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KLM Technology Group #03-12 Block Aronia, Jalan Sri Perkasa 2 Taman Tampoi Utama 81200 Johor Bahru Malaysia	INSULATION OF PIPING & EQUIPMENT (PROJECT STANDARDS AND SPECIFICATIONS)	

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SCOPE

This Project Standard and Specification gives the minimum requirements for the thermal and personnel protection insulation of piping and equipment (vessels, heat exchangers, pumps, etc) and method of application.

Equipment and piping shall be insulated for the purposes of conservation of heat, maintenance of stabilized process temperatures during atmospheric temperature changes, condensation prevention, burn prevention of personnel or limiting noise levels according to the classification nominated.

REFERENCES

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

- ASTM C165 Test Method for Measuring Compressive Properties of Thermal Insulation
- ASTM C195 Mineral Fibre Thermal Insulating Cement
- ASTM C303 Test Method for Density of Preformed Block Type Thermal Insulation
- ASTM C335 Test Method for Steady-State Heat Transfer Properties
- ASTM C449 Mineral Fibre Hydraulic Setting Thermal Insulation and Finishing Cement
- ASTM C518 Test Method for Steady-State Heat Transmission Properties
- ASTM C547 Mineral Fibre Pre formed Pipe Insulation
- ASTM C552 Cellular Glass Block and Pipe Insulation
- ASTM C591 Un-faced Preformed Rigid Cellular Polyurethane Thermal Insulation
- ASTM C592 Mineral Fibre Blanket Insulation
- ASTM C612 Mineral Fibre Block & Board Thermal Insulation
- ASTM D1621 Test Method for Compressive Properties of Rigid Cellular Plastics
- ASTM D1622 Test Method for Apparent Density of Rigid Cellular Plastics

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- ASTM D2126 Test Method for response of Rigid Cellular Plastics to Thermal & Humid Aging
- ASTM D2826 Test Method for Open Cell Content of Rigid Cellular Plastics
- ASTM D3014 Test Method for Flame Height, Time of Burning & Loss of Mass of Rigid Thermoset Cellular Plastics in a Vertical Position
- ASTM E84 Test Method for Surface Burning Characteristics of Building Materials
- ASTM E96 Test Method for Water Vapour Transmission of Materials

ENVIRONMENTAL DESIGN CRITERIA AND UTILITIES

Design Basis Climatic Conditions

Designs shall be based on outdoor exposure to the conditions described as normal atmospheric conditions. Conditions specific to the relevant Equipment Package & process parameters related to piping will be detailed by the contractor on individual Equipment Data Sheets as per approved P&ID's on the basis of process design criteria attached in bid package and the same shall be submitted to the company for review.

Design Life

The process facilities design life requirement is 25 years.

GENERAL REQUIREMENTS

The Supplier's standard designs (if applicable) which meet the performance requirements and which will operate in the marine environment for 25 years may be considered with prior approval of Company.

Items Requiring Insulation

1. Items shall be insulated for the purpose of conservation of heat, temperature stabilization, personnel protection, condensation prevention (anti-sweat) or limiting noise levels.
2. Piping and equipment operating with fluid temperature in excess of 54°C or below 10°C shall be insulated as burn or freeze protection for personnel to a height of 2.1m above grade and platforms and 0.6m outside the platforms,

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walkways, etc. with the exception that lines operating above 200°C shall be fully insulated.

3. Heat transfer equipment in hot services, other than coolers and condensers, shall be completely insulated except for supporting members and flanges. Shell flanges, channel flanges and nozzle necks shall not be insulated. Nozzle necks shall be insulated to the nozzle flanges.
4. All piping and equipment operating with fluid temperatures below 27°C shall be insulated for condensation prevention ("anti-sweat"). Nozzles, components and appurtenances shall be insulated and covered with vapor barrier and weatherproof cladding.
5. All accessories (such as level controllers, level gauges, pipe bridles, etc) which are attached to insulated equipment shall be insulated with equivalent thickness and materials required for the equipment. The insulation shall not obstruct operation or necessary viewing of equipment components, drains, vents and sample points.
6. Piping that is considered a potential source of noise should be acoustically insulated.

Exclusions

The following hot parts shall not be insulated, except for burn protection:

- Man ways, manholes and inspection openings on hot vessels.
- Code inspection plates and nameplates
- Connectors and tube unions on fin-tube heat exchang
- Flanges of piping and equipment in hot service
- Expansion and rotating joints

MATERIALS

General

All new materials shall be used. Materials showing any evidence of containing contamination or moisture shall not be used.

Insulation materials for equipment and piping shall be suitable for the application, operation, and temperature and be compatible with the contained fluids.

Insulation materials shall have the following properties:

- Completely free from all forms of asbestos.
- Water-soluble chloride and fluoride ion concentrations as low as possible, 20ppm by mass maximum.
- Chemically neutral, with pH preferably between 7 and 8 in the wet condition.

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- Non-combustible and odorless at operating temperatures.
- Have sufficient compressive strength that the method of fixing and finish shall not damage the insulation.

Phenolic and polyisocyanurate (polyurethane) foams shall not be used for services, which may exceed 100°C because these produce toxic smoke when burning.

Any wire mesh reinforcement shall be stainless steel grade 316L.

Classifications

The Line schedule and the Piping and Instrument Diagrams shall indicate the thickness and insulation classification required.

The following insulation classifications are described in this Specification:

- **C** Low temperature insulation designated for processes with operating temperatures below 21°C where heat gain is undesirable, or for the prevention of condensation on pipes and equipment with operating temperatures below 27°C.
- **H** Heat conservation insulation designated for all processes (except heat transfer fluids) with operating temperatures at or above 25°C.
- **PP** Personal protection insulation designated for equipment and vessels with operating temperatures in excess of 54°C or below 10°C.

Materials for Low Temperature Services (Class C)

The following materials shall be used for piping and vessel insulation for Class C:

- Preformed or foamed-in-place polyurethane for piping up to and including DN900.
- Polyurethane blocks, segments or foamed in place sections for piping and vessels greater than DN900.

Polyurethane foam shall conform to ASTM C591, Type 11, with a flame spread rating not exceeding 25 in accordance with ASTM E84. Higher density and higher strength foam may be used as load bearing insulation if the properties are approved.

Insulating material used on austenitic steel surfaces shall contain less than 20ppm leachable chlorides and a minimum of 20ppm sodium silicate for each part per million of leachable chlorides.

Foamed in place polyurethane foam shall, as a minimum, conform to the following:

- Density of the core shall be between 30 and 35kg/m³.

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- Thermal Conductivity shall not exceed 0.019 W/mK when the foam is new and cured. This value shall be based on a mean temperature of 25°C as determined in accordance with ASTM C518.
- Flammability shall be guaranteed to have a flame spread classification not exceeding 75 in accordance with ASTM E84.
- Compressive Strength in accordance with ASTM D1621 shall be not less than 170kN/m.
- Closed Cell Content shall not be less than 90%. The cell structure shall be uniform throughout the core and the average cell size shall be no more than 0.40mm. Elongated cells shall be no longer than three times the smallest dimension. These requirements are to be verified in accordance with ASTM D2856, Procedure A.
- Dimensional Stability :the maximum volumetric change shall not be more than 6% after 7 days exposure at 75+3°C and 100+0/-3% relative humidity in accordance with ASTM D2126.
- The permeability shall not exceed 2.5perm in accordance with ASTM C335.
- Friability: A 6mm cube, when properly cured, shall not powder when crushed.
- Vapor barrier coatings shall cover insulation completely before weatherproofing is installed and have the following characteristics:
 - o They must be compatible with the process piping insulation
 - o They must be flexible at the lowest temperature to which they are exposed
 - o Permeability shall not exceed 0.03 perm in accordance with Procedure E of ASTM E96 for the thickness used.
 - o Minimum dry film thickness shall equal or exceed 0.76mm
 - o Flame spread rating shall not exceed 30 in accordance with ASTM E84.
 - o They shall be weatherproof and non-absorbent and shall constitute a vapor barrier.

Material for Heat Conservation Insulation (Class H)

The following materials shall be used for piping and equipment insulation for Class H:

- For equipment and piping which is to be operated intermittently or continuously at temperatures not exceeding 100°C, the insulation may be rigid urethane foam.
- For equipment operated intermittently or continuously above 100°C or for acoustic insulation applications, the insulation may be calcium silicate. Calcium silicate insulation which contain asbestos filler shall not be acceptable.

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- For equipment and piping which is to be operated intermittently or continuously at temperatures up to 260°C, primary insulation may be foam glass complying with ASTM C552 and with density of at least 88kg/m³ and a temperature rating of 315°C.
- For equipment and piping which is to be operated intermittently or continuously at temperatures up to 500°C, the insulation may be mineral wool with temperature rating of 500°C. All mineral wool shall be water repellent and tested for water absorption and retention.

Mineral wool blankets for piping and vessels greater than DN900 shall conform to ASTM C592. They shall have density of at least 128 kg/m³ and shall be faced with wire mesh inside and either wire mesh, expanded metal, or glass mat outside.

Mineral wool preformed sections shall be used for piping larger than DN40 and up to and including DN900. They shall conform to ASTM C547, have density of at least 160 kg/m³ and shall be faced with wire mesh inside and wire mesh or glass mat on the outside.

Mineral wool blocks and boards shall conform to ASTM C612. Their minimum nominal density shall be 160 kg/m³.

Materials for Personnel Protection (Class PP)

Piping, vessels and equipment operating at a temperature of 54°C and above, or below 10°C for a cold service and not falling within any other insulation category, shall be protected by Stainless Steel metal mesh guard or similar protective material. The minimum distance between hot or cold surfaces and guarding shall be 32 mm.

Where this is not practical, thermal insulation, Class H or C as appropriate, shall be applied.

Sealers & Accessories

Flashing compounds, joint sealers and bedding compounds shall be permanently flexible through a temperature range of -18°C to 500°C, be capable of withstanding repeated expansion and contraction without cracking and experience minimum shrinkage.

All metal accessories shall be stainless steel.

Wire to secure insulation shall be a minimum of 1.2 mm annealed stainless steel. Heavier stainless wire or cable shall be used for insulation on vessel heads where floating rings are employed.

Expander bands shall be capable of remaining in tension during the heating and cooling cycles experienced during normal operation.

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Breather springs for bands (if used) shall be capable of remaining in tension during the heating and cooling cycles experienced during normal operation. Screw fasteners shall be stainless steel, self-tapping with pan heads. Wire mesh for cement reinforcement shall be 25 mm hexagonal mesh with 0.8mm diameter Monel or stainless steel wire. Mineral wool insulating cement shall meet the requirements of ASTM C449, and be suitable for temperatures up to 315°C. Finishing cement shall be asbestos free, meet the requirements of ASTM C449 and shall be suitable for temperature upto 315° C. It shall be fast drying cement that provides smooth, hard surfaces when dry. The cement shall contain a corrosion inhibitor to prevent corrosion when wet.

Materials for Weather Proofing & Ancillaries

1. General

Jacketing materials for vessels, equipment and piping shall be stainless steel grade 316L, corrugated in accordance the thickness and corrugation requirements as follows:

- Aluminium sheets as per ASTM B209 for piping, for vertical vessels with 0.40mm thick with 32mm corrugations and for all horizontal vessels, shall be 0.40mm thick with 5mm corrugations.
- Aluminium shall be epoxy coated on exterior surface for all services and for all services and

Jacketing shall be installed and supported to withstand direct fire hose stream impingement, site and climatic conditions.

2. Pipe work & equipment less than DN900

Stainless steel jacketing used for pipework shall be so arranged that it shed water at all times. Overlaps shall be swaged and rendered watertight. Bands for piping shall be at least 12mm wide x 0.4mm thick and secured with wing type seals.

Jacketing for flange, valve and in-line instrument boxes shall be fabricated from stainless steel flat sheet as used for cladding of the adjacent pipework and shall be built in at least two parts. Joints in the jacketing at pipe tees, branches, welds, etc. shall be sealed with stainless steel segmented flashing or preformed sections and metal seam sealant.

3. Piping & equipment greater than DN 900

Panels on vessels and large diameter equipment shall be held tight over the insulation by means of 316SS circumferential metal bands and attachment to insulation support rings. Panels shall have minimum overlaps of 100mm for

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vessels and 50mm or pipes. All overlaps, which are not subject to thermal expansion, shall be rendered watertight by use of a metal seam sealant.

Bands shall be positioned on all horizontal overlaps and at 300mm centers maximum. The bands shall be held in their relative positions with clips fitted to jacketing at suitable centers. Bands for equipment and vessels shall be at least 19mm wide x 0.5mm secured with wing type seals. Breather springs with flat bands shall be used where required for expansion or contraction.

Vessel head jacketing shall consist of preformed flat stainless steel sheets in a 'segmented' construction with all radial seams overlapping. The exact method of construction shall be made available to the Company for review.

The Supplier shall propose details of methods of attachment and support of jacketing.

The vessels, nozzles and piping shall have removable plugs in insulation lining for facilitating of thickness check (ultrasonic) of wall during lifetime of vessel. Typical drawings for the same are enclosed. Plug shall be made with the compatible materials. For nozzle pocket (plug) shall be in four directions at the center of the nozzle.

INSULATION THICKNESS

The following insulation thickness are to applied to piping and equipment for the various applications:

Table 1. - Minimum thickness of insulation (mm)

Nominal Equipment Size or Diameter of Pipe	Cold to 100C	Aco stic	Burn* r Freeze Stabilin	20 to 70	71 to 100	101 to 200	201 to 300	301 to 400	401 to 500
DN40 & smaller	40	75	25	25	25	40	50	75	90
DN50 to DN100	50	75	25	25	40	50	75	100	120
DN150	50	75	25	25	40	65	75	115	140
DN200 & larger	65	75	40	40	40	80	100	145	170

* For line temperature greater than 301 deg. C, the burn protection insulation thickness shall be as specified for conservation of heat.

Where the insulation thickness requirement exceeds 80mm, the insulation shall be applied in not less than two staggered layers.

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INSTALLATION

Application of Low Temperature Insulation (Class C)

1. Items requiring insulation

All pipe, valves, flanges and fittings shall be insulated. Valves shall be insulated to the packing gland.

Vessel and exchanger flanges, manhole covers, and all appurtenances shall be insulated. All attachments to the vessel or exchanger such as skirts, supports, ladder and platform clips, etc. shall be covered with insulation for a distance of three (3) times the basic insulation thickness, with the vapour barrier continuing and sealing to the metal.

2. General application

Insulation shall not be applied until welds have been inspected, the piping system has been pressure tested, and all related piping and equipment has been painted.

The insulation manufacturer's installation recommendations shall be followed. In the event of conflict between manufacturer's recommendations and this Specification, the former shall govern.

Piping, vessel and equipment insulation thickness shall be as shown above. The thickness listed is those required to prevent condensation forming on the insulation surface at 20°C and a relative humidity of 85%.

3. Piping application

Contraction joints shall be provided on straight runs of piping at 10m intervals. Insulation supports shall be provided on vertical piping immediately above each pair of flanges and at contraction joints.

Pipes, valves and fittings shall be fitted with preformed insulation and secured in place with bands placed on 230mm centers. Joints are to be snugly butted together and sealed with joint sealer. Voids between fittings and fitting covers shall be filled with glass fibre insulation.

Insulation shall be installed around valves and flanges so as to allow removal and re-use without damage to the insulation or jacketing.

Pipe, fittings and valves of insulated lines shall be weatherproofed with a metal jacket. The jacket shall be secured with bands on 230mm centers. A band shall be applied over each circumferential lap joint.

4. Equipment application

Insulation shall be installed around access hatches, inspection hatches, manholes and exchanger tube sheet flanges, vents, drains and sample points