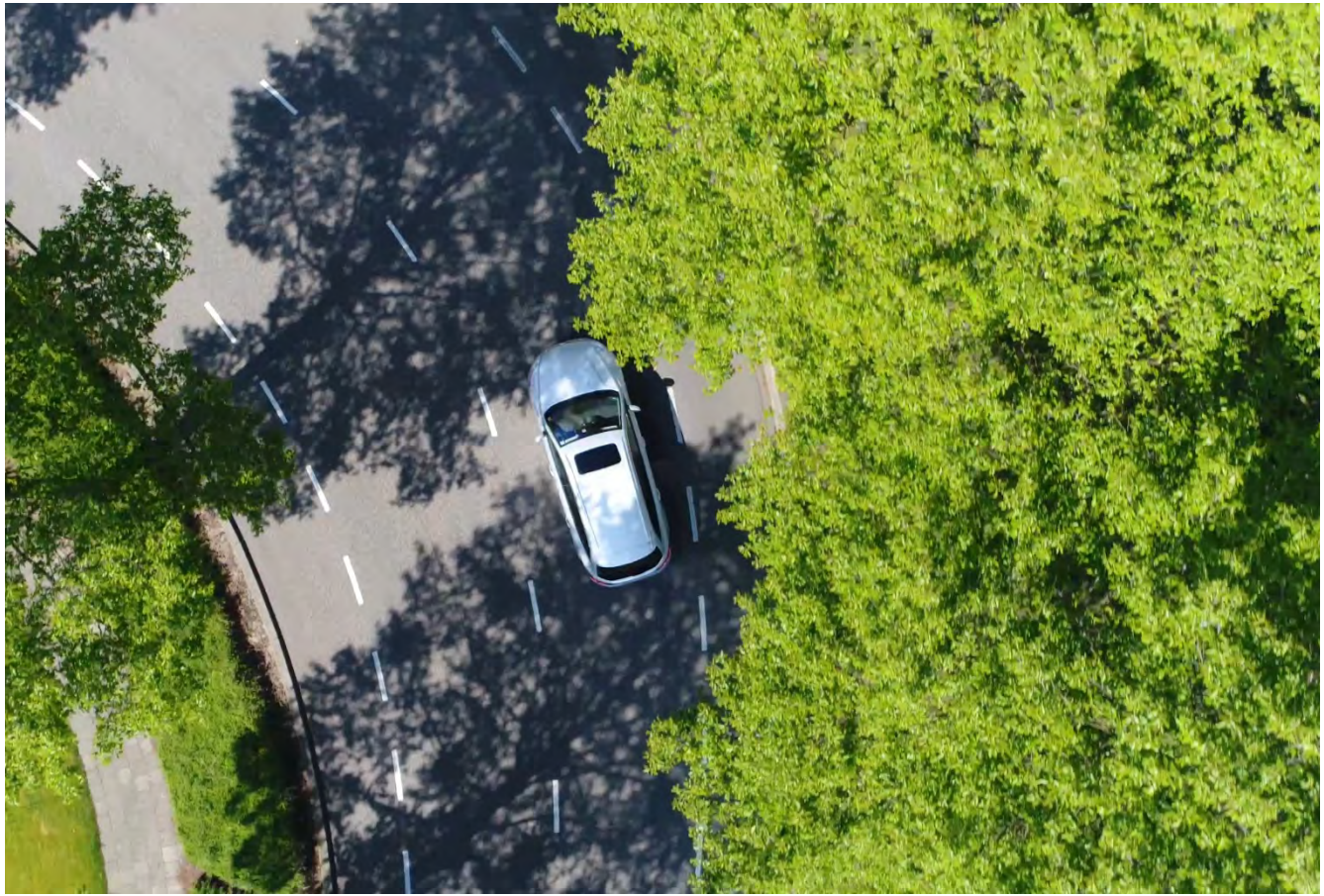


Higher Efficiency and Longer Service Life for Gears and Bearings - Automotive

REWITEC GmbH
Dr.-Hans-Wilhelmi-Weg 1
35633 Lahnau
Germany

REWITEC

Target Markets

- **Automotive**
  - **Consumer**
  - **OEM**
  - **Motorcycles**
  - **Racing**
  - **Classic cars**

- Wind energy
  - Onshore
  - Offshore

- Marine
  - Shipping
  - Barges
  - Yachts
  - Submarine

- Industry
  - Steel
  - Cement
  - Mining
  - Oil, Gas

REWITEC Products

DuraGear™

Gears

GR400

Bearings

PowerShot™

Engine Oils

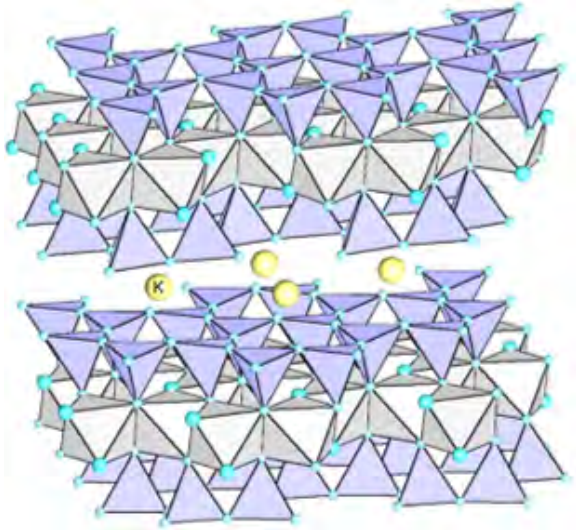
Sprays

Multi-purpose

REWITEC Technology

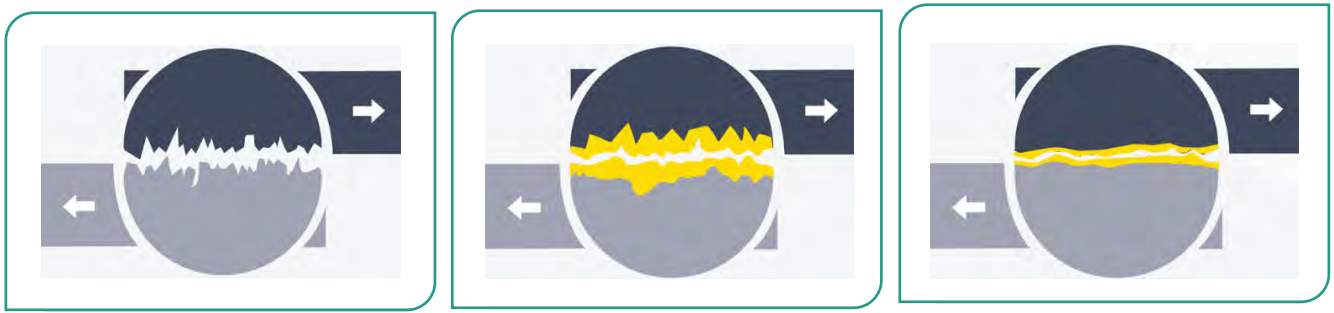
Phyllosilicate Based Particle Additives

- Platelet-shaped particles with layered crystal structure
  - Si-O and Al-O based layers
  - Strong *covalent* bonds within the layer
  - Weak *van der Waals* interaction between the layers
- Easy shearing between the layers
  - **Friction reduction**
- Big specific area with high adsorption ability
  - covering the surface, filling the holes
    - **Protective, repairing and smoothing effect**
- Particle size d90 = 4 µm
- Soft material: Mohs Hardness Scale 2.5 (like fingernail!)



Scientific publication:
”Tribological properties of a phyllosilicate based microparticle oil additive”, Chizhik et al., Wear 426–427 (2019) 835–844

Mechanism of Action



Step 1 Step 2 Step 3

Significant reduction of friction, wear, roughness and temperature

Advantages:

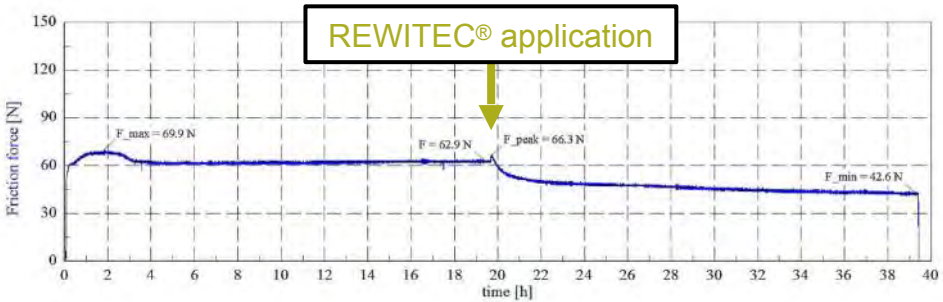
- Compatibility with all common lubricants
- Temperature independent
- No chemical interactions with other lubricant components
- Low dosage

Scientific Tests

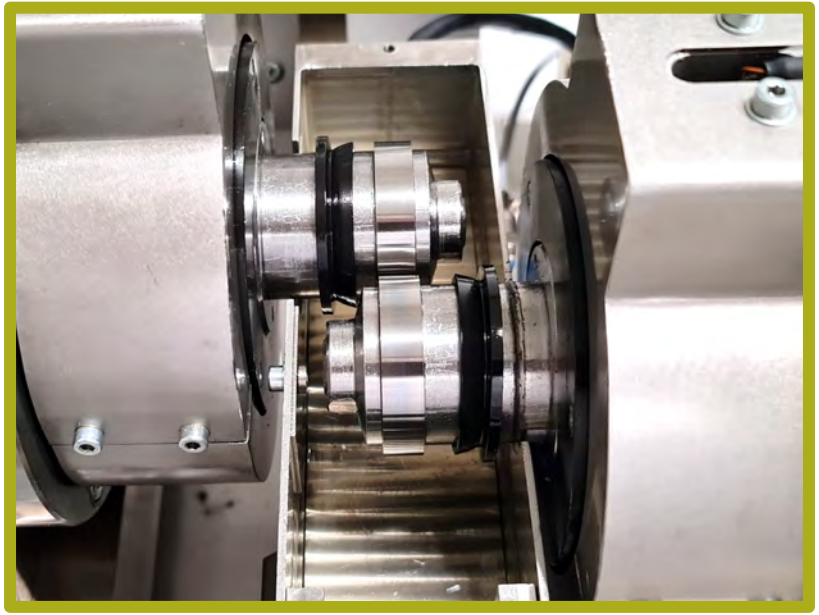
2-Disc Assembly Rolling Wear Test – Gear Oils

Reduction in friction

- Stress value: 1 GPa (normal force 2150 N)
- Rotating speed: 424 rpm / 339 rpm, slip 20 %
- Test-duration: 39,3 h
- Temperature: oil inlet temperature 60 °C
- Friction coefficient: μ=normal force/friction force



Castrol Optigear Synthetic X320

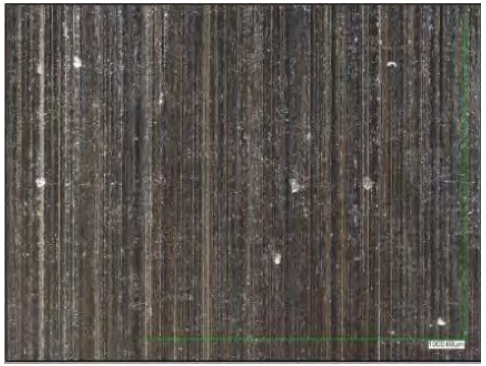


2-Disc Assembly Rolling Wear Test – Gear Oils

Oil	Friction reduction	Roughness reduction
Castrol Optigear Synthetic X320	33 %	41 %
Mobilgear SHC XMP 320	35 %	44 %
Klübersynth GEM 4-320N	40 %	54 %
Fuchs Unisyn CLP 320	36 %	50 %
Amsoil PTN 320	46 %	18 %
Shell Omala S4 GX 320	42 %	25 %
Klüberbio EG 2-150	55 %	40 %
Fuchs Pentosin EG FFL-7A	41 %	35 %
Automotive racing gear oil	55 %	40 %

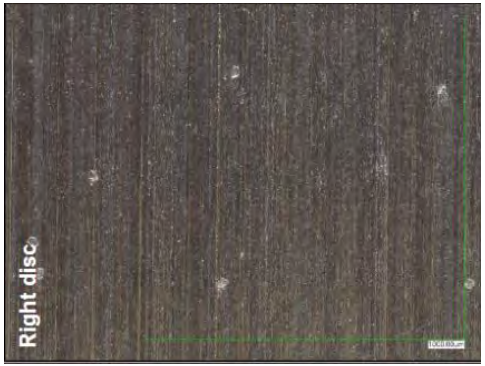
2-Disk surface roughness:
Ra reduced by 34 % / Rz reduced by 40 %

Blank disk



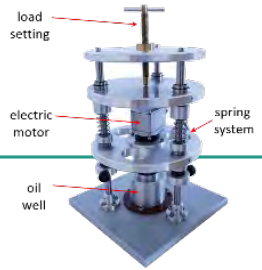
Ra = 0.30 µm
Rz = 2.70 µm

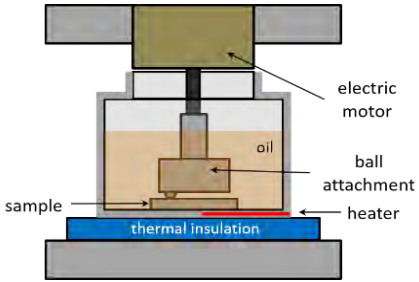
Gear oil + Phyllosilicate



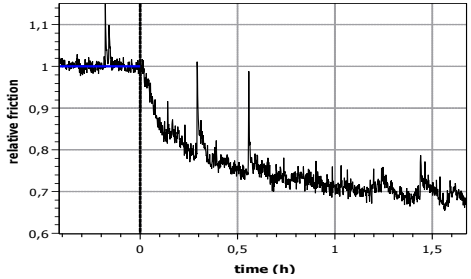
Ra = 0.20 µm
Rz = 1.62 µm

Pin-on-disk Tribometer





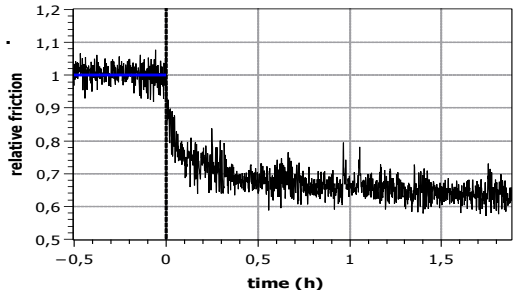
Honda Ultra Next motor oil (0W-8)
- Room temperature
- Load 5 N; 4000 min^{-1}



Honda Ultra Green engine oil (0W25)
1. Room temperature
2. 70°C

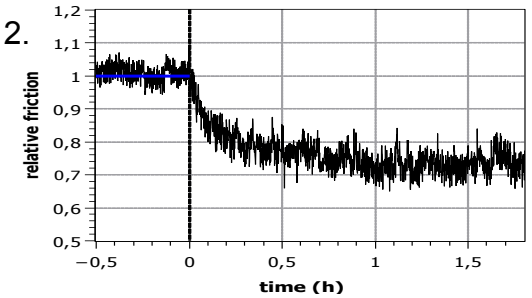
Load 5 N; 4000 min^{-1}

1.



35 % friction reduction after 1 hour

2.



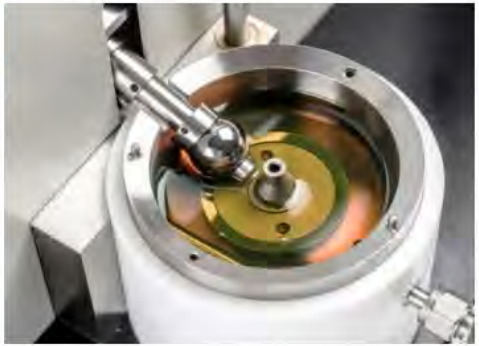
27 % friction reduction after 1 hour

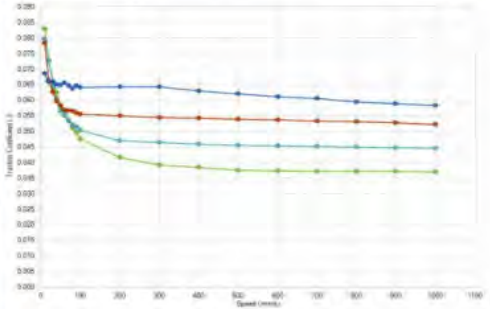
MTM Test – Tribological Testing of Several Oil Additive Samples

1. MTM-Tests
1.1 Description of possible testing parameters

KOMPETENZZENTRUM tribologie MANNHEIM — Steinbeis

Testing parameters:	
Upper Specimen	Ball (100Cr6, 800-920 HV, polished, Ra <0,02 µm), O-Ring, Cylinder
Lower Specimen	Disc (100Cr6,720-780 HV, polished, Ra <0,02 µm), other materials possible
Normal force	0 - 75 N
Hertzian contact pressure	0.5 bis 1.25 GPa (Standard-Ball/Disc) up to 3.1 GPa (with alternative geometries and materials)
Movement types	Rolling (with Slip), Slip continuously variable between 0 - 100%
Friction types	Boundary lubrication, mixed lubrication, elastohydrodynamic lubrication
Speeds	0 - 4000 mm/s Rolling speed per specimen
Lubrication	Immersion lubrication (up to 120 °C), initial lubrication
Measurements	Normal force, Friction force, Friction/Traction coefficient, Temperatures





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MTM Test – Tribological Testing of Several Oil Additive Samples

- Test with Castrol EDGE 5W30

Testing parameters:

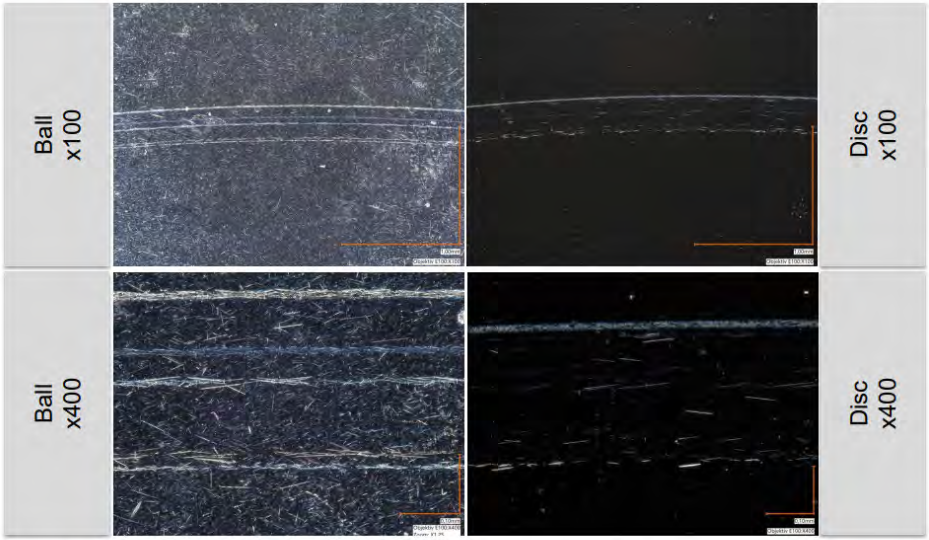
Step / Type	Load	Speed/Slip	Temperature
1 / Stribeck - Test	39 N (~1,00 GPa)	10 – 3500 mm/s @ 20 % Slip	80 °C
2 / Traction - Test		1 % – 50 % @ 1000 mm/s	

Step 1 and 2 get repeated 12 times each resulting in 12 stribeck and 12 traction curves with a total test time of 2 h. The repetition of the tests is supposed to show run-in behavior of the samples.

Tribological Testing - Microscopies

1.2.9 Microscopy
Valvoline 15W40

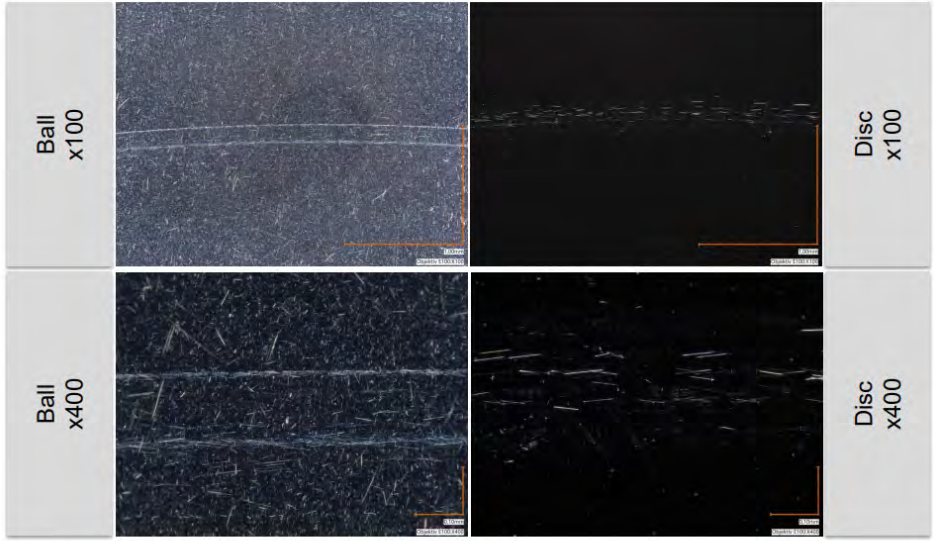
KOMPETENZZENTRUM tribologie MANNHEIM — Steinbeis



Ball and disc show slight abrasive wear.

1.2.10 Microscopy
Valvoline 15W40 + 2% PP01

KOMPETENZZENTRUM tribologie MANNHEIM — Steinbeis

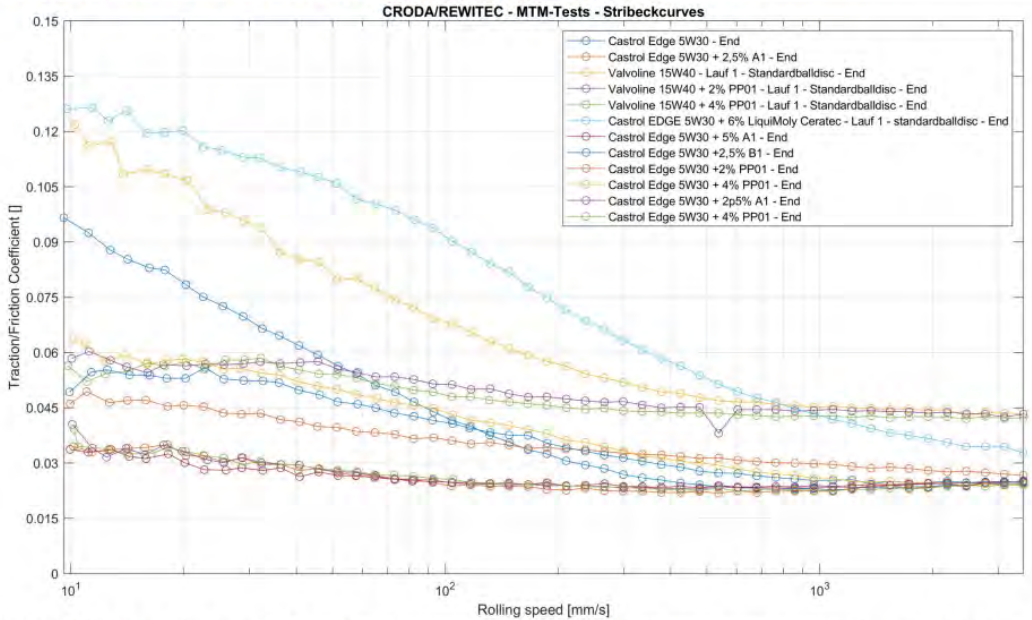


Ball and disc show minimal abrasive wear, less than with pure base oil.

Tribological Testing – Stribeck Curves

3. Comparison graphs
Stribeck curves in last step (logarithmic x-axis)

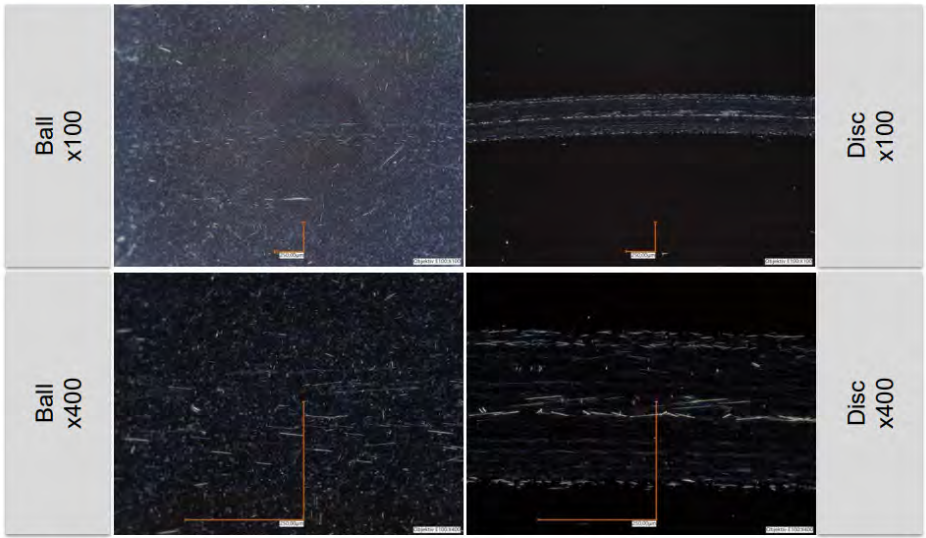
KOMPETENZZENTRUM tribologie MANNHEIM — Steinbeis



Last curve of each test are shown: Sample A1 5% and PP01 2% show lowest friction levels overall. All other additive samples increase in friction levels and also show delayed transition to full hydrodynamic lubrication. This is probably due to the observed surface damages, roughing up the surface and increasing the needed minimum lubrication film thickness. Repeat-runs of 2,5% A1 and 4% PP01 don't show any degradation regarding friction, most likely due to less surface damage. Reference oil shows higher boundary and mixed friction levels but prevents surface damage, so transition to hydrodynamic lubrication does not increase significantly with test run time. Due to higher base oil viscosity, Valvoline 15W40 friction levels are generally higher - 2% PP01 is now tied with 4% PP01 in mixed friction.

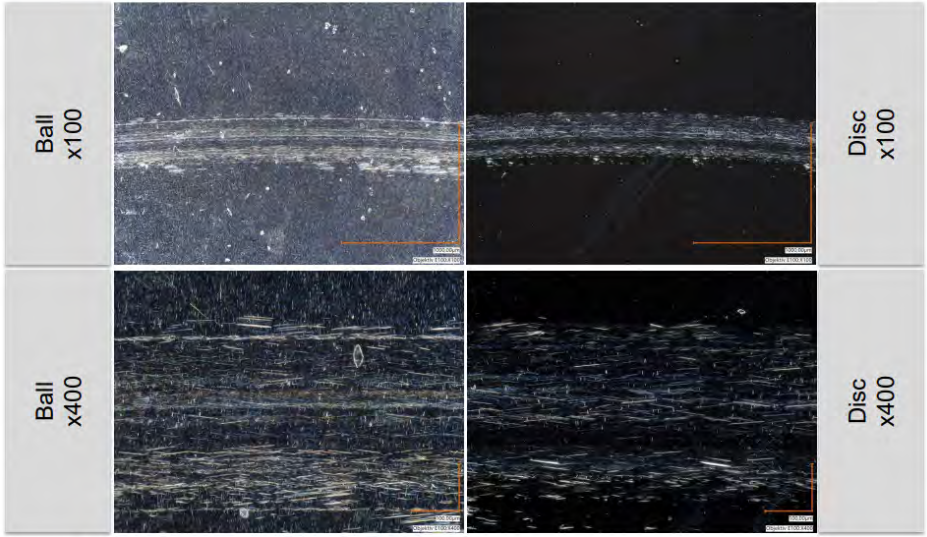
Tribological Testing - Microscopies

1.2.3 Microscopy
Castrol Edge 5W30 + 5% Sample A1



Disc shows increased abrasion marks but now galling damage this time, ball wear is only barely visible.

1.2.11 Microscopy
Castrol EDGE 5W30 + 6% Ceratec -



Compared to other samples Ball and disc show noticeably increased abrasive wear.

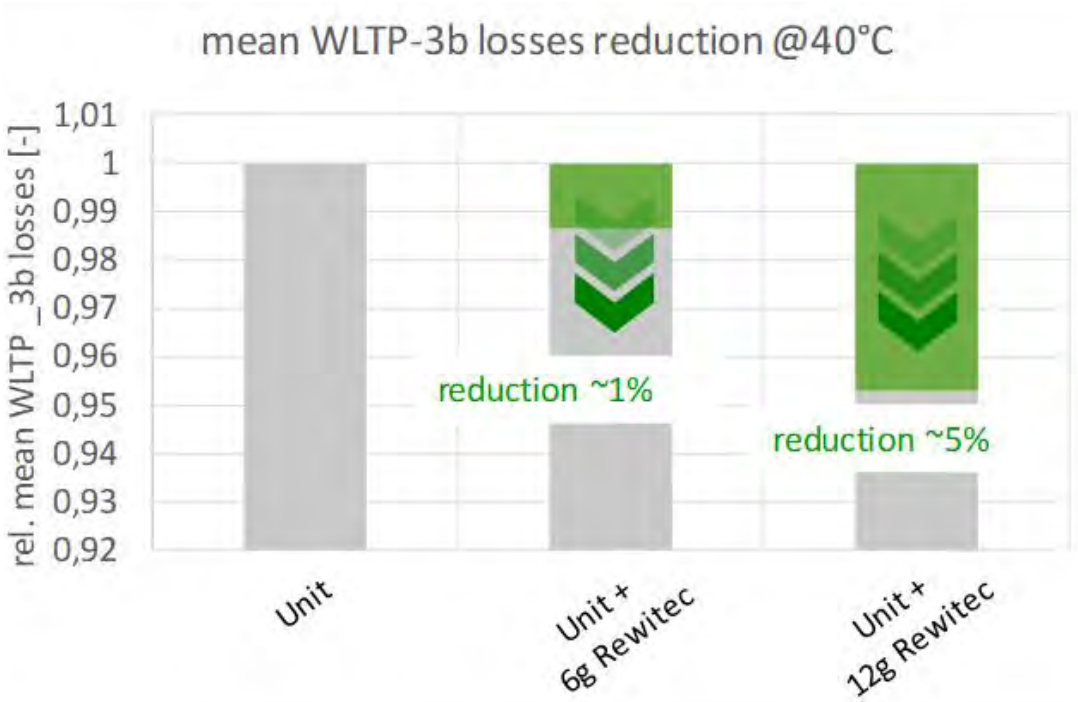
Results MTM Test

- Up to 56 %* lower friction than pure Valvoline 15W40
- Lower wear than pure Valvoline HDD
- Up to 65 %* lower friction than Castrol Edge 5W30
- Up to 72 %* lower friction than Liqui Moly's Ceratec in Castrol Edge
- Lower wear than Liqui Moly's Ceratec in Castrol Edge

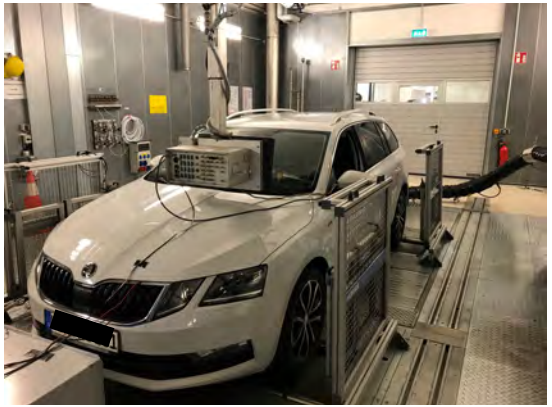
*in mixed and border lubrication

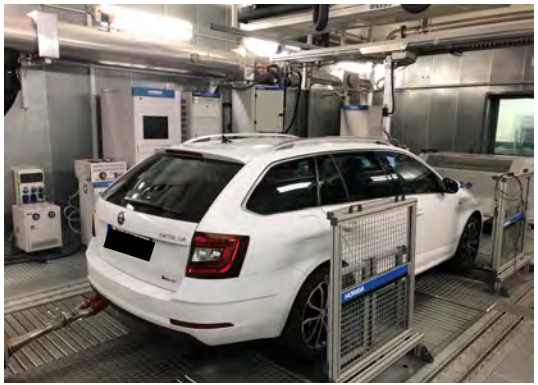
EV Gearbox Tests

- WLTP losses at 40^{0}C



REWITEC PowerShot M for Car Engines





Horiba: Emission tests
BE Performance: Torque & power measurements

2 cars: Audi A3 1.5 TSI
Skoda Octavia 2.0 TDI

REWITEC

Results

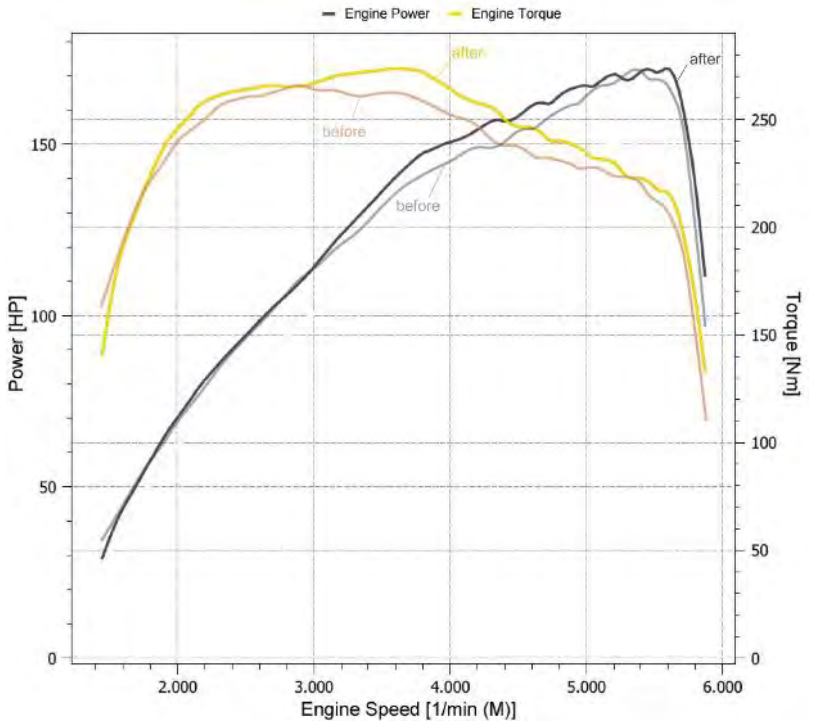
Horiba: Emission tests (roller test bench, NEDC, WLTP) 04_2020
BE Performance: Torque & power measurements (test on the street in 3rd gear)

2 cars: Audi A3 1.5 TSI
Skoda Octavia 2.0 TDI

	Audi A3 1.5 TSI	Skoda Octavia 2.0 TDI
Fuel consumption (NEDC, WLTP)	-0.67%	- 1.02%
Torque	+5.3%, +13.8Nm	+3.7%, +12.9Nm

Application in Audi A3 1.4 TFSI at Horiba 04_2020

- All measurements performed in 3rd gear
- 3% increase in peak engine torque
- 3% increase in engine power at 4,000 rpm

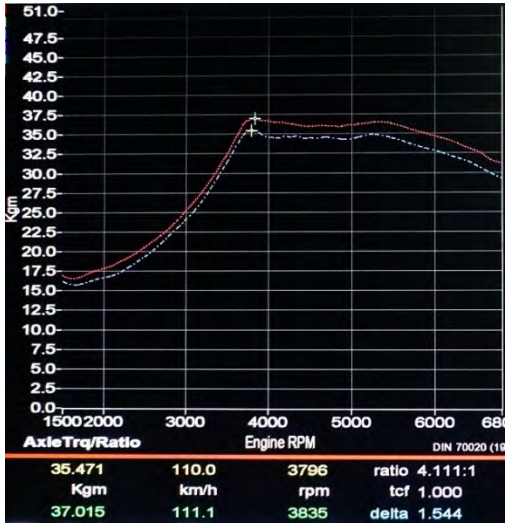


Nissan GT-R R32 Engine Treatment by M. Krumm

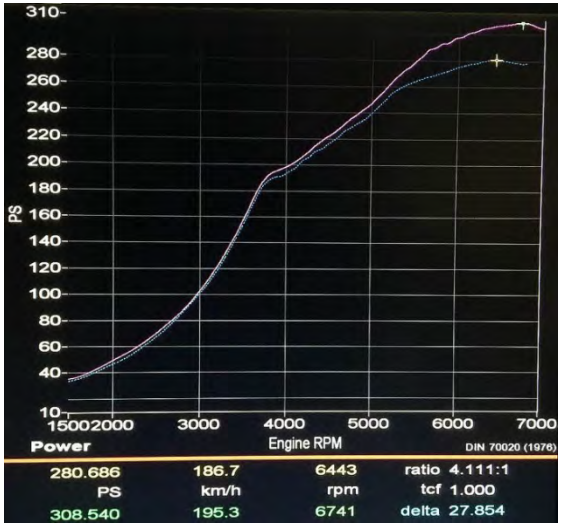
- Test dynamometer:
  - Dynapack Chassis Dynamometers Evolution 3000
- Baseline: 281 BHP / 348 Nm
- Treatment with REWITEC® PowerShot® L (29.01.2016)
- Improvement after 2 h: **+16 BHP / 15 Nm**
- Additional transmission treatment with REWITEC® G5 (30.01.2016)
- Complete end-result-improvement after 6 weeks: **+28 BHP**

Nissan GT-R R32 Engine Treatment by M. Krumm

29.01.2016



29.01.2016

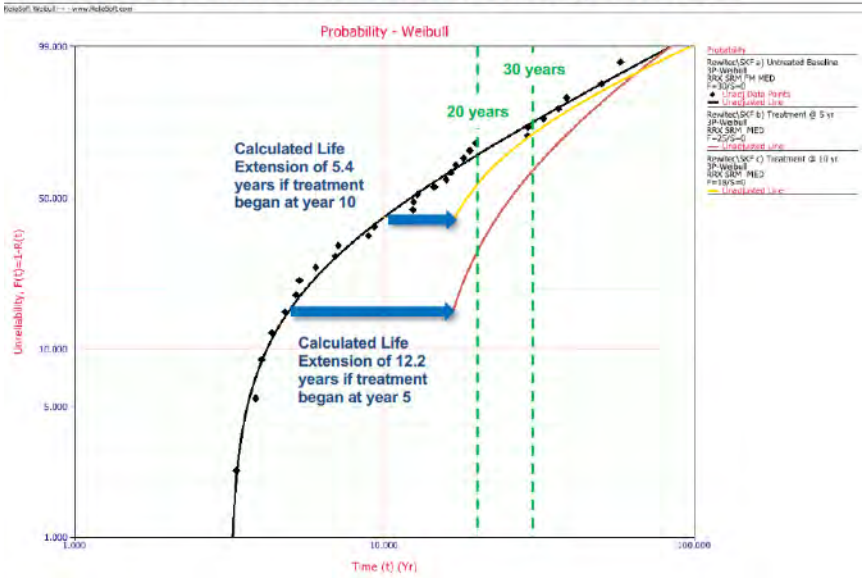


17.03.2016

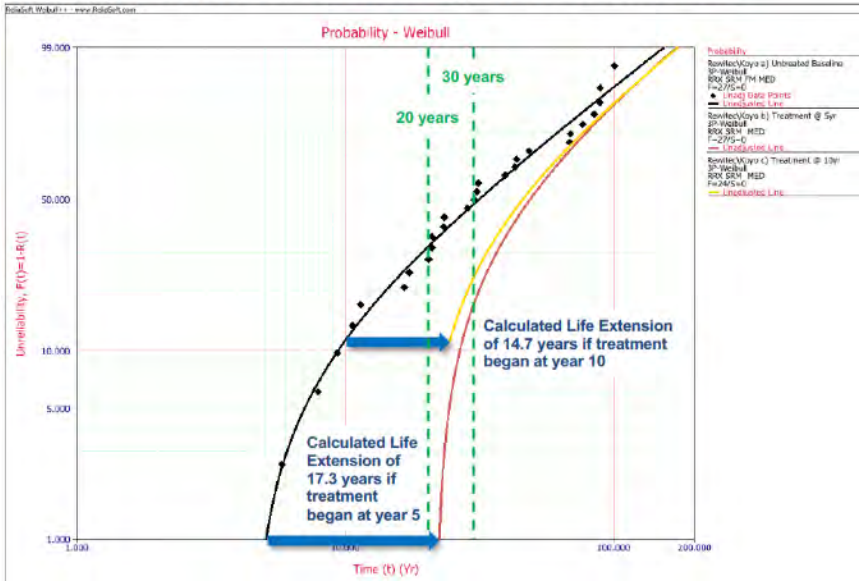
Lifetime Calculation

Calculated Life Extension of upto 17 Years

Acciona AW1500 Generator Side Mainshaft bearing – SKF 23188



GE Energy 1.6/1.7-100 Mainshaft bearing – KOYO Model 240/710



Significant reduction in the probability of failure of a main bearing post application

The earlier the application, the greater the lifetime extension

Do you need more information?

Please do not hesitate to contact us.

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