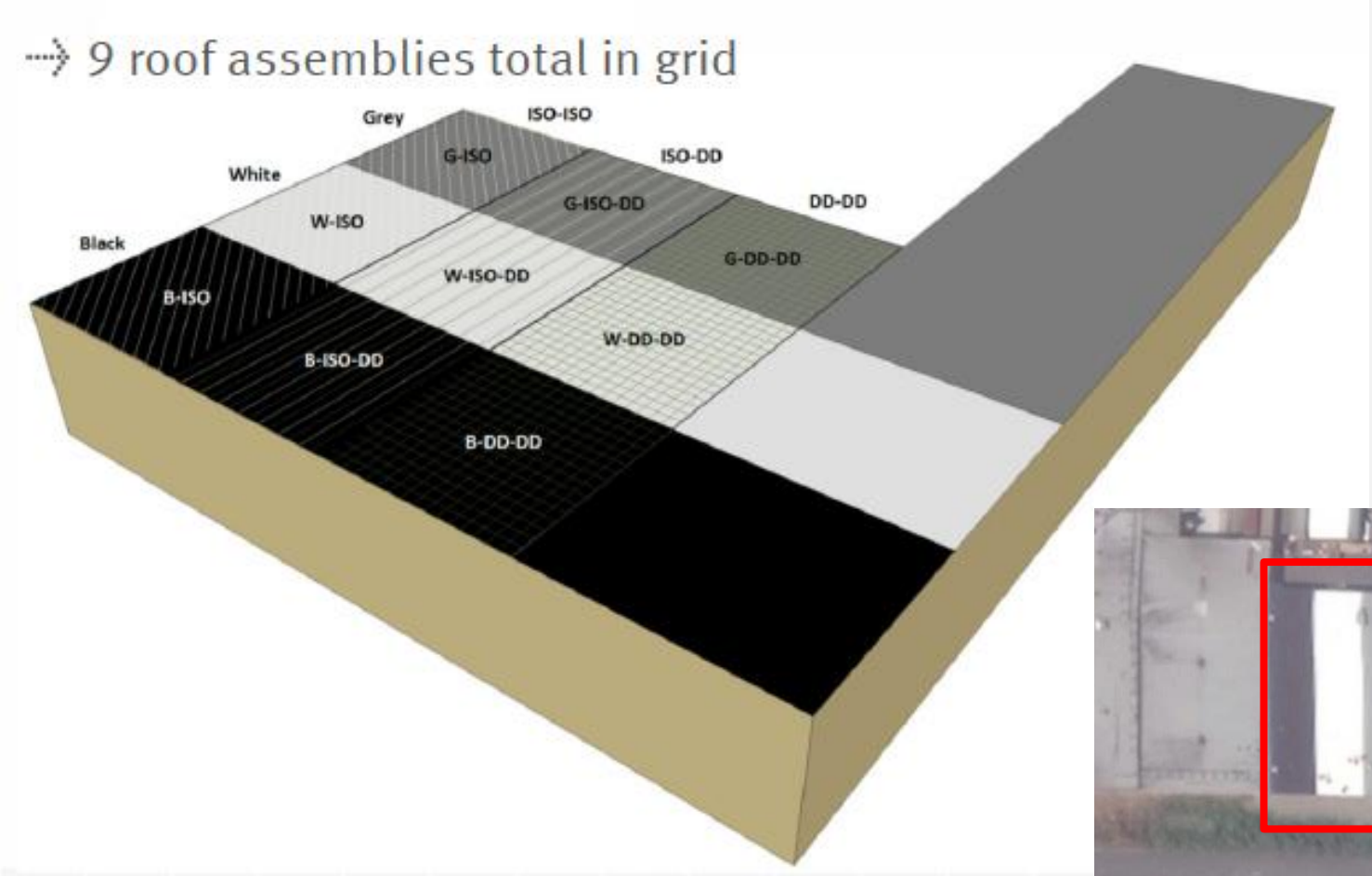
Polyiso - R-21.0
(2.0" + 1.5" R-6.0/inch)
(ISO)



Hybrid – R-21.5
(2.0" Polyiso + 2.5" Soprarock DD+)
(ISO-DD)

**All insulation assemblies approximately R-21 nominal.**

# ROOF RESEARCH




# Sensor Installation

- Temperature
- Heat Flux
- Relative Humidity
- Displacement

Temperature

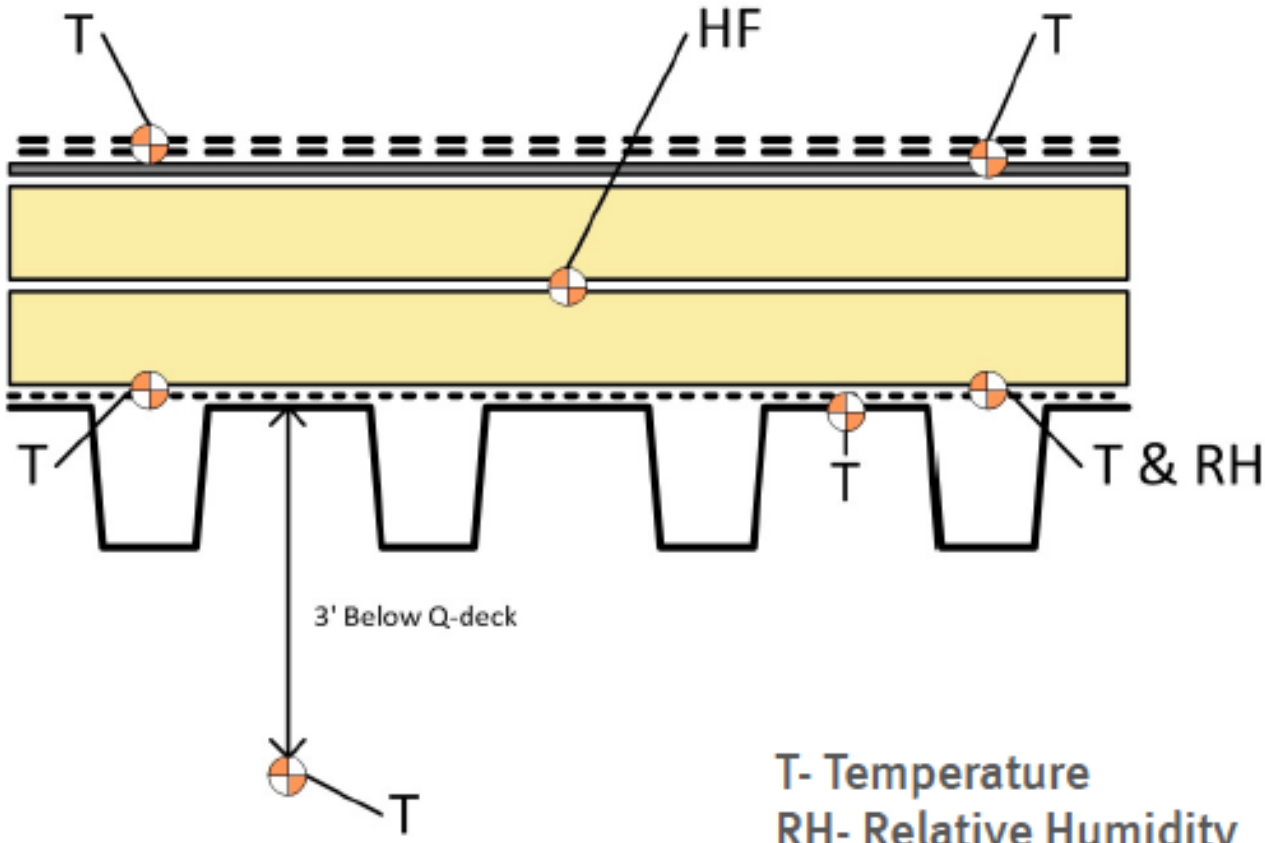
CH

Heat Flux

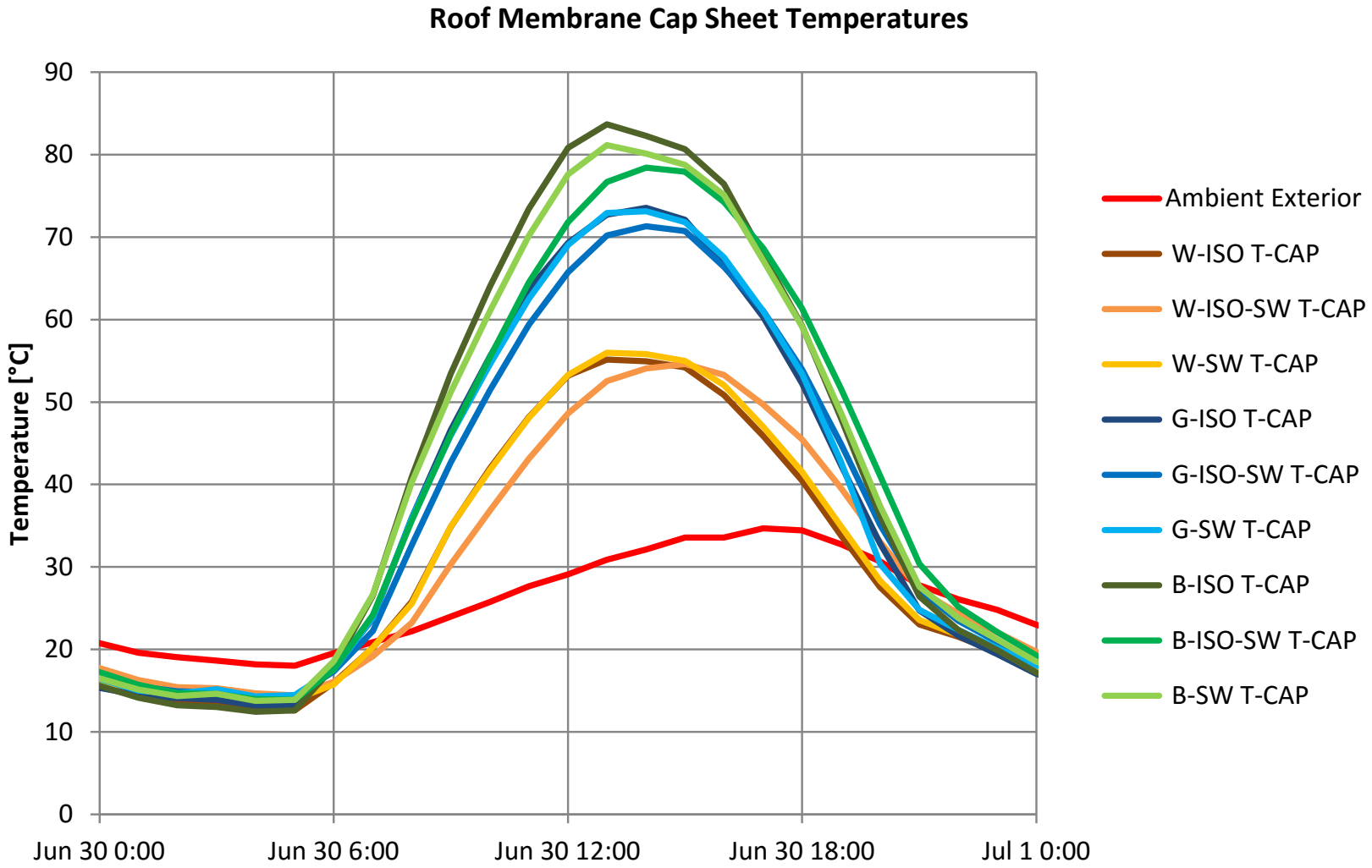
Relative Humidity

Displacement

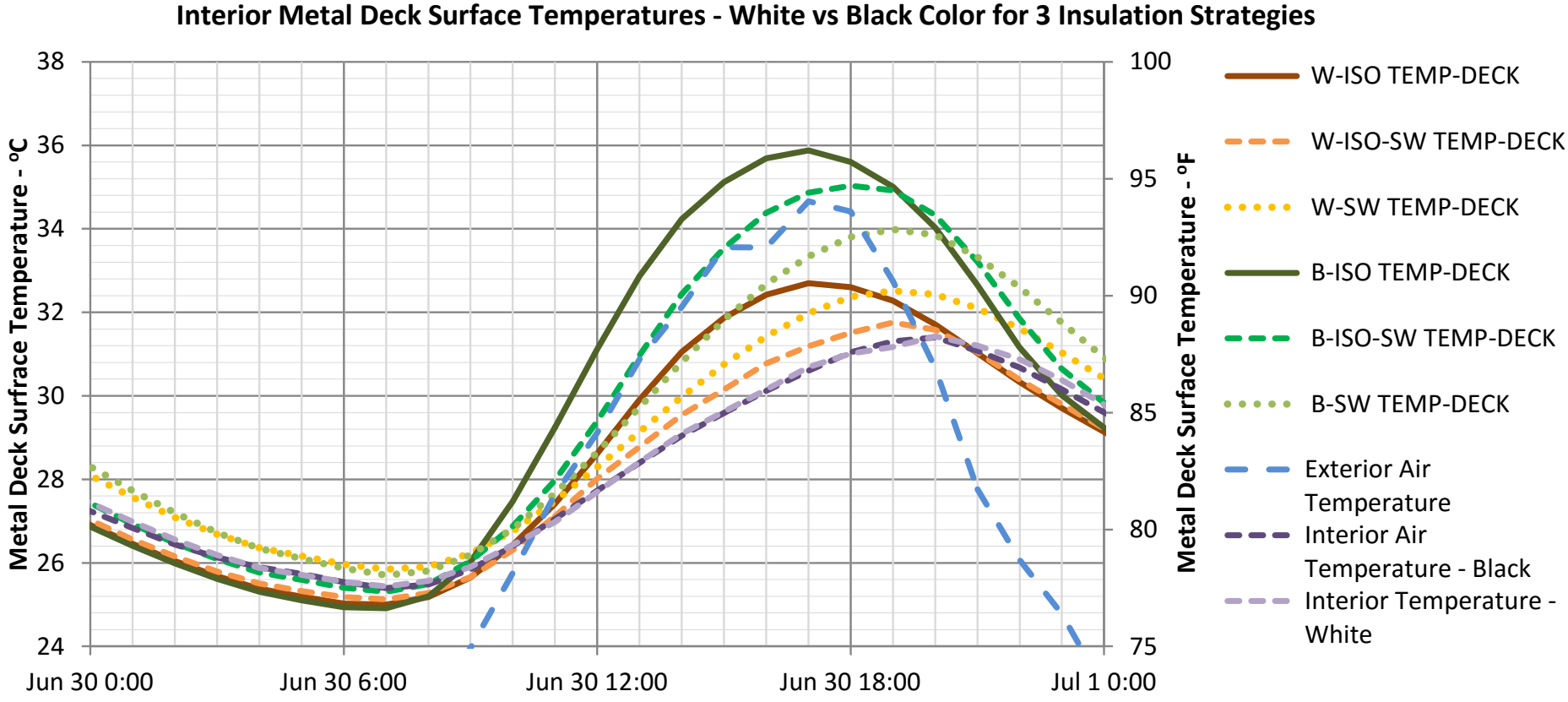
# ROOF RESEARCH



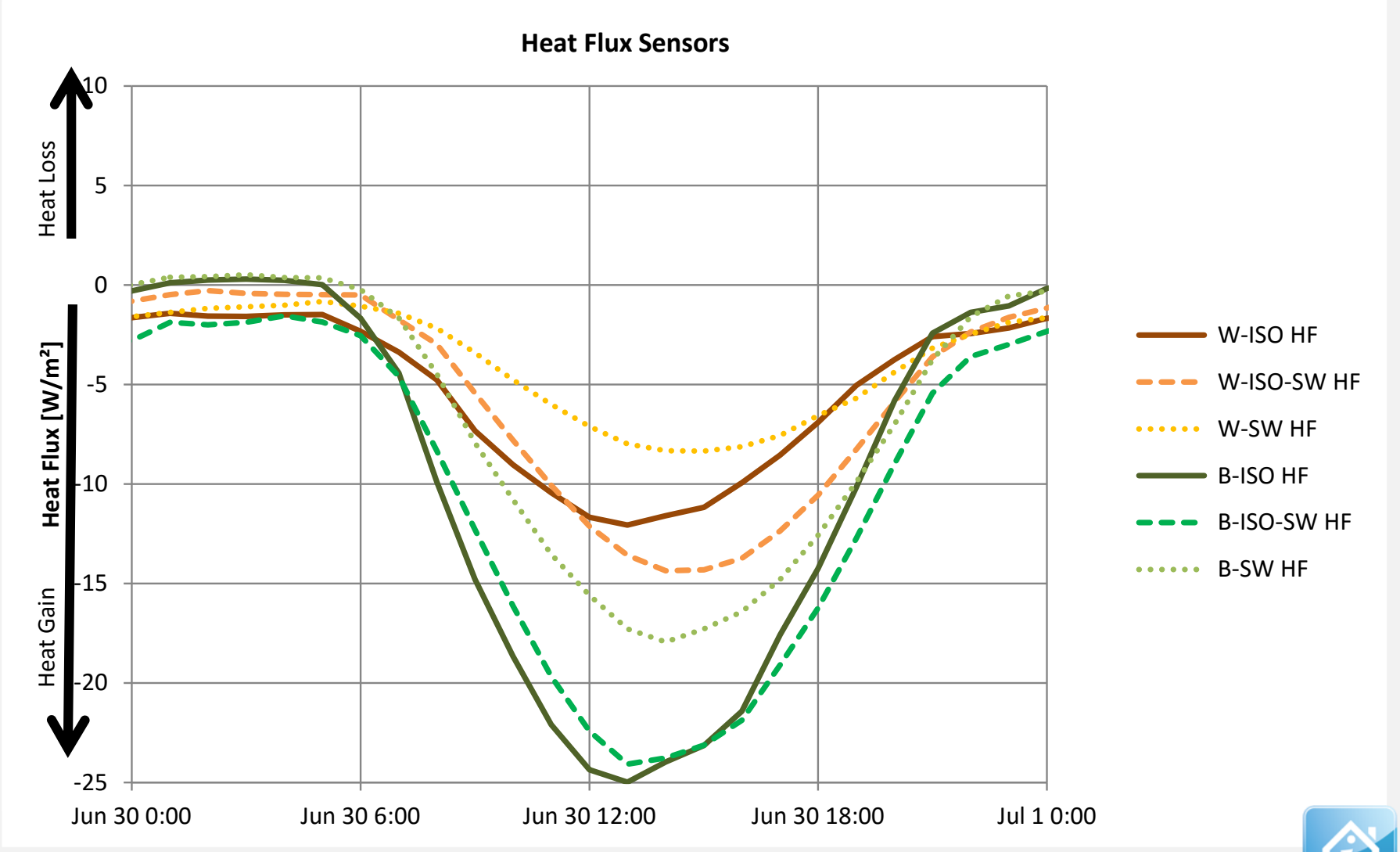

- Plan is continue monitoring for at 3+ years to look at long-term effects and aging
- Temperatures Heat Flux Relative Humidity Insulation Movement



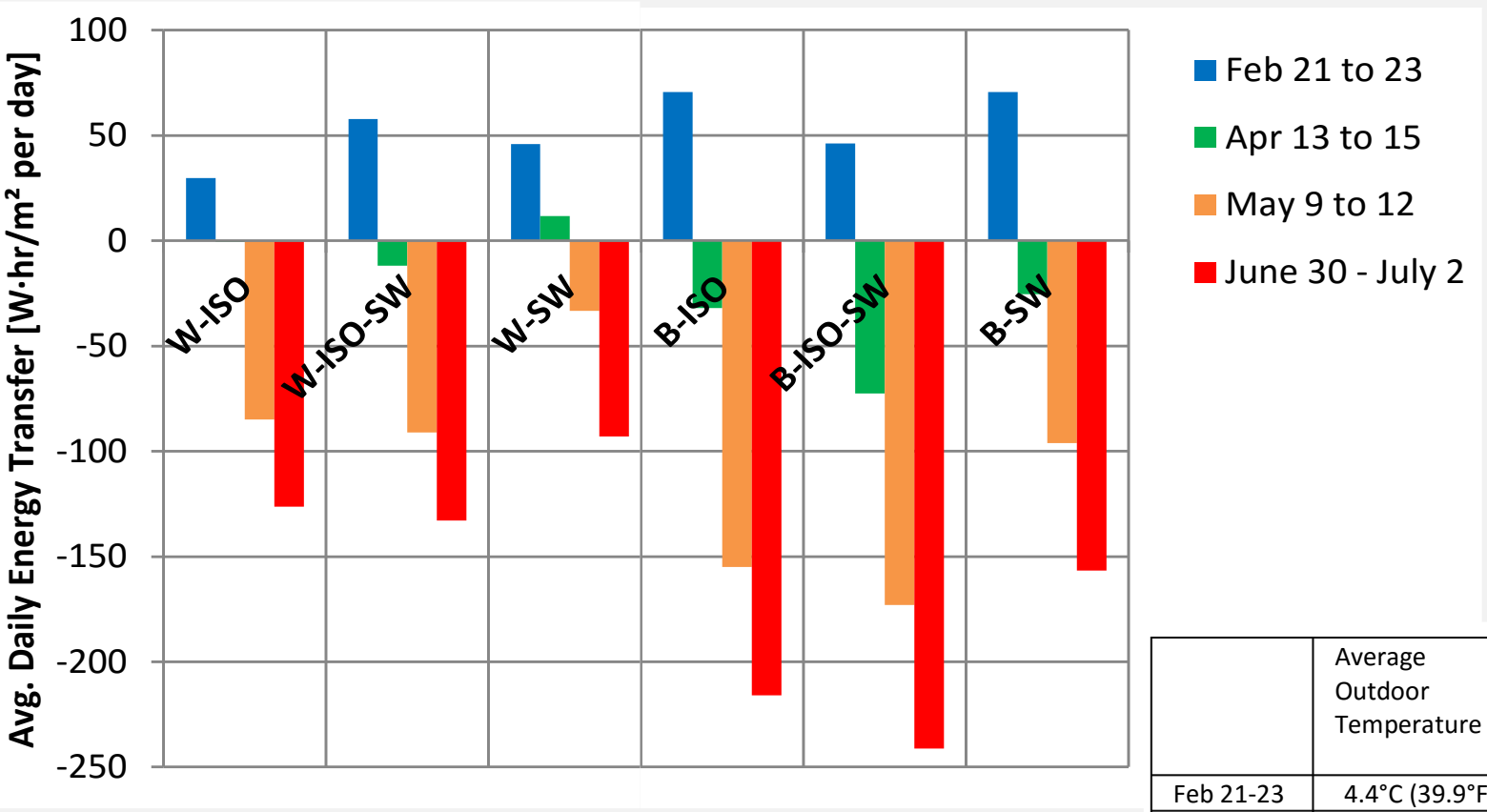

W- white, G-grey, B-black, SW-stone wool, ISO - polyiso




Heat capacity of stone wool as installed here is 3.4x higher than polyiso.


Heat Flux Sensors
Heat Loss
Heat Gain
Heat Flux [W/m²]
10
5
0
-5
-10
-15
-20
-25
Jun 30 0:00
Jun 30 6:00
Jun 30 12:00
Jun 30 18:00
Jul 1 0:00
W-ISO HF
W-ISO-SW HF
W-SW HF
B-ISO HF
B-ISO-SW HF
B-SW HF

# ROOF RESEARCH

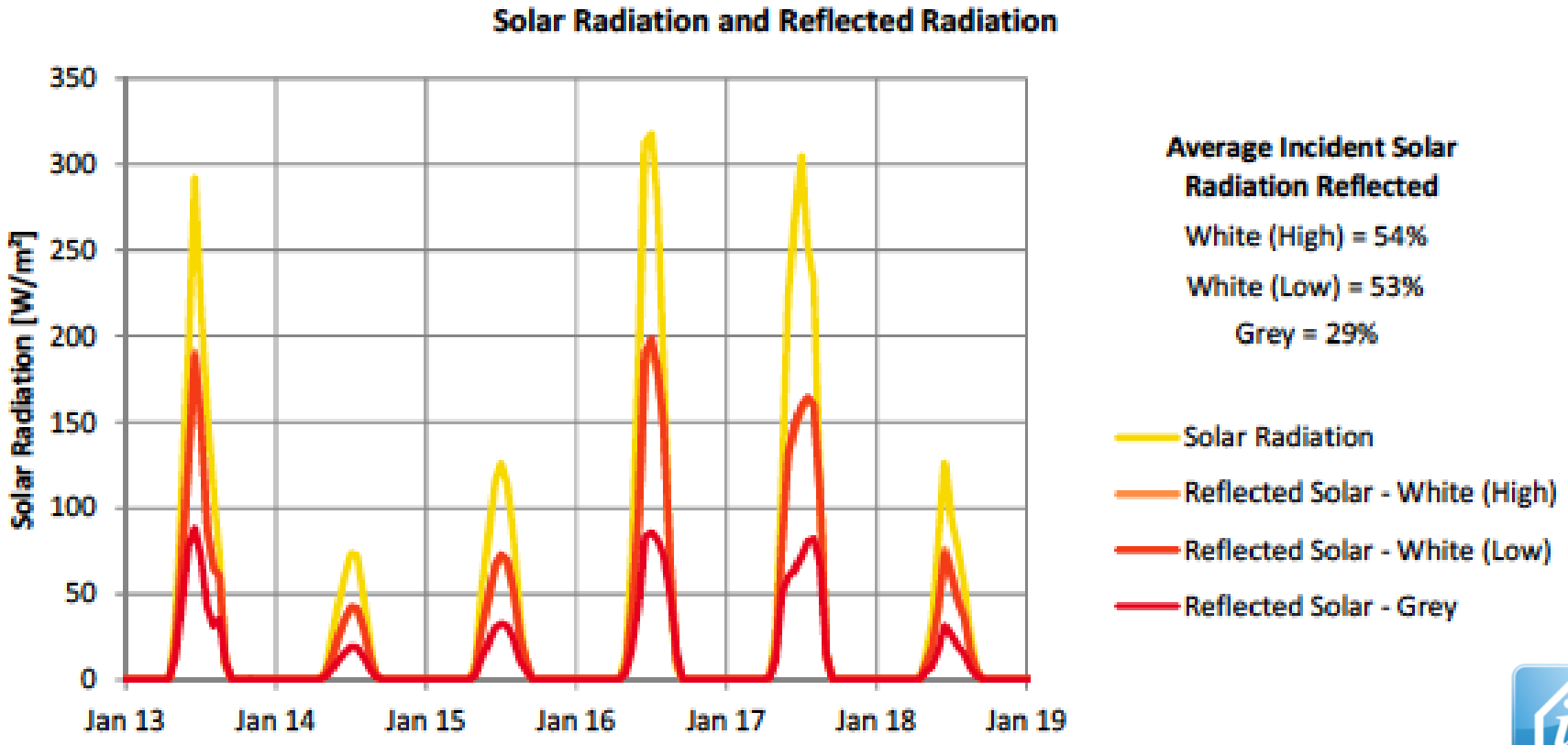



| | Average Outdoor Temperature | Average Solar Intensity on horizontal roof, all hours of day |
|---|---|---|
| Feb 21-23 | 4.4°C (39.9°F) | 27 W/m$^2$ |
| Apr 13-15 | 6.9°C (44.4°F) | 200 W/m$^2$ |
| May 9-12 | 18.7°C (65.6°F) | 261 W/m$^2$ |
| Jun 30 - 2 | 25.8°C (78.4°F) | 331 W/m$^2$ |

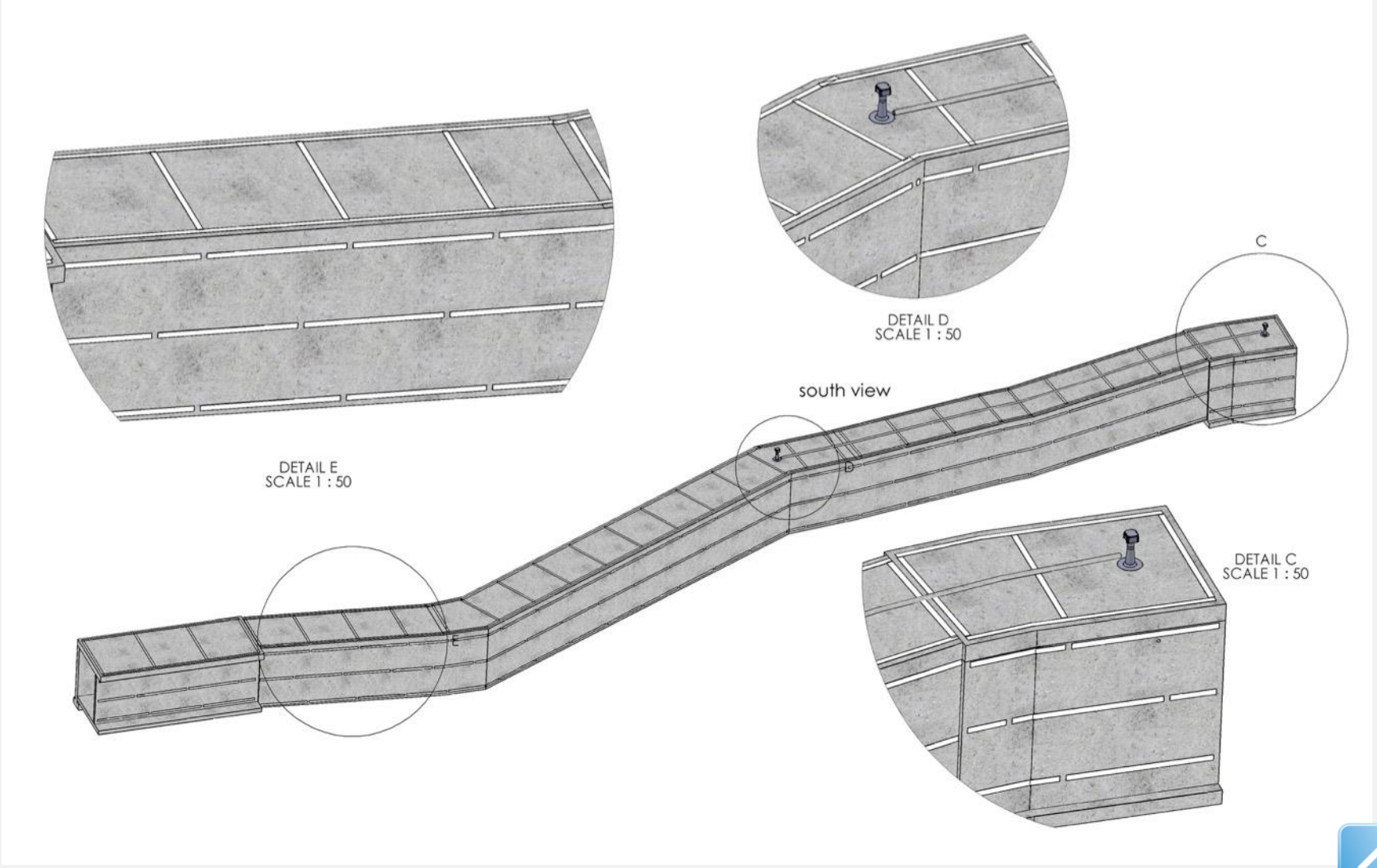
→ Visual indication to observe roof getting dirtier over time

# ROOF RESEARCH

- White membrane reflects more solar radiation
- Amount of reflection expected to decrease as cap sheet becomes soiled/ages



# Leak Detection in a Pedestrian Tunnel



# Pedestrian Tunnel

# Staggered Horizontal Sensor Grid

# Precast segments

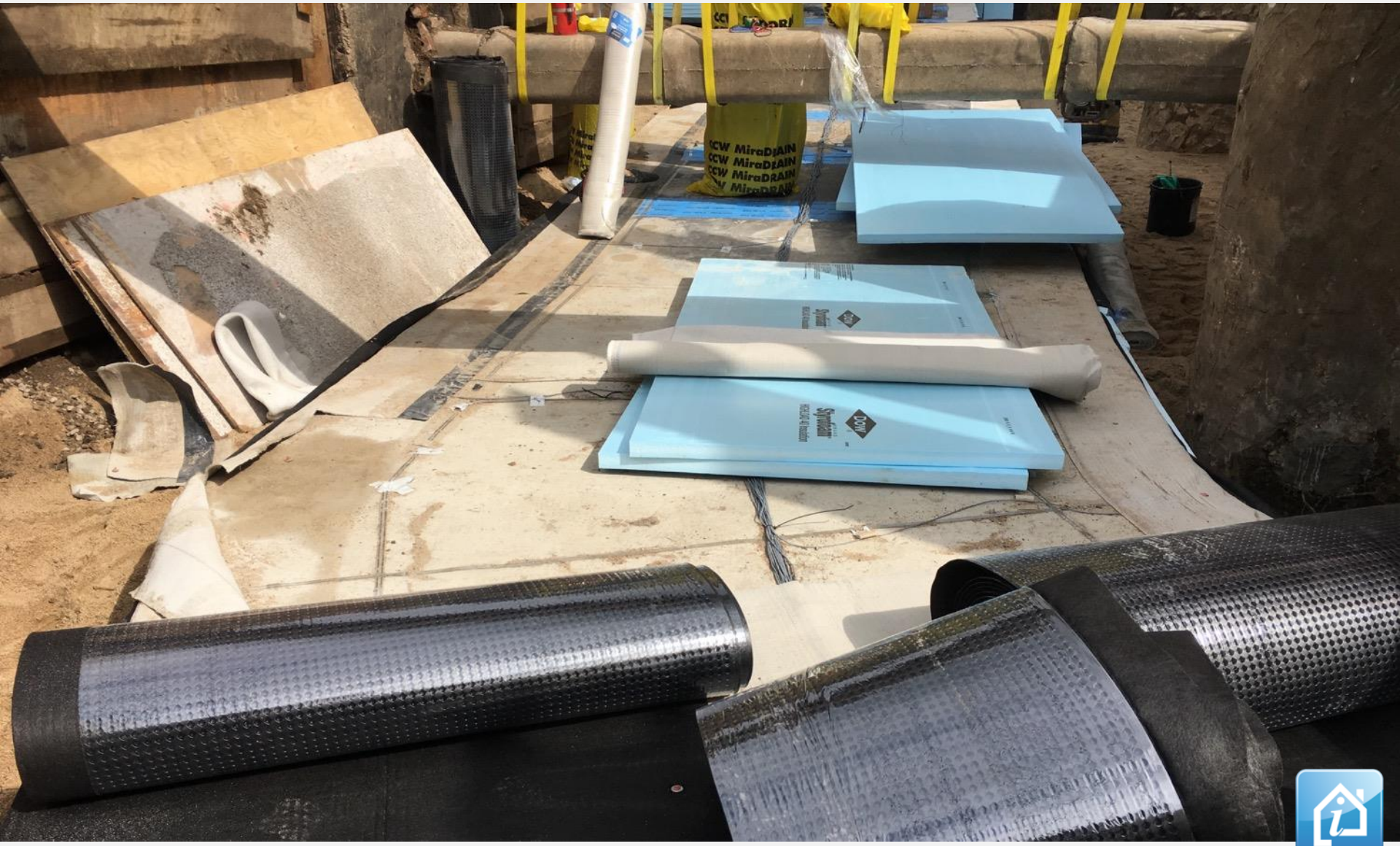
# Bentonite, mechanically fastened

# Waterproofing, Drainage, and Insulation

# Sequencing

# Square Grid on tunnel roof


CCW-705


CCW MiraDRAIN
CCW MiraDRAIN
CCW MiraDRAIN

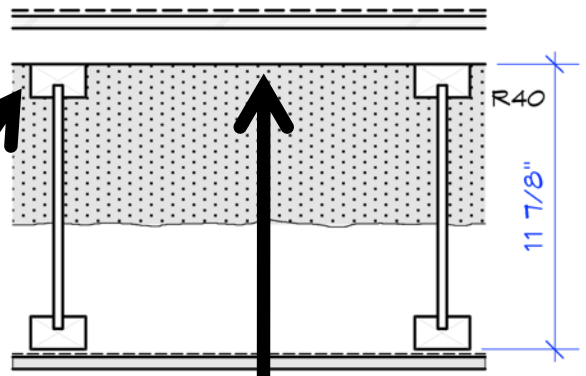
# Titel

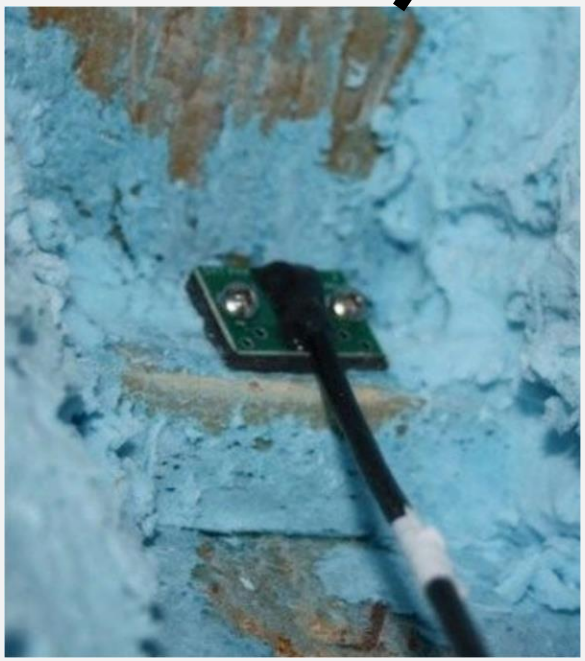
# ROOF INVESTIGATION

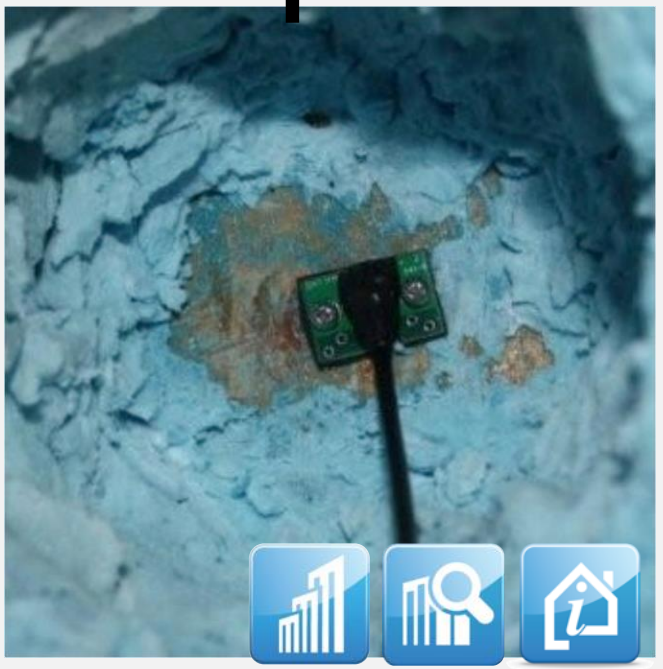
R1

2 LAYERS 20-mil LIQUID APPLIED WATERPROOF MEMBRANE (ECOLINE-R OR EQUIVALENT)
3/4" EXTERIOR GRADE T&G PLYWOOD SHEATHING (SLOPE TO DRAIN AS PER PLAN)
2X4 STRAPPING
11-7/8" TJI (REFER TO STRUCTURAL DRAWINGS)
6.67" POLYURETHANE SPRAY FOAM INSULATION (R40)
1/2" G.W.B.

TOTAL ASSEMBLY INSULATION VALUE: R40





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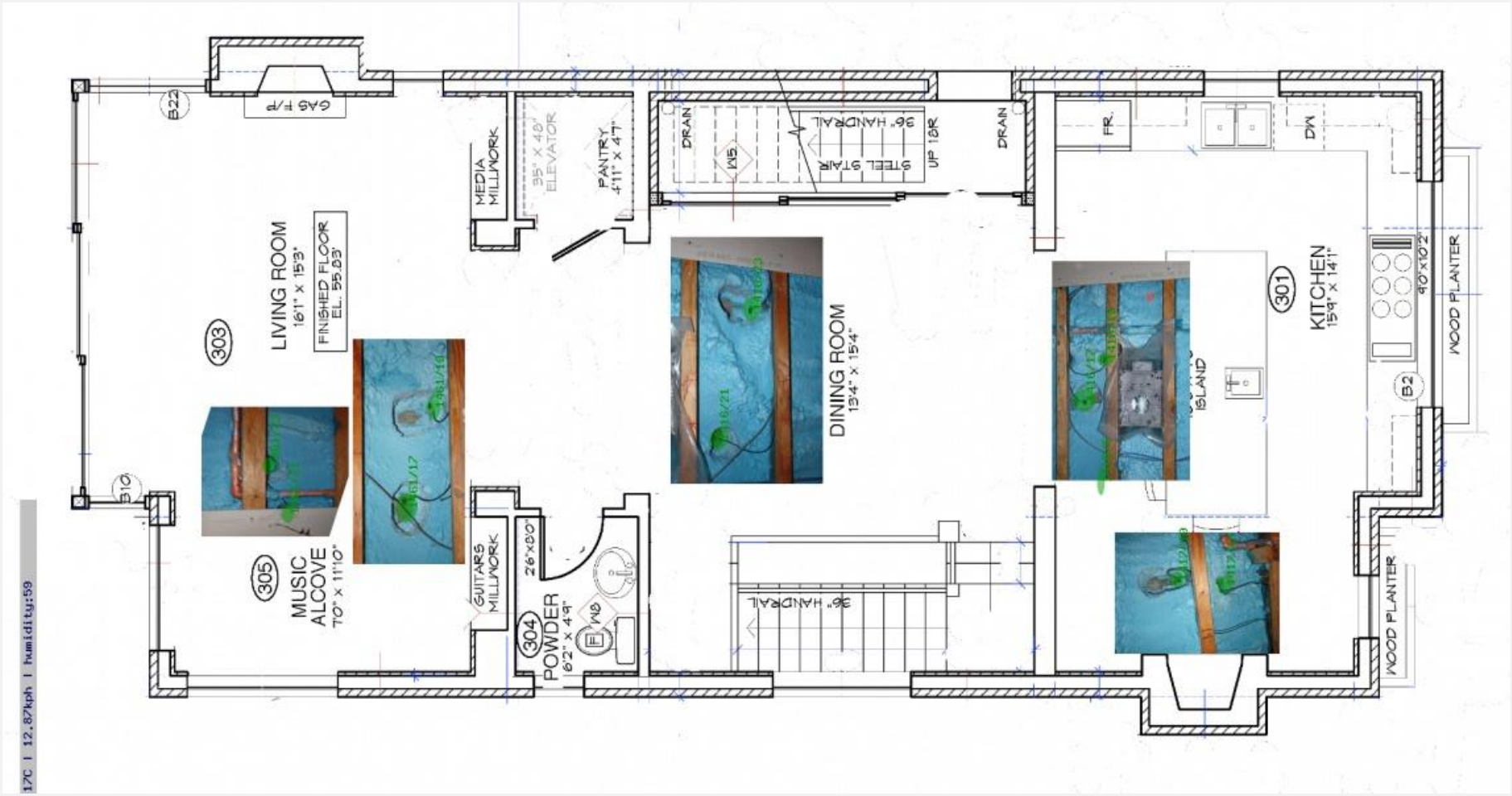

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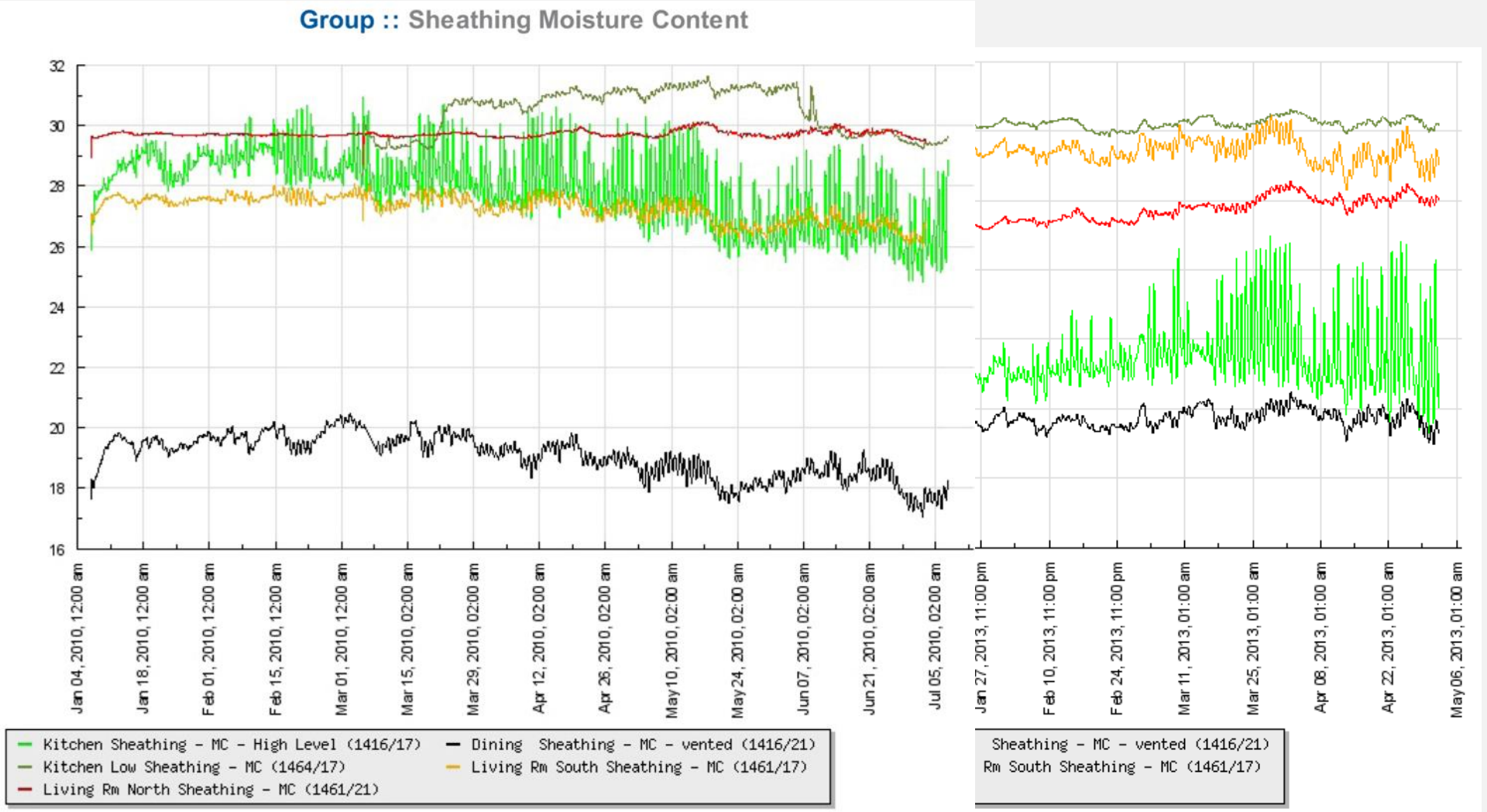

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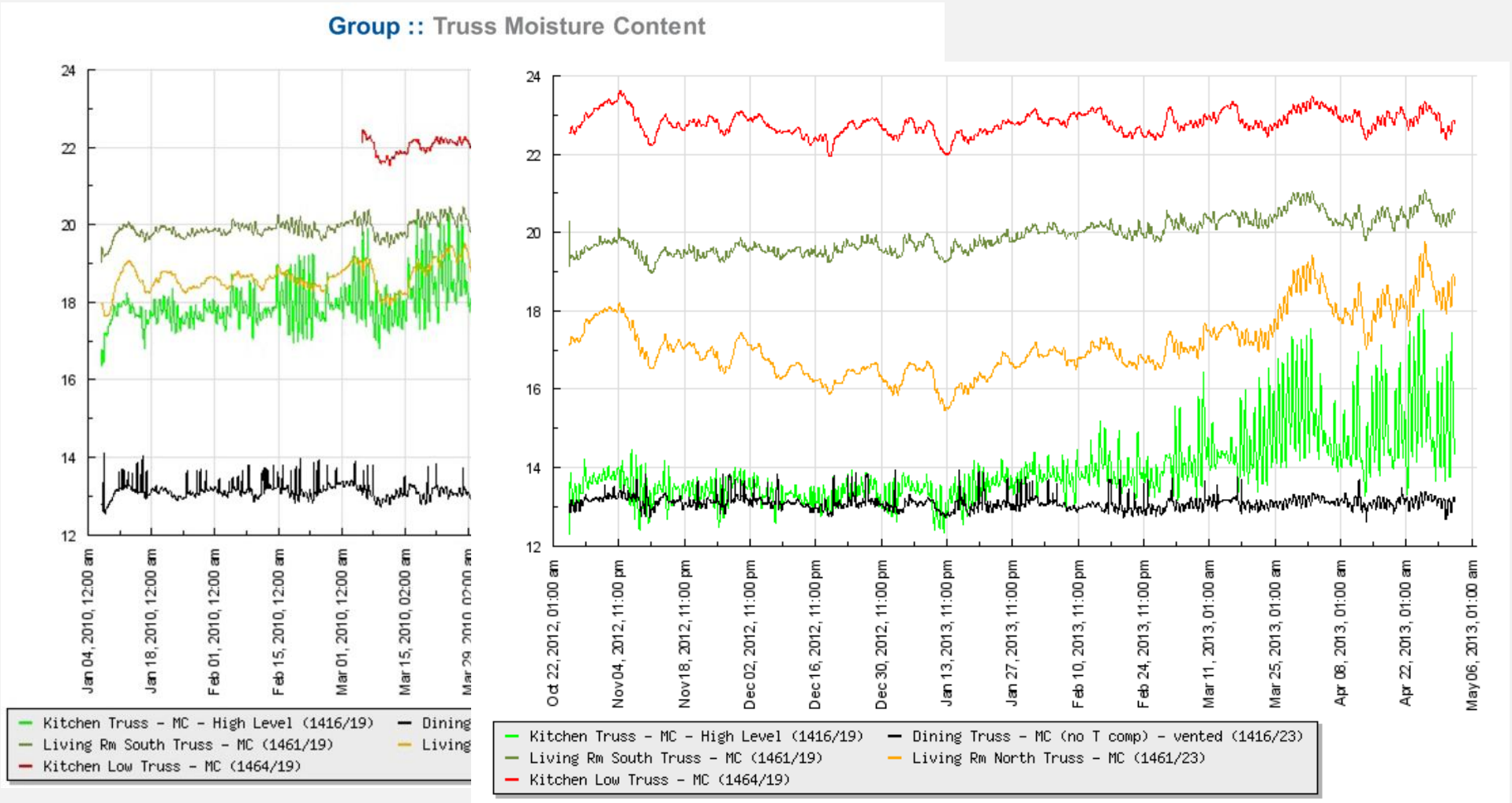

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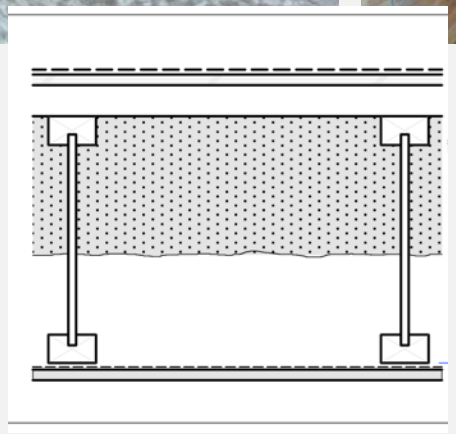
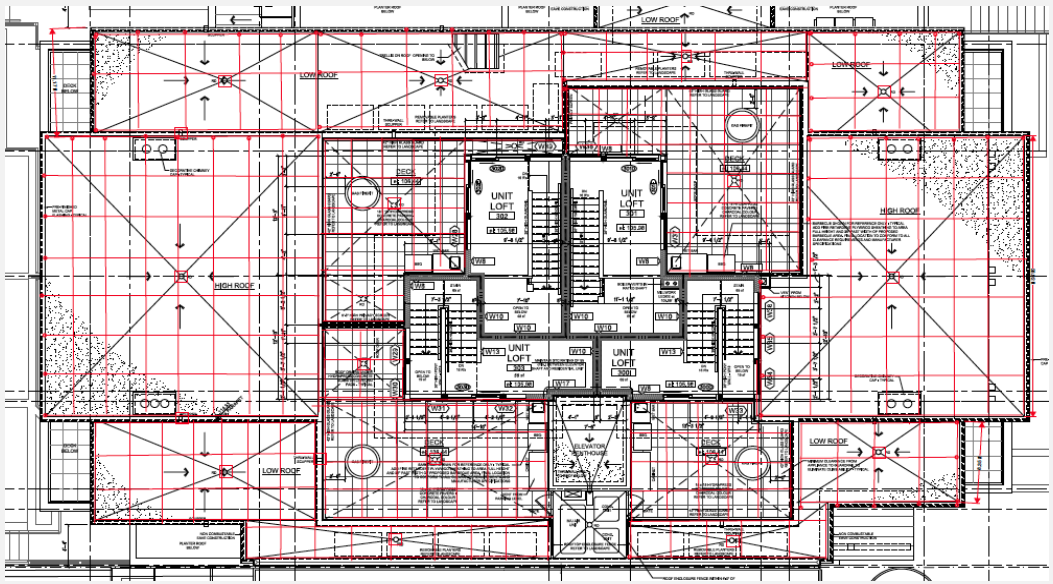
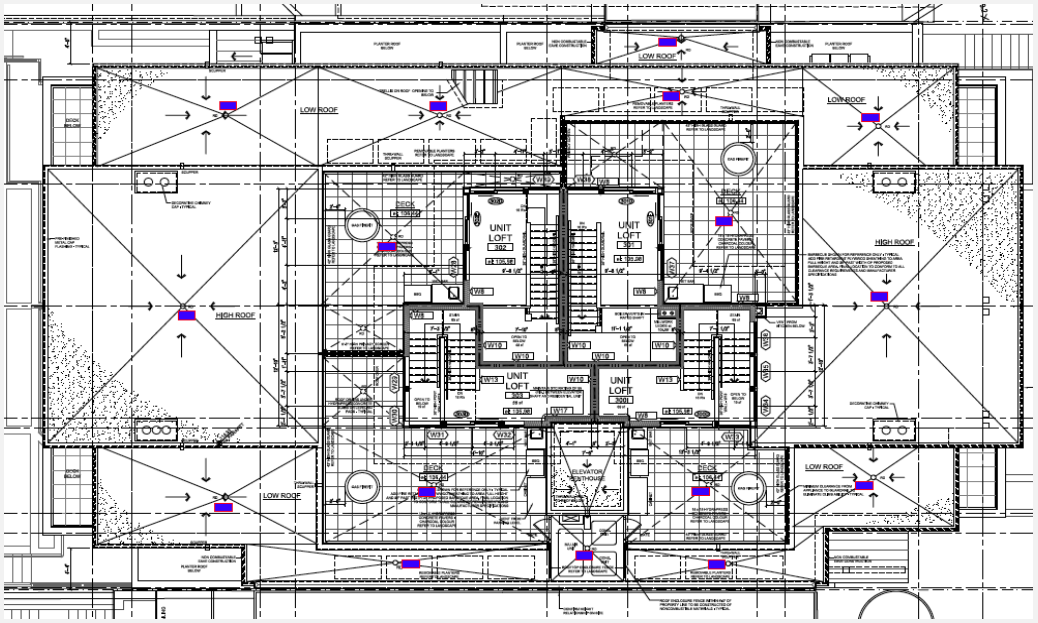
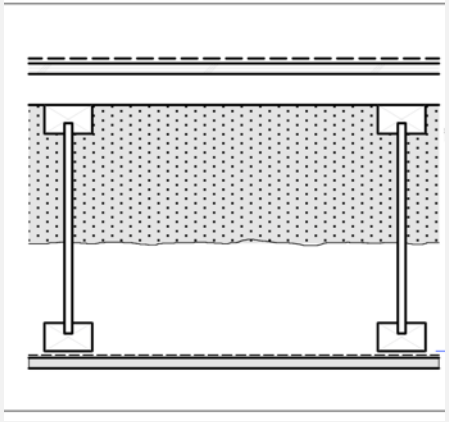


# ROOF INVESTIGATION



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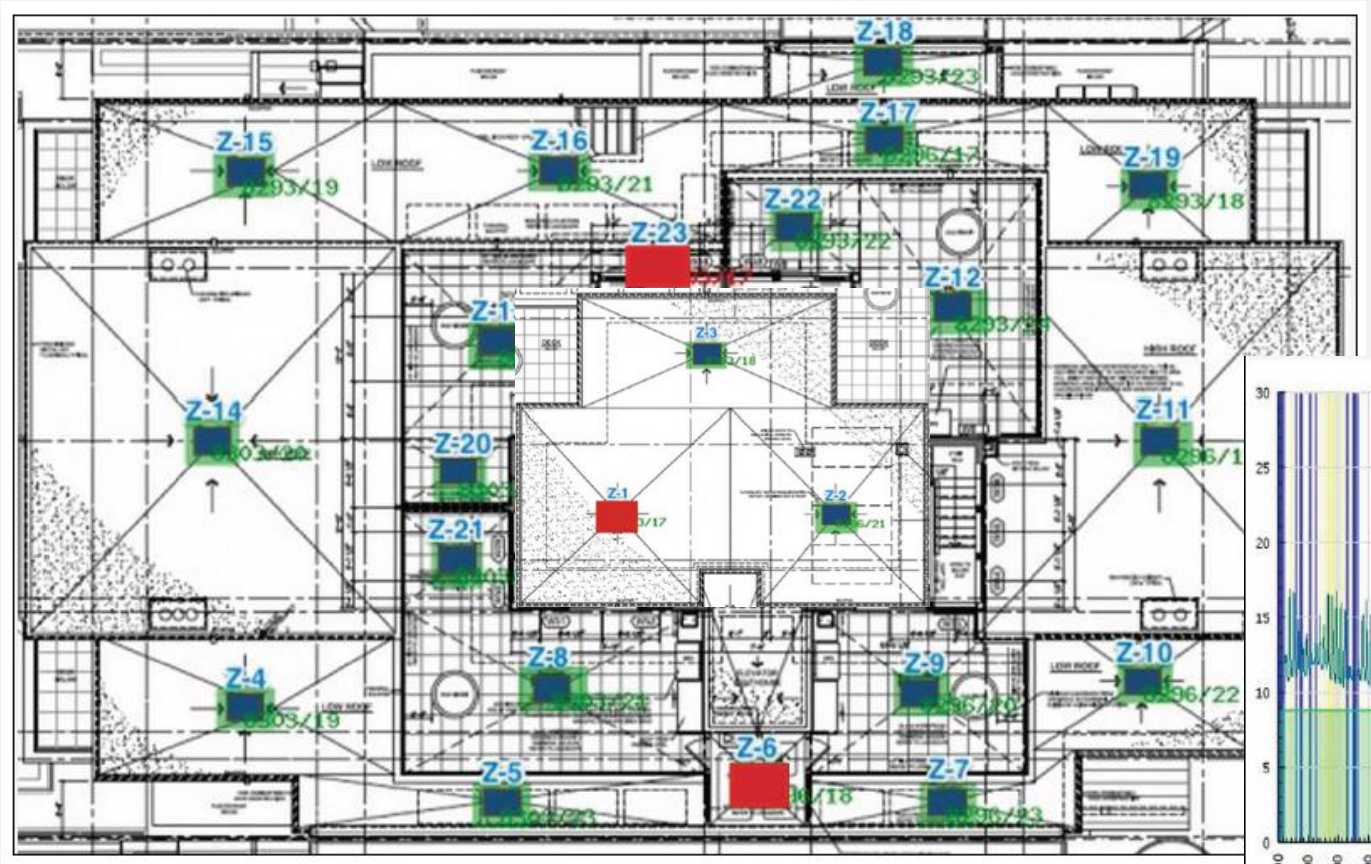


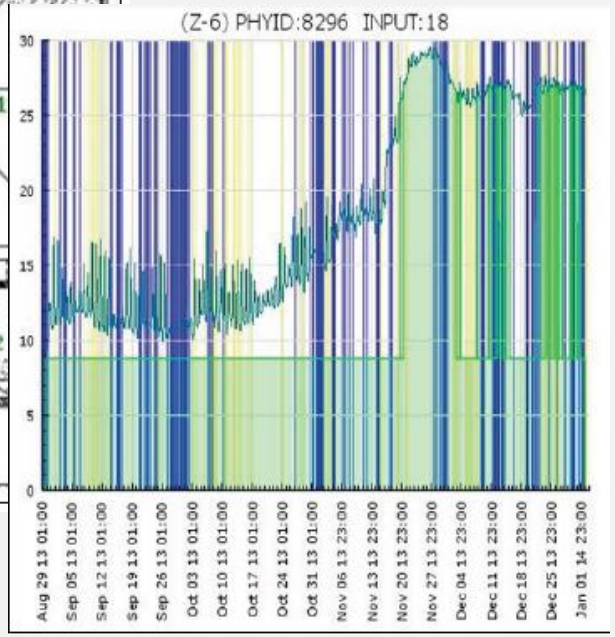

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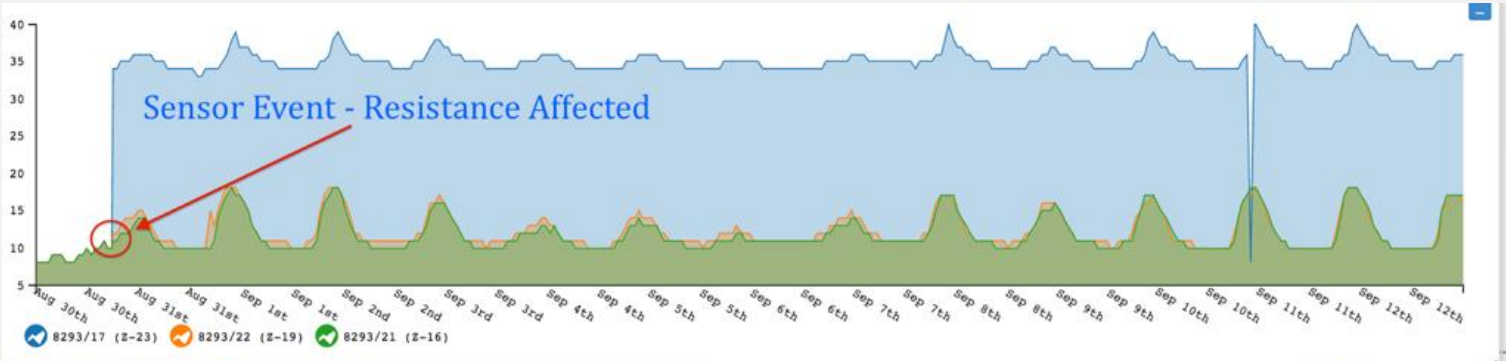


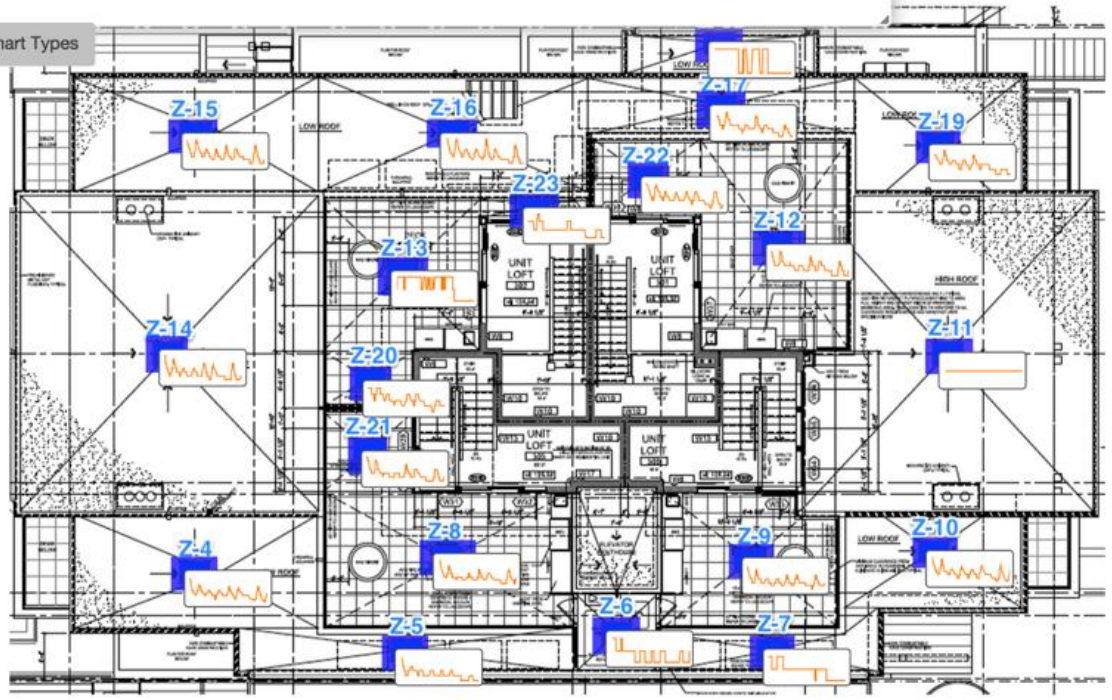

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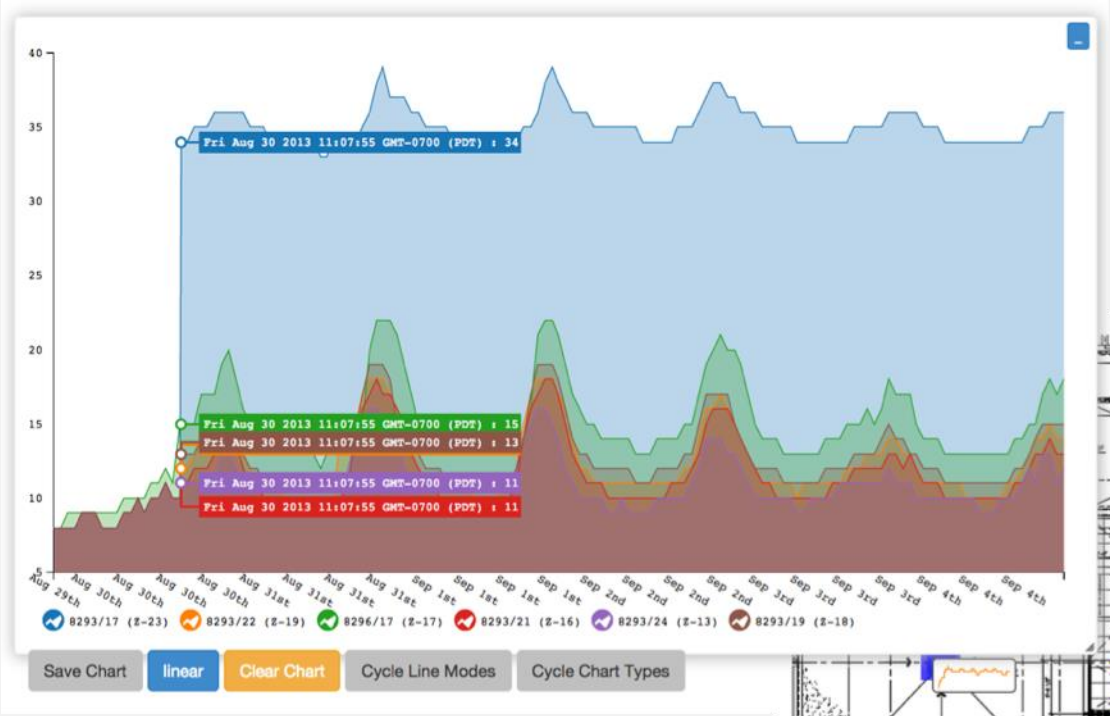
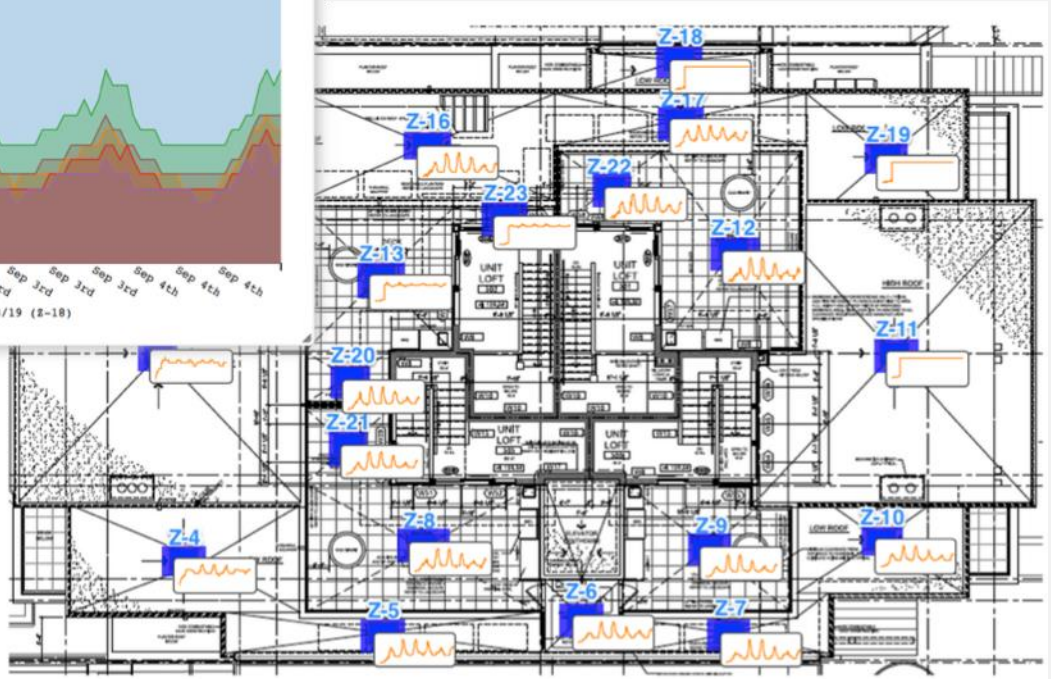
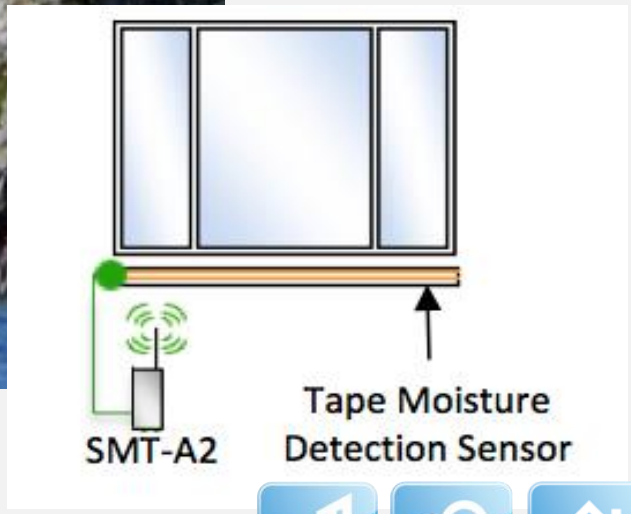
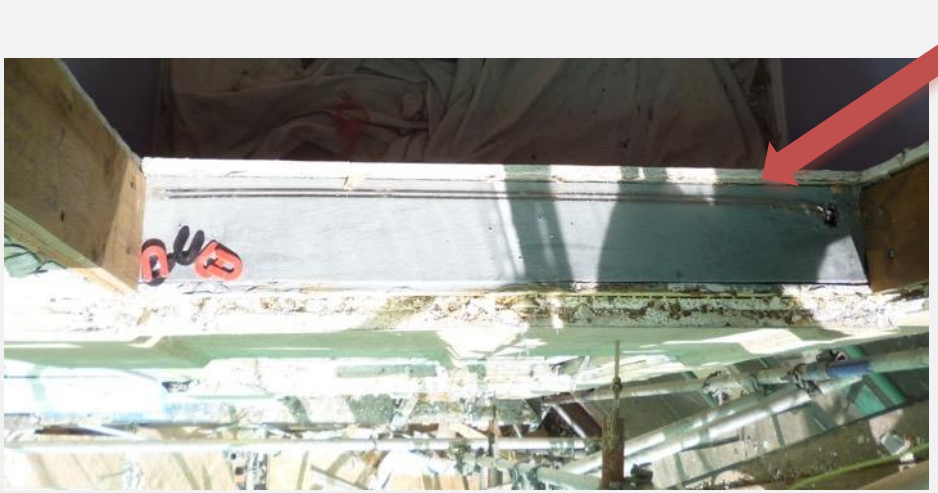


# WINDOW MONITORING



# WINDOW MONITORING




# BUILDING INTELLIGENCE - Investigations

**Exterior Conditions:**
**- Solar radiation**
**- Glass temperature**
**- Weather station data**

**Interior Conditions:**
**Rh/T, Radiation, Duct Pressure, Supply Temp, Lights On/Off, Curtain Status,Interior Glass T**

# BUILDING INTELLIGENCE - Investigations

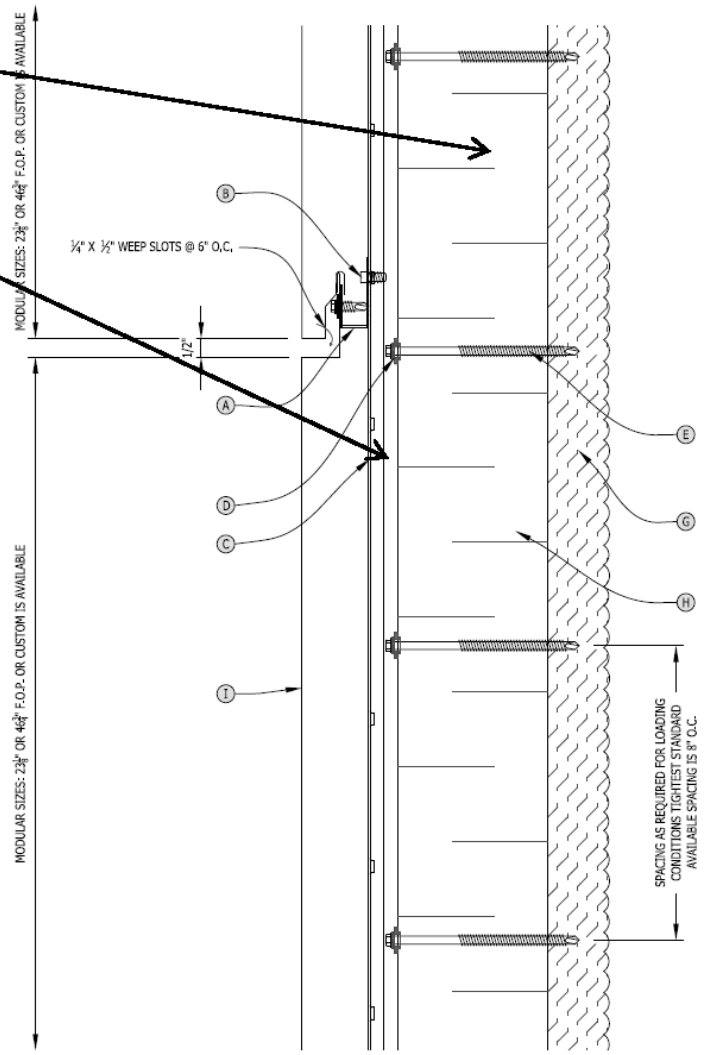


25psi = 3600psf

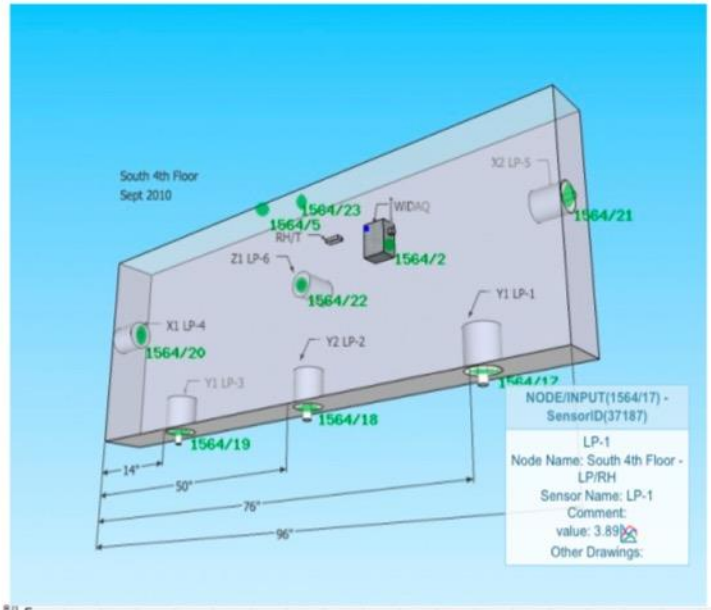
Exterior furring strips transfer gravity and wind load through foam

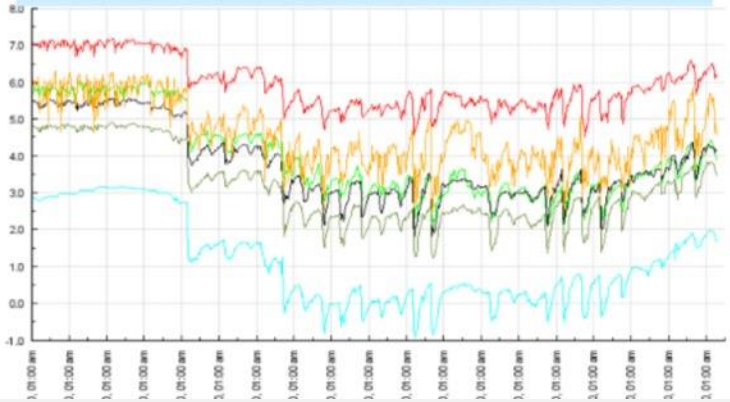
Loads are transferred through exterior frame or cladding to foam resulting in compression load on the foam and tension load on the fastener.

Shear load similar to conventional attachment.

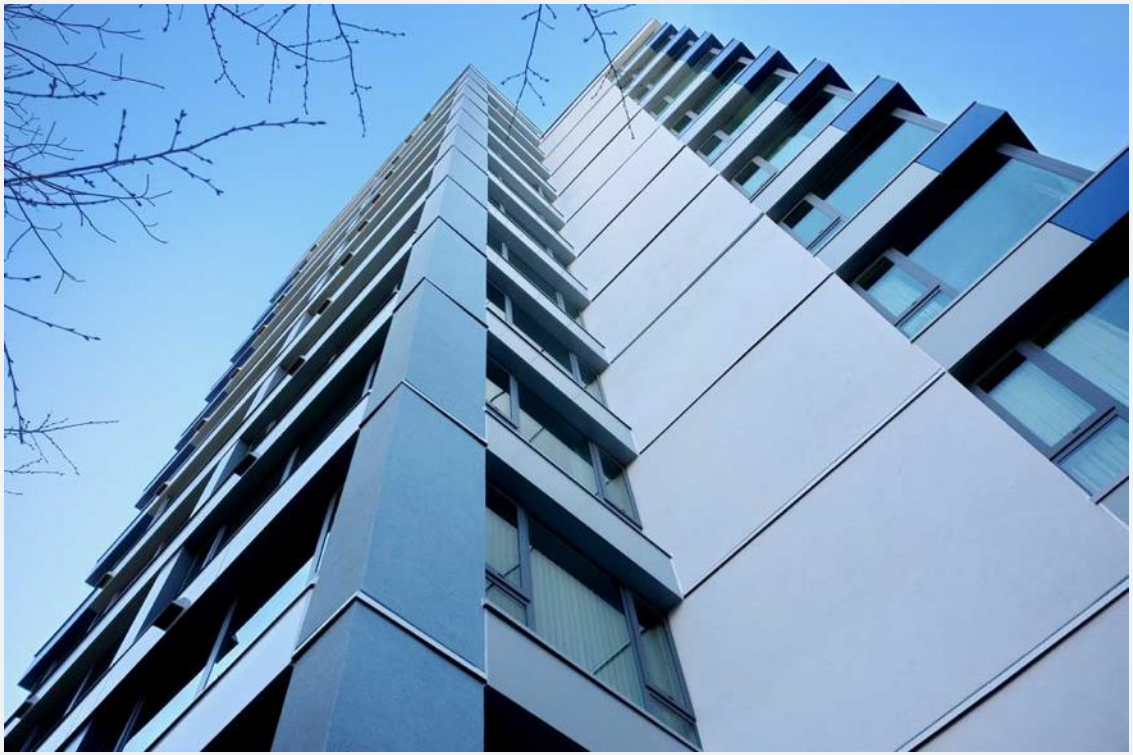


# EXTERIOR INSTALLATIONS



# SENSOR PRESSURE



- Differential Pressure sensors with 0.1Pa resolution
- Wireless CO2 sensors capable of measuring 0-5000ppm
- RH/T sensors used both indoor and outdoors
- Pulse Counting sensors for measuring energy usage
- Temperature monitoring for measuring when the gas fireplaces were turned on/off
- Exterior weather station used to correlate climatic events with internal sensor readings

# SENSOR PRESSURE

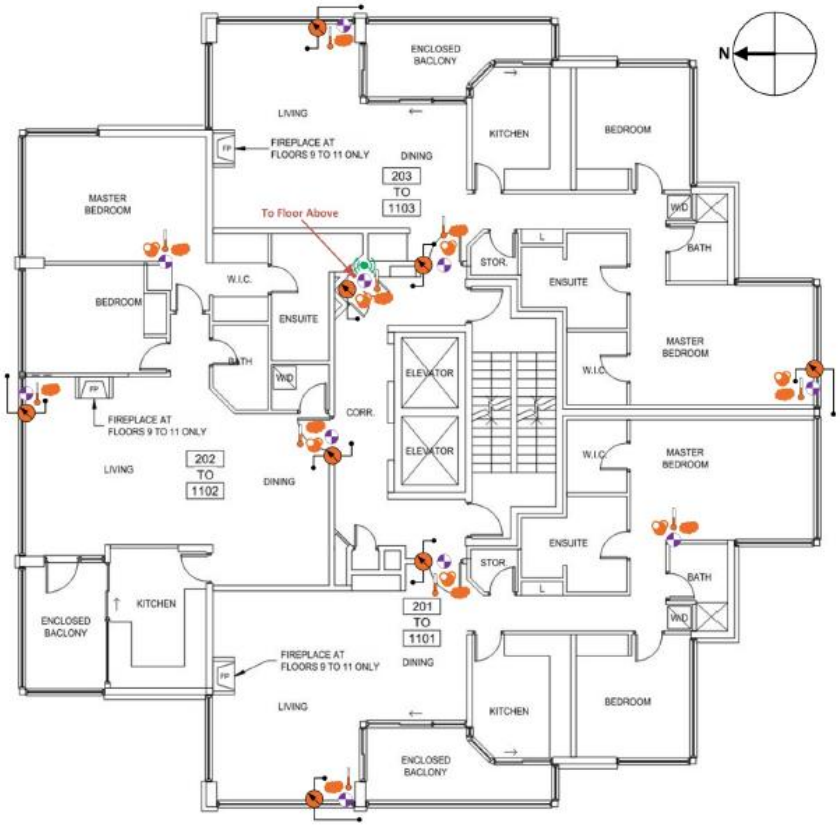



Figure 7-27: Floor plan showing layout of monitoring equipment for Floors 3 and 11


**Figure 7-26: Legend of symbols used for interpretation of Figure 7-27 and Figure 7-28**

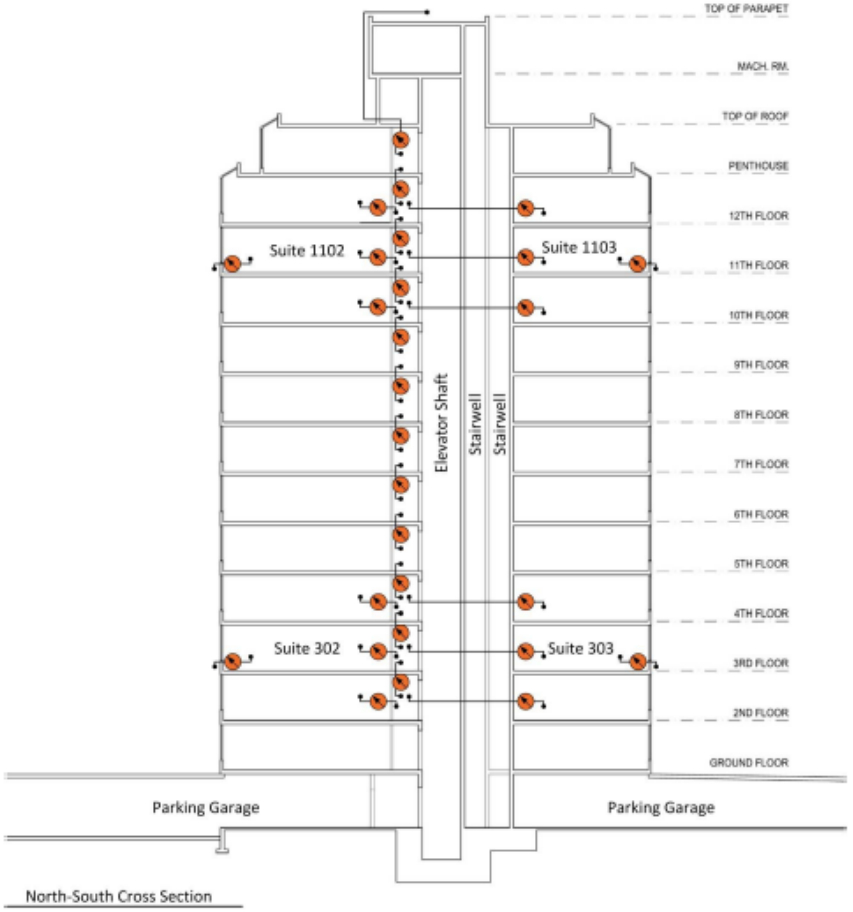



**Figure 7-28: North-south cross-section of the case study building illustrating how the pressure measurements are linked**

# SENSOR PRESSURE

- Pressure Differences across exterior building enclosure
- Pressure Differences from the corridors to the suites
- Pressure Differences across floors and ceiling to the zones above and below
- Pressure Differences between adjacent suites
- C02 Concentration & Dew Points in ventilation air, corridors and suites
- Exterior Temperature
- Wind Speed and Direction

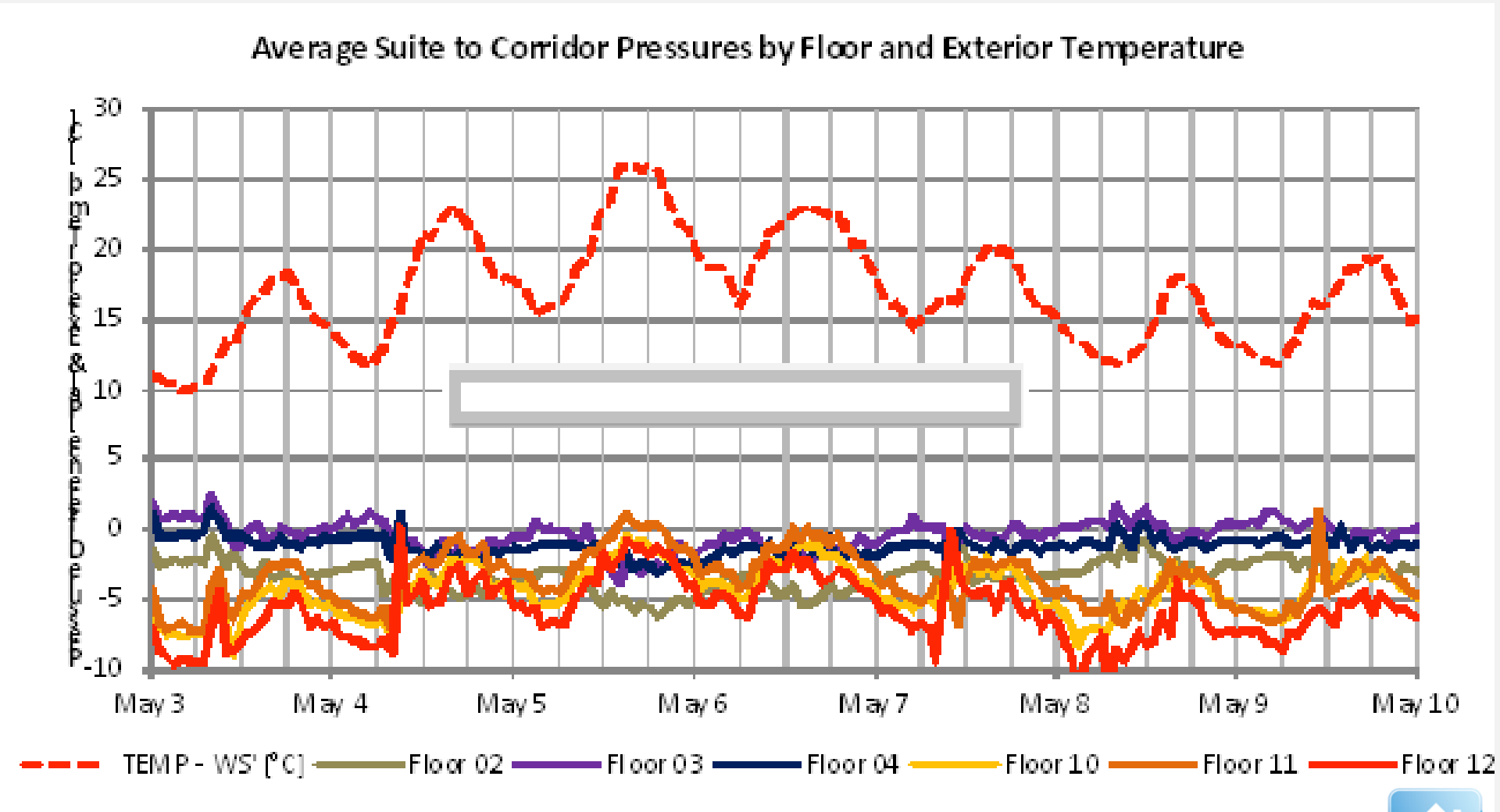
Figure 7-23: Typical SMT-A3 unit being installed in a wall above a suite entrance door

Figure 7-24: Typical data acquisition unit installed above a suite entrance door

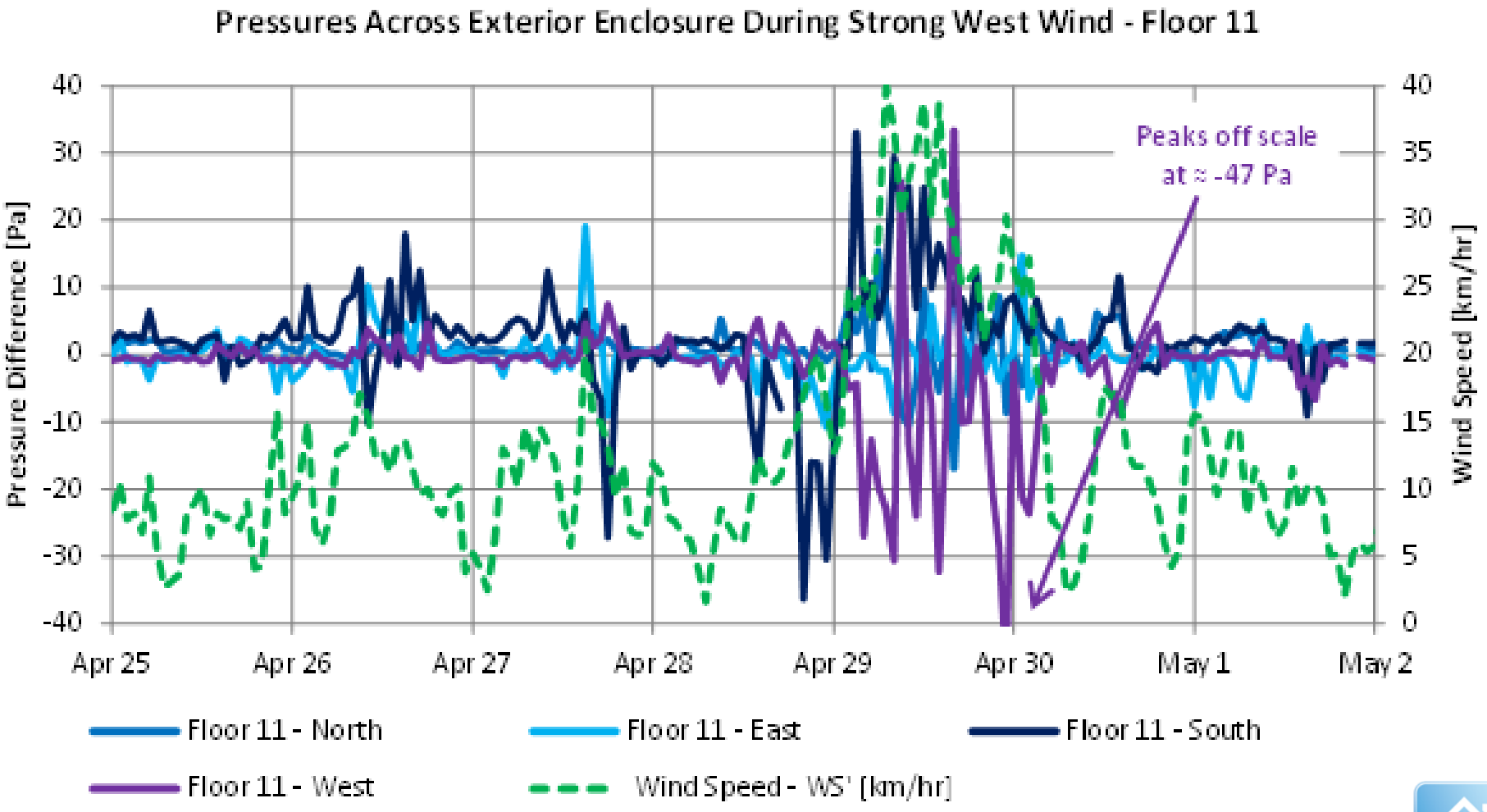
Figure 7-25: Typical exterior pressure tap configuration

# SENSOR PRESSURE

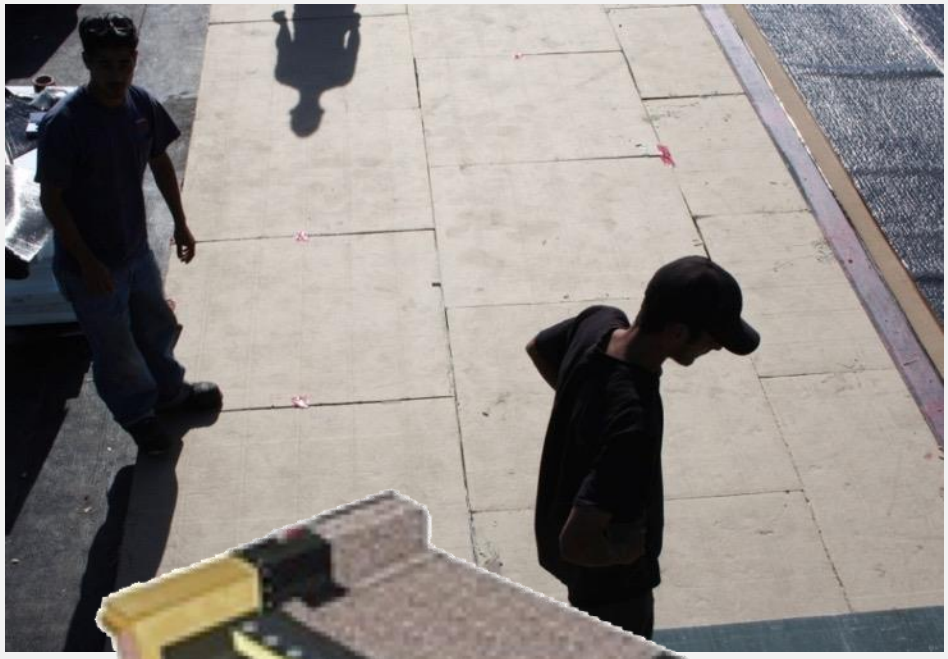
# SENSOR PRESSURE

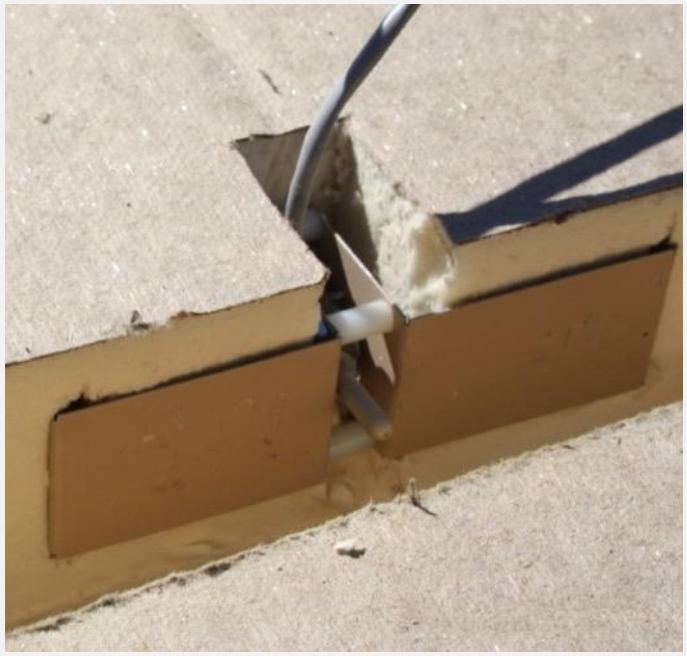


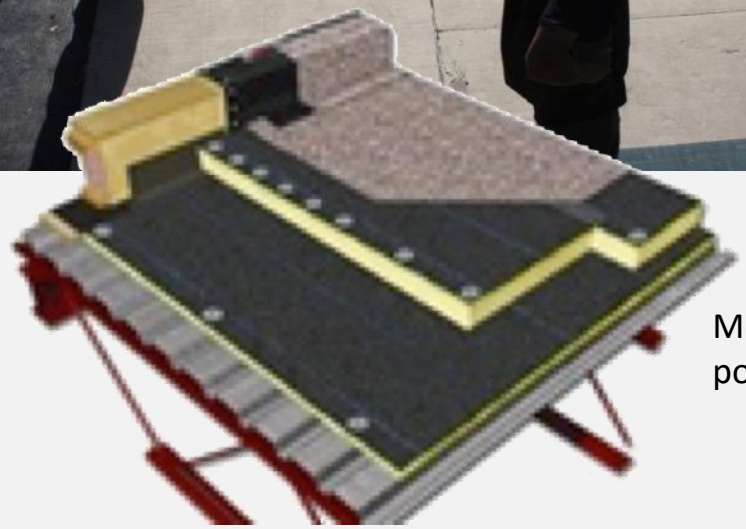
# SENSOR PRESSURE



# ROOF INVESTIGATION

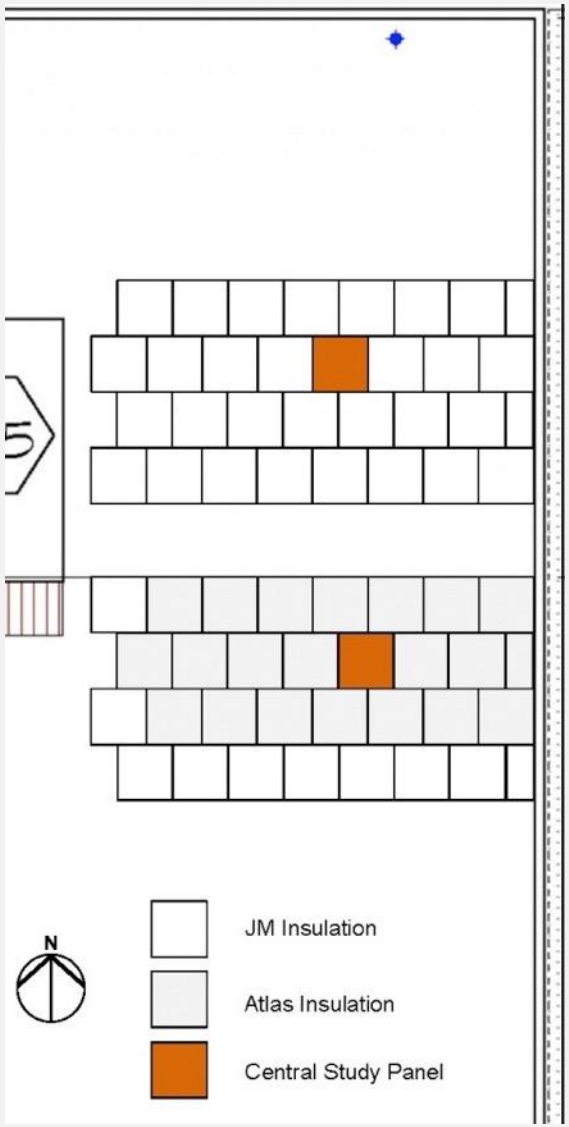


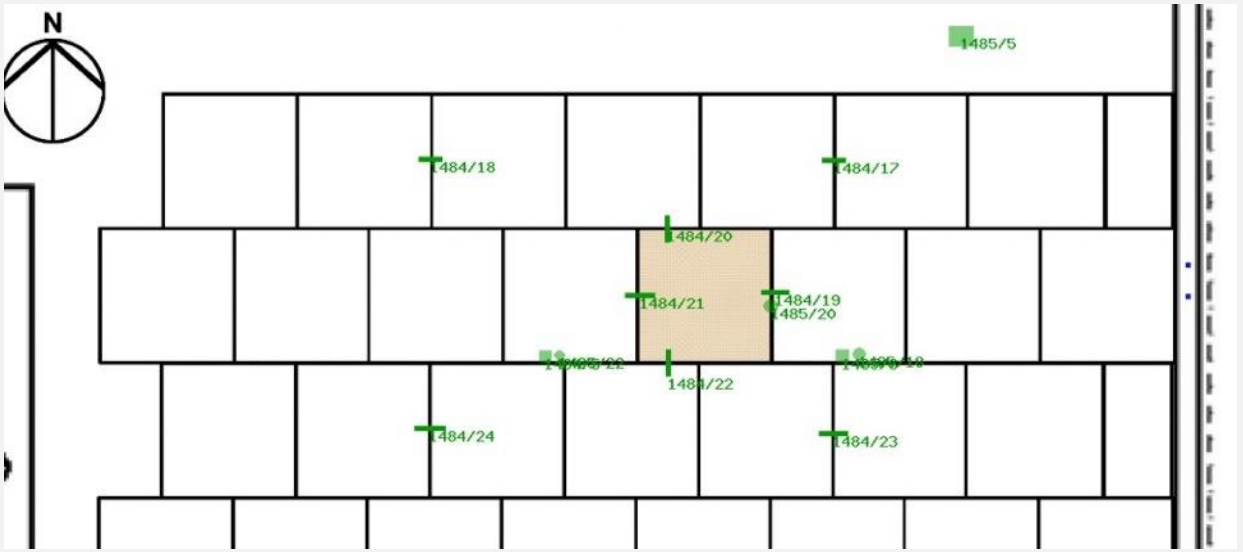


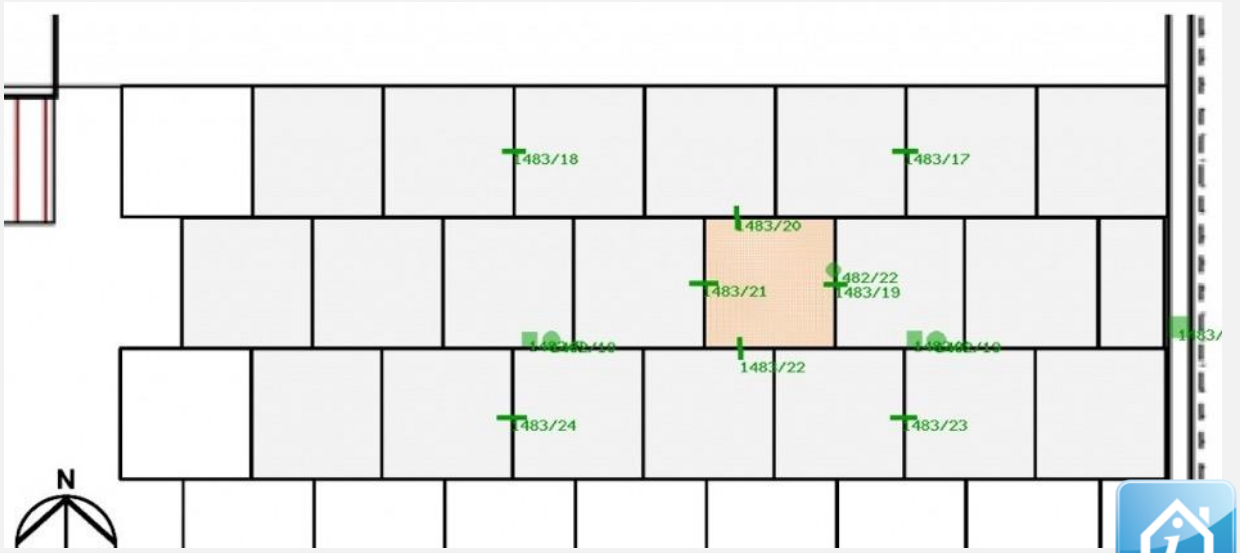


Measure conditions leading to dimensional change in polyiso roof insulation.

# ROOF INVESTIGATION

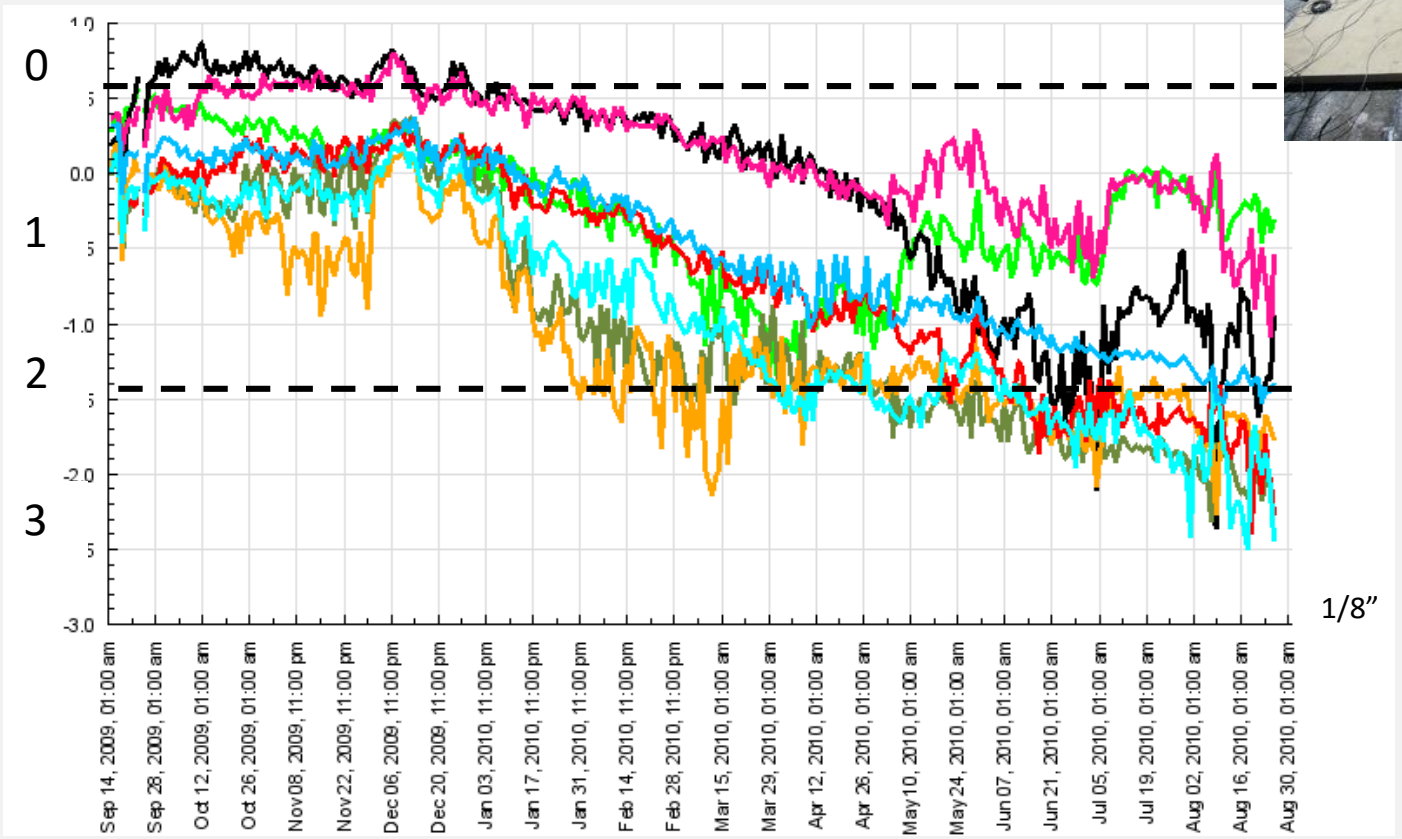


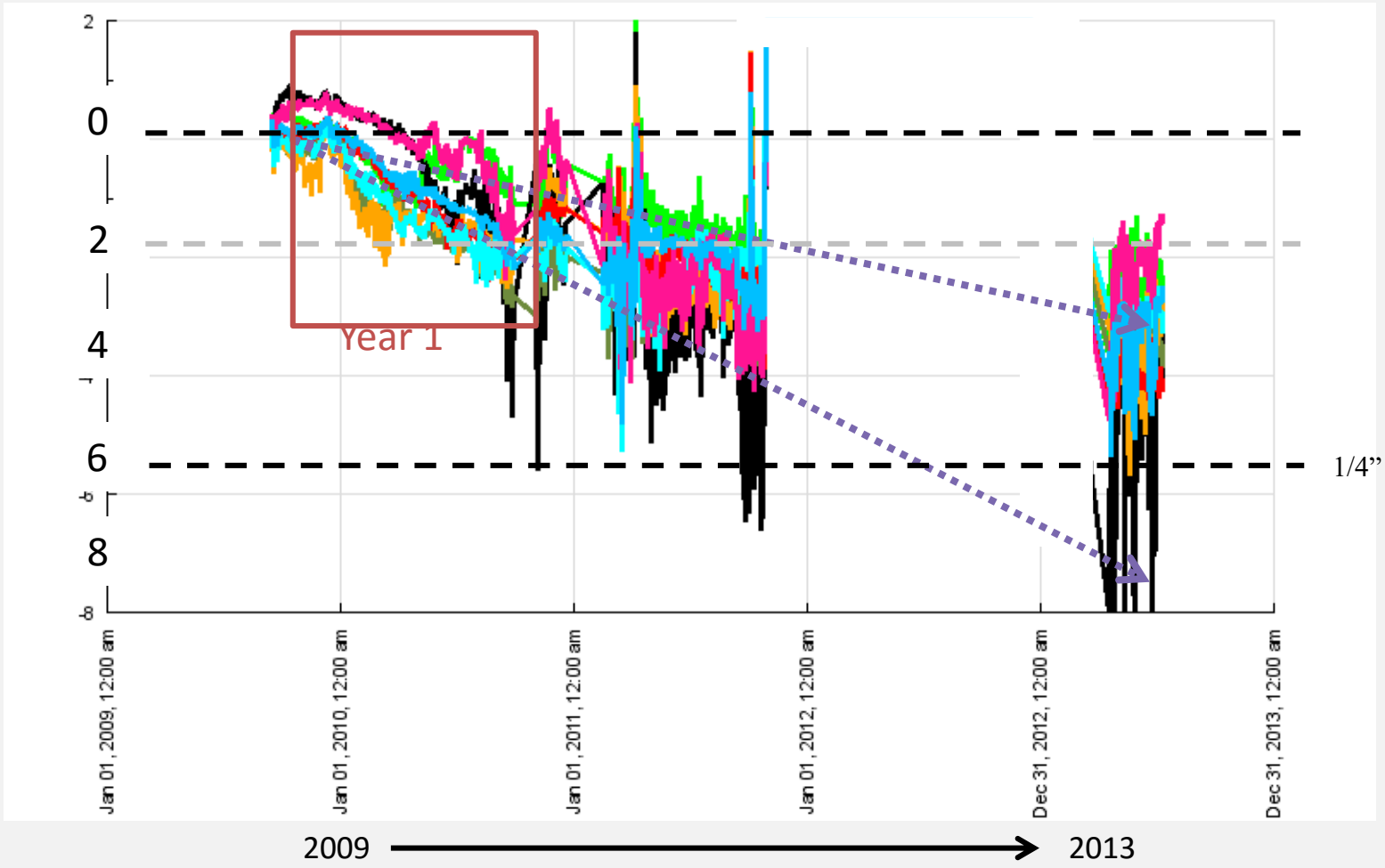
# ROOF INVESTIGATION

- Year 1 – 0.2% (2 mm in 1200 mm)

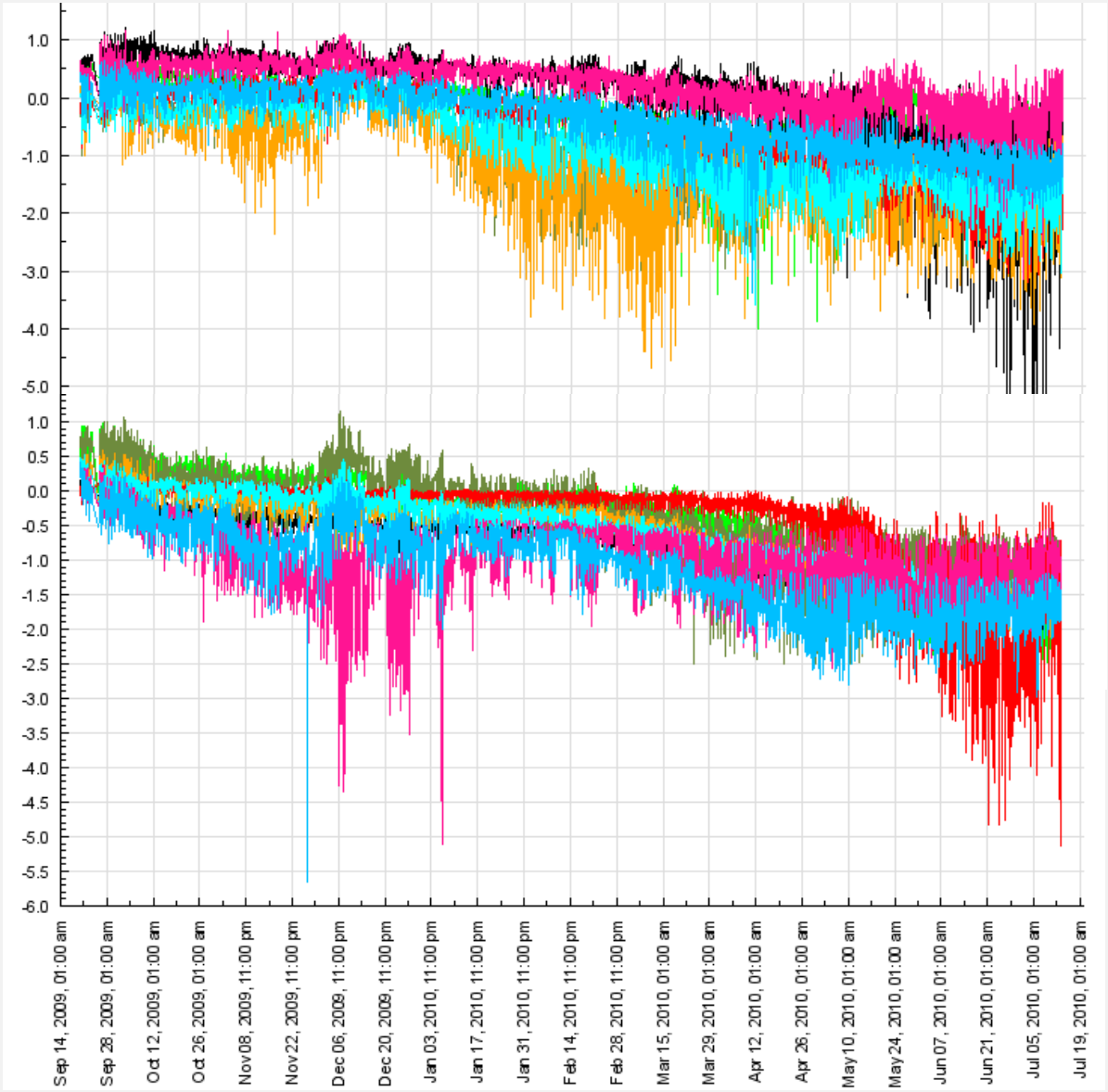


# ROOF INVESTIGATION

- Year 4 – 0.2% to 0.7% (2-8 mm in 1200 mm)

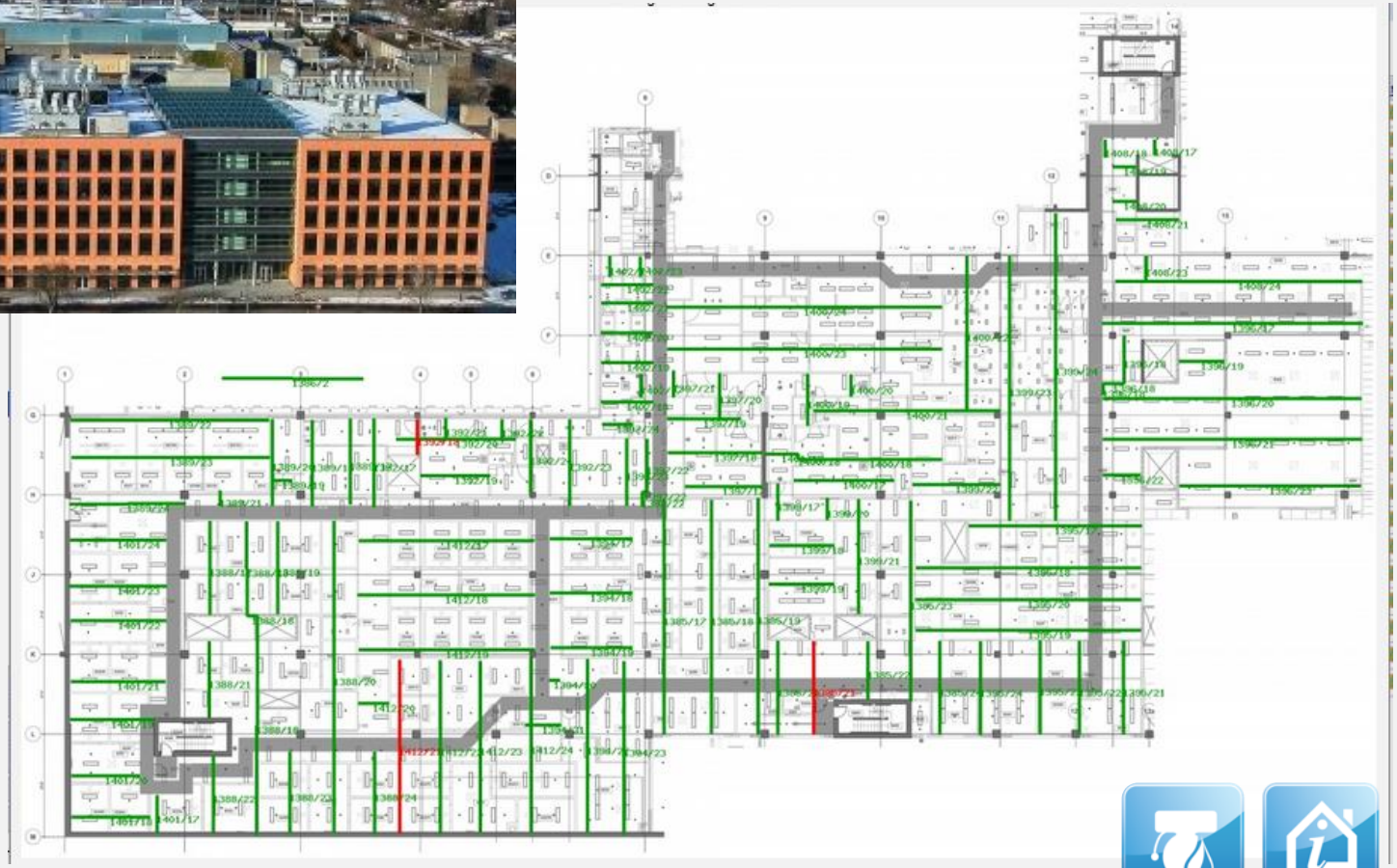


# ROOF INVESTIGATION

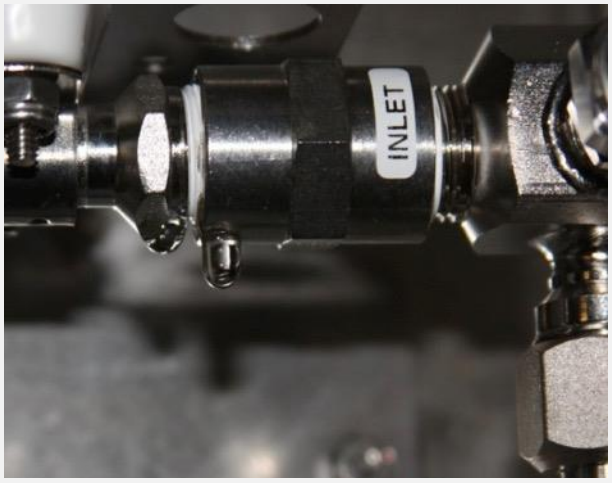


# FLOOD MONITORING

UBC Life Sciences Centre
Interstitial Floor Flood Monitoring



# FLOOD MONITORING




# BALCONY INVESTIGATION

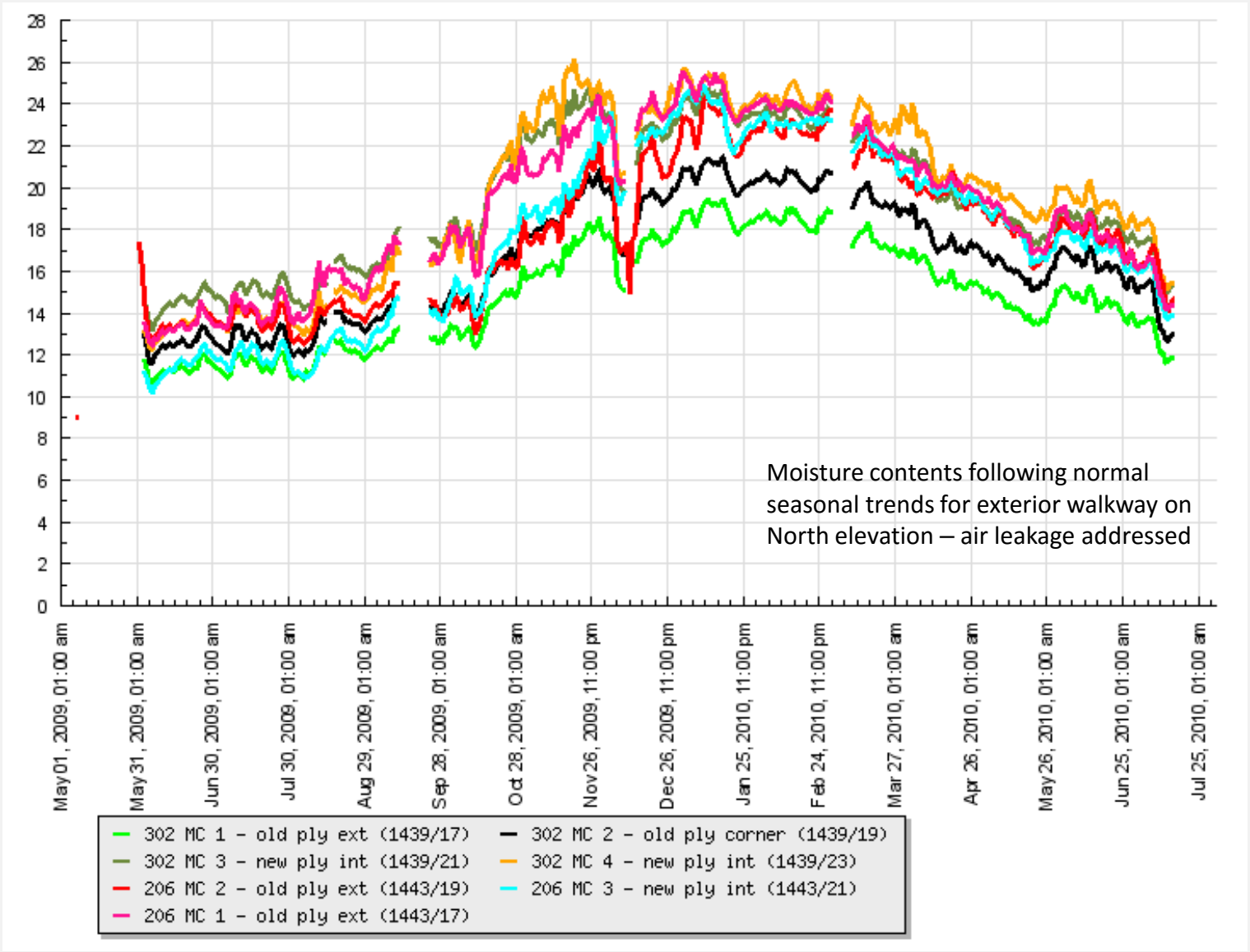
- Air leakage from suites leaking into exterior walkways of a wood frame building caused widespread damage.
- Rehabilitation to repair wood framing and air-seal joist spaces from interior.
- North facing walkway – low drying potential if leaks do occur.

# BALCONY INVESTIGATION

# BALCONY INVESTIGATION

- Walkway Repair & Verification using moisture content monitoring.
- Sensors installed at locations of severe damage and at control locations.

# BALCONY INVESTIGATION

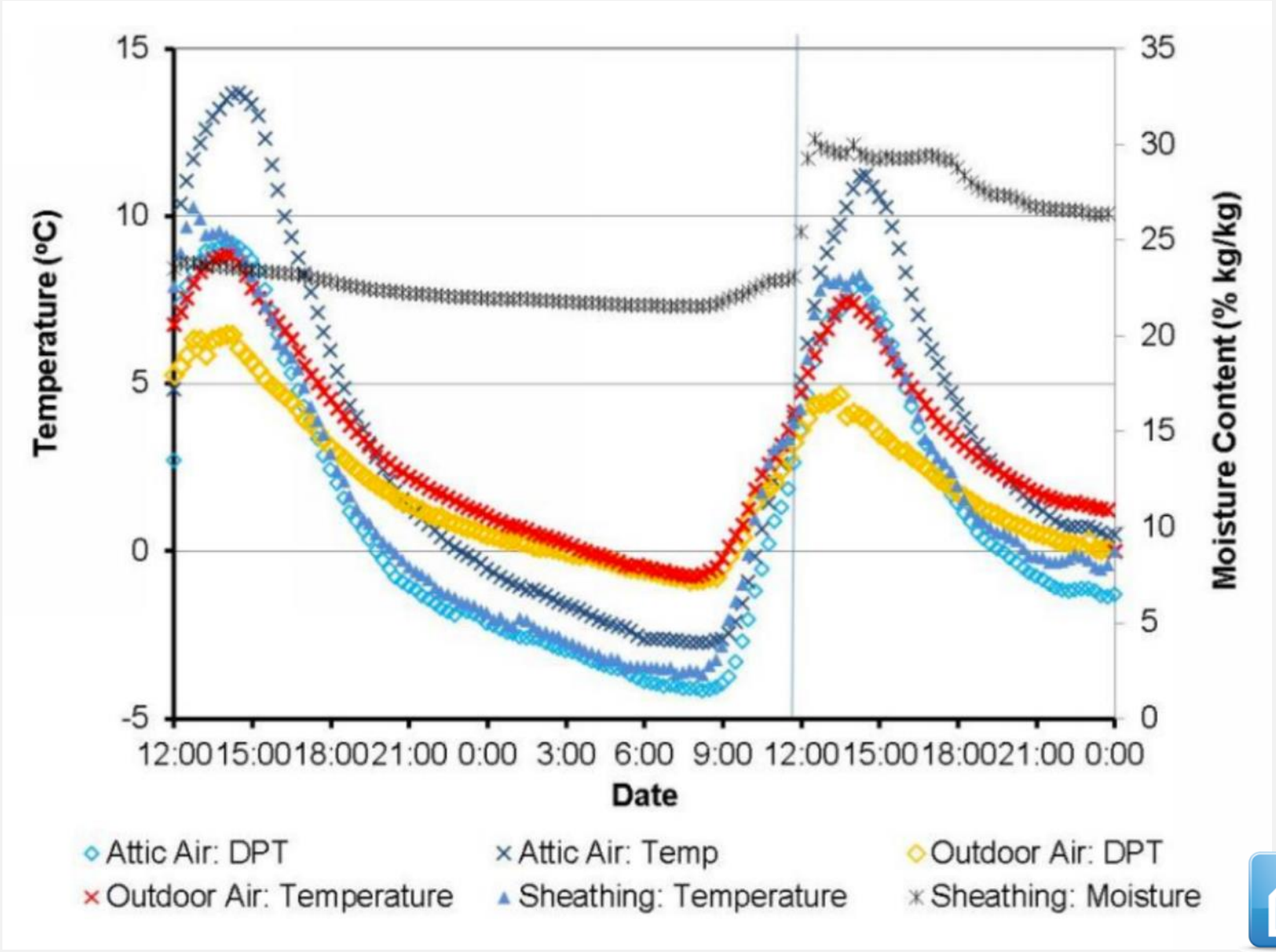



Moisture contents following normal seasonal trends for exterior walkway on North elevation – air leakage addressed

# ATTIC MOISTURE

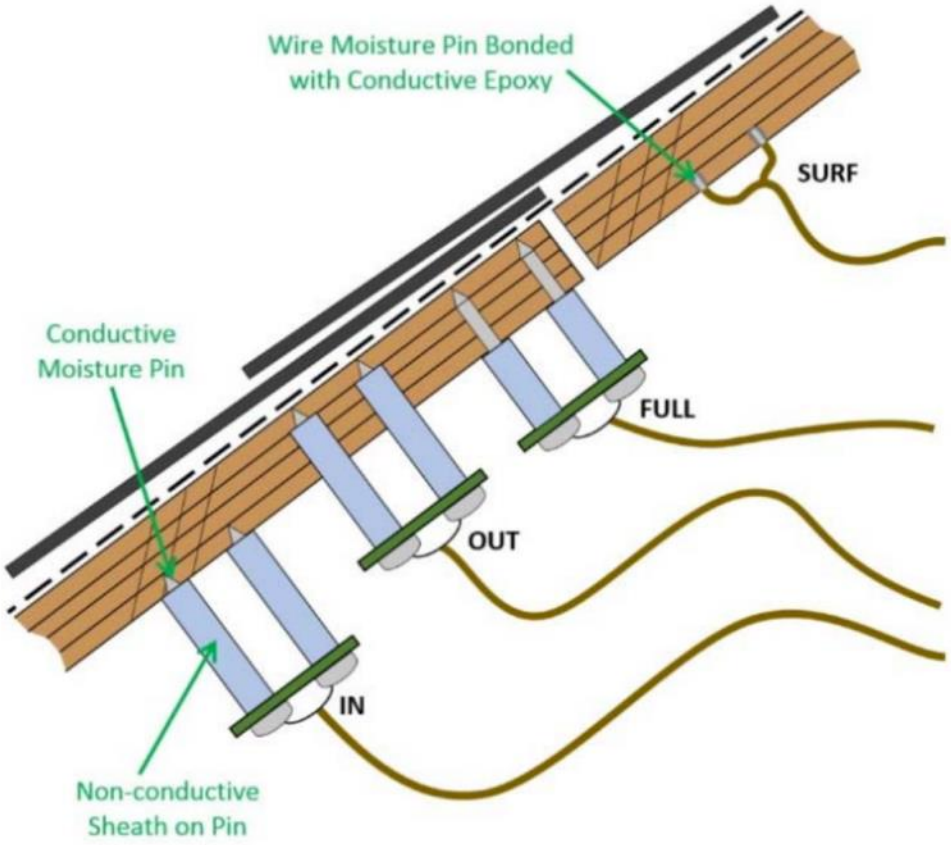
# ATTIC MOISTURE

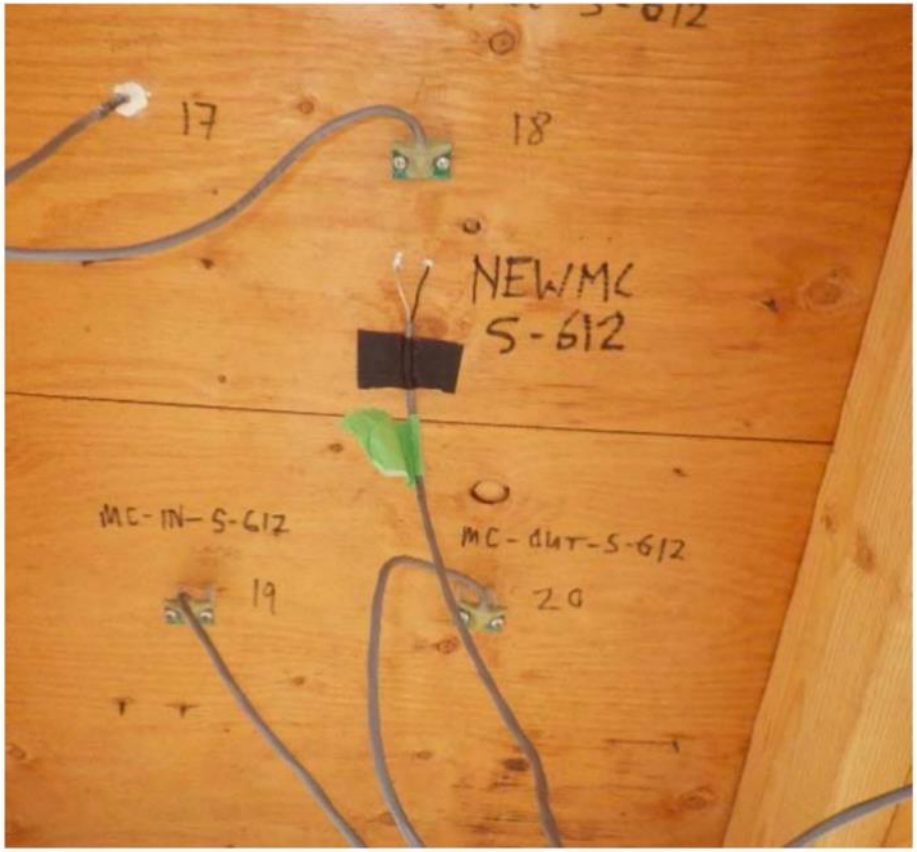
# ATTIC MOISTURE



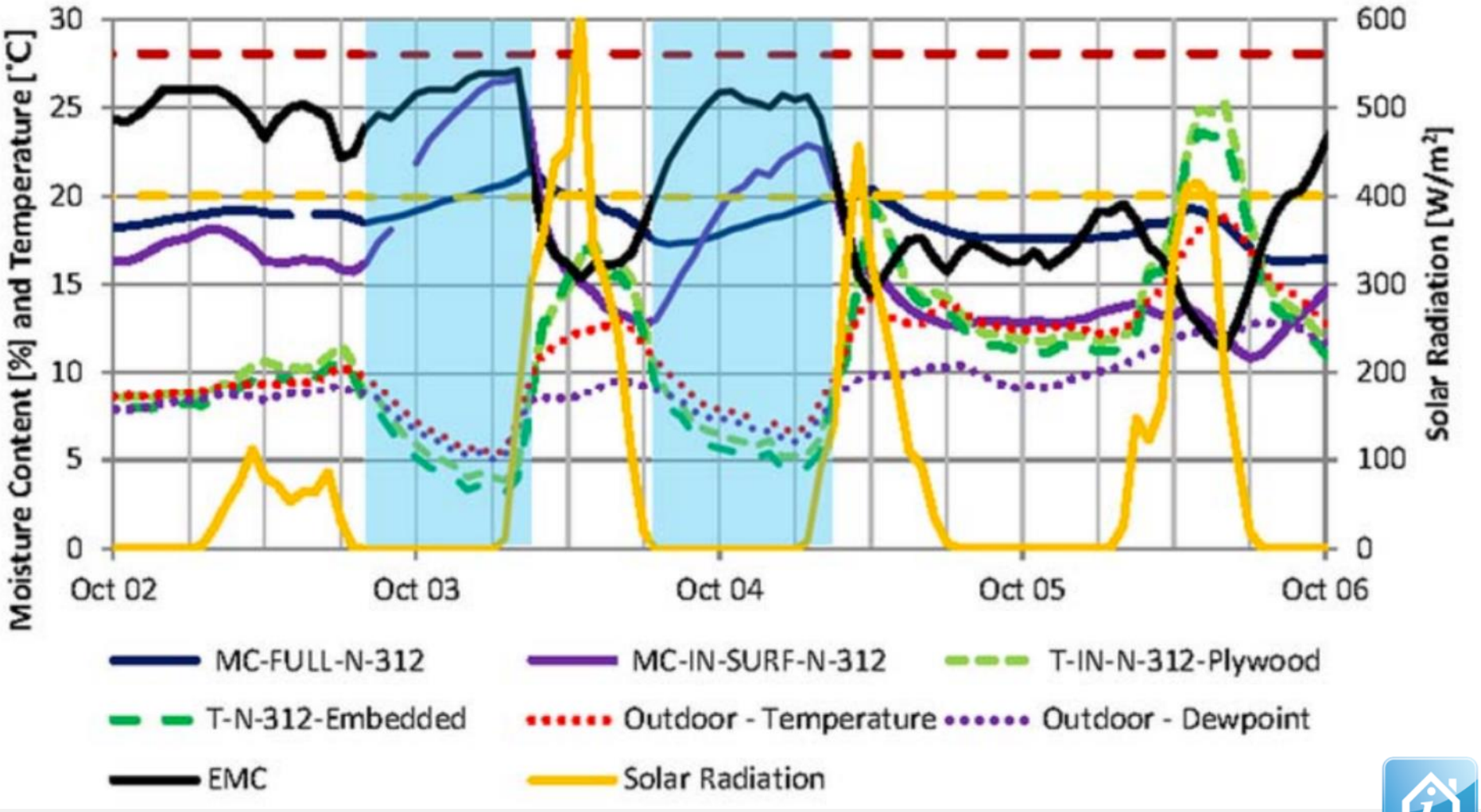
# ATTIC MOISTURE

# ATTIC MOISTURE



# ATTIC MOISTURE



# WALL MONITORING

# WALL MONITORING

# WALL MONITORING

# WALL MONITORING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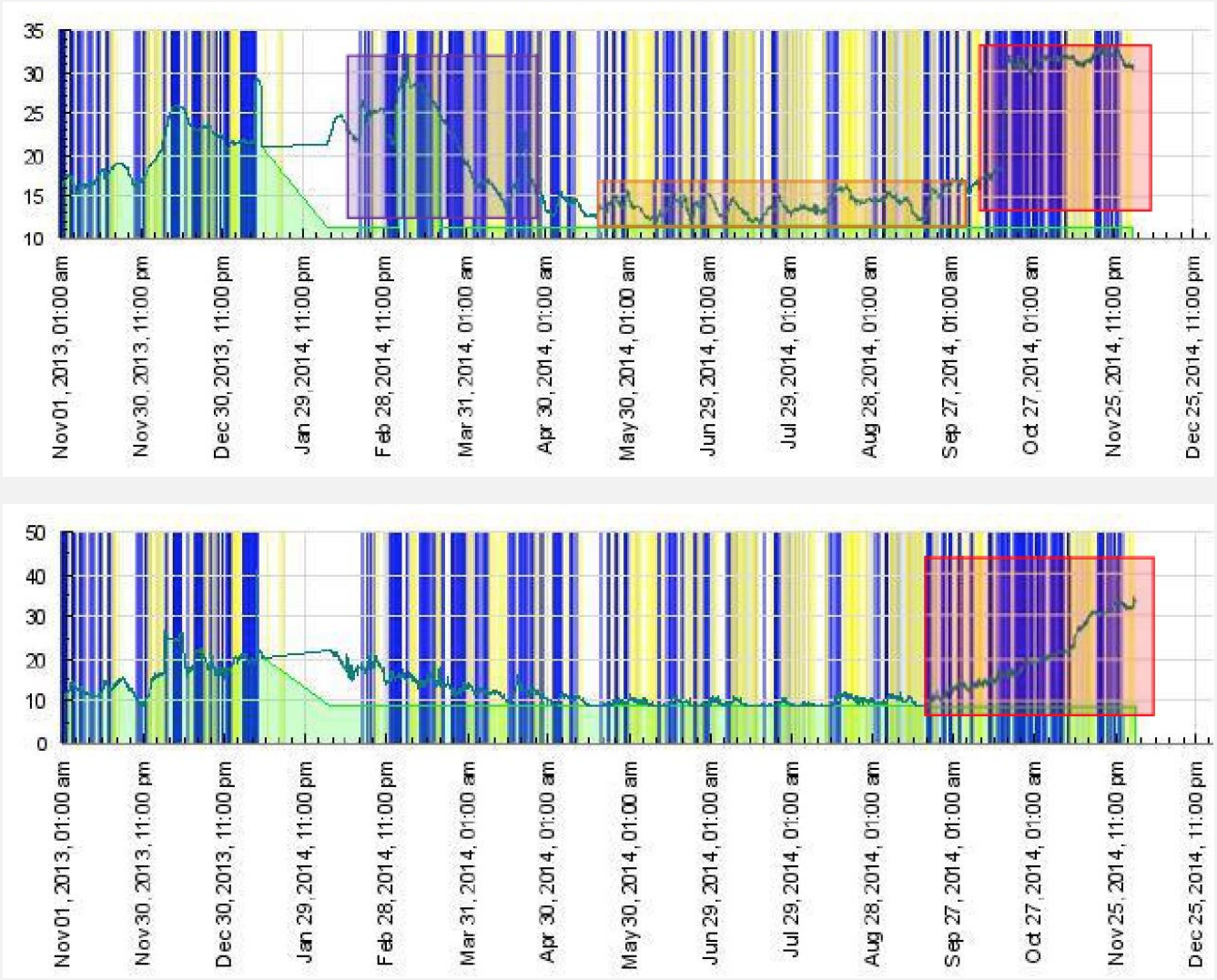
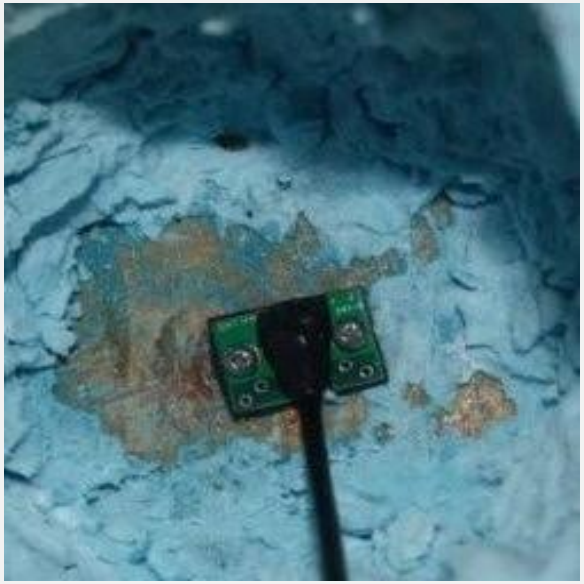


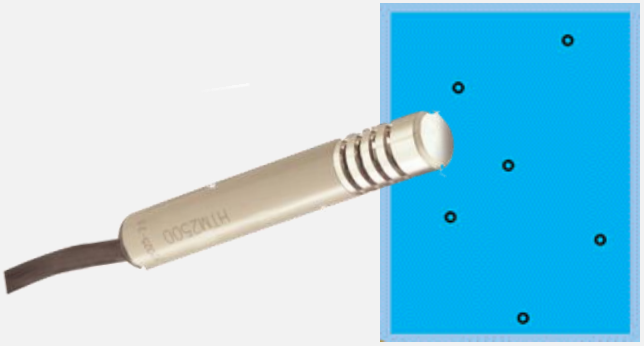


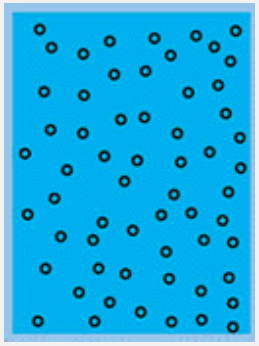
*Figure 3: Sensors having elevated moisture content in the 2nd floor of Townhouse 108.*

# WALL MONITORING

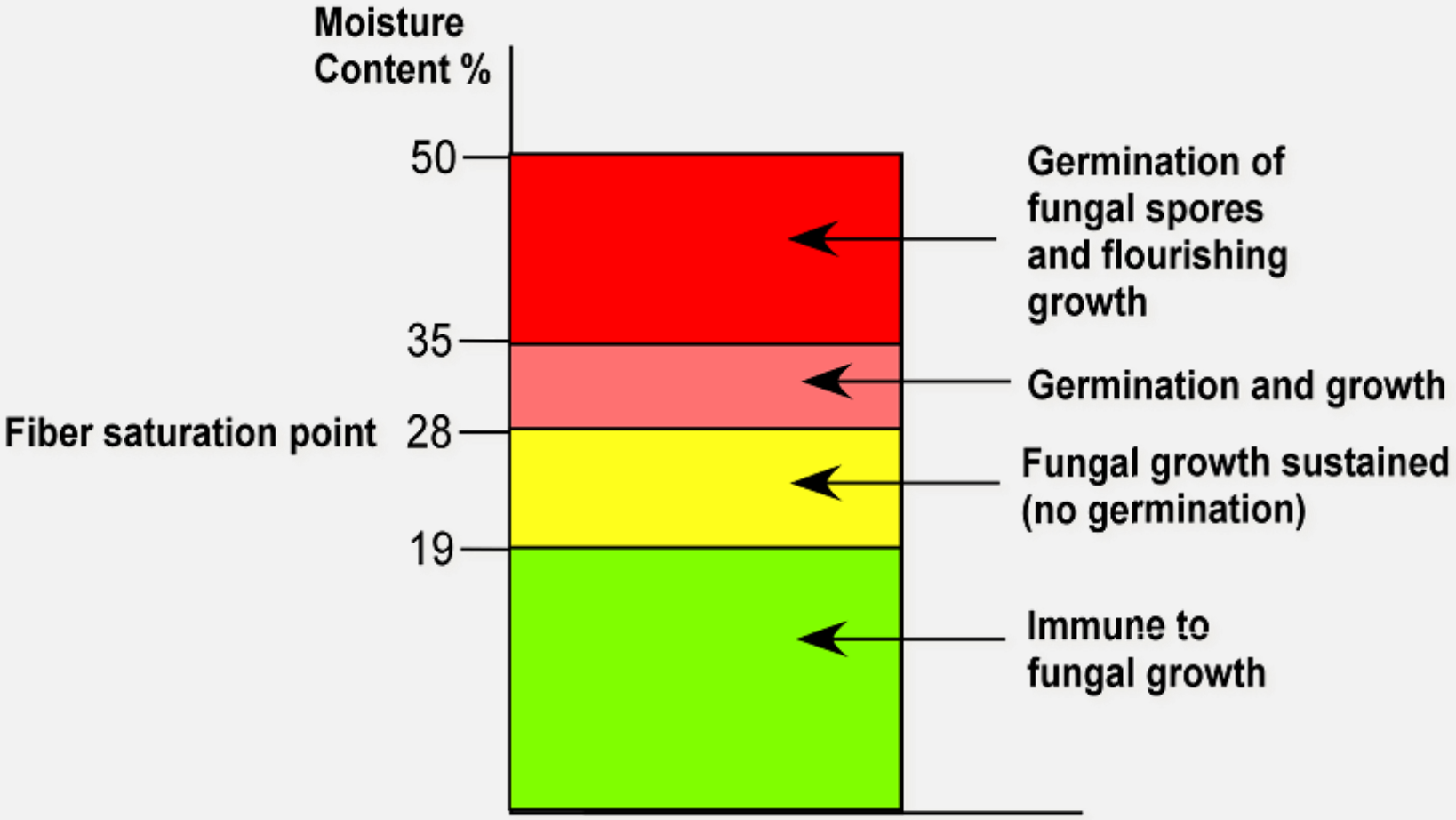
# MOISTURE SENSORS







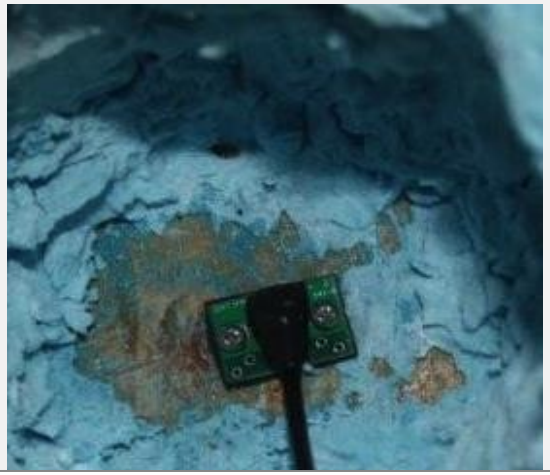
| RH Air | 20% | 40% | 60% | 80% | 95% | $H_20$ → | | |
|---|---|---|---|---|---|---|---|---|
| MC Wood[1] | 4.5% | 7.7% | 11% | 16% | 24% | 30% | 35% | >40% |
| MC Gypsum | 0.1% | 0.5% | 0.75% | 1% | 2% | 4% | >6% | |
| MC Sandstone | <0.5% | <0.75% | <1% | 1.75% | 2% | | | |



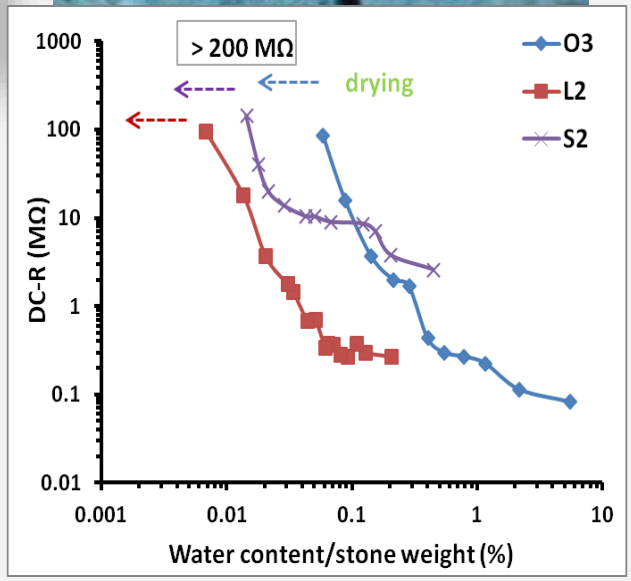

Fungal Growth in Wood (CMHC)

# POINT MOISTURE SENSOR

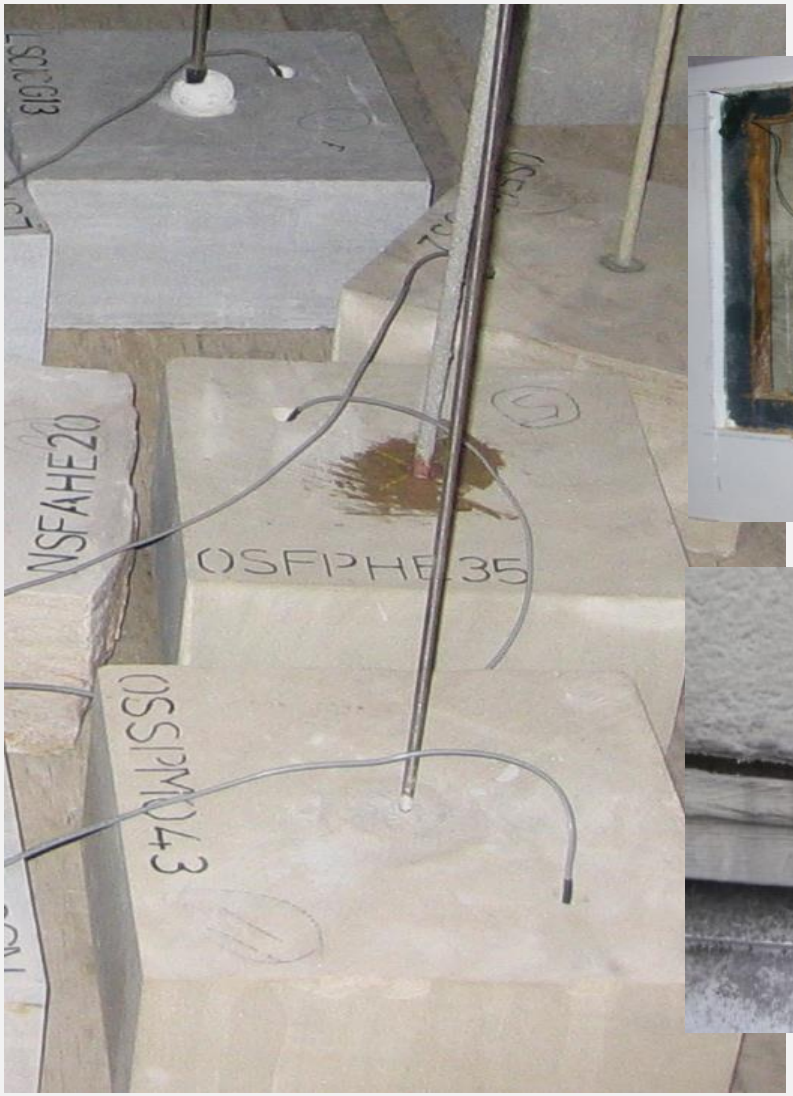

Photo courtesy Delmhorst



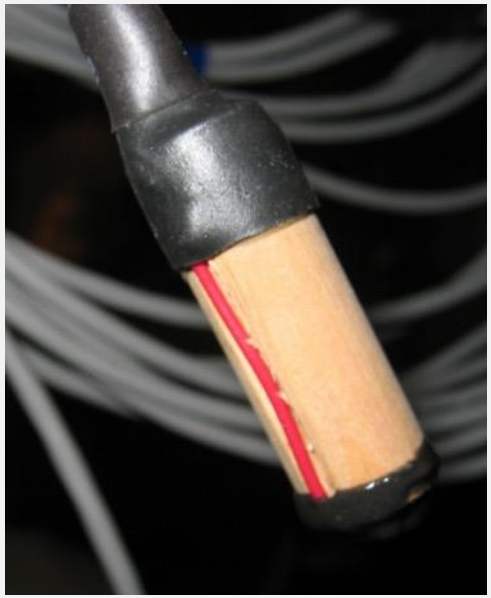
hambers at the University of Manitoba



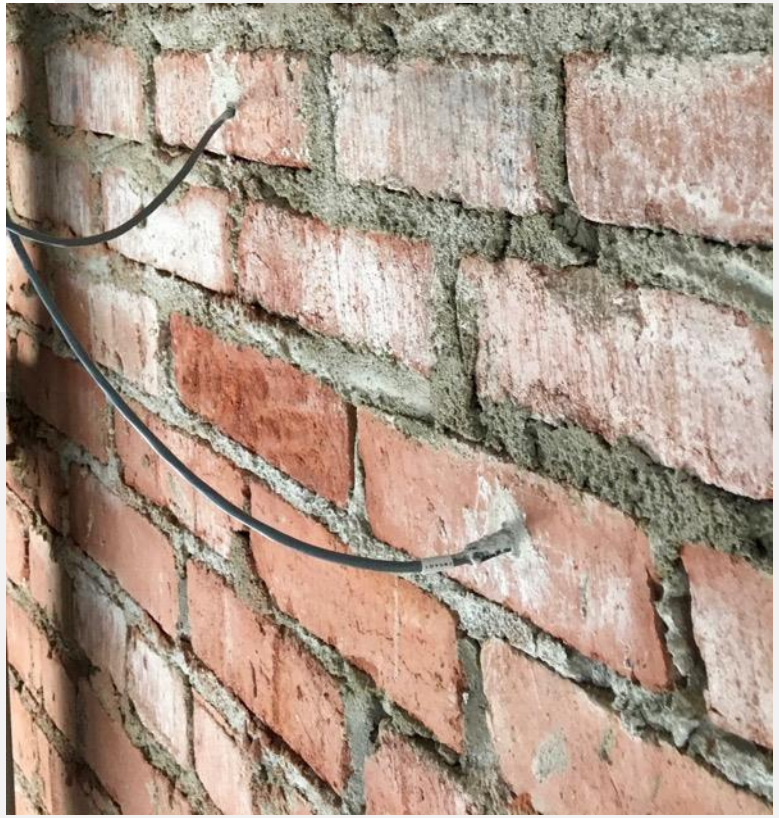
# EMBEDDED MOISTURE SENSOR



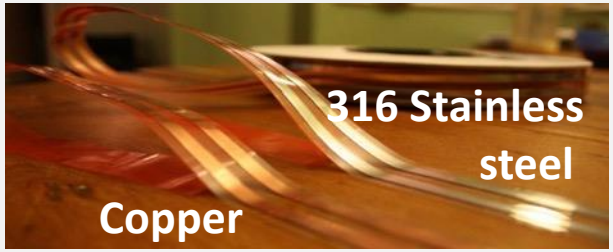

- Research Grade
- Integrated Temprature
- Moisture Content & Level
- Wood, Gypsum, Insulation, Concrete, Masonry



# EMBEDDED MOISTURE SENSOR



# LINEAR MOISTURE SENSORS




- Presence of moisture
- Wide coverage area
- Limited accurancy

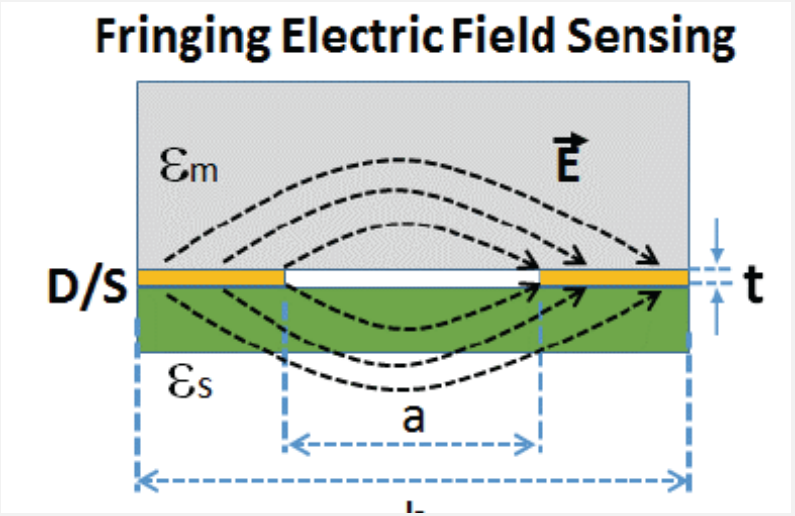
**WALL**

**ROOF**

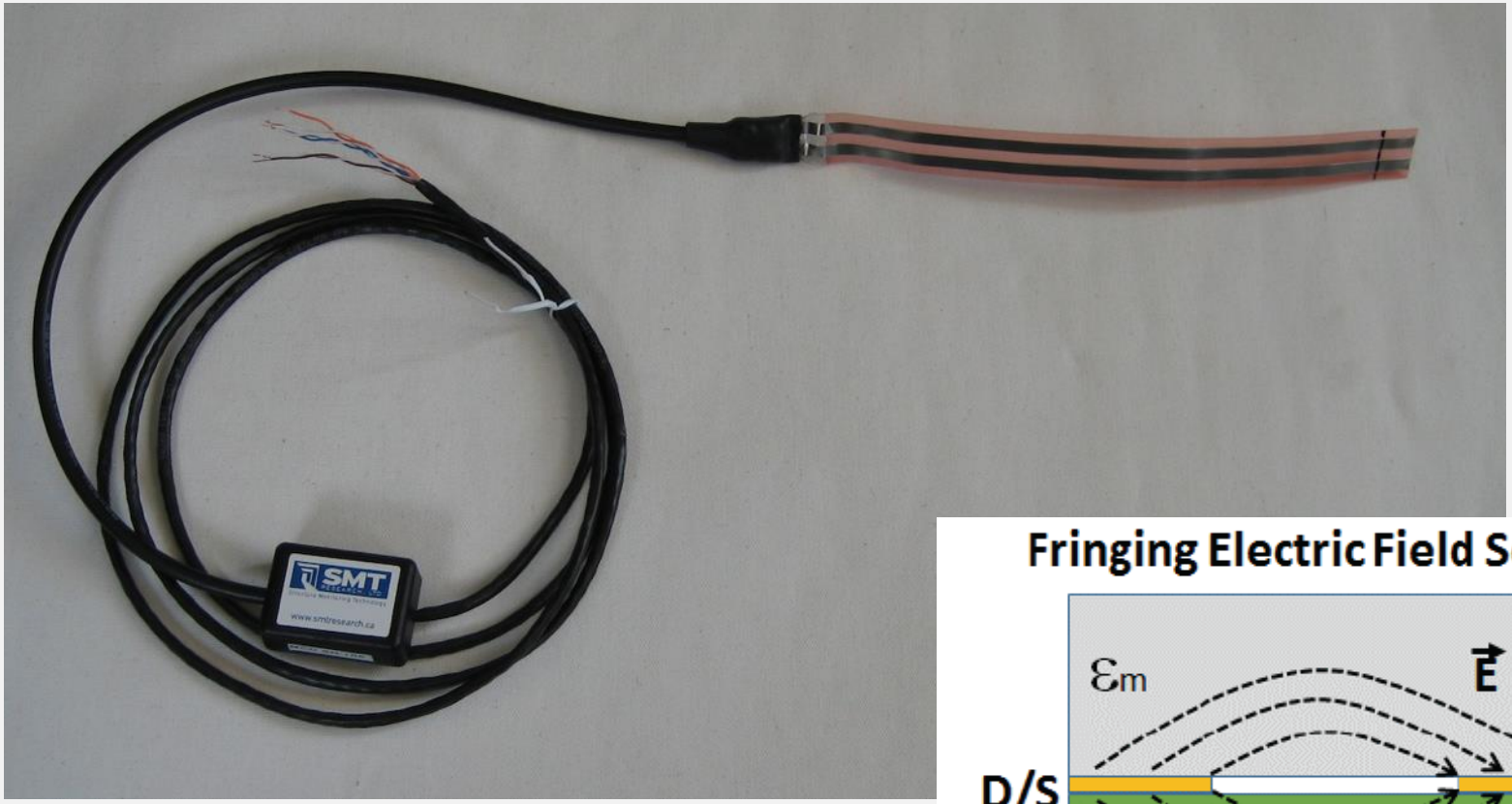
**FLOOD**

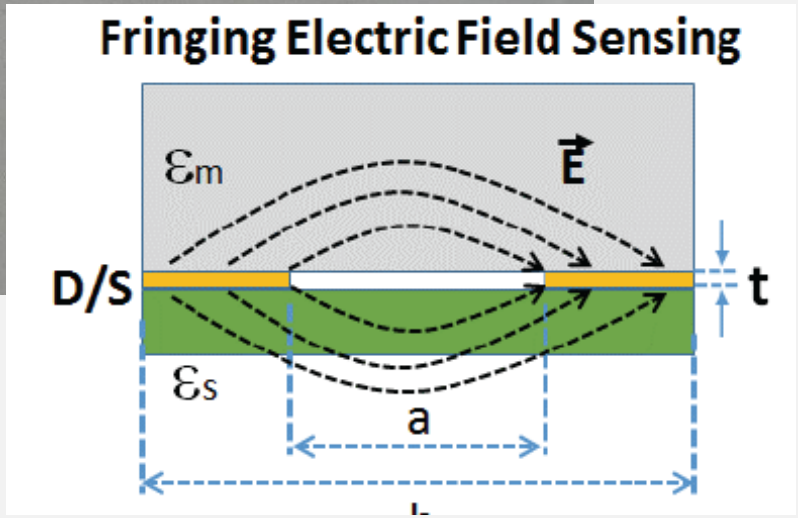
# DIELECTRIC MOISTURE SENSORS

Photo courtesy Kett at the University of Manitoba

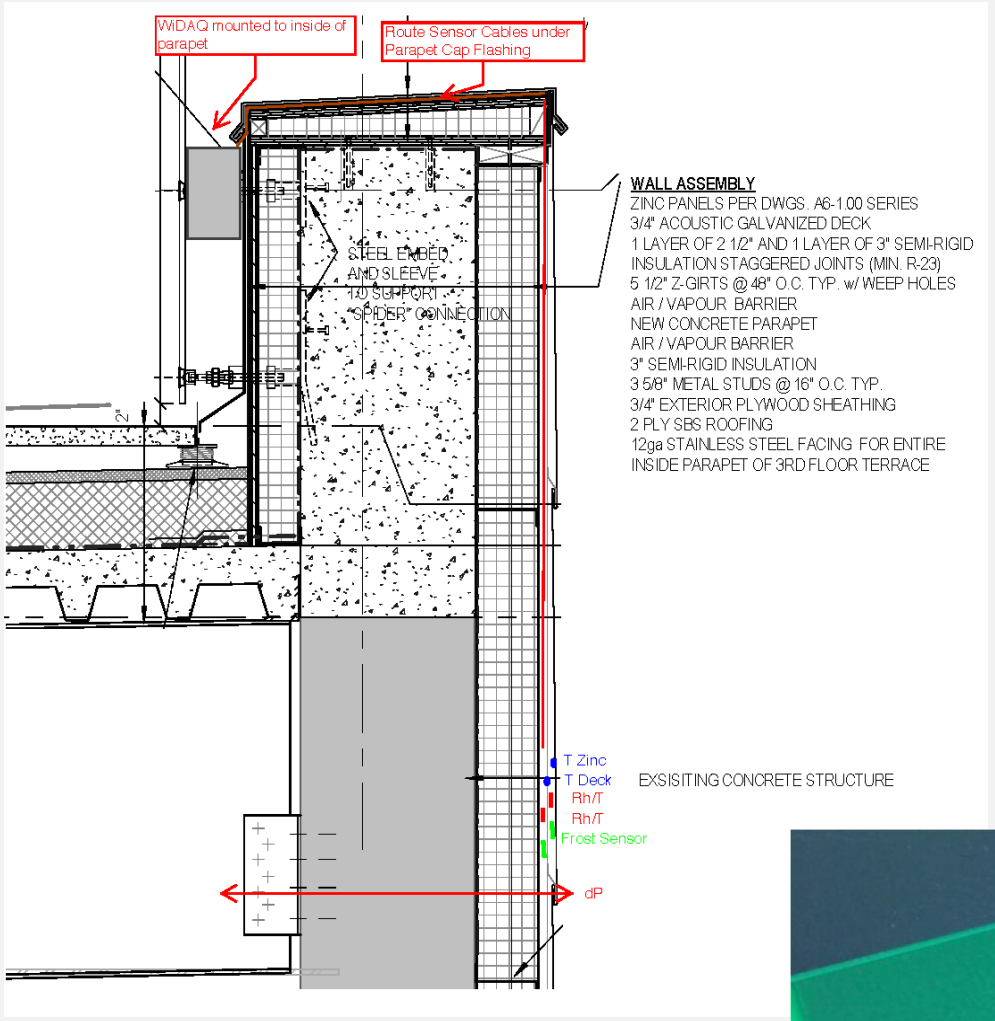


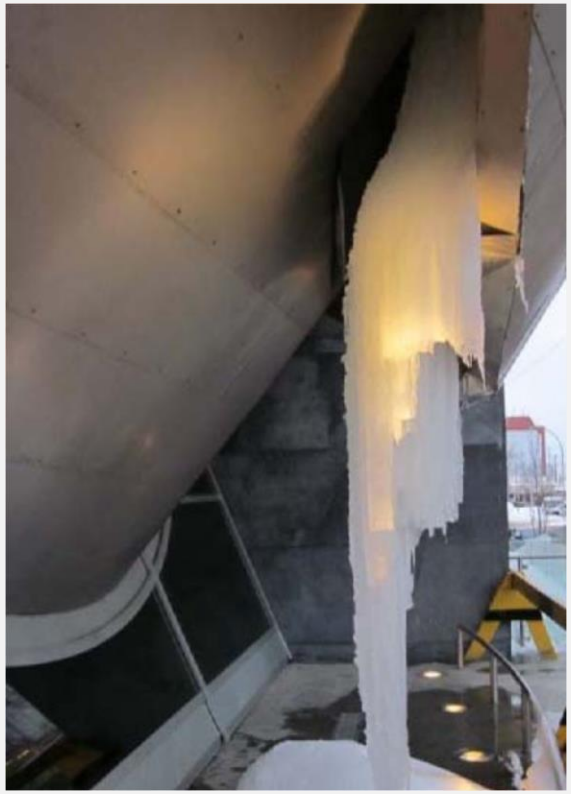

# DIELECTRIC MOISTURE SENSORS

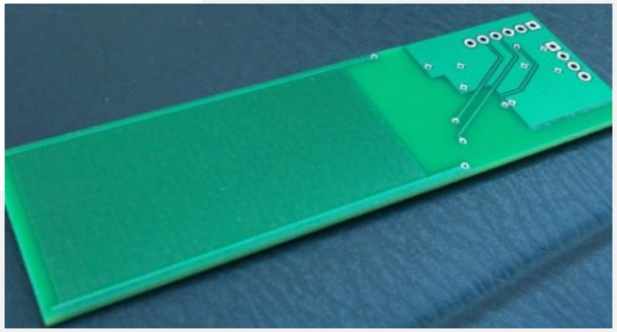


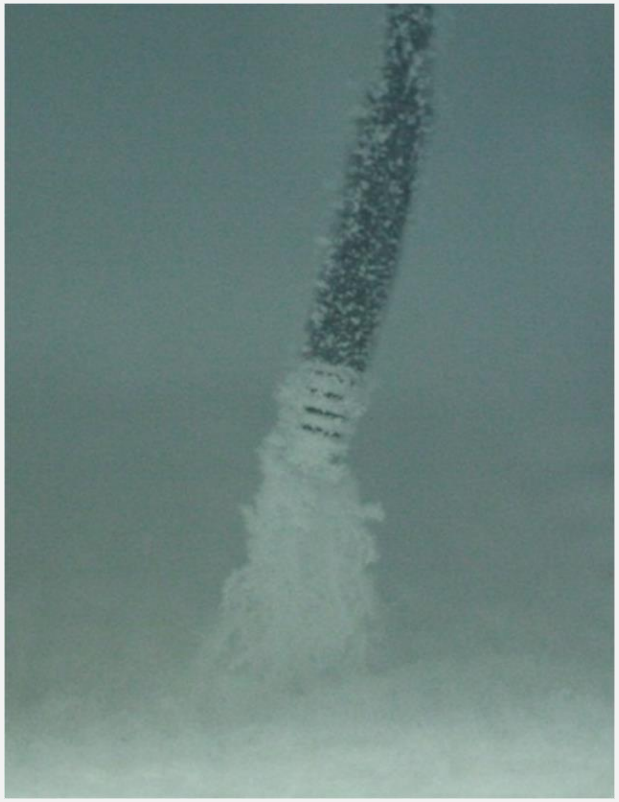
# FROST SENSORS

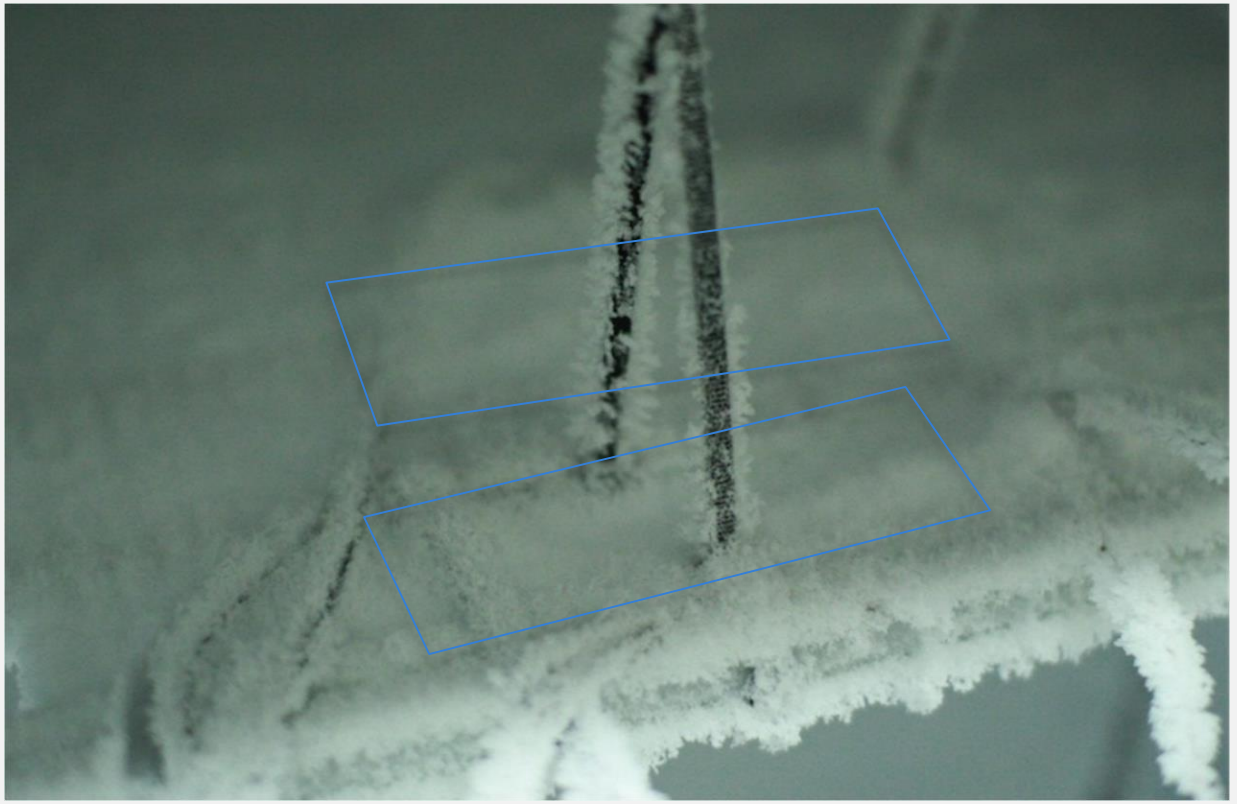


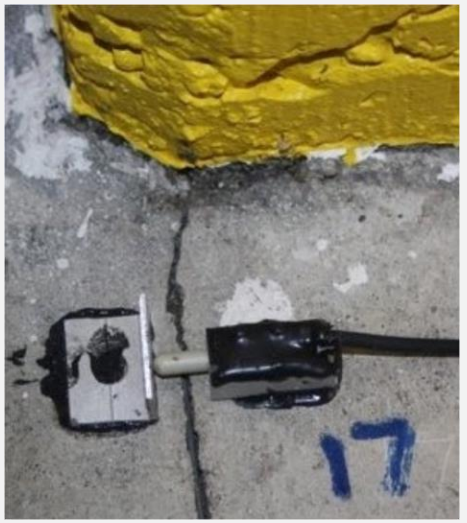


# FROST SENSORS



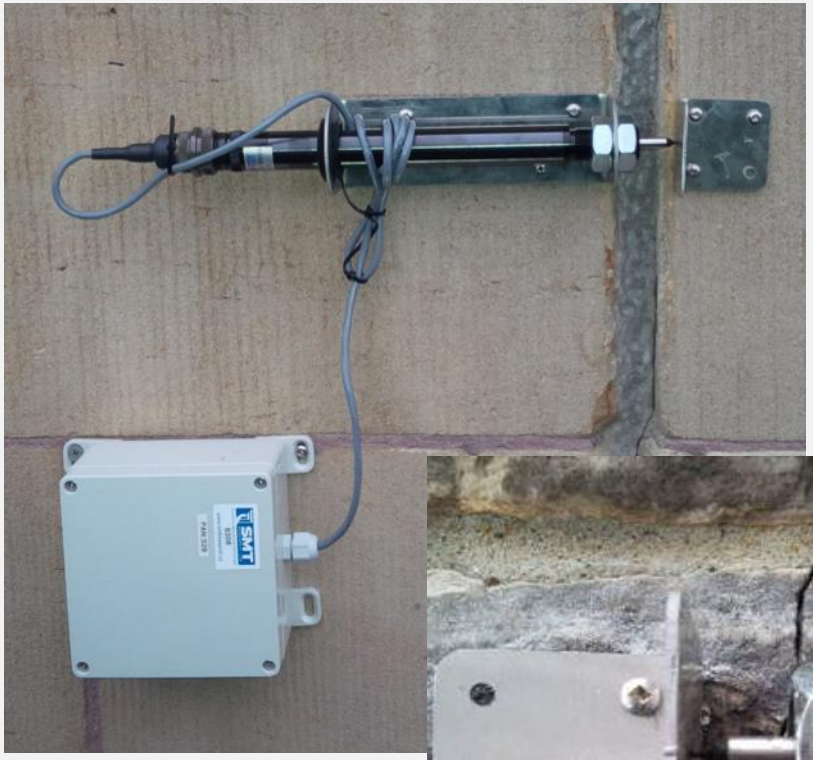


# DISPLACEMENT SENSORS




- Custom mounting options
- Various ranges and resolutions

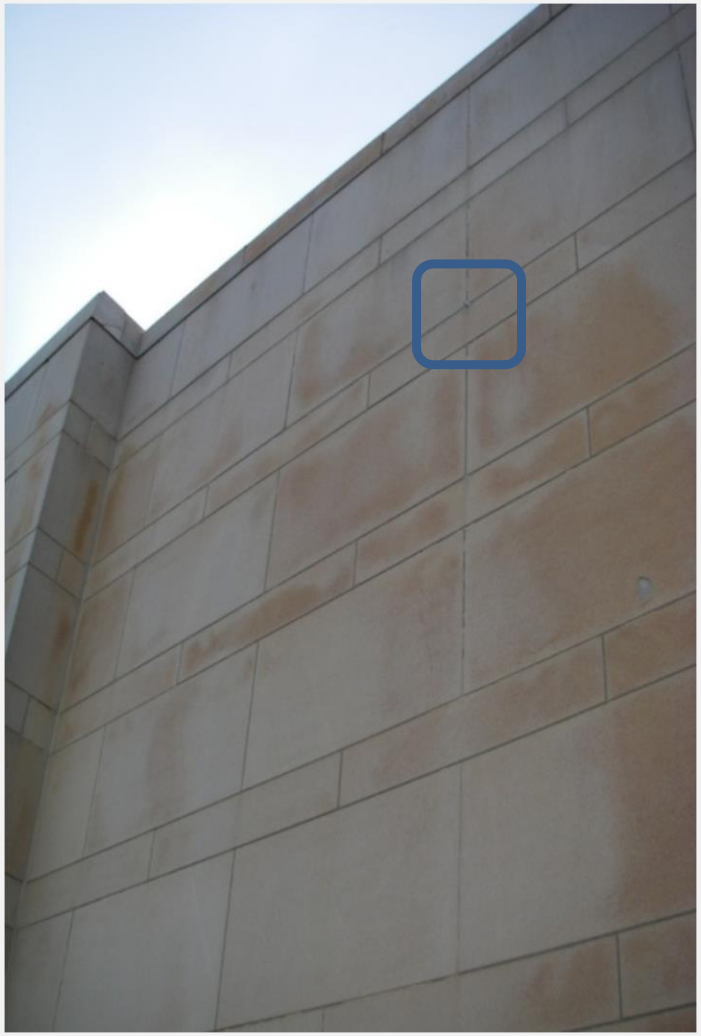
# DISPLACEMENT SENSORS


# ENVIRONMENTAL SENSORS

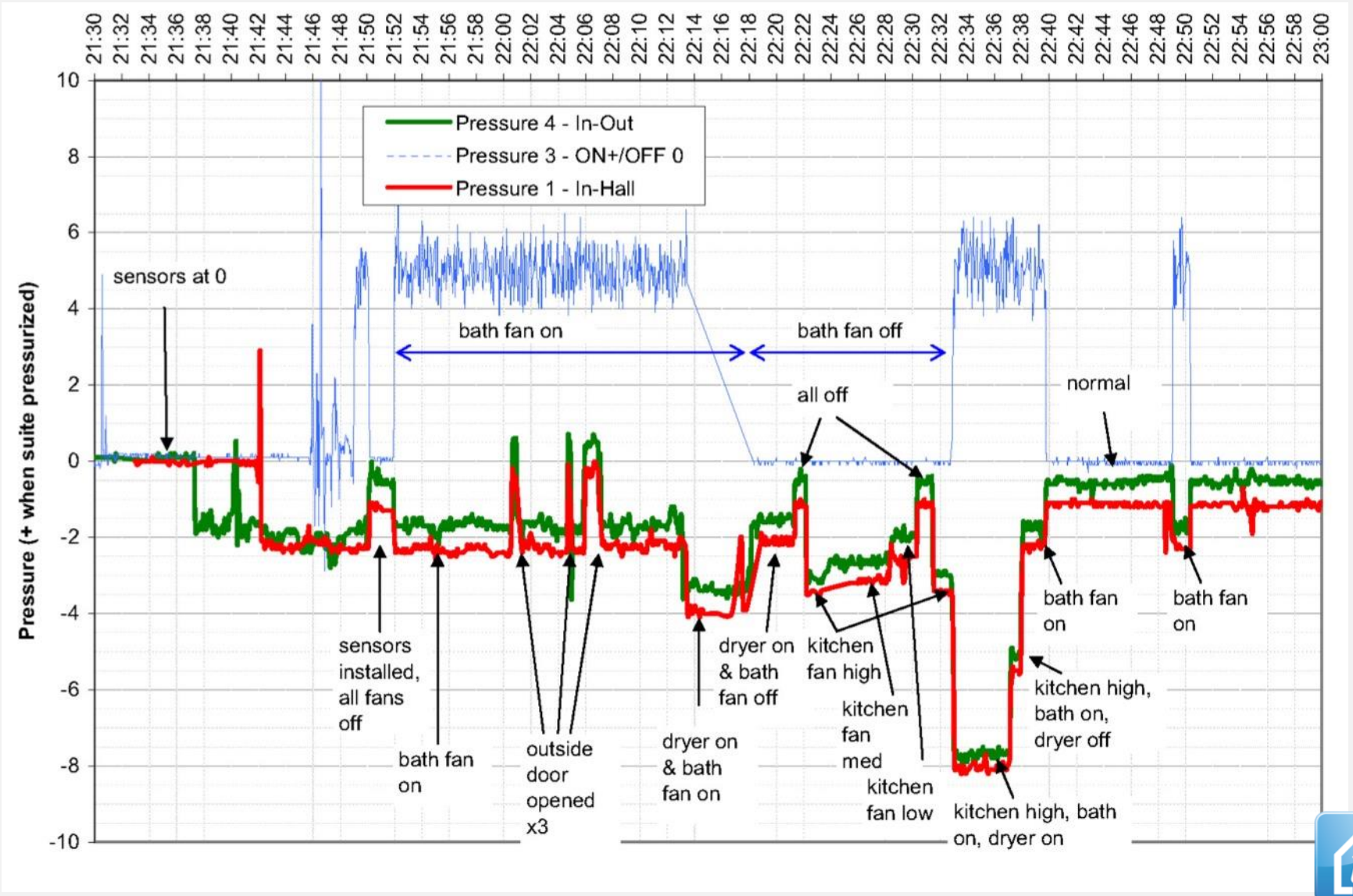
- Wind speed
- Wind direction
- Temperature
- Relative Humidity
- Ultra Violet Radiation
- Solar Radiation
- Precipitation
- Timed photographs
- Pan-tilt-zoom camera

# DIFFERENTIAL PRESSURE SENSORS



- Differential wall pressure
- Pitot tube to interior space
- Range +/- 250 pascal
- Auto zero feature

# DIFFERENTIAL PRESSURE SENSORS



# HEAT FLUX SENSORS

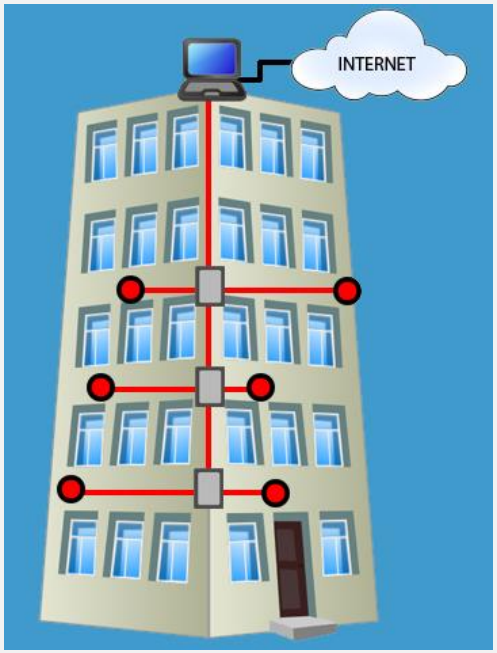


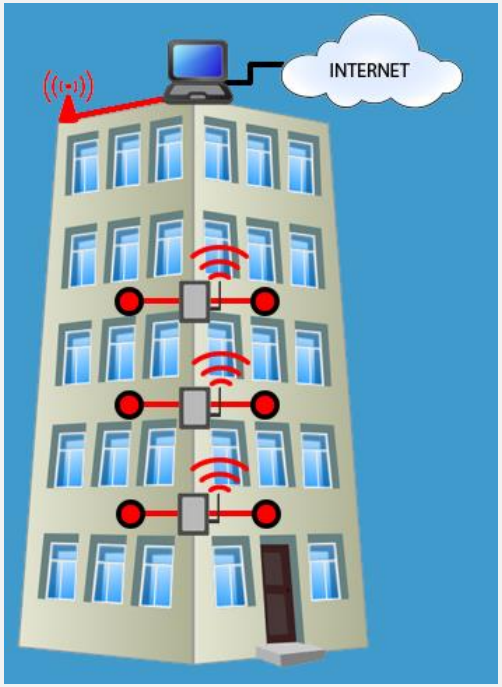
Guidelines for field deployment:

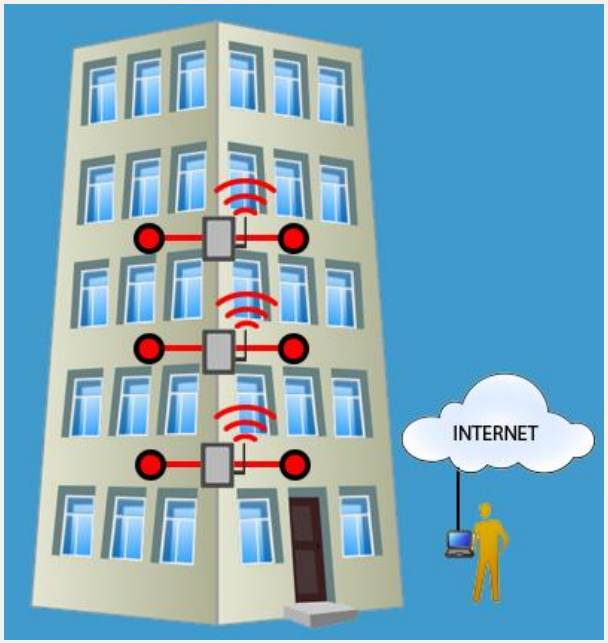
- Heat Flux sensors should be embedded in the material under test. Installation on the surface could be influenced by external factors.
- R value is a static value so the building must be at steady state in order to calculate it. To do this use two HF sensors once the outer sensor equals the inner sensor then take delta T over Q and calculate R value.

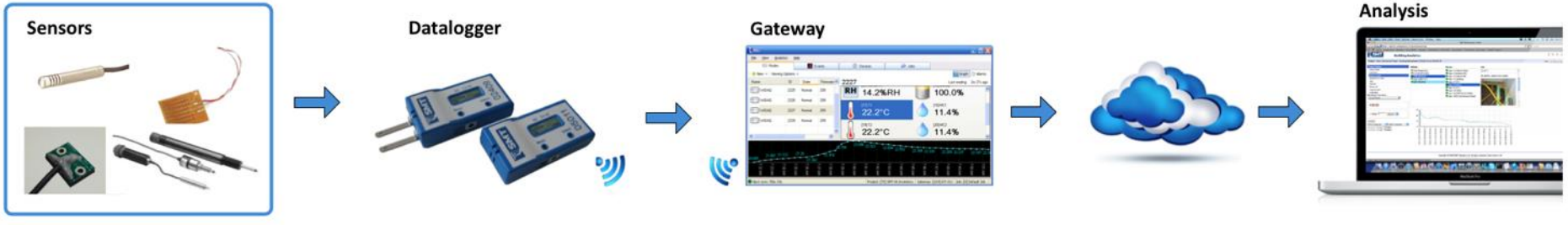
R Value (US) = RSI x 5.67, RSI = deltaT/Heat Flux

# MONITORING SYSTEMS

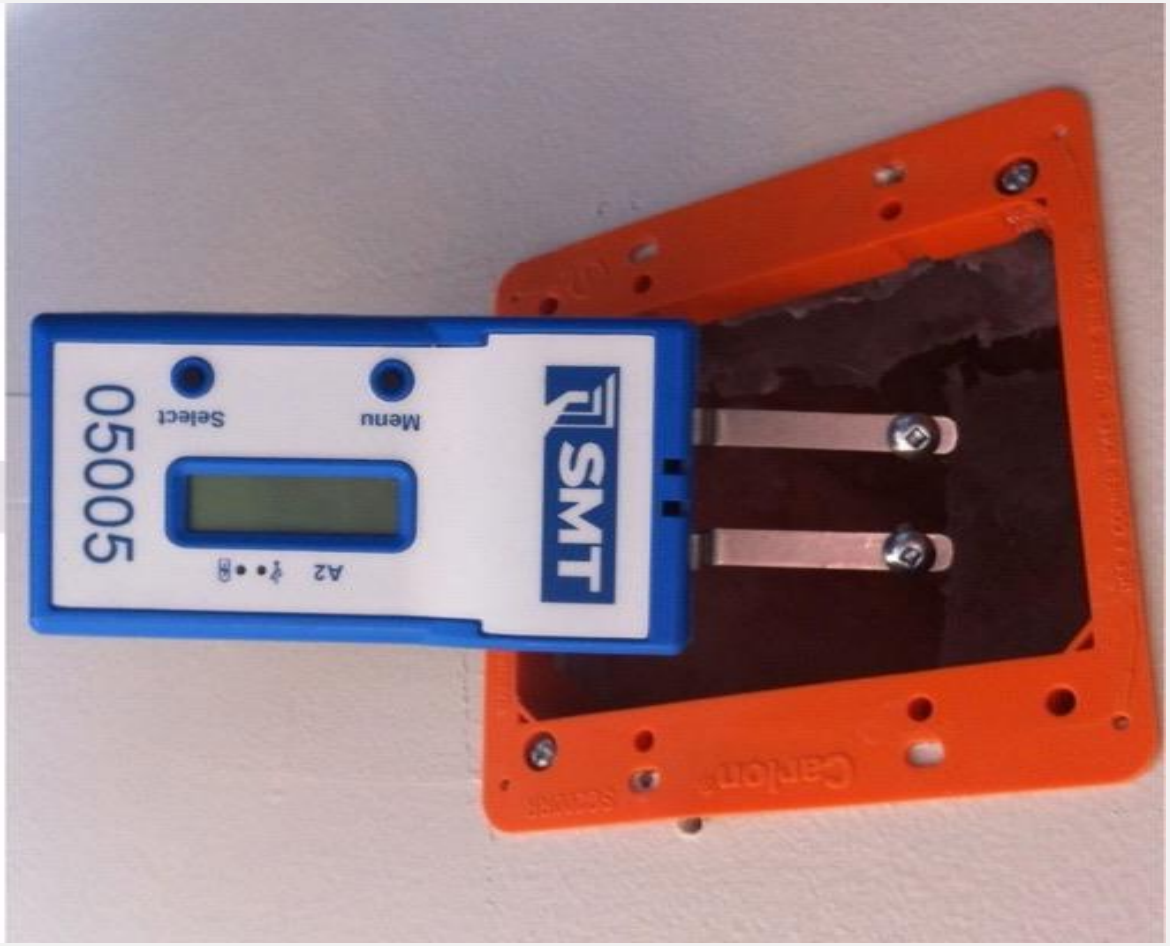


# NODES -A2

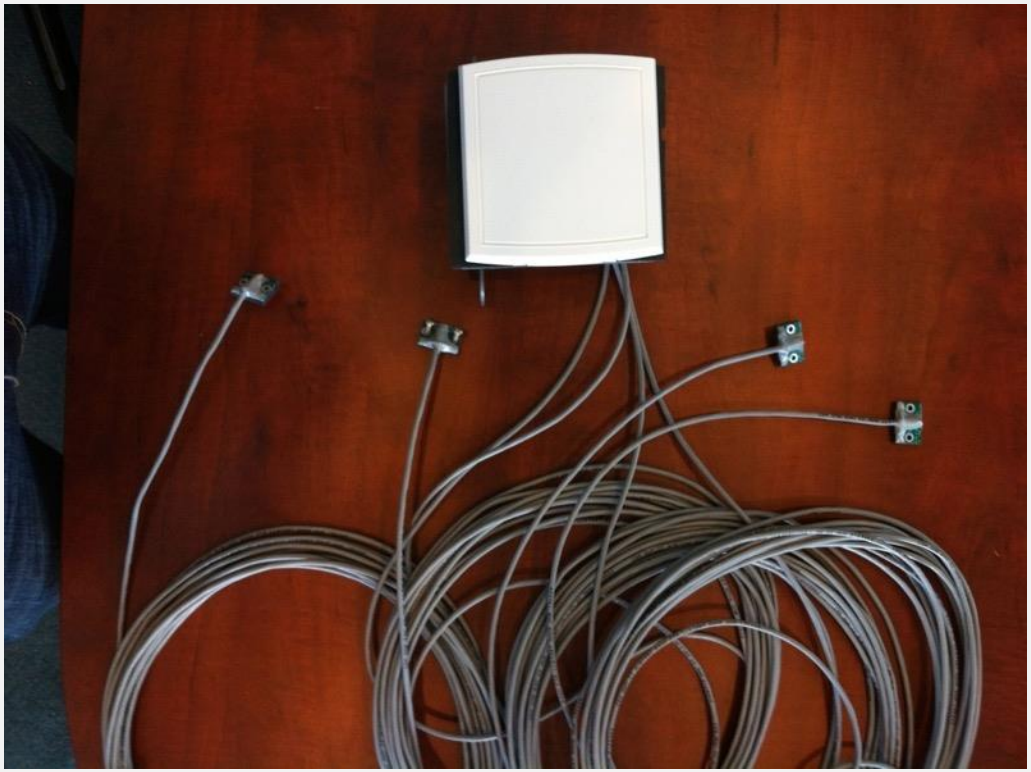



Internal RH/T
1- Moisture
1- Ext RH or pressure

- Wireless live
- Datalogging
- Hybrid wireless
- Battery – long life
- 16x memory as WIDAQ
- USB rechargeable
- Standalone PC device

Other models:
- Pressure A2
- Water resistant A2

# NODES –A3

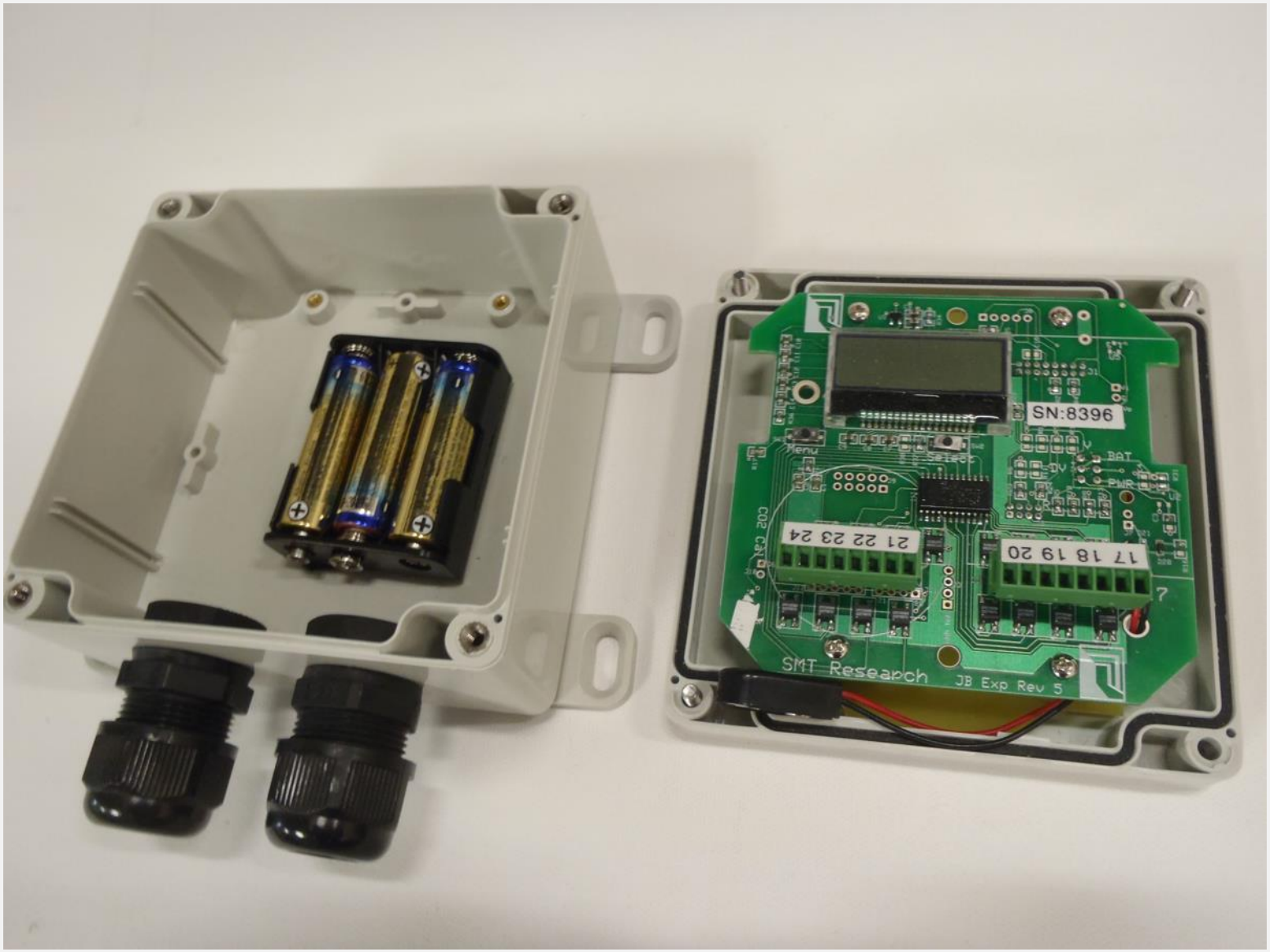
Internal RH/T options:

- 4 moisture/4 temp
- CO2, delta pressure
- Custom Dev

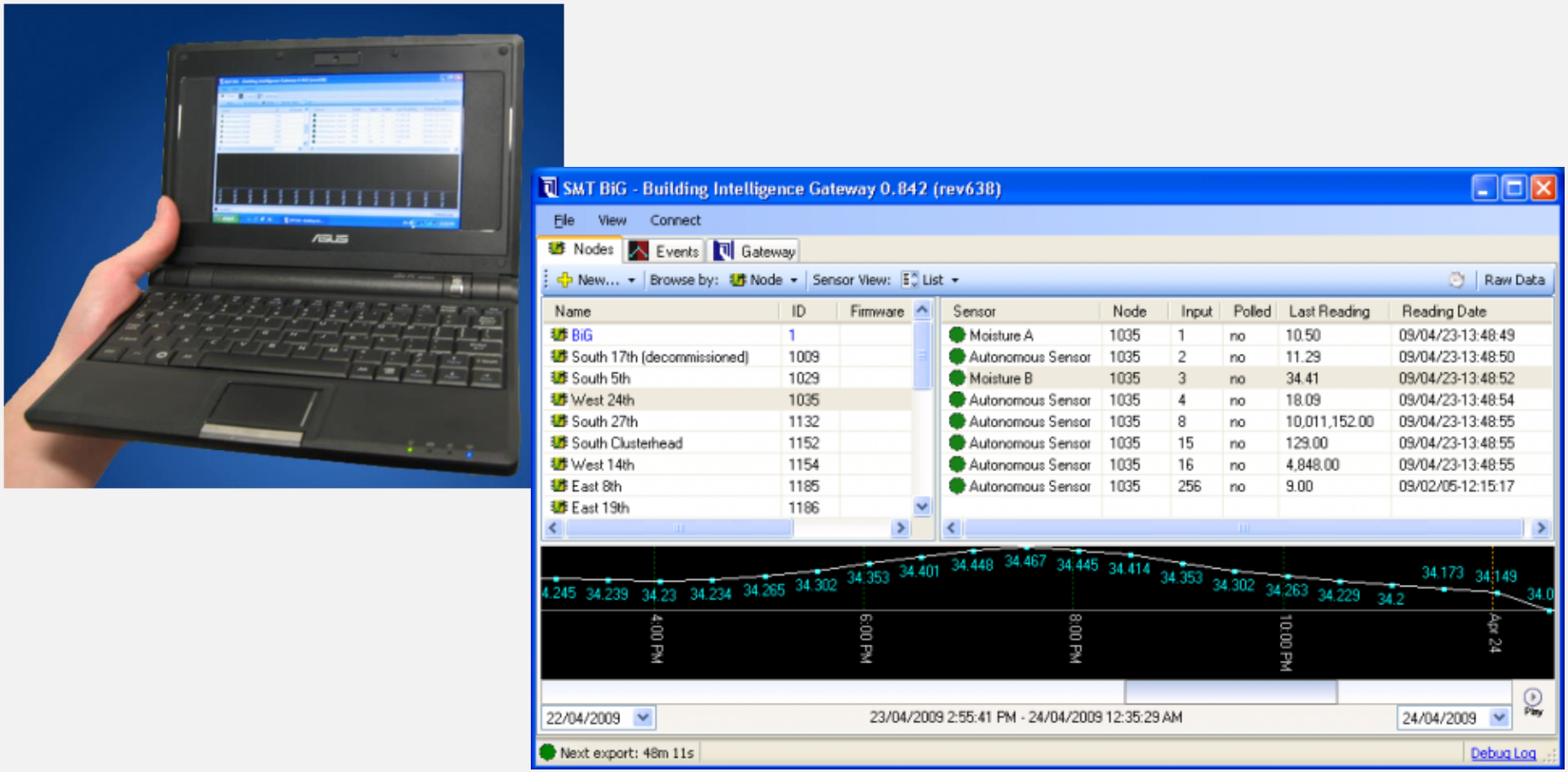
- Wireless live
- Datalogging
- Hybrid wireless
- Battery – long life

- 16x memory as WIDAQ
- USB rechargeable
- Standalone PC device

# NODES –A3

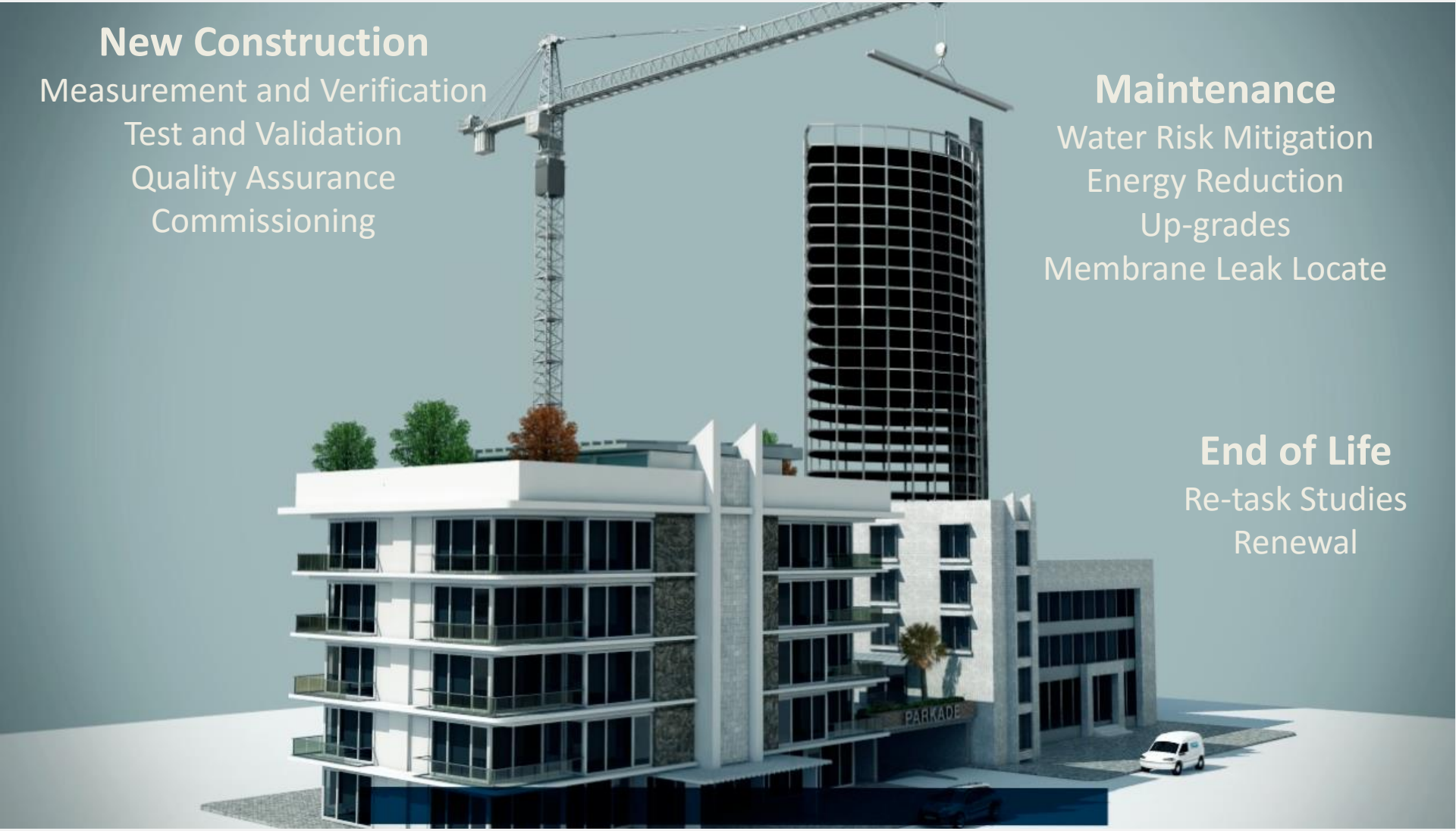

SN:8396
Menu
Select
BAT
PWR
CO2 Cargo
21 22 23 24
17 18 19 20
SMT Research
JB Exp Rev 5

# GATEWAY DATA COLLECTION

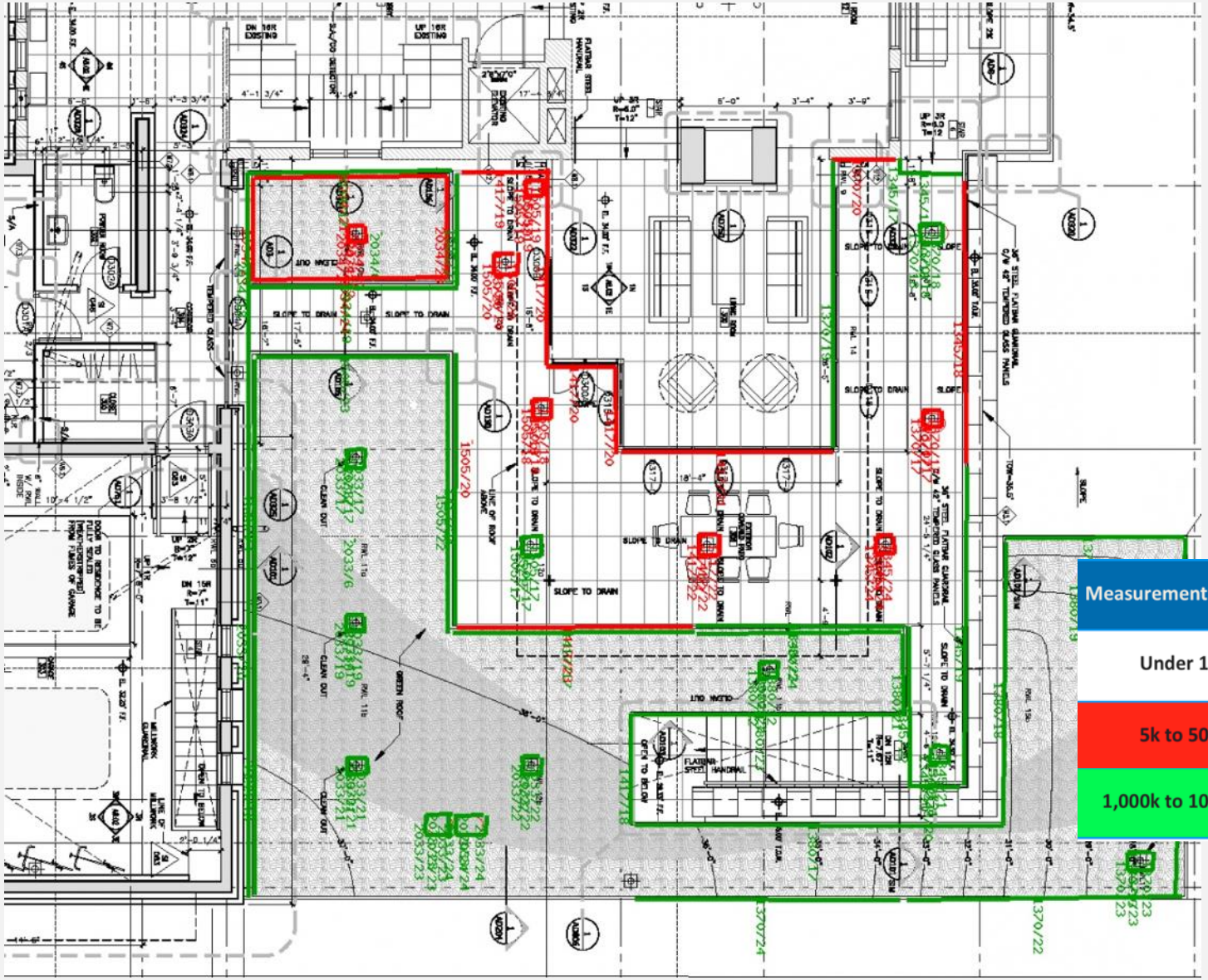



- **Real time data**
- **Wireless datalogging**

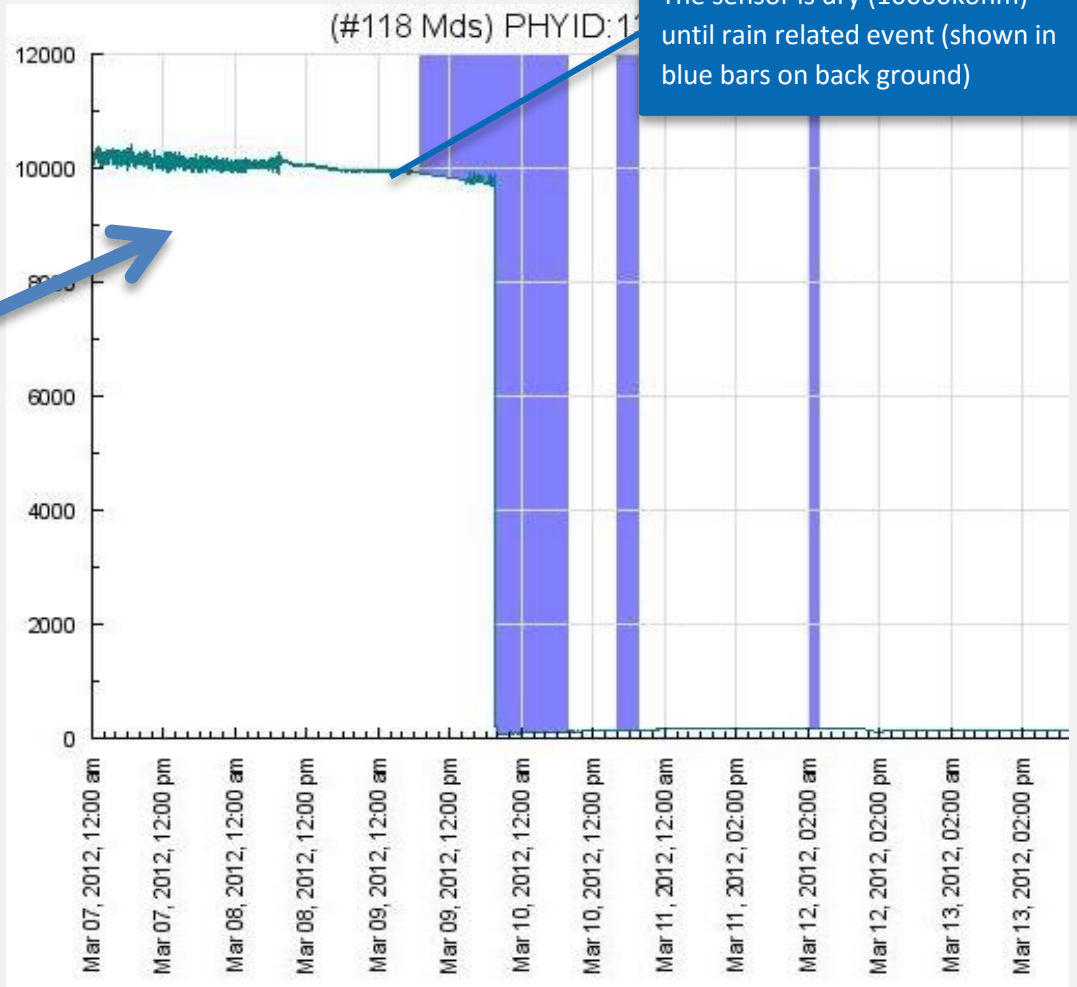
# Sensor Applications



BUILDING INTELLI

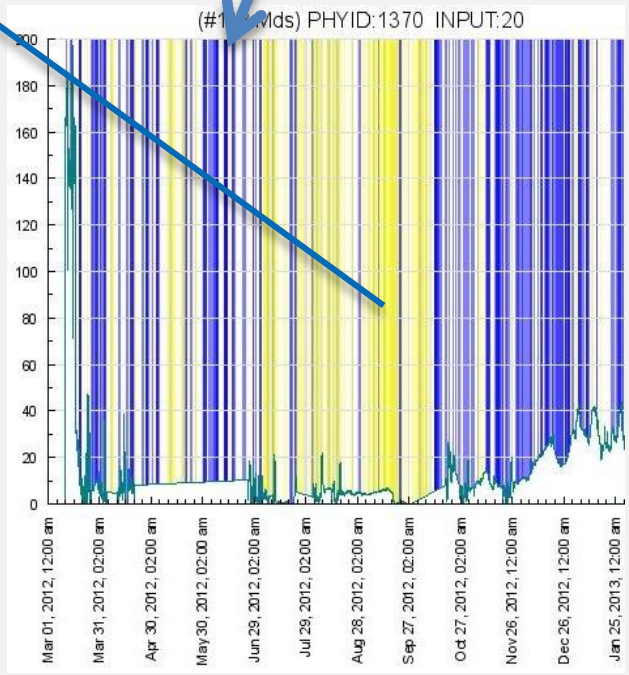


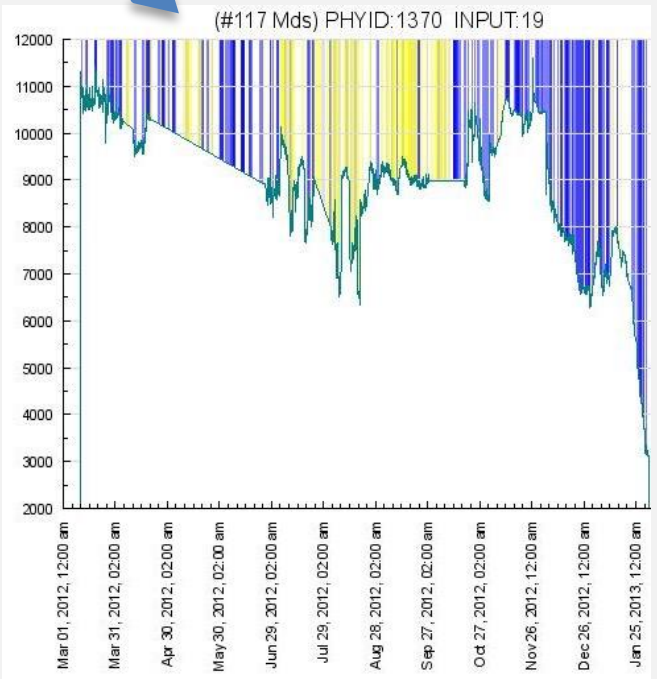
| Measurement (ohms) | Tape Status |
|---|---|
| Under 1k | Shorted Detection Tape |
| 5k to 50k | Wet |
| 1,000k to 10,000k | Dry |

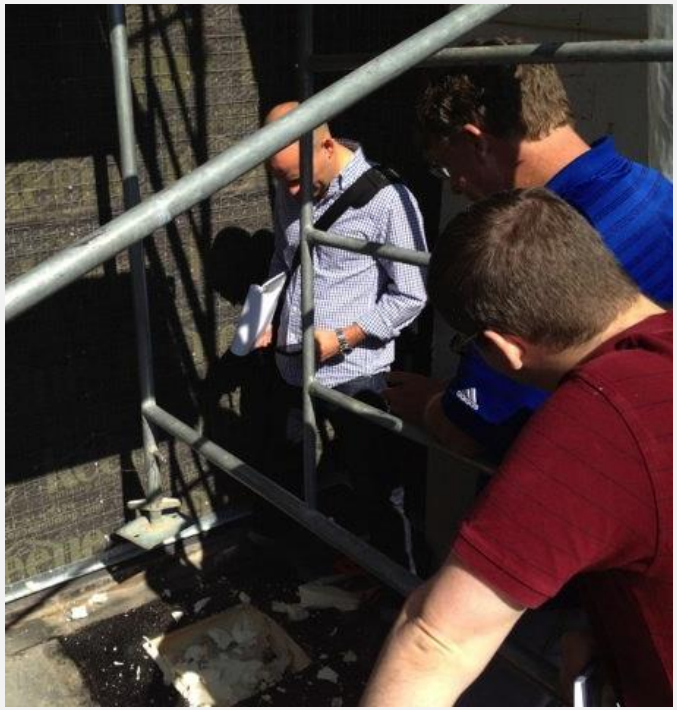



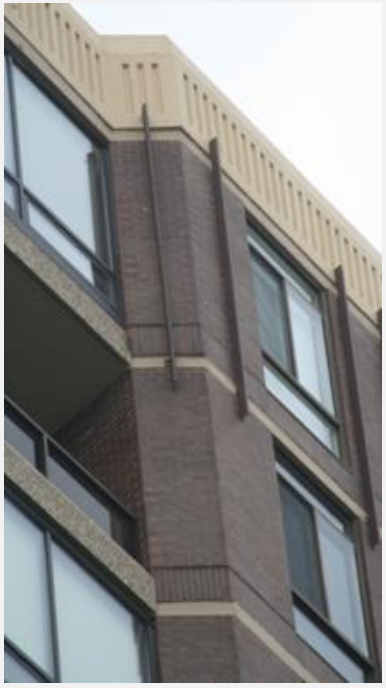

The sensor is dry (10000kohm) until rain related event (shown in blue bars on back ground)


Once the leak was repaired, the trending to a dry condition was observed even during significant rainfall events








Styrofoam

## Roof Monitoring
Linear detection sensors installed into roof system for moisture detection. Installation to new construction or even in existing construction during reroofing.

## Penetration Monitoring
Install moisture detection around roof penetrations from the underside of the roof deck. Installation can be applied to new or old buildings.

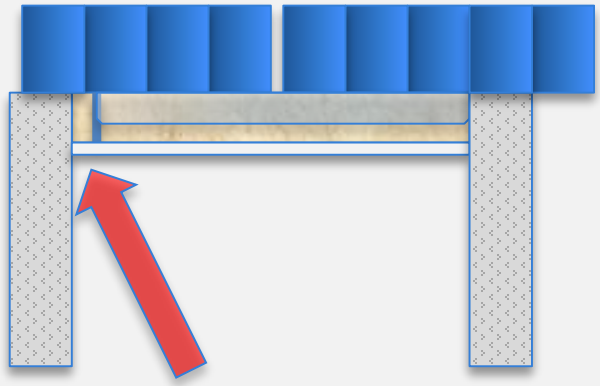
## Indoor Leak Protection
Monitor indoor plumbing, mechanical equipment, and under tubs and showers for water leaks.

## Indoor Air Monitoring
Monitor indoor conditions for relative humidity, CO2, and temperature.

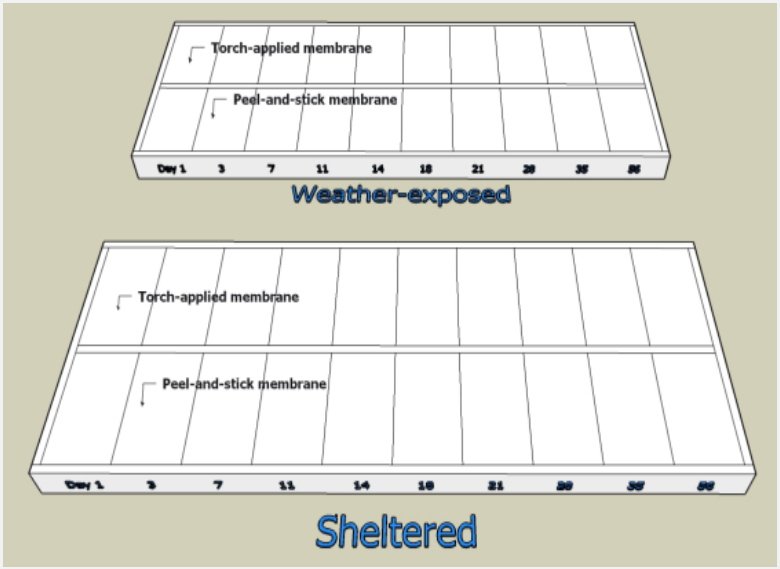
## Sample Moisture Monitoring
Sensor probes installed into wall system from exterior to interior. Installation to existing construction with minimal disruption to clading.

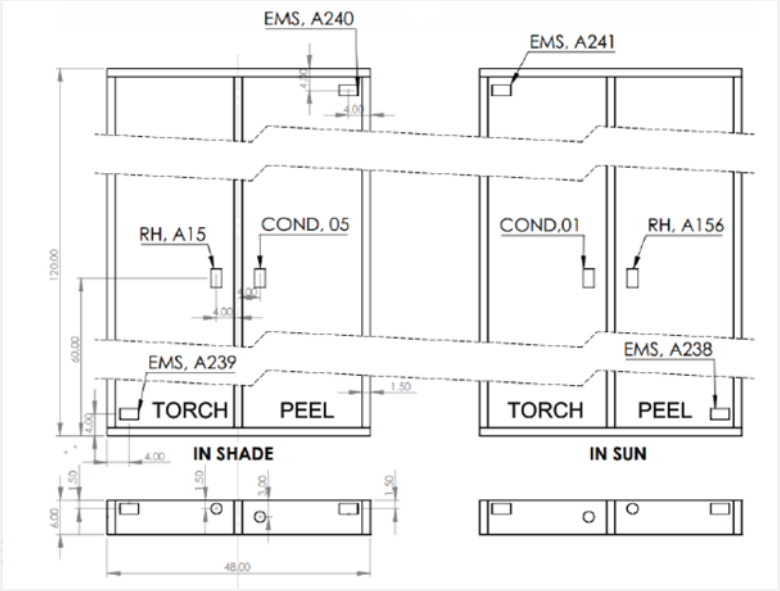
## Extensive Moisture Monitoring
Linear detection sensors installed into wall system from exterior to interior. Installation to new construction or even in existing construction during routine maintenence or renovations.

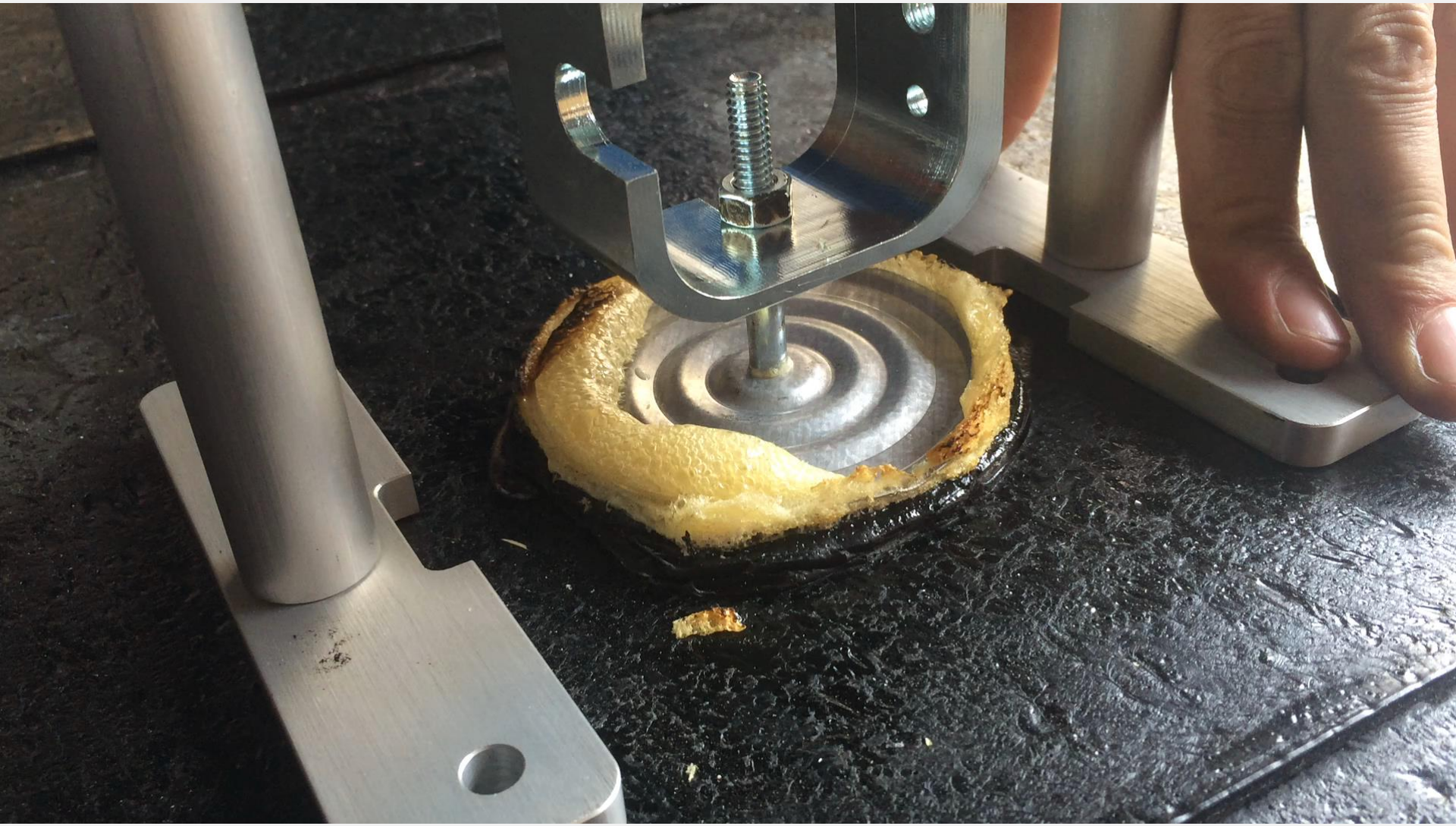
# INTERIOR INSTALLATION

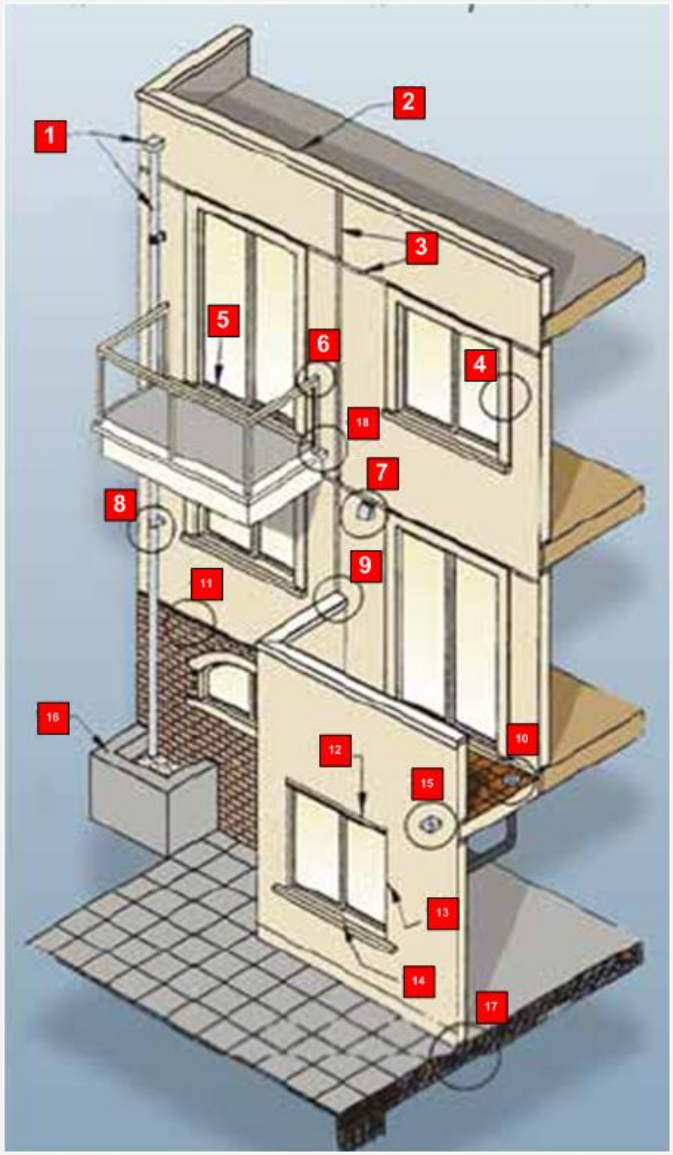


# MEMBRANE


Torch-applied membrane
Peel-and-stick membrane
Day 1 3 7 11 14 18 21 28 35 56
Weather-exposed
Torch-applied membrane
Peel-and-stick membrane
Day 1 3 7 11 14 18 21 28 35 56
Sheltered


EMS, A240
EMS, A241
RH, A15
COND, 05
COND,01
RH, A156
EMS, A239
EMS, A238
TORCH
PEEL
TORCH
PEEL
IN SHADE
IN SUN
120.00
60.00
4.00
48.00






Reference CMHC

1. Scupper & downspout
2. Parapet cap flashing
3. Control Joint
4. Wall-window interface
5. Balcony door threshold
6. Balcony rail attachment
7. Vent hood
8. Downspout attachment
9. Saddle detail
10. Deck Drain
11. Jct between different materials
12. Window head
13. Window jamb
14. Windowsill
15. Overflow scupper
16. Planter
17. Wall concrete slab interface
18. Balcony-wall interface