WHAT THE FLEXIBLE TEMPERATURE CONTROL OF A NEW VISCOMETER CAN DO FOR YOU

ANTON PAAR HAS RECENTLY INTRODUCED THE NEW SVM™ 3001 STABINGER VISCOMETER™

The predecessor, SVM™ 3000 introduced in 2001, has revolutionised viscosity measurement of petroleum products. Sometimes called "the missing link" between dynamic viscosity and kinematic viscosity, it was the first to combine the advantages of rotational viscometers with the high accuracy of kinematic viscometers. An integrated density meter combines the two worlds and allows for results both in dynamic and kinematic viscosity.

Figure 1: Approximate size of the thermostatted volume of the SVM™ 3001 is 50mL

Stabinger Viscometer™ has received several standard test methods starting with ASTM D7042 in 2004 and more recently EN16896 and DIN 51659-2. Many specification standards refer to one of these test methods, most prominently ASTM D396, D975, D1655 and D2270.

The next generation SVM™ 3001 is not a revolution anymore, but a very significant evolutionary step.

In addition to an entirely new user interface with a 10.4" touch screen and a totally new measuring cell, the new SVM™ 3001 features an upgraded metal oscillator and fully complies to the standards for digital density measurements like ASTM D4052 and D5002, IP 365 and EN ISO 12185. It remains fully compliant to the existing viscosity standard test methods ASTM D7042, EN ISO 16896 and DIN 51659-2. Once again, Stabinger Viscometer™ combines two worlds.

This paper will mainly focus on the new thermostatting concept of SVM™ 3001, which is a big step forward compared to the already highly appraised SVM™ 3000.

On the upper end, the temperature range has been increased up to +135 °C from the original 105 °C. Yet, an even more important feature is the improved cooling performance. Consequently, it is possible to reach -60 °C in a fraction of the time the SVM™ 3000 needed to reach its minimum of -56 °C.

Temperature is the most critical influencer of viscosity.

Therefore, viscosity tests are performed at many different temperatures, e. g. motor oils at 40 °C and 100 °C, residual fuels at 50 °C and 100 °C and jet fuel at -20 °C or lower.

Accurate temperature control is an indispensable requirement for accurate viscosity measurement. As a rule of thumb, viscosity of typical petroleum based liquids decreases by about 5 % per degree centigrade.

Traditionally, temperature control of viscometers is achieved by use of a water bath or an oil bath, which both show good temperature stability due to their big thermal mass and achieve thermal uniformity by circulating the liquid through the bath. When properly set up, i. e. when the viscosity of the bath liquid matches the circulation pump speed as well as the required heating or cooling power, such baths can provide good stability and uniformity.

However, problems begin the moment one tries to change the temperature. As – bearing in mind the above mentioned – changing the temperature has a strong influence on viscosity, this also applies to the bath liquid and becomes especially problematic in the low temperature range, where water cannot be used anymore:

For example, viscosity of a typical 65% water / 35% glycol mixture would change from 2.49 mPa.s at +20 °C to 14.1 mPa.s at -20 °C – thus increasing by more than five times . As the thermal transfer capacity is mostly influenced by viscosity, the thermal equilibration between bath and viscometer would also be 5 times worse. To compensate the viscosity change, a higher pump speed would be required to achieve the same uniformity. That requires a separate calibration of the bath temperature for each measuring temperature.

At temperatures lower than -20 °C the choice of bath liquids becomes difficult and the low viscosity requirement is only achievable with either ethanol/methanol or silicone oils. Those alternatives are both highly flammable and harmful, or very expensive.

As a further drawback, the big thermal mass of the bath liquid makes temperature changes and the required temperature equilibration very slow.

Due to the above limitations a typical thermostat bath is used only for a single temperature and stays there 24/7 until the next scheduled maintenance.

In dramatic contrast to the above scenario, the new SVM™ 3001 Stabinger Viscometer™ ensures temperature uniformity by using a highly conductive copper block instead of a liquid circulating bath. The ultra-compact design allows for integrating both the viscometer as well as the density meter in just about 50 mL of volume.

Together with the small sample volume of just 1.5 mL (for both viscosity and density determination) not only temperatures 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. With integrated air cooling, the SVM™ 3001 can reach the standard test temperature of -20 °C without the need of any thermal transfer liquids or external devices.

An additional advantage is the low power requirement for heating and cooling which reduces electricity costs, air condition load and environmental damage.

The full cooling capability of the system is unleashed when connecting an external circulation chiller. Using pure water at +5 °C even with the smallest external chiller on the market, a test temperature of -40 °C can be reached. Even the lowest temperature of -60 °C can be reached using water/glycol mixtures; you need not trouble with flammable liquids at all.

What practical advantage does this flexible thermostat provide to the operator?

Standard Mode (S) and Repeated Mode (RM)

Versatile as it is, SVM™ 3001 can be used at any temperature desired. After entering a new set temperature, it takes only a few minutes for the instrument to be ready for the next test. The instrument's temperature adjustment covers the full range of -60 °C to +135 °C as delivered out of the box.

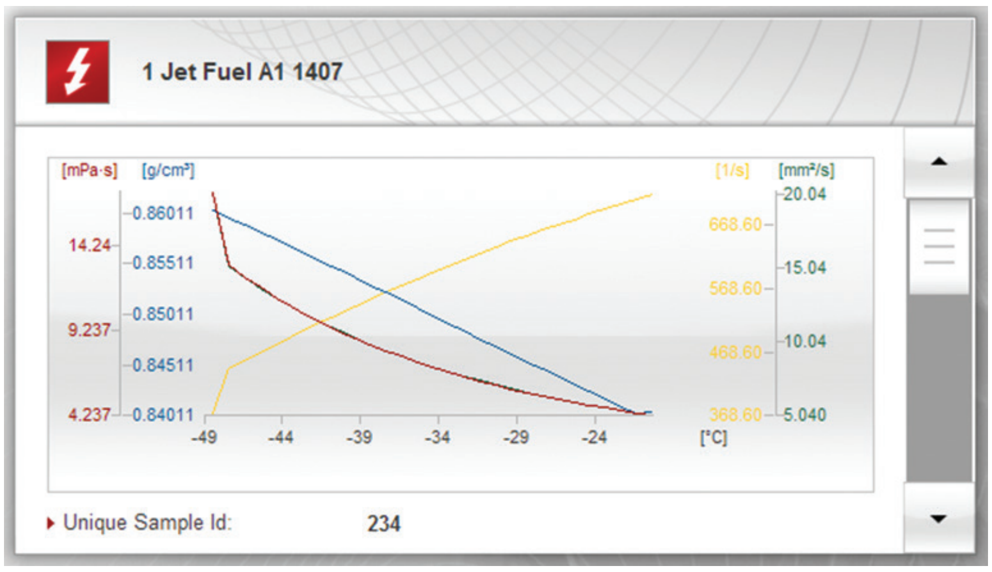
During measurement, the instrument's software continuously monitors the current viscosity and density values and checks the stability of the values over time. When the stability is within the programmed limits, the determination is declared valid. Thereby the thermal equilibration of the sample is perfectly under control and not dependent on user-defined waiting times.

In Repeated Mode, a fresh sample is introduced into the measuring cell and tested again. The device software automatically calculates the repeat deviation for viscosity and density and decides whether a result is already valid or additional determinations are required.

In combination with an Anton Paar Abbemat Refractometer, ASTM D2140 "Practice for Calculating Carbon-Type Composition of Insulating Oils of Petroleum Origin" is supported by the instrument's software.

Viscosity Index (VI) mode

This mode tests at two different temperatures (typically +40 °C and +100 °C). Not only can the SVM™ 3001 calculate the viscosity index (VI) according to ASTM D2270, but it can also extrapolate the measured viscosity and density to any desired temperature using standardised calculations like ASTM D341 for viscosity and ASTM



Unique Sample Id: 234

Figure 2: Screenshot of a temperature scan graph showing irregular jet fuel behavior (with warning) near the freeze point (ASTM D2386: -44.43 ±2.38 °C).

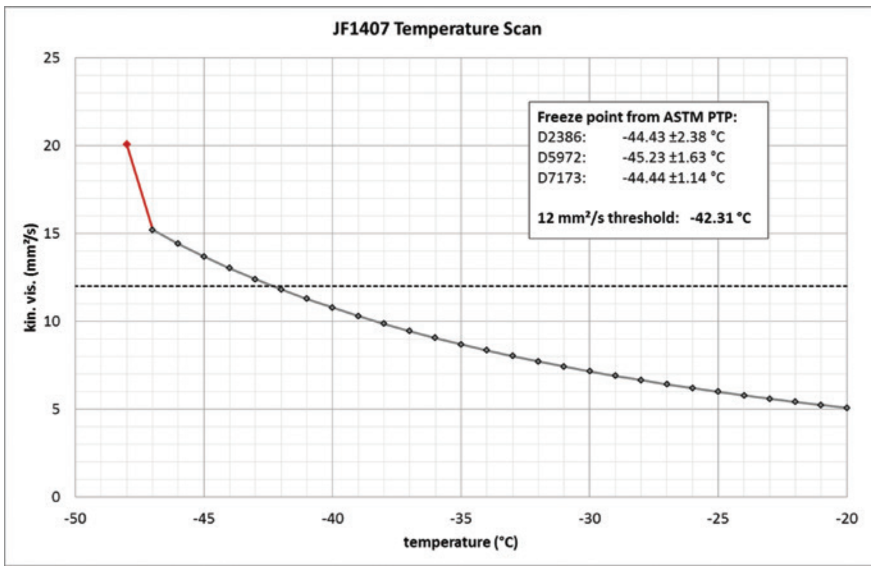


Figure 3: Detailed graph derived from the temperature scan result.

D7042 (linear extrapolation) and API D2540 (petroleum tables) for density.

In addition, the "Estimation of Mean Relative Molecular Mass of Petroleum Oils from Viscosity Measurements" according ASTM D2502 can be calculated in this mode.

In combination with an Anton Paar Abbemat Refractometer also ASTM D3228 "Calculation of Carbon Distribution and Structural Group Analysis of Petroleum Oils by the n-d-M Method" is performed automatically by the instrument's software.

Temperature scan (TS) mode

This mode allows testing of a sample over a wide range of temperatures with a fixed step width. Thus, it is possible to check viscosity and density of e. g. a jet fuel between -20 °C and -60 °C with 1 °C steps to check its applicable temperature range.

As the viscosity-temperature-dependence changes strongly when approaching a phase transition point (like the cloud point or the pour point), the viscosity curve increases visibly near that point. This can be used as an indicator for the commencing solidification of e. g. paraffins in a fuel.

Temperature table scan (TTS) mode

This mode enables the user to enter freely selectable temperatures in a table. ASTM D4054 "Standard Practice for Qualification and Approval of New Aviation Turbine Fuels and Fuel Additives" presents a practical example for such a temperature table scan.

This standard states that viscosity has to be tested at -40, -20, +25 and +40 °C, and density at -20, +20 and +60 °C: a total of 6 temperatures is required.

SVM™ 3001 can perform this test in less than one hour.

Conclusion

Flexible temperature control combined with a wide temperature range makes the new SVM™ 3001 one of the most versatile kinematic viscometers and density meters for petroleum products. Time saving technology and ease of use round up the unique user experience. The instrument's software provides many parameters for a broad variety of applications from aviation to residual fuels, lubricants and hydraulic oils to specialties such as insulating oils.

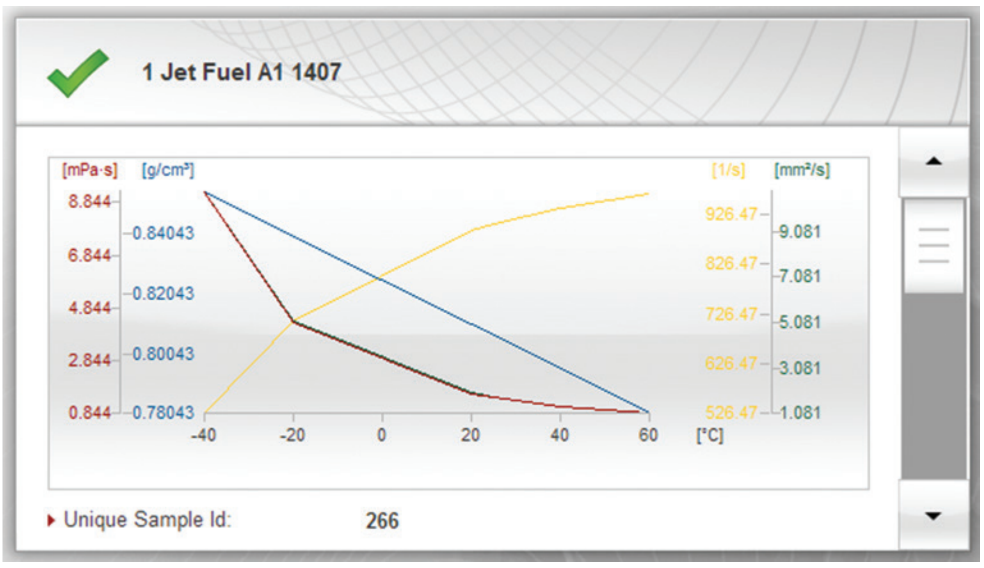


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Figure 4: Screenshot of a temperature table scan graph results as required by ASTM D4054.

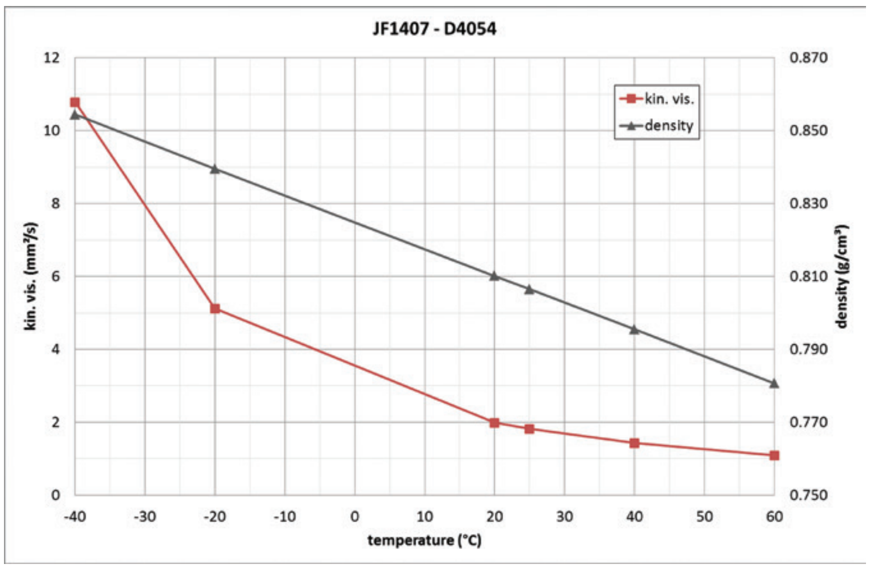

Figure 5: Detailed graph derived from the temperature table scan result.

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