Marijan Podobnik, Josip Bambić

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NISKOTEMPERATURNA SVOJSTVA MOTORNIH ULJA

Sažetak

Motorna ulja predstavljaju grupu maziva čiji značaj stalno raste s razvojem motorne industrije i čine najveći dio potrošnje maziva. Njihova kvaliteta definirana je klasifikacijom prema viskoznosti i specifikacijama prema radnim svojstvima.

Klasifikacijom prema viskoznosti SAE J300 niskotemperaturna svojstva motornih ulja definirana su najvećom dinamičkom viskoznošću pri pokretanju motora kod niskih temperatura i najvećom dinamičkom viskoznošću pumpanja ulja kod niskih temperatura. Navedena svojstva određuju se na Cold Cranking Simulator (CCS) uređaju odnosno Mini Rotary Viscometer (MRV) uređaju.

U najnovijem izdanju klasifikacije SAE J300 iz veljače 2000. godine uvedene su nove za 5 °C niže temperature za određivanje dinamičke viskoznosti na CCS uređaju i nove granice dinamičke viskoznosti.

U skladu s tim promjenama analizirana su niskotemperaturna svojstva motornih ulja (CCS) koja su pokazala da ispitivane formulacije motornih ulja u potpunosti zadovoljavaju i nove zahtjeve navedene klasifikacije.

Uvod

Prvu klasifikaciju motornih ulja prema viskoznosti izradilo je udruženje automobilskih inženjera SAE (Society of Automotive Engineers) iz SAD-a još davne 1911. godine (1). To je jedina klasifikacija motornih ulja po viskoznosti i nosi oznaku SAE J300. Kontinuirano se mijenjala u skladu s promjenama zahtjeva podmazivanja motora.

Klasifikacija definira dva niza gradacija viskoznosti motornih ulja. Prvi niz predstavlja gradacije viskoznosti označene slovom W, koje su definirane

zahtjevima za viskoznošću kod niskih temperatura te najmanjom kinematičkom viskoznošću kod 100 °C. Drugi niz predstavlja gradacije viskoznosti koje ne sadrže slovo W, koje su definirane najmanjom i najvećom kinematičkom viskoznošću kod 100 °C te viskoznošću kod visokih temperatura i velikog smicanja.

Klasifikacijom su niskotemperaturna svojstva motornih ulja definirana:

- najvećom dinamičkom viskoznošću ulja pri pokretanju motora kod niskih temperatura, koja se određuje na uređaju Cold Cranking Simulator (CCS)
- najvećom dinamičkom viskoznošću pumpanja ulja kod niskih temperatura, koja je mjera sposobnosti dobavljanja ulja do uljne pumpe i uspostavljanja odgovarajućeg tlaka motornog ulja za vrijeme početne faze rada motora i određuje se na Mini Rotary Viscometer (MRV) uređaju.

SAE J300 Dec99 klasifikacija

Najnovije izdanje SAE J300 klasifikacije iz prosinca 1999. godine zamjenjuje klasifikaciju SAE J300 iz travnja 1997. godine (2). Njena obvezna primjena počela je nakon 18 mjeseci prijelaznog razdoblja tj. od 01.06.2001. godine. Glavni razlog uvođenja nove klasifikacije su rezultati ispitivanja, koji su pokazali da moderni motori mogu startati kod nižih temperatura i s uljima veće viskoznosti u odnosu na motore starijih konstrukcija.

Tablica 1: SAE J300 Dec99 – dinamička viskoznost (CCS)
Table 1: SAE J300 Dec99 – dynamic viscosity (CCS)

Gradacija viskoznosti	**Najveća dinamička viskoznost (CCS)** mPa·s / °C
0 W	6 200 / -35
5 W	6 600 / -30
10 W	7 000 / -25
15 W	7 000 / -20
20 W	9 500 / -15
25 W	13 000 / -10

Klasifikacija je doživjela jedinu promjenu u zahtjevima za niskotemperaturnim svojstvima ulja, koja se određuju na Cold Cranking Simulatoru (CCS). Za svaku gradaciju viskoznosti označenu slovom W uvedene su nove za 5 °C niže temperature za određivanje dinamičke viskoznosti i nove granice dinamičke viskoznosti, koje su uglavnom dvostruke u odnosu na prethodne (SAE J300 Apr97).

U tablici 1 navedene su gradacije viskoznosti označene slovom W i odgovarajuće nove granice najveće dinamičke viskoznosti određene na CCS-u kod definirane niske temperature.

Cold Cranking Simulator

Kao što je već ranije navedeno dinamička viskoznost kod niskih temperatura određuje se na Cold Cranking Simulatoru (CCS) (3). To je uređaj čiji je rotor, koji je tijesno smješten unutar statora, pogonjen električnim motorom. Zračnost između rotora i statora ispunjena je uljem. Temperatura se mjeri u blizini unutrašnje stjenke statora i održava protokom rashladnog sredstva kroz stator. Brzina rotora je kalibrirana kao funkcija viskoznosti. Viskoznost ispitivanog ulja određuje se pomoću kalibracijske krivulje i izmjerene brzine rotora i daje se u mPa·s.

Na ovom uređaju određuje se dinamička viskoznost motornih ulja kod temperatura između -10 i -35 °C, kod smičnih naprezanja od 50000 do 100000 Pa i brzine smicanja od 10^4 do 10^5 s^{-1}. Ispitivanje simulira mogućnost pokretanja motora kod niskih temperatura.

Program ispitivanja

U skladu s promjenama SAE J300 Dec99 klasifikacije napravljen je program ispitivanja tj. određivanja dinamičke viskoznosti kod niskih temperatura slijedećih grupa motornih ulja:

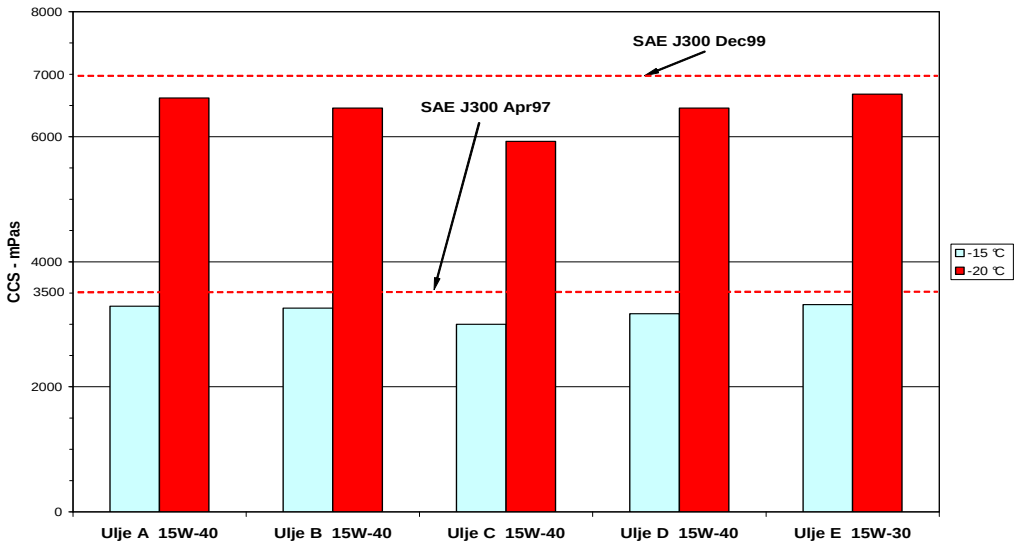
- mineralnih multigradnih motornih ulja
- djelomično sintetičnih multigradnih motornih ulja
- potpuno sintetičnih multigradnih motornih ulja

Rezultati ispitivanja

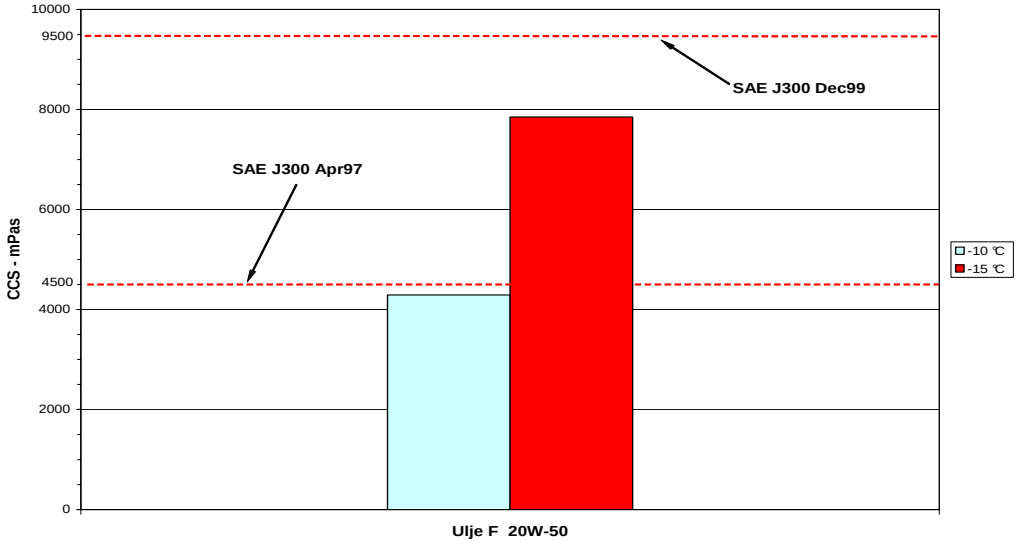
Od mineralnih multigradnih motornih ulja gradacije viskoznosti 15W-xx, ispitano je 5 uzoraka ulja i to 4 uzorka gradacije viskoznosti 15W-40 i jedan uzorak gradacije viskoznosti 15W-30.

Rezultati ispitivanja pokazali su da sva ispitana ulja (uzorci ulja A,B,C,D i E) koja su zadovoljavala granicu viskoznosti od 3500 mPa·s kod -15 °C prema prethodnoj SAE J300 Apr97 klasifikaciji, zadovoljavaju i novu granicu dinamičke viskoznosti od 7 000 mPa·s kod -20 °C prema SAE J300 Dec99 klasifikaciji. Od mineralnih multigradnih motornih ulja gradacije viskoznosti 20W-xx ispitan je samo jedan uzorak ulja gradacije viskoznosti 20W-50 (uzorak ulja F).

Slika 1: Mineralna multigradna motorna ulja 15W-xx
Figure 1: Mineral multigrade motor oils 15W-xx

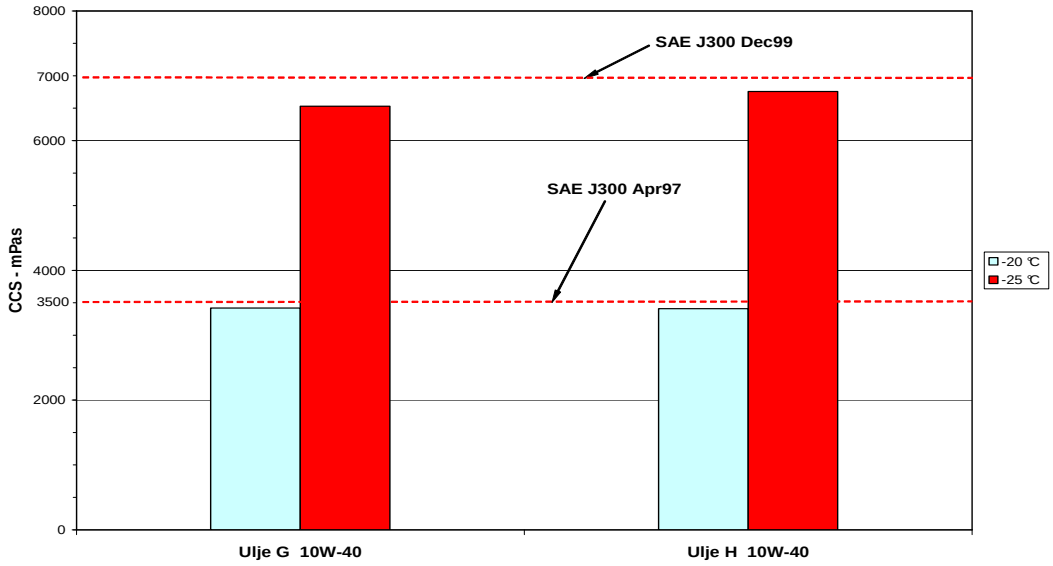


Slika 2: Mineralno multigradno motorno ulje 20W-xx
Figure 2: Mineral multigrade motor oil 20W-xx



Ispitivanje je pokazalo da i ovo ulje koje je zadovoljavalo granicu dinamičke viskoznosti od 4500 mPa·s kod -10 °C prema SAE J300 Apr97, zadovoljava i novu granicu dinamičke viskoznosti od 9 500 mPa·s kod -15 °C prema SAE J300 Dec99 klasifikaciji. Od djelomično sintetičnih multigradnih motornih ulja gradacije viskoznosti 10W-xx, ispitana su 2 uzorka ulja gradacije viskoznosti 10W-40.

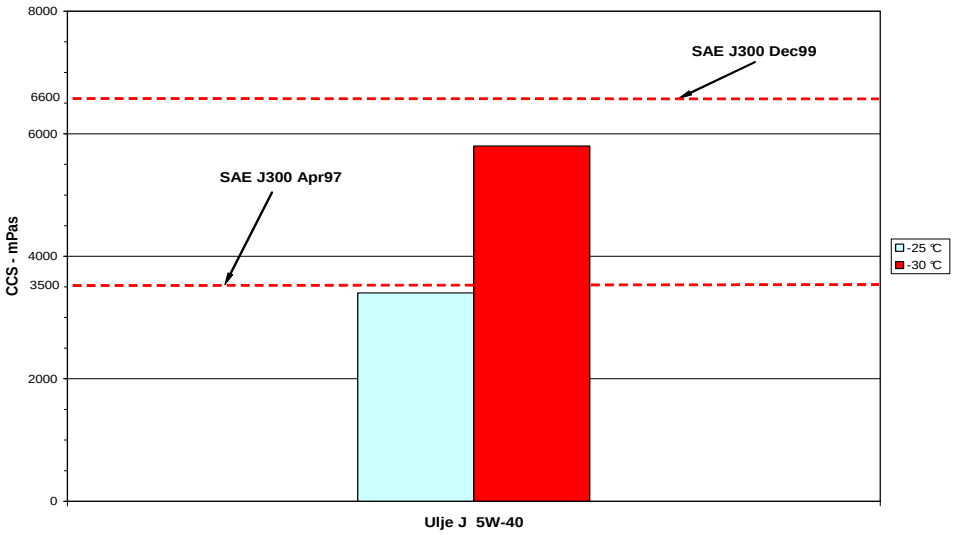
Slika 3: Djelomično sintetična multigradna motorna ulja 10W-xx
Figure 3: Partly synthetic multigrade motor oils 10W-xx



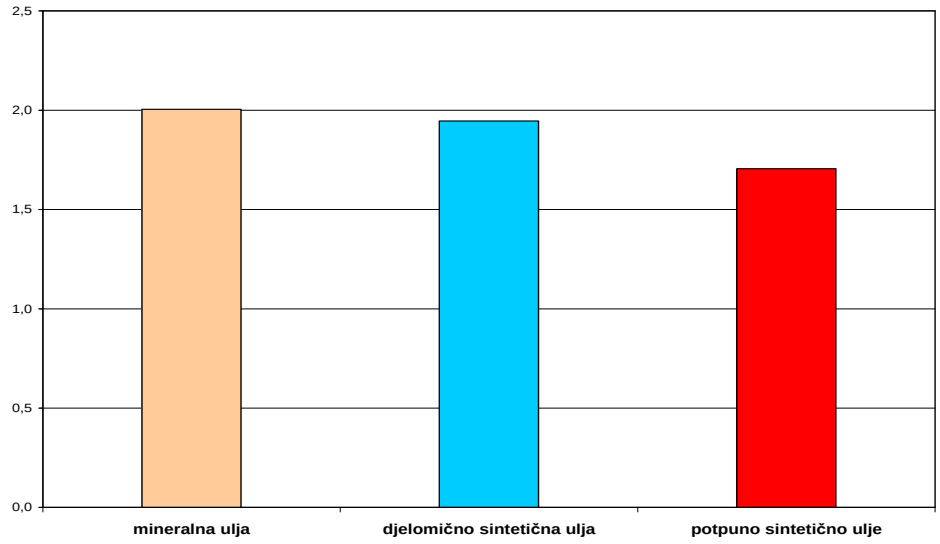
Rezultati ispitivanja pokazali su da ispitana ulja (uzorci ulja G i H) koja su zadovoljavala granicu viskoznosti od 3500 mPa·s kod -20 °C prema SAE J300 Apr97 klasifikaciji, zadovoljavaju i novu granicu dinamičke viskoznosti od 7000 mPa·s kod -25 °C prema SAE J300 Dec99 klasifikaciji. Od potpuno sintetičnih multigradnih motornih ulja gradacije viskoznosti 5W-xx ispitan je samo jedan uzorak ulja gradacije viskoznosti 5W-40 (uzorak ulja J).

Ispitivanje je pokazalo da i ovo ulje koje je zadovoljavalo granicu dinamičke viskoznosti od 3500 mPa·s kod -25 °C prema SAE J300 Apr97, zadovoljava i novu granicu dinamičke viskoznosti od 6600 mPa·s kod -30 °C prema SAE J300 Dec99 klasifikaciji.

Slika 4: Potpuno sintetično multigradno motorno ulje 5W-xx
Figure 4: Fully synthetic multigrade motor oil 5W-xx



Slika 5: Omjeri dinamičkih viskoznosti (CCS) – SAE J300 Dec99/Apr97
Figure 5: Dynamic viscosity ratio (CCS) – SAE J300 Dec99/Apr97



Na temelju rezultata ispitivanja dinamičkih viskoznosti ispitanih uzoraka ulja na Cold Cranking Simulatoru izračunati su omjeri dinamičkih viskoznosti SAE J300 Dec99/SAE J300 Apr97 za mineralna, djelomično sintetična i potpuno sintetična multigradna motorna ulja.

Za mineralna multigradna motorna ulja dobiven je omjer dinamičkih viskoznosti 2.00, za djelomično sintetična multigradna motorna ulja 1.95 te za potpuno sintetična multigradna motorna ulja 1.71.

Ovi rezultati su u potpunosti u skladu s rezultatima ispitivanja provedenih prilikom donošenja nove SAE J300 Dec99 klasifikacije (4). Ta su ispitivanja pokazala da sniženjem temperature ispitivanja za 5 °C dinamička viskoznost motornih ulja poraste za 1.7 (sintetična bazna ulja) do 2.0 puta (mineralna bazna ulja).

ZAKLJUČAK

Nova SAE J300 Dec99 klasifikacija gradacija viskoznosti motornih ulja osigurava bolja niskotemperaturna svojstva motornih ulja.

Korisnici motornih vozila trebali bi imati lakši, sigurniji start motora na niskim temperaturama.

Rezultati ispitivanja pokazali su da zahvaljujući kvaliteti baznih ulja, sva ispitana motorna ulja zadovoljavaju i zahtjeve nove SAE J300 Dec99 klasifikacije.

Rezultati ispitivanja pokazali su da nije potrebno reformulirati ispitana motorna ulja.

MOTOR OIL LOW TEMPERATURE PROPERTIES

Abstract

Motor oils constitute a group of lubricants whose significance is constantly growing with motor industry development, constituting the largest amount of lubricant consumption. Their quality is defined by classification per viscosity and specifications per performances.

The classification defines motor oil low temperature properties by the highest dynamic viscosity at low temperature cold start and by the highest oil pumping

dynamic viscosity at low temperatures. The said properties are checked by the Cold Cranking Simulator (CCS) device i.e. by the Miny Rotary Viscometer (MRV) device.

In the latest edition of the SAE J300 classification from February, 2000, new, 5 ^{0}C lower temperatures have been introduced for identifying dynamic viscosity with the CCS device, as well as new dynamic viscosity limits.

In keeping with these changes, (CCS) motor oil low temperature properties have been analyzed, showing that the motor oil formulations tested fully meet also the said classification's new requirements.

Introduction

The first motor oil classification per viscosity was made by the American Society of Automotive Engineers (SAE) back in 1911 (1). It is the only motor oil classification per viscosity and bears the mark SAE J300. It has been changing continuously in keeping with changes in the engine lubrication requirements.

The classification defines two motor oil viscosity grade series. The first series represents viscosity grades marked by letter W, defined by requirements for viscosity at low temperatures and the lowest kinematic viscosity at 100 ^{0}C. The other series consists of viscosity grades not containing the letter W, defined by the lowest and the highest kinematic viscosity at 100 ^{0}C, as well as by viscosity at high temperature and high shear. The classification defines motor oil low temperature properties as follows:

- the highest oil dynamic viscosity at low temperature cold start defined by the Cold Cranking Simulator (CCS) device,
- the highest low temperature oil pumping dynamic viscosity, understood as the measure of the capability of supplying oil to the oil pump and establishing suitable motor oil pressure during the initial engine operation phase, being defined on the Miny Rotary Viscometer (MRV) device.

SAE J300 Dec99 classification

The latest SAE J300 classification edition from Dec., 1999 has replaced the SAE J300 classification from April, 1997 (2). Its mandatory implementation began after 18 months of transitory period i.e. on 1 June, 2001. The main

reason for introducing the new classifications are the test results, showing that modern engines may start at low temperatures even with oils having higher viscosity with regard to older design engines.

The classification has had the only change in the requirements for the oil low temperature properties determined by the Cold Cranking Simulator (CCS) device. For each viscosity grade marked by letter W, new, 5 ^{0}C lower temperatures have been introduced for identifying dynamic viscosity, and new dynamic viscosity limits, generally being doubled with regard to those previous (SAE J300 Apr97).

Table 1 lists viscosity grades marked by W and their corresponding new highest dynamic viscosity limits determined on CCS at the set low temperature.

Cold Cranking Simulator

As we have already stated, low temperature dynamic viscosity is determined by the Cold Cranking Simulator (CCS) (3). It is a rotary viscometer device whose rotor, being tightly positioned within the stator, is driven by an electric motor. The clearance between the rotor and the stator is filled with oil. The temperature is measured near the inner stator wall and maintained by the coolant flow through the stator. Rotor velocity is calibrated as a viscosity function. The viscosity of tested oil is defined by means of a calibration curve and the rotor velocity measured, expressed in mPas.

The said device defines motor oil dynamic viscosity at temperatures between –10 and –35 ^{0}C, at shear stress ranging from 50,000-100,000 Pa, and shear velocity from 10^4 to 10^5 s^{-1}. The tests simulate the possibility of low temperature engine starting.

The testing programme

In keeping with changes of the SAE J300 Dec99 classification, a programme of testing i.e. of determining low temperature dynamic viscosity has been elaborated for the following motor oil groups:

- mineral multigrade motor oils,
- partly synthetic multigrade motor oils,
- fully synthetic multigrade motor oils.

Test results

As regards mineral multigrade motor oils, of the 15W-xx viscosity grade, 5 oil samples have been tested, 4 of viscosity grade 15W-40 and one of viscosity grade 15W-30.

The test results have shown that all the oils tested (oil samples A,B,C,D and E) meeting the viscosity limit of 3,500 mPa at –15 ^{0}C according to the former SAE J300 Apr97 classification meet also the new dynamic viscosity limit of 7,000 mPa at -20 ^{0}C according to the SAE J300 Dec99 classification.

As regards mineral multigrade motor oils of viscosity grade 20W-xx, only one sample was tested, with viscosity grade 20W-50 (the F oil sample).

The test has shown that this oil too, meeting the dynamic viscosity limit at the level of 4,500 mPas at -10 ^{0}C according to SAE J300 Apr97, meets also the new dynamic viscosity limit of 9,500 mPa at -15 ^{0}C according to the SAE J300 Dec99 classification.

As regards partly synthetic multigrade motor oils of viscosity grade 10W-xx, two oil samples have been tested with viscosity grade 10W-40.

The test results have shown that the oils tested (oil samples G and H) that were meeting the viscosity limit at the level of 3,500 mPas at -20 ^{0}C according to the SAE J300 Apr97 classification meet also the new dynamic viscosity limit of 7,000 mPa at -25 ^{0}C according to the SAE J300 Dec99 classification.

As regards fully synthetic multigrade motor oils of viscosity grade 5W-xx, only one oil sample was tested, meeting viscosity grade 5W-40 (the J oil sample).

The test has shown that this oil that was meeting the dynamic viscosity limit at the level of 3,500 mPas at -25 ^{0}C according to SAE J300 Apr97 meets also the new dynamic viscosity limit of 6,600 mPa at -30 ^{0}C according to the SAE J300 Dec99 classification.

Based on the results of testing the oil samples dynamic viscosity by the Cold Cranking Simulator, we have calculated dynamic viscosity ratios between SAE J300 Dec99 / SAE J300 Apr97, for mineral, partly synthetic, and fully synthetic multigrade motor oils.

For mineral multigrade motor oils, we have obtained the dynamic viscosity ratio of 2.00; for partly synthetic multigrade motor oils, 1.95, and, for fully synthetic multigrade motor oils, 1.71.

These results are entirely consistent with the results of tests performed when passing the new SAE J300 Dec99 classification (4). These tests have shown that, by lowering the test temperature by 5 ^{0}C, the motor oils kinematic viscosity goes up by 1.7 (synthetic base oils), and up to 2.0 times (mineral base oils).

Conclusion

The new SAE J300 Dec99 classification of motor oils viscosity grades ensures better motor oil temperature properties.

Motor vehicle users should now have an easier and safer low temperature engine start.

The test results have shown that, owing to the base oil quality, all the motor oils tested meet also the requirements of the new SAE J300 Dec99 classification.

The test results have shown that there is no need for reformulating the motor oils tested.

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Autori / Authors:
Marijan Podobnik, Josip Bambić, INA-Maziva Rijeka

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