Water Vapor

Water vapor can penetrate virtually any insulation system. Once inside, this vapor will condense to a liquid whenever the dew point is reached, or it will freeze. This results in a system with severely diminished thermal efficiency and a high potential for corrosion.

Unfortunately, thin, easily damaged vapor retarders do not provide a satisfactory solution to water vapor migration. But, cellular glass insulation will provide maximum protection with minimum maintenance.

PROBLEMS

Water vapor is always present in the air, and it can be a threat to both low-temperature and high-temperature insulation systems. It makes up less than 1%, by volume, of our air, but water vapor is the only atmospheric gas that can change to a liquid or a solid under normal, ambient air temperatures. Consequently, it is also the only gas that threatens the thermal efficiency of insulation systems.

With low-temperature equipment, water vapor migrates to the cold substrate behind the insulation system. Here, the vapor condenses to liquid water and can even freeze. When this happens, thermal losses increase dramatically. The insulation system may even be physically damaged as it undergoes large, dimensional changes.

- *Vapor Transport*

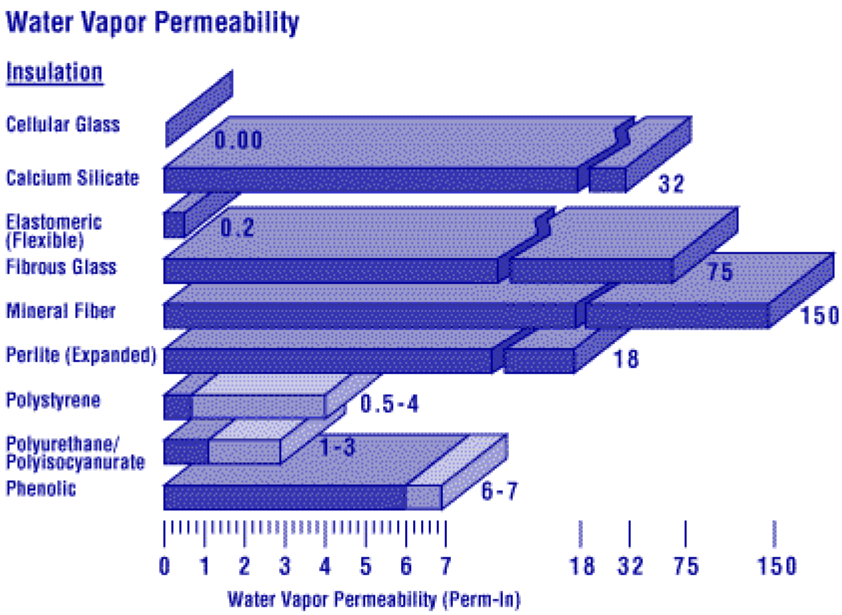
  The movement of water vapor in an insulation system is dependent upon changes in the relationship of relative humidity, temperature and vapor pressure.

  The actual weight of vapor per cubic foot of air at a given temperature is the air's absolute humidity. Relative humidity is the actual humidity of the air compared with absolute humidity at saturation for the same temperature. Warm air can hold more water vapor than cold air. And the temperature at which air is saturated is the dew point temperature.

  All gases in air—of which water vapor is just a very small portion—contribute to atmospheric pressure, and the pressure exerted by each is known as its partial pressure. Vapor in unsaturated air exhibits a lower partial pressure than does vapor in saturated air, i.e., vapor pressure is proportional to relative humidity.

  When vapor in two adjacent bodies of air exhibits a partial pressure difference, the balancing forces of nature cause the vapor to flow from the higher to the lower pressure area.

  The resistance of a material to the flow of this water vapor is its permeability as measured in perm-inches (1 perm-inch = the passage of 1 grain of vapor through 1 ft. squared of 1 inch-thick material in 1 hour under a pressure difference of 1 inch of mercury). Examples of the permeabilities of some insulation materials are shown in the graph.



- *Transport Experiments*

  In experiments, plastic foams have been shown to be more permeable to water pressure as the temperature gradient from one side to the other increases. This is because the water vapor pressure driving force is directly related to the temperature gradient. In the case of polyurethane, vapor intrusion reaches 20%, by volume, in 30 days with a 40ºF (22ºC) gradient. Obviously, there is a potential for massive water vapor intrusion.

  Other experiments have shown that the penetration of water vapor is faster and more critical than that of liquid water. For example, with polyurethane after just 20 days, vapor intrusion is >8%, by volume, while liquid penetration has peaked at 1%.

- *Unreliable Vapor Retarders*

  Vapor "barriers"—more correctly vapor checks or retarders—only reduce vapor flow, they cannot eliminate it. And, if damaged, they do not serve even this function. Vapor retarders are placed in direct contact with the thermal insulation, ideally on the warm side of the system. But for outdoor equipment and buildings operating in mild-to-cold environments, the "warm side" can change to the system side from the surrounding environment as the seasons change. Thus, for parts of the year, the vapor retarder is technically on the "wrong" side, retaining water vapor and increasing condensation.

  Because retarders for cold piping will always be on the outside surface of the insulation, they also are subject to damage by foot traffic, ladders, temperature change and weather. In addition, because retarders are usually adhered directly to insulation, any movement of the insulation also can contribute to retarder damage. Frequently, the elasticity required to maintain retarder integrity is severely compromised by aging and air pollution. Even foils, which are excellent vapor retarders, are very susceptible to puncturing and corrosion.

  Due to these forces, it is likely that some water vapor will eventually pass through vapor retarders, and as a result, other provisions must be made to protect insulation.

- *Cellular Plastic Insulations*

  These materials will transmit water vapor in varying degrees depending upon the permeability rating of the material. The reason for any diffusion is a partial pressure difference caused by a difference in temperature or in concentration of water vapor.

When water vapor migrates in, nothing happens as long as the dew point is not reached; but water vapor turns into water when this dew point temperature is achieved. While this migration can happen very suddenly and quickly, a very long time is required for dry out.

In actual service, however, conditions will probably never permit complete drying to occur. To dry something out, in all practical cases, a flow of nonsaturated air is required, and the amount of water that can be evacuated corresponds to the quantity of water vapor that can still be picked up by the circulating air.

While cellular plastics' absorption of water vapor is a slow process compared with fibrous materials, a gradual increase in thermal conductivity is occurring. With polyurethane, for example, permeability to water vapor is 2000 times greater than for air. That's why one manufacturer of urethane foam states that equipment with operating temperatures cycling from below to above ambient requires flawless installation and vigilant maintenance to assure the integrity of the vapor retarder and to guard against insulation failure. In addition, they recommend that the urethane be coated immediately upon installation. Research, however, has shown that vapor permeates most coatings.

In an Oakridge National Laboratory study, intermediate low- temperature applications using urethane insulation—even with a vapor retarder—developed ice deposits and underwent destruction of insulation integrity at the cold surface, while the warm surface appeared normal. Cellular glass was shown to be superior in this application.

Phenolic foams are the most absorptive of the cellular plastics. Tests have shown that water absorption of up to 449%, by weight, can occur after 227 days of exposure.

While polystyrene foams exhibit better vapor resistance than other plastic foams, at least one study has shown that extruded polystyrene used as roof insulation picked up nearly 21% moisture, by volume, primarily through vapor diffusion.

The FOAMGLAS® Cellular Glass Insulation Solution

FOAMGLAS® insulation offers redundant protection to water vapor intrusion, and, in the mastic-sealed joint area, it offers a vapor barrier mastic with a thickness corresponding to the applied FOAMGLAS® cellular glass thickness. With FOAMGLAS® insulation, virtually the entire outer surface is safe. Accidental mechanical damage to a few FOAMGLAS® cells has no influence on the water vapor tightness of the system. The specification of a FOAMGLAS® insulation system will provide maximum safety with minimal maintenance.