75W-90 Synthetic vs. Petroleum Gear Oil Testing
AMSOIL vs Valvoline

Overview

Gear oils are designed to lubricate, cool and protect geared systems. They also carry wear debris away from contact zones between gears and muffle the sound of geared system operation. The majority of gear oils are used in differential gears and some standard (non-automatic) transmission applications in commercial vehicles and passenger cars. They are also used in a variety of industrial machinery gears.

Most applications require gear oils that contain some degree of extreme pressure protection to prevent wear, pitting, spalling, scoring, scuffing and other types of distress that can result in equipment failure and downtime. Protection against oxidation, thermal degradation, rust, copper corrosion and foaming must also be provided. In addition, gear oils must be designed to remain fluid in the low ambient temperatures in which many applications operate.

Purpose

The purpose of this paper is to detail testing and provide performances data that consumers can use to evaluate gear oil quality and make educated purchasing decisions.

Method

Testing was performed on AMSOIL SAE 75W-90 Gear Lube and Valvoline 75W-90 Gear Lube. The Valvoline product is a mineral-based fluid and was selected as the reference oil due to the company's wide recognition level and the product's similarities to other conventional mineral-based products. The oils were tested according to ASTM testing procedures in several critical performance areas. Oxidation resistance was tested using the L-60-1 Thermal Oxidation Stability Test. Viscosity retention was measured using the KRL Shear Stability Test. The Brookfield Viscosity Test was used to measure cold temperature fluidity. The load carrying, wear, and extreme pressure properties were tested using the L-37 High Torque Axle Test, and the L-42 High Speed Axle Test was used to measure scoring protection.

L-60-1 Thermal Oxidation Stability Test:

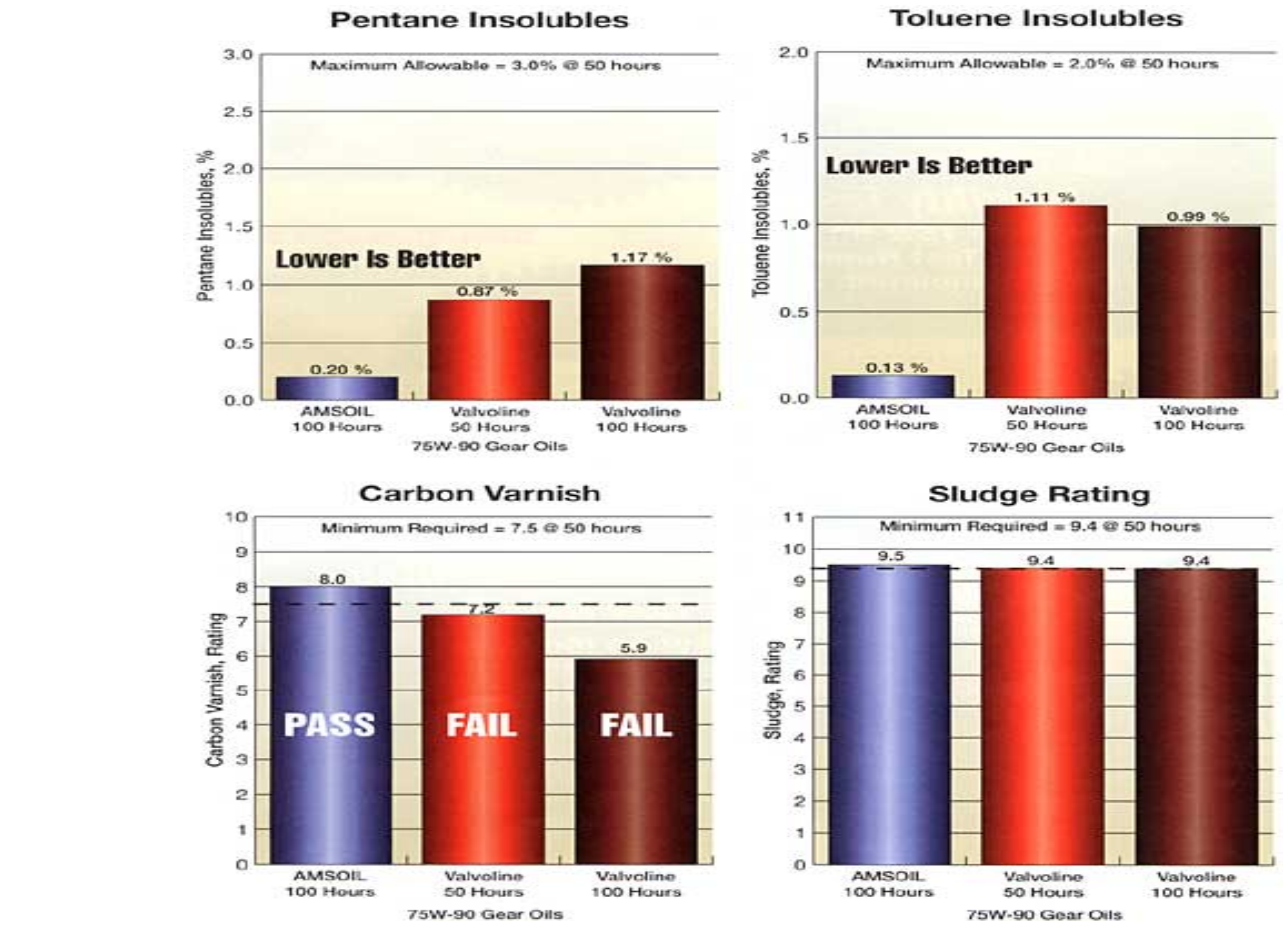
One aspect of high-quality gear oils is the ability to maintain oxidative stability. The general automotive trend today is to design automobiles that are smaller in size and molded for more aerodynamics, causing them to operate at significantly hotter temperatures than their predecessors. While this may be advantageous in many respects, it poses significant challenges for lubricants such as gear oils, as many are not designed to contend with elevated heat. A fluid that is oxidatively stable will maintain proper fluid viscosity and last longer, while aiding in the minimization of deposit formations. Lubricants used in today's automobiles must be formulated to minimize and control deposit buildup as well as dissipated heat.
The objective of the L-60-1 test is to determine the rate of deterioration of lubricants under severe oxidation conditions. It is conducted using a measured sample of test oil, which is then placed in a special gear case with two spur gears and a copper catalyst strip, Typically, the test is run for a duration of 50 hours at 163 C. While the gears are being driven at 1,725 rpm and air is bubbled through the sample.

When completed, viscosity increases along with deposits not soluble in pentane or toluene solvents are determined. The gears are also rated for carbon, varnish and sludge deposits. Specifications for the L-60-1 Thermal Oxidation Stability Test are as follows:

	API GL-5	API MT/SAE J-2360/MIL-PRF-2105E/Mack GO-J	Mack GO-J+
Test Conditions	50h @ 163° C.	50h @ 163° C.	100h @ 163° C.
Viscosity Rise, %	100 Max.	100 Max.	100 Max.
Pentane Insolubles, %	3 Max.	3 Max.	3 Max.
Toluene Insolubles, %	2 Max.	2 Max.	2 Max.
Carbon Varnish, rating	Not Required	7.5 Min.	7.5 Min.
Sludge, rating	Not Required	9.4 Min.	9.4 Min.

	AMSOIL Synthetic 75W-90	Valvoline 75W-90	Valvoline 75W-90
Test Conditions	100h @ 163° C.	50h @ 163° C.	100h @ 163° C.
Viscosity Rise, %	25.17	17.50	38.50
Pentane Insolubles, %	0.20	0.87	1.17
Toluene Insolubles, %	0.13	1.11	0.99
Carbon Varnish, rating	8.0	7.2	5.9
Sludge, rating	9.5	9.4	9.4

Although the L-60-1 test is designed to run for 50 hours, the AMSOIL 75W-90 Synthetic Gear Lube was run for double the test duration (100 hours). The Valvoline 75W-90 Gear Lube was run at both the standard 50-hour duration and the extended 100-hour limit. As the following charts and photos indicate, the AMSOIL product outperformed the Valvoline product at both the 50-hour and 100-hour time limits.



L-60-1 Thermal Oxidation Stability Test Results

AMSOIL 75W-90 (100 Hours)
Test Number: 5A-228
Date Completed: 2002/03/25

L-60-1 Thermal Oxidation Stability Test Results

Valvoline 75W-90 (100 Hours)
Test Number: 5A-232
Date Completed: 2002/03/25

L-60-1 Thermal Oxidation Stability Test Results

Valvoline 75W-90 (50 Hours)
Test Number: 5A-233
Date Completed: 2002/04/25

KRL Shear Stability Test:

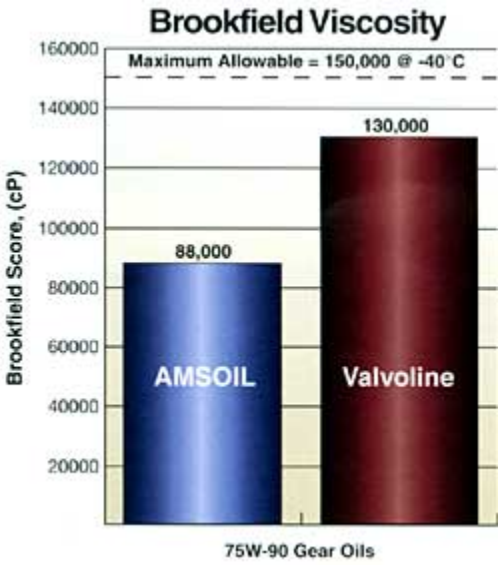
A second characteristic of well-formulated gear oils is high lubricant film strength. Higher film strength oils aid in minimizing overall friction and reducing wear on components. Throughout the lifespan of a lubricant, shearing can result which may lead to a significant decrease in fluid film protection and ultimately lead to equipment failure. Shearing refers to the rupturing of long molecules within a lubricant due to stresses, which converts them into shorter and lower weight molecules. These transformed molecules offer far less resistance to flow and minimizes their ability to maintain fluid thickness or viscosity. The shear stability requirement ensures that lubricants maintain oil film thickness during operation to sufficiently protect equipment against premature wear and other types of distress.

With the increasing use of multi-grade lubricants, this test is used to determine the mechanical shear stability of lubricating oils containing polymer, such as gear lubricants. It is a mandatory part of the standardized SAE J306 test methodology and pertains to the multi-viscosity 75W-90 gear lubricant category. The test requires a taper roller bearing, which is used to shear the fluid. The objective is to determine the permanent drop in viscosity caused by mechanical stresses under practical conditions. Under the specifications of the SAE J306 test, the measured viscosity at 100 degrees C (212 degrees F) of an SAE 90 Weight gear oil must exceed 13.5 cSt after 20-hours of the KRL. As the chart below demonstrates, Valvoline's 75W-90 failed this test by losing 14% of its initial viscosity. The AMSOIL 75W-90 easily passed at the 20-hour duration and was therefore allowed to continue for a total of 192 hours. Even after close to 10 times the recommended test duration, the AMSOIL gear oil lost only 0,40% of its original viscosity, and is therefore 99.6% shear stable.

	AMSOIL 75W-90	**Valvoline 75W-90**
KRL Test Results:	After 192 Hour KRL	After 20 Hour KRL
Beginning Viscosity @ 100° C (cSt)	15.09	14.46
Ending Viscosity @ 100° C (cSt)	15.03 (pass)	12.42 (fail)
% Viscosity Loss, 100° C	0.40%	14.10%

Brookfield Viscosity Test:

The Brookfield Viscosity Test (ASTM D2983) is used to determine the internal fluid-friction at cold temperatures and is a requirement for all gear oils. A lubricant fluid sample is cooled in an air bath at -40° C (-40° F) for 16 hours. The sample is then carried in an insulated container to a nearby Brookfield viscometer where the torque required to shear the oil is recorded and converted to centipoises (cP). For this test, it is more desirable to obtain a lower cold temperature viscosity result.



All 75W-90 gear oils must measure less than 150,000 cP @ -40° C (-40° F). The AMSOIL 75W-90 gear lube was measured at 88,000 cP, which is 42% less than the maximum allowed and signifies quicker flow, enhanced component protection in cold conditions and less drag, which

helps increase fuel efficiency. At the same time, many mineral-based 75W-90 gear oils have difficulties passing this test due to the cold temperature test conditions and their paraffin (wax) content. Valvoline, for example, met the test requirements by only 13% with a score of 130,000 cP.

L-37 High Torque Axle Test:

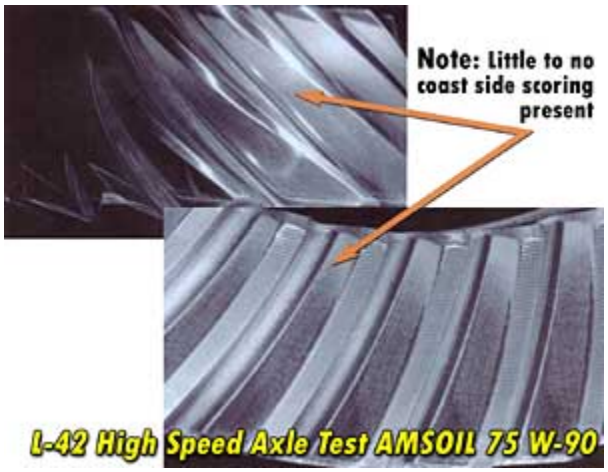
The L-37 test is used to evaluate the load-carrying, wear and extreme pressure characteristics of gear lubricants in hypoid gears under high speed - low torque and low speed-high torque operation. A Dana Model 60 hypoid gear axle (5.86 gear ratio) is used with either coated or uncoated drive gear and pinion and setup to drive two dynamometers from an 8-cyclinder, 5.7-liter gasoline engine. The axle is filled with the test oil and driven under varying conditions. A high speed - low torque test is first run for 100-minutes and the gears visually assessed via an inspection plug. Next, a low speed - high torque sequence is then run for a further 24-hours. At the conclusion of the test, a thorough inspection of the gears is performed, and any deposits or bearing discolorations are noted. Lubricant performance to API GL-5 and MIL-PRF-2105E is assessed on the basis of tooth surface rippling, ridging, pitting and wear, together with any deposits or discoloration.

The photo above and table below summarizes the L-37 passing results obtained on AMSOIL's 75W-90 Gear Oil conducted using uncoated gear and pinion.

Run No. 3-787	AMSOIL 75W-90 Ring	Reference Oil Ring	AMSOIL 75W-90 Pinion	Reference Oil Pinion
Wear	9.0	9.0	8.0	8.0
Rippling	10.0	10.0	9.0	9.0
Ridging	10.0	10.0	9.0	9.0
Pitting/Spalling	10.0	10.0	9.9	9.9
Scoring	10.0	10.0	10.0	10.0

L-42 High Speed Axle Test:

L-42 High Speed Axle Test is designed to evaluate the anti-scoring characteristics of a gear lubricant under high-speed and shock loading conditions. The test used a Spicer Model 44-1 hypoid gear axle driven by a 5.7 liter, V8 gasoline engine mated to a 4-speed truck transmission and two high inertia dynamometers at a rate to simulate hard acceleration to 100 mph. To help simulate high shock loading conditions, the axle is accelerated through the gears to a speed of 1,050 r/min; then decelerated to 530 r/min. This cycle is repeated a total of 5 times and then followed by 10 shock loadings - the shock sequence. To calculate the results, lubricant performance meeting API GL-5 and MIL-PRF-2105E specifications require gear scoring to be equal to or better than gears tested using a reference oil. Only the back (coast) side of the gear is rated. The front (drive) side is only considered if a large



amount of scoring is evident. The same holds true for the drive gear and opinion; only the coast side is rated unless significant scoring is present, at which time the drive side is considered.

The table below summarizes the coast side ratings obtained on AMSOIL's 75W-90 Gear Lube. It should be noted that there was no need for drive side rating as the AMSOIL scored well in the L-42 High Speed Axle Test as indicated below.

Run No. 2-740	**AMSOIL 75W-90 (AGR)**	**Reference Oil**
Ring	13	19
Pinion	18	27

Conclusion

The results outlined in this report demonstrate AMSOIL Synthetic 75W-90 gear oil surpasses the performance offered by well-known petroleum-base gear lubricants. Using industry-accepted test methods, Valvoline consistently failed to meet the basic performance requirements for high quality gear lubricants, including API MT-1, MIL-PRF-2105E, MACK GO-J and GO-J+. In addition, Valvoline failed the shear stability requirements of the SAE J-306, which is a requirement for all 75W-90 gear lubricants. In comparison, AMSOIL AGR not only met all the listed requirements, but exceeded them in every instance, even at extended test limits.

Although Valvoline claims to meet the performance requirements for several of the tests listed above, the product tested clearly did not demonstrate the ability to meet these requirements. AMSOIL 75W-90 Synthetic Gear Lube provides the added benefits of deposit control, heat resistance, longer life, viscosity stability and better cold temperature performance when compared to mineral-based gear oils such as Valvoline 75W-90.

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