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Requirements for Shell & Tube Heat
Exchangers**

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Executive Summary

This specification together with the referenced documents within this specification defines the minimum requirements for the thermal and mechanical design; certification, shop fabrication and testing of carbon and alloy steel shell and tube heat exchangers.

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1. GENERAL

- 1.1. The purpose of this specification is to define the minimum design and fabrication requirements for shell and tube heat exchangers. This specification shall be used in conjunction with the design codes ASME BPV Code Section VIII, Division 1 or 2, 2015 edition and latest addenda, as appropriate; API 660, Latest Edition and Tubular Exchanger Manufacturers Association (TEMA) Standards, Class R, 8th edition 2007 plus amendments as referenced in this specification.
- 1.2. Heat exchangers in special service e.g. lethal, cryogenic or sour service may be subject to additional design and inspection requirements. These shall be defined on the exchanger data sheets.
- 1.3. It is the intention of this specification that the SUPPLIER provides the most economical exchanger based on his standard equipment design and fabrication methods provided the SUPPLIER complies with the requirements of the specified design code, TEMA Standards, and this specification.

2. CODES, REGULATIONS AND STANDARDS

The shell and tube heat exchanger shall be designed, fabricated and tested in accordance with the applicable sections of ASME Code Section VIII the latest edition Division 1 or 2, using the latest addenda TEMA Standard, Class R and API 660 Standard. Code stamping is required.

Reference to any standard or code shall mean the latest edition of that standard or code including addenda, supplements or revisions thereto, unless specified otherwise.

2.1. RoK Standards

Supplier to carry out check to ensure that the heat exchanger comply with the following Local Standards:

GOST 31842-2012	Oil and Gas Industry Shell & Tube Heat Exchangers General Requirements
ST RK ISO 16812-2004	Shell & Tube Heat Exchangers for Gas and Oil Industry
GOST R 52857 (1-12)-2007	Vessels & Apparatus, Norms & Methods of calculating strength
GOST R 52630-2012	Steel, welded steel vessels & apparatus. General Technical Requirements
RoK Investments and Development Minister's Order dated 30 th December 2014 No.358. Registered with the Republic of Kazakhstan Ministry of Justice on 20 th February 2015 No. 10303	On approval of Rules for assurance of industrial safety during operations of equipment under pressure

2.2. International Codes & Standards

API 660	Shell-and-tube Heat Exchangers for General Refinery Services
ANSI B16.5	Pipe Flanges and Flanged Fittings
ASME B16.47	Large Diameter Steel Flanges
ASME B36.10	Carbon, Alloy and Stainless Steel Pipes
NACE MR 0175 / ISO 15156	Petroleum and Natural Gas Industries Materials for use in H ₂ S containing environments in Oil & Gas Production
EJMA Standards	Standards of the Expansion Joint Manufacturer's Association
BS EN 10204	Metallic Products – Types of Inspection Documents
TEMA	Tubular Exchanger Manufacturers Association

2.3. KPO Project Specifications

KPO-00-CVS-SPC-00005-E	Steelwork for Structures and Buildings - Materials and Fabrication
KPO-00-ENG-SPC-00013-E	Welding of structural steel for packages and equipment
KPO-00-ENG-SPC-00035-E	Specification for External Coating
KPO-00-QAC-SPC-00001-E/R	Welding Procedure Approval and Welding Quality Requirements
KPO-00-PIP-SPC-00008-E/R	Specification for Piping, Forgings, Castings and Plate in Sour Service

Platforms and ladders, where applicable, shall be in accordance with the project specification KPO-00-CVS-SPC-00005-E steelwork for structures and buildings-materials and fabrication and the specification for welding of structural steel for packages and equipment KPO-00-ENG-SPC-00013-E.

3. RESPONSIBILITIES

- 3.1. Supplier shall be responsible for the design and construction of the heat exchangers and their integral components. The design details shown on the data sheets are the minimum design requirements.

- 3.2. The Supplier shall comply with applicable Federal, State or Local codes, regulations, ordinances, and rules of Kazakhstan unless defined otherwise.
- 3.3. In case of conflict, actual or implied, among documents relating to a Material Requisition or order, the following order of precedence should govern:
- a) Notes in the Material Requisition;
 - b) Equipment data sheets and drawings;
 - c) This Specification;
 - d) API 660 Shell & Tube Heat Exchangers Standard for General Refinery Services;
 - e) Design Code and TEMA Standards;
 - g) Other Specifications and standards referenced in the Material Requisition.

Should conflict occur it shall be the responsibility of the Supplier to call the Purchaser's attention to the conflict and request a ruling or interpretation from Purchaser. Supplier is not at liberty to assume which instruction would govern.

In any case, all conflicts must be submitted to PURCHASER for individual resolution.

- 3.4. The Purchaser's right of inspection shall not take the place of the required testing based on the material specifications quoted by the Supplier, nor shall they relieve the Supplier of any responsibility for any testing which should be done as a result of design requirements. A final cleanliness inspection shall be performed on all the piping and appurtenances furnished by the Supplier including the exchanger internals.

4. **DESIGN**

4.1. **General**

- 4.1.1. Design pressures, design temperature, operating conditions, fluid properties, pressure drops and fouling factors shall be as specified on the exchanger data sheet.
- 4.1.2. Where specified, exchangers with removable bundles shall be designed so that 180 degree rotation of the tube bundle is possible to compensate for unequal corrosion loss, or fouling tendencies.
- 4.1.3. Tube inserts for turbulence promotion are not allowed without BUYER approval.

- 4.1.4. The SUPPLIER shall calculate the heat transfer rate for each unit and advise the minimum surface necessary for him SUPPLIER to guarantee that it is satisfactory for the duty, fouling factors, and pressure drops specified on the shell and tube exchanger data sheet. The SUPPLIER shall verify the thermal design and state that he will provide completed mechanical data sheet and thermal, hydraulic and mechanical guarantee.

Calculations provided by SUPPLIER shall demonstrate that the shell and tube heat exchangers supplied meet the requirements of the Design Code and applicable RoK standards.

- 4.1.5. The SUPPLIER shall verify all geometry (per setting plan) and shall state calculated shell diameters in his quotation. Price adjustments for increased shell diameters, after the order is placed, will not be allowed.
- 4.1.6. When shellside fouling factor exceeds $0.002 \text{ HR.FT}^2 \text{ }^\circ\text{F/BTU}$ ($0.0004 \text{ M}^2 \text{ }^\circ\text{C/W}$), the shellside pressure drop shall be calculated with all leakage streams blocked. This pressure drop shall not exceed clean pressure drop by more than fifty (50) percent.
- 4.1.7. The Standard Mechanical Drawings are issued for guidance. Supplier shall verify the design.
- 4.1.8. Exchanger shall be designed to eliminate acoustic and flow induced vibration. The vibration calculations shall be submitted as part of the thermal design calculations and shall be analysed for each exchanger. Mechanical design of the tube bundle shall be allowed for up to 110% design flow rate without vibration, where there is a risk of slugging flow on the shell side of the exchanger, mechanical design shall be allowed for up to 200% design shell side flow without tube vibration.
- 4.1.9 Supplier shall warrant that exchangers are free from vibrations over the full range of operating conditions as specified on the data sheet.

4.2. Tubes and Tube Bundles

- 4.2.1. The number of tubes in any pass shall be within 10% of the average number of tubes per pass.
- 4.2.2. Bypass seal devices are required when the radial clearance between the outer tube limit (OTL) and shell is greater than one tube diameter, or when a large number of tubes are dropped for impingement plates. Dummy tubes or solid bars shall be placed in the void areas caused by pass ribs. Only those areas parallel to cross flow need be considered. Sealing devices are not required for isothermal shellside vaporisation or condensation.
- 4.2.3. Skid bars are required on removable bundles 760 mm in diameter and larger to facilitate bundle removal. Slide rails shall be provided in kettle type shells.

- 4.2.4. Bundles shall be withdrawn after insertion, a distance equal to the lesser of two central baffle spaces or four feet (1,220 mm). In the case of stacked heat exchangers, only the bottom bundle need be withdrawn in the stacked position. Grinding of baffles to permit insertion is not acceptable.
- 4.2.5. When impingement plates are provided the bundle entrance and exit areas shall be calculated at a plane through the first row of tubes and shall exclude the area obstructed by the impingement plate (if used). Flow velocities around the impingement plate shall be evaluated for its effect on tube vibrations. Effectiveness of heat transfer of the tubes under the impingement plate shall also be evaluated.
- 4.2.6. Cross baffles and support plates shall be provided with suitable notches to facilitate venting and draining of shell.

4.3. Tubesheet

- 4.3.1. Four tapped holes for bundle pulling shall be equally spaced in the face of all removable bundle tubesheets. Plugs of the same material as the tubesheet shall be provided for plugging the holes. Gasketed shoulder plugs of the same material as the cladding shall be provided for plugging holes in clad tubesheets.
- 4.3.2. Jackscrews (three minimum) and tapped holes shall be provided in all removable bundles larger than 300 mm O/D.
- 4.3.3. Design of fixed tubesheet exchangers shall take into consideration the most stringent of the following criteria in determining the need for an expansion joint:
- a) Normal operating conditions
 - b) Shellside start up, no fluid tubeside
 - c) Tubeside start up, no fluid shellside; shell at most severe ambient temperature
 - d) Shellside pressure failure
 - e) Tubeside pressure failure
 - f) Specified turn down operating conditions
 - g) Hydro-test
 - h) Steam out or other cleaning procedures when specified.

Tubesheet calculations shall be based on the above conditions in both corroded and uncorroded state.

Shell to tubesheet welded joint geometry on fixed tubesheet exchangers must provide a full penetration weld with no shellside crevices.

- 4.3.4. Where hub type fixed tubesheets are required, the hub shall be integrally forged with the tubesheet. Hubs made from built up weld metal are not permitted. Hub type tubesheets shall be provided for low temperature services and all services where 100% radiography of shell butt welding is required per code.
- 4.3.5. Unless otherwise noted on the data sheet, the design temperature for tubesheets shall be taken as the maximum of either the shellside or tube side design temperatures as specified on the exchanger data sheets.
- 4.3.6. For fixed tubesheet exchangers, tube to tubesheet joint loads shall not exceed allowance loads as defined in Appendix A2 of ASME VIII Div.1.
- 4.3.7. Unless a greater minimum thickness results from the requirements of TEMA Class R, tubesheet thickness (including corrosion allowance) measured at the bottom of the pass partition groove shall be 25mm.
- 4.3.8. Tube holes in tubesheets shall conform to requirements for "Standard Fit" in TEMA Class R.
- 4.3.9. Clad tubesheets shall be as follows:
- a) Minimum thickness of cladding shall be 10 mm.
 - b) If tubes are to be seal welded to tubesheet, both grooves shall be in base material.
 - c) If tubes are not to be seal welded, outer groove shall be in cladding.
 - d) Cladding shall be weld overlay or explosive bonded.
 - e) Other methods of cladding shall be subject to Buyer approval.
- 4.3.10. Tube holes in tubesheets with austenitic steel tubes for corrosion resistance shall conform to requirements for "Special Close Fit" in TEMA Class R.
- 4.3.11. Full diameter tubesheets may be used with TEMA Type B stationary heads, subject to Buyer approval. Optionally, fully threaded tubesheet bolt holes or shoulder bolts may be used.
- 4.3.12. Tube holes at shell side face of tubesheet shall have at least a 0.8 mm 45° chamfer.

4.4. Floating Heads

- 4.4.1. For split ring designs, an overlapping, L shaped split ring is preferred. Split rings which are recessed in grooves on the tubesheet periphery shall not be used in corrosive shellside services. Split rings shall be designed in accordance with ASME VIII Div 1 Article 2.9.

- 4.4.2. Seating gasket ribs for partitions must be taken into account when designing the floating head.
- 4.4.3. On floating head type units when one pass tubeside construction is specified, the following limitations shall be followed:
- a) A packed gland type is acceptable only in shellside water service.
 - b) For all other services, an internal bellows joint must be used. All internal bellows joints must be fabricated from Inconel 625 unless otherwise specified. Minimum fatigue life shall be 7,000 cycles.
- 4.4.4. Floating head covers shall be provided with lifting lugs welded on each side at 45 degrees from top.

4.5. Shells, Shell Covers and Shell Supports

- 4.5.1. It is the responsibility of the SUPPLIER to determine the need for shell expansion joints for the conditions specified on the data sheet and/or paragraph 4.3.3 of this specification.
- 4.5.2. The minimum permissible shell cover thickness specified in TEMA is to be after forming, but not less than 6 mm nominal.
- 4.5.3. Shell supports shall be designed to withstand a vertical load including the heat exchanger weight, weight of heat exchangers stacked above, weight of water contained in the stacked heat exchangers, other specified loads, including wind and seismic loads plus fifteen percent of the above loads, without distortion to the shells.
- 4.5.4. The horizontal support load on the stationary end shall be taken as follows:
- The horizontal load induced by pulling a tube bundle from a heat exchanger unit without jacking screws shall be taken as 150% of the tube bundle weight.
- 4.5.5. One (1) grounding lug shall be provided on each exchanger. On stacked exchangers, a lug is required only on the bottom shell. The lug shall be located on the "fixed" shell support, approximately 150 mm above the exchanger foundation.
- 4.5.6. Vertical height of supports shall be minimised to permit maintenance without scaffolding. Saddle supports higher than 450 mm shall be fireproofed. Supplier shall attach nelson studs to supports.
- 4.5.7. Stacked multiple shell units shall conform to the following:

- a) Lower shells shall have support members to carry upper exchangers per 4.5.3. above and resist axial loads required to pull upper bundles per 4.5.4. above.
- b) Lower shells shall be adequate to accommodate superimposed load from shells above without causing distortion that might cause binding of the tube bundle. Effects of differential thermal expansion between interconnecting nozzles and support shall be investigated to determine that stresses are within allowable limits.
- c) Upper shells with flanged intermediate shell nozzles shall have a minimum allowance of 6 mm for shims between intermediate supports. Nozzle length shall be sufficient to allow for this shimming. Shims shall be tack welded to upper base plate of lower shell after accuracy of fit-up is checked.
- d) Stacked units shall be shop-assembled to check saddle and nozzle fit up.
- e) Nozzle tolerances for stacked assemblies shall conform to TEMA tolerances for a single individual exchanger.

4.6. Nozzles and Other Connections

- 4.6.1. Flanges through 24" in size shall be per ANSI B 16.5. Above 24", flanges shall be in accordance with ASME B16.47 Series B unless otherwise noted. Nozzles shall be designed to withstand the loadings shown in Appendix A of this specification, in the hot and corroded condition.
- 4.6.2. All reinforcing pads shall have one ¼ inch NPT test hole. After completion of welding, the pad shall be subjected to a 1 bar (g) air and soapy water test. Test hole shall be filled with heavy grease prior to shipment. Do not plug the test holes. Sectioned pads shall have a test hole in each section.
- 4.6.3. For stacked exchangers, the SUPPLIER shall provide the stud bolts, nuts and gaskets for interconnection nozzles and bolts and shims for saddles. Intermediate gaskets shall be spiral wound.
- 4.6.4. Nozzles shall be flanged, welded and radially orientated. All auxiliary connections shall be flanged. Screwed connections are not permitted.
- 4.6.5. Nozzles made from solid corrosion alloy material are not permitted on clad vessels unless written approval is received from the buyer.
- 4.6.6. Screwed flanges shall not be used.
- 4.6.7. Nozzle length shall be as follows:
 - a) Stacked units shall have flanged intermediate nozzles that are long enough to permit bolt removal from either side of flanges with an assumed 75 mm thickness of insulation on shells and channels.

- b) Remaining nozzles shall have flange faces at least 200 mm from outside of shell or channel to which they are attached.

4.6.8. Minimum wall thickness including corrosion allowance shall be as follows:

- a) Unlined nozzles:

Diameter (NPS)	Carbon Steel Wall Thickness (ASME B36.10)	Solid Alloy Wall Thickness (Note 1) (ASME B36.10)
1, 1-1/2, 2	Schedule 160	Schedule 160
3	Schedule 160	Schedule 80
4	Schedule 80	Schedule 120
6, 8	Schedule 80	Standard
10 and larger	Extra strong	Standard

Note 1: Solid non-ferrous alloys and solid ferrous alloys with chromium content greater than 9%. Use of solid alloy nozzles shall be subject to Buyer approval.

- b) Lined nozzles, excluding thickness of lining shall be:

Diameter (NPS)	Wall Thickness (ASME B36.10)
1-1/2, 2	Schedule 160
3, 4	Schedule 80
6 and larger	Standard

4.7. Expansion Joints

- 4.7.1. Expansion joints shall preferably be the flanged and flued type. If the differential expansion between the shell and the tubes makes it impractical, then the thin wall bellows type shall be used.
- 4.7.2. All expansion joints in the shell must have an internal sleeve welded to the upstream side to minimise deposits in the joint. Expansion joints shall be of single layer standard one-piece construction unless otherwise approved by the Company. Supplier shall advise the length of the bellow and preset.
- 4.7.3. Flanged and flued expansion joints must be the same material as the shell, with the same corrosion allowance. Minimum thicknesses shall satisfy TEMA and ASME requirements.

- 4.7.4. Bellows type of expansion joints must be designed in accordance with the Standards of the Expansion Joint Manufacturers Association (EJMA) and ASME Section VIII, Division 1, Appendix 26. Prototype designs are not permitted. The expansion joint manufacturer must have previous experience with a production expansion joint of similar design, size and pressure/temperature rating. Bellows shall be designed for a minimum fatigue life of 7000 cycles for the conditions of Paragraph 3.3.3 of this Specification.
- 4.7.5. Prior to forming, the longitudinal seam in the bellows must be fully radiographed.
- 4.7.6. Bellows type expansion joints must not be subjected to any heat treatment other than that performed by the expansion joint manufacturer.
- 4.7.7. Bellows type expansion joints must be equipped with tie bars (limit stops) and shipping stays. Exchangers with shellside expansion joints shall be shipped with the expansion joints cold sprung.
- 4.7.8. Bellows type expansion joints in the shell shall be equipped with an external cover.
- 4.7.9. Internal expansion joints must be designed for full internal and external design pressures with no pressure being applied to the opposite side. Additionally, the design must allow for shellside hydrotest pressure with no pressure on the tubeside. New expansion joint shall be hydrotested at expansion joint Supplier's shop.

4.8. Flanged External Girth Joints

- 4.8.1. All girth flanges shall be of the weld neck type and shall be manufactured from forged materials only. Lap joint flanges may be acceptable on high alloy exchangers, with BUYER approval.
- 4.8.2. All end flanges shall be checked for axial alignment and gasket face flatness after welding to the shell and stress relieving. Final gasket surface machining must be carried out after welding and stress relieving. For normal applications, flatness tolerance, maximum deviation from a plane shall be 0.8 mm. For design pressure greater than 70 bar flatness tolerance shall be in accordance with API 660 para 6.8.5.
- 4.8.3. When nubbins are used to facilitate gaskets seating, they shall be located on the female component of the joint.
- 4.8.4. For multipass exchangers, the design of exchanger shall take into account effect of gasket seating at the pass partitions.

4.9. Gaskets

- 4.9.1. Where spiral wound gaskets are used and pass partitions are required, the gasket for the pass partition shall be a metal jacketed non asbestos strip of the same thickness as the girth gasket, with ends pinched together and welded at each end to the spiral wound gasket.

5. MATERIALS

- 5.1. Materials for pressure containing components shall be as specified on the exchanger data sheets, any special requirements for material testing such as sour service operation should be covered by a separate specification.
- 5.1.1. Materials of construction and corrosion allowance shall be as specified in the exchanger data sheets. Written approval for use of materials other than those specified must be obtained from the BUYER.
- 5.1.2. As a minimum, material grade and heat treatment condition shall comply with the appropriate national or international material standards allowed by the applicable pressure heat exchanger code. This requirement also applies to welding consumables.
- 5.1.3. For exchangers with a minimum design temperature below 0°C, carbon and low alloy steel shall be impact tested for that temperature, this shall include exchanger supports. Testing shall be carried out in accordance with the ASME code.
- 5.1.4. For exchangers specified as being in sour service, materials shall comply with NACE MR-0175, and the requirements of specification for piping, forgings, castings and plate in sour service KPO-00-PIP-SPC-00008-E/R.
- 5.1.5. Clad exchangers shall meet the requirements of the supplementary Attachment 1 of this specification.

5.2. Welded Attachments

5.2.1. Carbon Manganese and Low Alloy Steel Exchangers

- 5.2.1.1. *All permanent welded attachments to pressure parts shall be of the same grade and meet the same impact test requirements as the pressure part to which it is attached.*
- 5.2.1.2. *Temporary welded attachments to pressure parts shall be removed and ground smooth. Following removal the pressure part shall be examined by either magnetic particle inspection (MPI) or dye penetrant inspection (DPI) techniques in order to establish freedom from defects.*

5.2.2. Stainless Steel Exchangers

5.2.2.1. All welded attachments temporary or permanent shall be of the same grade as the pressure part.

5.3. Product Forms and Composition

5.3.1. Castings shall not be used for pressure parts without the written agreement of the buyer.

5.3.2. Pipe used for pressure containing components shall be seamless.

5.3.3. For carbon and carbon manganese steel parts the carbon content shall be 0.25% maximum and the carbon equivalent (CE) shall be 0.45 maximum.

$$\text{Where CE} = \text{C} + \frac{\text{Mn}}{6} + \frac{\text{Cr} + \text{Mo} + \text{V}}{5} + \frac{\text{Cu} + \text{Ni}}{15}$$

5.4. Heat Treatment Condition

5.4.1. Carbon and low alloy steels shall be heat treated as required by the material specification. All plate shall be in the normalised heat treated condition for all thicknesses.

5.4.2. All austenitic stainless steels shall be in the solution annealed condition.

5.4.3. Certification and Marking

5.4.4. Material test certificates shall be to BS EN 10204 type 3.1 for pressure retaining parts and type 2.2 for other parts.

5.4.5. Materials for use in low temperature or cyclic service shall not be hard stamped.

6. WELDING AND FABRICATION

6.1. All welding and post weld heat treatment shall comply with the requirements of Specification KPO-00-QAC-SPC-00001-E/R Welding Procedure Approval and Welding Quality Requirements.

6.2. No welding or cutting is permitted on heat exchangers after they have been stress relieved (when required).

6.3. Tube to Tubesheet welding shall be in accordance with KPO-00-QAC-SPC-00001-E specification requirements.

6.4. No fabrication may commence until the Suppliers quality plan, fabrication and weld procedures and drawings have been reviewed by the KPO.

- 6.5. Welding procedure qualifications shall include impact testing of weld metal and heat affected zone to match parent material requirements.
- 6.6. Heat exchangers shall be post weld heat treated as required by the ASME code and also if required by the data sheet.
- 6.7. All parts hot formed from carbon steel (heads etc.) shall be normalised after forming, unless it can be demonstrated to the satisfaction of BESP that those parts were formed within the normalising temperature range. The upper limit of the temperature whether for normalising or forming, shall not exceed 1050°.

7. INSPECTION, EXAMINATION AND TESTING

7.1. **NDE Requirements (Non-Destructive Examination)**

- 7.1.1. Inspection, examination and testing shall as a minimum comply with the requirements of the Design Code and this specification. Minimum NDE acceptance criteria shall be in accordance with applicable section of ASME Section V.
- 7.1.2. NDE operators shall be certified to ASNT-TC-1A, Level II with interpretation by supervisors certified to Level III or an approved equivalent.
- 7.1.3. Shell and Head Plates welded together before forming shall be subject to 100% radiography after forming and any subsequent heat treatment.
- 7.1.4. All acceptance NDE shall be carried out after post weld heat treatment (PWHT).
- 7.1.5. Where attachments, that cover heat exchanger weld seams, are not provided with a cutout, then the weld seam plus 50mm each side of attachment shall be 100% RT/UT checked before they are fitted.
- 7.1.6. Carbon and low alloy steel plate greater than 60mm thick and operating at pressure greater than 100MPa shall be 100% ultrasonic tested.
- 7.1.7. Heat Exchangers grouped in design categories, 1 to 4, dependent on design pressure and temperature comply with relevant GOST. Exchanger design group category number will be specified on exchanger data sheet.

For group category numbers 1 & 2, extent of radiography is 100% of ALL main weld seams for exchanger, boots, nozzles and attachment but welds of shell connections.

For group category 3, 50% (spot) X-ray of total joint length is required for all seams, which includes 'T'-joints.

For group category 4, 25% (spot) X-ray of total joint length is required for all seams, which includes 'T'-joints.

7.2. Surface Examination

All attachment welds to pressure parts which are not subject to 100% radiography shall be subjected to Magnetic Particle or Dye Penetrant crack detection testing performed as follows:

- a) The full length of all nozzle attachment welds
- b) A minimum of 10% of the length of all other attachment welds to pressure containing parts, and welds to primary structural steel.
- c) All carbon steel shall be examined using magnetic particle examination, method only.
- d) If nozzle attachments are of the "set on" type, all weld joint preparations shall be subject to 100% ultrasonic examination (UT).
- e) All plate weld preparations greater than 30mm shall be subject to 100% ultrasonic examination.

7.3. Base Materials

7.3.1. All plates and forging of thickness greater than 60mm shall be ultrasonically examined in accordance with ASME V, SA435 or SA388 as applicable.

7.4. Pressure Testing

7.4.1. The hydrostatic test procedure pressure shall meet the requirements of the Design Code. Minimum duration of hydrotest shall be 1 hour.

Test pressure shall be determined in accordance with paragraph UG-99(c) of ASME VIII Division 1 and paragraph AT-301 of ASME VIII Division 2, as applicable.

7.4.2. All hydrostatic test shall be made in the presence of Buyer's inspector. No preliminary tests, regardless of pressure, shall be made prior to any required PWHT.

7.4.3. Hydrostatic test water shall be potable, except where heat exchanger containing high alloy cladding or internal attachments shall be tested with water whose chloride content is below 50 parts per million. Minimum temperature of hydrotest water shall be 16°C.

7.4.4. All reinforcing pads shall be tested with 1 bar (g) air and soap suds solution after completion of final post weld heat treatment.

7.4.5. Pneumatic testing of heat exchangers shall not be used without the consent of the Buyer.

7.4.6. Gaskets and bolting used for hydrotest shall be of same type as required for service.

8. NAMEPLATE

8.1. Heat exchanger nameplate shall be permanently mounted on a dedicated bracket sufficiently strong to allow nameplate stamping.

8.2. The bracket shall be raised to 25 mm above the level of the insulation surface.

8.3. The nameplate shall be made from austenitic stainless steel 2mm thick and be riveted to the bracket. All data and text on the nameplate shall be stamped and be shown in English and Russian.

8.4. The nameplate shall be located in a conspicuous place on the pressure shell.

8.5. Heat Exchangers designed to ASME Code shall be stamped with the ASME Code symbol.

8.6. Individual exchanger components such as channel cover, bonnet, tubesheet and shell shall be permanently tagged or marked with equipment number.

9. CLEANING COATING AND SHIPPING PROTECTION

9.1. **Cleaning**

All heat exchanger surfaces shall be cleaned to remove loose scale, rust, grease, dirt, weld spatter, hydrotest water and other foreign matter. Internal surfaces are to be thoroughly dried.

9.2. Surface preparation and painting shall be in accordance with the Project Specification for External Coating No. KPO-00-ENG-SPC-00035-E. It is a responsibility of Supplier to ensure that all equipment, including sub-supplier equipment, is supplied in accordance with the Project Specification.

9.3. All exposed machined and threaded surfaces shall be thoroughly coated with a suitable rust preventative compound and suitably protected for shipment. All vent holes in reinforcing pads or lined nozzles shall be plugged with heavy grease.

9.4. All loose parts shall be adequately crated and given clear markings relating the parts to the heat exchanger identification number.

9.5. After application of the paint required by paragraph 9.2, each stress relieved heat exchanger shall have the following stencilled along opposite sides of the heat exchanger in large contrasting letters, in English and Russian:

"DO NOT WELD OR STRIKE ARCS - STRESS RELIEVED HEAT EXCHANGER".

10. DOCUMENTS

- 10.1.** Supplier shall provide all documents as required by purchase order and it's attachments.
- 10.2.** Calculations provided by Supplier shall demonstrate that the heat exchanger supplied meet the requirements of the Design Code and applicable Kazakh standards.
- 10.3.** Supplier is to provide a CU TR Certificate (Custom Union Technical Regulation Conformity Certificate) for each heat exchanger and include in the heat exchanger passport.
- 10.4.** Calculations shall be provided as follows:
 - a) A front cover title sheet showing purchase order number, heat exchanger tag number, heat exchanger title, and document number.
 - b) An index sheet showing list of contents and page reference numbers.

APPENDIX A**NOZZLE LOADS**

1. The Appendix defines the minimum loadings for nozzles 3 inch N.B and larger to which the heat exchanger equipment shall be designed.

Table 1.0 indicates the allowable nozzle loads and moments on the equipment, from external piping, note that shear and torsion effects are omitted as they have negligible effect on final stress resultants. The sign convention for the applied external loading is shown on page A3 of 3.

NOZZLE SIZE NB	See Figure for convention ML= Longitudinal Moment M \varnothing = Circumferential Moment MR = Resultant Moment FA = Axial Load		FLANGE RATING, CLASS					
			150	300	600	900	1500	2500
3" (DN75)	Longitudinal	(kNm)	0.53	0.062	0.71	0.79	0.88	0.97
	Circumferential	(kNm)	0.41	0.47	0.54	0.61	0.68	0.74
	Resultant	(kNm)	0.67	0.77	0.89	0.99	1.11	1.22
	Axial Load	+/- (kN)	2.7	3.15	3.60	4.05	4.50	4.95
4" (DN100)	Longitudinal	(kNm)	0.94	1.10	1.25	1.40	1.56	1.72
	Circumferential	(kNm)	0.72	0.84	0.96	1.08	1.20	1.32
	Resultant	(kNm)	1.18	1.38	1.58	1.77	1.97	2.17
	Axial Load	+/- (kN)	3.6	4.2	4.80	5.40	6.00	6.60
6" (DN150)	Longitudinal	(kNm)	2.11	2.46	2.81	3.16	3.51	3.86
	Circumferential	(kNm)	1.62	1.89	2.16	2.43	2.70	2.97
	Resultant	(kNm)	2.66	3.10	3.54	3.98	4.43	4.87
	Axial Load	+/- (kN)	5.40	6.30	7.20	8.10	9.00	9.90
8" (DN200)	Longitudinal	(kNm)	3.74	4.37	4.99	5.62	6.24	6.86
	Circumferential	(kNm)	2.88	3.36	3.84	4.32	4.80	5.29
	Resultant	(kNm)	4.73	5.51	6.30	7.09	7.88	8.66
	Axial Load	+/- (kN)	7.20	8.40	9.60	10.80	12.00	13.20
10" (DN250)	Longitudinal	(kNm)	5.85	6.83	7.80	8.78	9.75	10.73
	Circumferential	(kNm)	4.50	5.25	6.00	6.75	7.50	8.25
	Resultant	(kNm)	7.38	8.61	9.84	11.07	12.30	13.53
	Axial Load	+/- (kN)	9.00	10.50	12.00	13.50	15.00	16.50
12" (DN300)	Longitudinal	(kNm)	8.42	9.83	11.24	12.64	14.04	15.44
	Circumferential	(kNm)	6.48	7.56	8.64	9.72	10.80	11.88
	Resultant	(kNm)	10.63	12.40	14.17	15.94	17.72	19.49
	Axial Load	+/- (kN)	10.80	12.60	14.40	16.20	18.00	19.80
14" (DN350)	Longitudinal	(kNm)	11.47	13.38	15.29	17.20	19.11	21.03
	Circumferential	(kNm)	8.82	10.29	11.76	13.23	14.70	16.17
	Resultant	(kNm)	14.47	16.88	19.29	21.70	24.11	26.52
	Axial Load	+/- (kN)	12.60	14.70	16.80	18.90	21.00	23.10
16" (DN400)	Longitudinal	(kNm)	14.98	17.48	19.97	22.46	24.96	27.46
	Circumferential	(kNm)	11.52	13.44	15.36	17.28	19.20	21.12
	Resultant	(kNm)	18.89	22.04	25.20	28.34	31.49	34.64
	Axial Load	+/- (kN)	14.40	16.80	19.20	21.60	24.00	26.40
18" (DN450)	Longitudinal	(kNm)	18.95	22.11	25.28	28.43	31.59	34.75
	Circumferential	(kNm)	14.58	17.01	19.44	21.87	24.30	26.73
	Resultant	(kNm)	23.91	27.90	31.88	35.87	39.86	43.84
	Axial Load	+/- (kN)	16.20	18.90	21.60	24.30	27.00	29.70
20" (DN500)	Longitudinal	(kNm)	23.40	27.30	31.20	35.10	39.00	42.90
	Circumferential	(kNm)	18.00	21.00	24.00	27.00	30.00	33.00
	Resultant	(kNm)	29.52	34.44	39.36	44.28	49.20	54.12
	Axial Load	+/- (kN)	18.00	21.60	24.00	27.00	30.00	33.00
24" (DN600)	Longitudinal	(kNm)	33.69	39.32	44.93	50.54	56.16	61.78
	Circumferential	(kNm)	25.92	30.24	34.56	38.88	43.20	47.52
	Resultant	(kNm)	42.51	49.59	56.68	63.77	70.85	77.93
	Axial Load	+/- (kN)	21.60	25.20	28.80	32.40	36.00	39.60

TABLE 1

MINIMUM LOADS FOR DESIGN OF NOZZLES

