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Technical specifications for centrifugal pumps — Class I

Spécifications techniques pour pompes centrifuges — Classe I

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Contents

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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. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 9905 was prepared by Technical Committee ISO/TC 115, *Pumps*, Subcommittee SC 1, *Dimensions and technical specifications of pumps*.

Annexes A, B, C and D form an integral part of this International Standard. Annexes E, F, G, H, J, K and L are for information only.

Introduction

This International Standard is the second of a set dealing with technical specifications of centrifugal pumps; the specifications are designated as Classes I, II and III. Class I (this International Standard) comprises the most severe and Class III (see ISO 9908) the least severe requirements. For requirements for Class II centrifugal pumps, see ISO 5199.

The selection of the class to be used is made in accordance with the technical requirements for the application for which the pump is intended. **The class chosen is to be agreed between purchaser and manufacturer/supplier.**

The safety requirements of the field of application are furthermore to be taken into account.

However, it is not possible to standardize the class of technical requirements for centrifugal pumps for a certain field of application, because each field of application comprises different requirements. All classes (I, II and III) can be used in accordance with the different requirements of the pump application, e.g. for an oil refinery plant, chemical plant or power plant. It may happen that pumps built in accordance with classes I, II and III may work beside each other in one plant.

Conditions covering specific applications or industrial requirements are dealt with in separate standards.

Criteria for the selection of a pump of the class required for a certain application may be based on:

— reliability,

— operating conditions,

— environmental conditions,

— local ambient conditions.

Throughout this International Standard, text written in bold letters indicates where a decision may be required by purchaser, or where agreement is required between purchaser and manufacturer/supplier.

Technical specifications for centrifugal pumps — Class I

1 Scope

1.1 This International Standard covers the Class I (most severe) requirements for centrifugal pumps used in various industries. It consists of a basic text covering general requirements. The technical requirements refer only to the pump unit.

Storage pumps are not included in this International Standard. A separate standard will be issued by IEC.

1.2 This International Standard includes design features concerned with installation, maintenance and safety of such pumps, including baseplate, coupling and auxiliary piping.

1.3 Where this International Standard specification has been called for:

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

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

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 7-1:1982, *Pipe threads where pressure-tight joints are made on the threads — Part 1: Designation, dimensions and tolerances.*

ISO 76:1987, *Rolling bearings — Static load ratings.*

ISO 185:1988, *Grey cast iron — Classification.*

ISO 228-1:1982, *Pipe threads where pressure-tight joints are not made on the threads — Part 1: Designation, dimensions and tolerances.*

ISO 281:1990, *Rolling bearings — Dynamic load ratings and rating life.*

ISO 427:1983, *Wrought copper-tin alloys — Chemical composition and forms of wrought products.*

ISO 544:1989, *Filler materials for manual welding — Size requirements.*

ISO 1940-1:1986, *Mechanical vibration — Balance quality requirements of rigid rotors — Part 1: Determination of permissible residual unbalance.*

ISO 2372:1974, *Mechanical vibration of machines with operating speeds from 10 to 200 rev/s — Basis for specifying evaluation standards.*

ISO 2548:1973, *Centrifugal, mixed flow and axial pumps — Code for acceptance tests — Class C (It is planned to combine ISO 2548 with ISO 3555 during their next revision to create a new International Standard).*

ISO 2858:1975, *End-suction centrifugal pumps (rating 16 bar) — Designation, nominal duty point and dimensions.*

ISO 3069:1974, *End suction centrifugal pumps — Dimensions of cavities for mechanical seals and for soft packing.*

ISO 3274:1975, *Instruments for the measurement of surface roughness by the profile method — Contact (stylus) instruments of consecutive profile transformation — Contact profile meters, system M.*

ISO 3506:1979, *Corrosion-resistant stainless steel fasteners — Specifications.*

ISO 3555:1977, *Centrifugal, mixed flow and axial pumps — Code for acceptance tests — Class B (It is planned to combine ISO 3555 with ISO 2548 during their next revision to create a new International Standard).*

ISO 3744:1981, *Acoustics — Determination of sound power levels of noise sources — Engineering methods for free-field conditions over a reflecting plane.*

ISO 3746:1979, *Acoustics — Determination of sound power levels of noise sources — Survey method.*

ISO 3755:1991, *Cast carbon steels for general engineering purposes.*

ISO 4863:1984, *Resilient shaft couplings — Information to be supplied by users and manufacturers.*

ISO 7005-1:1992, *Metallic flanges — Part 1: Steel flanges.*

ISO 7005-2:1988, *Metallic flanges — Part 2: Cast iron flanges.*

ISO 7005-3:1988, *Metallic flanges — Part 3: Copper alloy and composite flanges.*

3 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1 normal conditions: Conditions at which usual operation is expected.

3.2 rated conditions: Specified guarantee-point operating conditions, including flowrate, head, power, efficiency, net positive suction head, suction pressure, temperature, density, viscosity and speed.

3.3 operating conditions: All operating parameters (for example temperature, pressure) determined by a given application and pumped liquid.

These parameters will influence the type of construction materials.

3.4 allowable operating range: Flow range, defined by the manufacturer/supplier, at the specified operating conditions using the impeller supplied, as limited by cavitation, heating, vibration, noise, shaft deflection and other similar criteria; range whose upper and lower limits are denoted by maximum and minimum continuous flow, respectively.

3.5 maximum allowable casing working pressure: Greatest outlet pressure at the specified operating temperature for which the pump casing is suitable.

3.6 basic design pressure: Pressure derived from the permitted stress at 20 °C of the material used for the pressure-containing parts.

3.7 maximum outlet working pressure: Sum of the maximum inlet pressure plus maximum differential pressure at rated conditions using the supplied impeller.

3.8 rated outlet pressure: Outlet pressure of the pump at the guarantee point with rated flow, rated speed, rated inlet pressure and density.

3.9 maximum inlet pressure: Highest inlet pressure to which the pump is subjected during operation.

3.10 rated inlet pressure: Inlet pressure for the operating conditions at the guarantee point.

3.11 maximum allowable temperature: Highest allowable continuous temperature for which the equipment (or any part to which the term refers) is suitable when handling the specified operating fluid at the specified operating pressure.

3.12 rated power input: Power required by the pump at the rated conditions.

3.13 maximum dynamic sealing pressure: Highest pressure expected at the shaft seals during any specified operating condition and during startup and shutdown.

NOTE 1 In determining this pressure, consideration should be given to the maximum inlet pressure, circulation or injection (flush) pressure and the effect of internal clearance changes.

3.14 minimum permitted flow

(1) for stable flow: Lowest flowrate at which the pump can operate without exceeding the noise and vibration limits imposed by this International Standard.

(2) for thermal flow: Lowest flowrate at which the pump can operate and still maintain the temperature of the pumped liquid below that at which net positive suction head available equals net positive suction head required.

3.15 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 4.4.2.2 and 4.4.2.4.

3.16 maximum allowable continuous speed: Highest speed at which the manufacturer will permit continuous operation.

3.17 rated speed: Number of revolutions of the pump per unit time required to meet the rated conditions.

NOTE 2 Induction motors will operate at a speed that is a function of the load imposed.

3.18 trip speed: Speed at which the independent emergency overspeed device operates to shut down a prime mover.

3.19 first critical speed: Speed of rotation at which the lowest lateral natural frequency of vibration of the rotating parts corresponds to the frequency of rotation.

3.20 design radial load: Maximum hydraulic radial forces on the largest impeller (diameter and width) operating within the manufacturer's specified range on its maximum speed curve using the design liquid (normally 1 000 kg/m^3).

3.21 maximum radial load: Maximum hydraulic radial forces on the largest impeller (diameter and width) operating at any point on its maximum speed curve with a maximum liquid density.

3.22 shaft runout: 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.

3.23 face runout: 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.

3.24 shaft deflection: Displacement of a shaft from its geometric centre in response to the radial hydraulic forces acting on the impeller.

NOTE 3 Shaft deflection does not include shaft movement caused by tilting within the bearing clearances, bending caused by impeller unbalance or shaft runout.

3.25 circulation (flush): Return of pumped liquid from a high pressure area to seal cavity, by external piping or internal passage, 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.

NOTE 4 In some cases it may be desirable to circulate from the seal cavity to a lower pressure area (for example, the inlet).

3.26 injection (flush): Introduction of an appropriate (clean, compatible, etc.) liquid into the seal cavity from an external source and then into the pumped liquid.

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

3.28 barrier liquid (buffer): An appropriate (clean, compatible, etc.) liquid inserted between two seals (mechanical seal and/or soft packing).

NOTE 5 The barrier liquid pressure depends on the seal arrangement. The barrier liquid may be used to prevent air entering the pump. The barrier liquid is normally easier to seal than the pumped liquid and/or creates less hazard if leakage occurs.

3.29 throttle bush (safety bush): Close-clearance restrictive bush around the shaft (or sleeve) at the outboard end of a mechanical seal to reduce leakage in case of seal failure.

3.30 throat bush: Close-clearance restrictive bush around the shaft (or sleeve) between the seal (or packing) and the impeller.

3.31 pressure casing: Composite of all stationary pressure-containing parts of the unit, including all branches and other attached parts.

3.32 double casing: Type of construction in which the pressure casing is separate and distinct from the pumping elements contained in it.

3.33 barrel casing: Refers specifically to a pump of the double casing type.

3.34 vertical canned pump: Vertical pump inserted in an outer casing (can or caisson) taking its suction from the liquid in the annular space.

3.35 vertical canned motor pump: Glandless pumping set in which the stator of the (electric) motor is sealed by a can against the rotor which runs in the pumped liquid or in any other liquid.

3.36 hydraulic power recovery turbine: Pump operated with reversed flow to deliver mechanical energy at the coupling obtained from the recovery of energy released by the reduction of fluid pressure (and sometimes from the additional energy released by vapour or gas evolution from the fluid).

NOTE 6 For hydraulic power recovery turbine branches, all references in this standard to suction and discharge apply to the outlet and inlet, respectively.

3.37 radial split: Refers to casing joints that are transverse to the shaft centreline.

3.38 axial split: Refers to casing joints that are parallel to the shaft centreline.

3.39 net positive suction head (NPSH): Absolute total inlet head above the head equivalent to the vapour pressure referred to the NPSH datum plane.

NOTE 7 NPSH is referred to the datum plane, whereas inlet total head is referred to the reference plane. The NPSH datum plane is the horizontal plane through the centre of the circle described by the external points of the entrance edges of the impeller blades; in the case of double inlet pumps with vertical or inclined axis, it is the plane through the higher centre. The manufacturer/supplier should indicate the position of this plane with respect to precise reference points on the pump.

3.40 net positive suction head available (NPSHA): NPSH determined by the conditions of the installation for a specified liquid, temperature and rate of flow.

3.41 net positive suction head required (NPSHR): Minimum NPSH for a pump achieving a specified performance at the specified rate of flow and speed (occurrence of visible cavitation, increase of noise due to cavitation, appearance of head or efficiency drop, head or efficiency drop of a given amount, etc.).

3.42 suction specific speed: Parameter relating the rotational speed, the flowrate and the NPSHR, determined at the best efficiency point.

3.43 hydrodynamic bearing: Bearing whose surface is oriented to another surface such that relative motion forms an oil wedge to support the load without metal-to-metal contact.

3.44 hydrodynamic radial bearing: Bearing of sleeve-journal or tilting-shoe type construction.

3.45 hydrodynamic thrust bearing: Bearing of multiple-segment or tilting-shoe type construction.

3.46 design values: Values used in the design of a pump for the purpose of determining the performance, the minimum permissible wall thickness and physical characteristics of the different parts of the pump.

NOTE 8 Use of the word design in any term (such as design pressure, design power, design temperature or design speed) should be avoided in the purchaser's specifications. This terminology should be used only by the equipment designer and manufacturer/supplier.

3.47 coupling service factor: A factor k, by which is multiplied the nominal torque T_N of the driver in order to obtain the rated torque $T_K = kT_N$, which makes due allowance for cycle torque fluctuations from the pump and/or its driver, and therefore ensures satisfactory coupling life.

4 Design

4.1 General

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 C and D);

b) data sheet (see annex A);

c) this International Standard;

d) other standards to which reference is made in the order (or enquiry, if no order is placed).

The applicability of any national and local codes, regulations, ordinances or rules shall be mutually agreed upon by the purchaser and the manufacturer/supplier.

4.1.1 Characteristic curve

4.1.1.1 The characteristic curve for the supplied impeller shall show the head, efficiency, NPSHR and the power input, plotted against flowrate. It shall also show the allowable operating range of the pump. Head/flowrate curves (on the basis of calculation or test) for the largest and smallest impeller diameters shall be plotted for single stage pumps, and for multistage pumps when requested.

4.1.1.2 Pumps that have stable head/flowrate curves which continuously rise to shutoff are preferred for most applications and are required when parallel operation is specified by the purchaser. Unstable head/flowrate curves or curves with dips (such as propeller pump curves) can be offered providing the application is suitable and the curve shape deviations are shown. When service conditions are such that a stable curve is technically impossible, other means of ensuring the desired flow(s) must be used. When parallel operation is specified, the rise of the head at rated flowrate shall have sufficient slope to avoid instability of flow.

4.1.1.3 The best efficiency point for the supplied impeller should preferably be between the rated point and the normal point (see 3.1).

4.1.1.4 When the pump design permits a constant-speed driver, the pump shall be capable of approximately a 5 % head increase at rated conditions by installing a new larger impeller or impellers.

4.1.1.5 Pumps that handle Newtonian liquids more viscous than water shall have their performance corrected in accordance with the conversion factors to be agreed between purchaser and manufacturer/supplier. Non-Newtonian liquids require special consideration.

4.1.2 Net positive suction head (NPSH)

NPSHR shall be based on cold water according to ISO 2548 and/or ISO 3555[1] unless otherwise agreed.

The NPSHR curve as a function of flow for water shall be provided.

NPSHA must exceed NPSHR by a 10 % margin but in each case by not less than 0,5 m. The basis for use in performance curves is the NPSH corresponding to a drop of 3 % of the total head of the first stage of the pump (NPSH3).

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

The manufacturer/supplier shall specify on the data sheet the net positive suction head required (NPSHR) when the pump is operated with water at the rated flowrate and rated speed.

Hydrocarbon reduction or correction shall not be applied.

For NPSH tests, see 6.3.5.

4.1.3 Pump design

4.1.3.1 Pumping units may be of single-stage or multistage design. When the rated inlet gauge pressure is positive or the differential pressure is more than 3,5 bar, the pump should be designed to minimize the pressure on the shaft seals unless thrust balance requirements dictate otherwise. On single-stage overhang designs this can be accomplished with rings or pumping vanes on the back of the impeller. On multistage pumps this can be accomplished either by a back-to-back impeller arrangement combined with a close clearance throttle bush, or by an in-line impeller arrangement using balance drums or discs.

Other means can be used after agreement between purchaser and manufacturer/supplier.

4.1.3.2 High-energy pumps (head greater than 200 m per stage and power more than 225 kW per stage) require special consideration to ensure that the radial distance between the volute tongue (including double volute casing) or diffuser vane and the impeller periphery is so dimensioned to avoid undue vibrations and noise (blade-passing frequency and low frequency at reduced flowrates).

4.1.3.3 Vertical pumps with threaded line shaft coupling that could be damaged by reverse rotation shall be provided with a non-reverse ratchet or other approved means.

1) A combination of ISO 2548 and ISO 3555 and their simultaneous revision in a new International Standard is foreseen.

4.1.3.4 All equipment shall be designed to permit rapid and economical maintenance. Major parts such as casing components and bearing housings shall be designed (shouldered or dowelled) to ensure accurate alignment on reassembly.

4.1.3.5 Control of the sound level of all equipment supplied shall be a joint effort of the purchaser and the manufacturer/supplier. Unless otherwise specified, the equipment supplied by the manufacturer/supplier shall conform to the requirements of local regulations and to the maximum allowable sound level specified by the purchaser.

NOTE 9 The scope of this International Standard excludes the driver, but a contribution of the driver to the sound level should be taken into account.

4.1.4 Outdoor installation

The purchaser shall specify whether the installation is indoors (heated or unheated) or outdoors (with or without a roof) and the local ambient conditions in which the equipment must operate (including maximum and minimum temperatures, unusual humidity, corrosive air or dust problems). The unit and its auxiliaries shall be suitable for operation in these specified conditions. For the purchaser's guidance, the manufacturer/supplier shall list in the proposal any special protection that the purchaser is required to supply.

4.2 Drivers

4.2.1 General

4.2.1.1 Requirements for determining rated drive performance

The following shall 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 characteristics, shall be considered;

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

c) shaft seal friction loss;

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

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

f) power loss and slip through the transmission;

g) atmospheric conditions at the pump site.

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 but not 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.

4.2.1.2 Thrust load

When the thrust bearing is not part of the pump, and unless otherwise approved by the purchaser, motor, turbine or gear drivers for vertical pumps, including in-line vertical pumps, shall be designed to carry the maximum thrust the pump may develop while starting, stopping or operating at any flowrate. The maximum thrust load shall be determined at double the initial internal clearances. If the driver is not supplied by the manufacturer/supplier he shall notify the purchaser of such requirements.

4.2.2 Turbine-driven pumps

4.2.2.1 Steam turbines

The steam turbines selected shall be capable of carrying the pump rated power input required for the rated conditions based on the guaranteed pump efficiency, or alternatively the maximum power input required for the full operating range of the pump. The steam turbine power rating shall be based on the minimum inlet and maximum exhaust steam conditions specified.

4.2.2.2 Turbine-driven pump speed

The turbine-driven pumps shall be designed to operate continuously at 105 % of rated speed and to operate briefly, under emergency conditions, at up to 110 % of rated speed (turbine overspeed trip setting).

For steam turbines and reciprocating engines, the trip speed shall be at least 110 % of the maximum allowable continuous speed. For gas turbines the trip speed shall be at least 105 % of the maximum allowable continuous speed.

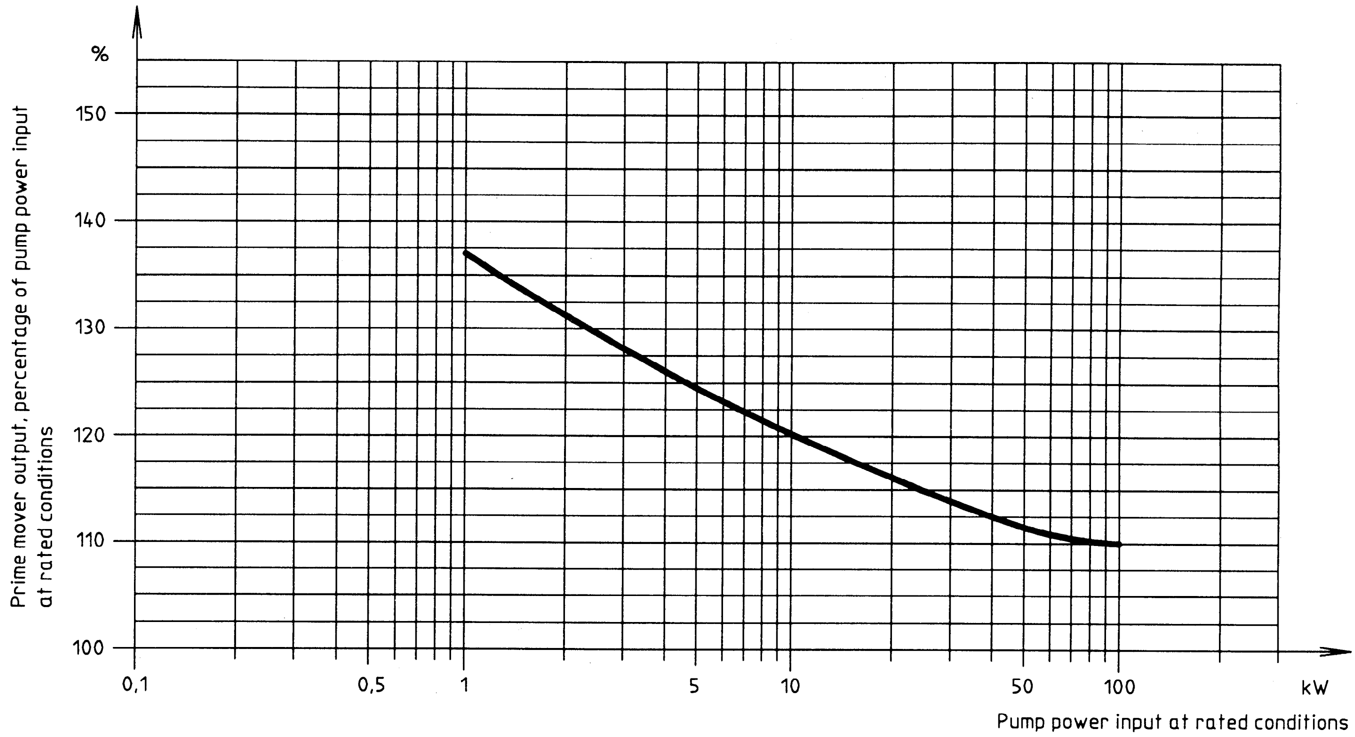


Figure 1 — Driver output percentage of rated pump power required in the range of 1 kW to 100 kW

4.3 Critical speed, balance and vibration

4.3.1 Critical speed

4.3.1.1 Critical speeds correspond to resonant frequencies of the rotor-bearing support system. The basic identification of critical speeds is made from the natural frequencies of the system and of the forcing phenomena. If the frequency of any harmonic component of a periodic forcing phenomenon is equal to or approximates the frequency of any mode of rotor vibration, a condition of resonance may exist. If resonance exists at a finite speed, that speed is called a critical speed. This specification is concerned with actual critical speeds rather than various calculated values both in lateral vibration and in torsional oscillation.

4.3.1.2 A forcing phenomenon or exciting frequency may be less than, equal to, or greater than the synchronous frequency of the rotor. Such forcing frequencies may include but are not limited to the following phenomena:

a) unbalance in the rotor system,

b) oil film effects,

c) internal rub frequencies,

d) blade, vane, nozzle or diffuser passing frequencies,

e) gear meshing and side band frequencies,

f) coupling misalignment frequencies,

g) loose rotor system component frequencies,

h) hysteresis and friction whirl frequencies,

i) boundary layer (vortex shedding),

j) acoustic or aerodynamic effects,

k) start-up conditions, for example, speed detents (under inertial impedance) or torsional deflections contributing to torsional resonances,

l) number of cylinders, angle between banks, and whether two- or four-stroke in the case of internal combustion engines.

4.3.1.3 Actual critical speeds shall not encroach upon specified speed ranges.

The first critical speed (in bending) shall preferably be at least 20 % above the maximum operating speed, except when it is not possible to design a stiff shaft pump, and shall have the purchaser's agreement.

For vertical shaft pumps, this applies particularly when the liquid handled contains an appreciable proportion of solid particles.

When it is not possible to design a stiff shaft pump and with the purchaser's agreement

— the first critical speed N_{c1} shall not exceed 0,37 (= 1/2,7) times the minimum operating speed N_{min},

— the second critical speed N_{c2} shall not be less than 1,2 times the maximum continuous speed N_{max}.

This can be illustrated as in figure 2.

4.3.1.4 The separation margin of encroachment from all lateral modes (including rigid and bending) shall be at least

a) 20 % over the maximum continuous speed for rigid rotor systems, or

b) 15 % below any operating speed and 20 % above the maximum continuous speed for flexible-shaft rotor systems.

Torsional modes of the complete unit shall be at least 10 % below any operating speed or at least 10 % above the trip speed.

The separation margins specified are intended to prevent the overlapping of the critical response envelope into the operating speed range.

4.3.1.5 Slow roll, start-up and shutdown of rotating equipment shall not cause any damage as critical speeds are passed.

4.3.1.6 Support and bearing housing resonances of the driver and driven equipment shall not occur within the specified operating speed range or the specified separation margins.

4.3.1.7 When specified by purchaser, critical speeds shall be confirmed by test stand data, or if above test speeds, they shall be

a) **calculated damped values, or**

b) **values determined by externally applied rotor excitations.**

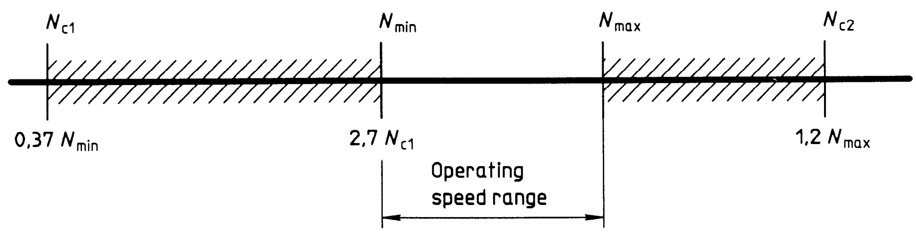


Figure 2 — Conditions of critical speed (see 4.3.1.3)

4.3.1.8 When specified by the purchaser, the calculations detailed in items a) and b) below shall be provided by the manufacturer/supplier. If the purchaser supplies the driving equipment, it shall be his responsibility to provide the data for these calculations:

a) a lateral critical speed analysis to determine that the critical speeds of the driver are compatible with the critical speeds of the pump and that the combination is suitable for the specified operating speed range;

b) a torsional vibration analysis of the pump-driver system and a transient torsional vibration analysis for synchronous motor-driven systems. The manufacturer/supplier shall be responsible for the satisfactory performance of the system.

   In case of drive by internal combustion engine, the manufacturer/supplier of the latter is responsible for the analysis.

4.3.2 Balance and vibration

4.3.2.1 General

4.3.2.1.1 All major rotating components shall be balanced. **When specified by the purchaser, the assembled rotors shall be balanced.**

4.3.2.1.2 When specified by the purchaser, the manufacturer/supplier shall demonstrate that the pump can operate at the quoted minimum continuous stable flow without exceeding the vibration limits given in 4.3.2.2.

4.3.2.1.3 Pumps shall operate smoothly throughout their speed range in reaching rated speed, and to the overspeed limit in the case of turbine-driven units.

4.3.2.1.4 The smooth running of the pump (and its driver) after installation shall be the joint responsibility of the manufacturer/supplier and the purchaser. The units shall perform as well on their permanent foundation as they do on the manufacturer/supplier's test stand.

4.3.2.2 Horizontal pumps

Unfiltered vibration shall not exceed the vibration severity limits given in table 1 when measured on the manufacturer/supplier'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. This can normally be achieved by balancing in accordance with grade G 6.3 of ISO 1940-1; for further information see ISO 5343 and ISO 8821.

Pumps with a special impeller, for example a single channel impeller, may exceed the limits given in table 1. In such case the pump manufacturer/supplier should indicate this in his offer.

Table 1 — Limits of vibration severity for horizontal pumps with multivane impellers (based on ISO 2372)

Speed of rotation, N	Maximum rms values, in mm/s, of the vibration velocity for the shaft centreline height h_1 [1)]	
min⁻¹	$h_1 \leqslant 225$ mm	$h_1 > 225$ mm
$N \leqslant 1\,800$	2,8	4,5
$1\,800 < N \leqslant 4\,500$	4,5	7,1

1) For horizontal foot-mounted pumps h_1 is the distance between baseplate area in contact with pump feet (including supports) and pump shaft centreline.

4.3.2.3 Vertical pumps

4.3.2.3.1 Vibration readings shall be taken on the top flange of the driver mount on vertical pumps with rigid couplings and near to the top pump bearing on vertical pumps with flexible couplings.

4.3.2.3.2 Vibration limits for both rolling and sleeve bearing pumps shall not exceed a velocity of 7,1 mm/s during shop test at rated speed (± 5 %), and rated flow (± 5 %) operating without cavitation.

4.4 Pressure-containing parts (see also 5.1)

4.4.1 Pressure-temperature rating

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

4.4.2 Pump casing

4.4.2.1 Pumps with radially split cases are required if any of the following operating conditions are specified:

a) pumping temperature of 200 °C or higher (a lower temperature limit should be considered when thermal shock is probable);

b) toxic pumped liquid or flammable liquid with a density of less than 0,7 kg/dm^3 at the specified pumping temperature;

c) flammable pumped liquid at a rated discharge gauge pressure above 70 bar.

NOTE 10 Pumps with axially split cases may be supplied for the conditions specified above with the specific approval of the purchaser. (It is recommended that the purchaser consider design details and previous manufacturer/supplier operating experience before approving pumps with axially split cases for these conditions. Maximum hydrostatic test, horizontal joint sealing technique, pump location, and the skill of field maintenance personnel should be factors in the decision.)

4.4.2.2 The thickness of the pressure casing shall be suitable for the maximum outlet working pressure plus allowances for head and speed increases at pumping temperature, and for hydrostatic test pressure at ambient temperature.

The maximum allowable casing working pressure shall be equal to or greater than the maximum outlet pressure.

Areas of double-casing, horizontal multistage (three or more stages) and axially split casing pumps normally subjected to inlet pressure need not be designed for discharge pressure. (The purchaser should consider installation of relief valves on the suction side of such installations.) **The purchaser shall specify if the vertical canned pump inlet can is to be suitable for maximum discharge pressure.** (This is advisable when two or more pumps are connected to a common discharge system.) The stress used in design for any given material shall not be in excess of the values given in specified material standards. The calculation methods for pressure-containing parts and the safety factors for the selected materials shall be in accordance with the relevant national rules.

The pressure-containing parts shall have a corrosion allowance of 3 mm unless a lower corrosion allowance can be accepted (e.g. for titanium).

4.4.2.3 The maximum discharge pressure shall apply to all parts referred to in the definition of pressure casing (see 3.31), except in the case of double-casing pumps, horizontal multistage (three or more stages) and axially split casing pumps.

4.4.2.4 The inner casing of double-casing pumps shall be designed to withstand the maximum internal differential pressure or 3,5 bar, whichever is greater.

4.4.2.5 If there is a risk of misalignment between pump and driver due to temperature differences or any other cause, precautions shall be taken to minimize this, for example centreline support, cooled pedestals, pre-alignment.

4.4.3 Materials

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

4.4.4 Mechanical features

4.4.4.1 Dismantling

With the exception of vertical lineshaft pumps and ring-section type multistage pumps, the pump shall be designed to permit removal of the impeller, shaft, shaft seal and bearing assembly without disturbing the inlet and outlet flange connections.

For axially split pumps, lifting lugs or eyebolts shall be provided for lifting only the top half of the casing. Methods of lifting the assembled pump shall be specified by the manufacturer/supplier.

4.4.4.2 Jackscrew and casing alignment dowels

Jackscrew and casing alignment dowels shall be provided to facilitate dismantling and reassembly. When jackscrews are used as a means of parting contacting faces, one of the faces shall be relieved (counterbored or recessed) to prevent a leaking joint or improper fit caused by marring.

4.4.4.3 Jackets

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

Jacket cooling systems shall be designed to positively prevent leakage of pumped liquid into the coolant. Coolant passage shall not open into casing joints.

4.4.4.4 Casing gaskets

Casing gaskets shall be of a design suitable for the working conditions and for hydrostatic test conditions at ambient temperature.

For radial split casings the casing-cover gaskets shall be confined on the atmospheric side to prevent blow-out.

Radially split casings (including mechanical seal end plate gaskets) shall have metal-to-metal fits with confined controlled compression gaskets.

4.4.4.5 External bolting

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

The use of bolts or studs smaller than 12 mm diameter, if necessary due to space limitations, shall be agreed upon between purchaser and manufacturer/supplier. In such a case the bolting torque should be specified by the manufacturer/supplier.

4.4.4.5.2 The bolting selected (property class according to information in annex L) shall be adequate for the maximum allowable working pressure and temperature and for normal tightening procedures. If at some points it is necessary to use a fastener of special quality, interchangeable fasteners for other joints shall be of the same special quality.

4.4.4.5.3 Tapped holes in pressure parts shall be held to a minimum. Sufficient metal in addition to the metal allowance for corrosion shall be left around and below the bottom of drilled and tapped holes in pressure sections of casings to prevent leakage.

4.4.4.5.4 To facilitate dismantling, internal bolting for vertical pumps shall be of a material fully resistant to corrosive attack by the fluid pumped.

4.4.4.5.5 Studded connections shall be supplied with studs installed. Blind stud holes should be drilled only deep enough to allow a preferred tap depth 1,5 times the major diameter of the stud.

4.4.4.5.6 Studs are preferred to cap screws.

4.4.4.5.7 A clearance shall be provided at bolting locations to permit the use of socket or box-type wrenches. The manufacturer/supplier shall supply any required special tools and fixtures.

4.5 Branches (nozzles) and miscellaneous connections

4.5.1 General

For the purpose of this International Standard, the terms branch and nozzle are synonymous.

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

4.5.2 Vent, pressure-gauge and drain

4.5.2.1 All pumps shall be provided with a vent connection unless the pump is made self-venting by the arrangement of the nozzles.

4.5.2.2 Preferably, no tapped openings shall be supplied in the suction or discharge passages or in other high-velocity areas of the pump unless they are essential for pump operation. **If drain, vent, or pressure gauge connections are required, they shall be specified by the purchaser in the enquiry and order.**

4.5.3 Closures

The material for the closures (plugs, blank/blind flanges etc.) shall be appropriate for the pumped liquid. Attention shall be paid to the suitability of material combinations to resist corrosion 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 for containing pressure.

4.5.4 Auxiliary pipe connections

4.5.4.1 All auxiliary pipe connections shall be of adequate material, size and thickness for the intended duty (see also 4.14).

4.5.4.2 Connections shall be at least 15 mm (outside diameter) for pumps with discharge openings of 50 mm and smaller. Connections shall be at least 20 mm (outside diameter) for pumps with discharge openings of 80 mm and larger, except that connections for seal flush piping and lantern rings may be 15 mm (outside diameter) without regard to pump size. When, because of space limitations, smaller connections must be used, all precautions shall be taken to protect them from damage and ensure their reliability.

4.5.5 Connection identification

All connections shall be identified on the installation drawing in accordance with their duty and function. If possible it is recommended that this identification also be applied on the pump, particularly for mechanical seals and for bearing lubrication and cooling (see annex H).

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

The method given in annex B shall be used for pumps with flexible coupling unless another method is agreed upon between the purchaser and the manufacturer/supplier.

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

The manufacturer/supplier shall verify that these loads are permissible for the pump under consideration. **If the loads are higher than those given in annex B, the solution to the problem shall be agreed upon between purchaser and manufacturer/supplier.**

4.7 Inlet and outlet flanges and facings

4.7.1 Flanges shall conform to ISO 7005 except as specified in items a) to c) below:

a) cast iron flanges shall be flat-faced;

b) flat-faced flanges on casings other than cast iron are acceptable only with full raised-face thickness;

c) flanges that are thicker or have a larger outside diameter than required by the specified standard are acceptable but shall be faced and drilled as specified.

4.7.2 Good seating of the bolt head and/or nut on the back face of cast flanges shall be ensured, if necessary by machining.

Bolt holes shall straddle the flange centreline.

4.8 Impellers

4.8.1 Impeller design

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

4.8.1.2 The impeller, excluding wear rings, shall consist of one piece (such as cast or welded manufacture).

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

4.8.1.3 Impellers shall preferably have solid hubs.

4.8.1.4 If the pump shaft is wetted by the pumped fluid such that danger can occur or the product may become contaminated should the fluid become trapped in a confined space, then the design of the impeller and its securement shall be such that, when assembled onto the shaft, any enclosed spaces shall be freely drained by passageways of not less than 10 mm^2 cross-sectional area.

4.8.2 Securing of impellers

4.8.2.1 Impellers shall be secured against circumferential and axial movement when rotating in the intended direction. Pinning of impellers is not acceptable.

4.8.2.2 Overhung impellers shall be secured to the shaft by a cap screw or cap nut that does not expose shaft threads. Either securing device shall be threaded to tighten by liquid drag on the impeller during normal rotation, and a positive mechanical locking method (for example, a staked and corrosion-resistant set screw or a tongue-type washer) is required. Cap screws shall have fillets and a reduced diameter shank to decrease stress concentrations.

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 must be paid to the possibly dangerous effect on the mechanical seal(s) (see also 4.11.6).

4.9 Wear rings

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

4.9.2 Mating wear surfaces of hardenable materials shall have a difference in Brinell hardness number of at least 50, unless both the stationary and rotating wear surfaces have a Brinell hardness number of at least 400 or if this difference in hardness is impossible to obtain with the material specified.

4.9.3 Renewable wear rings shall be held in place by a press fit with locking pins or threaded dowels (axial or radial) or by flanged and screwed methods. Other methods, including tack welding at three or more points, require the purchaser's approval.

4.10 Running clearances

4.10.1 When establishing running clearances between wear rings and between other moving parts, consideration shall be given to pumping temperatures, suction conditions, the character of the fluid handled, the expansion and galling characteristics of the materials, and hydraulic efficiency.

Clearances shall be sufficient to assure dependability of operation and freedom from seizure under normal operating conditions.

4.10.2 For cast iron, bronze, chromium hardened 11 % to 13 % and materials of similar low galling tendencies, the minimum clearances given in table 2 shall be used. For diameters greater than 150 mm the minimum diametral clearance shall be 0,43 mm + 0,025 mm for each additional 25 mm of diameter or fraction thereof. For materials with greater galling tendencies and/or for operating temperatures above 260 °C, 0,125 mm shall be added to these diametral clearances.

When materials such as cast iron and/or bronze are used with cold and clean fluids such as water at temperatures below 50 °C, then the manufacturer/supplier may use clearances below those of table 2.

Table 2 — Minimum running clearances

Dimensions in millimetres

Diameter of rotating member at clearance	Minimum diametral clearance
50	0,25
50 to 64,99	0,28
65 to 79,99	0,30
80 to 89,99	0,35
90 to 99,99	0,40
100 to 114,99	0,40
115 to 124,99	0,40
125 to 149,99	0,43

4.10.3 Interstage bushes on multistage pumps may have clearances to the manufacturer/supplier's standard, provided the clearances are stated in the proposal.

4.10.4 For vertical pumps, the running clearances specified in 4.10.2 shall not apply to the clearances of steady bearings or interstage bushings if materials of low galling tendencies are used. The clearances used shall be stated in the proposal.

4.11 Shaft and shaft sleeves

4.11.1 General

4.11.1.1 Shafts shall be of ample size and stiffness to:

a) transmit the prime mover rated power,

b) ensure satisfactory packing or seal performance,

c) minimize wear and the risk of seizure,

d) take due consideration of method of starting and inertia loading involved,

e) take due consideration of radial thrust (static and dynamic).

4.11.1.2 The pump shaft of vertical pumps shall be where possible of one piece, unless otherwise approved by the purchaser (because of total shaft length or shipping restrictions).

4.11.2 Surface roughness

The surface roughness of the shaft or sleeve at the stuffing box, mechanical seal, and lubricant seal, if provided, shall be not greater than 0,8 µm R_a unless otherwise required for the seal. Measurement shall be in accordance with ISO 3274 (see also 4.11.7.1).

4.11.3 Shaft deflection

In order to have satisfactory packing or seal performance, avoid shaft breakage and prevent internal wear or seizure, the shaft stiffness for one- and two-stage horizontal and vertical in-line pumps shall limit the total shaft deflection under the most severe dynamic conditions over the complete head-capacity curve — with a maximum-diameter impeller and the specified speed and fluid — to a maximum of 50 µm at the face of the stuffing box (or at the mechanical seal face for built-in seal pumps) and to less than one-half the minimum diametral clearance at all bushes and wear rings. On in-line pumps, the stiffness of the total shaft system, including coupling and motor, shall be included in the calculations.

The required degree of shaft stiffness can be achieved by a combination of shaft diameter, shaft span or overhang and casing design (including use of dual volutes or diffusers). Support by conventional packing shall not be considered when determining shaft deflection.

4.11.4 Diameter

The dimensions of shaft ends should be in accordance with ISO/R 775, and the dimensions of key for shaft ends should be in accordance with ISO/R 773 where practical.

4.11.5 Shaft runout

4.11.5.1 Shafts shall be machined and properly finished throughout their length.

4.11.5.2 Manufacture and assembly of the shaft and sleeve, if fitted, should ensure that the runout (see 3.23) at a radial plane through the outer face of the stuffing box is not greater than 50 µm for nominal diameters smaller than 50 mm, not greater than 80 µm for nominal diameters 50 mm to 100 mm and not greater than 100 µm for nominal 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 Shaft sleeves

4.11.7.1 Shaft sleeves when provided shall be locked or clamped to the shaft. The sleeves shall be of wear resistant and when necessary of corrosion- and erosion-resistant material. The outside surface of sleeves shall be suitable for the actual application (see also 4.11.2).

4.11.7.2 For shafts that require gaskets to pass over threads, the threads shall be at least 1,5 mm less than the internal diameter of the gasket, and the diameter transition shall be chamfered 15° to 20° to avoid damage to the gasket.

4.11.7.3 With the purchaser's approval, sleeves may be omitted for in-line pumps and for small horizontal pumps, provided the proposal so states and the shaft is constructed of a material that has equal wear and corrosion resistance and equal finish to that of a sleeve. If sleeves are not supplied, shafts or stub shafts shall include centres to permit refinishing.

4.11.7.4 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 throttle bush, 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.

4.11.7.5 On horizontal pumps, removable casing bushes and interstage shaft sleeves, or the equivalent, shall be provided at all interstage points.

4.11.7.6 On vertical pumps, renewable bushes shall be provided at all interstage and steady bearing points. However, the character of the fluid handled (for example, dirty or non-lubricating) should influence the need for corresponding shaft sleeves.

4.12 Bearings, bearing housings and lubrication

4.12.1 Bearings and bearing housings

4.12.1.1 Radial bearings shall be of the standard available design (ball, roller, sleeve or pivoted shoe) unless otherwise specified by the purchaser. Thrust bearings shall be either rolling or hydrodynamic as required.

4.12.1.2 Rolling bearings shall be selected and rated in accordance with ISO 76 and ISO 281. The minimum basic rating life L_{10} shall be 3 years (25 000 h), in continuous operation at rated pump conditions but not less than 16 000 h at maximum axial and radial loads and rated speed, within the allowed operating range.

4.12.1.3 Rolling bearings shall be retained on the shaft and fitted into housings according to the bearing manufacturer/supplier's instructions. Snap rings in direct contact with the bearings shall not be used for transmitting the thrust from the shaft to the inner face of the thrust bearing. Locknuts and lockwashers are preferred.

4.12.1.4 Hydrodynamic radial and/or thrust bearings shall be required under the following conditions:

a) when DN factors are 300 000 or greater [the DN factor is the product of bearing size (bore) in mm and the rated speed in revolutions per minute];

b) when the product of rated pump power input (in kilowatts) and rated speed (in revolutions per minute) is 2×10^6 or greater;

c) when standard rolling bearings fail to meet the basic rating life L_{10} given in 4.12.1.2.

4.12.1.5 When allowed by the pump design and justified by the operating conditions, hydrodynamic radial bearings should be split for ease of assembly and shall be of the precision-bored sleeve or pad type, with babbited replaceable liners, shells or pads. Bearings shall be equipped with antirotation pins and shall be positively secured in the axial direction. The bearing design shall suppress hydrodynamic instabilities and provide sufficient damping to limit pump vibrations to the maximum specified amplitudes (see 4.3.2.2 and 4.3.2.3) while operating loaded or unloaded at specified operating speed, including operation at any critical frequency. The liners, pads or shells shall be in axially split housing and shall be replaceable. The removal of the top half of the casing of an axially split machine or the head of a radially split machine shall not be required for replacement of these elements. The bearing design shall not require removal of the coupling hub to permit replacement of the bearing liners, pads or shells.

4.12.1.6 Thrust bearings shall be sized for continuous operation under all specified conditions, including conditions such as maximum internal differential pressure. All loads shall be determined at design internal clearances. As a guide, hydrodynamic thrust bearings should be selected at no more than 50 % of the bearing manufacturer/supplier's rating, and shall be adequate for the pump design and application.

In addition to thrust from the rotor and any internal gear reactions due to the most extreme allowable conditions, the axial force transmitted through the flexible coupling shall be considered a part of the duty of any thrust bearing.

Thrust bearings must provide full load capabilities if the normal direction of rotation of the pump is reversed. Consideration should be given to type of driver, coupling and possible misalignment.

4.12.1.7 Hydrodynamic thrust bearings shall be designed for equal thrust capacity in both directions and arranged for continuous pressurized lubrication to each side. The thrust collar shall be replaceable when specified by the purchaser and shall be positively locked to the shaft to prevent fretting. When integral thrust collars are supplied, they shall be provided with a minimum of 3 mm of additional stock for refinishing should the collar be damaged. Both faces of the collar shall have a surface finish not exceeding 0,4 µm R_a and the axial total indicated runout of either face shall not exceed 13 µm.

4.12.1.8 Housings for oil-lubricated non-pressure-fed bearings shall be provided with 15 mm minimum thread tapped and plugged fill and drain openings. They shall be equipped with constant level sight-feed oilers connected to transparent containers (not subject to sunlight- or heat-induced opacity or deterioration), which shall be installed at an appropriate position on the bearing housing and positively locked in the operating position. **These oilers shall meet the purchaser's preference when specified.** A permanent indication of 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, and shall state whether that level represents stationary or running conditions.

4.12.1.9 Bearing housings for hydrodynamic bearings designed for pressure lubrication shall be arranged to minimize foaming. The drain system shall be adequate to maintain the oil and foam levels below the shaft end seals. Oil temperature rise through the bearing and housings shall not exceed 30 °C under the most adverse specified operating conditions when oil inlet temperature is 40 °C. When oil inlet temperatures exceed 50 °C, special consideration shall be given to bearing design, oil flows and allowable temperature rise. Oil outlets from thrust bearings shall be tangential in the control ring, or in the thrust bearing cartridge if oil control rings are not used.

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

4.12.1.11 All openings in the bearing housing, particularly the sealing between the bearing housing and the shaft, shall be designed to prevent the ingress of contaminants and the escape of the lubricant under normal operating conditions.

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

4.12.1.13 Housing for ring-oil-lubricated bearings should be provided with means to allow visual inspection of the oil rings while the pump is running.

4.12.1.14 If specified by the purchaser, the manufacturer/supplier shall supply oil heaters when the ambient or operating temperature dictates.

4.12.1.15 Bearing housings shall preferably be arranged so that bearings can be replaced without disturbing pump drives or mountings.

4.12.1.16 Sufficient cooling, including allowance for fouling, shall be provided to maintain oil temperature below 70 °C for drain oil in pressurized systems and below 80 °C for ring-oiled or splash systems based on specified operating conditions and 40 °C ambient temperature. Cooling coils (including fittings), if used, shall be of non-ferrous material and shall have no internal pressure joints or fittings. The coils shall be 1 mm minimum material thickness and 12 mm minimum tube outside diameter.

4.12.2 Guide bushes and bearings for vertical lineshaft pumps

4.12.2.1 The maximum spacing between shaft guide bushes shall be in accordance with figure 3, except for cantilever-type pumps. If these bushes are product-lubricated, they must be suitably corrosion and abrasion resistant for the specified product and temperature.

4.12.2.2 Thrust bearings that are integral with the driver are covered in 4.2.1.2. Where the thrust bearing is integral with a vertical lineshaft pump, the paragraphs under 4.12.1 that relate to thrust bearings and housings shall apply.

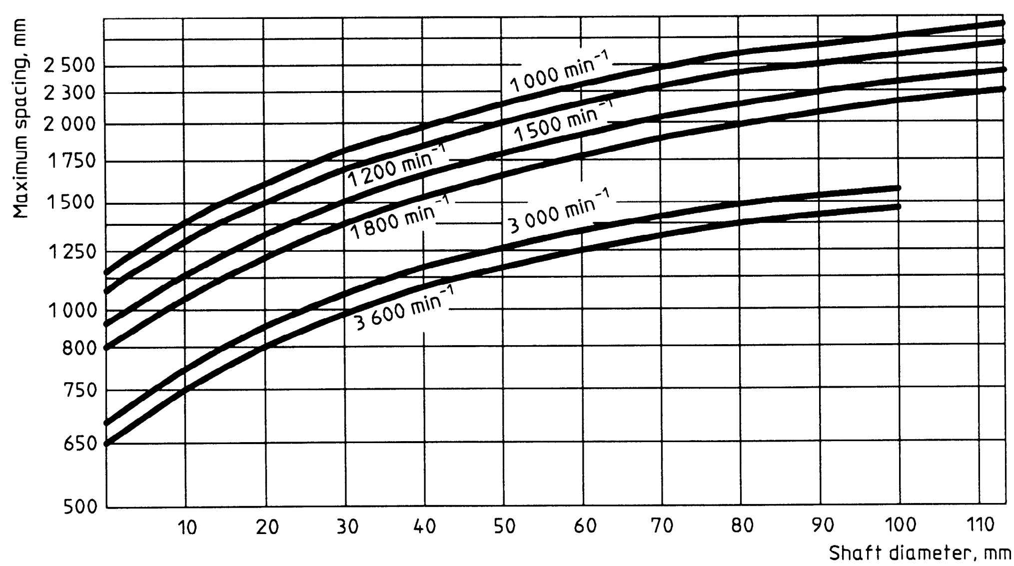


Figure 3 — Maximum spacing between shaft guide bushes (vertical lineshaft pumps)

4.12.3 Lubrication

4.12.3.1 Bearings and bearing housings shall be arranged for hydrocarbon oil or grease lubrication unless otherwise specified.

4.12.3.2 A pressure lubrication or oil mist lubrication system shall be supplied if specified by the purchaser or if recommended by the manufacturer/supplier and approved by the purchaser. Oil lubrication shall be ensured at constant level by internal arrangement.

4.12.3.2.1 If an external pressure lubrication system is required, it shall consist, as a minimum, of an oil pump with a suction strainer and/or filter, a supply-and-return system, an oil cooler when required, an oil reservoir, a full-flow filter and means for lubrication before the pump unit is running, and all necessary controls and instruments, including a low-oil-pressure alarm and shutdown (see G.6).

4.12.3.2.2 When specified by the purchaser, a removable steam-heating element external to the oil reservoir or a thermostatically controlled electrical immersion heater shall be provided for heating the charge capacity of oil prior to start-up in cold weather. The heating device shall have sufficient capacity to heat the oil in the reservoir from the specified minimum site ambient temperature to the manufacturer/supplier's required start-up temperature within 4 h when the lubrication oil system is running.

4.12.3.2.3 An oil reservoir, with the characteristics specified in items a) through f) below, shall be supplied:

a) the ability to provide a 3-minute minimum retention time, to avoid frequent refilling, and to provide adequate allowance for the contents of the system when drained;

b) provision to eliminate air and to minimize flotation of foreign matter to pump suction;

c) fill connections, level indicators and breathers suitable for outdoor use;

d) sloped bottoms and connections for complete drainage;

e) cleanout openings of practicable size;

f) descaling, rust protection and permanent surface coating of the interior according to the manufacturer/supplier's standard procedure, unless otherwise specified.

4.12.3.2.4 Flingers or oil rings shall have a submergence above the lower edge of a flinger or above the lower edge of the bore of an oil ring. Oil flingers shall have mounting hubs to maintain concentricity and shall be positively secured to the shaft.

4.12.3.2.5 The manufacturer/supplier shall state in the operating manual the amount of and the specification for the lubricating oil required, taking into consideration the ambient and service conditions.

4.12.3.2.6 Refer to 4.14.3 for lubricating-oil piping requirements.

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

4.13 Shaft sealing

4.13.1 General

When the pump shaft has to be sealed, the pump design shall permit the use of one or more of the following alternatives:

— soft packing (P),

— single mechanical seal (S),

— multiple mechanical seals (D),

as shown in annex F. **If it is necessary to interchange one or the other alternative, this shall be specified by the purchaser. Other means of sealing devices (e.g. labyrinth seals, hydrodynamic seals, magnetic couplings) shall be mutually agreed upon.** Quench arrangements (Q), which in certain cases can become necessary, are also shown in annex F. Devices shall be provided for limiting, collecting and draining all liquid leakage from the sealed area, in particular if the mechanical seals have controlled leakage.

The following information shall be given in the data sheet (see annex A):

— shaft seal arrangement (as specified in annex F);

— for mechanical seals:

type:	balanced (B) unbalanced (U) bellows (Z)
size:	nominal shaft or sleeve diameter, in millimetres, based upon shaft diameter passing through stationary ring (see ISO 3069);

— for stuffing box:

size:	diameter of seal cavity as specified in ISO 3069.

4.13.2 Operating criteria for selection

The principal operating criteria for selection of mechanical seals and soft packings are:

— chemical and physical properties and the nature of the pumped liquid;

— minimum and maximum expected sealing pressures;

— temperature of the liquid at the seal;

— special operating conditions (including start-up, shutdown, thermal and mechanical shocks, etc.);

— shaft diameter and speed;

and as a supplementary criterion for mechanical seals:

— direction of rotation of the pump.

4.13.3 Mechanical seals

4.13.3.1 Type and arrangement

Mechanical seals shall be of the balanced type. **Unbalanced seals shall only be supplied when specified or approved by the purchaser.**

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

Mechanical seal design shall take account of axial adjustment of shaft and shaft movement during normal operation.

Arrangement (e.g. single or multiple mechanical seal) shall be agreed upon (see annex F).

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 multiple mechanical seals is applied, the barrier liquid between the seals must be compatible with the process and at a pressure higher than the sealing pressure.

If a back-to-back arrangement of multiple mechanical seals 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.

4.13.3.2 Cooling or heating requirements

If required by the duty, jackets shall be provided on pump seal chambers. **Cooling (or heating) requirements for pumps containing mechanical seals shall be mutually agreed upon by the purchaser, pump manufacturer/supplier and seal manufacturer/supplier.** As a guide, jackets are normally required for the conditions and services specified in items a) to e) below:

a) fluid temperatures above 150 °C, unless bellows-type mechanical seals are used;

b) fluid temperatures above 315 °C;

c) dead-end seal arrangements;

d) low flash point fluids;

e) high melting point fluids (heating).

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 pump 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.

The material code for mechanical seal components in table J.2 (annex J) shall be used for designation in the data sheet (annex A).

4.13.3.4 Construction features

4.13.3.4.1 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.

4.13.3.4.2 The seal end plate shall have sufficient rigidity to avoid distortion. The seal housing and end plate including fixing bolts (see 4.4.4.5) shall be designed for the permissible operating pressure at operating temperature and the required gasket seating load.

4.13.3.4.3 Gaskets between seal housing and stationary seal ring (seat ring and/or spring-loaded ring) or seal end plate shall be externally confined or of equivalent design in order to prevent blow-out.

4.13.3.4.4 All stationary seal components including seal end plates shall be protected from accidental contact with the shaft or sleeve and from rotation. In case a stationary sealing component (seat ring and/or spring-loaded ring) 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.

4.13.3.4.5 Machining tolerance of the seal chamber and seal end plate must restrict the face run-out at the stationary seal ring (seat ring and/or spring-loaded ring) of the mechanical seal to maximum permissible values as given by the seal manufacturer/supplier.

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

$$\frac{\text{shaft diameter}}{150} + 0{,}65$$

4.13.3.4.7 A throat bush shall be provided when specified by the purchaser or recommended by the manufacturer/supplier. Throat bushes are used to increase the box pressure, isolate the fluid, or reduce the flow in or out of the seal chamber.

4.13.3.4.8 Where leakage must be avoided an auxiliary seal (for example, multiple seal) is necessary (see annex F).

4.13.3.4.9 The seal chamber shall be designed to prevent trapping vapour (see 4.5.2.1) 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.

4.13.3.4.10 Liquid inlets to and if necessary outlets from the chamber shall be as close as possible to the seal faces, preferably at the rotary ring side (spring-loaded ring and/or seat ring).

4.13.3.4.11 Holes may be drilled and tapped even where a connection is not required (see 4.5.2 and 4.5.4) unless otherwise agreed.

4.13.3.5 Assembly and test

For assembly for dispatch see 7.1.

The mechanical seal shall not be subjected to a hydrostatic test pressure exceeding the seal pressure limit. The mechanical seal may be used during all running or performance tests (see 6.3.3.4 and 6.3.4.4). On pumps that require final adjustment in the field, the manufacturer/supplier shall attach a metal tag warning of this requirement.

4.13.4 Stuffing box

4.13.4.1 General

4.13.4.1.1 When required by the duty or by the purchaser, soft packing shall be provided with a lantern ring for the introduction of a cooling fluid directly into the packing. Inlet and outlet connections shall be provided for the lantern ring.

4.13.4.1.2 Ample space shall be provided for repacking without removing or dismantling any part other than gland components and guards. The gland components shall be positively retained even if the packing loses its compression.

4.13.4.1.3 Where split glands are used, the halves shall be bolted together. The use of eyebolts for gland fasteners is undesirable; studs screwed into the pump case are preferred.

4.13.4.1.4 A drain shall be provided on vertical pumps to prevent the collection of liquid in the driver support piece.

4.13.4.1.5 For service above 90 °C or for handling liquids with an absolute vapour pressure greater than 1 bar at pumping temperatures, glands shall be of the water-smothering split type. For high-temperature service, steam may be substituted for water. When cooling-water piping is provided by the manufacturer/supplier, the flexible hose or tubing to the quench gland shall have a minimum inside diameter of 6 mm.

4.13.4.1.6 Cooling jackets shall be provided on stuffing boxes of packed pumps when either of the following conditions is specified:

a) the fluid temperature is above 150 °C, or

b) the absolute vapour pressure is above 0,7 bar at pumping temperature.

4.14 Piping and accessories

4.14.1 General

When specified by the purchaser, cooling-water, lubricating oil and auxiliary product piping systems, including all accessories such as gauges and valves, shall be supplied by the manufacturer/supplier fully assembled and installed on horizontal pumps and, where practical, on vertical pumps.

4.14.1.1 Design of piping

The design of piping systems shall provide the conditions specified in items a) through d) below:

a) permit removal of piping for maintenance unless welded piping is specified;

b) proper support to prevent damage from vibration during operation and during maintenance using generally accepted practices;

c) proper flexibility and normal accessibility for operation, maintenance and thorough cleaning;

d) installation in a neat and orderly arrangement adapted to the contour of the machine and not obstructing access openings.

4.14.1.2 Quotation of piping

The manufacturer/supplier shall include in his quotation all integral piping he considers necessary for the successful operation of the pump, as well as all integral piping in accordance with the specific plans covered in annex G and items indicated on the data sheet.

4.14.1.3 Construction features

4.14.1.3.1 Pipe threads shall be in accordance with ISO 7 or ISO 228-1. Flanges shall be in accordance with ISO 7005-2 or ISO 7005-3. **Slip-on flanges are permitted with the specific approval of the purchaser.**

4.14.1.3.2 The bolting requirements of 4.4.4.5 apply to auxiliary piping.

4.14.1.3.3 For handling nonflammable or nontoxic fluids, including lubricating oil, pipe joints and connections may be to the manufacturer/supplier's standard or as specified by the purchaser on the data sheet.

4.14.2 Cooling-water piping

4.14.2.1 Cooling-water piping shall be G 1/2 nominal pipe size minimum. Where space does not allow this, G 1/4 nominal pipe size may be used.

4.14.2.2 Material for cooling-water piping shall be specified on the data sheets. If the material is not specified, copper tubing soft-annealed with G 1/2 brass fittings shall be supplied. **If agreed to by the purchaser, stainless steel tubing, type CrNi or CrNiMo may be substituted. If agreed to by the purchaser, galvanized pipe with screwed fittings for PN 20 of galvanized malleable iron may also be substituted.**

4.14.2.3 When specified by the purchaser, sight flow indicators (open or closed as specified) shall be supplied in each outlet line.

4.14.2.4 Drains shall be provided at all low points to allow complete drainage of piping and jackets. Piping should be designed to eliminate air pockets in the cooling jackets.

4.14.3 Lubricating oil piping

4.14.3.1 Oil piping shall be G 1/2 nominal pipe size minimum. Where space does not allow this, G 1/4 nominal pipe size may be used.

4.14.3.2 Oil return lines shall be sized to run no more than half full and arranged to ensure good drainage (recognizing the possibility of foaming conditions). Horizontal runs shall slope continuously, a minimum of 20 mm per 1 m, towards the reservoir.

4.14.3.3 Sight flow indicators shall be supplied for each return line.

4.14.3.4 All lubricating oil piping shall be cleaned thoroughly before assembly to the pump, by a method of cleaning appropriate to the piping material. If piping is shipped separately, the open ends shall be plugged. Galvanized piping shall not be used.

4.14.4 Other auxiliary piping

4.14.4.1 Other auxiliary piping includes vents and drains, balance lines and process fluid lines. For auxiliary piping for soft packing and mechanical seals see 4.14.5.

4.14.4.2 Auxiliary process piping shall be G 1/2 nominal pipe size minimum. Where space does not allow this, G 1/4 nominal pipe size may be used.

4.14.4.3 Piping components subject to the process fluid shall have a pressure-temperature rating at least equal to the maximum discharge pressure and temperature of the pump casing.

4.14.4.4 When the pump casing is of alloy material, all piping components subject to the process fluid shall be equal to or better than the casing material with respect to corrosion and erosion resistance.

4.14.4.5 If a restriction orifice is provided, its diameter shall be not less than 3 mm. When using adjustable orifices, a minimum continuous flow shall be ensured.

4.14.4.6 When heating or cooling is provided, the exchanger components shall be suitable for the pumped liquid and/or the coolant to which each is exposed, and shall be sized for the respective circulation rate.

4.14.4.7 Unless valves are specified, threaded-casing vent and drain connections shall be plugged with solid plugs. Carbon steel plugs shall be used with cast iron casings.

4.14.5 Auxiliary piping for stuffing box and mechanical seal

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

4.14.5.2 Auxiliary piping may be required for the following:

— Category a)

Service which involves process liquids or liquids that can enter the process:

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

— Category b)

Service for liquids which do not enter the process:

- heating;
- cooling;
- quenching.

In each case the range of supply and details of piping connection for external services are to be agreed between purchaser and manufacturer/supplier.

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

4.14.5.3 A suitable material shall be used for process fluid category a) piping to mechanical seals and stuffing boxes. Tubing fittings may be to the manufacturer/supplier's standard.

4.14.5.4 Auxiliary piping shall have the following construction features:

a) the temperature and pressure rating of auxiliary piping handling process liquids (see 4.14.4.3 and 4.14.5.2) shall not be less than that of the casing (see 6.3). The piping material shall resist corrosion caused by the liquid handled (see 4.5.4) and by ambient conditions;

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

c) steam services shall be "top in, bottom out". In general other services should be "bottom or side in, top out";

d) if a restriction orifice is provided, its diameter shall be not less than 3 mm;

e) when using adjustable orifices, a minimum continuous flow shall be ensured.

4.15 Labelling

4.15.1 Direction of rotation

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

4.15.2 Nameplate

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

The minimum information on the nameplate shall include name (or trademark) and address of the manufacturer/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), allowable working pressure and rated temperature of the pump.

In addition to appearing on the nameplate, the pump serial number shall be plainly stamped on the pump casing (e.g. pump outlet flange outside diameter).

4.16 Couplings

4.16.1 General

4.16.1.1 The pump is normally coupled to the drive by flexible coupling. Other types such as rigid, semi-flexible couplings or cardan shaft may be used if appropriate. In relation to the application (type of drive, possibility of hydraulic shock, speed variation, variation of hydraulic thrust, etc.) the coupling shall be chosen to transmit the maximum torque of the intended driver and axial thrust with appropriate factors in accordance with ISO 4863. The speed limitation of the coupling shall correspond to all possible operating speeds of the intended pump driver.

4.16.1.2 Spacer coupling shall be provided to permit the pump rotor to be dismantled or permit replacement of seal assembly including sleeve without removing the driver. 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 ISO 2858 where possible.

4.16.1.3 For couplings using flexible elements the design shall be such that in the event of coupling flexible element failure the spacer and/or elements are prevented from escaping. If axial movement of a coupling hub on the shaft would permit escape of the spacer or elements, such movement shall be positively prevented.

4.16.1.4 A limited end float coupling shall be required on horizontal pumps if the driver has no thrust bearing (see table 3).

Table 3 — Maximum coupling end floats

Dimensions in millimetres

Minimum motor rotor end float	Maximum coupling end float
6	2
12	5

4.16.1.5 Coupling halves shall be effectively secured against circumferential and axial movement relative to the shafts.

4.16.1.6 If specified by the purchaser or recommended by the manufacturer/supplier, couplings shall be dynamically balanced in accordance with ISO 1940-1. The balance class shall be mutually agreed upon by the purchaser and the manufacturer/supplier.

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

4.16.1.8 The permissible operating radial, axial and angular misalignments shall not exceed the limits given by the coupling manufacturer/supplier. Coupling shall be selected so that the operating conditions, such as temperature, torque variations, number of starts, pipe loads, etc. and the rigidity of the pump and baseplate or driver support are taken into account.

4.16.1.9 A service factor k of at least 1,5 shall be applied to flexible-element couplings (see also 3.47).

4.16.1.10 An appropriate coupling guard shall be provided. Guards shall be designed in accordance with national safety regulations.

4.16.1.11 If the pump is to be delivered without driver, the pump manufacturer/supplier and purchaser should agree on the following:

a) **drive system: type, power, dimensions, mass, mounting method;**

b) **coupling: type, manufacturer/supplier, dimensions, machining (bore and keyway), guard;**

c) **speed range and power input.**

4.16.2 Coupling for vertical lineshaft pumps

If solid shaft drivers are used on vertical lineshaft pumps without integral thrust bearings, the couplings shall be all steel and of the rigid adjustable type. In the case of threaded shaft connections, the connection shall be locked by a suitable device.

4.17 Baseplate

4.17.1 General

The baseplate, as installed at site, and pump supports shall be designed to withstand external forces on pump branches given in 4.6, without exceeding shaft misalignment specified by the coupling manufacturer/supplier, and to minimize misalignment caused by other mechanical forces, such as internal differential thermal expansion and hydraulic piping thrust. Baseplates may be manufactured from various materials.

4.17.2 Baseplate for horizontal pumps

4.17.2.1 Provision should be made on the baseplate for collecting and draining leakage if required. When a drain-rim baseplate is specified, connections for a drain shall be tapped (25 mm minimum) in the raised lip at the pump and shall be located to effect complete drainage. The pan or upper surface of the baseplate shall be sloped 8,5 mm per 1 m (minimum) towards the drain end.

4.17.2.2 The baseplate shall extend under the pump and driver, unless otherwise agreed upon.

4.17.2.3 All mounting pads provided for securing the pump and motor shall be fully machined flat and parallel to receive the equipment. Corresponding surfaces shall be in the same plane within 0,2 mm per 1 m of distance between pads, as machined.

All driver-train pads on the baseplate shall be machined to allow for installation of shims (1,5 mm minimum thickness) under the driver train. When the pump manufacturer/supplier provides the driver, a set of stainless steel shim packs (3 mm minimum thickness) shall be included. When the pump manufacturer/supplier does not mount the driver, the pads for the driver shall be machined but not drilled, and shim packs shall not be provided. All shims shall straddle holding-down bolts.

4.17.2.4 The underside of fabricated baseplates beneath the pump and driver supports shall be reinforced by welding to cross-members shaped to lock positively into the grout to resist upward movement of the baseplate.

4.17.2.5 Where possible, baseplates for single-stage, overhung, IEC-frame motor-driven pumps shall preferably have standardized dimensions. For end suction single-stage foot-mounted pumps, baseplate dimensions should preferably be in accordance with ISO 3661. Baseplates may or may not be designed for grouting.

4.17.2.6 When baseplates are to be grouted, they shall be provided with at least one grouting opening having a clear area of no less than 0,01 m^2 and no dimension less than 80 mm in each bulkhead section. These holes shall be located to permit filling the entire cavity under the baseplate without creating air pockets. Vent holes shall be provided for each bulkhead compartment. For dropped centre-trough baseplates, the holes shall be in the high section adjacent to the trough. Where practical, holes shall be accessible for grouting with the pump and driver installed. Grout holes in the drip-pan area shall have raised-lip edges, and if located in an area where liquids could impinge, metallic grout hole covers shall be provided.

4.17.2.7 Non-grouted baseplates shall be rigid enough to withstand loads described in 4.6 for freestanding installation or for installation by bolting on a foundation without grouting.

4.17.2.8 When specified by the purchaser or manufacturer/supplier, pedestals for centreline-supported pumps handling hot fluids shall be designed for supplemental cooling to maintain alignment.

4.17.2.9 For driver trains over 150 kW, alignment positioning screws shall be provided for each drive element to facilitate longitudinal and transverse horizontal adjustments. The lugs holding these positioning screws shall be attached to the baseplate so that they do not interfere with the installation or removal of the drive element.

4.17.2.10 When specified by the purchaser, vertical levelling screws spaced for stability shall be provided on the outside perimeter of the baseplate. These shall be numerous enough to carry the weight of the baseplate, pump and driver without excessive deflection, but in no case shall fewer than six screws be provided.

4.17.2.11 The height of the pump shaft centreline above the baseplate shall be minimized.

4.17.2.12 When specified by the purchaser, a minimum vertical clearance of 50 mm shall be provided beneath the centreline at each end of the drive (driver and gear) for insertion of a hydraulic jack.

4.17.2.13 When epoxy grout is indicated by the purchaser on the data sheet, the manufacturer/supplier shall pre-coat all the grouting surfaces of the mounting plates with a catalysed epoxy primer applied to degreased clean metal.

4.17.2.14 All double bearing and multistage pumps operating 170 °C above ambient temperature shall be centreline-mounted and should be provided with transverse and longitudinal guideways between the pump feet and the baseplate pedestals to provide accurate horizontal alignment during temperature transients.

4.17.3 Baseplates for vertical pumps

4.17.3.1 Double-casing vertical pumps shall have a steel mounting plate attached directly to the outer can or barrel. The foundation bolts shall not be used to secure the flanged joint under pressure. A separate base-mounting flange is desirable but not mandatory.

4.17.3.2 Single-casing vertical pumps shall have the manufacturer's standard mounting arrangement.

4.17.3.3 If specified by the purchaser, a minimum of four alignment positioning screws shall be provided for each drive element (driver and gear) to facilitate horizontal adjustments.

4.18 Special tools

Any tools which are specially designed by the pump manufacturer/supplier and which are only used for assembling and dismantling the pump must be supplied by the manufacturer/supplier.

5 Materials

5.1 Selection of materials

5.1.1 Materials are normally specified in the data sheet. If the materials are selected by the purchaser but the pump manufacturer/supplier considers other materials to be more suitable, these shall be offered as alternatives by the manufacturer/supplier according to the operating conditions specified on the data sheet.

Materials used for hazardous liquids shall be agreed between purchaser and manufacturer/supplier. Non-ductile materials should not be used for the pressure-containing parts of pumps handling flammable liquids.

For high or low temperature applications (i.e. above 175 °C or below − 10 °C) the pump manufacturer/supplier shall give due consideration to mechanical design. For seal materials, see 4.13.3.3.

5.1.2 Materials shall be identified in the proposal with the applicable standard designation (see table J.1, annex J, for ISO materials standard). When such designation is not available, the manufacturer/supplier's material specification, giving physical properties, chemical composition and test requirements, shall be included in the proposal.

5.1.3 The manufacturer/supplier shall specify the optional tests and inspections necessary to ensure that materials are satisfactory for the service. Such tests and inspections shall be listed in the proposal. **The purchaser should consider specifying additional tests and inspections, especially for critical service.**

5.1.4 Classification of pump materials shall be in accordance with items a) through c) below:

a) the outer pressure-casing parts of double-casing pumps shall be of carbon steel or alloy steel;

b) pressure-casing parts of pumps that are to handle flammable or toxic liquids shall be of carbon steel or alloy steel;

c) cast iron or other material construction may be offered for other services.

5.1.5 Low-carbon or stabilized grades of austenitic stainless steels shall be used when parts made of these materials will be fabricated, hard-surfaced, overlaid or repaired by welding and exposed to a motive or process fluid or to an environmental condition that promotes intergranular corrosion.

5.1.6 Materials, casting criteria and the quality of any welding shall be in conformity with the relevant ISO/national standards.

5.1.7 When specified by the purchaser, the manufacturer/supplier shall supply chemical and mechanical data for pressure-casing parts from the melt (heat) of the material supplied.

5.1.8 The purchaser shall specify the presence of corrosive agents in the motive and process fluid and in the environment, including constituents that may cause stress corrosion cracking.

5.1.9 Minor parts not identified (nuts, springs, gaskets, washers, keys, etc.) shall have corrosion resistance equivalent to that of specified parts in the same environment. Gasket or seal material between the shaft and the shaft sleeve under the packing or mechanical seal shall be verified by the manufacturer/supplier as satisfactory for the service conditions.

5.1.10 Where mating parts such as studs and nuts of 18-8 stainless steel or materials having similar galling tendencies are used, they shall be lubricated with a suitable antiseizure compound before assembly.

5.1.11 Materials for the pressure casing, drive shafts, balance pistons, impellers and bolting having a yield strength in excess of 620 N/mm^2 or a hardness in excess of Rockwell C22 shall be used for components exposed to wet H_2S service, including trace quantities. Components that are fabricated by welding shall be stress relieved, if required, so that both welds and the heat-affected zones meet the yield strength and hardness requirements. **It shall be the responsibility of the purchaser to specify the presence of such agents in the media.**

5.2 Castings

5.2.1 The manufacturer/supplier shall specify material grade for castings on the data sheet.

5.2.2 Castings shall be sound and free of shrink holes, blow holes, cracks, scale, blisters and other similar injurious defects. The surface of castings shall be cleaned by sandblasting, shotblasting, pickling or any other standard method. All mould-parting fins and remains of gates and risers shall be chipped, filed or ground flush.

5.2.3 The use of chaplets in castings shall be held to a minimum. The chaplets shall be clean and corrosion free (plating permitted) and of a composition compatible with the casing.

5.2.4 Ferrous and nonferrous pressure-casing castings shall not be repaired by peening, plugging, fusing or impregnating. When weld repair to castings are authorized by the material specification, repair welding shall be in accordance with that specification. Unless otherwise specified, weld repairs shall be inspected according to the same quality standards used to inspect the casting.

5.3 Welding

5.3.1 Piping connections to pressure casings shall be installed as specified in items a) through c) below:

a) attachment of suction and discharge nozzles shall be by full-penetration welds. Dissimilar metal weldments are not allowed. **The purchaser shall specify if magnetic particle inspection or dye penetrant inspection of nozzle welds is required;**

b) auxiliary piping welded to alloy steel casing shall be of material with the same nominal properties as the casing or shall be low-carbon austenitic stainless steel. **Other materials compatible with the casing material and intended service may be used with the purchaser's approval.** All weldments shall be heat treated in accordance with the relevant material standard. If this is impossible, suitable precautions shall be taken during the welding, in accordance with the relevant material specification. **Auxiliary piping welded to the casing shall terminate with a flange unless the purchaser specifies that it will be welded in the field.**

c) **When specified by the purchaser, proposed connection design shall be submitted to the purchaser for approval prior to fabrication.** Drawings shall show weld design, size, materials, and preheat and post-heat treatments.

5.3.2 All welding of piping and pressure-casing parts shall be performed by operators and procedures qualified in accordance with the agreed welding qualifications. Weld repairs are covered in 5.2.4.

5.4 Material inspection

5.4.1 When necessary or if specified by the purchaser, tests (radiography, ultrasonic, magnetic particle or dye penetrant inspection of welds or materials) shall be conducted in accordance with the agreed ISO/national standard.

5.4.2 If specified by the purchaser, records of all heat treatment and radiographs (fully identified), whether performed in the normal course of manufacture or as part of a repair procedure, shall be kept available for five years for review by the purchaser.

5.4.3 When inspection by methods specified in 5.4.1 is required, acceptability of defects shall be agreed between purchaser and manufacturer/supplier. Where defects exceed the agreed limits they shall be reduced to meet the quality standards agreed, as determined by additional inspection prior to repair welding.

5.5 Low temperature use

For operating temperatures below − 30 °C or when specified by the purchaser for low ambient temperatures, steels shall have an impact strength at the lowest specified temperature sufficient to qualify under the minimum relevant ductility standard. For materials and thicknesses not covered by the relevant standard, the purchaser shall specify the requirements on the data sheet.

6 Shop inspection and tests

6.1 General

6.1.1 Any or all of the following inspections and tests may be requested by the purchaser and where so requested they shall be specified in the data sheet (see annex A). This implies agreement between the purchaser and the manufacturer/supplier. Such inspections and tests may be witnessed or certified. The reading sheets of witnessed inspections and tests shall be signed by the inspector and representative of the manufacturer/supplier. The certification shall be issued by the manufacturer/supplier's representative.

6.1.2 Where inspection is specified, the purchaser's inspector shall be granted access to the manufacturer/supplier's works, and the facilities and data to enable inspection to be carried out satisfactorily.

The manufacturer/supplier shall maintain a complete, detailed list of all final tests and shall prepare the required number of copies, including test curves and data, certified as to correctness. All running tests and mechanical checks shall be completed by the manufacturer/supplier prior to the purchaser's inspection.

6.1.3 Acceptance of shop tests shall not free the manufacturer/supplier from the requirements to meet the pump performance under the specified operating conditions, nor does inspection relieve the manufacturer/supplier of any of his responsibilities.

6.2 Inspection

6.2.1 It is intended that the purchaser's inspection work will be reduced to a minimum by assigning to the manufacturer/supplier the responsibility for providing the inspector with all specified certification of materials, and shop test data to verify that the requirements of the specifications and contract are being met.

6.2.2 When shop inspection is specified by the purchaser, no surface of pressure-containing parts is to be painted until the inspection is completed, unless otherwise agreed.

6.2.3 When shop inspection is specified by the purchaser, a meeting between the purchaser and the manufacturer/supplier may be requested to coordinate manufacturing hold points and inspector's visits.

6.2.4 The following inspections may be required:

— examination of components before assembling;

— internal examination after test running;

— installation dimensions;

— auxiliary piping and other auxiliaries;

— verification of information on the nameplate (see 4.15.2).

6.3 Tests

6.3.1 General

6.3.1.1 The purchaser shall specify the extent of his desired participation in the testing:

a) "Witnessed test" means that a hold shall be applied to the production schedule and the test carried out with the purchaser in attendance. It usually implies a double test.

b) "Observed test" means that the purchaser requires notification of the test's timing. However, the test is performed as scheduled, and if the purchaser is not present, the manufacturer/supplier may proceed to the next step. Since only one test is scheduled, the purchaser should expect to be in the factory longer than for a witnessed test.

6.3.1.2 Vertical pumps normally are to be tested as complete assemblies. Tests using only bowls and impellers are not acceptable. In cases where assembly testing is impractical because of pump length, the pump manufacturer/supplier shall submit alternative testing procedures with the proposal.

6.3.1.3 The purchaser shall specify if any of the tests specified in items a) through f) below are to be performed on the pumps:

a) hydrostatic test as in 6.3.3;

b) performance test as in 6.3.4;

c) NPSH test as in 6.3.5;

d) shop inspection as in 6.2;

e) dismantling, inspection and reassembly of liquid ends after the running test, if not needed to satisfy the requirements of 6.3.4.7;

f) other tests not listed or defined herein and other forms of inspection to be completely described in the enquiry and order.

Furthermore the purchaser shall specify whether these tests are to be witnessed or observed.

6.3.2 Material tests

If required by the purchaser, the following test certificates shall be available:

a) chemical composition: according to manufacturer/supplier's standard specifications or with specimen per melt;

b) mechanical properties: according to manufacturer/supplier's standard specification or with specimen per melt and heat treatment;

c) susceptibility to intergranular attack where applicable;

d) nondestructive tests, e.g. leakage, ultrasonic, dye penetrant, magnetic particle, radiographic, spectroscopic identification.

6.3.3 Hydrostatic test

6.3.3.1 Each pressure casing (as defined in 3.31) shall be hydrostatically tested with clean water at ambient temperature (15 °C minimum for carbon steel) according to the criteria specified in items a) through c) below:

a) pumps with radially and axially split casings (all materials) shall be tested at a minimum of 1,5 times the maximum allowable working pressure;

b) double-casing pumps, horizontal multistage pumps and other special-design pumps as approved by the purchaser may be segmentally tested at the appropriate suction pressure;

c) auxiliary equipment, including piping exposed to pumped fluid, shall be tested at a minimum of 1,5 times the maximum allowable working pressure.

Even though a part to be tested is to operate at a temperature at which the strength of the material will be below the strength of that material at room temperature, the hydrostatic test pressure shall be 1,5 times the maximum allowable casing pressure at room temperature, unless the hydrostatic test is performed at the elevated temperature. The data sheet shall list actual hydrostatic test pressure.

6.3.3.2 Cooling passages and jackets for bearings, stuffing boxes, pedestals, oil coolers, etc. shall be tested at a test pressure of 1,5 times their maximum allowable working pressure but at a minimum of 3 bar.

6.3.3.3 Tests shall be maintained for a sufficient period of time to permit complete examination of parts under pressure. The hydrostatic test shall be considered satisfactory when no casing or casing joint seepage or leaks are observed for a minimum of 30 min. Large and heavy casings may require a longer testing period, to be agreed upon by the purchaser and the manufacturer/supplier. Seepage past internal closures required for testing of segmented casings and operation of the test pump to maintain pressure shall be accepted.

6.3.3.4 If any hydrostatic test of the complete assembled pump is specified, overstrain of the auxiliary fittings such as gland packing, mechanical seal, etc. (see 4.13.3.5) should be avoided.

6.3.4 Performance test

6.3.4.1 Unless otherwise specified, the manufacturer/supplier shall operate the pump in the shop for a sufficient period to obtain at least five points of complete test data, including head, flowrate and power. These five data points are subject to negotiation between the purchaser and the manufacturer/supplier but will normally be shutoff, minimum continuous stable flow, midway between minimum and rated flows, rated flow, and 110 % of rated flow.

6.3.4.2 Conversion methods for test liquids other than clean cold water and for operating conditions (e.g. for high inlet pressure) shall be agreed between purchaser and manufacturer/supplier.

6.3.4.3 The purchaser's driver shall not be used for the shop test if there is any possibility of serious overload.

6.3.4.4 Pumps shall be tested with all seals installed when these and their components are compatible with water. Pumps for oil services with double or tandem seals shall have a clean hydrocarbon oil seal fluid or clean water supplied between the two seals.

6.3.4.5 During the shop tests, pumps shall operate with no undue heating of bearings or other display of unfavourable operation, such as noise caused by cavitation.

6.3.4.6 If it is necessary to dismantle any pump after the shop test for the sole purpose of machining impellers to meet the tolerances of differential head, no retest will be required unless the head reduction exceeds 8 % for pumps of type number $K \leqslant 1{,}5$. (For definition of K see 3.2.6 of ISO 2548:1973.) The diameter of the impeller during the shop test, together with the final diameter of the impeller, shall be recorded on a certified shop test curve sheet showing the operating characteristics during the test and the calculated characteristics after the diameter of the impeller has been reduced.

6.3.4.7 If dismantling is necessitated because of some other correction, such as improvement of efficiency, NPSH, or mechanical operation, the initial test is not acceptable and a final shop test shall be run after such corrections are made.

6.3.4.8 Hydraulic performance tests shall be in accordance with ISO 2548 or ISO 3555[2)].

6.3.4.9 If specified in the purchase order, the following additional conditions shall be checked during performance tests: vibration (see 4.3.2), bearing temperature, seal leakage.

6.3.4.10 If a noise test is required, a test of airborne noise emitted by the pump shall be carried out in accordance with ISO 3744 and ISO 3746 or by agreement between purchaser and manufacturer/supplier.

6.3.5 NPSH test

6.3.5.1 NPSHR data shall normally be taken at the following four points: minimum continuous stable flow, midway between minimum and rated flows, rated flow and 110 % of rated flow.

6.3.5.2 A closed loop test is preferred. NPSH testing by suction valve throttling or variable depth inlet well may be used when mutually agreed upon.

6.3.5.3 NPSH test shall be in accordance with ISO 2548 or ISO 3555[2)].

6.4 Final inspection

A final inspection shall be carried out to verify whether the scope of supply is correct and complete according to the purchase order, including component identification, painting and preservation, and documentation.

2) A combination of ISO 2548 and ISO 3555 and their simultaneous revision in a new International Standard is foreseen.

7 Preparation for dispatch

7.1 General

7.1.1 Preparation for shipment shall be made after all testing and inspection of the equipment has been accomplished and the equipment has been approved by the purchaser.

7.1.2 Pumps with three or more stages shall be disassembled after the shop running test and inspected, and all internal parts shall be coated with a suitable rust preventive before assembling if not made of corrosion resistant material. Single- and two-stage pumps need not be dismantled after the shop running test, provided the pump, including the stuffing box, is completely drained and dried and all internal parts are coated with a suitable rust preventive. All pumps shall be shipped completely assembled, except where size or configuration makes this impractical; in such instances sufficient information for assembling must be supplied by the manufacturer/supplier.

7.1.3 Equipment shall be suitably prepared for the type of shipment specified. The preparation shall make the equipment suitable for six months of outdoor storage from the time of shipment, with no disassembly required before operation, except for inspection of bearings and seals. If storage for a longer period is contemplated, the purchaser will consult with the manufacturer/supplier regarding the recommended procedures to be followed.

7.2 Shaft seals

If not otherwise agreed:

a) soft packings are to be separately shipped for installation on site. In this case a label warning that the stuffing box is not packed shall be securely attached to the pump;

b) mechanical seals and end plates shall be installed in the pump before shipment and shall be clean, lubricated if necessary and ready for initial service.

7.3 Preparation for transport and storage

7.3.1 All internal parts made of material which is not resistant to corrosive attack by the environment shall be drained and treated with a water-displacing rust preventative prior to shipment.

7.3.2 All exterior surfaces subject to atmospheric corrosion, with the exception of machined surfaces, shall be given a coat of the manufacturer/supplier's standard paint or coated as specified. **For the invisible surfaces of vertical pumps, whether or not submerged, the method of protecting these surfaces must be agreed between purchaser and manufacturer/supplier.**

7.3.3 All exterior machined surfaces shall be coated with a suitable rust preventative.

7.3.4 Bearings and bearing housings shall be protected by preservative oil which is compatible with lubricant. A label, warning that the oil-lubricated bearing housing must be filled with oil to the proper level prior to start, shall be securely attached to the pump.

7.3.5 Information on preservation agents and their removal shall be securely attached to the pump.

7.3.6 The manufacturer/supplier shall provide the purchaser with the instructions necessary to preserve the integrity of the storage preparation after the equipment arrives at the job site and before start-up.

7.4 Securing of rotating parts for transport

In order to avoid damage to bearings caused by vibration during transport, rotating parts should be secured as required according to mode and distance of transport, and to mass of rotor and bearing design. In such cases a warning label shall be securely attached.

7.5 Openings

All openings to the pressure chamber shall have weather-resistant closures substantial enough to withstand accidental damage (see also 4.5.3). Jacket closures shall not be capable of retaining pressure.

7.6 Piping and auxiliaries

All precautions must be taken to ensure that small piping and auxiliaries are protected from damage during shipment and storage.

7.7 Identification

The pump and all components supplied loose with it are to be clearly and durably marked with the prescribed identification number.

7.8 Installation instructions

One copy of the manufacturer/supplier's standard installation instructions shall be packed and shipped with the pump.

8 Responsibilities

8.1 The manufacturer/supplier of equipment parts is responsible for design, workmanship and supply of non-defective materials.

8.2 The manufacturer/supplier of equipment is responsible for satisfactory performance at all operating conditions specified in the data sheet.

8.3 The purchaser is responsible for correctly defining the operating conditions in the data sheet.

8.4 The purchaser is responsible for storage, installation, operation and maintenance of the equipment.

Annex A
(normative)

Centrifugal pump — Data sheet

If a data sheet is requested or required, the following centrifugal pump data sheet serves:

- the purchaser for enquiring, ordering and contract handling; and
- the manufacturer/supplier for tendering and manufacturing.

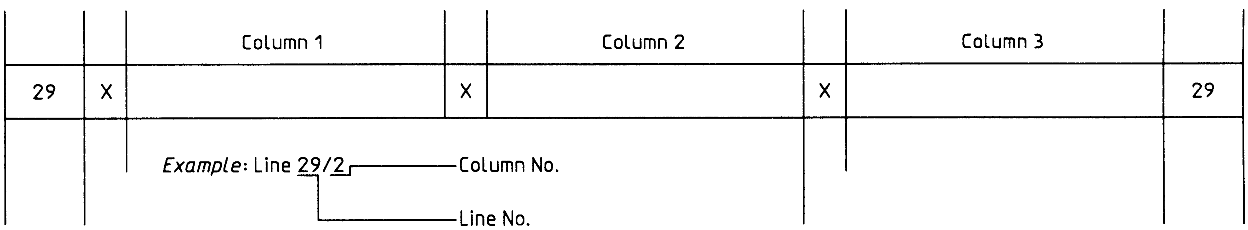
The specification of the components is in accordance with this International Standard.

To provide more space for writing or typing, the data sheet can be enlarged and split in two pages but the line numbering in each case shall conform to the standard data sheet.

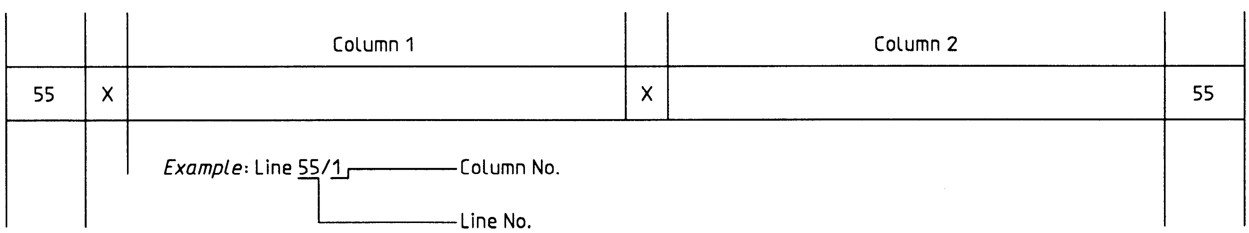
Instructions for completing the data sheet:

- the information required is to be indicated with a cross (×) in the appropriate column;
- the ◤ so marked lines are to be completed by the purchaser for enquiry;
- the blank columns can be used to indicate information required and also for revision marks indicating where information has been inserted or revised;
- to facilitate communication about the information in an intended line and position of the column, use the following key:

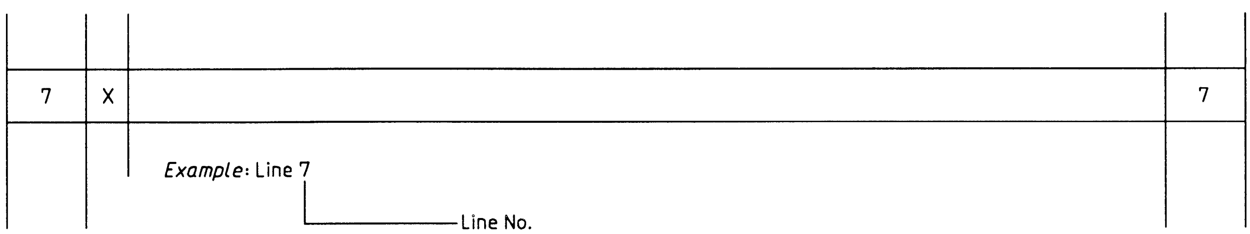
for 3 columns



for 2 columns



for 1 column



More detailed explanations on the individual terms are given below, insofar as the terms are not considered to be generally understood.

Line	Term	Explanation
1/1 2/1	Plant	Kind of plant, location, operation, building or other characteristics
1/2	Service	Operational duty, for example boiler feed water pump, waste water pump, fire water pump, circulation pump, reflux pump, etc.
2/2	Specification class	For example, ISO 9905
3/2 4/2	Driver	Should drive not be direct, information is to be given under "Remarks"
5/1 6/1	Purchaser	Company name
5/2 6/2	Manufacturer/supplier	Company name
7	Site conditions	For example, outdoor, indoor installation, other environmental conditions
8/1	Liquid	A fairly accurate designation of the fluid. When fluid is a mixture, an analysis should be given under "Remarks"
8/3	NPSH available at rated/normal flow	It may be necessary, when specifying NPSH available, to take into account abnormal operating conditions
9/1	Solid content	Solid constituents in fluid with grain size, quantity in mass percentage of liquid, grain character (round, cubic, oblong) and solids density (kg/dm^3) and other specific properties (for example, tendency to agglomerate) are to be given under "Remarks"
10/1	Corrosion by	Corrosive constituents of liquid
12/2	Inlet gauge pressure, max.	Maximum pressure in the inlet during operation, for example, by varying level, system pressures, etc.
13/3	Maximum pump power input at rated impeller diameter	Maximum pump power requirements at rated impeller diameter, specified density, viscosity and speed
14/3	Maximum pump power input at maximum impeller diameter	Maximum pump power requirements at maximum impeller diameter, specified density, viscosity and speed
15/3	Rated driver power output	To be specified by consideration of: a) duty and method of operation; b) location of operating point in performance diagram; c) friction loss at shaft seal; d) circulation flow for mechanical seal; e) properties of medium (solids, density, viscosity).
16/1	Hazard	For example, flammable, toxic, odorous, caustic, radiation
16/2	Head rated/curve, maximum	Maximum head at installed impeller diameter

Line	Term	Explanation
20/2	Thrust reduction by	For example, axial thrust bearing, balancing disc/drum, balancing hole, opposed impeller
21/2	Radial bearing type, size	Internal clearances to be included
22/2	Thrust bearing, type, size	Internal clearances to be included
23/2	Lubrication	Type of lubricant, for example, oil, pressure oil, grease, etc.
	Lubricant supply	For example, oil pump, grease pump, oil level controller, grease cup, sight glass gauge stick, etc.
24/1	Impeller type	Type of impeller, for example, closed, open, channel, etc.
24/2	Shaft seal arrangement	Use adequate designation according to annex F
26/2	Shaft seal	For mechanical seal:
	Type, size	— type: balanced (B) unbalanced (U) bellows (Z) — size: nominal shaft or sleeve diameter in mm based upon shaft diameter passing through stationary ring (e.g. ISO 3069) For stuffing box: — size: diameter of seal cavity according to ISO 3069
26/3	Design pressure	Relating to auxiliaries (piping, cooler, etc.)
27/3	Test pressure	Relating to auxiliaries (piping, cooler, etc.)
33/1	Casing support	For example, shaft centre, bottom, bearing bracket
34/1	Casing split	Radial, axial, relating to the shaft
35/3 to 36/3	Driver	For more information, use separate data sheets or space under "Remarks"
44/2 to 49/2	Mechanical seal components	Use material code for mechanical seal components according to annex J
46/2 to 47/2	Mechanical seal	For example, O-rings
50 to 52	Tests	Company or authority which is to carry out the different tests, for example manufacturer/supplier, and to what standards (51), and name of authority for witnessed tests (52)

Centrifugal pump
Data sheet

1	Plant:					Service:			1
2						Specification class:			2
		No. req.	Pump type and size: horizontal[1]	Pump type and size: vertical[1]	Manufacturer serial No.	Driver: Kind	Driver: Type, size	Item No.	
3	Operation								3
4	Standby								4
5	Customer:	Enquiry No.:		Date:		Supplier:	Proposal No.:	Date:	5
6		Order No.:		Date:			Contract No.:	Date:	6
7	Site conditions:								7

Operating conditions

8	Liquid		Flow	rated	m³/h	NPSH at rated/normal flow	available	/ m	8
9	Solid content	% of mass	Flow	normal/max.	/ m³/h	NPSH at rated/normal flow	required	/ m	9
10	Corrosion by		Flow	min. required/perm.	/ m³/h	Pump speed rated		min⁻¹	10
11	Erosion by		Inlet gauge pressure	rated	bar	Pump power input	rated	kW	11
12	Operating temp. (O.T.)	°C	Inlet gauge pressure	max.	bar	Pump power input	normal	kW	12
13	Density at O.T.	kg/dm³	Outlet gauge pressure	rated	bar	Max. pump power input	at rated impeller ϕ	kW	13
14	Kinematic viscosity at O.T.	mm²/s	Outlet gauge pressure	max.	bar	Max. pump power input	at max. impeller ϕ	kW	14
15	Vapour pressure (abs.) at O.T.	bar	Diff. pressure	rated	bar	Rated driver output		kW	15
16	Hazard		Head rated curve max./nom.		/ m	Self priming		yes, no	16

Construction features

17	Basic design pressure		bar	Total clearance	Wear ring/plates	mm	Cooling (C), Series (S)	C	H	S	P	17
18	Rated pressure	pump	bar at °C	Total clearance	Shaft bushes	mm	Heating (H), Parallel (P)					18
19	Rated pressure	auxiliaries	bar at °C	Total clearance	Balance drum	mm	Casing					19
20	Test pressure		bar	Thrust reduction by			Bearing					20
21	Number of stages			Radial bearing	Type, size		Oil cooler					21
22	Impeller	rated ϕ / installed ϕ	/ mm	Thrust bearing	Type, size		Seal chamber					22
23	Impeller	max. / min. ϕ	/ mm	Lubrication/supply		/	Seal circ. cooler					23
24	Impeller	Type		Shaft seal	Arrangement		Seal seat					24
25	Rotation facing pump driven end	pump*	clockwise/anticlockwise	Shaft seal	Manufacturer		Pedestals					25
26	Rotation facing pump driven end	driver**	clockwise/anticlockwise	Shaft seal	Type, size		Design pressure bar			X	X	26

27	Inlet flange — Size / Position		Shaft seal — Pressure limit	bar	Test pressure	bar	27
28	Inlet flange — Rating and facing		Shaft seal — Static pressure	bar	External supplies — Function / Fluid	l/h / °C / inlet/outlet bar	28
29	Outlet flange — Rating and facing		Shaft seal — Dynamic pressure	bar	External supplies		29
30	Outlet flange — Size / Position		Shaft seal — Temperature	°C	External supplies		30
31	Vent, tapped		Seal piping — Arrangement		External supplies		31
32	Drain, tapped		Seal piping — Suppl. by		External supplies — Cooling		32
33	Casing support		Total weight incl. drive, ca.	kg	External supplies — Heating		33
34	Casing split	radial/axial	Volute/Diffuser	single/double/ multi	External supplies — Electricity	V / Phase / Hz	34
	Auxiliaries						
35	Coupling — Manufacturer		Coupling guard suppl. by		Driver — suppl. by		35
36	Coupling — Type / Size		Baseplate — for	pump/drive/driver	Driver — mounted by		36
37	Coupling — Spacer length	mm	Baseplate — Type	freestd./grouted/non-gro.	Aux. piping suppl. by		37
38	Coupling — Suppl. by		Baseplate — Suppl. by		Anchor bolts suppl. by		38
	Materials						
39	Casing		Shaft sleeve		Stuffing box — Gland follower		39
40	External bolting		Throat bush		Stuffing box — Packing		40
41	Casing gasket		Mechanical seal — Seal end plate		Stuffing box — Lantern ring		41
42	Impeller		Mechanical seal — Throttle bush		Coupling — Hubs/spacer	/	42
43	Wear ring — Impeller		Mechanical seal	pump side / atmosph. side	Coupling — Flexible elem.		43
44	Wear ring — Casing		Mechanical seal — Rotating ring		Coupling — Guard		44
45	Wear plate / lining	/	Mechanical seal — Stationary ring		Baseplate		45
46	Shaft		Mechanical seal — Secondary seal — rotating		Paint		46
47	Case bush		Mechanical seal — Secondary seal — stationary				47
48	Bearing housing adapter		Mechanical seal — Spring				48
49	Bearing housing		Mechanical seal — Other metal parts				49

Tests

	Tests	Material	Hydrostatic	Hydraulic	NPSH		Inspection	Final Inspection	
50									50
51	Reference								51
52	Witnessed by								52

Documentation

53	Performance curve No. — Proposal		Drawings — Installation dim.		53
54	Performance curve No. — Test		Drawings — Piping — Seal		54
55	Instruction manual		Drawings — Piping — Auxiliary system		55
56	Spare part list No.		Drawings — Assembly — Pump		56
57			Drawings — Assembly — Shaft seal		57

Remarks: 1) Strike out if not applicable; ◤ so marked lines are to be completed by the purchaser for enquiry.
2) All pressures are gauge, except vapour and differential pressure.

* viewed from the drive to the pump
** viewed from the pump to the drive

Sheet	of	Rev. Date:	Drawing No.

Annex B
(normative)

External forces and moments on branches

B.1 General

Forces and moments acting on the pump flanges due to pipe loads may cause misalignment of pump and driver shafts, deformation and overstressing of pump casing, or overstressing of the fixing bolts between pump and baseplate.

This annex is intended to give manufacturer/suppliers, installation contractors and users of pumps a simple method for checking that loads transmitted to a pump by its piping remain within acceptable limits. This is done by comparing:

— the loads (forces and moments) calculated by the piping designer

with

— the maximum values allowed on the flanges, as given in this annex for various pump families, as a function of their size and the installation conditions.

NOTE 11 This method is part of the result of a study and tests undertaken within EUROPUMP (European Committee of Pump Manufacturers) together with the support of piping specialists. ISO will prepare a Technical Report with more detail on this subject.

B.2 Definition of pump families

A certain number of pump families have been defined in accordance with the configuration of the pump and the most frequently used operating conditions.

The characteristics of the pump families are shown in table B.1 for horizontal pumps and table B.2 for vertical pumps.

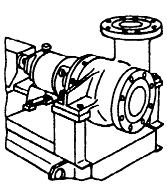
If certain pumps do not have the characteristics mentioned in this table, the manufacturer/supplier will be able to consider them similar to one of the families of his choice, or else a special agreement should be signed between purchaser and manufacturer/supplier for each particular case.

B.3 Allowable values of forces and moments

B.3.1 The maximum allowable forces and moments for each pump family were established by applying the appropriate coefficients to the basic values considered the most suitable to each pump family.

B.3.2 The basic values given in table B.3 are applicable to each of the pump flanges, respecting the identification of the three axes in function of the considered flange.

Table B.1 — Characteristics of horizontal pump families

Family No. and Number of stages	General picture	Technical limits: Allowable working pressure bar	Technical limits: Allowable working temperature °C	Technical limits: Flange DN_{max}	Material
1 1 and 2		55	430	350	Cast steel

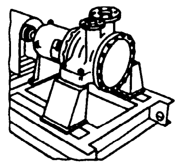
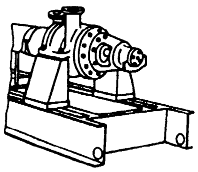
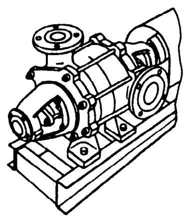
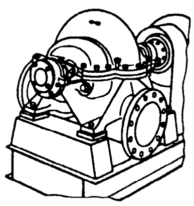
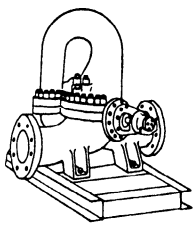
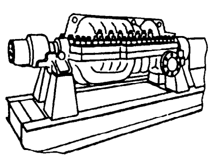
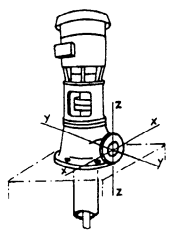
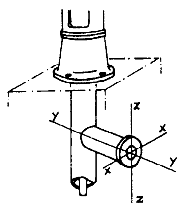
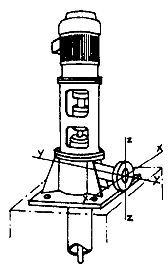
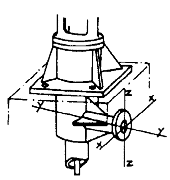
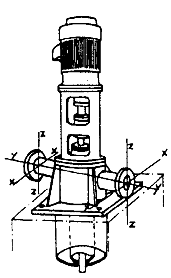
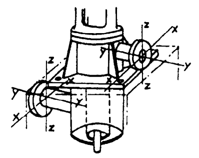
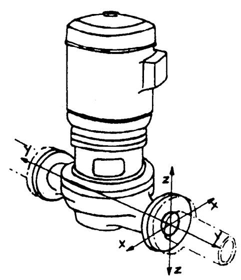
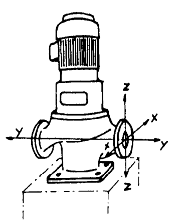
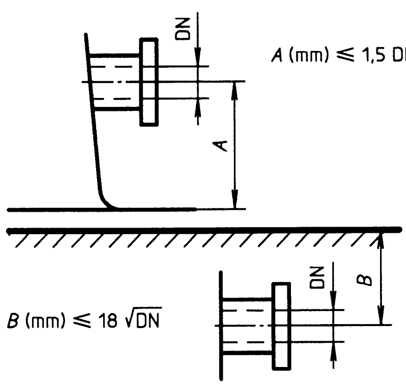
Family No. and Number of stages	General picture	Technical limits: Allowable working pressure bar	Technical limits: Allowable working temperature °C	Technical limits: Flange DN_{max}	Material
2 1 and 2		55	430	350	Cast steel
3 1 and 2		55	430	400	Cast steel
4A Multi		25	110	150	Cast iron
4B Multi		40	175	150	Cast steel
5A 1 and 2		20	110	600	Cast iron
5B 1 and 2		120	175	450	Cast steel
6 2		120	175	450	Cast steel
7A 3 to 5		150	175	350	Cast steel
7B 6 to 10					
7C 11 to 15					

Table B.2 — Characteristics of vertical pump families

Family No.	General picture		Technical limits: Allowable working pressure bar	Technical limits: Allowable working temperature °C	Technical limits: Flange DN	Material
10A[1,2]		Suction branch is sub-merged	20	60	50 to 600	Cast iron
10B[1,2]						Cast steel
11A[1]			20	60	50 to 600	Cast iron
11B[1]						Cast steel
12A[1]			30	0 to 110	40 to 350	Cast iron
12B[1]			55	– 45 to 250		Cast steel
13A[1]			30	0 to 110	40 to 350	Cast iron
13B[1]			55	– 45 to 250		Cast steel
14A[1]			30	0 to 110	40 to 350	Cast iron
14B[1]			55	– 45 to 250		Cast steel

Family No.	General picture	Technical limits: Allowable working pressure bar	Allowable working temperature °C	Flange DN	Material
15A[1)]		30	0 to 110	40 to 350	Cast iron
15B[1)]		55	– 45 to 250		Cast steel
16A		30	110	40 to 150	Cast iron
16B			250	40 to 200	Cast steel
17A		30	110	40 to 150	Cast iron
17B			250	40 to 200	Cast steel

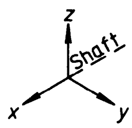
1) The allowable values of forces and moments for the families 10 to 15 in table B.3 and table B.5 are only valid when the distance between the centreline of the flanges on which the loads are applied is within the limits indicated below.



2) For families 10A and 10B, the values given for the forces and moments are based on the assumption that the discharge elbow is monobloc with the driver stand, which itself serves as the supporting base of the complete pump unit. In the case of separate construction of this assembly (two or more components) the values indicated in table B.5 must be divided by 2.

NOTE — Parts fabricated from steel (welded) can be assimilated to cast steel insofar as allowable loads are concerned, provided that they are of rigid construction with equivalent wall thickness.

Table B.3 — Basic values of forces and moments for horizontal and vertical pumps

	**Diameter** 1) DN	**Force** (daN)				**Moment** (daN·m)			
		F_y	F_z	F_x	ΣF	M_y	M_z	M_x	ΣM
	40	100	125	110	195	90	105	130	190
	50	135	165	150	260	100	115	140	205
	80	205	250	225	395	115	130	160	235
	100	270	335	300	525	125	145	175	260
Horizontal pump	150	405	500	450	785	175	205	250	365
	200	540	670	600	1 045	230	265	325	480
	250	675	835	745	1 305	315	365	445	655
	300	805	1 000	895	1 565	430	495	605	890
Top branch	350	940	1 165	1 045	1 825	550	635	775	1 140
	400	1 075	1 330	1 195	2 085	690	795	970	1 430
z-Axis	450	1 210	1 495	1 345	2 345	850	980	1 195	1 760
	500	1 345	1 660	1 495	2 605	1 025	1 180	1 445	2 130
	550	1 480	1 825	1 645	2 865	1 220	1 405	1 710	2 530
	600	1 615	1 990	1 795	3 125	1 440	1 660	2 020	2 990
	40	125	100	110	195	90	105	130	190
Horizontal pump	50	165	135	150	260	100	115	140	205
	80	250	205	225	395	115	130	160	235
Side branch	100	335	270	300	525	125	145	175	260
	150	500	405	450	785	175	205	250	365
y-Axis	200	670	540	600	1 045	230	265	325	480
	250	835	675	745	1 305	315	365	445	655
	300	1 000	805	895	1 565	430	495	605	890
Vertical pump	350	1 165	940	1 045	1 825	550	635	775	1 140
	400	1 330	1 075	1 195	2 085	690	795	970	1 430
Side branch at right angles	450	1 495	1 210	1 345	2 345	850	980	1 195	1 760
to shaft	500	1 660	1 345	1 495	2 605	1 025	1 180	1 445	2 130
	550	1 825	1 480	1 645	2 865	1 220	1 405	1 710	2 530
y-Axis	600	1 990	1 615	1 795	3 125	1 440	1 660	2 020	2 990
	40	110	100	125	195	90	105	130	190
	50	150	135	165	260	100	115	140	205
	80	225	205	250	395	115	130	160	235
	100	300	270	335	525	125	145	175	260
Horizontal pump	150	450	405	500	785	175	205	250	365
	200	600	540	670	1 045	230	265	325	480
	250	745	675	835	1 305	315	365	445	655
End branch	300	895	805	1 000	1 565	430	495	605	890
	350	1 045	940	1 165	1 825	550	635	775	1 140
x-Axis	400	1 195	1 075	1 330	2 085	690	795	970	1 430
	450	1 345	1 210	1 495	2 345	850	980	1 195	1 760
	500	1 495	1 345	1 660	2 605	1 025	1 180	1 445	2 130
	550	1 645	1 480	1 825	2 865	1 220	1 405	1 710	2 530
	600	1 795	1 615	1 990	3 125	1 440	1 660	2 020	2 990

1) **For DN exceeding 600, agreement is to be reached between purchaser and manufacturer/supplier on the values of forces and moments.**

B.3.3 In the case of the most unfavourable configuration, the shaft end displacement will be at maximum 0,15 mm for every pump family.

B.3.4 The basic values mentioned in table B.3 should be multiplied, for the family of pumps concerned, by the corresponding coefficient as given in table B.4 or table B.5.

B.3.5 The values shown in table B.3 and table B.5 are valid for the materials specified in table B.1. For other materials they must be corrected proportionately to the ratio of their modulus of elasticity at the appropriate temperature (see B.4.3).

B.3.6 The values can be applied simultaneously in all directions with positive or negative signs, or separately on each flange (suction and discharge).

Table B.4 — Coefficients for actual values of horizontal pumps

Pump family No.	Coefficient	
	Force	Moment
1	0,85	M_y, M_z, M_x (– 500 N·m) × 1
2	0,85	M_y, M_z, M_x (– 500 N·m) × 1
3	1	1
4A	0,30	ΣM (– 500 N·m) × 0,35
4B	0,72	ΣM (– 500 N·m) × 0,84
5A	0,40	0,30
5B	1	1
6	1	1
7A	1	1
7B	1	0,75
7C	1	0,50

Table B.5 — Coefficients for actual values of vertical pumps

Pump family No.	Coefficient	
	Force	Moment
10A1)	0,3	0,3
10B1)	0,6	0,6
11A	0,1	0,1
11B	0,2	0,2
12A	0,375	M_y, M_z, M_x (– 500 N·m) × 0,5
12B	0,75	M_y, M_z, M_x (– 500 N·m) × 1
13A	0,262	M_y, M_z, M_x (– 500 N·m) × 0,35
13B	0,525	M_y, M_z, M_x (– 500 N·m) × 0,7
14A	0,375	M_y, M_z, M_x (– 500 N·m) × 0,5
14B	0,75	M_y, M_z, M_x (– 500 N·m) × 1
15A	0,262	M_y, M_z, M_x (– 500 N·m) × 0,35
15B	0,525	M_y, M_z, M_x (– 500 N·m) × 0,7
16A	0,5	0,5
16B	1	1
17A	0,375	M_y, M_z, M_x (– 500 N·m) × 0,5
17B	0,75	M_y, M_z, M_x (– 500 N·m) × 1

1) The coefficients are given for a maximum working pressure of 20 bar. For much lower pressures, which justify light fabricated construction, the coefficients must be reduced in direct proportion to the pressure, with a minimum limit of 0,2. This is the case for pumps of very high specific speed (e.g. propeller pumps).

B.4 Additional possibilities

B.4.1 General

The basic values are given for pumps with standard frames and for normal service. It is possible, if the concept of the piping requires it, to offer the user an increase in the basic values in order to facilitate the design and construction of the piping system.

B.4.1.1 Horizontal pumps

Two types of possibilities are to be taken into consideration for horizontal pumps:

a) reinforced baseplates, which are the manufacturer/supplier's responsibility;

b) installation adjustments, which are the user's responsibility:

  — pumps at shut-down with or without realignment,

  — pre-loading.

B.4.1.2 Vertical pumps

For vertical pumps only the families 12B, 14B, 15B, 16B and 17B may take advantage of these additional possibilities. The following are excluded:

— shut-down pumps, with or without realignment,

— reinforced or grouted baseplates.

The only possibilities applicable are therefore the following:

— pre-loading the piping,

— use of a weighting or compensation formula,

— a combination of the two possibilities.

The pre-loading of piping is not applicable for family 16B.

If these additional possibilities are to be applied, a prior agreement between purchaser and manufacturer/supplier should be reached.

B.4.2 Weighting or compensation formula

When the applied loads do not all attain the maximum values allowed, one of these loads may exceed the normal limit, provided that the following supplementary conditions are satisfied:

— any component of a force or of a moment shall be limited to 1,4 times the maximum allowable value;

— the actual forces and moments acting on each flange are governed by the following formula:

$$\left(\frac{\sum |F|_{\text{calculated}}}{\sum |F|_{\text{max. allow.}}}\right)^2 + \left(\frac{\sum |M|_{\text{calculated}}}{\sum |M|_{\text{max. allow.}}}\right)^2 \leqslant 2$$

in which the total loads $\Sigma\ |F|$ and $\Sigma\ |M|$ are the arithmetic sums for each flange (inlet and outlet), for both the calculated and maximum allowable values without taking into account their algebraic sign, at the level of the pump (inlet flange + outlet flange).

B.4.3 Influence of material and temperature

In the absence of any counter-indication, all values of forces and moments are given for the base material of the pump family, as shown in table B.1 and table B.2, and for a maximum temperature of 100 °C.

Above this temperature, and for other materials, the values should be corrected in function of the ratio of their moduli of elasticity, as follows:

$$\frac{E_{t,\text{m}}}{E_{20,\text{b}}}$$

where

$E_{20,\text{b}}$ is the modulus of elasticity of the base material at 20 °C;

$E_{t,\text{m}}$ is the modulus of elasticity of the material chosen at pumping temperature t.

B.5 Responsibilities of the manufacturer/supplier and purchaser

The manufacturer/supplier shall indicate to the purchaser the family to which the proposed equipment belongs.

The two parties shall agree on the type of baseplate to be used (standard, reinforced, concreted to foundation).

The purchaser (or the erection contractor, engineering consultant, etc.) shall calculate the loads applied to the pump at its flanges, considered to be fixed, under all conditions (hot, cold, shutdown, under pressure).

The purchaser shall ascertain that the values of these loads do not exceed the limits given in the appropriate table for the pump selected. If they do, then either the piping must be modified to reduce these loads, or another type of pump, capable of withstanding higher loads, must be chosen.

B.6 Practical considerations

B.6.1 A pump is not a static element of a piping system, but a precision machine comprising a moving part running at high speed with minimal clearance and possessing high-precision sealing elements such as mechanical seals. Therefore, it is important to remain within the maximum limits authorized by this specification whenever possible.

B.6.2 This specification, agreed upon and jointly set up by the manufacturer/supplier and user in their mutual best interests, points out the following recommendations:

a) the initial alignment of the pump-driver coupling must be made with great care (in the range of 5/100 to 7/100 on the dial gauge) and should be periodically checked according to the instructions of the pump or coupling manufacturer;

b) coupling with a spacer piece having two articulated connecting points is always preferable, especially for a large pumping unit and/or a system concerning fluids at temperatures exceeding 250 °C;

c) the piping connections, during initial erection, must be made strictly according to rules and respecting the instructions given by the pump manufacturer/supplier or designer of the piping system. A check is recommended every time there is a possibility to partially or totally dismantle the pumping unit;

d) according to the type of pump involved and the temperature during service, in certain cases the initial alignment of the coupling must be made at a temperature higher than ambient.

The manufacturer/supplier and the user will have to define very strictly the assembly conditions and the coupling alignment, should this solution be adopted.

B.6.3 Vertical pumps, other than the monobloc "in-line" type, have the special feature of a long or fairly long lineshaft, running in sleeve bearings spaced at regular intervals, often lubricated by the pumped liquid. As a result, smooth operation of the rotating assembly depends upon good alignment. This can only be ensured if the external constraints applied to the pump flanges do not cause distortions greater than those allowed by the manufacturer/supplier.

This is why, in view of the design concept of vertical pumps and their sensitivity to misalignment, the present code limits the forces and moments on their flanges to values lower than those allowed on horizontal pumps.

Furthermore, visual assessment of distortion at the level of the coupling is not as easy as in the case of horizontal pumps, since the motor and its stool are often closely connected to the upper part of the pump. Such distortions can in fact only be related to a fixed reference point in space. Verification being difficult, the user should follow closely the recommendations given by the manufacturer/supplier.

Excessive constraints on the flanges, in addition to compromising good operation and/or reliability, usually give rise to:

— a vibration level greater than normal;

— difficulty in turning the rotor by hand at rest (at the operating temperature), when the mass of the rotor allows such hand-turning.

Annex C
(normative)

Enquiry, proposal, purchase order

C.1 Enquiry

The enquiry shall include the data sheet with the technical information indicated by ◤ .

C.2 Proposal

The proposal shall include the following technical information:

— completed data sheet, where indicated by "X";

— preliminary outline drawing;

— typical cross-section drawing;

— characteristic curve.

C.3 Purchase order

The purchase order shall include the following technical information:

— completed data sheet;

— required documentation.

Annex D
(normative)

Documentation after purchase order

D.1 The agreed number of copies of the following certified documents shall be supplied to the purchaser at the agreed time.

Any special style or form of documentation shall be a matter of agreement.

D.2 Normally the documentation consists of

- data sheet;
- dimensioned outline drawing;
- instruction manual, including information for installation, commissioning (preparation for first start-up), operation, shutdown, maintenance (monitoring, servicing and repair) including cross-section drawings, with part list, running tolerances, etc., and if necessary special instructions for specific operating conditions;
- performance curves;
- spare parts list.

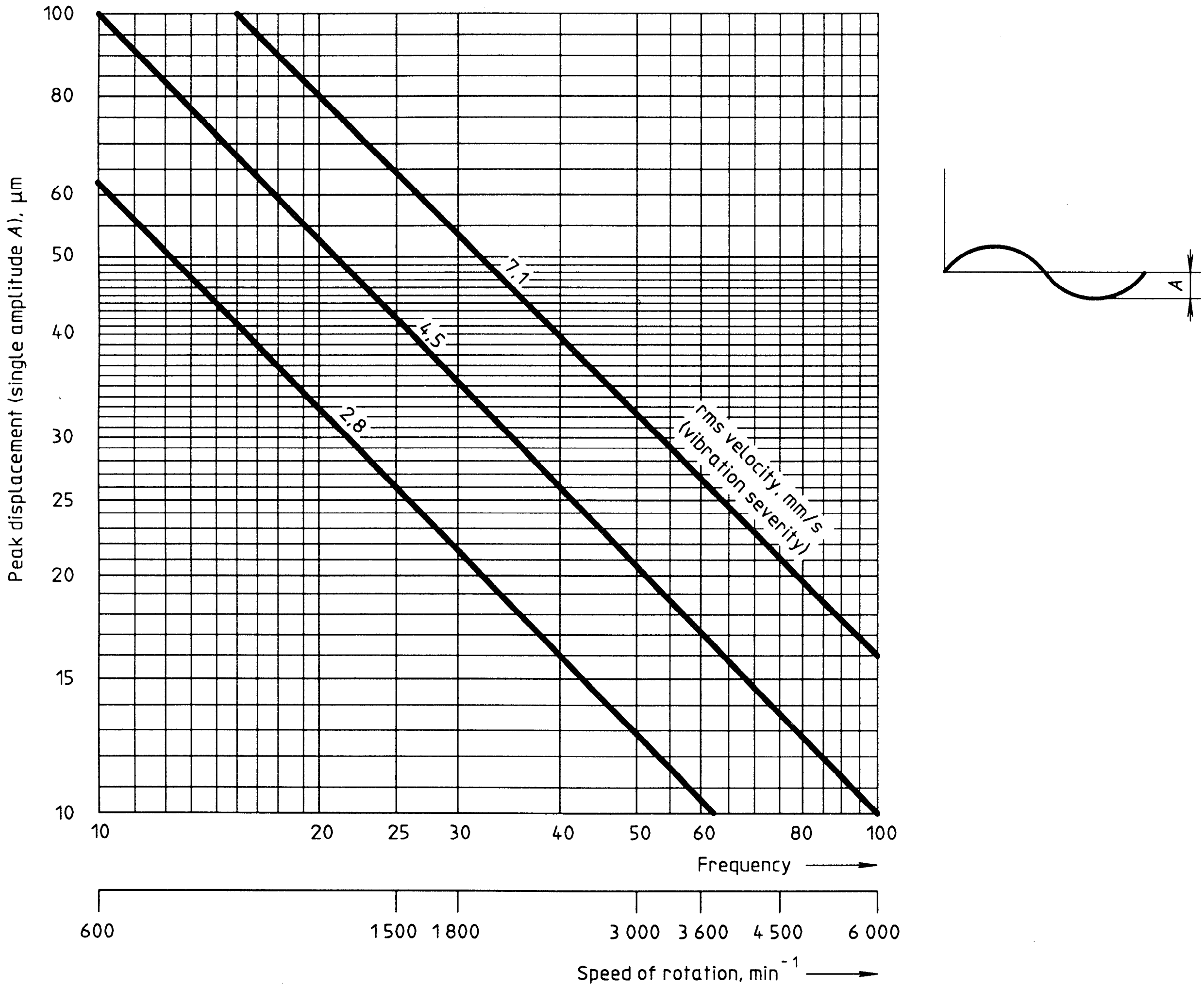
D.3 The documentation is to be clearly identified by

- item number;
- purchase order number;
- manufacturer/supplier order number.

Annex E
(informative)

Peak displacement

The relationship between the amplitude, frequency and vibration velocity is given in figure E.1.



NOTE — This graph is for guidance; it shows the relationship at any discrete frequency whereas vibration severity measurements cover a band of frequency.

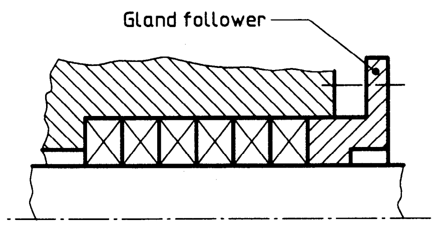
Figure E.1 — Single amplitude, *A*, as a function of speed of rotation for various rms-velocity values (for the definition of rms, see ISO 2372)

Annex F
(informative)

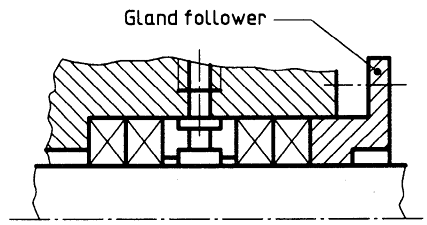
Examples of seal arrangements

The following figures show the principle of seal arrangements and not details of their construction.

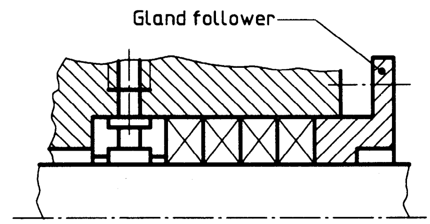
F.1 Soft packing[3] (P)



P1 Soft packing



P2 Soft packing with lantern ring (used for injection or circulation of liquid for sealing, buffering, cooling, etc.)



P3 Soft packing with lantern ring (normally with throat bush used for injection and circulation of liquid for cooling, to clear deposits, etc.)

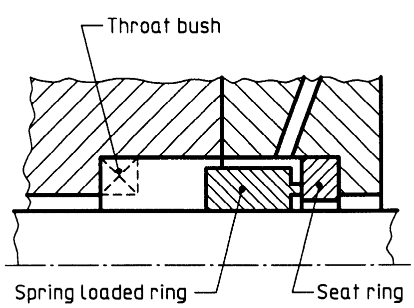
F.2 Single mechanical seal[3] (S)

These seals can be

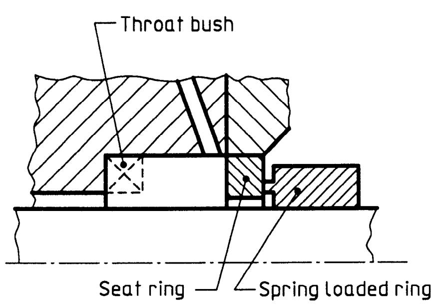
a) unbalanced (U) (as in the figure) or balanced (B) or bellows (Z) normally;

b) with or without circulation or injection to the sealed faces;

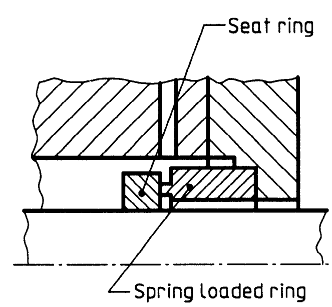
c) with or without throat bush.



S1 Internal arrangement



S2 External arrangement

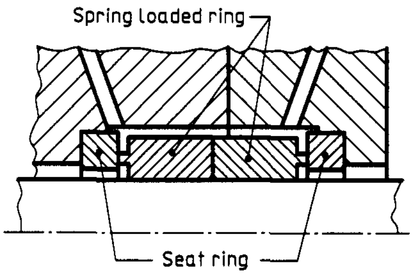


S3 Internal arrangement rotating seal ring (mating ring)

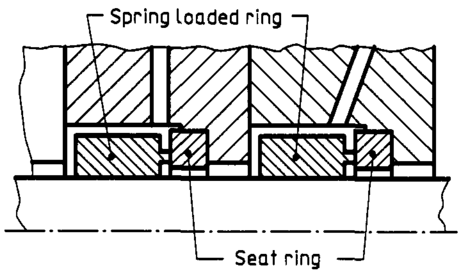
3) Left-hand side of figures shows the pump side, right-hand side shows the atmospheric side.

F.3 Multiple mechanical seal[3] (D)

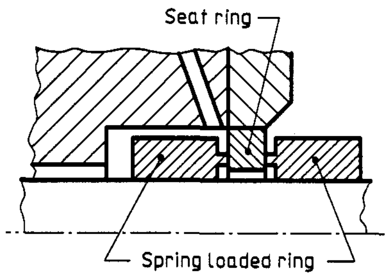
Either or both of these seals may be unbalanced (as in the figure) or balanced.



D1 Back-to-back arrangement

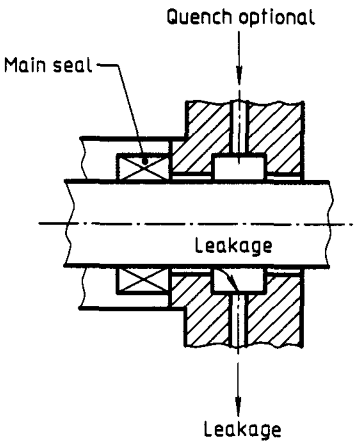


D2 Tandem arrangement

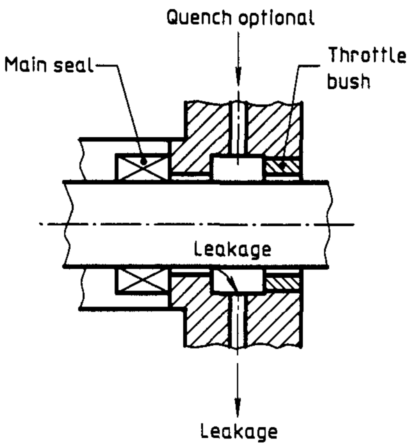


D3 Face-to-face arrangement [The same arrangements are possible with a rotating ring (mating ring)]

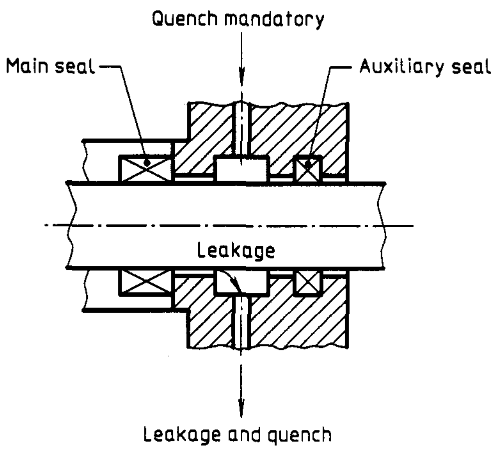
F.4 Quench arrangement (Q) for soft packing, single and multiple mechanical seal[3]



Q1 Main seal without throttle bush or auxiliary seal



Q2 Main seal with throttle bush



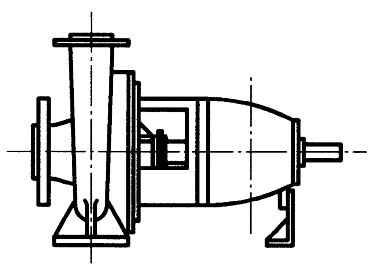
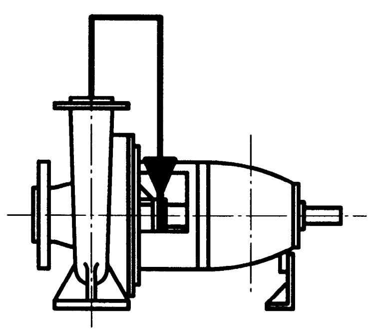
Q3 Main seal with auxiliary seal or packing

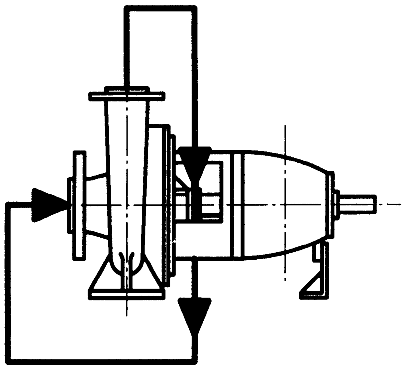
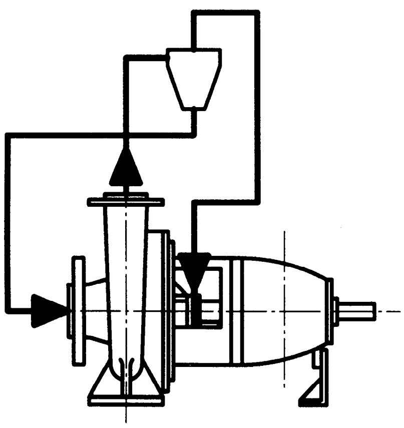
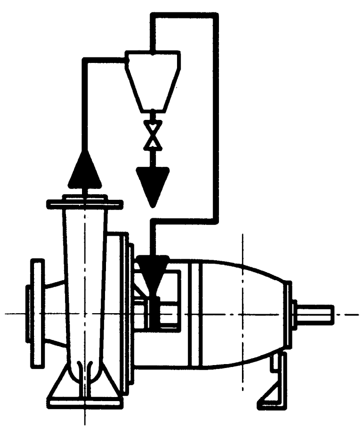
Annex G
(informative)

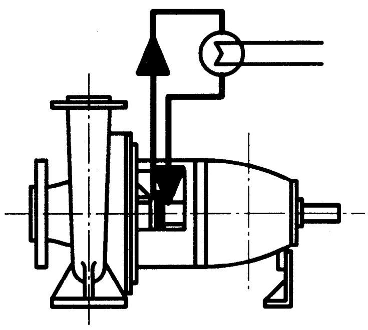
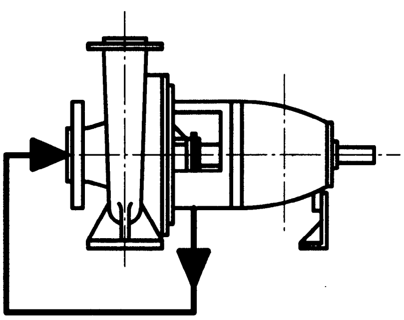
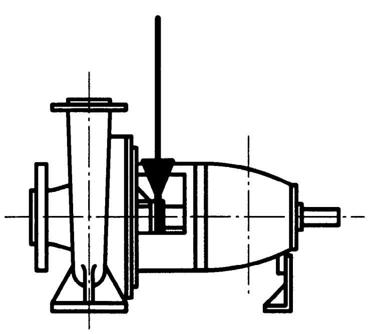
Piping arrangements for seals

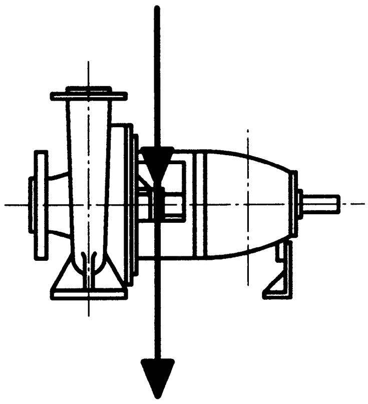
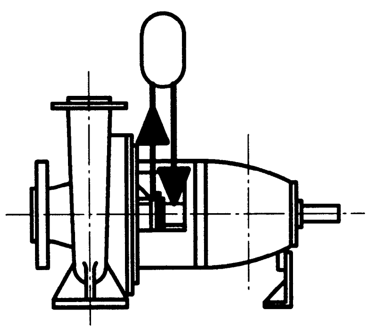
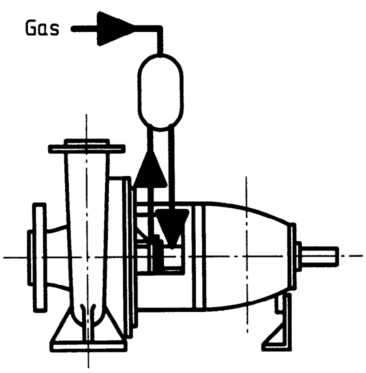
The following figures show the principle of piping arrangements for seals and not details of their construction.

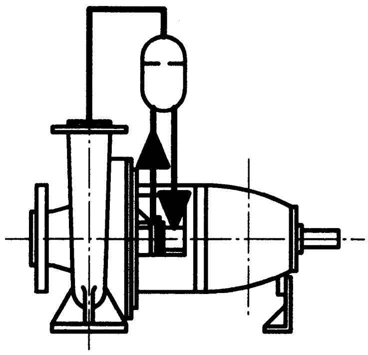
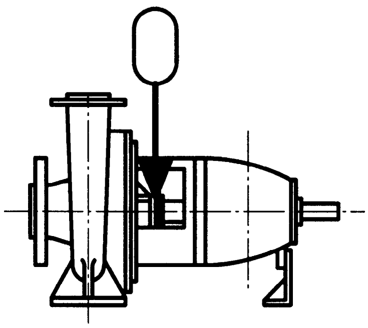
G.1 Seal types according to basic piping

Basic arrangement			Applied to			
Designation code	Figure	Description	Soft packing P	Single mechanical seal S	Multiple mechanical seal D	Quench Q
00		No piping, no circulation	X	X		
01		No piping, internal circulation	X	X		
02		Circulated fluid from pump outlet to seal cavity (with internal return)	X	X		

Basic arrangement			Applied to			
Designation code	Figure	Description	Soft packing P	Single mechanical seal S	Multiple mechanical seal D	Quench Q
03		Circulation fluid from pump outlet to seal cavity and return to pump inlet	X	X		
04		Circulation fluid via cyclone (with internal return) dirty line to pump inlet	X	X		
05		Circulation fluid via cyclone; dirty line to drain	X	X		

Basic arrangement			Applied to			
Desig-nation code	**Figure**	**Description**	**Soft packing** **P**	**Single mechan-ical seal** **S**	**Multiple mechan-ical seal** **D**	**Quench** **Q**
06		Circulation fluid by pumping device from seal cavity via heat exchanger back to seal cavity		X		
07		Internal circulation fluid to seal and re-turn to pump inlet	X	X		
08		Fluid from an external source a) to seal cavity with flow into pump b) to quench	X	X	X	X

Basic arrangement			Applied to			
Desig- nation code	Figure	Description	Soft packing P	Single mechan- ical seal S	Multiple mechan- ical seal D	Quench Q
09		External fluid (for ex- ample, injection, buffer fluid) to seal cavity/quench, outlet to an external system	X	X	X	X
10		Barrier or quenching fluid supplied by head tank, circulation by thermosiphon or pumping device			X	X
11		Barrier or quenching fluid supplied by pressurized tank, cir- culation by thermosiphon or pumping device			X	X

Basic arrangement			Applied to			
Designation code	Figure	Description	Soft packing P	Single mechanical seal S	Multiple mechanical seal D	Quench Q
12		Barrier liquid supplied by pressurized tank, circulation by thermosiphon or pumping device; tank pressurized by pump outlet via pressurizing device (for example, tank with diaphragm)			X	
13		Barrier or quenching fluid supplied from head tank	X			X

G.2 Designation of piping arrangements for seals

The designation consists of a capital letter, representing the seal arrangement (P, S, D, Q) and a number (1, 2, 3, see annex F), representing the basic piping arrangement (01, 02, 03, etc., see G.1) (which does not represent the location of the seal cavity) linked by a full stop.

Where the auxiliaries are connected, they are represented by their code numbers (see G.3). The sequence corresponds to their arrangement in the direction of flow.

When the flow starts and ends at the seal cavity (closed circuit) the enumeration of the code has the same sequence.

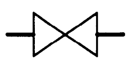
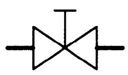
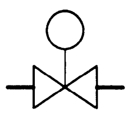
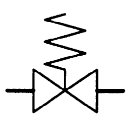
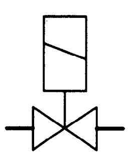
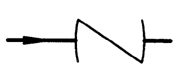
The position of the seal cavity in a piping arrangement, which starts before and is continued after the seal cavity, shall be denoted by a dash.

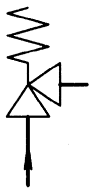
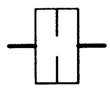
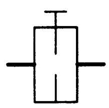
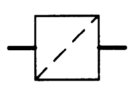
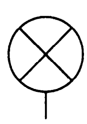
Combination of different pipe arrangements with different seal arrangements is possible. In such cases the designation sequence of piping arrangements corresponds to those of the seal arrangement starting at the pump side (see designation examples 5 and 8).

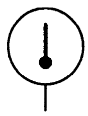
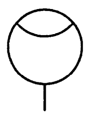
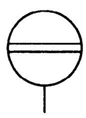
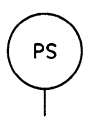
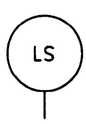
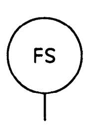
When an auxiliary component is part of or within the pump or other components, its code shall be enclosed by brackets.

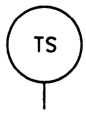
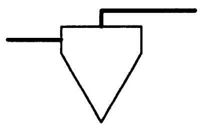
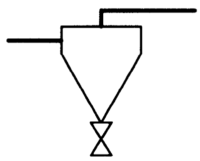
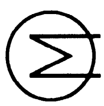
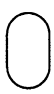
G.3 Explanation for auxiliaries for seal piping

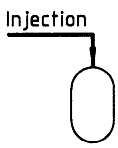
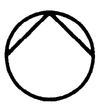
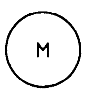
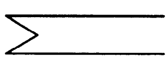
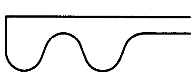
NOTE 12 Symbols are under study within Technical Committees ISO/TC 10, *Technical drawings*, and ISO/TC 145, *Graphical symbols*. Relevant references are indicated in the "Remarks" column.

Designation code	Symbol	Designation	Remarks
10		**Valves**	
11		Shut-off valve	ISO 3511-1:1977, cf. 3.4
12		Hand control valve for pressure or flow control	
13		Automatic control valve	ISO 3511-1:1977, cf. 3.4 and 3.5.1
14		Automatic pressure control valve	
15		Solenoid valve	ISO 3511-1:1977, cf. 3.4 ISO 3511-2:1984, cf. 6.4.4
16		Check valve	

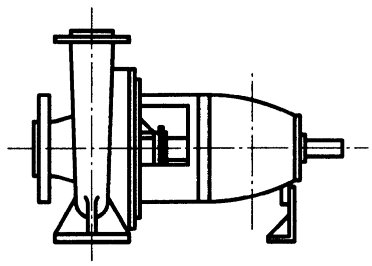
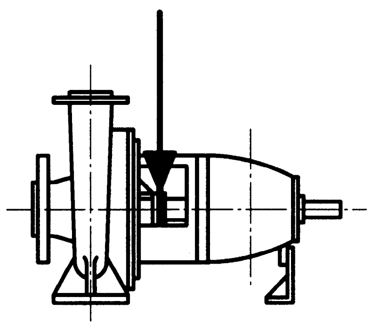
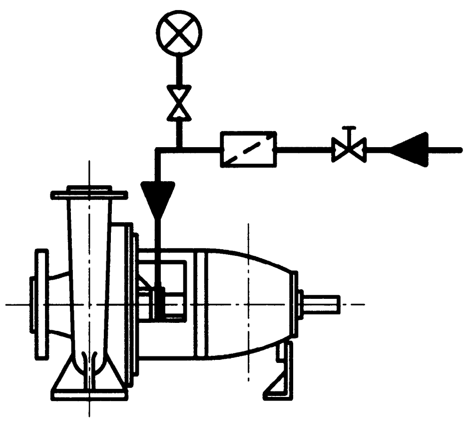
Designation code	Symbol	Designation	Remarks
17		Relief valve	
20		**Orifices**	
21		Non-adjustable orifice	
22		Adjustable orifice for flow and pressure control	
30		**Filter and strainer**	
31		Strainer	
32		Filter	ISO 3511-3:1984, cf. 3.5.1.4
40		**Indicators**	
41		Pressure indicator	

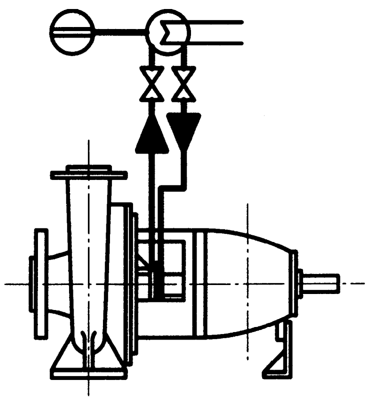
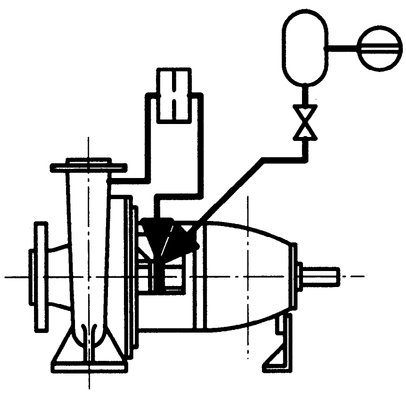
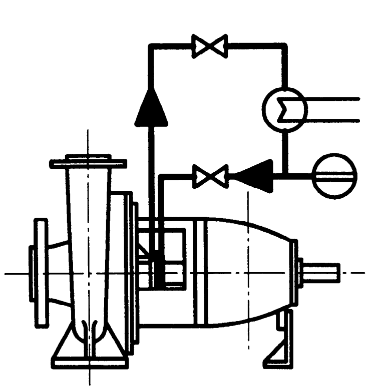
Designation code	Symbol	Designation	Remarks
42		Temperature indicator	ISO 1219-1:1991, cf. 10.1.2
43		Flow indicator	ISO 3511-1:1977, cf. 6.1.1
44		Level indicator	ISO 3511-1:1977, cf. 6.1.6
50		**Switches**	
51		Pressure switch	
52		Level switch	
53		Flow switch	

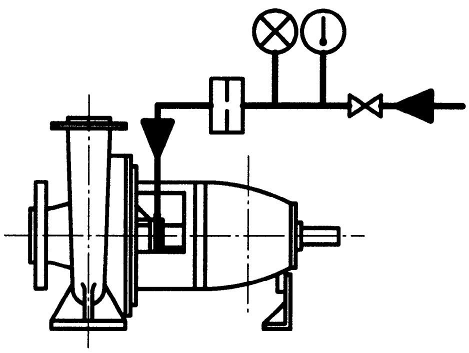
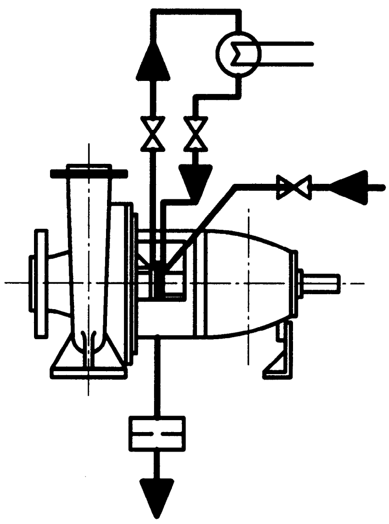
Designation code	Symbol	Designation	Remarks
54		Temperature switch	
60		**Apparatus**	
61		Cyclone	
62		Cyclone with hand regulating valve in dirty line	
63		Heat exchanger	ISO 7000:1989, 0111
64		Tank	ISO 3511-3:1984, cf. 3.5.1.6
65		Tank with diaphragm	

Designation code	Symbol	Designation	Remarks
66		Tank with pressure intensifier	
67		Tank with liquid injection of refilling device	
68		Circulation pump	ISO 7000:1989, 0134
69		Electric motor	
70		Cooling coil	
71		Electric tank heater	

G.4 Designation examples

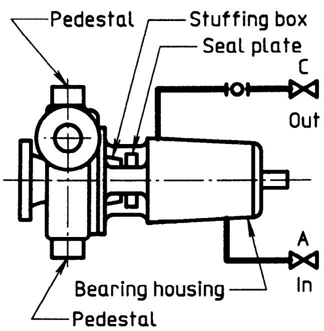
Example No.	Figure	Designation	Explanation
1		P1.01	Soft packing Basic arrangement 01
2		S1.08	Single mechanical seal Basic arrangement 08
3		S1.08-12.32.11.41	Single mechanical seal Basic arrangement 08 Hand control valve Filter Shut-off valve Pressure indicator

Example No.	Figure	Designation	Explanation
4		D1.10-11.64(63.44)11	Double mechanical seal Basic arrangement 10 Isolation valve (optional) Tank Heat exchanger (internal) Level indicator (internal) Shut-off valve (optional)
5		S1.02-21Q3.13-64(44)11	Single mechanical seal Basic arrangement02 Orifice Quench Basic arrangement13 Tank Level indicator (internal) Shut-off valve
6		S1.06-11.63.41.11	Single mechanical seal Basic arrangement 06 Shut-off valve (optional) Heat exchanger Pressure indicator Shut-off valve (optional)

Example No.	Figure	Designation / Explanation
7		S1.08-11.42.41.21 Single mechanical seal Basic arrangement 08 Shut-off valve Temperature indicator Pressure indicator Orifice
8		S1.06-11.63.11Q3.09-11-21 Single mechanical seal Basic arrangement 06 Shut-off valve (optional) Cooler Shut-off valve Quench Basic arrangement09 Shut-off valve (optional) Orifice

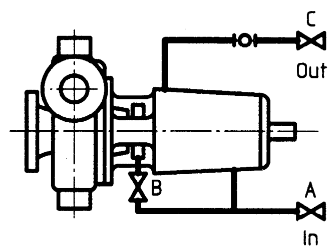
G.5 Piping arrangement for cooling water

G.5.1 Cooling water piping arrangements for overhung impeller pumps



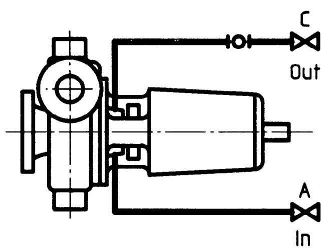
Plan A

Cooling to bearing housing



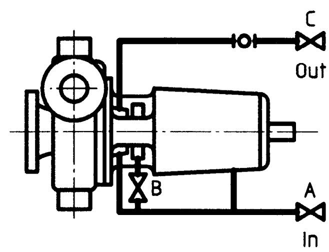
Plan B

Cooling to bearing housing with parallel flow to seal plate



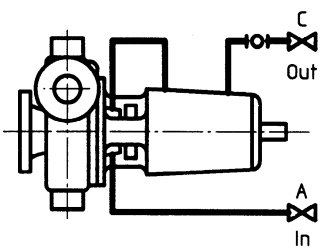
Plan C

Cooling to stuffing box jacket



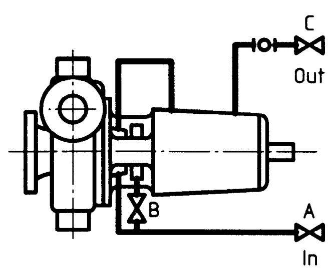
Plan D

Cooling to stuffing box jacket with parallel flow to seal plate



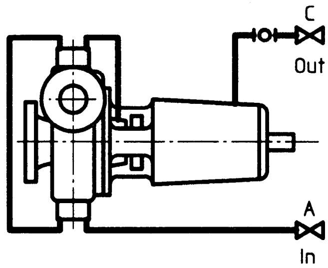
Plan E

Cooling to stuffing box jacket and bearing housing in series



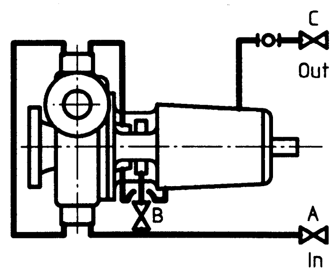
Plan F

Cooling to stuffing box jacket and bearing housing in series with parallel flow to seal plate



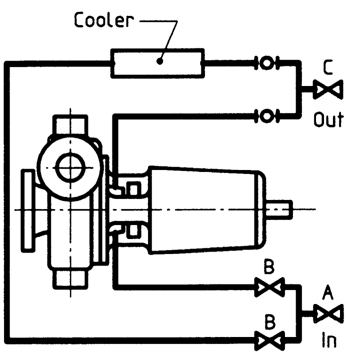
Plan G

Cooling to pedestals, stuffing box jacket and bearing housing in series



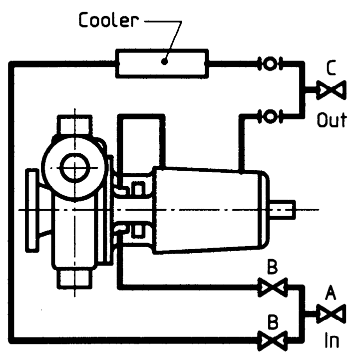
Plan H

Cooling to pedestals, stuffing box jacket and bearing housing in series with parallel flow to seal plate



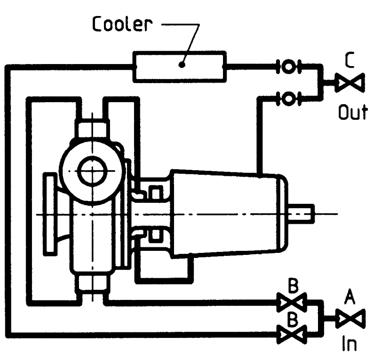
Plan J

Cooling to stuffing box jacket with parallel flow to cooler



Plan K

Cooling to stuffing box jacket and bearing housing in series with parallel flow to cooler



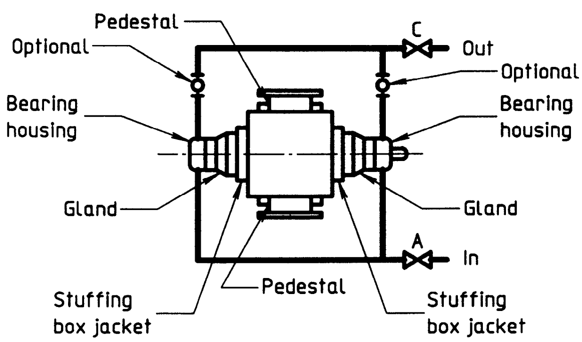
Plan L

Cooling to pedestals, stuffing box jacket and bearing frame in series with parallel flow to cooler

Key

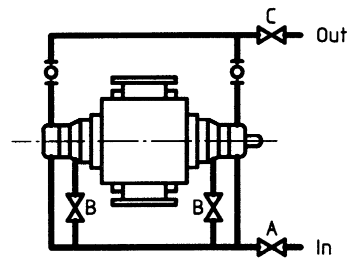
	Valve
	Sight flow indicator when specified
Valve A:	Inlet shutoff valve
Valve B:	Branch flow control valve
Valve C:	Outlet shutoff valve (optional)

G.5.2 Cooling water piping arrangements for between-bearing pumps



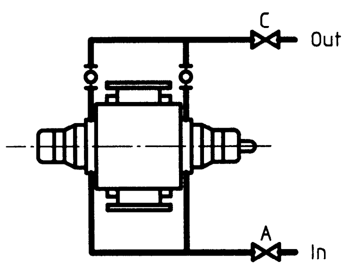
Plan A

Cooling to bearing housing



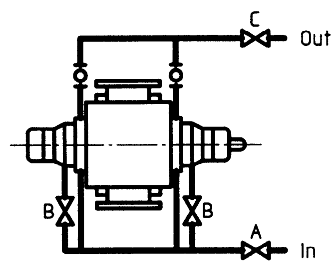
Plan B

Cooling to bearing housing with parallel flow to seal plate



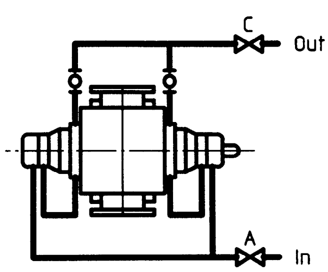
Plan C

Cooling to stuffing box jacket



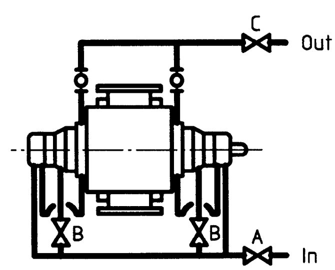
Plan D

Cooling to stuffing box jacket with parallel flow to seal plate



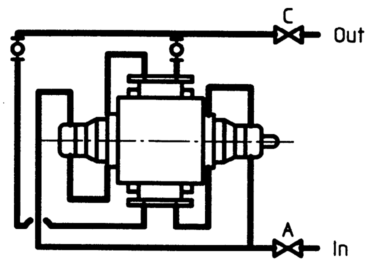
Plan E

Cooling to bearing housing and stuffing box jacket in series



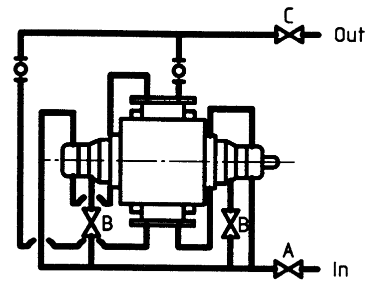
Plan F

Cooling to bearing housing and stuffing box jacket in series with parallel flow to seal plate



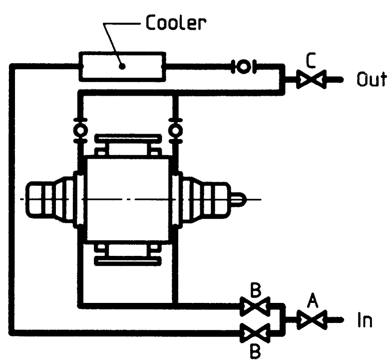
Plan G

Cooling to bearing housing, stuffing box jacket, and pedestals in series



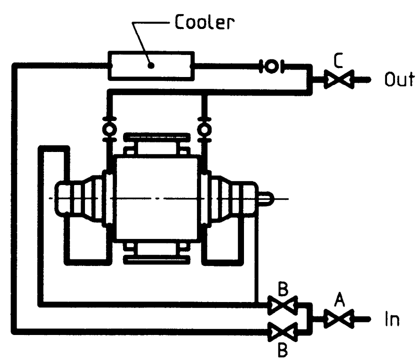
Plan H

Cooling to bearing housing, stuffing box jacket, and pedestals in series with parallel flow to seal plate



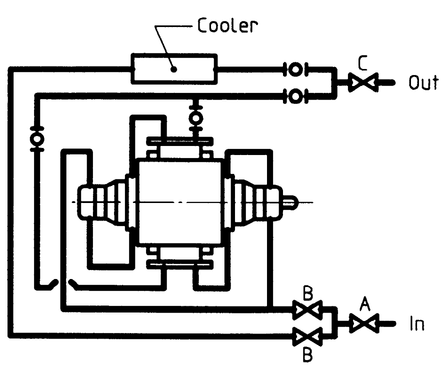
Plan J

Cooling to stuffing box jacket with parallel flow to cooler



Plan K

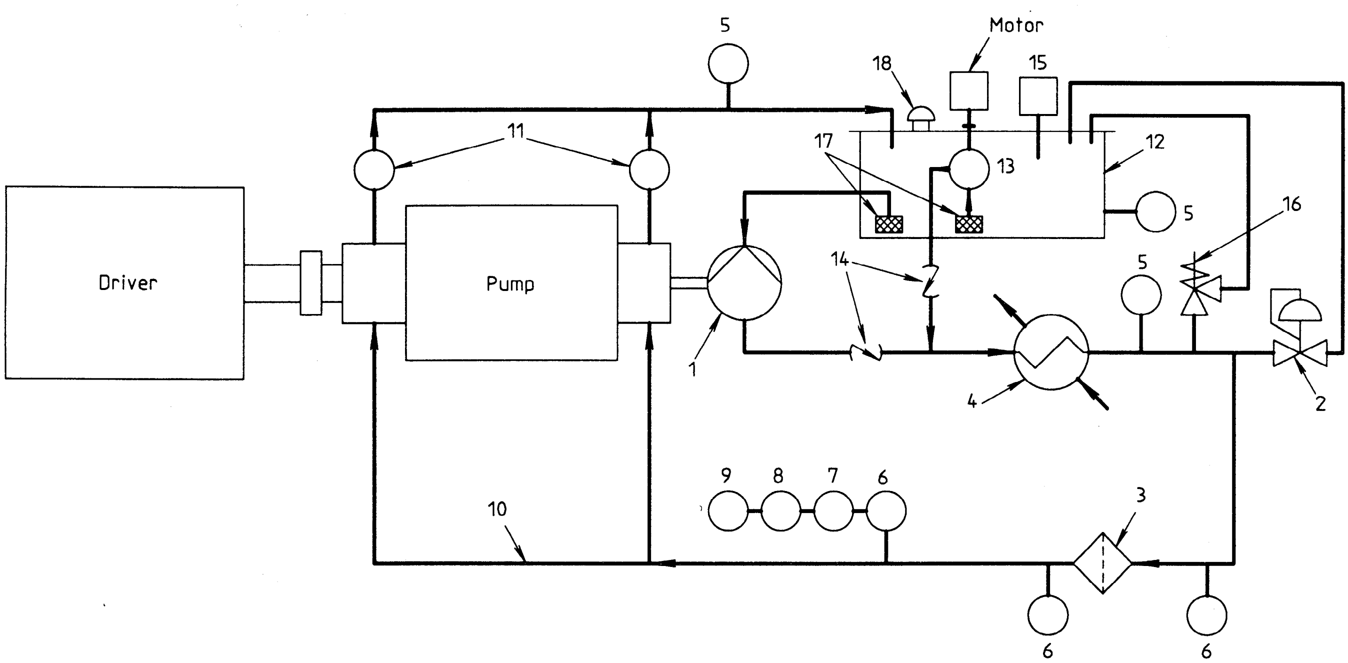
Cooling to bearing housing, and stuffing box jacket in series with parallel flow to cooler



Plan L

Cooling to bearing housing, stuffing box jacket, and pedestals with parallel flow to cooler

G.6 Typical pressurized lubricating oil system



NOTE 13 This illustration is a typical schematic and does not constitute any specific design, nor does it include all details (for example, vents and drains).

Key

1	Shaft-driven main oil pump	10	Piping (supply and return)
2	Pressure-regulating valve	11	Sight flow indicators
3	Full-flow filter	12	Oil reservoir
4	Oil cooler	13	Auxiliary oil pump
5	Temperature gauge	14	Check valve
6	Pressure gauge	15	Oil level indicator
7	Low-pressure alarm and shutdown switch	16	Relief valve
8	Startup switch for main pump	17	Suction strainer
9	Auxiliary pump pressure switch	18	Filter/Breather

Annex H
(informative)

Code for identification of fluid connections

The following symbols may be used for the identification of fluid connections for the documentation of pumps (e.g. drawings, manuals and similar brochures) or on the pump itself and its auxiliaries.

The identification code consists of two letters as given in table H.1 and table H.2 in combination side by side (e.g. II = injection inlet). When several connections with identical symbols appear in one document, a differentiation is necessary by using an added number (e.g. PM 1 = pressure measurement 1, PM 2 = pressure measurement 2).

Table H.1 — Identification of connections for measurement devices

Code	Type
F	flow
P	pressure
T	temperature
L	level
V	vibration
M	measurement

Table H.2 — Identification of connections for auxiliary devices

Code	Type
F	fluid
L	leakage
B	barrier
I	injection
C	circulation
Q	quench
K	cooling
H	heating
G	lubrication
E	balance
I	inlet
O	outlet
F	filling
D	drain
V	vent

Annex J
(informative)

Materials and material specifications for centrifugal pump parts

Table J.1 and table J.2 present specifications and codes for centrifugal pump materials respectively. Hard-facing materials (Stellite, Colmonoy, tungsten carbide, etc.) should be selected by the manufacturer/supplier unless specified by the purchaser.

Table J.1 — Material specification for centrifugal pump parts

Material	Pressure-containing parts	Forgings	Bar stock	Bolts and studs
Cast iron	ISO 185	—	—	—
Carbon steel	ISO 3755	ISO 683-1	ISO 683-1	—
CrMo steel	—	—	—	—
5 % Chrome steel	ISO 683-13	ISO 683-13	1)	1)
12 % Chrome steel	ISO 683-13:1986, steel type 4	ISO 683-13:1986, steel type 4	1)	1)
18-8 Stainless steel	1)	ISO 683-13:1986, steel type 11	1)	ISO 3506:1979, A2
18-10-2,5 Stainless steel	1)	ISO 683-13:1986, steel type 20	1)	ISO 3506:1979, A4
Bronze	—	—	ISO 427	ISO 544

1) Relevant International Standards have not been published to date.

The purchaser may also specify materials according to national standards.

Table J.2 — Material code for mechanical seal components

Mating face material of spring-loaded face and seat face	**Material of secondary seal**[1)]	**Material of other components**[2)] (for example springs or bellows, but not the sealing cover or shaft sleeve)
Synthetic carbon	**Elastomers**	
A = Carbon, metal-impregnated	P = Nitrile rubber	
B = Carbon, resin-impregnated	N = Chloroprene	
C = Other carbons	B = Butyl rubber	
	E = E/P[3)] rubber	
Metals	S = Silicon rubber	
D = Carbon steel	V = Fluorocarbon rubber	D = Carbon steel
E = Chrome steel	K = Perfluoroelastomers	E = Chrome steel
F = CrNi steel	X = Other elastomers	F = CrNi steel
G = CrNiMo steel		G = CrNiMo steel
K = Hard-coated metals	**Non-elastomers**	
M = Nickel-based alloys	T = PTFE	
N = Bronze	M = PTFE/FEP[3)] jacketed	M = Nickel-based alloys
P = Cast iron	A = Compressed impregnated asbestos	N = Bronze
R = Alloyed cast iron	G = Graphite foil	
S = Chrome steel casting	Y = Other non-elastomers	
T = Other materials		T = Other materials
	Special cases	
Carbides	U = Different materials for secondary seals	
U = Tungsten carbide		
U_1 = Tungsten carbide with cobalt binder		
U_2 = Tungsten carbide with nickel binder		
U_3 = Tungsten carbide with NiCrMo binder		
Q = Silicon carbide		
Q_1 = Silicon carbide without free silicon		
Q_2 = Silicon carbide with free silicon		
Q_3 = Silicon carbide graphite compound with free silicon		
Q_4 = Silicon-converted carbon		
J = Other carbides		
Metal oxides		
V = Al oxide		
W = Cr oxide		
X = Other metal oxides		
Synthetics		
Y = PTFE[3)], reinforced		
Y_1 = PTFE, glass-fibre reinforced		
Y_2 = PTFE, carbon reinforced		
Z = Other synthetics		

1) Secondary seals are rotating parts which seal the shaft to the shaft sleeve, or stationary rings wich seal the casing to the cover plate. They can also be bellows.

2) Further details can be obtained from the manufacturer/supplier of the mechanical seals.

3) PTFE = polytetrafluoroethylene, E/P = ethylene/propylene, FEP = perfluoro(ethylene/propylene).

Annex K
(informative)

Check-list

The following list indicates by subclause number where a decision may be required by purchaser, or agreement is required between purchaser and manufacturer/supplier.

4 Design

4.1	General
4.1.1.5	Newtonian liquids
4.1.2	NPSHR basis
4.1.3.1	Means to minimize the pressure on the shaft seals
4.3.1.7 **4.3.1.8**	Critical speed
4.3.2.1.1	Assembled rotors
4.3.2.1.2	Minimum continuous stable flow
4.4.2.2	Vertical canned pump inlet can
4.4.4.5.1	External bolting
4.5.2.2	Drain, vent and pressure gauge
4.6	External forces and moments on flanges
4.8.1.2	Impeller construction
4.11.7.3	Sleeves
4.12.1.1	Radial bearings
4.12.1.8	Bearing oilers
4.12.1.14	Bearing oil heaters
4.12.3.2	Lubrication system
4.12.3.2.2	Oil-reservoir: oil heating system
4.13.1	Shaft seal
4.13.3.1	Mechanical seal arrangement
4.13.3.2	Cooling or heating requirements
4.13.3.4.7	Throat bushes
4.14.1.3.1	Slip-on flanges
4.14.2.2	Material for cooling water piping
4.14.2.3	Sight flow indicators
4.14.5.2	Auxiliary piping for external services: range of supply and piping connections
4.16.1.6	Coupling: balance class
4.16.1.11	Coupling: information if the pump is delivered without driver
4.17.2.2	Baseplate extension
4.17.2.8	Pedestals for centreline-supported pumps
4.17.2.10	Levelling screws for baseplates

4.17.2.12	Vertical clearance at drive element for baseplates
4.17.2.13	Epoxy grout: precoating of baseplates
4.17.3.3	Alignment positioning screws for vertical pumps

5 Material

5.1.1	Materials for hazardous liquids
5.1.3	Additional material tests and inspections
5.1.7	Chemical and mechanical data for pressure casing parts
5.1.11	Materials for wet H_2S service
5.3.1	Inspection of nozzle welds
5.4.1	Radiography, ultrasonic, magnetic particle or dye penetrant material inspection
5.4.2	Material inspection records
5.4.3	Acceptability of defects
5.5	Low temperature use

6 Shop inspection and tests (all)

7 Preparation for dispatch

7.3.2	Preservation

Annex

B.2	Definition of pump families
Table B.3	Flanges exceeding DN 600
B.4.1	Additional possibilities
B.5	Type of baseplate
D.1	Documents: number of copies and special style or form of documents

Annex L
(informative)

Bibliography

[1] ISO 683-1:1987, *Heat-treatable steels, alloy steels and free-cutting steels — Part 1: Direct-hardening unalloyed and low-alloyed wrought steel in form of different black products.*

[2] ISO 683-13:1986, *Heat-treatable steels, alloy steels and free-cutting steels — Part 13: Wrought stainless steels.*

[3] ISO/R 773:1969, *Rectangular or square parallel keys and their corresponding keyways (Dimensions in millimetres).*

[4] ISO/R 775:1969, *Cylindrical and 1/10 conical shaft ends.*

[5] ISO 1219-1:1991, *Fluid power systems and components — Graphic symbols and circuit diagrams — Part 1: Graphic symbols.*

[6] ISO 3511-1:1977, *Process measurement control functions and instrumentation — Symbolic representation — Part 1: Basic requirements.*

[7] ISO 3511-2:1984, *Process measurement control functions and instrumentation — Symbolic representation — Part 2: Extension of basic requirements.*

[8] ISO 3511-3:1984, *Process measurement control functions and instrumentation — Symbolic representation — Part 3: Detailed symbols for instrument interconnection diagrams.*

[9] ISO 3661:1977, *End-suction centrifugal pumps — Baseplate and installation dimensions.*

[10] ISO 5199:1986, *Technical specifications for centrifugal pumps — Class II.*

[11] ISO 5343:1983, *Criteria for evaluating flexible rotor balance.*

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