



Exploration & Production

GENERAL SPECIFICATION

Field Operations

GS EP EXP 213

Minimum maintenance requirements

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1. Scope

1.1 Preamble

This General Specification provides the basis for a project or subsidiary's elementary maintenance strategy, by type of equipment. The implementation of this strategy is therefore to provide to projects and subsidiaries the fundamentals for the maintenance strategy based on the Total E&P integrity standards.

It is the responsibility of the head of maintenance of operational subsidiary to determine and apply the optimum level of maintenance to reach plant required availability and therefore these minimum requirements should only be seen as a minimum below which maintenance plan shall never fall.

1.2 Application

The scope of this document covers the equipments inbound the plant in on shore installation, and above the sea level for off shore installation.

The requirements of this document apply to:

- All new projects planned, designed and constructed by and for the Company,
- All oil and gas installations, operated by the Company.

Any deviation from the minimum inspection requirements stipulated hereafter must be cleared through a formal Request for Exemption.

The requirements are minimum established for each class of equipment, however, Manufacturer recommendations shall be studied and reported in the maintenance plan, in accordance with the global plant maintenance strategy.

2. Reference documents

The reference documents listed below form an integral part of this General Specification. Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the EFFECTIVE DATE of the CONTRACT.

Standards

Reference	Title
IEC 60364	Low-voltage electrical installations – Part 6: Verification
IEC 62402	Obsolescence management – Application guide
IEC 61936	Power installations exceeding 1 kV a.c.
IEC 60079	Explosive atmospheres

**Professional Documents**

Reference	Title
Not applicable	

Regulations

Reference	Title
DIRECTIVE 94/9/EC	Equipment and protective systems intended for use in potentially explosive atmospheres (ATEX)
SOLAS III/20	Life saving appliances and arrangements, Operational readiness, maintenance and inspections
MSC Circ 850	Guidelines for the maintenance and inspection of fire protection systems and appliances
MSC Circ 851	Guidelines on engine room oil fuel systems
MSC 1 Circ 1318	Annex guidelines for the maintenance and inspection of fixed carbon dioxide fire extinguishing systems

Codes

Reference	Title
Not applicable	

Other documents

Reference	Title
Not applicable	



Total General Specifications

Reference	Title
GS EP ELE 031	Design of earthing and bonding systems
GS EP ELE 079	Electrical apparatus for potentially explosive gas atmospheres
GS EP ELE 081	Lighting
GS EP ELE 141	Power transformers
GS EP INS 111	Design and supply of liquid custody transfer metering units
GS EP INS 112	Design and supply of gas custody transfer metering units
GS EP INS 120	Control valves
GS EP INS 135	Cyber Security requirements for design and supply of ICSS and Package Systems
GS EP INS 137	Off/on valve control panel and actuators functional and construction requirements
GS EP EXP 107	Commissioning execution
GS EP EXP 311	Plant integrity. Minimum inspection requirements.
GS EP SAF 216	Area classification
GS EP SAF 261	Emergency Shut-Down and Emergency De-Pressurisation (ESD & EDP)
GS EP SAF 371	Emergency control facilities
GS EP TEC 007	Obsolescence and lifetime cycle management

3. Definitions, abbreviations and terminology

BDV:	Blow Down Valve
BSW:	Basic Sediment Water
CCR:	Central Control Room
CMMS:	Computerized Maintenance Management System
ESDV:	Emergency Shut Down Valve
F&G:	Fire and Gas
FPSO:	Floating Production Storage and Off-loading unit
GMC:	General Maintenance Contractor
HMI:	Human Machine Interface
ICSS:	Integrated Control and Safety System
MAINTENANCE:	Activities required to preserve as nearly, and as long, as possible the original condition of an asset normal wear and tear.
MANUFACTURER:	Company which designed and manufactured the equipment.
MIEC:	Maintenance & Inspection Engineering Contract
OEM:	Original Equipment Manufacturer
PAGA:	Public Address and General Alarm
PC:	Predictive maintenance (stands for Préventive Conditionnelle)
PCS:	Process Control System
PDMS:	Process Data Management System
PLC:	Programmable Logic Controller
PPE:	Personal Protection Equipment
PS:	Preventive Maintenance (stands for Préventive Systematique).
PSS:	Process Safety System
PSV:	Pressure Safety Valve
RCM:	Reliability Centered Maintenance
SAP:	Systems, Applications, and Products in Data Processing (business software, including a CMMS module – SAP/PM)
SCE:	Safety Critical Equipments
SCS:	Subsea Control System
SDV:	Shut Down Valve
SIM:	SuperIntendant de Maintenance
SSS:	Safety Shutdown System
UCP:	Unit Control Panel

4. Pumps

Pumps are devices used to move fluids and are commonly grouped in two types; centrifugal and volumetric pumps. Essentially, this classification describes the method used by them to move fluids; flow and pressure.

4.1 Centrifugal pumps

4.1.1 Technology

In this category of pumps, the liquid flows in along the axis of the pump via the distributor and the centrifugal force generated by the vaned wheel's rotation drives it toward the outside of the wheel (impeller). It acquires high kinetic energy, which is converted into pressure energy in the manifold, where the cross-section increases.

Often simply referred to as centrifugal pumps, according to their disposition they can be grouped into; vertical or horizontal and classified and classified by the number of impellers; one-stage or multistage pumps.

A centrifugal pump consists of a rotor-dynamic organ; impeller and a static diffuser; volute. Other component parts according to their function; to control the clearance between the wheel and the body, and to limit the inevitable leakage of fluid at the wheel outlet to the suction (Sealing rings or wear rings ...); and rotating mechanical components (ball bearing, roller bearing, bearing bush...).

4.2 Maintenance of centrifugal pumps

Generally, centrifugal pumps are reliable equipments manly because, they have very few moving parts. However, they include a certain numbers of components which must be followed closely; bushing bearings (roller / balls bearings or plan bearings) and the sealing systems (braided packing, mechanical seals and others).

- Any rotating mechanical component (roller and/or ball bearings, plain bearings ...), requires appropriate lubrication. The use of an appropriate lubricant (by oil or grease) regular contributes to an increase of their life. Besides, they are part of organs which are followed in conditional monitoring.
- Sealing systems: by definition, a pump is used for raising the pressure of a liquid, so the interior of a pump contains a pressurized liquid, which can escape into the atmosphere along the shaft. Mechanical seals are greatly used for sealing pumps or rotating machines in general and they have very different specifications according to the fluid to be sealed. To operate correctly they may be cooled and continuously supplied with a flushing fluid. Parameters to be monitored:
 - Laks (visual inspection or monitoring with a flow-meter),
 - Monitoring the mechanical seal assembly temperature,
 - Flushing fluid level and temperature.

Maintenance operations	When	Maint. type	Comments
Pre-start up Phase			
Commissioning			
Verification of technical records related to pre-commissioning tests, these data include: - Factory acceptance tests report - Cold alignment records - Preliminary check results	Before start up		
Verification of all as-built drawings			
Make sure that both suction and discharge piping have been properly installed and are free of stress			
Verification of alignment(s) and distance between shafts ends,			
Before coupling, verification of rotation right way,			
Make sure that the suction strainer is installed (if necessary)			
General external visual inspection (site survey) and witness functional tests			To be done in compliance with GS EP EXP 107
Operational Phase			
First in-service operations (General pumps)			
General external visual inspection	Start up	PC	
Hydraulic performance evaluation at start up		PC	To be compared with FAT
Bearing temperature and vibrations measurements		PC	See MANUFACTURER's requirements
In-service Maintenance activities ¹⁾ (General pumps)			
Bearing temperature and vibrations measurements	1 Month	PC	See the referential for guidelines
Carry out 1 st level of maintenance (washing, greasing, painting, general checks)	1 Month	PS	
In-service Maintenance activities (additional requirements for multi stage pumps)			
Process parameters records	1 Month	PC	See the referential for guidelines
Oil sampling for analysis if required	6 Months	PC	
Hydraulic performance test (to be recorded)	6 Months	PC	Carried out by GMC

Maintenance operations	When	Maint. type	Comments
Other time-based Maintenance activities			
General overhaul in a specialized workshop (in accordance with hydraulic performance test results and vibrations level)		PC	Carried out by GMC or SMC

- 1) Generally, when they are not followed-up in condition based maintenance, small centrifugal pumps (with a power of less than 30 kW) are overhauled after damage (break down based maintenance).

Maintenance operations	When	Maint. type	Comments
Standards performances			
Check the pressure at zero flow	Yearly	PC	
Measure the flow at operation pressure	Yearly	PC	
Measure the electric current intensity at operation pressure	Yearly	PC	

Table 1: Minimum maintenance requirements for centrifugal pumps

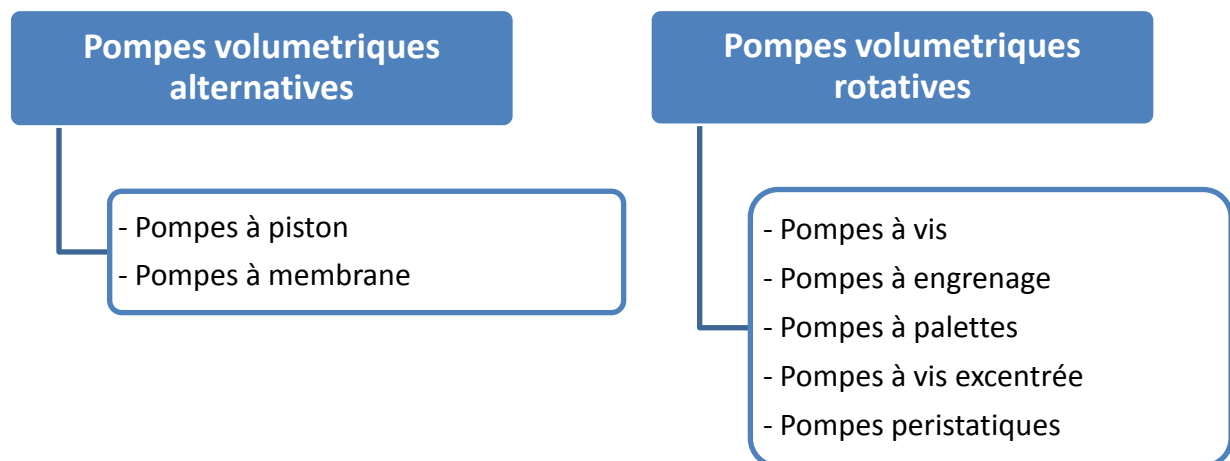
4.3 Positive displacement pumps (volumetric)

4.3.1 Technology

Positive displacement pumps consist of an air-tight enclosed volume (pump barrel) with a moving element inside which alternately increases and decreases the volume of the chambers as it moves. The movement is cyclic: a given volume of liquid is sucked in at the beginning and is discharged at the end.

Different types of positive displacement pumps are based two operating principles; either rotary-type or reciprocating-type (alternative) mechanisms.

Positive displacement pumps can be divided into two main classes:



4.4 Maintenance of volumetric pumps

In comparison to the rotary-type pumps, the reciprocating-type pumps are those who are the most complex to maintain, reflecting the assembly of a considerable number of moving parts and their associated dysfunctions. The most common troubleshooting associated are concerned with: seals, outflow valves, pistons, braided packing conditions, sealing systems (lack or excessive lubrication), bearings (mechanical defectiveness or defect of lubrication), etc.

Maintenance operations	When	Maint. type	Comments
Pre-start up Phase			
Commissioning			
Verification of technical records related to pre commissioning tests, these data include: • Factory acceptance tests report • Cold alignment records • Preliminary check results	Before start up		
Verification of all as-built drawings			
Verification of alignment(s) and distance between shafts ends,			
Before coupling, verification of rotation right way,			
Make sure that both suction and discharge piping have been properly installed and are free of stress			
Make sure that the suction strainer is installed (if necessary)			
General external visual inspection (site survey) and witness functional tests	Comm. Team		To be done in compliance with GS EP EXP 107
Operational Phase			
First in-service operations (General pumps)			
General inspection of pump	Start up	PC	
Hydraulic performance evaluation at start up	Start up	PC	To be compared with FAT
Process and equipment parameters records	Start up	PC	See the referential for guidelines
In-service Maintenance (Reciprocating pumps)			
Process and operating parameters records and daily maintenance routine	Daily	PC	See the referential for guidelines
Carry out 1 st level of maintenance (washing, greasing, painting, general checks)	1 Month	PS	
Oil sampling for analysis when required	3 Months	PC	

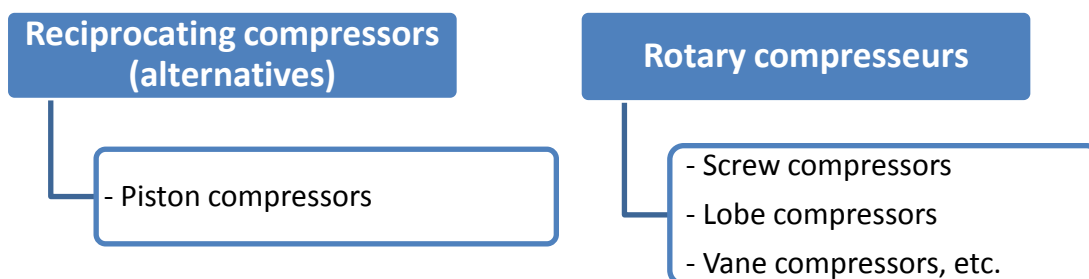
Check all shock absorbers	3 Months	PS	
Other time-based Maintenance activities (reciprocating pumps)			
Tests of all relief valves for proper operation and setting	8 Khrs	PS	Based upon MANUFACTURE'S requirements and RCM
Biennial Maintenance	16 Khrs	PS	
General overhaul in a specialized workshop	32/ 48 Khrs	PS	
Standards performances			
Measure flow and pressure at operation speed	Yearly	PC	Based upon MANUFACTURE'S requirements and RCM
Test the pressure safety valve if possible	Yearly	PC	

Table 2: Minimum maintenance requirements for positive-displacement pumps

5. Compressors

As gases are compressible, a compressor is a machine that, by a purely mechanical process, increases the pressure of a gas by reducing its volume. Compressors can be classified in two groups: the volumetric and centrifugal compressors.

The volumetric compressors can be grouped into two main categories: the reciprocating (alternative) compressors and the rotary compressors. Piston compressors and screw compressors are those who are the most common in oil refinery and in chemical industry.



5.1 Reciprocating compressors - Piston

5.1.1 Technology

Taking into account the multitude of the elements which compose this type of compressors, they can be further classified according to their two constituting mechanisms:

- The "**cylindrical**" group which regroups the elements which are in contact with gas and that participate directly in compression (pistons, segments, valves, etc),
- The "**motive drive**" which is outside and provides drive to the compressor that transforms the rotation movement of the machine into an alternative movement requested by the "cylindrical" group (crankshaft, connecting rods, etc).

They also include auxiliary systems and several other elements, to ensure the operation of the above mechanisms: lubrication, cooling system, etc.

5.2 Maintenance of reciprocating compressors

Reciprocating compressors are very complex machines to maintain, mainly due to their considerable number of moving components. The main breakdowns concerning this type of machines are: segments and valves.

The majority of the valves used nowadays are known as “passive” type: their movement of opening or closing is acquired by the difference of pressure applied on their two sides; the closing is nevertheless helped by springs. There are three big categories of valves: valves with small strips, valves with discs and valves with concentric rings.

Typical compressors breakdowns associated to valves failure, can be grouped in several categories: mechanical stress or wear in the moving parts, particles conveyed by the gas, existence of corrosion in the elements that contact directly the compressed fluid (may be due to the gas characteristics), etc.

Maintenance operations	When	Maint. type	Comments
Pre-start up Phase			
Commissioning			
Verification of technical records related to pre commissioning tests, these data include : • Factory acceptance tests report • Cold alignment records • Preliminary check results	Before start up		
Verification of all as-built drawings			
Connection of gas process piping and make sure that they are not subject to stress			
Verification of alignment(s) and distance between shafts ends,			
Before coupling, verification of rotation right way,			
Make sure that all electrical wiring and instrumentation are connected			
Connection of auxiliary systems and other utilities			
General external visual inspection (site survey) and witness functional tests			In conformity with GS EP EXP 107

Maintenance operations	When	Maint. type	Comments
Operational Phase			
First in-service operations			
General external visual inspection	Start up	PC	
Vibration and bearing temperature measurement of all auxiliary electric motors; (oil pump, cooling water pump, etc.)	Start up	PC	Based upon MANUFACTURE'S requirements
Process and operating parameters records	Start up	PC	See the referential for guidelines
In-service Maintenance activities			
Process and operating parameters records and daily maintenance routine.	Daily	PC	See the referential for guidelines
Vibration and bearing temperature measurements for all auxiliary electric pumps; (oil, cooling water, etc.)	Monthly	PC	
Oil sampling for analysis when required.	3 Months	PC	
Other time-based Maintenance activities			
Semi-annual Maintenance	4 Khrs	PS	Based upon MANUFACTURE'S requirements and RCM
Annual Maintenance (valves, pistons rings, rods packings)	8 Khrs	PS	
Biennial Maintenance (8 KH + crankshaft bearings, connecting rod sleeves, cylinder liners)	16 Khrs	PS	
4-years Maintenance – complete overhaul of unit.	32 Khrs	PS	

Table 3: Minimum maintenance requirements for reciprocating compressors

5.3 Volumetric compressors - Rotary

5.3.1 Technology

Rotary compressors; screw, vanes and lobes are the most common types in the oil industry. They are volumetric type of machines, with a low working pulsation rate and significantly quieter operation. The global efficiency of a rotary compressor is typically intermediate, comparing an equivalent alternative type unit and a centrifugal compressor.

Liquid ring and lobe compressors are inherently of low friction design, with the rotor being the only moving part and sliding friction being limited to the shaft seals. From the technological point of view, all common maintenance operations can easier be performed by local personnel and with a minimum range of tools.

Screw compressors

As the centrifugal type of compressors, the rotary screw compressor is also a positive displacement machine that operates without the need for suction or discharge valves. The only



significant moving parts in a screw compressor are the male and female rotors. There are no valves, pistons, rings, or connecting rods that require regular maintenance.

A screw compressor is often delivered in form of 'package' ready to be connected electrically and it may include all required components; (filters, separators, cooling systems, dryers, valves,...).

They are usually be classified in two categories: the **oil lubricated screw compressors** (oil-flooded heavy duty process gas machines) and **oil-less screw compressors**.

Oil lubricated screw compressors

Screw oil-lubricated compressors are commonly used in our installations, in particular to produce and supply compressed-air, essential to equipments such as **instruments** and in general to feed the **compressed-air network**.

A rotary screw compressor is very simple in design. Some of the major components include one set of male and female helically grooved rotors (screws), a set of axial and radial bearings and a slide valve, all encased in a common housing. The continuous rotation of both screws allows the aspiration, compression and pushing back of air.

In an oil-flooded rotary screw compressor, oil is injected into the compression cavities to aid sealing, to lubricate and provide cooling media for the moving parts. The oil is separated from the discharge stream, then cooled, filtered and recycled. This is rectified (by the installation of receiver tanks) that allow oil to condense and drop out of the air stream.

To ensure the optimum operating conditions, oil-lubricated screw compressors, include other components/systems:

- Air intake filters,
- Compressed air cooling system,
- Oil and water separators in the compressed air stream,
- Compressed air dryer to retain water condensates,
- Output regulation valves to supply compressed air to pneumatic equipments below their maximum admissible pressure,
- Pressure safety valve – PSV.

Oil-less screw compressors

Thanks to their functioning without oil, the 'oil-less compressors' produce quality air and completely exempt from particles of oil. However, this does not preclude the need for filtration as hydrocarbons and other contaminants captured from the atmospheric air must also be removed prior to the point-of-use.

Oil-free compressors are used in applications where entrained oil carry-over is not acceptable. Under certain working conditions, mixture air - oil can have consequences not negligible; ignition, fire, etc.

The two rotors are meshed together thanks to a pair of synchronization gears located outside the machine, enabling the screws to operate without touching each other. The absence of metal-to-metal contact practically eliminates all risk of wear to the compression parts, and avoids any loss of power due to friction.

On the other hand, oil-lubricated screw compressor is significantly quieter in operation than equivalent oil-less screw compressor which, heats up and vibrates lightly more.

Vane and lobe compressors

Not relevant in oil industry or low usage in our installations. This type of volumetric compressors will not be included in the present guide.

5.4 Maintenance of rotary compressors

Screw compressors are usually reliable equipments (exception for vane compressors) and this is mainly due to their fewer components, comparing equivalent alternative compressors.

However, certain components have to be given particular attention. Rotors are supported by bearings (ball or roll bearings, plain bearings), sealing between the internal chambers and packing glands, sealing rings which are usually installed on the ends of the rotor shaft to prevent leakage. As a result of operational conditions, the reduced clearance between the two rotors can increase and the wear may induce contact between them.

Maintenance operations	When	Maint. type	Comments
Pre-start up Phase			
Commissioning			
Verification of technical records related to pre commissioning tests, these data include : • Factory acceptance tests report • Cold alignment records • Preliminary check results	Before start up		
Verification of all as-built drawings			
Connection of process piping and make sure that they are not subject to stress			
Verification of alignment(s) and distance between shafts ends,			
Before coupling, verification of rotation right way,			
Make sure that all electrical wiring and instrumentation are connected			
Connection of auxiliary systems and other utilities			
General external visual inspection (site survey) and witness functional tests			In conformity with GS EP EXP 107

Maintenance operations	When	Maint. type	Comments
Operational Phase			
First in-service operations			
General external visual inspection	Start up		
Before coupling, verification of rotation right way,	Start up		
Process and operating parameters records	Start up		To be compared with FAT
In-service Maintenance activities on compressor assembly			
Process and operating parameters records and daily maintenance routine and report any unusual noise.	Daily	PC	
For all filters, check pressure drop across filter and clean or replace as required.	weekly	PC	
Check level of oil and add oil if necessary.	weekly	PS	
Annual maintenance (8 KH). Replacement of filters, oil, replace coupling element.	yearly	PS	Based upon MANUFACTURE'S requirements
Replacement of air, oil and control hoses.	4 years	PS	
In-service Maintenance activities on Control Valves			
Inspect all control valves and adjust as required, or note for future maintenance. Report all discrepancies to supervisor. Inspection shall include checking for: - Air leaks; - Erratic air pressure at inlet or outlet; - Actual pressure compared to pressure setting valve.	Monthly	PS	Based upon MANUFACTURE'S requirements and RCM
In-service Maintenance activities on Safety Relief Valves			
Perform operational test of relief valve either in service or remove and perform test on test bench	4 years	PS	In accordance with GS EP EXP 311
In-service Maintenance activities on Inter-coolers and After-Coolers			
For air-cooled units: Verify cooling surfaces are clear of debris (waste paper, rags, packing material, etc.); clean area as required.	Monthly	PS	Based upon MANUFACTURE'S requirements and RCM

For water-cooled units: - Check inlet and outlet air and coolant temperatures and adjust coolant flow as required; - Visually inspect units for leaks or corrosion and report discrepancies to supervisor.	Monthly	PS	
In-service Maintenance activities on Air Dryer			
General checks and inspections should be performed to verify or determine: - Drains, if present, are clear; - Automatic traps are functioning; - Operating pressure drops, and air and coolant stream temperatures are within normal ranges.	Monthly	PS	Based upon MANUFACTURE'S requirements and RCM
Replacement of desiccant	Yearly	PS	Based upon MANUFACTURE'S requirements and RCM
In-service Maintenance activities Instrumentation			
For thermometers, pressure gauges, level, flow indicators, and transmitters: See instrumentation part of this document.	Yearly	PS	Based upon MANUFACTURE'S requirements and RCM
Standards performances			
Process and operating parameters records	6-Months	PC	

Table 4: Minimum maintenance requirements for rotating compressors

5.5 Centrifugal compressors

5.5.1 Technology

Centrifugal compressors are dynamic compression equipments that use aerodynamic processes to increase the pressure of fluid (gas) between one point and another. The rows, alternate between the rotating airfoils (rotors) and stationary airfoils (stators), with the rotors imparting energy into the fluid, and the stators converting the increased rotational kinetic energy into static pressure through diffusion.

Compared with the volumetric compressors, the centrifugal compressors have considerable advantages. In fact, they have less friction components and, as a result, they require less maintenance. Besides, they can have comparatively high efficiencies.

Generally, centrifugal compressors consist of the following rotating and stationary components:

- A compressor casing (one or two elements), which provides the mechanical strength, supports and locates the machine,
- The connections to the process by means of intake and discharge flanges, ensuring the pressure of the gas to be sealed inside, so as to limit leakage towards the outside of the machine; dry-gas seals, labyrinths, lubrication, etc,
- A shaft that drives a central drum, retained by bearings, which has a number of annular airfoil rows attached and ...,
- A similar number of stationary airfoil rows attached to a stationary tubular casing.

A pair of rotating and stationary airfoils is called a stage. The cross-sectional area between rotor drum and casing is reduced in the flow direction to maintain axial velocity as the fluid is compressed.

5.6 Maintenance of centrifugal compressors

Maintenance operations	When	Maint. type	Comments
Pre-start up Phase			
Commissioning			
Verification of technical records related to pre commissioning tests, these data include : • Factory acceptance tests report • Cold alignment records • Preliminary check results	Before start up		
Verification of all as-built drawings			
Connection of process piping and make sure that they are not subject to stress			
Verification of alignment(s) and distance between shafts ends,			
Before coupling, verification of rotation right way,			
Make sure that all electrical wiring and instrumentation are connected			
Connection of auxiliary systems and other utilities			
General external visual inspection (site survey) and witness functional tests			In conformity with GS EP EXP 107