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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 special purpose steam turbines intended for work in Grupa LOTOS S.A. plants.

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 applicable ISO/API standards and 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 steam turbines 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

Turbines shall be designed and delivered in accordance with API standard 611 4th ed. or newer including requirements stated herein. Other standards may be used if agreed with Grupa LOTOS S.A.

Applicable standard shall be stated in 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 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 Guarantees

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

The checking of drawings, the intermediate and final inspections of the compressor by Grupa LOTOS S.A. as well as the release for shipping shall not relieve the Supplier from his responsibility for the compliance of the compressor with the terms and conditions of the purchase order.

4 Design Criteria

4.1 General

4.1.1 Special purpose turbines and auxiliaries shall be designed for unsheltered outdoor installation in applicable explosion zone, unless otherwise specified in the data sheets.

4.1.2 The overall mechanical and thermodynamic performance of the turbine unit shall be the turbine Supplier's responsibility.

4.1.3 The turbine Supplier has to supply all engineering data and documents so that the driven machine Supplier can fulfill his overall responsibility.

4.1.4 Special purpose steam turbine design and construction recommended by the Supplier shall be mutually agreed to and in compliance with applicable laws and standards. Supplier shall indicate where specifications require excessive measures that result in non-standard material supply. The Supplier is obligated to identify such requirements.

4.2 Basic Design

4.2.1 Special purpose turbines shall be capable of delivering rated load at its corresponding speed with minimum inlet and maximum exhaust conditions.

4.2.2 Special purpose turbines shall be capable of continuous operation at the lowest speed at which maximum torque is required with minimum inlet and maximum exhaust conditions.

4.2.3 The Supplier shall review and comment on Grupa LOTOS's piping and foundation drawings.

4.2.4 Cooling water systems shall be designed in accordance with the condition specified in applicable codes and standards for the geographical location of site installation.

4.2.5 Through-bolts and studs shall be used. Machine bolts may be used only with Grupa LOTOS's written permission.

4.2.6 Clearance shall be provided at bolting locations to permit the use of socket or box-type wrenches and impact driver. The Supplier shall provide any required special tools and fixtures.

4.2.7 The turbine and its auxiliaries shall be suitable for periods of idleness of several months duration under the specified site conditions, without requiring any special maintenance procedures, unless otherwise specified in the data sheet.

4.2.8 Winterization shall be provided by the Supplier of the steam turbine with regard to the location and the ambient conditions. Ambient conditions are stated in the data sheets.

4.3 Casing Connection

4.3.1 All connecting flanges and all internal flanges shall be in accordance with the design data and as per the applicable piping specification.

4.3.2 If the existing flange thickness exceeds the maximum dimensions, e.g. to ISO/ANSI, it must be clarified with Grupa LOTOS S.A. whether the flange thickness can be retained in view of the bolt length.

4.3.3 An underrun of the flange thickness by more than the minimum dimension, e.g. to ISO/ANSI is not allowed.

4.4 Rotating Elements

4.4.1 The Supplier shall provide tapped bolt circles at each end of the rotor exclusive of coupling for balance purposes. A preferred arrangement is one in which the wheel thickness is increased to form the balance rim. They are to be used for shop, not field, balancing.

4.4.2 Rear stages of condensing turbines shall be provided with drip rims to protect casings from erosion. Erosion protection for condensing turbines shall be described in the proposal.

4.4.3 The turbine manufacturer shall calculate with manufacture of driven machine the maximum transient torques that will occur in the shaft system under start-up, running, stop and duty change. All components including the coupling and the fit of the coupling hub on the shaft shall be suitable for at least 175 % of this maximum transient torque figure, unless otherwise specified in the data sheets.

4.5 Bearing and Bearing Housing

4.5.1 The bearing temperatures are to be measured using a double thermocouple (NiCrNi) direct in the bearing metal.

The following arrangement is to be selected:

Radial bearing - per bearing — 2 measuring points with temperature indication and alarm, 1 standby measuring point without indication.

The standby measuring point suitable for change-over during operation shall only be provided if the design permits.

Axial bearing - per bearing — 4 measuring points with temperature indication and alarm (2 measuring points with max. value of selection for each direction of thrust), 2 (1 per each bearing side) standby measuring points without indication.

The standby measuring point suitable for change-over during operation shall only be provided if the design permits.

4.5.2 The labyrinths in the bearing casing are to be provided with a connection for sealing medium. If no sealing medium is applied, the connection is to be plugged.

4.6 Shaft Seals

4.6.1 Any shaft seal other than labyrinth seals requires Grupa LOTOS's written approval.

4.6.2 A separate vacuum device shall be furnished. The device shall be mounted and connected. The vacuum device shall be in accordance with applicable codes for gland vacuum systems, unless otherwise specified in the data sheets.

4.7 Dynamics

4.7.1 The Supplier shall provide with:

- assumptions regarding bearings and support stiffness for the calculation of the lateral critical frequencies in a summary report
- calculated response curves of deflection versus revolutions per minute for varying amounts of imbalance.

4.7.2 The balancing methods:

- low speed balancing (balancing speed lower than operating speed)
- high speed balancing (balancing speed equal or near to the operating speed) will be selected by the turbine Supplier according to the requirements of the machine.

4.7.3 After completion of the final balancing of the assembled rotating element, the sensitivity of the rotor balancing machine system shall be reported in the manner as described in applicable codes and standards.

4.8 Materials

4.8.1 Material selection shall be in accordance with API 612.

4.8.2 All shop welding (construction and production welds) shall be carried out in accordance with the standards stated in the data sheet.

4.8.3 These standards listed in the data sheet also apply to the welder qualifications and the quality of the welding.

4.8.4 All root weld seams of piping in the supply schedule shall be welded with shields gas. The same also applies to the piping fabrication on site.

4.8.5 All pipes in the scope of supply of turbine Supplier are subject to the same test and inspection conditions as for the piping of the process plant, independent whether they are fabricated in the workshop or on site.

4.8.6 Type and extend of non-destructive examination for welds are stated in the data sheet.

5 Accessories

5.1 Couplings and Guards

5.1.1 A flexible coupling between driver and driven equipment shall be provided by the Supplier of the driven equipment unless otherwise specified in the data sheet. Flexible couplings with steel membranes are preferred.

5.1.2 Couplings for ratings greater than 1.5 MW are to be provided with hydraulically mounted and dismounted hubs.

5.1.3 Couplings with spacers must exhibit sufficient length to permit the following work to be carried out:

- Removal of each half coupling (with hydraulic equipment)

- Removal of bearings

The couplings and adapters must be dynamically balanced at max. continuous speed independent of other rotating parts.

5.1.4 For balancing and test run purpose the turbine manufacturer shall provide a dummy.

5.2 Mounting Plates

5.2.1 If not otherwise specified, turbines shall be mounted on a common continuous base frame, delivered by Supplier of driven machine.

5.2.2 If a separate base frame for turbine is required the base frame shall be a single, fabricated unit. The selection of the axial height and the dimension of the frame shall be such that proper work on the flange connections of all machine nozzles is permitted.

5.2.3 The Supplier shall provide decking on top of the base frame covering on all walk and work areas.

5.2.4 Base frames shall be designed to support not less than the total equipment weight and shall withstand external forces and moments resultant from twice the allowable flange loadings in accordance with API Std 612. Structural calculations shall be submitted for review.

5.2.5 The data sheets shall state who is to supply the anchor bolts. The base frame shall always be fastened to the table-type foundation with full penetration bolts, which may not be grouted. Hammer headed bolts are to be used for block foundation. The appropriate Grupa LOTOS S.A. specifications are to be observed for designing the anchor bolts.

5.2.6 The Supplier will provide the shims required for erection and fine alignment of the machines during installation.

5.3 Controls and Instrumentation

5.3.1 General

- The scope of supply, manufacturer, type, design and installation of the instruments to be supplied by the turbine Supplier are stated in the data sheets or in the order-specific Grupa LOTOS S.A. specifications.
- Where not covered by any specific job requirements instrumentation and installation shall conform to Grupa LOTOS S.A. Instrument Specifications and referred standards.
- All instruments must be identified in accordance with P&I diagram or the instrument specification. The P&I diagram is also binding for the scope of supply.
- Coordination of instrumentation for driven machine and turbine will be done by Supplier of driven machine.
- All instrumentation shall be fully mounted and piped. An instrument air header shall be provided where all users are connected in accordance with the applicable instrument specification. All instrument cables shall be wired to skid mounted junction boxes in accordance with the instrument specifications.
- All instrumentation shall be readily accessible and rigidly supported. Vibration isolation shall be considered for all based-mounted instruments and gauge boards.
- All controls and instrumentation shall be suitable for outdoor installation unless otherwise specified in the data sheets.

- All instrumentation shall be constructed of materials resistant to corrosion due to the process fluid with which they will or may come into contact internally, and to ambient air environment to which they are externally exposed.

5.3.2 Supply requirements

The Supplier scope of supply with regard to package instrumentation shall include, but shall not be limited to, the following (see also relevant data sheets):

- Local gauge boards for driver and auxiliaries
- The supply and installation of all necessary instrumentation to monitor and control the safe start up, running and shutdown of the steam turbine – driven machine and auxiliaries.
- All instrument air piping and tubing.
- Instrumentation for installation in an equipment control cabinet cubicle and control room shall be delivered according to the contract. Supplier shall provide dimensional and power requirements of the control cabinet together with full description and maximum distance from the turbine along cable path.

5.3.3 Design requirements
Supplier shall provide complete design documentation concerning local instruments, local control panel and control room cabinets. The documentation must enable implementation of controls and protections to DCS and/or PLC. Documentation shall be in compliance with the Grupa LOTOS S.A. specification no. 6400.

5.3.4 Instrument wiring
All wiring from instruments to junction boxes at the edge of equipment baseframe shall be provided by Supplier. Inside junction boxes all wiring terminator shall be provided with identification tags.

5.4 Piping and Appurtences

5.4.1 Piping and valves within the interfaces stated by Grupa LOTOS S.A. are to be in accordance with the standards applicable to the plant in question. These are stated in the data sheets.

5.4.2 Compression connectors are not allowed for the product and utility lines. All connections shall be flanged. Forged WN flanges or LWN shall be used.

5.4.3 Lubrication and control oil lines shall be of stainless steel.

5.4.4 The nominal diameter for small lines shall not be less than DN 15 (NPS 1/2 inch).

5.4.5 Connections are to be flanged from DN 15 (NPS 1/2 inch) unless otherwise specified in the data sheets.

5.5 Thermal insulation

5.5.1 The steam turbines shall be provided with thermal insulation and metallic protective hoods. The surface temperature on the atmospheric side shall not exceed 60 °C.

5.5.2 All parts must be easily dismantled and assembled and are to be identified permanently and unmistakably.

6 Inspection and Testing

6.1 General

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

6.2 Inspections and Testing

6.2.1 All inspection and tests according to Supplier's standard for the application and according the applicable specifications listed in the data sheets shall be performed. The scope of tests and inspections and optional tests which are specified in the data sheets have to be summarized in the Inspection and Test Plan (ITP) submitted to Grupa LOTOS S.A. for approval.

6.2.2 The ITP shall show each inspection or test plan point for all equipment and shall include the following information:

- the inspection or test activity reference number indicated on a flow chart
- the inspection methods
- reference to the relevant documents (i.e. procedures, specifications and drawings which control the specific operation)
- the quality characteristics to be verified at each inspection or test point and the acceptance criteria
- reference to and examples of the specific forms used by the Supplier to document the results of each inspection or test.

6.2.3 The Supplier shall verify by testing and certify that hardness of all parts, welds and heat affected zones are within the allowable values. The chosen method of testing shall be submitted to Grupa LOTOS S.A. for approval.

6.2.4 Grupa LOTOS S.A. shall have access at any time to the Supplier's quality control program for review

6.2.5 Grupa LOTOS S.A. reserves the right to conduct surface and subsurface inspection on all the compressor's parts.

6.2.6 Certified copies of all test data shall be submitted to Grupa LOTOS S.A.as requested in the data sheets.

6.2.7 All manufacturing errors or deviations affecting the mechanical integrity and/or performance of major components shall be documented and proposed repair schemes submitted for approval to Grupa LOTOS S.A. within 14 days of discovery of error or deviation.

6.2.8 No repair shall be made without Grupa LOTOS's prior concurrence based on the mutually agreed procedure involved. Submittal of these procedures shall be made within 30 days of receipt of the purchase order, unless otherwise specified in the data sheets.

6.2.9 Except for cases approved by Grupa LOTOS S.A. all equipment shall be presented for inspection in an unpainted state.

6.2.10 Acceptance factory tests and inspections shall not constitute a waiver of requirements to meet the specified plant operating conditions, nor relieve the Supplier of his contractual responsibilities.

6.2.11 All spare parts shall be subject to the same inspection and full material certification as the main order.

7 Painting

Painting shall be in accordance with specification no. 2400.

8 Documentation

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

9 Relevant documents

9.1 Grupa LOTOS S.A. specifications

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

9.2 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 612 – Petroleum, Petrochemical and Natural Gas Industries - Steam Turbines - Special purpose Applications
- API 614 – Lubrication, Shaft-Sealing and Control-Oil Systems for Special-Purpose Applications
- API 670 – Machinery Protection Systems
- API 671 – Special-Purpose Couplings for Refinery Service
- API 684 – Tutorial on the API Standard Paragraphs Covering Rotor Dynamics and Balancing: An Introduction to Lateral Critical and Train Torsional Analysis and Rotor Balancing
- API 686 – Recommended Practices for Machinery Installation and Installation Design
- ASME PTC 6 – Performance Test Code for Steam Turbines
- TEMA Cl. C – Mechanical Standards, Heat Exchanger
- ASME Code Sect.VIII, Div.1 - Pressure Vessels and Heat Exchanger
- H.E.I. – Standards for Steam Surface Condensers
- EN ISO 12100 Safety of Machinery – General principles for design – Risk assessment and risk reduction
- EN ISO 3744 Acoustics - Determination of sound power levels and sound energy levels of noise sources using sound pressure - Engineering methods for an essentially free field over a reflecting plane
- ISO 1940-1 - Mechanical Vibration; Balance Quality Requirements for Rotors in a constant (rigid) state. Specification and verification of balance tolerances
- ISO 21940-14 - Mechanical Vibration. Rotor balancing. Part 14: Procedures for assessing balance errors
- ISO 11342 - Mechanical vibration-Methods and criteria for the mechanical balancing of flexible rotors
- ISO 10816 (applicable part) - Mechanical Vibration-Evaluation of Machine Vibration by Measurement on non-rotating parts
- ISO 21940-32 - Mechanical Vibration; Rotor Balancing; Shaft and Fitment Key Convention
- EN 10204 - Metallic Products-Type of Inspection Documents
- ISO 10474 - Steel and steel products – Inspection documents

- ASTM A435/A435M-90 - Standard Specification for Straight-Beam Ultrasonic Examination of Steel Plates
- ASTM A578/A578M-07 - Standard Specification for Straight-Beam Ultrasonic Examination of Rolled Steel Plates for Special Applications
- MSS Standards - MSS-SP-6-2012 Standard Finishes for Contact Faces of Pipe Flanges and Connecting-end Flanges of Valves and Fittings
- EN ISO 3651-2 Determination of resistance to intergranular corrosion of stainless steels — Part 2: Ferritic, austenitic and ferritic-austenitic (duplex) stainless steels — Corrosion test in media containing sulfuric acid

10 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