




A Study of SAE 5W-30 Synthetic Motor Oils

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AMSOIL Signature Series Synthetic Motor Oil
Castrol Edge® with Titanium Fluid Strength Technology®
Lucas Synthetic
Mobil 1™ Extended Performance
Pennzoil Ultra™
Petro-Canada SUPREME Synthetic™
Quaker State Ultimate Durability™
Red Line High Performance Motor Oil
Royal Purple High Performance Motor Oil
Valvoline SynPower® Full Synthetic Motor Oil



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Overview

While conventional motor oil sales remain flat, synthetic motor oils continue to demonstrate strong annual growth. Motorists now recognize that synthetics legitimately improve engine performance, particularly in engines that operate under severe service. Performance cars and many traditional family vehicles today leave the factory with synthetic oil installed and recommended as the service fill, contributing to synthetics' increased demand. Oil manufacturers have responded. Many now formulate multiple synthetic motor oils, often led by a flagship product that represents each company's most advanced technology.

Objective

Compare the performance in laboratory tests and cost-effectiveness of AMSOIL Signature Series Synthetic Motor Oil to several passenger-car/light-truck synthetic motor oils widely considered by marketers and consumers to be the best available.

Methodology

Laboratory bench testing conducted in accordance with American Society of Testing and Materials (ASTM) procedures examined several important areas of motor oil performance, including resistance to deposit formation, wear protection, high-temperature stability, resistance to acid formation and cold-temperature performance. Bench tests are used widely to differentiate between formulations.

Note: Test results published in this Technical Study describe and represent properties of oils that were acquired on the dates listed in Table 1 (page 3). Results do not apply to any subsequent reformulations of such oils or to new oils introduced after completion of testing. All oils were available to consumers at the time of purchase. Testing was completed February 2013 by an independent, third-party lab. Formulations were coded to eliminate bias, and samples were tested in random order. An appropriate number of trials of each oil were run to produce results at the 95 percent confidence level when compared to Signature Series Synthetic Motor Oil.¹

ASTM Tests Performed

Each oil was subjected to the following ASTM test methodologies:

- Four-Ball Wear Test (ASTM D4172 Mod.)
- Total Base Number (ASTM D2896)
- Cold Cranking Viscosity (ASTM D5293)
- Thermo-Oxidation Engine Oil Simulation Test (TEOST, ASTM D6335)
- NOACK Volatility Test (ASTM D5800)

¹ The 95 percent confidence level only applies when comparing AMSOIL Signature Series 5W-30 Synthetic Motor Oil to the other oils. The 95 percent confidence level does not apply when comparing the other oils to one another.

Candidate Oils

The following 10 synthetic motor oils were selected. All oils were 5W-30 and are recommended for the American Petroleum Institute (API) SN and International Lubricants Standardization and Approval Committee (ILSAC) GF-5 performance specifications.

Table 1

Motor Oil	Acquired	Batch Code	API/ILSAC Specification
AMSOIL Signature Series Synthetic Motor Oil	Nov. 2012	15455 298	SN/GF-5
Castrol Edge with Titanium Fluid Strength Technology	Dec. 2012	A1229220921 H1	SN/GF-5
Lucas Synthetic	Nov. 2012	12206 I512:33	SN/GF-5
Mobil 1 Extended Performance	Dec. 2012	11012L04A 15 5888	SN/GF-5
Pennzoil Ultra	Dec. 2012	10413471 U001 22MAR12 0701 1	SN/GF-5
Petro-Canada SUPREME Synthetic	Dec. 2012	121019LX 011137 122163* 121019LX 011154 122163* 121019LX 011186 122163*	SN/GF-5
Quaker State Ultimate Durability	Dec. 2012	10492378 U002-1 11OCT12 15:13	SN/GF-5
Red Line High Performance Motor Oil	Nov. 2012	62286 9343P-003442	SN/GF-5
Royal Purple High Performance Motor Oil	Dec. 2012	ICPR33A18201	SN/GF-5
Valvoline SynPower Full Synthetic Motor Oil	Dec. 2012	J2212C5 1949	SN/GF-5

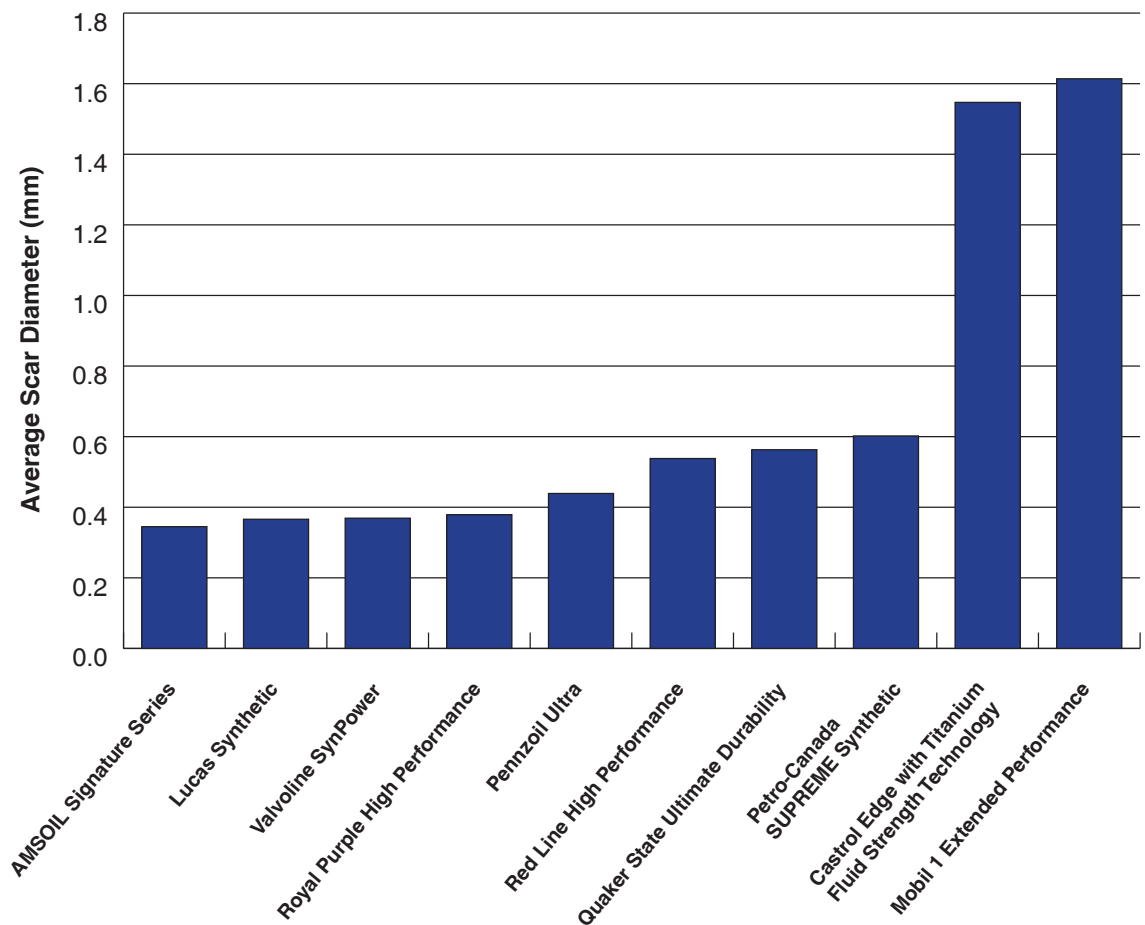
*Individual liters originated from the same case (code 121019LX 00930).

Four-Ball Wear Test (ASTM D4172 Mod.)

According to the ASTM, the Four-Ball Wear Test “can be used to determine the relative wear preventive properties of lubricating fluids in sliding contact under the prescribed test conditions. No attempt has been made to correlate this test with balls in rolling contact. The user of this test method should determine to his own satisfaction whether results of this test procedure correlate with field performance or other bench test machines.”¹

Although not widely used as an engine oil test, the Four-Ball Wear Test provides a means of comparing relative wear-protection properties of lubricating oils. To better differentiate between lubricants, the severity of the test was increased with higher rpm and temperature (the test standard allows for running the test under modified parameters). The size of the scar as a result of the test indicates the level of wear protection the lubricant provides.

Four-Ball Wear Test (ASTM D4172 Mod.)
1,800 rpm, 150°C, 40 kg, 1 hour
Performed by independent, third-party lab February 2013.
The smaller the wear scar, the better the performance in the test.



Results

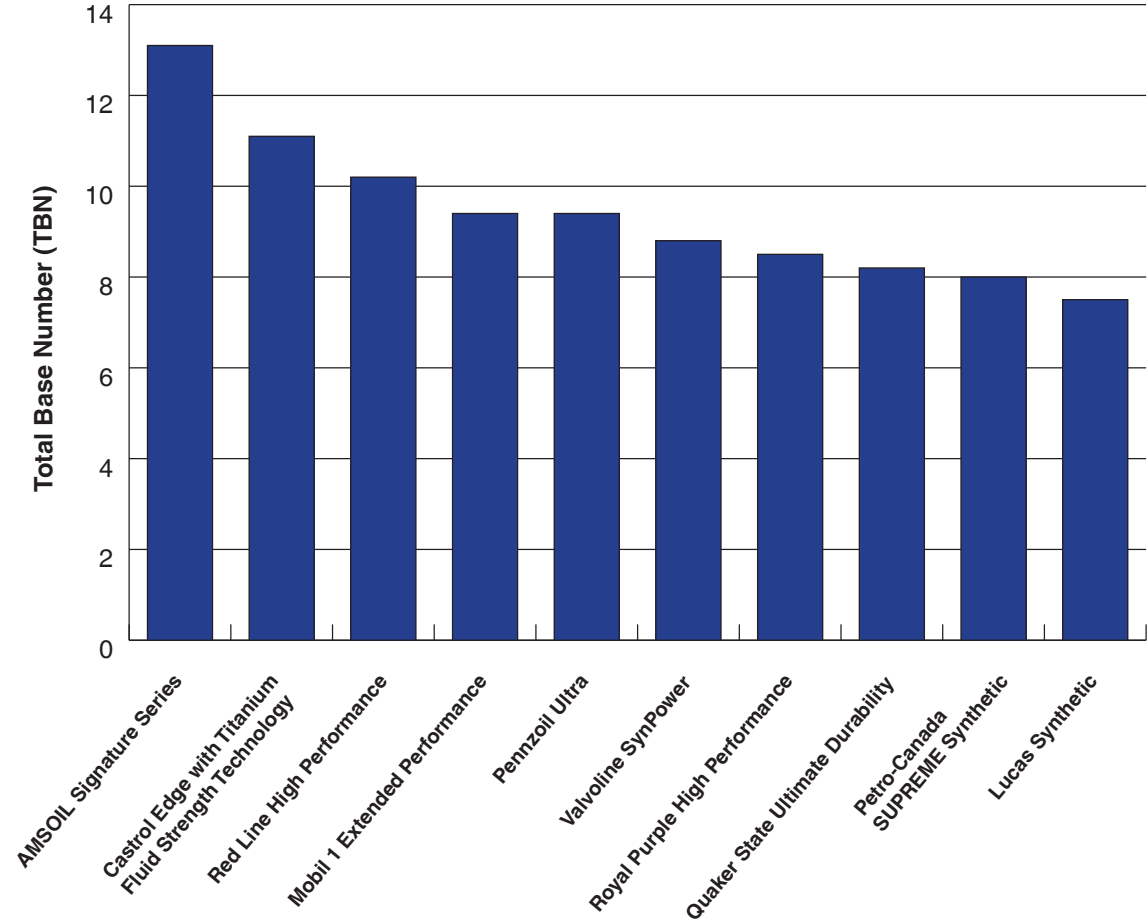
Four-Ball Wear Test results indicate significant differences in relative wear protection between oils. The top four performers limited wear scars to under 0.40 mm. AMSOIL Signature Series Synthetic Motor Oil demonstrated the best wear protection in the Four-Ball Wear Test.

¹ <http://www.astm.org/Standards/D4172.htm>

Total Base Number (ASTM D2896)

Total Base Number (TBN) is the measure of a lubricant's reserve alkalinity, which aids in the control of acids formed during the combustion process. TBN can also be used as a measure of lubricant degradation in service.¹ Motor oils that have a high TBN and demonstrate good TBN retention are known to effectively reduce the corrosive effects of acids over an extended period.

Total Base Number (ASTM D2896)
Performed by independent, third-party lab February 2013.
The higher the number, the better the performance in the test.



Results

AMSOIL Signature Series Synthetic Motor Oil tested two numbers higher than the nearest competitor.

¹ <http://www.astm.org/Standards/D2896.htm>

Cold Cranking Viscosity (ASTM D5293)

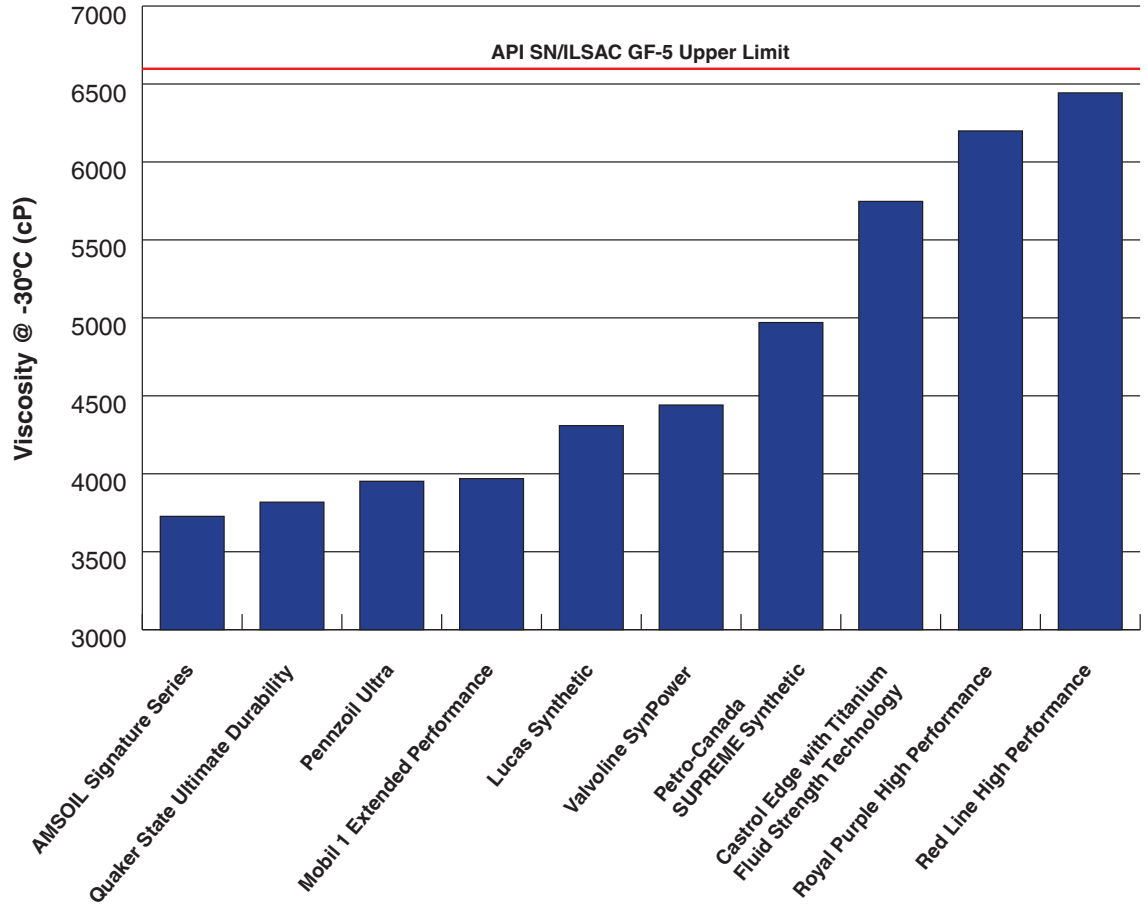
The Cold Crank Simulator Test determines the apparent viscosity of lubricants at low temperatures and high shear rates. Viscosity of lubricants under these conditions is directly related to low-temperature engine cranking.¹ The test was performed at -30°C (-22°F). Results are reported in centipoise (cP), with lower values reflecting easier cold starts and reduced battery strain. To meet the API SN and ILSAC GF-5 motor oil specifications, a motor oil's cold crank viscosity must not exceed 6,600 cP.

Cold Crank Viscosity (ASTM D5293)

cP @ -30°C (-22°F)

Performed by independent, third-party lab February 2013.

The lower the value, the better the performance in the test.



Results

Although synthetic motor oils are known to provide increased low-temperature performance compared to conventional oils, results suggest performance differences between formulations. AMSOIL Signature Series Synthetic Motor Oil demonstrated the lowest cold-crank viscosity (3,727 cP).

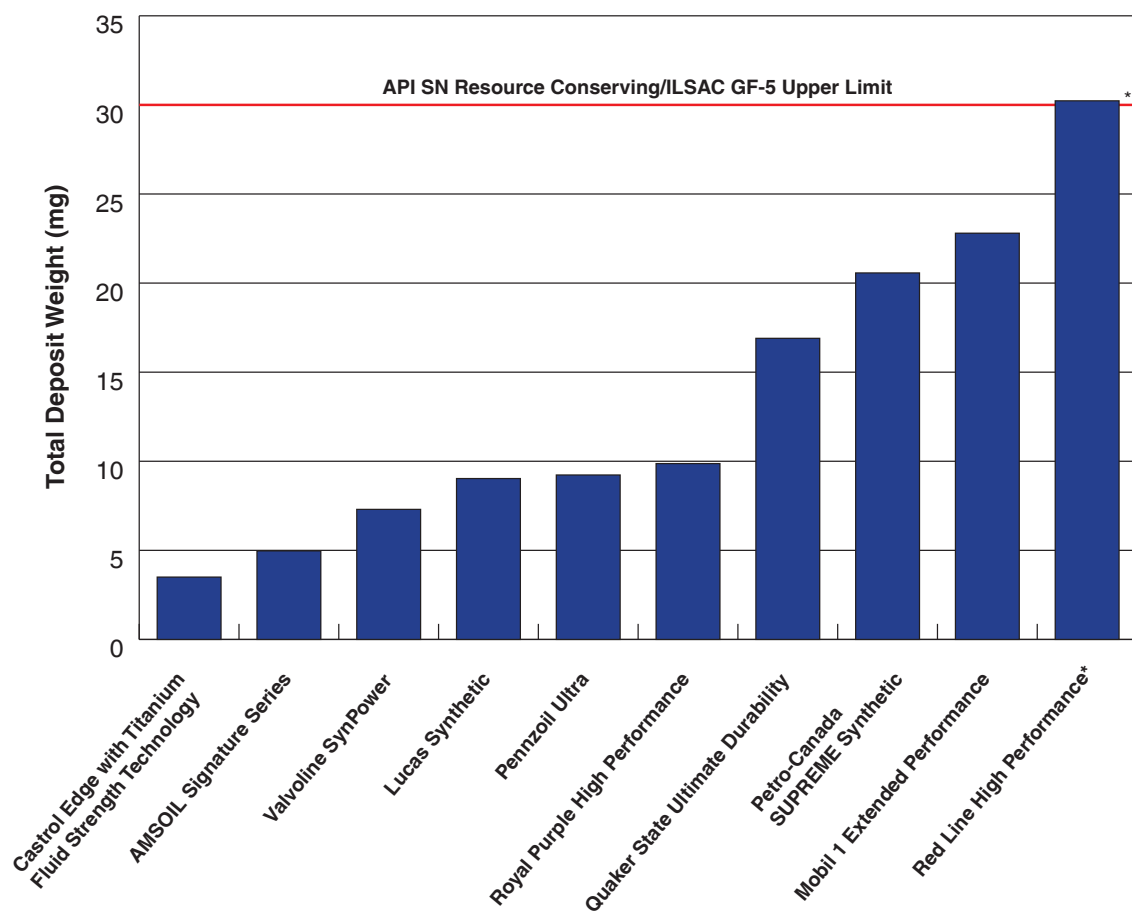
¹ <http://www.astm.org/Standards/D5293.htm>

Thermo-Oxidation Engine Oil Simulation Test (TEOST, ASTM D6335)

Motor oils can form deposits when exposed to increased heat, reducing efficiency and contributing to poor overall performance. According to the ASTM, the TEOST test method “is designed to predict the high temperature deposit forming tendencies of an engine oil. This test method can be used to screen oil samples or as a quality assurance tool.”¹ Given the number of vehicles now equipped with direct fuel injection, turbochargers and other performance-enhancing technologies that increase heat, deposit control has taken on increased importance. To meet the API SN Resource Conserving and ILSAC GF-5 motor oil specifications, a 5W-30 motor oil must limit total deposit formation to 30 mg or less.

TEOST Test (ASTM D6335)

Performed by independent, third-party lab February 2013.
The lower the value, the better the performance in the test.



*Results for Red Line High Performance ranged from 29.1 mg to 31.4 mg. The average of the three tests run is shown in the graph.

Results

Results demonstrate a range of performance differences between oils. Only Castrol Edge with Titanium Fluid Strength Technology and AMSOIL Signature Series Synthetic Motor Oil limited total deposit weight to 5 mg or less.

¹ <http://www.astm.org/Standards/D6335.htm>

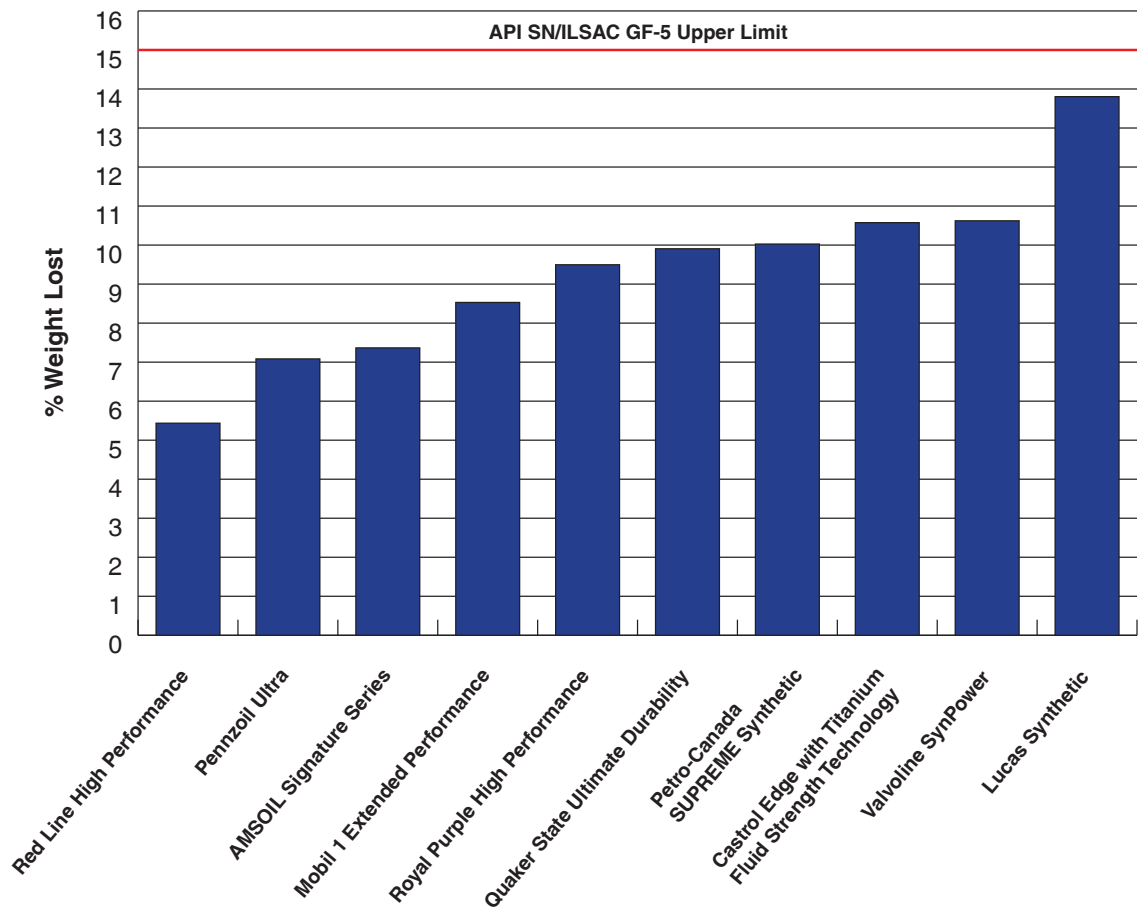
NOACK Volatility Test (ASTM D5800)

The NOACK Volatility Test determines the evaporation loss of lubricants in high-temperature service. According to the ASTM, "Evaporation may contribute to oil consumption in an engine and can lead to a change in the properties of an oil."¹ As with the TEOST test, low values in the NOACK Volatility Test are of particular benefit in modern, hot-running engines.

In the NOACK test, a candidate oil is exposed to heat and circulating air. Following 60 minutes, the remaining oil volume is weighed and compared to the original weight, with the difference reported as the percentage of weight lost. Results must be limited to 15 percent or less to meet the API SN and ILSAC GF-5 specifications.

NOACK Test (ASTM D5800)

Performed by independent, third-party lab February 2013.
The lower the value, the better the performance in the test.



Results

While all oils were below the API SN and ILSAC GF-5 upper limit, results indicate differences in high-temperature volatility. Half of the oils limited the percentage weight lost from volatility to under 10 percent, with AMSOIL Signature Series Synthetic Motor Oil having the third-best result.

¹ <http://www.astm.org/Standards/D5800.htm>

Overall Annual Cost

Although AMSOIL Signature Series Synthetic Motor Oil is recommended for 25,000 miles/one year in normal service¹, light-duty vehicles accumulate an average of 11,318 miles a year² and are generally used in driving conditions that fall under the severe service³ category. For those reasons, overall annual cost is evaluated at 11,318 miles under severe service driving conditions. Signature Series Synthetic Motor Oil carries a drain interval of up to 15,000 miles/one year, whichever comes first, in severe service. Because the other nine oils do not carry a recommended drain interval, a drain interval of 4,777 miles was used, which represents the average drain interval of motorists as reported in the 2012 *National Oil & Lube News Operator's Survey*. Although Mobil 1 Extended Performance is recommended for 15,000 miles in out-of-warranty vehicles in certain driving conditions, its extended drain recommendation does not apply for this evaluation. According to the official statement on the Mobil 1 Extended Performance label, "Extended service is not recommended in severe service applications involving racing and commercial use, frequent towing or hauling, extremely dusty or dirty conditions, or excessive idling."

Per-quart prices (Table 2) reflect the MSRP where available or average of a cross-section of retail outlets surveyed January 2013. Costs are based on a five-quart capacity. Overall value represents the cost of the oil only.

Table 2

	Price/ Qt.	Price/Oil Change	# Oil Changes Required for 11,318 Miles	Overall Annual Cost
AMSOIL Signature Series Synthetic Motor Oil (MSRP)	\$10.15	\$50.75	1	\$50.75
Castrol Edge with Titanium Fluid Strength Technology	\$9.52	\$47.60	2.37	\$112.81
Lucas Synthetic	\$7.81	\$39.05	2.37	\$92.55
Mobil 1 Extended Performance	\$9.51	\$47.55	2.37	\$112.69
Pennzoil Ultra	\$9.16	\$45.80	2.37	\$108.55
Petro-Canada SUPREME Synthetic	\$10.28	\$51.40	2.37	\$121.82
Quaker State Ultimate Durability	\$7.99	\$39.95	2.37	\$94.68
Red Line High Performance Motor Oil	\$10.95	\$54.75	2.37	\$129.76
Royal Purple High Performance Motor Oil	\$9.80	\$49.00	2.37	\$116.13
Valvoline SynPower Full Synthetic Motor Oil	\$9.03	\$45.15	2.37	\$107.01

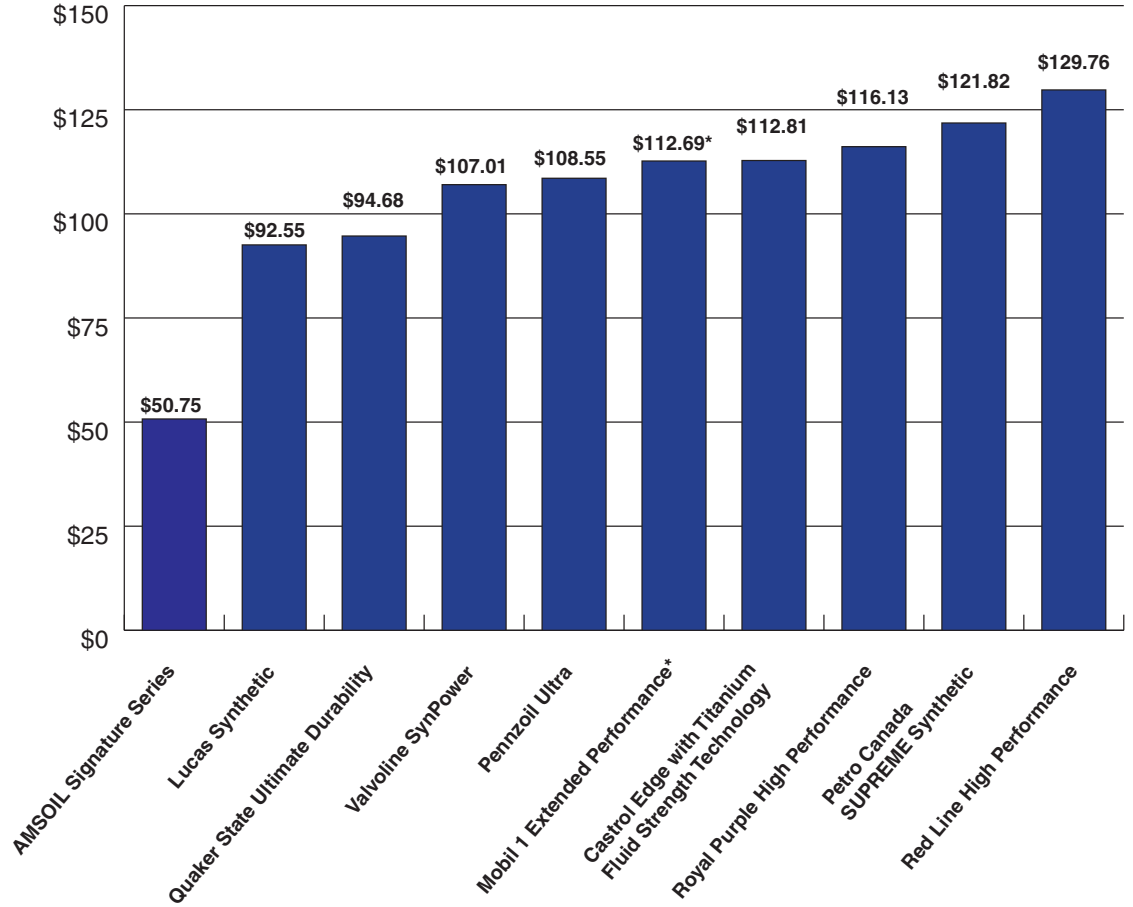
¹ AMSOIL defines **normal service** as personal vehicles frequently traveling greater than 10 miles at a time and not operating under severe service.

² "Average Vehicle Distance Traveled in Miles and Related Data – 2011 (1) By Highway Category and Vehicle Type". <http://www.fhwa.dot.gov/policyinformation/statistics/2011/pdf/vm1.pdf>.

³ AMSOIL defines **gasoline engine severe service** as turbo/supercharged engines; commercial or fleet vehicles; excessive idling; daily short-trip driving less than 10 miles (16km); frequent towing, plowing or hauling; dusty-driving conditions; or in vehicles with 100,000 or more miles that will be using AMSOIL engine oil for the first time.

Annual Cost Per 11,318 Miles in Severe-Service Conditions

Five-quart capacity. Cost of oil only. Based on MSRP where available or a cross-section of retail outlets surveyed January 2013.



*Not recommended for extended service in vehicles used in severe-service driving conditions. See official statement on the Mobil 1 Extended Performance label.

Results

Though the retail price per quart of AMSOIL Signature Series Synthetic Motor Oil is initially higher, it provides lower costs compared to the other oils. Overall, Signature Series is the most cost-effective oil.

Conclusion

AMSOIL Signature Series Synthetic Motor Oil ranked first in four of the six comparisons. In contrast, while some oils performed well in a few areas, they did not perform as well in others. Different results from one test to another indicate an emphasis in one area of performance does not correspond to increased performance in other areas of testing. It also reveals the difficulty inherent in formulating a high-quality motor oil that performs well in tests designed to assess optimum engine protection and life.

As engines continue to evolve and demand more from motor oil, the need for premium lubrication becomes more critical. Industry-standard testing performed by an independent, third-party laboratory reveals AMSOIL Signature Series Synthetic Motor Oil to be the overall top-performing oil in these tests. When considering the savings of time and money available due to its 15,000-mile/one-year drain interval in severe service, Signature Series is also the most economical choice.



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