Contents

1 Subject of specification 2
2 Scope of validity 2
2.1 Order of precedence 2
2.2 Local regulations 2
2.3 Deviations 2
3 Classification of machines 3
4 Range of monitoring 3
4.1 Group A machines 3
4.2 Group B machines 4
4.3 Group C machines 5
4.4 Group D machines 5
4.5 Recommended range of set points for temperature sensors 5
5 Recommended configurations of monitoring for selected machines 5
5.1 Compressors 6
5.2 Critical single pumps 6
6 Electrical motors 6
7 Relevant documents 7
7.1 Grupa LOTOS S.A. specifications 7
7.2 Standards 7
8 Record of changes 7

1 Subject of specification

This specification used in conjunction with other technical specifications of Grupa LOTOS S.A. establishes minimum requirements regarding design and execution of machinery monitoring.

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 base for preparation of other detailed specifications and quotations relevant for package units or other equipment deliveries.

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

Machinery monitoring system 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 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 Classification of machines

During project execution (design stage) each machine shall be assigned by Contractor to one of the following groups:

- **A -** critical single machines
- **B -** critical doubled machines
- **C -** important machines
- **D -** other machines

The assignment of each machine to individual group shall be agreed with Grupa LOTOS S.A. (based on a recommendation provided by Contractor/Supplier considering process and technical safety issues, failure probability, and complexity of overhaul activities).

4 Range of monitoring

It is preferred that all sensors for monitoring of machines (serving specific parameter measurement) are from the same manufacturer. Supplier of specific machine is obliged to specify type of measuring system used in offered machine. Specification of alarm and shutdown levels for all types of sensors falls within scope of machine supplier responsibility as well.

It is applicable to all the machines in the groups. Machines in reserve must have identical monitoring system as machines being reserved.

Machinery monitoring system shall comply with requirements of API standard 670 (the latest edition), as well as standards related to specific equipment types, e.g. API 610, API 611, API 612, API 617, API 618, API 619, etc.

Detailed configuration of monitoring systems shall conform to Grupa LOTOS S.A. specification no. 3200.

Monitoring system proposed by Supplier (including number and type of sensors) shall be each time verified and approved by Grupa LOTOS S.A.

Group A and B machines shall be provided with continuous monitoring system connected to a machine protection system.

The following minimum range of monitoring of operating parameters is required for each group of machines

4.1 Group A machines

All machines assigned to this group shall be equipped with the monitoring systems measuring the following:

- vibrations
- temperatures
- pressures
- capacity
- speed (for turbines)

Measurement of vibrations:

- For vibration measurement of machines equipped with slide bearings, use of proximity probes is strongly recommended (measurement of shaft relative vibrations).
- For machines which shaft is supported by means of antifriction bearings, proximity probes sensing vibrations of outer ring of antifriction bearings, or piezoelectric sensors (acceleration sensors) registering absolute vibrations of bearing housing shall be used. In both cases two sensors (of the same type) per each bearing node arranged at angle approx. 90 º to each other, shall be installed.
- Phase sensor (so-called key-phasor) for measurements of phase characteristics and shaft rotational speed,
- Monitoring of axial position of rotor shall be accomplished by means of minimum two proximity probes.

Measurement of temperatures:

- For slide bearings use of thermocouples is strongly preferred (thermocouples: K type, 2 for measurement + 1 as a reserve per each bearing),
- Antifriction bearings temperature shall be measured by means of resistance thermometers or thermocouples (sensing of bearings outer rings temperature).

Furthermore, for machines of this group the following measurements shall be applied:

- temperature of oil to slide bearings at supply manifold (common measurement) and return lines,
- motor windings temperature (two Pt100 per winding, 1 of them as a spare)
- temperature of seals (for applications where this is required).

Pressure pulsation measurement shall be possible using applied pressure measurement devices.

For machines of this group measurements of capacity are recommended, which in specified cases can serve as good indicator of machine technical condition.

4.2 Group B machines

Monitoring of Group B machines shall be implemented basing on identical principles, as described for Group A machines, however considering presence of stand-by machines in this variant, some requirements for monitoring system can be limited as agreed with Grupa LOTOS S.A.

The machines assigned to this group can be equipped both with slide and antifriction bearings, therefore the type of the bearings decides in essence on specified sensor type application in order to make machine monitoring effective.

All machines assigned to this group

Machines which shafts are supported by means of slide bearings shall be equipped with the following:

- radial bearings – two proximity probes, shifted 90°, in each bearing node
- thrust bearing – at least two proximity sensors, monitoring axial position of rotor shaft
- phase sensor (so-called key-phasor) for measurements of phase characteristics and shaft rotational speed,

- measurement of bearings temperature (preferred thermocouples: K type, 2 for measurement + 1 as reserve per each bearing). In case of stand by machines (A/B) the reserve measurement is not required.

Machines which shafts are supported by means of antifriction bearings shall be equipped with the following:

- 2 proximity probes perpendicular to each other for each bearing node (vibrations measurement of rolling bearing outer ring), or 2 acceleration sensors perpendicular to each other for each bearing node,
- phase marker (so-called key-phasor) for measurements of phase characteristics and shaft rotational speed,
- measurement of bearings temperature (temperature measurement of rolling bearings outer ring by means of thermoelements).

4.3 Group C machines

The machines assigned to this group shall be equipped with one acceleration sensor per each bearing node.

Vibrations at direction perpendicular to the acceleration sensor will be measured periodically by means of a portable vibration analyzer. Supplier of the machine is obliged to prepare a surface (or measuring rods) on bearing nodes to which the portable vibration analyzer sensor will be attached.

4.4 Group D machines

Monitoring of technical condition for machines from this group is not required, however monitoring of their technical condition by means of a portable vibration analyzer shall be possible. Supplier of the machine is obliged to prepare a surface (or measuring rods) on bearing nodes to which the portable vibration analyzer sensor will be attached.

4.5 Recommended range of set points for temperature sensors

For all groups of machines that require temperature measurement, the following set point values are recommended, depending on the type of applied lube oils (accurate value of set points shall be each time agreed with Grupa LOTOS S.A.):

- for bearing blocks lubricated with mineral oils:

- run temperature - 80°C
- alarm - 90°C
- trip - 100°C

- for bearing blocks lubricated with synthetic oils:

- run temperature - 100°C
- alarm - 115°C
- trip - 125°C

5 Recommended configurations of monitoring for selected machines

5.1 Compressors

Reciprocating compressors of power above 50 kW shall be furnished with:

- Monitoring system for valve covers temperature, interstage temperatures and pressures, and capacity,
- Piston rod drop sensors (proximity type),
- Pressure transducers, enabling determination of indicator diagrams for each cylinder,
- Acceleration sensors (one per each cylinder),
- Velocity sensors (two transducers installed on both sides of compressor crankshaft casing)
- Phase sensor – key-phasor (measurement of phase angle),
- Temperature measurement (bearing sleeves, lube oil)

All measured values shall be transmitted to control room and recorded by DCS. Local indication of excessive vibrations (without sending signals to control room) is allowed for Group C machines.

5.2 Critical single pumps

For critical pumps with shafts supported by means of slide bearings, monitoring system of equipment dynamic condition shall include the following measurements:

- each bearing node shall be equipped with two of relative vibrations sensors, located 90º to each other,
- axial displacement of rotor thrust collar shall be sensed by means of at least two proximity probes,
- phase angle measurement (key-phasor),
- temperature measurement of bearing bushing or segment, by means of thermocouples (K type thermocouples are preferred, 2 for measurement + 1 as reserve per each bearing), temperature measurement of lube oil at bearing node supply and return lines.

The signals generated by sensors of monitoring system shall be transmitted to control room and recorded by DCS.

Scope of monitoring system for critical pumps being reserved can be limited per agreement with Grupa LOTOS S.A.

6 Electrical motors

Refer to Grupa LOTOS S.A. specification no. 4200 required temperature measurement on motors.

Vibration measurement/monitoring of motors shall be as per requirements of the group to which the driven machine is assigned.

If motor is not equipped with vibration sensors then its bearing node on non-driven side shall be provided with two rods perpendicular to each other to enable measurement of vibrations by means of a portable vibration analyzer.

Location and fastening of the rods in bearing node shall provide the minimum possible distortion of vibro-acoustic signal generated in bearing node.

The rods are not required for small motors i.e. mechanical size below 160M.

7 Relevant documents

7.1 Grupa LOTOS S.A. specifications

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

7.2 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 670 – Machinery protection system
- ISO 10816-1 – Assessment of machine vibration based on measurements on non-rotating parts

8 Record of changes

No.	Date	Description	Introduced by
0		This specification entirely replaces the former Grupa LOTOS S.A. standard No. PR 07 248 with the same title.	T. Wójcik
1	17.11.2006.	Changed point 4.2. – temperature measurement.	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