Impact of Challenging Environments on Sealings and Packings

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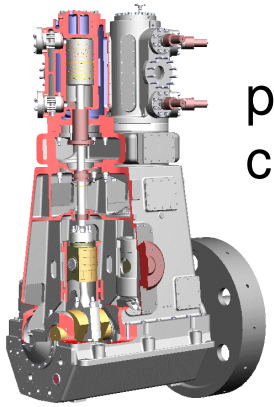
STASSKOL

Agenda

- Importance of Material & Layout
- Case 1: HCl containing gas
- Case 2: Fluorinated monomer gas
- Material Development

Importance of Material and Layout

⇨ Most important at compressor operation: RELIABILITY and SAFETY!



piston compressor

piston rod packing

SEALING ELEMENTS

B) SEALING RING LAYOUT

Different designs,
Different gaps,
Different Thicknesses,
etc.

A) SEALING RING MATERIAL

Different wear resistances,
Different mechanical properties,
Different chemical resistances,
etc.

Importance of Material and Layout

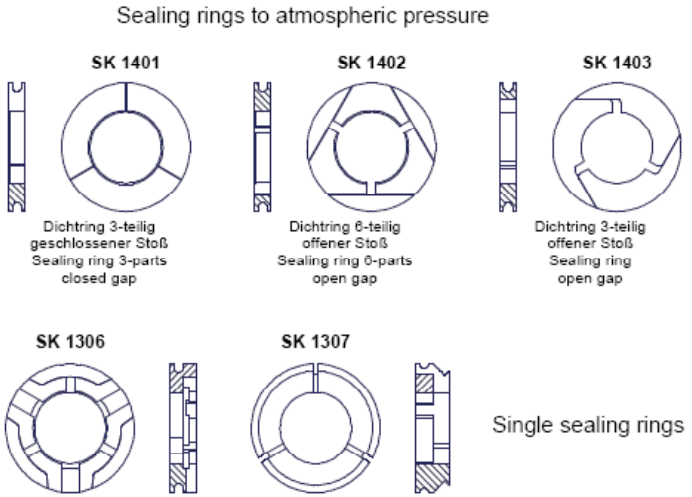
Material:

Materials are chosen according to
- Gas composition
- Dew point
- Pressure & mean piston speed
- Temperature
- Counter surface (rod material)

Matrix: PTFE, PEEK, PI, …
Filler: Carbon, glass, graphite, …
Cold and hot compression molded grades

Layout:

Layouts (Design, thickness, …) are chosen according to
- Gas composition
- Pressure



Factory standards are available at suppliers

Harsh conditions

It's even more important to know <u>all details about a process</u>!

Best solution can only be provided by knowing all the facts…

<u>Harsh conditions</u> <u>can be for example:</u>

- Piston speed > 4 m/sec
- Pressures > 150 bar (g) in dry-running application
- Average Temp. > 150 °C
- Gas contains HCl, SO_2, SO_3
- Dew points < - 100 °C
- Fluorinated gas
- Monomer gas
- Gas contains dirt
- Reactive gaseous media

⇨ Provide your supplier with all information about the machine, the process and the gas

⇨ Provide <u>actual values</u> instead of target values

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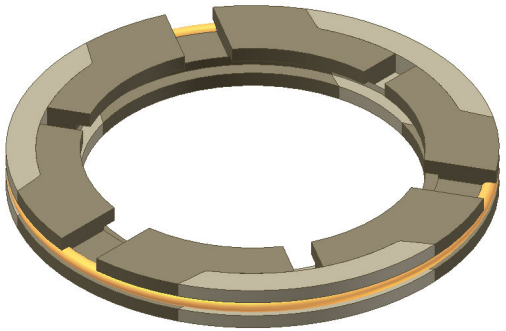
CASE 1: HCl containing gas

Application details:

- Refinery application:
  Compression of hydrocarbons
  (methane, ethane, propane, etc.)
- 1 stage, 2 cranks, dry running
- Suction pressure: 24 bar (g)
- Discharge pressure: 31 bar (g)
- Sealing material in use:
  PTFE with polymeric fillers &
  molybdenum disulfide
- Sealing design in use:
  3 single sealing rings



CASE 1: HCl containing gas

Problems:
- Low service-time of max. 900 hrs
- High pressure at the leakage gas vessel

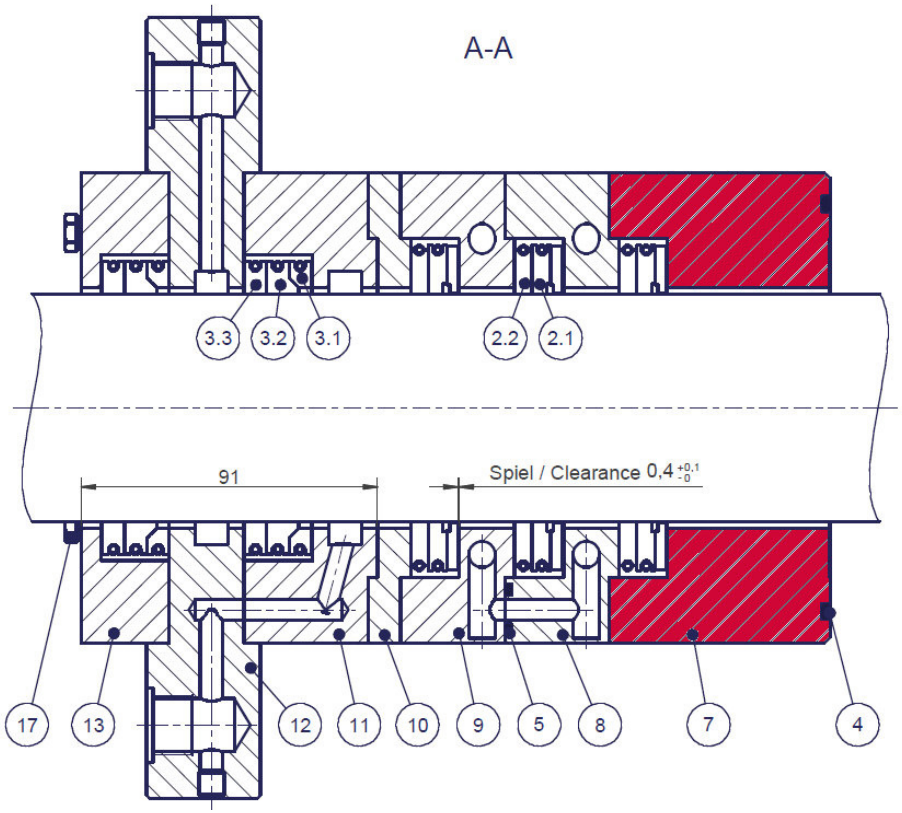
Analysis:
- Update of gas analysis: Gas contains HCl
- Material not suitable for HCl application

Solution:
- Change of sealing material
- Change of sealing ring design
- Add an additional ring pair

Servizio / Item no.			Rated
Stadio			1
Normale o alternativo			
		Peso molecol kg/kmol	Vol.-%
Water vapor	H2O	18,016	
Nitrogen	N2	28,016	
Hydro. Sulfide	H2S	34,076	
Hydrogen	H2	2,016	76,58
Methane	CH4	16,042	14,45
Ethylene	C2H4	28,052	
Ethane	C2H6	30,068	3,19
Propylene	C3H6	42,078	
Propane	C3H8	44,094	1,13
Isobutane	C4H8	56,107	
i-Butane	C4H10	58,120	0,45
n-Butane	C4H10	58,120	0,25
Cyclo-Pentane	C5H10	70,134	
i-Pentane	C5H12	72,146	1,44
n-Pentane	C5H12	72,146	0,37
Hexane+	C6H14	86,177	2,06
Hydro.Chlor.	HCl	36,461	0,05
Totale [%]			
Peso molecolare calcolato [kg/kmol]			8,84
Dewpoint [°C / bar]			3

CASE 1: HCl gas

Initial layout:

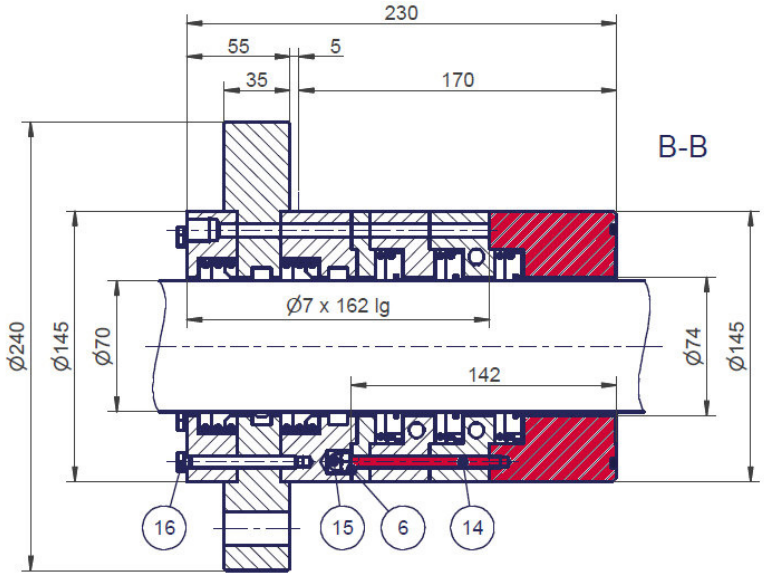


Details

- 4 Chamber rings (15, 11, 9, 8)
- 1 Flange (12)
- 1 Intermediate ring (10)
- 1 Base chamber (7)

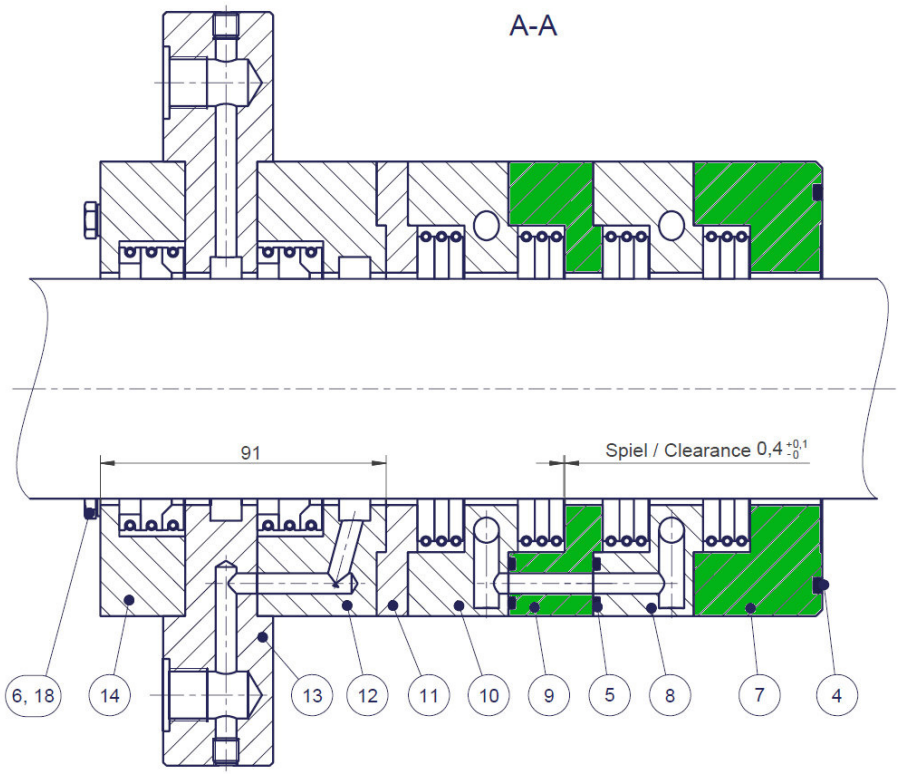
Items that have to be removed

- Old base chamber (7)
- Old tie rod (14)



CASE 1: HCl gas

Updated layout:

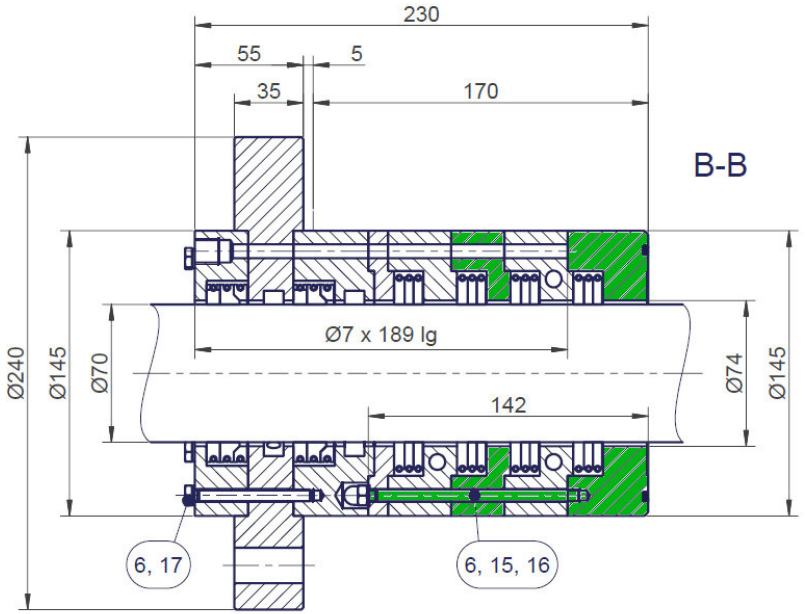


Details

- 5 Chamber rings (14, 12, 10, 9, 8)
- 1 Flange (13)
- 1 Intermediate ring (11)
- 1 Base chamber (7)

Items that have to be added

- New chamber ring (9)
- New base chamber (7)
- New tie rod (15)

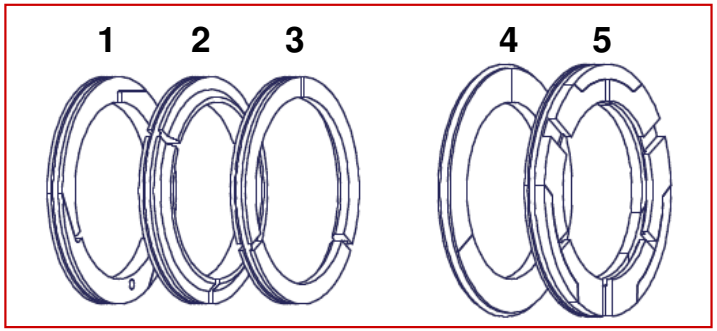


Additional ring pair for increased RELIABILITY and SAFETY

CASE 1: HCl gas

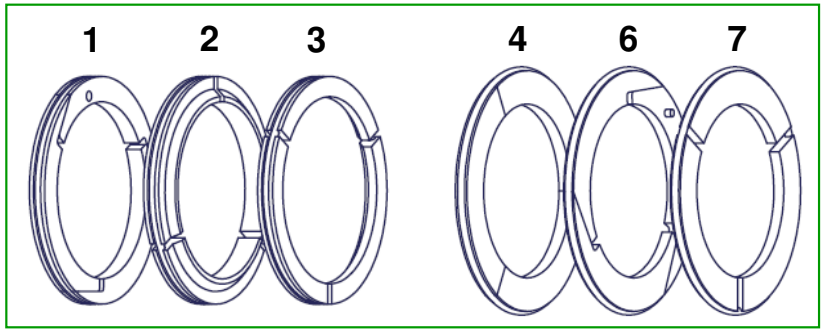
Internals:

Initial layout



- Single sealing ring design (5)
- 3 Sealing ring pairs (4,5)
- Different materials used (always PTFE, polymeric fillers and molybdenum disulfide)

Updated layout



- Traditional sealing ring design (6,7)
- 4 Sealing ring pairs (4,6,7)
- Material: SK404 (PTFE only filled with carbon)

Details that stay the same

- Backup rings (4)
- Design of the buffer gas ring pairs (1,2,3)
- Amount of the buffer gas ring pairs (2 pairs)

Increased tightness for increased RELIABILITY and SAFETY

CASE 1: HCl containing gas

Outcomes:

- Pressure at the leakage gas vessel far below the threshold
- Running time up till now: 7632 hrs and still very gastight

Key learnings:

- Not every material can handle HCl in the process gas
- With an up-to-date gas analysis the supplier of the stuffing box can chose the suitable material

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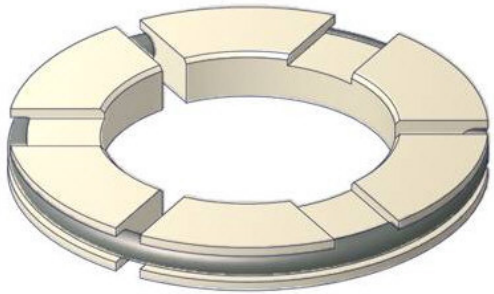
CASE 2: Fluorinated monomer gas

Application details:

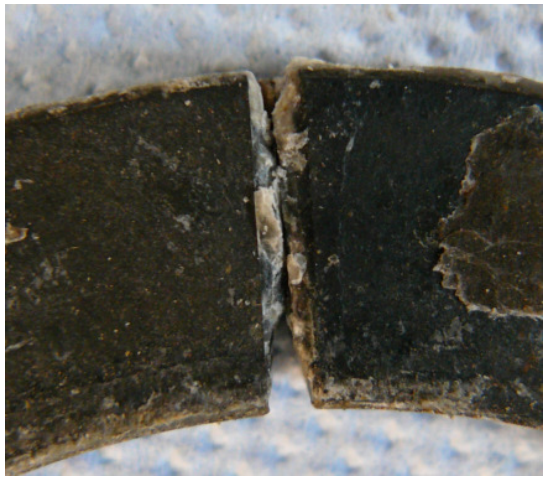
- Compression of fluorinated gas
- 3 Stage compression, dry running
- Suction pressure 1st stage: 1.5 bar (g)
- Discharge pressure 3rd stage: 67 bar (g)
- Sealing material in use:
  PTFE with carbon black & graphite
- Sealing design in use:
  3/3 part radial cutted rings

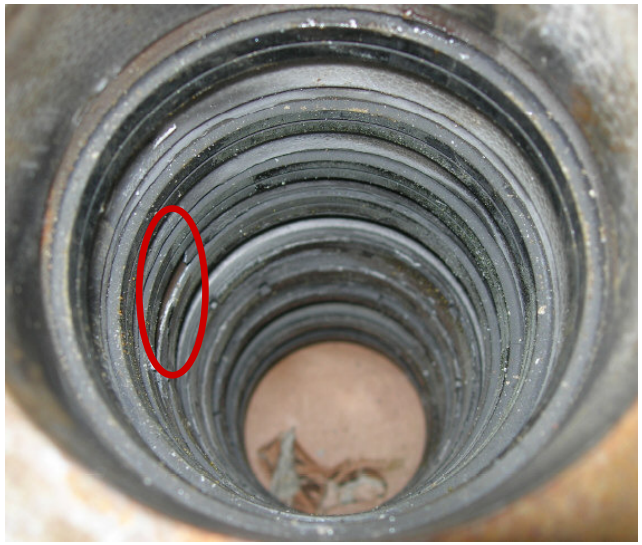


CASE 2: Fluorinated monomer gas

Problems:

- Increasing piston rod temperatures after 2 days of operations above 80 °C
- Leakage into the distance piece
- Clogging of the packing with polymer
- Swollen and broken ring segments

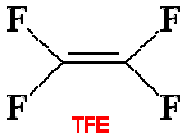




CASE 2: Fluorinated monomer gas

Updated information:

- Process gas is TFE (monomer gas)



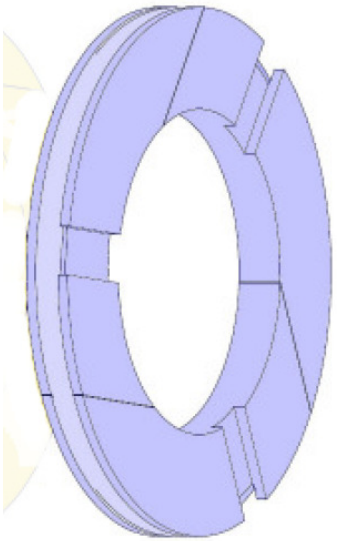
Root cause analysis:

- PTFE not chemically resistant
- Material swells by taking up gas
- Material breaks and gets jammed
- Increasing temperature
- Auto-polymerization takes place
- Sealing ring gaps filled with polymer
- No further adjustment to piston rod
- Increased leakage rate
- Leakage gas system is also affected
- High leakage into the distance piece

CASE 2: Fluorinated monomer gas

Actions:

- Change of sealing material into PEEK ⇨ SK904
- Change of sealing design into tangential cutted rings



CASE 2: Fluorinated monomer gas

Outcomes:

- Temperatures are below 60 ℃
- No leakage into the distance piece
- Leakage to flare significantly reduced
- Still good performance at revision
- Low amount of polymer after 8700 hrs
- Increased customer satisfaction

Key learnings:

- PTFE materials are not the solution for every application
- Provide detailed information about the process gas to for choosing the best material

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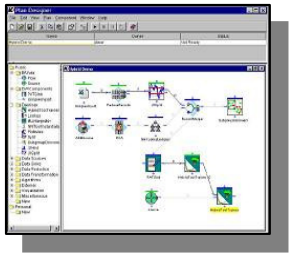
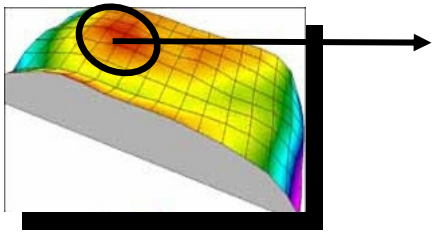
Materials / Layouts for Special Conditions

Mixture



Test program

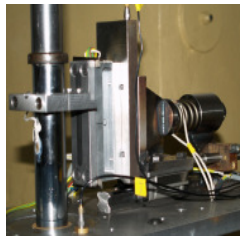
Analysis



Finding the right mix

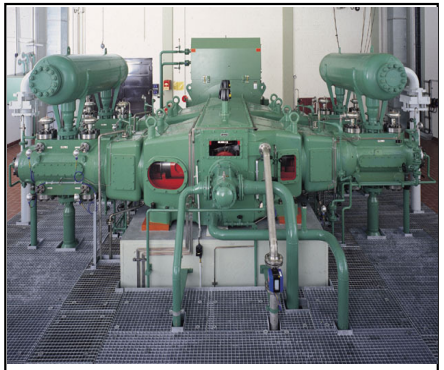
Test compressor

Semi finished product



Characterization (tribological, mechanical, etc.)

- ⇨ Efficient chain for a quick development of custom-made solutions!
- ⇨ Materials / Layouts can be tested upfront to work at extreme conditions
- ⇨ Ask your supplier



Product (Field)

Testing capabilities (STASSKOL example)

Reciprocating tribometer

- Unique testing device
- Broad variety of gaseous media
- Mean speed up to 6 m/sec
- Pressures up to 100 bar
- Temperatures up to 200 ℃
- Stroke of 130 mm

Test compressor

- Real life testing
- Broad variety of gaseous media
- Mean speed up to 3.5 m/sec
- Pressures up to 250 bar
- Stroke of 130 mm
- Cooled & uncooled packings

Summary

- Material & Layout have to be a suitable choice according to the specifications of the application especially at “non-standard conditions”!
- Knowing all actual details about the machine, the process and the gas enables the right choice
- Wear resistance and chemical resistance are crucial properties for choosing materials
- Continuous Material Development enhances the capabilities of sealing materials when dealing with extreme conditions