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NGF nature energy



# Technical specification for Gas Compressor Package

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NGF NATURE ENERGY

# TECHNICAL SPECIFICATION FOR GAS COMPRESSOR PACKAGE

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## 1. Introduction

NGF Nature Energy A/S intends to install a number of compressors for injection of upgraded biogas, into the natural gas grid in Denmark.

The compressor must cover the capacity from 800 to 1000 Nm<sup>3</sup>/hr, with an inlet pressure in the range 2.0 - 4.0 bar g and an outlet pressure of approx. 19 bar g. In general designation of pressure in the different grids is in bar overpressure. The compressor must be delivered as packaged unit.

### 1.1 Units

Metric units shall be used in documentation as well as installations.

### 1.2 Design data

The design data are in general given in the compressor data sheet 89712-M-002 and basic requirements are presented in P&I diagram 89712-DWG-009 (appendix). Both documents are enclosed in appendices to this specification.

According to GPTC all pressure retaining materials shall in general have a design factor of 0.5. In special cases for vibration bottles a lower design factor may occur.

The design pressure of the gas piping system shall be the same from the unit inlet flange to the unit outlet flange (19 barg, ANSI Cl. 150).

Gas composition is according to C-12 "gasreglementet" – gas data are listed in the compressor data sheet.

### 1.3 Definitions

Supplier: Vendor/Manufacturer of the packaged compressor unit

Purchaser: NGF Nature Energy A/S

AT : "Arbejdstilsynet" – The Danish Working Environment Authority

PED: Pressure Equipment Directive, DIR 97/23/EC

P&ID: Process and Instrumentation Diagram

CE : European Conformity

DBI : Danish Institute of Fire and Security Technology

FAT : Factory Acceptance Test (Shop Test)

SAT : Site Acceptance Test

QHSE: Quality, Health, Safety, and Environment

SIK : Danish Safety Technology Authority

## 2. Scope

The scope of this specification is to define the requirements for the supply of the mechanical and electrical equipment for the compressor unit as well as for the enclosure.

The equipment must be placed within one or more enclosures.

The detailed package unit design must be developed based on specific design data for each package ordered under this specification.

### 2.1 Scope of supply

Supplier's scope of supply for each complete unit is the design, manufacture, installation, testing and commissioning of the following equipment and materials:

1. A complete reciprocating compressor installation placed in one or more enclosures for outdoor installation, equipped with all equipment necessary for the compression process, the end product being a gas that meets the listed outlet pressure specifications. The pressure equipment shall fulfil demands as stated in PED and rotating equipment shall fulfil demands as stated in the EU Machinery Directive, including risk assessment for the compressors. The equipment scope is as follows, but is not limited to the listed equipment depending on the applied technology.
2. Inlet and outlet piping to the compressor including motorised isolation valves.
3. Cooling unit and lube oil unit, including pumps and heat exchangers.
4. All internal piping, including safety measures as required by AT and all other functional demands.
5. Control and Safety equipment, pressure safety valves connected to vent system, gas detectors in compressor room (optionally fire detectors and active fire protection system in switchboard room, including approval by Notified Body selected according to AT Notice 661 and approval by DBI (F&G equipment)).
6. Verification of the plant equipment (pressure retaining parts) by Notified Body according to AT Notice 661, expenses shall be included in tender.
7. All instrumentation, electrical equipment, frequency converter as speed controller, all cabling and local control unit, necessary for the operation of the compressor.
8. Bearing temperature monitoring for motor and compressor shall be provided with alarm to the control centre.
9. Pulsation study, in case of two or more compressors in parallel.
10. Control philosophy and programming for compressors in parallel with adaption of control signals from the system for control of load etc. e.g. flow/pressure at biogas plant.
11. The control system shall have a web-interface accessible from the Internet for external monitoring of the gas compressor operation status incl. alarm. The web-interface shall be used by the operation centre to evaluate any malfunctions for the compressor.
12. Signals ready at terminal row and bus connection for Gas Control Centre monitoring of unit.



13. Design of enclosure and cooler foundations, including load requirements for construction by Purchaser.
14. Planning, execution of FAT, SAT and Commissioning.
15. Training of operators, minimum 2 persons for 1 day at NGF NE premises in Denmark.
16. Any required special tools.
17. CE-marking of the entire system in accordance to applicable EC directives.
18. Compressor design approval by The Danish Working Environment Authority.
19. Documentation including material certificates, FAT, SAT, As-Built, declaration of conformity etc.
20. 2 years of warranty valid from the date of delivery.

### **2.1.1 Works by Others**

Other contractors will provide the following services:

- Local authority approval covering building permit and environmental approval only.
- Construction of the foundations for compressor unit and for the enclosure based on Supplier design drawings.
- Tie-in piping from supply distribution piping and tie-in piping to discharge distribution piping, finished at agreed compressor pipe inlet/outlet flange.
- Main power supply, 3 x 400 VAC, from the electricity Supplier to compressor main switchboard.
- Signal transfer cable to the interfaced PLC unit.
- Supply and installation of cable pipes outside the enclosures.

### 3. Regulations, Norms & Standards

#### 3.1 Regulations

Danish legislation, incl. all EU directives implemented applies, e.g.

- Pressure Equipment Directive (PED) 2014/68/EU.
- ATEX Directive 2014/34/EU.
- Machinery Directive 2006/42/EC.
- Low Voltage Directive 73/23/EEC c/w revision 93/68/EC.
- EMC Directive 89/336/EC c/w 92/31/EC.
- AT notice no. 190, design of pressure equipment.
- AT notice no 414, Safety requirements for natural gas systems.
- AT notice no. 661, Designation of Notified Bodies.
- AT Guideline F.0.1, natural gas installation – The Danish Working Environment Authority.
- Danish Building Regulation - 2008.
- Danish Environmental Protection Agency – external noise no.5/1984.
- Danish Safety Technology Authority – “Gasreglementet C-12” Natural gas regulations.
- Danish Power Regulation: Stærkstrømsbekendtgørelsen, afsnit 6 Elektriske installationer, 2001.
- Danish Law announcement 990 of December 8, 2003- “Stærkstrømsloven” – Consolidated Act electrical power installations and electrical equipment.
- Danish Guidance note VEJ nr. 14018 the 01 of November 1984 "Ekstern støj fra Virksomheder" - External noise from enterprises.
- Regulation 232, Automatic Fire alarm systems, DBI - Danish Institute of Fire and Security Technology, or equal European standard.
- Regulation 233, Automatic Fire alarm systems, DBI - Danish Institute of Fire and Security Technology, or equal European standard.

#### 3.2 Norms & standards

Applicable norms and standards are:

- ANSI B 16.5, Pipe flanges and pipe fittings.
- API 5L, Specification for line pipe.
- API 546, Brushless Synchronous Machines - 500 kVA and Larger.
- API 614, Lubrication, shaft-sealing and oil- control systems and auxiliaries.
- API 618, Reciprocating Compressors for Petroleum, Chemical, and Gas Industry Services.
- API 661, Air-Cooled Heat Exchangers for General Refinery Services.
- API 671, Special purpose couplings for Petroleum, Chemical and Gas Industry Services.
- ASME (BPVC) VIII, Boilers and pressure vessels.
- BS CP 2012-1 - Foundations for reciprocating machines.
- DS 452 Code of practice for thermal insulation of technical service and supply systems in buildings
- EN 1012-3, Compressors and vacuum pumps – Safety requirements
- EN 13501, fire classification of construction and building elements
- EN 9606, Qualification test of welders.
- EN 837, Pressure gauges.
- EN 17637, Non-destructive examination of fusion welds.
- EN 17636-1, Radiographic testing of welded joints.

- EN 1990 (Eurocode 0), Basis of structural Design, including Danish Annexe to the code DS/EN 1990 DK NA:
- EN 1991 (Eurocode 1), Actions on Structures, including Danish Annexes to the codes, DS/EN 1991-1-(1-7) DK NA:2007.
- EN 10204, Metallic products - Types of inspection.
- DS/EN 3183, Steel pipes for pipelines for combustible fluids.
- EN 10675-1, Non-destructive testing of welds.
- EN 12944-2, Paints and Varnishes. Corrosion protection of steel structures by protective paint systems. Part 2, Classification of environments.
- EN 13445, Unfired pressure Vessels.
- EN 14382, Gas safety shut-off devices for inlet pressure up to 100 bar.
- EN 13480, Metallic industrial piping.
- EN 15609, Specification and qualification of welding procedures for metallic materials.
- EN 23278, Non-destructive testing of welds - Magnetic particle testing of welds - Acceptance levels.
- EN 60034-1 to 18: Rotating Electrical Machines.
- IEC 60947-4, low voltage switchgear and controlgear
- EN 60079-0: Explosive Atmospheres - Part 0: Equipment - General Requirements
- EN 60079-14: Explosive Atmospheres - Part 14: Electrical Installations Design, Selection and Erection
- EN 60079-17, Explosive atmospheres – Part 17:Electrical installations inspection and maintenance
- EN 60204-1, Safety of machinery – Electrical equipment of machines – part 1 : General requirements.
- EN 60445, Basic and safety principles for man-machine interface, marking and identification - Identification of equipment terminals, conductor terminations and conductors.
- EN 60751, Industrial platinum resistance thermometers and platinum temperature sensors.
- EN 60947/1-7 Low Voltage Switchgear and Controlgear Components.
- EN 61439-1, DS/EN61439-2 and 61439-5: Low-Voltage Switchgear and Controlgear Assemblies.
- ISO 3183, Steel pipe for pipeline transportation systems.
- ISO 3511, Industrial process measurement control functions and instrumentation.
- ISO 1217, Displacement compressors - Acceptance tests.
- ISO 5208, Industrial valves - Pressure testing of metallic valves.
- ISO 10438, Petroleum, petrochemical and natural gas industries - Lubrication, shaft-sealing and control-oil systems and auxiliaries.
- ISO 10628, Diagrams for the chemical and petrochemical industry – Graphic symbols.
- ISO 13706, Petroleum, petrochemical and natural gas industries - Air-cooled heat exchangers.
- ISO 15547, Plate Heat Exchangers for General Refinery Services.
- ISO 17638, Non-destructive testing of welds - Magnetic particle testing.
- ISO 17640, Non-destructive testing of welds - Ultrasonic testing - Techniques, testing levels, and assessment.
- GPTC Z380.1 - Guide for Gas Transmission and Distribution Piping Systems TEMA C, Manufacturers design standard – Air cooled heat exchangers.

Any deviation from current EN standards will only be accepted, if a written acceptance from Purchaser exists.

The equipment must comply with existing regulations at the time of approval.

In case applicable norms and standards are not strictly adhered, it shall be clearly stated in the tender documentation from the Supplier.

### **3.3 Authority approval**

The compressor package unit must be CE marked in accordance with relevant European directives, as minimum:

- Pressure Equipment Directive (PED) 2014/68/EU.
- ATEX Directive 2014/34/EU.
- Machinery Directive 2006/42/EC.
- Low Voltage Directive 73/23/EEC c/w revision 93/68/EC.
- EMC Directive 89/336/EC c/w 92/31/EC.

The declaration of conformity with the pressure equipment directive for the compressor unit must be based on full quality assurance plus design examination.

In case the vendor includes enclosures in the unit declaration of conformity with Machinery directive 2006/42/EC, the vendor can disregard eventually requirements in section 9 after approval from Purchaser.

The declaration of conformity must be in both English and Danish language.

## 4. General Technical Requirements

### 4.1 General

The design life of the compressor package shall be minimum 20 years.

#### 4.1.1 Stationary compressor units

The compressor and auxiliary equipment shall be delivered as packaged units in one or more enclosures. The enclosures for the gas compressor and utilities shall comply with the area classification given in section 4.3.4.

The gas compressor shall be installed in one enclosure. Utilities may be installed in a separate enclosures if found most appropriate.

The compressor units will normally be installed close to existing M/R-stations, and Purchaser will provide the necessary power supply and connections to the gas control centre (GCC/Panda) as well as the interface piping from the gas supply line to the compressor unit and from the compressor unit to the main gas pipeline.

The foundations for the enclosures shall be designed as part of this Contract, see section 9.2.

### 4.2 Compressor equipment

#### 4.2.1 General

The compressor package includes frame oil lubrication, capacity control, closed cooling water system incl. air cooled heat exchanger, pulsation dampener on suction side, pulsation dampener on discharge side, suction strainer, non-return valve, bypass, safety valves, instrumentation, control cabinet, gas piping, cooling water piping, instrument piping/tubing, main driver, frequency converter and compressor enclosure. In the following sections, the main functional requirements for the equipment is described.

#### 4.2.2 Skid boundary connections

The compressor including lubrication, cooling systems etc. shall be packaged skid mounted equipment, and the exact location of inlet and outlet connections on the compressor, dimension, schedule and material shall be shown on P&I diagrams and plant layout drawings.

#### 4.2.3 Compressor

The compressor shall be of proven construction for gas compression and built according to recognised standards such as API 618/EN 1012-3. The Compressor shall have speed control by a frequency converter and shall be constructed for potentially explosive atmosphere according to the ATEX directive. For a reciprocating compressor, Supplier shall include adequate pulsation damping in his scope of supply incl. documentation for this.

Safety protection systems shall be present, including but not limited to:

- Pressure monitoring at compressor suction to protect the compressor and prevent gas inlet pressure falling below the "minimum suction pressure" specified by the Purchaser.

- Pressure protection at compressor discharge to protect from overpressure.  
 Protection of compressor suction side, preventing the downstream distribution net pressure to accidentally flow back into the upstream system.
- Over-speed protection.
- Protection against backflow of gas into the cooling lines

The overpressure protection system for the downstream system shall fulfill the Danish requirements, given in AT Guideline F.0.1. The protection shall consist of two independent safety devices. Furthermore the downstream system shall be protected with a safety relief valve, with a capacity of min. 1% of the compressor outlet capacity.

In the example shown in figure 6.1, the compressor is considered being the active regulator. The Supplier shall design and document the compressor pressure control system.

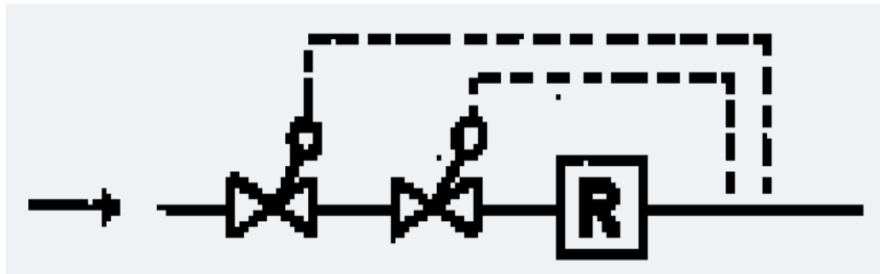


Fig. 6.1: Pressure safety system with two slam-shut valves.

Typical pressure settings for the pressure safety devices is given in the tables below.

Abbreviations:

Acc.: Closing Accuracy; Acv.: Vent Accuracy; Acr.: Reg. Accuracy; Pcp.: Closing point regulator; Setp.: Setpoint

Relief valve	Slam-Shut valve 2	Slam-Shut valve 1	Compressor
Acv. 1,0%	Acc. 2.5%	Acc. 2.5%	Acr. 1.0%
Acv. 19.400 barg	Acc. 18.800 barg	Acc. 18.800 barg	Pcp. 18.200 barg
Setp. 19.200 barg	Setp. 18.300 barg	Setp. 18.300 barg	Setp. 18.000 barg

Table 6.1: Typical pressure settings for 20 bar net.

#### 4.2.4 Oil lubrication and cooling unit

Complete oil lubrication system, including pump, cooler, filter, fittings, piping and instrumentation, accessories etc.

The oil cooling system shall be designed to comply with the parameters in ISO 10438-3 section 4.6 para. f).

#### 4.2.5 Pulsation dampeners

Vessels, connecting pipes, flanges, instruments, etc. must be designed for internal pressure and temperature stresses, and if necessary designed for fatigue (life time of 20 years).

Vessels must be designed and fabricated in accordance with PED.

The compressor unit must be provided with pulsation dampeners. The pulsation suppression system must be designed in accordance with design approach 2, as according to API 618. As pulsation suppression device, volume bottles with choke tubes are preferred. The pulsation dampeners shall limit the pressure fluctuations to  $\pm 1\%$  ripple at the average pressure on inlet as well as discharge.

Maximum allowable pressure drop through the pulsation suppression devices shall be less than 0,25 % of the average pressure at rated flow conditions.

Pulsation dampeners must be provided with a drain valve automatic operated.

The pulsation dampeners must be furnished with liquid level switches for detection of condensates (not required if the installed inlet gas filter is provided with a liquid switch).

If the pulsation dampeners are fabricated of pipe and fittings, the maximum allowed design factor is 0,4 in accordance with GPTC.

**4.2.6 Fire & Gas systems**

Hazardous processes and operations for the compressor must be clearly described, and a safety plan describing the safety systems, fire and gas detection and active fire protection systems, shall be documented and approved by a third party accredited (Danish) Notified Body and prepared for authority approval.

**4.2.7 Operating environment**

The compressor installation locations can be of different nature. The compressor may be placed close to the sea, in a housing area or in an industrial area. Therefore the environment may contain moisture and chloride solutions that need to be taken into account when choosing finishing of materials.

Outdoor temperature will be:

- Lowest minimum -25 °C
- Highest maximum +35 °C

Mean of yearly max. temperature +10.9 °C

Mean of yearly min. temperature + 4.3 °C

Mean barometric pressure 1013 hPa

Mean relative humidity 84%

Frost proof depth below ground: 0.90 m

Air environment Saliferous atmosphere

Gas Temperature inlet 0- 20°C

Gas Temperature outlet < 45°C

**4.3 Functional requirements**

The following functional requirements shall apply.

Background information about 19 bar grid:

The pressure in Purchasers 19 bar grid can vary in range of approx. 10 and 19 bar, therefore the compressor shall be able to handle this.

#### **4.3.1 Operational availability**

Availability of the compressor unit is important. The Supplier must specify a guaranteed availability which must be minimum 95%. The compressor unit is not considered to be available, when it is stopped for planned maintenance.

#### **4.3.2 Compressor control philosophy**

The biogas network will typically supply biogas to local customers. Typical network configurations shown in appendix 89712-P-003.

The local biogas customers upstream of the compressor unit shall have a guaranteed biogas supply, i.e. a minimum guaranteed gas pressure at the supply point.

In parallel operation with two or more compressors, a fully automatized master/slave control system shall be included. All compressors delivered must be prepared for parallel operation.

#### **4.3.3 Operation and Control System**

The compressor shall be fully automatically controlled. The compressor shall be instrumented, so that the gas compressor can safely start and stop depending on the gas pressure at the inlet and the outlet side of the compressor.

Any not normal operation shall be handled by the control system, giving a controlled shutdown. Any unintended stop shall give an alarm, forwarded to the Purchaser SCADA system, called GCC.

The compressor units shall be controlled by a local control unit (PLC). The PLC shall be able to communicate with a Siemens ET200S by a bus connection giving an easy data exchange to the GCC. The PLC shall be provided with a coloured graphic operator LCD-panel as interface to the gas compressor status, alarms and for adjusting parameters.

Furthermore the control system shall have a web-interface accessible from the Internet for external monitoring of the gas compressor operation status incl. alarm. The web-interface shall be used by the operation centre to evaluate any malfunctions within the compressor.

The compressor injects the biogas production and supplies it to the 19 bar grid.

Parallel to the compressor(s) will be a MR-station controlling the gas pressure in the 4 bar distribution system by taking gas from the 19 bar grid.

The control of the gas compressor shall be as follows:



The compressor shall have a ready signal from the system allowing the compressor to start at suction pressure above high pressure start level specified by the Purchaser.

The above set points and variables shall be parameters which an operator can adjust from a local panel. The local panel shall have a login before allowance to adjust parameters is possible.

The gas cooler shall be automatically controlled by the gas compressor PLC.

Data for status, alarm and measurements shall be delivered at the PLC communication interface ready for forwarding to GCC.

Further status signals and alarm signals for the compressor shall be available at a terminal row for connection to GCC.

All communication to GCC must be in compliance with Purchasers security requirements and patterns as defined in the following documents:

- ICS Security Requirements
- IT Security patterns for remote access

The following list contains the operational level of signals to be available, but special alarm signals and ESD shut down signals are not included, but shall be included. As a minimum, the following signals shall be delivered:

Signals	Unit	GCC signals (1)	Web-interface (2)
Inlet valve	ON/OFF	X	X
Inlet pressure	Barg	X	X
Compressor run 1 or 2	1 or 2	X	X
Compressor trip 1 or 2	1 or 2	X	X
SAV.	ON/OFF	X	X
Outlet pressure	Barg	X	X
Outlet gas temp.	°C	X	X
Flow	Nm <sup>3</sup> /h	X	X
Outlet valve	ON/OFF	X	X
Gas Alarm	ON/OFF	X	X
Low lube oil press.	bar	X	X
High lube oil Δp	bar	X	X
Low lube oil level frame	mm	X	X
Aux. lube oil pump fail to start	ON/OFF	X	X
Cylinder lube system protection	ON/OFF	X	X
Oil temp out of frame	°C	X	X
High gas outlet temp each cylinder	°C	X	X
Low suction press. First stg. inlet	Barg	X	X
Hi. LIQ. lev pulsation dampner stg. 1		X	X
Hi. LIQ. lev pulsation dampner stg. 2		X	X
Pneumatic press	bar	X	X

(1) Signals to be available on terminal row and PLC bus interface

(2) Signals at the web interface. Further if remote start/reset/stop of the compressor is possible please state that in your tender material. Please inform if these signals if available can be disabled, if not found acceptable for the Purchaser.

**4.3.4 Area Classification**

The biogas is an explosive gas and so following ATEX requirements are valid for the project.

The biogas is lighter than air with a relative mass index of 0,6 and will therefore spread upwards in the atmosphere.

The compressor including switchboards and control panel is expected to be installed in one enclosure. Switchboards and control panels must be located in a separate gas tight electrical room. Furthermore an air – water cooler is expected to be installed on a separate foundation.

Ex zones:

ZONE 2 is defined inside compressor containment as follows:

Equipment group II

Category 3 G

Gas group II A

Temperature class T3

Furthermore the following outside locations shall be zone 2 as defined above:

Enclosure/containment: 3 m around enclosure/containment openings is zone 2

Around vents: 3 m around is zone 2

Flanges, valves etc.: 3 m is zone 2

ATEX certification of equipment

Both electrical and mechanical equipment shall be certified to the area they are installed in, but instrumentation and electrical equipment installed in Zone 2 classified area shall be certified for Zone 1 defined as follows:

Equipment group II

Category 2 G

Gas group II A

Temperature class T3

#### **4.3.5 Interfaces**

The compressor has two process interface points, suction inlet line and the compressor outlet line.

The compressor package must be furnished with ANSI cl 150 flanges for the 19 bar grid.

#### **4.3.6 Emission demands**

The compressor shall be as gas tight and emission free as possible. The Supplier shall state estimated gas emission rate per hour of operation in the tender.

The compressor stages must be oil free design, meaning lubrication oil is prevented from entering the compressed gas.

Furthermore venting to atmosphere is only acceptable in case of emergency operation. If required, a solution in which the gas is returned to the suction line shall be implemented, please note the required protection of the suction line in accordance to F.0.1.

#### 4.3.7 Sound emission levels

Noise and environmental requirements of the compressor shall comply with the Danish guidance note guideline no 14018 of 01/11/1984 table I & II. The compressor unit including auxiliary equipment shall as a minimum comply with the noise limits for a type 3 area (area for both private household and industry areas).

The supplier may be asked to deliver a compressor, enclosure and cooler with maximum allowable joint average noise values as stated in the table below.

	All nights 22.00-07.00
Type 2 industry areas	60 dB(A)
Type 3 for both private household and industry areas	40 dB(A)
Type 6 summerhouse or recreational areas	35 dB(A)

The above stated levels shall be kept at area fence line, which is defined as 10 m from equipment acoustic center (compressor enclosures and air coolers ect., respectively).

The values are average values in dB (A) within the 30 minute period with the most noise. However, in case of "pure tone" (ren tone) the maximum allowable values shall be lowered with 5 dB (A). Also, in case of audible impulse noise the maximum allowable values shall be lowered with 5 dB (A).

Furthermore, noise impulse level shall not exceed 55 dB(A) measured as FAST (125 ms average). i.e. the blow down stack for emergency blow down must therefore be designed to comply with this demand.

#### 4.3.8 Compressor performance

The tender material shall be filled out with specification of power consumption at nominal rated flow [kWh/Nm<sup>3</sup>] for the entire compressor package including all auxiliary equipment. The compressor shall be tested in accordance with the requirements in section 11.2. The stated efficiency at guarantee at nominal rated flow will be treated as guarantee point at the factory acceptance test.

## 5. Engineering by Supplier

The engineering shall include the design of all specified systems, including but not limited to following:

- Enclosures incl. explosion relief opening in roof
- Complete compressor and motor design
- Gas piping system within compressor enclosure
- Piping system to gas cooler
- Complete cooling, lube oil and lubrication system, including monitoring system for compressor lubrication
- Venting systems
- Control system design including ESD system
- Control panel
- Electrical system design, including single line diagrams, wiring and cabling plans
- Vibration and pulsation study according to API 618
- Acoustic and piping restraint analysis for the complete suction and discharge piping.

## 6. Mechanical

### 6.1 General requirement

The compressor, including lubrication, cooling systems etc. shall be packaged skid mounted equipment. The Supplier shall include plot plans and general arrangement drawings in tender material.

#### 6.1.1 Skid boundary connections

The exact location of inlet and outlet connections on the compressor, dimension, schedule and material shall be shown on P&I diagrams and plant layout drawings.

The compressor shall be supplied with motorised isolation valves at the gas inlet connection and at the gas outlet connection.

All interfaces and connections to the compressor shall be specified on P&I diagram and layout drawings.

Plot plans showing ATEX classification zones shall be prepared by the Supplier.

### 6.2 Compressor design requirements

#### 6.2.1 Compressor Cylinders

The design discharge pressure of the connected piping systems and gas cooler is specified in the data sheet.

The Supplier shall forward documentation proving the cylinder design is applicable for operation at the design discharge pressure + 10 % for approval by the Danish Working Environment Authority.

The compressor cylinders shall be of the liner type for easy exchange.

### 6.2.2 Cylinder flanges

The flange type and facing shall be welded neck flanges and facing and bolting shall comply with ANSI B.16.5. Flange rating shall be in accordance with data sheet.

### 6.2.3 Cylinder and packing cooling

Cylinder cooling shall be performed by a self-contained, closed jacket system in accordance the requirements in API 614 and API 618.

### 6.2.4 Cylinder Tap connections

Each cylinder end shall be provided with a ½ NPT plugged tap in accordance with figure G-2 in API 618. The taps will be used for measurement of valves and piston tightness (P-V diagrams) for predictions of when the overhauls shall be carried out.

### 6.2.5 Valve Assemblies

Compressor valve assemblies shall be Supplier's standard, arranged for easy removal and maintenance, and shall be interchangeable within the suction or the discharge side.

### 6.2.6 Valve unloaders

For start-up and capacity control of the compressor, valve unloaders to be used instead of a by-pass line for small gas volumes.

Valve unloaders and clearance pockets shall be included.

Required capacity control range as specified in the data sheet.

### 6.2.7 Crankshafts, Connecting Rods, Bearings and Crossheads

All components in these areas of the compressor shall be designed for a compressor effect above 150 kW in accordance with the requirements in API 618 section 6.11.

### 6.2.8 Distance Pieces

The Supplier shall in the proposal select the type of distance piece to be preferred, considering that it shall comply with mini lubricated design and that it shall house packing cases which minimize venting of gas leakages.

The distance piece type shall be a Supplier standard type, however, the Purchaser prefers a type D in accordance with API 618 section 6.12.1.4.

The distance pieces shall be furnished with connections to

- (A) vent
- (B) purge, pressure packing
- (C) lube
- (D) drain
- (E) coolant out
- (F) coolant in
- (G) common drain
- (P) plugged connection

### **6.2.9 Packing Cases and Pressure Packing**

The Supplier shall in his proposal select the type of packing, taking into account that the compressor may be stopped in the pressurized condition for periods of up to twelve (12) hours and that gas leakage shall be minimized as much as at all possible, both during operation and when the compressor is stopped in the pressurized conditions.

### **6.2.10 Compressor Frame Lubrication**

Auxiliary oil pump driver:

The driver of the auxiliary oil pump shall have an electric motor.

Oil cooler type:

Water-cooled shell and tube type is preferred.

### **6.2.11 Cylinder and packing lubrication**

Lubricators shall preferably be driven by the main electrical motor.

The lubrication system shall be furnished with divider blocks, monitoring each lubrication line. Pressure relief valve shall be used to protect against overpressure.

#### *6.2.11.1 Lubricant and reservoir*

Synthetic low lube oil is preferred as lubricant.

High and low level alarms shall be implemented as part of the unit control.

### **6.2.12 Compressor Materials**

Materials by manufacturers' standard in compliance with API 618 are accepted.

### **6.2.13 Couplings**

The compressor and driver shall be designed for direct flexible coupling without reduction gear.

The coupling shall comply with the requirements in API 671.

### **6.2.14 Base plates**

The base plate shall be common for the compressor and driver.

Parts of the frame lubrication systems, cylinder and packing lubrication systems, cooling system etc. shall to the extent possible be mounted and pre-piped on the base plate.

### **6.2.15 Piping and Appurtenances**

Coolant piping requirements:

The coolant medium as stated in the data sheet 89712-M-002.

The coolant system shall be a closed forced circulation system with a pressurized expansion tank, pumps, valves, thermostat controlled bypass, freezing and corrosion precautions, control and monitoring system (temperature and pressure).

Drain and Vent piping:

Drains for coolant containing equipment shall preferably end together in one outlet.

All gas vents from relief valves shall be piped to a vent header leading to above roof.

Vent line from the crankcase shall be connected to the gas recovery unit.

Insulation:

All thermal and acoustic insulation shall be carried out in accordance with DS 452 and in a way that prevents corrosion under the insulation.

Hot surfaces of equipment exposed to personnel during normal operation shall be avoided. When guarding is not possible, there shall be adequate warning signs with graphical symbols.

With regards to insulation material, fibreglass or mineral fibre shall be used for all installations. Piping jackets shall be made of hard rolled aluminium plate AlMnCu minimum 1 mm thick. At all low points, the jacket shall have a Ø 10 mm drain hole.

For acoustic insulation the jacket shall be provided with an internal coating of anti-vibration compound. Supports of the jackets shall be constructed in a way to prevent vibrations in piping from being transferred to the jacket.

In order to reduce the vibrations at skid equipment, supporting structures shall be reinforced or supporting legs added.

The piping material for the lubrication system shall comply with ISO 10438-1 table 4.

#### **6.2.16 Cooling system**

The water-cooled intercooler(s) and aftercooler(s) must be a shell-tube heat exchanger TEMA C type designed in accordance with API 660, selecting of materials must be in accordance with EN 13455-2.

Air cooled heat exchangers with low speed low noise fans shall be delivered with certified noise data sheet.

The heat exchanger air fans shall be frequency controlled variable speed drive 50 - 100 %.

The heat exchanger shall be designed in accordance with ISO 13706.

The air cooled heat exchanger shall be mounted on a foundation and will be located in unclassified area, but motors shall be certified ATEX EEx e IIIA (Zone 2) motors.

The cooling system shall be furnished with alarm, shutdown and control system.

It is in Supplier scope to furnish the fabricated piping between compressor and air cooled heat exchanger.

Pump and filter to the cooling water system must be placed indoor in same enclosure as the compressor.

A redundant water-to-water heat exchanger may be required on the compressor for use of the generated heat in secondary processes. This heat exchanger is an option which will only be asked for when relevant.



### **6.2.17 Pulsation and Vibration Control Requirements**

The Supplier shall supply pulsation dampeners at the suction and discharge connections, including necessary supports. Dampener vessels shall be in accordance with the requirements in section 4.2.5.

Vibrations shall be kept at a minimum and must be monitored at all times during operation. In start and stop sequence it is allowed to ignore vibrations. If an area of resonance is defined the control philosophy must take this into account reducing the risk of brake down and decreased lifetime expectancy.

### **6.2.18 Filter**

Inlet gas filter is within scope of supply. The filter shall be a single stage gas filter for separation of solids and liquids larger than allowed for safe compressor operation.

The filter shall have quick-closing door and cartridge shall be easy interchangeable installed downstream of the actuated inlet valve. The filter shall be provided with a drain valve. Manufacturer standard is acceptable.

The filter shall be designed in accordance with ASME VIII and vessel materials in accordance with DS/EN 13445-2.

The filter shall be pressure tested to 1,5 x design pressure and tightness tested afterwards.

### **6.2.19 Special Tools**

All special tools necessary for the normal maintenance shall be part of the supply.

## **6.3 Other Mechanical requirements**

### **Flange connections**

All flange connections for gas piping and equipment must be raised face type and in accordance with ASME B.16.5. Only stud bolts to be used for flange assemblies. Internal sockets are not allowed.

## **6.4 Pressure and tightness testing**

All gas containing components, vessels, filters, heat exchangers etc. must be pressure tested to min. 1,5 x design pressure and tightness tested afterwards.

## **7. Electrical**

### **7.1 Introduction**

The general electrical specifications given in the present section shall be fulfilled for all electrical equipment, components and installations provided for the Project.

### **7.2 Limits of Supply**

The limits of supply for electrical installations shall be as described below unless otherwise specified in previous sections.

### 7.2.1 Included in the Works

Design, supply and installation of below equipment are included in the Works:

- All switchboards including motor starters, contactors for operation of pilot valves, switches and indicators for manual operation, etc.
- Termination of main power supply cables type AI.
- All unit mounted components, including motors, valve actuators, emergency switches, repair switches, instruments and transmitters, on/off switches for automatic control, junction boxes.
- All power distribution cabling between switchboards included in the Works.
- All unit cabling of power supply cables.
- All unit cabling of control cabling.
- All cable racking including cable penetrations through fire separations, concrete walls/ceilings, etc.
- Any special lighting mounted on or inside machines and equipment.

### 7.2.2 Supplied by Others

Other contractors will provide the following services:

- Main power supply AI cables 3x400 V from transformer to the switchboards included in the Works done by others.

## 7.3 Regulations

### 7.3.1 General

The Supplier shall comply with the terms and intentions of the relevant Danish law and codes which apply to the design, manufacture, installation and operation of the system. These include, but are not limited to, the listed codes and standards.

## 7.4 General Conditions and Requirements

### 7.4.1 Power Supply

Electrical power supply will be:

- Voltage : 400/230 Volt, +6%/-10%
- Frequency : 50 Hz,  $\pm 1$ Hz
- Wiring : 3-phase, 5-wire system (TN-S-5, 3L+N+PE).

The Supplier shall in his contract clearly indicate whether the offered equipment and system cannot accept above conditions.

### 7.4.2 Control Voltages and Signals

In general the following control voltages shall be applied:

- Relay coil voltages: 24 VDC  
(motor starters, pneumatic/hydraulic valve actuators, PLC binary output)
- On/off switches: 24 VDC  
(PLC binary input)

- Analogue signals: 4-20 mA / 24 VDC  
(PLC analogue input)

All DC-coils shall be provided with a by-pass diode for protection of switches in the circuit.

The requirement for 24 VDC coil voltage may be exempted upon written approval by Purchaser in the case of heavy duty contactors.

#### **7.4.3 Transient Protection**

The electrical main supply for the installations shall be provided with overvoltage protection class II in the main switchboard. Protection level max. 1.5 kV at 15 kA, profile 8/20 $\mu$ s (combined surge gap and varistor discharger).

In case above protection is found insufficient by the Supplier to provide and secure the specified performance this shall be clearly indicated in the offer.

#### **7.4.4 Electro Magnetic Compatibility (EMC)**

The electrical installation shall be designed for EMC – Environment 2 (unprotected industrial environment). The project includes high voltage installations and electronic frequency converters. Cable glands shall be EMC-type. Pig-tail connection of cable sheathing is not allowed. Special cable clamps shall be used.

#### *Radio frequency interference*

All electrical and electronic equipment involved in this supply, including interconnecting cables shall be protected in order to avoid interference with the radio based digital telephone system (DECT).

### **7.5 Workmanship**

#### **7.5.1 General**

All workmanship shall be of a very high standard in order to meet the specified requirements.

The Supplier shall ensure that all works, for which he is responsible, are executed by persons skilled in the processes to be adopted. When requested, the Supplier shall provide such documentation as necessary to demonstrate an individual's ability to carry out the work for which Supplier has been assigned.

The Supplier shall be responsible for ensuring that all materials and processes employed in the works are comparable with each other and meet the current requirements of the relevant Danish standards, codes of practice and construction codes. Reference to a code or standard shall be deemed to include all other codes and standards referred to in the specified code or standard.

All materials and associated components shall be stored in a clean, dry area and stored in accordance with the manufacturer's recommendations.

The Supplier shall be responsible for all materials, components and equipment supplied or manufactured on his behalf by others, until the end of the warranty period defined in the Contract.

The Supplier shall submit samples, test certificates, etc. for review.

All material shall be treated and handled carefully to prevent any damage.

As regards materials subject to surface treatment, special attention shall be given to the substrate to ensure that the preparation is compatible with the surface treatment.

The Supplier shall ensure that all superficial dust and friable materials are removed and adequate protection provided during the process of the surface treatment to prevent contamination by dust and other debris.

Materials proposed by the Supplier must not be a potential hazard to health and environment.

Cutting of metal products shall be straight and free from burrs. All joints shall be flush, without gaps or imperfections. If base metal is exposed, the surface is to be protected to the same specification as general surfaces. All bolt holes to be drilled. Burning of dislocated bolt holes is not acceptable.

All components shall be installed in such a way that they are truly plumb or horizontal and line up with adjacent components, in all directions, taking account of the allowable tolerances.

#### **7.5.2 Design**

Switchboards shall be located in a separate mechanically ventilated room. Provisions for access to switchboards shall be provided in a safe and practical manner.

Switchboards shall be designed in accordance to EN61439-1, but breakers in the switchboards shall be selected so that the breakers can be continuously loaded with the designed rating. This may include selection of next higher rated component. E.g. a "630A" breaker shall be able to load 630A continuously, this may require installation of a 800A breaker.

Further the rated diversity factor for the busbars in the switchboard shall be 1.0. No diversity derating will be accepted.

All speed control of motors shall be by the use of frequency converters.

In general all electrical installations shall be designed and carried out to allow for easy access for maintenance and repair purposes.

Main motor is to be provided with a safety/repair switch disconnecting all phases.

#### **7.5.3 Cable Installations**

Cable shall be routed in such a manner that it does not interfere with the removal of mechanical equipment for service and repair.

Horizontal cable racking for single or few cables shall be conduits or cable trays.

In general power cables and control cables shall be installed in separate cable racks.

All cables connected to components, which are moving during operation or maintenance activities, shall be provided with an extra length. The cable extra length shall at the component be coiled and fastened by plastic strips.

All cables shall at both ends be relieved at the termination so that the cables are fixed immediately at the entering of a component, junction box, switchboard or control panel.

Splicing of cables, by any means, will not be accepted.

## **7.6 Electrical Equipment**

### **7.6.1 General**

The Supplier shall supply materials as specified and ensure that they are new, carefully selected, and of adequate quality according to the intended service and installation conditions.

### **7.6.2 Switchboards**

Below the phrase "switchboard" includes all electrical switchboards, cabinets, cubicles, panels and other enclosures used for electrical installations and control purposes.

### **General Mechanical Design**

All electrical switchboards must be of a sheet metal, front entry, with a minimum of 1.5 mm wall thickness without sharp edges or corners. Doors and casing of sheet steel, folded and seam welded to form a rigid self-supporting structure. Brace and stiffen to accept the weight of internal components and control assemblies.

All floor-mounted switchboards shall be provided with a bottom frame of 100 mm height.

Switchboards shall be built-up using standard modules, and they shall be furnished with main circuit breakers or power interrupters for each individual system.

Units shall be fully enclosed and constructed for easy maintenance. Special emphasis shall be placed on easy replacement of components, easy access for adjustment, control and fault-finding. Extra space shall be allowed for connections, enclosures and adaptation to changes and expansion.

All switchboards and control panels shall have a uniform design and be manufactured to enclosure protection IP44.

The switchboards shall be provided with a high quality heat-treated paint. They must be properly prepared, primed and provided with two coats of enamel paint on all sides.

Switchboards weighing more than 50 kg, including installed components, shall be fitted with eyebolts.

All external cables shall enter the switchboards through cable glands. The switchboards shall be provided with bolted flanges for insertion of cable glands. The flanges shall be sized according to the number of incoming cables in the different cable sections.

All parts of requiring access for operation or maintenance shall be mounted at least 500 mm and no more than 1800 mm above floor/platform level.

Clearance in front of switchboards and control panels must not be less than 1 m.

The front design of the switchboards shall be subject to approval by Purchaser.

*General Electrical design*

Supply cables rated higher than 63 A will be stranded aluminium conductors. Other cables will be stranded copper conductors.

The termination plinth for incoming main supply cables shall be designed for connection of parallel cables.

The incoming cables will at the supply end in the main switchboard (supplied by others) be provided with disconnectors and fuses. The Fuses will be sized according to information provided by the Supplier.

The short circuit level at the end of the main supply cables will be informed by Purchaser.

All main switchboards shall be provided with front mounted meters for voltage (one meter and 7-position switching) and current measurements (3 A-meters).

Circuits rated 63 A or lower shall be protected by MCBs.

Motor starter contactors shall be chosen in accordance with the operational classification AC-3 given in IEC 60947-4.

Motor starters shall be of the electronic type with integrated I/O and communication modules.

Motors rated 12.5 kW or lower may have direct start, while motors above 12.5 kW shall have starting limitation to 2.2 times normal current and in addition be equipped with full protective devices (thermistor protection).

Special attention shall be given to motors with long starting duration and motors started in loaded situation.

Switchboards providing power supply shall be equipped with facilities for indication of actual and maximum current and voltage level preferable by a multifunction meter. Furthermore, it shall be provided with facilities for kWh and kW readings. Signals shall be available at a bus interface for the Purchaser monitoring system.

Requirements to internal separations, as per EN 61439-1:

- Circuits up to 63 A: Form 1, Components can be placed in an open cabinet.
- Circuits above 63 A: Form 3b, with horizontal and vertical covers. Each circuits to be provided with separate door.

The switchboards shall be of a fuse-less design. MCB's and similar shall be used for short circuit protection.

Each switchboard shall be provided with an internal 400V/16A CEE socket outlet.

For circuits up to 63 A external cables shall be terminated in terminal rows. Only one wire per terminal is accepted.

For circuits above 63 A external cables shall be terminated directly at the terminals on the component in the switchboard.

Equipment, which requires online adjustment and testing by non-electrically qualified personnel, shall be accessible and adjustable without interrupting the supply or overriding safety interlocks.

All wiring within switchboards shall be arranged in looms and/or perforated trunking.

Terminals shall be fully shrouded, recessed or otherwise protected against accidental contact.

Any live equipment, which cannot be isolated, shall be covered with a shield carrying appropriate warning labels.

All wiring looms and trunking shall allow minimum 20% future extension.

Only one wire from incoming cable must be terminated in each terminal.

Switchboards shall be provided with temperature controlled electrical heating elements and/or other means to effectively avoid moist inside the switchboard.

#### *Control panels*

Flexible looms shall be used for connection between door mounted and interior mounted components, so that wires do not break or weaken with repeated door openings.

Control panels shall be provided with temperature controlled electrical heating elements and/or other means to effectively avoid moist inside the panels.

Outdoor cable conduits to be properly sealed for entrance of water and/or vermin etc.

### **7.6.3 Electrical Motors**

Motors shall be in accordance with IEC Publication no.60034-1 to 18.

Motors shall be high efficiency types - at least IE2 level preferable IE3.( in accordance to European Commission ecodesign regulation No 640/2009 on electric motors). Type of motors shall be designed and selected in accordance with the mode of operation and the environment, in which they will be used. Motor rating shall be minimum 110 % of the requirement of the compressor.

Motors operated by frequency converters shall be provided with thermo sensors embedded in the stator.

The motor shall be designed to perform at least six successive starts per hour at operating temperature.

#### **7.6.4 Frequency Converters**

Frequency converters shall be delivered as separate units. (Not as part of a motor).

Frequency converters shall have efficiency higher than 97% at 75% load.

The THiV extent on the power supply side shall comply with the Danish Regulations. The installation site may be in office areas, in industrial areas and in the open land. Therefore the highest THiV requirement shall be complied to.

The power factor at the power supply side of the frequency Converter shall be better than 0,99.

The frequency converter cables shall be a type approved for frequency converter operation and shall be recommended by the frequency manufacturer. The outgoing motor cables shall be screened cables and be installed in accordance to the frequency converter manufacturers recommendation.

The frequency converter shall CE-marked and be in compliance with the Low Voltage directive, The Machinery Directive and the EMC-directive.

#### **7.6.5 Safety/Repair Switches**

The switch shall have additional contacts for remote indication of switch position.

#### **7.6.6 Emergency Stops**

Design of emergency stop buttons must be in accordance with DS/EN 13850.

Push buttons for emergency stop shall be of the "mushroom" type with locking function. The push buttons shall be coloured red and shall be locked in the off-position when pressed. Push buttons shall have contacts for remote indication of switch positions.

All push buttons shall be located within easy reach of the operator.

Each emergency stop push button shall be marked with a red sign with the text "NØDSTOP" in 50 mm letters heights.

#### **7.6.7 Cables**

All cables shall be rated 750 VAC minimum.

Motor cables for frequency controlled motors shall be of fully symmetrical design and shall be provided with screen.

Cables shall be selected to suit the specific purposes. Special consideration shall be given to cables in areas submitted to vibrations, high temperature, sunlight (UV rays) and oil spillage.

Conductors in control and signal cables with more than 5 conductors shall be individually numbered.

#### **7.6.8 Cable Racks and Supports**

All cable racking and cable supports shall be in galvanized steel.



## 7.7 Earthing and Bonding

The Works shall include bonding of the complete assembled process equipment, cable racks, reinforcement in foundation and all other supplies included in the Contract.

A 2 ohm earth electrode shall be included in the TN-S system to the gas compressor supply. The earth electrode may be installed with the foundation by Purchaser on basis of Supplier design.

The Supplier shall ensure that all extraneous conductive parts of the system are effectively bonded to earth. An extraneous conductive part is defined as being a part, which is liable to transmit a potential, including earth potential and not forming part of the electrical installation. Each component constitutes an extraneous conductive part.

Bonding shall be provided to ensure that the various exposed conductive parts and extraneous conductive parts as defined by the regulations shall carry substantially equal potentials.

Electronic and electrical equipment shall be protected against over-voltage.

All earthing, bonding and electrical protection shall comply with regulations as laid down in the Danish Power Regulation "Stærkstrømsbekendtgørelsen".

## 8. Instrumentation

### 8.1 General

All instrumentation shall be insensitive to shock or vibration effects normally encountered in gas and oil installations.

Instrumentation to be connected directly to pipes shall be insensitive to - and not affect - cathodic protection currents.

Explosion Protection for instrumentation shall generally be certified for Zone 1, as defined in section 4.3.4 inside the gas compressor containment. If possible, instrumentation shall be intrinsically safe - EEx i.

Electrical equipment shall be certified for Zone 1 as well.

Electrical supply voltage for electrical instrumentation shall be 24V DC except for electrical supply to EEx i circuit instrumentation.

All electrical connections shall be Pg16/M20.

All housings shall have a minimum enclosure protection to IP 54 in accordance with IEC 60529.

Safety systems (Gas-, Fire-, ESD-, etc.) instruments shall be fail-safe.

Generally instruments shall be delivered with an accuracy class requirement of 1.0 or better, and shall include calibration curves with traceability maintained.

## **8.2 Temperature instruments**

### **8.2.1 Temperature Indicators**

Thermometers shall be of industrial type in steel or high pressure nitrogen dial type suitable for thermowell mounting. Thermometers for outdoor use or vibration application shall be liquid filled.

Thermometers mounted directly to thermowells shall be fitted with an adjustable nipple for positioning.

Thermometers with remote indication shall be temperature compensated, and generally be insensitive to changes in the surrounding ambient temperature.

Thermometers shall have minimal response times.

Thermometer housings shall be waterproof and corrosion resistant, preferably of a stainless steel construction.

Thermometers shall be function tested by the manufacturer and issued with a test certificate.

Certificates for thermometers with an accuracy class requirement of 1.0 or better shall include a calibration curve with traceability maintained via the thermometer serial number.

### **8.2.2 Temperature Switches**

Temperature switches for remote control or alarm purposes shall be no-touch inductive proximity sensors built integral with an indicating thermometer.

The switches shall be part of an Exi circuit where explosion protection is required.

Temperature switches shall be function tested by the manufacturer and issued with a test certificate.

### **8.2.3 Temperature Sensing Elements**

Temperature sensing elements shall be Resistance Temperature Detectors (RTD's) of the type Pt 100 in accordance with EN60751 form B for insertion in thermowells.

The elements shall be part of an EEx i circuit where explosion protection is required.

The RTD shall be connected to a temperature transmitter by a 4-wire cable making lead resistance adjustment unnecessary. The supply will be a constant DC voltage giving a suitable measuring current.

All temperature sensing elements shall be function tested by the manufacturer and issued with a test certificate.

### 8.2.4 Electronic Temperature Transmitters

2-wire smart analogue/digital signal transmitter with an analogue output signal directly proportional to the temperature, and digital communication facilities for configuration and maintenance.

The smart transmitter shall be a microprocessor designed for:

- attainment of high accuracy, including automatic recalibration of amplifiers, zero drift elimination, ambient temperature correction and self-diagnostic tests.

The smart transmitter shall at the same time give a continuous analogue output signal and allow digital communication on the output signal lines by connection of a portable terminal to the lines. The digital communication shall at least make ranging, calibration and diagnosis via the terminal possible.

The temperature transmitter shall transmit power to a Resistance Temperature Detector of the type Pt 100 in accordance with EN60751 form B and receive the input signal via a 4-wire cable.

Supply and signal circuit shall be part of an Exi circuit where explosion protection is required.

The temperature transmitter shall comply to following:

- Span - Adjustable between 20 and 100% of the range.
- Zero - Adjustable between  $\pm 20$  and +80% of the span.
- Input signal - Via Pt 100, maximum load current 10 mA.
- Output signal: 4-20 mA directly proportional to temperature.
- Output load  $\leq 600$  ohm.
- Accuracy  $\leq \pm 0.25\%$  of calibrated span

Testing and certification:

All temperature transmitters shall be function tested by the manufacturer and issued with a test certificate

## 8.3 Pressure Instruments

### 8.3.1 Pressure and Differential Pressure Indicators

Pressure gauges shall comply with the requirements of EN 837.

Additional codes and standards:

- EN837-1+2+3 Pressure Gauges

Pressure gauges shall be capable of withstanding a permissible overload in excess of 10% of its range without effect to its accuracy, and 30% without bursting.

Differential pressure gauges shall be capable of withstanding the maximum operation pressure.

Pressure gauges shall be liquid filled and fitted with a safety blowout plug. Material of wetted parts shall be stainless steel.

Type test - All pressure gauges shall have a type test approval certificate issued by an approved independent inspection authority (TÜV, Lloyd's, DnV, etc.).

Pressure gauges with an accuracy class requirement of 0.6 or better shall also have calibration curves issued with the test certificates with traceability being maintained via the pressure gauge serial number.

### **8.3.2 Pressure and Differential Pressure Switches**

Pressure and differential pressure switches for remote control or alarm purposes shall be:

- No-touch inductive proximity sensors built integral with pressure gauges, or Diaphragm-operated electronic switches

The switches shall be part of an Exi circuit where explosion protection is required.

They shall comply to following standard: EN60947-5-6: Low Voltage Switchgear and Controlgear: Part 5-6 Control Circuit Devices (Namur)

The setpoints shall be visible and adjustable over the entire scale range and - for the pressure gauge type - visible.

Differential travel shall not exceed 1% of the pressure gauge scale.

All pressure and differential pressure switches shall be function tested by the manufacturer and issued with a test certificate.

### **8.3.3 Electronic Pressure Transmitters**

2-wire smart analogue/digital signal transmitter with an analogue output signal directly proportional to the pressure, and digital communication facilities for configuration and maintenance.

The smart transmitter shall be a microprocessor designed for:

- accuracy, including automatic recalibration of amplifiers, zero drift elimination, ambient temperature correction and self-diagnostic tests.

The smart transmitter shall at the same time give a continuous analogue output signal and allow digital communication on the output signal lines by connection of a portable terminal to the lines. The digital communication shall at least make ranging, calibration and diagnosis via the terminal possible.

The sensor shall be separated from the process by a diaphragm with the pressure transmission between the diaphragm and sensor provided by silicone oil.

The sensor may be of the semi-conductor, strain gauge or capacitor type.

The power supply to the pressure transmitter and the output signal shall be via a 2-wire cable.

Supply and signal circuit shall be part of an Exi circuit where explosion protection is required.

Span - Adjustable between 20 and 100% of the range.

Zero - Adjustable between 20 and +80% of the span.

Output signal: 4-20 mA directly proportional to the pressure.

Output load:  $\leq 600$  ohm.

Accuracy:  $< \pm 0.5\%$  of the measured value

All pressure transmitters shall be function tested by the manufacturer and issued with a test certificate, inclusive of a calibration curve for the required span. Traceability between the certificate and the transmitter shall be maintained via the transmitter's serial number.

#### **8.4 Gas Detectors**

Detectors shall be designed, tested and approved as described in "DBI Forskrift 233 AGA Automatic gas detection system" to the extent required by the authorities and this specification.

Detectors shall be operable over the range 0-100% lower explosivity limit, LEL, with a sensitivity span of 0-30% LEL at an accuracy to within  $\pm 2\%$  of the operable range. (LEL being approximately 5% volume in air for methane at 25°C and at atmospheric pressure).

Detector type Gas detectors shall be of the type based on the catalytic combustion principle, with two elements (one sensing and one as reference) suitable for detecting natural gas below the LEL.

All gas detectors shall be fitted with a collecting cone to allow sensing at a very low % LEL.

The gas detectors shall not be poisoned by gas concentrations over the LEL.

Terminals shall be for a 4-wire cable.

Gas detectors shall be tested and approved as described in "Forskrift 233 for AGA-anlæg" by a company accredited with certification and inspection by "Industri-og Handelsstyrelsen" (The National Agency of Industry and Trade).

## 8.5 Technical Documentation

All instruments exposed directly to process medium pressure shall have material certificate EN 10204–2.1 (certificate of compliance).

All instruments shall have manufacturer's test certificates conforming to EN 10204-2.3 or equivalent (inclusive of calibration details).

All electrical equipment suitable for use in potentially explosive atmospheres shall have EEx approval and conformity certificates. The certificate requirements for EEx i (intrinsically safe) equipment shall make connection to standard EEx i relays possible.

Manufacturer's test certificate to EN 10204-2.3 or equivalent together with EEx approval and conformity certificates all as stated above.

## 8.6 Reference Designation and Marking

### 8.6.1 Equipment Identification

All equipment and components shall be identified by an ID-number according to the P&IDs.

The extent of application of equipment identification shall correspond to the documentation provided, and shall allow for a unique and unambiguous identification of each piece of equipment and component.

### 8.6.2 Signs and Marking

#### *General*

All marking shall be clear and durable. Life expectancy of marking shall correspond to the life expectancy of the units labelled.

All text marking shall be in Danish and easily readable.

Marking shall generally be replaceable and made of metal or sturdy white plastic signs with at least 0.5 mm recess black characters.

Markings of field components shall be fixed with bolts and nuts.

Marking text shall be given on plans and drawings and approved by Purchaser prior to production whenever practicable.

### 8.6.3 Marking of electrical equipment

All equipment shall be marked with an ID-number corresponding to the agreed Reference Designation System.

The marking shall be carried out with signs, which are safely and securely fixed to the equipment.

The Supplier shall propose a marking system for the different installations (switchboards, switchboard components, cable terminals, cables, components, etc.).

### *Marking of Switchboards and Panels*

On the front of each switchboard and panel the following information shall be indicated (on the door of the incoming section):

- The switchboard ID-number.
- ID-number of the main switchboard (main power supply)
- The voltage level within the panel section (for clear warning of risks).
- Size and type of main supply cable

All front mounted switches, controls and indicators shall be clearly marked with their function.

All components inside the panel shall clearly be labelled with ID-number corresponding to ID used at schematics. All labels shall be glued or fixed by screws at the fixed parts of the components or at the cabinet.

All wires shall be provided with permanently fixed numbered ferrules with numbers corresponding to numbers fixed to terminals. Terminal shall be provided with identification and coding as used on drawings, schematics and schedules.

### *Cable marking*

All wiring inside switchboards and panels shall be colour coded as follows: DS/EN 60445

- Line (L): Brown, Black, Grey
- Neutral (N): Blue
- Protective earth: Yellow/green

Control voltage wiring:

- 24 VAC control voltage (L): Violet
- 24 VDC control voltage (+): White
- 24 VDC control voltage (-): Black
- 24 VDC control wire: Grey
- 230 VAC Control Voltage Phase: Brown
- 230 VAC Control Wire: Red
- 230 VAC Control Voltage Neutral: Darkblue
- 4-20mA intrinsic safe: Light blue
- 4-20mA not intrinsic safe: Orange
- External control voltage: Transparent

The individual cables shall be marked unambiguously, clearly and durably as follows, so that they can be identified immediately in connection to fault-finding, etc.:

- At terminal blocks, in switchboards, control panels, etc.
- At all junction boxes, wiring accessories, etc.
- At both sides of fire barriers
- On cables entering enclosures from below ground
- On cables leaving cable routing arrangements

The marking shall be carried out no more than 200 mm from terminal block, junction boxes, wiring accessories, etc. The marking shall identify the cables in accordance with the relating documentation.

At cable terminations the cables shall in addition be marked with identification of the equipment connected at the opposite end of the cable.

The principle and the cable numbering system shall be approved by the Purchaser supervision team.

## 9. Enclosures

### 9.1 General

Either one or two enclosures depending on design and size of equipment shall be included. The enclosures may be either light weight concrete building or steel containers.

In design of the enclosure sufficient working space around the compressor skid must be obtained for maintenance and overhaul. If adequate space is not available inside the compressor room, service openings must be installed in the enclosure for easy access to the compressor unit.

The roof shall be designed with an explosion relief opening. Alternatively the roof shall be designed as a light structure as defined by F.0.1.

Roofs shall be sloping with minimum 1:40 so rain is drained away from the building according to "the 2010 Building Regulation".

An eye for hook-up for a safety sling shall be installed on the roof with minimum load capacity of 100 kilograms.

Floors shall be designed in a non-sparking material with, anti-static resistance 1 mΩ.

The enclosures shall fulfil the requirements of the Danish building regulation and the Danish requirements defined in At Guideline F.0.1, natural gas installation – The Danish Working Environment Authority.

The enclosures shall be equipped with lighting, ventilation etc. Further the enclosures shall be delivered painted in RAL 7016.

### 9.2 Enclosure Works and foundations

The Suppliers scope of work includes planning and design of the foundations required for the gas compressor unit and utilities.

The compressor foundation shall be designed in accordance with BS CP 2012-1 to prevent vibrations from the compressor. The design parameters shall ensure reasonable comfort to persons as per line ABB in figure 3.

It is in Supplier scope to design compressor foundations, on basis of geotechnical investigations carried out by the Purchaser, for the given location(s).



The Supplier shall prepare and issue all documentation needed to obtain Authority approvals for civil, enclosure and structural works.

The documentation shall include Operation and Maintenance Manuals for the enclosures and facilities.

All work shall be planned, documented and executed according to Danish Regulations.

### 9.3 Walls for compressor enclosure

The walls surrounding the compressor unit shall be classified REI 60 A2-s1,d0 according to EN 13501. The walls shall be able to resist an internal pressure of 5 kN/m<sup>2</sup>. Doors in the wall (to the compressor room) shall be able to withstand the same pressure of 5 kN/m<sup>2</sup>. Any double doors shall be furnished with locking pawl at top and bottom which can withstand a pressure of 5 kN/m<sup>2</sup>. Locking pawl at top must be operational from maximum 1,7 m above room floor level.

The wall between the compressor room and the electrical switchboard room shall be gastight. Any cabling wall penetration shall be installed in gas tight mct frames. Windows are not allowed.

### 9.4 Ventilation

The compressor enclosure shall be ventilated either forced or naturally in order to keep the room free of gas and the room temperature at a reasonable level ( $< +35^{\circ}\text{C}$ ).

A natural ventilation system shall meet the following requirements:

- Ventilation openings shall be evenly distributed over the length of the walls and/or the roof in such a way that an effective ventilation of the complete room is obtained.
- The total area of ventilation openings must be no less than 0.6% (0.3% at the roof, 0.3% at the floor) of the floor area assuming that all vent lines and blow down piping from the gas installations is piped to the outside of the enclosure with openings minimum 1 m above the roof of the enclosure and minimum 3 m away from any ventilation openings and doors.
- Ventilation openings shall be covered with a corrosion resistant mesh screen to keep birds out of the enclosure. Further the openings shall be equipped with silencers to keep the total noise emission below the specified limit for the total plant. Furthermore arrangement must be taking to prevent any vermin, from entering the housing/containment through the ventilation.

A mechanical ventilation system shall meet the following requirement:

- Air renewal shall be min. 4 times per hour.
- Under pressure inside the compressor room shall be avoided.

The Switchboard enclosures shall be mechanical ventilated. Ventilation air shall be taken at least 1 m above the roof. The switchboard enclosure will be unclassified area.

### **9.5 Lighting System**

The enclosures shall be provided with necessary lighting for normal service and inspection functions at least 200 lux shall be provided.

The lighting system light fittings and installation in the compressor enclosure shall be certified for zone 2.

In case of activation of emergency bottom the lighting system must still be in operation.

### **9.6 Heating**

The enclosure shall not be heated. The switchboards and terminal boxes may be provided with anti condensation heating. This is the responsibility of the contractor to assure that the gas compressor can start at any condition within the specified environmental window.

### **9.7 Gas detection**

The compressor room shall be equipped with a gas detection system applicable for detection of upgraded biogas + natural gas and approved by the Danish Authorities.

In case of one of the gas detectors detects a gas concentration of 10 % of lower explosion limit (LEL) a high gas alarm shall be transmitted to the GCC-system.

Coincident detection of gas at 25 % of LEL of two or more detectors shall cause a high-high gas alarm, which shall be transmitted to the SCADA system. The high-high gas alarm shall cause an ESD of the gas compressor in operation.

### **9.8 Control room**

The control room shall be prepared with power sockets next to the entrances.

- 1 pc. 230V/13A Danish model socket outlet.
- 1 pc. 400V/16A CEE

Power and internet sockets for temporary installation of laptop.

- 2 pc. 230V/13A Danish model socket outlet.

In front of the control cabinets free space of minimum 1,0 m is required inside the control room.

## 10. Fabrication

### 10.1 General

The Supplier shall follow the fabrication procedures and material recommendations in accordance with API 618.

The Supplier shall collect and ensure that all relevant information related to the fabrication process.

### 10.2 Materials and material certificates

#### 10.2.1 Piping

Piping material shall generally be carbon steel piping according to recognised standards, such as ISO EN 3183 PSL 2 or API 5L.

All main gas piping shall be flanged, screwed connections is not acceptable. Cooling water piping shall be flanged for dimensions  $DN \geq 40$  mm.

For all pressure retaining materials the following requirements are applicable:

- Materials shall be normalised.
- Max. Carbon content is 0.25% and max. CE-value is 0.42%
- Material certificates level 3.1 according to EN 10204 for all materials having a specified minimum tensile strength  $< 450$  N/mm<sup>2</sup>
- Material certificates level 3.2 according to EN 10204 for all materials having a specified minimum tensile strength  $\geq 450$  N/mm<sup>2</sup>
- As specified in ISO EN 3183 shall be Charpy V tested at -20 °C to minimum 27 J.

#### 10.2.2 Tubing

Instrument tubing shall be stainless steel 316L. Tubing fittings shall be of the twin ferrule compression type.

The Purchaser uses compression fittings of make Parker EO in other installations. Tubing dimensions shall all be in metric.

#### 10.2.3 Valves

All valves installed in gas systems shall be of fire proof design.

The actuated shut-off valves at compressor unit inlet and outlet shall be double block and bleed ball valves.

Safety block valves must be fitted so that testing of the valve is possible without dismantling of the valve. Pilot tubes must be furnished with one valve and two test couplings (stauff type) for connection of manometer and test gas (nitrogen).

Valve leakage rates:

Valves shall be tested in accordance with ISO 5208 and the acceptable rates shall be as follow:

- Ball valves - rate A
- Other valves - rate AA

Pressure safety valves shall be delivered with certificates in accordance with PED category IV. All valves must be delivered in accordance to F.0.1. Piping design for

pressure safety valves must be prepared for testing without dismantling, the PSV must be isolated with a block valve and have two test connections for a manometer and test gas, manoflanges may be used if feasible. All block valves required for testing must be locked in open position with a mechanical lock (customs seal).

### **10.3 Welding and welding inspection**

The Supplier shall submit preliminary welding procedure specifications, WPS and approved WPQR according to DS/EN ISO 15609-1. All dimensions, all combinations of materials to be joined and all repair weldings shall be covered.

Welders shall be qualified in accordance with the requirements of DS/EN ISO 9606 + AC, bend test is mandatory.

Weld seams on gas pressure retaining piping shall be 100% inspected using radiographic inspection.

Inspection requirements in accordance with DS/EN ISO 17636/A1. Acceptance criteria as per DS/EN ISO 10675.

Visual inspection, 100% of all weld seams, shall be performed according to DS/EN ISO 17637. Accept criteria level B.

Where radiographic inspection cannot be performed, ultrasonic inspection according to DS/EN ISO 17640 may be used.

Where ultrasonic inspection cannot be performed, magnetic particle inspection according to DS/EN ISO 17638 shall be used. Accept criteria as per DS/EN ISO 23278 level 2.

All welding inspection and non-destructive examination shall be performed by authorised personnel with accreditation.

### **10.4 Pressure testing**

Before painting and surface treatment, all gas containing pipespools, must be pressure tested to min. 1,5 x design pressure and tightness tested afterwards.

### **10.5 Painting and surface treatment**

Painting systems shall be minimum for corrosion class 4 (industrial areas) in accordance with DS/EN 12944-2.

## **11. Inspection and Testing**

### **11.1 General**

Factory and Site acceptance tests shall be included in the supply. Test procedures and protocols shall be provided by supplier and submitted for Purchasers approval no later than 4 weeks prior to tests.

Prior to acceptance of the compressor, the Supplier must demonstrate and document that the equipment meets the performance requirements as specified.

Prior to delivery, the compressor shall be tested at the Suppliers shop as far as possible and punch items shall be cleared and accepted by the Purchaser before delivery on site.

- Functional and performance test of the complete gas compressor unit incl. utility consumption and a noise test as per API standard and any requirements specified in this document.
- Actual compressor performance.

The Supplier shall prepare test protocols and Purchaser shall be invited to the tests with a minimum of one week notice. The testing protocol shall be submitted to the Purchaser for approval not less than 4 weeks before the test date.

Quality plan:

Supplier shall perform the standard quality control plan and if necessary supplemented with following.

Test	Controlled by Supplier	Witnessed by third party	Observed by Purchaser	Witnessed by Purchaser
Material certificates for pressurized components	Yes (2.2)			
Hydrostatic test	Yes (3.1)			
Leakage test	Yes (3.1)			
Functional tested	Yes (3.1)			

All tests shall be reported and included in the documentation package of the unit.

All expenses to control by Supplier and third party inspection are paid by the Supplier.

"Observed" means that Purchaser can participate in the tests.

"Witnessed" means that Purchaser or representative inspector shall participate in tests and tests cannot be started without presents of Purchaser or representative.

**11.2 Factory acceptance test (FAT)**

The FAT shall be carried out in accordance with the requirements in API 618 and performance test in accordance with ISO 1217.

Hydrostatic and leakage test:

The manufacture shall perform hydrostatic and leakage test of the compressor cylinders. Cylinders shall be leakage tested with helium. Both tests shall be witnessed by Notified Body.

Test of unit control and electrical system:

In connection with the mechanical running test the electric motor driver shall be tested according to EN 60034-5.

The following test and check procedures shall as a minimum, but not limited to, consist of:

- Check of performance of components and unit control system
- Check of quality of component materials and surface treatment

- Check of cable and wiring systems
- Check of function of components
- Test of electrical insulation
- Total function test of unit control system with simulated input signals

If the manufacturers standard test program has additional requirements, these additional tests shall be carried out as well.

Compressor performance test:

The performance measurements with the acceptance criteria's in the following table 11.2, shall be carried out at:

- Minimum volume flow rate
- Three volume flow rates between min. and max. flow (25%, 50%, 75%)
- Maximum volume flow rate
- No load power

Nitrogen is to be used as test media.

Measured variable	Maximum permissible deviations	Maximum permissible fluctuation from average during any set of readings
Inlet pressure	± 5 %	± 1 %
Discharge pressure	± 2 %	± 1 %
Pressure ratio	± 5 %	-
Isentropic exponent	± 3 %	-
Gas constant x compressibility, R x Z	± 5 %	-
Shaft speed, N	± 4 %	± 1 %
Difference between inlet temperature of external coolant and the gas inlet temperature	± 10 °K for coolant air ± 5 °K for coolant liquid	± 2 °K ± 2 °K
External coolant flow	± 10 %	± 10 %

Table 13.2 Maximum deviations from specified values and fluctuations from average readings

In general the performance test shall be carried out and all measured values of the different parameters shall be treated in accordance with BS ISO 1217.

The Supplier shall in the tender material specify overall efficiency at the five stated flow rates above.

**Mechanical running test:**

The complete compressor unit and auxiliary equipment shall pass 4 hours mechanical non-stop running test. The running test shall be observed by the Purchaser and cannot start before Purchaser is present. The manufacture shall no later than 10 working days before test date confirm the date to Purchaser.

**11.3 Inspection**

After the running and performance test, the compressor shall be inspected by random inspection, e.g. disassembly of at least one main bearing, one cross head and one cylinder. All inspections of parts shall be performed with boroscope by the Supplier proving excellent condition of internal surfaces.

If irregularities are found the compressor has to be further disassembled and inspected, and damaged parts shall be replaced.

In case of exchange of parts as a result of inspection, after assembly, the 4 hour mechanical running test shall be repeated and new parts installed shall be inspected and found in order.

**11.4 Preparation for shipment**

All materials shall be properly packed and protected as required for the chosen method of transport and shall be suitable for a storage period of approx. 1 year.

Packing shall be strong enough to withstand rough and frequent handling.

Openings in equipment shall be suitably covered to prevent damage and/or foreign matter from entering.

All equipment shall be completely drained of water, thoroughly dried and cleaned prior to packing and shipment to prevent freezing and corrosion.

Threaded or bevelled pipe ends shall be covered with plastic caps to prevent foreign matter from entering. Finished and coated surfaces shall be protected from abrasion.

**11.5 Site installation**

Site installation is part of the Suppliers scope of work including crane operations and all other necessary works.

Supplier shall connect the compressor to interface flanges inside or outside enclosure/containment depending on final compressor concept.

Foundation works will be carried out by Purchaser on basis of Supplier design and specification.

Supplier must facilitate the connection of the earthing electrode to the compressor unit.

Purchaser will install cabling from transformer to the compressor unit on basis of Suppliers specification and time schedule.

## 11.6 Commissioning

All test and findings shall be reported.

### Leakage test:

The main contractor shall perform a complete leakage test on compressor package, auxiliary systems and all connected piping at the compressor area. At the same time the Supplier shall test the pulsation dampener system and the compressor cylinders for any leakage.

### Test of unit control and electrical system:

The following test and check procedures shall as minimum be carried out:

- Check of cable and wiring systems
- Check of function of components
- Total function test of unit control system with input signals from existing control system.
- 

## 11.7 Site Acceptance Testing (SAT)

All SAT tests shall be witnessed by the Purchaser and documented in a SAT-report.

Purchaser shall document the Noise emission from the compressor unit including auxiliary system(s). Measurements shall be for start-up, continuous operation and shut down. Supplier shall demonstrate that the equipment meets the performance requirements as specified.

The SAT-report shall be forwarded for comments as specified in API 618 sec. 8.3.1.

### Mechanical 72 hours running test:

The mechanical 72 hours test of continuous operation with gas of a pressure within the stated operating pressure range shall be performed by the Supplier or under his direction and responsibility, but in close co-operation with the Purchaser.

During start-up the compatibility between the unit parts supplied by the Supplier and the equipment provided by others shall be checked.

During the test no faults of the unit parts shall occur. Perfect operation of the unit devices and controls shall be verified. In case of interruption, due to a fault in the unit or auxiliary equipment, the test shall start again from the beginning as soon as the fault has been eliminated.

The mechanical running test shall as a minimum include 3 (three) starts and 3 (three) shutdowns with no fault in the sequence.

Noise emission from the compressor unit including auxiliary system(s) shall be measured for start-up, continuous operation and shut down.

In case of repetition of testing for leakage, mechanical running and / or performance test caused by Suppliers failure, the arising costs shall be carried by the Supplier accordingly.

In case gas pressures are lower than indicated for guarantee points, the Supplier shall perform the verification performance data by calculation.



Final acceptance will be given when the Purchaser receives a written certification stating that the Supplier had complied with all existing laws and regulations and delivered documents and certificates as required.

## 12. Documentation

### 12.1 General

After signing of the contract, and within agreed time schedule, the Supplier shall substantiate that all relevant equipment including access to all equipment and enclosure are in accordance with EU machinery directive 2006/42/EC and CE marked in accordance with directive 93/68/EEC.

The Supplier shall submit all necessary documents to Purchaser for design approval of the compressor package by the Danish Working Environment Authority. Purchaser will have all contact with the Danish Authorities.

### 12.2 Documentation

Documentation shall be submitted as follows:

#### With the Tender documents

To be supplied with Suppliers quotation:

1. System description
2. Description of Control and Safety systems and equipment, safety plan, description of safety procedures when servicing the compressor
3. Estimated availability
4. Preliminary P&ID's for compressor skid and auxiliary systems
5. Typical general arrangement drawings for the largest and smallest skid/system, including overall dimensions and weight
6. Noise Emission (expected and guaranteed sound pressure level) with detailed description of noise reduction of the enclosure, coolers and blow down stack
7. Quality system description
8. Utility requirements
9. Interface specification for SCADA
10. Signal list/Instrument list
11. Performance test plan according to ISO 1217 and guaranteed efficiency verification
12. A list of any non-conformities to this specification
13. Capacity and efficiency curves for the compressors types

### Engineering documentation

To be supplied in accordance with the agreed time schedule:

1. Detailed drawings and calculation of enclosures incl. explosion relief opening in roof
2. System description incl. sizes of equipment and materials and painting specifications
3. P&ID, PFD's and mass balance diagrams
4. Plot plan
5. Area classification
6. Detailed arrangement drawings of the unit complete with auxiliaries, and of all other major system components
7. Instrument schedule and list of alarms and trip points
8. Instrument connections to the control system
9. Software documentation
10. Cause and effect diagram and list including all interface ESD/EDP signals
11. Interface list incl. loads on pipe tie-ins, and utility consumption
12. Specification of electricity supply capacity required.
13. Input for foundation design drawings and specification
14. Vibration and pulsation study
15. Acoustic simulation and piping restraint analysis
16. Performance curves, including torque/speed curves for compressor and motor

### Authority approval documentation

Material required for the authority approval shall be supplied by the Supplier to Purchaser.

### Construction documents

Revised and detailed versions of the documents listed above incl. operation and maintenance instructions, mass balance diagrams, test protocols and equipment and piping drawings etc. specifying all interfaces incl. tie-in loads. Data sheets on equipment and major valves shall be included together with a detailed spare parts list.

### Documentation stored by Supplier

The Supplier shall deliver following data to Purchaser and store copy of the data for at least 10 years:

- Necessary or specified certification of materials, such as mill reports
- Test data and results to verify that the requirements of this specification have been met
- Fully identified records of heat treatment, whether performed in the normal course of manufacture or as part of a repair procedure and other examinations such as magnetic particle, liquid penetrant, radiography and ultrasonic
- Results of quality control tests and inspections
- Details of all repairs

## **12.3 Tag Numbering**

Any item of a system and equipment (e.g. valve, instrument, line) shall be given a tag number for identification.

Tag numbering shall be in accordance with recognised standards as ISO 10628 and ISO 3511/1 and 2.

#### **12.4 Numbering System and Formats**

Suppliers standard numbering system are accepted. All documents shall be furnished with a unique number or name.

Document numbering system shall be enclosed with the Suppliers proposal.

Documentation on papers shall be supplied in the original size.

Other documentation on data files has to be agreed upon. Information can include

- format, i.e. definition and contents.
- medium (e.g. DVD or CD-ROM)
- standard (e.g. ASCII, IGES)
- or name of program and version

### **13. Time Schedule**

#### **13.1 Delivery on site**

The 2 Compressor units must arrive on site Industrivej 20, 5471 Sønderød, Denmark no later than June, the 5<sup>th</sup> 2017.

#### **13.2 Commissioning**

Commissioning of at least 1 of the 2 compressors must be completed no later than June the 20<sup>th</sup> 2017.

#### **13.3 Hand over**

Hand over of the complete compressor installation must take place on June the 30<sup>th</sup> 2017.

## 14. **Appendices**

1. Doc. no. 89712-DWG-009: P&I diagram,
2. Compressor data sheet, Doc. no. 89712-M-002

**W-03**  
HEAT EXCHANGER  
LIQUID AIR

**W-04**  
HEAT EXCHANGER  
LIQUID TO LIQUID

**F-01**  
FILTER

**B-01**  
PULSATION DAMPENER

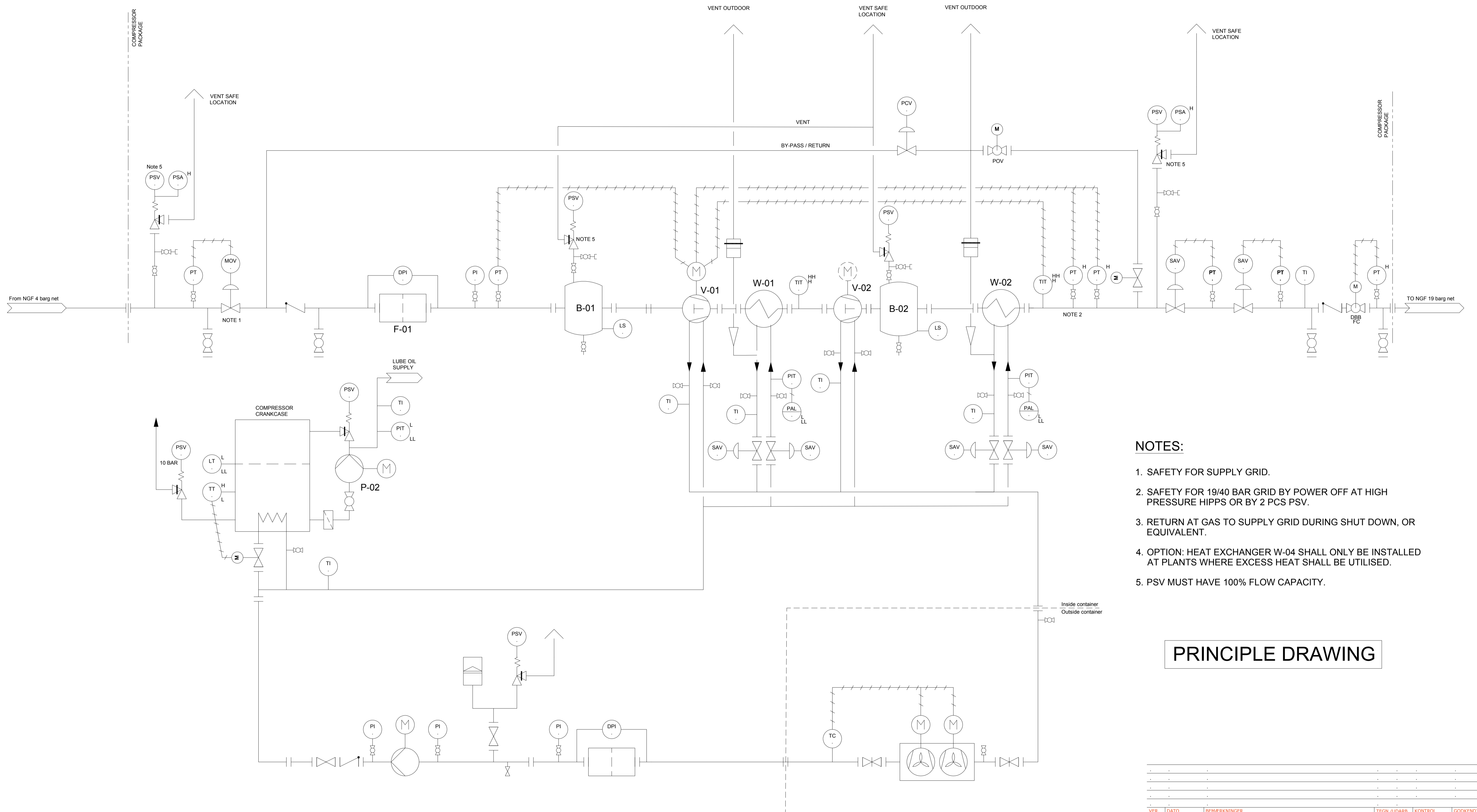
**V-01**  
RECIPROCATING COMPRESSOR  
STAGE 1

**W-01**  
HEAT EXCHANGER  
INTERCOOLER

**V-02**  
RECIPROCATING COMPRESSOR  
STAGE 2

**B-02**  
PULSATION DAMPENER

**W-002**  
HEAT EXCHANGER  
AFTER COOLER



**NOTES:**

1. SAFETY FOR SUPPLY GRID.
2. SAFETY FOR 19/40 BAR GRID BY POWER OFF AT HIGH PRESSURE HIPPS OR BY 2 PCS PSV.
3. RETURN AT GAS TO SUPPLY GRID DURING SHUT DOWN, OR EQUIVALENT.
4. OPTION: HEAT EXCHANGER W-04 SHALL ONLY BE INSTALLED AT PLANTS WHERE EXCESS HEAT SHALL BE UTILISED.
5. PSV MUST HAVE 100% FLOW CAPACITY.

**PRINCIPLE DRAWING**

VER.	DATE	BEMERKNINGER	TEGN./UDARB.	KONTROL	GOEKENDT

**Søndersø**  
**NGF Nature Energy**

Udkast for kommentering  
PID General specification  
BEMERKNINGER

PROJEKTNR.	A089712
TEGN./UDARB.	MVTH /
KONTROLLERET	(HDFR) / (LLJE)
GOEKENDT	(ERH)
MÅL	~
DATE	2016.12.13

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www.cowi.dk  
DOKUMENTNR. 89712-DWG-009  
VERSION 0.2

Data sheet 89712-M-002

JOB NO. A089712 ITEM NO. \_\_\_\_\_  
 PURCHASE ORDER NO. \_\_\_\_\_  
 SPECIFICATION NO. 89712-M-001  
 REVISION NO. A DATE 10.01.2017  
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Revision

**RECIPROCATING COMPRESSOR  
 API 618 5TH EDITION DATA SHEET  
 SI UNITS**

1 APPLICABLE TO:  PROPOSALS  PURCHASE  AS BUILT  
 2 FOR/USER DONG GAS DISTRIBUTION SITE/LOCATION DENMARK SERVICE UPGRADED BIOGAS NO. REQ'D  
 3 NOTE:  INDICATES INFO. TO BE COMPLETED BY PURCH.  BY MANUFACTURER WITH PROPOSAL  BY MANUFACTURER AFTER ORDER  BY MANUFACTURER OR PURCHASER AS APPLICABLE  
 4  
 5 COMPR. MFGR. \_\_\_\_\_ TYPE MODEL NO(S) \_\_\_\_\_ SERIAL NO(S) \_\_\_\_\_  
 6 COMPR. THROWS: TOTAL NO. \_\_\_\_\_ NO. WITH CYLS. \_\_\_\_\_ NOMINAL FRAME RATING \_\_\_\_\_ BkW @ RATED R/MIN OF \_\_\_\_\_  
 7  MAX/MIN ALLOWABLE SPEED \_\_\_\_\_ / \_\_\_\_\_ r/min  
 8 DRIVER MFGR. \_\_\_\_\_ DRIVER NAMEPLATE HP/OPERATING r/min \_\_\_\_\_ / \_\_\_\_\_  
 9 DRIVE SYSTEM:  DIRECT COUPLED  GEARED & COUPLED  V-BELT  
 10 TYPE OF DRIVER:  IND. MOTOR  SYN. MOTOR  STEAM TURBINE  GAS TURBINE  ENGINE  OTHER \_\_\_\_\_  
 11 CYLINDERS CONSTRUCTION:  LUBE  NON-LUBE  
 12  
 13  MAX ACCEPTABLE AVG PISTON SPEED \_\_\_\_\_ m/s

**OPERATING CONDITIONS (EACH MACHINE)**

	Upgraded biogas	NATURAL GAS			
15 <input type="radio"/> SERVICE OR ITEM NO.					
16 <input type="radio"/> STAGE					
17 <input type="radio"/> NORM. OR ALT. CONDITION					
18 <input type="radio"/> CERTIFIED PT. (X) MARK ONE					
19 <input type="radio"/> MOLECULAR WEIGHT	16,77	18,35			
20 <input type="radio"/> Cp/Cv (K) @ 65°C OR _____ °C					
21 <input type="radio"/> INLET CONDITIONS: AT INLET TO: <input checked="" type="radio"/> PULSE DEVICES <input type="radio"/> COMPRESSOR CYLINDER FLANGES					
22 NOTE: <input type="radio"/> SIDE STREAM TO _____ STAGE(S), THESE INLET PRESS. ARE FIXED					
23 <input type="radio"/> PRESSURE (bar) @ PUL. SUPP. INLET	2,0-3,9 or 3,9-6,8	2,0-3,9 or 3,9-6,8			
24 <input checked="" type="checkbox"/> PRESSURE (bar) @ CYL. FLANGE					
25 <input type="radio"/> TEMPERATURE (°C)	0-20	0-20			
26 <input type="radio"/> REC: SIDE STREAM TEMPS (°C)					
27 <input type="checkbox"/> COMPRESSIBILITY (Z <sub>s</sub> )	0,9976	0,9969			
28 <input type="radio"/> INTERSTAGE: INTERSTAGE Δ P INCL: <input type="radio"/> PULSE DEVICES <input type="radio"/> PIPING <input type="radio"/> COOLERS <input type="radio"/> SEPARATORS <input type="radio"/> OTHER _____					
29 <input checked="" type="checkbox"/> ΔP BETWEEN STAGES, %/bar					
30 <input type="radio"/> DISCHARGE CONDITIONS: AT OUTLET FROM: <input checked="" type="radio"/> PULSE DEVICE <input type="radio"/> COMP. CYL. FLANGES <input type="radio"/> OTHER _____					
31 <input checked="" type="checkbox"/> PRESSURE (bar) @ CYL. FLANGE					
32 <input type="radio"/> PRESS. (bar) @ PUL. SUPP. OUTLET	20 or 40	20 or 40			
33 <input type="checkbox"/> TEMP., ADIABATIC, °C					
34 <input type="checkbox"/> TEMP., PREDICTED, °C					
35 <input type="checkbox"/> COMPRESSIBILITY (Z <sub>2</sub> ) OR (Z <sub>AVG</sub> )					
36 * CAPACITY AT INLET TO COMPRESSOR, NO NEGATIVE TOLERANCE (-0%)					
37 <input type="radio"/> kg/h CAPACITY SPECIFIED					
38 IS <input type="radio"/> WET <input type="radio"/> DRY					
39 <input type="radio"/> m <sup>3</sup> /h (1 bar & 60°C)					
40 * MFGR.'S RATED CAPACITY (AT INLET TO COMPRESSOR & kW @ CERTIFIED TOLERANCE OF ±3% FOR CAP. & ±3% FOR kW)					
41 <input type="checkbox"/> kg/h CAPACITY SPECIFIED					
42 IS <input type="radio"/> WET <input type="radio"/> DRY					
43 <input type="checkbox"/> INLET VOLUME FLOW (m <sup>3</sup> /h)					
44 <input type="checkbox"/> MMSCCD/SCCM (14.7 PSIA & 60°C)					
45 <input type="checkbox"/> BkW/STAGE					
46 <input type="checkbox"/> TOTAL BkW @ COMPRESSOR SHAFT					
47 <input type="checkbox"/> TOTAL kW INCLUDING					
48 V-BELT & GEAR LOSSES					
49 * CAPACITY FOR NNT					

REMARKS: \_\_\_\_\_  
 \_\_\_\_\_  
 \_\_\_\_\_

**RECIPROCATING COMPRESSOR  
API 618 5TH EDITION DATA SHEET  
SI UNITS**

JOB NO. A089712 ITEM NO. \_\_\_\_\_  
 REVISION A DATE 10.01.2017  
 PAGE 2 OF 17 BY \_\_\_\_\_

Revision

**GAS ANALYSIS AT OPERATING CONDITIONS  
MOLE % (BY VOLUME) ONLY**

**REMARKS**

	SERVICE/ITEM NO. STAGE NORMAL OR ALT	M.W.	UPGRADED	NATURAL			
			BIOGAS	GAS			
7	AIR	28.966					
8	OXYGEN O <sub>2</sub>	32.000	max.. 0,5				
9	NITROGEN N <sub>2</sub>	28.016	0,2				
10	WATER VAPOR H <sub>2</sub> O	18.016					
11	CARBON MONOX. CO	28.010					
12	CARBON DIOX. CO <sub>2</sub>	44.010	max.. 3,0	1,06			
13	HYDRO. SULFIDE H <sub>2</sub> S	34.076					
14	HYDROGEN H <sub>2</sub>	2.016					
15	METHANE CH <sub>4</sub>	16.042	97,3	88,84			
16	ETHYLENE C <sub>2</sub> H <sub>4</sub>	28.052					
17	ETHANE C <sub>2</sub> H <sub>6</sub>	30.068	-	6,11			
18	PROPYLENE C <sub>3</sub> H <sub>6</sub>	42.078					
19	PROPANE C <sub>3</sub> H <sub>8</sub>	44.094	-	2,44			
20	I-BUTANE C <sub>4</sub> H <sub>10</sub>	58.120	-	0,37			
21	n-BUTANE C <sub>4</sub> H <sub>10</sub>	58.120	-	0,54			
22	I-PENTANE C <sub>5</sub> H <sub>12</sub>	72.146	-	0,13			
23	n-PENTANE C <sub>5</sub> H <sub>12</sub>	72.146	-	0,08			
24	HEXANE PLUS		-	0,06			
25	AMMONIA NH <sub>3</sub> <b>Note 1</b>	17.031	max. 3,0	max.. 3,0			
26	HYDRO. CHLOR. HCl	36.461					
27	CHLORINE Cl <sub>2</sub>	70.914					
28	CHLORIDES - TRACES						
29	<b>Note 2</b>						
30							
31							
32	<input type="checkbox"/> CALCULATED MOL WT.						
33	<input type="checkbox"/> C <sub>p</sub> /C <sub>v</sub> (K) @ 65° OR _____ °C						

Note 1: Stated value for ammonia content is in mg/m<sup>3</sup>  
 Note 2: Siloxane contents is max. 1,0 mg/m<sup>3</sup>

**APPLICABLE SPECIFICATIONS**

● API 618, RECIPROCATING COMPRESSORS  
 FOR PETROLEUM, CHEMICAL AND GAS  
 INDUSTRY SERVICES  
 NACE MR-0175 (6.15.1.11)

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- 

**NOTE: IF WATER VAPOR AND/OR CHLORIDES ARE PRESENT, EVEN MINUTE  
 TRACES, IN THE GAS BEING COMPRESSED, IT MUST BE INCLUDED ABOVE.**

**SITE/LOCATION CONDITIONS**

ELEVATION 0 m \_\_\_\_\_ bar AMBIENT TEMPS: MAX 35 °C MIN -25 °C  
 ● MIN DESIGN METAL TEMP -20 °C (6.15.8.1) RELATIVE HUMIDITY: MAX 90 % MIN 30 %  
 COMPRESSOR LOCATION: ● INDOOR ○ HEATED ○ UNHEATED ○ AT GRADE LEVEL ○ ELEVATED: \_\_\_\_\_ m  
 ○ OUTDOOR ○ NO ROOF ○ UNDER ROOF ○ PARTIAL SIDES ○ PLATFORM: ● ON-SHORE  
 ○ OFF-SHORE ○ WEATHER PROTECTION REQ. ○ TROPICALIZATION REQ.  
 ○ WINTERIZATION REQUIRED  
 UNUSUAL CONDITIONS: ○ CORROSIVES ○ DUST ○ FUMES ○ OTHER \_\_\_\_\_

**ELECTRICAL CLASSIFICATIONS**

	HAZARDOUS	NON-HAZARDOUS
47 MAIN UNIT	● CLASS <u>ATEX ZONE 1*</u> GROUP _____ DIVISION _____	○
48 L.O. CONSOLE	● CLASS <u>ATEX ZONE 1*</u> GROUP _____ DIVISION _____	○
49 CW CONSOLE	● CLASS <u>ATEX ZONE 2*</u> GROUP _____ DIVISION _____	○

\* See technical specification for distances to hazardous areas





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**SCOPE OF BASIC SUPPLY**

PURCHASER TO FILL IN (    ) AFTER COMMODITY TO INDICATE:  BY COMPR. MFR.  BY PURCH.  BY OTHERS

- 3 ● DRIVER (    ): ● VARIABLE SPEED SPEED RANGE \_\_\_\_\_ r/min TO \_\_\_\_\_ r/min
- 4 ● INDUCTION MOTOR  SYNCHRONOUS MOTOR  STEAM TURBINE  ENGINE  OTHER \_\_\_\_\_
- 5  API 541 ● API 546  API 611  API 612
- 6 ● OUTBOARD BEARING  PROVISION FOR DRY AIR PURGE FOR OUTBOARD BEARING.
- 7 ● SLIDE BASE FOR DRIVER (    ) SOLE PLATE FOR DRIVER (    )
- 8  MOTOR STARTING EQUIPMENT (    ); DEFINE \_\_\_\_\_
- 9  GEAR (    ):  BASEPLATE FOR GEAR  API 613  API 677
- 10 ● COUPLING(S) (    ):  LOW SPD.  HI-SPD. ● QUILL SHAFT  KEY-LESS DRV.  KEY'D DRV. ● OTHER \_\_\_\_\_
- 11 ● API 671
- 12  V-BELT DRIVE (    ):  SHEAVES & V-BELTS (    )  STATIC CONDUCTING V-BELTS  BANDED V-BELTS
- 13 ● DRIVE GUARD(S) (    ): ● MANUFACTURER'S STD. ● NON-SPARKING  CALIF CODE  API 671, ANNEX G
- 14  OTHER

- 15 ● PULSATION SUPPRESSORS (    ): ● INITIAL INLET & FINAL DISCHARGE ● SUPPORTS (    )
- 16  INTERSTAGE  SUPPORTS (    )
- 17 ● SUPPRESSOR(S) TO HAVE MOISTURE REMOVAL SECTION:  INITIAL INLET ● ALL INTERSTAGE INLET
- 18 ● ACOUSTICAL SIMUL. STUDY (    ):  DESIGN  1, EMPIRICAL PULSATION SUPPRESSION DEVICE SIZING
- 19  APPROACH ● 2, ACOUSTIC SIMULATION AND PIPING RESTRAINT ANALYSIS
- 20  CHECK ONLY ONE, SEE 7.9.4.1.1, TABLE 6)  3, ACOUSTIC SIMULATION AND PIPING RESTRAINT ANALYSIS
- 21 STUDY TO CONSIDER: PLUS MECHANICAL ANALYSIS
- 22 ALL SPECIFIED LOAD COND., INCL.  SINGLE ACT., PLUS  COMP. OPER. IN PARALLEL  ALTERNATE GASES
- 23 ● CRITICAL FLOW MEASUREMENT (7.9.4.2.5.3.3)  WITH EXISTING COMP. AND PIPING SYSTEMS
- 24 ● PULSATION SUPPRESS'N DEVICE LOW CYCLE FATIGUE ANALYSIS  PIPING SYSTEM FLEXIBILITY
- 25  VENDOR REVIEW OF PURCHASER'S PIPING ARRANGEMENT
- 26 NOTE: SEE APPENDIX N FOR INFORMATION REQUIRED FOR STUDY

- 27 PACKAGED:  NO ● YES (    ) DEFINE BASIC SCOPE OF PACKAGING IN REMARKS SECTION, PAGE 5
- 28  DIRECT GROUTED  CEMENTED/MORTAR GROUT  EPOXY GROUT; MFG/TYPE \_\_\_\_\_ / \_\_\_\_\_
- 29  RAILS  CHOCK BLOCKS  SHIMS  BASEPLT. ● SKID  SOLEPLT.  BOLTS OR STUDS FOR SOLEPLT. TO FRAME
- 30  SUITABLE FOR COLUMN MOUNTING (UNDER SKID AND/OR BASEPLATE)
- 31 ● LEVELING SCREWS  NON-SKID DECKING  SUB SOLEPLATES
- 32  INTERCLR(S) (    )  OFF MOUNTED  MACHINE MTD. ● AFTERCLR(S) (    )
- 33 ● SEPARATOR(S) (    ) ● CONDENSATE SEPARATION & COLLECTION FACILITY SYSTEM (7.8.2.1)
- 34  INTERSTAGE PIP. (    ):  FINAL DISC. PIP. (    ):  PARTIAL PRE FAB, FIELD FIT  SHOP FITTED
- 35 FLANGE FINISH  API 618 FLANGE FINISH > 125 < 250 (7.9.5.1.16) ● FLANGE FINISH PER ANSI 16.5  SPECIAL FINISH
- 36  SPECIAL PIPING REQUIREMENTS (7.7.1.13). (DEFINE IN REMARKS SECTION NEXT PAGE)
- 37  INITIAL INLET,  INTERSTAGE SUCTION PIPING ARR'D FOR:  INSULATION (    )  HEAT TRACING (    )
- 38 ● INLET STRAINER(S) (    ): ● INITIAL INLET  SIDESTREAM INLET  SPOOL PIECE FOR INLET STRAINERS
- 39 ● MANIFOLD PIPING; ● DRAINS ● VENTS  RELIEF VALVES  AIR/GAS SUPPLY
- 40 ● RELIEF VALVE(S) (    ):  INITIAL INLET  INTERSTAGE ● FINAL DISCHARGE
- 41  RUPTURE DISC(S) (    )  THRU STUDS IN PIPING FLANGES
- 42  FOR ATMOSPHERIC INLET AIR COMPR. ONLY:  INLET AIR FILTER (    )  INLET FILTER-SILENCER (    )
- 43 ● PREFERRED TYPE OF CYLINDER COOLING (    ):  FORCED  THERMOSYPHON \_\_\_\_\_ STAGE CYL(S)
- 44 NOTE: MANUFACTURER SHALL RECOMMEND  STATIC (STAND-PIPE) \_\_\_\_\_ STAGE CYL(S)
- 45 BEST TYPE OF COOLING AFTER  CYL. COOLANT PIPING BY (    )  MATCH M'RKED
- 46 FINAL ENGINEERING REVIEW OF ALL  SINGLE INLET/OUTLET MANIFOLD & VALVES  SIGHT GL'SS(ES)
- 47 OPERATING CONDITIONS  INDIVIDUAL INLET/ OUTLET PER CYL.  VALVE(S)
- 48 ● CLOSED SYSTEM WITH PUMP, COOLER, SURGE TANK, & PIPING





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1		CYLINDER DATA AT FULL LOAD CONDITION					
2	SERVICE/ITEM NO.						
3	STAGE						
4	INLET PRESSURE, barg	} @ CYLINDER FLANGES					
5	DISCHARGE PRESSURE, barg						
6	CYLINDERS PER STAGE						
7	SINGLE OR DOUBLE ACTING (SA OR DA)						
8	BORE, mm						
9	STROKE, mm						
10	RPM:	RATED / MAX ALLOW	/				
11	PISTON SPEED, m/s:	RATED / MAX ALLOW	/				
12	CYLINDER LINER, YES/NO						
13	LINER NOMINAL THICKNESS, mm						
14	PISTON DISPLACEMENT, m <sup>3</sup> /h						
15	CYLINDER DESIGN CLEARANCE, % AVERAGE						
16	VOLUMETRIC EFFICIENCY, % AVERAGE						
17	VALVES, INLET/DISCHARGE, QTY PER CYL.	/	/	/	/	/	
18	TYPE OF VALVES						
19	VALVE LIFT, INLET/DISCHARGE, mm	/	/	/	/	/	
20	VALVE VELOCITY, m/s						
21	SUCTION VALVE(S)						
22	DISCHARGE VALVE(S)						
23	ROD DIAMETER, mm						
24	MAX ALLOW. COMBINED ROD LOADING, kN, C *						
25	MAX ALLOW. COMBINED ROD LOADING, kN, T *						
26	CALCULATED GAS ROD LOAD, kN, C *						
27	CALCULATED GAS ROD LOAD, kN, T *						
28	COMBINED ROD LOAD (GAS + INERTIA), kN, C *						
29	COMBINED ROD LOAD (GAS + INERTIA), kN, T *						
30	ROD REV., DEGREES MIN @ X-HD PIN**						
31	RECIP WT. (PISTON, ROD, X-HD & NUTS), kg**						
32	MAX ALLOW. WORKING PRESSURE, barg						
33	MAX ALLOW. WORKING TEMPERATURE, °C						
34	HYDROSTATIC TEST PRESSURE, barg						
35	GAS LEAKAGE TEST PRESSURE, barg						
36	INLET FLANGE SIZE/RATING	/	/	/	/	/	
37	FACING						
38	DISCHARGE FLANGE SIZE/RATING	/	/	/	/	/	
39	FACING						
40	DISCHARGE RELIEF VALVE SETTING DATA AT INLET PRESSURES GIVEN ABOVE:						
41	RECOMMENDED SETTING, barg						
42	GAS ROD LOAD, kN, C *						
43	GAS ROD LOAD, kN, T *						
44	COMBINED ROD LOAD, kN, C *						
45	COMBINED ROD LOAD, kN, T *						
46	ROD REVERSAL, °MIN @ X-HD PIN**						
47	NOTE: CALCULATED AT INLET PRESSURES						
48	GIVEN ABOVE & RECOMMENDED SETTING.						
49	○ SETTLE-OUT GAS PRESSURE						
50	(DATA REQUIRED FOR STARTING)						
51	NOTES/REMARKS:						

\* C = COMPRESSION      \* T = TENSION      \*\*X-HD = CROSSHEAD





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1	<input type="checkbox"/> <b>UTILITY CONSUMPTION</b>	
---	---	--

2	<b>ELECTRIC MOTORS</b>	
---	------------------------	--

	FOR INDUCTION MOTORS SEE NOTE OF 7.1.2.6 AND MOTOR DATA SHEET	NAMEPLATE kW	LOCKED ROTOR AMPS	FULL LOAD STEADY STATE AMPS	MAIN DRIVER NON-STEADY STATE AMPS AT COMPRESSOR RATED HORSEPOWER (INDUCTION MOTORS ONLY)
3					
4					
5					
6					
7					
8					
9	<input type="checkbox"/> MAIN DRIVER	_____	_____	_____	_____ AMPS
10	<input type="checkbox"/> MAIN LUBE OIL PUMP	_____	_____	_____	@ COMPRESSOR RATED
11	<input type="checkbox"/> AUX LUBE OIL PUMP	_____	_____	_____	kW OF _____
12	<input type="checkbox"/> MAIN CYLINDER COOLANT PUMP	_____	_____	_____	@ CURRENT PULSATIONS
13	<input type="checkbox"/> AUX CYLINDER COOLANT PUMP	_____	_____	_____	OF _____ %
14	<input type="checkbox"/> MAIN ROD PKG COOLANT PUMP	_____	_____	_____	
15	<input type="checkbox"/> AUX ROD PKG COOLANT PUMP	_____	_____	_____	
16	<input type="checkbox"/> CYLINDER LUBRICATOR	_____	_____	_____	
17	_____	_____	_____	_____	
18	_____	_____	_____	_____	
19					

20	<b>ELECTRIC HEATERS</b>	
----	-------------------------	--

		WATTS	VOLTS	HERTZ
21				
22	<input type="checkbox"/> FRAME OIL HEATER(S)	_____	_____	_____
23	<input type="checkbox"/> CYLINDER COOLANT HEATER(S)	_____	_____	_____
24	<input type="checkbox"/> CYL. LUBRICATOR HEATER(S)	_____	_____	_____
25	<input type="checkbox"/> MAIN DRIVER SPACE HEATER(S)	_____	_____	_____
26	_____	_____	_____	_____
27	_____	_____	_____	_____
28				

29	<b>STEAM</b>	
----	--------------	--

	FLOW	PRESSURE	TEMPERATURE	BACK PRESSURE
30				
31	<input type="checkbox"/> MAIN DRIVER	_____ kg/h @ _____ barg	_____ °CTT TO _____	_____ barg
32	<input type="checkbox"/> FRAME OIL HEATER(S)	_____ kg/h @ _____ barg	_____ °CTT TO _____	_____ barg
33	<input type="checkbox"/> CYL. LUB. HEATER(S)	_____ kg/h @ _____ barg	_____ °CTT TO _____	_____ barg
34	_____	_____ kg/h @ _____ barg	_____ °CTT TO _____	_____ barg
35	_____	_____ kg/h @ _____ barg	_____ °CTT TO _____	_____ barg
36				

37	<b>COOLING WATER REQUIREMENTS</b>	
----	-----------------------------------	--

	FLOW	INLET TEMP	OUTLET TEMP	INLET PRESS	OUTLET PRESS	MAX PRESS
	m <sup>3</sup> /h	°C	°C	barg	barg	barg
38						
39						
40	<input type="checkbox"/> CYLINDER JACKETS	_____	_____	_____	_____	_____
41	<input type="checkbox"/> CYLINDER COOLANT CONSOLE	_____	_____	_____	_____	_____
42	<input type="checkbox"/> FRAME LUBE OIL COOLER	_____	_____	_____	_____	_____
43	<input type="checkbox"/> ROD PRESSURE PACKING*	_____	_____	_____	_____	_____
44	<input type="checkbox"/> PACKING COOLANT CONSOLE	_____	_____	_____	_____	_____
45	<input type="checkbox"/> INTERCOOLER(S)	_____	_____	_____	_____	_____
46	<input type="checkbox"/> AFTERCOOLER	_____	_____	_____	_____	_____
47	_____	_____	_____	_____	_____	_____
48	<input type="checkbox"/> TOTAL QUANTITY, m <sup>3</sup> /h	_____	_____	_____	_____	_____

49	REMARKS/SPECIAL REQUIREMENTS:	
50	*ROD PACKING COOLANT MAY BE OTHER THAN WATER	
51		



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**FRAME LUBE OIL SYSTEM**

**BASIC LUBE OIL SYSTEM FOR FRAME:**       SPLASH       PRESSURE (FORCED)       HEATERS REQUIRED:

REF: TYPE MAIN BEARINGS:       TAP'RD ROLL'R       PRECISION SL'VE       ELEC. W/THERMOSTAT(S)       STEAM

**PRESSURE SYSTEM:**      ● MAIN OIL PUMP DRIVEN BY:      ● COMP. CRANKSHAFT       ELEC. MOTOR       OTHER \_\_\_\_\_

PSV FOR MAIN PUMP EXTERNAL TO CRANKCASE       CHECK VALVE ON MAIN PUMP (FIG G-5)

   ● AUX OIL PUMP DRIVEN BY:      ● ELEC. MOTOR       OTHER \_\_\_\_\_

HAND OPERATED PRE-LUBE PUMP FOR STARTING      ● OPERATIONAL TEST & 4 HOUR MECH RUN TEST

   ● CONTINUOUS OIL FLOW THROUGH SWITCH SENSING LINE (7.7.2.5)

**SEP. CONSOLE FOR PRESS. LUBE SYS:**       ONE CONSOLE FOR EA. COMP.       ONE CONSOLE FOR \_\_\_\_\_ COMPRESSORS

Note: Instrumentation to be listed on Instrumentation Data Sheets.       CONSOLE TO BE OF DECK PLATE TYPE CONSTRUCTION SUITABLE FOR MULTI-POINT SUPPORT AND GROUTING WITH GROUT & VENT HOLES.

ELECTRICAL CLASSIFICATION: CLASS \_\_\_\_\_, GROUP \_\_\_\_\_, DIV \_\_\_\_\_       NON-HAZARDOUS

**BASIC SYS. REQ'MTS (NORM. OIL FLOWS & VOLUMES)**

LUBE OIL	FLOW m <sup>3</sup> /h	PRESSURE barg	VISCOSITY SSU @ 40°C	VISCOSITY SSU @ 100°C	SUMP VOLUME m <sup>3</sup>
<input type="checkbox"/> COMPRESSOR FRAME	_____	_____	_____	_____	_____
<input type="checkbox"/> DRIVER	_____	_____	_____	_____	_____
<input type="checkbox"/> GEAR	_____	_____	_____	_____	_____

**SYSTEM PRESSURES:**       DESIGN \_\_\_\_\_ barg       HYDROTEST \_\_\_\_\_ barg

PRESSURE CONTROL VALVE SETTING \_\_\_\_\_ barg       PUMP REL'F VALVE(S) SET \_\_\_\_\_ barg

**PIPING MATERIALS:**

	CARBON STEEL	STAINLESS STEEL WITH SS FLANGES	STAINLESS STEEL WITH CARBON STEEL FLANGES
● UPSTREAM OF PUMPS & FILTERS	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
● DOWNSTREAM OF FILTERS	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/> _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**PUMPS** (Gear or Screw Type Only)       RAT'D FL'W m<sup>3</sup>       PRESSURE barg       COLD START REQ'D kW       DRIVER kW       SPEED R/MIN       COUPLING REQ'D       MECH. SEAL REQ'D

MAIN      \_\_\_\_\_      \_\_\_\_\_      \_\_\_\_\_      \_\_\_\_\_      \_\_\_\_\_           

AUXILIARY      \_\_\_\_\_      \_\_\_\_\_      \_\_\_\_\_      \_\_\_\_\_      \_\_\_\_\_           

PUMP CASING MATERIAL (Ref. 6.14.2.1.5):      MAIN PUMP \_\_\_\_\_      AUX PUMP \_\_\_\_\_

● GUARD(S) REQ. FOR COUPLING(S):      ● MAIN PUMP       AUX PUMP       GUARD TYPE OR CODE \_\_\_\_\_

● AUXILIARY PUMP CONTROL:       MANUAL      ● AUTOMATIC       ON-OFF-AUTO SEL. SWITCH:       BY PURCH.       BY MFR.

WIRING TO TERMINAL BOX:       BY PURCH.       BY MFR.

SWITCHES       RTD'S/THERMOCOUPLES

**COOLERS:**      ● SHELL & TUBE       SINGLE       DUAL W/TRANSFER VALVE       MFG'S STD.       TEMA C       TEMA R (API 660)

REMOVABLE BUNDLE      ● WATER COOLED       AIR COOLED W/AUTO TEMP CONTROL (API-661) Data Shts - Attached

W/BYPASS & TEMP CONTROL VALVE:       MANUAL       AUTO

SEE SEPARATE HEAT EXCHANGER DATA SHEETS FOR DETAILS, SPECIFY % GLYCOL ON COOLING WATER SIDE

**FILTER(S)**       SINGLE      ● DUAL W/TRANSFER VALVE      ● ASME CODE DESIGN       ASME CODE STAMPED

DESIGN PRESSURE, \_\_\_\_\_ barg       Δ P CLEAN, \_\_\_\_\_ barg       Δ P COLLAPSE, \_\_\_\_\_ barg

MICRON RATING, \_\_\_\_\_       CARTRIDGE MATERIAL, \_\_\_\_\_       CARTRIDGE P/N \_\_\_\_\_

BONNET MATERIAL, \_\_\_\_\_       CASING MATERIAL, \_\_\_\_\_       FURN.SPARE CARTR.,QTY \_\_\_\_\_

**SYS. COMPONENT SUPP.**

	MANUFACTURER	MODEL		MANUFACTURER	MODEL
<input type="checkbox"/> MAIN PUMP	_____	_____	<input type="checkbox"/> OIL COOLER(S)	_____	_____
<input type="checkbox"/> AUXILIARY PUMP	_____	_____	<input type="checkbox"/> TRANSFER VALVE(S)	_____	_____
<input type="checkbox"/> MECHANICAL SEALS	_____	_____	<input type="checkbox"/> PUMP COUPLING(S)	_____	_____
<input type="checkbox"/> ELECTRIC MOTORS	_____	_____	<input type="checkbox"/> SUCTION STRAINER(S)	_____	_____
<input type="checkbox"/> STEAM TURBINES	_____	_____	<input type="checkbox"/> CHECK VALVE(S)	_____	_____
<input type="checkbox"/> OIL FILTER(S)	_____	_____	<input type="checkbox"/> _____	_____	_____

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**COOLANT SYSTEM**

**BASIC COOLING SYS. FOR:**  COMPRESSOR CYL.(S)  ROD PACKING(S)  PROCESS COOLER(S)  OIL COOLER(S)  
 HEATERS REQ'D FOR PRE-HEATING:  ELEC., W/ THERMOSTAT(S)  STEAM

**PRESSURE FORCED CIRCULATING SYS:**  OPEN, PIPING BY:  PURCH.  MFR  CLOSED, PIPING BY MFR.  
 MAIN COOLANT PUMP DRIVEN BY:  ELEC. MOTOR  STEAM TURBINE  OTHER \_\_\_\_\_  
 AUX COOLANT PUMP DRIVEN BY:  ELEC. MOTOR  STEAM TURBINE  OTHER \_\_\_\_\_

**SEP. CONSOLE FOR COOLANT SYSTEM:**  ONE CONSOLE FOR EA. COMP.  ONE CONSOLE FOR \_\_\_\_\_ COMP'RS

NOTE: Instrumentation to be listed on instrumentation data sheets.  CONSOLE TO BE OF DECK PLATE TYPE CONSTRUCTION SUITABLE FOR MULTI-POINT SUPPORT AND GROUTING WITH GROUT & VENT HOLES.

ELECTRICAL CLASSIFICATION: CLASS \_\_\_\_\_, GROUP \_\_\_\_\_, DIV \_\_\_\_\_  NON-HAZARDOUS

**BASIC SYS. REQ'MTS (NORM. COOLANT FLOW DATA)**  COOLANT TO BE 50 % ETHYLENE GLYCOL  SITE

	FORCED COOL'G	THERMO SYPHON	STAND PIPE	FLOW m <sup>3</sup> /h	PRESSURE barg	INLET TEMP °C	OUTLET TEMP °C	FLOW IND'TR
CYLINDER(S), _____ STAGE	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	_____	_____	_____	_____	<input type="radio"/>
CYLINDER(S), _____ STAGE	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	_____	_____	_____	_____	<input type="radio"/>
CYLINDER(S), _____ STAGE	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	_____	_____	_____	_____	<input type="radio"/>
CYLINDER(S), _____ STAGE	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	_____	_____	_____	_____	<input type="radio"/>
CYLINDER(S), _____ STAGE	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	_____	_____	_____	_____	<input type="radio"/>
CYLINDER(S), _____ STAGE	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	_____	_____	_____	_____	<input type="radio"/>
PISTON ROD PACK'G TOTAL	<input type="radio"/>			_____	_____	_____	_____	<input type="radio"/>
INTERCOOLER(S) TOTAL	<input checked="" type="radio"/>			_____	_____	_____	_____	<input type="radio"/>
AFTERCOOLER	<input checked="" type="radio"/>			_____	_____	_____	_____	<input type="radio"/>
OIL COOLER(S)	<input checked="" type="radio"/>			_____	_____	_____	_____	<input type="radio"/>
_____	<input type="radio"/>			_____	_____	_____	_____	<input type="radio"/>
TOTAL FLOW _____								

**SYS. PRESSURES:**  DESIGN, \_\_\_\_\_ barg  HYDROTEST, \_\_\_\_\_ barg  RELIEF VALVE(S), SETTING \_\_\_\_\_ barg

**COOLANT RESERVOIR:**  SIZE, \_\_\_\_\_ mm IN DIA X \_\_\_\_\_ mm IN HT.  CAPACITY \_\_\_\_\_ m<sup>3</sup> @ NORMAL OPERATING LEVEL

RESERVOIR MATERIAL \_\_\_\_\_  INTERNAL COATING, TYPE \_\_\_\_\_

LEVEL GAUGE  LEVEL SWITCH  DRAIN VALVE  INSPECTION & CLEAN-OUT OPENINGS

**PUMPS: (CENTRIFUGAL ONLY)**  RAT'D FL'W \_\_\_\_\_ m<sup>3</sup>/h  PRESS. \_\_\_\_\_ barg  REQ'D \_\_\_\_\_ kW  DRIVER \_\_\_\_\_ kW  SPEED \_\_\_\_\_ r/min  COUPLING MECH. SEAL

MAIN	_____	_____	_____	_____	_____	<input type="radio"/>	<input type="radio"/>
AUXILIARY	_____	_____	_____	_____	_____	<input type="radio"/>	<input type="radio"/>

**PUMP CASING MATERIAL (Ref 6.14.2.1.5):**  MAIN PUMP \_\_\_\_\_  AUX PUMP \_\_\_\_\_

GUARD(S) REQ'D FOR COUP'G(S)  MAIN PUMP  AUX PUMP  GUARD TYPE OR CODE \_\_\_\_\_

AUX. PUMP CONTROL:  MANUAL  AUTO  ON-OFF-AUTO SEL. SWITCH:  BY PURCH.  BY MANUFACTURER

WIRING TO TERMINAL BOX:  BY PURCH.  BY MANUFACTURER

**COOLANT HEAT EXCHANGER:**  SHELL & TUBE  SINGLE  DUAL W/TRANSFER VALVE  TEMA C  TEMA R (API 660) (DATA SHEETS ATTACHED)

AIR COOLED EXCHANGER W/AUTO TEMP CONTROL (API 661 DATA SHEETS ATTACHED)

W/BYPASS & TEM. CONTROL VALVE  MANUAL  AUTO  LOUVERS FOR AIR EXCH.

SEE SEPARATE COOLER DATA SHEET FOR DETAILS; SPECIFY % GLYCOL ON BOTH SIDES OF SHELL & TUBE

SYS. COMPONENT SUPP.	MANUFACTURER	MODEL	MANUFACTURER	MODEL
<input type="checkbox"/> MAIN PUMP	_____	_____	<input type="checkbox"/> TEMP CONTROL VALVE(S)	_____
<input type="checkbox"/> AUXILIARY PUMP	_____	_____	<input type="checkbox"/> TRANSFER VALVE(S)	_____
<input type="checkbox"/> MECHANICAL SEALS	_____	_____	<input type="checkbox"/> PUMP COUPLING(S)	_____
<input type="checkbox"/> ELECTRIC MOTORS	_____	_____		_____
<input type="checkbox"/> STEAM TURBINES	_____	_____		_____
<input type="checkbox"/>	_____	_____		_____
<input type="checkbox"/>	_____	_____		_____





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**INSTRUMENTATION**

PURCHASER TO FILL IN (    ) AFTER COMMODITY TO INDICATE:  BY COMP. MFR.  BY PURCH.  BY OTHERS

- INSTRUMENT & CONTROL**  ONE FOR EA. UNIT  ONE COMMON TO ALL UNITS
- PANEL** (    ):  MACHINE M'T'ED  FREE STANDING (OFF UNIT)  LOCAL  REMOTE  OUTDOORS
- PNEUMATIC  ELEC.  ELECTRONIC  HYDRAULIC  PROGRAMMABLE CONTR'L'R
- NEMA 7, CLASS \_\_\_\_\_, GROUP \_\_\_\_\_, DIVISION \_\_\_\_\_  INTRINSICALLY SAFE
- I/S BARRIERS (    )
- NEMA 4, WATERTIGHT & DUSTTIGHT  PURGED TO NFPA 496 TYPE  X  Y  Z
- OTHER NEMA \_\_\_\_\_ LOW PURGE PRESS.  ALARM  SHUTDOWN
- VIB, ISOLATORS  STRIP HEATERS  PURGE CONN.  EXTRA CUTOUTS
- ANNUNCIATOR W/FIRST-OUT INDICATION LOCATED ON CONTROL PANEL
- PURCHASER'S CONN. BROUGHT OUT TO TERMINAL BOX BY VENDOR
- BUFFER GAS CONTROL**  ONE FOR EA. UNIT  ONE COMMON TO ALL UNITS
- PANEL** (    ):  MACHINE M'T'ED  FREE STANDING (OFF UNIT)  WITH STAND  OUTDOORS
- CLASS \_\_\_\_\_, GROUP \_\_\_\_\_, DIVISION \_\_\_\_\_
- CONSTANT PRESSURE DISPOSAL SYSTEM  VARIABLE PRESSURE DISPOSAL SYSTEM

**ADDITIONAL PANEL REMARKS:**

INSTRUMENTATION SUITABLE FOR:  INDOORS  OUTDOORS  OTHER \_\_\_\_\_

PREFERRED INSTRUMENT SUPPLIERS, (TO BE COMPLETED BY PURCHASER), OTHERWISE MFR'S STANDARD APPLIES

	MFR	SIZE & TYPE	MTL
22	PRESSURE GAUGES	_____	_____
23	TEMPERATURE GAUGES	_____	_____
24	LIQUID LEVEL GAUGES	_____	_____
25	DIFF. PRESSURE GAUGES	_____	_____
26	PRESS. TRANSMITTERS	_____	_____
27	LIQUID LEV. TRANSMITTER	_____	_____
28	PRESSURE SWITCHES	_____	_____
29	TEMPERATURE SWITCHES	_____	_____
30	LIQUID LEVEL SWITCHES	_____	_____
31	DIFF. PRESSURE SWITCHES	_____	_____
32	CONTROL VALVES	_____	_____
33	PRESSURE SAFETY VALVES	_____	_____
34	SIGHT FLOW INDICATORS	_____	_____
35	VIBRATION MONITORS & EQUIP.	_____	_____
36	THERMOCOUPLES	_____	_____
37	RTD'S	_____	_____
38	SOLENOID VALVES	_____	_____
39	ANNUNCIATOR	_____	_____
40	PROGRAMMABLE CONTROLLER	_____	_____
41	_____	_____	_____

PRESSURE GAUGE REQUIREMENTS  LIQUID-FILLED PRESSURE GAUGES:  YES  NO

FUNCTION	LOCALLY MOUNTED		PANEL MOUNTED		PROCESS GAS: INLET PRESS.	LOCALLY MOUNTED		PANEL MOUNTED	
	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )		( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )
LUBE OIL MAIN PUMP DISCHAR.	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	_____	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )
LUBE OIL AUX. PUMP DISCHARG.	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	@ EA. STAGE	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )
LUBE OIL PRESS. AT FRAME HEADER	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	DISCH. PRESS.	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )
LUBE OIL FILTER Δ P	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	@ EA. STAGE	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )
COOLING H <sub>2</sub> O INLET HEADER	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	_____	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="radio"/> <input type="checkbox"/> )

**REMARKS:**

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**INSTRUMENTATION (CONT'D)**

**TEMPERATURE MEASUREMENT REQUIREMENTS**

FUNCTION				LOCALLY	PANEL	GAUGE W/	THERMO	RTD	I/S
	INLET TO	OUT OF	FRAME	MOUNTED	MOUNTED	CAPILLARY	CPL SYS	SYS	SYS
LUBE OIL	<input checked="" type="radio"/>	<input checked="" type="radio"/>		( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
LUBE OIL	<input checked="" type="radio"/>	<input checked="" type="radio"/>	COOLER	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
MAIN JRNL BEARINGS	(THERMOCOUPLES OR RTD'S ONLY)			( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
MOTOR BEARING(S)	(THERMOCOUPLES OR RTD'S ONLY)			( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
CYL. COOLANT MANIFOLD:	<input type="checkbox"/> INLET	<input type="checkbox"/> OUTLET		( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
CYL. JKT. COOLANT:	<input type="checkbox"/> INLET	<input type="checkbox"/> OUTLET	<input type="checkbox"/> EA. CYL	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
PROCESS GAS:	<input type="checkbox"/> INLET	<input type="checkbox"/> DISCH.	<input type="checkbox"/> EACH CYL	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
INTERCOOLER(S)	<input type="checkbox"/> INLET	<input type="checkbox"/> GAS	<input type="checkbox"/> COOLANT	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/> OUTLET	<input type="checkbox"/> GAS	<input type="checkbox"/> COOLANT	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
AFTERCOOLER:	<input type="checkbox"/> INLET	<input type="checkbox"/> GAS	<input type="checkbox"/> COOLANT	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/> OUTLET	<input type="checkbox"/> GAS	<input type="checkbox"/> COOLANT	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
PKG COOLANT	<input type="checkbox"/> INLET	<input type="checkbox"/> OUTLET		( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
PRESS. PGK CASE, CYL PIST ROD	(THRM'CPLS OR RTD'S ONLY)			( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
COMPRESSOR VALVES	<input type="checkbox"/> SUCT.	<input type="checkbox"/> DISCH.	TC'S OR RTD'S ONLY	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
				( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
				( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**ALARM & SHUTDOWN SYSTEM REQ'MTS**

NOTE: ALARM & SHUTDOWN DEVICES SHALL BE INDIVIDUALLY SEPARATE ANNUNCIATION POINTS

ALARM DEVICES:  TRANSMITTER  SWITCH  
 SHUTDOWN DEVICES  TRANSMITTER  SWITCH

**FUNCTION**

ALARM SHUT DOWN

FUNCTION	ALARM		SHUTDOWN		TOTAL NO. OF POINTS
	IN PNL BY MFR	IN CTL ROOM PANEL OTH'RS	IN PNL BY MFR	IN CTL ROOM PANEL OTH'RS	
LOW LUBE OIL PRESS. @ BEARING HEADER	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	<input type="checkbox"/>	<input type="checkbox"/>	_____
HIGH LUBE OIL Δ P / P ACROSS FILTER	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	<input type="checkbox"/>	<input type="checkbox"/>	_____
LOW LUBE OIL LEVEL, FRAME	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	<input type="checkbox"/>	<input type="checkbox"/>	_____
AUX LUBE OIL PUMP, FAIL TO START	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	<input type="checkbox"/>	<input type="checkbox"/>	_____
CYL LUBE SYSTEM PROTECTION	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	<input type="checkbox"/>	<input type="checkbox"/>	_____
COMPR. VIBRATION, SHUTDOWN ONLY		( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	<input type="checkbox"/>	<input type="checkbox"/>	_____
VIBRATION, W/ CONTINUOUS MONITORING	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	<input type="checkbox"/>	<input type="checkbox"/>	_____
ROD DROP DETECTOR, CONTACT TYPE(1/CYL)	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	<input type="checkbox"/>	<input type="checkbox"/>	_____
ROD DROP PROXIMITY PROBE (1/CYL)	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	<input type="checkbox"/>	<input type="checkbox"/>	_____
OIL TEMP OUT OF FRAME	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	<input type="checkbox"/>	<input type="checkbox"/>	_____
HIGH GAS DISCH. TEMP EACH CYLINDER	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	<input type="checkbox"/>	<input type="checkbox"/>	_____
HIGH JACKET COOLANT TEMP., EA. CYL	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	<input type="checkbox"/>	<input type="checkbox"/>	_____
LOW SUCTION PRESS., FIRST STG INLET	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	<input type="checkbox"/>	<input type="checkbox"/>	_____
HI DISCH. PRESS. <input type="checkbox"/> FINAL <input type="checkbox"/> EA STG	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	<input type="checkbox"/>	<input type="checkbox"/>	_____
HI CYL. GAS Δ P, EACH STAGE	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	<input type="checkbox"/>	<input type="checkbox"/>	_____
HI LIQ. LEV., EA. MOISTURE SEPARATOR	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	<input type="checkbox"/>	<input type="checkbox"/>	_____
LOW PURGE GAS PRESS, DISTANCE PIECE(S)	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	<input type="checkbox"/>	<input type="checkbox"/>	_____
HI X-HD PIN TEMP	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	<input type="checkbox"/>	<input type="checkbox"/>	_____
PRESS PKG CASE (PISTON ROD TEMP)	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	<input type="checkbox"/>	<input type="checkbox"/>	_____
	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	<input type="checkbox"/>	<input type="checkbox"/>	_____

TOTAL NUMBER OF ANNUNCIATION POINTS

SWITCH CONTACT OPERATION

NOTE: EACH SWITCH SHALL BE MINIMUM SPDT ARRANGEMENT

ALARM CONTACTS SHALL:  OPEN ( DE-ENER.) TO SOUND ALARM & BE ENERGIZED WHEN COMPR. IS IN OPERATION  
 CLOSE (ENERGIZE) TO SOUND ALARM & BE DE-ENERGIZED WHEN COMPR. IS IN OPERATION  
 SHUTDOWN CONTACTS SHALL:  OPEN ( DE-ENERGIZED) TO SHUTDOWN & BE ENERGIZE WHEN COMPR. IS IN OPERATION  
 CLOSE (ENERGIZE) TO SHUTDOWN & BE DE-ENERGIZE WHEN COMPR. IS IN OPERATION

REF: 7.6.6.2 FOR MINIMUM RECOMMENDED PROTECTION REQUIREMENTS

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**INSTRUMENTATION (CONT'D)**

**MISCELLANEOUS INSTRUMENTATION**

SIGHT FLOW IND. (COOLANT ONLY) (    ) FOR:  INTERCOOLER(S)  AFTER CLR  OIL COOLER  
 CYL JACKET COOLANT  ROD PRESS. PKG COOLANT

PNEUMATIC PRESSURE TRANSMITTERS (    ) FOR: \_\_\_\_\_

PRESSURE TRANSMITTERS (ELEC. OUTP.) (    ) FOR: \_\_\_\_\_

PNEUMATIC LEVEL TRANSMITTERS (    ) \_\_\_\_\_

ALARM HORN & ACKN'LMT TEST BUTTON (    ) \_\_\_\_\_

CONDUIT & WIRING W/JUNCT. BOXES (CON-SOLES) (    ) \_\_\_\_\_

TEST VALVES (    ) FOR: \_\_\_\_\_

DRAIN VALVES (    ) FOR: \_\_\_\_\_

GAUGE GLASS(ES) (    ) FOR: \_\_\_\_\_

TACHOMETER (    ) \_\_\_\_\_ SPEED RANGE \_\_\_\_\_ TO \_\_\_\_\_ r/min

CRANKSHAFT KEY PHASER (    ) FOR: \_\_\_\_\_

AND TRANSDUCER (    ) \_\_\_\_\_

**SEPARATE LUBE OIL CONSOLE INSTRUMENTATION:** PURCH. TO LIST REQ'MTS IN ADDITION TO ANY ABOVE REQ'MTS

\_\_\_\_\_ (    ) \_\_\_\_\_

\_\_\_\_\_ (    ) \_\_\_\_\_

\_\_\_\_\_ (    ) \_\_\_\_\_

\_\_\_\_\_ (    ) \_\_\_\_\_

\_\_\_\_\_ (    ) \_\_\_\_\_

\_\_\_\_\_ (    ) \_\_\_\_\_

**SEPARATE COOLING WATER CONSOLE INSTRUMENT:** PURCH. TO LIST REQ'MTS IN ADDITION TO ANY ABOVE REQ'MTS

\_\_\_\_\_ (    ) \_\_\_\_\_

\_\_\_\_\_ (    ) \_\_\_\_\_

\_\_\_\_\_ (    ) \_\_\_\_\_

\_\_\_\_\_ (    ) \_\_\_\_\_

\_\_\_\_\_ (    ) \_\_\_\_\_

\_\_\_\_\_ (    ) \_\_\_\_\_

**RELIEF VALVES**

LOCATION	BY	MANUFACTURER	TYPE	◇ SIZE	◇ SETTING
_____	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	_____	_____	_____	_____
_____	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	_____	_____	_____	_____
_____	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	_____	_____	_____	_____
_____	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	_____	_____	_____	_____
_____	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	_____	_____	_____	_____
_____	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	_____	_____	_____	_____
_____	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	_____	_____	_____	_____
_____	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	_____	_____	_____	_____
_____	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	_____	_____	_____	_____
_____	( <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> )	_____	_____	_____	_____

**NOTES:** SEE MOTOR DATA SHEET FOR ADDITIONAL MOTOR INSTRUMENTATION REQUIREMENTS  
 FOR TURBINE DRIVERS USE APPLICABLE API DATA SHEETS  
 FOR GEAR REDUCERS USE APPLICABLE API DATA SHEETS  
 ELECTRICAL & INSTRUMENTATION CONNECTIONS SHALL BE MADE DIRECTLY BY THE PURCHASER TO INDIVIDUAL INSTRUMENTS ON THE COMPRESSOR

**ADDITIONAL INSTRUMENTATION REMARKS/SPECIAL REQUIREMENTS:**

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_