TESTING THE LUBRICATING OIL VISCOSITY FOR UTILITY VEHICLE ENGINES

In a motor vehicle, the term "powertrain" describes the main components that generate power and deliver it to the road surface, water, or air. This includes the engine, transmission, drive shafts, differentials, and the final drive (drive wheels, continuous track as in military tanks or caterpillar vehicles, etc.). In this context, the term "operating fluids" refers to fluids that comprise products designed to aid the operation of a vehicle, such as engine oil, gearbox oil, transmission fluids, etc. This article focuses in particular on lubricating oils for heavy-duty vehicles.

The most important requirement of a lubricant is to form a film between the moving parts to keep the surfaces separate under all loads and temperatures. The viscosity of the oil can be influenced with additives to have a viscosity that is high enough to form the protective film but low enough not to cause excessive energy losses within the film.

Nowadays, fuel economy is becoming more and more important and the viscosity of the oils is getting lower and lower. It is of great importance that the viscosity remains stable during the whole oil drain interval.

Innovation in Viscosity Determination: SVM™ Stabinger Viscometer™ Series

The highly precise viscometers of the SVM™ series are based on a rotational measuring principle and have an integrated density measuring cell. The small viscosity measuring cell contains a tube which rotates at a constant speed and is filled with sample fluid. A measuring rotor with a built-in magnet floats freely in the sample. The sample's shear forces drive the rotor while magnetic effects retard its rotation. Shortly after the measurement starts, the rotor reaches equilibrium speed. This speed is a measure of the fluid's viscosity.

As the density cell of SVM™ is integrated, the density measurement does not have to be carried out separately. In fact, one combined measuring cell covers the entire measuring range for viscosity, density, and temperature and is filled in one go. A minimum sample amount of only 1.5 mL is sufficient for multiparameter results in one fast measurement.

Top Benefits for Lubricating Oil Testing

Measuring Range

In virtually every lab, from time to time a sample outside the "usual" viscosity range needs to be measured. This often poses a problem with traditional measuring methods and is time-consuming to perform. With SVM™ 3001, one combined measuring cell covers the entire measuring range for viscosity, density, and temperature and is filled in one go. The viscosity measuring range of the cell is from 0.2 mm²/s to 30 000 mm²/s, whereby the temperature range is from -60 °C to +135 °C (-20 °C is reached without external cooling). This measuring range allows for measuring a wide range of samples of different viscosity with one integrated measuring cell and, combined with very fast heating and cooling rates as well as the powerful temperature scans, this opens new possibilities in lubricating oil testing.

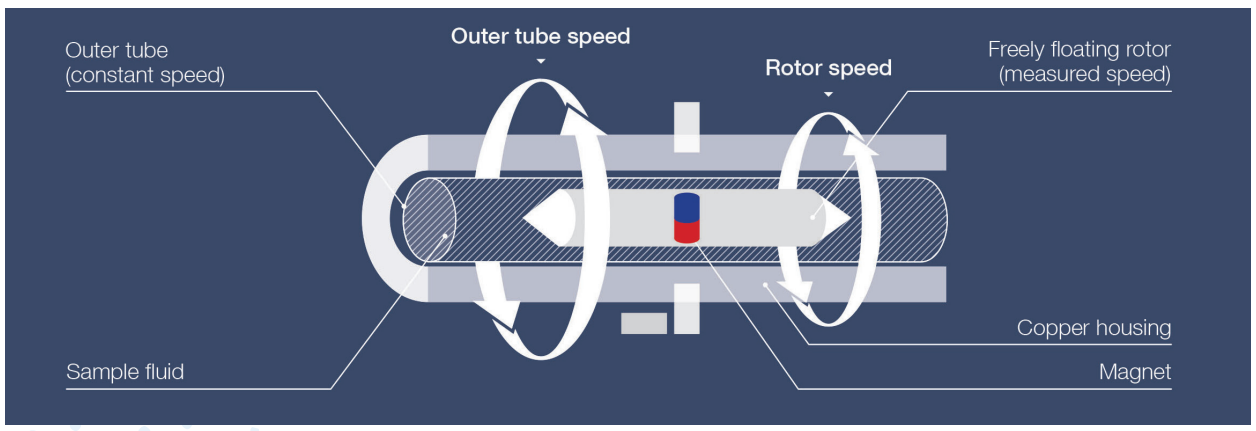


Figure 1. Stabinger Viscometer™ measuring principle

Fast Heating/Cooling Rates

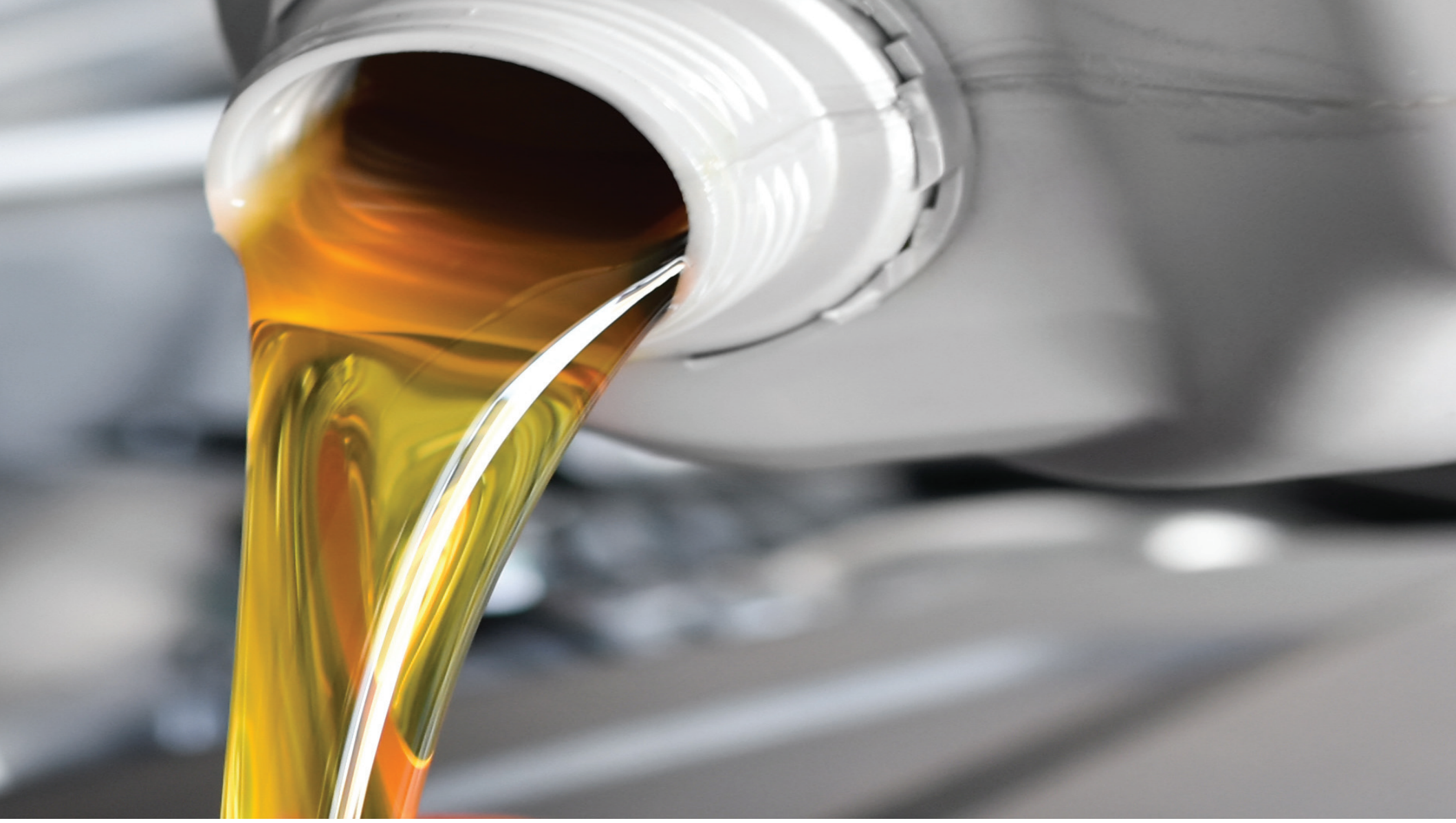
With traditional bath systems for temperature control, the user normally needs to choose the measuring temperature and never change this temperature 24/7 until the next scheduled maintenance. In contrast, SVM™ 3001 has very fast heating/cooling rates of up to 20 °C/min. Such fast temperature changes allow for extraordinary flexibility when choosing the samples, measuring temperatures, and tests that need to be performed. Paired up with the wide temperature range of SVM™ 3001 from -60 °C to +135 °C and the possibility to perform fast and easy temperature scans, it is possible to obtain valuable information on the viscosity behavior of the lubricating oils. Together with the small sample volume of just 1.5 mL (for both viscosity and density determination) not only temperature changes but also thermal uniformity is rapidly achieved. The direct thermo-electric cooling by Peltier elements provides very sensitive and fast control of the cell temperature. So, after entering a new set temperature, it takes only a few minutes for the instrument to be ready for the next test.

With built-in air cooling, SVM™ 3001 can reach -20 °C without the need for any thermal transfer liquids or external devices.

The True Value of Temperature Scans

As fuel economy and long drain intervals are the most important requirements for trucks and buses, when developing engines the analysis of the oil is very important. One of the most important parameters is the viscosity of the oil – at different temperatures. Therefore, a temperature scan is very helpful for the construction engineers to do calculations of the bearings in order to ensure that enough protective film is available.

After one injection of the sample via syringe, SVM™ 3001 can run a temperature table scan from -20 °C to +130 °C in 10 °C steps. Since SVM™ 3001 does not need any external cooling to reach -20 °C, the entire measurement is done with one stand-alone instrument in a simple manner. All data are available about 1h



25 min after the start of the scan and no operator attendance is needed in the meantime. Measurement values for kinematic viscosity are obtained, but also for dynamic viscosity and for density – all in one graph (Figures 1 and 2).

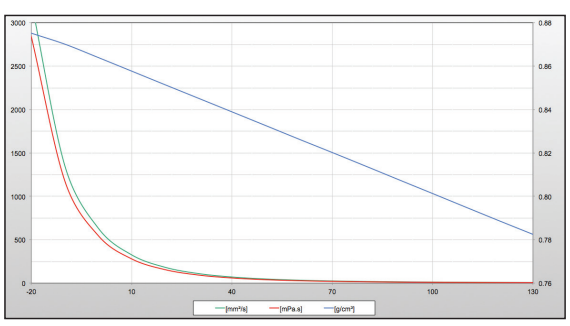


Figure 1. Temperature scan graph

Time	Sample name	Cell temp. °C	Dyn. Viscosity mPa·s	Kin. Viscosity mm²/s	Shear rate 1/s	Shear stress Pa	Density g/cm³
08:04:02	Motor oil SAE 5W-30	-20.000	2845.4	3251.3	4.258	12.12	0.87516
08:10:45	Motor oil SAE 5W-30	-10.000	1179.0	1354.9	9.784	11.54	0.87015
08:15:57	Motor oil SAE 5W-30	0.000	548.00	634.27	19.97	10.94	0.86399
08:22:56	Motor oil SAE 5W-30	10.000	279.32	325.65	36.93	10.32	0.85772
08:29:42	Motor oil SAE 5W-30	20.000	155.24	182.33	62.18	9.653	0.85143
08:36:12	Motor oil SAE 5W-30	30.000	92.892	109.91	96.38	8.953	0.84519
08:42:22	Motor oil SAE 5W-30	40.000	59.143	70.497	139.1	8.226	0.83894
08:48:11	Motor oil SAE 5W-30	50.002	39.721	47.704	188.6	7.492	0.83267
08:56:30	Motor oil SAE 5W-30	60.002	27.890	33.750	242.8	6.771	0.82638
09:01:47	Motor oil SAE 5W-30	70.000	20.388	24.858	298.5	6.086	0.82019
09:07:01	Motor oil SAE 5W-30	80.000	15.389	18.908	354.1	5.449	0.81392
09:12:17	Motor oil SAE 5W-30	90.000	11.947	14.793	407.6	4.870	0.80759
09:17:24	Motor oil SAE 5W-30	99.999	9.5011	11.857	457.9	4.351	0.80130
09:22:22	Motor oil SAE 5W-30	110.001	7.7166	9.7067	504.4	3.892	0.79497
09:27:10	Motor oil SAE 5W-30	120.000	6.3860	8.0971	546.8	3.492	0.78868
09:31:28	Motor oil SAE 5W-30	130.001	5.3870	6.8844	584.3	3.148	0.78249

Figure 2. Table temperature scan

Integrated Density Measurement

Due to the density oscillator integrated in SVM™, the density measurement according to ASTM D4052 or ISO 12185 is carried out simultaneously with the viscosity measurement. In other words, the density thermal coefficient of the current sample is a measured value instead of the typical value for the product group. This offers various possibilities and hence flexibility. Since density at 15 °C or 20 °C is commonly needed, a temperature table scan can be set up with the required temperatures (e.g. 15 °C, 40 °C, 100 °C) as shown in Fig. 3. Another possibility would be API calculations of density over temperature, which are integrated in the instrument software and are freely selectable on the 10.4" touchscreen.

Fresh Oils	Kin. Viscosity 40 °C *[mm²/s]*	Kin. Viscosity 100 °C *[mm²/s]*	Viscosity Index	Density 15 °C *[g/cm³]*
Motor oil SAE 5W-30	72.79	12.13	164.5	0.85780
Motor oil SAE 10W-40	99.82	14.53	150.5	0.86800
Motor oil SAE 15W-40	114.6	14.33	126.5	0.87409
ATF (Automatic Transmission Fluid)	36.06	7.19	167.8	0.84723
Hypoid Oil	145.53	14.53	98.1	0.89752

Figure 3. Kinematic viscosity, density, and VI values of various operating fluids

Viscosity Index Reloaded

In the automatic Viscosity Index mode, temperature changes are performed automatically and the Viscosity Index is calculated in compliance with ASTM D2270. Typically, the measurements are performed at 40 °C and 100 °C, but since viscosity-temperature extrapolations according to ASTM D341 are integrated in the instrument software, the measurements can also be performed at two different temperatures and the Viscosity Index automatically calculated. The benefit of this measurement is that the actual density of the lubricating oil at both temperatures is also measured. This means that the extrapolation of the density from these two points (lying far apart) is precise. It is sometimes also referred to as a "density-temperature slope". For the lubricating oils tested, the extrapolations error was found to be lower than 0.0001 g/cm³.

Low Sample Volume – Importance in Real Life

The viscosity is also important for used oils. Change in viscosity can reveal oil thinning due to fuel dilution or oil aging. For example, in contrast to conventional diesel, bio-diesel does not evaporate out of the engine oil and this leads to a continuous thinning, which in turn requires more frequent oil change.

In such cases of oil samples from the field, often only low sample volume is available, but a number of different tests need to be performed in the laboratory. In such cases, the low sample volume required for a multiparameter determination with SVM™ is very beneficial. The minimum sample volume required for SVM™ 3001 is only 1.5 mL; typical sample volume amounts to approximately 5 mL. Also, with the small cell of the new SVM™ the cleaning requires low solvent amounts, which means a fraction of waste liquid of that with traditional methods ensuring reduction of solvent disposal costs.

Conclusion

Having the flexibility to measure various samples with different viscosities at various temperatures with one measuring cell is perhaps one of the most striking advantages of SVM™ 3001. With one integrated viscosity and density cell, measurements of lubricating oils, fresh and used, as well as ATFs, hypoid oils and also fuels can easily be performed. Due to very fast heating and cooling rates and the wide measuring range in temperature, viscosity, and density, the SVM™ technology sets new standards for flexibility in testing. Temperature scans for kinematic viscosity, density, and dynamic viscosity – all in one scan - can be performed over an incomparably wide temperature range in the fastest manner. This not only significantly simplifies measurement routines and saves time for multiple tests, but also gives an important insight, for example, into the construction of engines for heavy duty vehicles, in this particular case for temperatures from -20 °C to +130 °C. Paired with excellent reproducibility and repeatability in both viscosity and density measurement as well as unbeatable ease of operation, the SVM™ technology represents one of the most versatile viscosity and density testing technologies for petroleum products.

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