THERMAL INSULATION HANDBOOK

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THE THERMAL INSULATION ASSOCIATION OF SOUTHERN AFRICA
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INTRODUCTION

The Thermal Insulation Association of Southern Africa (TIASA), currently under the aegis of AAAMSA, promotes that part of the industry that specializes in the insulation of ceilings, walls, floors, piping and vessels with cold and hot insulation.

Membership constitutes manufacturers and suppliers of insulation materials, consultants for thermal insulation as well as contractors who sell and install insulation materials.

This specification refers to the measuring of completed insulation installations for industrial applications and will enable Architects, Engineers, Quantity Surveyors, Developers and other Specifiers to quantify their insulation requirements.

Having the installation done by contractors who are members of TIASA will ensure that the installation meets with the specified performance standards.

This handbook only addresses hot and cold insulation. TIASA is presently preparing information regarding ambient (building) insulation and the acoustical properties of insulation materials for inclusion in future editions of this handbook.

Readers are encouraged to submit their comments to the TIASA, which will be considered for inclusion in future editions.

We acknowledge the valuable input received from TIMSA (Thermal Insulation Manufacturers & Suppliers Association) whose information has been included in the Product Selection Guide – Hot Insulation Page 8-12 and Cold Insulation – Pages 19-27.

INTRODUCING TIASA

South Africa ratified the United Nation Framework Convention on Climate Change in August 1997 and is obliged to develop and submit a National Communication that contains an inventory of greenhouse gas emissions for a base year (1990) and a strategy to address climate change.

Globally at the centre of this activity are the window, glass and insulation industries and we take this opportunity to advise our readers that AAAMSA has been appointed to administer "TIASA – The Thermal Insulation Association of Southern Africa".

Energy consumption in South Africa measured against output (GDP) is very high compared to its global competitors and conversely the use of insulation is very low. This is due to the misconception that insulation in the region is not essential and regarded as a luxury item and also because of the relatively inexpensive cost of electricity. Cheap fuel has not been used to Southern Africa's advantage in the production of lower cost goods, to the contrary it has been abused and used excessively diminishing the long-term resources and contributing to environmental pollution. Apart from these issues, peak demand for electricity during the winter months far exceeds the capacity which Eskom can cost effectively supply and the vast majority of affordable homes currently being built are not energy efficient, further escalating the problem of energy abuse into the future.

THESE ISSUES LED TO THE FORMATION OF TIASA

The initiative of the Residential Demand Side Management (RDSM) Department of Eskom and a broad spectrum of concerned parties from government, NGOs and industry resulted in the establishment of TIASA.

TIASA embraces the entire thermal insulation marketplace, including manufacturers, distributors, contractors, specifiers, consultants, designers, architects, energy service companies, government, utilities and end users.

The mission of TIASA is to improve the environment, and the social and economic well-being of Southern Africans through the greater use, and better application of, thermal insulation.

Insulation has proved to be effective and beneficial in the following:

- Reducing energy costs
- Safety of personnel working in "hot" applications
- Home comfort control
- Temperature control in processing equipment
- Assisting in the reduction of environmental pollution
- Increasing the manufacturing competitiveness of companies
- Reducing the consumption of natural resources
- Reducing noise pollution
- Increasing the productivity of workers in factories, commercial buildings etc.

Southern Africa can no longer afford to disregard these benefits and ignore the advantages of a carefully and clearly defined policy on thermal insulation application.

TIASA PROMOTES THE BENEFITS OF INSULATION

Although providing a service to all industries, TIASA will initially focus the development of its products and services for the building and construction industry with specific attention being paid to sustainable energy efficient affordable homes by:

- Promoting greater understanding and co-operation among all segments of the insulation industry.
- Capacity building through education and training on the correct selection and installation of energy-saving thermal insulation.
- Developing a database of all products, suppliers, contractors, and interested parties in thermal insulation and appropriate dissemination of information.
- Participating in technical, legislative and regulative committees on insulation.
- Developing international relationships.
- Enlisting the resources and support of government agencies, utilities, academic and professional societies.

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1. INTRODUCTION TO INSULATION

Energy Conservation is "buzz" words of our times. There are many forms of energy conservation and this handbook is only concerned with the methods of conserving energy by means of thermal insulation.

To change the temperature of an object, energy is required in the form of heat generation to increase temperature, or heat extraction to reduce temperature. Once the heat generation or heat extraction is terminated a reverse flow of heat occurs to revert the temperature back to ambient. To maintain a given temperature considerable continuous energy is required. Insulation will reduce this energy loss.

Heat may be transferred in three mechanisms: conduction, convection and radiation. Thermal conduction is the molecular transport of heat under the effect of a temperature gradient. Convection mechanism of heat occurs in liquids and gases, whereby flow processes transfer heat. Free convection is flow caused by differences in density as a result of temperature differences. Forced convection is flow caused by external influences (wind, ventilators, etc.). Thermal radiation mechanism occurs when thermal energy is emitted similar to light radiation.

Heat transfers through insulation material occur by means of conduction, while heat loss to or heat gain from atmosphere occurs by means of convection and radiation.

Heat passes through solid materials by means of conduction and the rate at which this occurs depends on the thermal conductivity (expressed in W/mK) of the material in question and the temperature drive. In general the greater the density of a material, the greater the thermal conductivity, for example, metals has a high density and a high thermal conductivity.

Materials, which have a low thermal conductivity, are those, which have a high proportion of small voids containing air or gas. These voids are not big enough to transmit heat by convection or radiation, and therefore reduce the flow of heat.

Thermal insulation materials fall into the latter category. Thermal insulation materials may be natural substances or man-made.

If the density of insulation is low, the air or gas voids are comparatively large and this makes for the best insulation for low to medium temperatures where compression and/or vibration is not a factor.

However, where higher temperatures are encountered, the air or gas voids need to be reduced in size to minimize the convection within the voids and this is achieved by increasing the density of the insulation. Density may be increased to a point where the solids content of the insulation is such that the heat bridge of the solids overcomes the insulating effect of the voids. It follows therefore, that by encasing a container of heat with thermal insulation material the reverse heat flow will be retarded with resultant reducing energy loss and cost.

The word "retarded" is important because no matter how much insulation is applied, the reverse flow of heat to ambient can never be stopped. The primary reasons for insulation are many and varied, the main ones being:

- To conserve energy
- To reduce heat loss or gain
- To maintain a temperature condition
- To maintain the effective operation of equipment or chemical reaction
- To assist in maintaining a product at a constant temperature
- To prevent condensation
- To create a comfortable environmental condition
- To protect personnel

The type and thickness of insulation depend on the foregoing primary reasons together with the parameters of the specific conditions.

Economic thickness is the thickness of insulation, which will result in minimum total cost of energy losses plus the cost of the erected insulation. The calculation of economic thickness is complex and in some cases is overruled by the other listed primary reasons, which can make the calculation unnecessary.

The exception is when retro fitting of insulation is envisaged. Retro fitting is the application of additional insulation to existing insulation to further reduce heat loss or gain in order to reduce the cost of energy losses.

The economic thickness calculation has to be prepared by the user and is not usually the function of the insulation contractor. It includes salient factors such as:

- Cost of the energy losses, which include capital cost of installed equipment to generate/extract heat
- Expected price movement in the cost of fuel
- Capital cost of installed insulation
- Payback period that the user requires for capital investments
- Various other accounting factors

CHAPTER 2: OVERVIEW OF INSULATION SYSTEMS

In order to describe all the complexities of thermal insulation a large volume would be required.

Consequently, this handbook has been produced as a reference for common practice in South Africa. If more detail is required, it is suggested that BS 5970 “Code of practice for thermal insulation of pipe work and equipment in the temperature range - 100°C to 870°C” be consulted.

If there is a temperature differential between the process and ambient conditions, heat will flow from the higher to the lower temperature.

Throughout the handbook the following shall apply:

- Where the insulation is used to prevent heat loss from the process the term hot insulation will be used.
- Where the insulation is used to prevent heat gain to the process the term cold insulation will be used.
- Where the insulation is used to prevent heat loss and heat gain in buildings the term Ambient Insulation will be used. The Ambient Insulation section is currently under preparation and will be published at a later date.

In addition to the basic insulation material, a system may need:

- Supports for the insulation
- Fastenings for the insulation
- A vapour seal in case of cold insulation
- Mechanical or weather protection of the insulation, for example, metal cladding
- Supports for the protection
- Fastenings for the protection
- Finishing, for example, paint coatings, decorative finishes or identification bands
- Heat tracing with or without heat transfer cement

In this handbook unit designations are (according to the SI system):

- Density kg/m^3
- Thickness mm
- Temperature °C
- Differential temperature K
- Thermal conductivity W/mK

2.1 PRE-INSULATION APPLICATION

2.1.1 Before insulation is applied; all surfaces to be insulated shall be thoroughly cleaned to remove dirt, oil, moisture, loose rust or any other foreign matter.

2.1.2 PRESSURE AND LEAK TESTING

It is recommended that pressure and leak testing be carried out and any repairs effected prior to application of insulation. In many cases this is a statutory requirement.

2.1.3 HEAT TRANSFER CEMENT AND HEAT TRACING

If a temperature is to be maintained by means of external heat sources such as heat tracers, heat transfer cement may have to be applied to improve the heat transfer from the tracer in severe cases. The manufacturer’s recommendations should be consulted.

2.1.4 CORROSION PROTECTION

Where the operating temperature is less than 130°C and the equipment or pipe work is other than austenitic alloy, the surfaces should be coated with a suitable paint. It has been found that below this temperature corrosion conditions can occur.

Most thermal insulations will not, of themselves, cause stress corrosion cracking as may be shown by tests. When exposed to elevated temperature (boiling point range 80°C and 200°C), environments containing chlorides, moisture and oxygen, however, insulation systems may act as collecting media, transmigrating and concentrating chlorides on heating stainless steel surfaces. If moisture is not present, the chloride salt cannot migrate, and stress corrosion cracking because of chloride contaminated insulation cannot take place – ASTM C692-97.

If insulation is to be applied over certain austenitic alloy steel where the operating temperature is between 80°C and 200°C, it is recommended to apply a stress corrosion barrier before the application of the insulation so as to prevent stress corrosion. At 500°C and above none of the stress corrosion barrier materials can withstand the temperatures and therefore should not be used.

It should be noted that during startup and shutdown, operating temperatures might occur within this temperature band and under such circumstances stress corrosion could occur.

The barrier may be aluminium foil not less than 0,06mm thick or a specially formulated paint may be applied. The recommendations of the manufacturer should be followed particularly in respect of limiting temperature of the dried film.

2.1.5 PRE-INSTALLATION SUPPORTS

Insulation supports shall be installed prior to the application of the insulation.

2.2 DESIGNING INSULATION SYSTEMS

Factors, which influence the design of an insulation system, are:

2.2.1 LOCATION OF PLANT

- Indoors
- Outdoors protected from the weather
- Outdoors exposed to the weather
- Shape, size and elevations all need to be taken into consideration

2.2.2 TEMPERATURE CONDITIONS

- The normal operating temperatures
- The extreme temperature if other than normal operating temperature
- Any fluctuating temperature
- Duration of extreme or fluctuating temperatures

2.2.3 SURROUNDING ATMOSPHERIC CONDITIONS

- Ambient temperature
- Relative humidity to establish dew point for cold insulation
- Flammable conditions
- Potentially corrosive atmosphere
- Acidic conditions in atmosphere
- Air flow over insulated surface (wind velocity)

2.2.4 SPECIAL OR SERVICE CONDITIONS REQUIREMENTS

- Resistance to compression, for example, foot traffic
- Resistance to fire
- Resistance to vibration
- Resistance to mechanical damage
- Resistance to corrosive fluids or gases
- Anticipated wide fluctuations of temperature, for example, steam out
- Resistance of insulation protection to ingress of oils and flammable liquids
- Application of insulation over special alloys
- Resistance to moisture and other weather conditions
- Resistance to Vermin

2.3 DESIGN CALCULATIONS

The design of an insulation system is governed by the insulated operating values, which the plant requires after insulation.

The values may be:

- Emissive
- Thermal conditions – Heat loss/Heat gain
- Process temperature drop or rise
- Condensation prevention
- Personnel protection temperature
- Optimal economic conditions (See page 1)
- Thermal conductivity of insulation material
- Ambient temperature
- Wind velocity

Calculations are by the formulae as set in Section 5.2, which are to British Standard BS 5422. Other international standards may be used. The calculated values are theoretical and should be adjusted for practical, design and atmospheric considerations.

2.4 SUPPORT SYSTEMS

Support systems may be required for insulation, cladding or composite for both. The cost of fabrication and attachment of supports to the equipment forms a significant part of the insulation cost and therefore the method of attachment must be well defined prior to the issue of any insulation inquiry.

It is recommended that where post-manufacture welding is not permitted, the equipment manufacturer undertake the fitting of supports.

2.4.1 CYLINDRICAL VESSELS

Where post-welding is not permitted and the manufacturer has not included supports the contractor must fit support rings using a non-welding method.

The criteria for this method are:

- Suitable pitch
- The total weight of the system to be supported
- Thermal expansion or contraction of the equipment

2.4.2 FLAT SURFACES

Support systems on flat surfaces should take into account:

- The disposition of the surface, i.e., underside, vertical, horizontal or inclined
- The total system mass to be supported
- Thermal expansion or contraction of the equipment.

2.4.3 HEAT BRIDGES

Where metal cladding comes in contact with support steel, hot spots for hot insulation and condensation for cold insulation will occur. It is therefore recommended to insulate between the contact points.

2.5 MAIN INSULATION TYPES

- Boards or batts - A rigid binder bound fibrous insulation for use on flat or large cylindrical surfaces
- Felt - A semi-flexible binder bound fibrous insulation for use on all surfaces where vibration is of a low order for example Boilers
- Loose - Loose or granulated insulation with a low binder content for filling voids

- Mattress - A flexible low binder fibrous insulation for use on all surfaces. A wire mesh fixed to one or both sides by through stitching maintains the mattress shape. Because of the low binder content the material is able to withstand higher temperature without binder breakdown.
- Pipe section - Insulation preformed to fit in two halves round cylindrical surfaces of various diameters.
- Pipe section covered - As for pipe section except that the outer surface is fitted with a cover by the manufacturer, for example, canvas or foil
- Segments - Cylindrical insulation for fitting round large cylindrical surfaces in more than two parts. Confined to the closed cell insulants.
- Slab - All the closed cell flat insulation and expanded/extruded insulants fall into this category and may be applied to all surfaces provided they are suitably shaped.
- Rope - Usually of fibrous material for spirally wrapping around small pipes.
- Spray fibre - Used for insulating irregular shapes such as turbines and also for fireproofing.
- Spray foam - Usually polyurethane or polyisocyanurate. The main applications are for large regular surfaces such as roofs or tanks and for cavity filling.
- Tape - Usually of fibre and used for spiral wrapping on pipe work where conditions so demand.

2.6 GENERAL NOTES ON INSULATION TYPES

The use of felt or mattress is not recommended over cylindrical shapes of less than 200mm outside diameter.

Under certain circumstances boards or slab may be used on cylindrical surfaces by cutting the insulation into bevelled staves.

The general practice on certain applications when installing where the total insulation thickness exceeds 50mm, a multi-layer system should be used with staggered joints to reduce heat loss or gain through direct paths to atmosphere.

When very high or very low temperatures are encountered expansion or contraction joints should be provided. These are usually 40mm wide and packed with a suitable insulant.

It is incumbent on the manufacturers to provide all the necessary values such as thermal conductivity (k factor) and water vapour permeance based on the tests conducted by a testing authority. If required, the test number and date should be given together with the particular test method and conditions.

Important: Because of the health hazards involved, products containing asbestos should not be used. Where asbestos has to be used, adherence to the OSH act and regulations should be followed.
Local insulation is normally preferred due to cost, delivery and wastage factors.

2.7 VAPOUR BARRIERS

All insulation designated as “cold” must be provided with a vapour barrier and this procedure is set out in Chapter 4 - Cold insulation.

2.8 PROTECTION OF INSULATION

The insulation required to be protected from mechanical damage and the elements (weather barrier). Protection of the insulation may consist of metal cladding or a coating system.

2.8.1 METAL CLADDING

The main metals used are:

- Galvanised steel
- Pre-painted or pre-coated steel
- Aluminium
- Stainless steel
- Other specialised formulations

Depending upon the requirements of the application the metal may be flat sheet or profiled.

The thickness depends on the degree of mechanical damage, which the cladding is expected to withstand and may vary from 0,5mm to 1,2mm. For areas susceptible to heavy damage a thicker gauge may be required.

In the application of cladding it should be ensured that:

- Good water shedding exists at all joints or sealing of joints where this is not possible.
- At point where dissimilar metals may come in contact with one another precautions must be taken to prevent galvanic action.
- All metal joints must be straight and square to preserve a symmetrical appearance.
- The cladding system must be constructed so that due allowance is provided for the expansion or contraction of the equipment.
- Where the cladding is applied over a vapour barrier, great care must be taken to avoid puncturing the vapour barrier either during or after erection, for example, a spacer or protective liner.

2.8.2 PLASTER FINISHES

The term plaster includes both hard-setting plaster and mastics, which may be used separately or together.

Plaster may be used on all surfaces but when exposed to the weather it should be over coated with a mastic or finishing paint.

If plaster is to be used over a fibrous insulation the insulation must be of sufficient density to withstand the trowel application.

Mastic is not suitable for direct application to fibrous insulation. Generally, the purpose of the plaster is to provide a surface resistant to mechanical damage and/or a foundation for the mastic, which provides the waterproofing.

Both the plaster and the mastic should be applied in two layers with a reinforcing between the layers, i.e., galvanised wire mesh for the plaster and fibreglass mesh for the mastic. The first coat in each case should provide an anchor to ensure a key for the second.

Because of its high mass, the plaster coat is subject to slipping on large vertical surfaces. The wire mesh reinforcing must therefore be tied back, with binding wire, to fixed supports on the equipment.

3. HOT INSULATION

3.1 GENERAL NOTES

Equipment or pipe work with an operation temperature greater than 55°C in case of metallic surfaces and 65°C in the case of non-metallic surfaces should be insulated so that the surface temperature after insulation (cold surface temperature) does not exceed 55°C.

It is recognised that temperatures of 60°C or greater will result in extreme discomfort to personnel and therefore a maximum cold surface temperature of 55°C should be considered as prudent.

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.

3.2 SELECTION OF HOT INSULATION MATERIALS

The objective is to select a material, which will serve the insulation purpose at the lowest cost. This can be a complicated procedure.

In addition to the factors listed in section 2.2 careful considerations should be given to insulation thickness. On pipe work an over-specification of thickness creates a needless increase in the cost of the outer protection.

When a multi-layer system of insulation is envisaged, the selection of materials is interdependent on the type of protection and the calculations as set out in Annex 2 paragraph 5.2. For example, an aluminium protection will result in a higher cold surface temperature and a lower heat. (Aluminium protection has a low emissivity and therefore radiates less heat).

Where constant load supports are involved, the mass of the insulation system becomes critical and must be kept within the tolerances of such constant load supports. Where used for internal linings of ventilation ductwork the thermal insulating material itself should be non-combustible as defined in BS 476: Part 4

3.3 HOT INSULATION MATERIALS

Common to all these materials, it is recommended that their use be limited to conditions of 90% of the manufacturer's limiting temperatures in order to safeguard against temperature surge at start-up operations of plant.

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.

3.3.1 HOT INSULATION MATERIALS

CALCIUM SILICATE

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

	Thermal conductivity (W/mK) at density indicated below
Mean temp °C	240 kg/m^3
100	0,054
150	0,058
200	0,063
250	0,068
300	0,074
350	0,082

3 **Service Temperature range** 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) — 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) — N/a

6 **Mechanical Properties**
a. Compressive strength — 600kN/m^2 at 1,5% deformation
b. Flexural strength — 550 kN/m^2
c. Tensile strength — N/a
7 **Thickness Range** Available from 25 to 100mm
8 **Forms available** Lags, Sections, Slabs

TYPICAL USES AND APPLICATIONS
Steam, superheated steam and hot water pipe work, fitments and vessels. Oven construction – furnace-backing insulation. Used in power generation, petrochemical and general industrial applications on process plant and heating insulations. Suitable for use in food processing industries.

CERAMIC FIBRE (BLANKET)

1 **Density (and range, if applicable)** 64 to 192 kg/m^3
2 **Thermal Conductivity**

	Thermal conductivity (W/mK) at density indicated below		
Mean temp °C	64 kg/m^3	96 kg/m^3	128 kg/m^3
100	-	0,041	0,030
300	-	0,079	0,06
600	0,18	0,14	0,12
800	0,27	0,22	0,18
1000	0,42	0,36	0,28

3 **Service Temperature range** 1250°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) — 542 µgm/Nh
- Composite finish/foil faced product (if appropriate) — 0,001g/(s. MN)

6 **Mechanical Properties** (At 128 kg/m^2)
a. Compressive strength — 2,5kN/m^2 at 10% deformation
b. Flexural strength — N/a
c. Tensile strength — 65 kN/m^2
7 **Thickness Range** Available from 6 to 50mm
8 **Forms available** Lags, Sections, Slabs

TYPICAL USES AND APPLICATIONS
Refractory grade material suitable for use to 1400°C. Available in form of loose wool, non-woven blankets, papers, boards, preformed shapes, textiles and wet mixes. Use for thermal and acoustic insulation within process industries such as motor, petrochemical and power generation. Also fire protection of commercial buildings and offshore structures.

3.3.2 HOT INSULATION MATERIALS

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

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	48 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.

3.3.3 HOT INSULATION MATERIALS

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

1	**Density (and range, if applicable)**	130 kg/m³
2	**Thermal Conductivity**	

	Thermal conductivity (W/mK) at density indicated below
Mean temp °C	130 kg/m³
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.

MELAMINE FOAM (FLEXIBLE)

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

	Thermal conductivity (W/mK) at density indicated below
Mean temp °C	11 kg/m³
10	0,034
20	0,035
40	0,039
50	0,040
80	0,046

3	**Service Temperature range**	10 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)	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)	350 µgm/Nh
	Composite finish/foil faced product (if appropriate)	0,001g/(s. MN)
6	**Mechanical Properties**	
	a. Compressive strength	5 to 20 kN/m² at 10% deformation
	b. Flexural strength	N/a
	c. Tensile strength	120 kN/m²
7	**Thickness Range**	Available from 10 to 50mm
8	**Forms available**	

TYPICAL USES AND APPLICATIONS

Fibre free insulation suitable for use on L.T.H.W. and M.T.H.W. heating services. Applications in market such as food processing, breweries, pharmaceuticals, electronics and hospitals. Specified as combined thermal and acoustic insulant in petrochemical sector.

3.3.4 HOT INSULATION MATERIALS

PERLITE EXPANDED		
1	**Density (and range, if applicable)**	50 to 150 kg/m^3
2	**Thermal Conductivity**	

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

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.

ROCK MINERAL WOOL			
1	**Density (and range, if applicable)**		60 to 160 kg/m^3
2	**Thermal Conductivity**		

Mean temp °C	Thermal conductivity (W/mK) at density indicated below: 60 kg/m^3	80 kg/m^3
10	0,033	0,033

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	7,5	10.5
	b. Flexural strength		
	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.

3.3.5 HOT INSULATION MATERIALS

ROCK MINERAL WOOL (HIGH DENSITY)

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
200	0,064	0,060	0,059

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** — 100 kg/m^3 / 140 kg/m^3 / 200 kg/m^3

a. Compressive strength — 13 / 14,5 / 16

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 Sections, Preformed pipe bends, Profiled Panels, Rolls, Slabs, Wired mattresses (available with or without a variety of facings)

TYPICAL USES AND APPLICATIONS

Thermal and acoustic insulation and fire protection of plant, equipment and building structures, etc. in the marine, offshore, heavy industrial and process plant sectors. The higher density gives improved mechanical properties and lower thermal conductivities at high mean temperatures.

VERMICULITE

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

2 **Thermal Conductivity**

	Thermal conductivity (W/mK) at density indicated below			
Mean temp °C	96 kg/m^3	101 kg/m^3	104 kg/m^3	109 kg/m^3
10				0,066
30			0,067	
60		0,075		
150	0,083			

3 **Service Temperature range** 0 to 1300°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) — 350 μgm/Nh
- Composite finish/foil faced product (if appropriate)

6 **Mechanical Properties**

a. Compressive strength — N/a

b. Flexural strength — N/a

c. Tensile strength — N/a

7 **Thickness Range** — Available from depends upon form and application

8 **Forms available**

TYPICAL USES AND APPLICATIONS

Loose fill granular insulant used in loft insulation, steel works and foundries, hazardous goods packaging, insulating concretes, plasters and building boards (both general purpose and fire resistant) to insulate mechanical fitments when bonded with silicate solutions to form suitable shapes.

3.4 RECOMMENDED THICKNESS OF HOT INSULATION

NB: This should be regarded as a general guide, and depending on relative fuel cost and cost of applied insulation, the indicated thickness need not necessarily be the most economic thickness of insulation.

Criteria used in selection below:

- To achieve an approximate cold surface temperature of 55°C
- Ambient of 20°C
- Zero wind speed
- Galvanized cladding

3.4.1 FIBREGLASS

3.4.1.1 **FIBIREGLASS FLAT SURFACES**		
Operating temperature range (°C)	**Fibreglass insulation density (kg/m3)**	**Thickness of insulation (mm)**
Up to 200	24	40
201 to 250	24	40
251 to 300	47,5	70*
301 to 350	64	75*
351 to 400	64	100*
401 to 450	64	125*
Remarks: * Non-standard thickness		
Double layer recommended. With double layer, first layer should be 40 to 50mm. Second layer can be in lower density product, but this should be checked with the insulation supplier.		

3.4.1.2 **FIBREGLASS PREFORMED PIPE SECTION**		
Operating temperature range (°C)	**Nominal bore range (Mm)**	**Thickness of insulation (mm)**
0 to 100 101 to 200 201 to 250 251 to 300 301 to 350 351to 400	15 - 32	15 20 25 40 50 60*
0 to 100 101 to 200 201 to 250 251 to 300 301 to 350 351 to 400	40 - 100	20 25 40 50 60* 70*
0 to 200 201 to 250 251 to 300 301 to 350 351 to 400	125 - 200	25 40 50 70* 80*
0 to 200 201 to 250 251 to 300 301 to 350 351 to 400	225 - 400	35 40 50 70* 90*
Remarks: * Non-standard thickness		

3.4.2 ROCKWOOL

3.4.2.1 FLAT SURFACES

Operating Temperature (°C)	Most suitable product	
	Density (kg/m3)	Thickness (mm)
50 - 199	60	25
200 - 249	60	40
250-299	80	50
300-349	80	75
350-399	100	75
400-449	120	75
450-499	120	100
500-549	160	100
550-599	160	40
(Two layers)	+120	75
600-649	160	50
(Two layers)	+120	100
650-700	160	50
(Three layers)	+120	50
	+100	100

3.4.2.2 ROCKWOOL – Preformed pipe section

Operating temperature range (°C)	Nominal bore range (mm)	Thickness of insulation (mm)
0 to 100	15 - 32	20
101 to 200		20
201 to 250		25
251 to 300		30
301 to 350		40
351 to 400		50
0 to 100	40 - 100	20
101 to 200		25
201 to 250		30
251 to 300		40
301 to 350		50
351 to 400		60
0 to 200	125 - 200	25
201 to 250		30
251 to 300		40
301 to 350		50
351 to 400		60
0 to 200	225 - 400	25
201 to 250		30
251 to 300		40
301 to 350		50
351 to 400		60
0 to 200	350-400	40
201 to 250		40
251 to 300		50
301 to 350		60
351 to 400		70

3.5 APPLICATION OF HOT INSULATION

Pipe section, mattress or any flexible insulation may be used for pipe work. However, practical reasons preclude the use of mattress or flexible insulation where the outside diameter of the pipe or the outside diameter of any previous layer of insulation is 200mm or less.

Where mattress or materials of low density are used and metal is the protection medium, supports should be provided for the metal at not more than 1-metre intervals where the pipe work is horizontal or inclined up to 45°. Between 45° and the vertical the spacing of the supports is dependent on temperature and expansion requirements. (Refer BS 5970).

As a guide, the expansion allowances on pipe work are generally 1mm per running meter per 100°C of temperature. In all applications of insulation the material must be well butted together and in the case of multi-layer applications all joints of each subsequent layer must be staggered from the previous layer. Weld pins or clips, binding wire and strapping are used for securing the insulation as a single or composite system dependent on the circumstances.

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.

TIASA
Thermal Insulation Association of South Africa

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 para	32 kg/m^3 perp	40 kg/m^3 para	40 kg/m^3 perp	50 kg/m^3 para	50 kg/m^3 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 para	80 kg/m^3 para	100 kg/m^3 para	100 kg/m^3 para	120 kg/m^3 para	120 kg/m^3 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/m^3	32 kg/m^3	38 kg/m^3	45 kg/m^3
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/m^3	28 kg/m^3	28 kg/m^3
a. Compressive strength at 10% Deformation (in kN/m^2)	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/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 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/m^3		40 kg/m^3		50 kg/m^3	
	para	perp	para	perp	para	perp
a. Compressive strength at 10% Deformation (in kN/m^2)	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.

LIST OF ANNEXES

5.1 List of Reference Standards

5.2 Heat loss or gain calculations

5.3 System of Measurement – Method of Measuring Completed Insulation

5.4 Conversion Factors

5.5 Glossary of terms

5.1 LIST OF REFERENCES STANDARDS

Re: BRITISH STANDARDS

These are the principal ones:

1. BS 476 – Fire tests on building materials and structures.

Part 3: 1975	External fire exposure roof test.
Part 4: 1970 (1984)	Non-combustibility test for materials.
Part 6: 1989	Method of test for fire propagation for products.
Part 7: 1997	Method of test to determine the classification of the surface of flame of products.
Part 12: 1991	Method of test for ignitability of products by direct flame impingement.
Part 20: 1987	Method for determination of the fire resistance of elements of construction (general principles)
Part 22: 1987	Methods for determination of the fire resistance of non-load bearing elements of construction.

2. BS 747: 1994 - Specification of roofing felts.

3. BS 853 – Specification for vessels for use in heating systems.

Part 1: 1996	Calorifiers and storage vessels for central heating and hot water supply.
Part 2: 1996	Tubular heat exchangers and storage vessels for building and industrial services.

4. BS 874 – Methods for determining thermal insulating properties.

Part 1: 1986	Introduction definitions and principles of measurement.
Part 2	Tests for thermal conductivity and related properties
Part 2: Sec 2.1: 1986	Guarded hot-plate method.
Part 2: Section 2.2: 1988	Upgraded hot-plate method
Part 3	Tests for thermal transmittance and conductance.
Part 3: Section 3.1: 1987	Guarded hotbox method
Part 3: Section 3.2: 1990	Calibrated hotbox method

5. BS 1387: 1985 (1990) – Specification for screwed and socketed steel tubes and tubules and for plan end steel tubes suitable for welding or for screwing to BS 21 pipe threads.

6. BS 1566 – Copper indirect cylinders for domestic purposes.

Part 1: 1984 (1990)	Specification for double feed indirect cylinders.
Part 2: 1984 (1990)	Specification for single feed indirect cylinders.

7. BS 2871 – Specification for copper and copper alloys. Tubes.

Part 2: 1972	Tubes for general purposes.
Part 3: 1972	Tubes for heat exchangers.

8. BS 2972: 1989: Section 12 – "The Partial Immersion Test" Methods of test for inorganic thermal insulating materials.

9. BS 3177: 1959 (1995) – Method for determining the permeability to water vapour of flexible sheet materials used for packaging.

10. BS 3198: 1981 – Specification for copper hot water storage combination units for domestic purposes.

11. BS 3416: 1991 – Specification for bitumen-based coatings for cold application, suitable for use in contact with potable water.

12. BS 3533: 1981 – Glossary of thermal insulation terms.

13. BS 3601: 1987 (1993) – Specification for carbon steel pipes and tubes with specified room temperature properties for pressure purposes.

14. BS 3602 – Specification for steel pipes and tubes for pressure purposes: carbon and carbon manganese steel with specified elevated temperature properties

Part 1: 1987 (1993)	Specification for seamless and electric resistance welded including induction welded tubes.
Part 2: 1991	Specification for longitudinally arc welded tubes.

15. BS 3603: 1991 – Specification for carbon and alloy steel pipes and tubes with specified low temperature properties for pressure purposes.

16. BS 3604 – Steel pipes and tubes for pressure purposes: ferrite alloy steel with specified elevated temperature properties.

Part 1: 1990	Specification for seamless and electric resistance welded tubes.
Part 2: 1991	Specification for longitudinally arc welded tubes.

17. BS 3605 - Austenitic stainless steel pipes and tubes for pressure purposes.

Part 1: 1991	Specification for seamless tubes.
Part 2: 1992	Specification for longitudinally welded tubes

18. BS 4142: 1997 – Method for rating industrial noise affecting mixed residential and industrial areas.

19. BS 4718: 1971 – methods for test for silencers for air distribution systems.

20. BS 5228 – Noise and vibration control on construction and open sites.

Part 1: 1997	Code of practice for basic information and procedures for noise and vibration control.
Part 2: 1997	Guide to noise and vibration control legislation for construction and demolition including road construction and maintenance

21. BS 5250: 1989 (1995) – Code of practice for control of condensation in buildings.

22. BS 5422: 1990 – Method for specifying thermal insulating materials on pipes, ductwork and equipment (in the temperature range 0°C to +700°C).

23. BS 5588 – Fire precautions in the design, construction and use of buildings.

Part 9: 1989	Code of practice for ventilation and air conditioning ductwork.

24. BS 5628 – Code of practice for use of masonry.

Part 3: 1985	Materials and components, design and workmanship.

25. BS 5803 – Thermal insulation for use in pitched roof spaces in dwellings.

Part 1: 1985 (1994)	Specification for man-made mineral fibre thermal insulation mats.
Part 2: 1985 (1994)	Specification for man-made mineral fibre thermal insulation in pelleted or granular form for application by blowing.
Part 3: 1985 (1994)	Specification for cellulose fibre thermal insulation for application by blowing.
Part 4: 1985 (1994)	Methods for determining flammability and resistance to smouldering.
Part 5: 1985 (1994)	Specification for installation of man-made mineral fibred and cellulose fibred insulation.

26. BS 5821 – Methods for rating the sound insulation in buildings and of building elements.

Part 3: 1984 (1993)	Method for rating airborne sound insulation of façade elements and facades.

27. BS 5970: 1992 – Code of practice for thermal insulation of pipe work and equipment (in the temperature range -100°C to +870°C).

28. BS 6229: 1982 – Code of practice for flat roofs with continuously supported coverings

29. BS 6399 – Loadings for buildings.

Part 1: 1996	Code of practice for dead and imposed loads.
Part 2: 1997	Code of practice for wind loads

30. BS 6515: 1984 (1996) – specification for polyethylene damp-roof courses for masonry.

31. BS8217: 1994 – Code of practice for built-up felt roofing

32. VDI 2055:1994 – Thermal Insulation for Heated and Refrigerated Industrial and Domestic Installations (German Standard)

5.2 HEAT LOSS CALCULATION PRINCIPLES

5.2.1 SYMBOLS

Q	Heat loss through the insulation – per square meter	(W/m^2)
Q’	Heat loss through the insulation – per linear meter of pipe run	(W/m)
th	Hot face temperature, i.e. temperature of vessel/pipe	(°C)
tc	Cold face temperature, i.e. temperature of outer surface of insulation	(°C)
ta	Ambient temperature of still air	(°C)
tj	Temperature at junction/interface of two layers of insulation	(°C)
t1	Temperature of 1st interface (between 1st and 2nd layer) of insulation	(°C)
t2	Temperature of 2nd interface (between 2nd and 3rd layer) of insulation	(°C)
tn	Temperature of nth interface (between nth and n+1 layer) of insulation	(°C)
x	Overall thickness of insulation	(m)
x1	Thickness of 1st (inner) layer of insulation	(m)
x2	Thickness of 2nd layer of insulation	(m)
xn	Thickness of nth layer of insulation	(m)
k	Thermal conductivity of insulation	(W/mK)
k1	Thermal conductivity of 1st (inner) layer of insulation	(W/mK)
k2	Thermal conductivity of 2nd layer of insulation	(W/mK)
kn	Thermal conductivity of nth layer of insulation	(W/mK)
R	Thermal resistance of insulation	(mK/W)
Rs	Thermal resistance of outer surface of insulation	(mK/W)
dp	Outer diameter of pipe	(m)
ds	Outer diameter of total insulation	(m)
d1	Outer diameter of 1st (inner) layer of insulation	(m)
d2	Outer diameter of 2nd layer of insulation	(m)
dn	Outer diameter of nth layer of insulation	(m)
f	Surface heat transfer coefficient	(W/m^2K)

5.2.2 THERMAL CALCULATIONS

HEAT LOSS FROM INSULATED SURFACES - May be calculated either from a knowledge of the thermal conductivity and thickness of each individual insulation layer or from a knowledge of the “equivalent thermal Conductivity.”

HEAT GAIN – When the surface to be insulated is below ambient temperature, heat will be gained rather than lost. This fact will be indicated in the formulae in this section by a negative value being show for “Q”.

AMBIENT CONDITIONS – Calculations are based on “still air” conditions. It is possible to consider “exposed” conditions, but this then needs details of wind speed, size, type and orientation of the surface being insulated.

However, it is the heat loss from bare or non-insulated surfaces that is most affected by exposed conditions and the increased in heat loss from well-insulated surfaces is minimal.

SURFACE TEMPERATURE OF PIPE/VESSELS – Calculations are based on the assumption that the surface temperature of the pipe/vessel is the same as that of the contained fluid. This is not quite true, but the difference is very small.

5.2.3 SURFACE HEAT TRANSFER COEFFICIENT

The surface heat transfer coefficients of the cladding will vary according to the nature of the surface and the temperature. Each surface material has its own unique emissivity. For practical purposes these can be grouped into the following three categories:

- BRIGHT surfaces are those with low emissivity, e.g. bright metal surfaces, polished aluminium, etc.
- PLANISHED surfaces are those with medium emissivity, e.g. galvanized steel, hammered aluminium, aluminium paint, etc

- NORMAL surfaces are those with high emissivity, e.g. composition, canvas, plastic sheeting, unfaced insulation, painted metal surfaces, etc.

The surface coefficients are:

Bright f = 5,7 W/m^{2}K ………. Aluminium f = 5,7 W/m^{2}K
Planished f = 8,0 W/m^{2}K ……….. Galv. Steel f = 6,3 W/m^{2}K
Normal f = 10,0 W/m^{2}K ………. Mastics f = 10,0 W/m^{2}K

Above approximately 50°C, the surface coefficients will increase slightly with an increase in temperature. For a given hot face temperature and thickness of insulation, a Bright finish will give a higher surface temperature and lower heat loss than other finishes. A Normal finish will give a lower surface temperature but a higher heat loss.

Thus, when designing for specific surface temperatures, the nature of the surface finishes can have a considerable effect on the thickness of insulation required.

The effect of air velocity is important. For example, increasing air velocity will decrease cladding temperature of a hot vessel.

5.2.3 CALCULATION PROCEDURES

Most calculations must start by making an estimate of the outer surface temperature of the insulation and, for multi-layer insulation, estimates of the interface temperatures. The surface coefficients can be established. The k-value can be determined from the relevant nomographs, using the estimated temperatures.

Inserting the hot face and ambient temperatures, the insulation thickness and k-values and, if appropriate, the pipe diameter into the heat loss formula, will result in a heat loss.
The surface temperature (and interface temperatures for multi-layer insulation) is then calculated. If the calculated temperatures agree, or are within 1°C of the estimated temperatures, the calculations can be considered to be correct.

Agreement is seldom reached on the first calculation, so the calculation must be repeated, using the calculated temperatures as the new "estimates", bearing in mind that the relevant k-values will change according to the change in the hot face and cold face/interface temperatures.

Repeat the procedure of using the calculated temperatures as the new estimates until agreement is reached.

5.2.4 THERMAL CONDUCTIVITY

The units of thermal conductivity – k-value – are W/mK, where K represents a differential temperature of 1 degree Kelvin, which is exactly the same as a differential temperature of 1 degree Celsius.

5.2.5 HEAT LOSS FORMULAE

5.2.5.1 FLAT SURFACES – SINGLE LAYER INSULATION

5.2.5.2 **FLAT SURFACES – MULTILAYER INSULATION**

5.2.5.3 **PIPES – SINGLE LAYER INSULATION**

5.2.5.4 **PIPES – MULTILAYER INSULATION**

5.2.6 DETERMINE INSULATION REQUIRED TO ACHIEVE A SPECIFIED HEAT LOSS

5.2.7 DETERMINE REQUIRED INSULATION THICKNESS FOR CONDENSATION CONTROL

Condensation will occur if the surface temperature falls below the dew point temperature – the temperature at which the ambient air of a certain relative humidity will be become saturated if cooled.

The insulation thickness must be sufficient to ensure that the surface temperature of the vapour barrier is above the dew point temperature for the worst anticipated conditions of temperature and humidity.

5.2.7.1 **FLAT SURFACES**

5.2.7.2 **PIPES**

5.2.8 SPECIALISED CONDITIONS AT THE POINT OF DELIVERY

During the flow through a pipe system, a fluid will lose or gain heat, the effects of which are associated directly with the transmission of heat through the insulation and also with that in local areas of bare surfaces.

The heat transmission to or from the system remains constant given constant temperature conditions, but the change in temperature depends on:

- The rate of mass flow

- The specific heat capacity of the fluid. Variation in pressure during passage through the system is an additional consideration if the fluid is a gas or a vapour.

Logarithmic formula:

Where	tA	=	initial temperature (°C)
	tB	=	final temperature (°C)
	tM	=	ambient temperature (°C)
	tX	=	mean temperature of fluid (°C)
	G	=	mass flow rate (kg/s)
	c	=	specific heat capacity (J/kgK)
	L	=	length off pipe line (m)

5.2.9 SPECIFIC HEAT CAPACITIES AND DENSITIES

FLUID	SPECIFIC HEAT CAPACITY (kJ/kg K)		DENSITY kg/m^3		FLUID	SPECIFIC HEAT CAPACITY (kJ/kg K)		DENSITY kg/m^3	
Ammonia	4,45	(-50°C)	695	(-50°C)	Benzene	1,73	(20°C)	879	(20°C)
(Liquid)	5,07	(50°C)	561	(50°C)		1,97	(100°C)	793	(100°C)
Bitumen	2,09 - 2,30		1020 - 1060		Butane	2,28	(O°C)	601	(0°C)
Caster Oil	1,80		960		Chlorine	0,89	(-50°C)	1598	(-50°C)
						0,93	(0°C)	1469	(0°C)
Chloroform	0,97	(0°C)	1526	(0°C)	Ethane	3,52	(-150°C)	622	(-150°C)
	1,28	(100°C)	1433	(50°C)		4,81	(-100°C)		
Ethanol	2,40	(20°C)	789	(20°C)	Ethene	2,43	(-150°C)		
						2,41	(-100°C)	564	(-100°C)
Fuel Oil	1,67		915		Glycerol	2,26	(0°C)	1273	(0°C)
						2,81	(100°C)	1209	(100°C)
Methane	3.52	(-150°C)	409	(-150°C)	Methanol	1.42	(25°C)	790	(20°C))
Methyl	1,50	(-50°C)	1050	(-50°C)	Mineral Oil	1,67		450 – 950	
Chloride	1,55	(0°C)	960	(0°C)					
Muriatil acid	3,64		1639		Nitric acid	1,72		1502	
Nitrobenzene	1,47	(20°C)	1203	(20°C)	Oil of	1,76		870	
	1,51	(60°C)	1147	(50°C)	turpentine				
Olive oil	1,97		910		Petrol	2,09		700 – 740	
Petroleum	2,14		800		Phenol	2,20	(50°C)	1050	(50°C)
Sulphuric acid	1,42		1834		Tar	2,09	(0-100°C)	1200	
Toluene	1,61	(0°C)	885	(0°C)	Water	4,22	(0°C)	1000	(0°C)
	1,97	(100°C)	793	(100)		2,18	(50°C)	988	(50°C)

5.2.10 DEW POINT FOR RELATIVE HUMIDITIES FOR AMBIENT STILL AIR TEMPERATURES FROM -20°C TO + 50°C WITH STANDARD BAROMETRIC PRESSURE – BS 5422:1990

AMBIENT TEMPERATURE (in °C)	RELATIVE HUMIDITY (in %)									
	50	55	60	65	70	75	80	85	90	95
	DEW POINT TEMPERATURE (in °C)									
-20	-27,7	-26,0	-25,2	-24,5	-23,7	-22,9	-22,3	-21,7	-21,1	-20,5
-15	-22,3	-21,3	-20,4	-19,6	-18,8	-18,0	-17,5	-16,7	-16,2	-15,6
-10	-17,6	-16,6	-15,7	-14,7	-13,9	-13,2	-12,5	-11,8	-11,2	-10,6
-8	-15,7	-14,7	-13,7	-12,8	-12,0	-11,3	-10,5	-9,8	-9,2	-8,6
-6	-13,9	-12,8	-11,8	-10,9	-10,1	-9,9	-8,6	-7,9	-7,2	-6,6
-4	-12,0	-10,9	-9,9	-9,0	-8,1	-7,4	-6,6	-5,9	-5,3	-4,6
-2	-10,1	-9,0	-8,0	-7,1	-6,2	-5,4	-4,6	-3,9	-3,3	-2,6
0	-8,1	-7,1	-6,0	-5,1	-4,2	-3,4	-2,7	-1,9	-1,3	-0,6
2	-6,5	-5,4	-4,4	-3,4	-2,6	-1,7	-1,0	-0,2	0,5	1,3
4	-4,9	-3,8	-2,7	-1,5	-0,9	0	0,9	1,7	2,5	3,3
6	-3,2	-2,1	-1,0	0,1	0,9	2,0	2,8	3,7	4,5	5,3
8	-1,5	-0,5	-0,7	1,8	2,9	3,9	4,8	5,7	6,5	7,3
10	0,1	1,4	2,6	3,7	4,8	5,8	6,7	7,6	8,4	9,2
12	1,9	3,4	4,5	5,7	6,7	7,7	8,7	9,6	10,4	11,2
14	3,7	5,1	6,4	7,5	8,6	9,7	10,5	11,5	12,4	13,2
16	5,6	6,9	8,1	9,4	10,5	11,6	12,5	13,4	14,3	15,2
18	7,4	8,8	10,1	11,3	12,4	13,5	14,5	15,5	16,3	17,2
20	9,2	10,7	12,0	13,2	14,4	15,4	16,4	17,4	18,3	19,2
22	11,0	12,6	13,9	15,1	16,3	17,5	18,4	19,4	20,3	21,2
24	12,9	14,4	15,8	17,0	18,2	19,3	20,3	21,3	22,2	23,1
26	14,8	16,2	17,6	18,9	20,1	21,2	22,3	23,3	24,2	25,1
28	16,6	18,1	19,5	20,8	22,0	23,1	24,2	25,3	26,2	27,1
30	18,4	19,9	21,4	22,7	23,9	25,1	26,2	27,2	28,1	29,1
35	23,0	24,5	26,0	27,4	28,7	29,9	31,0	32,1	33,1	34,1
40	27,6	29,3	30,7	32,2	33,5	34,7	35,9	37,0	38,0	39,0
45	32,2	33,8	35,4	37,0	38,2	39,5	40,7	42,0	42,9	44,0
50	36,7	38,5	40,1	41,6	43,0	44,7	45,5	46,8	47,9	49,0

5.3 SYSTEM OF MEASUREMENT

METHOD OF MEASURING COMPLETED INSULATION

5.3.1 METHOD A

Applicable where contractor has quoted unit rate per linear metre of straight pipe and per each for pipefitting.

5.3.1.1 STRAIGHT PIPE

Shall be measured from origin to terminus point or junction, along the centerline of pipe. Measurements shall be through valves, flanges and fittings, but only if the valves, flanges and fittings are insulated. Elbows or bends shall be measured through to the intersection of the centre lines of the pipe. Reducers shall be counted as one fitting of the larger size involved, and omitted from the count of the smaller size. Tees shall be counted as one fitting, and if an unequal tee, shall be counted as a fitting of the smaller size. Quantities shall be to the nearest whole number (0.51 and larger to the whole number above).

5.3.1.2 FITTINGS - VALVES

Shall be counted per each. (Flanges on flanged valves shall be counted separately).

5.3.1.3 FLANGES

Shall be counted per pair of flanges. (Including flanges on valves and connections to vessels and equipment).

5.3.2 METHOD B

Applicable where the contract has quoted unit rate per square metre of completed insulation. Areas of completed insulation will be measured as defined in attached schedule. Should there be any items not detailed, the client and the contractor are to agree a system of measurement in advance.

Notes:

- All external insulation is measured over the outer surface area of the completed insulation.
- All internal insulation is measured over the surface area, which has been insulated.
- The method establishes actual areas of insulation, and makes no extra over allowance for difficulty of work as regards formwork or height. Should the contractor wish to charge an increased rate for difficult work he should specify to which items the quoted increased rate will apply.
- Quantities shall be calculated to the nearest whole number (0.51 and larger to the whole number above).

5.3.3 GENERAL

- Cutouts under 1,0m^2 are not deducted.
- End cap areas are measured to establish the actual surface area of insulation.
- Cut outs in such areas are treated as follows:

  a) If gross area of end cap is less than 1,0m^2 cutouts are not deducted.
  b) If gross area of end cap is 1,0m^2 or greater, deduct cutouts, but subject to rule (a) above.
  c) Pockets, niches, flattening shall be measured as if the cladding remains symmetrical.

5.4 CONVERSION FACTORS - (Per BS 2972: 1975)

5.4.1 VENTILATING AND MECHANICAL SERVICES					
1	2	3	4	5	6
Quantity	**Units and selected decimal multiples and submultiples**	**Unit symbol**	**Conversion factors**		**Remarks**
			British to SI	**SI to British**	
Customary temperature	Degree Celsius	°C *	n°F = 0,555 6 (n-32)°C n°F = $^5/_9$ (n-32) °C	n°C = (1,8n + 32) °F n°C = ($^9/_5$n + 32) °F	Temperature level "n" is the expressed temperature
Temperature interval	Degree Celsius	°C *	1 deg F = 0,555 6 deg C	1 deg C = 1,8 deg F	Temperature range or difference
Heat	Joule Kilojoule	J kJ	1 Btu = 1 055 J 1 Btu = 1,055 kJ	1J = 0,947 8 x 10^{-3} = Btu 1kJ = 0, 947 8 Btu	
Heat flow	Watt Kilowatt	W KW	1 Btu/h = 0,2931 W 1 Btu/h = 0,293 1 x 10^{-3} kW	1 W = 3,412 Btu/h 1 kW = 3,412 Btu/h	
Intensity of heat flow rate and radiation	Watt per square meter	W/m^2	1 Btu/ft^{2}h = 3,155 W/m^2	1 W/m^2 = 0,317 0 Btu/ft^{2}h	
Thermal conductivity	Watt per meter degree Celsius	W/m °C *	1 Btu in/ft^{2}h °F= 0,1442 W/m deg C	1 W/m deg C = 6,933 Btu in/ft^{2}h deg F	"k" value
Coefficient of heat transfer, thermal conductance of material of given thickness and of air spaces	Watt per square meter degree Celsius	W/m^2 °C *	1 Btu/ft^{2}h °F = 5,678 W/m^2 deg C	1 W/m^2 deg C = 0,176 Btu/ft^{2}h deg F	
Thermal resistivity	meter degree Celsius per watt	m deg * C/W	1 ft^2 deg F/BTU in = 6,933m deg C/W	1 m deg C/W = 0,1442 ft^{2}h deg F/Btu in	'R' value
Specific heat and thermal capacity	kilojoule per kilogram degree Celsius kilojoule per cubic meter degree Celsius	kJ / kg °C * kJ/m^3 °C *	1 Btu/lb deg F = 4,187 kJ/kg deg C 1 Btu/ft^3 = 67,07 kJ/m^3 deg F deg C	1 kJ/kg = 0,238 8 deg C Btu/lb deg F 1 kJ/m^3 = 0,014 91 deg C Btu/ft^3 deg F	
Calorific value	kilojoule per kilogram kilojoule per cubic meter	kJ/kg kJ/m^3	1 Btu/lb = 2,326 kJ/kg 1 Btu/ft^3 = 37,26 kJ/m^3	1 kJ/kg = 0,430 0 Btu/lb 1 kJ/m^3 = 0,026 84 Btu/ft^3	
Refrigeration	Watt	W	1 short ton = 3 517W 1 long ton = 3 939W	1 W = 0 000 284 3 short ton 1 W = 0 000 253 8 long ton	1 short ton = 12 000 Btu/h 1 long ton = 13 400 Btu/h
Gas velocity	meter per second	m/s	1ft/min = 0 005 080 m/s	1 m/s = 196,8 ft/min	
Gas delivery rate	Cubic meter per second	m^3/s	1 ft^3/min = 0,000472 m^3/s	1 m^3/s = 2 119ft^3/min	1 m^3/s = 35,31 ft^3/s

Note: °C can be substituted for K

5.4.2 WATER VAPOUR PERFORMANCE CONVERSION FACTORS – (BS 2972:1989)

	g/(s MN)	g/(cm^2 s mbar)	g/(m^2 24h mmHg) = 1 metric Perm	1b/(ft^2 h atm) (see note 2)	gr/(ft^2 h bar) (see note 4)	gr/(ft^2 h in Hg) = 1 perm	Temperate g/(m^2 24h)	Tropical g/(m^2 24h)
g/(s MN)	1	1 x 10^{-8}	1,152 x 10	7,471 x 10^{-2}	5,161 x 10^{-1}	1,749 x 10	2,052 x 10^{2}	5,149 x 10^{2}
g/(cm^2 s mbar)	1 x 10^{8}	1	1,152 x 10^{9}	7,471 x 10^{6}	5,161 x 10^{7}	1,749 x 10^{9}	2,052 x 10^{10}	5,149 x 10^{10}
g/(m^2 24h mmHg)	8,681 x 10^{-2}	8,681 x 10^{-10}	1	6,486 x 10^{-3}	4,481 x 10^{-2}	1,517	1,782 x 10	4,472 x 10
1b/(ft^2 h atm) (see note 2)	1,339 x 10	1,339 x 10^{-7}	1,542 x 10^{2}	1	6,909	2,339 x 10^{2}	2,747 x 10^{3}	6,896 x 10^{3}
gr/(ft^2 h mbar) (see note 4)	1,937	1,937 x 10^{-8}	2,233 x 10	1,447 x 10^{-1}	1	3,388 x 10	3,975 x 10^{2}	9,980 x 10^{2}
gr/(ft^2 h in Hg) = 1 perm	5,719 x 10^{-2}	5,719 x 10^{-10}	6,590 x 10^{-1}	4,275 x 10^{-3}	2,951 x 10^{-2}	1	1,174 x 10	2,948 x 10
Temperate g/(m^2 24 h)	4,874 x 10^{-3}	4,874 x 10^{-11}	5,613 x 10^{-2}	3,641 x 10^{-4}	2,515 x 10^{-3}	8,514 x 10^{-2}	1	See note 3
Tropical g/(m^2 24 h)	1,942 x 10^{-3}	1,942 x 10^{-11}	2,236 x 10^{-2}	1,450 x 10^{-4}	1,002 x 10^{-3}	3,392 x 10^{-2}	See note 3	1

Notes:

1. To convert units in the first column to the units shown in the heading multiply by the factor given at the intersection of the appropriate row and column
2. This was the term used by the building industry
1. No conversions from temperate to tropical are shown for the following reasons:

If it is desired to express the results normalized to a standard atmosphere this can be calculated from knowledge of the vapour pressure at each of the test conditions.

Temperature 25°C and 75 % r.h. = 0,0234 atmospheres
Tropical 38°C and 90 % r.h. = 0,0588 atmospheres

The standard atmosphere used for the purposes of this test is 1013,2 mbar * corresponding to a pressure of 760 mmHg of density 13,5951, gravitational acceleration being taken as the standard acceleration,
g_n (9,806 65 m/s^2). The vapour pressure of anhydrous calcium chloride is taken as zero.

The table enables the permeance to be expressed in other units. Where the results are converted to a standard atmosphere, or any of the units shown in this table, this original tests conditions shall be stated because the conversion factors to different units are only applicable to the same test conditions.

2. The symbol "gr" refer to grains

5.5 GLOSSARY OF TERMS

The definitions in this section are phrased in terms commonly used within the insulation industry. Although they may indicate a somewhat difference definition that appears in a dictionary or scientific glossary, they are, nevertheless, accurately turned to the ear of the insulation contractor or specifying engineer.

ABRASION RESISTANCE: See Mechanical Properties of Insulation

ABSORPTION: The property of a material, which allows it to take up liquids and to assimilate them.

ABUSE COVERINGS AND FINISHES: Jackets or mastics used to protect insulation from mechanical abuse.

ADHESION: The property of a material, which allows it to bond to the surface to which it is applied.

ADHESIVE: A substance capable of holding materials together by surface attachment.

AIR CONDITIONED SPACE: Building area supplied directly with conditioned air.

AIR CONDITIONING: See Conditioned Air

ALKALINITY: The tendency of a material to have a basic alkaline reaction. The tendency is measured on the pH scale, with all readings above 7,0 alkaline, and below 7,0 acidic.

AMBIENT: (adj.) Surrounding. (Generally applied to temperature, humidity and atmospheric conditions.)

AMBIENT TEMPERATURE (Ta): The temperature of the medium, usually air, surrounding the object under consideration.

APPEARANCE COVERING: A material or materials used over insulation to provide the desired colour or texture for aesthetic purposes.

APPLICATION TEMPERATURE LIMITES: Temperature range of a surface to which insulation materials are being applied that will not endanger the integrity of the insulation material and or finish at the point of application.

ASPHALT EMULSION: Petroleum asphalt in water. (This is breather mastic.)

ASPHALT CUTBACK: Petroleum asphalt in mineral solvents. (This is vapour-barrier mastic.)

ATTENUATION: The sound reduction process in which sound energy is absorbed or diminished.

BEND: See Pipe and Fittings.

BITUMEN: Hydrocarbon material of natural or pyrogenous origin which may be liquid, semi-solid, or solid and which is completely soluble in carbon disulfide.

BLANKET: Insulation of the flexible type, which may be fibrous glass, mineral wool, polyester fibres or polyamic fibre.

BLANKET – TURBINE: Insulation material and high temperature fabric fabricated into an insulating unit, which is installed on turbines and other irregular surfaces.

BLISTER: Rounded elevation of the surface of mastic somewhat resembling a blister on the human skin.

BLOCK: Rigid insulation formed into rectangular or curved shapes.

BOARD: Rigid or semi-rigid, self-supporting insulation formed into rectangular shapes.

BOND STRENGTH: The force in tension, compression, impact or cleavage required to break an adhesive assembly.

BONDING TIME: Time period after application of adhesive during which the adherents may be combined.

BREATHER MASTIC: mastic, which permits water vapour to pass through to the low-pressure side.

BRITISH THERMAL UNIT (Btu): The amount of heat necessary to raise one pound of water from 59°F to 60°F at sea level, atmospheric pressure.

"C" VALUE (Thermal Conductance): See Thermal Properties of Insulation.

CANVAS: A light, plain weave cotton fabric used for jacketing.

CAPILLARITY: The action by which the surface of a liquid where it is in contact with a solid is raised or lowered.

CASINGS: See Ducts, Housings and Fans.

CELLULAR GLASS: Glass produced in a closed-cell form through expanding the material into foam by thermal or chemical means.

CELLULAR INSULATION: See Insulation.

CELLULAR PLASTIC: Plastic expanded by thermal or chemical means and containing open and closed cells throughout.

CELSUIS: A metric system for measuring temperature in which the freezing point of water is 0° and the boiling point is 100° at sea level, atmospheric pressure.

CEMENTS:

> **INSULATING CEMENT:** A mixture of various insulating fibres and binders with water to form an insulation material for irregular surfaces.
>
> **FINISHING CEMENT:** A mixture of various long fibres and binders, which is applied over insulation to provide a hard, smooth finish.
>
> **ONE COAT CEMENT:** A mixture of various fibres and binders which results in a product which combines the insulating properties of an insulating cement and the aesthetic qualities of a finishing cement.

CENTIGRADE: See Celsius.

CHECKING: A defect in a coated surface characterized by the appearance of fine cracks in all directions.

CHEMICAL REACTION: The property of a material to combine or react with other materials to which it may come into contact.

CHEMICAL RESISTANCE: Capability of a material to withstand exposure to acids, alkalis, salts and their solutions.

CLOSED-CELL PLASTIC: A cellular plastic with a large predominance of non-interconnecting cells.

COATING: A liquid, or semi-liquid protective finish, applied to thermal insulation.

COEFFICIENT OF EXPANSION/CONTRACTION: See Mechanical Properties of Insulation.

COMBUSTIBLE: Capable of burning.

COMBUSTIBILITY: A measure of the tendency of a material to burn.

COMPACTION RESISTANCE: See Mechanical Properties of Insulation.

COMPRESSIVE STRENGTH: See Mechanical Properties of Insulation.

CONCEALED SPACES: Spaces not generally visible after the project is completed such as furred spaces, pipe spaces, pipe and duct shafts, and spaces above suspended ceilings, unfinished spaces, crawl spaces, attics and tunnels.

CONDENSATE: Hot – See Steam Supply and Condensate Return. Cold – See Condensate Drain.

CONDENSATE BARRIER: A coating or laminate on the inner surface of metal jacketing.

CONDENSATE DRAIN: Piping carrying condensed water from air conditioning or refrigeration drip pans to a point of discharge.

CONDENSATION: The act of water vapour turning into liquid water upon contact with a cold surface.

CONDITIONED AIR: Air treated to control simultaneously its temperature, humidity and cleanliness to meet the requirements of a conditioned space. (May be cool and/or heated and should be clearly defined).

COLDFACE: The surface to be insulated (Cold insulation).

CONDITIONED SPACE: See Air Conditioned Space.

CONDUCTION: The transfer of heat energy within a body or between two bodies in physical contact.

CONDUCTIVITY (K): See Thermal Properties of Insulation.

CONTACT ADHESIVE: An adhesive which when dry to the tough will adhere to itself instantaneously to contact.

CONVECTION: The transfer of heat by movement of fluids.

COUPLINGS: See Pipe and Fittings.

COVER: (v) To place insulation and/or finish materials on, over or around a surface so as to insulate, protect or seal.

COVERAGE: The rate in m^2/Lt (coatings), or Lt per m^2 (mastics), at which products must be applied to obtain satisfactory performance.

CRYOGENIC INSULATION: See Insulation.

CURE: To change the properties of a plastic or resin by chemical reaction, usually accomplished by the action of either heat or a catalyst.

CURING AGENT: An additive incorporated in a coating or adhesive resulting in an increase or decrease in the rate of cure.

DELAMINATION: The separation of the layers of material in a laminate.

DEW POINT: The temperature at which the quantity of water vapor within a material or in the air surrounding a material reaches saturation, with resultant condensation of the vapor into liquid by any further reduction of temperature.

DIMENSIONAL STABILITY: See Mechanical Properties of Insulation.

DRY: (v.) To change the physical state of a substance where the solvent's constituents are lost by evaporation, absorption, oxidation, or a combination of these factors.

DUCTS, HOUSING AND FANS:

> **DUCT:** A passageway made of sheet metal or other suitable material used for conveying air or other gas.
>
> **DUCT FLANGE (Stiffener):** A perpendicular projection exterior to a duct wall composed of structural shapes such as pocket type transverse joints or reinforcement angles.
>
> **EXHAUST DUCT:** A duct carrying air from a conditioned space to an outlet outside the building.
>
> **FAN:** A mechanical air-moving device.
>
> **FRESH AIR DUCT:** Any duct used to convey outdoors air to a point within a building, terminating at a mixing plenum or duct, air handling equipment or discharge grille.
>
> **HIGH VELOCITY DUCT:** A duct with airflow designed at over 10.16 m/s velocity with a static pressure exceeding 152.4mm.
>
> **HOUSINGS (Castings):** Enclosures of sheet metal or other material to house fans, coils, filters or other components of air handling equipment.
>
> > **BUILT-UP:** Assembled at the construction site.
> >
> > **MANUFACTURED PACKAGE:** Assembled by the manufacturer. (The unit may or may not be factory-insulated).
>
> **LOW VELOCITY DUCT:** A duct with airflow designed at not more than 10.16 m/s velocity with a static pressure not above 50.2mm.
>
> **MEDIUM VELOCITY DUCT:** A duct with airflow designed at over 10.16 m/s velocity with a static pressure below 152.4mm.

MIXED AIR DUCT: A duct located at a point where air returned from a space inside the building and air from outside the building is mixed for redistribution.

PLENUMS (Sheet Metal): Enclosures for the collection of air at the termination or origin of duct systems.

RETURN (recirculating) DUCT: A duct carrying air from a conditioned space to an air-handling unit.

SUPPLY AIR DUCT: A duct that carries conditioned air from air supply units to room diffusers or grilles.

VENTILATING DUCT: General ductwork involved with the process of supplying or removing air by natural or mechanical means, to or from any space.

ELASTOMETRIC: A foamed plastic insulation containing elastomers, which lend it the property of high elasticity.

EMMISIVITY (E): See Thermal Properties of Insulation.

EMULSION: A colloidal suspension of one liquid in another, usually water based material.

EXPANDED METAL: A lattice type of material of various gauges and sizes used to provide reinforcement for insulation materials.

EXPOSED SPACES: Those spaces not referred to as concealed or as defined by the specifier.

FABRIC: A material used for reinforcing or finishing surfaces of insulation materials. (See Glass Cloth, Glass Fabric, etc.)

FACING: A thin layer or laminate, usually factory applied, on the surface of an insulating material.

FAHRENHEIT (°F): A temperature scale with the freezing point at 32° and the boiling point at 212°, sea level, atmospheric pressure.

FELT: An insulation material composed of fibres of one or more kinds, which are interlocked and have been compacted under pressure.

FIBRE GLASS: A composite material consisting of glass fibres with a resin binder.

FILL INSULATION: See Insulation.

FILM (Wet): The layer of mastic or coating applied before curing or drying.

FINISHING AND INSULATING CEMENT: See Cements.

FIRE RESISTANCE: That property of a material, which enables it to resist fire.

FIRE RETARDANCE: That property of a material, which retards the spread of fire.

FISH-MOUTH: A gap between layers of sheet materials caused by warping or bunching of one or both layers.

FITTINGS: See Pipe and Fittings.

FITTING COVER: The insulation for a pipe fitting composed of the specified thickness of insulation material and preformed into its proper shape before application.

FLAME SPREAD: The rate expressed in distance and time at which a material will propagate flame on its surface.

FLAMMABILITY: That property of a material, which allows continuous, burning, as compared to a standard material.

FLANGE COVER: The insulation for a pipe flange composed of the specified thickness of insulation material and preformed into its proper shape before application.

FLANGES: See Pipe and Fittings, or Duct Flange.

FLASH POINT: The temperature at which combustion is initiated.

FLASHING: A strip of material installed at the junction of two planes to divert water or any substance.

FLEXIBILITY: See Mechanical Properties of Insulation.

FOAMED PLASTIC: See Cellular Plastic.

FREEZE-THAW RESISTANCE: See Thermal Properties of Insulation.

FRESH AIR: Air taken from outdoors.

FUEL: Basic substance to produce heat energy.

FUEL CONTRIBUTION: Flammable by-products of fire generated by and emitted from a burning object.

GLASS – CELLULAR: See Cellular Glass.

GLASS CLOTH: Closed weave glass fibre used s a finish jacket.

GLASS FABRIC: Open weaves glass fibre used for reinforcing mastic or coating finish on insulating materials.

GLASS FIBER: See Fibre Glass.

GLOSS: A term used to express the shine, sheen, or lustre of a dried film.

HANGER (Insulation): A device such as a welded pin, stud or adhesive secured fastener, which carries the weight of insulation.

HANGER (Pipe): See Pipe and Fittings.

HEAT: The form of energy that is transferred by virtue of a temperature difference or a change of state.

HEATED SPACE: Building area supplied directly with heat.

HEXAGONAL WIRE MESH: Poultry netting, chicken wire, etc. (See Netting)

HIGH RIB LATH: A metal lath with a built-in rib used to provide air space under insulation applications.

HOTFACE: The surface to be insulated (Hot Insulation).

HOUSINGS: See Ducts, Housings and Fans.

HUBS: See Pipe and Fittings.

HUMIDITY: A measure of the amount of water vapour in the atmosphere.

IGNITION: The initiation of combustion.

IGNITION TEMPERATURE: The minimum temperature required to initiate combustion.

IMPACT RESISTANCE: Capability of an insulation material and/or finish to withstand mechanical or physical abuse.

INSULATE: To cover with a material of low conductivity in order to reduce the passage or leakage of heat.

INSULATING CEMENT: See Cement.

INSULATION: Those materials or combination of materials, which retard the flow of heat.

> **CELLULAR:** Insulation composed of small individual cells separated from each other. The cellular may be glass or plastic such as polystyrene (closed cell), polyurethane and elastomeric.
>
> **CRYOGENIC:** Insulation for extremely low temperature surfaces from (-100°C to absolute zero -273°C).
>
> **FIBROUS:** Insulation composed of small diameter fibres, which finely divide the air space. Fibres used are silica, rock wool, slag wool or alumina silica.
>
> **GRANULAR:** Insulation composed of small modules, which contain void or hollow spaces. The material may be calcium silicate, diatomaceous earth, expanded vermiculite, perlite or cellulose.

LOOSE OR FILL: Insulation consisting of loose granules, fibres, beads, flakes, and etc. These must be contained and are usually placed in cavities.

REFLECTIVE: Insulation composed of closely spaced sheets of either aluminium or stainless steel, which obtains its insulating value from the ability of the sheets to reflect a large part of the radiant energy incident on them.

REFRACTORY: Insulation of extremely high temperatures above 1500°F.

SPRAYED-ON INSULATION: Insulation of the fibrous or foam type, which is applied to a surface by means of power spray devices.

THERMAL: Insulation applicable within the general temperature range of -150°F to 1500°F.

UNDERGROUND: Insulation applied on piping and equipment located below grade and in direct contact with the surrounding soil.

JACKET: A covering placed over insulation for various functions. See Section II.

"K" (Conductivity): See Thermal Properties of Insulation.

LAG: **(v.)** To apply lagging. **(n.)** A single piece of lagging material.

LAGGING – INSULATION: A block material for insulating tanks and boilers, usually curved or tapered and can be made from any of several insulation materials.

LAGGING – METAL: Metal covering installed over insulation. (See Metal Jacketing.)

LAMINATE: **(n.)** A product made by bonding together two or more layers of material or materials.

LAP ADHESIVE: The adhesive used to seal the sides and laps of insulation jackets.

LATH – PLASTER: Plasterer's lath. (See also High Rib Lath and Expanded Metal).

LINEAR EXPANSION OR CONTRACTION: See Mechanical Properties of Insulation – COEFFICIENT OF EXPANSION.

LOG MEAN (Radius): The equivalent value of insulation pipe thickness (curved surfaces) to product the same resistance to heat flow as per flat areas.

MASTIC: A protective coating, usually a petroleum or base product, applied by spray or trowel to weather proof or otherwise prevent deterioration of the insulation to which it is applied.

MAT: A piece of insulation of the semi-flexible type, cut into easily handled sizes, usually square or rectangular in shape, composed of fibres of one or more kinds in which the fibres are in random arrangement.

MEAN TEMPERATURE: Operating temperature + Ambient ÷ 2. (Thermal Conductivity charts are calculated to use mean temperatures).

MECHANICAL COUPLINGS: See Pipe Fittings.

MECHANICAL PROPERTIES OF INSULATION:

ABRASION RESISTANCE: The ability of a material to withstand abrasion without wearing away.

BREAKING LOAD: That load, concentrated in the middle of a span, which will just break a measured sample of insulation under test.

COEFFICIENT OF EXPANSION/CONTRACTION: The change in a unit length of a material corresponding to a unit change in the temperature of the material.

COMPACTION RESISTANCE: That property of a fibrous or loose fill material, which resists compaction under load or vibratory conditions.

COMPRESSIVE STRENGTH: That property of an insulation material that resists any change in dimensions when acted upon by a compaction force.

DIMENSIONAL STABILITY: That property of a material, which enables it to hold its original size, shape and dimensions.

FLEXIBILITY: That property of a material, which allows it to be bent (flexed) without loss of strength.

PUNCTURE RESISTANCE: That property of a material, which enables it to resist punctures of perforations under blows or pressure from sharp objects.

RESILIENCY: That property of a material, which enables it to recover its original thickness after compression.

RESISTANCE TO AIR EROSION: The property, which indicates the ability of an insulation material to resist erosion by air currents over its surface.

RIGIDITY: That property of a material, which opposes any tendency for it to bend (flex) under load.

SHEAR STRENGTH: The property of a material, which indicates its ability to resist cleavage.

SHRINKAGE: The property of a material, which indicates its proportionate loss in dimensions or volume when its temperature is changed.

TEAR STRENGTH: That property of a material, which enables it to resist being pulled apart by opposing forces.

VIBRATION RESISTANCE: The property of a material, which indicates its ability to resist mechanical vibration without wearing away, settling or dusting off.

MEMBRANE REINFORCEMENT: See Glass Fabric.

METAL JACKETING: See Jacketing.

MIL: A unit used in measuring thickness (0.001”).

MINERAL WOOL (Fiber): A general generic term, which applies to all types of inorganic fibrous insulations.

MOISTURE BARRIER: See Condensate Barrier.

MOLD AND MILDEW RESISTANCE: That property of a material, which enables it to resist the formation of fungus growths.

NETTING: Interwoven wires of metal used as reinforcement. (See Hexagonal Mesh).

NONCOMBUSTIBLE: A material that will not contribute fuel or heat to a fire to which it is exposed.

NONFLAMMABLE: A material that will not release heat when exposed to fire or flame.

PANEL: A prefabricated unit of insulation and lagging.

PERLITE: A material composed of volcanic rock and produced in expanded cellular form or loose fill.

PERMEABILITY: See Water Vapor Permeability.

PERMEANCE (Perms): See Water Vapor Permeance.

PERSONNEL PROTECTION: Insulation installed for the purpose of protecting personnel from high temperature surfaces.

PINHOLE: Very small hole through a mastic or coating.

PHENOLIC FOAM: A foamed insulation made from resins of phenols condensed with aldehydes.

PIPE AND FITTINGS:

PIPE: A circular conduit for the conveyance of liquids or semisolids.

BENDS (Tube Turns): Pipe, factory or field formed, to predetermined radii.

COUPLINGS: Screwed, soldered or welded connections between links of pipe.

FITTINGS: Items used to change size, direction of flow, level or assembly of piping, except for unions, grooved couplings, flanges, valves or strainers.

HANGERS: Devices used to support piping.

HUBS: Caulking or cement connections between pipe joints.

MECHANICAL COUPLINGS: Bolting devices used in assembly of piping such as Victaulic couplings for grooved piping.

STRAINER: A filter or sieve used in fluid piping to trap scale and other entrained particles.

UNIONS: A coupling device for connecting pipes.

VALVES: Any of various devices that regulate liquid or gas flow by opening, closing or obstructing its passage. They may be of the flanged, screwed, sweated, "body only" or welded types.

PLENUMS: Enclosures for the collection of air at the termination or origin of duct systems. They may be a space below floors, above ceilings, a shaft or a furred area. (See Ducts, Housings and Fans for the Sheet Metal type.)

POLYESTER FIBRE: Synthetic material that is a polymer containing recurring –coo- groups.

POLYSTYRENE: A resin made by polymerisation of styrene as the sole monomer.

POLYURETHANE: A resin made by the condensation of organic isocynates with compounds or resin that contain hydroxyl groups.

POLYVINYL CHLORIDE (PVC): A polymerised vinyl compound.

PRESSURE SENSITIVE TAPE: A tape with adhesive pre-applied.

PUNCTURE RESISTANCE: See Mechanical Properties of Insulation.

"R" VALUE (Resistance): See Thermal Properties of Insulation.

RADIANT HEAT: That heat transmitted through space by wave motion.

RADIATION: The passage of heat from one object to another without warming the space between.

REFLECTIVE INSULATION: See Insulation.

REFRACTORY INSULATION: See Insulation.

REFRACTORY MATERIALS: Materials, usually fibres, which do not significantly deform or change chemically at high temperatures. Manufactured in blanket, block, and brick or cement form.

REINFORCING CLOTH OR FABRIC: A woven cloth or fabric of glass or resilient fibres used as reinforcement to a mastic vapour/weather barrier.

REINSULATE: To repair insulation to its former condition. (If insulation is to be removed and replaced, it should be so stated).

RESILIENCY: See Mechanical Properties of Insulation.

RESISTANCE (R): See Thermal Properties of Insulation.

RESISTANCE TO ACIDS, CAUSTICS, AND SOLVENTS: The property of a material to resist decomposition by various acids, caustics and solvents to which it may be subjected.

RESISTANCE OT AIR EROSION: See Mechanical Properties of Insulation.

RETROFIT: The application of additional insulation over existing insulation, new insulation after old insulation has been removed, or new insulation over existing, previously non-insulated surfaces.

RETURN AIR: Air returned from conditioned spaces to an air-handling unit.

RETURN DUCT: See Ducts, Housing and Fans.

RIGID WRAP-AROUND INSULATION: Segments of insulation material that have been adhered to a facing giving rigid insulation materials flexibility of application.

"S" CLIP: A support device for banding or jacketing.

SELF-EXTINGUISHING: That property of a material, which enables it to stop its own ignition after external ignition sources are removed.

SEAL: (v.) To make watertight.

SEALER: A liquid coating or mastic used to prevent excessive absorption of finish coats into porous surfaces.

SECUREMENTS (Insulation): Any device, wire, strap or adhesive used to fasten insulation into its service position and hold it there.

SHEAR STRENGTH: See Mechanical Properties of Insulation.

SHELF LIFE: The period of time during which a packaged adhesive, coating, or sealant can be stored under specified temperature conditions and remain suitable for use.

SHRINKAGE: See Mechanical Properties of Insulation.

SILICATE: A pipe covering or block insulation manufactured from a granular compound containing silicon, oxygen and a metallic or organic radical.

SMOKE DENSITY: The amount of smoke given off by the burning material compared to the amount of smoke given off by the burning of standard material.

SOLAR RESISTANCE: The property of a material to resist decomposition by the ultra-violet rays from the sun or the passage of radiant heat from the sun.

SOLIDS COTENT: The percentage of the non-volatile matter in adhesives, coatings or sealants.

SOLVENT: Any substance, usually a liquid, which dissolves another substance.

SPRAYED-IN-PLACE INSULATION: See Insulation.

STEAM SUPPLY AND CONDENSATE RETURN:

> **CONDENSATE:** The liquid formed by condensation of vapor. In stream heating it is water condensed from steam. In air conditioning it is the water extracted from the air by cooling.
>
> **HIGH PRESSURE CONDENSATE:** That condensate directly received from high-pressure streamlines.
>
> **HIGH PRESSURE STEAM:** Steam at or above 5.28 kg/cm^2
>
> **LOW PRESSURE CONDENSATE:** That condensate directly received from low-pressure stream.
>
> **LOW PRESSURE STEAM:** Steam at or below 1.05 kg/cm^2.
>
> **MEDIUM PRESSURE CONDENSATE:** That condensate directly received from medium pressure steam.
>
> **MEDIUM PRESSURE STEAM:** Steam under 5.28 kg/cm^2, but above 1.05 kg/cm^2.
>
> **PUMPED CONDENSATE (Discharge):** Condensate in liquid state from condensate receivers to feed water heaters, deaerators or boilers.

STUD: Used to hold heavy insulation and/or panels in place. Applied with arch welder, studs differ from pins in that studs are generally 6mm or greater in diameter.

SUPPLY DUCT: See Duct.

SUPPLY MAINS: The source of a piping system where the run outs and risers originate from.

SUPPORT (Insulation): A device, which carries the weight of insulation.

SURFACE TEMPERATURE (Ta): The surface temperature of finished insulation.

TACK: The property of an adhesive that enables it to form a measurable bond immediately after adhesive and adherent are brought into contact under low pressure.

TEAR STRENGTH: See Mechanical Properties of Insulation.

TEMPERATURE LIMITES: See Thermal Properties of Insulation.

THERMAL INSULATION: See Insulation.

THERMAL PROPERTIES OF INSULATION:

> **CONDUCTANCE (C):** Transfer of heat through the vibration of molecules within a fiber or between fibers in physical contact with each other.
>
> **CONDUCTIVITY (K-or λ-value):** The amount of heat transferred in a unit time through a unit area and unit thickness with a unit temperature difference between the two surfaces.
>
> **EMMISIVITY (E):** The ability of a surface to radiate energy as compared to that emitted by an ideal black body at the same temperature.
>
> **FREEZE/THAW RESISTANCE:** The property of a material, which permits it to be alternately frozen and thawed through many cycles without damage.
>
> **RESISTANCE (R):** A measure of the ability to retard heat flow rather than the ability to transmit heat. "R" is the numerical reciprocal of "U" or "C", thus combination with numerals to designate thermal resistance values: R-11 equals 11 resistance units. The higher the "R", the higher the insulating value.
>
> **TEMPERATURE LIMITS:** The upper and lower temperatures at which a material will experience no change in its properties.

THERMAL SHOCK RESISTANCE: The property of a material that indicates its ability to be subjected to rapid temperature changes without physical failure.

TRANSMITTANCE (U): The combined thermal value of all the materials in a building section, air spaces and surface air films. It is the time rate of heat flow and usually expressed as watt (W).

THERMAL SHOCK RESISTANCE: See Thermal Properties of Insulation.

TRACED: The supplying of auxiliary heat to a pipe or piece of equipment by means of a companion line containing a hot fluid or electric resistance. It can be thermally or mechanically bonded to the pipe or equipment.

TUBE TURNS: See Pipe and Fittings.

VALVES: See Pipe and Fittings.

VAPOUR-BARRIER: A material or materials which when installed on the high vapor pressure side of a material retard of the moisture vapor to the lower vapor pressure side.

VENTILATING AIR: Air supplied to or removed from a source by natural or mechanical means.

VIBRATION RESISTANCE: See Mechanical Properties of Insulation.

WARPAGE: The change in the flatness of a material caused by differences in the temperatures and/or humidity's applied to opposite surfaces of the material.

WASHER (Insulation): Used with weld pins to hold insulation in place.

WATER ABSORPTION: The increase in weight of a test specimen expressed as a percentage of its dry weight after immersion in water for a specified time.

WATERPROOF: (adj.) Impervious to prolonged exposure to water.

WATER RESISTANT: Capable of withstanding limited exposure to water.

WATER VAPOUR PERMEABILITY: The property of a substance that permits passage of water vapour and is equal to the permeance of an 1 inch thickness of the substance. Permeability is measured in perm inches.

WATER VAPOUR PERMEANCE: The ratio of water vapour flow to the vapor pressure difference between the two surfaces of a sheet of material (or the assembly between parallel surfaces). Permeance is measured in perms.

WEATHER-BARRIER: A material or materials which, when installed on the outer surface of thermal insulation, protects the insulation from weather damage incurred by rain, snow, sleet, wind, solar radiation and atmospheric contamination.

WEATHER/VAPOUR-BARRIER: A material, which combines the properties of a weather-barrier and a vapour-barrier.

WELD PIN: Made of carbon steel, stainless steel or aluminium in various lengths for attaching insulation to metal surfaces. Applied by welding, manufactured in 10, 12 and 14 gauges.

WELD STUD: See Stud.

WICKING: Action of absorbing by capillary action.

"Z" CLIP: See "S" Clip.