भारतीय मानक

–80° से० से अधिक और 700° से० तक तापमानों के लिए तापरोधन सामग्रियों के औद्योगिक अनुप्रयोग और फिनिशिंग — रीति संहिता

Indian Standard

INDUSTRIAL APPLICATION AND FINISHINGS OF THERMAL INSULATION MATERIALS AT TEMPERATURES ABOVE –80°C AND UP TO 700°C — CODE OF PRACTICE

UDC 662·998 : 006·76

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FOREWORD

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

Lately, with the growing thrust on energy conservation considerable impetus has been provided to the thermal insulation industry. In the light of the latest technological advancements and the development of new thermal insulating materials and, considering the preponderance of commonalities and similarities in IS 7240 : 1981 'Code of practice for industrial application and finishing of thermal insulations materials at temperatures from −80°C to 40°C (*first revision*)' and IS 7413 : 1981 'Code of practice for industrial application and finishing of thermal insulations materials at temperatures above 40°C and up to 700°C, (*first revision*) in respect of materials, methods of application, finishing and work measurements, it was felt necessary to amalgamate both these Indian Standards.

This standard supersedes both IS 7240 : 1981 and IS 7413 : 1981. It covers the insulation of plant and equipment containing fluids at temperatures above −80°C and up to 700°C. It 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 is applicable for the insulation of plant and equipment constructed of carbon steel or alloy steels, such as vessels or piping carrying hot or cold fluids including gases, at temperatures within the range indicated.

A number of modifications in the mode of measurements have also been incorporated in this standard based on the experience gained and feedbacks received from the various segments of the thermal insulation trade and industry.

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 economic thickness. Further, other similar theoretical calculations, such as heat loss/gain through the insulation, 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 in order to restrict the scope of this stand to code of practice primarily for practical application in the field. However, it is proposed to publish a separate standard covering the theoretical design background and applicable calculations for the guidance of the thermal insulation industry.

Accordingly, only the symbols used in thermal insulation, explanatory note on assessment of thermal conductivity values and design of thermal insulation, surface temperature and surface 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 amalgamated standard as Annex A to E respectively for the information and guidelines.

It is hoped that the amalgamated standard would facilitate unambiguous exchange of commerical and scientific information within the industry.

While formulating this standard, considerable assistance has been taken from VDI 2055 : 1982 Heating and Cooling protection/Shielding for factories, published by *Verein Deutscher Ingenieure*, ISO/DIS 12241 : 1993 Calculation rules for Thermal Insulation of pipes, ducts and equipments published by International Organisation for Standardization and BSI 5422 : 1990 'Method for Specifying Thermal Insulating Materals on Pipes Duct work and Equipments (in the Temperature Range − 40°C to 700°C), which is thankfully acknowledged.

The composition of technical committee responsible for the formulation of this standard is given at Annex F.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

INDUSTRIAL APPLICATION AND FINISHING OF THERMAL INSULATION MATERIALS AT TEMPERATURES ABOVE –80°C AND UPTO 700° C — CODE OF PRACTICE

1 SCOPE

1.1 This standard prescribes code of practice for application and finishing of thermal insulation materials applied to surfaces at temperatures above –80°C and up to 700°C.

1.2 It does not deal with metal surfaces which are protected on their inner faces with structural boundary materials, such as refractory brick work or other linings, the temperatures of which change as a result of the application of external thermal insulation.

2 REFERENCES

2.1 The Indian Standards listed below are the necessary adjuncts to this standard:

IS No.	*Title*
702 : 1988	Industrial bitumen (*second revision*)
1322 : 1982	Bitumen felts for water-proofing and damp-proofing (*third revision*) (Reaffirmed 1987)
2074 : 1992	Ready mixed paint, air drying, red oxide-zinc chrome, priming (*second revision*)
3069 : 1994	Glossary of terms, symbols and units relating to thermal insulation materials (*first revision*)
9743 : 1990	Thermal insulation finishing cements (*first revision*)

3 TERMINOLOGY

3.1 For the purpose of this standard, the definitions given in IS 3069 : 1994 and the following shall apply. Additional symbols used in this standard are described in Annex A.

3.1.1 *Applicator*

An individual or organization undertaking thermal insulation of the installations.

3.1.2 *Operating Temperature*

The temperature of the hot or cold fluid inside the pipe or vessel under consideration.

3.1.3 *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.

3.1.4 *Economic Thickness*

The thickness of insulation which gives a minimum total cost over a chosen evaluation period.

3.1.5 *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.

3.1.6 *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.

3.1.7 *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.

3.1.8 *Thickness*

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

3.1.9 *Hot Surfaces for Insulation*

For the purpose of this standard, surfaces to be insulated having a temperature of over 40°C are classified as hot surfaces.

3.1.10 *Cold Surfaces for Insulation*

For the purpose of this standard, surfaces having a temperature of 40°C and below 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 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, provided 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 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.

4.3 In the case of plants operating at dual temperatures i.e. 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 temperatures involved during services without physical deformation or deterioration.

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 sections 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 Hot Surfaces

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

5.2.2 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 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.

5.2.3 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 required for cold insulation is relatively higher than for heat 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 clearance between pipes, vessels and structures to allow easy application of all the materials involved.

5.3.2 Special care shall 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 indicated in 5.1.3, the final two layers shall at least be provided with adequate vapour 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 either with bituminous or other adhesives.

b) *Bituminous and resinous mastics* – Bitumen (conforming to fully blown type of IS 702 : 1988 and its various compounds and resinous mastics having a water vapour permanence (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 at least equal to that applied 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 support 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 These will depend on the insulation materials 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 75 percent of the total insulation thickness, in order to avoid punctures in the vapour barrier.

5.4.3 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.

5.4.4 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 brush-coated with a suitable anti-corrosive primer wherever necessary, before they are insulated (*see* IS 2074 : 1992).

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, such as by wrapping with aluminium foil, 0.1 mm thick, or painted with suitable heat resistant, anti-corrosive paint, before application of insulation, as protection against stress corrosion due to presence of chlorides above 35 ppm in the insulating material at the time of application. The initial chloride content and the possibility of chloride contamination during transport, handling and storage should also be kept in view in this regard.

5.6 Application of Insulation

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 5.6.5.

5.6.1 *Flexible Insulation*

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

a) By means of a tie wire (0.9 mm dia GI);

b) By means of metal bands (e.g. 0.56 mm thick, 20 mm wide);

c) By means of a wire netting on outer side, suitably laced; 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 minimum and the wire netting shall be of maximum 20 mm mesh and minimum 0.56 mm diameter.

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

5.6.2 *Preformed Insulation*

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

a) By means of suitable metal bands (e.g. 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 (e.g. 0.56 mm thick, 20 mm wide) or tie wire (0.9 mm dia, GI); 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 should be taken so that minimum number of segments are chosen.

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

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

5.6.3 *Plastic Composition Thermal Insulation*

5.6.3.1 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.

5.6.3.2 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.

5.6.3.3 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.

5.6.3.4 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 5.6.3.3 but leaving the lugs protruding. When half the total thickness has been 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.

5.6.4 *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.

5.6.5 Insulation of pipe, 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 5.6.5.1 to 5.6.5.3 subject to the precautions outlined in 5.1 to 5.5 above.

5.6.5.1 *Pipes*

On continuous runs of 6 metres or more of vertical pipe, support rings shall be provided at not more than 3-metre 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.

5.6.5.2 *Ducts*

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

5.6.5.3 *Vessels*

All large vertical vessels of a height of 6 metres or more shall be provided with support rings at not more than 3-metre intervals. Such rings should 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° 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,

b) Protection against weather or chemical attack,

c) Retardation of flame spread,

d) Appearance,

c) Identification of pipe or vessel, and

f) Providing the insulation with an easily cleaned surface.

6.2 Protective Finishes

The following are the commonly applied protective finishes.

6.2.1 *Finishing Cement*

The finishing cements shall have a minimum thickness of 10 mm or as specified and shall be reinforced with wire netting of maximum 20 mm mesh and minimum 0.56 mm diameter or equivalent metal lath.

6.2.2 *Bituminous Mastics*

Minimum of 3 mm dry thickness, inclusive of the reinforcement, with suitable reinforcement where necessary.

6.2.3 *Sheet Metal*

Aluminium, galvanized iron or mild steel sheet of suitable thickness as agreed to between the purchaser and the applicator.

6.2.3.1 Galvanized iron or mild steel sheets shall be given a suitable protective coat of anti-corrosive paint on the inner side. In case there is a possibility of chemical corrosion, aluminium sheets shall also be given an anti-corrosive protection.

6.2.3.2 Sheet metal, whether applied to pipes or to vessels, shall preferably be secured by metal bands.

6.2.3.3 All joints between adjacent sheets shall be either grooved or over-lapped, 50 mm minimum, against the weather, to prevent ingress of rain-water.

6.2.3.4 The shells of all large vessels/tanks of 5 m diameter and above, situated in areas subject to heavy winds, shall preferably be finished with corrugated sheet metal, for better wind resistance.

6.3 The following protective finishes are generally associated with insulation for hot surfaces.

6.3.1 *Asbestos Cloth*

Not less than 1.5 mm thick and weighing not less than 1.1 kg/m^2, suitably stitched with asbestos twine.

6.3.2 *Roofing Felt*

Self-finish, conforming to Type 3, Grade 1 of IS 1322 : 1982.

6.3.3 *Other Finishes*

Where conditions of exposure are not very severe, low cost outer coverings, such as jute canvas (weighing not less than 0.34 kg/m^2), cotton canvas (weighing not less than 0.27 kg/m^2) and scrim cloth (loose weave hessian weighing not less than 0.13 kg/m^2) may also be used.

7 FITTINGS

7.1 The word 'fittings' shall include valves, flanges, bends, stubs, endcaps, 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 bolts without disturbing the insulation.

7.3 The insulation of the fittings shall be carried out on the same lines as indicated in 5.6 above.

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.

8.2 In all cases where support rings are provided on vessels or vertical pipes for rigid insulation 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 materials or thermal insulating cements, expension 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° 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 breaks 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 Insulation Over Tanks, Columns, Vessels, Exchangers and Equipment

9.1.1 Measurement shall be taken in square meter over the finished insulation surfaces. Any other unit of measurement may also be adopted if agreed between the purchaser and the applicator.

9.1.2 No deduction shall be made for any area required to be left uninsulated, the area of which is equivalent to a circle of 600 mm in diameter, or less.

9.1.3 In case of insulated nozzles, projections or manholes, such nozzle or projection or manhole is equivalent in area to a circle of 600 mm in diameter or less than in addition to the area of such nozzle, projection, or manhole not being deducted from the insulation measurements of the tank, column, vessel, exchanger or equipment, as the case may be, the projection of such nozzle, projection or manhole, from the insulated surface around it, shall be measured as pipe insulation of appropriate diameter. If the area of the nozzle, projection or manhole exceeds the area equivalent to a circle

of 600 mm in diameter, then twice the actual insulated area of such nozzle, projection or manhole shall be considered for measurement and paid for as vessel insulation, after deducting the area of the tank, column, vessel, exchanger or equipment covered by such nozzle, projection, or manhole.

9.1.4 Insulated areas with different specifications shall be specified and measured separately, such as:

a) Roof/tops of tanks and vessels incorporating hardsetting composition and/or waterproofing layer.

b) Sides of larger diameter tanks and vessels where corrugated aluminium sheets are to be used; measurements being taken over the crest of corrugated sheets.

c) Insulation systems requiring special supports/structure to be provided by applicator prior to application of insulation.

d) Insulated areas clad with different thicknesses of aluminium sheets.

9.1.5 Insulated dished ends of vessels, columns or equipment shall be considered as twice the projected plan area of the dished ends for purpose of measurement.

9.1.6 Insulated equipment flanges shall be measured as prescribed in **9.1.3**.

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

9.2 Insulation Over Piping (Including Ducts)

9.2.1 All measurements for piping (ducting) shall be taken over the finished insulated surface in meters, corrected to nearest centimetre along the centre line of piping (ducting), through all fittings, insulated or otherwise, such as valves, flanges, elbows, bends, tees and reducers.

9.2.2 If the valves, flanges or other fittings are also insulated, then, in addition to the lengths being already covered under piping and ducting insulation as stipulated in **9.2.1**, extra measurement as prescribed below shall be allowed in linear meter of the connected piping or ducting:

Insulated Fitting	*For Sheet-Metal Finish*	*For Other Finishes*
Valve/venturi/steam traps/strainers including flanges and body (up to 300 mm size)	1.50 m	1.40 m
Valve/venturi/steam traps/strainers including flanges and body (for sizes larger than 300 mm)	2.00 m	1.90 m
Pair of flanges including orifice plate and flanges	0.80 m	0.60 m
Bends and elbows	Twice the actual length, as measured along the centre line of the piping or ducting.	
Reducer	Actual length of larger size (along the centre line of piping)	
Tees	$2\,(D_1 + D_2)$, where D_1 and D_2 are insulated diameters of the two pipelines forming the tee.	
Any other special fitting	To be specified and measured separately on number basis.	

NOTE – Measurements of all valves, flanges and other fittings shall be based on actual count and then converted into equivalent lengths of connected piping, to arrive at the total equivalent lengths of piping or ducting of various diameters. Fittings that connect two or more different sizes of piping/ducting shall be counted as part of the larger size.

9.2.3 Where fittings are to be provided with separate sheet metal boxes, the sizes and types of such boxes shall be separately specified and quoted for.

9.2.4 Wherever 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 waterproofing treatment is/are provided, the insulation of such pipelines shall be specified and measured separately.

9.2.5 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.

9.2.6 *Steam-traced/and Non-steam-traced piping*

9.2.6.1 Steam-traced and non-steam-traced pipelines shall be normally specified and measured separately. Steam-traced pipelines with single or multiple tracers shall also be normally specified and measured separately according to the number of tracers.

9.2.6.2 For steam-traced pipelines, which are specified and are measured separately, only the diameter of the main pipeline(s) shall be reckoned for measurement of insulation. No separate measurement shall be made for the insulation of the steam-traced line(s), which shall be deemed to have been covered under the insulation of the main pipeline.

9.2.6.3 In respect of steam-traced lines, which have not been specified as measurable separately, the pipeline size shall be reckoned as the diameter of the circle enveloping the main pipeline and the steam-traced line(s) corrected to the nearest higher decimetre, for purposes of measurement.

9.2.6.4 In case any special treatment to steam-traced pipelines, other than wrapping with wire netting and/or lacing with G.I./black annealed wire, is to be carried out, such as application of special heat conducting compounds or wrapping with aluminium foil, such special treatment shall be measured separately.

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

9.3 Instruments

Insulation of instruments shall be measured separately and the length covered by such instruments which are not axial with the pipeline shall not be considered in the measurement of the connected piping insulation.

9.4 Inspection plugs, if any, provided in insulation of piping or any equipment shall be measured separately on number basis and no deduction shall be made on this account from the overall-measurement of insulation of the concerned equipment of piping.

9.5 All expansion/contraction joints provided in insulation shall be measured separately as extra over the main insulation.

9.6 All provisions in respect of piping, in this standard shall be applicable to ducting also. Wherever the ducts are having shapes other than circular, they shall be considered equivalent to a pipe of equivalent perimeter.

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 comprehensive offer/quotation.

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

10.1.2 Type(s) of finish(es) required.

10.1.3 If the thicknesses of the various insulations in the system are not furnished/or specified by the purchaser, then the basis for 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;
e) Specified temperature of the carried fluid along with *Max* and *Min* flow rates at the point of delivery; and
f) Any other specific requirement to be fulfilled by the thermal insulation.

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.

10.1.4 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.

10.1.5 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

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.

11.3 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 bulk density at any particular location is beyond ±15 percent from the agreed bulk density, 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 : 1990.

ANNEX A

(*Foreword* and *Clause* 3.1)

SYMBOLS

q = Heat loss through the insulation per square centimetre of hot surface per second (mw/cm^2)

θ_h = Temperature of hot surface (°C)

θ_e = Temperature of exterior surface (°C)

θ_a = Ambient temperature (°C) (assumed to be 30°C unless otherwise specifically stated)

l = Overall thickness of insulation (cm)

L = Length of pipeline (m)

λ = Thermal conductivity of insulation (mW/cm °C)

λ_{LM} = Laboratory measured thermal conductivity of insulation (mW/cm °C)

λ_D = Design thermal conductivity of insulation (mW/cm °C)

λ_{eff} = Effective thermal conductivity of insualtion system (mW/cm °C)

E = Emissivity

f_e = External total heat transfer surface coefficient (mW/Cm °C)

d_i = Outer diameter of bare pipe (cm)

d_e = Exterior diameter of the insulated pipe (cm)

L_{eff} = Effective length of pipeline (m)