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1 Subject of specification

This specification used in conjunction with other technical specifications of LOTOS Group S.A., establishes minimum requirements regarding designing and execution of Machinery Monitoring System.

2 Scope of validity

This specification shall be used when preparing both quotations and Purchase Orders concerning planned LOTOS Group S.A. new investments and modernizations.

It shall also be a base for preparation of other detailed specifications and quotations relevant for package units or other equipment deliveries.

2.1 Deviations

Any deviation from this specification and the relevant specifications, standards and related documents including proposals, which the bidder claims to be economically and / or technically superior solutions, must be submitted in writing for review and approval by Grupa LOTOS SA. Non-approved exceptions are not acceptable by Grupa Lotos S.A.

The supplier must report in writing any ambiguity in this or any other specifications of Grupa LOTOS SA or non-compliance with the referred documents / standards and obtain a written explanation from Grupa Lotos SA.

3 Hierarchy of documents

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 with GLSA
- Data Sheets approved by GLSA
- This specification
- Other Specifications
- Drawings and other documents
- Standards

4 Definitions and designations

Machinery Monitoring System – measurement of machine operating parameters, such as vibration, shaft displacement, over speed, piston rod drop, bearings temperature, etc.

The system consists of: sensors of vibration and displacement, speed, phase, piston rod drop, transmitters, temperature sensors, connecting cables, junction boxes, system card cage, modules, power supplies and display panels (if required), as well as communication equipment.

Protection System of Machinery Monitoring – the system able to receive signals from Machinery Monitoring System and to shutdown the machine automatically in case of necessity, or to send information about exceeding of some measured parameters to operator. This function can be accomplished by DCS or PLC and SIS-PLC where required.

Connection of DCS to Machinery Monitoring System shall be implemented as two-channel: for information purposes by means of communication link with use of Modbus or Profibus protocol,

while in situations where transmission of control signals serving machine shutdown is required, the connections shall be implemented as hard-wired.

Machinery Monitoring Visualisation System (a computer in automatics systems able to operate as server) – the computer collecting data from Monitoring System, and operating autonomously as operator's station for service purposes, to be used by operation maintenance services. The computer is able to collect, store, process data and to print required reports, as well as make the data available to other systems (e.g. DCS or system aid production management and operation maintenance system).

GLSA – Grupa Lotos S. A.

DCS - Distributed Control System

PLC - Programmable Logic Controller

SIS-PLC- PLC controller in which functions with defined SIL level are implemented

I/O - Input/Output

DC - direct current

AC - alternate current

UPS - UPS supplied voltage distribution system

MCC - electrical switchhouse

TIR - Technical Instrumentation Room

SQL - Structured Query Language for database creation and serving

OLE - Object Linking and Embedding – technology of objects and applications linking under Microsoft Windows® operating systems

OPC - OLE method for process control

5 Description

Monitoring shall include the following machines:

- reciprocating and centrifugal compressors
- pumps
- steam and gas turbines
- air fans
- impellers of air coolers
- Diesel drives
- generators

Depending on machine type, the following parameters, or some of them, subject to monitoring: shaft vibrations, housing vibrations, shaft displacement, rotational speed, piston rods dropping, accelerations of rotating parts, phase angle measurement and temperature of machine and drive bearings and motors winding's temperature.

Number and selection of machinery instrumentation sensors serving their monitoring, falls within the scope of machine supplier responsibility, and shall conform to specification GLSA 2450 and directions of API 670 – Machinery Protection Systems as well as norms regarding individual types of equipment. eg.API610,API611, API612, API617, API618, API619, etc.

5.1 Signalling of parameters exceeding conditions and emergency shutdown

All signals indicating excess of parameters being monitored, as well as causing emergency shutdown of the machine, shall be directly connected to DCS or PLC machine control system, and to SIS-PLC where required.

The signals causing machine shutdown can originate from three sources:

- machinery monitoring system, including temperature of bearings and motor's' windings
- lubrication system, cooling system, oil temperature and level
- the process.

5.2 Sensor – connections

All sensors, such as vibration measurement, shaft displacement, piston rods dropping, acceleration, speed, phase angle, etc., as well as vibration monitoring systems shall originate from the same manufacturer. Sensors for vibration monitoring system shall be connected through separated junction boxes (one junction box per each machine – motor unit). Sensor – junction box connections shall be implemented with use of original cables of sensors' supplier, screened and armoured. Application of other screened cables is allowed, on condition that they shall be routed in steel Peschel type protective tubes and after obtaining GLSA approval.

Special attention shall be paid on adequate selection of cable sizes and their proper routing, i.e. in the furthest possible distance from motor power cables.

The junction boxes cannot be fastened to the machine, but to foundation, or installed on separate rack.

Multi-pair cables between junction boxes and system modules must feature capacitance, inductance and resistance values corresponding to the system requirements, and shall be shielded in pairs(triple) and externally as well.

Set values for alarm signalling and machine shutdown points shall be specified by the machine supplier.

5.3 Temperature measurement of bearings and motors' windings

In case of application of superior system, which uses automatic diagnostics program of machine condition, temperature measurement of bearings and motors' windings shall be directed to the system of vibration monitoring, and in other cases to control and interlocks' system.

5.4 Installation of modules

The modules of monitoring system shall be installed in system boxes according to manufacturer standard. The boxes shall be installed in separated cabinet or in TIR room.

Design of system installation must enable possibility of dismounting and installing each of modules in the box, while not bringing about interferences to whole system operation.

5.5 Segregation of modules

For double machines or such of minor importance, installation of input signals for more than one rotating machine in single box is allowed, on condition that redundant system of box supply is used.

5.6 Electrical supply

Vibration monitoring system shall be supplied from uninterruptible power supply (UPS).

Preferable type of supply: 24 V DC

In case of vibration monitoring system for machine of high importance to technological process, and in case of installing modules in single box for several machines, redundant electrical supply is required. Failure of single power supply cannot bring about problems to the system operation.

5.7 Communication of Machinery Monitoring System with DCS

Machinery Monitoring System must be equipped with communication port for communication with DCS purposes through RS-232/422/485, or Ethernet. Communication link shall operate with Profibus, Modbus or TCP/IP protocols. Close cooperation of monitoring system supplier with DCS supplier is required for proper definition of this communication requirements, in scope of transmission parameters and formats of data being sent.

The system supplier shall deliver complete list of I/O signals transmitted via serial link to DCS, taking into consideration the following data, as a minimum:

- number of measuring point
- description of measuring point (service)
- data type: analogue/binary
- range of values and units (in case when „raw" values are being sent, also range expressed in engineering units, to which the specific variable shall be scaled in DCS)
- value of active binary signal 0/1
- communication address (register number, code of transmission function)

Internal clock of Machinery Monitoring System must be synchronized with DCS clock. The supplier shall specify implementation method of this synchronization (list of data registers, code of transmission function)

The following data shall be transmitted to the DCS:

- Measured value of each canal
- Status of the canal
- Sensor condition (OK)
- Diagnostics of measuring channel
- Communication status
- Gap alarm for each channel (if exists)

Communication system shall enable possibility of the following functions realization in DCS:

- Setting of channel alarm status: present/not present
- Change of data storage period in memory
- Change of threshold value for alarm signalling or shutting down the machine
- Event time setting for each transmitted information (synchronization with DCS time)
- Configuration of access (logging in) for changes' introduction evidencing

Events of alarm and machine shutdown shall be indicated in visualisation system along with visual and audible signalling.

For purpose of machine shutting down, the signal coming from relay card, hardwired directly to DCS, PLC or SIS-PLC shall be used. It is necessary to consider purposefulness of using individual signals from sensors for shutting down the machine, or cumulative signal from all sensors for specific machine.

5.8 Requirements for protection system (DCS/PLC) of Machinery Monitoring

Each signal causing machine shutdown shall be equipped with by-pass (MOS), for maintenance and testing purposes.

The by-passes shall be configured in DCS. Access to them shall be possible through access authorization system and activation by means of mechanical switch protected with key. Each event of by-pass activation shall be registered.

Activation of by-pass must be signalled with visual and audible signal.

5.9 Requirements for Machinery Monitoring System visualisation, and diagnostics of results

Complete diagnostic and visualisation system shall be used for machines qualified according to specification GLSA 2450 as Group A or Group B machines. For machines from Groups C and D continuous monitoring system need not to be used, unless its application is required by the machine manufacturer.

Proper management of machinery stock requires data of its technical condition. Those data shall be accessible in industrial information system, which shall include the following domains:

- visualisation of operating equipment status
- historic analyses
- machinery stock management, i.e. collecting of information regarding failures and periodical inspections, progress of machinery wear, necessary repairs and spare parts.

The data from Machinery and Rotating Equipment Monitoring System shall be collected by computer operating autonomously as operator's station (computer in automatics systems). The data shall be mainly used by adequate operation maintenance services for servicing purposes, but shall be also made available to superior systems, constituting part of industrial information system.

Software installed on the workstation shall perform the following functions:

- On-line machinery monitoring, accomplished by means of adequate visualisation packages with built-in diagnostic functions, and including:
  - current tracing of machines' operation and their parameters
  - configuration of utilizing graphics with displaying of process data
  - automatic analysis of impermissible and failure conditions
  - quick data delivering in form of messages on events' and alarms' logs
- Historic analysis of machinery operation parameters.

  Industrial database

Considering large numbers of data collected for such analyses purposes (frequently collected at high frequency), industrial database shall be installed on the computer (e.g. SQL or Oracle system), capable to acquire and archive up to few dozen thousands of records per second. The database shall enable:

- creation of multi-variable trends of monitored values as time function
- creation of graphs of arbitrary machine parameters interdependencies on XY co-ordinate system
- creation of suitable reports by operation maintenance services, regarding machinery operation history (e.g. start-up sequences reports, number of operating cycles, length of cycles, interdependencies of arbitrary machinery parameters), without need to be skilled information specialist

- Diagnostics of machinery condition with forecasting (expert system)

  The function, basing on input signals (database of diagnostic data) and determined algorithms or formulas enables real-time forecasting of machinery operation statuses in the future (assessment of proper technical condition of machinery for mechanical and electrical considerations, as well as control and automatics systems), which shall enable recognition and planning of any type actions related to machinery maintenance service (overhauls, replacements of parts, maintenance, etc.) on adequately early stage. This shall bring to significant reduction of machinery stock maintenance costs.

  The software shall feature the following functions:

  - built-in library of algorithms and diagnostic formulas
  - possibility of extending already built-in algorithms, as well as creation of proprietary algorithms on the grounds of experience gained during operating of the machines
  - high quality of numerical procedures in scope of accuracy and speed
  - possibility of numerical data visualisation and interactive modification of visualisation method for selected charts or trends

- Data transmission

  The computer shall have possibility to operate as server and making data available for superior production management and operation maintenance systems, such as e.g. SAP R/3 PM. The communication shall be bilateral and proceed over Ethernet with use of OPC protocol.

6 Relevant documents

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

7 Norms and standards

Design, execution and erection shall comply with the latest editions of below listed norms and standards.

Only norms that are directly connected with machinery operation monitoring and protection systems are listed below. The other norms and standards are given in specification GLSA 3010.

API 670 – Machinery protection systems

PN-ISO 10816-1 Assessment of machine vibration based on measurements on rotating parts.

8 Enclosures

- Enclosure No. 1 Requirements regarding documentation

9 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

Grupa LOTOS S.A.	**ENCLOSURE No. 1**	Spec. N^{o}
	Requirements regarding documentation	3200

	WITH OFFER	ON DELIVERY	NOTES
TECHNICAL SPECIFICATION OF MANUFACTURER	Yes		
LIST OF DISCREPANCIES TO TENDER QUERY SPECIFICATION	Yes		
SPARE PARTS LIST ALONG WITH PRICES, RECOMMENDED FOR 2-YEAR OPERATION	Yes		
SPARE PARTS LIST FOR PRE-COMMISSIONING AND COMMISSIONING PERIOD	Yes		
TESTS CERTIFICATES		Yes	if specified
MATERIAL CERTIFICATES ACCORDING TO EN-10204 3.1		Yes	if specified
EQUIPMENT CONFORMITY CERTIFICATES FOR OPERATION IN EXPLOSION HAZARD ZONE	Yes	Yes	if applies
CERTIFICATES ISSUED BY ADEQUATE BODY FOR EQUIPMENT SERVING FOR SETTLEMENT MEASUREMENTS		Yes	if applies
DIMENSIONAL DRAWINGS	Yes		
ELECTRICAL WIRING DIAGRAMS		Yes	
INSTALLATION, OPERATING AND MAINTENANCE INSTRUCTIONS		Yes	
ELECTRONIC VERSION ON CD DISK		Yes	
INSPECTION BOOK		Yes	if specified
PRODUCTION QUALITY PLAN		Yes	if specified
DECLARATION OF CONFORMITY TO EUROPEAN UNION DIRECTIVE (CE MARK), ISSUED BY MANUFACTURER		Yes	
CERTIFICATES OF MANUFACTURER		Yes	if specified
CALIBRATION SHEETS		Yes	if specified