NET4GAS, s.r.o

COMPRESSOR STATION JIRKOV 73 BAR

SPECIFICATION FOR ELECTRIC MOTOR COMPRESSOR SET (EMCS)

01.08.2017

Annex 1

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REVISION HISTORY

002	01.08.17	APPROVED	TEAM	Foltin	Schorling
001	20.07.17	APPROVED	Fanaca / TEAM	Foltin	Schorling
000	13.07.17	APPROVED	Fanaca / TEAM	Foltin	Schorling
B01	19.05.17	IFR	Fanaca / TEAM	Foltin	Schorling
Rev.	Date	Issue, Purpose	Prepared	Checked	Approved

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1 GENERAL

1.1 Scope of the Document

This specification outlines the minimum requirements for the engineering, construction, installation, commissioning and testing of the electric motor-compressor sets (EMCS) to be purchased and installed within the framework of the project ”Jirkov 73 bar Compressor Station” (the PROJECT) of NET4GAS s.r.o. (the Owner).

1.2 Definitions

Term	Explanation
PROJECT	Compressor Station Jirkov 73 bar
Owner (*)	NET4GAS
Consultant	ILF Consulting Engineers
Scope of Supply	All equipment and services which shall be delivered by the Supplier to the Owner as per requirements and conditions specified in the CONTRACT.
Supplier	Vendor of the Electric Motor Compressor Sets
Offer	Offer for the Electric Motor Compressor Sets submitted to the Owner by the Supplier
SCS Supplier	Vendor of the Station Control System

(*) It is noted that within other technical documents the term Employer is used. It is herewith clarified that the meaning of the terms Owner and Employer is intended as the same, both meaning NET4GAS.

1.3 Abbreviations

Term	Explanation
AC	Alternative Current
ACP	Anti-Corrosion Protection

AGM	Absorbent Glass Mat
AN	Air Natural
API	American Petroleum Institute
BTS	Border Transfer Station
BTS HSK	Border Transfer Station Hora Svaté Kateřiny
CAPEX	Capital Expenditures
CS	Jirkov 73 bar Compressor Station
ČSN	Czech Technical Standards
ČSN EN	European Standard
C&I	Controls and Instrumentation
CU	Compressor Unit
DC	Direct Current
DCC	Dispatching Control Centre (Prague)
DN	Nominal diameter
DSP	Documentation for construction announcement or building permit
DUR	Documentation for land permit decision of construction placement
LVDG	Low Voltage Diesel Generator
EMC	Electromagnetic Compatibility
EMCS or Unit	Electric Motor Compressor Set (CU, EM, EM cooling system, VSD, VSD transformer, VSD cooling system, UCS)
E&IC	Electrical and Controls & Instrumentation
EM	MV Electric Motor
EMD	Electric Motor Drive system (VSD Transformer, VSD, EM)
E-Motor	LV Electric Motor (general)

ESD	Emergency Shut-Down System
FAT	Factory Acceptance Tests
FFS	Fire Fighting System (fire detection, fire extinguishing system)
F&G	Fire and Gas Detection System
FDS	Fire Detection System
FOC	Fiber Optic Cable
GDS	Gas Detection System
HAZOP	Hazard and Operability Study
HAZID	Hazard Identification Study
HMI	Human Machine Interface
HP	High Pressure
HV	High Voltage
HW	Hardware
I&C	Instrumentation and Controls
IGBT	Insulated Gate Bipolar Transistor
IGCT	Integrated Gate Commutated Thyristors
IPPC	Integrated Pollution Prevention and Control
IS	Intrinsically Safe
JB	Junction Box
KVM-E	Keyboard, Video, Mouse Extender
LEL	Lower Explosion Limit
LV	Low Voltage
MAWP	Maximum Allowable Operating Pressure

MCB	Miniature Circuit Breaker
MCC	Motor Control Centre
MCCB	Molded Case Circuit Breaker
mcm/d	Million cubic meter per day at specified reference conditions
MOP	Maximum Operating Pressure
MOT	Maximum Operating Temperature
MT	Magnetic Particle Examination
MV	Medium Voltage
N4G, NET4GAS	NET4GAS, s.r.o.
NDT	Non-destructive Testing
NPSH	Net Positive Suction Head
OEM	Original Equipment Manufacturer
ONAF	Oil Natural, Air Forced
ONAN	Oil Natural, Air Natural
OPC	Open Platform Communication
OPEX	Operational Expenditure
PAR	Peak to Average Ratio
PT	Liquid Penetrant Testing
PCC	Point of Common Coupling
PLC	Programmable Logic Controller
PMI	Positive Material Identification
PN	Nominal Pressure
PWHT	Post Weld Heat Treatment

PQR	Procedure Qualification Record
REPEX	Renovation Expenditures
RTD	Resistance Temperature Detector
RT	Radiographic Testing
RCD	Residual Current Device
RCM	Reliability Centered Maintenance
r.m.s.	Root Mean Square
rpm	Rotations per minute
ROW	Right of Way
SAE	Society of Automotive Engineers
SAT	Site Acceptance Test
SDRL	Supplier Document Requirements List
SIL	Safety Integrity Level
SCS	Station Control System
SF	Safety Factor
SL	Single Line Diagram
TPS	Technical Protection Systems
QA	Quality Assurance
QRA	Quantitative risk assessment
SIL	Safety Integrity Level
SPDT	Single Pole Double Throw
SW	Software
TELCO	Telecommunication Infrastructure

THD	Total Harmonic Distortion
UCS	Unit Control System
UPS	Uninterruptible Power Supply
US	Ultrasonic
UT	Ultrasonic Inspection
VSD	Variable Speed Drive
VSI	Voltage Source Inverter
WPS	Welding Procedure Specifications

1.4 References

The Supplier shall refer to Annex 1, Attachment 1.1 - List of Attachments for all reference project documents applicable for the Scope of Supply. All annexes referred to in this document (e.g. Annex 1, etc.) shall mean annexes to the CONTRACT signed between the Owner and the Supplier for engineering, construction, installation, commissioning and testing of the electric motor-compressor sets (EMCS).

2 GENERAL INFORMATION

2.1 Codes and Standards

The Supplier shall refer to Annex 1, Attachment 1.2 for all standards and regulations applicable to the Scope of Supply.

The Supplier shall apply the latest revision of all standards and regulations listed in Annex 1, Attachment 1.2 during the execution of the Scope of Supply.

2.2 Operating Media, Auxiliaries

2.2.1 Process Gas Composition / Transport Gas

The Supplier shall consider the process gas composition listed in Annex 1, Attachment 1.6 during the execution of the Scope of Supply.

2.2.2 Power Supply

The Supplier shall refer to Annex 1, Attachment 1.8 and Annex 1, Attachment 1.23 for details and requirements for connection to the the local power supply network.

2.2.3 Instrument air supply

Instrument air is available from the station instrument air supply system at one single TAKEOVER point for each EMCS. The quality of the instrument air supplied to the EMCS is according to ISO 8573-1, class 1.2.1. The supply parameters for instrument air are as follows:

a) pressure 8 barg (10 barg max.),

b) temperature (5-20) °C.

The Supplier shall prepare Attachment 1.22.1 where the maximum consumption for one EMCS, considering all possible operational modes and the environmental conditions specified in Annex 1, Attachment 1.13, shall be specified. The Supplier shall state in Attachment 1.22.4 – List of Comments, Exceptions and Deviations all requirements for instrument air quality, pressure and temperature parameters if these deviate from the above listed parameters. The Supplier shall keep the instrument air consumption as low as possible. The Supplier shall provide filtering and pressure reduction according to his requirements

2.2.4 Other operating media

The Supplier shall specify in Attachment 1.22.1 all operating media (instrument air, water, gas etc.) required for the operation of the EMCS including all required parameters and all operating modes.

2.3 Environmental conditions

The Supplier shall execute the Scope of Supply under full consideration of the site environmental conditions. The environmental conditions including information on the geographic location of the installation shall be considered from Annex 1, Attachment 1.13.

2.4 Noise Emissions

The Supplier shall execute the Scope of Supply under full consideration of the noise limits specified in Annex 1, Attachment 1.9.

2.5 Design Life

The design life of the main equipment in scope of the Supplier (CU, EMD including EM, VSD, VSD transformer, UCS and all auxiliary systems) shall be at least 25 years.

Equipment supplied as kits, valves and additional support systems like instrumentation etc., shall be designed to operate a minimum of 100 000 running hours.

3 SCOPE OF SUPPLY

The Supplier shall execute the Scope of Supply in accordance with the the CONTRACT, content of this specification (C4G-JI73-KS007-STR-SPC-800) and all related documents included in Annex 1, Attachment 1.1. The Supplier shall execute the Scope of Supply in compliance with the applicable legal provisions and official regulations, as well as in accordance with the established rules and the current best practice of the oil & gas industry and Owner internal standards. Subcontracting of relevant parts of the Scope of Supply to subcontractors is permitted only after approval by the Owner.

The Supplier shall deliver a complete, self-contained and brand new package. All activities, materials and supplies included in the Scope of Supply shall be provided by the Supplier, even if they are not mentioned and / or described in this document.

The Scope of Supply shall include the design, documentation, manufacturing, shop-testing, certification according to applicable regulations and standards, transport to Site, on-site installation (as specified by the Owner), commissioning and testing up to the TAKEOVER by the Owner of the entire Scope of Supply.

3.1 Scope of Components and Documentation

The scope of components and documentation shall include the following as a minimum:

1) Three (3) VSD Transformers suitable for outdoor installation incl. enclosure controls and instrumentation; shall include all auxiliary equipment (see Annex 1, Attachment 1.11),
2) Three (3) VSD for variable frequency generation, shall include all required controls and instrumentation as well as secondary installations,
3) Three (3) EM installed on common base frames with the CU,
4) Three (3) complete cooling systems, one for each EM installed on common base frames with the CU and EM including, controls and instrumentation, air cooled heat exchangers, all required interconnecting piping to EM and all required piping to the Owner station process piping, including counter-flanges, gaskets, bolts, nuts, washers,

5) Three (3) complete cooling systems, one for each VSD including, controls and instrumentation, outdoor air cooled heat exchangers, all required interconnecting piping to VSD pump cabinets and all materials required for installation of the interconnecting piping,

6) Three (3) turbo compressor units (CU) installed on common base frame with the EM; base frame shall be supplied with all anchor bolts, lifting points for mechanical handling and leveling pads,

7) Three (3) suction strainers, one for each CU (see Annex 1, Attachment 1.10), designed for 1 year operation (starting from Owner TAKEOVER) including differential pressure transmitter with process hook-ups, pipe spooling, flanges, counter-flanges, gaskets, bolts, nuts, washers and spacer (spacer shall be installed after removal of the suction strainer). The Supplier shall include three (3) additional sets of gaskets, bolts, nuts, washers for suction strainer for each CU with the commissioning spares (totally six (6) sets),

8) Three (3) commissioning suction strainers – if required by Supplier – one for each CU, for commissioning purpose only,

9) Three (3) anti-surge valves, one for each CU including flanges, counter flanges, bolts, washers, gaskets etc.

10) Three (3) hot bypass valves (if required), one for each CU including flanges, counter flanges, bolts, washers, gaskets etc.

11) Local vents for each EMCS including all required vent valves, piping, restriction orifice, bursting discs, flame arrestors, noise silencer, etc.,

12) All materials and special tools required for the installation and commissioning of all three EMCS including installation of all interconnecting piping included in the Scope of Supply,

13) Counter flanges for the suction and discharge flanges of each CU including all consumables (bolts, nuts, washers, gaskets) and all required bolt tightening torque specifications and flange alignment criteria,

14) Three (3) pressurization / filling valves as per Annex 1, Attachment 1.10, one for each CU including flanges, counter-flanges, gaskets, bolts, nuts and washers,

15) Three (3) complete control and instrumentation systems, including the following as a minimum:

- Unit control systems and cabinets
- Active magnetic bearing control cabinets
- Instrumentation and sensors
- Signal cabling and junction boxes for the unit control system
- Hook-up and installation material

- Software back-up / recovery CDs

16) Two (2) sets of operator and engineering workstations for all three EMCS, which shall be installed as per following:
    - one (1) set for all three ECMS including server and KVM-E to be installed in the Electrical Building as per Annex 1, Attachment 1.20 and Attachment 1.21,
    - one (1) set for all three ECMS including KVM-E to be installed in the Administration Building as per Annex 1, Attachment 1.21,
17) Three (3) LV switchgear panels (MCC), one for each EMCS (see Annex 1, Attachment 1.8),
18) All required junction boxes including MV, LV, I&C, earthing, lighting,
19) Terminal boxes, local control stations including maintenance switches for each supplied skid / equipment,
20) Three (3) uninterruptible power supply systems, one for each EMCS magnetic bearing system, including batteries, charger and related switching equipment,
21) All on-skid cabling (package cabling) including MV, LV, I&C, telecommunication, earthing, equipotential equalization, lighting,
22) Interconnecting cabling between all equipment in the Scope of Supply, including MV, LV, I&C, telecommunication, earthing, equipotential equalization, lighting,
23) All cabling between UCS and I&C equipment controlled by the UCS and supplied by others (ESD valves on suction and discharge lines, isolation valves in the recirculation and discharge lines, vent valve, pressure equalization valve, see Annex 1, Attachment 1.10),
24) All materials (cable trays, conduits, glands, gas sealed cable transitions etc.) and tools required for installation of all package and Site cabling in the Scope of Supply,
25) Earthing connection points for all equipment / skids included in the Scope of Supply. The Site common earthing network will be supplied by others,
26) Trace heating including insulation and cladding,
27) Lighting including emergency lighting inside the acoustic enclosures (if required),
28) Three (3) acoustic enclosures for the EM and CU incl. ventilation system as per chapter 4.7 (if required),
29) One (1) set of Special Tools required for maintenance and overhaul of all equipment included in the Scope of Supply,
30) Three (3) sets of Safety Special Tools required for maintenance and overhaul, one for each EMCS (separate tools for VSD, VSD Transformer, MCC, etc.),

31) One (1) set of Special Tools required for the first inspection,

32) Spare parts required for start-up, commissioning, guarantee period and first inspection,

33) First fills for all equipment included in the Scope of Supply,

34) Documentation as per chapter 9 and Annex 1, Attachment 1.3,

35) Guarantee period for the Scope of Supply as required in the CONTRACT,

36) All facilities required to comply with the technical connection conditions of the electrical power grid operator (e. g. filter systems & compensation equipment on mains side),

37) Three (3) interlocking systems for the MV components of the EMD.

The design and selection of all equipment included in the Scope of Supply listed above shall be as per this specification and all documentation listed in Annex 1, Attachment 1.1.

3.2 Scope of Services

The Scope of Supply for each EMCS shall include but not be limited to the following services:

1) Detailed analysis of the local electrical network supply (Harmonic Study). This shall include calculation of the short circuit ratios, network resonances, harmonic analysis of the power supply system for the operating conditions specified in chapter 4.1,

2) Design and selection of the complete EMD system as specified in chapter 4.1,

3) Detail engineering for the EMCS and all auxiliary systems included in the Scope of Supply,

4) Detail engineering for all interconnecting cabling in the Scope of Supply,

5) Detail engineering for all cabling between UCS and I&C field equipment controlled by the UCS and supplied by others (isolation valves on suction, anti-surge and discharge lines, see Annex 1, Attachment 1.10),

6) Detail engineering for all interconnecting piping in the Scope of Supply,

7) Detail engineering for all local EMCS vents (see chapter 4.2.11),

8) Detail engineering for all mechanical (Annex 1, Attachment 1.10), electrical and E&IC interfaces (Annex 1, Attachment 1.11),

9) Factory inspections and testing, certification, protocols, inspection and testing reports for all equipment in Scope of Supply according to chapter 5 and all specified regulations and standards, refer to Attachment 1.2 of Annex 1 (List of relevant Standards and Regulations),

10) Lateral and torsional analysis for the entire EM – CU train, including couplings (if applicable) as per API 617,

11) Conformity Assessment and CE Marking as per directive 768/2008/EC for the equipment in the Scope of Supply,

12) Preservation prior to shipping, packing and transportation to site,

13) Unloading, unpacking, storage/ removal of preservations prior to installation,

14) Unit skid grouting (if required),

15) On-site chemical cleaning / flushing for all piping included in Scope of Supply,

16) Supervision for Site installation and assembly of all equipment included in the Scope of Supply; all tools and procedures required for Site installation and assembly shall be provided by the Supplier,

17) All required 3rd Party Site Inspections as well as Site inspections and examinations by Czech authorities,

18) Start-up, commissioning, Site testing up to TAKEOVER by the Owner as per chapter 8,

19) Modification works on the material/equipment on site (if needed),

20) Training at Supplier premises and on-site including training documentation; shall include training for maintenance and operation personnel, as per chapter 12,

21) All inspections applicable during the Guarantee Period for the equipment included in the Scope of Supply.

The Supplier shall provide prices for the equipment and services listed in chapters 3.1 and 3.2 with considering the requirements (e.g. base scope, optional scope, etc.) and the project templates specified in the commercial part of the tender documentation.

3.3 Void

3.4 Scope for Maintenance (optional)

The Scope of Supply shall include maintenance works for all equipment listed in chapter 3.1. The proposed maintenance works shall include maintenance by the Owner and by the Supplier and shall consider the specified life time as per chapter 2.5 of this specification. The Supplier shall fill in the maintenance schedule as specified in Annex 1, Attachment 1.22.10.

The scope for maintenance shall include as a minimum the following information for all maintenance levels as per Annex 1, Attachment 1.22.10:

- All maintenance tools required,

- All spare parts required,
- All media required,
- All Site maintenance personnel required from the Supplier and Owner,
- Unit Downtime,
- Requirements and extent for equipment dismantle.

For the maintenance, the Supplier shall include in the offer prices for 15 years of maintenance.

The prices for maintenance shall include the 1st major overhaul. The Supplier shall consider the requirements listed in chapter 11 and shall fill in the maintenance prices with using the project templates as specified in the commercial part of the tender documentation.

3.5 Accepted technical solutions

The Supplier shall offer the **Integrated Solution with High Speed Electric Motor** (the electric motor with compressor packed together and isolated in process gas).

The typical requirements for equipment and auxiliaries are shown in the table below:

	Requirements
VSD Transformer	Required
VSD	Middle-voltage inverter - (MV VSD) including cooling system and outdoor air-water heat exchanger
Electric motor drive – EM	High speed asynchronous induction motor located together with the centrifugal gas compressor in one case body, isolated in process gas
Natural Gas Compressor Unit – CU	
Gearbox	Not applicable
Bearing system	Magnetic bearings
Seal system	Not applicable
Load Couplings	Not applicable
Instrumentation & Controls	Required
Oil lubrication systems including oil cooler	Not applicable

Motor cooling system	Required (motor cooled with process gas)
Anti-surge valve	Required
Hot-bypass valve	Required
Accessories	common base frame with acoustic enclosure

Table 1: Requirements for equipment and auxiliaries

4 TECHNICAL DESCRIPTION

The EMCS shall be designed for indoor installation and for fully automatic and unmanned operation. The EMCS shall be designed to operate to a large extent independently of operator intervention and with the primary emphasis on maximum efficiency and maximum availability.

All equipment provided by the Supplier shall be part of an established and proven product range, shall meet the requirements (explicit or implicit) of this specification, and serve the intended purpose. Unproven or prototype equipment or components shall not be delivered by the Supplier unless such equipment has been accepted in writing by the Owner.

The Supplier shall confirm that the technical solution proposed – main equipment – has completed min. 10,000 operating hours in similar projects.

The Supplier shall consider the following documents which specify all battery limits for the equipment included in the Scope of Supply:

a) Mechanical Interfaces (Annex 1, Attachment 1.10 and Attachment 1.19)

b) Electrical and I&C Interfaces (Annex 1, Attachment 1.11, Attachment 1.19, Attachment 1.21)

c) Civil interfaces referred to in this specification: for the installation on foundation connection all necessary connection equipment (foundation guiding template, anchor bolts, nuts, earthing lugs, etc.) and drawings in the Scope of Supply shall be provided by the Supplier.

4.1 Electric Drive

4.1.1 General Information

This paragraph applies for all electrical equipment of the turbo compressor units and secondary installations included in the Scope of Supply. The detailed Scope of Supply is listed in chapter 3.

4.1.2 Scope of Equipment

The scope of electrical equipment supply consists mainly of:

- Medium voltage drive motor (EM),
- Medium voltage converter (VSD) for each electric driven turbo compressor unit, incl. all secondary installations,
- Converter transformers for outdoor installation,
- All facilities required to comply with the technical connection conditions of the grid operator (e. g. Filter systems & compensation equipment on mains side),
- MCC for each EMCS,
- Medium Voltage cabling interconnecting the VSD-transformer, VSD and EM,
- Control, instrumentation and low voltage cabling interconnecting the single components of the scope of supply as well as to the specified terminals for connection to equipment provided by others,
- Trace heating including insulation and cladding,
- Lighting and emergency lighting within the acoustic enclosure, if applicable,
- Terminal boxes, local control stations, maintenance switches,
- Potential equalization of all components of the scope of supply and connection to the grounding network of the overall plant, provided by others.

All electrical interfaces are shown schematically in Annex 1, Attachment 1.11.

All cabinets shall be painted in RAL 7035.

4.1.3 Noise Emission and Noise Protection

The sound power level for the drive motor, transformers with enclosure and converters must be factory tested and certified in the factory test certificate.

The drive motor shall, in all converter operating ranges, incl. all auxiliary drives and equipment, be well below the EN 60034-9 sound power level limit value. The achievable values with converter feeding shall be given for the complete operating range.

The sound power level emitted from the operating converter system must allow the personnel to work in the converter room without ear protection. The achieved level must be specified for all operating ranges.

For all other components the type-testing protocol must be provided as a proof.

4.1.4 Electric Power Supply

The electric drive system is powered from the plant medium voltage switch gear. The medium voltage switch gear is designed for 22 kV (24 kV) and has a bus bar with two (2) sections.

The medium voltage switch gear is powered from a 110/ 22 kV transformer station. From the 22 kV feeders of the new transformer station to the compressor station medium voltage switch gear, a new power supply cable system will be installed.

Grid connection point to the power supply company (point of common coupling) is the cable terminals of the 22 kV cable systems in the upstream transformer station.

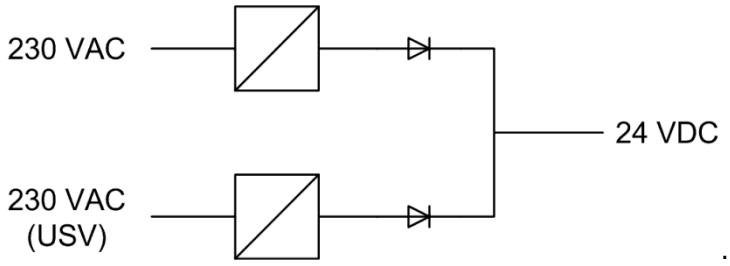
The auxiliary equipment is supplied with low voltage. Depending on the supply voltage and supply reliability required by the Supplier, the power supply will be from normal or emergency power supply system. An uninterruptible power supply (UPS) is available for control functions. The power requirements from emergency power supply and uninterruptible power supply shall be reduced to the absolute unavoidable minimum.

The power requirements have to be provided to the Owner as part of the offer.

Available voltage levels:

- Medium voltage: 22 kV, 50 Hz, EN 50160
- Low voltage normal supply: 230/400 VAC, 50 Hz, +/- 10%
- Low voltage diesel generator supply: 230/400 VAC, 50 Hz, +/- 10%
- UPS system: 230 VAC, 50 Hz, +/- 5%
- UPS system: 110 VDC, 50 Hz, +/-5%
  (DC power supply for MV control circuits)

Internal 24 VDC, if required, have to be generated redundant (2x100%) from both 230 VAC (UPS) as well as from 230 VAC normal power (energy supply during maintenance, replacement of the UPS system, etc.). The resulting DC voltages shall be decoupled as shown below.



4.1.5 Scope of Supply: Technical Description

4.1.5.1 General Requirements

4.1.5.1.1 Equipment

Supplier must ensure that selection of all equipment and components is based on simple maintenance, trouble-free fault detection and long maintenance intervals.

Equipment and utilities have to be designed for continuous operation with nominal power and in due consideration of the ambient conditions. Only components of proven industrial standard and high technical availability shall be used. They shall as far as possible be part of Suppliers standard supply program.

Equipment and components of identical kind and type must be used for equal or similar functions. In any case exchangeability must be guaranteed.

4.1.5.1.2 Tagging

All equipment, components and installations must be tagged with suitable nameplates of corrosion free material with long-lasting, light and weather proof labelling. Plates on cabinet front sides or other housings must be screw fastened. The Supplier shall apply the project specific tagging procedures as per Annex 1, Attachment 1.18.

4.1.5.1.3 Units

All scales and displays must adopt the metric system based on SI units.

4.1.5.1.4 Design Basis

The complete drive train has to be designed in a way that there is a spare power margin of 10% in the complete drive system with respect to the maximum required power of the driven system under worst case conditions, without any limitations within the speed range defined and relevant for operation. If the Supplier needs to make reservations in this respect these must be notified to the Owner in the document List of Comments, Exceptions and Deviations (Annex 1, Attachment 1.22.4) before order placement as part of the offer.

4.1.5.2 Frequency Converter Transformer

Converter-transformers shall be dry-type and designed in enclosure for outdoor installation without auxiliary ventilation. A self-cooled protective housing shall be supplied. The installation will take place in dedicated transformer compartments. The details related to the location of the VSD transformers are shown in Annex 1, Attachment 1.24.

4.1.5.2.1 Base Frame

The base frame shall be fitted with removable flat-rim wheels which can be arranged for either longitudinal or cross travel. The base frame shall be welded to the tank bottom and shall be equipped with four towing lugs.

For the definition of the foundation dimensions the weight and dimensions of the transformers must be provided to the Owner for further coordination with Civil Contractor.

4.1.5.2.2 Short-Circuit Strength

The transformers must be designed and constructed to withstand the thermal and mechanical stress of short-circuits.

The short-circuit strength as well as surge voltage strength must meet the requirements of the EN standards.

4.1.5.2.3 Permissible Temperature Rise

The thermal construction of the transformers must ensure that the permissible temperature limits of the insulation material as per EN 60076 standard are not exceeded during nominal operation conditions.

4.1.5.2.4 Tappings

Tapping points must be provided on primary side in order to align the transformer voltage to local network conditions. Switch over must be possible in de-energized condition only.

The minimum tap range shall be 0, ± 2.5, ± 5% of the rated primary voltage. Nominal voltage is 22 kV + /- 10%.

4.1.5.2.5 Temperature monitoring

A temperature monitoring system must protect the windings and the transformer core from overheating in case of increased ambient temperature or overload.

The system shall provide two limit values (alarm and shut down).

The sensor/element cables must be connected to a terminal box (minimum protection class IP 54) which is placed directly on the transformer. The monitoring and tripping unit is part of this specification and to be integrated in the converter cabinet. The sensor alarm and trip values must be defined and adjusted by the Supplier.

4.1.5.2.6 Rating Plate, Designation Plate

Each transformer must be provided with a rating plate according to the EN 60076 standard, a connection diagram and a designation plate. In addition warning signs complying to regulations as well as safety indications have to be provided in English language.

4.1.5.2.7 Cable Connections

The bushings and primary and secondary terminals, including any neutral points, shall be designed to allow connection with cables considering the requirements of the specific installation location. The location will be finally defined in the course of civil permit application planning.

In case of parallel cables the corresponding terminal bus bars have to be provided.

4.1.5.2.8 Accessories and Spare Parts

The Supplier must supply all accessories necessary for the operation of the frequency converter transformer. All spare parts required for a two-year operating period and for start must be included in the Scope of Supply.

The transformer monitoring devices shall be handed over to the frequency converter manufacturer.

The transformer shall allow the connection of short circuit / earthing equipment at pre-installed fixed ball points (Ø25 mm). These and the associated short circuit / earthing equipment including wall mounting brackets are part of the Scope of Supply. Each transformer shall have its own associated short circuit / earthing equipment set.

4.1.5.3 Frequency Converter (VSD)

4.1.5.3.1 General Requirements

The frequency converter shall be designed such that the limit values contained in EN 61800-3 for the C4 category are maintained as minimum requirements after cabling to the frequency converter transformer.

Further requirements with respect to limitation of harmonics could be necessary depending on the connection conditions to the medium voltage system. Refer also to paragraph “4.1.5.5 Harmonic Distortions".

In order to the requirements of the HAZOP and SIL assessment, shall be the main circuit breaker from the VSD Transformer feeder delivered by Supplier in class SIL2 according to IEC61508/61511.

4.1.5.3.2 Construction

4.1.5.3.2.1 General Information

The VSD shall be designed as a medium voltage frequency converter for variable frequency with intermediate circuit DC voltage, and ensure that the connected medium voltage motor can be regularly operated in all adjustable ranges. The technical data, especially the converter's performance and voltage as well as the output signal (curve type, harmonics, crest factor (peak to average ratio) and common mode voltage) must be adjusted to the drive motor used.

The converter consists of the following, essential components:

- Feeder, protected by the upstream 22 kV switchgear. Special requirements to the 22 kV switches are to be indicated in the tender
- Rectifier,
- Intermediate circuit DC voltage, with visible earthing device
- Converter / DC to AC converter,
- Motor sinus filter,
- Cooling,
- Safety devices for drive motor and transformer
- Pre-magnetization of the transformer,
- Control and operating cabinet incl. HMI,
- Operating panel,
- Serial and hardwired communication interface with the UCS / SCS,
- Hardwired loops for emergency functions, with UCS,
- Interlocking system, including upstream converter transformer and switchgear.

4.1.5.3.2.2 Mechanical Construction

All units are to be installed in metal-clad self-supporting cabinets with lockable swing-out doors, lifting lugs and cable entries from the bottom. Cabinet doors shall not block escape routes in the building while opened and shall have an opening angle of more than 90 degrees.

The power electronics, the control and monitoring equipment and the cooling skid shall be placed in separate cabinets. It is planned to install the cabinets for control and monitoring and cooling on the one hand and the MV cabinets on the other hand in separate, neighboured rooms. The interconnecting cabling and piping shall be supplied as specified in chapter 3.1. The location of the VSD cabinets is shown schematically in Annex 1, Attachment 1.20.

All cabinets containing MV installations must be kept closed during operation and fitted with built-in safety locks. An interlocking system has to be provided for the high voltage cabinets within the scope. This system shall consider also the transformer enclosure as

well as the feeding 22 kV switchgear cubicle not in the scope. The interlock hardware shall be aligned with type of switchgear and handed over to the switchgear manufacturer for integration. The use of padlocks for this purpose is not allowed. If the system design includes harmonic filters, these shall be also integrated in the interlock systems and the relevant keylock hardware has to be supplied.

The frequency converter will be installed in an electrical room. The cabinets must be designed for installation on raised cable floor. In order to plan the raised floor, the Supplier must provide a layout plan of the converter showing dimensions, weights/loads, maintenance space requirements and information on minimum distances between the converter and other construction parts as, for instance, wall, ceilings etc. to be complied with. A layout of the base frame shall be provided to be realized by contractor for raised floor system.

All cabinets must be designed for installation next to walls, but also for free standing installation in rooms (space around the Cabinets).

All nuts for fixing of cabinets / components shall be welded on the steel structure or threads will be cutted in the steel structure. The use of loose nuts or self-cutting screws shall be avoided. Screws, nuts and washers shall be galvanised or cadmium plated.

4.1.5.3.2.3 Wiring

The wires shall be selected according to load, insulation level, function and operating requirements. The wires shall be adequately rated and equipped with fuses / circuit breakers of adequate size.

The wiring colors and the minimum cross section must comply with the paragraph “4.6.4 Cables and trays”.

The wiring shall be carried out solid and safe against damages. Wires shall be bundled and fixed. Wires shall be routed in cable ducts. The cable ducts shall offer spare capacity of 20% after finished installation.

All circuits and auxiliary contacts including not used contacts for disconnecting devices and relays shall be terminated on terminal stripes. Terminal stripes shall have 10 % spare terminals. If wires with different potential will be terminated on one terminal stripe the respective terminals shall be separated by means of isolating plates. The termination of multiple stranded wires has to be carried out by means of multiple core cable ends.

Terminals shall be marked durable and easy readable, corresponding to the drawings. Wires shall be marked on the termination of each wire with the number of the corresponding connection point.

4.1.5.3.2.4 Earthing

All exposed conductive parts likely to be accidentally charged shall be joined together by an earthing circuit. For this purpose a minimum cross section of 100 mm² bare copper earthing bus shall be installed.

This earthing bus shall be connected to the general grounding system by means of conventional cable connection terminals.

For the removable parts, electric continuity shall be ensured by fastening screws and bolts. Swing frames assembled on hinges shall be bonded to the enclosure by a tinned copper braid, or hinges shall be certified for this purpose.

The following shall be also connected to the earthing circuit:

- secondary windings of the instrument transformers,
- neutral point of voltage transformers,
- Armouring / shielding of the MV cables,
- operating handles, mounting plates, doors, etc.

Furthermore, both ends of the complete mounted frequency converter are to be connected to the general grounding system by separate cables.

The converter shall allow the connection of short circuit / earthing equipment at pre-installed fixed ball points (Ø25 mm), on the converter incomer and on the motor feeder. The associated short circuit / earthing equipment including voltage tester and wall mounting brackets are part of the scope of supply. Each converter unit has its own associated two earthing equipment sets and one voltage tester.

4.1.5.3.2.5 Overvoltage protection

The design of the frequency converter and its equipment must limit the effects of overvoltages caused by switching and lightning strikes. The Supplier should provide a protection concept for approval.

4.1.5.3.2.6 Auxiliary Power Supply

The frequency converter is supplied with power from the low voltage switchgear (MCC) part of scope of supply of the compressor, with the auxiliary voltage levels defined above.

All other control levels required are to be generated internally.

The power requirements from auxiliary power supply have to be evaluated by the Supplier and notified to Owner.

4.1.5.3.2.7 Anti-Condensation Heating

The frequency converter shall be equipped with anti-condensation heating, which shall be fed from the 230/400 V, 50 Hz level. The heaters shall be humidity and temperature

controlled. A failure of heaters shall be indicated on the HMI. High voltage compartments may not be equipped, if manufacturer standard does not allow the installation of LV-heaters and humidity is avoided by means of other measures. Anti-condensation heaters shall be protected by RCD's.

4.1.5.3.2.8 Power Feeding

Switching of the frequency converter is performed by the circuit breaker of the upstream medium voltage switch gear. The circuit breaker ON and OFF switching command will exclusively be received from the frequency converter.

If additional protection devices, e.g. HH fuses, are required, the installations shall be integrated inside the converter.

The converter incomer shall be equipped with a manually operated three – pole disconnector. The position of the switch shall be monitored by the converter controls.

Fuses shall be monitored and trip signals must be displayed on the operator panel and signaled as a fault message on the unit control.

For feeder cables, connection preferably shall be realized by means of disconnectable cable sealing ends. Feeder/Incomer cabinet shall be equipped with floor plates, preventing from touching of any active parts from false floor.

4.1.5.3.2.9 Rectifier

The rectifier shall be equipped with min. 24-pulse diode bridge or diode/thyristor bridge (minimum requirement). A higher pulse-rate should be used if necessary in order not to exceed the limits for network harmonic distortions.

4.1.5.3.2.10 Intermediate DC Voltage Circuit

The intermediate DC voltage circuit shall be provided with long-life, maintenance-free, self-restoring film capacitors. An earthing device (earthing switch) shall be provided.

4.1.5.3.2.11 Inverter

The Inverter design preferably shall be based on a 6-pulse semiconductor bridge which allows the three-phase connection of the drive motor to the frequency converter. Semiconductors used shall be Medium Voltage Insulated Gate Bipolar Transistors (IGBT) or Integrated Gate Commutated Thyristors (IGCT). Semiconductors shall preferably be installed in a n+1 configuration which allows full load operation also in case of a failure of one transistor / thyristor block.

In order to reduce the harmonic distortion and keep the output voltage near to an ideal sinusoidal waveform, a sine filter shall be installed.

The output signal of the inverter shall not generate excessive motor shaft voltages or discharge currents in the motor bearings.

The inverter shall be optimized with regards to the installation location and the cable lengths between inverter and motor and shall ensure an optimal and reflection-free transmission of the electric power.

4.1.5.3.2.12 Frequency Converter Cooling

The frequency converter shall be water cooled. The cooling system shall be designed with an internal pure water circuit and a connection to the outer process water circuit by means of a water – water heat exchanger. If according to manufacturer's standard design, the external cooler can also be directly connected to the inner water circuit.

The internal cooling system should be designed as a closed circuit with water treatment incl. de-ionisation, control, monitoring and instrumentation.

The circulation pumps shall be designed in a redundant configuration with an automatic switch-over philosophy based on operation time. The replacement of one pump must be possible during converter operation. The pump valves must be lockable in open position.

The frequency converter cooling should basically be by direct water cooling, i.e. the construction parts to be cooled are subjected to a flow of cooling water. The frequency converter's power electronics are strictly to be water cooled.

For the cooling of components which cannot be directly water cooled, corresponding internal fans and air/water heat exchanger are to be installed. The cooling system is to be constructed in a way that, at any time, waste heat can be discharged without overheating the units and devices. All fans shall be monitored and designed in a redundant or N+1 configuration. The design of the cooling system shall prevent from condensation for any operating condition.

As far as possible, the total waste heat of the frequency converter shall be discharged to the external water cooling system, avoiding waste heat to the room. The residual heat for each inverter in the converter room has to be minimized and must be specified in the offer.

More details with regards to the external process cooling system are given in chapter 4.4 Cooling System.

Further requirements to the frequency converters cooling system are:

- Leakage detection,
- Automatic regeneration cycles,
- drain system,
- Automatic pump switch over, depending on operating hours,
- Automatic refilling system

4.1.5.3.2.13 Premagnetization Device

The frequency converter shall be equipped with a system for pre-magnetization of the frequency converter transformer. The premagnetization control is to be integrated in the frequency converter. The device must ensure that the transformer is energized avoiding the typical transformer inrush-currents.

4.1.5.3.2.14 Frequency Converter Control System

A control system shall be integral part of the frequency converter.

A state of the art digital control unit, widely-used, modular and programmable and with ensured spare-parts stock for the specified life-time shall be used.

The control unit must control, monitor and protect the frequency converter inclusive all auxiliary systems.

In particular, this covers:

- The feeding circuit breaker of the medium voltage switchgear,
- The compressor's motor drive,
- The frequency converter transformer.

The offer must include a block diagram illustrating the hardware and software platform used.

The control unit shall fulfil the following requirements:

- Real time operating system,
- Graphically forwards and backwards documenting,
- Ability to set parameters during operation,
- User program on non-volatile memory,
- Real time data stamping of messages and alarms (time synchronisation with unit control / station control system via NPT-protocol),
- Non-volatile event memory,
- Monitoring of all installed breakers, switches, fuses, etc.

Besides the proven standard features, the system shall comply with the following requirements:

- The frequency converter controls exclusively the upstream MV feeder,
- Monitoring and protection of the frequency converter transformer (note: all protective functions must be realised within the frequency converter, the transformer protection relay is to be installed inside converter cabinet),
- Monitoring and protection of the compressor's motor drive (note: all protective functions must be realised within the frequency converter, the motor protection relay is to be installed inside converter cabinet),
- Monitoring and control of filter units when applied,
- Automatic / parameterizable regeneration cycles in case of system standstill,

- Flying restart of the system,
- Low voltage / Power loss ride through.

A complete event and alarm list shall be realized, remote access shall be possible.

Serial Interfaces

A serial interfaces for signal exchange shall be established between the frequency converter control system and the compressor unit control system. All converter signals shall be available on the serial interface. The interface protocol shall be preferably based on Modbus TCP/IP or equivalent for acceptance by the Owner.

Parallel Interfaces

The safety-related signal exchange between the frequency converter, the compressor unit control and other systems, e.g. upstream medium voltage circuit breaker, transformer, shall be established via a parallel interface. The parallel interface shall be potential free or potential segregated, if required for analogue signals by means of active isolation amplifiers.

4.1.5.3.2.15 Operation and Monitoring System

An operation and monitoring system shall be integrated in the frequency converter, fulfilling the following minimum requirements:

- HMI with colour display,
- Displaying of all converter related measuring values, parameters, status and fault messages (a feature list shall be part of the offer),
- Harmonic analysis of input and output voltages and currents, time domain and frequency domain analysis.
- Displaying of all status signals of auxiliary systems and of motor, transformer, etc.,
- Control elements to operate and parameterize,
- User interface in German language,
- Local /remote switching via key-operated switch,

The operation and monitoring unit preferably is installed in the control cabinet’s door.

4.1.5.3.2.16 Accessories and Spare Parts

The Supplier shall supply all accessories necessary for frequency converter operation.

All spare parts necessary for start-up and for two years operation shall be included in the scope of supply.

Spare part list shall be a combined list incl. drive motor and auxiliaries and agreed with the Owner. The spare parts shall be delivered in dedicated steel cabinets, to be installed in the frequency converter rooms or stock rooms.

4.1.5.4 Drive Motor (EM)

4.1.5.4.1 General Requirements

4.1.5.4.1.1 Selection of the Drive Motor

As a rule, the manufacturer of the working machinery is responsible for selecting the correct type of motor. This also comprises coordination with the motor manufacturer regarding the data of the corresponding motor (rpm, shaft power, rotation direction) as well as the construction and coupling requirements.

If not otherwise specified, the motor's shaft power should be selected according to the maximum performance of the compressor, multiplied by a factor of 1.1 and using the next higher standard rating. Integrated compressors shall match these requirements as far as applicable.

4.1.5.4.1.2 Coating

Coating shall be carried out according to manufacturer standard and should consist of at least one primer and two final coatings. The film thickness of the final coatings should not be less than 140 µm.

The overall coating should be able to resist temperatures up to 130 °C. A temporary increase to 150 °C should be supported.

Final coat color optional according to Owner's choice.

Damages caused by transport, installation, cabling or putting into operation should be rectified in accordance with the original quality in all manners. A further overall coating at the installation site is not permitted.

4.1.5.4.1.3 Operating Mode

The motor should comply with the S9 operating mode acc. to EN 60034. Due to converter operation it must be possible to restart the motor successively for an unlimited number of times from cold and at operating temperature.

4.1.5.4.1.4 Tagging

All operating media, components and installations must be provided with suitable labels in corrosion free material with long-lasting, media resistance and lightproof and waterproof labelling. Plates on housing front sides must be screw fastened.

4.1.5.4.2 Construction

4.1.5.4.2.1 Requirements for Start and Operating Torque

The motor shall be designed for converter operation and start-up considering the loading of the compressor. During start up the starting current should not exceed nominal current.

The drive system should be designed with a design margin of 10%.

The motor shall be designed for re-acceleration against 100% residual field at phase opposition.

4.1.5.4.2.2 Insulation, Winding Protection

The state of the art winding insulation shall be aligned with the selected converter system, and be insensitive to humidity, chemically aggressive atmosphere and periodical heat stress.

High quality modern synthetic resin insulation systems shall be used. After insertion of the coils into the stator core, the whole winding shall be vacuum impregnated with epoxy resin, free from any solvent.

The winding ends should be reinforced in order to exclude mechanical damage during shock loads.

The motors shall be designed for class F insulation, thermal utilisation of the motors shall be for class B only.

Inside the stator windings at least two resistance thermometers (Pt 100) should be embedded. The resistance thermometers shall be wired to the auxiliary terminal box, independent from the main terminal box.

4.1.5.4.2.3 Monitoring Systems

The following physical technical motor parameters shall be monitored:

- Winding temperature,
- Bearing temperature, (winding temperature of magnetic bearings, oil temperature as far as oil is in use),
- Rotational speed,
- Vibration monitoring, if defined as general feature of the string.

The winding (stator) temperature is controlled by the above described Pt 100 resistance thermometer.

The bearing temperature is to be measured by PT 100 resistance thermometers installed in the bearing. Two (2) resistance thermometers shall be installed per bearing, one for monitoring, one for backup.

In case of magnetic bearings the bearing temperature supervision is to be integrated in the magnetic bearings.

The rotation / speed monitoring shall be carried out redundant by means of transmitters, the signals shall be processed in the fail-safe part of the unit control system.

The Supplier shall be responsible to align the motor vibration sensors with the overall string vibration monitoring system. The system technology shall be harmonised, the sensors shall be interchangeable where applicable.

The motor instrumentation shall be wired to separate terminal boxes. All wires shall be equipped with overvoltage protection to be installed this terminal boxes.

4.1.5.4.2.4 Explosion Protection

The EMC shall be certified for use in hazardous area, Zone 1. The compressor design is based on an integrated solution. If a rupture disk is required for the main terminal box, a vent line is part of the Supplier's scope, to be routed and installed to any location outside of the compressor building. The exact location will be defined by the Owner, based on the overall hazardous area and lightning protection concept. A pressure transmitter shall be installed, monitoring the main terminal box.

All instrumentation and any further necessary electric equipment (e.g. motor cooling fans) must comply with the explosion protection requirements for the main machinery. Cable terminal compartments shall be Exe or Exi, motor design for LV motors shall be Exde.

None of the used equipment's explosion protection can or should depend on on-site conditions or obligations to the Owner.

4.1.5.4.2.5 Cooling

The motor shall be cooled by means of a partial flow of the gas to be compressed (integrated solution). The Supplier shall explain the cooling concept incl. monitoring as part of the offer.

4.1.5.4.2.6 Bearings

The motor shall be equipped with active magnetic bearings and emergency bearings in case of power loss or malfunction of the magnetic bearings.

The Supplier shall confirm that the bearings can withstand an unplanned de-energization of the active bearing system. Statement shall also include the minimum numbers of landings until an overhaul is mandatory. The number of landings shall be monitored.

4.1.5.4.2.7 Terminal Boxes

The motor should be provided with separate terminal boxes for the main supply, the resistance thermometers and other instrumentation If in accordance with certificates, the bearing's resistance thermometer, if installed, can be wired to the winding temperature terminal boxes. For the terminal box for the main supply non-magnetic material shall be applied.

Terminal boxes are to be provided with glands suitable for the cable type used and in accordance with the number of cables installed. As far as possible, Exd gland shall be avoided, Exe and Exi are preferred.

The main terminal boxes are to be provided with fixed ball points (Ø25 mm) for visible connection of a short circuit / earthing equipment set . The Earthing and short circuiting

kit should comply with the requirements in the above paragraphs. A separate labelled Earthing and short circuiting kit is to be supplied for each drive motor and to be installed in the converter room, incl. the required wall brackets.

4.1.5.4.2.8 Accessories and Spare Parts

Supplier must supply all accessories required for the operation of the drive motor.

All spare and wear parts, necessary for commissioning and a two-year operation period must be included in the scope of supply.

Spare part list shall be a combined list incl. converter and auxiliaries and agreed with the Owner. The spare parts shall be deliverd in dedicates steel cabinets, to be installed in the frequency converter rooms or stock rooms.

4.1.5.5 Harmonic Distortions

4.1.5.5.1 General

It is Supplier’s obligation and part of the scope of supply that the drive system can be connected to the grid in compliance with the grid operator’s technical connection conditions, and that no existing installation is negatively influenced. Moreover, the Supplier has to ensure that the drive system itself can be operated failure-free when connected to the electrical grid. Any combinations of drives in operation at any possible operation point shall be considered, as well as different network topologies resulting from different switch settings of the upstream 22 kV switchgear.

The requirements of the grid operator have to be fulfilled even if the operating conditions of the network deem not to require this, or if the grid operator does not insist on a compliance with all requirements.

In addition to the technical connection conditions of grid operator, the design requirements, limits, etc. defined in IEEE Std 519-2014 and EN 61000-2-4 shall be considered and guaranteed.

The point of common coupling (PCC) is defined at feeding terminals in upstream 22 kV switchgear (substation of grid operator).

4.1.5.5.2 Principles for the Evaluation of the Harmonic Distortion

The principles for the evaluation of the harmonic distortions can be found in the a.m. standards. Moreover, Supplier has to ensure that the power quality for all consumers

connected to the energy supply still complies with the limits required by EN 50160 after connecting the drive systems to the network.

The reference value for the short-circuit power at PCC, relevant for the harmonic study to be carried out is not finalised yet and will be notified later.

4.1.5.5.3 Measurements

To proof the conformity to the requirements of grid operator and standards, a network analysis must be carried out prior and after commissioning of the drive systems, especially concentrated on harmonics measurement at PCC (22 kV level). The Supplier shall decide on duration of the testing period. However, the minimum requirement is two (2) weeks each. Generally, all operating points of the drive systems shall be measured. The Supplier shall note, that the site has to be fully operable to allow the operation of all drive systems at the several predefined operating points and therefore the accomplished commissioning of the drive systems themselves is no sufficient starting condition for the second measurement. The Supplier shall be prepared to start the measurements in a time frame of 6 months after drive system commissioning, at any time process conditions allow the start. The first measurement can be performed after commissioning of the 22 kV switchgear feeding the drive systems.

The two harmonics measurements should be performed as far as possible on identical conditions:

This means:

- Identical measurement period
- Identical measurement device
- Identical or similar seasonal conditions

Measurement process and procedure for data storage has to be elaborated by the Supplier and submitted to the Owner for review and approval.

A report, confirming the conformity to the specifications shall be issued.

4.1.5.5.4 Design for increased network compatibility

Preferably, the following measures shall be determined to reach grid compatibility and limit the harmonic distortions:

- Measures to be implemented at the converter transformer
- Measures to be implemented at the converter

4.1.5.5.4.1 Filter systems (optional)

Generally, the installation of filters shall be avoided. The Supplier shall confirm that filter circuits are not required, due to design of the drive systems and based on the requirements of grid operator. This confirmation shall be stated explicitly in the offer, a supporting harmonic study shall be part of the offer.

If filters are unavoidable, this shall also be clearly stated in the offer. In this case, heavy load filters (switched depending on the operation points,) and base load filters (switched directly with drive, covering the complete range of the drive systems) are in the scope of supply. The filters shall be designed for outdoor installation; an adequate housing has to be delivered. The control, monitoring and protection of the filter circuits are totally undertaken by the frequency converter which is to be equipped with the corresponding devices. If the filters have impermissible impact on the power factor, additional measures have to be taken for power factor compensation within the scope of this specification. Besides the feeders for the heavy load filters, which are provided in 22 kV switchgear, the Supplier is responsible for a fully functional subsystem.

4.1.5.5.4.2 Measures implemented at the Transformer

Corrective measures implemented at the transformer are preferred and shall be carried out with highest priority.

The following solutions can be implemented:

- Selection of appropriate vector group (secondary side)
- Installation of phase shifting transformers (primary side)

4.1.5.5.4.3 Measures implemented at the VSD

In case the measures implemented at the transformer are not sufficient, the Supplier shall implement additional corrective measures at the converter.

The following measures can be employed at the converter:

- Rectifier with pulse modulation higher than 24

4.1.6 Emergency shut down

The complete compressor package has to be equipped with an emergency shut down system according to the requirements of this specification (EN 60204-1/11, category 0) as well as HAZOP/SIL requirements, see also chapter 4.5.3.5 “Safety functions”. A SIL assessment considering the overall plant as well as the compressor package will be performed. The resulting SIL category has to be observed and implemented by Supplier.

The shutdown philosophy will include the de-energization of the main motor incl. frequency converter. The design of the EMCS shall ensure that the de-energization of

the main motor is realized within the scope of Supplier, in compliance with safety requirements.

The Supplier shall install within his scope a suitable load isolator (or circuit breaker, MV contactor or equivalent) at least SIL2 certified with data such as PFD, Lambda values, proof, etc, according to IEC61508 and IEC61511. The load isolator (or equivalent) by Supplier shall be installed in an indoor cabinet inside the respective frequency converter room.

The feeder of the upstream switchgear in scope of supply by the Owner will be a standard medium voltage circuit breaker without SIL certification, with the main scope of electrical protection. The circuit breaker shall be tripped by the frequency converter, using dedicated de-energization relays and standard trip coils.

4.2 Natural Gas Compressor Unit (CU)

The engineering, manufacturing, testing, installation and commissioning of the CU and auxiliary systems shall be performed in compliance with the specified regulations and standards listed in Annex 1, Attachment 1.2 and in compliance with this specification and all referenced documents listed in Annex 1, Attachment 1.1.

The Supplier shall list in Attachment 1.22.4 all comments, exceptions and deviations from API 617 5th Edition and from all PROJECT documentation listed in Annex 1, Attachments 1.1 and 1.2.

In certain points, API 617 requires that decisions are made by the Owner. These amendments as well as clarifications and additional requirements to the different components are specified in the following paragraphs where applicable with reference to the corresponding API 617 paragraphs.

4.2.1 Design Basis

The Supplier shall consider the following technical requirements as a minimum for the design and selection of the CU:

- Design and guaranteed operating points listed in Annex 1, Attachment 1.9,
- Operating points specified in Annex 1, Attachment 1.5,
- Gas compositions as specified in Annex 1, Attachment 1.5,
- Environmental conditions as specified in Annex 1, Attachment 1.13,
- API 617 Compressor Data-Sheet in Annex 1, Attachment 1.5 (Supplier shall fill in the blank spaces in the Data-Sheet),
- All relevant information as per Annex 1, Attachment 1.2,
- Mechanical Interfaces as per Annex 1, Attachment 1.10,

- Electrical and I&C interfaces as per Annex 1, Attachment 1.11 and Attachment 1.21.

Furthermore, the Supplier shall design and select the CU such that:

- the Design Point 1 specified in Annex 1, Attachment 1.9 shall exhibit the highest compressor efficiency,
- the operating points specified in Annex 1, Attachment 1.5 shall exhibit polytrophic efficiencies above 80% as far as possible,
- all operating points specified in Annex 1, Attachment 1.5 shall be located in the compressor operating envelope,
- all operating points specified in Annex 1, Attachment 1.5 shall be at min. 10% (flow) from the anti-surge line.

The Supplier shall consider the station main process piping layout as per Annex 1, Attachment 1.12.

The Supplier shall consider the Owner deviations to API 617 8th Edition for the design and selection of the CU. These are listed in chapter 4.2.2, chapter 4.2.3 and chapter 4.2.13.

4.2.2 General Construction Data

API 617, Para 4.4.1.9 – Installation of all EMCS will be in heated compressor buildings in an unmanned, remote controlled natural gas compressor station. The environmental conditions are specified in Annex 1, Attachment 1.13

API 617, Para 4.4.1.10 – Regarding the guaranteed noise level reference is made to Annex 1, Attachment 1.9

API 617, Para 4.4.4 – Alignment and testing of the installed connection piping by separation of the flanges shall be performed by the Supplier as part of the Scope of Supply.

API 617, Para 4.4.5 – Regarding selection and execution of the electrical components the Supplier shall refer to chapter 4.1, chapter 4.2, chapter 4.5 and chapter 4.6.

4.2.3 Housing and Connections

4.2.3.1 Design Pressure

API 617, Para 4.6.1.1 - The design pressure of the CU casing shall be at least 73.5 barg (in no case shall it be less than 1,25 × maximum discharge pressure).

A high integrity pressure protection system shall protect the CU against overpressure events. This shall include safety loops with certified pressure transmitters operating in a

2 out of 3 voting configuration and having direct access to the medium voltage feeder of the VSD Transformer (ESD). The system shall guarantee that the maximum allowable working pressure of the station (63 barg) will not be exceeded.

4.2.3.2 Process Gas and Auxiliary Connections

The process gas connections of the CU i.e. suction and discharge flanges shall be arranged in lateral position.

The flange connections shall be designed according to ANSI B16.5; the counter flanges with corresponding bolts, nuts, washers and gaskets including the required bolt tightening torque specifications and flange alignment criteria shall be part of the Scope of Supply.

The CU shall be designed to resist external forces and moments of the connection piping which sums to at least 10 × NEMA SM23.

Drain connections shall be provided for both in- and outlet sections as well as for the section between the inner and outer housing.

4.2.4 Base Frame

API 617, Para 5.4.2

The base frame of the EMCS shall accommodate the CU, the EM, the cooling system of the EM and all required instrumentation racks.

Anchor bolts and all connection materials (refer to chapter, point c) as well as all required alignment equipment shall be part of the Scope of Supply. The base frame construction must allow good accessibility for inspection and maintenance purposes and shall be provided with access platforms.

4.2.5 Dry Gas Seal System (not applicable)

4.2.6 Dynamics

API 617, Para 4.8.1 - **4.8.8** – An analysis of the critical rotation speeds (lateral and torsional) shall be performed and issued for the complete EMCS.

The Supplier shall include in the Attachment 1.22.2 the Campbell diagram, showing the EM torques generated by non-harmonic courses from the VSD including the amplitude of torques in the relevant frequency/speed range.

These data shall also be used for the torque analysis according to ISO/API617, Annex D.3, D1 and D.5.

4.2.7 Lubricating Oil System (not applicable)

4.2.8 Surge Control Valve

The Supplier shall deliver a surge control valve including actuator as required by this specification (see chapter 3.1). The anti-surge protection system including the anti-surge valve shall protect the CU against surge events during all operating conditions.

A pneumatic actuator shall be selected. Instrument air of the same quality and pressure as described in chapter 2.2.3 will be provided by the Owner for each EMCS at one supply point. Filtering and final pressure reduction is the responsibility of the Supplier.

The Supplier shall include in Annex 1, Attachment 1.22.6 the specification for the surge control valve. This shall include the following as a minimum:

- Technical valve data,
- Desired diameter,
- Requirements to the valve construction and its characteristics with respect to the quick opening and recirculation function as well as the noise level.

The anti-surge control valve shall be certified according to EN 10204-level 3.2.

The anti-surge control valve shall be designed to ensure safe start without using any further auxiliary equipment and with considering parallel operation of two (2) EMCS.

If the Supplier is of the opinion that an additional hot-bypass valve in parallel with the surge control valve is required (simulation shall be provided), this shall fall under the requirements of this specification as for the surge control valve. The hot-bypass valve shall be included in Scope of Supply as required in chapter 3.1.

4.2.9 Suction Strainer

The Supplier is responsible to provide a suction strainer which shall be installed in the suction line of the CU. The clean suction strainer shall have a maximum pressure loss of 0,3 bar at maximum performance. The suction strainer must be designed for a differential pressure of 5 bar. During operation the pressure difference across the suction strainer shall be monitored continuously by a transmitter; the differential pressure transmitter shall be included in the Scope of Supply. The differential pressure transmitter shall be included in the CU safety system and shall include an alarm and shut-down function. Details of the suction strainer have to be approved by the Owner. The suction strainer shall be designed for a continuous operation of least for one (1) year after TAKEOVER. The spacer and spool-pieces shall be part of the Scope of Supply as required in chapter 3.1. The Supplier shall include an additional set of bolts, gaskets, nuts and washers for each suction strainer (totally six additional sets) as required in chapter 3.1.

4.2.10 Load Couplings (not applicable)

4.2.11 Local Vents

All local vent piping included in the Scope of Supply shall be routed above roof of the EMCS hall. The design including the extension of the hazardous area shall be performed by the Supplier during detail design and shall be submitted to the Owner for review and approval.

The Supplier shall design the vents as per project specifications and standards specified in Annex 1, Attachment 1.2.

The vent termination outside of the EMCS hall shall be designed to avoid intrusion of water. Each EMCS building will be fitted with lightning rods (by others). All local vents included in the Scope of Supply shall be provided with flame arrestors.

4.2.12 Performance Data

The Supplier shall include in Annex 1, Attachment 1.22.7 the following CU performance data as a minimum:

- performance curves in the coordinates polytrophic head [kJ/kg] vs. actual suction flow [m^3/h],
- performance curves in the coordinates polytrophic head [kJ/kg] vs. actual suction flow [m^3/s],
- performance curves in the coordinates polytrophic head [kJ/kg] vs. normal daily flow [mcm/d],
- performance curves in the coordinates isentropic head [kJ/kg] vs. actual suction flow [m^3/h],
- performance curves in the coordinates isentropic head [kJ/kg] vs. actual suction flow [m^3/h],
- performance curves in the coordinates isentropic head [kJ/kg] vs. normal daily flow [mcm/d],
- Polytrophic efficiency [%] vs. actual suction flow [m^3/h],
- Polytrophic efficiency [%] vs. actual suction flow [m^3/s],
- Polytrophic efficiency [%] vs. normal daily flow [mcm/d],
- Isentropic efficiency [%] vs. actual suction flow [m^3/h],
- Isentropic efficiency [%] vs. actual suction flow [m^3/s],
- Isentropic efficiency [%] vs. normal daily flow [mcm/d],

- performance curves in the coordinates discharge pressure [bara] vs. actual suction flow [m^3/h],
- performance curves in the coordinates discharge pressure [bara] vs. actual suction flow [m^3/s],
- performance curves in the coordinates discharge pressure [bara] vs. normal flow [mcm/d],
- performance curves in the coordinates compressor power [kW] vs. actual suction flow [m^3/h],
- performance curves in the coordinates compressor power [kW] vs. actual suction flow [m^3/s],
- performance curves in the coordinates compressor power [kW] vs. normal daily flow [mcm/d]
- EM performance curves for efficiency and output max. power as per IEC 61800-4,
- Efficiency curves for VSD, VSD Transformer.

The reference conditions which shall be considered for the normal daily flows are specified in Annex 1, Attachment 1.5.

The Supplier shall plot all operating points defined in Annex 1, Attachment 1.5 on the CU performance curves required above. The CU performance curves shall include all operating limitations:

- surge line incl. anti-surge control line,
- stonewall line,
- speed curves including min. and max speeds,
- max. power limitations.

4.2.13 Additional Owner comments and deviations to API 617:

API 617, Para 4.2

See Annex 1, Attachment 1.2

API 617, Para 4.4.1.1.2

See Annex 1, Attachment 1.5, Attachment 1.13 and Attachment 1.9

API 617 Para 4.4.1.9

See Annex 1, Attachment 1.13

API 617 Para 4.4.1.10

See Annex 1, Attachment 1.9

API 617 Para 5.6.1.2

No liquid injection.

API 617 Para 4.4.4

The Supplier shall review the layout of the CU piping system.

API 617 Para 4.4.5

See Annex 1, Attachment 1.5

API 617 Para 4.4.7

Operation on air/ not applicable

API 617 Para 4.5.1.3

No corrosive agents so far

API 617 Para 4.5.1.6 and 4.5.1.7

Not applicable

API 617 Para 4.5.1.16

Not applicable

API 617 Para 4.5.1.19.2

Not applicable

API 617 Para 4.5.1.19.3

The Supplier shall consider the minimum temperature of -20 °C metal for all equipment installed outdoors as shown in Annex 1, Attachment 1.24. For the equipment installed indoors, the Supplier shall consider the minimum temperature of 0°C.

API 617 Para 4.5.1.17

Not applicable

API 617 Para 4.6.3.2

The Supplier shall perform non-destructive testing (NDT) of all for welds of pressure containing parts.

API 617 Para 4.6.4.1.7

Manual drains at the lowest point are required.

API 617 Para 4.8.1.3

Mandatory

API 617 Para 4.8.2.5 and 4.8.2.6

Mandatory

API 617 Para 4.8.7.2

Torsional analysis must cover the entire system, including EM, NGC, coupling and gearbox (if applicable).

API 617 Para 4.9.3

Axial bearings and labyrinth must be rated for continuous operation under the characteristic curve of the NGC.

API 617 Para 4.8.3

The Supplier to advise in Annex 1, Attachment 1.22.4

API 617 Para 5.1

See additionally chapter 4.1.

API 617 Para 5.4.1.1

In addition, the Supplier shall deliver the base plate screw joints / anchor bolts, leveling equipment, foundation guiding template and injection for grouting.

API 617 Para 6.1.4

See chapter 5 of this specification.

The Supplier shall include in Annex 1, Attachment 1.22.8 the Inspection and Testing Plan (ITP), this shall be subject to Owner review and approval during the tender evaluation.

API 617 Para 6.2.1

Mentioned items shall also be part of the final documentation, which shall be submitted to the Consultant and Owner for review and approval.

API 617 Para 6.2.1.5

Shall apply for all piping in Scope of Supply which will be installed on-Site.

API 617 Para 6.2.1.6

Shall be discussed during the conclusion of the CONTRACT.

API 617 Para 6.3.1.2.

The Supplier shall notify the Owner no later than 10 working days prior to the date the equipment is ready for testing.

API 617 Para 6.3.5.2 and 6.3.5.9.4

All values measured during the vibration test must be recorded within a prescribed system of monitoring of vibration and sent to the Owner for review and approval.

API 617 Para 6.3.5.3

See Annex 1, Attachment 1.3

API 617 Para 6.3.7.2

See chapter 5

API 617 Para 7.3.3

This information is available in the appropriate section of this technical specification.

4.3 Gearbox (not applicable)

4.4 Cooling System

4.4.1 Design Basis

The EMCS cooling system shall include the following equipment as a minimum:

- Cooling system for the VSD
- Cooling system for the EM
- Back cooling system

All EMCS cooling systems shall be controlled by the UCS.

The Supplier shall be responsible for sizing all cooling systems included in the Scope of Supply. All cooling systems shall be designed with considering the following operating conditions:

- Environmental conditions: as per Annex 1, Attachment 1.13,
- Load conditions: maximum load of the compressor train / rated power of the drive system,
- Cooling medium: water/propylene glycol mixture in concentration corresponding to the worst environmental conditions.

Under no circumstances shall the EMCS shut-down if the environmental conditions exceed the highest ambient temperatures specified in Annex 1, Attachment 1.13.

4.4.1.1 VSD cooling

The VSD cooling system shall consist either of an inner pure water circuit and a connection to the outer process water-glycol anti-icing circuit or of a deionised water cooling loop with glycol anti-icing.

In case the Supplier offers the first solution, the primary cooling system shall use deionise water and shall be constructed as a closed circuit with water conditioning, measurement and instrumentation. The detailed requirements for the inner cooling system (i.e. automatic regeneration cycle [deionisation], automatic pump exchange, leakage detections, and possibility of collecting cooling water) are listed in chapter 4.1.5.3.2.12. The waste heat should be discharged to the outer cooling circuit via water/water heat exchangers realized in high-quality stainless steel. The outer cooling system shall use a water-glycol mixture. The heat exchangers shall be redundant (2 x 100%) and shall be air cooled finned-tube coolers for outdoor installation. The piping of the outdoor back-cooling system shall be approved double rigid wall pipes with leak detection. The heat exchangers shall be provided with a corresponding back cooling water temperature control unit (e.g. thermistor or 3-way valve). The Supplier shall refer to chapter 4.4.1.4.1 for detail requirements for the design and selection of outdoor air / water heat exchangers.

4.4.1.2 EM cooling

The cooling of the EM shall be with process gas.

4.4.1.3 Lubricating Oil cooling (not applicable)

4.4.1.4 Back Cooling System

4.4.1.4.1 Central Back Cooler

The back cooler shall be constructed as a finned-tubed cooler fitted for outdoor installation. It shall meet the following requirements:

- Seal welded and rolled in finned-tubes (“extruded type”) shall be preferred as bundled tubes on both ends in the chambers. The inside diameter of the finned-tubes should not be less than 16 mm in order to enable cleaning.
- The chambers are welded with threaded plugs corresponding to the number of tubes or realized in separable construction. In case of welded construction the dimension of the thread plugs shall permit the use of protective sleeve corresponding to the diameter of the finned-tubes in order to prevent damages of the thread pitches during cleaning.
- As fan blade only aluminium or GRP (glass fibre reinforced plastic) fans shall be operated. The fan (min. 2 × 100 %) shall be provided with three-phase current able to cover the maximum power requirement. Each fan cooler drive motor should be provided with a safety switch. The safety switch shall be installed in the central back cooler.
- Fan, motors and gear boxes shall be easily accessible for maintenance operations.

- Slow running E-motors (noise reduction) with a power reserve of 30 – 40 % in front of the required nominal power rating shall be selected. Motor data:
  - Mech. Protection type: IP 54
  - Insulation material class: F, utilized according to insulation material class B
  - Ex-protection: Exde IIB T3
- Each fan shall be provided with a vibration switch. The vibration switch ensures that – in order to prevent further damages in case of the occurrence of vibrations – an alarm is issued and the respective fan is shut-down,
- Fan drives shall be variable frequency controlled e-motors,
- Fan belts, if applicable shall be electric conducting. Preferably, drive belts which do not require clamping device shall be used for each drive. Alternatively, 3-5 piece narrow V-belts according to ISO 254 or 1-piece Poly-V-belts (with clamping device) could be used. Belt protection mechanisms shall be provided. The calculation of the fan belts shall include a safety factor S = 1,5,
- In case a gear box is needed this shall be so dimensioned to be able to transfer 2,8x the moment of the total transmissible power for one minute without any additional heating. A shock factor of at least 1,5 shall to be employed. Slope-meshed or spiral bevel gears shall be employed,
- The cooler shall be assembled on a steel construction. The connection shall be designed such that it excludes the occurrence of tension or noises through thermic expansion (e.g. friction bearing). The motor vibrations shall be damped in accordance to ISO 14694, category BV3. The certification needs to be carried out at full and partial load measurement by an authorized expert. Walk-in platforms shall be provided for assembly, disassembly, cleaning etc. All platforms must have lanyard rails in accordance to valid guidelines. Lanyards shall be self-locking. Steel constructions, in particular staircases, platforms and gangways shall be hot-dip zinc coated,
- The fan construction should comply with the requirements for noise emission,
- The inlet and outlet cooling water connections shall be provided with positive isolation (removable piping spools or block valves) for enhancing piping removal, e.g. interconnecting cooling piping to VSD,
- The maximum noise emissions shall be 55 dBA sound pressures at 1 meter from equipment with N fans running (guarantee value as per Annex 1, Attachment 1.9).

4.4.1.4.2 Pump-Skid

4.4.1.4.2.1 General Information

This chapter is not applicable, if the VSD cooling is designed as a single circuit without water / water heat exchanger.

The centrifugal pumps of the VSD cooling shall be certified to ISO 2858 and ISO 5199.

The scope of delivery shall include the following as a minimum:

- Centrifugal pumps in redundant configuration (2 × 100%)
- Drive electric motors,
- Couplings,
- Fittings (shut-off valves and fittings, check valves),
- Sifter,
- Instrumentation according to principle flow diagram (minimum),
- Base plate (pump-skid)

The pump-skids will be installed in explosion-free, heated rooms (electric buildings as per Annex 1, Attachment 1.20). The Supplier shall consider the environmental conditions inside the room as specified in Annex 1, Attachment 1.13.

In case of failure, the change-over from operating pump to the spare pump shall be done fully automatically.

The pump skid for the outer cooling circuit shall have local START / STOP pushbuttons which shall allow turning on / off the outer water – glycol cooling loop (maintenance).

4.4.1.4.2.2 Process Engineering

The pumps shall possess stable and permanent increasing characteristics for decreasing flow-rate.

The “shut-off” discharge head shall be at least 110% of the nominal discharge head according to construction conditions.

The required NPSH values of the circuit shall be at least 1,0 m under the pump NPSH value in all operating conditions.

4.4.1.4.2.3 Mechanical Design

Wall thickness of the pump housing (casting) inclusive valve cup shall be certified in accordance with ISO 5199.

Nozzles shall be supplied in flanged version in accordance with ANSI B16.5.

Pump housing shall be provided with venting and discharge connections.

Impellers shall be made of precision casting parts. They shall be balanced to degree G6.3 according to ISO 1940.

The shafts shall be provided with rolling bearings (ball- or roller bearings) and mechanical seals.

Coupling between pumps and E-motor shall be provided with a flexible application and factor 1,75 constructed.

The pump vibrations shall not exceed “Zone A” values according to ISO 10816-3.

4.4.1.4.2.4 Factory Tests

Factory test shall be carried out according to ISO 5199.

4.4.1.4.2.5 LV E-Motors

The E-Motor drives shall be designed and selected with considering the environmental conditions specified in Annex 1, Attachment 1.13 and shall be controlled by the VSD control cabinets.

The ingress protection shall be IP55 as a minimum. Motors shall be totally enclosed and cooled, the equivalent to cooling code shall be IC411, IC416 or IC511 according to IEC 60034 part 6. The motors shall be of the three phase squirrel cage induction motor type, of totally enclosed fan-cooled (TEFC) construction.

The motors shall be fitted with ball or rolling contact bearings, supplied with life time grease. Motors which require surplus grease discharge openings shall not be considered.

The E-Motor drives shall comply with the Low Voltage Directive (LVD) 2014/35/EU.

4.4.1.4.3 Expansion Vessel

The expansion vessels shall be constructed according to the pressure equipment directive.

The expansion vessels shall be filled in with nitrogen.

The sizing of the expansion vessels shall ensure proper operations of the VSD for all environmental conditions specified in Annex 1, Attachment 1.13.

4.4.1.4.4 Interfaces - Engineering of the Integrated Cooling Circuit

In relation to the interface engineering, the Supplier shall submit all necessary information about the on-site Scope of Supply for construction to the Owner and Consultant. This information shall include the following as a minimum:

- Space needed
- Basement load
- Electric connections
- Indications about sensors and actuators.

4.4.2 Further requirements

For further requirements on the design of all cooling systems in scope, the Supplier shall refer to the overall requirements for equipment cooling listed in the chapters 4.1.5.3.2.12 and 4.1.5.4.2.5.

4.5 Control and Instrumentation

4.5.1 General

The complete electrical and I&C equipment shall include the following components as a minimum:

- Unit Control System including cabinets
- Magnetic Bearings system including internal UPS, control cabinets
- All on-skid and field control valves (anti-surge valve, hot-by-pass valve, pressurization valves)
- Interconnecting cabling and junction boxes between packages / cabinets in Scope of Supply
- Complete sensor/instrument technology
- Complete actuator technology
- ESD System
- Vibration monitoring system
- Cyber security solution hardware and software

The battery limits for instrumentation and valves to be controlled by the unit control system are shown in the process P&IDs referenced in Annex 1, Attachment 1.10 and Attachment 1.11.

All systems shall be designed to operate under the environmental conditions specified in Annex 1, Attachment 1.13.

4.5.2 Multiproject EMCS/SCS

Requirement of the Owner is to provide the UCS of EMCS based on the same platform of the SCS.

The operation of the EMCS shall be possible also from the operator workstations of the SCS. All HMI screens of the EMCS shall be available at the operator workstations of the SCS. All alarms and events and historical/trend functions of the EMCS shall be available in the SCS.

To achieve this requirement the EMCS and SCS shall be of the same type, therefore EMCS shall be based on equipment type Siemens PCS7 (CPU family 400), with I/O modules type ET200M and visualisation system WIN CC or equivalent. Additionally, to be considered as advantage, the operational department of Owner is skilled with this kind of equipment since already installed in similar plants.

The UCS including HMI in scope of work by EMCS shall be integrated in the SCS according to feature of multi-projects in the system configuration. The data shall be kept by the SCS workstations direct from the EMCS servers, respective UCS.

The program of the EMCS shall be hand over by the EMCS Supplier to SCS Contractor for implementation in the SCS at a certain point of commissioning, in agreement with Owner.

The interfaces between SCS and EMCS shall be over redundant terminal bus and control bus.

All necessary agreements shall be taken between Supplier and SCS-Vendor under the coordination of Owner in order to obtain this requirement.

At least version of the HMI software, the resolution of the screens and the headers of the screens shall be common.

The operator workstation of EMCS in the administration building will be installed by SCS-Vendor under the supervision of Supplier. Supplier shall fully support all activities and material to fulfil the requirement of this paragraph.

4.5.3 Functional requirements

In this chapter the functional requirements are described, which shall be carried out by the Unit Control System and related instrumentation and actuators.

4.5.3.1 General functions of the Unit Control System

The freely programmable Unit Control System (UCS) carries out all required instrumentation and control functions, covering all operation cases under consideration of all CU imposed boundary conditions. It shall be set up and constructed in a way to ensure in every operation case safe and reliable operation. The following functional hierarchy shall be applied:

1. Safety of personnel
2. Protection of machinery
3. Remote control
4. Local control

The UCS shall cover the following operational cases:

- Local start and stop of the units
- Remote start and stop of the units
- Closed loop speed control
- (Emergency) stop in case of exceeding certain thresholds
- At the unit control system it shall be possible to smoothly switch the operation from
    1. Local to Remote
    2. Remote to Local

4.5.3.2 Control philosophy of the compressor station

The control hierarchy is as follows:

1. Remote operation and control of the station from the Dispatcher Centre in Prague (DN4G)
2. Operation from local control room in exceptional cases (failure of DN4G, failure of communication system, test of station equipment, etc.). During times when the site is normally manned (Monday-Friday during the day), the stations are normally still under remote control.
3. CU control by the Unit Control System. The UCS is equipped with a local HMI-system (operator workstation) in order to control the unit especially for commissioning, tests and service works.

The station control system is controlling the whole station, with the following main tasks:

a. Station start / stop sequence

b. Unit start / stop

c. Station shut down

d. Automatic closed loop control of station flow, inlet-pressure and outlet-pressure with override control by the outlet temperature

Furthermore the station control is responsible for supervisory and control, event and alarm listing, reports, signal archiving and trending etc. of the whole station.

4.5.3.3 Operating modes

The following operating modes shall be provided:

OFF-Mode

The CU is turned off and cannot be started. Selection of OFF mode shall be possible through OFF/LOCAL/REMOTE key switch.

LOCAL Mode

The CU can manually be started and stopped. The starting and stopping shall be carried out with an automatic sequence. The set-point values of the speed control shall be manually adjustable at the HMI/workstations of the UCS. LOCAL mode shall be selected through OFF/LOCAL/REMOTE key switch.

REMOTE Mode

The CU is started and stopped via the higher level Station Control System. The set-point values are also provided by the Station Control System. REMOTE operating mode shall be selected through HMI screen selector of the UCS.

TEST Mode

The CU can be tested or maintained; e.g. manual operation of valves, safety related functions are fully in operation. The Test Mode shall allow manual operation of the single equipment as for example pumps on/off and test of all process valves. Interlocks for safety reasons shall be provided according requirements of CU protection. For selection of TEST mode a software HMI screen pushbutton shall be provided.

4.5.3.4 Sequential functions

Supplier shall describe all sequences in logic diagrams and shall provide the descriptions for approval prior to implementation.

Switching of operation modes

In order to switch between operation modes an operating mode selector switch shall be provided at the Unit Control System. It shall always be possible to switch between “Remote”, “Local” and “Test Mode”.

Switching between control modes shall be smooth.

Leak test - as part of the Start sequence - shall be provided for the check valve.

The following sequences shall be provided:

CU - Start

The CU start shall be initiated as soon the starting preconditions are fulfilled, such as unit vales are in the required position. As soon as the nominal speed is reached the CU speed control is taken over by the Station Control System – load sharing. The speed is increased via a ramping function.

CU – Stop

Independent on the operation mode (local/remote) the CU can be stopped either locally or remotely. This command carries out the standard stop procedure. The CU piping stays under pressure until the provided limit of the hold time has been exceeded.

CU – Emergency Stop

Independent on the operation mode (local/remote) the CU can be stopped in emergency either locally or remotely with or without depressurisation.

4.5.3.5 Safety functions

The design requirements for all safety-related systems of the CS (including the EMCS) shall be issued based on the results of a HAZOP and SIL-risk assessments performed according to EN 62061 or EN 61511 and requirements as per EN 12583.

The safety functions shall meet the requirements set in the SIL assessment reports. All components part of SIL safety function must be SIL certified and suitable for the required SIL level.

The Supplier shall deliver risk analysis reports (HAZID, HAZOP, SIL and QRA) including calculations, technical as well as functional specifications for all SIL safety related loops in the Scope of Supply, as per Annex 1 Attachment 1.3.

The EMCS shall be protected against improper operating conditions. The shut-down functions of the EMCS and all auxiliary systems shall be managed by the Unit ESD system which is part of the UCS (see Annex 1, Attachment 1.11).

The ESD of the UCS shall be based on not programmable devices at least SIL2 certified such as HIMA Planar4 or equivalent.

The ESD of UCS shall forward the required signals to the VSD and others systems of the EMCS as required. The shutdown signal to the power feeder (EMCS circuit breaker) through the VSD shall be provided in the required SIL level. The ESD system of the EMCS shall control all EMCS process valves (see Annex 1, Attachment 1.10).

The Supplier shall verify and validate that the SIL of the protection loops has been implemented correctly and the required SIL (Safety Integrity level) is achieved.

The Supplier shall use for the SIL calculation the SIL data of the actuators provided by Owner. The actuators provided by Owner will be generally suitable for SIL2 according to IEC 61508/61511. Any other requirement which is necessary to achieve compliance with SIL assessments shall be stated by Supplier in the offer.

The station shut down signals (plant shut down) will require a SIL certified interface to the ESD of the station.

Short-circuit and wire break monitoring shall be provided for all safety-related loops. Potential free contacts shall be provided with appropriate resistor modules.

The safety functions of EMCS shall include the following instrumentation loops as a minimum:

a) Process compressor discharge pressure max.

b) Process compressor discharge temperature max.

c) Emergency shutdown from ESD of the station with depressurisation

d) Emergency shutdown from ESD of the station without depressurisation

e) Emergency shutdown from local emergency pushbuttons

f) Emergency shutdown from SCS (not SIL classified)

g) Failure ESD of CU

h) Wrong position CU´s process gas valves (i.e. suction, discharge, venting)

i) Criteria by Supplier (temperature windings, vibrations, speed, etc.)

The Supplier shall include in the Annex 1, Attachment 1.22.9 the design philosophy for the Unit ESD system. The Owner could accept the standards of the Supplier's ESD functions based on the Supplier's risk analysis after mutual approval. If the HAZOP and SIL yields action points for the EMCS, these shall be implemented by the Supplier at no additional costs.

4.5.3.6 CU Control functions

The following control loops are foreseen:

- Unit Speed Control, implemented in UCS
- Anti-Surge Control, implemented in UCS

4.5.3.6.1 Load Sharing Control

The control of the compressor shall permit equal load sharing between the compressors operating in parallel. Load sharing is implemented in the Station Control System. Load sharing control defines a speed set-point for all available, pre-selected compressors.

The process input variables used by the SCS to define unit speed set point are flow, suction pressure, discharge pressure and discharge temperature.

Load sharing shall ensure equidistance from surge line to minimize recycle under all operating conditions. Furthermore every compressor shall have equal flow as far as possible. Load sharing control shall open the station recirculation valve if the distance from the surge line to the operating curve is smaller than 8% (settable). Supplier shall provide input data for defining control lines of load sharing function.

Supplier shall provide as feedback to the station control system the distance of the compressor operating point to the surge limit line.

4.5.3.6.2 Anti-Surge Control

In case the compressor flow falls below a minimum threshold, instable operation conditions are caused (surge). The rapid and unstable reversal of pressure and flow through the compressor can cause considerable mechanic and thermal cyclic stress for the CU.

The operating curve of a turbo compressor is divided by the surge line into a stable and an instable area. The anti-surge control shall keep the flow above the minimum threshold and shall ensure a stable operation, utilizing predefined control curves, control algorithms and the anti-surge valve (ASV).

Surge protection for each unit shall be carried out via individual unit anti-surge valve.

The anti-surge control is implemented in the UCS and receives the required input process parameter signals to determine the actual unit operating point in relation to a pre-defined surge safety margin line. The anti-surge control shall control the opening of the anti-surge valve (ASV) as the surge safety margin line is approached. The definition of the required process input signals, as well as ASV control loop parameters, is responsibility of the unit Supplier. Furthermore, the unit Supplier shall define the characteristics of, and supply, the ASV, based on a detailed calculation model of the system considering piping volume, geometry, etc. The surge safety margin line shall be finally defined during commissioning.

Anti-Surge Control to include override function, triggering quick-open solenoid of anti-surge valves, in case safety line is passed.

The control output signal to the anti-surge valve is to be provided as a 4-20 mA signal by Supplier. The manual control of the ASV shall be allowed via AUTO/MANUAL selector switch and OPEN/CLOSE pushbuttons installed at the Unit Control Panel.

The fast stop valve (if applicable) is for protection in case of unit trip and shall be actuated by the unit ESD system (i.e. open in case of unit trip).

Flow, pressure and temperature measurement shall be provided by Supplier for anti-surge control. This shall be flow element differential pressure, pressure and temperature RTD. Maximum accuracy shall be ensured; type and accuracy shall be provided within Documentation.

The anti-surge control system comprises:

- Head vs. flow control algorithm integrated into the UCS
- Control software programmed and tested for staging
- Anti-surge control valve and accessories
- Fast-stop volume analysis
- Surge control calculation and software program constants
- Automatic override of manual control mode

- Speed set point decoupling
- Surge detection
- On screen, real time graphic display and control parameter setting
- Surge control parameters available for remote monitoring
- Suction flow differential pressure transmitter
- Suction and discharge pressure transmitters
- Suction and discharge temperature

4.5.3.6.3 Unit speed control

Unit speed control is implemented in the UCS to achieve the speed set point as received from the SCS or manual set in the UCS. The UCS forwards the speed set point to the VSD. Unit speed control has additional input signals, over-rides, ramps, interlocks, etc. to protect the machine as defined by, and under full responsibility, of the unit Supplier. For Start – and Stop of the CU ramping shall be applied.

4.5.3.6.4 Gas Cooler Control

Gas cooler control is implemented in the SCS.

4.5.3.6.5 Interface SCS - UCS

At least the following feedbacks to SCS shall be available over serial communication (Control network):

- Unit in emergency shutdown condition with depressurization
- Unit in emergency shutdown condition without depressurization
- Remote/local control mode
- Unit not ready for operation
- Unit not in operation
- Unit pressurized (e.g. Pressure > 2 bar)
- Unit ready to start, waiting start command
- Starting, start sequence activated
- Minimum speed, unit rotating at minimum speed
- Max load, depending on the operating conditions, the maximal load has been reached; increase of speed set point from SCS is not possible (for example max speed oder max power drive)

- Minimum load, depending on the operating conditions, the minimum load has been reached; decrease of speed set point from SCS is not possible (for example min speed).
- Speed set point from SCS is active for regulation
- Unit in operation
- Stop sequence active
- Alarm summary, at least one alarm active
- Warning summary, at least one warning active
- Operating position of the unit in the compressor map (mandatory for load sharing, 0% surge line – 100% stone line)
- Actual speed (preferably %, to be defined)
- Actual flow in [Nm3/h], calculation based on the dP compressor inlet
- Actual flow in [m3/h], calculation based on the dP compressor inlet
- Pol. head in [m] or [kJ/kg]

The definition of the feedback signals in detail will be provided during project execution. Depending on unit P&ID and specific requirements for the control/regulation in the SCS, the feedback signals might be extended.

At least the following commands from SCS to UCS shall be available over serial communication (control network):

- start
- stop
- speed set point
- permissive to start

At least the following signals shall be exchange for Station ESD and unit ESD over hardwired interface:

- ESD shutdown without depressurization
- ESD shutdown with depressurization

Time Resolution shall be 500 ms or better for all signals.

Functions of each signal will be defined during detail design.

All signals necessary for the HMI-screens of the EMCS in the SCS-Workstations shall be exchanged over Terminal Network see 4.5.2 “Multiproject EMCS/SCS”.

4.5.3.7 Specific functions

4.5.3.7.1 Frequency Converter and related power systems

The following functions shall be integrated in the UCS

- Regulation, set point calculation
- Start/Stop/ESD commands and permissive to start
- Monitoring of the frequency converter including electrical items such as power feeder, transformer and related equipment of the main power supply

Emergency shutdown of the unit shall be acting to the power feeder in the required SIL class.

4.5.3.7.2 Electrical systems MCC

The following functions shall be integrated in the UCS

- Monitoring
- Start/Stop/ESD commands and permissive to start

4.5.3.7.3 Magnetic Bearings system

The following functions shall be integrated in the UCS

- Monitoring
- Start/Stop/ESD commands as required

4.5.3.7.4 Filter Separator of the unit

Monitoring and control of filter separator is implemented in the SCS.

4.5.3.7.5 Unit process valves

The unit process valves shall be controlled and monitored by the UCS. At least the following interlocks shall be implemented:

- Differential pressure over main process valves: it shall be not possible to open the main process valves if the differential pressure over the valve is greater than 2 bar (adjustable).
- Vent valves: the vent valve(s) can be open only if the unit is isolated (main process valves and pressurization valves are closed)
- Unit shut down shall be activated in case of wrong position of the process valves.

Further details and functions shall be defined and agreed with Owner during project execution.

4.5.4 Unit Control System

This chapter describes in more details the requirements for the UCS in particular:

- the HMI-System, Workstations and Servers
- the PLCs for standard - and SIL-classified functions

If the Supplier can provide the UCS on more platforms, the Owner will prefer the same platform type in used for the SCS. The SCS system will be defined during project execution. For the bidding, reference shall be made to Siemens PCS7, with CPU Series 400 and I/Os Profibus system ET200M or equivalent.

All automation tasks shall run on embedded functions as well as functions programmed directly in the PLC.

User roles in operating system of UCS shall be clearly segregated at least for administrator, operator and technician.

Redundancies are required for:

- Power supply
- Network interfaces of HMI-workstations and servers

Reference is made to architecture diagram of the SCS and Battery Limits for EMCS (Annex 1, Attachment 1.11 and Attachment 1.21).

4.5.4.1 HMI System

The UCS shall be provided with a HMI supervision system to serve all three units generally based on:

- Operator workstation in the control room
- 2nd operator workstation in the electrical room with engineering features
- Redundant servers
- Redundant HMI Network

Reference is made to the architecture station control system (Annex 1, Attachment 1.21) and the electrical and I&C battery limits as per Annex 1, Attachment 1.11.

The requirements for the workstations are as follows:

- 19'' rack mounted system chassis mounted in server cabinet
- Redundant LAN cards

- LCD Monitors, Screen diagonal 21”, borderless display, 1600 × 1200 native resolution (HOLD)
- Keyboard and mouse

The servers and the computers of the workstations shall be installed in a suitable server cabinet, 19” rack type, door with window, accessible from both front and rear side.

The operator workstation (monitors, keyboard and mouse) shall be interfaced with the servers and computers over KVM-E preferably over FOC.

Printers will be delivered by Owner and shall be integrated in the system by the Supplier.

One remote access LAN card shall be installed in the Engineering Workstation (OWS1) as spare for future.

4.5.4.2 HMI-Displays

The appearance and the handling (look and feel) of the HMI must be consistent over all applications, for example:

- Consistent sequences of action
- Identical terminology shall be used in prompts, menus, help screens and dialogs
- Consistent colour, layout, capitalization and fonts
- Consistent layout of process views and symbols
- As standard language for the HMI Czech shall be used; The HMI shall be anyway in English and Czech programmed with switch to select the language

The system shall be designed to prevent errors, for example:

- Commands and Menu items, which cannot be selected, shall be greyed out.
- The system shall not accept wrong input.

Each Display call up must be completed within 1 second, independently of the number of objects within a display and independently of the number of displays already opened. I.e. all data visualized within the display are updated and full usability is provided.

The Main Menu shall be configurable for the full range of actions which can be carried out within the Unit Control system. It shall support cascading. Depending on the level of user rights, the menu shall be user specific.

The project specific displays shall be as follows:

- reflect the process of the EMCS according P&IDs
- reflect all the sub-systems, especially the VSD, Magnetic Bearing, MCC and related equipment

- provide overviews of UCS hard- and software status (fault in the CPU, communication, etc.)
- provide dedicated displays for maintenance, tuning and commissioning
- display of compressor map and cause and effect matrix of the unit
- displays of the counters, status, etc.
- dedicated display showing the status of the actuators in the different operating conditions, also those provided by Owner
- displays showing the sequences of the unit (pressurisation, start, etc.)
- displays for settable parameters, available only with special password.

Operational state like EMCS start, shut-down, shut-off with and without interlocking, etc. shall be included in text form. Moreover, process malfunctions, run-time errors and stop position faults shall be displayed.

Visualisation of step-sequences i.e. for the start- and stop operation of the EMCS shall be as follows:

- Each condition, which must be fulfilled in order to continue the sequence, shall be visualized.
- Each step shall be monitored that time limits are not exceeded.
- It shall be possible to switch the step-sequences to manual, i.e. manual input is required to proceed with the step-sequence

All Symbols shall support blinking and shall be capable of changing appearance (shape, colour, position, visibility) according to the actual device status.

The displays shall be optimized for ergonomic supervision and control. Problem oriented, hierarchical presentation of information shall be provided. Important items shall be fast and easy to access. Seldom used, less important features shall not distract the operators or continuously cover display space. The displays shall offer informative feedback, enabling easy error handling; this includes fast access to information - reducing selecting and searching (scrolling) to a minimum.

The characteristics of the HMI displays (i.e. screen resolution, graphical objects, headers, etc.) shall be in compliance with the standard of the Owner, which are also in use in the SCS. The Owner will hand over in the design phase typical screens and additional basic information accordingly. Dedicated meetings with the Owner and SCS Supplier shall be held to define the requirements HMI screens.

4.5.4.3 Events and Alarms

Events and alarms shall be configured. It shall be possible to assign three different levels (severities) of alarm

- alarm level 1
- alarm level 2, (warning)
- event

The alarm and event window is presented in a list, sorted in a chronological order; the latest alarm and event is listed on the top of the list.

All alarms and events are archived. The depth of the archive shall be at least six months and shall be only limited due to hardware limitations.

The alarms and events shall be presented according to their severity level in different colours.

Each alarm and event entry is listed with the following attributes and descriptions:

- Data point key with textual description
- Nature of event or alarm (LL, L, H, HH etc.)
- Point of origin (which application generated the alarm)
- Value and corresponding unit
- Timestamp of alarm or event
- Acknowledgement status (alarms only)
- Timestamp of alarm acknowledgement
- Tag of Operator who acknowledged

4.5.4.4 Unit ESD

All safety functions as described in the chapter 4.5.3.5 “Safety functions” shall be implemented in the unit ESD as part of the UCS, which shall be based on not programmable devices at least SIL2 certified according to IEC 61508, such as HIMA Planar4 or equivalent.

All data of the unit ESD (status, values, etc.) shall be forwarded to the UCS over Profibus DP for implementation in the HMI-workstations, including visualization in the screens, alarms, trends, etc.

The detail C&E Matrix of the EMCS shall be implemented in the UCS HMI-screens.

4.5.4.5 Trends

Signal trends shall display the trend of one or more signal graphs against time. It shall be possible to display each signal trend in one window as far back as the archiving function for this signal was activated. The scale, the time domain and the range of values shall be adjustable online while the signal trend is selected.

Signal trends shall be shown as line charts with up to 10 graphs in a common time domain but in different ranges of values. It shall be possible to save trend selections.

Trend Performance:

- Historical data shall be available for at least 12 months
- The trend call up time shall be finished in 2 seconds, independently of selected time, number of signals or number of data point entries called up.

Trends of the UCS shall include the signals of the different EMCS subsystems such as for example VSD and magnetic bearing at least.

4.5.4.6 UCS layout

Requirements for control cabinets are defined in the chapter 4.5.5.

As references following cabinets shall be considered:

Field 1 – Power supply and CPU

Field 2 – Unit ESD, including ESD normal and Ex-i signals

Field 3 – I/O cards and interfaces of normal signals

Field 4 – I/O cards and interfaces of ex-i signals

4.5.4.7 Process interfaces

The process interfaces shall be constructed with interface components for analogue inputs/outputs and digital inputs/outputs process signal acquisition. Process interfaces must meet the following as a minimum:

- I/Os shall have minimum 20% spare capacity, this shall include VSD and the ESD system
- Ex-i signals with intrinsically safe barriers located in the control cabinets is the preferred solution, with HART protocol available
- All I/O’s with cables laid outside the UCS building shall be provided with suitable overvoltage protection on the UCS sides, type Phoenix PT-IQ or equivalent.
- Acquisition and transformation of process dependent signal types and signal level as described in the tables below,

- Potential free and total decoupling of any signal from the process
- Short-circuit proof and voltage drop feeding circuits to the field
- Independent and autonomous routines for fault detection and error notification
- Circuit faults, wire break and short-circuit monitoring

The following system interface components shall be employed:

UCS

Signal	Type
Analog input	4 – 20 mA/HART
Binary input	Contact 24 V DC / Namur
Analog output	4 – 20 mA
Binary output	24 V DC
Potential free relay outgoing circuits	24 V DC

Unit ESD

Signal	Type
Analog input	4 – 20 mA
Binary input	Namur
Binary output	24 V DC
Potential free relay outgoing circuits	24 V DC

4.5.5 Control Cabinets

Layout of cabinets shall be provided in an early state of the project, showing dimensions, all major PLC components, circuit breakers, size of HMI screen, IS and non IS areas, IS-segregation.

The requirements for the control cabinets shall be as follows:

- Space reserve of 30% shall be provided. The equipment in the cabinets shall be easy accessible.
- Control Cabinet shall be of standalone type height: 2000mm depth: 600 mm, suitable for indoor conditions of natural ventilation. Server cabinet shall be with depth 1200m.
- Colour: RAL 7035, plinth 200 mm

- Every centralized power supply input of a cabinet group or stand alone cabinet is provided with overvoltage protection
- Ingress protection level: min. IP 31, for opened cabinets minimum IP 20
- Control cabinets shall be provided with internal LED illumination controlled by a door switch. The lights shall be energized only when the door is not closed.
- Each cabinet shall be equipped with one 230VAC service socket
- Each cabinet group shall have a pocket for documentation.
- Cabinets are standing on the false floor. Cabling shall be directly routed through the false floor into the bottom of the cabinets, where they shall be tied to a rail for strain relief, connected at segregated terminals strips individually dedicated (labelled min. 6mm letters) to the related unit. Internal wiring shall be clearly tagged on both ends according to the documentation.
- The cable ducts for Ex-i-cables shall be blue. Segregation shall be provided between normal and Ex-i signals.
- 230 VAC will be supplied by redundant power cables from the UPS power distribution board. The two feeds shall be individually supervised and individually reported to the SCS in case of a failure.
- The control power that goes out to the field, shall be of floating type means as earth free circuit and shall be continuously supervised by an isolation measurement. Isolation faults shall be reported to the SCS.
- Insensible to interference according to the IEC standards

4.5.6 Requirements for programming

a) For programming software tools in the latest edition shall be used.

b) Programs shall be modular structured, system wide the same functions, procedures and names shall be used.

c) Programs shall be well documented; Czech shall be used for program comments.

d) Programs should not have functions or unused source code, which are not required for this project. Such code shall be preferably be deleted or as a minimum well documented that such parts are not required for this project.

e) Programs shall provide extensive support for debugging and trouble shooting. Especially concerning the communication, statistics shall be recorded.

f) Programs shall use the exact same data point naming and unit as used for the HMI, I/O list and P&IDs.

g) Programs shall provide easy access to set points. Set points must be readable in SI units (human readable) and shall be programmed as input parameter of functions or procedures.

h) Function block diagram (FBD), graphical programming shall be used as far as possible.

i) The Supplier shall hand over the source code without restrictions (i.e. password).

4.5.7 Licences

Permanent and transferable licenses for all computers of the system shall be provided. All required licenses shall be written out on behalf of the Owner and shall be submitted latest after installation of the system/licenses on site.

All workstations shall be provided with antivirus software according to the standard of the Owner. Operating system of all PCs should be MS™ Windows 10 with latest patch.

4.5.8 Engineering Workstation

The Supplier shall provide an engineering workstation for development, modifications, administration and maintenance of the UCS according to architecture diagrams (Annex 1, Attachment 1.21.

The engineering station shall serve all EMCS by individual connection to the UCS. The access to the engineering applications shall be restricted by software passwords.

The following software shall be preinstalled, at least:

- MS™ Office 2016
- Programming software for all PLCs and HMI visualisation system. All files for downloads shall be provided and finally updated after acceptance.

In addition the Supplier shall supply one (1) engineering laptop for development, modifications, administration and maintenance of the EMCS auxiliaries, for example VSD or magnetic bearing control systems.

The Supplier shall provide specialised training for the Owner operating personnel who will use the engineering stations. These includes training courses, certifications and rights for modifications of all delivered systems after guarantee period and should respond to above mentioned requirements for development, modifications, administration and maintenance knowledge and authorization.

4.5.9 Field operator interfaces

The cabinets of the EMCS shall be provided with local push buttons such as start, stop, local/ remote, etc. and indicators lamps such as failure, running, etc. where required providing local operator interfaces in all cases when HMI is not available.

ESD push-buttons shall be located on the skid and at the doors of the cabinets and shall be easily accessible for the operating personnel. The number and location of all ESD-buttons of equipment in the Scope of Supply shall be verified based on a risk analysis.

4.5.9.1 System Diagnostic

All control systems shall provide comprehensive information about the status of each component. The proper function of all system components shall be continuously supervised; any failure or interruption (e.g. I/O failure, power supply error, communication failure, etc.) must be logged with timestamp. If the detected error can have consequences on the proper operation of the system, the error shall be brought to the attention of the operator.

4.5.10 Remote Diagnostic and Maintenance

Remote monitoring, programming and online program observation is not foreseen.

4.5.11 Time synchronisation

The time of the UCS shall be synchronized with the station SCS over NTP protocol.

The UCS shall forward the time and synchronized the other subsystems of the EMCS, for example VSD control system and magnetic bearing control system.

4.5.12 Cyber Security

The compressor station shall be regarded as a critical infrastructure. All requirements according to the Act No. 181/2014 Coll. Cyber Security Act, as amended, and ‘Regulation No 316/2014 Coll. on Security Controls, Cyber Security Incidents, Reactive Actions and on the Determination of the Requirements for the Applications in the Field of Cyber Security (Regulation on Cyber Security)’ must be fulfilled.

In addition, the following standards and regulations shall be taken into account:

- ISO/IEC 27001 Information technology – Security techniques – Information security management systems – Requirements
- ISO/IEC 27002 Information technology — Security techniques — Code of practice for information security controls

- ISO/IEC 27004 Information technology — Security techniques — Information security management — Monitoring, measurement, analysis and evaluation
- BDEW Whitepaper Requirements for Secure Control and Telecommunication Systems

A Risk analysis will be performed during the Basic Design phase according to ISO/IEC 27004. The main concept of cyber security will be developed according to the requirements of the risk analysis.

The cyber security of the compressor unit must be designed and implemented in such a way that all threats from a cyber-attack (locally or remote) are detected in time, so that the effects of a cyber-attack can be minimized.

It shall be possible to restart or even to restore (disaster recovery) the UCS and all other critical systems of the compressor units within 8 hours, or less.

Following measures shall be considered for network security, as minimum:

- All relevant equipment shall be installed in lockable cabinets.
- Multiple access levels shall be provided. The command power will be clearly defined.
- Access to the management systems shall be restricted.
- Unused ports shall be disabled.
- A communication matrix with information about the communication relationships (source and destination, protocols, ports (physical, UDP, TCP), IP addresses, etc.) has to be created.
- Restore, automatic restart and disaster recovery procedures of the control equipment shall be implemented.

The cyber security concept for the compressor unit will be coordinated with the Owner according Owner's overall guidelines, based on the risk assessment according to the standards listed above.

The IT/SECPOL Security Policy (SM_I04_06_02) and the IT/SECPOL Methodology for Control Systems (MP_I04_06_02_03) shall be considered

After the award of the contract the Supplier has to prepare a concept for cybersecurity for the EMCS in close coordination with the supplier of the Station Control System SCS and submit it to the Owner for approval.

The recommendations of the concept are to be implemented by the Supplier in the detailed planning and execution phase of the project.

The Supplier shall appoint a central coordinator for IT and cybersecurity for the coordination and communication of all aspects of cyber- and IT security during the execution phase of the project.

4.5.13 Hazardous Area

All equipment and associated auxiliaries which are located in hazardous areas must be in compliance with applicable standards IEC 60079 and ATEX Directive.

For reasons of standardization all equipment shall be certified for Zone 1 also if they shall be installed in Zone 2 (Equipment Category II 2G).

Field-mounted electrical equipment shall generally utilize the methods of protection Ex-i, Ex-e or Ex-de with minimum degree IIB T3. Other type of protection may be used only after written agreement of the Owner.

As far as technically achievable the Ex-i execution shall be preferred. All components forming part of the Ex-i loop shall comply with the relative standard and regulation in use and being documented accordingly. All Ex-i loops shall be implemented with typical RAL 5015 colour (Sky Blue). For all Ex-i loops a calculation according to IEC 60079 shall be provided by Supplier. Data of equipment and cables shall be available for the specific type in use.

An Ex-Device List shall be provided by the Supplier for all devices which are installed within the hazardous area. In this list all installed mechanical and electrical devices together with their Ex-Certificate and types of Ex-Protection definition shall be included as minimum.

4.5.14 Vibration Monitoring

The Supplier shall provide a vibration monitoring integrated in the magnetic bearing control system. All related signals, alarms and values shall be available in the HMI-system of the UCS.

Position and temperature sensors at bearings and motor windings shall be foreseen and integrated in the UCS.

4.5.15 Process instrumentation

All necessary instrumentation required to guarantee a safe and reliable operation, monitoring and control/adjustment of the unit shall be included in the scope by SUPPIER.

The Supplier shall consider the following for the design and selection of all instruments:

- All instruments shall be new and of high standard industrial type;

- All instruments shall be solidly built using well proven high quality components of the latest up-to-date technology;
- All parts of the instruments in contact with the process fluids shall be fully compatible with those fluids and shall not deteriorate under operational environment;
- Particular attention shall be paid to the ease of access to all instruments. The instruments shall be suitable for mounting in visible positions with easy access for adjustments;
- Measuring errors and response time shall be as low as possible;
- Electronic type instrumentation with incorporated local digital displays shall be used, if applicable.
- All instruments shall return to accurate measurement without manual resetting upon restoration of power after power failure;
- It shall be possible to isolate the systems from the main process.
- Use of smart/intelligent transmitters with HART communication protocol facility, which have remote accessibility and can provide useful information for maintenance and operation. (e.g. zero point calibration, range calibration, remote diagnostic, etc.);
- Special attention shall be given to the outdoor and indoor ambient temperature if corresponding requirements for analysis equipment;
- All instruments and components shall be suitable for the test pressure and temperature of the corresponding pipe class.

All instrumentation shall comply with Typical Hook Ups (Annex 1, Attachment 1.19).

Marshalling loops shall generally comply with C4G-JI73-ILF-GENER-MAR-DIA-103 “Typical Loops Diagram”.As far as technically achievable the instrumentation shall be provided as pre-fabricated, work-shop tested and calibrated in order to reduce to minimum installation works at site.

All equipment shall be provided with complete documentation (ATEX certificates, Material certificates according to EN10204, SIL certificates, etc.) demonstrating compliance with applicable regulations and standards.

4.5.15.1 Pressure Measurement

Transmitter or instrument connections to the process shall be designed with at least a 12 mm stainless steel material with Swagelok connection.

Bourdon type pressure gauges filled with glycerine and designed in compliance with operational safety requirements of EN 837-1 standard shall be used (WIKA 233.30 or equivalent, Dial 160mm).

Gauges shall be able to withstand, without zero or calibration shift, over-range pressure of 1.3 x calibrated range as standard.Gauges exposed to vibration or process pulsations shall be fitted with pulsation dampers to the same material as the element. Pulsation dampers shall both absorbs pressure shocks and average out pressure fluctuations.SMART transmitters for remote indication shall be provided with a local indicator in two-wire system (type Emerson 3051C or equivalent). The transmitter shall be 24 VDC loop powered, providing 4-20 mA output signal. SMART series with HART protocol is required for remote maintenance and parameter setting.

The instrument body and all connection parts must be of corrosion resistant material, at least high quality CrNi-steel shall be used for the body and the process connection part.

Pressure transmitters and differential pressure transmitter shall be provided with a 3-way respectively 5-way valve manifold block.

4.5.15.2 Temperature Measurement

The Supplier shall provide bimetallic thermometers (Type WIKA TM54.01 or equivalent) for local indication, Dial 160mm. The temperature gauges should be selected in such a way that the normal operating temperature shall be between 30% and 75% of their full scale measuring range. Tolerance class shall be "Class A" in accordance with EN 60751, calibration in degree Celsius (°C).

The type of transmitters shall be digital type SMART series transmitters with HART Protocol for remote calibration and troubleshooting (type Emerson 3144P or equivalent). The electronic output shall be two wire 24 VDC loop powered, providing 4-20 mA output signal. Resistance thermometer (Platinum Resistance Thermometers,Pt100/RTD 3-wire in accordance with EN 60751) shall be provided.

Temperature element stem shall be AISI 316L stainless steel as minimum. Suitable thermal paste shall be filled into the thermo-well before insertion of the temperature element.The Supplier shall provide temperature measurements of process fluids in pipes with thermowells according to the pipe class and Typical Hook Ups (Annex 1, Attachment 1.19). The Supplier shall provide design certification including weak frequency calculation to proof compliance with strength and resonance frequency requirements.

4.6 Electrical requirements

The electrical part of the scope includes the delivery, installation and final commissioning of all electrically controlled and supplied equipment necessary to operate the EMCS in

the specified manner. As battery limit the power connection terminals of the low voltage power distribution board (LVDB) and the UPS distribution board is defined.

Any upstream power switch(es) for the EMCS equipment in the LVDB and UPS distribution boards will be delivered by the Owner while the engineering data of these switches will be under responsibility of the Supplier. Any necessary engineering data for switch(es) must be handed over to the Owner at least 6 weeks after contractual agreement.

The Supplier installs the power, control and instrumentation cables interconnecting LV/MCC/UCP – cabinets and all consumers and other installations within the scope. The cables will be laid in indoor cable tray systems provided and installed by the Owner. The detailed engineering of these cables and the individual cable routing is part of the Supplier's scope as well as the timely provision of the related engineering results to the Owner. The cableway construction within the skids is carried out by the Supplier in accordance to its needs. Sufficient space for inter skid cabling has to be provided.

The power cables from the LVPD and UPS distribution boards towards Supplier's LV/MCC-cabinets will be installed in outdoor cable conduits and in indoors cable tray systems, provided and installed by the Owner. The detailed engineering of these cables considering the individual cable routing is part of the Supplier's scope as well as the timely provision of the related engineering results to the Owner. The Owner himself will separately organize cable installation work for the commissioning phase of the plant to aim a concentrate cable installation work for all cabling between buildings for any discipline on site. In this issue, the outer wall of the EMCS-building incl. electrical rooms are the boundary of responsibility between the Owner and Supplier, regarding cable delivery and installation.

Any installation and deliverables on-skid is under Supplier's scope.

4.6.1 Earthing and equipotential bonding

The Owner provides an equipotential meshed grounding network on site. All exposed conductive parts or elements of the station systems shall be connected to this network by Supplier, in detail:

- electrical cabinets,
- electric motors, pumps, compressors and other machinery,
- metallic frame works, structures, walkways, etc.,
- vessels and all kinds of metallic containers,
- metallic framework of buildings and houses,
- metallic reinforcement of concrete foundations,

The earth resistance of the overall interconnected station grounding network shall not exceed 1Ω and must be testified by the Supplier for any connection he makes to the earthing system. Inside the EMCS hall, earthing bars will be installed on the outer walls. In the electrical rooms, earthing bars will be installed inside the false floor.

The metal screens of the cables are connected according to the overall earthing concept, considering lightning protection zones. At all entries in buildings, the outer cable screens shall be connected to earthing system.

4.6.2 Motor control center (MCC) and Switchboards

The LV power distribution and feeding power towards the electrical consumers inside the EMCS-package shall be realized by a motor control center (MCC). The basic construction shall be realized by use of type tested switchboards in withdrawable design and possible exceptions (approved by Owner) in fixed-mounted design. Manufacturing shall follow the standard regulation according to EN 61439 and EN 60947, the equipment shall be suitable for operation and utilization according to EN 50110.

The MCC shall be an industrial standard system, with interface to UCS as defined in chapter 4.5 “Control and Instrumentation”

To protect the equipment against lighting shocks, overvoltage arrester Class II acc. EN 61643-331 shall be installed next to the main power supply terminals of any MCC-cabinet.

The MCC will be equipped with one feeder from busbars of upstream LV switchgear and one feeder from upstream UPS distribution board.

After a power failure of the common power supply, the UCS shall automatically restore the operation status of the whole equipment as it had before power outage. That means that after restoration of power supply, no resets or pushing of buttons shall be required in order to return to normal operation.

4.6.2.1 MCC design basics

The cabinets shall be constructively straight aligned, unique in height and depth. Cabinets shall also be suitable for back to back installation or installation near walls.

The motor control centre parts of the switchboard shall consist of totally enclosed, vertical sections joined together with the incoming panel to form a rigid, free-standing assembly. The MCC panels shall contain busbars, motor starters, feeder circuit breakers and control as required to comply with this specification.

The status of the busbar condition, voltages (L1/L2; L2/L3; L1/L3) and the single phase current will be supervised, displayed at incomer cabinet and provided to the UCS / SCS

in real values. A multifunctional power measuring device with bus interface shall be installed.

Each panel shall have a separate vertical cable compartment, minimum width 400 mm. Each cable compartment shall have its own hinged door. Hinged front doors shall swing out more than 90°.

The PE busbar shall be located in the cable compartment.

The form of separation shall be 3b according to EN.

The vertical busbars shall be isolated in a way that with the compartment door open and the draw out unit removed, personnel is protected against unintentional contact. Live parts shall be protected by flexi glass or equivalent. The busses for the phases shall be arc-proof insulated.

Minimum degree of protection for MCC: IP21 (acc. EN 60529).

Except for the miniature circuit breaker (MCB) feeders, which shall be realized as fix-mounted installations, all consumer feeders shall be designed as withdrawable units.

All consumer feeders shall be designed for breaking phases and neutral. For this purpose, neutral mandatorily shall be conducted through the withdrawable units, miniature circuit breakers shall be equipped with a separate contact for neutral. The fusing of neutral is not required.

The units shall be withdrawable without use of special tools or disconnecting works. A withdrawal or an engage of the withdrawable units must only be possible with opened power circuit. The withdrawable units shall be supported from the frame as far as the whole unit can be lifted out.

For all withdrawable units, a defined operating position, test position and outside position shall be provided which shall be discernible from outside, too. In test position the main contacts shall be opened, but the control circuits shall be in function. In the test position, the testing of the withdrawable unit from a local control panel on site must be possible, if installed.

Contactors shall be designed for category AC 3, a minimum power of 7.5 kW and a mechanical life time of $1x10^7$ operations. An operation of the coils shall be possible with voltages down to 75 % of nominal voltage.

Signals indicating the operating and test position of all withdrawable units shall be transmitted to the superior control system. In addition, further control and monitoring devices and signals to remote systems shall be provided, depending on the type of the withdrawable units, as below.

The withdrawable units shall be designed for being secured with at least two padlocks per feeder (e.g. electrical and mechanical locking).

Standard feeder units of different size, corresponding to the power and the type of consumer are to be used. The following types are applicable:

Incomer

As incoming feeder of the MCC, hand-operated molded case circuit breakers (MCCB's) shall be installed. Adjustable overcurrent and short-circuit current relays shall be used.

For protection against overload a current-dependent, delayed releaser shall be used. The setting range shall be from 0.2 to 1.0 of nominal current and the time delay adjustable from 2 to 30 seconds.

For selective short-circuit protection an independent releaser shall be used. The setting range shall be from 2 to 12 of the setting range of overload releaser. The delay time of the independent releaser shall be adjustable.

On the front of the withdrawable units the following indication lights shall be placed:

- ON
- OFF
- TRIP

Each withdrawable unit shall be provided with respective push buttons for ON and OFF.

Each incomer shall be provided with a multifunction measuring device to measure single phase voltages and currents, apparent power, real power and reactive power.

LV-Motor Feeder - single speed

The feeder is to be realized without fuses. Each withdrawable unit shall be equipped with the following indications:

- ON
- OFF,
- Operating hours
- Failure

Operation of the feeder shall only be possible from remote. In test position a test of the control functions shall be possible.

Each withdrawable unit shall be provided with an emergency shut-off relay according to the EN 60204, category 0, which is controlled by the safety related part of the UCP. Moreover, each withdrawable unit shall be provided with a feeder for anti-condensation heating as well as a monitoring device for positive temperature coefficient thermistors of LV-Motor. The latter, as well as the E-Motor protection relay, must be certified for use in hazardous area.

The following signals shall be available for remote monitoring:

- E-Motor running
- E-Motor off
- E-Motor failure

LV-Motor Feeder with Soft Start

For E-Motor sizes of 15 kW or more, an electronic soft starter has to be provided and integrated in the withdrawable unit. The soft starter is automatically activated as soon as voltage is applied at the input terminals. After start up, a bypass relay is switched on. The use of an electronic bypass relay is not permitted. Apart from that the above mentioned requirements for “LV-Motor Feeder - single speed” are valid. Additionally, the position of the bypass relay has to be displayed and transmitted.

LV-Motor Feeder for frequency converter

The frequency converter feeder is realized in withdrawable technology in accordance with the description for “LV-Motor Feeder - single speed”. For temperature reasons, the frequency converter is installed in a cabinet adjacent to the switchgear panel. The frequency converter shall be equipped with a disconnector.

At least the following signals shall be available for remote monitoring:

- Rotation speed – set point value
- Rotation speed – actual value
- Frequency converter failure

In case several frequency converters are used, they can be installed together in one cabinet.

Circuit Breaker Feeder

Withdrawable circuit breaker feeders shall be manually operated MCCBs. Adjustable overcurrent and short-circuit current relays shall be used.

On the front of the withdrawable units the following indication lights shall be placed:

- ON
- OFF
- TRIP

Each withdrawable unit shall be provided with respective push buttons for ON and OFF.

The signals are transmitted for remote monitoring:

- ON
- OFF
- TRIP

Circuit Breaker Feeder with Contactor

The feeder is to be realized without fuses. Each withdrawable unit shall be equipped with the following indications:

- ON
- OFF,
- Operating hours
- Failure

Operation of the feeder shall only be possible from remote. In test position a test of the control functions shall be possible.

Each withdrawable unit shall be provided with an emergency shut-off relay according to the EN60204, category 0 requirements, which shall be controlled by the safety related part of the UCS.

RCDs shall be installed if required according to consumer certificate (e.g. in case of explosion proof heaters).

Miniature Circuit Breaker (MCB) Feeder Circuits

MCB feeders shall be realized fixed mounted. A group of MCBs is protected by a back-up fuse if required due to high the short-circuit currents. If RCDs are required, preferably a combined miniature circuit breaker with RCD shall be used. Cabinet sockets shall always be provided with RCD.

The use of only one RCD for several MCBs is not permitted.

Back-up fuses have to be provided with electronic safety monitoring and the failure/trip signal has to be transmitted to the UCS. MCBs have to be provided with auxiliary switches to indicate switch position as well as failure to the UCS. The trip of RCDs has to be signaled too.

4.6.2.2 Labelling

Labels of white RESOPAL and black writing must be used and permanently fixed.

The following must be provided per distribution board:

1 type plate

1 switchgear label with TAG identification and plain text in accordance with Owners tagging regulation.

1 terminal diagram per compartment/cubicle:

1 compartment label with TAG identification on the front (and back if isolated) per branch:

2 labels with branch identification with TAG identification and plain text in accordance with Owner's tagging regulation, 1 x on fixed part and 1 x on drawer or insert

The built-in devices must be provided with an adhesive label with equipment identifier on the device and next to the device.

4.6.3 Electromagnetic compatibility (EMC)

The central requirement of the EMC is to prevent any current flow within the earthing or equipotential system. For this the whole power distribution system of the EMCS must follow the TN-S net characteristic acc. IEC 60364-1.

All electrical equipment supplied under this contract shall comply with the following requirements in regard to EMC:

- the harmonic content of the power supply is in accordance with IEC 61000-2-4, Class 3,
- the harmonic content caused by the equipment may not exceed the requirements of IEC 61000-2-2 for LV Variable Speed Drives.

4.6.4 Cables and trays

Supplier shall use only cable types in accordance to the below mentioned list. The selection of the cross section lies in the responsibility of Supplier. Supplier shall consider the cable load, cable operation, environmental conditions, installation conditions and requirements of protective multiple earthing.

The power cables between converter transformers and the frequency converters as well as between upstream MV switchgear and converter transformer will be laid in protective pipes (conduits).

The maximum allowed voltage drops under full load conditions are the following:

- At consumer by nominal load 3 %
- At the LV motor terminals during start up 15 %
- Supply cable for lighting and uninterruptable equipment 2 %
- Supply cable for distributions at nominal power 2 %
- At the busbars of the distributions during start-up of the biggest LV-Motors 12 %

The cross section of power cables must be calculated on the basis for the following specified maximum conductor temperature:

- PVC – insulated cable 70 °C
- XLPE – insulated cable 90 °C

- All cables shall comply with the core colour acc. to HD308.

Cables have to be designed considering that the cable between the buildings will be routed in conduits.

4.6.4.1 Medium voltage cable

Supplier shall use long time water proof PE insulated cables of the types N2XS(F)2Y for the medium voltage cables between switchgear and converter transformer and between converter transformer and frequency converter.

The minimum cross section of medium voltage cables should not be less than 70 mm².

When a cross section of more than 185 mm² is necessary, two or more parallel cables shall be laid.

Medium voltage cables must comply with the EN 61936-1 and the EN 60228.

Supplier shall propose appropriate cable types for the connection between frequency converter and drive based on the requirements for the VSD operation as well as hazardous area classification. The proposed cable type must be submitted to and approved by the Supplier.

4.6.4.2 Power cables

Supplier shall use multi conductor cables of the following type for all low voltage cables:

- NYCY or equivalent
- NYCWY or equivalent

The minimum cross section of the low voltage cables and – conductors should not be less than 2,5 mm².

When a cross section of more than 185 mm² is necessary, two or more parallel cables are to be laid.

The concentric conductor is utilized as protective earthing conductor. Reduced cross section for protective earthing conductors shall be used only if the loop impedance remains below the maximum allowed value. A common conductor for protection and neutral use is not allowed for the load feeders.

Low voltage cables shall comply with EN 60228 and shall be self-extinguishing and flame resistant according to EN 60332-2-1.

If no other solution is possible because of technical necessities, other cable types e.g. with sheathing can be employed. These require Owner’s approval.

Core coding: Color coding acc. HD 308.

4.6.4.3 Control cables

Supplier shall use multi conductor cupper cables of the type N-YCY control and signal cable.

The cables must be provided with at least 20% reserve conductors. The outer sheath colour on intrinsically safe cables should be light blue.

Control and signal cables shall comply with the EN 60502-1 They must be self-extinguishing and flame resistant according to EN 60332-2-1

If due to technical requirements no other solution is possible other cable types e.g. with armouring may be employed. These require Supplier's approval.

Core coding: Color coding acc. HD 308

4.6.4.4 Instrumentation cables

The Supplier shall use multi core cupper cables of the type RE-2YCYv and RE-2YYCYv (from 12 pairs) for instrumentation cables. The following number of cores and cross section of shielding shall be used preferably:

Type RE-2YCYv

- 1 X 2 x 1.0 / 2.5 mm²
- 2 X 2 x 1.0 / 2.5 mm²
- 4 X 2 x 1.0 / 2.5 mm²

Type RE-2YYCYv

- 8 X 2 x 1.0 / 6 mm²
- 12 X 2 x 1.0 / 10 mm²
- 20 X 2 x 1.0 / 16 mm²

Any deviations require Owner and Consultant approval.

The instrumentation cables are made of twisted pairs of shielded cupper wires and cupper overall screen. The cables must be suitable for buried outdoor installation. The conductors must be identified by engraved numbers on the conductor insulation. The conductor colours should preferably black and white for each pair.

The cables must be provided with at least 20 % spare conductors. The outer sheath colour on intrinsically safe cables should be light blue.

Instrumentation cables must comply with the EN 60811-2-1 CLAUSE 10. For normal use cables with flame-retardant insulation should be employed.

If no other solution is possible because of technical necessities, other cable types e.g. with sheathing can be employed. These require Owner and Consultant approval.

Supplier's attention shall be paid to the fact that this cable type is available only in a certain minimum length and needs extended delivery time.

4.6.4.5 Profibus cable

Profibus cable shall be suitable for indoor use, compliance with profibus DP standard, resistant to environmental specified conditions and with typical violet outer jacket. Profibus cables for outdoor installation shall be installed in protection conduits.

4.6.4.6 Fibre optic cable (FOC)

FO cables and related equipment shall be according to the C4G-JI73-ILF-GENER-TEL-SPC-801.

FOC shall be single mode. Connector type will be defined during project execution.

4.6.4.7 Cable laying

4.6.4.7.1 Cable ways

Cables can be laid as follows:

- Directly in the ground,
- In protective pipes,
- In concreted cable channels,
- In buildings,
- In open air,
- On the wall or on cable racks,
- On the cable bridges,
- Others to be discussed and approved by the Owner / Consultant

The cable laying will be performed based on the cable plot plans prepared and reviewed in close coordination with the Owner.

Cables for power systems and signal systems shall be routed as far as possible separate from each other. Power cables and signal cables must be laid in separate cable trays and protecting tubes. For intrinsically safe cables separate routes are to be planned as well. Intrinsically safe cables can be laid together with other signal cables in the same cable trays on the condition that proper separation is ensured.

Transitions from hazardous areas to non-hazardous areas shall be designed with certified pressure, water and gas sealing and in case of necessity with mineral oil sealing pass-through. Protective pipes must be interrupted if necessary. After cable laying all cable runs including the spare transitions shall be closed. The sealing shall be performed

by a certified company. All protective pipes in outdoor surrounding, also spare tubes, will be water proof sealed after the cable installation.

4.6.4.8 Cable trays

Supplier's cable tray system shall be made of hot dipped galvanized material.

Cable trays must be connected to the earthing system at every distance of 20 mtr.

Underneath the upper tray an isolated earthing wire (NYY 1x 70²) will be installed in parallel over the full length of the cable tray system. The Supplier has to connect this earthing cable to the earthing system on both sides.

The Supplier's scope contains the interconnection of his cable tray system to the plant cable tray system.

For cables with different voltage levels, a separated tray or barrier strip –if applicable- has to be provided.

4.6.4.8.1 Laying

Cables shall be laid with considering the manufacturer's instructions. In particular the allowable minimum bending radius, maximum allowable torque strength and minimum laying temperature shall be considered.

Shielded signal cables are generally to be earthed on both sides. Ex-i signal cables are not earthed in the field. All conductors shall be connected.

Supplier shall deliver all necessary auxiliary equipment required for cable installation, i.e. cable train rolls, corner rolls, tools, lifting devices, ladders, frameworks, cordon material, cable drum unrolling devices, transport means for cable drum transports from storage place to construction side and the working place lighting as a minimum.

After laying, the cable ends must immediately be protected with water-repellent material (heat shrink tubing) in order to avoid moisture.

Cables shall be marked in a long-lasting, UV resistant and acid proof way. Cables shall be marked at both ends and in case of underground cables also at the beginning and at the end of the protective pipes, at the buildings entering, at branch-off from main routes (only the branching cable) and at each sleeve. A system must be employed that guarantees long lasting readability even when placed under ground, e.g. aluminium card corners with engraved cable number.

Delivery and placement of the labels is part of the supply.

The Supplier shall coordinate the delivery of cables with the Consultant and sub-contractor such that the cable installation shall be made during a frost free period of the

project. Cable installation at temperatures below 5 degrees C is allowed only after Owner's approval.

4.6.4.9 Cable Testing

Low Voltage Cabling

For all cables and conductors loop resistance and insulations measurements according to valid EN standards shall be carried out and registered before putting into operation. This procedure includes I&C as well as intrinsically safe cables and conductors.

Medium Voltage Cabling

For all medium voltage cables measurements according to valid standards must be carried out before putting into operation. Casing tests according to EN 61442. Voltage testing according to the VLF (very low frequency) procedure – test level and time according to EN 61442 part 4 shall be made. The medium voltage cabling testing shall be carried out by a properly equipped cable testing device.

Traction Force Recording

If lifting gear/winches are employed, a traction force record must be kept and submitted to the Owner.

Only professional auxiliary mounting devices shall be used for the pulling like hoisting grip, slide and deflection roller and a correspondent record over their use is to be compiled.

4.6.4.10 Junction Boxes

All cables in the external system shall be inserted from below. The junction boxes outdoors must have a minimum degree of protection IP 65. The junction boxes shall be provided with a grounding terminal.

All Ex – junction boxes and their components to be delivered with appropriate ATEX certificates and approvals.

The Ex i – junction boxes are to be equipped with blue terminals and cable entries.

Only metric cable glands shall be used. Inside the junction boxes the latest respective terminal plan has to be fixed undetectable and waterproof.

A weather-proof label with the name or tagging of the box has to be installed. Signs are to be taped with double sided tape UV-resistant and curing.

Sufficient terminals shall be provided to terminate all spare cores with 20% additional spare terminals. Separate junction shall be provided for each of the following cases:

- Intrinsically safe instrumentation circuits

- Non-intrinsically safe instrumentation circuits
- 24VDC control circuits
- 230VAC control circuits

4.7 Acoustic Enclosure (if applicable)

4.7.1 General Information

The EMCS shall be supplied with an acoustic enclosure for the compressor skid if the acoustic enclosure is required to comply with the noise emission limitations specified in Attachment 1.9.

If required, the acoustic enclosure shall be mounted completely on the base frame and shall comply with the following requirements:

- Designed for installation in a Zone 2 hazardous area (compressor building),
- Internal confinement shall allow free access to the system components which require maintenance,
- Access doors shall be operable from inside when the EMCS is running and shall be provided with windows and proximity switches to confirm the “closed” position,
- For major repair or overhaul free access a swing door or an easy-dismountable access panel shall be provided,
- In the area of suction and pressure line connections the panels shall allow dismantling of the piping,
- The auxiliary systems of the acoustic enclosure (ventilation, FFS, GDS, lighting and internal maintenance equipment) shall meet the requirements listed in the chapters 4.7.2, 4.7.3, 4.7.4 and 4.7.5,
- The safety functions for the inspection during operation must be decided by the Supplier and agreed with the Owner and Consultant before construction,
- The Supplier has to arrange a 30-minute-tightness test performed by independent third party during COMMISSIONING.

4.7.2 Ventilation

The acoustic enclosure must be provided with a ventilation system which ensures that the temperature within enclosure does not exceed a maximum temperature of 50 °C. Moreover, the compliance of the minimum air exchange to the explosion protection must be ensured. Open or semi-enclosed spaces which are designed to be ventilated by natural means shall achieve a minimum of 12 air changes (AC)/hour for 95% of the time. This natural ventilation may be augmented by mechanical means. The system consists

in a suction filter, suction and foul-air ducts with muffler and fans. The following requirements are to be complied with:

- Two AC fans (2 x 100% one in operation, second stand-by, alternating in agreed intervals) for normal operation shall be provided. The E-Motors are frequency converter adjusted. Both frequency converters shall be integrated in the MCC by the Supplier,
- The fans and the corresponding E-Motors must be easily accessible for maintenance,
- The start sequence shall only be initiated when a fan is operating and the gas concentration is below the alarm limit. In case of a malfunction in the venting system, the fan shall be shut-down by an adjustable switch after a certain bridging time,
- In case of fire inside the acoustic enclosure, the venting system shall be shut-down, the ventilation flaps closed and the fire extinguishing system triggered,
- Supply air and discharge air channels are to be provided with lifting lugs for easy maintenance,

The Supplier shall provide supporting structures and compensators for the ventilation ducting if required.

The suction and outlet duct openings shall be protected with bird protective grids; this shall be protected against icing.

The enclosure including enclosure ventilation shall comply with the noise emission values specified in Annex 1 Attachment 1.9.

4.7.3 Lighting system

The Supplier shall provide a lighting system including emergency lighting system inside the acoustic enclosure, if applicable.

The system shall be designed for Ex-zone 1 and for the temperatures present in the acoustic enclosure and shall provide the following lighting level:

- min. 200 lux for normal lighting
- min. 20 lux for emergency lighting

The normal lighting is partly powered by the UPS voltage for emergency lighting purpose.

4.7.4 Internal Maintenance Equipment

The acoustic enclosure shall be provided with an internal crane necessary for assembly and disassembly of the main components of the EMCS. The acoustic enclosure shall

allow the exchange of the CU bundle, CU rotor and EM rotor. The Supplier shall submit in the Annex 1, Attachment 1.22.11 all drawings showing all steps including the necessary space required for maintenance including exchange of CU bundle, CU rotor and EM rotor. This shall include a description of the single phases / movements / weights shall to be submitted.

4.7.5 Access Platforms

The acoustic enclosure shall be provided with the corresponding ladder / platforms for access. Inside the acoustic enclosure the accessibility to all system and parts subject to maintenance and test operations shall be provided by suitable platforms. All platforms must have guardrails in accordance to valid regulations. Guardrails have to be self-locking.

4.8 Further Requirements

4.8.1 Labeling and Marking

All equipment shall be provided with identification Tag-Number out in conformity with the respective drawings and documents. The tags used for the various labels are subject to Owner´s approval, Supplier shall issue a list of all labels intended to be used for his systems.

4.8.2 Tagging

Tagging shall strictly comply with the tagging system of the project, see document Annex 1, Attachment 1.18.

The concept for tagging by the Supplier shall be approved by the Owner during project execution. Tagging and naming convention must be strictly consistent within the whole system and documentation.

4.8.3 Pressure Piping, Fittings and Pressure Vessels

The Supplier shall consider the buttery limits specified Annex 1, Attachment 1.10 for the design and selection of all tie-in points at the skid limits as well as for all piping required in the Scope of Supply.

The EMCS shall be factory packaged with all required equipment, piping and fittings and shall be delivered to site as packaged skids. All piping required for utilities supply (instrument air, etc.) and all vent piping shall be assembled on skid in the Supplier workshop and shall be routed to the skid edge.

The local vents of the EMCS shall be included in the Scope of Supply as required in chapter 3.1 and shall be routed to the outside, i.e. roof of the EMCS hall. The Supplier

shall perform detail design of the local vents during the project execution and shall submit this to the Owner and Consultant for review and approval. All local vents shall be provided with flame arrestors, if required. The Supplier shall indicate the position, size and construction type of all tie-in point connections at the EMCS base frame.

All piping, filters and control valves required for the EM cooling system shall be included in the Scope of Supply and shall be installed on the EMCS skid in the Supplier workshop. If certain piping elements require installation tie-in to the station process piping, these shall be supplied loose for installation on Site. The Supplier shall design these and all required process interfaces to the station process piping during the project execution and shall submit the technical solution to the Owner and Consultant for review and approval.

All piping shall be realized and installed in such a way that no improper forces, e.g. resulting from temperature and pressure changes and no improper vibration can occur during the transportation, installation and operation of the EMCS. The piping shall, especially in regard to employed materials, comply with the requirements of Annex 1, Attachment 1.2. In case of tubing, high-quality stainless steel connection shall be used.

All pressure vessels, supplied either on-skid or off-skid (e. g. filter, finned-tube cooler etc.) shall be designed and tested in accordance with valid Czech regulations and Pressure Equipment Directive (PED) listed in Annex 1, Attachment 1.2.

When supplying piping, fittings and pressure vessels, the Supplier shall ensure that these are compliant with all relevant standards, norms and technical regulations listed in Annex 1, Attachment 1.2 and all certifications required by the Owner and third parties and/or authorities are included in the Scope of Supply.

4.8.4 Coating and Corrosion Protection

4.8.4.1 Coating

The EMCS shall be provided with coating, whenever meaningful and necessary. This shall apply also for thermally insulated connections. The Supplier shall refer to the Owner standards for coating and painting for details on the requirements for coating and painting. The colour to be applied will be communicated during project execution.

The following shall be considered as a minimum:

- Surface preparation shall comply with the requirements of EN ISO 12944 – part 4 “Preparation and testing of surfaces” - degree of derusting Sa 2 1/2,
- Sandblasting shall be applied at an air moisture lower than 85 %,
- The maximum throatiness should not exceed half of the primer coat’s layer thickness,

- The primer coat must be carried out in a closed room within 12 hours after the sandblasting (zinc-abundant and silicone coatings within 5 hours)
- The aluminium percentage should be < 25 %
- The overall film must be at least 150 µm thick,
- Testing of the dried film thickness is to be carried out with a non-destructive device like “Mikrotest” or similar.

4.8.4.2 Corrosion Protection with Zinc Coating

The Supplier shall provide corrosion protection with zinc coating for the following steel constructions as a minimum:

- frameworks
- operating platforms
- pipe - support etc.

The Supplier shall consider all relevant Owner specifications (and technical conditions) and requirements as per applicable international and Czech Standards and Regulations.

4.8.4.3 Thermal Insulation

The maximum surface temperature of the thermal insulation shall not exceed 60°C. All thermal insulations and contact protections foreseen for hot components shall be easily removable. All electric connections shall extend beyond the thermal insulation and shall provide for easy access. All cables shall be the laid outside the insulation.

4.8.5 Packaging and Transport

The Supplier is responsible for proper packaging of the parts delivered to Site as well as for the transport to the installation Site, unload, transport to point of usage.

5 FACTORY INSPECTION AND TESTING

5.1 General Information

Factory inspection and testing of the CU shall be carried out according to API 617 and the requirements listed herein.

The Owner has the right to witness all factory inspections and testing. The number of factory inspections and testing to be carried out in the presence of the Owner as well as the extend of EMPOYER's or his representative participation to testing shall be defined in the Annex 1, Attachment 1.22.8 and shall be submitted to the Owner for review and approval as required in Annex 1, Attachment 1.3.

The Supplier shall notify the Owner at least 10 days before the fixed day for the test.

The Owner or his representative shall have free accessibility to the quality management programmes of the Supplier.

All factory certificates issued according to EN 10204 3.2, sub deliverers' specifications, heat treatment protocol, QA protocols as well as the final CU tolerances shall be kept for at least 10 years and, if requested, put at Owner's disposal.

The Supplier shall include the Inspection and Test Plan in Annex 1 Attachment 1.22.8.

5.2 Non-Destructive Testing (NDT)

The Supplier shall include in Annex 1, Attachment 1.22.8 all non-destructive material testing. The non-destructive material testing shall include the following parts as a minimum:

- Casting (only steel casting is allowed)
- Shafts
- CU impellers
- Weld seams of pressure vessels and high pressure piping as specified in chapter 4.2.13.

All welds shall be subjected to 100% visual examination and surface crack detection.

Long seam and circumferential welds of pressure piping and pressure vessels shall be tested to the following extent:

- minimum 100% RT or
- minimum 100% UT

Nozzles and nozzle welds shall be subjected to 100% UT.

All Non-Destructive Testing shall be performed as per standard API 617.

The Supplier shall consider the following requirements if the CU impellers are forged and welded:

- NDT of welds shall follow the requirements listed herein above
- The load in one direction or another must not exceed the minimum yield strength with more than 65 % at maximum rotation speed and operations temperature.
- The material must have certificates documenting the composition, hardness test and ultrasonic test,
- Moreover, specimens from the forged piece should undergo the tensile and notch tests
- After the overspeed test with 115 % of the nominal rotation speed a test of the impeller with dye penetration procedure shall be performed

5.3 Hydrostatic test

The water pressure test shall be carried out for the following parts:

- All pressure components of the CU with test pressure=1,45 x 73,5 and as required in the standard API 617
- High-pressure piping as required per PED,
- All pressure vessel according to the European Pressure Vessel Directive PED 2014/68/EU,
- All water pressure testing shall be certified by an independent third party expert, as per EN 10204 3.2.

5.4 Testing of EMCS components

The following tests shall be carried out in Supplier's or OEM´s factory:

- Mechanical running test (no load) of the CU, magnetic bearings cabinet, coupling, instrumentation as per standard API 617; shall be witnessed by the Owner,
- Factory aerodynamic test of the CU according to PTC 10 Type 2. All guarantee operating points listed in Annex 1, Attachment 1.9 and the CU operating map limitation lines including the surge limit for three different rotation speeds shall be tested. The results shall be documented in the test report of the CU performance test. Factory aerodynamic test will be witnessed by the Owner,
- FAT of the UCS; shall include all control cabinets of EMCS and magnetic bearings; shall include testing of all communication interfaces to the SCS and to equipment

supplied by others; shall include I/O testing; the FAT will be witnessed by the Owner,

- FAT of VSD including accessories (full-load test); shall include verification of VSD efficiency; the FAT will be witnessed by the Owner
- FAT of EM (full-load test); shall include verification of EM performance /efficiency as per IEC 60034-2-1; the FAT will be witnessed by the Owner,
- FAT of VSD Transformer, incl. partial discharge test; the Fat will be witnessed by the Owner,
- FAT of MCCs; the FAT will be witnessed by the Owner,
- FAT of all cooling systems (EM, VSD),

The Supplier shall prepare 1 month before starting of each test FAT procedure and acceptance test criteria complying with Inspection and Testing Plan. In particular, the procedure for the measurements being part of the performance tests shall be described in detail. This FAT procedure is subject to the Owner and Consultant approval.

6 PACKING AND TRANSPORTATION

The objective of this chapter is to specify the minimum requirements and procedures related to protection of material and equipment during the air transport, maritime transport, road transport and storage at Site. The material shall be in any case prepared for transport in such a way as to withstand the multiple handling, storage, exposure to rain, salty water impact and external storage for the minimum period of one year.

The Supplier shall be held fully responsible for any damage or loss of goods due to the following reasons:

- inadequate and/or inappropriate packing into containers
- inadequate and/or inappropriate packing
- inadequate and/or inappropriate labelling and/or tagging
- inadequate and/or inappropriate documentation distribution

The packing methods used shall be appropriate also for the extended storage at Site under the environmental conditions specified in chapter 2.3. If it is assumed that the time of storage exceeds six months due to reasons on the Owner's side, the Owner will notify the Supplier.

Each transport container shall contain full lists of packages in English and Czech language, which shall enable to unpack and sort the received equipment. Each part of the equipment shall be sufficiently labelled so that it can be matched to the transportation documents.

The Supplier shall not pack, load and/or transport the Equipment to the Site prior to the Ready for Delivery Certificate being issued by the Owner with respect to the Equipment (or relevant part thereof). The transport of each piece of equipment shall be notified to the Owner sufficiently in advance.

7 INSTALLATION AT SITE

7.1 Site Installation of the complete Scope of Supply (Base Scope)

The Supplier shall perform the site installation of the complete Scope of Supply including mechanical, electrical and I&C equipment as defined in chapter 3.

For installation of the complete Scope of Supply, the Supplier shall provide own site storage infrastructure if the equipment must be stored after arrival on site and prior to installation. The Supplier shall consider storage in the own facilities for a period of three (3) months and shall include in the offer the price adder for storage periods exceeding three months. The final location where the mechanical, electrical and I&C equipment must be installed is shown in Annex 1, Attachment 1.20 and Attachment 1.24.

The site coordination for the site installation activities will be done by the station main contractor (EPC). The Supplier shall coordinate his working aspects with the EPC Contractor accordingly.

The HSE Manager of the construction site will be a nominated person of the main contractor. Supplier shall organized and coordinate his HSE activities with the HSE Manager and where and when required shall abide by decisions made by the HSE Manager related to HSE aspects.

7.2 Supervision for Site Installation (base scope)

The Supplier shall include in the base scope the supervision of site installation of all equipment included in the Scope of Supply as defined in chapter 3.

8 COMMISSIONING, PERFORMANCE TESTS

8.1 Mechanical Completion COMMISIONING

The Supplier shall inform the Owner in writing as soon as the assembling, installation and test activities are completed and the complete equipment is set up and tested without gas, inclusive loop and functions test in the system.

At this point the Supplier shall have the following documentation ready for submission to the Consultant and Owner:

- Reports and certificates of all factory tests
- Reports certificates, and any other documents required by the Authorities and Notified Body
- Site QA/QC reports (in original)

- Operating and maintenance manuals
- Certificates for all E- and I&C equipment installed in hazardous areas, including a relevant list
- All other documents, drawings, tables, lists, test protocols etc. which were produced in connection with the inspection and tests performed on site (e.g. loop test certificates, certificates for compressor connection to the station process piping)

After a written notification from the Supplier, the Owner and the Consultant will:

- verify the completeness of the installation work,
- run simulations for the functions of the safety systems,
- verify including cooperation and check at Site for I/O signals from/to station control system (SCS) and to all other systems which communicate with the UCS. The Supplier shall ensure qualified person for this activities at Site. The Owner assumes at least 10 working days for one EMCS; in total 20 days.
- verify the completeness of the documentation.

After the conclusion that the assembly, test and installation work is completed and all necessary documentation is available, a Protocol (certificate) on the mechanical completion will be set up. At this point the CS is ready for pressurisation with process gas. After gas filling, the Supplier shall continue with the commissioning activities according to the agreed program. The Supplier shall prepare the program for the subsequent commissioning activities for approval 3 months prior hot commissioning (first start of EMCS) announcement at latest and shall submit this to the Consultant and Owner. When all inspections and tests are completed, the Supplier shall inform the Owner in writing that he is ready for the test runs.

The Supplier shall bring all tools required for unloading, unpacking, storage/ removal of preservations, grouting, chemical cleaning / flushing, field installation and assembly, as well as for Start-up and commissioning.

8.2 Test Runs, Reliability Test, Availability Test

After the receipt of the written notification that the EMCS is ready for putting into operation, the Owner has the right if required to ask for improvements which in his opinion are indispensable for the safety of the Site.

During the first phase of the Test-Runs, the Supplier shall make all controls and fine adjustments.

The Test Runs are to be performed as follows:

- At the beginning 10 starts and stops of the EMCS at maximum pressure ratio have to be performed, out of which at least 9 have to take place without alarms or shut-downs,
- One additional start has to be performed from the condition with equal suction and discharge pressure,
- In the next step the EMCS shall be started and kept in operation for an entire week. In this period the EMCS must run completely fault-free automatically controlled. It must be possible to carry out further starts and stops, to adjust load and rotation speed range within the complete operating envelope, test the correct functionality of the safety arrangements, make fine adjustments and control the surge valve,
- the EMCS must manage the supply voltage drop out on the 110 kV side with min. duration of 1s (transition to the generator-mode of EM – kinetic back-up of VSD)
- the selected tests will be performed locally from UCS and remotely from SCS and from Control system of the Owner in Prague (DN4G),
- the Supplier shall prepare 3 month before starting of hot commissioning each test SAT procedure and acceptance test criteria. This SAT procedure is subject of the Owner and Consultant approval.

Further on the EMCS shall be regularly checked in order to detect malfunctions (vibrations in the piping etc.).

At the end of the above listed tests, the 72 hours test (Reliability Test) shall be started in the presence of the Owner or his representative.

The test begins with five starts and four stops at maximum pressure ratio. At the end of the 72 hours, four starts and five stops shall be performed. During the start and stop procedures possible tests of the safety systems of the EMCS can be carried out (e.g. shut-down after a simulated gas detection alarm). The following acceptance criteria apply for the successful completion of the 72 hours test:

- the Supplier shall perform 72 hours test based on the approved test procedure,
- the 72 hours test shall be completed without equipment malfunctions, failures, alarms or trips.

If – during the 72 hours test – the EMCS suffers malfunctions, alarms or trips, the Supplier shall mitigate the cause of the respective failure and then repeat the test from the beginning. The costs for electrical power required for the 72 hours test shall be as per following:

- the Owner will cover the costs for the electrical power consumption for the first 72 hours test-run,

- if the first 72 hours test fails because of malfunctions, alarms or trips associated with the equipment included in the Supplier scope and the 72 hours test must be repeated, then the Supplier shall cover the costs for electrical power of the subsequent 72 hours test(s).

As specified in Attachment 1.3, the Supplier shall submit the 72h test procedure to the Owner and Consultant for review and approval, the program for the 72 hours test shall be issued based on the requirements stated in the this chapter.

After successful completion of the 72 hours test, the 600 hours test shall be commenced in the presence of the Owner. The Supplier shall prepare the program of the 600 hours test and shall submit this to the Owner and Consultant for review and approval. The Owner reserves the right to change the test program for the 600 hours test depending on the transport requirements of the CS or include additional testing scope in the testing program. The Supplier shall plan the Performance Tests as per chapter 8.3.1 during the 600 hours test.

The 72 and 600 hours tests require that the Supplier representative shall be available during normal daily working hours and outside normal working hours in readiness mode. Outside normal working hours, the Supplier representative shall be available on the CS on request no later than 1 hour from time of request.

8.3 Measurement of the Guarantee Parameters and Availability Tests

8.3.1 Performance Test

The purpose of the Performance Test is to verify – for all EMCS supplied – the guarantee values for the electrical power consumption specified in Annex 1, Attachment 1.9 and to determine the compressor operating envelope. The applicable tolerance for increased electric power requirements of the guarantee operating points listed in Annex 1, Attachment 1.9 is 0%.

During the 600 hours test period, the Supplier shall verify that the defined guarantee values specified in Annex 1, Attachment 1.9 are fulfilled for all EMCS supplied. The performance tests will be carried out by the Supplier based on the approved Performance Test Procedure.

The Performance Test of each EMCS will be organized mainly as per the following principles:

- as specified in Annex 1, Attachment 1.3, the Supplier shall prepare the Performance Test procedure and submit this to the Owner and Consultant for review and approval. The Performance Test Procedure shall include all measurement instrumentation, measurement parameters, calculation methodology and formulas required for evaluating the Performance Test results.
- the Owner will provide all instrumentation which is required for the Performance Test as per the approved Performance Test procedure. This will including the flow measurement (the location of the US flow measurement is shown in Attachment 1.14) as well as the pressure and temperature instrumentation to be installed in the CU suction and discharge piping as required by ASME PTC 10,
- if required, the Supplier shall provide all instrumentation for measuring the process parameters of the EM cooling gas; the Supplier shall measure all required data,
- The Owner will measure all process data required for evaluating the guarantee values as per approved Performance Test procedure,
- The Owner will submit to the Supplier all process data which is required for evaluating the guarantee parameters,
- The Owner will supply the process gas composition required for the site Performance Test,
- The Supplier shall evaluate the data measured during the Performance Test, elaborate the Performance Test report and submit this to the Owner for review and approval; the report shall include the evaluation results which shall prove the compliance with the guarantee values specified in Annex 1, Attachment 1.9 for all supplied EMCS,
- The on-site Performance Tests shall be carried out as per PTC 10 Type 1 for each EMCS,

If, according to the results of the Performance Test, modifications are necessary, these shall be implemented by Supplier immediately. After a positive end of the contractual defined Performance Tests, further operation points shall run in order to determine the "as built" performance maps of each EMCS. It is the responsibility of the Supplier to elaborate the “as-built” performance maps for each EMCS and submit these to the Owner.

8.3.2 Noise Emission Tests

The verification of the guarantee values for noise shall be performed by an independent third party accepted by the Owner and the Supplier. The third party shall prepare the noise measurement report. Third party will be ordered by the Owner. The Supplier shall assist and operate the equipment in the Scope of Supply during the whole test.

The measurement of the noise emissions shall take place in accordance to valid CSN standards and Czech regulations.

The measurement and report is not in Scope of Supply. If the guarantee values (refer to Annex 1, Attachment 1.9) are not met, the Supplier shall apply measures to comply with the guarantee values and compensate addition costs related to extra tests required.

8.3.3 Guarantee Parameters of Harmonic Distortion

24-pulse VSD harmonic current distortion limits in percentage of full load current according to IEEE Std 519-2014 and EN 61002-2-4 shall be fulfilled by the Supplier.

Moreover, the Supplier has to guarantee harmonic distortion limits at the PCC (Point of Common Coupling) according to IEEE Std 519-2014.

Measurement of current and voltage harmonics distortion as defined in IEEE Std 519, shall be performed under the following conditions:

- operation of one (1) EMCS
- simultaneous / parallel operation of two (2) EMCS

The limits for harmonic currents and harmonic voltages given in the standard IEEE 519 are minimum requirements. All additional requirements according to applicable international or national standards and norms as well as conditions imposed by the technical conditions of the local network operator have to be fulfilled by the Supplier.

Measurements of current and voltage harmonics distortion prior and after installation of the EMCS has to be carried out by the Supplier in order to proof compliance with the applicable standards, norms and network condition requirement of local network operator.

8.3.4 Guarantee Parameters for Availability

The Availability of each EMCS incl. all auxiliary equipment shall be min. 97% @ 364 days per year. The Supplier is required to provide in the Offer the Guaranteed Availability value of the EMCS and detailed conditions for its fulfilment. The Availability of the EMCS shall be evaluated after 10,000 operating hours or a period of two years starting from unit release for operation whichever occurs first.

8.3.4.1 Definitions for Availability

The Availability of the EMCS represents the percentage of time when the unit is capable of operating, i.e. it is not on a forced or scheduled outage:

AVAILABILITY (%) = 100% - FOF – MOF – POF

where FOF is the Forced Outage Factor, MOF is the Maintenance Outage Factor and POF is the Planned Outage Factor.

The Forced Outage Factor (FOF) of the EMCS represents the percentage of time when the unit is inoperable due to an event that has been assigned as forced outage unavailability:

$$FOF\ (\%) = (FOH/PH) * 100\%$$

where FOH is the Forced Outage Hours and PH is the reference Period Hours.

The Maintenance Outage Factor (MOF) of the EMCS represents the percentage of time when the unit is inoperable due to an event that has been assigned as unscheduled maintenance unavailability:

$$MOF\ (\%) = (MUH/PH) * 100\%$$

where MUH is the unscheduled Maintenance Outage Hours and PH is the reference Period Hours.

The Planned Outage Factor (POF) represents the percentage of time when the unit is inoperable due to an event that has been assigned as scheduled maintenance unavailability:

$$POF\ (\%) = (MSH/PH) * 100\%$$

where MSH is the scheduled Maintenance Outage hours and PH is the reference Period Hours.

For the Availability evaluation specified in chapter 8.3.4, the reference Period Hours PH shall be 10,000 hours or a period of two years starting from unit release for operation whichever occurs first.

8.3.5 Availability Test at the End of the Guarantee Period

The availability test shall be performed by the Supplier directly before the expiration of the guarantee period. The guarantee period for the Scope of Supply is specified in the Contract.

The availability test shall include the following:

- Verification of the EMCS availability as specified in chapter 8.3.4,
- Performance Test as specified in chapter 8.3.1, where the data of the original Performance Test conducted shall be verified,
- Measurements of the power network quality as specified in chapter 4.1.5.5.3, where again the data as originally verified in the tests after Take-over shall be verified.

As specified in Attachment 1.3, the Supplier shall submit the test procedure for the Availability Test to the Owner and Consultant for review and approval.

9 DOCUMENTATION

9.1 Required documentation in Supplier's Offer

The Supplier shall include in Offer all data required in Annex 1, Attachment 1.3. Furthermore, the Supplier shall furnish in Offer the following data as required in Annex 1, Attachment 1.22:

- Utility Consumption List as specified in chapter 9.2.2.6 and in Annex 1 Attachment 1.22.1,
- Harmonic Study as specified in Annex 1, Attachment 1.3,
- Filled in data sheets as per Annex 1, Attachment 1.22.2, Attachment 1.22.6,
- CU performance maps as specified in chapter 4.2.12, in Annex 1, Attachment 1.22.7,
- Residual heat load list in Annex 1 Attachment 1.22.3,
- List of Comments, Exceptions and Deviations in Annex 1 Attachment 1.22.4,
- UCS control architecture as specified in chapter 4.5.4, in Annex 1, Attachment 1.22.9
- Communications Block Diagram as specified in chapter 4.5.13, in Annex 1 Attachment 1.22.12,
- Electric Load List in Annex 1, Attachment 1.7,
- Compressor Data Sheet API 617 in Annex 1, Attachment 1.5,
- Performance Guarantees for Electric Motor Compressor Set in Annex 1, Attachment 1.9,
- Preliminary basic frame plan over the EMCS with all Owner connections (mechanical and electrical utilities) in Annex 1 Attachment 1.22.16,
- EMCS P&ID's in Annex 1 Attachment 1.22.13,
- Manufacturing, factory testing, delivery and installation plan in Annex 1, Attachment 1.22.15,
- Equipment maintenance drawings in Annex 1, Attachment 1.22.11,
- Preliminary Inspection and Test Plan (ITP) in Annex 1, Attachment 1.22.8
- Maintenance and regular overhaul schedules in Annex 1, Attachment 1.22.10.

The Supplier shall refer to the CONTRACT and technical documents included in Annex 1 for further requirements. The minimum requirements for the form and scope for all documentation including documentation for project execution are specified in Annex 1, chapter 9 and Annex 1, Attachment 1.2 and Attachment 1.3.

9.2 Documentation elaboration

9.2.1 General requirements

The Supplier Document Requirement List attached in Annex 1, Attachment 1.3 specifies all documents and submission dates which shall be met by the Supplier during the project execution. Based on the requirements listed in Annex 1, Attachment 1.3, the Supplier shall prepare a project document list, which shall list all document required during the project execution including the number of copies and submission dates.

Each document shall be identified based on the following minimum information:

- Purchase Order number
- Project name
- Document number and title as per Owner document numbering system (Annex 1, Attachment 1.4),
- Document status,
- Revision history table,
- The As-Built revision of documents shall include also the denomination “As-Built” beside the alphanumeric revision number,
- Number of copies (to be defined later),
- Planned and actual document submission date.

All documents shall be issued by the Supplier with considering the Owner’s requirements listed in this specification and in Annex 1, Attachment 1.4. All documents issued by the Supplier shall be as per the project templates submitted in Annex 1, Attachment 1.4.

For each drawing which consists of more than one page the project title block shall be applied on the cover sheet (cover letter), however on the following pages the title block of the Supplier may be used. The drawing shall have a table of contents of the drawing reflecting all sub-drawings, with the individual revision index.

Changes made in subsequent revisions of drawings shall be clearly marked up with “revision clouds”.

Changes made in subsequent revisions of text documents shall be clearly marked with revision bars located on the left side of the text block.

Changes made in subsequent revisions of excel tables shall be clearly marked with colors.

The documents shall be transmitted in electronic form by e-mail prior being sent by post (hardcopy). During the project execution, the Supplier shall submit all documents by using the document exchange platform provided by the Supplier or Owner / Consultant.

Supplier may suggest the usage of Supplier's document management system and shall provide a respective documentation with the offer. A decision on which document management system shall be considered shall be made during the clarifications meetings,

The Supplier's project documentation shall be generated using:

- AutoCAD™ (drawings),
- Microsoft Word™,
- Adobe Acrobat Writer™ (documents),
- Microsoft Excel™
- Microsoft Access™ and
- Microsoft Project™ (time schedules)

Upon request, the Supplier shall provide all documents in digital form as DXF-files for drawings and Microsoft Office for Text and lists.

Electronic native files submitted to Owner and Consultant shall be always accompanied by 'pdf' or other agreed format copies to assure integrity and traceability of the original native files.

The documents in the pdf format shall enable text searching (OCR).

The Owner and Consultant will put all reasonable effort in checking documents submitted by the Supplier without any delay. The Owner and Consultant will review the documents submitted by the Supplier within 2 weeks (10 working days) starting from the date of receive.

The documentation rejected by the Owner and sent back to the Supplier shall be updated with considering all comments submitted and shall be re-submitted to the Owner within 2 weeks (10 working days).

The documentation may only be approved by the Owner if no obvious errors are discernible and if documentation is complete. The Supplier shall not submit during the project execution documentation marked as "Preliminary" or "Typical" to the Owner. On inquiring about approval, the Supplier shall assure the Owner that the documentation has been compiled in compliance with the terms and conditions specified herein (Annex 1) and in the CONTRACT, including the subsequently incorporated amendment requirements. Approval shall not release the Supplier from any subsequent updating or correction obligation at no extra cost for the Owner.

The Supplier can include preliminary or typical documents, drawings and schematics only in the Offer provided these are marked as such clearly.

All documents required from the Supplier as per Annex 1, Attachment 1.3 shall contain the counter-reference of all signals or cables, even if the counter-terminals are not included in the Scope of Supply (supplied and installed by others). The Supplier shall incorporate the cable number, core identifier, counter terminal identifier (including switchgear identifier, terminal strip identifier and terminal number) in their documents. The Supplier shall include in his documents all required cross-references to all relevant documents including documents of the Owner. The Supplier documentation shall include as well all counter-references to station process piping including piping of the EMCS anti-surge loop. The Supplier is responsible for obtaining all necessary information.

With regard to the applicable legislation, within the project phases it is required to elaborate and supply all and any required documentation for project:

- Design documentation for issue of the Building Permit or Building Notification (DSP),
- Detailed Engineering Documentation,
- Documentation required for Site acceptance by the responsible authorities,
- As-built documentation as required in Annex 1, Attachment 1.3.

The documents required as per Annex 1, Attachment 1.3 shall include – where possible – all battery limits for the Scope of Supply as defined in chapter 3 and Annex 1, Attachment 1.10, Attachment 1.11 and Attachment 1.21. The battery limits shall be shown in the following documentation as a minimum:

- Mechanical interface list / tie-in schedule,
- General arrangement drawings,
- General layout drawings,
- Piping and instrumentation diagrams (P&IDs),
- Instrumentation loop diagrams,
- LV and MV electrical wiring diagrams,
- LV and MV single line diagrams,
- Cable block diagrams / interconnection schedule,
- Cable lists,
- Hook-up drawings,
- EMCS control architectures.

9.2.2 Detailed Documentation Requirements

The Supplier shall consider the following detailed requirements for the preparation of all documentation as per Annex 1, Attachment 1.3.

9.2.2.1 General Arrangement Drawings and General Layout Drawings

The general arrangement drawings are required for all equipment included in the Scope of Supply (EM and CU skid, VSD cabinets, UCP cabinets, VSD Transformers, outdoor heat exchangers, package and field instrumentation, package and field valves, interconnecting piping, etc.) which shall be installed or connected to the Owner's pipework / foundations or cabling.

The general layout drawings are required to indicate the overall location of equipment. The general layout drawings shall include all requirements for maintenance space as well as the clearance space for the doors of cabinets and junction boxes.

The general arrangement drawings and the layout drawings shall show all equipment included in the Scope of Supply with considering the equipment corresponding to one EMCS as well as the total number of EMCS supplied.

The general arrangement drawings shall indicate the following as a minimum:

- Envelope dimensions,
- Access, withdrawal and lay-down maintenance space requirements,
- Mechanical, electrical, I&C and civil termination and interface points (numbered as per PROJET tagging system according to Annex 1, Attachment 1.18),
- List – in tabular form – with all mechanical, electrical, I&C and civil termination and interface points with including the PROJECT TAG numbers, location with reference to a common axis reference system, scope, dimension, number, size, materials, rating, type, operating medium; the termination and interface points shall include the following as a minimum: CU process flange connections suction and discharge, EM cooling gas return line tie-in, instrument air flange connections at EMCS skid edge, drain flange connections at EMCS skid edge, earthing bosses, junction boxes (LV, MV, I&C), etc.,
- Overall weights, maintenance weights and transportation weights for major components,
- Lifting points and centre of gravity of skid and components and overall centre of gravity with skid and components assembled to be shown,
- Lifting drawings,
- Assembly drawings including list of components,
- Acceptance flange loads based on relevant design standard,
- Acceptance alignment tolerances for all flanged interfaces,
- Cross reference with detail drawings for Document Number, Title and Views,
- Static and dynamic forces acting on the foundation during all operating and test conditions,

- For control valves and similar, envelope drawings and/or tables showing flange sizes and ratings, face to face dimensions and maximum envelope sizes shall be provided,
- Earthing lugs, electrical trace heating and cathodic protection anodes, if any.

In the case the Scope of Supply includes packages / skids with several different types of equipment, the above information shall be supplied for each individual package or skid as appropriate; each package or skid shall be separately identified and an overall general layout drawing showing the mechanical, electrical and I&C interconnections between each individual package / skid. In this case the Supplier shall group and submit all drawings as a set.

The following data shall be furnished additionally for all packages and skids included in the Scope of Supply:

- General arrangement and overall dimensions of package / skid,
- On-skid mechanical equipment including PROJECT TAG numbers,
- On-skid electrical equipment and electrical junction boxes including PROJECT TAG numbers,
- On-skid instrumentation and instrumentation junction boxes including PROJECT TAG numbers,
- All on-skid cable routes including cable trays,
- Identification of all major on-skid components with PROJECT TAG numbers,
- Foundation bolt location / orientation,
- Foundation bolt diameter,
- Base plate thickness,
- Special Supplier anchor bolt requirements e.g. shape, material, pre-tensioning, etc.,
- Minimum grout thickness,
- Special grout requirements of the Supplier, e.g. epoxy, precision non-shrinking, fully-filled base plate etc.,
- Limiting dimensions for plinths and other structural elements where critical for clearances around piping, nozzles and the like,
- Special maintenance requirements,
- Requirements for cable trenches at package / skid limits for all interconnecting cabling,
- Requirements for drain systems at package / skid limits,

- All on-skid access platforms including hand rails.

The Supplier shall refer to the following tabulations for further specific information required:

- Total operating weight of the EMCS compressor skid (including CU, EM, EM cooling system, auxiliary equipment, baseplate),
- VSD weight,
- VSD transformer weight,
- Weight of all auxiliary equipment including outdoor heat exchangers, anti-surge valves, etc.,
- Centre of gravity of the EMCS compressor skid (dry and wet) in x, y, z directions (in table form)
- Centre of gravity of all auxiliary equipment in x, y, z directions (in table form)
- Centre of gravity of the base frame in x, y, z directions (in table form)
- CU rotor weight and centre of gravity
- EM rotor weight and centre of gravity
- Centre of gravity of CU rotor in x, y, z directions (in table form)
- Centre of gravity of EM rotor in x, y, z directions (in table form)
- CU speed (rpm) or range of speeds
- EM speed (rpm) or range of speeds
- Magnitude, location and direction of specific static loads such as thermal, normal torque, short circuit torque and other EMCS operating loads
- Magnitude, location and direction of all dynamic unbalanced forces (transverse and vertical)
- Limits of differential deflection between two points on the frame, or allowable differential deflection of the bearings,
- Special alignment tolerances for supporting foundations / structures,
- Specific limits of dynamic amplitudes that could damage the EMCS at normal operating speed, or could shut-down the EMCS,
- Specific recommendations for the design and construction of EMCS foundation, if any,
- Maximum lifting weight and clearances for maintenance,
- Leveling screw plate requirements.

9.2.2.2 Equipment Foundation Interface Details

The design of all foundations required for the equipment included in the Scope of Supply is not in Supplier's responsibility; however the Supplier shall submit foundations templates as well as foundation interface details including load lists which shall include the following information as a minimum:

- Number and location of all base frame anchor bolts including size, materials, pre-tensioning requirements, grouting requirements and detail drawings, etc.,
- Number and location of all base frame levelling bolts including size and materials,
- Requirements for levelling pads including location, size, materials, etc.,
- Table with static and dynamic loads for all anchoring points; these shall consider the following type of loads: dead loads, wind loads (equipment installed outdoors), live loads, dynamic loads during operation, short-circuit loads, etc.,
- Foundation template drawings including construction requirements for all equipment included in the Scope of Supply,
- Special requirements for foundation design.

9.2.2.3 3D model of EMCS, all auxiliary systems, bulky spare parts

The 3D model (native file) of the EMCS including auxiliary equipment, (bulky) Capital Spares shall include the following as a minimum:

- All major on-skid components,
- All mechanical, electrical, I&C and civil interfaces,
- Physical outer boundaries including lifting supports, transportation and storage dollies,
- Dimensioning and positioning of all utility connections at skid / equipment limits,
- Detailed representation with dimensioning and positioning of all foundation anchoring,
- Obstruction volumes due to requirements for maintenance space.

Shell 3D model of equipment / skids / packages without internal components is acceptable.

9.2.2.4 Equipment Data Sheets

The Supplier shall provide equipment data sheets as required in Annex 1, Attachment 1.3.

The Supplier shall furnish ISA Data Sheets for valves and instrumentation for all instruments included in the Scope of Supply. These shall include project Tag-numbers, instrument OEM, instrument description, model number, measurement domain and

precision, IP class, electrical and process connections, explosion protection. The Data Sheets shall meet the ISA Standard S20 format. Where the same instrument data applies to several Tag-numbers, then these Tag-numbers may be listed on one sheet.

Material Safety Data Sheets (MSDS) shall be provided for all chemicals (preservatives, sealants, coolant, lubricants and chemicals for water wash) or any materials requiring careful handling. An MSDS for each substance shall be prepared in accordance with the ASCC document “National Code of Practice for the Preparation of Material Safety Data Sheets” 2nd Edition [NOHSC: 2011 (2003)].

9.2.2.5 Calculation Reports

The Supplier shall submit the train (EMCS) lateral rotor-dynamic analysis report. Lateral critical analysis calculations shall determine the natural frequency of the shaft assembly and identify all excitation frequencies and harmonic components relative to operating speed range of the EMCS. The analysis and results shall be presented in graphical and narrative form, and shall include the following as a minimum:

- Critical Speed Analysis
- Undamped Critical Speed Map
- Damped Unbalance Response Analysis
- API Stability Analysis including LOG DEC
- Method used
- Graphic display of bearing and support stiffness and its effect on critical speeds
- Graphic display of rotor response to unbalance
- Stiffness and damping coefficients
- Journal bearing static loads
- Tilt pad bearing pad geometry and configuration

The Supplier shall submit train torsional analysis report for the entire EM and CU including couplings (train) as per API 617. Calculations shall clearly indicate number and details of finite elements that the system has been divided into for the calculation, and a table of stiffness and inertia for each element shall be included. The results shall be presented in graphical and narrative form, and shall include the following as a minimum:

- Method used
- Graphic display of mass elastic system
- Tabulation identifying the mass moment torsional stiffness for each component in the mass elastic system
- Graphic display of exciting sources (revolutions per minute)

- Graphic display of torsional critical speeds and deflections (mode shaped diagrams).

The Supplier shall submit the CU performance curves and data as required in chapter 4.2.12.

The Supplier shall submit the EM performance curves (power and torque vs. speed) as per IEC 61800-4.

The Supplier shall submit start-up curves.

The Supplier shall perform stress analysis calculations for all interconnecting piping in scope and shall submit these to the Owner and Consultant for review and approval as specified in Annex 1, Attachment 1.3.

9.2.2.6 Utility Consumption List

The utility consumption list required in Annex 1, Attachment 1.22.1 shall list all utility consumptions required to start, operate (under all reasonable conditions/operating scenarios), and maintain the equipment included in the Scope of Supply. The list shall indicate the following as a minimum:

- Type of utility,
- Quantities,
- Duty consumption rates during start-up, continuous operation, stand-by, run-down, ESD, etc.,
- Pressures,
- Temperature,
- Flows.

The list shall include, instrument air, gas, nitrogen (if applicable), demineralised water, etc. as defined hereto in Annex 1.

9.2.2.7 Documentation for electrical equipment

The Supplier shall submit general layout drawings for all electrical equipment included in the Scope of Supply (EM, VSD cabinets, VSD Transformers, Low Voltage Switchgear Panel (MCC), all electrical and I&C cabinets including active magnetic bearing cabinets).

The Supplier shall submit disposition drawings for all electrical equipment included in the Scope of Supply. The electrical disposition drawings shall show the location of equipment in the compressor station buildings specified in Annex 1, Attachment 1.20.

The Supplier shall provide cable block diagrams for all electrical and I&C equipment included in the Scope of Supply as per Annex 1, Attachment 1.3. The cable block diagrams (electrical and I&C equipment, LV and MV cabling, I&C cabling) shall show

equipment arrangements and identification of termination points as well as all interconnecting cables (in single line format) between individual instruments, junction boxes, cabinets and panels including cable types (number of cores/pairs, and core size). The cable block diagrams shall list of all junction boxes with location as per Annex 1, Attachment 1.20. The junction boxes, cabinets, panels and cables shall be tagged as per the project tagging procedure (Annex 1, Attachment 1.18). The cable bock diagrams shall include all electrical, instrument and telecom interconnecting cables included in the Scope of Supply and shall consider the cables specific to one EMCS as well as the total number of EMCS supplied.

The Supplier shall submit electrical wiring diagrams and device outline drawings for all electrical equipment included in the Scope of Supply. The wiring diagrams shall include the battery limits, termination panels, PROJECT TAG-numbers, cable number, core identifier, reference drawings and shall cover all areas (field, junction boxes, cabinets, equipment rooms etc.). The wiring diagrams shall include all interconnections between equipment / packages included in Supplier's scope as well as all wiring connections between Supplier's scope and external systems (SCS, 22 kV MV switchgear, LV switchgear, etc.). The electrical wiring diagrams shall show the location of electrical equipment and cabling, i.e. location indoors and outdoors as per Annex 1, Attachment 1.20.

The wiring diagrams shall include the layout drawings of panel interiors and panel doors. The layout diagrams shall show the scaled location of such devices including:

- Front of panel layout clearly showing overall size and layout, with a table of instruments showing duty/label engraving/model number,
- Back of panel arrangement showing same data as front of panel,
- Construction drawing showing main dimensions hinging/opening of doors, door restraints, method of locking, plinths, stiffeners, hold down details (fully dimensioned) anti-vibration methods, materials, panel finish procedure and colours,
- Mimic/ annunciator drawing (where applicable),
- Terminal/ connection blocks,
- Wire ways,
- Power supplies,
- Bill of material,
- External cable entry locations and hubs.

The panel internal layout drawings shall show all lighting, cable entries and terminal strip locations, wiring trays, segregation of voltage level, IS and non-IS equipment, hydraulic, pneumatic layouts (where applicable), grounding points and power isolation.

The Supplier shall submit Single Line Diagrams for all electrical equipment included in the Scope of Supply as specified in Annex 1, Attachment 1.3. The Single Line Diagrams shall illustrate electrical circuits including representations of electrical power, and/or control circuits, electrical major components including functions and instrument control circuits, defining the relationships as following (as appropriate):

- Control systems
- Consumer ratings
- Switchgear/control gear ratings
- Busbar ratings
- Equipment descriptions and Tag-numbers
- Protection devices.

The Single Line Diagrams shall show all earthing requirements along with required conductor sizes.

The Supplier shall submit cable schedules / cable lists as per Annex 1, Attachment 1.3, for all electrical equipment included in the Scope of Supply. The cable schedules / cable lists shall include all electrical, instrument and telecom cables in Supplier's scope and shall consider the cables specific to one EMCS as well as the total number of EMCS supplied. The cable schedules / lists shall include the cables for each EMCS; even though the cables of EMCS 1 are of similar types with the cables of EMCS 2 and EMCS 3, the cable schedules / lists shall list the cables for EMCS 1, EMCS 2 and EMCS 3 separately. The cable lists shall include packaged / on-skid cabling as well as Site (off-package, field) cabling. The cable schedules / cable lists shall provide the following information for each cable as a minimum:

- Cable Project TAG number,
- Number of cores,
- Cable size, type and cross-section,
- Gland size and type,
- To and from location including the project specific TAG numbers for cabinets and junction boxes,
- Cable laying details , i.e. skid / off-skid, indoor / outdoor including scope for installation (factory packaged, site installation),
- Inter-connection diagram cross reference,
- Cable length, in meters (inter-connecting cables only),
- Voltage grade,
- Reference wiring diagram document number.

As specified in Annex 1, Attachment 1.3, the Supplier shall submit data sheets for all electrical equipment included in the Scope of Supply.

The Supplier shall issue the cable numbering / tagging for the electrical wiring diagrams, cables lists and cable block diagrams according to Owner indications and project standards (see Annex 1, Attachment 1.18).

The electrical load lists shall contain the following as a minimum (see Annex 1, Attachment 1.7):

- Type of electrical load,
- Service,
- Duty (continuous, emergency, standby, etc.),
- Power (normal, nameplate),
- Voltage, phase, frequency.

The Supplier shall submit all protection configuration/settings for all relays, control units and all other electrical equipment in scope at the latest 8 weeks prior to delivery.

The Supplier shall submit the Hazardous Area Classification Documentation as required in Annex 1, Attachment 1.3. This shall include the Hazardous Area Classification Report issued in accordance with IEC 60079.10.1. The Report shall include the following, as a minimum:

- Summary Narrative of the Hazardous Area Classification Report
- Definitions
- Industry Standards Reference List used to develop the Report
- Design Criteria including the following:
- Sources of Release with Estimated Release Rates (Refer to IEC 60079.10.1, Annex A)
- Ventilation Calculations to determine the Type of Zone Classification (Refer to IEC 60079.10.1, Annex B)
- Flammable Materials List and Characteristics per IEC 60079.10.1, Table C.1
- List of Sources of Release per IEC 60079.10.1, Table C.2
- Hazardous Area Classification Drawing showing location of classified Zones 1 or 2 using the Preferred Symbols for Hazardous Area Zones per IEC 60079.10.1, Figure C.1

9.2.2.8 Control and Instrumentation Documents

The Supplier shall submit instrumentation lists as required in Annex 1, Attachment 1.3. Instrument Lists/ Index shall detail all tagged instrument items for both packaged and field instruments and include the following as a minimum:

- Tag-number as per project requirements (Annex 1, Attachment 1.18)
- Instrument description (pressure switch, control valve, level gauge, etc.)
- Manufacturer's name
- Model number
- Service description (e.g., vessel low level, etc.)
- Instrument location or line (size/number/spec). Location Drawings shall show all tagged instrument items, local panels, and JBs in plan and elevation views.
- P&ID reference number
- Data sheet number
- Hook-up drawing reference
- Wiring diagram number
- Schematic drawing number
- Set point and range (including alarms and shut-down)
- Gland sizes

The Supplier shall provide instrumentation data sheets as required in Annex 1, Attachment 1.3. Instrument data sheets shall include packaged instruments as well as field instrumentation. The instrument data-sheets shall include the following information as a minimum:

- project tag-numbers as per Annex 1, Attachment 1.18,
- Manufacturer (OEM),
- Model number and description
- Size,
- Measurement range and precision,
- IP class,
- Electrical and process connections,
- Materials of construction,
- Certification details and explosion protection,
- Process data.

Specifications shall be provided for major instrument items, control and safety systems as well as the FFS.

The Supplier shall specify all installation materials (typically cable, glands, JBs, cable tray, tubing and fittings, and instrument valves).

Hook-up drawings (process, pneumatic and hydraulic, as applicable) shall be provided for each instrument installation type, with a list of all materials required for operation, installation and maintenance.

The Supplier shall provide instrumentation loop diagrams as required in Annex 1, Attachment 1.3. The instrumentation loop diagrams shall be issued for each electronic instrument showing interconnecting cables between instruments and associated junction box and/or cabinet, panel, with cable, core and terminal numbers identified. The instrumentation loop diagrams shall show the scope for instrumentation and cabling and shall include the location of equipment, i.e. indoor, outdoor as per Annex 1, Attachment 1.20. The core identifiers shall be those as ferruled on to the conductors. The equipment and cable numbering shall follow the project tagging numbering system as per Annex 1, Attachment 1.18. Each loop shall be shown on a separate sheet. The Supplier shall submit instrument the loop diagrams for the package instrumentation as well as for the Site instrumentation.

The Supplier shall submit instrumentation loop diagrams also for the ESD system F&G and EMCS protection system incl. magnetic bearing vibration and temperature monitoring system.

Drawings shall show segregation between IS and Non-IS signals together with cable and/or core screen terminations. Inputs and outputs shall be identified using the project Tag-numbers. For ease of identification cable destinations shall be shown with any cross-reference drawing numbers.

The Supplier shall provide cable block diagrams for instrumentation loops as required in Annex 1, Attachment 1.3. The Supplier shall include the instrumentation cable block diagrams in the electrical cable block diagrams (chapter 9.2.2.7).

Functional Schematic Diagrams shall include Control System Topology Diagrams, Shutdown System Diagrams and Logic Diagrams as a minimum. The description of the Control System shall address:

- Modes of operation
- Basis for selection of the mode of operation
- Operator dependent actions
- Health and safety responsibilities
- Start-up, shut-down abnormal operating condition and special maintenance operations

- Input, output, permissive signals, including internal logic signals to accomplish start-up, shutdown, etc.
- Information displayed and operator interface
- Listing of pre-alarm and shut-down alarm trip requirements and the failure mode of all valves and equipment must be clearly indicated
- Shall clearly indicate switch room equipment, control room equipment and types of signal to and from, with interface information clearly stated

Functional Schematic Diagrams shall include the list of all alarms and shut-downs with set values for EMCS, VSD and all auxiliary equipment.

The cause and effect charts shall show, in matrix form, all shutdown (including fire and gas) requirements associated with Supplier equipment.

The Supplier shall submit control system I/O List/ Signal List. The I/O List shall include all signals provided or required by the Supplier for the system to effectively work as specified in P&ID's, logic diagrams and cause and effect drawings. The I/O List is not supposed to be a software list of signals (The Modbus List should contain this information).

The System I/O Schedule shall identify all I/O signals within packages in Supplier's scope, between systems/ packages in Supplier's scope and between systems in Supplier scope and project systems (ex. SCS). The schedule shall identify signal type and voltage level as a minimum and serial link interface data if applicable. The I/O List shall include the following as a minimum:

- Instrument or signal Tag-number (project specific)
- Descriptions
- P&ID or related document
- Range (general and calibrated)
- Set point(s) for alarm and shut-down (if available)
- Signal origin/destination (from/to)
- Type of signal (Analog Input / Analog output, discrete input, discrete output, etc.).
- Other data relevant to the configuration of the signal (receiving device, I/O card, etc. if required).

The Supplier shall submit instrumentation and control interface lists. These shall provide details of PLC type, device address, all jumper settings, cable and connector types with port pin definitions, interface type, protocol, baud rate and parity bit and data bit. All alarms, analogue variables, diagnostic and status registers, permitted remote commands and timer accumulators shall be stored in contiguous registers and be available for

transmission to SCS. For this data the following details shall be supplied as a minimum for each signal.

- Tag-numbers as per Annex 1, Attachment 1.18
- Engineering units for analogue signals
- Engineering high scale for analogue signals
- Engineering low scale for analogue signals
- For binary signals, 0 and 1 descriptors and operator alarm requirements
- PLC registers.

The Supplier shall provide visualization displays of UCS incl. summary of all warnings and alarms as specified in Annex 1, Attachment 1.3.

The Supplier shall submit layout drawings of all instrumentation in scope, both packaged and field instrumentation including local gauge board layouts. Layout drawings of instrument panels shall identify panel dimensions, connection points, all faceplate-mounted instrumentation and gland plates. Major “back of panel” items and trunking, terminals, and isolators shall be also shown.

Instrument Power and Air Distribution Diagrams shall identify the distribution of instrument electrical (AC /DC) and pneumatic power to individual users within the Supplier system or package from a single supply point provided by the project.

Instrument Calculations shall include control valve sizing and noise, relief valve sizing, flow meter sizing, control system reliability and availability as a minimum. The calculations shall cover all the identified design cases and shall identify the calculation methods and standards used.

The Supplier shall submit P&IDs for the following equipment as a minimum:

- EMCS including, DGS, EMCS monitoring system, NGC recirculation loops with anti-surge valve and hot-bypass valve (if required)
- EMD cooling system
- VSD cooling system
- FFS
- All control and shut-off valves including pneumatic and hydraulic actuators

P&IDs shall indicate the following as a minimum:

- Battery limits
- Equipment names and Tag-numbers (project symbols shall be used)
- Major items of equipment shall have duties and design conditions stated

- Interface numbers
- Insulation and trace heating requirements
- Venting and draining requirements
- Relief valve location, project Tag-numbers, sizes and set pressure
- PSV interlock valves and interlocking sequence and set pressure
- Positive isolation requirements
- Block and check valves, with type identified
- Valves and actuators and solenoids; failure mode to be stated
- Nozzles of vessels, sizes, man ways, and other inspection provisions
- Slope of vessels
- Levels in vessels, NLL, LSL, LSH, LSLL, LSHH, etc.
- Instrumentation warning and alarm levels (LL, L, H, HH)
- Elevations of major equipment
- Process and utility flow lines with directional arrows
- In/Out continuation boxes with references to other Supplier P&ID drawing numbers as applicable
- Line sizes, numbers, pipe specifications, specification breaks and goods designation
- Piping special items
- Piping notes
- Switches and instruments with Tag-numbers, and alarm trip set points
- Instrument signals and interactions with SCS
- ESD valves
- Interfaces with other P&IDs including Owner P&IDs
- All interface equipment, instruments, valves, etc., shall be tagged, with Owner Tag-numbering system requirements.

9.2.2.9 Materials Engineering Technology

The Supplier shall submit Welding Procedure (WPS/PQR) Documents. The Supplier shall provide all welding procedures (WPS and PQR), including welding procedures used for base material repairs, together with cross-referenced Weld Maps in accordance with the Owner requirements. Weld Maps shall specify and show the following as a minimum:

- WPS(s) to be used for each weld joint (WPS shall be made available to Owner / Notified Body for review upon request)
- The type of weld joint (full penetration, partial penetration, fillet, socket, etc.)
- Actual materials thickness at each weld joint
- Specific base materials by Type and Grade for each weld joint
- Whether back gouging and back welding will be applied for each joint
- Preheat temperature for each weld joint
- Whether Post Weld Heat Treatment (PWHT) will be applied
- Weld Filler Material(s) Classification to be used for each weld joint

The Supplier shall submit Non-Destructive Testing (NDT) Procedures. All proposed NDT procedures (radiography, ultrasonic, dye penetrant, magnetic particle, PMI, or similar) shall be utilized in accordance with the Owner requirements specified herein (see chapter 5.2 and shall be defined and cross-referenced with the Weld Map to determine procedures to be used.

The Supplier shall submit Heat Treatment and PWHT Procedures. The Supplier shall provide detailed Heat Treatment and PWHT procedures in compliance with the Owner's requirements specified herein.

The Supplier shall provide Painting Specifications for the EMCS and all auxiliary equipment included in Scope of Supply. Painting Specifications and Procedures shall include the following information for each equipment item:

- Surface cleaning
- Preparation
- Shop or field painting
- Paint/coating manufacturer
- Paint/coating composition
- Linings (where applicable)
- Anti-rodent/insect treatment
- Repairs to damaged finishes
- Quality system in place

The Supplier shall submit Material Traceability Procedures as per requirements from Annex 1, Attachment 1.3.

The Supplier shall submit Positive Material Identification (PMI) Procedures.

9.2.2.10 Installation and Operation Manuals (IOM)

Installation, Operation and Maintenance Manuals shall be provided in English and Czech language and include description of equipment, operating procedures for start-up, steady state, shutdown, emergency and fault conditions, operating parameters, function of protective devices and controls, copies of fault finding guidelines. Manuals shall include the following as a minimum:

- Cause and effect charts
- Data sheet for equipment
- Data sheet for the EMD
- Data sheet for auxiliaries and components
- Performance curves
- General arrangement drawings
- Outline and cross section drawings including base plate
- Drawings of ancillary equipment such as fans, gearboxes, filters etc.
- Complete Parts lists
- Block diagrams
- Schedule of packing
- Purchasing specifications
- Piping and instrumentation diagrams
- Instructions for installation, preservation, operation, maintenance, disassembly, repair, overhaul and assembly
- Recommended spare parts listing
- System of trouble detection and remedy
- Electrical drawing and details
- Control schematics
- Details on sub-contractor equipment with information on the specific model utilised
- Owner approved drawings as specified in the Supplier Document Requirements List shown in Annex 1, Attachment 1.3.
- Special Tools List shall include all tools necessary for removing equipment from transport at Site, all tools necessary for installation and maintenance. For each list item, a brief description shall be given and where necessary for clarity, a drawing shall be provided.

Unloading, Unpacking and Installation procedures shall include the following information, as a minimum:

- Construction method statement
- Assembly instructions
- Erection drawings
- Lifting points
- Lifting weights
- Shipping break points for panels and switchboard assemblies
- Erection match markings
- Fixing points
- Leveling procedures
- Alignment procedures
- Erection fasteners summary list
- Details of any special unpacking/handling requirements shall be stated
- Procedures for removing transportation and storage preservations applied prior to installation.

The installation instructions shall cross reference with documents such as Packing List, Erection Drawings, General Arrangement Drawings, Panel/ Junction Box Termination Details etc. that will facilitate the assembly of the package.

commissioning and Start-up procedures shall detail all pre-commissioning, commissioning and start up steps, including loop-checks, commissioning of all individual equipment and start-up of the whole ES package, see also chapter 8.1 and 8.2.

The Supplier shall submit all installation procedures for all equipment included in the Scope of Supply which shall be installed by others (see chapter 3). This shall include, welding and testing procedures as well as cleaning, flushing and bursting procedures with minimum level of cleanliness required to be achieved prior to package commissioning.

9.3 Documentation for Building Permit

The Supplier shall submit all documentation required for the Building Permit as specified in Annex 1, Attachment 1.3.

A Building Permit is required for the PROJECT according to the building permitting legislation listed in Annex 1, Attachment 1.2.

The Supplier shall provide at least the following documents, which will be used in the Application for documentation preparation:

- Summary technical report on EMCS and their equipment;
- Drawing documentation of EMCS and their equipment.

The Consultant will prepare the Project documentation for building permit and the Application for the issue of the building permit based on the submitted documents from the Supplier and in cooperation with the Owner. The Supplier shall support Owner and Consultant in aspect related to permiting process with relevant technical information and descriptions as required.

9.4 Marked Red and As-built Documentation

The Supplier shall submit the Change Documentation Marked Red as well as the As-built Documentation to the Owner.

The Change Documentation Marked Red shall contain the following as minimum:

a) The Project As-built Documentation

b) Accompanying Technical Documentation

The Change Documentation Marked Red shall be submitted by the Supplier for a commission check by the Owner in two Project execution stages:

1. The 1st stage of Change Documentation Marked Red submission: no later than within 10 days prior hot commissioning commencement. Supplier is responsible for completeness and formal aspect of the submitted documentation.
2. The 2nd stage of Change Documentation Marked Red submission: no later than within 5 days after finishing of the 72-hour test. The Supplier is responsible for completeness and formal aspect of the submitted documentation. They shall add and incorporate any changes occurred since the 1st stage of Change Documentation Marked Red submission.

The Supplier shall incorporate in red colour all changes and additions arising in connection with the installation and commissioning to all documents. Prior to handing over the documentation to the Owner, the Supplier 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 Owner's operation personnel at the place of the works until the final Change Documentation Marked Red is handed over to the Owner by the Supplier (see the 2nd Stage).

The As-built Documentation shall contain the following as minimum:

a) The Project As-built Documentation

b) Accompanying Technical Documentation

The Supplier shall submit the As-built Documentation for a commission check by the Owner within 7 days after the 72-hour test.

Having incorporated all corrections to the As-built Documentation, the entire As-built Documentation shall be handed over to the Owner in form of structured files (including the contents).

The final version of the As-built Documentation shall be handed over to the Owner in 3 hardcopies and 3 electronic versions (in an editable format on a CD-ROM – e.g. drawings in CAD format and text in MS Word) within 20 days after a successful 72-hour reliability test.

The Accompanying Technical Documentation in the Czech language shall form an integral part of the As-built Documentation

The Accompanying Technical Documentation of the classified technical equipment shall form a part of the Change Documentation Marked Red as well as of the As-built Documentation and shall contain in particular:

a) the data related to the identification of the manufacturer (OEM) or Supplier, basic data of the equipment minimally in the Scope of Supply, the characteristics of the environment where the equipment can operate,

b) the operating instructions or references to the regulations containing:

1. permissible ways of use,

2. instructions for operation, maintenance, inspections and tests,

3. summary of the requirements for administration of the operating documentation and papers,

4. the requirements for professional qualification of persons performing the operation, maintenance, inspection and tests,

5. the instructions for assembly, testing and conditions for commissioning of the technical equipment,

6. the list of spare parts and auxiliaries

c) takeover documents containing:

1. a passport, inspection book or other document of the technical equipment to the extent determined by the safety-technical requirements,

2. a certificate of the documentation, if issued,

3. declaration of the manufacturer on conformity of the technical equipment with the safety-technical requirements,
4. a certificate on the type-approval test of the technical equipment,
5. a certificate on the first authorized test and repeated authorized test or on the test performed by a testing technician or qualified expert,
6. test certificates, certificates, descriptions of exceptions, and other.

9.5 Documentation Language

Documentation commenting and approval process between the Owner and the Supplier will be in the English language.

The Supplier shall refer to Annex 1, Attachment 1.3 for all requirements related to documentation which shall be submitted in the Czech and English language.

9.6 Certifications

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 EMCS shall be supplied by the Supplier after completion and assessment of the 72-hour reliability test. The Declaration of Conformity of the EMCS systems will be supplied by the Supplier. The Supplier will be responsible for obtaining all necessary certifications to operate the EMCS according to European and Czech applicable laws.

9.7 Preparation of Reports

9.7.1 Monthly Progress Reports

During the project execution the Supplier shall prepare monthly reports (reports on progress of works) for each EMCS separately. The reports shall minimally contain the following items necessary to be checked during the execution of the project:

- Status of delivery of particular levels of the documentation
- Status of delivery of particular components
- Manufacturing process
- Updated project schedule
- Works progress of Supplier and his sub-suppliers
- Commercial data (date of order, contractual affirmation, delivery deadlines)

- Status of assembly works execution (execution of works/time schedule of a subcontractor where appropriate)
- Reasons for failure to meet the deadlines (if any)
- Critical points/items
- Forecast (execution of works/time schedule of a subcontractor where appropriate)

The Owner reserves the right to request additional information.

The Supplier is obliged to send to the Owner the Works Progress Report for the current month not later than by the 5th day of the subsequent month.

9.7.2 Weekly Progress Reports

The Supplier shall prepare weekly reports regarding the status of all activities performed on Site during installation and construction, commissioning, 72- and 600-hour tests.

9.7.3 Construction Log-Book

The Construction Log-Book is a document which forms a part of the documentation stored at the Site. All and any significant events which occur at Site shall be recorded in the Log-Book. The Log-Book shall be kept by the Construction Manager. The Owner shall authorize the CS constructor by keeping the Log-Book starting as of the first day of the preparatory works until the completion of the construction works. The Supplier represented by their authorized Construction Manager shall record all and any significant events occurring at Site starting as of the first day of the works at the Site until the completion of the works at the Site.

10 SPECIAL TOOLS AND SPARE PARTS

The Supplier shall include in the Scope of Supply all tools, lifting gears and eyelets necessary for routine maintenance and overhaul for all equipment included in the Scope of Supply. The Supplier shall include in the Offer all special tools and shall provide for each item a short description, article number, manufacturer and price. The Supplier shall include in the Scope of Supply all tools required for the 1st inspection.

All consumables, materials, spare parts and/or technological media required for commissioning and acceptance tests under Article 8 of TECHNICAL SPECIFICATION, including the primary filling of media for the EMCS, VSD cooling system, VSD transformer, etc., with the exception of process gas and electricity supplied by the Owner, are included in the CONTRACT price.

The Supplier shall submit to the Owner within 60 days after completion of FAT of the first EMCS an offer for spare parts that they recommend as basic (typical) for 3 year operation of EMCS, including spare parts needed to carry out scheduled maintenance according to the maintenance schedule submitted in Attachments 1.22.10 and 1.2.11. Offered spare parts shall be indicated by numbers and codes of spare parts catalogue (P/N) of the Supplier (resp. OEM of appropriate spare part). The Supplier is obliged to offer the prices of their spare parts with a discount of at least 10% compared to the prices mentioned in publicly available catalogue or price list of spare parts of the Supplier. The validity of the offers of the Supplier shall be at least six months.

The Supplier shall recommend spare parts additionally to those listed in the tender documentation, if deems necessary according to experience.

All spare parts shall be delivered in lockable steel boxes suitable for transportation.

The Supplier shall guarantee that all spare parts are available on the market for at least twenty five (25) years.

11 MAINTENANCE

The Supplier shall design the equipment in order to minimize maintenance. Critical items shall be spared to increase reliability. When designing the layout of the equipment package, due considerations shall be given for easy accessibility to all items for maintenance as well as operational requirements. The equipment shall be designed so that all maintenance can be carried out with the minimum special facilities or tools.

The Supplier shall offer his standard maintenance plan for the equipment supplied. The Supplier shall issue the maintenance plan and maintenance costs with considering the following requirements:

- Design life of equipment as specified in chapter 2.5,
- Number of operating hours / machine / year specified in Attachment 1.5,
- Environmental conditions as specified in chapter 2.3,
- The operating conditions as specified in chapter 4.2.1,
- Technical requirements as specified in chapter 4.

11.1 Preventive maintenance plan

The Supplier shall include in the Scope of Supply the preventive maintenance plan in accordance with the RCM method. The preventive maintenance plan shall address the following items as a minimum:

- Define a three level breakdown structure of technical points of the Scope of Supply,
- Functionality of equipment included in the Scope of Supply,
- Failure modes based on HAZOP and HAZID studies,
- Causes of all functional failures (failure modes),
- Consequences of failures of equipment (failure effects, what will happen if the given component loses its functionality),
- Risk limits of the respective components based on the risk matrix,
- Preventive maintenance on the respective components, allocate professions, intervals or periodicity of the activities.

The Supplier shall elaborate the evaluation of the equipment and its components according to SAE JA1011.

The Supplier shall provide in the offer all maintenance lifting requirements for the equipment and advise on suitable lifting methods, e. g runway beam, overhead travelling

crane etc. The Supplier shall submit the Maintenance Schedule and Maintenance Drawings as specified in Annex 1, Attachment 1.3.

12 TRAINING

The Supplier shall include in the Price Breakdown on-site training for the Owner's personnel. The Supplier's training shall include:

- Maintenance personnel
- Operating personnel
- Technical managers- specialist

Furthermore, the Supplier shall provide training for:

- Mechanical personnel,
- Electrical personnel,
- Instrumentation, control and telecommunication personnel.

The Supplier shall include in the Offer both classroom training as well as "hand-on" training.

The Supplier shall include in the Scope of Supply for training all equipment included in the Scope of Supply. The Supplier shall foresee separate sessions for the FFS as well as for the EMCS safety systems.

The Scope of Supply of maintenance training shall be to ensure that the Owner maintenance personal shall be able to carry out regular inspections and / or maintenance independently, without the need to request support of foreign suppliers.

The Scope of Supply of training for EMCS operation shall include EMCS start-up, normal operation, monitoring and control, trouble-shooting and optimisation, shut-down as well as remote operation from SCS and Owner dispatching centre in Prague.

The SCOPE Of SUPPLY of training for the system management, shall ensure that the Owner system management team shall be able to administrate all required consumables and spare and ware parts (operating media like cooling medium, guarantee period spares, capital spares etc.).

The Supplier shall include the price for each type of training, including program. The Supplier shall consider a number of ten (10) persons for each type of training listed above (maintenance, operation etc.). The Supplier shall consider all necessary training manuals and documentation; the training documentation shall be submitted in English and Czech language. The training sessions will be held in English. The Supplier shall submit all training documentation as required in Annex 1, 1.3. The Supplier shall prepare the schedule for all training sessions included and shall submit this to Owner for review and approval.

All training in the Scope of Supply which is required for the operating and maintenance personnel shall be completed before commissioning of the EMCS.