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ILSAC GF-5: NEW PERFORMANCE STANDARD FOR PASSENGER CAR ENGINE OILS

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The newest engine oil performance standard for automotive gasoline engines, ILSAC[(1)] GF-5, becomes official October 1, 2010. ILSAC GF-5 defines the performance requirements for engine oils for use in 2011 model-year vehicles. Development of ILSAC GF-5 targeted three key performance improvements relative to ILSAC GF-4: (1) improved fuel economy; (2) improved engine oil robustness, in particular piston cleanliness and engine sludge protection; and (3) improved protection of emissions control systems. In addition, new performance criteria are included to demonstrate compatibility with E85 fuel, turbocharger protection (from deposits) and seal compatibility with five commonly used elastomers.

A comparison of the test requirements for ILSAC GF-5 and ILSAC GF-4 is shown in Table 1, with tighter limits and new test requirements highlighted in red. In this article, we will discuss these changes and their significance.

Improved Fuel Economy

EPA-mandated Corporate Average Fuel Economy (CAFE) targets for passenger cars and light trucks are being increased again in order to further reduce CO_2 emissions. Failure to meet these targets results in substantial fines to the automakers. Thus, fuel consumption remains a critical issue, and all potential sources of improved fuel economy are important, including the use of fuel-efficient engine oils. Consumers also benefit from improvements in fuel economy as the price of fuel continues to increase.

Engine oil fuel efficiency is measured in the **Sequence VID** engine test, which replaces the previous Sequence VIB engine test. Two measurements of fuel economy improvement (FEI) relative to a reference oil are made. The first measurement, FEI1, is taken after the oil has been "aged" for 16 hours, and provides an indication of fuel economy improvement with new or fresh oil. The second measurement, FEI2, is taken after an additional 84 hours of aging (100 hours total) and gives an indication of retention of fuel economy improvement (i.e., durability) with used oil. Specific requirements depend on the viscosity grade, as shown in Table 1.

Although the GF-5 test requirements appear to be much more severe than the GF-4 limits, the absolute numbers are not directly comparable because the VID test uses a newer, GM 3.6-liter V-6 engine, whereas the VIB test used a Ford 4.6-liter V-8 engine. The new test limits were established to target a 0.5% increase in fuel economy performance compared with GF-4 quality engine oils.

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Test / Performance Characteristic	**Test Parameter**	**Test Limit ILSAC GF-4**	**Test Limit ILSAC GF-5**
Sequence IIIG High-Temperature Wear & Oil Thickening	Viscosity Increase Ave. Cam + Lifter Wear Ave. Weighted Piston Deposits	150% max 60 µm max 3.5 min	150% max 60 µm max 4.0 min
Sequence IIIG-A or ROBO Test Low-Temperature Used Oil Pumpability	MRV TP-1	Stay-in-grade or next highest grade	Stay-in-grade or next highest grade
Sequence IVA Valve Train Wear	Ave. Cam Wear	90 µm max	90 µm max
Sequence VG Low-Temperature Sludge & Wear	Ave. Engine Sludge Ave. Rocker Cover Sludge Oil Screen Clogging	7.8 min 8.0 min 20% max	8.0 min 8.3 min 15% max
Sequence VIII Bearing Corrosion	Bearing Weight Loss	26 mg max	26 mg max
Sequence VID Fuel Economy Improvement	XW-20 0W-30, 5W-30 10W-30	16-hr FEI / 96-hr FEI 2.3 / 2.0 min 1.8 / 1.5 min 1.1 / 0.8 min	Sum FEI / 100-hr FEI 2.6 / 1.2 min 1.9 / 0.9 min 1.5 / 0.6 min
Ball Rust Test (BRT) Engine Rust	Ave. Gray Value	100 min	100 min
Catalyst Compatibility	Phosphorus Content, max Phosphorus Volatility/Retention Sulfur Content 0W-XX, 5W-XX Sulfur Content 10W-30	0.08% max, 0.06% min none 0.5% max 0.7% max	0.08% max, 0.06% min 79% min 0.5% max 0.6% max

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Elastomer Compatibility	Volume Hardness Tensile Strength	N/A	Polyacrylate Rubber Nitrile Rubber Silicone Rubber Fluorocarbon Rubber Ethylene Acrylic Rubber
Emulsion Retention	Water Separation, 24 hrs, 0°C Water Separation, 24 hrs, 25°C	N/A	None None
TEOST MHT-4 High-Temperature Deposits	Deposit Weight	35 mg max	35 mg max
TEOST 33C High-Temperature Deposits	Total Deposit Weight	N/A	30 mg max (except no limit for SAE 0W-20)
Volatility	Weight Loss, NOACK Weight Loss, Sim Dist	15% max 10% max	15% max. 10% max.

Table 1. Comparison of ILSAC GF-5 and ILSAC GF-4 Test Requirements.

More Robust Engine Oils

Automakers desire more robust engine oils to provide better overall engine protection as well as improved engine durability. This benefits not only the consumer, but also protects the automakers' investment in leased vehicles, which may not be serviced as frequently as customer-owned vehicles. Three performance criteria targeted for improvement in GF-5 are piston cleanliness, engine sludge protection and turbocharger protection.

The **Sequence IIIG** engine test evaluates oil thickening, piston deposits and valve train wear under high-speed, high-temperature conditions that simulate trailer towing in hot weather. For GF-5, the limits for viscosity increase and valve train wear have not changed, but the minimum requirement for piston deposits merit rating is more severe, 4.0 versus 3.5 for GF-4 (higher number means less deposits). Failure to control piston deposits can lead to decreased engine performance and high oil consumption, which in turn can lead to increased exhaust emissions.

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The **Sequence VG** engine test evaluates engine sludge and varnish formation under low- to moderate-temperature conditions comparable to daily commuting and stop-and-go delivery service. Sludge leads to deposit formation buildup in the engine and can lead to engine failure. For GF-5, test limits are slightly more severe than in GF-4 (again, higher rating numbers mean less sludge).

The **TEOST 33C** bench test evaluates an engine oil's tendency to form high-temperature deposits. This test was originally developed and included in GF-2 to evaluate turbocharger deposits. It was not part of GF-3 or GF-4, but is back in GF-5 in anticipation of greater use of turbochargers. Turbochargers allow the automakers to use smaller displacement, more fuel-efficient engines while still maintaining high power output. Deposit buildup in the turbocharger bearing areas can lead to loss of engine performance, turbocharger failure and possibly engine failure. In GF-2, the maximum limit for deposits was 60 mg. For GF-5, the maximum limit is 30 mg (except there is no limit for SAE 0W-20 oils because some Japanese OEMs recommend SAE 0W-20 oils with high molybdenum content which will not pass this test).

Emissions System Protection

Phosphorus and sulfur are both known to be "poisonous" to emissions system catalysts, and therefore chemical limits on phosphorus content in engine oils have been in place since GF-1, and limits on sulfur content were introduced with GF-4. In GF-5, there is no change on chemical limits except for the sulfur content in SAE 10W-30 oils, which is reduced from 0.7% maximum to 0.6% maximum. However, a new bench test for phosphorus volatility is now included, with a requirement that the engine oil retain a minimum of 79% of its original phosphorus content. This test has been included because different phosphorus compounds (antiwear additives) can have different volatilities and therefore have different poisoning effects on emissions catalysts, even though the finished oils have the same total phosphorus content. It is added insurance against catalyst poisoning.

Compatibility with E85 Fuel

With increased numbers of flexible-fuel vehicles expected in the marketplace, engine oil compatibility with E85 (85% ethanol/15% gasoline) becomes a concern if there is a high level of fuel dilution. The concern is that under short trip, cold weather driving conditions, if sufficient unburned fuel and combustion by-products (i.e., water) get into the engine oil, phase separation could occur. This would leave a layer of water/ethanol (ethanol is miscible in water) at the bottom of the oil sump to be picked up by the oil pump. To address this concern, a new emulsion retention bench test (ASTM D7563) is included in GF-5. In this test, a mixture of engine oil (80%), distilled water (10%) and E85 (10%) is "blended" in a Waring blender to form an emulsion. To pass the test, there can be no water separation after 24 hours at 0°C and at 25°C, and no additive dropout can occur when the emulsified oil is subsequently heated above 110°C.

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Seal Compatibility

Although automakers have included requirements for seal compatibility in their own factory fill and service fill specifications (e.g., GM6094M and GM4718M for GF-4), there have been no formal requirements for such testing in the previous ILSAC standards. Previous ILSAC standards have referred to the availability of reference elastomers for compatibility testing, but it was left to the additive companies and oil manufacturers to do sufficient testing to ensure there is no chance of seal failures with new engine oils.

Now, OEM test requirements for seal compatibility have been incorporated into the ILSAC GF-5 standard. Testing is done with five commonly used seal materials (see Table 1). The seal materials are immersed into hot oil for 336 hours and then evaluated for changes in volume, hardness and tensile strength.

Formulation Requirements

To provide improved deposit and sludge control, engine oils need to be formulated with high-quality (low-volatility) base oils and higher treat rates of oxidation inhibitors and detergent/dispersant additives. To provide improved fuel economy performance, higher treat rates of friction modifiers are often required. The phosphorus volatility requirement will require careful selection of antiwear additives. As usual, formulators must achieve a delicate balance as additive treatments designed to improve one performance characteristic (e.g., piston deposits) may have a negative impact on another performance characteristic (e.g., fuel economy).

API Service Category SN

The new API SN and API SN with “Resource Conserving” service classifications are still being finalized, and will be discussed in a future article.

Benefits of ILSAC GF-5 Oils

In summary, the ILSAC GF-5 standard provides enhanced performance benefits compared with the ILSAC GF-4 standard. These improvements include better protection against high-temperature deposits, better protection against engine sludge and varnish formation, improved protection of emissions system catalysts, and fuel economy improvement. Also, new tests have been included to ensure compatibility with E85 fuel, compatibility with various elastomer seals, and protection of turbochargers. A summary of these performance improvements and consumer benefits are listed in Table 2.

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Improved fuel economy & retention of fuel economy benefits	Lower fuel costs Reduced emissions Better air quality
Improved high-temperature deposit control	Piston ring cleanliness Lower oil consumption Improved turbocharger performance
Improved sludge & varnish control	Cleaner engine
Phosphorus & sulfur limits Phosphorus volatility	Increased catalyst durability Reduced emissions
Emulsion retention	Compatibility with E85 fuel
Seal compatibility	Confidence against oil leaks in older vehicles

Table 2. Benefits of ILSAC GF-5 Oils.

October 1, 2010, is the first official licensing date for ILSAC GF-5. ConocoPhillips Company has been working closely with the OEMs and additive suppliers to develop these next-generation engine oils. Stay tuned for additional information on the introduction of our GF-5 engine oils.

(1) *ILSAC = International Lubricant Standardization and Approval Committee*