

Clarification No.04

Tender No PROC/LF/PT/P&P/17650/19 - Supply & Fabrication Lean Rich Glycol Heat Exchanger at Qadirpur Plant

| Query | OGDCL Reply |
|--|--|
| Can we use Pipe (SA 106 Gr B) instead of Shell plate (SA 516 GR 70) as rolling to required size is not feasible; please confirm? | Pipe of SA 106 Gr. B material can be utilised. |
| Kindly confirm the Shell, tube sheet, girth flanges and flanges material origin. | Origin of material is as per TOR |
| As per our understanding we consider only supply and fabrication of heat exchanger without skid and piping works please confirm. | Supply of fabrication of heat exchanger skid mounted without piping works. |



Oil & Gas Development Company Ltd

SPECIFICATION FOR SHELL & TUBE HEAT EXCHANGER DOCUMENT NO.4929-DS-001

Consultant:

April 2018



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1.0 INTRODUCTION

1.1 GENERAL

This Specification covers the minimum requirements for the design, manufacture, supply, inspection, testing and commissioning of Shell & Tube Heat Exchangers.

1.2 DEFINITIONS

Following definitions apply throughout this document:

| | |
|-------------------|--|
| Company / Owner | Oil and Gas Development Company Limited (OGDCL) |
| Contractor | “Contractor” means the person or persons, firm or Proprietor whose proposal has been accepted by the Company for engineering design, verification of engineering design, procurement, inspection, testing and shipment of heat exchanger and one year of defectliability period. |
| Vendor / Supplier | The organization, firm or agency with whom order for the supply of equipment and or material has been placed. |

1.3 ERROR OR OMISSIONS

The review and comment by the COMPANY of any CONTRACTOR / VENDOR’s drawings, procedures or documents shall only indicate acceptance of general requirements and shall not relieve the CONTRACTOR / VENDOR of its obligations to comply with the requirements of this specification and other related parts of the Contract Documents. Any errors or omissions noted by the CONTRACTOR / VENDOR in this Specification shall be immediately brought to the attention of the COMPANY.

1.4 DEVIATIONS

All deviations to this Specification, other related specifications or attachments shall be brought to the knowledge of the COMPANY as section in the bid. All deviations made during the procurement, design, manufacturing, testing and inspection shall be with written approval of the COMPANY prior to execution of Work. Such deviations shall be shown in the documentation prepared by the CONTRACTOR / VENDOR.

1.5 CONFLICTING REQUIREMENT

In the event of any conflict, inconsistency or ambiguity between the CONTRACTOR / VENDOR's scope of work, this Specification, Codes & Standards, referenced in the Specification or any other documents, the CONTRACTOR / VENDOR shall refer to the COMPANY whose decision shall prevail.

1.6 REPORTING PROCEDURE

A reporting and documentation system shall be agreed between the CONTRACTOR / VENDOR and the COMPANY for the status of procurement, design, manufacturing, inspection, testing and shipment of the equipment/material to be supplied under this specification. CONTRACTOR / VENDOR shall provide reports and summaries for production performance and testing operations in conformance with a manufacturing schedule approved by COMPANY. Daily, weekly, monthly and run summaries of all major aspects of the production process shall be provided as reports to the COMPANY.

In addition to the inspection and witnessing of tests by the inspectors to be appointed by the CONTRACTOR / SUPPLIER during the manufacturing and shipment of the equipment/material, COMPANY may appoint a THIRD PARTY or its own inspector for witnessing of the inspection and tests to be carried out at CONTRACTOR / SUPPLIER'S facility under this specification.

1.7 UNIT RESPONSIBILITY & THIRD PARTY INSPECTION

The CONTRACTOR / VENDOR shall be responsible for the complete design, supply, fabrication, inspection and testing of the Shell & Tube Heat Exchanger, including full compliance with all applicable design codes and standards listed in Section 2.0, of this document, all project specifications, datasheets, P&IDs and with the requirements of the certifying authority, if applicable. The CONTRACTOR / VENDOR shall handle and expedite drawings and data, and supervise and coordinate all inspection and testing.

CONTRACTOR / VENDOR shall guarantee that all materials and parts included in construction of the specified Shell & Tube Heat Exchanger shall be new, unused and of the required/ specified grade.

1.8 DOCUMENTATION

- a) Documents, calculation sheets, drawings, etc., to be submitted to the COMPANY shall be in the English Language.
- b) Unless otherwise specified, the U.S Customary System of units shall be used in documents and drawings, except that pipe sizes, flange sizes and bolts/nuts shall be indicated in inches.
- c) The form of fabrication drawings and documents may be as per the CONTRACTOR / VENDOR's Standards. However, the format of the data sheet will be submitted to COMPANY for approval.
- d) Fabrication drawings and documents shall be submitted for the approval of the COMPANY. But, such approval of the COMPANY shall in no way relieve the CONTRACTOR / VENDOR of his obligations with respect to such drawings and documents.
- e) Variations from or additions to this specification shall be called to the attention of the COMPANY and approved in writing by the COMPANY prior to starting fabrication.

- f) Welding procedure specification and welding qualification record shall be submitted to the COMPANY prior to the start of fabrication.

- g) Information for installation, operating, maintenance or inspection purposes shall be submitted to COMPANY.

2.0 CODES AND STANDARDS

The design, fabrication, inspection and testing of heat exchanger shall conform to ASME Code, Sec. VIII, Div. 1, "Pressure Vessels", TEMA Standard Class "R" Latest Editions. The latest edition of the following codes and standards, including applicable standards, which are referred to in the codes and this specification, shall be used as supplements.

ASME Codes

ASME Code Sec. V "Non-destructive Examination"

ASME Code Sec. IX "Welding & Brazing Qualifications"

ASME Code Sec. II "Material Specification"

ASME Code Sec. VIII Div-1 ASME Boiler and Pressure Vessel Code - Wikipedia

ASME B-Series Standards

ASME B1.1 "Unified Inch Screw Threads"

ASME/ANSI B16.5a "Pipe Flanges and Flanged Fittings"

ASME B16.20 "Metallic Gaskets for Pipe Flanges Ring-Joint, Spiral-wound and Jacketed"

ASME B16.21 "Non-metallic Flat Gaskets for Pipe Flanges"

ASME B16.47 "Large Diameter Steel Flanges"

ASME/ANSI B18.2.2 "Square and Hex. Nuts"

ANSI/ASME B36.10M "Welded and Seamless Wrought Steel Pipe"

ANSI/ASME B46.1 "Surface Texture"

ASTM Standards

"American Society for Testing and Materials";

AISC “American Institute of Steel Construction”

“Manual of Steel Construction”;

OCMA TEW 1

“Oil Companies Material Association: Recommendations for Tube EndWelding”;

TEMA

Tubular Exchanger Manufacturers Association, Inc. (TEMA)

2.1 ORDER OF PRECEDENCE FOR DOCUMENTS

In case of conflict between this specification and the above codes and standards, the CONTRACTOR / SUPPLIER bring the matter to the COMPANY'S attention for resolution and approval in writing. In all cases the more stringent requirement shall apply.

Should any conflict occur as a result of applying data sheets and specifications, the order of precedence shall be as follows:

- This Specification.
- Other referenced Project Specifications
- Codes and Standards referred to within this specification.

All deviations from the requirements of this specification, its attachments and the referenced codes and standards shall be listed as a section in the bid. In the absence of such a statement, full compliance will be assumed. Compliance by the CONTRACTOR / SUPPLIER with the provisions of this specification does not relieve him of his responsibility to furnish equipment and accessories of a proper mechanical design suited to meet the specified service conditions and/or local codes governing health and safety.

3.0 SCOPE OF SUPPLY

3.1 GENERAL

This specification sets forth the minimum acceptable standards governing the thermal and mechanical design, manufactures, supply of materials, fabrication, construction, inspection, guarantees, testing and delivery of shell and tube heat exchanger.

3.2 MATERIALS, WORKMANSHIP AND SUITABILITY

All materials and parts included in the construction of the specified Heat Exchanger shall be new, unused and of the highest grade, being free from all defects or imperfections likely to affect their performance.

4.0 ENVIRONMENTAL DESIGN CRITERIA

4.1 GENERAL

Unless otherwise stated on the data sheets, the Shell and Tube Heat Exchanger will be located in an open, exposed area.

4.2 AREA CLASSIFICATION

Exchanger will be located in a safe area unless otherwise specified in the datasheet.

5.0 DESIGN

5.1 GENERAL

The thermal and mechanical requirements shall be indicated on the heat exchanger data sheet. Design margin of 15% shall be taken into account. The maximum shell diameter shall be limited to 1200 mm (48 inches). Tube diameters and wall thicknesses shall conform to the TEMA preferred values, except that for exotic materials e.g. titanium, the wall thickness shall be subject to agreement with the COMPANY.

Straight tube lengths shall not exceed 6100 mm (20 ft) without the COMPANY'S approval. Standard lengths shall be 2500 mm, 3600 mm, 5000 mm and 6100 mm. Formed heads shall be semi-ellipsoidal with 2:1 ratio unless otherwise specified on the data sheet. Cold formed heads shall not be used without the COMPANY'S approval.

Shell and tube heat exchanger with bonnet type channels shall be provided with full diameter tube-sheet and collar bolts. All channels, channel covers and bonnets shall be provided with suitable lifting lugs attached by full penetration welds. Welded tube to tube-sheet joints shall be strength welded with the total load being carried by the weld. For tubes with wall thickness less than 2mm, the preparation shall be in accordance with Figures 2B or 3A of OCMA TEW I, Part I. Weld process shall be TIG with filler unless otherwise agreed with the Company. Tests shall be conducted on production test pieces in accordance with OCMA TEW I, including tear and pullout tests. CONTRACTOR / SUPPLIER shall ensure adequacy of ligament between adjacent welds. Due account shall be taken of differential stresses resulting from heat treatment. Flow induced vibrations must be considered for all cases, and the CONTRACTOR / SUPPLIER shall be responsible for submitting proposed methods of eliminating vibration damage, which shall be substantiated by calculations. Where cladding is specified, the relevant sections of the Project Specification for Unfired Pressure Vessels shall be met. Maximum interchangeability of components shall be provided if two or more heat exchangers have the same design conditions.

5.2 NOZZLE LOADING

| NOZZLE LOADING (INCH) | RESULTANT FORCE (N) | RESULTANT MOMENT (NM) |
|--------------------------|------------------------|--------------------------|
| 2 | 1435 | 380 |
| 3 | 2930 | 1140 |
| 4 | 4100 | 2080 |
| 6 | 7000 | 5230 |
| 8 | 10190 | 9800 |
| 10 | 13950 | 16510 |
| 12 | 16500 | 22820 |
| 14 | 17500 | 26110 |
| 16 | 19350 | 32310 |
| 18 | 21000 | 38310 |
| 20 | 22450 | 44260 |
| 24 - 30 | 24750 | 54880 |

The above table gives the resultant forces and moments induced from pipework systems, which are to be allowed. The CONTRACTOR / SUPPLIER shall consider the force acting radially together with the moment acting either in a longitudinal or circumferential direction. The CONTRACTOR / SUPPLIER shall ensure that the above loadings will not induce unacceptable stress levels in the exchanger shell, head or channel, in compliance with the relevant vessel design code. The above table does not apply to equipment nozzles within packaged units where actual loading conditions should be applied.

5.3 NOZZLES

Nozzles shall conform to the requirements of applicable codes and standards listed in section 2.0. The protection of a flanged connection shall provide adequate clearance (including insulation) when a valve is to be installed on the neck of the nozzle. The CONTRACTOR / SUPPLIER shall provide stud bolts, nuts and gaskets for interconnecting nozzles of stacked exchangers.

5.4 STACKED UNITS

Stacked units shall be assembled and mounted in the shop to ensure a correct fit. Stacked units shall be tested in the fully assembled condition. Interconnecting nozzles of stacked units shall be fitted with spiral wound gaskets, which contain a compression limiting ring. One pack (per saddle/support) of shims 10mm total shall be supplied with all stacked heat exchangers.

5.5 EXPANSION BELLOWS

Expansion bellows shall not normally be acceptable. Requirements for bellows, if specified, shall be agreed between the COMPANY and CONTRACTOR prior to order placement.

5.6 BUNDLE

U-Tubes shall have a minimum bend radius of 1.5 times the tube outside diameter. U- Tubes, where the extreme fibre strain exceeds 5 percent, shall be heat-treated. The proposed procedure for heat treatment shall be submitted to the COMPANY for approval. Tie rod maximum centres shall be 350mm, the number of tie rods to be per TEMA requirement as a minimum and the rod diameter to be 12mm (min). Tie rods shall be located around the bundle periphery except for those acting as supports for impingement plates. Impingement plates shall be 10mm (min) thickness and be rectangular in shape, the size to be based upon nozzle diameter + 50mm. An additional impingement plate shall be provided for rotatable bundles. Baffle sealing strips shall be the same material and thickness as the baffle and shall extend from edge of baffle to first tube. A 3mm gap shall be provided between tube and baffle edges. As a general guide, baffles with a 45 percent cut require only one strip. For baffle cuts of less than 45 percent 4 strips should be employed. If adequately spaced these strips can be used as bundle runners. Bundle runners shall be fitted to all removable bundles. Pulling eyes shall be fitted to the fixed tube sheet of all removable bundles. The baffle cut shall be defined to suit the thermal design requirements and shall be VEE notched top and bottom for vents and drains.

5.7 SPARES

The following shall be supplied as a minimum:

- 10% approx. spare stud bolts and nuts for each joint size, or a minimum of 4, except for bolts subject to hydraulic tensioning, where a complete set shall be included.
- Two spare sets of gaskets for all blanked connections, girth flanges and floating head connections.

5.8 SUPPORTS

Support saddles shall be designed to withstand a horizontal force, parallel to the axis of the heat exchanger of not less than 1.5 times the bundle weight. One support saddle shall have slotted holes to allow for expansion. Dynamic transportation loadings shall be considered in the design of exchangers, including support saddles. Exchangers shall withstand acceleration forces of 0.5g applied at any time in any direction, unless otherwise stated on the heat exchanger data sheets.

Each heat exchanger shall be provided with two earthing bosses, welded to the heat exchanger support saddles. The skid shall be provided with at least 2 Nos. Earth bosses suitable for termination of 70 sq. mm earth cable. The heat exchanger CONTRACTOR / SUPPLIER shall supply bolting for interconnecting supports on stacked exchangers.

6.0 THERMAL AND MECHANICAL GUARANTEES

The Thermal and Mechanical design of heat exchangers shall be carried out by CONTRACTOR / SUPPLIER. The CONTRACTOR / SUPPLIER shall provide both the Thermal and Mechanical guarantees for the equipment, provided against process and mechanical conditions given on data sheets. When physical properties are not given by the COMPANY, the CONTRACTOR / SUPPLIER shall use the physical properties for the process fluids from the Physical Properties Data Service (PPDS) Data Bank. Where properties are not available the CONTRACTOR / SUPPLIER shall refer to the COMPANY for guidance and final agreement. The CONTRACTOR / SUPPLIER shall use the appropriate design methods from either the HTRI or HTFS computer programs for the vibration analysis. Alternative methods shall be subject to prior agreement with the COMPANY.

7.0 MATERIALS

7.1 GENERAL

Materials shall conform to ASME material specifications and ASTM material specification may be used with subject to COMPANY'S approval. For non-pressure retaining parts, ASTM material specification or equivalent material specification may be used. Materials shall be identified as to MANUFACTURERS and heat numbers. All materials shall be new. Each plate or forging shall be legibly stamped or stenciled with the grade and the plate or forging number. When metal stamping is required, it shall preferably be done on the long edge of each component. In general cast iron shall not be used.

7.2 PRESSURE PARTS

Carbon steel for pressure retaining parts in normal service shall be as given in Table-1.

Table - 1

| PARTS | 0°C TO 427°C |
|------------------------------------|----------------------|
| Shell, shell cover channel etc | SA 516 Gr. 70 |
| Tube Sheet | SA 266 Gr.2 |
| Girth flange, flat cover | SA 266 Gr.2 |
| Nozzle flange, coupling plug, etc. | SA 105 |
| Tube (Note-2) | SA 179 |
| Nozzle neck & pipe shell | SA 106 Gr. B, SA 105 |
| Bolts & Nuts | (Note-1) |

Note:

- 1) Upto 427°C: ASTM A-193 Gr. B7/A-194 Gr. 2H, Cadmium plated.
- 2) Unless otherwise specified, seamless tube shall be used.
- 3) Material cannot be used over the temperature specified on the table for allowable stress in Code.

Pressure retaining parts to be welded for carbon steel heat exchangers shall have the following chemical composition:

- Carbon Content (C) : < 0.25%
- Carbon Equivalent (Ceq) : < 0.41%, where $Ceq = C + Mn/6$

All tubes shall be in the fully heat treated condition as received from the mill. Heat treatment may be annealed, normalized, or normalized and tempered as per material specification. Welded austenitic stainless steel tubes shall be cold drawn to a minimum reduction of 15% in wall thickness prior to a final full solution anneal. Selective cold reduction of the weld bead is an acceptable alternative.

7.3 MATERIALS FOR SHELL & TUBE HEAT EXCHANGER IN COLD SERVICE

Materials, for pressure retaining parts in Shell & Tube Heat Exchangers in cold service shall be as given in the following Table-2:

| PARTS | MIN. DESIGN TEMP. °C | MATERIAL |
|-----------------|----------------------|---|
| Tubes | -55 | SA 269 TO 316-L |
| Tube Sheet | -55 | SA 240 TP 316-L |
| Channels | -55 | SA 350 LF 3 |
| Shells, Baffles | -55 | SA-516, Gr. 70 |
| Tie Rods | -55 | SA-182, Gr. F316L |
| Botls & Nuts | -100 | SA 320 Gr. & SA 194 Gr. Cadmium Plated |

7.4 NON-PRESSURE PARTS

Non-pressure retaining parts directly welded to pressure retaining parts of a heat exchanger, having a design temperature of 344°C and over, or being made of low or high alloy steel, shall be of the same material as the heat exchanger shell or head. Welded attachments on carbon steel pressure parts below 344°C should be A-283, A-236 or better. Reinforcing pads of nozzles and manholes, and wear-plates of saddles for heat exchangers shall be of the same materials as the heat exchanger shells or heads, regardless of design temperatures.

External bolting shall be carbon steel ASTM A-307 Gr. B or equivalent. Material of anchor bolts shall be carbon steel ASTM A-307 Gr. B.

7.5 GASKET

Gaskets for Blanked-off Nozzles Blanked-off gaskets, including manholes and hand-holes, if required, shall conform to the piping specification for lines connected to nozzles in the same zone of heat exchangers. Gaskets for Girth Flange Joints Use of gaskets for girth flange joints shall conform to the following conditions and also the requirements of TEMA Standard, unless otherwise specified:

- a) Flat metal jacketed non-asbestos filled gaskets

Design Temperature : Upto 400°C

Design Pressure : Upto ANSI Class 300 rating

- b) Spiral wound non-asbestos filled gaskets

Design Temperature : Upto 450°C

Design Pressure : Upto ANSI Class 2500 rating

- c) Spiral wound graphite filled gaskets

Design Temperature : Upto 600°C

Design Pressure : Upto ANSI Class 2500 rating

7.6 IMPACT TEST REQUIREMENTS

The requirements for Charpy "V-notch Impact Testing shall be in accordance with the pressure vessel code and the requirements of the Project Specification for Unfired Pressure Vessels;

8.0 WELDING

Before any welding commences on the vessel, all welding procedures shall be approved by the COMPANY and shall be qualified by the appropriate tests specified herein. All welding procedure including non-pressure welds shall be identified by a number and shall be referenced on weld maps. Qualification for welding procedures and welders shall be conducted in accordance with the ASME Code Sec. IX requirements. The actual test may be waived, where the welding procedure qualification test has already been qualified, and the welding procedure specifications and welding procedure qualification records have been approved.

All welding shall be done by a metal arc process. All shell and head joints shall be double welded butt joints with full penetration. Double welded groove joints shall have their root passes back gouged to sound metal on the reverse side before welding on that side. In case where double welding is impractical, the root pass shall be made by the Gas Tungsten Arc Welding (GTAW) process. All pressure shell weld joints of categories A or B shall be Type No. 1 fully penetration butt welds in accordance with UW-3 and table UW-12 of the ASME Code. Full penetration weld with full fusion shall be required for pressure retaining part welds. Nozzles and manholes shall be attached to heat exchangers by full penetration welds. Fillet weld is acceptable for the outside circle of reinforcing pads. Longitudinal seams shall clear nozzles and their reinforcement with a minimum distance of 25mm.

Longitudinal seams for vertical heat exchangers shall preferably be located 180° apart. In horizontal heat exchangers, the longitudinal weld seams shall not be located at the under parts of heat exchanger shells, and saddles shall be located so as not to coincide with the circumferential and longitudinal seams of heat exchanger shells. Joints of heat exchanger shell plates with different thicknesses shall be aligned inside surface flush. Tube to tube sheet weld shall use the TIG process, with a minimum of two passes, and shall conform to OCMA TEW 1. Post weld heat treatment if required by the codes shall take place by heating the applicable component(s) of exchanger in an enclosed furnace.

Longitudinal and circumferential welds of shells except for kettle-type exchangers shall be finished flush with the inner contour for ease of tube-bundle insertion and withdrawal. Welding shall be performed in "Flat" position as far as possible, and the welding sequence shall be established in order to minimize residual stresses. Alloy elements containing flux powder for submerged arc automatic and semiautomatic welding techniques shall not be employed. Welding shall be completed prior to final heat treatment. The use of the Flux Cored Arc Welding (FCAW) and Gas Metal Arc Welding (GMAW) processes shall be approved by the COMPANY. The Flux Cored Arc Welding Process shall utilize an external shielding gas and is not permitted for single sided tee for corner joints. The Gas Metal Arc Welding process in the short-circuiting mode (GMAW-S) may be used for following applications only:

- a) The root pass for any material thickness.
- b) Complete groove or fillet welds providing that the wall thickness does not exceed ¼" (6mm).
- c) Tack welds, temporary attachments and other applications where the weld made by this process is completely removed.

The Gas Metal Arc Welding process in the spray transfer mode shall not be used for the root pass. Covered welding electrodes for non-alloy welding shall be in accordance with Specification AWS A5.1, ASME SFA-5.1. Bare electrodes shall be in accordance with the following:

| WELDING PROCESS | ELECTRODES |
|------------------------|--------------------------|
| Sub merged Arc Welding | AWS A5.17, ASME SFA-5.17 |
| Inert Gas Welding | AWS A5.18, ASME SFA-5.18 |
| Flux Cored Arc Welding | AWS A5.20, ASME SFA-5.20 |

Each category A or B pressure retaining weld in accordance with Figure UW-3 of the ASME Code shall be spot radiographed, as a minimum requirement. Each spot radiograph shall be a minimum of 150mm in length and in accordance with the ASME Code. All welds to be covered by nozzle reinforcing pads and at least one

weld inter-section shall be included. Nozzle welds shall be spot examined by magnetic particle or dye penetrant as a minimum requirement.

Welds in vessel shells 50mm and greater in thickness shall be 100% examined by ultrasonic in accordance with the ASME Code, after final post weld heat treatment. Deposited weld metal mechanical properties shall conform to the ASME requirements for the base metal. Low-alloy, high strength weld material for carbon steel vessel shall not be used.

9.0 INSPECTION, TESTING AND CERTIFICATION

9.1 GENERAL

Inspection and testing shall be carried out at the CONTRACTOR / SUPPLIER'S works and shall be witnessed by the COMPANY'S authorized representatives and/or certifying authority, if required. The responsibility for inspection rests with the CONTRACTOR / SUPPLIER; however, the COMPANY and their authorized representative reserve the right to inspect the heat exchangers at any time during fabrication to ensure that materials and workmanship are in accordance with this specification, the individual exchanger data sheets and/or drawings. The CONTRACTOR / SUPPLIER shall provide a projected shop schedule with appropriate fabrication stages at the time drawings are submitted for approval, to highlight the inspection activity schedule. The approval of any work by the COMPANY or their authorized representative and the release of a vessel for shipment shall in no way relieve the CONTRACTOR / SUPPLIER of any responsibility for carrying out the provisions of this specification.

9.2 NON-DESTRUCTIVE EXAMINATION (NDE)

All non-destructive examination shall be carried out in accordance with the design code as a minimum. Clad tube-sheets shall be ultrasonically tested, the procedures and defect levels being agreed with the COMPANY prior to award of contract. All heads shall be normalized after forming. A full NDE programme shall be submitted for review by the COMPANY at the quotation stage.

9.3 TESTING

As a minimum, a helium leak test at 0.35 barg will be performed to verify tube/tubesheet joints. A hydrostatic test shall be carried out in the presence of the COMPANY'S appointed inspector. Hydrostatic testing shall be to the Code. For exchangers containing austenitic stainless steels, the test water shall have a maximum chloride ion content of 30 ppm. Where necessary, test rings for confined tube sheets and testing rigs for floating tube sheets shall be supplied for completion of adequate shop and site testing. All such equipment, including studs and nuts where necessary, shall become the property of the COMPANY and be clearly marked by stamping with the equipment Tag Number; All test equipment shall be shipped with the exchanger. Test rings shall be designed to the higher of the two test pressures, with an allowable design stress of 90% of the yield stress at the test temperature.

9.4 TEST BOLTING

Service bolting on girth flanges (low alloy steel) may be used for shop tests. Stainless steel bolts shall not be used for testing. Where stainless steel service bolts are supplied, separate alloy steel bolts shall be used for testing. These bolts shall form part of the total equipment supply.

9.5 NAMEPLATE

General

Each complete shell and tube heat exchanger shall be provided with a type 316 stainless steel nameplate securely attached to the shell, and located so that it is clearly visible after installation. Nameplates shall be riveted to a bracket welded onto the exchanger. Stamped Data

The following information shall be stamped on the nameplate:

- Equipment Item No.
- Contractor's Order No.
- Year of Manufacture.

- Outside Heat Exchange Surface (m²).
- Design Code.
- Test Pressure (New) Shell/Tube (barg).
- Max Allowable Working Pressure Shell/Tube (barg).
- Max Allowable Working Temperature Shell/Tube (OC).
- Radiography.
- PWHT.

Letters and figures shall be 5mm high and clearly stamped.

9.6 REPORTS AND ACCEPTANCE CERTIFICATES

The CONTRACTOR / SUPPLIER shall prepare a report on the tests and the results, for inclusion in the Certification Data Book.

10.0 PAINTING AND PREPARATION FOR SHIPMENT

10.1 PAINTING AND PROTECTIVE COATINGS

Painting, protective coatings and the procedures used for the preparation of surfaces shall be as specified in the Project Specification for Painting and Surface Preparation. Where painting is specified, the entire heat exchanger shall be painted. Nozzles shall be painted on the flange edges, inside bolt holes, and up to the gasket surface. Fireproofed or insulated surfaces shall be shot blasted and given one coat of primer only. The CONTRACTOR / SUPPLIER shall stencil in a prominent position in 50 mm high characters the dry lifting weight of the heat exchanger and for stress relieved and/or clad vessels the words "NO WELDING PERMITTED".

10.2 PREPARATION FOR SHIPMENT

Before the final hydrostatic test, the Shell and Tube Heat Exchanger shall be dried and cleaned thoroughly of all grease, loose scale, rust, flux and weld spatter, both internally and externally. The preparation for shipment of the skid Packages shall meet the Preparation For Shipment as detailed in Specification for Skid Mounted Packages. All machined surfaces and threaded connections shall be protected by coating with rust preventative. Flanged openings shall be protected with steel plate covers attached by proper bolting or strapping and sealed with a plastic compound.

Screwed connections shall be protected with threaded forged steel plugs. The CONTRACTOR / SUPPLIER shall be responsible for loading and anchoring heat exchangers to prevent any damage during shipment. When shipped loose, all instruments, valves, parts, etc. of a Shell and Tube Heat Exchanger shall be tagged with the item number and purchase order number to facilitate installation in the field. Tags and wire shall be stainless steel. CONTRACTOR / SUPPLIER shall state in the proposal his recommendations for long-term storage (up to 12 months) for both indoor and open-air storage in a marine environment.

11.0 DRAWINGS AND DATA REQUIRED

CONTRACTOR / SUPPLIER information shall be supplied in accordance with the COMPANY'S procurement documentation. This shall include, as a minimum, the following:

- Completed data sheets.
- General arrangement and cross-sectional drawings complete with parts list, materials and equipment description.
- Materials and thickness of principal parts not covered by the data sheet.
- Itemized weights, including maintenance weights.
- Contractor connection drawings complete with detailed nozzle schedule.
- Anchor bolt sizes and locations.
- Itemized list of CONTRACTOR / SUPPLIER's deviations from Specification.
- CONTRACTOR / SUPPLIER shall supply separate prices for the following:
 - Supply and installation of additional nozzles rated per data sheet, with and without reinforcement for the following nominal bores: 2", 3", 4", 6", 8", 10".
 - Per kg of all supports clips and lugs.
- Proposed test procedure and erection details
- Priced list of recommended commissioning spares.
- Priced list of spare parts for two years operation (optional).
- Priced list of special tools.

12.0 GUARANTEE & WARRANTY

The warranty shall be for a period of 12 months from date of initial commissioning or for a period of not less than 18 months from the date of shipment/dispatch, whichever is earlier. The CONTRACTOR / SUPPLIER will warrant the equipment to be free of defects in material and workmanship, and that it is of adequate size and capability to fulfill the design and operating conditions specified herein. The CONTRACTOR / SUPPLIER shall replace and install, without cost to the COMPANY, any materials, supplies, or equipment, which fails under design conditions due to defects in material or workmanship. If the defect is observed and/or such failure occurs within warranty. Acceptance of this order will signify acceptance of all conditions of this warranty. The CONTRACTOR / SUPPLIER shall guarantee that the system provided meets the requirements of the functional performance of this specification, data sheets and P & IDs. All equipment shall be guaranteed as follows:

- All equipment shall perform satisfactorily under the specific operating conditions as detailed on the data sheet and shall be fit for the intended purpose.
- Tests shall confirm the CONTRACTOR / SUPPLIER's guaranteed performance.

The CONTRACTOR / SUPPLIER shall guarantee the mechanical and structural integrity, workmanship and the materials of construction used in accordance with the requisition and requirements of this specification.



OIL & GAS DEVELOPMENT COMPANY LIMITED

SPECIFICATION # 4929-SP-003

INSULATION

CONSULTANTS:

MAY. 2018



PETROCHEMICAL ENGINEERING CONSULTANTS

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1.0 INTRODUCTION

1.1 SCOPE

This specification covers the minimum requirements for the manufacture, supply and installation of insulation for piping and equipment.

1.2 DEFINITIONS

Following definitions apply throughout this document:

Company / Owner : Oil and Gas Development Company Limited (OGDCL)

Contractor: "Contractor" means the person or persons, firm or Proprietor whose proposal has been accepted by the Company for engineering design, verification of engineering design, procurement, inspection, testing and shipment of heat exchanger and one year of defect liability period.

Vendor / Supplier : The organization, firm or agency with whom order for the supply of equipment and or material has been placed.

1.3 ERRORS OR OMISSIONS

The review and comment by the COMPANY of any CONTRACTOR's or its CONTRACTOR / SUPPLIER's drawings, procedures or documents shall only indicate acceptance of general requirements and shall not relieve the CONTRACTOR / SUPPLIER of its obligations to comply with the requirements of this specification and other related parts of the Contract Documents.

Any errors or omissions noted by the CONTRACTOR / SUPPLIER in this Specification shall be immediately brought to the attention of the COMPANY.

1.4 DEVIATIONS

All deviations from the requirement of this specification, its attachment and the referenced codes and standards shall be stated in the Tender. In the absence of such a statement, full compliance will be assumed

Compliance by the CONTRACTOR / SUPPLIER with the provisions of this

specification does not relieve him of his responsibility to furnish equipment and accessories of a proper mechanical design suited to meet the specified service conditions and/or local codes governing health and safety

1.5 CONFLICTING REQUIREMENTS

In the event of any conflict, inconsistency or ambiguity between the Contract scopes of work, this Specification, Codes and Standards referenced in this Specification or any other documents, the CONTRACTOR / SUPPLIER shall refer to the COMPANY whose decision shall prevail.

1.6 WORK PROCEDURE

The CONTRACTOR/ SUPPLIER shall submit for approval to the COMPANY detailed procedures for:

- Surface cleaning / preparation
- Paint material storage and preparation procedure
- Primer application
- Intermediate and finish coat application
- Inspection and data recording procedures
- Paint repair procedure
- Painted equipment/material transportation, storage and handling procedure
- Type of abrasive to be used

The above procedure shall include the application equipment/tools. All procedures shall meet the minimum requirement stated in this specification.

Material specification for the cleaning and painting, and mixing materials, shall be submitted to the COMPANY for approval. Detailed CONTRACTOR / SUPPLIER's/manufacture's data shall be submitted with these specifications. Material shall not be procured prior to approval of the COMPANY.

2.0 CODES AND STANDARDS

2.1 CODES, STANDARDS & REGULATIONS

All insulation material, installation and inspection shall, as a minimum, comply with the requirements of this specification, its attachments and the latest editions of the following Codes, Standards and Regulations (where applicable):

BS 874 Methods for determining insulating properties with definitions of thermal insulating terms.

BS 5422 Specification for the use of thermal insulating materials.

BS 5970 Thermal insulation of Pipework and Equipment

CONTRACTOR / SUPPLIER may offer insulation supplied in accordance with other Codes and Standards provided that they are equal to the above and that COMPANY gives full approval prior to commencement of work.

3.0 SCOPE OF SUPPLY**3.1 GENERAL**

3.1.1 This Specification covers the minimum requirements for the supply and installation of all elevated and low temperature insulation and shall be adhered to in all respects unless deviations are specifically noted on the procurement documentation or agreed and approved in writing by the COMPANY.

3.1.2 CONTRACTOR / SUPPLIER to provide insulation supports and rings.

3.1.3 CONTRACTOR / SUPPLIER shall start insulation job on piping and equipment after issuance of clearance certificate. COMPANY shall issue the clearance certificate after completion of successful testing, treatment, cleaning/flushing and painting.

3.2 SCOPE OF SUPPLY

3.2.1 CONTRACTOR / SUPPLIER to provide all required facilities for the supply and installation of the works. This shall include, but not necessarily be limited to, all categories of labor, supervisory and administrative staff, materials, equipment, scaffolding, tools, buildings, transportation and other services as necessary to complete the installation in accordance with the project schedule.

3.2.2 The CONTRACTOR / SUPPLIER shall be responsible for the material take-off for insulation.

3.2.3 The CONTRACTOR / SUPPLIER shall submit details of the intended method of application, fabrication and installation, including expansion and contraction joints, to COMPANY for approval.

3.2.4 Provision shall be made for the acceptance, dry storage, control and issue of materials delivered to the job site.

3.2.5 Site cleanliness, with regard to insulation materials and work shall be ensured by regular cleaning of work areas, particularly if so requested by the COMPANY'S representative. Areas allocated for temporary storage, buildings and work areas shall be cleared to the COMPANY'S satisfaction on completion of the work.

3.2.6 CONTRACTOR / SUPPLIER to clear the surfaces in order to remove all oil and dirt deposits prior to insulation.

3.2.7 Insulation shall be kept completely dry prior to completion of the specified permanent weather barrier. If insulation should become wet or stained, it shall be removed and replaced by dry material and all costs for replacement shall be the responsibility of the CONTRACTOR / SUPPLIER.

3.3 MATERIALS, WORKMANSHIP & SUITABILITY

3.3.1 All materials shall be new and of the best quality. The quality and workmanship shall conform to the Codes and Standards listed in Section 2.0.

3.3.2 All deviations to this specification or Codes and Standards listed in Section 2.0 shall be brought to the knowledge of the COMPANY as a section in the bid. All deviations made during the procurement, design, manufacturing and inspection shall be with written approval of the COMPANY prior to execution of the work. Such deviations shall be shown in the documentation prepared by the CONTRACTOR / SUPPLIER.

3.3.3 Any work or material found to be defective or which does not meet the requirements of this Specification shall be replaced by the CONTRACTOR / SUPPLIER at his own expense.

3.3.4 Equipment, structures and piping etc., shall be protected from splashing and debris of materials. Items damaged shall be repaired and cleaned at the CONTRACTOR / SUPPLIER's cost, to the COMPANY's satisfaction.

4.0 DESIGN

- 4.1 For personnel protection, all metallic surfaces, which could be contacted in the course of normal operating duties, where the design temperature (hot or cold) is excessive, shall be insulated or otherwise guarded or screened as specified in Section 7.0.
- 4.2 Tables I and II give typical thicknesses of hot insulation for various ranges of operating temperature; these thicknesses do not include the finishing, the insulating effect of which is neglected. If significant differences in 'K' values are used, the thicknesses shall be adjusted accordingly. Table II thicknesses are to be used when personnel protection is the only criterion for the provision of insulation.
- 4.3 Piping and Equipment shall be insulated for heat conservation or process control.
- 4.4 Insulation materials and accessories shall be packed in substantial shipping containers, which shall be constructed so as to ensure safe delivery and handling of materials in a condition to the satisfaction of the COMPANY.
- 4.5 All containers shall be legibly marked with the name of the Manufacturer, insulation class, size, type, density, quantity contained and gross weight in kilograms.
- 4.6 Where stainless steel piping or equipment is to be insulated, the material shall be protected from stress corrosion cracking. Prior to application of the insulation, the CONTRACTOR / SUPPLIER shall completely shield the stainless steel from the insulation.
- 4.7 The use of dissimilar materials subject to corrosion as a result of Electrolytic action is not permitted.
- 4.8 The cutting of insulation and cladding around protrusions and pipe supports, or the shaping required for closely adjacent piping and equipment shall be considered normal practice within the CONTRACTOR / SUPPLIER's prices and/or unit rates.
- 4.9 Where supports, other than those provided on equipment, are required for the correct installation of insulation, such supports shall be supplied and fitted by the CONTRACTOR / SUPPLIER, at his own cost, after obtaining approval in writing from

the COMPANY. The CONTRACTOR / SUPPLIER shall provide proposals for such supports prior to installation.

- 4.10 Support rings for vertical piping runs shall be supplied by the CONTRACTOR /SUPPLIER and shall be of bolted construction.
- 4.11 Provision shall be made for expansion and contraction of piping and equipment inthe insulation system.
- 4.12 Insulation support rings and vessel stiffening rings shall be fully insulated andclad so that they will accommodate vertical and circumferential expansion, where applicable.
- 4.13 All name-plates on insulated equipment shall remain visible without impairing the weathering protection of the insulation.
- 4.14 Unless otherwise agreed, pipe bends exposed to the weather shall be covered by segmental cladding having either swaged joints or a sufficient overlap to exclude moisture. Particular attention shall be paid to the over lapping and sealing where the bend and straight pipe adjoin.
- 4.15 Provision shall be made to prevent seepage of water down pipe hangers and on tothe insulation.
- 4.16 On vertical exchangers and pipework, flashing and sealing shall be incorporated to prevent leakage at joints penetrating the insulation, Particular attention shall be paid to effective sealing around nozzles, etc. The CONTRACTOR / SUPPLIER shall ensure that no sharp corners are left and that exposed cut edges are folded.

5.0 INSPECTION

The COMPANY'S Inspector shall have the right to inspect all work and materials on site at the Contractor's works. Such inspection shall not relieve the CONTRACTOR /SUPPLIER from full responsibility for the quality and correctness of the materials or work.

6.0 APPLICATION REQUIREMENTS: HEAT CONSERVATION - CLASS H

6.1 APPLICATIONS TO PIPING & EQUIPMENT

- 6.1.1 Fittings, flange and valve insulation covers shall be fabricated from the same material and insulation thickness as specified for the adjacent piping. The covers shall be of the two-piece removable type, and shall be secured with the required specified bands and seals.
- 6.1.2 Valves and flanges shall not be insulated until permission is obtained from the COMPANY'S representative.
- 6.1.3 The insulation of bends and fittings shall be continuous from the adjacent pipe. Erection of metal elbows etc., and filling the void between cladding and pipe with loose insulation is permitted.
- 6.1.4 On vertical insulated pipe, the CONTRACTOR / SUPPLIER shall supply and install insulation supports at 3700 mm pitch. Welding is not permitted on any lines or equipment. Tee branches and pipe support brackets may be utilized as insulation supports.
- 6.1.5 Supports on tanks and vessels should be spaced to suit the insulation but in no case should exceed 3700 mm vertical pitch and should be an integral part of the equipment as delivered.
- 6.1.6 The insulation on vertical tanks shall terminate at 100 to 150 mm above the bottom of the tank shell and 75 to 100 mm above the wind girder. Adequate means of support for the insulation materials shall be provided.
- 6.1.7 Electrical tracing will be installed and tested by the CONTRACTOR / SUPPLIER before insulation. The extent of Electrical tracing shall be as indicated on the isometrics.
- 6.1.8 Suitably oversized insulation material shall be used on traced services to ensure that no burying of the tracer occurs in the insulation. A layer of 0.06 mm aluminum foil shall be applied to the line prior to the application of the insulation.
- 6.1.9 Unless otherwise noted, insulation shall not normally be applied to fans, compressors, pumps and other rotating equipment, valves and flanges, vessel manway covers, nozzles and flanges on equipment.

The exception to this shall be:

- a) Heat traced lines and equipment.
 - b) Where operating temperature exceeds 95°C
- 6.1.10 Bonnet and channel flanges on heat exchangers shall be insulated by means of a removable double skin box. On large exchangers boxes shall be in two or more parts and no part shall weigh more than 25 kg.
- 6.1.11 For heat exchangers in CO₂ service the tube sheet and channel flanges shall not be instated, but a simple removable galvanized sheet metal protecting shroud shall be placed over the bolts to protect them from the effect of thermal shock from rain storms. A suitable gap should be left between the bolts and the shroud to allow adequate ventilation.
- 6.1.12 The insulation surrounding equipment name plates which indicate design and/or operating data shall be neatly trimmed and sealed so that the name plates are clearly visible.
- 6.1.13 For the purpose of taking shell or pipe thickness measurements a movable section of insulation shall be provided as and where indicated by the COMPANY'S Inspector. The CONTRACTOR / SUPPLIER shall supply design details for approval.
- 6.1.14 Single layer insulation shall be applied to pipe and vessels with lateral joints in a staggered arrangement. All joints shall be tightly butted and fitted together so as to eliminate voids. Large voids shall be eliminated by refitting or replacing insulation. Additional layers of pipe insulation, where required, shall be applied in the same manner as the first layer, with lateral and end joints staggered over the preceding layer so that no joints coincide, except where they cross at right angles. The outer layer of insulation shall be secured with specified bands and seals on approximately 600 mm centers. Inside layers shall be secured with wire on approximately 600 mm centers. With double layer insulation, the thickness of any single layer shall not exceed 50 mm.
- 6.1.15 Where flanges or flanged fittings are not being insulated, the insulation shall be cut to a 45 bevel and sealed to the pipe adjacent to each side of the flange or flanged fittings to allow bolt removal without damaging the insulation.

- 6.1.16 Expansion joints shall be installed in insulation for horizontal and vertical straight run piping and vessels in increments of not more than 12 metres. When flanged fittings or valves are installed within this limit, the joint shall be provided for in flange or valve cover only.

Expansion joints shall have a 12 mm space between adjoining pipe insulation sections. Insulation cover over the joint shall be of a specified thickness of insulation and shall extend one and one-half times the insulation thickness on each side of the 12 mm space.

- 6.1.17 Specified sheet cladding shall be applied over all pipe and vessel insulation. The cladding shall be installed with seams and laps arranged to shed water. The cladding on vessels shall be secured with specified bands on 1000 mm centers and hardened steel screws on ISO mm centers. Pipe cladding shall be secured with hardened screws on 150 mm centers. All joints in the cladding shall have an overlap of 50 mm minimum and shall be sealed with non-setting mastic.

On vertical piping and vessels the cladding shall be supported with 50 mm 'S' clips secured to the next lower section. The 'S' clips shall be made from the specified banding. Cladding shall not be installed over any insulation that is not thoroughly dry. Spring buckles or bands which will allow for expansion shall be used on vessels where necessary.

- 6.1.18 Polyvinyl acetate weather-barrier coating may be applied to insulated surfaces of screwed or socket weld valves in preference to cladding.

The surface of insulation shall receive an adhesive coat of polyvinyl acetate mastic. While still tacky, glass reinforcing cloth per clause 6.2.5 shall be stretched taut and thoroughly embedded in the coating, care being exercised that the weave is not stretched and that the cloth is overlapping approximately 40 mm. Before the surface becomes dry to touch, a second coating shall be applied and allowed to dry. Total dry thickness of coating shall be 3.5 mm minimum.

Cloth shall not be visible on the finished surface. Weather coating shall extend 75 mm under cladding adjacent to fittings prior to application of the galvanized sheet cladding.

All sharp corners of insulation shall be rounded and the weather coating provided with a double layer of reinforcing cloth.

Coating shall not be applied when the atmospheric temperature is such that condensation of moisture and ultimate freezing may occur on the finished surface within 24 hours from time of application. Polyvinylacetate weather-coating shall not be thinned with water.

6.2 MATERIALS FOR HOT SERVICES

6.2.1 Insulation - Class H

| <u>Material</u> | <u>Temp. Range</u> | <u>Application</u> |
|--|--------------------|---|
| Mineral Wool preformed Section (100kg/m ³) | Up to 350°C | Piping and Equipment below 36" OD |
| Mineral Wool slab (65-80kg/m ³) | Up to 350°C | Equipment above 36" OD |
| Mineral Wool sections slabs, (144 kg/m ³) | Up to 650°C | Equipment and Piping |
| Mineral Wool wired blanket (90 kg/m ³) | Up to 450°C | Removable boxes Equip. and irregular surfaces |
| Mineral Wool wired blanket (48 kg/m ³) | Up to 50°C | Irregular surfaces |
| Mineral Wool slabs (48 kg/m ³) | Up to 250°C | Rectangular Equip |

6.2.2 Insulation Securement - Class H

| <u>Material</u> | <u>Spacing</u> | <u>Application</u> |
|---|------------------------|--|
| 1.6mm Soft Annealed Wire | 600mm Stainless Steel | Equipment and Piping upto 1500mm OD Inner layer |
| 12mm Wide by 0.5m Stainless Bonding | 600mm Steel - Type 316 | Equipment and Piping 250mm OD to 600mm OD |
| 18mm Wide by 0.5m Stainless Bonding | 600mm Steel - Type 316 | Equipment and Piping above 600mm OD upto 1500mm OD |
| 25mm Wide by 0.5m Stainless Bonding | 600mm Steel - Type 316 | Equipment above 1500mm OD |
| 9mm dia. weld pins and self adhesive double prong clips | As necessary | Irregular surfaces or as required |

6.2.3 Insulation Cladding - Class H

| <u>Material</u> | <u>Application</u> |
|--|---|
| Stainless steel Type 316 Sheet 0.5 mm thick. | Piping and Equipment upto 300 mm OD |
| Stainless steel Type 316 Sheet 0.5mm | Piping and Equipment 350mm to 1500mm OD |
| Corrugated stainless steel Type 316 Sheet | Equipment above 1500mm OD |

6.2.4 Cladding Securement - Class H

| <u>Material</u> | <u>Spacing</u> | <u>Application</u> |
|---|-----------------------|--|
| 12mm x No. 10 hardened self tapping screws, steel cadmium plated. | 150mm | Equipment and Piping |
| Stainless Steel Type 316 Banding 12mm wide x 0.5mm thick. | 1000mm | Equipment and Piping above 300mm OD TO 1500mm OD |
| Stainless steel Type 316 Banding 25mm wide x 0.5 thick | 1500mm | Equipment and Piping above 1500mm OD |

6.2.5 Coating and Mastics - Class H

| Material | Application |
|---|---|
| Flare resistive mastic and glass cloth, natural or impregnated with material compatible with the mastic | Piping insulation terminations at flanges and valves etc. Insulation finish on horizontal equipment heads, screwed and socket weld fittings |
| Non Setting Mastic | Sealing against water ingress on removal items |
| Sealing Mastics | Sealing against water ingress of sheeting joints/laps/cutouts, etc |

TABLE – TYPICAL ECONOMIC THICKNESS FOR HOT INSULATION MATERIAL HEAT CONSERVATION - CLASS H

Thickness of Insulation mm at Hot Face Temperature (°C)

| Nominal Dimensions of Pipe mm (in) | Upto 100 | 150 | 200 | 250 | 300 | 350 | 400 | 450 | 500 | 550 | 600 | 650 |
|------------------------------------|----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 25 (1) | 40 | 50 | 50 | 63 | 63 | 75 | 75 | 75 | 88 | 88 | 100 | 100 |
| 40 (1½) | 40 | 50 | 63 | 63 | 63 | 88 | 88 | 88 | 100 | 100 | 113 | 113 |
| 50 (2) | 40 | 50 | 63 | 63 | 63 | 75 | 78 | 88 | 100 | 113 | 125 | 125 |
| 80 (3) | 40 | 50 | 63 | 63 | 63 | 88 | 100 | 113 | 125 | 125 | 138 | 150 |
| 100 (4) | 50 | 50 | 63 | 75 | 88 | 100 | 113 | 125 | 125 | 138 | 150 | 150 |
| 150 (6) | 50 | 63 | 75 | 75 | 100 | 113 | 125 | 138 | 150 | 150 | 150 | 150 |
| 200 (8) | 63 | 63 | 63 | 75 | 113 | 113 | 125 | 138 | 150 | 150 | 150 | 150 |
| 250 (10) | 63 | 63 | 63 | 100 | 113 | 125 | 138 | 138 | 150 | 150 | 150 | |
| 300 (12) | 63 | 63 | 63 | 100 | 113 | 125 | 138 | 150 | 150 | 150 | | |
| 350 (14) | 63 | 63 | 63 | 100 | 113 | 125 | 138 | 150 | 150 | 150 | | |
| 400 (16) | 63 | 63 | 63 | 100 | 113 | 125 | 138 | 150 | 150 | | | |
| 450 (18) | 75 | 75 | 75 | 100 | 125 | 125 | 150 | 150 | | | | |
| 500 (20) | 75 | 75 | 100 | 100 | 125 | 125 | 150 | 150 | | | | |
| 550 (22) | 75 | 75 | 100 | 100 | 125 | 125 | 150 | | | | | |
| 600 (24) | 75 | 75 | 100 | 100 | 125 | 125 | 150 | | | | | |
| And above | | | | | | | | | | | | |

The thickness given above is based on the use of preformed mineral wool and calculations based on BS.54.22.

Hot face Temperature, for Personnel Protection, is defined as the design temperature.

7.0 APPLICATION REQUIREMENTS: PERSONNEL PROTECTION CLASS P

7.1 Where personnel protection is specified on the Piping Line List, all piping, valves, flanges, nozzles and equipment within 2 metres height and one metre reach of walkways, working platforms, ladders etc., shall be insulated, or otherwise guarded or screened.

7.1.1 Where design temperature is at 55°C and above, the protection shall be by means of either:

* A suitable guard or screen (eg. extended handrailing or weldmesh shield)

OR

* Application of hot insulation

This shall be in accordance with sections 6.1 and 6.2 of this specification with the exception of the insulation thickness, which shall be in accordance with Table II.

7.1.2 Where the design temperature is -25°C and below, the protection shall be by means of a suitable guard or screen, (e.g. Extended handrailing or weldmesh shield).

TABLE - II**INSULATION THICKNESS REQUIRED FOR PERSONNEL PROTECTION - CLASS P**

Thickness of Insulation mm at Hot Face Temperature (°C)

| Pipe Nom Bore | Upto 205 | 260 | 315 | 375 | 425 | 480 | 540 | 590 | 650 |
|-----------------|----------|-----|-----|-----|-----|-----|-----|-----|-----|
| Up to | | | | | | | | | |
| 1" | 25 | 25 | 25 | 38 | 38 | 38 | 50 | 63 | 63 |
| 1 1/2" | 25 | 25 | 38 | 38 | 38 | 50 | 50 | 63 | 63 |
| 2" | 25 | 25 | 38 | 38 | 50 | 50 | 63 | 63 | 75 |
| 3" | 25 | 25 | 38 | 38 | 50 | 50 | 75 | 75 | 75 |
| 4" | 25 | 38 | 38 | 38 | 50 | 63 | 75 | 75 | 100 |
| 6" | 38 | 38 | 38 | 50 | 50 | 63 | 75 | 75 | 100 |
| 8" | 38 | 38 | 38 | 50 | 50 | 63 | 75 | 100 | 100 |
| 10" | 38 | 38 | 38 | 50 | 50 | 63 | 75 | 100 | 100 |
| 12" | 38 | 38 | 38 | 50 | 63 | 63 | 75 | 100 | 100 |
| 14"OD | 38 | 38 | 38 | 50 | 63 | 63 | 75 | 100 | 100 |
| 16"OD | 38 | 38 | 38 | 50 | 63 | 63 | 75 | 100 | 100 |
| 18"OD And above | 38 | 38 | 38 | 50 | 63 | 75 | 75 | 100 | 100 |

NB: The above table is based on the same data as Table 1 and on that basis the above thicknesses will reduce insulation surface temperature to 55°C or lower.

Hot face temperature, for Personnel Protection, is defined as the maximum design temperature.

8.0 APPLICATION REQUIREMENTS: FROST PROTECTION - CLASS C

8.1 Tanks, flow lines and instrumentation lines carrying fluids subject to freezing conditions shall be insulated against freezing to (minus) -15°C.

Flanges and valves shall not be insulated unless otherwise indicated on the isometrics and other COMPANY procurement documentation.

8.2 Insulating thickness required

40 mm thick for lines below 8" N.B.

25 mm thick for lines 8" and above

8.3 Application and materials shall be in accordance with 6.1 and 6.2, except as noted above.

8.4 Lines where the movement of fluid subject to freezing is very slow or static shall be electrically traced. (Refer paragraph 6.1.7).

9.0 APPLICATION REQUIREMENTS: COLD SERVICES - CLASS K**9.1 APPLICATION TO PIPING & EQUIPMENT**

- 9.1.1 Equipment and piping operating at a temperature of 10°C or less shall be insulated when required for process reasons, conservation of refrigeration, or control of condensation, as indicated on the Piping Line List and other COMPANY procurement documentation.
- 9.1.2 Manholes, hand holes, nozzles and equipment flanges shall be insulated to the specified thickness.
- 9.1.3 Flanges, valves and fittings on insulated lines shall be fully insulated to the specified thickness.
- 9.1.4 Insulation of manways, flanges and valves, hand holes and any item that may need to be accessible, shall be constructed in such a manner as to enable removal of the insulation without disturbance to adjacent insulation.
- 9.1.5 All insulated protrusions on insulated lines and equipment shall be insulated to a distance equal to four times the insulation thickness.
- 9.1.6 Surfaces to be insulated, shall be cleaned, dried and free of all foreign matter and moisture before the application of insulation.
- 9.1.7 After the surface is cleaned and prepared, the insulation shall be applied as soon as possible. Cleaned areas shall not be left unprotected overnight.
- 9.1.8 Insulation shall not be applied to unprotected areas during rain or when high humidity is likely to cause moisture filming on equipment or mastics.
- 9.1.9 Piping and equipment shall be insulated with preformed sections, mattress or slab as appropriate. Refer to the appropriate materials and thickness tables
- 9.1.10 Single layer insulation shall be applied to pipe and equipment with lateral joints in a staggered arrangement. All joints shall be tightly butted and fitted together so as to eliminate voids. Large voids shall be eliminated by refitting or replacing the insulation. Additional layers of pipe insulation, where required, shall be applied in the same manner as the first layer, with lateral and end joints staggered over the preceding layer so that no two joints coincide, except where they cross at right angles. Inside layer of insulation shall be secured with wire on 600mm

centers, outer layers shall be secured with specified bands on 600mm centers approximately. With double layer insulation no layer shall exceed 50mm thickness.

- 9.1.11 Flange and valve covers requiring insulation shall be fabricated from the same material and insulation thickness as specified for the adjacent piping. The covers shall be of the removable type and shall be secured with required specified bands and sealed with vapor barrier mastic or tape as required.
- 9.1.12 Contraction Joints shall be installed in insulation for horizontal and vertical straight run piping and vessels in increments of 12 metres. When flanged fittings or valves occur within this limit, the joint shall be provided for in flange or valve cover only.
- 9.1.13 Cladding shall be installed on all external insulation.
- 9.1.14 The circumferential joints in cladding for piping and vessels shall be ballswage type. All cladding joints shall have a lap of 50mm minimum.
- 9.1.15 Cladding shall be secured with specified bands at 600mm or 1000mm internals as applicable. Screw or pop rivets shall not be used.
- 9.1.16 Cladding shall not be applied until the COMPANY'S Inspector has inspected piping/equipment insulation and vapor barrier. Such inspection will not relieve the CONTRACTOR / SUPPLIER from his responsibility concerning insulation soundness.
- 9.1.17 Pipe supports on lines with cold insulation should not be in direct contact with the pipe. They shall be isolated from the line by means of a suitable insulation material and any voids shall be vapor sealed with mastic.

9.2 REFRIGERATION CONVERSATION - CLASS K

- 9.2.1 Equipment and piping operating at a temperature below 10°C shall be insulated with foam glass pre-formed sections or slabs as appropriate. Refer to materials and thickness tables Section 9.3.1 and Table III.
- 9.2.2 Butting edges of insulation shall be coated with the appropriate mastic as provided for in the material section vapor seal at the joints.
- 9.2.3 All outer insulation layers shall be secured with specified bands on 600mm centers. Inner layers are to be secured with stainless steel wire.

- 9.2.4 Insulation on equipment heads or other difficult contours shall be secured with suitable fire resistant mastic.
- 9.2.5 Contraction joints shall be installed at fixed points or at insulation supports as required to ensure the proper functioning of the insulation. Vapor tight sliding joints shall be provided in the insulation by the use of non-setting sealant.
- 9.2.6 All piping and equipment insulation shall have cladding installed in accordance with Clauses 9.1.14 to 9.1.16.
- 9.2.7 Where it is more practical for insulation of equipment on self-contained packages to be affected by complete boxing on of the packaged unit, alternative materials may be utilized e.g. loose fill insulation. In such instances, the CONTRACTOR / SUPPLIER shall provide full details of all insulating and cladding materials including thermal insulating properties, and obtain prior approval from the COMPANY.

9.3 MATERIAL FOR COLD SERVICES

- 9.3.1 Materials for Refrigeration Conservation - Class K (see Cl. 9.2.7)

| <u>Insulation Material</u> | <u>Temp Range</u> | <u>Application</u> |
|----------------------------|-------------------|--|
| Foam Glass | -160°C to +250°C | All low temperature Piping and Equipment |

- 9.3.2 Insulation Securement - Class K

| <u>Material</u> | <u>Spacing</u> | <u>Application</u> |
|---|----------------|---|
| 0.7mm stainless wire | 600mm | Inner layers of multiple layer System |
| 12mm wide x 0.5mm thick stainless steel Type 316 Bands and Seals. | 600mm | Equipment and Piping up to 600mm OD |
| 18mm wide x 0.5mm thick stainless steel Type 316 Bands and Seals. | 600mm | Equipment and Piping above 600mm OD up to 1500mm OD |
| 25mm wide x 0.5mm thick stainless steel Type 316 Bands and Seals. | 600mm | Equipment over 1500mm OD |

9.3.3 Coatings and Mastics - Class K

| <u>Material</u> | <u>Application</u> |
|--|--|
| Fire resistant mastic and glass cloth. Natural or impregnated with material compatible with the mastic | Piping insulation terminations at flanges and valves etc. insulation finish on horizontal equipment heads, screwed and socket weld fittings. |
| Non Setting Mastic | Sealing against water and vapor ingress on removable items. |
| Sealing Mastics | Sealing against water and vapor ingress on heating joints/laps/cutouts, etc. |

9.3.4 Cladding - Class K

| <u>Material</u> | <u>Application</u> |
|--------------------------------------|---|
| Stainless Steel Type 316 0.5mm thick | Piping and Equipment up to 300mm OD |
| Stainless Steel Type 316 0.5mm thick | Piping and Equipment 350mm to 1500mm OD |
| Corrugated Stainless Steel Type 316 | Piping and Equipment above 1500mm OD |

9.3.5 Cladding Securement - Class K

| <u>Insulation Material</u> | <u>Temp Range</u> | <u>Application</u> |
|--|--------------------------|---|
| 12mm wide x 0.5mm thick Stainless Steel Type 316 banding and seal. | 600mm | Equipment and Piping up to 1500mm OD |
| 25mm wide x 0.5mm thick stainless steel Type 316 Banding and Seals | 600mm | 600mm Equipment and Piping up to 600mm OD |