An alternative approach to Synthetic Wind Turbine Gear Oil formulation.

Phil Hutchinson. Evonik Oil Additives, Singapore.

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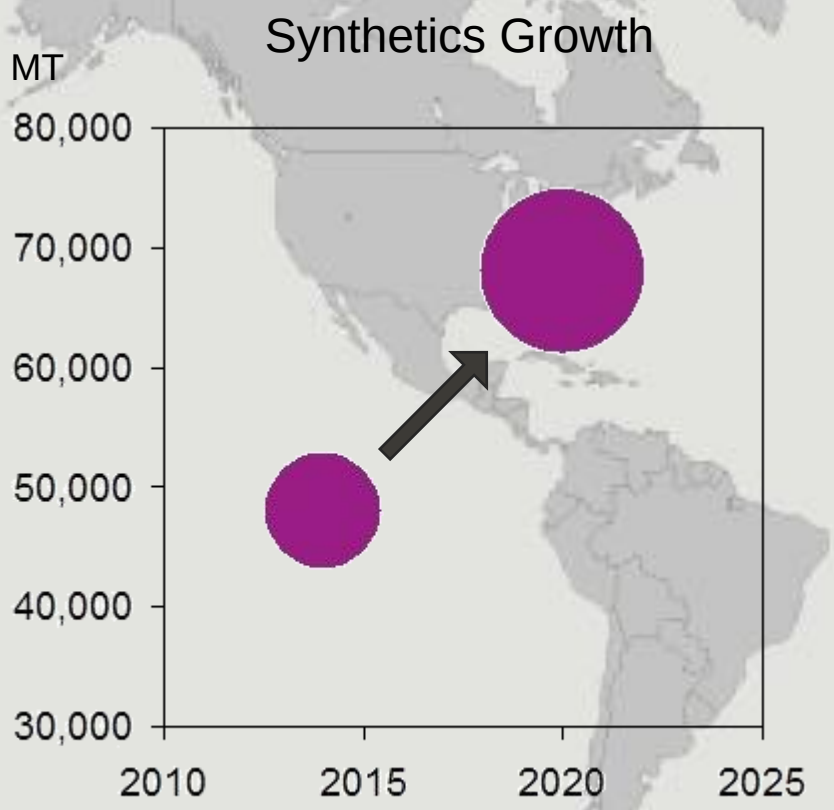
Synthetic Industrial Gear-Oils / Wind Turbine Gear-oils (WTGO)



Source: Evonik Market Intelligence

- Significant growth in the use of Synthetic Gear-Oils.
- Wind Turbine Gear-boxes a significant part of this.

Why Synthetic WTGOs?

- Routine maintenance more difficult
- Widely varying and severe operating environments
- Expectations for longer service life, machine efficiency and protection.
- Higher loads, temperatures and speeds.

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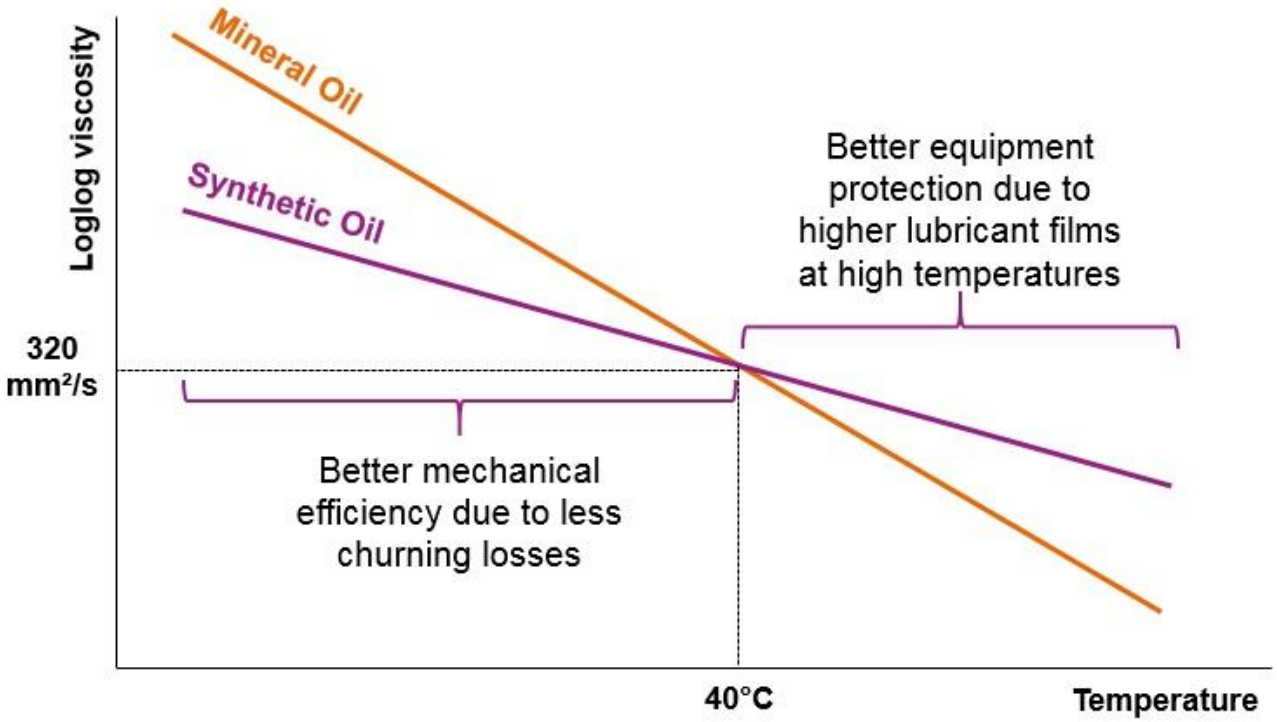
Wind Turbine Gear Oils (WTGO)

- **ISO VG 320** is typical.
- Formulated with heavy **P**oly **A**lpha **O**lefins (PAO 40/100)
- (Ester-only formulations where biodegradability is key. Also Polyglycols.)

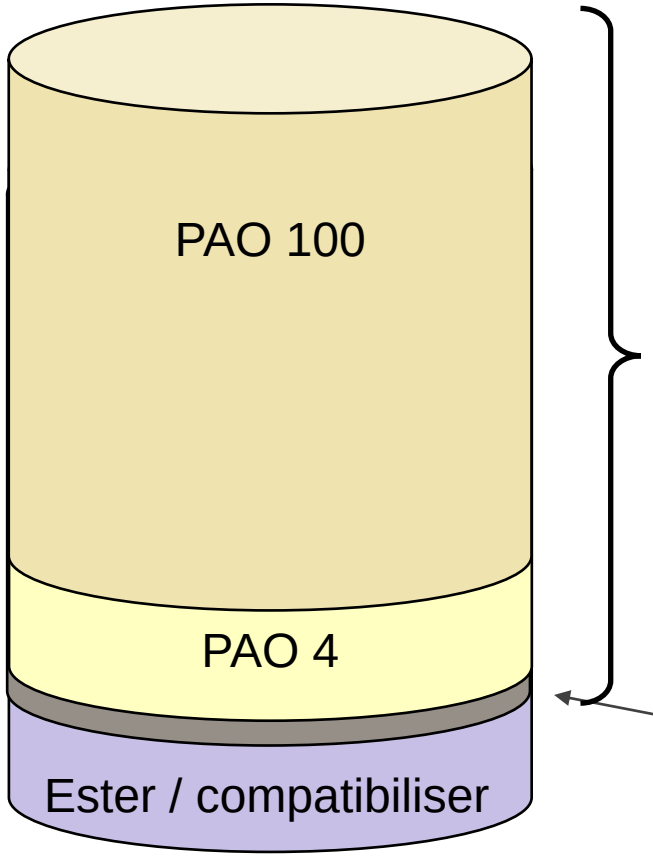
PAO based Synthetic Gear-Oils,

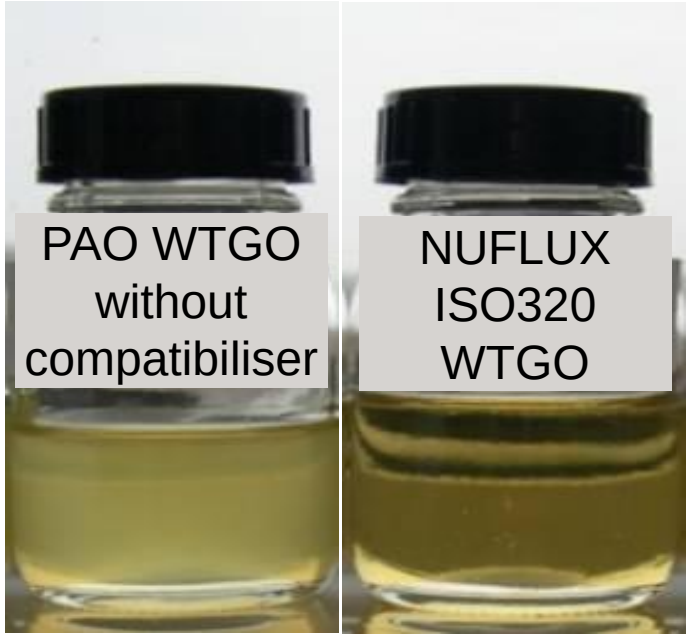
- Stable. (oxidation / thermal resistance)
- Synthetic / Multigrade temperature performance properties
- Good fluid film - protection against micro pitting and wear



Wind Turbine Gear Oils. NUFLUX compared to PAO.

Typical PAO based
ISO320 WTGO





Anti-wear, anti-oxidant Package

NUFLUX
ISO320 WTGO

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Wind Turbine Gear Oil Testing

- **Pre-requisite**: DIN 51517-3 (“CLP Lubricants”)
- Evaluation of **NUFLUX** according to **extended OEM specifications** of Siemens MD (=Flender), **Winergy**, Moventas, Eickhoff (…)
  - **Oxidation** stability
  - **Rust** and **corrosion** protection
  - **Seal** compatibility (static, dynamic)
  - **Coating** compatibility
  - **Gear** protection (FZG micropitting, FZG scuffing)
  - **Bearing** protection (FE8, FAG 4-step)
  - Balanced **foam / filtration** behavior

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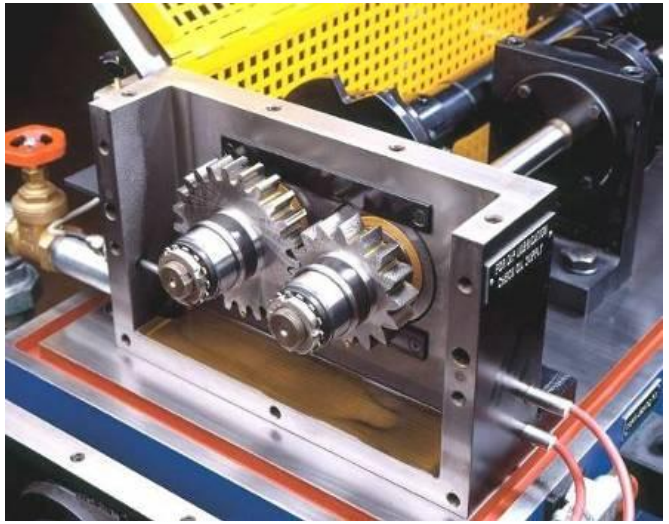
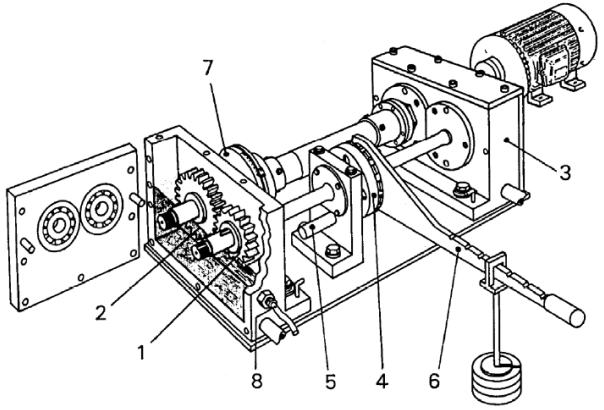
Micropitting Test according to FVA 54/I-IV

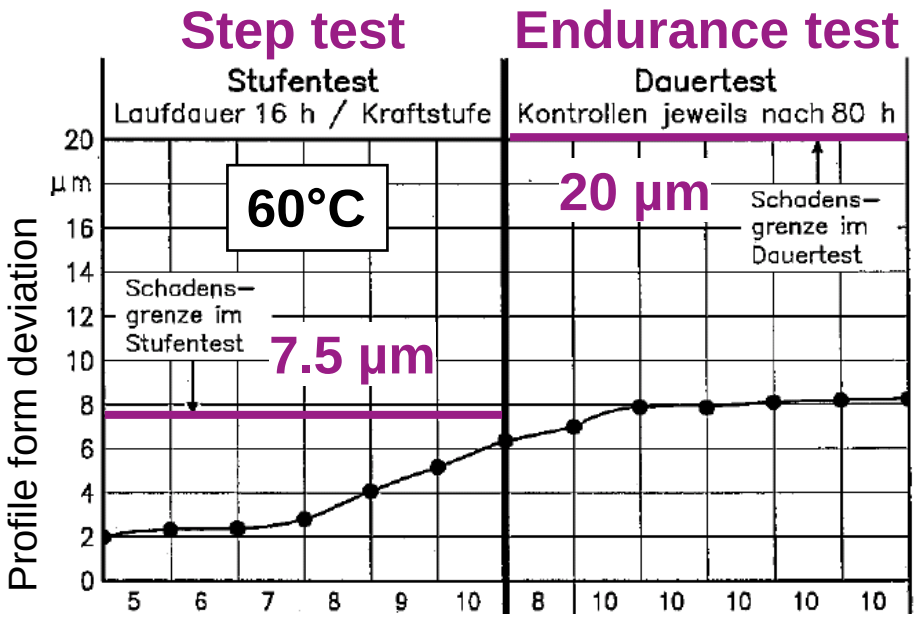
- Run at 1.500 rpm under increasing load
- Apparatus consists of a **conventional FZG test apparatus** with an oil circulating system added
- FZG type **‘C’ case-hardened gears**
- Assessed results include:
  - **Tooth profile deviation**
  - % micropitting area
  - Weight loss
- **Two phases**
  - 6 x 16 hours increasing load stages
  - 6 x 80 hours high load endurance stage

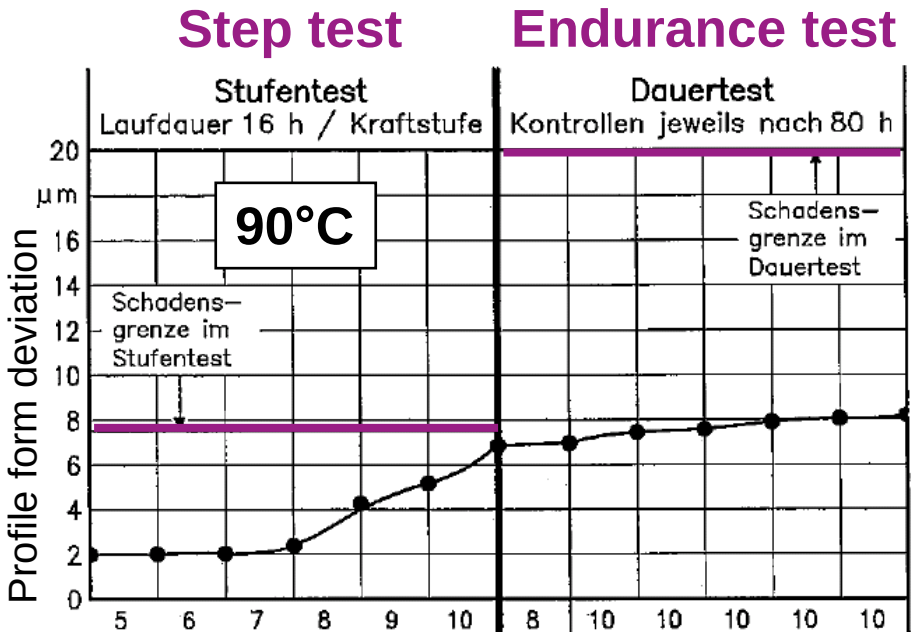




1 Test Pinion
2 Test Wheel
3 Slave Gear
4 Load Clutch
5 Locking Pin
6 Load Lever and Weights
7 Torque Measuring Clutch
8 Temperature Sensor

Micropitting Performance of NUFLUX Formulation





Results by FZG Munich

Nuflux Formulation shows excellent gear protection in this test

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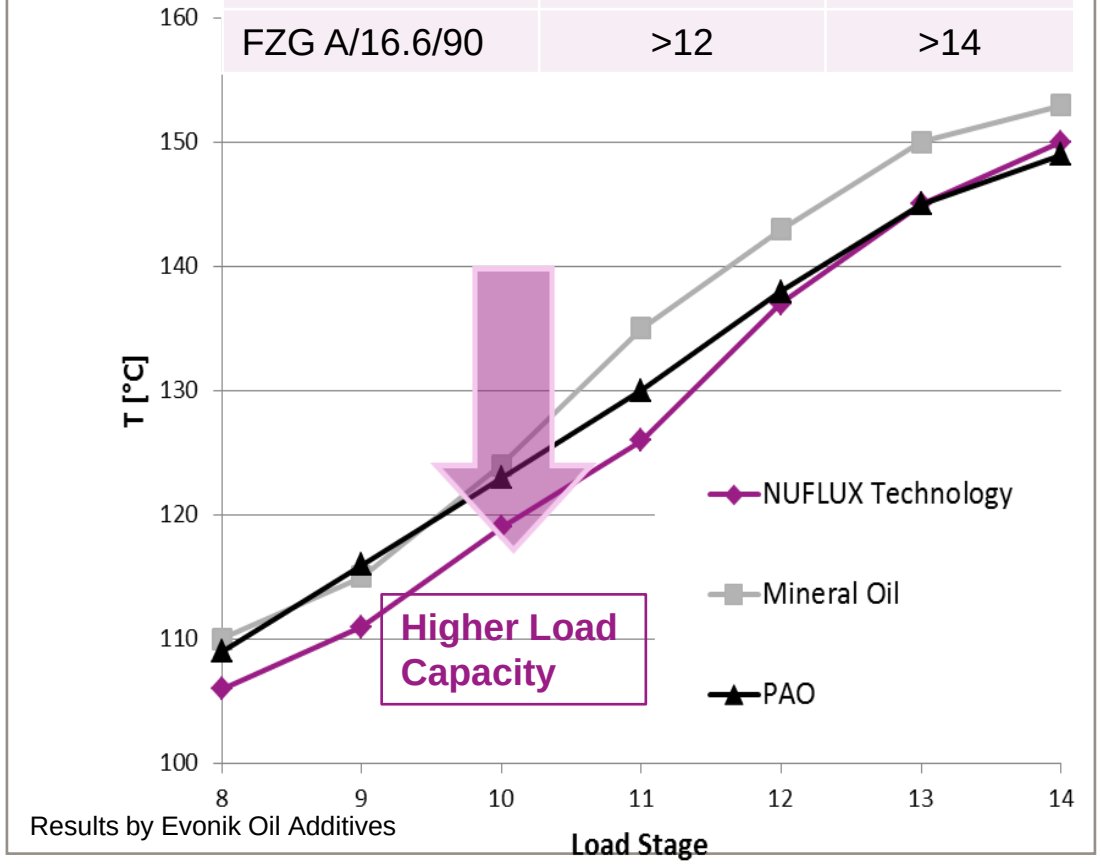
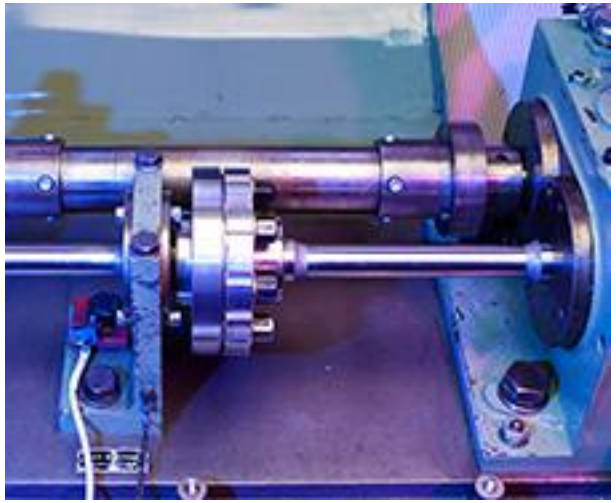
FZG Load Carrying Capacity

NUFLUX™ technology	Specification	Result
FZG A/8.3/90	>14	>14
FZG A/16.6/90	>12	>14



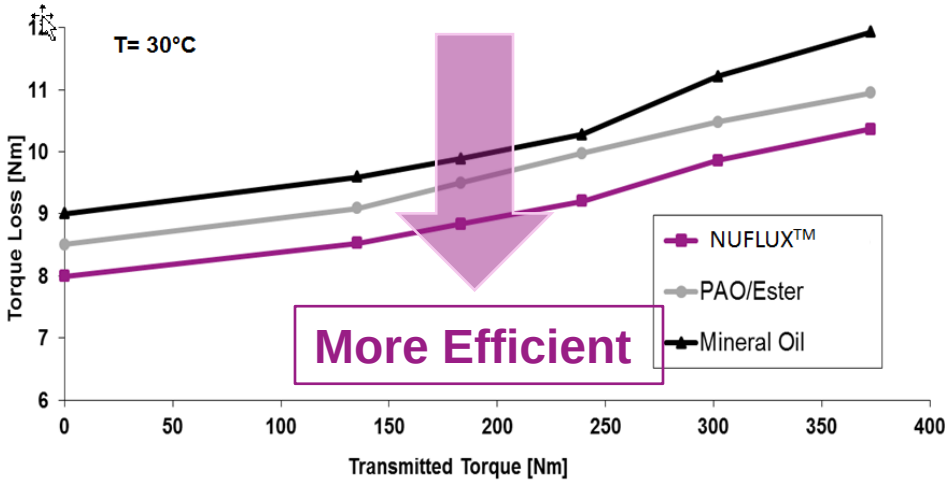
Results by Evonik Oil Additives

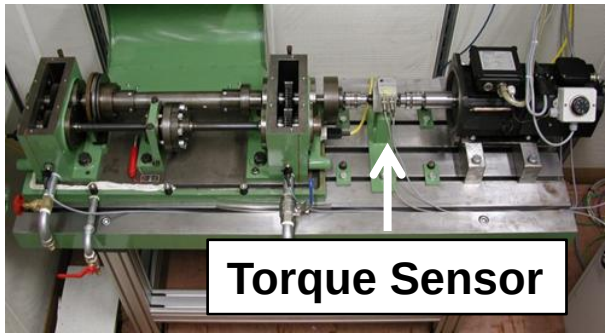


NUFLUX exhibits lower temperature increase reflecting reduced internal losses, higher efficiency and excellent gear protection

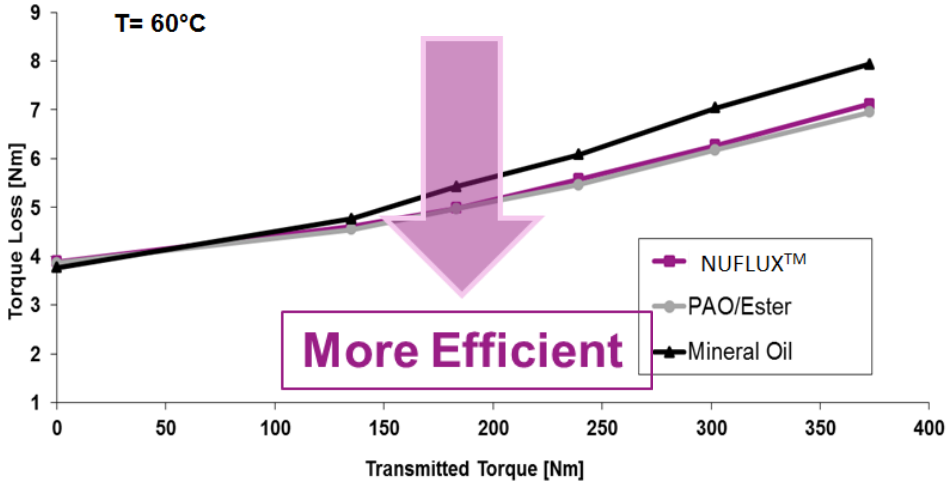
FZG Efficiency of NUFLUX™ compared to PAO and Mineral Oil

At 30°C, NUFLUX™ formulation showed the lowest torque losses across all load stages.





At 60°C, PAO formulation and NUFLUX™ outperform mineral oil at higher loads



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FAG Schaeffler's 4-Step Test: Examination of Lubricants in Different Severe Bearing Operating Modes

1. **Bearing Wear – High Load/Low Speed – Extreme Mixed-Friction**
   FE8 Cylindrical Roller thrust bearing; 100 kN, 7,5 rpm,
   80°C, 80 hrs; brass cage, steel rollers

Run No.	1		2	
Bearing No.	**1**	**2**	**1**	**2**
Roller Wear [mg]	4	4	7	4
Cage Wear [mg]	109	139	77	59

Passed: 1.0

2. **Fatigue – Moderate Mixed Friction**
   FE8 Cylindrical Roller thrust bearing; 100 kN, 75 rpm, 70°C, 800 hrs; polyamide cage, rollers

Bearing No.	1	2
Roller Wear [mg]	5	3

Passed: 1.0

3. **Fatigue – EHL Conditions**
   L11 Ten deep groove ball bearings; 8,5 kN, 9.000 rpm, 80°C, 700 hrs
   All 10 bearings ran until predetermined stop time of 700 hrs . Running tracks look almost like new.

Passed: 1.0

4. **Deposit Test / Water Added**
   FE8 Cylindrical Roller thrust bearing; 60 kN, 750 rpm, 100°C, 600 hrs

Passed: 1.7

Excellent Overall Result: 1.2

Results and pictures by FAG Schaeffler

Approval Letters from FAG Schaeffler, Winergy and Moventas

▪Bearing Manufacturer

Corporate Materials

FAG

Investigation Report

Report-No.: SWE-ETMTS_12-0467

Topic: Evonik Industries 8179 - Inspection of the oil concerning suitability in bearings for wind turbine gears – 4 Stage test

Distribution	Object
ST/SWE-ETVL2, Broocks (pdf)	ST/HZA-ETM, Hofmann (pdf) ST/HZA-ETMC, Steinmetz (pdf) ST/SWE-ETMTS, Karbacher (pdf) ST/HZA-ETMTS, Kanfer (pdf) ST/SWE-ETMCP, Demuth (pdf) ST/SWE-ETMCL Wotz (pdf) ST/SWE-ETMTS (Original)

Object notation	Type / Drawing-No.
	–

Requested by			Report	
Name	Broocks, Alexander		Date request	2011-06-11
Dept.	ST/SWE-ETVL2		Date report	2012-06-25
Phone	-4144	C.C.	Pages / enclosures	1/ 1
Suppl. / Customer	Evonik Industries		Filing U	kind: Bo

1. **Background / Task**

Oil test of suitability for roller bearings in wind turbine gears - 4 Stage test. All Stages were tested at Schaeffler Technoligies AG & Co. KG. The tests stage 1, 2 and 4 were done with the oil named Evonik Industries 8179/1 and the stage 3 with Evonik Industries 8179/2. According to Evonik the 8179/2 is a new blend with 100% identical formulation. This was done, because there wasn't enough oil available from 8179/1 for Stage 3.

Operating conditions

The operating conditions of all steps are described in the attached reports of each step. Step1: 000-524-923/001/00, Step 2: 000-536-537/001/00, Step 3: 000-613-630/001/00; Step 4: 000-551-769/001/00.

2. **Summary**

The single results of step 1 to 4 are described in the above mentioned reports. A summery of all single results is listed in enclosure 1.
These results were compared to the presently known requirements for wind turbine gears. According to the result reached we determined a grade for each stage of the test – these grades are also listed in enclosure 1. All test stages were rated as "passed".

3. **Conclusion**

According to the presently known requirements for roller bearings in wind turbine gears at Schaeffler Technologies AG & Co. KG, the tested oil Evonik Industries 8179 passed all tests and reached a grade of 1,2.

4. **Liability**

This evaluation is based on

- the knowledge derived from a test of one batch only, so any scattering or product modification is not considered
- on our know how and experience in the field of bearing application in wind turbine gears

and carried out with every reasonable care. We do not accept any liability for loss or damages or any nature whether direct or indirect due to deficiencies in the performance and result of this test report except willful conduct.

Evonik Industries

Invoicing		Process No test department	Processed (lubrication technologie)	Approved by
Hours	ST/SWE-ETMTS 4.0	000-524-923/001/00; 000-613-630/001/00; 000-551-769/001/00; 000-536-537/001/00	ST/SWE-ETMTS – Fiedler	ST/SWE-ETMTS - Schöppner
Work-order				
Order				
Project	X-002667-09-02-01		Phone: +49 9721 91-2342	Phone.: +49 9721 91-6545

Gearbox Manufacturers

winergy

Winergy AG • P.O. Box 22 11 60 • 46553 Voerde

Dipl.-Chem. **Mark Zundel**
Head of Modelling, Verification & Tribology

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Fax: +49 2871 92-2380
E-Mail: mark.zundel@winergy-group.com

Page(s): 1 / 1

Evonik Industries AG
Dr. Rene Koschabek
Kirschenallee
64293 Darmstadt

Voerde-Friedrichsfeld, 2013-01-31

and

TO WHOM IT MAY CONCERN

Use of EVONIK Formulation 8175 for field trials in WINERGY gear boxes

Dear Dr. Koschabek,

We herewith declare that we approve EVONIK Formulation 8175 for field testing in Winergy gear boxes.

We confirm that the laboratory test results of EVONIK Formulation 8175 presented to us meet the requirements of our specification for gear oils used in Winergy gear boxes (Rev. 5) and we don't expect problems or irregularities by using this oil for a field test.

It has to be understood that a correct flushing of the gear box has to be performed if gear oils are changed. Please refer to our flushing procedure.

This approval can be withdrawn if abnormalities or damages occur in the future.

This statement is only valid for test purposes and no general approval.

With kind regards,

winergy ag
Engineering

i.V. M. Zundel

i.V. Dipl.- Chem. **Mark Zundel**
Head of Modelling, Verification & Tribology

i.V. Dipl.- Ing. **Frank Kretschmann**
Head of Customer Project Management

moventas

Letter of Approval 1 (1)

Moventas Gears Oy / Technology & Verification

Approval for Evonik Neste Oil Formulation 8175

We hereby confirm that the above mentioned product fulfill the oil requirements (dated 8.4.2011) for wind turbine gearboxes of Moventas Gears. Based on the technical data Moventas has approved Evonik Neste Oil Formulation 8175 to factory test in Jyväskylä factory and after accepted factory test to field test.

Moventas have to have follow up of field trial by oil analysis and by visual inspection report after feasible time in operation. Typically this is one year.
Report has to cover tooth and bearing contacts from helical and planetary stage as well general view inside the gear unit. There have to be also information of the bearing temperature and lubrication pressure under nominal conditions.

This approval is valid for the formula numbers of **8175**. The producer of the oil must guarantee that the properties of the oil are maintained worldwide within the tolerance limits. We ask you to immediately inform us if any changes to formulation of the oil are made.

This approval shall not be considered as a contractual document. This approval does not either mean that Moventas assumes any liability for these oils.

Moventas Gears Oy
10.12.2013

Jari Toikkanen
R&D Manager; Technology & Verification

Jaakko Marjamäki
Research Engineer, Verification

NUFLUX is used in the field in Germany since Q2 2013.

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Conclusion

NUFLUX Methacrylate Oligomer Synthetic baseoil (VISCOBASE 5-220) as an alternative to PAO based WTGOs:

- Higher **viscosity index** for better film thickness at high temperatures
- **Low viscosity at cold temperatures**
- Excellent **package solvation** → no need for esters
- Excellent **gear** and **bearing protection**
- **Superior gear efficiency** over PAO and Mineral Oil
- First **field experience** in Germany

- **Secure global availability** for Group III and Methacrylate Oligomer
- Compared to PAO/ester **very economic base oil concept**

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