INSPECTION AND MAINTENANCE OF THERMAL INSULATION

OISD STANDARD 177

OIL INDUSTRY SAFETY DIRECTORATE
Government of India
Ministry of Petroleum & Natural Gas

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INSPECTION AND MAINTENANCE
OF
THERMAL INSULATION

Prepared by:
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Preamble

Indian petroleum industry is the energy lifeline of the nation and its continuous performance is essential for sovereignty and prosperity of the country. As the industry essentially deals with inherently inflammable substances throughout its value chain – upstream, midstream and downstream – Safety is of paramount importance to this industry as only safe performance at all times can ensure optimum ROI of these national assets and resources including sustainability.

While statutory organizations were in place all along to oversee safety aspects of Indian petroleum industry, Oil Industry Safety Directorate (OISD) was set up in 1986 Ministry of Petroleum and Natural Gas, Government of India as a knowledge centre for formulation of constantly updated world-scale standards for design, layout and operation of various equipment, facility and activities involved in this industry. Moreover, OISD was also given responsibility of monitoring implementation status of these standards through safety audits.

In more than 25 years of its existence, OISD has developed a rigorous, multi-layer, iterative and participative process of development of standards – starting with research by in-house experts and iterating through seeking & validating inputs from all stake-holders – operators, designers, national level knowledge authorities and public at large – with a feedback loop of constant updation based on ground level experience obtained through audits, incident analysis and environment scanning.

The participative process followed in standard formulation has resulted in excellent level of compliance by the industry culminating in a safer environment in the industry. OISD – except in the Upstream Petroleum Sector – is still a regulatory (and not a statutory) body but that has not affected implementation of the OISD standards. It also goes to prove the old adage that self-regulation is the best regulation. The quality and relevance of OISD standards had been further endorsed by their adoption in various statutory rules of the land.

Petroleum industry in India is significantly globalization at present in terms of technology content requiring its operation to keep pace with the relevant world scale standards & practices. This matches the OISD philosophy of continuous improvement keeping pace with the global developments in its target environment. To this end, OISD keeps track of changes through participation as member in large number of International and national level Knowledge Organizations – both in the field of standard development and implementation & monitoring in addition to updation of internal knowledge base through continuous research and application surveillance, thereby ensuring that this OISD Standard, along with all other extant ones, remains relevant, updated and effective on a real time basis in the applicable areas.

Together we strive to achieve NIL incidents in the entire Hydrocarbon Value Chain. This, besides other issues, calls for total engagement from all levels of the stake holder organizations, which we, at OISD, fervently look forward to.

Jai Hind!!!

Executive Director
Oil Industry Safety Directorate
FOREWORD

The Oil Industry in India is 100 years old. Because of various collaboration agreements, a variety of international codes, standards and practices have been in vogue. Standardisation in design philosophies and operating and maintenance practices at a national level was hardly in existence. This, coupled with feedback from some serious accidents that occurred in the recent past in India and abroad, emphasised the need for the industry to review the existing state of art in designing, operating and maintaining oil and gas installations.

With this in view, the Ministry of Petroleum and Natural Gas in 1986 constituted a Safety Council assisted by the Oil Industry Safety Directorate (OISD) staffed from within the industry in formulating and implementing a series of self-regulatory measures aimed at removing obsolescence, standardising and upgrading the existing standards to ensure safe operations. Accordingly, OISD constituted a number of functional committees of experts nominated from the industry to draw up standards and guidelines on various subjects.

The present document on "Inspection & Maintenance of Thermal Insulation", has been prepared by the Functional Committee on "Thermal Insulation". This document is based on the accumulated knowledge and experience of industry members and the various national and international codes and practices. This document is meant to be used as supplement and not as a replacement for existing codes and practices. It shall be borne in mind that no standard can be a substitute for the judgment of a responsible qualified Engineer. Suggestions are invited from the users after it is put into practice to improve the document further. Suggestions for amendments to this document should be addressed to

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These documents are intended only to supplement and not replace the prevailing statutory requirements.
# FUNCTIONAL PANEL ON THERMAL INSULATION

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In addition to the above, various other experts from the industry contributed in the preparation, review and finalisation of this document.
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INSPECTION AND MAINTENANCE OF THERMAL INSULATION

1.0 INTRODUCTION

The need for effective and efficient thermal insulation has become more important with increasing energy costs & higher operating temperatures. The requirement to keep a product at the appropriate temperature is necessary either due to process requirements or to maintain the flow characteristics. These liquids lose their heat energy through metal surfaces in which they are contained or flowing. As this heat loss amounts to the loss of energy, methods to minimise these losses need attention. The minimisation of heat loss can be achieved by judicious application and maintenance of thermal insulation. It also serves the purpose of reduction of pressure relief loads in event of fire.

2.0 SCOPE

This standard lays down the minimum inspection/ maintenance practices and procedures adopted for external hot & cold insulation on static/ rotary and mobile equipment/vessels and pipelines in oil and gas industries. The standard also covers in brief inspection checks at the time of installation. The design aspects like need for providing insulation at particular location do not fall under the scope of this standard.

3.0 DEFINITIONS:

3.1 Hot & Cold Insulation:

For the purpose of this standard, insulation material used at service temperature of approx. 5°C and below are termed as “Cold Insulation” whereas, insulation material for service temperature of approx. 60°C and above are termed as “Hot Insulation”.

3.2 Prefomed Insulation:

Thermal insulating material which is prefabricated in such a manner that at least one surface conforms to the shape of the surface to be covered and which, when handled, will maintain its shape without cracking, breaking, crumbling or permanent deformation.

3.3 Blanket Insulation:

A flexible insulating material composed of felt fibrous material without binder, but reinforced with confining media.

3.4 Block Insulation:

Straight or segmental blocks of board insulation with or without facing and with or without attachment for application purposes.

3.5 Fibrous Insulation:

Insulation material composed of filaments generally circular in cross section and of length considerably greater than the diameter.

3.6 Moisture Barrier:

Material used to restrict the transmission of water/vapour.

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3.7 Thermal Conductivity:

The quantity of heat flow per unit time (in the steady state) through one square centimeter cross-section of an infinite piece of material, when the temperature difference between two planes normal to thermal flux and one centimeter apart is one degree unit.

4.0 HOT INSULATION

4.1 INSULATING MATERIALS

There is a wide range and choice of insulation materials used for thermal insulation. However, it is necessary that materials used should conform to relevant IS standards like IS3144 etc. for properties like chloride content, toxicity, incombustibility. Some of the commonly used insulating materials are described below:-

4.1.1 Glass Wool

Glass wool is made from molten glass in form of staple fiber, continuous filaments mattresses on semi rigid bonded slabs. It can be used for insulation on surfaces having temperature not exceeding 550°C. However when bonded the same can be used on surfaces with temperature not exceeding 400°C.

4.1.2 Mineral Wool (Rock Wool)

Mineral wool is made from molten mineral rocks by centrifugal spinning process. They can be applied to hot surfaces with temperatures not exceeding 700°C both as blanket and preformed sections.

4.1.3 Ceramic Fibers

Ceramic fibers are made by spinning or blown process by making fibers out of molten Aluminium Oxide and Silica (Ceramic). They are pressed to form a blanket. They are suitable for use upto temperature of 1400°C.

4.1.4 Calcium Silicate

Calcium Silicate block & pipe thermal insulation are composed principally of hydrous calcium silicate reinforced with mineral fibers (except slag wool). It is suitable for temperatures upto 800°C.

4.2 PROCEDURE FOR APPLICATION OF HOT INSULATION

Effectiveness and better operational life of an insulation depends on the way it has been installed. An improper installation may not only lead to higher heat losses and reduced life, but also it may lead to corrosion of insulated surfaces. Following minimum standards are recommended for installation of insulation on equipment, storage tanks and pipelines.

4.2.1 Surface Preparation And Paint Application

The surface to be insulated shall be cleaned thoroughly by solvent cleaning/ thorough wire brushing or pressure blasting.

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Based on service conditions, metallurgy and environment, an appropriate primer/paint coat shall be applied immediately after surface preparation. All equipment operating below 175°C needs to be painted before insulation and also equipment likely to remain idle for longer periods need painting as per the local environmental condition and irrespective of operating temperature.

In case of repairs of thermal insulation, thorough manual cleaning may be resorted to.

4.2.2 Moisture Barrier (Aluminium Foil)

Aluminium foil of 0.1 mm thickness may be used on bare pipe/equipment as a moisture barrier and also as confining material whenever required. Aluminium foil shall not be used for inner jacketing of hot SS equipment. Moisture barrier is generally not required for equipment operating above 200°C.

4.2.3 Insulation Fixing Arrangements

Insulation shall be properly held in position by welding lugs or supporting rings at suitable intervals. Binding/strapping materials like binding wire or band strips and self-tapping screws are to be used for proper fixing of the insulating material. Lugs should be welded on the equipment before final hydrotest and stress relieving, if any.

The outside diameter of support rings should be equivalent to the outside diameter of the insulation. In order to minimise direct heat conduction through the stays, a packing of insulation shall be provided at the joint of stays and equipment.

4.2.4 Insulation fixing procedures

a) Blanket Insulation:

Blanket Insulation mattresses are wrapped on the surface to be insulated and then tied with wires to hold it in position.

After making the blanket/mattress to required thickness, G.I. chicken wire mesh shall be placed over it to give it requisite mechanical/structural strength. While wrapping blankets on surfaces, chicken mesh shall remain outside.

After wrapping blanket on surface and positioning it correctly, the joining end circumferential as well as longitudinal shall be closed with stitching using galvanised wire.

After blankets are stitched up in position, a GI wire shall be helically wrapped over it and tightened suitably. This is to give extra strength and uniform shape to the blankets.

b) Preformed/Fabricated Sections:

Preformed shapes shall fit snugly to the surfaces and shall butt closely to each other. Joints should be staggered and gaps or cavities avoided by trimming the insulation to fit. Where this is not practical, loose-fill or trowelled-in material having comparable thermal insulation properties to the main material should be used.

Where shown to be more economical or technically advantageous, the insulation shall consist of two or more layers of dissimilar materials, provided their respective temperature limits are appropriate for the duty. All multi-layer insulation shall have individual layers secured by banding, wires or by self adhesive tapes and all longitudinal and circumferential joints staggered.

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4.2.5 Procedures for Fixing Outer Cover

a) Cladding

- Thickness and metallurgy of outer cover sheet should be selected considering service consideration, metallurgy of equipment and environment.

- All the joints (longitudinal & circumferential) shall have sufficient overlap after wrapping of outer cover sheet. The overlap shall be arranged to shed water at all times. The minimum overlap is 50 mm for piping insulation and 80 mm for vessel insulation. In case of corrugated cover sheets, the overlap should at least be one corrugation on vertical joint and 80 mm on horizontal joints.

- Sheet shall be fixed using self taping screws (also known as Parker Screws) at a maximum pitch of 150 mm. Screws are not provided in case of joints needing expansion/contraction.

- Aluminium/GI cover sheets wherever required shall be fixed to insulation supports using self tapping screws.

- In vertical equipment and storage tanks, outer cover sheets shall be provided in such a way so as to avoid ingress of water at the joints.

- Outer cover sheets provided on equipment shall have their joints in such a manner so as to avoid ingress of water into the insulation.

- End covers shall be provided at the end of insulation.

- For tall columns, tanks and vertical pipelines, where extra strengthening to outer cover sheets is required, GI/ Al/SS strips or bands shall be provided.

- All openings and joints shall be properly sealed with bituminous mastic to prevent ingress of water.

- Aluminium sheets may be protected on the side in contact with the insulation with bituminous anticorrosive paint.

- Parker/tapping screws may be locked against vibration using synthetic resins.

b) Plastering

One coat of hard sealing compound of required thickness troweled to smooth finish is to be provided. The finishing layer will be of a suitable water proofing compound reinforced with additional GI hexagonal wire netting. Plastering is generally used for offsite piping.

4.3 INSULATION PROCEDURES FOR SPECIFIC EQUIPMENT/ COMPONENTS

4.3.1 Carbon/Alloy Steel Equipment

The general guideline on procedure for installation of insulation shall be as per para 4.2. However, additional care as given below shall be taken during insulation of the following:

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a)  **Pipes/ Elbows & Tees**

For Preformed Fibrous Insulation (Rigid insulation), the insulation shall be carried out with the least number of material pieces as possible. The longitudinal joints between the two segments shall be staggered.

All the circumferential joints shall be closely fitted and the gap, if any, shall be filled with insulating material.

The insulation shall be fastened using galvanised steel wire and/or strapping bands at suitable intervals. A band shall be fastened at suitable distance from either end. The ends of the binding wire shall be tightly twisted together, bent under and pressed into the surface of insulation. Strapping bands shall be crimped suitably.

In the case of Flexible Fibrous insulation, the blankets, cut to adequate size, shall be applied with the galvanised chicken wire netting on the outside and be fastened into position with galvanised wire.

The chicken wire mesh shall be stitched on to one side of insulation blankets with annealed galvanised wire.

On horizontal lines, loose support rings with stays of Carbon Steel shall be attached to the pipe at suitable intervals to support the outer cover sheets and to prevent sagging of the insulation. On vertical piping or piping inclined at more than 45° from the horizontal and where straight runs are in excess of 3mtr., an insulation support shall be provided in form of a metal ring or part ring either clamped or welded to the pipe. Alternatively, angle studs may be used to prevent downward displacement of the insulation. Support shall be located at the bottom of run and suitable interval thereafter.

For Preformed/Flexible Insulation on Elbows and Bends, Insulation material shall be mitered and shall be same as that applied on pipe. Each mitered section shall be suitably secured with wires/bands. In the case of Preformed/Flexible Fibrous Insulation on Tees, the Insulation material shall be same as that applied on pipe. Preformed pipe sections/flexible mattress shall be carefully cut and shaped around "Tee" junctions and applied to the parent pipe without the creation of voids and gaps at the junction. Insulation shall be adequately secured by wire/band.

Insulation at solid welded or clamped supports shall be cut and shaped to fit around the support and bonded securely.

b)  **Steam Traced Lines**

The steam tracing that are used with mainlines shall be held in position. The pipe and steam tracer shall then be wrapped with a galvanised hex chicken wire mesh/Aluminium foil and bound with GI wire at suitable intervals.

The insulating material, cut to adequate size, shall be provided with the galvanised chicken wire netting on the outside. An outer insulating cover shall be then provided and suitably fastened.

The section of the steam tracer that is not required to be in touch with main line shall be wrapped using 25 mm dia asbestos rope. The winding shall be tight with no gap. The grooves and notches shall be filled with quick setting plaster. After drying of plaster, bituminous weather proofing coat shall be applied.
c) Flanged Joints and Valves

Flanged joints and Valves shall be insulated with prefabricated removable aluminium covers, lined with preformed/flexible fibrous wool insulation. The insulation shall be carried out after commissioning and hot bolting of the system. Care shall be exercised to seal the gaps from where rain water may ingress.

In case of valves, the stuffing box shall be kept outside to replace the packing without damaging insulation.

d) Horizontal Equipment

The vessel shall be provided with insulation support at the horizontal center line and ring support at radial lines. The insulation supports shall be designed to prevent the channeling and entrapment of the water. These supports shall have holes/fasteners for insulation securement. Both the dish end heads may be provided with a suitable ring made of steel rod for insulation securement.

When preformed insulation is used, the insulation shall be applied with the longer dimension parallel to the axis of the equipment. Where the total thickness of the slab exceeds 75 mm, multilayer should be used and no layer shall exceed 75 mm in thickness. When blocks are applied in multiple layers, all joints in successive layers shall be parallel to the long axis and staggered between 3 o’clock and 9 o’clock position. The gaps, if any, shall be filled with insulating material.

e) Vertical Equipment

The vessel shall be provided with suitable insulation supports for insulation securement. The insulation support on vessels shall be spaced to suit the standard size of insulation but in no case shall exceed 3 mtr vertical pitch.

The insulation shall be applied on the shell, top and bottom in similar manner as described for horizontal equipment. Care should be taken while designing insulation and its support for bottom dish end.

f) Pumps, Compressors, Turbines & Irregular Surfaces

These shall be insulated with portable removable type aluminium/steel boxes lined with fibrous wool insulation.

g) Flanged Nozzle, Exchanger Channels/Covers, Manway etc.

These parts shall be insulated with removable prefabricated covers lined with preformed fibrous/flexible insulation and secured suitably.

Insulation shall be stopped short of uninsulated flanges and nozzles etc., by leaving a sufficient distance to permit withdrawal of bolts without affecting the remainder of the insulation. Insulation shall be weather proofed and sealed. The insulation shall be carried out after commissioning and hot bolting of the system. It is preferable to lead the nozzle reinforcement pads’ tell-tale holes to outside of insulation through proper connection with a 90° bend.

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h) **Vertical Storage Tanks**

Vertical storage tanks shall be provided with insulation supports. The insulation shall be applied between rings in horizontal mode. Mattress insulation shall be applied with joints tightly butted and laced together with galvanised lacing wire. The outside of the insulation shall have a galvanised chicken wire netting stitched on to one side of insulation blankets. Bottom 150 mm of the shell should not be insulated to prevent wicking action.

The protective sheeting is to be further fastened by application of strapping bands externally over it.

i) **Tank Trucks**

Mobile tank truck vessel shall be provided with insulation supports at the horizontal center line and ring supports circumferentially. ‘L’ Shaped lugs shall be welded to the tank shell for supporting the circumferential rings and providing additional supports in longitudinal direction, in addition the provision of long lugs of appropriate size welded at suitable intervals on either side to hold the insulation.

Insulation blanket of suitable thickness shall be then impaled through the lugs. The entire insulated area is then covered with GI wire netting. In order to prevent conduction between L-lugs and the circumferential rings, asbestos miller board of required thickness to be provided. Finally the outer cover sheet of aluminium is to be provided and fixed in position. Care shall be taken that all grouped lap joint of cladding shall face downwards and sealed to avoid ingress of water into the joint.

4.3.2 **Stainless Steel Equipment**

a) Inner jacketing (between metal surface and insulation) shall be carried out using austentic stainless steel foil of 0.1 mm thickness. Aluminum shall never be used for inner jacketing. If Aluminum cover sheet is used over insulation, care shall be taken to avoid contact between Aluminum and Stainless Steel.

b) Only materials that contain less than 25 PPM of Chlorides shall be used over stainless steel surfaces. However mineral wool shall not be used.

c) After application of insulation the joints & extreme ends of the weather protectors are to be sealed properly to avoid ingress of water into the insulation.

4.4 **INSPECTION**

Inspection of insulation plays a vital role to obtain desired results out of it. Inspection will guarantee that the work is carried out according to laid down norms/procedures and desired quality obtained.

4.4.1 **Inspection of New Insulation during Installation**

Inspection at following stages shall be carried out to ensure conformance to design specification.

a) **Material Inspection**

All materials used for insulation shall be inspected and checked for their conformance to relevant specifications.
b) **Welding Insulation Supports / Rings**

Only qualified welders and approved welding procedures shall be used for welding of insulation supports like lugs, rings etc. Care shall be taken not to induce any injurious defects on the equipment during welding.

c) **Surface Preparation and Painting**

The surface of equipment/pipelines to be insulated shall be prepared for application of coating of surfaces as described in 4.2.1.

The painting applied after thorough cleaning is checked for its quality and required dry film thickness.

d) **Fixing/Wrapping of Insulation**

Holding arrangement or any other fixing arrangements as required shall be inspected prior to fixing of the insulation. After wrapping of insulation it shall be checked for proper fitting, uniformity and moisture ingress, if any.

e) **Application of Moisture Barrier**

Wherever required, moisture barrier shall be applied over the fibrous insulation. After its application the same shall be inspected to ensure no left out or uncovered surfaces. While tightening tapping screws, care should be taken that moisture barrier does not get damaged.

f) **Fixing of Outer Cover**

Inspection of outer cover shall be carried out after fixing of the same on the insulated material. Following shall be checked:

- Bituminous anti-corrosive paint, where ever applicable
- Overlapping between longitudinal and circumferential cover joint.
- The pitch at which the screws are fixed.

g) **Sealing of Joint/Nozzles**

All the seal joints as well as the sealing around nozzles and locations where insulation ends shall be inspected and ensured that proper sealing is achieved.

h) **Strengthening of insulation**

Strengthening of insulation with strapping bands as required shall be inspected.

4.4.2 **Periodic Inspection of Existing Insulation**

a) **Frequency of Inspection**

i) **Visual Inspection**
Frequency of Visual Inspection shall be once a year for plants and mobile equipment, and once in 3 years for offsites. This visual inspection shall be preferably carried out before monsoon, to check for any damage/deterioration, and record the same.

ii) Comprehensive Inspection

Frequency of Comprehensive inspection shall be once in 3 Years in case of Plants and once in 5 years for offsites. The inspection should preferably coincide with M&I shutdown of the equipment.

b) Inspection Procedure

The following procedure shall be adopted for inspection of existing insulation.

i) Insulation having inspection windows

The inspection windows shall be opened, insulation material removed and the surface underneath inspected for paint failure, corrosion, etc.

ii) Inspection at random locations

Outer cover sheets shall be removed at random locations which are prone to deterioration/corrosion.

The insulation material shall be removed and the surface underneath shall be inspected for paint failure or corrosion. The insulation shall then be checked for deterioration, if any.

iii) Inspection at Corrosion Prone Location

Insulated Equipment/Pipelines operating below $120^\circ$ C are more prone to external corrosion underneath the insulation. Additional attention should therefore be given during inspection.

iv) Thermographic Inspection

Thermographic scanning may be carried out on insulated equipment/pipelines for assessing effectiveness of insulation. The surface temperatures will indicate the condition of the insulation.

v) General Remarks

After inspection and repairs if any, the inspection windows shall be refilled with insulation material and the covers fixed back securely in position.

Wherever insulation has been removed to facilitate inspection the same shall be refixed after repairs.

4.5 MAINTENANCE PROCEDURES

Like equipment, insulation also shall be checked and maintained at regular intervals. Preventive maintenance of insulation is very much necessary for safe and economic operation.

Insulation must be kept dry to remain effective. The prompt replacement of insulation, which for some reason has been removed or broken off, and the proper maintenance of the moisture barriers to keep insulation dry will result in significant saving in plant production and operational costs.

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There are many places where damage commonly occur:

a) Foot traffic which breaks the weather barrier and damages the insulation.

b) Cracks caused by expansion

c) Oil spillage ruins the weather barrier and soaks into insulation

d) Gaps on unsealed joints occur in weather barrier jacketing

e) Hot projection through the insulation

f) Shrinkage of weather barrier and subsequent cracks

g) Mechanical damage to insulation due to jobs being carried out in the near vicinity

h) Damage to insulation due to water jet during fire fighting operation

The replacement of damaged/deteriorated insulation shall be done using same type of insulation material.

A major thrust shall be give to replacement of detached/deformed Outer cover sheets.

It is better to standardise the inspection pockets on vessels, tanks and pipelines. It is also advisable to provide these pockets at the time of fresh insulation.

In case of prolonged idle period of equipment, removal of insulation may be done to avoid external corrosion underneath the insulation.

Whenever, it may become necessary to remove a large area of insulation to facilitate detailed inspection. In such cases, special care shall be taken to remove it. Aluminium sheets should be unscrewed and never torn out. Insulation blankets should be removed carefully and kept on straight flat surface. After completion of work, same material can be used for insulation purpose. However, at few locations, insulation thickness may have come down due to service over the years. In such cases, insulation thickness could be built up using fresh required extra thickness insulation material.

5.0 COLD INSULATION

5.1 INSULATION MATERIALS

5.1.1 Mineral Wool

Mineral wool is made from molten mineral rocks by centrifugal spinning process. They can be applied to cold surfaces with temperatures not below (-)100°C. both as blanket and preformed sections.

5.1.2 Expanded Polystyrene
The insulation material shall be self extinguishing with closed cell structure in accordance with IS 4671 type SE. These materials are prepared from styrene homopolymer or copolymer containing an expanding agent. They can be applied to cold surfaces with temperatures not below (-)195°C.

5.1.3 Polyurethane Foam

Polyurethane foam is used in the form of slabs or half sections of uniform closed structures, free from unreacted materials, shrinkage, distortion with a self extinguishing quality. They can be applied to cold surfaces with temperatures not below (-)180°C.

Polyurethane foam in the liquid form is also being used and application is by in-situ pouring method.

5.1.4 Cellular Glass

Cellular glass is alumino silicate cellular glass with a specially elaborated composition, totally inorganic, contains no binders. Its unique properties are as follows:

a) Water vapour proof
b) Water proof
c) Dimensionally stable
d) Non combustible
e) Vermin proof
f) Resistance to all common acids and its fumes

Due to very low coefficient of expansion, provision of expansion/ contraction joints are not necessary.

Due to this wide range of operation, and various other qualities, cellular glass is widely used for both hot and cold insulation application. For cold insulation application no vapour barrier is required. Only weather proofing to be done at the joints. They can be applied to cold surfaces with temperatures not below (-)260°C.

5.2 PROCEDURE FOR APPLICATION OF COLD INSULATION:

The following applies to all types of cold insulated equipment and piping.

5.2.1 Surface Preparation & Paint Application:

Surface of the equipment and piping shall be free of dust, foreign matter and loose paint. One coat of anticorrosive primer shall be applied over carbon/alloy steel surfaces and allowed to dry for minimum six hours before application of insulation. Austenitic stainless steel surfaces need no painting.

5.2.2 Insulation Fixing Procedures

Slabs of suitable width cut longitudinally with notch of suitable size, spaced at proper spacing so as to form a radial segment to match with the profile of the equipment. All insulation joints to be
sealed with bituminised joint sealer. When more than one layer is applied, each layer shall be bonded separately, with applicable adhesive. The joint sealer shall be applied to ends, edges of all sections, including those in the inner most layer to seal all joints. All the layers except the final layer shall be secured in position by metallic bands at suitable intervals. The final layer to be first secured by GI wire net and then with metallic bands. All the cracks/voids has to be filled up with applicable filler material.

5.2.3 Vapour Barrier:

A Wet coating of vapour seal mastic is applied on the surface of insulation immediately after application and then glass cloth of open weave is to be laid over the surface and embedded in the mastic. Care to be taken to ensure that the glass cloth is laid smooth and free from wrinkles and no pockets of air are trapped beneath the surface. At junctions in the glass cloth, suitable overlap to be provided. A second coating of mastic shall be applied after approximately twelve hours. Care must be taken to ensure that individual coats are not thicker than 3mm (especially in corners), otherwise some cracking of dried coat may result.

Vapour barrier shall be protected by cladding with aluminium/GI sheets to be secured by aluminium/GI bands after the vapour barrier is completely dried up. Self tapping screws shall never be used to secure cladding as they may puncture the vapour barrier.

Hence the following should be ensured:

a) There is no puncture in the vapour barrier

b) Mastic vapour barrier should be applied to uniform design thickness

c) Joints should be overlapped and sealed adequately

d) Where insulation has to be terminated, vapour barrier should be flushed over all the way upto the surface.

5.2.4 Contraction Joints :

When specified on a pipeline or vessel drawing or where deemed necessary to allow movement and contraction of the pipe or vessel without producing random cracking of the insulation, contraction joints shall be provided in the insulation. At contraction joint location, provision is made in cladding to accommodate contraction of pipe or vessel.

5.2.5 Procedure for Fixing Outer Cover

a) Cladding

- Cladding/Outer cover material is generally Aluminium/GI sheet.
- All the joints (longitudinal & circumferential) shall have sufficient overlap after wrapping of outer cover sheet.
- Aluminium sheeting shall be secured in position by tensioned metallic bands installed circumferentially in case vapour barrier has been applied. In case where vapour barrier is not used, cladding is fixed using self tapping screws.

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Aluminium cover sheets provided on equipment shall have their joints in such a manner so as to avoid ingress of water into the insulation.

End covers shall be provided at the end of insulation.

For tall columns, tanks and vertical pipelines, where extra strengthening to outer cover sheets is required, GI/Al strips or bands shall be provided.

All openings and joints shall be properly sealed with bituminous mastic to prevent ingress of water.

Aluminium sheets may be protected on the side in contact with the insulation with bituminous anticorrosive paint.

b) Plastering

One coat of hard sealing compound of required thickness trowelled to smooth finish is to be provided. The finishing layer will be of a suitable water proofing compound reinforced with additional GI hexagonal wire netting. Plastering is generally used for offsite piping.

5.3 INSULATION PROCEDURES FOR SPECIFIC EQUIPMENT/COMPONENTS

5.3.1 Using Insulation Slabs:

The general guidelines on procedure for installation shall be as per Para 5.2. However additional care should be taken during installation of the following:

a) Vertical Vessels:

i) Top Heads

Slab insulation sections to be installed on top head, bonded and butted tightly to each other. Insulation shall be held in position by use of suitable supports. The insulation shall be held in position by use of the radial metallic bands, one end of which shall be fastened to the floating ring and the other end shall be anchored to the bands placed around the cylindrical section close to the head. Radial bands shall be properly spaced measured around the circumference of the vessel.

The final layer of insulation shall be held in position also by metallic wire net laced at the nozzle location by 2-3 loops of galvanized wire and to the wire net over insulation on the shell of the cylindrical section close to the head.

When there exists no nozzle of the top of the vortex, the insulation shall be held in position by wire netting and metallic bands stretched and anchored on the cylindrical section close to the head by circumferential metallic bands on the shell and near the head.

ii) Bottom Heads

In all the skirt supported vessels, insulation supports are provided inside the skirt.

Suitable supports around the nozzle and bonds shall be used to support downward falling of insulation.

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It the nozzle is not existing, metallic bands to be stretched across the bottom head and anchored with lagging support angle ring inside the skirt. All the wire ends of wire netting shall be cut short and turned into the insulation.

Cladding jacket shall be secured in position by radial tensioned metallic bands anchored suitably.

Openings in metal jackets for nozzles, manways, brackets etc. shall be cut as close as possible for a snug fit. Sufficient space should be provided for maintenance of flanges.

b) **Horizontal Vessels**

Care should be taken to keep all the longitudinal joints in the aluminium sheet below the horizontal plane passing through the axis of the vessel to prevent water or other spillage from entering into the insulation.

Openings in metal jackets for nozzles, manways, brackets etc. shall be cut as close as possible for a snug fit.

c) **Spherical Vessels**

Insulation to be applied shall be shaped according to the contour of the sphere and bonded to the vessel with applicable adhesive.

All insulation joints should be sealed with joint sealer. The inner layer of insulation shall be held in position by aluminium bands. These bands are tied up with the floating rings made of SS rod at the top & bottom of the sphere. The bands shall be staggered at successive layers and the clips of the bands recessed into the insulation. Over the outermost layer galvanised wire netting shall be spread over and laced together.

Aluminium cladding of each hemisphere of spherical vessel shall be done with aluminium sheets placed horizontally and a thick circumferential tensioned band shall be used at the equator to hold the radial metallic bonds.

d) **Heat Exchangers**

Heat Exchanger shells shall be insulated exactly in the same manner as indicated for the vessels. Only exchanger channels, channel covers including flange bolting shall be insulated with removable aluminum covers lined with insulation slabs of required thickness.

e) **Machinery**

In general wherever cold insulation is required, aluminum boxes lined with slab insulation of adequate thickness shall be used for insulation of machinery after giving a coat of anticorrosive paint.

f) **Piping**

i) **Horizontal Piping:**

Application of cold insulation methods are same as indicated for horizontal type vessel shells. Insulation of piping shall be stopped short of flanges to allow for withdrawal of bolts for maintenance. For pipe fittings, the insulation shall be completed by applying cut segments of the same insulation sections used for pipes. For long run pipes, the ends of

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insulation section shall be sealed off at proper intervals and vapour barrier to be carried out upto the metal surface at the point of sealing. Contraction joint shall be provided at proper intervals.

ii) Vertical Piping

The procedure is same as indicated for horizontal piping. Only insulation supports/spacer rings be provided at adequate intervals.

iii) Pipe Supports and Hangers

In all the supporting arrangements of both horizontal and vertical piping, dry hard wood pipe support bearing blocks coated with fire retardant paint/mastic shall be used. Metal cradles, metal pipe supports, hangers shall be attached to outside of the pipe support bearing blocks and not directly to bare pipe. Provision to be made to prevent seepage of water into the insulation from pipe hangers.

iv) Flanges and Valves

Removable type covers shall be provided over all flanges and valves. These covers should be fitted with quick release clips.

v) Cold Insulation of Piping at or below Ground Level

For cold insulation of piping at or below ground level or where there is likelihood of foot traffic, instead of providing aluminium cladding over the final layer of vapour barrier, bituminised self finishing roofing felt confirming to IS-1322 type-3 grade-I shall be wrapped over the final layer of vapour barrier after it has fully dried with sufficient overlap both on longitudinal and circumferential joints. The roofing felt shall be secured with the G.I. wire netting laced with GI wire. A 3mm coat of bitumen emulsion mastic shall be applied for water and weather proofing. When bitumen emulsion has completely dried, the surfaces to be painted with two coats of bitumen based aluminium paint.

g) Stainless Steel Piping and Equipment

All pipes, vessels and equipment of stainless steel construction to be wrapped with aluminum foil (moisture barrier) with adequate overlap having barium chromate sealer interposed in the joint prior to application of insulation. Foil shall be secured in position by Aluminum bands, taking every precaution to avoid formation of pin holes or cracking in the aluminium foil. Aluminium/GI cladding to be done after providing the insulation and vapour barrier as described earlier.

5.3.2 Using In-situ Pouring Method

In-situ pouring of cold insulating material like Polyurethane foam is particularly used for the following:-

a) Where complicated shapes are involved which would not lend themselves to easy insulation treatment using preformed rigid materials.

b) Where a joint free insulation is desirable or where the number of joints to be kept to a minimum. The chances of damage of weather sealing are less.
c) Where very high disbonding stresses are to be encountered by the insulation system.

With the help of special spray gun the insulation material can be sprayed in-situ for storage tanks, vessels, columns, exchangers, piping, flanges, valves etc. After getting the required thickness the insulation material should be allowed to be dried up. After complete drying up the application of vapour barrier and aluminium cladding will be similar as that indicated for general cold insulation application.

This should be carried out as per IS-13205 (Latest Edition.)

5.4 INSPECTION

Inspection of insulation plays a vital role to obtain desired results out of it. Inspection will guarantee that the work is carried out according to laid down norms/procedures and desired quality obtained.

5.4.1 Inspection of New Insulation during Installation

Inspection at following stages during installation shall be carried out to ensure conformance to design specification. All the materials used for insulating surface shall be inspected and checked for their conformance to specifications as specified.

a) Welding Insulation Supports / Rings

Only qualified welders and approved welding procedures shall be used for welding of insulation supports like lugs, rings etc. Care shall be taken not to induce any injurious defects on the equipment during welding.

b) Surface Preparation and Painting

The surface of equipment/pipelines to be insulated shall be prepared for application of coating of surfaces as described in 5.2.1.

The painting applied after thorough cleaning is checked for its quality and required dry film thickness.

c) Fixing/Wrapping of Insulation

Holding arrangement or any other fixing arrangements as required shall be inspected prior to fixing of the insulation. After wrapping of insulation it shall be checked for proper fitting and moisture ingress.

d) Application of Moisture Barrier

Moisture barrier shall be inspected for its thickness after its application and also no holiday or uncovered surfaces should be ensured.

e) Fixing of Outer Cover

Inspection of outer cover shall be carried out after fixing of the same on the insulated material. Following shall be checked:
• Bituminous anti-corrosive paint, wherever applicable
• Overlapping between longitudinal and circumferential cover joint and sealing of joints
• Securing of cladding in position using proper fixing arrangement

f) Sealing of Joint/Nozzles

All the seal joints as well as the sealing around nozzles and locations where insulation ends shall be inspected and ensured that proper sealing is achieved.

5.4.2 Periodic Inspection of Existing Insulation

a) Frequency of Inspection

i) Visual Inspection

Frequency of Visual Inspection shall be once a year for plants and mobile equipment, and once in 3 years for offsites. This visual inspection shall be preferably carried out before monsoon, to check for any damage/deterioration, sweating of cladding sheet, ice-formation and record the same.

ii) Comprehensive Inspection

Frequency of Comprehensive inspection shall be once in 5 Years. The inspection should preferably coincide with M&I shutdown of the equipment.

If during plant operation some of the cold insulation cladding joints are found covered with green algae formation or some of the places on the cladding are found sweating, then during turnaround/shutdown, these areas to be exposed completely and a comprehensive inspection of the area is required to be carried out.

b) Inspection Procedure

The following procedure shall be adopted for comprehensive inspection of existing insulation.

i) Continuous Insulation

Outer cover sheets shall be removed at locations where deterioration is recorded during plant operation or which are prone to detoration/corrosion.

The insulation material shall be removed and the surface underneath shall be inspected for moisture barrier failure or corrosion. The insulation shall then be checked for deterioration, if any.

ii) Refixing of Insulation

After inspection and repairs if any the inspection windows shall be refilled with insulation material and the covers fixed back securely in position.

Wherever insulation has been removed to facilitate inspection the same shall be refixed after repairs.

5.5 MAINTENANCE PROCEDURES

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Like equipment, insulation also shall be checked and maintained at regular intervals. Preventive maintenance of insulation is very much necessary for safe and economic operation.

Due to ice formation at the bare surface during plant operation, application/repair of cold insulation is not possible unless deicing and drying the exposed surface completely are carried out after taking shut down.

The replacement of damaged/deteriorated insulation shall be done using similar type of insulation material.

A major thrust shall be given for replacement of detached/deformed Outer cover sheets.

In case of prolonged idle period of equipment, removal of insulation may be done to avoid external corrosion underneath the insulation.

Whenever, it may become necessary to remove a large area of insulation to facilitate detailed inspection. In such cases, special care shall be taken to remove it. Aluminium sheets should be unscrewed and never torn out. Insulation blankets should be removed carefully and kept on straight flat surface. After completion of work, same material can be used for insulation purpose. However, at few locations, insulation thickness may have come down due to service over the years. In such cases, insulation thickness could be built up using fresh required extra thickness insulation material.

During turn around/shutdown, wherever the cold insulation are required to be removed (like various strainers and its spool pieces, covers of heat exchangers, pumps, compressor and other equipment, flanges, NRVs, valves etc.) the same shall be reinsulated after completion of the job and before start-up of the plant.

It is not advisable to provide inspection pockets/ windows for cold insulation, as this will tend to increase the chances of ingress of water vapour, moisture, toxic acid fumes etc. and ultimately damage the insulation/parent material.
6.0 References

i) Piping Handbook (Chapter 6) on Thermal Insulation by E.J. Wesemann

ii) UOP 9-11-0 on External Thermal Insulation

iii) BS 3958 on Thermal Insulation Material

iv) IS 13205:1991 Code of Practice for the application of Polyurethane insulation by In-situ Pouring Method