



TECHNICAL REQUIREMENTS

MECHANICAL

Document No. OL-TR-MR-000

MACHINERY

Document No. OL-TR-MRR-000

CENTRIFUGAL PUMPS

Document No. OL-TR-MRR-011

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00	Final Issue	14-Sep-14	D ² RT' engineering	ORLEN Lietuva	ORLEN Lietuva
Rev.	Revision description	Date	Prep. by	Check. by	Appr. by

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1. SCOPE

1.1 The **API Standard 610 Twelfth Edition January 2021**, “*Centrifugal Pumps for Petroleum, Petrochemical and Natural Gas Industries*”, is an integral part of this job specification. The numbering of sections and paragraphs is the same as in API 610. The type of change e.g. addition, exception, modification or substitution is noted for each item.

1.2 Compliance with this job specification does not relieve the manufacturer or the vendor of the responsibility for supplying equipment of proper design and construction and fully suitable for all the specified operating conditions.

1.3 Exceptions to this and other applicable standards shall be clearly stated in vendor's proposal.

Vendor shall either submit a list of exceptions or a statement to the effect that its proposal is in full accordance with these job specification and standards. In this latter case the purchaser shall assume that the proposal includes the cost of the requirements of any of the applicable standards.

The vendor is responsible for ensuring that materials supplied by its subvendors comply with the requirements of this job specification.

2. REFERENCES

2.1 General

For references see:

- Section 2 of API Std. 610-12.

The latest editions of the following publications are to be used with this Specification as applicable:

2.2 OL Specifications

OL-TR-GR-000	<i>General Requirements</i>
OL-TR-GR-001	<i>General. Noise Level</i>
OL-TR-CR-011	<i>Civil. Corrosion Protection and Lining. Painting</i>
OL-TR-MR-000	<i>Mechanical. General</i>
OL-TR-MRR-000	<i>Mechanical. Machinery. General</i>

2.3 Local, State, National Codes and Legislations

Legislation of the Republic of Lithuanian	<i>Law on the Supervision of Potentially Dangerous Equipment No. I-1324 („Lietuvos Respublikos Potencialiai pavojingų įrenginių priežiūros įstatymas Nr. I-1324 (aktuali redakcija nuo 2011 -07-19)“)</i>
Legislation of the Republic of Lithuanian	<i>Law on Assessment of Conformity VIII-870 („Atitikties įvertinimo įstatymas VIII-870“)</i>

Legislation of the Republic of Lithuanian	<i>Technical Regulation on Pressure Equipment (Slėginių įrenginių techninis reglamentas)</i>
Legislation of the Republic of Lithuanian	<i>Technical Regulations for Equipment and Protection Systems Used in Potentially Explosive Atmosphere („Įrangos ir apsaugos sistemų, naudojamų potencialiai sprogioje aplinkoje, techninis reglamentas“)</i>
STR 1, 2 (Legislation of the Republic of Lithuanian)	<i>Technical regalement's of construction</i>

2.4 Others

Equipment shall comply also with the following:

2.4.1 Data sheet acc. to API Std. 610-12, Annex N (pages 198-204, SI units).

2.4.2 Pressure equipment, as defined in Pressure Equipment Directive (P.E.D.) 97/23/CE article 1, shall fully satisfy the P.E.D. essential safety requirements. In particular, design and construction shall be carried out by Manufacturer according to ASME or EN code, as amended under the supervision and approval of the nominated Notified Body, to fulfill P.E.D. requirements;

2.4.3 Equipment and Protection Systems intended for use in Potentially Explosive Atmospheres, shall be in full compliance with Directive 94/9/CE (ATEX) requirements.

NOTES:

- (1) *Detailed information relevant to Area Classification, Group, Ignition Temperature etc., shall be as indicated on individual Material Requisition.*
- (2) *Manufacturer shall affix the CE marking and shall prepare a declaration of conformity for the Equipment. Nomination of a Notified Body shall be made as needed.*

2.4.4 Compliance with European Directives includes all needed/requested CE nameplates, marking, declaration of conformity, operating instruction manuals etc.

3. TERMS AND DEFINITIONS

For terms and definitions see:

- Section 3 of API Std. 610-12.

4. REVISIONS TO API STANDARD 610

All headings contained herein correspond to paragraph numbering within API STD 610-12. All requirements specified in this specification are additions to those of API STD 610-12 unless specifically noted as exceptions. Paragraph numbers in this specification which do not appear in API STD 610-12 are new paragraphs.

4.1 Modifications to Section 1: General

1.1 New Paragraph: Vendor Qualification

Equipment offered by vendor shall satisfy the following minimum service and manufacturing experience requirements:

Pumps shall be identical or validly similar in power rating, speed, suction and/or discharge pressure as more appropriate, mechanical design, materials and rotor

dynamics as compared with at least two units produced at the proposed manufacturing plant. These units must have had at least one year's satisfactory operation.

1.2 New Paragraph: Conflicting Requirements

The local laws and regulations and hierarchically the specific requirements stated in the purchase order and material requisition shall take precedence over this job specification. The vendor shall in any case notify the purchaser of any possible conflict for resolution.

1.3 New Paragraph: Other Requirements

Proposals to furnish pumps or mechanical seals that do not meet all requirements of this specification (based on specific nonflammable, non-hazardous service conditions) shall be submitted to Purchaser for approval by the OL's Engineer.

4.2 Modifications to Section 4: Classification and Designation

4.2.2.2 Clarification: Pump Designations and Descriptions. Pump Type OH1

Pump type OH1 is acceptable for service temperatures below 150°C.

4.2.2.11 Clarification: Pump Designations and Descriptions. Pump Type BB4

Pump type BB4 is not accepted other than, when specifically approved, in water service.

4.3 Modifications to Section 6: Basic Design

6.1.9 Clarification: General

The NPSHA shall exceed the NPSHR by at least 0.3 m, over the entire anticipated operating range.

6.1.11 Addition: General

Unless otherwise agreed upon, pump suction specific speed shall be limited to 213 (11,000 in US units); except for pumps with an anticipated operating range down to 40% or below of their peak efficiency capacity, or water where the suction specific speed shall not exceed 194 (10,000 in US units). Pumps with suction specific speeds higher than those specified require purchaser review and approval. (Consideration shall also be given to fluid properties, NPSHA to NPSHR ratio, pump specific speed, shaft to impeller eye diameter ratio, type of process control, etc.).

6.1.12 Addition: General

Pumps handling high viscosity fluids (typically ≥ 400 cP), or products with higher than ambient pouring temperature shall be provided with heating jackets to the casing and stuffing box.

Vendor shall advise the maximum allowable viscosity at pump start-up.

6.1.13 Addition: General

- a) The head curve for the pump shall be continuously rising from the rated capacity point to the shutoff point. The pump head at shutoff shall be at least 110 percent of the head at the rated capacity point.
- b) The pump head at shutoff shall not exceed 120 percent of the head at the rated capacity point without approval of the OL's Engineer.
- a) Pumps for parallel operation shall have equal head rise (within 1 percent, as measured on the performance test) to shutoff.
- b) Low capacity, high head pumps may be exempt from the requirements of Section 6.1.11.a) and 6.1.11.b) of this specification, with approval of the OL's Engineer.

6.1.13 Exception: General

Proposals to use orifices as a means of providing a continuous rise to shutoff shall be submitted to Purchaser for approval by the OL's Engineer.

6.1.19 Exception: General

Pump Vendors shall furnish noise emission data for the quoted equipment with their proposal according to OL-TR-GR-001.

Should the pumping unit generate a noise level higher than specified, vendor proposal shall include and describe the proposed provisions to guarantee the required noise level.

6.1.20 Addition: General

Impeller blades under-filing, over-filing or V-cutting is not allowed on corrosive or erosive service.

6.1.22 Addition: General

Application of pump cooling water shall be as follows:

- a) Pumps with non-pressurized bearing lubrication, and pumping temperatures under 200°C (400°F) shall be designed to operate continuously without use of cooling. Bearing oil temperatures shall not exceed those of API STD 610-12, Paragraph 6.10.2.7, and shall assume no credit for motor cooling air. Cooling water may be used for cooling seal flush liquid to assure proper mechanical seal operation.
- b) Pumps with pressurized lubrication or pumping temperatures over 200°C (400°F) may utilize cooling water only where required for cooling of bearing oil, seal chambers, or seal flush liquid. Pumps with non-pressurized lubrication and pumping temperatures over 200°C (400°F) shall be furnished with bearing housing water jackets. Water jacket connections shall be plugged unless cooling is required.

6.1.42 New Paragraph: General

Pumps fitted with inducers shall not be selected, unless specifically approved by purchaser.

6.1.43 New Paragraph: General

Pumps and each component part thereof, which because of the weight, size or shape cannot be handled by hands, shall be provided with lifting lugs or equivalent features.

6.2.1 Clarification: Pump Types

Pump types listed in Table 3 of API Std. 610-12 are not accepted, except OH1 horizontal foot-mounted overhung (up to 150°C), and BB4 ring-section casing (multistage), when has specifically approved, on water service.

6.3.2 Clarification: Pressure Casings

Unless otherwise specified, the maximum discharge pressure shall consider the maximum specified relative density.

6.3.5 Addition: Pressure Casings

For low relative density applications, considerations shall be given in rating casing, seals and appurtenances for field water run-in (when specified) and/or full speed shop testing, as applicable.

6.3.6 Substitution: Pressure Casings

Unless otherwise specified or agreed upon, suction regions shall be designed for the same MAWP as the discharge section.

6.3.7 Addition: Pressure Casings

If more than 3 mm (1/8") corrosion allowance is required in cast iron and carbon steel casings, it will be specified.

6.3.8 Modification: Pressure Casings

After “maximum differential pressure” add: inclusive of the additional pressure resulting from the allowances applied in paragraph 6.3.5.

6.4.1.2 Exception: Nozzles and Pressure Sizing Connections. Casing Opening Sizes

Connections for the liquid barrier/buffer of dual seals shall be at least DN20 (3/4”) nominal pipe size, regardless of pump size.

6.4.1.2 Addition: Nozzles and Pressure Sizing Connections. Casing Opening Sizes

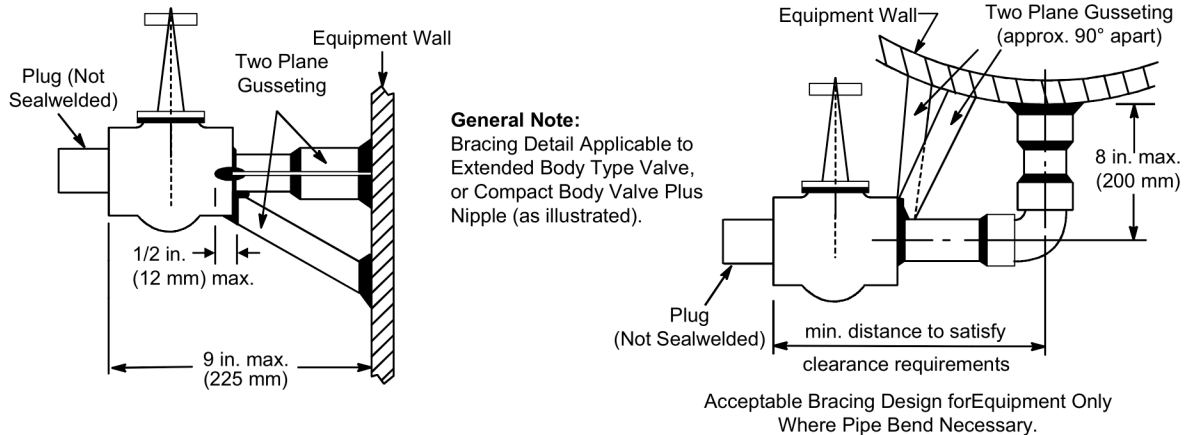
- Valved vent and drain connections shall be braced and supplied with threaded, non-seal welded round head plugs according to ASME B16.11.
- Bracing design shall be as shown in Figure 1 of this specification.
- Drain connections of pumps handling fluids with a viscosity ≥ 400 cP or products with higher than ambient pouring temperature shall be 1” minimum and run as straight as feasible.
- Connections for the liquid barrier/buffer of dual seals and for the seal plan 23 shall be at least DN20 (3/4”). If DN20 (3/4”) connections are not feasible, DN15 (1/2”) connections with adapters to DN20 (3/4”) pipe can be alternatively be supplied.

6.4.2.1 Modification: Nozzles and Pressure Sizing Connections. Suction and Discharge Nozzles

Unless otherwise specified or agreed upon, suction and discharge flanges shall have equal rating.

6.4.3.4 Exception: Nozzles and Pressure Sizing Connections. Auxiliary Connections

Auxiliary connections less than DN25 (1”) to the seal gland shall be threaded.



Notes:

- Gusseting material for welded gussets shall be of the same nominal chemistry as the connected parts except that carbon steel may be used for gusseting P-1, P-3, P-4, and P-5 materials.
- Connections shall be braced in two planes with gussets having a minimum thickness of 3/16 in. (5 mm), minimum width 3/4 in. (19 mm) as shown above.
- * Gusset attachment welds to a pressure boundary shall be postweld heat treated (PWHT) whenever: (1) PWHT is required for all welds, based on service conditions (see API STD 610, Paragraph 2.11.3.4.4; (2) PWHT is required in the alloy steel component to which the attachment is to be made, based on ASME B31.3 PWHT criteria for butt welds in alloy steel materials, whether or not butt welds are used in the assembly.
- * Proposals to use clamped or bolted gusset designs shall be submitted to Purchaser for approval by the Owner's Engineer.
- * Bracing design for piping connections requiring double block valves shall be submitted to Purchaser for approval by the Owner's Engineer.

Figure 1. Bracing Design for Nozzle and Pressing Casing

6.4.3.5 Exception: Nozzles and Pressure Sizing Connections. Auxiliary Connections

Tapped openings not connected to piping shall be plugged with round head plugs furnished according to the requirements of ASME B16.11. The plugs shall meet the material requirements of the casing. Plugs requiring removal for maintenance or operation shall not be seal welded. Plugs NOT requiring removal shall be seal welded according to this specification, **Section 6.4.3.11 Addition**. Plastic plugs are not permitted.

6.4.3.5 Addition: Nozzles and Pressure Sizing Connections. Auxiliary Connections

Seal welding of all threaded plugs and connections shall be as follows:

- a) Connections requiring seal welding shall be made up without the use of sealing compounds or PTFE tape. All cutting oil used shall be removed prior to assembly. After the joint has been tightened to full thread engagement, the seal welding shall cover all exposed threads or 6 mm (1/4") minimum.
- b) Seal welding shall be done with electrodes not to exceed 3.2 mm (1/8") in diameter, using amperage in the low range to avoid distortion of the connection or part being welded.

6.4.3.5 Clarification: Nozzles and Pressure Sizing Connections. Auxiliary Connections

Tapped openings, which do not require removal, shall be seal welded.

6.4.3.7 Exception: Nozzles and Pressure Sizing Connections. Auxiliary Connections

Drilled or tapped openings in the suction volutes, discharge volutes, or other high velocity areas are not permitted if the specified corrosion allowance of the pump casing is more than 3 mm (1/8"), or if the pump is in acid or erosive service. Suction nozzles, discharge nozzles, and seal chambers are not considered high velocity areas. Bosses for future casing drain openings shall be provided.

6.4.3.7 Addition: Nozzles and Pressure Sizing Connections. Auxiliary Connections

- a) Connections for mechanical seal self-flushing lines shall be made on the suction nozzle, the discharge nozzle, both nozzles, or the pump casing, if drilling and tapping of the casing is permitted.
- b) Drain openings shall be plugged with round head plugs according to ASME B16.11 unless a valved drain is specified.
- c) All pumps in vacuum service shall have valved casing vents.
- d) All required vents shall be valved.
- e) Gate valves according to OL-TR-MPR-001 shall be used for vents and drains. The socket weld or seal weld at the connection of extended body valves to fittings or the pump casing shall have a complete bridge weld from fitting or casing to the body of the valve.

6.4.3.7 Clarification: Nozzles and Pressure Sizing Connections. Auxiliary Connections

Pumps in corrosive or erosive service shall not feature vent and drain connections located in high-velocity sections.

6.4.3.11 New Paragraph: Nozzles and Pressure Sizing Connections. Auxiliary Connections

High temperature multistage pumps shall be provided with adequate warm-up casing connections to prevent pump thermal distortion in hot stand-by condition. Proposed

warm-up arrangement shall be submitted at proposal stage, together with the required product flowrate.

6.5.1 Exception: Nozzles and Pressure Sizing Connections. External Nozzle Forces and Moments

Pumps with nozzles DN400 (16") and smaller in size, with casings constructed of steel or alloy steel, shall be capable of satisfactory operation when subjected to forces and moments according to API STD 610-12, Paragraph F1.2 of Appendix F.

6.5.3 Addition: Nozzles and Pressure Sizing Connections. External Nozzle Forces and Moments

For pumps with casings constructed of materials other than steel or alloy steel and for pumps with nozzles larger than DN400 (16"), allowable nozzle loads shall be submitted to the Purchaser for approval by the OL's Engineer.

6.6.2 Modification: Rotors

Fabricated impellers require purchaser approval.

6.6.5 Modification: Rotors

Solid hub impellers are required.

Cast iron impellers are not allowed on applications with tip speed above 50 m/s.

6.6.6 Addition: Rotors

Where set screws or other methods for sleeve attachment are used which may cause upsetting of the shaft and resultant difficulty in removal of the sleeve, the shaft shall be relieved in the area of the set screw application a minimum of 1 mm (0.040 in.) diametrical.

6.6.14 New Paragraph: Rotors

The shaft shall be designed to transmit momentarily at least four times the rated torque of the pump driver.

6.7.1 Addition: Wear Rings and Running Clearances

When specified, provision shall be made for flushing wear rings and throat bushings. Flushed wear rings shall have a circumferential groove to provide distribution of flushing fluid. The axial position of the groove shall be selected to provide equal flow to the high and low pressure sides of the wear rings.

6.7.1 Exception: Wear Rings and Running Clearances

Integral impeller wear surfaces must be approved by the OL's Engineer.

6.7.1 Clarification: Wear Rings and Running Clearances

Unless otherwise specified or agreed upon, impellers shall have renewable wear rings.

6.7.2 Addition: Wear Rings and Running Clearances

Pumps handling fluids containing coke particles or in slurry services shall be provided with wear rings and all other close fit areas hard-faced to a minimum 600 HB. In presence of solid particle content in excess of 3% wt, flushing provisions with flanged connections and blinds shall also be incorporated to all close clearance areas.

6.8.1 Exception: Mechanical Shaft Seals

Mechanical seals shall be furnished unless otherwise specified except for:

- a) Firewater pumps;
- b) Water treatment plant pumps;
- c) Equipment cooling system pumps;
- d) Other water pumps approved by OL's Engineer,

which shall have packing.

6.8.1 Exception: Mechanical Shaft Seals

Unless otherwise specified, mechanical seals shall be according to OL-TR-MRR-013.

6.8.3 Exception: Mechanical Shaft Seals

In addition to the bolting, the allowable stress used to design all pressure-containing components (except the seal faces) shall not exceed the values for the material given in ASME (ASME SEC VIII D1) when a differential pressure equal to the rated discharge pressure is applied to the component. An example would be the cartridge of a pressurized dual seal.

6.8.14 New Paragraph: Mechanical Shaft Seals

Materials for self-flushing liquid coolers shall be according to Table 1 of this specification.

Table 1. Self-Flushing Liquid Materials

Cooling Media	Tube Coil	Casing (or Shell)
Fresh Water	Type 316 Stainless Steel or Monel	Carbon Steel
Salt or Brackish Water	Monel	Carbon Steel
Air	Type 316 Stainless Steel with Aluminum or Stainless Steel Fins	—

NOTE: Cooling water shall be on the casing side. Tubing shall be a minimum of DN20 (3/4") nominal size with minimum 1.2 mm (0.065") wall thickness.

6.8.15 New Paragraph: Mechanical Shaft Seals

Mechanical seal sleeves shall be hardfaced with Colmonoy 6TM or equal, on surfaces under dynamic seal rings and close clearance floating throttle bushings.

6.8.16 New Paragraph: Mechanical Shaft Seals

Use of external flushing shall be jointly reviewed with purchaser. Vendor shall advise the minimum required sealant pressure, and the required flowrate.

6.9.2.9 Addition: Dynamics. Torsional Analysis

When a torsional analysis is performed, a detailed report shall be provided to Purchaser for approval by the OL's Engineer.

6.10.1.4 Addition: Bearings and Bearing Housings. Bearings

Thrust bearings of single stage pumps in high suction pressure service shall be rated for continuous operation at the maximum specified suction pressure, and shall be adequate for any other suction pressure down to 3.5 bar(g) (plant startup). The design basis shall consider a minimum suction pressure operation of at least 400 hours/year.

6.10.1.12 Addition: Bearings and Bearing Housings. Bearings

Rolling element bearings shall feature metallic cage.

6.10.1.13 New Paragraph: Bearings and Bearing Housings. Bearings

Unless specified otherwise, cages for angular contact thrust bearings shall be of machined bronze or brass.

6.10.2.3 Addition: Bearings and Bearing Housings. Bearing Housings

When pumps are specified for wet sump oil mist lubrication, constant level oilers shall not depress or modify oil level due to pressure build-up in the bearing housing.

6.10.2.8 Addition: Bearings and Bearing Housings. Bearing Housings

Material for cooling coils shall be according to ASTM B 111 Alloy C44300, C44400, or C44500.

Pump designs intended for fan cooling but built without fan shall permit its future retrofit with minimum part replacement.

6.11.1 Addition: Bearings and Bearing Housings. Lubrication

Considerations shall be given to lubrication in case of variable-speed applications or slow-roll turbine driven idling pumps.

6.12.1.3 Exception: Materials. General

12 percent Chrome castings shall be according to ASTM A 487/A 487M, Grade CA6NM.

6.12.1.3 Addition: Materials. General

- a) Monel castings for general service shall be according to ASTM A 494/A 494M, Grade M-30C or M35-1, and shall be tested for weldability according to ASTM A 494/A 494M S.22.
- b) Materials not in accordance with Appendix "H" shall be stated in the proposal as a deviation from the specifications. Explanations for deviations and description of successful experience with the proposed materials in the service quoted shall be included in the proposal. When materials of construction are specified in the material requisition, the vendor shall not make any substitutions without prior written approval.
- c) Cast Iron casings (Material codes: I-1 and I-2) require the previous purchaser approval.

6.12.1.5 Addition: Materials. General

Impellers for category S-1 shall be carbon steel equivalent to S-4.

6.12.1.8 Clarification: Materials. General

Chemical and mechanical data for the heats from which the material is supplied shall be furnished for pressure casing parts on flammable, corrosive or toxic services, and on all applications above 260°C.

6.12.1.13 Clarification: Materials. General

Pump components in any wet H₂S service, including traces, shall meet hardness and yield strength requirements of NACE MR0103 or NACE MR0175, as applicable.

6.12.1.18 New Paragraph: Materials. General

Asbestos and its compounds, or other carcinogenic fibers classified under any of the applicable Hazard Warning Directive shall not be used in any form.

6.12.2.3.a) Exception: Materials. Castings

Welding shall be performed according to OL-TR-MR-001.

6.12.2.5 Addition: Materials. Castings

Casting repair procedures shall be submitted for review and approval by the OL's Engineer whenever repairs are required which meet the following criteria. Defect charts shall be submitted for review prior to start of repairs. The following repair castings shall be inspected:

- a) Repairs required after final heat treatment;
- b) Repairs made due to the inability of the pump to pass hydrostatic testing;
- c) Repairs that exceed 6500 mm² (10 in.²);

- d) Repairs that result in a repair cavity that exceeds 20 percent of the casting wall thickness or DN25 (1”), whichever is less.

6.12.2.5 Clarification: Materials. Castings

Weld procedures for all major repair welding's on pressure containing parts shall be submitted to purchaser for approval.

6.12.3.1 Exception: Materials. Welding

Welding shall be performed according to OL-TR-MR-001.

6.12.3.4.c) Addition: Materials. Welding

PWHT is required for all carbon and ferritic alloy steel pressure-containing components that are welded and/or weld repaired, when the weldment is exposed to a process containing wet H₂S. The PWHT procedure outlined in ASME SEC VIII D1, Paragraphs UW40, UW49, UHA32, and UCS 56, (ASME SEC VIII D1) shall be followed, except that the notes in ASME SEC VIII D1, Tables UHA 32 and UCS 56 do not apply. All welds (regardless of type or size) that are exposed to wet H₂S shall be PWHT at a minimum temperature of 620°C (1150°F). External attachments or seal welded threaded connections on P-1 Group 1 and 2 materials do not require PWHT.

6.12.3.4.c) Clarification: Materials. Welding

Wetted parts subject to welding shall be stress relieved, when presence of H₂S (including traces) is specified, to meet the yield strength and hardness requirements.

6.12.3.4.d) Modification: Materials. Welding

Unless otherwise specified, magnetic particle or liquid penetrant inspection of auxiliary connection welds is required.

4.4 Modifications to Section 7: Accessories

7.1.1 Addition: Drivers

Electric motor drivers shall be according to OL-TR-ER-009, as applicable.

Motor manufacturer shall be selected within the specified vendor list and to be approved by purchaser.

The intent of this requirement is to select motors from a single motor supplier to the greatest extent possible for a single plant site.

7.1.5 Addition: Drivers

Driver and transmission rating for pumps in parallel operation and for pumps being specified for automatic open valve start shall cover the maximum anticipated absorbed power, typically at end-of-curve operation.

When field water run-in is specified, driver and transmission ratings shall be checked for operation with water at minimum continuous flow.

7.1.7 Addition: Drivers

Rolling element bearings of any drive component shall feature metallic cage.

7.1.8 Exception: Drivers

All motors for vertical pumps shall meet the shaft and base tolerances shown in API STD 610-11, Figure 36.

7.1.10 Exceptions: Drivers

Steam turbine drivers shall be according to OL-TR-MRR-041.

7.1.11 Addition: Drivers

Unless otherwise specified, gears shall be according to OL-TR-MRR-051.

7.2.2 New Point: Couplings and Guards

- g) Couplings shall be of steel, and of the non-lubricated disc type with stainless steel discs.
- h) The minimum coupling service factor shall be 1.5.

7.2.2 Clarification: Couplings and Guards

Couplings shall be fail-safe multiple-disc, spacer type, with stainless steel discs and steel hubs, supplied by manufacturers approved by purchaser.

7.2.3 Addition: Couplings and Guards

Coupling selection shall be based on motor direct starting and, as a reference, on a locked rotor torque of 250 percent of rated torque.

Couplings, coupling-to-shaft junctures and any other torque transmission component shall be suitable to sustain peak torque transients due to short circuits and motor re-acceleration following momentary power interruptions (typically 5 times the rated torque).

7.2.7 Clarification: Couplings and Guards

Where servicing the mechanical seal requires the removal of the coupling hub, the hub shall be mounted with a taper fit for any shaft diameter.

7.3.2 New Point: Couplings and Guards

- e) When specified, the guard shall be furnished with a hinged door to provide access for inspection of the flexible elements.
- f) Non-sparking guards shall be used in hazardous area applications.

7.4.8 Exception: Baseplates

Additionally, each pad shall be level in all directions within 80 $\mu\text{m}/\text{m}$ (0.001 in./ft). Baseplates longer than 4 m shall be provided with leveling pads or targets welded and machined along the longitudinal beams for field leveling on the foundation.

7.4.9 Addition: Baseplates

All shims shall straddle hold down bolts and shall provide full support under the feet of drivers.

7.4.9 Clarification: Baseplates

Pump vendor shall provide the necessary driver hold-down bolts, washers, shims and dowel pins also in case the driver supply and/or mounting is by others. The bolts shall be hexagonal headed type, threaded in accordance with metric threads.

On shipment, above materials shall be securely fastened to pump baseplate.

7.4.14 Exception: Baseplates

Baseplate grouting holes shall be accessible without moving the machinery.

7.4.14 Clarification: Baseplates

The grout holes shall be so located to be accessible for grouting with the pump and driver installed on the baseplate.

The grouting holes shall be provided in each bulkhead section delimited by cross members, irrespective whether full or partial depth.

7.4.25 New Paragraph: Baseplates

All baseplates shall be provided with two diagonally oriented earthing bosses.

7.4.26 New Paragraph: Baseplates

Unless otherwise specified, the vendor shall prepare all grout contact surfaces of the baseplate for a non-shrinking cementitious grouting.

7.5 Exception: Instrumentation

When seals are specified NOT to be according to OL-TR-MRR-013, instrumentation shall be according to API STD 610-12 (Paragraph 7.5.1).

7.5.2.1/2/3/4/5/6/7 Clarification: Instrumentation. Vibration, Positioning and Temperature Detectors

Unless otherwise specified, when a bearing monitoring system is supplied it shall be installed, tested and calibrated in accordance with API Std. 670.

7.5.2.8 New Paragraph: Instrumentation. Vibration, Positioning and Temperature Detectors

Unless otherwise specified, controls and instrumentation shall be designed for outdoor installation and shall meet the requirements of IP 65 as detailed in IEC 60529 (NEMA 4, Publication 250) for mechanical protection and, when applicable, the pertinent section of IEC 60079 for protection against explosive atmosphere

7.6.1.5 Addition: Piping and Appurtenances. General

The proposed auxiliary piping layout, including type and orientation of battery limit connections shall be subject to purchaser approval. All battery limit connections shall be flanged.

7.6.1.6 Clarification: Piping and Appurtenances. General

Each piping system shall be manifolded to a single purchaser's inlet and outlet connection near the edge and within the confines of the baseplate.

7.6.1.9 New Paragraph: Piping and Appurtenances. General

All threaded connections shall be made up without the use of thread compounds or PTFE tape, and shall be seal welded except the following:

- a) Instruments downstream of valved take-off connections;
- b) Thermowells and other instruments requiring removal for maintenance;
- c) Valve outlets that are plugged or capped (see para. 6.4.1.2.b)) of this specification)
- d) Seal gland connections;
- e) Tubing fittings;
- f) Ring threads of pipe unions;
- g) Cast or nodular iron casings;

Seal welding shall be done according to para. 6.4.3.11 of this specification.

7.6.2.2 New Paragraph: Piping and Appurtenances. Auxiliary Process Liquid Piping

Auxiliary process piping shall be provided with a minimum corrosion allowance of 1.5 mm (0.060") unless otherwise specified.

7.6.2.4 Addition: Piping and Appurtenances. Auxiliary Process Liquid Piping

All orifice plates shall have a tab extending from the union or flange where they are installed to indicate their location. The tab shall be stamped with the orifice size.

Orifice plates shall be installed between a pair of flanges and shall incorporate a tang stamped with the bore diameter, line size and plate material.

7.6.2.7 Addition: Piping and Appurtenances. Auxiliary Process Liquid Piping

The design pressure of exchanger cooling water side shall be \geq at 0.77 times the process side.

7.6.2.8 Exception: Piping and Appurtenances. Auxiliary Process Liquid Piping

Except at mechanical seal glands, flanged connections are required throughout.

7.6.2.11 New Paragraph: Piping and Appurtenances. Auxiliary Process Liquid Piping

Piping supplying external flushing liquid to pump mechanical seals or wear rings shall be provided with the following features as a minimum, to be furnished by Purchaser or Vendor, as specified and meeting the pump casing pressure and temperature capability:

- a) Separate hand control valve and flow indicator for flow regulation to each seal chamber and close clearance injection point, with the valve located downstream from the indicator.
- b) Flow indicators shall be rated for the pressure and temperature of the pump casing as a minimum.
- c) Block valve in each supply lateral upstream from the flow regulation devices.
- d) Check valve in each supply lateral downstream from the flow regulation and flow indicating devices.

7.6.3.1 Addition: Piping and Appurtenances. Cooling-Water Piping

Cooling water harness shall include sight flow indicators (Refer to para. 7.5.3.3), inlet/outlet shutoff valves, as well as, valved high point vents and low point drains.

The standard cooling water piping material shall be galvanized steel ASTM A-53 sch. 40, or carbon steel ASTM A-106 sch. 80 up to DN40 (1-1/2") and sch. 40 for DN50 (2") and larger.

Valve material shall be of same metallurgy of the pipe.

7.5.3.4 New Paragraph: Piping and Appurtenances. Cooling-Water Piping

Sight flow indicators (bull-eye, with flapper or equivalent) shall be furnished in each return branch line.

7.5.3.5 New Paragraph: Piping and Appurtenances. Cooling-Water Piping

Inlet and outlet manifolds shall include parallel branches to barrier/buffer seal reservoirs, driver bearings and seal exchangers, as applicable.

4.5 Modifications to Section 8: Inspection, Testing and Preparation for Shipment

8.1.1 Clarification: General

The extent of inspection and testing participation, as well as the advance notice, are defined in the equipment data sheets, and OL specification OL-TR-MRR-000.

8.1.6 Modification: General

The vendor shall provide, at an early stage of the contract, a quality control plan listing the proposed program of inspection and testing, for purchaser review and agreement, on the items to be witnessed or observed and the hold points.

8.2.1.3 New Point: Inspection. General

- c) Positive Material Identification (PMI) shall be according to OL-TR-MR-002.

8.2.1.5 New Paragraph: Inspection. General

Inspection shall include verification of the equipment dimensions, compliance with baseplate machining tolerances after all machining steps, examination of test data, and checking preparation for shipment. For services with pumping temperatures 260°C (500°F) or higher, the Inspector shall verify that the internal clearances conform to those given in API STD 610-12, Paragraph 6.7.5.

8.2.1.6 New Paragraph: Inspection. General

Inspection shall include suborders, materials, welding, heat treatment, repairs, non-destructive testing, dimensional check, approval of test data and certification, final inspection prior to shipment and, when applicable, verification of the statutory certification, such as European Community Directives and associated "CE" marks, etc.

8.2.2.1 Addition: Inspection. Pressure-Casing Material Inspection

Final acceptance testing of parts requiring magnetic particle, liquid penetrant, radiographic, or ultrasonic examination shall be made after all machining has been completed.

8.2.2.7 Clarification: Inspection. Pressure-Casing Material Inspection

Hardness of parts, welds, and heat-affected zones shall be verified on H2S service.

8.3.1.1 Clarification: Testing. General

The vendor shall supply for review and approval the procedures for all running tests and all specified optional tests.

8.3.1.2 Addition: Testing. General

As a minimum, inspection and testing of all pumps shall be conducted according to Table 2 of this specification.

Table 2. Pump Testing Procedures

Inspection or Test	Required	Witnessed	Certified Data
Hydrostatic Test	Yes	No (4)	Yes
Performance Test	Yes	No (2)	Yes
NPSH Test	(1)	No	Yes
Inspection by Purchaser	Yes	—	—
Dismantled Inspection	(3)	—	—
Notes: 1) If the NPSH required by the pump differs from the specified available NPSH by 1.0 m (3 ft) or less, an NPSH suppression and performance test is required. 2) Performance tests shall be witnessed if: a) The manufacturing facility has no previous experience with the pump. b) Manufacturer has made significant changes to standard designs in critical areas such as hydraulic balance and shaft sealing. 3) Each pump receiving a witnessed performance test shall be dismantled by Manufacturer for inspection by Inspector following the final performance test, inspection shall include bearings and housings. 4) Hydrostatic tests shall be witnessed for all high alloy castings (e.g., 300 series S. S., Incolloy, Inconel, and Monel).			

8.3.1.2 Modification: Testing. General

Unless otherwise agreed upon, the shutoff head, inclusive of the positive tolerance shall not exceed the 120% of rated head.

Unless otherwise agreed upon, no negative tolerance shall be applied to pumps intended for parallel operation.

8.3.2.2 Exception: Testing. Hydrostatic Test

Sections and components of vertically suspended, multistage horizontal, and double casing pumps designed according to para. 6.3.6 of this specification shall have hydrostatic test pressure at least equal to casing maximum allowable working pressure.

8.3.2.6 Addition: Testing. Hydrostatic Test

- a) Mechanical seal flushing liquid coolers shall be hydrostatically tested to at least the same pressure as the pump casing.
- b) Hydrostatic testing, whether on a component basis or assembled pump, shall be done after all machining and welding (such as piping connections, drain, vents, seal welding) has been completed and all plugs installed.

8.3.3.2.1 Addition: Testing. Performance Test

- Seal chamber pressure shall be measured at each point during the pump performance test.
- Vendor shall ensure that measured seal chamber pressures (when corrected for rated suction pressure and specific gravity) are consistent with those assumed in designing the mechanical seal. In addition, the suitability of the seal maximum dynamic pressure rating shall be confirmed.
- Corrective steps needed to improve seal design or seal chamber operating conditions shall be submitted to Purchaser for approval by the OL's Engineer.
- If a tight shutoff auxiliary containment seal is used, the cavity between the main and auxiliary seals shall be vented during testing to confirm the acceptable operation of the main seal.

8.3.3.2.7 Addition: Testing. Performance Test

Unless otherwise specified, each pump shall be given a “witnessed” test in the following cases:

- Pumps rated ≥ 110 kW;
- Pumping temperature $\geq 260^{\circ}\text{C}$;
- Vertical multistage process pumps;
- Pumps operating in parallel;
- Multistage (3 or more stages) horizontal pumps;
- Pumps with normal specified capacity lower than pump minimum continuous flow (minimum flow shall be checked and recorded);
- Pumps with orifice plate or equivalent, on discharge nozzle;
- Prototype, or pumps operated beyond previous vendor experience;
- Pumps supplied by new vendors.

Following a witnessed test, each pump shall be given a witnessed post-test internal inspection.

8.3.3.3 Addition: Testing. Performance Test

All pumps shall be operated for at least one hour at rated capacity. One of the data points shall be the rated point.

8.3.3.5 Exception: Testing. Performance Test

In no case shall the minus tolerance allowance for shutoff head exceed 2 percent. The shutoff head with the positive tolerance allowance included shall not exceed 120 percent of the head at rated capacity unless previously approved by the OL's Engineer (see para. 6.1.13.b) of this specification).

8.3.3.8.1 Clarification: Testing. Performance Test

Any filing, grinding or other reworking of the impellers to meet the guaranteed performances shall be described in the test report and part list in sufficient detail to permit re-ordering of new impellers similarly reworked and/or supplied at the appropriate (without any blade filing) trimming diameter.

8.3.3.8.2 Clarification: Testing. Performance Test

Disassembly of multistage pumps for any head adjustment (inclusive less than 5% diameter change) after test shall be cause for retest.

8.3.3.10 New Paragraph: Testing. Performance Test

Unless otherwise agreed upon, no contract motors shall be used for conducting the performance test. A calibrated and certified shop motor or a torque meter shall be used for evaluating pump rated power.

8.3.3.11 New Paragraph: Testing. Performance Test

If Purchaser's driver is used for the performance test, it shall not be operated above nameplate power.

8.3.4.2.1 Clarification: Testing. Mechanical Run Test

The pump shall be run on the test stand until oil temperature stabilization has been achieved.

8.3.4.3.1 Addition: Testing. NPSH Required Test

- a) NPSH test shall be performed if the NPSH required by the pump differs from the specified available NPSH by 1.0 m (3 ft) or less. See Paragraph 8.3.1.2 of API STD 610-12.
- b) A vacuum tank suppression test is required unless suction valve throttling has been approved by the OL's Engineer.

8.3.4.5 Clarification: Testing. Sound Level Test

Sound level measurements shall be taken and recorded during the performance test, and witnessed as applicable.

8.4.2 Modification: Preparation for Shipment

Preparation for shipment shall be in accordance with the requirements stated in the purchase documents.

8.4.3.4 Exception: Preparation for Shipment

Painting of unmachined exterior surfaces for corrosive chemical or marine atmospheres will be specified.

8.4.3.4 Modification: Preparation for Shipment

The painting of all exterior surfaces shall be suitable for the specified environment. The paint, preparation, and painting procedure shall be approved by purchaser and shall include both primer and finish coat.

4.6 Modifications to Section 9: Specific Pump Types

9.1.2.7 Exception: Single-Stage Overhung Pumps. Vertical Inline (Type OH3) Pumps

Proposals to use grease lubricated bearings shall be approved by the OL's Engineer.

9.1.2.7 Clarification: Single-Stage Overhung Pumps. Vertical Inline (Type OH3) Pumps

Thrust bearings shall be oil lubricated.

9.2.4.1.2 Clarification: Between-Bearings Pumps (Types BB1, BB2, BB3 and BB5). Dynamics. Lateral Analysis

When the lateral analysis is performed, the complete report shall be submitted for review and approval.

9.2.6.1 Addition: Between-Bearings Pumps (Types BB1, BB2, BB3 and BB5). Lubrication

Pumps with hydrodynamic thrust bearings or tilting pad type hydrodynamic radial bearings shall be equipped with an external pressurized oil system.

9.2.6.2 Addition: Between-Bearings Pumps (Types BB1, BB2, BB3 and BB5). Lubrication

- a) Materials of construction for coolers in fresh water cooling service shall be carbon steel with admiralty metal tubes and brass tubesheets. Materials for salt water cooling shall be as shown in Table 3 of this specification.

- b) Motor drivers for lube oil pumps shall be according to *OL-TR-ER-009*.
- c) Non-shaft driven horizontal pumps shall have positive suction heads and suction lines sloped to vent to the reservoir.
- d) Unless otherwise specified, a separate shell & tube oil cooler shall be provided. The oil side operating pressure shall be higher than the water pressure.
- e) Oil filters shall be equipped with continuous flow switch over valve including a pressure equalization line.
- f) Unless otherwise specified, a thermostatically controlled electric heater shall be provided.

Table 3. Materials for Salt Water Cooling

Shell	Channels and Covers		Tubesheets		Tubes	
	Materials	Specification	Material	Specification	Material	Specification
Carbon Steel	Acid Resisting or Aluminum Bronze	ASTM B 584 Alloy C92200 ASTM B 169/B 169M Alloy C61400	Naval Brass	ASTM B 171/B 171M Alloy C46400	Inhibited Admiralty	ASTM B 111 Alloy C44300, C44400, or C44500

9.2.6.5 New Paragraph: Between-Bearings Pumps (Types BB1, BB2, BB3 and BB5). Lubrication

An adjustable, thermostatically controlled, electric immersion heater shall be provided with the lube oil reservoir.

9.3.2.2 Addition: Vertically Suspended Pumps (Types VS1 through VS7). Pressure Casings

Vertical pumps shall be supplied with flanged column pipes and, depending on the type of pump, either flanged and bolted bowls or a bolted casing assembly. Column and bowl bolting shall be corrosion resistant for the intended service.

9.3.6.1 Addition: Vertically Suspended Pumps (Types VS1 through VS7). Bushings and Bearings

The use of carbon or PTFE based guide bushings requires approval of the OL's Engineer.

9.3.6.2 Addition: Vertically Suspended Pumps (Types VS1 through VS7). Bushings and Bearings

Pump Manufacturer shall specify in the proposal the maximum upthrust and downthrust to be imposed on the motor thrust bearing, and shall be responsible for proper sizing of the thrust bearing to accommodate these loads.

9.3.6.2 Clarification: Vertically Suspended Pumps (Types VS1 through VS7). Bushings and Bearings

Thrust bearings integral with the driver are not acceptable.

9.3.7 Addition: Vertically Suspended Pumps (Types VS1 through VS7). Lubrication

When the line bushings are intended with lubrication from an external source, the complete harness shall be detailed in the proposal and included in the vendor's scope of supply.

9.3.8.1.1 Exception: Vertically Suspended Pumps (Types VS1 through VS7). Accessories. Drivers

Backstopping devices and non-reversing ratchets are not required on vertical pumps.

9.3.8.1.3 New Paragraph: Vertically Suspended Pumps (Types VS1 through VS7). Accessories. Drivers

For vertical pumps, Vendor shall assemble and dowel motor or gear to the pump in its shop to assure proper unit fit-up and shaft mating.

9.3.8.2.3 Substitution: Vertically Suspended Pumps (Types VS1 through VS7). Accessories. Couplings and Guards

When specified, vertical pumps equipped with mechanical seals shall be provided with a spacer type flexible coupling between pump and driver and a rigid spool coupling between the seal and the thrust bearing housing. The spool shall be of sufficient length to permit replacement of the seal assembly, including the sleeve, without removal of the thrust bearing.

9.3.8.3.2 Clarification: Vertically Suspended Pumps (Types VS1 through VS7). Accessories. Mounting Plates

Pumps intended for installation on concrete shall be equipped with separate steel mating sole plate for grouting to the foundation.

9.3.12.6 Modification: Vertically Suspended Pumps (Types VS1 through VS7). Single-Casing Line Shaft (VS4) and Cantilever (VS5) Pumps

Unless otherwise specified or agreed upon, thrust bearings shall be oil lubricated.

4.7 Modifications to Section 10: Vendor's Data

10.1. Addition: General

Supplementary instructions are included in the OL specification OL-TR-MRR-000.

4.8 New Section 11: Guarantee and Warranty

11.1 New Paragraph: Guarantee and Warranty

Pump vendor shall be responsible for the commercial and engineering coordination, supply, delivery and satisfactory operation of the complete pumping unit, including driver, gear, transmission, oil system and any other auxiliary equipment in vendor's scope of supply.

11.2 New Paragraph: Guarantee and Warranty

Pump vendor shall be responsible for parts supplied by its subsuppliers.

11.3 New Paragraph: Guarantee and Warranty

Unless exceptions are recorded in vendor proposal, it shall be understood that the vendor agrees to the guarantees and warranties specified below:

11.3.1 New Paragraph: Guarantee and Warranty. Mechanical

Unless otherwise specified in the purchase order, all equipment and component parts shall be warranted by the vendor against defective materials, design and workmanship for one year after being placed in service or 18 months after date of delivery whichever is the earliest.

11.3.2 New Paragraph: Guarantee and Warranty. Performance

The equipment shall be guaranteed for satisfactory performance at all operating conditions specified in the data sheet.

11.3.3 New Paragraph: Guarantee and Warranty. Make-Good

If any performance deficiency or defects occur during the guarantee and warranty period, the vendor shall make all necessary alterations, repairs and replacement at the conditions defined in the purchase documents.

4.9 Modifications to Annex H: Materials and Material Specifications for Pump Parts

Table H.4 Modification: Piping Materials. Auxiliary Process Liquid

Parker *Ferulok*TM or equal compression fittings shall be used in case of tubing.
Use of tubing on process fluids requires purchaser approval.

Table H.4 Modification: Piping Materials. Cooling Water

The standard cooling water piping material shall be galvanized steel ASTM A-53/53M sch. 40, or carbon steel ASTM A-106 sch. 80 up to DN40 (1-1/2") and sch. 40 for DN50 (2") and larger.

Valves, unions and fittings material shall be of same metallurgy of the pipe.

5. ADDITIONAL REQUIREMENTS

- 5.1 For pumping liquid temperature above 200°C the pump bearing housing shall be equipped with temperature indicators for radial and thrust bearing. Also pump shall be equipped with vibrations measurement. Reading and high temperature signals from these indicators shall be transmitted to DCS system.
- 5.2 Pumps with pumping liquid temperature below 200°C shall be equipped with bearing housing temperature indicators for radial and thrust bearing temperature measurement. Reading and high temperature signals from these indicators shall be transmitted to DCS system.
- 5.3 Double mechanical seals (pressurized or unpressurized) with barrier or buffer fluid systems are required where:
- Pumped flammable liquid temperature is above self-ignition temperature or at temperature > 250°C;
 - Pumped liquid vapor pressure is above atmospheric pressure;
 - Pumped liquid is toxic or carcinogenic;
 - LPG pumping;
 - Pump operating at high pressure 50 bar(g).