INTERNATIONAL STANDARD

ISO 15783

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Seal-less rotodynamic pumps — Class II — Specification

Pompes rotodynamiques sans dispositif d'étanchéité d'arbre — Classe II — Spécifications

Reference number
ISO 15783:2002(E)

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.ch
Web www.iso.ch

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

The main task of technical committees is to prepare International Standards. 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.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 15783 was prepared by Technical Committee ISO/TC 115, *Pumps*, Subcommittee SC 1, *Dimensions and technical specifications of pumps*.

Annex A forms a normative part of this International Standard. Annexes B, C, D, E, F and G are for information only.

Introduction

This International Standard is the first of a series dealing with technical specifications for seal-less pumps; they correspond to two classes of technical specifications, Classes I and II, of which Class I is the more severe requirements.

Where a decision may be required by the purchaser, or agreement is required between the purchaser and manufacturer/supplier, the relevant text is highlighted with • and is listed in annex G.

Seal-less rotodynamic pumps — Class II — Specification

1 Scope

1.1 This International Standard specifies the requirements for seal-less rotodynamic pumps that are driven with permanent magnet coupling (magnet drive pumps) or with canned motor, and which are mainly used in chemical processes, water treatment and petrochemical industries. Their use can be dictated by space, noise, environment or safety regulations.

Seal-less pumps are pumps where an inner rotor is completely contained in a pressure vessel holding the pumped fluid. The pressure vessel or primary containment device is sealed by static seals such as gaskets or O-rings.

1.2 Pumps will normally conform to recognized standard specifications (e.g. ISO 5199, explosion protection, electromagnetic compatibility), except where special requirements are specified herein.

1.3 This International Standard includes design features concerned with installation, maintenance and operational safety of the pumps, and defines those items to be agreed upon between the purchaser and manufacturer/supplier.

1.4 Where conformity to this International Standard has been requested and calls for a specific design feature, alternative designs may be offered providing that they satisfy the intent of this International Standard and they are described in detail. Pumps which do not conform with all requirements of this International Standard may also be offered providing that the deviations are fully identified and described.

Whenever documents include contradictory requirements, they should be applied in the following sequence of priority:

a) purchase order (or inquiry, if no order placed), see annexes D and E;

b) data sheet (see annex A) or technical sheet or specification;

c) this International Standard;

d) other standards.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 76, *Rolling bearings — Static load ratings*

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

ISO 3274, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Nominal characteristics of contact (stylus) instruments*

ISO 3744, *Acoustics — Determination of sound power levels of noise sources using sound pressure — Engineering method in an essentially free field over a reflecting plane*

ISO 3746, *Acoustics — Determination of sound power levels of noise sources using sound pressure — Survey method using an enveloping measurement surface over a reflecting plane*

ISO 5199, *Technical specifications for centrifugal pumps — Class II*

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

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

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

ISO 9906, *Rotodynamic pumps — Hydraulic performance acceptance tests — Grades 1 and 2*

IEC 60034-1, *Rotating electrical machines — Part 1: Rating and performance*

EN 12162, *Liquid pumps — Safety requirements — Procedure for hydrostatic testing*

3 Terms and definitions

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

3.1
magnetic drive pump
MDP
pump in which the shaft power of the drive is transferred to the impeller of the pump by means of a permanent magnetic field, which passes through a containment barrier (shell) to an inner rotor having permanent magnets or an induction device

3.2
canned motor pump
CMP
pump in which the stator of an electric motor is separated from the rotor by a sealed containment barrier (liner)

NOTE 1 The rotor runs in the liquid being pumped or in another liquid.

NOTE 2 The shaft power is transmitted by means of an electromagnetic field.

3.3
seal-less rotodynamic pump
〈general〉 pump design in which the impeller shaft also carries the rotor of either a canned induction motor or a synchronous or an asynchronous magnetic drive

NOTE The design does not use a dynamic shaft seal as a primary containment device. Static seals are the means used for containing the fluid.

3.3.1
hydraulic end
that end of the pump which transfers mechanical energy into the liquid being pumped

3.3.2
power drive end
that end of the pump containing the magnetic coupling (MDP) or the motor (CMP) which provides the mechanical energy necessary for the operation of the hydraulic end

3.3.3
lubrication and cooling flow
flow necessary in a magnetic drive in the area between the inner magnet and the containment shell, or in a canned motor between the rotor and the sleeve, for dissipation of the heat due to inherent eddy current losses in metallic containment shells and frictional heat generation from bearings, and for lubrication

NOTE Internal pump bearings are lubricated and cooled by the pumped fluid or an external, compatible flushing fluid.

3.3.4
close coupled
⟨MDP⟩ coupling arrangement in which the motor is supplied with a flange adapter which mounts directly onto the casing or body of the pump and in which the outer magnet ring is mounted onto the motor shaft

3.3.5
separately coupled
⟨MDP⟩ arrangement in which the motor and pump have separate mounting arrangements with the outer magnet ring mounted on its own shaft, supported by rolling bearings, and connected to the motor shaft by means of a flexible coupling

3.3.6
air gap
⟨MDP⟩ radial distance between the inner diameter (ID) of the outer magnet assembly and the outer diameter (OD) of the containment shell

3.3.7
liquid gap
⟨MDP⟩ radial distance between the ID of the shell and the OD of the rotor sheath

3.3.8
liquid gap
⟨CMP⟩ radial distance between the ID of the liner and the OD of the rotor sheath

3.3.9
total gap
magnetic gap
⟨MDP⟩ radial distance between the ID of the outer magnets and the OD of the inner magnets/torque ring

3.3.10
total gap
magnetic gap
⟨CMP⟩ total distance between the ID of the stator laminations and the OD of the rotor lamination

3.3.11
radial load
⟨MDP and CMP⟩ load perpendicular to the pump shaft and drive shaft due to unbalanced hydraulic loading on the impeller, mechanical and magnetic rotor unbalance, rotor assembly weight, and forces of the fluid circulating through the drive

3.3.12
axial load
⟨MDP⟩ load in line with the pump shaft caused by hydraulic forces acting on the impeller shrouds and inner magnet assembly

3.3.13
axial load
⟨CMP⟩ load in line with the pump shaft caused by hydraulic forces acting on the impeller shrouds and rotor

3.3.14
hydraulic load balance
axial load equalization by means of an impeller design, impeller balance holes or vanes, or by balancing through variable orifices in the drive section and hydraulics

3.4
starting torque
maximum net torque transmitted to the driven components during a hard (full voltage) start-up of the unit

NOTE It is affected by the inertia of the pump and motor rotors, the starting torque capacity of the motor and the power versus speed requirements of the liquid end.

3.5
break-out torque
torque load applied to the drive shaft with the rotor locked at the point at which magnetic decoupling occurs

3.6
locked rotor torque
maximum torque that a motor will develop when prevented from turning

3.7
eddy currents
electrical currents generated in a conductive material when strong magnetic fields are rotated around it

3.8
magnetic coupling
device which transmits torque through the use of magnet(s) attached to the drive and driven shafts

3.9
inner magnet ring
rows of magnets operating within the containment shell, driven by the outer magnet ring

NOTE The inner magnet ring is mounted on the same rotating element as the pump impeller.

3.10
outer magnet ring
rows of permanent magnets securely fixed to a carrier, evenly spaced to provide a uniform magnetic field

NOTE The outer magnet ring, while rotating, transmits power through a containment shell, driving the inner magnet ring or torque ring.

3.11 Eddy currents

3.11.1
eddy current drive
asynchronous magnetic coupling consisting of a permanent outer magnet ring and an inner torque ring containing a network of conductive rods supported on a mild steel core

NOTE The rotating outer magnet ring generates eddy currents in the copper rods which convert the core to an electromagnet. The electromagnet follows the rotating outer magnet ring but at a slightly slower speed due to slip.

3.11.2
eddy current loss
power loss resulting from eddy currents

NOTE The energy in these eddy currents is normally dissipated as heat due to the electrical resistance of the material.

3.11.3
torque ring
laminations and conductors mounted on the rotor in which electric currents are induced in an eddy current drive

3.11.4
decouple
failure of a synchronous magnetic coupling to rotate synchronously, or the stall condition of an eddy current drive

3.11.5
slip
speed differential between the torque ring and outer magnet ring in an eddy current drive pump or between the running speed and the synchronous speed in a CMP

3.11.6
demagnetization
permanent loss of magnetic attraction due to temperature or modification of the field

3.12 Containment

3.12.1
sheath
thin-walled hermetically sealed enclosure fitted to the inner rotor enclosing the inner magnet ring (MDP) or rotor laminations (CMP)

See Figures 1 and 2.

3.12.2
shell
hermetically sealed enclosure fitted within the total-gap between the inner and outer magnet rings of an MDP and which provides for the primary containment of the pumped liquid

See Figure 2.

3.12.3
liner
hermetically sealed enclosure fitted to the ID of the stator assembly of a CMP and providing for the primary containment of the pumped liquid

See Figure 1.

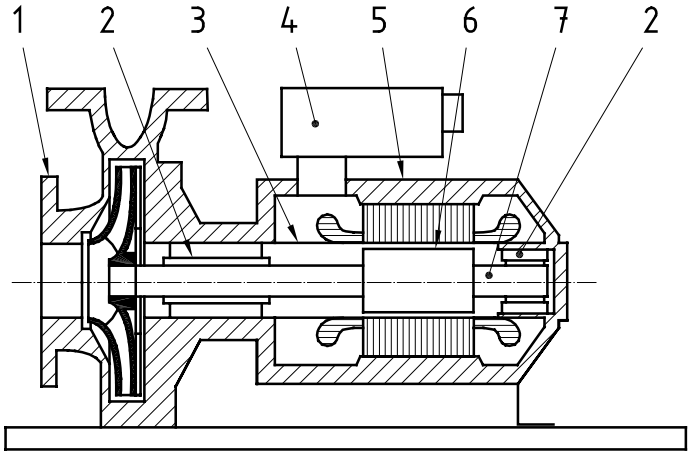
3.12.4
secondary containment
backup pressure-containing system using static seals only to contain leakage in the event of failure of the primary containment by shell or by liner, and including provisions to indicate a failure of the containment shell or liner

3.12.5
drive shaft
⟨MDP⟩ outer shaft of the magnetic drive coupling

3.12.6
secondary control
minimization of release of pumped liquid in the event of failure of the containment shell or stator liner

3.12.7
secondary control system
combination of devices (including, for example, a secondary pressure casing, a mechanical seal) that, in the event of leakage from the containment shell or stator liner, minimizes and safely directs the release of pumped liquid

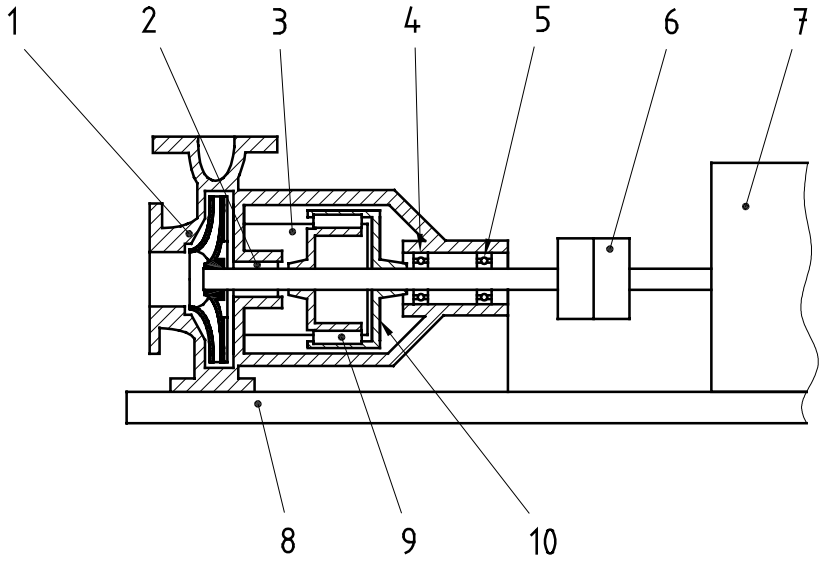
NOTE It includes provision(s) to indicate a failure of the containment shell or liner.



Key

1 Hydraulic end
2 Bearing
3 Liner
4 Terminal box
5 Stator assembly
6 Rotor sheath
7 Rotor

Figure 1 — Example of a canned motor pump (CMP)



Key

1 Hydraulic end
2 Bearing
3 Shell
4 Bearing housing
5 Rolling bearing
6 Coupling
7 Prime mover
8 Baseplate
9 Sheath: inner magnet ring
10 Outer magnet ring

Figure 2 — Example of a magnetic drive pump (MDP)

4 Design

4.1 General

4.1.1 Characteristic curve

The characteristic curve shall indicate the permitted operating range of the pump. Pumps should have a stable characteristic curve. In addition, the characteristic curves for the smallest and largest impeller diameters shall also be shown.

Minimum and maximum continuous stable flows at which the pump can operate without exceeding the noise, vibration and temperature limits imposed by this International Standard shall clearly be stated by the manufacturer/supplier.

4.1.2 Net Positive Suction Head (NPSH)

● The NPSH required (NPSHR) shall be based on cold water testing as determined by testing in accordance with ISO 9906 unless otherwise agreed.

The manufacturer/supplier shall make available a typical curve as a function of flow for water. NPSHR curves shall be based upon a head drop of 3 % (NPSH3).

Correction factors for hydrocarbons shall not be applied to the NPSHR curves.

Pumps shall be selected such that the minimum NPSH available (NPSHA) in the installation exceeds the NPSHR of the pump by at least the specified safety margin. This safety margin shall be not less than 0,5 m, but the manufacturer/supplier may specify a significantly higher margin depending on factors including the following:

— size, type, specific speed, hydraulic geometry or design of the pump;

— operating speed or inlet velocity;

— the pumped liquid and temperature;

— the cavitation erosion resistance of the construction materials.

4.1.3 Outdoor installation

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

● Local regulations or extraordinary ambient conditions, such as high or low temperatures, corrosive environment, sandstorms, for which the pump is required to be suitable shall be specified by the purchaser.

4.2 Prime movers

4.2.1 General

The following shall be considered when determining the power/speed requirements of the pump.

a) The application and method of operation of the pump. For example, in an installation intended for parallel operation, the possible performance range with only one pump in operation, taking into account the system characteristic.

b) The position of the operating point on the pump characteristic curve.

c) The circulation flow for lubrication of bearings and removal of heat losses (especially for pumps with low rates of flow).

d) Properties of the pumped liquid (viscosity, solids content, density).

e) Power loss, including slip loss through transmission (only magnet drive pumps).

f) Atmospheric conditions at the pump site.

g) Starting method of the pump:

— if a pump (e.g. a stand-by pump) is started automatically then consideration shall be given to whether the pump may start against a closed valve, or whether the pump may start against an open valve or be pumping into an empty pipeline; i.e. operates within a pumping system in which the pump pressure is provided only for pipeline friction losses.

h) For variable speed arrangements the minimum continuous speed shall be indicated by the manufacturer/supplier to ensure proper cooling and lubrication of the bearings.

Prime movers required as drivers for seal-less pumps covered by this International Standard shall have power output ratings at least equal to the percentage of rated power input given in Figure 3, this value never being 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.

4.2.2 Magnetic drive pumps

When determining the permanent magnetic drive to be used, the following points shall be taken into consideration in addition to the points a) to h) listed under 4.2.1.

a) The magnetic drive shall be selected for the allowed operating range with the selected impeller diameter at operating temperature and taking into consideration the characteristics of the liquid to be pumped.

• If the density of the liquid of the normal operation is below 1 000 kg/m^3 special agreements between the manufacturer/supplier and purchaser for testing and cleaning shall be made.

b) Heat generated by eddy current losses, power losses in the shell, power losses in the bearings and power losses due to liquid circulation shall be removed by pumped liquid or by supply of external cooling fluid.

c) The magnetic material temperature shall be maintained at or below rated values for the material used. Magnetic materials should not be subject to irreversible losses.

d) The irreversible magnetic losses at operating temperatures of the magnetic drive shall be considered.

Fluids containing magnetically attracted particles should be avoided unless such particles can be effectively removed.

Special arrangements may be provided to avoid formation of ice in air gaps when pumping cold liquids.

The magnetic drive shall be designed in such a manner that start-up will not cause the magnet assemblies to decouple.

4.2.3 Canned motor pumps

Canned motors are generally cooled by circulation of pumped liquid or by the use of coolant liquid to remove heat generated by the containment liner, eddy current losses, motor electrical losses and mechanical losses. Stator winding temperatures shall be maintained at or below values established for the grade of insulation used.

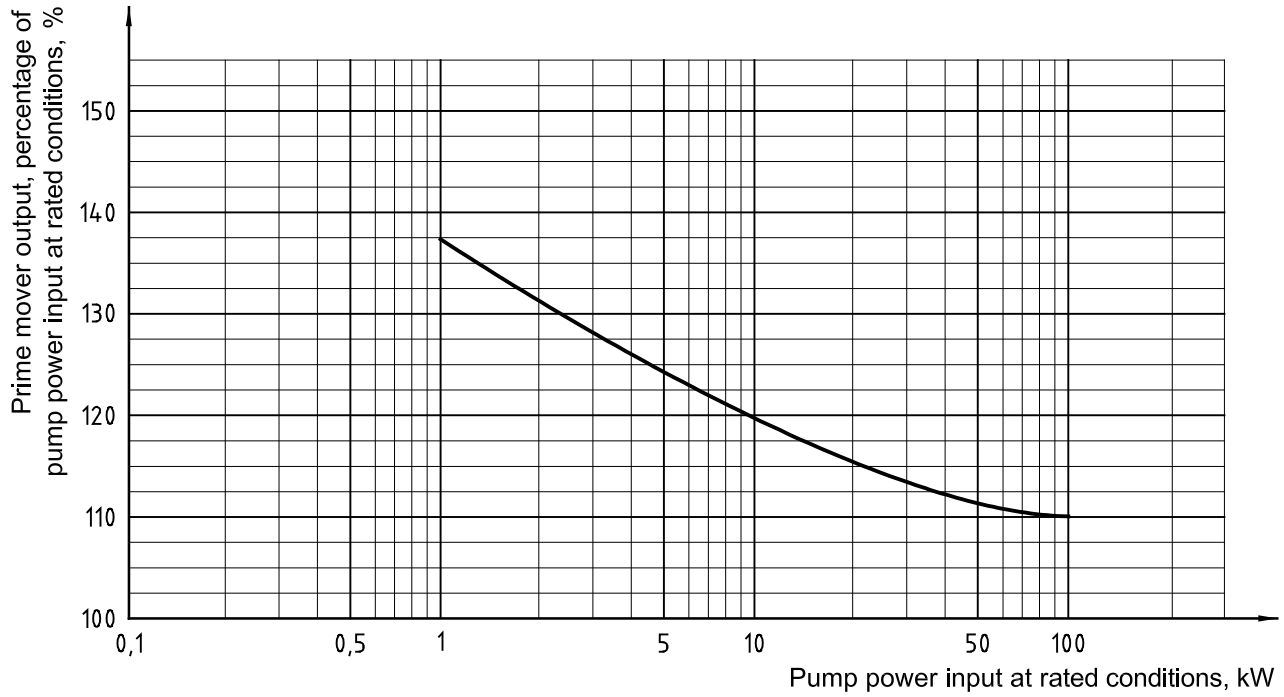


Figure 3 — Prime mover output, percentage of pump power input at rated conditions

When rating a canned motor the conditions listed below shall be taken into consideration in addition to points a) to h) listed under 4.2.1:

— power losses within the canned rotor;

— power losses in the bearings;

— power losses due to liquid circulation;

— explosion protection requirements.

Manufacturers/suppliers shall specify external cooling requirements when required.

Stand-by units may require special arrangements for flushing and/or heating to prevent the settling out of solids, or the formation of ice, or solidification or too low viscosity of the liquid to be pumped.

● The details of such arrangements should be agreed upon between the purchaser and manufacturer/supplier.

4.3 Critical speed, balancing and vibrations

4.3.1 Critical speed

The critical speed shall be calculated with liquid.

● For some pump types (e.g. vertical line shaft and horizontal multistage), the first critical speed may be below the operating speed when agreed between the purchaser and manufacturer/supplier.

Particular attention shall be paid to the critical speed when the pump is to be driven at variable speed.

4.3.2 Balancing and vibration

4.3.2.1 General

All major rotating components shall be balanced.

4.3.2.2 Horizontal pumps

Unfiltered vibration shall not exceed the vibration severity limits as given in Table 1 when measured on the manufacturer's/supplier's test facilities[1)]. 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.

The manufacturer/supplier shall determine the grade of balancing required in order to achieve acceptable vibration levels within the limits specified in this International Standard.

NOTE This can normally be achieved by balancing in accordance with grade G6.3 of ISO 1940-1.

Table 1 — Maximum allowable unfiltred vibration values

Values in millimetres per second (r.m.s.)

Pump arrangement	Pump type and criterion	
	Canned motor pump	Magnetic drive pump
Pump with rigid support centreline height ⩽ 225 mm	2,3	3,0
Pump with rigid support centreline height > 225 mm	3,0	4,5
Pump with flexible support	3,0	4,5
NOTE The values of vibration velocity filtered for rotating frequency and blade passing frequency can be expected to be lower than given in the table.		

4.3.2.3 Vertical pumps

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

Vibration limits for both rolling and sleeve bearing pumps shall not exceed the vibration severity limits as given in Table 1 during shop test at rated speed (± 5 %) and rated flow (± 5 %) operating without cavitation[1)].

4.4 Pressure-containing parts

4.4.1 Primary containment

Containment of the pumped liquid shall be by means able to withstand the stresses derived from the maximum allowable working pressure and any dynamic effects of operation. The wetted materials shall be compatible with each other and the pumped liquid, and shall be dimensioned to give an adequate working life.

It is recognized that several effective methods are suitable for the design of pressure-containing parts. These may be based upon recognized national codes or upon other proven methods. To satisfy the acceptance criteria, each design method shall

1) For *in situ* acceptance limits refer to ISO 10816-3.

— be a written procedure,

— recognize limits of material stresses,

— incorporate a checking stage,

— have been proven empirically or experimentally.

4.4.2 Secondary containment

Where containment of any leakage is considered to be desirable, the pump shall be provided with a secondary containment.

The secondary containment shall be designed to allow installation of a sensor by the purchaser to indicate change in status and either to shut-down the pump or to warn that attention and rectification is required. The secondary containment shall sustain this condition when exposed to the pumped liquid for a minimum of 48 h. It shall be capable of containment under the maximum allowable working pressure, temperature and any dynamic effects from operation.

4.4.3 Secondary control

Where the liquid is less hazardous, but uncontrolled leakage is unacceptable for environmental or personal comfort reasons, the pump shall be provided with a means to control leakage from the primary containment.

Secondary control shall provide a safe means to collect leakage from the primary containment and present it in a manner that will allow its safe disposal. The manufacturer/supplier shall define the maximum allowable working pressure and provide a disposal connection capable of discharging 20 % of the pump flow rate without this pressure being exceeded.

4.4.4 Pressure-temperature rating

The maximum allowable working pressure of the pump at the most severe operating conditions shall be clearly stated by the manufacturer/supplier. In no case shall the maximum allowable working pressure of the pump exceed the flange rating.

The basic design pressure of the pump shall be at least a gauge pressure of 16 bar at 20 °C when the tensile requirements of the material permit.

In the case of materials whose strength does not permit the basic design pressure for 16 bar rating at 20 °C, or where the pump is to be used at temperatures other than 20 °C, the pressure rating shall be adjusted according to the stress-temperature characteristics of the material and shall be clearly stated by the manufacturer/supplier.

The containment shell/liner shall be resistant to a pressure of 0,1 bar absolute and designed for a gauge pressure of 16 bar at 250 °C in the case of metallic materials, and to a vacuum of 0,5 bar absolute and a gauge pressure of 16 bar at 20 °C in the case of non-metallic materials.

4.4.5 Wall thickness

4.4.5.1 General

Pressure-containing parts, including containment shell/liner, shall be dimensioned so that they are capable of withstanding the allowable working pressure at working temperature without deformation which interferes with the safe operation of the pump. The test pressure shall not cause any permanent deformation in accordance with 6.3.1.

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

● The corrosion allowance for all pressure-containing parts, excluding the shell/liner, shall be agreed upon between the purchaser and manufacturer/supplier by consideration of corrosion rates for the liquids and materials involved.

4.4.5.2 Magnetic drive pumps

The containment shell shall be made of corrosion-resistant material of not less than 1 mm thickness, which shall include an allowance for any corrosion loss, as agreed upon by the purchaser.

4.4.5.3 Canned motor pumps

The minimum wall thickness of the liner shall be 0,3 mm and be of corrosion-resistant material.

4.4.6 Materials

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

4.4.7 Mechanical features

4.4.7.1 Dismantling

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

4.4.7.2 Jackscrews

When jackscrews are supplied as a means of separating contacting faces, the mating face shall be counter-bored to receive the jackscrews where damage to the surface offers a possibility of a leaking joint or a poor fit. Socket head screws shall be avoided, if possible.

4.4.7.3 Heating and cooling jackets

Jackets for heating and cooling shall be provided where required.

Heating jackets shall be designed for an operating pressure of at least 6 bar at 200 °C (steam) or 6 bar at 350 °C (heat transfer fluid). Cooling jackets shall be designed for a minimum operating pressure of 6 bar at 170 °C.

The manufacturer/supplier shall specify when external heating or cooling is required. Annex E gives typical systems.

4.4.7.4 Pressure-containment gaskets

Pressure-containment gaskets shall be of a design suitable for the allowable working conditions and for hydrostatic test conditions. They shall be confined to the atmospheric side to prevent blow-out.

4.4.7.5 External bolting

Bolts or studs connecting pressure-containing parts, such as pump casing and cover including magnetic coupling or canned motor, shall have a minimum size of 12 mm.

NOTE If owing to space limitations, the use of M 12 bolts or studs is impractible, smaller bolts or studs might be permitted.

The bolting selected (property class) shall be adequate for the maximum allowable pressure using the normal tightening procedures. If at some point it is necessary to use fasteners of special quality, interchangeable fasteners for other joints shall be of the same quality.

4.4.7.6 Casing support for high temperatures

For applications of magnetic drive pumps other than of close coupled construction above a working temperature of 350 °C, centreline support of the casing shall be provided.

4.5 Branches, nozzles and miscellaneous connections

4.5.1 Extent

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

4.5.2 Inlet and outlet branches

Inlet and outlet branches shall be flanged and in the case of single-stage centrifugal pumps shall be designed for the same nominal pressure, unless the pump manufacturer/supplier states that this is not so and emphasizes the requirements for pressure relief.

4.5.3 Venting and draining

4.5.3.1 The entire unit, including casing, drive section and manufacturer-supplied piping shall be self-venting or furnished with vent connections.

4.5.3.2 All areas containing pumped liquid, including vendor-supplied piping, shall be drainable.

● The purchaser shall advise when he requires additional flushing connections to allow the unit to be flushed prior to disassembly.

NOTE Connections for venting and draining are normally not drilled.

● The inquiry and/or order should state if connections for venting and draining are required to be drilled.

● For multistage pumps, draining devices should be agreed between the purchaser and manufacturer/supplier.

4.5.4 Pressure gauge connections

The connection of pressure gauges at the inlet and outlet branches shall be possible.

NOTE Pressure gauge connections are normally not drilled.

● The inquiry and/or order should state if pressure gauge connections are required to be drilled.

4.5.5 Closures

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

4.5.6 Auxiliary pipe connections

All auxiliary pipe connections shall be of adequate material, size and thickness for the intended duty.

The inside diameter shall 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.

For connections $\geqslant$ DN 25, flanged connections shall be used and have a rating compatible with the service pressure.

4.5.7 Connection identification

All connections for auxiliary piping 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 for use during installation.

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

● The method given in ISO 5199 shall be used unless another method is agreed between the purchaser and manufacturer/supplier.

The purchaser is responsible for calculating 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 permissible, the solution to the problem shall be agreed between the purchaser and manufacturer/supplier.

4.7 Branch (nozzle) flanges

The flange envelope shall be of a size to enable flanges in accordance with the appropriate part of ISO 7005 to be provided. If the pump manufacturer's/supplier's standard pattern entails a flange thickness greater than that of the rating specified, the heavier flange can 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 the 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 special materials.

● This however requires agreement with the purchaser.

4.8.2 Securing of impellers

Impellers shall be securely fixed against circumferential and axial movement when rotating in the intended direction. Impellers used in CMP units shall also be securely fixed against reverse rotation.

4.9 Wear rings or equivalent components

Where 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 the operating conditions and properties of the materials used (such as hardness and gall resistance) for the parts. Clearance shall be sized in order to avoid galling, erosion or contact between moving parts during normal operation.

4.11 Shafts

4.11.1 General

Shafts shall be of a size and stiffness

a) to transmit the prime mover rated power,

b) to minimize wear and risk of seizure, and

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

4.11.2 Surface roughness

In the case of magnetic drive pumps where lip seals are fitted, the roughness of the drive shaft in the area of the bearing sealing shall be not greater than $Ra = 0{,}8$ µm. Measurement of surface roughness shall be in accordance with ISO 3274.

4.12 Bearings

4.12.1 General

Rolling bearings of standard design shall be used on the power shaft of magnetic drive pumps unless load conditions necessitate a different design.

4.12.2 Rolling bearing life

Rolling bearings shall be selected and rated in accordance with ISO 76 and ISO 281. The “basic rating life (L_{10})” shall be at least 17 500 h when operating within the allowable operating range and based on the largest outer magnet assembly which can be put onto the drive frame.

4.12.3 Bearing temperature

The pump manufacturer/supplier shall specify if cooling or heating is necessary to maintain bearing temperatures within the limits given by the bearing manufacturer. The manufacturer/supplier shall make provisions to allow the fitting of a monitoring device by the purchaser.

4.12.4 Lubrication

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

4.12.5 Bearing housing design for magnetic drive pumps

In order to avoid the loss of lubricant and the mixing of cooling and heating liquid with lubricant, gasketed or threaded connections shall not be used between the cooling jacket and the lubricant.

All openings in the bearing housing shall be designed to prevent the ingress of contaminants (e.g. water spray) and the escape of the lubricant under normal operating conditions. Openings for shafts shall be designed in such a manner that they cannot become a source of ignition in hazardous areas.

In the case of oil lubrication, an oil drain plug shall be provided.

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

When regreasable bearings are used, a method of preventing excess greasing shall be provided.

4.12.6 Sleeve and thrust bearings for the pump shaft

Sleeve bearings supporting the impeller and shaft shall be designed using materials which are suitable for the maximum temperatures they may experience. They shall not give rise to temperatures causing flashing of the lubricating fluid, and shall be secured against turning or sliding. They shall be so dimensioned that all radial and axial forces which occur can be supported.

The magnitude of the axial forces and their direction for Q_{min}, Q_{opt} and Q_{max} shall be provided by the manufacturer/supplier on request.

The volume of liquid flow for removal of the bearing heat shall be adequate. The liquid flow shall be provided in such a manner that no gas bubbles can adhere to the sleeve bearings during operation.

If the containment shell/liner also performs the function of a housing for a liquid lubricated bearing, then its dimensioning shall be adequate for both the static and dynamic loadings. The manufacturer/supplier shall make provisions to allow the fitting of a monitoring device by the purchaser.

4.13 Circulation flow

4.13.1 General

The circulation flow required for heat removal shall be such that the vapour point of the circulating liquid is not exceeded at any point in the circuit, taking due account of local high temperature spots and zones at reduced pressures. The circulation flow shall automatically vent the shell/liner and prevent settlement of gas bubbles. A secondary impeller may be used to create the circulation flow.

● At the request of the purchaser, the calculated circulation flow rate as well as its pressure and temperature characteristics along the circulation path shall be provided.

When conditions of service require a device to clean the bearing lubricating liquid, either internal or external filtration shall be used. If internal filtration is used, it shall be self-cleaning. If external filtration is used, the filter system should allow for indicating when filter change is required. Loss of flow to the drive section shall be avoided and provision shall be made for the fitting of a sensor.

Welded points shall be tested for leakage. The welding and test procedures shall be provided upon request.

4.13.2 Circulation plans

Typical circulation plans are shown in annex E. Based on the application data supplied by the purchaser and design of his equipment, the manufacturer/supplier shall recommend the most suitable circulation plan.

4.13.3 Magnetic drives

● In the case of a metallic containment shell, temperature monitoring of the circulation flow shall be possible but provided only if requested.

Leak monitoring of the space between containment shell and the bearing housing shall be possible.

The design shall be such that in the event of a drive shaft bearing failure, the shell cannot be damaged from the outside.

● If magnets are attached by adhesive to the rotor (driven), information on the type of adhesive used shall be provided by the manufacturer/supplier on request.

4.13.4 Canned motor

When explosion-proof units are required, the manufacturer/supplier and purchaser shall select the approved design which meets the location requirements.

Provision of leakage monitoring in the area between the primary and secondary containment shell shall be possible.

The manufacturer/supplier shall specify external cooling or heating requirements when required. The manufacturer/supplier shall make provisions to allow the fitting of a monitoring device by the purchaser.

• The method of potting/encapsulating the cable feed from the motor to the terminal box shall be agreed for special hazardous liquids.

The type of potting/encapsulating material used shall be provided on request.

4.14 Nameplates

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

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

• Further space should be provided for additional information on rate of flow, pump total head, pump speed, impeller diameter (maximum and installed), rated pressure, hydrostatic test pressure and temperature of the pump, and materials of construction or for other marking as required as, for example, data for the protection against explosion.

4.15 Direction of rotation

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

4.16 Couplings for magnetic drive pumps

Where a magnetic drive pump is coupled to its driver by means of a flexible coupling, this shall be sized to transmit the maximum torque of the intended driver. The speed limitation of the coupling shall correspond to all possible operating speeds of the intended pump driver. The use of flexible metallic membrane couplings is permitted.

Where the magnetic drive pump is intended for use in a hazardous area, the coupling shall be designed so that no metallic contact is possible between the two coupling halves in the event of a failure the flexible element.

• Use of a coupling without a spacer piece shall be subject to agreement.

When a spacer coupling is used, the spacer should be of sufficient length to allow removal of the outer magnetic coupling without disturbing the containment shell/liner.

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

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

The permissible operating radial, axial and angular misalignment shall not exceed the limits given by the coupling manufacturer. The coupling shall be selected so that the starting and operating conditions, such as temperature, torque variations, number of starts, pipe load, etc. and the rigidity of pump and baseplate are taken into account.

• An appropriate coupling guard in accordance with local regulations of the place of installation shall be provided.

• Dynamic balancing shall only be carried out if requested by the purchaser.

NOTE Normally dynamic balancing is carried out to a quality grade G6.3 according to ISO 1940-1.

4.17 Baseplate

4.17.1 General

● The material of the baseplate (e.g. cast iron, steel, concrete) and its kind of installation (grouted or not) shall be agreed between the purchaser and supplier.

The pump manufacturer/supplier has to ensure that permissible forces on flanges in accordance with 4.6 do not cause any failure of the pump or the pump unit (e.g. by changing internal clearances or causing a shaft misalignment).

4.17.2 Non-grouted baseplates

Non-grouted baseplates shall withstand loads described in 4.6 for free-standing installation by bolting on a foundation without grouting.

4.17.3 Grouted baseplates

Baseplates requiring grouting shall be designed to ensure proper grouting (for example, trapping of air shall be prevented).

Where grout holes are necessary, they shall be not less than 100 mm in diameter or an equivalent area and accessible. Grout holes in drained areas shall have raised edges.

4.17.4 Assembly of magnetic drive pump and driver on baseplate

4.17.4.1 Provision shall be made for vertical adjustment of the driver to permit compensation for pump, driver and baseplate tolerances. This fine adjustment shall be made by using spacers or shims. The motor shall be mounted on shims of not less than 3 mm.

4.17.4.2 If the purchaser supplies a driver or coupling, he shall provide the pump manufacturer/supplier with certified installation dimensions of these components.

If the assembly of pump and driver is not carried out by the pump manufacturer/supplier, he shall provide and attach removable spacers for adjustment of the shaft centreline heights if the total requirement for shims and spacers exceeds 25 mm. The driver fixing holes shall not be drilled unless otherwise agreed.

4.17.5 Tools

When special tools and fixtures are required to disassemble, assemble or maintain the unit, they shall be included in the quotation and furnished as part of the initial supply of the machine.

● For multiple-unit installations, the requirements for quantities of special tools and fixtures shall be mutually agreed upon by the purchaser and manufacturer/supplier.

These or similar special tools shall be used during shop assembly and post-test disassembly of the equipment.

4.18 Monitoring

Provision shall be made on request for continuous or intermittent monitoring of the characteristics given in Table 2. The form of monitoring shall be appropriate for purposes described in the designated subclauses. In the case of containment liners used in explosive atmospheres (areas 1 and 2), mandatory characteristics shall be controlled.

Table 2 — Characteristics to be monitored

Characteristic to be monitored	Designated subclause
Vibration	4.3.2
secondary containment/control	4.4, 4.13.3, 4.13.4
bearing temperature	4.12.3
radial gap	4.12.6
filter blockage	4.13.1
circulation flow	4.13.1
containment shell/liner — temperature and leakage	4.13.3
stator winding temperature	4.13.4

5 Materials

5.1 Selection of materials

Materials are normally stated in the data sheet.

● If the materials are selected by the purchaser but the manufacturer/supplier considers other materials to be more suitable, these shall be offered as an alternative by the manufacturer/supplier according to the operating conditions specified on the data sheet and agreed by the purchaser.

● For hazardous liquids, the manufacturer/supplier shall propose suitable materials for agreement by the purchaser.

Non-ductile materials should not be used for 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 the mechanical design.

Annex F gives an informative list of international materials for pump parts.

5.2 Material composition and quality

Chemical composition, mechanical properties, heat treatment and welding procedures shall be in accordance with the relevant material standards.

● When tests and certificates for the above-mentioned properties are required, the procedures shall be agreed between the purchaser and manufacturer/supplier (see clause 6).

5.3 Repairs

Repairs by welding or other procedures shall be specifically related to the relevant material standards. The repair of leaks and defects in pressure castings by plugging, peening, painting or impregnation is prohibited. For explosion-proof motors, the repair shall be carried out in accordance with local regulations.

6 Testing

6.1 General

Any or all of the following tests may be requested by the purchaser and, where requested, they shall be specified in the data sheets (see annex A). Provision of such tests may be subject to extra charges. Such tests may be witnessed or certified. The test reading sheets of witnessed tests are to be signed by the inspector and representative for the manufacturer/supplier. The certificate shall be issued by the manufacturer's/supplier's quality control. Pressure-containing parts shall not be painted except for anti-corrosion primer until testing and inspection are completed.

● Where inspection is specified, the purchaser's inspector shall be granted access to the manufacturer's works at mutually agreed times and shall be given reasonable facilities and data to enable inspection to be carried out satisfactorily.

6.2 Material tests

The following test certifications should be available if requested in the purchase order:

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

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

c) susceptibility to intergranular attack (where applicable);

d) non-destructive tests (leakage, ultrasonic, dye penetrant, magnetic particle, radiographic, spectroscopic identification, etc.).

6.3 Pump test and inspection

6.3.1 Hydrostatic test

6.3.1.1 Wetted-material moisture retention characteristics should be reviewed against the application prior to testing.

6.3.1.2 Pressure-containing parts shall be hydrostatically tested in accordance with EN 12162.

Hydrostatic tests for pressure-containing parts shall be applied at a test pressure of 1,5 times the maximum allowable working pressure. The test should be carried out using clean cold water and the pressure maintained for at least 10 min without visible leakage.

If the seal-less pump is equipped with a secondary containment, a separate hydrostatic test of the secondary containment shall be conducted. The secondary containment may be tested as a separate unit, or it may be tested as an assembly with the primary containment assembly. If there is a risk of residual corrosion then testing by the alternative hermetic integrity shall be considered. If tested as an assembly it may be necessary to first pressurize the primary containment assembly before pressurizing the secondary containment. The secondary containment shall be considered to be a pressure-containing part and the test procedure and acceptance criteria for secondary containment hydrostatic testing are the same as for the pump assembly.

The secondary control collection arrangement shall not be considered to be a pressure-containing part and shall be hydrostatically tested to a gauge pressure of 1 bar applied for 10 min without visible leakage.

6.3.1.3 Hydrostatic tests shall be performed on cooling and heating jackets at a test pressure of 1,5 times the maximum allowable working pressure of the cooling and heating system.

6.3.1.4 Acceptance criteria are as follows:

a) no visible leakage from the assembly occurs;

b) mechanical deformation of the parts under pressure do not interfere with rotation of the pump.

6.3.2 **Hermetic integrity test** (optional)

6.3.2.1 Test parameters

This test is to demonstrate that a seal-less pump assembly does not leak when subjected to internal pressure.

Tests shall be conducted on completely assembled pump units. Disassembly after the test is not permitted. The primary and (if so equipped) the secondary containment and secondary control boundaries shall be tested separately.

The test pressure shall be maintained for a sufficient period of time to permit a complete examination of the parts under pressure. A minimum of 3 min is considered necessary for this examination.

The test fluid shall be an inert dry gas. There shall be no water or other liquid present in the test fluid.

Since a compressible fluid is being used, procedures should conform to local safety requirements. The minimum pressure shall be 1,75 bar for the primary and secondary containments, and 1 bar for the secondary control.

Tests shall be conducted at room temperature.

6.3.2.2 Test procedure

The gas shall be introduced into the primary and secondary containment boundaries. Each area shall be tested separately. The primary boundary shall be pressurized first. Once the primary boundary has been proven, the secondary boundary shall be pressurized. If pressurizing the secondary boundary could damage the primary boundary, it is permissible to pressurize the primary boundary during the test of the secondary boundary. After pressure has stabilized, one of three methods may be used to determine leakage:

a) inert gas sniffer test;

b) pressure drop observation; or

c) external soap bubble test.

6.3.2.3 Acceptance criteria

One of the following acceptance criteria shall be used, depending on the test method selected in 6.3.2.2, i.e. a) for test method a), etc.

a) A leakage of not more than 1×10^{-3} ml/s of gas shall be observed.

b) A pressure drop of not more than 0,4 kPa shall be observed after a period of not less than 10 min, during which time the temperature of the gas shall be shown to have not changed by more than 1 °C, or a measured pressure drop rate of not more than 7×10^{-4} kPa/s.

c) There shall have been no observable leakage for minimum of 10 min.

6.3.3 **Mechanical integrity** (optional)

6.3.3.1 Test parameters

This test is to demonstrate that the pump unit will operate mechanically as designed. It is intended to detect mechanical interferences, bearing defects or motor defects (canned motor pumps only).

The pump unit shall be tested with clear water. The speed of operation shall be that of the installation or higher.

● If a low installation specific gravity prevents full-speed operation, the test conditions shall be agreed.

The pump shall be operated for a minimum of 10 min.

6.3.3.2 Acceptance criteria

The pump shall operate without mechanical interference during the entire test period, or the pump shall be rejected. Interferences shall be identified by unusual noise and by the absence of a smooth gradual reduction in rpm when the unit is shut off. Visible leakage or excessive vibration shall also be cause for rejection.

The temperature rises of ball bearings shall be monitored until they stabilize. The rate of temperature rise shall be within the pump manufacturer's/supplier's standard.

6.3.4 Performance test (optional)

6.3.4.1 Tests in accordance with 6.3.3 and 6.3.4 are normally carried out at the same time.

● **6.3.4.2** Where the true operating conditions such as power and head cannot be reproduced in the test facility, the conversion methods for tests using clean cold water and other test conditions shall be agreed between the purchaser and manufacturer/supplier.

● **6.3.4.3** Hydraulic performance tests shall be in accordance with ISO 9906 unless otherwise agreed. The manufacturer/supplier and the purchaser shall agree whether Grade 1 or Grade 2 shall apply.

● **6.3.4.4** The NPSH test shall be in accordance with ISO 9906 unless otherwise agreed.

● **6.3.4.5** If a noise test is required, the 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.

6.3.4.6 The break-out torque test (optional for magnetic drive pumps) is carried out by locking the pump drive shaft to prevent it rotating and manually applying a torque to the drive input shaft. The break-out torque is the lowest value which will break the magnetic link.

6.3.5 Canned motor test

6.3.5.1 Winding integrity

Motor tests shall consist of resistance measurements of the windings, and of the connections to ground. A dielectric test is also required to determine the integrity of the winding insulation. Tests shall be performed in accordance with the appropriate part of IEC 60034.

6.3.5.2 Winding temperature test (optional)

Thermocouples shall be installed in the windings of each phase. The motor shall be operated at its design duty, pumping a liquid at its maximum permitted temperature, and the winding temperatures shall be monitored until a steady state is achieved. The maximum temperature of the windings shall not exceed the temperature rise stated by IEC 60034 for the insulation class used. For safety purposes, readings shall also be taken on the outside of the motor casing to find the hottest spot and its temperature shall be recorded.

6.3.6 Inspection of components

The following inspection of components may be required:

a) examination of components before assembling;

b) internal examination of the bearings and wear rings after test running;

c) installation dimensions;

d) auxiliaries;

e) information on the nameplate (see 4.14).

6.3.7 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.

7 Preparation for despatch

7.1 Surface protection

Pumps and pump parts shall be drained before despatch.

● All parts made of materials which are not resistant to corrosive attack by the environment shall be treated with an agreed corrosion preventative prior to shipment.

Parts subject to atmospheric corrosion may be protected by the following methods:

— rust removal by shot-blasting, to a degree of surface finish of grade Sa 2½ in accordance with ISO 8501-1;

— prime painting by means of a single or two component zinc-containing paint;

— a covering coat, the quality and colour of which may be chosen by the purchaser;

— a suitable and easily removable corrosion- and damage-protective coating on machined parts, e.g. shaft ends.

Bearings and bearing housings of magnetic drive pumps shall be protected by a preserving oil which is compatible with the lubricant. In the case of oil fill, a label shall be securely attached to the pump warning that the bearing housing has to be filled with oil to the proper level prior to starting.

Information on the preservation agents and their removal shall be securely attached to the pump, together with the need to observe local regulations.

7.2 Securing of rotating parts for transport

When necessary to prevent damage to bearings caused by vibration during transport, the manufacturer/supplier shall secure the rotating parts. When the rotor is locked a warning label shall be attached.

7.3 Openings

All openings to the pressure chamber shall have weather-resistant closures substantial enough to withstand accidental damage. None of these enclosures shall be required to retain pressure (for permanent enclosures see also 4.5.5).

7.4 Pipes and auxiliaries

Piping and auxiliaries shall be protected and secured to prevent damage during shipment and storage.

7.5 Identification

The pump and all loose components supplied with it shall be clearly marked with a prescribed identification number. A tie-on label is acceptable.

● Additional marking of pressure-containing parts shall be provided by request of the purchaser.

8 Information for use

The manufacturer/supplier shall supply operating instructions defining the installation procedures, operating procedures and maintenance requirements and including recommended spare parts.

In the case of magnetic drive pumps, the operating instructions shall contain the following warning notice:

WARNING — Persons working with permanent magnet parts must be made aware that there is a potential danger from magnetic fields, e.g. influence on heart pacemakers, credit cards, computers, computer tape/discs and watches.

NOTE When shipping raw or bare magnet assemblies, especially by air, special precautions may be necessary.

The operating instructions should give information about normal and maximum gaps between rotating and stationary parts.

Annex A
(normative)

Data sheet for magnetic drive pumps and canned motor pumps

The pump and its operating conditions shall be described on a suitable data sheet. The attached example can be used by the purchaser.

If a data sheet is requested or required, the following centrifugal pump data sheet can serve

— 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 but the line numbering in each case shall conform to the standard data sheet.

Instructions for completing the data sheet are as follows:

— the information required is to be indicated with a cross (x) in the appropriate column;

— the lines marked ◤ are to be completed by the purchaser for enquiry;

— the blank columns can be used to indicate additional information required and also for revision marks indicating where information has been inserted or revised;

— to facilitate communication about the information in a particular entry, the following key can be used to identify its line and position of the column:

for 3 columns

		Column 1		Column 2		Column 3	
29	x		x		x		29

Example: Line 29/2

Line No.

Column No.

for 2 columns

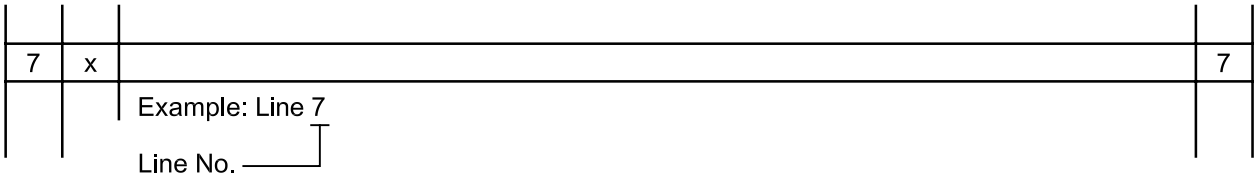
		Column 1		Column 2	
55	x		x		55

Example: Line 55/1

Line No.

Column No.

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: — process pump, — chemical pump (with standard hydraulic), — refrigiant pump, — heat transfer pump, — booster pump, — tank emptying pump, — liquid gas pump, — vaccuum pump, — pump for nuclear application
2/2	Specification class	For example, ISO 5199
3/2	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	Solids 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 of magnetic parts) 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 pressure.
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

Line	Term	Explanation
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, d) circulation flow, and 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
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.
	Lubricant supply	For example, oil pump, grease pump, oil level controller, grease cup, sight glass gauge stick
24/1	Impeller type	Type of impeller, for example, closed, open, channel
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”
50 to 52	Tests	Company or authority which is to carry out the different tests, for example, purchaser and to what standards (51) and name of authority for witnessed test (52)

Centrifugal pumps
Magnetic drive pumps and canned motor pumps
Data sheet

1	Plant				Service			1
2					Specification class			2
		No req.	Pump type and size Horizontal[1)]	Vertical[1)]	Manufacturer serial No.	Driver Kind	Driver Type, Size	Item No.
3	Operation							3
4	Stand by							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	m^3/h	NPSH at	NPSHA		m	8
9	Solid content	% of mass	Flow	normal/max.	m^3/h	rated/normal flow	NPSHR		m	9
10	Corrosion by		Flow	min. required/perm.	m^3/h	Pump speed rated			min^{-1}	10
11	Erosion by		Inlet gauge pressure	rated	bar	Pump power input Pa	rated		kW	11
12	Operating temp. t_A	°C	Inlet gauge pressure	max.	bar	Pump power input Pa	normal		kW	12
13	Density at t_A	kg/dm^3	Outlet gauge pressure	rated	bar	Pa	at rated impeller - ∅		kW	13
14	Kinematic viscosity at t_A	mm^2/s	Outlet gauge pressure	max.	bar	max.	at max. impeller - ∅		kW	14
15	Vapor pressure (abs) at t_A	bar	Diff. pressure rated		bar	Rated driver output			kW	15
16	Hazard		Head rated curve/max.		m	Self priming		yes/no		16
17	Specific heat at t_A	kJ/kg·K	Shut-off head		m	Circulation flow			m^3/h	17
18						Max. Temp. - increase in circ. flow			°C	18

Construction features

19		Basic design pressure	bar	Total clearance	Wear ring/plates	mm	Cooling (C) Heating (H)	C	H	S	P	19
20	Rated pressure	Pump	bar at °C	Total clearance	Shaft bushes	mm	Series (S) Parallel (P)					20
21	Rated pressure	Auxiliaries	bar at °C		Balance drum	mm	Casing					21
22		Test pressure	bar	Thrust reduction by			Bearing					22
23		Number of stages		Radial bearing	Type		Oil cooler					23
24	Impeller ∅	rated/installed	mm	Axial bearing	Size		Canned motor					24
25	Impeller ∅	max./min.	mm	Lubrication/supply			Cooler for circulation					25
26	Impeller	Type										26
27	Rotation facing pump	Pump*)	clockwise/anticlock-wise	Permanent Magnetic Drive	Size		Pedestals					27
28	Rotation facing pump	Driver **)	clockwise/anticlock-wise	Permanent Magnetic Drive	Max. allowable power input at t_A ; n_N	kW	Design pressure	bar				28
29	Inlet flange	DN orientation		Permanent Magnetic Drive	Power losses at n_N	kW	Test pressure	bar				29
30	Inlet flange	PN and facing		Permanent Magnetic Drive	Static torn-off moment at t_A	N·m	External suppliers	Function	Fluid	l/h	°C	M A bar	30
31	Outlet flange	PN and facing		Permanent Magnetic Drive	Wall thickness containment shell	mm	External suppliers					31
32	Outlet flange	DN orientation		Wall thickness stator tube		mm	External suppliers					32
33		Vent, tapped		Clearance gap		mm	External suppliers					33
34		Drain, tapped		Pump content		l	External suppliers	Cooling				34
35		Casing support		Total weight incl. drive		kg	External suppliers	Heating				35
36		Casing split	radial/axial	Volute/Diffuser		single/double/multi	External suppliers	Electricity	V	Phase	Hz	36

Auxiliaries

37	Coupling	Manufacturer		Coupling guard			Driver	supplied by		37
38	Coupling	Type/Size		Baseplate	For	Pump/Driver	Driver	mounted by		38
39	Coupling	Spacer length	mm	Baseplate	Type		Auxiliary piping supplied by			39
40	Coupling	Supplied by		Baseplate	Supplied by		Anchor bolts supplied by			40

	Materials													
41		Casing			Containment shell/Stator tube				Stator casing					41
42		External bolting			Cover of magnet/Can									42
43		Casing gasket			Magnet material									43
44		Impeller			Rotor (driven)			Coupling	Hubs	Spacer				44
45		Wear ring impeller			Plain bearing	Shaft bearing sleeve			Flexible elements					45
46		Wear ring casing				Thrust collar			Guard					46
47		Wearplate/lining				Radial bearing			Baseplate					47
48		Shaft				Bearing sleeve			Paint					48
49		Case bush				Thrust collar sleeve								49
50		Bearing housing adapter			Specification of adhesive									50
51		Bearing housing			Sealing compound (Terminal box)									51

	Tests								
52	◤	Test	Material	Power	NPSH		Inspection	Final inspection	52
53	◤	Reference							53
54		Witnessed by							54

	Documentation								
55		Performance curve	Proposal		Drawings	Installation dimensions			55
56		No.	Test			Piping	Auxiliary systems		56
57		Instruction manual							57
58		Spare part list No.				Assembly	Pump		58
59		Explosion-proof certificate							59

NOTES
1) Strike out if not applicable.
2) All pressures are gauge, except vapour and differential pressure.
◤ Lines so marked are as a minimum to be completed by the purchaser for enquiry
*) Viewed from the drive to the pump
**) Viewed from the pump to the drive

Sheet of	O Rev. Date:	Drawing No.

Annex B
(informative)

External forces and moments on flanges

For external forces and moments on flanges see ISO 5199.

Annex C
(informative)

Enquiry, proposal and purchase order

C.1 Enquiry

The enquiry should include a data sheet with the technical information indicated by ◤

C.2 Proposal

The proposal should include the following technical information:

— completed data sheet, where indicated by “x”;

— preliminary installation drawing;

— typical cross-section drawing;

— characteristic curve.

C.3 Purchase order

The purchase order should include the following technical information:

— completed data sheet;

— required documentation.

Annex D
(informative)

Documentation after purchase order

• The agreed number of copies of the following certified documents should be supplied to the purchaser at the agreed time.

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

Normally the documentation consists of

— data sheet;

— installation drawing;

— information for use, including information for installation, commissioning (preparation for first start up), operation, shut down, maintenance (monitoring, servicing and repair) including cross-section drawings with part list, running tolerances, etc. and, if necessary, special instructions for specific operating conditions;

— electric connection diagrams;

— characteristic curves;

— spare parts list.

The documentation should be clearly identified by

— item number,

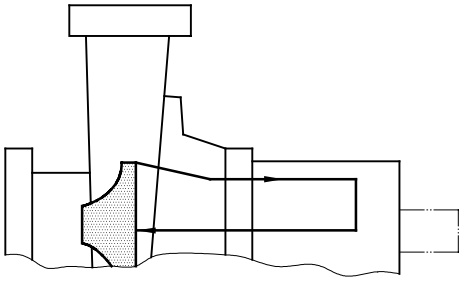
— purchase order number, and

— manufacturer/supplier order number.

Annex E
(informative)

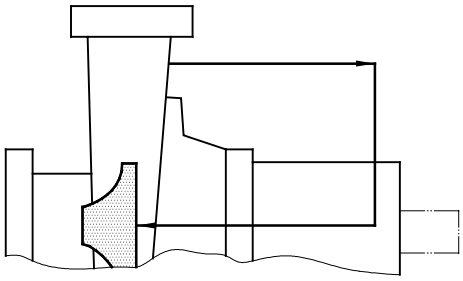
Typical circulation piping plans and characteristics for canned motor pumps and magnetic drive pumps

E.1 Clean liquid — Non-volatile — Moderate temperature



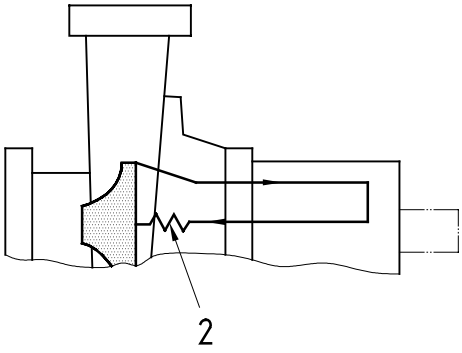
Plan 101

Internal circulation through drive section to suction.



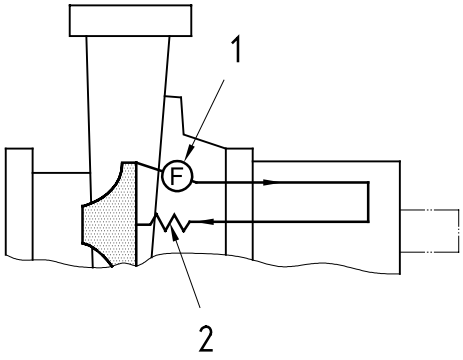
Plan 111

Recirculation from discharge filter through drive section to suction.



Plan 114

Internal recirculation from discharge through drive section and internal restriction to suction.



Plan 115

Internal recirculation through centrifugal or mechanical filter through drive section through internal restriction to suction.

Key

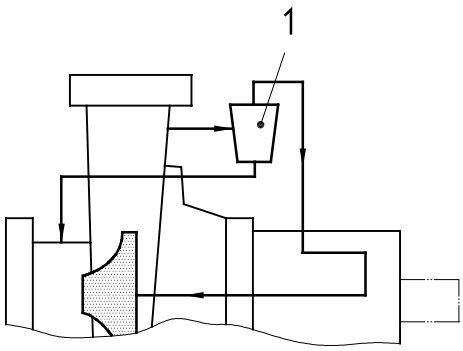
1 Filter
2 Internal flow resistor

NOTE 1 Plan numbers used are similar to those in API 610.

NOTE 2 Plan numbers are grouped in this text by type of application.

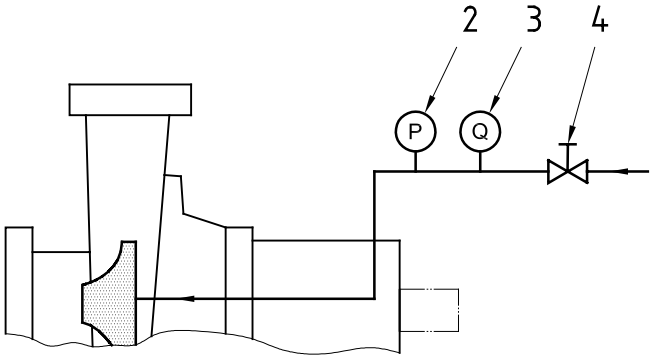
Figure E.1 — Typical circulation piping plans for canned motor and magnetic drive pumps

E.2 Dirty liquid



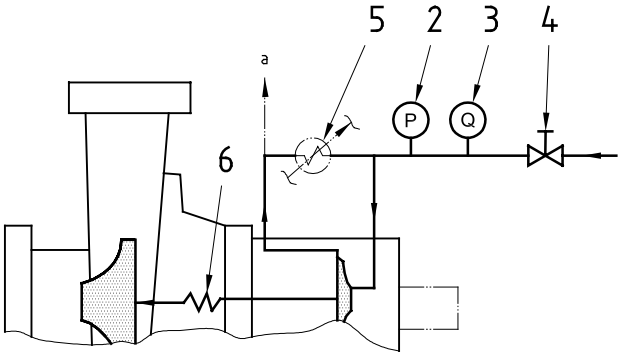
Plan 131

a) Recirculation through external or internal centrifugal separator through drive section to suction.
b) Non-volatile process liquid.
c) Moderate temperature.



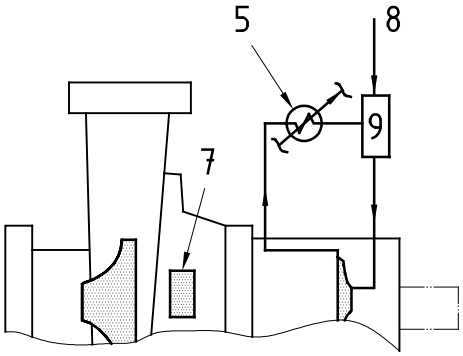
Plan 132

a) Full flush with external clean non-volatile liquid.
b) Drive heat removed by flush liquid.
c) Non-volatile flush liquid.
d) Moderate or high temperature.
e) May inject at intermediate pressure behind pump impeller as an option.



Plan 133

a) Back flush at reduced flow rate into process.
b) Supply of clean external liquid required.
c) Back flush limited by internal restriction.
d) Moderate or high temperature.
e) Optional full flush flow to external point for cooling instead of recirculation through heat exchanger.



Plan 153

a) Pressurized external fluid reservoir.
b) Shaft seal between drive section and pump end.
c) Minimum leakage of external flush liquid past seal into process.
d) Moderate or high temperature.
e) Volatile or non-volatile process liquid.

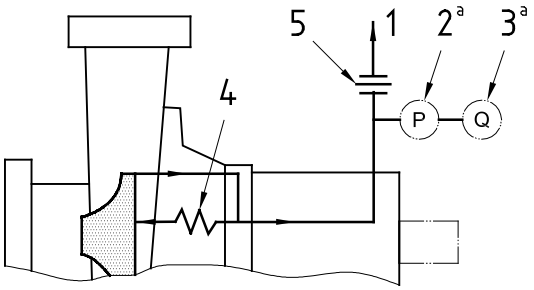
Key

1	Centrifugal separator	4	Valve	7	Seal
2	Pressure gauge	5	Heat exchanger	8	Pressure source
3	Flow indicator	6	Internal flow resistor	9	Reservoir

[a] Optional

Figure E.2 — Typical circulation piping plans for canned motor and magnetic drive pumps

E.3 Clean liquid — Volatile — Moderate temperature



Plan 113

a) Reverse circulation through drive section to suction vessel.

b) Drive heat not returned to suction.

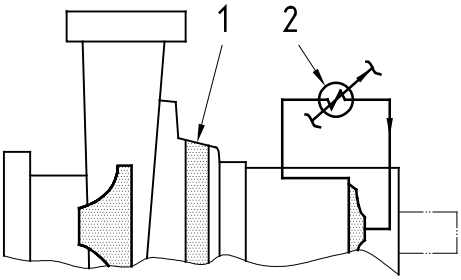
Key

1 Suction vessel
2 Pressure gauge
3 Flow indicator
4 Internal flow resistor
5 Orifice or internal restriction

[a] When specified

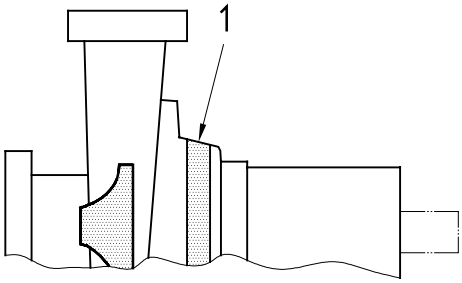
Figure E.3 — Typical circulation piping plans for canned motor and magnetic drive pumps

E.4 Clean liquid — High temperature — Non-volatile



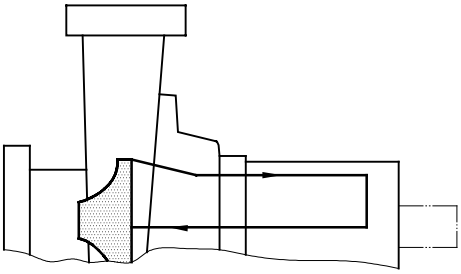
Plan 123

a) Recirculation from drive section through heat exchanger with auxiliary impeller.
b) Heat barrier between pump and drive.



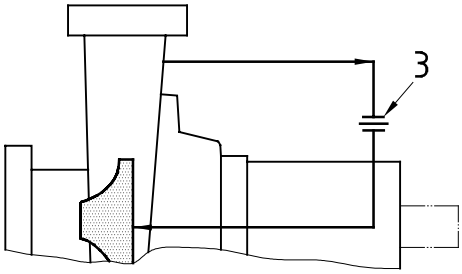
Plan 102

a) Dead-ended drive section.
b) Drive heat to atmosphere.
c) Primarily for MDP.



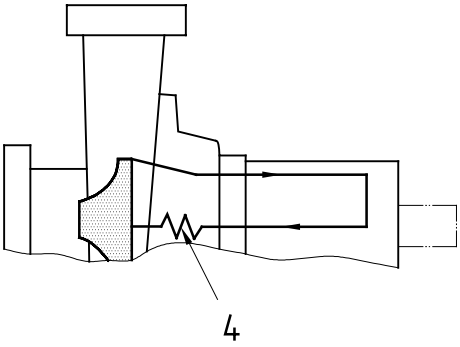
Plan 101

a) High temperature drive materials.
b) Cooling (at high temperature) by internal recirculation through drive section.



Plan 111

a) High temperature drive materials.
b) Recirculation from discharge through orifice to drive section to suction.



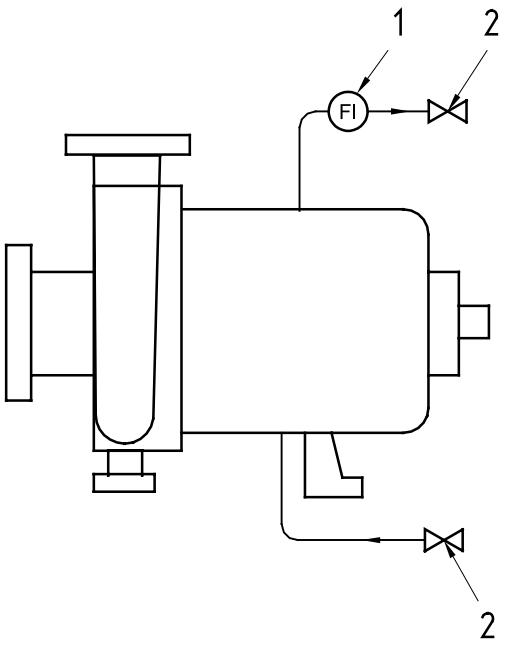
Plan 114

a) High temperature drive materials.
b) Cooling (at high temperature) by internal recirculation through drive section and internal restriction to suction.

Key

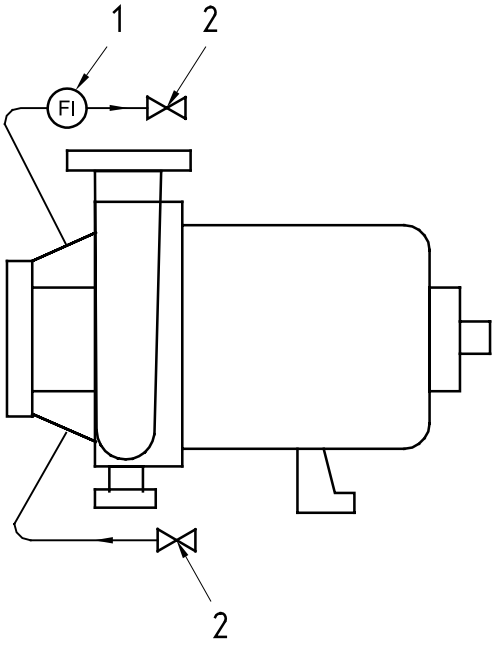
1 Heat barrier
2 Heat exchanger
3 Orifice or internal restriction
4 Internal flow resistor

Figure E.4 — Typical circulation piping plans for canned motor and magnetic drive pumps



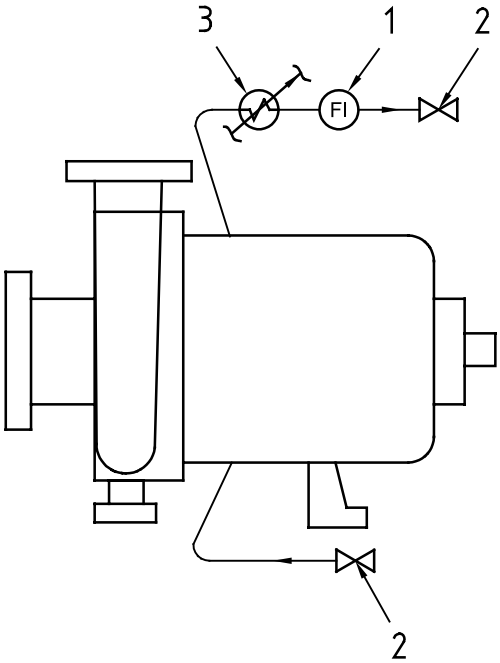
Plan A

Cooling or heating to drive section



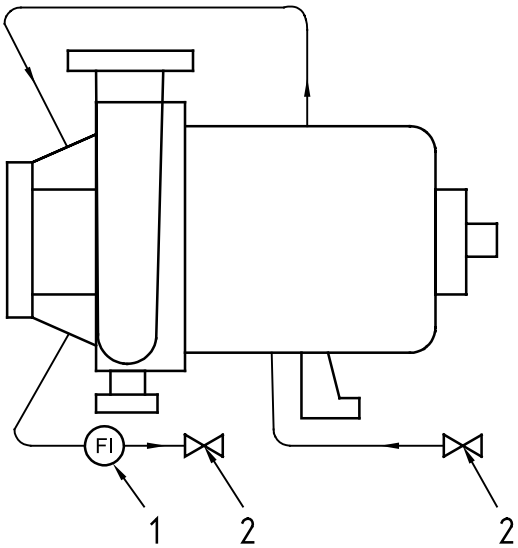
Plan M

Cooling or heating to casing jacket



Plan P

Cooling or heating to heat exchanger



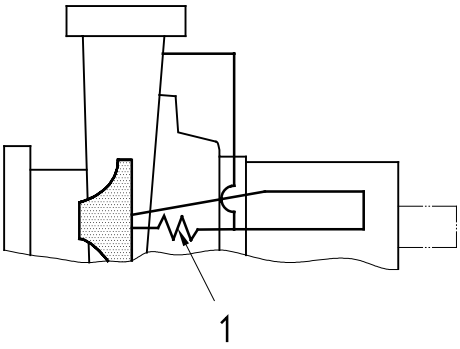
Plan N

Cooling or heating to drive section and casing jacket

Key

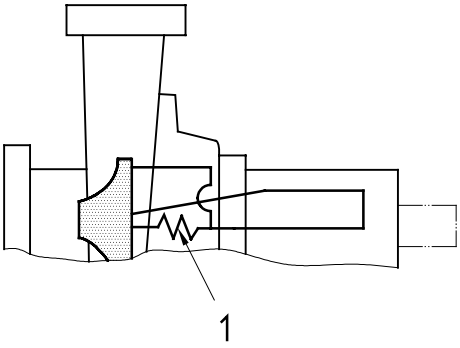
1 Flow indicator (only when specified)
2 Block valve
3 Heat exchanger

Figure E.5 — Typical circulation piping plans for canned motor and magnetic drive pumps



Plan

External circulation to intermediate pressure from discharge through drive section and return to intermediate pressure region only



Plan

External circulation to intermediate pressure from behind the impeller through drive section and return to intermediate pressure region only

NOTE All plans can also have some form of filtration.

Key

1 Orifice or internal restriction

Figure E.6 — Typical circulation piping plans for canned motor and magnetic drive pumps

Annex F
(informative)

Internationally accepted materials for pump parts

Table F.1 offers equivalent national specifications for a range of metallic material types. It is provided as an aid to manufacturers/suppliers and to purchasers who have to specify materials for pumps conforming to this International Standard.

The material specifications listed are intended to be a guide only. Those using references taken from this table should confirm the suitability of the material for a particular application by consulting the full chemical make-up of the material and its heat treatment.

Inclusion of a material reference does not imply a recommendation for its use, nor does absence of a material imply that it is unsuitable. This is particularly the case for non-metallic materials, none of which are included in this table.

Table F.1 is not exhaustive and many materials which may be appropriate for particular chemical applications are not included.

Table F.1 — Internationally and nationally accepted materials for pump parts

Material Class	Applications	International (ISO)	France (AFNOR)	Germany (DIN)		Japan	UK	USA	
				17007	17006	(JIS)	(BSI)	(ASTM)	(UNS)
Cast iron	Pressure castings	185/Gr. 250		0.6025	GG-25	G 5501, Gr. FC 300	1452 Gr. 220	A 278 Class 30	F 12 401
	General castings	185/Gr. 300	FLG 250/300	0.6030	GG-30	G 5501, Gr. FC 250/300	1452 Gr. 220	A 48 Class 25/30	F 11 701/ F 12 101
Carbon steel	Pressure castings		A480 CP-M	1.0619	GS-C 25	G 5151, CI SCPH 2	1504 161 Gr. 480	A 216 Gr. WCB	J 03 002
	Wrought/Forgings	683-18-C25	AC 48 CP	1.0402	C 22	G 3202, CI SFVC 2A	1503 221 490	A 266 Class 2	K 03 506
	Bar Stock: Press.	683-18-C25	AC 48 CP	1.0402	C 22	G 4051, CI S25C		A 695 Gr. B40	G 10 200
	General	683-18-C45e	Z10 C13	1.0503	C 45	G 4051, CI S45C	970 080 1450	A 576 Gr. 1045	G 10 450
	Bolts and studs	2604-2-F31	42 Cr Mo 4	1.7258	24 Cr Mo 5	G 4107, Class 2, SNB7	1506 630 790	A 193 Gr. B7	G 41 400
	Nuts	683-1-C35e	2C35	1.1181	CK 35	G 4051, CI S45C	1506 162	A 194 Gr. 2H	K 04 002
	Plate		P295 GH	1.0254	St. 37.0	G 3106, Gr. SM400B	10028 265 10028 295	A 516 Gr. 65/70	K 02 403 K 02 700
	Pipe		TU 42C	1.0305	St. 35.8	G 3456, Gr. STPT 370/410	1501 161 430	A 106 Gr. B	K 03 006
	Fittings		AF 48N	1.0308	St.35.0	G 4051, CI S25C	1503 221 490	A 105	K 03 504
AISI 4140 steel	Bar stock	683-2-3	42 Cr Mo 4	1.7225	42 Cr Mo 4	G 4105, CI SCM 440	970 708 M 40	A 434 Class BB	G 41 400
	Bolts and studs		42 CVD 4	1.7711	40 Cr Mo V 4 7	G 4107, Class 3, SNB16	1506 630 790	A 193 Gr. B7	G 41 400
	Nuts	2604-2-F31	45 D2	1.7258	24 Cr Mo 5	G 4051, CI S45C	1506 162	A 194 Gr. 2H	K 04 002
12 % Chrome steel	Pressure castings		Z 12 C 13-M	1.4008	G-X 8 Cr Ni 13	G 5121, CI SCS 1	1504 420 C29	A 217 Gr. CA 15	J 91 150
			Z 6 CN 1304-M	1.4313	G-X 5 Cr Ni 13 4	G 5121, CI SCS 6	1504 425 C11	A 487 Gr. CA6 NM	J 91 540
	Wrought/forgings	683-13-3	Z 10 C 13	1.4006	X 10 Cr 13	G 3214, CI SUS F6 B	1503 410 S21	A 182 Gr.F6a Class1	S 41 000
	Pressure		Z 6CN 13-D4	1.4313	X 4 Cr Ni 13 4	G 3214, CI SUS F6 NM		A 182 Gr. F6 NM	S 41 500
	Wrought/forgings General	683-13-3	Z 6CN 13-D4	1.4313	X 4 Cr Ni 13 4	G 3214, CI SUS F6 NM	970 410 S21	A 473 Type 410	S 41 000
	Bar stock: Press.	683-13-4	Z 10 C 13	1.4006	X 10 Cr 13	G 4303, Gr. SUS 410	1503 420 C29	A 479 Type 410	S 41 000
	Bar stock: Gen.							A 276 Type 410	S 41 400
	Bar stock/forg.: Wear Parts[a]	683-13-4	Z 20 C 13	1.4021	X 20 Cr 13	G 4303, Gr. SUS 403 or 420	970 420 S37	A 276 Type 420 A 473 Type 416	S 42 000
	Bolts and studs		Z 13 C 13	1.4923	X 22 Cr Mo V 12 1	G 4303, Gr. SUS 403 or 420	1506 410 S21 760	A 193 Gr. B6	S 41 000
	Nuts		Z 13 C 13	1.4923	X 22 Cr Mo V 12 1	G 4303, Gr. SUS 403 or 420	1506 410 S21 760	A 194 Gr. 6	S 41 000
	Plate	683-13-3	Z 13 C 13	1.4006	X 10 Cr 13	G 4304/4305, Gr. SUS 410	970 410 S21	A 240 Type 410	S 41 000

Table F.1 (*continued*)

Material Class	Applications	International (ISO)	France (AFNOR)	Germany (DIN)		Japan	UK	USA	
				17007	17006	(JIS)	(BSI)	(ASTM)	(UNS)
Austenitic Stainless steel	Pressure castings	683-13-10	Z2 CN 18-10M	1.4306	G-X 2 Cr Ni N 18 9	G 5121, Cl SCS 13A	1504-304-C12	A 351 Gr. CF3 A 743 Gr. CF3	J 92 500
		683-13-19	Z3 CND 18-12	1.4404	G-X 2 Cr Ni Mo N 18 10	G 5121, Cl SCS 14A	1504-316-C12	A 351 Gr. CF3M A 744 Gr. CF3M	J 92 800
	Wrought/forgings	683-13-10	Z 3 CN 18-10	1.4306	X 2 Cr Ni 19 11	G 3214, Gr. SUS F 304 L	1503 304 S11	A 182 Gr. F 304L	S 30 403
		683-13-19	Z 3 CND 17-12-02	1.4404	X 2 Cr Ni Mo 17 13 2	G 3214, Gr. SUS F 316 L	1503 316 S11	A 182 Gr. F 316L	S 31 603
	Bar stock	683-13-10 683-13-19	Z 3 CN 18-10 Z 3 CND 17-12-02	1.4306 1.4404	X 2 Cr Ni 19 11 X 2 Cr Ni Mo 17 13 2	G 4303, Gr. SUS F 304 L G 4303, Gr. SUS F 316 L	970 304 S11 970 316 S11	A 479 Type 304 L A 479 Type 316 L	S 30 403 S 31 603
			Z 3 CN 18-10 Z 3 CND 17-12-02	 1.3974	 X3GCrNiMnMoNNb			A 479 Type XM19	S 20 910
	Plate	683-13-10 683-13-19	Z 3 CN 18-10 Z 3 CND 17-12-02	1.4306/ 1.4404	X 2 Cr Ni 19 11 X 2 Cr Ni Mo 17 13 2	G 4304/5, Gr. 304L/316L	970 304 S11 970 316 S11	A 240 Gr. 304 L/316L	S 30 403 S 31 603
	Pipe	683-13-10 683-13-19	TU22 CN 18-10 TU22 CND 17-12-02	1.4306/ 1.4404	X 2 Cr Ni 19 11 X 2 Cr Ni Mo 17 13 2	G 3459, Gr. 304LTP/316LTP	3605 304 S11 3605 316 S11	A 312 Type 304L/ 316L	S 30 403 S 31 603
	Fittings	683-13-10 683-13-19	Z 3 CN 18-10 Z 3 CND 17-12-02	1.4306/ 1.4404	X 2 Cr Ni 19 11 X 2 Cr Ni Mo 17 13 2	G 3214, Gr. SUS 304L/316L	1503 304 S11 1503 316 S11	A 182 Gr. F304L/ 316L	S 30 403 S 31 603
	Bolts and studs	683-1-21	Z 6 CN DT 17.12	1.4571	X 6 Cr Ni Mo Ti 17 12 2	G 4303, Gr. SUS 316	1506 316 S31	A 193 Gr. B 8 M	S 31 600
	Nuts	683-1-21	Z 6 CN DT 17.12	1.4571	X 6 Cr Ni Mo Ti 17 12 2	G 4303, Gr. SUS 316	1506 316 S31	A 193 Gr. B 8 M	S 31 600
DUPLEX Stainless steel	Pressure castings		Z 6 CND26-5-02M	1.4468	G-X 3 Cr Ni Mo N 26 6 3	G 5121, Cl SCS 11		A 890 Gr. 3A	J 93 3371
			Z 3 CNDU 26-05M	1.4517	G-X3Cr Ni Mo Cu N26 6 3 3			A 351 Gr. CD4 MCu	J 93 370
	Wrought/forgings		Z 3 CND 22-05 AZ	1.4462	X 2 Cr Ni Mo N 22 5	G 4319, Cl SUS 329	1503 318 S13	A 182 Gr. F 51	S 31 803
	Bar stock		Z 3 CND 22-05 AZ	1.4462	X 2 Cr Ni Mo N 22 5	G 4303, Gr. SUS 329		A 276-S31803	S 31 803
	Plate		Z 3 CND 22-05 AZ	1.4462	X 2 Cr Ni Mo N 22 5	G 4303, Gr. SUS 329		A 240-S31803	S 31 803
	Pipe		Z 3 CND 22-05 AZ	1.4462	X 2 Cr Ni Mo N 22 5	G 3459, Gr. SUS 329		A 790-S31803	S 31 803
	Fittings		Z 3 CND 22-05 AZ	1.4462	X 2 Cr Ni Mo N 22 5		1503-318-S13	A 182 Gr. F 51	S 31 803
	Bolts and studs		Z 3 CND 22-05 AZ	1.4462	X 2 Cr Ni Mo N 22 5	G 4303, Gr. SUS 329		A 276-S31803	S 31 803
	Nuts		Z 3 CND 22-05 AZ	1.4462	X 2 Cr Ni Mo N 22 5	G 4303, Gr. SUS 329		A 276-S31803	S 31 803

[a] Not suitable for shafts.

Annex G
(informative)

Checklist

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

Paragraph	Decision to be made or agreement to be reached
Design	
4.1.2	NPSHR test and test liquid
4.1.3	Local regulations or extraordinary ambient conditions
4.2.2	Testing and cleaning if density is below 1 000 kg/dm^3
4.2.3	Special arrangements for flushing and/or heating
4.3.1	Critical speed
4.4.5	Corrosion allowance
4.5.3.2	Additional flushing connections Drilling venting and draining connections
	Draining devices for multistage pumps
4.5.4	Drilling of pressure gauge connections
4.5.6	Type of auxiliary pipe connections
4.6	External forces and moments on flanges Loads (if higher than permissible)
4.8.1	Special impeller design
4.13.4	Method of potting/encapsulating the cable feed through for special hazardous liquids
4.14	Further space on nameplates
4.16	Use of a coupling without a spacer piece
	Dynamic balancing
4.17.1	Material and kind of installation of baseplate
4.17.5	Quantities of special tools and fixtures
Materials	
5.1	Selection of materials
5.2	Material composition and quality for tests and certificates

Tests

6.1	Timing to execute tests
6.3.2.1	Test parameters
6.3.4.2	Conversion methods for other liquids and operating conditions
6.3.4.3	Grade of hydraulic performance tests
6.3.4.4	NPSH test
6.3.4.5	Noise test

Preparation for despatch

7.1	Corrosion preventative for non-corrosion-resistant parts
7.5	Additional marking

Annexes

D	Documents: number of copies and special style for documentation

Bibliography

[1] ISO 1940-1, *Mechanical vibration — Balance quality requirements of rigid rotors — Part 1: Determination and verification of balance tolerances*

[2] ISO 7919-1, *Mechanical vibration of non-reciprocating machines — Measurements on rotating shafts and evaluation criteria — Part 1: General guidelines*

[3] ISO 7919-3, *Mechanical vibration of non-reciprocating machines — Measurements on rotating shafts and evaluation criteria — Part 3: Coupled industrial machines*

[4] ISO 8501-1, *Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness — Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings*

[5] ISO 10816-3, *Mechanical vibration — Evaluation of machine vibration by measurements on non-rotating parts — Part 3: Industrial machines with nominal power above 15 kW and nominal speeds between 120 r/min and 15 000 r/min when measured in situ*

[6] EN 12723, *Liquid pumps — General terms for pumps and installations — Definitions, quantities, letter symbols and units*

[7] API 610, *Centrifugal pumps for petroleum, heavy duty chemical, and gas industry services*

ICS 23.080

Price based on 44 pages