



## Application of Double Vs Tandem Dry gas seal Advantages.

---



### **John Sears**

WW Director, Compressor Products.  
Flowserve Corporation.  
Unit #2207, 220 Fisher Street, SE, Calgary,  
Alberta, T2H 2H8 Canada;

*World Wide Director at Flowserve Corporation. John has over 40 years of experience in Oil and Gas Industry; over 30 of them were dedicated to application of dry gas seals and magnetic bearings. John was involved in the first application of the above in Nova Corporation. He participated in further development of these technologies as one of the founders of Revolve Technologies. John has co-authored numerous papers related to dry gas seals and magnetic bearings that were presented at ASME, Turbo-Machinery Symposium and Pipeline Conferences.*



### **Vladimir Bakalchuk**

Global Technology Transfer Lead,  
Flowserve Corporation,  
2100 Factory Street,  
Kalamazoo, MI, 49000 USA,

*Global Technology Transfer Lead at Flowserve Corporation. With over 35 years of experience in various fields of Oil and Gas Industry, Vladimir has spent over 20 years specializing in Dry Gas Seal / Rotating Equipment. Vladimir predicated his career in various technical capacities by Ukrainian Academy of Sciences, Mechanical Engineering Department of University of Calgary, Brown-Root-Braun, Nova Gas Transmission, Canadian Fracmaster, Revolve Technologies and John Crane. Vladimir is a registered Professional Engineer in the province of Alberta, Canada.*



### **Detlev Steinmann**

Director of Engineering  
Flowserve Corporation  
Flaspoete 101, D-44388 Dortmund, Germany,

*World Wide Head of Compressor Seal Engineering.*

*Detlev is a 1985 graduate from the University of Dortmund, Germany with a B.Sc. degree in Mechanical Engineering . He started his career 28 years ago in the engineering department of the Flowserve Corporation in Germany . From early days Detlev specialized in Dry Gas Seal technology , including the development of High Pressure Seals for the industry . After leading the development group and the test facility in Dortmund , Germany , in his current position , Detlev and his specialized engineering team are responsible for the compressor seal technology covering R&D, design, testing, standards, training and troubleshooting support*



### **S.P. Asokan**

Manager Compressor Systems &  
Technical Services Asia Pacific.  
Flowserve Corporation  
33 Changi South Avenue  
Singapore – 486 445,

*Heading Compressor Systems Engineering and Manufacturing for Flowserve Asia Pacific. SP Asokan has over 30 years of experience in field of Petrochemical Process & Engineering Mechanical seal & systems. He Specialized in API seal support systems Design & Manufacturing for the last 18 years for both Pump & Compressor seals for John Crane in the past and currently for Flowserve with the experience of over 350 Dry Gas Seal Support systems for various global OEM & End Users.*

---

## ABSTRACT

Traditionally double seals have been used for low pressure applications when nitrogen gas at pressure higher than process was available for sealing. Double seals were not applied to low pressure processes where process contamination by nitrogen was not permitted.

In these cases application of the process gas for sealing in a

double seal was considered “unsafe” and the preference was given to a tandem seal.

In recent years this approach has been re-evaluated and additional steps to insure safety in case of a secondary seal failure undertaken. Since both tandem and double seals can be used for applications with sealing pressure below approximately 40 bar, what benefits are to be gained by double seal application?



Double seal arrangement, among other things, allows for system simplification and more reliable operation, significant reduction of sealing gas volumes, prevention of seal reverse pressurization and shorter in-between the bearings shaft span. A possibility of secondary seal failure and prevention of uncontrolled process gas emission can be addressed in a variety of ways - from incorporation of flow restriction to utilization of separation seal as safety seal.

## INTRODUCTION

### Tandem Seal Systems:

Tandem seal configuration consists of two single seals in tandem arrangement. Newer, reduced emission configuration also incorporates an “intermediate” labyrinth between two seals (Fig 1). In tandem seal configuration, the sealing gas is supplied between the process side seal and primary. Source of the sealing gas is usually compressor discharge. The gas undergoes quality conditioning (liquids and particulate above 3 micron are removed, temperature maintained to 20°C superheat) and volume or pressure regulation by the support

system (Fig. 2). The sealing gas is injected into the seal. A small amount of gas (1 to 2 %) leaks between the seal faces with the remaining volume flowing through the process side labyrinth into compressor cavity creating a barrier that prevents dirty process gas in compressor cavity from entering the seal. Primary seal leakage enters the primary vent cavity where it is directed into the primary vent by flow of inert gas applied to secondary seal supply.

The primary vent is monitored for the leakage volume; the latter being indication of the seal health. The secondary seal is pressurized by inert gas and its leakage leaves the seal via secondary vent that contains the above mentioned leakage and part of separation seal leakage, i.e., just inert gas. Traditionally, the secondary vent has not been monitored. Recent requirements for the secondary seal monitoring necessitate in some cases placement of flow monitoring devices in the secondary vent. To prevent bearing oil migration, a separation seal is employed between the dry gas seal and an oil bearing. Separation gas is usually an inert gas or air.

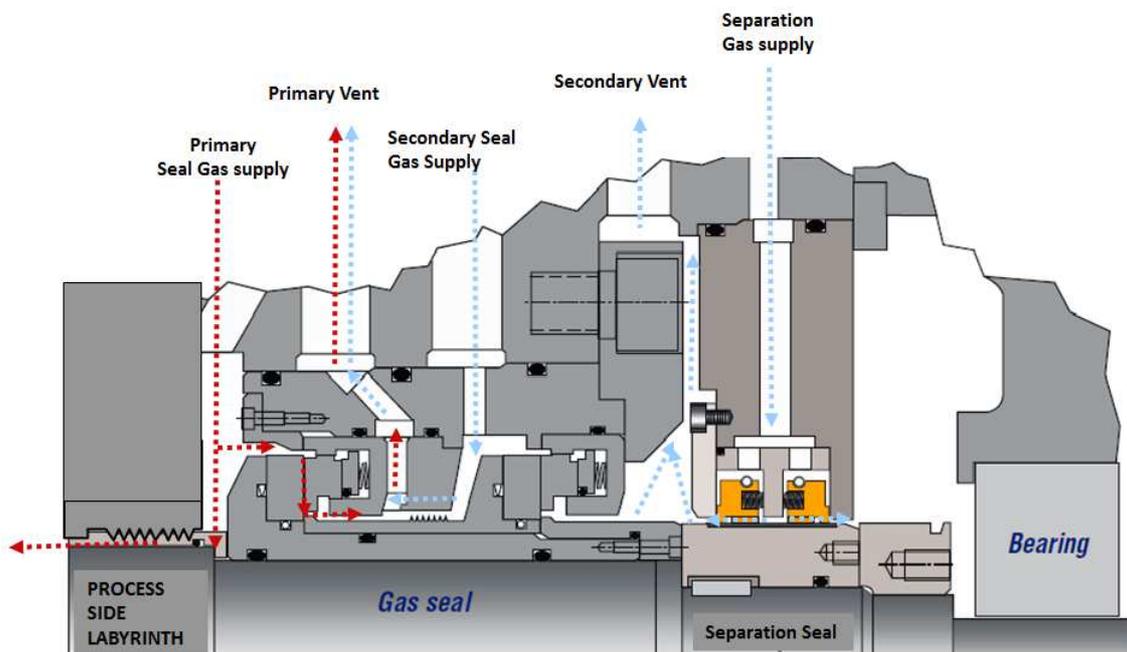


Fig-1 : Tandem Seal with Intermediate Labyrinth and Separation Seal

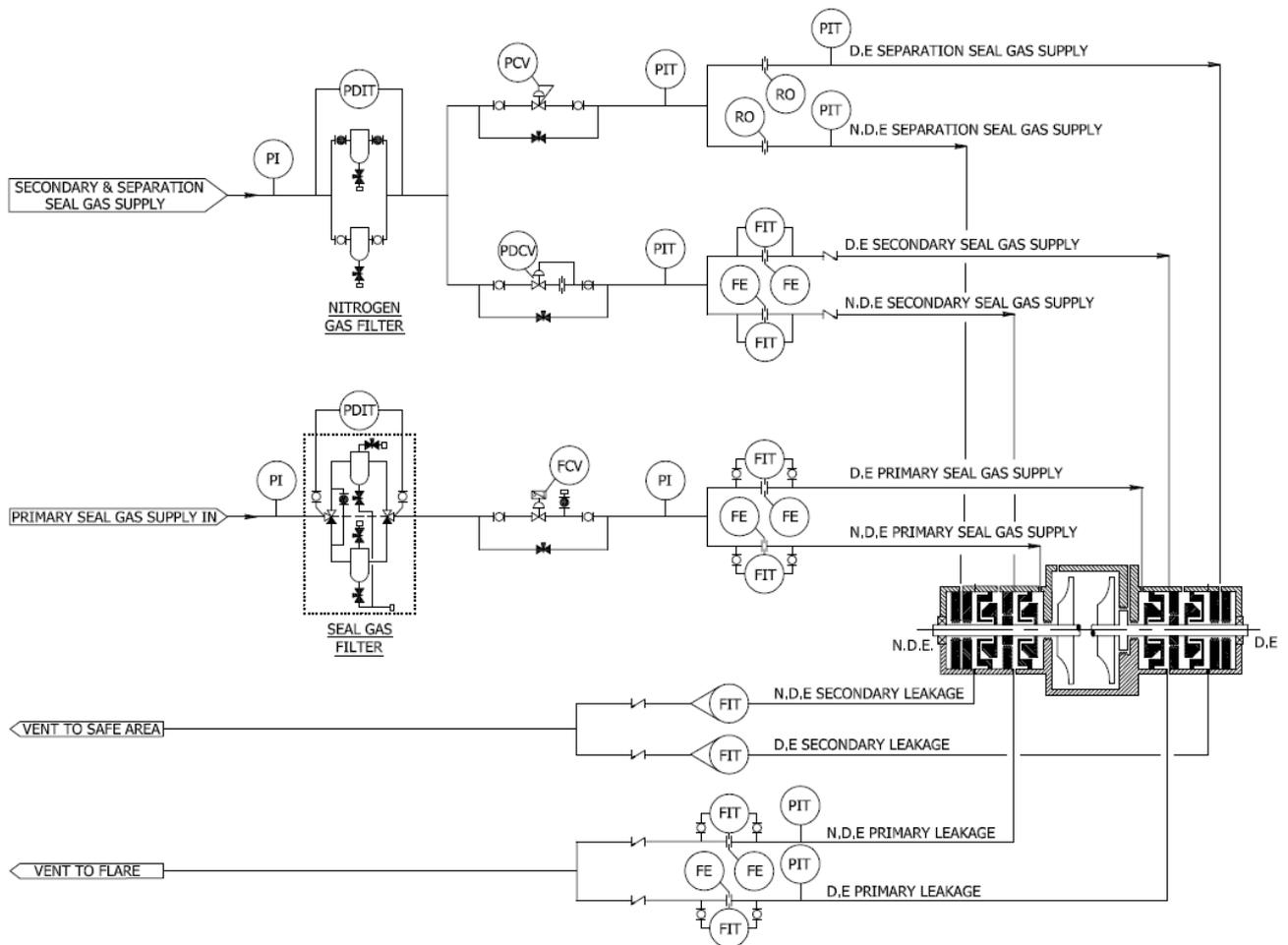


Fig-2 : Tandem Seal support system



**Double Seal Systems:**

Double seal configuration consists of two seals in back-to-back arrangement (Fig 3.).

The seal supply leaks between the faces of both seals and exits towards the process (primary seal leakage) and towards the vent cavity (secondary seal leakage).

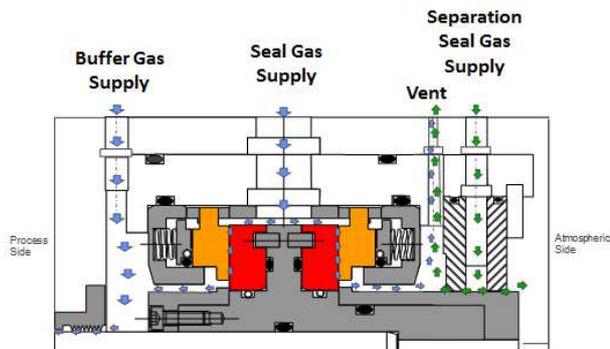


Fig-3 : Double Seal

As the primary seal leakage is very small, to keep the seal free of contamination, a roughly conditioned buffer gas (liquid and particulate above 10 μ removed) is supplied into the cavity between primary seal of the double seal arrangement and process side seal (usually a labyrinth). Buffer gas is regulated to provide a flow through the process side seal into the compressor cavity at a velocity of about 5 m/s. As all the sealing gas exits the seal in the form of the leakage, health of both seals in double seal arrangement is monitored by the pressure or volume of sealing gas supply. Vent flow monitoring is optional. A double seal support system is shown on Fig 4a and 4b.

In double seal configuration, conditioned sealing gas (liquids and particulate above 3μ are removed, temperature maintained to 20°C superheat) is supplied between two seals.

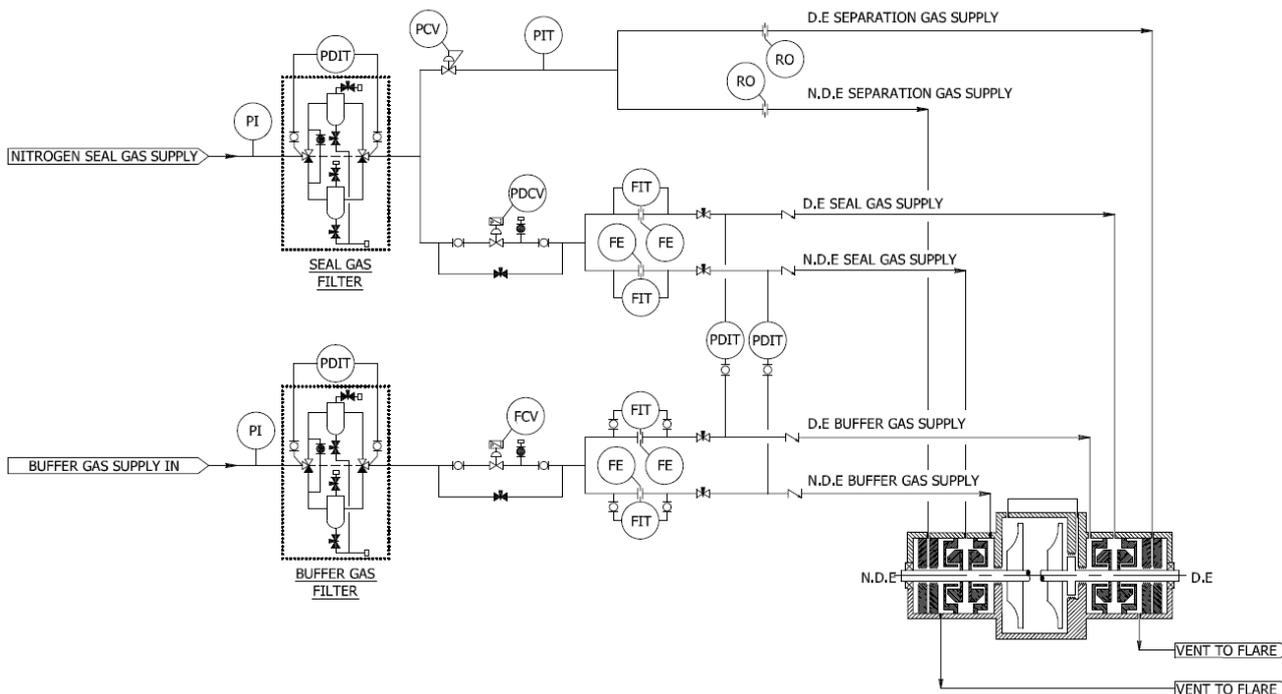


Fig-4a : Double Seal support system with Nitrogen as Seal Gas Supply

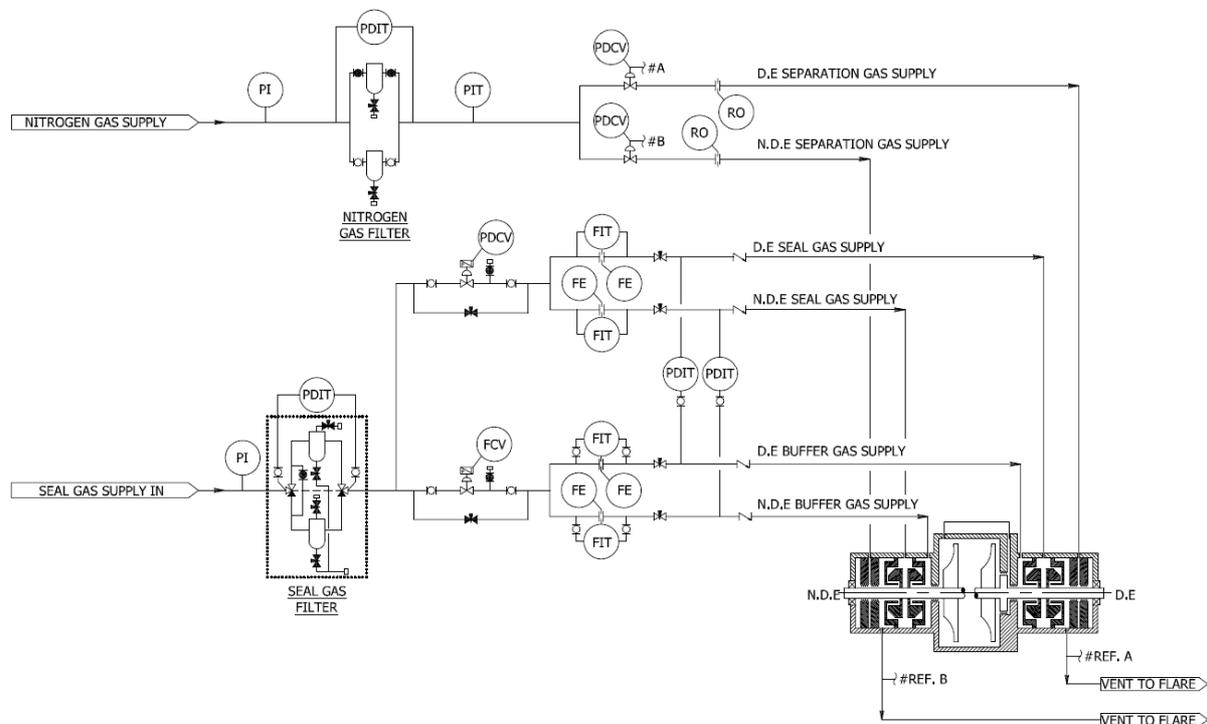


Fig-4b : Double Seal support system with Process Gas as Seal Gas Supply

**Seal Application:**

In applications where the sealed (process) gas is hazardous or poisonous, industry standards require a compressor seal to contain a secondary or back up seal in case of primary seal failure. Both tandem and double seal consist of primary and secondary seals and are compliant with this regulation.

Current seal design allows utilization of the tandem seal arrangement for the pressures of up to 650 bar. Tandem seal performs well in applications where the sealing gas is properly conditioned and seal reverse pressurization is avoided. Reverse pressurization of the seal occurs when the pressure on the OD of the sealing faces is below pressure on ID, i.e., sealing gas supply pressure ( $P_{sg}$ ) is less than vent pressure ( $P_v$ ) (Fig 5.) Applications most prone to seal reverse pressurization are low pressure applications where suction pressure is similar in magnitude to the vent pressure. In these

applications precaution has to be taken to avoid reverse pressurization.

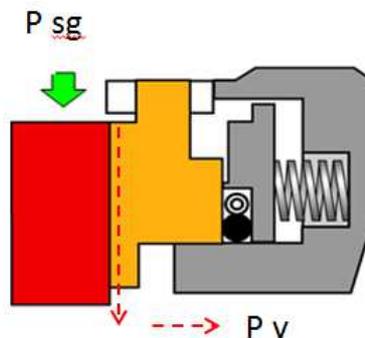


Fig-5 : Pressures acting on Dry Gas Seal



Due to a small volumetric consumption of the sealing gas, gas supply to the double seal can be provided at a pressure much higher than the sealed (suction or flare) pressure, thus enabling a significant buffer against reverse pressurization. This differential provides an ample warning range, should either primary or secondary seal fail and sealing pressure cannot be maintained. It also provides effective means of secondary seal monitoring. Rotating sealing faces of a double seal are placed in “back to back” position. This design and a small quantity of available cooling gas (seal leakage) that passes through the seal limits dissipation of heat generated in shear of the sealing gas. As a result, common applications of double seals are limited by pressure to around 35 to 40 bar. It is essential to keep in mind that double seal arrangement is shorter in length than a tandem and requires 4 ports compared to 5 for Tandem with an intermediate labyrinth. Thus, this seal is ideal for oil seal retrofits.

Nitrogen has been traditionally used as a sealing gas for double seal application. Due to the purity of the gas, seals that use Nitrogen as a sealing medium are expected to fail less than ones sealed with the process gas. Since a small amount of nitrogen seal leakage enters compressor cavity, double seal with nitrogen seal supply cannot be used in processes that are completely nitrogen intolerant. Majority of other processes can easily tolerate injection of one to two normal cubic meters per hour of nitrogen.

In recent years double seals have been used with the process gas as a sealing medium. In what cases such application becomes beneficial?

#### **Double Seal Failure Scenarios:**

Currently the main reasons behind tandem seal application for sealing low pressure process are:

1. Process incompatibility with N<sub>2</sub> injection

2. Assumption that failure of the secondary seal in double seal configuration sealed by process gas would lead to process gas ingress into bearing cavity and then into atmosphere.

To overcome issue number 1, one should consider application of the process gas as a sealing medium. To illustrate proposed solution, let's consider a propylene refrigeration compressor with atmospheric suction, 20 bar discharge and vent routed to the flare system with maximum pressure of 1 bar. Compressor shaft under the seal is 225 mm.

#### **Double Seal Application:**

For double seal application seal supply pressure is selected to be 3 bar, 2 bar higher than greater of suction or maximum flare pressure. Since the discharge of the compressor is 20 bar, it can be used as source of sealing gas for a double seal pressurized at 3 bar. Assuming that seal guaranteed leakage is 30 NI/min @ 3 bar, total seal gas supply at a shutdown condition would be 300 NI/min @ 3 bar (2 seals at 30NI/min x 5 x guaranteed leakage, which is the HH alarm - shutdown value).

In case of the issue number 2, let's keep in mind that separation seal (close clearance carbon ring bushing) is rated at 8 bar. This seal supplied by nitrogen via differential pressure regulator with a sensing line connected to the vent would insure that supply pressure to the separation seal is always higher than the pressure in a vent cavity. Thus, the process gas that ingresses into the vent cavity during normal operation and the in a case of the secondary seal failure will be directed into the seal vent connected to the flare.

Double seal supply lines should be designed for the seal supply flow of a maximum of 300 NI/min @ 3 bar. Utilizing conservative approach to line sizing: 0.75” seal gas supply pipe splitting into 0.5” individual seal lines will be required and filter sized to 300 NI/min flow. The buffer gas flow to achieve the velocity of 5 mps through the process side labyrinth would be around 220 NI/min @ atmospheric pressure.



**Tandem seal application:**

Let's assume that guaranteed seal leakage for 225 mm seal @ 3600 rpm and 2 bar pressure is 20 NI/min. Setting shutdown flow in the primary vent at 100 NI/min + 100 NI/min of N2 = 200 NI/min flow. 200 NI/min at mean specific gravity at shutdown would build a differential pressure of 0.5 bar going through the metering orifice plate. That means that to avoid reverse pressurization, maximum expected pressure in the seal gas supply cavity should be higher than a sum of dP across the orifice, cracking pressure of the check valve and maximum flare pressure, i.e., 1.7 bar. To prevent reverse pressurization at a worst possible scenario - maximum flare pressure associated with deteriorating primary seal leakage, a pressure

higher than 1.7 bar would have to be created in a seal gas supply cavity (See Figure 5). To build that pressure in the seal supply cavity, a flow of 300 Nm3/hr (5000 NI/min) will be required at nominal clearance of the process side labyrinth. The flow doubles if double open clearance, as per relevant industry standards, is assumed. To keep gas velocity in a pipe below 50 m/s, a 3" pipe will be required up to a split into individual seal supplies, which then reduces to 2". The compressor seal supply ports would also have to be at least 2" in diameter. The filter canister and element will have to be sized for the flow of 1200 Nm3/hr.

**Conclusion:**

Let's compare the results of Seal Gas Flow Comparison Tandem seal Vs Double Seal.side by side:

	Tandem Seal	Double Seal
Flow though sealing gas supply system (filters, control valves, isolation valves, etc.) [Nm3/hr]	1200	18
Line size before individual seal supply split	3"	0.75"
Line size of individual seal supply line	2"	0.5"
Sealing gas supply port size	> 2"	> 0.5"
Buffer Gas Supply Volume [Nm3/hr]	N/A	13.2
Bearing Cavity / Atmosphere Isolation from the process gas in case of a catastrophic seal failure	YES	YES

Table-1 : Seal Gas Flow Comparison Tandem seal Vs Double Seal.

Therefore, application of double seal with process gas being used for sealing offers significant advantages over tandem seal. The benefits are smaller support systems and compressor

ports, smaller recirculation and thus better compressor efficiency and prevention of possibility of seal reverse pressurization.

**NOMENCLATURE**

- mm* = Length
- bar* = Pressure
- Nm3/hr* = Flow
- $\mu$  = particle size in micron
- m/sec* = velocity



**ASIA TURBOMACHINERY & PUMP SYMPOSIUM**  
**SINGAPORE | 22 - 25 FEBRUARY 2016**  
**M A R I N A B A Y S A N D S**

**REFERENCES:**

- 1) API Standard 617 Axial and Centrifugal Compressors and Expander compressors
- 2) API Std 614 Lubrication, Shaft-sealing and Oil-control Systems and Auxiliaries, Fifth Edition

**ACKNOWLEDGEMENTS**

- 1) Flowsolve Corporation.
-