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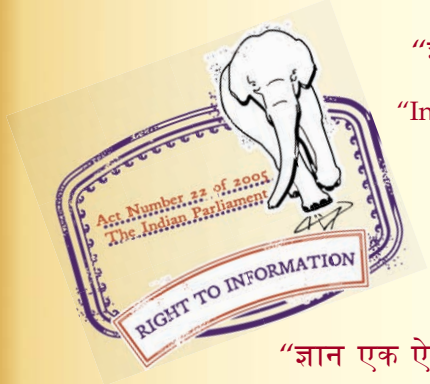
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IS 14164 (2008): Industrial application and finishing of thermal insulation materials at temperature above -80 deg C and up to 750 deg C - Code of practice [CHD 27: Thermal Insulation]

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भारतीय मानक

–80°सें. से अधिक और 750°सें. तक तापमानों के लिए तापरोधन सामग्रियों के औद्योगिक अनुप्रयोग और फिनिशिंग — रीति संहिता

(पहला पुनरीक्षण)

Indian Standard

INDUSTRIAL APPLICATION AND FINISHINGS OF THERMAL INSULATION MATERIALS AT TEMPERATURES ABOVE –80°C AND UP TO 750°C — CODE OF PRACTICE

(First Revision)

ICS 27.220

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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Price Group 12

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Thermal Insulation Sectional Committee had been approved by the Chemical Division Council.

This standard was first published in 1994 superseding both IS 7240 : 1981 and IS 7413 : 1981 which were in force earlier hoping that the amalgamated standard would facilitate unambiguous exchange of commercial and scientific information within the Industry. While formulating this standard considerable assistance was taken from VDI 2055 : 1982 'Heating and cooling protection/shielding for factories', published by Verein Deutscher Ingenieure', ISO/DIS 12241 : 1993 'Calculations rules for thermal insulation of pipes, ducts and equipments' published by International Organization for Standardization, and BS 5422 : 1990 'Method for specifying thermal insulating materials on pipes duct work and equipments (in the temperature range –40° to 750°C)'. This standard covers the insulation of plant and equipment containing fluids at temperatures above –80°C and up to 750°C.

This standard does not deal with the insulation of buildings, land or marine cold stores or other cold storages. This standard also does not deal with the insulation of metal surfaces, which are protected on their inner surface, with refractory brickwork or other refractory linings, the temperatures of which change, with the application of external insulation. Thus, this standard covers external insulation of surfaces such as vessels or piping carrying hot or cold fluids including gases, at temperatures within the range indicated.

This standard also does not include calculations for thickness of insulation application as the determination of the required thickness of insulation is likely to be governed by many considerations and factors other than economics alone. Further, other similar theoretical calculations, such as interface temperatures in multi-layer insulations, specified temperature on the surface of the insulation, determination of temperature at the point of delivery, thickness required to prevent condensation on the surface of the insulation, etc have also not been included in this standard.

Accordingly the symbol used in thermal insulation, determination of heat gain/heat loss, surface temperature and insulation coefficient for different surfaces for working out appropriate surface temperature and insulation thickness for specific surface temperatures, additional heat losses due to components in a pipeline, etc and conversion factors have been included in this standard in Annexes A, B and C.

The Committee felt a need for its revision based on the experience gained and feedbacks received from the various segments of the thermal insulation trade and industry and also to harmonize with BS 5970 : 2001 'Code of practice for thermal insulation of pipe work and equipment in the temperature range of 100°C to 870°C'. There is no ISO Standard on this subject. During this revision assistance has also been derived from ASTM C 680 and also from Thermal Insulation Handbook by William C. Turner and John F. Malloy (1981).

In this revision calculation for heat loss/gain through the insulation, attachments, thickness of metal cladding have been incorporated. Typical exemplification figures both for equipment and piping are also incorporated for better understanding. Major modifications have been done in the application and measurement clauses. This standard takes care of the health hazard of the asbestos fibre and hence incorporates the requirement of asbestos-free insulation materials.

The composition of the Committee responsible for the formulation of this standard is given at Annex D.

In reporting the results of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'.

AMENDMENT NO. 1 DECEMBER 2011
TO
IS 14164 : 2008 INDUSTRIAL APPLICATION AND FINISHINGS OF THERMAL INSULATION MATERIALS AT TEMPERATURES ABOVE – 80°C AND UP TO 750°C — CODE OF PRACTICE

(First Revision)

(*Page* 26, *Table* 2, *col* 9, *line* 3) — Insert '1.32' *for* '1.12'.

(CHD 27)

Reprography Unit, BIS, New Delhi, India

Indian Standard

INDUSTRIAL APPLICATION AND FINISHINGS OF THERMAL INSULATION MATERIALS AT TEMPERATURES ABOVE –80°C AND UP TO 750°C — CODE OF PRACTICE

(First Revision)

1 SCOPE

1.1 This Code of practice prescribes for application and finishing of thermal insulation materials applied to surfaces at temperatures above –80°C and up to 750°C.

1.2 In cases where metal surfaces are protected on their inner faces with structural boundary materials, such as refractory brickwork or other linings, the temperatures of which change as result of the application of external thermal insulation, consequently change in metal temperature shall be checked against safe design temperature limits.

2 REFERENCES

The following standards contain provisions which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
702 : 1988	Industrial bitumen (*second revision*)
1322 : 1993	Bitumen felts for water-proofing and damp-proofing (*fourth revision*)
3069 : 1994	Glossary of terms, symbol and units relating to thermal insulation materials
9743 : 1990	Thermal insulation finishing cements (*first revision*)

3 TERMINOLOGY

For the purpose of this standard, the definitions given in IS 3069 and the following shall apply. Additional symbols used in this standard are described in Annex A.

3.1 Applicator — An individual or organization undertaking thermal insulation of the installations.

3.2 Operating Temperature — The temperature of the hot or cold fluid inside the pipe or vessel under consideration.

3.3 Effective Ambient Temperature — For structures surrounded by air (or other fluid), the effective ambient temperature is a suitably weighted mean between air (fluid) temperature and the mean radiant temperature of the surroundings (°K/°C). For a fluid opaque to radiation, the effective ambient temperature is the same as the surrounding fluid temperature. For operational feasibility of field assessments of the exposed surface temperature of insulated system, the effective ambient temperature shall be considered as the temperature measured by a sensor located normally at a distance of 1 m from the surface at which the temperature is measured. This is not to be mistaken for the atmospheric temperature.

3.4 Economic Thickness — The thickness of insulation, which gives a minimum total cost over a chosen evaluation period.

3.5 Preformed Insulating Material — Thermal insulating material which is fabricated in such a manner that at least one surface conforms to the shape of the surface to be covered and which will maintain its shape without cracking, breaking, crushing or permanent deformation during handling and application.

3.6 Flexible Insulating Material — Thermal insulating material in loose dry or formed matts/slabs/batts/mattresses, which tends to drape or conform to the shape of the surface on which it is applied.

3.7 Plastic Composition Insulating Materials — Thermal insulating materials in loose dry form, which are prepared for application as a paste or dough by mixing with water, usually on site. The normal variety sets under the influence of heat applied to the internal surface.

3.8 Microporous Insulation — A family of inorganic products of very low thermal conductivity featuring silica fibrous matrix with opacifying powders distributed throughout the silica structure to reflect, refract or absorb infrared radiation resulting in a flat conductivity *versus* Temperature profile.

3.9 Reflective Insulation — An insulation system composed of closely spaced sheets/foils of high reflectivity (low emittance) obtaining its insulating value from the ability of the surfaces to reflect a large part of radiant energy incident on them. This arrangement may or may not be evacuated.

3.10 Thickness — The thickness of the insulation material only that is, excluding any protective or other finish.

3.11 Hot Surfaces for Insulation — For the purpose of this standard, surfaces to be insulated having a temperature over 40°C and where heat flux is expected to be away from the surfaces are classified as hot surfaces.

3.12 Cold Surfaces for Insulation — For the purpose of this standard, surfaces having a temperature of 40°C and below and where the heat flux is expected to be towards the surfaces to be insulated are classified as cold surfaces.

4 MATERIALS

4.1 The materials used for insulation and its application shall conform to the relevant Indian Standards, wherever they exist.

4.2 Asbestos — Free Thermal Insulating Material

All thermal insulation materials used at site shall be asbestos-free in order to safeguard the health of individuals who are working in the vicinity.

4.3 Types of Insulating Materials

Although all thermal insulating materials, with the exception of reflective insulation, depend on entrapped air or gas for their effectiveness, it is convenient to classify them according to their type of structure or method of application:

a) *Preformed* — Normally the term is applied to slabs, pipe sections and related shapes based on cellular granules or mineral fibres that are bonded to form a substantially rigid cellular plastic, cellular glass and bonded natural materials, for example, cork and exfoliated minerals.

b) *Flexible* — This type includes fibrous products such as felts, blankets, mats and mattresses, which differ from the preformed materials only in the ease with which they can be shaped to conform to irregular surfaces. Textile products, for example, woven cloth, tapes, twisted yarns, and plaited packings are also of this type. This also includes flexible closed cell foams of plastic and specialized rubber formulations.

c) *Loose Fill* — Included in this type are all granular, fibrous and various discrete aggregates that can be poured or lightly packed into cavities, casings or jackets. Loose or lightly bonded fibrous materials, shredded plastics polymers and loose expanded volcanic or micaceous products, for example, perlite or vermiculite, as well as such insulating aggregates as foamed slag and granulated diatomaceous brick would also fall under this heading.

d) *Plastic Composition*—Material of this type consists of insulating aggregate, with or without fibrous reinforcement that is prepared for application as a paste or dough by mixing with water. Normally the wet materials require the use of heat for drying out after application, but some products harden by hydraulic setting, it is important to distinguish between plastic compositions and organic plastics, the latter are spelt with water a letter 's' at the end of the word 'plastic'.

e) *Spray* — Granular, foamed or fibrous material that adheres to the surface on application by means of a spray-gun. An adhesive may be included in the original mix or it may be applied through a separate nozzle during the application process.

f) *Foamed-in-situ* — Normally cellular organic plastics agglomerates that are foamed in a cavity by physical or chemical means during or immediately after application.

g) *Microporous Insulation (Silica Aerogel)* — Opacified fine powder having microscopic pores that confer particularly low thermal conductivity properties, lower than those of still air at the same temperatures. It is available as block encapsulated in metal foil or woven fabric.

h) *Reflective Insulation* — Multiple layer of foil or thin sheet material of low emissivity that has the ability to reflect incident radiant heat separated by fleece or tissue. Metal foils such as aluminium foil and thin polished stainless steel sheet with mineral fiber tissue are common examples, but reflective metal deposited on plastics film will also be included but for lower temperatures only. These materials are normally used in association with one or more air spaces, which may be closed or open and which may or may not be evacuated.

j) *Insulating Boards* — Rigid or mainly rigid boards, often with fibrous reinforcement, bonded into a compact mass and baked. The

bonding material may be a hydraulic cement, a lime-silica reaction product, gypsum, or an organic plastic polymer.

k) *Prefabricated Shapes* — For specialized types of application it may be advantageous to fabricate the insulation to predetermined shapes for ease of application and removal. Various types of insulating material can be used for this purpose, as also can various types of covering material. Typical products would be prefabricated valve covers, insulated metal valve boxes, prefabricated flexible mattresses and thin layers of fibrous or granular filling sealed inside prefabricated metal-foil envelopes.

4.4 The applicator shall ensure that the thermal insulating and finishing materials used are suitable for service at the operating temperatures and under the physical conditions stated by the purchaser, in case the material is supplied by the applicator. In case the purchaser or any other agency appointed by the purchaser specifies or supplies the material, the responsibility for the performance of such materials shall rest with the purchaser or the supplier, as the case may be, and the applicator of such materials shall rest with the purchaser or the supplier, as the case may be, and the applicator shall be responsible only for the workmanship. If the material supplied conforms to the relevant Indian Standard, the applicator's responsibility shall then be confined to the methods of application as stated in this Code, unless otherwise specifically agreed to between the purchaser and the applicator.

4.5 In the case of plants operating at dual temperatures, that is, below and above ambient temperature, such as cold insulated systems which are periodically steam cleaned, the insulation material used shall be capable of withstanding the highest and lowest temperature involved during services without physical deformation or deterioration. In all such cases extreme care is required in selection of insulants, vapour barriers and their positioning in the system and proper study of the interface temperature between layers.

5 METHODS OF APPLICATION

5.1 General

5.1.1 All insulation materials, fixed in any manner should be applied so as to be in close contact with the surface to which they are applied and the edges or ends of suctions shall butt up close to one another over their whole surface except in special application. For this reason edges or ends shall, where necessary, be cut or shaped at site.

5.1.2 While applying flexible materials care shall be taken to ensure that the material is applied at the required density.

5.1.3 While applying multi-layer insulation all joints shall be staggered; and each layer shall be separately secured to the surface.

5.1.4 As a rule fittings on vessels shall be covered with an independent insulation so as to allow easy access and removal without disturbing the main insulation.

5.2 Insulation on Ambient and Hot Surfaces

5.2.1 *Guidelines for Normal Ambient and Elevated Temperatures*

As there is possibility of differential movement of jointly insulated pipe lines due to differences in the temperature of the fluids carried by the pipe lines, each pipe line is to be insulated separately, wherever space is available.

5.2.1.1 When the surface to be insulated is of regular shape it is likely that preformed materials will be the most suitable; their physical properties, shapes and dimensions can be controlled during works manufacture. Also, they are easy to apply and they are likely to retain their physical characteristics under service conditions. Care should be taken to ensure that the material stays satisfactorily in service, and this will include the need to preserve physical and mechanical integrity as well in order to maintain thermal effectiveness.

5.2.1.2 Certain types of plant with double-skin construction, that is reaction or storage vessels, may require the annular space to be packed with a loose mass of fibre or a porous granular aggregate. In such cases, it is necessary to achieve reasonably uniform packing at an optimum bulk density, for example, by the provision of internal spacer supports to prevent settlement under service conditions.

For some specific applications, notably the horizontal or near-horizontal tops of large outdoor ducts and flues with multiple external stiffeners, it may be convenient to build up an appreciable depth of granular aggregate to form a camber, either from the longitudinal center line outwards or across the full width of the surface, before applying preformed slab insulation, which may be finished with a layer of self-setting cement. A final coat of weatherproofing compound may be added, as required.

5.2.1.3 For irregular shapes of plant it may be convenient to make use of plastic composition insulating materials but in these cases, it will be necessary to preheat the plant and to maintain the heat until all the insulation is dry. Wet plastic composition has to be applied in successive layers, allowing each

one to dry before the next is applied. Plastic composition mixes are likely to contain soluble chloride salts, either as normal impurities or in the water used for forming the paste, which may cause or accelerate stress-corrosion attack on austenitic steel surfaces. Additionally, only potable water should be used for mixing in order to ensure freedom from attack on carbon steel surfaces by soluble nitrates.

5.2.1.4 Notably low thermal-conductivity values, together with light weight, are characteristic of many types of foamed-in-situ insulating materials, which normally involve the mixing of two reactive chemicals, for example, for the production of polyurethane. They are of particular value for filling the annular spaces between the containment surfaces of a light weight structure as, in many cases, they can increase the mechanical stability of the structure. It is possible to use a similar process for the production of preformed insulating shapes. Care should be taken to ensure that the foamed material is used only within the correct temperature range and that it does not add to the fire hazard in the insulated plant.

5.2.1.5 Microporous insulation is characterized by its low thermal conductivity, which persists to high temperatures. This characteristic permits the use of lower thickness than those of conventional materials. It is important that microporous insulation should never become wet as this can result in an irreversible breakdown of the microporous structure.

5.2.1.6 Reflective insulation is more effective in reducing the absorption or emission of radiant heat than in a non-metallic surface. It may be used in conjunction with granular, fibrous, or powder-type insulating materials, and insulation purposes. Where the use of non-metallic insulation is not acceptable for technical reasons, for example, in certain types of plant heated by nuclear fuels, multilayer reflective metallic insulation may be particularly suitable.

5.2.1.7 Insulating boards may be substantially of organic composition, for example, made from wood fibre, sugarcane etc, or they may be wholly inorganic, for example, mineral fibres bonded with a cement-type product. Included in this range are gypsum plasterboard and sheet products made from rigid organic polymer foam, both of which may have one or both surfaces covered with aluminium foil to reduce thermal transmission. When a choice is to be made from various types of board for a specific application, attention should be paid to fire hazard, moisture absorption, and the upper limiting temperature, as well as to the thermal conductivity under the required conditions of use.

5.2.1.8 At high temperature (above 500°C) with the combination of back-up material. Ceramic fibre may be used in applications where low thermal mass and high resistance to thermal shock are important.

5.2.1.9 It may be convenient to use two different types of insulating material for a portion of plant if the operating temperature is above the limiting temperature for the preferred main insulating material. In such cases the inner layer, of suitable resistance for the higher temperature is used in sufficient thickness to reduce the temperature at the interface with the main insulating material to an acceptable level.

5.2.2 *Application System for Hot Insulation*

5.2.2.1 *Pipes*

Preformed pipe sections should be fitted closely to the pipe and any unavoidable gaps in circumferential or longitudinal joints should be filled with compatible insulating material where the pipe diameter is too large by building up the radius and bevelled piping. Where there is more than one layer of insulating material, all joints should be staggered.

Each section should be held in position and covered by a fabric, this should be secured by stitching or by the use of an adhesive. The edges of the fabric, if stitched should overlap by at least 25 mm. Alternatively, with a fabric or sheet outer finish, the whole may be secured by circumferential bands.

For vertical and near vertical 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. These supports should be located at intervals of not more than 5.0 m and in any case, there should be a support immediately above each expansion break in the insulation.

5.2.2.2 *Piping bends*

Bends are usually insulated to the same specification as the adjacent straight piping. Where preformed material is used it should be cut in mitred segment fashion and wired or staggered 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 mitred segments.

5.2.2.3 *Flanges, valves and other fittings on hot piping*

It is essential that valves and flanges be insulated along with the piping.

Valve and flange boxes are lined with preformed rigid or flexible insulating material. Direct contact between the metal of the box and the insulated metal surface should be avoided. This can be insulated by mattresses which consist of glass or silica fibre cloth envelope packed with loose fill.

5.2.2.4 *Flexible insulation*

Where flexible insulation (for example, mattresses) are used for insulation of pipes, it is necessary to understand that a flat product is to be wrapped around a curved profile of a pipe where there is considerable difference in the inner and outer perimeters of the applied insulation. It is therefore essential to size the mattress of a specified width with a length equal to the outer perimeter to ensure that the blanket material provides a total thermal envelope. It is also necessary to limit the thickness of individual layers of insulation for a distortion-free condition of the insulant. Further, a flexible matrix may not have the required compressive strength to bear the external load, including the weight of the outer covering. Cladding support rings, fitted with spacers (equal to thickness of insulation) would be required for the purpose.

5.2.2.5 *Plastic composition*

Before application of plastic composition, the pipe surface should be heated to a minimum temperature of 65°C. The composition should be applied by hand in layers, each layer being allowed to dry before successive layers are applied. The first layer should be limited to 12 to 25 mm in thickness. Remaining layers may be built up of 25 mm thickness.

5.2.2.6 *Spray insulation*

Spray applied insulation is generally suitable for irregular surfaces where it is applied on pipes suitable for diameter greater than 150 mm nominal size and good all round access is necessary. Adjacent equipment should be protected from overspray. Mineral fibres and polyurethane foam can be applied by spraying. Workshop spraying should be carried out in suitable booth and the operator should wear protective clothing, including a fresh-air mask.

5.2.2.7 *Loose fill insulation*

Loose-fill will require an outer retaining cover fitted to the pipe with necessary spacers and the filling should be poured or packed to the density as called for to meet required thermal conductivity. In vertical pipes, baffle plates should be fitted as necessary to prevent settling.

5.2.2.8 *Vessels and large surface*

Generally the need to dismantle associate pipe work for inspection should be anticipated and permanent insulation ended sufficiently far from flanges to enable bolts to be withdrawn.

5.2.2.9 *Preformed materials*

It may be necessary to cut preformed materials to fit any irregular contour. Alternatively, suitable material may be applied to render the surface close to a regular shape as a foundation layer. All cut faces should be clean and care should be taken to butt adjacent edges closely.

5.2.2.10 *Flexible material*

Adjacent edges of flexible insulation should be secured in close contact with each other by binding together outer containing medium such as a wire netting. Care should be taken to see that air spaces are kept to a minimum and that there are no free passages from hot surfaces to atmosphere.

5.2.2.11 *Spray insulation*

The material consists of a mixture of milled mineral fibre and hydraulic binders. It is applied by spraying together with jets of deionized water.

5.2.3 Where protrusions are such that they are also insulated (like pipe-connections) but with an insulation thickness less than that of the main system, full thickness of the main system is to be extended along such extensions for a length of not less than thrice the full thickness.

5.3 Insulation Over Cold Surfaces

5.3.1 For an equal temperature difference across the insulation, the thickness of same material required for cold insulation is relatively higher than for hot insulation. Since the vapour seals applied to the insulated cold surfaces are frequently trowelled or sprayed-on, it is essential that the purchaser gives consideration, at the design stage, to the sealing to be used, to ensure that there is sufficient working space between pipes, vessels and structures to allow easy application of all the materials involved.

5.3.2 Special care should be taken over the application and vapour-sealing of cold insulation, since even minute faults can lead to condensation taking place within the insulation or to ice formation on the cold surface.

5.3.3 Even though there is less possibility of movement of pipes having cold surfaces, it is preferable to insulate the pipes separately as far as possible.

5.3.4 Where multilayer insulation is adopted on cold surfaces, in addition to the precautions given in **5.3.1**, the final two layers shall be provided with adequate vapor barrier where the operating temperature is below 0°C.

5.3.5 Stiffener angles, weld protrusions, ladder supports, insulation support rings, pipe hangers or any metal connections not otherwise scheduled to receive insulation shall be insulated, if in direct contact with the cold surface. The insulation over such protrusions shall have an insulation thickness over them of at least

80 percent of the thickness of the adjoining insulation. In all such cases the insulation shall be extended to ensure that the nearest exposed surface has a temperature above 0°C or above dew point as specified by the purchaser.

5.3.6 Wherever there is any discontinuity in vapour barrier in the vicinity of fittings or other protrusions on insulated cold surfaces, adequate vapour barrier shall be provided at such joints also.

5.3.7 *Vapour Sealing for Cold Insulation*

5.3.7.1 A cold insulation system is only as effective as its vapour barrier. A poor vapour barrier causes moisture migration into the body of the insulation causing the following:

a) Deterioration in the insulation value,
b) Physical damage to the insulation, and
c) Corrosion of the insulated surface.

5.3.7.2 *Materials for vapour sealing*

The following materials are suitable for use as vapour seals:

a) *Foils* — Aluminium foil, minimum 0.05 mm thick or foil laminated to kraft paper of 60 g/m^2, *Min*, or other suitable laminates sealed with bituminous or other adhesives.
b) *Bituminous and Resinous Mastics* — Bitumen (conforming to fully blown type of IS 702 and its various compounds and resinous mastics having a water vapour permeance (for two coats) of not more than 2.8×10^{-3} g/s MN.
c) *Plastic Sheets* — Mainly polyester, polyethylene, polyisobutylene and PVC coated fabric suitably sealed. Such sheets normally need further protection.

5.3.8 *Application for Vapour Seals*

5.3.8.1 When a vapour seal material is applied over insulation, it shall be carried down over all exposed edges of the insulation (for example, fittings on pipes or skirts on vessels) and bonded to the surface of the pipe or vessel. At all such points a mastic fillet shall be provided to round off the angle between the insulation and the cold surface.

5.3.8.2 When insulating long runs of pipe, the ends of the insulation shall be sealed off at suitable intervals and the vapour seal shall be carried down to the pipe surface.

5.3.9 In the case of cold insulation, the vapour seal and the protective finish of the main system shall have been completed before the insulation of the fittings is taken up. The main insulation shall stop short of the fittings on both the sides so as to allow for withdrawal of the bolts without disturbing the main insulation. In all cases, the vapour seal on the fittings shall be carried over to at least 50 mm beyond the finished vapour barrier of the main insulation system and sealed properly. The thickness of insulation applied to a fitting shall be atleast equal to the system on which the fitting is located.

5.3.10 Vapour sealing materials shall be carried over expansion joints or contraction breaks without a joint.

5.4 Insulation Supports

5.4.1 The insulation shall be supported when applied to the sides of or underneath large vessels or ducts or to long runs of vertical piping. Supports shall be cleats, studs, washers, nuts, bolts, lugs, pins or collars (rings) which shall be either welded to the hot surface or to bands which are then strapped round the surface. These supports serve to hold the insulation in place, prevent its slipping, or support it above expansion joints. In addition, they shall provide necessary anchorage for lacing wire or wire netting which may be required to hold the insulation in place and/or to provide reinforcement for the insulation or a finishing material. Depending on their function, supports shall either penetrate only partly through the insulation or protrude slightly beyond it. But in no case the supports shall protrude through the final finish.

5.4.2 Carbon steel lugs and attachments shall not be welded directly to alloy steels. Angles, flat cleats and similar large attachments may be secured by electric arc (welding) or gas welding, using a procedure appropriate to the materials, the thickness of the surface, and that of the attachment. For that surface on which site-welding of attachments is not permissible, it may be essential to pre-weld suitable metal pads to fix such attachments.

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 spacing would be as given below:

Vertical surfaces	:	450 mm^2 spacing
Upward-facing surfaces	:	600 mm^2 or 750 mm^2 spacing
Over-hanging and downward-Facing surface	:	300 mm^2 spacing

For large-radius curved surfaces, if welding is permitted, 450 to 600 mm uniform spacing is considered suitable, but this may be modified for vertical large cylindrical surfaces when cleats are required to prevent downward movement of the insulating material. Cleats may not be required for

horizontal cylindrical surface if it is possible to provide circumferential straps that can be tensioned over the insulation.

Welded attachments should preferably penetrate into the insulating material only to the minimum extent necessary. In special circumstances, such penetration should not be > 0.7 times the thickness of the insulating material. The cross-sectional area of the attachments should be the minimum consistent with the required mechanical strength in order to avoid excessive transfer of heat (or cold) by metallic conduction.

It is important to remember that a welded attachment will be subjected to the same extent of thermal movement as the insulation with the resultant possibility of tearing the insulation or finish, unless care is taken to allow for this, for example, by expansion joints or by use of ship lap joints.

5.4.3 Insulation supports will depend on the insulation used, finish, mode of application and shall be adequate to prevent displacement of the insulation and its vapour barrier during operation. In no case shall the lugs or other insulation supports project over the cold surfaces for more than 0.70 times of the total insulation thickness, in order to avoid punctures in the vapour barrier.

5.4.4 Insulation supports are normally provided after the final erection of plant. However, where for any reason whatsoever site welding is not permitted, the question of securing the insulation shall be considered at the design stage, so that provision for this purpose can be made while the equipment is being fabricated or erected.

5.4.5 The purchaser shall indicate in his specification, the type of supports for insulation and cladding, which are to be supplied and fixed, and shall state whether welding will be allowed at site and on the surface to be insulated.

5.5 Surface Preparation

5.5.1 Before application of the insulation, the surface shall be wire-brushed to remove all dirt, rust, scale, oil, etc and dried.

5.5.2 All surfaces shall be coated with a suitable anti-corrosive primer wherever necessary before they are insulated. Any shop-paint film has to be removed locally, down to the bare metal, before attachments are welded to the surface. Ideally, this paint would be applied after all welded attachments have been fixed in position.

5.5.3 All austenitic stainless steel surfaces, proposed to be insulated and subjected to an operating temperature of 250°C and above shall be suitably protected by using inhibited insulating materials.

5.6 Application of Insulation

5.6.1 The method of Installation and securing of the insulating material shall be consistent with the requirements defined in **5.1**, **5.2**, **5.3**, **5.4** and **5.5**. The following methods applicable to flexible insulation, rigid insulation etc, shall be followed. Further specific areas of work, namely, pipes, ducts, vessels etc, shall be insulated as given in **5.6.6**.

Stiffener angles, weld protrusions, ladder supports, insulation supports rings, pipe hangers or any metal connections not otherwise scheduled to receive insulation shall be insulated if there is an indirect contact with the hot surface. Thickness of insulation on such protrusions shall be not less than 50 percent of the thickness (t) of the main system. The minimum extension of the insulation over the protrusions from the main vessel or pipeline shall be equal to 4 t.

5.6.2 *Flexible Insulation*

Flexible materials, namely, mats, batts, or blankets faced on one or both sides with a suitable facing material, shall be applied in any of the following manner:

a) By means of a tie wire (0.9 mm dia G.I.);
b) By means of metal bands (for example 0.56 mm thick, 20 mm wide);
c) By means of wire netting on outer side, suitably laces; or
d) By means of an adhesive between the layer and metal surface further assisted by a tie wire, if necessary. This is specially applicable for cold insulation.

NOTES

1 Unless otherwise specified, the diameter of lacing wire shall be 0.56 mm, *Min* and the wire netting shall be of maximum 20 mm mesh and minimum 0.56 mm diameter.

2 For interface temperature of 400°C and above, stainless steel binding wire/band/wire mesh shall be used.

5.6.3 *Preformed Insulation*

Rigid insulating materials, namely, blocks or boards may be applied in any of the following manner:

a) By means of suitable metal bands (for example 0.56 mm thick, 20 mm wide);
b) By means of wire netting on outer side;
c) With edges lightly coated with an approved joint sealer, and further secured with metal bands (for example 0.56 mm thick, 20 mm wide) or tie wire (0.9 mm dia, G.I.); or
d) By means of suitable adhesives, keeping in view the service temperature, with the joints duly sealed.

NOTES

1 Wherever preformed thermal insulating material is used, care shall be taken so that minimum numbers of segments are chosen.

2 In all cases, care shall be taken to till the joints with the same basic insulating material in the loose form are properly packed into the joints.

3 Effective vapour seal shall also be ensured while applying over cold surfaces.

5.6.4 *Plastic Composition Thermal Insulation*

5.6.4.1 These are supplied in the form of a dry powder, which is mixed with water to form a soft mortar of even consistency suitable for application by hand or with a trowel.

5.6.4.2 Thermal insulating cements require heat for drying to ensure initial adhesion to the surface. All surfaces insulated with thermal insulating cements may, therefore, be kept warm throughout the application of the insulation. The temperature of the surface shall be as specified by the manufacturer of the cement.

5.6.4.3 Initial adhesion between the insulation and the surface is best obtained by rubbing the surface with a handful of wet mortar. When this initial coat is dry, the first layer of insulation not more than 12 mm thick is applied by hand, the fingers being drawn through the material and pressed at the edges to ensure good adhesion. The surface shall be left rough and finger marked to form a good key for the next layer. Successive layers, each not more than 12 mm thick, shall then be applied in the same manner, until the required thickness is built up. Each layer shall be allowed to dry out completely before application of the next layer. The final layer only shall be trowelled to a smooth surface. Excessive troweling shall be avoided.

5.6.4.4 On vessels, pipes and ducts, thermal insulating cements require reinforcement for thickness in excess of 40 mm. In such cases short lugs at suitable intervals shall be attached to the surface (*see* **5.4.1**) to which are secured soft lugs of 2 mm diameter. These lugs wires shall be greater in length than the total thickness of the insulation. The insulation is then applied as prescribed in **5.6.4.3** but leaving the lugs protruding. When half the total thickness has cell applied and has dried out, the insulation shall be wrapped with soft wire netting 25 mm mesh and 0.56 mm diameter. This shall be laced together with soft lacing wire 0.56 mm diameter and fastened down to the lugs. When the final layer of insulation has been applied and trowelled smooth, and has dried out, a second layer of wire netting shall be wrapped around the insulation, laced together, and secured with the tie wires. The ends of the tie wires should then be pushed well into the insulation.

5.6.5 *Loose-Fill Insulation*

This may be adopted by agreement between the purchaser and the applicator. Locations where loose-fill insulation is recommended include the following:

a) Expansion/contraction joints in an application when rigid insulation has been used, or

b) Specific areas of the equipment where conventional methods of application may not be possible and where packing with loose fill is the only possible method of providing insulation.

NOTE — The thermal insulation cement and loose-fill insulation are generally associated with insulation of hot surfaces and are not recommended for insulation of cold surfaces.

5.6.6 Insulation of pipes, ducts, vessels, etc, shall be carried out by any one of the methods already mentioned. However, specific considerations pertaining to insulation of pipes, ducts, vessels etc, are detailed below in **5.6.6.1** to **5.6.6.3** subject to the precautions outlined in **5.1** to **5.5** above. Typical insulation of pipe at elevated temperature, pipe for cold application, pipe with elbow, bunch of tubes, and tank/equipment/vessels are shown as example in Fig. 1 to 7.

5.6.6.1 *Pipes*

On continuous runs of 6 m or more of vertical pipe, support rings shall be provided at not more than 3-m intervals. Such rings shall encircle the pipe and the radial lugs thereon shall have a length equal to 75 percent of the total insulation thickness.

5.6.6.2 *Ducts*

When insulation is applied around the corners of the duct, care shall be taken to counteract the tendency of the material to thin down at these locations.

5.6.6.3 *Vessels*

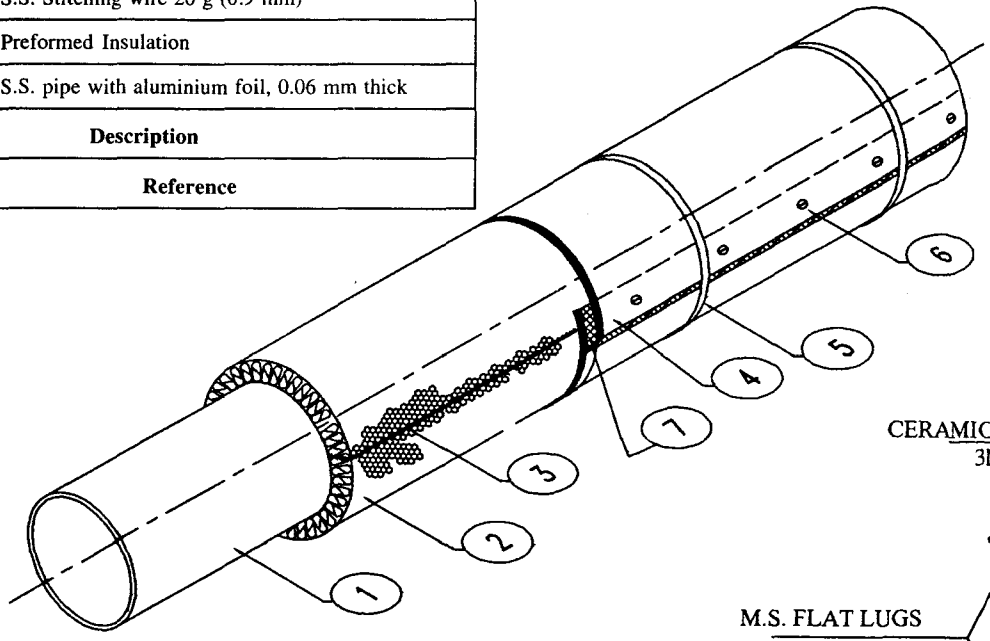
All large vertical vessels of a height of 6 m or more shall be provided with support rings at not more than 3 m intervals. Such rings shall encompass the vessel and the radial lugs thereon shall have a length equal to 75 percent of the total insulation thickness. Extra insulation shall be provided over the support rings (*see* **5.1.4**) This shall extend for 25 mm on each side of the ring and shall be mitred to 45°C for water-shed on the upper side.

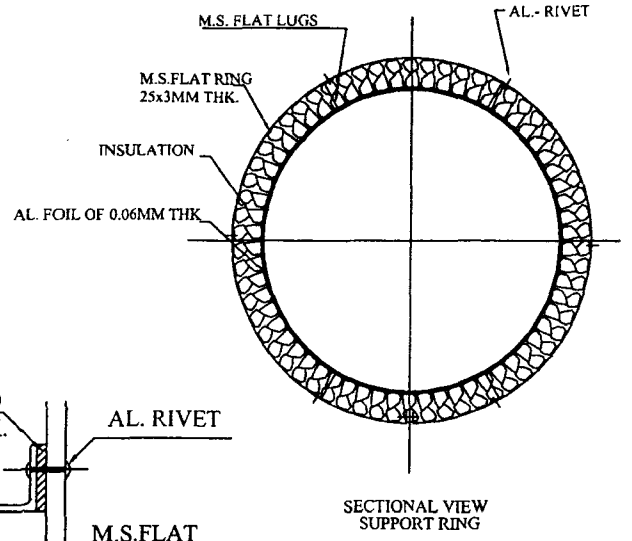
6 FINISHING

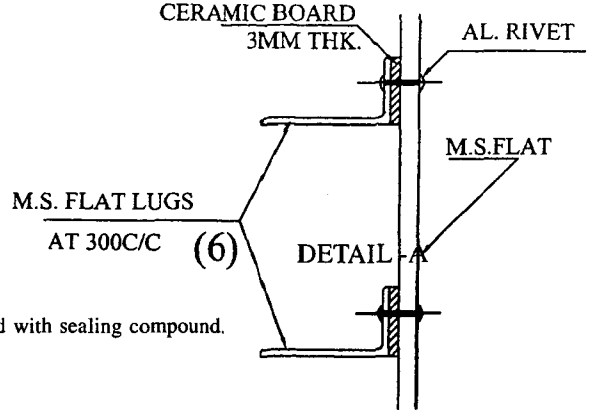
6.1 Protective coverings or finishes are required over the insulation for one or more of the following reasons:

a) Protection against mechanical damage,

Item	Description
7	Sealing Compound
6	13 mm length × 5.5 mm ØS.S. Self-tapping Screw 150 mm c/c longitudinally
5	S.S. band 13 mm wide × 0.4 mm thick
4	Metal Sheet Cladding
3	S.S. Stitching wire 20 g (0.9 mm)
2	Preformed Insulation
1	S.S. pipe with aluminium foil, 0.06 mm thick
Reference	







NOTES

1 M.S. Rings shall be provided wherever required at suitable intervals as per sectional view.

2 Metal cladding have 50 mm overlap longitudinally and cirumferential joints will be sealed with sealing compound.

3 In case of preformed insulation pipe section spacer ring not required.

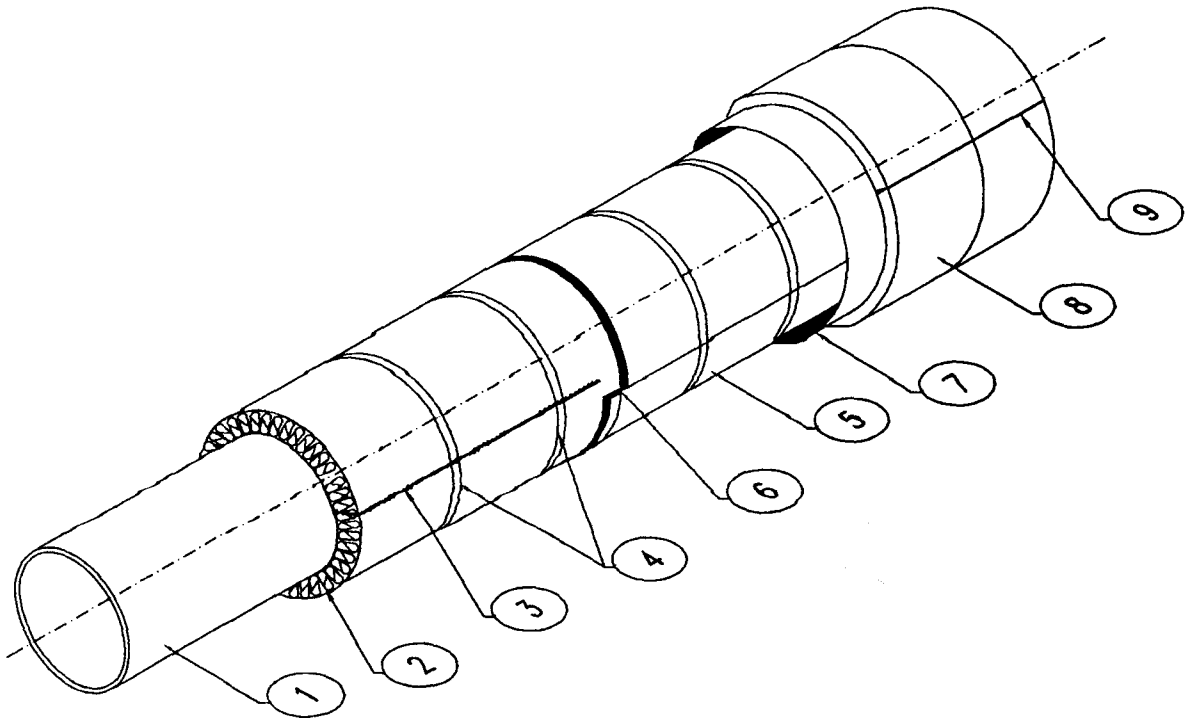
4 S.S. band:

a) Up to Ø609 mm-13 mm wide × 0.4 mm thick.

b) Over Ø609 mm-19 mm wide × 0.5 mm thick.

5 In case of MOC IS S.S. a strip of 30 mm wide and 0.06 mm thick S.S. foil shall be provided whenever spacer ring lugs shall be setting.

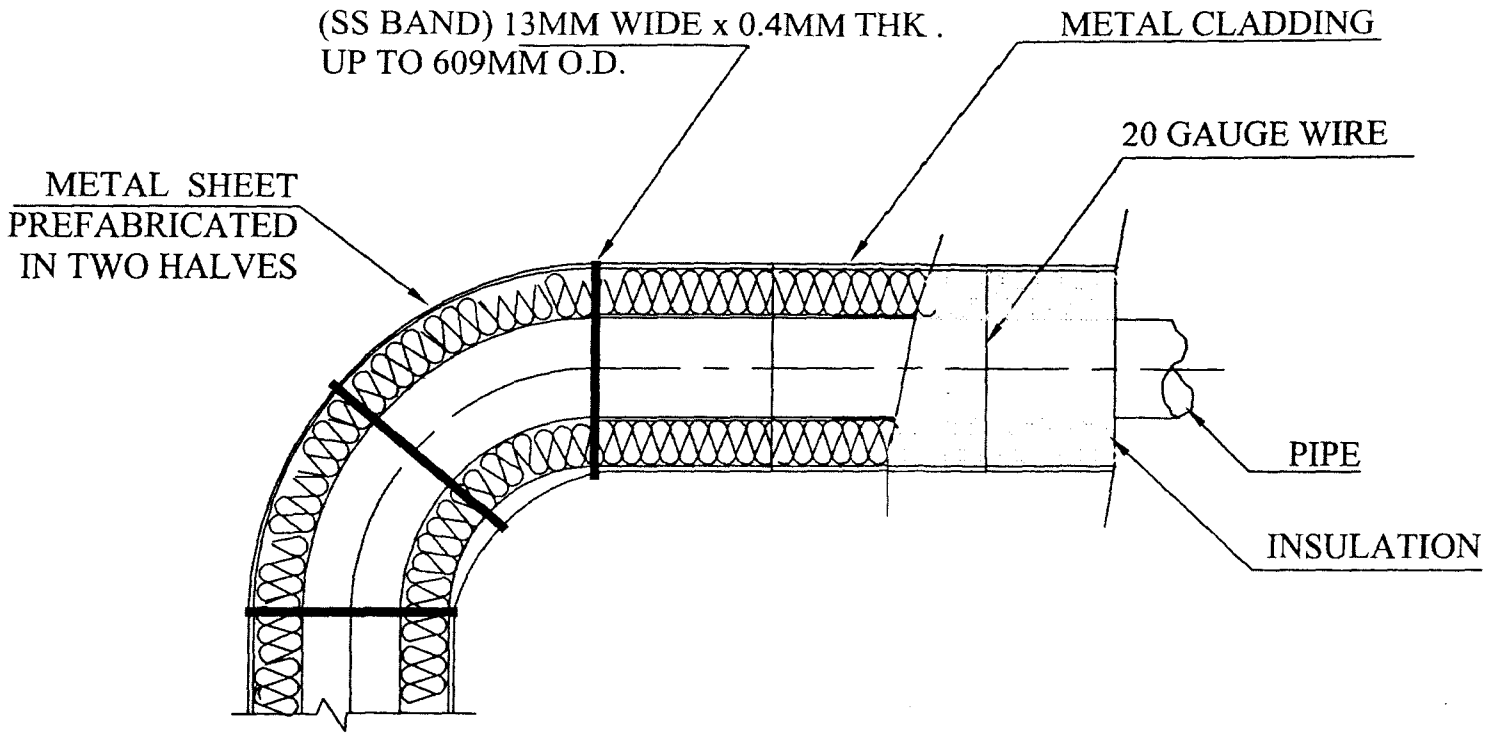
FIG. 1 PIPE INSULATION AT ELEVATED TEMPERATURE



Item	Description
1	Process pipe
2	Performed pipe sections like Polyurethane foam
3	Sealant for insulation
4	S.S. Band of ½" wide and 0.02" thick of S.S.-304
5	Fire retardant Aluminium Foil-Craft paper laminate jacket of 0.1 mm thick foil
6	Adhesive for laps of vapour barrier
7	Vapour barrier with adhesive for laps
8	Metal cladding
9	Sealent for metal cladding

Reference

FIG. 2 PIPE INSULATION FOR COLD APPLICATION



NOTES

1 M.S. Ring shall be provided wherever required at suitable intervals as per sectional view.

2 Metal cladding have 50 mm overlap longitudinally and circumferential joints will be sealed with sealing compound.

3 In case of preformed insulation section spacer ring not required.

4 S.S. Band:

a) Up to ϕ609 mm-13 mm wide × 0.4 mm thick.

b) Over ϕ609 mm-19 mm wide × 0.5 mm thick.

5 In case of MOC IS S.S. a strip of 30 mm wide and 0.06 mm thick S.S. foil shall be provided wherever spacer ring lugs shall be setting.

FIG. 3 INSULATION OF PIPE AND ELBOW

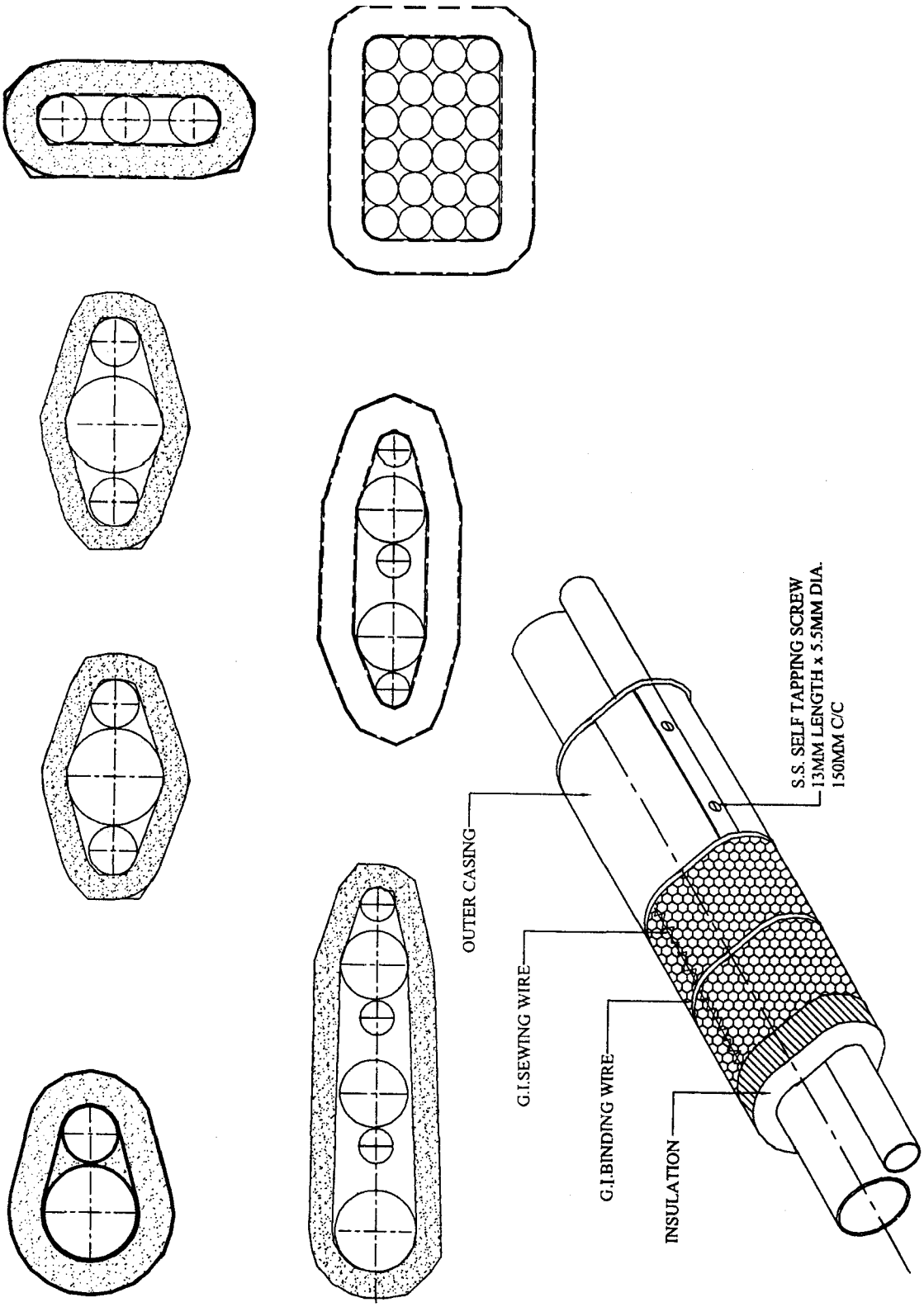
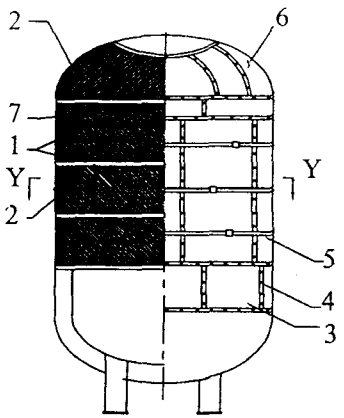
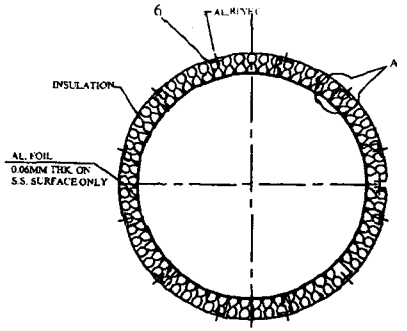
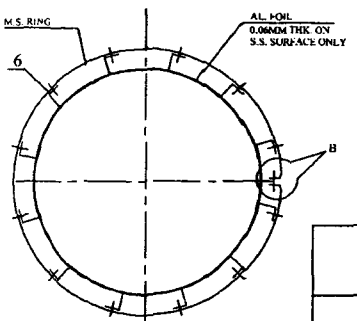


FIG. 4 INSULATION OF BUNCH OF TUBES

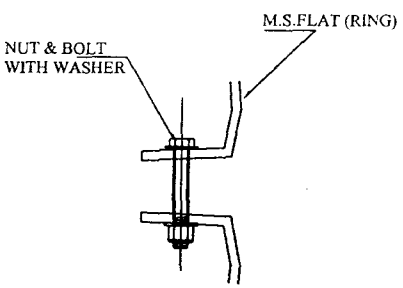




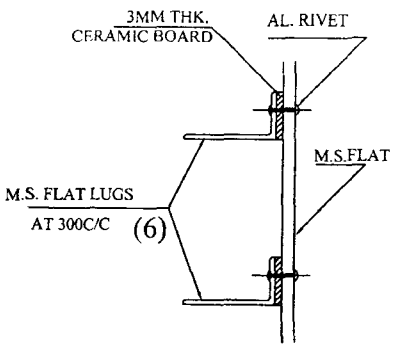
SECTION-XX FOR SUPPORT RINGS



SUPPORT RINGS



DETAIL - B



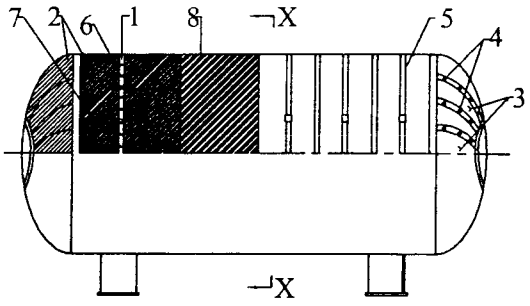
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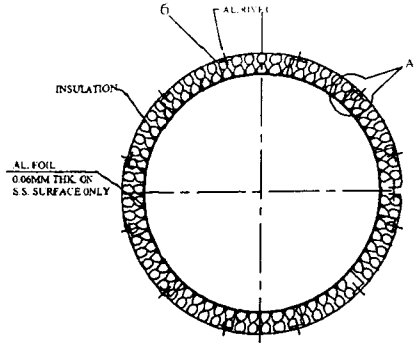
1 M.S. Flats are to be tightened on body with nuts & bolts diagonally at 300 mm C/C.

2 Aluminium cladding have 50 mm overlap longitudinally and circumferential joints will be sealed with sealing compound.

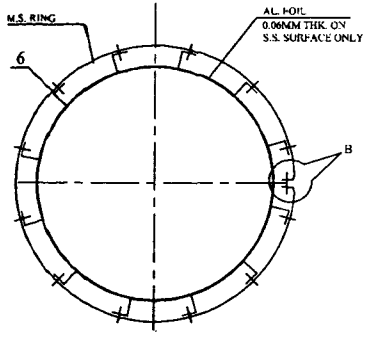
Item	Description
	Reference
1	25 mm × 3 mm M.S. Flat at 850 mm Interval
2	Insulation
3	Metal sheet for cladding
4	S.S., S.T. Screws 13 mm length × 5.5 mm dia 150 mm
	Over 609 mm O.D. -19 mm wide × 0.5 mm or (0.4 mm) thick
5	S.S. band
6	M.S. Flat Lugs
7	S.S. Stitching wire 20 g (0.9 mm Ø) up to 10" O.D.

FIG. 5 TYPCIAL TANK/EQUIPMENT/VESSELS INSULATIONS APPLICATION WITH ROCKWOOL INSULATORY

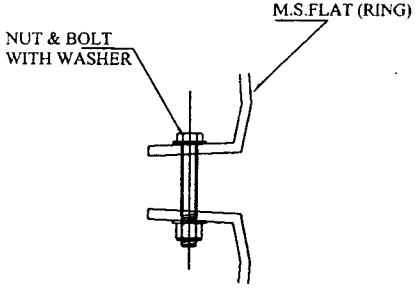




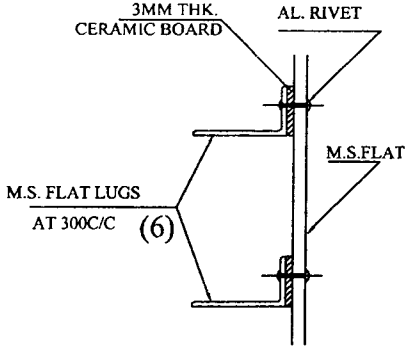
SECTION-XX FOR SUPPORT RINGS



SUPPORT RINGS



DETAIL - B



DETAIL - A

NOTES

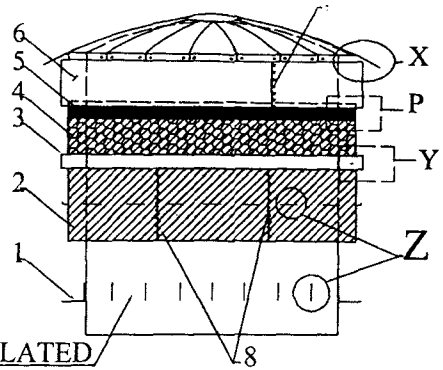
1 M.S. Flats are to be tightened on body with nuts & bolts diagonally at 300 mm C/C.

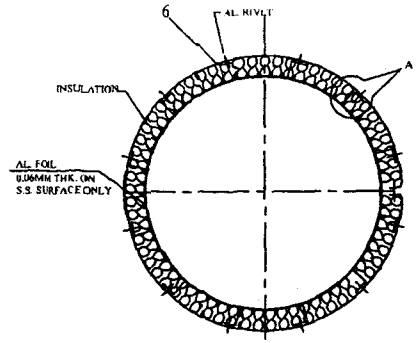
2 Aluminium claddings have 50 mm overlap longitudinally and circumferential joints will be sealed with sealing compound.

Item	Description
7	S.S. Stitching wire 20 g (0.9 mm Ø) up to 10" O.D.
6	M.S. Flat Lugs
5	S.S. band
	Over 609 mm O.D. -19 mm wide × 0.5 mm or (0.4 mm) thick
4	S.S., S.T. Screws 13 mm length × 5.5 mm dia 150 mm
3	Metal sheet for cladding
2	Insulation
1	25 mm × 3 mm M.S. Flat at 850 mm Interval

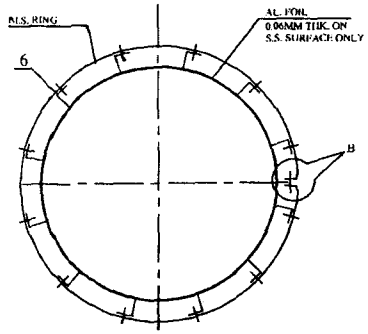
Reference

FIG. 6 TYPICAL TANK/EQUIPMENT/VESSELS INSULATIONS APPLICATION WITH ROCKWOOL INSULATION

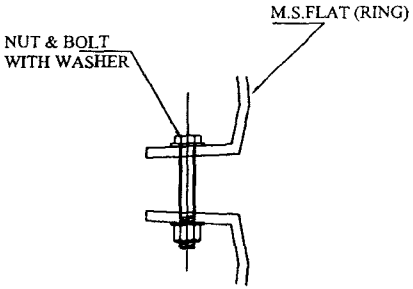




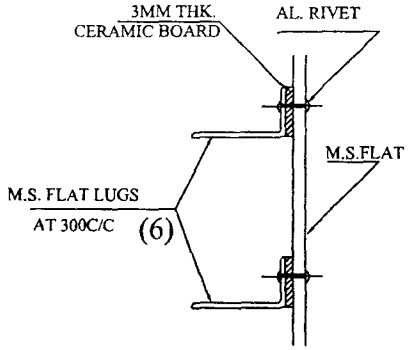
SECTION-XX FOR SUPPORT RINGS



SUPPORT RINGS



DETAIL - B



DETAIL - A

NOTE — All claddings with one side bitumastic paint will have 50 mm overlap longitudinally and circumferential joints will be sealed with roofing felt strips.

Item	Description
	Reference
8	G.I. Stitching wire 20 g
7	Self-tapping screw
6	Metal Sheet 18 g (Corrugated)
5	12 mm thick plaster
4	Wire netting 20 g
3	Space ring at 1 000 mm distance
2	Insulation
1	M.S. Spokes at 500 mm c/c Diagonally

FIG. 7 TYPICAL TANK/EQUIPMENT INSULATIONS

b) Protection against weather or chemical attack,
c) Retardation of flame spread,
d) Appearance,
e) Identification of pipe or vessel, and
f) Providing the insulation with an easily cleaned surface.

6.2 Protective Finishes

The choice of the protective covering for thermal insulating materials can influence the choice of the insulating material itself. It is convenient to classify finishing materials under four broad types.

6.2.1 *Metal Sheet Materials*

Sheet materials of the types indicated in Table 1 are mainly recommended for plant, equipment and pipework. Metal sheet are widely used over both preformed and flexible insulating materials characterized by their resistance to mechanical damage and for their attractive appearance when correctly applied.

External and internal corrosion is often a problem and for this reason aluminium and galvanized steel are preferred for majority of applications, provided that isolation from dissimilar metals is ensured.

Profiled metal sheets give increased rigidity, while permitting lateral expansion movement. If there is a danger of condensation on the inner surface of the metal that is in direct contact with the insulating material, it is advisable to protect the contact surface with a suitable paint or a lamination of poly-coated paper/polymeric plastics compound before site application.

6.2.2 *Dry Mixtures*

Dry mixtures brought to paste consistency with water, for example, hard setting composition/Self-setting finishing cements are used mainly over preformed insulation on pipework and plant that can be heated for drying out. For spray-applied insulation, for example, over turbines in power stations, the finish invariably is self-setting cement; hard setting composition is used largely for the heating and ventilating applications. In all cases, some form of metal mesh reinforcement should be used and the final dry thickness should be sufficient to resist accidental mechanical damage. Sometimes it is possible to toughen the surface of a relatively friable hard-setting composition by embedding open-mesh woven textile fabric into the exposed surface.

All the typical finishes of this group will absorb water, but may not disintegrate when wet.

6.2.3 *Solutions or Dispersion Coatings of Bituminous or Polymeric Plastics Origin*

Solutions or dispersion coatings of bituminous or polymeric plastics origin, which may vary in consistency from a heavily filled viscous mastic applied by trowel, to a mobile liquid applied by brush or spray gun. The products may be used for mechanical protection or for weatherproofing, or they may be self-coloured for colour-coding purposes over the finishes indicated in **6.2.2** above.

Aqueous dispersions, on drying, tend to give films that are porous to water vapour (the so-called breather coats) whereas solutions in organic solvents tend to give dry films of low porosity. Application normally is by brush or spray gun.

Thickness may vary according to the degree of protection required, but the final dry films for most normal coatings are likely to be about 1 mm or less. Mastics, which are heavy dough-like products of

Table 1 Thickness of Metal Cladding
(*Clause* 6.2.1)

Sl No.	Type of Area	Protected Mild Steel		Aluminium	
		Flat mm	Ribbed mm	Flat mm	Ribbed mm
(1)	(2)	(3)	(4)	(5)	(6)
i)	Large Flat Area over flexible insulation	1.2	1.0	1.2	0.9 to 0.7
ii)	Smaller flat areas over flexible insulation or large areas over preformed slabs (including large curved surfaces)	1.0	0.8	1.2	0.9 to 0.7
iii)	Removable insulated manhole and door covers	1.6	—	1.6	—
iv)	Flange boxes and valve covers	As metal on adjacent pipes	—	—	—
v)	Pipes for more than 450 mm outside diameter over insulation	1.0	—	1.2	—
vi)	Pipes of more than 450 mm outside diameter over insulation	0.8	—	0.9	—
vii)	Pipes of less than 150 mm outside diameter over insulation	0.6	—	0.7	—
viii)	Recommended thickness for kicking plates	—	—	—	—
ix)	For flat surfaces, large curved areas and pipes of 450 mm or more outside diameter over insulation	1.6	—	1.6	—
x)	For pipes of less than 450 mm outside diameter over insulation	1.0	—	1.2	—

asphalt, bitumen, or polymeric plastics compounds, are used mainly as 'high-build' coatings, usually thicker than 1 mm. All of them may be reinforced with short mineral fibres to give increased durability. For heavy-duty weatherproofing the material preferably should be applied in two layers, with suitable open-mesh reinforcement, to give a final dry thickness of about 3 to 5 mm.

6.2.4 *Flexible Sheet Materials of Organic Polymeric Compound*

Flexible sheet materials of organic polymeric compound, for example, high density polyethylene, flexible polyvinyl chloride or polypropylene, are of value when used as integral dry finishes over preformed pipe sections, in which case they may be secured to the outer surface of the insulating material by means of mechanical banding, welding or a suitable adhesive. Otherwise they may be applied as an outer covering for washability, in food/pharma industries.

6.3 Ultimate Treatment of Finish Painting

Paint over the external finish of the insulation is not only of utilization value; as it is the painted surface that is exposed to view, the quality of the insulation work tends to be judged instinctively by the finished appearance. Correct choice and the correct methods of application should therefore receive adequately early consideration. For elevated surface temperature care should be taken to ensure that the paint used offers sufficient resistance to heat.

7 FITTINGS

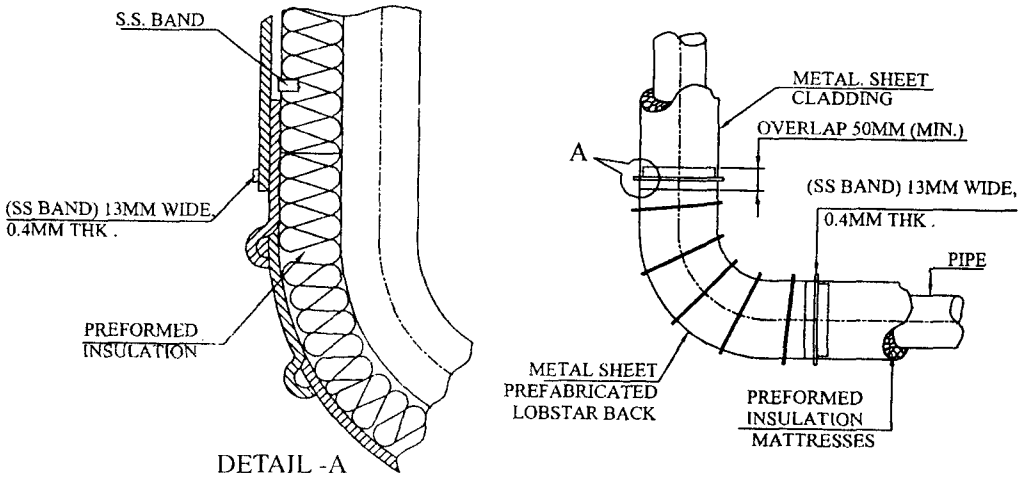
7.1 The word fittings shall include valves, flanges, bends, stubs, end caps, bellows, expansion/contraction joints, venturies, orifice plates, elbows, reducers, tees, etc.

7.2 Before the insulation of fittings is taken up, insulation of the pipe, with its protective finish, shall be completed. The insulation shall be stopped short of the fitting on both sides of the fittings so as to allow for the withdrawal of bolt without disturbing the insulation.

7.3 The insulation of the fittings shall be carried out on the same as indicated in **5.6** above. Typical insulation of elbow, tee, flanges and valve are shown as example in Fig. 8 to 11.

8 INSULATION OF EXPANSION JOINTS AND CONTRACTION JOINTS

8.1 Depending upon the type of insulation used, the operating temperature and the nature of the plant, it may be necessary to provide expansion joints in hot insulation or contraction joints in cold insulation of vessels or pipes so as to prevent the insulation from rupturing or buckling when the hot or cold surface expands or contracts. Typical insulation of expansion joints are shown as example in Fig. 12.



NOTES

1 M.S. Rings shall be provided wherever required at suitable intervals as per sectional view.

2 Metal cladding have 50 mm overlap longitudinally and circumferential joints will be sealed with sealing compound.

3 Metal sheet cladding of specified thickness.

4 In case of pipe section spacer ring not required.

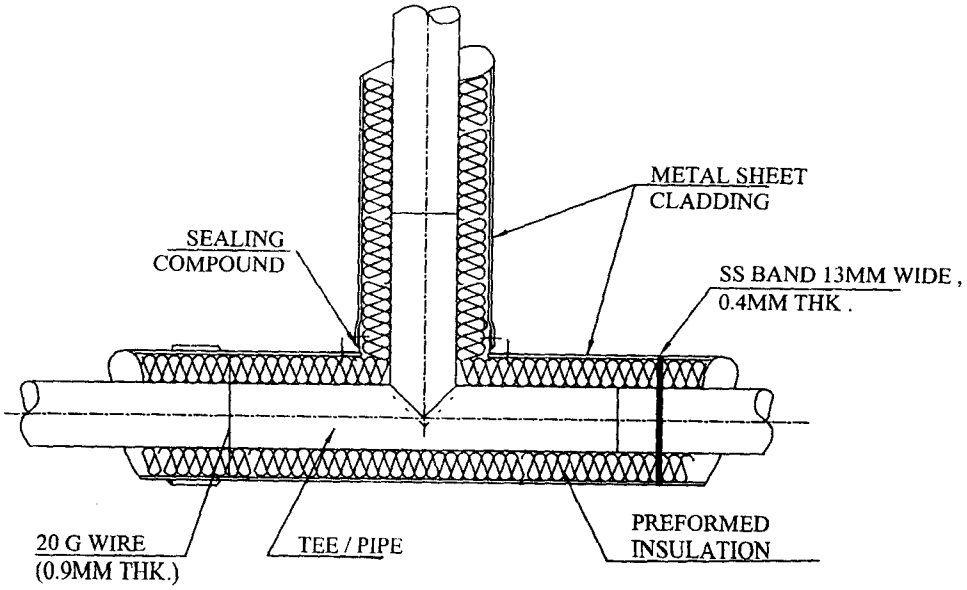
5 S.S. Band:

a) Up to Ø609 mm-13 mm wide × 0.4 mm thick.

b) Over Ø609 mm-19 mm wide × 0.4 mm thick.

6 In case of MOC IS S.S. a strip of 30 mm wide and 0.06 mm thick S.S. foil shall be provided wherever spacer ring lugs shall be setting.

FIG. 8 INSULATION OF ELBOW



NOTES

1 M.S. Rings shall be provided wherever required at suitable intervals as per sectional view.

2 Metal cladding have 50 mm overlap longitudinally and circumferential joints will be sealed with sealing compound.

3 Metal sheet cladding of specified thickness.

4 In case of pipe section spacer ring not required.

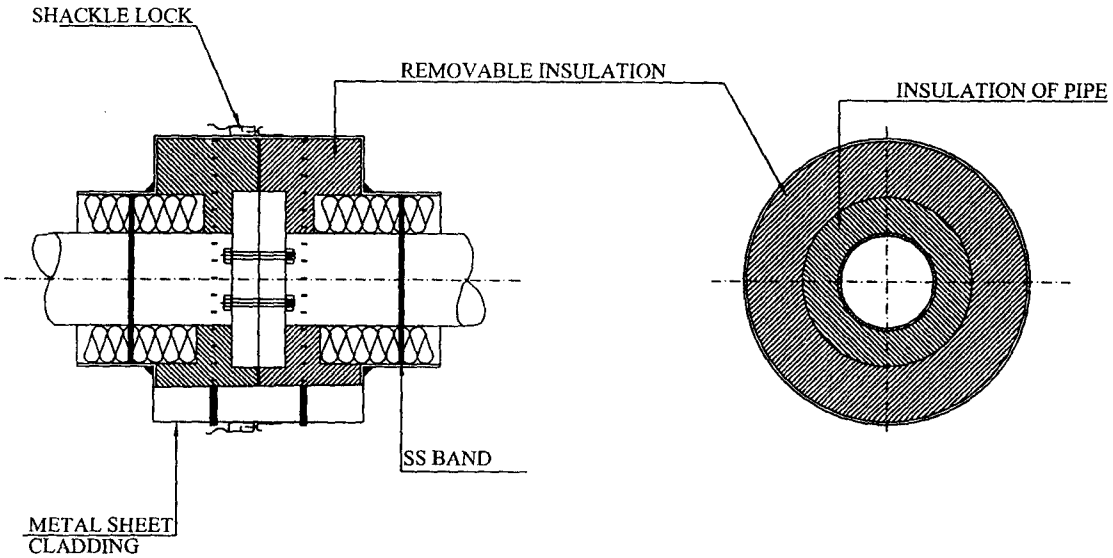
5 S.S. Band:

a) Up to Ø609 mm-13 mm wide × 0.4 mm thick.

b) Over Ø609 mm-19 mm wide × 0.4 mm thick.

6 In case of MOC IS S.S. a strip of 30 mm wide and 0.06 mm thick S.S. foil shall be provided wherever spacer ring lugs shall be setting.

FIG. 9 INSULATION OF TEE



NOTES

1 M.S. Rings shall be provided wherever required at suitable intervals as per sectional view.

2 Metal cladding have 50 mm overlap longitudinally and circumferential joints will be sealed with sealing compound.

3 In case of preformed rockwool pipe section spacer ring not required.

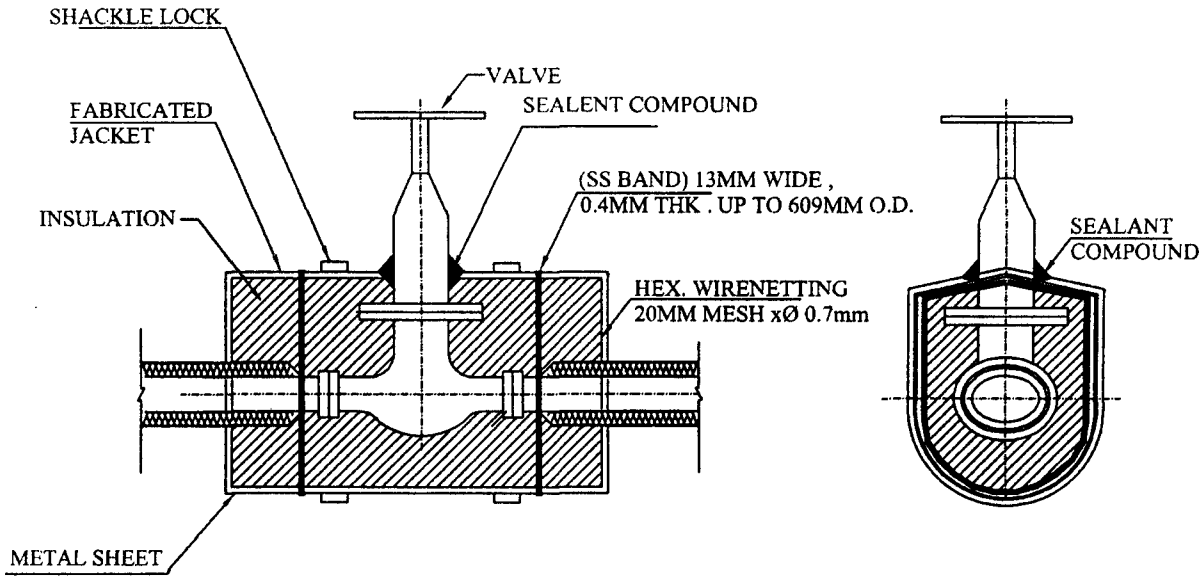
4 S.S. Band:

a) Up to Ø609 mm -13 mm wide × 0.4 mm thick.

b) Over Ø609 mm -19 mm wide × 0.5 mm thick.

5 In case of MOC IS S.S. a strip of 30 mm wide and 0.06 mm thick S.S. foil shall be provided wherever spacer ring lugs shall be setting.

FIG. 10 INSULATION OF FLANGES



NOTES

1 M.S. Rings shall be provided wherever required at suitable intervals as per sectional view.

2 Metal cladding have 50 mm overlap longitudinally and circumferential joint will be sealed with sealing compound.

3 In case of preformed rockwool pipe section spacer ring not required.

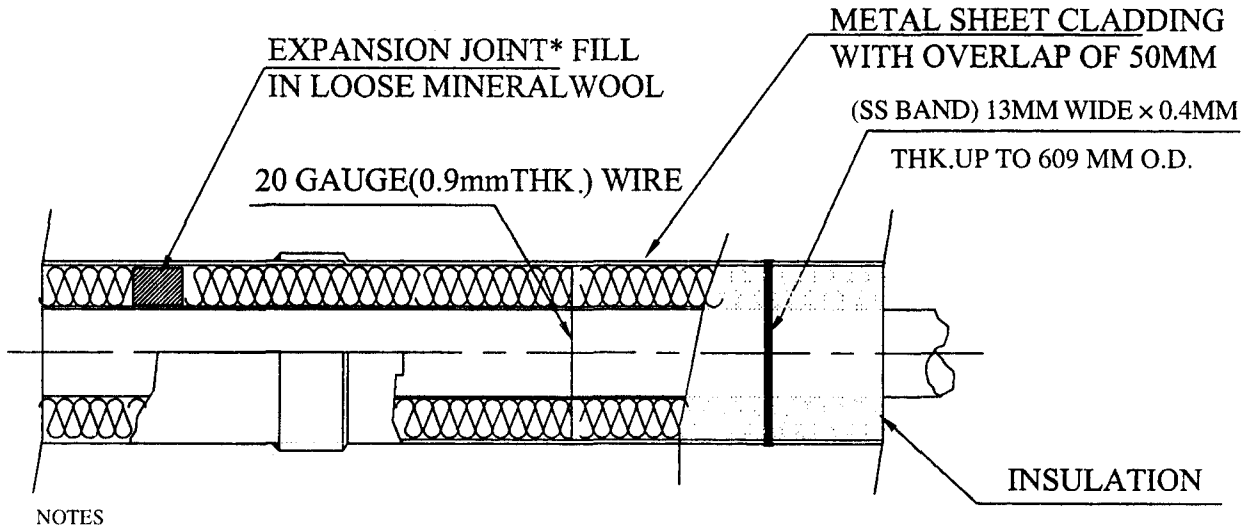
4 S.S. Band:

a) Up to Ø609 mm-13 mm wide × 0.4 mm thick.

b) Over Ø609 mm-19 mm wide × 0.5 mm thick.

5 In case of MOC IS S.S. a strip of 30 mm wide and 0.06 mm thick S.S. foil shall be provided wherever spacer ring lugs shall be setting.

FIG. 11 VALVE INSULATION



NOTES

1 M.S. Rings shall be provided wherever required at suitable intervals as per sectional view.

2 Metal cladding have 50 mm overlap longitudinally and circumferential joint/will be sealed with sealing compound.

3 In case of preformed rockwool pipe section spacer ring not required.

4 S.S. Band:

a) Up to Ø609 mm - 13 mm wide × 0.4 mm thick.

b) Over Ø609 mm - 19 mm wide × 0.5 mm thick.

5 In case of MOC IS S.S. a strip of 30 mm wide and 0.06 mm thick S.S. foil shall be provided wherever spacer ring lugs shall be setting.

*In case expansion joint longitudinal overlap is without any groove for free movement of metal sheet.

FIG. 12 PROVIDING EXPANSION JOINTS

8.2 In all cases where supports rings are provided on vessels or vertical pipes for rigid materials, the insulation shall be stopped short about 5 mm from each ring, and the space between the insulation and the ring filled with a flexible insulation material.

8.3 On horizontal pipes and vessels insulated with rigid insulation material or thermal insulating cements, expansion joints or contraction breaks filled with flexible insulating material shall be provided at suitable intervals.

8.4 Flexible Thermal Insulations do not normally need expansion joints or contraction breaks. Mineral wool rigid sections used at temperatures not exceeding 230°C also do not normally need expansion joints.

8.5 Where sheet metal is used as the finish, the joints over the expansion joints or contraction break shall not be secured with screws or pop rivets.

8.6 All other finishing materials shall be carried over expansion joints or contraction breaks without a joint.

9 MEASUREMENTS

9.1 General

Insulation work consists of providing all materials required for the system which includes the required quantity of insulation material, support system for insulation and the cladding, finishing and other ancillary items like wire-netting, securing devices like bands, screws, etc, along with other needs like labour required for carrying out the task.

While performing this work over each unit area of insulation work, certain overlaps, cutting wastage, etc, are involved, all of which are to be provided by the installer. Plane areas such as in ducts, Boiler walls, etc, are considered as Flat Surface where such extra material needs would be minimum. Actual work in field would consist of many different situations-curved surfaces like tanks, cylindrical vessels, domed/dished ends of such vessels, etc, which would involve larger elements of such efforts, apart from additional work with longer labour deployment, when compared to work on a flat surface.

In cylindrical surfaces, although the inner perimeter may be less than the outer, the quantity of insulation materials required to carry out work would correspond to the larger perimeter — a block type/preformed material requiring cutting and shaping from the larger sized starting material, while a flexible material is taken to cover the larger perimeter and applied with higher and higher compression as we proceed towards the inner surface. Hence, all insulation work is measured on the larger (outer) surface.

9.2 Measurement of Apparatuses (Insulated) Surfaces

9.2.1 Basic parameter in work measurement considered being a flat surface, a set of diagrammatic presentations are furnished on various possible shapes which may be encountered in field, with the factors to be applied to account for extra materials for such items of work (*see* Fig. 13 to Fig. 26). The formulae for calculation of the conventional surfaces are indicated against each figure.

The main symbols appearing in said figures/formula are the following:

L, L_1 = lengths relevant to straight parts of insulations included between the references defined, case by case, in the typical exemplifications, in m;

C, C_1 = circumferences measured on the external surface of insulation, in m;

X = conventional equivalent lengths of insulated parts having irregular shapes, in m;

Y = increased coefficients of insulated parts having irregular shapes, in m;

Z = height of the dished end; and

D, D_1 = conventional external diameter of insulated apparatuses, in m, obtained by the following formula:

$$D \text{ (or } D_1) = D_e + 2T$$

where

D_e = external diameter of the apparatus, in m; and

T = nominal thickness of insulating material provided by mechanical (finishing excluded), in m.

9.2.2 Any mode of measurement other than the above may also be adopted, if agreed to between the purchaser and the applicator.

9.3 Measurement of Piping Surfaces

9.3.1 *Insulated Piping Outside Diameter*

The outside diameter of the insulated piping, to be taken into account when calculating the insulating surface, shall be the theoretical conventional diameter determined according to the following formulae:

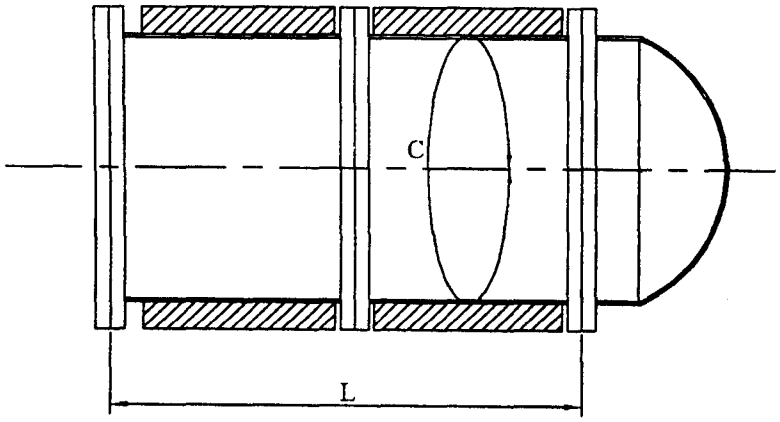
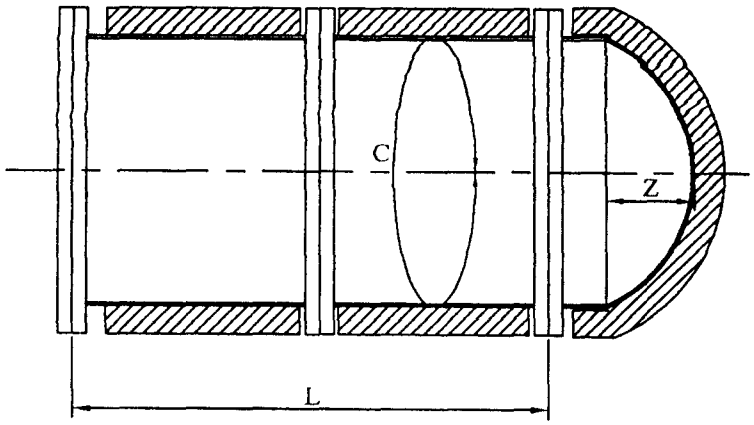
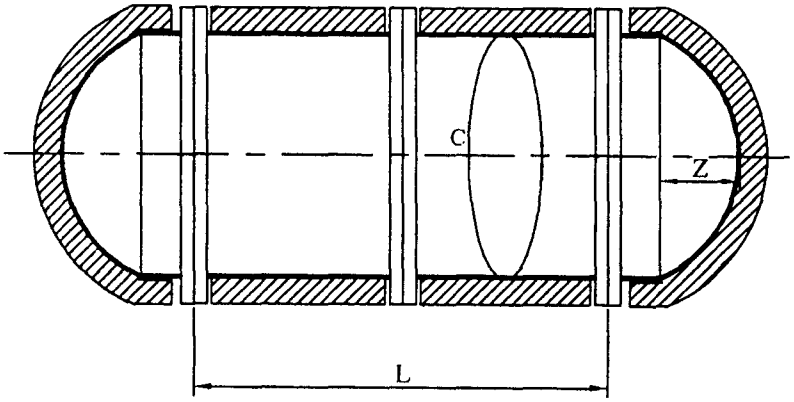
where

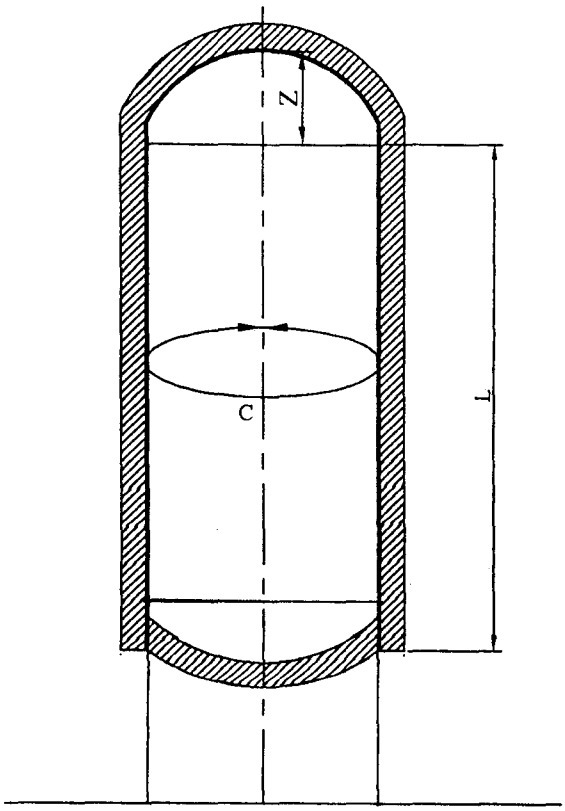
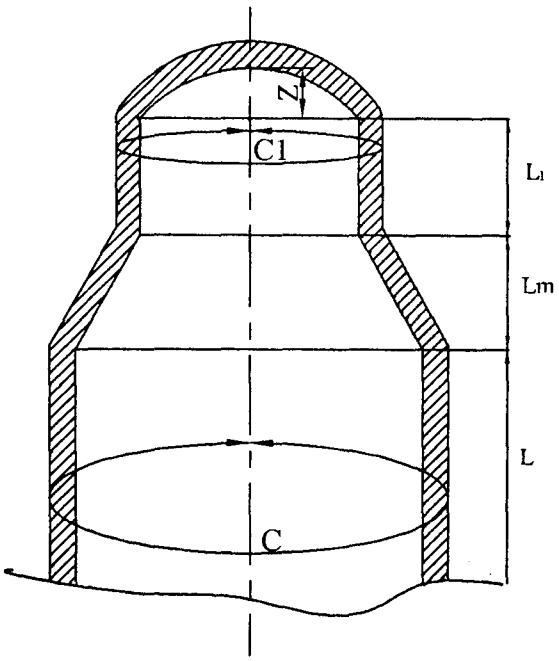
D = outside diameter of insulated piping, in mm;

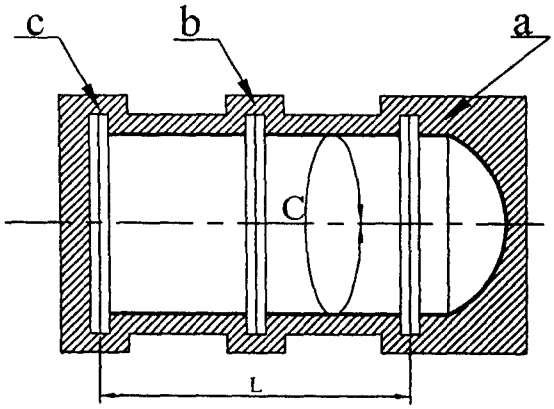
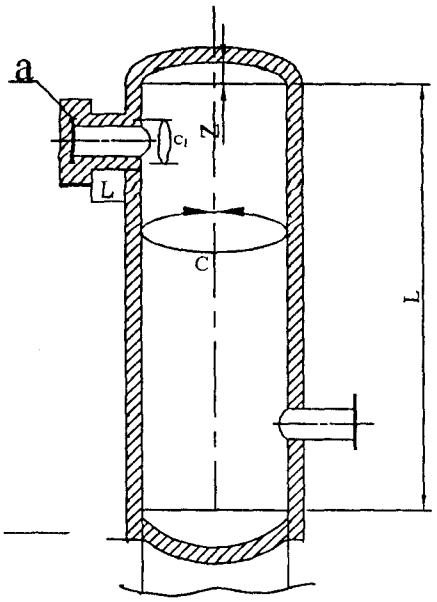
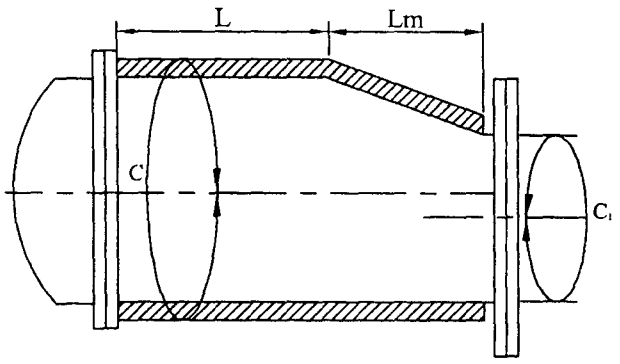
D_e = outside diameter of bare piping, in mm;

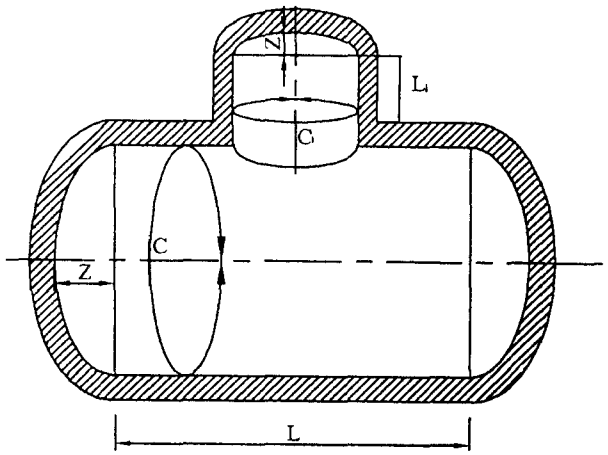
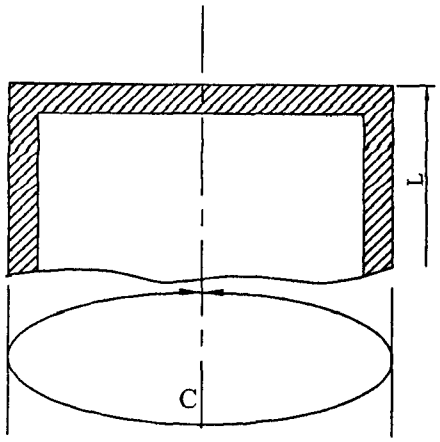
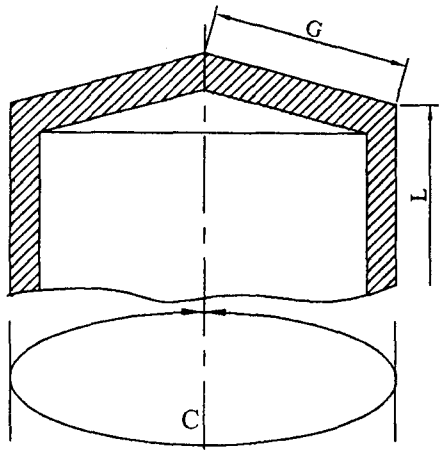
D_t = outside diameter of tracing pipe, corresponding to 20 mm (conventional value), in mm; and

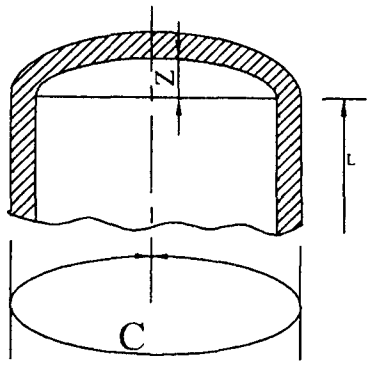
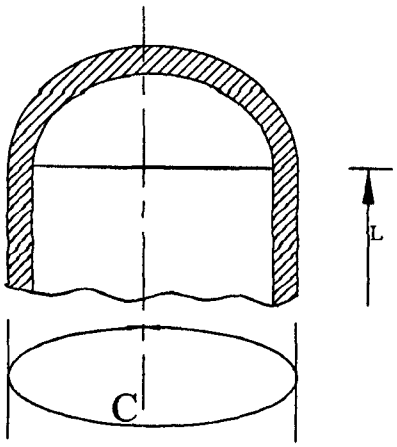
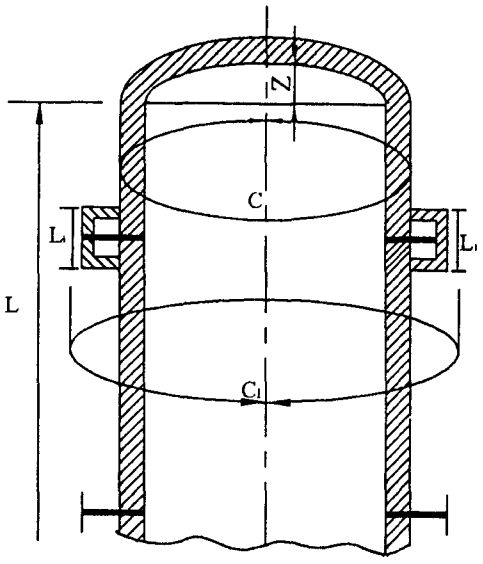
T = thickness of insulation material provided by the design (finish excluded), in mm.

Typical Exemplifications		Relevant Surfaces
FIG. 13		*CL*
FIG. 14		$CL + \frac{D^2\pi}{4} Y$ $Y = 1.27$ where $Z < D/3$ and $Y = 1.75$ where $Z \geq D/3$
FIG. 15		$CL + \frac{d^2\pi}{2} Y$ $Y = 1.27$ where $Z < D/3$ and $Y = 1.75$ where $Z \geq D/3$

Typical Exemplifications		Relevant Surfaces
FIG. 16		$CL + \frac{D^2\pi}{2} Y$ $Y = 1.27$ where $Z < D/3$ and $Y = 1.75$ where $Z \geq D/3$
FIG. 17		$CL + \frac{C + C_1}{2} Lm.Y +$ $C_1 L_1 + \frac{D_1^2\pi}{4} Y_1$ $Y = 1.2$ and $Y_1 = 1.27$ where $Z < D/3$ and $Y_1 = 1.75$ where $Z \geq D/3$

Typical Exemplifications		Relevant Surfaces
FIG. 18		$C\ (L + Xa + Xb + Xc)$ where $Xa = 1$ $Xb = 0.5$ $Xc = 0.5$
FIG. 19		$CL + C_1\ (L_1 + Xa) + \frac{D^2\pi}{2}\ Y$ where $Xa = 0.5$ $Y = 1.27$ where $Z < D/3$ and $Y = 1.75$ where $Z \geq D/3$
FIG. 20		$CL + \frac{C + C_1}{2}\ Lm.Y$ where $Y = 1.2$

Typical Exemplifications		Relevant Surfaces
FIG. 21		$CL + \frac{D^2}{2} Y$ $C_1L_1 + \frac{D^2\pi}{4} Y$ $Y = 1.27$ where $Z < D/3$ and $Y = 1.75$ where $Z \geq D/3$
FIG. 22		$CL + \frac{D^2\pi}{4}$
FIG. 23		For $G > 3$ m: $CL + G^2\pi$ For $G < 3$ m $CL + G^2 \pi.Y$ where $Y = 1.5$

Typical Exemplifications		Relevant Surfaces
FIG. 24		$CL + \frac{D^2\pi}{4} Y$ $Y = 1.27$ where $Z < D/3$ and $Y + 1.75$ where $Z \geq D/3$
FIG. 25		$CL + \frac{D^2\pi}{4} Y$ where $Y = 1.27$
FIG. 26		$CL + \frac{D^2\pi}{4} Y + C_1 + L_1.Y_1$ $Y = 1.27$ where $Z < D/3$ and $Y = 1.75$ where $Z \geq D/3$ and $Y_1 = 1.2$

9.3.1.1 Hot and cold insulation with sheet metal finish:

$$D = D_e + 2T$$

9.3.1.2 Traced piping hot service insulation with sheet metal finish:

$$D = D_e + D_t + 2T$$

NOTE — For areas having non-circular section (for example square section) the above formulae are still valid, considering D as equivalent diameter.

$$D = D_{eq}$$

where

$$D_{eq,\ mm} = \frac{\text{Perimeter of non-circular section, in mm}}{\pi}$$

9.3.2 *Measurement of the Lengths Relevant to Insulated Piping*

9.3.2.1 Measurements shall be carried out in compliance with typical examples as per Fig. 27 for NB < 50 mm piping and Fig. 28 for NB ≥ 50 mm piping.

9.3.2.2 *Pipe fittings*

Irregularly shaped insulation involving special execution procedure (like elbows, fittings, T-branches, etc) shall be converted to equivalent straight piping lengths, according to Table 2.

9.3.3 Measurement criteria of L lengths relevant to NB < 50 mm piping is given in Fig. 27.

9.3.4 Measurement criteria of L lengths relevant to NB ≥ 50 mm piping is given in Fig. 28.

9.3.5 *Calculation of Surface to be Insulated*

9.3.5.1 *Insulation of single piping*

The surfaces being insulated shall be conventionally determined as follows:

$$A = \frac{\pi \Sigma D_i (L_i + L_{ei})}{1\,000}$$

where

A = surface being insulated, in m^2;

Di = outside diameter of insulated 'i' piping, according to the definitions as per **9.3.1** in mm;

ΣL_i = summation of lengths of straight 'i' piping lengths, m (*see* Fig. 27 and Fig. 28); and

ΣL_{ei} = summation of conventional equivalent lengths L_i for special parts relevant to 'i' piping, m (*see* Fig. 28), in m.

Table 2 Conventional Equivalent Lengths for Special Parts (1)

(*Clause* 9.3.2.2)

Piping NB[6]	Elbow 90E	Elbow 45E	Tee Branch[2) 3)]	Reducer[2)]	Cap	Insulated Flange Pair with Removable Box[4)]	Insulated Flanged Valve with Removable Box[5)]	Insulated Flange Pair with Fix Box[4)]	Insulated Flanged Valve with Fix Box[5)]	Insulated Welded Valve with Fix Box[5)]
	(M)	(M)	(M)	(M)	(M)	(m)	(M)	(M)	(M)	(M)
					Hot and Cold Service Insulation with Sheet Metal Finish[1)]					
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
≤ 40	0.5	0.35	0.70	0.20	0.20	1.80	2.50	1.08	1.50	0.20
≥ 50 to 85	0.6	0.40	0.70	0.20	0.20	1.90	3.00	1.14	1.80	0.60
≥ 100 to 150	1.00	0.65	0.70	0.20	0.20	2.00	3.50	1.12	2.10	0.60
≥ 200 to 350	1.40	0.85	0.75	0.20	0.20	2.50	4.00	1.50	2.40	0.60
≥ 350 to 500	1.50	0.90	0.85	0.30	0.20	2.70	4.50	1.62	2.70	0.60
≥ 600	1.70	1.05	1.10	0.45	0.20	3.00	6.00	1.80	3.00	0.60

NOTE — Radius of elbow is considered as 1.5 D.

1) The equivalent lengths shown in the tables are applicable for types of insulation specified in same tables (these are the most frequently used insulation types); changing the application procedure of insulation (by eliminating, for example, the aluminium protection), the equivalent lengths might be different from the tabulated figures.

2) For reducers and T-branches, the equivalent lengths refer to the higher NB.

3) Typical installations, such as pressure plugs, temperature plugs, vents, drains, etc, are not considered and calculated as 'T' branches.

4) Orifice fittings are conventionally considered as a pair of fittings.

5) Flow meters, Y-strainers, control valves, safety valves, sight glasses, expansion joints are conventionally considered as valves.

6) For areas having non-circular section (*see* Note under **9.3.1.2**).

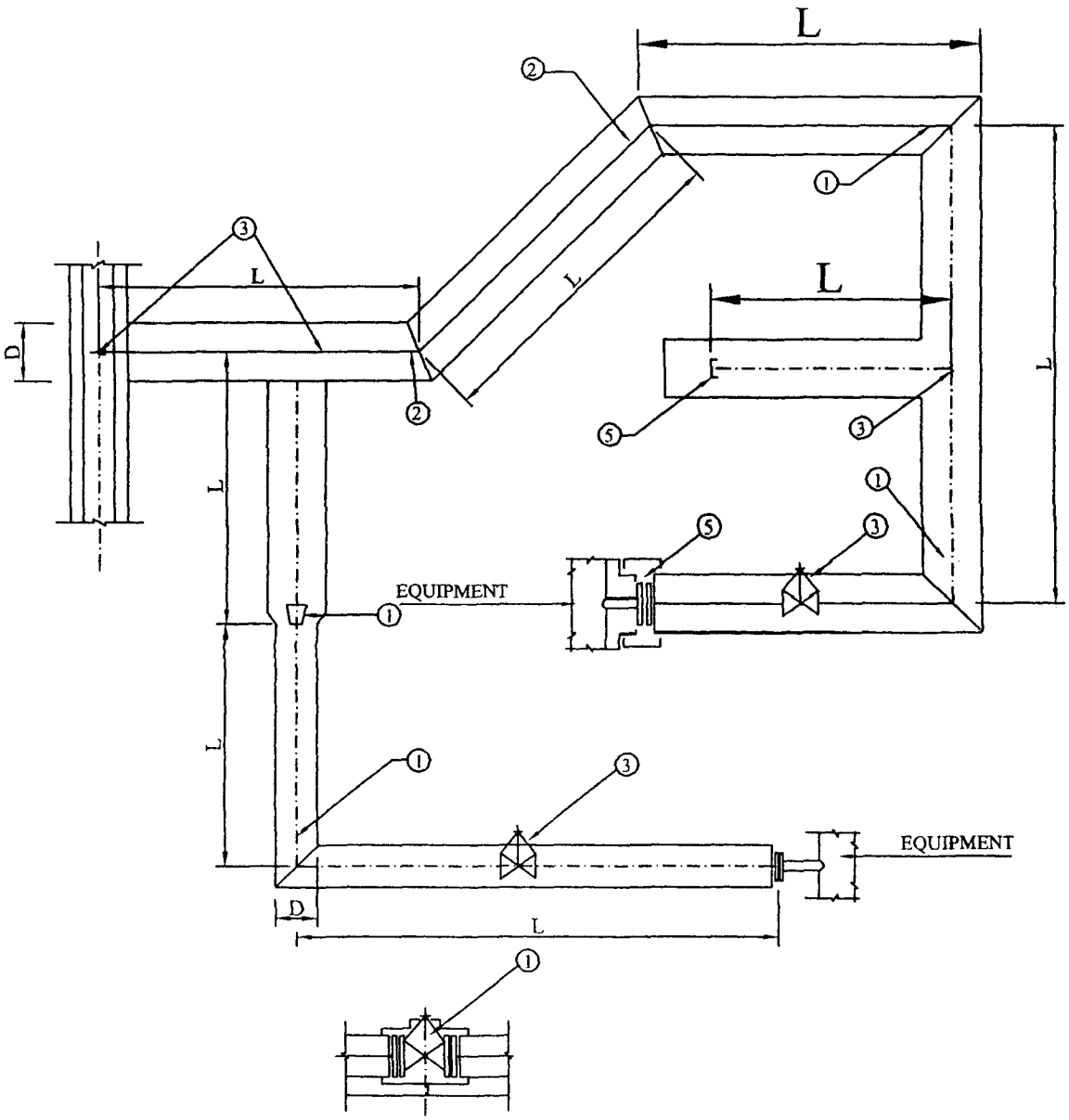


FIG. 27 MEASUREMENT CRITERIA OF '*L*' LENGTHS RELEVANT TO NB < 50 mm PIPING — TYPICAL EXAMPLE EQUIPMENT

9.3.5.2 Bundle of piping insulated together is shown in Fig. 29.

9.3.6 For protection of insulated pipelines, running close to the ground, from mechanical damage, due to foot traffic and/or from corrosion due to moisture from ground, any hardsetting compound and/or water proofing treatment is/are provided, such items of work are to be measured separately.

9.3.7 Anti-corrosive painting or wrapping with aluminium foil over stainless steel/alloy steel piping and equipment prior to application of insulation shall be measured separately.

9.3.8 Any mode of measurement other than the above may also be adopted, if agreed to between the purchaser and the applicator.

10 INFORMATION REQUIRED

10.1 The purchaser shall provide the contractor with the appropriate information under each of the following headings to enable the contractor to make a compressive offer/quotation.

10.1.1 *Application Specifications*

10.1.1.1 *Selection of thermal insulating material*

Before deciding on the insulating material to be used for any specific purpose, the following factors should be considered:

Heat Insulation	*Refrigeration*
Cold-face temperature (minimum and maximum)	Cold-face temperature (minimum and maximum)
Hot-face temperature (maximum and minimum)	Warm-face temperature (maximum and minimum)
Ambient temperature	Ambient temperature and humidity
Thermal conductivity	Thermal conductivity (aged)
Thickness of insulation required	Thickness of insulation required
Mechanical strength	Mechanical strength
Health hazard	Health hazard
Fire hazard	Fire hazard
Thermal movement (expansion)	Thermal movement (contraction)
Permeability of insulating material with need for protection	Vapour sealing of system
Protective covering and finish	Protective covering and finish
Cost (including that for application and finish)	Cost (including that for application and finish)

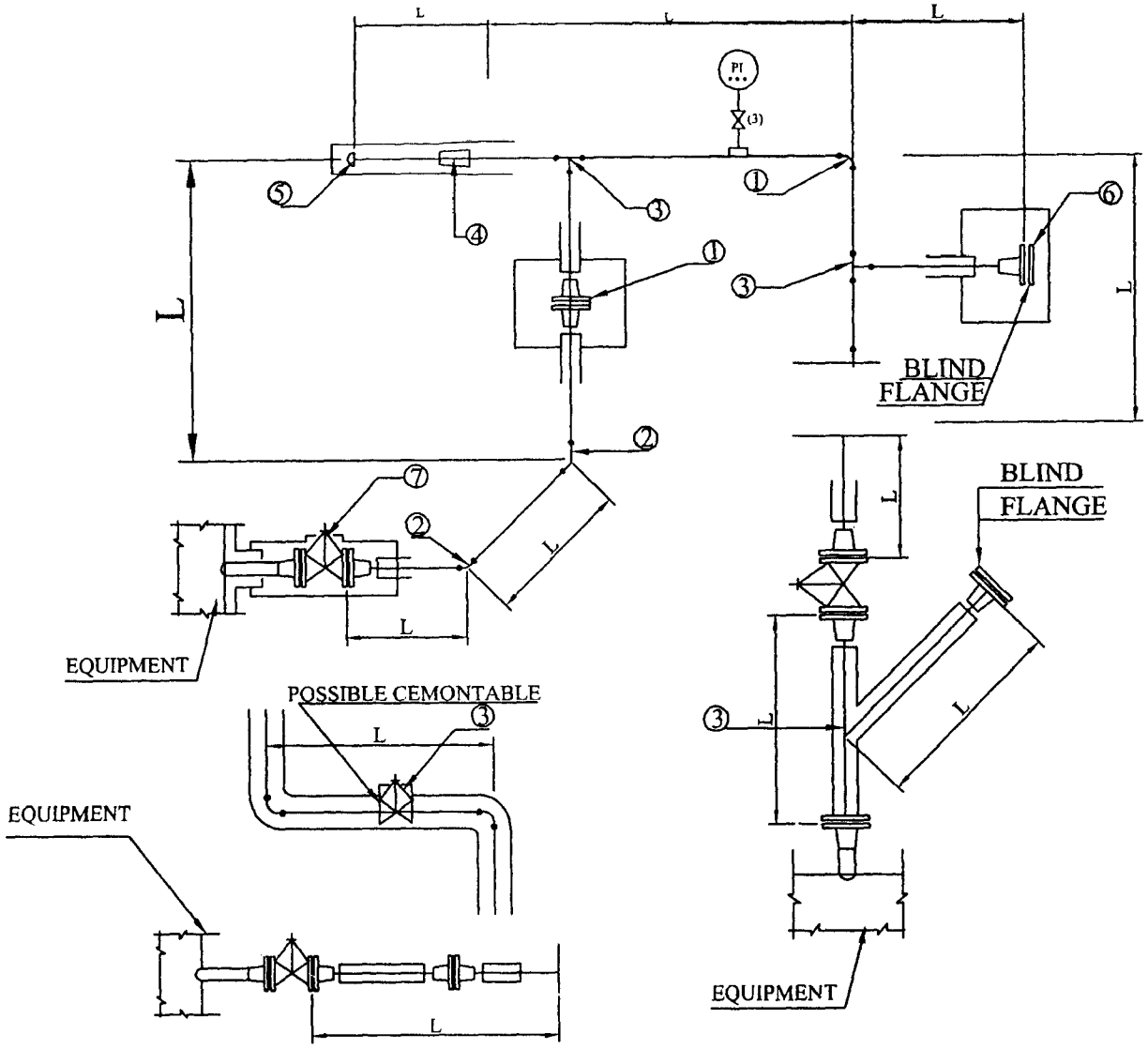


FIG. 28 MEASUREMENT CRITERIA OF '*L*' LENGTHS RELEVANT TO NB < 50 mm PIPING — TYPICAL EXAMPLE

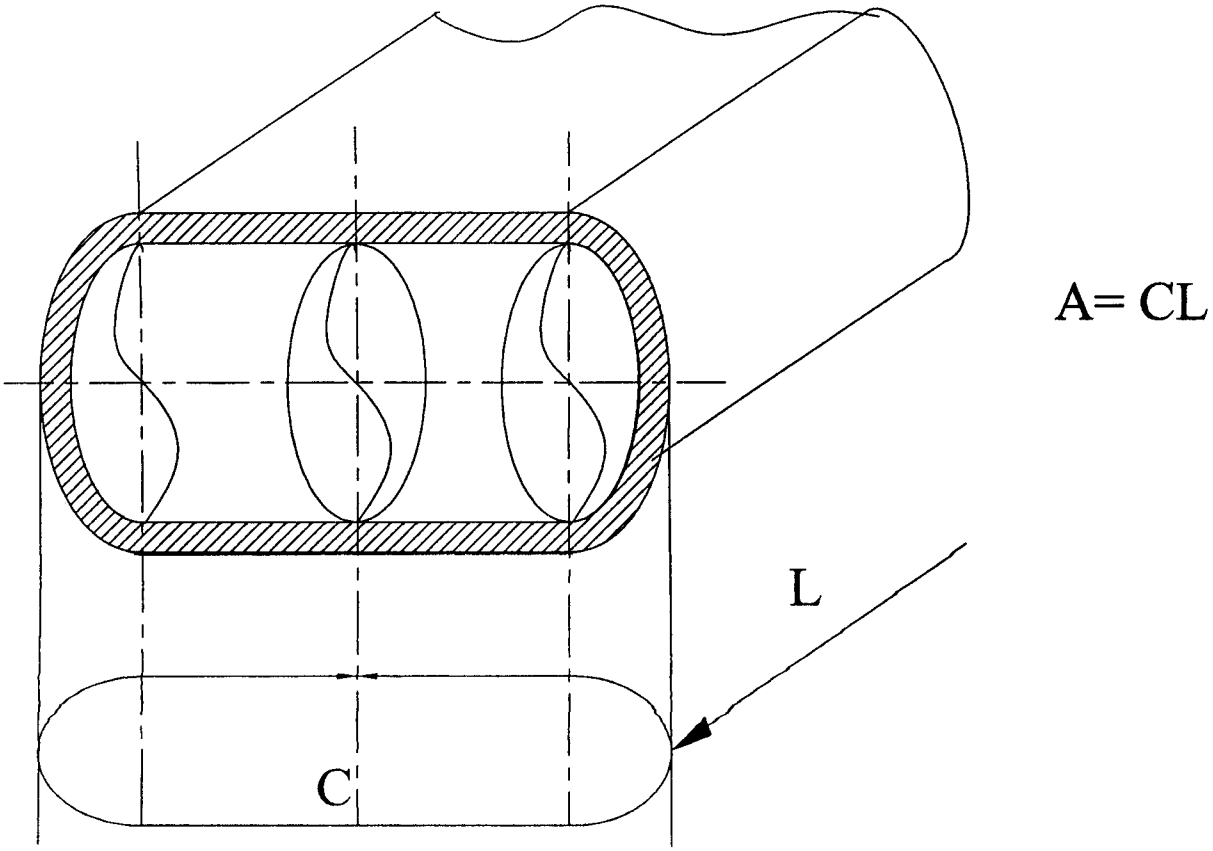


FIG. 29 BUNDLES OF PIPES INSULATED TOGETHER

10.1.2 Types of insulation required for the main vessels, and pipes of each part of the plant and for bends, fittings, valves, hangers and other fittings.

10.1.3 *Type(s) of Finish(es) Required*

10.1.4 If the thickness of the various insulations in the system are not furnished/or specified by the purchaser, then the basis of working out the different thicknesses shall be furnished by the purchaser, as for example, whether the thicknesses are to be calculated, based on:

a) Economical thickness for a specified evaluation period;
b) Specified heat loss or heat gain per unit dimension of the insulation;
c) Specified temperature on outer surface of the insulation for personnel protection and safety;
d) Prevention of condensation on the outer surface of the insulation. Outer surface temperature should be above the dew point;
e) Specified temperature of the carried fluid along with maximum and minimum flow rates at the point of delivery;
f) Any other specific requirement to be fulfilled by the thermal insulation;
g) Velocity of the outside fluid (air);
h) Material of the cladding surface; and
j) Relative humidity.

In each case, the purchaser shall provide the applicator with the requisite information as above, to enable the applicator to make the necessary calculations before making his offer/quotation.

10.1.5 Details of the plant to be insulated including:

a) Location:
   1) Indoors;
   2) Outdoors but protected;
   3) Outdoors exposed to weather;
   4) Ventilated or open trenches; and
   5) Difficult or unusual site conditions which will influence the selection of insulating and/or finishing materials, for example, in regard to transport, scaffolding or weather protection.
b) Nature and material of construction of vessel and piping to be insulated.
c) Dimensions of surfaces. If these are adequately detailed in drawings the provision

of copies shall suffice. Otherwise information of the following nature is required:

1) Surface dimensions of vessels,
2) External diameters and lengths of pipe
3) Number and type of fittings, and
4) Whether rotating or stationary.

d) Temperature conditions including the normal and maximum working temperature of each portion of the plant and the ambient temperature to be reckoned for calculations.

10.1.6 Special service requirements such as resistance to compression, in combustibility, abnormal variations or attack by solvents/corrosive media.

11 TESTS

11.1 Tests for Thickness

Tests for thickness shall be carried out after application. Local irregularities (for example, rivet heads) on the *insulated surface shall be ignored.*

11.1.1 If the arithmetic mean of not less than nine probe measurements at a given location is less than the minimum thickness as required by the purchaser or less than the commercial thickness offered by the applicator (subject to previously agreed tolerances), whichever is appropriate, the material applied at that location shall be deemed not to comply with this standard.

11.2 Uniformity of Thickness

11.2.1 Uniformity of thickness shall be assessed from the same measurements as in **11.1.1**, if any measurement varies by more than ±13 mm or ±15 percent whichever is appropriate, the material applied at that location shall be deemed not to comply with this standard.

11.2.2 If thickness at any particular location is beyond ±15 percent from the agreed thickness, the test shall be repeated at two more locations in the immediate vicinity of the first location. If both the tests are within 15 percent from the agreed bulk density, the results shall be deemed to be satisfactory. However, if any of the two tests are beyond ±15 percent, the insulation shall be deemed to have failed in the bulk density test and the purchaser shall be at liberty to ask the supplier to redo the insulation in the required area.

11.2.3 The test location shall be made good by the applicator at no extra cost to the satisfaction of the purchaser.

11.3 Test for Bulk Density

This test shall be optional and shall be resorted to only if previously agreed upon between the purchaser and the supplier. In such a case, the number of such tests for the whole work shall also be predetermined (*see also* **5.1.2**).

11.3.1 The test for bulk density shall be carried out after the measurements of thickness and area have been taken on the insulating material.

11.3.2 The location where tests for bulk density are to be conducted shall be selected by the purchaser.

11.3.3 If thickness at any particular location is beyond ±15 percent from the agreed thickness, the test shall be repeated at two more locations in the immediate vicinity of the first location. If both the tests are within 15 percent from the agreed bulk density, the results shall be deemed to be satisfactory. However, if any of the two tests are beyond ±15 percent, the insulation shall be deemed to have failed in the bulk density test and the purchaser shall be at liberty to ask the supplier to redo the insulation in the required area.

11.3.4 The test location shall be made good by the applicator at no extra cost to the satisfaction of the purchaser.

11.4 Test for Finishing Cements

The test for finishing cements shall be carried out after application and finishing of thermal insulation work and shall be done in accordance with the method prescribed in IS 9743.

ANNEX A

(*Foreword* and *Clause* 3)

SYMBOLS

Symbol	Title	Unit
C, C_1	Circumferences measured on the external surface of insulation, defined case by case, in the typical exemplifications	m
D, D_1	Conventional external diameter of insulated apparatuses defined case by case, in the typical exemplifications	m
D_i	Outside diameter of insulated '*i*' piping	m
D_e	Outer diameter of bare pipe	m
D_t	Outside diameter of the tracing pipe	m
d_m	Cylinder diameter to be taken as 0.6 for flat surface or diameter over 0.6 m	m
d_n	Diameter of the outer surface of the *n*th layer	m
T	Nominal thickness of insulating material provided by mechanical (finishing excluded)	m
A	Surface area being insulated	m^2
$\sum L_i$	Summation of lengths of straight '*i*' piping	m
$\sum L_{ei}$	Summation of conventional equivalent lengths L_i for special parts relevant to '*i*'	m
Q	Quantity of heat passing through a unit area of the pipe/equipment/wall during a unit time	$kcal/m^2.h$
Q_r	Quantity of heat transfer by radiation	$kcal/m^2.h$
Q_c	Quantity of heat transfer by convection	$kcal/m^2.h$
h_c	Heat transfer coefficient by convection	$kcal/m^2.h\ °C$
h_r	Heat transfer coefficient by radiation	$kcal/m^2.h\ °C$
t_a	Ambient temperature	°C
t_s	Temperature of cold face of pipe/equipment/wall or cladding surface	°C
t_o	Temperature of hot face of pipe/equipment/wall	°C
I	Overall thickness of insulation	m
l_n	Thickness of the *n*th layer of insulation	m
L, L_1	Length of straight parts of pipe line defined case by case, in the typical exemplifications	m
l_n	Thickness of the *n*th layer of insulation	m
K	Thermal conductivity of insulation	mW/cm °C
K_n	Thermal conductivity of the *n*th layer	$kcal/m^2.h\ °C$
E	Emissivity	—
F	External total heat transfer surface coefficient, $F = h_c + h_r$	$kcal/m^2.h\ °C$
L_{eff}	Effective length of pipe line	m
V	Air velocity	m/s
X	Conventional equivalent lengths of insulated parts having irregular shapes	m
Y	Applied coefficients of insulated parts having irregular shapes	—
Z	Height of the dished end	m

ANNEX B

(Foreword)

METHOD OF CALCULATION OF HEAT LOSS/GAIN FOR INSULATION

B-1 Thermal conductivity is measured using standard test method. A series of measurements are generally made at different hot and cold face temperatures to get the values at different mean temperatures. From these experimentally determined values, it is necessary for the purpose of heat transfer calculation to deduce the conductivity at the combination of hot and cold face temperatures appertaining to each particular installation. To do this, the values are plotted against the corresponding mean temperature (the mean temperature being the arithmetic mean of the hot and cold face temperatures) and a smooth curve is drawn through the points. For any particular installation the appropriate Thermal conductivity value is then the value read from the graph for the mean temperature corresponding to the actual hot and cold face temperatures of that illumination.

B-2 Where the conductivity values at the exact mean temperature are not available even by intrapolation/ extrapolation (if permissible) as given in relevant index, values for the nearest higher temperature may be accepted for design, the difference between desired and available temperature being not more than 50°C.

NOTE — Normal conditions here mean broadly that the cold face of the insulation is, apart from any finishing materials, exposed to the atmosphere. It may, of course, reach a temperature well above atmospheric temperature.

B-3 Design thickness of any insulation material for a particular use may be done according to the specific requirement of the user/purchaser according to the normal methods of calculations which are normally available.

B-4 METHOD OF CALCULATION

B-4.1 For Flat Wall

Heat transfer through a flat wall, hearth, or roof consisting of 'n' layers is given by the following equation.

$$Q = (t_o - t_a)/[(l_1/K_1 + l_2/K_2 + \text{-----} + l_n/K_n) + 1/F]$$

where

$$F = h_r + h_c$$

B-4.2 For Cylindrical Wall

In case of a cylindrical wall calculate the quantity of heat passing through the insulation by the equation given below:

$$Q = \frac{(t_o - t_a)}{[(d_n/2K_1 \ln d_1 d_e + d_n/2K_2 \ln d_2/d_1 + \ldots\ldots + d_n/2K_n \ln d_n/d_{n-1}) + l/F]}$$

Heat is transferred from the cold face of the wall in to open air through radiation and convection. Calculate the heat transferred through radiation and convection by the equation given below:

$$Q = Q_r + Q_c = (h_r + h_c)(t_s - t_a)$$

B-4.3 Radiation Heat Transfer Coefficient

Calculate the radiation heat transfer Coefficient (h_r) by the equation given below:

$$h_r = 4.876 \times 10^{-8} \times \varepsilon \times \{(t_s + 273)^4 - (t_a + 273)^4\}/(t_s - t_a)$$

B-4.4 Heat Transfer Coefficient for Convection

Calculate the convection heat transfer co-efficient (h_c) by the equation given below:

$$h_c = 2.71 \times 1.15 \times 1/(39.37 \times d_m)^{0.2} \times (0.55/t_{av})^{0.181} \times (t_s - t_a)^{0.266} \times (1.8)^{1.266} \times (196.85V/68.9 + 1)^{0.5}$$

where

Q = quantity of heat passing through a unit area of the pipe/equipment/wall during a unit time, in kcal/m^2.h;

Q_r = quantity of heat transfer by radiation, in *K*cal/m^2.h;

Q_c = quantity of heat transfer by convection, in kcal/m^2.h;

d_e = pipe outer diameter, in m;

d_1 = diameter of the outer surface of the first layer, in m;

d_n = diameter of the outer surface of the *n*th layer, in m;

t_o = temperature of hot face of pipe/equipment/ wall, in °C;

t_s = temperature of cold face of pipe/equipment/ wall or cladding surface, in °C;

t_a = ambient temperature, in °C;

F = heat transfer co-efficient, in kcal/m^2.h °C;

h_r = heat transfer co-efficient by radiation, in kcal/m^2.h °C;

h_c = heat transfer co-efficient by convection, in kcal/m^2.h °C

ε = emissivity of the wall;

K_1 = thermal conductivity of the first layer, in kcal/m^2.h °C;

K_2 = thermal conductivity of the second layer, in kcal/m^2.h °C;

K_n = thermal conductivity of the *n*th layer, in kcal/m^2.h °C;

l_1 = thickness of the first layer of insulation, in m;

l_2 = thickness of the second layer of insulation, in m;

l_n = thickness of the *n*th layer of insulation, in m;

d_m = cylinder diameter in meters, to be taken as 0.6 for flat surface or diameter over 0.6 m;

t_{av} = average of surface temperature and ambient temperature, °K = $[0.5 \times (t_a + t_s)] + 273.15$; *and*

V = air velocity, in m/s.

NOTE — Thermal conductivity, k(kcal/m.h°C) used in this formula represents the value at mean temperature.

B-4.5 Recommendation

Temperature over insulated systems are parameters that are influenced by the heat flow from (or inch) system and the ambient factors like air temperature and air flow velocity over the surface.

Apart from safety criteria from which they should be limited to 55°C, *Max* under all conditions of exposure, this parameter is the only easily measurable entity to determine heat loss/gain.

Permissible heat losses differ from application to application. However, the following criteria are normally advisable:

Operating Temperature Range, °C	*Maximum Permissible Heat Loss*, kcal/m^2/h	*Maximum Surface Temperature Differential*
<150	50	10
150-250	85	17
250-400	100	20
400-550	125	25

B-5 ADDITIONAL HEAT LOSSES DUE TO COMPONENTS IN A PIPE LINE

For a realistic calculation of heat losses, the following modifications are required to be done:

a) *Valves and Slide Valves*

Additional length (Δ *L*), in metres, from the table below are to be added to the real length (*L*) of pipeline, to account for the presence of valves and slide valves in a piping system before calculating the heat loss. These values account for the valve and its own flanges, but not for the flanges where the valve mounts in the piping system.

$$L_{eff} = L + \Delta L$$

Values in the table assume typical industrial insulation thicknesses for the temperatures given, and thermal conductivities K = 0.8 mW/(m.°C) at 100°C mean temperature, and K = 1.0 mW/(m°C) at 400°C mean temperature.

Pipe diameter d_e, in cm		10.0		50.0	
Pipe temperature, in °C		100	400	100	400
Pipe located inside	Non-insulated valve	6	16	9	25
	2/3 Insulated valve	3.0	6.0	4.0	10.0
	3/4 insulated valve	2.5	5.0	3.0	7.5
Pipe located outside	Non-insulated valve	15	22	19	32
	2/3 Insulated valve	6.0	8.0	7.0	11.0
	3/4 insulated valve	4.5	6.0	6.0	8.5

b) *Pair of Flanges*

To account for the heat losses from a pair of flanges in a piping system (including the flange pair when a valve is mounted):

1) *Non-insulated flanges*: From the table above, use one third given for a valve of the same diameter. Add this to the real length of the piping before calculating the heat losses.
2) *Insulated with flange boxes*: To the real length of the piping, add one metre for each flange with flange box, before calculating the heat losses.
3) *Insulated flanges*: No adjustment required; calculate heat losses based on real length.

c) *Pipe Suspensions*

Add to heat loss calculation (without previous compensation for other components):

In interior spaces : 15 percent of the heat loss

In the open air without wind : 20 percent of the heat loss

In the open air with wind : 25 percent of the heat loss

d) *Supports for Sheet — Metal Pipelines Jackets*

Additions to thermal conductivity:

1) For steel supports : 0.10 mW/cm°C
2) For ceramic supports: 0.03 mW/cm°C

B-6 SURFACE TEMPERATURE AND SURFACE COEFFICIENTS

B-6.1 It is often stipulated in practice, for operational reasons, that a certain surface temperature, temperature of the surface above that of the air (also called excess temperature) must not be exceeded. The surface temperature is no measure for the quality of the thermal insulation. This depends not only on the heat transmission but also on operating conditions, which cannot be readily determined or guaranteed by the manufacturer. These include among other things: Ambient temperature, movement of the air, state of the insulation surface, effect of adjacent bodies, meteorological conditions, etc. Reduction of heat loss by convection would mean reduction of air movement over the surface and consequent reduction of convective heat transfer surface coefficient. Reduction of heat transfer by radiation would mean reduction of surface emissivity and consequent reduction of radiative heat transfer surface coefficient. Although the increase in total surface resistance, which is reciprocal of the total surface coefficient will decrease the heat flow, but would increase the surface temperature to a considerably greater extent.

B-6.2 It may, however, be mentioned that convective heat transfer to cooler and modiative heat transfer from hotter environment would work in opposite direction and will have a moderating effect on surface temperature.

B-6.3 Although the surface temperature is not a parameter, which can serve as a guarantee because of the above reasons, it plays an important practical role for carrying out thermal insulation work. Mostly, the radiative and convective heat transfer from the surface introduces significant deviation. As a very rough guide, for comparison purposes, measurement of surface temperatures could be done, if black radiation shields are provided and still air conditions are created around the surfaces temperature measurement point. However, it may be stressed that actual surface temperature will be dependent on the prevailing exposure conditions. If surface temperature measurement are needed to be done for the purchaser, the above conditions may be agreed to by the applicator/supplier and the purchaser/ user.

B-6.4 Since an accurate registration of all relevant parameters will be impossible, the calculation of the surface temperature and excess temperature are inexact and cannot be guaranteed. Although it includes the effect of the ambient temperature on the surface temperature it assumes that the heat transfer by convection and radiation can be covered by a total heat transfer coefficient whose magnitude must also be known. However, this condition is generally not fulfilled because the air temperature in the immediate vicinity of the surface, which determines the convective heat transfer, mostly departs essentially from the temperature of other surfaces with which the insulation surface is in radiative exchange.

B-6.5 Many heat transfer calculations involve the use of total external surface heat transfer coefficient (E) which is defined as the heat transfer per square metre of surface/hour for 1 °C temperature difference between the surface and surroundings (mW/cm^2 °C).

Combining the effects of radiation and convection.

Surface	*E*
Aluminium, bright rolled	0.05
Aluminium, oxidized	0.13
Austenitic steel	0.15
Aluminium — zinc smelt	0.18
Galvanized sheet metal, blank	0.26
Galvanized sheet metal, dusty	0.44
Non-metallic surfaces	0.94

ANNEX C

(Foreword)

CONVERSION FACTORS

C-1 QUANTITY OF HEAT

C-1.1 The fundamental unit is the joule (J) or watt-second, but in this standard milliwatt-seconds (m W.s) = J × 10^3 is used for convenience.

	mW.S	kcal	Btu
1 milliwatt-second (mW.s)	1	2.388×10^{-7}	9.478×10^{-7}
1 kilocalorie (kcal)	4.187×10^{6}	1	3.968
1 British thermal unit (Btu)	1.055×10^{6}	0.252	1

C-2 THICKNESS

	cm	m	in
1 centimetre (cm)	1	0.01	3.937×10^{-1}
1 inch (in)	2.54	0.025 4	1

C-3 AREA

	cm^2	m^2	ft^2
1 square centimeter (cm^2)	1	1.0×10^{-4}	1.076×10^{-3}
1 square meter (m^2)	1.0×10^{4}	1	1.076×10
1 square foot (ft^2)	9.29×10^{2}	9.29×10^{-2}	1

C-4 THERMAL TRANSMISSION

The fundamental unit is the mW which equals to J/s × 10^3

	mW	kcal/h	Btu/h
1 milliwatt (mW)	1	8.590×10^{-4}	3.41×10^{-3}
1 kilocalorie/hour (kcal/h)	1.163×10^{3}	1	3.968
1 British thermal unit/ hour (Btu/h)	2.931×10^{2}	2.52×10^{-1}	1

C-5 THERMAL CONDUCTIVITY

The fundamental unit is milliwatt-seconds per square centimeter per second for 1 cm thickness and 1°C difference in temperature, abbreviated in its rationalized form as mW/cm°C.

	mW/cm °C	kcal/m h °C	Btu in/ft^2 h °F
1 mW/cm°C	1	8.598×10^{-2}	6.933×10^{-1}
1 kcal/m h°C	1.163×10	1	8.064
1 Btu in/ft^2 h°F	1.442	1.24×10^{-1}	1

C-6 THERMAL CONDUCTANCE AND TRANSMITTANCE

Surface Convection and Radiation Coefficient

	mW/cm^2 °C	kcal/m^2.h °C	Btu/ft^2 h °F
1 mW/cm^2 °C	1	8.598	1.761
1 kcal/m^2 h °C	1.163×10^{-1}	1	2.048×10^{-1}
1 Btu in/ft^2 h °F	5.678×10^{-1}	4.882	1

C-7 HEAT LOSS

The fundamental unit is milliwatt-seconds per square centimeter per second, abbreviated in its rationalized form as mW/cm^2.

	mW/cm^2	kcal/m^2.h	Btu/ft^2 h
1 mW/cm^2	1	8.598	3.17
1 kcal/m^2.h	1.163×10^{-1}	1	3.691×10^{-1}
1 Btu in/ft^2 h	3.15×10^{-1}	2.71	1

C-8 HEAT GAIN

The fundamental unit is milliwatt-seconds per square centimeter per second abbreviated in its rationalized form as mW/cm^2.

	mW/cm^2	kcal/m^2.h	Btu/ft^2 h
1 mW/cm^2	1	8.598	3.17
1 kcal/m^2 h	1.263×10^{-1}	1	3.69×10^{-1}
1 Btu//ft^2 h	3.15×10^{-1}	2.71	1

ANNEX D

(Foreword)

COMMITTEE COMPOSITION

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