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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 fans and blowers.

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.

These specifications shall be considered together with Specifications 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 fans and blowers 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

The fans and blowers shall be designed and delivered in accordance with standards referred to in this specification. 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 Design Criteria

Blower and fans units shall be suitable for outdoor installation. The equipment shall be furnished with all necessary weather and anti-corrosion protection to prevent damage due to weather, fumes or dust from the plant.

The blower or fan shall be completely shop-assembled and ready for installation except for such items which must be removed for shipping clearance or which could be damaged during transit.

Centrifugal fans in process service shall be in compliance with API Std 673.

The blower/fan and driver and auxiliaries shall be designed for continuous operation at full or part load conditions.

The overall mechanical and aerodynamic performance of the blower/fan unit shall be the Supplier's responsibility, even if the driver is furnished by Grupa LOTOS S.A.

All components shall be the Supplier's standard for this service unless specified otherwise in this specification or in the data sheets.

Blowers/fans intended for parallel operation shall have suitable head-capacity characteristics for easy control and operation.

Performance curves shall have a continuous rising pressure characteristic from the rated point, as specified, to 60% rated flow or less.

The performance curves shall be drawn for several positions of damper (inlet guide vanes) or several speeds of fan/blower shaft in case variable speed controller is applied.

The Supplier shall indicate, in the proposal, the ratio of specific heats temperature rise and compressibility factor for the gas composition specified which the Supplier has used to size the equipment.

Suction and discharge pressures specified in the data sheets shall apply to suction and discharge flanges of the entire blower/fan package, including any filters, silencers or other gas-path components furnished. Pressure drop allowances for such components shall be stated in the Supplier's proposal.

Rotary/centrifugal blowers or centrifugal fans proposed by Supplier shall be mutually agreed to and in compliance with applicable laws and standards. The Supplier shall indicate where specifications require excessive measures that result in non-standard material supply. The Supplier is obligated to identify such deviations.

4 Mechanical Design Requirements

4.1 General

If control of rotational speed is not provided, fans/blowers should be fitted with a throttling gate (louvers) at the inlet.

For gases of a temperature higher than ambient temperature, fans/blowers shall be designed mechanically for a temperature 40°C higher than the temperature at the inlet.

For gases of a temperature higher than 180°C bearing temperature measurement is required.

4.2 Centrifugal Blowers /Fans

The blower/fan pressure curve shall be provided with indicated Test Block (the area within which blower/fan is operating without disturbances). The Test Block shall enclose the rated point. The rated pressure shall not exceed 95% of the max. pressure point and surge point. Test Block rated point shall have a 20% margin on capacity and 44% margin on pressure of the maximum operating point. The Supplier shall submit with the proposal the characteristic curves corresponding to all operating points specified in the data sheets.

The Supplier, unless specified on data sheets, shall indicate whether such operating points are attained through speed variation, inlet/outlet shutter (louvers) control or any combination of these. All operating points must be located sufficiently to the right of the surge point to avoid unstable operation.

4.3 Rotary blowers

Rotary blowers shall be designed for continuous operation at the specified relief valve set pressure.

The blower performance at the rated operating point shall be guaranteed within the following tolerances:

- Blower capacity: -0%
- Blower horsepower: +4%
- Blower static differential pressure at rated capacity: +5%

The blower shall be designed and the required performance of the blower shall be guaranteed within the limits of the process and environmental conditions specified on the data sheets.

If specified on the data sheets, blowers shall be designed for liquid injection. Guaranteed blower brake horsepower values shall include allowances for liquid injection.

4.4 Blowers/Fans for Process Furnaces

Air and flue gas blowers and fans for process furnaces shall meet the requirements set out in API Std 560 and specification no. 2100.

- General requirements:

The fan's rated point shall include the flow required to meet the heater maximum design firing rate (including excess of air for system leakage and design safety factor).

The arrangement of the fan and driver equipment shall provide adequate clearance areas and safe access for operation, maintenance and removal.

The selected operating speed of the fan shall not exceed 1500 rpm unless otherwise approved by the Grupa LOTOS S.A.

Motor drivers shall be capable of starting the fan at 80% of the nominal voltage (a throttle in the close position).

In case of control signal failure or lack of power, the throttle (louvers) shall be designed to move to the position specified by Grupa LOTOS S.A.

- Flue Gas Fan:

The pressure difference generated by the fan shall cover the flow resistance across the louvers, gas ducts, air heater etc. and continuously ensure the required draught in the convection section.

The fan shall be provided with an automatically controlled throttle valve (louvers) at the suction side.

The rated power output of the motor drive shall be at least 125% of the maximum power demand for normal operating conditions.

The fan shall meet API requirements. Any deviations require Grupa LOTOS S.A approval.

Motors shall meet the requirements of Grupa LOTOS S.A. specification no. 4200.

- Combustion Air Fan:

Two fans with electric drives (one working and one as a hot stand-by) shall be provided for forced air draught to burners.

Each fan shall ensure at least 120% of the capacity required for the burners, allowing for leakages at the air heater.

The discharge pressure of the fan must cover all flow resistance and ensure the overpressure required for the burners.

The rated power output of the motor drive shall be at least 125% of the maximum power demand for normal operating conditions.

The fans shall meet API requirements. Any deviations require Grupa LOTOS S.A. approval.

Motors shall meet the requirements of Grupa LOTOS S.A. specification no. 4200.

4.5 Air Cooler Fans

Air cooler fans shall be in compliance with API Std 661 and Grupa LOTOS S.A. specification no. 2320.

Fans shall be of the axial flow type.

Forced draught fans are preferred.

Motors with variable speed drives are preferred.

Capacity shall be remotely controlled.

Each fan shall be provided with a vibration switch, which will stop the motor in case of inadmissibible vibrations.

If V-belts are used for drive transmission, they must be of the anti-electrostatic type (confirmed by the manufacturer's certificate).

Method of motors and fans disassembly from the cooler shall be described in the offer. Required special tools, if any, shall be proposed optionally.

Two or more fans aligned in the direction of tube length shall be provided for each bay, except that single-fan arrangement may be used if agreed by the Grupa LOTOS S.A.

Each fan shall be sized such that the area occupied by the fan is at least 40% of the bundle face area served by the fan.

The fan tip speed shall not exceed the maximum value specified by the manufacturer for the selected fan type. Fan tip speed shall not exceed 60 m/s unless approved by the Grupa LOTOS S.A. In no case shall the fan tip speed exceed 80 m/s. Noise limitation may require lower speeds.

Each fan assembly shall be balanced by one of the following means:

- Dynamic balancing as an assembly.
- Dynamic balancing of the hub and static moment-balancing of the blades (however in this case manufacturer shall perform onsite verification of dynamic parameters of the fan).

The fan assembly shall be designed to minimize reverse air flow at the hub.

Fan blades, hubs and blade retainers shall not be exposed to temperature above the manufacturer's recommended operating limit, regardless of whether the fan is at rest or in operation.

Ant-friction shaft bearings shall have a calculated rating life L_{10} of 50 000h at maximum load and speed.

Connection shall be provided outside of fan guards to permit grease lubrication of fan shaft bearings during the fan operation.

The motors shall be intended for air-cooled heat exchanger service and outdoor operation without roof.

4.6 Critical Speeds

First lateral critical speeds shall be at least 120 percent of maximum continuous speed.

For geared drivers, torsional natural frequencies shall be no closer than 10 percent to any shaft speed in the allowable operating speed range.

4.7 Baseplate

Blowers/fans drivers, gears, auxiliaries shall be mounted on a common fabricated steel baseplate.

The baseplate, unless otherwise specified, shall be welded steel construction and rigidly designed to minimize misalignment after installation.

A baseplate with anti-vibration dampers is preferred.

For a larger blower or fan unit where a common baseplate is not practical, the Supplier shall provide detailed drawings and all necessary information of proposed construction to minimize site work.

4.8 Blower/fan Casing

The casing shall be designed for rapid and economical maintenance. Casing split shall be designed for easy removal of impeller without dismantling the ductwork.

The casing shall be designed for the maximum discharge pressure. Valved drain connections shall be furnished at low points of the casing.

Inlet and discharge connections, and other connections over 11 inches, shall be furnished with flanges conforming to the applicable ANSI standards.

Threaded connections shall conform to applicable ANSI standards.

The casing shall be made of welded steel or ductile (nodular) cast iron, unless otherwise specified on the data sheet. Min. corrosion allowance is 3mm.

The casing components shall be assembled with recessed fits or dowels.

A rotation arrow shall be cast into the blower/fan or made of the same material as the nameplate and permanently attached to the equipment.

4.9 Rotor (Impeller)

The impeller shall be designed such that the maximum stress calculated at any point on the impeller shall not exceed 50 percent of the yield tensile strength of the material while running at maximum test block speed and temperature.

The impeller shall be secured to the shaft by press fit or shrinking and by a key and locked to insure against any loosening.

The rotors shall be balanced statically and dynamically – the final balancing must meet at least requirements of G-6.3 class if rated speed is upto 1000rpm and G2.5 if rated speed is greater than 1000rpm.

Vibration speeds measured on bearing housings shall not exceed the values specified below:

- During shop test

Rotor Speed (RPM)	Vibration speed, mm/s rms
Up to 1800	2.5
Above 1800	2.0

- Field operation

Rotor Speed (RPM)	Vibration speed, mm/s rms
Up to 1800	3.0
Above 1800	2.5

During shop tests or field operation, vibration amplitude measured on the casing shall not exceed 2,5 mm/s rms.

A centrifugal blower/fan shall be furnished with a radial bearing housings vibration monitoring and alarm system (if specified in data sheets).

Seals as specified on the data sheets shall be provided where the shaft enters the housing to minimize leakage into or out of the blower. Recent proved technologically advanced solutions are preferred.

Labyrinths or other close clearance seals shall be replaceable.

4.10 Timing Gears

Timing gears for rotary blowers shall be forged steel.

4.11 Blower/fan Bearing and Lubrication

Anti-friction radial and thrust bearings shall be selected to give at least L10 of 100,000 hours at all loads resulting from operation at zero to maximum capacity (not applicable to air cooler fans).

Bearings shall be oil lubricated.

Pressurized lubrication system is not preferred and shall not be used without a written approval from Grupa LOTOS S.A. If approved (and specified in relevant data sheet) the lubrication system shall include, but not be limited to the following:

- Oil sump with level gauge, filling, vent and drain connections
- Shaft driven main oil pump

- Pressure gauge on discharge side
- Stand-by oil pump driven by electric motor (if specified on the data sheets)
- Twin oil filters, each rated for full flow
- Oil cooler (air or water cooled as specified on the data sheet) with automatic TCV and oil inlet and outlet thermometers
- Sight flow indicator on oil drain line for each radial and thrust bearing
- Oil heater for freeze protection

One common pressurized lubrication system may be furnished to supply oil to the blower/fan and drive.

Bearing housings for non-pressurized lubrication shall be furnished with cooling jackets or coils, if required, to maintain acceptable oil temperatures. In that case it shall include the following features:

- The water jacket shall have no joints which may permit water leakage into the oil chamber
- Cooling coils, where used, shall be non-ferrous and shall have no joints within the housing

Bearing housings for non-pressurized lubrication shall be furnished with level gauges, constant level oilers with transparent containers and protecting wire cages, vents with dust filters, and filling and drain connections.

Bearings shall be sealed against entry of foreign matter and against loss of lubricant. Recent proved technologically advanced solutions are preferred.

Bearing housings temperature under any operating condition and at maximum ambient temperature shall not exceed 65°C.

Sleeve radial bearings shall be furnished with replaceable liners or sleeves be designed to maintain oil film stability at any operating speed.

For blowers/fans handling gas at elevated temperatures, at least one floating bearing shall be furnished to allow for shaft thermal expansion.

4.12 Drivers and Gears

The electric motor shall be furnished in accordance with the applicable Grupa LOTOS S.A. specifications and the motor data sheets.

Motors with frequency converters shall be used wherever speed control is required.

Blowers/fans driver shall be suitable for continuous full load duty under the specified operating conditions.

If stringent requirements are not specified then nameplate power of electrical motor drivers shall be at least 110 percent of required power consumption of fan /blower including any transmission losses at the maximum capacity (not relevant for drivers of blower/fan for process furnaces – see point 4.4).

Speed increasing or reducing gears shall be in accordance with the applicable AGMA standards and the gear nameplate power shall be at least equal to the motor nameplate power, including motor service factor.

Steam turbine drivers shall be in accordance with Grupa LOTOS S.A. specification no.2440.

The motor shall be furnished with an adjustable base and, if the motor drives "V"- belts, a provision for adjusting the "V"-belt tension.

"V"-belts, if furnished, shall be in matched sets. Both drive and driven sheaves shall have easily removable "Taper-lock" (or equal) hubs. Belts shall be oil-resistant and static conducting. If "V"-belts are used with a motor larger than 55kW, a jackshaft in "V"-belt arrangement shall be furnished. "V"-belts shall not be used with a motor larger than 75kW.

4.13 Couplings

For a direct-coupled unit, a steel-membrane-type coupling shall be furnished and accurately aligned. All couplings shall be rated for continuous operation at driver rated power, including service factors. For motor drivers with sleeve bearings, couplings shall be designed to limit axial movement of motor rotors.

Couplings compliant with API Std 671 shall be required only for critical services.

Couplings shall be flexible type, grease lubricated (if approved by Grupa LOTOS S.A. representative) or preferable non-lubricated design (for couplings of air cooler fans see p. 4.5).

Coupling overload factor shall be minimum 1.4.

All couplings and belt drives shall be furnished with removable guards in compliance with applicable regulations.

The guards shall meet applicable regulatory requirements, and be fabricated steel, easily removable and sufficiently rigid to withstand deflection and prevent rubbing as a result of bodily contact.

For explosion hazard zones, couplings and their guard shall be made of non-sparking materials.

4.14 Accessories

Inlet/outlet silencers shall be furnished if specified on the data sheet or if required to meet overall sound level limitation (including motors) specified in data sheets.

Silencers shall be furnished with drains at the lowest points.

Duct connected to silencer shall be designed with sufficient stiffness to prevent resonant vibration.

Silencer shall be designed to permit inspection and maintenance of internals.

The Supplier shall furnish an intake filter with screen and rain hood for an air blower/fan with atmospheric suction, if it is specified on the data sheets.

4.15 Welding

All welders and procedures shall be qualified in accordance with applicable AWS standard. All welding procedures shall be submitted for review.

4.16 Materials of Construction

Materials shall be as specified in the data sheets. Where not specified, material of components shall be the Supplier's standard suitable for the intended service.

Material shall conform to industry recognized standards.

5 Inspection and Testing

5.1 General

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

5.2 Tests

Pressure containing parts shall be hydrostatically tested at 1.5 times the maximum discharge pressure for a minimum of 30 minutes.

Blowers/fan shall be given a mechanical run test at the maximum operating speed with a shop driver for not less than 2 hours during which the mechanical operation of all equipment shall be satisfactory. Gear reducers shall be run tested with the blower/fan. As a minimum, vibration amplitudes and bearing metal and/or oil temperature shall be recorded during the test at 15 minute intervals. Recorded vibration amplitudes shall not exceed values given in section 4.9.

If not specified otherwise on the data sheets, the fan/blower shall be given a performance test in the shop per ISO 5801. Test tolerances for the test shall be as per API 673.

Fans and blowers intended to operate with toxic or flammable gases shall undergo pressure test as per API 673.

6 Painting

6.1 General

Painting shall be in accordance with specification no. 2400.

7 Nameplate

A stainless steel nameplate containing, at a minimum, the following information shall be permanently attached at an easily accessible point on the blower/fan:

- Supplier's name and serial number
- Model, size and date of fabrication
- Grupa LOTOS S.A. purchase order number and tag number
- Rated capacity (m3/h) and head (Pa (g))
- Rated power (kW)
- Rotor (impeller) diameter
- Rated rotor (impeller) speed (RPM)
- Bearing designations

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 Std 673 - Centrifugal Fans for Petroleum, Chemical and Gas Industry Services
- API Std 560 - Fired Heaters for General Refinery Service
- API Std 661 - Petroleum, Petrochemical, and Natural Gas Industries - Air-cooled Heat Exchangers
- ISO 5801 Industrial fans – Performance testing using standardized airways
- ISO 1940-1 - Mechanical vibration - Balance quality requirements of rigid rotors - Part I : Determination of permissible residual unbalance

10 Record of changes

No.	Date	Description	Introduced by
0		This specification entirely replaces the former Grupa LOTOS S.A. standard No. PR 07 246 with the same title.	B. Kowalewski
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