ROTTING ROOFS: CAUSES, MITIGATION AND CODE REQUIREMENTS

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NOW PRESENTING

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Introductions

- Program
- People
- History
  - 2000 IBC changes
    - Fire Protection in concealed areas or fill with fiberglass
    - Continuous air barrier.
    - Northern climate issue

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The Problem

- Vapor retarders and proper placement
- Sources of moisture
  - Air bypass versus diffusion
- Understanding dewpoints
- Sprinklers in concealed spaces

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Vapor Retarders

- Never perfect
- Sheets versus foam
- Areas that may not get covered.
- Original construction different than repairs

Sources of Moisture

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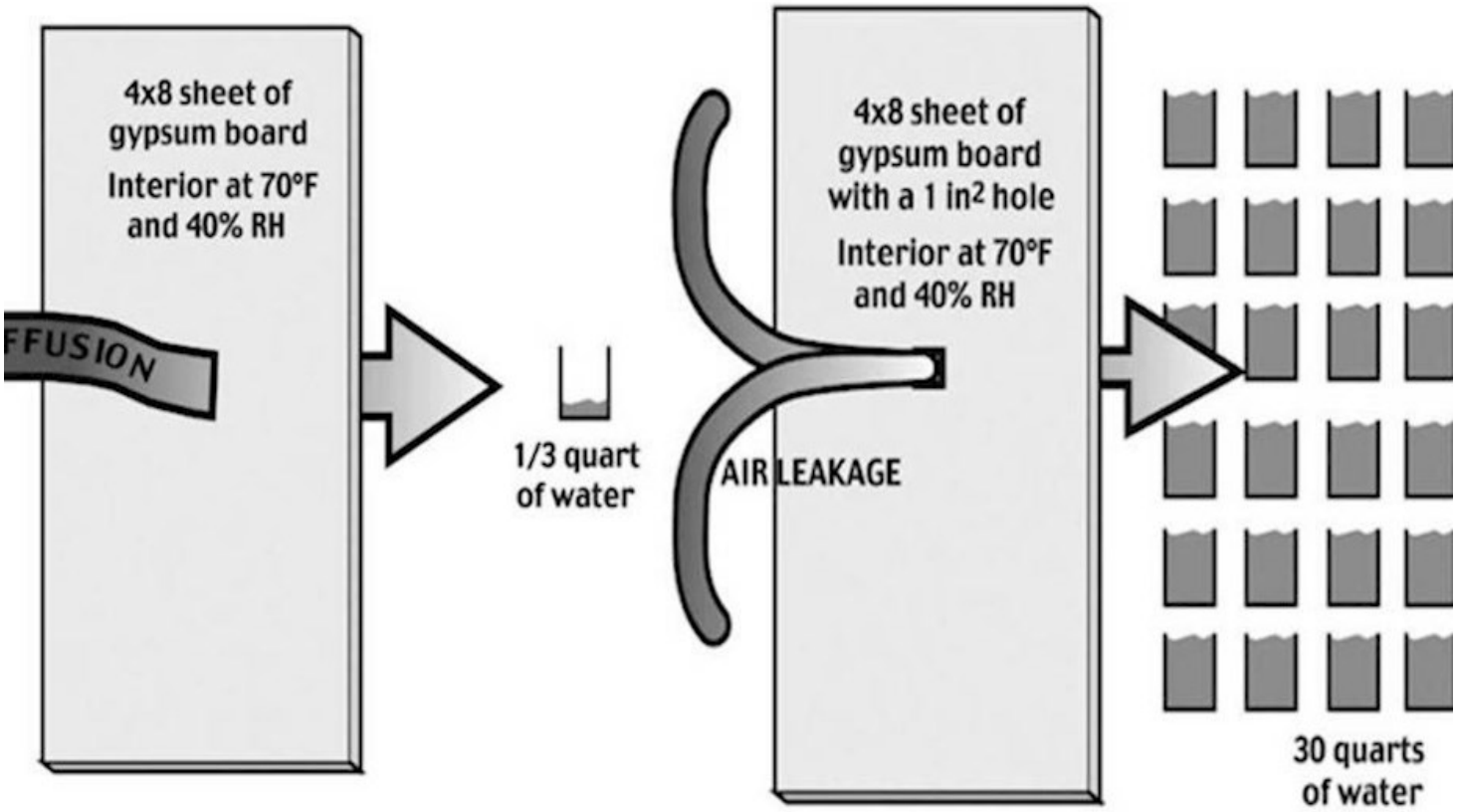
Dewpoints

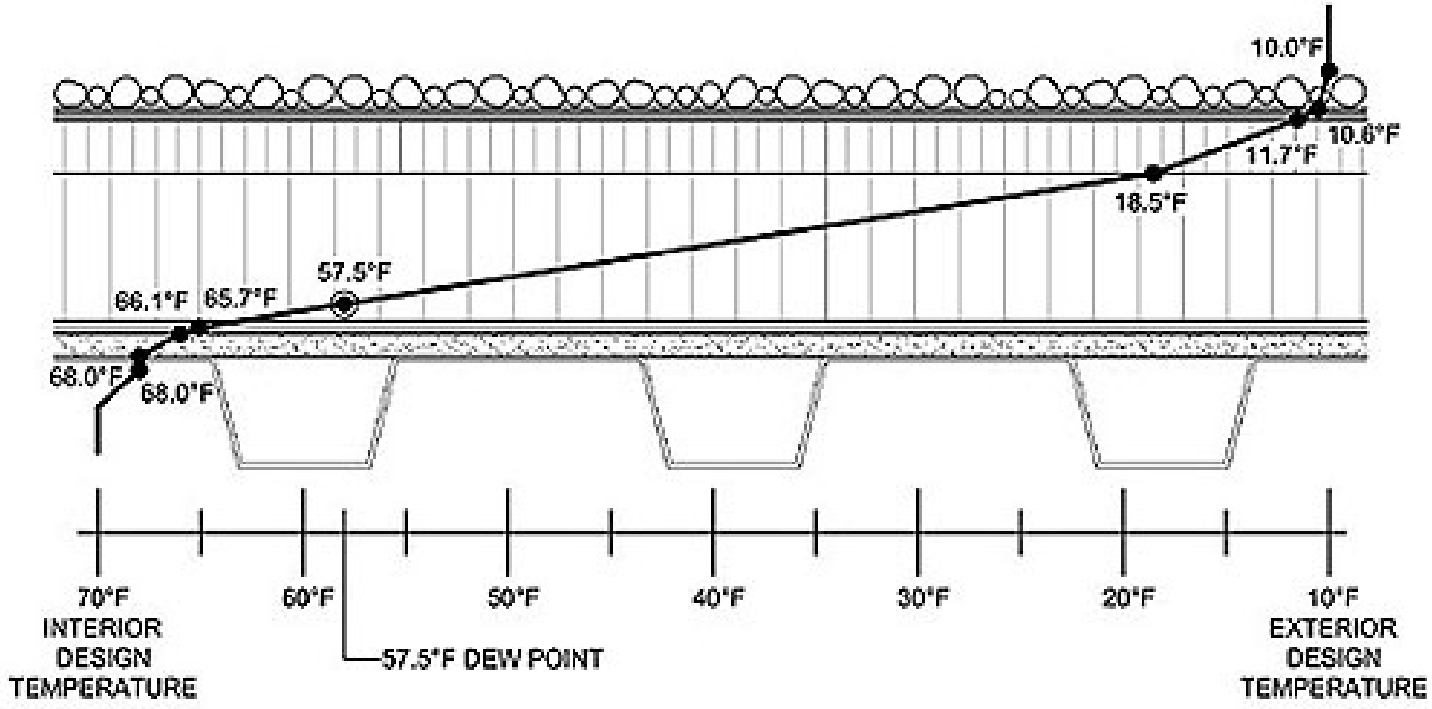
- This is a point where 100% relative humidity is reached and water will start to condense on anything colder than the dewpoint.
- Dewpoints need to fall OUTSIDE the vapor retarder. Otherwise condensation will occur INSIDE the building.
- Bypasses of the vapor retarder is what is causing the damage we are finding
- Learn as much as you can about dewpoints, vapor diffusion and methods to evaluate condensation and where it will occur. This has a similar impact of the water intrusion issues over the last 10 years.

Diffusion versus Air bypass -90X the water



From Building Science Corp.

Dewpoints



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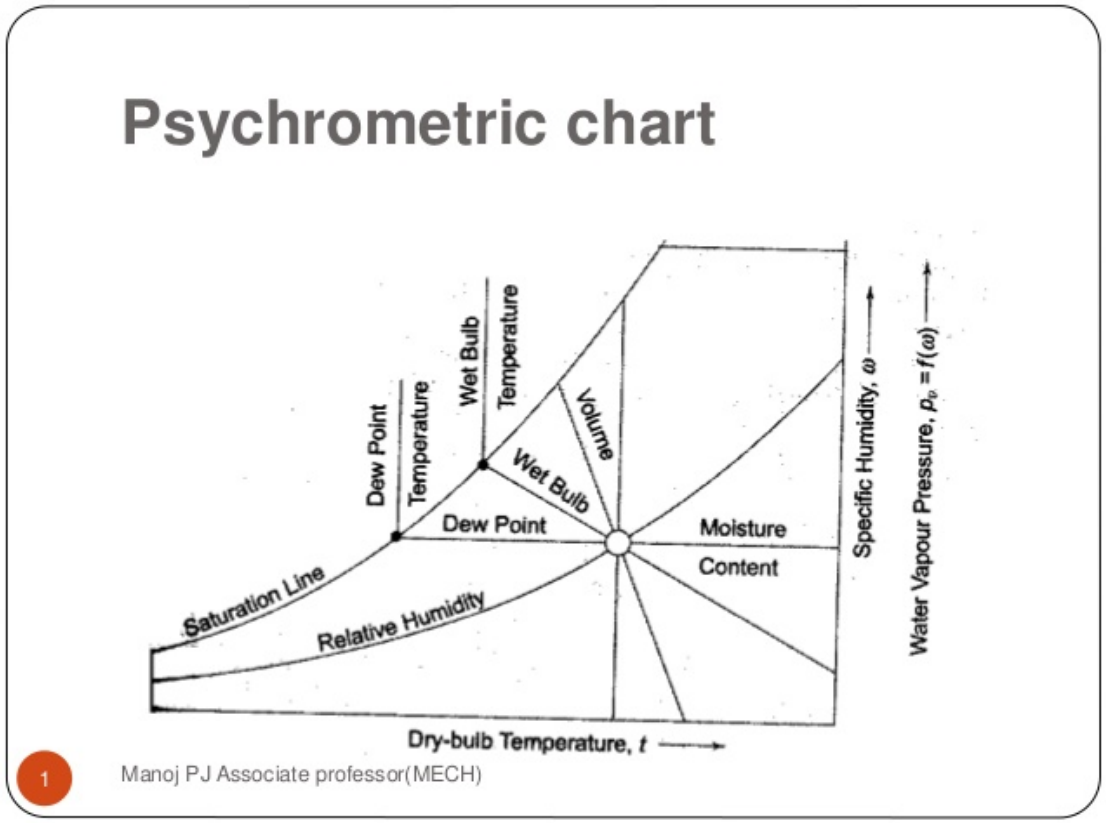
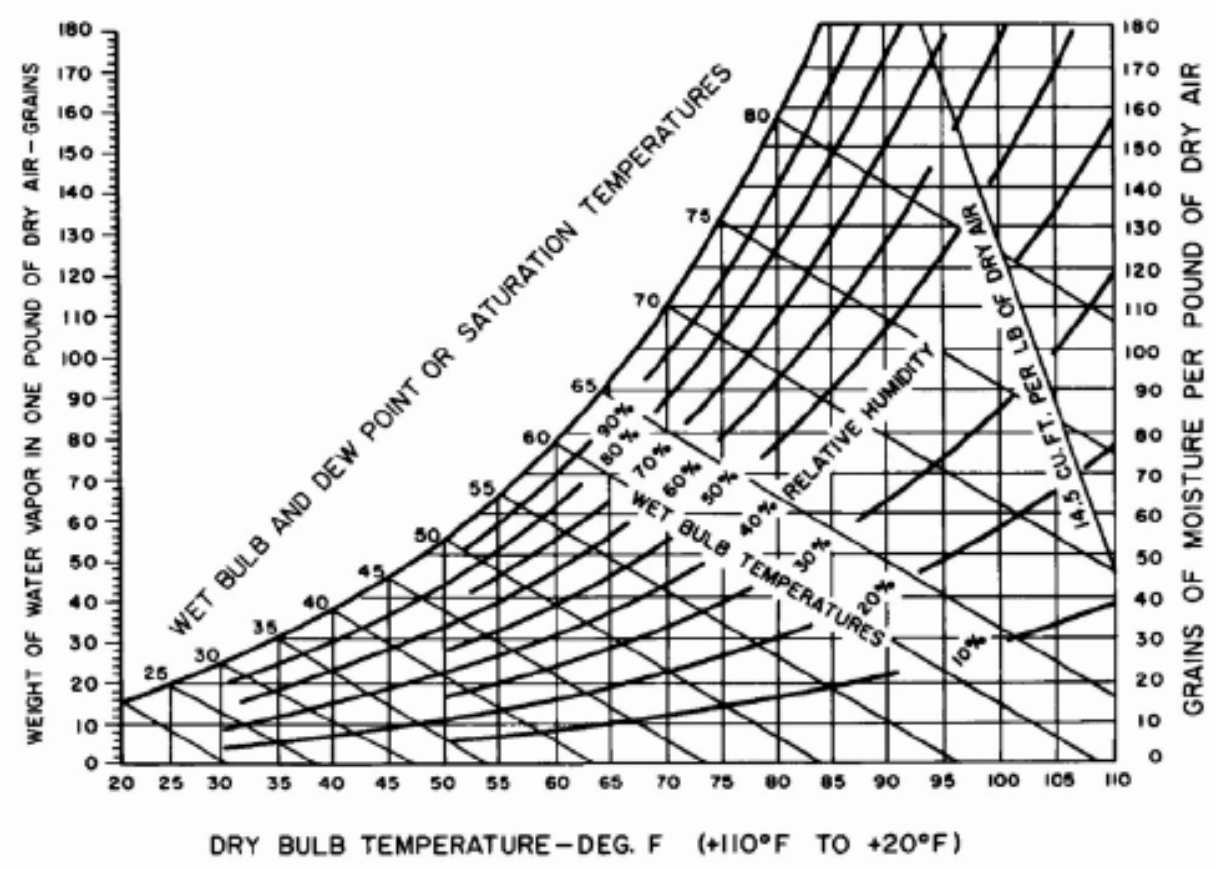
Psychometric Charts



More Detail


WEIGHT OF WATER VAPOR IN ONE POUND OF DRY AIR – GRAINS
GRAINS OF MOISTURE PER POUND OF DRY AIR
WET BULB AND DEW POINT OR SATURATION TEMPERATURES
RELATIVE HUMIDITY
WET BULB TEMPERATURES
14.5 CU.FT. PER LB OF DRY AIR
DRY BULB TEMPERATURE – DEG. F (+110°F TO +20°F)

Case Studies

- Where did we see it start.
  - Parapets
- Modes of failure

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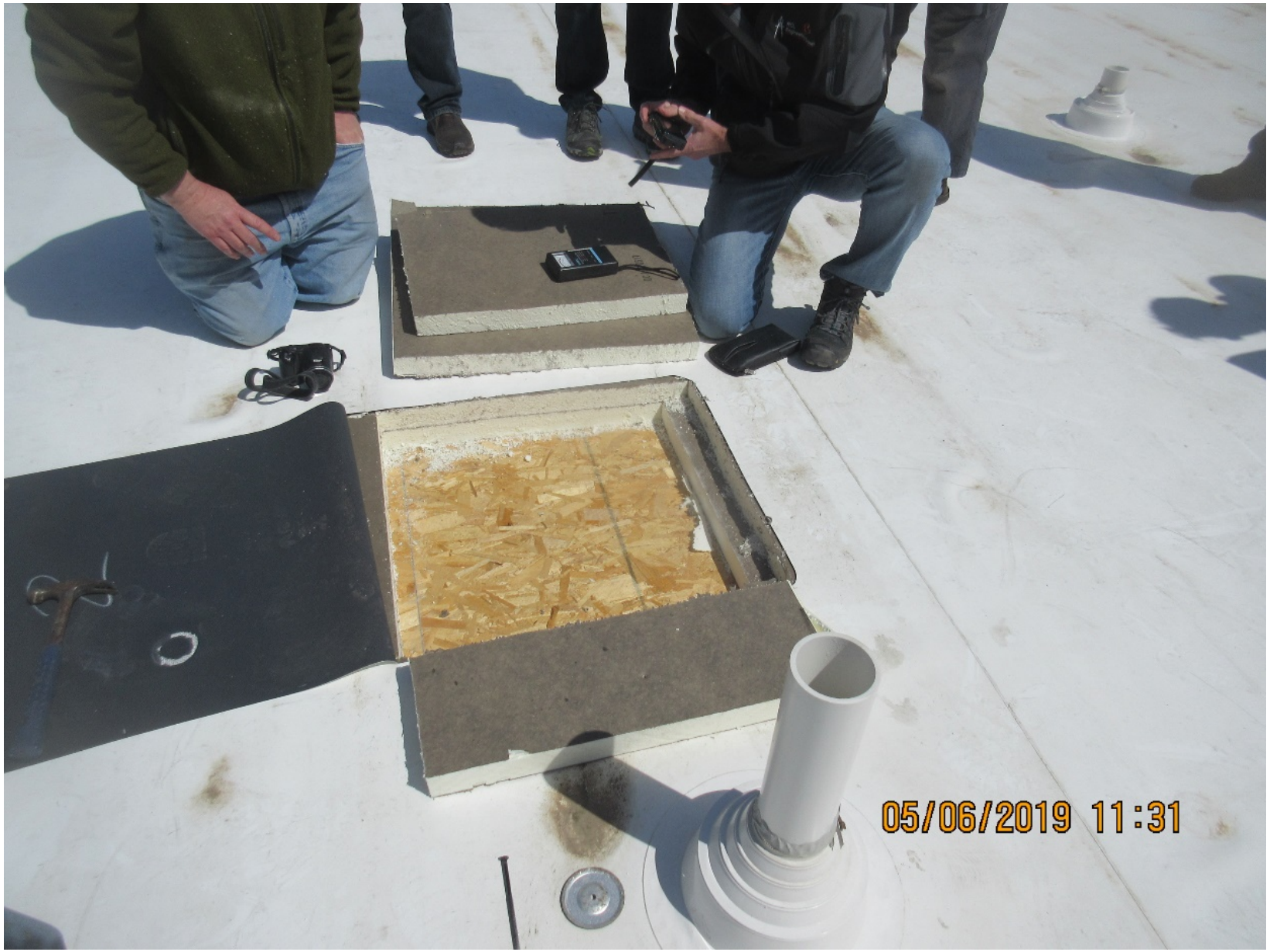

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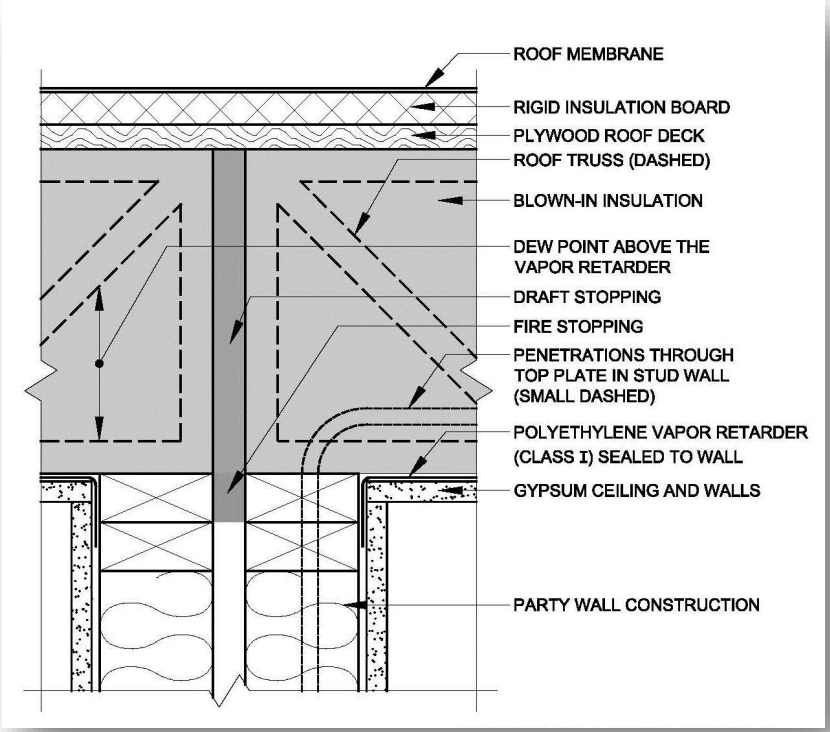
CASE STUDIES – ROTTING ROOF EVALUATIONS

MN Multi-Family Residential Buildings

- Roughly 10 years old
- Wood open truss roof construction
- Conventional roofs BU, BSP, MFSP
- Ceiling vapor retarder



Initial Symptoms

- No water entry
- Deck deflection
- Ceiling mold

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Destructive Test Opening Results

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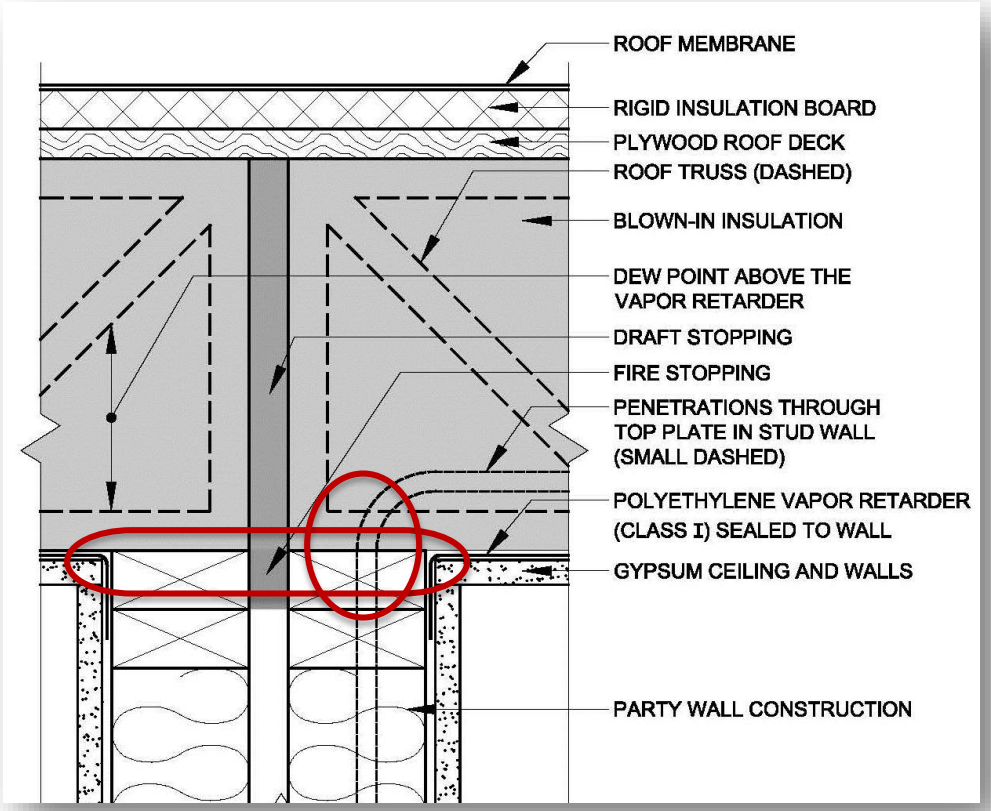
CAUSES

MOISTURE ACCUMULATION FROM VAPOR RETARDER BYPASSES

- Interrupted vapor retarder at walls and wall penetrations

- Open/unsealed penetrations thru ceiling vapor retarder

- Warm interior moisture laden air condenses on surfaces below the dew point



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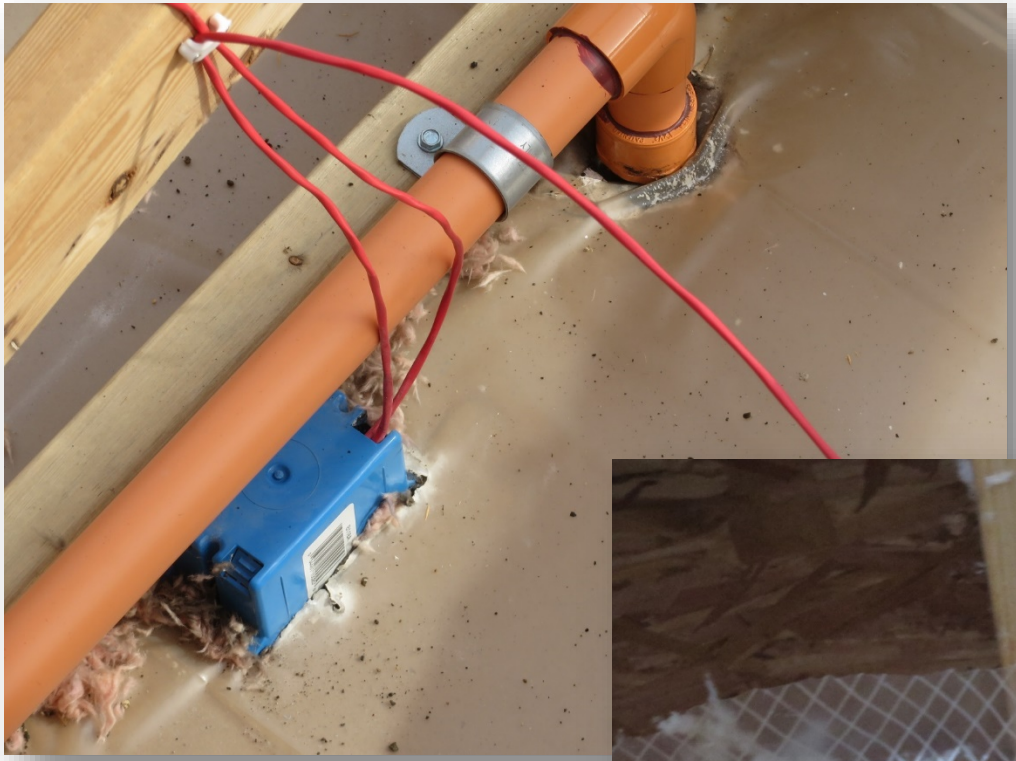

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DUCT JOINTS NOT SEALED

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MOISTURE ANALYSIS TOOLS

TRADITIONAL STEADY-STATE MODELING

Dew Point Method, Glaser Diagram, Kieper Diagram

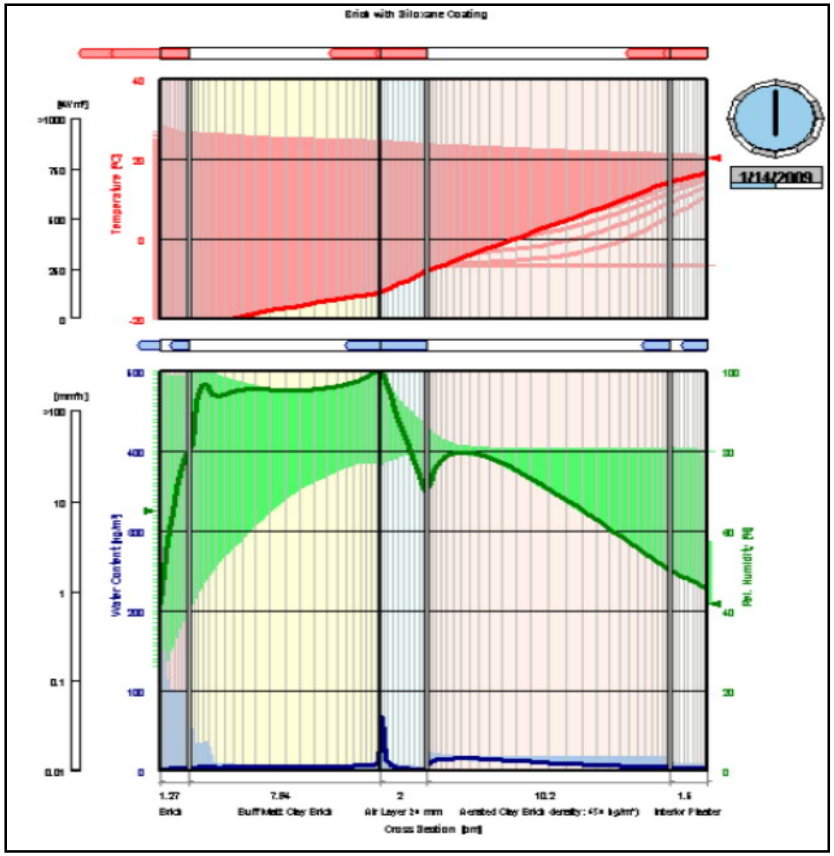
One point in time modeling. Not able to measure storage capacity in building materials or transient effects of moisture drive

WUFI HYGROTHERMAL MODELING

Computer-based model to analyze moisture and thermal transmission through the exterior envelope materials in a given system, building parameters, and historic conditions every hour for a year and then over a 5-year period

WUFI Modeling evaluation results include:

- Total Water Content in the Building Section
- Water Content in Specific Building Components
- Temperature, Relative Humidity, and Dew Point Monitoring and Analysis



Key is careful and thorough information input

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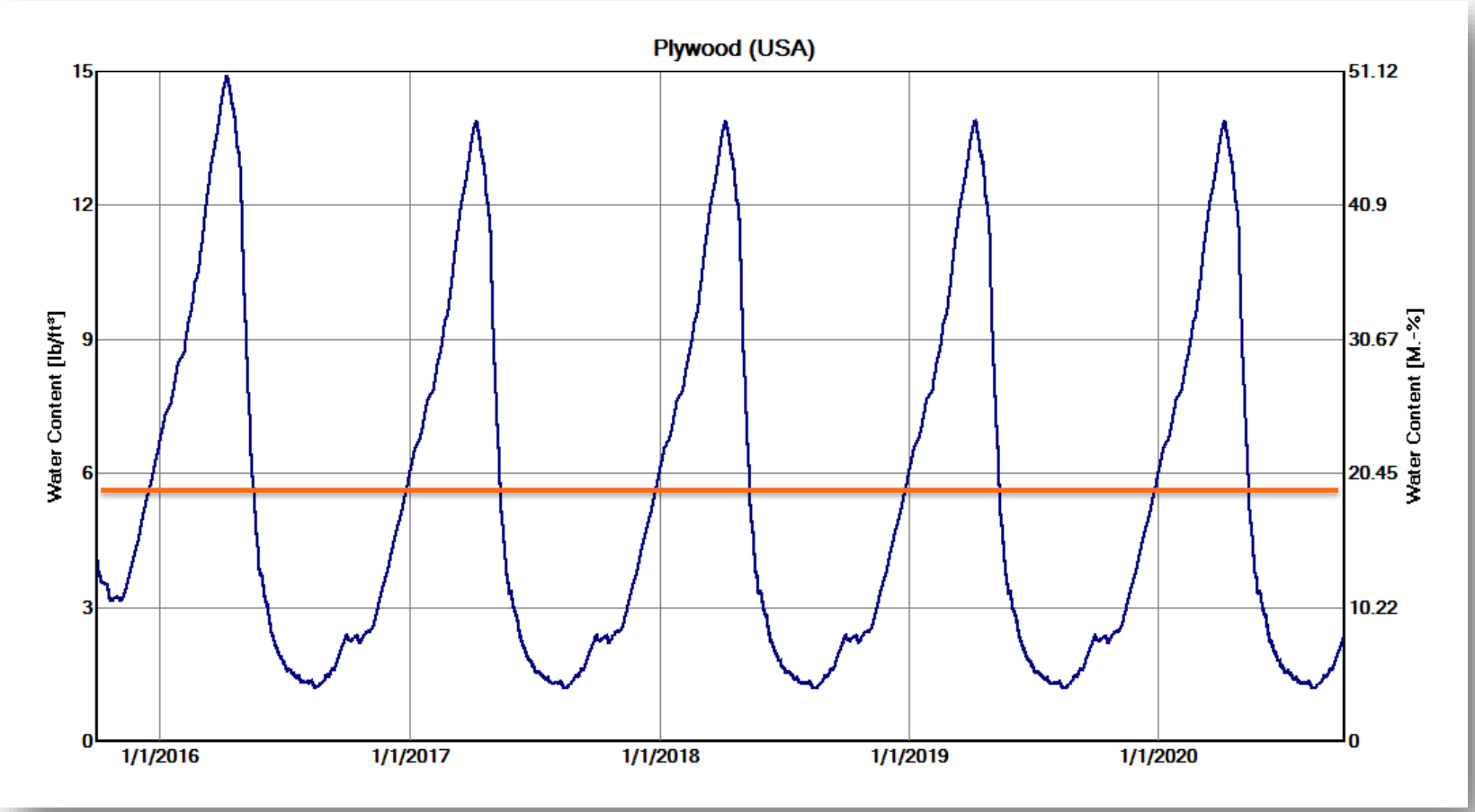

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SOME MITIGATION OPTIONS

VENTILATE THE TRUSS SPACE

- Not effective to manage moisture
- Not a viable option

CONSTRUCT A COMPLETE CEILING VAPOR RETARDER FROM INSIDE THE BUILDING

- New construction suited
- Seal to the wall vapor retarder
- Complete/continuous vapor retarder construction almost impossible to do
- Not a viable option

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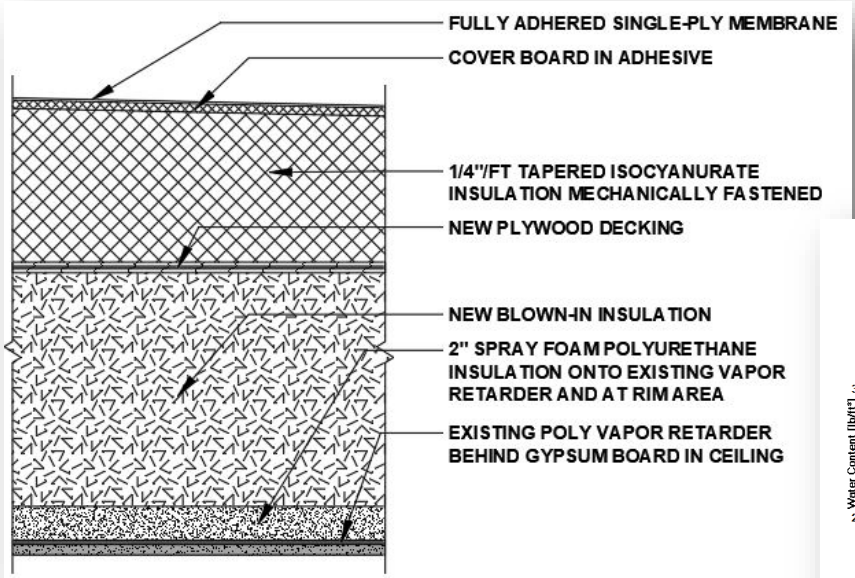
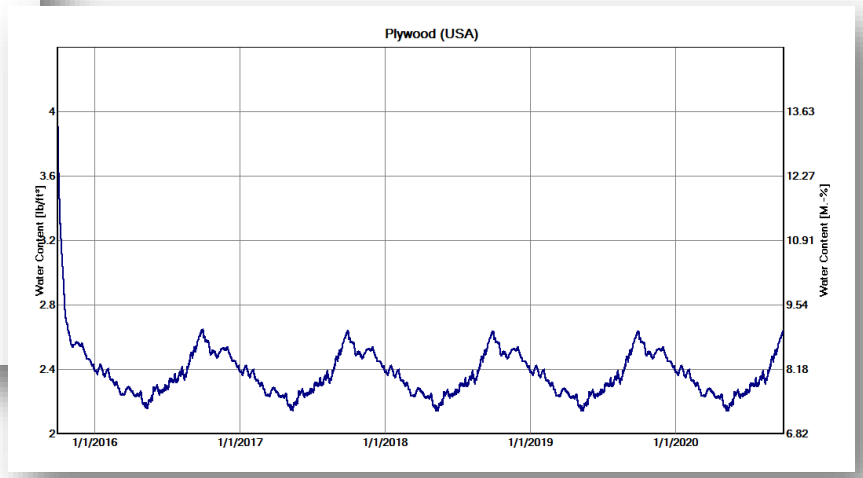
CONSTRUCT A COMPLETE VAPOR RETARDER FROM OUTSIDE THE BUILDING

- Roof replacement suited
- Closed cell spray foam over ceiling vapor retarder from topside
- Seal to wall vapor retarder
- Exposing the truss space/weather protection
- A viable option





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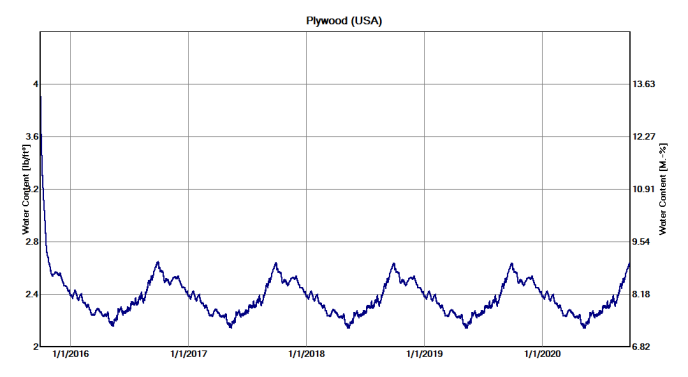
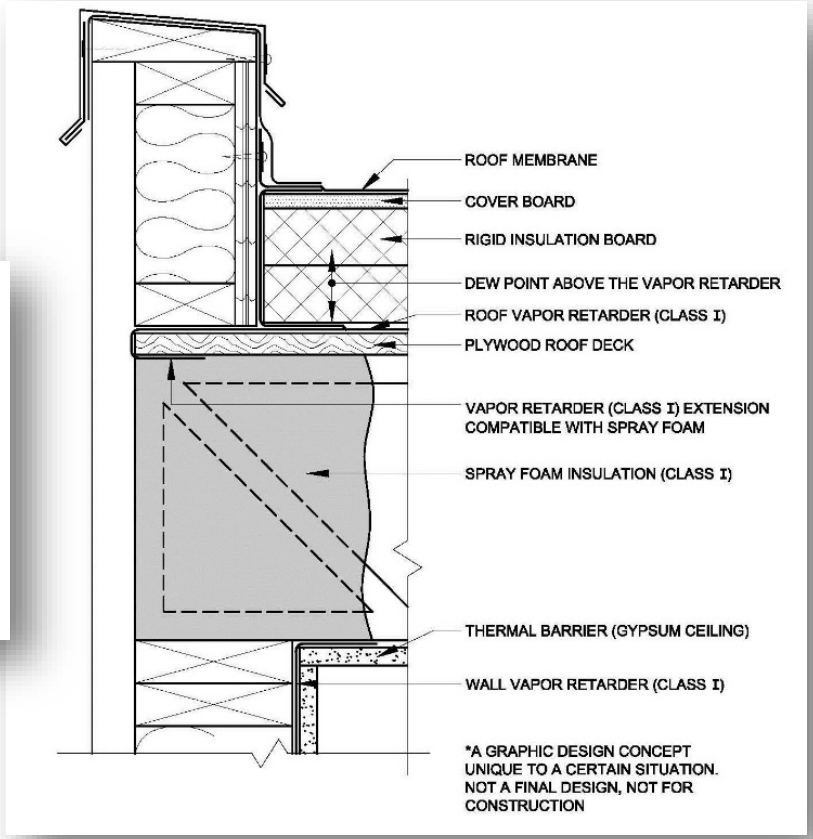
CONSTRUCT A COMPLETE WALL/ROOF VAPOR RETARDER VIA THE BUILDING TRUSS PERIMETER

- New Roof and Roof replacement suited
- Top side application perimeter area in roof replacement scenario
- Closed cell spray foam tie-in to wall and roof vapor retarder
- Insulation filled concealed space or compartmented to eliminate insulation/sprinklers
- A viable option





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CASE STUDY - FIXING A FAILED/ROTTING ROOF

Central MN Apartment Building

- Several attempts to stop moisture migration
- Moisture accumulation one year later!
- Mitigation options reviewed

Viable options:

- CONSTRUCT A COMPLETE CEILING VAPOR RETARDER FROM OUTSIDE THE BUILDING

- CONSTRUCT A COMPLETE VAPOR RETARDER VIA THE BUILDING TRUSS PERIMETER

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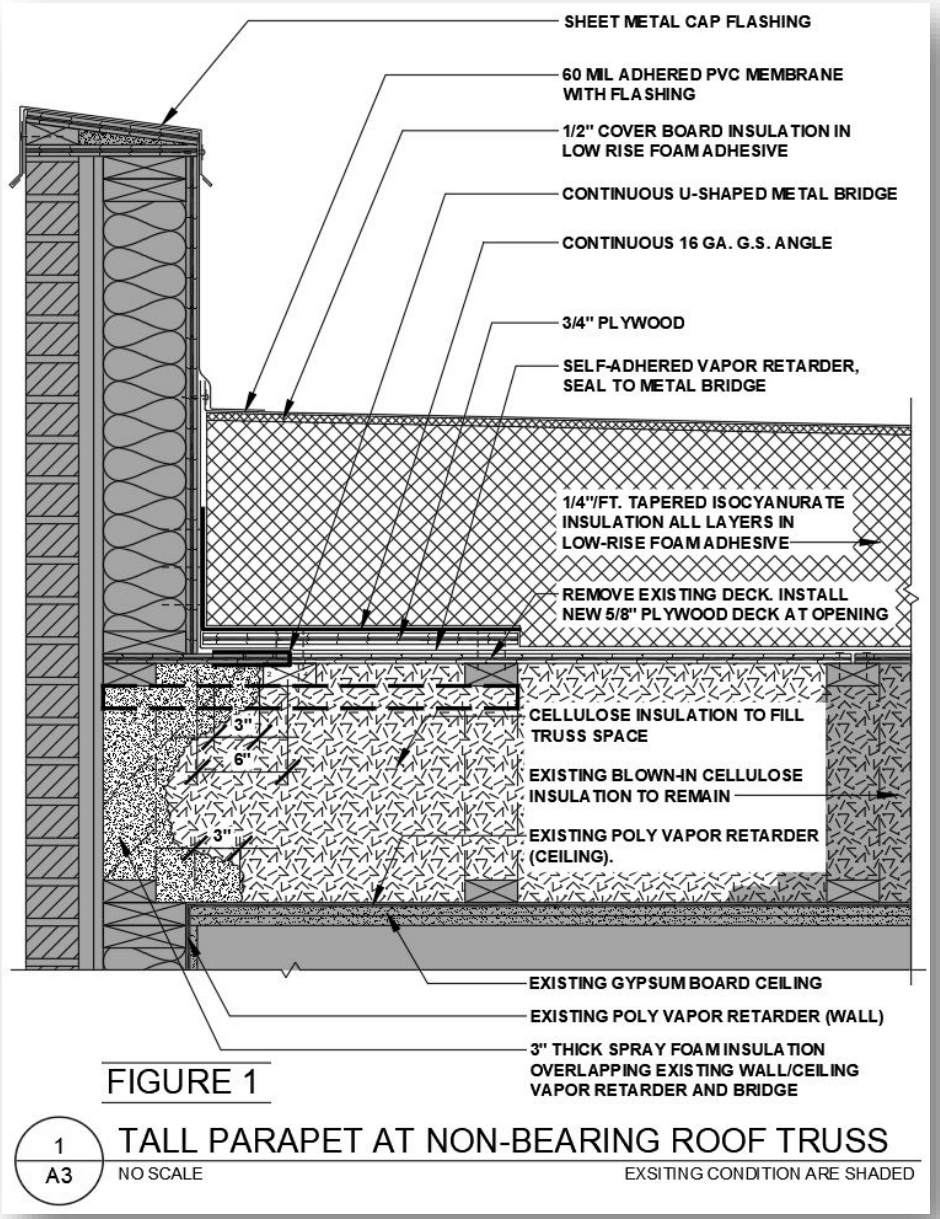
CONSTRUCT A COMPLETE VAPOR RETARDER VIA THE BUILDING TRUSS PERIMETER OPTION



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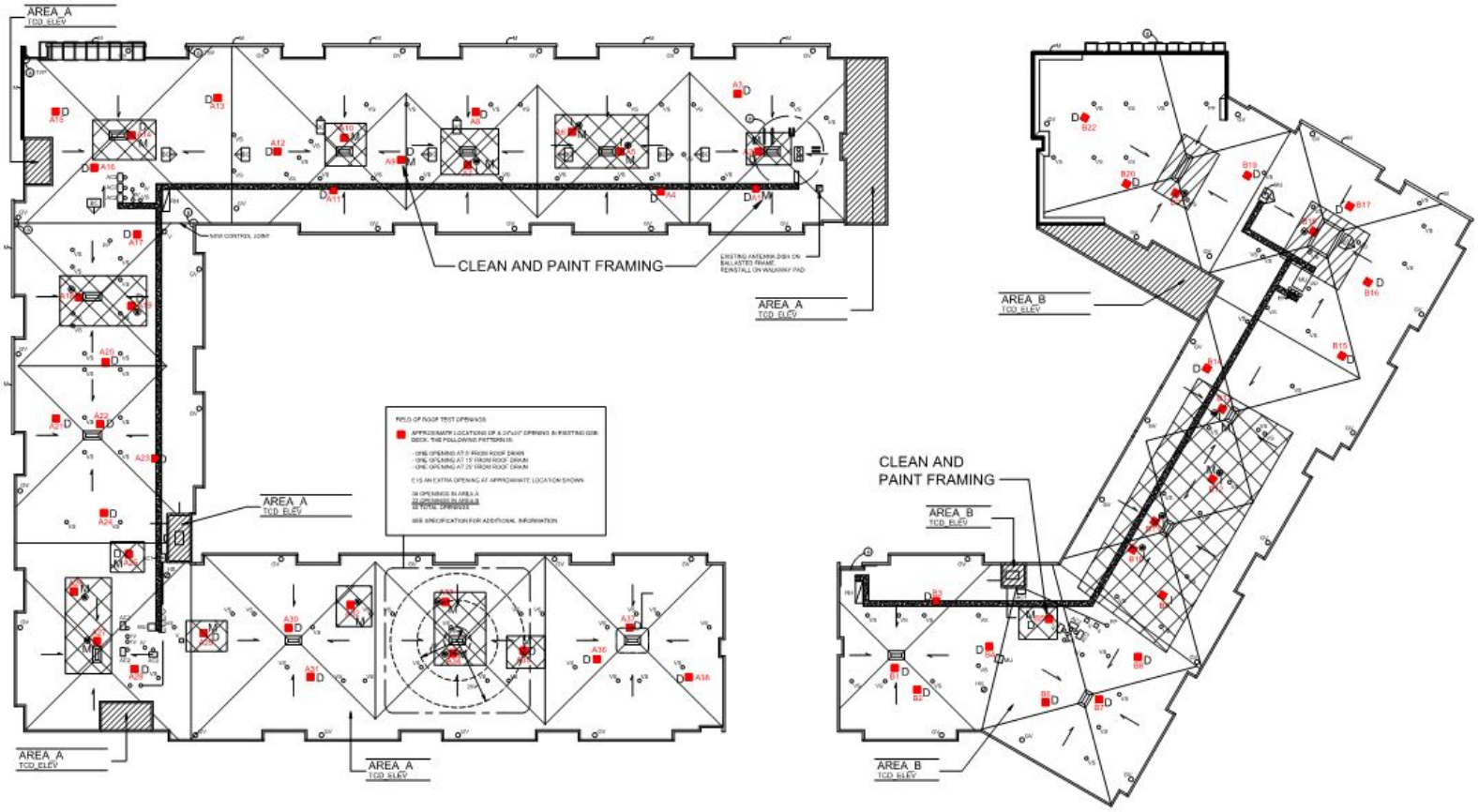
ROOF PLAN NOTATION

D	DRY OSB DECK AND FIBERGLASS INSULATION
•	WET OSB DECK
I	WET FIBERGLASS INSULATION
M	MOLD

AREA OF DECK TO BE REPLACED

AREA OF DECK AND FIBERGLASS INSULATION TO BE REPLACED



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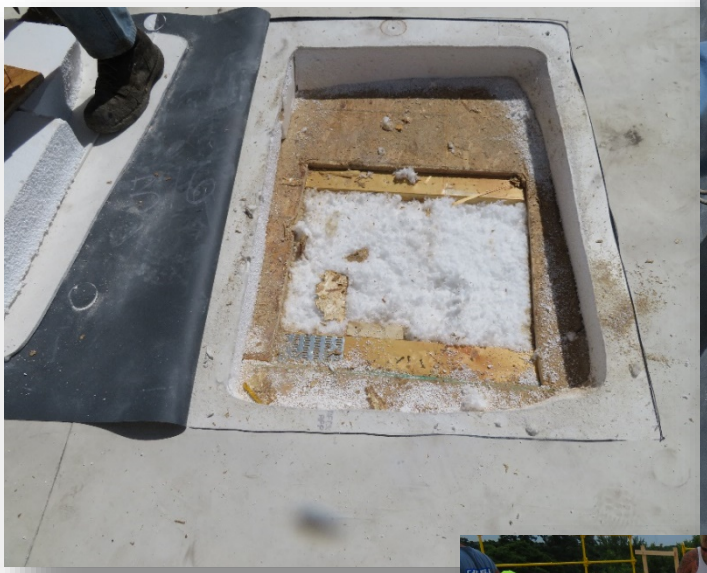

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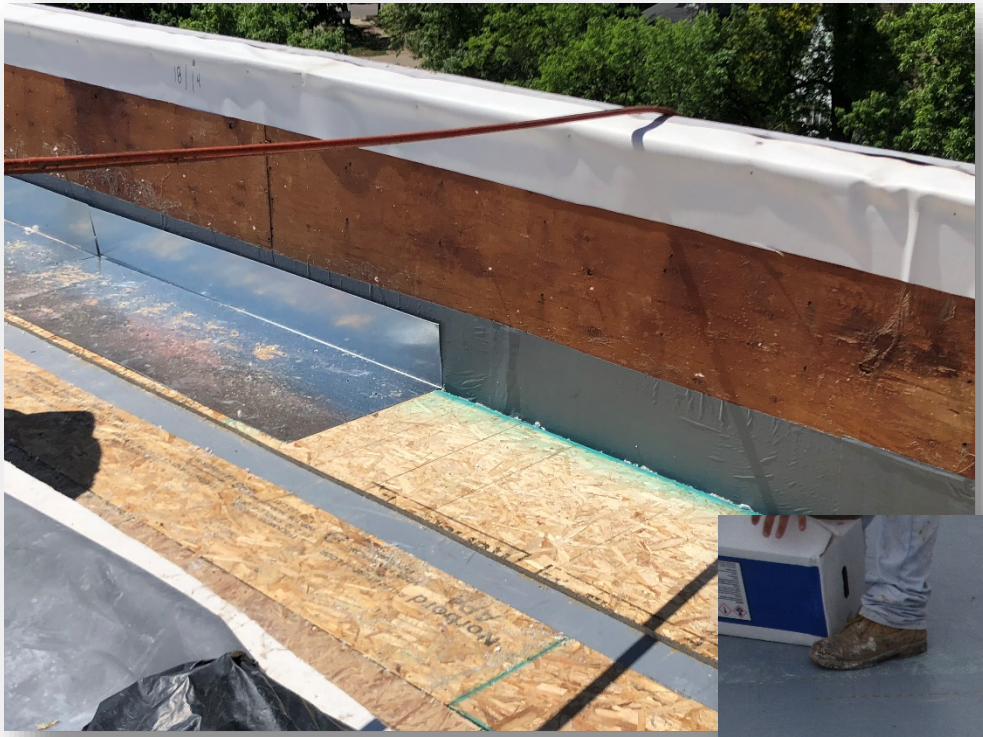

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CASE STUDY – PREVENTING A NEW ROOF FROM FAILING

St. Paul MN Senior Residential Building
New Building Construction

Roof/Wall Vapor Retarder Design Consultation

Solution:

CONSTRUCT A COMPLETE VAPOR RETARDER VIA THE BUILDING TRUSS PERIMETER

- Explored Options

- WUFI Modeling support

- Architect Developing Final Detailing

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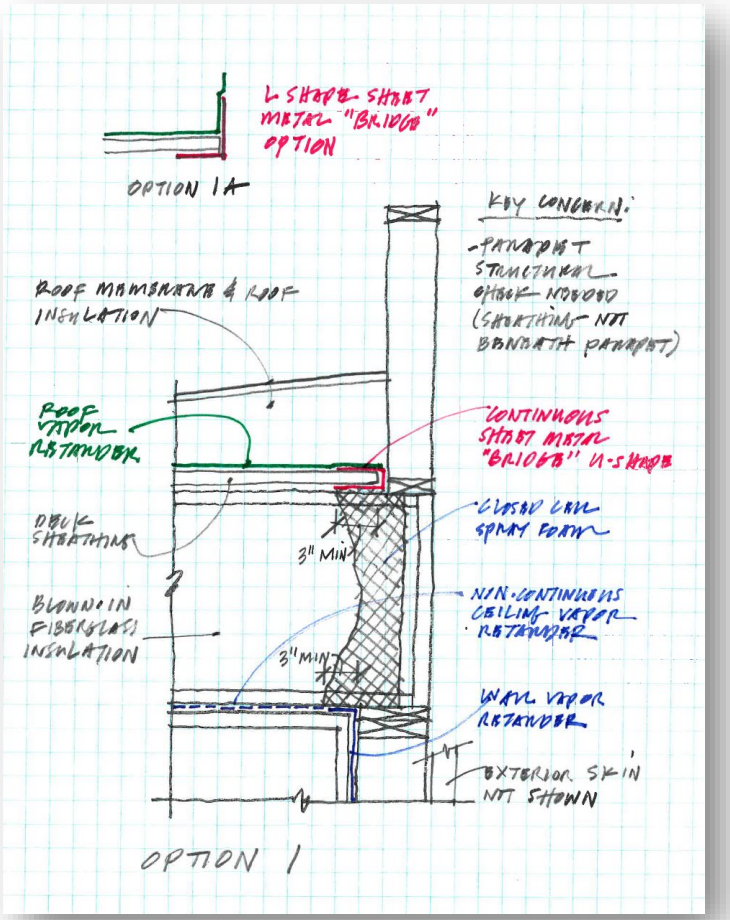
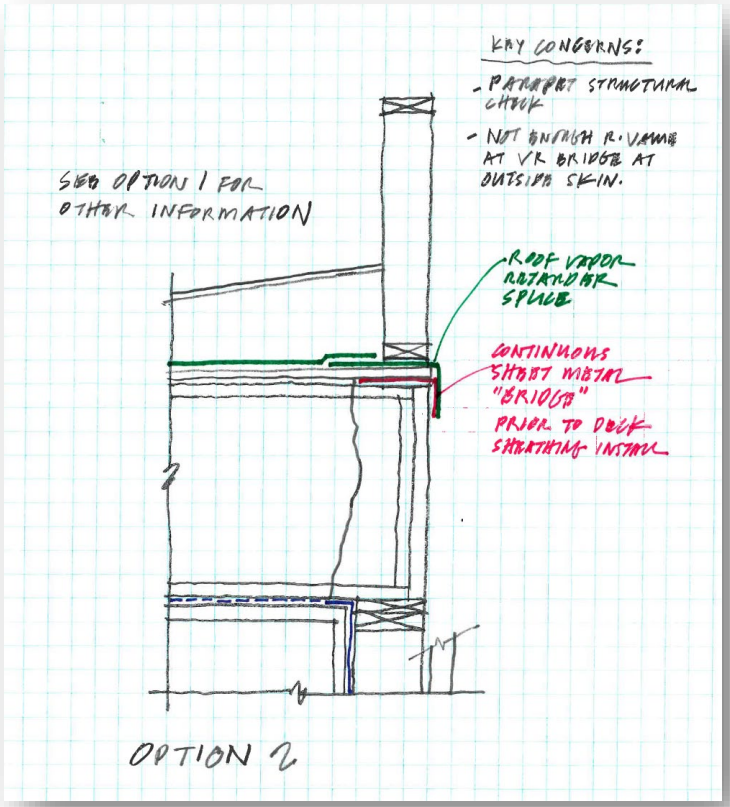
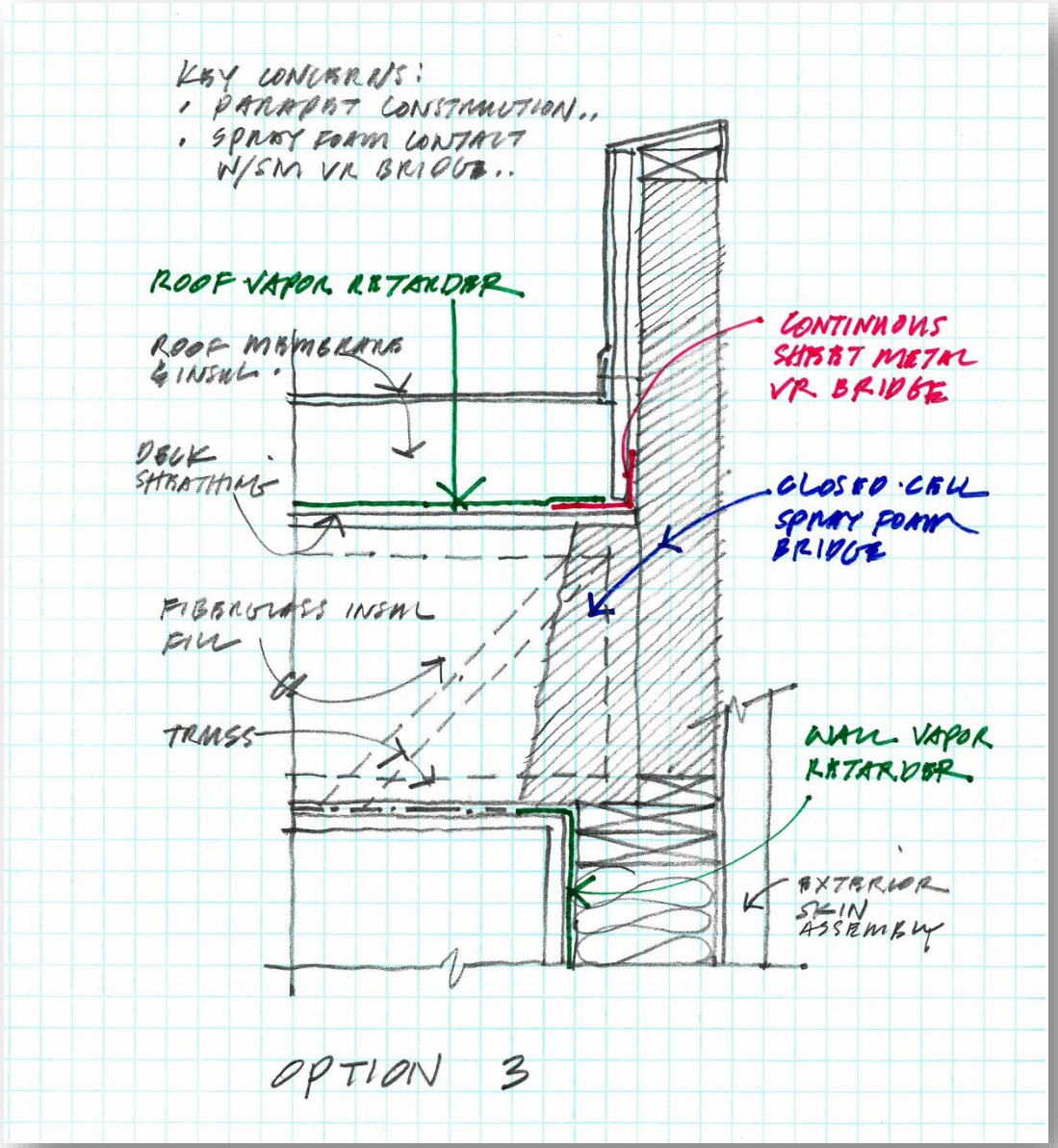

L SHAPE SHEET METAL "BRIDGE" OPTION
OPTION 1A
KEY CONCERNS:
-PARAPET STRUCTURAL CHECK NEEDED (SHEATHING NOT BENEATH PARAPET)
ROOF MEMBRANE & ROOF INSULATION
ROOF VAPOR RETARDER
CONTINUOUS SHEET METAL "BRIDGE" U-SHAPE
DECK SHEATHING
CLOSED CELL SPRAY FOAM
3" MIN
BLOWN-IN FIBERGLASS INSULATION
NON-CONTINUOUS CEILING VAPOR RETARDER
3" MIN
WALL VAPOR RETARDER
EXTERIOR SKIN NOT SHOWN
OPTION 1


KEY CONCERNS:
- PARAPET STRUCTURAL CHECK
- NOT ENOUGH R-VALUE AT VR BRIDGE AT OUTSIDE SKIN.
SEE OPTION 1 FOR OTHER INFORMATION
ROOF VAPOR RETARDER SPLICE
CONTINUOUS SHEET METAL "BRIDGE" PRIOR TO DECK SHEATHING INSTALL
OPTION 2



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What Owners Can Do

- Become familiar with your type of roof/ceiling construction
- Roof walkovers and interior observations
- Indoor climate maintenance/lower RH the better
- Indoor bathroom/kitchen fan maintenance
- Take action early on

What Architects Can Do

- Incorporate a roof vapor retarder, make it complete/continuous with the wall vapor retarder
- WUFI Hygrothermal Modeling recommended during design. Trained technician is key
- Consider other types of construction

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Combustible Concealed Spaces Fire Protection

- Fire Prevention is good, we don’t have many fires, but if we did…

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How Does Fire Protection Tie in Here?

- Building and Fire Codes generally require fire protection systems – sprinklers, throughout combustible construction.
  - International Building Code
  - International Fire Code
  - National Fire Protection Association (NFPA) 1.

How Does Fire Protection Tie in Here?

- Cold climates require freeze protection (e.g. dry sprinkler systems, antifreeze, heat, insulation, or some combination).
- Wet or dry systems and insulation, or lack thereof, can be problematic.

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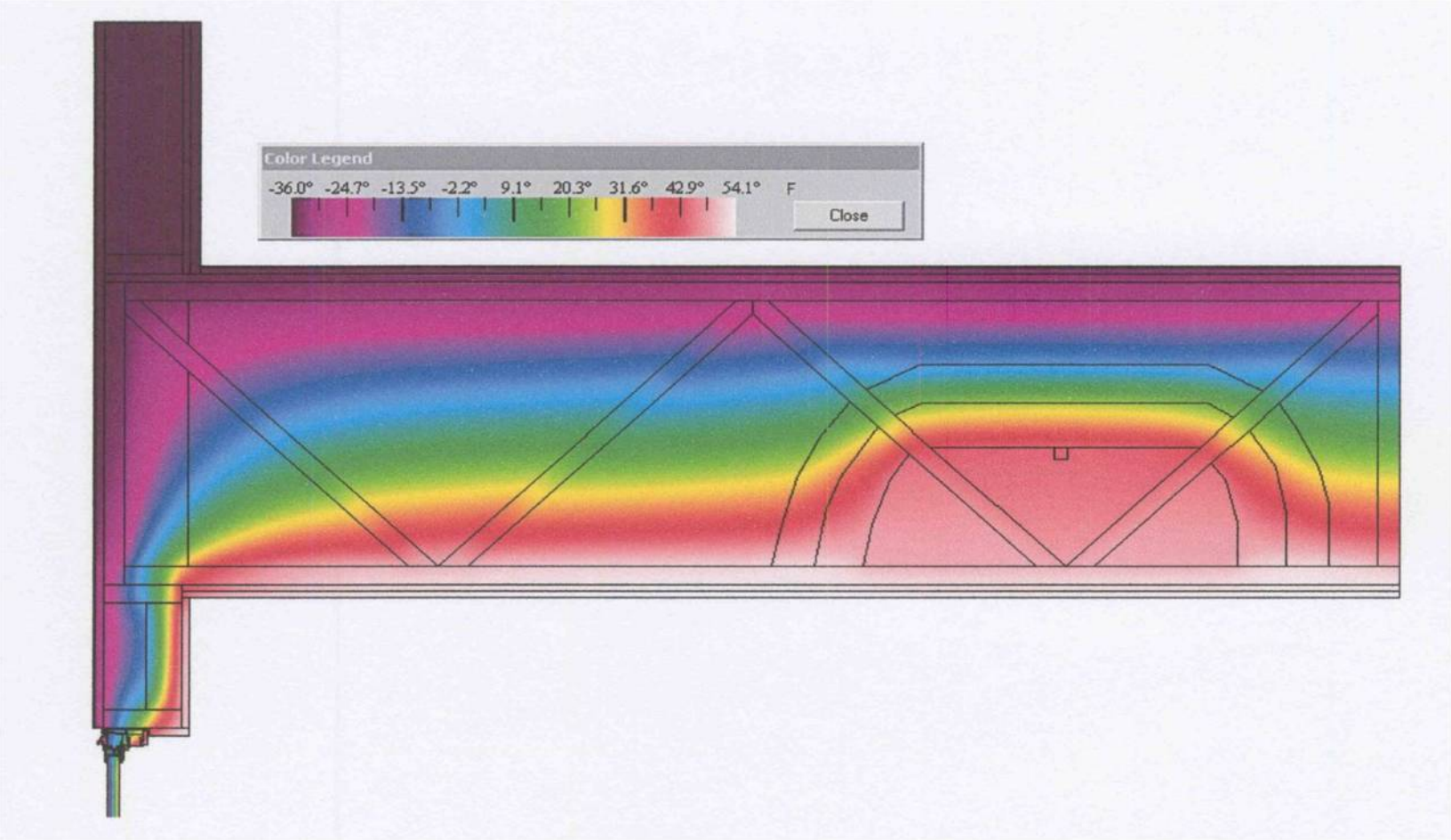
Alternates to Blown-in Insulation

- Dry sprinkler system.
- Antifreeze systems – maybe.
- Wet sprinkler system with adequate and appropriate insulation.
- Wet sprinkler system with adequate heat (>38^{o}F in every corner) in attics and other concealed spaces.
- Non-combustible construction without fuel loading or ignition sources.
- NFPA 13 exclusions such as 8.15.1.2.6.

Cause and Effect



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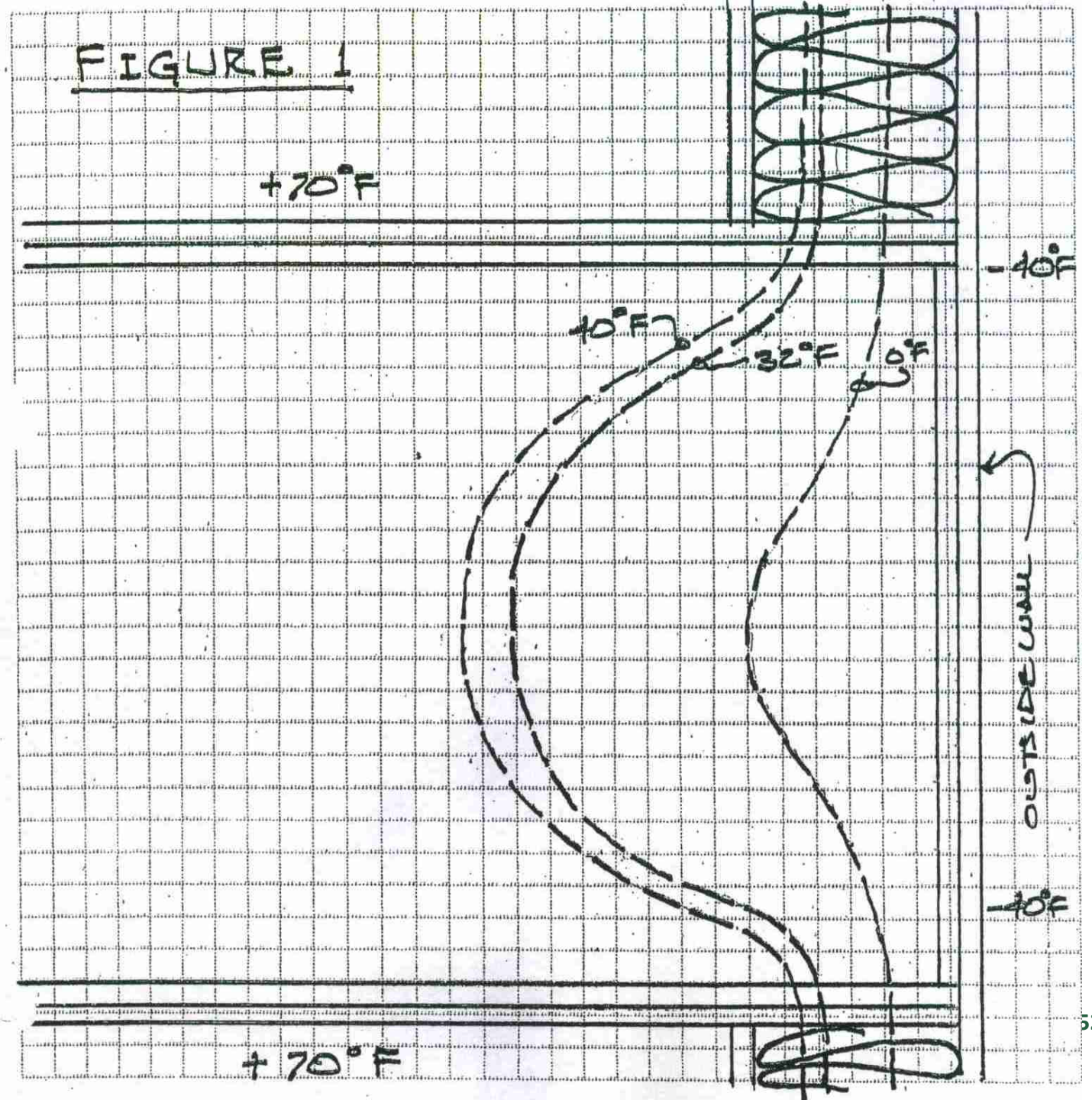
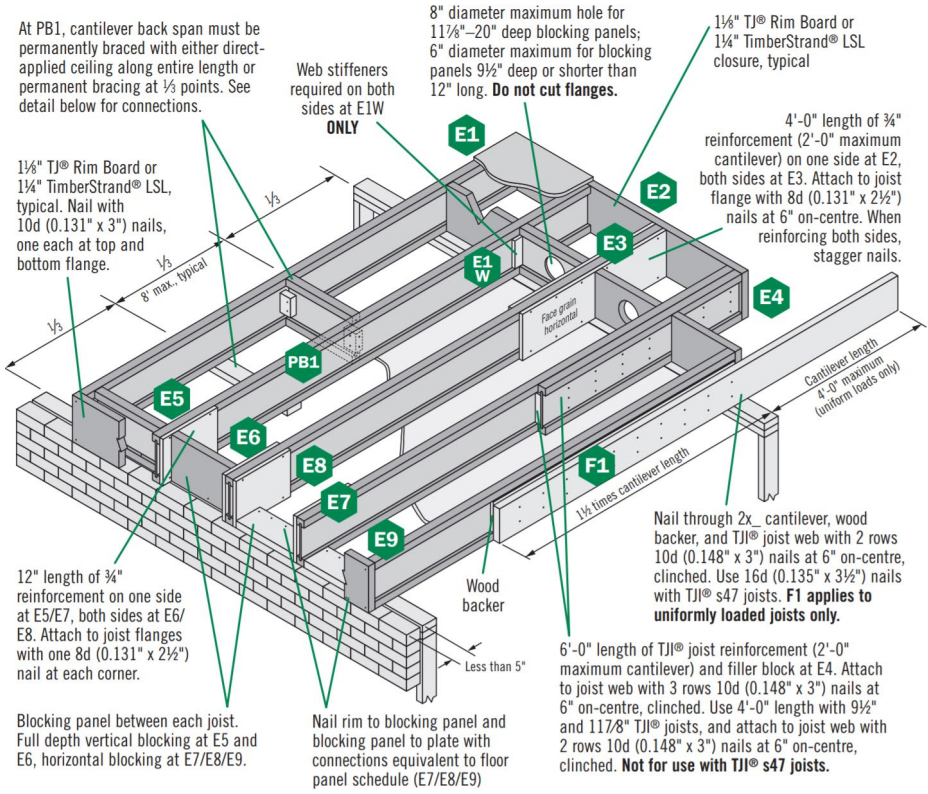


FIGURE 1
+70°F
-40°F
10°F
32°F
0°F
OUTSIDE WALL
-10°F
+70°F

Alternates to Blown-in Insulation

- NFPA 13, 2010 edition: 8.15.1.2.6* Concealed spaces formed by ceilings attached to composite wood joist construction either directly or onto metal channels not exceeding 1 in. (25.4 mm) in depth, provided the joist channels are firestopped into volumes each not exceeding 160 ft^3 (4.53 m^3) using materials equivalent to the web construction and at least 3 1⁄2 in. (90 mm) of batt insulation is installed at the bottom of the joist channels when the ceiling is attached utilizing metal channels, shall not require sprinkler protection.[1]



1 National Fire Protection Association, Standard for the Installation of Sprinkler Systems, NFPA 13, 2010 edition, One Batterymarch Park Quincy, MA.

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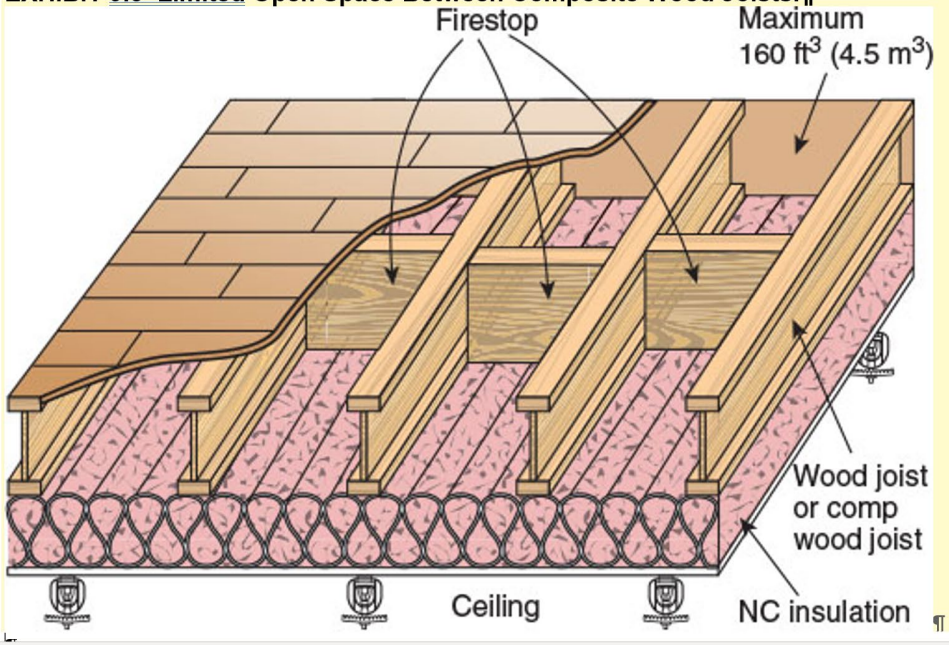
Alternates to Blown-in Insulation

9.2.1.9¶

Concealed·spaces·within·composite·wood·joist·construction·having·noncombustible·insulation·filling·the·space·from·the·ceiling·up·to·the·bottom·edge·of·the·composite·wood·joist·of·the·roof·or·floor·deck·and·with·the·joist·channels·separated·into·volumes·each·not·exceeding·160°ft³°(4.5°m³)·to·the·full·depth·of·the·composite·wood·joist,·with·material·equivalent·to·the·web·construction,·shall·not·require·sprinkler·protection.¶

For·an·example·of·composite·wood·joist·construction·separated·into·160·ft³°(4.5·m³)·volumes,·see°Exhibit·9.5.¶

EXHIBIT·9.5°·Limited·Open·Space·Between·Composite·Wood·Joists.¶



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National Fire Protection Association, Automatic Sprinkler Systems Handbook, NFPA 13, 2019 edition, One Batterymarch Park Quincy, MA.

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Alternates to Blown-in Insulation

- NFPA 13, 2010 edition, A.8.15.1.2.6[1].
- To use this option you are required to increase the design area from 1500 ft^2 to 3000 ft^2 or from four sprinklers to eight sprinklers. [11.2.3.1.4(3)].
  - This could double, or more, the cost of the sprinkler systems..
  - My guess is D/B specifications overlook this requirement.

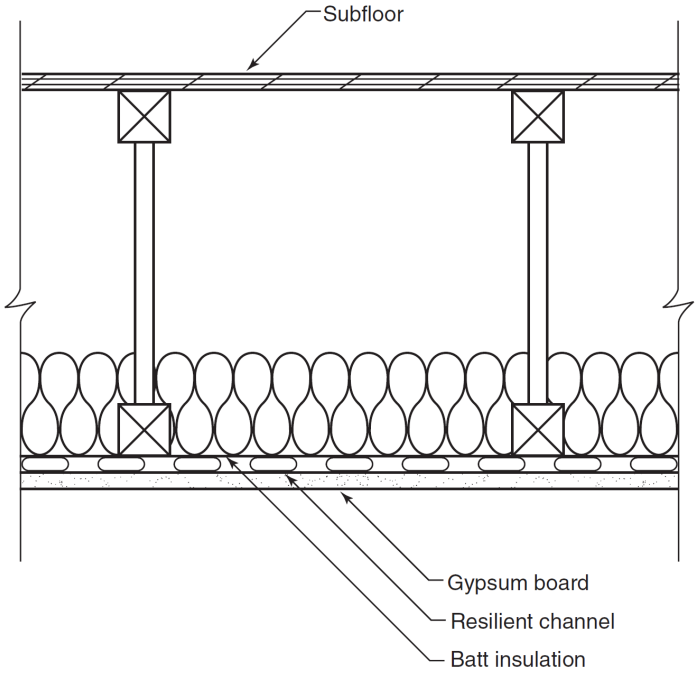

FIGURE A.8.15.1.2.6 Combustible Concealed Space Cross Section.

Insulation Related Failures

- Freeze failures because:
  - Floor / ceiling space filled with insulation.
  - Rim joist not properly sealed / insulated.
  - Exterior penetrations not properly sealed.
  - Water-filled domestic and sprinkler pipe too close to exterior walls and insulated from heat.

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Avoiding Insulation Related Failures

- "Tenting" / sealing water-filled pipe in joist / ceiling / floor spaces.
- "Tents" have to be sealed completely.
- Heating the attic space and using water-filled sprinkler systems.
- Non-combustible roof construction eliminating fire sprinkler requirements.

Tear it off and Re-do it!

Corrosion in Dry Systems

- Causes freeze failures.
- Can obstruct sprinklers and piping from waterflow in a fire condition.
- Reduces the life expectancy of steel pipe systems to 7-12 years with thinwall pipe.

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Dry Systems are Problematic

7-12 year life expectancy with design/build construction and minimum NFPA 13 compliant designs.

Freeze failures due to improper installation.

Freeze failures due to corrosion.

Corrosion failures.

Failure to maintain the systems.

Worst-case scenario is clogged pipes and sprinklers in a fire scenario or sprinkler system out of service in a fire.

What Architects and Owners Need to Know

- It costs more to do it correctly from the start with dry systems.
- Design/build, low bid, NFPA 13 minimum is NOT the best.
- Design/build sprinkler systems in unheated attics are not appropriate for the long-term of the building or owner.
- There are options, but you won't get them from design/build specifications.

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What Architects and Owners Need to Know

- These are life safety, property protection, and fire fighter safety systems.
- Design / Build and cost savings to fire protection systems is not in your client's best interest.
- The possibility / probability of failure increases with the use of design / build in fire and life safety systems.
- Performance-Based Design is an option.
  - Utilize a competent Fire Protection Engineer on the design team to maximize protection and minimize failure probabilities.
- Non-combustible construction:
  - Exterior walls
  - Roof structure
  - Decks / balconies

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- We need to do a better job of protection in floor / ceiling / attic spaces that are combustible.

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QUESTIONS?

Looking for more information?

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