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Pumps — Shaft sealing systems for centrifugal and rotary pumps

Pompes — Dispositifs d'étanchéité de l'arbre pour pompes centrifuges et rotatives

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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 21049 was prepared by Technical Committee ISO/TC 115, *Pumps*, Subcommittee SC 3, *Installation and special applications*, 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 is based on the accumulated knowledge and experience of manufacturers and users of equipment in the petroleum, natural gas and chemical industries, but its use is not restricted to these industries.

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.

The purpose of this International Standard is to assist purchasers with the selection and operation of mechanical seals for pumps.

This International Standard is a stand-alone seal standard and is referenced normatively in ISO 13709. It is applicable to both new and retrofitted pumps, and to pumps other than ISO 13709 pumps (e.g. ASME B73.1, ASME B73.2 and API 676 pumps).

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

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 C).

Pumps — Shaft sealing systems for centrifugal and rotary pumps

1 Scope

This International Standard specifies requirements and gives recommendations for sealing systems for centrifugal and rotary pumps used in the petroleum, natural gas and chemical industries. It is applicable mainly for hazardous, flammable and/or toxic services where a greater degree of reliability is required for the improvement of equipment availability and the reduction of both emissions to the atmosphere and life-cycle sealing costs. It covers seals for pump shaft diameters from 20 mm (0,75 in) to 110 mm (4,3 in).

This International Standard is also applicable to seal spare parts and can be referred to for the upgrading of existing equipment. A classification system for the seal configurations covered by this International Standard into categories, types, arrangements and orientations is provided.

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 (all parts), *Pipe threads where pressure-tight joints are made on the threads*

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 286-2, *ISO system of limits and fits — Part 2: Tables of standard tolerance grades and limit deviations for holes and shafts*

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

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

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

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

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

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

ISO 13709, *Centrifugal pumps for petroleum, petrochemical and natural gas industries*

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

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

IEC 60529, *Degrees of protection provided by enclosures (IP code)*

AISI, *Standards, codes and specifications of the American Iron and Steel Institute* [1)]

API RP 520 (all parts), *Sizing, selection, and installation of pressure-relieving devices in refineries* [2)]

API Std 526, *Flanged steel pressure relief valves*

ASME V, *ASME Boiler and pressure vessel code, Section V, Non-destructive examination* [3)]

ASME VIII, *ASME Boiler and pressure vessel code, Section VIII, Rules for the construction of pressure vessels*

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

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

ASME B1.20.1, *Pipe threads, general purpose, inch*

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

ASME B16.20, *Metallic gaskets for pipe flanges — Ring joint, spiral-wound, and jacketed*

ASME B73.1, *Specification for horizontal end suction centrifugal pumps for chemical process*

ASME B73.2, *Specification for vertical in-line centrifugal pumps for chemical process*

ASME PTC 8.2, *Centrifugal pumps, performance test codes*

AWS D1.1, *Structural welding code — Steel* [4)]

EN 287 (all parts), *Approval testing of welders — Fusion welding* [5)]

EN 288 (all parts), *Specification and approval of welding procedures for metallic materials*

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

EPA Method 21, Appendix A of Title 40, Part 60 of the U.S. Code of Federal Regulations, *Environmental Protection Agency, United States* [6)]

NEMA 250, *Enclosures for electrical equipment (1 000 volts maximum)* [7)]

NFPA 70, *National Electrical Code* [8)]

Title 1, Part A, Section 112, *U.S. National Emission Standards for Hazardous Air Pollutants (NESHAPs) (Clean Air Act Amendment)* [9)]

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1) Available from the American Iron and Steel Institute: 1140 Connecticut Ave., Suite 705, Washington, D.C. 20036, USA.

2) Available from the American Petroleum Institute, 1220 L Street, NW, Washington, D.C. 20005-4070, USA.

3) Available from the American Society of Mechanical Engineers: Three Park Avenue, New York, NY 10016-5990, USA.

4) Available from the American Welding Society, 550 N.W. Le Jeune Rd, Miami, FL 33126, USA.

5) Comité Européen de Normalisation, 36, rue de Stassart, B-1050 Brussels, Belgium.

6) Available from the National Archives and Records Administration, 700 Pennsylvania Avenue, N.W., Washington, D.C. 20408, USA.

7) Available from the National Electrical Manufacturers Association, 1300 North 17th Street, Rosslyn, VA 22209, USA.

8) Available from the National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101, USA.

9) Environmental Protection Agency, Ariel Rios Building, 1200 Pennsylvania Avenue, N.W., Mail Code 3213A, Washington, D.C. 20460, USA.

3 Terms and definitions

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

3.1
anti-rotation device
device used to prevent rotation of one component relative to an adjacent component in a seal assembly

EXAMPLES Key, pin.

3.2
Arrangement 1 seal
seal configuration having one seal per cartridge assembly

3.3
Arrangement 2 seal
seal configuration having two seals per cartridge assembly with a containment seal chamber which is at a pressure lower than the seal chamber pressure

3.4
Arrangement 3 seal
seal configuration having two seals per cartridge assembly that utilize an externally supplied barrier fluid

3.5
back-to-back configuration
dual seal in which both of the flexible elements are mounted between the mating rings

3.6
balanced seal
mechanical seal in which the seal balance ratio is less than 1

3.7
barrier fluid
externally supplied fluid at a pressure above the pump seal chamber pressure, introduced into an Arrangement 3 seal to completely isolate the process liquid from the environment

3.8
bellows seal
type of mechanical seal which uses a flexible metal bellows to provide secondary sealing and spring-type loading

3.9
buffer fluid
externally supplied fluid, at a pressure lower than the pump seal chamber pressure, used as a lubricant and/or to provide a diluent in an Arrangement 2 seal

3.10
cartridge seal
completely self-contained unit (including seal faces, flexible elements, seal gland plate, sleeve and mating ring) which is pre-assembled and preset before installation

3.11
connection
threaded or flanged joint that mates a port to a pipe or to a piece of tubing

3.12
contacting seal
seal design in which the mating faces are not designed to intentionally create aerodynamic or hydrodynamic forces to sustain a specific separation gap

NOTE Contacting seals can actually develop a full fluid film but this is not typical. Contacting seals do not incorporate geometry, e.g. grooves, pads, face waviness, to ensure that the faces do not touch. The amount of contact is generally very low and permits reliable operation with low leakage.

3.13
containment seal
seal design with one flexible element, seal ring and mating ring mounted in the containment seal chamber

NOTE The outer seal for all Arrangement 2 configurations is a containment seal.

3.14
containment seal chamber
component forming the cavity into which the containment seal is installed

3.15
crystallizing fluid
fluid which is in the process of forming solids or which may form solids due to dehydration or chemical reaction

3.16
distributed flush system
arrangement of holes, passages, baffles, etc., designed to promote an even distribution of flush fluid around the circumference of the seal faces, qualified by testing in accordance with this International Standard

3.17
drive collar
external part of the seal cartridge that transmits torque to the seal sleeve and prevents axial movement of the seal sleeve relative to the shaft

3.18
dual mechanical seal
Arrangement 2 or Arrangement 3 seal of any kind

3.19
dynamic sealing-pressure rating
highest pressure differential that the seal or seal assembly can continuously withstand at the maximum allowable temperature while the shaft is rotating

NOTE Thereafter, the seal retains its static sealing pressure rating.

3.20
face-to-back configuration
dual seal in which one mating face is mounted between the two flexible elements and one flexible element is mounted between the two mating seal rings

3.21
face-to-face configuration
dual seal in which both of the mating seal rings are mounted between the flexible elements

3.22
flashing
rapid change in fluid state from liquid to gas

NOTE In a dynamic seal, this can occur when frictional energy is added to the fluid as it passes between the primary seal faces, or when fluid pressure is reduced below the fluid's vapour pressure because of a pressure drop across the seal faces.

3.23
flashing hydrocarbon
liquid hydrocarbon with an absolute vapour pressure greater than 0,1 MPa (1 bar) (14,7 psi) at the pumping temperature, or a fluid that will readily boil at ambient conditions

3.24
flexible element
combination of components which move axially relative to the shaft/sleeve or seal chamber

3.25
flexible graphite
pure carbon graphite material used for static (secondary seal) gaskets in mechanical seal design, from cryogenic to hot service

3.26
floating bushing
bushing that fits around the shaft or sleeve and has sufficient clearance around the outside diameter so it can move or "float" radially

3.27
FFKM perfluoroelastomer
FFKM
chemically resistant O-ring elastomer material suitable for high temperature service

3.28
FKM fluoroelastomer
FKM
type of O-ring elastomer material commonly used in mechanical seals

3.29
flush, noun
fluid which is introduced into the seal chamber on the process fluid side in close proximity to the seal faces and typically used for cooling and lubricating the seal faces

3.30
flush plan
configuration of pipe, instruments and controls designed to route the fluid concerned to the seals

NOTE Auxiliary piping plans vary with the application, seal type and arrangement.

3.31
gland plate
end plate which connects the stationary assembly of a mechanical seal to the seal chamber or containment seal chamber

3.32
hook sleeve
sleeve, with a step or hook at the product end, placed over the shaft to protect it from wear and corrosion

NOTE The step is usually abutted against the impeller to hold it in place with a gasket between the shaft and the step (hook).

3.33
inner seal
⟨Arrangement 2 and Arrangement 3⟩ seal that is located closest to the pump impeller in the seal chamber

3.34
internally-mounted seal
seal configuration in which the seal is mounted within the boundaries of the seal chamber and gland plate

3.35
internal circulating device
pumping ring
device located in the seal chamber to circulate seal chamber fluid through a cooler or barrier/buffer fluid reservoir

3.36
leakage concentration
measure of the concentration of a volatile organic compound or other regulated emission in the environment immediately surrounding the seal

3.37
leakage rate
volume or mass of fluid passing between the seal faces through a seal in a given length of time

3.38
light hydrocarbon
hydrocarbon liquid that will readily boil at ambient conditions

NOTE Typically this definition includes pure and mixed streams of pentane (C_5) and lighter liquids.

3.39
mating ring
disk- or ring-shaped member, mounted either on a sleeve or in a housing such that it does not move axially relative to the sleeve or the housing, which provides the mating seal face for the seal ring

3.40
maximum allowable temperature
maximum continuous temperature for which the manufacturer has designed the equipment (or any part to which the term is referred) when handling the specified fluid at the specified maximum operating pressure

NOTE 1 This information is supplied by the seal manufacturer.

NOTE 2 The maximum allowable temperature is usually set by material considerations. This may be the material of the casing or a temperature limit imposed by a gasket or O-ring. The yield strength and ultimate strength are temperature-dependent. A component's stress level can depend on operating pressure. Thus, the margin between the strength limit of the material and the operating stress depends on both the material's operating temperature and the component's stress level. If the temperature is lowered, the material's strength increases and the stress level of the component may increase. This is the reason for associating the maximum allowable temperature to the maximum specified operating pressure.

3.41
maximum allowable working pressure
MAWP
maximum continuous pressure for which the manufacturer has designed the equipment (or any part to which the term is referred) when handling the specified fluid at the specified maximum operating temperature

cf. **static sealing-pressure rating** (3.69), **dynamic sealing-pressure rating** (3.19)

3.42
maximum dynamic sealing pressure
MDSP
highest pressure expected at the seal (or seals) during any specified operating condition and during start-up and shutdown

NOTE In determining this pressure, consideration is given to the maximum suction pressure, the flush pressure, and the effect of clearance changes within the pump. This is a process condition and is specified by the purchaser.

3.43
maximum operating temperature
maximum temperature to which the seal (or seals) can be subjected

NOTE This is a process condition and is specified by the purchaser.

3.44
maximum static sealing pressure
MSSP
highest pressure, excluding pressures encountered during hydrostatic testing, to which the seal (or seals) can be subjected while the pump is shut down

NOTE This is a process condition and is specified by the purchaser.

3.45
non-contacting seal
seal design in which the mating faces are designed to intentionally create aerodynamic or hydrodynamic separating forces to sustain a specific separation gap between the seal ring and the mating ring

NOTE Non-contacting seals are specifically designed so that there is always an operating gap between the stationary and rotating face.

3.46
non-flashing hydrocarbon
liquid hydrocarbon whose vapour pressure at any specified operating temperature is less than an absolute pressure of 0,1 MPa (1 bar) (14,7 psi), or a fluid that will not readily boil at ambient conditions

3.47
non-hydrocarbon service
service in which the fluid, such as sour water, boiler feed water, sodium hydroxide, acids and amines, contains no hydrocarbons or the fluid has relatively small quantities of entrained hydrocarbons

3.48
non-pusher seal
seal in which the secondary seal is not required to slide axially to compensate for wear and misalignment

NOTE A non-pusher seal is usually the metal-bellows Type B or C.

3.49
observed test
product test which is observed at the discretion of the purchaser, who has been given notice of the test by the manufacturer, but does not constitute a manufacturing hold point

3.50
orifice nipple
pipe nipple made of solid bar stock with an orifice hole drilled through it to regulate the flush flow

NOTE Orifice nipples are commonly found on Plan 11 systems.

3.51
O-ring
elastomeric sealing ring with an O-shaped (circular) cross-section, which may be used as a secondary seal or as a gasket

3.52
outer seal
〈Arrangement 2 and Arrangement 3〉 seal located farthest from the pump impeller

3.53
polymerizing fluid
fluid which is in the process of changing, or is capable of changing, from one chemical composition to another with longer-chain components and different properties, usually becoming significantly more viscous and/or tacky