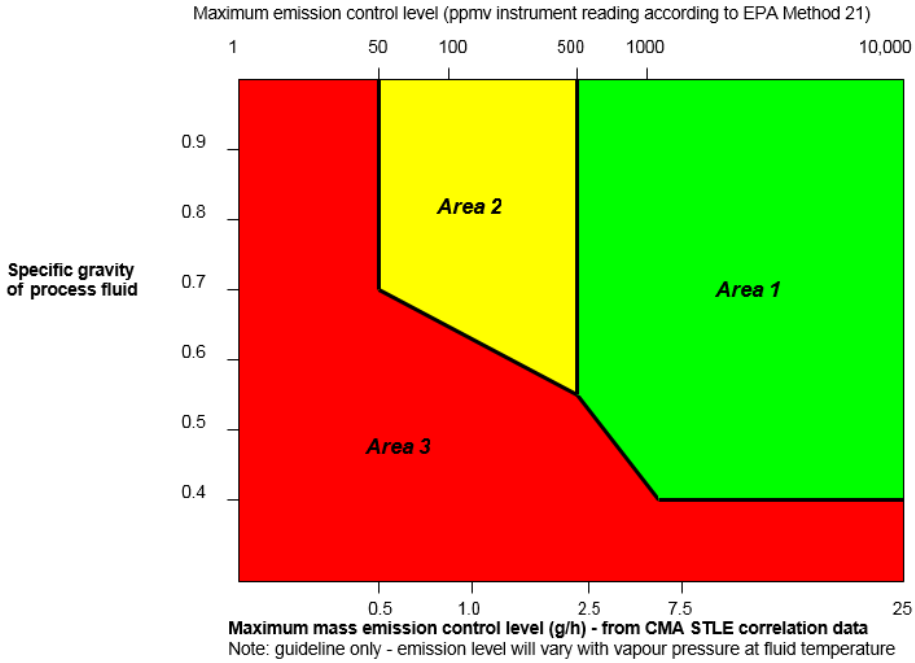
Mechanical Seals for High Reliability and Emission Control

The chart was developed in the 1990's by the Society of Tribologists and Lubrication Engineers (STLE) and published as STLE SP-30. This work was further enhanced and published by the European Sealing Association as document ESA 005/95.



Area	Leak rate maximum (g/h)	Specific gravity of process fluid	Acceptable sealing solution
1	2.5 – 24.0	> 0.4	General purpose single seals, advanced technology single seals, dual unpressurised (tandem) or dual pressurised (double) seals
2	0.5 – 2.5	> 0.5 – > 0.7	Advanced technology single seals, dual unpressurised (tandem) or dual pressurised (double) seals
3	< 0.5	> 0.4	Advanced technology single seals vented to a closed vent system, dual unpressurised (tandem) seals vented to a closed vent system, dual pressurised (double) seals, or sealless systems
		< 0.4	Liquid or gas, dual pressurised (double) seals, or sealless systems

This general guideline describes typical performance of mechanical seals

- less than 150 mm (6 inch) shaft size,
- pressures less than 4100 kPa,
- speeds of less than 28 m/sec
- temperatures between -40°C and +260°C.

Area 1 mainly represents simple refinery sealing duties where control of emissions may not be an important operational consideration. Most of these applications can be covered by general purpose mechanical seal solutions.

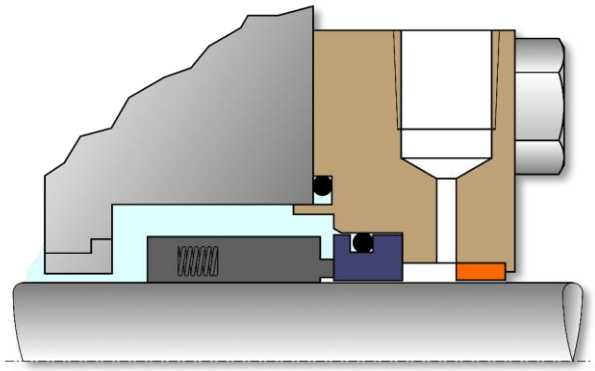
Area 2 is a more demanding area for seals with emission control levels down to much lower ppm requirements for normal operating conditions in the field. Where low emission rates are essential, use of advanced technology seals from respected mechanical seal manufacturers is recommended. Advanced technology mechanical seals incorporate 'designed-in' capabilities to offset the combined effects of pressure distortion, thermal distortion and heat generation.

Area 3 covers the most demanding of refinery applications and generally requires the use of dual unpressurised (tandem) seals vented to a closed vent system or dual pressurised (double) seals. For some applications, use of an advanced technology single seal vented to a closed vent system can be a more cost-effective alternative to a dual seal but each application should be discussed with an experienced seal supplier.

Note

- The chart cannot be considered an ‘absolute guide to selection’ as local emission and/or hazardous fluid legislation may require specific solutions.
- The chart is focussed on mechanical seal emission control and can be used as a guideline for seal selection based on EPA Method 21 emission levels or mass emission rate.

Single Seal Solutions



General Purpose Seal

A single mechanical seal, aimed at general purpose applications, typically comprises a fixed ring in the casing held in tight contact with a rotating ring on the shaft to form a seal. These rings are (usually) located using o-rings to provide a low leakage solution with good service life.
General purpose seals are normally applied to less hazardous mechanical seal applications ranging from aqueous solutions, through hydrocarbons and general chemicals. They are applied when lower cost solutions are required and small levels of leakage are not hazardous.

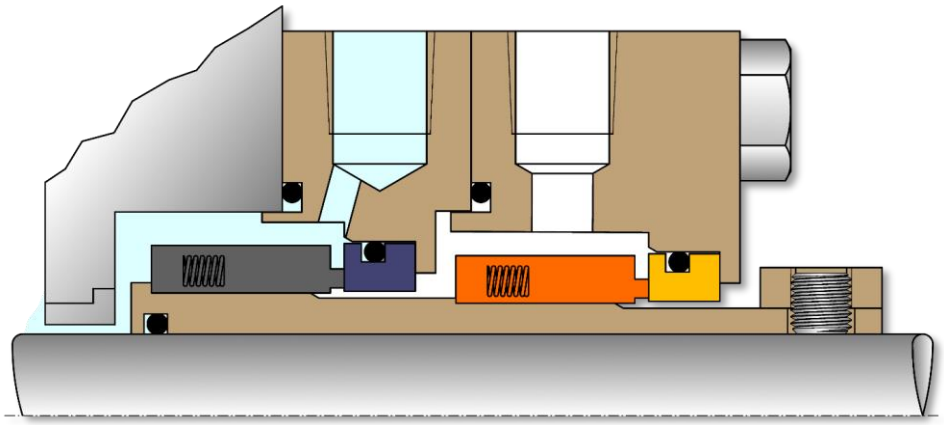
Advanced technology single seals

Application of advanced sealing technology has enabled the development of reliable single mechanical seals, which can give Low leak rates (and so low emissions) close to those of some dual seal installations. The technologies employed include

- highly sophisticated finite element and other modelling techniques for optimisation of component shapes
- computational fluid dynamics

- specific and specialised materials
- improved tribological properties with rubbing face surface profile adjustments
- pre-set packaged assemblies to eliminate fitting errors.
  A further essential factor, in support of the enhanced performance and reliability of new seal technologies, is the performance testing capability of reputable seal manufacturers.

Single seals with a mechanical containment seal (dual unpressurised seals)
For applications where hazard containment is required from the single seal arrangement, it is usual to include some form of external containment device to allow collection of any abnormal levels of vapour leakage and, where required, warn operators through a pressure induced alarm system.
There are many kinds of secondary containment devices, including fixed or floating bushing and lip seals (spring energised or pressure energised). The space between the mechanical seal and some types of secondary containment device can be filled with a fluid to provide an environment where degradation or crystallisation of leakage is prevented.
The simple application of a single seal, to contain the process fluid, is attractive to operators but where the process fluid is a VOC and emissive leakage to the atmosphere must be kept extremely low, it is common to include a second mechanical seal outboard of this primary seal. This provides a far more effective containment device than bushings.

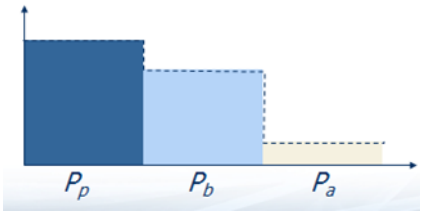


VOC leakage entering the containment chamber between the two seals can then be channeled to a plant flare or vapour recovery system.

Dual mechanical Seals
Dual mechanical seals have two sets of seals operating together in a single unit and separated by a buffer or barrier fluid. The original concept of a dual seal, took two component mechanical seals and placed them ‘Back to Back’ within the seal chamber. Modern designs can be orientated Face to Back, Back to Back or Face to Face, the arrangement being chosen to suit the application.

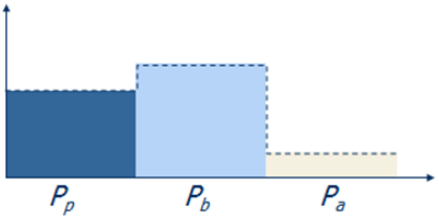
Dual seals are categorized by hydraulic orientation.

Dual Unpressurised seals utilise a buffer fluid where the pressure is lower than the process pressure.



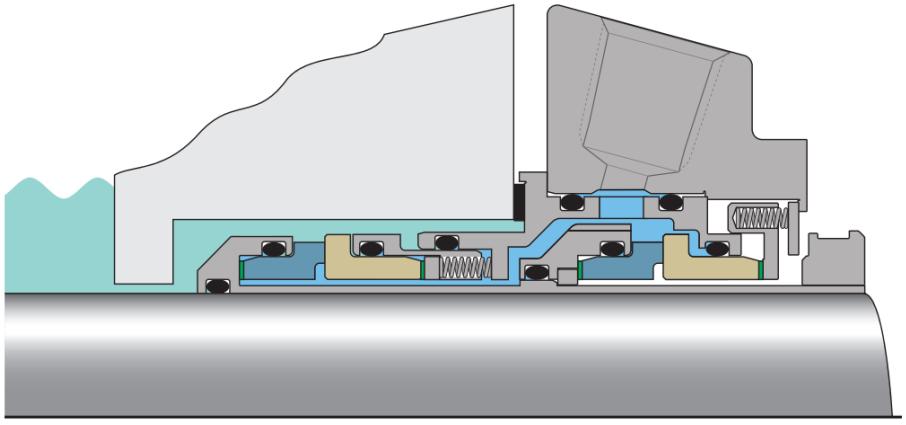
- Sealing of (high) process pressures
- Allows venting (flaring) of pumped fluid
- Provides redundancy in case of failure (back-up)
- Process fluid lubricates the inboard faces
- Associated API plans: 52, 55

Dual Pressurised seals utilise a barrier fluid where the pressure is higher than the process pressure.



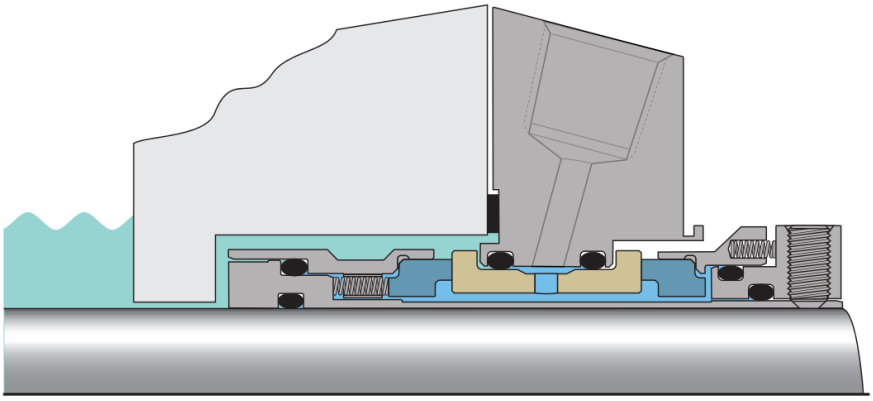
- Full Containment of pumped fluid
- Barrier fluid lubricates inboard and outboard seal faces
- Associated API plans: 53A, 53B, 53C, 54

Dual Unpressurised (tandem) seal arrangements



Although different technologies exist, most dual unpressurised seals fill the containment chamber with a separate buffer liquid that is piped to and from an adjacent reservoir. Flow is induced around the circuit, both lubricating the containment seal and assisting the channeling of VOC leakage into the buffer-fluid reservoir, where it is separated from the carrier buffer liquid. Ordinarily there is a connection from the top of the reservoir to a plant flare or vapour recovery system together with an orifice and an alarm to warn of deterioration in the performance of the primary seal. This is referred to as flush Plan 52

Dual pressurized (double) seals with a separate barrier system



This solution consists of two seals with a barrier fluid (liquid or gas) between them operated at a pressure greater than the process stream. Any leakage (outboard to atmosphere or inboard to the process stream) is of the barrier fluid so selection of a safe barrier fluid compatible with the process stream is essential.

This type of seal arrangement is useful for sealing

- process fluids with poor lubricating properties, where single seals are unreliable
- where process fluids may change frequently (such as in pipeline services)
- when the process fluid is particularly hazardous.

Dual pressurised systems virtually eliminate leakage of the process fluid into the environment and typically have emission values approaching zero, usually described as ***'not measurable with existing instrument technology'***. Liquid lubricated mechanical seals typically use water or a light lubricating oil as the barrier fluid supplied from a self-contained support system. Gas lubricated designs utilise a convenient plant gas source such as Nitrogen managed by a control system. This former is referred to as flush Plan 53 or 54 and the latter flush Plan 74. The simplicity and very low energy consumption of dual pressurised gas seals has been a strong driver in the growth of this technology in recent years.

Gas Lubricated Dual Seals

At the time of the original work on STLE SP-30 and ESA 005/95, dual seal designs in use in process plants were almost always liquid designs. Over more recent years, gas seals have become more common.

Gas seals are a variation of dual mechanical seals whereby the liquid barrier fluid is replaced by a dry, pressurised gas. Typical barrier fluids used in gas seals include nitrogen, steam, purified air or other inert gases. Contrary to dual mechanical seals using a liquid barrier fluid, a barrier gas does not provide the required lubrication to keep the seal faces running cool. Gas seals operate differently, by generating a gas barrier film. This gas film is generated through shallow, step height, changes on the face to squeeze the film and generate fluid pressure. Gas seals eliminate leakage of the process fluid into the environment and are recognised as zero-emissions technology.