International Standard ISO 5199

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Technical specifications for centrifugal pumps — Class II

Spécifications techniques pour pompes centrifuges — Classe II

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 5199 was prepared by Technical Committee ISO/TC 115, *Pumps*.

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

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Technical specifications for centrifugal pumps — Class II

0 Introduction

This International Standard is the first of a series dealing with technical specifications for centrifugal pumps; they correspond to three classes of technical specifications, I, II and III, of which class I has the most severe, and class III the least severe requirements.

Where a decision may be required by the purchaser, or agreement is required between purchaser and manufacturer, the relevant text is printed in bold typeface and listed in annex H.

1 Scope and field of application

1.1 This International Standard covers class II requirements for centrifugal pumps of back pull-out construction as used primarily in the chemical and petrochemical industries. However the Standard, or individual clauses of it, can be applied in other industries, for general industrial use or to pump designs other than of back pull-out construction.

1.2 Pumps as specified in ISO 2858 are typical of those conforming to this International Standard.

1.3 This International Standard includes design features concerned with installation, maintenance and safety for these pumps, including baseplate couplings and auxiliary piping but excluding the driver.

1.4 Where application of this International Standard has been called for

a) and a specific design feature is required, alternative designs which meet the intent of the Standard may be offered, provided that the alternative is described in detail;

b) pumps not complying with all requirements of the Standard may be offered for consideration provided that all deviations are stated.

1.5 Whenever the documents include contradicting technical requirements, they shall apply in the following sequence:

a) purchase order (or enquiry if no order is placed) (see annexes F and G);

b) data sheets (see annex A);

c) this International Standard;

d) other standards to which reference is made in the order or enquiry.

2 References

To the extent specified in the text, the following International Standards are used in the application of this Standard.

ISO 76, *Rolling bearings — Static load ratings.*

ISO 281/1, *Rolling bearings — Dynamic load ratings and rating life — Part 1: Calculation methods.*

ISO 1940, *Balance quality of rotating rigid bodies.*

ISO 2084, *Pipeline flanges for general use — Metric series — Mating dimensions.*

ISO 2229, *Equipment for the petroleum and natural gas industries — Steel pipe flanges, nominal sizes* 1/2 *to* 24 in *— Metric dimensions.*

ISO 2372, *Mechanical vibration of machines with operating speeds from* 10 *to* 200 rev/s *— Basis for specifying evaluation standards.*

ISO 2373, *Mechanical vibration of certain rotating electrical machinery with shaft heights between* 80 *and* 400 mm *— Measurement and evaluation of the vibration severity.*

ISO 2548, *Centrifugal, mixed flow and axial pumps — Code for acceptance tests — Class C.*

ISO 2858, *End-suction centrifugal pumps (rating* 16 bar*) — Designation, nominal duty point and dimensions.*

ISO 3069, *End-suction centrifugal pumps — Dimensions of cavities for mechanical seals and for soft packing.*

ISO 3274, *Instruments for the measurement of surface roughness by the profile method — Contact (stylus) instruments of consecutive profile transformation — Contact profile meters, system M.*

ISO 3555, *Centrifugal, mixed flow and axial pumps — Code for acceptance tests — Class B.*

ISO 3661, *End-suction centrifugal pumps — Baseplate and installation dimensions.*

ISO 3744, *Acoustics — Determination of sound power levels of noise sources — Engineering methods for free-field conditions over a reflecting plane.*

ISO 3746, *Acoustics — Determination of sound power levels of noise sources — Survey method.*

3 Definitions

Terms in this International Standard which are not self-explanatory are defined as follows.

3.1 operating conditions: All parameters (for example, operating temperature, operating pressure) determined by a given application and pumped liquid. These parameters will influence the type of construction and construction materials.

3.2 allowable operating range: The flow range at the specified operating conditions with the impeller supplied as limited by cavitation, heating, vibration, noise, shaft deflection and other similar criteria. This range shall be defined by the manufacturer.

3.3 rated conditions: Conditions (driver excluded) that define the (guarantee) point necessary to meet all defined operating conditions, taking into account any necessary margins.

3.4 rated driver output: The maximum permissible driver output under site operating conditions.

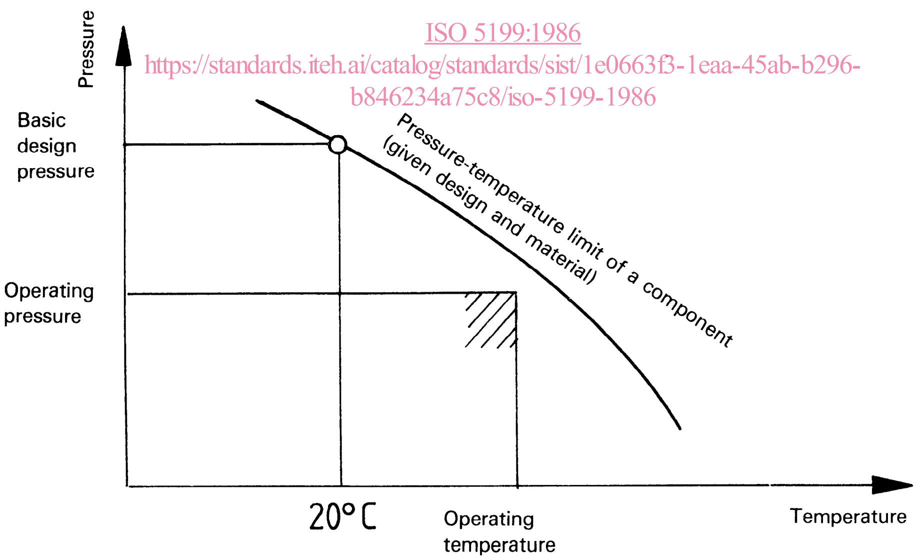
3.5 basic design pressure: This is derived from the permitted stresses at 20 °C of the material used for the pressure-containing parts.

3.6 rated pressure: The pressure limit at the most severe operating conditions in a given application.

3.7 rated inlet pressure: The inlet pressure which, with the rated head (converted to pressure) at rated flow, results in the rated outlet pressure.

3.8 rated outlet pressure: Outlet pressure of the pump at rated flow, rated head (converted to pressure) rated inlet pressure.

3.9 pressure - temperature rating: Relationship between pressure and temperature given in the form of a graph (see below).



3.10 corrosion allowance: That portion of the wall thickness of the parts wetted by the pumped liquid in excess of the theoretical thickness required to withstand the pressure limits given in 4.4.1.

3.11 maximum allowable continuous speed: The highest speed at which the manufacturer permits the pump to operate continuously.

3.12 trip speed: The speed of rotation at which the turbine emergency stop mechanism operates.

3.13 first critical speed: The speed of rotation of a machine at which the first (lowest) lateral natural frequency of vibration of the rotating parts corresponds to the frequency of rotation.

3.14 design load: The maximum hydraulic radial forces on the largest impeller (diameter and width) operating within the manufacturer's specified range on its maximum speed curve with a liquid density of 1 000 kg/m³.

3.15 maximum load: The maximum hydraulic radial forces on the largest impeller (diameter and width) operating at any point on its maximum speed curve with a liquid density of 1 000 kg/m³.

3.16 shaft runout: The total radial deviation indicated by a device measuring shaft position in relation to the bearing housing as the shaft is rotated manually in its bearings with the shaft in the horizontal position.

3.17 face runout: The total axial deviation indicated at the outer radial face of the stuffing box by a device attached to and rotated with the shaft when the shaft is rotated manually in its bearings in the horizontal position. The radial face is that which determines the alignment of a seal component.

3.18 shaft deflection: The term as used in this International Standard describes the displacement of a shaft from its geometric centre in response to the radial hydraulic forces acting on the impeller. It does not include shaft movement caused by tilting within the bearing clearances, bending caused by impeller imbalance or shaft runout.

3.19 circulation (flush): Return of pumped liquid from high pressure area to seal cavity can be by external piping or internal passage and is used to remove heat generated at the seal or to maintain positive pressure in the seal cavity or treated to improve the working environment for the seal. In some cases it may be desirable to circulate from the seal cavity to a lower pressure area (for example, the inlet).

3.20 injection (flush): Introduction of an appropriate (clean, compatible, etc.) liquid into the seal cavity from an external source and then into the pumped liquid. Used for the same purpose as circulation but also used to provide an improved working environment for the seal.

3.21 quenching: Continuous or intermittent introduction of an appropriate (clean, compatible, etc.) fluid on the atmospheric side of the main shaft seal. Used to exclude air or moisture, to prevent or clear deposits (including ice), lubricate an auxiliary seal, snuff out fire, dilute, heat or cool leakage.

3.22 barrier liquid (buffer): An appropriate (clean, compatible, etc.) liquid inserted between two seals (mechanical seal and/or soft packing). The barrier liquid pressure depends on the seal arrangement. The barrier liquid may be used to prevent air entering the pump. The barrier is normally easier to seal than the pumped liquid and/or creates less of a hazard on leaking.

4 Design

4.1 General

4.1.1 Characteristic curve

The characteristic curve shall indicate the permitted operating range of the pump. Pumps with a stable characteristic curve are preferred. The characteristic curves of the smallest and largest impeller diameter of the pump shall be plotted on the performance chart as a function of flow.

4.1.2 Net positive suction head (NPSH)

The NPSH required, $(NPSH)_r$, shall be based on cold water as specified in ISO 2548 or ISO 3555 unless otherwise agreed.

A $(NPSH)_r$ curve shall be provided for water as a function of flow.

Should the pump manufacturer consider that, because of the construction material and liquid pumped, more NPSH is required, this should be stated in the proposal and the appropriate curve provided.

The NPSH available $(NPSH)_a$ shall exceed $(NPSH)_r$ by a margin of at least 0,5 m. Correction factors for hydrocarbons are not allowed.

For NPSH tests, refer to 6.3.2.3.

4.1.3 Outdoor installation

The pumps shall be suitable for outdoor installation under normal ambient conditions.

Extraordinary local ambient conditions, such as high or low temperatures, corrosive environment, sand storms, etc. for which the pump must be suitable shall be specified by the purchaser.

4.2 Prime movers

The following have to be considered when determining the rated performance of the drive:

a) application and method of operation of the pump. For instance in the case of parallel operation, the possible performance range with only one pump in operation taking into account the system characteristic shall be considered;

b) position of the operating point on the pump characteristic curve;

c) shaft seal friction loss;

d) circulation flow for the mechanical seal (especially for pumps with low rate of flow);

e) properties of pumped liquid (viscosity, solids content, density);

f) power and slip loss through transmission;

g) atmospheric conditions at pump site.

Prime movers required as drivers for any pumps covered by this International Standard shall have power output ratings at least equal to the percentage of rated pump power input given in figure 1, this value being never less than 1 kW.

Where it appears that this will lead to unnecessary oversizing of the driver, an alternative proposal shall be submitted for the purchaser's approval.

4.3 Critical speed, balance and vibration

4.3.1 Critical speed

Under operating conditions, the actual first lateral critical speed of the rotor when coupled to the drive agreed upon shall be at least 10 % above the maximum permitted continuous speed including the trip speed of a turbine driven pump.

4.3.2 Balance and vibration

Balancing of the pump rotating parts shall be carried out. Vibration shall not exceed the vibration severity limits as given in table 1 when measured on the manufacturer's test facilities. These values are measured radially at the bearing housing at a single operating point at rated speed (± 5 %) and rated flow (± 5 %) when operating without cavitation.

For information, this can normally be achieved by balancing in accordance with grade G 6,3 of ISO 1940.

Table — Limits of vibration severity for horizontal pumps with multivane impellers*

Speed of rotation, n	Maximum r.m.s. values of the vibration velocity for the shaft centreline height h_1	
	$h_1 \leqslant 225$ mm	$h_1 > 225$ mm
min^{-1}	mm/s	mm/s
$n \leqslant 1800$	2,8	4,5
$1800 < n \leqslant 4500$	4,5	7,1

* The table is based on ISO 2372 and ISO 2373.

Pumps with a special impeller, for example a single channel impeller, may exceed the limits given in the table. In such a case the pump manufacturer should indicate this in his offer.

See also annex B.

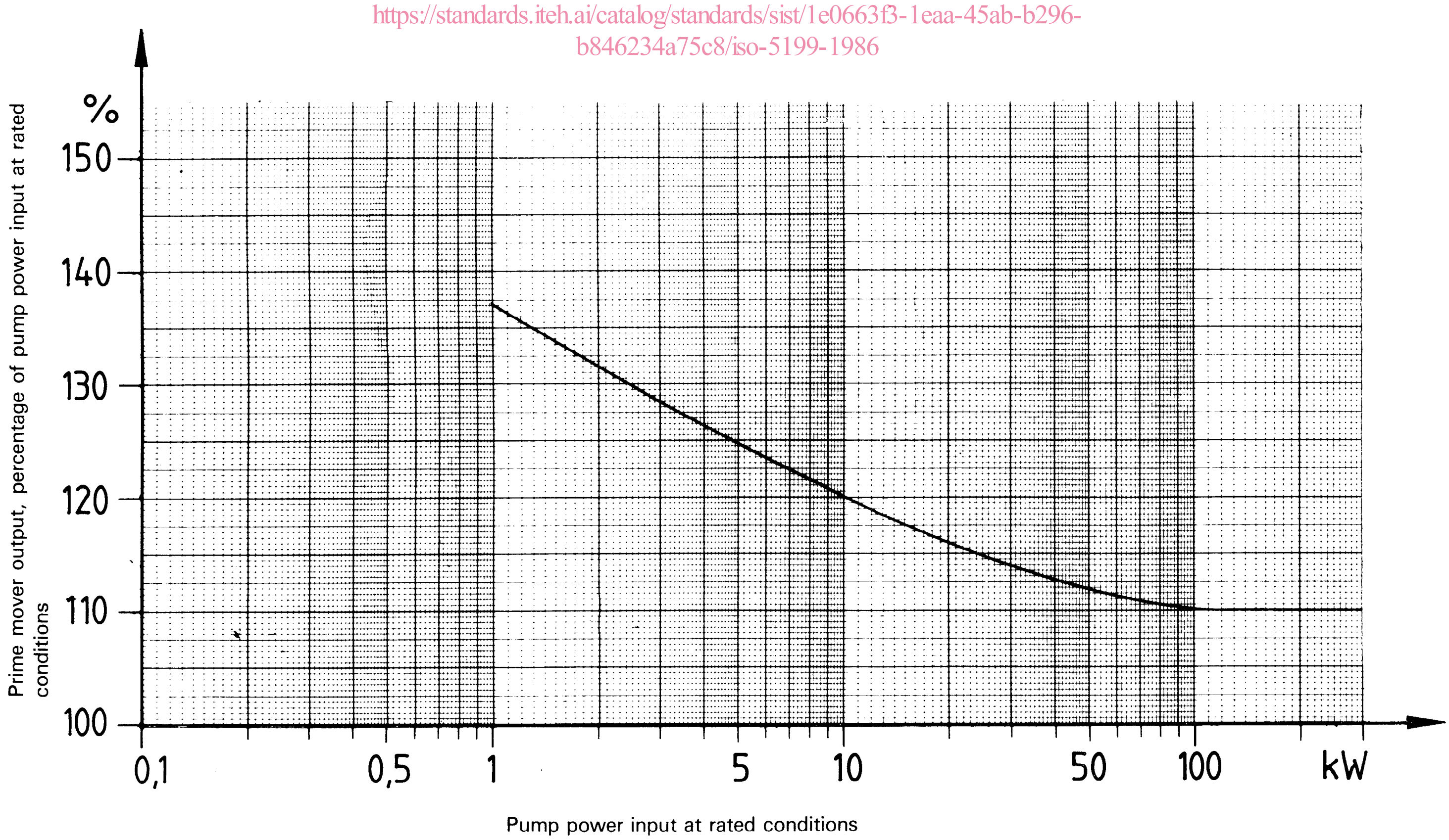


Figure 1 — Prime mover output, percentage of pump power input at rated conditions

4.4 Pressure-containing parts

4.4.1 Pressure-temperature rating

The pressure limit (rated pressure) of the pump at the most severe operating conditions shall be clearly defined by the manufacturer. In no case may the rated pressure of the pump (casing and cover including shaft seal housing and gland follower/end plate) exceed that of the pump flanges.

The basic design pressure of the pump shall be at least a gauge pressure of 16 bar[1)] at 20 °C when made of cast iron, ductile iron, carbon steel or stainless steel.

For materials the tensile requirements of which do not permit the 16 bar rating, the pressure-temperature rating shall be adjusted according to the stress-temperature rating for the material and shall be clearly stated by the manufacturer.

4.4.2 Wall thickness

Pressure casings including the shaft seal housing and gland end plate shall be of such thickness as will be suitable for containing pressure and limiting distortion under the rated pressure at operating temperature.

The casing shall also be suitable for the hydrostatic test pressure (see 6.3.1) at ambient temperature.

The pressure-containing parts shall have a corrosion allowance of 3 mm unless otherwise agreed.

4.4.3 Materials

The materials used for pressure-containing parts shall depend on the liquid pumped and the application of the pump (see clause 5).

4.4.4 Mechanical features

4.4.4.1 Dismantling

The pump shall preferably be designed in back pull-out construction in order to permit removal of the impeller, shaft, shaft seal and bearing assembly without disturbing the inlet and outlet flange connections. Provision shall be made for easy separation of components, for example jackscrews.

4.4.4.2 Jackscrews

When jackscrews are supplied as a means of separating contacting faces, the mating face shall be counterbored to receive the jackscrews where marring offers a possibility of a leaky joint or poor fit. Hollow-head screws should be avoided if possible.

4.4.4.3 Jackets

Jackets for heating or cooling the casing or stuffing box, or both, are optional. Jackets shall be designed for cooling at an operating pressure of at least 6 bar at 170 °C.

4.4.4.4 Casing gaskets

Casing gaskets shall be of a design suitable for the rated operating conditions and for hydrostatic test conditions at ambient temperature. The casing-cover gaskets shall be confined on the atmospheric side to prevent blow-out.

4.4.4.5 Vapour venting

A pump handling a liquid at a pressure near its vapour pressure or with a gas content shall be designed so that the vapours can be properly vented.

4.4.4.6 External bolting

Bolts or studs that connect parts of the pressure casing, including shaft seal housing, shall be at least 12 mm diameter (ISO metric thread).

NOTE — If, due to space limitations, the use of 12 mm bolts or studs is impractical, smaller bolts or studs may be used.

The bolting selected (property class) shall be adequate for the rated pump pressure and for normal tightening procedures. If at some point it is necessary to use a fastener of special quality, interchangeable fasteners for other joints shall be of the same quality. Hollow-head screws should be avoided if possible.

4.4.4.7 Casing support for high temperature

For applications above 175 °C for example, due consideration should be given to supporting the centreline pump casing.

4.5 Branches (nozzles) and miscellaneous connections

NOTE — For the purposes of this Standard the terms branch and nozzle are synonymous.

4.5.1 Extent

This section is concerned with all fluid connections to the pump whether for operation or maintenance.

4.5.2 Inlet and outlet branches

Inlet and outlet branches shall be flanged and designed for the same pressure unless the pump manufacturer states this is not so and emphasizes the requirement for pressure relief.

4.5.3 Vent, pressure-gauge and drain

Venting of all areas of casing and seal chamber shall be provided unless the pump is made self-venting by arrangement of branches.

The connection of pressure gauges at the inlet and outlet branches shall be possible. The connections are not drilled. The enquiry and/or order should state if such connections are required to be drilled.

1) 1 bar = 0,1 MPa

Provision shall be made for draining at the lowest point, or points, of the pump. The enquiry and/or order should state if such connections are required to be drilled and to be fitted with a plug or other closures.

4.5.4 Closures

The material for the closures (plugs, blank/blind flanges, etc.) shall be appropriate to the pumped liquid. Attention shall be paid to the suitability of material combinations for corrosion resistance and to minimize the risk of seizure or galling of screw threads.

All openings exposed to the pumped liquid under pressure, including all shaft seal openings, shall be fitted with removable closures adequate to contain pressure.

4.5.5 Auxiliary pipe connections

All auxiliary pipe connections shall be of adequate material, size and thickness for the intended duty (see also 4.13.5).

The inside pipe diameter shall always be at least 8 mm and the wall thickness 1 mm. Greater diameters and wall thicknesses are preferred. Auxiliary piping shall be provided with detachable joints to permit easy dismantling. **The type of connections shall be subject to agreement.**

4.5.6 Connection identification

All connections shall be identified in the installation drawing in accordance with their duty and function. It is recommended that this identification also be applied on the pump.

4.6 External forces and moments on flanges (inlet and outlet)

The method given in annex C shall be used for cast steel pumps unless another method is agreed upon between the purchaser and the manufacturer.

The purchaser shall calculate the forces and moments exerted by the piping on the pump.

The manufacturer shall verify that these loads are permissible for the pump under consideration. **If the loads are higher than permissible, the solution of the problem shall be agreed upon between purchaser and manufacturer.**

4.7 Branch (nozzle) flanges

The flange envelope shall be of a size to enable flanges to ISO 2084 and/or ISO 2229 to be provided. If the pump manufacturer's standard pattern entails a flange thickness and a diameter greater than that of the rating specified, the heavier flange may be supplied, but it shall be faced and drilled as specified. Good seating of the bolt head and/or nut on the back face of cast flanges shall be ensured. Bolt holes shall straddle the centreline.

4.8 Impellers

4.8.1 Impeller design

Impellers of closed, semi-open or open designs may be selected according to the application.

Cast or welded impellers shall consist of one piece, excluding wear rings.

Impellers fabricated by other means are permissible in special cases, i.e. for small impeller outlet widths or of special materials. This, however, requires agreement with the purchaser.

4.8.2 Securing of impellers

Impellers shall be secured against circumferential and axial movement when rotating in the intended direction.

4.8.3 Axial adjustment

If field adjustment of impeller axial clearance is required, external means of adjustment shall be provided. If adjustment is achieved by axial movement of the rotor, attention shall be paid to the possibly dangerous effect on the mechanical seal(s) (see also 4.11.6).

4.9 Wear rings or equivalent components

Wear rings should be fitted where appropriate. When wear rings are fitted they shall be renewable and securely locked to prevent rotation.

4.10 Running clearance

When establishing running clearances between stationary and moving parts, consideration shall be given to operating conditions and properties of the material used (used as hardness and gall resistance) for these parts. Clearances shall be sized to prevent contact, and material combinations selected to minimize the risk of seizure and erosion.

4.11 Shafts and shaft sleeves

4.11.1 General

Shafts shall be of ample size and stiffness to

a) transmit the prime mover rated power;

b) minimize unsatisfactory packing or seal performance;

c) minimize wear and the risk of seizure;

d) take due consideration of the static and dynamic radial loads, the critical speed (see 4.3.1) and the methods of starting and inertia loading involved.

4.11.2 Surface roughness

The roughness of the shaft or sleeve at the stuffing box, mechanical seal and oil seal shall be not greater than 0,8 µm unless otherwise required for the seal. Measurement of surface roughness shall be in accordance with ISO 3274.

4.11.3 Shaft deflection

The calculated shaft deflection at the radial plane through the outer face of the stuffing box caused by radial loads exerted during operation of the pump shall be consistent with the proper functioning of mechanical seals. In the case of ISO 2858 pumps, this value shall not exceed 50 µm as verified by prototype testing.

The following condition a) always applies; **in addition condition b) and/or condition c) may be required by agreement**:

a) within the allowable operating range of the pump;

b) at design load;

c) at maximum load.

Support by packing shall not be considered when determining shaft deflection.

4.11.4 Diameter

The diameter of the portions of the shaft or shaft sleeves in contact with shaft seals shall be in accordance with ISO 3069 where practicable.

4.11.5 Shaft runout

Manufacture and assembly of the shaft and sleeve, if fitted, should ensure that the runout (see 3.16) at a radial plane through the outer face of the stuffing box is not greater than 50 µm for nominal outside diameters smaller than 50 mm, not greater than 80 µm for nominal outside diameters 50 to 100 mm, and not greater than 100 µm for nominal outside diameters greater than 100 mm.

4.11.6 Axial movement

Axial movement of the rotor permitted by the bearings shall not adversely affect the performance of the mechanical seal.

4.11.7 Securing and sealing of shaft sleeve

When a shaft sleeve is fitted it shall be positively secured against circumferential and axial movement. The shaft sleeve shall be sealed against the impeller hub so that the shaft is not wetted.

4.11.8 Arrangment of shaft sleeve, if fitted

On a pump arranged for packing, the end of the shaft sleeve assembly, if fitted, shall extend beyond the outer face of the packing gland follower. On a pump arranged for mechanical seals, the shaft sleeve shall extend beyond the seal end plate. On pumps employing an auxiliary seal or a throttle bushing, the shaft sleeve shall extend beyond the seal end plate. Leakage between the shaft and sleeve thus cannot be confused with leakage through box packing or mechanical seal faces.

For certain mechanical seal arrangements (for example, external mechanical seals, double mechanical seals) deviations may be offered.

4.11.9 Securing of thrust bearing

Snap rings in direct contact with the bearings shall not be used for transmitting the thrust from the shaft to the inner race of the thrust bearing. Locknuts and lockwashers are preferred.

4.12 Bearings

4.12.1 General

Rolling bearings of standard design are normally employed. **Other types of bearings may be used.**

4.12.2 Rolling bearing life

Rolling bearings shall be selected and rated in accordance with ISO 76 and ISO 281/1; the "basic rating life (B10)" shall be at least 17 500 h when operating within the allowable operating range. The manufacturer shall specify the limits of the inlet pressure as a function of the pump head at maximum load to achieve a calculated bearing life of at least 17 500 h.

4.12.3 Bearing temperature

The pump manufacturer shall specify if cooling or heating is necessary to maintain bearing temperatures within the limits given by the bearing manufacturer.

4.12.4 Lubrication

The operation instructions shall include information on the type of lubricant to be used and the frequency of application.

4.12.5 Bearing housing design

In order to prevent loss or contamination, gasketed or threaded connections shall not be used to separate cooling or heating fluids from lubricants.

All openings in the bearing housing shall be designed to prevent the ingress of contaminants and the escape of the lubricant under normal operating conditions.

In hazardous areas any device for sealing the bearing housing shall be designed not to be a source of ignition.

In case of oil lubrication a plugged oil drain hole shall be provided.

If the bearing housing also serves as an oil chamber, an oil level indicator or constant level oiler shall be used. The mark for the recommended oil level or the setting of the constant level oiler shall be permanent and visible and shall state whether the level is stationary or running.

Where regreasable bearings are used, grease relief shall be provided.

4.13 Shaft sealing

4.13.1 General

The pump design shall permit the use of all the following alternatives:

— soft packing (P),

— single mechanical seal (S),

— double mechanical seal (D),

as shown in annex D.

Quench arrangements (Q), which in certain cases can become necessary, are also shown in annex D.

The seal cavity dimensions shall be in accordance with ISO 3069 except where the operating conditions dictate otherwise.

Arrangements shall be available for containing, collecting and draining all liquid leakage from the seal area.

4.13.2 Stuffing box

Provision shall be made to allow fitting of a lantern ring. **Outlet connections where required shall be specified by the purchaser or manufacturer.** Ample space shall be provided for repacking without removing or dismantling any part other than gland components or guards. The gland components shall be positively retained even if the packing loses its compression.

4.13.3 Mechanical seals

4.13.3.1 Operating criteria for selection

Some principal operating criteria for selection of mechanical seals are

- chemical and physical properties and the nature of the pumped liquid;
- minimum and maximum expected sealing pressures;
- temperature and vapour pressure of the liquid at the seal;
- special operating conditions (including start up, shut down, thermal and mechanical shocks, etc.);
- speed and direction of rotation of the pump.

4.13.3.2 Type and arrangement

This International Standard does not cover the design of the components of the mechanical seal but the components shall be suitable to withstand operating conditions specified in the data sheet (see annex A).

Arrangement (for example, single, double, balanced or unbalanced mechanical seal, see annex D) shall be specified in the data sheet (see annex A).

If pumps handle liquids near their boiling point, the pressure in the mechanical seal chamber shall be sufficiently above inlet pressure, or the temperature in the immediate vicinity of the seal shall be sufficiently below vaporization temperature, to prevent vaporization at the seal faces.

If a back-to-back arrangement of seals is applied, the barrier liquid between the seals shall be compatible with the process and at a pressure higher than the sealing pressure.

If a back-to-back mechanical seal is installed, the stationary ring on the impeller side shall be secured so that it cannot move due to pressure drop of the barrier liquid.

For pumps operating at temperatures below 0 °C, quench may be provided to prevent ice formation.

4.13.3.3 Materials

Appropriate material for the seal components shall be chosen to withstand corrosion, erosion, temperature, thermal and mechanical stress, etc. For mechanical seals, metallic parts wetted by the pumped liquid shall have at least the same material quality as the pump casing (see clause 5) as far as mechanical properties and corrosion resistance are concerned.

4.13.3.4 Construction features

Provision shall be made for centring the seal end plate in relation to the seal chamber bore. An inside or outside diameter register fit is an acceptable method of achieving this.

The seal end plate shall have sufficient rigidity to avoid distortion. The seal housing and end plate including fixing bolts (see 4.4.4.6) shall be designed for the permissible operating pressure at operating temperature and the required gasket seating load.

Gaskets between seal housing and stationary seal ring or seal end plate shall be externally confined or of equivalent design in order to prevent blow-out.

All stationary seal components including seal end plate shall be protected from accidental contact with the shaft or sleeve and from rotation. When a stationary sealing component contacts the shaft or sleeve, the surface in contact with the seal shall be adequately hard and corrosion-resistant. Lead-ins shall be provided and sharp edges removed to prevent damage to the seal during fitting.

Machining tolerances of the seal chamber and the seal end plate shall restrict the face runout at the stationary seal ring of the mechanical seal to maximum permissible values as given by the seal manufacturer.

If a throttle bushing is provided in the end plate to minimize leakage on complete failure of the seal, the diametral clearance, in millimetres, between bushing and shaft should be the minimum practical but in no case greater than

$$\frac{\text{shaft diameter}}{100} + 0{,}2$$

Where leakage must be avoided an auxiliary seal (for example, double seal) will be necessary (see annex D).

The seal chamber shall be designed to prevent trapping of air where practicable. If this is not possible, the seal chamber shall be ventable by the operator. The method of doing this shall be given in the instruction manual.

Liquid inlets to, and if necessary outlets from, the seal chamber shall be as close as possible to the seal faces.

Holes may be drilled and tapped even where a connection is not required (see 4.5.3 and 4.5.5) unless otherwise agreed.

4.13.3.5 Assembly and test

For assembly for despatch, see 7.1.

A mechanical seal shall not be subjected to a hydrostatic test pressure exceeding the seal pressure limit.

The purchaser shall be informed before ordering if seal faces are not suitable for operation with water (start up conditions).

4.13.4 Auxiliary piping for stuffing box and mechanical seal

4.13.4.1 The pump shall be designed to accept such auxiliary piping as may be required by the shaft seal for the specified conditions.

4.13.4.2 Auxiliary piping may be required for the following:

a) for category a) which concerns process liquids or liquids that can enter the process:

- circulation, if not by internal passages,
- injection (flushing),
- barrier,
- pressurizing;

b) for category b), services which do not enter the process:

- heating,
- cooling,
- quenching.

4.13.5 Mechanical design of auxiliary piping

Auxiliary piping shall be in accordance with annex E or an agreed alternative.

In each case the range of supply and details of piping connections for external services shall be agreed between purchaser and manufacturer.

When specified, the piping system, including all accessories, shall be supplied by the pump manufacturer and fully assembled on the pump when possible.

The piping shall be designed and arranged to permit removal for maintenance and cleaning and shall be adequately supported to prevent damage due to vibration under normal operation and maintenance activities.

The temperature and pressure rating of auxiliary piping handling process liquids [see 4.13.4.2 a)] shall not be less than that of the casing (see 6.3). The piping material shall resist corrosion caused by the liquid handled (see 4.5.5) and by environmental conditions.

Services piping [see 4.13.4.2 b)] shall be designed for the appropriate service design pressure and temperature rating (see 4.4.4.3).

Drains and leakage outlets shall be provided at all low points to allow complete drainage. Piping shall be designed to avoid gas pockets.

Steam services shall be "top in, bottom out". In general other services should be "bottom or side in, top out".

If a restriction orifice is provided, its diameter shall preferably be not less than 3 mm.

When using adjustable orifices, a minimum continuous flow shall be ensured.

4.14 Nameplates

Nameplates shall be made of corrosion-resistant material, suitable for the environmental conditions and shall be securely attached to the pump.

The minimum information required on the nameplate shall be name (or trademark) and address of the manufacturer or supplier, identification number of the pump (for example, serial number or product number), type and size.

Further space may be provided for additional information on rate of flow, pump total head, pump speed, impeller diameter (maximum and installed), rated pressure and temperature of the pump.

4.15 Direction of rotation

The direction of rotation shall be indicated by a prominently located arrow of durable construction.

4.16 Couplings

The pump shall normally be coupled to the drive by flexible coupling. The coupling shall be sized to transmit the maximum torque of the intended driver. The speed limitation of the coupling shall correspond to all possible operating speeds of the intended pump driver.

A spacer coupling shall be provided to permit the pump rotor to be dismantled without moving the drive. Coupling spacer length is dependent on the distance required between shaft ends for dismantling the pump. The distance between shaft ends should be in accordance with an International Standard[1] where possible.

A limited end float coupling may be required if the drive has no thrust bearing.

Coupling halves shall be effectively secured against circumferential and axial movement relative to the shafts. Shaft ends may have threaded centre bores to provide proper coupling assembly.

If coupling components are balanced together, the correct assembly position shall be shown by permanent and visible marks.

1) Such as ISO 2858.