To: API Lubricants Group
Cc: Lubricants Group Mailing List
API

Ballot for Table Q-7—ILSAC GF-6B Passenger Car Engine Oil Standard

On April 4, 2019 the Lubricants Standards Group (LSG) reviewed "Table Q-7—ILSAC GF-6B Passenger Car Engine Oil Standard".

Table Q-7 is given below and in the Electronic Ballot Attachment.

Q.6 ILSAC GF-6A/GF-6B Standard for Passenger Car Engine Oils (Effective May 1, 2020)

The Japan Automobile Manufacturers Association, Inc. and representatives from Fiat Chrysler Automobiles, Ford Motor Company, and General Motors LLC, through an organization called the International Lubricants Standardization Advisory Committee (ILSAC), jointly developed and approved the ILSAC GF-6A and GF-6B minimum performance standards for engine oils for spark-ignited internal combustion engines (see Tables Q-6 and Q-7).

This standard specifies the minimum performance requirements (both engine sequence and bench tests) and chemical and physical properties for engine oils for spark-ignited internal combustion engines. It is expected that many engine manufacturers will recommend ILSAC GF-6A and/or GF-6B oils. However, performance parameters other than those covered by the tests included or more stringent limits on those tests included in these standards may be required by individual OEMs.

In addition to meeting the requirements of the standards, it is the oil marketer's responsibility to be aware of and comply with all applicable legal and regulatory requirements on substance use restrictions, labeling, and health and safety information when marketing products meeting the ILSAC GF-6A and GF-6B standards. It is also the marketer's responsibility to conduct its business in a manner that represents minimum risk to consumers and the environment.

The ultimate assessment of an engine oil's performance must include a variety of vehicle fleet tests that simulate the full range of customer driving conditions. The engine sequence tests listed in this document have been specified instead of fleet testing to minimize testing time and costs. This simplification of test requirements is only possible because the specified engine sequence tests have been judged to be predictive of a variety of vehicle tests.

The relationships between engine sequence tests and vehicle fleet tests are judged valid based only on the range of base oils and additive technologies investigated — generally those that have proven to have satisfactory performance in service and that are in widespread use at this time. The introduction of base oils or additive technologies that constitute a significant departure from existing practice requires sufficient supporting vehicle fleet testing data to ensure there is no adverse effect to vehicle components or to emission control systems. This vehicle fleet testing should be conducted in addition to the other performance requirements listed in these standards.

It is the responsibility of any individual or organization introducing a new technology to perform this vehicle fleet testing, and the responsibility of the oil marketer to ensure the testing of new technology was satisfactorily completed. No marketer can claim to be acting in a reasonable and prudent manner if they knowingly use a new technology based only on the results of engine sequence testing without verifying the suitability of the new technology in vehicle fleet testing that simulates the full range of customer operation.

The ILSAC GF-6A and GF-6B Minimum Performance Standards include tests for which Viscosity Grade Read Across and Base Oil Interchange Guidelines have been developed by the appropriate groups. It should be pointed out, however, that when oil marketers use the guidelines, they do so based on their own judgment and at their own risk. The use of any guidelines does not absolve the marketer of the responsibility for meeting all specified requirements for any products the marketer sells in the marketplace that are licensed as ILSAC GF-6A or GF-6B with API.

Table Q-7—ILSAC GF-6B Passenger Car Engine Oil Standard

Requirement	Criterion
Fresh Oil Viscosity Requirements	
SAE J300	Oils shall meet all requirements of SAE J300. Viscosity grades are limited to SAE 0W-16 multigrade oils
Gelation index	ASTM D5133 12 (max) To be evaluated from –5˚C to temperature at which 40,000 cP is attained or –40˚C, or 2 Celsius degrees below appropriate MRV TP-1 temperature (defined by SAE J300), whichever occurs first
Engine Test Requirements	
Wear and oil thickening	ASTM Sequence IIIH (ASTM D8111)
Kinematic viscosity increase @ 40°C, %	100 (max)
Average weighted piston deposits, merits	4.2 (min)
Hot stuck rings	None
Wear, sludge, and varnish	ASTM Sequence VH (ASTM DXXXX)
Average engine sludge, merits	7.6 (min)
Average rocker cover sludge, merits	7.7 (min)
Average engine varnish, merits	8.6 (min)
Average piston skirt varnish, merits	7.6 (min)
Oil screen sludge, % area	Rate and report
Oil screen debris, % area	Rate and report
Hot-stuck compression rings	None
Cold stuck rings	Rate and report
Oil ring clogging, % area	Rate and report
Valvetrain wear	ASTM Sequence IVB (ASTM DXXXX)
Average intake lifter volume loss (8 position avg), mm^3	2.7 (max)
End of test iron, ppm	400 (max)
Fuel efficiency	ASTM Sequence VIF (ASTM D8226)
SAE 0W-16 viscosity grade	
FEI SUM	4.1% min
FEI 2	1.9% min after 125 hours aging
Low-speed preignition prevention	ASTM Sequence IX (ASTM DXXXX)
Average number of events for four iterations	5 (max)
Number of events per iteration	8 (max)
Chain wear	ASTM Sequence X (ASTM DXXXX)
Percent increase	0.085 (max)

Bench Test Requirements	
Catalyst compatibility	ASTM D4951 or D5185
Phosphorus content, % (mass)	0.08 (max)
Phosphorus volatility (Sequence IIIHB, phosphorus retention)	ASTM D7320 81% (min)
Sulfur content	ASTM D4951, D5185, or D2622
SAE 0W and 5W multigrades, % (mass)	0.5 (max)
Wear	ASTM D4951 or D5185
Phosphorus content, % (mass)	0.06 (min)
Volatility	ASTM D5800 (B&D)
Evaporation loss, %	15.0 (max), 1 hour at 250°C
Filterability	ASTM D6794
EOWTT, %	
with 0.6% H_2O	50 (max) flow reduction
with 1.0% H_2O	50 (max) flow reduction
with 2.0% H_2O	50 (max) flow reduction
with 3.0% H_2O	50 (max) flow reduction Note: Test formulation with highest additive (DI/VI) concentration. Read across results to all other base oil/viscosity grade formulations using same or lower concentration of identical additive (DI/VI) combination. Each different DI/VI combination must be tested.
EOFT, %	ASTM D6795 50 (max) flow reduction
Fresh oil foaming characteristics	ASTM D892 (Option A and excluding paragraph 11)
Tendency, mL	
Sequence I	10 (max)
Sequence II	50 (max)
Sequence III	10 (max)
Stability, mL, after 1-minute settling	
Sequence I	0 (max)
Sequence II	0 (max)
Sequence III	0 (max)
Fresh oil high temperature foaming characteristics	ASTM D6082 (Option A)
Tendency, mL	100 (max)
Stability, mL, after 1-minute settling	0 (max)

Aged oil low temperature viscosity Measure aged oil low temperature viscosity on final formulation (pursuant to existing read across described in Annex F)—this includes base oil and additive combination being licensed—for each viscosity grade by either ROBO or IIIHA Measure CCS viscosity of EOT ROBO or IIIHA sample at CCS temperature corresponding to original viscosity grade	ROBO (ASTM D7528) a) If CCS viscosity measured is less than or equal to the maximum CCS viscosity specified for the original viscosity grade, run ASTM D4684 (MRV TP-1) at the MRV temperature specified in SAE J300 for the original viscosity grade. b) If CCS viscosity measured is higher than the maximum viscosity specified for the original viscosity grade in J300, run ASTM D4684 (MRV TP-1) at 5°C higher temperature (i.e., at MRV temperature specified in SAE J300 for the next higher viscosity grade). c) EOT ROBO sample must show no yield stress in the D4684 test and its D4684 viscosity must be below the maximum specified in SAE J300 for the original viscosity grade or the next higher viscosity grade, depending on the CCS viscosity grade, as outlined in a) or b) above. or
Aged oil low temperature viscosity Measure aged oil low temperature viscosity on final formulation (pursuant to existing read across described in Annex F)—this includes base oil and additive combination being licensed—for each viscosity grade by either ROBO or IIIHA Measure CCS viscosity of EOT ROBO or IIIHA sample at CCS temperature corresponding to original viscosity grade	ASTM Sequence IIIHA (ASTM D8111) a) If CCS viscosity measured is less than or equal to the maximum CCS viscosity specified for the original viscosity grade, run ASTM D4684 (MRV TP-1) at the MRV temperature specified in SAE J300 for the original viscosity grade. b) If CCS viscosity measured is higher than the maximum viscosity specified for the original viscosity grade in J300, run ASTM D4684 (MRV TP-1) at 5°C higher temperature (i.e., at MRV temperature specified in SAE J300 for the next higher viscosity grade). c) EOT IIIHA sample must show no yield stress in the D4684 test and its D4684 viscosity must be below the maximum specified in SAE J300 for the original viscosity grade or the next higher viscosity grade, depending on the CCS viscosity grade, as outlined in a) or b) above.
Shear stability KV @ 100°C after 30 passes, cSt	Diesel Injector (ASTM D6278) 5.8 (min)
Homogeneity and miscibility	ASTM D6922 Shall remain homogeneous and, when mixed with ASTM Test Monitoring Center (TMC) reference oils, shall remain miscible.
Engine rusting Average gray value	Ball Rust Test (ASTM D6557) 100 (min)
Emulsion retention 0°C, 24 hours 25°C, 24 hours	ASTM D7563 No water separation No water separation
Elastomer compatibility	ASTM D7216 Annex A2 Candidate oil testing for elastomer compatibility shall be performed using the five Standard Reference Elastomers (SREs) referenced herein and defined in SAE J2643. Candidate oil testing shall be performed according to ASTM D7216 Annex A2. The post-candidate-oil-immersion elastomers shall conform to the specification limits detailed below:

Elastomer Material (SAE J2643)	Test Procedure	Material Property	Units	Limits
Polyacrylate Rubber (ACM-1)	ASTM D471	Volume	% Δ	-5, 9
	ASTM D2240	Hardness	pts.	-10, 10
	ASTM D412	Tensile Strength	% Δ	-40, 40
Hydrogenated Nitrile Rubber (HNBR-1)	ASTM D471	Volume	% Δ	-5, 10
	ASTM D2240	Hardness	pts.	-10, 5
	ASTM D412	Tensile Strength	% Δ	-20, 15
Silicone Rubber (VMQ-1)	ASTM D471	Volume	% Δ	-5, 40
	ASTM D2240	Hardness	pts.	-30, 10
	ASTM D412	Tensile Strength	% Δ	-50, 5
Fluorocarbon Rubber (FKM-1)	ASTM D471	Volume	% Δ	-2, 3
	ASTM D2240	Hardness	pts.	-6, 6
	ASTM D412	Tensile Strength	% Δ	-65, 10
Ethylene Acrylic Rubber (AEM-1)	ASTM D471	Volume	% Δ	-5, 30
	ASTM D2240	Hardness	pts.	-20, 10
	ASTM D412	Tensile Strength	% Δ	-30, 30

Applicable Documents:

1. SAE Standard, Engine Oil Viscosity Classification—SAE J300, *SAE Handbook*.
2. SAE Standard, Standard Reference Elastomers (SRE) for Characterizing the Effects on Vulcanized Rubbers, Proposed Draft 2003-5—SAE J2643, *SAE Handbook*.
3. ASTM Annual Book of Standards, Volume 5, Petroleum Products and Lubricants, current edition.
5. M. Batko and D. F. Florkowski, "Low Temperature Rheological Properties of Aged Crankcase Oils," SAE Paper 2000-01-2943.
6. M. Batko and D. F. Florkowski, "Lubricant Requirements of an Advanced Designed High Performance, Fuel Efficient Low Emissions V-6 Engine," SAE Paper 01FL-265

After review and discussion, the LSG agreed by voice vote to **Ballot Table Q-7—ILSAC GF-6B Passenger Car Engine Oil Standard.** The Motion to Ballot Table Q-7 is given below and in the Ballot Attachment.

Motion

Motion to Ballot: Adopt ILSAC GF-6B, Revision 25 (as Accepted by AOAP on April 3, 2019) into API 1509 Annex Q with a First Licensing Date of May 1, 2020.

- Motion by: Mike Alessi
- Second by: Bill O'Ryan
  - ✓ Affirmative: 16
  - ✓ Negative: 0
  - ✓ Abstain: 0

Motion Passed

Lubricants Group Members should use the API Ballot System to cast their vote and make comments. The Ballot Link is: http://Ballots.api.org. The Lubricants Group Member votes will be counted, and all received comments reviewed and considered before the ballot results are final.

Non-Lubricants Group Members should comment on the Ballot Motion using the Ballot system. The Ballot Link is: http://Ballots.api.org . All comments on the Ballot Motion will be reviewed before the ballot results are final.

This Ballot will close on May 6, 2019. All Votes and/or Comments must be received by that date. If approved the balloted change will be effective as of April 4, 2019.

Attachment 1

Table Q-7—ILSAC GF-6B Passenger Car Engine Oil Standard

Q.6 ILSAC GF-6A/GF-6B Standard for Passenger Car Engine Oils (Effective May 1, 2020)

The Japan Automobile Manufacturers Association, Inc. and representatives from Fiat Chrysler Automobiles, Ford Motor Company, and General Motors LLC, through an organization called the International Lubricants Standardization Advisory Committee (ILSAC), jointly developed and approved the ILSAC GF-6A and GF-6B minimum performance standards for engine oils for spark-ignited internal combustion engines (see Tables Q-6 and Q-7).

This standard specifies the minimum performance requirements (both engine sequence and bench tests) and chemical and physical properties for engine oils for spark-ignited internal combustion engines. It is expected that many engine manufacturers will recommend ILSAC GF-6A and/or GF-6B oils. However, performance parameters other than those covered by the tests included or more stringent limits on those tests included in these standards may be required by individual OEMs.

In addition to meeting the requirements of the standards, it is the oil marketer's responsibility to be aware of and comply with all applicable legal and regulatory requirements on substance use restrictions, labeling, and health and safety information when marketing products meeting the ILSAC GF-6A and GF-6B standards. It is also the marketer's responsibility to conduct its business in a manner that represents minimum risk to consumers and the environment.

The ultimate assessment of an engine oil's performance must include a variety of vehicle fleet tests that simulate the full range of customer driving conditions. The engine sequence tests listed in this document have been specified instead of fleet testing to minimize testing time and costs. This simplification of test requirements is only possible because the specified engine sequence tests have been judged to be predictive of a variety of vehicle tests.

The relationships between engine sequence tests and vehicle fleet tests are judged valid based only on the range of base oils and additive technologies investigated — generally those that have proven to have satisfactory performance in service and that are in widespread use at this time. The introduction of base oils or additive technologies that constitute a significant departure from existing practice requires sufficient supporting vehicle fleet testing data to ensure there is no adverse effect to vehicle components or to emission control systems. This vehicle fleet testing should be conducted in addition to the other performance requirements listed in these standards.

It is the responsibility of any individual or organization introducing a new technology to perform this vehicle fleet testing, and the responsibility of the oil marketer to ensure the testing of new technology was satisfactorily completed. No marketer can claim to be acting in a reasonable and prudent manner if they knowingly use a new technology based only on the results of engine sequence testing without verifying the suitability of the new technology in vehicle fleet testing that simulates the full range of customer operation.

The ILSAC GF-6A and GF-6B Minimum Performance Standards include tests for which Viscosity Grade Read Across and Base Oil Interchange Guidelines have been developed by the appropriate groups. It should be pointed out, however, that when oil marketers use the guidelines, they do so based on their own judgment and at their own risk. The use of any guidelines does not absolve the marketer of the responsibility for meeting all specified requirements for any products the marketer sells in the marketplace that are licensed as ILSAC GF-6A or GF-6B with API.

Table Q-7—ILSAC GF-6B Passenger Car Engine Oil Standard

Requirement	Criterion
Fresh Oil Viscosity Requirements	
SAE J300	Oils shall meet all requirements of SAE J300. Viscosity grades are limited to SAE 0W-16 multigrade oils
Gelation index	ASTM D5133 12 (max) To be evaluated from –5˚C to temperature at which 40,000 cP is attained or –40˚C, or 2 Celsius degrees below appropriate MRV TP-1 temperature (defined by SAE J300), whichever occurs first
Engine Test Requirements	
Wear and oil thickening	ASTM Sequence IIIH (ASTM D8111)
Kinematic viscosity increase @ 40°C, %	100 (max)
Average weighted piston deposits, merits	4.2 (min)
Hot stuck rings	None
Wear, sludge, and varnish	ASTM Sequence VH (ASTM DXXXX)
Average engine sludge, merits	7.6 (min)
Average rocker cover sludge, merits	7.7 (min)
Average engine varnish, merits	8.6 (min)
Average piston skirt varnish, merits	7.6 (min)
Oil screen sludge, % area	Rate and report
Oil screen debris, % area	Rate and report
Hot-stuck compression rings	None
Cold stuck rings	Rate and report
Oil ring clogging, % area	Rate and report
Valvetrain wear	ASTM Sequence IVB (ASTM DXXXX)
Average intake lifter volume loss (8 position avg), mm^3	2.7 (max)
End of test iron, ppm	400 (max)
Fuel efficiency	ASTM Sequence VIF (ASTM D8226)
SAE 0W-16 viscosity grade	
FEI SUM	4.1% min
FEI 2	1.9% min after 125 hours aging
Low-speed preignition prevention	ASTM Sequence IX (ASTM DXXXX)
Average number of events for four iterations	5 (max)
Number of events per iteration	8 (max)
Chain wear	ASTM Sequence X (ASTM DXXXX)
Percent increase	0.085 (max)

Bench Test Requirements	
Catalyst compatibility	ASTM D4951 or D5185
Phosphorus content, % (mass)	0.08 (max)
Phosphorus volatility (Sequence IIIHB, phosphorus retention)	ASTM D7320 81% (min)
Sulfur content	ASTM D4951, D5185, or D2622
SAE 0W and 5W multigrades, % (mass)	0.5 (max)
Wear	ASTM D4951 or D5185
Phosphorus content, % (mass)	0.06 (min)
Volatility	ASTM D5800 (B&D)
Evaporation loss, %	15.0 (max), 1 hour at 250°C
Filterability	ASTM D6794
EOWTT, %	
with 0.6% H_2O	50 (max) flow reduction
with 1.0% H_2O	50 (max) flow reduction
with 2.0% H_2O	50 (max) flow reduction
with 3.0% H_2O	50 (max) flow reduction Note: Test formulation with highest additive (DI/VI) concentration. Read across results to all other base oil/viscosity grade formulations using same or lower concentration of identical additive (DI/VI) combination. Each different DI/VI combination must be tested.
EOFT, %	ASTM D6795 50 (max) flow reduction
Fresh oil foaming characteristics	ASTM D892 (Option A and excluding paragraph 11)
Tendency, mL	
Sequence I	10 (max)
Sequence II	50 (max)
Sequence III	10 (max)
Stability, mL, after 1-minute settling	
Sequence I	0 (max)
Sequence II	0 (max)
Sequence III	0 (max)
Fresh oil high temperature foaming characteristics	ASTM D6082 (Option A)
Tendency, mL	100 (max)
Stability, mL, after 1-minute settling	0 (max)

Aged oil low temperature viscosity Measure aged oil low temperature viscosity on final formulation (pursuant to existing read across described in Annex F)—this includes base oil and additive combination being licensed—for each viscosity grade by either ROBO or IIIHA Measure CCS viscosity of EOT ROBO or IIIHA sample at CCS temperature corresponding to original viscosity grade	ROBO (ASTM D7528) a) If CCS viscosity measured is less than or equal to the maximum CCS viscosity specified for the original viscosity grade, run ASTM D4684 (MRV TP-1) at the MRV temperature specified in SAE J300 for the original viscosity grade. b) If CCS viscosity measured is higher than the maximum viscosity specified for the original viscosity grade in J300, run ASTM D4684 (MRV TP-1) at 5°C higher temperature (i.e., at MRV temperature specified in SAE J300 for the next higher viscosity grade). c) EOT ROBO sample must show no yield stress in the D4684 test and its D4684 viscosity must be below the maximum specified in SAE J300 for the original viscosity grade or the next higher viscosity grade, depending on the CCS viscosity grade, as outlined in a) or b) above.
	or
Aged oil low temperature viscosity Measure aged oil low temperature viscosity on final formulation (pursuant to existing read across described in Annex F)—this includes base oil and additive combination being licensed—for each viscosity grade by either ROBO or IIIHA Measure CCS viscosity of EOT ROBO or IIIHA sample at CCS temperature corresponding to original viscosity grade	ASTM Sequence IIIHA (ASTM D8111) a) If CCS viscosity measured is less than or equal to the maximum CCS viscosity specified for the original viscosity grade, run ASTM D4684 (MRV TP-1) at the MRV temperature specified in SAE J300 for the original viscosity grade. b) If CCS viscosity measured is higher than the maximum viscosity specified for the original viscosity grade in J300, run ASTM D4684 (MRV TP-1) at 5°C higher temperature (i.e., at MRV temperature specified in SAE J300 for the next higher viscosity grade). c) EOT IIIHA sample must show no yield stress in the D4684 test and its D4684 viscosity must be below the maximum specified in SAE J300 for the original viscosity grade or the next higher viscosity grade, depending on the CCS viscosity grade, as outlined in a) or b) above.
Shear stability KV @ 100°C after 30 passes, cSt	Diesel Injector (ASTM D6278) 5.8 (min)
Homogeneity and miscibility	ASTM D6922 Shall remain homogeneous and, when mixed with ASTM Test Monitoring Center (TMC) reference oils, shall remain miscible.
Engine rusting Average gray value	Ball Rust Test (ASTM D6557) 100 (min)
Emulsion retention 0°C, 24 hours 25°C, 24 hours	ASTM D7563 No water separation No water separation
Elastomer compatibility	ASTM D7216 Annex A2 Candidate oil testing for elastomer compatibility shall be performed using the five Standard Reference Elastomers (SREs) referenced herein and defined in SAE J2643. Candidate oil testing shall be performed according to ASTM D7216 Annex A2. The post-candidate-oil-immersion elastomers shall conform to the specification limits detailed below:

Elastomer Material (SAE J2643)	Test Procedure	Material Property	Units	Limits
Polyacrylate Rubber (ACM-1)	ASTM D471	Volume	% Δ	-5, 9
	ASTM D2240	Hardness	pts.	-10, 10
	ASTM D412	Tensile Strength	% Δ	-40, 40
Hydrogenated Nitrile Rubber (HNBR-1)	ASTM D471	Volume	% Δ	-5, 10
	ASTM D2240	Hardness	pts.	-10, 5
	ASTM D412	Tensile Strength	% Δ	-20, 15
Silicone Rubber (VMQ-1)	ASTM D471	Volume	% Δ	-5, 40
	ASTM D2240	Hardness	pts.	-30, 10
	ASTM D412	Tensile Strength	% Δ	-50, 5
Fluorocarbon Rubber (FKM-1)	ASTM D471	Volume	% Δ	-2, 3
	ASTM D2240	Hardness	pts.	-6, 6
	ASTM D412	Tensile Strength	% Δ	-65, 10
Ethylene Acrylic Rubber (AEM-1)	ASTM D471	Volume	% Δ	-5, 30
	ASTM D2240	Hardness	pts.	-20, 10
	ASTM D412	Tensile Strength	% Δ	-30, 30

Applicable Documents:

1. SAE Standard, Engine Oil Viscosity Classification—SAE J300, *SAE Handbook*.
2. SAE Standard, Standard Reference Elastomers (SRE) for Characterizing the Effects on Vulcanized Rubbers, Proposed Draft 2003-5—SAE J2643, *SAE Handbook*.
3. ASTM Annual Book of Standards, Volume 5, Petroleum Products and Lubricants, current edition.
5. M. Batko and D. F. Florkowski, “Low Temperature Rheological Properties of Aged Crankcase Oils,” SAE Paper 2000-01-2943.
6. M. Batko and D. F. Florkowski, “Lubricant Requirements of an Advanced Designed High Performance, Fuel Efficient Low Emissions V-6 Engine,” SAE Paper 01FL-265

Attachment 2

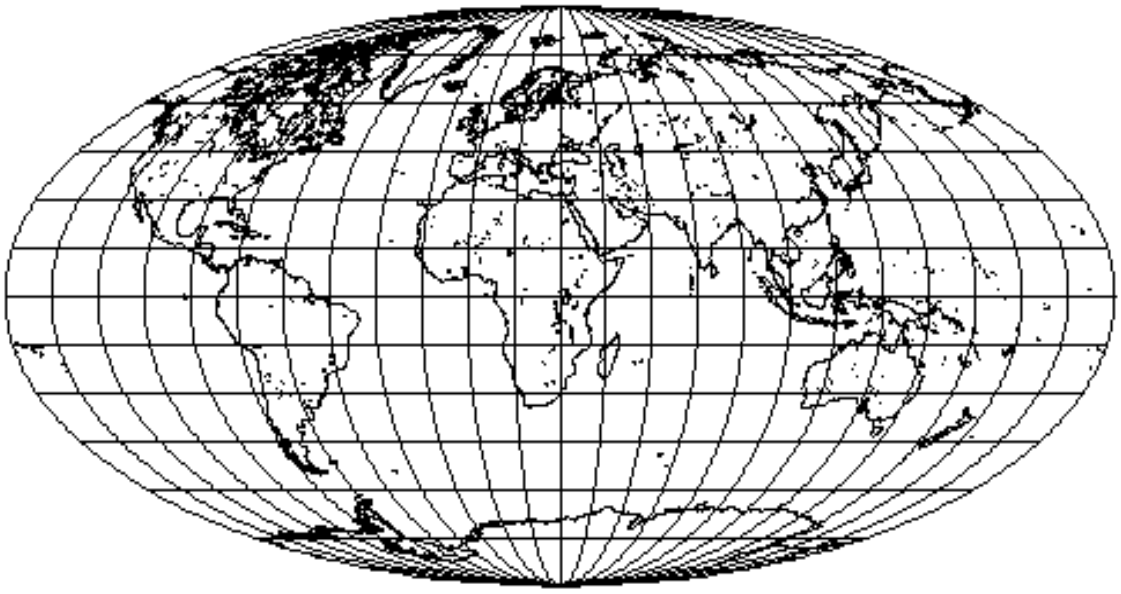
ILSAC GF-6B RECOMMENDATIONS FOR PASSENGER CAR ENGINE OILS

Rev. 25

DRAFT DOCUMENT

These ILSAC recommendations are being developed with input from automobile manufacturers, lubricant producers and lubricant additive companies in a process that is open to public review.

INTERNATIONAL LUBRICANT SPECIFICATION ADVISORY COMMITTEE



ILSAC GF-6B RECOMMENDATIONS FOR PASSENGER CAR ENGINE OILS

DRAFT April 3, 2019

ILSAC GF-6B RECOMMENDATIONS

April 3,, 2019

1. FRESH OIL VISCOSITY REQUIREMENTS

1.a SAE J300

Viscosity grades shall be limited to SAE 0W-16

Note: Any viscosity grades lower than SAE 16 as defined by HTHS150, i.e., <2.3 mPa-s, would have to be reviewed and approved by AOAP (or its successor group) before being included in the above list of viscosity grades approved for GF-6B

1.b Gelation Index: ASTM D5133 — 12 maximum

To be evaluated from –5°C to the temperature at which 40,000 cP is attained or –40°C, or 2 Celsius degrees below the appropriate MRV TP-1 temperature (defined by SAE J300), whichever occurs first.

2. ENGINE TEST REQUIREMENTS

2.a Oil Thickening: ASTM Sequence IIIH Test, ASTM D8111

Kinematic Viscosity Increase @ 40°C, %	100 maximum
Average Weighted Piston Deposits, merits	4.2 minimum
Hot Stuck Rings	None

2.b Sludge, and Varnish Test: Sequence VH ASTM DXXXX

Average Engine Sludge, merits	7.6 minimum
Average Rocker Cover Sludge, merits	7.7 minimum
Average Engine Varnish, merits	8.6 minimum
Average Piston Skirt Varnish, merits	7.6 minimum
Oil Screen Sludge, % area	Rate and report
Oil Screen Debris, % area	Rate and report
Hot Stuck Compression Rings	None
Cold Stuck Rings	Rate and report
Oil Ring Clogging, % area	Rate and report

2.c Valvetrain Wear: Sequence IVB ASTM DXXXX

Average Intake Lifter Volume Loss (8 position average), mm^3	2.7 maximum
End of Test Iron, ppm	400 maximum

2.d Fuel Efficiency, Sequence VIF ASTM D8226

SAE 0W-16 viscosity grade:

FEI SUM	4.1 minimum
FEI 2	1.9 minimum after 125 hours aging

2.d Chain wear: Sequence X

% increase	0.085 maximum

2.f Low Speed Preignition Prevention, Sequence IX

Average number of events for 4 iterations	5 maximum
Number of events per iteration	8 maximum

3. BENCH TEST REQUIREMENTS

3.a Catalyst Compatibility

Phosphorus Content, ASTM D4951	0.08% (mass) maximum
Phosphorus Volatility, ASTM D8111 (Sequence IIIHB phosphorus retention)	81% minimum
Sulfur Content, ASTM D4951 or D2622	0.5% (mass) maximum

3.b Wear

Phosphorus Content, ASTM D4951	0.06% (mass) minimum

3.c Volatility

Evaporation Loss, ASTM D5800 B/D	15.0% maximum, 1 h at 250°C

3.e Filterability

EOWTT, ASTM D6794

with 0.6% H_2O	50% maximum flow reduction
with 1.0% H_2O	50% maximum flow reduction
with 2.0% H_2O	50% maximum flow reduction
with 3.0% H_2O	50% maximum flow reduction

Test formulation with highest additive (DI/VI) concentration. Read across results to all other base oil/viscosity grade formulations using the same or lower concentration of the identical additive (DI/VI) combination. Each different DI/VI combination must be tested.

EOFT, ASTM D6795	50% maximum flow reduction

3.f Fresh Oil Foaming Characteristics,
ASTM D892 (Option A and excluding paragraph 11)

	Tendency	Stability*
Sequence I	10 mL maximum	0 mL maximum
Sequence II	50 mL maximum	0 mL maximum
Sequence III	10 mL maximum	0 mL maximum

*After 1 minute settling period

3.g Fresh Oil High Temperature Foaming Characteristics,
ASTM D6082 (Option A)

Tendency	Stability*
100 mL maximum	0 mL maximum

*After 1-minute settling period

3.h Aged Oil Low Temperature Viscosity,

Aged oil low temperature viscosity must be measured on the final formulation, this includes base oil and additive combination being licensed, for each viscosity grade by either ROBO or IIIHA

Measure CCS viscosity of the EOT ROBO or IIIHA sample at the CCS temperature corresponding to original viscosity grade

Aged Oil Low Temperature Viscosity ROBO Test, ASTM D7528

a) If CCS viscosity measured is less than or equal to the maximum CCS viscosity specified for the original viscosity grade, run ASTM D4684 (MRV TP-1) at the MRV temperature specified in SAE J300 for the original viscosity grade.
b) If CCS viscosity measured is higher than the maximum viscosity specified for the original viscosity grade in J300, run ASTM D4684 (MRV TP-1) at 5°C higher temperature (i.e., at MRV temperature specified in SAE J300 for the next higher viscosity grade).
c) The EOT ROBO sample must show no yield stress in the D4684 test and its D4684 viscosity must be below the maximum specified in SAE J300 for the original viscosity grade, or the next higher viscosity grade, depending on the CCS viscosity, as outlined in a) or b) above.

or

Aged Oil Low Temperature Viscosity, ASTM Sequence IIIHA Test, ASTM D8111

a) If CCS viscosity measured is less than or equal to the maximum CCS viscosity specified for the original viscosity grade, run ASTM D4684 (MRV TP-1) at the MRV temperature specified in SAE J300 for the original viscosity grade.
b) If CCS viscosity measured is higher than the maximum viscosity specified for the original viscosity grade in J300, run ASTM D4684 (MRV TP-1) at 5°C higher temperature (i.e., at MRV temperature specified in SAE J300 for the next higher viscosity grade).
c) The EOT IIIHA sample must show no yield stress in the D4684 test and its D4684 viscosity must be below the maximum specified in SAE J300 for the original viscosity grade, or the next higher viscosity grade, depending on the CCS viscosity, as outlined in a) or b) above.

3.i Shear Stability, Diesel Injector, ASTM D6278

KV @ 100°C (after 30 passes)	5.8 cSt minimum

3.j Homogeneity and Miscibility, ASTM D6922

Shall remain homogeneous and, when mixed with TMC reference oils, shall remain miscible.

3.k Engine Rusting, Ball Rust Test, ASTM D6557

Average Gray Value	100 minimum

3.l Emulsion Retention, ASTM D7563

0°C, 24 Hours	No water separation
25°C, 24 Hours	No water separation

3.m Candidate oil testing for elastomer compatibility shall be performed using the five Standard Reference Elastomers (SREs) referenced herein and defined in SAE J2643. Candidate oil testing shall be performed according to ASTM D7216 Annex A2, The post-candidate-oil-immersion elastomers shall conform to the specification limits detailed herein.

Elastomer Material (SAE J2643)	Test Procedure	Material Property	Units	Limits
Polyacrylate Rubber (ACM-1)	ASTM D471	Volume	%	-5, 9
	ASTM D2240	Hardness	pts.	-10, 10
	ASTM D412	Tensile Strength	%	-40, 40
Hydrogenated Nitrile Rubber (HNBR-1)	ASTM D471	Volume	%	-5, 10
	ASTM D2240	Hardness	pts.	-10, 5
	ASTM D412	Tensile Strength	%	-20, 15
Silicone Rubber (VMQ-1)	ASTM D471	Volume	%	-5, 40
	ASTM D2240	Hardness	pts.	-30, 10
	ASTM D412	Tensile Strength	%	-50, 5
Fluorocarbon Rubber (FKM-1)	ASTM D471	Volume	%	-2, 3
	ASTM D2240	Hardness	pts.	-6, 6
	ASTM D412	Tensile Strength	%	-65, 10
Ethylene Acrylic Rubber (AEM-1)	ASTM D471	Volume	%	-5, 30
	ASTM D2240	Hardness	pts.	-20, 10
	ASTM D412	Tensile Strength	%	-30, 30

4. APPLICABLE DOCUMENTS