

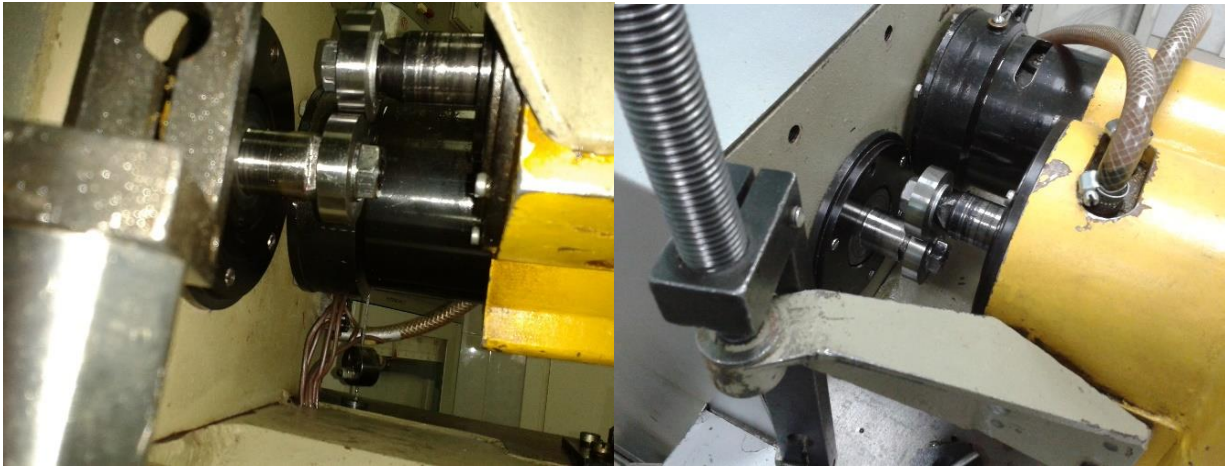
REPORT No. 3 dated 18.11.2016

Tests of SUPROTEC Tribotechnical Compounds on II-5018 Friction Machine

Tests of SUPROTEC tribotechnical compounds in LUKOIL LUX lubrication oil SAE 10W-40 were carried out on a II5018 friction machine by comparing tribotechnical characteristics. Test No. 1 - TC SUPROTEC, Batch 451. Test No. 2 - TC SUPROTEC, Batch 452. Test No. 3 - LUKOIL LUX oil, 10W-40.

The tests were performed in the presence of Yu.V. Shumlyansky, chief specialist of Federal Autonomous Institution "Russian Maritime Register of Shipping" Main Administration, Department for Certification of Management Systems, Products and Services.

Test pattern: - "disk on disk" (moving disk - $d=50$. $h=12$. fixed disk - $d=50$. $h=10$), lubrication is carried out by splashing by the moving sample (immersed in oil by 1-2 cm).



Samples were run in on "clean" LUKOIL LUX 10W-40 oil, the SUPROTEC material was added for 30 thous. cycles (30 minutes) of tests. Subsequently, tests continued until 100 thous. cycles (70 minutes more).

Sample and countersample material: 30KhGSA steel (tempered, ground $Ra=0.5-1 \mu\text{m}$)

Operation mode: - $n=1100 \text{ min}^{-1}$ ($V= 2.88 \text{ m/s}$), Load $P = 150 \text{ N}$;

Registered parameters:

- frictional resistance moment $M \text{ (N*m)}$;
- oil temperature in the chamber $T \text{ (}^\circ\text{C)}$;
- number of cycles N .

The wear of the sample (bottom disc - Δm_o) was determined by weighing it before and after tests on electronic analytical scales AB210M-01A accurate within 0.1 mg. The kinematic diagram of the friction machine is presented in Figure 1.

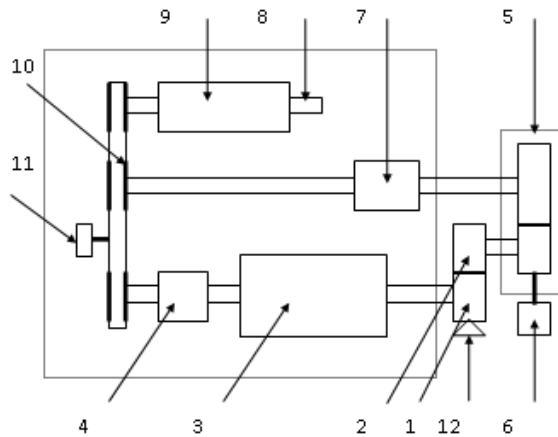


Figure 1 Kinematic Diagram of II-5018 Friction Machine
 1 - sample; 2 - countersample; 3 - spindle; 4 - torque sensor; 5 - carriage;
 6 - load sensor; 7- clutch; 8 - rotation velocity sensor; 9 - electric motor;
 10 - belt transmission; 11 - cycle sensor; 12 - temperature sensor.

The results of the tests are presented in Table 1 and in Figures 2-4.

Table 1. Tribotechnical Characteristics of Compounds.

№	Grease	Average Cfr Value	Average Cfr Reduction, %	Average T Value, °C	Temp. Reduction, Final, %	Sample Wear, mg
1	Tests date: 17.11.2016	0.082	26.1	47.0	12.1	0.9
2	Tests date: 18.11.2016	0.066	46.9	44.5	36.6	0.7
3	"clean" oil	0.096	7.1	59.5	-21.3	0.7

Av. Cfr reduction, % - average friction coefficient value referred to friction coefficient after 30 minutes' running in;

Temp. reduction final, %- oil temperature value at the end of the tests referred to the sample temperature after 30 minutes' running in.

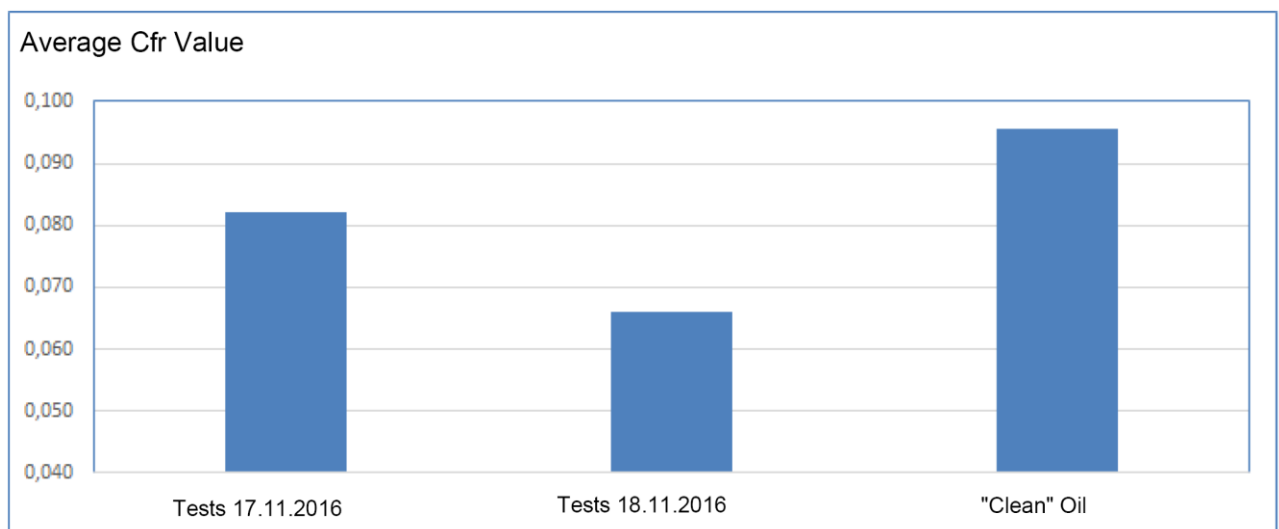
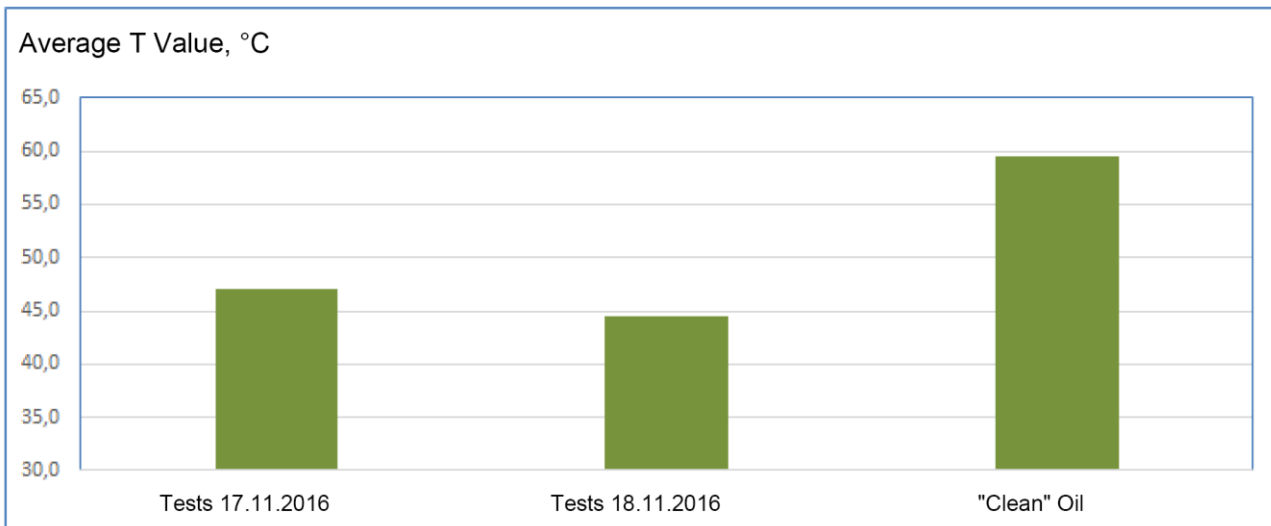


Figure 2 Average Cfr values



Average 3 Average sample temperature values.

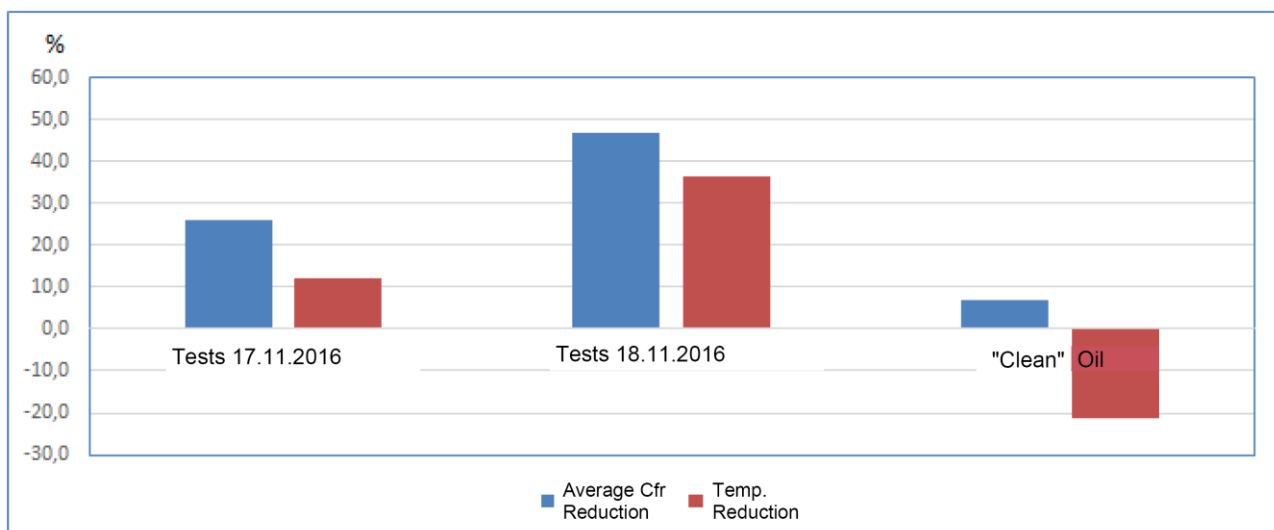


Figure 4 Average friction coefficient and sample temperature reduction.

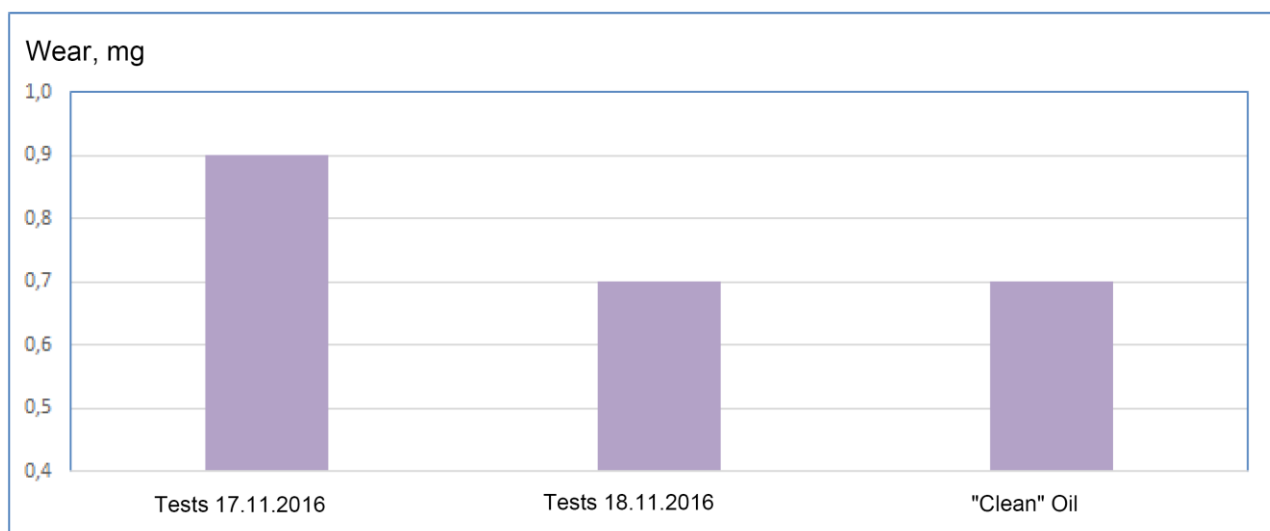


Figure 5 Sample wear.

The results of the tests are shown in Table 2.

Table 2. Friction coefficient and oil temperature dynamics

Test	N, thous. cycles	0	5	10	20	30	32	40	50	60	70	80	90	100
№1	Cfr.	0.065	0.068	0.088	0.11	0.084	0.091	0.081	0.071	0.081	0.081	0.071	0.091	0.065
	T, °C	22.7	41	50.4	55.4	50.8	51.9	51.4	48.7	47.6	48.4	46.7	48.7	22.7
№2	Cfr.	0.078	0.084	0.084	0.104	0.078	0.078	0.065	0.045	0.049	0.042	0.042	0.042	0.078
	T, °C	22.1	36.1	53.1	58.8	52.8	53.2	49	46.3	43.7	42	39.4	37.3	22.1
№3	Cfr.	0.085	0.079	0.097	0.105	0.068	0.091	0.097	0.091	0.11	0.11	0.091	0.122	0.085
	T, °C	31.68	43.02	53.28	59.58	60.48	59.52	64.16	65.0	66.3	68.25	70.5	72.3	31.68

The dynamics of samples friction coefficient and temperature is presented in Figures 6 and 7.

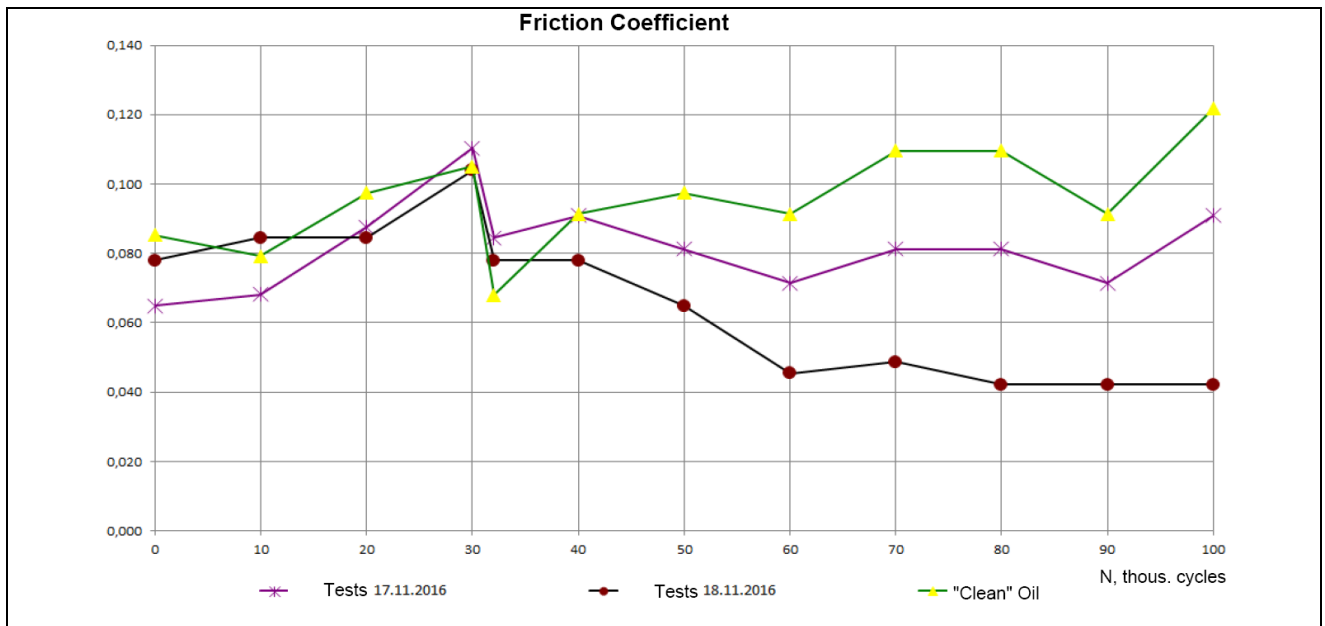


Figure 6 Friction coefficient dynamics.

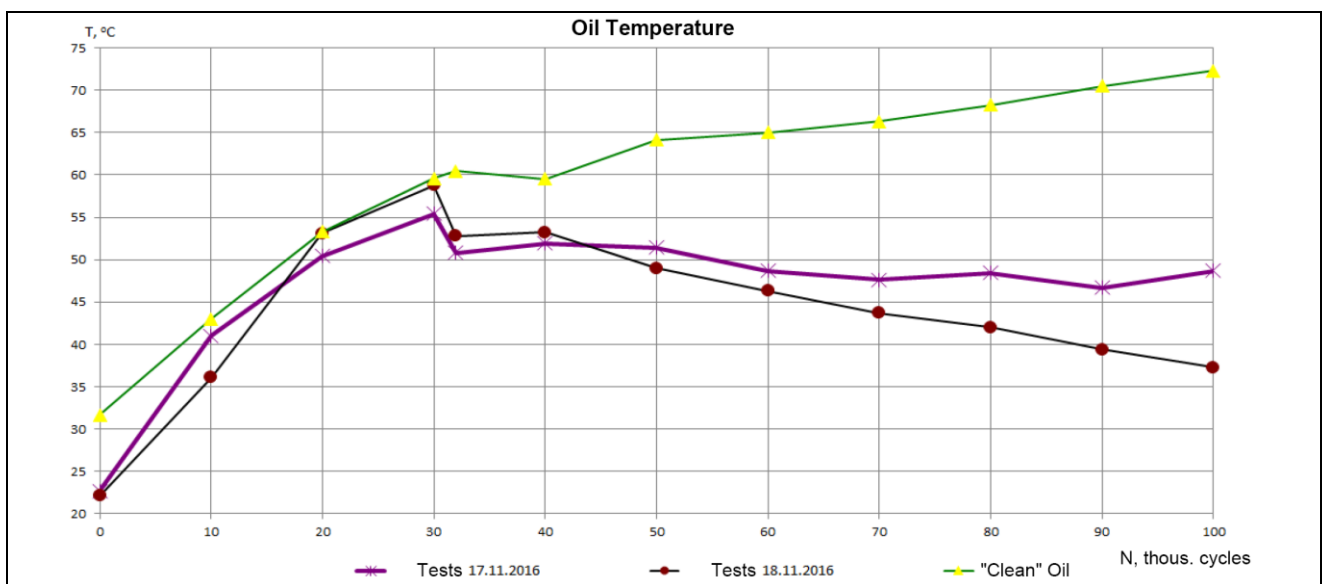


Figure 7 Sample temperature dynamics.

Visual analysis of friction surfaces before and after the tests was performed on a LaboMet-1 metallographic microscope. Photos of the surfaces taken with x500 magnification are presented in Figure 8.

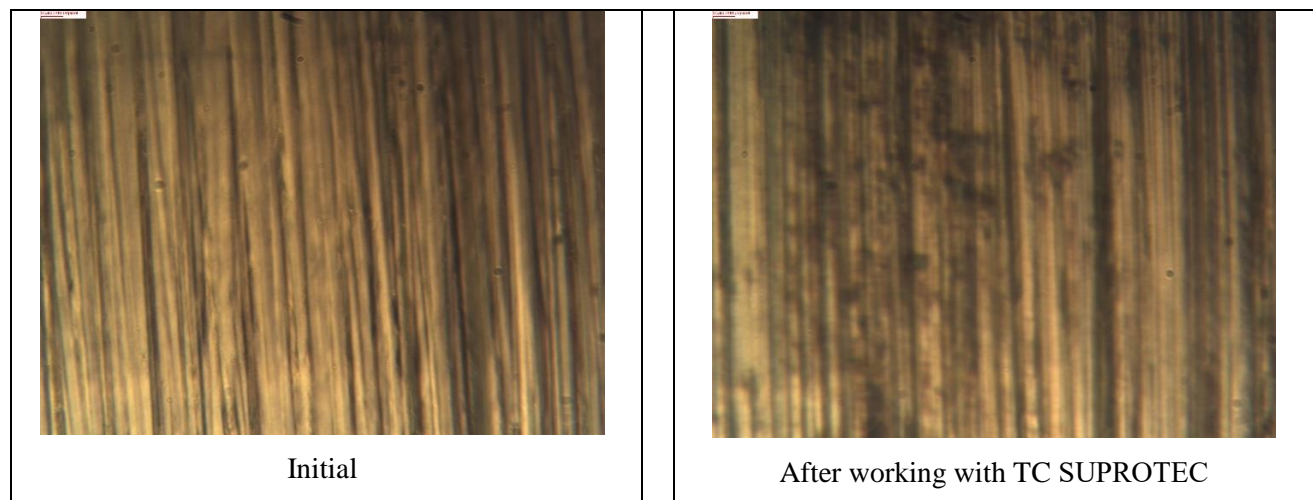


Figure 8 Photos of friction samples

Analysis of roughness of the initial (polished) sample and the sample after 2 hours of work with TC SUPROTEC with the help of a MarSurf PS1 profile meter. Profilograms and the Abbot curve are presented in Appendix 1. Profile analysis demonstrates reduction of roughness indicators from 0.678 to 0.433. Rz from 4.26 to 2.6. and increase of v_0 from 0.003 to 0.009. This gives evidence of increased smoothness level and increased oil-retaining ability of friction surfaces.

CONCLUSIONS:

Control tests of SUPROTEC materials have demonstrated conformity of protective layer formation parameters to the requirements the norms of friction coefficient reduction (more than 20%), oil temperature (more than 5%) in the chamber and wear (less than 2 mg).

Admit a batch of SUPROTEC materials to the production of SUPROTEC Lubrication Composition.

For LLC NTPK SUPROTEC

Head of R&D Department
LLC NTPK SUPROTEC

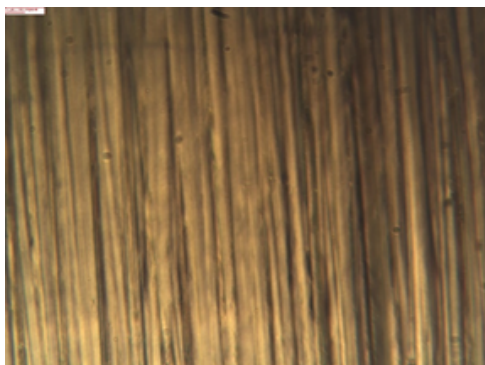
Yu.G. Lavrov
November 18. 2016

**For the Main Administration of
Federal Autonomous Institution "Russian
Maritime Register of Shipping"**

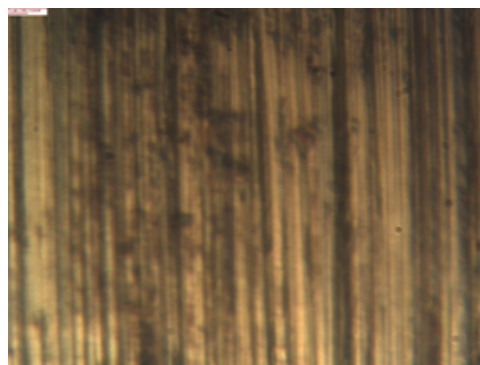
Chief specialist of the Department For Certification
of Management Systems, Products and Services

Yu.V. Shumlyansky
November 18. 2016

Визуальный анализ поверхностей трения до и после испытаний проводился на металлографическом микроскопе ЛабоМет-1. Фото поверхностей с увеличением x500, представлены на рисунке 8.



Исходный



После работы с ТС «СУПРОТЕК»

Рисунок 8 Фото образцов трения.

Анализ шероховатости исходного (полированного) образца и образца после 2 часов работы с ТС «СУПРОТЕК» с помощью профилометра «MarSurf PS1». Профилограммы и кривая Абота представлены в приложении 1. Анализ профиля показывает снижение показателей шероховатости Ra с 0,678 до 0,433, Rz с 4,26 до 2,62 и увеличение v_0 с 0,003 до 0,009. Что свидетельствует о повышении уровня чистоты и увеличении маслоудерживающей способности поверхностей трения.

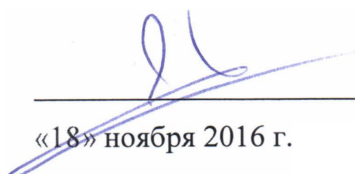
ВЫВОДЫ:

Контрольные испытания материала СУПРОТЕК показали соответствие параметров формирования защитного слоя требованиям норм снижения коэффициента трения (более 20 %), температуры масла (более 5 %) в камере и износа (менее 2 мг).


Партию материала СУПРОТЕК допустить к производству Смазочной композиции «СУПРОТЕК»

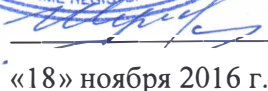
От ООО «НПТК «СУПРОТЕК»

Начальник департамента НТР
ООО «НПТК «СУПРОТЕК»


Лавров Ю.Г.
«18» ноября 2016 г.

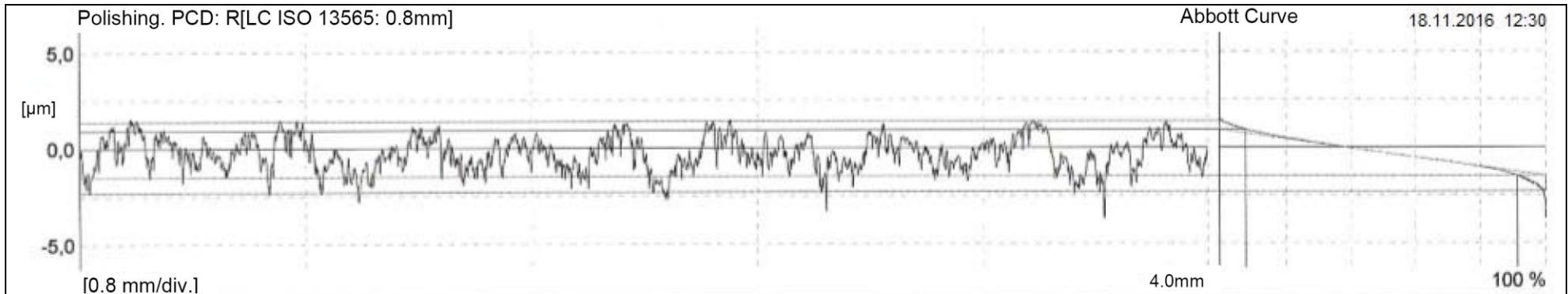
От Главного управления
ФАУ «Российский морской регистр


судоходства)
Главный специалист отдела
сертификации систем менеджмента,
продукции и услуг


Шумлянский Ю.В.
«18» ноября 2016 г.

	Mahr GmbH	PS1 Explorer
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Object: Number: Comment:	Lt: 5.60 mm Ls: 2.5 µm VB: 350 µm Vt: 0.50 mm/s References: 11200 Gauge: PHT 350
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Ra	0.678 µm	Rq	0.828 µm	Rz	4.26 µm
Rzj	2.44 µm	Rmax	5.00 µm	Rp	1.67 µm
Rpm	1.83 µm	Rpk	0.46 µm	Rk	2.43 µm
Rvk	0.81 µm	Mr1	7.91 %	Mr2	91.4 %
A1	18.02 µm ² /mm	A2	34.8 µm ² /mm	Vo	0.003 mm ³ /µm ²
Rt	5.07 µm	R3z	3.17 µm	RPc (0.5; -5.0)	70 /sm
Rmr1 (-1.0; 5.0)	35.0 %	Rmr2 (-2.0; 5.0)	76.0 %	Rmr3 (-3.0; 5.0)	98.0 %
RSm	116 µm	RSk	-0.023	S	22 µm
CR (5.0; 15.0)	0.46 µm	CF (20.0; 80.0)	1.48 µm	CL (85.0; 98.0)	0.84 µm
R	2.23 µm	Ar	127 µm	Rx	5.4 µm

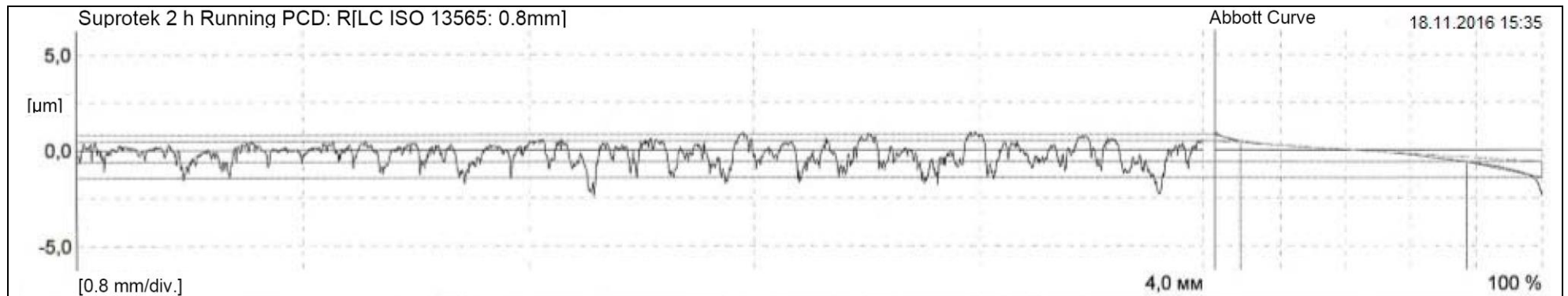


Mahr GmbH

PS1
Explorer

Object:
Number:
Comment:

Lt: 5.60 mm
Ls: 2.5 µm
VB: 350 µm
Vt: 0.50 mm/s
References: 11200
Gauge: PHT 350



Ra	0.433 µm	Rq	0.550 µm	Rz	2.62 µm
Rz]	1.53 µm	Rmax	3.27 µm	Rp	0.91 µm
Rpm	1.21 µm	Rpk	0.34 µm	Rk	1.11 µm
Rvk	0.83 µm	Mr1	7.55 %	Mr2	77.8 %
A1	12.75 µm ² /mm	A2	93 µm ² /mm	Vo	0.009 mm ³ /µm ²
Rt	3.31 µm	R3z	1.97 µm	RPc (0.5; -5.0)	50 /sm
Rmr1 (-1.0; 5.0)	68.0 %	Rmr2 (-2.0; 5.0)	97.0 %	Rmr3 (-3.0; 5.0)	100.0 %
RSm	116 µm	RSk	-0.702	S	35 µm
CR (5.0; 15.0)	0.28 µm	CF (20.0; 80.0)	0.89 µm	CL (85.0; 98.0)	0.70 µm
R	1.53 µm	Ar	193 µm	Rx	3.2 µm