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1 Subject of specification

This specification and other documents referenced herein establish the minimum requirements for the design, manufacture, erection, inspection and tests for plate heat exchangers being operated on Grupa LOTOS S.A. plant.

2 Scope of validity

This specification applies to preparation of inquires and contracts for newly planned investment or modernisation projects of Grupa LOTOS S.A.

It is also serves as the base for preparation of detailed specifications and inquires for individual and package delivery.

2.1 Deviations

Any deviation from this specification and the relevant specifications, standards and related documents including proposals, which the bidder claims to be economically and / or technically superior solutions must be submitted in writing for review and approval by Grupa LOTOS S.A. Non-approved exceptions are not acceptable by Grupa LOTOS S.A.

The supplier must report in writing any ambiguity in this or any other specifications of Grupa LOTOS S.A. or non-compliance with the referred documents / standards and obtain a written explanation from Grupa LOTOS S.A.

3 General

3.1 Scope

This specification, used in conjunction with the purchase documents, data sheets, and/or drawings establishes the minimum requirements for the mechanical design, fabrication, inspection and testing of plate heat exchangers. In this specification only the term "Heat Exchanger(s)" will be used.

This specification is based on the ASME Boiler and Pressure Vessel codes and referenced standards and specifications. These specification requirements, irrespective of code of manufacture, shall, however, apply to all heat exchangers.

The heat exchangers to be designed, manufactured and supplied in accordance with Pressure Equipment Directive (97 / 23 / EC) and marked with “CE” mark.

3.2 Order of Precedence

In case of conflicts exististing between this specification and other documents, the following order of precedence shall govern:

- The current Polish legislation
- Terms of purchase order / contract and other requirements agreed in writing Grupa LOTOS S.A.
- Data Sheets approved by Grupa LOTOS S.A.
- This specification

- Other Specifications
- Drawings and other documents
- Standards

4 Design Criteria

4.1 General Requirements

The design, construction and inspection of heat exchangers shall, as a minimum, meet the requirements of API 662/ISO 15547 including Annex A, ASME Section VIII, Division 1 and requirements specified on the drawings or/and data sheets and referenced specifications.

4.2 Design Conditions

Manufacturer shall be responsible for the mechanical layout and design of the heat exchanger as shown by heat exchanger specifications, drawings and/or process data sheets of Grupa LOTOS S.A.

In special cases manufacturer shall also be responsible for the process design in accordance with process data sheet of Grupa LOTOS S.A.

4.3 Stresses

The basic allowable stress for pressure parts shall be the values specified in the applicable code.

The basic allowable stresses for non-pressure parts, except as listed below, shall be 33-1/3 percent of the ultimate tensile strength, 66-2/3 percent of the yield strength, or that producing a creep rate of 1 percent in 10,000 hours, whichever is lower.

4.4 Design Pressure and Temperature

Heat exchangers shall be designed to the design pressure and design temperature specified in the heat exchanger drawings/data sheets.

In case several pressure-temperature combinations are specified all of them shall be taken into account.

4.5 Loads

The heat exchangers and its supports shall be designed for the following conditions of loading. Erection dead weight, test weight under test pressure, operating weight under design pressure and piping loads on nozzles, weights and loading during anticipated handling and shipping.

If required in the technical requisition the static design calculations for wind shall be performed in accordance with applicable regulations agreed with Grupa LOTOS S.A. Process induced loads must always be taken into account.

4.6 General Construction Features

Units shall be of conventional vertically supported heat exchanger plates mounted on a steel frame, which is designed as a freestanding unit for installation on client's horizontal base or plant floor.

The frame shall be capable of accepting a 20 percent increase in the number of exchanger plates above that number of plates which is required for the performance specified herein.

The preferred design is a single pass unit with all nozzles located in the fixed head end. However, if the required performance conditions are more suitable for a multi-pass and/or counter-flow design, this will be considered.

When for technological reasons there is necessity to use few the same heat exchangers, they shall be designed to enable interchange ability of components between them.

4.7 Frame and Plate Design

The frame shall consist of a movable cover and fixed cover, which shall stand vertically (bolted to floor) and between which are two horizontal plate pack bars. The top bar carries the plate pack and the bottom bar serves as a guide bar. The movable cover used to compress the plate pack shall be suspended from the top bar by means of a grease lubricated roller bearing assembly enabling it to move back and forth between the head plate and end support.

An adequate number of tie bolts shall be provided to compress the plate pack. They shall be properly spaced to provide even compression. The tie bolts shall be mounted in external slots of the fixed cover and movable cover to allow easy disassembly of the heat exchanger plates.

The necessary tie box spanner wrench shall be furnished with the equipment. The operating ports shall be fitted with bushes and unused ports shall have blanking plates. The bushes and plates shall be of the same material as the heat exchanger plates.

The plate pack shall consist of flow plates, seal plate (adjoining fixed cover), end plate (adjoining movable cover) and pass plates (if required). All plates shall be marked with the equipment type reference symbol and individually numbered in sequence and specifically indicated on the drawing for the item as purchased.

Seal plate corrugation pattern may be washboard parallel or herringbone type. All flow and end plates shall have leakage grooves open to atmosphere to prevent cross-leakage and intermixing of the primary and secondary fluids.

On units having operating ports in the movable cover, manufacturer shall state total maximum movement of plate pack for thermal expansion and subsequent compression.

The frame plate support bars shall be designed to permit removal of individual plates for gasket and/or plate replacement. These support bars should be of sufficient length to allow plate separation for clean out.

Provisions shall be made for thermal expansion and contraction for all anticipated operating conditions including start-up and shutdown.

Supporting members that are subject to torsion shall be fabricated to form closed (boxed) cross sections.

4.8 Nozzles

All nozzles and connections shall be flush inside, unless otherwise specified

Minimum nozzle necks thickness, including up to 3 mm (1/8") corrosion allowance shall be Sch. XS for carbon steel and for stainless steel shall be Sch. 40S.

Unless otherwise specified on the drawings or / and data sheets, flanges for all external nozzles 24 inch nominal size and less shall be in accordance with ASME B16.5 with respect to class and flange

facing type and for nominal size of 26 through 60 inch shall be in accordance with ASME B16.47, Series A flanges and checked per ASME, Section VIII, Div.1, Appendices 2 and S.

The finish of the gasket contact surface of nozzle flange facing shall conform to ASME/ANSI B16.5, unless otherwise specified. When a "raised face" (RF) is specified, the gasket contact surface roughness shall be 1.6 to 3.2 µm Ra to ISO 4287 (63 to 125 µin. AARH), unless otherwise specified.

Nozzles necks shall be of seamless pipe. Nozzle necks may be of rolled plate when the nozzle size is NPS 16 or larger for carbon steel and NPS 8 and above for other materials.

All rolled plate nozzle necks shall be 100% radiographed.

The drilling for all flanges of external and internal pipe nozzles shall straddle natural axis of the heat exchanger.

All threaded connections shall conform to ANSI B1.20.1.

4.9 Flanges and Gaskets

Forged welding neck flanges or long weld neck flanges shall be used for nozzles.

Slip-on type flanges shall not be used for class 300 and higher or for design temperature above 250 °C and also when the service is designated to be hydrogen, hydrogen sulphide, sour water, cyclic or corrosion allowance is more than 3 mm.

All facings shall be adequately protected against damage during fabrication, storage and/or heat treatment.

Oval type gaskets shall be used with ring joint flanges.

Flanges shall have the same inside bore as the nozzle pipe.

4.10 Connections

Vent and drain connections shall be provided on high and low points when the heat exchanger is not vented or drained through the nozzles.

5 Design Requirements

5.1 Materials

Materials used for pressure retaining parts shall meet Pressure Equipment Directive (97 / 23 / EC) requirements.

Materials shall be selected based on the service, kind of process medium and the design temperature as well as the minimum design metal temperature (MDMT) and shall be in accordance with applicable specifications listed in the ASME Code, Section II, but shall be limited to those that are permitted in Section VIII.

Carbon steel shall be killed for pressure parts and components welded to the pressure parts. Carbon content shall not exceed:

- 0,23 % for plates and pipes
- 0,25 % for forgings

and carbon equivalent describe with the following formula:

CEV=C+Mn/6+(Cr+Mo+V)/5+(Ni+Cu)/15 shall not exceed 0,43 %.

Plates 50 mm thick and above shall be 100 % ultrasonic tested per ASTM A 435 in steel work.

Clad plates shall be 100 % ultrasonic tested per ASTM A 578 (in accordance with SA-263, SA-264 and SA-265 additional requirements S12) – acceptance level class 3 (in accordance with SA-263, SA-264, SA-265) and shall pass shear test. Minimum shear strength of the alloy cladding and base metals shall be 140 N/mm^2.

Main materials will be indicated on the heat exchanger drawing/data sheet.

After forming, heads made of clad plate shall be ultrasonic tested per ASTM A 578 – additional requirement S12 in accordance with SA-263, SA-264, SA-265 acceptance level class 3.

Internal and external non-pressure parts as welded to pressure retaining parts shall be of the same material grade or the same P number as the pressure plate, unless noted otherwise. For these parts non-impact tested materials are acceptable.

For bolts and nuts the process of manufacture, heat treatment, chemical and mechanical requirements, coatings and marking shall be in accordance with the requirements of applicable codes and specifications. The applicable "Identification Symbol" shall be stamped on bolts and nuts as required by the material codes and specifications. Material and test data sheets shall be provided to Grupa LOTOS S.A. upon request.

Gaskets shall be of asbestos free material suitable for the process and service conditions.

All materials shall be new and unused.

5.2 Bolts and Gaskets

Pressure bolting for nozzle flange connections or blind flanges shall be stud bolts threaded full length with two hex nuts each. The strength of studs shall be based on the cross-section of the smallest diameter.

Stud bolts should protrude two (2) threads beyond nuts.

Hard steel washers 6 mm thick shall be furnished under studs 1 ½ inches and larger.

Bolt sizes and threads shall conform to ASME/ANSI B1.1, Class 2A (external thread) or Class 2B (internal thread):

- Bolts in 1 inch diameter and smaller shall be coarse threads series (UNC).
- Bolts over 1 inch diameter shall be 8 thread series (8UN).

The threads of external studs and nuts shall be coated with a suitable thread lubricant (e.g. containing molybdenum disulphide) to prevent galling.

Gaskets shall be as specified on the heat exchanger drawing/data sheet.

Two spare gaskets and 10 % bolts with nuts (min. 1 bolt with nuts per bolt size and per material grade) shall be furnished for each flanged connection with installed gasket.

All gaskets furnished shall be new and shall be installed before the heat exchanger is shipped. Gaskets used for shop test purposes shall be replaced with new materials.

5.3 Fabrication and Workmanship

All weld procedures including non-pressure welds shall be identified by number and shall be referenced in weld details on fabrication drawings.

5.4 Welding

All welded joints should be made by arc welding.

Covered electrodes shall comply with the relevant AWS-ASME specifications, and the electrode covering shall be basic type. Low-hydrogen electrodes shall be used to avoid cold cracking (hydrogen cracking).

Nozzles and their reinforcements shall be connected with the shell by full penetration welds.

If heat treatment is required than all welding has to be finished earlier. In case of clad material, plate shall be 100 % ultrasonic tested to check cladding adherence to the base material. Weld overlay shall be checked with liquid penetrant. If 100 % weld overlayed surface was checked with penetrant before heat treatment than after heat treatment the surface shall be randomly tested, however not less than 10 %.

Hardness of low alloy Cr-Mo materials shall be checked after heat treatment in seam area and in area of heat treatment. Hardness shall not exceed:

- 215 HB for steel with Cr < 2 %.
- 240 HB for steel with Cr > 2 %

When austenitic stainless steel is welded to carbon steel or low alloy steel, if working temperature is less than 350 °C welding consumables 309(L) or 309Mo(L) (for austenitic steel with Molybdenum for example 316L) shall be used. For higher working temperature a nickel based electrodes should be used for example ENiCrFe-3.

Welding of equipment parts made of carbon steel to stainless steel needs every time Grupa LOTOS S.A. permission in writing.

5.5 Tolerances

Tolerances for connecting dimensions of nozzles and supports shall conform to the requirements of the API 662/ISO 11547-1 standard but nominally identical parts shall be interchangeable.

All gasket faces and other machined surfaces shall be checked for warpage and distortion.

6 Inspection and Testing

6.1 Testing

Radiographic examination shall be in accordance with the ASME code.

When 100% radiography is specified, the root passes and the finished fillet welds of all nozzle attachment welds shall be inspected by magnetic particle, liquid penetrant or ultrasonic method approved by Grupa LOTOS S.A. Welds need be ground only when necessary to effect proper interpretation of the radiograph.

All heat exchangers shall be subjected to a hydrostatic test in accordance with the Code. The hydraulic test pressure shall be maintained for at least 1 hour.

Equipment shall be hydrostatically tested in accordance with PED requirements. Stainless steel and /or high nickel alloy, including clad materials shall be tested with low chloride water.

If not specified otherwise content of chloride in test water shall not exceed:

- Carbon steel < 500 ppm

- Austenitic stainless steel and high nickel alloy material < 25 ppm

Pressure tests shall be performed separately for each pressure compartment and for both compartments.

Service gaskets and service bolting shall be used for shop tests. Any materials damaged during the tests shall be replaced by the supplier with new material.

Test reports shall be prepared for each unit and together with procedures issued to Grupa LOTOS S.A.

6.2 Inspection

The Inspection and Test Plan (ITP) shall be completed and sent to Grupa LOTOS S.A. for fixing the notification, review, witness and hold points.

All mandatory inspection requirements of applicable national, regional, local laws and regulations for the area of installation or as furnished by the client have to be observed.

A visual and dimensional spot check by Grupa LOTOS's S.A. authorised representative will be carried out prior to the hydraulic test and/or heat treatment or coating of the heat exchanger, if any.

The Manufacturer shall notify in writing (by e-mail and/or fax) Grupa LOTOS at least 10 working days in advance when the heat exchanger will be ready for inspection.

Inspection by Grupa LOTOS S.A. shall in no way relieve the Manufacturer of his responsibility to meet the requirements of the purchase documents.

Grupa LOTOS's S.A. authorised representative shall have the right to inspect all work in progress, to insure that proper workmanship, orientation, welding, testing, painting, etc. are being obtained.

Grupa LOTOS S.A. reserves the right to make preliminary intermediate and final inspection.

The heat exchangers as made available for the inspection shall be free from slag, dirt, oil, welding spatter and other foreign matter.

The heat exchangers presented for the inspection shall be subjected to a previous dimensional check by the manufacturer. The manufacturer shall prepare a dimensional record indicating the actual dimensions for each heat exchanger (including out of roundness; offset in welded joints, deviations from true alignment) and submit it to the Grupa LOTOS S.A. authorised representative. Any deviation from the specified tolerances shall be clearly marked in this record.

All loose components included in the scope of supply of the heat exchangers shall be kept ready for the inspection.

If the heat exchangers or heat exchangers' components to be inspected are not ready to the expected extent or in the specified quality at the scheduled date, the Manufacturer shall bear all additional costs arising from subsequent inspections.

After specified hold points have been reached, Manufacturer shall not proceed with performing the activity until authorization is received from Grupa LOTOS S.A.In case of the following problems, Grupa LOTOS S.A. shall be informed in writing without any delay:

- Deviations from the standard
- Rejected or insufficient test results
- Objections raised in connection with the checking of drawings
- Failure to comply with the specified tolerances

- Fabrication defects / repairs
- All events resulting in fabrication delays and thus jeopardising the delivery date.

6.3 Documents Required During Inspection

Grupa LOTOS S.A. authorized representatives at the time quality surveillance activities are being conducted at Manufacturer premises shall have available a complete set of below listed documents related to the purchase order:

- Confirmed purchase orders for materials
- Material certificates together with part list for which they will be used
- Welding procedures approved by Notified Body
- Welder's qualification records
- Weld map
- Certificates of performed tests of welds
- Certificates of heat treatment
- Plan of marking of materials on the equipment (main pressure parts)
- Certificates of manufacturer's pressure tests
- Certificates of first pressure tests issued by Notified Body
- Manufacturer's dimensional check record
- Manufacturer's certificate of conformity, that equipment was manufactured in accordance with:

- relevant code agreed in purchase order and PED 97/23/EC
- standards
- technical documentation

- Notified Body certificate of conformity, that equipment was manufactured in accordance with relevant code and PED 97/23/EC.

6.4 Rejection

Equipment or parts thereof and materials entering therein, indicating irremediable or injurious defect, improper fabrication, excessive repairs, or that they are not in accordance with the requirements of this specification shall be subject to rejection. They shall be subject to rejection at any time or place by the Grupa LOTOS S.A. authorised representative if such conditions are discovered after acceptance of the items at the supplier's plant.

7 Nameplates

Completed heat exchangers shall have a nameplate in Polish language or Polish and English language in accordance with PED 97/23/EC and API 662/ISO15547-1. Nameplates shall be made of corrosion resistant material installed on a nameplate bracket by solid stainless steel rivets on the fixed cover. . Inscriptions on the nameplate shall be engraved.

To ensure correct tensioning of the tie rods; the dimension (with the allowable tolerance) between the fixed cover and the movable cover shall be specified on the Manufactureres drawing. The dimensions shall take into account the number of installed plates. The dimension with the tolerance shall also be shown on the exchanger nameplate or an additional nameplate near the nameplate.

8 Painting, Marking, Packing

8.1 Painting

Painting shall be in accordance with Grupa LOTOS S.A. specification No.: 1190.

Unless otherwise noted on the drawings, shop fabricated equipment shall be painted on outside surfaces only.

Shop painting shall not be applied within 150 mm (6 inches) of any weld before Grupa LOTOS's S.A. inspection.

Stainless steel and high nickel alloy (inconel, hastelloy, etc.) are not to be painted, unless noted otherwise. Only stainless steel brushes, clean, iron free sand or stainless grit shall be used for cleaning alloy surfaces. All welding flux shall be completely removed. Solvents used to clean or remove scale or oil shall be free of organic and inorganic chlorides.

Derusting, painting as well as preservation of the eqipment shall be carried out after hydrostatic testing and the inspection by Grupa LOTOS S.A.

Exposed machined parts for example: flange facing, threads shall be protected during fabrication/ blasting and painting. Stainless steel equipment, which does not require painting, shall have the outside surface pickled and passivated.

8.2 Marking

The heat exchanger shall be marked with the item number. (Character height about 200 mm)

Care shall be taken to ensure that water insoluble ink or paint is used for marking.

When austenitic and high nickel alloy (inconel, hastelloy, etc.) steels are to be marked with fabrication or shipping information, the marking shall be done with water insoluble ink that does not contain sulphur, chlorides or metallic pigments.

Parts to be supplied loose such as spare parts shall be identified by means of a tag indicating the relevant part number as per the workshop drawing as well as the item number.

8.3 Packing

Heat exchangers shall be shipped fully assembled.

All openings shall be sealed watertight and in such a way as to avoid damage to the connecting faces.

Small parts and spare parts included in the scope of supply shall be separately packed and shipped together with the heat exchanger.

Further information on packing and transport are included in the packing and shipping instructions.

Unless otherwise specified, the heat exchanger interior shall be thoroughly cleaned and dried.

If specified in relevant purchase order documents; stainless steel or clad heat exchangers shall be filled with nitrogen and provided with nitrogen cylinder, 3-way valve, gauge and stainless steel shroud. The required overpressure shall be written on the shroud.

9 Guarantees

All materials, design and construction shall be subject to the conditions and guarantees required by the purchase order.

The heat exchanger manufacturer shall guarantee that the equipment designed by him, will meet the conditions specified in the purchase order. In case the equipment does not fulfil the specified conditions the heat exchanger manufacturer shall, without cost to Grupa LOTOS S.A., furnish such new equipment or redesign, and rebuild the equipment furnished, so that the specified conditions will be met.

Drawings review, intermediate and final inspections of heat exchangers carried out by Grupa LOTOS S.A., and also Release Note do not relieve manufacturer from his responsibility to fulfill requirements of purchase order.

10 Relevant documents

Any "Technical Specification" issued by Grupa LOTOS S.A. listed in Contract Files.

11 Codes and standards

Codes and standards listed below form part of this specification. Each publication shall be the latest revision and addendum in effect at the Contract award, unless otherwise specified:

- 97/23/WE (PED) Directive of the European Parliament and of the Council on the approximation of the law of the Member States concerning pressure equipment
- 2009/105/EC Directive of the European Parliament and of the Council relating to simple pressure vessels (replaces Directive 87/404/EEC of 25 June 1987)
- ASME BPVC ASME Boiler & Pressure Vessels Code – Sections I through X
- ASME B16.5 Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24
- ASME B16.47 Large Diameter Steel Flanges NPS 26 Through NPS 60
- ASME B16.20 Metallic Gaskets for Pipe Flanges Ring-Joint, Spiral-Wound, and Jacketed
- ASME B16.21 Nonmetallic Flat Gaskets for Pipe Flanges
- ASME B 1.1 Unified Inch Screw Threads (UN and UNR Thread Form)
- API 662/ISO 15547-1 Plate Heat Exchangers for General Refinery Services
- ASTM A 435 Standard Specification for Straight-Beam Ultrasonic Examination of Steel Plates
- ASTM A 578 Standard Specification for Straight-Beam Ultrasonic Examination of Rolled Steel Plates for Special Applications

- ASTM A 262 Standard practice for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steel
- ASTM A 263 Standard Specification for Stainless Chromium Steel-Clad Plate
- ASTM A 264 Standard Specification for Stainless Chromium-Nickel Steel-Clad Plate
- ASTM A 265 Standard Specification for Nickel and Nickel-Base Alloy-Clad Steel Plate
- PN-EN-10204 Metallic products - Types of inspection documents
- Welding Research Council (WRC) Bulletin:
    - WRC Bulletin 537
- DIN 580 Eye bolts
- DIN 8558 Part 2 Design and workmanship of welded joints. Steel vessels and apparatus used in the chemical industry
- DIN 28085 Lifting lugs on apparatus for mounting

12 Record of changes

No.	Date	Description	Introduced by
1	30-11-2013 (rev.1)	Review, update, standardize and changes to the Standard within scope of order No. OK/990/2012	Editorial board coordinated by T.Wróbel
-	31-08-2015	Page layout corrections, no contents changes.	T. Wróbel