

GENERAL SPECIFICATION

ROTATING MACHINERY

GS EP MEC 271

Centrifugal Pumps for the Petroleum, Chemical and Gas Industry Services according to API Standard 610

05	10/2012	Update
04	01/2012	Revision and Update to cope with 11 th edition
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02	10/2009	Update
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Rev.	Date	Purpose of the revision

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1. Scope

This specification clarifies how to use the recommendations of [API Std 610](#) for the supply to Company of Centrifugal Pumps.

The purpose of this specification is to clarify the requirements of [API Std 610](#) standard eleventh edition, September 2010.

Technical proposal shall be supported by the data sheets part of the Appendix 1 of this specification.

This document modifies or complements some requirements of [API Std 610](#) standard, 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 may be presented with new paragraph numbers. The summary sheet at front indicates where to find the information for each paragraph of [API Std 610](#) shown with a bullet.

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

Reference	Title
94/9/EC (ATEX 100a¹/ATEX 95²)	European Directive 94/9/EC (23/03/94) on the approximation of the laws of the Member State concerning equipment and protective systems intended for use in potentially explosive atmosphere
API Std 610	Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industries
API Std 613	Special Purpose Gear Units for Petroleum, Chemical and Gas Industry Services
API Std 614	Lubrication Shaft-sealing and Oil-control Systems and Auxiliaries
API Std 671	Special Purpose Couplings for Petroleum, Chemical and Gas Industry Services
API Std 682	Pumps - Shaft Sealing Systems for Centrifugal and Rotary Pumps
EN 10204	Metallic product - Types of inspection documents

¹ Reference to Articles 100/118 of the Treaty of Rome

² Reference to Articles 95/137 of the Treaty of Amsterdam

Reference	Title
IECEX 01/02/03	International Electrotechnical Commission System for Certification to Standards relating to Equipment for use in Explosive Atmospheres
ISO 21940-32	Mechanical vibration - Rotor balancing - Part 32: Shaft and fitment key convention
ISO 10474	Steel and steel products. Inspection documents
ISO 21049	Pumps - Shaft sealing systems for centrifugal and rotary pumps
ISO 281	Rolling bearings - Dynamic load ratings and rating life
ISO 3744	Determination of sound power levels of noise sources using sound pressure

Total General Specifications

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published in the applicable yearly collection.

Reference	Title
GS EP MEC 242	Special Purpose Gear Units for Petroleum, Chemical and Gas Service Industries According to API Standard 613

3. Comments to API Std 610

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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	
(Clarification) All equipment installed in a hazardous area shall be ATEX certified according to directive 94/9/EC . For packages installed outside the European Union, as an alternative to ATEX certification, IECEx scheme (IECEx 01/02/03) 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.
6.1.3 The equipment shall be capable of operation at the normal and rated operating points and any other anticipated operating conditions specified by the Purchaser.	(Clarification) When the specific gravity of the fluid being pumped is less than 1, at the pumping temperature, the Vendor shall ensure that the pump and its accessories shall be able to operate without deterioration during the performance test with water. Performance tests at reduced speeds shall require Company approval prior to any purchase order.
6.1.4 Pumps shall be capable of at least a 5% head	(Clarification) The proposed rated impeller diameter for

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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.	pumps with constant speed drivers shall be not be greater than 95% or less than 80% of the maximum impeller diameter that can be installed in the pump casing. 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 (per API Std 610 clause 5.1.6 Note) and to correct any head shortfall during testing, including the -2% tolerance per table 14. For overhung impellers the tip speed of the selected impeller, at the rated operating point, shall not exceed 62 m/s.
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	(Clarification) The NPSHR specified on the data sheets and the performance curve shall correspond to the rated impeller diameter. The difference between the required NPSH (NPSHR) and the available NPSH (NPSHA) at the rated point shall be greater than 20% of the available NPSH (NPSHA). The difference between the NPSHA and NPSHR shall not be less than 0.5 m throughout the allowable operating region of flow. If the difference between the NPSHA and NPSHR is less than 1 meter at the rated point, or if an inducer is proposed, the Vendor shall provide in the proposal the test NPSH curve. The NPSH requirements for variable speed pumps shall apply for all speeds required to meet the specified operating conditions.

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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 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><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 HMT < 500 m</th><th>Pump with shaft through the eye and HMT > 500 m</th></tr><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></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><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><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></table>	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 HMT < 500 m	Pump with shaft through the eye and 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
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	5. The design of the inducer shall be such that it does not create pulsations at part load operation. 6. For any proposal with higher Nss, Vendor shall clearly document the reason for such a choice.
6.1.10 Pumps that handle liquids more viscous than water shall have their water performance corrected in accordance with ISO/TR 17766. Corrections factors used for viscous liquid shall be submitted with both sales proposal curves and final test curves.	(Clarification) 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 with a stable head/capacity curve (continuous head rise to shut-off) are required for all the applications. Pumps that are specified to operate in parallel shall have: a) The same shut off head, which shall be confirmed at the performance test. For each of the test points, of such pumps, 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. This does not allow the second pump to be outside the contractual performance limits. b) The head at 50% of rated operating point flow shall be at least 110% of the head at the rated operating point. c) Discharge orifice are not allowed. Suction side restriction ring, commonly known as a "Bull Ring" are not allowed.
6.1.13 The best efficiency point flowrate for the pump as furnished should preferably be between the rated point and the normal point.	The normal operating point for the pump shall be between 0 and 10% to the left of the best efficiency point.

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● 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.	(Substitution) For the pump skid, or any individual component, operating at full load, in a free field over a reflecting plane, the sound pressure level measured at any point on a surface 1 meter from the surface of the reference box shall not exceed 85 dBA. No positive tolerance will be allowed. If a noise test is specified, ISO 3744 will be used as a basis for sound pressure measurement. A parallelepiped measurement surface (ISO 3744 paragraph 7.3) shall be used for pump skids. The dimensions l_1, and l_2 shall be the length and width of the pump skid and l_3 shall be the height from the underside of the skid to the top of the highest element of the pump train excluding cabling, piping and auxiliaries such as the barrier/buffer fluid reservoir. Background (K_1) and environmental corrections (K_2) may be applied. Sound pressure measurements will be taken at each of the microphone positions indicated in ISO 3744 Annex C as a minimum. The sound pressure measurement at each point will include twenty four 1/3rd octave band measurements (50 to 10,000 Hz) for calculation of the A weighted sound pressure level at that point and the detection of any narrow band noise. Pumps and auxiliary components emitting narrow band noise are to be identified in the proposal and options to eliminate this noise will be presented. Initial detection of narrow band noise will be a subjective determination by the witness during test. If such a subjective detection is made, for the purpose of this specification, narrow band noise shall be considered present if any of the 1/3rd octave band sound pressure levels (dB) exceeds that of both of the 1/3rd octave bands on each side of by 5 dB. Equipment found to emit narrow band noise during the test will not be accepted. The sound power will be calculated per

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	paragraph 8.6 for information and compared to that predicted. As far as possible, standard motors with low noise levels shall be used.								
● 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								
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$260^{\circ}\text{C} \leq T_m$	Water								
6.1.21 The arrangement of the equipment, including piping and auxiliaries, shall be developed jointly by the Purchaser and the Vendor. The arrangement shall provide adequate clearance areas and safe access for operation and maintenance.	(Clarification) The arrangement of the equipment, including piping and auxiliaries shall be submitted to Company for review and/or approval.								
● 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.								
6.1.24 All equipment shall be designed to permit rapid and economical maintenance. 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.	(Clarification) Any non-rotating maintenance part weighing more than 25 kg shall be fitted with permanent lifting lugs or equipped for removable lifting eyes.								

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6.1.29 Bolting and Threads																	
● 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.	Refer to Project Specification.																
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. Table 2 — 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>Close-coupled (impeller mounted on motor shaft), OH5</td><td>a) Motor construction (6.1) b) Motor bearing and winding temperature at high pumping temperatures c) Seal removal (5.8.2)</td></tr> <tr> <td>Rigidly coupled vertical in-line, OH4</td><td>a) Motor construction (6.1) b) Rotor stiffness (5.6.9) c) Product-lubricated guide bearing (5.10.1.1) d) Shaft runout at seal (5.6.8, 5.8.5)</td></tr> <tr> <td>Horizontal foot-mounted overhung, OH1</td><td>a) Pressure rating (5.3.5) b) Casing support (5.3.11)</td></tr> <tr> <td>Two-stage overhung</td><td>a) Rotor stiffness (5.6.9)</td></tr> <tr> <td>Double-suction overhung</td><td>a) Rotor stiffness (5.6.9)</td></tr> <tr> <td>Ring-section casing (multistage), BB4</td><td>a) Pressure containment (5.3.3, 5.3.10) b) Dismantling (5.1.27)</td></tr> <tr> <td>Built-in mechanical seal (no separable seal gland)</td><td>a) Seal removal (5.8.2)</td></tr> </tbody> </table>	Pump type	Features requiring special consideration	Close-coupled (impeller mounted on motor shaft), OH5	a) Motor construction (6.1) b) Motor bearing and winding temperature at high pumping temperatures c) Seal removal (5.8.2)	Rigidly coupled vertical in-line, OH4	a) Motor construction (6.1) b) Rotor stiffness (5.6.9) c) Product-lubricated guide bearing (5.10.1.1) d) Shaft runout at seal (5.6.8, 5.8.5)	Horizontal foot-mounted overhung, OH1	a) Pressure rating (5.3.5) b) Casing support (5.3.11)	Two-stage overhung	a) Rotor stiffness (5.6.9)	Double-suction overhung	a) Rotor stiffness (5.6.9)	Ring-section casing (multistage), BB4	a) Pressure containment (5.3.3, 5.3.10) b) Dismantling (5.1.27)	Built-in mechanical seal (no separable seal gland)	a) Seal removal (5.8.2)	(Clarification) The pump types listed in Table 3 are not acceptable and shall not be proposed. (Addition) For fixed structures For pump applications in fixed structures where the total riser column length does not exceed 20 m, long-shaft, vertical pumps and pumps driven by a submerged electrical or hydraulic motor shall be accepted. For applications where the total riser column length exceeds 20 m, long-shaft vertical pumps are not allowed, and only pumps driven by a submerged electrical or hydraulic motor shall be 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. In pump applications where submergence is limited (vessel draft, etc.), end-suction pumps are preferred. It is recommended, that seawater pumps installed in caissons are externally coated (pump head and discharge piping), and supplied with an external anode mass suitable for the protection of the caisson internals from corrosion.
Pump type	Features requiring special consideration																
Close-coupled (impeller mounted on motor shaft), OH5	a) Motor construction (6.1) b) Motor bearing and winding temperature at high pumping temperatures c) Seal removal (5.8.2)																
Rigidly coupled vertical in-line, OH4	a) Motor construction (6.1) b) Rotor stiffness (5.6.9) c) Product-lubricated guide bearing (5.10.1.1) d) Shaft runout at seal (5.6.8, 5.8.5)																
Horizontal foot-mounted overhung, OH1	a) Pressure rating (5.3.5) b) Casing support (5.3.11)																
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Built-in mechanical seal (no separable seal gland)	a) Seal removal (5.8.2)																
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	(Addition) ...When operating with the furnished maximum impeller diameter at the rated speed and specified normal relative density (specific gravity).																

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specified normal relative density (specific gravity).	
● 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: 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.	The maximum discharge pressure shall be increased by the additional differential pressure developed during all a) to c) operating circumstances.
● 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.	For pumps to be operated in parallel, the suction regions shall be designed for the same MAWP as the discharge section. This is applicable for all pumps.
● 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	For casing joints, the use of gaskets other than spiral-wound type shall be submitted for Company approval.

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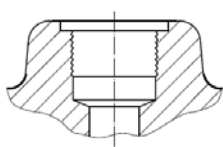
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had better availability, are more conducive to material identification, have a broader chemical compatibility and temperature range, contact a wider sealing surface (are less susceptible to leakage because of sealing surface irregularities) and are 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.	
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.	Refer to Project Specification.
6.4.2 Suction and Discharge Nozzles	
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.	(Clarification) For high-energy pumps as per API definition, flanges with machined and studded connections, are not allowed.
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.	(Clarification) If non-standard studs or bolts are required they shall be included in the Vendor scope of supply.
6.4.3 Auxiliary connections	
• 6.4.3.1 All auxiliary connections to the pressure casing, except the seal gland, shall	Refer to Project Specification.

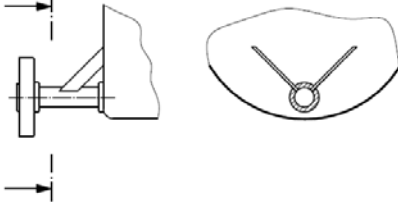
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terminate in a flange meeting the requirements of 6.4.2.2 or 6.4.2.3. These connections shall be integrally flanged, socket welded or butt welded as specified by the purchaser. Seal welding of threaded connections is not permitted. Purchaser interface connections shall terminate in a flange.	
● 6.4.3.2 If specified, for pumps in pipeline service with a maximum operating temperature of 55 °C (130 °F) or less, auxiliary connections may be threaded.	Type of auxiliary connections shall be submitted for Company approval.
● 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.	Type of auxiliary connections shall be submitted for Company approval.
● 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.	Use of clamped or bolted gusset designs shall be submitted for Company approval.

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 Figure 20 — Typical gusset design 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.	
● 6.4.3.12 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 be as per 6.4.3.1.
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	(Clarification) 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. Drain and vents shall be equipped with a gate

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drawing indicating the quantity and location(s) of the liquid remaining in the pump.	valve 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).	(Clarification) 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.
6.7 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.	(Clarification) Integral impeller wear rings shall not be used without Company approval. Axially split multistage pumps, fitted with dynamically balanced rotors per clause 8.2.4.2.1, shall be equipped with two-piece casing wear rings, bearings and thrust bearings.
6.7.2 Mating wear surfaces of hardenable materials shall have a difference in Brinell hardness number of at least 50 unless both the stationary and the rotating wear surfaces have Brinell hardness numbers of at least 400.	(Clarification) The actual hardness of each wear surface shall be marked on the part and visible after assembly.
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	The proposed seal Vendor's comments and exceptions to ISO 21049 shall be submitted to the Purchaser as part of the proposal.

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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.	
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.	(Clarification) Flush piping shall be provided with a ½" NPT plugged tee as a provision for future pressure measurement. This tee shall be between the flow control device or any other device (cooler, cyclone etc.) and the seal gland. If the pump is supplied with a pressure measurement drilling into the seal chamber, the tee is not required. For between bearing pumps the seal flush piping shall be separate for each seal. If this is not possible it shall be stated in the proposal and the piping system shall be designed to avoid preferential flow.
● 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.	Refer to Project Specification.
● 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.	(Substitute) 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].	Refer to Project Specification.
6.8.14	(Addition) The Vendor shall ensure that the lubricant used to reassemble and/or protect the mechanical seal after testing and before

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	shipping is compatible with the pumped product.
6.8.15	(Addition) Mechanical seals shall be designed to withstand the full reverse pressure at standstill (defined by the pump outlet pressure or by the piping rating).
6.8.16	(Addition) In case of API Std 682 - PLAN 53 seal flush Plan, a make up barrier fluid console (one per type of barrier fluid) with a pneumatic pump shall be delivered as part of standard furniture. This barrier fluid refilling unit should preferably be installed on a transportable trolley.
6.9 Dynamics	
6.9.2 Torsional analysis	
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 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	(Clarification) When a torsional analysis is specified or required for any motor driven pump train, transient and steady state conditions shall be evaluated. Transient conditions include short circuit between two phases, start-up and, if specified, 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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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 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.	(Clarification) The Vendor shall perform a torsional analysis of the entire shaft line in one of the following cases: • It is a contractual requirement • 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. 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.
• 6.9.2.3 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	A steady-state damped-response analysis shall always be part of the torsional analysis.

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that produce significant torsional pulsations.	
● 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 always be part of the torsional analysis.
● 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.	The delivery of this torsional analysis report is mandatory.
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.	The FFT spectra shall be plotted and included in the pump test result.
6.9.4 Balancing	
● 5.9.4.4 If specified, impellers, balancing drums and similar rotating components shall be	Unbalance U shall be expressed in g.mm.

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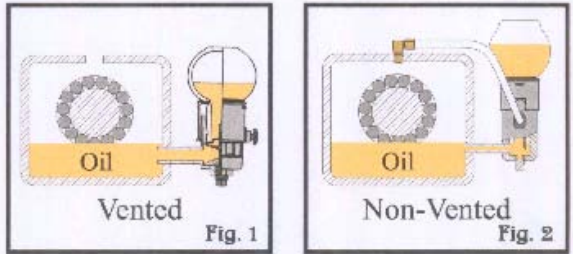
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dynamically balanced to ISO 1940-1 grade G1 (equivalent to 4 W/n, in USC terminology). In USC units, where the symbol W is used for mass, unbalance is expressed in Equation (2): $U = KW / n \quad (2)$ Where: U is the unbalance per plane, expressed 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 arbours to $U=4W/n$ (USC units) (nominally equivalent to ISO grade G1), or even lower depending upon the mass of the assembly, and to verify the unbalance of the assembly with a residual unbalance check. However, the mass eccentricity, e, associated with unbalance less than $U=8W/n$ (USC units) (nominally equivalent to ISO grade G2.5) is so small [e.g. $U=4W/n$ (USC units) gives $e=0,000\ 070$ in for an assembly intended to run at 3600 r/min] that it cannot be maintained if the assembly is dismantled and remade. Balance grades below G2.5 ($8W/n$) (USC units) are, therefore, not repeatable for components.	Final rotor balancing shall be ISO grade G1.

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6.10 Bearings and bearing housings	
6.10.1 Bearings	
● 6.10.1.1 Each shaft shall be supported by two radial bearings and one double-acting axial (thrust) bearing which might or might not be combined with one of the radial bearings. Bearings shall be one of the following arrangements: - Rolling-element radial and thrust - Hydrodynamic radial and rolling-element thrust - Hydrodynamic radial and thrust. Unless otherwise specified, the bearing type and arrangement shall be selected with the limitations in Table 10.	Ball and roller bearings shall have a basic rating L_{10th} per ISO 281 of at least 40,000 hours with continuous operation at rated conditions and at least 25,000 hours at maximum radial and axial loads and rated speed. Bearing life calculations shall be supplied for each pump and shall include axial and radial loads across the operating range at design and two times design internal clearances.
6.10.1.3 Single-row, deep-groove ball bearings shall have a radial internal clearance in accordance with ISO 5753 Group 3 [larger than —NII (Normal) internal clearance]. Single- or double-row bearings shall not have filling slots. Non-metallic cages shall not be used. Greater internal clearances can reduce the temperature rise of the lubricant. However, vibration velocities can be increased with greater clearances. The vendor shall ensure that the values for temperature rise (6.10.2.4) and vibration (6.9.3.6) meet the requirements of this International Standard. NOTE: For the purpose of this provision, ANSI/ABMA 20 Group 3 is equivalent to ISO 5753 Group 3.	(Clarification) Axial and radial fits and clearances, as well as any pre-load, shall be clearly indicated on the section drawing and in the manual.
● 6.10.1.6 Bearing system life (the calculated life of the combined system of bearings in the pump) shall be equivalent to at least 25 000 h with continuous operation at rated conditions, and at least 16 000 h at maximum radial and axial loads and rated speed. The system life shall be calculated as given in Equation (3): $L_{10th,system} = \left[\sqrt[3]{L_{10thA}^{3/2} + L_{10thB}^{3/2} + \dots + \sqrt[3]{L_{10thN}^{3/2}}} \right]^{-2/3} \quad (3)$ where L_{10thA} is the basic rating life, L_{10th}, in accordance with ISO 281 for bearing A; L_{10thB} is the basic rating life, L_{10th}, in accordance with ISO 281 for bearing B; L_{10thN} is the basic rating life, L_{10th}, in accordance with ISO 281 for bearing N; N is the number of bearings.	Bearing system life calculations shall be furnished.

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If specified, the bearing system life calculations shall be furnished. See Clause K.2 for a discussion of bearing system life. NOTE: A bearing system L10h life of 25,000 h and 16,000 h requires that the L10h life of each individual bearing be significantly higher.	
6.10.2 Bearing Housings	
6.10.2.2 Bearing housings for oil-lubricated non-pressure-fed bearings shall be provided with threaded and plugged fill and drain openings of at least DN 15 (NPS 1/2). The housings shall be equipped with constant level sight feed oilers at least 1,2 dl (4 fl oz) in volume, with a positive level positioner (not an external screw), heat resistant glass containers, and protective wire cages. Means shall be provided, such as a bulls-eye or an overfill plug, for detecting overfilling of the housings. A permanent indication of the proper oil level shall be accurately located and clearly marked on the outside of the bearing housing with permanent metal tags, marks inscribed in the castings, or other durable means. The Purchaser shall specify if a particular model of oiler is required.	Constant level oilers shall be of the balanced or non-vented type.  This trap design shall be equipped with a drain valve with a safety lock (locked in the closed position).
6.10.2.10 If specified, bearing housings shall have a threaded connection(s) for permanently mounting vibration transducers in accordance with API STD 670. If metric fasteners are supplied, the threads shall be M8 x 1.25. See figures 31 through 33.	The probe types and methods of fixation shall be approved by Company.
6.10.2.11 If specified, a flat surface at least 25mm (1 in) in diameter shall be supplied for the location of magnetic-based vibration-measuring equipment.	These machined surfaces are required for each machine, including driver and any gear or speed variation unit. For equipment where this is not feasible such as the non-drive end of electric motors another system such as an extension bar shall be fitted to the bearing housing to permit vibration measurement.
6.10.2.12 The purchaser shall specify whether synthetic oil shall be used. If specified, the purchaser shall specify the oil type. The vendor shall ensure that bearing-housing internal paint, if used, is compatible with the specified oil.	"Total" brand mineral lubricants shall be used. The Vendor shall specify the type and quantity required.

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6.11 Lubrication	
• 6.11.3 If specified, provisions shall be made for either pure oil or purge oil-mist lubrication (see 6.10.2.7 for requirement).	Refer to Project Specification to know if oil mist leakage to atmosphere is allowed.
• 6.11.4 If specified, rolling-element bearings shall be grease-lubricated in accordance with the following. a) Grease life (re-lubrication interval) shall be estimated using the method recommended by the bearing Manufacturer or an alternative method approved by the Purchaser. b) Grease lubrication shall not be used if the estimated grease life is less than 2,000 h. c) If the estimated grease life is 2,000 h or greater but less than 25,000 h, provision shall be made for re-greasing the bearings in service and for the effective discharge of old or excess grease, and the Vendor shall advise the Purchaser of the required re-greasing interval. d) If the estimated grease life is 25,000 h or more, grease nipples or any other system for the addition of grease in service shall not be fitted.	Rolling element bearings for pumps shall be oil lubricated. Grease lubricated bearings may be proposed only as an option and only if accompanied by a complete technical and commercial argument.
6.12 Materials	
• 6.12.1.1 The Purchaser shall specify the material class for pump parts. Table G.1 provides a guide showing material classes that may be appropriate for various services. Alternative materials recommended for the service by the Vendor, including material that can improve life and performance in service, may also be included in the proposal and listed on the final data sheets.	Refer to Project Specification.
• 6.12.1.5 The Vendor shall specify the optional tests and inspection procedures that are necessary to ensure that materials are satisfactory for service. The Purchaser shall specify if any additional tests and inspections are required, especially for materials used for components or in services considered critical	Refer to Project specification.

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by the Purchaser. Purchaser-specified test and inspection requirements should be identified in the "remarks" section of the datasheet (Annex N).	
• 6.12.1.8 If specified, the Vendor shall furnish material certificates that include chemical analysis and mechanical properties for the heats from which the material is supplied for pressure-containing castings and forgings, impellers and shaft. Unless otherwise specified, piping nipples, auxiliary piping components, and bolting are excluded from this requirement.	The Vendor shall supply material inspection certificates in accordance with ISO 10474 or EN 10204 standards for pressure casing parts, impellers and shafts. These certificates shall be, as a minimum, "3.1".
• 6.12.1.9 The Purchaser shall specify any erosive or corrosive agents (including trace quantities) present in the process fluids and in the site environment, including constituents that may cause stress-corrosion cracking or attack elastomers.	In the event that the data sheet specifies an erosive fluid the Vendor shall propose an erosion allowance, coating or cladding or other technique to avoid degradation of the mechanical strength or integrity of the rotating parts due to erosion.
• 6.12.1.10 If specified, coatings of a type agreed between the Purchaser and the Vendor shall be applied to impellers and other wetted parts to minimize erosion or to improve efficiency. If coatings are applied to rotating components, the acceptance balance shall be performed after coatings have been applied. The sequence of procedures for balancing and coating of rotating components shall be agreed between the purchaser and the vendor. The "remarks" section of the datasheets (see Annex N) should be used for stating these coating requirements. Rotating parts should be balanced before coating in order to minimize balance corrections to coated areas. By minimizing the area to be recoated, a final check balance after coating repair may not be required.	Coating shall not be used to improve efficiency.
• 6.12.1.12 The purchaser shall specify the amount of wet H₂S that can be present, considering normal operation, start-up, shutdown, idle standby, upsets, or unusual operating conditions such as catalyst regeneration.	Company shall only note on the data sheets that materials resistant to sulfide stress-corrosion cracking may be required.

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In many applications, small amounts of wet H₂S are sufficient to require materials resistant to sulfide stress corrosion cracking. If trace quantities of wet H₂S are known to be present or if there is any uncertainty about the amount of wet H₂S that can be present, the purchaser should consider specifying that reduced-hardness materials are required.	
• 6.12.1.12.1 The purchaser shall specify if reduced-hardness materials are required.	For H₂S-containing environments, Vendor shall propose alternative solutions to the use of reduced-hardness materials.
• 6.12.1.12.3 If specified, reduced-hardness materials shall be supplied in accordance with ISO 15156-1. NOTE 1: For the purposes of this provision, ANSI/NACE MR0175 is equivalent to ISO 15156-1. NOTE 2: ISO 15156 (all parts), which is the equivalent of ANSI/NACE MR0175, applies to material potentially subject to sulfide and chloride stress-corrosion cracking in oil and gas production facilities and natural gas sweetening plants.	Company shall be informed of any attention of considering reduced-harness materials.
• 6.12.1.12.6 Renewable impeller wear rings that it is necessary to through-harden above HRC 22 for proper pump operation shall not be used if reduced-hardness materials are specified. Impellers may be provided with either hard-coated or surface-hardened integral wear surfaces or renewable wear rings. If approved by the purchaser, in lieu of furnishing renewable wear rings, wear surfaces may be surface-hardened or hardened by the application of a suitable coating.	Company shall be informed of any attention of considering reduced-harness materials.
6.12.2 Castings	
	(Addition) Company shall be informed, in writing, whenever a proposed casting is to be the first one from a new set of patterns.
• 6.12.2.5 If specified, for casting repairs made in the Vendor's shop, repair procedures including weld maps shall be submitted for Purchaser's approval. The Purchaser shall specify if approval is required before proceeding with repair. Repairs made at the	Repair procedures shall be submitted and approved by Company prior to any repair. Each defect shall be located on a weld map. Any part requiring a major repair may be rejected at the discretion of the Company

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foundry level shall be controlled by the casting material specification ("producing specification").															
6.12.3 Welding															
• 6.12.3.1 Welding and weld repairs shall be performed by Operators and in accordance with procedures qualified to the requirement of table 11. Alternative standards may be proposed by the Vendor for the Purchaser's approval. The welding and material inspection datasheet in Annex N may be used for this purpose. Table 11 — Welding requirements <table border="1"> <thead> <tr> <th>Requirement</th><th>Applicable code or standard</th></tr> </thead> <tbody> <tr> <td>Welder/operator qualification</td><td>ASME BPVC IX or ISO 9606 (all parts)</td></tr> <tr> <td>Welding procedure qualification</td><td>Applicable material specification or, where weld procedures are not covered by the material specification, ISO 15609 (all parts), ASME BPVC IX or ANSI/ASME B31.3</td></tr> <tr> <td>Non-pressure-retaining structural welding, such as baseplates or supports</td><td>ISO 10721-2</td></tr> <tr> <td>Magnetic-particle or liquid-penetrant examination of the plate edges</td><td>ASME BPVC VIII, Division 1, UG-93(d)(34)</td></tr> <tr> <td>Post-weld heat-treatment</td><td>Applicable material specification, EN 13445-4, ASME BPVC VIII, Division 1, UW 40, or ANSI/ASME B31.3</td></tr> <tr> <td>Post-weld heat-treatment of casing fabrication welds</td><td>Applicable material specification, EN 13445-4, or ASME BPVC VIII, Division 1</td></tr> </tbody> </table>	Requirement	Applicable code or standard	Welder/operator qualification	ASME BPVC IX or ISO 9606 (all parts)	Welding procedure qualification	Applicable material specification or, where weld procedures are not covered by the material specification, ISO 15609 (all parts), ASME BPVC IX or ANSI/ASME B31.3	Non-pressure-retaining structural welding, such as baseplates or supports	ISO 10721-2	Magnetic-particle or liquid-penetrant examination of the plate edges	ASME BPVC VIII, Division 1, UG-93(d)(34)	Post-weld heat-treatment	Applicable material specification, EN 13445-4, ASME BPVC VIII, Division 1, UW 40, or ANSI/ASME B31.3	Post-weld heat-treatment of casing fabrication welds	Applicable material specification, EN 13445-4, or ASME BPVC VIII, Division 1	Welding procedures shall be submitted for Company approval for all piping subject to wet sour service. This includes, but is not limited to, pump flush, vent and drain connections and piping.
Requirement	Applicable code or standard														
Welder/operator qualification	ASME BPVC IX or ISO 9606 (all parts)														
Welding procedure qualification	Applicable material specification or, where weld procedures are not covered by the material specification, ISO 15609 (all parts), ASME BPVC IX or ANSI/ASME B31.3														
Non-pressure-retaining structural welding, such as baseplates or supports	ISO 10721-2														
Magnetic-particle or liquid-penetrant examination of the plate edges	ASME BPVC VIII, Division 1, UG-93(d)(34)														
Post-weld heat-treatment	Applicable material specification, EN 13445-4, ASME BPVC VIII, Division 1, UW 40, or ANSI/ASME B31.3														
Post-weld heat-treatment of casing fabrication welds	Applicable material specification, EN 13445-4, or ASME BPVC VIII, Division 1														
6.12.3.4 Connection welded to pressure casings shall be installed as specified in a) through e) below: • d) If specified, proposed connection designs shall be submitted to the Purchaser for approval before fabrication. The drawing shall show weld designs, size, materials, and pre-weld and post-weld heat-treatments. • e) Suction and discharge nozzle welds shall be inspected by magnetic particle or liquid penetrant examination after back chipping or gouging and again after post-weld heat-treatment or, for austenitic stainless steels, after solution annealing. The Purchaser shall specify if the following additional examinations shall be performed. 1) Magnetic-particle or liquid-penetrant examination of auxiliary connection welds; 2) Ultrasonic or radiographic examination of any casing welds.	d) Connection designs for fabricated pressure casings shall be approved by Company before fabrication commences. e) All auxiliary connection welds, including any seal welds, shall undergo magnetic particle or liquid penetrant examination. If feasible a radiographic examination shall also be carried out to ensure correct fit-up of socket welded connections and thread engagement of seal welded NPT connections.														
6.12.4 Low temperature service															
• 6.12.4.1 The Purchaser shall specify the	When material is being selected for low														

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minimum design metal temperature the pump will be subjected to in service. This temperature shall be used to establish impact test requirements. Normally, this will be the lower of the minimum surrounding ambient temperature or minimum liquid pumping temperature. However, the Purchaser may specify a minimum design metal temperature based on pump liquid properties, such as autorefrigeration at reduced pressures.	temperature applications, the Purchaser shall take into consideration the temperature resulting from transient operations such as: line filling, first start up and draining of liquids that may be vaporized.
• 6.12.4.3 The Purchaser shall specify whether EN 13445 (all parts) or ASME VIII, Division 1 shall apply with regard to impact-testing requirements.	Refer to project Specification.
6.13 Nameplates and rotation arrows	
6.13.1 A nameplate shall be securely attached at a readily visible location on the equipment and on any other major piece of auxiliary equipment.	(Clarification) Nameplates and rotation arrows shall be 316 stainless steel.
6.13.2 The nameplate shall be stamped with the following information, in unit consistent with the data sheet: a) Purchaser's item number; b) Vendor's size and model number; c) Pump serial number; d) Rated flow; e) Rated head; f) Casing hydrostatic test pressure; g) Speed; h) Manufacturer's bearing identification numbers (if applicable); i) Maximum allowable working pressure (MAWP); j) Temperature basis for MAWP.	(Clarification) Nameplates shall be in SI units except for units to be installed in the USA. The year of the pump manufacture shall be included on the plate.
6.13.3 In addition to being stamped on the nameplate, the pump serial number shall be plainly and permanently marked on the pump casing.	(Clarification) For axially split pumps the serial number shall be stamped on each half. These markings shall remain legible after painting.

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7. Accessories	
7.1 Drivers	
● 7.1.5 The Purchaser shall specify the type of motor, its characteristics and the accessories, including the following: a) Electrical characteristics b) Starting conditions (including the expected voltage drop on starting) c) Type of enclosure d) Sound pressure level e) Area classification, based on IEC 60079 or API RP 500 f) Type of insulation g) Required service factor h) Ambient temperature and elevation above sea level i) Transmission losses j) Temperature detectors, vibration sensors and heaters, if these are required k) Vibration acceptance criteria l) Applicability of IEC 60034-1, IEC 60034-2-1, ANSI/API Std 541; API Std 547 or IEEE 841.	Transmission losses (i) and vibration criteria (k) shall be submitted by the Vendor to Company for review approval.
7.1.6 Unless otherwise specified, the motor shall be capable of accelerating the pump to rated speed at 80% voltage against a closed discharge valve. Some pumps are equipped with bypasses, in which case alternative starting conditions should be used.	(Clarification) Motors for pumps with “open valve” or open circuit start up shall be capable of accelerating the pump to rated speed assuming maximum (usually end of curve) power at 80% voltage. The separation between the motor and pump speed torque curve shall never be less than 10% of the rated torque.
7.1.9 Unless otherwise specified, gears shall conform to API 677.	(Clarification) Gears with a rated power greater than 1,000 kW shall comply with the API STD 613 "Special purpose gear unit for refinery service" latest edition and GS EP MEC 242 . The proposal shall include the proposed gear Vendor's comments and exceptions.

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7.2 Coupling and Guards	
7.2.3 If specified, couplings shall be balanced to ISO 1940-1, grade G6.3.	Couplings components shall have an inherent balance. The residual unbalance of all the transmission unit shall be checked by assembly balance method, and shall not exceed G6.3.
7.2.4 If specified, couplings shall meet the requirements of ISO 14691, ISO 10441, or ANSI/API Std 671/ISO 10441.	Multistage pumps with hydrodynamic bearings or any pump with a rated speed greater than 3600 rpm shall be supplied with couplings that meet the requirement of API STD 671.
7.2.5 Information on shafts, keyway dimensions (if any), and shaft end movements due to end play and thermal effects shall be furnished to the Vendor supplying the coupling.	(Clarification) The coupling drawing will include coupling thermal growth data in millimeters per 100°C temperature rise. The Vendor will ensure that the alignment data in the manual includes any coupling pre-stretch required due to thermal growth of casings and coupling. Keys shall fill the keyway in the shaft and hub. Any part of the key protruding shall be machined flush with the shaft. Prior to delivery the Vendor shall establish, for Purchaser witness, a balance dossier including all relevant balance certificates of rotors, shafts and couplings to demonstrate a consistent philosophy regarding filling keyways during balancing of the individual components by different Suppliers. Keys and half keys shall meet the requirements of ISO 21940-32 including marking of keys and shaft ends with the applicable key convention.
7.2.10 If specified, couplings shall be fitted hydraulically.	Refer to Project Specification
7.2.11 If specified, couplings shall be fitted with a proprietary clamping device. Acceptable clamping devices may include tapered bushes, frictional locking assemblies and shrink discs. The Vendor responsible for the final machining of the hub bores shall select a suitable rating/size device to suit the coupling and the application.	Proprietary clamping device shall be submitted for Company approval.

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● 7.2.14 If specified, coupling guards shall be constructed of an agreed spark-resistant material (see 6.10.2.6, note).	Couplings guards shall be non-sparking.
● 7.2.15 If specified for coupling guards with potentially explosive atmospheres, an "ignition hazard assessment" (risk analysis) in accordance with EN 13463-1 shall be conducted and a suitable report provided.	Refer to project specification.
7.3 Baseplates	
● 7.3.1 Single-piece drain-rim or drain-pan baseplates shall be furnished for horizontal pumps. The purchaser shall specify the rim or pan type as follows: a) Drain rim surrounding the entire baseplate; b) Drain pan surrounding the entire baseplate; c) Partial drain pan that covers the entire width of the baseplate. The rim or pan of the baseplate shall be sloped at least 1 in 120 towards the pump end, where a tapped drain opening of at least DN 50 (NPS 2) shall be located to effect complete drainage.	FPSO application: The design of the drain pan and the location of the drain flanges shall ensure complete drainage including sub-equipment under the most adverse FPSO motions.
● 7.3.5 Mounting pads shall be provided for the pump and all drive-train components, such as motors and gears. The pads shall be larger than the foot of the mounted equipment, including extra width of shims under drive-train components, to allow levelling of the baseplate without removal of the equipment. The pads shall be fully machined flat and parallel. Corresponding surfaces shall be in the same plane within 150 µm/m (0,002 in/ft) of distance between the pads. If specified, this requirement shall be demonstrated in the pump-vendor's shop prior to mounting of the equipment and with the baseplate supported at the foundation bolt holes only. This demonstration can be performed only when the clamps are released in the milling machine after completion of machining. Installed baseplate flatness can be affected by transportation, handling and installation	The baseplate design shall include a minimum of 4 machined surfaces positioned to allow the baseplate to be levelled (laterally and longitudinally) without having to disassemble any equipment. These surfaces are to be machined at the same time as the pump and driver mounting pads and left unpainted but protected from corrosion.

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procedures beyond the vendor's scope. Installation practices in API RP 686 should be followed.	
● 7.3.6 All pads for drive-train components shall be machined to allow for the installation of shims at least 3 mm (0.12 in) thick under each component. If the vendor mounts the components, a set of stainless steel shims (shim packs) at least 3 mm (0.12 in) thick shall be furnished. Shim packs shall not be thicker than 13 mm (0.5 in) nor contain more than 5 shims. All shim packs shall straddle the hold-down bolts and vertical jackscrews, and extend at least 5 mm (1/4 in) beyond the outer edges of the equipment feet. If the vendor does not mount the components, the pads shall not be drilled and shims shall not be provided. Shims shall not be used under the pump. If specified, in addition to shim packs, a stainless steel spacer plate of not less than 5 mm (0,200 in) thickness, machined on both sides, and of the same length and width as the specific mounting feet, shall be furnished and installed under all equipment feet, including the pump, driver, and any speed increaser or reducer.	Refer to Project Specification.
● 7.3.13 If specified, the baseplate and pedestal support assembly shall be sufficiently rigid to be mounted without grouting.	For offshore application, grouting shall not be permitted.
● 7.3.14 If specified, the baseplate shall be supplied without a deck plate, i.e. open deck design.	Refer to Project Specification.
● 7.3.21 If specified, the Vendor shall test to demonstrate that the pump and its baseplate assembly, anchored at foundation bolt hole locations, are in compliance with 7.3.20. The pump casing shall be subjected to moments M_{Yc} and M_{Zc} applied to either nozzle, but not both, such that the corresponding shaft displacements can be measured and recorded. M_{Yc} and M_{Zc} shall not be applied simultaneously to either nozzle. The shaft displacement measurements shall be absolute (not relative to the baseplate). For record purposes, the	If, due to piping restraints, the Purchaser requires that the pump accept higher forces and moments than those listed in table 5, the baseplate shall undergo a stiffness test and the pump feet shall be dowelled at the Vendor's works. The stiffness test may be substituted by a calculation or a test report of previously witnessed test of a similar pump/chassis combination. If the type of calculation or test report is not clarified before the order a

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Vendor's test data shall include a schematic drawing of test set-up, the calculated moment loads (M_{Yc} and M_{Zc}), and the applied moment loads and their corresponding displacements at the drive end of the pump shaft.	stiffness test shall be included in the scope of supply.
7.3.22	(Addition) For double casing vertical pumps weighing more than 100 kg, the base plate shall be equipped with levelling jackscrews. Machined surfaces shall be supplied for verification that the pump train is vertical. Horizontal positioning screws shall be provided. The base plates and/or the support cages shall include lifting lugs. The casing flanges shall be separate from the base plate to allow for the use of stud bolts.
7.4 Instrumentation	
7.4.1 Gauges • If furnished, temperature indicators and pressure gauges shall be in accordance with ISO 10438 (all parts).	Refer to Project Specification.
7.4.2 Vibration, position and temperature detectors	
• 7.4.2.1 If specified, accelerometers shall be supplied, installed and tested in accordance with API STD 670.	Refer to Project Specification.
• 7.4.2.2 If specified for equipment with hydrodynamic bearings, provision shall be made for mounting two radial-vibration probes in each bearing housing, two axial-position probes at the thrust end of each machine, and a one-event-per-revolution probe in each machine. The Purchaser shall specify whether detectors shall be supplied. The detectors and their mounting and calibration shall be supplied, installed and tested in accordance with ANSI/API STD 670.	Permanent shaft vibration monitoring Large Pump (> 500 kW) with hydrodynamic bearings: • 2 shaft displacement probes X and Y at each journal bearing location, in position $-45^{\circ}/+45^{\circ}$ wrt the position "12h" (this for horizontal pumps of course). • 2 shaft axial displacement probes on the thrust side (this to avoid to be disturbed by the thermal growth). • 1 keyphasor. Large Pump (> 500 kW), with non hydrodynamic bearings: • 2 accelerometers X and Y on each bearing housing in position "12h" and "15h".

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	Small Pump (< 500 kW): 2 accelerometers X and Y on each bearing housing in position "12h" and "15h". Very small Pump (< 100 kW) No permanent instrumentation, periodic controls by hand held portable readout equipment. The probe cables shall include a positive and proven "anti-wicking" feedthrough design to prevent oil from migrating from the bearing housing into the cable conduit and junction box. RTDs shall be duplex type
7.4.2.3 If specified, hydrodynamic thrust and radial bearings shall be fitted with bearing metal temperature detectors. If pressure-lubricated hydrodynamic thrust and radial bearings are supplied with temperature detectors, the detectors and their mounting and calibration shall be supplied, installed and tested in accordance with ANSI/API STD 670.	Permanent bearing temperature monitoring Large Pump (> 500 kW) with hydrodynamic bearings: - On the journal bearing, 2 redundant thermocouples in the most loaded bearing quadrant. - On the axial thrust bearing, 1 thermocouple in two different pads on both the inboard and outboard side. Large Pump (> 500 kW), with non hydrodynamic bearings: 1 PT100 to measure the oil temperature at each bearing, either on the bearing outer race or in the oil bath. Small Pump (< 500 kW): 1 PT100 to measure the oil temperature at each bearing, either on the bearing outer race or in the oil bath. Very small Pump (< 100 kW) No permanent instrumentation, periodic controls by hand held portable readout equipment. The probe cables shall include a positive and proven "anti-wicking" feedthrough design to prevent oil from migrating from the bearing housing into the cable conduit and junction box.
7.4.2.4 If specified, monitors with cables	Refer to Project Specification

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connecting to vibration, axial-position or temperature detectors shall be supplied and/or installed in accordance with ANSI/API STD 670.	
7.4.2.5	(Addition) Pump performance monitoring Very small Pump (< 100 kW) No permanent instrumentation, periodic controls by hand held portable readout equipment. All other pumps: • Pump flow • Inlet/ discharge pressure and temperature • Speed • Bearing vibrations and temperatures as described above.
7.5 Piping and appurtenances	
7.5.1 General	
• 7.5.1.4 If specified, barrier/buffer fluid reservoirs shall be designed for mounting off the pump baseplate and shall be shipped separately. These reservoirs shall be fully assembled, except that the fluid-circulation tubing shall not be supplied.	The reservoir support structure shall be attached to the baseplate.
• 7.5.1.6 If specified, each piping system shall be manifolded to a single Purchaser's inlet or outlet connection near the edge and within the confines of the baseplate. NOTE: The datasheet allows selection of this option for vent, cooling water and drain connections.	Drains and vents shall be equipped with a gate valve. If the specification for the piping connected to the pump calls for double block valves, this requirement shall apply to vent and drain valves. If a pump has several drains or vents each shall have a separate valve. After the gate valve, pump casing drains shall be run to a manifold and then to the skid edge terminating with a flanged connection. For pumps specified for liquids that are toxic or flammable or have a pumping temperature greater than 60°C, each vent shall have a flanged connection after the gate valve. This connection shall be routed to a closed drain or flare system. For other liquids, each vent shall have a connection after the gate valve for disassembly and then be run to the drain pan. The end of

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	the pipe shall be fitted with a flange and blind flange in accordance with the applicable piping specification.
7.5.1.7 The bolting requirements of 6.1.30 apply to the connection of auxiliary piping to the equipment. Flange fasteners on stainless steel piping systems in lubricating oil service need not to be stainless steel unless specified. If the Purchaser does not specify stainless steel fasteners, they shall be low-alloy steel (e.g. ASTM A193/A193M Grade B7) and the Purchaser shall specify whether they shall be coated (such as by PTFE coating or galvanizing in accordance with ISO 10684 or ASTM A153/A153M)) or painted.	Flange fasteners on stainless steel piping shall be stainless steel.
7.5.2 Auxiliary process liquid piping	
7.5.2.4 Orifice openings shall not be less than 3 mm (0.12 in) in diameter. Orifice hole size shall be stamped on the orifice plate. The purchaser shall specify orifice tagging or labelling requirements.	Refer to Project Specification
7.5.2.8 The purchaser shall specify where flanges are required in place of socket-welded unions. With purchaser approval, socket-welded unions may be used in place of flanges at the first connection from the seal gland. NOTE: Threaded connections are allowed on gland connections (see 6.4.3.11). If the remainder of the piping arrangement is flanged, repeated assembly and disassembly can overstress this threaded connection, since adjustment is possible only in 90° increments. Socket-welded unions supplied in stainless steel tend to leak after repeated assembly and disassembly.	Union connectors may only be used for piping containing flammable or hazardous fluids when it can be demonstrated that flanges cannot be used. The acceptance of any union connectors shall be subject to Company written approval. Screwed piping into mechanical seal glands shall be straight and provided with Lap joint flanges at the connection with the piping package. Screwed piping into mechanical seal glands shall be such that self-gripping wrenches need not be used. Screwed piping damaged by such wrenches is not acceptable.
8. Inspection, testing, and preparation for shipment	
8.1 General	
8.1.1 The Purchaser shall specify the extent of his participation in the inspection and testing. a) If shop inspection and testing have been specified, the Purchaser and the Vendor shall coordinate manufacturing hold points	The Vendor shall supply with the proposal the inspection/quality control plan listing all inspection operations for the equipment taking into account the project specification requirements. This plan, with the Purchaser comments, shall constitute the inspection

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and Inspector's visits. b) The expected dates of testing shall be communicated at least 30 days in advance and the actual dates confirmed as agreed. Unless otherwise agreed, the Vendor shall give at least five working days advanced notification of a witnessed or observed inspection or test. For smaller pumps where set-up and test time is short, five days notice may require the removal of the pump from the test stand between preliminary and witnessed tests. All witnessed inspections and tests are hold points. For observed tests, the Purchaser should expect to be in the factory longer than for a witnessed test. c) If specified, witnessed mechanical and performance tests shall require a written notification of a successful preliminary test. The Vendor and Purchaser shall agree whether or not to maintain the machine test set-up or whether the machine can be removed from the test stand between the preliminary and witnessed tests. Many Purchasers prefer not to have preliminary tests prior to witnessed tests, in order to understand any difficulties encountered during testing. If this is the case, Purchasers should make it clear to the Vendor.	program. The Vendor's bid shall clearly state any tests the Vendor cannot carry out Witnessed mechanical and performance tests shall require a written notification of a successful in-house test. Vendor shall inform Company about the dates of the in-house tests, and about difficulties encountered during testing if any.
8.1.3 After advance notification to the vendor by the purchaser, the purchaser's representative shall have reasonable access to all vendor and sub-vendor plants where manufacturing, testing or inspection of the equipment is in progress. The level of access shall be agreed upon.	(Clarification) Vendors shall give to Company representatives all the accesses that allows to verify that the purchased equipment meet all the contractual requirements.
● 8.1.5 If specified, the Purchaser's representative, the Vendor's representative, or both, shall indicate compliance in accordance with an Inspector's checklist such as that provided in annex E by initialling, dating, and submitting the completed checklist to the Purchaser before shipment.	This section applies. The checklist shall be signed and dated by both the Vendor and Purchaser representatives prior to release of the equipment for expedition. The API Std 682 checklist shall be signed and dated by the Vendor representative and shall be available for review at the same time as the

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	pump checklist.
8.2 Inspection	
8.2.1 General	
• 8.2.1.1 The Vendor shall keep the following data available for at least 20 years: - Necessary or specified certification of materials, such as mill test reports; - Test data and results to verify that the requirements of the specification have been met; - If specified, details of all repairs and records of all heat-treatment performed as part of a repair procedure; - Results of quality control tests and inspections; - As-built running clearances; - Other data specified by the Purchaser or required by applicable codes and regulations (see 9.3.1 and 9.3.2).	Refer to Project Specification.
• 8.2.1.3 In addition to the requirements of 6.12.1.5 the Purchaser may specify the following: - Parts that shall be subjected to surface and subsurface examination; - Type of examination required, such as magnetic-particles, liquid-penetrant, radiographic and ultrasonic examinations.	Refer to Project Specification.
8.2.2 Pressure-casing materials Inspection	
• 8.2.2.5 Unless otherwise specified, inspection methods and acceptance criteria shall be in accordance with those in Table 15 as required by the material specification. If additional radiographic, ultrasonic, magnetic-particle or liquid-penetrant examination of the welds or materials is specified by the purchaser, the methods and acceptance criteria shall also be in accordance with the standards shown in Table 15. Alternative standards may be proposed by the vendor or specified by the purchaser. The welding and material inspection data sheet in Annex N may	For equipment requiring post weld heat treatment, final non-destructive testing of welds shall be carried out after heat treatment.

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be used for this purpose.	
● 8.2.2.6 If specified, the Purchaser may inspect for cleanliness of the equipment and all piping and appurtenances furnished by or through the Vendor before assembly.	Refer To Project Specification.
● 8.2.2.7 If specified, the hardness of parts, welds and heat-affected zones shall be verified as being within the allowable values by testing. The method, extent, documentation and witnessing of the testing shall be agreed upon the Purchaser and the Vendor.	Refer To Project Specification.
● 8.2.2.8 If specified, pressure boundary parts of alloy materials shall be subject to positive material identification (PMI) using recognized testing methods, instrumentation and standards. The purchaser and vendor shall agree on the specific parts tested, procedures used and acceptance criteria. Only techniques providing quantitative results shall be used. Mill test reports, material composition certificates, visual stamps or markings shall not be considered substitutes for PMI testing. NOTE: PMI is not available to differentiate between grades of carbon steels.	Refer To Project Specification.
8.3 Testing	
8.3.1 General	
● 8.3.1.1 If specified, at least six weeks before the first scheduled running test, the vendor shall submit to the purchaser, for his review and comment, detailed procedures for all running tests and all specified optional tests (8.3.4). The test procedure shall include the actual measurement uncertainty of all data used in the calculation of flow, head and power as well as all acceptance criteria.	Detailed test procedures, in accordance with this clause, are required for all pumps. Test procedures shall be reviewed and accepted by Company prior to the commencement of acceptance tests.
	8.3.1.2 (Addition) If shop tested equipment is damaged before contractual delivery, the equipment shall be retested, after any repairs, to a level to be decided by the Purchaser.

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8.3.2 Hydrostatic test	
● 8.3.2.6 If the part tested will operate at a temperature at which the strength of a material is below the strength of that material at the testing temperature, the hydrostatic test pressure shall be multiplied by a factor obtained by dividing the allowable working stress for the material at the testing temperature by that at the rated operating temperature. The stress values used shall be determined in accordance with 6.3.4. For piping, the stress shall conform to ISO 15649 or ASME B31.3, as specified. The pressure thus obtained shall then be the minimum pressure at which the hydrostatic test shall be performed. The data sheets shall list actual hydrostatic test pressures.	Refer to Project Specification.
8.3.2.10 Austenitic or duplex stainless steel pressure-casing components may be hydrostatically tested in the proof (rough) machined condition. See 8.2.2.3. Any areas that are machined after hydrostatic testing shall be identified on the hydrotest report.	(Clarification) The hydrotest report shall be reviewed and accepted by Company prior to hydrostatic test post machining.
8.3.3 Performance test	
8.3.3.1 Unless otherwise specified, each pump shall be given a performance test.	(Clarification) Performance tests shall be witnessed by Company. Spare rotor shall undergo the same performance test and mechanical running tests as the main equipment.
● 8.3.3.2 The following requirements of a) through i) shall be met while the pump is operating on the test stand and before the performance test is performed. a) The contract seals and bearings shall be used in the pump for the performance test. b) If approved by the purchaser, substitute seals may be used during the performance test if needed to prevent damage to the contract seals or if the contract seals are not compatible with the test liquid. See ISO	b) The need for substitute seals shall be notified in the proposal.

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21049:2004, 10.3.5. c) The seal (or seals) shall not have a leakage rate during any phase of the pump performance test that is in excess of that specified in ISO 21049:2004, A.1.3, or as otherwise agreed by the vendor and purchaser. Any unacceptable leakage during the pump performance test requires a disassembly and repair to the seal. If the seal is disassembled or removed, the seal shall be retested with an air test of the pump using the criteria defined in 8.3.3.7 d). When the pump is on the test stand and water is used as the test liquid, liquid seals suitable for testing on water shall exhibit no visible signs of leakage. ISO 21049:2004, A.1.3, should be reviewed to confirm that a zero-visible-leakage criterion is appropriate for the seals being tested. Notably, pressurized dual seals with high barrier-fluid pressures [greater than 4,000 kPa (40 bar; 600 psi)] should be reviewed. NOTE: For the purpose of this provision, ANSI/API Std 682/ISO 21049, is equivalent to ISO 21049. d) If specified, seal leakage during test shall require the assembled pump and seal to be rerun to demonstrate satisfactory seal performance. e) All lubricating-oil pressures, viscosities and temperatures shall be within the range of operating values recommended in the vendor's operating instructions for the specified unit being tested. f) Bearings specified as normally lubricated from a pure oil-mist system shall be pre-lubricated prior to performance testing using a suitable hydrocarbon oil. g) All joints and connections shall be checked for tightness and any leaks shall be corrected. h) All warning, protective and control devices used during the test shall be checked and	c) Containment seal and quench drains shall be left open or unplugged during the performance test. d) Any seal leakage over limit specified in Test Procedure during test shall require the assembled pump and seal to be re-run to demonstrate satisfactory seal performance. Such a re-run shall be subject to a witness by the Purchaser's Inspector.

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adjusted as required. i) Unless otherwise agreed, performance tests shall be performed using water at a temperature not exceeding 55°C (130 °F).	j) (Addition) If, because of its length, a vertical pump may not be tested completely assembled, a proposal for a special testing procedure must be included in the bid. Any length tested must include at least two intermediate bearings.
• 8.3.3.3 Unless otherwise specified, the performance test shall be conducted as specified in a) through e) as follows. a) The vendor shall take test data, including head, flowrate, power and vibration at a minimum of five points. These points will normally be 1) shutoff (no vibration data required), 2) minimum continuous stable flow (beginning of allowable operating region), 3) between 95% and 99% of rated flow, 4) between rated flow and 105% of rated flow, 5) approximately the best efficiency flow (if rated flow is not within 5% of best efficiency flowrate), 6) end of allowable operating region. b) The test data shall be fit to a spline or appropriate polynomial (typically third or fourth order) for head and for power using a least squares method. The rated/guarantee flow shall be inserted into the resulting equation and a value for head and power calculated. These values shall be corrected for speed, viscosity and density (specific gravity). The corrected values of head and power shall be within the tolerance bands allowed in Table 16. In the case of high-energy pumps (see 6.1.15), integral-gear and multistage pumps, it might not be feasible to test at shutoff.	a) (These six points shall be measured from minimum flow to maximum flow, and then measured again from maximum flow to minimum flow. Head hysteresis, if any shall be limited to measurement uncertainties. Each time when running at shut off is possible, vibration f shall be measured.

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c) Unless otherwise agreed, the test speed shall be within 3% of the rated speed shown on the pump data sheet (see example in Annex N). Test results shall be corrected to rated speed. d) The vendor shall maintain a complete, detailed log of all final tests and shall prepare the required number of copies, certified for correctness. Data shall include test curves and a summary of test performance data compared to guarantee points (see 10.2.4, 10.3.2.2 and example in Annex M). e) If specified, in addition to formal submittal of final data in accordance with 10.3.2.2, curves and test data (corrected for speed, specific gravity and viscosity) shall be submitted within 24 h after completion of performance testing for purchaser's engineering review and acceptance prior to shipment.	d) Test report shall contain vibration spectra for the six points mentioned here above, and the Bode plots for the pumps equipped with shaft displacement probes. All difficulties encountered, abnormalities and incidents during testing, including internal preliminary testing, shall be noted on the test report. For vertical pumps, such as Fire Water Pumps and Sea Water lift pumps, Vendor shall convert Flow head curve to available discharge pressure as required in the Data Sheet. e) Test data shall be submitted within 24 h after completion of performance testing for Company review and acceptance prior to shipment. Addition) f) Corrections factors submitted in accordance with § 5.1.12 shall be indicated on test curves.
● 8.3.3.4 For higher-power pumps (1 MW), performance tolerances other than those in Table 16 can be appropriate. If specified, pump efficiency at rated flow shall be quoted to the tolerance given by the purchaser and shall be included in the pump's rated performance. If a tolerance is specified for rated efficiency, an additional test point as close to rated flow as practical shall be taken. The rated efficiency and tolerance shall be consistent with the test code being used, with particular attention to the uncertainty of efficiency determined by test to that code.	Refer to project Specification

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The purchaser should expect that adding efficiency with a specific tolerance to the pump's rated performance usually affects pump cost and delivery.	
● 8.3.3.5 During the performance test, the requirements of a) through d) as follows shall be met. a) Vibration values shall be recorded at each test point except shutoff during the test in accordance with 6.9.3.2. Vibration values shall not exceed those given in 6.9.3.6. b) For ring and splash-oil systems, oil temperatures shall be recorded at the beginning and the end of the test. For pressurized systems, bearing metal temperatures shall be recorded at the beginning and the end of the test. The duration of the test shall be indicated on the test report. c) Pumps shall operate within bearing temperature limits as defined in 6.10.2.4 and shall not display signs of unusual operation, such as noise caused by cavitation. d) When operated at rated speed, pumps shall perform within the tolerances given in Table 16 [see 8.3.3.3 b)].	a) For each test point, vibration values shall be presented through a frequency analysis. For pumps equipped with shaft displacement probes, vibration data shall be presented in the way of a Bode Plot. When applicable (see 6.9.1.1) predicted critical speeds shall be confirmed during the test. d) For pumps destined for parallel operation the conditions of paragraph 6.1.11 shall be verified.
● 8.3.3.6 If specified, the performance test shall be conducted with test stand NPSHA controlled to no more than 110% of the NPSHA specified on the data sheet. NOTE: It is the purpose of this test to evaluate pump performance with the specified NPSHA at pump suction.	This paragraph is applicable.
● 8.3.3.7 The requirements of a) through d) below shall be met after the performance test is completed. a) If it is necessary to dismantle a pump after the performance test for the sole purpose of machining impellers to meet the tolerances	a) (Substitution) Any modification of the pump to improve

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for differential head, no retest is required unless the reduction in diameter exceeds 5% of the original diameter. The diameter of the impeller at the time of shop test, as well as the final diameter of the impeller, shall be recorded on a certified shop test curve that shows the operating characteristics after the diameter of the impeller has been reduced. b) If specified, disassembly of multistage pumps for any head adjustment (including less than 5% diameter change) after test, shall be cause for retest. c) If it is necessary to dismantle a pump for any other correction, such as hydraulic performance, NPSH or mechanical operation, the initial test shall not be acceptable, and the final performance test shall be run after the correction is made. d) If it is necessary to disturb the mechanical seal assembly following the performance test, or if the test seal faces are replaced with the job seal faces, the final seal assembly shall be air-tested as follow: 1) Pressurize each sealing section independently with clean air to a test gauge pressure of 172 kPa (1.72 bar) (25 psi) 2) Isolate the test set-up from the pressurizing source and maintain the pressure for a minimum of 5 min, or 5 min per 30L (1 ft³) of test volume, whichever is greater 3) The maximum allowable pressure drop during the test shall be 14 kPa (0.14 bar; 2 psi).	mechanical or hydraulic performance will require that the modified part is re-balanced (if applicable). For high-energy pumps and for any multistage pump with a number a stage greater or equal to 4, mechanical and/or performance tests shall be repeated. No sharpening of vanes is allowed without prior written agreement by Company.
● 8.3.3.8 Unless otherwise specified, pumps shall not be disassembled after final performance testing. The pump, including the seal chamber, shall be drained to the extent practical, filled with a water-displacing inhibitor within 4 h of testing and redrained.	(Addition) All pumps with hydrodynamic bearings lubricated by an API STD 614 lubrication unit shall be disassembled for bearing inspection. If a pump cannot be completely drained (see clause 5.4.3.10) the Vendor shall explain in the proposal how it will be drained and dried prior to protection for shipment.

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8.3.4 Optional tests	
8.3.4.1 General If specified, the shop test described in 8.3.4.2 through 8.3.4.7 shall be performed. Test details shall be agreed upon the Purchaser and the Vendor.	Refer to project Specification.
8.3.4.2 Mechanical run test	
8.3.4.2.1 If specified, the pump shall be run on the test stand at the rated flow until oil temperature stabilization (6.10.2.4) has been achieved.	Pump shall be run on the test stand until oil temperature stabilization (6.10.2.4) has been achieved.
8.3.4.2.2 If specified, the pump shall be mechanically run at the rated flow for 4 h.	Mechanical run test shall occur only after oil temperatures are stabilized. Pump shall be mechanically run for 4h, at maximum continuous speed, maximum power. For pressurized systems, the test shall be performed with the lowest bearing oil supply pressure, and the maximum bearing oil supply temperature. Lubrication oil used for this test shall have the same viscosity as the contractual lubrication oil.
8.3.4.3 NPSHR required test	
8.3.4.3.1 If specified, NPSH3 shall be determined at each test point identified in 8.3.3.3 a) except shut-off.	NPSH3 shall be determined at each test point except shut-off and a curve shall be plotted at maximum operating speed. The NPSHR curve plotted from this test shall not deviate from the predicted curve by more than 5% of the predicted curve value. NPSH tests shall be witnessed. If the contract covers several identical pumps, NPSH3 test shall be done on one pump only.
8.3.4.3.2 A 3% drop in head (first stage head on pumps with two or more stages) shall be interpreted as indicating performance impairment, thus the terminology NPSH3. The first-stage head of pumps with two or more stages shall be measured using a separate connection to the first-stage discharge if possible. If this is not feasible, testing of the first stage only should be considered. With purchaser approval, first-stage head may be	NPSH3 test procedure shall be submitted for Company approval before contract award.

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determined by dividing total developed head by the number of stages.	
8.3.4.3.3 The NPSH required test shall determine the actual NPSH required at a 3% head drop. Unless otherwise specified or agreed, curves shall be developed at constant flow by reducing the NPSHA to a point where the head curves break away from that developed with sufficient NPSHA (8.3.4.3.2) by at least 3%. The NPSH required test shall start with at least the same NPSHA as the performance test and at least twice the NPSH3 shown on the proposal curve. The first two test points shall not differ by more than the uncertainty of the head measurement. If the second test point at the same flowrate shows a decrease in differential head then the NPSHA shall be increased to a value sufficient to establish two consecutive points of equal head. The first two points shall be separated by a minimum of 1 m (3 ft) of NPSHA. These NPSH3 curves shall be developed and submitted in accordance with Hydraulic Institute Standards (ANSI/HI 1.6) or ISO 9906, as specified. The test shall not proceed beyond a 20% head breakdown (20% of first-stage head for multistage pumps). Note: If 8.3.3.6 is specified, it is possible that the head has already been affected by insufficient NPSHA, so starting at a higher NPSHA is desirable.	Refer to Project Specification.
8.3.4.4 Complete unit test	
8.3.4.4.1 Complete unit test If specified, the pump and driven train, complete with all auxiliaries that make up the unit, shall be tested together. If specified, torsional vibration measurements shall be made to verify the Vendor's analysis. The complete-unit test shall be performed in place of or in addition to separate tests of individual components specified by the Purchaser.	Refer to Project Specification for the need to verify by test the torsional analysis. Complete unit test (string test) shall be done at Full Load and Max Continuous speed. Vibration values shall be presented through a frequency analysis, Shaft vibration, if any, shall be monitored and displayed in Bode diagram.
8.3.4.5 Sound level test If specified, sound level tests shall be performed as agreed between the Purchaser	Refer to Project Specification.

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and the Vendor. NOTE: ISO 3740, ISO 3744, and ISO 3746 may be consulted for guidance.	
• 8.3.4.6 Auxiliary equipment test If specified, auxiliary equipment such as oil systems, gears and control systems shall be tested in the Vendor's shop. Details of the auxiliary equipment test(s) shall be developed jointly by the Purchaser and the Vendor.	Refer to Project Specification.
• 8.3.4.7 Bearing Housing resonance test If a resonance test is specified, the bearing housing(s) shall be excited by impact or other suitable means with the pump unpiped, and the natural frequency(ies) shall be determined from the response. A separation margin shall exist between the natural frequency(ies) and the following excitation frequencies: a) Multiples of running speed (r/min): 1,0; 2,0; 3,0 b) Multiples of vane passing frequency: 1,0; 2,0 Test acceptance criteria shall be agreed upon between the Purchaser and the Vendor.	Refer to Project Specification.
8.4 Preparation for Shipment	
• 8.4.1 Unless otherwise specified, equipment shall be prepared for domestic shipment. Domestic shipment preparation shall make the equipment suitable for outdoor storage for a period of at least six months with no disassembly required before operation except possibly inspection of bearings and seals. Preparation for longer storage or export shipment is more rigorous and, if specified, shall be provided by the vendor following agreed procedures.	Refer to Project Specification
8.4.2.1 Rotors shall be blocked if necessary. Blocked rotors shall be identified by means of corrosion resistant tags attached with stainless steel wire.	(Clarification) Rotors shall be blocked and identified by means of corrosion resistant tags attached with stainless steel wire.

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9. Specific pump types	
9.1 Single-stage overhung pumps	
● 9.1.1.3 If specified, the shaft flexibility index shall be calculated by the vendor in accordance with K.1 and stated on the data sheet. The design and operation requirements for overhung pump rotors are detailed in several areas of this standard. K.1 lists these requirements and establishes a standardized process of calculating a shaft flexibility index that may be used to evaluate these latter parameters and to establish a baseline for the comparison of shaft flexibility.	The shaft flexibility index of the pump proposed shall be well within the existing references of the Vendor.
9.1.2 Vertical in-line (Type OH3) pumps	
● 9.1.2.6 If specified, a device that allows direct rigging or lifting of the back-pullout assembly from outside the motor support with the driver in place shall be provided.	Any device which allows safe and easy handling of the pump unit shall be provided.
9.1.3 Integral gear-driven (Type OH6) pumps	
● 9.1.3.4 The need for a rotor lateral analysis shall be determined as described in 9.2.4.1. A lateral analysis should be specified only for unique, new or critical pump. NOTE: Lateral critical speeds can be of concern with type OH6 pumps. Normally, pumps of this type are thoroughly investigated during development, and typical rotor dynamics are available and applicable.	Rotor lateral analysis is always requested.
● 9.1.3.6 Temperature and pressure gauges mounted directly on the gearbox shall be in accordance with ISO 10438 (all parts) except that the diameter of the gauges shall be 50 mm (2.0 in). If specified, separable threaded solid-bar thermowells shall be supplied for temperature gauges.	Refer to Project Specification.
9.2 Between-bearings pumps (types BB1, BB2, BB3 and BB5)	
9.2.1 Pressure casings	
● 9.2.1.4 If specified, proposed connection designs shall be submitted to the Purchaser for approval before fabrication. The drawing shall show weld designs, size, materials, and pre-	Proposed connection designs shall be submitted to Company for approval before fabrication.

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weld and post-weld heat treatments.	
9.2.1.5 For pumps with machined and studded suction and discharge nozzles, the vendor shall provide the minimum acceptable length for break-out spool pieces to facilitate maintenance activity. Spool pieces should be provided by the purchaser. NOTE: Break-out spool pieces eliminate the requirement to remove large sections of piping in order to take the pump casing out during major overhauls.	Vendor shall propose, in option of his Tender to supply the spool pieces.
9.2.2 Rotor	
9.2.2.3 If specified, rotors with shrink-fit impellers shall have mechanical means to limit movement in the direction opposite to normal hydraulic thrust to 0.75 mm (0.030 in) or less.	Impellers for all multistage pumps shall be individually secured against axial movement in either direction. Vendor shall submit, in the proposal, a drawing showing attachment method
9.2.4 Dynamics	
9.2.4.1 Lateral analysis	
9.2.4.1.3 If a lateral analysis is required by the process in 8.2.4.1.2, or if specified by the Purchaser, it shall be carried out and its results assessed in accordance with Annex I.	Lateral analysis is always required.
9.2.5 Bearings and bearing housings	
9.2.5.2.4 Thrust bearings shall be sized for the maximum continuous applied load (see 6.10.1.2). At this load, and the corresponding rotative speed, the following parameters shall be met: - Minimum oil-film thickness of 8 μm (0.0003 in). - Maximum unit pressure (load divided by area) of 3,500 kPa (35 bar; 500 psi). - Maximum calculated babbit surface temperature of 130°C (265°F). - If specified, thrust-bearing sizing shall be reviewed and approved by the Purchaser. The limits given above correspond to a design factor of two or more, based on the bearing's ultimate capacity. The calculated babitt surface temperature is a design value and is not representative of actual babitt temperatures	Thrust bearing design conditions and size shall be reviewed by Company.

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under these conditions. Bearings sized to meet the above criteria have the following allowable metal temperature on shop test and in the field (see 6.10.2.4). Shop test on water and normal operation in the field [see 8.3.3.5 c): 93°C (200 °F). Field alarm or trip: 115°C (240°F).	
9.2.6 Lubrication	
9.2.6.1 If specified or if recommended by the Vendor and approved by the Purchaser, a pressure-lubrication system shall be furnished to supply oil at a suitable pressure to the pump bearings, the driver, and other any driven equipment, including gears.	Refer to Project Specification.
9.2.6.2 External pressure-lubrication systems shall comply with the requirements of ISO 10438-3. Figure B.8 and Table B.1 show details of the minimum acceptable system for equipment furnished to this International Standard.	(Clarification) Oil side pressure shall always be higher than water side pressure.
9.2.6.4 If specified, the pressure-lubrication system shall conform to the requirements of ISO 10438-2. For such a lubrication system, datasheets should be supplied.	Refer to Project Specification.
9.2.7 Testing	
9.2.7.5 If specified, hydrodynamic bearings shall be removed, inspected by the Purchaser or his representative, and reassembled after the performance is completed.	Hydrodynamic bearings shall be removed and inspected after test.
9.2.8 Preparation for shipment	
9.2.8.2 If specified, spare rotors and cartridge-type elements shall be prepared for vertical storage. A rotor shall be supported from its coupling end with a fixture designed to support 1.5 times the rotor's mass without damaging the shaft. A cartridge-type element shall be supported from the casing cover (with the rotor hanging from its thrust bearing).	Refer to Project specification.
9.2.8.3 If specified, a shipping and storage container designed to store the rotor or cartridge vertically shall be provided.	Refer to Project specification.

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● 9.2.8.4 If specified, the shipping and storage container shall be designed to allow inert-gas inhibition during storage.	Refer to Project specification.
9.3 Vertically suspended pumps (types VS1 through VS7)	
● 9.3.5 Dynamics If specified, the Vendor shall furnish a dynamic analysis of the pump and its support structure to confirm acceptability of the design. The Purchaser and the Vendor shall agree on the extent, method and acceptance criteria for this analysis. Vertically suspended pumps are generally flexible structures with running speeds located between natural frequencies. As such, they are susceptible to resonant vibration if their separation margins are not verified during design. The basic structural elements typically include the foundation, pump structures and motor frames. Typically, the deflection of the foundation represents less than 5% of the total deflection of the structural elements. If foundation data are not available when the analysis is being conducted, an agreed-upon value should be used. Generally, a 20% margin of separation should be maintained between the natural frequency of the motor support structure and the operating speed.	Vendor shall furnish a dynamic analysis of the pump and its support structure. Extent, method and acceptance criteria for this analysis shall be mutually agreed.
9.3.8 Accessories	
9.3.8.3 Mounting plates	
● 9.3.8.3.1 If specified, the mounting plate for double-casing pumps shall be separate from the main body flange and located sufficiently below it to permit the use of through-bolting on the body flange (see figure 38). This results in a higher joint integrity and should be considered for critical and cryogenic services.	Installation shall ensure the use of through-bolting on.
● 9.3.8.3.3 If specified, pumps shall be provided with a separate sole plate for bolting and grouting to the foundation (see figure 38). This plate shall be machined on its top surface for mounting of the discharge head, can, or motor support.	Pumps shall be provided with separate sole plates with 25 mm (1") minimum radius corners for bolting and grouting to the foundation.

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9.3.9 Testing	
● 9.3.9.2 If specified, a resonance test with the pump unpiped shall be conducted on the pump structure/driver frame assembly. The test shall be performed as follow: • Excite the assembly by making an impact on the driver frame in the direction of the discharge flange. • Determine the natural frequencies by the response. • Excite the assembly by making an impact on the driver frame at 90° to the direction of the discharge flange. • Determine the natural frequencies by the response. The natural frequencies so determined shall be at least 10% below the minimum continuous operating speed or shall be at least 10% above the maximum continuous operating speed.	Refer to Project specification.
9.3.10 Single-case diffuser (VS1) and volute (VS2) pumps	
● 9.3.10.5 If specified, line shafting shall be furnished with hardened sleeves under each bushing.	Vendor shall detail in his offer how shaft sleeve wear will be controlled considering the specified pumped.
9.3.13 Double-casing diffuser (VS6) and volute (VS7) pumps	
● 9.3.13.2 If specified, bowls and column pipe shall be hydrostatically tested with liquid at a minimum of 1.5 times the maximum differential pressure developed by the bowl assembly. Hydrostatic testing shall be conducted in accordance with the requirements of 8.3.2.	Vendor shall detail in his offer how he intends to hydrostatic test bowls and column pipes.
● 9.3.13.5 If specified, the suction can shall be supplied with a drain piped to the surface.	The suction shall be supplied with a drain, piped to the surface.
10. Vendor's data	
10.1 General	
● 10.1.3 If specified, a coordination meeting shall be held, preferably at the Vendor's plant, within four to six weeks after order commitment. Unless otherwise specified, the Vendor shall prepare and distribute an agenda prior to this meeting, which as a minimum shall	The Vendor shall be aware that there may be pre-commitment, coordination and design audit meetings as deemed necessary by Company. These meetings shall be considered part of any purchase order.

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include a review of the following items: a) purchase order, scope of supply, unit responsibility, and Sub-Vendor items; b) data sheets; c) Applicable specifications and previously agreed-upon exceptions; d) Schedules for transmittal of data, production, and testing; e) quality assurance programme and procedures; f) Inspection, expediting, and testing; g) Schematics and bills of material for auxiliary systems; h) physical orientation of the equipment, piping and auxiliary systems; i) Coupling selection and rating; j) Thrust and journal bearing sizing, estimated loadings and specific configurations; k) Rotor dynamic analyses (lateral, torsional and transient torsional, as required; commonly not available for 10 weeks to 12 weeks); l) Equipment performance, alternative operating conditions, start-up, shutdown and any operating limitations; m) Scope and details of any pulsation or vibration analysis; n) Instrumentation and controls; o) Identification of items for stress analysis or other design reviews; p) Other technical items.	
10.2 Proposals	
10.2.3 Technical data The following data shall be include in the proposal • I) If specified, a list of similar machines installed and operating under similar conditions:	I) The Vendor shall provide a reference list covering at least two (2) similar installations. The pumps proposed as references shall have operated satisfactorily for more than 2 years. A general reference list with all types of pumps and operating conditions is unacceptable unless similar examples are clearly indicated.

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10.2.5 Options If specified, the Vendor shall furnish an outline of the procedures used for each of the special or optional tests that have been specified by the Purchaser or proposed by the Vendor.	Refer to Project Specification.
10.3 Contract data	
10.3.2 Drawings and technical data	
10.3.2.3 If specified, a generic casing drawing defining casing retirement thickness(es) in critical areas shall be provided. The retirement thickness(es) shall be based on failure to comply with any of the criteria in 6.3.3 and 6.3.4.	Refer to Project Specification
Annex A (informative) Specific Speed and Suction Specific Speed	
An alternative definition of specific speed is sometimes used (flowrate per impeller eye rather than total flowrate). The purchaser is cautioned to understand which definition is being used when comparing data.	This is not an alternative definition. Specific speed shall always been calculated based on the flowrate per impeller eye.
Annex C (normative) Hydraulic Power recovery turbines	
C.3 Design	
C.3.1 Fluid Characteristic	
C.3.1.1 The Purchaser shall advise the HPRT Manufacturer whether any portion of the process stream entering the HPRT can flash to vapour and whether absorbed gas in the stream can evolve at any pressure less than the inlet pressure.	Refer to Project Specification
C.3.1.2 The Purchaser shall specify the volume percentage of vapour or gas, or both, at the turbine outlet and the pressure and temperature at which the vapour can flash off.	Refer to Project Specification

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Annex J (normative) Determination of residual unbalance	
J.4 Residual unbalance check	
J.4.1 General	
J.4.1.2 To check the residual unbalance, a known trial mass is attached to the rotor sequentially in 6 (or 12, if specified by the Purchaser) equally spaced radial positions, each at the same radial distance. The check is run in each correction plane, and the readings in each plane are plotted on a graph using the procedure specified in J.4.2.	Refer to Project Specification



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Appendix 1

Appendix 1 Data Sheets

API 610 11th Edition Data Sheets

This data sheet is intended to be used in its Excel format. As such there are numerous cells which contain drop-down selections.

As these selections are not presented to the user until the cursor is on the cell, the cells which contain a drop-down selection have been identified by colouring the cell Light Green.

In addition if the selected cell has a cross reference in the specification, a pop-up box will appear indicating the reference paragraph and some or all of the content of the referenced paragraph. These cells are coloured Light Grey

User should use 'Page Setup' to ensure printing is on the correct paper size.

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Appendix 1

TOTAL

CENTRIFUGAL PUMP DATA SHEET

1	Note	APPLICABLE TO: _____	APPLICABLE NTU/INTNTL STANDARD: _____	
2		FOR _____	UNIT _____	
3		SITE _____	SERVICE _____	
4		NO. REQ _____ PUMP SIZE _____	TYPE _____	No. STAGES _____
5		MANUFACTURER _____	MODEL _____	SERIAL NO. _____
6		LIQUID CHARACTERISTICS		
7			Units	Maximum
8			Minimum	Note
9		LIQUID TYPE OR NAME: _____		Max & min values refer only to the property listed
10		VAPOR PRESSURE: _____	Bara	
11		RELATIVE DENSITY: _____		
12		SPECIFIC HEAT: _____	kJ/(kg·K)	
13		VISCOSITY: _____	Cp	
14		OPERATING CONDITIONS (6.1.2)		
15			Units	Maximum
16			Rated	Normal
17			Minimum	
18		NPSHa Datum: _____	C.L. Impeller	
19		PUMPING TEMPERATURE: _____	°C	
20		FLOW: _____	m ³ /h	
21		DISCHARGE PRESSURE: (6.3.2) _____	Bara	
22		SUCTION PRESSURE: _____	Bara	
23		DIFFERENTIAL PRESSURE: _____	Bar	
24		DIFFERENTIAL HEAD: _____	m	
25		NPSH _A : _____	m	
26		HYDRAULIC POWER: _____	kW	
27		SITE AND UTILITY DATA		
28		LOCATION: _____		
29		MOUNTED AT: _____ ☐ TROPICALISATION REQ'D		
30		ELECTRIC AREA CLASSIFICATION: 6.1.22 ZONE _____		
31		GROUP _____	TEMP CLASS _____	
32		SITE DATA:		
33		ELEVATION (MSL): _____ m	BAROMETER: _____ mmHg	
34		RANGE OF AMBIENT TEMPS: MIN / MAX _____ / _____ °C		
35		RELATIVE HUMIDITY: MIN / MAX _____ / _____ %		
36		UNUSUAL CONDITIONS: _____		
37		UTILITY CONDITIONS:		
38		ELECTRICITY:	DRIVERS	HEATING
39			CONTROL	SHUTDOWN
40		VOLTAGE _____		
41		PHASE _____		
42		HERTZ _____		
43		PERFORMANCE		
44		PROPOSAL CURVE NO. _____	RPM _____	
45		As Tested Curve No. _____		
46		IMPELLER DIA.: RATED _____	MAX. _____	MIN. _____
47			mm	
48		RATED POWER _____	kW	EFFICIENCY _____ (%)
49		RATED CURVE BEP FLOW (at rated impeller dia) _____	m ³ /h	
50		MIN FLOW: THERMAL _____	m ³ /h	STABLE _____
51			m ³ /h	
52		PREFERRED OPERATING REGION (6.1.11) _____	to _____ m ³ /h	
53		ALLOWABLE OPERATING REGION _____	to _____ m ³ /h	
54		MAX HEAD @ RATED IMPELLER _____	m	
55		MAX POWER @ RATED IMPELLER (6.8.9) _____	kW	
56		NPSH ₃ AT RATED FLOW: _____	m	
57		CL PUMP TO U/S BASEPLATE _____	m	
58		NPSH MARGIN AT RATED FLOW: _____	m	
59		SPECIFIC SPEED (6.1.9) _____	m ³ /s, rpm, m	
60		SUCTION SPECIFIC SPEED LIMIT _____		
61		SUCTION SPECIFIC SPEED _____	m ³ /s, rpm, m	
62		MAX. ALLOW. SOUND PRESS. LEVEL REQ'D (6.1.14) _____	(dBA)	
63		EST MAX SOUND PRESS. LEVEL _____	(dBA)	
64		MAX. SOUND POWER LEVEL REQ'D (6.1.14) _____		
65		EST MAX SOUND POWER LEVEL _____		
66		DRIVER (7.1.5)		
67		Driver Type _____		
68		GEAR _____		
69		VARIABLE SPEED REQUIRED _____		
70		SOURCE OF VARIABLE SPEED _____		
71		OTHER _____		
72		MANUFACTURER _____		
73		NAMEPLATE POWER _____	kW	
74		Nominal RPM _____		
75		RATED LOAD RPM _____		
76		FRAME OR MODEL _____		
77		ORIENTATION _____		
78		LUBE _____		

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Appendix 1

TOTAL

CENTRIFUGAL PUMP DATA SHEET

1		Note		CONSTRUCTION		Rev	
2	API PUMP TYPE:	[Based on API 610 definitions]		CASING MOUNTING:			
3				CASING TYPE:		(6.3.10)	
4	NOZZLE CONNECTIONS:	(6.5.5)		OH3 BACKPULLOUT LIFTING DEVICE REQD. (9.1.2.6)			
5		Size	Facing	Rating	Position		
6	SUCTION						
7	DISCHARGE						
8	PRESSURE CASING AUX. CONNECTIONS: (6.4.3.2)	No.	Size	Type	Facing	Rating	Posn.
9							
10	BALANCE/LEAK OFF						
11	DRAIN						
12	VENT						
13	PRESSURE GAGE						
14	TEMP GAGE						
15	WARM-UP LINE						
16							
17	Drain Valve Supplied By						
18	DRAINS MANIFOLDED						
19	VENT Valve Supplied By						
20	VENTS MANIFOLDED						
21	THREADED CONS FOR PIPELINE SERVICE & < 50°C (6.4.3.2)						
22	SPECIAL FITTINGS FOR TRANSITIONING (6.4.3.3)						
23	CYLINDRICAL THREADS REQUIRED (6.4.3.8)						
24	GUSSET SUPPORT REQUIRED						
25	MACHINED AND STUDDED CONNECTIONS (6.4.3.12)						
26	VS 6 DRAIN						
27	DRAIN TO SKID EDGE						
28							
29	MATERIAL (6.12.1.1)						
30	APPENDIX H CLASS						
31	MIN DESIGN METAL TEMP (6.12.4.1)					°C	
32	REDUCED-HARDNESS MATERIALS REQ'D (6.12.1.12.1)						
33	Applicable Hardness Standard (6.12.1.12.3)						
34	BARREL :						
35	CASE :						
36	DIFFUSERS						
37	IMPELLER :						
38	IMPELLER WEAR RING :						
39	CASE WEAR RING :						
40	SHAFT:						
41	Bowl (if VS-type)						
42	Inspection Class						
43	BEARINGS AND LUBRICATION (6.10.1.1)						
44	BEARING (TYPE / NUMBER): (6.11.4)						
45	RADIAL		/				
46	THRUST		/				
47	REVIEW AND APPROVE THRUST BEARING SIZE : (9.2.5.2.4)						
48							
49	LUBRICATION : (6.10.2.2) (6.11.3) (9.6.1)						
50	PRESSURE LUBE SYSTEM TO ISO 10438- (9.2.6.5)						
51	ISO 10438 DATA SHEETS ATTACHED						
52	Pressurized Lube Oil System mtd on pump baseplate						
53	Location of Pressurized Lube Oil System mounted on baseplate :						
54	INTERCONNECTING PIPING PROVIDED BY						
55							
56	OIL VISC. ISO GRADE			VG			
57	CONSTANT LEVEL OILER :						
CASE PRESSURE RATING: MAWP : (6.3.6) Bara @ °C HYDROTEST : Bara @ °C							
HYDROTEST OH PUMP AS ASSEMBLY SUCTION PRESS. REGIONS DESIGNED FOR MAWP ROTATION: (VIEWED FROM COUPLING END) • IMPELLERS INDIVIDUALLY SECURED : • BOLT OH 3/4" PUMP TO PAD / FOUNDATION : • PROVIDE SOLEPLATE FOR OH 3/4" PUMPS							
ROTOR: SHAFT FLEXIBILITY INDEX (SFI) (9.1.1.3) First Critical Speed Wet (Multi stage pumps only) COMPONENT BALANCE TO ISO 1940 G1.0 SHRINK FIT - LIMITED MOVEMENT IMPELLERS (9.2.2.3)							
COUPLING: (7.2.3) (7.2.13.f) MANUFACTURER MODEL RATING (POWER/100 RPM) SPACER LENGTH mm SERVICE FACTOR RIGID COUPLING WITH HYDRAULIC FIT (7.2.10) COUPLING BALANCED TO ISO 1940-1 G6.3 (7.2.3) COUPLING WITH PROPRIETARY CLAMPING DEVICE (7.2.11) COUPLING IN COMPLIANCE WITH (7.2.4) COUPLING GUARD STANDARD PER (7.2.13.a) Window on Coupling Guard							
BASEPLATE API BASEPLATE NUMBER : BASEPLATE CONSTRUCTION (7.3.14) BASEPLATE DRAINAGE (7.3.1) MOUNTING : NON-GROUT CONSTRUCTION : (7.3.13) VERTICAL LEVELING SCREWS : LONGITUDINAL DRIVER POSITIONING SCREWS : SUPPLIED WITH : • GROUT AND VENT HOLES • DRAIN CONNECTION MOUNTING PADS SIZED FOR BASEPLATE LEVELING (7.3.5) MOUNTING PADS TO BE MACHINED (7.3.6) PROVIDE SPACER PLATE UNDER ALL EQUIPMENT FEET OTHER							
REMARKS :							

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1	Not	
2	SURFACE PREPARATION AND PAINT	
3	MANUFACTURER'S STANDARD	
4	OTHER (SEE BELOW)	
5	SPECIFICATION NO. _____	
6	PUMP:	
7	PUMP SURFACE PREPARATION _____	
8	PRIMER _____	
9	FINISH COAT _____	
10	BASEPLATE:	
11	BASEPLATE SURFACE PREPARATION _____	
12	PRIMER _____	
13	FINISH COAT _____	
14	DETAILS OF LIFTING DEVICES _____	
15	SHIPMENT: (8.4.1)	
16	EXPORT BOXING REQUIRED	
17	OUTDOOR STORAGE MORE THAN 6 MONTHS	
18	SPARE ROTOR ASSEMBLY PACKAGED FOR:	
19	ROTOR STORAGE ORIENTATION (9.2.8.2)	
20	SHIPPING & STORAGE CONTAINER FOR VERT STORAGE (9.2.8.3)	
21	N2 PURGE (9.2.8.4)	
22	SPARE PARTS	
23	START-UP	
24	NORMAL MAINTENANCE	
25	WEIGHTS kg	
26	ITEM No. PUMP DRIVER GEAR BASE TOTAL	
27		
28		
29		
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31		
32	OTHER PURCHASER REQUIREMENTS	
33	COORDINATION MEETING REQUIRED (10.1.3)	
34	MAXIMUM DISCHARGE PRESSURE TO INCLUDE	
35	MAX RELATIVE DENSITY	
36	OPERATION TO TRIP SPEED	
37	MAX DIA. IMPELLERS AND/OR NO OF STAGES	
38	CONNECTION DESIGN APPROVAL (9.2.1.4)	
39	TORSIONAL ANALYSIS / REPORT (6.9.2.10)	
40	PROGRESS REPORTS	
41	OUTLINE OF PROC FOR OPTIONAL TESTS (10.2.5)	
42	ADDITIONAL DATA REQUIRING 20 YEARS RETENTION (8.2.1.1)	
43	LATERAL ANALYSIS REQUIRED (9.1.3.4) (9.2.4.1.3)	
44	MODAL ANALYSIS REQUIRED (9.3.9.2)	
45	DYNAMIC BALANCE ROTOR (6.9.4.4)	
46	INSTALLATION LIST IN PROPOSAL (10.2.3.1)	
47	VFD STEADY STATE DAMPED RESPONSE ANALYSIS (6.9.2.3)	
48	TRANSIENT TORSIONAL RESPONSE (6.9.2.4)	
49	BEARING LIFE CALCULATIONS REQUIRED (6.10.1.6)	
50	IGNITION HAZARD ASSMT TO EN 13463-1 (7.2.13.9)	
51	CASING RETIREMENT THICKNESS DRAWING (10.3.2.3)	
52	FLANGES RQD IN PLACE OF SKT WELD UNIONS (7.5.2.8)	
53	INCLUDE PLOTTED VIBRATION SPECTRA (6.9.3.3)	
54	CONNECTION BOLTING (7.5.1.7)	
55	CADMIUM PLATED BOLTS PROHIBITED	
56	VENDOR TO KEEP REPAIR AND HT RCDS (8.2.1.1.c)	
57	VENDOR SUBMIT TEST PROCEDURES (8.3.1.1)	
58	SUBMIT INSPECTION CHECK LIST (8.1.5)	
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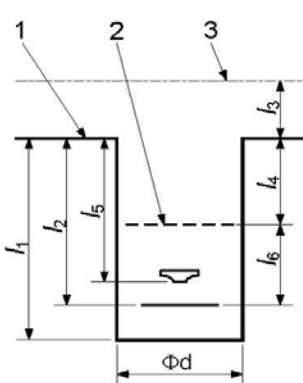
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1 Note VERTICAL TYPE (FIG 1.1)		Rev
2	REMARKS	
3		
4		
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6	VERTICAL PUMPS	
7	PUMP THRUST: (+) UP (-) DOWN	
8	STATIC THRUST	_____ N _____ N
9	AT MIN FLOW	_____ N _____ N
10	AT RATED FLOW	_____ N _____ N
11	AT MAX FLOW	_____ N _____ N
12	MAX THRUST	_____ N _____ N
13	SOLEPLATE REQUIRED	_____ X _____
14	SOLEPLATE Length x Width	_____ m _____ m
15	SOLEPLATE THICKNESS	_____ mm
16	MOUNTING FLANGE REQUIRED	_____
17	COLUMN PIPE:	
18	DIAMETER	_____ mm
19	LENGTH	_____ m
20	NUMBER	_____
21	SPACING	_____ m
22	GUIDE BUSHINGS:	
23	NUMBER	_____
24	LINE SHAFT BEARING SPACING	_____ mm
25	GUIDE BUSHING LUBE:	_____
26		
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28		
29	VERTICAL PUMPS (CONTD)	
30	LINE SHAFT:	
31	LINE SHAFT DIAMETER	_____ mm
32	TUBE DIAMETER	_____ mm
33	LINE SHAFT COUPLING:	
34	LINESHAFT CONNECTION	_____
35	• SUCTION STRAINER TYPE _____ • LEVEL CONTROL _____	
36	IMPELLER COLLETS ACCEPTABLE	_____
37	HARDENED SLEEVES UNDER BEARINGS (9.3.10.5)	_____
38	RESONANCE TEST	_____
39	STRUCTURAL ANALYSIS (9.3.5)	_____
40	DRIVER ALIGNMENT SCREWS	_____
41	SUCTION CAN	
42	SUCTION CAN	THICKNESS _____ mm
43		LENGTH _____ m
44		DIAMETER _____ mm
45	SEPARTATE MOUNTING PLATE (9.3.8.3.1)	_____
46	PROVIDE SEPARATE SOLEPLATE (9.3.8.3.3)	_____
47	DRAIN PIPED TO SURFACE (9.3.13.5)	_____
48	BOWL HEAD CALCULATION REQUIRED	_____
49	MATERIALS (additional)	
50	SUCTION CAN / BARREL:	_____
51	DISCHARGE HEAD * _____	_____
52	BOWL SHAFT :	_____
53	LINESHAFT :	_____
54	LINESHAFT HARDFACING :	_____
55	BELLMOUTH :	_____
56	BOWL BEARING :	_____
57	LINESHAFT BEARING :	_____
58	LINESHAFT SLEEVES :	_____
59	BEARING RETAINER :	_____
60	SHAFT ENCLOSING TUBE :	_____
61	DISCHARGE COLUMN :	_____
62	PRESSURE RATING:	MAWP HYDRO
63	HEAD	_____
64	COLUMN PIPE	_____
65	BOWL	_____
66	SUMP ARRANGEMENT	
67	SUMP DIMENSIONS :	
68	GRADE ELEVATION	1 _____ m
69	LOW LIQUID LEVEL	2 _____ m
70	C.L. OF DISCHARGE	3 _____ m
71	SUMP DEPTH	l_1 _____ m
72	PUMP LENGTH	l_2 _____ m
73	GRADE TO DISCH.	l_3 _____ m
74	GRADE TO LOW LIQUID LVL	l_4 _____ m
75	GRADE TO 1ST STG IMPL'R.	l_5 _____ m
76	SUBMERGENCE REQ'D	l_6 _____ m
77	SUMP DIAMETER	Φd _____ m
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TOTAL		CENTRIFUGAL PUMP DATA SHEET																									
1	Note	PRESSURE VESSEL DESIGN CODE REFERENCES																									
2		THESE REFERENCES MUST BE LISTED BY THE MANUFACTURER																									
3		CASTING FACTORS USED IN DESIGN (TABLE 3)																									
4		SOURCE OF MATERIAL PROPERTIES																									
5																											
6		WELDING AND REPAIRS																									
7		THESE REFERENCES MUST BE LISTED BY THE PURCHASER. (DEFAULT TO TABLE 10 IF NO PURCHASER PREFERENCE IS STATED)																									
8		ALTERNATE WELDING CODES AND STANDARDS																									
9		WELDING REQUIREMENT (APPLICABLE CODE OR STANDARD)																									
10		WELDER/OPERATOR QUALIFICATION																									
11		WELDING PROCEDURE QUALIFICATION																									
12		NON-PRESSURE RETAINING STRUCTURAL WELDING SUCH AS BASEPLATES OR SUPPORTS																									
13		MAGNETIC PARTICLE OR LIQUID PENETRANT EXAMINATION OF PLATE EDGES																									
14		POSTWELD HEAT TREATMENT																									
15		POSTWELD HEAT TREATMENT OF CASING FABRICATION WELDS																									
16																											
17		MATERIAL INSPECTION																									
18		THESE REFERENCES MUST BE LISTED BY THE PURCHASER																									
19		ALTERNATIVE MATERIAL INSPECTIONS AND ACCEPTANCE CRITERIA (SEE TABLE 14) (8.2.2.5)																									
20		<table border="1"> <thead> <tr> <th>TYPE OF INSPECTION</th> <th>METHOD</th> <th>FOR FABRICATIONS</th> <th>FOR CASTINGS</th> </tr> </thead> <tbody> <tr> <td>RADIOGRAPHY</td> <td></td> <td></td> <td></td> </tr> <tr> <td>ULTRASONIC INSPECTION</td> <td></td> <td></td> <td></td> </tr> <tr> <td>MAGNETIC PARTICLE INSPECTION</td> <td></td> <td></td> <td></td> </tr> <tr> <td>LIQUID PENETRANT INSPECTION</td> <td></td> <td></td> <td></td> </tr> <tr> <td>VISUAL INSPECTION (all surfaces)</td> <td></td> <td></td> <td></td> </tr> </tbody> </table>		TYPE OF INSPECTION	METHOD	FOR FABRICATIONS	FOR CASTINGS	RADIOGRAPHY				ULTRASONIC INSPECTION				MAGNETIC PARTICLE INSPECTION				LIQUID PENETRANT INSPECTION				VISUAL INSPECTION (all surfaces)			
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