4. COLD INSULATION

4.1 GENERAL NOTES

Cold insulation should be considered and where operating temperatures are below ambient where protection is required against heat gain, condensation or freezing.

In designing an insulation system where formulae and surface coefficients are used they should be to an appropriate international standard, for example, BS 5422 is recommended. In selection of material density, it should be considered whether insulation requires being load bearing or not.

For whatever purpose cold insulation is required, the insulation system is only as good as its vapour barrier and the care with which it is installed. A vapour barrier is a membrane of very low permeance placed on the warm side of insulation to limit the flow of water vapour into the insulation. Table **7** of BS 5970 shows the water vapour permeance of various insulation materials.

Where there is a differential in temperature or humidity between the cold surface of the equipment and the ambient temperature a differential water vapour pressure occurs. The greater the temperature differential, the greater the differential water vapour pressure. Water vapour should not be confused with moisture. Water vapour is a transparent, tasteless and odourless gas capable of permeating through most materials depending on the pressure differential on either side of the insulation.

Permeability of water through a vapour barrier is expressed in Metric Perms in the metric system. A Metric Perm is the passage of 1 gram of water through a material with a surface area of $1m^2$ for 24 hours and a pressure difference of 1mm Hg.

Many materials, which are moisture-resistant, are not necessarily vapour-resistant. All insulation materials are susceptible to water vapour penetration to various degrees. If penetration is not prevented, the water vapour condenses to moisture or ice when its temperature reaches the dew point. This will, in time, saturate the insulation thereby rendering it useless. To prevent this from taking place, a vapour barrier is applied on the warm side of the insulation.

Even a pinhole through the vapour barrier can eventually render the insulation system useless; therefore the selection of a vapour barrier needs careful consideration. Foil or sheet usually have the better permeability rating but foil has poor resistance to mechanical damage and needs a protective cover or protective laminate. Sheet metal has a good rating but requires great care in the sealing of joints and fastenings.

Water, solvent and mastic based vapour barriers tend to be resistant to mechanical damage. Their permeability rating varies from water based at the bottom of the scale to cured resins at the top. Most of these types, however**,** need to be suitably reinforced.

When using water-based formulations, they dry out, and in doing so leave minute pinholes. It is therefore essential that the manufacturer’s recommended thickness be considered as a minimum to prevent pinholes extending continuously through the coating and, as a further precaution, the application must consist of multiple coats.

In the case of solvent based vapour barriers the manufacturer’s application procedures must be carefully followed, as the danger of solvent entrapment exists due to premature over coating resulting in surface “bubbles”.

Resin-cured vapour barriers are excellent but again the manufacturer’s recommended thickness should be considered minimum. Adherence to the manufacturer’s mixing proportions is mandatory. The application must be multiple coats. Vapour barrier applications are only as good as the applicator. Where the insulation terminates, the vapour barrier must be returned to the cold equipment so as to totally encapsulate the insulation.

In selecting a vapour barrier, material comparisons should be made between the various permeability ratings as supplied by manufacturers as there may be vast differences between materials as reference to Table 7 of BS 5970 shows.

Care should be taken to ensure that the choice of vapour barriers does not affect the fire performance of the whole assembly of insulating and finishing materials (see 4.2).

The design of the cold insulation system should assume that at some time a breakdown of the vapour barrier might occur.

In such an event, and in the case of cold rooms, it is better that the water vapour has an unhindered path to the cold surface to enable it to be drawn off by the refrigeration equipment. In the case of pipe work and vessels, it is preferable that the water vapour has free passage to the cold surface where the resultant water or ice will be encased by the insulation.

A break in the vapour barrier of the insulation system will eventually cause the system to fail but its effective life will have been prolonged by a design which permits the through transmission of water vapour.

Adhesives or mastics for the application of insulation should be used with care as vapour dams may be created which would negate the principle of the previous paragraph.

If one has limited experience, it is recommended that a member of TIASA be consulted before embarking on cold insulation. Whatever the primary reason for cold insulation, it should be designed to prevent condensation.

Condensation occurs when water vapour in the atmosphere comes in contact with a surface at a temperature of less or equal to the dew point. Therefore, if the surface temperature is less than the dew point, condensation will occur.

The presence of condensation on the warm side of the vapour barrier has no detrimental effect on the insulation but, nevertheless, it is a condition, which has to be avoided. To prevent condensation, the insulation thickness should be so designed that temperature on the warm side of the vapour barrier is above the dew point.

In calculating the thickness of insulation required to prevent condensation, it is prudent to know or assume conditions of high relative humidity. If the fluid inside the pipe or vessel is likely to remain static for long periods when the ambient temperature is below the freezing point of the fluid, it is important that this shall be stated. Also, the fluid in small diameter pipes may be especially susceptible to freezing, particularly if the rate of flow is intermittent or slow, it may be necessary to consider the use of supplementary means of heating, possibly only in local areas, like heat tracing.

4.2 VACUUM INSULATION PANELS

4.2.1 VACUUM INSULATION

Vacuum insulation is an advanced thermal insulation technology that significantly outperforms closed-cell foams, foam beads or fibre blankets. While these traditional systems attempt to trap gases to reduce the transfer of heat, vacuum insulation removes the gases within the insulating space. With the space evacuated or placed ‘under vacuum’, the molecular presence and movement needed to transfer heat is greatly reduced.

4.2.2 VACUUM INSULATION PANELS

Vacuum Insulation panels, or VIP’s, consist of a filler material called a ‘core’ that is encapsulated by a thin, super-barrier film, such as a metal foil or metallic film laminate. The encapsulated system is then evacuated to a vacuum between 0,13 and 1,30 Pa and sealed. The actual vacuum required depends on the specific core material used and the desired thermal resistance or ‘R-value’ of the finished panel. The core, when under vacuum, serves to interrupt the ‘mean free path’ of what few heat transmitting molecules remain in the panel, while also withstanding external pressures that can be as high as 101,3 kPa due to the forces exerted on the VIP from atmospheric pressure. Being nearly impervious to outside gases, the barrier film sustains the required vacuum level (and thus, R-value) for the desired life of the panel. To trap any molecules entering the panel or the modest ‘out gassing’ that may occur from the VIP component materials, water and/or gas adsorbing materials are also placed inside the panel to maintain the vacuum for the intended life of the VIP.

4.2.3 PRODUCT SUMMARY

The vacuum insulation 'core' is 100 percent open-cell, micro cellular polystyrene foam used as filler in VIP's. When vacuum levels are held between 13 and 130 Pa, the insulating potential for VIP's is three to seven times greater than conventional insulating systems. Therefore, where thinner or more reliable insulation is required, VIP's can offer significant design flexibility and cost savings. The insulation core is available as grey board stock in various grades and thickness to meet the performance needs of the marketplace.

4.3 VACUUM INSULATION FOR CRYOGENIC PIPING AND VESSELS

This is a system that utilizes an outer metal jacket, which is installed around the pipe or vessel containing the medium in such a way so as to achieve a cavity between the outside of the pipe/vessel and the jacket.

This cavity is then placed under a negative pressure and a vacuum sustained.

This insulating system is conventionally utilized for maintaining cryogenic products such as oxygen and nitrogen at temperatures of -196°C and -187°C respectively.

4.4 SELECTION COLD INSULATION OF MATERIALS

Closed-cell insulation is the most commonly specified material used for cold work because it possesses a degree of resistance to water vapour and because the thermal conductivity (K factor) of some of these materials is better than the fibrous alternative products.

Selection of insulation materials should be carefully considered where the possibility of steam purging of the equipment is required or for other reasons which may cause the temperature to be increased to a level which exceeds the maximum limiting temperature of the insulation materials, i.e., material then deteriorate.

Special precautions to prevent the possibility of combustion must be exercised when insulating piping, fittings or equipment containing oxygen, as the insulation system should then not contain any organics. It is therefore strongly recommended that the material suppliers are consulted prior selection of the insulation material. The fibrous materials referred to in section 3.3 may be used for cold insulation where conditions such as fire resistance so demand. However, because of their poor resistance to water vapour, extra care must be taken in the selection and application of the vapour barrier.

In case of fire, certain insulation systems may generate appreciable quantities of smoke and noxious and toxic fumes. Consideration should be given to the choice of materials, bearing in mind their location, for example, in enclosed areas or adjacent to air ducts through which smoke or fumes may spread as per the local requirement and specifications.

If there is a potential hazard from contamination by oil or other flammable chemicals, a suitably resistant finish, for example, metal sheet or appropriate non-absorbent coating, shall be applied over the vulnerable areas. The lapped joints of sheet finishes shall be arranged to shed contaminating fluids away from the insulating material.

4.5 PRODUCT SELECTION GUIDE – COLD INSULATION

Please note: Information provided in the following tables is generic information suitable for feasibility studies and cost estimates.

Actual figures may differ from manufacturer to manufacturer and must be confirmed with the individual manufacturer.

4.5.1 PRODUCT SELECTION GUIDE – COLD INSULATION

CELLULAR GLASS

1 **Density (and range, if applicable)**

2 **Thermal Conductivity**

	Thermal conductivity (W/mK) at density indicated below	
Mean temp °C	120 kg/m^3	135 kg/m^3
-100	0,034	
0	0,038	0,044
10	0,040	0,046
100	0,081	

3 **Service Temperature range** -260 to 430°C

4 **Reaction to Fire Characteristics**

a. Combustibility to BS476 part 4 Non Combustible

b. Surface spread to flame to BS476 part 7

- Insulant (if appropriate) Class 1
- Composite finish (if appropriate) Class 1
- Foil faced products (if appropriate) Class 1

c. Building Regulations

- Insulate (if appropriate) Class 0
- Composite finish (if appropriate) Class 0
- Foil faced products (if appropriate) Class 0

5 **Water Vapour Transmission**

- Insulant (if appropriate) Zero μgm/Nh
- Composite finish/foil faced product (if appropriate) N/a

6 **Mechanical Properties**

a. Compressive strength 700kN/m^2

b. Flexural strength 400 kN/m^2

c. Tensile strength N/a

7 **Thickness Range** Available from 40 to 160mm

8 **Forms available** Board, Pipe shells, Slabs, Vessels segments

TYPICAL USES AND APPLICATIONS

Industrial: tank bases, vessels, piping and equipment, cold stores and marine applications. Buildings: roofs, floors, walls (internal and external), car park decks, soffits.

CORK

1 **Density (and range, if applicable)**

2 **Thermal Conductivity**

	Thermal conductivity (W/mK) at density indicated below
Mean temp °C	112 kg/m^3
10	0,038

3 **Service Temperature range** -180 to 100°C

4 **Reaction to Fire Characteristics**

a. Combustibility to BS476 part 4 Combustible

b. Surface spread to flame to BS476 part 7

- Insulant (if appropriate) Class 3
- Composite finish (if appropriate) Class 1
- Foil faced products (if appropriate) Class 1

c. Building Regulations

- Insulate (if appropriate) Exceeds limits
- Composite finish (if appropriate) Up to Class 0
- Foil faced products (if appropriate) Up to Class 0

5 **Water Vapour Transmission**

- Insulant (if appropriate) 20 to 40 μgm/Nh
- Composite finish/foil faced product (if appropriate) 0,001g/(s. MN)

Mechanical Properties

6 a. Compressive strength KN/m^2 at 10% deformation

b. Flexural strength

c. Tensile strength

7 **Thickness Range** Available from 13 to 305mm

8 **Forms available** Pipe Insulation

TYPICAL USES AND APPLICATIONS

Available as slabs and pipe sections used as a roof insulating material either on its own or laminated to rigid cellular plastic foams. A resilient material, which can withstand foot traffic. Suitable for use on chilled water and industrial refrigeration pipe work.

4.5.2 PRODUCT SELECTION GUIDE – COLD INSULATION

GLASS MINERAL WOOL

1 **Density (and range, if applicable)** 10 to 80 kg.m^3

2 **Thermal Conductivity**

	Thermal conductivity (W/mK) at density indicated below		
Mean temp °C	16 kg/m^3	47.5 kg/m^3	80 kg/m^3
-20	0,031	0,028	0,028
10	0,037	0,030	0,031
20	0,040	0,032	0,032
50	0,047	0,035	0,035
100	0,065	0,044	0,042

3 **Service Temperature range** -200 to 450°C

4 **Reaction to Fire Characteristics**

a. Combustibility to BS476 part 4 — Non Combustible

b. Surface spread to flame to BS476 part 7
- Insulant (if appropriate) — Class 1
- Composite finish (if appropriate) — Class 1
- Foil faced products (if appropriate) — Class 1

c. Building Regulations
- Insulate (if appropriate) — Class 0
- Composite finish (if appropriate) — Class 0
- Foil faced products (if appropriate) — Class 0

5 **Water Vapour Transmission**
- Insulant (if appropriate) — N/a
- Composite finish/foil faced product (if appropriate) — 0.001g/(s. MN)

6 **Mechanical Properties**

a. Compressive strength — 1 to 8 kN/m^2 at 5% deformation

b. Flexural strength — N/a

c. Tensile strength — N/a

7 **Thickness Range** Available from 15 to 150mm

8 **Forms available** Blown Fibre, Pipe Sections, Rolls, Slabs

TYPICAL USES AND APPLICATIONS

Glass mineral wool is available in a wide range of forms ranging from flexible rolls to rigid slabs and preformed pipe sections. It is particularly suitable for thermal and acoustic applications in the H & V sector and is also used as both a thermal and an acoustic insulation in transport, shipping, building and industrial applications.

GLASS MINERAL WOOL NEEDLE MAT (E-GLASS TEXTILE TYPE)

1 **Density (and range, if applicable)** 130 kg/m^3

2 **Thermal Conductivity**

	Thermal conductivity (W/mK) at density indicated below
Mean temp °C	130 kg/m^3
0	0,035
50	0,045
100	0,056
250	0,073
350	0,096
500	0,141

3 **Service Temperature range** -200 to 750°C

4 **Reaction to Fire Characteristics**

a. Combustibility to BS476 part 4 — Non Combustible

b. Surface spread to flame to BS476 part 7
- Insulant (if appropriate) — Class 1
- Composite finish (if appropriate) — Class 1
- Foil faced products (if appropriate) — Class 1

c. Building Regulations — Class 0

5 **Water Vapour Transmission** N/a

6 **Mechanical Properties**

a. Compressive strength — N/a

b. Flexural strength — N/a

c. Tensile strength — N/a

7 **Thickness Range** Available from 5 to 25mm

8 **Forms available**

TYPICAL USES AND APPLICATIONS

Mechanically bonded E-Glass needle mat can be used in various acoustic and thermal insulation applications.

E-Glass needle mat is ideal as in infill for high temperature, flexible, thermo-acoustic removable insulation jackets, mats, flange and valve covers.

It is also used for heat treatment and stress relief blankets, exhaust systems, stacks and silvers. The product is non-resin bonded and is able to withstand extreme vibration without stakeout.

4.5.3 PRODUCT SELECTION GUIDE – COLD INSULATION

NITRILE RUBBER EXPANDED

1 **Density (and range, if applicable)**

2 **Thermal Conductivity**

	Thermal conductivity (W/mK) at density indicated below	
Mean temp °C	60 kg/m^3 (class 1)	90 kg/m^3 (class 0)
-20	0,033	0,036
0	0,035	0,038
20	0,037	0,040
50	0,040	0,044

3 **Service Temperature range** -40 to 116°C

4 **Reaction to Fire Characteristics**

a. Combustibility to BS476 part 4 Combustible

b. Surface spread to flame to BS476 part 7

- Insulant (if appropriate) Class 1
- Composite finish (if appropriate) Class 1
- Foil faced products (if appropriate) N/a

c. Building Regulations

- Insulate (if appropriate) Up to Class 0
- Composite finish (if appropriate) Up to Class 0
- Foil faced products (if appropriate) N/a

5 **Water Vapour Transmission**

- Insulant (if appropriate) 0,25 μgm/Nh
- Composite finish/foil faced product (if appropriate) N/a

6 **Mechanical Properties**

a. Compressive strength 14 to 35 kN/m^2 at 25% deformation

b. Flexural strength N/a

c. Tensile strength 210 to 420 kN/m^2

7 **Thickness Range** Available from 6 to 32mm

8 **Forms available**

TYPICAL USES AND APPLICATIONS

Closed cell, flexible integral vapour barrier insulation. Available in tube, sheet and tape forms. Widely used for condensation control and reducing heat gain on air-conditioning, chilled water and refrigeration services. Also used for frost protection and energy conservation on domestic heating, and hot and cold-water pipe work.

PERLITE EXPANDED

1 **Density (and range, if applicable)** 50 to 150 kg/m^3

2 **Thermal Conductivity**

	Thermal conductivity (W/mK) at density indicated below
Mean temp °C	80 kg/m^3
20	0,057
	0,035

3 **Service Temperature range** -250 to 1000°C

4 **Reaction to Fire Characteristics**

a. Combustibility to BS476 part 4 Non Combustible

b. Surface spread to flame to BS476 part 7

- Insulant (if appropriate) Class 1
- Composite finish (if appropriate) N/a
- Foil faced products (if appropriate) N/a

c. Building Regulations

- Insulate (if appropriate) Class 0
- Composite finish (if appropriate) N/a
- Foil faced products (if appropriate) N/a

5 **Water Vapour Transmission**

- Insulant (if appropriate) N/a
- Composite finish/foil faced product (if appropriate) N/a

6 **Mechanical Properties**

a. Compressive strength N/a

b. Flexural strength N/a

c. Tensile strength N/a

7 **Thickness Range** Available from 25 to 300mm

8 **Forms available**

TYPICAL USES AND APPLICATIONS

Loose fill granular material can be used as structural insulation in domestic roof spaces. Suitable for use below - 180°C as it contains no organic materials. Can be used in plasterboard manufacture and insulating renders, concretes and refractory materials.

4.5.4 PRODUCT SELECTION GUIDE – COLD INSULATION

PHENOLIC FOAM

1 **Density (and range, if applicable)** 35 to 120 kg/m^3

2 **Thermal Conductivity**

	Thermal conductivity (W/mK) at density indicated below
Mean temp °C	35 kg/m^3, 120 kg/m^3
10	0,018 – 0,022

3 **Service Temperature range** -180 to 120°C

4 **Reaction to Fire Characteristics**

a. Combustibility to BS476 part 4 — Non Combustible

b. Surface spread to flame to BS476 part 7

- Insulant (if appropriate) — Class 1
- Composite finish (if appropriate) — Class 1
- Foil faced products (if appropriate) — Class 1

c. Building Regulations

- Insulate (if appropriate) — Class 0
- Composite finish (if appropriate) — Class 0
- Foil faced products (if appropriate) — Class 0

5 **Water Vapour Transmission**

- Insulant (if appropriate) — 10 µgm/Nh
- Composite finish/foil faced product (if appropriate) — 0,001g/(s. MN)

6 **Mechanical Properties** 35 kg/m^3

	Para	perp
a. Compressive strength at 10% deformation (in kN/m^2)	172	84
b. Flexural strength	210	140
c. Tensile strength	210	150

7 **Thickness Range** Available from 10 to 600 mm

8 **Forms available** Bends, Lags, Laminate, Pipe Insulation, Sections, Slabs

TYPICAL USES AND APPLICATIONS

Used in commercial and institutional H & V applications where high insulation standards are required but space is tight. Also as a substitute for PUR and PIR in low temperature and heating applications. (Up to MTHW) where Class 0 fire rating and low smoke emission characteristics are required.

POLYETHYLENE FOAM

1 **Density (and range, if applicable)**

2 **Thermal Conductivity**

	Thermal conductivity (W/mK) at density indicated below	
Mean temp °C	30 kg/m^3	30 kg/m^3
-20	0,038	0,033
0	0,040	0,035
20	0,042	0,037
50	0,045	0,040

3 **Service Temperature range** -50 to 105°C

4 **Reaction to Fire Characteristics**

a. Combustibility to BS476 part 4 — Combustible

b. Surface spread to flame to BS476 part 7

- Insulant (if appropriate) — Unclassifiable
- Composite finish (if appropriate) — N/a
- Foil faced products (if appropriate) — N/a

c. Building Regulations

- Insulate (if appropriate) — Unclassifiable
- Composite finish (if appropriate) — N/a
- Foil faced products (if appropriate) — N/a

5 **Water Vapour Transmission**

- Insulant (if appropriate) — 0,5 gm/Nh
- Composite finish/foil faced product (if appropriate) — N/a

6 **Mechanical Properties**

a. Compressive strength at 10% Deformation (in kN/m^2) — 19 to 168 kN/m^2 at 25% deformation

b. Flexural strength — N/a

c. Tensile strength — 210 to 420 kN/m^2

7 **Thickness Range** Available from 6 to 32mm

8 **Forms available**

TYPICAL USES AND APPLICATIONS

Closed cell, insulant, refinements to cell structure have made improved thermal conductivity grades available, widely used in the form of pipe insulation for frost protection and energy construction in domestic applications. Available in tube and tape forms.

4.5.5 PRODUCT SELECTION GUIDE – COLD INSULATION

POLYISOCYANURATE FOAM (PIC)

1 **Density (and range, if applicable)**

2 **Thermal Conductivity**

	Thermal conductivity (W/mK) at density indicated below		
Mean temp °C	32 kg/m^3	40 kg/m^3	50 kg/m^3
-150	0,016	0,016	0,016
-50	0,022	0,022	0,022
0	0,021	0,021	0,021
10	0,023	0,023	0,023
50	0,026	0,026	0,026
100	0,032	0,032	0,032

3 **Service Temperature range** -180 to 140°C

4 **Reaction to Fire Characteristics**

a. Combustibility to BS476 part 4 — Combustible

b. Surface spread to flame to BS476 part 7
- Insulant (if appropriate) — Class 1
- Composite finish (if appropriate) — Class 1
- Foil faced products (if appropriate) — Class 1

c. Building Regulations
- Insulant (if appropriate) — N/a
- Composite finish (if appropriate) — Class 0
- Foil faced products (if appropriate) — Class 0

5 **Water Vapour Transmission**
- Insulant (if appropriate) — 30 µgm/Nh
- Composite finish/foil faced product (if appropriate) — 0,001g/(s. MN)

6 **Mechanical Properties**

	32 kg/m^3		40 kg/m^3		50 kg/m^3	
	para	perp	para	perp	para	perp
a. Compressive strength	172	100	280	230	325	250
b. Flexural strength	250	225	400	380	500	400
c. Tensile strength	200	170	400	350	450	350

7 **Thickness Range** Available from 15 to 100 mm

8 **Forms available** Lags, Laminate, Moulded, Pipe Insulation, Rigid Boards, Sections, Slabs

TYPICAL USES AND APPLICATIONS

Widely used to insulate cryogenic pipe work and equipment in the petrochemical and gas processing industries. Also suitable for heating services up to MTHW used in board form for structural insulation and building services ducting applications where space is tight. Also for temperature control on refrigerated vehicles and tanker

POLYISOCYANURATE FOAM (HIGH DENSITY)

1 **Density (and range, if applicable)**

2 **Thermal Conductivity**

	Thermal conductivity (W/mK) at density indicated below		
Mean temp °C	80 kg/m^3	100 kg/m^3	120 kg/m^3
-20	0,024	0,026	0,026
0	0,026	0,028	0,028
20	0,028	0,030	0,030
50	0,031	0,033	0,033

3 **Service Temperature range** - 180 to 140°C

4 **Reaction to Fire Characteristics**

a. Combustibility to BS476 part 4 — Combustible

b. Surface spread to flame to BS476 part 7
- Insulant (if appropriate) — Class 1
- Composite finish (if appropriate) — Class 1
- Foil faced products (if appropriate) — Class 1

c. Building Regulations
- Insulant (if appropriate) — N/a
- Composite finish (if appropriate) — Class 0
- Foil faced products (if appropriate) — Class 0

5 **Water Vapour Transmission**
- Insulant (if appropriate) — 20 gm/Nh
- Composite finish/foil faced product (if appropriate) — 0,001g/(s. MN)

6 **Mechanical Properties**

	80 kg/m^3		100 kg/m^3		120 kg/m^3	
	para	para	para	para	para	para
a. Compressive strength at 10% Deformation (in kN/m^2)	750	600	1100	950	1650	1550
b. Flexural strength	1150	1250	1700	1800	2100	2330
c. Tensile strength	850	700	1250	1050	1550	1350

7 **Thickness Range** Available from 15 to 150mm

8 **Forms available** Pipe Insulations, Supports

TYPICAL USES AND APPLICATIONS

Used as pipe supports and for other load-bearing purposes in cryogenic, process plant and H & V applications. Grades available at densities up to 160 kg/m3 for special applications.

4.5.6 PRODUCT SELECTION GUIDE – COLD INSULATION

POLYPROPYLENE

1 **Density (and range, if applicable)** 20 kg/m^3

2 **Thermal Conductivity**

	Thermal conductivity (W/mK) at density indicated below
Mean temp °C	20 kg/m^3
10	0,34

3 **Service Temperature range** - 40 to 130°C

4 **Reaction to Fire Characteristics**

- a. DIN 4102 — B2 pass
- b. NPF 92-501 — M2 pass
- c. SIA 183 — 5.2 pass

5 **Absorption by diffusion, SIA 179 in vol %** 1

6 **Vapour permeability SIA 279 in ng/Pa.m.s.** 0,45

7 **Chloride ion level**

8 **Mechanical Properties** Less than 15ppm

- a. A comprehensive strength at 10% deflection (vertical director) (ASTM3575) — 35

9 **Thickness Range** 43 and 50mm

10 **Forms available** Boards of 600 by 2800mm

TYPICAL USES AND APPLICATIONS

Used for thermal insulation in tank container industry where a lightweight product with no water absorption and with low chloride ion industrial and process plant sectors. The higher density gives improved mechanical properties and lower thermal conductivities at high mean temperatures.

POLYSTYRENE EXPANDED

1 **Density (and range, if applicable)**

2 **Thermal Conductivity**

	Thermal conductivity (W/mK) at density indicated below			
Mean temp °C	15 kg/m^3	20 kg/m^3	25 kg/m^3	30 kg/m^3
10	0,038	0,035	0,033	0,033

3 **Service Temperature range** -150 to 80°C

4 **Reaction to Fire Characteristics**

- a. Combustibility to BS476 part 4 — Combustible
- b. Surface spread to flame to BS476 part 7
  - Insulant (if appropriate) — Unclassifiable
  - Composite finish (if appropriate) — Class 1
  - Foil faced products (if appropriate) — Class 1
- c. Building Regulations
  - Insulate (if appropriate) — Unclassifiable
  - Composite finish (if appropriate) — Up to Class 0
  - Foil faced products (if appropriate) — Up to Class 0

Water Vapour Transmission

Insulant (if appropriate) — 25 μgm/Nh

6 Composite finish/foil faced product (if appropriate) — 0,001g/(s. MN)

7 **Mechanical Properties**

8
- a. Compressive strength — 15 kg/m^3
- b. Flexural strength — N/a
- c. Tensile strength — 200 kN/m^2

Thickness Range Available from 5 to 610mm

9 **Forms available** Beads, Laminates, Sheets, Pipe Insulation

TYPICAL USES AND APPLICATIONS

Construction – floor, wall, roof insulation in domestic, commercial and industrial buildings. As laminated panels, e.g. Gypsum board and various other facings. As a pipe insulation material in commercial and industrial refrigeration applications.

4.5.7 PRODUCT SELECTION GUIDE – COLD INSULATION

POLYSTYRENE FOAM EXTRUDED

1 **Density (and range, if applicable)**
2 **Thermal Conductivity**

	Thermal conductivity (W/mK) at density indicated below			
Mean temp °C	28 kg/m³	32 kg/m³	38 kg/m³	45 kg/m³
10	0,027	0,028	0,025	0,036

3 **Service Temperature range** -60 to 75°C

4 **Reaction to Fire Characteristics**

a. Combustibility to BS476 part 4 — Combustible

b. Surface spread to flame to BS476 part 7
- Insulant (if appropriate) — Unclassifiable
- Composite finish (if appropriate) — Up to Class 1
- Foil faced products (if appropriate) — Up to Class 1

c. Building Regulations
- Insulate (if appropriate) — Exceeds limits
- Composite finish (if appropriate) — Up to Class 0
- Foil faced products (if appropriate) — Up to Class 0

5 **Water Vapour Transmission**
- Insulant (if appropriate) — 0,15 to 0,075 µgm/Nh
- Composite finish/foil faced product (if appropriate) — 0,001g/(s. MN)

6 **Mechanical Properties**

	28 kg/m³	28 kg/m³	28 kg/m³
a. Compressive strength at 10% Deformation (in kN/m²)	250	500	700
b. Flexural strength	450kPa	650kPa	800kPa
c. Tensile strength	365kPa	465kPa	900kPa

7 **Thickness Range** Available from 12,5 to 200 mm

8 **Forms available** Boards, Pipe Insulation, Slabs

TYPICAL USES AND APPLICATIONS

Structural uses include floor, wall and roof insulation in domestic, commercial and industrial applications cold store. Panel and refrigerated truck manufacture. Used in commercial and industrial applications on refrigeration pipe work.

RIGID POLYURETHANE FOAM (PUR)

1 **Density (and range, if applicable)**
2 **Thermal Conductivity**

	Thermal conductivity (W/mK) at density indicated below		
Mean temp °C	35 kg/m³	40 kg/m³	50 kg/m³
-150	0,016	0,016	0,016
-50	0,022	0,022	0,022
0	0,021	0,021	0,021
10	0,023	0,023	0,023
50	0,026	0,026	0,026
100	0,032	0,032	0,032

3 **Service Temperature range** -180 to 110°C

4 **Reaction to Fire Characteristics**

a. Combustibility to BS476 part 4 — Combustible

b. Surface spread to flame to BS476 part 7
- Insulant (if appropriate) — Class 4
- Composite finish (if appropriate) — Class 1
- Foil faced products (if appropriate) — Class 1

c. Building Regulations
- Insulate (if appropriate) — N/a
- Composite finish (if appropriate) — Class 0
- Foil faced products (if appropriate) — N/a

5 **Water Vapour Transmission**
- Insulant (if appropriate) — 20 µgm/Nh
- Composite finish/foil faced product (if appropriate) — 0,001g/(s.MN)

6 **Mechanical Properties**

	35 kg/m³		40 kg/m³		50 kg/m³	
	para	perp	para	perp	para	perp
a. Compressive strength at 10% Deformation (in kN/m²)	172	100	260	200	350	250
b. Flexural strength	300	250	415	380	550	450
c. Tensile strength	250	200	540	390	650	400

7 **Thickness Range** Available from 15 to 150 mm

8 **Forms available** HD Mouldings, Moulded, Pipe Insulation, Sections, Slabs

TYPICAL USES AND APPLICATIONS

Used in medium to heavy-duty refrigeration to reduce heat gain and provide condensation control. Low temperature tankage of carbon dioxide, propane, etc. Laminated panels used in cold stores and refrigerated vehicles. Foam in-site and spray systems available.

4.5.8 PRODUCT SELECTION GUIDE – COLD INSULATION

ROCK MINERAL WOOL

1 **Density (and range, if applicable)**
2 **Thermal Conductivity**

	Thermal conductivity (W/mK) at density indicated below		
Mean temp °C	100 kg/m^3	120 kg/m^3	160 kg/m^3
10	0,033	0,033	0,034
50	0,037	0,037	0,038
100	0,044	0,044	0,043
200	0,064	0,060	0,059
300	0,088	0,081	0,079
400	0,122	0,106	0,100

3 **Service Temperature range** - 200 to 900 °C
4 **Reaction to Fire Characteristics**
a. Combustibility to BS476 part 4 — Non Combustible
b. Surface spread to flame to BS476 part 7
Insulant (if appropriate) — Class 1
Composite finish (if appropriate) — Class 1
Foil faced products (if appropriate) — Class 1
c. Building Regulations
Insulate (if appropriate) — Class 0
Composite finish (if appropriate) — Class 0
Foil faced products (if appropriate) — Class 0
5 **Water Vapour Transmission**
Insulant (if appropriate) — N/a
Composite finish/foil faced product (if appropriate) — 0,001g/(s. MN)
6 **Mechanical Properties** — 60kg/m^3 80kg/m^3
a. Compressive strength at 5% deformation (in kN/m^2) — 7,5 10,5
b. Flexural strength — N/a
c. Tensile strength — N/a
7 **Thickness Range** — Available from 20 to 120mm
8 **Forms available** — Loose fill, Mats, Pipe section, Rolls, Slabs, Wired mattresses (available without a variety of facings)

TYPICAL USES AND APPLICATIONS
Thermal and acoustic insulation and fire protection of plant, equipment and building structures in the marine, offshore, H & V, heavy industrial, commercial, institutional and domestic sectors.

SYNTHETIC RUBBER EXPANDED

1 **Density (and range, if applicable)**
2 **Thermal Conductivity**

	Thermal conductivity (W/mK) at density indicated below
Mean temp °C	60 kg/m^3
-20	0,038
0	0,040
20	0,042
50	0,048

3 **Service Temperature range** — -50 to 150°C
4 **Reaction to Fire Characteristics**
a. Combustibility to BS476 part 4 — Combustible
b. Surface spread to flame to BS476 part 7
Insulant (if appropriate) — Class 1
Composite finish (if appropriate) — Class 1
Foil faced products (if appropriate) — N/a
c. Building Regulations
Insulate (if appropriate) — N/a
Composite finish (if appropriate) — N/a
Foil faced products (if appropriate) — N/a
5 **Water Vapour Transmission**
Insulant (if appropriate) — 0,1 µgm/Nh
Composite finish/foil faced product (if appropriate) — N/a
6 **Mechanical Properties**
a. Compressive strength at 10% Deformation (in kN/m^2) — 14 to 35 Kn/m^2 at 25% deformation
b. Flexural strength — N/a
c. Tensile strength
7 Thickness Range — 210 to 420 kN/m^2
8 **Forms available** — Available from 9 to 25mm

TYPICAL USES AND APPLICATIONS
Closed cell, flexible, integral vapour barrier insulant. Grades suitable for higher temperature applications such as MTHW, HTHW and low-pressure steam services are available. A halogen free grade is available for temperatures up to 105°C.

4.5.9 PRODUCT SELECTION GUIDE – COLD INSULATION

VACUUM INSULATION PANEL (properties of CORE material)			
PHYSICAL PROPERTIES, CORE	**TEST METHOD**	**CORE AF**	**CORE HT**
1. Density	ASTM D 1622-93	80 kg/m^3	110 kg/m^3 145 kg/m^3
2. Thermal conductivity at 13Pa or 25°C mean temp	Dow 101390-E193A	0,0052 W/m-K	0,0056 W/m-K
3. Foam compressive strength at 5% strain	ASTM D 1621-94	280 kPa vertical 340 kPa horizontal	340 kPa vertical 410 kPa horizontal
4. Foam flexural strength	ASTM C203-92	620 kPa horizontal	1100 kPa horizontal
5. Foam tensile strength	ASTM C412-87	210 kPa vertical	210 kPa vertical
6. Thickness		25mm	15 and 20mm
7. Board size		610 by 1200mm	610 by 1200mm
8. Foam temperature stability	ASTM D 2126	0% shrinkage at 88°C	0% shrinkage at 88°C
9. Vacuum panel temperature stability		Less than 5% shrinkage at 60°C	Less than 2% shrinkage at 60°C

TYPICAL USES AND APPLICATIONS

Vacuum insulation core is open cell polystyrene foam material, which provides design flexibility, improved insulation, performance and cost savings, when used as the core material in Vacuum Insulation panels. Key applications are for refrigerators and freezers, insulated shipping containers, refrigerated trucks, cold storage units and industrial refrigeration, marine refrigeration and vending machines.

4.6 APPLICATION OF COLD INSULATION

Generally on pipe work, preformed pipe sections should be used or alternatively an in-situ or spray application could be considered. All insulation should fit snugly around piping and equipment. On low temperature insulation work all attachments to the piping or equipment and projecting through the insulation should also be insulated for a distance of four times the thickness of the basic insulation from the point where the projection is exposed.

All the insulation and the vapour barrier should be continuous at pipe supports. Where metal cradles preformed to the outside diameter of the insulation are provided at the pipe supports the cradle should be designed to prevent undue compression of the insulation due to the weight of the insulated pipe.

Higher density insulation preformed material often manufactured from PUR, PIC, phenolic foam or wood can be used between the support and the pipe to accommodate the weight if considered necessary.

Insulation contraction joints should be provided for Firebreaks should be provided at, for example, 20m maximum or where the insulated pipe passes from one building to another. Where total thickness of insulation exceeds 50mm it should be applied to multiple layers and all joints should be staggered to prevent direct heat paths to the cold face. The creation of cavities should be avoided.

4.6.1 JOINT SEALERS AND ADHESIVES

All materials intended for use for cryogenic insulation of pipes and vessels should be checked for their suitability at low temperatures and if, for example, no acceptable joint mastic is available for -196°C (liquid oxygen, nitrogen, etc) then only the joints on the outer layer on a multi-layer system should be sealed.

Joint sealers and adhesives should be completely compatible with the insulation, vapour barrier and the item being insulated (refer manufacturer's recommendations).

When insulating low temperature pipe work, it is advisable to create circumferential vapour dams extending from the bare pipe to the vapour seal on the warm side of the insulation. The longitudinal spacing of the dams is arbitrary and as a guide, 2m, for very low temperatures to 10m for, say chilled water, should be considered. The purpose of the dams is to prevent the failure of long sections of pipe insulation should the warm side vapour seal be ruptured in any way.

4.6.4 SUPPORTS FOR INSULATION

The following can support insulation:

- Adhesive
- Pins – plastic or nylon
- Strapping bands for large cylindrical surfaces
- Pressure-sensitive tape for small diameter surfaces
- Pre-installed insulation support rings, normally used on large vertical vessels.

4.6.3 VAPOUR BARRIERS

The following tables provides a guideline for the required water vapour permeance for different plant cold surface temperatures:

Required water vapour permeance in relation to plant temperature at an ambient temperature of +10°C (dry bulb)		
Temperature of plant (cold surface)	**Water vapour permeance of barrier**	
°C	**g/(s. MN)**	**Metric Perms**
0	0,010	0,12
-5	0,004	0,046
-10	0,002	0,023
-15	0,0015	0,017
-20 to –40	0,001	0,012

Note: For temperatures lower than –40°C please consult a TIASA member. Refer matrix of members elsewhere in this publication.

4.6.4 SELECTION GUIDE FOR VAPOUR BARRIERS

TYPE	PRODUCT NAME	TEMP RANGE °C	REC D.F.T (mm) **	WET FLAMABLE	EXPOSURE RESISTANCE	NON-SUITABLE SUBSTRATE	WATER VAPOUR PERMEANCE g/s MN *	METHOD OF APPLICATION
Bituminous	BE2 Bitumen Emulsion	-5/55	1,5	No	Internal	None	0,0083	Brush
	BE Emulsion	-5/55	1,5	No	Internal	None	0,0022	Trowel
	570 Rubberised Emulsion	-30/60	1,5	No	Internal	None	-	Brush
Epoxy	769 Epoxy Paint	-10/8	0,3	Yes	External	EPS	-	Brush/Spray
	304 Epoxy Coating	-10/120	0,3	No	External	None	-	Brush
	Abecote SF322	Dry 120	±1,0	Flash 0°C			0,005	Brush
	Flintoat 390	-10/50	±0,5	Flash 0°C			0,058	Brush
	Ivory 340	-10/90	0,8	No	Internal	None	0,003	Brush
	1 C KL		Film	N/A	Internal	None	0,001	N/A
	1 C KH		Film	N/A	Internal	None	<0,001	N/A
	1 C RH		Film	N/A	Internal	None	Neg.	N/a
Electrometric	Foster Monolar	-30/120	0,76	Yes	External	EPS	0,006	Brush/spray trowel
	Foster 95-44	-73/121	Seal't	Yes	External	EPS		Trowel/glove
	Foster 30-45	-60/149	Seal't	Yes	External	None		Trowel/glove
	800 Hypalon	-40/120	0,3	Yes	External	EPS	0,000	Brush/spray
	795 PU Coating	-20/180	0,3	Yes	External	EPS	0,000	Brush/spray
	696 Elastothane	-30/120	1,0	No	External	None	-	Brush
	153 FR Mastic	-30/80	1,9	Yes	External	EPS	N/A	Trowel
	625 Non-slump Mastic	-40/120	Bead	Yes	External	EPS	N/A	Gun
	151 Oleo Mastic	-70/150	Bead	No	Internal	None	N/A	Gun/trowel
Synthetic Emulsions	Foster 30-36	-18/82	0,9	No	Internal	None	0,083	Brush/spray
	Foster 30-70 (lagtone)	-46/82	0,4	No	External	None	0,180	Brush/spray
	Foster 35-00	-29/93	1,0	No	External	None	0,090	Trowel/glove
	2415 Plustex	-20/120	0,45	No	External	None	0,057	Brush/trowel
	2191 Plustex	-20/80	0,45	No	External	None	0,072	Brush/trowel
	249 Plustex	-20/90	0,45	No	External	None	0,05	Brush/trowel
	835 Acryl seal	-20/80	0,5	No	External	None	-	Brush
	147 Acryl Coat	-20/80	0,2	No	External	None	-	Brush
	158 Vapour seal	-30/85	1,3	No	External	None	-	Brush/trowel
Other	Foster 65-05	-29/93	2,0	Yes	External	EPS	0,007	Brush/spray
	Foil-Mylar	-70/100	Film	N/A	Internal	None	0,001	N/A

* Tested in acceptance with ASTM E96 Desiccant method.
** Recommended Dry Film Thickness

Note: It is recommended that the users contact the manufacturer for fore information.

4.6.5 STRUCTURAL BARRIERS

Often prefabricated to exact dimensions required and ready to install, these are rigid sheets of reinforced plastic, galvanized, aluminium or stainless steel jacketing - flat, corrugated or embossed.

4.6.6 MEMBRANE BARRIERS

Metal foils, laminated foils and treated papers, plastic films and sheets, and coated felts and paper - these are either part of the insulation as supplied or can be supplied separately.

4.6.7 COATING BARRIERS

In fluid form as a paint or mastic (or semi-fluid of the hot-melt variety) the material can be asphaltic, resinous or polymeric. These provide a seamless coating but require time to dry and are normally reinforced with a membrane sandwiched between layers.

Special attention must be given to vapour sealing of protrusions, joints or any other discontinuities such as glands, local to valve spindles or mechanical drives, etc. Refer to the following tables

4.6.8 PROTECTION OF INSULATION

Protection of the insulation may consist of metal cladding or a coating system.

Metal and non-metallic finishes should generally be as per the insulation guideline for hot insulation. However, care should be taken where piping and equipment is being clad; the cladding should be manufactured and installed so as to prevent the vapour barrier being punctured. Cushioning material applied between screws or rivets and vapour barrier, or other suitable means, would be a normal practice.