eustream, a.s.

Project:
Replacement of hydraulic parts of turbo-compressors 650-21-2 at KS01 Veľké Kapušany

TECHNICAL SPECIFICATION

CONTENTS

1 GENERAL INFORMATION

1.1. Introduction

This specification with attachments and other documents, to which it refers (standards, regulations, decrees), is used as the basic document for the tender for selection of the supplier, and defines minimal requirements relating to content, scope of the adjustment, and terms of its implementation. The subject of the adjustment is represented by 2+1 units (from that one unit is only an option) of existing turbo-compressors, type ČKD 650-21-2, driven by electric motors, installed in the framework of the transit system of Slovak Republic at the compressor station KS01 in Veľké Kapušany.

The main task of the designed adjustments of turbo-compressors is to change their work characteristics so, that after the adjustment the work area of the compressor will enable operation of these machines in changed operational regime of the compressor station with decreased flow rate and reaching the highest possible efficiency of the compression.

1.2. List of applicable standards and regulations

Design, production, installation, testing, and commissioning of the offered device must preferentially meet all terms of Slovak legislation in force. In the case of area appearance connected with the project, which is not covered by Slovak or American standards/regulations, it is possible to admit application of European norms and standards. If it is not agreed in some other way, the offered device and its installation must be in conformity with the following standards and regulations:

- API 617 Centrifugal Compressors for Petroleum, Chemical and Gas Service Industries
- ISO 10439 Centrifugal Compressors for Petroleum and Gas Industries (only as an option to API 617)
- ASME PTC 10 Performance Test Code on Compressors and Exhausters, as a guideline, execution shall be based on existing measuring system.
- API 614 Lubrication, Shaft Sealing and Control Oil Systems for Special Purpose Applications

- API 670 Vibration, Axial Position and Bearing Temperature Monitoring Systems
- EC Directive 97/23/EC Pressure Equipment Directive
- EC Directive 98/37/EC Machinery Directive (implemented in Decree of SR's Government No.391/1999 Coll. (amendment in No.161/2002 Coll.))
- STN EN ISO 9000/ISO 9001 Quality Assurance System
- STN EN ISO 11204+AC1 Acoustics. Noise emitted by machines and devices. Determination of emission levels of acoustic pressure on the working place and on other exactly limited places. The method which requires correction on the impact of environment (ISO 11204: 1995)
- STN EN ISO 11200+AC Acoustics. Noise emitted by machines and devices. Instruction for the use of basic standards for determination of emission levels of acoustic pressure on the working place and on other exactly limited places (ISO 11200: 1995)
- STN EN ISO 12001+AC Acoustics. Noise of machines and devices. Regulations for creation and presentation of testing procedures for noise determination (ISO 12001:1996)
- STN ISO 1996 Acoustics. Description, measurement, and assessment of noise in outer environment. (ISO 1996:2003).
- STN ISO 7919 Mechanical vibration of machines with irreversible motion. Measurement on rotating shafts and criteria of assessment.
- Decree of SR's Government No. 393/2006 Coll. on minimal requirements to provide safety and health protection at work in explosive environment.
- Regulation No. 508/2009 Coll. to provide safety and health protection at work and safety of technical devices, valid from 1.1.2010, supersedes Regulation No. 718/2002 Coll.
- Decree of SR's Government No.310/2004 Coll. on technical requirements relating to products and machine devices, as amended in subsequent regulations.
- The Act of National Council of SR No. 124/2006 Coll. on safety and health protection at work, and on amendment and completion of some acts.

- The Act of National Council of SR No. 355/2007 on protection, support, and development of public health, and on amendment and completion of some acts.
- Decree of SR's Government No.392/2006 Coll. on minimal safety and health requirements at the use of work means.
- Decree of SR's Government No.395/2006 Coll. on minimal requirements to provide and to use personal protection work aids.
- Decree of SÚBP and SBÚ No. 59/1982 Coll., which determines basic requirements in order to provide safety of work and technological devices.
- Decree of SÚBP and SBÚ No. 86/1978 Coll. On inspections, revisions, and tests of gas engineering devices (§11, §12 sec. 2 and 3 were cancelled), as amended in Regulation No. 74/1996 Coll.
- Decree of MPSV and R SR No. 500/2006 Coll., which presents sample of the record on registered work injury.
- Decree of SR's Government No. 56/2018 Coll., which determines of the conformity assessment STN EN 61508 Functional safety of electrical/electronic/programmable electronic safety-related systems…
- STN EN 12583 Gas Infrastructure - Compressor stations – Functional requirements Machinery Directive 2006/42/EC of the European Parliament and of the Council
- ATEX 94/9/EC
- All other new possible directives applicable to CE marking

Listed standards and regulations are applicable only for the scope of supply. Conformity with above stated standards and regulations does not eliminate responsibility of the CONTRACTOR for the proper design of the device so, that it meets required guaranteed operational terms. In the case of discrepancy between individual documents provided as basic documents or standards, the CONTRACTOR has an obligation to inform about it, and to consult and agree further steps with the CUSTOMER.

For the delivered device the CE certification is required.

For works at the place of installation in the existing area of KS01 the internal regulation Eustream and KS01 Veľké Kapušany are applied (they will be provided to the winner of the tender).

1.3. Abbreviations

KS	Compressor station
UCS	Unit control system
FAT	Factory acceptance test
PC	Process controller
CFD	Computational fluid dynamics

2. DEFINITION OF BASIC OPERATIONAL TERMS

2.1. General information

The designed service life of the device should be at least 20 years or 170 thousand operational hours at specified maintenance cycle. No „principal" intervention into existing casing of the compressor is allowed, it means such one, which would require its dismantling from the basement as well as disconnecting from the process gas pipelines. The device will be installed in the environment with controlled temperature in range 5 up to 40°C. Classification of the environment – ZONA 2 – for details see Attachment No.12 Protocol in force No. TPk/07/2008 on determination of space with danger of explosion elaborated in conformity with STN EN 60079-10, determination of external impacts in accordance with STN 33 2000-5-51 and NVSR 393/2006.

2.2. Basic parameters of natural gas

All main properties and parameters of transmitted natural gas are presented in the following tables. The presented parameters are binding for all relating technical and designing calculations and are valid for normal conditions: temperature 20°C, absolute pressure 101 325 Pa.

Property	Value
Sulphur content	0.3 mg/std m^3
Maximum solid particle concentration	0.1 mg/std m^3
Maximum particle size	<10 µm
Methanol content	83.34 mg/std m^3

std m3/d at reference conditions 101 325 Pa, 20 °C

Tab. 1 – Gas properties

GAS COMPONENTS		VALUE mol. %	LIMIT VALUE mol. %
Methane	(CH4)	95.473	min. 85
Ethane	(C2H6)	2.428	max. 7
Propane	(C3H8)	0.729	max. 4
i-Butane	(C4H10)	0.109	max. 2
n-Butane	(C4H10)	0.115	max. 2
i-Pentane	(C5H12)	0.022	max. 2
n-Pentane	(C5H12)	0.017	max. 2
Hexane and higher	(C6H14)	0.017	max. 0.02
Nitrogen	(N2)	0.76	max. 5
Carbon dioxide	(CO2)	0.33	max. 3
Oxygen	(O2)	0.0	max. 0.02
Hydrogen	(H2)	-	max. 5

Tab. 2 – Gas composition

Hydrosulphide (H2S)	max. 6.8 mg/std m^3
Mercaptan sulphur	max. 16.9 mg/std m^3
Sulphur total	max. 150 mg/std m^3
Water dew point	max. -4°C at pressure 4,0 MPa
Carbohydrate dew point	Maximum 0°C in pressure range from 1 to 7 MPa measured at pressure corresponding to critical

	condensation temperature

std m3/d at reference conditions 101 325 Pa, 20 °C

Tab. 3 – Other parameters of gas

3. DESCRIPTION OF PRESENT STATUS

Present turbo-compressor units were designed and installed in the first half of 80-ties by ČKD Praha – Kompresory. The device was originally designed for operational conditions corresponding to the nominal compression rate in design point 1.44 (suction pressure 5.18 MPa (abs), discharge pressure 7.45MPa (abs), flow rate 46 mil. std m^3/d (at temperature 20°C, absolute pressure 101 325 Pa) and it referred to terms in the time of installation. With regard to running rationalization measures in the operation of the transmission system the adjustment to new operational parameters is presumed, to which the existing device at KS01 should be adjusted.

3.1. Description of the unit

All three referred units are placed in common separately built hall, where the operational temperature is maintained in range between 5 up to 40°C. Each of the units consists of radial centrifugal compressor with electric motor driving unit. The compressor is connected with the driving unit by means of torque rod with integrated coupling. The compressor with electric motor is placed on common concrete basement inside of the acoustic enclosure. The enclosure is equipped with overpressure ventilation and fire extinguishing device. Each unit has its own auxiliary device – lubrication and sealing system. The above stated accessories of the unit are arranged in blocks and are placed nearby of the unit's basement. The lubrication system is common for the turbo-compressor and the electric motor. The configuration of all three units and their relating devices is identical.

The turbo-compressor is centrifugal, radial of barrel type with vertical dividing plane for cover, at present with two stages. Its parts are the casing with the cover and internal hydraulic part of the turbo-compressor – a bundle. The bundle consists of a shaft with impellers, pressed on clutch disc with gearing, balance piston, and supporting ring of axial bearing. In addition to that there are contact carbon seals placed on the shaft, one axial segment bearing and a couple of two-section radial sliding bearings, a set of safety nuts, auxiliary rings (for monitoring of axial movement, restricting, and safety), a set of labyrinth seals, and parts of stator assembly of the compressor.

3.2. Casing of the turbo-compressor

The casing is produced as a casting made of cast steel. On the front side /non-driven side the casing is equipped by a cover, which is connected with the casing by bolts and nuts (screws and female screws). Tightness of the dividing plane (casing - cover) is secured by a sealing O-ring. Suction and discharge throats of the compressor create a part of the casting casing of the compressor. Ends of throats are adjusted by weld deposits/reduction pieces of the pipe, by means of which the dimensions of throats are adjusted to dimensions of welded on process pipeline on suction, respectively discharge of the compressor. In the compressor's casing there are integrated the following connection points:

- Inlet of high-pressure oil from the accumulation tank into the space between seals and radial bearings (2 x DN40 PN100 on the driven side and the non-driven side)
- Outlet of oil from bearings (2 x DN150 PN6 on the driven side and the non-driven side)
- Outlet of gas and oil compound into the separation system/float chambers (2 x DN40 PN100 on the driven side and the non-driven side)
- Inlet of low pressure oil to the axial bearing (1 x DN 40 on the non-driven side)
- Outlet of oil from the axial bearing, respectively gear box of the main oil pump (on the non-driven side)
- Off-take of high-pressure oil for needs of regulation (2 x DN40 PN100 on the driven side and the non-driven side)
- Interconnection between the suction throat of the compressor and flooding of the space behind the buffer piston (DN80 PN100 on the non-driven side)
- Impulse pipelines for the surge control

In the lower part of the casing there are supports as parts of the cast casing, by means of which the compressor is fixed to the basement of the unit. In the upper part of the casing there is placed the high-pressure oil accumulator (pressure tank with volume 0.9 m^3). In rear part of the casing (on the driven side) there are holes for connection of the bundle with the casing. The connection is done by special screws and the sealing is secured by O-rings. The holes are connected between each other

by a ring groove made on the rear face of the casing, while during operation this space is flooded by high pressure oil brought to sealing in order to restrict eventual leakage of gas from the machine. The tightness of all holes in the place of their contact with holes in the bundle is secured by O-rings.

3.3. The rotor of the turbo-compressor

The current design of the rotor consists of the shaft, two pressed-on impellers, pressed-on gear toothed disc, balancing piston, safety/distance bushings and nuts, axial bearing support ring and axial thrust reading ring.

The new rotor must be designed in such a way, that it will be possible to install it into existing casing of the compressor without the need of bigger adjustments and, consequently, the operation would be possible while existing oil system is used.

3.4. Radial bearings of the turbo-compressor

At present the rotor of the turbo-compressor is embedded in two radial bearings with identical structure (driven respectively non-driven side), it means – two-section divided sliding bearing. The radial bearing is lubricated by high pressure oil and, simultaneously, it creates sealing for maintenance of oil pressure on the contact carbon sealing. The proper functionality of bearings is controlled during the operation by two thermocouples placed in the lower half of the bearing.

3.5. The axial bearing of the turbo-compressor

The axial bearing is used for balancing of axial forces of the compressor and the electric motor, and determines the relative position of the rotor against stator. It consists of two-section body, in which the segments are placed with holding-down spring system. The low-pressure lubrication oil is brought into the space between the supporting disc and segments of bearing bodies on both sides. The outlet of oil from both sides of the bearing leads to the drainage oil pipeline. The proper function of the axial bearing is monitored by means of thermocouples placed in segments on each side of the axial bearing; it means 2 pieces on each side of the bearing, together 4 pieces.

3.6. Contact seal

Existing oil sealing serves for sealing of the compressor against gas leakage outside of the compressor's casing. They are placed between through-flow part of the compressor and radial bearings.

Existing structure of sealing consists of the sealing body, its rotor part including carbon sealing ring, and the rotor part held-down to the sealing ring by a spring. The sealing is flooded by high pressure oil. High pressure oil also secures heat abstract in addition to compressor sealing on gas leakage. The oil pressure in the space between the radial bearing and the sealing is maintained automatically by the regulation system by the release on the value min 0.12 MPag.

3.7. Bundle of the compressor

Internal hydraulic part of the compressor – bundle creates one section. It consists of a rotor part and the internal body of the stator part. The internal body consists of the suction part, barrier, diffusers, and the discharge part. The internal body is horizontally divided. Completely assembled bundle, including all parts, is placed in turbo-compressors casing as one assembly. In the suction part of the bundle there are oil inlet channels to the contact sealing and the radial bearing, channels of oil + gas mixture is released into the separation system, and holes for release of oil to the regulator. In the suction part there is also hole for the gas inlet into the space for terminal labyrinth sealing. The dividing plane of the lower part of the bundle is equipped by two grooves in the suction, and also in the discharge part by two grooves. One groove is connected with the oil inlet space to the contact sealing and the other with the space for mixture of oil + gas. This provides the complementary guide restricting the gas leakage through the dividing plane. In addition to that in the dividing line there are two grooves with pipes for gas inlet/pressure reading for needs of monitoring and the surge control, respectively flow measurement. During the operation the bundle of the turbo-compressor is pushed down by gas pressure to the bottom of the casing. In the case of pressurized turbo-compressor outside of the operation the bundle is in balanced position. Because of that the bundle is connected with the casing by eight special bolts going through the bottom of the casing. The tightness of the bolted joint is secured by O-rings. In the discharge part there are also holes for the inlet of high-pressure oil to the contact

sealing and the radial bearing, inlet and waste oil of the axial bearing, waste oil + gas to the sealing system, and inlet of high pressure oil to the regulator. The tightness of the dividing plane is secured in the same way as it is in the suction part.

3.8. Oil system

The oil system is common for the turbo-compressor and the electric motor, and consists of the lubrication system and the sealing system. The lubrication system provides lubrication of the axial bearing of the turbo-compressor, clutch and lubrication of bearing on the electric motor. The sealing system provides flooding of contact sealing and by that also tightness of the compressor in the pressurized state during the operation and also at the shut-down, and simultaneously the lubrication of radial bearings. The oil system consists of the following main parts:

- The main oil pump
- Oil tank
- Low-pressure oil block
- High-pressure oil block
- Accumulator if the high-pressure oil
- Air cooler of the oil
- Oil interconnection pipeline

The main oil gear-wheel pump is placed on the front/not driven side of the turbo-compressor, and is driven by the gear from its shaft. During the operation of the compressor the main oil pump delivers oil with flow 1200 l/min into the lubrication system and into the suction system of high pressure pumps. The oil vessel has capacity 10 m^3. In addition to that the low-pressure oil block contains electrically controlled:

- auxiliary oil pump, 200.13 – spiral type 15.7 l/s, provides circulation of the low pressure oil at the start/shutdown
- circulation pump for oil heating, 200.03 – gear type, provides circulation of oil through the heat exchanger at the low temperature of oil in the vessel
- heat exchanger, 200.06

The temperature control of the low pressure oil system is performed by:

- TIAB202 in the tank, min 30°C – low temperature, by circulation pump switching
- TIAB211 behind coolers, max 45°C – high temperature, by the blower drive switching

Pressure control of the low pressure oil system runs by by-passing back to the tank by means of PC209 regulator to max 0.40 MPag.

The high-pressure oil block contains also the following:

- 2 oil filters, 200.27,30, separation 20 microns
- 2 high pressure pumps, 200.34,35, screw pumps 275~304 l/min
- Accumulation tank of high-pressure oil, 200.50, capacity 0.9m^3
- 2 chambers with floaters, 200.58,61
- Oil separator with accessories (regulators of pressure difference on sealing – PDC249,250, ejectors – 200.64,100.03)

Temperature control of the high-pressure oil system is common with the low pressure system, pressure control of the high pressure oil system is carried out by oil release from the space for inlet of pressure oil into oil separator through pressure regulators PDC249, respectively PDC250 so, that the pressure difference between suction gas pressure in the compressor and the oil pressure was at least 0.120 MPa.

3.9. Anti-surge control

Anti-surge control of compressor belongs to the group of sub-systems of the unit control system . This is an electric regulation (from point of view of signal transfer) with hydraulic control (hydraulic drive of anti-surge system), where working medium is a compressed oil. Its task and purpose is to secure compressor operation in stable area of operational map in automatic manner. Working point of compressor is determined by transmitted volume of gas and by compression ratio. For establishing the compression ratio the pressure difference is measured between discharge and suction of the compressor, gas flow through the compressor is derived from measuring of pressure difference at piece of suction pipeline. By re-calculation of these values control system establishes a current position of working point of the

compressor within its operational map. Working point in operational map in any operational state must be distanced from surge line at minimum of 5%. When working point gets closer to the limit of unstable area, control system sends signal for adjustment of position of anti-surge valve K-06, which by partial opening lets part of gas go out from the compressor discharge to compressor suction. In case of reaching limit of 5% from surge line (e.g. in case of emergency) this valve has a task to unload the compressor by immediate opening of the anti-surge valve K-06. Interval of immediate opening of the anti-surge valve is 2 seconds. Each compressor is equipped by its own system of anti-surge control. Pipe of anti-surge branch DN500 PN100 is connected to compressor discharge pipe DN1000 PN100 and ends at common header ES 1, 2, 3 (see Attachment No. 8). On anti-surge pipe DN500 there is placed, in the flow direction, anti-surge valve K-06 (DN300 PN100) with two reductions R500/300 and closure armature DN500 PN100. Anti-surge valve is a flange ball tap type ARGUS equipped with hydraulic drive produced by PC producer PC INTERTECHNIK (type EH1DHFSOX). Control electronics as well as control system, which is part of unit control system is also from PC Intertechnik (detailed specification available upon request). Antisurge line is not equipped with coolers.

4. SUBJECT OF THE DELIVERY

The subject of the offer are two pieces of new (+ 1 piece as the option) identical hydraulic parts for existing gas centrifugal compressors, it means the replacement of their original hydraulic parts.

4.1. Design Points

The compressor must be able to utilize stabile operational shaft power in all design points. By the replacement of the bundle the following working points must be achieved, which simultaneously are also guaranteed points.

Design points for 2 pieces of new hydraulic parts:

Point	Flow std m^3/d	Suction pressure MPa	Discharge pressure MPa	Temperature °C	Description
1	$18.5 * 10^6$	5.0	7.35	20	Maximum allowed speed 3700 min^{-1}
2	$9.5 * 10^6$	5.0	6.45	20	Recycled operation is allowed
3	$19.0 * 10^6$	5.0	6.28	20	Minimum efficiency 82%
4	$27.5 * 10^6$	5.0	6.10	20	Maximum allowed speed 3700 min^{-1}

Flow std m3/d at reference conditions 101 325 Pa, 20 °C

All above stated values of pressure are absolute. Recycling operation (by station recycling valve) is allowed only for Point 2.

For these above stated gas inlet and outlet conditions of points 2, 3, 4 the guaranteed isentropic efficiency of the compressor shall be specified by supplier in Attachment No.10.

Direction of rotation at the existing compressor must remain the same. It turns clockwise at the view from the electric motor. Suction is on the right side and gas discharge on the left side at the view from the electric motor.

Design of new hydraulic parts must take into account minimal continuous speed of rotor 2050 min^{-1} and Attachment No. 11.

4.2. Scope of supply

The subject of the delivery for each unit will include the following items:

- Design and engineering of new internal hydraulic parts including anti-surge regulation evaluation
- Elaboration of CFD study (Computational fluid dynamics)
- Design and engineering for new Instrumentation & Control (I&C) parts
- The new bundle which contains:
    - New diffusers (if it is not possible to use the original one)
    - New rotor with impellers (if it is not possible to use the original rotor)
    - New Bearings - 2 x radial and 1 x axial (if it is not possible to use the original bearings)
    - New Oil seals (if it is not possible to use the original seals)

      Remark: Structure of sealing and bearings must be designed in such a way that their replacement will not cause the need to adjust the casing of the compressor. In case it is inevitable to adjust them, it shall be included in the scope of supply and price.

      Recommended producers: John Crane, Burgmann, Flowserve
    - New vibration sensors of compressor (9 pcs for each unit) and their installation. New brackets for vibration sensors (9 pcs for each unit) and their installation. For details see point 4.3.
    - New sensors for temperature measurement of radial bearings (2 x 2 pieces) and axial bearing (4 pieces) for each unit. For details see point 4.4.
- Manufacturing
- FAT tests
- Transport
- Disassembling of the old parts, including acoustic enclosure
- On site installation of new/modified parts, loose items (delivery and installation) and assembling of acoustic enclosure including tightness test
- Documentation according to point 7 of this document.
- Commissioning spare parts
- Acceptance tests according to point 5 of this document, including supervisor's attendance on tests of guaranteed parameters.
- Training for operation staff
- Pre-commissioning and Commissioning

- Set of special tools for assembling and disassembling for the new bundle and rotor (1set).
- Evaluation of existing antisurge regulation and modification in accordance with new design if necessary.
- Evaluation of existing oil system including main oil pump as well auxiliary oil pump and modification if necessary, taking in consideration new range of operational speed 2050 – 3700 RPM.
- Evaluation of existing seal oil system and modification if necessary. The new system shall not exceed the oil consumption of the current system 24l/24hours.
- Modification of software on existing Unit Control system (Siemens PCS7) including modification of antisurge regulation

The scope of supply will exclude the following items:

- Casing of the compressor
- Driving electric motor

The scope of supply may include the following items (in the case that it is required by technological solution):

- Cover of the compressor's casing
- Coupling (must be able to transfer axial force from the electric motor on the compressor's shaft, because axial bearing is common for compressor and electric motor)

The total weight of the compressor after the replacement of the bundle must not exceed maximal allowed load of the basement under the compressor 62 000 kg.
Present weight of individual parts:

- Casing 16 550 kg
- Cover 4 350 kg
- Bundle 14 000 kg
- Rotor 2 400 kg
- Oil tank 1 250 kg

4.3. Compressor vibration sensors

Existing five vibration sensors of compressor will be replaced by new ones. Additional four new vibration sensors will be installed. The composition of above described nine vibration sensors will be following:

Front bearing stand:

Two vibration sensors of shaft vibrations with extending cable.

Rear bearing stand TD:

Two sensors of shaft vibrations with extending cable will be replaced by new ones.
One sensor of shaft axial position with extending cable will be replaced by new one.
One sensor of axial position with extending cable will be added.
Three stator vibrations sensors will be added.
For each vibrations sensor must be delivered and installed new bracket.
CUSTOMER reserves the rights to decide position of the sensors.

Existing monitoring system Compass Classic will be replaced by new monitoring system in 2019/2020 therefore all activities related to the supply of vibration sensors and their brackets as well as their installation must be approved by CUSTOMER and vibration monitoring system SUPPLIER.

Battery limits (see Attachment No. 13)

4.4. Compressor temperature sensors

All sensors of bearing temperature PT100 TS2.2-1600 should be replaced by new PT100 TS 2.2-A or PT100 equivalent. Existing connectors of sensors should be replaced by an interconnecting box or by other type of industrial connectors. Interconnecting cabling from interconnecting box/industrial connectors up to unit control system has to be replaced when necessary. Intrinsic Safety Isolators has to be added if it is necessary. CONTRACTOR battery limits are on terminals in unit control system cabinets (units ES1, ES2, ES3) UCS01_ES1_RIO2, UCS01_ES2_RIO2, UCS01_ES3_RIO2.

4.5. Battery limits

Presumed boundaries of delivery for existing systems:

- Internal surface of the compressor's casing
- All connecting points on the compressor's casing (flanges of the inlet oil and waste oil to/from bearing and sealing, flanges of balance pipe behind the balance piston, etc.)
- The end of the shaft on the non-driven side of the compressor for setting of the assembly of the main oil pump
- The end of the compressor's shaft on the driven side for mounting of the coupling hub (it is necessary to maintain its shape, dimension, and position in space) only in the case keeping existing coupling
- The end of the electric motor's shaft for mounting of the coupling hub (it is necessary to maintain its shape, dimension, and position in space) only in the case of new coupling
- Face flange of the compressor's casing – connection point of the cover to the compressor's casing (only in the case of the new cover)
- Battery limits are on the terminals of existing systems (see Attachment 13)

5. ACCEPTANCE TESTS

5.1. Factory tests

Tests performed at the CONTRACTOR. Tests of the device must meet minimal requirements API 617 in the scope of supply of hydraulic parts of the compressor without the casing, eventually other applicable standards or internal regulations of the CONTRACTOR after the approval of the CUSTOMER. Within the tests at the CONTRACTOR the performance of the following tests is presumed:

- Test of sealing (static test) – test certificate is required to submit
- Test of dynamic balance of the rotor (including imbedded impellers)
- Test of rotor's integrity at increased revolutions (over speed test)
- Rotor unbalance response test

Procedure and program of tests are submitted to the approval of the CUSTOMER. The term of each test must be announced in writing at least 10 working

days before its start. The presence of the CUSTOMER representative will be according to an agreement.

5.2. Takeover tests and Takeover

After completion of COMMISSIONING and after completion of the respective works the CONTRACTOR shall launch the TAKEOVER TESTS for each UNIT. The TAKEOVER TESTS include the 72-hour test and 600-hour trial operation test. Running hours during COMMISSIONING shall be not counted as the hours required for the 72 and 600-hour test.

5.2.1. 72-hour Uninterruptable Test

The CUSTOMER reserves the right to approve the schedule of the 72-hour test prepared by the CONTRACTOR. In case the test is interrupted, the 72-hour test shall start as a new one, after identification and removal of the cause of the interruption. In case the interruption is caused due to the reasons on the side of the CONTRACTOR, the costs for the repeated tests will be borne by the CONTRACTOR.
The CONTRACTOR'S representatives shall be present at the compressor station permanently during the whole 72-hour trial operation test and they shall keep the operation register of the 72-hour test. The CONTRACTOR shall provide the assessment of the 72-hour test and shall submit it to the CUSTOMER for approval.

5.2.2. 600-hour Trial Operation Test

The CUSTOMER reserves the right to approve the schedule of the 600-hour test prepared by the CONTRACTOR. The 600-hour trial operation test shall be performed after successful completion of the 72-hour test. Safe and reliable operation in the full scope of supply during the 600-hour test shall run with no occurrence of any technical problem resulting from the CONTRACTOR'S scope of the supply.
In case of unscheduled down time the decision of continuation or repetition of the 600-hour trial operation shall be solely at the CUSTOMER'S discretion.
During each trial operation test the presence of the CUSTOMER'S personnel at the compressor station for the period of 10 hours of the day shift is required.

The CUSTOMER reserves the right to shorten duration of the 600-hour test.

During the trial operation the presence of the CONTRACTOR is required only for the period of 10 hours of the day shift, however, during the whole period of the trial operation the representatives of the CONTRACTOR shall be in readiness to be at the site no later than within 1 hour after having been called by phone in case of any problems.

5.2.3. Guaranteed parameters

Measurement and verification of the GUARANTEED PARAMETERS (Attachment 10) provided according procedure prepared by CONTRACTOR and approved by CUSTOMER will be performed during the 600-hour trial operation test.

The CONTRACTOR shall prepare the Guaranteed Parameter Measurement Project and they shall send it to the CUSTOMER for approval. The project shall contain a detailed procedure of measurement, calculation and result assessment methodology. The instruments and devices used for the measurement in compliance with the standards where possible (ASME PTC10) shall be supplied and installed by the CUSTOMER. Operation sensors and additionally installed sensors will be used in the measurement. The list of the sensors shall be approved by the CUSTOMER and the CONTRACTOR.

The whole GUARANTEED PARAMETER measurement procedure shall be performed in accordance with applicable technical standards,

The CUSTOMER shall carry out the measurement at each unit separately according to the Measurement Project, with the participation of CONTRACTOR'S representatives. If the test cannot be performed according to the agreement of both Parties due to any reason (technical, operating conditions, etc.), the test shall be performed at the alternative date upon the mutual agreement of the CUSTOMER and CONTRACTOR.

In case of discrepancy of the results of the GUARANTEED PARAMETER measurement the CONTRACTOR may ask, at their expense, a reputable INDEPENDENT VERIFIER (mutually accepted one) for a statement.

In case the GUARANTEED PARAMETERS are not met, the measurement will be repeated at the expense of the CONTRACTOR, after identification and elimination of the cause.

CUSTOMER and CONTRACTOR agreed to perform performance test within first 272 operating hours.
The 272 operating hours will start with beginning of the 72h successful test unless the 72h fails reasons attributable to the CONTRACTOR.

5.2.4. UNIT Takeover

The CUSTOMER accepts and takes over the UNIT after the successful 72-hour test, 600-hour trial operation test, after meeting the guaranteed parameters (in accordance with Attachment 10), after submission of all official tests, submission of the positive statement of the Labour Inspection Authority and final As-Built Documentation. The audit of the installed software of the control systems carried out by the CUSTOMER shall form an integral part of the UNIT Takeover. The list of installed software (Attachment 14.1, 14.2|, where the CONTRACTOR shall add missing required data and which will serve as a supporting document to prove the installed licences, will be the output of the audit.
Conformity of the List (Attachment 14.1, 14.2) to the installed software will be the condition.

The Parties to the Contract shall confirm the compliance with all conditions of the UNIT TAKEOVER by attaching their signature to the Takeover Report.

6. PACKAGING AND TRANSPORTATION

The used type of packaging must be suitable for all kinds of transportation from producer's locality to the place of installation. The contractor will carry full responsibility for the transportation to the destination station and any damage or loss of the goods. The device will be prepared for the transportation so, that it will have to withstand multiple manipulation, storing, exposition to rain and outer environment during transportation. After transportation to the station of destination the device will be placed in the hall of machines. The price of the transportation and the packaging shall be a part of the delivery.

7. DOCUMENTATION

7.1. Documentation Elaboration

7.1.1. Execution Documentation of the CONTRACTOR'S Scope of Supply

The CONTRACTOR shall elaborate the Execution Project Documentation. Before submitting to the AUTHORIZED PERSON, the execution documentation of the CONTRACTOR'S scope of supply shall be submitted to the CUSTOMER for commenting and review.

7.1.2. Marked Red and As built Documentation

The CONTRACTOR is required to submit the Marked Red Documentation as well as The As built Documentation to the CUSTOMER.

The CONTRACTOR shall elaborate Mark Red Documentation. The changes at the site shall CONTRACTOR marked by the Red Pen into the Project Execution Documentation. Prior to handing over the documentation to the CUSTOMER the CONTRACTOR shall check and mark each page with the changes and supplements by the current date and signature as the confirmation of the correctness.
Complete Documentation Marked Red shall be always available to the CUSTOMER'S operation personnel at the place of the works until the final Marked Red Documentation is handed over to the CUSTOMER by the CONTRACTOR.

The Marked Red Documentation shall be submitted by the CONTRACTOR for a commission check by the CUSTOMER in two PROJECT execution stages:

1. The 1st stage of the Marked Red Documentation submission:
No later than within 10 days prior Commissioning commencement. The CONTRACTOR is responsible for completeness and formal aspect of the submitted documentation.

2. The 2nd stage of the Marked Red Documentation submission:
No later than within 5 days after finishing of the 72-hour test. The CONTRACTOR is responsible for completeness and formal aspect of the submitted documentation. CONTRACTOR shall add and incorporate any changes occurred since the 1st stage of the Marked Red Documentation submission.

7.1.3. Documentation Language

Documentation commenting and approval process between the CUSTOMER and CONTRACTOR will be in the English language.
The final As-Built Documentation shall be handed over in the Slovak (3pc) and English language (3pc).
The final documentation shall be elaborated in Slovak language.

7.2. Certification

According to current European regulation every single item included in the scope of supply shall be CE marked and will be proved by the Declaration of Conformity. The Declaration of Conformity for the whole UNIT shall be supplied by the CONTRACTOR after completion and assessment of the 600-hour trial test. The Declaration of Conformity for independent UNIT systems will be supplied by the CONTRACTOR before the OFFICIAL TEST is issued. The CONTRACTOR will be responsible for obtaining all necessary certifications to operate the machine according to European and Slovak applicable laws.

Numbers, units, and symbols will be in compliance with international system SI, with exception of the following units:

- Pressure will be expressed in megapascal [MPa] or [MPag]
- Temperature in Celsius degrees [°C]
- Length dimensions will be expressed in millimetres [mm].

8. ATTACHMENTS OF TECHNICAL SPECIFICATION

Attachment No. 1: Compressor assembly
Attachment No. 2: Casing assembly
Attachment No. 3: Compressor rotor
Attachment No. 4: Compressor 650-21-2
Attachment No. 5: Coupling assembly
Attachment No. 6: Oil pump
Attachment No. 7: Oil system PID, compressor 25 MW-hall E
Attachment No. 8: Compressor pipe yard
Attachment No. 9: API 617 Data sheet
Attachment No. 10: Guaranteed parameters
Attachment No. 11: Maximal output of driving electric motor
Attachment No. 12: Protocol No. TPk/07/2008 on determination of space with danger of explosion
Attachment No. 13: Vibration monitoring system and control system battery limits
Attachment No. 14.1: List of software
14.2: Obligation of Contractor
Attachment No. 15: Existing Lube a Seal Oil system drawings
Attachment No. 16: Field matrix of responsibilities