INTERNATIONAL STANDARD

ISO 16330

First edition
2003-05-01

Reciprocating positive displacement pumps and pump units — Technical requirements

Pompes volumétriques à mouvement alternatif — Prescriptions techniques

Reference number
ISO 16330:2003(E)

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Published in Switzerland

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 2.

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 document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 16330 was prepared by the European Committee for Standardization (CEN) in collaboration with Technical Committee ISO/TC 115, *Pumps*, Subcommittee SC 1, *Dimensions and technical specifications of pumps*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

Throughout the text of this document, read "...this European Standard..." to mean "...this International Standard...".

Contents

Foreword

The document (EN ISO 16330:2003) has been prepared by Technical Committee CEN/TC 197 "Pumps", the secretariat of which is held by AFNOR, in collaboration with Technical Committee ISO/TC 115 "Pumps".

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of an identical text or by endorsement, at the latest by November 2003, and conflicting national standards shall be withdrawn at the latest by November 2003.

The annexes A, C and D are informative. Annex B is normative.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

This European Standard is applicable to both direct-acting and power pump types. It is applicable to series production pumps or pump units, limited production pumps or pump units and custom production pumps and pump units. It specifies all the technical requirements for reciprocating positive displacement pumps and reciprocating positive displacement pump units with the exception of safety and testing. Safety and testing of positive displacement pumps and reciprocating positive displacement pump units are specified in the following European Standards:

EN 809 *Pumps and pump units - Common safety requirements*.

EN 12162 *Liquid pumps - Procedure for hydrostatic testing*.

EN 12639 *Liquid pumps and pump units- Noise test code - Grades 2 and 3 of accuracy*.

prEN 14343 *Positive displacement pumps - Performance tests for acceptance*.

Users of this European Standard should be aware that further or differing requirements may be needed for individual applications. This European Standard is not intended to inhibit a supplier from offering, or the purchaser from accepting, alternative equipment or engineering solutions for the individual application. This may be particularly applicable where there is innovative or developing technology. Where an alternative is offered, the supplier should identify any variations from this European Standard and provide details.

1 Scope

This European Standard specifies the technical requirements, other than safety and testing, for reciprocating positive displacement pumps and pump units. This standard applies to pumps which utilise reciprocating motion derived from crankshafts and camshafts and also direct-acting fluid driven pumps.

This European Standard does not apply to reciprocating positive displacement pumps, not pumping water, where the whole pump is lubricated with the liquid being pumped.

2 Normative references

This European Standard incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 287-1	*Approval testing of welders - Fusion welding - Part 1: Steels (equivalent to ISO 9606-1)*.
EN 287-2	*Approval testing of welders - Fusion welding - Part 2: Aluminium and aluminium alloys (equivalent to ISO 9606-2)*.
EN 288-1	*Specification and qualification of welding procedures for metallic materials - Part 1: General rules for fusion welding (equivalent to ISO 9956-1)*.
EN 288-2	*Specification and approval of welding procedures for metallic materials - Part 2: Welding procedure specification for arc welding (equivalent to ISO 9956-2)*.
EN 288-3	*Specification and approval of welding procedures for metallic materials - Part 3: Welding procedure tests for the arc welding of steels (equivalent to ISO 9956-3)*.
EN 288-4	*Specification and approval of welding procedures for metallic materials - Part 4: Welding procedure tests for the arc welding of aluminium and its alloys (equivalent to ISO 9956-4)*.
EN 809	*Pumps and pump units for liquids - Common safety requirements*.
prEN 10226-1	*Pipe threads where pressure tight joints are made on the threads – Part 1: Taper external threads and parallel internal threads - Dimensions, tolerances and designation*.
EN 12639	*Liquid pumps and pump units - Noise test code - Grade 2 and grade 3 of accuracy*.
EN 12723:2000	*Liquid pumps - General terms for pumps and installations - Definitions, quantities, letter symbols and units*.
EN 20898-2	*Mechanical properties of fasteners - Part 2: Nuts with specified proof load values - Coarse thread (ISO 898-2:1992)*.
prEN ISO 228-1	*Pipe threads where pressure-tight joints are not made on the threads - Part 1: Dimensions, tolerances and designation (ISO 228-1:2000)*.

EN ISO 898-1	*Mechanical properties of fasteners made of carbon steel and alloy steel - Part 1: Bolts, screws and studs (ISO 898-1:1999)*.
EN ISO 9934-1	*Non-destructive testing - Magnetic particle testing - Part 1: General principles (ISO 9934-1:2001)*.
ISO 14	*Straight-sided splines for cylindrical shafts with internal centering - Dimensions, tolerances and verification*.
ISO 1027	*Radiographic image quality indicators for non-destructive testing - Principles and identification*.
ISO 2491	*Thin parallel keys and their corresponding keyways (Dimensions in millimetres)*.
ISO 2492	*Thin taper keys with or without gib head and their corresponding keyways (Dimensions in millimetres)*.
ISO 3117	*Tangential keys and keyways*.
ISO 3453	*Non-destructive testing - Liquid penetrant inspection - Means of verification*.
ISO 3912	*Woodruff keys and keyways*.
ISO 4156	*Straight cylindrical involute splines - Metric module, side fit - Generalities, dimensions and inspection*.
ISO 6149-1	*Connections for fluid power and general use - Ports and stud ends with ISO 261 threads and O-ring sealing - Part 1: Ports with O-ring seal in truncated housing*.
ISO 6149-2	*Connections for fluid power and general use - Ports and stud ends with ISO 261 threads and O-ring sealing - Part 2: Heavy duty (S series) stud ends - Dimensions, design, test methods and requirements*.
ISO 6149-3	*Connections for fluid power and general use - Ports and stud ends with ISO 261 threads and O-ring sealing - Part 3: Light duty (L series) stud ends - Dimensions, design, test methods and requirements*.
ISO 6162-1:2002	Hydraulic fluid power – Flange connectors with split or one-piece flange clamps and metric or inch screws – Part 1: Flange connectors for use at pressures of 3,5 Mpa (35 bar) to 35 Mpa (350 bar), DN 13 to DN 127.
ISO 6162-2:2002	Hydraulic fluid power – Flange connectors with split or one-piece flange clamps and metric or inch screws – Part 2 Flange connectors for use at pressures of 35 Mpa (350 bar) to 40 Mpa (400 bar), DN 13 to DN 51.
ISO 6164	*Hydraulic fluid power -- Four-screw, one-piece square-flange connections for use at pressures of 25 MPa and 40 MPa (250 bar and 400 bar)*
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 10375	*Non-destructive testing - Ultrasonic inspection - Characterization of search unit and sound field*.

ISO/TR 13593 *Enclosed gear drives for industrial applications*.

3 Terms and definitions

For the purposes of this European Standard, the terms and definitions given in EN 12723:2000 and the following apply:

3.1
ancillaries
individual components that are mounted on the pump or pump unit including accessories such as pulsation suppression devices. Auxiliary components not used in the primary operation of the pump or pump unit are not included

3.2
auxiliaries
individual components that provide an emergency service to cover breakdown of the primary service, such as an auxiliary generator

3.3
custom production
pumps or pump units that are made specifically to meet a purchaser's requirements. A custom production pump unit may contain a series or limited production pump or components. Overall documentation will be unique to the pump or pump unit

3.4
limited production
pumps or pump units that are made to an established design, in production quantities of less than 10 per batch. A limited production pump unit can contain a series production pump or components

3.5
reciprocating positive displacement power pump
a machine in which liquid is trapped in confined volumes and transported from an inlet connection to an outlet connection by the reciprocating movement of pistons or plungers. The reciprocating motion being derived from a rotating shaft

NOTE According to EN 809, pumps are defined as being terminated by their inlet and outlet connections as well as, in general, by their shaft ends without couplings.

3.6
reciprocating positive displacement direct-acting pump
a machine in which liquid is trapped in confined volumes and transported from an inlet connection to an outlet connection by the reciprocating movement of pistons or plungers. The reciprocating motion being provided by a fluid powered piston

3.7
reciprocating positive displacement pump unit
an assembly of a pump and its driver, with necessary transmission and structural supporting elements terminating at the inlet and outlet connections and at the energy supply to the driver.

An assembly of a direct-acting pump with ancillaries and structural supporting elements terminating at the pump inlet and outlet connections and at the motive fluid inlet and outlet connections on the motive cylinder.

A pump unit can include ancillary equipment, such as relief valves or pulsation suppression devices, when furnished by the supplier and mounted on the pump or pump unit

3.8
series production
pumps or pump units that are regularly made to the same specification and in production batches of not less than 10 at a time. They can be selected and purchased from standard specification sheets supplied by the supplier. In agreement between the purchaser and supplier a series production pump can be used as a custom production pump for a specification not covered in the standard specification sheet

NOTE When the purchaser is familiar with the supplier's limited production or series production pump or pump units he can make his own selection from the specification sheet. Data in the specification sheet should be such that it can be validated on the supplier's test facilities. Water is the test liquid unless otherwise shown on the specification sheet.

4 Information and requirements to be confirmed, agreed and documented

4.1 Purchaser information

When the supplier is required to make the pump selection, the purchaser shall provide the supplier with the information necessary for the proper selection of a pump or pump unit. To facilitate this the data sheet included as annex A may be used. The selection shall consider all received and relevant information on performance requirements, environment and intended operating conditions. When the supplier is required to make the pump selection and considers that information necessary for the pump selection is missing he shall request this from the purchaser. However it is the purchaser's responsibility to notify the supplier of all relevant details that may affect pump performance and longevity.

4.2 Optional items

The purchaser's information shall include the specification of options and items for special agreement according to this standard and, where applicable, requests for deviations from this standard. Clauses of this standard referring to options and items for special agreement are listed in annex B

4.3 Supplier's Information

The supplier shall provide a general arrangement drawing giving at least the following information:

- -overall dimensions;
- -mounting dimensions;
- -shaft dimensions;
- -inlet connection dimensions;
- -outlet connection dimensions.

The supplier shall also provide a specification sheet, that allows details of the flow rate and pressure that can be simultaneously obtained at a particular shaft rotational speed together with the power absorbed to determine, by interpolation, that the purchaser's requirements can be met.

5 Fitness for purpose

The design and selection of the pump and pump components shall be compatible with the liquid, motive fluid when appropriate, environment and operating conditions supplied by the purchaser in accordance with 4.1

6 Pump design

6.1 Environmental conditions

Reciprocating positive displacement pumps and pump units shall be capable of operating under the following nominal conditions:

- minimum air temperature 2 °C;
- maximum air temperature 40 °C;
- maximum relative humidity 80 %.

If environmental or operating conditions (see also annex C), such as those listed below, have been specified by the purchaser at the time of enquiry, the pump shall be capable of meeting these requirements subject to agreement between purchaser and supplier:

- ambient temperatures or humidity deviating from the above values;
- exposure to direct sunlight;
- atmospheric pollution including airborne solids;
- biological attack;
- wetting by directed water;
- cleaning by hot water, steam or chemicals;
- external shock or vibration; mechanical or seismic;
- lack of ventilation;
- flooding;
- extended periods of shut-down or storage;
- working out of the horizontal plane;
- marine environment.

6.2 Basic design criteria

6.2.1 Pumps shall be capable of operating either continuously or intermittently with each appropriate set of parameters supplied by the purchaser in accordance with 4.1.

6.2.2 Consideration shall be given during design or selection to the handling of components and assemblies when installing, assembling and maintaining the pump or pump unit. Facilities shall be provided, where necessary, for jacking bolts, extraction screws, locating dowels, spigots and lifting eyes.

6.2.3 Designs shall conform to the safety requirements of EN 809.

6.2.4 A direct-acting pump shall be capable of performing at rated conditions with all the specified motive fluid conditions.

6.2.5 The motive power cylinder and valves for direct-acting pumps shall incorporate an over-speed limiting device to protect the pump in the event of loss of output pressure.

6.3 Design of structural and pressure containing parts

The design of the pump and pump unit components shall be suitable for the operating conditions (see also annex C) and for the environment specified by the purchaser. The combined action of normal stressing and predicted corrosion shall not result in component failures due to fatigue during the expected life and at the rated conditions as specified by the supplier.

6.4 Sealing systems

The following components shall be fitted with a suitable seal:

- rotating shafts extending beyond the pump crankcase;
- reciprocating crosshead extensions extending beyond the pump crankcase;
- reciprocating plungers extending beyond the stuffing box;
- reciprocating piston rods extending beyond the stuffing box;
- reciprocating pistons within cylinders.

The seal shall be selected and installed according to the seal manufacturer's recommendations for the operating conditions.

6.5 Bearing lubrication

6.5.1 If grease lubricated bearings require re-lubrication during the service life of the pump, suitable means for re-lubrication shall be provided. Full details shall be provided in the maintenance manual.

6.5.2 Lubricated bearings which are not lubricated by the process water shall have an oil reservoir with a visual oil level indicator. Adding or draining oil shall be accomplished without disassembly other than drain plugs or filler caps. Full details shall be provided in the maintenance manual.

NOTE Constant level oilers may be used providing the working oil level is clearly marked on the bearing housing.

6.6 Shafts

The shaft dimensions shall be such that the power of the driver can be absorbed in accordance with the appropriate clauses 6.6.1 to 6.6.6.

6.6.1 Shafts with rectangular or square parallel keys shall conform to ISO 2491.

6.6.2 Shafts with tapered keys shall comply with ISO 2492.

6.6.3 Shafts with parallel or tapered ends for couplings shall have threaded centre bores or other means shall be provided to ensure proper coupling assembly.

6.6.4 Shafts with tangential keys shall conform to ISO 3117.

6.6.5 Shafts with Woodruff keys shall conform to ISO 3912.

6.6.6 Splined shafts shall conform to ISO 14 or ISO 4156.

6.7 Process inlet and outlet pipe connections

6.7.1 Inlet and outlet connections shall be flanged or threaded and positioned as specified on a dimensional drawing or in the supplier's literature.

NOTE 1 Connection flanges can be studded provided it is not necessary to remove the associated pipework during routine maintenance.

The type, size and rating of connections shall be as specified in ISO 7005–1 or ISO 7005–2 or ISO 7005–3 and fully detailed on the supplier's specification including any special surface finishes.

NOTE 2 Other connection specifications can be supplied if agreed between the purchaser and the supplier.

Thread forms for screwed pipe connections shall conform to prEN 10226-1 or prEN ISO 228-1.

NOTE 3 Alternative pipe thread forms can be supplied if agreed between the purchaser and the supplier.

6.7.2 Inlet and outlet connections shall have a design pressure higher than, or equal to, the maximum allowable operating pressure plus any relief valve accumulation pressure for that connection.

6.7.3 Unless intended for venting to atmosphere during operation tapped auxiliary openings not connected to pipework shall be fitted with plugs of material at least equivalent in mechanical strength and corrosion resistance to the component.

6.7.4 Metallic process connections shall be capable of supporting the forces and moments as specified by the supplier, acting simultaneously, which should not exceed the values indicated in Table 1.

Table 1 - Maximum permissible forces and moments on process connections

Pipe dia Mm	Forces		Moments	
	$F_{(x, y \text{ or } z)}$ max. N	$F_{(total)}$ max. N	$M_{(x, y \text{ or } z)}$ max. Nm	$M_{(total)}$ max. Nm
25	190	270	85	125
40	255	360	115	170
50	295	420	145	210
80	425	600	215	315
100	505	720	260	385
125	610	870	325	480
150	720	1 020	385	565
200	930	1 320	500	735
250	1 140	1 620	625	920
300	1 355	1 920	740	1 090
350	1 565	2 220	865	1 270
400	1 775	2 520	980	1 445
450	1 980	2 815	1 095	1 615
500	2 200	3 125	1 220	1 795
600	2 625	3 725	1 460	2 145

Threaded connections shall not be subject to moments which tend to tighten or loosen the pipe in the pump casing.

NOTE 1 $F_{(total)} = \sqrt{F_x^2 + F_y^2 + F_z^2}$ *and* $M_{(total)} = \sqrt{M_x^2 + M_y^2 + M_z^2}$

NOTE 2 This means that at no time can the values of F_x, F_y and F_z or M_x, M_y and M_z all be maximum values

6.7.5 The type and rating for motive fluid connections shall be agreed between supplier and purchaser.

NOTE It is the purchasers' responsibility to ensure motive fluid piping has sufficient flexibility to prevent excess forces and moments being transmitted to the pump.

Connections for hydraulic and pneumatic power shall conform to ISO 6149-1, ISO 6149-2, ISO 6149-3, ISO 6162 and ISO 6164.

6.8 Draining and venting

When agreed between purchaser and supplier, methods shall be provided for draining and venting the pump and shall be shown in the instruction manual.

6.9 Threaded fasteners

Threaded fasteners of carbon steel or alloy steel for pressure containing parts shall conform to EN ISO 898-1 and EN 20898-2.

Where mating parts such as studs and nuts of materials with galling tendencies are used, they shall be lubricated with a suitable anti-seizure compound before assembly.

7 Ancillary equipment

7.1 General

Ancillary equipment for the operation of the pump or pump unit shall be clearly indicated by the supplier including any ancillary equipment that has to be provided by the purchaser. Interface points, connections, etc. shall be indicated.

Equipment provided by the supplier shall be clearly identified. If assembled with the pump or pump unit, the applicable general design requirements apply equally to the entire assembly.

7.2 Driver

The power of the driver shall be at least 5 % above the running conditions requiring the most power, including allowance for relief valve accumulation pressure, to meet the specifications referred to in 4.1. In addition to the above requirement, the power provided may have to be increased when factors such as low temperature starting are to be taken into account. The pump supplier shall properly select the driver when included in the scope of supply.

7.3 Shaft couplings

7.3.1 General

When the pump shaft is directly connected to the shaft of an independently mounted driver, a flexible shaft coupling shall be used to connect the shafts.

7.3.2 Rating

The type of shaft coupling and its rating shall be selected in accordance with the coupling manufacturer's recommendations using the power calculated in accordance with 7.2.

7.3.3 Selection of shaft coupling

Selection of shaft couplings shall be in accordance with the environmental conditions - see 6.1.

7.3.4 Parallel shaft couplings

When an interference fit is used for mounting couplings on parallel shafts the supplier shall make provision for removal and replacement of the coupling.

Transitional fit couplings shall be securely locked to the shaft.

7.3.5 Tapered shaft couplings

Taper bored hubs and keys if fitted shall be effectively secured against circumferential and axial movement relative to the shafts. The supplier when fitting the coupling shall ensure that best contact is achieved at the large end of the taper. The coupling shall be clamped in position by a positively locked locking device.

7.4 Baseplates

7.4.1 The baseplate or baseframe shall be made sufficiently rigid to avoid permanent distortion during transport, if necessary by temporary means, and shall maintain alignment between the pump shaft and driver shaft during operation when the maximum stipulated forces and moments on the pump inlet and outlet connections is applied.

NOTE If drain rims or special facilities are required they should be agreed between the purchaser and the supplier.

7.4.2 The baseplate shall incorporate anchorage points*.*

7.5 Guarding

Guards shall be provided in accordance with EN 809.

7.6 Heating and cooling

7.6.1 Design of heating/cooling passages

All heating and cooling passages shall be designed to operate under the operating conditions specified by the purchaser in accordance with 4.1.

7.6.2 Connections for heating/cooling

7.6.2.1 Where heating and/or cooling is required to be incorporated in the pump, finished ancillary connections to the heating and/or cooling chambers shall be provided by the supplier.

7.6.2.2 The specification of additional equipment to be supplied, such as pipework, isolating/drain/control valves, instrumentation, condition monitoring equipment; shall be subject to agreement.

7.7 Pressure safety-relief devices

7.7.1General

NOTE Systems using positive displacement pumps should be fitted with pressure safety-relief devices.

7.7.2 . It shall be capable of passing the maximum flow produced by the pump as installed

7.7.3 The maximum pressure safety-relief valve over-pressure shall be the higher of 5 bar or 25 % of the set pressure, without exceeding the maximum pressure to which the pump has been tested and not exceeding the power available from the driver.

7.7.3 The name plate shall clearly state the cold test pressure of any internal pressure safety-relief device. The user shall install an external safety relief device of the correct setting if it is required to provide a protection to piping or instrumentation that needs a lower pressure limit.

7.8 Pulsation suppression devices

7.8.1 The type of pulsation suppression device supplied shall be agreed between the purchaser and the supplier.

7.8.2 When inlet and outlet pulsation suppression devices are included in the scope of supply, annex D can be used as a guide to their selection.

7.8.3 When pulsation suppression devices are supplied loose for mounting in the purchaser's process pipework the supplier shall provide instructions for the correct installation of the devices. The installation instructions shall be submitted to the purchaser with the first issue of the pump or pump unit certified general arrangement drawing.

7.8.4 When pulsation suppression devices are supplied attached to the pump or pump unit the full extent of process pipework shall be agreed between purchaser and supplier.

7.9 Speed reduction

7.9.1General

NOTE When speed reduction is integral with the pump design, it is the responsibility of the manufacturer to ensure is of adequate size.

7.9.2 When speed reduction is necessary between the driver and a power pump the type of reduction shall be agreed between the purchaser and the supplier.

7.9.3 Belt drives shall not be used in ambient temperatures greater than 65 °C. Belt drive service factors shall not be less than:

- for multiplex plunger pumps 1,5;
- for duplex double acting piston pumps 1,6;
- for duplex single acting pumps 1,75.

For operation in hazardous areas, belts shall be static conducting.

7.9.4 When belt drives are used they shall be guarded in accordance with 7.5.

7.9.5 Enclosed gear drives between an electric motor and the pump shall conform to ISO TR 13593. When an appropriate drive selection factor is not available, one at least double that used for rotodynamic pumps shall be used.

Flexible couplings between the gearbox shaft and the pump shaft shall conform to 7.3.

7.10 Ancillary pipe connections

7.10.1 There shall be only one inlet connection and one outlet connection per function, unless otherwise agreed between purchaser and supplier.

7.10.2 All ancillary connections shall be clearly identified in the instruction manual.

7.10.3 All ancillary port connections shall conform to ISO 7005-1, ISO 7005-2, ISO 7005-3, prEN 10226-1, prEN ISO 228-1, ISO 6149-1, ISO 6149-2 and ISO 6149-3.

NOTE Other connection specifications can be supplied if agreed between the purchaser and the supplier.

8 Noise

8.1 Requirements for noise emission shall be in accordance with EN 809.

8.2 Any testing agreed between the purchaser and supplier shall be in accordance with EN 12639.

9 Installation and maintenance

9.1 General

Pump units installed for dangerous liquids shall be installed in accordance with EN 809.

9.2 The pump or pump unit should be designed and constructed to allow installation, routine maintenance, inspection and the replacement of consumables such as oil, packing, valves and gaskets to be performed without the need to remove major components.

9.3 Documentation supplied with the pump or pump unit shall be in accordance with EN 809.

9.4 For installation, commissioning and maintenance the design shall permit the use of standard tools, unless technically unsuitable for function or other relevant reasons. If special tools are required, these shall be listed by the supplier in the parts list.

9.5 Jacking screws, lifting lugs or eyebolt holes and dowels shall be provided where necessary to facilitate disassembly and assembly. When jacking screws are provided the stationary face shall be relieved locally if any possible surface damage by the jacking screws could jeopardise tightness or function.

10 Materials, welding and repairs

10.1 Selection of materials

The materials shall be selected relative to their physical properties and chemical compositions to meet the requirements of 4.1 and 6.1.

10.2 Manufacture

10.2.1 Castings

Castings shall be free from significant imperfections, such as shrink holes, blow holes, cracks, scale, blisters and other similar injurious defects. The surface of castings shall be cleaned by sandblasting, shot blasting, pickling or any other standard method. All mould flash and remains of gates and risers shall be chipped, filed or ground flush.

10.2.2 Welded fabrications

10.2.2.1 All welding of process pipework and pressure containing parts shall be performed by suitably qualified operators and procedures in accordance with EN 287-1, EN 287-2, EN 288-1, EN 288-2, EN 288-3 and EN 288-4.

10.2.2.2 Cast iron shall not be welded.

10.2.2.3 Inlet and outlet connections attached to pressure containing parts by welding shall have full penetration welds.

10.2.2.4 Piping connections attached to carbon or alloy steel pressure containing parts shall have the same nominal composition as the part or shall be low carbon austenitic stainless steel.

10.2.2.5 Fabricated pressure containing parts, operating at 75 % or more of the allowable design stress, shall be stress relieved after welding.

10.3 Repairs

10.3.1 Components shall not be repaired if any of the following conditions exist, unless by agreement between purchaser and supplier:

- depth of defect exceeds 20 % of design wall thickness;
- length of defect exceeds 20 % of the component dimension in that direction;
- total surface area affected exceeds 10 % of component surface area;
- replacement material exceeds 10 % of the raw component weight;
- pressure containment component is forged.

Defects shall be excavated and inspected, by dye penetrant, in accordance with ISO 3453, or magnetic particle, in accordance with EN ISO 9934-1, to ensure all defective material is removed prior to repair.

Pressure containing castings shall not be repaired by peening or burning-in.

NOTE Shallow surface defects, which do not impair the pressure containing capabilities, can be repaired by metal spraying.

10.3.2 Only components in readily weldable material shall be repaired by welding using qualified operators and procedures.

10.3.3 Repairs shall only be implemented when the repair will have the same, or exceed the, physical and chemical properties of the parent material and a permanent seal on pressure containing parts is ensured.

10.3.4 To prove the soundness of the repair, pressure containing parts shall be pressure tested. Other components shall be inspected by non-destructive methods to prove the soundness of the repair. Such methods include:

- dye penetrant in accordance with ISO 3453;
- magnetic particle in accordance with EN ISO 9934-1;
- ultrasonic in accordance with ISO 10375;
- radiography in accordance with ISO 1027.

11 Surface protection

When the materials used are not corrosion resistant all external non-functional surfaces shall be protected with the supplier's standard coating system suitable for the environmental conditions set out in 6.1.

When the information supplied by the purchaser in accordance with 4.1 indicates special environmental conditions, materials which are not corrosion resistant shall be suitably treated and painted or otherwise protected from the stated hazards.

12 Nameplates and marking

Nameplates and marking shall be in accordance with the requirements of EN 809.

13 Preparation for shipment

13.1 Corrosion protection

The pump shall have adequate internal and external corrosion protection prior to shipment. Necessary action to remove the protection, if necessary, shall be described in the start-up instructions and necessary warnings securely attached to the pump. Information to maintain the effectiveness of the corrosion protection at site shall be provided by the supplier.

13.2 Openings

To prevent the ingress of foreign matter during shipment, storage and installation, all openings shall be fitted with suitable covers prior to shipment.

13.3 Piping, ancillaries and auxiliaries

Precautions shall be taken to ensure that small piping, ancillaries and auxiliaries are protected from damage during transportation and storage.

13.4 Identification

All components supplied loose with the pump shall be clearly and durably identified as agreed between purchaser and supplier.

13.5 Installation and or operating instructions

The supplier's installation and/or operating instructions shall be packed and shipped with the pump and/or pump unit together with any other documentation agreed with the purchaser, unless otherwise requested by the purchaser.

Annex A
(informative)

Data sheet

The data sheet presented in this annex can be used by the purchaser to communicate the pump requirements to prospective suppliers. All necessary information on the data sheet would be provided by the purchaser to describe the pump or pump unit operating environment.

In the table entitled ‘Operating conditions for each pump’, each column is for a specific 'set' of information. It should be noted that the pump or pump unit would not be guaranteed for undocumented operating conditions or not in conformity with documented operation conditions.

The left-hand column lists the important liquid properties which will exist at the pump connections. NPIPA is a function of the inlet liquid properties and the system design and can be modified by the position of the pump inlet connection. The second column is used to identify the units which quantify the liquid properties.

The third column, 'Rated conditions', lists the operating conditions which the supplier will guarantee the pump can attain, For a fixed speed pump each box in the column should only contain a single value. A variable speed pump should have the minimum and maximum flows indicated. The 'Rated' column may only show one temperature and one viscosity.

Some pumps do not operate at a single condition but operate over a range of conditions. The remainder of the columns allow specific alternative duty conditions to be specified. It is not necessary to complete all the columns. It is only necessary to fill columns which completely describe the extremes of pump operation. Fixed speed pumps should not have additional flows specified.

Positive displacement pump operating conditions data sheet

Item No.	Purchaser
	Purchaser ref.
	Service
	Site/location
	Pump type

No. of pumps running	No. of pumps standby
Driver for running pumps	Driver for standby pumps
Driver Specifications	
Baseplate/ skid/ trailer	Baseplate/skid/trailer

Liquid		
Density	Specific heat capacity	pH
Corrosive Y/N (If Y give values on next page)	Abrasive Y/N	
Allowable leakage rate to atmosphere at rated operating conditions		
Solids		Hard/soft
Density	Hardness	% by WT/VOL
Friable Y/N	Miller No. or similar	Settling velocity
Particle size/ shape/ distribution		

OPERATING CONDITIONS FOR EACH PUMP

Type of operating conditions	Units	Rated conditions	Values of operating conditions for				
			Maximum outlet pressure	Minimum outlet pressure	Maximum inlet pressure	Minimum inlet pressure	Max differential pressure
inlet temperature							
Viscosity							
vapour pressure							
inlet pressure							
NPIPA (1)							
Flow (2)							
Outlet pressure							
Compressibility							
Duty							

Duty definitions	Continuous	Light	Intermittent	Cyclic	Irregular
	8/24 h/day	3/8 h/day	0/3 h/day	Describe	Describe

R V Back pressure	R V set pressure		R V overpressure

Description of cyclic or irregular duty	
	Motor starting (S-D/DOL/etc.)
Pump starting (on load/by-pass)	No. of pumps running on this inlet pipe
Inlet pipe bore x length (for acceleration HD)	Outlet pipe bore x length
Is inlet line straight	
Residual inlet pressure pulsations %	Residual outlet pressure pulsations %

PRESSURE CONTAINMENT DESIGN CONDITIONS

Inlet design pressure / temperature	Outlet design pressure / temperature
Fatigue Life required	
Cooling system media / design pressure/ temperature	Heating system media / design pressure / temperature

APPLICABLE STANDARDS, CERTIFICATION AND TESTING REQUIREMENTS

SITE CONDITIONS

Indoor / outdoor / onshore / offshore / attended / unattended	Concrete / structural steel foundations
Atmospheric pollution	Maintenance interval
Special precautions	Maximum / minimum temperature
	Black bulb temperature
Cooling water	Humidity
Compressed air	Altitude
Steam	Water available for heating/cooling / flush Y / N
Electrical supplies	
Electrical area classification	
Electrical equipment physical protection	

COMMENTS

(1) At underside of baseplate (2) For compressible liquids outlet volume will be less than inlet volume	

Positive displacement pump operating conditions data sheet *(continued)*

PERSONNEL HAZARDS

- ☐ Intoxicating by inhalation
- ☐ Intoxicating in contact with skin
- ☐ Intoxicating if swallowed
- ☐ Harmful by inhalation
- ☐ Harmful in contact with skin
- ☐ Harmful if swallowed
- ☐ Toxic by inhalation
- ☐ Toxic in contact with skin
- ☐ Toxic if swallowed
- ☐ Very toxic by inhalation
- ☐ Very toxic in contact with skin
- ☐ Very toxic if swallowed
- ☐ Contact with water liberates toxic gas
- ☐ Contact with acids liberates toxic gas
- ☐ Contact with acids liberates very toxic gas
- ☐ Harmful/toxic by inhalation when smoking
- ☐ Danger of harmful reaction with clothing
- ☐ Danger of cumulative effects
- ☐ Causes burns
- ☐ Causes severe burns
- ☐ Irritating to eyes
- ☐ Irritating to respiratory system
- ☐ Irritating to skin
- ☐ Danger of very serious irreversible effects
- ☐ Possible risk of irreversible effects
- ☐ Risk of serious damage to eyes
- ☐ May cause sensitisation by inhalation
- ☐ May cause sensitisation by skin contact
- ☐ May cause cancer
- ☐ May cause inheritable genetic damage
- ☐ May cause birth defects
- ☐ Danger of damage to health by prolonged exposure
- ☐ Danger of serious damage to health by prolonged exposure

GENERAL HAZARDS

- ☐ Explosive when dry
- ☐ Risk of explosion by shock, friction, fire or other sources of ignition
- ☐ Extreme risk of explosion by shock, friction, fire or other sources of ignition
- ☐ Forms very sensitive explosive compounds
- ☐ Heating may cause an explosion
- ☐ Explosive with or without contact with air
- ☐ May cause fire
- ☐ Contact with combustible material may cause fire
- ☐ Explosive when mixed with combustible material
- ☐ Flammable
- ☐ Highly flammable
- ☐ Extremely flammable
- ☐ Low ignition temperature °C
- ☐ Reacts violently with water
- ☐ Contact with water liberates highly flammable gases
- ☐ Spontaneously flammable in air
- ☐ May cause flammable / explosive vapour-air mixture
- ☐ May form explosive peroxides
- ☐ Can become highly flammable in use
- ☐ Risk of explosion if heated when confined
- ☐ Risk from static electricity

PUMP / PERFORMANCE HAZARDS

- ☐ Corrodes cast iron
- ☐ May crystallise on contact with air
- ☐ May crystallise on cold surfaces, < °C
- ☐ May crystallise at low velocity, < m/s
- ☐ May solidify on contact with air
- ☐ May deposit wax on cold surfaces, < °C
- ☐ May deposit wax at low velocity, < m/s
- ☐ May deposit solids at low velocity, < m/s
- ☐ Contains dissolved gas % by wt / vol
- ☐ Contains entrained gas % by wt / vol
- ☐ Gas evolves at absolute pressure below bar
- ☐ Good solvent for petroleum based lubricants
- ☐ Excellent solvent for petroleum based lubricants
- ☐ Mixture emulsifies at high velocity, > m/s
- ☐ Liquid is pseudoplastic
- ☐ Liquid is dilitant
- ☐ Liquid is thixotropic
- ☐ Liquid is rheopectic
- ☐ Liquid is Bingham plastic
- ☐ Liquid may not be contaminated with hydrocarbon based lubricants
- ☐ Liquid may not be contaminated with hydrocarbon based lubricants
- ☐ Lubricants must be food quality
- ☐ Pump will be cleaned with steam °C
- ☐ Pump will be cleaned with chemicals /solvents
- ☐ Non-Newtonian products require shear rate data with viscosity

Positive displacement pump operating conditions data sheet *(continued)*

PURCHASER MATERIAL RECOMMENDATIONS

Metallic materials in contact with liquid:
corrosion rate (mm/year)

a) _____

b) _____

c) _____

d) _____

e) _____

Non- metallic materials in contact with liquid:

f) _____

g) _____

h) _____

j) _____

k) _____

Materials not allowed in contact with liquid:

m) _____

n) _____

p) _____

q) _____

r) _____

s) _____

t) _____

u) _____

v) _____

w) _____

x) _____

y) _____

Annex B
(normative)

Optional requirements and items to be agreed

B.1 Optional requirements

If the purchaser wishes to include any of the optional requirements given in this standard such requirements shall be specified and documented at the time of inquiry and confirmed at the time of order. See clauses:

4.1 data sheet;
4.2 optional items,
6.5.2 constant level oilers;
6.7.1 studded flange connections;
10.3 repairs;

C.1 NPIP margin;

D.1 NPIP margin;
D.2 NPIP margin;
D.4 pressure pulsations

B.2 Items to be agreed

Items to be agreed between purchaser and supplier shall be fully documented. See clauses:

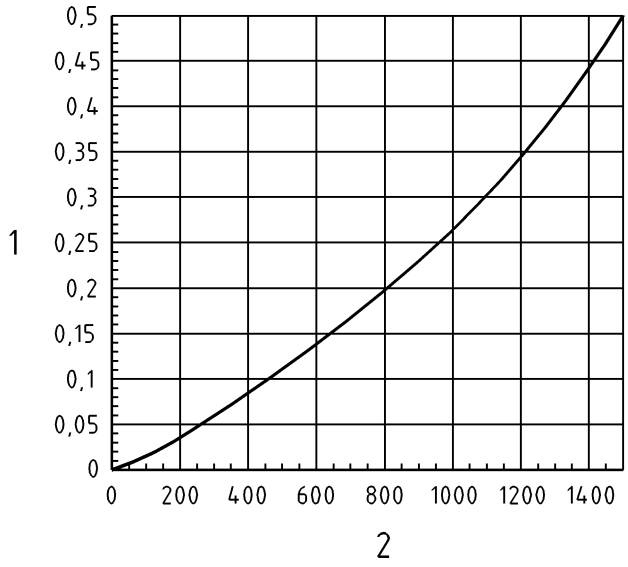
6.1 environment;
6.7.1 alternative process connections;
6.7.5 connections for motive fluid;
6.8 draining and venting;
7.4.1 drain rims and special baseplate facilities;
7.6.2.2 additional equipment;
7.8.1 type of pulsation damper;
7.8.4 extent of process pipework;
7.9.2 type of speed reduction;
7.10.1 ancillary connections;
7.10.2 ancillary connections;
8.2 noise testing;
10.3 repairs;
13.4 identification;
13.5 documentation shipped with the pump.

Annex C
(informative)
Operating margins between NPIPA and NPIPR

C.1 Reciprocating power pumps should be operated with a safety margin between the NPIPA and NPIPR values. The normal methods used for calculating acceleration head losses; Hydraulic Institute and VDMA; are approximations and subject to errors.

The severity of pump damage likely to be caused by cavitation is a function of pump speed, crankshaft rotation and mean piston/plunger speed, and the operating differential pressure compared to the design value. Pumps operating at low speed and low differential pressures are more tolerant to NPIP deficiencies. A variable NPIP margin based on operating conditions can be used successfully. The following curves allow the specific NPIP margin to be evaluated.

C.2 Using the pump speed, rpm, and Figure C.1 evaluate the NPIP margin M_1.



Key
1 NPIP margin, M_1, bar
2 Pump speed rpm

Figure C.1 NPIP margin for pump speed

Calculate the mean piston/plunger speed using Equation C.1.

$$v_m = \frac{v_{\text{pump}} \cdot l_{stroke}}{30000} \qquad \text{(C.1)}$$

where

v_m is the mean piston/plunger speed, in metres per second (m/s),
v_{pump} is the pump speed, revolutions per minute (min^{-1})
l_{stroke} is the stroke length, in millimetres (mm).

Using the mean piston speed and Figure C.2 evaluate the NPIP margin M_2.
Calculate the operational differential pressure percentage using Equation C.2.

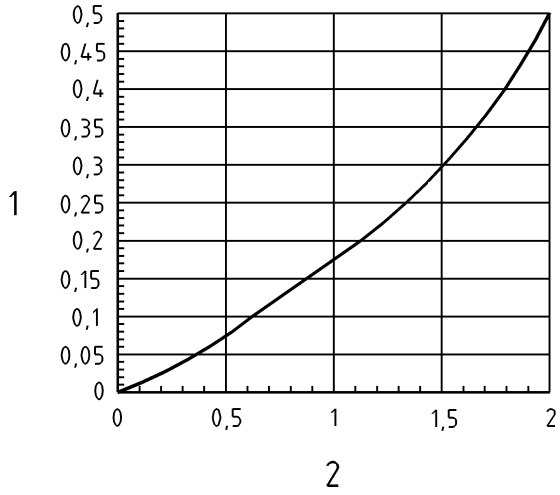
$$\Delta p\,\% = \frac{100(p_2 - p_1)}{p_{2d}} \qquad \text{(C.2)}$$

where

$\Delta p\%$ is the percentage of design differential pressure,
p_1 is the rated inlet gauge pressure, bar[1)],

[1)] 1 bar = 100 000 Pa

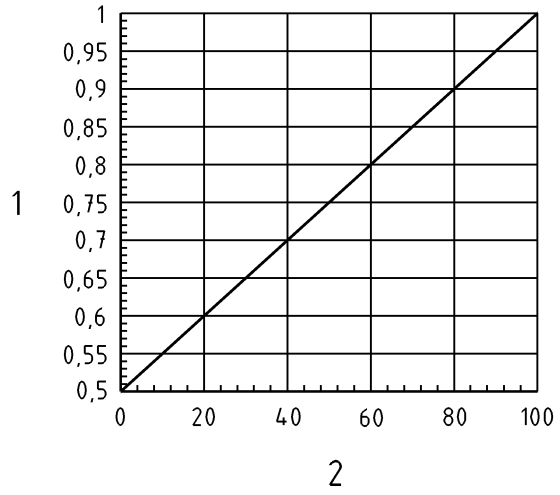
p_2 is the rated outlet gauge pressure, bar,
p_{2d} is the design outlet gauge pressure, bar,



Key
1 NPIP margin, M_2, bar
2 Mean piston/plunger speed m/s

Figure C.2 - NPIP margin for mean piston/plunger speed

Using the operational differential pressure percentage and Figure C.3 evaluate the NPIP margin proportion, ΔM.



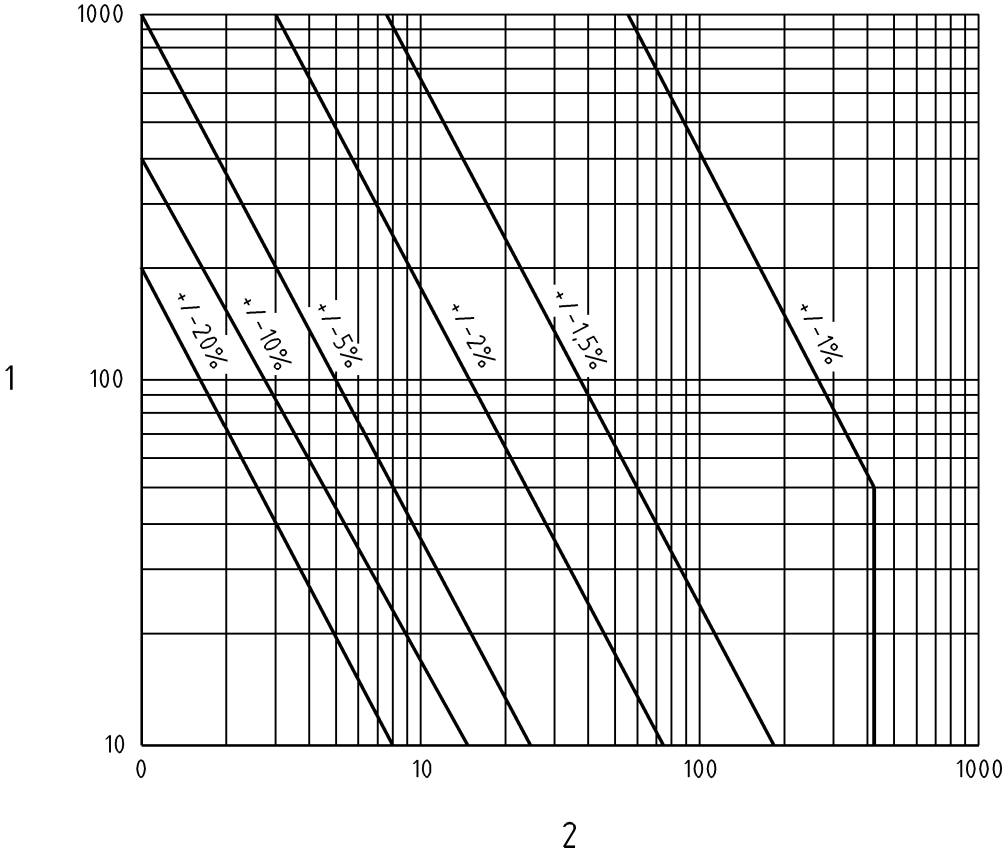
Key
1 Proportion of NPIP margin, ΔM
2 Percentage of design differential pressure

Figure C.3 - NPIP proportion for differential pressure

Multiply the larger value of M_1 and M_2 by ΔM to produce the recommended minimum NPIP margin.

Annex D
(informative)

Recommended maximum permissible residual pressure pulsations



Key
1 Pipe bore mm
2 Nominal pressure barg

Figure D.1 - Recommended residual pressure pulsations

D.1 Figure D.1 can be used as a guide to determine allowable residual pressure pulsations in pipework based on the nominal pressure and the pipe bore. Consideration should be given to NPIPA, relief valve set pressure and overpressure.

D.2 The effect of the negative pulse in inlet pipework on NPIPA should be considered. Pressure pulsations reduce the NPIPA by the magnitude of the negative pulse. Lower pressure pulsations, than indicated, can be necessary to preserve an adequate NPIP margin.

D.3 The effects of the relief valve set pressure, the relief valve overpressure and the predicted duty cycles at these pressures should be considered when deciding acceptable pressure pulsations in outlet piping. If process requirements dictate operation at set or overpressure for extended periods then these pressures should be used, rather than rated outlet pressure, for pulsation suppression device sizing and residual pressure pulsation evaluation.

D.4 Other equipment within the piping system, such as flow meters or accurate pressure measurement devices, can require smaller pressure pulsations than indicated in Figure D.1. In these cases the smaller pressure pulsations should apply.

ICS 23.080

Price based on 21 pages