CUSTOMER REPORT

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Analysis of field, bench and laboratory test results with the use of Nanol additive in the lubricating oil

Authors: Kenneth Holmberg, professor

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Report's title

Analysis of field, bench and laboratory test results with the use of Nanol additive in the lubricating oil

Customer, contact person, address	**Order reference**
Ab Nanol Technologies Oy Johan von Knorring Annankatu 9 A 11 00120 Helsinki	Johan von Knorring
Project name	**Project number/Short name**
Nanol lubrication	117728 / Nanol lubrication

Summary

Eleven field tests with ships, three field tests with trucks, single field tests at a power plant and with a race car in addition to four diesel engine bench tests and fifteen laboratory tribometer tests were analysed based on test reports and documentation received from Nanol Technologies. The tests were carried out during the period 2010–2017. The following can be concluded from the analysis. In the ship field tests was 4 % reduction in fuel consumption observed for middle size (1600–10000 kW) diesel engines and 1–2% reduction for larger (12600–15600 kW) engines with the use of 0.3% Nanol additive. In bench testing single observations showed a 4% reduction in friction, 0 and 3% reduction in fuel consumption and 1% increase in torque and power in diesel engines of various size (60–4000 kW) with the used of 0.3% Nanol. The laboratory tribotests showed in average 20% reduction in friction and 25% reduction in wear with 0.3–3% Nanol additive in the lubricating oil. Also 2–10 fold lifetime improvements with regard to pitting wear and white etching cracks were reported from single observations. No negative side effects influencing on engine reliability or efficiency has been observed

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Written by	**Reviewed by**	**Accepted by**
Kenneth Holmberg Principal Scientist, Professor	Helena Ronkainen Principal Scientist	Satu Tuurna Research Team Leader,

VTT's contact address

VTT, P.O.Box 1000, FI-02044 VTT

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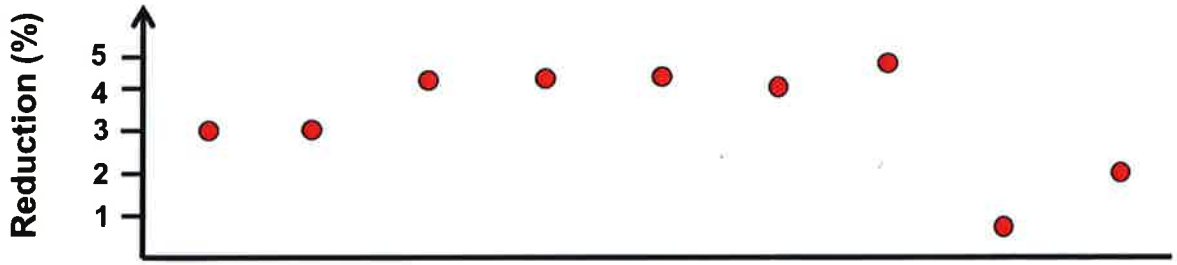
1. Introduction

Ab Nanol Technologies Oy develops and manufactures oil additives as a purpose to reduce friction and wear in machines, engines and devices. The Nanol additives are finely dispersed copper nanoparticles that are typically added as additive e.g. to engine oils. The structure and mechanisms of such additives has been described in literature recently by Scherge et al (1).

In this report are the results from 36 research reports analysed and summarised (2-33). The reports were provided by Nanol Technologies and they describe various field, bench and laboratory testing for investigation of the effect of lubrication with Nanol additive on the friction, wear and lifetime performance in engines and tribocontacts. The friction and other performance values presented in this report were taken or calculated from the measured data as presented in the reports and they represent the improvments in lubrication that have been observed in optimal running conditions. The used test methods are relevant for this purpose but assessment of the quality of the testing is beyond the scope of this work.

2. Field testing with ships, trucks, cars and at a power plant

Eleven field tests with ship diesel engines were reported. The impact on fuel consumption is showen in Figure 1. A reduction in fuel consumption of 4% was observed for middle size (1600–10000 kW) diesel engines and 1–2% reduction for larger (12600–15600 kW) engines with the use of 0.3% Nanol additive in the engine oil.



Engine power (kW)	1 600	1 600	1 800	2 400	2 800	8 400	10 000	12 600	15 600
Engine	Wärtsilä	Wärtsilä	Wärtsilä	Deutz	Pielstick	Wärtsilä	Wärtsilä	Wärtsilä	Wärtsilä
Running time (h)	1 200	1 000	3 500	4 000	3 500	12 000	250	600	2 300
Ship type	Cruise ferry	Car ferry	Passenger & car ferry	Cargo vessel	Ro-Ro vessel	Multipur-pose ship	Cruise ferry	Container ship	Ro-Ro vessel
Refe-rence code	FT-2013-2 Viking	FT-2015-4 Wärtsilä	FT-2016-8 Wärtsilä	FT-2012-3 Bore	FT-2010-1 Pielstick	FT-2016-5 Aila	FT-2013-2 Viking	FT-2017 Eniram	FT-2016-6 Napa

Figure 1. Reduction in fuel consumption by the use of Nanol as lubricant additive in ship diesel engine field tests.

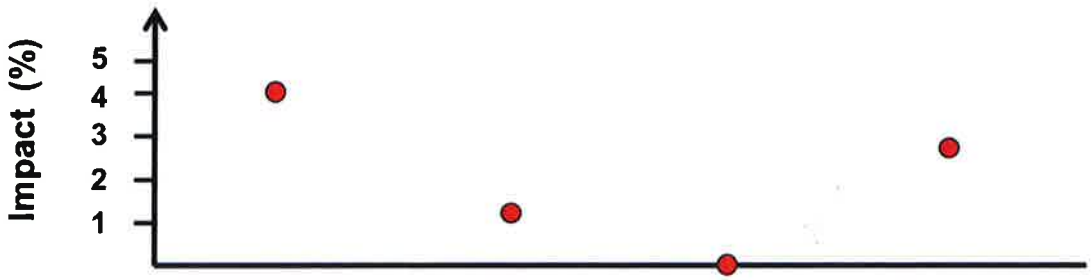
The following observations were also reported from field tests with ships, power plants, trucks and race cars:

- In one ship test 10% reduction in lubrication oil consumption was measured (FT-2011 Lillgard)
- In three power plants 2% reduction in fuel consumption and 2% reduction in heath rate was measured (FTP-2017 Nanol)

- In tests with two DAF trucks 4.3% reduction in fuel consumption was measured (FTT-Addinol)
- In tests with three trucks 38% reduction in lubricant oil consumption was measured at a change interval of 22,500 km (FTT-2011 Avelon)
- In tests with a race car 3% increase in power and torque was measured in acceleration tests with a Renault Megane (FTC-2015 Miller Oils).

3. Bench testing with diesel engines

Four bench tests with diesel engines were reported. The impact of Nanol lubrication on friction, fuel consumption, torque and power are shown in Figure 2. Single observation of 4% reduction in friction, 0 and 3% reduction in fuel consumption and 1% increase in torque and power were reported for various size (60–4000 kW) diesel engines with the use of 0.3% Nanol additive in the engine oil.

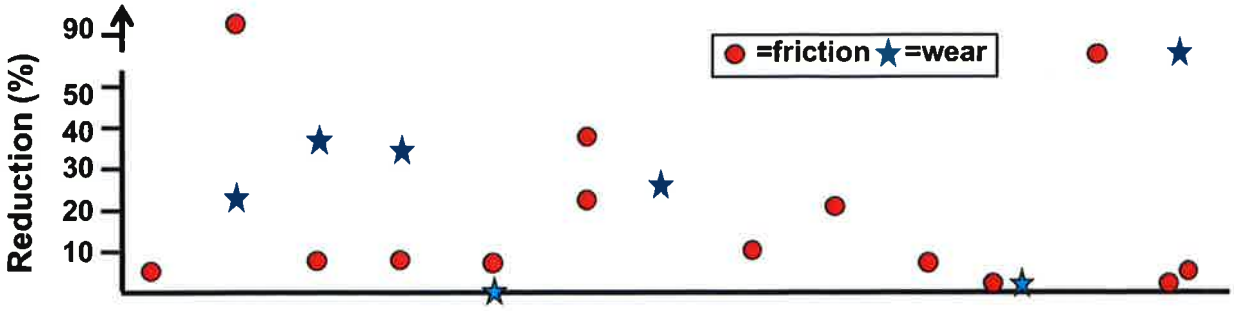


Impact on	friction reduction: - 4 %	torque and power increse: + 1 %	fuel consumption & bearing temperature: 0 %	fuel consumption reduction: - 2.8 %
Engine power (kW)	60	120	3480	4000
Engine	Research engine	Daimler	Wärtsilä	MTU
Engine type	One cylinder diesel engine	4 cylinder in-line gasoline engine	6 cylinder marine engine	8 cylinder
Reference code	BT-2014 FVTR	BT-2012 APL	BT-2016 Wärtsilä	BT-2016 Addinol

Figure 2. Impact of Nanol as lubricant additive on friction, fuel consumption and torque in diesel engine bench tests.

4. Laboratory testing with various tribometers

Fifteen laboratory tests have been carried out with a set of typical adequate test rigs and state-of-art tribometers with the following contact configurations: pin-on-disk, ball-on-disk, 4-ball, high frequency reciprocating, twin disk, roller trust bearing and piston ring vs cylinder. The Nanol additive content in the lubricant oil was in the rage of 0.3–3% and results are shown in Figure 3. In average there was 20% reduction in friction and 25% reduction in wear. There was no case of increase in friction or wear when using Nanol in the tests. In one test was no impact on wear measured and in another was the impact on friction and wear minor, only 1% or below. In several cases the results represent only sinle measuremants and no scatter information was available.



Lab test	Pin-on-disk	Pin-on-disk	Pin-on-disk	Pin-on-disk	Pin-on-disk	Ball-on-disk	4-ball	Twin-disk	Roller trust bearing	Pin-on-flat recipr.	HFRR	Piston ring vs cylinder	Piston ring vs cylinder
Contact pressure (Mpa)	(600 N)	25-45	45	5	1000	50-130& 600-1000		1000	1900 (8000 N)	(100 N)	(5 N)		60 & 90
Speed (m/s)	2	2	2	0.2	0.2	0.02		1.5 roll 10% slip	700 rpm	0.005 (15 mm/10 Hz)	0.04 ave (1 mm/ 20 Hz)		0.03 ave (1.44 mm/ 10 Hz)
Lub. mecha-nism	Mixed lub.	Mixed lub.	Mixed lub.	Bound . Smooth Ra=0.06	Boundar y lub.	Boundar y lubr.	Mixed lubr.	EHD 0-wear	EHD	Mixed lubr.	Mixed lub.	HD & BL lubr.	HD & BL lubr.
Nanol (%)	0.3	3	0.3	0.3	3	3	0.3	0.3	3	1	0.3	0.3	0.3
Refe-rence code	LT-2012 Fh	LT-2014 Fh	LT-2016a Fh	LT-2016a Fh	LT-2013 VTT	LT-2015 Fh	LT-2015 Millers/ Leeds U	LT-2013 VTT	LT-2015 Fh	LT-2016 Comp-any	LT-2015 Millers	LT-2015 Millers/ Leeds U	LT-2017 Fh

Figure 3. Reduction in friction and wear by the use of Nanol as lubricant additive in laboratory tests.

The following observations were also reported as single observations:

- More than twofold increase in pitting lifetime was observed in testing with axial roller bearings at 60 kN load, 750 rpm rotational speed and with 3% Nanol additive (LT-2014 KT Mannheim)
- More than tenfold increase in lifetime with regard to white etching cracks was observed at roller bearing testing with 60 kN load, 750 rpm rotational speed and with 3 % Nanol additive (LT-2014 FAG).

The laboratory testing has been carried out in various conditions in the following test parameter ranges:

- temperature range: 40–140 °C
- with Nanol content: 0.1–5%, (rec. 0.3–3%)
- loading pressure rage: 2.5–1900 MPa
- speed range: 0.0001–2.5 m/s
- surface roughness: 0.06–0.23 µm Ra.

5. Conclusions

The results from the thirty-six test reports analysed show that in close to all test was a positive effect as friction and wear reduction observed with the addition of Nanol additive to the lubricant oil. Only in one case was no effect reported and in two was the effect very minor, only 1% or below. In field testing with ships was the reduction in fuel consumption 4% for smaller diesel engines and 1–2% for larger. In bench testing single observations as 4% reduction in friction and 1–3% reduction in fuel consumption were reported. The laboratory tribotesting showed in average 20% reduction in friction and 25% reduction in wear. No negative side effects influencing on engine reliability or efficiency has been reported.

References

1. Scherge M, Böttcher R, Linsler D, Kurten D, Multi-phase friction and wear reduction by copper nanoparticles. Lubricants 4(2016)36, 1-13.

2. FT-2010-1 Pielstick Ro-ro

3. FT-2011 Lillgard

4. FT-2012-2 Bore

5. FT-2013-2 Viking

6. FT-2015-4 Wärtsilä car ferry

7. FT-2016-5 Wärtsilä multipurpose vessel

8. FT-2016-8 Wärtsilä ferry

9. FT-2016-6 NAPA

10. FT-2016 Seagard

11. FT-2017 Seagard

12. FT-2017 Eniram

13.FT-2017 Langh Ship

14. FTP-2017 Nanol

15. FTT-2011 Avelon

16. FTT-2016 Addinol

17. FTC-2015 Miller oil

18. BT-2012 APL

19. BT-2014 FVTR

20. BT-2016 Addinol

21. BT-2016 Wärtsilä

22. LT-2012 Fh

23. LT-2013 VTT

24. LT-2014 Fh

25. LT-2014 FAG

26. LT-2014 KT Mannheim

27. LT-2015 Fh

28. LT-2015 Millers oils / Leeds U

29. LT2015 Millers

30. LT-2016a,b Fh

31. LT-2016 Company

32. LT-2017 Fh

33. LA – DOW

Abbreviation key: A = analysis, B = bench, C = car, F = field, L = laboratory, P = power plant, T = truck