INTERNATIONAL STANDARD

ISO 13709

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Centrifugal pumps for petroleum, petrochemical and natural gas industries

Pompes centrifuges pour les industries du pétrole, de la pétrochimie et du gaz naturel

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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 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 13709 was prepared by Technical Committee ISO/TC 115, *Pumps*, Subcommittee SC 3, *Installation and special application*, in collaboration with Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, SC 6, *Processing equipment and systems*.

Introduction

This International Standard was developed from API Standard 610, 8th edition, 1995, with the intent that the 9th edition of API 610 will be the same as this International Standard.

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

Annex A specifies calculations for specific speed and suction-specific speed.

Annex B contains schematic drawings of cooling water and lubrication systems.

Annex C specifies requirements for hydraulic power recovery turbines.

Annex D specifies requirements for standard baseplates.

Annex E contains an inspector's checklist.

Annex F specifies criteria for piping design.

Annex G give guidance on material class selection.

Annex H specifies requirements and gives guidance on materials selection.

Annex I specifies requirements for lateral analysis.

Annex J specifies requirements for determining residual unbalance.

Annex K contains seal chamber runout illustrations.

Annex L contains forms which may be used to indicate vendor drawing and data requirements.

Annex M contains forms which may be used to record test data.

Annex N contains data sheets which purchasers are encouraged to use.

A bullet (•) at the beginning of a clause or subclause indicates that either a decision is required or further information is to be provided by the purchaser. This information should be indicated on data sheets or stated in the enquiry or purchase order (see examples in Annex N).

In this International Standard, where practical, US Customary units are included in brackets for information.

Centrifugal pumps for petroleum, petrochemical and natural gas industries

1 Scope

This International Standard specifies requirements for centrifugal pumps, including pumps running in reverse as hydraulic power recovery turbines, for use in petroleum, petrochemical and gas industry process services.

This International Standard is applicable to overhung pumps, between-bearings pumps and vertically-suspended pumps (see Table 1). Clause 8 provides requirements applicable to specific types of pump. All other clauses of this International Standard are applicable to all pump types. Illustrations are provided of the various specific pump types and the designations assigned to each specific type.

This International Standard is not applicable to sealless pumps.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 7-1, *Pipe threads where pressure-tight joints are made on the threads — Part 1: Dimensions, tolerances and designation*

ISO 228-1, *Pipe threads where pressure-tight joints are not made on the threads — Part 1: Dimensions, tolerances and designation*

ISO 261, *ISO general-purpose metric screw threads — General plan*

ISO 262, *ISO general-purpose metric screw threads — Selected sizes for screws, bolts and nuts*

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

ISO 286 (all parts), *ISO system of limits and fits*

ISO 724, *ISO general-purpose metric screw threads — Basic dimensions*

ISO 965 (all parts), *ISO general-purpose metric screw threads — Tolerances*

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

ISO 4200, *Plain end steel tubes, welded and seamless — General tables of dimensions and masses per unit length*

ISO 5753, *Rolling bearings — Radial internal clearance*

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

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

ISO 8501 (all parts), *Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness*

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

ISO 10436, *Petroleum and natural gas industries — General-purpose steam turbines for refinery service*

ISO 10438 (all parts), *Petroleum and natural gas industries — Lubrication, shaft-sealing and control-oil systems and auxiliaries*

ISO 10441, *Petroleum and natural gas industries — Flexible couplings for mechanical power transmission — Special purpose applications*

ISO 11342, *Mechanical Vibration — Methods and criteria for the mechanical balancing of flexible rotors*

ISO 14691, *Petroleum and natural gas industries — Flexible couplings for mechanical power transmission — General purpose applications*

ISO 15649, *Petroleum and natural gas industries — Piping*

ISO 21049:—[1)], *Pumps — Shaft sealing systems for centrifugal and rotary pumps*

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

IEC 60079 (all parts), *Electrical apparatus for explosive gas atmosphere*

EN 287 (all parts), *Approval testing of welders — Fusion welding* [2)]

EN 288, *Specification and approval of welding procedures for metallic materials*

EN 13445 (all parts), *Unfired pressure vessels*

ABMA 7, *Shaft and housing fits for metric radial ball and roller bearings* [3)]

AGMA 9000, *Flexible couplings — Potential unbalance classification* [4)]

AGMA 9002, *Bores and keyways for flexible couplings (inch series)*

API 541, *Form-wound squirrel-cage induction motors — 250 horsepower and larger*

API 611, *General purpose steam turbines for refinery service*

API 670, *Noncontacting vibration and axial position monitoring system*

API 671, *Special-purpose couplings for refinery service*

API 677, *General-purpose gear units for petroleum, chemical and gas industry services*

ASME B1.1, *Unified inch screw threads, UN and UNR thread form* [5)]

ASME B15.1, *Safety standard for mechanical power transmission apparatus*

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1) To be published.

2) Comité Européen de Normalization, 36, rue de Stassart, B-1050 Brussels, Belgium.

3) American Bearing Manufacturers Association, 2025 M Street, NW, Suite 800, Washington, DC 20036, USA.

4) American Gear Manufacturers Association, 1500 King Street, Suite 201, Alexandria, VA 22314, USA.

5) American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990, USA.

ASME B16.1, *Cast iron pipe flanges and flanged fittings classes 25, 125 and 250*

ASME B16.5, *Pipe flanges and flanged fittings NPS 1/2 through NPS 24*

ASME B16.11, *Forged fittings, socket-welding and threaded*

ASME B16.42, *Ductile iron pipe flanges and flanged fittings classes 150 and 300*

ASME B16.47, *Large diameter steel flanges NPS 26 through NPS 60*

ASME B17.1, *Keys and keyseats*

ASME, *Boiler and pressure vessel code, Section V, Nondestructive examination*

ASME, *Boiler and pressure vessel code, Section VIII, Pressure vessels*

ASME, *Boiler and pressure vessel code, Section IX, Welding and brazing qualifications*

AWS D1.1, *Structural welding code — Steel* 6)

DIN 910, *Heavy-duty hexagon head screw plugs* 7)

HI 1.3, *Centrifugal pumps — Horizontal baseplate design* 8)

HI 1.6, *Centrifugal pump test*

HI 2.6, *Vertical pump test*

IEEE 841, *Standard for petroleum and chemical industry — Severe duty totally enclosed fan-cooled (TEFC) squirrel cage induction motors — Up to and including 370 kW (500 hp)* 9)

MSS-SP-55, *Quality standard for steel castings for valves, flanges and fittings and other piping components — Visual method for evaluation of surface irregularities* 10)

NACE MR0175, *Sulfide stress cracking resistant metallic materials for oilfield equipment item No. 21304* 11)

NFPA 70, *National electrical code handbook* 12)

SSPC SP 6, *Surface Preparation Specification* 13)

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6) American Welding Society, 550 North LeJeune Road, Miami, FL 33136, USA.

7) Deutsches Institut für Normung, Burggrafenstrasse 6, Berlin, Germany D-10787.

8) Hydraulics Institute, 9 Sylvan Way, Parsippany NJ, 07054, USA.

9) Institute of Electrical & Electronics Engineers, 445 Hoes Lane, Piscataway, NJ 08855-1331.

10) Manufacturers Standardization Society of The Valve and Fittings Industry Inc., 127 Park Street N.E., Vienna, VA 22180-4602, USA.

11) National Association of Corrosion Engineers, 1440 South Creek Drive, Houston, TX 77084-4906, USA.

12) National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269-9101, USA.

13) Society for Protective Coatings, 40 24th Street, 6th Floor, Pittsburgh, PA 15222-4643, USA.

3 Terms and definitions

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

3.1
axially split
split with the principal joint parallel to the shaft centreline

3.2
barrel pump
horizontal pump of the double-casing type

3.3
barrier fluid
fluid, at a higher pressure than the process pressure being sealed, introduced between pressurized dual (double) mechanical seals to completely isolate the pump process liquid from the environment

3.4
best efficiency point
BEP
flowrate at which a pump achieves its highest efficiency

3.5
buffer fluid
fluid, at a lower pressure than the process pressure being sealed, used as a lubricant or buffer between unpressurized dual (tandem) mechanical seals

3.6
critical speed
shaft rotational speed at which the rotor-bearing-support system is in a state of resonance

3.7
dry critical speed
rotor critical speed calculated assuming that there are no liquid effects, that the rotor is supported only at its bearings and that the bearings are of infinite stiffness

3.8
wet critical speed
rotor critical speed calculated considering the additional support and damping produced by the action of the pumped liquid within internal running clearances at the operating conditions and allowing for flexibility and damping within the bearings

3.9
datum elevation
elevation to which values of NPSH are referred

cf. **net positive suction head** (3.28)

3.10
double casing
type of pump construction in which the pressure casing is separate from the pumping elements contained in the casing

NOTE Examples of pumping elements include diffuser, diaphragms, bowls and volute inner casings.

3.11
drive train component
item of the equipment used in series to drive the pump

EXAMPLES Motor, gear, turbine, engine, fluid drive, clutch.

3.12
element
bundle
assembly of the rotor plus the internal stationary parts of a centrifugal pump

3.13
cartridge-type element
assembly of all the parts of the pump except for the casing

3.14
hydraulic power recovery turbine
turbomachine designed to recover power from a fluid stream

3.15
hydrodynamic bearing
bearing that uses the principles of hydrodynamic lubrication

3.16
maximum allowable speed
highest speed at which the manufacturer's design permits continuous operation

3.17
maximum allowable temperature
maximum continuous temperature for which the manufacturer has designed the pump (or any part to which the term is referred) when handling the specified fluid at the specified maximum operating pressure

3.18
maximum allowable working pressure
MAWP
maximum continuous pressure for which the manufacturer has designed the pump (or any part to which the term is referred) when handling the specified fluid at the specified maximum operating temperature

3.19
maximum continuous speed
highest rotational speed at which the pump, as built, is capable of continuous operation with the specified fluid at any of the specified operating conditions

3.20
maximum discharge pressure
maximum specified suction pressure plus the maximum differential pressure the pump with the furnished impeller is able to develop when operating at rated speed with fluid of the specified normal relative density (specific gravity)

3.21
maximum dynamic sealing pressure
highest pressure expected at the seals during any specified operating condition and during start-up and shut-down

3.22
maximum static sealing pressure
highest pressure, excluding pressures encountered during hydrostatic testing, to which the seals can be subjected while the pump is shut down

3.23
maximum suction pressure
highest suction pressure to which the pump is subjected during operation

3.24
minimum allowable speed
lowest speed (in revolutions per minute) at which the manufacturer's design permits continuous operation

3.25
minimum continuous stable flow
lowest flow at which the pump can operate without exceeding the vibration limits imposed by this International Standard

3.26
minimum continuous thermal flow
lowest flow at which the pump can operate without its operation being impaired by the temperature rise of the pumped liquid

3.27
minimum design metal temperature
lowest mean metal temperature (through the thickness) expected in service, including operation upsets, auto-refrigeration and temperature of the surrounding environment

3.28
net positive suction head
NPSH
total absolute suction pressure determined at the suction nozzle and referred to the datum elevation, minus the vapour pressure of the liquid

NOTE It is expressed in metres (feet) of head of the pumped liquid.

3.29
net positive suction head available
NPSHA
NPSH determined by the purchaser for the pumping system with the liquid at the rated flow and normal pumping temperature

3.30
net positive suction head required
NPSHR
NPSH that results in a 3 % loss of head (first stage head in a multistage pump) determined by the vendor by testing with water

3.31
nominal pipe size
NPS
designation, usually followed by a size designation number, corresponding approximately to the outside diameter of the pipe expressed in inches

3.32
normal operating point
point at which the pump is expected to operate under normal process conditions

3.33
normal-wear part
part normally restored or replaced at each pump overhaul

EXAMPLES Wear rings, interstage bushings, balancing device, throat bushing, seal faces, bearings and gaskets.

3.34
observed
inspection or test where the purchaser is notified of the timing of the inspection or test and the inspection or test is performed as scheduled, regardless of whether the purchaser or his representative is present

3.35
oil mist lubrication
lubrication provided by oil mist produced by atomisation in a central unit and transported to the bearing housing, or housings, by compressed air

3.36
pure oil mist lubrication
⟨dry sump⟩ systems in which the mist both lubricates the bearing(s) and purges the housing and there is no oil level in the sump

3.37
purge oil mist lubrication
⟨wet sump⟩ systems in which the mist only purges the bearing housing

3.38
operating region
portion of a pump's hydraulic coverage over which the pump operates

3.39
allowable operating region
portion of a pump's hydraulic coverage over which the pump is allowed to operate, based on vibration within the upper limit of this International Standard or temperature rise or other limitation; specified by the manufacturer

3.40
preferred operating region
portion of a pump's hydraulic coverage over which the pump's vibration is within the base limit of this International Standard

3.41
overhung pump
pump whose impeller is cantilevered from its bearing assembly

3.42
pressure casing
composite of all stationary pressure-containing parts of the pump, including all nozzles, seal glands, seal chambers and other attached parts but excluding the stationary and rotating members of mechanical seals

3.43
purchaser
owner, or owner's agent, that issues the order and specification to the vendor

3.44
radially split
split with the principal joint perpendicular to the shaft centreline

3.45
rated operating point
point at which the vendor certifies that pump performance is within the tolerances stated in this International Standard

NOTE Normally the rated operating point is the specified operating point with the highest flow.

3.46
relative density
specific gravity
property of a liquid expressed as the ratio of the liquid's density to that of water at 4 °C (39,2 °F)

3.47
rotor
assembly of all the rotating parts of a centrifugal pump

3.48
specific speed
index relating flow, total head and rotational speed for pumps of similar geometry

See Annex A.

3.49
standby service
normally idle or idling piece of equipment that is capable of immediate automatic or manual start-up and continuous operation

3.50
suction-specific speed
index relating flow, NPSHR and rotative speed for pumps of similar geometry

See Annex A.

3.51
throat bushing
device that forms a restrictive close clearance around the sleeve (or shaft) between the seal and the impeller

3.52
total indicator reading
total indicated runout
TIR
difference between the maximum and minimum readings of a dial indicator or similar device, monitoring a face or cylindrical surface, during one complete revolution of the monitored surface

NOTE For a perfectly cylindrical surface, the indicator reading implies an eccentricity equal to half the reading. For a perfectly flat face the indicator reading gives an out-of-squareness equal to the reading. If the diameter in question is not perfectly cylindrical or flat, interpretation of the meaning of TIR is more complex and may represent ovality or lobing.

3.53
trip speed
⟨electric motor driver⟩ synchronous speed at maximum supply frequency

3.54
trip speed
⟨variable-speed driver⟩ speed at which the independent emergency overspeed device operates to shut down the driver

3.55
unit responsibility
responsibility for coordinating the documentation, delivery and technical aspects of the equipment and all auxiliary systems included in the scope of the order

NOTE The technical aspects to be considered include but are not limited to such factors as the power requirements, speed, rotation, general arrangement, couplings, dynamics, lubrication, sealing system, material test reports, instrumentation, piping, conformance to specifications and testing of components.

3.56
vendor
supplier
manufacturer or manufacturer's agent that supplies the equipment and is normally responsible for service support

3.57
vertical in-line pump
vertical-axis pump whose suction and discharge connections have a common centreline that intersects the shaft axis

NOTE The pump's driver is generally mounted directly on the pump.

3.58
vertically suspended pump
vertical-axis pump whose liquid end is suspended from a column and mounting plate

NOTE The pump's liquid end is usually submerged in the pumped liquid.

3.59
witnessed
type of inspection or test for which the purchaser is notified of the timing of the inspection or test and a hold is placed on the inspection or test until the purchaser or his representative is in attendance

4 Classification and designation

4.1 General

The pumps described in this International Standard are classified and designated as shown in Table 1.

Table 1 — Pump classification type identification

Pump type			Orientation		Type code
Centrifugal pumps	Overhung	Flexibly coupled	Horizontal	Foot-mounted	OH1
				Centreline-supported	OH2
			Vertical in-line with bearing bracket		OH3
		Rigidly coupled	Vertical in-line		OH4
		Close-coupled	Vertical in-line		OH5
			High-speed integrally geared		OH6
	Between-bearings	1- and 2-stage	Axially split		BB1
			Radially split		BB2
		Multistage	Axially split		BB3
			Radially split	Single casing	BB4
				Double casing	BB5
	Vertically suspended	Single casing	Discharge through column	Diffuser	VS1
				Volute	VS2
				Axial flow	VS3
			Separate discharge	Line shaft	VS4
				Cantilever	VS5
		Double casing	Diffuser		VS6
			Volute		VS7

NOTE Illustrations of the various types of pump are provided in 4.2.