

## TESTING THE REPLACEMENT OF TOTAL AND MOBIL PLASTIC LUBRICANTS WITH MAPU-1 AND MAKN-2 LUBRICANTS

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**Abstract:** Solution of the replacement of plastic lubricants of the Mobil-NLGI 00 type (to the PSU-planetary directional device) and Total-NLGI 0 (to the KP-final gear) for the MAPU-1 (in PSU) and MAKN-2 (in KP) lubricants. The design of plastic lubricants was performed in cooperation with Armed Forces Academy of General Milan Rastislav Štefánik represented by Ing. Miroslav Marko, PhD. and CMAŠ ZZ II Žilina, represented by Ing. Stanislav Kolomazník within the Project VV-1/2018 to 2020. Testing of PM (plastic lubricants) was performed on a special vehicle type GM 578. After changing MAPU-1 and MAKN-2 lubricants for PM (NLGI 00 and 0) and running 197 km was carried out "1. Check collection". Further inspections will follow in the next period. On behalf of Armed Forces Academy of General Milan Rastislav Štefánik, Major was also actively involved in tribodiagnostics Ing. Vladimír Kadlub and Capt. Ing. Pavol Lukášik.

**Keywords:** PSU-Planetary directional device; KP-Final transfer; PM-Lubricants; NLGI-Lubricant penetration scale, which is standardized in ISO 6743/9, resp. in STN ISO 65 6901.

### 1 INTRODUCTION

Within the Project VV1 (VV4) „Design and application of tribodiagnostic methodologies for operation and maintenance of ground equipment of the Armed Forces of the Slovak Republic in the years 2018 - 2020, the requirement was set: and MT-55 through the CMAŠ ZZ II Quality Control Department, Žilina. The specification will be processed by CMAŠ Žilina in cooperation with AOS.

To procure the currently available proposed compensations from the funds allocated for the solution of the VV-4 project. In terms of meeting the objectives of the VV-1 Project, substitutes were proposed for the special vehicle GM 578 as follows: For PSU-Mobil Mobilux EO 004, classification DIN 51 502, NLGI 00 and KP-Total Ceran AD Plus, classification DIN 51 502, NLGI 0.

Other types of the above vehicles and PM will not be mentioned in the article.

### 2 TESTED PARTS OF A SPECIAL VEHICLE

Lubricants were replaced by PM at the department in the presence of designated specialists, for Project VV-1- Eng. Miroslav Marko, PhD., Eng. Stanislav Kolomazník and Capt. Eng. Martin Marchveka, PhD.



Fig. 2 GM 578 test vehicle  
Source: authors.



Fig. 1 GM 578 test vehicle  
Source: authors.

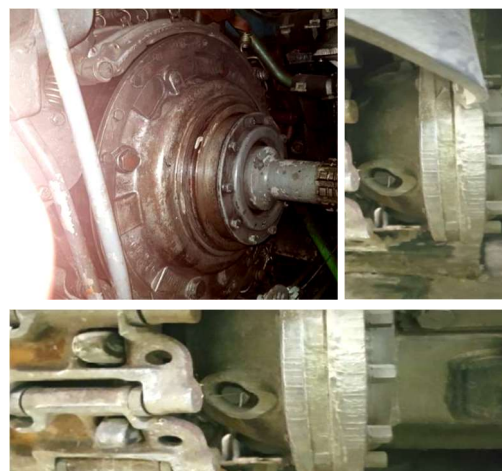


Fig. 3, 4, 5 Left PSU and right and bottom KP  
Source: authors.



**Fig. 6** Sampling  
Source: authors.



**Fig. 9** Laboratory of Tribodiagnostics, Armed Forces Academy of General Milan Rastislav Štefánik  
Source: authors.

### 3 SOME MEANS OF TRIBODIAGNOSTICS

Tribodiagnostic means for detecting “Drop point [°C]; Penetration at 25 °C [penetration unit]; Corrosivity to copper, 3h / 100 °C [Comparative standard] - photo not available - performed by CMAŠ ZZ II Žilina.

Tribodiagnostic tool for detection of selected elements-Tribodiagnostic laboratory Armed Forces of General Milan Rastislav Štefánik:



**Fig. 7** SpectroCUBE X-ray spectrometer  
Source: authors.



**Fig. 8** X-ray measuring part-Column  
Source: authors.

The SPECTRO CUBE ED-XRF analyzer is intended for screening for compliance with restricted elements. For each analysis, it displays the full spectrum of all relevant elements. Importantly, as the lists of restricted materials continue to grow, the user can activate new configurations so that they can work with other matrices, elements, and compounds in the future through simple software updates.

### 4 MEASURED PM AND THEIR TRIBODIAGNOSTICS

#### 4.1 Visual diagnostics

Visualization of PM Mobil Mobilux EP 004, NLGI 00, UNUSED, BEFORE the first test filling into the PSU:

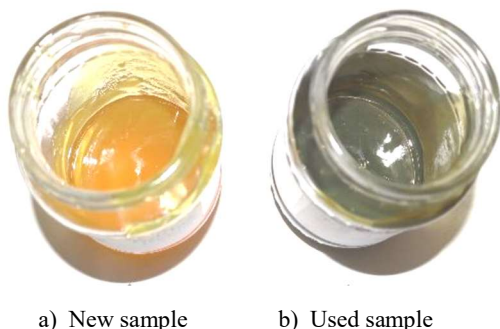


**Fig. 10** PM Mobil Mobilux EP 004, NLGI 00, NEW  
Source: authors.

Visualization of PM Mobil Mobilux EP 004, NLGI 00.

WHEN TAKING A TEST SAMPLE, 08.09.2020, AFTER approx. 197 km / 292 days from the submission of the PM for performance to the PSU GM 578.

Comparison of UNUSED and USED samples from 08. 09. 2020.



**Fig. 11** PM Mobil Mobilux EP 004, NLGI 00.  
Comparison of Reference and used sample  
Source: authors.

Comparison of samples of UNUSED PM and samples of USED PM: See a very slight darkening of used PM, which indicates a workload (PM was at a workload of 197 km / 292 days approximately from 21.11.2019 to 08.09.2020). PM is clear and visually shows no signs of sedimentation / separation of solid particles.

From the point of view of this test PM Mobil Mobilux EP 004, NLGI 00 SUITABLE for further use.

Visualization of PM Total Ceran, NLGI 0, UNUSED, BEFORE the first test filling into PSU:



**Fig. 12** PM Total Ceran, NLGI 0, NEW  
Source: authors.

Comparison of samples of UNUSED PM and samples of USED PM: See a very slight darkening of used PM, which indicates a workload (PM was at a workload of 197 km / 292 days approximately from 21.11.2019 to 08.09.2020). PM is clear and visually shows no signs of sedimentation / separation of solid particles.

In view of this PM Total Ceran AD Plus test, NLGI 0 SUITABLE for further use.



**Fig. 13** PM Total Ceran, NLGI 0  
Comparison of Reference and used sample  
Source: authors.

#### 4.2 Tribodiagnostic control of PM properties on the SPECTRO CUBE device, PM Mobil Mobilux EP 004, NLGI 00 in PSU

**Measured parameters of reference sample (RI.MO) PM Mobil Mobilux EP 004 in PSU:**

Trace occurrence: 26Fe, 28Ni

Occurrence: 38Sr; 39Y; 40Zr; 41Nb; 42Mo; 43Tc; 44Ru; 45Rh; 46Pd; 47Ag; 48Cd; 49In.

**Measured parameters of the sample of used (PI.MO) PM Mobil Mobilux EP 004 in PSU:**

Change in monitored elements:

Occurrence: 25Mn-track new; 26Fe-increase; 28Ni-foot; 29Cu-foot-new; 30Zn-occurrence-new-increase; 32Ge-occurrence-new-increase; 37Rb-foot-new. The occurrence of other monitored elements is similar to that of RI.MO.

**Measured parameters of reference sample (RII.TO) PM Total Ceran AD Plus in KP:**

Trace occurrence: 26Fe, 28Ni.

Occurrence: 20Ca; 21Sc; 38Sr; 39Y; 40Zr; 41Nb; 42Mo; 43Tc; 44Ru; 45Rh; 46Pd; 47Ag; 48Cd; 49In.

**Measured parameters of the sample used (PII.TO) PM Total Ceran AD Plus in KP:**

Change in monitored elements: (20Ca-occurrence unchanged; 21Sc-occurrence unchanged).

Occurrence: 26Fe-increase; 28Ni-occurrence; 30Zn-occurrence-new-increase; 32Ge-foot; 33As-occurrence-new; <sup>35</sup>Br-foot. The occurrence of other monitored elements is similar to that of RII.TO.



### 4.3 Tribodiagnostics of PM in the Laboratory CMSaOTD - ZZ II, quality control department, Žilina

#### Dropping point [° C] -Total Ceran AD Plus:

Reference sample:  $\pm 20\%$  (240-360) >300

PM used: -118 / -39.3 % 182

#### Penetration at 25 ° C [penetration unit] -Total Ceran AD Plus:

Reference sample:  $\pm 20\%$  (267 -401) 334

PM used: + 45 / + 13.5 % 379

#### Corrosivity to copper, 3h / 100 °C [Comparative standard]] -Total Ceran AD Plus:

Reference sample: 1a

PM used: 1a

#### Drop point [° C] -Mobile Mobilux EP 004:

Reference sample: Not measured

PM used: Not measured

#### Penetration at 25 °C [penetration unit] - Mobil Mobilux EP 004:

Reference sample:  $\pm 20\%$  (327-491) 409

PM used: + 19 / + 4.6 % 428

#### Corrosivity to copper, 3h / 100 °C [Comparative standard]] - Mobil Mobilux EP 004:

Reference sample: 1b

Used PM: 1b

Reference sample Total Ceran AD Plus: Meets the requirements of the manufacturer's specification.

Sample of PM Total Ceran AD Plus used: DOES NOT MEET the requirements of the manufacturer's specification in the "Dropping point" parameter.

Reference sample Mobil Mobilux EP 004: Meets the requirements of the manufacturer's specification.

Sample of PM used Mobil Mobilux EP 004: Meets the requirements of the manufacturer's specification.

## 5 CONCLUSION

Overall conclusion on the evaluation of PM MOBIL and TOTAL in GM 578:

#### Visual examination:

Filling PM to G 578 - tachometer: 2,957 km. PM sampling - tachometer: 3,154 km.

Samples were taken from the RIGHT PSU and KP - The same PM, which was filled into the given machine nodes at the beginning of the test, was supplemented after sampling to the volume prescribed by the regulation for treatment in terms of technology for replacement and replenishment of PM.

Comparison of samples of UNUSED PM from 21.11.2019 and UNUSED PM from 08.09.2020 - samples are without visible color changes, lubricating oils are not separated from penetrators, no signs of disturbance of PM colloidity can be seen), i.e., the

separation of the oil from the solids-penetrating component PM is not visible.

Comparison of samples of UNUSED PM (from 21.11.2019, 08.09.2020) and samples of USED PM: See a very slight darkening of used PM, which indicates a workload (PM were at a workload of 197 km / 292 days from approximately 21.11.2019 to 08.09. 2020). PMs are clear and visually show no signs of sedimentation-separation of solid particles.

In view of this test, PM Mobil Mobilux EP 004, NLGI 00 and PM TOTAL Ceran AD Plus, NLGI 0 are SUITABLE for further use.

#### Spectral analysis of monitored elements:

#### **Measured parameters of the sample of used (PI.MO) PM Mobil Mobilux EP 004 in PSU:**

Change in monitored elements:

**Occurrence:** 25Mn-track new; 26Fe-increase; 28Ni-foot; 29Cu-foot-new; 30Zn-occurrence-new-increase 32Ge-incidence-new-increase; 37Rb-foot-new

The occurrence of other monitored elements is similar to that of RI.Mo

#### **Measured parameters of the sample used (PII.TO) PM Total Ceran AD Plus in KP:**

Change in monitored elements: 20Ca-occurrence without change; 21Sc-occurrence without change.

**Occurrence:** 26Fe-increase; 28Ni-occurrence; 30Zn-occurrence-new-increase; 32Ge-foot; 33As-occurrence-new; 35Br-foot;

The occurrence of other monitored elements is similar to that of RII.TO.

**Despite the naturally increased occurrence of ferrous metals and other elements from the contact surfaces of the given machine nodes, PM IS APPLICABLE IN FURTHER OPERATION GM 578.**

**The PM in the PSU and KP on the right side of the vehicle were, after sampling, supplemented with a new unused PM of the given specifications.**

**The PM in PSU and KP on the left side of the vehicle was left without additions for comparison in the next period.**

#### **PM evaluation performed by CMSaOTD Žilina:**

Reference sample PM Total Ceran AD Plus, NLGI 00, used in KP - sample no. 214/20: **SUITABLE** requirements of the manufacturer's specification. Sample of used PM TOTAL CERAN AD PLUS - SAMPLE NO. 215/20: DOES NOT MEET THE FLIP POINT PARAMETER according to the requirements of the manufacturer's specification.

Note: Ing. Miroslav Marko, PhD., Armed Forces Academy of General M. R. Štefánik: "The decrease in the drip point was probably caused by insufficient drying of kerosene, which was used to clean KP from the previous MAKN-2 type lubricant. Total Ceran AD Plus grease, NLGI 0, was replaced by new- unused ones in KP".

Reference sample PM Mobil Mobilux EP 004 - sample no. 217/20: MEETS the requirements of the manufacturer's specification.

Sample of used PM Total Ceran AD Plus, sample no. 215/20: MEETS the requirements of the manufacturer's specification.

#### **Acknowledgments:**

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**Vladimír Kadlub** - was born in Trstená, Slovakia in 1981. He received his M.Sc (Eng.) at the Armed Forces Academy of General M. R. Štefánik in Liptovský Mikuláš in 2004. He started his dissertation studies in 2019 his research interests are focused on repairs and maintenance. Currently he is working as an assistant professor at the Department of Mechanical Engineering, Armed Forces Academy of General M. R. Štefánik in Liptovský Mikuláš.