

Asteric™ Viscosity Modifiers

Advanced Polymer Technology for High VI Industrial and Automotive Lubricants

Passenger vehicle manufacturers, heavy duty equipment OEMs, along with lubricant end-users are demanding higher performing, longer lasting and more fuel efficient lubricants. The call for fluids that work better under severe conditions and can be used year-round in all climates has influenced the trend to high Viscosity Index (VI) high performance fluids in industrial and automotive applications.

In response to these OEM and lubricant end user demands, Lubrizol has developed breakthrough polymer additive technology called Asteric™. Asteric technology allows control of the polymer architecture which isn't possible with conventional polymer additives. Asteric polymers have radial or star architecture which allow us to overcome some of the performance trade-offs seen with conventional linear Viscosity Modifiers (VM) polymers.



The Advantages of Asteric VMs

Asteric VMs offer formulating and performance advantages over conventional PAMA VMs in high performance fluids. These advantages are listed below.

- **Asteric VMs provide much greater Viscosity Index increase** per unit treat rate and thickening.
- **Asteric VMs can more easily achieve very high finished fluid VI** compared to conventional PAMA VMs of similar shear stability.
- **Asteric VMs have greater thickening efficiency** compared to conventional PAMA VMs with similar shear stability - meaning less polymer additive is needed to achieve the finished blend viscosity.

- **Asteric VMs exhibit better low-temperature fluidity** especially in driveline formulations and can achieve lower -40°C Brookfield viscosity.
- **Greater formulating flexibility.** Asteric VMs allow use of a higher starting base oil viscosity for similar fluid performance. And they can reduce the need for low viscosity trim stocks to achieve higher performance.
- **Better long duration shear stability.** Asteric VMs resist viscosity loss in long duration shear testing which is important in long drain or fill-for-life applications.
- **Better long-term protection for copper alloys.** Fluids containing Asteric VMs had lower Cu in drain oil samples from long duration testing.
- **Better color stability.** Fluids formulated with Asteric VMs maintained a lighter color in long term oxidation testing.
- **Enhanced wear protection.** Fluids containing Asteric VMs had improved wear results in bench and rig testing.

Blended to the Same Viscosity at 100C in 4 cSt Oil

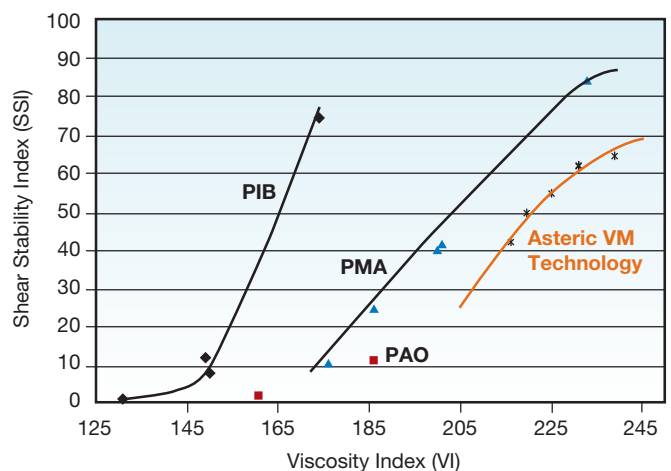


Figure 1

Figure 1 illustrates the VI increase advantage of Asteric VM compared to other VM chemistry. High VI fluids are achieved more easily with Asteric VMs without sacrificing shear stability.

Thickening Efficiency per SSI on a Solid Polymer Basis

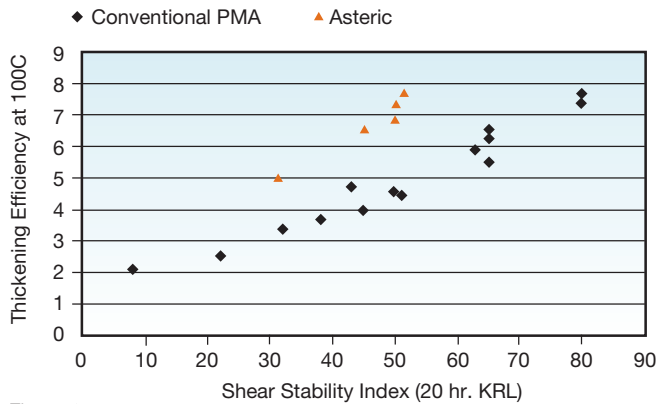


Figure 2

The thickening efficiency advantage of Asteric VMs compared to conventional PAMA VMs is seen in Figure 2. Greater thickening translates to lower polymer treat levels in the formulation.

The VI increase, thickening and low temperature fluidity advantages of Asteric VMs provide real benefits when formulating driveline and hydraulic fluids. Asteric VMs:

- Provide the formulator with the flexibility to get the viscosity performance needed.
- Provide high-end performance of very high VI and very low Brookfield viscosity comparable to a PAO based formulation using all Group III oils.
- Provide conventional fluid performance using a reduced treat level and higher starting base oil viscosity.

Asteric VMs had better viscosity retention compared to conventional PAMA VMs in long duration testing as shown in Figure 3.

Extended Shear Durability in Tapered Bearing Shear Test ISO 46 175 VI Fluids

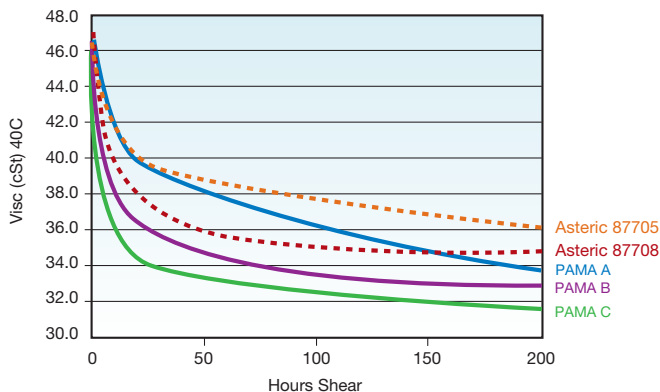


Figure 3

Asteric PMA Copper Corrosion



New and after pump test fluids were evaluated for copper corrosion in ASTM D130 test (140C, 12 hours). Asteric PMA end of test fluid showed much better copper corrosion result compared to the conventional PMA fluid.

Figure 4

EOT refers to end of test fluids

Asteric VMs demonstrated an advantage in protecting copper alloys compared to conventional PAMA VMs. Figure 4 shows a comparison of ASTM D130 copper corrosion test results. The fluids containing Asteric VM retained excellent copper protection properties after extended duration testing. Fluids containing conventional PAMA VMs showed worse copper protection after testing.

The importance of copper protection in hydraulic fluids is seen in Figure 5. The fluid containing Asteric VM had lower copper in oil especially during the wet phase testing compared to conventional PAMA VM. The benefit is longer copper alloy component life as well as longer fluid life.

Copper in Hydraulic Pump Test Drain Oil Samples

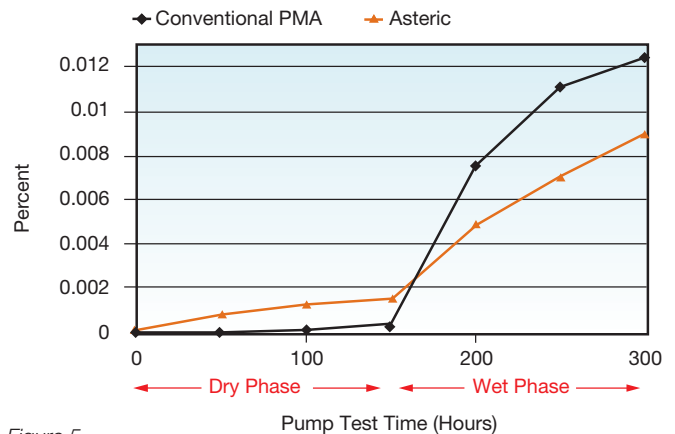
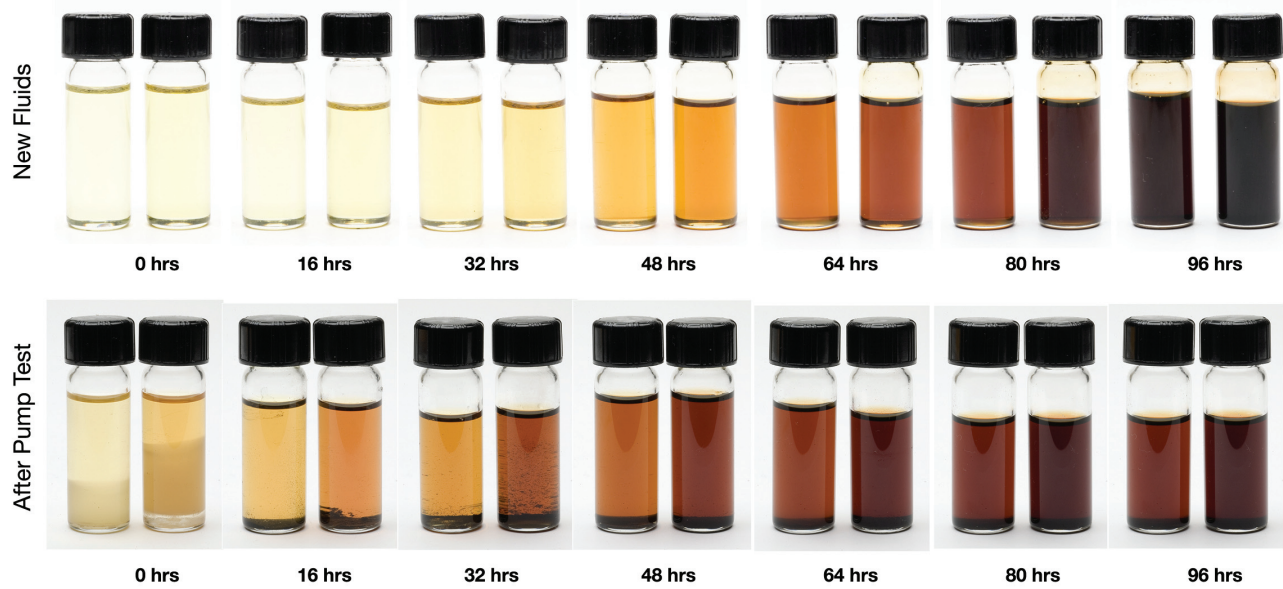


Figure 5

Color Stability Comparison of Hydraulic Fluids Containing Asteric PMA (left) and Conventional (right) PMA Viscosity Modifiers

ISO-46 (150 VI) Fluids Using Group I Stocks Held at 150C



Fluids containing Asteric PMA showed better color stability during both severe service testing and in bench testing.

Figure 6

As seen in Figure 6 fluids containing Asteric VM had better color stability compared to conventional PAMA VM. Asteric fluids retained a lighter color after thermal stress.

The vanes and pump cam ring from the Asteric fluid are seen in Figure 8 and show little sign of scuffing wear.

The ability to protect hydraulic pumps from premature wear and failure is critical for a high performance hydraulic fluid. In severe high pressure pump testing, the fluid containing Lubrizol 87705 Asteric VM had significantly lower pump wear than fluids containing conventional PAMA VMs as shown in Figure 7.

Denison HF-0 Test 600 Hr. Combined Ring/Vane Wear

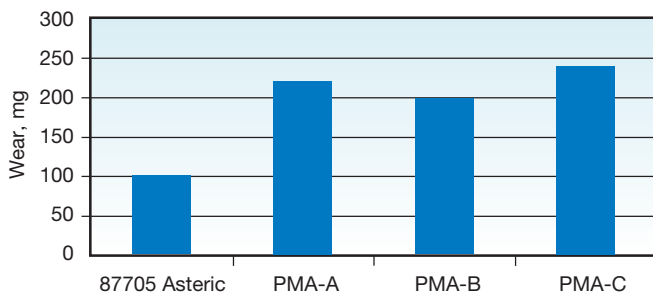


Figure 7

Vane and Cam Ring from Denison T6H20C Test Cam Ring and Vanes at 608 Hours—End of Test

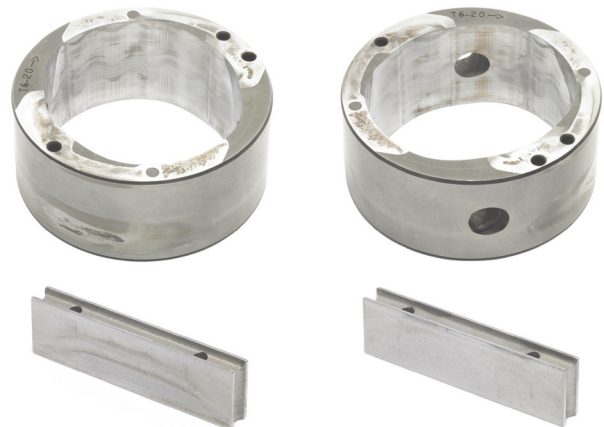


Figure 8

Wear Failure of Multigrade Fluid Containing Conventional VM—608 Hour End of Test Photos of Cam Ring



This multigrade fluid failed the Denison T6H20C pump test on wear. Significant scuffing wear is visible especially at the oil inlet where oil pressure is low while vane tip pressure is high. This is evidence of protective fluid film breakdown

Figure 9

Pump parts shown in figure 9 are from a fluid containing conventional PAMA VM and show significant scuffing wear especially near the oil inlet port. The result of this wear would eventually be loss of pump output leading to early failure.

Advantages of High VI Fluids

High VI fluids offer multiple benefits to the lubricant user:

- Maintains a more consistent viscosity as temperature changes
- Better low temperature fluidity for improved cold weather performance and efficiency
- Maintains viscosity at high temperatures to protect critical components
- Greater mechanical and volumetric efficiency for improved energy efficiency
- Maintains transmission shift feel and behavior at all temperatures

The ability of Asteric VMs to achieve very high finished fluid VI is important in formulating the next generation of high performance lubricants. Very high VI driveline fluids for example can provide greater fuel and energy efficiency, better low temperature fluidity, while maintaining viscosity and performance at high temperatures.

- High VI transmission and driveline fluids have lower viscosity at cold start up and at moderate operating temperatures which provides smoother operation, better shifting performance and less running losses.
- High VI fluids also maintain viscosity at high temperatures under severe operating conditions to protect against wear and maintain optimal shifting behavior.

This is illustrated in figure 10.

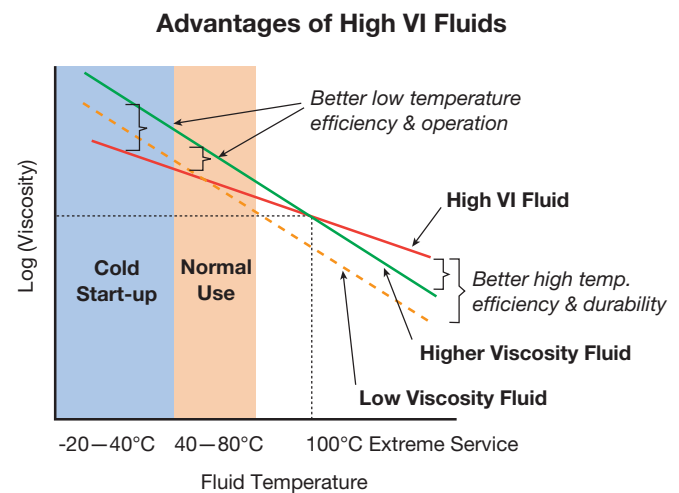


Figure 10

The performance and formulating advantages that have resulted from Asteric VM technology are significant. Lubrizol's breakthrough polymer additive technology was developed in response to the shift to High VI fluids for industrial and automotive applications. Our customer partnerships and understanding of the marketplace helps Lubrizol to help our customers stay in step with changing technology and market demands.

For more information on Asteric VMs, email us at VMinfo@lubrizol.com

With you every step of the way.

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