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Optimizing Compressor Packing Designs by Predicting Rod Temperatures

Andreas Brandl, John Ladd, Karl Markey

HOERBIGER

Author Bios

Andreas Brandl is the Engineering Manager at HOERBIGER Service Inc. in Houston TX. His work focuses on Reciprocating Compressors for the Oil & Gas and Chemical/Petrochemical industry.
Before coming to Texas he was working in the corporate R&D department for HOERBIGER in Austria. Andreas earned his Master's degree in mechanical engineering at the Vienna University of Technology and his MBA at the Jones Graduate School of Business at Rice University.

John Ladd is a Solutions REE Engineer and Compressor Analyst at HOERBIGER Service In. in Houston, TX. His primary role is conducting comprehensive technical evaluations of reciprocating compressors to identify and quantify unit improvements in reliability, efficiency, and environmental soundness. Prior to his current role John earned his Master's in mechanical engineering at Colorado State University with a focus on legacy integral pipeline compressors.

Karl Markey is the R&P Engineering Team Manager at HOERBIGER in North America. His team focuses on product design and support for compressor OEM's and end users in a variety of industries. Karl has 15 years of experience in the Rings and Packing business and he has additional prior experience with product design and development outside the oil and gas industry. Karl has a Bachelor of Science degree from Massachusetts Institute of Technology and a Master of Engineering Degree from Rensselaer Polytechnic Institute.

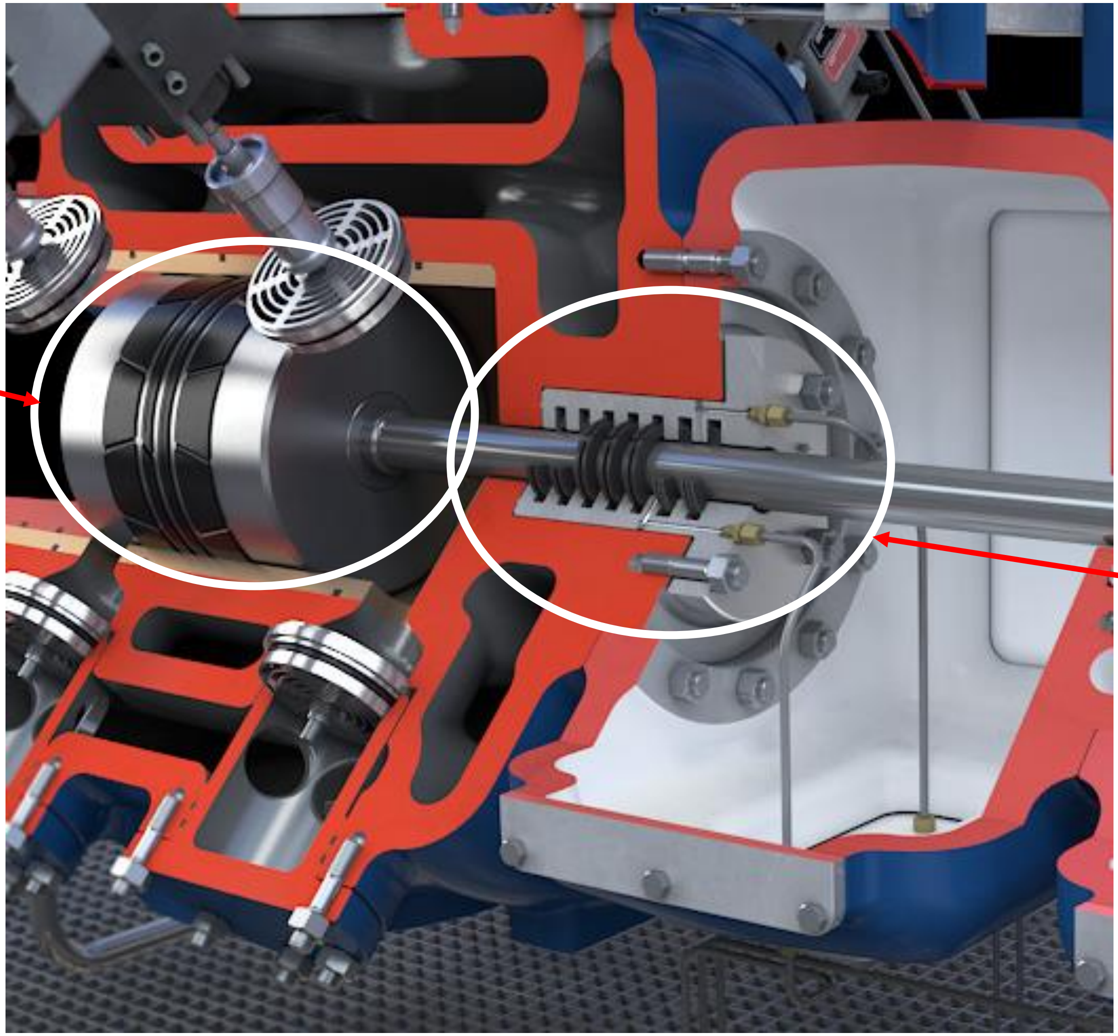
Abstract

Current compressor rod packing engineering standards rely on rule of thumb methods and selection tables. This lecture presents a method to maximize the packing run time by optimizing the performance determining parameters of the packing. By predicting the rod temperature distribution, the performance of different packing layouts (case length, number of rings, backup ring material, ring design, case ID) can be compared and a relative run time prediction can be given. The lecture describes the model details, discusses the heat transfer correlation assumptions and deducts general packing design guidelines based on the model results. Several packing optimizations have been performed using this approach and two case studies are discussed in this lecture.

Agenda

Seal System – Piston & Pressure Packing

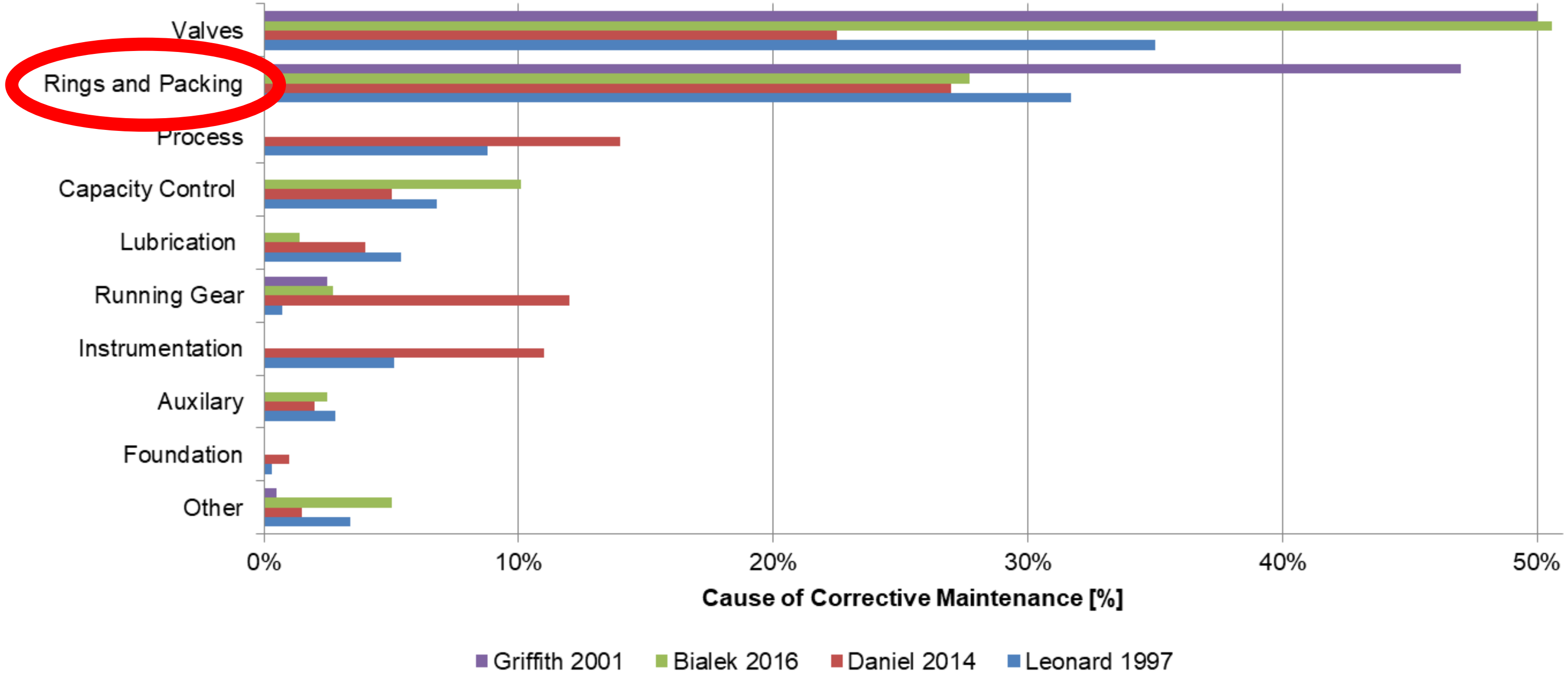
Compressor
Piston

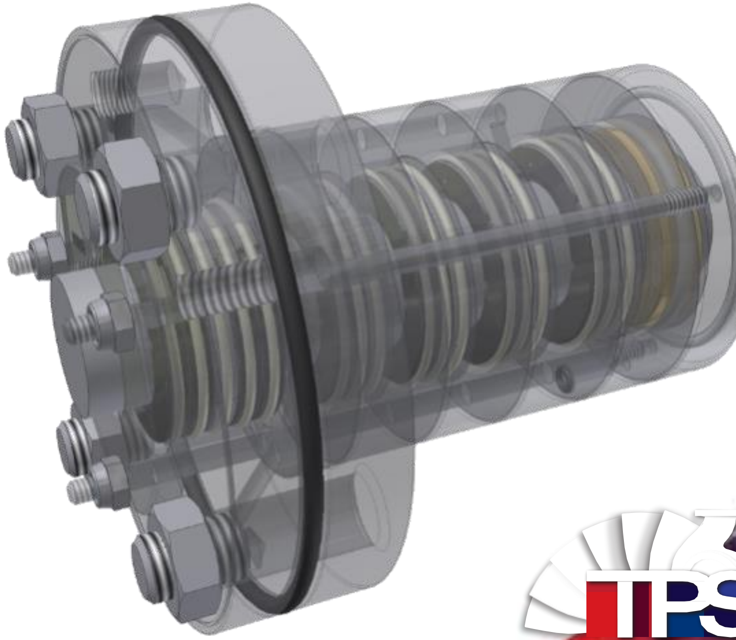


Pressure
packing

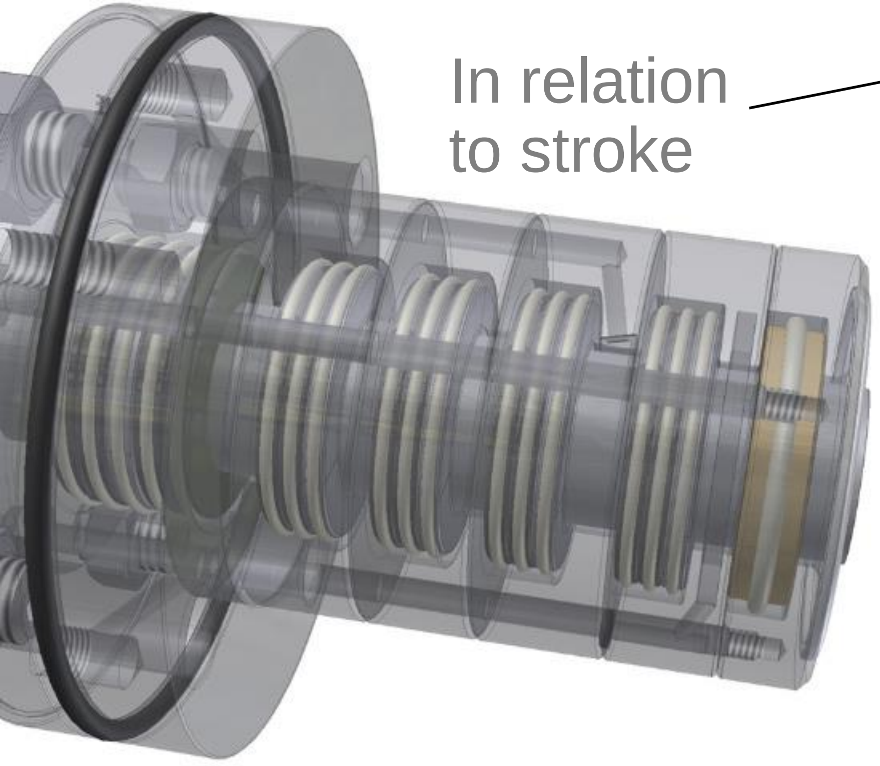
Seal system = Rings and Packing

27% - 47% of corrective maintenance events!





Relevant packing design parameters



Number of packing rings

Pressure
Gas Lube

Length of packing case

In relation to stroke

Back-up ring material

PEEK vs Metallic

Case – rod clearance

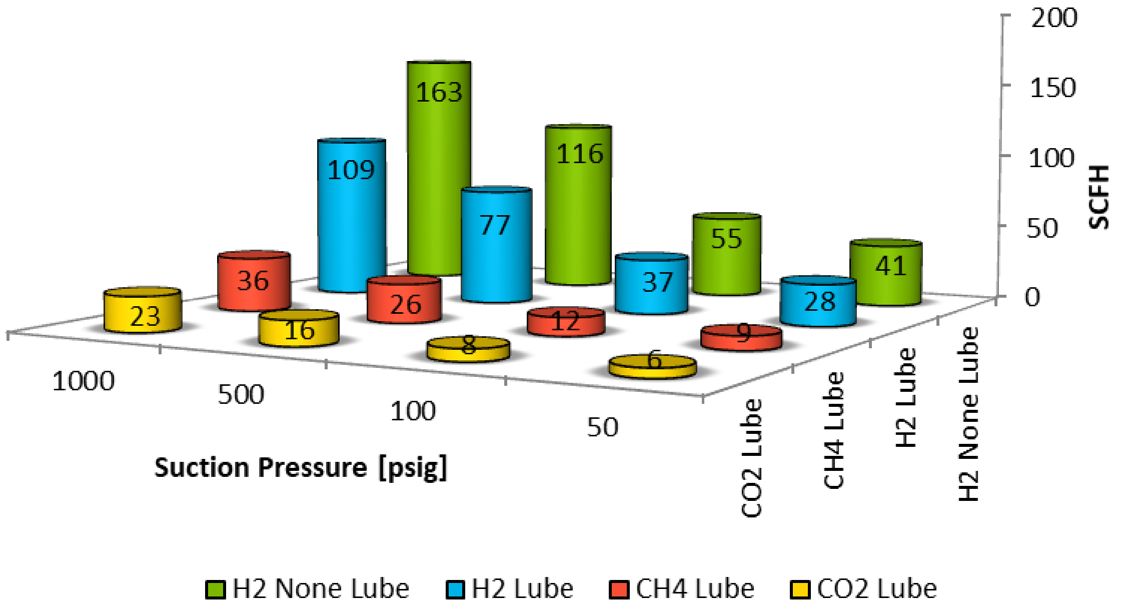
1/8in vs 3/16in

Ring style

Standard vs. pressure balanced

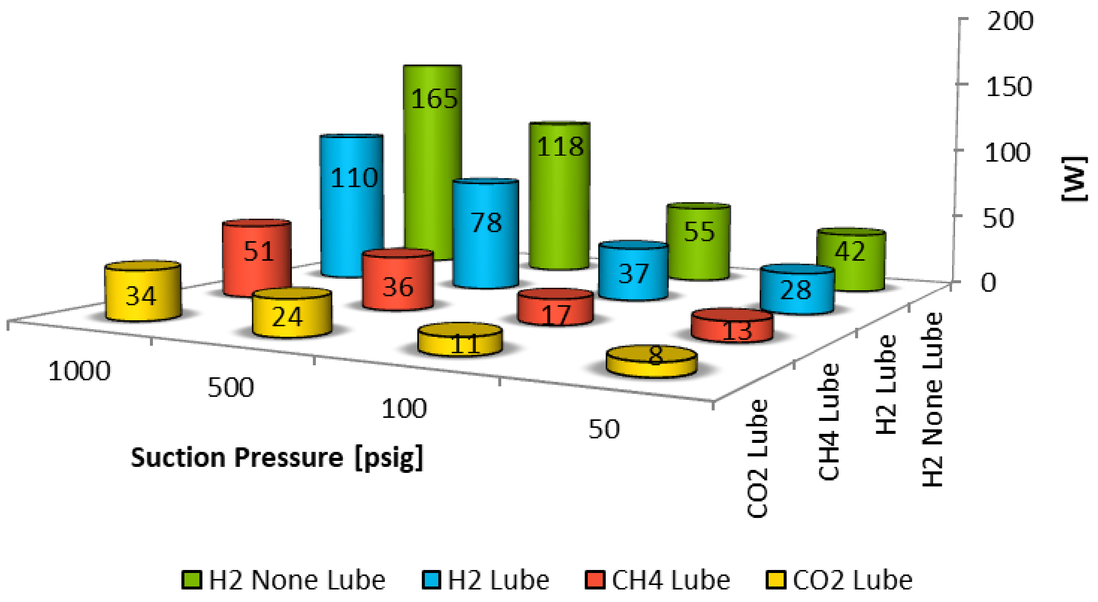
Typical leakage rates and heat removal

Expected Packing Leakage Rates (Based on empirical data)



Assumptions: Compression ratio of 2.5, 2in rod dia, 9in stroke

Expected Heat Removal From Rod via Gas Leakage

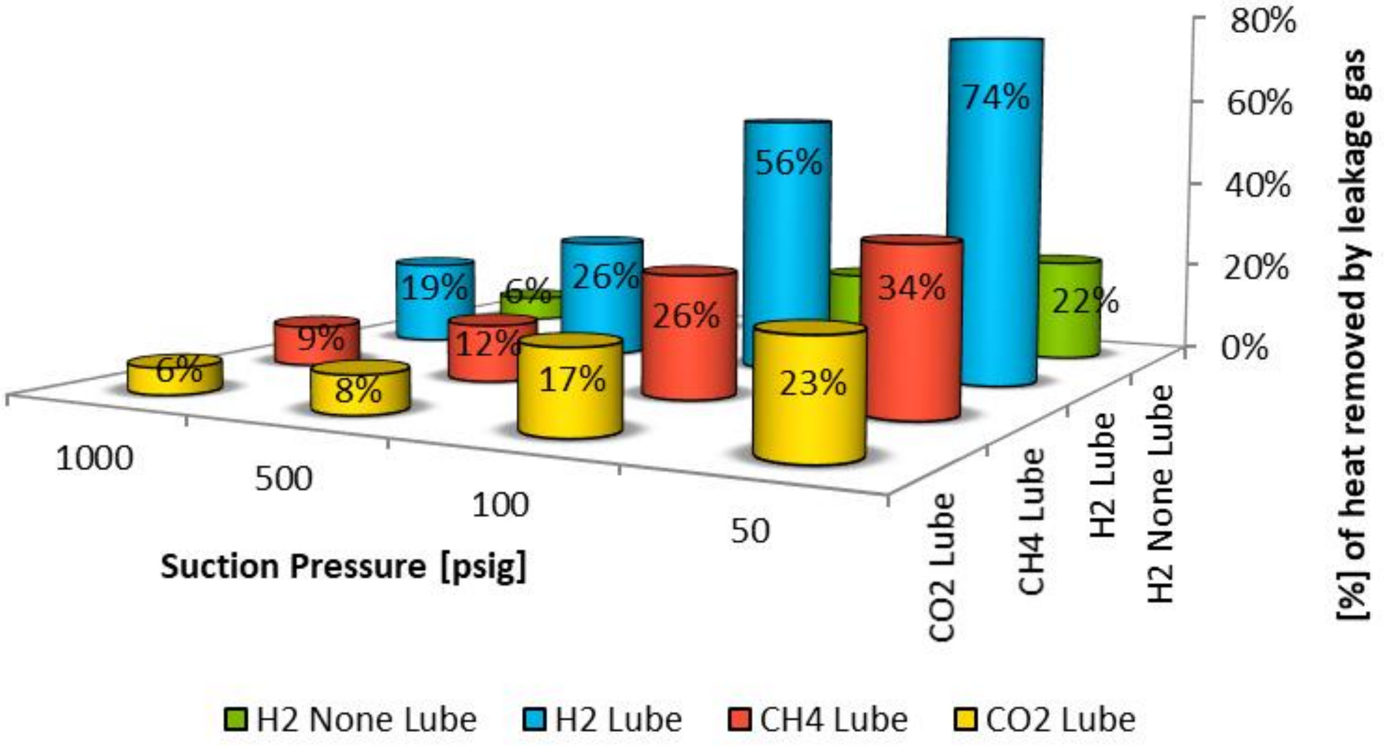


Assumptions: Compression ratio of 2.5, 2in rod dia, 9in stroke, temperature rise of gas of 180°F

The leakage gas removes only a small fraction of the generated heat

Assumptions

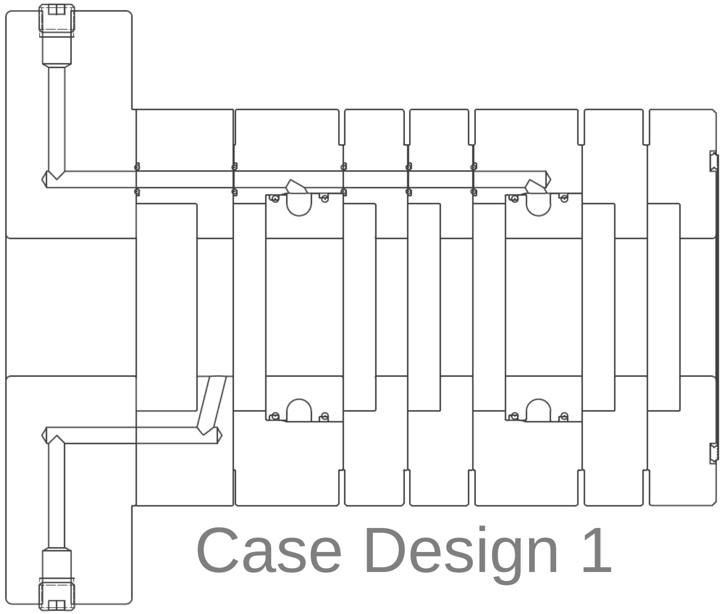
- Compression Ratio: 2.5
- Rod dia: 2in
- Stroke: 9in
- Temperature rise: 180°F
- Frictional coefficient:
  - 0.2 (none-lube)
  - 0.04 (lube)



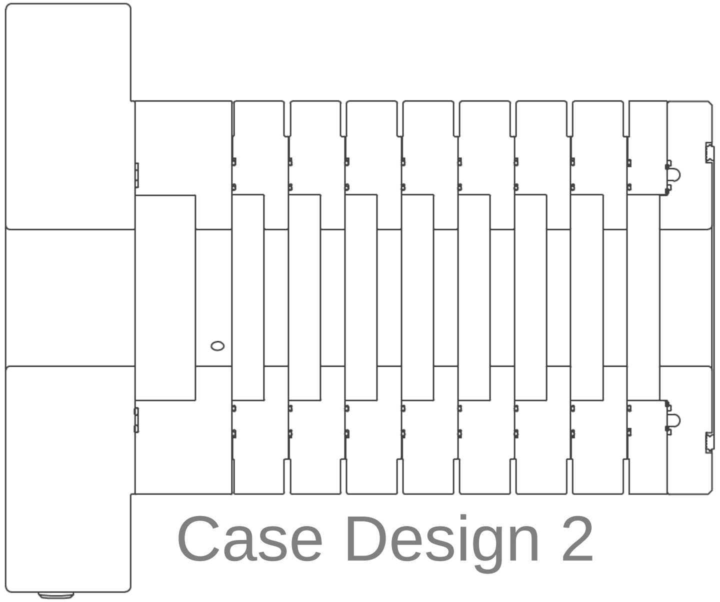
Lube oil

Heat removal from packing lube oil is negligible

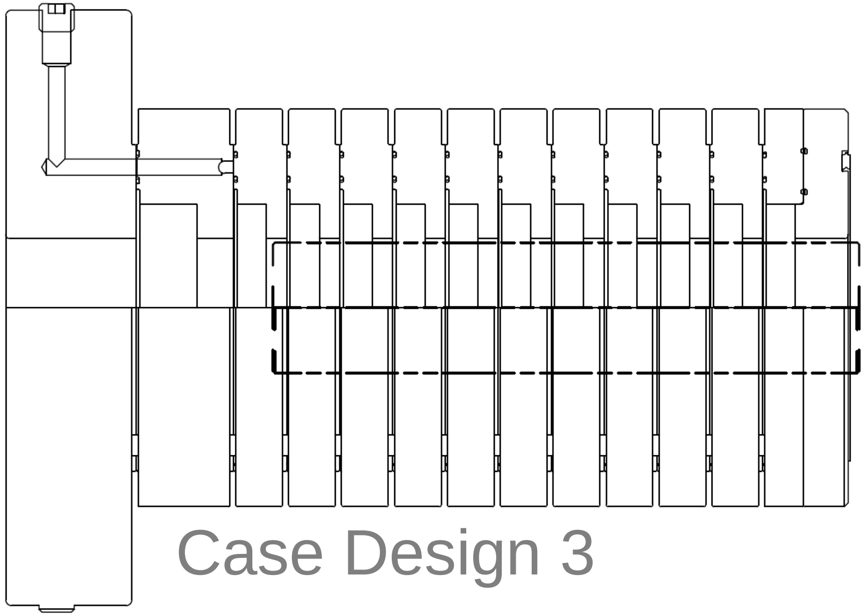
Ideal Packing Case – Rod Temperature is a key parameter



Case Design 1



Case Design 2



Case Design 3

	Case Design 1	Case design 2	Case design 3
Number of rings	6	8	11
Case Length [in]	9	9	11
Rod Temp [°F]	?	?	?

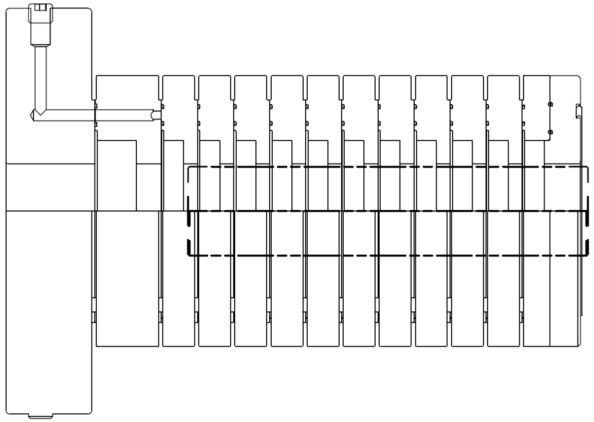
Agenda

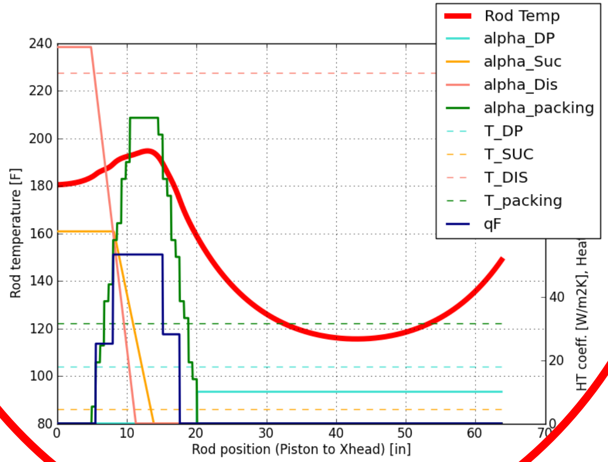
Optimization Process – Increase the ring count without increasing the rod temperature

Add packing rings, increase the case length

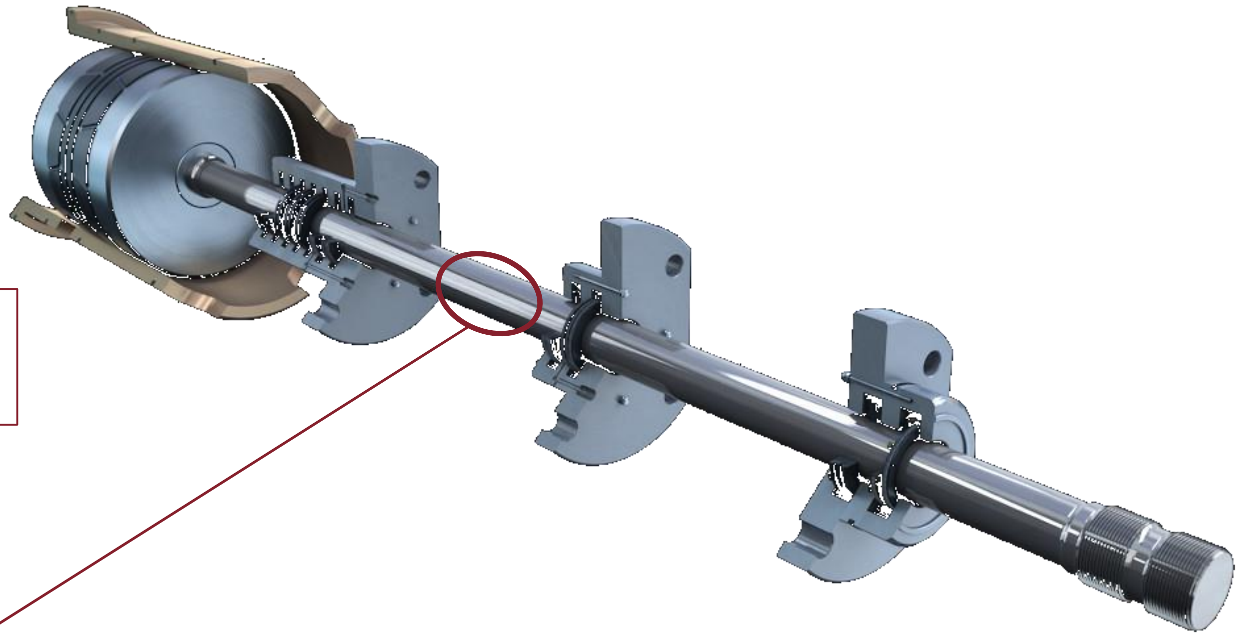
Verify that the rod temperature does not increase

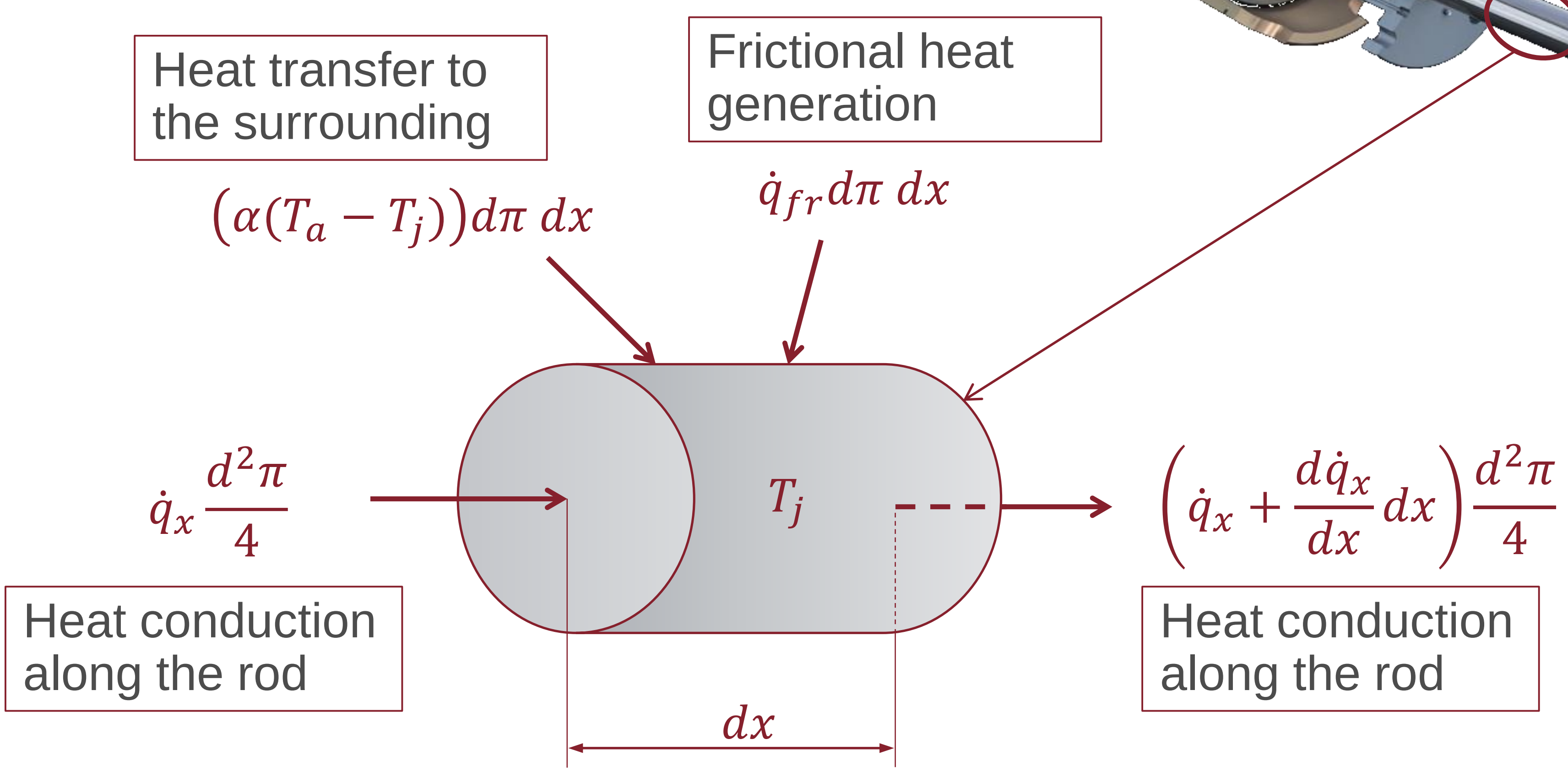
Increased packing run time



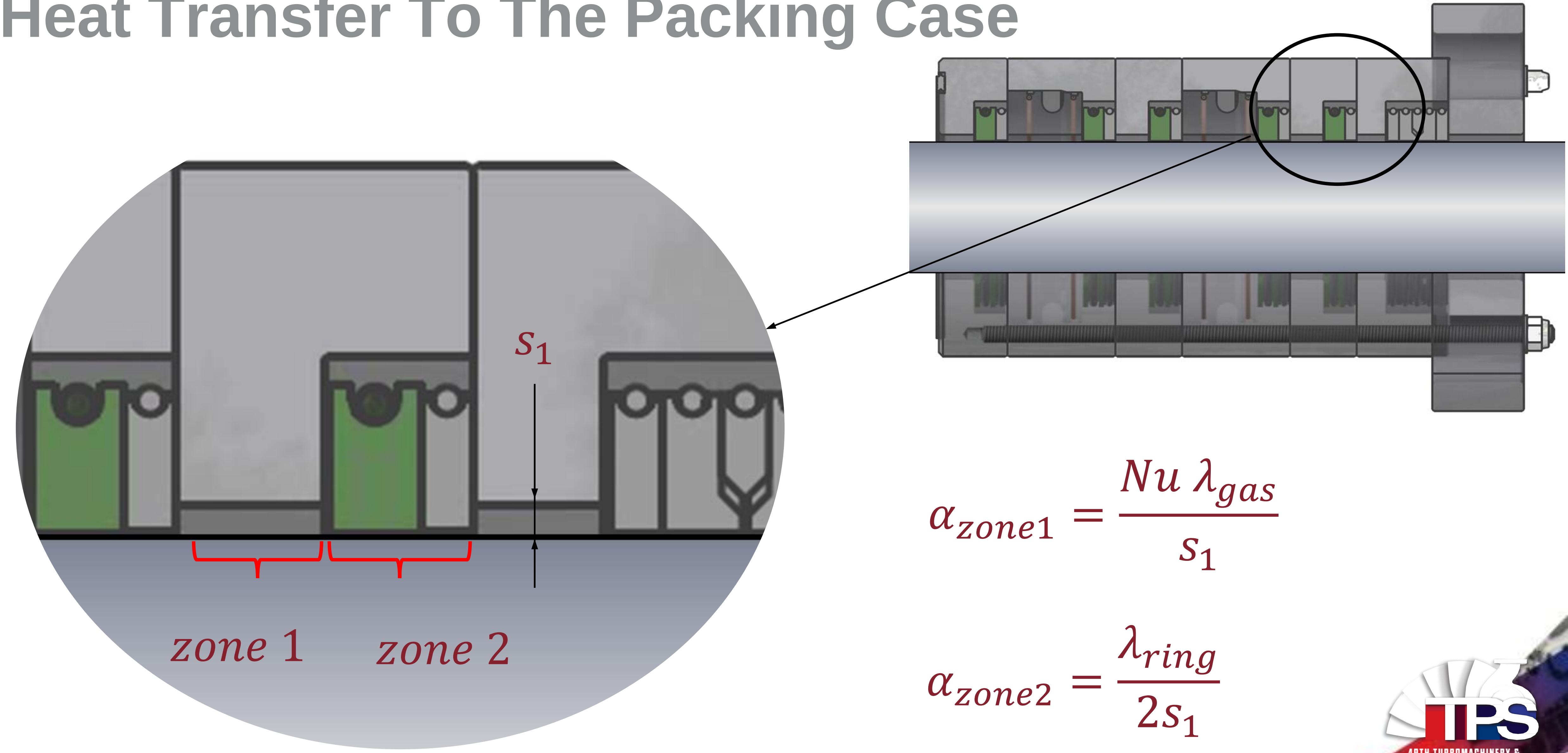


Thermal Model – Heat Generation, Heat Conduction, Heat Transfer





Heat Transfer To The Packing Case



$$\alpha_{zone1} = \frac{Nu\,\lambda_{gas}}{s_1}$$

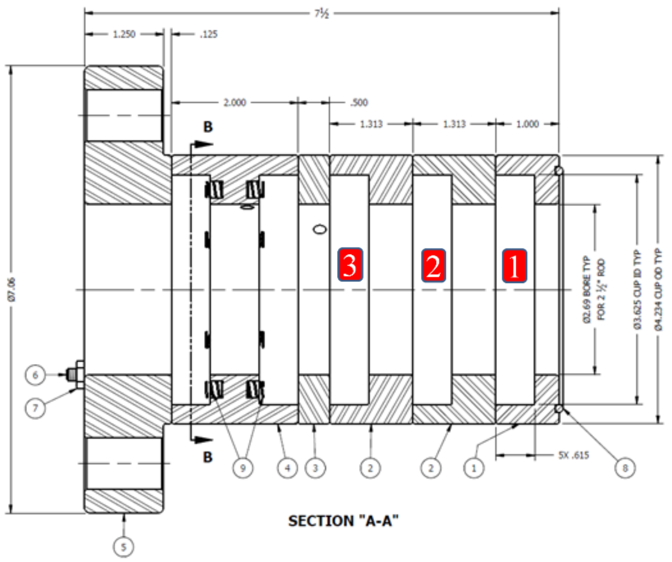
$$\alpha_{zone2} = \frac{\lambda_{ring}}{2s_1}$$

Agenda

1	Introduction and Motivation
2	Description of the Rod Temperature Model
3	**Optimization examples**
4	Summary

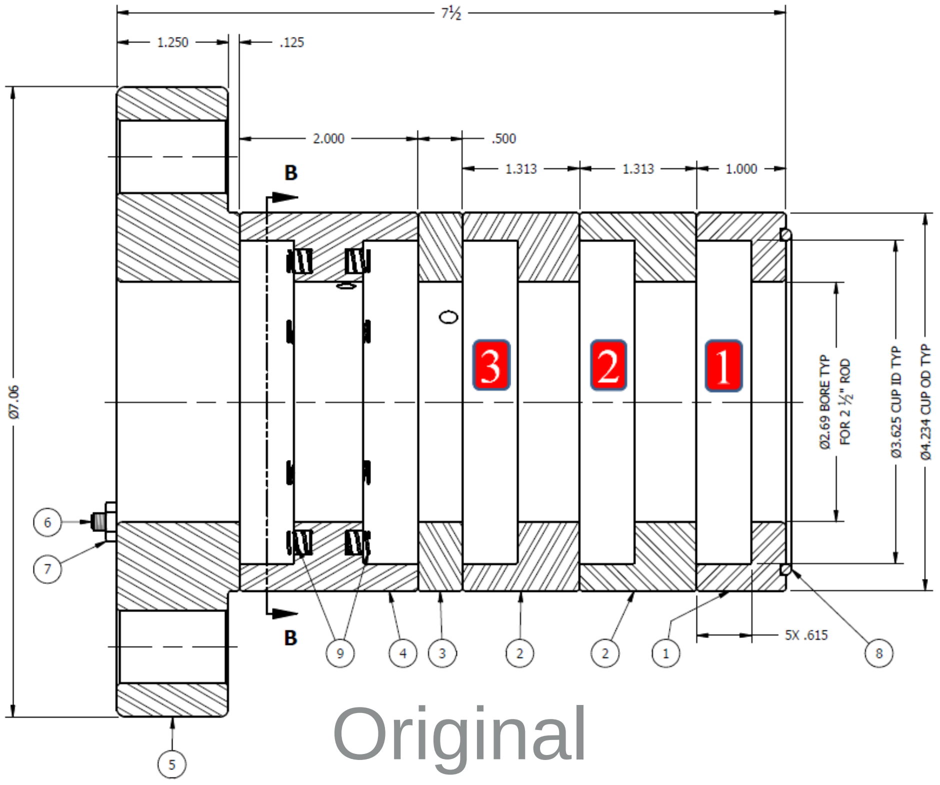
Low Pressure, Ethylene, None Lube

Parameter	
Speed [rpm]	440
Cylinder dia	16.5
Stroke [in]	9
Avg. p. speed [ft/min]	660
Rod dia [in]	2.5
Isentropic Exp. []	1.29
Molar mass [kg/kmol]	25.8
Cylinder Lubrication	None Lube
p_{suc} [psig]	14
p_{dis}[psig]	65

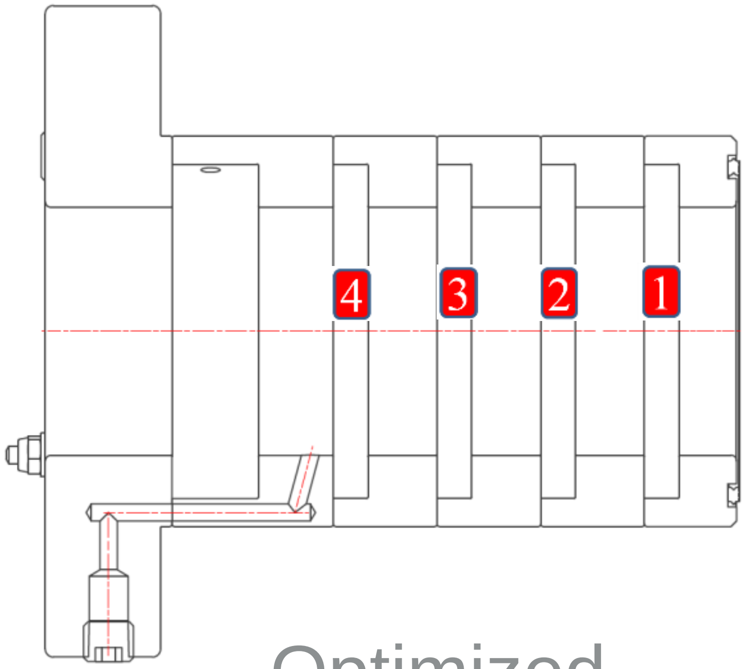


Packing Parameter	
# of seal rings	3
Length of case [in]	6.25
Back up ring material	NA
Rod – case cl. [in]	3/16
Ring style	RT

Packing Optimization



Original



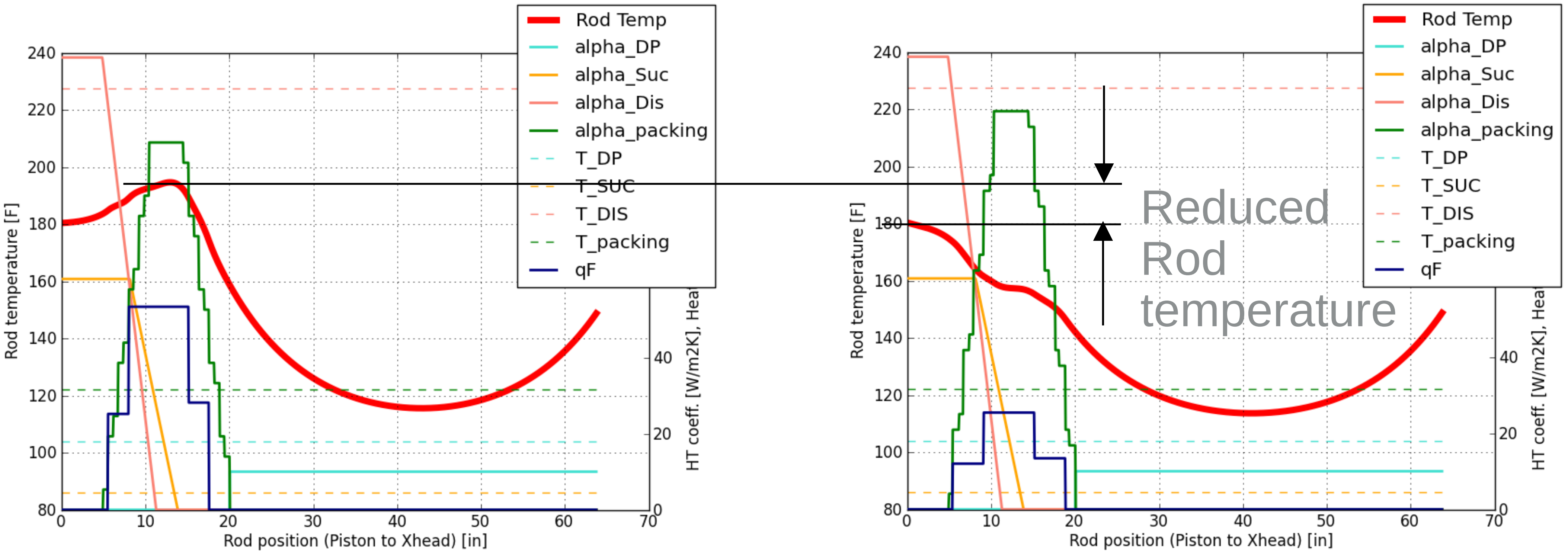
Optimized

[1] Radial / Tangential cut ring
[2] Pressure balanced ring

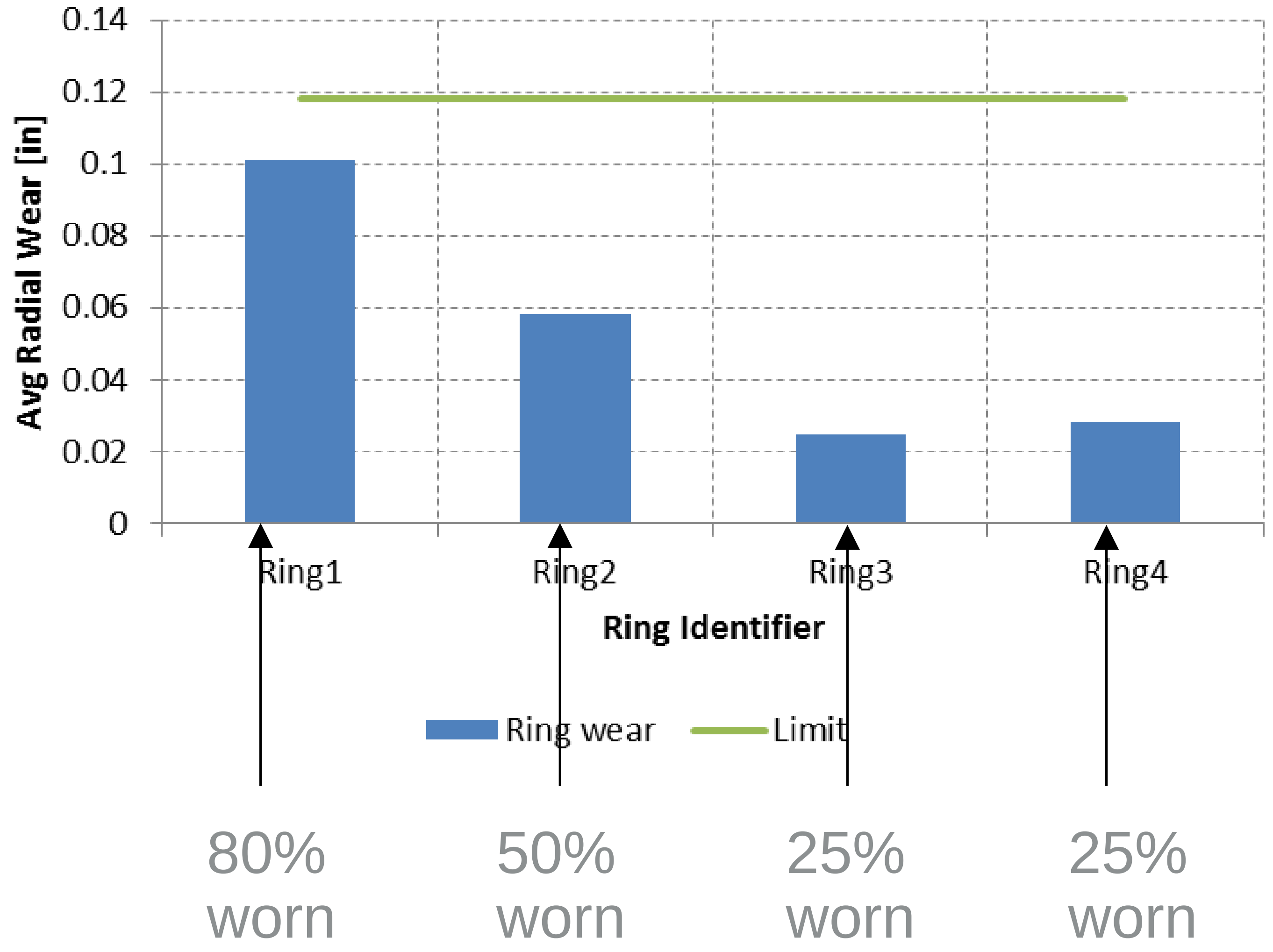
Packing Parameter	Existing	New	Impact
# of seal rings	3	4	Increased wear life
Length of case [in]	6.25	6.25	NA
Back up ring material	NA	NA	NA
Rod – case clearance [in]	3/16	3/16	NA
Ring style	RT[1]	PB[2]	Reduced heat generation

Increased number of ring + Reduced Rod Temperature

- Increased number of rings
- Pressure balanced packing rings

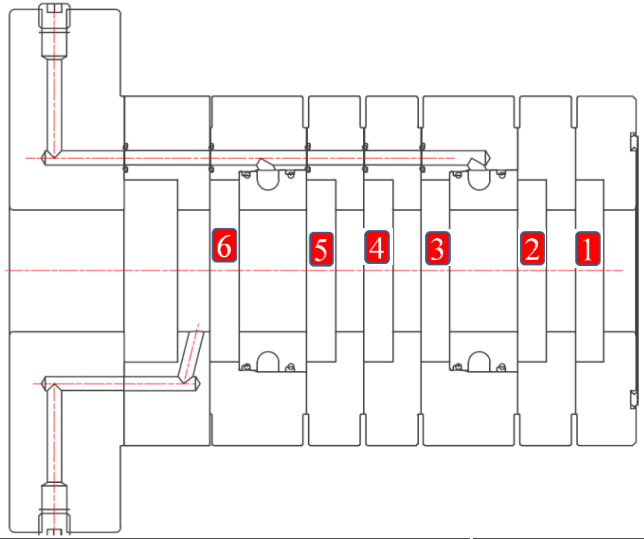


50% wear progress after 14 months of run time



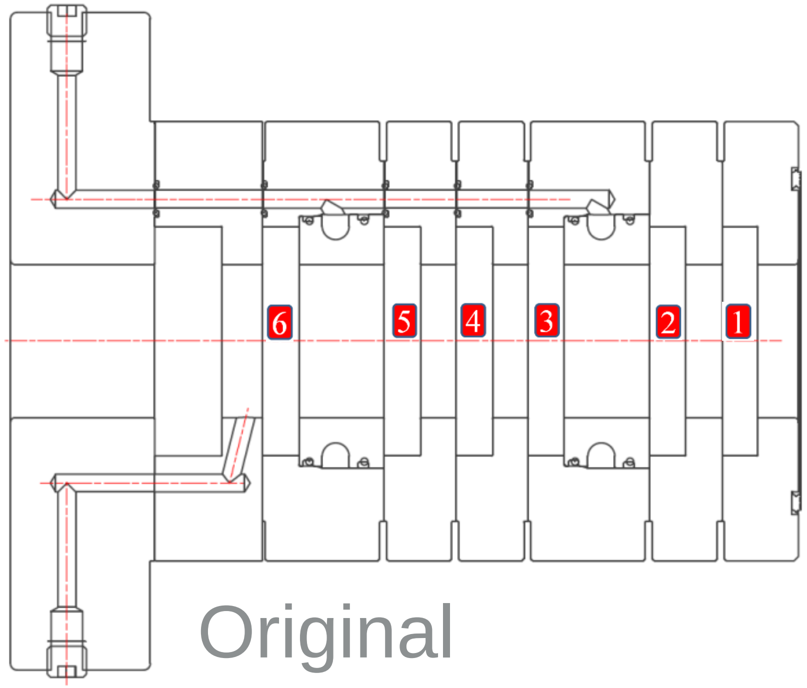
Medium Pressure, Hydrogen, None Lube

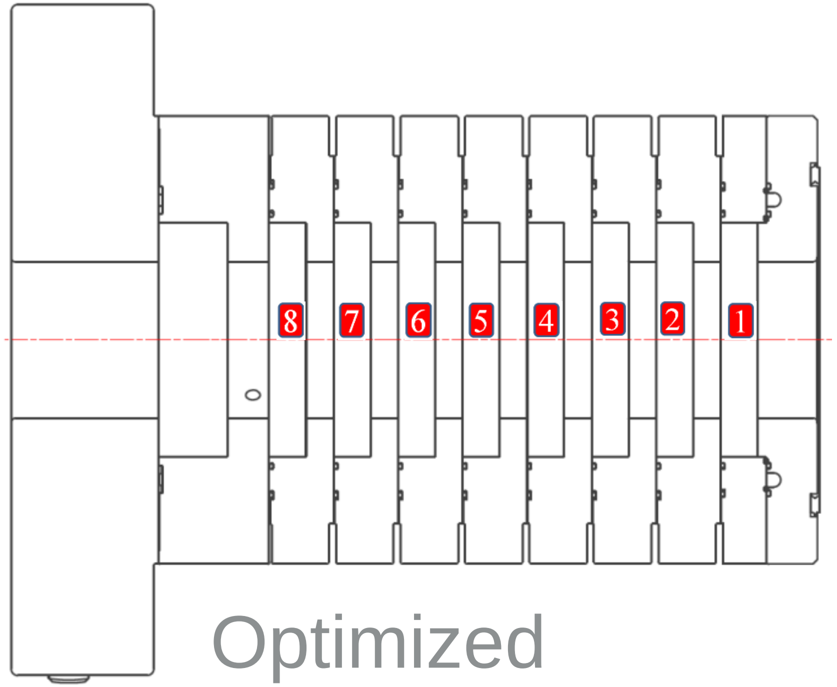
Parameter	
Speed [rpm]	396
Cylinder dia [in]	4.75
Stroke [in]	9
Avg. P. speed [ft/min]	593
Rod dia [in]	2
Isentropic Exp. []	1.4
Molar mass [kg/kmol]	2
Cylinder Lubrication	None Lube
p_{suc} [psig]	920
p_{dis}[psig]	1530



Packing Parameter	
# of seal rings	6
Length of case [in]	9
Back up ring material	PEEK
Rod – case cl.[in]	1/8
Ring style	RT

Packing Optimization



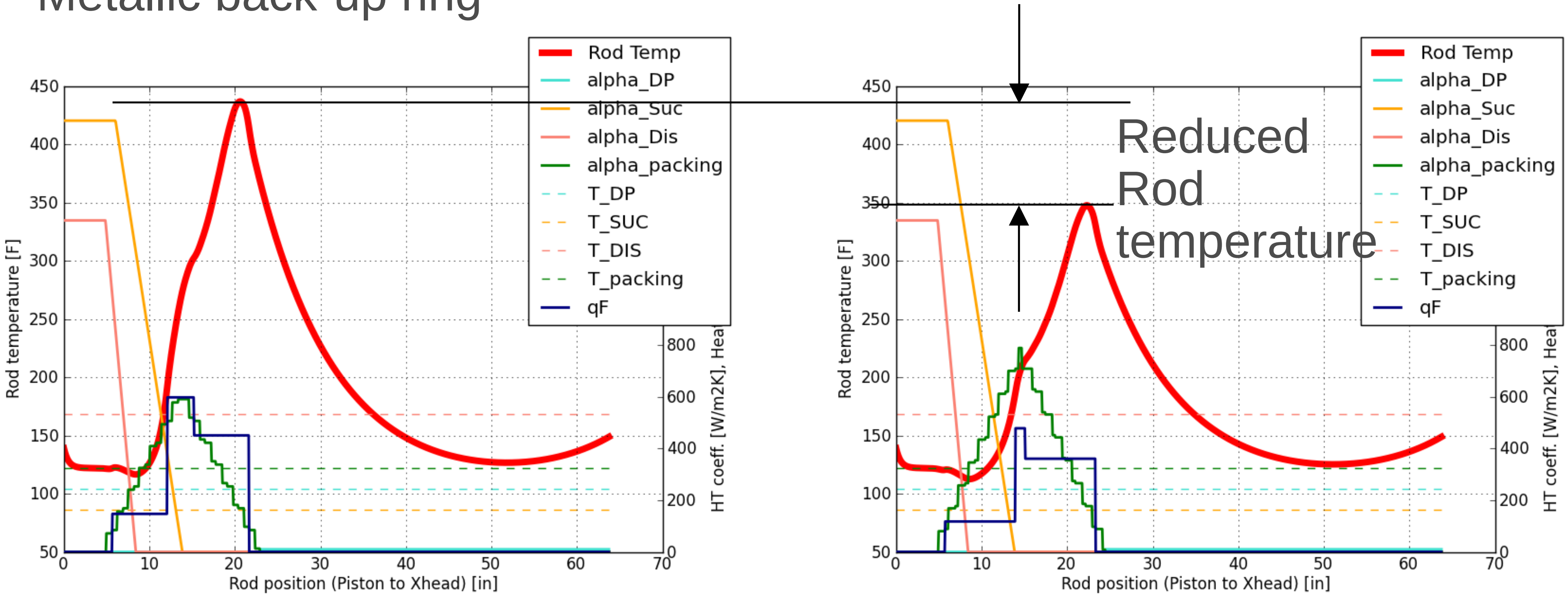


[1])Radial / Tangential cut ring
[2])Pressure balanced ring

Packing Parameter	Existing	New	Impact
# of seal rings	6	8	Increased wear life
Length of case [in]	9	9	NA
Back up ring material	PEEK	Bronze	Better heat transfer
Rod – case clearance [in]	1/8	1/8	NA
Ring style	RT[1])	PB[2])	Reduced heat generation

Rod Temperature Distribution

- Increased number of rings
- Pressure balanced packing rings
- Metallic back-up ring



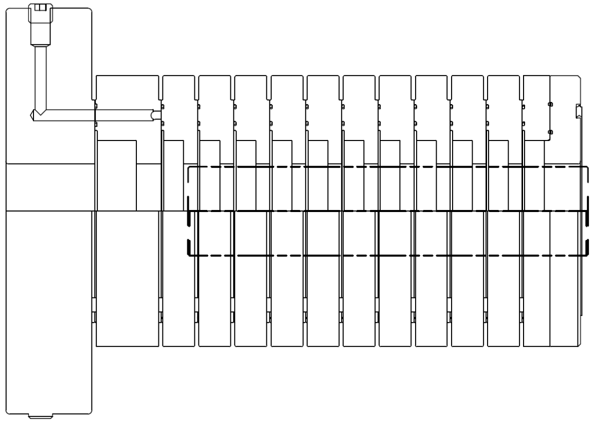
Agenda

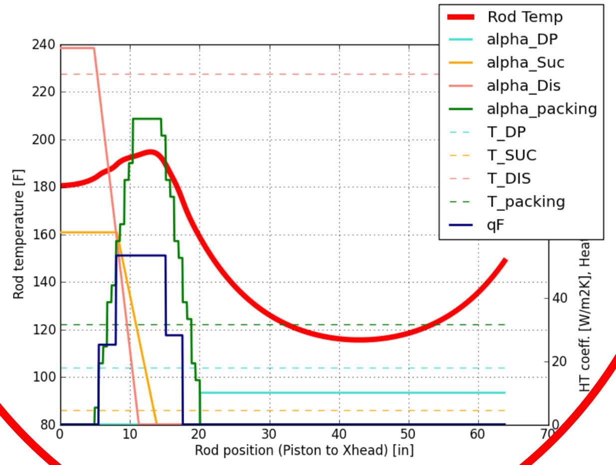
Optimization Process – Increase the ring count without increasing the rod temperature

Add packing rings, increase the case length

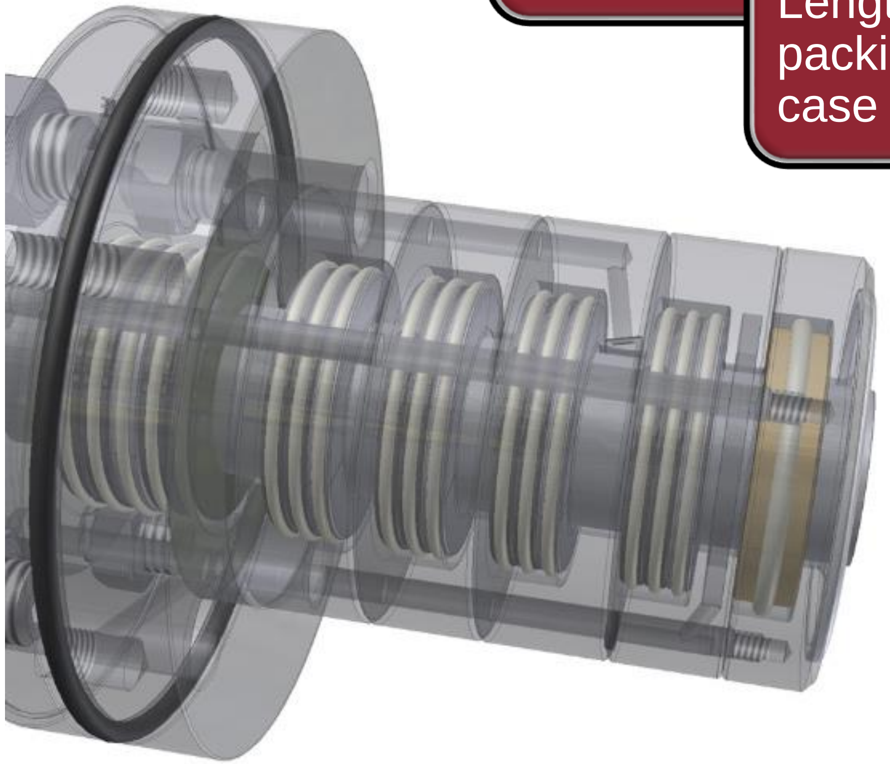
Verify that the rod temperature does not increase

Increased packing run time





Making Pressure Packings more Reliable by Taking the Rod Temperature into Consideration



- Number of packing rings
- Length of packing case
- Back-up ring material
- Case – rod clearance
- Ring style