EFRC Training Workshop

Control of Emissions in Reciprocating Compressor Systems

How to cope with Packing Emissions at Different Compressor Layouts

Christian Hold - HOERBIGER

Vienna, Austria

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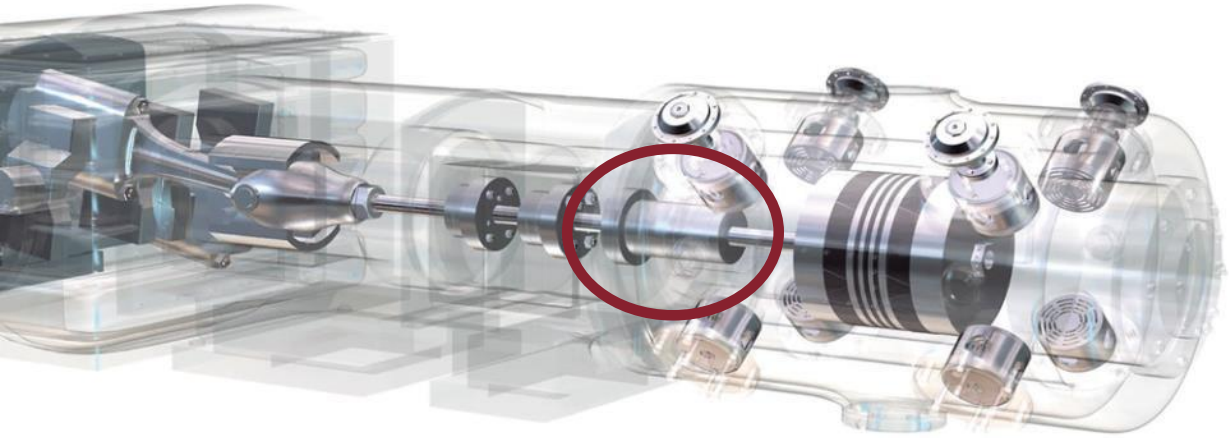
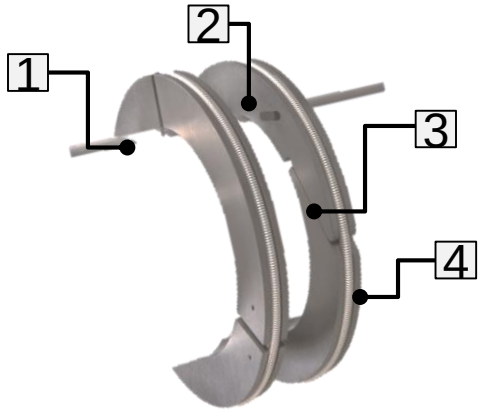
I. Introduction to Sealing
II. Compressor Layouts
III. Field Studies

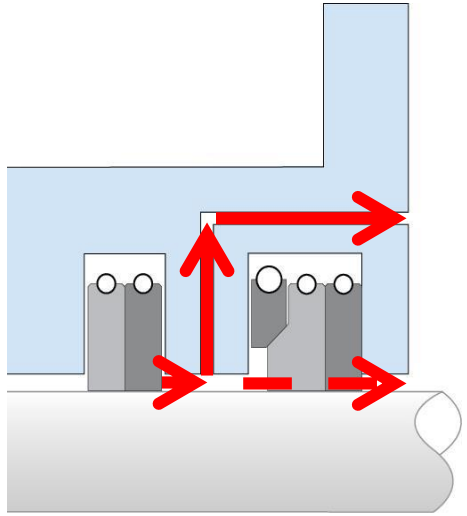
Reciprocating Compressors – chronic leakers?

In terms of emissions the weakest design part of every reciprocating compressor is the packing case

No packing is capable of totally eliminating leakage!







This design weakness is having a major impact on the compressor design!

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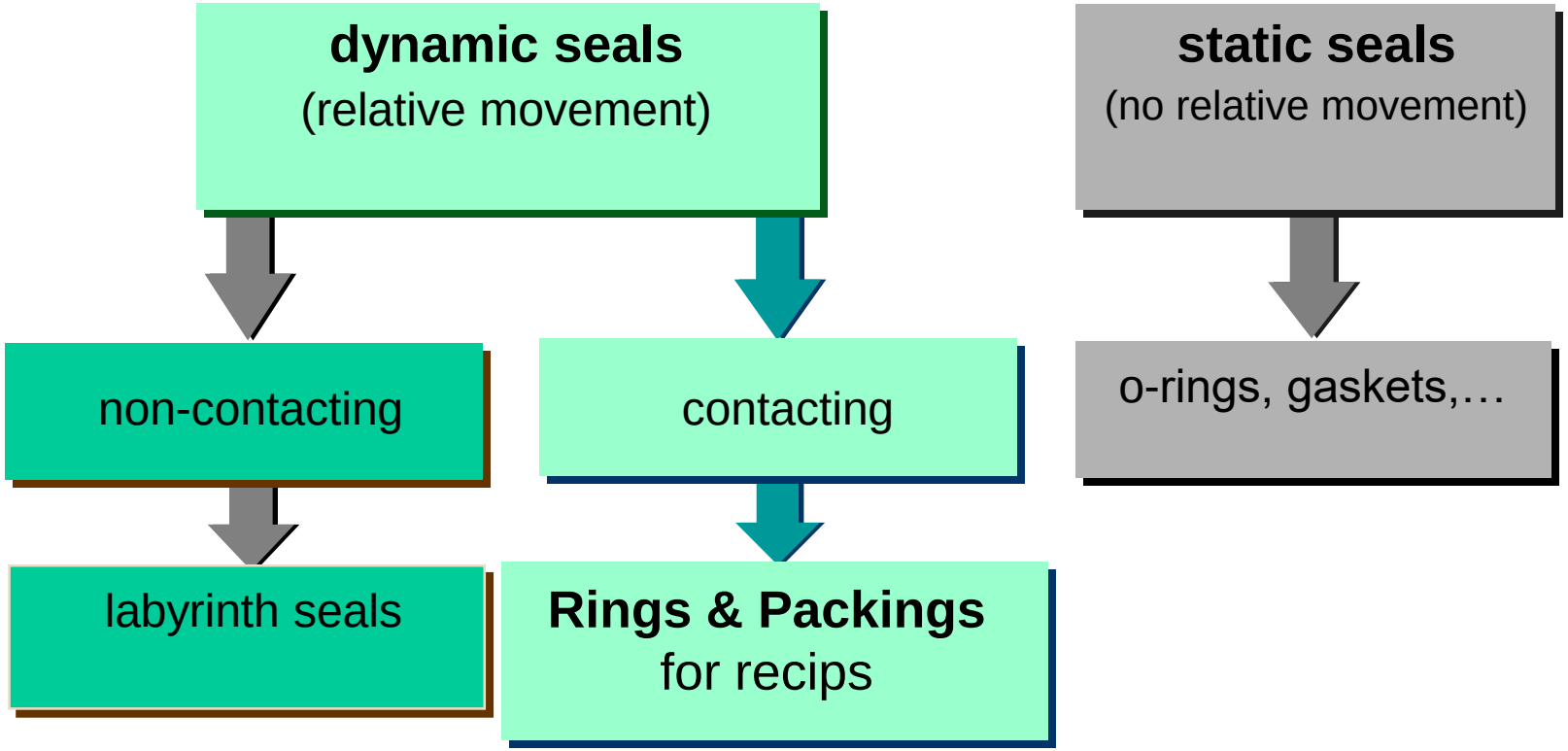
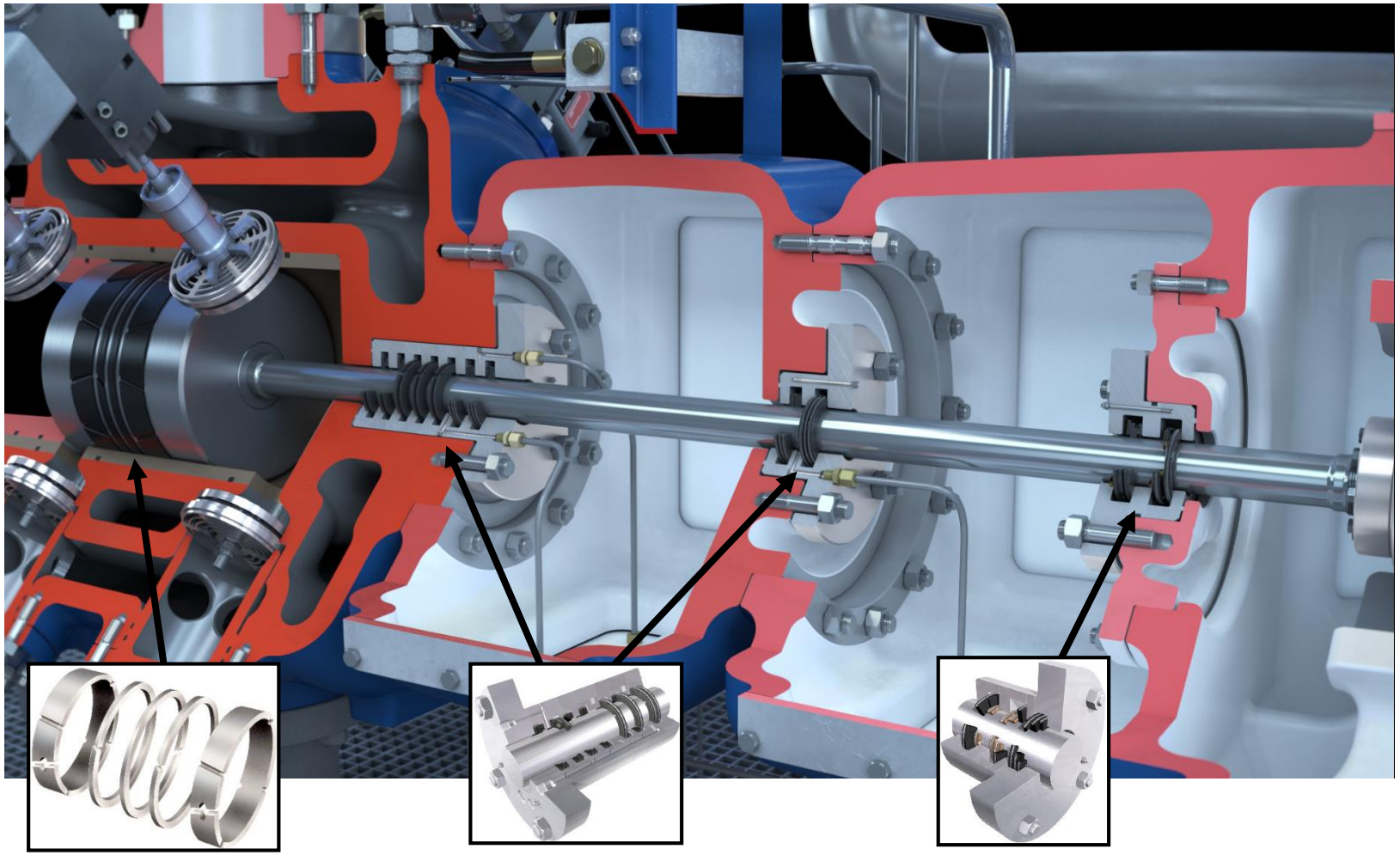
Introduction to seals



How to cope with packing emissions at different compressor layouts



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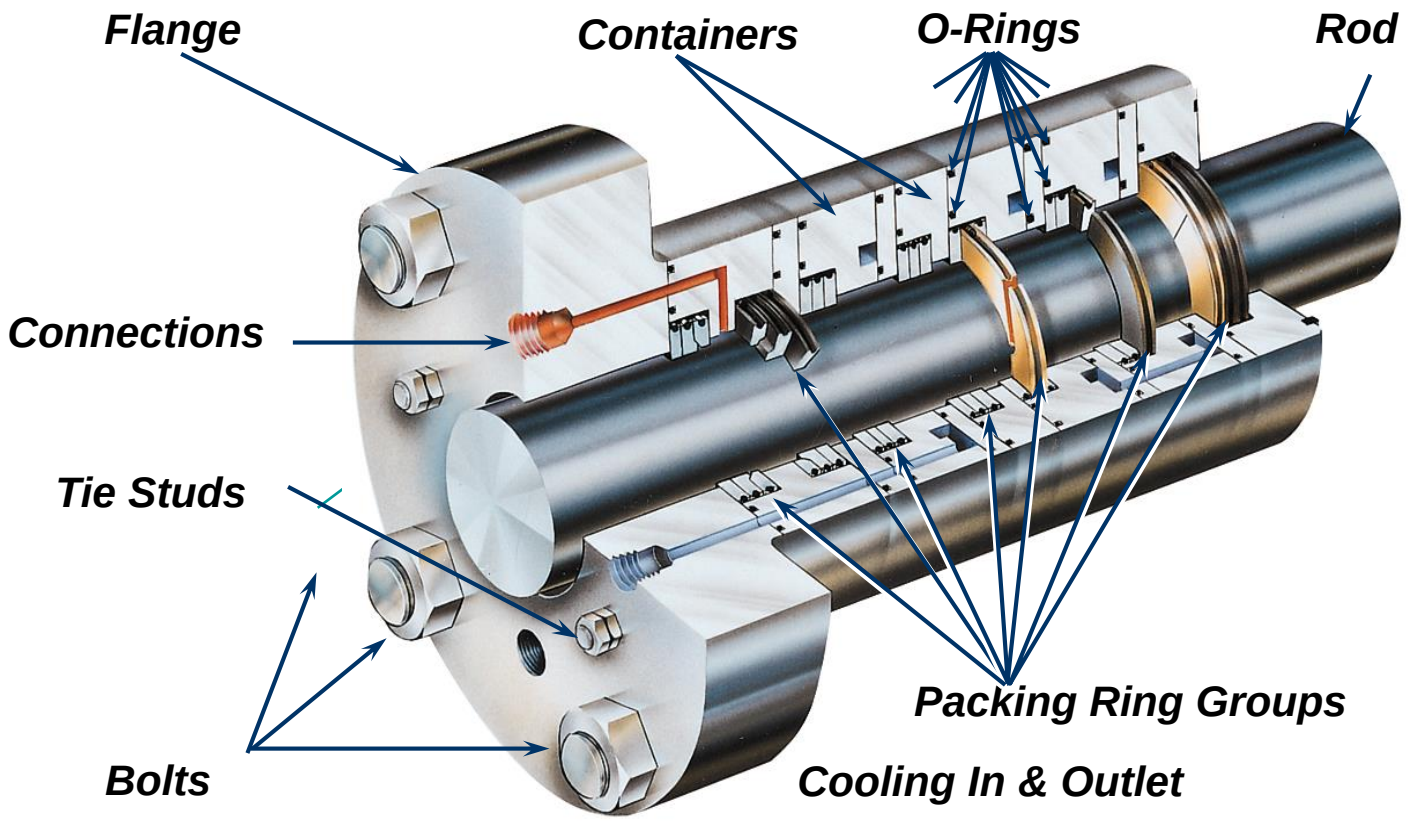
How to cope with packing emissions at different compressor layouts

Function: Seal the compression chamber against the intermediate piece.



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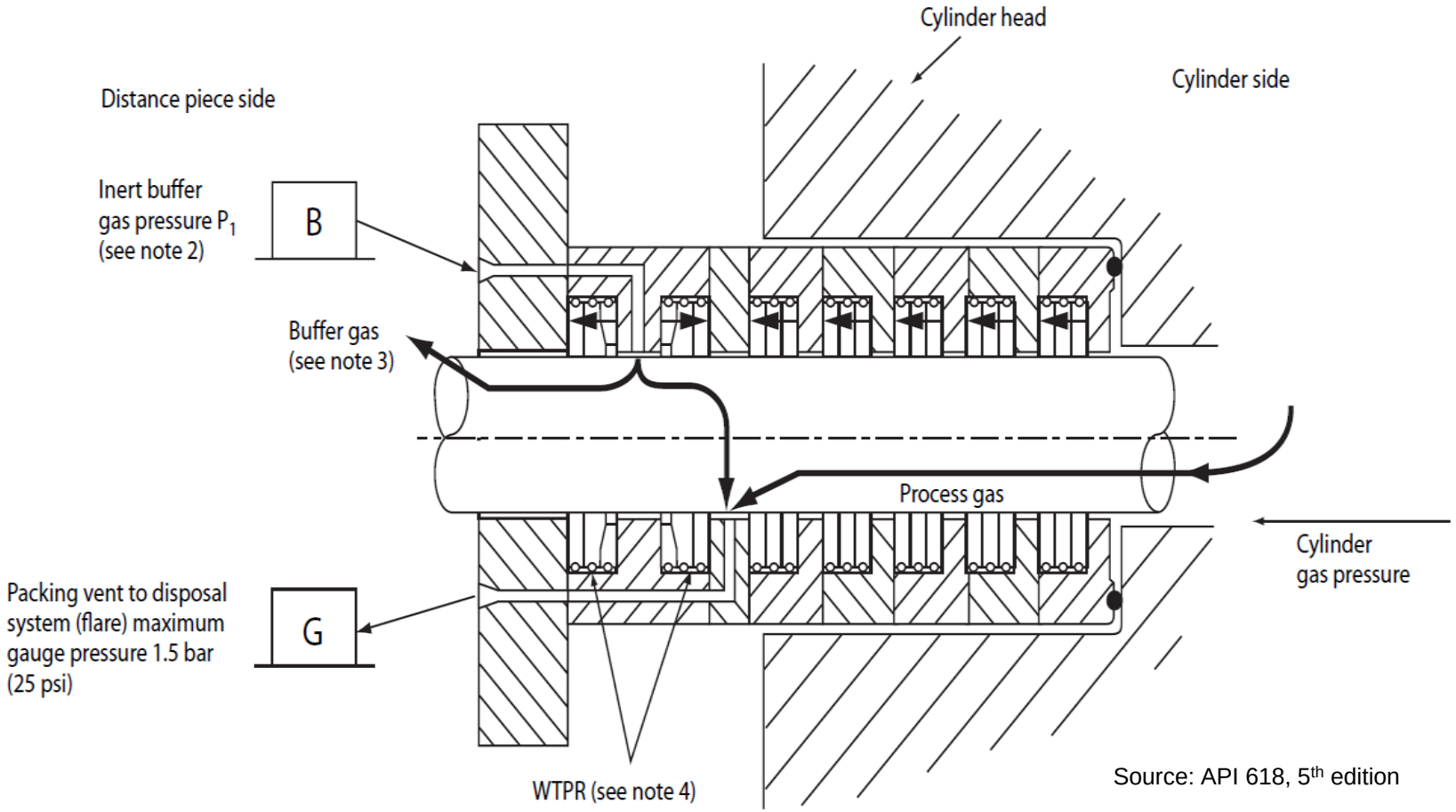
How to cope with packing emissions at different compressor layouts



Source: API 618, 5th edition

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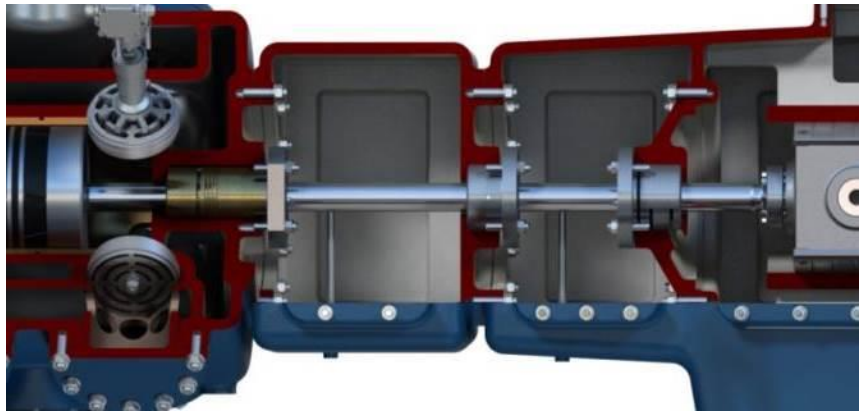
Why do we need distance pieces?



Purpose of distance piece and vent:

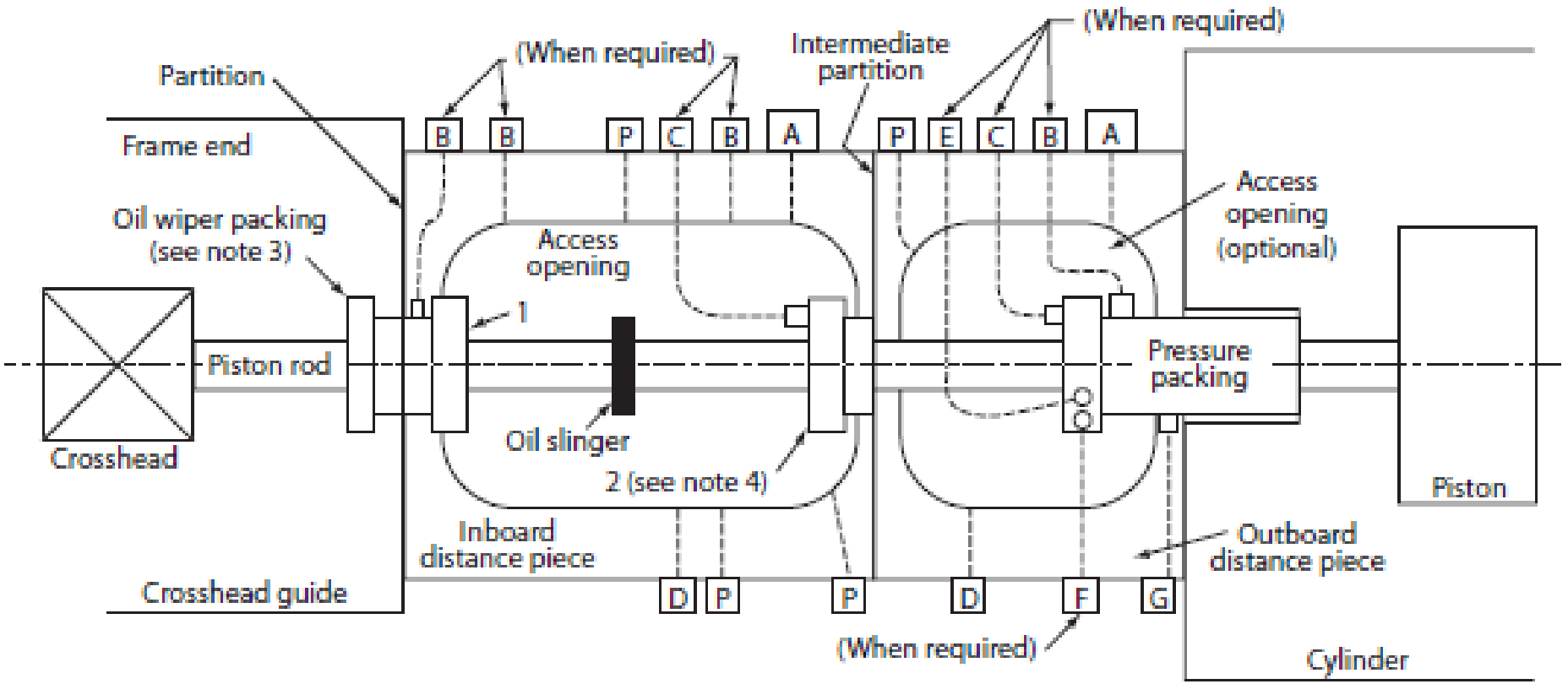
- Confining and collecting of packing case leakages
- Carrying the gas leakage to a safe location
- Preventing gas leaking into the area around the machine

API618 5th edition considers 4 different distance piece arrangements:

- Type A & B – short or long single compartment (lubricated or non-lubricated service)
- Type C & D – long/long or long/short double compartment

  (distance piece designed to contain flammable, hazardous or toxic gases)

How to cope with packing emissions at different compressor layouts



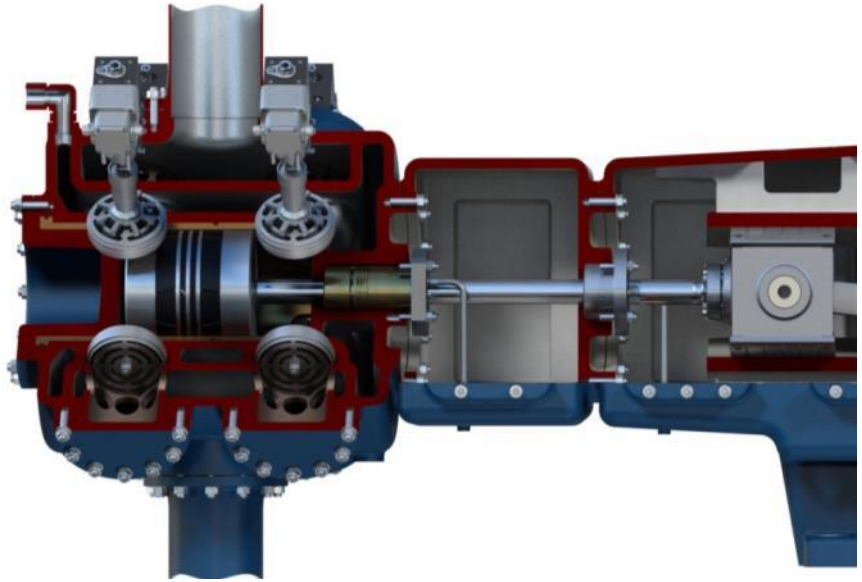
TYPE D

Source: API 618, 5th edition

Typical Natural Gas Compressors with single compartment

Controlling fugitive emissions is the order of the day

- Natural gas has an equivalent global warming potential (GWP) of 28 times compared to the GWP of CO2 based on 100 years!
- ~34% of recip fugitives are caused by rod packing, the „chronic leakers“!

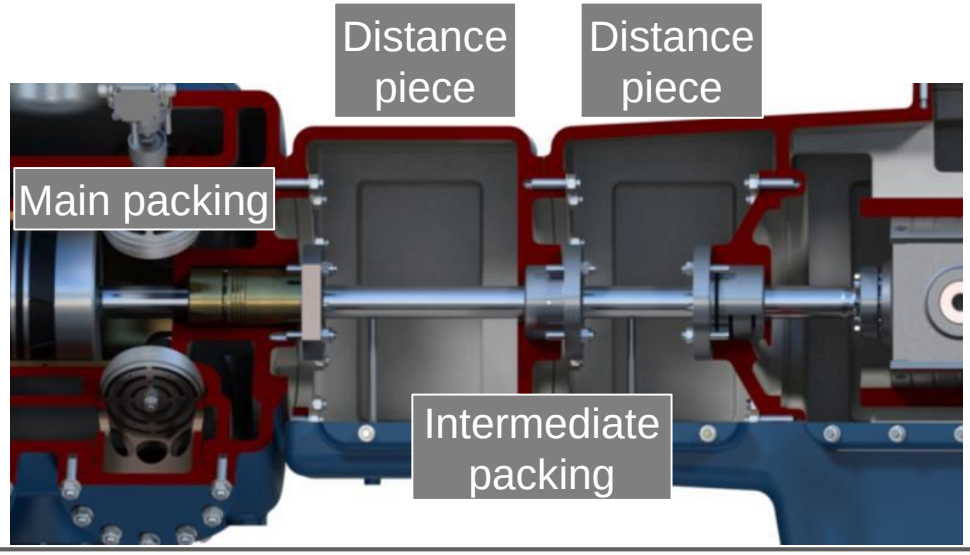


Natural Gas packing challenges:

- Crankcase oil contamination
- Explosive gas mixtures
- Efficiency losses
- Emission & Health

Double compartment Process Gas Compressors

- Double compartment arrangements only reduce the possibility that process gas leaks into the crank case or into the area around the machine.
- Purge gas systems will not have a positive effect on packing leakage rates, it only dilutes packing case leakages to an uncritical level.
- Overall machine efficiency suffers from process gas leakage and purge gas consumption.

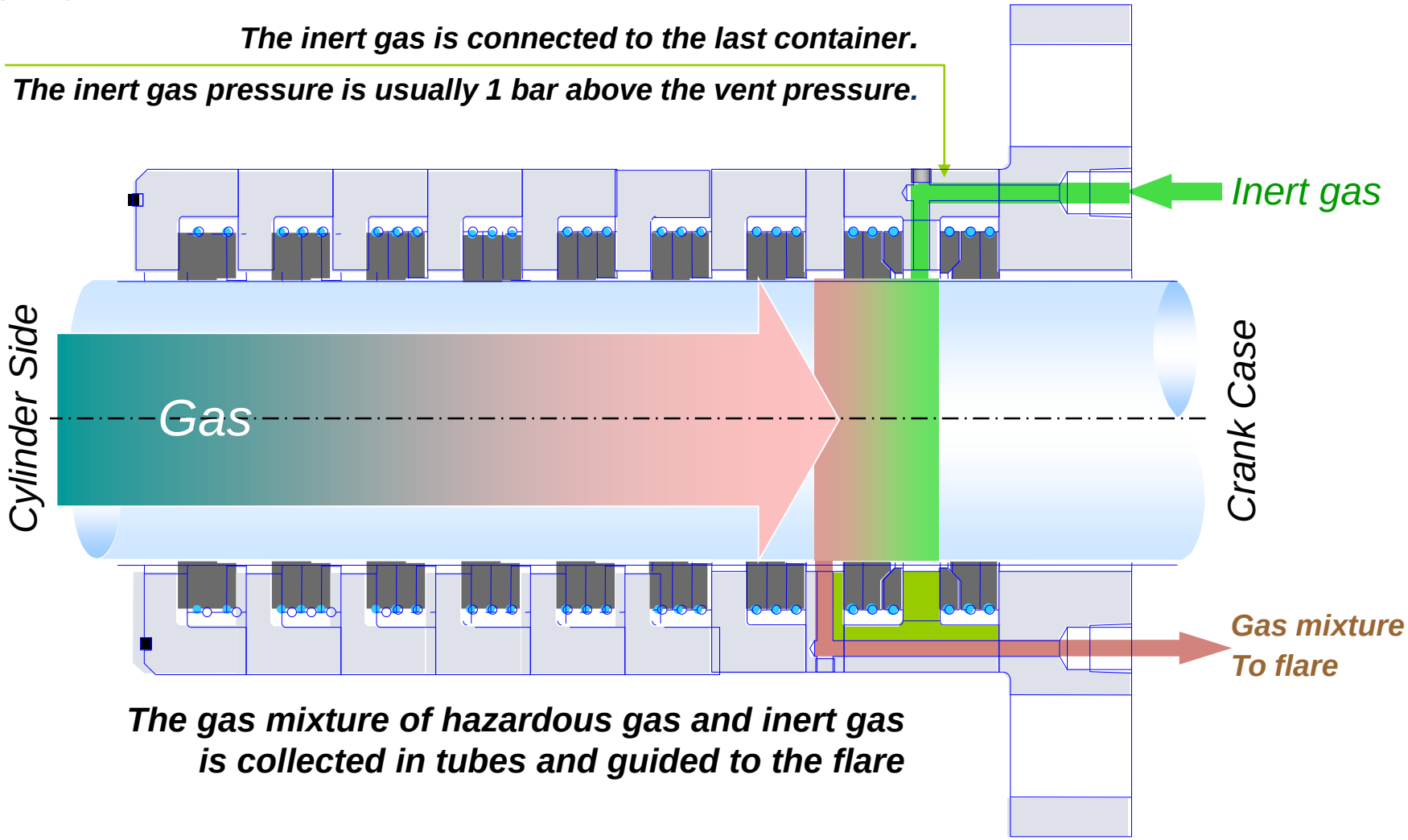


How to cope with packing emissions at different compressor layouts

Purging:

The inert gas is connected to the last container.

The inert gas pressure is usually 1 bar above the vent pressure.



The gas mixture of hazardous gas and inert gas is collected in tubes and guided to the flare

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Impacting parameters on packing leakage

Parameter		Leakage
Packing ring wear	↑	↑
Piston rod diameter	↑	↑
Rider Ring Wear	↑	↑
Discharge pressure	↑	↑
Gas molecular weight	↑	↓
Lubricated packing		↓
Non-lubricated packing		↑

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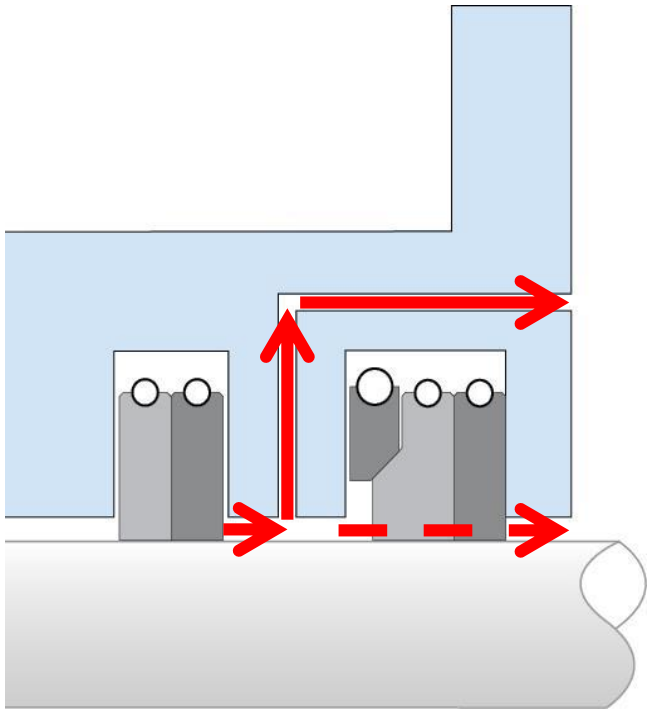
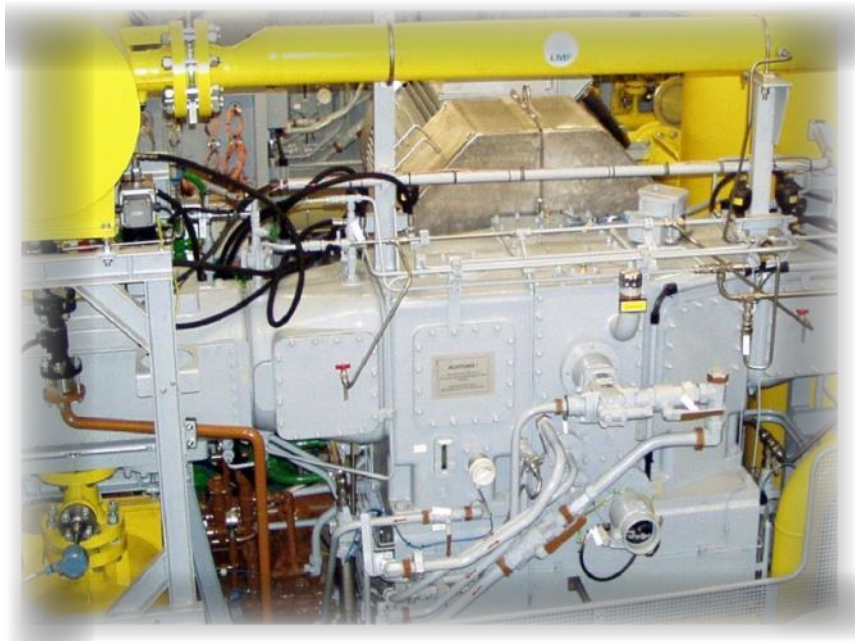
Gaps in API618 specifications

- API doesn't demand buffer gas as necessary
- Only a vent connection on the distance piece is required
- It is up to the end-user to specify purge gas systems
- No standard exists on purge gas systems



High risk of improper designed vent/purge system which can lead to unsafe machine operation!

Field Study Case 1

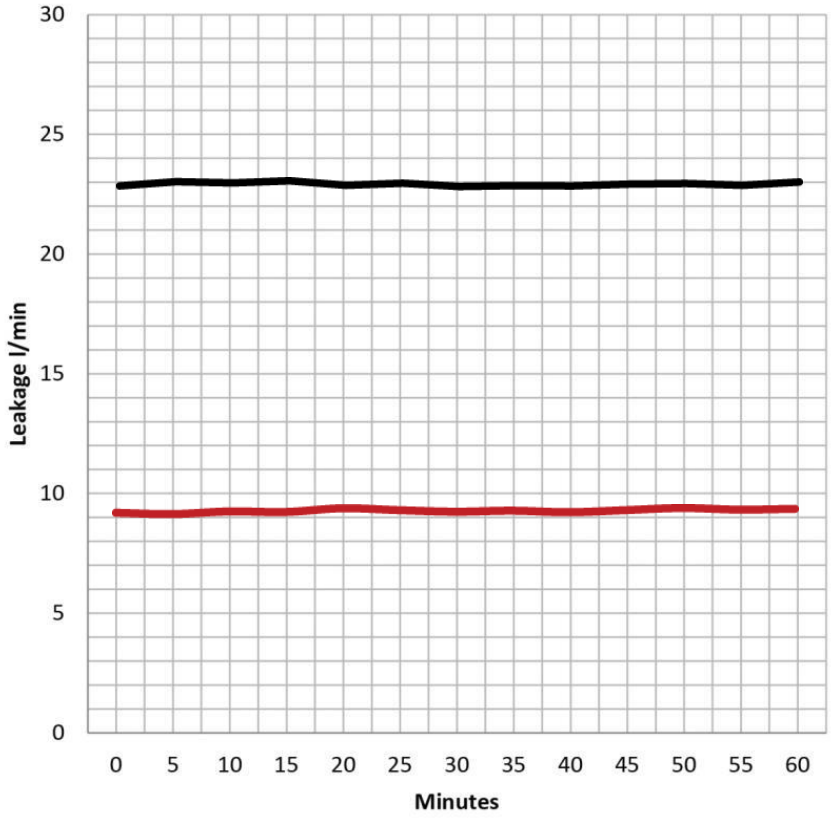


Compressor style:	***Single compartment***
Stages / Cylinders:	***1 / 2***
Pressures:	***12 – 32 bar***
Rod diameter:	***50mm***
rpm / Stroke / Speed:	***740; 150mm; 3,7m/s***

Challenges:

Eliminate gas leakage and save purge gas (N2)
Increased gas leakage at stand still
Total gas losses ~7000m³/year (2 packing cases)
Total N2 purge gas consumption of ~2300 m³/year (2 packing cases)

How to cope with packing emissions at different compressor layouts



Why is the leakage at stand still increasing?

Leakage RGV3 operating

Leakage RGV3 at stand still

Field Study Case 2

In 2013 A major customer commissioned a life-cycle study of ten GE/Gemini wellhead compressors in the Eagleford Shale

Challenges - Produced solids and liquids carry-over typically includes:
sand, paraffin, NGL, saltwater, chemicals and frac fluid in varying volumes.

Goal: To examine how the latest generation of valves & compressor rod seals can…..

a) improve reliability

b) improve emissions - Achieve emissions performance level as good as suggested by EPA – 325l/h

c) Improve operational cost

Compliance with EPA Regulations

1. Includes both Green House Gas (GHG) Methane and Volatile Organic Compound (VOC) gases for new or modified equipment/installations.

   a) Replace rod packing before 26,000 actual run hours or prior to 36 months
   b) Above to be monitored, recorded and reported
   c) Install a negative pressure collection system
   d) Fugitives might be a leaking packing seal and if identified must be repaired within 15 days

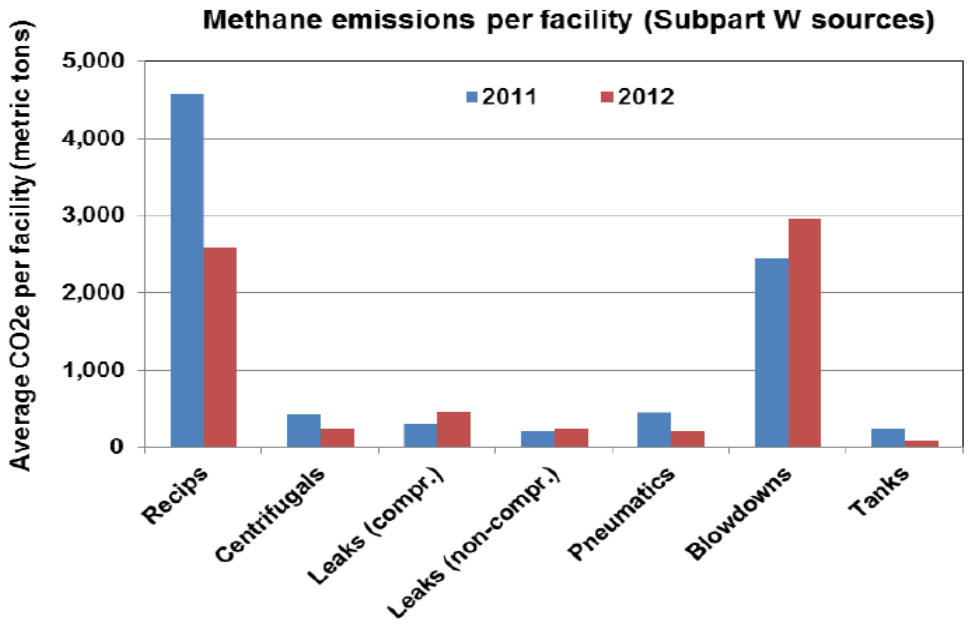
The EPA has recognized Recips are “dirty”

Table 3-3. Summary of GRI/EPA Methane Emissions from Reciprocating and Centrifugal Compressor Seals

Type of Compressor	Average Methane Emission Factor (Mscf/yr)	Activity Factor, Compressor Count	Annual Methane Emissions (Mscf/yr)	Average Methane Emissions (MT/yr)
Natural Gas Production				
Reciprocating	9.48	17,152	162,601	3,071
Natural Gas Processing				
Reciprocating	1,125	4,092	4,603,500	86,949
Centrifugal	342	726	248,292	4,690
Natural Gas Transmission				
Reciprocating	1,307	6,799	8,886,293	167,841
Centrifugal	248	681	168,888	3,190
Natural Gas Storage				
Reciprocating	1,350	1,396	1,884,600	35,596
Centrifugal	189	136	25,704	485
Total			15,978,655	301,799

Report for Oil and Natural Gas Sector Compressors Review Panel April 2014

< 300million tons/year!



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Data Collection - Rod Packing Leakage

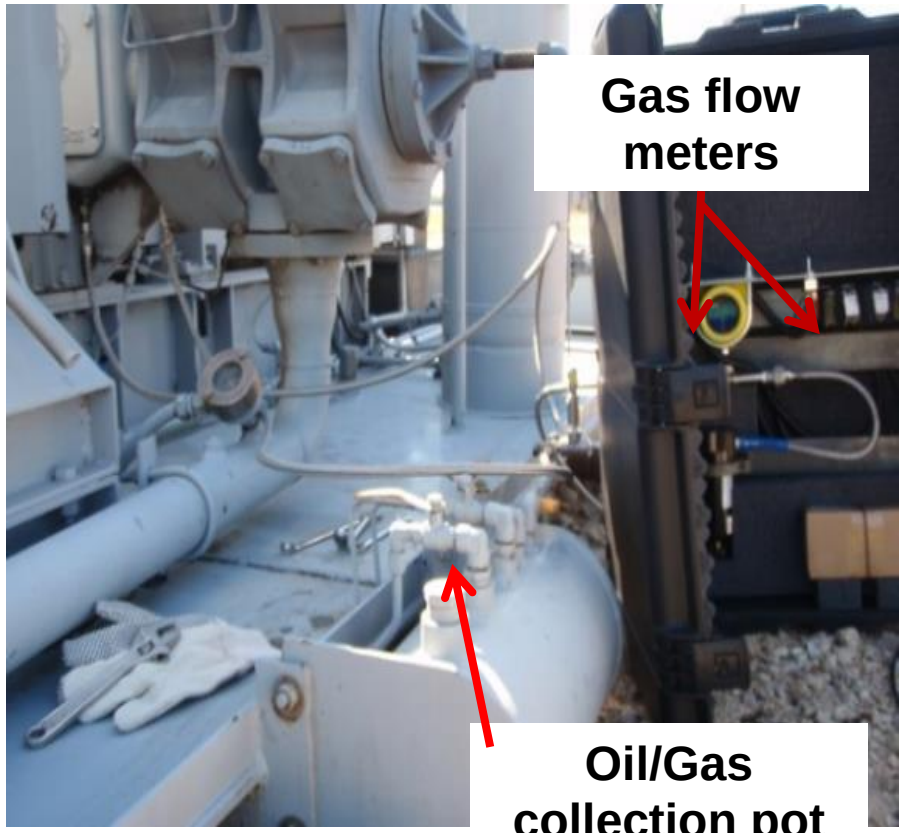
Two measurements were made for each throw:

- packing flange vent outlet
- packing case cavity

Used two calibrated mass flow meters; a high range (hot wire type) and a low range (differential pressure).

- each point measured separately then totaled

- testing 3 years with 12 readings per unit



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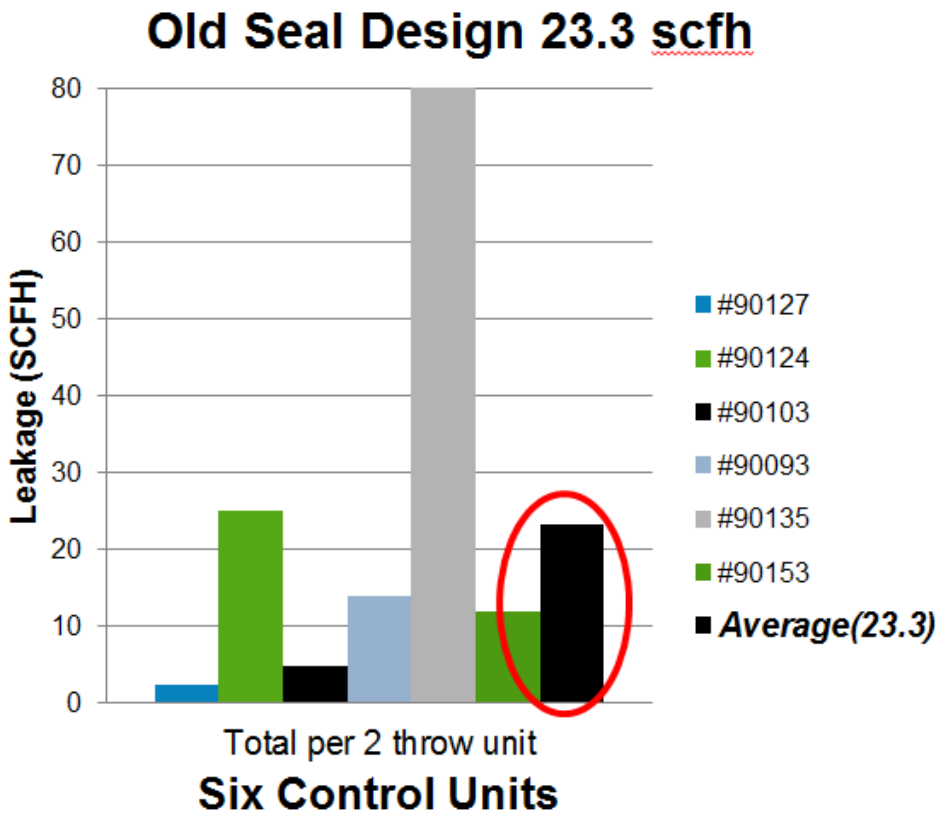
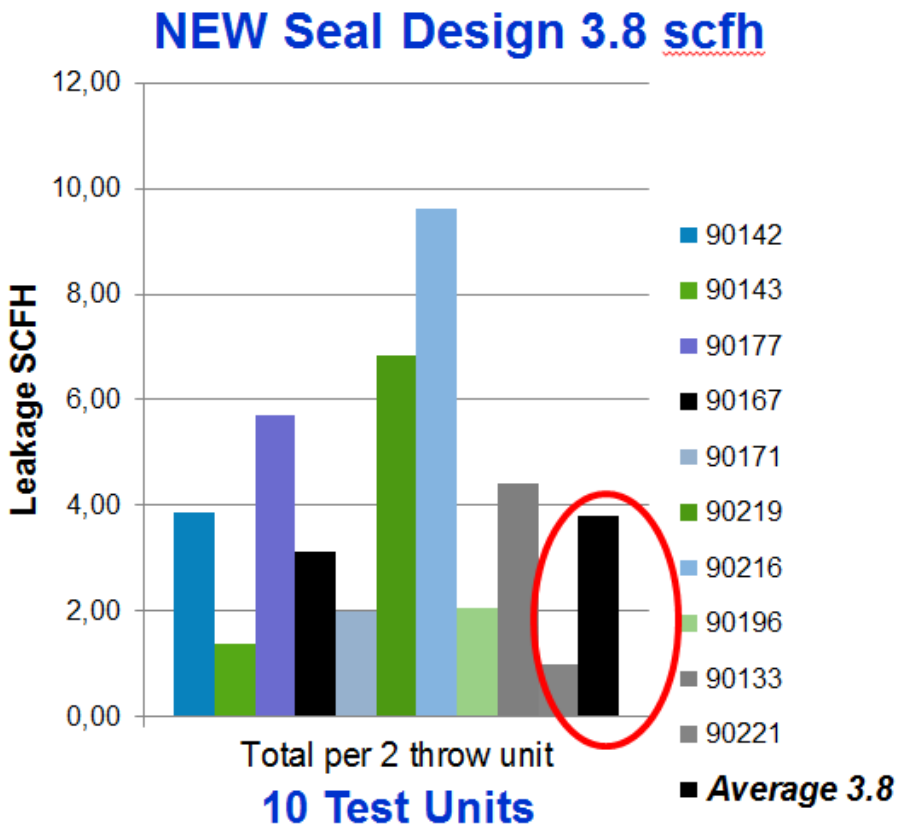
Study Results – Packing Leakage





3.8 scfh is well below the EPA guidelines of 10-12scfh

Notes: * Total readings of both throws(packings),does not consider the one day wear in.

Field Study Case 3

Application:

CHP plant

2 off fuel gas boosters for turbine

Challenge:

- No constant operation
- Short stroke, no cooling
- Short packing life time, typically 2000 hours
- High leakage, resulting in economical & environmental concerns, as well as nuisance of strong smell.

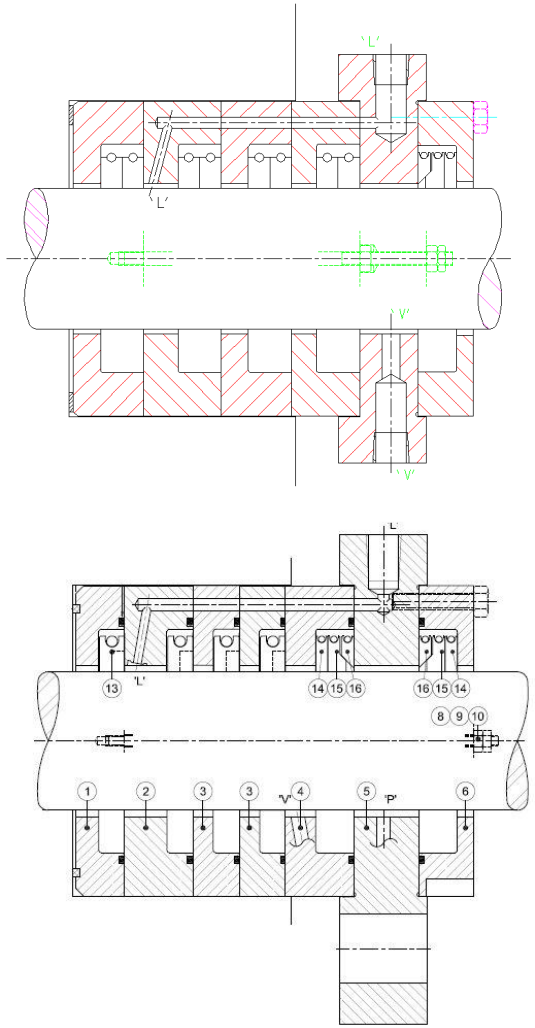
Actions executed:

Upgrade packing rings for first and second stage on both non-lubricated compressors

… with upgraded seals:

- ✓ Reduction of rod temperature, no overheating.
- ✓ Lifetime greatly extended. Inspection at 7500 hrs, little wear, rings re-installed and still running.
- ✓ Virtually no leakage detectable.

Field Case Study 4



Application:

Two compressors over 40 years old

Heavy hydrocarbon duty

Challenge:

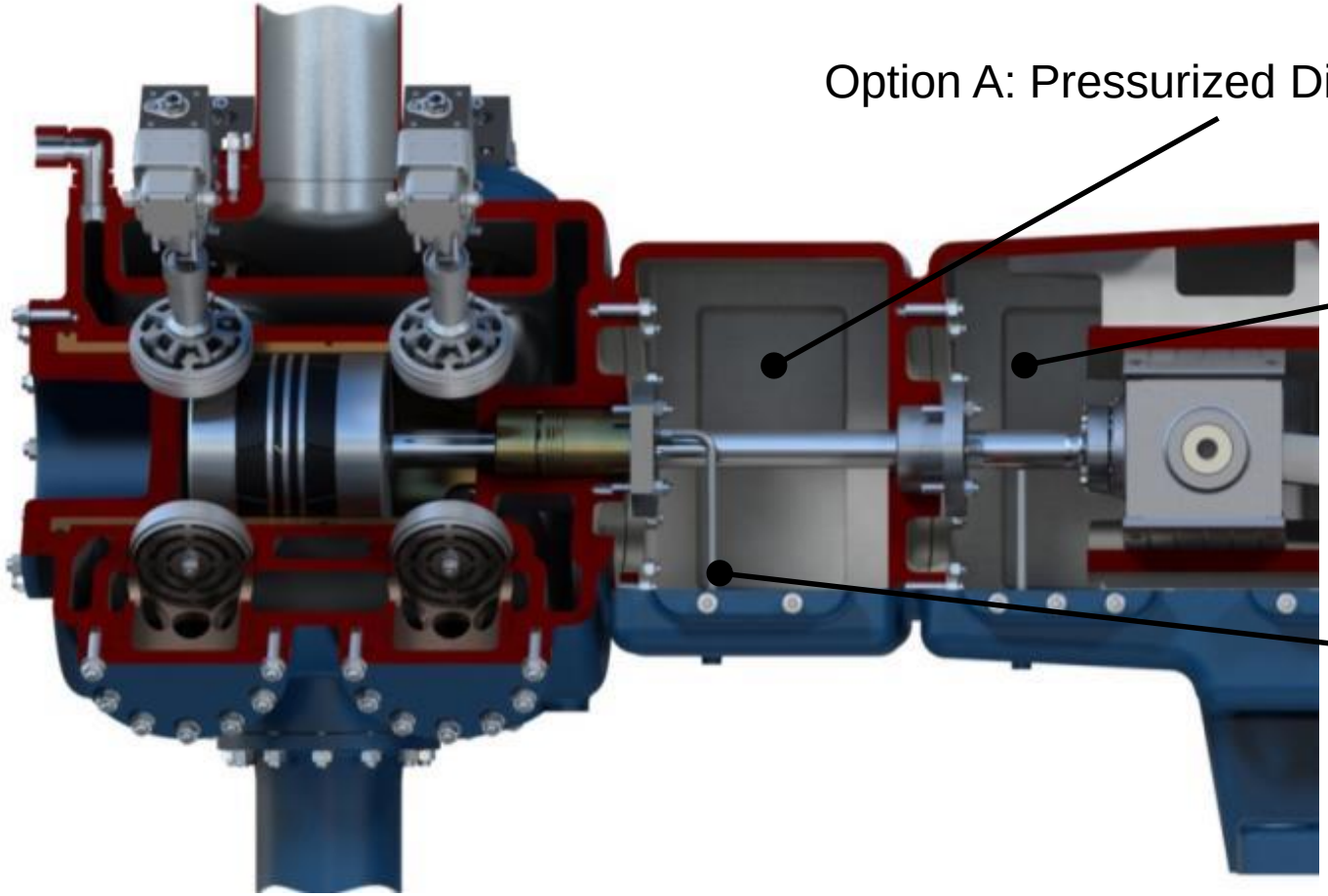
- Limited space
- Adopt purge to the packing
- Standard options = compromise on quantity of seals

… with new seal ring technology:

Installation packing rings in new packing boxes

- ✓ **Small footprint of the new ring**
- ✓ **new design of packing box**
- ✓ **allowed nitrogen purge without compromise on seal**

Other possibilities to handle gas leaks



Option A: Pressurized Distance Piece

Option B: Pressurized Crank Case

Option C: Vent Gas Recompression

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Questions?