

GENERAL SPECIFICATION

Rotating Machinery

GS EP MEC 271

Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industries according to API Standard 610

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1. Scope

This specification covers the minimum requirements necessary for design, selection of materials, construction, inspection, testing and preparation for shipment related to the equipment subject of this specification.

The purpose of this specification is to respond to bullet points or to supplement or to amend or to clarify the requirements of [API STD 610](#).

The paragraph numbering is identified in the same way as in [API STD 610](#). Additional provisions that are not covered by [API STD 610](#) are identified by extrapolation of the numbering chronology.

Paragraphs of [API STD 610](#) not mentioned in this document are fully applicable.

Paragraphs of [API STD 610](#) starting by “Unless otherwise specified”, not identified by a bullet point and not specifically addressed in this document, are fully applicable.

2. Reference documents

This document is the TOTAL E&P transposition of the TOTAL S.A. Harmonized GS GR MEC 610.

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 addendums, is the latest revision published at the effective date of this document.

External Documents

Reference	Title
ANSI/ASME B1.1	Unified Screw and Pipe Threads Package
ANSI/HI 14.6	Rotodynamic Pumps for Hydraulic Performance Acceptance Tests
ANSI/HI 2.6	Vertical Pump Tests
API STD 610	Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industries
API STD 614	Lubrication, Shaft-sealing and Oil-control Systems and Auxiliaries
API STD 682	Pumps - Shaft Sealing Systems for Centrifugal and Rotary Pumps
ASME BPVC, Section VIII, Division 1	Rules for Construction of Pressure Vessels
EN 10204	Metallic product - Types of inspection documents
EN 13445 (All Parts)	Unfired pressure vessels - All parts
European Directive 2014/34/EU	Directive 2014/34/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres

Reference	Title
ISO 10474	Metallic products - Inspection documents
ISO 21940-11	Mechanical vibration - Rotor balancing - Part 11: Procedures and tolerances for rotors with rigid behaviour
ISO 261	ISO general purpose metric screw threads - General plan
ISO 262	ISO general purpose metric screw threads - Selected sizes for screws, bolts and nuts
ISO 281	Rolling bearings - Dynamic load ratings and rating life
ISO 724	ISO general-purpose metric screw threads - Basic dimensions
ISO 965 (All Parts)	ISO general purpose metric screw threads - Tolerances - All parts
ISO 9906	Rotodynamic pumps - Hydraulic performance acceptance tests - Grades 1, 2 and 3
NACE MR 0103	Petroleum, petrochemical and natural gas industries - Metallic materials resistant to sulfide stress cracking in corrosive petroleum refining environments
NACE MR 0175	Petroleum and natural gas industries - Materials for use in H ₂ S-containing environments in oil and gas production

Total General Specifications

Reference	Title
GS EP ELE 111	HV Induction Motors
GS EP ELE 116	Low Voltage Induction Motor
GS EP MEC 215	Petroleum, Petrochemical, and Natural Gas Industries - Steam Turbines - Special-purpose Applications according to API Standard 612
GS EP MEC 240	Special Purpose Couplings for Petroleum, Chemical, and Gas Industry Services according to API Standard 671
GS EP MEC 242	Special Purpose Gear Units for Petroleum, Chemical and Gas Industry Services According to API Standard 613
GS EP MEC 270	Pumps - Shaft Sealing Systems for Centrifugal and Rotary Pumps according to API Standard 682
GS EP MEC 281	Lubrication, Shaft Sealing and Oil Control Systems and Auxiliaries according to ISO 10438/API Standard 614



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Reference	Title
GS EP MEC 541	Form-wound Squirrel-Cage Induction Motors - 500 Horsepower and Larger according to API Standard 541
GS EP MEC 546	Brushless Synchronous Machines - 500 kVA and Larger according to API Standard 546

3. Applicability

This specification applies to offshore and onshore applications.

4. Definitions of terms

For the purpose of this document, the following terms and definitions apply:

Company: Any entity of the TOTAL Group mentioned in the contract or the order.

5. Comments and/or additions to API STD 610 11th Edition

Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industries shall be in accordance with [API STD 610 11th Edition](#), September 2010.

API	Requirements
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	
	All equipment installed in a hazardous area shall be ATEX certified according to European Directive 2014/34/EU . For packages installed outside the European Union, as an alternative to ATEX certification, IECEx scheme (IEC Scheme for Certification relating to Equipment for use in Explosive Atmospheres) may be used as guidelines for Ex certification of all electrical & instrumentation equipment.
6.1 General	
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 if the pump is intended for use as an HPRT and if Annex C shall apply.	Refer to Project Specification and datasheet. HPRT service is not applicable.
6.1.4 Pumps shall be capable of at least a 5% head increase are rated conditions by replacement of the impeller(s) with one(s) of larger diameter or different hydraulic design, variable-speed capability or use of a blank stage.	The proposed rated impeller diameter for pumps with constant speed drivers shall not be greater than 96% or less than 80% of the maximum impeller diameter that can be installed in the pump casing.

API	Requirements
	For pumps with variable speed drives, the impeller diameter giving the maximum efficiency shall be selected. If this results in the selected impeller diameter being the maximum for the chosen casing, then the driver and pump shall be capable of the speed increase necessary to give a 5% increase in head (as per API STD 610 clause 6.1.4 Note) and to correct any head shortfall during testing, including the -3% tolerance per table 16.
6.1.8 The Vendor shall specify on the data sheets the NPSH3 based on water (at a temperature of less than 55°C (130 °F)) at the rated flow and rated speed. A reduction of correction factor for liquids other than water (such as hydrocarbons) shall not be applied. The Purchaser should consider an appropriate NPSH margin in addition to the NPSH3 specified. It is usually desirable to have an operating NPSH margin that is sufficient at all flows (from minimum continuous stable flow to maximum expected operating flow) to protect the pump from damage caused by flow recirculation, separation and cavitation. The Vendor should be consulted about recommended NPSH margins for the specific pump type and intended service. In establishing NPSHA, the Purchaser and the Vendor should recognize the relationship between minimum continuous stable flow and the pump's suction specific speed. In general, minimum continuous stable flow, expressed as suction-specific speed increases. However, other factors, such as the pump's energy level and hydraulic design, the pumped liquid, and the NPSH margin, also affect the pump's ability to operate satisfactorily over a wide flow range. Pump design that addresses low-flow operation is an evolving technology, and selection of suction specific speed levels and NPSH margins should take into account current industry and Vendor experience. Unless otherwise specified, the datum elevation shall be the shaft centreline for	The NPSH3 specified on the data sheets and the performance curve shall correspond to the rated impeller diameter. Impellers shall be selected so that: • $NPSHA > 1.2 \times NPSH3$ throughout the whole operating region, • Minimum $NPSHA = NPSH3 + 1 \text{ m}$ throughout the whole operating region, • For liquids containing dissolved gases, to avoid cavitation damage due to vapour-induced flow path restrictions, NPSHA shall be $1.5 \times NPSH3$, with a minimum margin of 5 m between NPSHA and NPSH3. A NPSH test shall be performed when required by paragraph 8.3.4.3 or when the pump is fitted with an inducer. In his offer, the vendor shall also indicate the NPSH3 at the pump BEP with the maximum impeller diameter.

API	Requirements																								
horizontal pumps, the suction nozzle centreline for vertical in-line pumps, and the top of the foundation for vertically-suspended pumps.																									
• 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.	1. Vendor shall indicate, in the proposal the Nss for the pumps proposed. 2. Nss, without inducer, shall be limited as indicated in the table below: <table><thead><tr><th>Suction specific speed $S = N \frac{(Q)^{0.5}}{(NPSHR)^{0.75}}$ With Q in m³/s - NPSHR in m</th><th>End suction pump with axial inlet</th><th>Pump with shaft through the eye and total HMT < 500 m</th><th>Pump with shaft through the eye and total HMT > 500 m</th></tr></thead><tbody><tr><td>Maximum allowable</td><td>270</td><td>240</td><td>220</td></tr><tr><td>Maximum preferred</td><td>230</td><td>200</td><td>180</td></tr><tr><td>Maximum allowable for pumps handling liquefied gases, volatile liquids or containing dissolved gases</td><td>190</td><td>170</td><td>150</td></tr></tbody></table> 3. Vendor shall indicate if a double-suction impeller is proposed. 4. Vendor shall clearly indicate the use of an inducer. Nss of the inducer shall be limited as indicated below: <table><thead><tr><th>Suction specific speed $S = N \frac{(Q)^{0.5}}{(NPSHR)^{0.75}}$ With Q in m³/s - NPSHR in m</th><th>Inducer</th></tr></thead><tbody><tr><td>Maximum allowable</td><td>700</td></tr><tr><td>Maximum preferred</td><td>500</td></tr><tr><td>Maximum allowable for pumps handling liquefied gases, volatile liquids or containing dissolved gases</td><td>350</td></tr></tbody></table> 5. The design of the inducer shall be such that it does not create pulsations at part load operation. For any proposal with higher Nss, Vendor shall clearly document the reason for such a choice.	Suction specific speed $S = N \frac{(Q)^{0.5}}{(NPSHR)^{0.75}}$ With Q in m³/s - NPSHR in m	End suction pump with axial inlet	Pump with shaft through the eye and total HMT < 500 m	Pump with shaft through the eye and total HMT > 500 m	Maximum allowable	270	240	220	Maximum preferred	230	200	180	Maximum allowable for pumps handling liquefied gases, volatile liquids or containing dissolved gases	190	170	150	Suction specific speed $S = N \frac{(Q)^{0.5}}{(NPSHR)^{0.75}}$ With Q in m³/s - NPSHR in m	Inducer	Maximum allowable	700	Maximum preferred	500	Maximum allowable for pumps handling liquefied gases, volatile liquids or containing dissolved gases	350
Suction specific speed $S = N \frac{(Q)^{0.5}}{(NPSHR)^{0.75}}$ With Q in m³/s - NPSHR in m	End suction pump with axial inlet	Pump with shaft through the eye and total HMT < 500 m	Pump with shaft through the eye and total HMT > 500 m																						
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API	Requirements
6.1.10 Pumps that handle liquids more viscous than water shall have their water performance corrected in accordance with ISO/TR 17766. Correction factors used for viscous liquid shall be submitted with both sales proposal curves and final test curves. NOTE: For the purpose of this provision, ANSI/HI 9.6.7 is equivalent to ISO/TR 17766.	The proposal for such a pump shall also include: - The water performance curve without corrections, - The correction coefficients for efficiency, head and capacity in accordance with the Hydraulic Institute Standards, - The expected performance curve with specified product. The maximum expected power consumption (viscosity range, cold start up and normal operation).
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 that have stable head/flowrate curves (continuous head rise to shutoff) are required for all applications. The head rise from rated point to shutoff shall be at least 10 %. If a discharge orifice is required as a means of providing a continuous rise to shutoff, this shall be subject to purchaser approval. Where offered, vendor shall furnish full performance curves for the pump with and without the orifice installed. A pump suction side restriction ring, commonly known as a 'Bull Ring' is not allowed. Pumps that are specified to operate in parallel shall have: - The same shut off head (tolerance $\pm 3\%$), which shall be confirmed at the performance test. - Between 80% and 110% of Best Efficiency Point, the tested head of the second pump shall be less than 101.5% and greater than 98.5% of the tested head of the first pump at the same flow. For boiler feed pumps, the head at the minimum continuous flow shall be at least 120% of the head at the rated operating point.
6.1.13 The best efficiency point flowrate for the pump as furnished should preferably be between the rated point and the normal point.	For sake of clarity of API STD 610, this paragraph is NOT applicable. Refer to paragraph 6.1.12 where it is stated that 80% BEP < Rated < 110% BEP.

API	Requirements								
	Furthermore, for all non-High Energy Pumps except Fire Water Pumps, the normal operating point for the pump shall be between 0 and 20% to the left of the best efficiency point. For all High Energy Pumps except Fire Water Pumps, the normal operating point for the pump shall be between 0 and 10% to the left of the best efficiency point.								
6.1.14 If specified, the Vendor shall provide both maximum sound pressure and sound power level data per octave band for the equipment. Control of the sound pressure level (SPL) of all equipment furnished shall be a joint effort of the Purchaser and the Vendor who has unit responsibility. The equipment furnished by the Vendor shall conform to the maximum allowable sound pressure level specified. ISO 3740, ISO 3744 and ISO 3746 may be consulted for guidance.	Refer to Project specification and datasheet.								
6.1.17 The need for cooling shall be determined by the Vendor, and the method shall be agreed upon by the Purchaser. Fan cooling should be the first choice. If fan cooling is inadequate, one of the plans in Annex B shall be selected. The cooling system shall be suitable for operation with the coolant type, pressure and temperature specified by the Purchaser. The Vendor shall specify the required flow. To avoid condensation, the minimum temperature at the cooling-water inlet to bearing housings should be above the ambient air temperature.	As a minimum bearing cooling shall be provided as follows: <table border="1"> <thead> <tr> <th>Maximum pumping temperature T_m</th><th>Cooling method</th></tr> </thead> <tbody> <tr> <td>$T_m \leq 177^\circ\text{C}$</td><td>Air, if necessary</td></tr> <tr> <td>$177^\circ\text{C} < T_m < 260^\circ\text{C}$</td><td>Air + heat shield</td></tr> <tr> <td>$260^\circ\text{C} \leq T_m$</td><td>Water</td></tr> </tbody> </table>	Maximum pumping temperature T_m	Cooling method	$T_m \leq 177^\circ\text{C}$	Air, if necessary	$177^\circ\text{C} < T_m < 260^\circ\text{C}$	Air + heat shield	$260^\circ\text{C} \leq T_m$	Water
Maximum pumping temperature T_m	Cooling method								
$T_m \leq 177^\circ\text{C}$	Air, if necessary								
$177^\circ\text{C} < T_m < 260^\circ\text{C}$	Air + heat shield								
$260^\circ\text{C} \leq T_m$	Water								
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.	Refer to Project Specification and datasheet.								
6.1.24 All equipment shall be designed to permit rapid and economical maintenance.	Any non-rotating maintenance part weighing more than 25 kg shall be fitted with permanent								

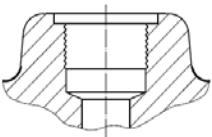
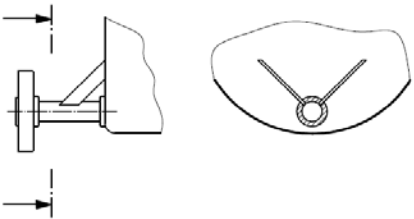
API	Requirements
Major parts such as casing components and bearing housings shall be designed and manufactured to ensure accurate alignment on reassembly. This may be accomplished by the use of shouldering, dowels and keys.	lifting lugs or equipped for removable lifting eyes.
6.1.28 Equipment, including all auxiliaries, shall be designed for outdoor installation and the specified site environmental conditions. The vendor shall advise of any equipment protection required for the jobsite location (i.e. winterization for low ambient temperatures, or protection against unusual humidity, dusty or corrosive conditions, etc.).	<u>Add to subclause:</u> For floating applications, the vendor shall state the maximum inclination and time period of oscillation at which the pump can operate.
6.1.29 Bolting and Threads	The Vendor shall specify the tightening torque for the casing joint bolting and for all the pump internal bolting (wetted) when applicable. Tightening torques shall be specified as "dry" or "lubricated". If lubricated, the type of lubrication shall be specified on the cross-sectional drawing and/or in the manual. The pump internal bolting (wetted) of 12 mm diameter or smaller shall be made of 316L stainless steel provided it is compatible with pumped liquid.
6.1.29.1 The details of threading shall conform to ISO 261, ISO 262, ISO 724 and ISO 965 (all parts), or to ANSI/ASME B1.1. The vendor shall advise the type of bolting used on the pump.	This paragraph is applicable. <u>Replace first sentence with:</u> The details of threading shall conform to ISO 261, ISO 262, ISO 724, ISO 965 (all parts), ANSI/ASME B1.1 or other internationally standardized threading.
6.2 Pump types The pump types listed in Table 3 have special design features and shall be furnished only if specified by the Purchaser and if the Manufacturer has proven experience for the specific application; Table 2 lists the features requiring special consideration for these pump types, and gives in parentheses the relevant subclause(s) of this international Standard.	OH1 type pump are allowed for service temperatures below 120 °C. Except OH1 type pumps, pump types listed in Table 3 are not acceptable and shall not be proposed. In addition: For offshore fixed structures For pump applications in fixed structures where the total riser column length does not exceed 15 m, long-shaft, vertical pumps and pumps driven by a submerged electrical or hydraulic motor shall be accepted.

API	Requirements																
Table 3 — Special design features of particular pump types <table border="1"> <thead> <tr> <th>Pump type</th><th>Features requiring special consideration</th></tr> </thead> <tbody> <tr> <td>Horizontal foot-mounted overhung, OH1</td><td>a) Pressure rating (6.3.5) b) Casing support (6.3.11)</td></tr> <tr> <td>Rigidly coupled vertical in-line, OH4</td><td>a) Motor construction (7.1.7, 7.1.8) b) Rotor stiffness (6.9.1.3) c) Product-lubricated guide bearing (6.10.1.1) d) Shaft runout at seal (6.6.9, 6.8.5)</td></tr> <tr> <td>Close-coupled (impeller mounted on motor shaft), OH5</td><td>a) Motor construction (7.1.7, 7.1.8) b) Motor bearing and winding temperature at high pumping temperatures c) Seal removal (6.8.2)</td></tr> <tr> <td>Two-stage overhung</td><td>a) Rotor stiffness (6.9.1.3)</td></tr> <tr> <td>Double-suction overhung</td><td>a) Rotor stiffness (6.9.1.3)</td></tr> <tr> <td>Ring-section casing (multistage), BB4</td><td>a) Pressure containment (6.3.3, 6.3.10) b) Dismantling (6.1.25)</td></tr> <tr> <td>Built-in mechanical seal (no separable seal gland)</td><td>a) Seal removal (6.8.2)</td></tr> </tbody> </table>	Pump type	Features requiring special consideration	Horizontal foot-mounted overhung, OH1	a) Pressure rating (6.3.5) b) Casing support (6.3.11)	Rigidly coupled vertical in-line, OH4	a) Motor construction (7.1.7, 7.1.8) b) Rotor stiffness (6.9.1.3) c) Product-lubricated guide bearing (6.10.1.1) d) Shaft runout at seal (6.6.9, 6.8.5)	Close-coupled (impeller mounted on motor shaft), OH5	a) Motor construction (7.1.7, 7.1.8) b) Motor bearing and winding temperature at high pumping temperatures c) Seal removal (6.8.2)	Two-stage overhung	a) Rotor stiffness (6.9.1.3)	Double-suction overhung	a) Rotor stiffness (6.9.1.3)	Ring-section casing (multistage), BB4	a) Pressure containment (6.3.3, 6.3.10) b) Dismantling (6.1.25)	Built-in mechanical seal (no separable seal gland)	a) Seal removal (6.8.2)	For applications where the total riser column length exceeds 15 m, long-shaft vertical pumps are not allowed, and only pumps driven by a submerged electrical or hydraulic motor are acceptable. For FPSOs and other floating installations Only submerged electrical or hydraulic motor driven pumps shall be accepted. Long-shaft vertical pumps are not allowed, independent of the riser column length.
Pump type	Features requiring special consideration																
Horizontal foot-mounted overhung, OH1	a) Pressure rating (6.3.5) b) Casing support (6.3.11)																
Rigidly coupled vertical in-line, OH4	a) Motor construction (7.1.7, 7.1.8) b) Rotor stiffness (6.9.1.3) c) Product-lubricated guide bearing (6.10.1.1) d) Shaft runout at seal (6.6.9, 6.8.5)																
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Built-in mechanical seal (no separable seal gland)	a) Seal removal (6.8.2)																
6.3 Pressure casings 6.3.1 The maximum discharge pressure shall be the maximum suction pressure plus the maximum differential pressure that the pump is able to develop when operating with the furnished impeller at the rated speed and specified normal relative density (specific gravity). NOTE: The basis of determining maximum discharge pressure is an application issue. • 6.3.2 Maximum discharge pressure shall be stated on the data sheet. If specified, the maximum discharge pressure shall be increased by the additional differential pressure developed during one or more of the following operating circumstances:	The maximum discharge pressure is the maximum suction pressure plus the maximum differential pressure that the pump is capable of developing at shut-off when operating with the maximum specified relative density (specific gravity) with: - The maximum impeller diameter at the rated speed for constant speed applications and the maximum number of stages that the pump can accommodate. - The rated impeller diameter at the maximum speed trip speed for variable speed applications. Refer to paragraph 6.3.1.																

API	Requirements
a) Maximum specified relative density at any specified operating condition. b) Installation of an impeller of the maximum diameter and/or number of stages that the pump can accommodate. c) Operation to trip speed. The Purchaser should assess the likelihood of the occurrence of a), b) and/or c) before specifying any of them. NOTE: Rare occurrences can be taken as excursions into the hydrotest margin. The additional differential pressure developed at trip speed is normally a momentary excursion that is absorbed by the hydrotest margin.	
• 6.3.6 Unless otherwise specified, vertically suspended, double-casing, integral gear-driven (type OH6) and horizontal, multistage pumps (pumps with three or more stages) may be designed for dual pressure ratings. If specified, suction regions shall be designed for the same MAWP as the discharge section. The Purchaser should consider installation of relief valves on the suction side of such installations.	All parts referred to in the definition of pressure casing shall have the same MAWP.
6.3.9 Unless otherwise specified, pumps with radially split casings are required in services for any of the following operating conditions: a) Pumping temperature of 200°C (400°F) or higher (a lower temperature limit should be considered if thermal shock is probable). b) Liquids with a relative density of less than 0,7 at the specified pumping temperature. c) Liquids at a rated discharge gauge pressure above 10 MPa (100 bar; 1.450 psi). Axially split casings have been used successfully beyond the limits given above, generally for off-plot applications at higher pressure or lower relative density (specific gravity). The success of such applications depends on the margin between design pressure and rated pressure, the manufacturer's experience with similar	In addition, axially split design is not allowed for any of the following operating conditions: • Pumping temperature above 150°C • Relative density below 0.8. • Discharge pressure above 100 bar in hazardous service, and 140 bar in non-hazardous service.

API	Requirements
applications, the design and manufacture of the split joint, and the user's ability to correctly remake the split joint in the field. The purchaser should take these factors into account before specifying an axially split casing for conditions beyond the above limits.	
6.3.10 Radially split casings shall have metal-to-metal fits, with confined controlled-compression gaskets, such as an O-ring or a spiral-wound type. Gaskets other than spiral-wound may be proposed and furnished if proven suitable for service and approved by the purchaser. Radially split pressure casing joints and bolting shall be designed to seat a spiral-wound gasket (see 9.3.2.3 for VS type pumps). NOTE: Table H.1 shows only spiral-wound gaskets for casing joints. Spiral-wound gaskets are generally preferred because they are perceived by users to have had better availability, are more conducive to material identification, have a broader chemical compatibility and temperature range, contact a wider sealing surface (are less susceptible to leakage because of sealing surface irregularities) and are easier to handle and store than O-rings. ISO 21049 and ANSI/API STD 682 / ISO 21049, specifically require O-ring gaskets on low-temperature [175°C (350°F)] pressure-seal gland plates.	This paragraph is applicable. <u>Replace third sentence of note with:</u> ANSI/API STD 682 specifically requires O-ring gaskets on low temperature [$< 175^{\circ}\text{C}$ (350°F)] pressure-seal gland plates.
6.4 Nozzles and pressure casing connections	
6.4.1 Casing Opening sizes	
6.4.1.2 Casing connections other than suction and discharge nozzles shall be at least DN 15 (NPS 1/2) for pumps with discharge nozzle openings DN 50 (NPS 2) and smaller. Connections shall be at least DN 20 (NPS 3/4) for pumps with discharge nozzle openings DN 80 (NPS 3) and larger, except that connections for seal flush piping and gauges may be DN 15 (NPS 1/2) regardless of pump size.	This paragraph is applicable.
6.4.2 Suction and Discharge Nozzles	Piping classes indicated in the purchase inquiry or purchase order shall apply.

API	Requirements
	When the Vendor cannot meet the required flange standards, fully machined mating flanges with gaskets and bolts shall be supplied.
6.4.2.1 Suction and discharge nozzles shall be flanged, except those on pumps with forged casings, which shall be flanged or machined and studded. One- and two-stage pumps shall have suction and discharge flanges of equal rating. If the pump is supplied with machined and studded connections, the pump vendor shall provide drawings showing the dimensions of break-out spool pieces to allow the pump to be conveniently removed from the piping.	All pumps shall have flanged suction and discharge nozzles of equal ASME/ANSI pressure/temperature ratings. Screw-on flanges shall not be used.
6.4.2.4 Flanges in all materials that are thicker or have a larger outside diameter than required by the relevant ISO or ASME standards in this International Standard are acceptable. Non-standard (oversized) flanges shall be completely dimensioned on the arrangement drawing. If oversized flanges require studs or bolts of non-standard length, this requirement shall be identified on the arrangement drawing.	If non-standard studs or bolts are required they shall be included in the Vendor scope of supply with one additional complete spare set.
6.4.3 Auxiliary connections	
6.4.3.1 All auxiliary connections to the pressure casing, except the seal gland, shall terminate in a flange meeting the requirements of 6.4.2.2 or 6.4.2.3. These connections shall be integrally flanged, socket welded or butt welded as specified by the purchaser. Seal welding of threaded connections is not permitted. Purchaser interface connections shall terminate in a flange.	All auxiliary connections to the pressure casing shall be fitted with flanged stubs that are full penetration welded to the casing. Socket welded connections shall not be used when: a) The pump nozzles are Class 900 or above, or; b) The minimum pumping temperature is 0 °C (32 °F) or below, or; c) The pump is for hazardous service, or; d) NACE MR 0175 or NACE MR 0103 is applicable. Valves shall not be welded to the casings.
6.4.3.2 If specified, for pumps in pipeline service with a maximum operating	Threaded connections to the pressure casing shall not be used, except on seal glands.

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temperature of 55 °C (130 °F) or less, auxiliary connections may be threaded.	
• 6.4.3.3 If specified, special threaded fittings for transitioning from the casing to tubing for seal flush piping may be used provided that a secondary sealing feature, such as O-rings, are used and that the joint does not depend on the thread contact alone to seal the fluid. The connection boss shall have a machined face suitable for sealing contact.	Refer to GS EP MEC 270 .
• 6.4.3.8 If specified, cylindrical threads in accordance with ISO 228-1 shall be used. If cylindrical threads are used, they shall be sealed with a contained face gasket, and the connection boss shall have a machined face suitable for gasket containment (see Figure 19).  Figure 19 — Machined face suitable for gasket containment if using cylindrical threads	Cylindrical threads shall not be used.
• 6.4.3.10 If specified, piping shall be gusseted in two orthogonal planes to increase the rigidity of the piped connection, in accordance with the following stipulations. a) Gussets shall be of a material compatible with the pressure casing and the piping and shall be made of either flat bar with a minimum cross section of 25 mm by 3 mm (1 in by 0,12 in) or round bar with a minimum diameter of 9 mm (0,38 in). b) Gusset design shall be as shown in Figure 20.  Figure 20 — Typical gusset design	Piping less than DN 50 (2 inch) shall be gusseted in two orthogonal planes to increase the rigidity of the piped connection in accordance with the stipulations. Gussets shall be welded. Options e) and f) from the list are not allowed.

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c) Gussets shall be located at or near the connection end of the piping and fitted to the closest convenient location on the casing to provide maximum rigidity. The long width of gussets made with bar shall be perpendicular to the pipe and shall be located to avoid interference with the flange bolting or any maintenance areas on the pump. d) Gusset welding shall meet the fabrication requirements (see 6.12.3), including PWHT when required, and the inspection requirements (see 8.2.2) of this International Standard. e) Gussets may also be bolted to the casing if drilling and tapping is done prior to hydrotest. f) Proposals to use clamped or bolted gusset designs shall be submitted to the purchaser for approval.	
6.4.3.11 Threaded openings not connected to piping are allowed only in seal glands and in pumps furnished of material classes I-1 and I-2 (see Annex H). If supplied, they shall be plugged. Taper-threaded plugs shall be long-shank solid round-head, or long-shank hexagon-head, bar stock plugs in accordance with ANSI/ASME B16.11. If cylindrical threads are specified in 6.4.3.7, plugs shall be solid hexagon-head plugs in accordance with DIN 910. These plugs shall meet the material requirements of the casing. A lubricant/sealant that is suitable for high temperature duty shall be used to ensure that the threads are vapour-tight. Plastic plugs are not permitted.	Plugs that may require subsequent removal or plugs in cast iron casing shall be 316 stainless steel. PTFE tape is not acceptable.
6.4.3.12 If specified, auxiliary connections to the pressure casing shall be machined and studded. These connections shall conform to the facing and drilling requirements of ISO 7005-1 or ISO 7005-2. Studs and nuts shall be furnished installed. The first 1,5 threads at both ends of each stud shall be removed.	Auxiliary connections shall conform to 6.4.3.1.

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NOTE: For the purpose of this provision, ANSI/ASME B16.1 and ANSI/ASME B16.5 are equivalent to ISO 7005-2 and ISO 7005-1, respectively.	
6.4.3.14 All pumps shall be provided with vent and drain connections, except that vent connections may be omitted if the pump is made self-venting by the arrangement of the nozzles. Pumps that are not self-venting shall be provided with vent connections in the pressure casing, as required (see 6.8.10). If the pump cannot be completely drained for geometrical reasons, this shall be stated in the proposal. The operating manual shall include a drawing indicating the quantity and location(s) of the liquid remaining in the pump. As a guide, a pump is considered functionally self-venting if the nozzle arrangement and the casing configuration permit sufficient venting of gases from the first-stage impeller and volute area to prevent loss of prime during the starting sequence.	All pumps will be fitted with drain connections that will completely drain the pump. If this requirement cannot be met, the Vendor shall indicate, in the proposal, the amount of fluid that will remain and where it will remain. This information shall be clearly stated on the outline drawing and in the manual. Pump casing vent and drain connections shall be braced and shall be provided with flanged valves as close as possible to the pump casing while remaining easily accessible.
6.5 External nozzle forces and moments	
• 6.5.5 Annex F gives methods of qualifying nozzle loads in excess of those in Table 5. The purchaser should be aware that the use of the methods in Annex F can result in a misalignment up to 50% greater than that based on the loads given in Table 5 and can impact equipment installation criteria. The use of the methods in Annex F requires approval by the purchaser and specific direction to the piping designers for its use.	Annex F shall not be used without Company written approval.
6.6 Rotors	
6.6.9 Shafts shall be machined and finished throughout their length so that the TIR is no more than 25 µm (0.001 in).	Plating of the shaft is not permitted on bearing surface areas, except for hydrodynamic bearings when used as a Manufacturers standard. Machining errors shall not be corrected by plating.
6.6.15 (New paragraph)	<u>Add new subclause:</u> Repairs to correct machining errors shall be subject to approval by the purchaser. Metal plating shall not be used for impeller repairs.

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6.7 Wear rings and running clearances	
6.7.1 Radial running clearances shall be used to limit internal leakage and, where necessary, balance axial thrust. Impeller pumping vanes or close axial clearances shall not be used to balance axial thrust. Renewable wear rings shall be provided in the pump casing. Impellers shall have either integral wear surfaces or renewable wear rings.	Integral impeller wear rings shall be provided if any of the following conditions apply: - The peripheral velocity of the impeller wear surface exceeds 50 m/s, - The head per stage exceeds 200 m, - Operating temperature or severe transients that could result in loosening of the wear ring fit, - Erosive service.
6.7.3 Renewable wear rings, if used, shall be held in place by a press fit with locking pins, screws (axial or radial) or by tack welding. The diameter of a hole in a wear ring for a radial pin or threaded dowel shall not be more than one-third the width of the wear ring.	<u>Replace subclause with:</u> Renewable wear rings, if used, shall be held in place by a press fit with three axial screws or by tack welding in at least three places.
6.7.4 Running clearances shall meet the requirements of 6.7.4 a) to 6.7.4 c). - When establishing internal running clearances between wear rings and other moving parts, consideration shall be given to pumping temperatures, suction conditions, the liquid properties, the thermal expansion and galling characteristics of the materials, and pump efficiency. Clearances shall be sufficient to assure dependability of operation and freedom from seizure under all specified operating conditions. - For cast iron, bronze, hardened martensitic stainless steel and materials with similarly low galling tendencies, the minimum clearances given in Table 6 shall be used. For materials with higher galling tendencies and for all materials operating at temperatures above 260 °C (500 °F), 125 µm (0,005 in) shall be added to these diametral clearances. - For non-metallic wear-ring materials with very low or no galling tendencies (see Table H.3), clearances less than those given in Table 6 may be proposed by the	Wear parts shall be composite materials type (PEEK, or similar graphite charged with proven dry run capability) for boiler

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vendor. Factors such as distortion and thermal gradients shall be considered, to ensure clearances are sufficient to provide dependability of operation and freedom from seizure under all specified operating conditions. NOTE: There are published data showing successful applications of non-metallic wear-ring materials with API clearances (see 6.7.4) reduced by 50 %. Reasonable reductions in clearances are believed to be dependent on the materials applied and other service conditions, such as cleanliness and temperature.	feed water and for clean light hydrocarbon where the specific gravity is less than 0.7.
6.8 Mechanical shaft seals	
• 6.8.1 Pumps shall be equipped with mechanical seals and sealing systems in accordance with ISO 21049. Pump and seal interface dimensions shall be in accordance with table 7 and figure 26 of this International Standard. The purchaser shall specify the category of seal required. The Purchaser should use the data sheets in ISO 21049 for this purpose. NOTE: For the purpose of this provision, ANSI/API STD 682/ISO 21049 is equivalent to ISO 21049.	Pumps shall be equipped with mechanical seals and sealing systems in accordance with GS EP MEC 270.
6.8.2 The seal cartridge shall be removable without disturbing the driver.	<u>Replace subclause with:</u> The seal cartridge shall be removable without disturbing the driver, except for vertical pumps types OH5 and OH6.
6.8.8 Seal glands and seal chambers shall have provision for only those connections required by the seal flush plan. If additional tapped connection points are specified and are not used, they shall be plugged in accordance with 6.4.3.11.	A connection point for seal chamber pressure measurement shall be provided. For between bearing pumps, complete individual seal system shall be provided for each mechanical seal.
• 6.8.9 Seal chambers shall be designed with space available to provide for an additional flush port to approximately the centre of the chamber and extending vertically upward. If specified, this port shall be drilled and machined for a piping connection. Tapered pipe thread connections are not allowed.	For Arrangement 3 configurations a flush connection shall always be supplied. If flush connection is located on the pump casing, the flush port shall be flanged, welded on pump casing (according to the piping classes applied for the pump) and fitted with a blind flange if not used.

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	If flushing connection is located on the seal cartridge, the flush port shall be drilled and threaded and fitted with a NPT plug which is screwed and sealed into the cartridge.
6.8.11 If specified, jackets shall be provided on seal chambers for heating. Heating requirements shall be agreed upon by the Purchaser, the Vendor, and seal Manufacturer for high melting point products.	The Supplier shall determine the necessity for seal chamber heating or cooling based on the pump service details as defined in the data sheet and in the project specification.
6.8.13 The vendor and purchaser shall agree on the maximum static and dynamic sealing pressures that can be anticipated to occur in the seal chamber and the vendor shall state these values on the data sheet [see 3.23 and 3.25].	This paragraph is applicable.
6.8.14 (New paragraph)	The Vendor shall ensure that the lubricant used to reassemble and/or protect the mechanical seal after testing and before shipping is compatible with the pumped product.
6.9 Dynamics	
6.9.1 General	
6.9.2 Torsional analysis	The Vendor shall be responsible to obtain all necessary information from the Suppliers of the other train components to perform this analysis. In the event that these Suppliers are not the Vendor's own Sub-Contractors, an agreement shall be reached during the Contract negotiations.
6.9.2.1 There are three general types of torsional analyses that are normally performed on pumps: a) Undamped natural frequency analysis: determination of the unit's torsional natural frequencies and associated mode shapes and generation of a Campbell diagram to determine potential resonance points. b) Steady-state damped response analysis: evaluation of the resonance points uncovered in the undamped analysis via a forced response analysis that utilizes representative values for excitation	When a transient analysis is required according to figure 29, the following applies: Transient conditions include short circuit between two phases, start-up and re-acceleration. A stress analysis shall be performed for the transient conditions to ensure that shaft-end, coupling and drive-component ratings are not exceeded.

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magnitudes and damping; the results are cyclic torques and stresses in all shaft elements in the model, which can then be used to evaluate the structural adequacy of the machine. c) Transient torsional analysis: similar to a steady-state damped response analysis, except that it is done for the transient condition and its results are cyclic torques and stresses as functions of time; by far, the most common application for this analysis type is the start-up of a synchronous motor. A flow chart for the torsional analysis is shown in Figure 29.	
6.9.2.2 Unless otherwise specified, an undamped natural frequency analysis shall be performed by the manufacturer having unit responsibility if any of the following describe the machinery train: a) Trains comprised of three or more coupled machines rated 1,500 kW (2,000 hp) or higher, b) Induction motor, or turbine, through gear rated 1,500 kW (2,000 hp) or higher, c) Internal combustion engine rated 250 kW (335 hp) or higher, d) Synchronous motor rated 500 kW (670 hp) or higher, e) Electric motor with variable-frequency adjustable-speed drive (ASD) rated 1,000 kW (1,350 hp) or higher, f) Vertical pump with a driver rated 750 kW (1,000 hp) or larger. Experience of some manufacturers is that vertical pumps, particularly those with long shafts, have relatively large inertias in the driver and pump stages and are susceptible to very small torsional excitations. The analysis shall be for the train as a whole unless the train includes a device that has weak dynamic coupling, for example a hydraulic coupling or torque converter. In all	The Vendor shall perform a torsional analysis of the entire shaft line in one of the following cases: • The rated power of the driver is greater than or equal to 1,000 kW, • The shaft line has more than two machines, • There is a variable speed prime mover.

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cases, the vendor having unit responsibility shall be responsible for directing any modifications necessary to meet the requirements of 6.9.2.3 through 6.9.2.9.	
• 6.9.2.3 If specified, for variable-frequency ASD's, a steady-state, damped-response analysis shall be performed. The analysis shall consider all resonant frequencies through 12 times line frequency. Most modern variable-frequency ASD's, when performing properly, produce insignificant torsional vibration and shaft stress. Variable-frequency ASD malfunctions can produce significant excitation. Certain designs still exist that produce significant torsional pulsations.	A steady-state damped-response analysis shall always be part of the torsional analysis.
• 6.9.2.4 If specified, or if the driver is a synchronous motor rated 500 kW (670 hp) or higher, a transient torsional analysis shall be performed. If performed, the time-transient analysis shall meet the requirements of 6.9.2.11 through 6.9.2.14. NOTE: Some purchasers choose to perform transient analysis if generator phase-to-phase or phase-to-ground faults are considered a significant risk or if rapid bus switching occurs on loss of power.	Transient analysis shall be performed when required by Figure 29.
• 6.9.2.10 If specified, or if either a steady-state, damped-response analysis or a transient torsional analysis is performed, the Manufacturer shall furnish a detailed report of the torsional analysis. The report shall include the following: a) Description of the method(s) used to calculate the natural frequencies, b) Diagram of the mass elastic system, c) Table of the mass moment and torsional stiffness of each element of the mass elastic system, d) Campbell diagram, e) Mode-shape diagram with peak stresses shown for each resonant frequency, if a stress analysis is performed.	This paragraph is applicable. The delivery of this torsional analysis report is mandatory.

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6.9.3 Vibration	
6.9.3.3 The FFT spectra shall include the range of frequencies from 5 Hz to 2Z times running speed (where Z is the number of impeller vanes; in multistage pumps with different impellers, Z is the highest number of impeller vanes in any stage). If specified the plotted spectra shall be included with the pump test results. NOTE: The discrete frequencies 1,0,2,0 and Z times running speed are associated with various pump phenomena, and are therefore of particular interest in the spectra.	This paragraph is applicable. The FFT spectra shall be plotted and included in the pump test result.
6.9.4 Balancing	
6.9.4.4 If specified, impellers, balancing drums and similar rotating components shall be dynamically balanced to ISO 1940-1 grade G1 (equivalent to 4 W/n, in USC terminology). In USC units, where the symbol W is used for mass, unbalance is expressed in Equation (2): $U = KW I n \quad (2)$ Where: U is the unbalance per plane, expressed in ounce-inches K is a constant W is the component mass (for components), expressed in pounds; or the load per balancing machine journal (for rotors), expressed in pounds n is the rotational speed of the pump, expressed in revolutions per minute. KW/n is a balance tolerance denominated solely in USC units. In International Standards, unbalance is expressed as a balance quality grade of ISO 1940-1. Each of the ISO balance quality grades covers a range of unbalance. The nominal equivalent USC unit limits given throughout this International Standard correspond approximately to the midpoint of the ISO range. With modern balancing machines, it is feasible to balance components mounted on their	This paragraph is applicable.