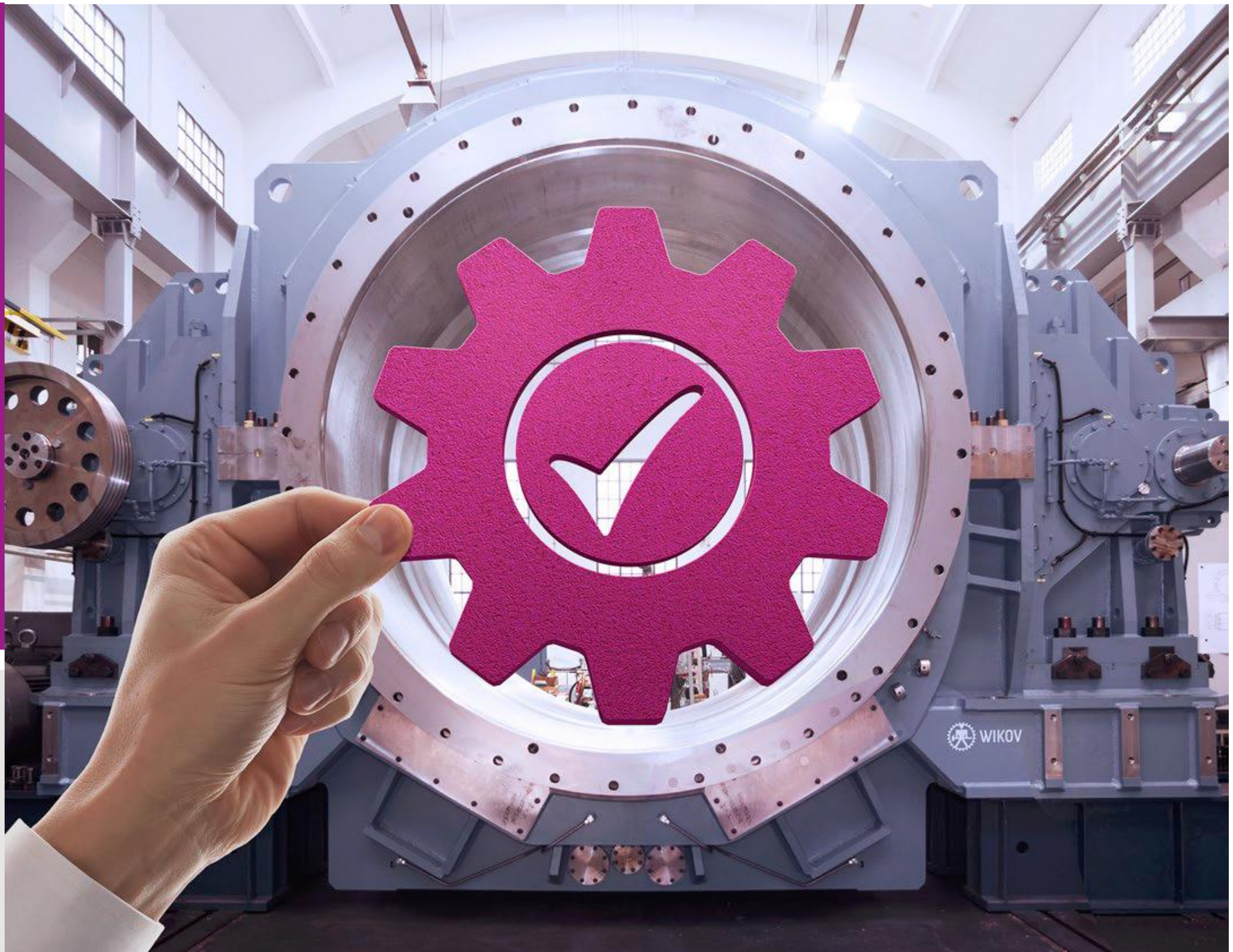
Meet market demands for high-performance lubricant products with new additive and base oil chemistry

Thomas Schimmel

2nd Asian Industrial Lubricants Conference

November 2019 | Singapore

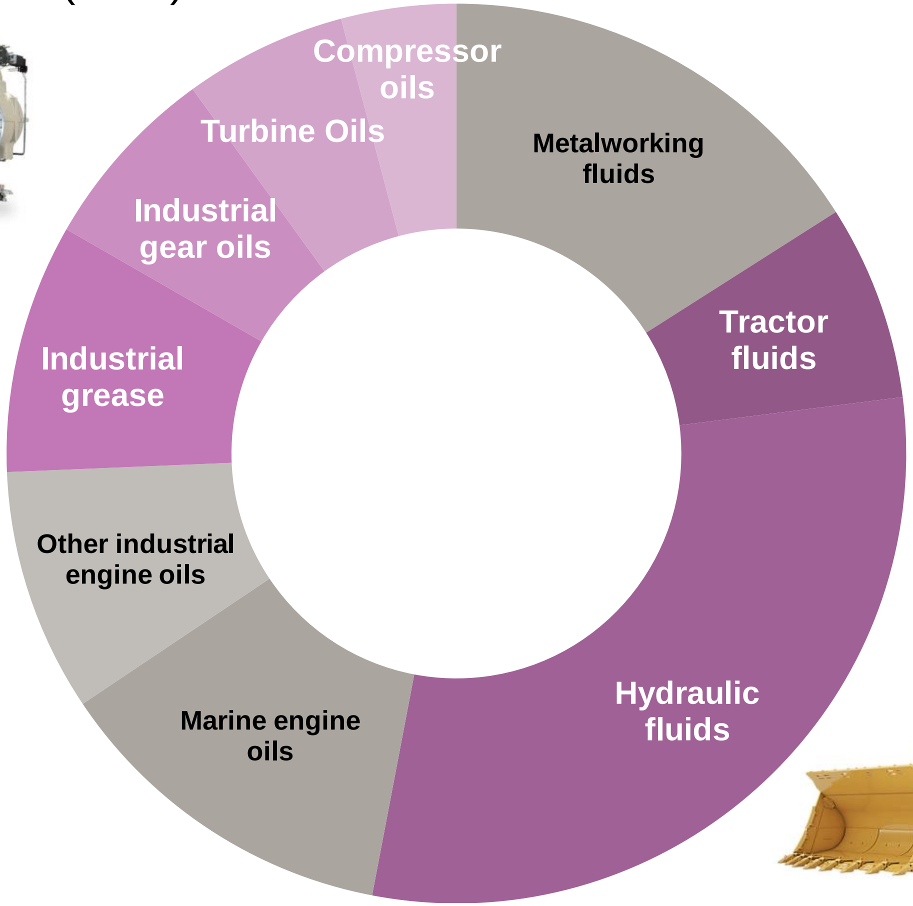


Planetary Gear Box Educational Model. Picture courtesy of Merkur®, CZ

EVONIK
POWER TO CREATE

Industrial lubricants and where performance matters the most

Finished lubricant volume: 14 million mt (2018)



EVONIK
POWER TO CREATE

Outline

- **Challenges for industrial gear oils**
- Impact of hydraulic fluids on equipment performance
- Hydraulic fluid performance demonstration

These are some of the most challenging industrial applications

EVONIK
POWER TO CREATE

Different applications – similar demands - same need for fluid performance

Mining

Operating conditions

- Extreme loads
- Contaminants: dust, debris, water

Demands on oil

- Extreme pressure and anti-wear performance
- Corrosion protection
- Low temperature fluidity

Steel

Operating conditions

- High ambient temperature
- Heavy loads and wet conditions

Demands on oil

- Extreme pressure and anti-wear performance
- Rust and corrosion protection
- High flash point

Wind Energy

Operating conditions

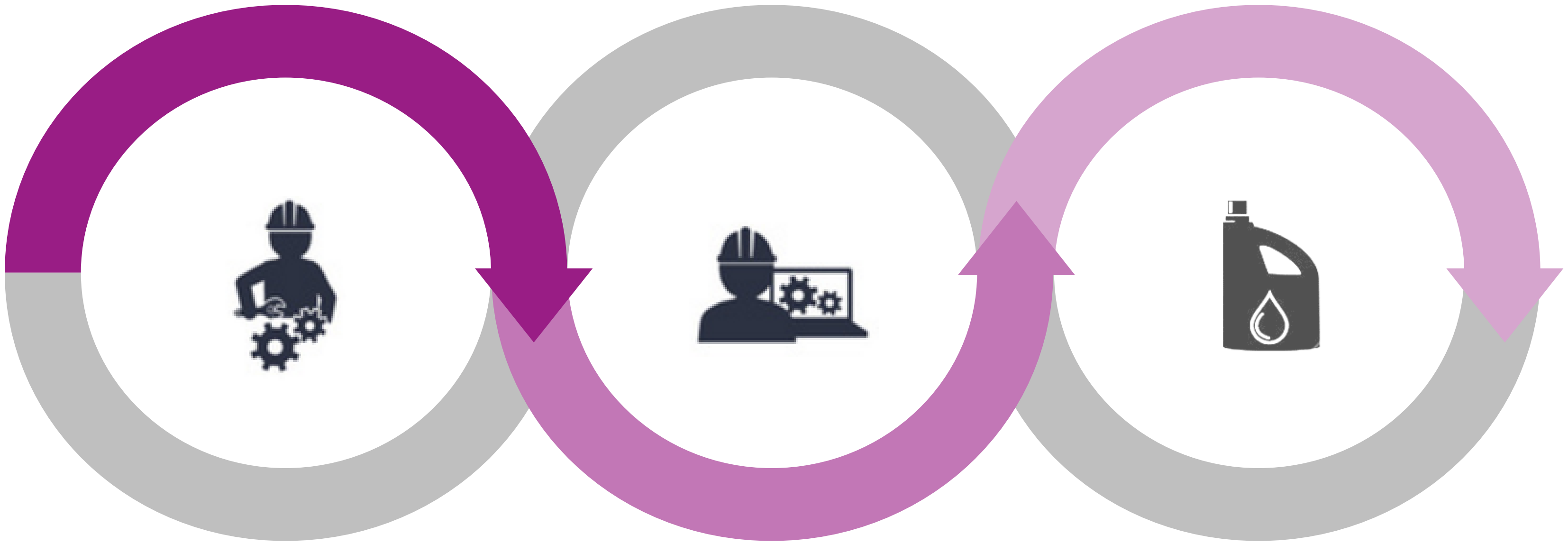
- Arid/humid, cold/hot climate
- Long service intervals

Demands on oil

- Sufficient film strength and micro-pitting protection
- Excellent oxidative stability
- Low temperature fluidity

EVONIK POWER TO CREATE

Engineering trends define the requirements for industrial gear oils



Engineering

- New materials
- Surface finishing
- Lower oil volume

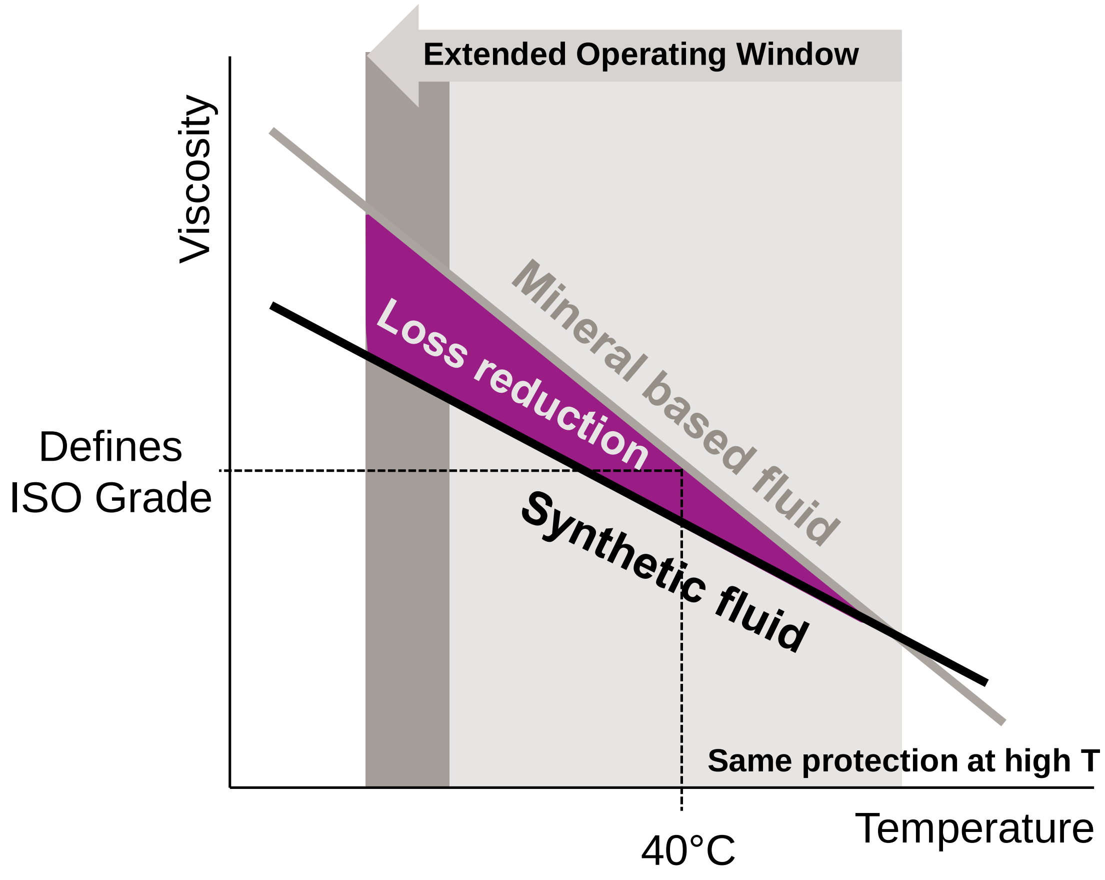
Operating Conditions

- High torque and high loads
- Increased power density
- High bearing temperature

Lubricants

- Micropitting protection
- Seal compatibility
- Oxidative and thermal stability

Why do synthetic fluids offer improved performance and high efficiency?



Colder temperatures

- Lower churning losses
- Lower friction

→ Improved mechanical efficiency

→ Better cold start behavior

Warmer temperatures

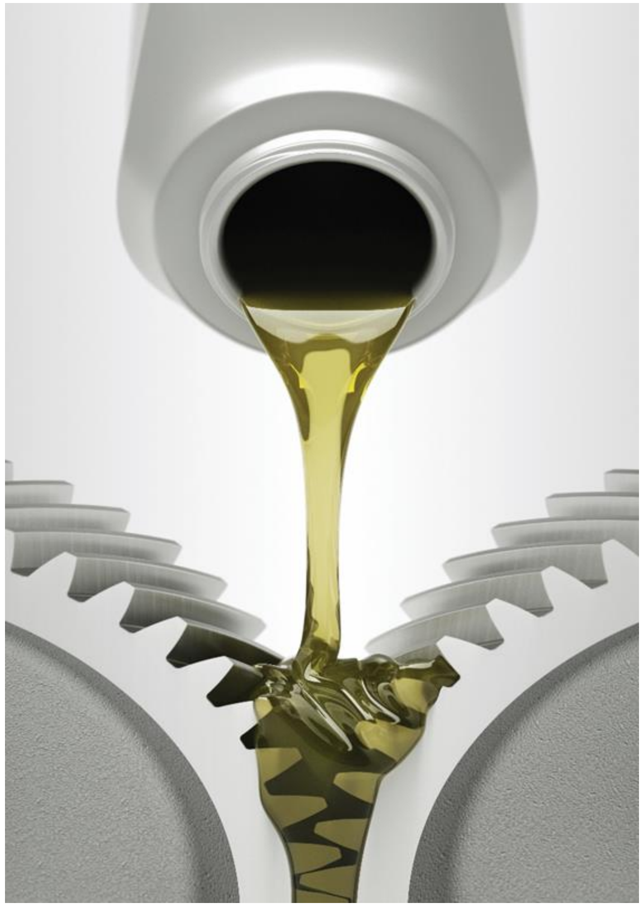
- Less leakage
- Increased film thickness

→ Improved equipment protection

EVONIK POWER TO CREATE

Approaches to formulating high performance industrial gear oils

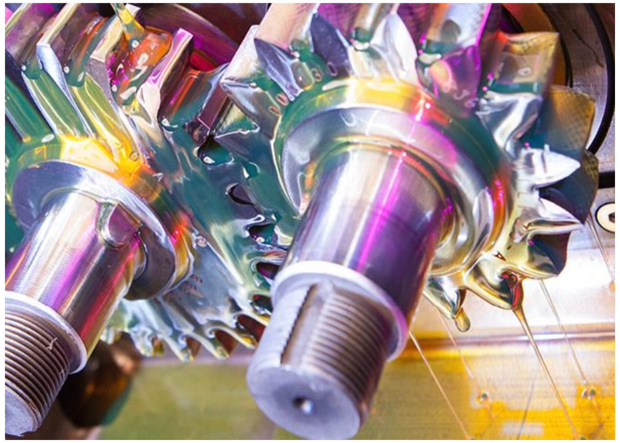
- Mostly formulated with **non-polar** base fluids
  - 6 or 8 cSt polyalphaolefin (PAO) as base fluid
  - High-viscosity PAO (e.g. PAO 100) to adjust viscosity to the desired level
  - Addition of ester (10-20%) is necessary to provide package compatibility → can cause hydrolytic stability and seal swelling issues
- Base fluid system can also be **polar**
  - Polyalkylene glycols (PAG) → not miscible with other base fluids
- High-viscosity base fluids with **well-balanced polarity**
  - Performance **advantages** in combination with **Group III** base oil or **PAO**
  - Excellent additive package, seal and coatings compatibility, in particular in combination with PAO



EVONIK
POWER TO CREATE

Performance benefits of synthetic fluids

- High viscosity index
  - Viscosity control across operating temperatures
  - Excellent cold start properties
  - Equipment protection at high temperature
- Thermal and oxidative stability
  - Extended fluid service life
- Reduced frictional losses
  - Higher efficiency
  - Lower operating temperature → longer equipment life
- Well-balanced polarity
  - Highly compatible with a wide range of base fluids and additive systems



EVONIK POWER TO CREATE

High performance OEM approved formulations

		VG 150	VG 220	VG 320	VG 460	VG 680	Benefit
VISCOBASE® 5-220	%wt	28.4	37.0	45.1	51.5	58.5	
NEXBASE® 3080	%wt	68.25	59.65	51.5	45.15	38.15	Grp III oil lowers formulation cost
VISCOPLEX® 1-180	%wt	0.7	0.7	0.7	0.7	0.7	
VISCOPLEX® 14-520	%wt	0.2	0.2	0.2	0.2	0.2	
Afton HiTEC® 307	%wt	2.65	2.65	2.65	2.65	2.65	
KV 40	mm^2/s	151	223	320	465	689	
KV 100	mm^2/s	20.6	27.7	37.0	48.8	65.5	
Viscosity index		159	161	165	165	167	High VI for superior viscosity control
Pour point	°C	-39	-39	-39	-36	-33	Low PP for cold climates
Flash point	°C	>220	>220	>220	>220	>220	High FP for safe operation

Leading OEM approvals and key requirements

Some of the most severe tests can only be passed by synthetic fluids

- FE-8 roller bearing test
- FAG Schaeffler 4-step-test
- Filterability test
- Coatings compatibility tests
- Micropitting test FVA 54/7
- Seal compatibility tests
  - Static or dynamic
  - Liquid seal tests
- Scuffing tests
- SKF Non-metal bearing cage compatibility

SIEMENS FLENDER

FLENDER GEAR UNITS

Approval of Formulation for Gear Oils

No. A-EV-20150811

Date of expire: 27 July 2020

For the formulation — Formulations 8175, 8344, 8328
with the base oil — Neste Oil Nexbase 3080 API III; Evonik Industries Viscobase 11-522 API V
with a viscosity range of — ISO VG 320 - 680
for sale by the company — Evonik Industries AG

The compliance with the CLP quality in accordance with DIN 51517-3 is guaranteed by the selling company.
The selling company has had performed the following tests according to the
Specification of oil approvals for FLENDER gear units , Rev. 15
for Helical-, Bevel-, Worm-, Planetary- and Marine gear units
with the mentioned formulation. The test results were presented to Siemens.

- FZG scuffing test (A/8.3/90) in accordance with DIN ISO 14635-1
- FE-8-rolling bearing test (D-7,5/80-80) in acc. with DIN 51819-3
- Filterability test in accordance with test description FFT 7300
- Compatibility with internal coatings used in Flender gear units
- Compatibility with liquid sea
- Compatibility with elastomer
- Flender oil foaming test acc 12152
- Micropitting test in accordan
- Double speed FZG scuffing

APPROVED

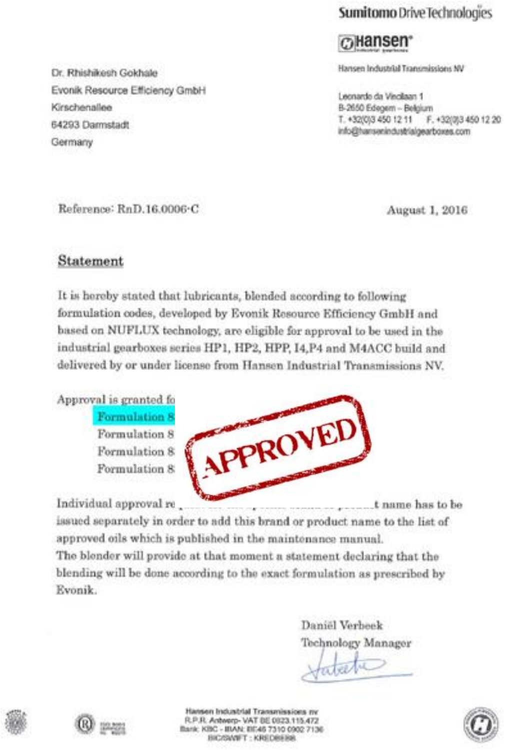
According to the presented test results, the conditions demanded by Siemens were satisfied.
We recommend the using of the above mentioned formulation for our following gear units:
Helical-, Bevel- and Planetary gear units

Bocholt, 11-08-2015

Dr.-Ing. Gerhard Gajewski
Siemens AG
Mechanical Drives
Quality, Lubricant Management

Michael Knoblich
Siemens AG
Mechanical Drives
Quality, Product Safety

Hansen® industrial gearboxes



Sumitomo Drive Technologies

Hansen

Hansen Industrial Transmissions NV

Leonardo da Vincilaan 1
B-2650 Edegem – Belgium
T. +32(0)3 450 12 11 F. +32(0)3 450 12 20
info@hansenindustrialgearboxes.com

Dr. Rhishikesh Gokhale
Evonik Resource Efficiency GmbH
Kirschenallee
64293 Darmstadt
Germany

Reference: RnD.16.0006-C

August 1, 2016

Statement

It is hereby stated that lubricants, blended according to following formulation codes, developed by Evonik Resource Efficiency GmbH and based on NUFLUX technology, are eligible for approval to be used in the industrial gearboxes series HP1, HP2, HPP, I4,P4 and M4ACC build and delivered by or under license from Hansen Industrial Transmissions NV.

Approval is granted fo
Formulation 8
Formulation 8
Formulation 8
Formulation 8

APPROVED

Individual approval re t name has to be issued separately in order to add this brand or product name to the list of approved oils which is published in the maintenance manual.
The blender will provide at that moment a statement declaring that the blending will be done according to the exact formulation as prescribed by Evonik.

Daniël Verbeek
Technology Manager

Hansen Industrial Transmissions nv
R.P.R. Antwerp- VAT BE 0823.115.472
Bank: KBC - IBAN: BE46 7310 0902 7136
BIC/SWIFT : KREDBEBB

EVONIK
POWER TO CREATE

Performance demonstrations in different applications

Water Treatment

Sebokeng water care works, South Africa

Mining Industry

Mooiplaas dolomite quarry, South Africa

Wind Turbines

USA, Europe, Asia Onshore/offshore

Inhouse

RAG, Germany

EVONIK POWER TO CREATE

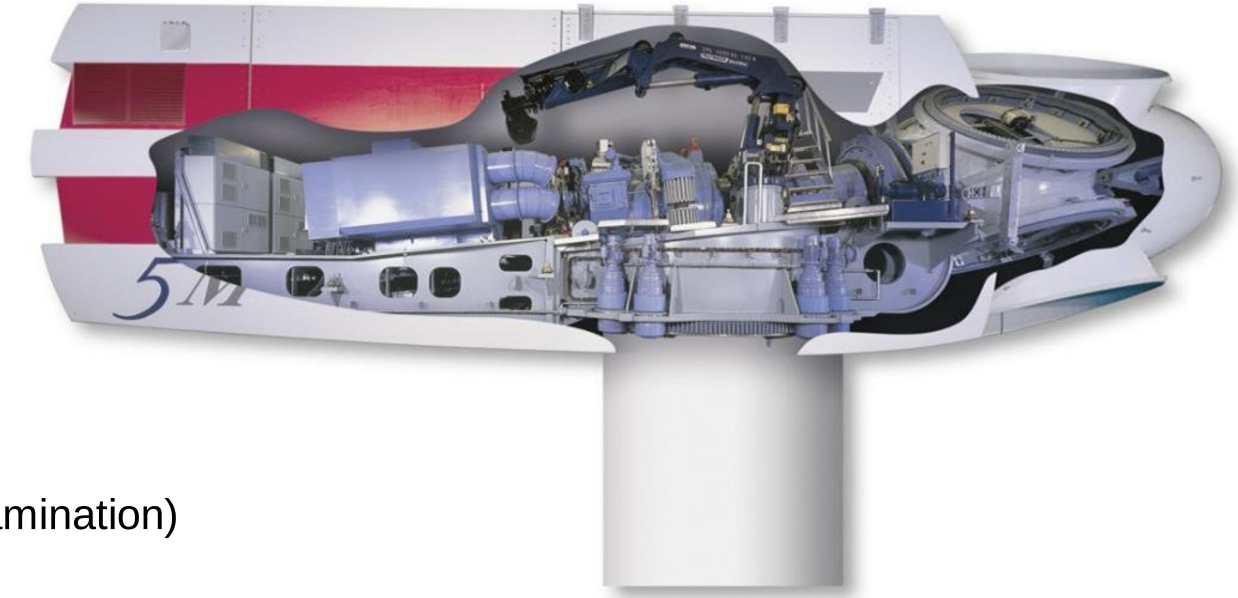
Wind turbine gear oils and their special requirements

Wind turbine gearbox

- Often uses a 3-step transmission, consisting of planetary and spur gears
- Typically lubricated by **ISO VG 320** gear oil (**300..1000 l,** depending on power and size)
- Oil drain **every 3..5 years,** targeting >7 years

Wind turbine gear oils must pass demanding tests

- Micropitting test (grey staining)
- FZG scuffing test (at two different loads)
- FAG FE-8 four stage test (steel/steel & steel/brass)
- Static elastomer test (NBR @100°C, FKM @110°C)
- Freudenberg dynamic elastomer test
- Flender foam test (also with corrosion preventive contamination)
- …and many others



Source: Repower Systems AG

EVONIK POWER TO CREATE

Comparison of fluids in a Moventas gear box

- Test setup consisted of two PLH-1400 gearboxes that were run back-to-back
- One gearbox was filled with a gear oil using novel base oil technology and the other with a commercial PAO gear oil
- Temperature was measured at 8 spots, oil pressure was measured at 3 spots
- Gears were painted to examine the contact patterns:
  - *No abnormal behavior*
  - *No hard end contacts*
  - *No marks of particles*
  - *No sludge or varnish*
  - *Improved cleanliness*

EVONIK
POWER TO CREATE

Performance comparison of industrial gear oil technologies

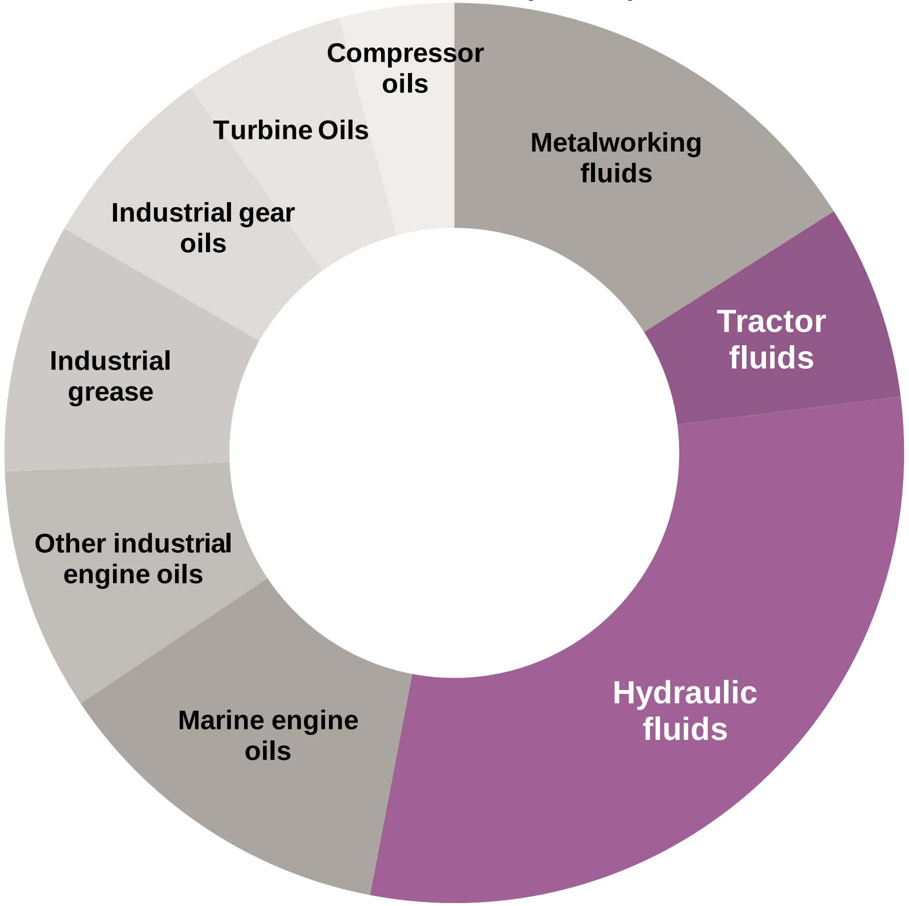
	Thermal efficiency	Bearing protection	Micropitting protection	Additive compatibility	Total fluid cost
Mineral based	Low	Medium	Medium	High	Low
PAO based	High	High	Medium	Low	High
New technology	High	High	High	High	Medium

Outline

- Challenges for industrial gear oils
- **Impact of hydraulic fluids on equipment performance**
- Hydraulic fluid performance demonstration

Hydraulic fluids represent a highly fragmented market

Finished lubricant volume: 5 million mt (2018)



EVONIK
POWER TO CREATE

Industrial efficiency has many faces

Oil drain interval

Fuel economy

Fast system response

Extended wear protection

Productivity

Machine uptime

Noise level

Fast start-up

The requirements vary with the application…

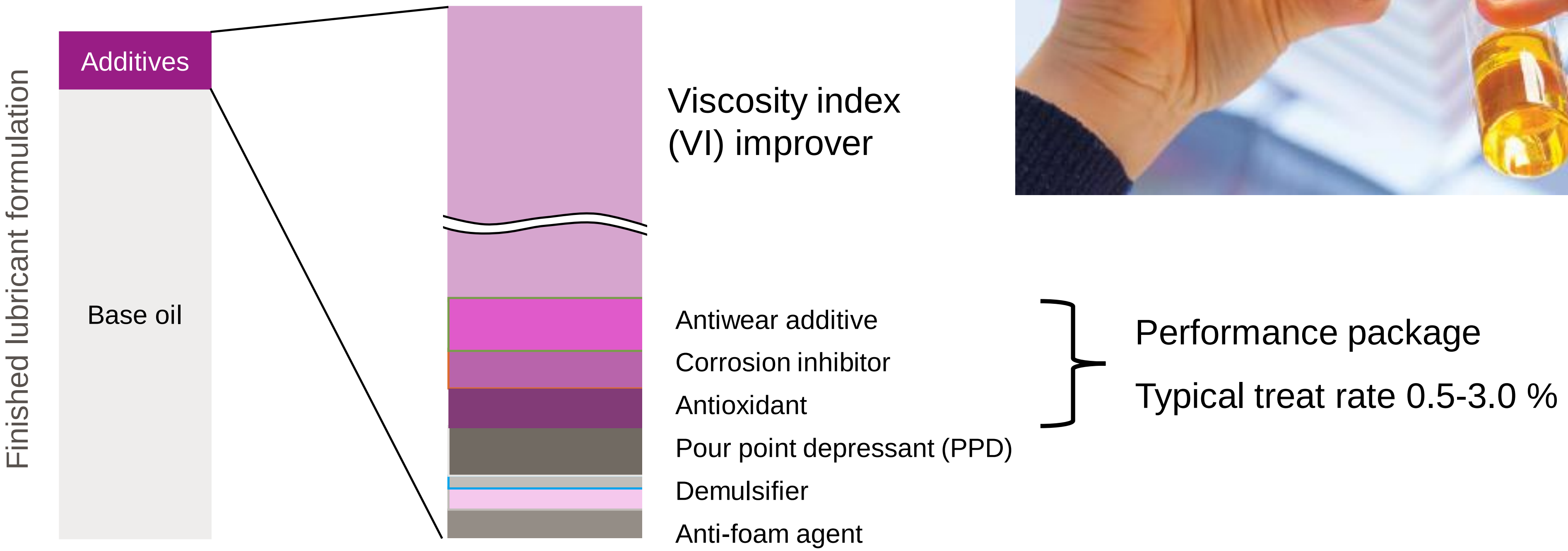
Manufacturing equipment	Mobile construction equipment	Special application: door closer
		
• Equipment availability • Long oil drain interval • Wear protection • Maximized energy efficiency • Precision	• High productivity • Good cold start behavior • Wide temperature range • High fuel efficiency	• Long life • Good seal compatibility • Low foam and good air release • Low noise • Wide temperature range

EVONIK POWER TO CREATE

…but the right lubricant can meet many challenges

Lubricants consist of base oils and additives

- Base oils define the basic properties of the lubricant
- Additives determine the full range of performance

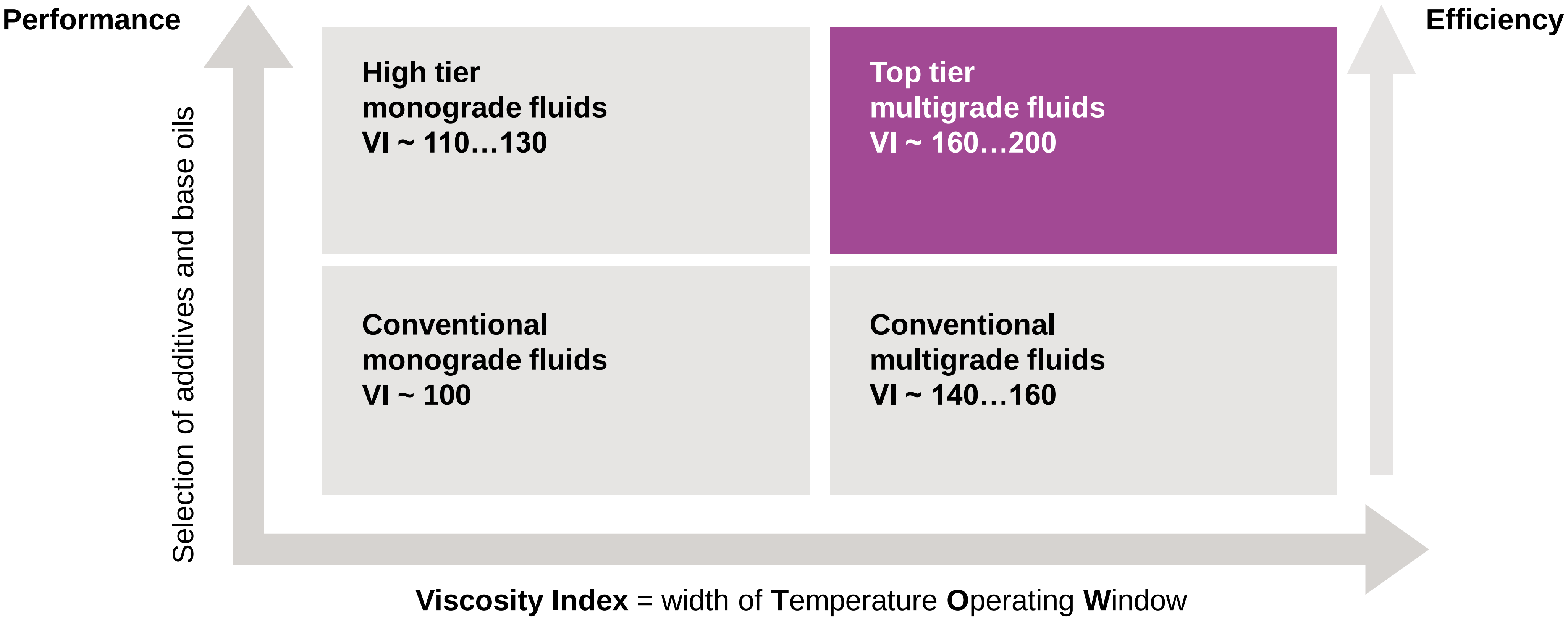


EVONIK
POWER TO CREATE

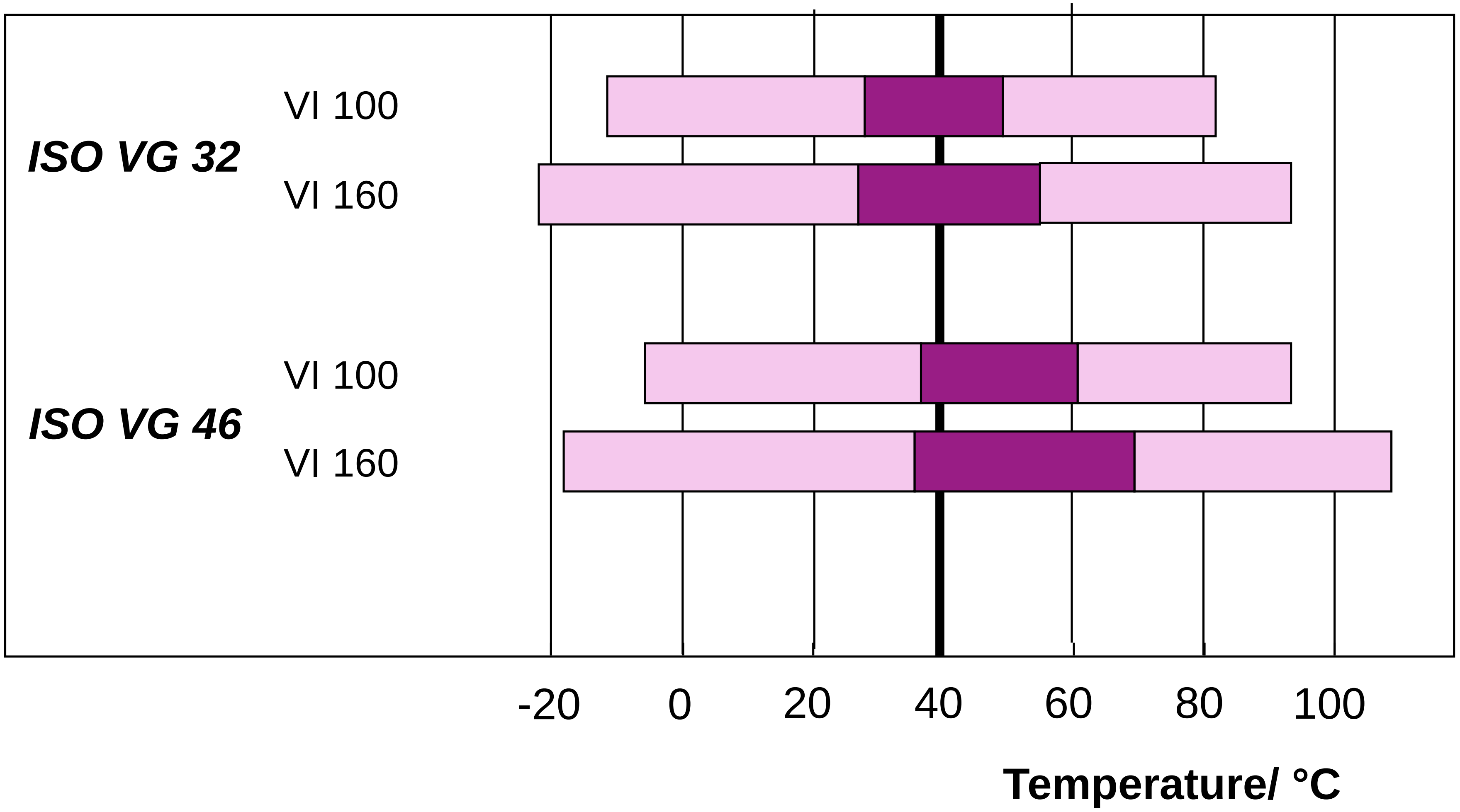
Protection against wear and corrosion is guaranteed through OEM approvals

Denison HF-0	Bosch Rexroth RDE 90235	Eaton E-FDGN-TB002-E
DENISON Hydraulics	Rexroth Bosch Group	EATON Powering Business Worldwide
• Hybrid piston/vane pump • Up to 280 bar at 1,700 rpm • 608 hours • Dry and wet phase • Very sensitive to corrosion	• Piston pump and piston motor • Up to 500 bar at 4,000 rpm • 510 hours • Dry • Severe shear requirements	• Vane pump • Up to 207 bar at 2,400 rpm • 3*50 hours • Dry • Sensitive to wear

The landscape of hydraulic fluids
Performance and efficiency



The temperature operating window of hydraulic fluids



EVONIK
POWER TO CREATE

Power losses in hydraulic systems - balance is essential

Power losses at *low viscosity*

- Internal leakage
- External leakage
- Poor lubrication
- Compressibility

Power losses at *high viscosity*

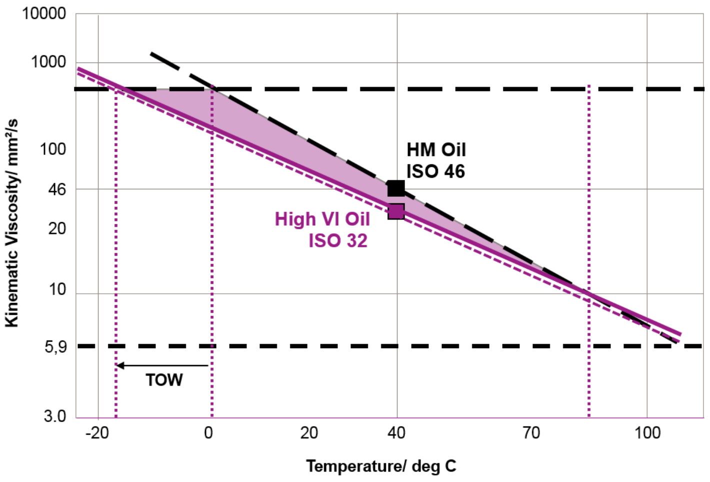
- Hydrodynamic friction
- Churning losses

EVONIK
POWER TO CREATE

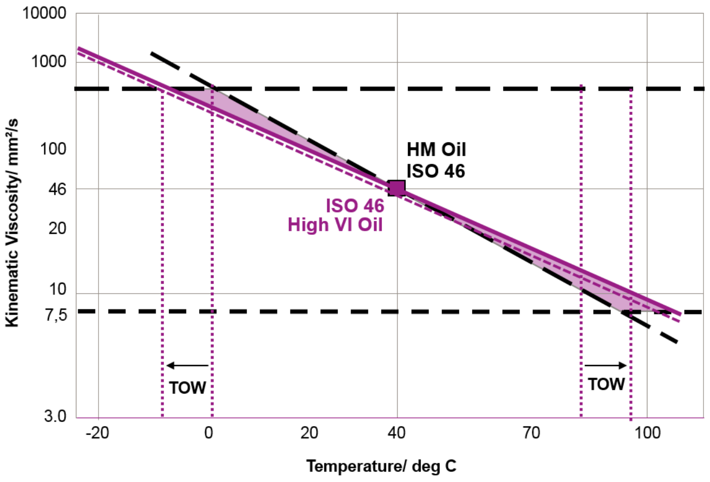
Criteria for energy efficient high VI hydraulic fluids

Performance requirement	Comment	Unit	ISO VG 32	ISO VG 46	ISO VG 68
Viscosity index	Fresh oil	-	> 160		
Shear stability	KV100 after 40 min sonic shear	mm^2/s	>5.9	>7.5	>10.0
Low temperature viscosity	Brookfield viscosity	mPa·s	<750 at -15°C	<750 at -8°C	<750 at -2°C

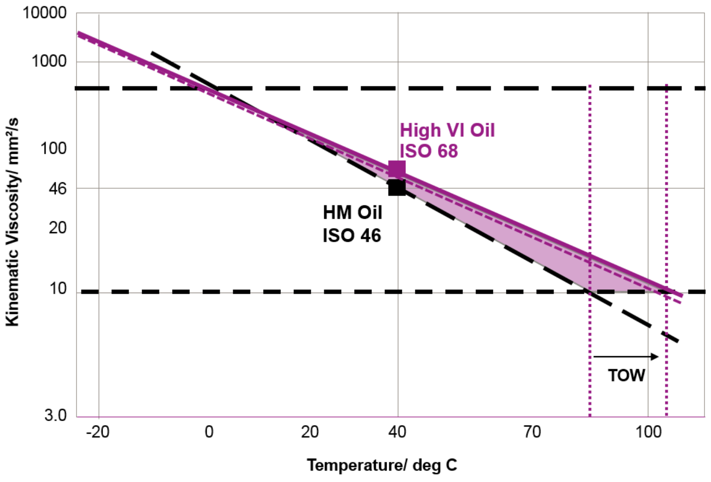
ISO VG 32



ISO VG 46



ISO VG 68



Outline

- Challenges for industrial gear oils
- Impact of hydraulic fluids on equipment performance
- **Hydraulic fluid performance demonstration**

What are the limiting factors to productivity?

Construction and mining

- Volumetric losses limit the speed and maximum payload of the equipment
- Hydromechanical losses delay equipment start-up
- Frequent maintenance and oil drains cause downtime

Rubber processing

- Oil heat-up limits the power output of the equipment

Manufacturing

- Pack and hold time in plastics injection molding
- Dynamics of the hydraulic unit (e.g. injection molding fast runner, dynamic presses and cutters)

EVONIK POWER TO CREATE

Hydraulic fluid performance demonstration

Equipment

- Two hydraulic excavators using axial piston pumps
- Two dump trucks, on-site truck scale, wheel loader
- Test phases: truck loading and digging at 90° and 180°

Parameter variations

- Two operators
- Four different oil temperature ranges
- Test sequence A-B-A under repeatable conditions

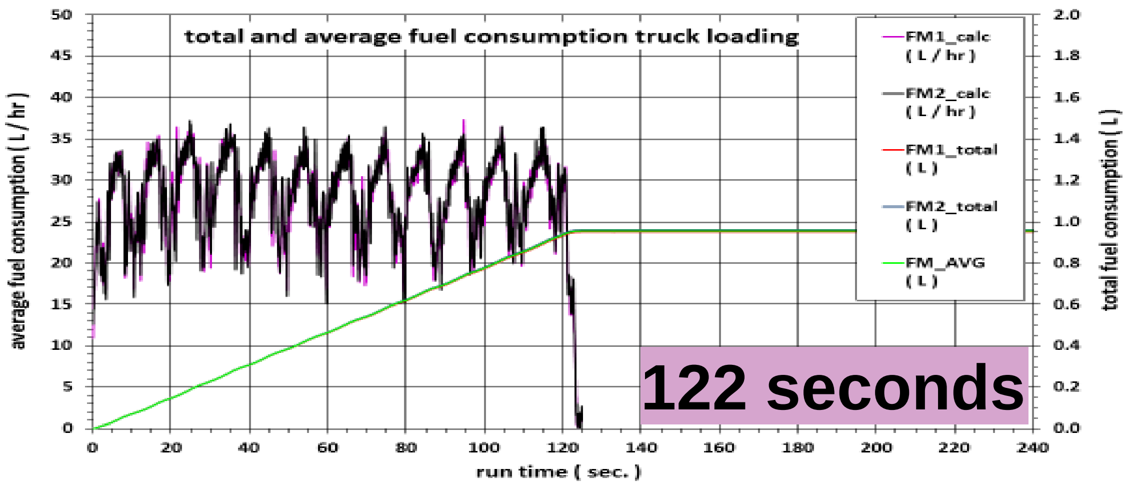
Statistical analysis

- Thorough statistical evaluation of the performance of 19 different hydraulic fluids

EVONIK
POWER TO CREATE

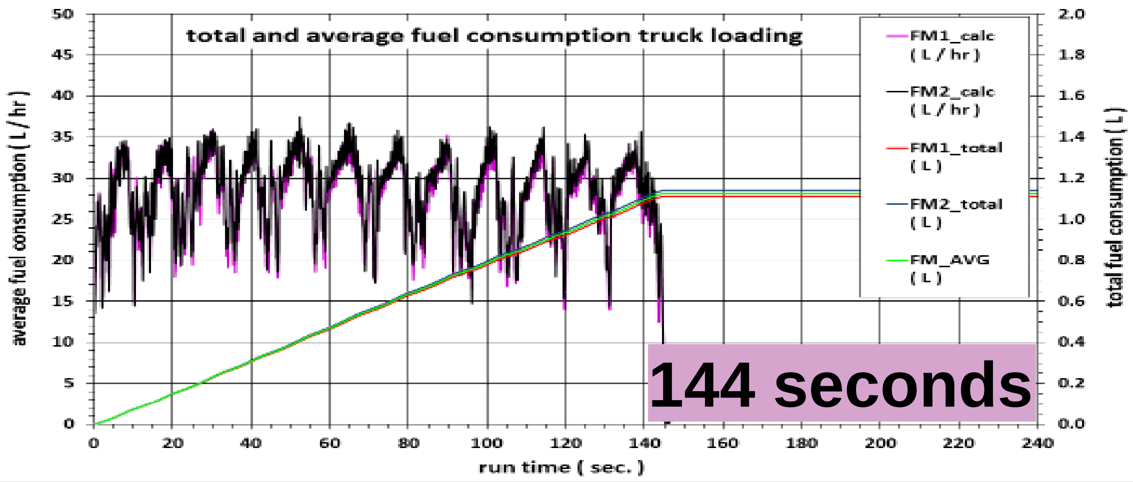
Example truck loading at 90° swivel angle

High VI oil
ISO VG 46



Increase in Productivity: 18%

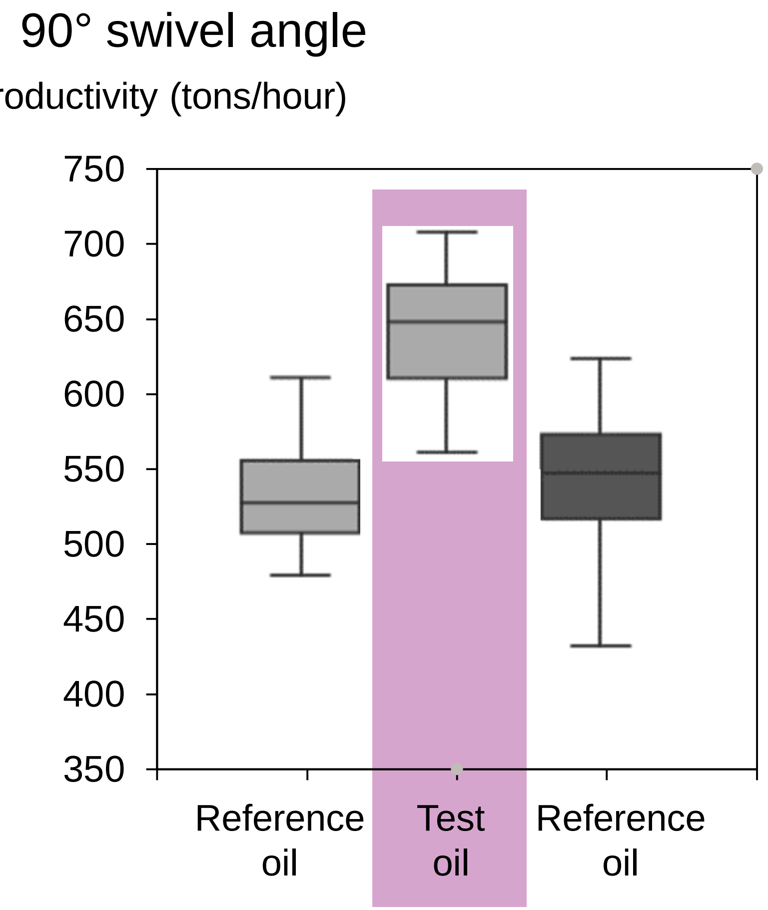
Low VI oil
ISO VG 46
(Reference)

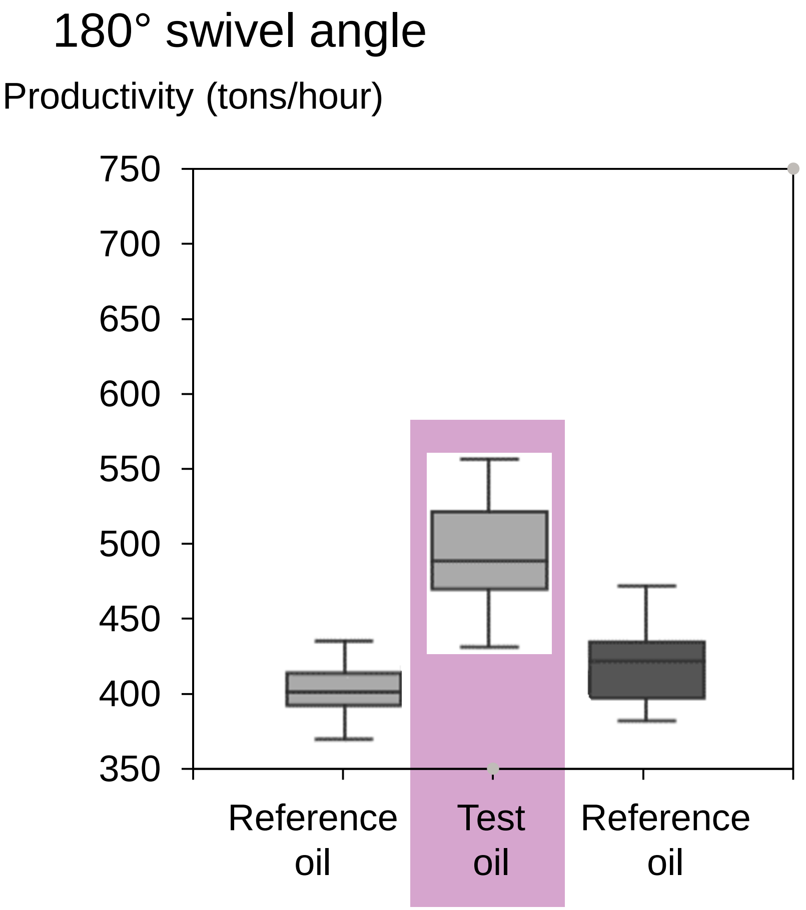


EVONIK
POWER TO CREATE

Example truck loading at 90°/180° swivel angle

Results from 128 truck loadings per oil with statistical analysis





Increase in Productivity: 15-18%

EVONIK POWER TO CREATE

Performance demonstration results: shear stability

	Test fluid 1	Test fluid 2
Reference fluid	ISO 46 – VI 100	
Test fluids	ISO 46 – VI 170 Poor shear stability	ISO 46 – VI 170 Excellent shear stability
Type of work	Digging & Truck loading	
Efficiency improvement (∅)	3%	13%
Productivity improvement (∅)	4%	16%

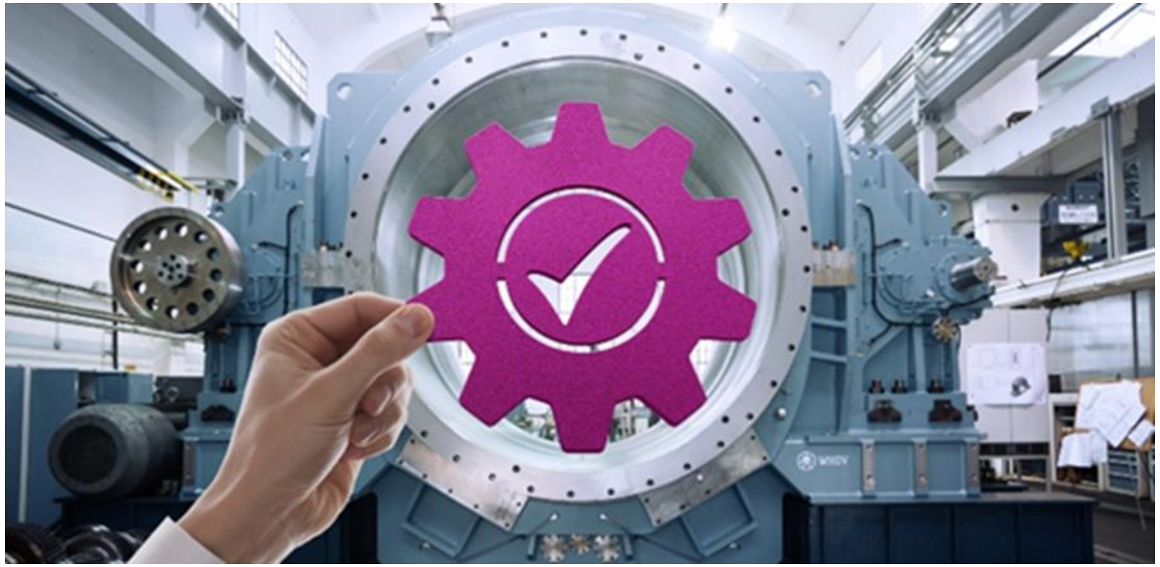
A combination of **good shear stability** and a **high VI** of the fluid can significantly increase efficiency and productivity.

EVONIK
POWER TO CREATE

Conclusion

High performance industrial lubricants offer a wide range of benefits over conventional fluids

- Increased productivity
- Longer oil drain interval
- Improved system durability and machine life extension
- Lower energy/fuel consumption
- Reduced operating temperature (e.g. bearings)
- Improved gearbox cleanliness
- Avoidance of costly downtime losses



Thank you for your attention.

EVONIK

POWER TO CREATE