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FOR THE BUILT ENVIRONMENT

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ARCHITECT'S NEWSPAPER

Four Barriers For Four Wetting Potentials: How To Design Effective Exterior Walls

Presented by:

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Consulting, Inc.

www.exo-tec.biz

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Learning Objectives

Upon completing this program, the participant should understand

1. **Basic Building Physics**
2. **Basic Building Science**
3. **The Four Barriers Needed For The Weather Barrier System**
4. **How to properly design & specify the Weather Barrier System**

The Wetting Potentials

Liquid Water Ingress (Water Barrier)

Moisture Transport Due To Air Flow (Air Barrier)

Dew Point (Heat Barrier Location)

Vapor Migration (Vapor Barrier)

How Do We Properly Deal With These Four Wetting Potentials???

Good HAMM!!!

What the #@$& is HAMM ?

- **HAMM is the 4 barriers needed to protect a building against the effects of weather. These barriers are:**

H **Heat Barrier**

A **Air Barrier**

M_L **Water Barrier (Liquid Moisture)**

M_V **Vapor Barrier (Gaseous Moisture)**

HAMM is the WEATHER BARRIER SYSTEM

HAMM Order Of Magnitude

M_L Water Barrier (Liquid Moisture)

A Air Barrier

H Heat Barrier

M_V Vapor Barrier (Gaseous Moisture)

Good HAMM effectively deals with thermal transfer, wetting and drying potentials:

Heat Barrier

- **Thermal loss, gain and bridging**
- **Wetting potential due to a dew point (location)**

Air Barrier

- **Thermal loss and gain**
- **Wetting potential due to moisture transport via air flow**

Good HAMM effectively deals with thermal, wetting and drying potentials:

Water Barrier

- Wetting potential due liquid moisture intrusion into and through the Building Enclosure System.

Vapor Barrier

-Wetting potential due to vapor diffusion into and through the Building Enclosure System.

THE DEW POINT ANALYSIS TOOL

The Dew Point Analysis Tool is the most widely used design tool in determining suitability of building enclosure system design for moisture control.

But guess what????

<u>It doesn’t work!!!</u>

Oak Ridge National Laboratories

http://www. ornl.gov/sci/btc/apps/moisture/ibpe_sof1.html

“ Out of Date: Dew-Point(Glaser)”

“ The Dew-Point method as detailed in ASHRAE has been a common method to assess the moisture balance of a building component by considering vapour diffusion transport in its interior. However, this method does not allow for the capillary moisture transport in the component, nor for its sorption capacity, both of which reduce the risk of damage in case of condensation. Furthermore, since the method only considers steady-state transport under heavily simplified boundary conditions, it cannot reproduce individual short-term events or allow for rain and solar radiation. It is meant to provide a general assessment of the hygrothermal suitability of a component, not to produce a simulation of realistic heat and moisture conditions in a component exposed to the weather prevailing at its individual location.”

Moisture Control In Buildings

Heinz R. Trechsel, Editor
ASTM Manual Series

Chapter 11: Design Tools by Anton TenWolde

Commentary on the Dew Point Analysis, Glaser Diagram and Kieper Diagram

“ The methods discussed previously have the same severe limitations and should therefore be used with caution. The methods only “ predict “ condensation, not moisture damage. Many constructions can sustain limited periods of condensation without significant damage, especially if the temperature are near or below freezing and the material is able to dry quickly. In addition, performance problems such as mold and mildew or paint failure are not necessarily related to surface condensation.

These methods ignore air leakage. If air leakage is present, it tends to dominate moisture transport. Even small amounts of indoor air leaking into the wall (exfiltration) can more than double the condensation rate during Winter………

Moisture Control In Buildings

Heinz R. Trechsel, Editor
ASTM Manual Series

Chapter 11: Design Tools by Anton TenWolde

Commentary on the Dew Point Analysis, Glaser Diagram and Kieper Digram

" The methods do not recognize liquid capillary action transport or any transport mechanisms other than diffusion. This tends to result in the underprediction of moisture transfer in materials such as wood in higher moisture contents…….

All three methods are steady state and do not recognize the effects of moisture and heat storage. This may be a major drawback in in trying to determine the potential for damage in a wall or roof with large storage capacity in a climate with a low drying potential…….

All three methods are one dimensional; that is, the effect of corners, holes, or cracks, studs or other thermal bridges cannot be evaluated.

THE HEAT BARRIER

• Resists thermal transfer through the building enclosure system.

- R-Value is the measure of resistance to thermal transfer.
- The higher the R-Value, the greater the resistance.
- The greater the resistance, the lower the heat gain / loss.

• The location of the heat barrier, in a properly designed and constructed building enclosure system, determines the location of the dew point.

THE HEAT BARRIER

Second Law Of Thermodynamics

“ The entropy of an isolated system which is not in equilibrium will tend to increase over time, approaching a maximum value at equilibrium. “

Translation anyone???

<u>Heat seeks cold!!!</u>

THERMAL PERFORMANCE

Factors affecting thermal performance of insulation

- **Air leakage through gaps in the insulation**
- **Wind wash effect on fibrous insulation**
- **Thermal Bridging**

New Whole Wall R-value Calculators As A Part Of The ORNL Material Database For Whole Building Energy Simulations

These calculators are replacing the old Whole Wall Thermal Performance calculator. These new versions of the calculator contain many new features and are part of the newly developed *Interactive Envelope Materials Database for Whole-Building Energy Simulation Programs.*

The simple version of the Whole Wall R-value calculator is now available for use. This calculator is similar to the previous Whole Wall Thermal Performance calculator and does not require any downloads from the user. However, it was updated to allow calculations for fourteen wall details instead of nine. It simply runs over the Internet. Use this calculator for whole wall R-value calculations and for direct comparisons of different wall technologies. This calculator uses a residential building containing a rectangle slab-on-grade foundation with one floor containing a set amount of windows and doors. A link is available for detailed specifications of the example building.

******* UPATDATE 08-30-05 *******

New Whole Wall R-value Calculator 2.0 Available For Download

****

http://www.ornl.gov/sci/roofs+walls/AWT/home.htm

THERMAL BRIDGING

What is the R-Value of a 6" LGMF wall with R-19 batts insulation, exterior gypsum sheathing and interior gypsum wallboard?

R 7.2

THE AIR BARRIER

Air Barrier System (ABS): A system of building components within the building enclosure system (BES) designed and installed in such a manner as to stop the flow of air into and out of buildings through the BES.

Self-Adhering Sheet Membranes

Self-Adhering Sheet Membranes

Fluid Applied Membranes

Fluid Applied Membranes

Fluid Applied Membranes

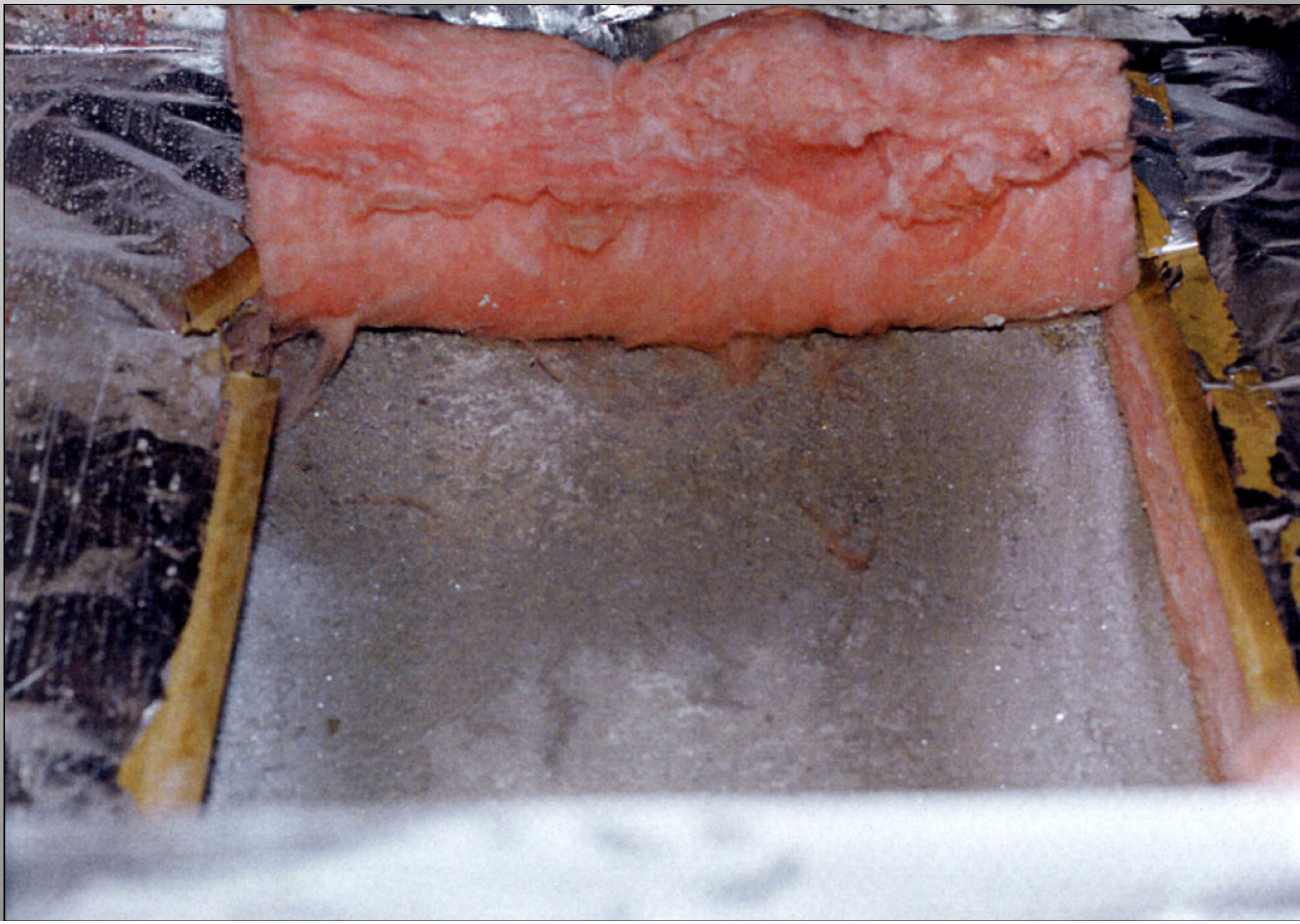
2 lb Density Closed Cell Spray Polyurethane Foam

2 lb Density Closed Cell Spray Polyurethane Foam

2 lb Density Closed Cell Spray Polyurethane Foam

Precast Concrete Panel Veneer

Fibrous Insulation Does Not Work On Precast



2 lb Density Closed Cell Spray Polyurethane Foam

Exterior Sheathing

Rigid Boardstock Insulation

Polyolefin Films

Air Barrier Systems

For the life of your building

by Leonard Anastasi, CSI

In the past decade, the use of air barrier systems (ABSs) in the building envelope has been steadily increasing because they have been proven to increase energy efficiency, reduce the potential for envelope system failures, and reduce the occurrence of indoor air quality (IAQ) problems.

To date, ABSs have primarily been included in envelopes for "high performance" or "high-end" buildings, such as field or pool houses, museum storage facilities, and "monumental" buildings. However, research into the theory, science, and performance of ABSs has significantly increased in this country, to the point where their advantages are significant in virtually all buildings.

The U.S. Department of Energy (DoE) has concluded that up to 40 percent of the energy required to heat/cool a building is wasted through uncontrolled air movement. As such, building owners can expect substantial savings in their heating and cooling costs. ABSs can also eliminate the occurrence of building envelope system failures caused by moisture infiltrating the system. Moisture corrodes metals and decreases the thermal performance of insulation.

Air flow has the ability to transport exponentially more moisture into and through building envelopes than can be transferred through vapor migration. By stopping the flow of air through the building envelope, the flow of moisture is virtually halted, and by reducing moisture, one can also eliminate many of the conditions under which mold and fungi grow. These biological agents are a major concern for building professionals due to the effects they have on both IAQ and the health of building occupants.

The incorporation of ABSs in new construction is not a passing fad. The state of Massachusetts, for example, implemented legislation this year requiring air barrier systems in all commercial buildings and certain multi-tenant buildings over 929 m² (10,000 sf)—and they are not alone. Currently, 21 states are considering incorporating ABSs in their building codes.

The real deal

Many in the construction industry do not know what an ABS is, nor what it does. The most succinct definition was penned by Lance Robson Jr. of Building Envelope Technologies Inc. for the Air Barrier Association of America (ABAA): "A combination of building envelope components designed and installed in such a manner as to control the infiltration and exfiltration of air through the building envelope.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wayODD.com

Air Barrier Systems

Air barrier systems can be classified as either:

Vapor Permeable Air Barrier Systems

or

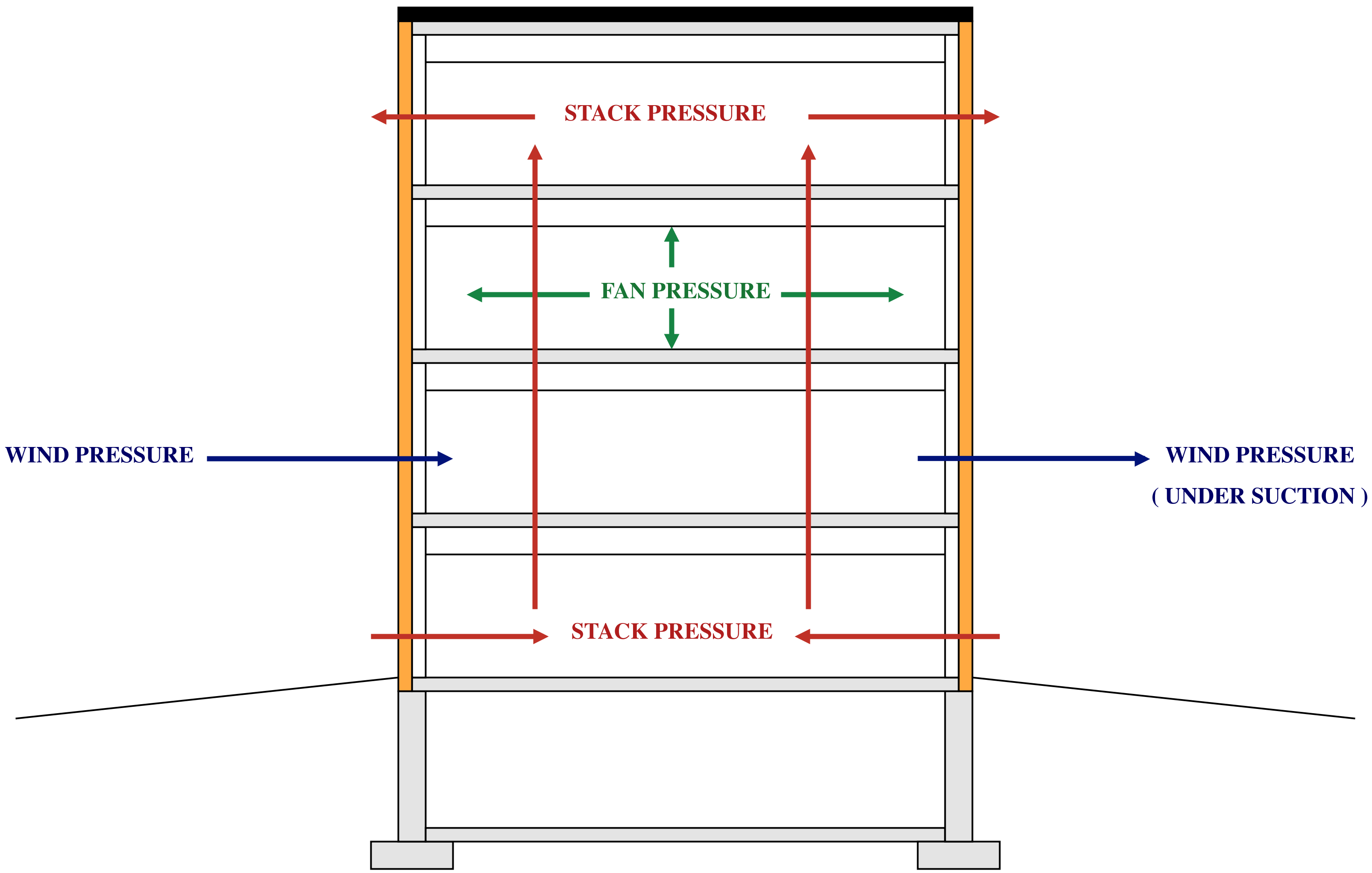
Air And Vapor Barrier Systems

Air flow into and out of buildings is caused by:

Wind pressure

Fan pressure

Stack pressure

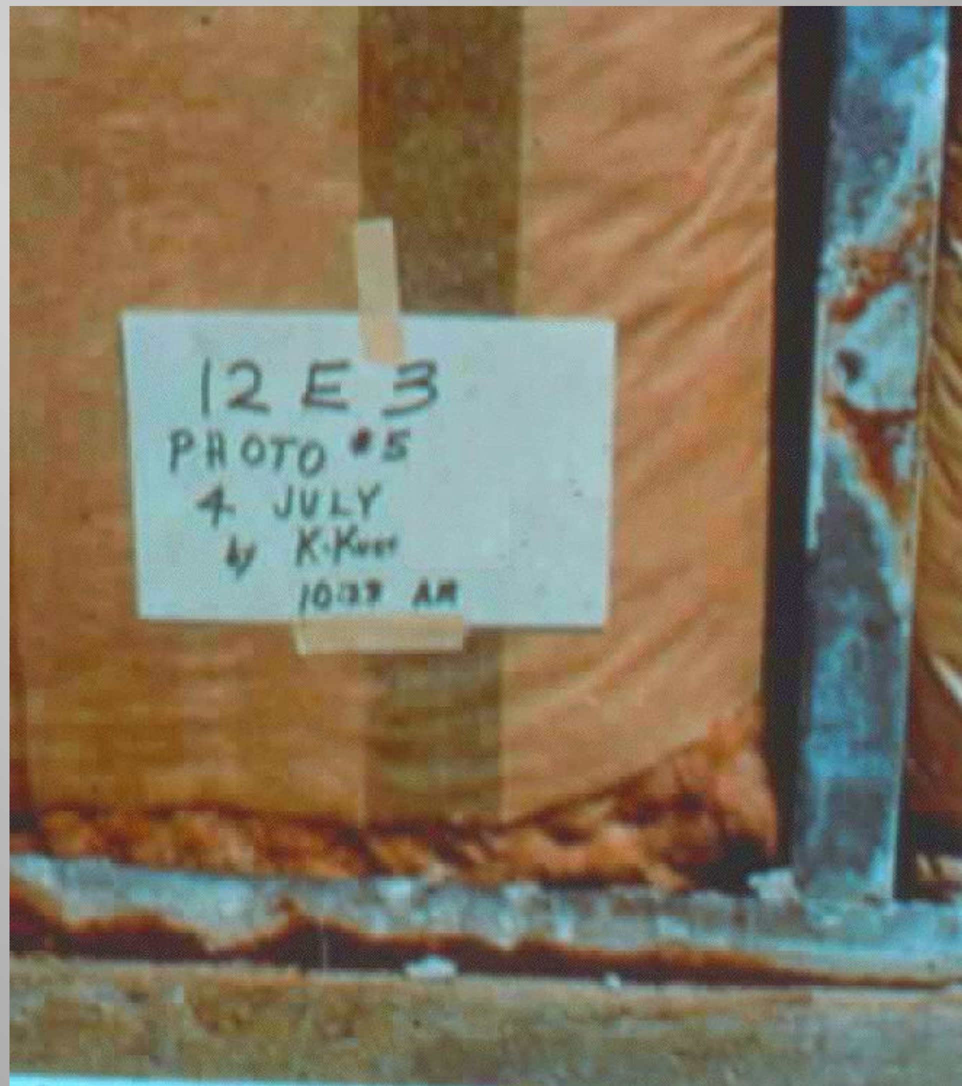

STACK PRESSURE
FAN PRESSURE
WIND PRESSURE
WIND PRESSURE
(UNDER SUCTION)
STACK PRESSURE

Why stop the flow of air into and through the BES?

First and foremost………..

1.) Air flow has the ability to transport exponentially more moisture into and through the building enclosure system than occurs through vapor migration or diffusion. Estimates range from 30 to 200 times more moisture transport occurs via air flow than vapor migration.

Excess moisture in exterior walls causes:



Corrosion of metal items

Excess moisture in exterior walls causes:

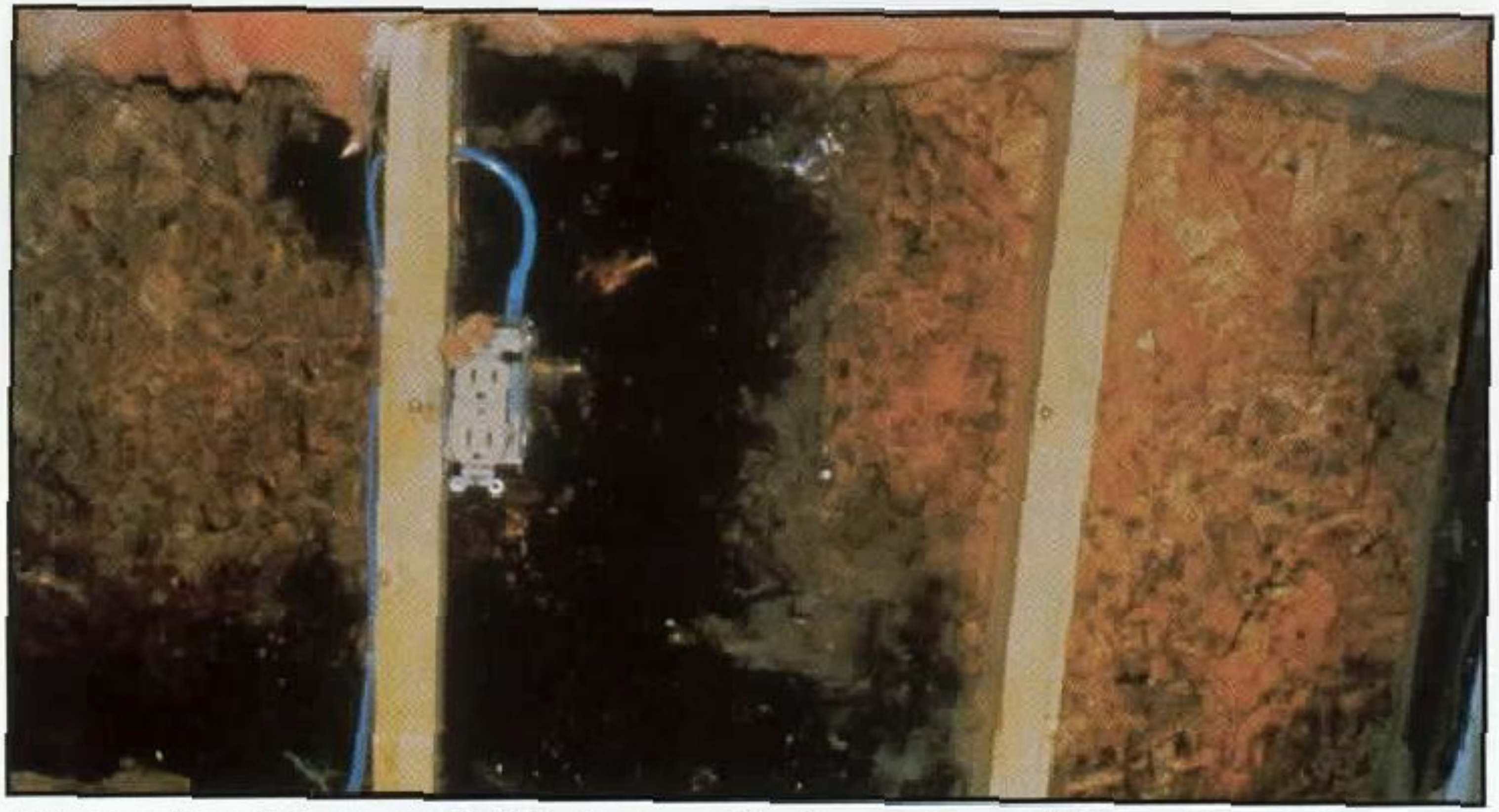


Photo of mold in wall. Photo supplied courtesy of Canadian Home Builders' Association (CHBA) and Canadian Mortgage and Housing Corp. (CMHC)

The " M " Word

Excess moisture in exterior walls causes:

Crumbling masonry

Excess moisture in exterior walls causes:

Efflorescence

2.) Air flow into and out of buildings can affect the location of the dew point.

3.) Air leakage into and out of buildings causes the HVAC system to expend extraneous energy in order to maintain the building's desired temperature and humidity levels.

4.) Air flow is a vehicle by which sound travels.

5.) Air flow is a vehicle by which particulate matter travels.

6.) Air flow is a vehicle by which odors and gaseous substances travel.

Why use Air Barrier Systems?

The use of Air Barrier Systems result in:

Reduced Building Enclosure System problems

Wetting potentials effectively dealt with

Improved indoor air quality

Reduced building energy consumption

Reduced building heating and cooling costs

Reduced fossil fuel consumption

Reduced pollution emissions

Reduction of the Greenhouse Effect

How much moisture gets in via air transport?

This value cannot be accurately calculated due to the fact that both the direction and rate of air flow into and through the BES can change dramatically on as little as a minute to minute basis. More importantly, the amount of moisture created due to condensation of this flowing air cannot be accurately calculated, predicted or accounted for.

Highly advanced computer modeling programs exist to analyze vapor transport, thermal performance, hygric capacity and drying times of exterior walls. Not one of them can account for the transport of moisture via air flow.

THE WATER BARRIER

• Resists the intrusion of moisture in its liquid form (water) into and through the building enclosure system.

• Over the history of Building Enclosure System use, water barriers have been:

- Ineffective due to their inability to resist water penetration.
- Ineffective due to improper installation.
- Ineffective due to lack of longevity.

• If an air barrier is properly designed and installed in a building enclosure system and the air barrier material is also a water barrier, won't the past deficiencies of water barrier be resolved?

Is this an effective water barrier?

Is this an effective water barrier???

THE VAPOR BARRIER

Vapor barriers are materials used in Building Enclosure Systems to retard the diffusion of vapor into and through the building enclosure system.

Why Are Vapor Barriers Needed?

By retarding the diffusion of vapor through the Building Enclosure System, conditions that create dew points within Building Enclosure Systems can be reduced or prevented and interior RH levels can be maintained.

What Is Vapor Diffusion?

Vapor diffusion is the process by which vapor seeks to equalize its content between different environments (the Ideal Gas Law).

The driving force (or "potential") for this occurrence is vapor pressure.

Vapor pressure is a function of the vapor content of the air (RH) and the temperature.

Vapor diffusion is caused by a vapor pressure differential (ΔP) between different environments. The greater the ΔP between environments, the greater the amount of vapor diffusion that occurs.

Table 1. VAPOR PRESSURE FOR VARIOUS TEMPERATURES AND RELATIVE HUMIDITIES (POUNDS PER SQUARE INCH).

Dry bulb temperature	Relative humidity (in percent)									
	100	90	80	70	60	50	40	30	20	10
°F.										
100	0.948	0.854	0.758	0.663	0.569	0.474	0.379	0.284	0.189	0.095
90	.698	.628	.558	.489	.419	.349	.279	.209	.140	.070
80	.506	.455	.405	.357	.303	.253	.202	.152	.101	.051
75	.429	.386	.343	.300	.258	.214	.172	.129	.086	.043
70	.362	.326	.290	.253	.217	.181	.145	.108	.072	.036
65	.305	.274	.244	.213	.183	.152	.122	.091	.061	.030
60	.256	.230	.205	.179	.153	.128	.102	.077	.051	.026
55	.214	.192	.171	.149	.128	.107	.085	.064	.042	.021
50	.178	.160	.142	.124	.107	.089	.071	.053	.036	.018
45	.147	.132	.118	.111	.088	.073	.059	.044	.029	.015
40	.122	.110	.098	.085	.073	.061	.049	.037	.024	.012
35	.100	.090	.080	.070	.060	.050	.040	.030	.020	.010
30	.080	.072	.064	.056	.048	.040	.032	.024	.016	.008
25	.063	.057	.050	.044	.037	.032	.025	.019	.012	.006
20	.052	.047	.042	.036	.031	.026	.020	.015	.010	.005
10	.031	.028	.025	.022	.018	.015	.012	.009	.006	.003
0	.018	.016	.014	.013	.010	.009	.007	.005	.003	.002
−10	.011	.010	.009	.008	.007	.006	.004	.003	.002	.001
−15	.008	.007	.006	.005	.005	.004	.003	.002	.002	.001

Reference: HUD Research Paper No. 28, Moisture Migration from the Ground.

The Dew Point

The dew point is the temperature at which air that contains a certain amount of vapor can no longer hold that vapor and must exhaust itself of excess vapor by depositing it on adjacent surfaces in the form of condensation (water).

Where does the water on the outside of the glass come from?

Dew Point Calculator

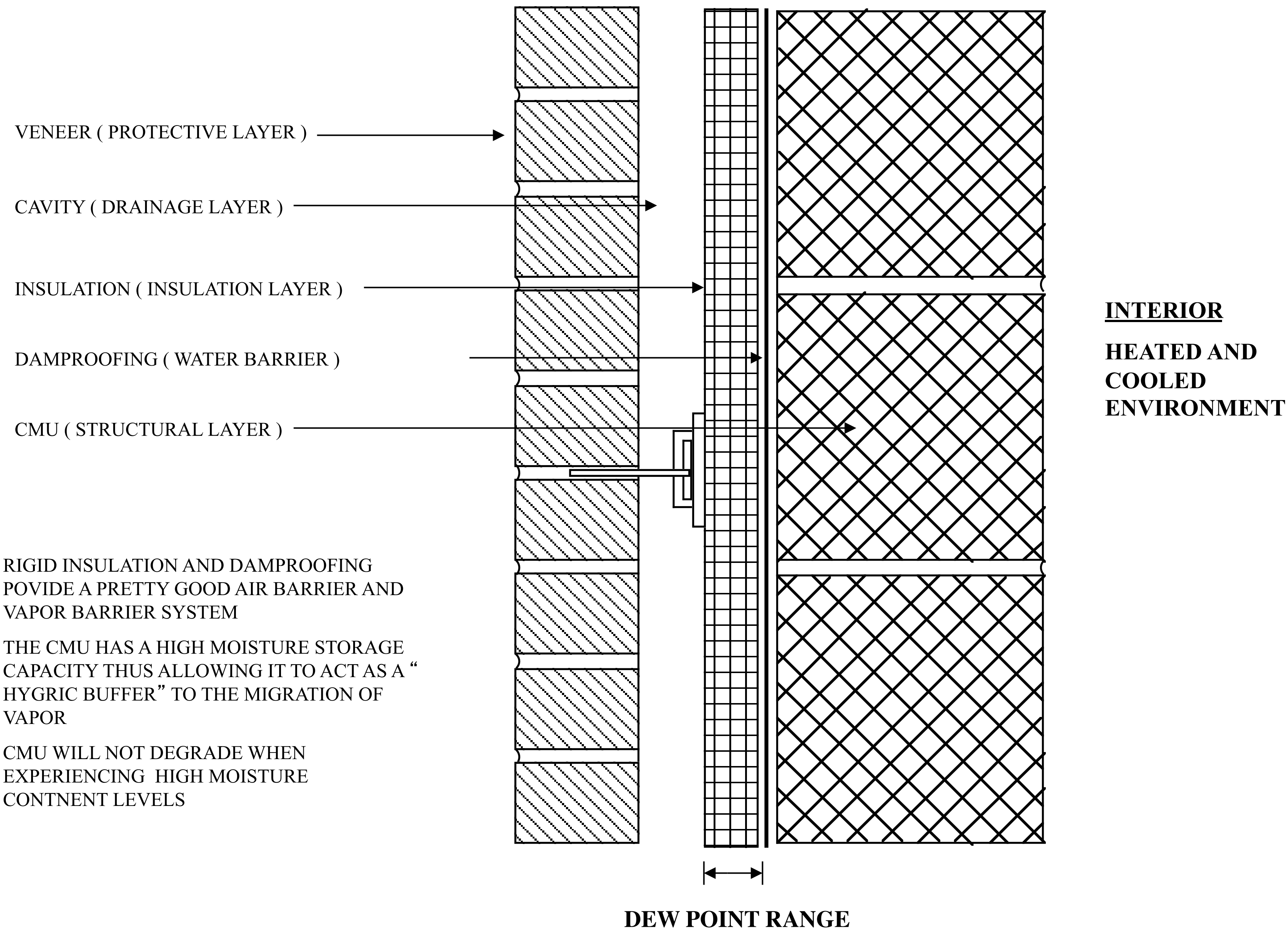
Air Temp °F	% Relative Humidity																		
	100	95	90	85	80	75	70	65	60	55	50	45	40	35	30	25	20	15	10
110	110	108	106	104	102	100	98	95	93	90	87	84	80	76	72	65	60	51	41
105	105	103	101	99	97	95	93	91	88	85	83	80	76	72	67	62	55	47	37
100	100	99	97	95	93	91	89	86	84	81	78	75	71	67	63	58	52	44	32
95	95	93	92	90	88	86	84	81	79	76	73	70	67	63	59	54	48	40	32
90	90	88	87	85	83	81	79	76	74	71	68	65	62	59	54	49	43	36	32
85	85	83	81	80	78	76	74	72	69	67	64	61	58	54	50	45	38	32	
80	80	78	77	75	73	71	69	67	65	62	59	56	53	50	45	40	35	32	
75	75	73	72	70	68	66	64	62	60	58	55	52	49	45	41	36	32		
70	70	68	67	65	63	61	59	57	55	53	50	47	44	40	37	32			
65	65	63	62	60	59	57	55	53	50	48	45	42	40	36	32				
60	60	58	57	55	53	52	50	48	45	43	41	38	35	32					
55	55	53	52	50	49	47	45	43	40	38	36	33	32						
50	50	48	46	45	44	42	40	38	36	34	32								
45	45	43	42	40	39	37	35	33	32										
40	40	39	37	35	34	32													
35	35	34	32																
32	32																		

The dew point is the temperature at which condensation forms on condensing surfaces. When air comes into contact with a surface that is at or below the dew point temperature of that air, condensation will form on it.

EXAMPLE 1: If the interior air temperature is 70˚ F and has an RH of 30%, the infiltration of air that is 37˚ F (the dew point temperature) can cool condensing surfaces to this temperature (37 ˚) causing dew to form on these surfaces.

EXAMPLE 2: If exterior air with a temperature of 85˚ F and an RH of 70% infiltrates into the building envelope, dew will form on condensing surfaces in the system that have temperatures of 74˚ F or less.

BUILDING EXTERIOR WALLS 30 - 40 YEARS AGO

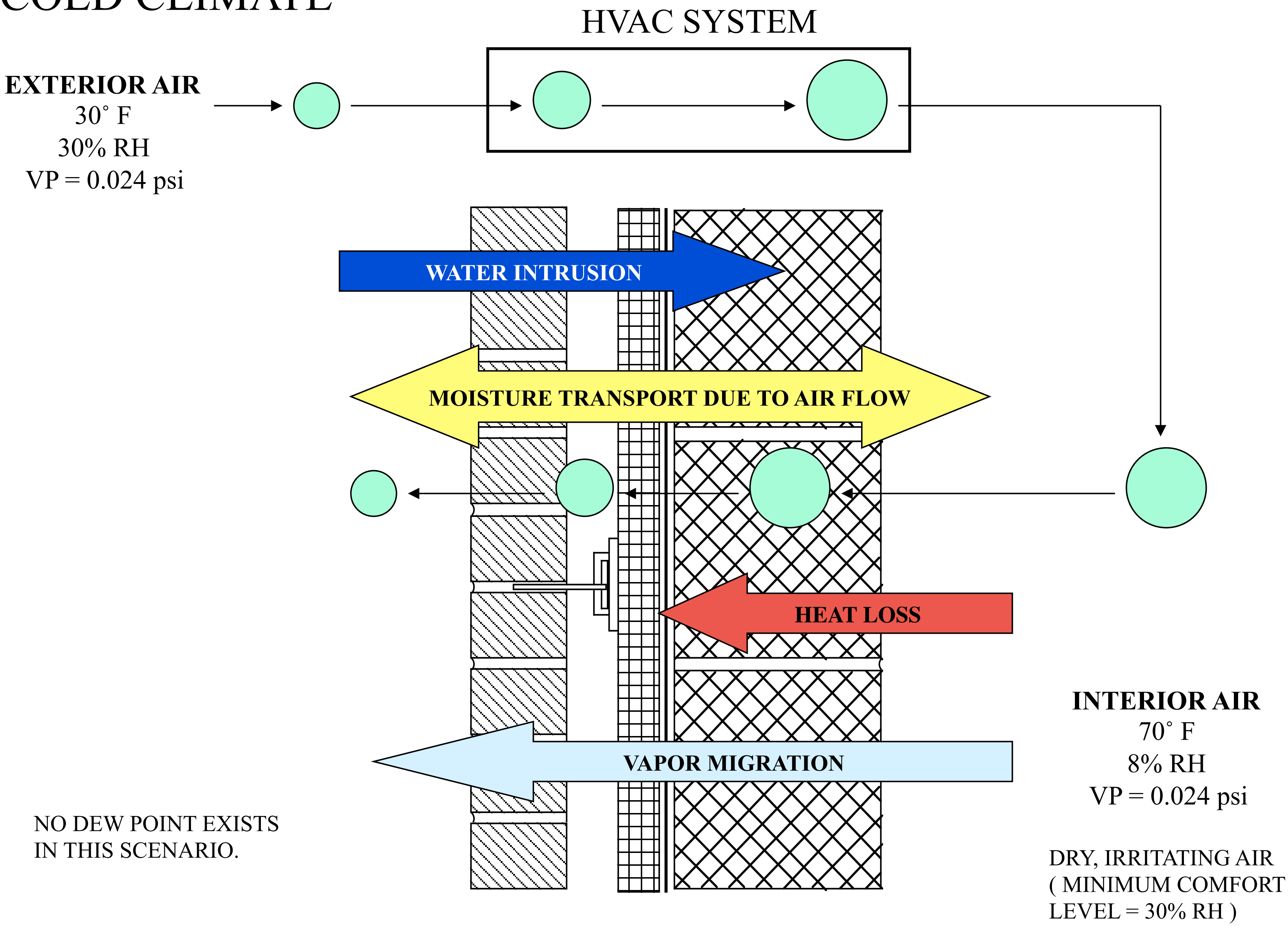


RIGID INSULATION AND DAMPROOFING POVIDE A PRETTY GOOD AIR BARRIER AND VAPOR BARRIER SYSTEM

THE CMU HAS A HIGH MOISTURE STORAGE CAPACITY THUS ALLOWING IT TO ACT AS A " HYGRIC BUFFER" TO THE MIGRATION OF VAPOR

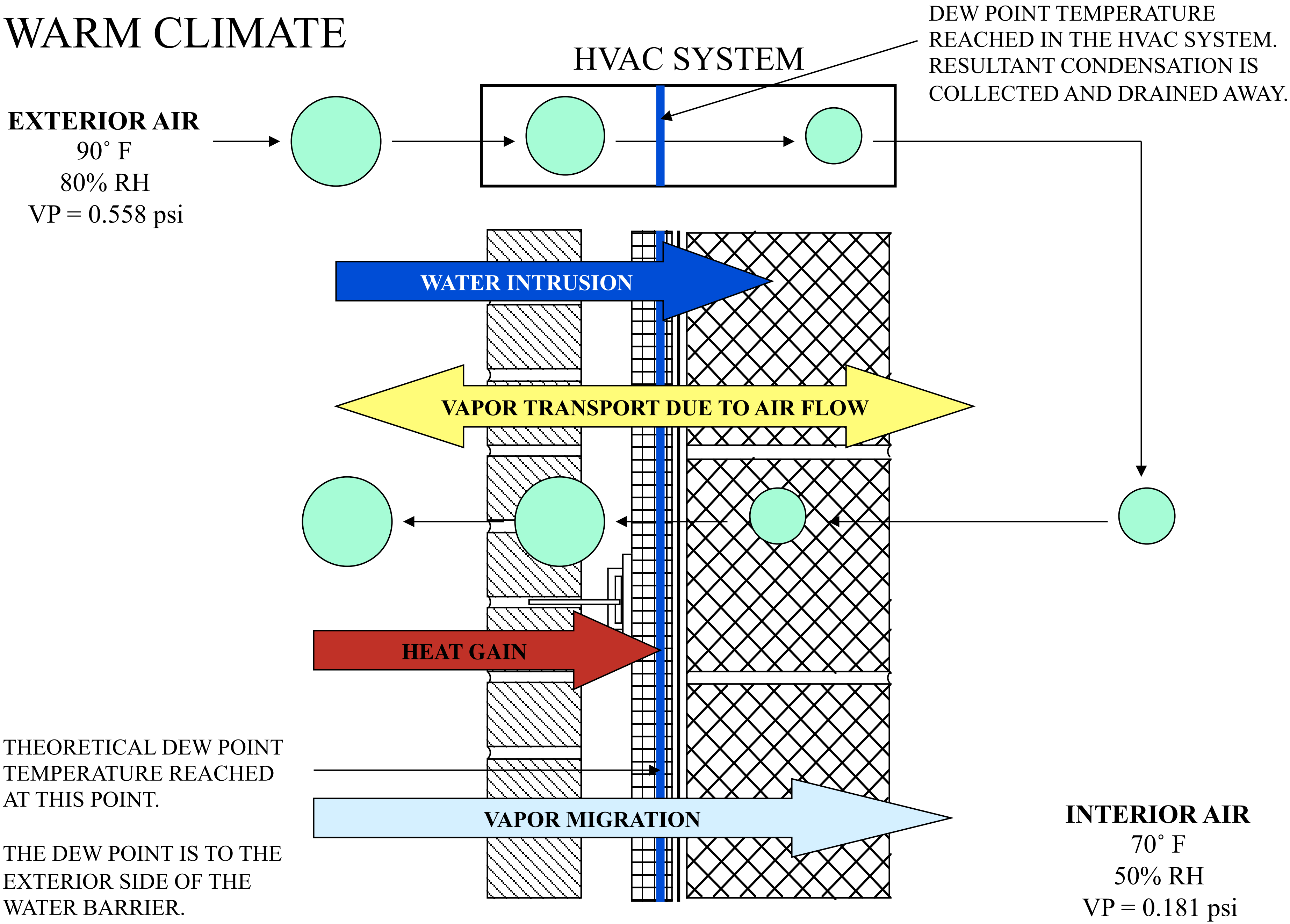
CMU WILL NOT DEGRADE WHEN EXPERIENCING HIGH MOISTURE CONTNENT LEVELS

COLD CLIMATE



One of the doors in Len’s house

WARM CLIMATE



THE DEW POINT IS TO THE EXTERIOR SIDE OF THE WATER BARRIER.

NOT A PROBLEM!!!

THE DYSFUNCTIONAL BUILDING ENCLOSURE SYSTEM

VENEER (PROTECTIVE LAYER)

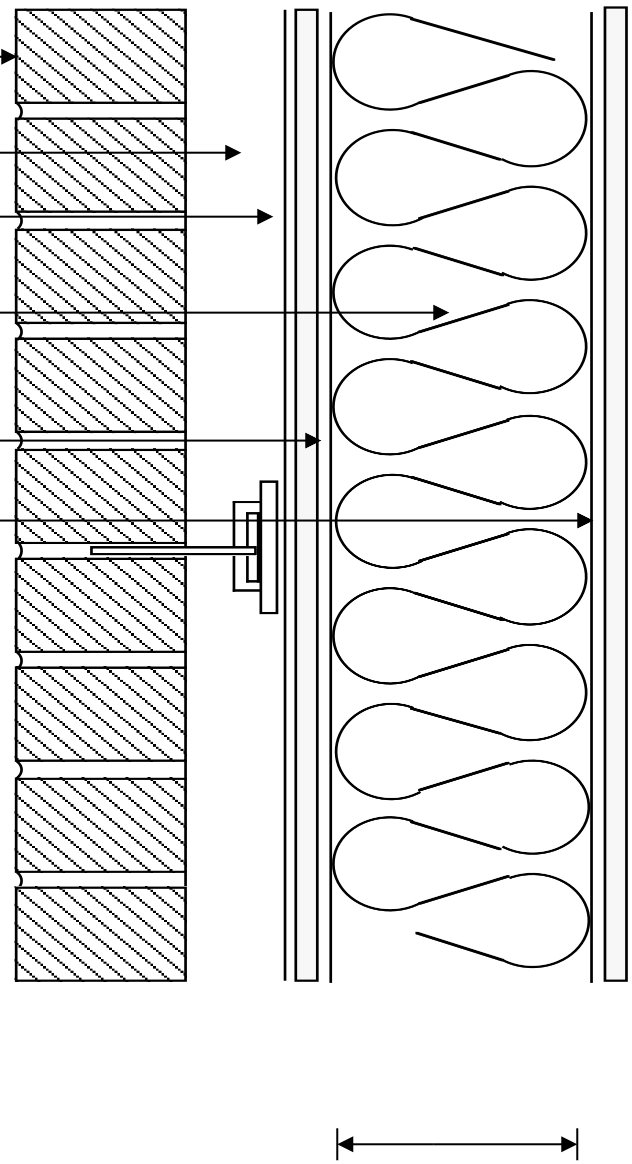
CAVITY (DRAINAGE SPACE)

WATER RESISTANT BARRIER
(DRAINAGE PLANE)

FIBERGLASS BATTS INSULATION
(HEAT BARRIER)

LGMF & GWB (STRUCTURAL LAYER)

VAPOR BARRIER ???



INTERIOR

HEATED, COOLED AND *HUMIDITY CONTROLLED* ENVIRONMENT

DEW POINT RANGE

BRICK VENEER IS A “ RESEVOIR “ CLADDING MATERIAL. IT WILL HOLD MOISTURE AND WHEN HEATED BY SOLAR RADIATION, WILL CREATE EXTREME TEMPERATURES AND VAPOR PRESSURE LEVELS IN THE CAVITY SPACE

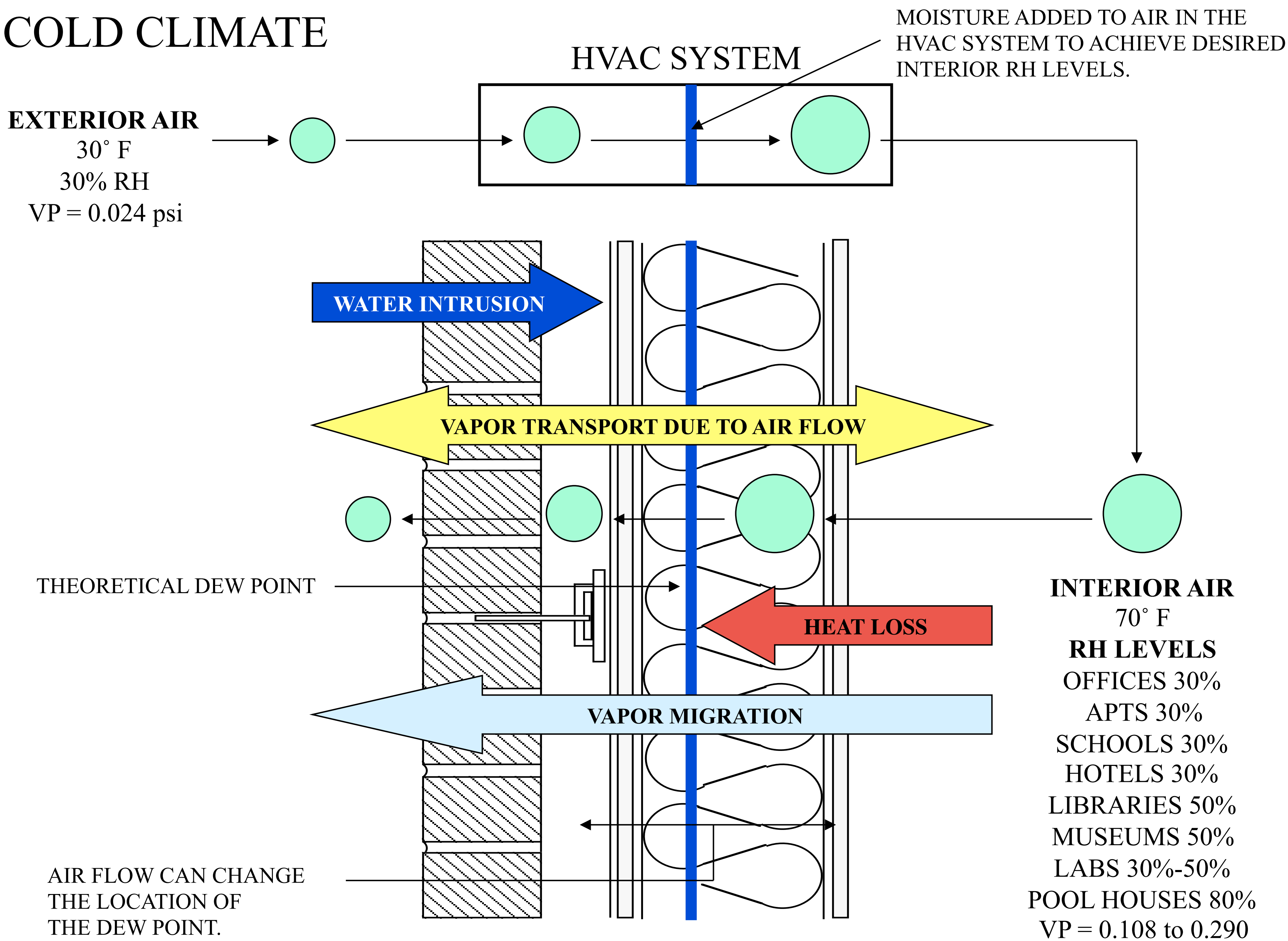
GWB SHEATHING IS NOT PROTECTED FROM MOISTURE INTRUSION IN ITS GASEOUS FORM

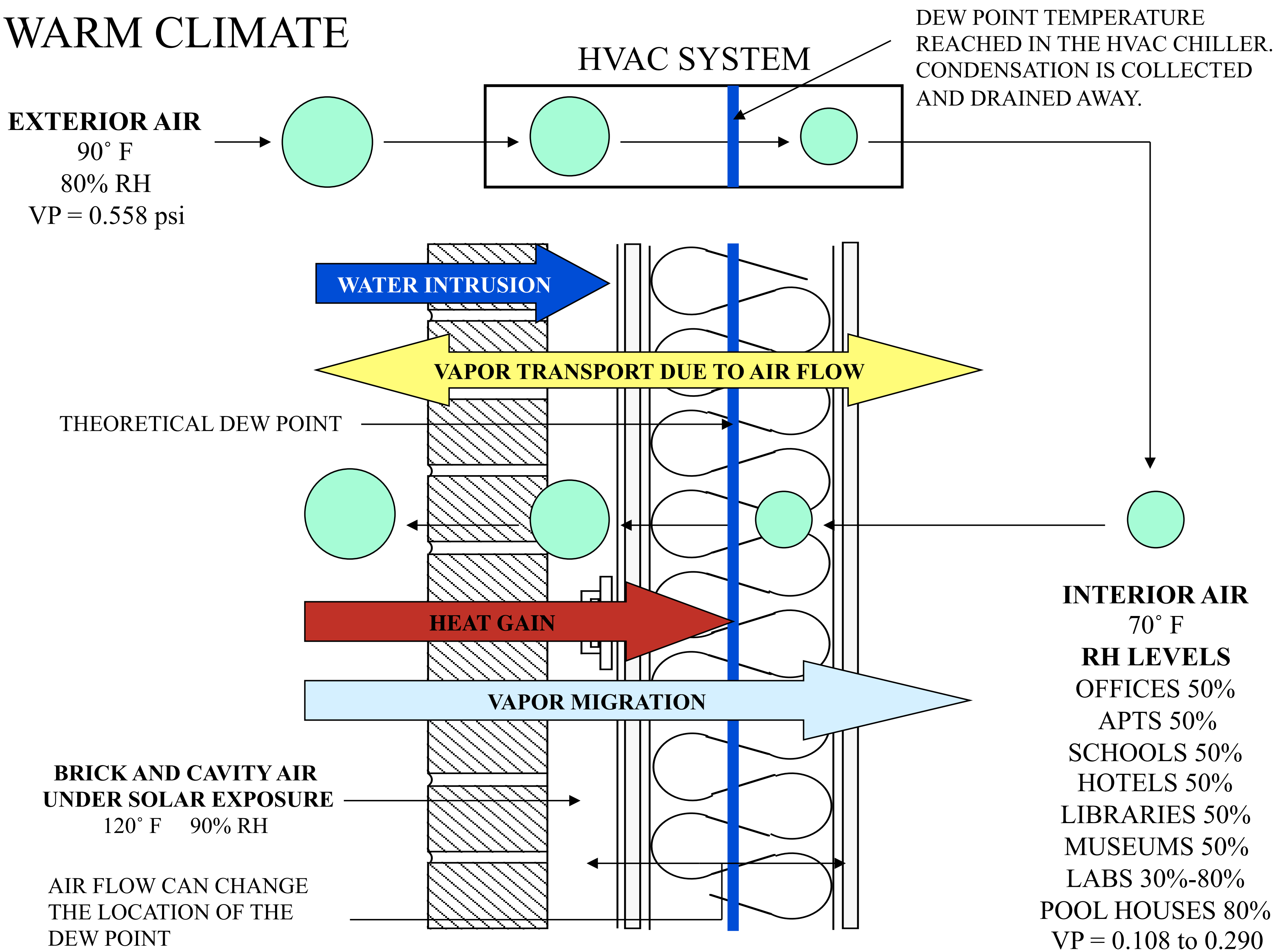
GWB ABSORBS AND RETAINS MOISTURE AND WILL DEGRADE OR DETERIORATE UNDER FAIRLY LOW MOISTURE CONTNENT LEVELS AS WELL AS HOST MICROBIAL GROWTH

LGMF SYSTEMS WITH GWB AND VAPOR BARRIERS CREATE CHAMBERS FROM WHICH VAPOR CANNOT BE EASILY VENTED

LGMF MEMBERS WILL CORRODE WHEN EXPOSED HIGH RH LEVELS

COLD CLIMATE




WARM CLIMATE
HVAC SYSTEM
DEW POINT TEMPERATURE REACHED IN THE HVAC CHILLER. CONDENSATION IS COLLECTED AND DRAINED AWAY.
EXTERIOR AIR
90˚ F
80% RH
VP = 0.558 psi
WATER INTRUSION
VAPOR TRANSPORT DUE TO AIR FLOW
THEORETICAL DEW POINT
HEAT GAIN
VAPOR MIGRATION
BRICK AND CAVITY AIR UNDER SOLAR EXPOSURE
120˚ F 90% RH
AIR FLOW CAN CHANGE THE LOCATION OF THE DEW POINT
INTERIOR AIR
70˚ F
RH LEVELS
OFFICES 50%
APTS 50%
SCHOOLS 50%
HOTELS 50%
LIBRARIES 50%
MUSEUMS 50%
LABS 30%-80%
POOL HOUSES 80%
VP = 0.108 to 0.290

How much moisture gets in via vapor migration?

The amount of moisture entering a building through the BES due to vapor migration depends on the vapor pressure differential (ΔP) and the perm rating of the material(s) it must pass through. This value is known as the Water Vapor Transmission Rate (WVTR). The calculation is simple.

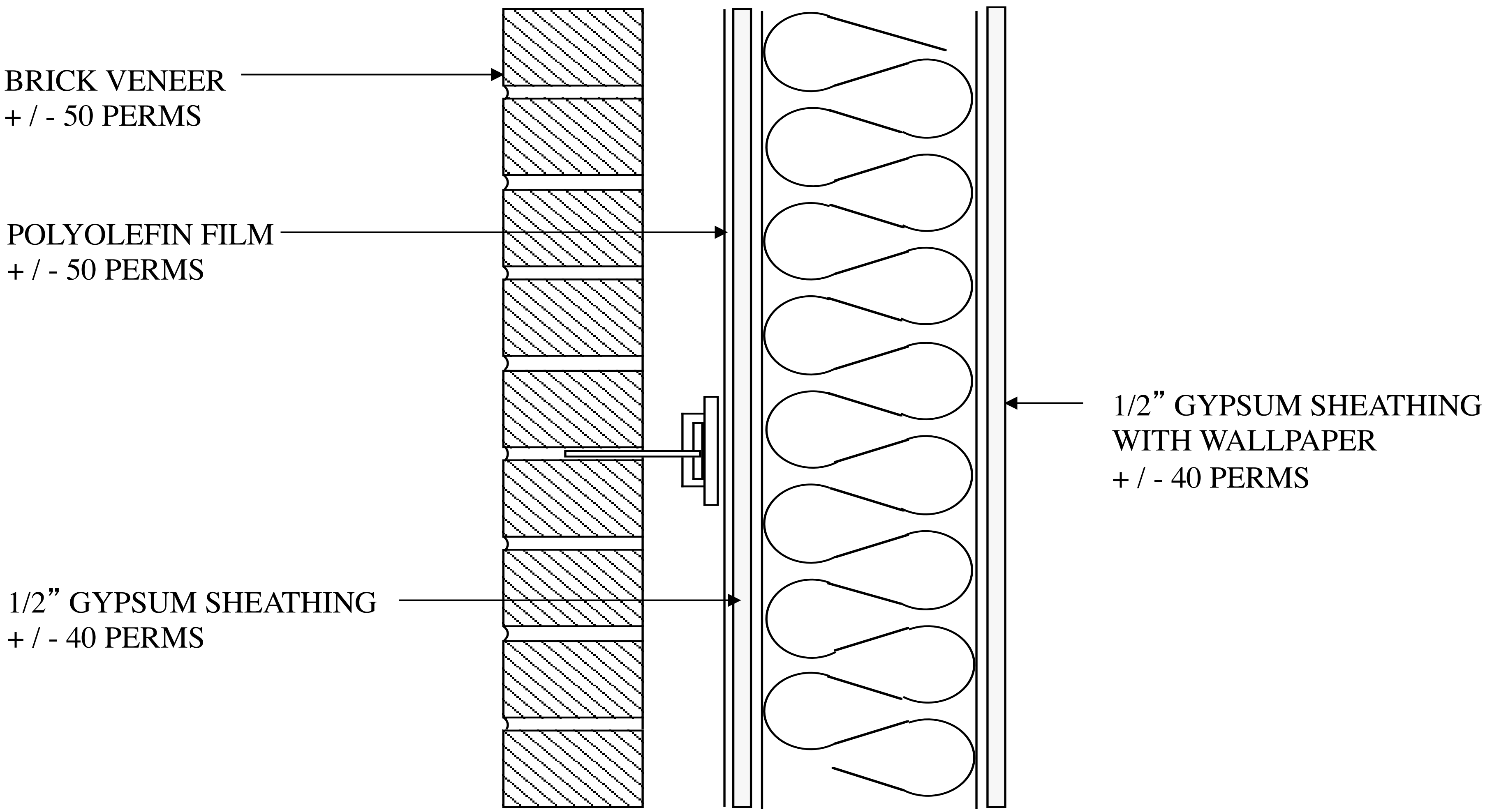
$$WVTR = A \times T \times \Delta P \times perms$$

A = Area in sq.ft
T = Time in hours
ΔP = difference in vapor pressure between inside and outside measured in inches of mercury (in Hg)

1 Perm = 1 grain of water / 1 sf of material / hr at a ΔP of 1 in. Hg

1 psi = 2.0434 in HG (68˚ F)

COMMON ABOVE GRADE BES WITHOUT A VAPOR BARRIER



WVT = A x T x delta P x Perms

A = 14,400 (net wall area of a 4 floor 80,000 sf office building)
T = 720 (24 hrs x 30 days)
Δ P = (VP at 85°F x RH) - (VP at 70°F x RH)
= (0.602 x .65) - (0.7397 x 0.3)
= 0.3913 - 0.108
= 0.2933
Perms = 40

WVT = 14,400 x 720 x 0.2933 x 40
= 121,637,376 grains (7,000 grains = 1 lb)
= 17,376.77 lbs.of water (8.28 lbs of water = 1 gallon)
= 2,098.64 gallons of water (0.63 oz / sf / day)

*** This does not include the moisture transport via air flow through the BES.**

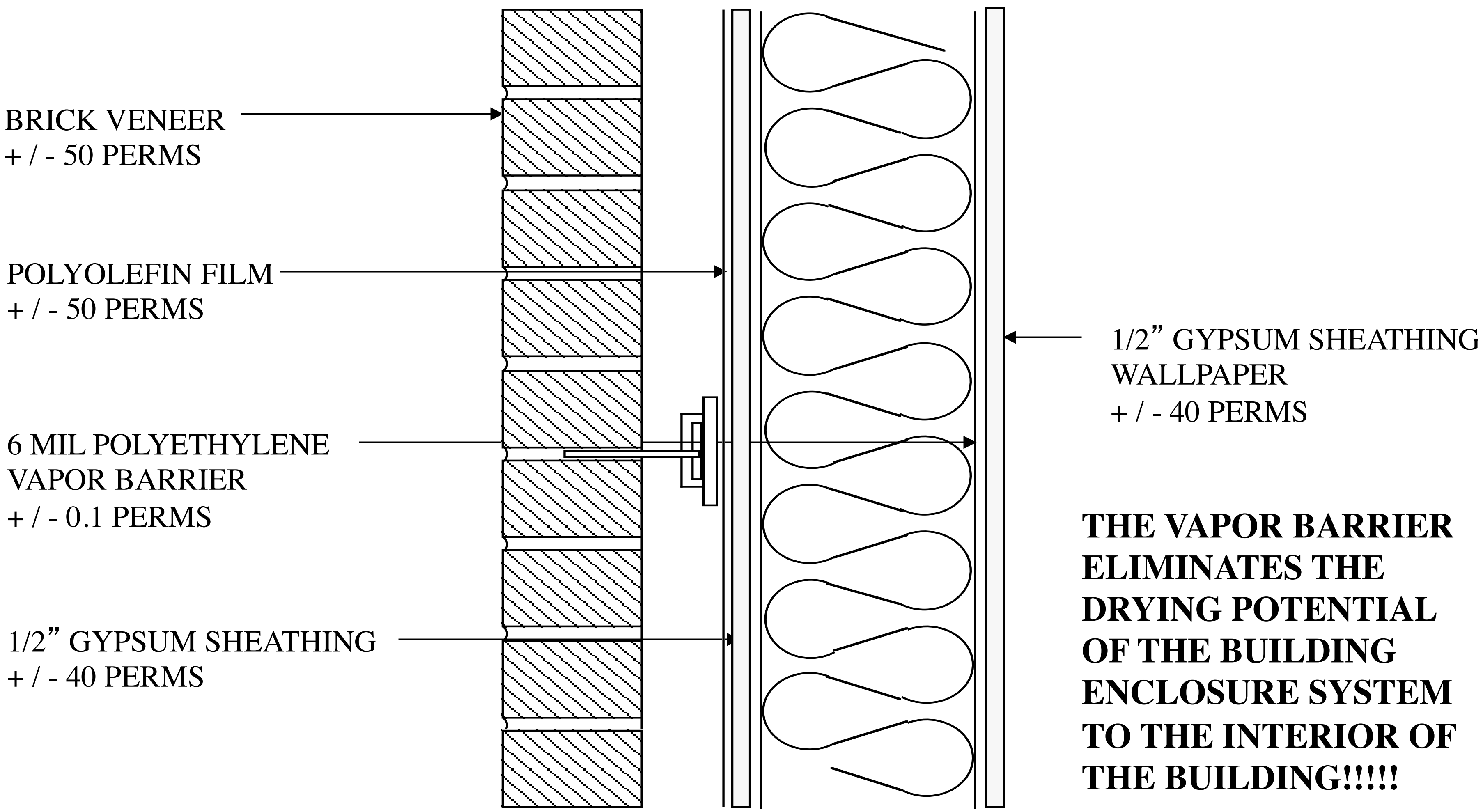
Now factor in air transport at 100X migration.

WVT = A x T x delta P x Perms

A = 14,400 (net wall area of a 4 floor 80,000 sf office building)
T = 720 (24 hrs x 30 days)
Δ P = (VP at 85°F x RH) - (VP at 70°F x RH)
= (0.602 x .65) - (0.7397 x 0.3)
= 0.3913 - 0.108
= 0.2933
Perms = 40

WVT = 14,400 x 720 x 0.2933 x 40
= 121,637,376 grains (7,000 grains = 1 lb)
= 17,376.77 lbs.of water (8.28 lbs of water = 1 gallon)
= 2,098.64 gallons of water (0.63 oz / sf / day)
x100
209,864 gallons of water (63.00 oz / sf / day)

COMMON ABOVE GRADE BES WITH A VAPOR BARRIER



THE VAPOR BARRIER ELIMINATES THE DRYING POTENTIAL OF THE BUILDING ENCLOSURE SYSTEM TO THE INTERIOR OF THE BUILDING!!!!!

WVT = A x T x delta P x Perms

A = 14,400 (net wall area of a 4 floor 80,000 sf office building)
T = 720 (24 hrs x 30 days)
Δ P = (VP at 85°F x RH) - (VP at 70°F x RH)
= (0.602 x .65) - (0.7397 x 0.3)
= 0.3913 - 0.108
= 0.2933
Perms = 0.1

WVT = 14,400 x 720 x 0.2933 x 0.1
= 304,093 grains (7,000 grains = 1 lb)
= 43.44 lbs.of water (8.28 lbs of water = 1 gallon)
= 5.25 gallons of water

*** This does not include the moisture transport via air flow through the BES.**

What happens when we factor in moisture transport due to air flow?

A = 14,400 (net wall area of a 4 floor 80,000 sf office building)

T = 720 (24 hrs x 30 days)

Δ P = (VP at 85°F x RH) - (VP at 70°F x RH)

= (0.602 x .65) - (0.7397 x 0.3)

= 0.3913 - 0.108

= 0.2933

Perms = 0.1

WVT = 14,400 x 720 x 0.2933 x 0.1

= 304,093 grains (7,000 grains = 1 lb)

= 43.44 lbs.of water (8.28 lbs of water = 1 gallon)

= 5.25 gallons of water

x 100

= 525 gallons of water

* With no drying potential to the inside

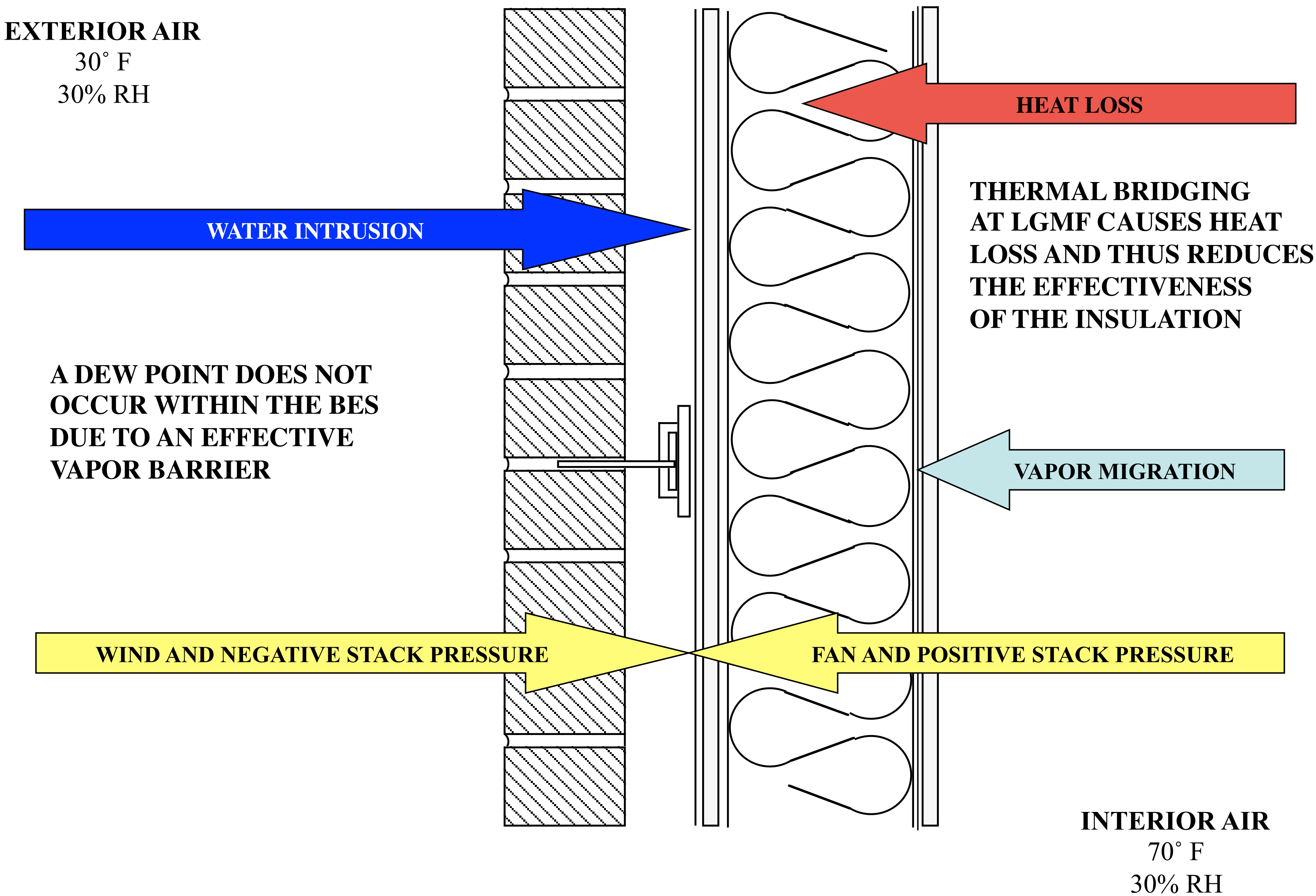
If moisture transport due to air flow is not properly dealt with, the water, vapor and heat barriers in the Building Enclosure System can easily become ineffective!

That is why the Building Enclosure System <u>NEEDS</u> an

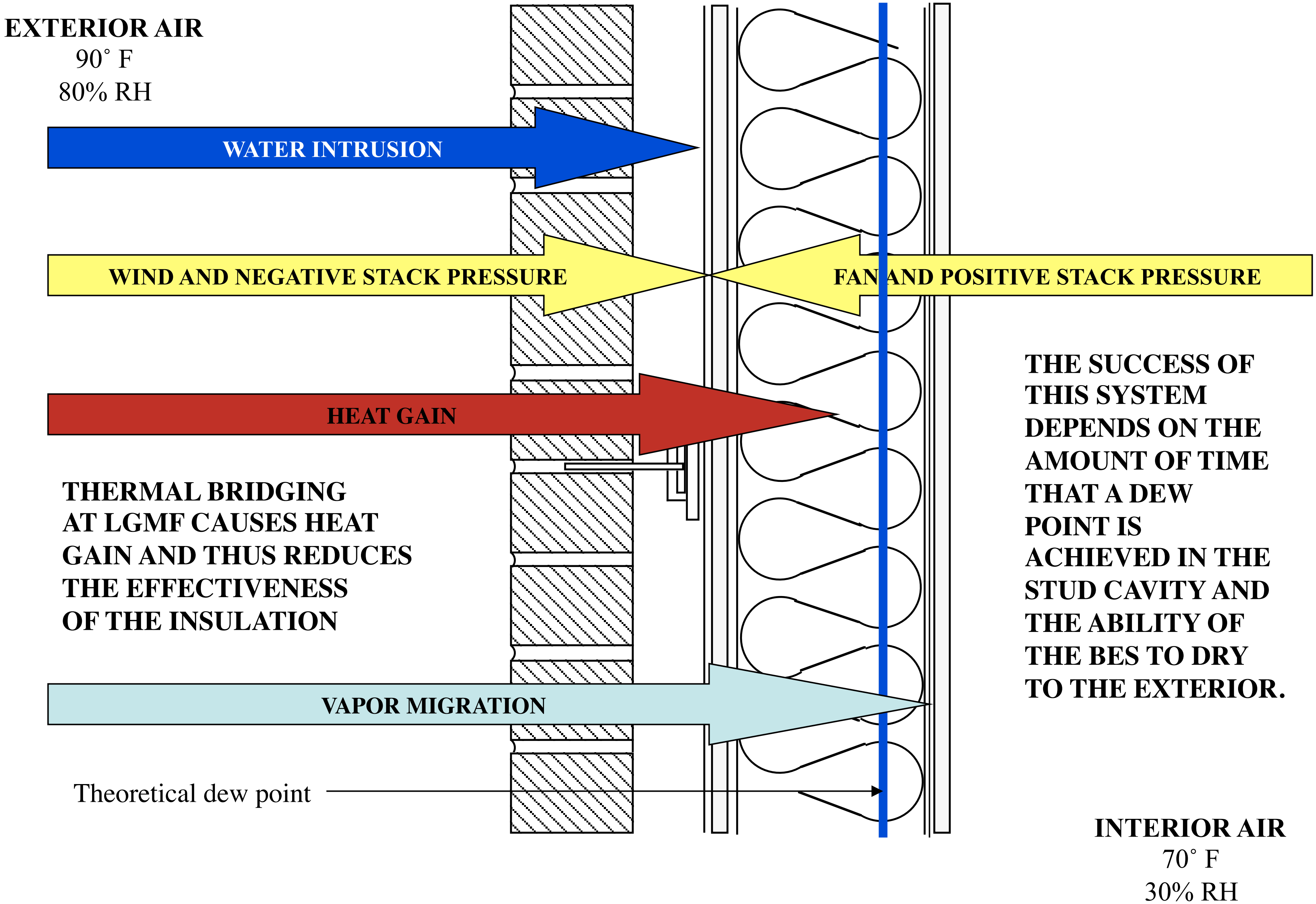
<u>Air Barrier System.</u>

How Do These Systems Work?

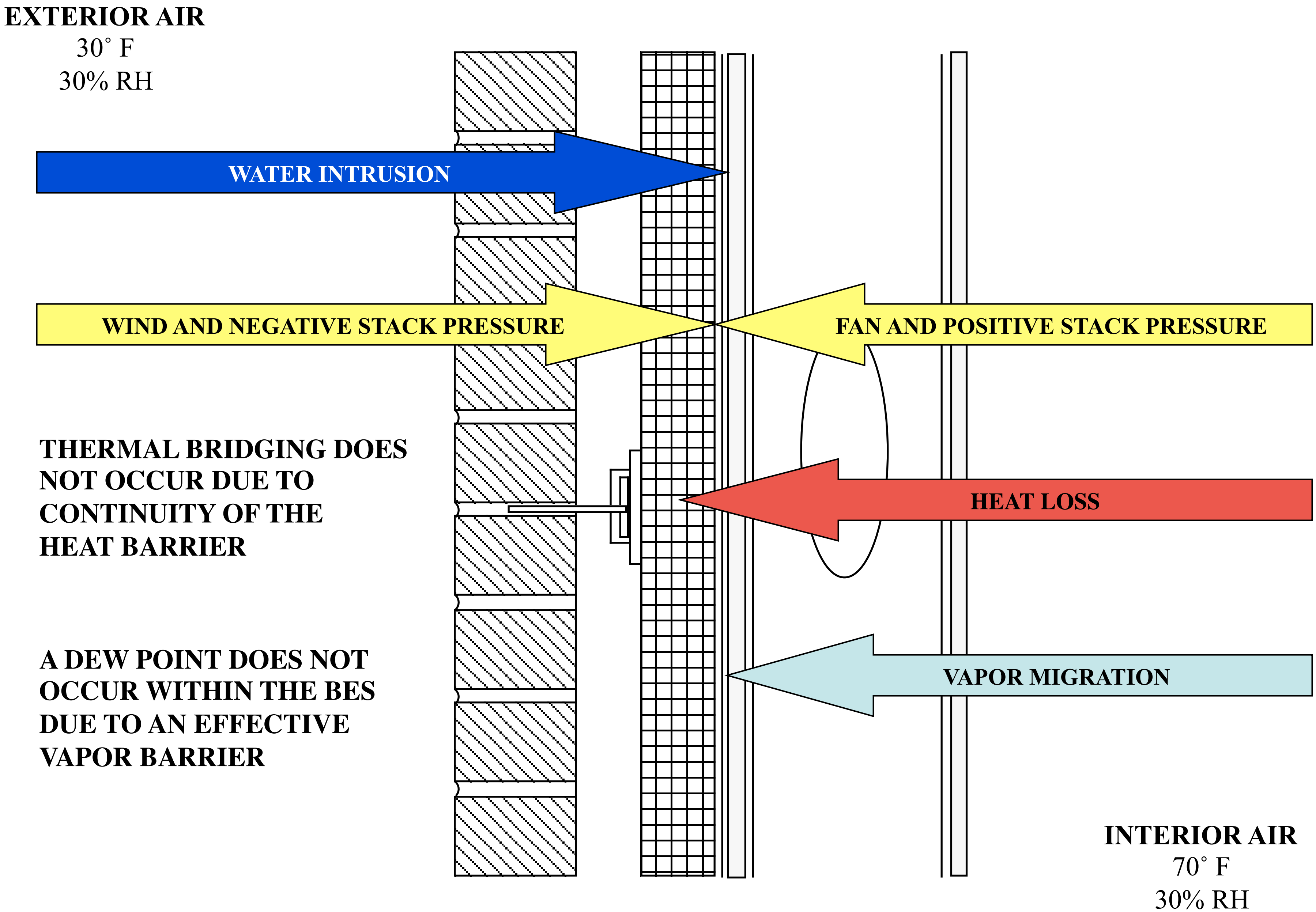
Cold Climate Vapor Permeable Air Barrier System: Winter



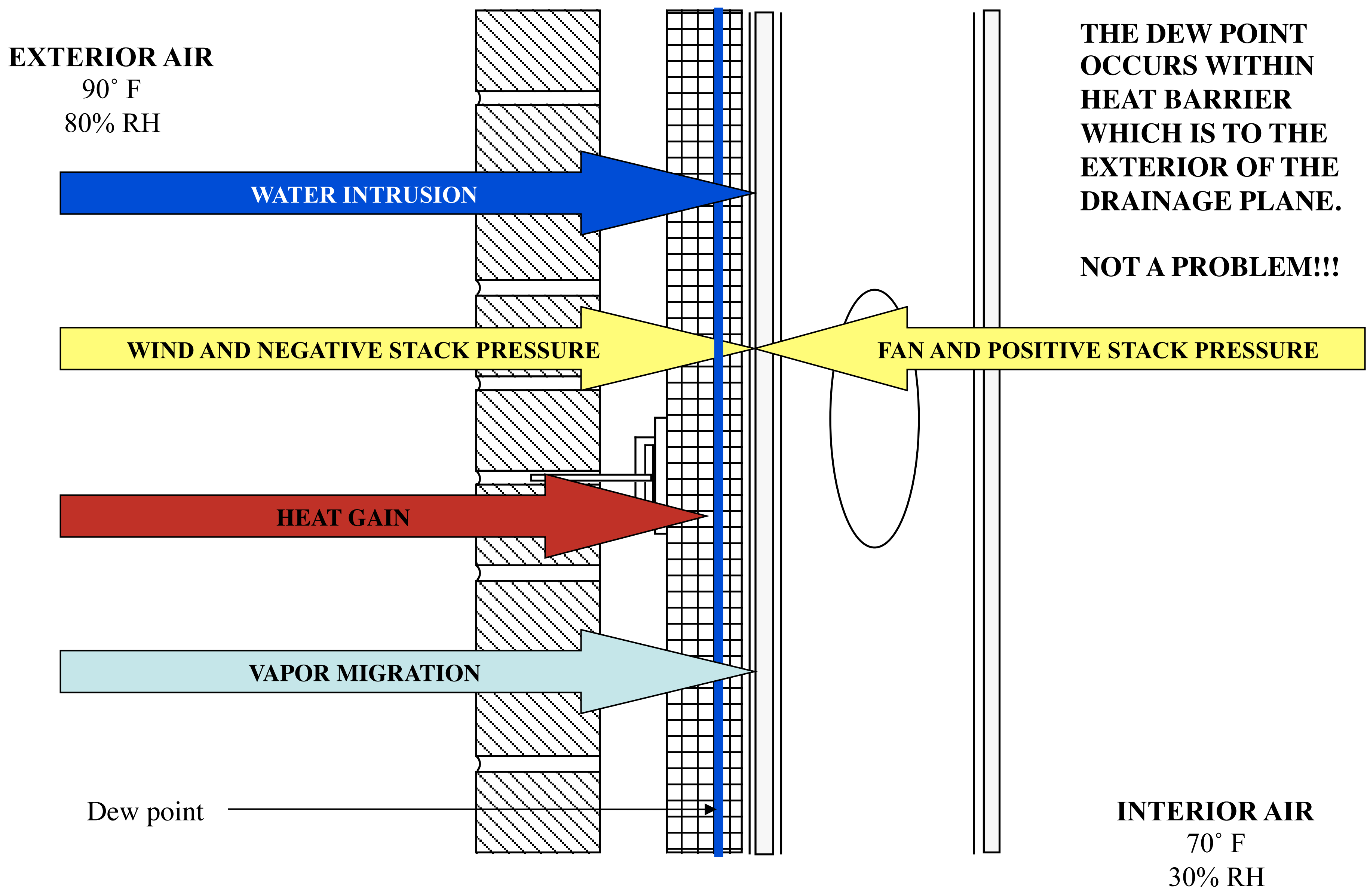
Cold Climate Vapor Permeable Air Barrier System: Summer



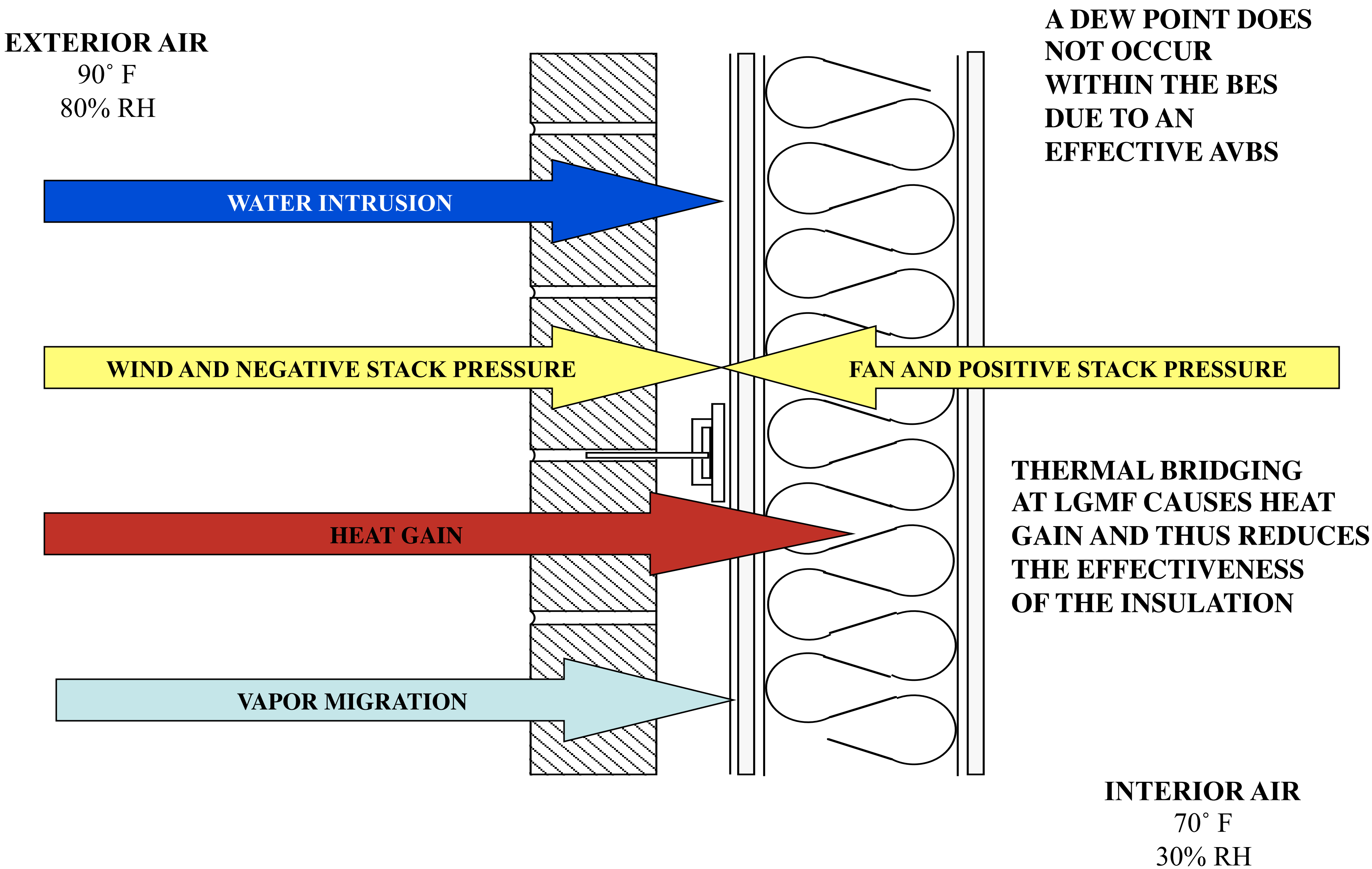
Cold Climate Air And Vapor Barrier System: Winter



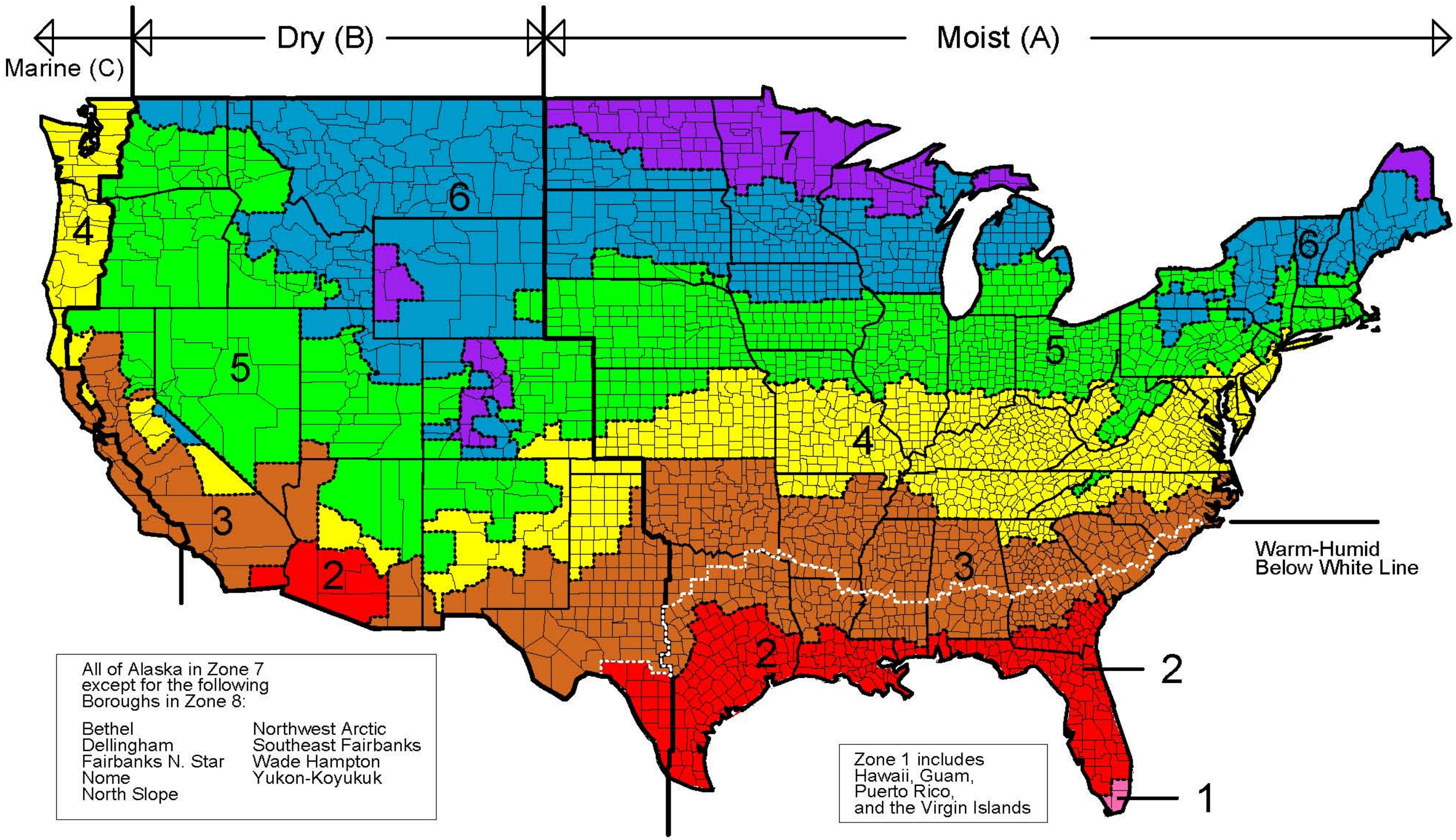
Cold Climate Air And Vapor Barrier System: Summer



Warm Climate Air And Vapor Barrier System



Map of DOE's Proposed Climate Zones



March 24, 2003

2012 IEC Insulation Requirements

TABLE C402.1.2
OPAQUE THERMAL ENVELOPE ASSEMBLY REQUIREMENTS[a]

CLIMATE ZONE	1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7		8	
	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R
Roofs																
Insulation entirely above deck	U-0.048	U-0.048	U-0.048	U-0.048	U-0.048	U-0.048	U-0.039	U-0.039	U-0.039	U-0.039	U-0.032	U-0.032	U-0.028	U-0.028	U-0.028	U-0.028
Metal buildings	U-0.044	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.031	U-0.031	U-0.029	U-0.029	U-0.029	U-0.029
Attic and other	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.021	U-0.021	U-0.021	U-0.021	U-0.021	U-0.021	U-0.021
Walls, Above Grade																
Mass	U-0.142	U-0.142	U-0.142	U-0.123	U-0.110	U-0.104	U-0.104	U-0.090	U-0.078	U-0.078	U-0.078	U-0.071	U-0.061	U-0.061	U-0.061	U-0.061
Metal building	U-0.079	U-0.079	U-0.079	U-0.079	U-0.079	U-0.052	U-0.052	U-0.052	U-0.052	U-0.052	U-0.052	U-0.052	U-0.052	U-0.039	U-0.052	U-0.039
Metal framed	U-0.077	U-0.077	U-0.077	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.057	U-0.064	U-0.052	U-0.045	U-0.045
Wood framed and other	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.051	U-0.051	U-0.051	U-0.051	U-0.036	U-0.036
Walls, Below Grade																
Below-grade wall[b]	C-1.140	C-1.140	C-1.140	C-1.140	C-1.140	C-1.140	C-0.119	C-0.119	C-0.119	C-0.119	C-0.119	C-0.119	C-0.092	C-0.092	C-0.092	C-0.092
Floors																
Mass	U-0.322	U-0.322	U-0.107	U-0.087	U-0.076	U-0.076	U-0.076	U-0.074	U-0.074	U-0.064	U-0.064	U-0.057	U-0.055	U-0.051	U-0.055	U-0.051
Joist/framing	U-0.066	U-0.066	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033
Slab-on-Grade Floors																
Unheated slabs	F-0.73	F-0.73	F-0.73	F-0.73	F-0.73	F-0.73	F-0.54	F-0.54	F-0.54	F-0.54	F-0.54	F-0.52	F-0.40	F-0.40	F-0.40	F-0.40
Heated slabs	F-0.70	F-0.70	F-0.70	F-0.70	F-0.70	F-0.70	F-0.65	F-0.65	F-0.58	F-0.58	F-0.58	F-0.58	F-0.55	F-0.55	F-0.55	F-0.55

a. Use of opaque assembly *U*-factors, *C*-factors, and *F*-factors from ANSI/ASHRAE/IESNA 90.1 Appendix A shall be permitted, provided the construction complies with the applicable construction details from ANSI/ASHRAE/IESNA 90.1 Appendix A.

b. Where heated slabs are below grade, below-grade walls shall comply with the *F*-factor requirements for heated slabs.

2012 IEC Insulation Requirements

								Walls, Above Grade
Mass	U-0.142	U-0.142	U-0.142	U-0.123	U-0.110	U-0.104	U-0.104	U-0.090
Metal building	U-0.079	U-0.079	U-0.079	U-0.079	U-0.079	U-0.052	U-0.052	U-0.052
Metal framed	U-0.077	U-0.077	U-0.077	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064
Wood framed and other	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064

2012 IEC Insulation Requirements

TABLE C402.2
OPAQUE THERMAL ENVELOPE REQUIREMENTS[a]

CLIMATE ZONE	1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7		8	
	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R
Roofs																
Insulation entirely above deck	R-20ci	R-20ci	R-20ci	R-20ci	R-20ci	R-20ci	R-25ci	R-25ci	R-25ci	R-25ci	R-30ci	R-30ci	R-35ci	R-35ci	R-35ci	R-35ci
Metal buildings (with R-5 thermal blocks)[a, b]	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-25 + R-11 LS	R-25 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS
Attic and other	R-38	R-38	R-38	R-38	R-38	R-38	R-38	R-38	R-38	R-49	R-49	R-49	R-49	R-49	R-49	R-49
Walls, Above Grade																
Mass	R-5.7ci	R-5.7ci	R-5.7ci	R-7.6ci	R-7.6ci	R-9.5ci	R-9.5ci	R-11.4ci	R-11.4ci	R-13.3ci	R-13.3ci	R-15.2ci	R-15.2ci	R-15.2ci	R-25ci	R-25ci
Metal building	R-13+ R-6.5ci	R-13 + R-6.5ci	R13 + R-6.5ci	R-13 + R-13ci	R-13 + R-6.5ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13+ R-19.5ci	R-13 + R-13ci	R-13+ R-19.5ci
Metal framed	R-13 + R-5ci	R-13 + R-5ci	R-13 + R-5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-15.6ci	R-13 + R-7.5ci	R-13+ R17.5ci
Wood framed and other	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-15.6ci or R-20 + R-10ci	R-13 + R-15.6ci or R-20 + R-10ci
Walls, Below Grade																
Below-grade wall[d]	NR	NR	NR	NR	NR	NR	R-7.5ci	R-7.5ci	R-7.5ci	R-7.5ci	R-7.5ci	R-7.5ci	R-10ci	R-10ci	R-10ci	R-12.5ci
Floors																
Mass	NR	NR	R-6.3ci	R-8.3ci	R-10ci	R-10ci	R-10ci	R-10.4ci	R-10ci	R-12.5ci	R-12.5ci	R-12.5ci	R-15ci	R-16.7ci	R-15ci	R-16.7ci
Joist/framing	NR	NR	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30[e]	R-30[e]	R-30[e]	R-30[e]	R-30[e]
Slab-on-Grade Floors																
Unheated slabs	NR	NR	NR	NR	NR	NR	R-10 for 24″ below	R-10 for 24″ below	R-10 for 24″ below	R-10 for 24″ below	R-10 for 24″ below	R-15 for 24″ below	R-15 for 24″ below	R-15 for 24″ below	R-15 for 24″ below	R-20 for 24″ below
Heated slabs[d]	R-7.5 for 12″ below	R-7.5 for 12″ below	R-7.5 for 12″ below	R-7.5 for 12″ below	R-10 for 24″ below	R-10 for 24″ below	R-15 for 24″ below	R-15 for 24″ below	R-15 for 36″ below	R-15 for 36″ below	R-15 for 36″ below	R-20 for 48″ below	R-20 for 24″ below	R-20 for 48″ below	R-20 for 48″ below	R-20 for 48″ below
Opaque Doors																
Swinging	U-0.61	U-0.61	U-0.61	U-0.61	U-0.61	U-0.61	U-0.61	U-0.61	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37
Roll-up or sliding	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75

For SI: 1 inch = 25.4 mm. ci = Continuous insulation. NR = No requirement.

LS = Liner System—A continuous membrane installed below the purlins and uninterrupted by framing members. Uncompressed, unfaced insulation rests on top of the membrane between the purlins.

a. Assembly descriptions can be found in ANSI/ASHRAE/IESNA Appendix A.

b. Where using *R*-value compliance method, a thermal spacer block shall be provided, otherwise use the *U*-factor compliance method in Table C402.1.2.

c. R-5.7ci is allowed to be substituted with concrete block walls complying with ASTM C 90, ungrouted or partially grouted at 32 inches or less on center vertically and 48 inches or less on center horizontally, with ungrouted cores filled with materials having a maximum thermal conductivity of 0.44 Btu-in/h-f^2 °F.

d. Where heated slabs are below grade, below-grade walls shall comply with the exterior insulation requirements for heated slabs.

e. Steel floor joist systems shall be insulated to R-38.

2012 IEC

						Walls, Above Grade				
Mass	R-5.7ci	R-5.7ci	R-5.7ci	R-7.6ci	R-7.6ci	R-9.5ci	R-9.5ci	R-11.4ci	R-11.4ci	R-13.3ci
Metal building	R-13+ R-6.5ci	R-13 + R-6.5ci	R13 + R-6.5ci	R-13 + R-13ci	R-13 + R-6.5ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci
Metal framed	R-13 + R-5ci	R-13 + R-5ci	R-13 + R-5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci
Wood framed and other	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-7.5ci or R-20 + R-3.8ci

2012 IEC

U-Factor for metal framed exterior walls in climate zone 5

U-0.064

U-Factor is the inverse of R-Value

R-15.63

2012 IEC

Exterior Air Film	R-0.17
Brick Veneer	R-0.44
Air Space	R-1.0
Insulation	?????
Air/Vapor Barrier	0.00
Sheathing	0.56
Metal Studs	0.79
Wallboard	0.53
Paint	0.00
Interior Air Film	0.68
Total Without Insulation	4.17

Insulation needs to be R-11.46 or better

2015 IEC

TABLE C402.1.4
OPAQUE THERMAL ENVELOPE ASSEMBLY MAXIMUM REQUIREMENTS, *U*-FACTOR METHOD[a, b]

CLIMATE ZONE	1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7		8	
	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R
Roofs																
Insulation entirely above roof deck	U-0.048	U-0.039	U-0.039	U-0.039	U-0.039	U-0.039	U-0.032	U-0.032	U-0.032	U-0.032	U-0.032	U-0.032	U-0.028	U-0.028	U-0.028	U-0.028
Metal buildings	U-0.044	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.031	U-0.031	U-0.029	U-0.029	U-0.029	U-0.029
Attic and other	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.021	U-0.021	U-0.021	U-0.021	U-0.021	U-0.021	U-0.021
Walls, above grade																
Mass	U-0.151	U-0.151	U-0.151	U-0.123	U-0.123	U-0.104	U-0.104	U-0.090	U-0.090	U-0.080	U-0.080	U-0.071	U-0.071	U-0.061	U-0.061	U-0.061
Metal building	U-0.079	U-0.079	U-0.079	U-0.079	U-0.079	U-0.052	U-0.052	U-0.052	U-0.052	U-0.052	U-0.052	U-0.052	U-0.052	U-0.039	U-0.052	U-0.039
Metal framed	U-0.077	U-0.077	U-0.077	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.057	U-0.064	U-0.052	U-0.045	U-0.045
Wood framed and other[c]	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.051	U-0.051	U-0.051	U-0.051	U-0.036	U-0.036
Walls, below grade																
Below-grade wall[c]	C-1.140[e]	C-1.140[e]	C-1.140[e]	C-1.140[e]	C-1.140[e]	C-1.140[e]	C-0.119	C-0.119	C-0.119	C-0.119	C-0.119	C-0.119	C-0.092	C-0.092	C-0.092	C-0.092
Floors																
Mass[d]	U-0.322[e]	U-0.322[e]	U-0.107	U-0.087	U-0.076	U-0.076	U-0.076	U-0.074	U-0.074	U-0.064	U-0.064	U-0.057	U-0.055	U-0.051	U-0.055	U-0.051
Joist/framing	U-0.066[e]	U-0.066[e]	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033
Slab-on-grade floors																
Unheated slabs	F-0.73[e]	F-0.73[e]	F-0.73[e]	F-0.73[e]	F-0.73[e]	F-0.73[e]	F-0.54	F-0.54	F-0.54	F-0.54	F-0.54	F-0.52	F-0.40	F-0.40	F-0.40	F-0.40
Heated slabs[f]	F-0.70	F-0.70	F-0.70	F-0.70	F-0.70	F-0.70	F-0.65	F-0.65	F-0.65	F-0.65	F-0.58	F-0.58	F-0.55	F-0.55	F-0.55	F-0.55
Opaque doors																
Swinging	U-0.61	U-0.61	U-0.61	U-0.61	U-0.61	U-0.61	U-0.61	U-0.61	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37	U-0.37

For SI: 1 pound per square foot = 4.88 kg/m^2, 1 pound per cubic foot = 16 kg/m^3.

ci = Continuous insulation, NR = No requirement, LS = Liner system.

a. Use of Opaque assembly *U*-factors, *C*-factors, and *F*-factors from ANSI/ASHRAE/IESNA 90.1 Appendix A shall be permitted, provided the construction, excluding the cladding system on walls, complies with the appropriate construction details from ANSI/ASHRAE/ISNEA 90.1 Appendix A.

b. Opaque assembly *U*-factors based on designs tested in accordance with ASTM C1363 shall be permitted. The *R*-value of continuous insulation shall be permitted to be added to or subtracted from the original tested design.

c. Where heated slabs are below grade, below-grade walls shall comply with the *F*-factor requirements for heated slabs.

d. "Mass floors" shall include floors weighing not less than:
1. 35 pounds per square foot of floor surface area; or
2. 25 pounds per square foot of floor surface area where the material weight is not more than 120 pounds per cubic foot.

e. These *C*-, *F*- and *U*-factors are based on assemblies that are not required to contain insulation.

f. Evidence of compliance with the *F*-factors indicated in the table for heated slabs shall be demonstrated by the application of the unheated slab *F*-factors and *R-values* derived from ASHRAE 90.1 Appendix A.

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	Walls, above grade									
Mass	U-0.151	U-0.151	U-0.151	U-0.123	U-0.123	U-0.104	U-0.104	U-0.090	U-0.090	U-0.080
Metal building	U-0.079	U-0.079	U-0.079	U-0.079	U-0.079	U-0.052	U-0.052	U-0.052	U-0.052	U-0.052
Metal framed	U-0.077	U-0.077	U-0.077	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064
Wood framed and other[c]	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064

2015 IEC

TABLE C402.1.3
OPAQUE THERMAL ENVELOPE INSULATION COMPONENT MINIMUM REQUIREMENTS, *R*-VALUE METHOD[a]

CLIMATE ZONE	1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7		8	
	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R
Roofs																
Insulation entirely above roof deck	R-20ci	R-25ci	R-25ci	R-25ci	R-25ci	R-25ci	R-30ci	R-30ci	R-30ci	R-30ci	R-30ci	R-30ci	R-35ci	R-35ci	R-35ci	R-35ci
Metal buildings[b]	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-19 + R-11 LS	R-25 + R-11 LS	R-25 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS	R-30 + R-11 LS
Attic and other	R-38	R-38	R-38	R-38	R-38	R-38	R-38	R-38	R-38	R-49	R-49	R-49	R-49	R-49	R-49	R-49
Walls, above grade																
Mass	R-5.7ci[c]	R-5.7ci[c]	R-5.7ci[c]	R-7.6ci	R-7.6ci	R-9.5ci	R-9.5ci	R-11.4ci	R-11.4ci	R-13.3ci	R-13.3ci	R-15.2ci	R-15.2ci	R-15.2ci	R-25ci	R-25ci
Metal building	R-13+ R-6.5ci	R-13 + R-6.5ci	R13 + R-6.5ci	R-13 + R-13ci	R-13 + R-6.5ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13+ R-19.5ci	R-13 + R-13ci	R-13+ R-19.5ci
Metal framed	R-13 + R-5ci	R-13 + R-5ci	R-13 + R-5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-15.6ci	R-13 + R-7.5ci	R-13+ R17.5ci
Wood framed and other	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R-13 + R-7.5ci or R-20 + R-3.8ci	R13 + R-15.6ci or R-20 + R-10ci	R13 + R-15.6ci or R-20 + R-10ci
Walls, below grade																
Below-grade wall[d]	NR	NR	NR	NR	NR	NR	R-7.5ci	R-7.5ci	R-7.5ci	R-7.5ci	R-7.5ci	R-7.5ci	R-10ci	R-10ci	R-10ci	R-12.5ci
Floors																
Mass[e]	NR	NR	R-6.3ci	R-8.3ci	R-10ci	R-10ci	R-10ci	R-10.4ci	R-10ci	R-12.5ci	R-12.5ci	R-12.5ci	R-15ci	R-16.7ci	R-15ci	R-16.7ci
Joist/framing	NR	NR	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30	R-30[f]	R-30[f]	R-30[f]	R-30[f]	R-30[f]
Slab-on-grade floors																
Unheated slabs	NR	NR	NR	NR	NR	NR	R-10 for 24″ below	R-10 for 24″ below	R-10 for 24″ below	R-10 for 24″ below	R-10 for 24″ below	R-15 for 24″ below	R-15 for 24″ below	R-15 for 24″ below	R-15 for 24″ below	R-20 for 24″ below
Heated slabs	R-7.5 for 12″ below	R-7.5 for 12″ below	R-7.5 for 12″ below	R-7.5 for 12″ below	R-10 for 24″ below	R-10 for 24″ below	R-15 for 24″ below	R-15 for 24″ below	R-15 for 36″ below	R-15 for 36″ below	R-15 for 36″ below	R-20 for 48″ below	R-20 for 24″ below	R-20 for 48″ below	R-20 for 48″ below	R-20 for 48″ below
Opaque doors																
Nonswinging	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75	R-4.75

For SI: 1 inch = 25.4 mm, 1 pound per square foot = 4.88 kg/m^2, 1 pound per cubic foot = 16 kg/m^3.

ci = Continuous insulation, NR = No requirement, LS = Liner system.

a. Assembly descriptions can be found in ANSI/ASHRAE/IESNA Appendix A.

b. Where using *R*-value compliance method, a thermal spacer block shall be provided, otherwise use the *U*-factor compliance method in Table C402.1.4.

c. R-5.7ci is allowed to be substituted with concrete block walls complying with ASTM C 90, ungrouted or partially grouted at 32 inches or less on center vertically and 48 inches or less on center horizontally, with ungrouted cores filled with materials having a maximum thermal conductivity of 0.44 Btu-in/h-f^2 °F.

d. Where heated slabs are below grade, below-grade walls shall comply with the exterior insulation requirements for heated slabs.

e. "Mass floors" shall include floors weighing not less than:

1. 35 pounds per square foot of floor surface area; or
2. 25 pounds per square foot of floor surface area where the material weight is not more than 120 pounds per cubic foot.

f. Steel floor joist systems shall be insulated to R-38.

2015 IEC

	Walls, above grade									
Mass	R-5.7ci[c]	R-5.7ci[c]	R-5.7ci[c]	R-7.6ci	R-7.6ci	R-9.5ci	R-9.5ci	R-11.4ci	R-11.4ci	R-13.3ci
Metal building	R-13+ R-6.5ci	R-13 + R-6.5ci	R13 + R-6.5ci	R-13 + R-13ci	R-13 + R-6.5ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci	R-13 + R-13ci
Metal framed	R-13 + R-5ci	R-13 + R-5ci	R-13 + R-5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci	R-13 + R-7.5ci
Wood framed and other	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-3.8ci or R-20	R-13 + R-7.5ci or R-20 + R-3.8ci

2015 IEC

TABLE C402.1.4.1
EFFECTIVE *R*-VALUES FOR STEEL STUD WALL ASSEMBLIES

NOMINAL STUD DEPTH (inches)	SPACING OF FRAMING (inches)	CAVITY *R*-VALUE (insulation)	CORRECTION FACTOR (F_c)	EFFECTIVE *R*-VALUE (ER) (Cavity *R*-Value × F_c)
$3^1/_2$	16	13	0.46	5.98
		15	0.43	6.45
$3^1/_2$	24	13	0.55	7.15
		15	0.52	7.80
6	16	19	0.37	7.03
		21	0.35	7.35
6	24	19	0.45	8.55
		21	0.43	9.03
8	16	25	0.31	7.75
	24	25	0.38	9.50

2015 IEC

C202 Definition of Continuous Insulation

CONTINUOUS INSULATION (ci). Insulating material that is continuous across all structural members without thermal bridges other than fasteners and service openings. It is installed on the interior or exterior or is integral to any opaque surface of the building envelope.

Say "Goodbye" to z-furring

2015 IEC

U-Factor for metal framed exterior walls in climate zone 5

U-0.064

U-Factor is the inverse of R-Value

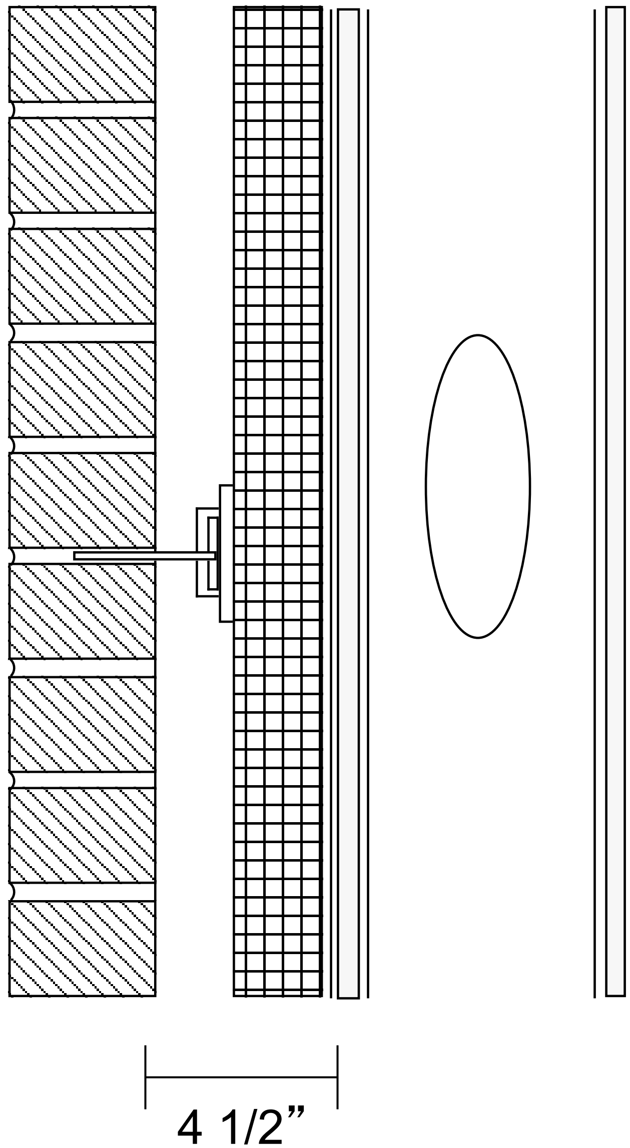
R-15.63

2015 IEC

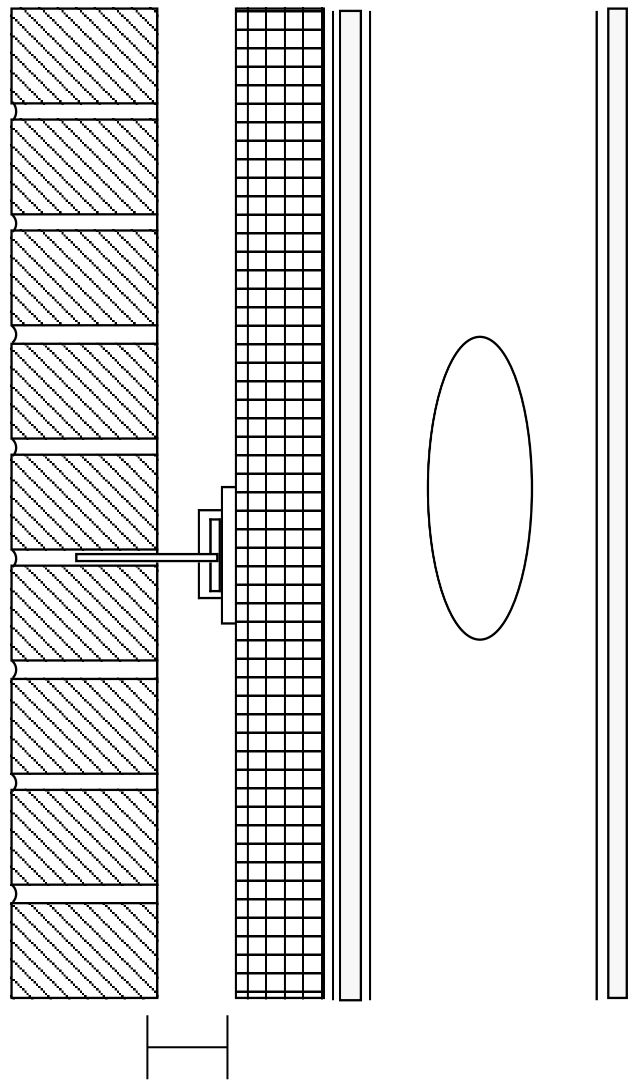
Exterior Air Film	R-0.17
Brick Veneer	R-0.44
Air Space	R-1.0
Insulation	?????
Air/Vapor Barrier	0.00
Sheathing	0.56
Metal Studs	0.79
Wallboard	0.53
Paint	0.00
Interior Air Film	0.68
Total Without Insulation	4.17

Insulation needs to be R-11.46 or better

ACI 530



BIA Tech Notes



1” Minimum……..2” Recommended

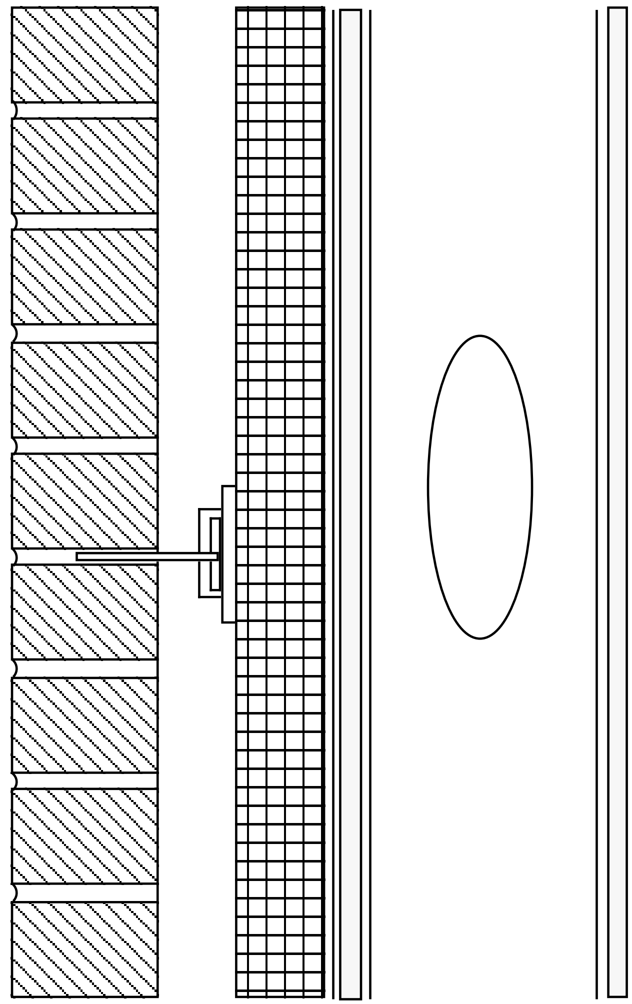
SPF In Cavity

3 1/2 " of 2 lb Density Closed-Cell SPF (R-6.7 / inch thickness)

= R-23.45 insulation layer

Leaves 1" cavity

Assembly: R-27.62



Code Requirements:

2012 IEC: R-15.63

90.1 2013: R-18.18

MA Stretch Code: R-24

Good applicators can control the thickness

Polyisocyanurate In Cavity

3 1/2" polyiso in cavity
(R-6.5 / inch thickness)

= R-22.75 insulation layer

Leaves 1" cavity

Multiple layer installation
(2" + 1 1/2 ")

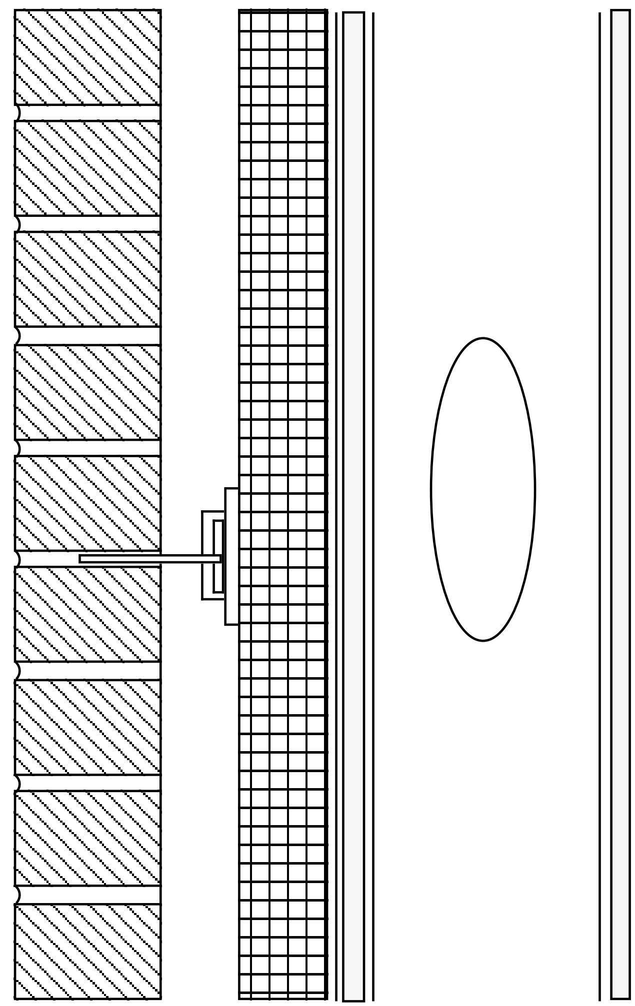
Assembly: R-26.92

<u>Code Requirements:</u>

2012 IEC: R-15.63

90.1 2013: R-18.18

MA Stretch Code: R-24



XPS In Cavity

3 1/2” XPS in cavity
(R-5 / inch thickness)

= R-17.5 insulation layer

Leaves 1” cavity

Multiple layer installation
(2” + 1 1/2 “)

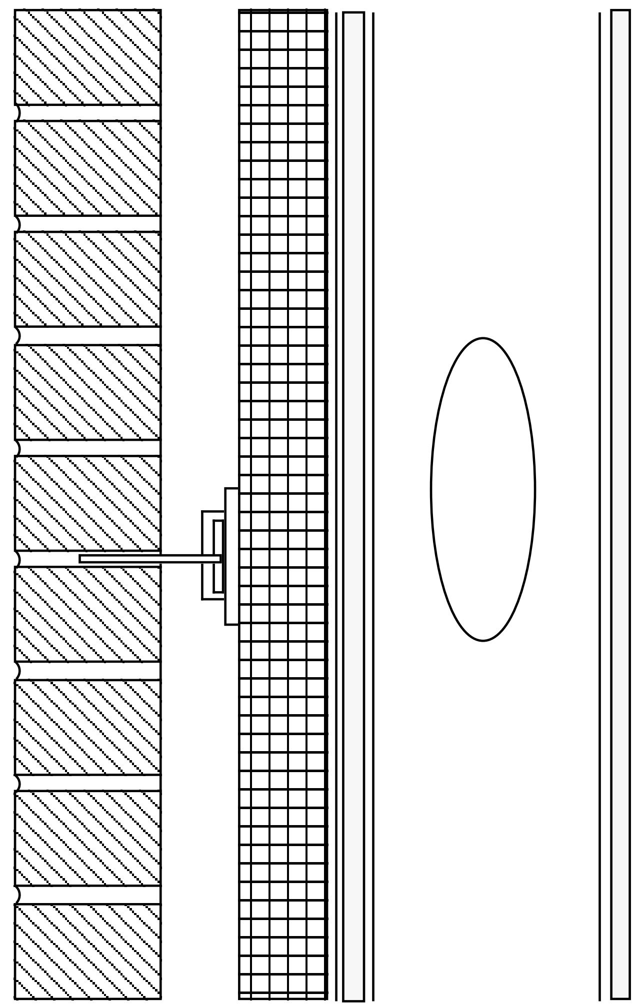
Assembly: R-21.67

<u>Code Requirements:</u>

2012 IEC: R-15.63

90.1 2013: R-18.18

MA Stretch Code: R-24



Rock or Mineral Wool In Cavity

3 1/2" mineral wool in cavity
(R-4.2 / inch thickness)

= R-14.7 insulation layer

Leaves 1" cavity

Multiple layer installation

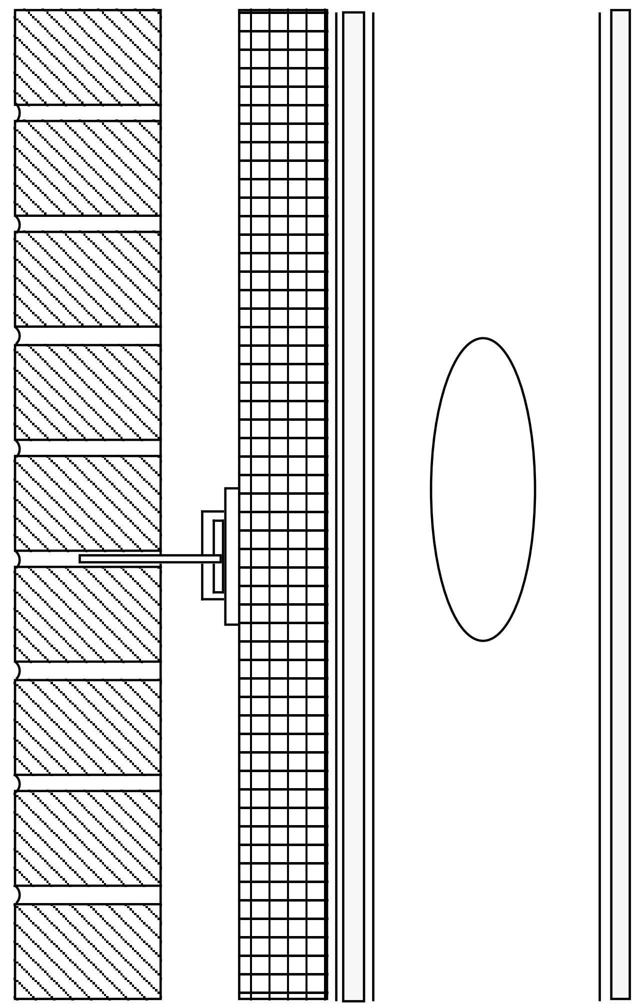
Assembly: R-18.87

Code Requirements:

2012 IEC: R-15.63

90.1 2013: R-18.18

MA Stretch Code: R-24



EPS In Cavity

3 1/2” EPS in cavity
(R-4 / inch thickness)

= R-14 insulation layer

Leaves 1” cavity

Multiple layer installation
(2” + 1 1/2”)

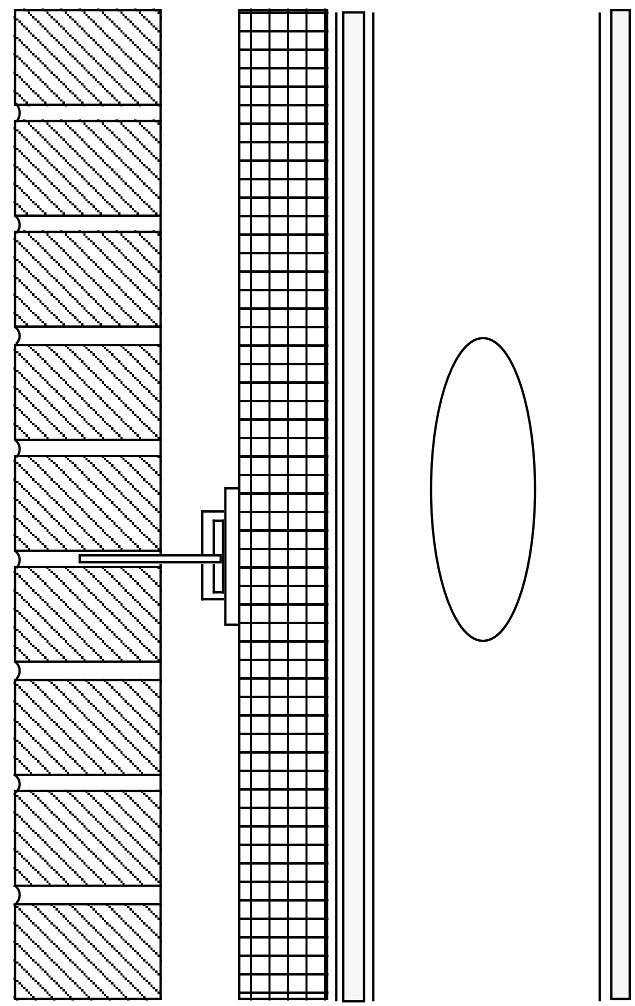
Assembly: R-18.17

<u>Code Requirements:</u>

2012 IEC: R-15.63

90.1 2013: R-18.18

MA Stretch Code: R-24



NFPA 285

Burn test for exterior wall assemblies over two floors (40 feet) in height that includes plastic insulation outboard of the sheathing and / or a weather resistive barrier.

Adopted in the 2006 International Building Code (IBC).

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Questions?

THANK-YOU

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