Importance of a Vapour Barrier in Cold Storage Design

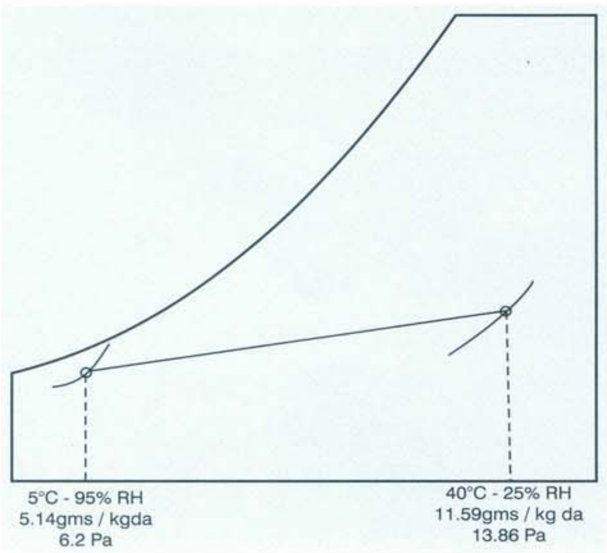
By Ramesh Paranjpey
Technical Advisor & Consultant, Pune

A vapour retarder or more commonly known as vapour barrier is the material which tries to prevent transfer of water vapour across the barrier which could be any external surface of the cold storage envelope such as walls, roof/ceiling or flooring.

Why Vapour Barrier for Cold Storage

The air within the cold store holds considerably less water vapour than air outside. Water vapour in the air gives rise to pressure and together with other gases like oxygen and nitrogen, exerts total atmospheric pressure.

The pressure exerted by water vapour is directly proportional to the quantity of water vapour present and vapour in the out side air having higher pressure will tend to migrate to an area of lower vapour pressure existing in the cold storage. When this vapour is cooled in the cold room, it condenses and in case of a negative temperature cold storage it gets converted in to ice. The presence of water inside the cold storage is detrimental as it weakens the insulation, its heat prevention ability and also considerably adds to refrigeration requirements with increased power consumption.



Psychrometric depiction

Relative Humidity & Absolute Humidity (Humidity Ratio)

As the heat flows from a higher temperature to a lower temperature, similarly as mentioned above the water vapour migrates from a higher water vapour pressure area to a lower water vapour pressure area. Since moisture ingress is invisible, it is normally overlooked but it can significantly affect the cold room conditions adversely.

Inordertounderstandthesephenomena we need to look at a psychrometric chart or some basic air properties.

It is a general perception that higher relative humidity means more moisture content, but it is not true. If we look at the properties of air, as given below, we notice that 5°C & 85% R.H. has less moisture content 4.6 gm/kgda as against 40°C & 25%. R.H.-11.59gm/kgda

Properties of Air

In cold storages which operate at much lower temperatures of –20°C or blast freezers operating at –40°C, there is even a much bigger difference in vapour pressures as can be seen from the table, which becomes a driving force for water vapour to enter the cold storage.

We should, therefore, always look at absolute humidity values and not relative humidity if we want to know the actual moisture content in the air to decide on which side the vapour barrier should be installed.

In the above mentioned example, the vapour pressure in the outside air would be 13.86 Pa as against inside vapour pressure would be only 5.56 Pa i.e. less than half and water vapour would therefore try to penetrate through the building construction material or through insulation inside the cold room.

Insulation & Vapour Barrier

ASHRAE volume 2006 -14.12 states "Primary concern in the design of a low temperature facility is the vapour retarder system, which should be as close to 100% effective as is practical. The success or failure of the insulation envelope is due entirely to the effectiveness of the vapour retarder system in preventing water vapour transmission into and through the insulation"

Providing insulation alone to prevent heat from seeping in is not enough, the insulation envelope must also be impermeable to water vapour in order to prevent the migration of water vapour from the warm ambient environment to the cold space. Failure to prevent this migration of water vapour results in condensation of water on the interior of refrigerated space and formation of ice. It also adds to refrigeration load leading to a higher energy bill.

About the Author

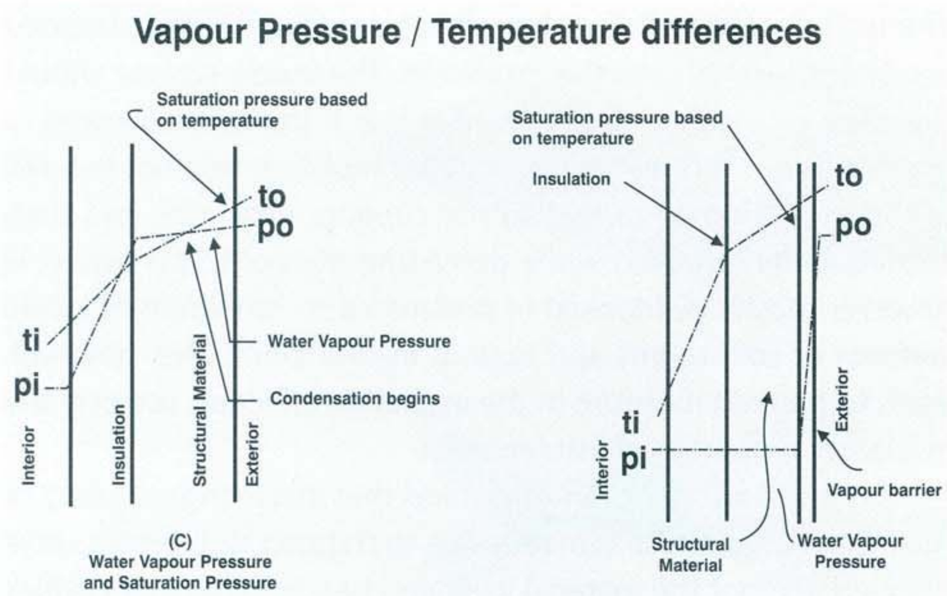
Ramesh Paranjpey is a mechanical engineer with an M.Tech in refrigeration from IIT Bombay with over 35 years experience. He has worked in very senior positions starting with Kirloskar Pneumatic in Pune, Carrier Transicold in Bangalore and Singapore as well as Voltas-Air International Pune. Presently he works for himself as a technical advisor & consultant. He is an ASHRAE Fellow, past president ASHRAE W.I. chapter and past president ISHRAE Pune chapter. He can be contacted at *pramesh@vsnl.com*

Temperature °C	Relative Humidity - %	Absolute Humidity - gm/kg of dry air	Partial pressure of water vapour-Pa
40	25	11.59	13.86
5	85	4.6	5.56
-20	95	0.6	0.73
-40	95	0.075	0.019

Properties of air

Additional Refrigeration Requirements & Energy

It is also important to be aware of the fact that one kg of dry air to be cooled by one deg C requires only 1.004 kJ heat whereas to condense 1 kg of water vapour to 1 kg of water we require 2500 kJ/kg i.e nearly 2500 times more energy and 334kJ/kg to convert this condensed water further in to 1 kg of ice, hence nearly 3000 times more energy is required. A lot of refrigeration plant capacity is therefore wasted if water vapour is entering in the cold room and getting converted in condensation or in ice formation.



With & without vapour barrier

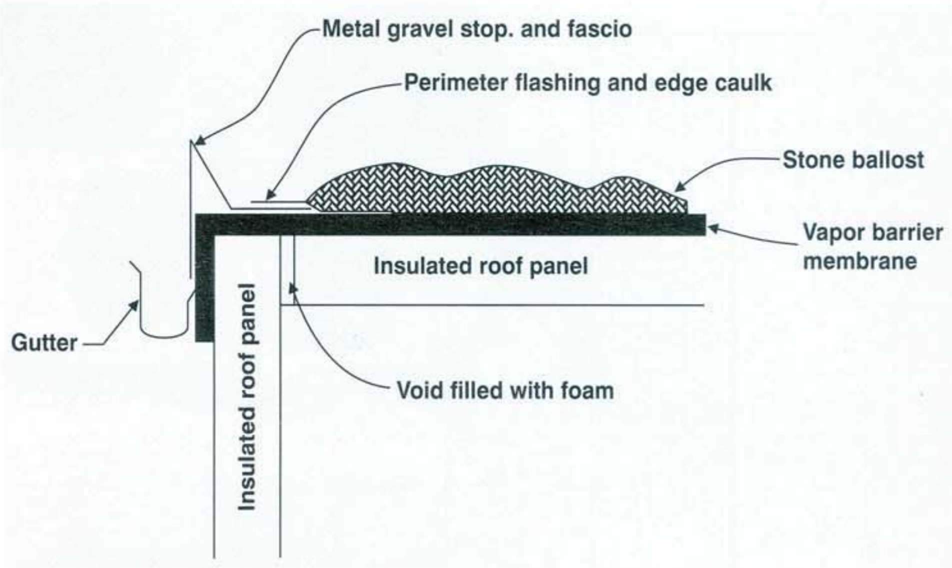
Requirements of Good Vapour Barrier

In rating the effectiveness of material, two terms, mainly Permeability and Permeance of material need to be understood.

Permeability: Permeability reflects the material's ability to allow passage of certain number of grains of moisture (1 grain =1/7000lb) per inch thickness of material per sq.ft per hour per inch of mercury vapour pressure difference (kg per Pa per sec per m). is the property of material per unit thickness.

Permeance or perm: It is Permeability divided by the actual thickness of the vapour retarder material. It can be any material that has a water vapour transmission rate less than 1 perm.

Material	Perm value
Concrete block 8" thick	2.4
Exterior grade plywood ¼" thick	0.7
Hot melt asphalt 2 oz/sq.ft.	0.5
Reinforced concrete slab 8" thick	0.4
Polyethylene film 0.20 mm thick	0.04
Polyethylene film 0.25 mm	0.03
Metal foil –aluminum	0.0



Vapour sealing for roof

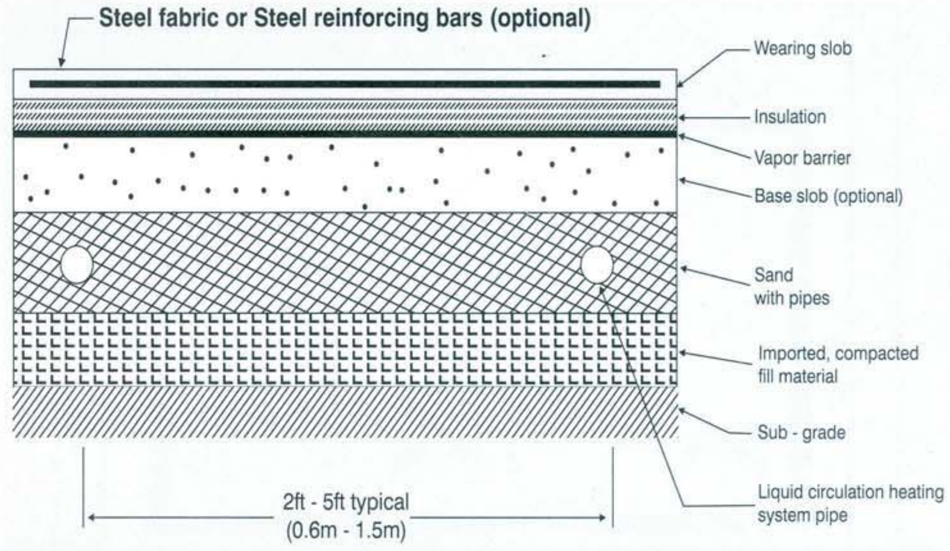
Although one perm looks very small it is not good enough for cold storage applications. Recommended vapour retarder perm rating should be 0.01 or finer, provided on the warm side of the insulation.

Types of Vapour Retarders

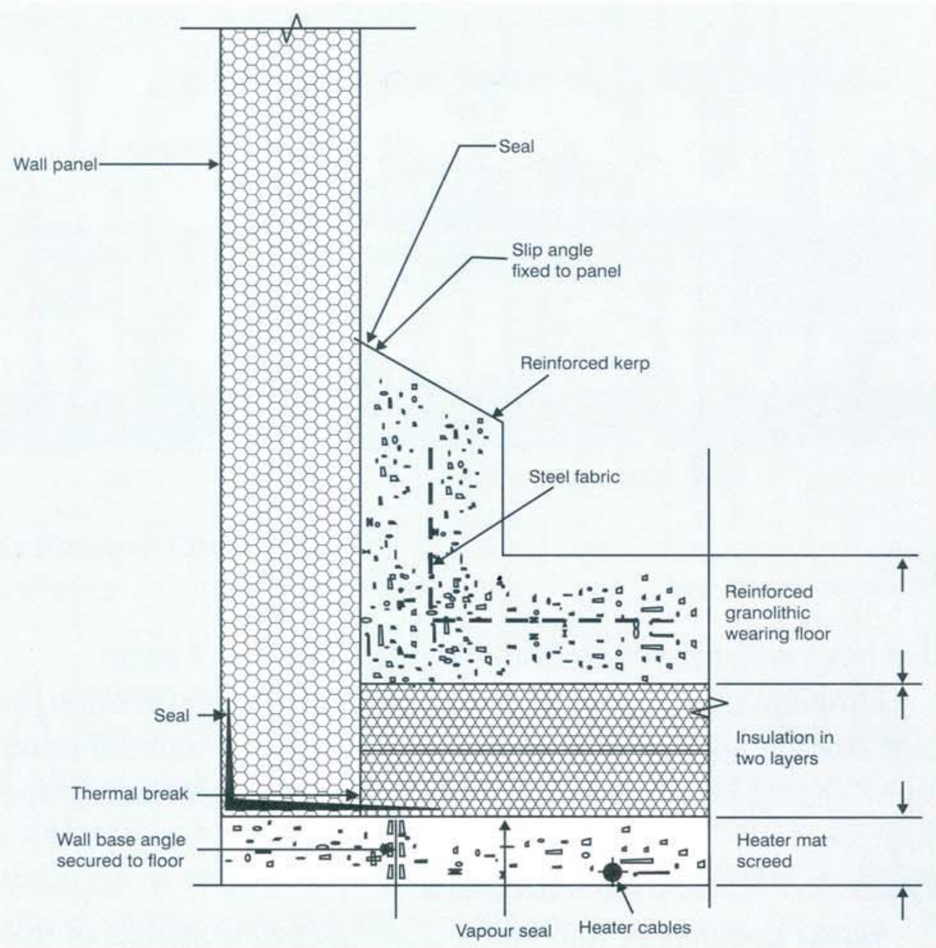
Plastic coatings or thin fluids - Examples of materials of this category are asphalt, bituminous emulsions and polymer resins. These types of vapour retarders are applied on the exterior surface of insulation, usually before the insulation is installed.

Sealing sheets - The examples in this category include asphalt paper, plastic sheets, and metal films. Metal films like aluminum foil is inexpensive and excellent vapour barrier but is difficult to install and it is impossible to make a fool proof seal without considerable punctures occurring. Also if applied to walls directly there is possibility of corrosion as well. Polyethylene installation becomes comparatively easier due to reduced number of joints and overlapping and bonding wherever required. Also polyethylene is quite stretchable before fracture occurs unlike metal foil. This characteristic is highly desirable in a cold storage vapour barrier in order to absorb building movement without rupture.It should be also noted that two thin layers of film are not as good as one thick layer since there are twice as many chances of failure of the vapour barrier and it would require double the labour, seals, and joint overlaps.

Prefabricated sandwitch panels - Due to ease of installation,



Vapour sealing for floor

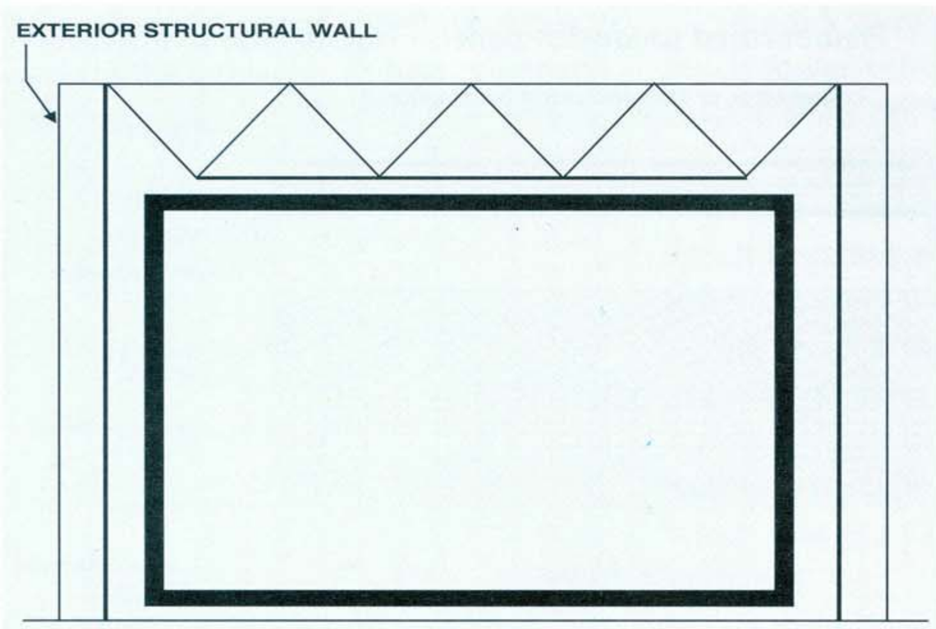


Vapour Sealing for Wall to Floor

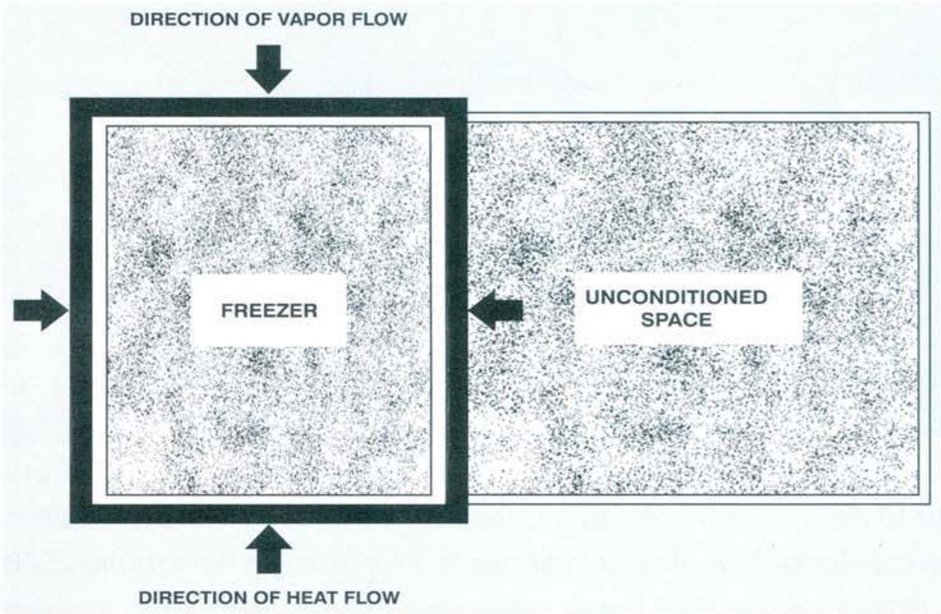
now a days these are predominantly used in the refrigerated facility designs. The external metal surface of the panels acts as vapour retarder. When using prefabricated panels, care should be taken to ensure continuous and uninterrupted joints between panels and they should be vapour sealed including all joints between wall and ceiling and between wall and floor. These panels should be installed to provide inside surface joints i.e. on cold side to be permeable so that in case of vapour leaks it will pass through the joint and not permeate in the core material. The panel joint must also be able to survive the differential movement between two panels and the sealant used must have sufficient elasticity to tolerate this movement without breaking down.

Installation Precautions

The performance of a cold storage facility is therefore predominantly dependant on how good is the insulation and vapour barrier.



Interior Vapour Retarder System



Exterior Vapour Retarder System

It is therefore necessary to provide proper vapour barrier on the warmer side of the walls. Similarly, the inside surface should never be made vapour tight, otherwise moisture that has entered into the insulation though outer walls will remain trapped inside and would spoil the insulation. The inside surface should therefore be made in such a manner that it should be allowed to breathe freely. This will ensure that the moisture that has entered in the insulation, is carried to the cooling apparatus and then subsequently removed while defrosting the coils. This aspect is however mostly overlooked in preference to sanitation of inside surfaces of cold rooms and ease of maintenance. This, however, leads to trapped moisture in the insulation affecting severely the insulating properties of insulation.

It is also important to understand that insulating property of the insulation material is mainly due to trapped air bubbles while foaming and not the material itself and hence if these air cavities get filled with moisture the insulating property is nearly lost and wet insulation is therefore no good.

If insulation retains moisture, then it also acts as breeding ground for bacteria, fungus growth besides loosing its insulating properties. If there is excessive moisture it may drip on the product and cause contamination of the product.

No vapour retarder system would be 100% effective. The properly designed vapour barrier system is the one in which, rate of moisture infiltration, if at all is taking place, it should be equal to rate of moisture removal by refrigeration plant without detectable condensation.

It is strongly recommended that cold storage owners/ consultants and contractors seriously consider this important aspect of providing proper vapour barrier while designing/ and constructing the cold rooms, otherwise a well designed refrigeration plant also may not deliver the desired performance.

It is also extremely important to install the vapour barrier properly with proper overlaps and sealed joints with out any puncture to get a vapour and air tight envelope. Failure of vapour retarder system is almost always a due to poor installation. The insulation contractor must therefore be experienced to ensure a vapour tight construction. ❖