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SPECIFIKACIJE MOTORNIH ULJA ZA OSOBNA VOZILA

Sažetak

Kvaliteta motornih ulja za osobna vozila definirana je međunarodnim specifikacijama (ACEA - Association des Constructeurs Europeens d'Automobiles, API - American Petroleum Institute, ILSAC - International Lubricant Standardization & Approval Committee) i specifikacijama najpoznatijih proizvođača motora/vozila.

Jedan od ciljeva uvođenja ACEA specifikacija 1996. godine bio je objedinjavanje svih zahtjeva europskih proizvođača vozila. Nažalost, u tome se nije uspjelo tako da smo svjedoci pojave sve većeg broja specifikacija pojedinih proizvođača vozila.

Broj specifikacija motornih ulja za osobna vozila povećava se zbog dva razloga. Pojavljuju se novi proizvođači vozila sa specifikacijama motornih ulja, dok proizvođači vozila koji su i do sada imali specifikacije povećavaju njihov broj. Situaciju pogoršava i činjenica da su zahtjevi pojedinih proizvođača vozila međusobno nesukladni.

Direktna posljedica navedene situacije jest da su proizvođači motornih ulja prisiljeni proizvoditi sve širi asortiman motornih ulja što značajno poskupljuje razvoj i proizvodnju ulja. Posebno je otežana pozicija manjih proizvođača ulja, koji teško mogu podnijeti povećane troškove ispitivanja velikog broja motornih ulja.

UVOD

Specifikacije motornih ulja definiraju se sa ciljem osiguravanja neophodne kvalitete motornog ulja za podmazivanje modernih konstrukcija motora. Proizvođačima motora i vozila, aditiva i motornih ulja one su temelj za razvoj novih ulja više razine kvalitete odnosno specijalne namjene.

Specifikacije su temeljene na odgovarajućim motornim testovima, razvijenim na reprezentativnim motorima, referentnim gorivima i uljima, kao i laboratorijskim

ispitivanjima. Strogo propisani postupci provođenja ispitivanja osiguravaju preciznost testova te pouzdanost i vjerodostojnost ispitnih rezultata.

U ovom radu naglasak će biti na europskim specifikacijama motornih ulja za osobna vozila, tj. ACEA specifikacijama te specifikacijama europskih proizvođača vozila.

Najvažniji faktori razvoja novih specifikacija motornih ulja za osobna vozila su:

- ograničenja emisije ispušnih plinova
- smanjenje potrošnje goriva
- produženje intervala zamjene ulja

Posljednjih godina ograničenja emisije ispušnih plinova imaju najveći utjecaj na promjene konstrukcije motora osobnih vozila, time i na promjene specifikacija motornih ulja. Europska komisija (1) je svojom direktivom 98/69/EC propisala dopuštenu emisiju motora osobnih vozila u pogledu:

- ugljičnog monoksida (CO)
- ugljikovodika (HC)
- dušikovih oksida (NO_x)
- čestica

Od 2000. g. važeća su Euro 3 ograničenja, dok 2005. g. na snagu stupaju Euro 4 ograničenja emisije ispušnih plinova. U tablici 1 prikazana su Euro 3 i Euro 4 ograničenja emisije ispušnih plinova.

Tablica 1: Euro 3 i Euro 4 ograničenja emisije ispušnih plinova

	Godina	CO	HC	HC + NOx	NOx	Čestice
Benzinski motori						
Euro 3	2000.	2,3	0,2	—	0,15	—
Euro 4	2005.	1,0	0,1	—	0,08	—
Dizelovi motori						
Euro 3	2000.	0,64	—	0,56	0,50	0,050
Euro 4	2005.	0,50	—	0,30	0,25	0,025

Direktivom 98/70/EC Europska komisija je također definirala i kvalitetu goriva za benzinske i dizelove motore osobnih vozila, koja mora odgovarati sljedećim zahtjevima (maksimalno dopuštene vrijednosti):

Od 01.01.2000. g.:

- benzin - 150 ppm sumpora, 1,0 % benzena, 42,0 % aromata
- dizelsko gorivo - 350 ppm sumpora, 11,0 % aromata

Od 01.01.2005. g.:

- benzin - 50 ppm sumpora, 35,0 % aromata
- dizelsko gorivo - 50 ppm sumpora

Navedena ograničenja bitno su utjecala na promjene konstrukcija motora osobnih vozila te su posljednjih godina proizvođači motora uveli sljedeće promjene:

- lakše komponente
- motori s 3 - 4 ventila po cilindru
- direktno ubrizgavanje goriva
- optimiziranje procesa izgaranja
- smanjenje trenja u motoru
- smanjenje potrošnje goriva
- smanjenje potrošnje ulja
- sustavi za obradu ispušnih plinova
- turbopunjači promjenjive geometrije

Interval zamjene motornog ulja posljednjih godina sve se više produžuje tako da trenutačno najpoznatiji proizvođači vozila dopuštaju sljedeće intervale (ovisno o kvaliteti ulja i goriva te eksploataciji vozila):

- BMW 20 – 30 000 km
- Fiat 25 000 km
- Ford 15 - 20000 km
- Mercedes-Benz 15 - 50 000 km
- Opel 30 - 50 000 km
- Porsche 30 000 km
- Peugeot Citroen 15 - 30 000 km
- Renault 30 000 km
- Volkswagen 15 - 50 000 km

Ugradnja posebnih sustava za obradu ispušnih plinova donijela je nove zahtjeve u pogledu formulacije motornog ulja, a to je kompatibilnost ulja s tim sustavima. Produženje intervala zamjene motornog ulja zahtijeva od motornog ulja povećanu oksidacijsku i termičku stabilnost ulja, dok smanjenje potrošnje goriva zahtjeva ulja niže viskoznosti i uporabu posebnih aditiva (modifikatora trenja).

ACEA SPECIFIKACIJE

Povijest CCMC i ACEA specifikacija već je prikazana u prethodnom radu (2).

ACEA 2002. specifikacije važeće su od 1. veljače 2002. g. (3). One definiraju motorna ulja za benzinske (klasa A) i dizelove motore (klasa B) osobnih vozila te motorna ulja za gospodarska vozila (klasa E) što nije predmet ovog rada.

Donošenje ACEA 2002. specifikacija dovelo je do sljedećih promjena u formulacijama i svojstvima motornih ulja:

- niža isparivost motornih ulja
- veća uporaba hidrokrekiranih i sintetičnih (PAO) baznih ulja
- bolja detergentno/disperzantna svojstva motornih ulja

Kategorije A5 i B5 posebno stvaraju probleme formulatorima ulja zbog kombinacije zahtjeva visoke kvalitete ulja i zahtjeva za uštedom goriva.

Motorna ulja za benzinske motore osobnih vozila

A1-02 Ulje namijenjeno za uporabu u benzinskim motorima, koji su posebno konstruirani za uporabu ulja niske viskoznosti koja štede gorivo i čija HTHS viskoznost iznosi 2,9 (2,6 za XW-20) – 3,5 mPa·s. Ovo ulje može biti neprikladno za uporabu u nekim motorima.

A2-96 issue 3 Ulje namijenjeno za uporabu u većini benzinskih motora s normalnim intervalom zamjene ulja, premda može biti neprikladno za uporabu u nekim visokoučinskim motorima.

A3-02 Ulje visoke smične stabilnosti namijenjeno za uporabu u visokoučinskim benzinskim motorima, kao i za produžene intervale zamjene ulja, odnosno za teže uvjete eksploatacije prema preporukama proizvođača motora.

A4-nn Rezervirano za ulja za benzinske motore s direktnim ubrizgavanjem goriva.

A5-02 Ulje visoke smične stabilnosti namijenjeno za uporabu uz produžene intervale zamjene ulja u visokoučinskim benzinskim motorima, koji su posebno konstruirani za uporabu ulja niske viskoznosti koja štede gorivo i čija HTHS viskoznost iznosi 2,9 – 3,5 mPa·s. Ovo ulje može biti neprikladno za uporabu u nekim motorima.

Motorna ulja za dizelove motore osobnih vozila

B1-02 Ulje namijenjeno za uporabu u dizelovim motorima kod kojih je konstrukcijski omogućena uporaba ulja niske viskoznosti koja štede gorivo i čija HTHS viskoznost iznosi 2,9 (2,6 za XW-20) – 3,5 mPa·s. Ovo ulje može biti neprikladno za uporabu u nekim motorima.

B2-98 issue 2 Ulje namijenjeno za uporabu u većini dizelovih motora (prvenstveno s indirektnim ubrizgavanjem goriva) s normalnim intervalom zamjene ulja, premda može biti neprikladno za uporabu u nekim visokoučinskim motorima.

B3-98 issue 2 Ulje visoke smične stabilnosti namijenjeno za uporabu u visokoučinskim dizelovim motorima (prvenstveno s indirektnim ubrizgavanjem goriva), kao i za produžene intervale zamjene ulja, odnosno za teže uvjete eksploatacije prema preporukama proizvođača motora.

B4-02 Ulje visoke smične stabilnosti prvenstveno namijenjeno za uporabu u dizelovim motorima s direktnim ubrizgavanjem goriva te također pogodno za uporabu kao pod B3-98 issue 2.

B5-02 Ulje visoke smične stabilnosti namijenjeno za uporabu uz produžene intervale zamjene ulja u dizelovim motorima kod kojih je konstrukcijski omogućena uporaba ulja niske viskoznosti koja štede gorivo i čija HTHS

viskoznost iznosi 2,9 – 3,5 mPa·s. Ovo ulje može biti neprikladno za uporabu u nekim motorima.

ACEA specifikacije motornih ulja definiraju i zahtjeve laboratorijskih i motornih testova koje motorno ulje mora zadovoljiti.

Laboratorijski testovi su propisani za sve klase i kategorije motornih ulja i obuhvaćaju:

- SAE J300 gradacije viskoznosti
- smičnu stabilnost
- dinamičku viskoznost kod visoke temperature i pri velikom gradijentu smicanja (HTHS)
- isparivost ulja (Noack)
- sulfatni pepeo
- pjenjenje
- pjenjenje na visokoj temperaturi
- kompatibilnost s elastomerima

Motorni testovi su također propisani za sve klase i kategorije motornih ulja, ali su različiti za pojedine klase odnosno kategorije. Podaci o motornim testovima potrebnim za zadovoljenje ACEA 2002. specifikacija navedeni su u prethodnom radu (2).

Treba naglasiti da su u pripremi nove ACEA 2004. specifikacije motornih ulja, no do trenutka pisanja ovog rada nije objavljen niti njihov radni prijedlog.

SPECIFIKACIJE PROIZVOĐAČA MOTORA / VOZILA

Namjera ACEA udruženja bila je da njihove specifikacije motornih ulja budu opće prihvaćene od svih europskih proizvođača motora/vozila. Nažalost, praksa je pokazala da to nije ostvarivo, jer veliki broj proizvođača (i to članova ACEA-e) i danas ima svoj poseban sustav homologacije motornih ulja. Pri tome zahtjevi ACEA specifikacija predstavljaju samo temeljne zahtjeve na koje proizvođači motora/vozila nadograđuju svoje dodatne zahtjeve.

Da bi zadovoljili sve strože zahtjeve emisije ispušnih plinova, proizvođači motora razvijaju različite konstrukcije motora i sustave obrade ispušnih plinova, što za posljedicu ima i različite zahtjeve za kvalitetom motornog ulja. U nastavku je dat pregled specifikacija motornih ulja osobnih vozila europskih proizvođača (4, 5, 6, 7).

VOLKSWAGEN

Volkswagen je proizvođač motora/vozila koji je u posljednjih nekoliko godina izdao najviše novih specifikacija motornih ulja (praktično svaka nova serija/konstrukcija motora zahtijeva novo različito motorno ulje). Za pojedina motorna ulja Volkswagen izdaje uporabne dozvole koje vrijede 3 godine.

Trenutačno važeće specifikacije Volkswagena su:

VW 502.00 Ulje za benzinske motore bez produženog intervala zamjene ulja (15000 km – 1 godina), HTHS viskoznost min. 3,5 mPa·s, ACEA A3 + dodatni VW testovi.

VW 503.00 Ulje za benzinske motore sa produženim intervalom zamjene ulja (30000 km – 2 godine), HTHS viskoznost 2,9 – 3,4 mPa·s, ACEA A3 + dodatni VW testovi.

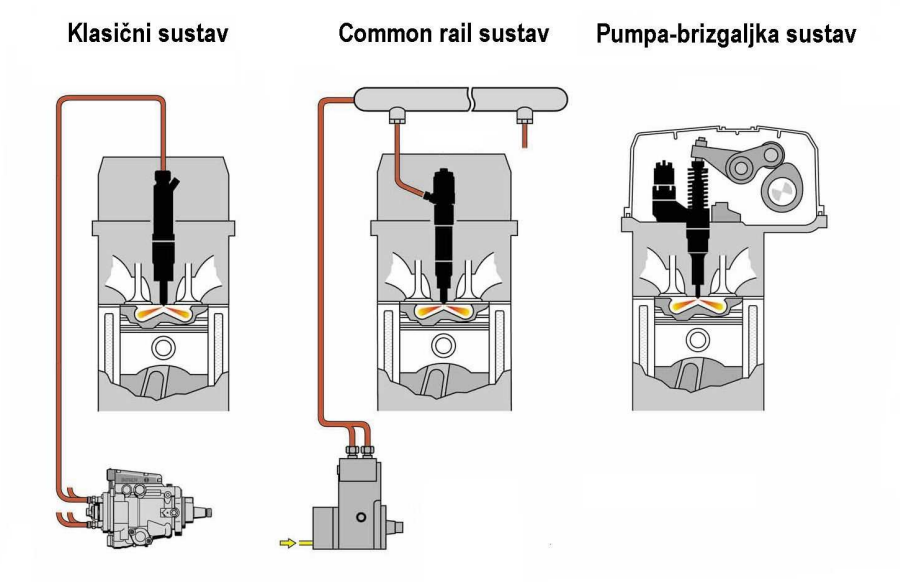
VW 503.01 Ulje za AUDI turbo-benzinske motore sa produženim intervalom zamjene ulja i Volkswagen W8 i W12 motore (30000 km - 2 godine), HTHS viskoznost min. 3,5 mPa·s, ACEA A3 + dodatni VW testovi.

VW 505.00 Ulje za dizelove motore bez produženog intervala zamjene ulja (15000 km – 1 godina), HTHS viskoznost min. 3,5 mPa·s, ACEA B3 + dodatni VW testovi.

VW 505.01 Ulje za dizelove motore sa pumpa-brizgaljka sustavom ubrizgavanja goriva bez produženog intervala zamjene ulja (15000 km – 1 godina), HTHS viskoznost min. 3,5 mPa·s, ACEA B3/B4 + dodatni VW testovi.

VW 506.00 Ulje za dizelove motore sa produženim intervalom zamjene ulja (30000 km – 2 godine), HTHS viskoznost 2,9 – 3,4 mPa·s, ACEA B4 + dodatni VW testovi.

Slika 1: Sustavi ubrizgavanja goriva kod dizelovih motora
Figure 1: Fuel injection systems in diesel engines



Conventional system Common rail system Pump-injector system

VW 506.01 Ulje za dizelove motore sa pumpa-brizgaljka sustavom ubrizgavanja goriva i produženim intervalom zamjene ulja (50000 km – 2 godine), HTHS viskoznost 2,9 – 3,4 mPa·s, ACEA B4 + dodatni VW testovi.

Posebna kvaliteta motornih ulja propisanih specifikacijama VW 505.01 i VW 506.01 posljedica je razvoja specifičnog pumpa-brizgaljka sustava ubrizgavanja goriva, tj. rješavanja problema podmazivanja dodira između pumpa-brizgaljke i bregaste osovine kod Volkswagenovih dizelovih vozila (slika 1).

Osim navedenih specifikacija na tržištu se i dalje pojavljuju motorna ulja koja zadovoljavaju zahtjeve specifikacija VW 500.00 i VW 501.01 koje su službeno nevažeće.

VW 500.00 Ulje za benzinske i dizelove motore s normalnim punjenjem bez produženog intervala zamjene ulja (15000 km – 1 godina), HTHS viskoznost min. 3,5 mPa·s, ACEA A3 + dodatni VW testovi.

VW 501.01 Ulje za benzinske i dizelove motore s normalnim punjenjem bez produženog intervala zamjene ulja (15000 km – 1 godina), HTHS viskoznost min. 3,5 mPa·s, ACEA A2 + dodatni VW testovi.

MERCEDES-BENZ

Mercedes-Benz daje veliku važnost kvaliteti motornog ulja, kojeg smatra integralnim konstruktivnim elementom motora. U svojim propisima opisuje 56 svojstava koje ulje mora zadovoljiti. Postupak homologacije motornih ulja definiran je već dugi niz godina. Uporabne dozvole nemaju ograničenu trajnost, ali jednom godišnje proizvođač ulja mora potvrditi proizvodnju ulja po nepromijenjenjoj formulaciji ulja. Ažurirane liste odobrenih motornih ulja objavljuju se 2 puta godišnje.

MB 229.1 Ulje za benzinske i neke dizelove motore bez produženog intervala zamjene ulja (15 - 30000 km odnosno 1 - 2 godine), HTHS viskoznost min. 3,5 mPa·s, ACEA A3/B3 + dodatni MB testovi.

MB 229.3 Ulje za sve benzinske i dizelove motore s uštedom goriva i bez produženog intervala zamjene ulja (15 - 30000 km odnosno 1 - 2 godine), HTHS viskoznost min. 3,5 mPa·s, ACEA A3/B4 + dodatni MB testovi.

MB 229.31 Najnovija specifikacija koja predstavlja modifikaciju specifikacije MB 229.3. Radi se o ulju s niskim sadržajem sulfatnog pepela, sumpora i fosfora, namijenjenom za Euro-4 motore, s uštedom goriva i bez produženog intervala zamjene ulja (15 - 30000 km odnosno 1 - 2 godine), HTHS viskoznost min. 3,5 mPa·s, ACEA A3/B4 + dodatni MB zahtjevi.

MB 229.5 Ulje za sve benzinske i dizelove motore s uštedom goriva i produženim intervalom zamjene ulja (25 - 50 000 km odnosno 1 - 3 godine), HTHS viskoznost min. 3,5 mPa·s, ACEA A3/B4 + dodatni MB testovi + eksploatacijsko ispitivanje

BMW

BMW je poznati europski proizvođač vozila, koji za potrebe podmazivanja svojih motora ima 3 važeće specifikacije motornih ulja. Sva prethodno odobrena ulja specificirana kao BMW Longlife oils (testirana na M44 motoru) svrstana su u BMW Longlife-98 specifikaciju.

U specifikacijama BMW Longlife-01 i BMW Longlife-01 FE uveden je novi BMW motorni test M54: 2,5 l, 6 cilindara, 4 ventila po cilindru, smanjena količina ulja u karteru motora, trajanje testa 370 sati. BMW izdaje uporabne dozvole koje vrijede 2 godine.

BMW Longlife-98 Ulje za benzinske i dizelove motore (modeli do 2001. g.) s produženim intervalom zamjene ulja (20 - 25000 km - 2 godine), HTHS viskoznost min. 3,5 mPa·s, ACEA A3/B3 + dodatni BMW test**.**

BMW Longlife-01 Ulje za sve benzinske i dizelove motore s produženim intervalom zamjene ulja (30000 km - 2 godine), HTHS viskoznost min. 3,5 mPa·s, ACEA A3/B3/B4 + dodatni BMW test.

BMW Longlife-01 FE Ulje za sve benzinske i dizelove motore, s uštedom goriva i produženim intervalom zamjene ulja (30000 km - 2 godine), HTHS viskoznost min. 3.0 mPa·s, ACEA A5/B1/B4 + dodatni BMW test.

PORSCHE

Do uvođenja svoje nove specifikacije motornog ulja za benzinske motore, krajem 2002. godine, Porsche je zahtijevao ACEA A3 razinu kvalitete motornog ulja i isparivost ulja manju od 12 %. Nova Porsche specifikacija uključuje sljedeće zahtjeve:

- novi motorni test Porsche 911 – 3,6 l, 6 cilindara, 320 KS, 200 sati
- SAE 0W-40, 5W-40, 5W-50
- HTHS viskoznost min. 3,5 mPa·s
- produženi interval zamjene ulja (30000 km - 2 godine)
- ACEA A3
- VW T-4 motorni test

Porsche izdaje uporabne dozvole koje vrijede 2 godine.

OPEL

Opel je tek 2002. g. izdao svoje prve specifikacije motornih ulja za moderne benzinske i dizelove motore s produženim intervalom zamjene ulja. Postupak homologacije ulja je vrlo kompliciran, jer nakon provedenih svih potrebnih motornih

testova neophodno je dodatno ispitivanje motornog ulja u nezavisnom laboratoriju. Opel izdaje uporabne dozvole koje vrijede 2 godine.

Opel B 040 2095 (GM-LL-A-025)

Ulje za benzinske i neke modele dizelovih motora, uštedom goriva i produženim intervalom zamjene ulja (30000 km benzinski i 50000 km dizelovi - odnosno 2 godine), HTHS viskoznost min. 2,9 mPa·s, TBN = min. 10 mg KOH/g, ACEA A3/B3/B4 + dodatni Opelovi testovi.

Opel B 040 2098 (GM-LL-B-025)

Ulje za neke modele dizelovih motora i produženim intervalom zamjene ulja (50000 km odnosno 2 godine), HTHS viskoznost min. 3,5 mPa·s, ACEA A3/B3/B4 + dodatni Opelovi testovi.

FORD

Iako ima definirane specifikacije motornih ulja Ford ne izdaje uporabne dozvole za servisno punjenje, već samo za motorna ulja za prvo punjenje. Ford definira 3 specifikacije motornih ulja:

Ford WSS-M2C-913-A

Ulje za benzinske i dizelove motore bez produženog intervala zamjene ulja (15-20000 km odnosno 1 godina), HTHS viskoznost min. 2,9 mPa·s, ACEA A1/B1 + ILSAC GF-2.

Ford WSS-M2C-913-B

Ulje za moderne benzinske i dizelove motore bez produženog intervala zamjene ulja (20000 km odnosno 1 godina), HTHS viskoznost min. 2,9 mPa·s, ACEA A1/B1 + ILSAC GF-2 ili GF-3.

Ford WSS-M2C-917-A

Ulje za dizelove motore s pumpa-brizgaljka sustavom ubrizgavanja goriva i bez produženog intervala zamjene ulja (15000 km odnosno 1 godina), HTHS viskoznost min. 3,5 mPa·s, ACEA B3/B4. Ova specifikacija praktično je identična specifikaciji VW 505.01 što je i logično jer se radi o Volkswagenovim motorima ugrađenim u Fordova vozila.

Ostali proizvođači osobnih vozila, koji nisu navedeni, nemaju posebnih zahtjeva po pitanju kvalitete motornih ulja za servisno punjenje, već zahtijevaju kvalitetu u skladu s ACEA specifikacijama. Međutim, neki od njih (npr. PSA, Renault, Fiat) izdaju uporabne dozvole ali samo za motorna ulja za prvo punjenje.

MOTORNA ULJA ZA OSOBNA VOZILA

Budući da su zahtjevi specifikacija pojedinih proizvođača osobnih vozila dosta različiti, a ponekad i međusobno nesukladni proizvođači maziva prisiljeni su

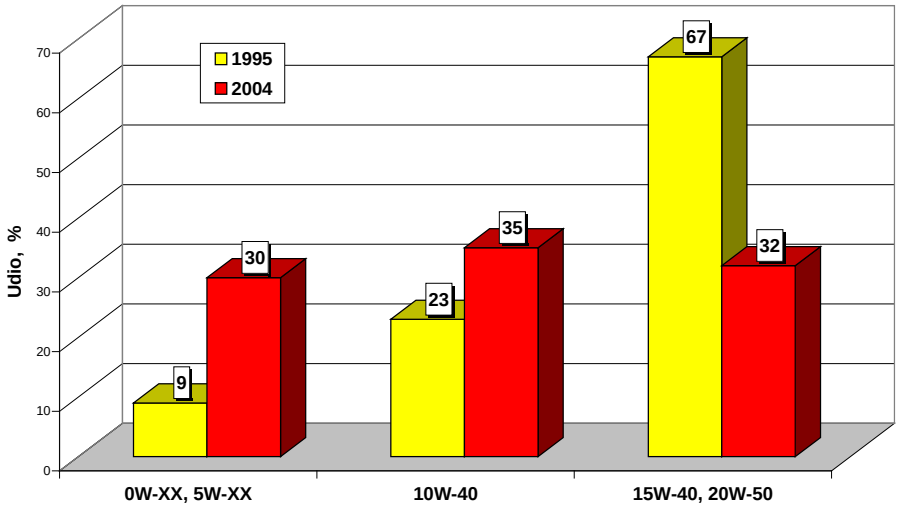
formulirati veliki broj motornih ulja za osobna vozila. Pri tome se dešava da je pojedino ulje praktično razvijeno samo za jednog proizvođača motora.

Najbolji primjer za to je HTHS viskoznost. Proizvođači motora su svojim zahtjevima praktično podijelili motorna ulja u 3 grupe:

HTHS viskoznost min. 2,9 (3,0) mPa·s	BMW Longlife-01 FE Opel B 040 2095 Ford WSS-M2C-913-A/B
HTHS viskoznost maks. 3,5 mPa·s	ACEA A1/A5/B1/B5 VW 503.00/506.00/506.01
HTHS viskoznost min. 3,5 mPa·s	ACEA A2/A3/B2/B3/B4 VW 502.00/503.01/505.00/505.01 MB 229.1/229.3/229.31/229.5 BMW Longlife-98/Longlife-01 Porsche Opel B 040 2098 Ford WSS-M2C-917-A

Zahtjevi za višom kvalitetom ulja i uštedom goriva izazvali su i promjene u udjelima gradacija viskoznosti motornih ulja za osobna vozila, tj. pomak prema manje viskoznim motornim uljima. Analiza tržišta pokazala je da je u posljednjih 10 godina došlo do značajnih promjena udjela pojedinih gradacija viskoznosti motornih ulja (slika 2).

Slika 2: Udio pojedinih gradacija viskoznosti motornih ulja
Figure 2: The share of individual motor oil viscosity grades



Razvoj i proizvodnja novih motornih ulja više kvalitete i nižih gradacija viskoznosti zahtijeva sve veću uporabu hidrokrekiranih i sintetičnih baznih ulja. Uz prije navedeni veliki broj različitih motornih ulja to uzrokuje visoke troškove. Pogotovo su u neravnopravnom položaju manji proizvođači motornih ulja koji prodanim količinama ulja ne mogu pokriti tako visoke troškove ispitivanja.

ZAKLJUČAK

1. Kvaliteta motornih ulja za osobna vozila definirana je međunarodnim specifikacijama i specifikacijama najpoznatijih proizvođača motora/vozila.

2. Ograničenje emisije ispušnih plinova, smanjenje potrošnje goriva i produženje intervala zamjene ulja su najutjecajniji faktori za razvoj novih specifikacija motornih ulja.

3. Posljednjih godina pojavio se veliki broj novih specifikacija proizvođača motora/vozila. Zahtjevi ACEA specifikacija predstavljaju samo minimum zahtjeva koje ulje mora zadovoljiti. Proizvođači motora/vozila na to dograđuju svoje dodatne zahtjeve za kvalitetom ulja.

4. Zahtjevi novih specifikacija motornih ulja za osobna vozila uvjetuju sve veću uporabu hidrokrekiranih i sintetičnih baznih ulja.

5. Specifikacije motornih ulja proizvođača motora/vozila često imaju međusobno nesukladne zahtjeve što na tržištu rezultira velikim brojem motornih ulja posebno ciljane kvalitete.

PASSENGER VEHICLE MOTOR OIL SPECIFICATIONS

Abstract

The quality of motor oils for passenger vehicles is defined by international specifications (ACEA-Association des Constructeurs Europeens d'Automobiles, API-American Petroleum Institute, ILSAC-International Lubricant Standardization & Approval Committee) and specifications by the reputable engine/vehicle manufacturers.

One among the goals of introducing ACEA specifications back in 1996 was the joining together of all requirements by European vehicle manufacturers. Sadly, this goal has never been achieved, so that we are now witnessing the appearance of a growing number of specifications by individual vehicle manufacturers.

The number of passenger vehicle motor oil specifications is increasing for two reasons. There are new vehicle manufacturers with motor oil specifications appearing, while those who have already had specifications are increasing their number. The situation is furtherly worsened by the fact that the requirements of individual vehicle manufacturers are mutually inconsistent.

A direct consequence of the said situation is that motor oil manufacturers are forced to keep widening their assortment of motor oils, which renders oil development and production considerably more expensive. Especially difficult is the position of small-scale oil manufacturers who find it very difficult to meet the increased costs of testing a large number of motor oils.

INTRODUCTION

Motor oil specifications are being defined with the purpose of ensuring the necessary quality of motor oil for lubricating modern engine structures. To the manufacturers of engines and vehicles, additives and motor oils, they are the foundation for the development of new oils of a higher quality level i.e. intended for special purposes.

Specifications are based on suitable engine tests, developed on representative engines, referential fuels and oils, as well as laboratory tests. Strictly set testing procedures ensure the precision of tests, as well as the reliability and accuracy of the test results.

In the present paper, the stress shall be put on European specifications for passenger vehicle motor oils i.e. ACEA specifications, as well as specifications by European vehicle manufacturers.
The most important factors in the development of new specifications for passenger vehicle motor oils are:

- limited exhaust gas emission
- reduced fuel consumption
- extended oil fill change interval

Over the past few years, exhaust gas emission limitations have had the greatest impact on the changes of passenger vehicle engine design, and hence also on the motor oil specification changes. The European Commission (1) has through its directive 98/69/EC prescribed permitted emission of passenger vehicle engines when it comes to:

- carbon monoxide (CO)
- hydrocarbon (HC)
- nitrogen oxide (NO_x)
- particles

Since 2000, the Euro 3 limitations have been in force, while in 2005 the Euro 4 exhaust gas emission limitations enter into force. Table 1 shows Euro 3 and Euro 4 exhaust gas emission limitations.

Table 1: Euro 3 and Euro 4 exhaust gas emission limitations

	Year	CO	HC	HC + NOx	NOx	Particles
Gasoline engines						
Euro 3	2000	2.3	0.2	—	0.15	—
Euro 4	2005	1.0	0.1	—	0.08	—
Diesel engines						
Euro 3	2000	0.64	—	0.56	0.50	0.050
Euro 4	2005	0.50	—	0.30	0.25	0.025

By Directive 98/70/EC, the European Commision has also defined fuel quality for gasoline and diesel passenger vehicle engines, which must meet the following requirements (maximum permissible values):

As of 01/01/2000:

- gasoline - 150 ppm of sulphur, 1.0 % of benzene, 42.0 % of aromatics
- diesel fuel - 350 ppm of sulphur, 11.0 % of aromatics

As of 01/01/2005:

- gasoline - 50 ppm of sulphur, 35.0 % of aromatics
- diesel fuel - 50 ppm of sulphur

The said limitations have had a considerable impact on the changes of engine design in passenger vehicles, so that over the past few years engine manufacturers have introduced the following changes:

- lighter components
- engines with 3 - 4 valves per cylinder
- direct fuel injection
- optimization of the combustion process
- reduced engine friction
- reduced fuel consumption
- reduced oil consumption
- exhaust gas treatment systems
- turbochargers with variable geometry

The oil fill change interval has over the past few years been increasingly extending, so that currently the best known vehicle manufacturers permit the following intervals (depending on oil and fuel quality and vehicle exploitation):

- BMW 20 - 30 000 km
- Fiat 25 000 km
- Ford 15 - 20 000 km
- Mercedes-Benz- 15 - 50 000 km
- Opel 30 - 50 000 km
- Porsche 30 000 km
- Peugeot Citroen 15 - 30 000 km
- Renault 30 000 km
- Volkswagen 15 - 50 000 km

The building in of a special exhaust gas treatment systems has brought along new requirements as to the motor oil formulation, which is oil compatibility with these systems. Extended oil fill change interval requires increased oxidation and thermal motor oil stability, while reduced fuel consumption requires lower viscosity oils and use of special additives (friction modifiers).

THE ACEA SPECIFICATIONS

The history of CCMC and ACEA specifications has already been presented in a previous paper(2).

The ACEA 2002 specifications have been valid since 1 February 2002 (3). They define motor oils for passenger vehicle gasoline (class A) and diesel engines (class B) and motor oils for commercial vehicles (class E), which is not the topic of the present paper.

The passing of ACEA 2000 specifications has brought to the following changes in the formulations and properties of motor oils:

- lower motor oil volatility

- increased use of hydrocracked and synthetic (PAO) base oils
- better detergent/dispersant motor oil properties

Categories A5 and B5 are a particular source of problems to oil formulators because of combined requirements for high oil quality and fuel saving.

Motor Oils for Passenger Vehicle Gasoline Engines

A1-02 Oil intended for use in gasoline engines designed especially for using low viscosity oils which save fuel and whose HTHS viscosity amounts to 2.9 (2.6 for SAE grade XW-20) - 3.5 mPa·s. This oil may prove unsuitable for use in some engines.

A2-96 issue 3 Oil intended for use in most gasoline engines with a normal oil fill change interval, although it may prove unsuitable for use in some high efficiency engines.

A3-02 Oil with high shear stability intended for use in high performance gasoline engines, as well as for extended oil fill change intervals, i.e. heavier service conditions according to engine manufacturer recommendations.

A4-nn Reserved for oils for gasoline engines with direct fuel injection.

A5-02 Oil with high shear stability intended for use with extended oil fill change interval in high performance gasoline engines, designed especially for using low viscosity oils that save fuel and whose HTHS viscosity amounts to 2.9 - 3.5 mPa·s. This oil may prove unsuitable for use in some engines.

Motor Oils for Passenger Vehicle Diesel Engines

B1-02 Oil intended for use in diesel engines whose design enables the use of low viscosity oils saving fuel, whose HTHS viscosity amounts to 2.9 (2.6 for XW-20) - 3.5 mPa·s. This oil may prove unsuitable for use in some engines.

B2-98 issue 2 Oil intended for use in most diesel engines (primarily with indirect fuel injection) with a normal oil fill change interval, although it may prove unsuitable for use in some high performance engines.

B3-98 issue 2 Oil with high shear stability intended for use in high efficiency diesel engines (primarily with indirect fuel injection), as well as for extended oil fill change intervals, i.e. for heavier service conditions, according to engine manufacturer recommendations.

B4-02 Oil with high shear stability intended primarily for the use in diesel engines with direct fuel injection, also suitable for use as under B3-98 issue 2.

B5-02 Oil with high shear stability intended for use with extended oil fill change intervals in diesel engines whose design permits the use of low viscosity oil saving fuel and whose HTHS viscosity amounts to 2.9 - 3.5 mPa·s. This oil may prove unsuitable for use in some engines.

The ACEA motor oil specifications define the requirements of both laboratory and engine tests which the engine oil has to meet.

Laboratory tests are prescribed for all classes and categories of motor oils and encompass the following:

- SAE J300 viscosity grades
- shear stability
- dinamic viscosity at high temperature and at high shear (HTHS)
- oil volatility (Noack)
- sulphated ash
- foaming
- foaming at high temperatures
- compatibility with elastomers

Engine tests are also prescribed for all classes and categories of motor oils, but vary per classes i.e. categories. Data on engine tests necessary for meeting ACEA 2002 specifications were listed in the previous paper (2).

We should point out that new ACEA 2004 engine oil specifications are currently under preparation, but that not even their draft proposal has been published so far.

SPECIFICATIONS BY ENGINE/VEHICLE MANUFACTURERS

The intention of ACEA association was for their motor oil specifications to be widely accepted by all European engine/vehicle manufacturers. Unfortunately, practice has shown that this is not feasible, because a large number of manufacturers (ACEA members) still have their own requirements for the approval of motor oils. The requirements of ACEA specifications constitute only basic requirements upon which engine/vehicle manufacturers are then building their additional requirements.

In order to meet the increasingly stringent exhaust gas emissions, engine manufacturers are developing advanced engine design and exhaust gas treatment systems, resulting in different requirements for the quality of engine oil. In further text we are providing a review of passenger vehicle motor oil specifications by European manufacturers (4, 5, 6, 7).

VOLKSWAGEN

Volkswagen is an engine/vehicle manufacturer who has over the past few years issued the most of the new motor oil specifications (practically every new engine series/design requires a new, different motor oil). For individual motor oils, Volkswagen issues approvals valid for 3 years.

Currently valid specifications by Volkswagen are:

VW 502.00 Oil for gasoline engines without extended oil fill change interval (15000 km – 1 year), HTHS viscosity min. 3.5 mPa·s, ACEA A3 + additional VW tests

VW 503.00 Oil for gasoline engines with extended oil fill change interval (30000 km – 2 years), HTHS viscosity 2.9 - 3.4 mPa·s, ACEA A3 + additional VW tests

VW 503.01 Oil for AUDI turbo-gasoline engines with extended oil fill change interval and Volkswagen W8 and W12 engines (30000 km - 2 years), HTHS viscosity min. 3.5 mPa·s, ACEA A3 + additional VW tests

VW 505.00 Oil for diesel engines without extended oil fill change interval (15000 km – 1 year), HTHS viscosity min. 3.5 mPa·s, ACEA B3 + additional VW tests

VW 505.01 Oil for diesel engines with pump-injector fuel injection system without extended oil fill change interval (15000 km – 1 year), HTHS viscosity min. 3.5 mPa·s, ACEA B3/B4 + additional VW tests

VW 506.00 Oil for diesel engines with extended oil fill change interval (30000 km – 2 years), HTHS viscosity 2.9 - 3.4 mPa·s, ACEA B4 + additional VW tests

VW 506.01 Oil for diesel engines with pump-injector fuel injection system and extended oil fill change interval (50000 km – 2 years), HTHS viscosity 2.9 - 3.4 mPa·s, ACEA B4 + additional VW tests

Special quality of motor oils prescribed by specifications VW 505.01 and VW 506.01 is the result of the development of a specific pump-injector fuel injection system i.e. resolving of the problem of lubricating the contact between pump-injector and camshaft in Volkswagen's diesel vehicles (Figure 1).

Apart from the above specifications, still appearing on the market are motor oils meeting requirements of the specifications VW 500.00 and VW 501.01, which are officially invalid.

VW 500.00 Oil for gasoline and diesel engines with normal fill without extended interval (15000 km – 1 year), HTHS viscosity min. 3.5 mPa·s, ACEA A3 + additional VW tests

VW 501.01 Oil for gasoline and diesel engines without extended oil change interval (15000 km – 1 year), HTHS viscosity min. 3.5 mPa·s, ACEA A2 + additional VW tests

MERCEDES-BENZ

Mercedes-Benz assigns great importance to the quality of motor oil, which it considers to be an integral structural element of the engine. In its regulations, it describes 56 requirements which the oil must meet. The procedure of approval of motor oils has been defined for a number of years now. Approvals do not have a limited duration, but once a year the oil manufacturer must confirm that the oil is being produced according to an unchanged formulation. Updated lists of approved motor oils are published twice a year.

MB 229.1 Oil for gasoline and some diesel engines without extended oil fill change interval (15 - 30000 km i.e. 1 - 2 years), HTHS viscosity min. 3.5 mPa·s, ACEA A3/B3 + additional MB tests

MB 229.3 Oil for all gasoline and diesel engines with fuel saving and without extended oil fill change interval (15 - 30000 km i.e. 1 - 2 years), HTHS viscosity min. 3.5 mPa·s, ACEA A3/B4 + additional MB tests

MB 229.31 The latest specification representing a modification of the specification MB 229.3. It is an oil with low sulphated ash, sulphur and phosphorous content, intended for Euro-4 engines, with fuel saving and without extended oil fill change interval (15 - 30000 km i.e. 1 - 2 years), HTHS viscosity min. 3.5 mPa·s, ACEA A3/B4 + additional MB requirements.

MB 229.5 Oil for all gasoline and diesel engines with fuel saving and with extended oil fill interval (25 - 50000 km i.e. 1 - 3 years), HTHS viscosity min. 3.5 mPa·s, ACEA A3/B4 + additional MB tests + field test

BMW

BMW is a famous European vehicle manufacturer who, for the needs of lubricating its engines, has 3 valid specifications of motor oils. All previously approved oils specified as BMW Longlife oils (tested on M44 engine) are classified in the BMW Longlife-98 specification.

In specifications BMW Longlife-01 and BMW Longlife-01 FE a new BMW engine test M54 was introduced. It is performed on 2.5 l, 6 cylinder engine, 4 valves per cylinder, reduced oil volume in the engine oil sump, test duration 370 hours. BMW issues use permits valid for 2 years.

BMW Longlife-98 Oil for gasoline and diesel engines (makes up to 2001) with extended oil fill change interval (20 - 25000 km - 2 years), HTHS viscosity min. 3.5 mPa·s, ACEA A3/B3 + additional BMW test**s**

BMW Longlife-01 Oil for all gasoline and diesel engines with extended oil fill change interval (30000 km - 2 years), HTHS viscosity min. 3.5 mPa·s, ACEA A3/B3/B4 + additional BMW tests

BMW Longlife-01 FE Oil for gasoline and diesel engines, fuel saving and extended oil fill interval (30000 km - 2 years), HTHS viscosity min. 3.0 mPa·s, ACEA A5/B1/B4 + additional BMW tests

PORSCHE

Until the introduction of its new gasoline engines motor oil specification towards the end of 2002, Porsche required ACEA A3 motor oil quality level and oil volatility below 12 %. The new Porsche specification includes the following requirements:

- new engine test Porsche 911 - 3.6 l, 6 cylinders, 320 KS, 200 hrs
- SAE 0W-40, 5W-40, 5W-50
- HTHS viscosity min. 3.5 mPa·s

- extended oil fill change interval (30000 km - 2 years)
- ACEA A3
- VW T-4 engine test

Porsche issues approvals valid for 2 years.

OPEL

Opel issued its first motor oil specifications for modern gasoline and diesel engines with extended oil fill change interval only in 2002. The oil approval procedure is highly complex, because after all the necessary motor tests it requires and additional testing of motor oil in an independent laboratory. Opel issues use permits valid for 2 years.

Opel B 040 2095 (GM-LL-A-025)

Oil for gasoline and some makes of diesel engines, fuel saving and extended oil fill change interval (30000 km for gasoline and 50000 km for diesel engines – i.e. 2 years), HTHS viscosity min. 2.9 mPa·s, TBN = min. 10 mg KOH/g, ACEA A3/B3/B4 + additional Opel tests.

Opel B 040 2098 (GM-LL-B-025)

Oil for some makes of diesel engines and extended oil fill change interval (50000 km i.e. 2 years), HTHS viscosity min. 3.5 mPa·s, ACEA A3/B3/B4+additional Opel tests.

FORD

Although it has defined motor engine specifications, Ford does not issue approvals for the service fill but only for motor oils for the factory fill. Ford defines 3 motor oil specifications:

Ford WSS-M2C-913-A

Oil for gasoline and diesel engines without extended oil fill change interval (15-20000 km i.e. 1 year), HTHS viscosity min. 2.9 mPa·s, ACEA A1/B1 + ILSAC GF-2.

Ford WSS-M2C-913-B

Oil for modern gasoline and diesel engines without extended oil fill change interval (20000 km i.e. 1 year), HTHS viscosity min. 2.9 mPa·s, ACEA A1/B1 + ILSAC GF-2 ili GF-3.

Ford WSS-M2C-917-A

Oil for diesel engines with pump-injector fuel injection system and without extended oil fill interval (15000 km i.e. 1 year), HTHS viscosity min. 3.5 mPa·s, ACEA B3/B4. This specification is practically identical to specification VW 505.01, which is only logical, because these are Volkswagen engines built into Ford's vehicles.

Other passenger vehicle manufacturers, which are not listed here, do not have special requirements as regards the quality of motor oils for service fill, but rather require quality in keeping with ACEA specifications. However, some of them (e.g. PSA, Renault, FIAT) issue approvals, but only for motor oil for the factory fill.

MOTOR OILS FOR PASSENGER VEHICLES

Since the specification requirements of individual passenger vehicle manufacturers are quite different, and sometimes even mutually incompatible, lubricant manufacturers are forced to formulate a large number of motor oils for passenger vehicles. It happens sometimes in the process that some oils are developed practically for a single engine manufacturer.

The best example for this is HTHS viscosity. Engine manufacturers have by their requirements practically classified motor oils into 3 groups:

HTHS viscosity min. 2.9 (3.0) mPa·s	BMW Longlife-01 FE Opel B 040 2095 Ford WSS-M2C-913-A/B
HTHS viscosity max. 3.5 mPa·s	ACEA A1/A5/B1/B5 VW 503.00/506.00/506.01
HTHS viscosity min. 3.5 mPa·s	ACEA A2/A3/B2/B3/B4 VW 502.00/503.01/505.00/505.01 MB 229.1/229.3/229.31/229.5 BMW Longlife-98/Longlife-01 Porsche Opel B 040 2098 Ford WSS-M2C-917-A

Requirements for a higher oil quality and fuel saving have caused changes in the share of viscosity grades of motor oils for passenger vehicles i.e. move towards motor oils of lower viscosity. Market analysis has shown that over the past 10 years there have been considerable changes in the share of individual motor oil viscosity grades (Figure 2).

Development and production of new motor oils of higher quality and lower viscosity grades requires an increased use of hydrocracked and synthetic base oils. With the previously large number of various motor oils, this causes high development and production costs. Especially difficult is the position of small-scale motor oil manufacturers which cannot cover such high testing costs with the oil volumes sold.

CONCLUSION

1. The quality of motor oils for passenger vehicles is defined by international specifications and specifications of the reputable engine/vehicle manufacturers.
2. Limitation of the exhaust gas emission, reduction of fuel consumption and extended oil life interval are the most influential factors for the development of new motor oil specifications.

3. Over the past few years, a large number of new engine/vehicle manufacturer specifications has appeared. The requirements of ACEA specifications represent only minimal requirements which the oil must meet. Engine/vehicle manufacturers build upon that their additional oil quality and performance requirements.
4. Requirements of new passenger vehicle motor oil specifications condition an increasing use of hydrocracked and synthetic base oils.
5. Specifications of motor oils by engine/vehicle manufacturers often have mutually incompatible requirements which on the market result in the large number of motor oils with specially targeted quality.

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389.6 specifikacije zahtjeva proizvođača motora za kvalitetom motornih ulja	engine manufacturer lubricating oil requirement specification
665.516.1 dopuštenja proizvođača motora za uporabu motornih ulja	engine manufacturer lubricanting oil approvals
629.113 : 061.2(4) Udruženje europskih proizvođača automobila	ACEA Association des Constructeurs Europeens d'Automobiles
629.114.6 : 061.2 proizvođači osobnih automobila	passenger car manufacturers
621.892.097.2 motorno ulje	motor oil
621.434 benzinski motor	gasoline engine
621.436 dizelov motor	diesel engine

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