

GENERAL SPECIFICATION

ROTATING MACHINERY

GS EP MEC 275

Multi-Phase Rotodynamic Pumps

04	11/2017	General revision
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1. Scope

The purpose of this specification is to define the minimum requirements for the design, construction, inspection, testing and delivery of a rotodynamic multiphase pump to be installed on the sea floor.

The purpose of this specification is to clarify the requirements of [API STD 610](#) 11th ed., when applied to multiphase pumps, in addition to other requirements. This document modifies or complements some requirements of [API STD 610](#), when deemed necessary considering Company experience.

The paragraph numbering is identified in the same way as in [API STD 610](#) except for additional requirements, which are presented with new paragraph numbers.

However, a subsea motor and pump unit is a highly integrated machine which combines both the pump and the motor to one single unit. Because of this integration, the motor and the pump cannot be treated as individual components.

Therefore, this specification also defines the minimum functional requirements for the motor, and the key auxiliary components that are fully part of the pump system, which are the barrier fluid system, the integrated by-pass line, the minimum flow protection system, the discharge non return valve, the inlet flow mixer, the outlet flow splitter and the ROV panel.

2. Reference documents

The reference documents listed below form an integral part of this General Specification.

External Documents

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and addendums, is the latest revision published at the effective date of this document.

Reference	Title
API STD 610	Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industries
ASME BPVC Section VIII Div 1	ASME Boiler & Pressure Vessel Code - Section 8: Rules for Construction of Pressure Vessels - Division 1: Pressure Vessels
ASME BPVC Section VIII Div 2	ASME Boiler & Pressure Vessel Code - Section 8: Rules for Construction of Pressure Vessels - Division 2: Alternative Rules
BS EN 10204	Metallic products. Types of inspection documents
PD 5500	Specification for unfired fusion welded pressure vessels
DNV-RP-B401	Cathodic Protection Design
DNV-RP-F112	Design of Duplex Stainless Steel Subsea Equipment exposed to Cathodic Protection
IEC 60034-1	Rotating Electrical Machines - Part 1 Rating and Performances

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Reference	Title
IEC 62271-200	High-voltage switchgear and controlgear - Part 200 AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV
ISO 10441	Petroleum, petrochemical and natural gas industries - Flexible couplings for mechanical power transmission - Special-purpose applications
ISO 13628 (Parts 1; 8)	Petroleum and natural gas industries - Design and operation of subsea production systems - Parts 1; 8

Total General Specifications

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and addendums, is the latest revision published.

Reference	Title
GS EP PVV 146	Bolting for piping
GS EP PVV 611	Welding of pressure containing piping and equipment
GS EP PVV 614	Welding of duplex and super-duplex stainless steel
GS EP PVV 619	Piping or pressure vessel components in duplex and superduplex stainless steel
GS EP SPS 002	Design of Subsea Stations
GS EP SPS 016	Subsea Choke Valves
GS EP SPS 029	Metallic Materials for Subsea Production Facilities
GS EP SPS 032	Power Connectors, Penetrators and Jumper assemblies with rated voltage from 3 kV to 30 kV
GS EP STR 201	Materials for offshore steel structures

3. Terms and definitions
Helico-axial Multiphase Pump

Helico-axial or so-called rotodynamics multiphase pumps have several stages that progressively compress the mixture dynamically, i.e. the rotational speed of the shaft generates the required head or pressure. Shaft torque is converted into fluid angular momentum. If the GVF increases, speed has to be increased to produce the required head. Each compression stage consists of an open type impeller, mounted on a rotating shaft, and a fixed diffuser. Profile of the impeller blades, helical, and the diffuser vanes are specifically designed to prevent separation of phases in the compression process.

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MPP unit	Pump and motor assembly
MPP system	MPP unit with all its subsea auxiliary system, which are the barrier fluid system, the integrated bypass line (IBPL), the minimum flow protection system, the discharge non return valve, the inlet flow mixer, the outlet flow splitter and the ROV panel.
Barrier Fluid system	System composed of topside barrier fluid HPU, topside and subsea accumulators, subsea Feed and Dump valves.
IBPL	The integrated bypass line (IBPL) is a circuit implemented in the MPP subsea station to protect the pump against the effects of start-up, stop and trip. The IBPL is mainly composed of a non-return valve. The IBPL is integrated within the pump unit and therefore can be retrieved with the pump for servicing.
HPU	Hydraulic Power Unit
GVF	Gas Volume Fraction $GVF = \frac{Q_{gas}}{Q_{total}} \text{ in } \%$ Q_{gas} = gas flow at pump suction conditions Q_{total} = total flow (oil + liquid + gas) at pump suction conditions
MPFM	Multiphase Flow Meter
ROV	Remotely operated vehicle
VSD	Variable Speed Drive
PCM	Power and Control Module installed on the FPSO topside All topside equipment shall be fitted into a Power and Control Module (PCM), designed as a container module. It shall be built as one unit for single lift by fixed facilities. The PCM shall contain necessary control equipment to drive one MPP station, including control systems, hydraulic generation, VSD and local HVAC functions. A typical subsea pumping station holds two MPP units, therefore the PCM shall include: • Two off VSDs for individual HV power supply and speed control of the two subsea MPP motors. • Internal LV power distribution, comprising Miniature Circuit Breakers (MCB), cabling, etc. for internal power supply of all LV and UPS consumers inside the PCM. • 1 off barrier fluid HPU for supply of the barrier fluid System for the two Subsea MPPs. Local control room with HMI for control of the two Subsea MPPs and associated equipment. • HVAC system.

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Note: The PCM may also hold 1 off control fluid HPU to provide control fluid to operate the subsea valves (architecture more relevant for brown field application).

LV	Low voltage
HV	High voltage
UPS	Uninterruptible Power Supply
HMI	Human Machine Interface
FPSO	Floating Production Storage & Offloading
FAT	Factory Acceptance Test
EFAT	Extended Factory Acceptance Test
CDT	Cool Down Test
SWT	Shallow Water Test

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4. Comments to API STD 610 11th Edition

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5. Requirements	
5.1 Units	
The purchaser shall specify whether data, drawings, and maintenance dimensions of pumps shall be in the SI or US Customary (USC) system of measurements. Use of an SI data sheet (see N.3.1) indicates the International Standard System of measurements shall be used. Use of a USC data sheet (see N.3.2) indicates the USC system of measurements shall be used.	Pumps shall have SI dimensions and comply with applicable ISO standard.
6. Basic design	
6.1 General	
6.1.1 The equipment (including auxiliaries) covered by this International Standard shall be designed and constructed for a minimum service life of 20 years (excluding normal-wear parts as identified in Table 20) and at least 3 years of uninterrupted operation. Shutting down the equipment to perform vendor-specified maintenance or inspection does not meet the continuous uninterrupted operation requirement. It is recognized that these requirements are design criteria and that service or duty severity, mis-operation or improper maintenance can result in a machine failing to meet these criteria.	(Modification and Addition) The equipment (including auxiliaries) covered by this International Standard shall be designed for at least 5 years of uninterrupted operation. The whole MPP system shall have a System Engineering approach, and not a component approach. MPP shall be designed by taking into account the environmental conditions as for instance: - Design pressure - Design temperature - Fluid composition and data - Design life time - Ambient temperature (subsea) - Flow line inner diameter - Water depth - Pump location - Sand concentration - Transportation - Main conditions of storage, i.e.: - Storage area: indoor or outdoor - Storage temperature: -25°C to +50°C - Maximum air humidity: 95% RH. - Subsea installation and retrieval.

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	Only field proven or fully qualified components, materials and systems shall be considered. The MPP covered by this General Specification is part of a MPP system. A MPP system consists of: • 1 off MPP unit (multiphase pump and motor assembly) that will be installed in a pump module as part of the manifold structure • 1 off flow mixer located at the pump inlet • 1 off flow splitter located at the pump outlet • 1 off barrier fluid system • 1 off recirculation loop for minimum flow protection • 1 off integrated bypass line (IBPL) • 1 off discharge check valve • 1 off ROV panel. For a segregated configuration (1 single MPP per production line), each MPP shall have its own MPP system as described here above. For a configuration of 2 MPPs working in parallel on a same production line, there shall be 1 single flow mixer for the two MPPs. Each MPP unit shall be individually electrical powered and independently retrievable (pump or module). Each MPP unit shall have a Variable Speed Drive (VSD) to give a better flexibility in operating the pump. Weight of the MPP unit shall be such that light intervention vessel can be used. The MPP unit shall have a single barrier fluid system. The Power and Control Module (PCM) located on the FPSO shall supply the electrical power, and the barrier fluid to the pump via the umbilical. All static sealing shall be based on dual seal philosophy. O rings in contact with process fluid (gas) shall be rapid decompression resistant.

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	To verify the most severe loading on the casing, hydrostatic pressure testing shall be made with one O ring, and with the O rings presenting the largest diameter.
● 6.1.2 The purchaser shall specify the operating conditions, the liquid properties, site conditions and utility conditions, including all data shown on the process data sheet (Annex N). The purchaser shall specify whether the pump is intended for use as an HPRT and whether Annex C shall apply.	Refer to 6.1.12 of this document.
6.1.6 Variable speed shall be designed for excursions to trip speed without damage.	(Clarification) MPP shall be designed for a trip speed corresponding to 106% of the maximum continuous operating speed. One MPP shall be tested at the VSD trip level, which is 103% of maximum continuous speed. The test shall last for 2 minutes and be run with only gas.
● 6.1.9 The pump suction-specific speed shall be calculated in accordance with Annex A and, if specified, limited as stated on the data sheet.	This paragraph is not applicable.
● 6.1.11 Pumps that have stable head/flowrate curves (continuous head rise to shutoff) are preferred for all applications and are required if parallel operation is specified. If parallel operation is specified, the head rise from rated point to shutoff shall be at least 10%. If a discharge orifice is used as a means of providing a continuous rise to shutoff, this use shall be stated in the proposal.	Pumps with a stable head/capacity curve that continuously rises from rated to shut-off without any "S" profile are required for all the applications.
6.1.12 Pumps shall have a preferred operating region of 70% to 120% of best efficiency flowrate of the pump as furnished. Rated flow shall be within the region of 80% to 110% of best efficiency flowrate of the pump as furnished.	(Substitution) Company shall provide operating data to be used for the lifetime design of the MPP. These operating cases will be defined from a selection of several years along the production profiles (early life, end of production plateau, end of field life) for which all critical aspects in Flow assurance will have been examined (liquid rate min max, gas rate min max, emulsion, etc.). Contractor shall issue the performance curves

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	for the complete range of operating conditions. Based on the operating range, one to three design points for the pump shall be selected, with special attention on the first five years of operation. These design points shall be centered on the operating envelop, as close as possible to the best efficiency point of each impeller. Flow at the last impeller in any hydraulic series shall not be below 60% of its BEP at any of the above operating conditions. The following margins on the most constricting operating point shall be considered for the design of the pump due to higher uncertainties when pumping multiphase fluid: • 300 rpm margin on speed at least • 15% margin on power at least. All remaining parameters shall be the same as operating conditions. The below sensitivity cases shall be part of the design of the pump and shall remain within the pump envelop curve, but above power and speed margins of the pump might be altered. • GVF + 0.2 fraction • Viscosity at double rated viscosity. All remaining parameters shall be the same as operating conditions. The pump system and its control system shall be designed to handle all transient in start-up, normal and shut-down operations. Contractor shall demonstrate through dynamic simulations studies, with inputs from Company that the design of the pump system and its mode of operation and control can cope with conform operating conditions.
● 6.1.22 Motors, electrical components and electrical installations shall be suitable for the area classification (class, group, and division or zone) specified by the purchaser and shall meet the requirements of the applicable sections of IEC 60079 (all parts) or NFPA 70:2008, Articles 500, 501, 502, 504 and 505 as well as any local codes specified and furnished on request by the purchaser.	This paragraph is not applicable.