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.