

TRIBOTECHNICAL DIAGNOSTICS - ENGINE OIL (MO) CHARACTERISTICS CONTROL MOGUL DIESEL DT SAE 20W50 T-72

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Abstract: This work is performed by tribotechnical diagnostics, specifically by checking the properties of motor oil type Mogul Diesel DT SAE 20W-50 used in heavy combat equipment, such as the T-72M1 tank. The work consists of expressing basic knowledge about measuring devices, which were used in the measurements and their properties and their operation. The work also contains basic knowledge about the measured liquid, which is a necessary aspect for the possibility of performing measurements. The practical part of this work consists of measurements and more detailed specification of oil properties and monitoring of its gradual degradation with the help of individual measuring instruments. All measurements were performed in the diagnostics laboratory of the Department of Mechanical Engineering at the Armed Forces Academy of General Milan Rastislav Štefánik (hereinafter, „AFA”) in Liptovský Mikuláš.

Keywords: Engine oil; ACEA; API; SAE; Analysis; Properties; Viscosity; Kinematics; T-72M1; Sample; Measuring instrument.

1 INTRODUCTION

The measurement of engine oil properties was performed on engine oil from a vehicle that belongs to the series of the Armed Forces of the Slovak Republic, the vehicle is a Tank T-72M. The measurements were performed at the Department of Mechanical Engineering in the AFA Tribodiagnosics Laboratory, where we used three different measuring instruments to measure the properties. A device known as FerroCheck 2000 was used to measure the Ferroparticle content, SpectroVisc-Q3050 on the kinematic properties and FluidScan Q1000 was used to measure the oil content properties.

The measurements performed were carried out in accordance with the rules and safety principles, which are short work at these facilities. After the measurement, we evaluated the results and compared them with the parameters of the reference sample.

2 MEANS OF MEASUREMENT MO-MOGUL SAE 20W50 IN THE LABORATORY OF TRIBODIAGNOSTICS AFA AND THE MEASURED BUILDING T-72

The measurements were performed in the laboratory of tribodiagnosics in the AFA, the laboratory of tribodiagnosics is equipped with various means suitable for performing various measurements to determine the properties of motor oils.

The instruments used include the SpectroVisc Q3050, Spectro Q1000 Fluidscan, Spectrocube, Ferrograph, ferrocheck and many other instruments and equipment for performing scientific activities within AFA and the surrounding area.



Fig. 1 Laboratory of tribodiagnosics, AFA
Source: authors.



Fig. 2 Tribodiagnostic Laboratory - SpectroVisc Q3050-blue, Spectro Q1000 Fluidscan-yellow
Source: authors.



Fig. 3 T-72M1
Source: authors.



Fig. 4 SpectroVisc Q3050, FerroCheck 200 and Spectro Q1000 (right)
Source: authors.

3 ENGINE OIL MOGUL SAE 20W50

Mogul Diesel DT 20W-50 is a year-round engine oil of very high performance. It is made from high-quality, low-evaporation petroleum base oils obtained by modern hydrogenation technology and state-of-the-art refining additives such as oxidation and corrosion inhibitors or detergent dispersants. As already mentioned, this oil is intended mainly for year-round lubrication of highly strained diesel engines, whether trucks, buses, or heavy vehicles of the Armed Forces, such as T-72 tanks. This oil is also used in cases where a fuel with a higher sulphur content is used, as it effectively suppresses the formation of wear, corrosion and high-temperature deposits. It allows strict emission limits to be met and guarantees very long exchange periods.

Reducing scale formation and maximizing engine response.

Advantages of MO MOGUL SAE 20W50:

- ensures perfect lubrication of modern, highly loaded engines,
- is a guarantee of trouble-free year-round operation,
- ensures good start ability at low temperatures,
- prevents the formation of high-temperature deposits and low-temperature turbidity and keeps the engine clean,
- has excellent antioxidant properties guaranteeing long life of the oil,
- perfectly protects the internal parts of the engine against corrosion,
- extends the oil change period,
- is a guarantee of compliance with strict emission limits.

Performance characteristics of Mogul SAE 20W50 oil:

- ACEA E2,
- MB 228.1,
- MAN 271,
- VOLVO VDS.



Fig. 5 MO Mogul Diesel DT SAE 20W-50
Source: authors.

Characteristic Parameters:

Tab. 1 Parameters of Mogul Diesel DT SAE 20W-50 oil

Parameter	Unit	Value
Kinematic viscosity at 100 ° C	[cSt]	18,5
Kinematic viscosity at 40 ° C	[cSt]	164
Viscosity index	-	130
Flash point ° C	[°C]	238
Melting point ° C	[°C]	-24
TBN	[Mg KOH/g]	9,4

Source: authors.

3.1 Storage of Mogul Diesel DT SAE 20W-50

Store in tightly closed containers in places protected from rain, dust, high temperatures and other weather conditions. The maximum storage temperature is 40 ° C. Protect against water ingress and ensure that markings on storage containers are not removed. Do not store the product above 60 ° C, do not expose it to direct sunlight and frost.

Oil sampling from tank T-72M1



Fig. 6 Tank T-72 M1
Source: authors.



Fig. 7 Oil sampling from MAF cleaner
Source: authors.



Fig. 8 Method of oil sampling
Source: authors.

3.2 Requirements for serviceability and evaluation of engine oil parameters

- Appearance (comparison of clarity, gloss, odor and turbidity).
- Determine whether it satisfies according to its own methodology (practical and professional experience). Do not allow turbidity - matt surface with light reflection.
- Kinematic viscosity (primary and basic property for the usability of engine oil in the vehicle engine)
- Engine oil may only be operated within a viscosity range of $\pm 20\%$ of the reference sample and diesel engine manufacturer's data
- Viscosity index - dependence of oil fluidity on temperature. The degree of viscosity index determines the guarantee of sufficient lubrication under operating conditions.

4 ANALYZER FERROCHECK 2000

FerroCheck 2000 is a portable benchtop analyser designed to help reduce costly vehicle and equipment failures by monitoring iron particles in all lubricating oils.

The core of FerroCheck is a pair of precise rounded coils that generate magnetic fields when powered. When a small amount of oil is introduced into one of the coils, ferroparticles such as iron, nickel and cobalt interact with the magnetic field, thus changing the current in the coils.

The magnitude of the current change is proportional to the amount of ferroparticles calibrated by weight in ppm per oil and lubricant.



Fig. 9 FerroCheck 2000 measuring device
Source: authors.



Fig. 10 Discharge pipette for sampling
Source: authors.

to the subsequent sample preparation. Remove the mixed oil from the container and then fill the tube with it along the filling line, then close the tube and mix the slightly again.

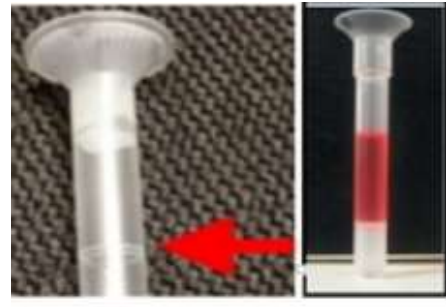


Fig. 11 Oil sample tube
Source: authors.

4.1 Using of FerroCheck 2000

Before using the FerroCheck 2000 analyser, it is necessary to prepare a sample of the used oil, which will then be subjected to the measurement itself. In the first step, we must make sure that the particles are not at the bottom of the container from which the sample will be taken, this will be ensured by its precise mixing in a circular motion. Once we have made sure that the metal particles do not settle to the bottom of the container, we can proceed

After these operations, the measurement itself can begin, after starting the instrument and starting the measurement, we insert the sample only when prompted at 15 % of the scheduled measurement time, while holding the tube above the opening of the device until prompted. After the time has elapsed, the sample is released into the hole and removed from the device at 60 % of the measuring.



Fig. 12 Method of loading the sample into the FerroCheck 2000 device
Source: authors.

Sample ID	Result	Date	T
516	516	Mar 1, 2022	12:01
413	413	Mar 1, 2022	11:56
573	573	Mar 1, 2022	11:57
434	434	Mar 1, 2022	11:55
395	395	Mar 1, 2022	11:54

Formatted CSV

Fig. 13 Display with our measured values
Source: authors.

Following the completion of the measurement, we read the results of the amount of Ferroparticles from the device display, which we report in ppm (1 ppm =

0.0001 %). The following limitation was set for Ferroparticles for the assessment of motor oils:

Tab. 2 Limitations of content of Ferroparticles

Limitation	Amount of Ferro particles [ppm]
Occurrence of Ferroparticles	0-30
Increased amount of Ferroparticles	30-70
Risk amount of Ferroparticles	70-100
Intolerable amount of Ferroparticles	101 and more

Source: authors.

Tab. 3 Table of measured values

Parameter	1. Measurement	2. Measurement	3. Measurement	4. Measurement	5. Measurement	Average value
Ferroparticles (Fe,Co,Ni) [ppm]	395	434	573	413	516	466,2

Source: authors.

According to the average of the measured values of ferroparticles in Mogul Diesel DT SAE 20W-50 oil, it can be concluded that this used oil contains an intolerable amount of ferroparticles and is therefore not operational.

5 MEASUREMENT OF PROPERTIES OF MO-MOGUL DIESEL DT SAE 20W-50 ON SPECTROVISC Q3000

The SpectroVisc Q3000 Series Viscometer is a portable device used to measure the kinematic viscosity of oils and other lubricating fluids. To perform the measurement, a small sample of oil is placed on two metal surfaces, which, after closing them, form a tunnel and the sample flows to the bottom of the tunnel by microchannel. The sensor detects the flow rate across the cell and the device automatically calculates the kinematic viscosity value.

Before starting the measurement, it is necessary to thoroughly clean the test area of any residues of other oils or impurities that would adversely affect the measurement results.

The next step is to apply the oil sample itself to the test area of the instrument using a disposable or discharge pipette.

However, as with FerroCheck, it is necessary to mix the sample precisely here, after mixing and taking the sample into the pipette, we apply the tested oil to the pouring tunnel at a reasonable speed, taking care that the oil does not escape outside the channel.



Fig. 14 Discharge pipette
Source: authors.



Fig. 15 Testing area of SpectroVisc Q3000
Source: authors.

5.1 Measurement

To measure the kinematic viscosity, we prepared a used sample of SAE 20W-50 oil, which we then compared with pre-measured values of the reference sample. Before starting the measurement, we thoroughly cleaned the test surface of the instrument according to the required procedure and took a suitable amount of oil sample into a disposable pipette, which we applied to the viscometer channel after the instrument prompt, after which we started measuring the kinematic viscosity on the device.

After displaying the measurement results on the screen of the device, we wrote down the given values and repeated the measurement twice more, we built a table from the recorded values as the next step.



Fig. 16 Application of oil sample
Source: authors.

Table 4 Measurements results of kinematic properties

Parameter	Unit	Reference sample SAE 20W-50	SAE 20W-50 test sample Measurement No.1	SAE 20W-50 test sample Measurement No.2	SAE 20W-50 test sample Measurement No.2	Arithmetic mean SAE 20W-50 test sample
Kinematic viscosity at 40 ° C	[cSt]	+20% 196,8 164 -20% 131,2	150 -8,54% -14	155 -5,5% -9	94,7 -42,26% -69,3	133,23 -28,77% -30,78
Kinematic viscosity 100 ° C	[cSt]	+20% 22,2 18,5 -20% 14,8	18,2 -1,63% -0,3	18,6 +0,54% +0,1	13,1 -29,19% -5,4	16,63 -10,11% -1,87
Viscosity index	-	130	-	-	-	-

Source: authors.

5.2 Measurement evaluation MO-Mogul Diesel DT SAE 20W-50

Reference sample No.R AFA

Kinematic viscosity at 40 ° C: COMPLIES [164 cSt. ± 20 % <131.2 cSt; 196.8 cSt>].

Kinematic viscosity at 100 ° C: COMPLIES [18.5 cSt. ± 20 % <14.8 cSt; 22.2 cSt>].

Used Sample MO-Mogul Diesel DT SAE 20W-50

Mileage since production 1,684 km

Mileage since MO exchange: 371 km

The oil was taken from the MAF body cleaner on 09.09.2020

Satisfactory book viscosity / 40 ° C: 133.23 [cSt], MO viscosity reduction is 30.78 [cSt] - Mo viscosity reduction by 28.77 [%]. The allowable tolerance is derived from a reference sample [164 cSt. ± 20 % <131.2 cSt; 196.8 cSt>]

COMPLIANT kinematic viscosity / 100 ° C: 18.5 [cSt],

MO viscosity reduction is 1.87 [cSt] - MO viscosity reduction is -10.11 % [%]. The allowable tolerance is

derived from a reference sample [18.5 cSt. ± 20 % <14.8 cSt; 22.2 cSt>]

6 MEASUREMENT OF OIL PROPERTIES USING THE SPECTRO Q 1000 FLUIDSCAN

FluidScan measures the oil absorption spectrum in the mean IR range from 2.5 µm to 12 µm. To measure oil, diffraction is used, which uses an optical grating with a detector for better accuracy and durability. The patented switching top cell uses one drop of oil or a grease stain, does not take more than a minute to clean and does not require any chemicals or solvents. There is an integrated database of active information and pre-set alarm limits using the colour system for operation to ensure that relevant personnel can make decisions as soon as the measurement is made. FluidScan has algorithms for many of the world's most common types of lubricants. These algorithms provide calibration for most types of lubricants, so you do not need to physically measure a fluid sample to provide a basis for comparative analysis.



Fig. 17 Spectro Q 1000 Fluidscan
Source: author.

At the beginning of the measurement on this device using a clean pipette, place a drop of oil on the lower half of the glass of the test cells until it is properly blurred. Then we close the cell. To close the cell, fold the upper half of the cell until the lower half remains and release the magnets to close the magnets, then return the test cell to the drawer after this step and press the OK button to start measuring the sample. Based on the configured settings, the results will be displayed on the device screen when the measurement is completed.

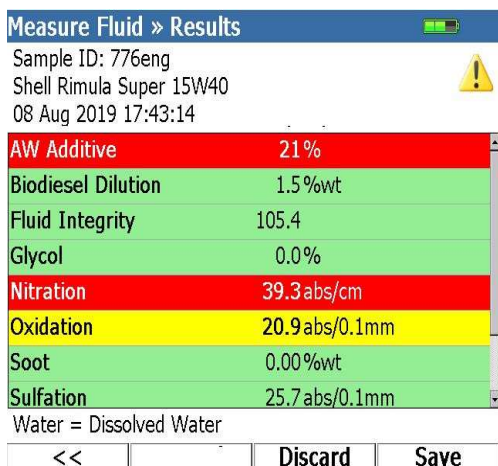


Fig. 18 Display of Spectro Q 1000 Fluidscan
Source: author.

Table 5 Results of Measurement

Parameter	Unit	Reference sample SAE 20W-50	SAE 20W-50 test sample Measurement
TBN	[mg KOH/g]	7,0	7,4 (+0,4)
carbon black	[% w/t]	0,0	0
Oxidation	[abs/01]	11,2	12 (+0,8)
Nitritation	[abs/cm]	-	-
Sulfation	[abs/01]	16,6	18 (+1,4)
Glykcols	[%]	0,0	0
Water content additive	[ppm]	339	902 (+563)
	[%]	100	108 (+8)

Source: authors.

6.1 Measurement

After following the procedures according to the device manual, the screen provided us with the measurement results, which we then entered the table.

- Alkalinity number (TBN) [mg KOH / g] / 7.4 / increase over R-AOS by 0.4 [mg KOH] not to allow engine oil operation when the TBN value decreases by more than 50% of the reference sample value. COMPLIES.
- Set [% w / t] / 0 / increase compared to R-AOS by 0 [% w / t] / maximum value is up to 2% w / t. COMPLIES.
- Oxidation [abs / 01] / 11.2 / increase compared to R-AOS by 0.8 [abs / 01] / do not allow MO operation when the value of antioxidant content decreases by more than 50% of the value of the reference sample. COMPLIES.
- Nitration-Nitridation [abs / cm] / xx / was not measured.
- Sulfation [abs / 01] / 18, an increase of 1.4 [abs / 01] / these processes in motor oil. They cause the decomposition of the components of the base oil and additives; the trigger is the presence of water in the MO - it is monitored in proportion to the presence of water
- Water content [ppm] / 902 / the reference sample was contaminated with water +563 ppm / monitored and the limit values of water content in motor oil are: 0.5% w / w / 5,000 ppm (risk factors are already concentrations 0.1 - 0 , 3% w / w / 1,000-3,000 ppm) / DOES NOT COMPLIES .
- Glycols [%] (0.0) same as R-AOS / The presence of glycols in the engine oil is not permitted. COMPLIES
- Addivation [%] / 108 / increase compared to R-AOS by 8 [%], (unknown additive added) / do not allow operation of engine oil when the value of total additive decreases by more than 50% / COMPLIES.

7 OVERALL EVALUATION OF THE MEASURED SAMPLE MO-MOGUL DIESEL DT SAE 20W-50 USED SAMPLE THE MEASURED VALUES IN THE TRIBODIAGNOSTICS LABORATORY

The measured values in the tribodiagnosics laboratory showed that the tested oil is NOT SUITABLE the requirements, mainly due to the high content of ferroparticles and the amount of water. The total sample of MO-Mogul Diesel DT SAE 20W-50 must therefore be considered NOT SUITABLE for further operation.

8 CONCLUSION

In this work, I approached the basic properties, characteristics and parameters of motor oil Mogul Diesel DT SAE 20W-50 used in heavy machinery OS SR, such as Tank T-72M1. At the Department of Mechanical Engineering at the Academy of the Armed Forces, General: Štefánik in Liptovský Mikuláš, based on the knowledge gained so far in the field of tribodiagnosics, we subjected this oil to closer observation and research. A sample of this type of oil was examined in comparison with its reference sample. We subjected the oil to a closer examination of its kinematic properties, viscosity properties as well as its ferroparticle content. We have created tables for comparing the measured values in comparison with the reference sample for a simpler idea of the change in its properties as a result of its use. We drew partial conclusions from the measured results, which helped us to determine the ability of the used sample for further operation, while the results showed that the used oil Mogul Diesel DT SAE 20W-50 does not meet the standards and norms for its further use and replacement of this engine oil is necessary.

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