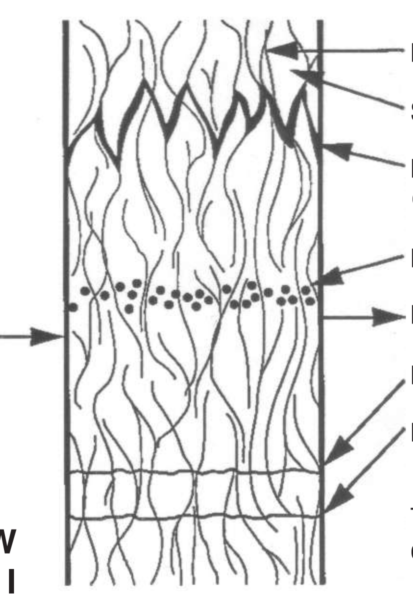
THE MICRO STRUCTURE OF DIFFERENT TYPES OF THERMAL INSULATION & THEIR APPLICATIONS

THE MICRO STRUCTURE OF DIFFERENT TYPES OF THERMAL INSULATION & THEIR APPLICATIONS.

Nowadays there is always an important & urgent emphasis on energy conservation because of the rising cost of fuel. Heat energy is one type of energy that can be conserved through using appropriate type and thickness of thermal insulation materials. There are insulations for hot water pipes used for heat generating machines and there are insulations for cold surface applications for residential & industrial air-conditioning machines. These various types of thermal insulation include cork polystyrene foam (PS. FOAM), glass fiber, rock wool, calcium silicate, urethane foam (PU. FOAM) and flexible closed cell insulation.

Thermal insulation materials serve as a filter; restraining as much heat as possible from permeating through to the other side. Most thermal insulations use the concept that air is a poor heat conductor and this, therefore, explains why thermal insulation materials contain porous air spaces. By compressing shreds of fibers or foam pellets together; such air spaces occur and are commonly referred to as 'cells'. The cells will have to be small enough to resist the internal air current which can substantially reduce convection. Heat loss caused by conductivity in the insulating material is reduced when the component material of the insulation is less or the cell walls are thin and are of maze-like structure. In addition, the insulating material itself should have low conductivity and should be dark-coloured or reflective in order to minimise the amount of heat loss that will occur from radiation. Figure I - shows the various types of heat energy loss discussed above. The thermal conductivity of 'K value' derives from the total heat energy loss caused by all of these factors.



MAGNIFIED VIEW
FIGURE I

However, before deciding on any particular insulating material, it is essential to have an understanding of the consequences of wrapping apparatus or heating cooling pipes with the various types of insulating materials. The study of such phenomena can take two forms:

1) HEATING PIPES & EQUIPMENT When equipment or heating pipes are insulated with certain insulating materials, like glass fiber or rock wool, a certain amount of moisture can be found within the insulation itself. As a result the air surrounding the insulated object will expand and water vapour pressure will increase immediately, causing air to penetrate the insulation. If the insulations permits this moisture to escape, the insulating properties of the material will be enhanced, as the K value of water is very high (K = 4.0 Btu. in / ft^2 h°F). Most insulators will have a K value of 0.2 - 0.5 Btu, in / ft^2 h °F when the temperature averages 75°F. If vapour barrier material is wrapped around the insulator (as illustrated in Fig. 2), air will penetrate through the insulation to the vapour barrier material. Water vapour pressure at the surface of the water-proofing will then be very high causing condensation on the inner surface of the vapour barrier material. This is the reason why metallic moisture-proofing materials corrode so quickly. Rust and corrosion-proof substances should therefore be used for this purpose.

2) COOLING PIPES & EQUIPMENT When cooling equipment or pipes are insulated, water vapour pressure will decrease in the area close to the surface of the insulated object, and air outside the insulation will then try to penetrate into the insulation material until a state of equilibrium is reached between the air pressure levels inside and outside of the insulation. Water vapour in the air that penetrates a certain distance into the insulation will condense when the air temperature falls below the condensation point. The resulting water will penetrate in to replace the air inside the insulation. When the temperature of the cooling pipes is below freezing the water will freeze (see Fig. 3). The thermal conductivity value of ice is 15.5 Btu. in / ft^2 h °F at an average temperature of 32^{0}F. When cold pipes or cooling equipment is insulated with a porous material in which contained moist air, moisture will be dispersed throughout the thickness of the insulator (for example, fibrous materials or interconnected cellular material): causing the pipes or object to corrode faster than usual. These are often found to be true while repairing glass fibre or polystylene foam insulated pipes.

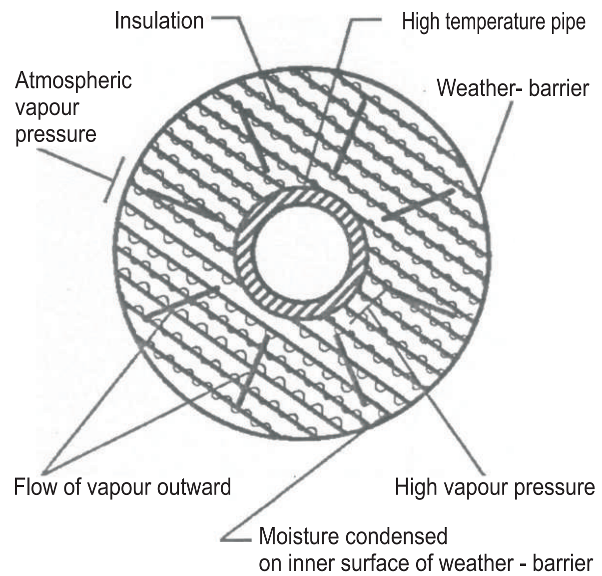
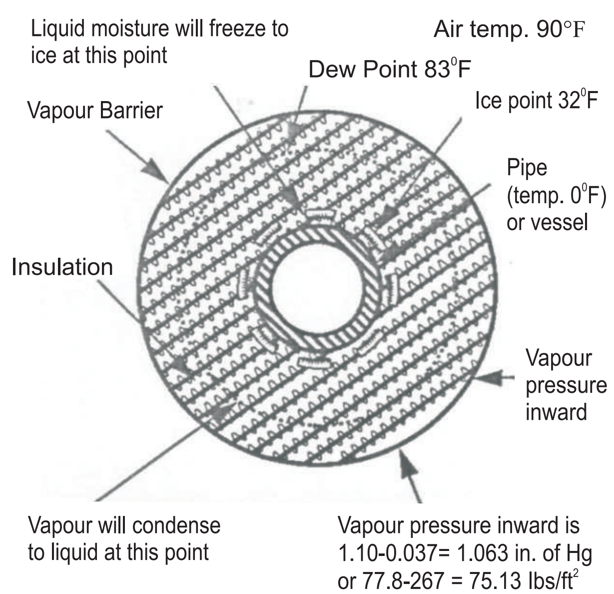


FIGURE 2



Pipe or Vessel
Temperature 0° F
Relative Humidity 100%
Vapour pressure = .037 inches of Hg.
or 2.67 lbs/ft^2

Ambient conditions
Air temperature = 90°F
Relative Humidity = 80%
Vapour pressure = 1.10 inches of Hg
77.8 lbs/ft^2

FIGURE 3

CHOOSING THE RIGHT TYPE OF INSULATION

It is very important to choose the right insulation material to suit the different kinds of application and installation conditions. Air-permeable insulators applied to cooling pipes should be used in conjunction with corrosion proofing substances which should be fully painted onto the pipes to be insulated to protect them from corrosion. It is essential to ensure that the surface of the insulation is fully coated with moisture proofing material. It is also extremely important that proper installation of the insulation is done to make sure that there is no torn vapour-barrier; if there is any existence of torn area, condensation will occur and the first place water droplets will form, in times of high humidity, is on the surface of the cooling pipe insulation. The highly humid air will penetrate through this torn area and condense the water in the insulation in great quantity causing the insulation to deteriorate rapidly.

If insulation of the closed-cell type is used (This type of insulation will be discussed below), attention should be paid to the surfacing, which should be thick on both the inside and outside. The material should be elastic enough to protect the cell wall against rupturing or tearing.

If temperature changes are to be encountered, the type of gas used to fill the cells is important If the gas used has a low boiling point or high vapour pressure in the temperature range of cold water or of environmental temperature, like some type of freon gases, these gases will condense; causing a drop in the gas pressure within the cells. This in turn causes air and moisture from outside to penetrate into the insulation in greater quantity than usual, and the layer of the insulation whose temperature is equal to the boiling point of the gas will convert heat into the cooling pipes at a faster rate. Insulation that uses gas of this type is better used with heating pipes whose temperature does not go too high (50-150°C as these temperatures have no effect on changing gas phases.

Closed-cell insulation of the types presently used on cooling pipes contains dry gas; mostly nitrogen and carbon dioxide. Though there are some gases that have a lower thermal conductivity value than that of dry air but have a low vapour pressure or boiling point (-40 to 30°C, they are not used because of the phenomenon already mentioned earlier It is also important that the walls of the cells be of appropriate thickness (proper thickness are usually in the neighbourhood of 3-6 microns), a factor which bears a direct relationship with density of the insulating material (proper density lies in the range of 3-6 pounds per cubic foot). Too low density can mean overly thin cell walls, which can admit moisture and tear easily, reducing the effectiveness of the insulator.

Choosing the appropriate insulator to use requires an understanding of the micro-structures of various heat insulating materials, which strongly affect the uniformity of their performance as insulators and their durability. It is also a factor to consider in selecting proper moisture-proofing material to use with the insulators. Below are the various types of insulators which are discussed in terms of their micro-structures.

1) Open CellType: Airspaces are interconnected in this type of insulating materials. As shown in Fig. 4, this type of insulation is made from compact small glass fibres. Air occupies the spaces between the fibres. Figure 5 - shows how moisture penetrates into such insulation and condenses into water droplets at the point within the insulation where the temperature drops to the condensation point

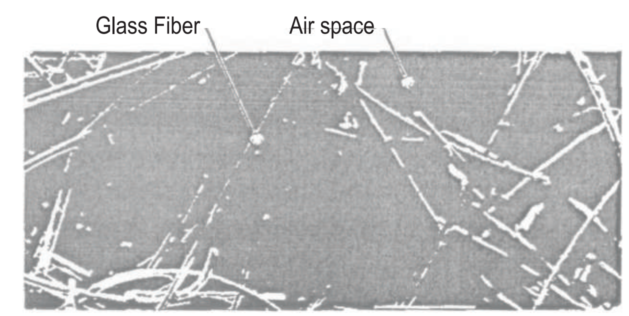


FIGURE 4
Enlarged picture of Open-Cell type *Class Fiber*

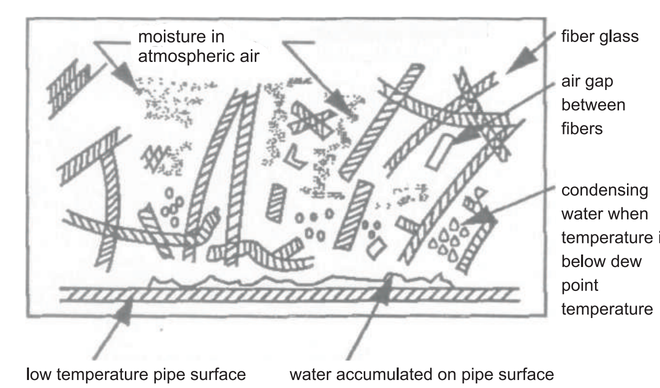


FIGURE 5
Penetration of moisture through fiber glass insulation when covering chilled water pipe

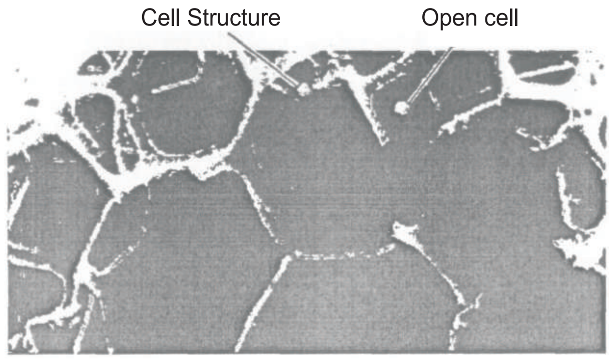


FIGURE 6

Enlarged picture of the open-cell structure of sponge for air filter

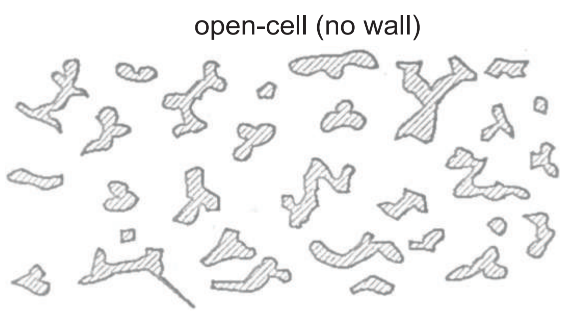


FIGURE 7

The open-ce// structure of sponge for air filter

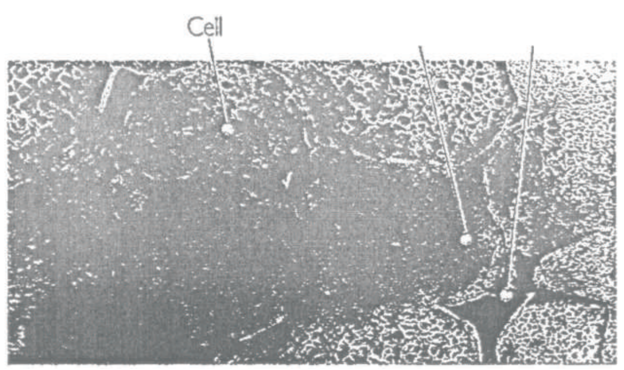


FIGURE 8

Enlarged picture of potystytene foam insulation which is the interconnected cell type

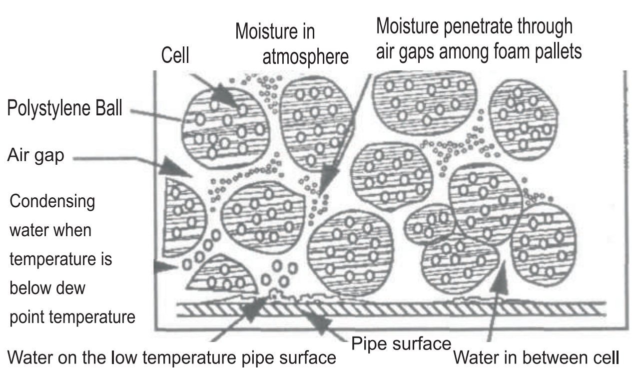


FIGURE 9

Moisture absorption through foam insulation

Figures 6 and 7 - shows open-cell material and a two-dimensional representation of a sponge; made from poly-urethane that is used to filter air Insulations that are made from calcium silicate also have such similar structure. These types of insulations are best used with equipment or pipes which are hotter than the boiling point of water(1OO°C). Water contained in the insulation will be evaporated and dispersed to the air outside. This will cause the air in the insulating material to become dry, giving it uniformity in its performance as an insulator. If this kind of insulation is used with cooling pipes, moisture-proofing material should be used to prevent condensation and formation of water droplets. If water penetrates into the insulation and spreads through it, it will become impossible to repair only a single part of it (see Figure 5). Besides using moisture-proofing, proper installation is also very necessary as the slightest tear can cause the insulation to deteriorate rapidly.

2) Interconnected CellType: This type of insulation is made by compressing foam or cork pellets to form sheets or tubes in which the individual sheets are surrounded by empty spaces, as shown in Figures 8 & 9.

Figure 9 - shows the penetration of moisture into the material It can be used to insulate pipes with temperatures below 1OO°C Moisture has more difficulty penetrating insulations of this type than insulations of the open - cell type, but wetness can still make its way through the spaces between the compressed pellets.

The degree to which the material can be penetrated by moisture depends on the density to which it has been compact Insulation of this type is compact to a density of 2 lbs/ft^3 which will be more effective in keeping moisture out than foam which has been compacted to only 1 lb/ft^3. For this reason, the use of moisture-proofing is a necessity; especially in cases where cold-water pipes are being insulated. Then, the foam should be painted with bitumen or water-based coating material and wrapped with raw cotton or linen cloth. Bitumen or coating emulsion has water component that allows water to permeate the insulation and thus increasing its thermal conductivity. In some countries, hot bitumen or asphait is applied This process must be done by an expert any misapplication will cause the foam to fuse and reduce the thickness of the insulation. Furthermore, foam has a tendency to shrink, which can loosen or break tine coated bitumen. When other moisture proofing materials, like aluminium foil or galvanized sheet are used, open spaces will result as these types of moisture proofing materials cannot shrink along with the insulation.

3) **Semi - closed Cell Type**: This type of insulation has many small independent cells. The walls of each cell shut from others, but imperfectly. This gives it a water absorption value of over 10% by weight according to ASTM D 1056. This insulation is made from light-weight polyethylene foam (PE foam) and low-density polyurethane foam as detailed in figures 10 and 11.

The figures shows moisture permeation of various types of insulation when they are used to insulate cold pipes. Semi-closed cell type insulation is most often used to insulate hot pipes. It has density in the range of I -3 lbs/ft^3. The reason for its low density is because it is manufactured with only adequate quality and reasonable price in mind. This explains why the wall of the cells are made thin and are higher in moisture permeability. If materials with low elasticity are used, expansion during production will occur; thereby weakening and tearing the walls more easily. The thermal conductivity value is consequently higher than that for closed-cell types when it is used for a period of time, particularly when the air humidity is high, as in those parts of the world where the humidity is at 70-90% at most period of the year.

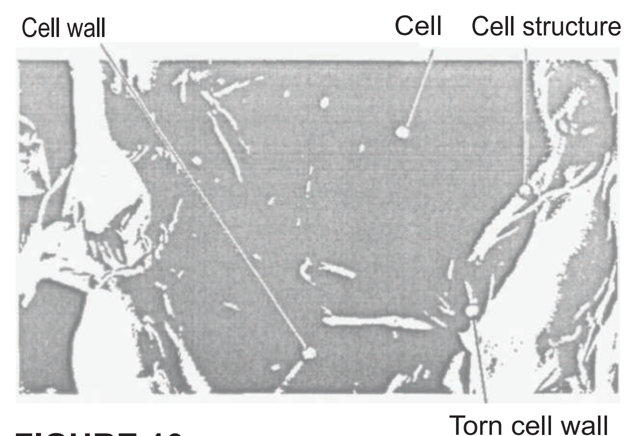


FIGURE 10

Enlarged picture of potyurethane foam which is the semi-closed cell type.

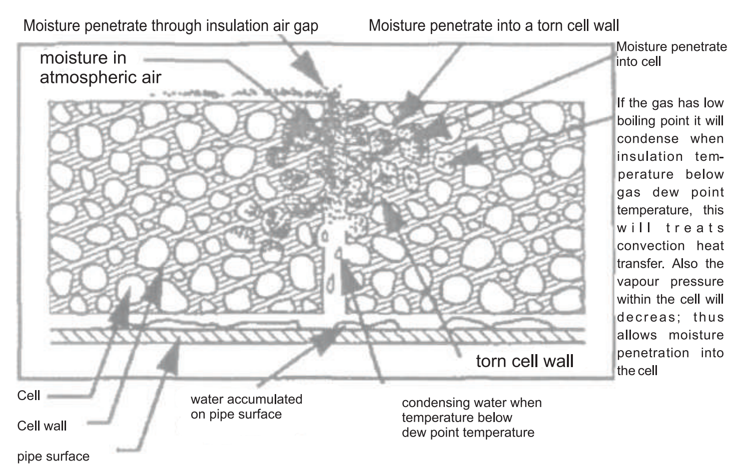


FIGURE 11

Moisture absorption through semi-closed cell insulation

4) **Closed Cell Type**: This type of insulating material is produced mostly from synthetic rubbers or a combination of synthetic rubbers and plastics (both are often referred to as Elastomers); which contains a great number of tiny singular closed cells. A single cell is enclosed by a wall, each cell contains a dry gas emitted from a blowing agent which through close control is made to produce a singular closed cell. Insulators made from elastomer materials have high resiliency and characteristically conforms to closed cells. The walls of the cells acts as an impenetrable wall against moisture as illustrated in Figure 11

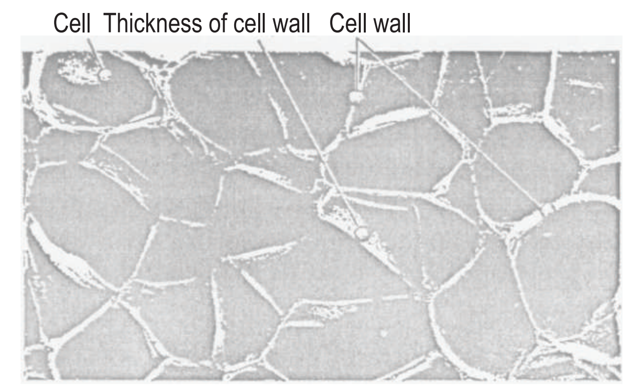
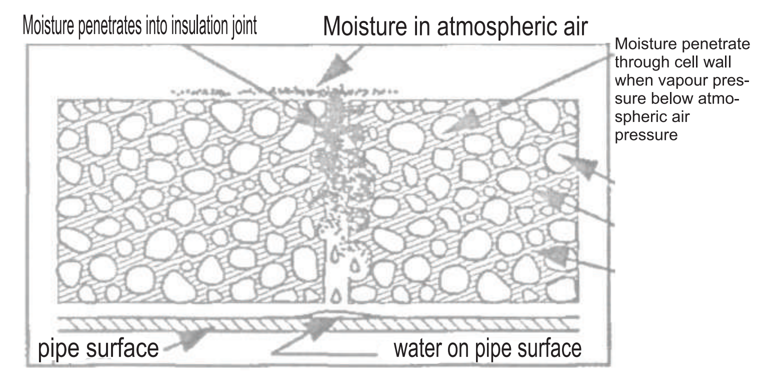


FIGURE 12

Enlarged picture of rubber Insulation which is closed-cell type.



If the gas has low boiling point it will condense when insulation temperature below gas dew point temperature, this will create convection heat transfer. Also the vapour pressure within the cell will decrease; thus allow moisture penetration into the cell.

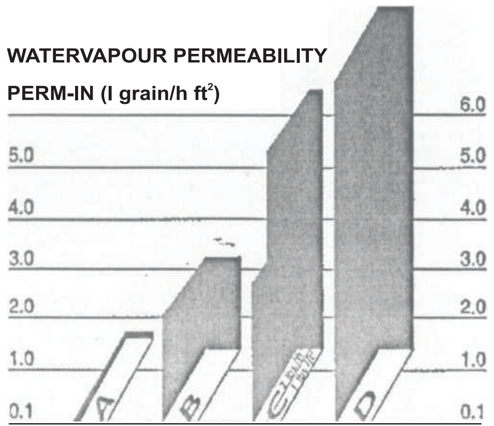
FIGURE 13

Moisture absorption through closed-cell insulation.

Figure 13 - shows the structure within the elastomer insulator and the permeation of moisture accordingly. Elastomer insulators used for wrapping around hot and cold water pipes have a density of between 3-8 lbs/ft3.

If the density is lower than this, the open-cell quality will be increased, and the conductivity of the material will be greater. Insulator of the dosed cell type has an absorption value of below 10% by weight according to ASTM D 1056. Its permeability by moisture is lowest in comparison with other types of insulating material (see Graph I); a factor which permits its heat conductivity to remain relatively constant throughout its life, as shown in Graph 2.

Closed-cell type insulation is therefore ideal for use in insulating cold pipes; for example, Freon pipes in split-type air-conditioners, chilled water pipes for central cooling system. It is also effective for indoor and outdoor hot water pipes.



Note:
This average water vapour permeability date are based on products without vapour barrier.

Water vapour permeability of various types of insulation

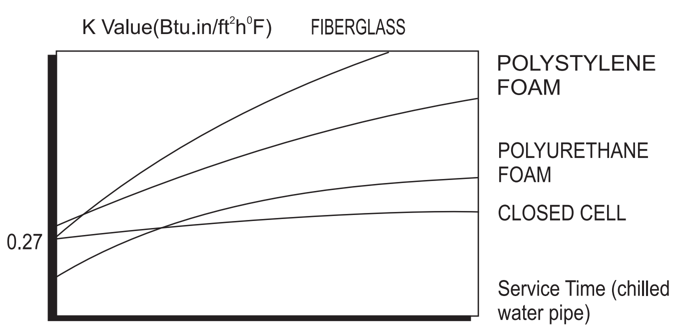
A **Close Cell Insulation**
The closed cell structure density 4-6 lbs/ft^3

B **Polyurethane Foam**
The semi-closed cell structure density 2-4 lbs./ft^3

C **Polystylene Foam**
The interconnecting cell structure density 1-2 lbs/ft^3

D **Fiberglass**
The open cell structure density 2-4 lbs/ft^3

GRAPH 1



K. Value of various types of insulation against service time when covering chilled water pipe.

GRAPH 2

Note:

Service time largely depends on humidity, temperature and also the workmanship. Under high humidity of tropical area, the low water vapour transmission is a very important factor for thermal insulation in chilled water pipelines to maintain stable thermal conductivity (K. value) during service. Condensation problems will occur when the K. value of the insulation increases and the surface temperature of insulation drops below DEW POINT This happens through high water vapour transmission (average K. value of water vapour is approximately 4.)

Most manufacturers of this type of insulation make it with a thick, tough waterproof surface so that it is not necessary to use any other vapour barrier material, even on pipes that are run along the outside of buildings. Although closed-cell type elastomer insulation is relatively easy to install, it is important to make sure that all joints and adhesive are tightly pressed and fully contacted, so that the air cannot penetrate to the low temperature pipes, causing condensation at the joints.

Presently, there are many types of heat insulation, each suitable for different applications. By studying the micro-structure of a given type of heat insulation, it is possible to conclude that when insulating hot pipes or equipments where temperatures frequently exceeding IOO°C, the open cell type insulations are mostly used The materials used to manufacture this type of insulation are heat resistant at application temperature. This type of insulation needs to have an appropriate density so that the thermal conductivity value is low and mechanically strong enough for installation.

On the other hand, in selecting material used to insulate cold pipes and equipment it is important to choose a material whose microstructure makes it impermeable to moisture. The preferred materials for insulating cold objects are the closed-cell types where the cells contain gas with vapour pressure close to that of the surrounding environment Every cell wall can be seen as a piece of moisture-barrier; in that any moisture that penetrates through the insulation must pass through thousands of cell walls. Moreover; if the difference between the vapour pressure of the gas inside the cells and the surrounding is low, it is difficult for air to penetrate into the cells. Therefore, closed cell type insulation has longer durability than other types and are widely used in tow temperature piping especially in those parts of the world where relative humidity is between 70-90% throughout the year.

CONDENSATION CONTROL & RECOMMENDATION

In areas with high humidity, condensation problems often occur on chilled water pipeline in central cooling system as well as other low temperature piping system. The condensation does not only damage ceiling, carpet and furniture, but also waste energy with higher heat gain, shorten insulation service life and so forth. Condensation problems can be avoided by applying 3 main factors: (1) appropriate insulation thickness, (2) good installation and (3) moist air movement. All details of each factor are as follow:

(1)Determine the proper thickness

- **Determine by using CONDENSATION CONTROL NOMOGRAPH** This nomograph is for your quick calculation in determining the required thickness of insulation for low temperature pipeline, when cold pipe temperature, room temperature and relative humidity are already known. More details as shown in Fig. 1.
- **Determine by using thickness calculation program**
  Thickness calculation program Is designed to calculate and determine the appropriate thickness of Aeroflex to prevent condensation, save energy and other calculation reports for HVAC&R system. It is simple to obtain required thickness by using Aeroflex calculation program to prevent condensation problem, just key in all condition factors as example below:

1. Operating Temperature 5 °C
2. Room Temperature 30 "C
3. Relative Humidity 70, 75,80, 85,90 and 95%RH
4. Convection Coefficient 8.0 W/m^{2}K
5. K.Value 0.0373 W/mK at mean temp of 17.5 °C, which is, from(5^{0}C + 30^{0}C}/2.
6. Pipe size ID: 35mm up to 508mm

MM	35	60	90	115	140	165	219	273	324	356	406	508
IPS	1"	2"	3"	4"	5"	6"	8"	10"	12"	14"	16"	20"

Thickness calculation results as shown in fig.2

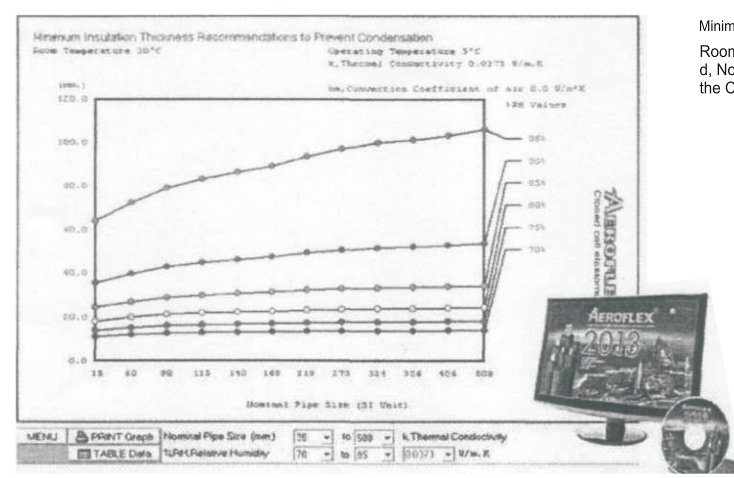
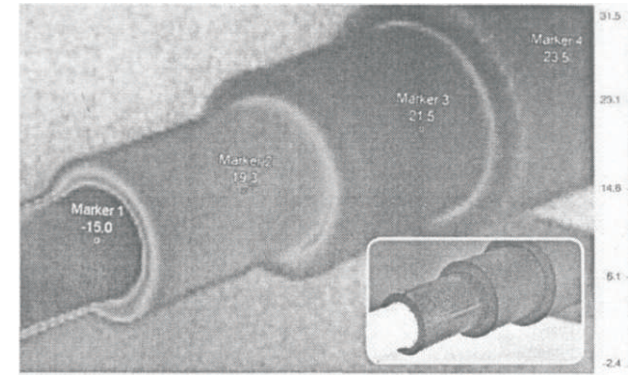


Fig. 2 *Minimum insulation thickness recommendation graph and data table shows insulation thickness required to prevent condensation at various %RH and various pipe sizes. Calculation program also calculates energy loss & gain, economic thickness and other calculation far HVAC&R industry.*



infrared photo shows thermal energy emitted from low temperature pipe without and with various thickness of thermal insulation, if surface temperature of insulation below dew point, condensation occurs.

CONDENSATION CONTROL NOMOGRAPH

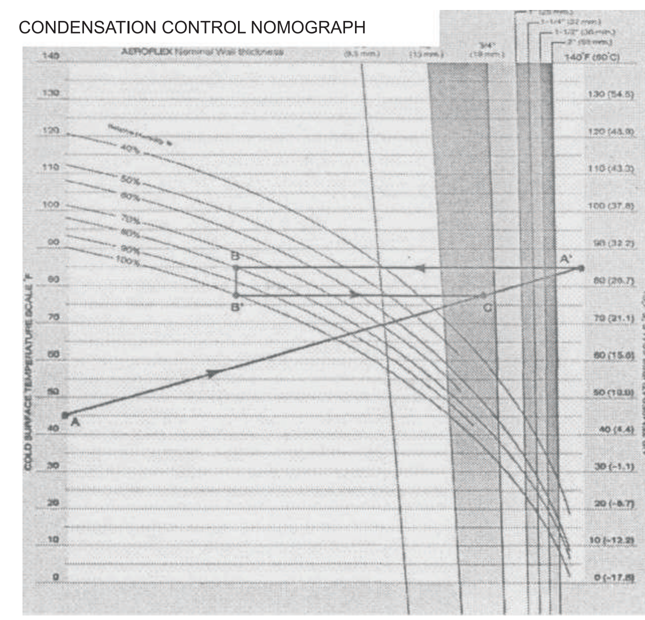


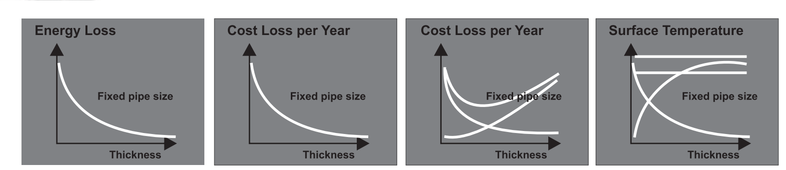
Fig. 1 *Condensation Control Nomograph is a convenient tool for determining insulation thickness to prevent condensation,*

Minimum insulation Thickness Recommendations to Prevent Condensation

Room Temperature 30^{0}C
d, Nominal Pipe Size (SI Unit)
the Convection Coefficient of air

Operating Temperature 5^{0}C
k, Thermal Conductivity 0.0373 W/m K
Insulation Thickness (mm)

d (mm)	RH, Relative Humidity (%)					
	70	75	80	85	90	95
35	11.4	14.3	16.4	24.6	35.7	64.2
60	12.3	15.6	20.1	27.2	40.0	72.5
90	12.8	16.4	21.0	29.1	43.1	79.1
115	13.1	16.8	22.0	30.1	45.0	83.2
140	13.3	17.1	22.5	30.9	46.4	86.5
165	13.5	17.3	22.8	31.5	47.6	89.3
219	13.7	17.7	23.4	32.5	49.4	93.3
273	13.9	17.9	23.8	33.2	50.8	97.4
324	13.9	18.1	24.0	33.7	51.7	100.0
356	14.0	18.1	24.2	33.9	52.2	101.4
406	14.1	18.2	24.3	34.2	52.9	103.3
508	14.1	18.4	24.6	34.7	53.9	106.3



- **Determine by using thickness recommendation**

The table beiow is thickness recommendation for controlling outer insulation surface sweating.

Pipe Size	Line Temp. 60°F[15.5°C]	Line Temp. 50°F[10°C]	Line Temp. 35°F[1.7°C]	Line Temp. 0°F[-18°C]
	Based on Normal Condition Max. 85°F (29.4°C) 70% RH*			
3/8" ID Thru 3" IPS Over 3" IPS	**1/4" Thickness 3/8" Thickness**	**3/8" Thickness 1/2" Thickness**	**1/2" Thickness 3/4" Thickness**	**1" Thickness 1-1/4" Thickness**
	Based on Mild Condition Max. 80°F (26.6°C) 50% RH**			
3/8" ID Thru 3" IPS Over 3" IPS	**1/4" Thickness 3/8" Thickness**	**3/8" Thickness 1/2" Thickness**	**3/8" Thickness 3/4" Thickness**	**3/4" Thickness 3/4" Thickness**
	Based on Severe Condition Max. 90°F (32.2°C) 80% RH***			
3/8" ID Thru 3" IPS Over 3" IPS Thru 10" IPS Over 10" IPS	**1/2" Thickness 3/4" Thickness 3/4" Thickness**	**3/4" Thickness 1" Thickness 1" Thickness**	**1" Thickness 1-1/8" Thickness 1-1/8" Thickness**	**1-1/2" Thickness 1-3/4" Thickness 2" Thickness**
	Based on Extremely Severe Condition Max. 90°F (32.2°C) 85% RH****			
3/8" ID Thru 3" IPS Over 3" IPS Thru 10" IPS Over 10" IPS	**3/4" Thickness 1" Thickness 1" Thickness**	**1" Thickness 1-1/4" Thickness 1-1/4" Thickness**	**1-1/4" Thickness 1-1/2" Thickness 1-1/2" Thickness**	**2" Thickness 2-1/2" Thickness 2-1/2" Thickness**

**EPDM insulation in the thickness noted and within the specified temperature ranges will prevent, condensation on piping under normal design condition max. temp, 85°F (29.4°C). 7O% RH.*

***conditions max. temp. 80°F (26.6°C). 5O% RH. Typical of these conditions are air-conditioned areas.*

*** conditions max. temp. 90°F (32.2°C). 8O% RH. Typical of these conditions are indoor areas, in-which excessive moisture is introduced or in-poorly ventilated areas, (research and field experience indicate that most tropical regions are .in this condition). Central cooling by chilled water systems in hotels, shopping centres, office buildings are concerned in this condition.*

***** EPDM insulation in this thickness is specially designed far extremely severe conditions max. temp. 90°F [32.2°C). 85% RH., in the condition that needs maximum protection from condensation, where excessive moisture is introduced or poorly ventilated [85% RH.]. Designed for central cooling by chilled water systems for hotels, hospitals, computer or electronics, installation areas, military weapon warehouses.*

NOTE: To prevent condensation problems under extremely severe condi tion, good ventilation design is recommended to avoid a continuous condensation problems.

(2) Good Installation

- **Keep insulated pipeline apart** Even use thicker than designed thickness and good installation, but condensation problems still occur if insulated pipeline contact to each other. This condensation is caused by less air movement or still air (Fig.3). So should keep all insulated pipeline apart, normally at least 3" for small pipe (less than 3" IPS) and 4" for pipe larger than 3* IPS (Fig.4). According to DIN 4140, distance between insulated pipe not less than 100 mm. (4") and not less than}: 1000mm. (40") for tanks and vessel.

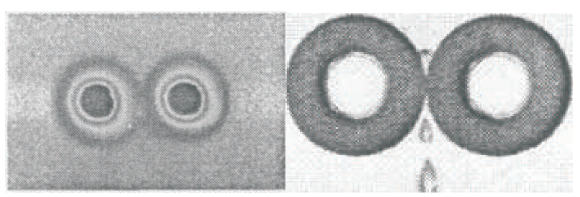


Fig.3 infrared photo shows thermal energy around the pipes, especially at the bottom contact of insulated pipe, where there is no or less air movement and accumulation of moisture that causes severe condensation.

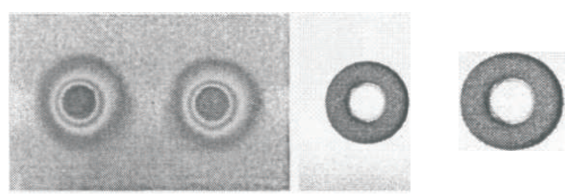


Fig.4 Infrared photo shows thermal energy around insulated pipes located 4" apart, allowing free air movement without accumulation of moisture of moisture and no condensation problem.

Completely insulated with design thickness All insulated pipeline should be insulated in designed thickness, no insulation thickness compressed, deformed or torn off and also all joints and seam surfaces must be fully applied with thin coat of AEROSEAL adhesive and press together firmly. During installation, do not stretch the insulation to avoid separation and thickness deformation.

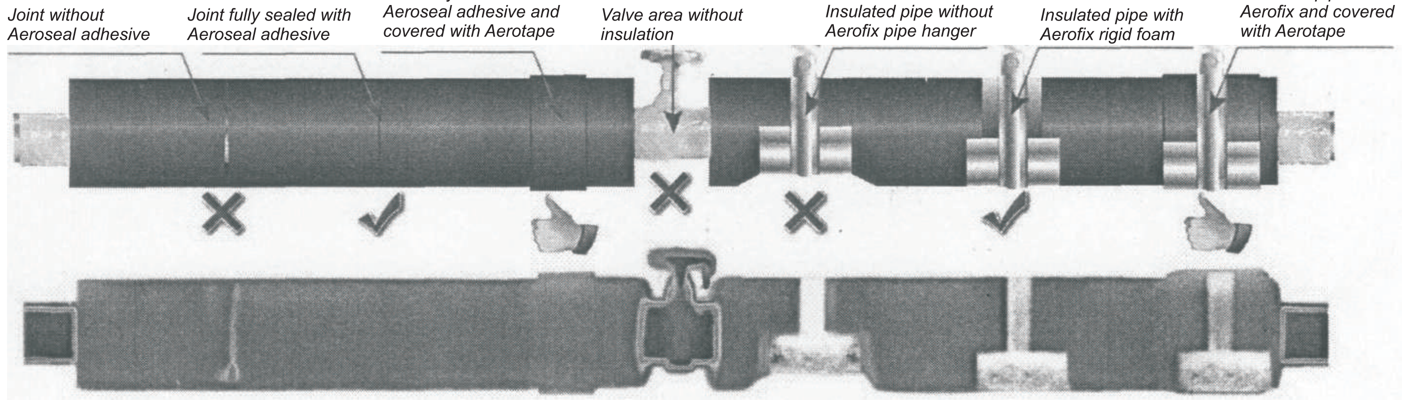


Fig. 5 The illustration shows the do's and don't when installing EPDM insulation on low temperature pipeline to prevent condensation,

- **Determine by using thickness recommendation**

The table beiow is thickness recommendation for controlling outer insulation surface sweating.

Pipe Size	Line Temp. 60°F[15.5°C]	Line Temp. 50°F[10°C]	Line Temp. 35°F[1.7°C]	Line Temp. 0°F[-18°C]
	Based on Normal Condition Max. 85°F (29.4°C) 70% RH*			
3/8" ID Thru 3" IPS Over 3" IPS	**1/4" Thickness 3/8" Thickness**	**3/8" Thickness 1/2" Thickness**	**1/2" Thickness 3/4" Thickness**	**1" Thickness 1-1/4" Thickness**
	Based on Mild Condition Max. 80°F (26.6°C) 50% RH**			
3/8" ID Thru 3" IPS Over 3" IPS	**1/4" Thickness 3/8" Thickness**	**3/8" Thickness 1/2" Thickness**	**3/8" Thickness 3/4" Thickness**	**3/4" Thickness 3/4" Thickness**
	Based on Severe Condition Max. 90°F (32.2°C) 80% RH***			
3/8" ID Thru 3" IPS Over 3" IPS Thru 10" IPS Over 10" IPS	**1/2" Thickness 3/4" Thickness 3/4" Thickness**	**3/4" Thickness 1" Thickness 1" Thickness**	**1" Thickness 1-1/8" Thickness 1-1/8" Thickness**	**1-1/2" Thickness 1-3/4" Thickness 2" Thickness**
	Based on Extremely Severe Condition Max. 90°F (32.2°C) 85% RH****			
3/8" ID Thru 3" IPS Over 3" IPS Thru 10" IPS Over 10" IPS	**3/4" Thickness 1" Thickness 1" Thickness**	**1" Thickness 1-1/4" Thickness 1-1/4" Thickness**	**1-1/4" Thickness 1-1/2" Thickness 1-1/2" Thickness**	**2" Thickness 2-1/2" Thickness 2-1/2" Thickness**

**EPDM insulation in the thickness noted and within the specified temperature ranges will prevent, condensation on piping under normal design condition max. temp, 85°F (29.4°C). 7O% RH.*

***conditions max. temp. 80°F (26.6°C). 5O% RH. Typical of these conditions are air-conditioned areas.*

*** conditions max. temp. 90°F (32.2°C). 8O% RH. Typical of these conditions are indoor areas, in-which excessive moisture is introduced or in-poorly ventilated areas, (research and field experience indicate that most tropical regions are .in this condition). Central cooling by chilled water systems in hotels, shopping centres, office buildings are concerned in this condition.*

***** EPDM insulation in this thickness is specially designed far extremely severe conditions max. temp. 90°F [32.2°C). 85% RH., in the condition that needs maximum protection from condensation, where excessive moisture is introduced or poorly ventilated [85% RH.]. Designed for central cooling by chilled water systems for hotels, hospitals, computer or electronics, installation areas, military weapon warehouses.*

NOTE: To prevent condensation problems under extremely severe condi tion, good ventilation design is recommended to avoid a continuous condensation problems.

(2) Good Installation

- **Keep insulated pipeline apart** Even use thicker than designed thickness and good installation, but condensation problems still occur if insulated pipeline contact to each other. This condensation is caused by less air movement or still air (Fig.3). So should keep all insulated pipeline apart, normally at least 3" for small pipe (less than 3" IPS) and 4" for pipe larger than 3* IPS (Fig.4). According to DIN 4140, distance between insulated pipe not less than 100 mm. (4") and not less than}: 1000mm. (40") for tanks and vessel.

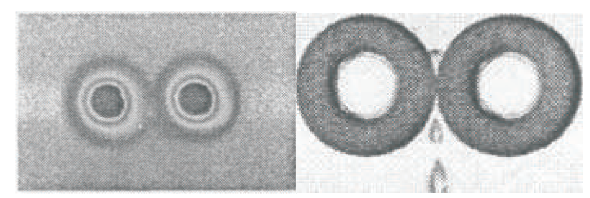


Fig.3 infrared photo shows thermal energy around the pipes, especially at the bottom contact of insulated pipe, where there is no or less air movement and accumulation of moisture that causes severe condensation.

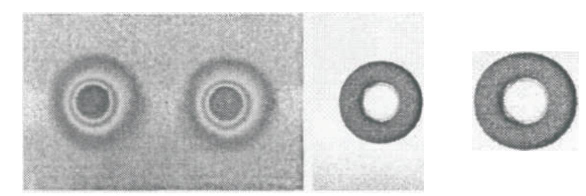


Fig.4 Infrared photo shows thermal energy around insulated pipes located 4" apart, allowing free air movement without accumulation of moisture of moisture and no condensation problem.

- Completely insulated with design thickness All insulated pipeline should be insulated in designed thickness, no insulation thickness compressed, deformed or torn off and also all joints and seam surfaces must be fully applied with thin coat of AEROSEAL adhesive and press together firmly. During installation, do not stretch the insulation to avoid separation and thickness deformation.

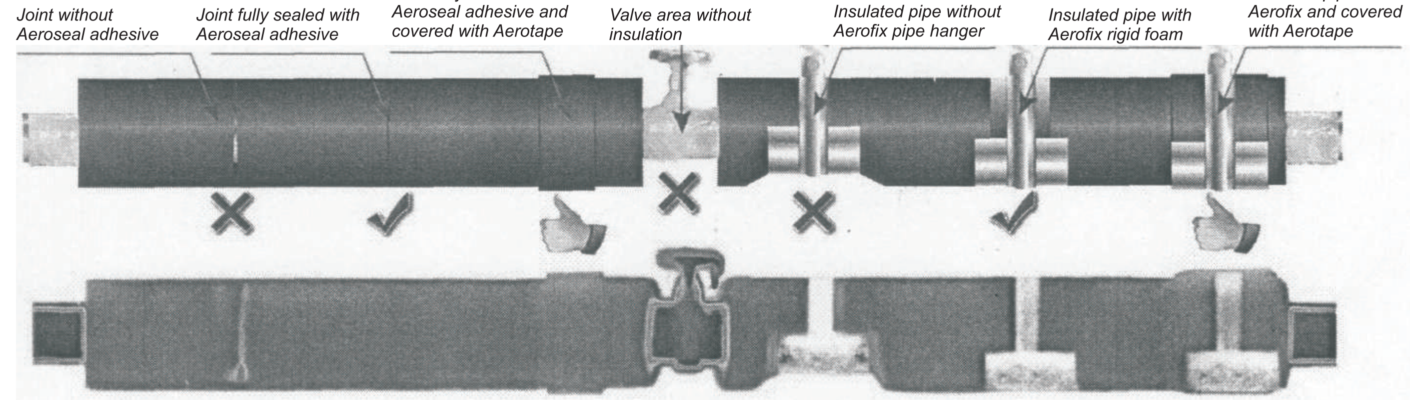


Fig. 5 The illustration shows the do's and don't when installing EPDM insulation on low temperature pipeline to prevent condensation,

The Ideal EPDM Thermal Insulation for HVAC & R