Viscosity Measurement by Manual Kinematic Method

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Viscosity

Tamson viscosity baths: TV2000, TV4000 and TV7000. Since decades the worldwide dominating brand for the determination of kinematic viscosity.

Viscosity is a principal parameter when any flow measurements of fluids, such as liquids, semi-solids, gases and even solids are made. Viscosity measurements are made in conjunction with product quality and efficiency. Anyone involved with flow characterization, in research or development, quality control or fluid transfer, at one time or another gets involved with some type of viscosity measurement.

The viscosity of a lubricating oil can be considered as its most important physical property. It must be monitored and controlled carefully because of its impact on the oil and the oil's impact on equipment life and reliability. Basically, the viscosity can be defined as the property of a liquid characterizing its internal friction or resistively to flow.

Many manufacturers now regard viscometers as a crucial part of their research, development, and process control programs. They know that viscosity measurements are often the quickest, most accurate and most reliable way to analyze some of the most important factors affecting product performance.

Physics defines several types of viscosity and separate two families between Newtonian -rate of strain curve is linear and passes through the origin- and non-Newtonian -the viscosity changes with the applied strain rate- fluids.

There are mainly two related measures of fluid viscosity:
- dynamic (or absolute) viscosity.
- kinematic viscosity.

The knowledge of viscosity is needed to adjust and define the required temperatures for storage, pumping or injection of fluids and is also critical to check if an oil can provide adequate lubrication.

Measurement Principle

There are many different techniques for measuring viscosity, each suitable to specific circumstances and materials. The selection of the right viscometer from the scores of instruments available to meet the need of any application is a difficult proposition. Today's instruments vary from the simple to the complex: from counting the seconds for a liquid to drain off a stick to very sophisticated automatic recording and controlling equipment. This places the instrument user in a position in which his own appreciation of the flow phenomena involved, coupled with the instrument manufacturer's "know how and experience", must be brought to bear.

ASTM D445 requires the oil sample to be injected in a capillary viscometer tube, which is then immersed in a heating bath at the prescribed test temperature. The time taken for an oil to flow from one capillary section to another is used to determine its kinematic viscosity.

We measure the viscosity of an oil according to a time and a tube constant. The time is measured between two points marked on the tube. Then the viscosity is obtained by applying the following calculation:

$$v = C \times t$$

With v as the kinematic viscosity in cSt or mmÇ/s, C the constant of the tube and t the efflux time in seconds to flow between the two points. Several types of viscometer tubes can be used which are described in standard ASTM D446.

Consequences of Unstable Bath Temperature

ASTM D445 describes the standard test method for kinematic viscosity of transparent and opaque liquids. In section 6 the specifications of the equipment – viscometers, viscometer holders, temperature-controlled bath, thermometers, and timing device – are described which have to be used to perform a kinematic viscosity measurement.

Section 6.3.1 of ASTM D445 describes the required temperature control of the bath. For each series of flow time measurements, the temperature control of the bath liquid shall be such that within the range from 15 to 100°C, the temperature of the bath medium does not vary by more than ± 0.02°C of the selected temperature over the length of the viscometer, or between the position of each viscometer, or at the location of the thermometer. For temperatures outside this range, the deviation from the desired temperature must not exceed ± 0.05°C. As you can read in the paragraph above, the ASTM committee allows quite a temperature unstability. But what is the consequence for the viscosity result if the bath temperature is varying by 0.02°C.

	Sample	1	2	3	4	5	6
2	Time [sec.]	132.43	132.69	131.81	131.76	132.79	132.14
3	Min. Temp. °C	49.166	49.177	49.172	49.173	49.177	49.162
4	Max. Temp. °C	49.193	49.204	49.200	49.202	49.201	49.198
5	Delta (±)	-0.027	-0.027	-0.028	-0.029	-0.024	-0.036
6	Average temp. °C	49.178	49.185	49.190	49.184	49.192	49.171

Table 1

We have tested 6 samples with an Ubbelohde viscometer with a constant of 0.009021. The time measurements were performed with an automatic measuring head. In table 1 the results of the six tests are reflected. Row 2 gives the duration of a measurement in seconds, where the time is measured via two optical infra red sensors. Row 3 and 4 show the minimum and maximum temperature during a test. Row 5 demonstrates the difference between the maximum and minimum temperature. Row 6 gives the average temperature of the bath during a test.

	cSt	Deviation	Temp °C	Deviation
	~~1.188607~~	~~99.538%~~	~~49.184~~	~~100.002%~~
	1.194651	100.044%	49.178	99.990%
	1.196996	100.240%	49.185	100.003%
	1.189058	99.575%	49.190	100.014%
	1.197899	100.316%	49.192	100.017%
	1.192035	99.825%	49.171	99.976%
Average	1.194128		49.183	

Table 2 shows the kinematic viscosity. For sample 1 it is calculated as follows:

$$v = C \times t = 0.009021 \times 132.43 = 1.194651$$

You are allowed to delete one test result, so we have deleted the results of sample 4. The average in table 2 is taken from the five other samples. The deviation is calculated by deviding the v by the average of the five samples. This result has been multified by 100%.

cSt	Deviation	Temp °C	Deviation
1.197899	100.316%	49.192	100.017%
1.192035	99.825%	49.171	99.976%

Table 3 is a part of table 2. The delta in temperature is 49.192°C – 49.171°C = 0.021°C. And the deviation in the measuring result is 100.316% – 99.825% = 0.491%!

Based on this experiment, we can conclude that a slight temperature variation by only 0.02°C - thus conform ASTM D445 - can cause a 0.5% deviation in the viscosity result.

Latest Innovation

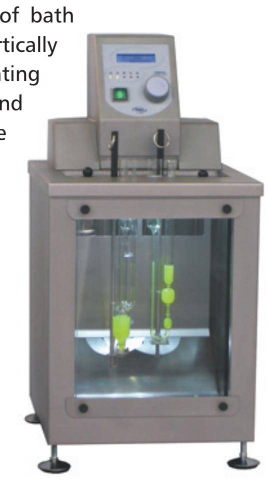
By seeing this result, the R&D department of Tamson started the development of a viscosity bath based on the latest technology. The target was to build a viscosity bath with the highest stability in order to get the most accurate viscosity measurement.

Recently, we have finalized the development of the new Tamson Viscosity 12 litre bath. The TV12 has a stability of ± 0.005K while only using 12 litres of bath content. Next to this, the stirring pump within the bath is moving vertically instead of horizontally. As a result, the bath content is circulating vertically. This means that when two viscometers of the same size and type are placed next to each other, the temperature will be the same for both tubes at the same height.

With the TV12 we have performed 4 tests (we followed the same procedure as described above) to calculate the deviation in the viscosity result. Table 4 and 5 show the results.

Sample	1	2	3	4
Time [sec.]	130.120	130.740	130.720	130.770
Min. Temp °C	49.196	49.195	49.197	49.194
Max. Temp °C	49.200	49.198	49.201	49.199
Delta (±)	-0.004	-0.003	-0.004	-0.005
Average temp. °C	49.198	49.198	49.198	49.198

Table 3



New TV12 by Tamson Instruments

	cSt	Deviation	Temp. °C	Deviation
	~~14424.12~~	~~99.642%~~	~~49.198~~	~~100.0007%~~
	14492.85	100.117%	49.197	99.9980%
	14490.63	100.101%	49.199	100.0024%
	14496.18	100.140%	49.197	99.9989%
Average	14475.95		49.198	

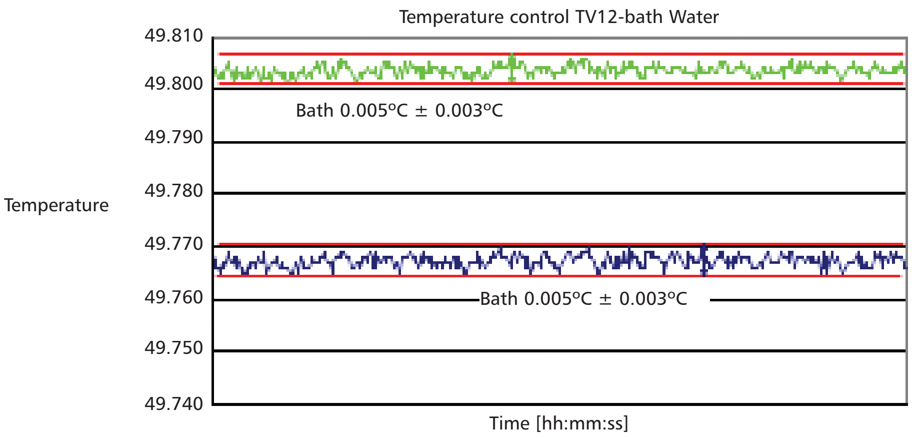
Table 4

cSt	Deviation	Temp	
14492,85	100,117%	49,197	99,9980%
14490,63	100,101%	49,199	100,0024%

Table 5

Table 6 is a part of table 5. The delta in temperature is 49.197°C – 49.199°C = -0.002°C. And the deviation in the measuring result is 100.117% – 100.101% = 0.015%!

Based on this experiment, we definitely see a difference between the measuring results of a bath with 0.02°C variation in the bath content and the new TV12 with better than 0.005°C stability. Below a graph shows the stability of the TV12 during two tests.



Summary: Viscosity Measurement

Viscosity is the single most important property of a lubricant. A reduction usually indicates that the system has been contaminated with a solvent or refrigerant fluid. A significant increase normally is traced to mixture with a high viscosity product, contamination, or oil oxidation. ASTM test requires that the bath content does not vary by ± 0.02°C if the working temperature is between 15 and 100°C. The efflux time is measured between two points in a glass capillary. The viscosity is computed by using the constant of the viscometer tube and the efflux time.

Summary: Unstable temperature

Unstable temperatures of the bath have dramatical consequences for the viscosity result. Even if a bath is operating conform ASTM D445 requirements, the viscosity result is highly influenced. This uncertainty can be minimized if the bath has a stability better than 0.005K.

Conclusion

The viscosity of a lubricating oil can be considered as its most important physical property. The new kin ematic viscosity bath - TV12 - is the ultimate innovation to guarantee the most accurate temperature control for the measurement of kinematic viscosity.

With the new TV12 the measurement faults caused by an unstable bath temperature – even if the bath stability is conform the requirements of ASTM D445 – are minimized. In this way Tamson continues to manufacture the best viscosity baths worldwide. With the latest technology integrated, the oil analysis labs now can have the most accurate kinematic viscosity bath which exceeds the requirements of the ASTM D445 method.

Features of new Tamson Viscosity Bath (TV12):

- Completely stainless steel,
- Small bath content,
- Working temperature from ambient up to 150°C (optional chiller can be connected to work below ambient),
- Exceeds the requirements of ASTM D445
- Extremely stable, better than ±0.005K (2 heating elements associated),
- Uniformity ± 0.005K,
- Homogeniety better than stability due to vertical circulation of bath content,
- Unique,
- Cover with 4 holes to accommodate viscometers,
- Easy bath maintenance and quick drainage by means of a tap,
- Compact design, saves space on work bench,
- Integrated backlight,
- RS232 communication,
- Cooling coil,
- Reliable,
- Equipped with an overflow outlet,
- The window is formed with two panes separated by 20 mm air space,
- The outside window pane can easily be unscrewed to clean the inner window,
- Equipped with a mechanical adjustable and resettable safety thermostat.

New Low-Cost Benchtop Analyser Offers Improved Resolution and Detection Limits

Jordan Valley's (USA) new low-cost EX-Cite will replace the EX-310, the previous base model energy dispersive x-ray fluorescence (EDXRF) benchtop analyser. The EX-Cite EDXRF benchtop spectrometer has many improved features over the EX-310, including an integrated computer system, a smaller footprint, vastly improved resolution and corresponding improved detection limits.

With newly developed improvements to proven PIN diode technology, the 35kV, 9 watt EX-Cite produces superior sensitivity with improved peak-to-background ratios, high count throughputs and superior resolution as compared to earlier PIN diode instruments. At the same time, the high-voltage, high-powered x-ray source delivers traditional laboratory instrument performance in a compact, self-contained package that fits conveniently on a traditional laboratory bench. The side window x-ray tube and advanced optical design permit extremely close coupling to the sample. The EX-Cite provides non-destructive qualitative and quantitative determination of Sodium through Uranium. It can be easily customized for several different industriesand applications.

Laura Oelofse, Vice President of Sales and Marketing at Jordan Valley said, "The EX-Cite is a natural evolution in Jordan Valley's quest to provide low-priced XRF analysis at the best possible price-performance ratio."

The integrated computer system combined with the robust design make the instrument ideal for a mobile laboratory. It meets MIL-810E specifications for shock testing.

For more powerful performance, Jordan Valley's new 50kV, 50 watt EX-Calibur includes a fully integrated computer system and provides full qualitative, semiqualitative and quantitative analytical capabilities. This liquid nitrogen free EDXRF spectrometer achieves similar resolution to a traditional LN2 cooled SI(Li) detector, while eliminating the cost and inconvenience associated with liquid nitrogen.

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Quartz Viscometer for Lab Instrumentation and for Process Control

The QVis quartz viscometer from **KMB²** (Germany) is an instrument for advanced process control and for laboratory instrumentation.

The core of this patented measuring system without moving parts is an oscillating quartz (56 kHz pure shear wave torsional transducer) which is dampened by the viscous properties of the surrounding sample. A Pt100 temperature probe is integrated. The measuring range is 1 to 10,000 mPas at –50°C to +300°C and up to 1450 psi. The oscillating quartz provides a self-cleaning effect.

The viscometer is available as easy-to-use lab instrument with an unthreaded sensor head (OD: 25 mm). Operation is stand-alone or by PC control. A battery pack is available.

The process type of this instrument (explosion-proof if required) has a 1" thread sensor module for in-line use, also in fluent media.

With its integrated PI controller, the process viscometer allows to actively control the viscosity of oils, paints, coatings, etc. As this instrument uses the same measuring principle in the lab as in the process, it is most suitable for research, development and for quality control, e.g. in production and blending lines.

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New Analyser for In-the-field Biodiesel Screening

Zeltex (USA) is proud to announce its ZX-101XL portable fuel analyser is now able to screen biodiesel in the field and at the pump. For over thirteen years, state and federal governments, as well as numerous private companies have been using the Zeltex ZX-101 line of fuel analysers to accurately test octane and cetane in the field. Now the ZX-101XL can perform the same test on biodiesel fuel. With calibrations for biodiesel percentage and ethanol percentage, the ZX-101XL will prove to be the only choice for in-the-field fuel screening. Across the United States and in forty countries worldwide, Zeltex's fuel analysers have established themselves as the analyser of choice. Their analysers will provide you with lab-accurate and dependable readings within sixty seconds. Operating on "AA" batteries, the ZX-101XL can be used to test biodiesel and ethanol-blended fuels.

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New XRF Data Sheet Helps Predict Machine Wear and Manage Maintenance

Leading analytical X-ray specialist, **PANalytical** (The Netherlands), has published new data on the MiniPal 4 energy dispersive X-ray fluorescence (EDXRF) and Axios-Petro wavelength dispersive X-ray fluorescence (WDXRF) spectrometers that show their effectiveness and value in predictive machine maintenance programmes.

As metal surfaces within a machine undergo physical and chemical wear, trace concentrations of the component metals appear in the lubricant. Elemental analysis of the lubricating oil provides a fingerprint of the worn component and enables its rapid identification. For example, Ni and Fe levels indicate worn pistons, rings and crankshaft wear, whilst Cu and Sn are associated with bearing and bush wear.

By enabling accurate, precise quantification of wear metals in lubricating oils, PANalytical systems, such as MiniPal 4 and Axios, can help to significantly improve predictive maintenance programs and scheduled down-time planning, minimize repair costs and increase safety margins by reducing the chance of catastrophic machine failure.

New application notes illustrate the detection limits, accuracy, precision and long-term stability of MiniPal 4 and Axios. Importantly, XRF is a non-destructive technique that requires only simple sample preparation.

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