Grupa LOTOS S.A.	**TECHNICAL SPECIFICATION**	Spec. N° 3430
	Temperature measurement instruments	

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1 Subject of specification

This specification used in conjunction with other technical specifications of LOTOS Group S.A. establishes the minimum requirements for the design, manufacture of temperature instruments.

2 Scope of validity

This specification applies to the preparation of tender documents, inquiries and contracts concerning new investments and modernization projects planned by LOTOS Group S.A.

It shall also be a basis for preparing both detailed specifications and inquiries for individual or package unit supplies.

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

4 Definitions and designations

GLSA – Grupa LOTOS S.A.

DCS – Distributed Control System

PLC – Programmable Logic Controller

ESD – Emergency Shut Down System

SIS – Safety Instrumented System

SIL – Safety Integrity Level

RTD – Resistance Temperature Detector (resistance thermometer)

T/C – Thermocouple

Thermowell– external protection of thermometer, installed in pipeline or process apparatus

Sheathed thermocouple or resistance thermometer – construction insulated with magnesium oxide and metal sheath, obtained by means of rolling and pulling.

Multiplexer – switch device of signals coming from temperature sensors.

5 Description

All specific features of given measurement type, scope of application and limitations apply to solutions that are most frequently used in industry. In each case, and particularly in relation to conditions of an instrument usage, detail arrangements with manufacturer or supplier are deciding. One shall also follow requirements of plant licensor if they are stronger than requirements of this specification, or condition of guarantee.

All component equipment of temperature measurement must be adapted to continuous work in ambient conditions present on location site.

Instruments mounted in pipelines and devices (external shields) must be made according to PED European Union Directive N° 97/23/EC, Pressure Equipment.

Local instruments must be accessible from ground level, from platform, or fixed ladder.

5.1 Thermowells

All sensors for temperature measurements in pipelines have to be installed in external shields (thermowells). Sensors for temperature measurements of bearings, windings of electric motors, in industrial heaters, and for surface temperature measurements of pipes and apparatus, are installed without thermowell.

5.1.1 Construction

Process flanged connection, of 1 1/2" diameter. Connection class according to pipe or vessel class, but not less than 600 lbs. Flanges according to ANSI B16.5. Length of thermowell must be such selected, so as to its end is located between 1/3 and 2/3 of pipeline diameter. For temperature measurements in devices, submersion length is specified each time on the grounds of process requirements and the device design. Thermowell that are welded to pipeline can be used only after given Lotos Group approval.

The thermowell must be conic and made from rod by means of drilling and turning. Thermowells made of pipe are not allowed. Maximum length of thermowell can be 600mm. Flange must be bilaterally welded to thermowell. Sensor connection ½" NPT. As a material, 316 SS shall be used, unless process conditions require other material. Manufacturer shall deliver 3.1 material certificate for thermowell according to EN-PN 10204, as well as declaration of conformity according to PED N° 97/23/EC, Pressure equipment.

Internal diameter of thermowell shall adequately correspond to sensors, where for remote temperature measuring sensors 6 mm diameter is assumed, while for local temperature measurements (thermometers), diameter of insert equal to 8 mm is assumed.

Use of threaded connections for thermowells is not recommended. Only in cases agreed and accepted by Lotos Group S.A., threaded connection of M27x1.5 size is allowable.

The thermowell shall be installed in pipelines of 4" diameter at least. In case of pipelines of smaller diameter, local pipeline extension to 4" diameter shall be used.

5.1.2 Special thermowells

Special thermowells are necessary for temperature measurements in reactors, particularly in case of multipoint measurement. All dimensions, as well as pressure and material parameters must be adapted to reactor design; therefore the thermowell is included in reactor scope of delivery.

5.1.3 Vibrations and static pressure strength of thermowell

For thermowells mounted in pipelines it is necessary to complete calculations of natural frequency and frequency of vibrations forced by swirls resulting from flow, according to ANSI/ASME PTC 19.3 TW-2010.

Supplier shall provide such calculations done by means of dedicated software, which takes into account all necessary computations.

When computations of vibration, pressure and static stress resistance do not allow for application of standard design and length of thermowell, then supplier shall propose solution to this problem. The solution proposed by supplier shall receive written approval of Lotos Group.

Constructions of thermowell: according to Attachment N° 2.

5.2 Sensors

Methods of remote temperature measurement, which use is preferred within LOTOS Group S.A., are:

- thermoelectric sensors of K type,
- resistance sensors of Pt100 type – which are preferred in range 0 ÷ 300ºC depending on application,
- use of other sensors' types requires GLSA approval

Application ranges of thermocouples used on GLSA units:

J type, Fe-Ko (iron - constantan)	0 to 750°C
K type, NiCr-Ni (chromel-alumel)	-40 to 1000°C
R type, Pt-RhPt (platinum, 13% of rhodium+platinum)	0 to 1650°C
S type, Pt-RhPt (platinum, 10% of rhodium+platinum)	0 to 1650°C

In course of thermocouple choice, design temperature and fluid type, which temperature is to be measured, shall be taken into account. Generally speaking, thermocouples that contain platinum, and particularly in ceramic sheaths, must not be used in reduction atmosphere that is frequently present in industrial heaters.

5.2.1 Thermocouples for measurements in pipelines and tanks

Thermoelectric temperature sensor– shall be made in class 1, according to PN-EN 60584-2 standard.

K-type class 1 thermocouples are used in temperature range –40ºC up to 1000 ºC. For higher temperature ranges it shall be individually specified, in agreement with LOTOS Group S.A..

Sensing element shall be of jacket design, non-earthed, and 6 mm of outer diameter.

Sensor shall be replaceable and spring-load mounted, in order to provide good contact of thermocouple tip with thermowell.

For thermocouples used for measurements of temperatures higher than 800ºC, ceramic thermometric sheaths are recommended.

The head of thermocouple shall be fastened to ½" NPT-F socket of thermometric sheath through spacing bush. Spacing bush used between flange and connecting head – 140 mm minimum length – shall take ambient temperature conditions into account.

The head shall be made of cast iron or aluminium alloy, as A type (according to DIN 43 729), and IP 65 protection class according to requirements of EN 60529 standard. Cable entry shall be M20x1.5 with suitable cable gland. For cable connection, bolted terminals shall be used.

5.2.2 Set of thermocouples for multipoint temperature measurement in reactors

Application: for temperature profile measurement in reactor bed.

Note: thermowell shall be delivered by reactor supplier, or made according to his detailed material and dimensional requirements. In special cases it applies also to single point temperature measurement in reactor.

Construction:

- Precisely adapted to of construction special thermowell, delivered with reactor
- All thermocouples to be mounted on common flange
- The set of thermocouples shall be furnished with elements facilitating good insertion to thermowell
- Contact of thermocouples hot tips to thermowell walls shall be ensured.
- Junction box with terminals for all thermocouples.
- Transmitters mounted in separate box.
- Note: enough space above thermowell flange shall be ensured, enabling installation and dismantling of thermocouple set.

5.2.3 Thermocouples for measurement of wall temperatures (skin thermocouples)

Measurements of reactor walls temperature, refer to Attachment N° 4

Such measurements are necessary for early detection of reactor walls overheating, e.g. because of internal reactor lining damage.

For these measurements, sheathed thermocouples and compensation cables shall be used. The length of cables shall be suitable for fixing of a head to platform. The thermocouple and compensating cable must be furnished with adequate mechanical protection: flexible tube, tray, etc. Thermocouple shall be furnished with a tip that enables screwing its end firmly to reactor shell. Bolts for securing thermocouples on the wall of reactor have to be welded in course of its manufacture.

Measurements of pipes walls temperature in industrial heaters, refer to Attachment N° 3

Condition for proper measurement of tube walls temperature in process heater, is metallic, permanent contact of thermoelement with the tube. Heater's contractor is obliged to present method of thermoelements assembly for GLSA approval. Used materials have to allow for the most disadvantageous working conditions in heater: flame, chemical destruction, etc.

K type thermocouples with insulated junction shall be used for temperature measurement

Skin type thermocouples of at least 8 mm diameter and at least 1,8 mm skin thickness shall be used.

Skin material shall fulfil condition of chemical resistance to components of fuel medium. It is recommended to use: 1.4749 grade for heaters fired with fuel oil.

A thermocouple entry through heater jacket and furnace lining must be shielded with a protective tube, longer than depth of lining, inserted inside the heater and filled with ceramic wool. Other types of protection against disadvantageous conditions, such as corrosion, overheating, are allowed if agreed in advance with LOTOS Group S.A.

Thermoelement route shall lead on heater process tube, within the shadow of flame boundaries.

Thermoelement shall be fixed on process pipe with determined number of clamps, which spacing shall not exceed 1 m. Clamps have to provide measuring element with necessary clearance, enabling thermal extension of sensor and pipeline.

Measuring tip of thermoelement must form metallic joint with metallic cover plate (as per Attachment No: 3), welded to pipe on flame side.

It is necessary to use thermal compensations of thermoelement directly behind heater lining.

5.2.4 Compensation leads

Compensation leads used shall be of THL KX type, 1st class grade according to EN-PN 60584-3 standard.

Compensation leads have to be used in case of remote installation of transmitter, and when multiplexer is used.

Compensation leads must be adapted to the type of thermocouple employed. Each pair of leads must be twisted and screened

In case of ungrounded thermocouples, screen of compensation cable shall be grounded in signal module conditioner (remote transmitter or multiplexer). Screen of the cable must be insulated in a head of thermocouple.

In case of grounded thermocouples, screen of extension cable shall be grounded in a thermocouple head.

Number of cable terminal connections shall be limited to minimum; direct connection from sensor head to transmitter or multiplexer is preferred.

5.3 Resistance thermometers (RTD)

Pt100 resistance sensors shall be manufactured in "A" class according to PN-EN 60751 standard.

Pt100 sensors are to be used exclusively in temperature range from –200°C up to 600 °C.

Sensors of thermal coefficient $\alpha = 0.00385$°C shall be used.

Commonly used wiring of resistance sensor is four-wire application.

The head of resistance sensor shall be fastened to ½" NPT-F socket of thermowell through spacing bush. Spacing bush used between flange and connecting head – 140 mm of minimum length – shall take ambient temperature conditions into account.

The head shall be made of cast iron or aluminium alloy, as A type (according to DIN 43 729 standard) and IP 65 protection degree according to EN 60 529 standard requirements.

Cable entry shall be M20x1,5 with suitable cable gland. Bolted terminals shall be used for cable connection.

Sensor shall be replaceable and spring load mounted, in order to ensure good sensor contact with thermowell.

Thermometers are mounted in thermowell. Delivery: an assembled unit, complete with thermowell.

5.3.1 Measurements of machine bearings temperature

Measurements on machine require special design, precisely adapted to mechanical elements of machine. Such measurements shall be included in package delivery of specific equipment. Type of measurements, their number and location are defined in specification GLSA 2450, Machines monitoring.

Double Pt100 sensors shall be used for remote measurement of machines elements temperature.

Assembly of sensors shall be completed away from the machine, for example in intermediate junction boxes.

Documentation of machine shall present in detail method of temperature measurement inside the machine, as well as detailed specification of measuring element.

Thermometers of 100 mm dial diameter are allowed for temperature measurement on machines.

5.3.2 Temperature measurements in storage tanks

Measuring system must include measurement of average liquid temperature, and consists of several vertically arranged sensors. Number of sensors depends on height of specific tank; standard of measuring system manufacturer shall be employed.

Measuring system must take liquid level into account.

5.4 Temperature transmitters

5.4.1 Basic requirements regarding transmitters

- Assembly in temperature sensor head. Transmitter design intended for remote installation is allowed, if assembly in head is impossible because of, for example, high temperature or ESD requirements; in each case GLSA approval is required for such solution. Remote transmitter shall also be used if local indicator is required.
- Intelligent type with signal linearization. Irrespective of their location, temperature transmitters have to ensure temperature compensation of thermocouple cold junction. In case of remote assembly of transmitter, this applies to temperature of compensation leads at transmitter terminals.
- Galvanic isolation of input and output signal.
- Input signal. Possibility of sensor type selection (conforming to PN-EN 60751 or PN-EN 60584 standard), and adjustment of measuring range on whole temperature range defined by standards for specific sensor.
- Output signal 4-20 mA + additional, digital HART
- Total accuracy better than 0.2%, repeatability 0.1%.
- For explosion hazardous areas, intrinsically safe design shall be used as a basic protection. Certificate according to ATEX.

- Class of protection against dust and water – minimum IP65.
- Transmitters must be calibrated by supplier as per the range specified in data sheet. In special cases certificate of calibration is required.

5.5 Multiplexers

Multiplexers are used for reduction of cables quantity. Multiplexers can be used only for temperature indication; their use in control and ESD loops-where use of transmitters is obligatory- is not allowed.

Application of multiplexers is purposeful, when several measurements are located in close proximity. Measurements of reactor shell temperature can be as an example. Each multiplexer must have at least 20% of spare inputs.

10 sensors located not further than 25 m one from another is assumed as purposefulness limit of the multiplexer use. Also at least two such small groups of sensors must be present on site, or one – but significantly larger group.

Contact switches are not allowed. Multiplexers must be adapted to installing them directly on unit, also in explosion hazardous area in adequate Ex execution. Protection degree - IP65 as a minimum, suitable for hazardous zone, where it will be located.

Protection against explosion: intrinsically safe design for inputs and outputs, certificate according to ATEX. Output signal of a signal module conditioner must be located in safe area.

Multiplexer receives signals coming from many sensors (thermocouples, resistance thermometers) and transfers them to DCS or PLC. Semiconductor type switch-over elements shall be used in multiplexer. It must ensure signal linearization and scaling. In case of thermocouples, multiplexer have to provide compensation of cold junction temperature.

Output signal: intrinsically safe, redundant communication output of RS485/Modbus RTL standard.

Calibration accuracy: < ±0.1% of range

Temperature compensation error of thermocouple cold junction: <1ºC at ambient temperature –20 up to +60ºC.

Power supply: in communication signal. Application of multiplexer that requires additional supply requires GLSA approval.

5.6 Local thermometers

Principle of measurement: Bimetal thermometer with compensation of ambient temperature influence. Liquid or gas thermometers are to be used only when this is required by process conditions, vessel connection or necessary range of temperature measurement. Use of mercury is not allowed.

Design: Durable, weather resistant, with dial indicator of 150 mm diameter, every-angle. Zero adjustment possibility shall be provided.
Capillary tube of liquid or gas thermometer must be protected with armour.

Vibration resistance

A thermometer has to be vibration resistant to the vibrations normally present on pipelines. In case of large magnitude vibrations, for example, on reciprocating compressors, indicator shall be filled with dedicated for ambient temperature -25ºC liquid.

Accuracy 1% of range

Indications Linear scale graduated in Celsius degrees, black letters on white background. Indications of normal temperature between 20% and 80% of scale range.

Thermometer connection 1/2" NPT, with possibility of immersion depth adjustment.

5.7 Temperature switch

Temperature switches are allowed only as a part of machines equipment, e.g. for oil temperature signalling.

The use of temperature switch of process temperature can be implemented only as software switch in DCS or PLC of analogue signal from temperature transmitter.

5.8 Optical pyrometers

All pyrometers types are working on the basis of thermal radiation (infrared), and implement measurement in the contact less way. This method enables temperature measurement in full range, but they are used in industry for high temperature measurements (above 500ºC), and in cases when direct „contact – type" measurement is impossible. It is possible to measure temperature of solids and gases, which emission and absorption bands are within infrared spectrum.

In cases, where pyrometers are installed in places exposed to high thermal radiation, protective shields and cooling housings shall be used.

In petrochemical industry practice, several types of pyrometers are used:

Instrument type	Advantages	Disadvantages
Infrared pyrometers with thermocouple. Thermocouple serves as sensor of radiation arriving at pyrometer	Low price Do not require power supply No signal creeping Readout can be implemented by standard thermocouple receiver Intrinsically safe design	Signal non-linearity Calibration required for specific application Susceptibility to electromagnetic interferences Susceptibility to optical signal interferences (fumes, dust)
Portable infrared pyrometers with semiconductor detection	Low cost Very good service tool	Measurement disturbed by fume, dust, etc. Short cable from sensor to receiver
Stationary infrared pyrometers with semiconductor detection	Measurement can be focused on selected point of measurement object, arbitrary distance from measuring point. Medium cost.	Measurement disturbed by fume, dust, etc. Susceptibility to optical signal interferences (fumes, dust)
Pyrometers with optical signal transmission by fibre optic	Can be used in harsh environment conditions Possibility of getting through signal masking barriers Insensitive to electromagnetic interferences	Fixed point of temperature measurement High cost
Bi-colour pyrometers. Possible transmission of optical signal by fibre optic	Measurement through smoke, dust, other optical contaminations Measurement does not depend on emissivity of radiating body	Very high cost

Optical pyrometers are uncommon instruments to be used on GLSA units, to be applied only if other measurement methods are impossible or purposeless. Selection of the instrument shall be focused on instrument destination at first.

6 Relevant documents

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

7 Standards and regulations

Designing, manufacturing and assembly shall conform to latest editions of standards and regulations given below.

Only specific standards, connected with temperature measurements are quoted here. Remaining standards concerning control and instrumentation are given in specification GLSA 3010 – General requirements.

PN-EN 60584-1	Thermocouples. Part 1: Reference tables
PN-EN 60584-2	Thermocouples. Part 2: Tolerances
PN-EN 60584-3	Thermocouples extension and compensating cables. Tolerances and identification system
PN-EN 60751	Industrial platinum resistance thermometer sensors
PN-EN 61515	Mineral insulated thermocouple cables and thermocouples
ANSI/ASME PTC 19.3 TW-2010	Thermowells (Performance Test Code).

8 Enclosures

Enclosure No. 1, Documentation requirements

Attachment No. 2, Thermometer with external shield (thermowell)

Attachment No. 3, Thermocouple for pipe wall temperature measurement

Attachment No. 4, Thermocouple for measurement of reactor wall temperature

Attachment No. 5, Instrument data sheets

9 Record of changes

No.	Date	Description	Introduced by
1		This specification entirely replaces the former LOTOS Group S.A. standard No. PR 07 330 with the same title.	M. Domaniewski
2	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}
	Documentation requirements	3430

	WITH BID	WITH DELIVERY	NOTES
MANUFACTURER'S DATA SHEET	Yes	Yes	
LIST OF DEVIATIONS TO INQUIRY SPECIFICATIONS	Yes		
LIST OF SPARES RECOMMENDED FOR 2 YEARS OPERATION WITH ITEMIZED PRICES	Yes		
LIST OF SPARES RECOMMENDED FOR COMMISSIONING AND PROVISIONAL ACCEPTANCE TEST	Yes		
TEST CERTIFICATES		Yes	If specified
MATERAIL CERTIFICATES ACCORDING TO EN-10204 3.1		Yes	If specified
CERTIFICATES ISSUED BY OFFCIAL ORGANIZATIONS FOR EQUIP. TO BE UTILIZED IN HAZARDOUS AREAS	Yes	Yes	If applicable
CERTIFICATES ISSUED BY OFFICIAL ORGANIZATIONS FOR EQUIPMENT TO BE UTILIZED FOR CUSTODY TRANSFER			
OUTLINE AND DIMENSIONAL DWGS, ELECTRICAL ARRANGEMENT	Yes	Yes	
ELECTRICAL DIAGRAMS		Yes	
INSTALLATION, OPERATION AND MAINTENANCE INSTRUCTION MANUALS		Yes	
DOCUMENTS IN ELECTRONIC VERSION ON CD		Yes	
INSPECTION BOOK		Yes	If specified
FABRICATION QUALITY CONTROL PLAN		Yes	If specified
MANUFACTURERS DECLARATION OF CONFORMITY WITH EU DIRECTIVES		Yes	
MANUFACTURING CERTIFICATES		Yes	If specified
CALIBRATION CERTIFICATE		Yes	If specified
HYDROSTATIC TEST REPORT		Yes	If applicable