CONSTRUCTION STANDARD

FOR

APPLICATION OF THERMAL INSULATIONS

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1. SCOPE

This Application Standard covers the minimum requirements for application of thermal insulation on pipeworks, vessels, tanks and equipment in the temperature range of -100°C to +650°C which categorize temperature range of -100°C to +5°C as the cold system and +5°C to +650°C as hot system. The standard excludes structural insulation of buildings, fire proofing, refractory lining of plants.

The standard is intended for use in oil, gas, and petrochemical and similar industries for overground, underground and under-water mainly for refineries, chemical and petrochemical plants and gas plants.

In the method of insulation application section of this Standard, necessary figures have been included in order to help better understanding the application details.

2. REFERENCES

Throughout this Standard the following standards and codes are referred to. The editions of these standards and codes that are in effect at the time of publication of this Standard shall, to the extend specified herein, form a part of this Standard. The applicability of changes in standards and codes that occur after the date of this Standard shall be mutually agreed upon by the Company and the Vendor.

BSI (BRITISH STANDARD INSTITUTION)

BS 2972 (1984)	"Methods of Test for Inorganic Thermal Insulating Materials"
BS 3974	"Specification for Pipe Support"
BS 4508	"Thermally Insulated Underground Piping Systems"
BS CP 3009	"Thermally Insulated Underground Piping Systems"
BS 5970	"Thermal Insulation of Pipework and Equipment in the Temperature Range of -100°C to + 870°C"

ASTM (AMERICAN SOCIETY FOR TESTING AND MATERIALS)

C-450-88	"Recommended Practice for Prefabrication and Field Fabrication of Thermal Insulating Fitting Covers for NPS Piping, Vessel Lagging, and Dished Head Segments"

IPS (IRANIAN PETROLEUM STANDARD)

IPS-E-TP-100	"Paints"
IPS-C-TP-101	"Surface Preparation"
IPS-C-TP-102	"Paint Application"
IPS-E-TP-700	"Engineering for Thermal Insulation"
IPS-M-TP-710	"Thermal Insulation Materials"

3. DEFINITIONS AND TERMINOLOGY

Asbestos

The generic name for those silicate minerals that cleave naturally into fibers, the three important forms being chrysotile (white asbestos), crocidolite (blue asbestos), and amosite.

Blanket

Insulation of flexible type, formed into sheets or rolls, usually with a vapor barrier on side and with or without a container sheet on the other side.

Block (Slab)

Rigid or semi rigid insulation formed into sections rectangular both in plan and cross section, usually 90-120 cm long, 15-60 cm wide and 2.5-15 cm thick.

Board

Rigid or semi-rigid isolation formed into section, rectangular both in plan and cross section, usually more than 120 cm long, 60-75 cm wide and up to 10 cm thick.

Calcium silicate insulation

Hydrated calcium silicate with added reinforcing fibers.

Cellular glass (foam glass)

A lightweight expanded glass with small cells, preferably non-intercommunicating, produced by a foaming process.

Ceramic fiber

Fiberous materials, loose or fabricated into convenient forms, mainly intended for use at appropriate metal silicate, e.g., alumino-silicate. Alternatively, they may be formed synthetically from appropriate refractory metal oxides, e.g. alumina, zirconia.

Cork board

Preformed material composed of granulated cork bonded by heating under pressure, with or without added adhesive.

Expanded metal

Metal network made by suitably stamping or cutting sheet metal and stretching it to form open diamond-shaped meshes.

Expansion joint

An arrangement in an insulation system to minimize the risk of cracking due to thermal movement.

Fibrous insulation

Insulation constructed from fiber, naturally occurring or manufactured that incorporate single or composite filaments generally circular in cross section and length considerably greater than the diameter.

Flexible insulation

A material that tends to conform to the shape of the surface against which it is laid, or is so designed as to alter its manufactured shape to accommodate bands and angles.

Foamed-in-situ plastics

Cellular plastics produced in situ and foamed by physical or chemical means.

Glass-cloth

Fabric woven from continuous filament or staple glass fiber.

Glass fiber (glass wool)

Mineral fiber produced from molten glass.

Loose-fill insulation

Material in the form of powder, granules, foamed expanded or exfoliated aggregate or loose or pelleted fibers, used in the dry state as a filling for cavities, casings or jackets.

Mastic

A relatively thick consistency protective finish capable of application to thermal insulation or other surface, usually by spray or trowel, in thick coats, greater than 75 mm.

Metal cleading/jacketing

Sheet metal fitted as a protective finish over insulation.

Mineral fiber

A generic term for all non-metallic organic fiber.

Mineral wool

A generic term for mineral fibers of a woolly consistent e.g. normally made from molten glass, rock or slag.

Pipe section

Sections of insulating material in cylindrical form suitable for applications to pipes.

Plastic composition

Insulating material in loose, dry form, prepared for application as a paste or dough by mixing with water, usually on site, and normally setting under the influence of heat applied to the internal surface.

Rock wool

Mineral wool produced from naturally occurring igneous rock.

Self setting cement

Finishing material, based on Portland cement, that is supplied as a dry powder and, when mixed with water in suitable proportion, will set without the application of heat.

Sprayed insulation

An adherent coating of insulating material.

Vapor barrier

A vapor check with water vapor permeance not exceeding 0.067 g/(SMN), when tested in accordance with BS 2972.

Weather barrier (weather coat)

A material or materials which when installed on the outer surface of thermal insulation, protects the insulation from the ravages of weather, such as rain, snow, sleet, wind, solar radiation, atmospheric contamination and mechanical damage.

4. GENERAL CONSIDERATIONS IN INSTALLATION

4.1 Installation Requirements

4.1.1 General

4.1.1.1 The installation requirements are those requirements that an insulation shall fulfill from the time it is manufactured until it is in service. After insulation is produced, it passes through several phases; i.e., it is shipped, stored, possibly fabricated, reshipped to the job, installed, and finally used in the service for which it was originally specified.

4.1.1.2 These phases that an insulation shall pass through may differ depending upon the method of manufacture, type of material, and use, but in general they may be listed as follows:

a) Shipping
b) Storage
c) Fabrication
d) Application
e) Service

4.1.1.3 Each of these phases imposes a set of requirements upon the insulating material. It must meet these requirements in order to fulfill successfully its economic function. Because of large number of requirements and also lack of reliable data on the requirements themselves, it is impossible to provide both an exact list of the requirements and of the properties whereby a precise selection of material can be determined. Therefore, this discussion must be kept general, for the final selection will be determined by engineering judgment.

4.1.1.4 Each "phase" include one or more of the following:

Mechanical requirements
Chemical requirements
Thermal requirements
Moisture requirements
Safety requirements
Economic requirements

4.1.1.5 All requirements specified in IPS-E-TP-700 and IPS-M-TP-710 shall also be considered when considering installation requirements.

4.1.2 Phases

4.1.2.1 Shipping

To be usable, an insulation produced in one location and used in another must be capable of being transported.

Rigid insulation must have a combination of compressive, tensile, and shear strengths to permit shipment without excessive breakage or excessively costly protective packaging.

Non-rigid materials, such as blankets, shall have sufficient strength in length, width, and depth to resist delamination. Their binders shall withstand vibration without dusting or excessive fiber release. Fibrous materials must resist permanent compaction caused by either compressive forces or vibration.

Fill materials must also withstand excessive compression or compaction, even though packaged in bags.

Practically all insulating materials must be packaged in cartons, bags, rolls, or some other type of acceptable shipping container. Proper selection of container and packaging influences the cost of handling and space requirements.

During loading, shipping, and unloading, materials may encounter water damage caused by rain or water vapor due to high humidity. The more highly absorbent or adsorbent the insulation is, the greater the hazard of excessive moisture pick-up. Thus, the greater the absorbency and absorbency, the greater the need for care in handling and weather-tight packaging.

4.1.2.2 Storage

Insulation is seldom used immediately upon receipt from the Manufacturer. In most instances it is stored first by a distributor and later on the job. During these periods of storage it often receives more physical abuse than it will receive in service. Thus rigid materials must have sufficient strength to withstand such handling. Flexible materials must withstand the same type of handling without compaction, or pulling apart. Of course, all in sulations should be dimensionally stable and not warp or shrink from moisture or age.

Few inorganic insulating materials are subject to chemical change during storage. However, some of the organic foam-spray chemicals may be affected by shelf life or temperature. These must be stored and used within their limits, or they may become unusable. The same applies to some accessory materials such as adhesives, sealers and weather barriers.

The problem of keeping absorbent insulations dry during this storage period is most important. An insulation which contains a large percentage of water may lose its strength, or chemically deteriorate, and will always lose its thermal efficiency. Improper warehousing and handling of absorbent insulation can be costly not only the insulation itself, but its packaging may be adversely affected by water. Water damage to cartons, with resultant loss of identification and damage to the contents, may be very expensive, needless to say, the more absorbent an insulation is, the greater the need for its protection from water in any form.

During storage, safety to property and personnel must be considered. Any combustible insulation shall be stored with care. Fire will spread rapidly in such light density material. Sealers weather-vapor-barriers, or other liquid combustibles, are always a potential fire hazard. Many insulations which do not support combustion by themselves will burn in the presence of flame. Any jacketing will produce toxic fumes when burning. Safe storage is therefore, essential for these materials.

4.1.2.3 Fabrication

Advanced techniques have made it practical and economical to prefabricate, preform, or premold insulation shapes prior to their installation in the field.

A rigid material requires sufficient mechanical strength to permit handling without breakage. It should have good cutting characteristics. Its cut surfaces shall be sufficiently smooth and free of dust in order than pieces can be cemented together into strong, integral finished shapes.

For ease of fabrication, the original blocks of insulation should be dimensionally true within acceptable tolerances. Out of square, non-parallel, and untrue planes in the original blocks will cause excessive waste of both material and labor. Materials which delaminate when cut also cause excessive labor and waste. In most instances, materials that have good tensile strength in all directions are more suitable for cutting into compatible parts, and can then be bonded together into the finished shape.

Light density, fibrous materials generally do not lend themselves to this cutting and cementing type of fabrication. Fittings composed of these materials are formed most frequently by molding and heat-curing uncured batts or blankets into the desired shapes. Inorganic insulations are treated in a similar manner. Organic insulations may be molded into desired shapes. During fabrication, or molding, safety is an important consideration.

4.1.2.4 Application

Industrial applications impose additional requirements on the insulation materials which are important to a successful installation. The materials must have the necessary strength to resist an excessive amount of handling. Storage space at most of these installations is limited, and the materials may be moved many times before they are finally installed.

When secured by wires materials must resist the tendency to crack into pieces due to cleavage along the wire, yet be of such texture that twisted wire ends can be embedded into their surface. Vessel block insulation and rigid pipe covering must withstand considerable force when pulled up to a tight fit by straps. The strapping tool will exert a 272-262 kg tensile pull with an insulation strap to draw the joints tight.

The dustier a material is the more difficult it becomes for field personnel to work with and install it. Dust, besides being a health hazard, irritates the eyes, makes scaffold boards slick, and causes a cleanup problem. In addition, dusty surfaces resist good bonding with insulation and finishing cements, and weather-barrier mastics.

The tendency of some insulating materials to absorb moisture adds to the cost of installation. Such installations must be protected from water, rain, and snow, both before and during their installation. The need for weather protection before, during, and after installation until the weather-barrier is installed adds considerably to costs. Trueness of dimensions of block pipe covering is essential to efficient field installation. If the ends of pipe covering are not square and true, the gaps must be plugged with insulating cement, or the end recut to fit.

4.1.2.5 Service

To perform its intended service, an insulation must remain where it was installed. Its properties must fulfill all the requirements imposed upon it during its service life.

The requirements of service phase is divided into various technical divisions in the order as following:

4.1.2.5.1 Mechanical requirements of insulation on equipment and pipes

Insulation on equipment located in industrial plants is subject to external and internal physical forces. The external is subject bumps, persons walking upon the insulation, vibration, wind, or even explosions. Many insulations are expected to protect pipe and equipment from fire. Many fires are started by an explosion, and if the insulation is blown off of surrounding items and piping it can not protect against fire.

The insulation shall be sufficiently strong to resist ordinary usage. This entail the compressive force of person walking on insulation, the force of vibration which causes abrasion between the insulation and the surface to which it is secured, the force of wind or partial vacuums which tends to compress, or pull insulation apart.

The forces most frequently damaging to insulation applications are those built into the system by poor design and application, which ignore the movement of vessels and pipes caused by thermal expansion (or contraction) of the metal. Expansion and contraction of vessels and pipes can cause serious damage to thermal insulation and weather-barrier coverings so that the cracks may develop. Additional heat loss from these small size crack would be quite small. The big difficulty is water entering the cracks which makes the insulation wet and increase thermal conductivity.

4.1.2.5.2 Chemical requirements

The insulation to be used shall not react to the chemical contained in the vessel or piping to which they are attached. Another factor to be considered is that the insulation shall be non-absorptive when used on toxic processes.

A selected insulation shall not be chemically corrosive to the metal to which it is applied. Basically, insulation installed on steel shall be neutral, or slightly alkaline. That installed on aluminum shall be neutral or slightly acidic. Austenitic stainless steels are susceptible to stress corrosion cracking by chloride ion, therefore insulations with limited chloride content shall be used or resistant coating shall be applied on stainless steel surface.

4.1.2.5.3 Thermal requirement

The thermal requirements of an insulation are related to a number of properties of materials. These thermal proportion of materials are as follows:

Temperature limits
Thermal shock resistance
Thermal diffusivity
Thermal specific heat
Thermal conductivity

The temperature requirements of an installation are the maximum and minimum temperature to which the insulation will be subjected. Other factors such as duration of time the insulation exposed to heat, mode of applying heat, the time-rate of raising or lowering the temperature should also be considered. The following questions must also be answered: is it on only one side, is it continuous, intermittent, cyclic, or rapidly changed.

4.1.2.5.4 Moisture requirements

Insulation, to be efficient, must be kept dry. Moisture in two forms, the liquid or the vapor state, can saturate the insulation. It can enter by various means, water pressure, vapor pressure, ingassing and simple leaks. The protection required will be determined by the installation conditions.

When insulated piping or equipment is submerged in water, a completely water-tight outer shell is required around the insulation. Such systems must be encased in metal, fabricated by welded sections, and/or flanged with jacketed flanges, so that the outer jacket is sufficiently tight and strong to withstand the water pressure.

Underground installations where insulation systems may not be directly subjected to definite water pressure must still be protected to prevent the entry of water. Such protection must not only prevent the said entry, but it must also resist corrosion to remain water-tight. The corrosion may be ordinary rust, chemical corrosion, or galvanic corrosion.

If the function of the two previously mentioned examples is the insulation of hot surfaces, vapor migration will be of no concern. However, if the installation is for low temperature service, water vapor migration will be an additional problem. Many conduit systems may be water-tight and not be vapor tight. Practically, it is relatively easy to construct water-tight systems, but almost impossible to construct vapor-tight ones. For this reason, it is suggested that, wherever possible, the cold equipment and piping be installed above grade.

The moisture protection necessary on equipment and piping located above grade is determined by whether the location is indoors or outdoors, and the operating temperature above or below ambient.

High temperature insulated equipment and piping located indoors and not subjected to rain, snow, or sleet does not require water or moisture protection. A word of caution-the insulation must be adequately protected from moisture due to possible spillage or the washing down of vessels.

Low temperature insulated equipment and piping located indoors must be protected against moisture vapor.

High temperature insulated equipment and piping located outdoors must be protected from liquid moisture in the form of rain, sleet, or snow.

Low temperature insulated equipment and piping located outdoors must be protected both from liquid water, and also moisture in the vapor phase.

These moisture requirements are summarized below:

SERVICE		MOISTURE PROTECTION REQUIRED		
Temperature	**Location**	**water pressure**	**Water**	**Vapor**
High temp.	Underwater	Required	Required	Not required
Cyclic temp.	Underwater	Required	Required	Required
Low temp.	Underwater	Required	Required	Required
High temp.	Below grade	Depends *	Required	Not required
Cyclic temp.	Below grade	Depends *	Required	Required
Low temp.	Below grade	Depends *	Required	Required
High temp.	Above grade indoors	Not required	Depends *	Not required
Cyclic temp.	Above grade indoors	Not required	Depends *	Required
Low temp.	Above grade indoors	Not required	Depends *	Required
High temp.	Above grade outdoors	Not required	Required	Not required
Cyclic temp.	Above grade outdoors	Not required	Required	Required
High temp.	Above grade outdoors	Not required	Required	Required

*** The word depends means if the condition of high pressure water or water may exist.**

4.1.2.5.5 Safety requirements

The major safety requirements may be separated into the following divisions:

Safe surface temperature for personnel protection or ignition.
Safety from radioactivity or chemical reaction.
Safety from toxic conditions.
Fire protection.

When hot equipment or piping is located where its insulation may be touched by personnel, the insulation shall be so designed that its thermal resistance, surface emittance, and jacket conductivity together create a condition which will not produce skin burns when its outer surface is accidentally touched.

Where combustible materials are present and changes of leakage or spillage prevail, a suitable low surface temperature of insulated vessels and piping may be very important in preventing the ignition of these materials. When this condition prevails, it becomes necessary that all hot surfaces, such as valves, flanges, and metal projections, be insulated so as to maintain all exposed surfaces below the maximum allowable surface temperature. Some areas which cannot be insulate, such as valve bonnets and stuffing boxes, may require shielding to prevent contact with the chemical.

As previously mentioned, non-combustible but absorptive insulation may be a fire hazard in two ways. First, in the case of combustible material leaks, the insulation's tremendous internal surface area can assist in causing rapid oxidation which will result in spontaneous combustion. Second, also in the case of leaks, any absorbent can hold large quantities of combustibles and, if an accidental fire occurs, the saturated insulation will feed and spread it. However, properly used insulation can be used as fire protection. An installation on equipment and piping must first, the combustibility of the insulation must be considered, including the speed at which the insulation will spread the fire, or the amount of heat and smoke it will contribute. second, the time rate at which temperature will pass through the insulation from the fire side to the vessel or pipe must be thought of.

4.1.2.5.6 Economic requirements

The economic value of the insulation depends upon the installation requirements, and as this has been previously discussed, a simple listing of the factors to consider is given.

1) Heat transmission allowable as determined by the process.

2) Savings in boil-off or vaporization of the product.

3) Temperature which must be maintained in the process.

4) Fire protection required by the process. Insulation as related to savings in additional fire protection such as spray heads, larger safety valves, etc.

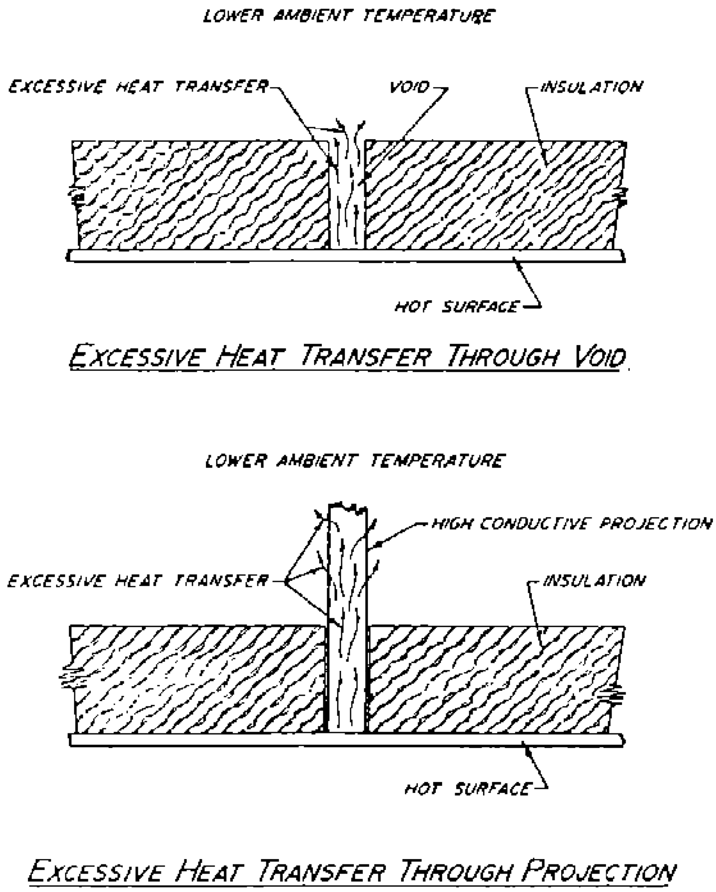
5) Savings in investment in heat or refrigeration equipment.

6) Savings in heat or refrigeration energy.

4.2 Installation System Details

4.2.1 General

4.2.1.1 The success of an insulation system depends upon individual consideration of design and insulation for the many details of the system. In all insulation design, thermal "short circuits" should be avoided or minimized. These thermal short circuits are most frequently the result of metal or other high conductive materials through the insulation. They are illustrated in figure 1. The illustration shows the excessive heat transfer from a hot surface to a lower ambient temperature. If the condition were reversed, with the temperature of surface lower than ambient, the same excessive heat transfer would exist, but the heat flow as shown, would be reversed.



THERMAL "SHORT CIRCUITS"
Fig. 1

4.2.2 Voids in insulation

4.2.2.1 Some voids in insulation are the result of insulation design and specifications. Typical of voids in the insulation system, which are a result of design, are those specifications which state that flanges and valves are not to be insulated. Voids which are not deliberately designed in, but develop in an insulation system are most often the result of expansion of the substrate to which the insulation, shrinkage of the insulation, or poor design or workmanship.

4.2.3 Projection through insulation

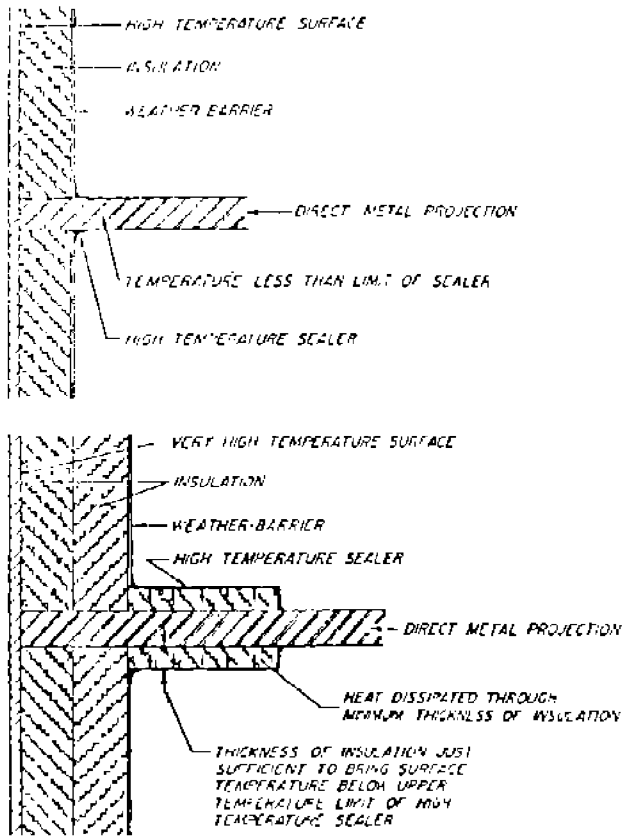
4.2.3.1 Metal projections through insulation should be avoided, if possible. Metals of two different temperatures should be isolated by insulation where it is practical.

4.2.3.2 Where it is necessary to have high conductive materials, such as metal, project through insulation, the heat transfer can be minimized by following methods:

- **a)** Keeping the cross section of the projection to a minimum.
- **b)** Use of a material of the lowest possible thermal conductivity.
- **c)** Providing a long flow path through insulation.
- **d)** Providing a thermal barrier in some phase of the projection connections or bearing.

4.2.3.3 The use of stainless steel, which, besides having a lower conductivity than carbon steel, also has higher strength, can reduce any thermal transfer to one-fourth that of carbon steel. The length of flow path of projection through insulation can be extended by insulating the projection beyond the basic insulation installed on a pipe or vessel. The insulation of hot projections are illustrated in Fig. 2.

4.2.3.4 Great emphasis has been placed on voids and projections through insulation on low temperature service. the reason for this is that these voids and projections will cause more rapid insulation failure on such service than on high temperature service.



SEALING OF HIGH TEMPERATURE PROJECTIONS
Fig. 2

4.2.3.5 One area where voids and projections through the insulation completely nullify the purpose of an insulation is where that insulation is used for fire protection of vessels and piping. In such a case a heavy projection through the insulation, which would be exposed to the fire, would transfer the fire heat through the insulation at that point and fire protection would not be achieved. this is also true of voids in insulation. During fire the insulation will shrink and cause voids at the butt joints. for this reason, when fire protection is a critical function of insulation, double layer, broken joint construction shall be used.

4.2.4 Traced piping and vessel

4.2.4.1 The tracers are used where it is necessary to add or remove heat from piping or equipment. If the additional temperature to be supplied by the tracers is small then they may simply be fastened to the pipe or vessel and the air space between the insulation and metal substrate will distribute the heat over the pipe or vessel surface. However where high temperature or close tolerance of temperature is required, then the tracers shall be thermally bonded to the pipe or vessel.

4.2.4.2 For efficient operation of tracing systems they must be installed correctly. The metal of the system shall resist corrosion. Where necessary, the tracer must be thermally bonded by heat transfer cement, or premolded strip, to the process pipe or equipment. The heat transfer cement must be suitable for the process pipe and tracer temperatures to which it is to be subjected and shall not cause corrosion or rusting of the tracer or piping.

4.2.5 Weather-vapor-barrier details

4.2.5.1 Vapor-barrier

4.2.5.1.1 Because vapor-barriers on the outer surface of insulation are subject to all the ravages of time, mechanical abuse, and stresses imposed upon the system, cracks, breaks, punctures, or tears are likely to occur and in this case a small leak will allow the entry of vapor into the entire system. This being true, the problem is to provide a system which is compartmentalized so that a break or puncture closes not ruin the entire system. Application of such a system is not important for cellular glass as almost universal material for low temperature insulation on pipes and vessels and may be eliminated but it is essential for efficient long service of permeable organic foam insulation.

4.2.5.1.2 The major property a vapor-barrier must have is its ability to retard the flow of vapor. This is its most important property, but its other properties, such as its ability to withstand mechanical abuse or weathering, may not be sufficient to fulfill the installation requirements. where this is true, it may be necessary to provide a weather barrier over the vapor-barrier. Although there are mastic materials which are formulated to serve both as vapor and weather-barriers, in many low temperature applications it is desirable to install a vapor-barrier and protect it with a weather-barrier.

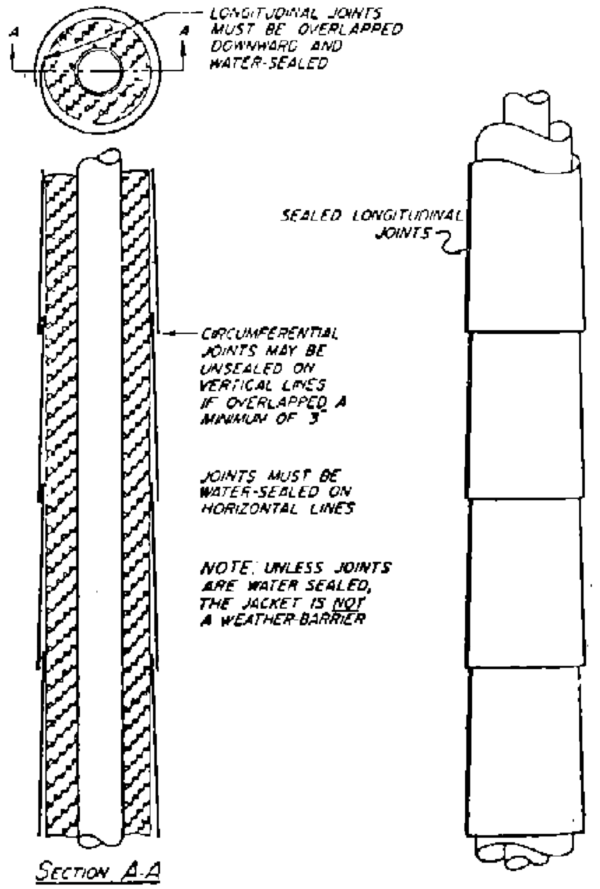
4.2.5.1.3 The vapor sealing of cellular glass is important, even though it has greater resistance to vapor transmission than most materials used as vapor-barriers. With proper joint sealing of cellular glass, and proper design to prevent its cracking or shearing due to expansion and contraction movement, there is no need to apply vapor-barrier material over its exterior surface. However it does require a weather-barrier outdoors, and a finish indoors to protect it from ordinary weathering and mechanical abuse.

4.2.5.2 Weather-barrier

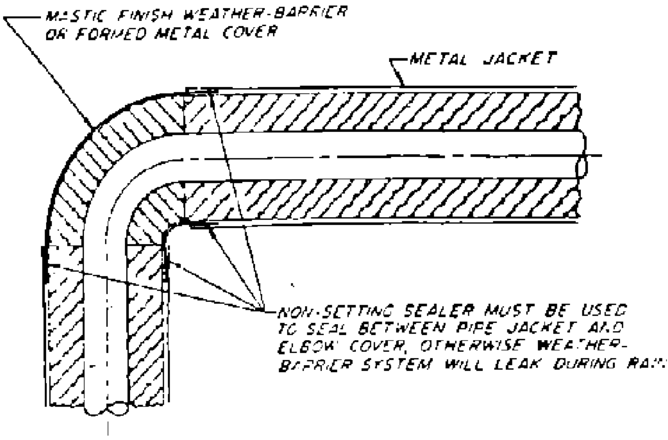
4.2.5.2.1 The prime function of the insulation weather-barrier is to provide conditions in which the insulation can function to retard the heat flow. The weather-barrier covering jacket, or finish forms the necessary protection around the insulation and for a successful installation, the details of application are of utmost importance. Regardless of the weather-barrier used, it is ineffective if it is installed in a manner which will allow water to leak into the insulation. An example of proper method of installing jacket is shown in Fig. 3 which prevents water leaking into insulation.

4.2.5.2.2 Fitting and valve covers present a difficult problem in obtaining water tightness. Too frequently metal covers are installed by slipping the halves together without sealing the overlapping metal with mastic sealers. This type of construction will not provide a water tight installation, and only serves to hide the water as it soaks into the insulation with every rain.

4.2.5.2.3 Another common incorrect installation practice is the use of mastics as the weather-barrier on valves and fittings while the straight pipe is jacketed with metal which projects over the extended mastic of the fittings, but with no sealing mastic used to prevent water from entering the overlap of the two. Nonsetting sealers must be used in these spots, as the expansion and contraction movement will break any sealer that sets and hardens. This is illustrated in Fig. 4.



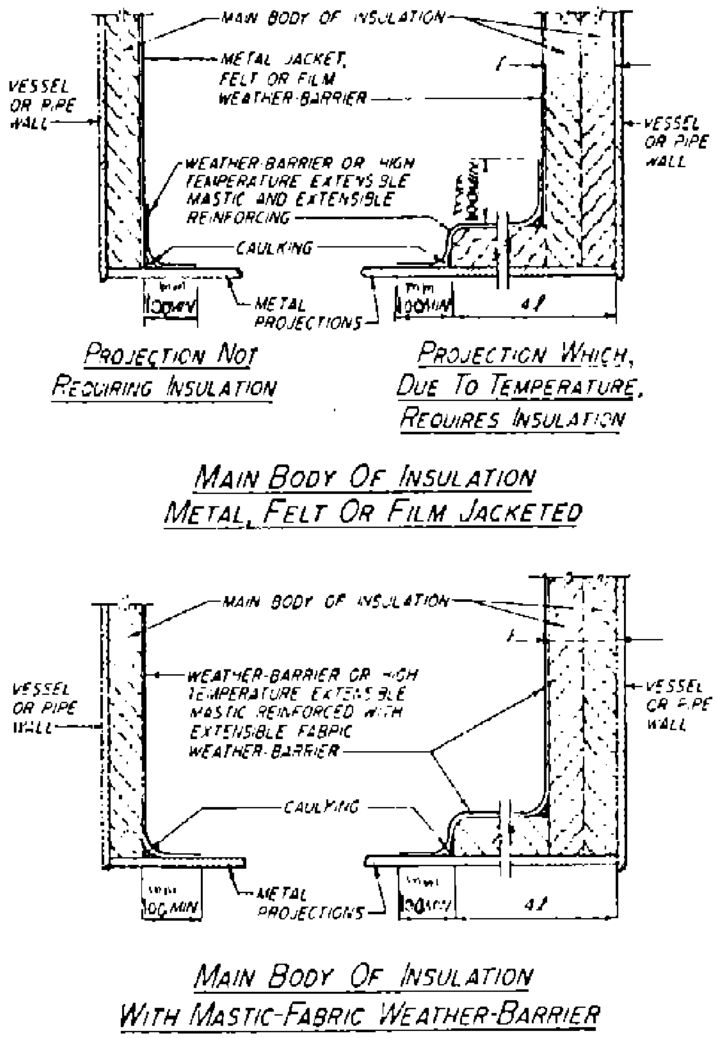
PROPER SEALING OF FELT, FILM, OR LAMINATED JACKET WEATHER BARRIER
Fig. 3



METHOD OF SEALING WEATHER-BARRIER AT FITTING COVERS AND JACKETS
Fig. 4

4.2.5.2.4 When projections are so hot where they emerge from the insulation that suitable mastics cannot be found to seal this joint, then the projection should be insulated a sufficient distance outward to a location where its exit point through the insulation can be sealed. Regardless of the type of weather-barrier used, the inside corner of these projections should be caulked with a caulking compound of high solids content to eliminate the sharp inside corner. This same procedure shall be used at all projections through the insulation, such as where the pipe itself projects through the insulation, and where vessels nozzles, manholes, or skirts projects through the insulation.

4.2.5.2.5 After the projections are properly insulated and caulked, the inside corners shall be weather protected with a flexible mastic coating reinforced with extensible fiber cloth. If the weather-barrier is mastic reinforced with cloth, the weather-barrier system shall extend a minimum of 100 mm out over the projection. If metal jacketing, felts, or plastic films are used as the basic weather-barrier system then the flexible mastic with the extensible fiber cloth shall extend a minimum of 100 mm in each direction from the inside corner. This is illustrated in Fig. 5 where projections are quite hot, the mastic used may be required to be high temperature sealer instead of ordinary weather-barrier mastic. The general method presented in Fig. 5 does not imply that other systems are not good and suitable, as there are many excellent methods of sealing inside joints. The major point is that inside joint must be sealed and stay sealed in service.



METHOD OF WEATHER-SEALING PROJECTIONS
Fig. 5

4.3 Application Procedure

4.3.1 The following application procedure which involves considerations of many variables may convey to the insulation Contractor, clearly and without equivocation the intent of the Company what he intends to be accomplished by the installation about which he is writing. Wherever necessary the procedure may be tailored to the specific job. The procedure must be written definitely and exactly to obtain the proper quality of material and assembled system.

4.3.2 This division will not attempt to present insulation application procedure as such, but will present a method for constructing a procedure, combined with a check list from which the items for the individual specification may be selected.

4.3.3 The insulation application procedure may be broken down into the major sections as following.

4.3.3.1 General conditions which state what job conditions are to be expected, such as ware housing, storage and responsibilities. It further acts to the specification to the contract agreement between the Contractor and his customer. As such, the general condition section of a specification is a legal document on agreement, and not a technical matter which is out of place in application specification.

4.3.3.2 The scope of the procedure sets the boundaries within which the procedure are to be used. This section shall be sufficiently directive to indicate to the reader what is the general purpose of the detail specifications which will follow, a general classification of the material to be used, the boundary limits of facilities to be served, and the location. To illustrate, if the procedure are to be used to insulate the roof of a building, say so in the scope. Also state the conditions under which the insulation is to serve.

4.3.3.3 Application specification

The general insulation specification to which individual specifications are referred shall have the following format:

General specification:

List of materials required;
Preparation;
Insulation application;
Weather barrier or covering application.

But each individual specification shall have the following format:

Individual specification:

Preparation;
Insulation application;
Weather barrier, or covering application.

4.3.3.3.1 The preparation section shall state what must have been done before the insulation is applied. In almost every instances these are operation which must have been performed by other crafts and possibly other contractors, prior to the application of the insulation. The specification must state what these operations are and place the responsibility for them correctly, so as to prevent conflict and delay.

4.3.3.3.2 The insulation application section shall spell out the intent as to the quality of the installation, and what is expected from the finished product of assembled insulation and accessories. Of course, no specification can detail each and every piece of the installation, but sufficient typical details must be provided that the applicators understand what is expected. For this reason, it is extremely helpful to include drawings in specifications to illustrate typical assemblies.

Most workmen, when shown a drawing, can get the idea of what is desired much more quickly than by reading a detailed description.

4.3.3.3.3 The weather-barrier or covering application section may be made a part of the insulation application section, as the barrier is a part of the insulation system, but because these are installed last, it does lend itself to being a separate section, especially as a different set of materials is being used. Another advantage in making such a separate section is that, under various conditions, insulation installed as called for under the insulation application section may require one type or system of weather-barriers in one location, and another in a different location. Conversely, one set of weather-barrier application specifications may be suitable for use on many various types and forms of insulation.

4.3.3.4 An example of the preparation of application specification follows

4.3.3.5 Application specifications-equipment and piping

4.3.3.5.1 Preparation

Equipment insulation supports, of same metal as vessel, projecting to a point 25.4 mm less than the thickness of the insulation, shall be welded or bolted to the vessels to support vertical insulation. They shall be located at base of insulation, at top of vessel, and at 457.2 mm centers above the base support. A support shall be located above each vessel flange, a sufficient distance above the flange bolts to allow for their easy removal. The bottom and top supports shall be slotted with 25.4 mm by 7.6 mm slots for attachment of straps or wire.

Pipe above 8.9 mm dia NPS shall be supplied with insulation supports welded or bolted just above lower elbow of risers. Projection of this support shall be a minimum of 38 mm. On long vertical runs of pipe, additional supports shall be installed on 457.2 mm centers.

Flat surfaces and large bottom heads shall be equipped with rectangular punched welding pins to support the insulation. These pins shall be welded to surface in an approved manner. On the top surfaces the pins shall be located on 0.61m centers-diamond pattern, on sides 0.457 m centers-diamond pattern, and 0.305 m centers-diamond pattern on bottom surfaces.

All surfaces shall be clean and dry.

Where metal surfaces are to be painted to prevent corrosion, the paint shall be completely dry prior to the installation of the insulation.

Where heat tracing is required it shall be installed prior to application of the insulation.

4.3.3.5.2 Equipment

4.3.3.5.2.1 Application to curved surfaces

On equipment operating at over 260°C and 1.83 m and larger in diameter, a one inch cushion blanket shall be applied over the entire surface before application of the calcium silicate curved segmental insulation. The blanket shall not be compressed, and shall be secured with a minimum amount of stainless steel wire.

On all equipment, calcium silicate shall be molded, or cut, into curved segments to fit the vessel surface, with one inch space allowed for cushioning blanket, where used. Curved block shall be applied to vessel sides in staggered position with all joints tightly butted. Insulation shall be secured with straps on 0.229 m centers. Multiple layers shall be applied so that the butt joints of one layer do not coincide with those of the other.

All layers of insulation shall be secured with straps where the contour of the vessel permits firm attachment. Insulation applied to irregular surfaces, where use of straps is impractical, shall be secured with wire.

4.3.3.5.2.2 Application to flat surfaces

Block insulation shall be applied to flat surfaces in staggered position with all joints tightly butted. Blocks shall be secured with wire attached to welding pins welded to surface. Multiple layers shall be applied so that the but joints of one layer do not coincide with those of any other layer.

After the specified thickness of insulation has been applied, wire netting shall be stretched tightly over block and secured with tie wires.

4.3.3.5.2.3 Application to vessel heads

Vessel heads shall be insulated with preformed block (and cushion blanket where required).

Insulation on top heads up to 3.658 m diameter shall be secured with straps. Top heads larger than 3.658 m diameter, all bottom heads, and vertical heads shall have insulation secured with wire attached to rectangular pins located.

4.3.3.5.2.4 Application to vessel flanges

All vessel flanges shall be insulated unless specifically excepted. The flange cover shall be a preformed-slip type flange cover of the same thickness as the specified insulation thickness. Flange cover shall be of step construction, so designed that it functions as an insulation expansion joint. The upper and lower sections of the cover shall be secured to the curved side wall insulation with straps and skewers. The midsection shall be secured at its bottom so that it may slide in respect to the upper section.

4.3.3.5.2.5 Application of expansion joints

Insulation expansion joints shall be provided on 4.572 m centers. The insulation support shall be 25 mm above the termination of the insulation below. This void shall be packed tightly with fibrous glass wool. Slip sleeves of stainless steel sheet shall cover this opening and protect it from the weather.

Where a vessel flange occurs on a vessel, expansion shall be considered as taking place, and be compensated for by the flange cover, at that location.

4.3.3.5.2.6 Application to manholes and nozzles

All manholes, blind nozzles, and connecting piping flanges shall be insulated (unless specifically excepted) with precut oversize covers. thickness shall be the same as specified for the vessel insulation. These covers shall be attached to the vessel insulation by wire, straps, and skewers in such a manner that movement of the vessel does not cause them to break loose.

4.3.3.5.2.7 Application to vessel legs

Channel legs for vessels shall be insulated with blocks which shall extend over channel flanges and down to fireproofing or footer. The thickness of insulation shall be a minimum of 13 mm that specified for the vessel but in no case less than 50 mm.

Vessel insulation shall be butted firmly against the tank leg flange. Re-entrant space between the channel flanges and over the channel flange between body insulation shall be filled with block. Leg insulation shall be secured with straps and wire.

4.3.3.5.2.8 Application to vessel skirts

Skirts of vertical vessels shall be insulated down a minimum of 4 times the insulation thickness specified for the vessel from their junction points with the vessels. Thickness of insulation shall be the same as specified for the vessel. Where required for fire protection, the outside and inside of skirts shall be insulated entirely, with a minimum of 50 mm of block insulation precut to fit skirt curvature. No cushion blanket shall be used under this block insulation.

Outer insulation on skirt shall be secured with straps. Inner insulation on skirt shall be secured with wire attached to rectangular pins welded to inside of he skirt on/25 mm centers.

4.3.3.5.2.9 Surface finish

Regular cylindrical surfaces, limited area flat surfaces, and preformed covers do not require any insulation or finishing cement surfacing. Any slight voids may be pointed up with insulating cement troweled flush with adjacent surfaces.

Large flat surfaces and irregular surfaces over which wire netting is installed shall be given a 12.5 mm thick, smooth and uniformly applied trowel coat of hydraulic setting insulating cement.

Weather barrier shall be as designated in insulation schedule. Materials and application shall be as called for under that designation.

4.3.3.5.3 Piping

4.3.3.5.3.1 Application to straight pipe

Vertical pipe over 76 mm NPS shall have insulation supported by an insulation support, welded or bolted to pipe directly above the lowest pipe fitting. Additional insulation supports shall be located 457 cm on centers above the bottom support. An insulation support shall also be installed above each valve or pair of line flanges located in the vertical run of the pipe.

Insulation shall be sectional up to 324 mm dia and may be sectional or curved segments above this diameter insulation shall be applied in staggered joint construction. Multiple layers shall be installed so that the butt joints of one layer do not coincide with that of another.

Securement of insulation shall be by wire up to 324 mm. Above this diameter the insulation shall be secured with straps, except that all inner layers shall be secured with wire. If metal jacketing is specified for the weather-barrier and it is secured by straps, then all layers of insulation, regardless of size shall be secured with wire.

4.3.3.5.3.2 Expansion joints

Expansion joints in the insulation shall be installed every 457 cm of uninterrupted straight pipe in both the horizontal and vertical. The insulation of single and each of multiple layers shall be terminated in a straight cut. A space of 25.4 mm shall be left between the insulation terminations. This void shall be packed tightly with glass wool blanket. The expansion joint shall be protected by stainless steel sleeves.

4.3.3.5.3.3 Application to flanged fittings

All flanged valves and fittings, with the exception of ball and plug valves, shall be insulated with preformed covers in accordance with the dimensions given in ASTM Recommended Practice C-450, latest revision. Ball and plug valve covers shall be field fabricated of the proper sectional pipe insulation. These covers shall be secured in position with straps.

4.3.3.5.3.4 Application of welded fitting covers

All welded fittings over 89 mm dia shall be insulated with preformed covers in accordance with ASTM Recommended Practice C-450, latest revision. These covers shall be secured in position by straps or wires, depending upon pipe diameter.

4.3.3.5.3.5 Application to small welded or screwed fittings

Welded fittings under 89 mm dia and screwed fitting covers may be preformed or field fabricated and secured in position with wire. Fittings less than 48 mm dia may be insulated with insulating cement installed to the specified thickness.

4.3.3.5.3.6 Finish

No insulating cement or finishing cement shall be used to cover any preformed pipe or fitting covers. Slight voids shall be pointed up with cement to bring flush with adjacent surfaces.

Application to heat traced pipe (where required).

Piping requiring tracing by tubing or electric conduit up to 16 mm dia shall be insulated with oversize insulation. The size of preformed fittings for this traced piping is given in the "Traced" section of ASTM Recommended Practice C-450, latest revision. After tracing is installed and is thermally connected by heat transfer cement, the pipe and fittings shall be insulated as previously specified.

4.3.3.6 Weather-barriers metal jacket pipe weather-barrier designation I

Application of metal jacket to insulated straight pipe

Jacket shall be installed by placing it around the pipe insulation and engaging the "Z" joint. The "Z" joint on horizontal piping shall be on the side of the insulation, with the open edge of the "Z" joint pointed down. The butt joints between adjacent jackets shall be sealed with a closure band. Closure band sealing compound shall be used to seal voids across interior of closure bands where they lap over "Z" joint. Closure bands shall be secured in place with insulation strap.

On pipe insulation less than 300 mm outside diameter an insulation strap shall be installed at the half way point from each end to secure the entire assembly. On pipe insulation above 300 mm outside diameter it shall be secured in position by two straps. Straps shall be spaced 300 from each end.

Weather-barrier for fittings and irregular shapes of piping insulation is given in weather-barrier designation II which follows.

4.3.3.7 Weather-barrier, reinforced mastic-designation II

Application

Surface of insulation shall be smooth, even, and free of voids, and in a relatively dry state. On outside installations, insulation shall be sloped for water drainage.

Sharp outside corners of insulation shall be rounded off to not less than a 25.4 mm radius. Inside corners shall be caulked with caulking mastic to obtain a minimum 25.4 mm radius inside corner.

A heavy fillet of heat resistant sealer shall be installed around all metal which projects through the insulation. The sealer shall extend over the insulation and 152 mm over the projection.

Insulation shall be protected from weather as soon as possible. However, the barrier shall not be applied when atmospheric temperature is below 0°C or when the temperature is expected to be as low as -3.9°C within the ensuing 24 hours.

Reinforcing cloth shall be bonded, taut and smooth, to the insulation surface with the weather-barrier mastic. All joints shall be overlapped a minimum of 51 mm. All inside and outside corners shall be rounded and overlapped with two layers of cloth. Cloth shall extend a minimum of 102 mm out on all projections through the insulation.

Mastic shall be troweled or palmed over the entire surface, pressing it through the mesh of the cloth to obtain bond with the insulation. The weather-barrier mastic shall be carried out 154 mm onto metal, beyond termination of the insulation on supports, skirts, or other metal projections. Care must be taken that mastic completely seals the openings in the cloth. After the weather-barrier has partly set, it shall be water brushed to smooth even surface. The combined thickness of the weather-barrier coating and the reinforcing cloth shall not be less than 1.6 mm when dry.

Drip, on floors, concrete, or splatter on gages, valve stems, instruments or other items must be immediately washed clean with water, then dried.

Expansion joints in weather-barriers over insulation expansion joints shall be constructed with expansion sleeves.

4.3.3.8 In this sample specification reference illustrations may be given for easier understanding the intend of the specification. The use of drawings to illustrate specifications is highly recommended as being a very effective means of communicatinginformation.

In the preparation of specifications, various means may be used to reduce the space and amount of written matter. For example, the properties of material may be presented in tabular form rather than by referring to each property and test method in written form. These methods of presentation are quite efficient and desirable.

Here it shall be reemphasized that the specification, as presented, was a sample of the items to be covered by a specification and a suggested format by which all these items can be presented to communicate the desires of the Designer-Engineer to the Contractor and his personnel. The presentation given is not a recommendation of insulation application. Only the engineer who knows his installation requirements, the properties of materials, and how they should be applied is in a position to prepare application specification for his installation.

5. EXTENT OF INSULATION

5.1 General

5.1.1 The Company shall specify the equipment to be insulated in the contract document based on the rules of this section so that the Contractor will have a clear view of the scope of work.

5.1.2 Hydrostatic pressure test on pipe, vessels and equipment shall, if possible, be completed before insulation is installed. If insulation is applied before testing, all welds, threads and bolted joints shall be left exposed until completion of testing.

5.1.3 To facilitate regular inspection of welds, bolted joints, thickness measurements, etc. removable portion of insulation and finishing material shall be provided in appropriate locations to be selected at site by the employer. The junction between removable and permanent insulation shall be made readily discernible, e.g. by painting the end of permanent insulation or laying a suitable textile fabric over the end. The removable cover shall be of the same basic material and thickness as the permanent insulation and of sufficient rigidity to withstand handling.

5.1.4 Vertical vessels which have a marked decrease in temperature from bottom to top shall be insulated as follows: lower half of the vessel shall be insulated for the bottom service temperature, and upper half may be insulated for the vessel overall average temperature.

5.1.5 Projections beyond the normal insulation thickness, such as stiffener rings on vessels which are on integral part of such equipment, shall be fully and independently insulated and finished in the same manner as the equipment and the cleading shall be arranged to allow for expansion of the vessel.

5.1.6 Pumps, compressors and turbines shall not be insulated unless required for process control or for safety aspects.

5.1.7 Nameplates containing design and/or operating data, stampings, thermowell bosses, pressure tappings and warning notices on heat exchangers with differential pressures, shall not be insulated and the insulation shall be beveled back and sealed or a window shall be provided if necessary.

5.1.8 Seals vent chamber, and drip pots in pipelines shall not be insulated unless specified otherwise by the Company.

5.1.9 The word "fitting" shall designate ells, tees, caps, reducers, meters and stub-in connections.

5.1.10 The installation of rings around nozzles of insulated vessels shall be avoided since this would interfere with the easy access for inspection measurements and hammer testing.

5.1.11 Skirts, legs or supports of insulated vessels shall be insulated externally along a minimum distance of 600 mm from their point of contact with the shell or to within 50 mm of the top of the fireproofing, where applicable.

5.2 Hot Insulation

5.2.1 Vessel manways, handholes weep hole nipples, samples connections, nozzles with blind flange, exchanger tubes sheet, flange, etc. shall not be insulated on hot insulated vessels exchangers or equipment, but shall be insulated where required for acoustical control. If specified to be insulated, preformed insulation of a design permitting removal and replacement shall be applied.

5.2.2 Piping bends are usually insulated to the same specifications as the adjacent straight piping. Where preformed material is used it shall be cut mitered segment fashion and wired or strapped into position; alternatively, prefabricated or fully moulded half-bends may be used if these are available. Plastic composition may be used to seal any gaps that may appear between mitered-segments.

5.2.3 It is preferable that flanges, valves and other fittings on hot piping above 300°C be insulated, but where hidden flange leakage may cause a possible fire or other hazard, e.g. with oil lines, or where repeated access will make it un-economical, insulation may be omitted.

5.2.4 Valves and flanges in piping for viscous fluids, e.g. asphalt and paraffin wax service, and in all lines in services above 300°C shall be provided with removable insulation covers. Attention shall be paid to the insulation details to pre-vent leaking product into the line insulation. Drainage outlets should be provided to give visible indication of a possible valve or flange leak.

5.2.5 Bonnet and channel hangs on heat exchangers shall preferably be insulated by means of a removable double skin box. If the weight of the box exceed 25 kg it shall be in two or more parts and the weight of each part be less than 25 kg.

5.2.6 For heat exchangers on hydrogen duty, tube-sheet and channel flanges shall not be insulated, but a simple remov-able galvanized sheet metal protecting shroud shall be placed over the bolts to protect them from the effect of thermal shock from rain storms. A suitable gap shall be left between the bolts and the shroud to allow adequater ventilation. Also flanges for hydrogen service shall never be insulated.

5.2.7 Steam traps and the outlet side of the steam trap piping shall not be insulated. Lines to steam traps shall be insu-lated. In the case of thermostatic type traps, 600-1000 mm of line before trap shall be left uninsulated.

5.2.8 Heat exchanger flanges, exchanger channel and shell cover, saddle support for horizontal equipment, equipment shell closure flanges, nozzles to which non insulated piping is attached, tube union, tube and shell connectors on fin tube exchangers also shall not be insulated unless specified otherwise or required for personnel protection.

5.2.9 The bodies of safety valves shall not be insulated.

5.2.10 Steam condensate lines shall remain uninsulated except as required for personnel or freeze protection.

5.3 Cold Insulation

5.3.1 All external surfaces shall be completely insulated except for pumps which shall be insulated only if specified.

5.3.2 Vessels and their skirts shall be thermally isolated from their holding down bolts and pipes shall also be ther-mally isolated from their supports. Hard wood blocks or other suitable material shall be used for this purpose. Ladders and platforms shall also be isolated from the vessels to which they are attached. Where hardwood blocks or similar ma-terial is used, this shall be suitably fire-proofed. Insulation shall be extended sufficiently to prevent frosting of adjacent parts.

5.3.3 Flanged connections on cold insulated vessels, heat exchangers, equipment or piping shall be insulated.

5.4 Finishes

5.4.1 General

5.4.1.1 Insulation exposed to the weather or subject to the mechanical damage should normally be protected with metal sheeting and shall be arranged to shell water. Consideration may be given to the use of plastic sheeting or mastic finishes in certain areas.

5.4.1.2 Within units processing hydrocarbons or other flammable materials, and on crude oil tanks and on tanks and vessels storing liquefied flammable gases, the cleading shall be galvanized or aluminized steel. Outside these areas and on the other pipes, tanks and vessels, aluminum cleading may be used.

5.4.1.3 In particularly corrosive or difficult situations, consideration may be given to the use of light gage stainless steel.

5.4.2 Hot services

5.4.2.1 When cleading is precluded by the shape of the equipment or when sheltered from the weather, rigid insulation finished with a hard setting cement shall be used.

5.4.2.2 Hard setting cement finishes shall only be used over flexible insulation in combination with well supported expanded metal reinforcement.

5.4.2.3 Heads of vessels should normally be finished with segmental metal cleading which shall be overlapped and sealed to prevent moisture entering under the vertical cleading.

5.4.3 Cold services

5.4.3.1 Sealing materials must be compatible with the insulation.

5.4.3.2 Where required as a protection from mechanical damage or to reduce the fire risk, insulation shall be protected with metal cleading which shall be secured by bands at approximately 500 mm centers. Self tapping screws should not be used since these may penetrate the sealing materials.

5.4.3.3 For rigid materials a joint sealer shall also be applied to all joints in the insulation material.

5.4.3.4 Precautions shall be taken to prevent leakage of solvents on to vapor barriers.

6. METHODS OF INSULATION APPLICATION

6.1 General

6.1.1 Insulating materials shall be kept dry in store and during erection, since wet insulation cannot always be dried out on site.

6.1.2 Insulation removed from storage shall be used the same day and neither to be returned to storage or left overnight on the job site.

6.1.3 Cartons containing rigid sections or segments need to be stored end-up and be stacked no more than three high.

6.1.4 Bales containing slab insulation shall be stored flat, stacked not more than six high and preferably only four high if storage is likely to exceed a year.

6.1.5 Bales containing mattress insulation shall be stacked flat and not more than four high.

6.1.6 Metal sheet e.g. aluminum or galvanized mild steel, may be delivered as single sheets or in bundles, dependent on the type of handling facilities in the stores.

6.1.7 Sheets or bundles should be stored under cover in a dry atmosphere under ambient temperatures. The first layer of sheets not exceeding 0.5 tone or first bundle shall be stacked on a pallet board, the second and subsequent layers or bundles shall be supported on timber spaced at not more than 600 mm center between each layer or bundles.

6.1.8 Sheet edges shall be examined at least monthly to see if any discoloration has taken place. If discoloration occurs faces of the sheet shall be examined and, if necessary, dried and restacked.

6.1.9 When storage for longer than three months is comtemplated the supplier shall be consulted for recommendations on packaging the sheets prior to storage.

6.1.10 Ancillary fixing materials, bandings, screws, mastics, etc., need to be stored under cover in a dry atmosphere not below 5°C. It is important, particularly with two-part adhesives, mastics or foam systems, to verify the shelf life.

6.1.11 Apart from certain loadbearing materials, most types of insulating materials require support or reinforcement when applied; they also require to be secured to the surface to be insulated. For these reasons, it may be necessary to attach fixing accessories to the piping or equipment before application of the insulating materials is commenced.

6.1.12 All insulating materials, however fixed, shall in close contact with the surfaces to which they are applied, unless an air space is specially required.

6.1.13 Where the main insulation consists of preformed, or flexible material, all edges or ends shall be closely butted; for multilayer work all joints shall be staggered.

6.1.14 As a general rule insulation shall be carried out at ambient temperature. In certain cases it may be advisable to apply finishing material at operating temperatures.

6.1.15 Before any section of the insulation work on piping, vessels or ductwork is commenced, all hangers, brackets, pipe clips, etc. shall be in position and the necessary acceptance tests for pressure/vacuum, etc. have been carried out.

6.1.16 Attention is drawn to the possible danger of skin irritation when using plastic compositions. Materials with a high-free-lime content require particular care.

6.1.17 The junction between removable and permanent insulation is to be so arranged as to be readily discerned, e.g. by painting the end of the permanent insulation or by laying a suitable textile fabric over it.

6.1.18 Application of "in situ" foaming or spraying shall be subjected to the approval of the Company.

6.1.19 Working conditions

6.1.19.1 Equipment, paved areas, etc. adjacent to components being insulated shall be protected from dripping compounds and cements. Any damage resulting through failure to observe protective measures shall be repaired.

6.1.19.2 The work area shall be kept clean and free of debris resulting from insulating work; and on completion of work all coating, unused insulating material, scaffolding, etc. shall be removed.

6.1.20 Stripping the old asbestos-containing insulation see also BS 5970.

6.1.20.1 The old insulating material shall be examined initially by company to determine whether asbestos is present and the Contractor shall remove the insulating material so specified.

6.1.20.2 During removal of insulations that contains asbestos, it is essential that safety requirements are observed. Thus all operators who are engaged in stripping asbestos-containing materials have to wear protective clothing and approved respiratory equipment which are available from safety department.

6.1.20.3 The area of the work has to be segregated by the provision of the barriers in locations outside which the level of asbestos dust will not contravene asbestos regulations.

6.1.20.4 Wetting is not obligatory, provided that the respiratory equipment is adequate for the concentration of asbestos dust produced, and that, where appropriate, there is an adequate standard of separation between the working area and other parts of the site to prevent the scope of dust.

6.1.20.5 Preformed insulation that is easily accessible, shall be removed dry and placed immediately in non-permeable bags, which shall be tied at the neck.

6.1.20.6 Plastic compositions, hard-setting compositions, or self-setting cements that require the use of saws or pneumatic tools for cutting shall preferably be wetted before removal. After the outer finish has been removed, the main insulating material can be wetted, either by spraying or by injection techniques. The use of water should be controlled in order to avoid the formation of slurry with consequent risk of injury on slippery floors.

6.1.20.7 Asbestos waste material shall be enclosed in bag marked clearly for identification.

6.1.20.8 Bags that contain asbestos waste shall be removed from the place of work for safe disposal.

6.2 Surface Preparation

6.2.1 General

Piping and equipment shall be clean, dry and free from grease, dirt, loose rust and scale. In special cases that ingress of rain-water or condensation of water vapour in the insulation can cause severe under lagging corrosion of carbon steel and low alloy equipment and piping, the surface shall be blast cleaned and painted.

6.2.2 Grease or oil contamination shall be removed as specified in Clause 5.1.1.3 of IPS-E-TP-700 and IPS-C-TP-101.

6.2.3 The steel to be sand blasted shall be dry and operating conditions shall be such that condensation does not occur on it during work. When compressed air is used, this shall be dry and free from oil.

6.2.4 Weld defects and surface imperfections such as sharp edges shall be removed.

6.2.5 Blasting operations shall never be allowed in the vicinity of painting work or near a wet paint surface, or anywhere that blast abrasive, grit or fall-out shall impinge on a freshly painted surface, or on any uncovered primed surface.

6.2.6 Blast cleaning operations shall not be conducted on surfaces that will be wet after blasting and before coating and when the surfaces temperature are less than 3°C above the dew point, when the relative humidity of the air is greater than %85 or when the ambient temperature is below 3°C.

6.2.7 Blast cleaning is permitted only during the daylight.

6.2.8 After blast cleaning the residual shot, grit and dust shall be completely removed by any means as appropriated. Care shall be taken not to recontaminate the blast cleaned surface.

6.2.9 The prepared blast cleaned surface shall be completely primed the same day as blasted and before any visible rusting or deterioration of the surface occurs. No blasted surface shall stand overnight before coating. If such surfaces are not primed in accordance with the above they shall be reblasted.

6.2.10 Care shall be taken not to contaminate blast cleaned surface prior to painting.

For more information on surface preparation see IPS-C-TP-101.

6.2.11 For selection of primer coat see IPS-E-TP-700 Clause 5.7 and IPS-E-TP-100 and for application of the primer see IPS-C-TP-102.

6.2.12 Austenitic stainless steel vessels, equipment and piping need special attention in coastal areas or where corrosive products, e.g. chlorine, chlorides and hydrogen chloride are being handled. In order to abate the effects of chlorides and moisture trapped from the atmosphere in such concentrations that contamination of the metallic surfaces under the insulation may cause stress-corrosion cracking, the external surfaces of these vessels, equipment and piping used occasionally or operating in the temperatures above 50°C shall be thoroughly cleaned and painted (see IPS-E-TP-100), or wrapped with aluminum foil.

6.3 Accessories

Accessories includes attachments, insulation supports, securing devices, and reinforcements.

6.3.1 Attachments

6.3.1.1 Usually the term 'attachment' is used for any anchor fitting fixed permanently to the surface to be insulated, usually by welding. Some types of plastics fittings, e.g. nylon clips, may be fixed to the surface by means of a suitable adhesive, subject to temperature limitations. Attachments for welding may be flat or angle cleats, pipe bosses, threaded pillar nuts, washers or nuts welded 'on edge', studs etc. Their purpose is to serve either for the direct support of insulating materials or as fixtures to which insulation supports can be secured, e.g. by bolting. Carbon steel fittings should not be welded directly to alloy steels.

6.3.1.2 For those surfaces on which site-welding of attachments is not permissible, e.g. for certain types of alloy steel, or where subsequent internal temperature and pressure could be a hazard, it may be satisfactory to weld suitable metal pads in the appropriate locations. These shall be applied during manufacture of the equipment at the works, which would permit subsequent stress relieving; the attachments would then be joined to the pads at site.

6.3.1.3 When the service conditions, (including any abnormal conditions that may occur as a result of incorrect operation or accident) make it necessary for a pipe or portion of plant equipment to have post-weld heat treatment to avoid any risk of brittle fracture at sub-zero temperatures, of stress-corrosion cracking, or of other type of failure, either:

a) weld the attachments in place before final post-weld heat treatment, or
b) attach the insulating material by means that do not involve welding.

6.3.1.4 For the choice and methods of attachment of plastics or metal clips by means of adhesive, the Manufacturer's literature should be consulted. Frequently these clips are formed with an integral perforated flat base that permits penetration of the adhesive through to the upper surface. Self-adhesive insulation pins may also be used on flat smooth surfaces, such as galvanized metal or plastics ducting, provided that the surface is free from dust, and the Manufacturer's weight and temperature limitations are not exceeded.

6.3.1.5 Typical attachments for gun welding would be plain pins of 3 mm diameter, end-fluxed studs of 10 mm diameter (plain or threaded), flat cleats 12 mm wide and 3 mm thick (or similar angle welded on edge), threaded pillar nuts up to 12 mm diameter, etc. Split pins, fork studs, and similar fastenings follow the general rule for studs, as above, with a preference that the contact area should not exceed about 78 mm^2.

6.3.1.6 The use of hand-welding technique may permit the application of attachments with larger contact areas than those indicated in 6.3.1.5 and, with relatively long angles or cleats, it may be sufficient to use intermittent (stitch) welding.

6.3.1.7 It is sometimes preferred to weld a thick threaded nut or pillar nut on to the surface to be insulated, thus providing a fixture into which a threaded stud may be screwed at a later stage. This can be useful for avoiding mechanical damage to the stud during transit or during erection of the plant. Also it can permit the use of an alloy stud on a surface of carbon steel, thus avoiding welding problems.

6.3.1.8 The locations of studs or cleats will depend on the weight of insulation to be attached, as well as on the location of the surface, and on the degree of vibration to which the plant may be subjected under service conditions; for large flat surfaces, reasonable average spacings would be:

Vertical surfaces	450 mm square spacing,
Upward-Facing surfaces	600 mm or 750 mm square spacing,
Over-Hanging and downward-facing surfaces	300 mm (maximum) square spacing.

Alternate rows may be offset by 50% of the spacing, depending on the dimensions of the material used. Usually there should be a row of attachments parallel to each edge and to each stiffener or flange, and at a distance of 75 mm to 150 mm away from the edge.

6.3.1.9 For large-radius curved surfaces, if welding is permitted, 450 mm to 600 mm uniform spacing is considered suitable, but this may be modified for vertical large cylindrical surfaces when the cleats are required to prevent downward movement of the insulating material. Cleats may not be required for horizontal cylindrical surfaces if it is possible to provide circumferential straps that can be tensioned over the insulation.

6.3.1.10 Welded attachments should preferably penetrate into the insulating material only to the minimum extent necessary to achieve effective support and except in special circumstances, such penetration shall not be greater than about half the thickness of the insulating material. The cross-sectional area of the attachments shall be the minimum consistent with the required mechanical strength in order to avoid excessive transfer of heat (or cold) by metallic conduction.

6.3.1.11 It is important to remember that a welded attachment will be subjected to the same extent of thermal movement as will the insulated surface, with the resultant possibility of tearing the insulation or finish, unless care is taken to allow for this e.g. by expansion or slip joints.

6.3.2 Insulation supports

6.3.2.1 Supports for insulation and any associated cleading are required only to bear relatively light loading; they may consist of metallic flat bars, rings, part rings, varying lengths of angle, or studs. The flat bars, rings and angles normally will rest on stud or cleat attachments welded in the appropriate locations to the surface to be insulated. (See Fig. 6 and 7). Angle supports, where used, may be bolted to the welded attachments on the plant, or they may rest loosely on top of floating flat rings; in the latter arrangement short angle pieces may be used to secure external metal cleading to which they are fastened, either by bolts or by rivets.

6.3.2.2 Stud-type supports are used mainly for preformed or for spray-applied insulation, although they may serve as suspension points for the metal-mesh covering of flexible insulating mattresses. The studs may be in the form of attachments welded directly to the plant, e.g. split pins, fork studs, or plain studs, or as threaded studs screwed into nuts that themselves are welded to the surface to be insulated. Alternatively, especially for vertical alloy-steel pipework, the studs may be welded radially to a ring that can be clamped around the pipe at the required vertical intervals. As these rings tend to slip downwards under service conditions, suitable support lugs or pads for the rings shall be welded on to the pipe at the Manufacturer's works, to be followed by any necessary stress-relieving process.

6.3.2.3 As a general rule, studs shall not be greater than 10 mm in diameter, or of equivalent contact area, for gun welding. Angle cleats and flat bar normally will be about 5 mm to 10 mm thick, depending on the weight of insulation (and finish) to be supported; widths conveniently may be about 75 mm, varying according to the total thickness of insulation to be supported. For anchorage of spray-applied mineral fibres and insulating concretes it is usual to provide Y-shaped studs of approximately 5 mm to 10 mm diameter for the main leg; these may be welded directly to the surface of the plant or may be threaded for screwing into corresponding nuts, which themselves are welded to the surface to be insulated.

6.3.2.4 Preferably, the supports shall not penetrate the insulation to a distance greater than about half its thickness unless through-metallic connection between cold and hot surfaces of the insulation can be avoided, or reduced to an appropriate minimum. This is of particular importance with insulation over refrigerated plant, or when the external finish over hot insulation is of sheet metal. Sometimes it is possible to interpose a pad of insulating material between the inner welded attachments and the supports of the main insulation system.

6.3.2.5 The cross-sectional area of each insulation support shall be not greater than that necessary to achieve the required mechanical stability, so that thermal conduction can be reduced to an acceptable minimum. In appropriate cases the support may be non-metallic, e.g. plastics or wood, and it is possible to take advantage of the fact that many alloy steels have lower thermal conductivity than has carbon steel, at corresponding temperatures.

6.3.2.6 Vertical vessels, insulated with block insulation, require a support at the bottom, and, if the vessel is over a certain height, intermediate supports to prevent the insulation from sliding downward. These supports may be angles, plates, rods, or other projections welded or bolted into position around the vessel.

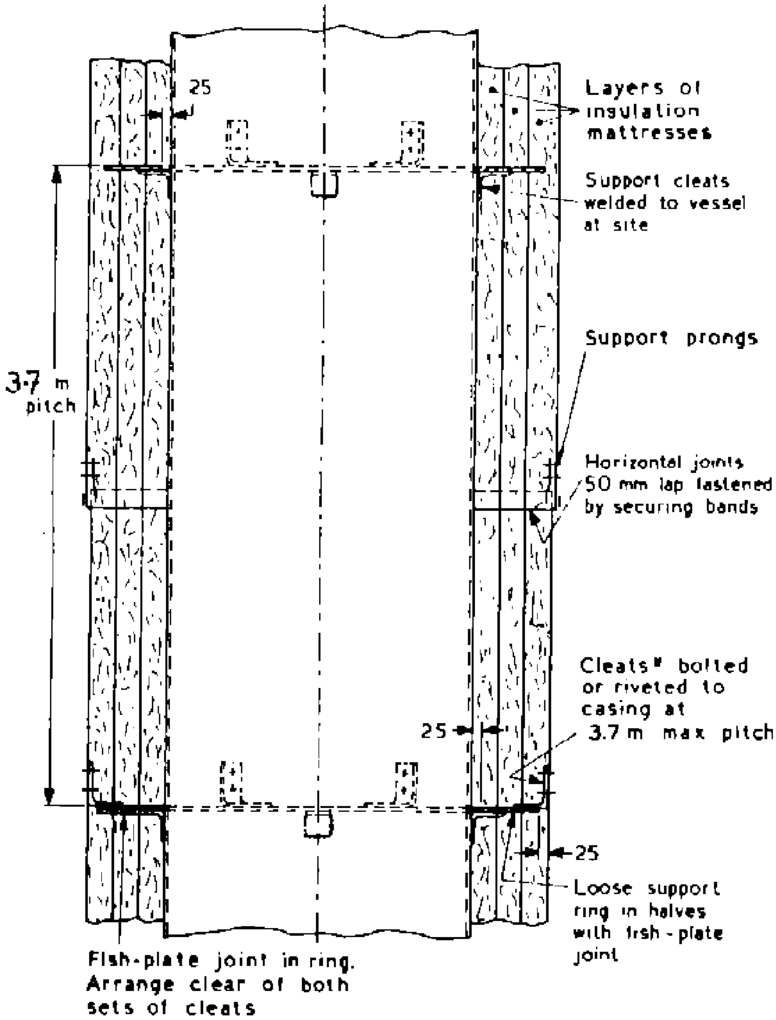
6.3.2.7 Insulation supports should be installed on vertical vessels on 3700 mm centers. (See Figs. 6 and 7). Compressive strength, and change in length caused by expansion or contraction of the vessel compared to the insulation change in length are two factors controlling the support centers. In some instances, the support distances are set by vessel flanges. In all cases, a support shall be installed above a vessel flange to prevent the insulation from sliding down and resting on the flange studs. The support shall be a sufficient height above the flange to permit easy removal of the studs. On low temperature vessels, the differential movements which occur at the contraction joint shall not exceed the dimensional flexibility of the caulking-weather-vapor seal at these joints.

6.3.2.8 Insulation on long runs of vertical pipe shall be supported in the same manner as that described for vertical equipment.

6.3.2.9 Except for vessels operating at very moderate temperatures, in which expansion and contraction of vessel is insignificant the insulation shall be sufficiently friction-free of the vessel surface so that expansion and contraction movement of the vessel is independent of the insulation. To obtain this freedom of movement, insulation shall be installed slightly oversize.

6.3.2.10 Factory attached, metal jacketed insulation panels are supported by a vessel in several ways. The first panel side rests on the tank base, and successive panels are supported on "S" clips attached to the top of the installed panel. In addition, the metal jackets are supported by pins welded to the side of the vessel. The jackets in turn support the insulation cemented to it. The panels are secured by clips or straps.

6.3.2.11 Large horizontal vessels (over 1.8 meter diameter) require supports to which securement straps, used to pull the bottom insulation into position, can be attached. Such supports are necessary, for, if straps were simply brought around the vessel insulation on top, the pull required to draw the bottom insulation into position would exceed the compressive limits of the insulation over which it passes. The supports are so located that bands can be drawn to secure the bottom third sector of insulation into position. Smaller horizontal vessels are their own support for the cylindrical insulation. The straps drawn around the insulation transmit the load of the lower insulation to that on top, which in turn is supported by the vessel. This is also true of all insulation installed on horizontal pipes.



All vertical joints of labyrinth type.

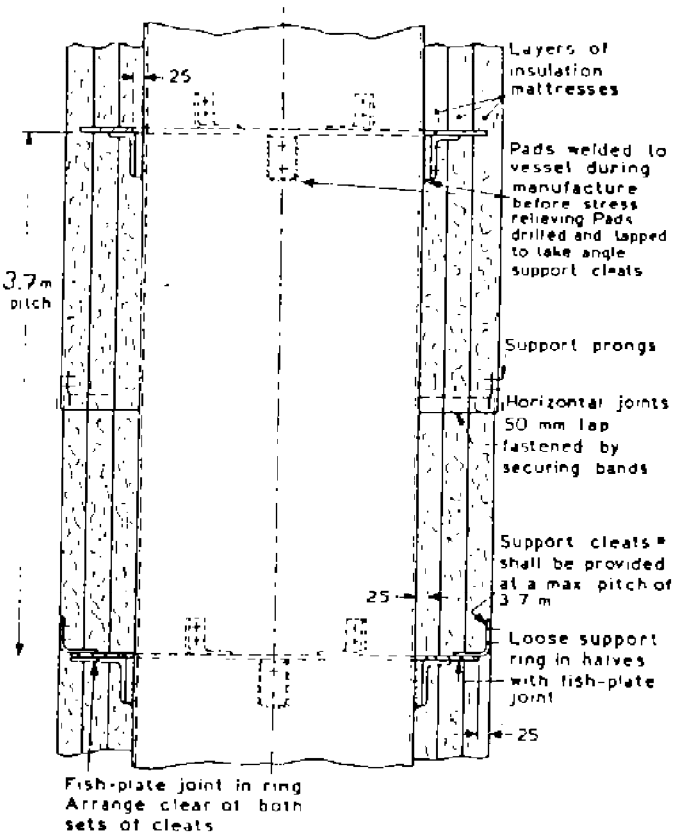
Sheeting support cleat has to have a spot of weld metal applied to its underside so that there is only point contact with the support ring.

Dimensions in millimeters unless otherwise indicated.

*** Cleats should preferably be of metal similar to the outer cleading.**

TYPICAL METHOD OF INSULATING VERTICAL VESSEL WHEN WELDING IS PERMISSIBLE ON SITE

Fig. 6



All vertical joints of labyrinth type.

Sheeting support cleat has to have a spot of weld metal applied to its underside so that there is only point contact with the support ring.

Dimensions in millimeters unless otherwise indicated.

*** Cleats should preferably be of metal similar to the outer cleading.**

TYPICAL METHOD OF INSULATING VERTICAL VESSEL THAT HAS BEEN STRESS RELIEVED
Fig. 7

6.3.2.12 The head insulation on horizontal vessels must also be supported. In most instances, the support for the head insulation is the same as that for the support of the cylindrical insulation, with slots or holes punched for the attachment of straps. The straps then pass from the cylindrical support on one side, over the insulation to the support on the other side, and when drawn tight secure the insulation in position.

Depending upon the method of installation various types of insulation supports are required. In summary, insulation supports are:

Structural angles
Formed strapping
Metal plates and rectangular bars
Metal rods
Road mesh
Pins-metal and plastic (welded or adhered to surface)

Blank nuts
Rectangular studs (punched, split, etc.)
Grooved studs
"S" clips
Grip nails

Accessories for the above are bolts, nuts, rivets, attachment by welding, or adhesives.

All these are used to transfer the weight of the insulation to the vessels, pipe, equipment, walls, or structural steel. They are structural members, regardless of whether they support the load in compression or tension.

6.3.2.13 As a general rule, supports for finishing materials, apart from those for the insulation proper, are not required except when a cleading of metal sheet is to be used over flexible fibrous material. Where such supports have to be used, they may consist of pads or short lengths of compression-resisting insulation, applied directly to the surface to be insulated or mounted over the ends of studs or angle cleats that themselves are attached to the surface. Alternatively if the insulating material is not of sufficient resistance to compression, particularly over horizontal surfaces, the supports may be in the form of metal rings or 'stools' spaced away from the surface on 'prongs' to restrict the total area of contact with the insulated surface, so reducing the rate of thermal transmission to an acceptable minimum.

6.3.3 Securement (tie wires, lacing wire, bands, clips, washers, nuts, etc.)

6.3.3.1 Unless the insulating material can be secured directly to the surface to be insulated, e.g. by means of adhesive, it is usually necessary to provide some form of mechanical accessory to secure it to the permanent attachments. Tie wires, lacing wire, washers, clips, or nuts, are the most common when associated with the types of attachment and supports described in 6.3.1 and 6.3.2. For cylindrical surfaces it may be satisfactory to secure the complete insulation system by means of circumferential bands that can be tensioned over the outer surface. Sometimes wire netting over the insulating material will serve the same purpose provided that the edges can be laced tightly together. Separate securing accessories may not be required if an integral sheet finish is arranged so that an edge overlap can be secured by means of adhesive.

6.3.3.2 For large flat surfaces it is usual to secure the insulating material by impaling it over the studs or cleat attachments, using lacing wire to hold it in position. Preferably the lacing wire should be wrapped round the main attachments and crossed for tensioning. With flexible fibrous mattresses enclosed in wire mesh it may be sufficient to tie the outer mesh to the individual attachments.

6.3.3.3 Lacing wire and tie wire normally will be of galvanized soft iron but one of the soft alloy steels may be required for special chemical resistance or for use at elevated temperatures or cold services. Typical sizes of wire are 1 mm diameter for general use, or 1.5 mm for heavier use see IPS-M-TP-710. For refrigeration work use plastics tapes instead of metal wires. Over flat surfaces or large cylindrical vessels it may be desirable to use multistrand wire that can be tensioned between attachments; wire with seven strands each of 0.7 mm diameter, twisted in rope form, is suitable for heavy work. Other soft wires may be useful for special applications.

6.3.3.4 Securing wires shall be fastened either by simple wrapping round each attachment or by means of nuts, clips or washers, as appropriate, at each fixed point. Rapid-fixing clips, which depend on spring-point devices for securement, may become loose in service as a result of corrosion of the points.

6.3.3.5 Insulation on cylindrical surfaces, with an outer finish of fabric or sheet, may be secured by means of outer circumferential bands of metal or plastics strip. Metal bands shall have sizes as recommended in IPS-M-TP-710, they shall be corrosion resistant, either by virtue of the nature of the metal or by a surface treatment. Plastics bands preferably will have the width as recommended in IPS-E-TP-700 and should be sufficiently robust to withstand prolonged conditions of service. Special forms of rapid-fastening 'bristle-type' securing strip can be useful for special duties.

For outer covering of aluminum sheet only aluminum or stainless steel bands shall be used. Metal bands for large vessels shall be of adequate width and thickness to provide stability to the insulation system under the required conditions of service. For overall economy on large vessels, stainless steel banding should be used.

6.3.3.6 Flexible insulating mattresses that have wire-mesh covering integral in their construction and are stabbed through with inter-surface ties, shall be impaled over the main attachments and further secured by tightly fastening together adjacent edges of the outer covering mesh. The tie wires for this purpose should be approximately 1.5 mm in diameter and of similar metal to that used for the wire-mesh. If a final covering of aluminum sheet is to be applied, care shall be taken to avoid direct contact between dissimilar metals.

6.3.3.7 Lacing wire or other securing device that is likely to be in direct metallic contact with a final cleading of aluminum sheet, shall be coated with a suitable plastics material in order to avoid bimetallic corrosion in the locations of contact. Alternatively, it may be convenient to use aluminum or stainless steel securing materials.

6.3.4 Reinforcement

6.3.4.1 The most commonly used reinforcing materials are galvanized wire hexagon netting or one of the various types of expanded metal, but open-mesh woven glass fabric may be suitable for certain applications, e.g. the reinforcement of weatherproofing compounds applied in paste form. The main uses for the metallic reinforcement are with plastic compositions, spray-applied fibrous insulation, wet applied finishing compositions, and wet finishing cements, but they also are of value for retaining dry fibrous insulation and various types of preformed materials.

The size of mesh for wire hexagon netting is normally 25 mm with wire of 1 mm diameter. See IPS-M-TP-710.

6.3.4.2 Expanded metal will normally vary from 12 mm to 50 mm across the short dimension of the mesh, with thickness of metal varying between 0.5 mm and 1.6 mm, but heavier material may be used, e.g. for reinforcement of insulating concretes.

6.3.4.3 Galvanized steel reinforcing mesh and securing devices shall not be subjected to temperatures in excess of 65°C under conditions of possible high humidity. Suitable heat-resisting alloy shall be employed for all service temperatures in excess of 400°C. For intermediate temperatures, carbon steel may be used, but this shall be coated with bitumen or paint for protection against corrosion during storage and prior to application on site.

6.3.4.4 Where substantial mechanical strength is required, e.g. for resistance to compression, it may be desirable to use square-pattern reinforcing mesh, which may vary according to the requirements from strands of 2 mm diameter at 40 mm spacing to strands of 6 mm diameter at 100 mm or 150 mm spacing. Sometimes the component wires may be welded together at the crossing points. It shall be noted that material of square mesh pattern is likely to distort on expansion at elevated temperatures if it is secured rigidly to attachments on the insulated surface.

6.3.4.5 If metal reinforcement is to be located over the outer layer of insulating or finishing material and is likely to be in direct contact with cleading of a dissimilar metal, precautions shall be taken to avoid electrolytic corrosion action, e.g. by the use of a suitable coating on the inner face of the cleading, or on the reinforcing metal.

6.3.4.6 Where mechanical strength is required, e.g. for puncture resistance, it is desirable to embed open-weave glass cloth or cotton scrim between layers of weather proof or vapourproof mastics.

6.4 Hot Insulation Application

Application for systems operating in the temperature range + 5°C to + 650°C.

6.4.1 General

6.4.1.1 Where the surface to be insulated is at a temperature below the dew point of the surrounding air, a vapour barrier should be provided on the exposed (warm) surface.

6.4.1.2 The piping and equipment shall be insulated after their pressure tests and other necessary tests and inspections have been completed. To facilitate regular inspection of welds and bolted joints, removable portion of insulating and finishing materials shall be provided in the appropriate locations.

6.4.1.3 All materials shall be subject to inspection and approval by the Company to ensure that all materials meet this specification.

6.4.1.4 Insulation application shall also be subject to inspection and any material which has been improperly installed or excessively damaged shall be removed and replaced properly with undamaged material.

6.4.1.5 All work shall be executed in a neat and workmanlike fashion in strict accordance with these specifications and as called for on drawings covering the work to be done. No changes or deviations will be permitted without advance written approval by the Company.

6.4.1.6 Every precaution shall be taken to see that each day's work is weatherproofed before leaving it for the night. Where this is impractical, a fillet of weatherproof mastic must be placed over the exposed ends of insulation.

6.4.1.7 No insulating work of any type may be performed in rainy weather or when atmospheric condensation is occurring. In the event of doubt regarding the prevailing dew point the decision will be made by the owner.

6.4.2 Hot pipework

6.4.2.1 General

6.4.2.1.1 Piping shall be insulated when coded on mechanical and utility flow diagram, pipeline lists and piping and spool drawings. In the event of descrepancies, the flow diagrams shall govern. Insulation thickness shall be as shown on drawing or tables specified in IPS-E-TP-700.

6.4.2.1.2 Insulation classification which may appear on flow diagrams and drawings are defined as following:

Ih: Insulation for heat control for operating temperature above 21°C.
Is: Insulation for personnel protection.
St: To be steam traced and insulated.
Stt: To be steam traced with insulation cement and insulated.
Et: To be electric traced and insulated.
Ett: To be electric traced with insulation cement and insulated.
Sts: To be steam traced with spacers and insulated.
Ias: Insulation for cycling or dual temperature service where temperature fluctuates from 15°C to 320°C.

6.4.2.1.3 It is preferable that the insulation of pipework should be carried out with preformed materials where the temperature limitations permit. where the pipe diameter is too large for moulded pipe sections to be used the pipe should be covered as far as practicable by building up with radiused and beveled lags.

6.4.2.1.4 The junction between removable and permanent insulation shall be made readily discernible, e.g. by painting the end or by laying a suitable textile fabric over the end of the permanent insulation.

6.4.2.1.5 If insulation thickness requirement exceeds 75 mm, the insulations shall be applied in multilayers with maximum of 75 mm per layer .

6.4.2.1.6 Hangers and supports shall be insulated from the pipe surface in a suitable manner, and where applicable should comply with the requirements of BS 3974. Recognized methods for hot pipes using direct-contact support or insulation rings are shown in Figs. 8, 9, 10, 11, 12, 13, 14, 15 and 16.

6.4.2.1.7 All joints shall be staggered as shown in Fig. 17.

6.4.2.1.8 Flexible piping, other than corrugated piping for steam services, shall be insulated as shown in Fig. 18.

6.4.2.1.9 Corrugated piping shall be insulated as plain piping.

6.4.2.1.10 Expansion bellows pieces are frequently left uninsulated for metallurgical considerations but where required they can be insulated as shown in Fig. 19, with suitable external protection as necessary. The purpose of such device is to permit free movement of bellows.

6.4.2.1.11 Pipe size larger than 760 mm shall be insulated and finished as described for vessel insulation.

6.4.2.2 Application of insulation to pipework heated by external tracing pipe

6.4.2.2.1 Piping which is steam traced shall be covered with oversize pipe insulation to include the tracer lines. Valves, flanges, unions, and tracer line loops shall not be insulated, unless specified on the piping drawings. Oversize pipe insulation thickness shall be in accordance with the tables of IPS-E-TP-700.

6.4.2.2.2 Flexible insulation may also be used to insulate traced pipework. If this is used, wire netting or metallic tape or foil shall be applied first to preserve an air space inside the insulation cover.

6.4.2.2.3 The open ends of the air gap in the region of flanges in the main pipe shall be sealed with a disc of insulating material and finished applied as for the adjacent insulation.

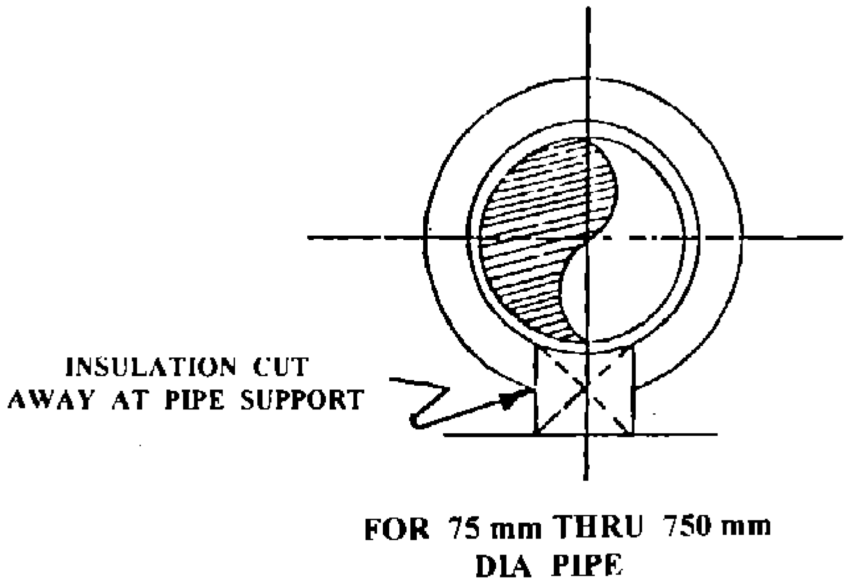
6.4.2.2.4 The effectiveness of heat transfer may be increased by:

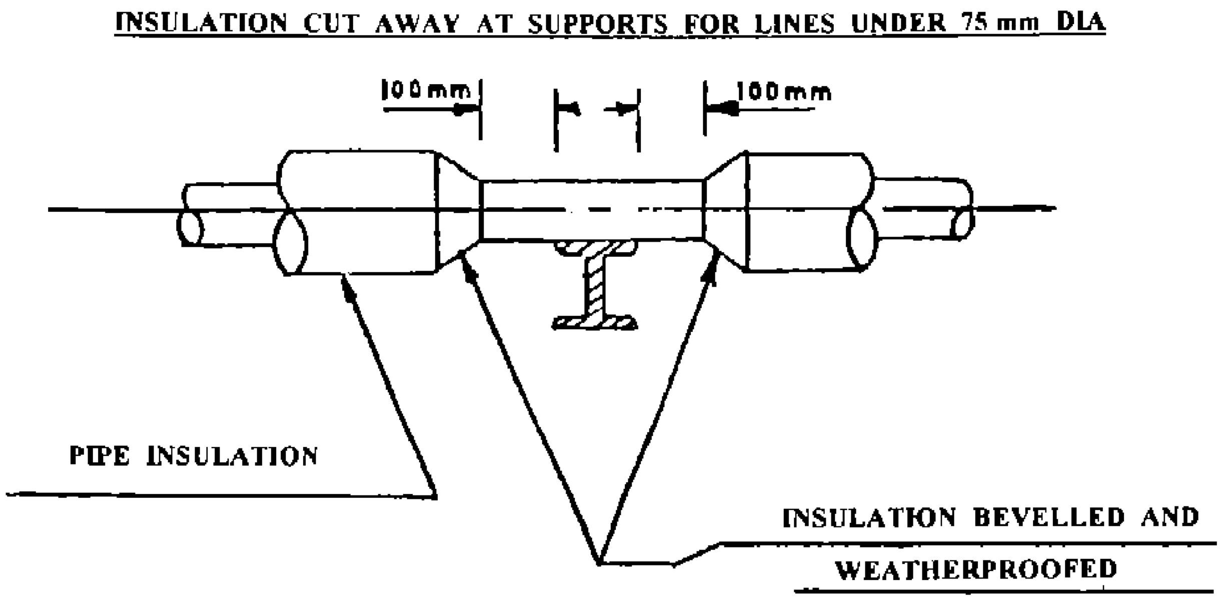
a) Maintaining a hot air space inside the insulation cover to increase the heat transfer area;
b) Maintaining direct contact between the tracer pipe and the main pipe by wiring or strapping at intervals;
c) Using heat-conducting cement to increase the contact area between the tracer and heated pipe.

6.4.2.2.5 When corrosive action between fluid and main pipe is liable to occur at local hot spots, direct contact between tracer and main pipe shall be prevented by fitting spacers of low conductivity between tracer and heated pipe. This may, however, decrease the effectiveness of heat transfer.

6.4.2.2.6 The tracer pipe itself shall be looped out and jointed (for example, by a compression fitting) near the main pipe flanges. The exposed length of tracer shall be insulated.

PIPE SHOE FOR LINES 75 mm AND LARGER

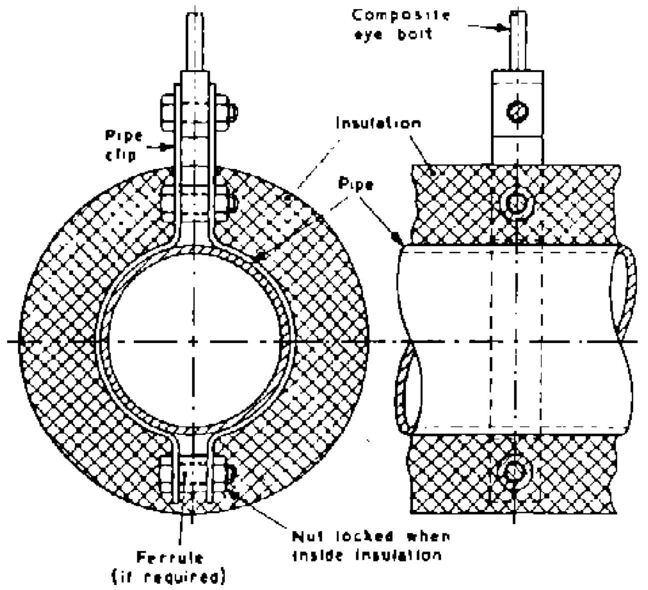




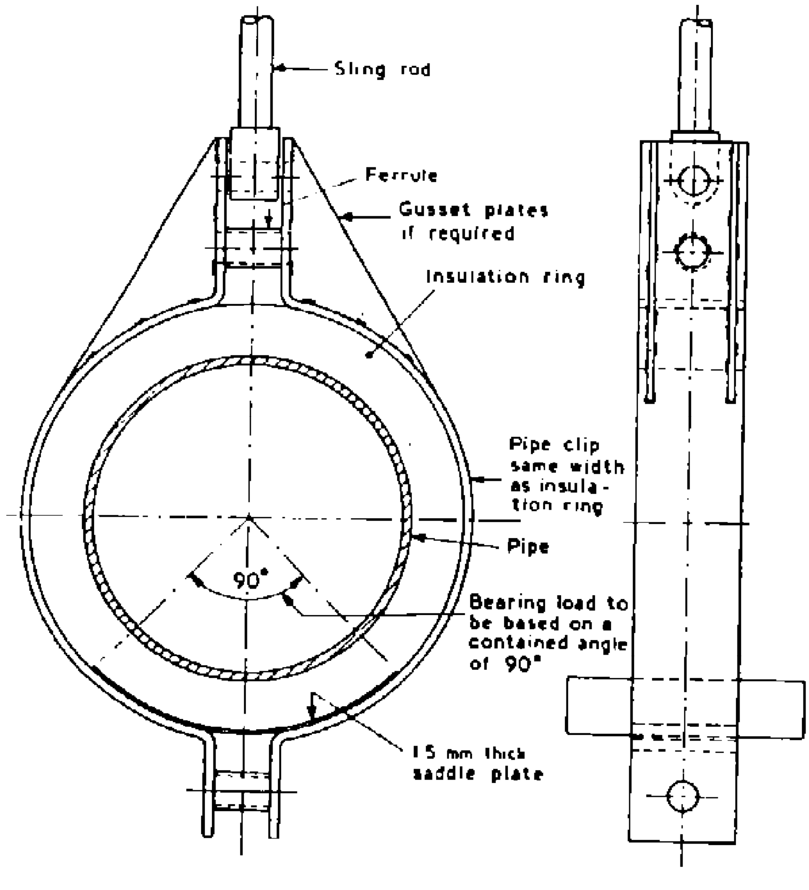
Note:

Insulation shall be continuous across supports.

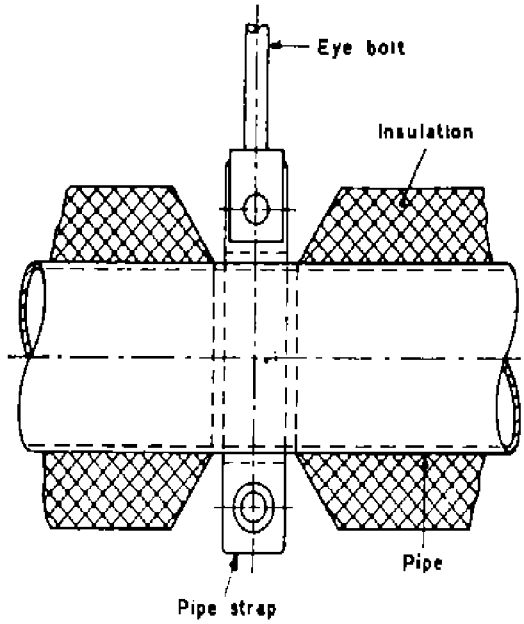
INSULATION AT THE PIPE SUPPORT-HOT SERVICES
Fig. 8



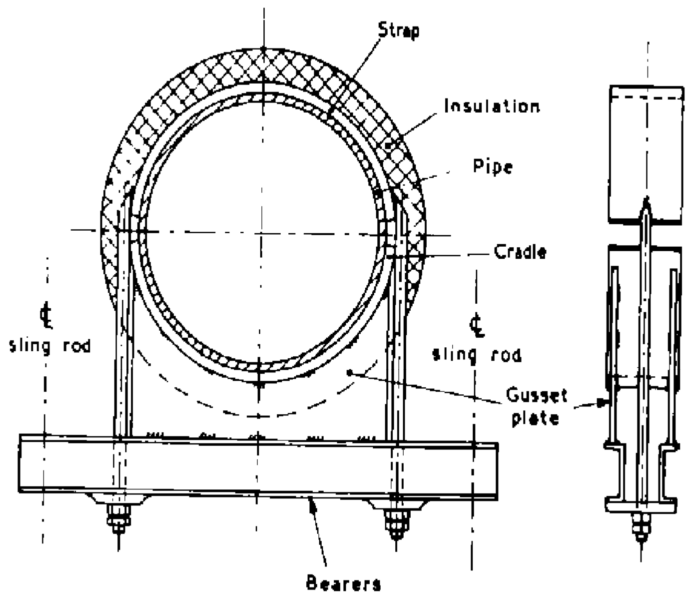
TWO-PIECE STRAP, DIRECT CONTACT, INSULATION COVERING STRAP
Fig. 9



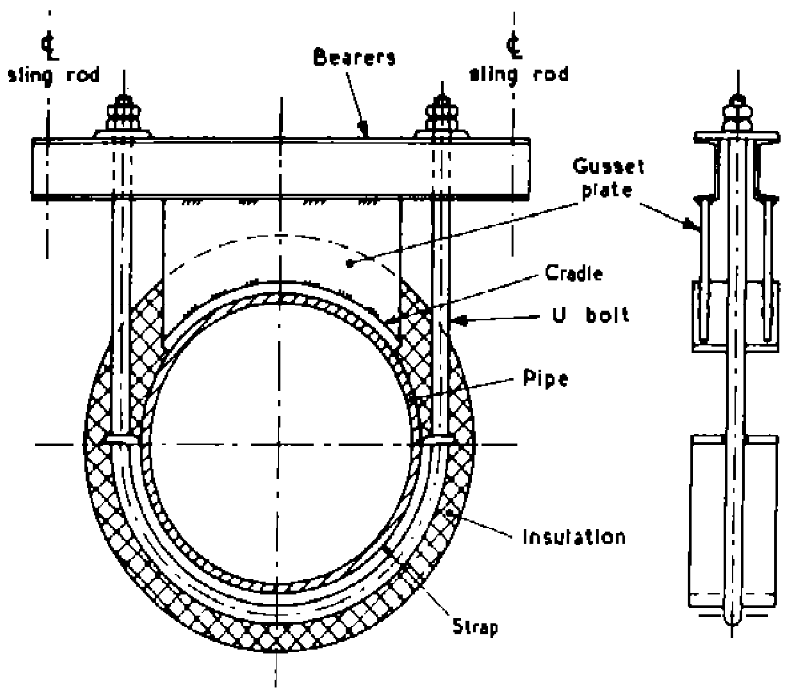
TWO-PIECE STRAP USING INSULATING RING
Fig. 10



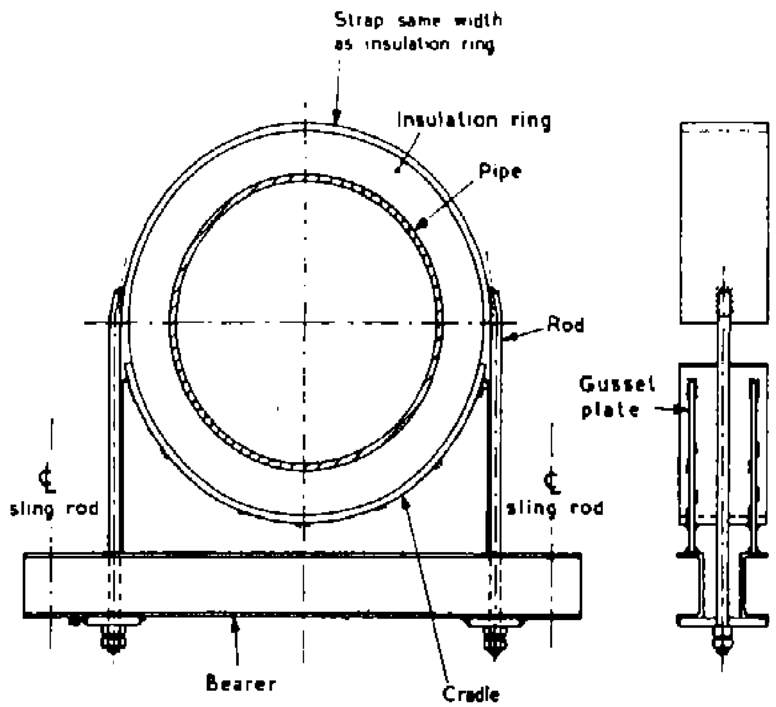
TWO-PIECE STRAP, DIRECT CONTACT, INSULATION CLEAR OF STRAP
Fig. 11



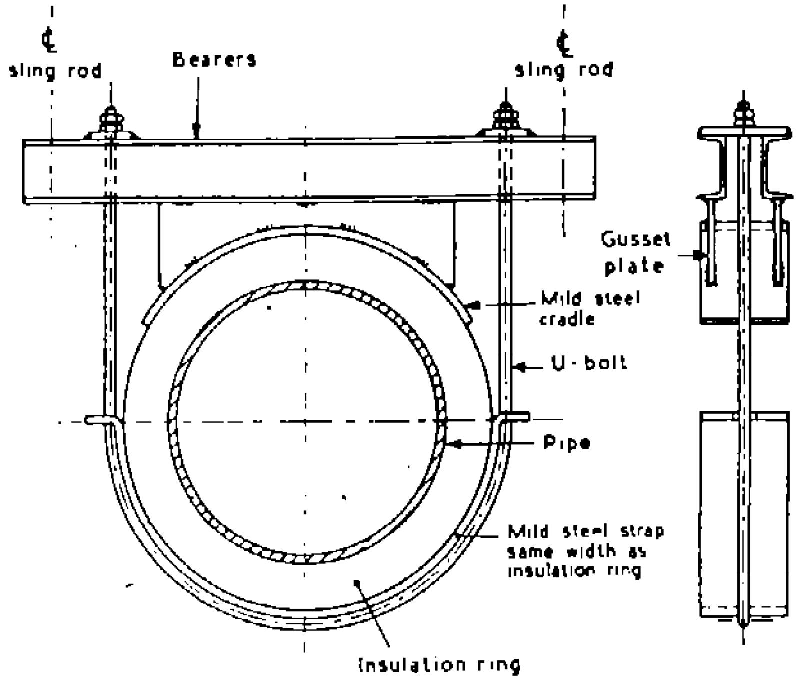
U-BOLT CRADLE, DIRECT CONTACT
Fig. 12



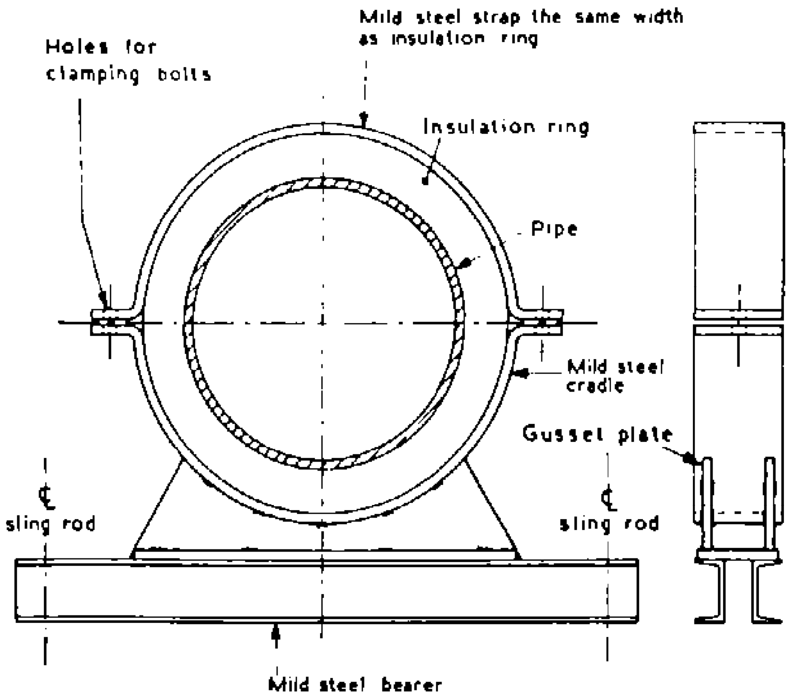
INVERTED U-BOLT CRADLE, DIRECT CONTACT
Fig. 13



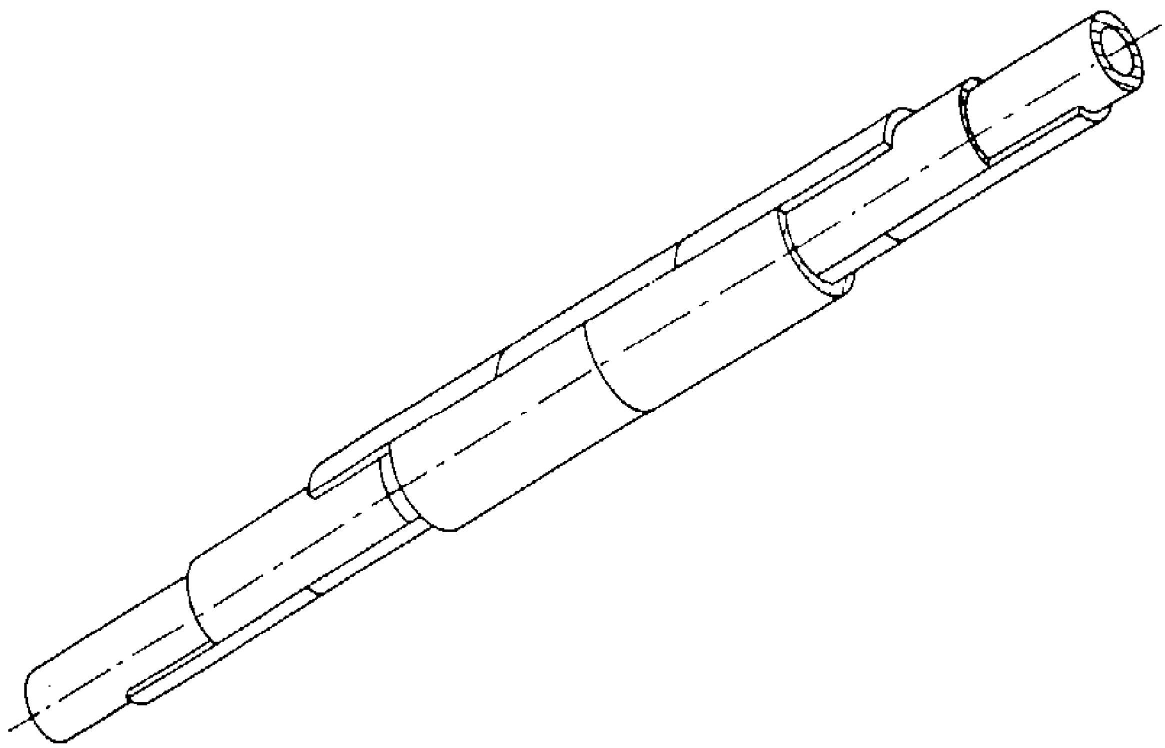
U-BOLT CRADLE USING INSULATION RING
Fig. 14



INVERTED U-BOLT CRADLE USING INSULATION RING
Fig. 15



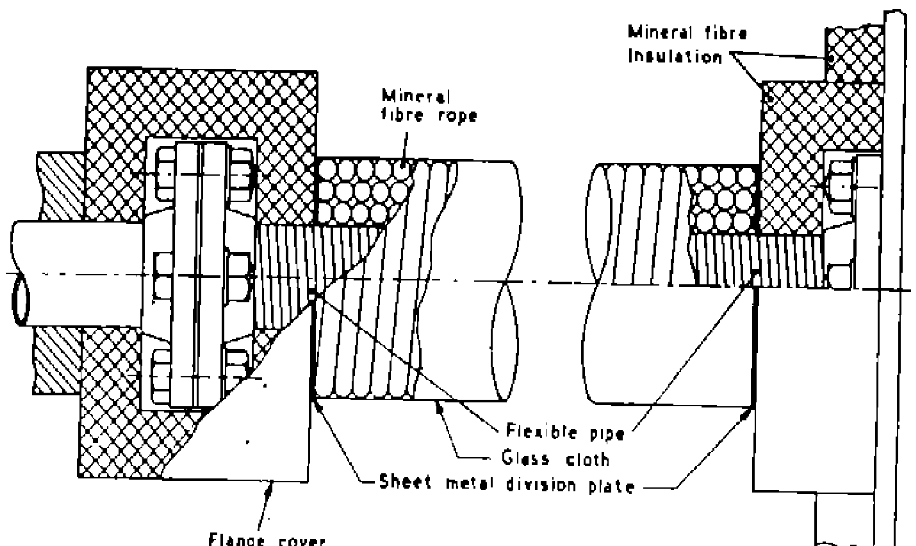
TWO-PIECE STRAP CRADLE USING INSULATION RING
Fig. 16



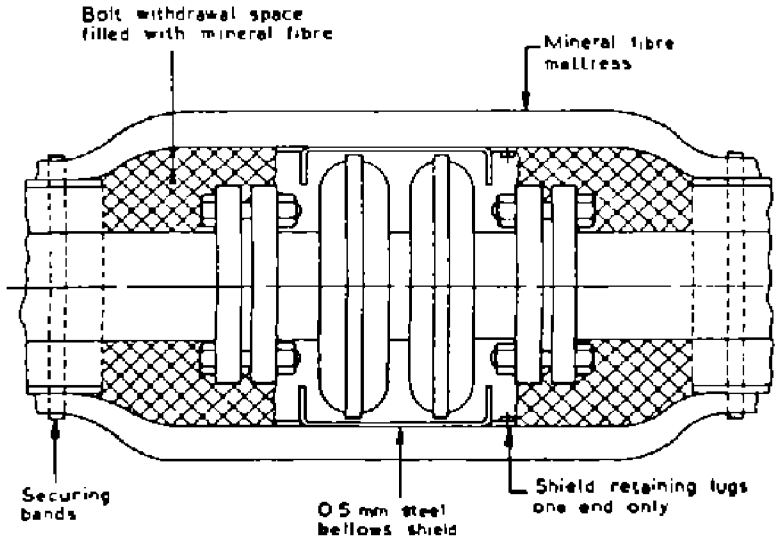
Note:

Binding wire or bands on each layer of insulation spaced at intervals of approximately 250 mm.

TYPICAL METHOD OF STAGGERING INSULATION SECTION ON A STRAIGHT PIPE
Fig. 17



TYPICAL METHOD OF INSULATING FLEXIBLE PIPE
Fig. 18



Note:

Steel cover to overlap bellows by 40 mm at each end. Cust to be made in the cover and lugs bent over to locate the cover. The purpose of the shield is to permit free movement of the bellows.

TYPICAL METHOD OF INSULATING EXPANSION BELLOWS
Fig. 19

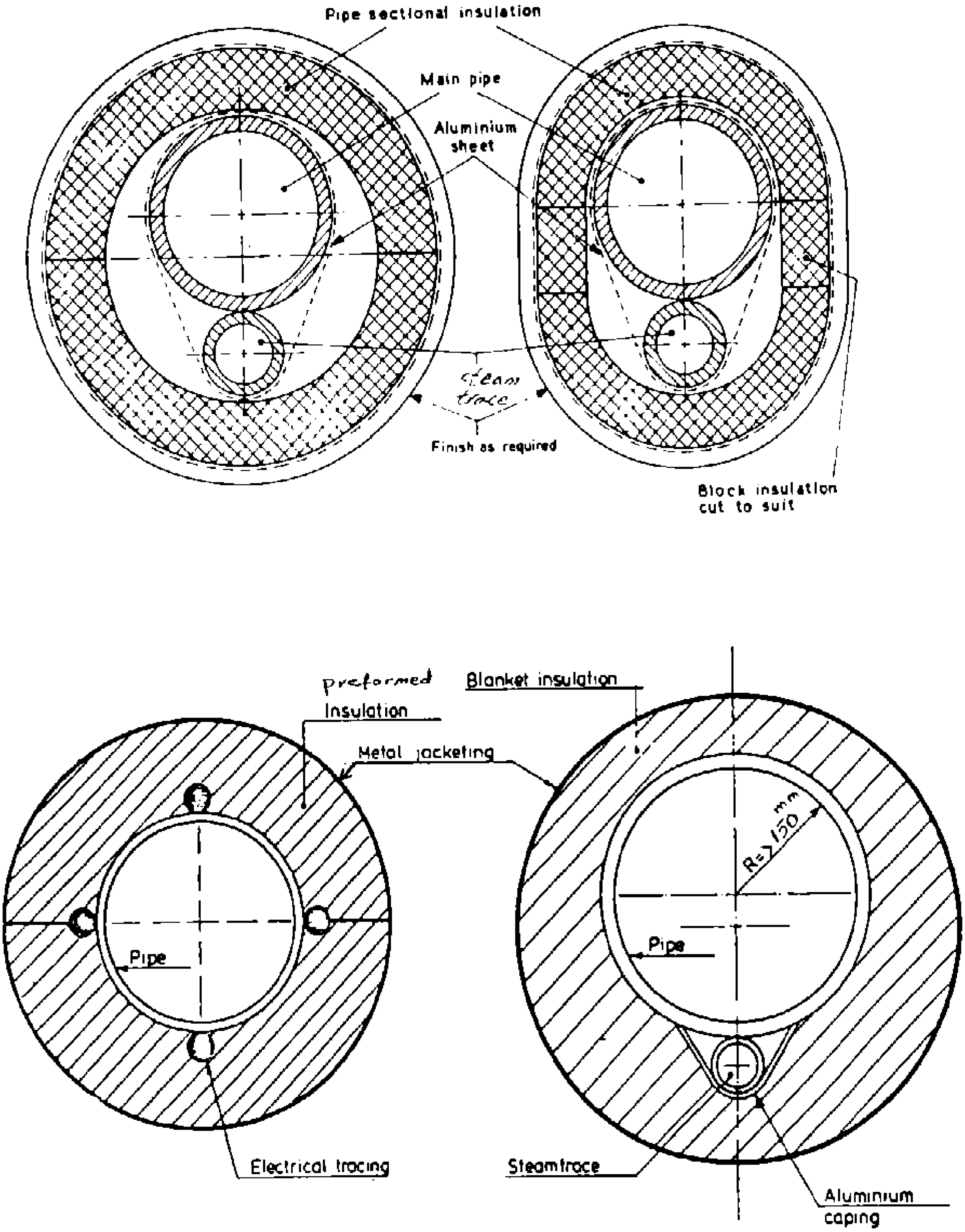
6.4.2.2.7 Leak testing shall be satisfactorily completed before the application of thermal insulation.

Fig. 20 shows typical methods for insulating steam traced pipe.

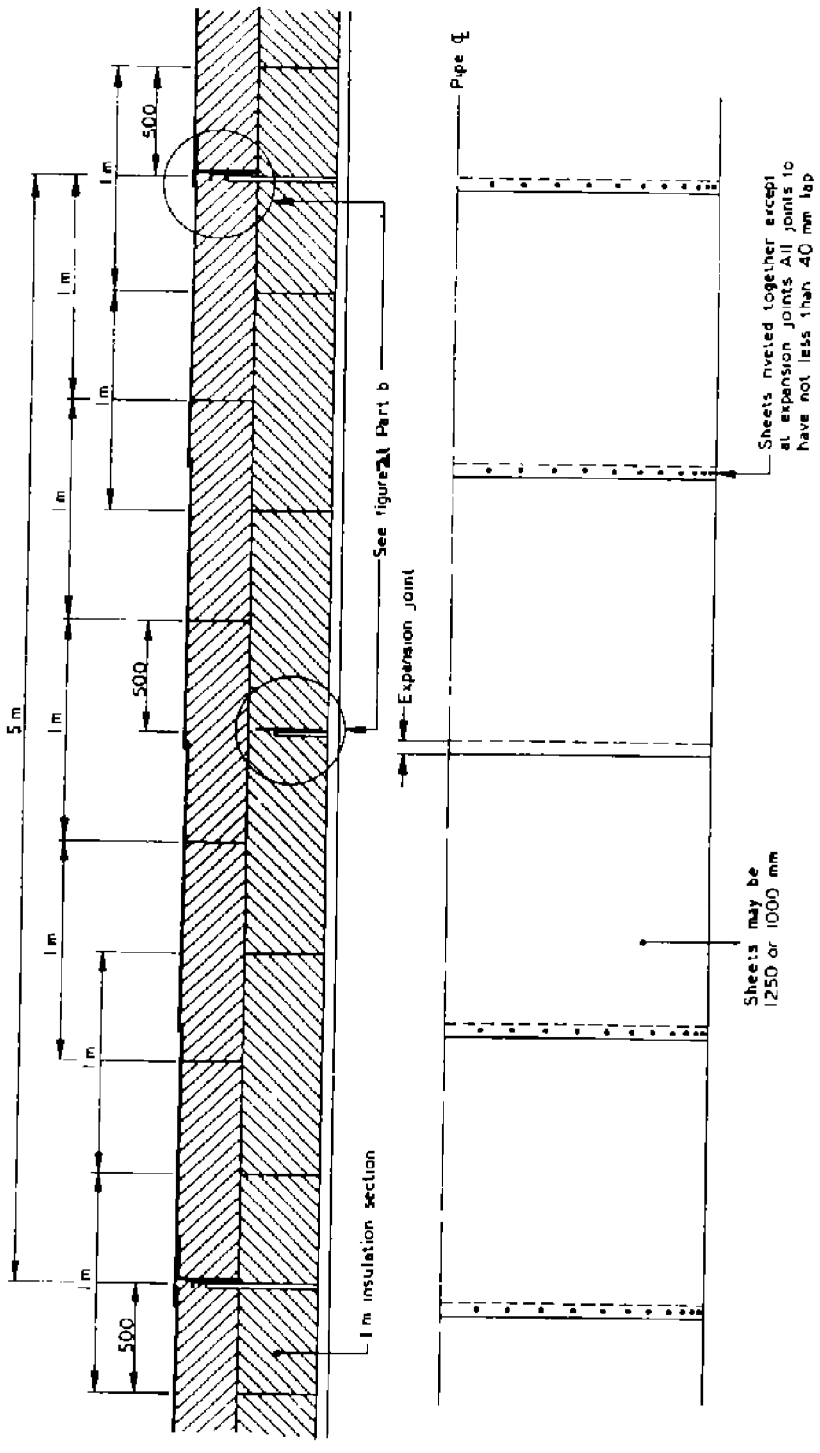
6.4.2.2.8 Electrical tracing should always be applied and insulated in accordance with the Manufacturer's instructions. Care shall be taken to avoid mechanical damage, and to protect the tape from water or chemical spillage. The makers shall be consulted before electrical tracing is specified for use in flameproof areas. Preferably, the insulation should be of preformed sections of appropriate inner diameter to fit over the tracing cable on the pipe. Where live electric tracing cables are buried in the insulation a warning notice shall be placed on the outside. For typical method of insulating electrical traced pipe see Fig. 20.

6.4.2.3 Vertical piping

For vertical runs of piping, or near vertical (inclined 45° or more) piping, it is important to prevent downward displacement of the insulating material by the use of appropriate supports, which may be in the form of metal rings, part rings, or studs (see 6.3 and IPS-E-TP-700). These supports shall be located at intervals of not more than 5 meters and, in any case, these shall be a support immediately above each expansion break in the insulation and also above all flanges in vertical lines and located as to allow removal of flange bolts, see Fig. 21.



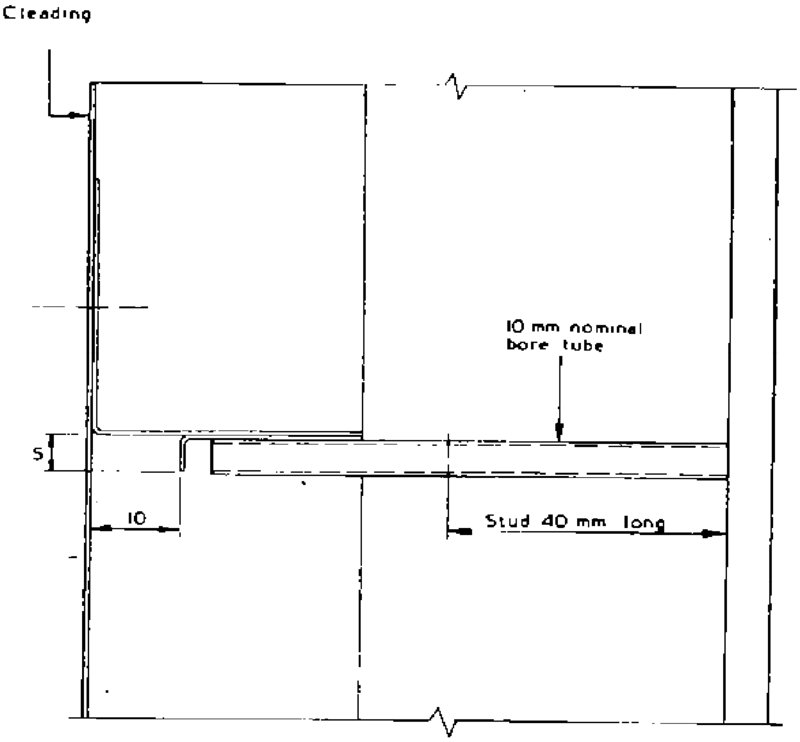
TYPICAL METHOD OF INSULATING HEAT TRACED PIPE
Fig. 20



a) Spacing of joints (hot insulation)

a) Spacing of joints (hot insulation)

TYPICAL CLEADING AND/OR INSULATION SUPPORT FOR VERTICAL PIPEWORK
Fig. 21



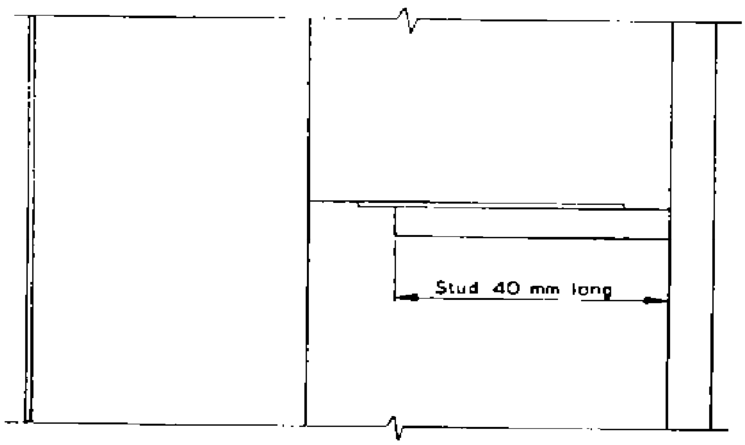
Note:

Angle cleats of the same material as the cleading are riveted to cleading.

Minimum: 4 cleats per ring. Maximum: Cleats at 230 mm centers.

Width of cleats as follows.

Insulation outer diameter (mm)	150 to 200	200 to 300	above 300
Cleat width (mm)	20	25	35



Dimensions in millimeters

b) Support arrangements (hot insulation)
Fig. 21 (concluded)

6.4.2.4 Application

6.4.2.4.1 Preformed materials

6.4.2.4.1.1 Preformed pipe sections shall be fitted closely with the all joints butted also cracks and voids to the pipe and any unavoidable gaps in circumferential or longitudinal joints shall be filled with compatible insulating materials such as insulating cement.

6.4.2.4.1.2 Single layer sectional pipe insulation shall be applied with longitudinal joints staggered (see Fig. 17) and shall be secured with bands or wire at approximately 250 mm spacing and not nearer than 50 mm to the end of the section. Additional layer or layers of sectional pipe insulation also shall be applied with all joints staggered and shall have inner layer secured by at least two wires per section with the outer layer secured by bands or wires at approximately 250 mm spacing. After tightening, the ends shall be pressed on to the insulating material (see 6.3.3). The choice of material for the bands or wires and its corrosion protection shall be based on the environmental condition. See IPS-M-TP-710 for recommended materials and sizes of bands and wires.

6.4.2.4.1.3 When sections are held in position and covered by a fabric, this shall be secured by stitching or by the use of an adhesive. The edges of the fabric, if stitched, shall overlap by at least 25 mm; if adhesive tape is used to cover the joints it should preferably be wound with an overlap of at least 25 %. Alternatively, with a fabric or sheet outer finish, the whole may be secured by circumferential bands.

6.4.2.4.1.4 Sections that are split down one side only shall be sprung on to the piping, and secured. Certain types of pipe sections can be secured by corrosion-resisting staples at the joints; these staples shall be not further apart than 100 mm.

6.4.2.4.1.5 To prevent "through joints" where temperatures exceed 260°C, with single layer insulation, apply an expansion filler material between the joints of the insulation. This filler to be strips of 2.5 cm thick, ¾ # (0.34 kg) density, long textile fiber resilient glass blanket material. Width of strips to be thickness of pipe insulation plus 1.3 cm. Filler is applied, squeezed to a minimum thickness less than 0.16 cm by the pipe insulation when installed. Projecting portion of filler is flattened by covering.

6.4.2.4.1.6 The need to dismantle pipework with a minimum disturbance of insulation shall be borne in mind, and permanent insulation shall end sufficiently far from flanges and fittings to enable bolts to be withdrawn. Therefore, unless otherwise specified, insulation shall be stopped at flange or union connections. Clearance shall be stud length plus 25 mm. At each stop, the insulation shall be weather proofed.

6.4.2.4.2 Flexible materials

6.4.2.4.2.1 Fabric-covered mattresses shall be made from a suitable flexible medium and filled with a suitable filling that contains a minimum of dust or foreign matter. The hem of the fabric cover shall be folded twice before sewing. The inner faces of mattresses in contact with surfaces above 400°C shall be of glass cloth, ceramic fibre cloth, stainless steel foil, or alumino-silicate paper. The edges of mattresses shall overlap adjoining insulation and be bound with wire. Care shall be taken that air spaces are kept to a minimum and that there are on free passages from hot surface to atmosphere. The filling material shall be prevented from packing down by quilting as necessary.

6.4.2.4.2.2 Strip and rope material shall be wrapped spirally around the surface, successive layers being applied to opposite hand. The ends of this material are to be firmly secured and all tie wires buried.

6.4.2.4.2.3 Care should be taken that flexible materials are not unduly compressed.

6.4.2.4.2.4 Where insulation is fitted in two layers these layers shall be staggered.

6.4.2.4.2.5 Flexible insulating blankets or mats need to be secured by means of circumferential bands of metal or plastics strip, as described in 6.3.3.1 with the exception that the use of circumferential tie wires of 1.6 mm to 1.0 mm diameter is permissible when the ultimate finish is to be of sheet metal. If the finish is to be aluminum sheet the securing bands have to be of compatible metal.

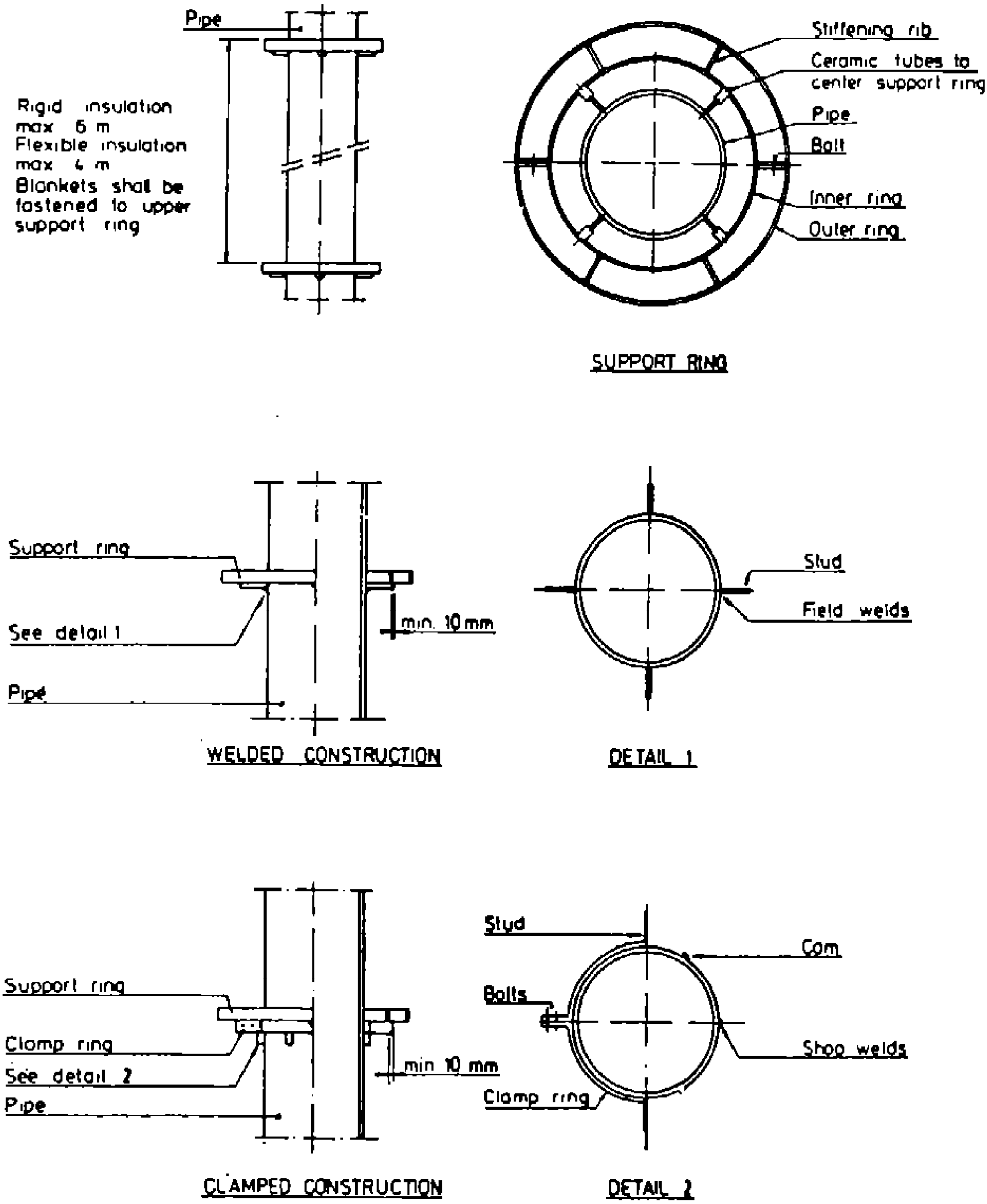
6.4.2.4.2.6 On vertical pipes of nominal size 100 mm and larger, welded or clamped support rings shall be applied at the upper end and under each flange see Fig. 22. Additional rings may be required at approximately 4 m intervals.

6.4.2.4.2.7 For vertical and near-vertical piping, it is important to prevent downward displacement of flexible insulating materials; whereas support from below is suitable for many preformed materials, flexible insulating materials shall be suspended from above, support ring.

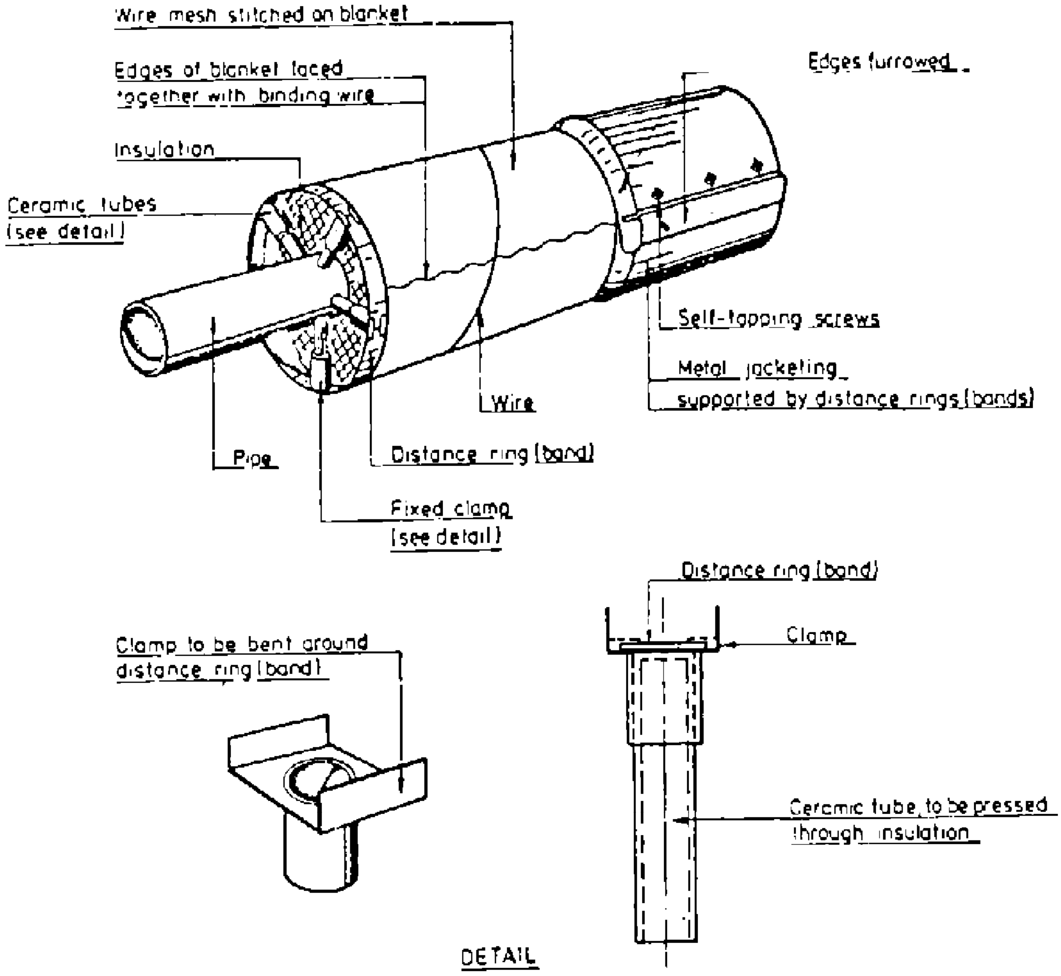
6.4.2.4.2.8 After application, the blankets shall have the required insulation thickness. At the ends of the blankets clamped distance rings shall preferably be attached to the pipe at intervals of approximately 1 m to support the metal jacketing and to prevent compression of the insulation see Fig. 23.

6.4.2.5 Weatherproofing and finishing

6.4.2.5.1 Straight portion of insulated lines shall have the basic insulation covered with aluminum jacket, with all joints lapped 50 mm and arrange to shed water. The jacket shall be secured with bands installed on 230 mm centers. Galvanized steel also may be used where mechanical resistance is important. The metallic sheet may be either flat or corrugated.



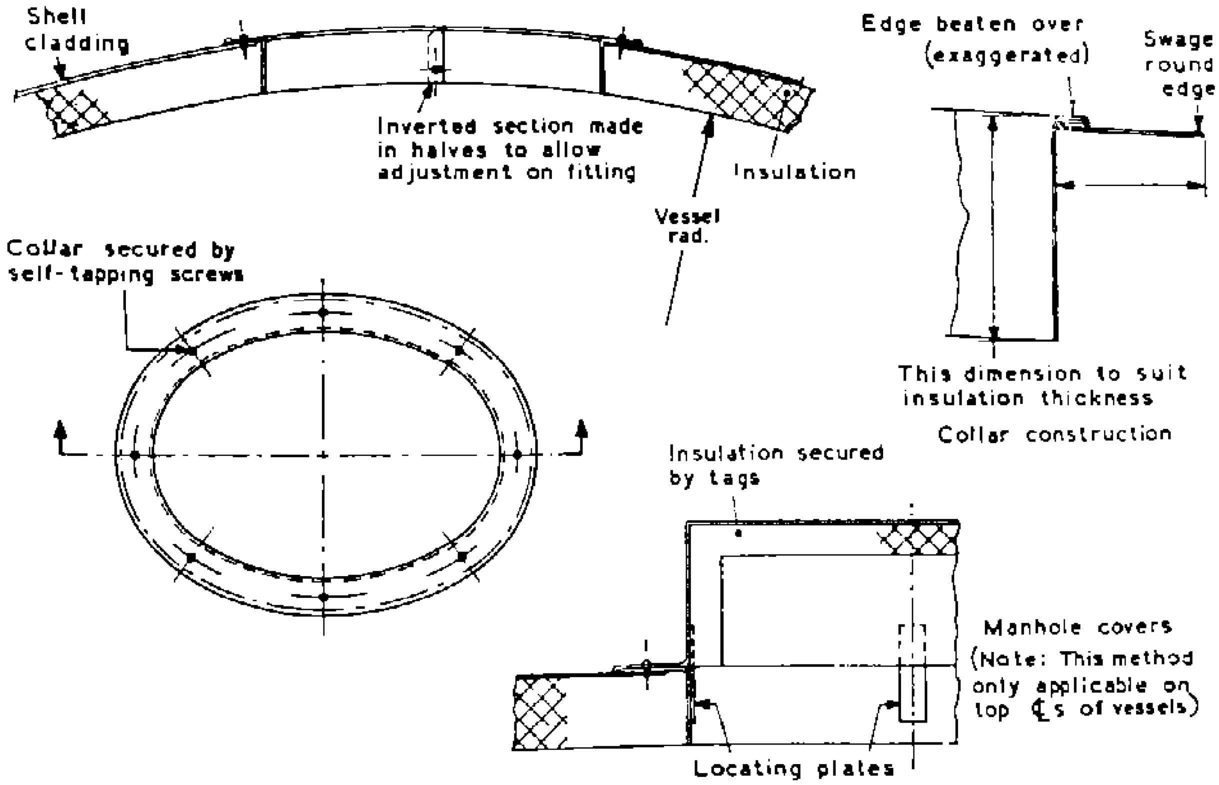
SUPPORT RING FOR VERTICAL PIPE WITH DOUBLE-LAYER INSULATION
Fig. 22



NUMBER OF CERAMIC TUBES REQUIRED PER DISTANCE RING

PIPE OR VESSEL DIAMETER (mm)	NUMBER OF CERAMIC TUBES
Up to 300	5
301-350	6
351-400	7
401-450	8
451-500	9
501-550	10
551-600	11
601-650	12
651-700	13
701-750	14
751-800	15
801-850	16
851-900	17
901-950	18
951-1000	19

INSULATION WITH BLANKETS ON PIPING
Fig. 23



DETAILS OF INVERTED COLLARS AT MANHOLES, ETC.
Fig. 24

6.4.3 Hot vessels

6.4.3.1 General

6.4.3.1.1 Vessels shall be insulated when indicated on the mechanical and utility flow diagram. Thickness shall be as shown on the vessel drawings and in the table of IPS-E-TP-700. In the event of descrepancies, the vessel drawing shall govern.

6.4.3.1.2 The shell and head of vessel shall be insulated with rigid type or blanket type insulation. The blocks shall be either curved, flat or beveled to fit the shell contours, with all joints tightly butted and secured with bands. Bands shall be machine stretched and sealed to prevent slackening.

6.4.3.1.3 Vessel skirts, saddle supports and bottom heads on vessels under skirts shall not normally be insulated unless the bottom is heat traced or insulation is specified by the owner.

6.4.3.1.4 The top head shall be insulated upwards successively from their uppermost insulation support ring to the top.

6.4.3.1.5 Small diameter vessels 760 mm outside diameter and under, shall be insulated and finished as described for piping insulation.

6.4.3.1.6 If insulation thickness requirement exceeds 75 mm the insulation shall be applied in not less than two layers.

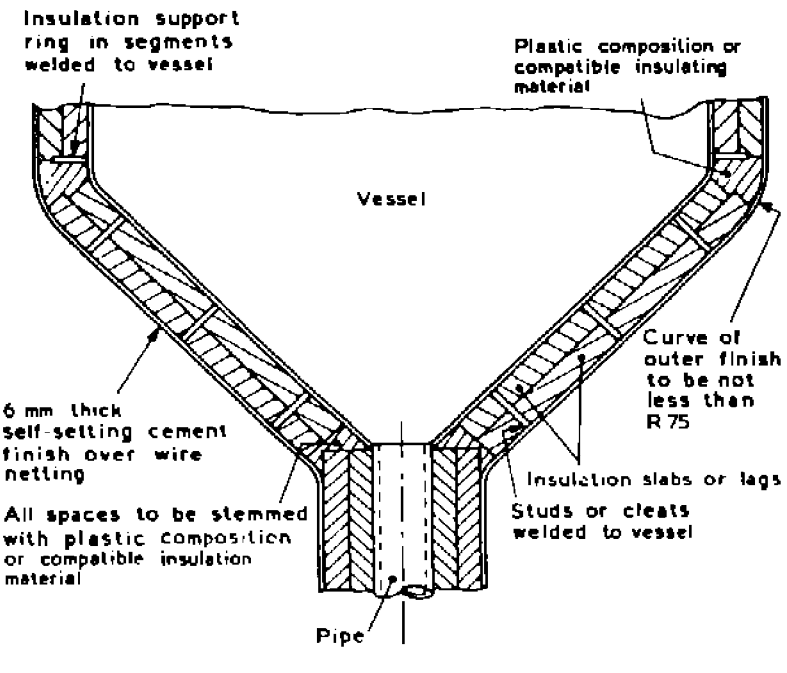
6.4.3.1.7 The need to dismantle associated pipework and inspection covers shall be anticipated, and permanent insulation ended sufficiently far from flanges and fittings to enable bolts to be withdrawn. To facilitate regular inspection of welds and bolted joints, removable portions of insulating and finishing materials shall be provided in the appropriate locations. The junction between removable and permanent insulation shall be made readily discernible, e.g. by painting the end of the permanent insulation or laying a suitable textile fabric over the end.

6.4.3.1.8 Inspection covers shall be insulated separately and particular care shall be taken that the insulation value is not less than that provided on the main body of the vessel (see Fig. 24).

6.4.3.2 Method of application

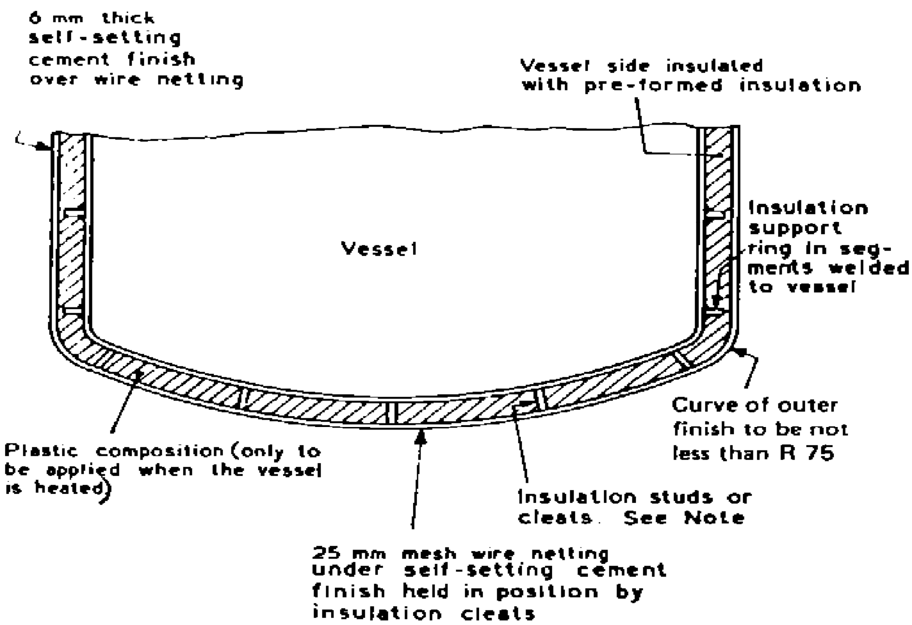
6.4.3.2.1 Preformed materials

6.4.3.2.1.1 It may be necessary to cut preformed materials to fit irregular contours. Alternatively, suitable material may be used to provide a regular foundation (see Fig. 25 and 26). All cut faces shall be clean and care shall be taken to butt adjacent edges. In multilayer applications joints shall be staggered (see Fig. 27).



TYPICAL METHOD FOR INSULATING VESSELS WITH CONICAL BOTTOMS
Fig. 25

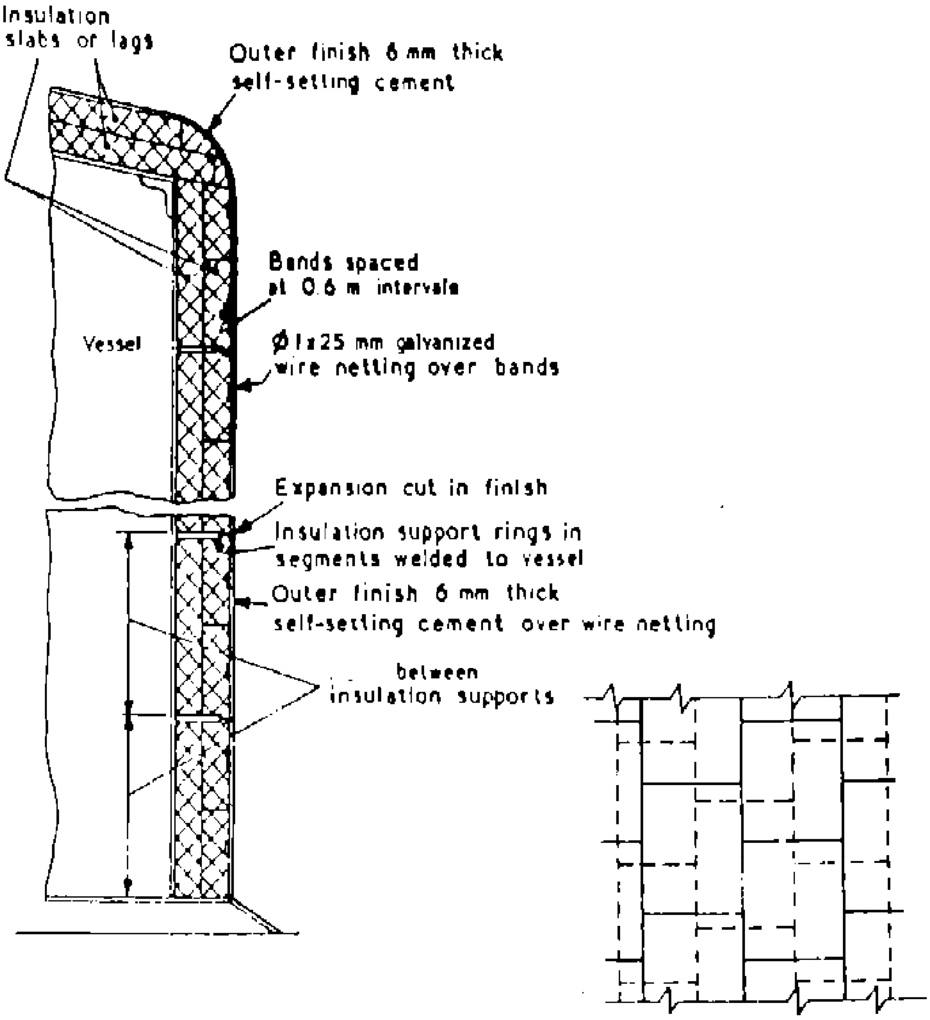
6.4.3.2.1.2 Block or preformed insulation on vertical vessels shall be supported by horizontal insulation rings on 3700 mm centers. These rings also form a break in the insulation to allow for wall expansion. The gaps shall be pressure filled with rock wool. (See Clause 6.3.2 and Figs. 6, 7). Blocks shall be secured in place with bands of proper size and materials which have been specified in IPS-M-TP-710. Bands shall be spaced on 300 mm centers. Where double layer insulation are used the inner layer shall be secured by suitable wire with approximately 450 mm spacing. Where necessary allowance shall be made for expansion by use of stainless steel expander band. After insulation application, gaps and voids, if any shall be filled with plastic composition of the same materials as that of the insulation.



Note:

Studs or cleats are to be welded to the bottom of the vessel at approximately 300 mm intervals. After applying an initial coating of plastic insulation, sections cut to suitable lengths may be used to build up insulation to correct thickness.

TYPICAL METHOD FOR THE INSULATION OF DISHED ENDS OF VESSELS
Fig. 26



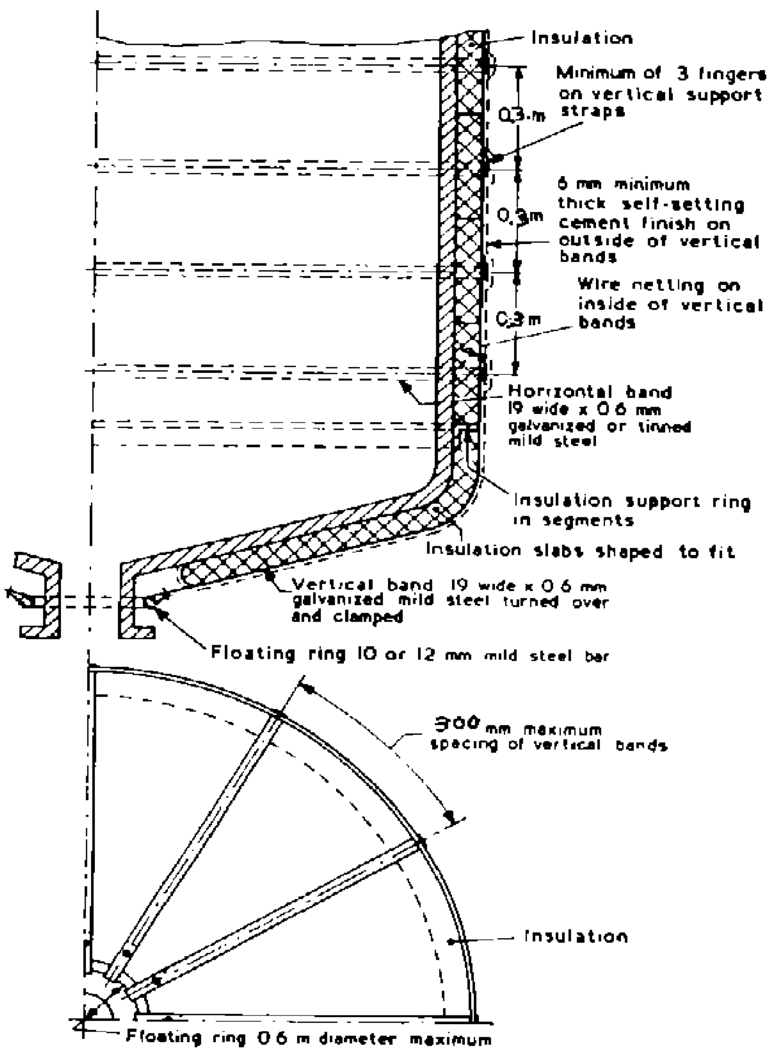
Note:

All vertical joints in adjacent layers to be staggered and the horizontal joints in any column of sections in the outer layer to be staggered with respect to those in the adjacent columns in the same layer. Where possible horizontal joints in the wire netting should not coincide with continuous joints in the sections.

TYPICAL METHOD FOR INSULATING ROOF AND SIDES OF VESSEL WITH INTERNALLY REINFORCED ROOF
Fig. 27

6.4.3.2.1.3 Insulation on horizontal vessels shall be applied in stagger joint arrangement with all edges securely laced together with 1.5 mm wire or hog rings on 300 mm centers. Nozzle projection through insulation shall be adequately insulated and secured with girdling rings.

6.4.3.2.1.4 Exposed vessels head shall be insulated with blocks secured by bands with floating ring-band spacing shall be 300 mm maximum at tangent line see Fig. 28. All voids to be filled with plastic composition and the whole to be covered with a 10 mm layer (when dry) of finishing cement as described in 6.3.3.2.3.



TYPICAL INSULATION SUPPORT FOR BOTTOM OF HOT VESSEL
Fig. 28

6.4.3.2.1.5 Unexposed vessels heads if insulated shall have the blocks impaled on 3 mm diameter wire pins and speed clips. Over the blocks apply a 10 mm thick layer (when dry) of finishing cement as described in 6.3.3.2.3.

6.4.3.2.2 Blanket insulation

6.4.3.2.2.1 Insulation on vertical vessels shall be supported by horizontal insulation rings on 2000 mm approximate spacing and shall be applied with stagger joints arrangement. Top and bottom edges shall be securely laced to the support ring with 1.5 mm diameter wire or hog rings on 300 mm centers. The insulation shall then be secured in place with bands spaced on 300 mm centers. Nozzle projections through insulation shall be adequately insulated and secured with girdling rings.

6.4.3.2.2.2 Insulation on horizontal vessels shall be applied in stagger joint arrangement with all edges securely laced together with 1.5 mm wire or hog rings applied on 300 mm center. Nozzle projections through insulation, shall be adequately insulated and secured with girdling ring.

6.4.3.2.2.3 Exposed vessel leads shall have the blanket shape insulation so that all sections are snug, tight and laced as on the straight sides and secured by a 10-12 mm round steel rod floating ring in the centers and bands on 300 mm maximum centers at the tangent line see Fig. 28. Over the blanket, apply a 10 mm thick layer, when dry, of finishing cement.

6.4.3.2.2.4 Unexposed heads on vessel shall have the blanket shape insulation so that all the sections are snug, tight and laced as on the straight sides and secured by a 10-12 mm round steel rod floating ring in the center, and bands on 300 mm maximum centers at tangent line see Fig. 28. Over the blanket, apply a 10 mm thick layer, when dry, of finishing cement.

6.4.3.3 Weatherproofing

6.4.3.3.1 Vessels shells shall be finished with the metal jacketing applied directly over block or blanket insulation.

6.4.3.3.2 On vertical vessels the corrugation in sheeting shall be vertical and the sheets supported on "S" clips.

6.4.3.3.3 The horizontal seams of metal jacketing shall be overlapped 75 mm and the vertical seams shall overlapped 100 mm.

6.4.3.3.4 Metal jacketing shall be secured with bands spaced not less than one band on each circumferential seams and one at the middle of each sheet so that spacing between bands not to exceed 60 cm. Band joints will consist of one double-pronged seal.

6.4.3.3.5 When expansion springs are required for the insulation securement, the same number of expansion springs per band shall be used on all banding securing the jacketing.

6.4.3.3.6 Sheet metal screws shall be applied on longitudinal seams to close the fish mouth. Spacing between screws shall be about 20 cm.

6.4.3.3.7 Vertical vessels shall have a rain shield applied at the bottom insulation support ring to prevent the entrance of moisture.

6.3.3.3.8 Opening in the jacketing for nozzles, etc. shall be provided. These opening shall be properly sealed to prevent ingress of water.

6.4.3.3.9 On horizontal vessels, the metal sheets shall be lapped a minimum of 75 mm on the circumferential seam and a minimum of 100 mm on the longitudinal seams and installed so that to shed water. Bands shall be installed on 450 mm centers and shall be machine-stressed and fastened under tension.

6.4.3.3.10 All vessel exposed dished ends to be covered with prefabricated or field fabricated segmental cladding (orange peel). The cladding shall be secured with bands and seals and joints shall be lapped 50 mm. Lapped joints shall be secured by means of self-tapping screws or rapid-fix rivets.

6.4.3.3.11 Heads and compound-curved sections that are difficult to jacket with metal economically shall be covered with weather-barrier coating and reinforcing cloth.

6.4.3.3.12 All cut-outs in metal jacketing shall be weatherproofed by flashing with aluminum sheet or with mastic.

6.4.3.3.13 For vessel diameters under 90 cm finishing shall be as for pipe.

See Fig. 29 for details of weatherproofing and finishing.

6.4.4 Exchangers

The method of insulation of heat exchanger shell, head, cover and nozzles shall be as specified for vessel. See Fig. 30 for detail of heat exchanger insulation.

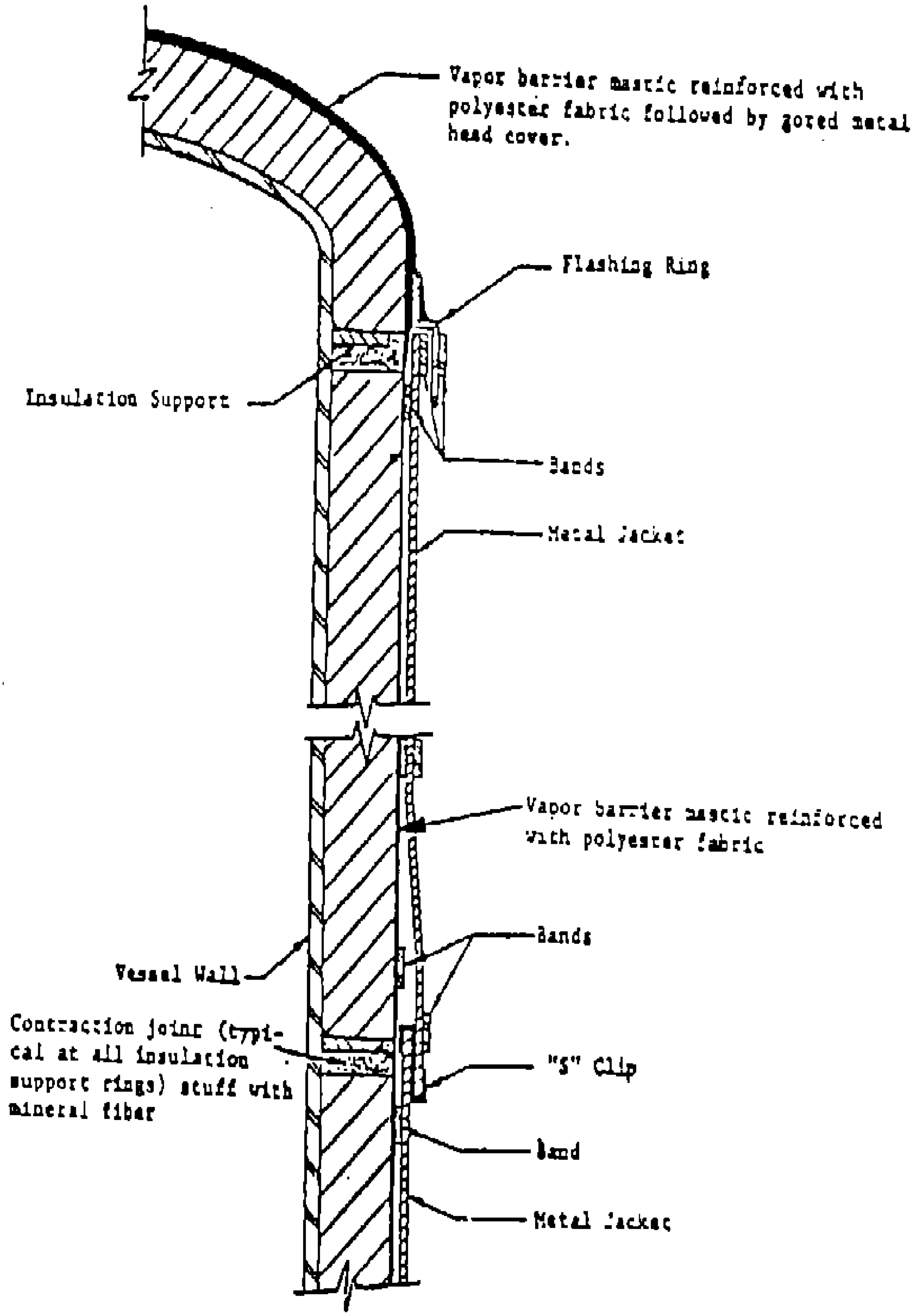
6.4.5 Tanks

6.4.5.1 General

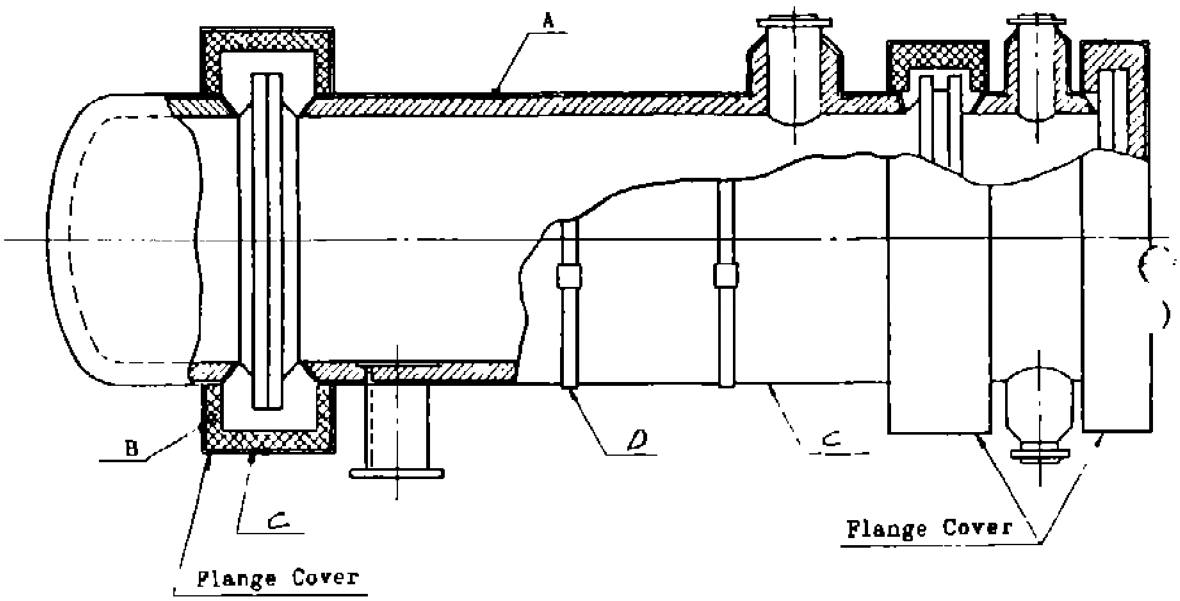
6.4.5.1.1 Tanks and tank roofs shall be insulated when indicated on tank drawings.

6.4.5.1.2 Tank insulation may be preformed block insulation, blanket insulation or sprayed rigid polyurethane foam.

6.4.5.1.3 All joint shall be staggered.



DETAIL OF WEATHERPROOFING, HOT INSULATION
Fig. 29



A) Block insulation
B) Blanket insulation
C) Metal jacketing
D) Banding

INSULATION OF HEAT EXCHANGER
Fig. 30

6.4.5.2 Method of application

6.4.5.2.1 Preformed materials

6.4.5.2.1.1 Tank wall insulation system for tank diameters up to and including 12 m shall be as indicated in Fig. 31 and for tank diameter above 12 m the insulation shall be as per Fig. 32.

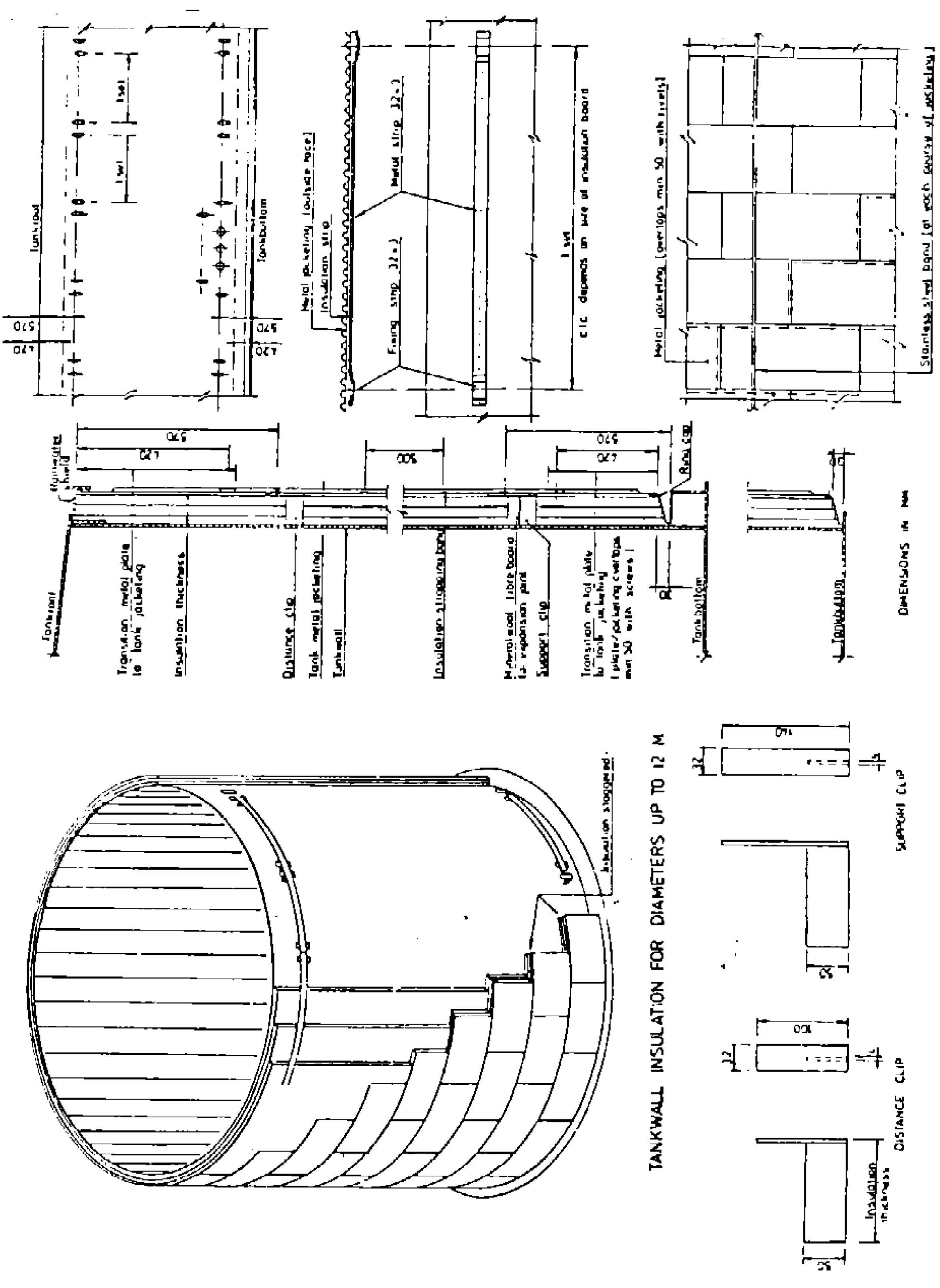
6.4.5.2.1.2 Hand railing on insulated tank roofs shall be installed in accordance with Fig. 33.

6.4.5.2.1.3 Rain water shield and ring cap shall be installed to prevent water ingress into the insulation.

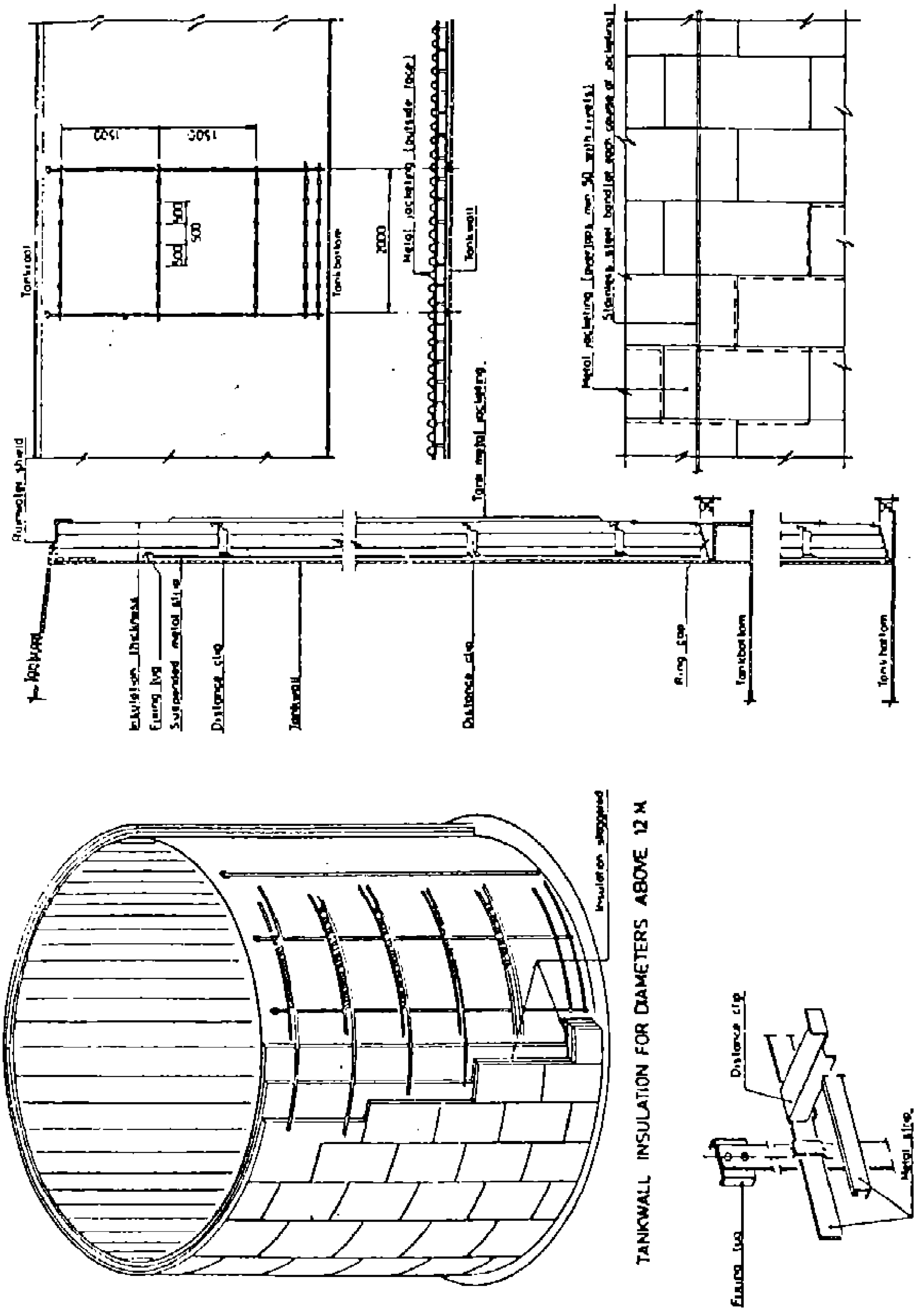
6.4.5.2.1.4 The insulation shall be protected with metal jacketing arranged with 50 mm overlaps (with rivet and screws) and supported on "S" clips and the whole jacketing be secured with stainless steel bands.

6.4.5.2.2 Blanket insulation

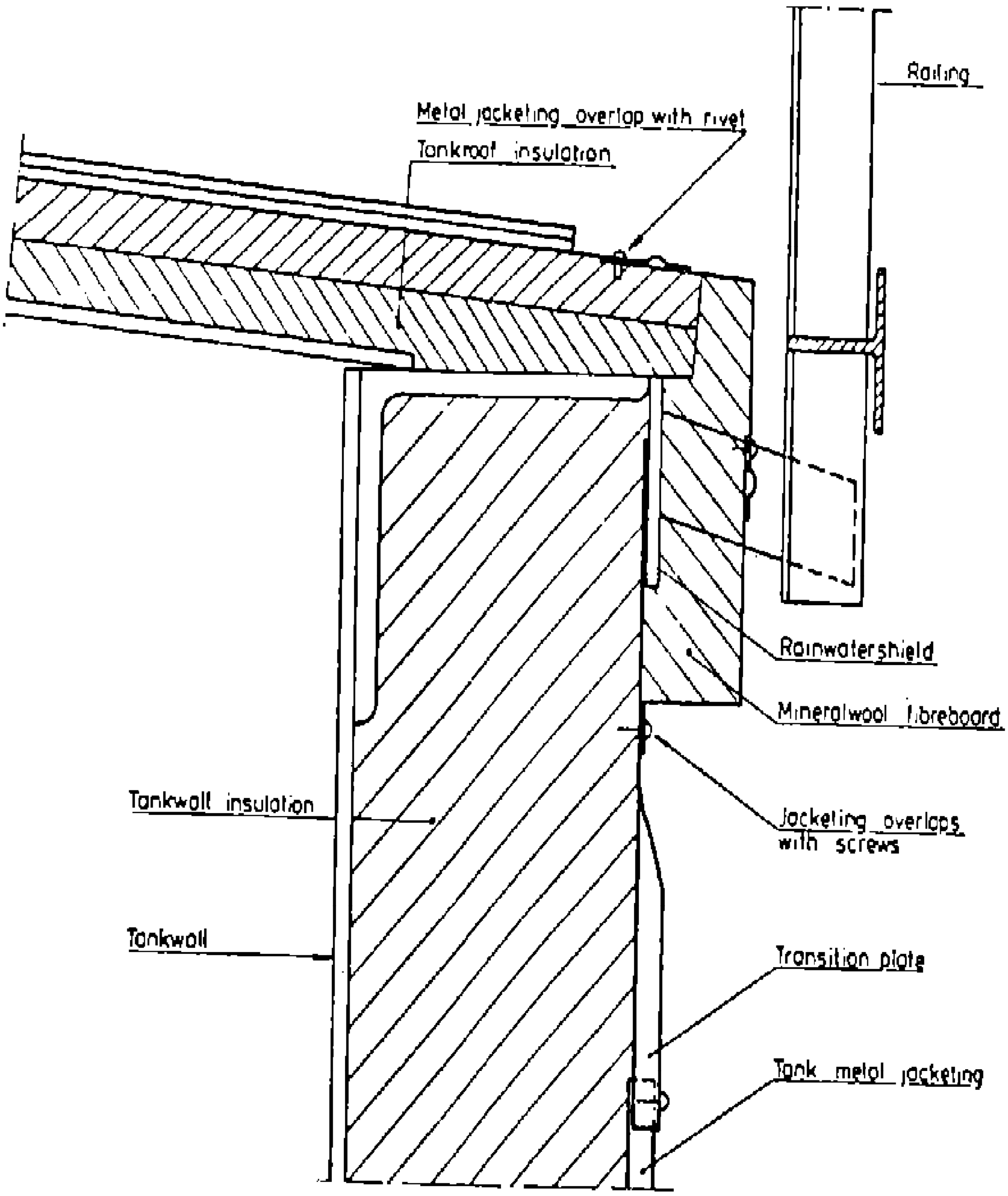
Blanket insulation on tank shells, shall be applied with stagger joint arrangement with all seams securely laced together with # 16 gage wire (1.5 mm) on 300 mm centers. In addition the blanket shall be impaled on welding pins and secured with speed clips. Weld pins shall be installed vertically on 3600 mm centers and on 600 mm centers circumferentially. After speed clips have been installed, trim the excess pin close to the speed clip. The insulation shall then be secured in place with 19 mm × 0.51 mm galvanized steel bands spaced on 300 mm centers and fastened to the 19 mm o pencil rods installed vertically at approximately 9000 mm spacing around the tank. Insulation shall be cut approximately 50 mm short of tank bottom and 75 mm wide × 3 mm thick layer, when dry, of mastic weather-coat applied to the bottom edge of the insulation to prevent wicking of moisture. See Fig. 34 for details.



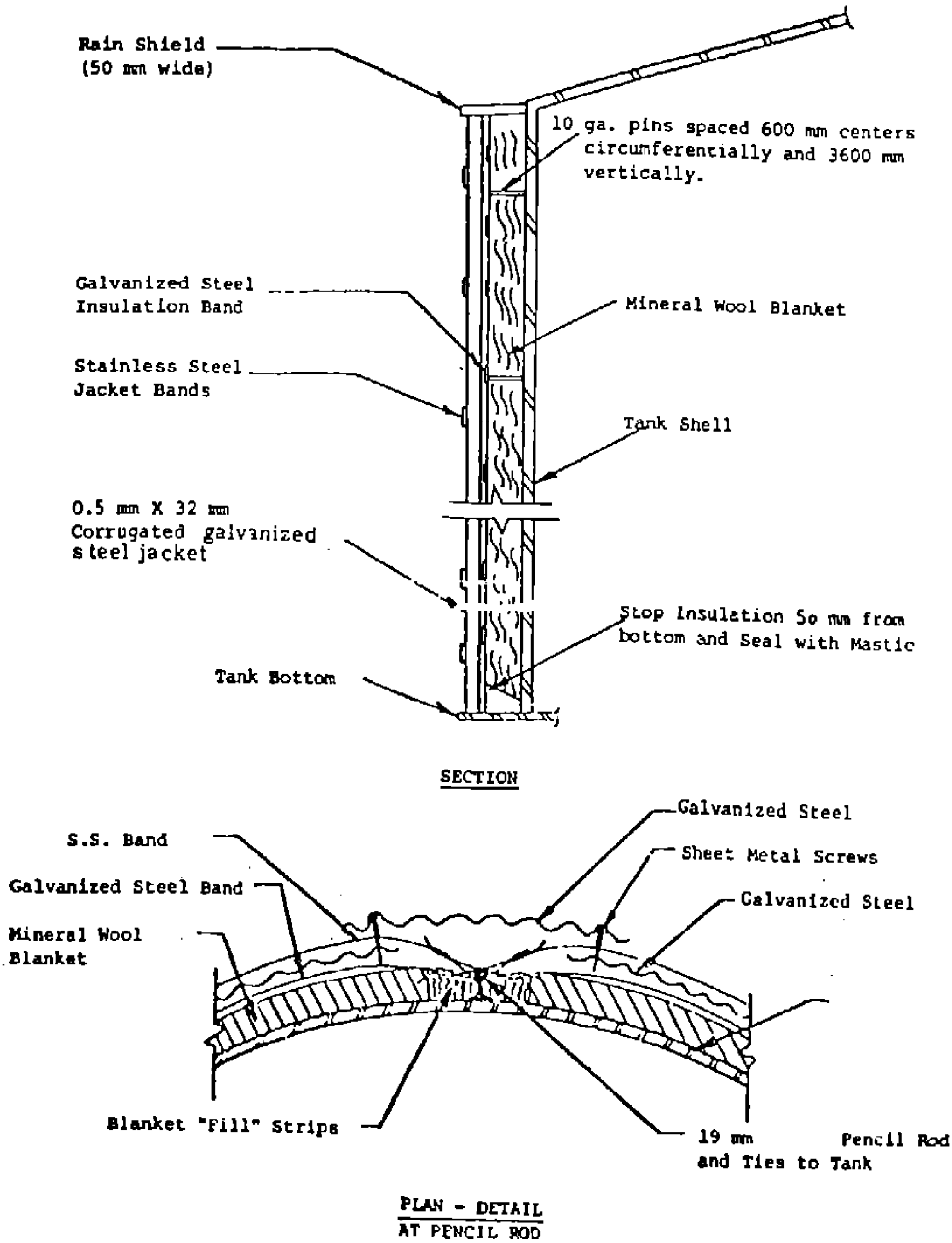
TANKWALL INSULATION FOR DIAMETERS UP TO 12 m
Fig. 31



TANKWALL INSULATION FOR DIAMETERS ABOVE 12 m
Fig. 32



HANDRAILING ON INSULATED TANKROOF
Fig. 33



INSULATION DETAILS, HOT TANKS
Fig. 34

6.4.5.2.3 Sprayed rigid Poly-Urethane Foam (PUF)

6.4.5.2.3.1 Sprayed PUF is intended for use on tank shells with operating temperatures above ambient and up to 90°C. It shall be applied only when overspray cannot cause damage to the adjacent objects, or when adequate protection against overspray is feasible.

6.4.5.2.3.2 Substantial protection from the weather is essential and in very cold weather some heating may be necessary.

6.4.5.2.3.3 The temperature of the liquid foam components shall be between 15°C and 25°C at the time of application.

6.4.5.2.3.4 the temperature of the surface to be insulated shall be between 20°C and 40°C during spraying. The insulation shall not be sprayed during rain or periods of high winds.

5.4.5.2.3.5 The insulation should be sprayed on a primed or painted surface after removal of any dirt, grease, loose paint or chalk. Rusted surfaces shall be blast-cleaned and painted. Mill scale and moisture shall be absent.

5.4.5.2.3.6 The insulation shall end at a sufficient height above the tank base to prevent contact between groundwater and insulation, e.g. after rainfall.

6.4.5.2.3.7 The PUF shall be sprayed in layers and each layer being a maximum of 12 mm thick until the specified thickness is obtained. The average finished thickness of sprayed PUF for the total tank surface shall be between 5 and 10 mm above the specified thickness. The thickness shall be measured using an electrical magnetic instrument.

6.4.5.2.3.8 The minimum insulation thickness of PUF applied shall be 25 mm.

6.4.5.2.3.9 Provisions shall be made to enable the removal of the insulation from parts which shall remain accessible or remain free of contamination, e.g. staircases, railings, manholes, gauge glasses or other accessories shall temporarily be covered with plastic foil.

6.4.5.2.3.10 Junctions between permanent and removable insulation shall be properly sealed against ingress of moisture.

6.4.5.2.3.11 The insulation shall be made smooth and properly sealed, including the seams where supports, nozzles, stair steps, etc., protrude through the insulation.

6.4.5.2.3.12 PUF used on tank roofs and shells shall be protected against ultraviolet radiation and weather conditions by applying an elastomeric coating of acrylate polymers.

6.4.5.2.3.13 Sprayed PUF without metal sheet covering shall not be used on roofs of tanks, since otherwise static electricity may occur by walking over the PUF, and furthermore damage to the PUF will cause severe corrosion of the roof plates. However, this prohibition does not include special proprietary tank roof insulation systems containing PUF that is free from these effects.

6.4.5.2.3.14 Failure of the foam to stick to the metal may not be evident immediately and is not readily defected by eye because of the uneven finish of the surface of the foam. It may be detected by tapping the foam, which will give a distinctive hollow sound if it is not stuck to the metal.

6.4.5.2.3.15 Special safety precautions have to be observed when spraying polyurethane foams and a fresh-air mask has to be worn.

6.4.5.3 Finishing and weatherproofing

6.4.5.3.1 Tank shells shall be finished with galvanized steel jacketing applied directly over the insulation. The metal sheet may be corrugated or plain. Corrugations shall run vertically with vertical seams lapped a minimum of 2 corrugations and horizontal seams lapped a minimum of 75 mm and supported on "S" clips. The metal jacketing shall be secured with 19 mm × 0.51 mm stainless steel bands spaced not less than one band on each circumterential lap and one at the middle of each sheet, but not to exceed 600 mm on center. Bands shall be fastened to the 19 mm diameter pencil rods installed vertically at approximate 9000 mm spacing around the tank. See Fig. 34 for details of pencil rod installation. Voids in the insulation at the pencil rods shall be filled with insulation blanket cut into suitable strips. Over the open joints of the open joints of the jacketing at the pencil rods apply a batten on corrugated steel of sufficient width to lap 2 full corrugation of the adjacent metal and secure with sheet metal screws at approximately 500 mm O.C. as required to close seams. All cut-outs at the uninsulated nozzles, manways, structural projections, nameplates, code inspection plates etc. shall be sealed with mastic.

6.4.5.3.2 On tanks and vessels where sufficient changes in circumference would occur as a result of thermal expansion, or loading e.g. asphalt storage, fractionating columns or large diameter crude storage tanks, insulation and weatherproofing bands shall have breather springs installed as follows:

VESSEL DIAMETER	OPERATING TEMPERATURE	No. OF SPRINGS REQUIRED
5" to 8"	Above 79°C (175°F)	One
Over 8" to 15"	All	One
Over 15"	All	One on every 15 meters

Breather spring to be equal to atlas expand-r-strap.

6.4.6 Irregular surfaces (including machinery)

6.4.6.1 Irregular surfaces whenever required shall be insulated according to the following methods.

6.4.6.1.1 All insulating materials, however fixed, shall be in close contact with the surfaces to which they are applied, unless an air space is required for special reasons. Where the main insulation consists of preformed, or flexible material, all edges or ends shall be closely butted; for multilayer work all joints shall be staggered. Where possible, pipes adjacent to the irregular surfaces should be insulated separately. Care shall be taken not to interrupt the moving member of the machinery when insulating these equipment.

6.4.6.1.2 If the insulation is not furnished with the equipment of irregular surfaces specially machinery, they shall be generally covered with insulation blanket securely tied in place of the same thickness as the adjacent pipe insulation. Over the insulation, when dry, apply a 10 mm thick layer of finishing cement. Heat exchanger ends and manhole covers when insulated, shall have the required thickness of insulation in block form securely wired together and completely enveloped in flat metal jacketing.

6.4.6.1.3 If such machinery, exchangers etc. are subject to regular maintenance necessitating removal of insulation, consideration shall be given to fabricating the insulation in detachable sections, completely jacketed in cladding which may be easily removed and replaced without damage.

6.4.6.1.4 Irregular surfaces, where application of molded-type or blanket insulation is impractical, shall be insulated to full specified thickness with insulating cement. Cement shall be applied with a trowel on surface to be insulated, filling all depressions for entire depth to eliminate insulating cement. Cement shall be applied with a trowel on surface to be insulated, filling all depressions for entire depth to eliminate voids of any nature. Care shall be exercised that the thickness of each application will be no greater than that which will set on vertical surfaces without excessive cracking upon subsequent drying. When sufficiently dry, additional applications may be made as required to build cement to full specified thickness. Where specified thickness of cement insulation exceeds 3.8 cm cement shall be reinforced with one layer of 2.5 cm wire netting for each additional 3.8 cm, or a part thereof, uniformly embedded midway between metal and finished surface.

6.4.6.2 Weatherproofing

6.4.6.2.1 Where specified thickness has been applied and secured in place, outer surface shall receive an adhesive coat of weather-barrier coating brushed on to a minimum thickness. While still tacky, reinforcing cloth shall be stretched taut and thoroughly embedded in coating. Care must be exercised that weave is not stretched and that cloth is overlapped approximately 3.8 cm to provide strength at joint equal to that maintained elsewhere. Before surface becomes dry to touch, a second coat of weather-barrier coating shall be applied by brushing over the reinforcing cloth to a uniform thickness, with a smooth, unbroken surface, and allowed to dry. Total thickness of weather-barrier coating and reinforcing cloth, when dry, shall not be less than 0.3 cm. No portion of cloth shall be visible on the finished surface.

6.4.6.2.2 Weather-barrier coating shall be carried out 15 cm on to any metal beyond termination of insulation. Application shall be built up in a uniform manner to prevent uneven contraction and tendency toward surface cracks. Openings around nozzles, manways, etc., shall be made water-tight.

6.4.6.2.3 All outside corners of insulation shall be rounded, and the weather-barrier coating provided with a double layer of reinforcing cloth.

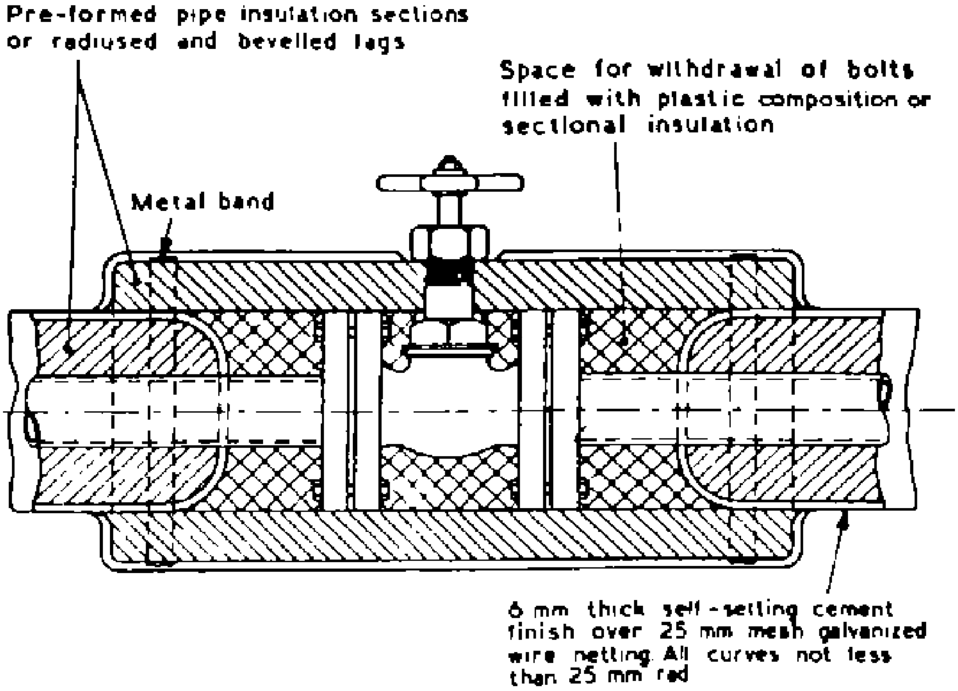
6.4.6.2.4 Care should be taken in applying weather-barrier coating over hot equipment insulation; severe blistering will occur if insulation contains more than 5% moisture. Weather-barrier coating shall not be applied when atmospheric temperature is such that condensate of moisture and ultimate freezing may occur on the finished surface with 24 hours from time of application.

6.4.7 Valves, flanges and fittings

6.4.7.1 It is preferable that valves and flanges should be insulated, but where hidden flange leakage may cause a possible fire or other hazard, e.g. with oil lines, or where repeated access will make it uneconomical, insulation may be omitted. For hot hydrogen duty, a simple sheet-metal shroud should be placed over the flanges to protect them from thermal shock due to changes in atmospheric conditions, whilst permitting access for safety etc.

6.4.7.2 Valves flanges and fittings shall be insulated with preformed sections as far as is practicable. See Figs. 35 and 36. It is appreciated that irregular surfaces are difficult to so insulate, but the maximum use of moulded sections entails the minimum wastage of material should it be necessary to remove and replace the insulation for inspection purposes. The insulation shall be finished in such a manner that there is free access to instruments. All thermometer pockets, including the boss and welded pad, shall be insulated. For some superheated steam installations it may be desirable to insulate pressure-gauge pipework for a reasonable distance from the tapping point to avoid pressure loss due to cooling.

6.4.7.3 Flanges shall be insulated as far as practicable by premoulded material or insulated boxes that can be removed for maintenance. Figs. 36 and 37 show a possible method of arranging this.



METHOD OF INSULATING A VALVE (APPLICABLE TO A PLASTIC FINISH)
Fig. 35

6.4.7.4 Some common methods adopted for insulating valves and flanges are described as follows.

a) Flange boxes

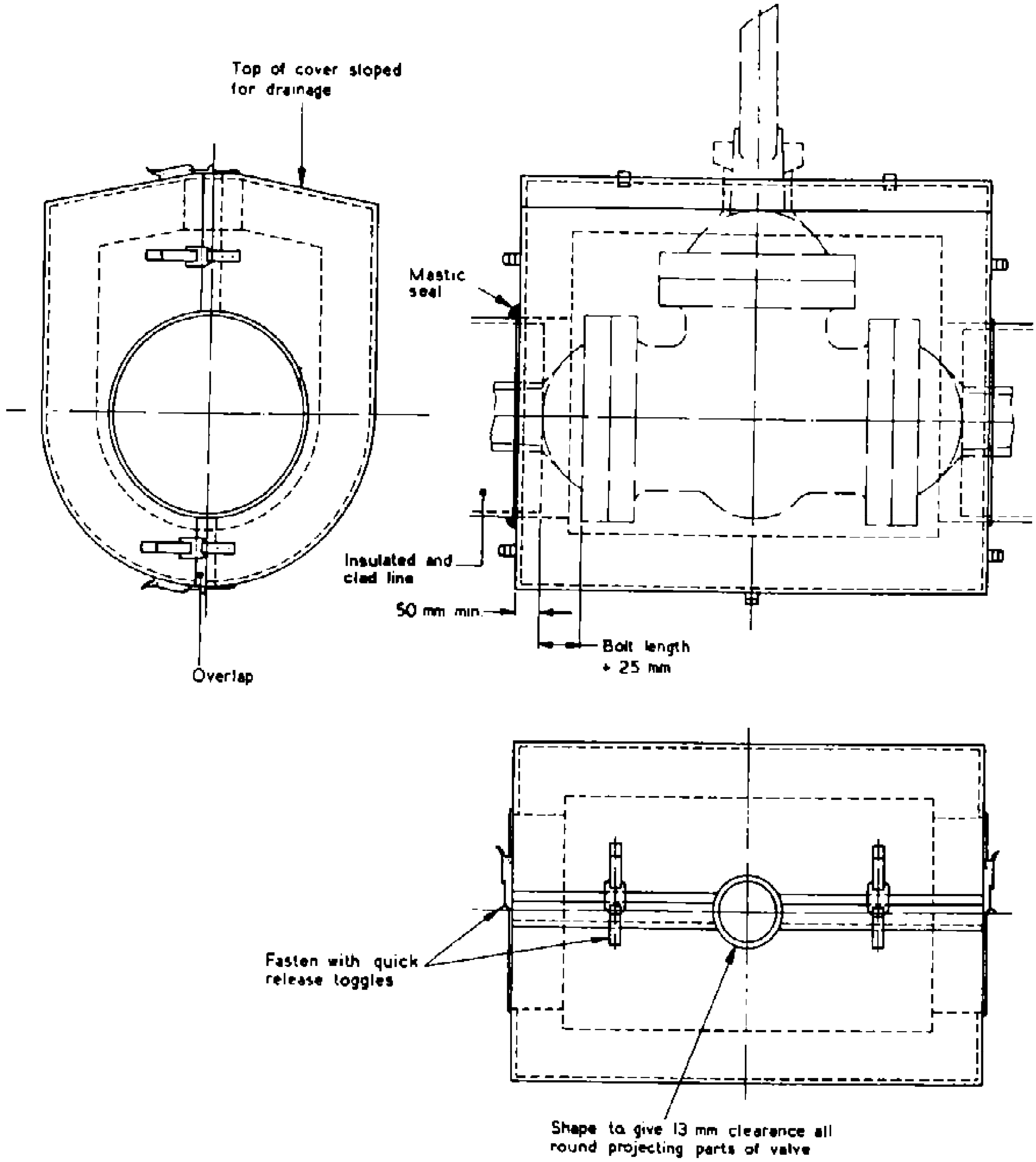
These are usually made from metal sheet and lined with preformed rigid or flexible insulating material. Direct contact between the metal of the box and the insulated metal surface shall be avoided. (See Figs. 36 and 37). A removable type of flange box is shown in Fig. 38.

b) Mattresses

These consist of a glass or silica fibre cloth envelope packed with loosefill insulating material. (See Fig. 39).

c) Plumber's joint

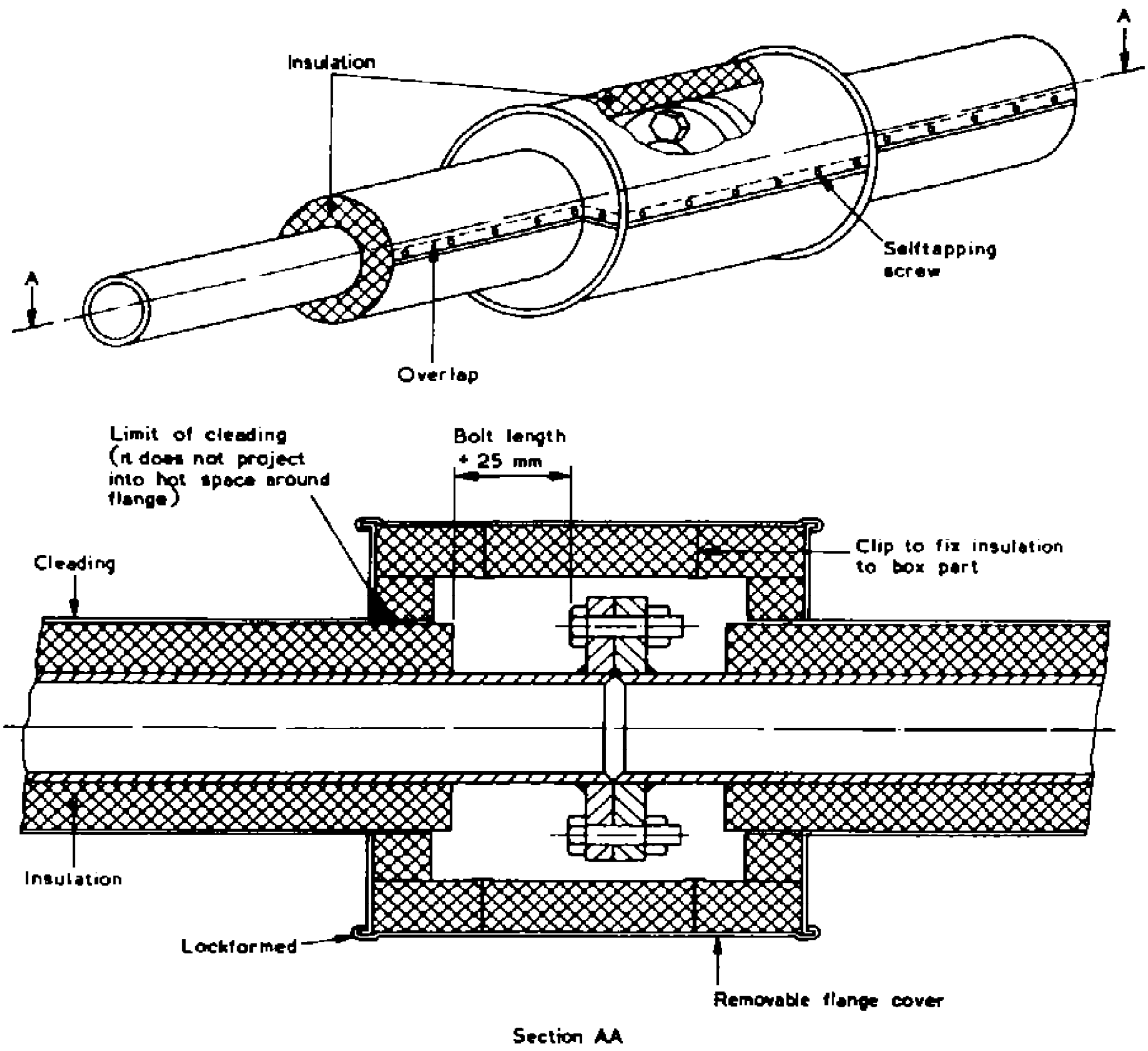
This is achieved by the application of plastic composition over flanges or valves, after the insulation on adjacent piping has been appropriately finished. The piping insulation shall terminate at points that allow for easy removal of flange bolts and the chamfered ends of the piping insulation shall be finished and suitably painted. This provides a specific area in which the insulation for the flanged joint or valve may be confined, and also allows for it to be removed periodically without disturbing the piping insulation. (See Fig 39 a).



Note:

Case made in two or more pieces insulation to be fixed to case parts for easy removal and replacement.

METAL BOX VALVE COVER
Fig. 36



Note:

Insulation to be fixed to box parts for easy removal and replacement.

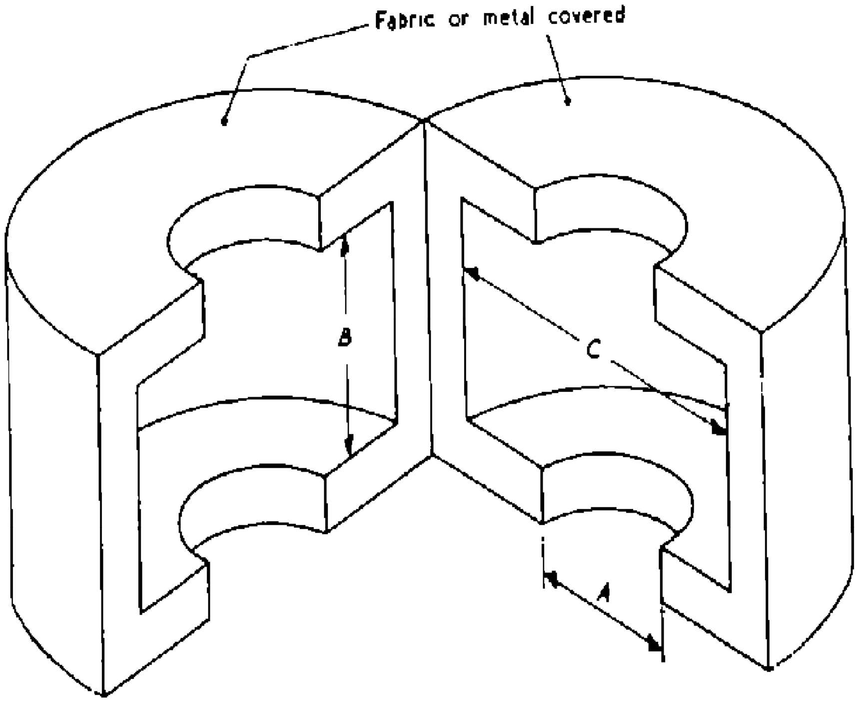
A METHOD OF INSULATING PIPE FLANGES
Fig. 37

d) Oversized sections

The insulation is built up with collars of preformed material on each side of the flange, leaving space for withdrawal of the bolts, and a length of large bore section is applied over the outside of the collars to bridge between them and cover the flange (see Fig. 35).

e) Muff covers

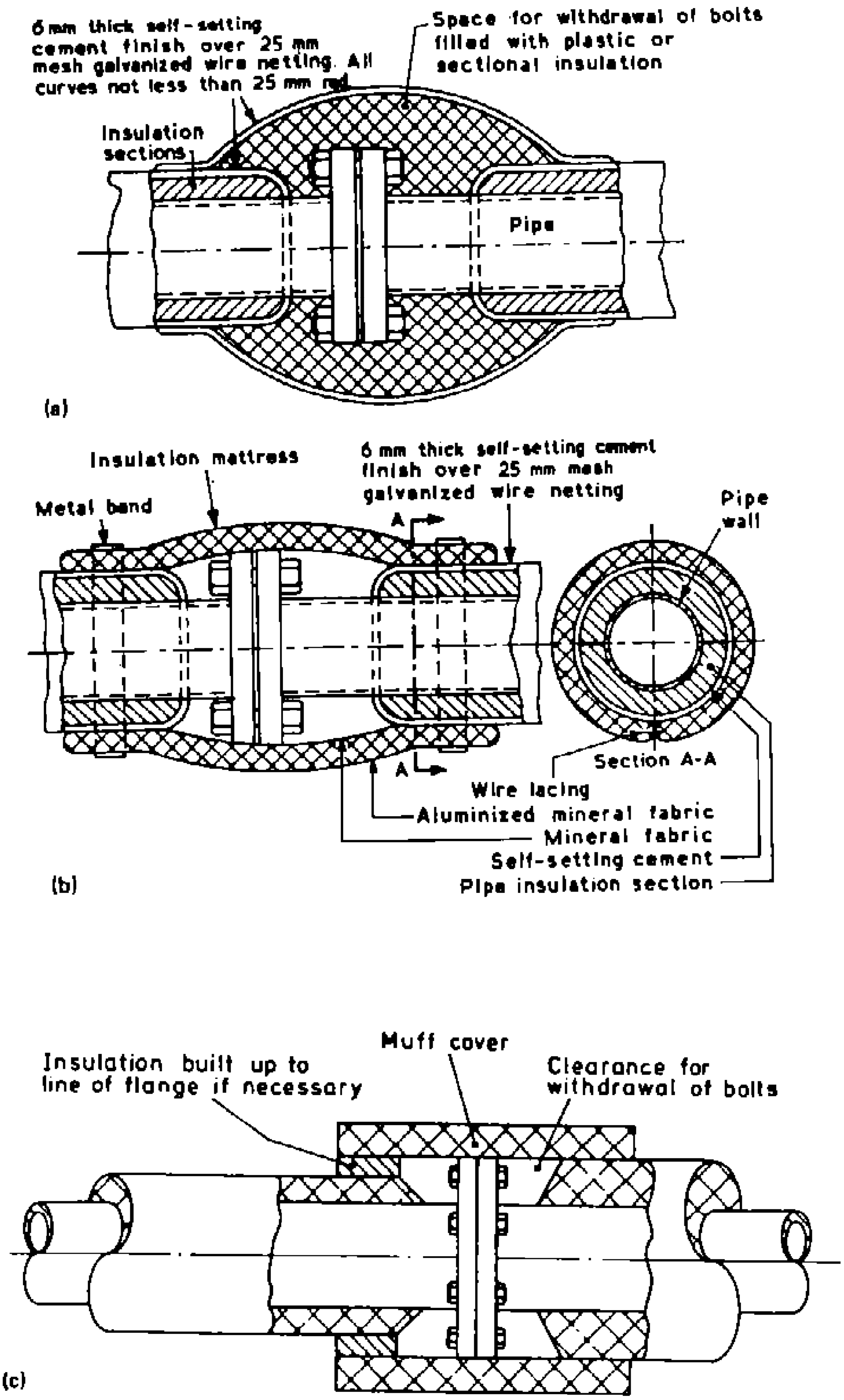
These are fabricated from preformed rigid insulating materials. They are constructed to allow for easy removal and are normally finished with a fabric, which may be sewn on or applied with a suitable adhesive (see Fig. 39 (c)).



Details to be stated when ordering:

A) Outside diameter of adjoining pipe.
B) Overall width over bolts.
C) Diameter of flange.

REMOVABLE FLANGE BOX
Fig. 38



TYPICAL METHODS OF INSULATING PIPE FLANGES
Fig. 39

6.4.7.5 Weatherproofing

Weatherproofing of flanges, valves and fitting are usually secured with encasement in flange boxes or application of weather-barrier coating or metal jacketing over the insulation. See Figs. 35, 36, 37, 38 and 39.

6.5 Cold Insulation Application

Application for systems operating in the temperature range -100°C to + 5°C.

6.5.1 General

6.5.1.1 Metal surfaces operating below the dew point shall be given a coat of priming paint, which has to be thoroughly dry before the insulation is applied see IPS-E-TP-700. The initial protective layer has to be compatible with any adhesive joint sealant and vapour seal used. It shall also be resistant to steam purging temperatures, where applicable.

6.5.1.2 Cold insulation shall be carried out at ambient temperature. It is sometimes possible to use a liquid with low freezing point to defrost very small items of operating plant. (The appropriate safety precautions have to be observed when using a solvent). If this is done the insulation and vapour seal has to be applied immediately. In general, this practice is not recommended and insulation applied after defrosting shall be regarded as temporary.

6.5.1.3 The Manufacturer's recommendations shall be followed, particularly in respect of:

a) The compatibility of the insulation material with adhesives, joint sealant and vapour sealants;
b) the maximum temperature of hot-dip adhesives;
c) the resistance to 'cheese knife' cutting if wire ties are used.

6.5.1.4 Where mechanical support of the insulation is required, wood, or plastics skewers, etc., are preferred. Such supports shall be wholly within the insulation.

6.5.1.5 It is important that the insulation be cut and fitted accurately. It is preferable that moulded preformed bends of insulating material shall be used, as appropriate, to ensure accurate fit without open joints. The practice of filling gaps in joints with plastic composition or rough slivers of insulation is deprecated.

6.5.1.6 Contraction joints may be required because of the differing rates of thermal movement between the equipment and various types of insulating materials. See Fig. 40 for some values relating to typical materials in the temperature range +20°C to -100°C.

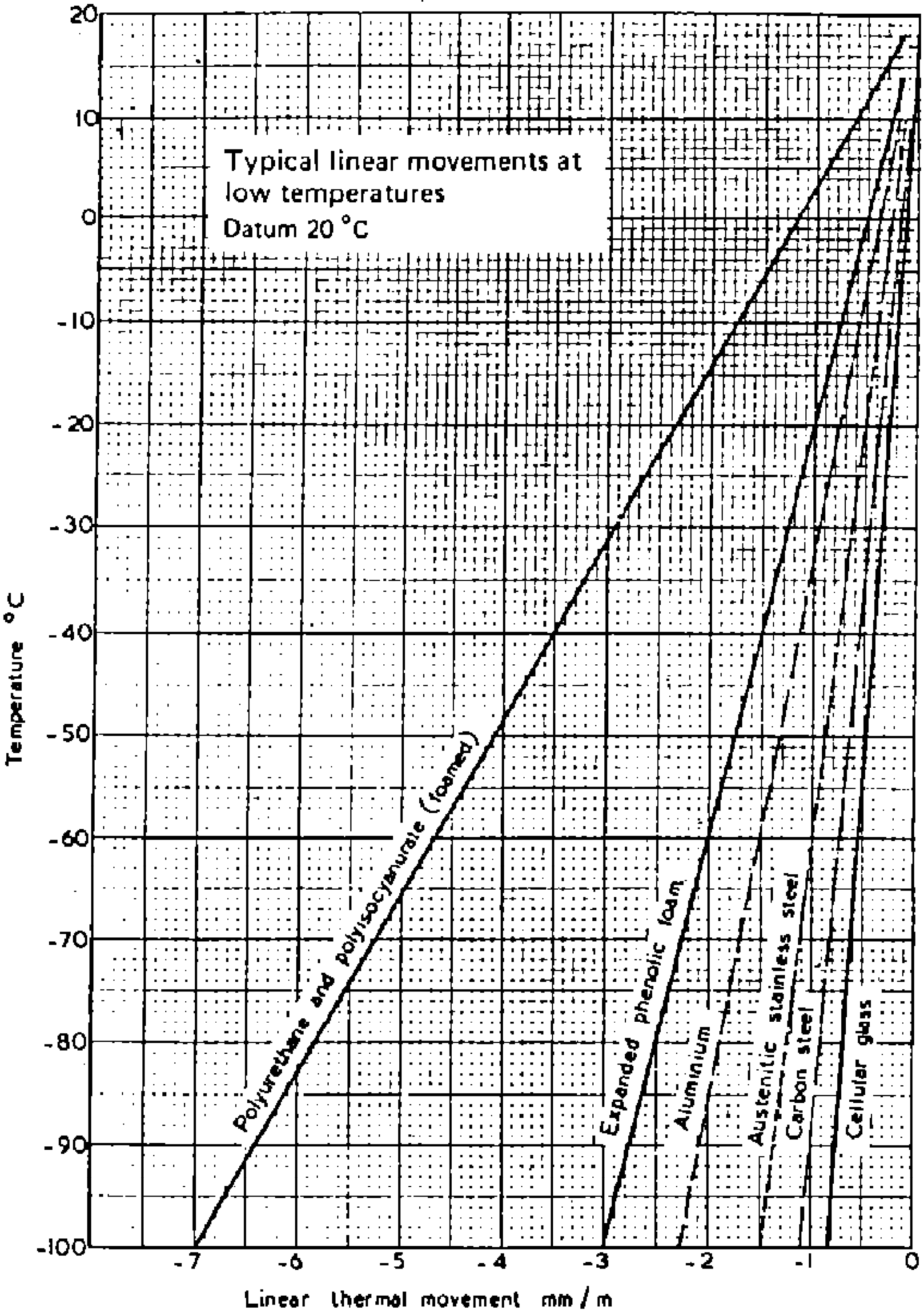
6.5.1.7 Where two or more layers of insulating material are required the inner layer shall not be bonded to the vessel or pipework with adhesive, although subsequent layers may be bonded to the appropriate previous layer.

6.5.1.8 Where the service temperature is very low where there are appreciably large fluctuations of temperature, and depending on the type of insulating material and the configuration of the system, contraction/expansion joints of the type shown in Fig. 41 may be adopted.

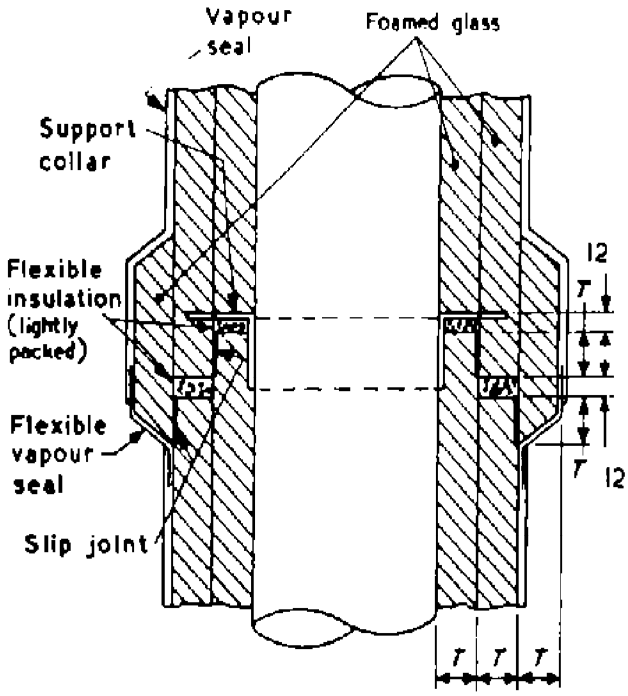
6.5.1.9 Joint-sealer mastic of suitable elasticity shall be applied to the edges of all portions of preformed insulating material, including those of the inner layer.

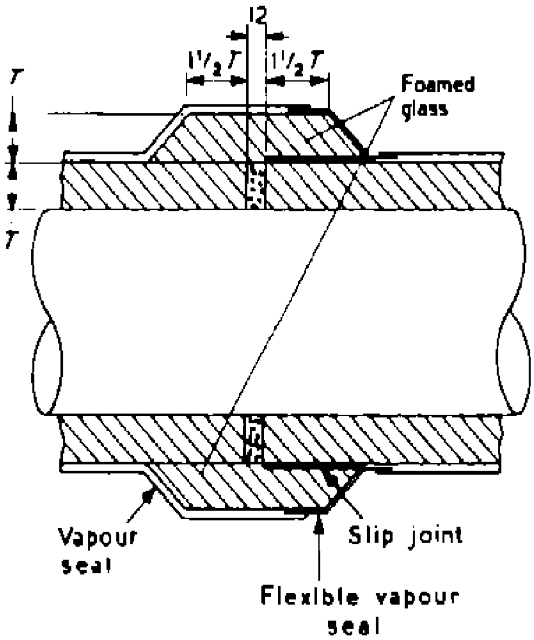
6.5.1.10 It is essential that the vapour seal be designed as an integral part of the insulation system and applied as soon as possible so as to keep the insulation dry. (See Figs. 42 and 43).

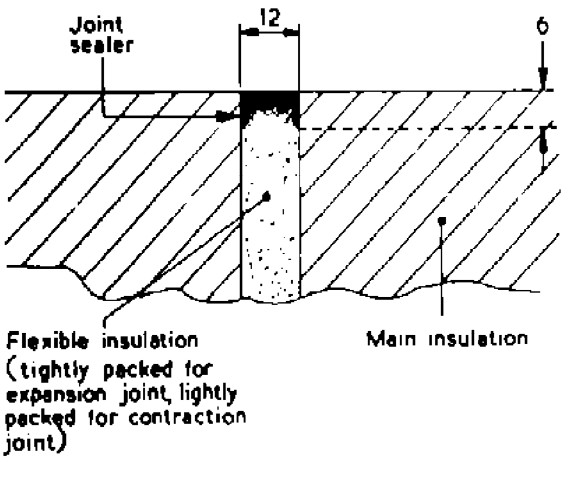
6.5.1.11 The piping and equipment shall be insulated after their pressure tests and other necessary test and inspection have been completed. To facilitate regular inspection of welds and bottled joints, removable portion of insulating and finishing materials shall be provided in the appropriate locations.



LINEAR THERMAL MOVEMENT OF VARIOUS MATERIALS BETWEEN +20°C AND - 100°C
Fig. 40







*** Dimensions in mm.**

Typical contraction joints in insulated piping (Refrigeration)

CONTRACTION JOINTS: LINEAR THERMAL MOVEMENT OF MATERIALS
Fig. 41

6.5.1.12 All materials shall be subjected to inspection and approval by the owner to ensure that all materials meet this specification.

6.5.1.13 Insulation application shall also be subjected to inspection and any material which has been improperly installed or excessively damaged shall be removed and replaced properly with undamaged material.

6.5.1.14 All work shall be executed in a neat and workmanlike fashion in strict accordance with these specifications and as called for on drawings covering the work to be done. No changes or deviations will be permitted without advance written approval by the owner.

6.5.1.15 Every precaution shall be taken to see that each day's work is weatherproofed before leaving it for the night. Where this is impractical, a fillet of weatherproof mastic must be placed over the exposed ends of insulation.

6.5.1.16 No insulating work of any type may be performed in rainy weather or when atmospheric condensation is occurring. In the event of doubt regarding the prevailing dew point the decision will be made by the owner.

6.5.1.17 Insulation classification for cold systems which may appear on flow diagrams and drawings is IC and defined as following:

IC: to conserve refrigeration, surface condensation and control fluid temperatures for operating temperatures 21°C and below.

6.5.2 Cold pipework

6.5.2.1 General

6.5.2.1.1 Piping shall be insulated when coded on mechanical and utility flow diagrams, pipeline lists and piping and spool drawings. Insulation thickness shall be as shown on drawing or tables of IPS-E-TP-700.

6.5.2.1.2 It is generally good practice to insulate piping with preformed material, although in-situ foam or sprayed foam may be used, especially on larger sizes. It is essential that cellular glass sections not secured to the pipe by adhesives shall have a bore coating of non-setting compound to act as an anti-abrasive lining; this bore coating has to be allowed to dry before the section is fitted.

6.5.2.1.3 When preformed insulating materials are use, two layer construction is preferred for surfaces operating below -18°C; all joints have to be staggered.

6.5.2.1.4 Bends shall be insulated with the same type of material cut lobster-back fashion and secured as for straight piping, with one tie per segment; although, alternatively, fully moulded or prefabricated bends may be used if these are available.

6.5.2.1.5 All attachments fastened to the pipe that protrude through the insulation shall, where possible, be insulated to a distance of four times the insulation thickness and sealed.

6.5.2.1.6 Contraction joints shall be provided on long straight runs of piping at approximately 7 meter intervals. Joints shall be packed with glass fiber or polyurethane and adequately sealed.

6.5.2.1.7 All insulation shall be continuous at supports . A mild steel cradle preformed to the O.D of insulation shall be provided at each support. This cradle shall be of sufficient length to prevent of undue compression of the insulation due to the weight of the insulated line.

6.5.2.1.8 Lines larger than 600 mm diameter shall be insulated and finished as described for vessels.

6.5.2.1.9 If required thickness exceeds 75 mm the insulation shall be applied in not less than two layers.

6.5.2.1.10 Expansion joints shall be insulated in such a manner as to allow freedom of movement of the bellows. Applications, sealing and weatherproofing to be in accordance with the requirements of this Standard.

6.5.2.2 Application

6.5.2.2.1 For single layer insulation, the ends and butt edges of the preformed insulation shall be buttered with joint sealer and tightly butted so that all voids are eliminated. The insulation shall then be secured with PVC tape bands on 250 mm centers back-taped at least 50 mm from the butt joint.

6.5.2.2.2 For multiple layer insulation all joints shall be buttered with joint sealer as in above. In addition each successive layer of insulation shall have a brush coat of non-setting compound applied to the bore face of the block to be applied. The layers shall be banded in place with PVC tape at approximately 300 mm centers and located 25 mm from butt joint.

6.5.2.2.3 Preformed insulation shall be snugly fitted on the pipe with all joints firmly butted together. Any broken or rounded corners of the insulation shall be cut off and squared so that all voids are eliminated. Where multiple layer insulation is used, the outer layer shall be placed in such a manner that all joints are staggered.

6.5.2.3 Weatherproofing

6.5.2.3.1 The entire outer surface of the insulation shall receive a tack coat of vapour barrier mastic, 1.5 liters per 1.0 m^2 with a minimum thickness of 1 mm unless specified otherwise, and glass cloth embedded into the surface while still wet, avoiding all wrinkles pockets, etc. and over-lapping the glass cloth a minimum of 50 mm.

A finish coat of vapour barrier mastic shall then be applied to the whole surface 3.0 liters per sq.m with a minimum finished and dried thickness of 3 mm unless specified otherwise. Care shall be taken to ensure that all glass cloth and bands are completely covered. The surface shall then be smoothed off with a suitable solvent if metal cladding is not to be applied.

6.5.2.3.2 The vapour barrier mastic and glass cloth shall extend at least 150 mm beyond the insulation at all metal projections to ensure a good seal. Heavy fillets of mastic shall be applied to all corners and crevices where water is likely to collect.

6.5.2.3.3 Vapour barrier mastic shall also be used as flashing at all possible sources of moisture penetration such as intersections of insulation, nozzles, building walls, valve bonnets tees and other protrusions through the surface coating.

6.5.2.3.4 Jacketing, where recommended, shall be aluminum sheeting with all joints lapped 50 mm and arranged to shed water. The jacket shall be secured with bands installed at 450 mm centers.

6.5.3 Vessels

6.5.3.1 General

6.5.3.1.1 Insulation requirements shall be as indicated on the mechanical and utility flow diagrams. Thickness of insulation shall be as shown on the vessels drawings and in the applicable tables of IPS-E-TP-700. In the event of discrepancies, the vessel drawing will govern.

6.5.3.1.2 Vessel and exchanger flanges, manhole covers, and appurtenance shall be insulated preferably with preformed material. All attachments to the vessel or exchanger such as skirts, supports, ladder and platform clips, etc. shall be covered with insulation for a distance of four (4) times the basic insulation thickness, with the vapor barrier continuing and sealing to the metal. Insulation shall be installed around manholes, exchanger channels and shell covers so as to allow removal and re-use without damage to the insulation or to adjacent insulation.

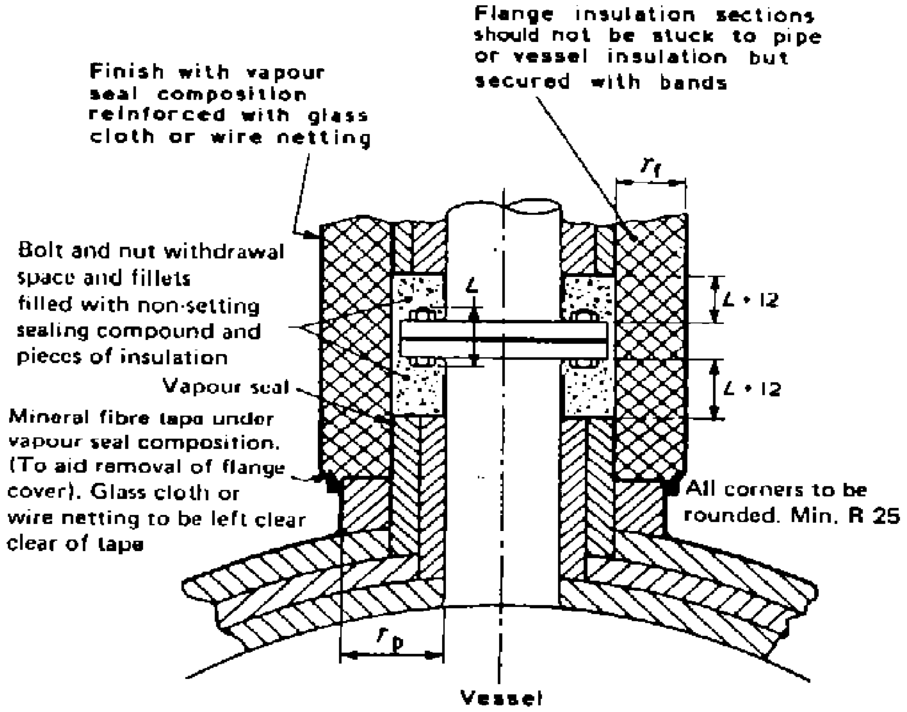
6.5.3.1.3 Insulation shall be pipe covering for vessels and exchangers smaller than 600 mm O.D. Insulation may be blocks, beveled lags, or curved segments for vessels and exchangers 600 mm O.D. and larger. All such pieces of insulation shall be beveled or shaped to fit closely to the contour of the equipment (or of the inner layer of multi-layer insulation). Vessel and heat exchanger heads and transition covers shall have aluminum covers of orange peel design.

6.5.3.1.4 Vessels and tubular equipment operationing at temperatures -40°C and lower shall have the insulation applied in two layers with joints staggered. See Figs. 42, 43, 44, 45.

6.5.3.2 Application

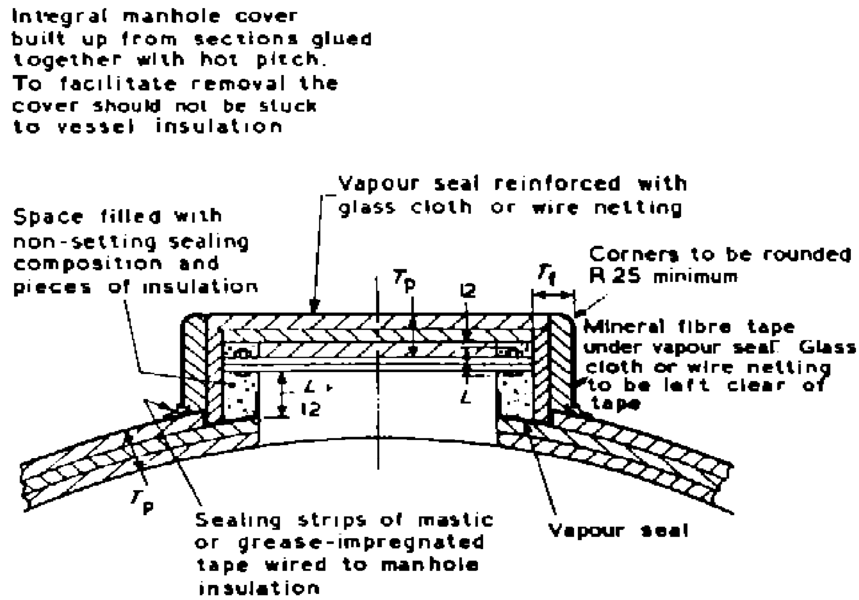
6.5.3.2.1 Block insulation on vertical vessels and tubular equipment shell shall be supported by horizontal insulation rings on 3.7 m spacing, supplied by vessel fabricator. Insulation support ring width shall be 13 mm less than the insulation thickness except the bottom ring and shall be 13 mm wider than the insulation thickness. The butt edge surfaces of all segments and block section of the insulation shall be buttered with approximately 2 mm thick coating of joint sealer prior to application. In case of multiple layers, only the outermost layer shall be buttered.

6.5.3.2.2 Each layer of insulation shall be secured in place with bands on approximately 150 mm centers. Where irregular surfaces make banding impractical, tie wire shall be used. For multilayer application, all joints shall be staggered. All voids shall be filled with glass fiber. Vertical contraction shall be provided by installing glass fiber in the 19 mm space below the support ring and covering with a suitable vapor seal.



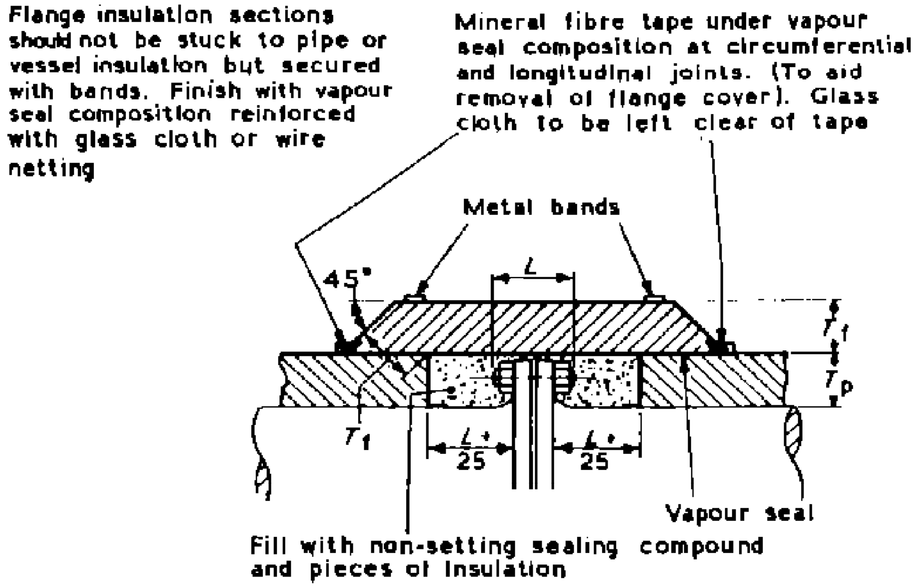
Dimensions in millimetres

TYPICAL METHOD OF INSULATING BRANCHES OF VESSELS (FOR COLD WORK)
Fig. 42

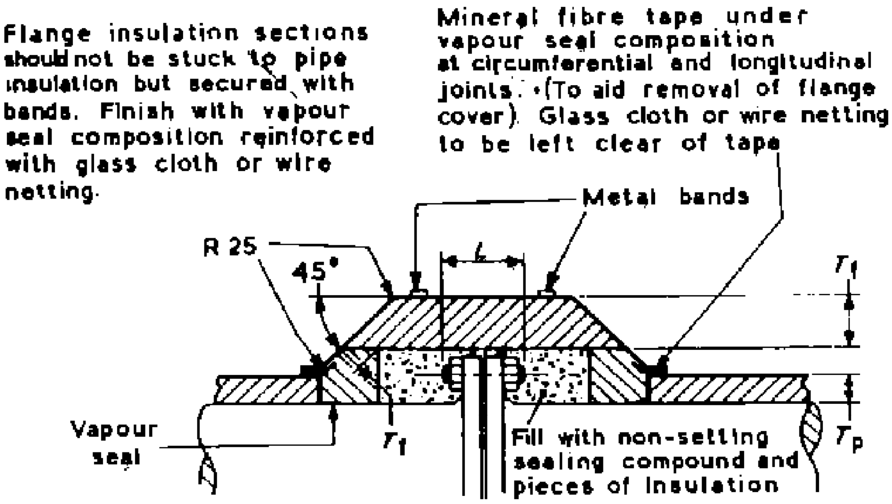


Dimensions in millimetres

TYPICAL METHOD OF INSULATING MANHOLE (COLD WORK)
Fig. 43



(a) Arrangement when diameter of insulation is greater than diameter of flange

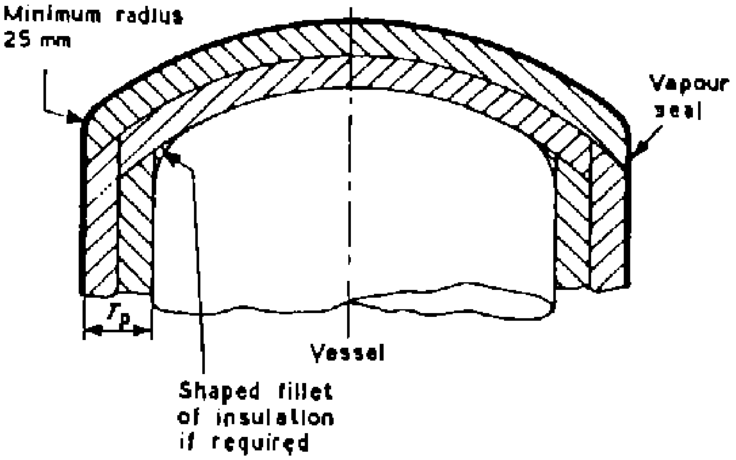


(b) Arrangement when diameter of insulation is less than diameter of flange

T_p is the thickness of insulation on pipe or vessel
T_1 is the thickness of insulation on flange
$T_1 = T_p$ where T_p is less than 100 mm
$T_1 =$ 100 mm where T_p is between 100 mm and 125 mm
$T_1 = T_p - 25$ mm where $T_p > 125$ mm

Dimensions in millimetres

TYPICAL METHOD OF INSULATING FLANGES (FOR COLD WORK)
Fig. 44



TYPICAL METHOD OF INSULATING DISHED ENDS OF COLD VESSELS
Fig. 45

6.5.3.2.3 Heads on vessels and tubular equipment shall be insulated with blocks. The butt edges of all segments shall be buttered with approximate 2 mm thick coating of joint sealer and secured with bands attached to a floating ring in the center and to a band installed at the tangent point of the vessel head. Band spacing shall be 300 mm maximum at the circumference of the vessel.

6.5.3.2.4 In addition to the use of adhesive, where it is recommended, each layer shall be banded on. Large slabs will need at least two ties per slab. Wooden skewers or thin clips may be used to hold second and subsequent layers to the first.

6.5.3.2.5 Where banding is impracticable slabs may be impaled on studs that partially penetrate the thickness of insulation.

6.5.3.2.6 Where differential movement between vessel and insulating material makes necessary the use of expansion/contraction joints, the positions of these shall be marked off before erection of the insulation begins. Suitable flexible vapourtight cover strips have then to be provided.

6.5.3.2.7 Before the erection of the main body of insulation all protruding pipe stubs, fittings, manhole necks, etc. shall be insulated.

6.5.3.2.8 The insulation shall extend down any vessel skirt or legs or cradle for a distance not less than four times the thickness of the insulation on the vessel, measured from the surface of the insulation.

6.5.3.3 Vapor barrier & weatherproofing

6.5.3.3.1 The entire outer surface of the insulation shall receive a tack coat of vapor barrier mastic, 1.5 liters per 1.0 m² with a minimum thickness of 1 mm unless specified otherwise, and glass cloth embedded into the surface while still wet, avoiding all wrinkles pockets, etc. and overlapping the glass cloth a minimum of 50 mm. A finish coat of vapour barrier mastic shall then be applied to the whole surface, 3.0 liters per sq.m., with a minimum finished and dried thickness of 3 mm unless specified otherwise. Care shall be taken to ensure that all glass cloth and bands are completely covered. The surface shall then be smoothed off with a suitable solvent if metal cladding is not to be applied.

6.5.3.3.2 At all metal flashing protusions, insulation terminals, corners and crevices a coat of foam sealant shall be applied prior to the mastic and glass cloth which shall extend 150 mm beyond the insulation to ensure a good seal. Heavy fillets of vapour barrier mastic shall be applied to all corners and crevices where water is likely to collect.

6.5.3.3.3 Vapour barrier mastic shall also be used at all possible sources of moisture penetration, such as intersections of insulation, nozzles, building walls and other protrusions through the surface coatings.

6.5.3.3.4 Vessel and tubular equipment heads and transitions shall be finished as follows:

A tack coat of mastic shall be applied over the insulation, and glass cloth shall be embedded and pulled down over the vessel shell insulation for a distance of at least 150 mm under the metal jacket, and secured with bands. The fabric shall lap at least 75 mm at all joints and be wrinkle-free. A 1.2 mm thick coat, when dry, of mastic shall then be applied.

6.5.3.3.5 Vessels and tubular equipment shell shall be finished with metal jacketing, where specified, applied directly over the vapor barrier coating.

6.5.3.3.6 On vertical vessels and tubular equipment the bottom course of metal shall be supported on the bottom insulation support ring. All other horizontal seams of the metal sheets shall be lapped 75 mm circumferentially, supported on "S" clips, and a minimum of 100 mm lap or two corrugations on each vertical seam. Metal covering shall be secured with bands spaced not less than one band on each circumferential lap and one at the middle of each sheet, but not to exceed 500 mm on centers. No metal screws shall be used.

6.5.3.3.7 On horizontal vessels, tubular equipment and fin-tube exchangers, the metal sheets shall be lapped a minimum of 75 mm on the circumferential seam and a minimum of 100 mm or two corrugations on the longitudinal seams. Bands shall be installed on 460 mm centers and shall be machine-stressed and fastened under tension.

6.5.3.3.8 On vertical and horizontal vessels, the junction between the mastic head and metal jacket shall be sealed with a mastic fillet.

6.5.4 Valves, flanges, fittings and irregular surfaces

6.5.4.1 Insulation application

6.5.4.1.1 All valves, flanges and fittings on insulated cold piping shall be insulated with preformed or mitered insulation of the same thickness as the adjacent piping insulation, and secured with bands and joint sealer in the same manner as that specified for straight piping. Care shall be taken to insure tight joints between fittings and straight pipe insulation. See Fig. 41.

6.5.4.1.2 Pumps compressors, or other irregularly shaped equipment shall be enclosed in block insulation with voids filled with glass fiber. Butt edges of all segments shall be buttered with approximately 2 mm coating of joint sealer and shall be securely banded or tied in place.

6.5.4.2 Weatherproofing

6.5.4.2.1 Fittings and flanges shall have attack coat of mastic applied directly over the insulant, followed by a layer of glass fabric installed wrinkle-free. Over the glass fabric a 1.2 mm thick layer, when dry, of mastic weather-coat shall be troweled to a smooth finish. This finish shall extend approximately 50 mm under the adjacent pipe weatherproofing jacket. Vertical joints between mastic and pipe jacket shall be sealed to prevent entrance of moisture.

6.5.4.2.2 Pumps, compressors or other irregular shapes shall have a tack coat of mastic applied to the outer surface and glass cloth shall be embedded into the mastic. The fabric shall lap at least 75 mm at all joints and shall be wrinkle free. A 1.2 mm thick coat, when dry, of mastic shall them be applied.

6.5.5 Cold spheres

6.5.5.1 General

6.5.5.1.1 Insulation requirements shall be as indicated on the mechanical flow diagrams. Thickness of insulation shall be as shown on the sphere drawings.

6.5.5.1.2 Flanges, manhole covers, and all appurtenances shall be insulated. All attachments to the sphere such as ladder and platform clips shall be covered with insulation for a distance of four times the basic insulation thickness.

6.5.5.1.3 Insulation shall extend over and down support legs a distance of not less than 900 mm from the lowest juncture of the leg with the sphere, and shall be supported by angle or plate welded around sphere support leg. Insulation shall be installed around manholes and shell covers so as to allow removal and re-use without damage to the insulation or to adjacent insulation.

6.5.5.1.4 Insulation shall be single layer construction and shall be properly vapor sealed.

6.5.5.2 Insulation application

6.5.5.2.1 Prior to application of insulation, all metal surfaces shall be cleaned and primed, see IPS-E-TP-700. The primer shall be fully cured before application of the insulation.

6.5.5.2.2 Sphere shall have a bar or plate support of such size as to support 13 mm the thickness of the insulation welded around the shell at the equator.

6.5.5.2.3 Insulation shall be blocks, beveled lags, or curved segments beveled or shaped to fit closely to the contour of the equipment with all joints butted snugly together.

6.5.5.2.4 A full coating of latex hydraulic cement adhesive shall be applied to the erection face of the insulant and a sealer to one side and two adjacent edges of each block. Joints shall be tightly butted and shall be staggered where possible. Latex cement to be equal to benjamin foster flexfas adhesive 82-10.

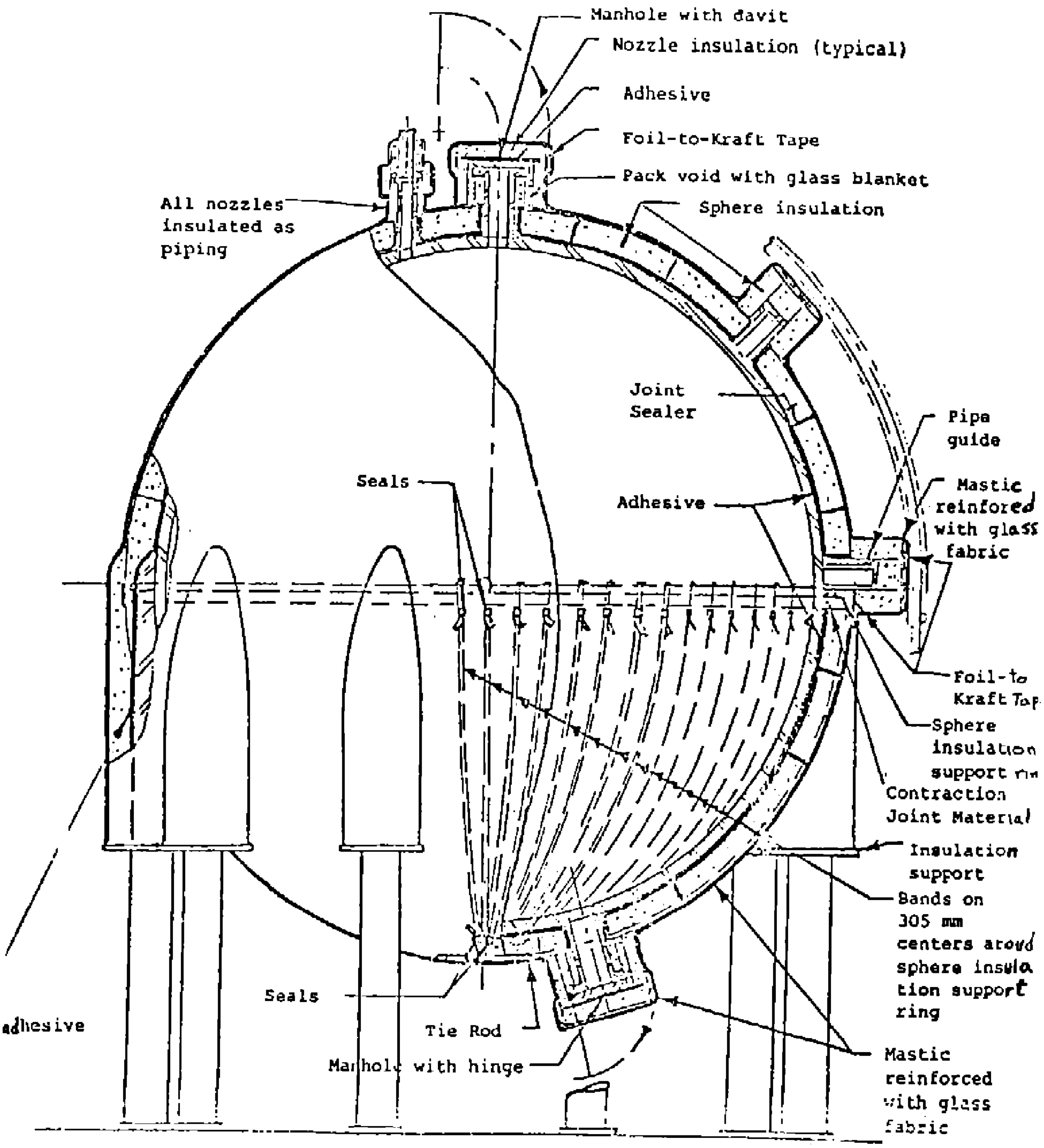
6.5.5.2.5 On the bottom half of the sphere, the insulation shall be banded in addition to being adhered. Bands shall be fastened to a 13 mm $\varnothing \times$ 1.80 m maximum carbon steel floating ring at the bottom of the sphere and to the equator support on 900 mm centers maximum. See Fig. 46.

6.5.5.3 Weatherproofing

6.5.5.3.1 Over the insulation a tack coat of mastic shall be applied. While still tacky, glass cloth shall laid smooth and thoroughly embedded into the mastic. The fabric shall lap at least 75 mm at all joints. A 1.2 mm thick coat, when dry, of mastic shall then be applied over the entire surface.

6.5.5.3.2 To insure seal at the junction of the insulation and the equator support, the insulation shall be cut in such a manner as to provide a flush surface over the ring, and a close fitting around the ring.

6.5.5.3.3 Whenever needed, over the vapor barrier/weather-coat mastic a galvanized iron jacket, may be fitted.



COLD SPHERE INSULATION DETAILS
Fig. 46

7. PREFABRICATED UNDERGROUND PIPE SYSTEMS

7.1 The prefabricated underground systems have all the insulation requirements as does insulation above grade. The systems shall fulfill the thermal, physical and economic requirements of the other insulation systems. Likewise, these requirements make it necessary to have a number of different types of underground systems.

7.2 These systems shall have water-tight joint closure of the insulation and jacket in the field with special jacket fitting and sealing technique. Other form of water-tight jacketing is application of reinforced mastic jackets which are installed after the insulation is installed.

7.3 Suitable expansion-contraction joints or loops for process pipe and jacket shall be provided.

7.4 In Fig. 74a an underground system using prefabricated cellular glass insulation is illustrated.

7.4.1 In this system the pipe insulation, fitting insulation and expansion loop (or joints) shall be installed after, the pipe is in position in the trench.

7.4.2 The pipe shall be held up by temporary supports which are removed as the insulation is installed.

7.4.3 The inners surface of the insulation shall be protected from abrasion by anti-abrasion coating or glass matt to prevent any movement of pipe in relation to insulation from wearing away the insulation.

7.4.4 Special loop insulation, to take care of change in configuration of pipe shall be provided.

7.4.5 The insulation surface shall be protected with a sealed laminate of glass fabric, aluminum bonded with bituminous, high molecular-weight polymers.

7.4.6 Care shall be taken that this protective jacket is water-tight before earth is back filled over the insulated pipe.

7.5 In Fig. 47b a factory prefabricated insulated pipe system where the insulation fills all the void between the pipe and outer jacket or conduit is shown.

7.5.1 In most instances, the insulation used in these systems is cellular organic foams or glass.

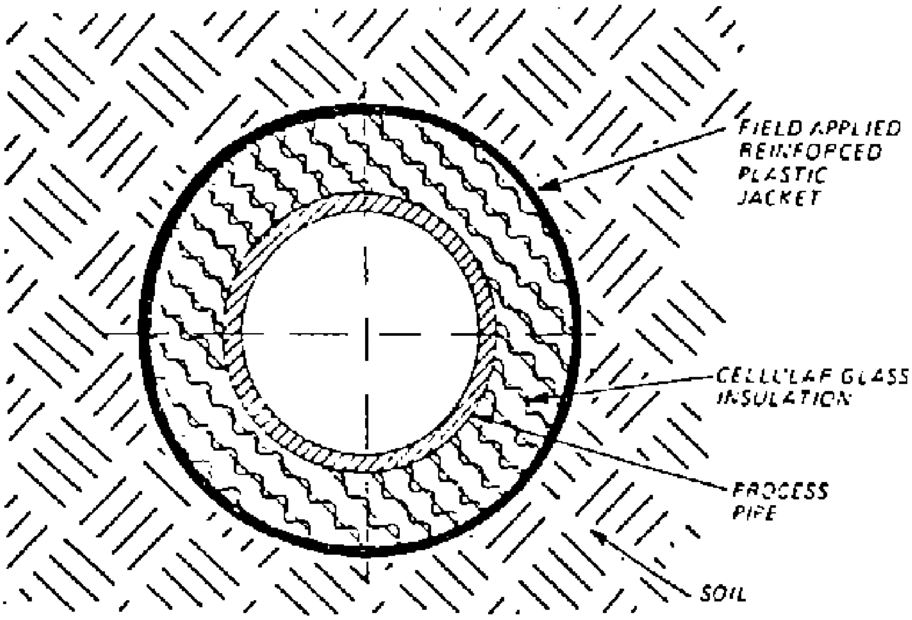
7.5.2 Fittings and connections are preformed for the particular systems and must be designed to fulfill the piping requirements.

7.6 Fig. 48a shows a conduit and the insulation is installed to provide an air space between it and the conduit.

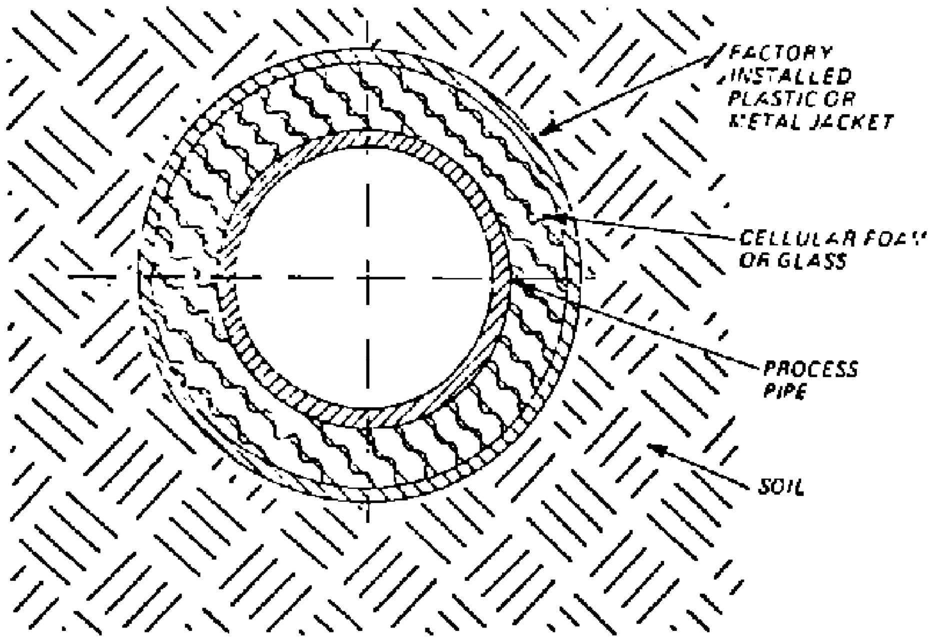
7.6.1 the insulation may be cellular glass, glass fiber, mineral fiber, calcium silicate, or equal.

7.7 Fig. 48b shows a pipe in a conduit system where heat is supplied by an external electric or fluid tracer.

7.8 For detailed information on design and application of thermally insulated underground piping system reference is made to BS 4508 Part 1 through 4 and BS CP 3009.

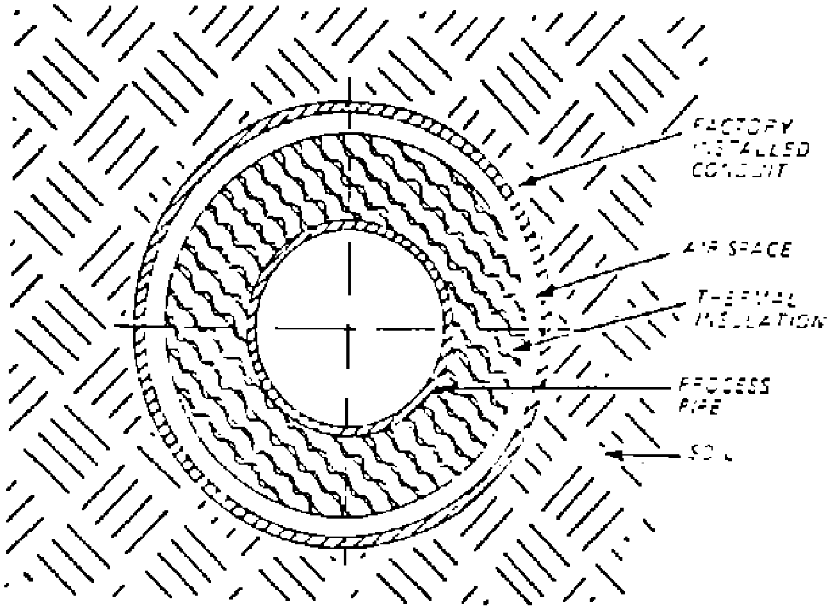


(a)

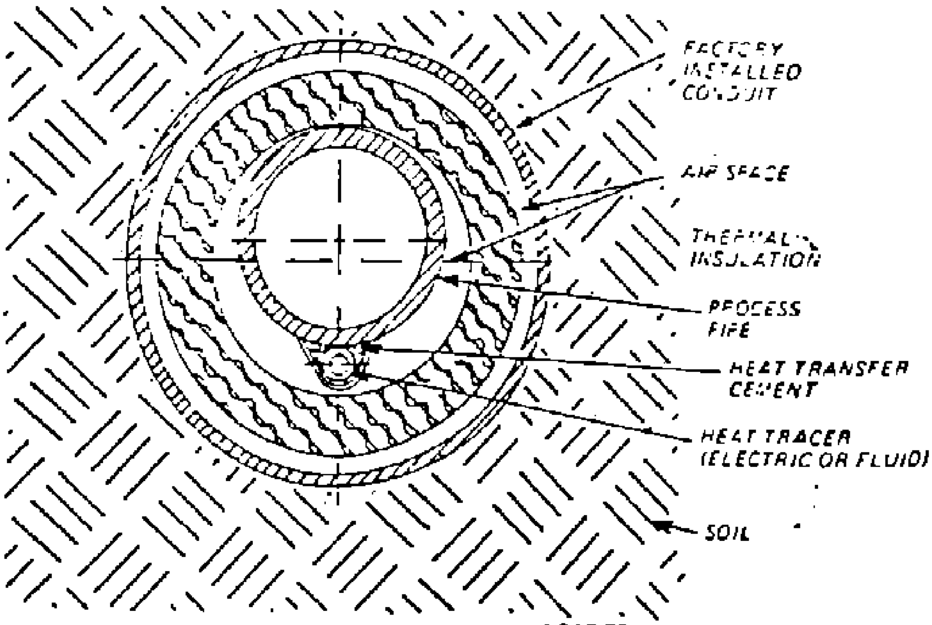


(b)

UNDERGROUND INSULATED PIPE
Fig. 47



(a)



(b)

UNDERGROUND INSULATED PIPE
Fig. 48

8. INSPECTION AND MAINTENANCE OF EXISTING INSULATION SYSTEMS

The consequences of failing insulation systems are very often detected only in an advanced state and are reflected in high repair and maintenance costs. The routine maintenance practice shall be extended with a system of scheduled inspections, preventive maintenance and a long-term maintenance program.

8.1 Inspection

8.1.1 Purpose of inspection

To detect shortcomings at the earliest possible time in order to prevent uncontrolled deterioration of the insulation system and consequential underlagging corrosion.

8.1.2 Items to be inspected

Of prime importance are the integrity of the jacketing system and the thickness of the insulating material. The inspection shall be aimed at detecting shortcomings/defects of these items. At locations with sagged insulation (e.g. pipelines or horizontal vessels) or at transition from vertical to horizontal pipes corrosion may be expected. The condition of hot-water/steam lines is crucial as minor leaks in these lines will promote underlagging corrosion in the main product lines.

8.1.3 Inspection techniques

Visual inspection is still the most widely used method of inspection for insulation systems and on surfaces of pipelines or equipment for corrosion checks. However, the frequent removal of insulation for visual inspection of underlagging corrosion is impractical. Inspection methods using conventional gamma radiography. Flash radiography (X-ray) or infrared scanning are used in these inspections. Flash radiography has been proved to be a quick and effective method of assessing the external condition of piping under insulation.

8.1.4 Inspection frequency

The optimal frequency of inspections depends on a number of factors such as plant size, previous maintenance programs and the type of insulation. For hot insulation, inspection shall be carried out once a year.

8.1.5 Inspection program

The plant shall be divided into a number of areas or zones. In each area an inspection route must be determined such that all major equipment and pipelines can be inspected. All the items to be inspected shall be listed on an inspection list. During the inspection all items shall be checked off. Damage and failures shall be reported.

In this way, no equipment or pipelines will be overlooked and the condition of the insulation at that moment will be recorded. Based on such records a plan of action and a budget can be made for preventive and programmed maintenance.

8.1.6 Inspection survey

Causes of shortcomings or damage of insulation system should be investigated and rectified. The renewing of damaged insulations without determining the actual cause is a wrong approach towards preventive maintenance.

8.2 Maintenance

8.2.1 Preventive maintenance

After an inspection survey has been completed the reported damage and remarks shall be translated into a plan of action for remedial and preventive maintenance. The recommendations for preventive maintenance refer to situations or structures which need to be modified to prevent future or repeated damage to insulations or the underlying surfaces.

Technical shortcomings in design shall be rectified, for example:

- Repositioning of supports and brackets to eliminate water ingress.
- The installation of rainwater shields.

Damages caused by personnel or equipment can be prevented by:

- installation of a walkway over insulated pipes in a pipetrack;
- rerouting of foot traffic by putting up handrailings;
- avoidance of fire drills on or near insulated tanks or equipment;
- instruction and monitoring of third parties, such as painters, cleaners and scaffolders.

Damaged or saturated insulation shall be discarded and the insulated metal surfaces cleaned, preferably gritblasted, and painted before installing the new insulating material.

A program of preventive maintenance will eliminate more expensive repairs later on.

8.2.2 Programmed maintenance

Based on the results of inspection surveys, the scope of long-term insulation maintenance can be determined and priorities can be set.

8.2.2.1 In order to systematically control the upgrading of existing insulations in a plant, it is recommended to divide the various units into manageable areas, indicated on a plot plan, and to carry out the work area by area. Simultaneously, maintenance painting in the same area shall be scheduled. Progress of work can then be properly recorded an costs for scaffolding will decrease substantially as compared to when pipelines are followed or when work is carried out randomly throughout the plant.