ENVIRONMENTAL TECHNOLOGY

The API 682 Standard 4th Edition

Shaft Sealing Systems for Rotary Pumps

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Introduction

The 4th Edition of API 682 Standard Shaft sealing systems for rotary pumps (i.e. mechanical seals and systems) was published on the 1st May 2014. API 682 is a key equipment standard for safe and reliable operation of mechanical seals and auxiliary piping systems. After six years of development, the 4th Edition now covers a multitude of seals designs and auxiliary piping systems. It can be referenced in the procurement of both new and retrofit equipment.

API Standards Historical Review

One of the most successful activities of the American Petroleum Institute (API) is the development of international standards for both plant operation and equipment in the Oil & Gas and Petrochemical Industries. The history of the Mechanical Seal Standard started in 1994, when mechanical seals broke away from the API 610 Pump Standard. The 2nd and 3rd Editions were published in 2002 and 2004, respectively. The recently published 250-page long 4th Edition Standard provides over 20 years of knowledge and wisdom from both users and manufacturers.

Key Elements of the 4th Edition API 682 Standard

The fundamental building blocks of API 2nd and 3rd Editions—seal types, arrangements, and configurations—remain effectively unchanged for the 4th Edition. Users who are familiar with the 3rd Edition do not have a major step to understand the 4th Edition. There are minor changes in the seal categories. For example:

- The grade of silicon carbide face materials should be selected based on chemical compatibility rather than using any default selection for each seal category.
- Floating bushes are now specified for Category 2 seals rather than fixed bushes.
- Category 2 and 3 seals pressure range has changed from 42 bar absolute to 40 bar gauge which aligns API 682 with the API 610 pump standard. Category 1 seals pressure range has changed from 22 bar absolute to 20 bar gauge.

Many of the changes in the 4th Edition are detail enhancements particularly with auxiliary systems and piping plans. For example, Plans 53B, 53C, 65, and 75 would now include construction and size defaults.

The primary 25,000 running hours and the emissions objectives remains unchanged from previous editions

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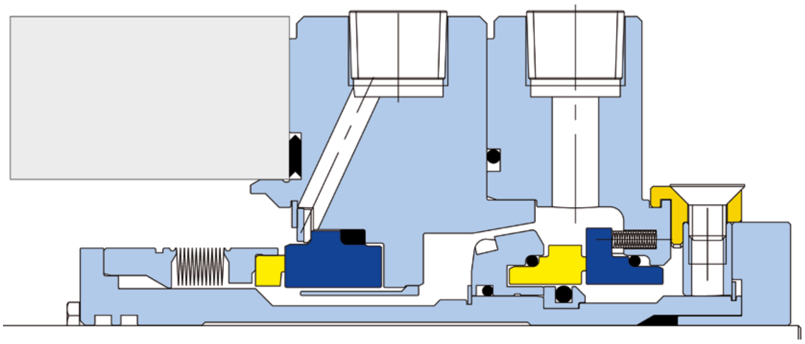
Definitions

Definitions are detailed in section 3 of the International Standard and many have been improved for greater clarity. A number of new definitions have also been added. For example, the term ‘engineered seal’ is now clearly defined as a mechanical seal for applications with service conditions outside the scope of the standard.

Seal Types – Mixed Dual Seals

The 4th Edition now clarifies that dual seals can be of mixed types. For example, mixing a type C (flexible graphite mounted bellows) inner seal with a type A (multi-spring pusher) outer seal could provide flexibility to the manufacturer or user. Such an assembly would be described as a type C/A.



Example Hybrid Bellows Dual Seal

Seal Design Features

Section 6 of the Standard details the design requirements and features. There are a number of subtle changes that reflect proven features commonly found in modern seal designs.

Rotating & Stationary Flexible Elements

The API Standard has always allowed a purchaser to specify either a rotating or stationary flexible element on the seal cartridge. However, historically it has been assumed that the defaults will always provide the best solution. The 4th Edition now clarifies that both rotating and stationary flexible elements are considered technically equivalent. The relevant clauses have now been modified to allow the seal vendor to ‘recommend’ . A tutorial is also provided within Annex F to provide guidance for any given service or application decision.

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Vapour Pressure Margin

The 2nd and 3rd Editions required a seal chamber vapour pressure margin (for single and unpressurised dual seals) of 30% or a product temperature margin of 20°C (68°F)

A user on the Task Force stated that there was confusion – is the vapour pressure multiplied by 1.3 or the seal chamber pressure multiplied by 0.7? The curve for the 20°C (68°F) margin was very different for the curve for a 30% margin.

The Task Force agreed to revert back to the 1st Edition 3.5 bar margin. However, pump manufacturers highlighted that this could not be achieved on many low differential, pressure-pumping applications. The final position was a minimum margin of 3.5 bar; when this cannot be achieved, a minimum fixed ratio (at least 1.3) between the seal chamber pressure and maximum fluid vapour pressure is required. A tutorial on the subject is provided in Annex F.

Chamfers and Lead-Ins

The Standard has previously specified very generous lead-ins for ease of assembly of O-Rings within the seal. However, seal designers have, for many years, frequently used different values internally within the seal cartridge. The 4th Edition now clarifies what has become accepted practice – chamfers for O-Rings are now only specified for the seal/pump interface.

Positive Retention of Seal Faces

For reverse pressure (or vacuum) service, positive retention of seal faces has been traditionally achieved by use of snap rings or similar features. An alternative method is to retain these components by balancing axial thrust forces hydraulically. The resulting designs offer resilient mounting of seal face mating rings, preventing metal contact with the brittle face material, and ease of assembly. The 4th Edition now recognises both methods.

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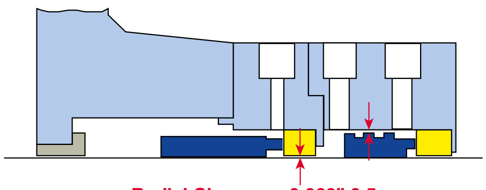
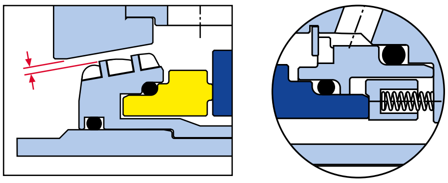
Internal Clearances



Radial Clearance 0.020" 0.5mm



Internal Clearances Radial 1.5mm

One issue debated at length was the internal clearance between rotating and stationary components within the cartridge seal,assembly Previous editions of the Standard only specified internal clearances for bushes and circulating devices (pump rings). A new Table 1 provides detailed clearances within the seal assembly, 1mm (0.039" (diameter for seals of shaft size below 60mm (2.36") and 2mm (0.079") for larger seals. The data was based on thecurrent practice of many seal manufacturers. The pump ring clearance, previously 3mm (0.118"), has been reduced in line with these values. There was an opinion that the newly defined clearances are too small and not fault-tolerant. Whilst the clearances are perfectly adequate for a new API 610 pump that has been correctly assembled and installed, the clearances may be inadequate for:

- Other types of pumps
- Mature machinery
- Machinery subject to pipe strain
- Pumps not reinstalled to an ''as new'' condition.

Contact between rotating and stationary components could be a safety issue. A number of informative notes were added to assist users in understanding the issues raised.

Following a field review of over ten thousand seals from all manufacturers returned for repair, contact was not observed on samples where clearances exceeded 2mm (0.0787") (diameter). AESSEAL® has made a policy decision to design API 682 seals to a minimum of 2mm (0.0787") (diameter) clearance even on the smaller shaft sizes.

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Recognising an API 682 4th Edition Seal

A 4th Edition seal is visibly very similar to previous API 682 seals. However, the key discernible feature that will identify a 4th Edition seal is the plugs in the gland plates. Traditionally, stainless steel plugs have been used during transportation. The plugs remain in the seal gland plate during installation, or are removed for connection of pipe work for piping plans. There was a concern that the anaerobic sealant specified in the 3rd Edition was causing issues when the plugs are removed with sealant debris falling into the seal. After considerable discussion within the 682 Task Force, it was decided that red plastic plugs will be used with a yellow label stating they should be removed and replaced with steel plugs or pipe work during assembly.

Seal Arrangement Selection Process

The choice of the seal arrangement, i.e. single seal or dual seal (pressurised, or unpressurised), is perhaps the most important decision to be made in the selection process. It has a significant impact on the safety, complexity of operation, and expenditure (capital and operational).

Many nations have now adopted the United Nations Globally Harmonized System of Classification and Labelling of Chemicals (GHS), or the similar European classifications systems. These systems use material safety data sheets. Annex A includes an alternative seal arrangement selection procedure that uses the toxicology information detailed on these data sheets to derive a seal arrangement selection.

Piping Plan - Figures

Historically, there has been a market perception that the seal and systems plans drawn are an absolute requirement. The 4th Edition clarifies that the illustrations generic. Coolers are drawn as water coolers; however, they could be air coolers. Seal designs from different manufacturers may have a different appearance than the generic seals used in the figures. The seals illustrated in the Standard are not an endorsement of a specific design or configuration.

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New Piping Plans

The 4th Edition International Standard now incorporates new piping plans. Piping Plan 03 depicts an open taper bore seal chamber rather than the traditional API 610 cylindrical seal chamber with a closed throat. Taper bore seal chambers have been used in many industries, and have proven reliability on solid handling services.

Plan 55 is a dual-seal piping plan where the buffer fluid is circulated via an external source between the dual seals at a pressure lower than the seal chamber pressure.

Plan 65 is leakage detection vessel used with single seals. This has now been renamed as API Plan 65A or 65B, which accommodates the two different methods users were implementing for this plan.

Plans 66A and 66B have also been added as simplified leakage detection plans for single seals that do not use a collection vessel. Leakage detection is via a pressure transmitter connected directly to the gland plate.

Plan 99 provides the purchaser a data sheet option for describing an engineered plan, or a highly modified existing plan.

Improved Specifications for Pressurised Dual-Seal Piping Plans & Leakage Detection Vessels

Plan 53B bladder accumulator and Plan 53C appeared as schematic designs on earlier editions of the Standard. However, there was no specification provided as to the materials of construction and sizing. The 4th Edition now defines sizing for these piping plans and the material of construction. It also indicates that these devices need to be sized to allow for a hold-up time of pressure of at least 28 days between refill interventions.

Historically, similar issues existed with Plan 65 and Plan 75. There was no sizing definition for these collection reservoirs and indeed, there were many examples in the field of Plan 65, when the collection volume is no greater than a “fat pipe” and other examples of 15 litre (3 US gallon) reservoirs being used. The 4th Edition now clearly defines a minimum requirement of 3 litres (0.8 US gallon) for a Plan 65 and 7 litres for a Plan 75 vessel. As with other piping plans, the systems are to be considered part of the pump pressure casing.

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Air Cooling

Over the last decade, the industry has increasingly used air cooling in auxiliary piping plans, such as Plan 53B and Plan 23. Cooler fouling, quality, and availability of cooling water have been the principal drivers for the 'air cooled' trend. Air cooling is now included in the 4th Edition with natural draft being the default with either stainless steel or aluminium fins.

Instrumentation - Transmitters Default Selection

A number of the API piping plans utilise instrumentation for sensing pressure, level, or temperature. Historically, switches were specified within the Standard. However, the task force recognised the growing trend within the industry for a preference for transmitters. Transmitters now form the default selection, with switches being an allowable alternative option.

Qualification Testing

Introduced by users on the 1st Edition task force, qualification testing remains a cornerstone of the International Standard. The qualification testing program was expanded in later editions to include gas seal and containment seal technologies. The 4th Edition retains this testing. However, as this section is primarily written for manufacturers, the testing section is removed from the main body of the text to a separate normative Annex I.

An additional test has been added for dual pressurised seals that are orientated in a back-to-back or face-to-face format.

Annex I also introduces the concept of core seal components and how these can be shared across differing designs and categories. This is to prevent the unnecessary duplication of qualification testing.

Air Test

The API 682 Standard has always had a requirement that all seal assemblies should be air-tested prior to shipment. One of the users within the 4th Edition task force requested to make this air test more rigorous and considered a performance verification test. The historical view was that the air test should remain a simple check of correct seal assembly. It is possible for a seal to pass this air test but have a significant liquid leakage. After lengthy discussions, the task force decided not to change the acceptance criteria from the previous editions. Readers are invited to review the following video link to gain a greater understanding of the issues discussed.

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https://www.youtube.com/watch?v=nqlwkz3E7Qk

Technical Tutorial and Illustrative Calculations

Annex F has been expanded considerably and now contains over 40 pages of useful seal and auxiliary system design information along with industry standard calculations.

API Seal Coding

API Seal Codes are commonly used in the procurement process of major projects by contractor businesses. The codes are normally found on the data sheets and provide the purchaser with the simple methodology of obtaining comparative pricing for identical, generic types of mechanical seals from competing seal vendors. The 3rd Edition coding covered seal category, seal type, seal arrangement, and piping plan. This coding has been widely adopted in most regions of the world. However, some regions still prefer to use the old API 610 coding dating back to the 1990s, which included materials of construction. The new 4th Edition code incorporates both 3rd Edition and historic API 610 coding. The new code also includes the shaft size.

Sometimes, at the early stage of the procurement process on major projects, not all of the information is available. With the new coding, the purchaser can insert an “X” where this information is unknown. As the project progresses, the coding can be amended as the information becomes finalised.

Conclusion

The API 682 Standard has evolved over 20 years and serves as a representative sound engineering practice in the application of mechanical seals. The latest edition has incorporated many of the improvements from the previous editions as highlighted by users. The Standard includes recently proven technologies and extended tutorials.

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