Lorman Educational Services

Reducing Liability Associated With Water Damage And Mold During Construction And Renovation In Michigan

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Lorman Educational Services

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Mold Science

Mold, or fungi, are neither plants nor animals.

Molds are organisms that contain a nucleus and undergo mitotic cell division. They belong to the kingdom of fungi. Molds are similar to the plant kingdom in that they have the ability to undergo photosynthesis. They differ from plants in that they lack chlorophyll. Unlike the animal kingdom, molds have no organs for food uptake.

A group of organisms that require an external food source, water, and suitable conditions for survival and proliferation.

Genus (i.e. *Stachybotrys*), species (*atra*)

Molds can be unicellular or multicellular. The cells are called hyphae, which are usually shaped like filaments. Reproduction can be sexual or asexual. Most molds reproduce asexually. Technically, fungal propagules from sexual reproduction are termed spores, and those from asexual organisms labeled conidia. However, the two terms are typically interchangeable.

There are in excess of 20,000 different genera and 1.5 million species.

Mold spores are generally 2-20 microns in size (a human hair is approximately 100 microns). Spores are highly adaptive for survival. When food sources run out, a fungus responds by switching to reproductive mode, resulting in spores. A one-inch diameter colony can produce 400,000,000 million spores. The small size provides for maximum dispersal, while the hardy cell wall protects them from destruction.

Are all molds toxic? Most molds are not toxic. To sensitive individuals, they may only be simple allergens.

The presence of fungi on building materials as identified by a visual assessment or by bulk/surface sampling results does not necessitate that people will be exposed or exhibit health effects. In order for humans to be exposed indoors, fungal spores, fragments, or metabolites must be released into the air and inhaled, physically contacted (dermal exposure), or ingested. Whether or not symptoms develop in people exposed to fungi depends on the nature of the fungi material (e.g., allergenic, toxic, or infectious), the amount of exposure, and the susceptibility of exposed persons.

Remediation:

In all situations, the underlying cause of water accumulation must be rectified or fungal growth will recur. Any initial water infiltration should be stopped and cleaned immediately. An immediate response (within 24 to 48 hours) and thorough clean up, drying, and/ or removal of water-damaged materials will prevent mold growth.

Four different levels of abatement, excluding HVAC, are described in the NYC consensus standard. The size of the area impacted by fungal contamination primarily determines the type of remediation. The sizing levels below are based on professional judgment and practically; currently there is not adequate data to relate the extent of contamination to frequency or severity of health effects. The goal of remediation is to remove or clean contaminated materials in a way that prevents the emission of fungi and dust contaminated with fungi from leaving a work area and entering an occupied or non-abatement area.

Level I: Small Isolated Areas (10 square feet or less)

Level II: Mid-Sized Isolated Areas (10–30 square feet)

Level III: Large Isolated Areas (30–100 square feet)

Level IV: Extensive Contamination (greater than 100 contiguous square feet)

Friend or Foe

- Molds are ubiquitous in nature. In and of themselves, molds are not "bad." They do not become a problem until they AMPLIFY indoors-causing degradation of furnishings and building materials and potentially making people sick.
- Molds are necessary for ecological balance. Without their degradation of organic material, the world would be a heap of garbage.
- Many molds are necessary for production of foods such as bread, beer, and cheeses.
- Mold is responsible for healing drugs such as penicillin.

Mold Amplification Indoors

Molds are very successful. They have adapted to building materials by developing digestive enzymes to break down cellulose. The branching growth tips provide for expansion and penetration into various building materials. Spores can remain dormant for long periods of time and amplify when conditions are suitable.

Growth Requirements

- Nutrients
  - High cellulose
  - Low nitrogen
  - Porous Building Materials are optimum
- Temperature Requirements are the same as for people 58°-85°F
- Moisture (limiting factor)

Nutrient Sources:

Construction Materials

- Wet insulation
- Damp carpets and/or pads
- Wet wall coverings
- Wood
- Paper layer of gypsum board
- Latex paints

Personal goods

- Cardboard boxes
- Cotton clothes
- Leather goods
- Furniture

Moisture:

Moisture can come from direct impact of water onto a substrate (i.e. flood), or from indirect sources (condensation). Mold will amplify on cellulose materials that remain wet for more than 48 hours.

Potential Hazard:

The presence of mold amplification is evidence of a potential hazard.

Cross-contamination should be avoided through proactive prevention (containment).

Existing indoor mold and any material with signs of water staining should be removed.

Mold Problems: Could They Threaten the Building Industry

Mold growth in buildings illustrates a disconnect between the technical wisdom of building science, and its practitioners and the economics of the market for hasty building construction and operation.

There are currently no laws or regulations in place that control the testing, evaluation, and remediation of mold issues. Furthermore, there are no regulations to control who can say they are a “mold expert”. The consensus standards usually referenced are ACGIH, IICRC, and NYC Guidelines noted in the Bibliography.

Faced with the explosive growth of mold related damage claims the insurance industry acted to eliminate their loss exposure. By adding exclusions for mold, fungus, and microbial matter claims, the insurance industry has shifted the financial burden for those losses back onto property owners, contractors, design professionals, suppliers, real estate agents, and lenders.

Health: Can Mold Make You Sick

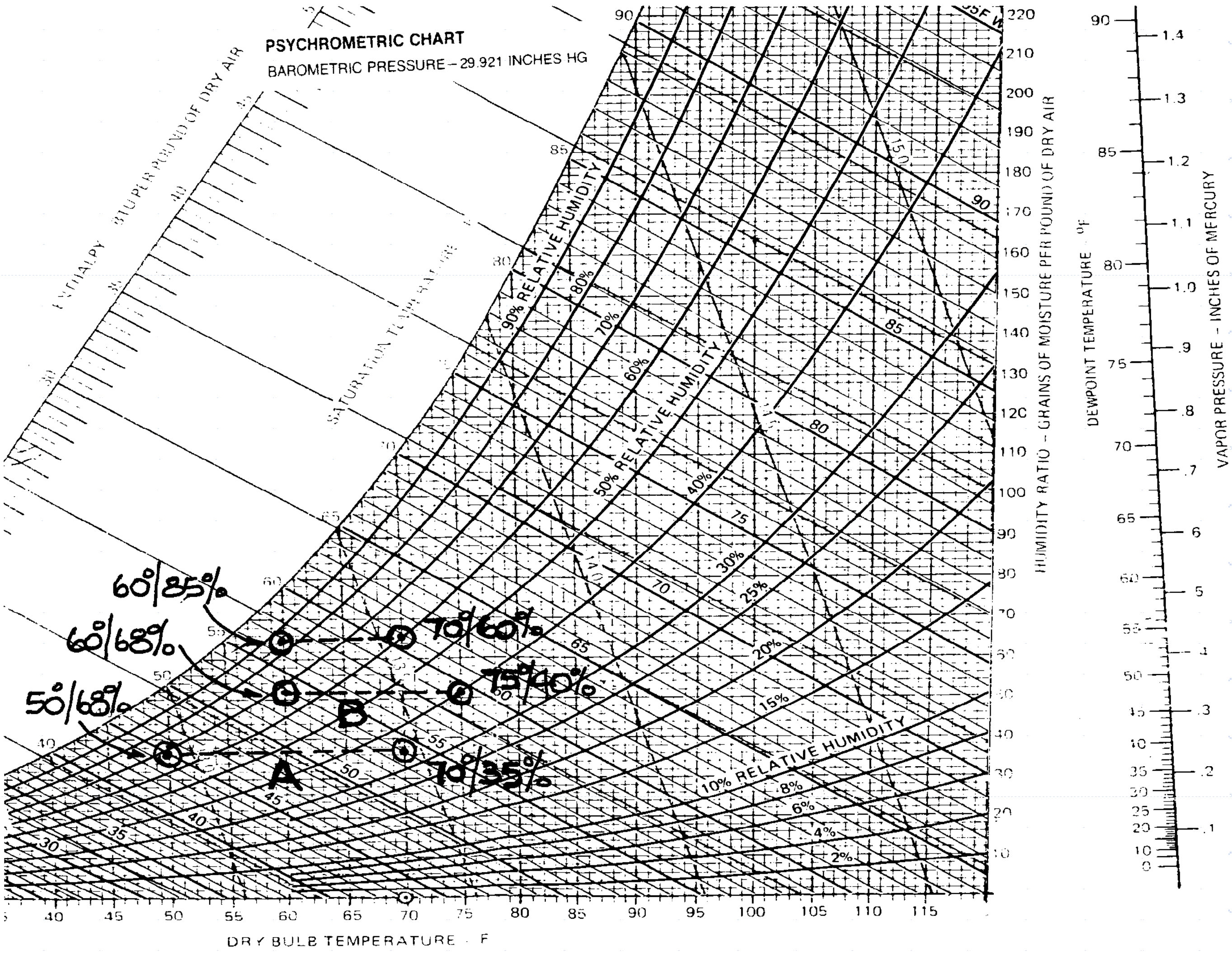
Widely Accepted Health Effects:

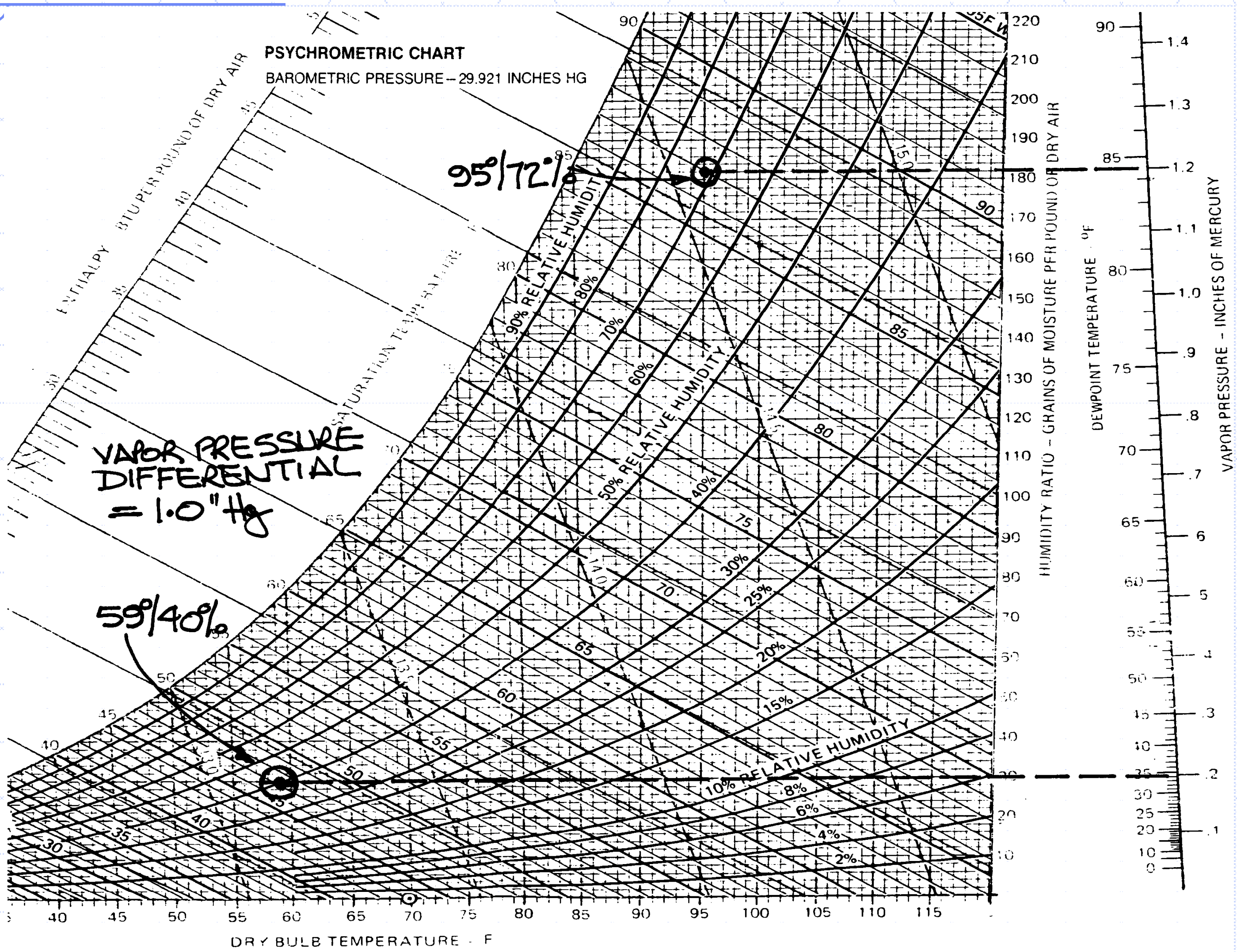
2000-Mayo Clinic published a study reporting mold to be a major cause of chronic sinusitis.

1999-Institute of Medicine Study included fungi in list of asthma triggers.

Allergic reactions are well documented health effects that can be attributed to mold exposure. Common symptoms can include skin rashes, runny nose, watery eyes, chest tightness, breathing difficulties, and headaches.

Psychometrics





PSYCHROMETRIC CHART
BAROMETRIC PRESSURE – 29.921 INCHES HG
95°/72%
VAPOR PRESSURE DIFFERENTIAL = 1.0" Hg
59°/40%
ENTHALPY - BTU PER POUND OF DRY AIR
SATURATION TEMPERATURE
RELATIVE HUMIDITY
HUMIDITY RATIO – GRAINS OF MOISTURE PER POUND OF DRY AIR
DEWPOINT TEMPERATURE - °F
VAPOR PRESSURE - INCHES OF MERCURY
DRY BULB TEMPERATURE - F

Codes

Flashings

Michigan Building Code (MBC) 2000 (1403.2) and Michigan Residential Code (MRC) 2000 (R703.1) require a weather-resistive exterior wall envelope with a water-resistive barrier behind the exterior veneer.

MBC (1404.2) and MRC (R703.2) specify 15 lb. felt or other approved alternate as a water-resistive barrier.

MBC (1405.3) and MRC (R703.8) specify the flashing shall be provided in a manner to prevent entry into the wall cavity and delineates the locations of such flashings.

Flashings

Michigan Energy Code (MEC), ASHRAE Standard 90.1/1999, (5.2.3.1) specifies envelope sealing to minimize air leakage.

Therefore, Contract Documents must clearly delineate what is to be installed and how the installation must be implemented to preclude water entry.

Attic Ventilation

MBC (1202.2) and MRC (R806.2) specify the minimum total net free area of the ventilators located in the upper portion of the space and at the eave. This net free area can be reduced by 50% if a vapor barrier is installed on the warm side of the ceiling.

Ice Dam Protection:

MBC (1507.2.8.2) and MRC (R905.2.7.1) require two layers of underlayment cemented together or a self-adhering polymer modified bitumen sheet to extend from the eave edge to a point at least 24 inches inside the exterior wall line of the exterior wall.

Crawl Space Ventilation:

MCB (1202.3.1) and MRC (R408.1) specify the minimum total net free area of the ventilators to be installed in the exterior foundation walls. This total ventilation area can be reduced to one-tenth if the ground surface is treated with an approved vapor retarder material.

Controlling Moisture Entry into Buildings

To deal effectively with moisture in buildings, these strategies are imperative:

Keep water out

Designing assemblies to dry out

Provide mechanical ventilation

Avoid condensation in the building

Avoid condensation within the building envelope

- Controlling entry of humid outside air
- Controlling indoor sources of humidity
- Avoid (or manage) plumbing leaks
- Provide mechanical dehumidification

Of these strategies many are controlled by the architect. These include:

- Flashing at all door and window penetrations
- Roof penetrations
- Roof-wall intersections
- Drainage planes in the envelope
- Capillary breaks
- Condensation within the envelope
- Condensation in the building

Flashings:

Provide proper flashing at all windows and doors penetrations. All components should be layered so that water is shed down and outward. Flashings can be installed before or after the housewrap or building felt "drainage plane."

Manufacturers of building wraps (water-resistive barriers (WRB)) provide the details and have the products available to properly flash windows and doors but typically this is not the requirement of the Contract Documents and therefore never installed.

Water-resistive Barriers (WRB's):

The industry as a whole seems perplexed concerning the breathability of wall systems and the effects of WRB's. Don't look to codes for answers. The forthcoming new codes (effective December 31, 2003) requires a WRB over the sheathing regardless of the siding type and doesn't address breathability or alternates to 15 lb. felt.

Vapor pressure differentials can be high in a wall assembly but air infiltration accounts for much more water-vapor entering the cavity than by diffusion. Therefore, the taping of all joints and edges is necessary.

Though 15 lb. felt is usually cited, substitution of “equivalent” materials is allowed-opening the door for plastic housewraps. There is no standard for testing WRB's. Therefore, every manufacturer submits test data to an independent evaluation service and there is no way of comparing their respective properties. I recommend review of this subject from studies conducted by the University of Massachusetts, Building Materials and Wood Technology Department <http://www.umass.edu/bmatwt/>.

Based on my experience of our industries ability to keep water out of building envelopes it is imperative the WRB's be breathable and let the water vapor escape to the exterior. Thus, a moderate perm rating is recommended.

One problem with plastic building wraps is the loss of water repellency. Contaminants such as surfactants can raise the surface energy of the building paper or lower the surface energy of the water allowing the “wetting” of the building wrap by water. Once this wetting occurs the pores or perforations become filled allowing the water (liquid phase) across the building wrap via capillary action or gravity.

Water soluble components in wood such as tannins and wood sugars are a type of surfactant that contaminate the surface of the plastic building wraps raising their surface energy.

I believe the smaller the holes in the wrap the better their water resistance capabilities in the presence of surfactants.

With surfactants increasing the probability of liquid water penetrating the building wrap it’s imperative the wrap have a moderate or above perm value to ensure the wall can dry to the exterior.

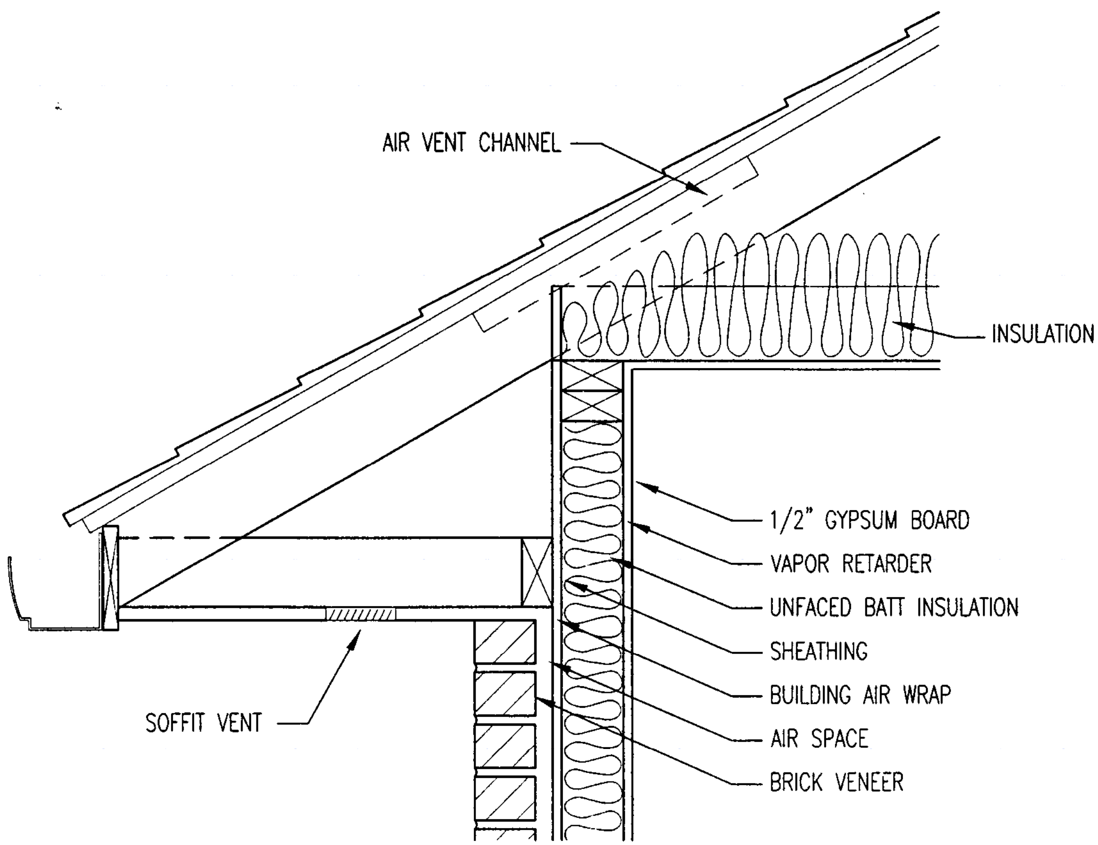
In numerous inspections I’ve seen cedar shingles applied directly to the plastic wrap which insures water intrusion from the surfactants and vapor diffusion if the wetted shingle temperature is raised. A “cedar-breather” or similar air space is essential.

Roof Ventilation (R806.2)

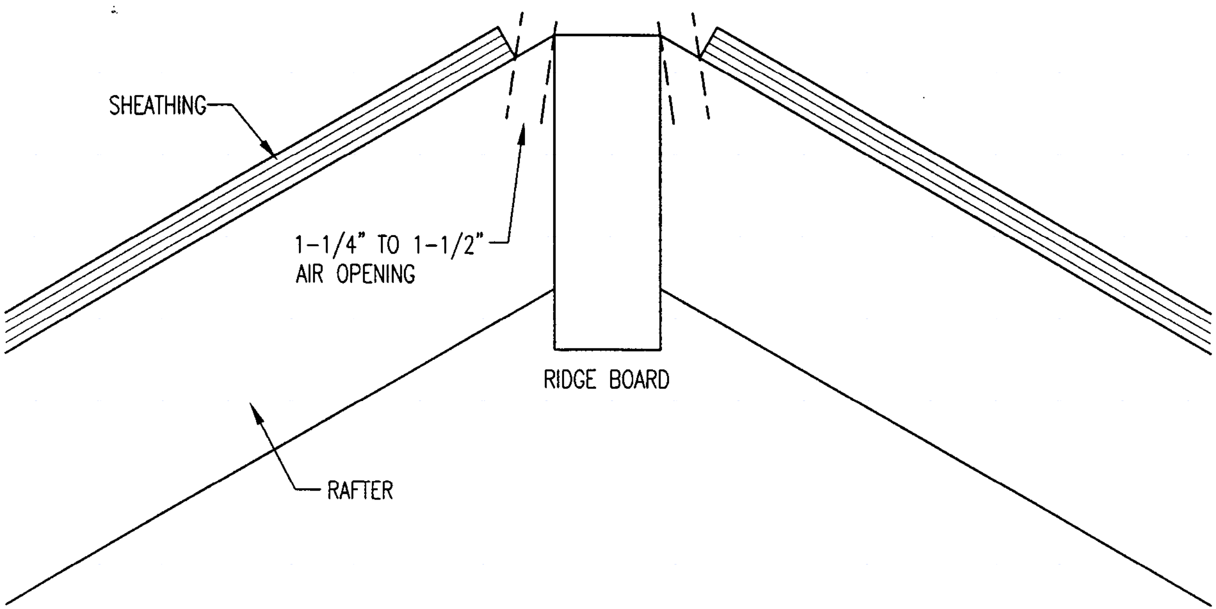
Ice damming is the primary cause of roof water intrusion in heating climates. Water from melting snow on a warm roof runs down the roof to the eave where lower temperatures freeze the water creating ice dams. The roof water accumulates, penetrates the shingle underlayment and enters the structure.

The minimum total net free ventilating area for roof/attic ventilation is not less than 1 to 150 of the area of the space being ventilated. This can be reduced to 1 to 300 if at least 50% and not more than 80% of the ventilating area is provided in the upper portion of the space and the balance at the eave. If a vapor barrier is used on the warm side of the ceiling then the ventilating area can also be reduced to 1 to 300.

There is no stipulation that the ventilating area be continuous at the eave and at the worst case can be as little as 20% of the required area. We recommend continuous soffit vent and ridge vent of at least 50% of the total net free area required based on 1 to 150 because construction techniques are not monitored closely and the vapor barrier used on the ceiling may not be adequately lapped and sealed or the Kraft paper backing on the insulation may not be stapled correctly.

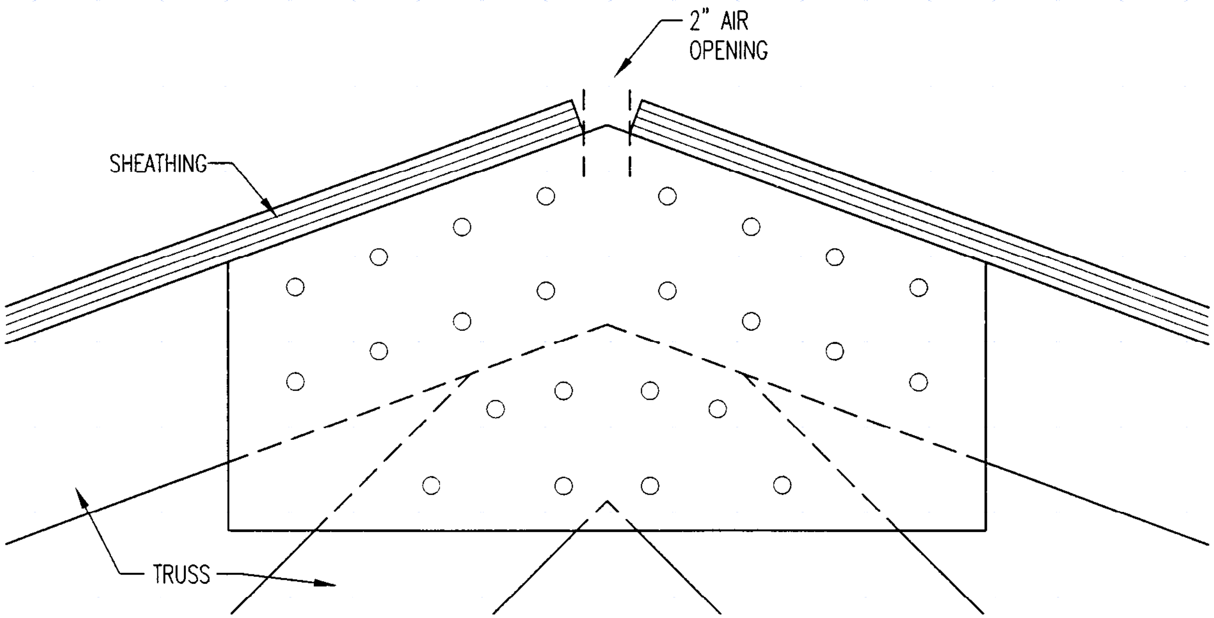


SOFFIT VENT DETAIL
NO SCALE



TRUSS DETAIL

NO SCALE



RAFTERS AND RIDGE BEAM DETAIL
NO SCALE

The air space between the insulation and the roof sheathing must be a minimum of 1". Air channel vents are frequently compressed by overzealous insulation installers.

SOFFIT AND RIDGE VENT REQUIREMENTS

Attic Area Square Feet	Vent Area Required @ 1 to 150	Vent Area Required @ 1 to 300	Code Upper Roof Vent 50% to 80% @ 1 to 300	Code Eave Vent 50% to 20%	Recommended @ 1 to 150					
									Roof Louvers	
					Upper and Eave Vent @ 50% each	2-3/4" Soffit Vent @ 76 sq. in. per 8 LF	3-3/4" Soffit Vent @ 104 sq. in. per 8 LF	Ridge Vent @ 18 sq. in. per LF	Pan Style Vent @ 50 sq. in. 9" dia.	Slant back Vent @ 50 sq. in. 8" dia.
1400	9.3	4.7	2.3 / 3.7	2.3 / 0.9	4.7	71.2	52.1	37.6	14	14
1600	10.6	5.3	2.65 / 4.2	2.65 / 1.1	5.3	80.3	58.7	42.4	16	16
1800	12.0	6.0	3.0 / 4.8	3.0 / 1.2	6.0	90.9	66.5	48.0	18	18
2000	13.3	6.7	3.4 / 5.4	3.4 / 1.3	6.7	101.6	74.2	53.6	20	20
2200	14.7	7.3	3.7 / 5.8	3.7 / 1.5	7.3	110.6	80.9	58.4	21	21
2400	16.0	8.0	4.0 / 6.4	4.0 / 1.6	8.0	121.3	88.6	64.0	23	23
2600	17.3	8.7	4.4 / 7.0	4.4 / 1.7	8.7	131.9	96.4	69.6	25	25
2800	18.7	9.3	4.7 / 7.4	4.7 / 1.9	9.3	141.0	103.0	74.4	27	27
3000	20.0	10.0	5.0 / 8.0	5.0 / 2.0	10.0	151.6	110.8	80.0	29	29

Ice Protection (R905.2.7.1)

Two methods of providing ice protection are code approved:

- Two layers of underlayment cemented together.
- Self-adhering polymer modified bitumen sheet.

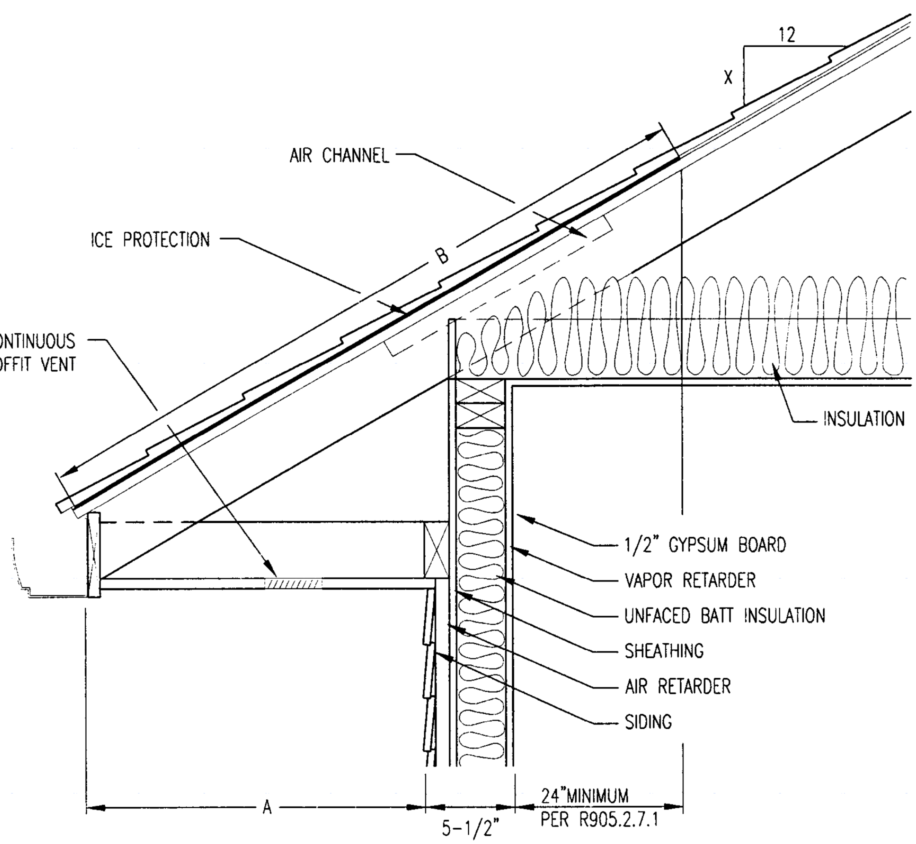
In many instances, a single felt is used and in some cases, we have seen roofs without felts. We would prefer the self-adhering bitumen sheet be specified exclusively and the extent of the installation stipulated on the Contract Documents.

The ice protection must extend at least 24” beyond the inside face of the exterior wall.

For various roof slopes and soffit widths, the length of the ice shield varies.

In many instances, a single 36” width of ice protection is installed in lieu of code mandates.

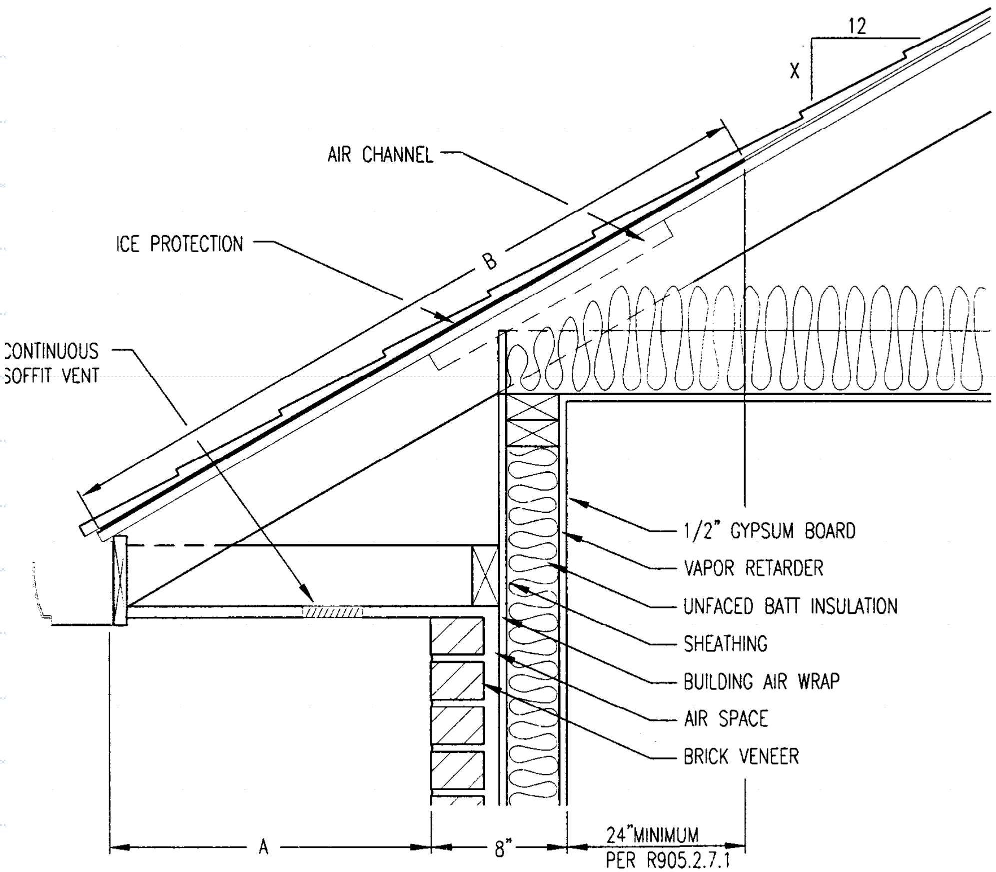
ICE PROTECTION REQUIREMENTS FOR 5-1/2" WALL WIDTH



ICE PROTECTION DETAIL
NO SCALE

A	B							
	SLOPE "X"							
	2.5	3	4	5	6	8	10	12
4	34.2	34.5	35.3	36.3	37.5	40.3	43.6	47.4
8	38.3	38.7	39.5	40.6	41.9	45.1	48.8	53.0
10	40.3	40.7	41.6	42.8	44.2	47.5	51.4	55.9
12	42.4	42.8	43.7	45.0	46.4	49.9	54.0	58.7
14	44.4	44.8	45.9	47.1	48.6	52.3	56.6	61.5
16	46.5	46.9	48.0	49.3	50.9	54.7	59.2	64.3
18	48.5	49.0	50.1	51.5	53.1	57.1	61.8	67.2
20	50.6	51.0	52.2	53.6	55.3	59.5	64.4	70.0
22	52.6	53.1	54.3	55.8	57.6	61.9	67.0	72.8
24	54.6	55.1	56.4	58.0	59.8	64.3	69.6	75.7

ICE PROTECTION REQUIREMENTS FOR 8"± WALL WIDTH



ICE PROTECTION DETAIL

NO SCALE

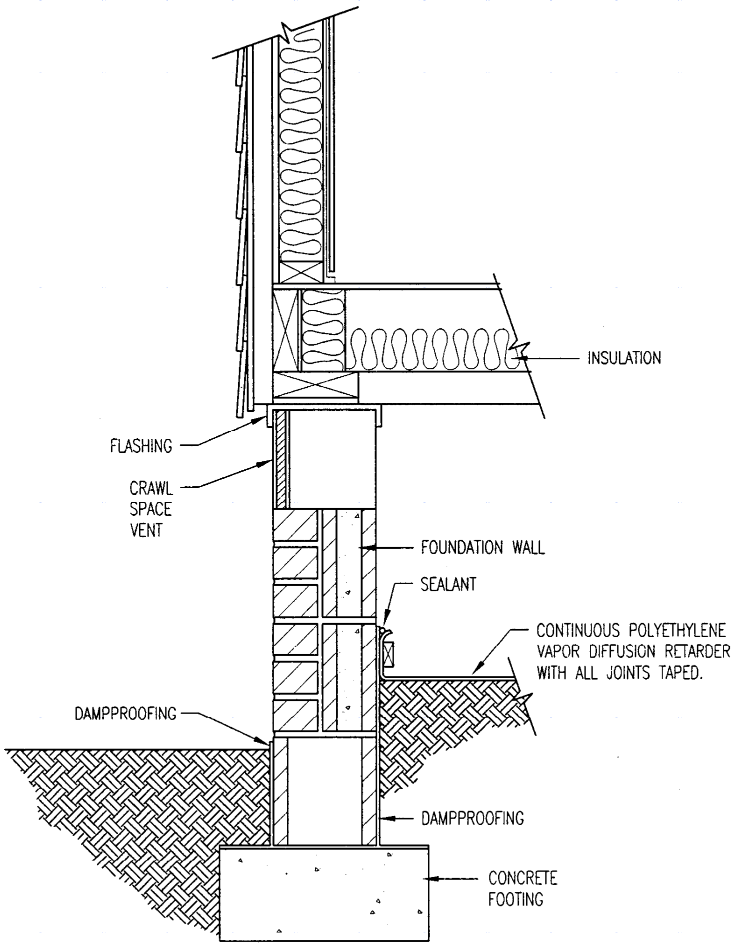
A	B							
	SLOPE "X"							
	2.5	3	4	5	6	8	10	12
4	36.8	37.1	37.9	39.0	40.2	43.3	46.9	50.9
8	40.9	41.2	42.2	43.3	44.7	48.1	52.1	56.6
10	42.9	43.3	44.3	45.5	47.0	50.5	54.7	59.4
12	44.9	45.4	46.4	47.7	49.2	52.9	57.3	62.2
14	47.0	47.4	48.5	49.8	51.4	55.3	59.9	65.1
16	49.0	49.5	50.6	52.0	53.7	57.7	62.5	67.9
18	51.1	51.5	52.7	54.2	55.9	60.1	65.1	70.7
20	53.1	53.6	54.8	56.3	58.1	62.5	67.7	73.5
22	55.2	55.7	56.9	58.5	60.4	64.9	70.3	76.4
24	57.2	57.7	59.0	60.7	62.6	67.3	72.9	79.2

Crawl Space Ventilation (R408.1.4.2)

The minimum net free ventilation of crawl spaces must not be less than 1 to 150 with one opening within 3 feet of each corner of the building. Thus at the very least each crawl space should have a minimum of four (4) vents.

The total area of ventilation can be reduced to 1 to 1500 when the ground surface is treated with an approved vapor retarder material. We do not recommend the latter under any condition because the vapor retarder does not have an indefinite life and normally is not installed to prevent moisture from entering the crawl space.

The sealing of a crawl space with a pliable reinforced water-resistive barrier and the sealing airtight of the ventilation openings, installation of drainage tile and sump pump will in certain instances eliminate an unhealthy environment.



CRAWL SPACE VENT DETAIL
NO SCALE

CRAWL SPACE VENTS

Crawl Space Area Square Feet	Vent Area Required @ 1 to 150 sq. ft.	Vent Area Required @ 1 to 1500 sq. ft.	Number of 16x8 Vents Required @ 1 to 150			
			Net Free Area 39 sq. in.	Net Free Area 46 sq. in.	Net Free Area 64 sq. in.	Net Free Area 74 sq.in.
1400	9.33	0.93	34.4	29.2	21.0	18.2
1600	10.67	1.07	39.4	33.4	24.0	20.8
1800	12.0	1.2	44.3	37.6	27.0	23.4
2000	13.3	1.3	49.2	41.7	30.0	25.9
2200	14.7	1.47	54.1	45.9	33.0	28.5
2400	16.0	1.6	59.1	50.1	36.0	31.1
2600	17.3	1.73	64.0	54.3	39.0	33.7

Electro-Osmotic Pulse Technology

Electro-osmotic pulse (EOP) technology is used to prevent moisture intrusion through concrete and masonry into below grade spaces and is now being applied to historic buildings.

The positive-voltage pulse has the longest interval, and the negative-voltage pulse has the shortest interval. The positive electrical pulse causes the positive ions and associated water molecules to move from the anode (interior or dry side) toward the cathode (exterior or wet side), against the direction of flow induced by the hydraulic gradient, thus preventing water penetration through the structure.

One of the most critical aspects of this technology is the negative-voltage pulse (polarity reversal). The negative pulse is of very short duration as compared to the positive pulse. During the time of the negative pulse, the water flows in the opposite direction.

Thus some moisture is retained in the application matrix between the anode and cathode, preventing over-drying of the material and maintaining the structural integrity of the matrix. Another advantage of the short negative pulse is the reversal in the chemical reactions at the electrodes (the anode becomes the cathode for an instant and vice versa), thereby eliminating electrode polarization and guaranteeing that the system will continue to operate efficiently.

An EOP system is installed by inserting anodes into the wall and/or floor on the inside of the structure and by placing cathodes in the soil directly outside the structure. The number of anodes and cathodes and their placement are determined from an initial electrical resistivity test of the material and soil. The objective is to achieve a certain current density and thus create an electric field in the material that is sufficiently strong to overcome the force exerted on the water molecules by the hydraulic gradient from outside the structure.

By combining EOP with standard repair techniques that seal cracks and other defects, EOP can solve the problems of active water intrusion (high water table) and saturation (rising damp). EOP can extend the life of the repairs to cracks or voids by controlling the amount of water reaching the repair material. For more information: <http://www.moisture-solutions.com/home.asp>

Design Strategies For Moisture Control

Keeping Water Out

- Flash all windows and doors
- Provide continuous drainage plain
- Provide water screen behind siding
- Seal wood and fiber-cement siding
- Provide capillary break above footings
- Provide drainage layer and poly vapor barrier under concrete slabs (without a layer of sand between the poly and slab).

- Provide perimeter drain tile
- Provide water-proofing on the outside of foundation walls
- Slope ground away from building (minimum pitch of 5%) and provide impermeable cap (high clay content).
- Provide roof overhang to keep rainwater away from building
- Provide self-sealing ice and water barrier on roof.

Design Building Assemblies to Dry Out

- Provide wall cavity potential for drying to the exterior
- Design below grade spaces to dry to the interior
- Use plywood instead of OSB
- Provide vented roof assembly
- Provide encapsulated crawl spaces
- Avoid thermal bridges

Bathroom Exhaust Fans

- Moisture in attics can be exacerbated by bathroom exhaust fans that do not discharge to atmosphere with a direct connection. Improper installation can cause localized damage to roof sheathing or contribute to higher moisture levels, which impacts the complete attic.
- Most bathroom exhaust fans do not exhaust much air and as a consequence, the room's relative humidity is elevated for extensive periods. For residential applications an exhaust fan should have an external static pressure rating of not less than 0.20 inches.

Discharge of bathroom exhaust fans should not be in soffits. Michigan Mechanical Code (MMC) 2000, 501.3 states in part, "…shall be discharged outdoors at a point where it will not cause a nuisance…" Drawing hot moist air into an attic can create a nuisance if mold starts to grow on the sheathing.

Avoid interior condensation by specifying a light/fan switch that with a single switch combination allow the exhaust fan to operate from 5 to 60 minutes after the light is turned off.

Structural Drying

- Mold forms in 4 days if elevation moisture levels exist as a consequence of structural wetting during construction.
- Desiccant materials attract water of the air as a vapor. Humid air has a high vapor pressure. Dry desiccant has a low vapor pressure.
- Propelled by this vapor pressure difference, water molecules (as a vapor) move out of the humid air to the desiccant which captures the water molecules onto the surface of the desiccant medium by a process called adsorption.

Solid desiccant materials are adsorbents with a tremendous internal surface area providing for the capacity to handle large volumes of water.

A single gram (less than one teaspoon) of dry desiccant can have more than 50,000 square feet of surface area (equivalent to the size of a football field).

After being loaded with water molecules the desiccant is reactivated (dried out) by heating, which raises the vapor pressure of the material above that of the surrounding air.

Desiccant drying controls mold formation.

Final Thoughts

Using the best building science we can not only design and construct buildings that will last but also reduce the risk of moisture-related health problems, including exposure to molds and other allergens. To apply building science, we have to address the interactions among components in a building—looking to manufacturers for solutions at the level of the individual product isn't enough.

Rarely is anyone filling the role of building scientist on design teams today. It's up to architects to either learn to play that role, or hire consultants who can work through details of the envelope and mechanical and plumbing systems with them.

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CDC: Centers for Disease Control and Prevention; National Center for Environmental Health.

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ASTM: American Society for Testing Materials, STP1422 "Performance of Exterior Building Walls."

AEE: Association of Energy Engineers.

AIAQC: American Indoor Air Quality Council.

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