SECTION 2: INSULATION MATERIALS AND PROPERTIES

SECTION 2

INSULATION MATERIALS AND PROPERTIES

2.1 DEFINITION OF INSULATION

Insulations are defined as those materials or combinations of materials which retard the flow of heat energy by performing one or more of the following functions:

1. Conserve energy by reducing heat loss or gain.
2. Control surface temperatures for personnel protection and comfort.
3. Facilitate temperature control of process.
4. Prevent vapour flow and water condensation on cold surfaces.
5. Increase operating efficiency of heating/ventilating/cooling, plumbing, steam, process and power systems found in commercial and industrial installations.
6. Prevent or reduce damage to equipment from exposure to fire or corrosive atmospheres.
7. Assist mechanical systems in meeting criteria in food and cosmetic plants.
8. Reduce emissions of pollutants to the atmosphere.

The temperature range within which the term **"thermal insulation"** will apply, is from -75°C to 815°C. All applications below -75°C are termed **"cryogenic"**, and those above 815°C are termed **"refractory"**.

Thermal insulation is further divided into three general application temperature ranges as follows:

A. LOW TEMPERATURE THERMAL INSULATION

1. From15°C through 1°C - i.e. Cold or chilled water.
2. 0°C through -40°C - i.e. Refrigeration or glycol.
3. -41°C through -75°C - i.e. Refrigeration or brine.
4. -76°C through -273°C (absolute zero) - i.e. Cryogenic. (Not addressed in this manual).

B. INTERMEDIATE TEMPERATURE THERMAL INSULATION

1. 16°C through 100°C - i.e. Hot water and steam condensate.
2. 101°C through 315°C - i.e. Steam, high temperature hot water.

C. HIGH TEMPERATURE THERMAL INSULATION

1. 316°C through 815°C - i.e. Turbines, breechings, stacks, exhausts, incinerators, boilers.

2.2 GENERIC TYPES AND FORMS OF INSULATION

Insulations will be discussed in this manual according to their generic types and forms. The type indicates composition (i.e. glass, plastic) and internal structure (i.e. cellular, fibrous). The form implies overall shape or application (i.e. board, blanket, pipe covering).

2.2.1 TYPES

1. Fibrous Insulation - composed of small diameter fibers which finely divide the air space. The fibers may be perpendicular or parallel to the surface being insulated, and they may or may not be bonded together. Silica, rock wool, slag wool and alumina silica fibers are used. The most widely used insulations of this type are glass fiber and mineral wool. Glass fiber and mineral wool products usually have their fibers bonded together with organic binders that supply the limited structural integrity of the products.

2. Cellular Insulation - composed of small individual cells separated from each other. The cellular material may be glass or foamed plastic such as polystyrene (closed cell), polyisocyanurate and elastomeric.

3. Granular Insulation - composed of small nodules which may contain voids or hollow spaces. It is not considered a true cellular material since gas can be transferred between the individual spaces. This type may be produced as a loose or pourable material, or combined with a binder and fibers or undergo a chemical reaction to make a rigid insulation. Examples of these insulations are calcium silicate, expanded vermiculite, perlite, cellulose, diatomaceous earth and expanded polystyrene.

2.2.2 FORMS

Insulations are produced in a variety of forms suitable for specific functions and applications. The combined form and type of insulation determine its proper method of installation. The forms most widely used are:

1. Rigid boards, blocks, sheets, and pre-formed shapes such as pipe insulation, curved segments, lagging etc. Cellular, granular, and fibrous insulations are produced in these forms.

2. Flexible sheets and pre-formed shapes. Cellular and fibrous insulations are produced in these forms.

3. Flexible blankets. Fibrous insulations are produced in flexible blankets.

4. Cements (insulating and finishing). Produced from fibrous and granular insulations and cement, they may be of the hydraulic setting or air drying type.

5. Foams. Poured or froth foam used to fill irregular areas and voids. Spray used for flat surfaces.

2.3 PROPERTIES OF INSULATION

Not all properties are significant for all materials or applications. Therefore, many are not included in manufacturers' published literature or in the **Table of Properties** which follows this section. In some applications, however, omitted properties may assume extreme importance (i.e. when insulations must be compatible with chemically corrosive atmospheres.)

If the property is significant for an application and the measure of that property cannot be found in manufacturers' literature, effort should be made to obtain the information directly from the manufacturer, testing laboratory or insulation contractors association.

The following properties are referenced only according to their significance in meeting design criteria of specific applications. More detailed definitions of the properties themselves can be found in the **Glossary**.

2.3.1 THERMAL PROPERTIES OF INSULATION

Thermal properties are the primary consideration in choosing insulations. Refer to the following **Glossary** for definitions.

a. **Temperature limits**: Upper and lower temperatures within which the material must retain all its properties.

b. **Thermal conductance "C"**: The time rate of steady state heat flow through a unit area of a material or construction induced by a unit temperature difference between the body surfaces.

c. **Thermal conductivity "K"**: The time rate of steady state heat flow through a unit area of a homogeneous material induced by a unit temperature gradient in a direction perpendicular to that unit area.

d. Emissivity "E": The **emissivity** of a material (usually written ε or e) is the relative ability of its surface to emit energy by radiation. It is the ratio of energy radiated by a particular material to energy radiated by a black body at the same temperature.

e. **Thermal resistance "R":** Resistance of a material to the flow of heat.

f. **Thermal transmittance "U"**: The overall conductance of heat flow through an "assembly".

2.3.2 MECHANICAL AND CHEMICAL PROPERTIES OF INSULATION

Properties other than thermal must be considered when choosing materials for specific applications. Among them are:

a. **Alkalinity (pH) or acidity**: Significant when moisture is present. Also insulation must not contribute to corrosion of the system. **See Section 3**.

b. **Appearance**: Important in exposed areas and for coding purposes.

c. **Breaking load:** In some installations the insulation material must "bridge" over a discontinuity in its support. This factor is however most significant as a measure of resistance to abuse during handling.

d. **Capillarity**: Must be considered when material may be in contact with liquids.

e. **Chemical reaction:** Potential fire hazards exist in areas where flammable chemicals are present. Corrosion resistance must also be considered.

f. **Chemical resistance:** Significant when the atmosphere is salt or chemical laden and when pipe content leaks.

g. **Coefficient of expansion and contraction**: Enters into the design and spacing of expansion/contraction joints and/or use of multiple layer insulation applications.

h. **Combustibility:** One of the measures of a material's contribution to a fire hazard.

i. **Compressive strength:** Important if the insulation must support a load or withstand mechanical abuse without crushing. If, however, cushioning or filling in space is needed as in expansion/contraction joints, low compressive strength materials are specified.

j. **Density:** A material's density may affect other properties of that material, such as compressive strength. The weight of the insulated system must be known in order to design the proper support.

k. **Dimensional stability:** Significant when the material is exposed to temperature; expansion or shrinkage of the insulation may occur resulting in stress cracking , voids, sagging or slump.

l. **Fire retardancy:** Flame spread and smoke developed ratings are of vital importance; referred to as "surface burning characteristics".

m. **Resistance to ultraviolet light:** Significant if application is outdoors and high intensity indoors.

n. **Resistance to fungal or bacterial growth:** Is important in all insulation applications.

o. **Shrinkage:** Significant on applications involving cements and mastics.

p. **Sound absorption coefficient:** Must be considered when sound attenuation is required, as it is in radio stations, some hospital areas where decibel reduction is required.

q. **Sound transmission loss value:** Significant when constructing a sound barrier.

r. **Toxicity:** Must be considered in the selection of all insulating materials.

2.4 MAJOR INSULATION MATERIALS

The following is a general inventory of the characteristics and properties of major insulation materials used in commercial and industrial installations. **See the Insulation Property Tables at the end of Section 2 for a comparative review**.

2.4.1 CALCIUM SILICATE

Calcium silicate insulation is composed principally of hydrous calcium silicate which usually contains reinforcing fibers; it is available in molded and rigid forms. Service temperature range covered is 35°C to 815°C. Flexural and compressive strength is good. Calcium silicate is water absorbent. However, it can be dried out without deterioration. The material is non-combustible and used primarily on hot piping and surfaces. Jacketing is field applied.

2.4.2 MINERAL FIBER

a. **Glass**: Available as flexible blanket, rigid board, pipe covering and other pre-molded shapes. Service temperature range is -40°C to 232°C. Fibrous glass is neutral; however, the binder may have a pH factor. The product is non-combustible and has good sound absorption qualities.

b. **Rock and Slag**: Rock and slag fibers are bonded together with a heat resistant binder to produce mineral fiber or wool. Upper temperature limit can reach 1035°C. The same organic binder used in the production of glass fiber products is also used in the production of most mineral fiber products. Mineral fiber products are non-combustible and have excellent fire properties.

2.4.3 CELLULAR GLASS

Available in board and block form capable of being fabricated into pipe covering and various shapes. Service temperature range is -273C to 200°C and to 650°C in composite systems. Good structural strength, poor impact resistance. Material is non-combustible, non-absorptive and resistant to many chemicals.

2.4.4 EXPANDED SILICA, OR PERLITE

Insulation material composed of natural or expanded perlite ore to form a cellular structure; material has a low shrinkage coefficient and is corrosion resistant; non-combustible, it is used in high and intermediate temperature ranges. Available in pre-formed sections and blocks.

2.4.5 ELASTOMERIC FOAM

Foamed resins combined with elastomers to produce a flexible cellular material. Available in pre-formed sections or sheets, Elastomeric insulation offer water and moisture resistance. Upper temperature limit is 105^{o}C . Product is resilient. Fire resistance should be taken in consideration.

2.4.6 FOAMED PLASTIC

Insulations produced from foaming plastic resins create predominately closed cellular rigid materials. "K" values decline after initial use as the gas trapped within the cellular structure is eventually replaced by air. Check manufacturers' data. Foamed plastics are light weight with excellent cutting characteristics. The chemical content varies with each manufacturer. Available in pre-formed shapes and boards, foamed plastics are generally used in the lower intermediate and the entire low temperature ranges. Consideration should be made for fire retardancy of the material.

2.4.7 REFRACTORY FIBER

Refractory Fiber insulations are mineral or ceramic fibers, including alumina and silica, bonded with extremely high temperature inorganic binders, or a mechanical interlocking of fibers eliminates the need for any binder. The material is manufactured in blanket or rigid form. Thermal shock resistance is high. Temperature limits reach 1750°C. The material is non-combustible.

The use and design of refractory range materials is an engineering art in its own right and is not treated fully in this manual, although some refractory products can be installed using application methods illustrated here.

2.4.8 INSULATING CEMENT

Insulating and finishing cements are a mixture of various insulating fibers and binders with water and cement, to form a soft plastic mass for application on irregular surfaces. Insulation values are moderate. Cements may be applied to high temperature surfaces. Finishing cements or one-coat cements are used in the lower intermediate range and as a finish to other insulation applications. Check each manufacturer for shrinkage and adhesion properties.

2.5 PROTECTIVE COVERINGS AND FINISHES

The efficiency and service of insulation is directly dependent upon its protection from moisture entry and mechanical and chemical damage. Choices of jacketing and finish materials are based upon the mechanical, chemical, thermal and moisture conditions of the installation, as well as cost and appearance requirements.

Protective coverings are divided into six functional types.

2.5.1 WEATHER RETARDERS

The basic function of the weather-barrier is to prevent the entry of water, ice, snow or atmospheric residue into the insulation. Sunlight and ozone can also damage certain insulations. Applications may be either jacketing of metal or plastic, or a coating of weather-barrier mastic. Jacketing must be over-lapped sufficiently to shed water. Avoid the use of plastic jacketing materials with low resistance to ultraviolet rays unless protective measures are taken.

2.5.2 VAPOUR RETARDERS

Vapour retarders are designed to retard (slow down) the passage of moisture vapour from one side of its surface to the other. Joints and overlaps must be sealed with a vapour tight adhesive or sealer free of pin holes or cracks. Vapour retarders take three forms:

a. Rigid jacketing - plastic fabricated jackets to the exact dimensions required and sealed vapour retarding.

b. Membrane jacketing - laminated foils, treated or coated products and plastic films which are field or factory applied to the insulation material. (Additional sealing beyond the factory seal may be necessary depending on temperature/humidity conditions of the installation.)

c. Mastic applications - solvent types which provide a seamless coating but require time to dry.

2.5.3 MECHANICAL ABUSE COVERINGS

Rigid jacketing provides the strongest protection against mechanical abuse from personnel, equipment, machinery, etc. The compressive strength of the insulation material should also be considered when designing for mechanical protection.

2.5.4 CORROSION AND FIRE RESISTANT COVERINGS

a. **Corrosion protection** - can be applied to the insulation by the use of various jacket materials. The corrosive atmosphere must be determined and a compatible material selected. Mastics may be used in atmospheres that are damaging to jacket materials. (see Section 3).

b. **Fire resistance** - can be applied to insulation systems by the use of jacketing and/or mastics. Fire resistant materials are determined by flame spread, smoke developed and combustibility. The total systems should be considered when designing for fire resistance. (see Section 3).

2.5.5 APPEARANCE COVERINGS AND FINISHES

Various coatings, finishing cements, fitting covers and jackets are chosen primarily for their appearance value in exposed areas.

2.5.6 HYGIENIC COVERINGS

Coatings and jackets must present a smooth surface which resists fungal or bacterial growth in all areas. High temperature steam or high pressure water wash down conditions require jackets with high mechanical strength and temperature ranges. (see Section 3).

2.6 PROPERTIES OF PROTECTIVE COVERINGS

The properties of jacketing and mastic materials that must be considered to meet the aforementioned functions are:

2.6.1 Chemical Compatibility

The chemical make-up of coverings must be compatible with the insulation material over which they are applied, as well as resistant to elements in the environment such as industrial chemicals, salt, air and ultraviolet or infrared light.

2.6.2 Resistance to Internal and External Movement

This property is significant if the covering must absorb or compensate for thermal expansion and contraction of the insulation it covers (i.e. shrinkage of high temperature insulation) or if the system vibration must be considered.

2.6.3 Temperature Range of the Finish or Covering

The temperature range must be compatible with the surface temperature of the insulation surface.

2.6.4 Vapour Permeability

Permeability should be considered for below ambient or dual temperature systems. The covering should significantly reduce the passage of moisture through the insulation.

2.6.5 Fire Retardancy

Flame spread and smoke developed ratings are of vital importance.

2.7 ACCESSORIES

The term **"accessories"** is applied to devices or materials serving one or more of the following functions:

1. Securement of insulation and/or jacketing
2. Reinforcement for cement or mastic applications
3. Stiffening around structures which may not support the weight of high density insulations
4. Support (pipe, vessel and insulation)
5. Sealing and caulking
6. Water flashing
7. Compensation for expansion/contraction of piping and vessels

Improper design or application in one or more of these accessories is a significant factor in the failure of insulation systems.

Securements: As most insulations are not structural materials they must be supported, secured, fastened or bonded in place. Securements must be compatible with insulation and jacketing materials. Possible choices include:

a. Studs and pins
b. Staples, serrated fasteners, rivets and screws
c. Clips
d. Wire or straps
e. Self-adhering laps
f. Tape*
g. Adhesives*
h. Mastics*

*Ambient temperature, humidity conditions and substrate surface cleanliness affects the efficiency of tapes and adhesives and mastics on certain installations. Check the properties of temperature range and vapour permeability before choosing adhesives. And, wherever possible, use mechanical securements.

Reinforcement for cements and mastics: Mastics and cements should be reinforced to provide mechanical strength. The following materials can be used:

a. Fiber fabrics
b. Expanded metal lath
c. Metal meshes

d. Wire netting

Compatibility of materials must be considered to prevent corrosion.

Flashing: Materials which direct the flow of liquids away from the insulation may be constructed of metal, plastic or mastic.

Stiffening: Metal lath and wire netting can be applied on high temperature surfaces before heavy density insulation is applied.

Supports: Pipe supports and accessories may be supplied in part or totally by the insulation contractor. Insulation treatment at points of support are illustrated on Details. Accessories at points of support are:

a. Heavy density insulation inserts

b. Pipe support saddles and shoes

c. Insulation and metal shields used to protect insulation

d. Wood blocks or dowels; these should not be used at below ambient temperatures

Insulation support rings on vertical piping and vessels should be supplied by the piping or vessel contractor, as field welding on coded piping or vessels voids the original coding by the manufacturers. See Detail for treatment.

Sealing and caulking: A variety of sealers, caulking and tapes are available for sealing vapour and weather-barrier jackets, joints and protrusions. These products are manufactured in a large range of temperature and vapour permeability properties. Some are designed specifically for use with one type of insulation or manufacturer's products.

Expansion/Contraction compensation: Accessories used in the design of expansion/contraction joints, etc. include:

a. Manufacturer overlapping or slip joints

b. Bedding compounds and flexible sealers

See Details for insulation treatments.

2.8 SUMMARY - INSULATION MATERIALS AND APPLICATION WITHIN THE GENERAL TEMPERATURE RANGES

Choices of the materials available within each temperature range are based on design conditions (other than thermal) of the installation. See Section 3 for more detailed design information.

2.8.1 LOW TEMPERATURE RANGE (15°C to -75°C)

The major design problems on low temperature installations are moisture penetration and operating efficiency. For below ambient applications, insulation should have low moisture absorption.

Vapour retarders are extensively used, but in practice it is difficult to achieve the perfect retarder in extreme applications. The pressure of the vapour flow from the warm outside surface to the cooler inside surface is such that, even with waterproof insulation, vapour may diffuse through the material, enter through unsealed joints or cracks, and condense, then freeze and cause damage.

Since the cost of refrigeration is higher than the cost of heating, more insulation is often justified in low temperature applications. Extra thicknesses of insulation, even beyond what would be economically dictated for cold line applications, are sometimes employed to keep the warm surface temperature above the dewpoint, thus preventing condensation from forming.

The low temperature range is further divided into application classifications.

1. Refrigeration (0°C through -75°C)

   Water vapour which passes through the vapour-retarder will not only condense, but will freeze. Built up frost and ice will destroy the insulation system.

2. Cold and chilled water (15°C through 0°C)

   Unless properly insulated, water vapour will condense on the metal causing corrosion and failure of the insulation assembly. The permeance of the vapour retarder should be no higher than 0.02 Perms.

The insulations generally used in this temperature range are:

a. Cellular Glass

b. Elastomeric Foamed Plastic

c. Glass Fiber

d. Mineral Fiber

e. Phenolic (foamed)

f. Polyethylene

g. Polyisocyanurate

h. Polyurethane

i. Polystyrene

See Insulation Materials Table 1.A.

2.8.2 INTERMEDIATE TEMPERATURE RANGE (15°C TO 315°C)

This temperature range includes conditions encountered in most industrial processes and the hot water and steam systems necessary in commercial installations. Selection of material in this range is based more on its thermal values than with low temperature applications. However, other factors such as mechanical and chemical properties, availability of forms, installation time, and costs are also significant.

The materials generally used in the intermediate range are:

a. Calcium Silicate

b. Cellular Glass

c. Elastomeric Foamed Plastic*

d. Expanded Silica, or Perlite

e. Glass Fiber

f. Mineral Fiber

g. Phenolic*

h. Polystyrene*

i. Polyurethane*

See Insulation Materials Table 1.B.

*The maximum temperature (315°C) exceeds these materials recommended maximum temperature.

2.8.3 HIGH TEMPERATURE RANGE (315°C TO 815°C)

As the refractory range of insulation is approached, fewer materials and application methods are available. High temperature materials are often a combination of other materials or similar materials manufactured using special binders. Jacketing is generally field applied. Industrial power and process piping and equipment, boilers, breechings, exhausts and incinerators fall within this application range. The materials generally used are:

a. Calcium Silicate

b. Cellular Glass*

c. Cements

d. Ceramic Fibers

e. Glass Fibers*

f. Mineral Fiber*

g. Perlite*

See Insulation Materials Table 1.C.

*The maximum temperature (815°C) exceeds these materials recommended service maximum temperature.

2.9 INSULATION AND JACKET MATERIAL TABLES

These tables represent a summation of available data and information. References to test data, form, temperature range, "K" factors at certain mean temperatures, and general notes are for classification purposes only. Actual descriptions, performances, etc will vary from one manufacturer to another. Specific information on material properties should be obtained from the manufacturers' current data prior to being included in specifications. Fire hazard ratings in particular must be determined to meet local codes.

BASIC TYPES OF INSULATION

TABLE 1.A LOW TEMPERATURE

-75°C (-103°F) through 15°C (60°F)

Type	Form	Temp. Range	K-Factor* Metric/ Imperial	Mean Temp. C (F)	Notes
GLASS CELLULAR	Pipe Covering Block	-268°C to 427°C -450°F to 800°C	.048 (.33) @	4° (40°)	Good strength, water and vapour resistant, non-combustible, poor abrasion resistance.
GLASS FIBER	Pipe Covering Board Blanket	to 455°C to (850°F) to 538°C to (1000°F) to 538°C to (1000°F)	.035 (.24) @ .032 (.22) @ .030 (.21) @	4° (40°) 4° (40°) 4° (40°)	Good workability, non-combustible, water absorbent. Readily available. Vapour retarder required. Low compressive strength.
ELASTOMERIC FOAM	Pipe Sheet Roll	-40°C to 104°C -40°F to 220°F	.038 (.27) @	10° (50°)	Closed cell good workability, finish not required. Limited thickness to meet flame spread/smoke. Required UV protection.
POLYSTYRENE (Extruded)	Pipe Covering Board	-183°C to 74°C -297°F to 165°F	.035 (.24) @	4° (40°)	Lightweight, good, workability. Check manufacturers' data. Combustible. Some are treated for fire retardancy. All are closed cell except polystyrene expanded.
POLYSTYRENE (Expanded)	Pipe Covering Board	-40°C to 80°C -40°F to 175°F	.036 (.25) @	4° (40°)	
POLYURETHANE	Pipe Covering Sheet	-40°C to 107°C -40°F to 212°F	.025 (.18) @	4° (40°)	K-value may change as these materials age. Combustible. High flame spread and smoke.
POLYURETHANE	Pipe Covering Sheet Roll	-70° C to 100°C -94°C to 212°F	.036 (.25) @	10° (50°)	
POLYISOCYANURATE	Pipe Covering Sheet	-183°C to 140°C -297°F to 300°F	.025 (.18) @	4° (40°)	Lightweight, good workability. Check manufacturers' data. Some are treated for fire retardancy. K Values may change with age.

NOTE: Special attention must be given to installation and vapour seal.

*K-Factor Metric = W/m.K (Imperial = Btu.in./h.ft2. °F

TABLE 1.B INTERMEDIATE TEMPERATURES

15°C (60°F) through 315°C (600°F)

Type	Form	Temp. Range	K-Factor* Metric/ Imperial	Mean Temp. C (F)	Notes
CALCIUM SILICATE	Pipe Covering Block Segments Type I	to 649°C (1200°F)	.065 (.45) @	93° (200°)	High compression strength, good workability, water absorbent, non-combustible. High flexural strength. Resistant to abrasion. See manufacturers' data for shrinkage factors.
GLASS CELLULAR	Pipe Covering Block Segments	to 427°C (800°F)	.050 (.35) @ .063 (.44) @	24° (75°) 93° (200°)	Good strength, water and vapour resistant, non-combustible, poor abrasion resistance. Subject to thermal shock. For applications over 204°C (400°F) see manufacturers' specifications.
GLASS FIBER	Pipe Covering Board	to 455°C (850°F) to 538°C (1000°F)	.037 (.26) @ .033 (.23) @	24° (75°) 24° (75°)	Good workability, non-combustible, water absorbent. Low compression resistance.
GLASS FIBER	Blanket	to 538°C (1000°F)	.033 (.23) @	24° (75°)	General purpose material, many facings available.
MINERAL FIBER	Pipe Covering Block Board Blanket	to 649°C (1200°F) to 1035°C (1895°F) to 649°C (1200°F) to 649°C (1200°F)	.037 (.26) @ .037 (.26) @ .037 (.26) @ .048 (.33) @	24° (75°) 24° (75°) 24° (75°) 24° (75°)	Good workability, non-combustible. Water absorbent. Low compression resistance.
PERLITE (Expanded)	Pipe Covering Board	to 649°C (1200°F)	.076 (.53) @	93° (200°)	Good workability, non-combustible. Poor abrasion resistance. Special packaging required to protect materials. Corrosion inhibitor.
ELASTOMERIC FOAM	Pipe Covering-I Sheet-II Roll	-40°C to 105°C -40°F to 220°F	.043 (.30) @	24° (75°)	Closed cell, finish not required, good workability. May require UV protection. Flame spread/smoke limited)
POLYSTYRENE (Extruded)	Pipe Covering Board	-183°C to 74°C -297°F to 165°F	.037 (.26) @	24° (75°)	Lightweight, excellent workability, combustible although some are treated for fire retardancy (check manufacturers' data sheet for properties) High flame spread/smoke. Check manufacturers' data sheets for values. K value may change as these materials age.
POLYSTYRENE (Expanded)	Pipe Covering Board	-40°C to 80°C -40°F to 175°F	.039 (.27) @	24° (75°)	
POLYURETHANE	Pipe Covering	-40°C to 105°C -40°F to 225°F	.027 (.19) @	24° (75°)	
POLYETHYLENE	Pipe Covering	-70°C to 100°C -94°F to 212°F	.037 (.26) @	24° (75°)	
POLYISOCYANURATE	Pipe Covering Board	-183°C to 149°C -297°F to 300°F	.027 (.19) @	24° (75°)	Lightweight, good workability. Check manufacturers' data sheets. Some are treated for fire retardancy. K values may change with age

CEMENTS – See Table 1.C
*K-Factor Metric = W/m.K (Imperial = Btu.in./h.ft2. °F)

TABLE 1.C HIGH TEMPERATURE

315°C (600°F) through 815°C (1500°F)

Type	Form	Temp. Range	K-Factor* Metric/ Imperial	Mean Temp. C (F)	Notes
CALCIUM SILICATE	Pipe Covering Block Segments Type I Type II	to 649°C (1200°F) to 871°C (1600°F)	.087 (.60) @ .101 (.70) @	260° (500°) 260° (500°)	High compressive strength, good cutting characteristics, water absorbent, non-combustible. High flexural strength. Resistant to abrasion. See manufacturers' data for shrinkage factors.
CLASS CELLULAR HIGH TEMP	Pipe Covering Block Segments	to 427°C (800°F)	.103 (.72) @	260° (500°)	Good strength, water and vapour resistant, non-combustible, poor abrasion resistance. Subject to thermal shock. For application over 204°C (400°F), see manufacturers' specifications.
GLASS FIBER	Pipe Covering Board Blanket	to 455°C (850°F) to 538°C (1000°F) to 538°C (1000°F)	.083 (.58) @ .086 (.60) @ .086 (.60) @	260° (500°) 260° (500°) 260° (500°)	Good workability, water absorbent, non-combustible. Check manufacturers' data for specific properties. Low compression resistance.
MINERAL FIBER	Pipe Covering Block Board Blanket	to 649°C (1200°F) to 1035°C (1895°F) to 649°C (1200°F) to 649°C (1200°F)	.072 (.50) @ .092 (.64) @ .101 (.70) @ .101 (.70) @	260° (500°) 260° (500°) 260° (500°) 260° (500°)	Good workability, non-combustible. Low compressive resistance. Water absorbent.
PERLITE (Expanded)	Pipe Covering Block	to 649°C (1200°F)	.106 (.74) @	260° (500°)	Good workability, non-combustible, friable. Check manufacturers' data for specific properties. Poor abrasion resistance. Special packaging required to protect material. Corrosion inhibitor.
CERAMIC FIBER (Refractory Fiber)	Blanket Board	to 1260°C (2300°F) to 1260°C (2300°F)	.086 (.60) @ .080 (.56) @	260° (500°) 260° (500°)	Temperature range varies with manufacturer, style and type.
CEMENTS Hydraulic Setting Cement High Temperature Mineral Wool Finishing Cement (Mineral Fiber or Vermiculite)	Type I Type II Type III	38-649°C (100-1200°F) 38-870°C (100-1600°F) 38-980°C (100-1800°F)	.180 (1.05) @ .160 (1.12) @ .150 (1.26) @	250° (482°) 250° (482°) 250° (482°)	One coat application – insulating and finishing. Slow drying, rough texture – Pointing and insulating and filling. Used over basic insulation – Smooth finish usually 1/8" or ¼" think application.

PROTECTIVE COVERINGS AND FINISHES

PLEASE NOTE: The following items are classified for use as weather barriers and/or vapour retarders. They also serve other purposes listed for protective coverings (i.e. mechanical abuse, corrosion, appearance, and hygienic), but each must be considered on its own merits for these aspects.

TABLE 2.A WEATHER BARRIERS*

Type	Composition	Fasteners	Notes
JACKETS:	1. Films laminated to felts or foil	Contact adhesives and/or tape	Corrosion resistant, bacteria and mildew resistant
	2. Stainless steel (various alloys – available with factory-applied moisture retarder)	Bands, screws or rivets	Excellent mechanical strength, corrosion, mildew and bacteria resistant. Excellent fire resistance.
	3. Galvanized steel (coated and with factory-applied moisture retarder)	Bands, screws or rivets	Good mechanical strength and fire resistance.
	4. Aluminum alloys (preferably with factory-applied moisture retarder)	Bands, screw or rivets	Good mechanical strength, good workability, poor fire resistance.
	5. Polyvinyl Chloride (PVC)	Mechanical fasteners, adhesive, or matching tape	May require protection from ultra-violet radiation. Resists chemicals and bacteria. Washable surface for food processing applications.
	6. High Impact Plastics (ABS)	ABS welding adhesive or mechanical fasteners	
	7. Plastic film (PVDC)	Adhesive or tape	Corrosion. Bacteria, mildew and chemical resistance. May require protection from ultra-violet radiation. Workable surface for food processing applications.
MASTICS:	1. Asphalt emulsion	Apply with reinforcing mesh	Water base, a breather mastic
	2. Asphalt cut-back	Apply with reinforcing mesh	Solvent base, also a vapour barrier
	3. Resin emulsion	Apply with reinforcing mesh	Tough, resilient film
	4. Polyvinyl acetate	Apply with reinforcing mesh	Tough, resilient film
	5. Acrylic	Apply with reinforcing mesh	Tough, resilient film

*Covering shall not be termed a weather barrier unless its joint and overlaps are adequate to prevent the entry of rainwater (See Section 2.5)

TABLE 2.B VAPOUR RETARDERS*

Type	Composition	Notes
JACKETS:	1. Foil-Scrim Laminate	Seal joints. Mechanical strength is less than metal or plastic. Easy installation.
	2. High Impact Plastics (ABS)	Seal with welding adhesive.
	3. Film Laminate	Seal with contact adhesive and/or tape.
MASTICS:	1 Asphalt cut-back	Apply with reinforcing mesh. Combustible.
	2. Resins – solvent type	Brush or spray application.
	3. Elastomeric Polymer	Apply with reinforcing mesh. Combustible.

NOTE: A perm rating of 0.05 is recommended on mechanical insulation coverings to be considered a vapour retarder.

*Covering shall not be termed a vapour retarder unless joints are sealed to prevent the entry of vapour.