EFRC Training Workshop Lubrication and Wear

Wear and Lubrication of Stuffing Boxes

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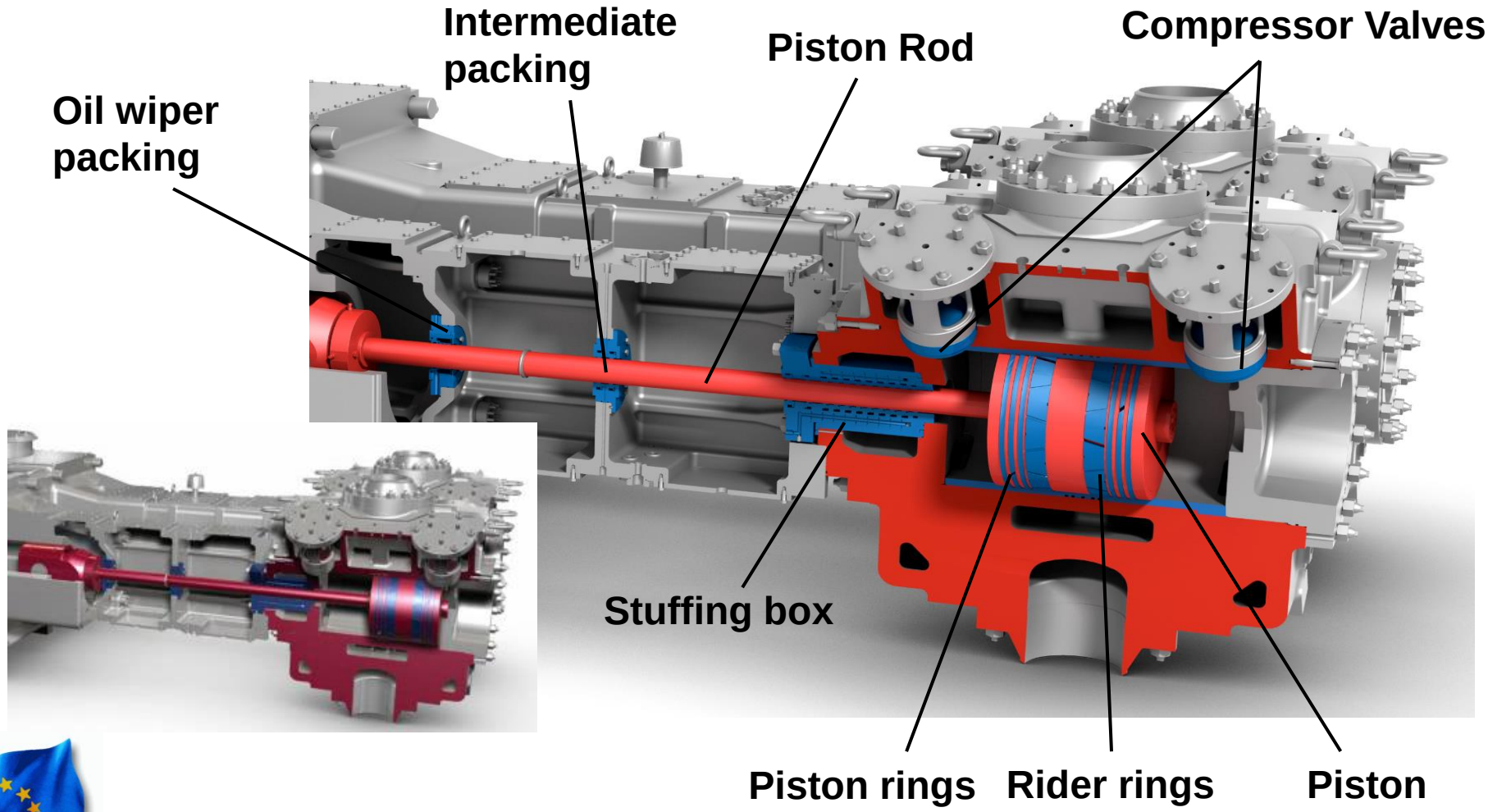
Burckhardt Compression

Compressors for a Lifetime™

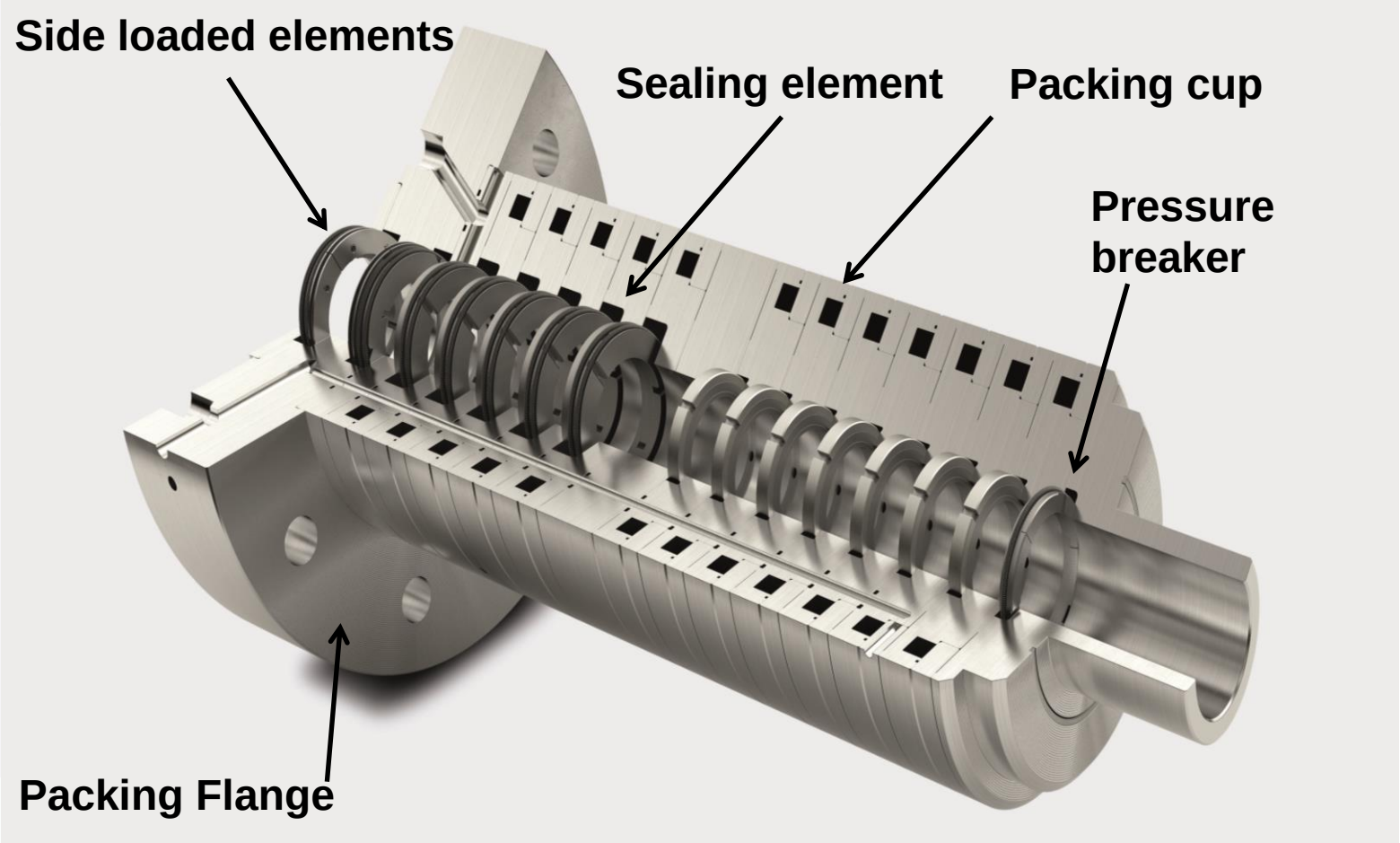
Outline

- **Overview Stuffing boxes**
  - Function and operation
  - Heat dissipation
  - Ring Materials
  - Ring Design
- **Lubricants**
  - Risk factors
  - Types
  - Demand
  - Degradation
  - Selection
- **Piston Rods**
- **Factors influencing packing lifetime**
- **Conclusions**

Overview Rings & Packings



Stuffing boxes - Function and operation



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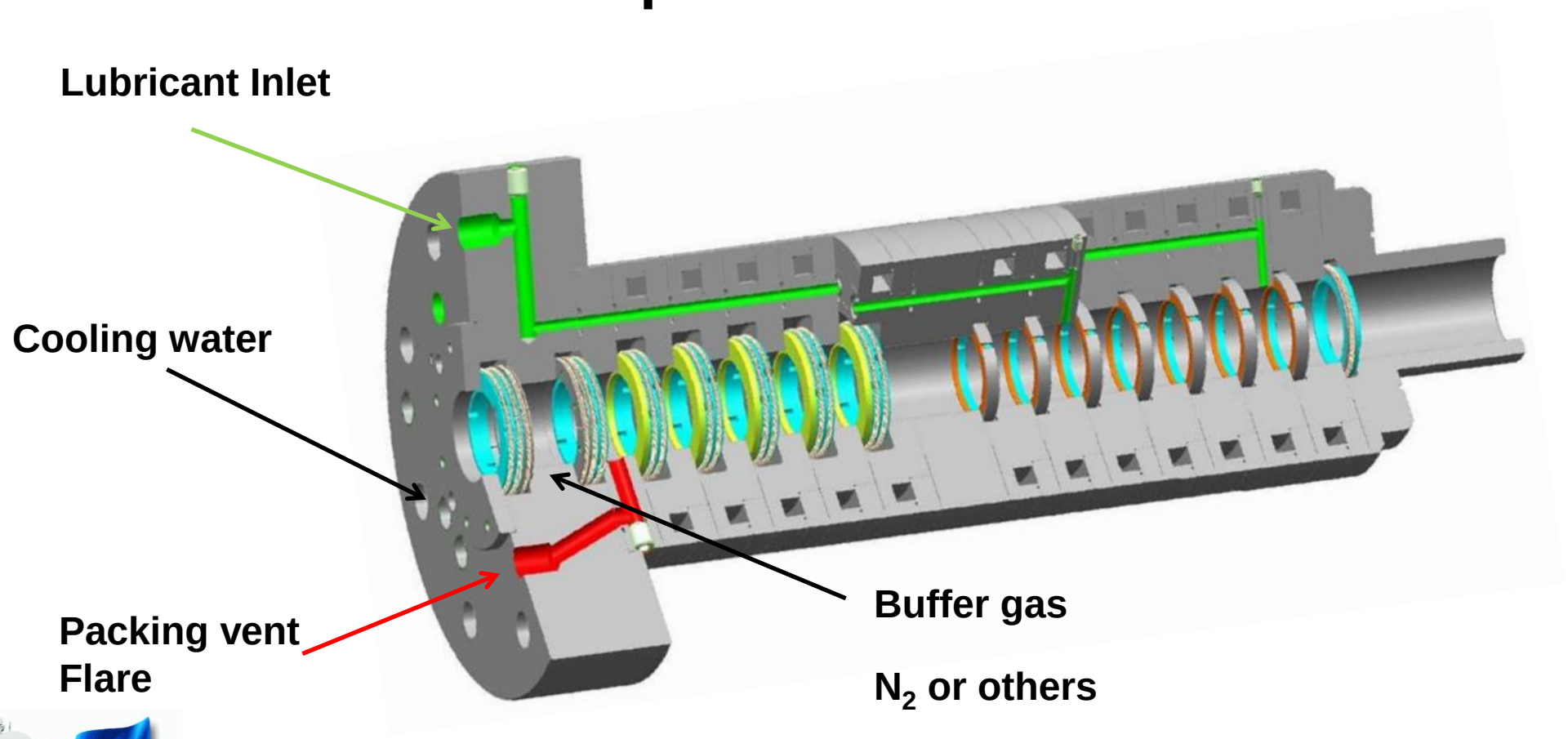
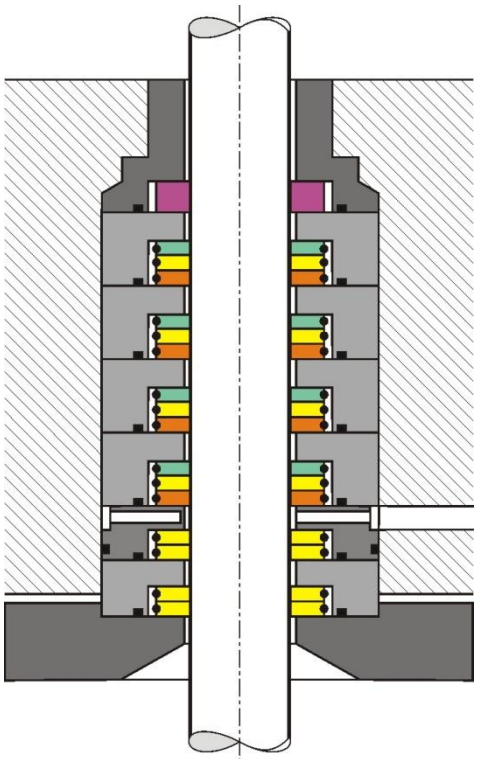
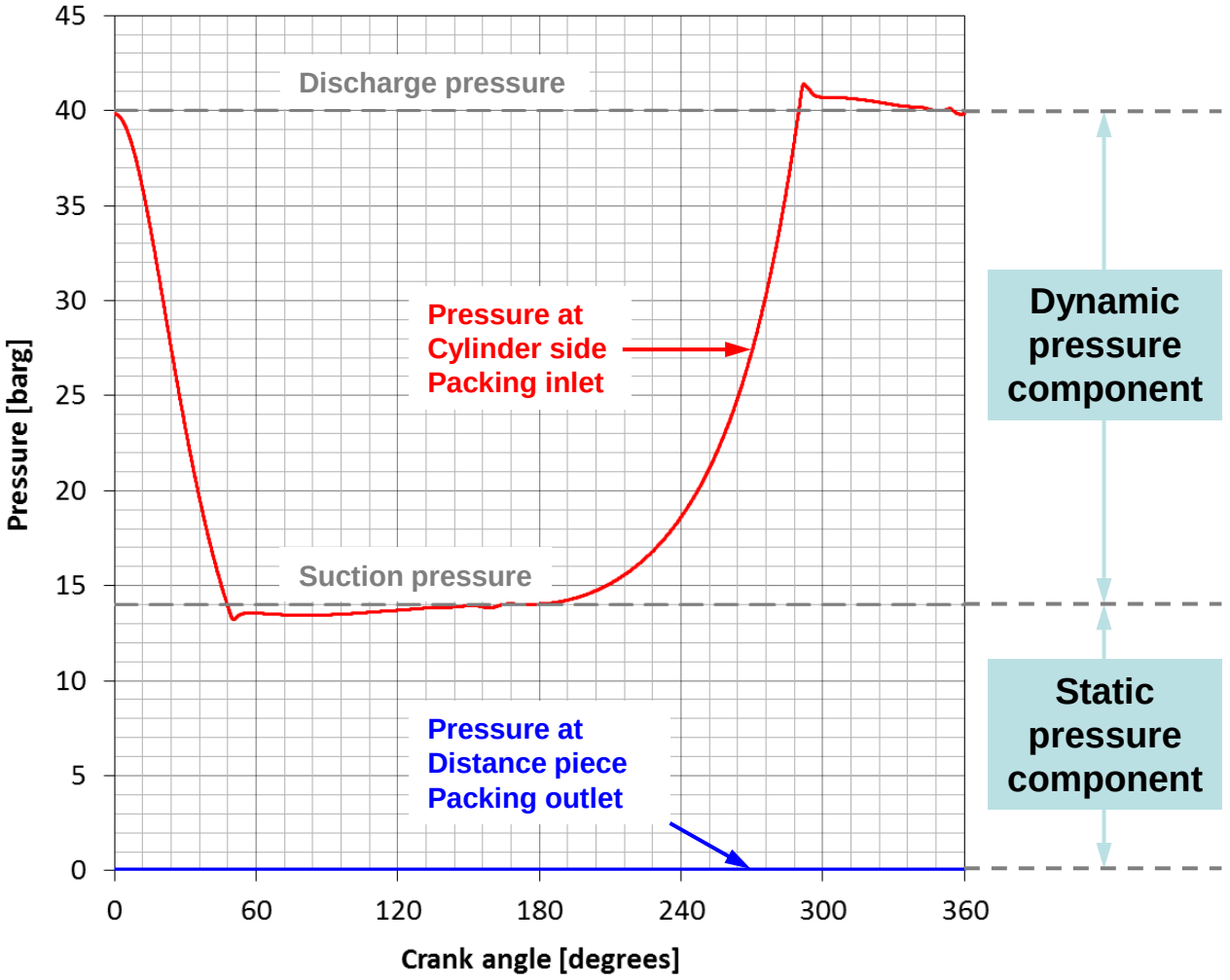


Stuffing boxes - Function and operation

Cylinder side
Packing inlet

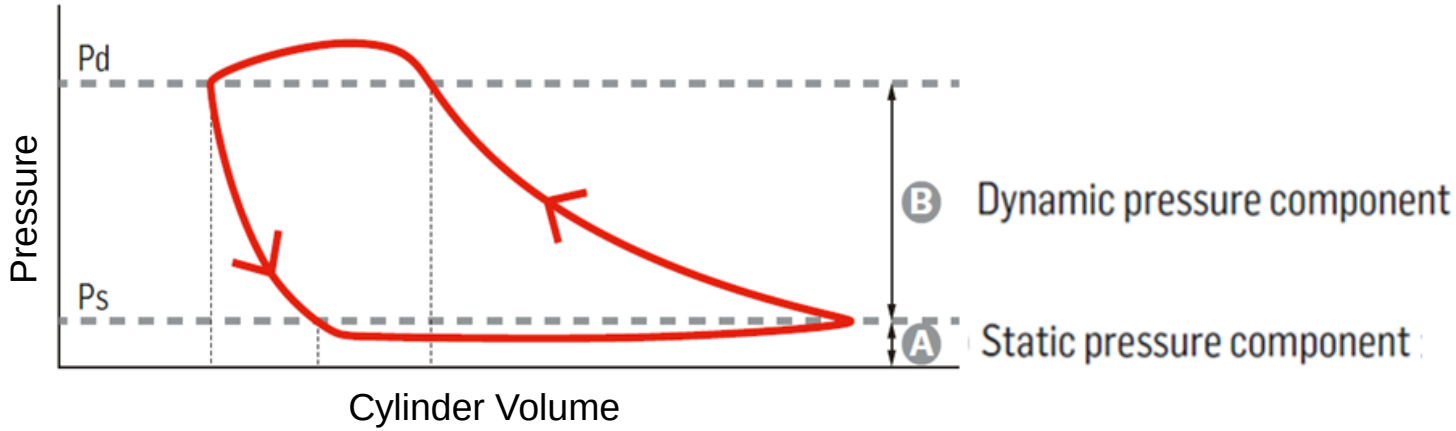


Packing outlet
Distance piece



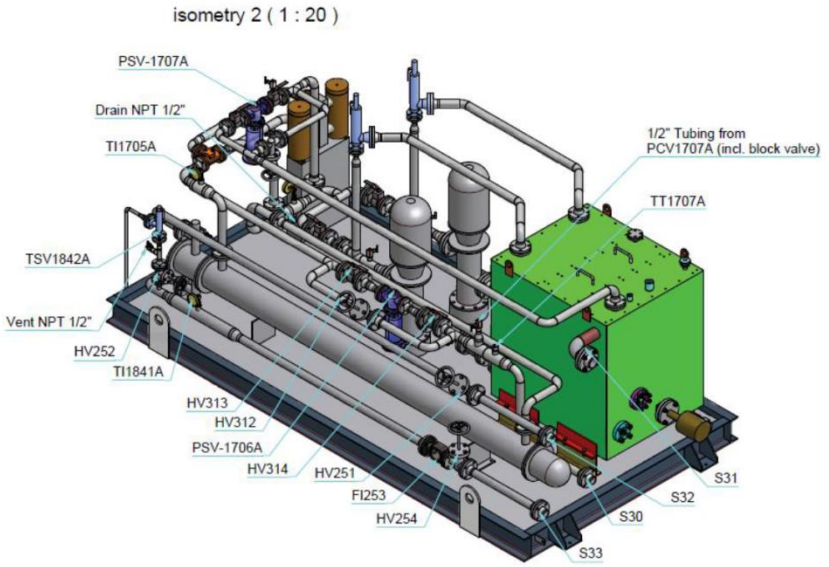
Stuffing boxes - Function and operation

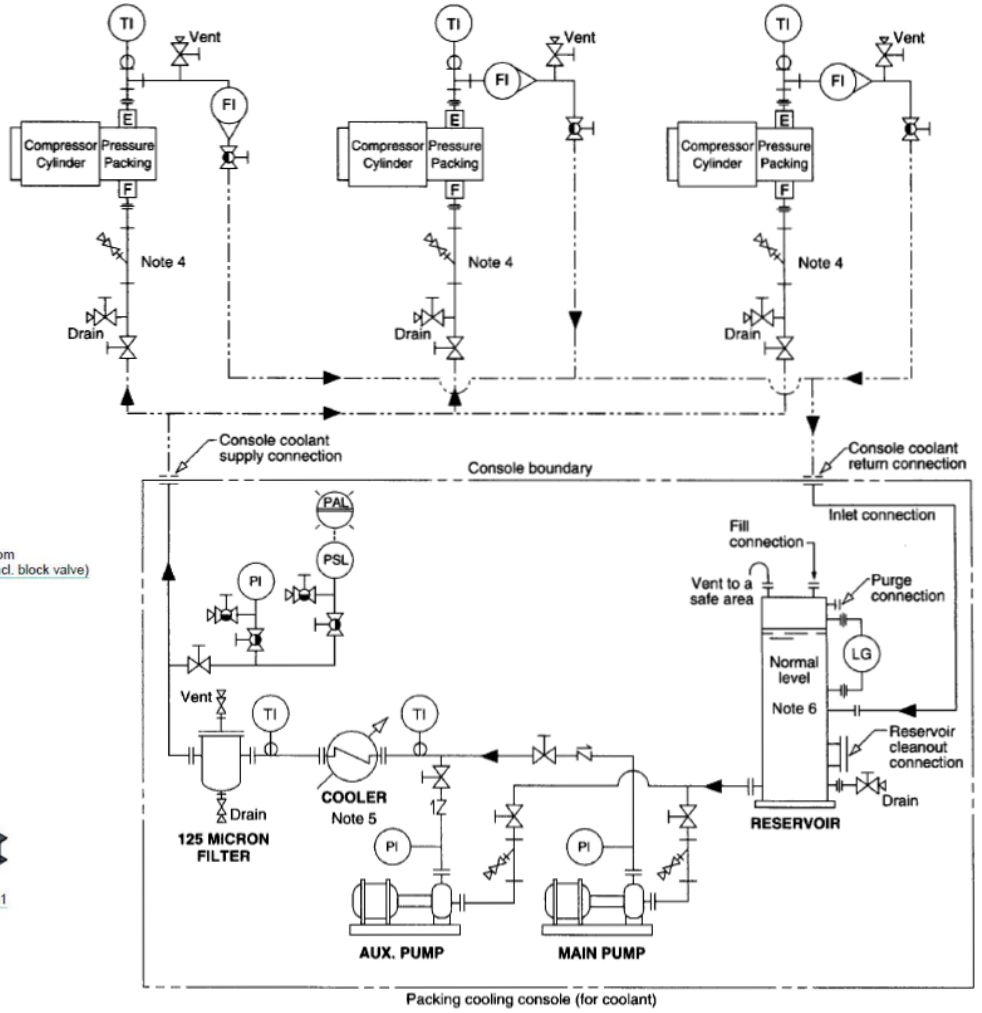
- **Dynamic pressure**
  - Values of dynamic pressure component vary between zero and maximum during a crankshaft revolution
  - Resulting in a high degree of wear, failure by fracture or creep
- **Static pressure**
  - Values and effect of static pressure component are constant during a crankshaft revolution
  - Static pressure difference constitutes the primary load parameter influencing the leakage rate



Stuffing boxes – Heat dissipation

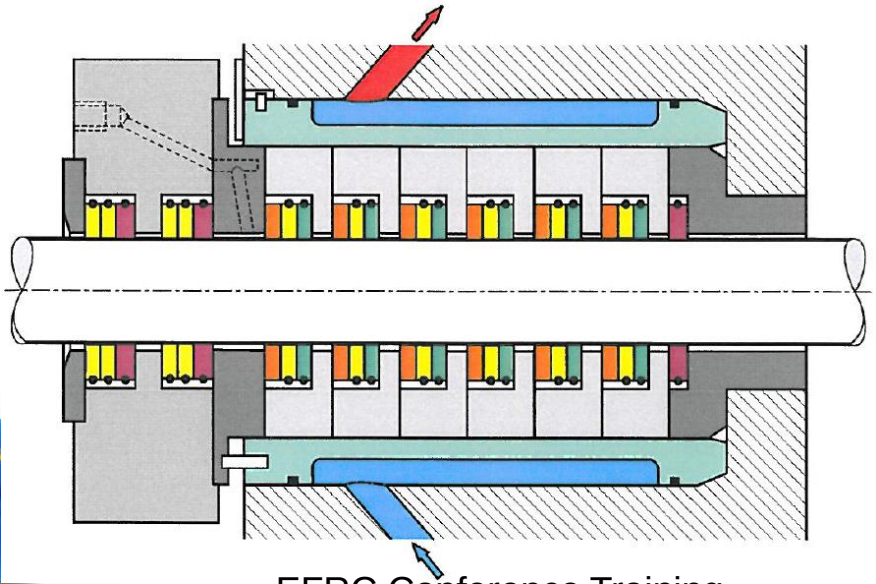
- Flow, pressure, temperature
- Stainless steel fittings
- Max inlet temperature 35°C
- Max pressure drop 1.7 bar
- Leak test min 8 bar

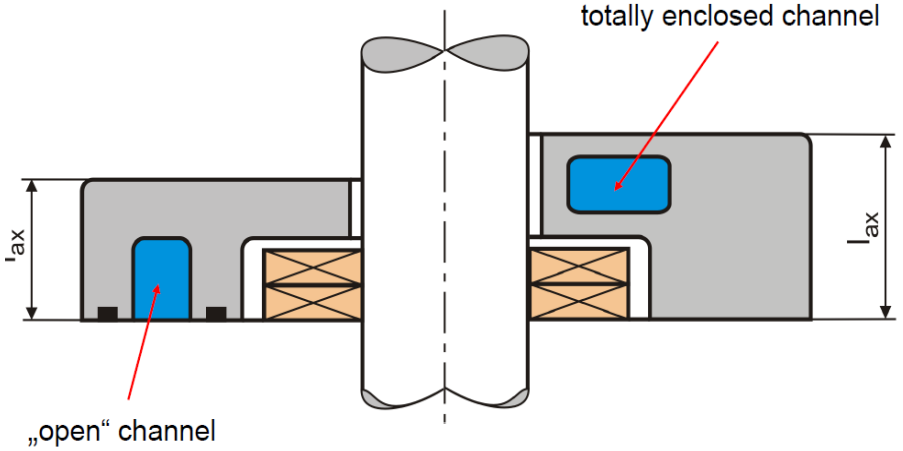




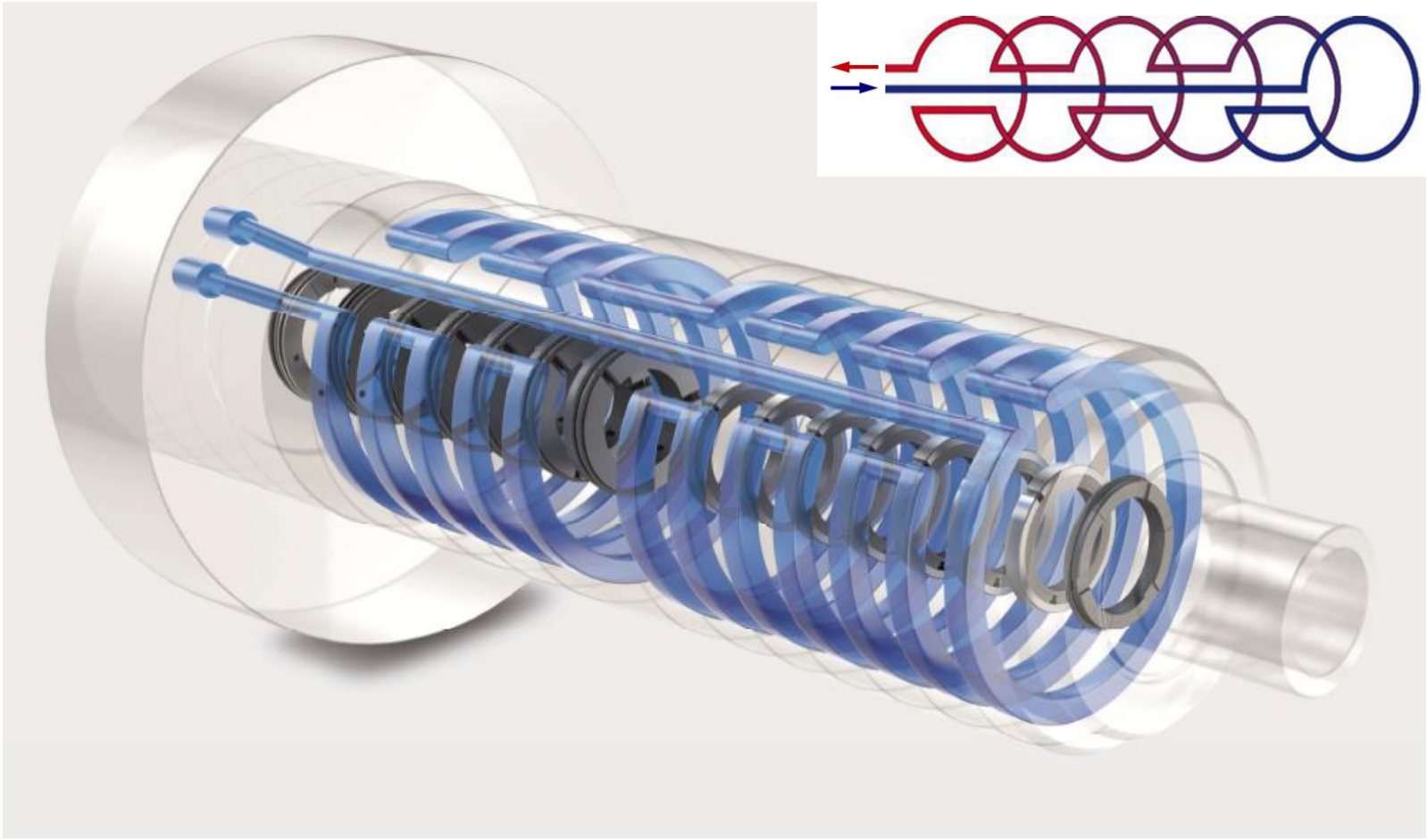
Stuffing boxes – Heat dissipation

- Cooling jacket (NOT API)
- Packing cup with open cooling channel (NOT API)
- Totally enclosed coolling channels cups
  - Non-metalic rings MAWP >35bar (500psi)
  - All materials MAWP >100 bar (1450psi)





Stuffing boxes – Heat dissipation



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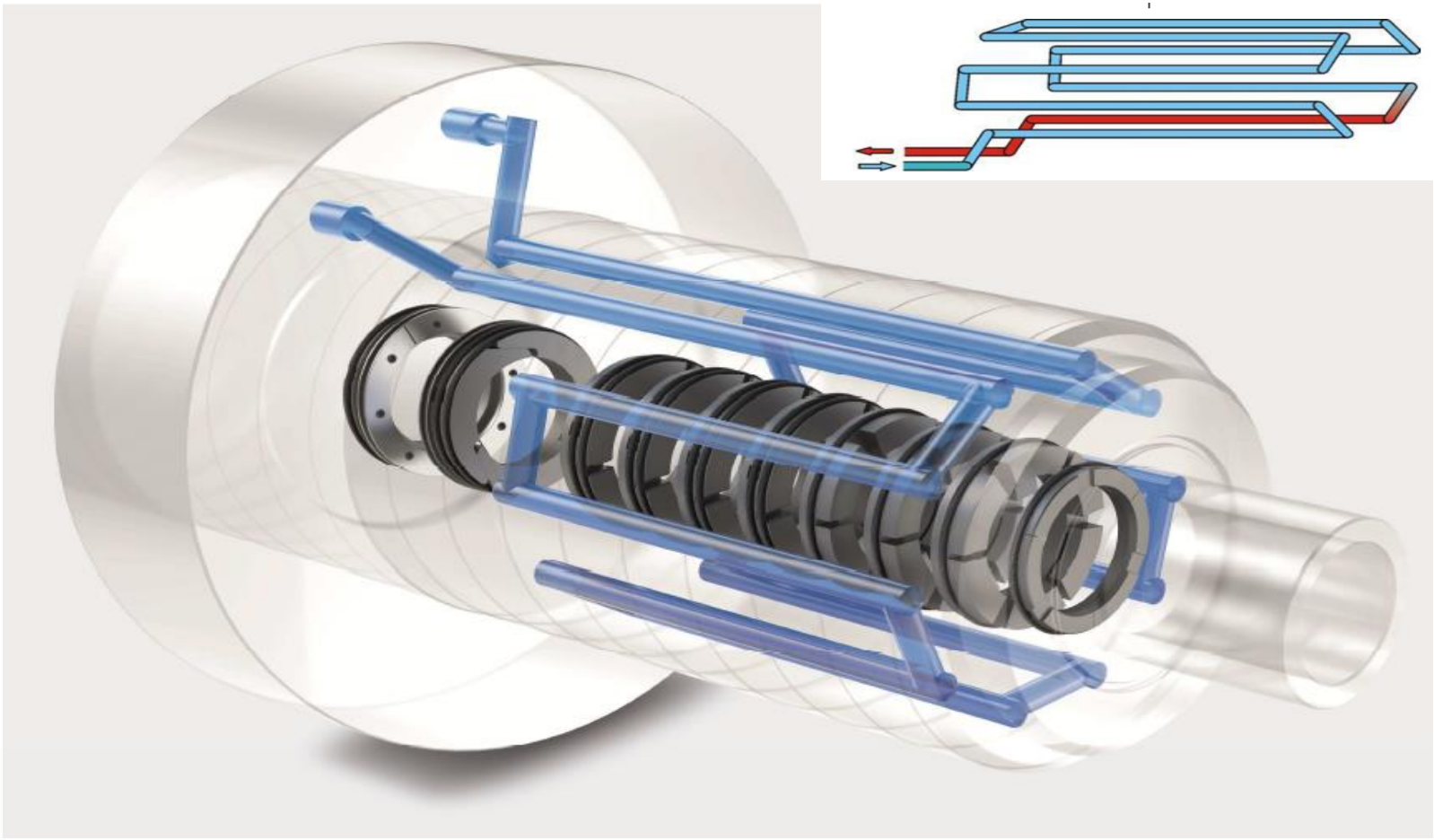
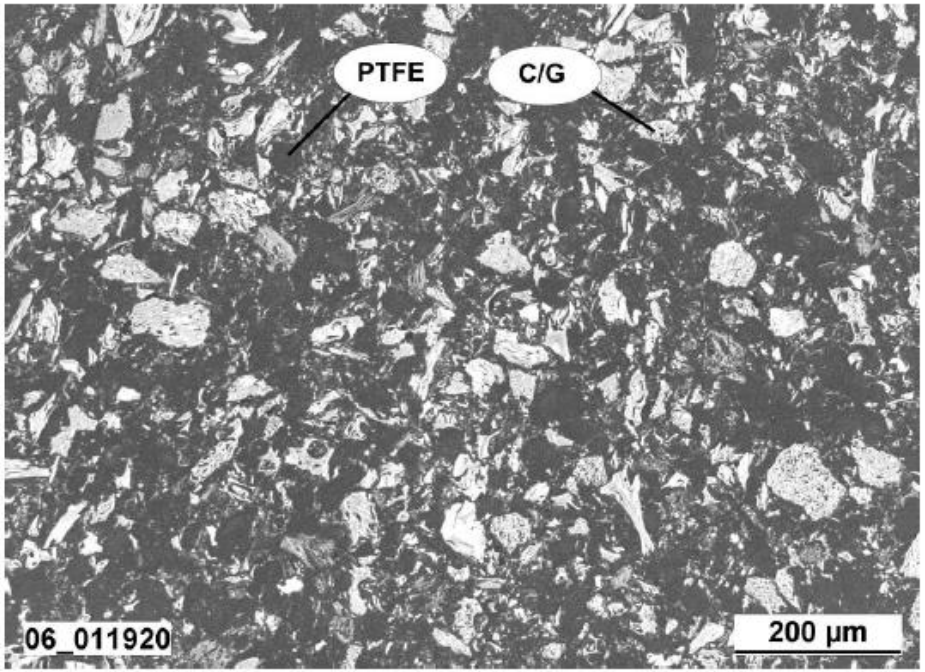


Stuffing boxes – Heat dissipation

Piston Rod Packing Ring Materials

- Polytetrafluorethylene (PTFE)
- Fillers: 25 – 35% by weight of inorganic materials:
- Carbon, graphite, glass fibre, copper bronze, ceramics, molybdenum disulphide
- Wide chemical compatibility
- Low mechanical strength and high creep sensitivity

Carbon/graphite-filled PTFE



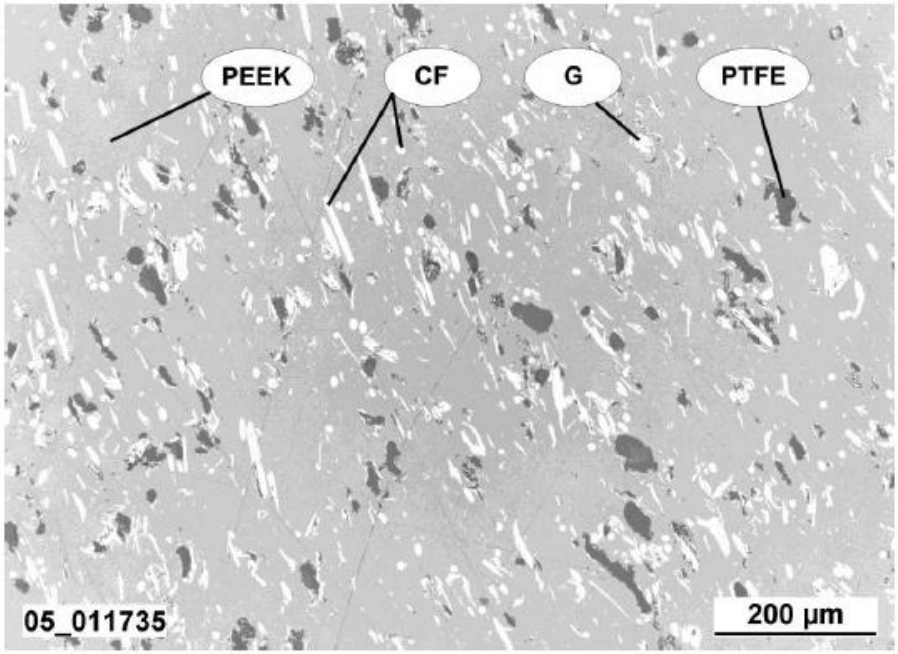
PTFE … Polytetrafluorethylene

C/G … Carbon/graphite powder

Piston Rod Packing Ring Materials

- Polyetheretherketone (PEEK)
- Wide chemical compatibility
- Fillers: carbon/graphite, glass, molybdenum disulphide, carbon fibre, glass fibre, etc
- Applications:
  high pressure +150bar
  high temperature +150°C

Modified PEEK material



PEEK … Polyetheretherketone
PTFE … Polytetrafluorethylene
CF … Carbon fibre
G … Graphite powder

Piston Rod Packing Ring designs

- Numerous ring designs available
- Ring design (3/6-piece, 3/3-piece piece – most commom)

Lubricant risk factors/function

Risk factors:

- Solubility → Compressor Performance
- Reactivity
- As a gas contaminant → Downstream equipment

Funtion:

- Flushing, cooling, corrosion protection
- Reducing friction/wear
- Reducing heat
- Preventing leakage

Lubricant types

- Classification of base oils – API Groups
- Mineral oils made from petroleum oils
- Synthetic oils: Man made - synthesized

Group	Weight (% Sulphur)	Weight (% Saturates)	Viscosity Index
I	> 0.03	<90	80-119
II	< 0.03	>90	80-119
III	< 0.03	>90	120+
IV	Synthetic Hydrocarbons		
V	PAG, Diesters		

Lubricant demand

- Cylinder diameter (D)
- Speed (n)
- Stroke (S)
- Pressure differential (Δp)
- k is experience factor depending on gas type, material combination

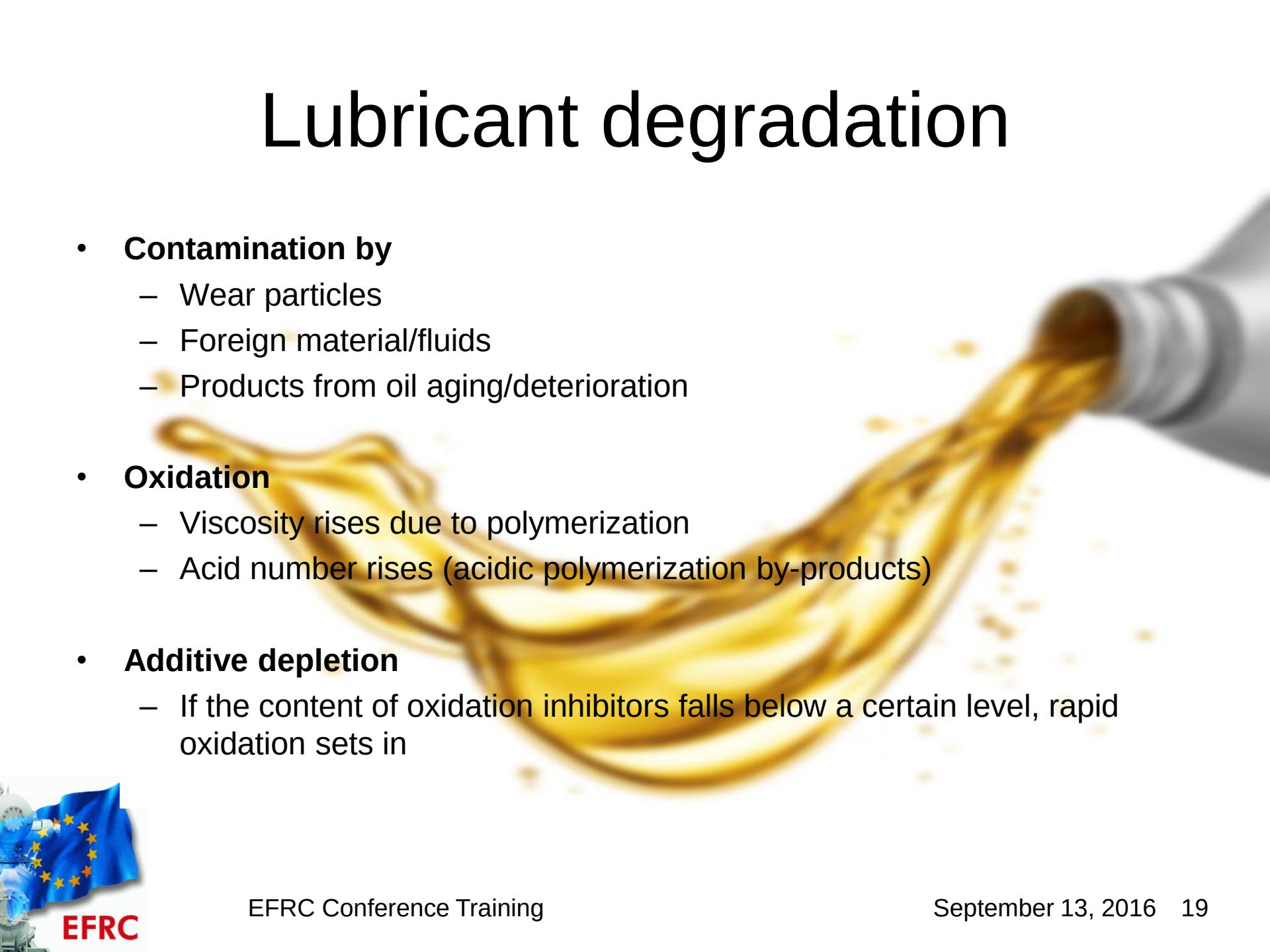
- Q= D n S k (Δp) = [g/h]

- Other available:

$$Gallons/24hours = \frac{\text{diameter (in.)} \times \text{stroke (in.)} \times \text{rpm}}{385{,}000}$$

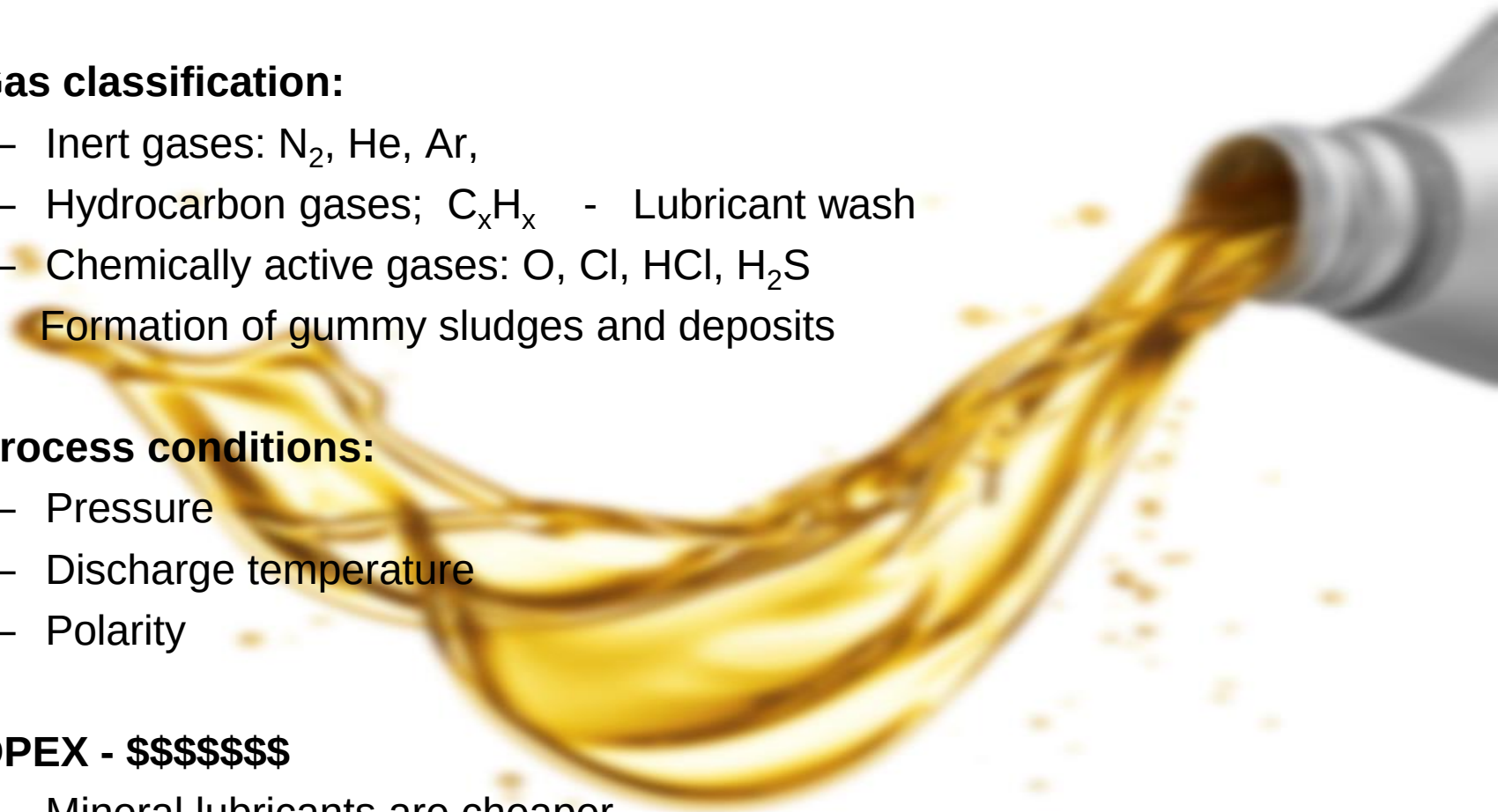
- Based on 4000 drops per gallon and 600 ft^2 of swept area per drop

Lubricant degradation



- **Contamination by**
  - Wear particles
  - Foreign material/fluids
  - Products from oil aging/deterioration
- **Oxidation**
  - Viscosity rises due to polymerization
  - Acid number rises (acidic polymerization by-products)
- **Additive depletion**
  - If the content of oxidation inhibitors falls below a certain level, rapid oxidation sets in

Lubricant Selection



- **Gas classification:**
  - Inert gases: N_2, He, Ar,
  - Hydrocarbon gases; C_xH_x - Lubricant wash
  - Chemically active gases: O, Cl, HCl, H_2S

    Formation of gummy sludges and deposits

- **Process conditions:**
  - Pressure
  - Discharge temperature
  - Polarity

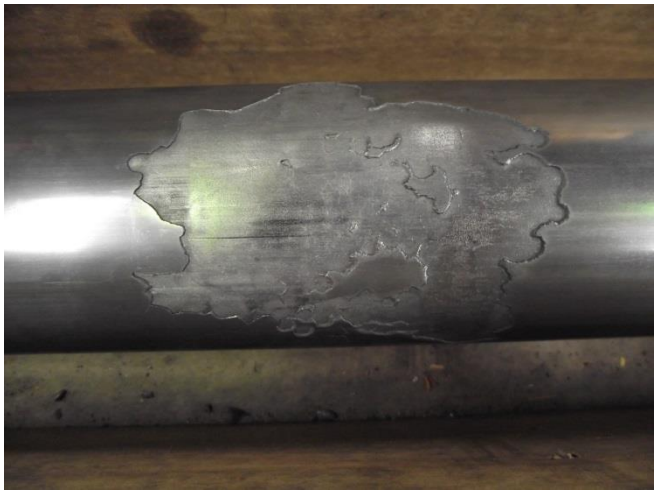
- **OPEX - $$$$$$$**
  - Mineral lubricants are cheaper
  - Synthetics can be 5 to 10 x higher cost

Piston Rods

- Wear resistant material to maximize rod and packing life
- Uncoated AISI 4140 (42CrMo4) or better
- Packing area to be hardened to min 50HRC (330HV)
- H_2S service - NACE MR0175
- Tolerances for finished rods
  - Roundness 12.5µm
  - Diametral variation 25µm
  - Ra (0.15µm to 0.4µm)

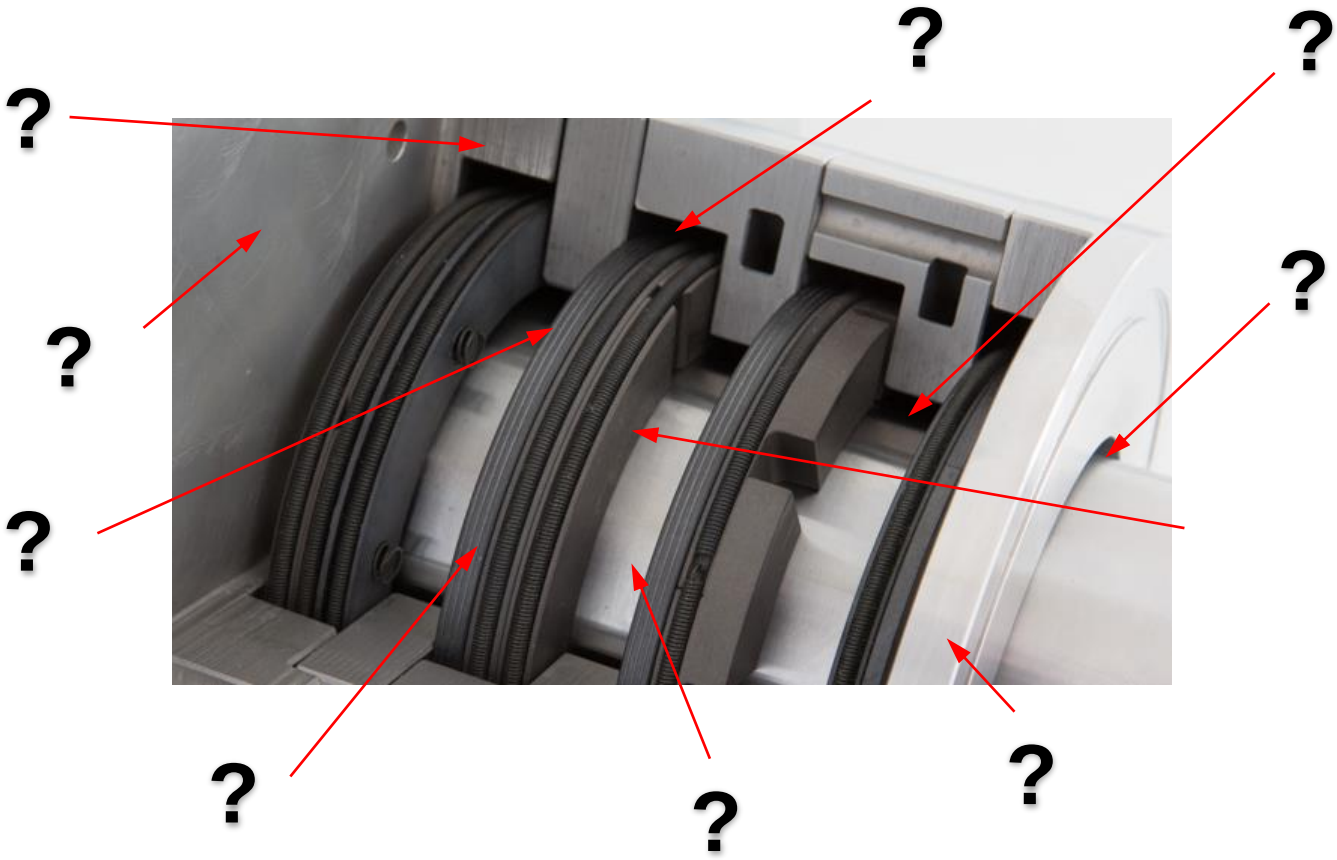
Piston Rods

- Coated/uncoated
- Forged steel/high alloy steel
- WC-Co coated
- Gas Nitrided
- Hardchrome plated
- Cr_2O_3



- Careful with coatings
- Specification to suppliers
- Quality Inspection

Factors Influencing Packing Life Time



Factors Influencing Packing Life Time

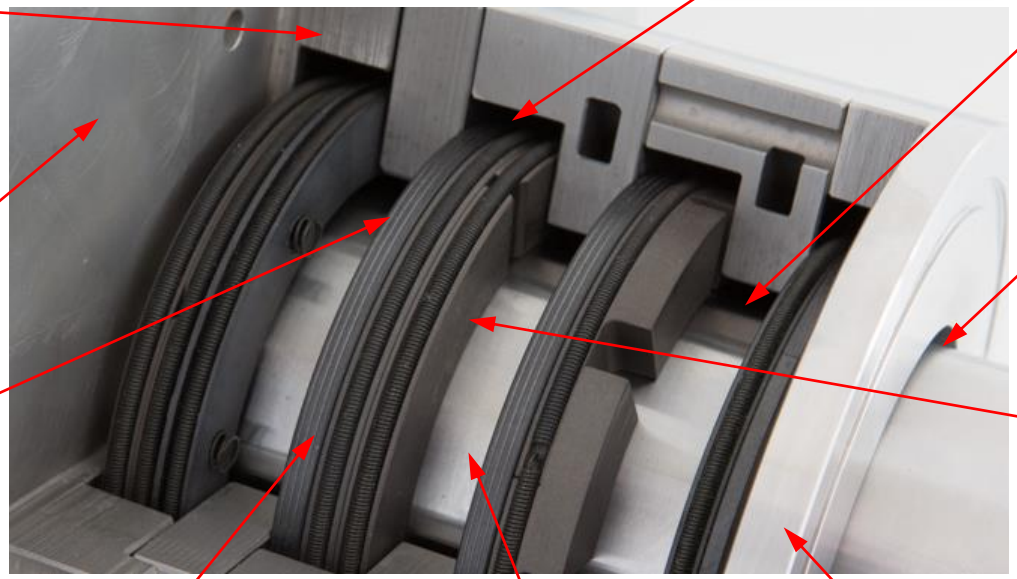
PACKING CUP
- Design
- Material
- Perpendicularity
- Finishing

CLEARANCES
- Axial
- Radial

GAS COMPOSITION
- C_xH_x
- H_2
- H_2S

CYLINDER
- Alignement
- Cyl. head movement in 3 directions

PROCESS CONDITIONS
- Starts / stops
- Gas temperature
- Cooling water



LEAKGAS
- Amount
- Relation with other cyl. parameter
- Temperature
- Pressure

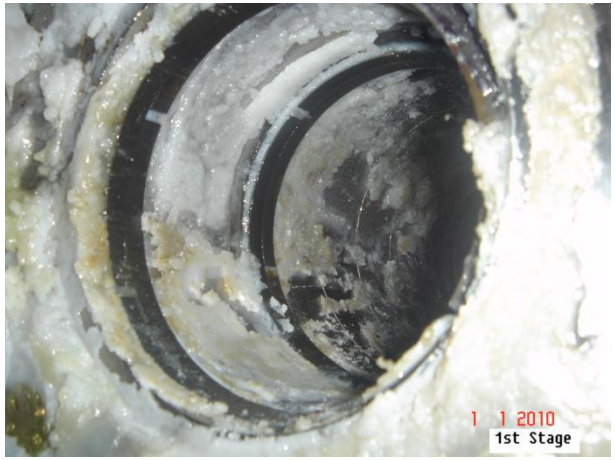
SEALING ELEMENT
- Geometry, Type, Dim.
- Material
- No. of sealing elements
- Configuration

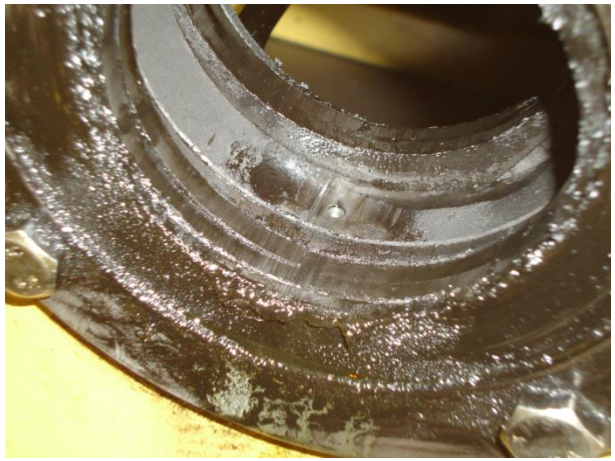
CYL. LUB OIL
- Mineral Oil or Synth
- Quantity
- No. of lub. points

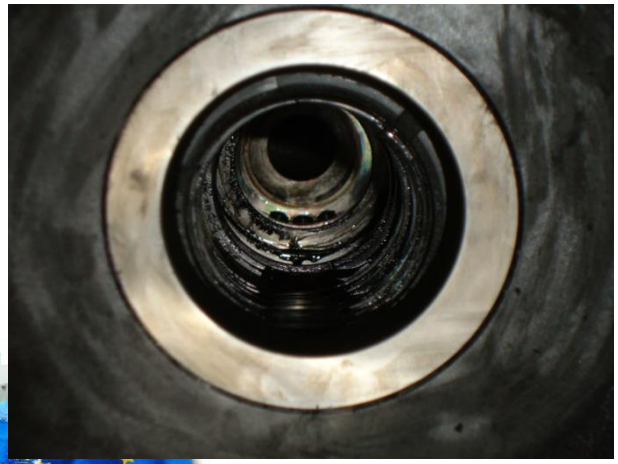
PISTON ROD
- Material
- Roughness
- Geometry
- Corrosion

PACKING BASIC DESIGN
- No. of stages
- No. of cylinders
- Rod Diameter
- Stroke
- Compressor RPM
- Lubricated or dry running

Failed Packings







Summary

Ring & Rod Material

- Chemical resistance
- Surface condition
- Ring design
- Ring /Rod material

Operation Case

- Temperature
- Speed
- Pressure
- Gas Type

Operational packing performance

System Tribology

- Ring & Rod wear
- Heat dissipation
- Lubricant type/Rate

Conclusions

- Packings are an essential compressor part with a direct impact on emissions
- Tribological systems requires extensive know-how
  - Sealing element design
  - Sealing and Piston rod Materials
  - Surface condition
  - Operation case
- Lubrication & cooling are critical
- Careful handling & installation

Questions