Croda Lubricants

Innovation you can build on™

New Oxidatively Stable Lubricity Additive

Felipe Lopes

www.crodalubricants.com

CRODA

Presentation Overview

- The Product
  - Oxidatively stable high viscosity complex ester
  - Referred to as **‘OSE’**
- Oxidation testing
- Application performance
  - Comparison vs Bright-stock
- Summary

The Product

- Low addition-rate oxidatively stable complex ester viscosity modifier for group I, II & III base oils
- Increases viscosity index while improving oxidation stability and lubricity

Parameter	Unit	Typical value
KV@ 40°C	mm^2/s	40000
KV@100°C	mm^2/s	2000
Viscosity index	-	290
Iodine value	gI/100g	7
Pour point	°C	6

Note: In the process of being added to the Ecolabel LuSC list for VGP

Why Should You Care About Oxidation Stability?

- Oxidation?
  - Chemical reaction
  - Substance and oxygen
- The rate of oxidation is accelerated by:
  - High temperatures
  - Water & acid ingress
  - Catalysts such as copper
- Left unchecked, heavily oxidised oil can:
  - Form sludge and varnish
  - Increase in viscosity
- Leading to:
  - Filter plugging
  - Blockage of critical oil clearances
  - Valve stiction and many other precursors to failure

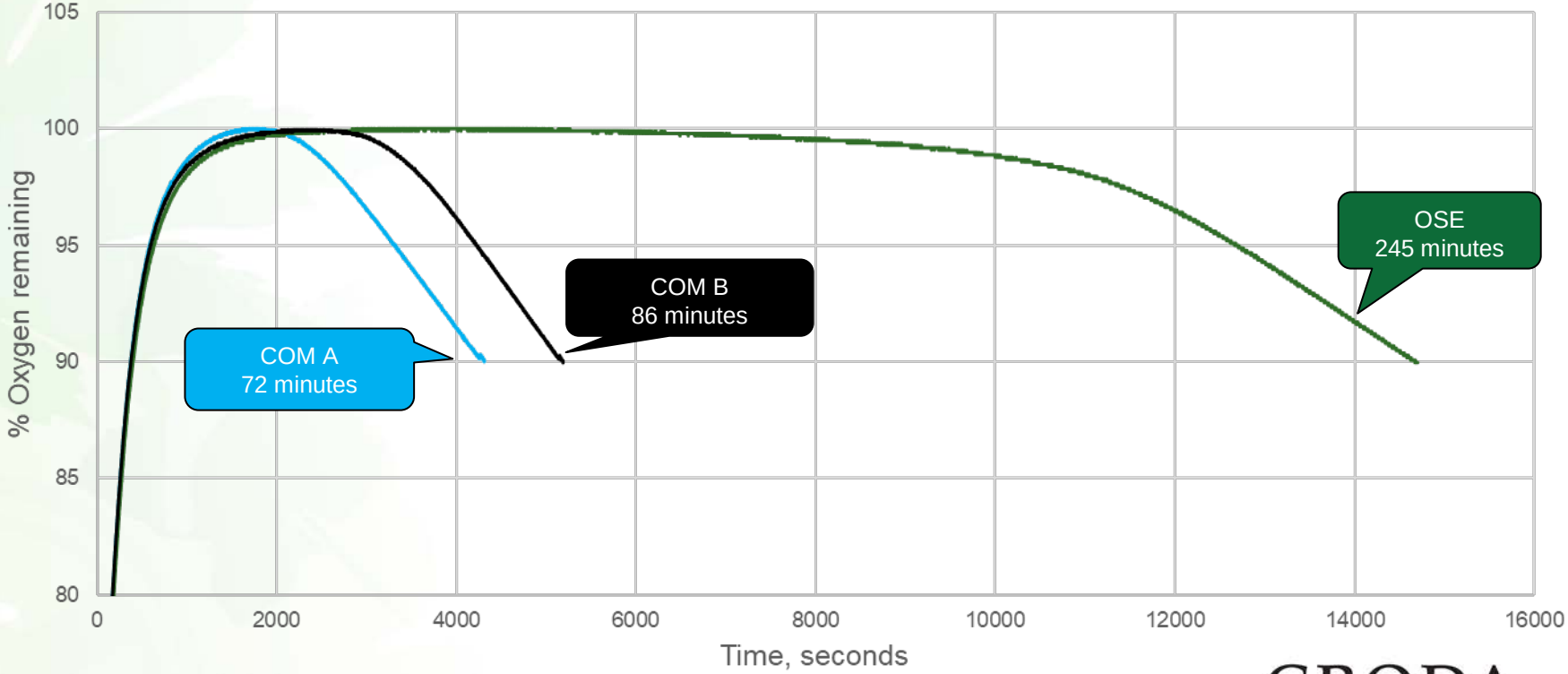
Getting the formulation right is pivotal in minimising oxidation

Oxidation Test Rig

- RapidOxy – static oxidation tester (ASTM7545)
- Only small sample required ~5mls
- Pressure vessel charged with O_2 at 700 kPa
- Temperature range 80 - 180ºC
- Test completed when pressure drops by 10% of maximum pressure
- Simulates oxidation onset
- All testing carried out without additional antioxidants

CRODA

Oxidation Stability at 140°C : Neat



www.crodalubricants.com

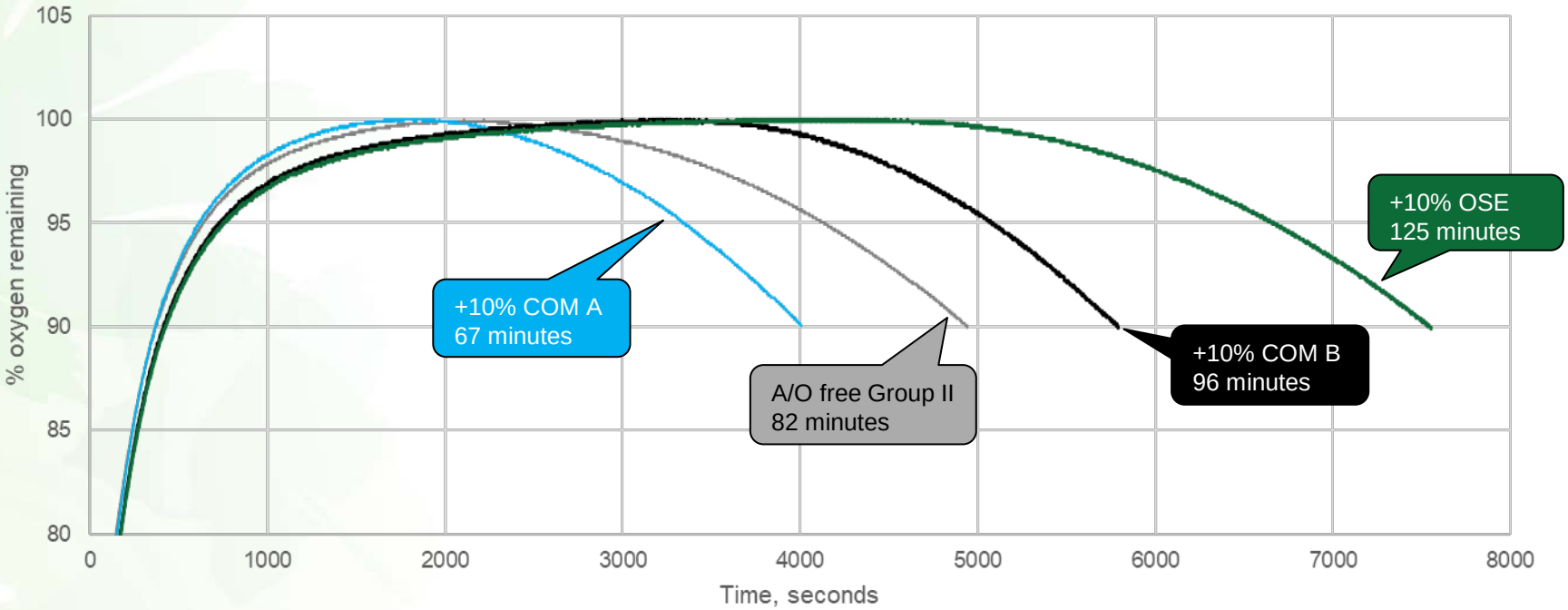
CRODA

Note: No antioxidant

Application Testing

- Improved oxidation stability in grp I & II base oils
- Potential as a bright-stock replacement
  - Lubricity and wear performance in model:
    - Industrial gear oil
    - Engine oil
- Viscosity and shear stability effects

Oxidation and Thermal Stability at 140°C: 10% in 600R* Group II Base Oil

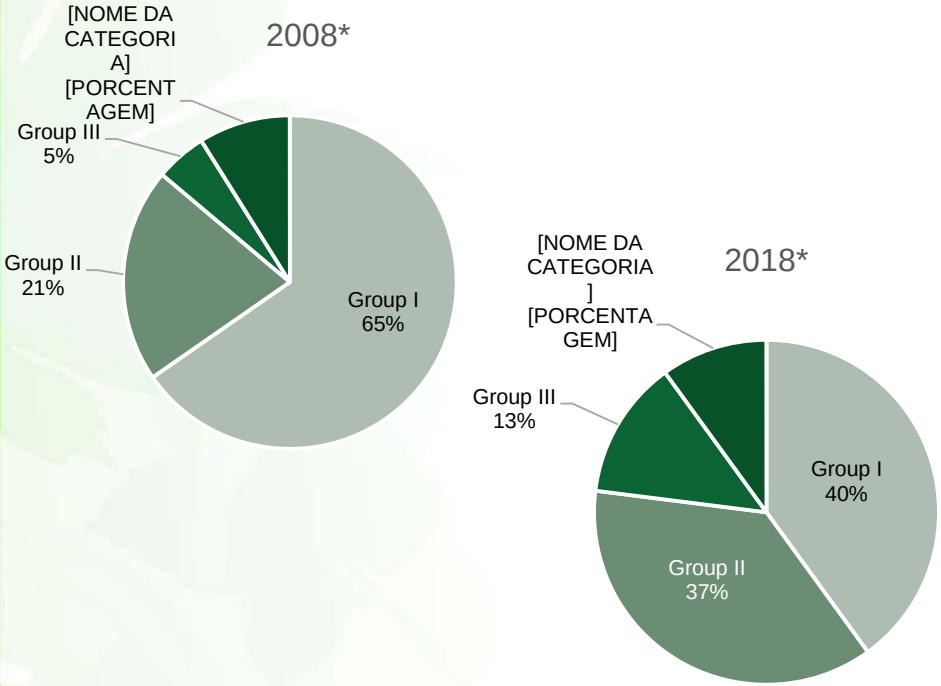


* Solubilised with 10% Polyol ester

Note: No antioxidant

CRODA

Bright Stock Replacement

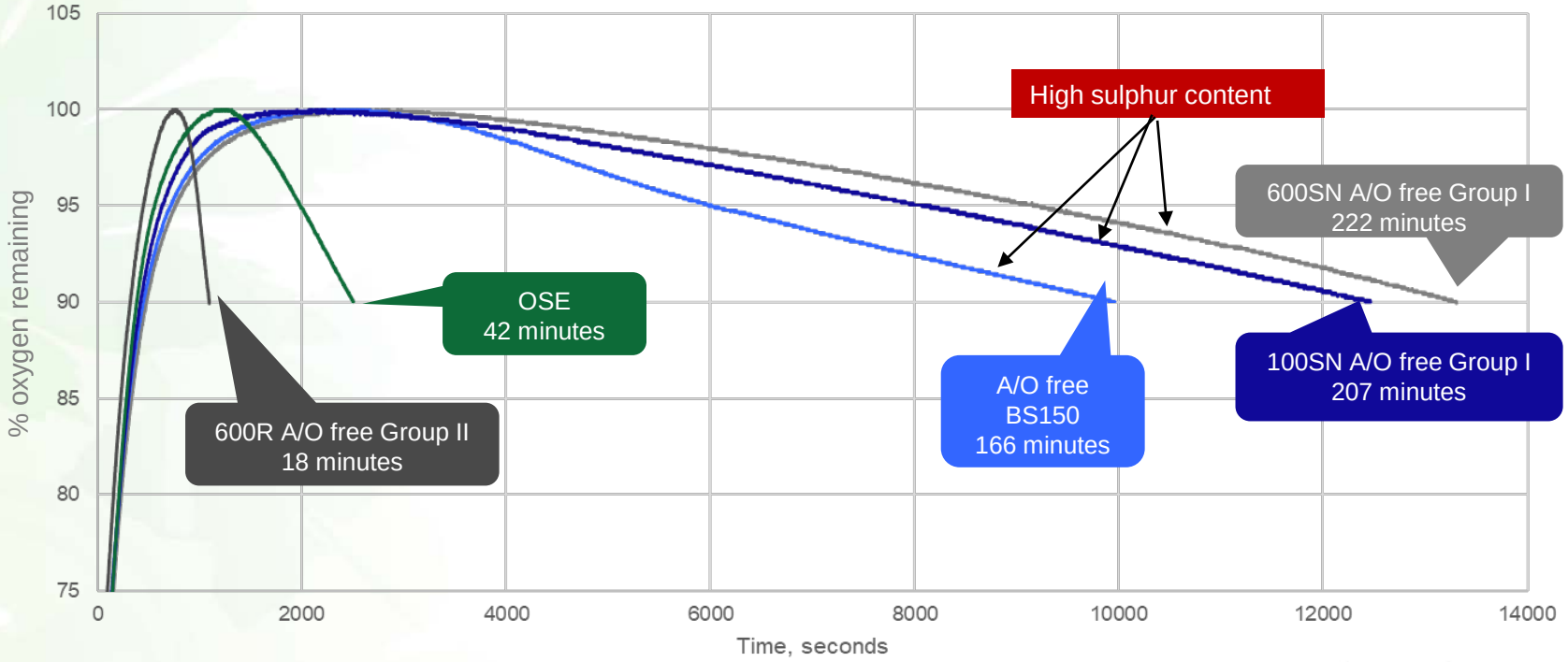


- Sulphur limits and lower viscosity oils reduced demand for group I base stocks.
- Reduced global capacity
- Bright stocks are produced as part of the Group I process
- Supply is becoming tighter and prices are going up.
- **OSE can be used to replace bright stock with multiple advantages**

*Source: 10th Annual Industry Factbook, Lubes‘n’Greases Magazine

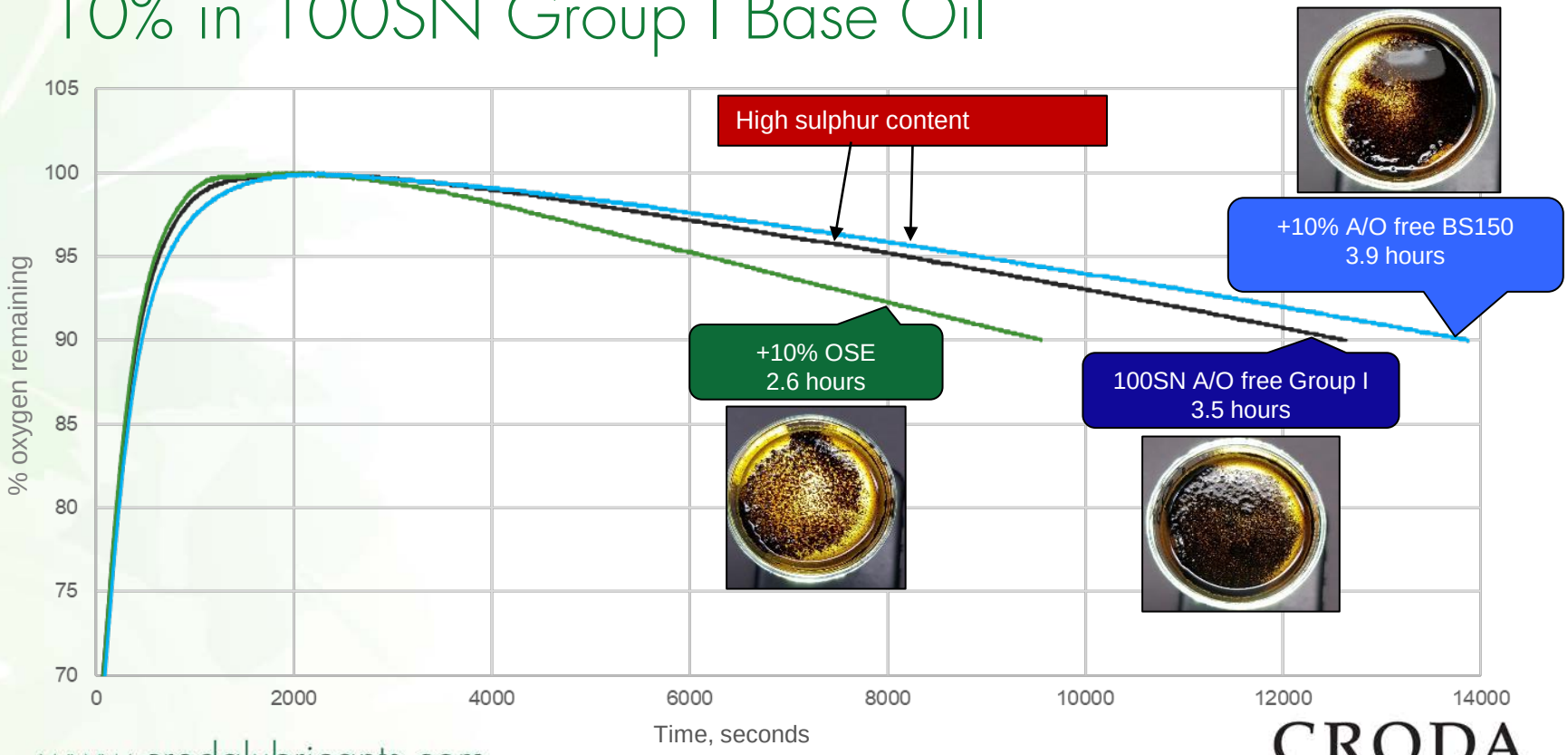
CRODA

Oxidation Stability at 180°C: Neat



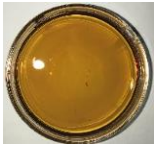
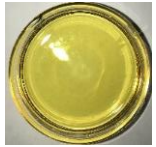
CRODA

Oxidation and Thermal Stability at 180°C: 10% in 100SN Group I Base Oil



CRODA

Oven Test at 180°C: Differences in Colour, Deposit and Sludge Formation, Neat

	0 hours	2 hours	4 hours	8 hours	16 hours
BS 150					
COM B					
OSE					

CRODA

Oxidation Summary

- Improved oxidation over commercially available alternatives
- Reduces the potential residue and deposits of grp I
- Cleaner, robust alternative to Bright-stock
- Enhance stability of grp II base stock

Industrial Gear Oil Formulations

- Model formulations used for the lubricity testing
- Range of typical gear oil viscosities were evaluated

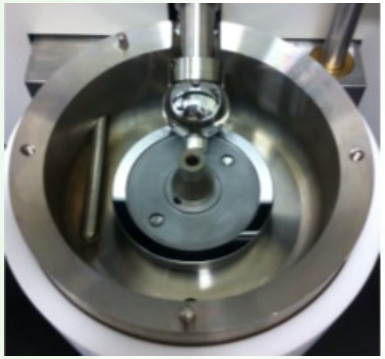
Component	Purpose	Composition (w/w %)							
		ISO 150 (150cSt at 40ºC)		ISO 220 (220cSt at 40ºC)		ISO 320 (320 cSt at 40ºC)		ISO 460 (460cSt at 40ºC)	
		A	B	A	B	A	B	A	B
OSE	Croda oxidatively stable ester	4.5	-	9	-	15	-	20	-
BS150	High viscosity Grp I base oil	-	22	-	52	-	76	-	98
COM A	Commercially available high viscosity ester from competitor	4.5	-						
COM B	Commercially available high viscosity ester from competitor	4.5	-						
600SN	Grp I base oil	93.5	76	89	48	83	22	78	-
Add Pack	Industrial gear oil additive package	2	2	2	2	2	2	2	2

Competitor products insoluble above ISO 150

No 600SN required

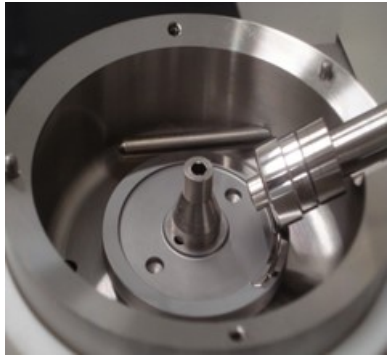
Friction Control – Mini Traction Machine

Ball-on disc – Stribeck & Traction Curves



Parameter	Value
Speed	Var/0.5mm/s
Temperature	100ºC
Contact Pressure	1.24Gpa 70N
Slide/Roll Ratio	30%/variable
Specimens	AISI 52100 steel

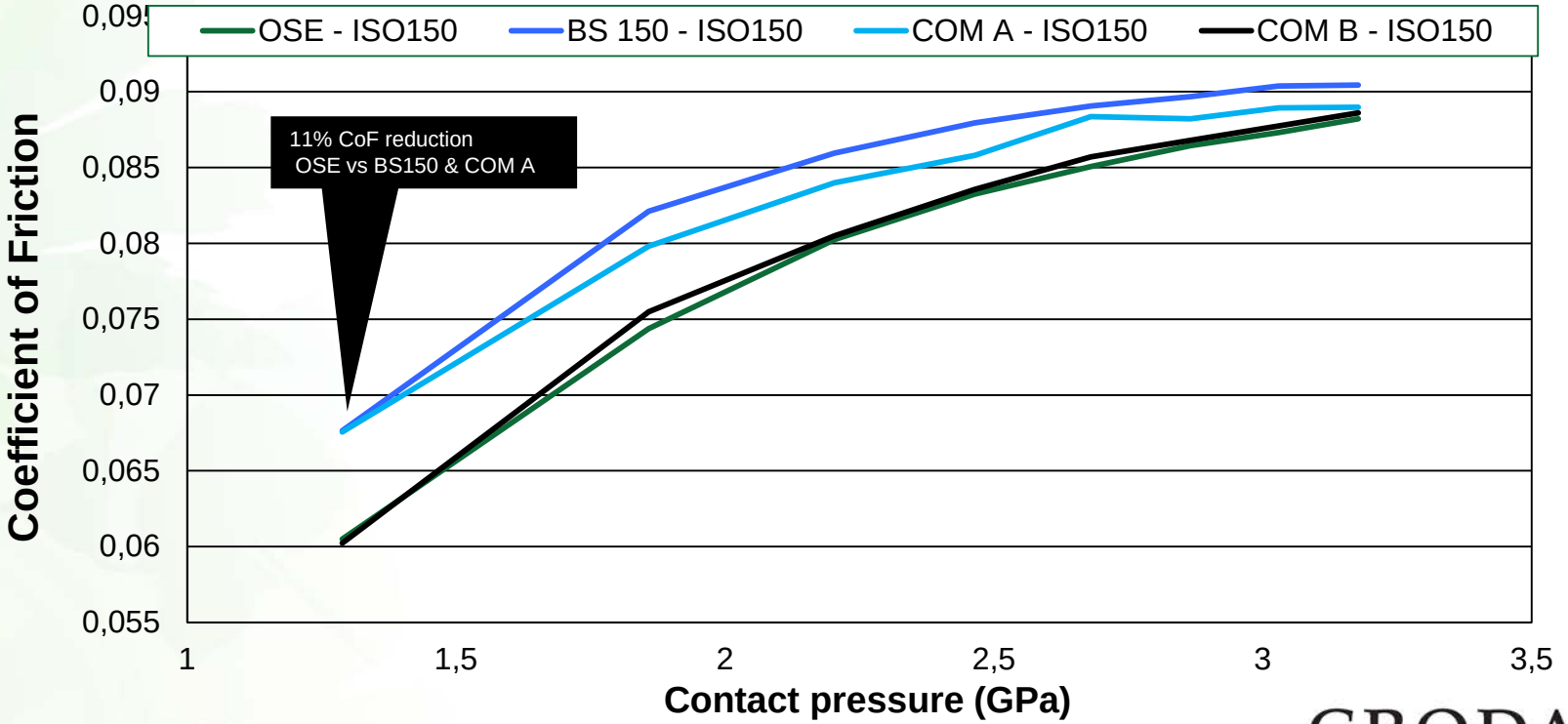
Barrel-on-disk - Variable Load Test



Parameter	Value
Speed	0.050m/s
Temperature	100ºC
Contact Pressure	1.25 – 3.2 Gpa 5 – 75 N
Slide/Roll Ratio	50%
Specimens	AISI 52100 steel

- Much higher contact pressures can be achieved (i.e. typical of those in gears)
- The contact pressure was slowly increased from 1.25 to 3.2 GPa

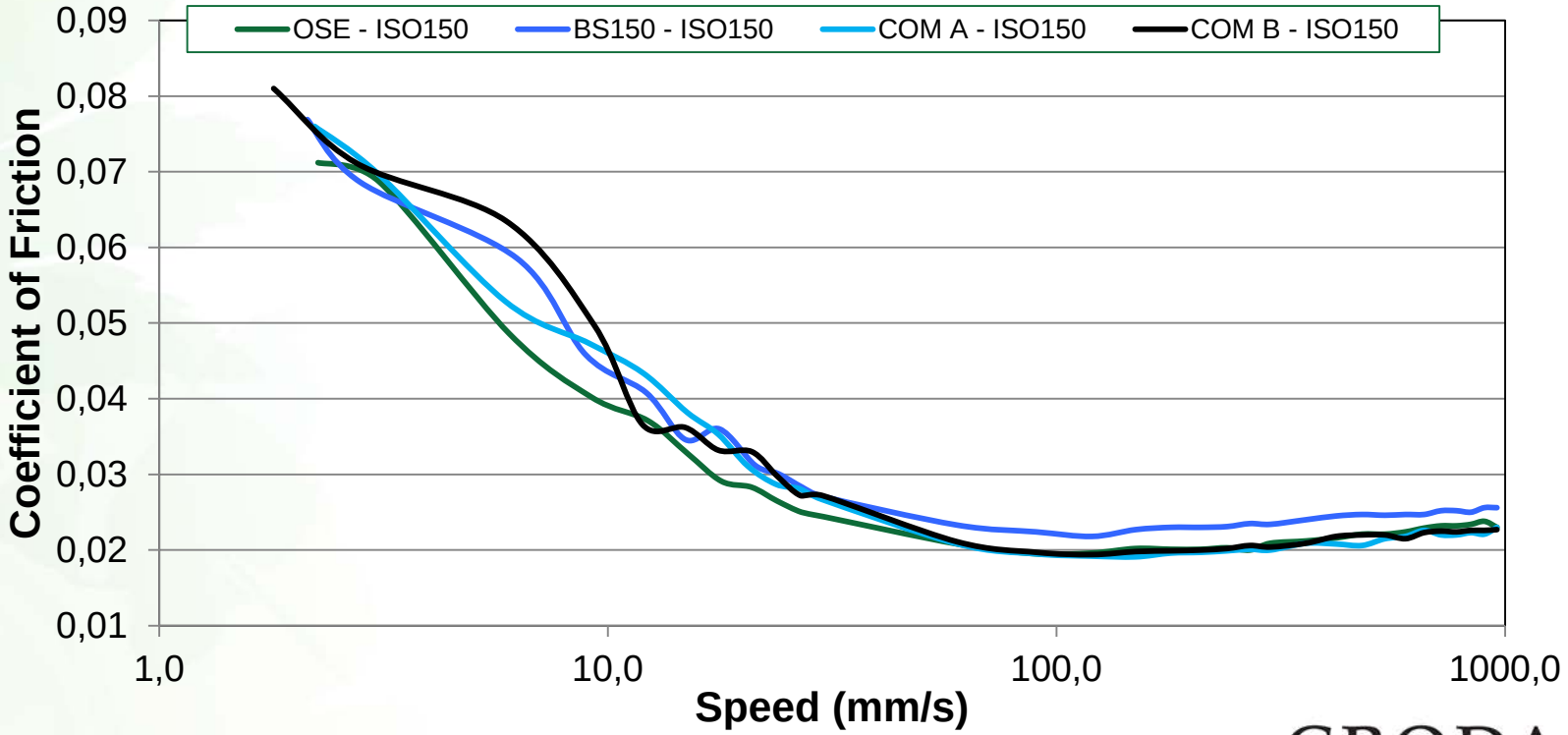
MTM – Barrel on Disk



50% Slide roll ratio

CRODA

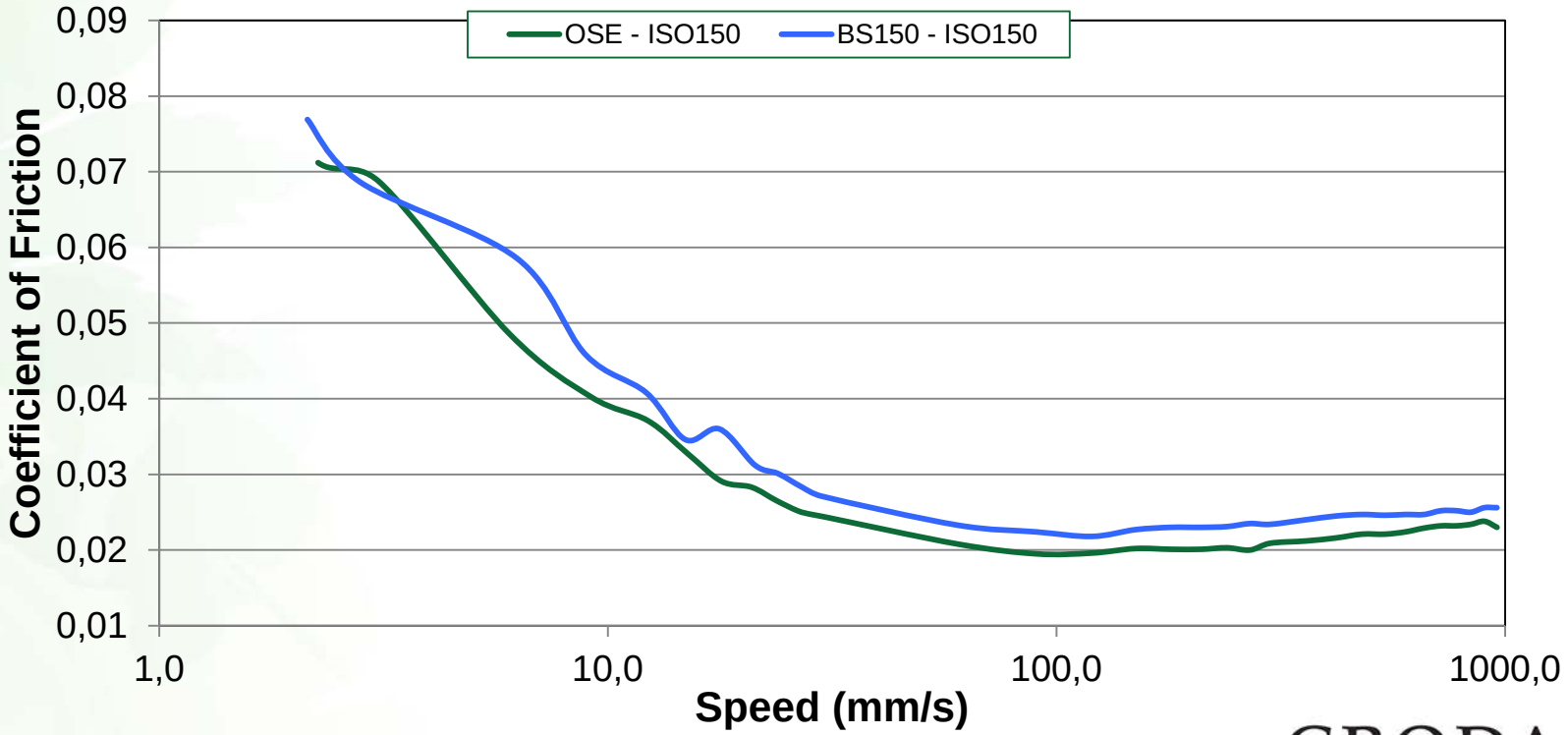
Stribeck Curves at 1.24 Gpa/ 70N



30% Slide roll ratio

CRODA

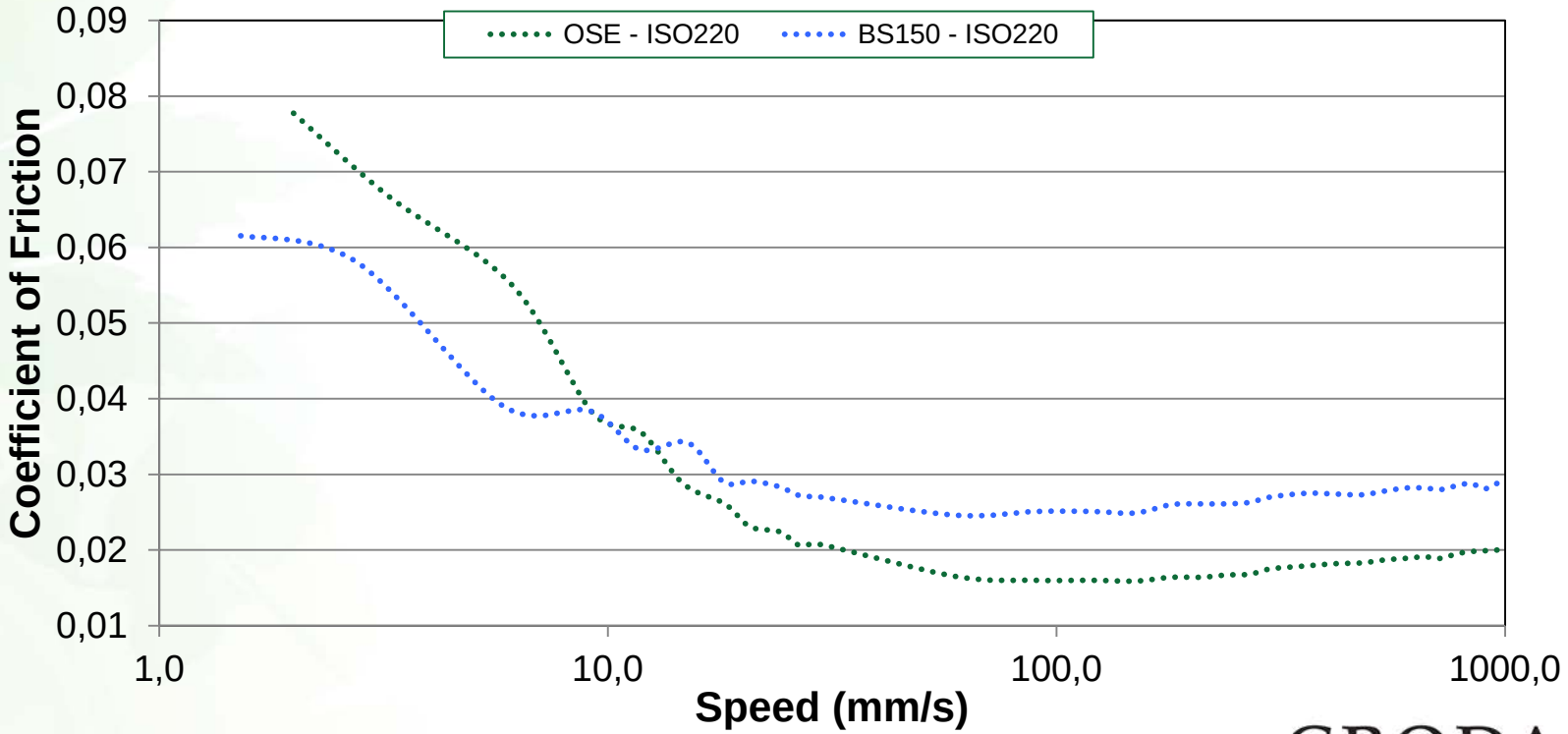
Stribeck Curves at 1.24 Gpa/ 70N



30% Slide roll ratio

CRODA

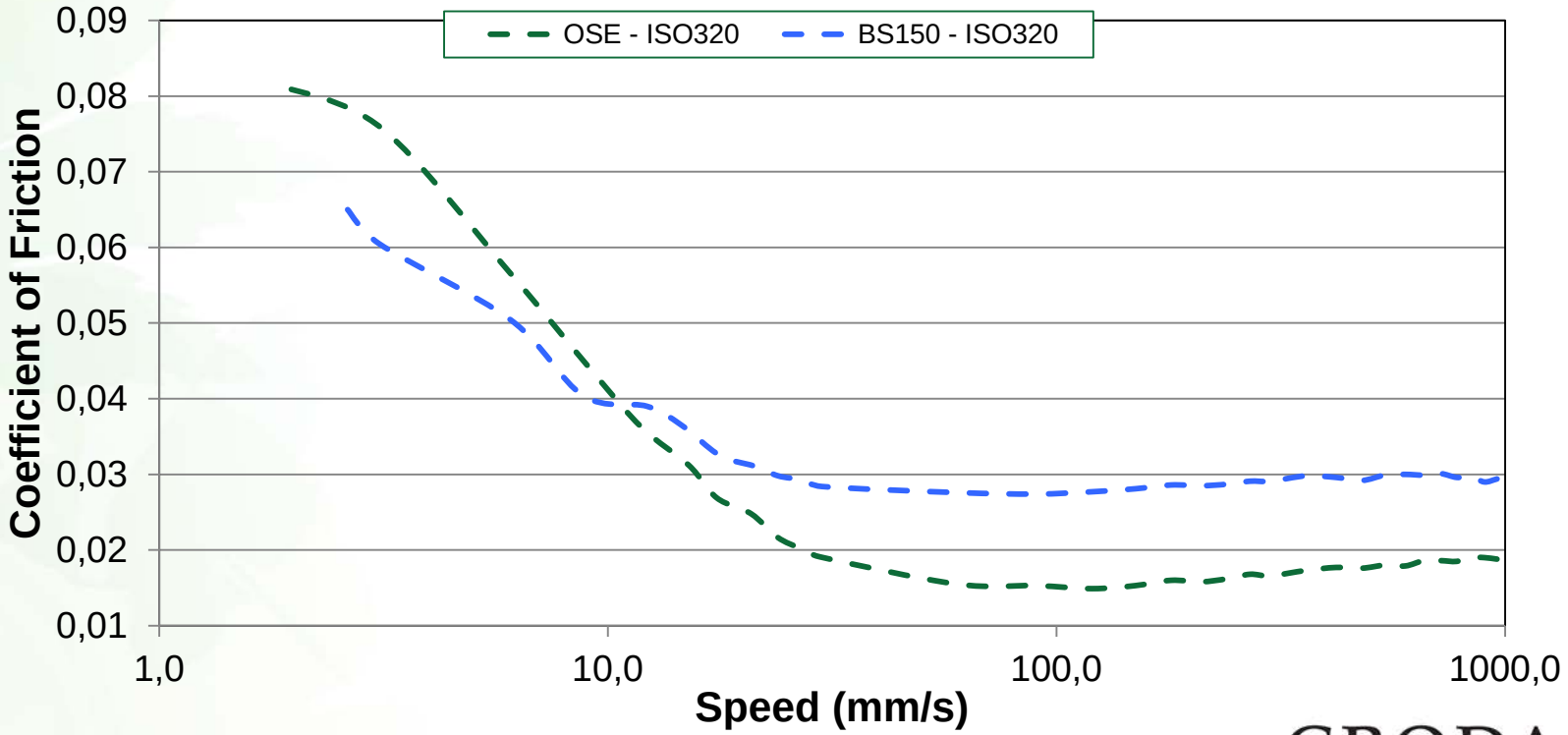
Stribeck Curves at 1.24 Gpa/ 70N



30% Slide roll ratio

CRODA

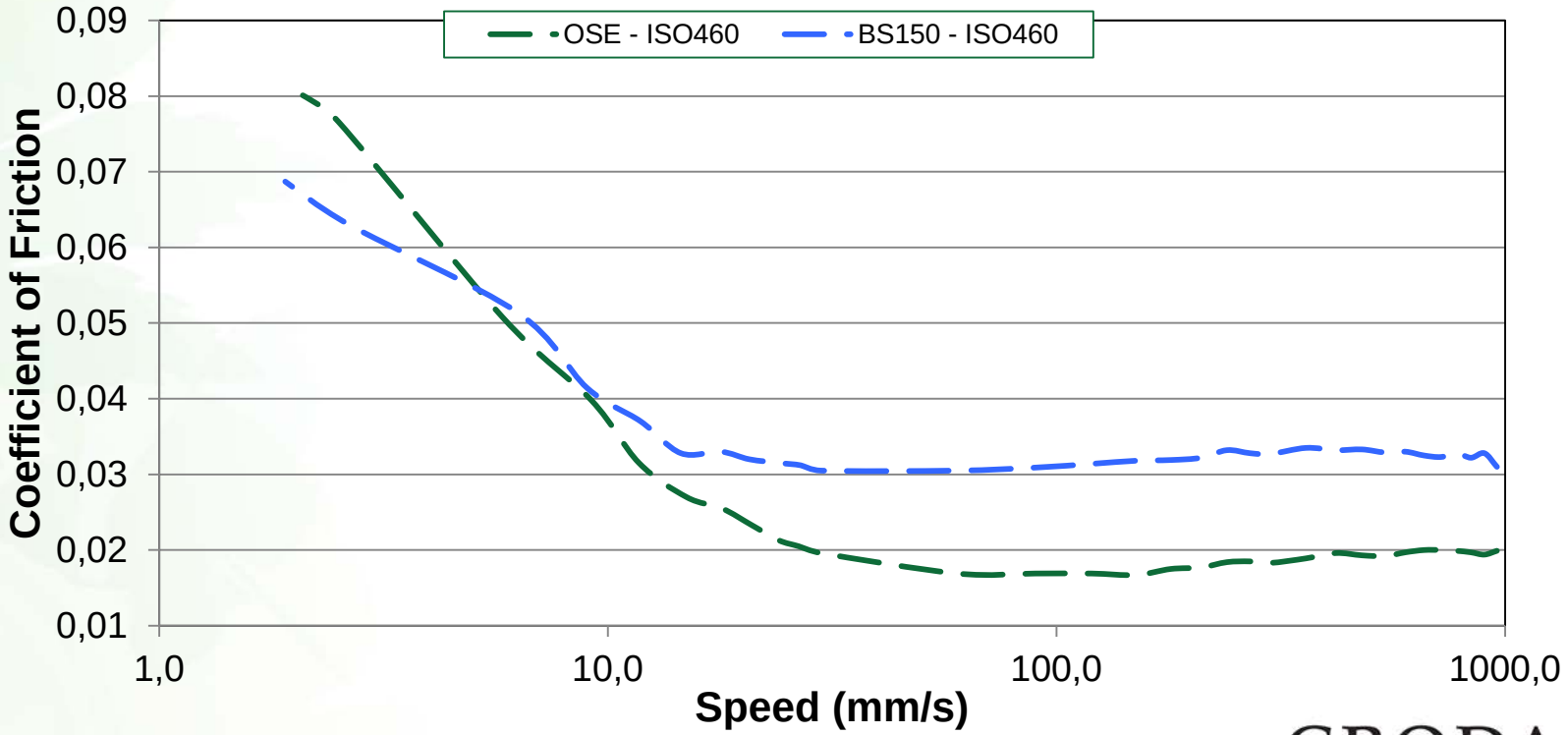
Stribeck Curves at 1.24 Gpa/ 70N



30% Slide roll ratio

CRODA

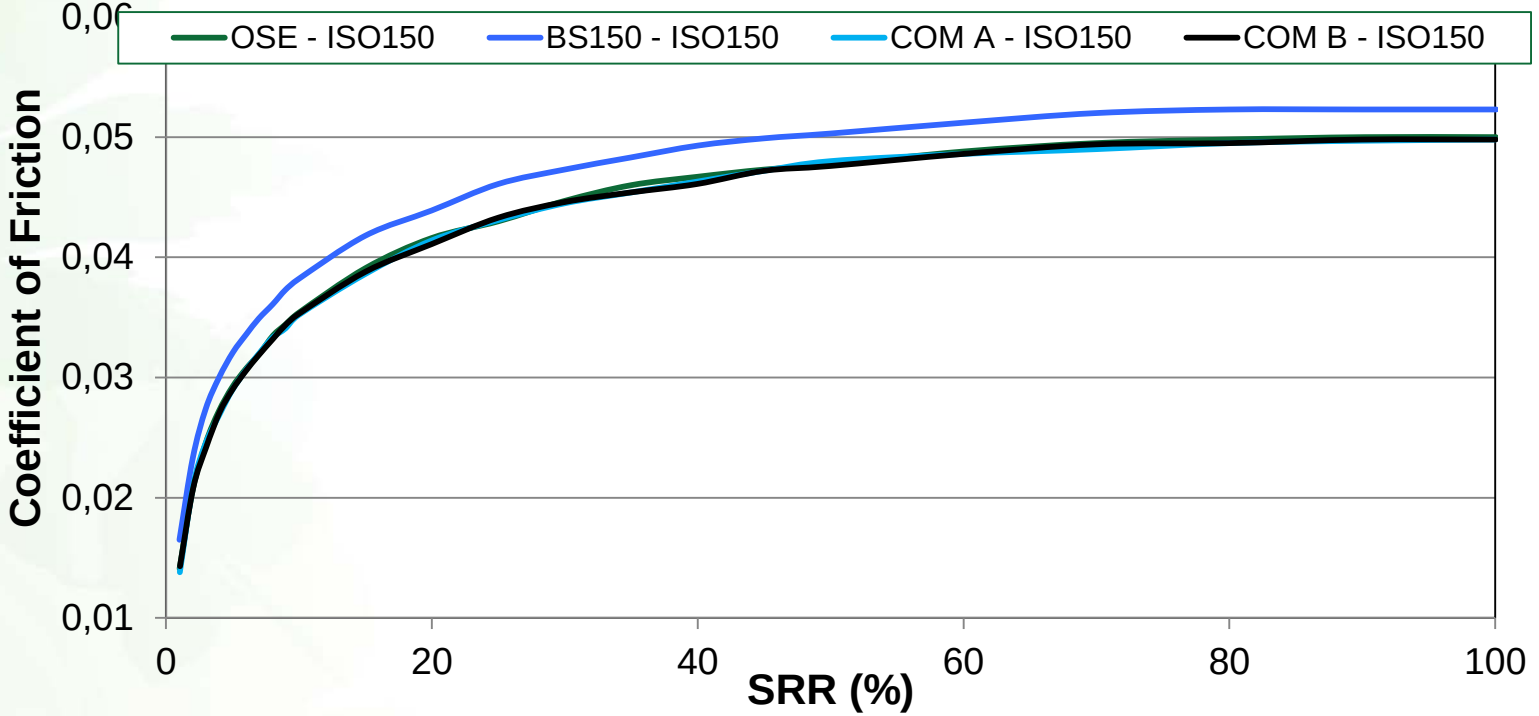
Stribeck Curves at 1.24 Gpa/ 70N



30% Slide roll ratio

CRODA

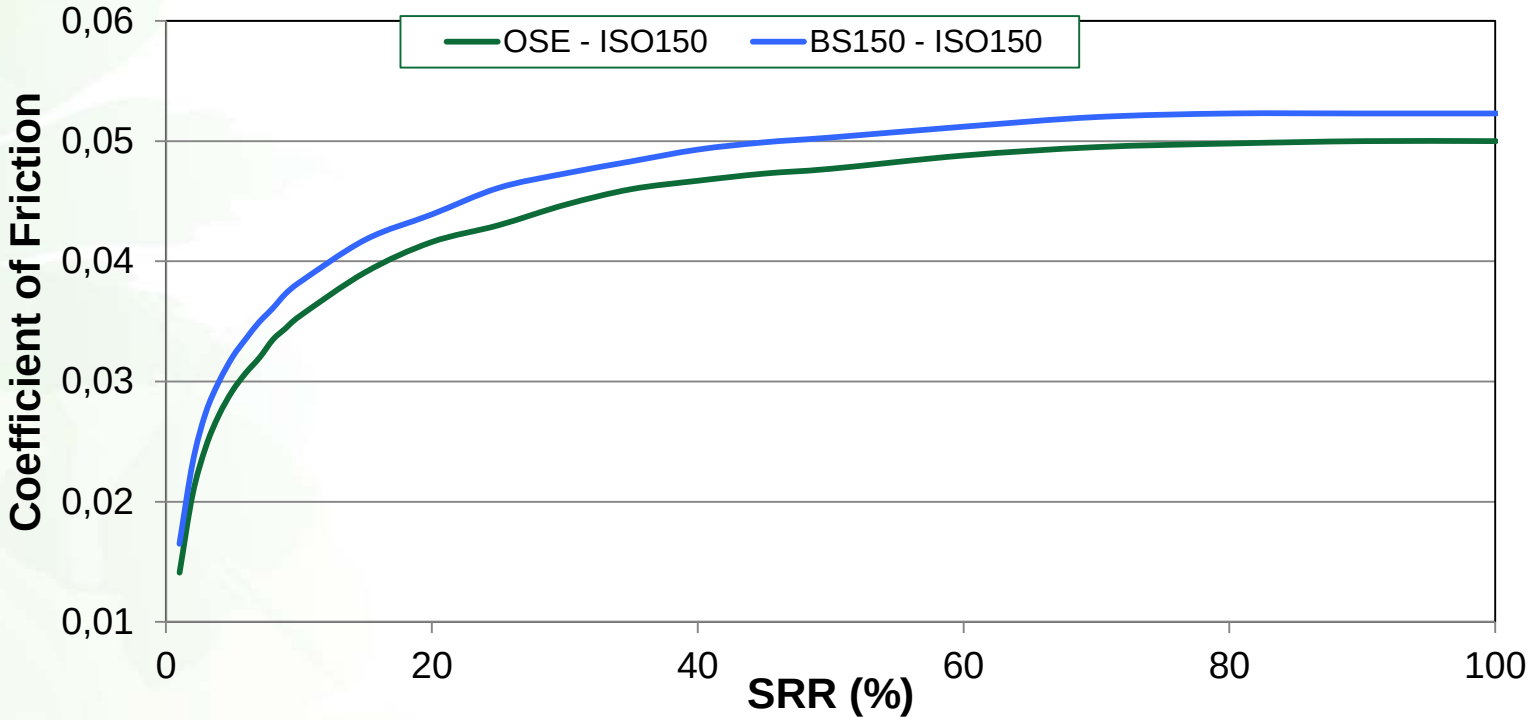
Traction Curves at 1.24 Gpa/ 70N



Speed - 500mm/s

CRODA

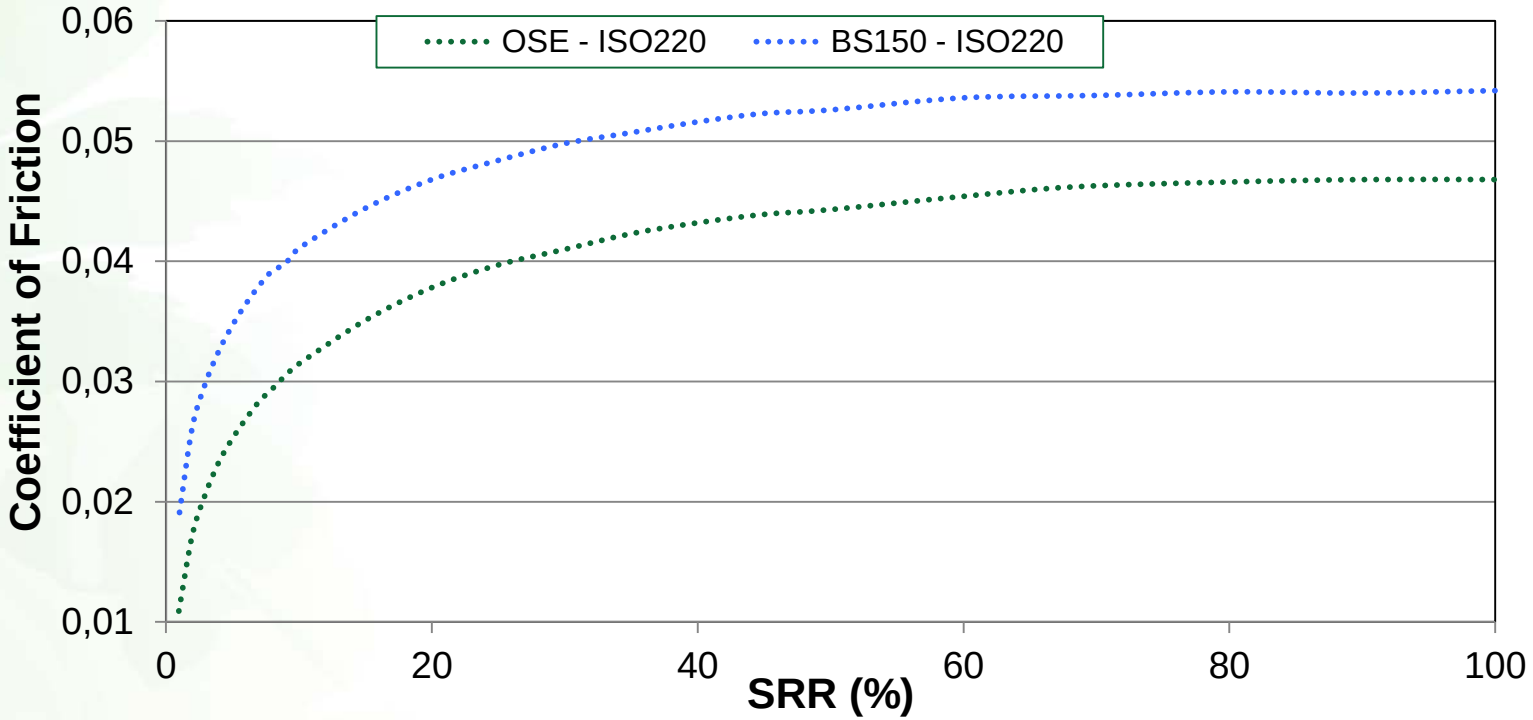
Traction Curves at 1.24 Gpa/ 70N



Speed - 500mm/s

CRODA

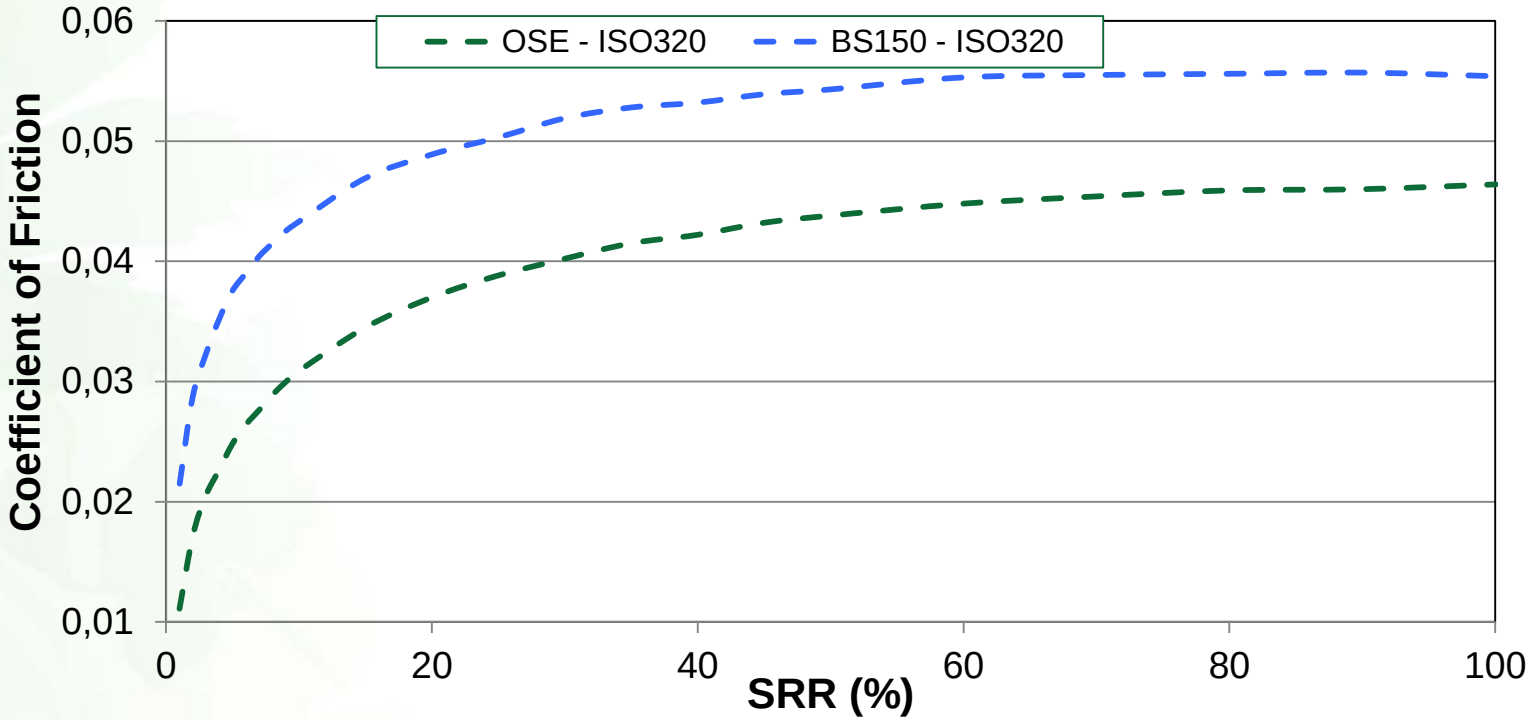
Traction Curves at 1.24 Gpa/ 70N



Speed - 500mm/s

CRODA

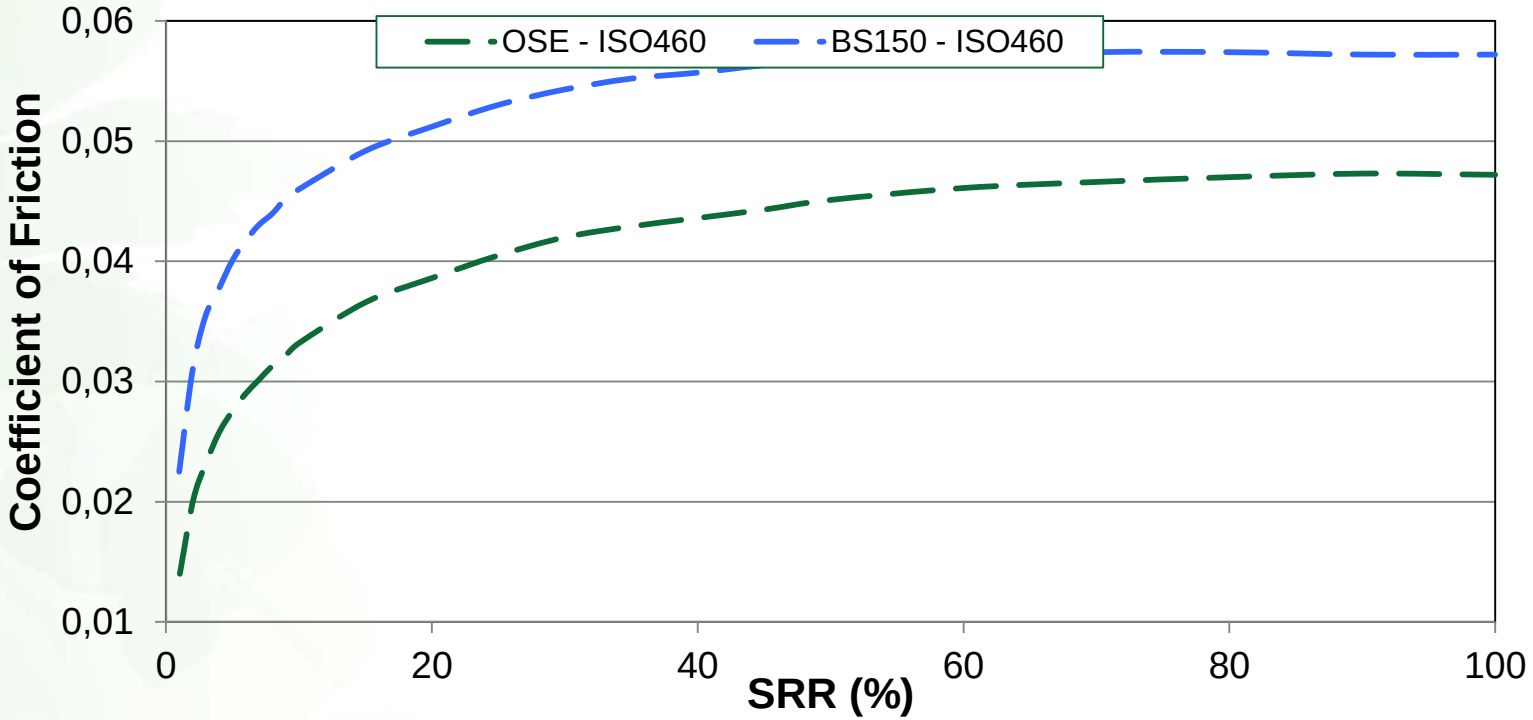
Traction Curves at 1.24 Gpa/ 70N



Speed - 500mm/s

CRODA

Traction Curves at 1.24 Gpa/ 70N

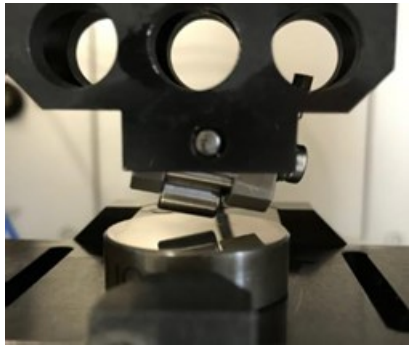


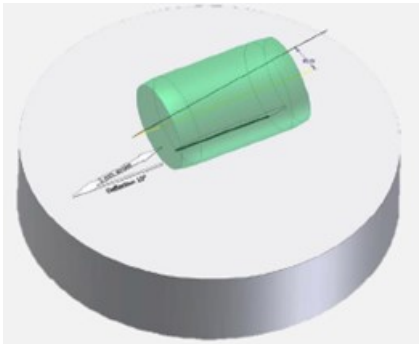
Speed - 500mm/s

CRODA

FZG-Loaded Stage Gear Test Simulation on SRV

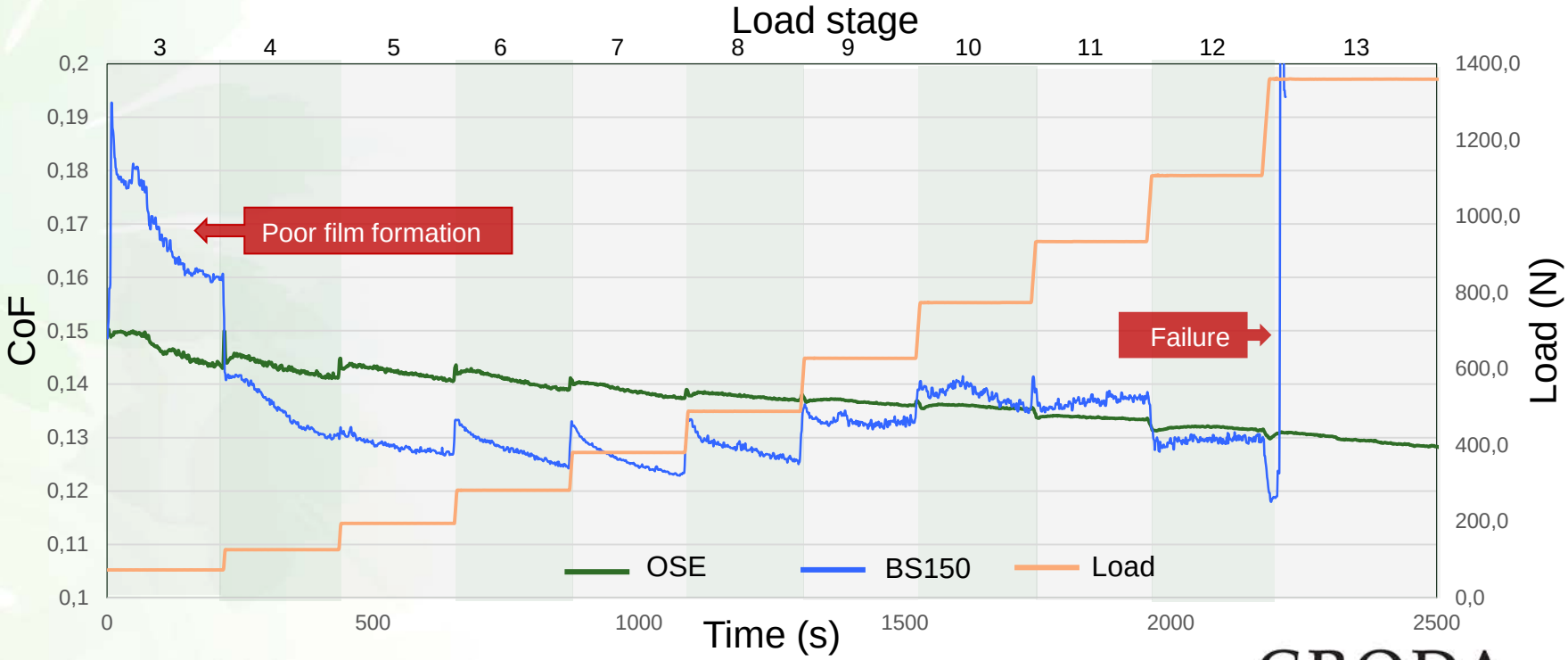
- Application-orientated bench tests on the FZG-loaded gear test
- SRV® standard DIN 51834-4 (roller) for the evaluation of friction and wear for Hertzian contact pressures of FZG load stages from 3 to 14 and beyond





CRODA

FZG-Loaded Stage Gear Test Simulation to Load Stage 13 on SRV



CRODA

Shear Stability

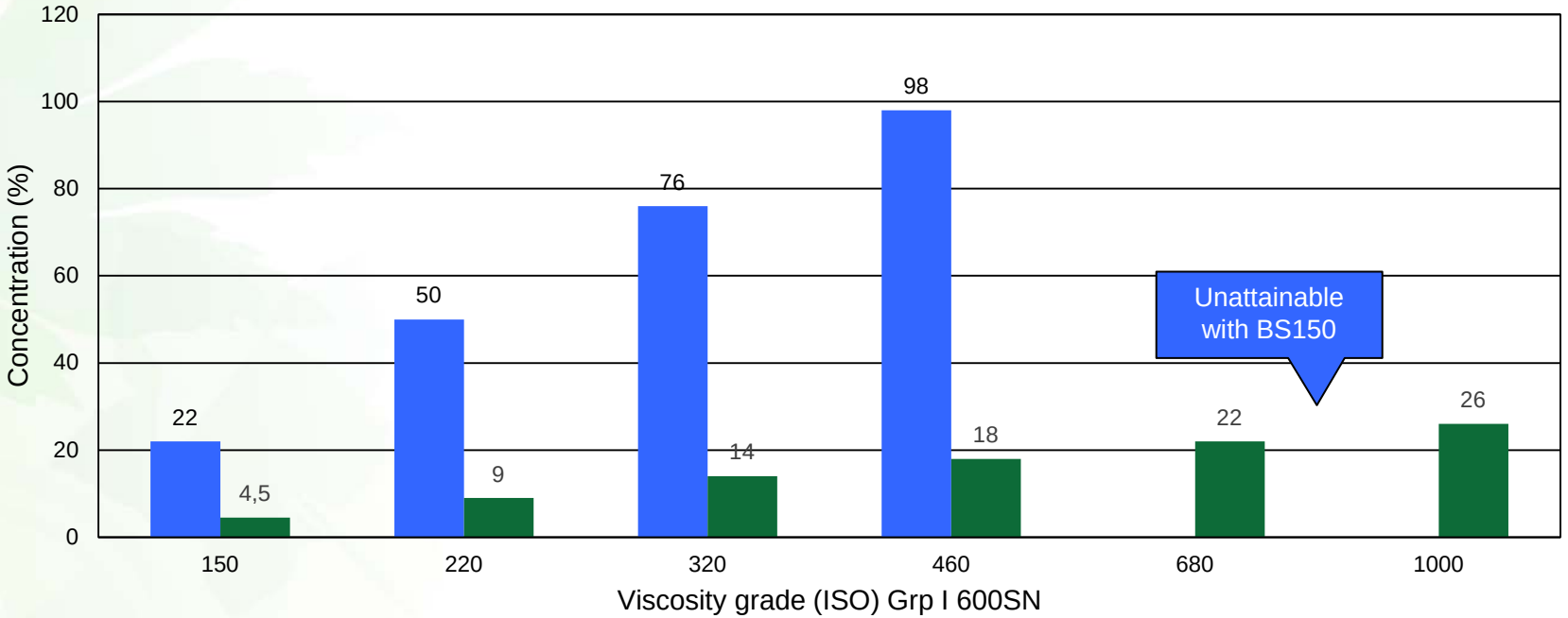
A-99 KRL Tapered Roller Bearing Test. CEC L45-A-99

Product	Result %
OSE	-4.1
COM B	-4.7
BS150	-0.1
COM A	-8.5

All oils remained within viscosity grade

ISO 150 industrial gear oils
5% concentration of VM

Percentage Concentration to Create ISO Grades



CRODA

Industrial Gear Oil Summary

OSE exhibits the following:

- Reduced friction compared to BS150 on:
  - High pressure barrel on disk
  - Stribeck and traction curves
- Maintains consistent low CoF across viscosity grades
- Potential to extend the FZG load stage rating
- 5x thickening power v's BS150
- Can be utilised to formulate >ISO460

OSE in Engine Oil

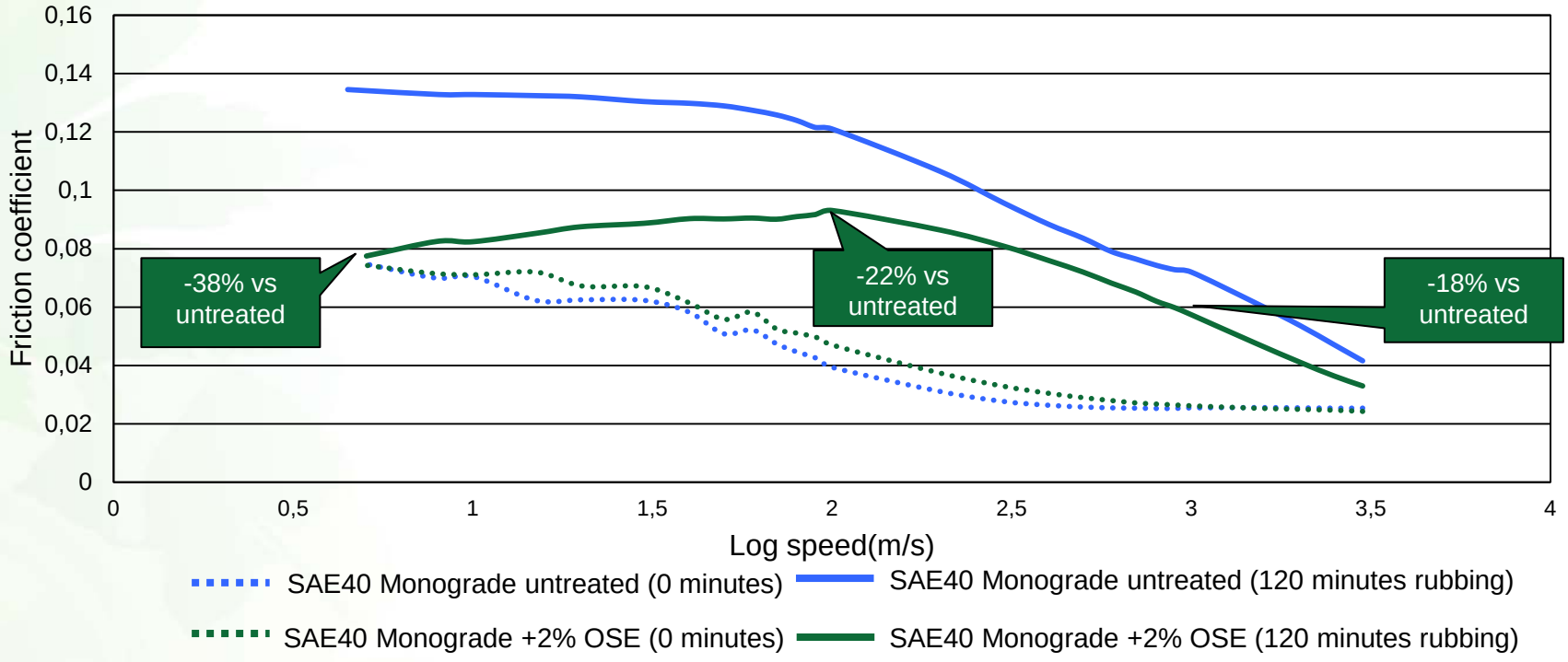
	SAE40 monograde	Partial BS replacement
Bright Stock 150	20.70%	11.00%
600 SUS Grp II	74.35%	82.05%
OSE		2.00%
CF-4 additive pack	4.85%	4.85%
ZDDP booster	0.10%	0.1%
KV@ 40	148.15	150.07
KV@ 100	15.16	15.48
VI	103	110

- OSE can improve Viscosity index of the formulation without the addition of VI

Steel/Steel Friction Evaluation

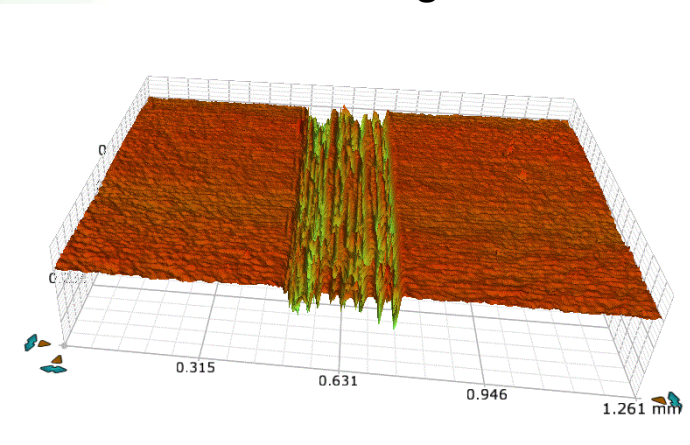
- **Mini-Traction-Machine used**
- **Stribeck curve conditions**
  - Mixed slide-roll – SRR = 50%
  - Entrainment speed: 3 – 0.005 ms^{-1}
  - Temperature: 135ºC
  - 36N Load ~ 1GPa initial Hertzian Contact pressure
- **Measured initially and after 2 hours rubbing at 0.5 ms^{-1}**

Friction Coefficient vs Log Speed (m/s)



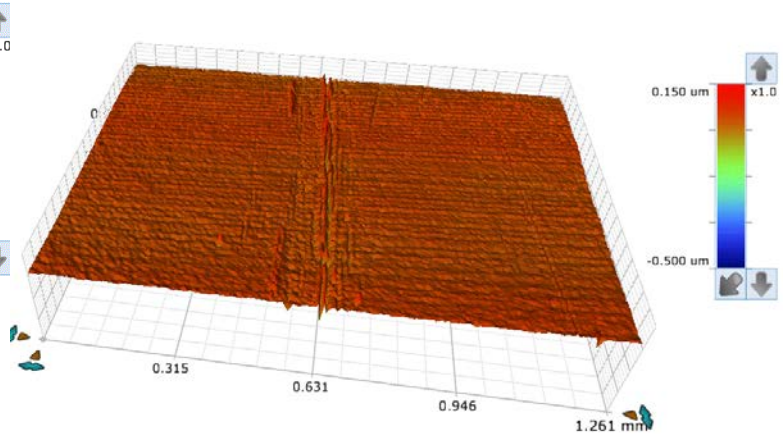
Wear Volume Measurement

SAE40 monograde



13919 µm^3

SAE40 monograde + 2% OSE



3230 µm^3

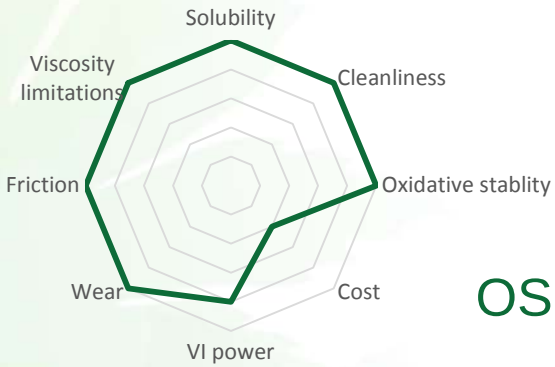
77% reduction in wear volume

Engine Oil Testing Summary

OSE

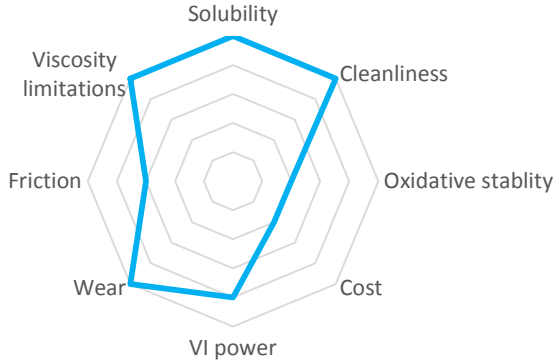
- Has a positive effect on VI, even at low concentrations
- Provides a friction and wear reduction

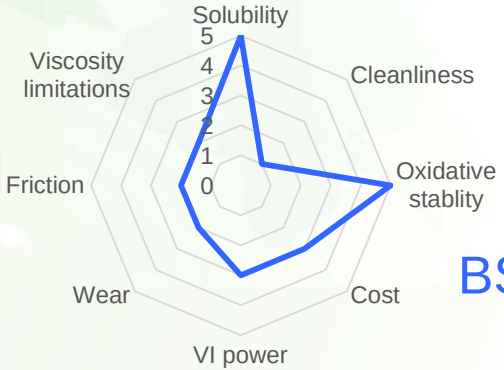
Overview of Performance Characteristics



OSE

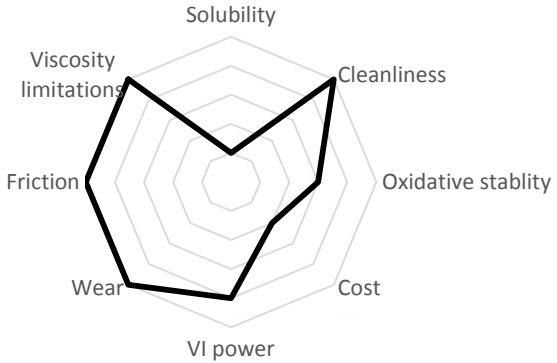
COM A





BS150

COM B



Conclusion

- ✓ **OSE** shows improved **oxidative stability**
- ✓ Viable alternative thickener to Bright-stock
- ✓ Improves VI and is shear stable
- ✓ Improved lubrication in Industrial Gear oils
- ✓ Potential to increase gear loading
- ✓ Reduced Friction and wear in HDDO
- ✓ Improved base oil solubility

Thanks!

Questions?

Felipe.lopes@croda.com

Disclaimer

The information in this publication is believed to be accurate and is given in good faith but no representation or warranty as to its completeness or accuracy is made.

Suggestions for uses or applications are only opinions. Users are responsible for determining the suitability of these products for their own particular purpose.

No representation or warranty, express or implied, is made with respect to information or products including without limitation warranties of merchantability or fitness for a particular purpose or non-infringement of any third party patent or other intellectual property rights including without limit copyright, trademark and designs.

Any trademarks identified herein are trademarks of the Croda group of companies.