EUROPEAN SEALING ASSOCIATION

OVERVIEW OF API 682 4th EDITION

This document has been compiled by the ESA as an overview of the API 682 standard and is provided for your convenience. It is not a substitute for the Standard.
This summary is intended to be consistent with the standard and not to modify or replace it. If you are uncertain as to application of any portion of this summary please refer to the text of API 682.

API 682 was first published in 1994 and it became established as the industry leading document for mechanical seals. It promoted proven, high reliability seal solutions across refining markets.
As new sealing technologies were developed, the 2nd and 3rd Editions of the standard were developed further and opened out to chemical, petrochemical and other industries. The 3rd Edition was also published as a joint API/ ISO standard, ISO 21049
Published in 2014 the 4th Edition of API 682 continues to promote proven sealing solutions but has been updated to be less prescriptive. With the 4th Edition the link with ISO also ended and it was published once again as a stand-alone standard.
It should be noted that

- API 682 is not a specification, there is no requirement to comply with all clauses of the standard.
- While some end users have adopted API 682 into their own standards, many have used it as the base for their own standards, making small adjustments to suit their individual business models
- API 682 does not attempt to cover all refinery duties but aims to cover >80% of applications
- Default sealing recommendations in the standard do not imply technical preference but reflect installed base and experience.

It is important to note that API 682 does not attempt to define seal design and application outside the scope of the standard. API 682 does not identify whether or not a specific service is excluded, it depends on the application conditions, though, in practice, applications on 'Offsites' duties, water circulation pumps etc. would not usually be considered API 682 applications.

API 682 4th Edition Key Elements

This overview covers some key elements of API 682, it is not a complete review of the standard and it is not an alternative to purchase of the standard. In the case of any differences, API 682 is the reference document that should be applied.

Objectives of API 682 continue to be

- Seals should operate continuously for 25,000 hrs (3 yrs)
- Arrangement 2 outer seals should operate for at least 25,000 hrs at chamber pressure ≤ 0.7 bar (10 psi) and at least 8 hrs at seal chamber conditions
- Seals should achieve compliance with local emissions regulations or a maximum of 1000 ppm (EPA Method 21)

IMPORTANT
The above are performance **objectives** not a performance specification. The API Task Force recognises that **seal performance is dependent on operation** not just on design so the seal maker cannot guarantee to meet the objectives. The wide variation in sealing duties across a refinery also mean that no standard can fully cover all potential applications.

API 682 4th Edition Scope

The API 682 Standard specifies requirements and makes recommendations for sealing systems for centrifugal and rotary pumps used in the petroleum, natural gas and chemical industries
API 682 is not intended to cover all sealing applications on a refinery or process plant but is mainly applicable for hazardous, flammable and/or toxic services where increased reliability leading to improved equipment reliability is a key objective.
Applications covered by the scope of API 682 are

Seal Chamber	Category 1	Category 2 & 3
Size	ASME B73.1 or ASME B73.2	API 610
Maximum Pressure	20 barg 300 psig	40 barg 600 psig
Temperature Range	– 40 °C to 260 °C – 40 °F to 500 °F	– 40 °C to 400 °C – 40 °F to 750 °F

Notes.
1. The values listed in the table are those covered by the API 682 standard. Seals covered by each Category are not required to be able to meet all maximum values listed e.g. a pusher seal is not expected to be able to operate at 400 ºC
2. Any seal operating with service conditions outside the scope of the standard is designated an Engineered Seal (ES). An Engineered Seal is not a seal Type but recognition that special design features may be required to meet the application conditions. An Engineered Seal is not covered by the requirements of the standard and is not required to be qualification tested.

API 682 applies to seal spares as well as original equipment and may be applied for upgrading existing plant.

API 682 seals are identified in terms of Category, Arrangement and Type.
Seal Type describes the basic design features of a seal, API 682 identifies three seal types, A, B & C and the definitions of these have not changed from the 3rd Edition

- Type A - are balanced, cartridge seals using elastomeric secondary seals
- Type B - are cartridge, metal bellows seals using elastomeric secondary seals.
- Type C - are cartridge, high temperature bellows seals using flexible graphite secondary seals.

API 682 4th Ed. has however adapted the definition of seal types to be less prescriptive. Historically Type A & B seals have been supplied with rotating flexible elements while Type C have been supplied with stationary flexible elements. API 682 now clarifies that both rotating and stationary flexible elements are considered 'technically equivalent'.
The 4th Ed. has also updated the definition of an Engineered Seal (ES) which is now clearly defined as a mechanical seal for applications with service conditions outside the scope of the standard.
API 682 also 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.

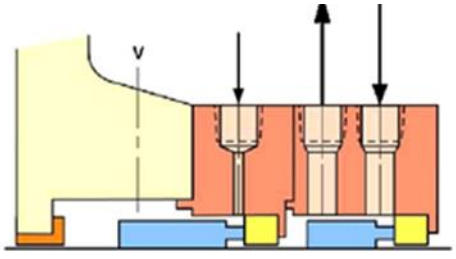
Seal Categories are used to identify the equipment type and market to which seals are normally applied. They do not exclude use of seals across categories, this is a customer choice.

- Category 1 - use in non-API 610 pump seal chambers (ASME B73.1, and ASME B73.2)
- Category 2 - use in seal chambers meeting API 610 chamber dimensions - reference to ISO 3609C has been dropped
- Category 3 - use in seal chambers meeting API 610 but with more documentation requirements than Category 2.

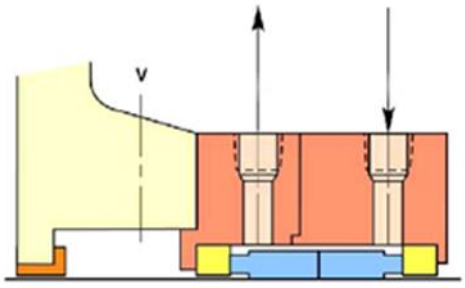
Seal Arrangements identify the seal assembly and whether designs are single or multiple seals. In the case of dual seals the arrangement does not define seal construction

- Arrangement 1 - one seal per cartridge (Single)
- Arrangement 2 – two seals per cartridge, inter-seal chamber pressure lower than seal chamber pressure (Tandem)
- Arrangement 3 - two seals per cartridge, inter-seal chamber pressure greater than seal chamber pressure (Double)

Earlier editions of API 682 led to some users thinking that certain orientations were 'preferred' by the standard. In practice this 'preference' was just recognition that Task Force members had more experience with some configurations compared with others. For the 4th Ed., while still referring to 'defaults' in the text, the standard states that configurations are 'technically equivalent' and should be selected on merit for any specific application.



Face to Back dual seal

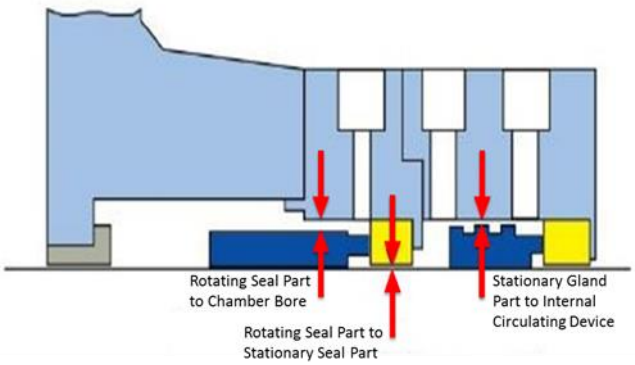


Back to Back dual seal

Face to Back, Back to Back and Face to Face (not illustrated) are considered technically equivalent, choice is based on application requirements.

API 682 Design Requirements define Default and Optional Seal Configurations.
Historical defaults are based on installed population not on performance, there is no technical preference for Default configurations over Optional configurations. There are a number of factors related to the design, manufacture, installation and repair of equipment, which should be considered when making the selection of a rotating or stationary flexible element.
Some design requirements covered by the standard are

- **Reverse Pressure Capability.** Seal faces which can be exposed to reverse pressure in operation or a vacuum under static conditions must have the faces retained so they will not dislodge under these conditions.
- **Seal Clearances.** Making clearances very large has the benefit of providing addition space around the seals for fluid circulation and radial motion but it also has the effect of limiting design features and in some cases can degrade the performance of the seal. The 4th Ed. clarified recommended clearances which had been the scope of some disagreement.



- **Vapour Pressure Margin** is the difference between the seal chamber pressure and the vapour pressure of the fluid. The 4th Ed. set requirements based on application.
  - For seal chamber pressure during operation
  - For vapour pressure margin during operation.
- **Gland Plugs** The 4th Ed. has eliminated the requirement to install metal plugs in all of the ports and replaced them with red plastic plugs.
- **Gland Plates** shall be provided by the seal manufacturer, have holes not slots and be centred with either an inside or outside diameter register fit (spigot).
- **Seal Sleeves** shall
  - be supplied by the seal manufacturer
  - be one piece (except when auxiliary sleeves are supplied)
  - be sealed at one end
  - extend beyond the gland plate
- **Seal Face Materials and Face Material Combinations** must pass the relevant qualification test
  - One ring shall be premium grade, blister-resistant, carbon graphite, except for services where two hard materials are required
  - One ring shall be reaction-bonded or self-sintered silicon carbide (dependant on chemical compatibility/ recommendation).

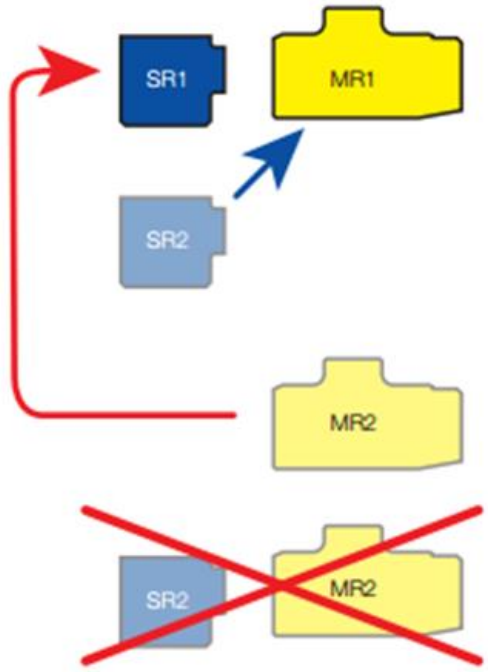
For **Seal System & Accessory Design** the purchaser and the mechanical seal manufacturer shall mutually agree which piping plan or plans shall be used

Seal Inspection & Test

A **Hydrostatic Air Integrity Test** shall be conducted after final assembly. The test is to demonstrate that seal cartridge has been correctly assembled, the seals are not expected to be leak-free. Results are not representative of the seal performance in liquid.
The question of using the air integrity test as an acceptance test was subject to considerable discussion. While the merits of making this an acceptance test are very valid it is difficult to apply the same test criteria to all seals e.g. gas or containment seals may be designed to operate on a slight leakage. New procedures were also introduced for Back to Back or Face to Face arrangements as they could not be tested without dismantling the seal using the old process (and so defeating the object of the test)

The purpose of **seal qualification testing** is to provide the end user with a high degree of confidence that a manufacturer's commercial product seal will perform as required by API 682 across a wide range of duties. Seals are, however, designed for specific applications (e.g. high temperature) and a single design will not be suitable for all applications, so it is only necessary to qualify seals for the services in which they will be used.
API 682 4th Ed. updated the seal qualification procedures to simplify (and reduce the cost) of seal qualification while retaining the important benefit of providing user confidence of seal performance.

- A new procedure was developed to demonstrate the performance of dual liquid seals in BB & FF orientations. The complete seal assembly must be tested and be accepted according to the existing dual liquid seal test criteria. In addition to this test, the seal must demonstrate its ability to survive reverse pressurisation and upset conditions which might be experienced in service.
- A new table showing how qualification testing for different seal configurations was included in the standard
- The Task force also addressed the ongoing requirement for seal OEM to qualify new seal face materials. To reduce testing requirements 4th Ed. allows face material combinations to be qualified as a mating pair and used across multiple seals with a single test. Additionally, new face pairings may be qualified by a single test (of the largest test size) provided only one face material is changed. This is most easily illustrated in a diagram



4th Ed. of API 682 allows for face material qualification of new seal or mating ring materials using a single test provided it is being tested against a qualified material. This does not mean that the two new materials are qualified to run against each other.

API 682 includes an Annex for **Standard piping plans**

- This annex contains drawings, descriptions, and tutorials of standard piping plans and auxiliary hardware which have regularly been used in industry.
- The details for each piping plan represents the minimum requirements for the plan. Users of API 682 may specify slight variations to plans.
- Substitutions for the instrumentation requirements in these plans are allowed (with purchaser's approval) while still retaining the piping plan designations
- To accommodate piping plans not shown in this annex, a Plan 99 should be selected which allows the purchaser to fully specify the requirements of the piping plan.

Useful References

API webpage for standards https://www.api.org/products-and-services/standards

API Standard 610, Tenth Edition, 2004, "Centrifugal Pumps for Petroleum, Heavy Duty Chemical, and Gas Industry Services", October 2004; ISO 13709: 2003; American Petroleum Institute, Washington, D. C.

API Standard 682, First Edition, 1994, "Shaft Sealing Systems for Centrifugal and Rotary Pumps," American Petroleum Institute, Washington, D.C.

API Standard 682, Second Edition, 2001, "Pumps – Shaft Sealing Systems for Centrifugal and Rotary Pumps," American Petroleum Institute, Washington, D.C.

API Standard 682, Third Edition, 2004, "Pumps – Shaft Sealing Centrifugal and Rotary Pumps," American Petroleum Institute, Washington D.C.

API Standard 682, Fourth Edition, 2014, "Pumps – Shaft Sealing Centrifugal and Rotary Pumps," American Petroleum Institute, Washington D.C.

Bowden, P.E. 2016 "The Development of API 682 4th Edition" Proceedings from the 1st Asia Turbomachinery & Pump Symposium, Singapore

Huebner, M. B., Buck, G. S., Azibert, H. V., 2014, "Advances in Mechanical Sealing –API 682 Fourth Edition," Proceedings of the Thirtieth International Pump Users Symposium, Turbomachinery Laboratory, Texas A&M University, College Station, Texas.

Typical Refinery Units and Application of API 682

IMPORTANT. The table includes examples of pump duties

- **Where API 682 would normally be applied**
- **Which may be API 682 or non API 682 and review of the application will dictate applicability**

This is not intended as a complete list of either refining units or associated equipment.
Plant operators may have their own specifications which dictate use of API 682 seals or alternative seal solutions.
Unless stated otherwise all equipment references pumps.

Unit	Duties normally considered to be API 682	Duties requiring application review API 682 applicability
Amine or H_2S Recovery	LPG feed MEA/DEA Regenerator	
Catalytic Reforming	Aromatics Bottoms Charge Reboiler	Compressors
Coker or Delayed Coking	Butane product Coker heater charge Compressor knock out Condensate Debutanizer reflux Feed Fractionator overhead Fractionator recirculation Heavy gas oil Light gas oil Primary absorber Slop oil Splitter Stripper feed	Boiler feed water Coker blowdown water Decoker water Fractionator sour water Quench water Recycle gas compressor Stripped sour water
Crude Distillation	Gas oil Light & Heavy Gas Oil Overheads product Pumparound	Crude charge pumps Sour water Steam turbines
Fluidic Catalytic Cracking	Feed Fractionator bottoms Heavy cycle oil Light cycle oil Naptha – fractionator Naptha – reflux Overhead product Overhead reflux	Blowers Overhead sour water Steam turbines

Fractionating	Caustic LPG Splitter Stabiliser column Stripper	
Gas Concentration	Fractionator reflux Overhead product Fractionator bottoms Stripper feed Rich absorber Debutanizer Depropanizer Splitter Primary absorber	Wet gas recovery compressor Steam turbines
Gas Oil Hydrofiner	Hydrofiner feed pumps Stripper overheads pumps Stripper bottoms pumps Stripper feed	Compressors
HF Alkylation	HF Alkylation is extremely hazardous and special sealing solutions are required. They must be considered outside the scope of API 682 solutions though may be designed 'in the spirit' of the standard. Some, acid free, pumps may be considered appropriate for API 682 seal solutions.	
Hydrocracker	Charge Debutanizer overheads Diesel fractionator Fractionator bottoms Fractionator hot recycle Fractionator overhead HP Separator sour water Kerosene fractionator LP Separator sour water Splitter overheads	Wash water Hydrogen compressors
Hydrotreater	Charge Feed	Compressors
Isomerisation	Charge De-isobutanizer bottoms De-isobutanizer overhead De-isobutanizer reboiler Reactor charge Scrubber Stabilizer bottoms Stabilizer overhead	Recycle gas compressor Hydrogen compressor

Liquefied Petroleum Gas	Absorber Caustic Naptha & Lean Naptha Splitter	
Merox – Gasoline	Caustic Feed Gasoline	
Merox - LPG	Caustic LPG Sour oil	
MTBE	Absorber Butane feed Charge Methanol feed MTBE Stripper bottoms Stripper overheads Stripper reboiler water	
Sulphur	Sulphur	
Vacuum Distillation	Bottoms Heavy gas oil Light gas oil Medium gas oil VDU feed	Steam turbines Wash water
Visbreaker	Feed Product Reflux Sour water Stripper bottoms Visbreaker bottoms	Compressors