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1 Subject of specification

This specification used in conjunction with other technical specifications of Grupa LOTOS S.A. establishes the minimum requirements for the design, fabrication, inspection and testing of centrifugal pumps.

2 Scope of validity

This specification applies to the preparation of tender documents, inquiries and contracts concerning new investments and modernization projects planned by Grupa LOTOS S.A.

It shall also be a basis for preparing both detailed specifications and inquiries for individual or package unit supplies.

This specification shall be read in conjunction with the Grupa LOTOS S.A. specification no. 2400 – „General Requirements for Machines and drives".

Reference to other industrial standards for compliance shall be interpreted as an integral part of this specification.

2.1 Order of precedence

In case of conflicts existing 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

2.2 Local regulations

The Pumps units shall be designed, constructed and installed in compliance with all applicable national and local laws and regulations, Grupa LOTOS S.A. specifications and current technical standards referred to in purchase order documents.

2.3 Standards/norms

Pumps shall be designed and delivered in accordance with API standard 610 11th ed. or newer including requirements stated herein. Other standards may be used (e.g. ISO 5199) if agreed with Grupa LOTOS S.A.

Applicable standard shall be stated in pump data sheets.

2.4 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 SA. 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 Design Criteria

If not stated otherwise in purchase order documents the pump units shall be suitable for outdoor unsheltered installation.

Pumps with constant speed drives shall be capable of minimum five (5) percent head increase at rated conditions by installing a larger diameter impeller. Selection of maximum diameter impeller is not acceptable.

Head-capacity curve shall be continuously rising toward shutoff with maximum head at shutoff (Q= 0 m3/h).

Pump selection shall be such that the specified normal capacity does not exceed the capacity at the highest efficiency point.

Rated point shall be as close as possible to the best efficiency point.

NPSHR shall be based on water and shall not exceed the specified available NPSH for any capacity between the min. continuous stable flow and the rated point.

The margin between the available and required NPSH shall be at least twenty (20) percent of available NPSH, but not less than 0,6m (2 feet) at the rated point. In certain cases the NPSH margin can be lower than 20% NPSHA. The lower margin requires Grupa LOTOS S.A. approval for each pump it concerns.

Witness NPSH test is required if the margin is lower than 20% NPSHA.

Pumps driven by steam turbine shall be designed to operate continuously at 105 percent of rated speed and to operate under emergency conditions up to 115 percent of rated speed (turbine over speed trip setting).

Pumps for parallel operation shall have identical performance curves with a minimum of ten (10) percent head rise to shutoff.

All one-stage and two-stage pumps working at temperatures lower than 150°C and multistage pumps working at temperatures lower than 95°C shall be suitable for immediate start-up from ambient temperature to the full working temperature. For higher working temperatures the manufacturer shall specify the starting procedure and foresee suitable measuring instruments (temperature measurement) to protect the pump and the mechanical seal against damage resulting from rapid heating.

Pumps shall be designed for continuous operation at temperature at least 30°C higher than the rated working temperature.

4 Mechanical Design

4.1 Pressure Casings and Connections

Centerline supported pump casing shall be offered for all horizontal pumps pumping liquid 150°C and higher.

Pump suction and discharge nozzles shall be flanged for all pumps.

Except for lined casing or metal casing on abrasive service, pumps shall be provided with the following connections:

- Casing drain connection
- Valved vent connection at the highest point except where pump is self-venting

A pump design must ensure the possibility of complete draining of the handled medium. Drain valves should be located as near to the pump as possible and in easily accessible places.

Minimum corrosion allowance of 3mm for casing shall be provided.

Cooling jacket shall be designed for not less than 5.5 bar(g).

Two-stage and single stage dual suction pumps shall not be in overhung design.

4.2 Impellers

Impellers shall be open, semi-open or closed type as specified in the data sheet.

Impellers shall be securely locked against loosening from the shaft in case of reverse rotation or against any axial movement.

All pumps with closed impeller shall have renewable casing and impeller wear rings.

The maximum diameter of an overhung impeller at the speed of 2900rpm cannot exceed 380mm.

4.3 Shaft and Shaft Sleeve

Shafts shall be one-piece construction.

Replaceable shaft sleeves shall be supplied and locked to the shaft. The sleeve shall properly seal against leakage between the sleeve and shaft and extend through the stuffing box. The sleeve shall be furnished with wear and corrosion resistant material with a maximum roughness of Ra 1.0 micrometer.

Where the size of the pump makes the use of a shaft sleeve impractical, the sleeve may be omitted provided that the shaft is constructed of suitable material that will wear equally as well. In this case it is manufacturer responsibility to select sealing solution which will not cause excessive wear of the shaft. The shaft material is subject to the Grupa LOTOS S.A. approval.

For all pumps, the maximum shaft deflection at the face of the stuffing box shall not exceed 50 micrometer over the entire head capacity curve while operating at rated speed with maximum diameter impeller and specified fluid.

A pump design must ensure a positive pressure in the sealing chamber i.e. 0.35bar above atmospheric pressure.

4.4 Mechanical Seal

Unless otherwise specified in the data sheet, all pumps shall be furnished with mechanical seals.

Seal flush and cooling water piping and instruments shall be provided in accordance with the API/ ISO plans or other arrangements as specified in the data sheet.

For pumps operating at temperatures exceeding 210°C metal bellows type seals shall be furnished.

Hydraulically balanced mechanical seals shall be furnished when required.

For toxic or flammable liquids, the seal end plate shall be fitted with non-sparking throttle bushing and with vent and drain connections.

The size of a mechanical seal chamber must allow for installation of double seal. Double mechanical sealing shall be used for the following cases:

- for hydrocarbons of a temperature ≥ 200°C, unless otherwise specified in data sheets,
- for hydrocarbons whose vapour pressure at the working temperature is higher than atmospheric,
- for toxic liquids.

Barrier/buffer fluid compatible with pumped liquid shall be proposed by pump supplier in collaboration with seal manufacturer during bidding period. Barrier/buffer fluid is subject to Grupa LOTOS S.A. approval.

4.5 Bearings and Lubrication

Bearings for all horizontal pumps shall be oil lubricated.

For non-pressurized oil lubrication, bearing housings shall be provided with constant level oilers and sight level gauge.

The design of any pressurized oil lubrication system, if required, shall be subject to Grupa LOTOS S.A. approval.

For pumps working at a temperature higher than 175°C lube oil cooling is required. If the new plants are furnished with pumps, with several pumps requiring cooling it is advisable to use a closed bearing and mechanical seal cooling system using a cooling fluid based on glycol.

Temperature of bearing housing shall not exceed 70°C, temperature of bearing parts shall not exceed 90°C during pump operation.

Thrust bearings with self-aligning blocks and pressure lubrication shall be applied for multistage horizontal pumps with impellers facing the same direction. Pressurized lube oil system shall be delivered together with pumps in this case.

4.6 Couplings

In-line pumps that require pump shaft to be coupled to the motor shall have all-metal, rigid spacer couplings which permit the removal of shaft seal, without disturbing either motor or process piping, unless otherwise specified in the data sheet.

Horizontal pump connections to power drives shall be made with suitable all-metal, flexible-type couplings. These couplings shall be spacer-type with the spacer length suitable to permit removal of coupling, bearings, seal, and rotor without disturbing the drive or process piping. Removable coupling guards shall be supplied per EN 953 requirements.

Couplings shall be completely machined to a tolerance of no more than 25 micrometer on the radius and face-to-face. Both halves of the couplings shall be distinctly match marked. They shall be properly keyed in place and cylindrical fits shall be designed to permit easy and rapid removal of hub in the field without heating.

Limited end-float couplings shall be supplied wherever a sleeve bearing motor is utilized.

All spacer type couplings shall be in accordance with AGMA 9000 class 9.

Elastic, spacer type couplings make Metastream with 18-8 stainless steel membranes are preferred.

If gear couplings are required, they should be of the heavy type, of wrought steel, with a flexible distance liner and grease/oil lubricated. Application of gear coupling requires written approval of Grupa LOTOS S.A.

4.7 Baseplates

A drain-rim type baseplate according to API 610 shall be supplied. The baseplate dimensions do not have to be as per annex D providing clause 7.3.2 (API 610 11th ed.) is fulfilled.

The raised lip on drain rims shall be a minimum of 2cm high.

Baseplate drain shall not be smaller than 1" NPT.

If internal thread is used at drain connection, the drain shall be located so that connection of drain pipe does not cause a threshold that blocks full drainage from the baseplate.

A stainless steel drain pan below the stuffing box shall be supplied for single seal pumps on corrosive services.

All pumps, drivers, and gear (if required) shall be mounted, aligned, and the baseplate bolt holes drilled at the pump manufacturer's shop. This applies even if the driver is to be shipped separately.

Grupa LOTOS S.A. must approve any deviation from this procedure in writing.

Feet support for pumps working at temperatures up to 260°C shall be air-cooled, above that temperature – water cooled.

The above listed requirements are applicable to baseplates of non-API pumps if the baseplates design has not been agreed otherwise.

4.8 Auxiliary piping

If a cooling water system is required, it shall be made by the pump manufacturer and it shall end with a single inlet and outlet connections at the edge of the baseplate.

In the case of a closed water system, cooling water manifolds shall be provided with flow indicators and valves at inlet and outlet.

Balancing lines for multistage pumps must have flange connections.

If pressure lubrication is used, the oil system containing the oil tank, oil pumps, filters, piping and instruments shall be supplied by the pump manufacturer.

Oil coolers shall have cooling water in tubes. The minimum outside diameter of the tubes cannot be less than 16 mm.

4.9 Materials

Materials of construction or material class per API 610 shall be specified in the data sheets. All materials shall conform to industry recognized material norms EN, ASTM, AISI unless otherwise agreed with Grupa LOTOS S.A.

5 Drivers and Gears

5.1 Electric Motors

Unless specified otherwise in the data sheets, motor driver power rating, excluding motor service factor, if any, shall be the maximum required for the rated impeller or the following percentage of pump rated power, whichever is lower.

Motor Nameplate Ratings	Percent of Rated kW (HP)
18.5 kW and less	125
22 kW to 55 kW	115
75 kW (100 HP) and over	110

Nominal motor power shall be greater than max. shaft power of the rated impeller for pumps which flowrate is not controlled by process or otherwise limited, i.e. selection for end of curve.

Motor selection shall allow for start-up conditions and mechanical seals drag and power consumption.

Motors for close-coupled pumps shall be designed to carry the maximum thrust and radial load which the pump may develop. In that case bearing lifetime L10 shall be not less than as required per applicable pump standard (API/ISO).

Motors shall be furnished in accordance with the applicable Grupa LOTOS S.A. specification no. 4200 and Electric Motor Data Sheet.

5.2 Steam Turbines

All steam turbines shall be rated for at least 110 percent of the pump rated power at rated speed. The steam turbine power rating shall be based on minimum inlet steam conditions and maximum exhaust conditions as stated in the turbine data sheets.

Steam turbines shall comply with applicable Grupa LOTOS S.A. specification no. 2440.

5.3 Gears

Gear units shall comply with applicable ISO/AGMA standards. Gear nameplate power shall be at minimum equal to the motor nameplate power including any motor service factor.

6 Inspection and Testing

6.1 General

For general requirements refer to Grupa LOTOS S.A. specification no. 2400 – "General requirements for machines and drivers."

6.2 Tests

The results of any non-witnessed tests shall be certified and submitted to the Grupa LOTOS S.A. for approval. If required, witnessing will be specified on the pump data sheet.

The Supplier shall notify Grupa LOTOS S.A. about the date of test in advance as stated in specification no. 2400.

Prior to shipment all hydrostatic, NPSH, or performance test reports must be approved by Grupa LOTOS S.A.

This or any specified testing requirements could only be waived in writing by Grupa LOTOS S.A.

6.3 Hydrostatic test

All pressure casing for each pump shall be hydrostatically tested with water at ambient temperature at a minimum of 1.5 times the maximum allowable casing pressure.

If not specified otherwise, chloride content of test water for selected materials shall be as follows:

- Carbon steel < 500 ppm
- Austenitic SS and high nickel alloy material < 25 ppm.

All cooling passages and jackets for stuffing boxes, bearing housings, pedestals, coolers, shall be tested at 1.5 times the maximum cooling liquid system pressure or 8 bar(g) whichever is higher.

All hydrostatic testing shall be done prior to painting and have a minimum duration of 30 minutes.

6.4 Performance Test

Performance tests shall be conducted at a minimum of five capacity points from shut-off to maximum flow. Vibration levels shall be recorded at each capacity point.

Vibration readings shall not exceed the limits specified in API 610.

Testing set-up, instrumentation and procedures shall conform to ISO 9906.

If specified, the pump shall be run on the test stand until oil temperature stabilization has been achieved.

If specified, the pump shall be mechanically run for 4 hours. Unless otherwise agreed, this run shall be performed at rated flow.

If specified, the beginning of the mechanical run test shall not occur until oil temperatures have stabilized.

Pump performance test report shall contain: test date, pump size and model, serial number, test speed, test liquid and temperature, Grupa LOTOS S.A. item number and service, head-capacity curve, impeller diameters (maximum, minimum, rated), and rated operating point. The manufacturer shall submit a test report with the certified test curve, including vibration data record.

6.5 NPSH Test

Witness NPSH test is required if (NPSHA-NPSHR)/NPSHA<0.2 or if specified on data sheet.

NPSH test shall be type I for 5 flowrate points as per ISO 9906.

If more than one pump is delivered for the same service the NPSH test is required for each pump.

NPSH tests will always be run in conjunction with a performance test. A test report shall be submitted with the certified curve. If witnessing is required, a description of the manufacturer's test stand shall be submitted prior to testing.

6.6 Drivers and Gear Tests

All gears shall receive a mechanical running test in accordance with AGMA. Verification and a brief description of this test shall be submitted prior to shipment of the pump.

Electric motors when specified to be supplied with the pump shall meet the requirements of Grupa LOTOS S.A. motor specification and motor data sheet.

Steam turbines shall be tested in accordance with Grupa LOTOS S.A. specification no. 2440.

6.7 Final inspection

The pump unit shall be fully assembled for final inspection. If painting was ordered it should be done. Dimensions, nameplates, markings, completeness and preparation for shipment shall be checked.

7 Painting

Painting shall be in accordance with specification no. 2400.

8 Nameplate

A stainless steel nameplate containing at a minimum the following information shall be permanently attached to an easily accessible place on the pump:

- Purchaser's item number
- Pump size and model
- Pump serial number
- Rated flow, - m^3/h
- Rated head, - m
- Speed, - rpm
- Operating temperature - °C
- Casing hydrostatic test pressure, - bar(g)
- Maximum allowable working pressure, - bar(g)
- Bearing manufacturer's identity numbers.

9 Documentation

Documentation delivered with pump unit shall be in accordance with Annex L of API 610 11th ed. Documentation for auxiliary equipment delivered by pump Supplier which is not addressed in the above mentioned annex e.g. frequency converter, shall be in accordance with applicable Grupa LOTOS S.A. specification. If such specification does not exist, manufacturer's standard documentation is acceptable.

Supplier shall ensure that the following data/documents are included in the final documentation.

Dimensional outline drawing

- total weight and the weight of the heaviest elements for repair purposes, rotor/impeller weight for rotating machines
- position of the centre of gravity for machines of a weight exceeding 1500 kG
- location of flanges and the dimensions of flanges, venting, draining openings, and of other threaded connections
- location of the lubricating points
- the values of the maximum allowable forces and torques on flanges and the maximum differences in their position during cold and hot working condition

- direction of rotation
- static and dynamic foundation loads
- tolerances for levelling the foundation plate on the foundation
- dimensions of the foundation plate (base frame) and location of the foundation bolts
- type and technical data of the mechanical (gas) seal
- type, dimensions and number of the foundation bolts
- type and the technical data of the drive
- type of the coupling, the distance between shaft faces, the length of the spacer
- type and the technical data for gear

Pipeline documentation

Pipeline documentation within the scope of supply of the machine shall be in accordance to the requirements of specification no. 6100.

Instrumentation and electric documentation

Documentation of the instrumentation and electrical discipline shall include the following:

- list of control and measuring instruments
- technical characteristics of the instruments and their set points
- wiring diagrams and control logic diagrams
- drawing of the control panel
- assembly drawings and list of materials
- installation, operation and maintenance manuals for individual equipment.

Operation and maintenance manuals

Operation and maintenance manuals shall include the following:

- the data sheet
- the report on the factory tests of the machine with the characteristic curves from these tests
- technical description of the machine
- technical description of the auxiliary equipment
- assembly and disassembly instructions
- operation manual (start-up, adjustment/regulation, shutdown)
- the maintenance and repair manual
- cross-section drawings of the machine, its subassemblies and auxiliary equipment with a list of parts including their construction materials and the manufacturer's code numbers
- the minimum and maximum clearance for mated parts
- the torques and the sequence of bolts tightening

- list of antifriction bearings, stating their symbols, the name of the manufacturer, the place of installation and their number (i.e. quantity) in a single machine. This applies also to elements used for mounting the bearing, such as bearing housings, bearing sleeves etc.
- the maximum allowable bearing temperature
- the allowable vibration level
- lubrication and cooling diagrams
- operating parameters for oil systems (pressure and temperature)
- list of oils and greases with recommendation (identification and the name of the manufacturer) and their substitutes, if any, as well as their physical and chemical characteristics, quantities required for the first filling (the capacity of the oil system or the greasing chamber), life time till the first replacement and the replacement frequency, expected annual consumption.

Manufacturer Data Book

MDB documentation shall include the following:

- Ex certificates
- material certificates
- heat treatment reports
- NDT reports
- reports on the dynamic balancing of impellers (if applicable)
- pressure test reports
- functional test reports
- information on already applied lubricants

10 Relevant documents

10.1 Grupa LOTOS S.A. specifications

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

10.2 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:

- API Std 610 – Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industries

11 Record of changes

No.	Date	Description	Introduced by
0		This specification entirely replaces the former Grupa LOTOS S.A. standard No. PR 07 241 with the same title.	T. Wójcik
1	29.08.2006	Added API 685 in point 3.	B. Kowalewski
2	30.11.2013 (rev.2)	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