Contents

1 Subject of specification 3
2 Scope of validity 3
2.1 Order of precedence 3
2.2 Local regulations 3
2.3 Standards/norms 3
2.4 Deviations 4
3 Guarantees 4
4 Design criteria 4
4.1 General 4
4.2 Basic Design 5
4.3 Casing 6
4.4 Diaphragms and inlet guide vanes 6
4.5 Casing connections 6
4.6 Rotating element 6
4.7 Bearings and bearing housings 7
4.8 Shaft seals 7
4.9 Dynamics 8
4.10 Lube oil, seal oil and control oil systems 9
4.11 Materials 9
5 Accessories 10
5.1 Drivers 10
5.2 Couplings and guards 10
5.3 Mounting plates 10
5.4 Controls and instrumentation 11

This document is the property of Grupa LOTOS SA.. Coping and giving it to other are forbidden without express written authority by Grupa LOTOS SA

5.5 Piping and appurtenances 12
6 Inspection and testing 13
6.1 General 13
6.2 Inspections and testing 13
7 Painting 14
8 Documentation 14
8.1 Operation and maintenance manuals 15
9 Relevant documents 16
9.1 Grupa LOTOS S.A. specifications 16
9.2 Standards 16
10 Record of changes 17

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 compressors 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 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

Centrifugal compressor 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

Centrifugal compressors shall be designed and delivered in accordance with API standard 617 7th 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 Compressors, drivers and auxiliaries shall be installed inside a dedicated shelters. The shelter construction should assure the reliable operation of the all main and auxiliary compressor systems and to make possible the free access to these systems in case of maintenance.

4.1.2 Compressors, drivers and auxiliaries placed outside the shelters (for each particular case is required GLSA acceptance) must be designed for unsheltered outdoor operation in applicable weather condition and in proper explosion zone, unless otherwise specified in the data sheets.

4.1.3 The overall mechanical and aerodynamic performance of the compressor unit shall be the compressor Supplier's responsibility. Compressors driven by induction motors shall be selected for the actual motor speed corresponding to rated load conditions and not the synchronous speed.

4.1.4 The compressor Supplier shall have unit responsibility for all equipment unless otherwise stated in the purchase orders. The unit consists of compressors, drivers, power transmissions and associated auxiliary equipment. The unit responsibility includes (but is not limited to) engineering responsibility for the following:

- Torsional analysis
- Lateral analysis
- Simulation study (if required)
- Rating and selection of power and speed transmission components
- Shaft seal and seal system design
- Lube oil system design
- Logic, interlock system integration, coordination with purchaser
- Vibration and bearing temperature system design and coordination of all units in the train
- Obtaining and transmitting all equipment engineering data to the purchaser
- Equipment layout, baseplate design, foundation and grouting requirements

- Piping layout, coordination with subvendors and purchaser as required
- Coordination of all physical and performance interfaces required to meet the applicable specifications, codes and standards
- Coordination of all assembly and testing requirements of the train components
- Coordination of site activities for the unit until final acceptance
- Sound level requirements acc. applicable regulations, Grupa LOTOS S.A. specification and/or other attachments of the purchase order.

4.1.5 The Supplier shall only offer such centrifugal compressors as have already been applied in similar design for the same or similar conditions and proved themselves.

4.1.6 Centrifugal Compressor design 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 deviations.

4.2 Basic Design

4.2.1 Where possible, compressors shall be furnished as complete packages including driver, gears, couplings, lubrication and seal system, intercoolers, package mounted instrumentation, antisurge control valves and antisurge control system.

4.2.2 Where winterization is specified, mutual provisions shall be made for the complete drainage of the compressor, auxiliary equipment, all steam and water. Freeze protection shall be provided for gauges, small piping (with heaters or oil circulation), pressurized lube oil system, electric motor and local control panels.

4.2.3 The Supplier shall review and comment on Grupa LOTOS S.A. piping and foundation drawings.

4.2.4 Calculation of the necessary process coolers (inter-, end-, recycle coolers) separators and silencers to be supplied by the Supplier shall be carried out applying the max. stage discharge pressure.

The following assumptions are to be taken into account:

- pressure at the surge limit at 1.1 times suction pressure
- trip speed for turbine drive
- being provided coolers, separators and silencers are to be designed for 1.1 times the safety valve blow-off pressure.

4.2.5 The compressor and its auxiliaries shall be suitable for periods of idleness of several months duration under the specified site conditions, without requiring any special maintenance procedure unless otherwise specified in the data sheets.

4.2.6 Characteristic Curve

4.2.6.1 The pressure drops between machinery nozzles and these interfaces, e.g. silencers, inter-coolers, separators, inter-connecting piping, etc. are to be given separately by the Supplier in the quotation.

4.2.6.2 These values are to be taken into account during tests at the manufacturing works. The characteristic curves are to be calculated and drawn incl. these drops.

4.2.6.3 Complete surge limit protection is to be designed and supplied by the compressor Supplier.

4.2.6.4 The design data of utilities given in the data sheets refer to the system. Data at connection interfaces can slightly differ.

4.3 Casing

4.3.1 A radially split compressors with welded suction and discharge nozzles positioned vertically are preferred.

4.3.2 The maximum allowable working pressure of each casing shall be stated on the data sheet. The MAWP shall be greater than max. discharge pressure defined in API 617 7th ed. p.1.5.19.

4.3.3 For radially split casings a shear ring design is preferred. Where bolted covers are offered they shall be designed to allow the use of hydraulic bolt tensioning devices which shall be provided as part of the Supplier's special tools.

4.3.4 A rotor bundle removal system shall be provided for radially split casings as part of the Supplier's special tools.

4.3.5 If a wobble plate-type support is used for heat expansion in the lateral and/or axial direction at the compressor inlet or outlet end, the Supplier shall provide with the quotation the calculated expansions expected in the lateral and/or axial direction, and shall explain how their design would prevent torsional roll and off centreline growth.

4.4 Diaphragms and inlet guide vanes

4.4.1 Vane entrances and exits shall not have sharp edges.

4.4.2 Interstage diaphragms shall be divided in the axial plane of the compressor.

4.4.3 If internal fastening bolts/nuts are required in the flow path, they shall be designed such that in case of failure or coming loose they cannot fall into and damage the compressors.

4.5 Casing connections

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

4.5.2 If non-ferrous pipes and their alloys are connected to steel or grey-cast iron parts of the compressor, measures shall be taken to prevent any galvanic stress corrosion.

4.5.3 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.

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

4.5.5 All casings have to be provided with drains, separate for each stage if demanded by the design. All drains and vents are to be fitted with block valves, unless otherwise specified in the data sheets.

4.5.6 Bolt holes on all flanges shall be fully back or spot faced.

4.5.7 Machined, studded and threaded connections are only acceptable with Grupa LOTOS S.A. specific approval.

4.6 Rotating element

4.6.1 The compressor Supplier shall calculate with the driver manufacture, the maximum transient torques that will occur in the shaft system under start-up, running, stop and fault conditions. 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.

4.6.2 For motor drives, train shall be engineered to withstand 3 and/or 2 phase terminal short circuit and reswitching after net interruption etc.

Further details will be given in the data sheets.

4.6.3 Cast impellers are allowed under certain conditions provided the Supplier has obtained written approval from Grupa LOTOS S.A. before the order is placed.

4.6.4 Careful consideration shall be given to impeller selection with regard (but not limited) to impeller eye inlet Mach number, hub ratio (D/D2) and limitation of maximum stress at maximum continuous speed.

These values shall be given in the data sheets.

4.6.5 The maximum allowable rotor speed at continuous operation of the compressor shall be not less than 105 % of the rated speed.

4.6.6 Shaft sleeves in the area of shaft seals at casing openings must be suitable for dismantling without heating.

4.6.7 The scope of supply shall include a complete spare rotor for the compressor, dynamically balanced and ready for installation.

4.7 Bearings and bearing housings

4.7.1 The bearing temperatures are to be measured using a double thermocouple (NiCrNi) direct in the bearing metal (as close to the shaft as possible and permissible).

The following arrangement is to be selected:

- Radial bearing: per bearing: 2 measuring points with indicator 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 indicator and alarm (2 measuring points with max. value of selection for each direction of thrust) and 1 standby measuring point without indicator per each side of the bearing.

4.7.2 Supplier shall submit with the proposal details of thrust balance calculations for whole range of operation and the worst cases, which might occur during operation.

4.7.3 The labyrinths in the bearing casings are to be provided with a connection for applying sealing medium.

4.7.4 Bearings shall be designed to avoid damages while running with driver's turning gear and/or slow roll with steam turbine driver. If applicable the Supplier shall provide data to prove successful operation at these conditions.

4.7.5 Supplier shall advise capabilities and limitations of the bearings design considering reverse rotation and load carrying capability.

4.7.6 Spare bearings shall be included in the scope of supply.

4.8 Shaft seals

4.8.1 The compressor Supplier shall deliver a complete seal system with all necessary equipment as specified in the data sheets.

4.8.2 Maintenance during operation must be possible.

4.8.3 The type of seal, which has to be used to meet the operating requirements and environmental requirements, is specified in the data sheets. Dry-running mechanical seals are preferred.

4.8.4 The shaft seal and the sealing system are to be designed for:

- the shut-down pressure (settling out pressure) of the medium/the overall system,
- other operating cases like: low pressure operation, acceleration, deceleration and reverse rotation, as specified in the data sheets.

4.8.5 Mechanical seals, oil film seals

4.8.5.1 The internal sealing liquid loss is to be stated by the Supplier in the quotation and guaranteed on an order being placed. The guaranteed value related to 24 operating hours is to be given in the data sheets. In addition to the sealing liquid loss to be guaranteed, the allowed deviations are to be stated in the data sheets without the on-stream time and operational reliability of the machinery set being impaired. Sealing liquid contaminated with process medium cannot be returned to the oil tank without the harmful components being removed.

4.8.5.2 Mechanical seals are to be equipped with a shutdown assembly to prevent process gas leakage during the compressor shut-down when the sealing system is out of operation or fails.

4.8.5.3 The external return lines of the sealing system are to be fitted with sight glasses.

4.8.6 Gas seals

4.8.6.1 The leakages of the gas seals (expected and guaranteed) shall be submitted in the relevant data sheets.

4.8.6.2 The gas seal shall be equipped with separation labyrinth or equal between atmospheric/isolating seal and bearing and shall be purged to ensure that any gas leakage is kept well below the explosive limit.

4.8.6.3 Purge medium shall be agreed between Grupa LOTOS S.A. and Supplier.

4.8.6.4 Process gas shall be filtered and used as seal gas, if suitable. The Supplier is responsible for selection and trouble-free operation of the buffer/barrier gas system with special regards paid to avoiding contamination of gas seals. The filters have to be selected and designed as required.

4.8.6.5 Supplier shall submit limitations of depressurisation ratio, if any in the applicable data sheets.

4.8.7 Complete spare seals shall be included in the scope of supply.

4.9 Dynamics

4.9.1 The compressor Supplier shall provide a total train dynamic stability analysis (aerodynamic, hydrodynamic and mechanical aspects) and a damped unbalance response analysis for each machine.

4.9.2 The compressor Supplier shall be responsible that no excitations caused by the driven machine (on gas side or on the mechanical side) results in impermissibly high vibration amplitudes and stressing of the connected piping system.

4.9.3 Before balancing, each impeller shall be strength tested by means of over speeding.

4.9.4 The balancing methods

- low speed balancing (balancing speed lower than operating speed)
- high speed balancing (balancing speed equal or near to the operating speed)

shall be selected by the compressor Supplier according to the requirements of the machine.

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

4.9.5 For torsional analysis, in addition to the API requirements, the forces/moments exciting the undamped torsional natural frequencies shall be considered:

- Torsional transients such as switch on and terminal short circuits of all types of electric motors including start-up, variable frequency and synchronous electric motors.
- Torsional excitation caused by variable speed drive systems including worst transient operational case.

4.9.6 The Supplier shall include assumptions regarding bearing and support stiffness for the calculation of the lateral resonance frequencies in a summary report and shall submit calculated response curves of deflection versus revolutions per minute for varying amounts of imbalance.

4.10 Lube oil, seal oil and control oil systems

4.10.1 Unless otherwise specified, lube oil and control oil systems in case of turbine driver, shall comply with API standard 614 5th edition, Grupa LOTOS S.A. specification and other attachments to the purchase order documents.

4.10.2 In the case of separate lubricating and sealing systems the bearing casings are to be firmly separated from the seal casings so that sealing media cannot contaminate the lubricating oil.

4.10.3 Four (4) spare filter cartridges for each a.m. auxiliary systems shall be in the scope of supply.

4.11 Materials

4.11.1 Materials shall be as specified in the data sheets according to applicable API and technical specifications. The Supplier is responsible for the material selection to meet the specified operating conditions.

The Supplier may offer as option alternative materials, if based on his experience that would be a more economic selection without any negative impact with regard to reliability and safety of the machines.

4.11.2 When ultrasonic inspection is specified, procedures and acceptance criteria shall be submitted to Grupa LOTOS S.A. for approval.

4.11.3 Overlays are only allowed if reference proven for the application and with Grupa LOTOS S.A. approval.

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

4.11.5 The standards listed in the data sheets also apply to the welder qualifications and the quality of the welding.

4.11.6 All roots of weld seams of piping in the oil systems shall be welded with shield gas. The same also applies to the piping fabrication on site.

4.11.7 All pertinent pipes are subject to the same test and inspection conditions as for the pipe-work of the process plant, independently whether they are fabricated in the workshop or on site.

4.11.8 The notch impact strength values shall be mentioned in the suppliers quote, even if the materials and material thicknesses are not included in the ASME-Code.

4.11.9 If required in the data sheets, the notch impact strength values have to be verified by material testing.

4.11.10 All impeller welds will be examined using the following method:

- Magnetic particle examination,

- Liquid penetrant examination,
- Ultrasonic examination.

Together with the impeller, a specimen is to be welded to verify the material and weld quality after heat treatment.

5 Accessories

5.1 Drivers

5.1.1 The determination of the thermodynamic properties of the gases involved and their effort on the design and performance of the compressor is the Supplier's sole responsibility. Steam turbine driving compressor shall be of special purpose whereas steam turbines driving auxiliary equipment shall be of general purpose, in accordance with the applicable Grupa LOTOS S.A. specification, and/or other attachments of the purchase documents.

5.1.2 Induction and synchronous motors for main and auxiliary drivers shall comply with the applicable Grupa LOTOS S.A. specification.

5.2 Couplings and guards

5.2.1 A flexible coupling between driver and driven equipment shall be provided by the Supplier of the driven equipment unless otherwise specified in the data sheets. Flexible discs couplings are to be preferred.

5.2.2 Couplings for ratings greater than 1.5 MW are to be provided with hydraulically mounted and dismounted hubs, unless otherwise specified in the data sheets.

5.2.3 Coupling with spacers must exhibit a sufficient length to permit the following work to be carried out:

- removal of each half coupling (with hydraulic equipment),
- removal of bearing,
- fitting and removal of seal components, such as seal rings, rotating rings, and the complete seals.

5.2.4 Complete couplings (with spacers) must be dynamically balanced at max. continuous speed independent of other rotating parts.

5.2.5 The max. limited axial play (insofar as required for drive motors with sliding bearing) shall be 6 mm. The overall limited play of the motor rotor must be greater than the play of the coupling. The magnetic centre of the motor is to be taken into account.

5.2.6 The coupling guard shall be made of steel. It must be in accordance with the local safety requirements and shall be designed for a vertical loading of at least 1000 N. If explosion protection is specified in the data sheets, a non-spark material shall be used. Aluminum is not allowed.

5.2.7 Couplings guards' surface temperature of flexible element couplings shall not exceed 70°C. Cooling by oil spraying shall not be used unless otherwise specified in the data sheet.

5.3 Mounting plates

5.3.1 The compressor train consisting of compressor casing(s), gear, driver(s), shall be mounted on a common continuous base plate unless otherwise specified in the data sheets. The compressor train shall be completely preassembled in the compressor Supplier's workshop. Unless otherwise specified, the base plate shall be a single, fabricated unit.

The base plate shall be suitable for any structural column mounting and sufficiently rigid without continuous grouting, unless otherwise specified in the data sheets.

Should (in the case of multi-casing machines or compressors with large units) this not be possible, separate base plates for compressor and drive shall be provided.

The selection of the compressor axis height and the dimension of the plate shall be such that proper work on the flange connections of all machine nozzles is permitted.

5.3.2 The Supplier shall provide decking on top of the base plate covering on all walk and work areas. Base plate 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 the applicable API standard with a maximum shaft deflection of 50 μm. Structural calculations shall be submitted for review.

5.3.3 The data sheets shall state who is to supply the anchor bolts. The Supplier shall provide requirements for the compressor unit foundation in due advance. If not stated otherwise, API RP 686 will be followed.

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

5.4 Controls and instrumentation

5.4.1 General

5.4.1.1 The scope of supply, manufacturer, type, design and installation of the instruments (including radial vibration and axial displacement monitoring system, and bearings temperature) to be supplied by the compressor Supplier are stated in the data sheets or in the order specifications of Grupa LOTOS S.A.

5.4.1.2 Where not covered by any specific job requirements, instrumentation and installation shall conform to Grupa LOTOS S.A. Instrument specifications and standards and technical specifications referenced there.

5.4.1.3 The compressor Supplier shall coordinate the instrumentation in scope of the drive Supplier and other equipment of the train.

5.4.1.4 All instrumentation shall be fully mounted and piped. An instrument air header shall be provided where all instruments 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.

5.4.1.5 All instrumentation shall be readily accessible and rigidly supported. Vibration isolation shall be considered for all base-mounted instruments and gauge boards.

5.4.1.6 All controls and instrumentation shall be suitable for outdoor installation unless otherwise specified in the data sheets.

5.4.1.7 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 environment to which they are externally exposed.

5.4.2 Supply requirements

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

Local:

- local gauge boards for driver, compressor and auxiliaries

- a local panel for the complete compressor/driver train and auxiliaries, including, but not limited to, the equipment listed in the data sheets
- the supply and installation of all necessary instrumentation to monitor and control the safe start-up, running and shutdown of the compressor driver train and auxiliaries
- wiring the above instruments to junction boxes - inside junction boxes all wiring terminator shall be provided with identification tags
- Supplier shall provide dimensional and power requirements of this control cabinet/cubicle together with full description and max. distance from compressor unit along cable path
- all instrument air piping and tubing to the edge of baseplate

The antisurge system shall, at least, include the following main components, unless otherwise specified

- differential pressure transmitter
- antisurge controller (redundant as option)
- antisurge valve (preferable low noise) fully equipped with positioner, solenoid valve with manual reset of valve position transmitter, end limit switches.
- The antisurge valve shall quickly (in standard application is max. 750 msec. to 2 sec.) open on signal failure, power failure and shut down of the unit.
- The antisurge valve shall be designed for continuous operation for control and safety functions.

Control room:

- equipment control cabinets according to relevant Grupa LOTOS S.A. data sheets included in the contract

5.4.3 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.

5.4.3.1 Instrument wiring
All wiring from instruments to junction boxes at the edge of equipment baseframe shall be provided by Supplier.

5.5 Piping and appurtenances

5.5.1 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.

5.5.2 Compression connectors are not allowed for the product and utility lines. Metal-to-metal sealing welding end connections shall be used with preference.

5.5.3 Lube oil, seal oil and seal gas piping shall be made of stainless steel (e.g. 316SS).

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

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

5.5.6 Interstage process gas or air piping furnished by Supplier shall be in accordance with Grupa LOTOS S.A. piping specification as called for in the data sheet.

6 Inspection and testing

6.1 General

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

6.1.2 The Supplier and his major sub-suppliers shall have an implemented and reference proven quality assurance system. The quality system shall comply with ISO 9000/9001 requirements or an equivalent international proven quality assurance standard that is acceptable to the Grupa LOTOS S.A.

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. Grupa LOTOS S.A. shall have access at any time to the Supplier's quality control program for review. Grupa LOTOS S.A. reserves the right to conduct surface and subsurface inspection on all the compressor's parts.

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

6.2.5 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.

6.2.6 No repair shall be made without Grupa LOTOS S.A. 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.

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

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

6.2.9 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

Documentation delivered with compressor unit shall be in accordance with API 617 7th ed. Documentation for auxiliary equipment delivered by Supplier which is not addressed in the above mentioned standard 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.

8.1 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 617 - Axial and Centrifugal Compressors and Expander Compressors for Petroleum, Chemical and Gas Industry Services
- API 613 - Special Purpose Gear Units for Petroleum, Chemical and Gas Industry Services
- API 671 - Special-Purpose Couplings for Refinery Service
- API 614 - Lubrication, Shaft-Sealing and Control-Oil Systems for Special-Purpose Applications
- API 670 - Machinery Protection Systems
- 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 10 - Performance Test Code for Turbo Compressors
- 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
0		This specification entirely replaces the former Grupa LOTOS S.A. standard No. PR 07 244 with the same title.	T. Wójcik
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