
British Standard Specification for

Centrifugal pumps: class II

Pompes centrifuges de classe II — Spécifications

Kreiselpumpen der Klasse II

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National foreword

This British Standard has been prepared under the direction of the Machinery and Components Standards Committee. It is identical with ISO 5199-1986 'Technical specification for centrifugal pumps — Class II' which was prepared by Technical Committee ISO/TC 115 of the International Organization for Standardization (ISO) and in the development of which the UK played a major part. However, it should be noted that in the UK, cast iron pumps ordered from catalogue would normally be drilled unless the purchase order specified otherwise whereas in the 2nd and 3rd paragraphs of 4.5.3 the alternative is given as the first option.

The second sentence of 5.3 is applicable to high integrity castings such as those used in the chemical and petroleum industries. Impregnation, for example, is permitted by Lloyds rules and Ministry of Defence specifications for certain applications whilst drilling out a defect and the fitting of a threaded plug is a recognized method of rectification of a casting fault. It is therefore advisable for this point also to be covered in the purchase order.

The UK committee also considers that in figure 1, below 1 kW, the factor of 1.37 should be applied, i.e. the curve of the graph should be taken as horizontal at 137 % below 1.0 kW pump power input. The 1 kW minimum power for the driver still of course applies.

Terminology and conventions. The text of the international standard has been approved as suitable for publication as a British Standard without deviation. Some terminology and certain conventions are not identical with those used in British Standards; attention is drawn especially to the following.

The comma has been used as a decimal marker. In British Standards it is current practice to use a full point on the baseline as the decimal marker.

Wherever the words 'International Standard' appear, referring to this standard, they should be read as 'British Standard'.

Cross-references

International standard	Corresponding British Standard
ISO 76-1978	BS 5645 : 1978 Specification for rolling bearings — static load ratings (Identical)
ISO 281/1-1977	BS 5512 Specification for rolling bearings — dynamic load ratings and rating life Part 1 : 1977 Calculation methods (Identical)
ISO 1219-1976	BS 2917 : 1977 Specification for graphical symbols used on diagrams for fluid power systems and components (Identical)
ISO 1940-1973	BS 5265 Mechanical balancing of rotating bodies Part 1 : 1979 Recommendations on balance quality of rotating rigid bodies (Identical)
ISO 2372-1974	BS 4675 Mechanical vibration in rotating machinery Part 1 : 1976 Basis for specifying evaluation standards for rotating machines with operating speeds from 10 to 200 revolutions per second (Identical)

Amendment No. 1
published and effective from 15 December 1992
to BS 6836 : 1987

Specification for centrifugal pumps: class II

NOTE. The European Committee for Standardization (CEN) has accepted ISO 5199 : 1986 as a European Standard designated as EN 25199 : 1992. This amendment implements EN 25199 : 1992 as a British Standard in the BS EN series.

Implementation of European Standard

Front cover

Delete the existing cover page and substitute the attached.

AMD 7527/December 1992

National foreword

At the end of paragraph 1 insert the following new paragraph.

'In 1992 the European Committee for Standardization (CEN) accepted ISO 5199 : 1986 as European Standard EN 25199 : 1992. As a consequence of implementing the European Standard this British Standard is renumbered as BS EN 25199 : 1992 and any reference to BS 6836 should be read as a reference to BS EN 25199.'

AMD 7527/December 1992

New EN title page and foreword

Immediately after the national foreword, insert the attached new EN title page and foreword page.

AMD 7527/December 1992

Technical specifications for centrifugal pumps — Class II

The European Standard EN 25199 : 1992 has the status of a
British Standard

Spécifications techniques pour pompes
centrifuges — Class II

Kreiselpumpen, technische Anforderungen —
Klasse II

UDC 621.671

UDC 621.671

Descriptors: Pumps, centrifugal pumps, specifications, design, materials, leaktightness, piping, tests, technical data sheets

English version

Technical specifications for centrifugal pumps — Class II

(ISO 5199 : 1986)

Spécifications techniques pour pompes
centrifuges — Class II
(ISO 5199 : 1986)

Kreiselpumpen, technische Anforderungen —
Klasse II
(ISO 5199 : 1986)

This European Standard was approved by CEN on 1992-10-15. CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

Central Secretariat: rue de Stassart 36, B-1050 Brussels

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Ref. No. EN 25199 : 1992 E

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Foreword

On proposal of the Technical Committee CEN/TC 197 'Pumps' the Technical Board of CEN decided to submit the International Standard: ISO 5199 : 1986 *Technical specifications for centrifugal pumps — Class II* to the formal vote.

The result of the formal vote was positive.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 1993, and conflicting national standards shall be withdrawn at the latest by April 1993.

In accordance with the Common CEN/CENELEC Rules, the following countries are bound to implement this European Standard: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

International standard	Corresponding British Standard
ISO 2548-1973	BS 5316 Specification for acceptance tests for centrifugal, mixed flow and axial pumps Part 1 : 1976 Class C tests (Identical)
ISO 3511/1-1977	BS 1646 Symbolic representation for process measurement control functions and instrumentation Part 1 : 1979 Basic requirements (Identical)
ISO 3555-1977	BS 5316 Specification for acceptance tests for centrifugal, mixed flow and axial pumps Part 2 : 1977 Class B tests (Identical)
ISO 3744-1981	BS 4196 Sound power levels of noise sources Part 4 : 1981 Engineering methods for determination of sound power levels for sources in free-field conditions over a reflecting plane (Identical)
ISO 3746-1979	Part 6 : 1981 Survey method for determination of sound power levels of noise sources (Identical)

The Technical Committee has reviewed the provisions of ISO 2084, ISO 2229, ISO 2373, ISO 2858, ISO 3069, ISO 3274, ISO 3511/2, ISO 3511/3 and ISO 3661, to which reference is made in the text, and has decided that they are acceptable for use in conjunction with this standard.

A related British Standard to ISO 2373 is BS 4999 'General requirements for rotating electrical machines' Part 142 : 1987 'Specification for mechanical performance : vibration'.

ISO 3511/2 and ISO 3511/3 are related, respectively, to BS 1646 'Symbolic representation for process measurement control functions and instrumentation' Part 2 : 1983 'Specification for additional basic requirements' and Part 3 : 1984 'Specification for detailed symbols for instrument interconnection diagrams'. (Parts 2 and 3 were published as technically equivalent to ISO/DIS 3511/2 and ISO/DIS 3511/3 respectively.)

BS 5257 : 1975 'Specification for horizontal end-suction centrifugal pumps' contains the technical requirements of ISO 2858, ISO 3069 and ISO 3661 but also contains additional requirements.

There is no related British Standard to ISO 7000 and the Technical Committee has not approved its provisions, but as it is referred to for information only this does not affect the validity of the standard.

It has been assumed in the drafting of this British Standard that the execution of its provisions is entrusted to appropriately qualified and experienced people.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

British Standard Specification for

Centrifugal pumps: class II

0 Introduction

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

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

1 Scope and field of application

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

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

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

1.4 Where application of this International Standard has been called for

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

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

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

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

b) data sheets (see annex A);

c) this International Standard;

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

2 References

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

3 Definitions

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

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

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

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

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

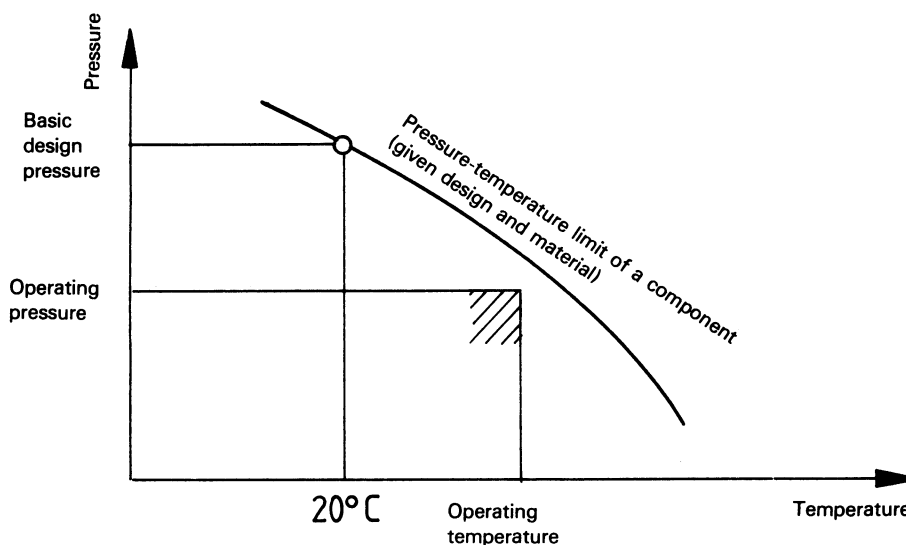
3.5 basic design pressure: This is derived from the permitted stresses at 20 °C of the material used for the pressure-containing parts.

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

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

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

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



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

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

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

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

3.14 design load: The maximum hydraulic radial forces on the largest impeller (diameter and width) operating within the manufacturer's specified range on its maximum speed curve with a liquid density of 1000 kg/m³.

3.15 maximum load: The maximum hydraulic radial forces on the largest impeller (diameter and width) operating at any point on its maximum speed curve with a liquid density of 1000 kg/m³.

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

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

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

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

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

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

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

4 Design

4.1 General

4.1.1 Characteristic curve

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

4.1.2 Net positive suction head (NPSH)

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

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

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

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

For NPSH tests, refer to 6.3.2.3.

4.1.3 Outdoor installation

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

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

4.2 Prime movers

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

- application and method of operation of the pump. For instance in the case of parallel operation, the possible performance range with only one pump in operation taking into account the system characteristic shall be considered;
- position of the operating point on the pump characteristic curve;

- c) shaft seal friction loss;
- d) circulation flow for the mechanical seal (especially for pumps with low rate of flow);
- e) properties of pumped liquid (viscosity, solids content, density);
- f) power and slip loss through transmission;
- g) atmospheric conditions at pump site.

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

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

4.3 Critical speed, balance and vibration

4.3.1 Critical speed

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

4.3.2 Balance and vibration

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

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

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

Speed of rotation, n	Maximum r.m.s. values of the vibration velocity for the shaft centreline height h_1	
	$h_1 < 225$ mm	$h_1 > 225$ mm
min ⁻¹	mm/s	mm/s
$n < 1800$	2,8	4,5
$1800 < n < 4\,500$	4,5	7,1

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

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

See also annex B.

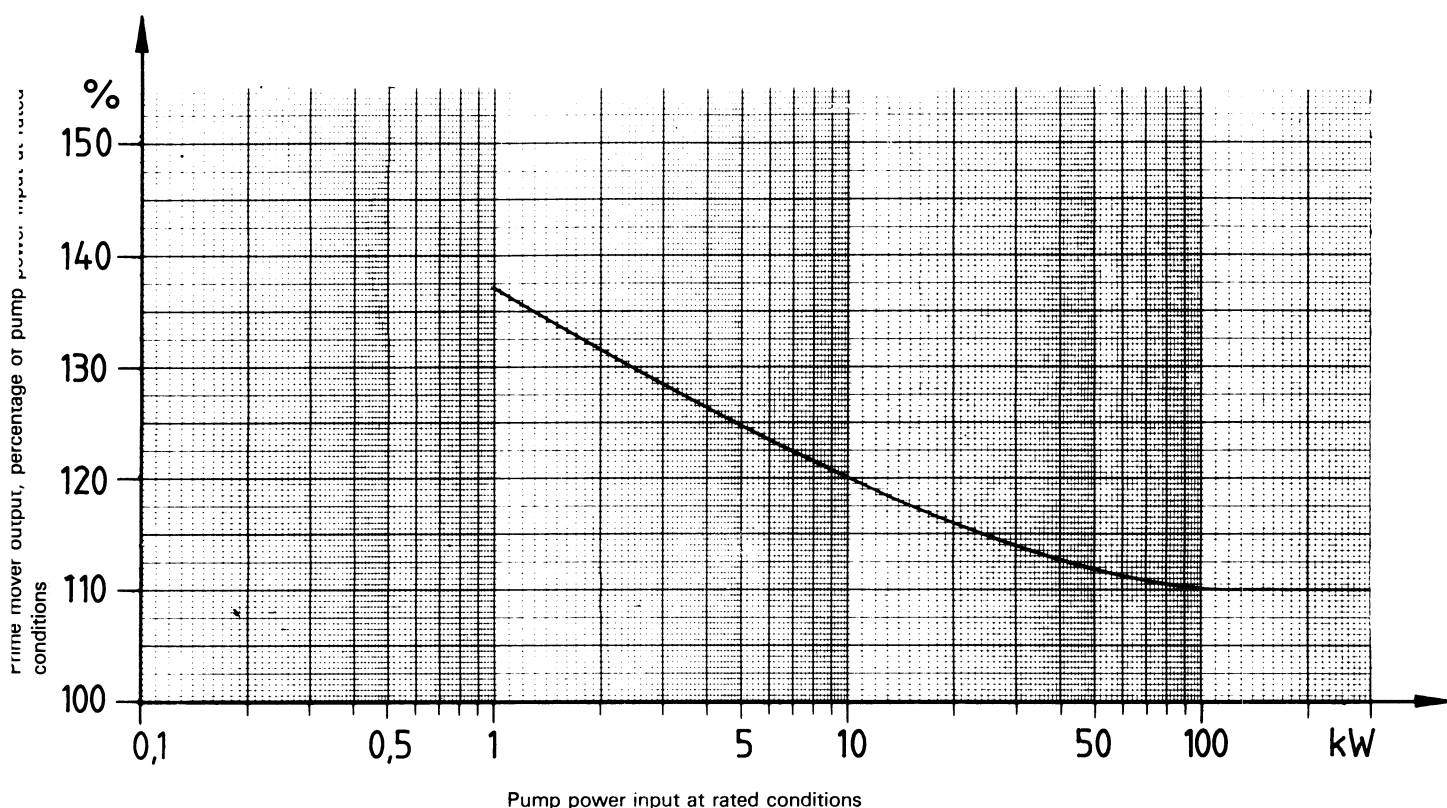


Figure 1 — Prime mover output, percentage of pump power input at rated conditions

4.4 Pressure-containing parts

4.4.1 Pressure-temperature rating

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

The basic design pressure of the pump shall be at least a gauge pressure of 16 bar¹⁾ at 20 °C when made of cast iron, ductile iron, carbon steel or stainless steel.

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

4.4.2 Wall thickness

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

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

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

4.4.3 Materials

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

4.4.4 Mechanical features

4.4.4.1 Dismantling

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

4.4.4.2 Jackscrews

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

4.4.4.3 Jackets

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

4.4.4.4 Casing gaskets

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

4.4.4.5 Vapour venting

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

4.4.4.6 External bolting

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

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

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

4.4.4.7 Casing support for high temperature

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

4.5 Branches (nozzles) and miscellaneous connections

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

4.5.1 Extent

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

4.5.2 Inlet and outlet branches

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

4.5.3 Vent, pressure-gauge and drain

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

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

*

1) 1 bar = 0,1 MPa

*See national foreword.

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

4.5.4 Closures

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

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

4.5.5 Auxiliary pipe connections

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

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

4.5.6 Connection identification

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

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

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

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

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

4.7 Branch (nozzle) flanges

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

4.8 Impellers

4.8.1 Impeller design

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

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

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

4.8.2 Securing of impellers

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

4.8.3 Axial adjustment

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

4.9 Wear rings or equivalent components

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

4.10 Running clearance

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

4.11 Shafts and shaft sleeves

4.11.1 General

Shafts shall be of ample size and stiffness to

- a) transmit the prime mover rated power;
- b) minimize unsatisfactory packing or seal performance;
- c) minimize wear and the risk of seizure;
- d) take due consideration of the static and dynamic radial loads, the critical speed (see 4.3.1) and the methods of starting and inertia loading involved.

4.11.2 Surface roughness

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

4.11.3 Shaft deflection

The calculated shaft deflection at the radial plane through the outer face of the stuffing box caused by radial loads exerted during operation of the pump shall be consistent with the

*See national foreword.