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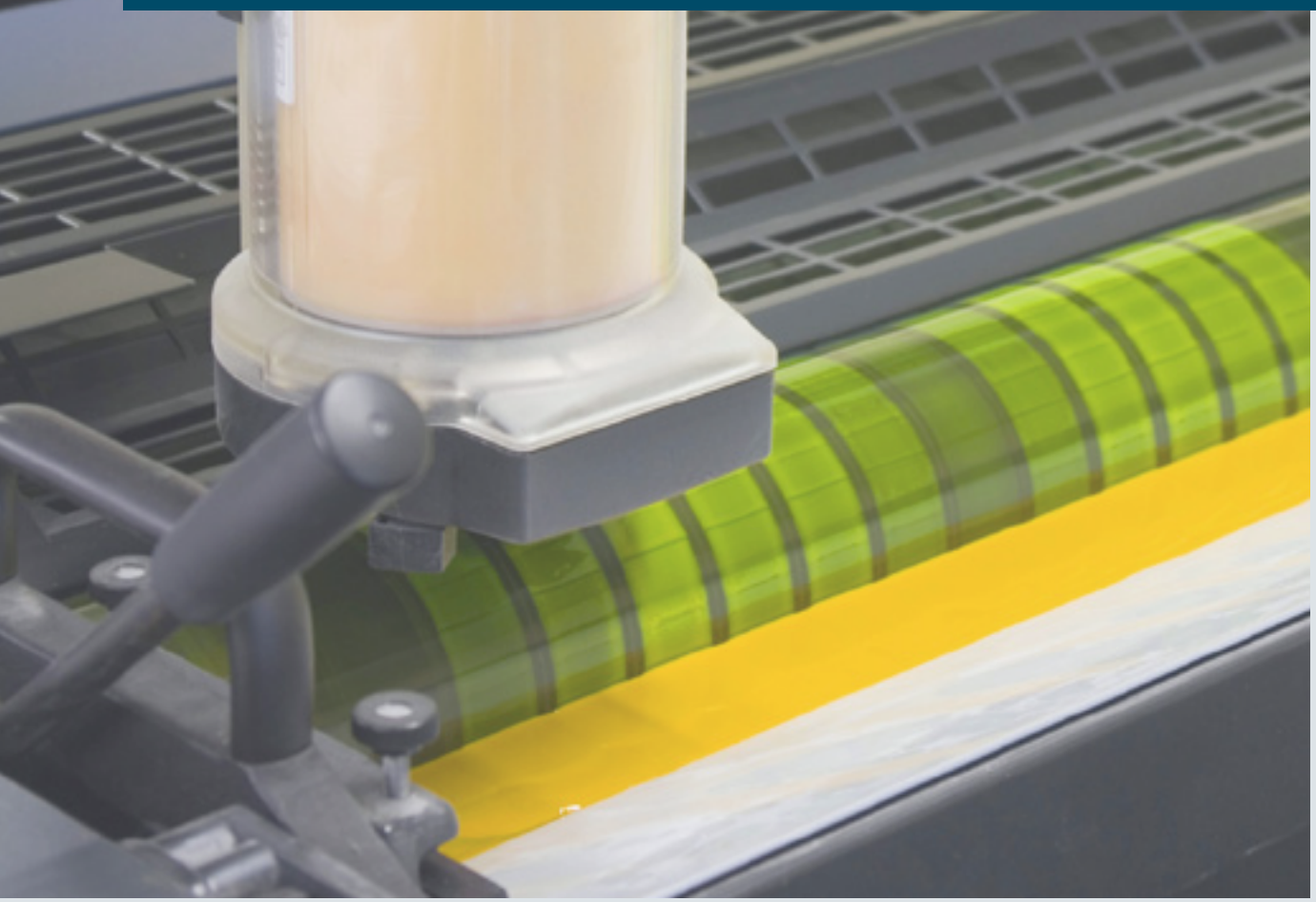
Viscosity Control Buyer's Guide

TOOLS AND ANALYSIS FOR COATING, PAINTING AND PRINTING PROCESSES



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VISCOSITY

What is it?

Dictionary.com defines viscosity as: *"The property of a fluid that resists the force tending to cause the fluid to flow." An easier, although slightly less accurate, way to look at it is how thick or thin a fluid is. For example, honey is generally thicker than water; likewise, honey is more viscous than water.*

Why should you care about it?

Whether you are coating, painting, printing or applying any type of fluid, changing viscosity can modify your finished product. If you are proactive, you can use viscosity and its changing effects to your advantage. If you are reactive, you may end up chasing an elusive target and compromising your finished product.

Below are some examples of print industry issues that may be the result of poor viscosity control.

- **Color changes or variations during a press run:** Since color is dependent on viscosity, measuring and maintaining the fluid viscosity throughout the press run is crucial to ensuring consistent color. Manually controlling or "spot checking" during the run does not allow for true viscosity/color control.
- **Excessive ink usage during a press run:** With manual viscosity monitoring, the ink can have large swings in viscosity due to the many other functions the operator is responsible for. This results in only occasional checking and adjusting of the ink. As solvent evaporates, ink viscosity rises and more ink is applied to the substrate.
- **Excessive solvent, amines, or extender usage during a press run:** Manual control increases the possibility of adding too much solvent or amines when dosing. This haphazard approach will certainly affect the ink color. Additionally, since these additives are poured in, not metered in, there is limited control on the amount used.

VISCOSITY

- **Dirty print or ink smearing:** If ink viscosity is not adequately maintained throughout a press run, the viscosity can rise and fall with solvent evaporation and replacement. The ink may adhere to or build up on the plate, impression roller, or substrate outside of the impression area. This may cause dirty print or smearing in non-image areas.
- **Anilox roller cells plug up:** This causes print problems such as deformed dots, dirty print, or other imperfections. Plugged anilox roller cells often result from improperly maintained viscosity or inadequately mixed inks, issues that cause ink solids to become trapped in the anilox cell.

  Additionally, ink viscosity directly affects the transfer of ink from the anilox roll to the plate. This changes the volume of ink applied to the substrate and therefore the color and intensity of the image. This is the reason that many printers use different anilox rolls at different times of the day or year.
- **Job rejections due to print-related issues:** For most companies, their brand is one of their most important marketing tools. When a print job is meant to align with a company's brand values, associated projects will receive more scrutiny and come with greater expectations for quality. If the color linked to the brand is not correct or if there are any print-related imperfections, there is a higher chance the job will be rejected. Often, these rejections or customer returns can be traced back to inconsistent ink viscosity.
- **Excessive cleanup time due to ink-related issues:** If you have housekeeping issues around the ink pail and throughout the press, you may have a viscosity-related problem. Ink management, including viscosity control and mixing, can help ensure fewer issues with ink slinging. Commonly, slinging is the result of either thin ink or buildup due to out-of-range viscosity.

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VISCOSITY

- **Press stoppage during a run to address cleaning-related issues:** Proper ink management can reduce the number of times it is necessary to stop a press during a run to clean plates, rolls or other press areas due to ink buildup or slinging.
- **Adhesion or flaking issues:** When ink viscosity is manually maintained, there is potential to add too much or too little solvent when bringing the viscosity back into spec. Further, if different inks require different solvent blends, there is a risk of adding the wrong solvent, which can result in ink contamination and other issues.
- **Inks either not drying or drying too quickly:** When manually measuring and controlling ink viscosity, there is always the possibility that the ink-to-solvent ratio may not be correct for the volume of ink applied. This can result in the ink drying either too quickly or not quickly enough. Variation in ink drying time can lead to a variety of print-related issues including inconsistent color, bleeding, smearing, and flaking. Each of these may cost valuable time, labor and income due to rejections.

Ink viscosity is one of the most crucial elements of any printing process. If you are experiencing any of these symptoms, ink viscosity may be the first and easiest place to start your investigation.

EFFLUX CUP

Overview

According to PrintWiki – the Free Encyclopedia of Print:

Essentially, an efflux cup is a container with a hole at the bottom.

The cup is lowered into the ink to be measured, and then lifted out.

When the hole is above the surface of the ink reservoir, a stopwatch is started, and the time it takes a fixed quantity to flow out of the hole can be measured.

Efflux cups come in a variety of shapes and sizes, such as a Ford Cup, a Zahn Cup, a Shell Cup, and a GRI Hiccup.

Each configuration of cup comes with a set of different hole sizes, suitable for inks with a range of viscosities. For example, a thicker, more viscous ink requires a larger hole than a thinner, less viscous ink.

The measurement of an ink's viscosity is an important factor in many printing processes, in particular gravure and flexographic printing.

Common applications

Due to the large variety of efflux cups available and their scalability using different fluid volume and orifice size, an efflux cup can be used to measure the viscosity of almost any fluid; however, the primary discussion of this document will be printing ink.

Click here to download a free copy of our online Viscosity Conversion Table or if you are working from a paper copy of this document, go to https://www.viscosity.com/viscosity-markets/printing-industries-ink-viscosity and find the download at the bottom of the page.

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EFFLUX CUP

Strengths

- **Inexpensive:** The efflux cup is by far the least expensive option reviewed in this document.
- **Quick:** Getting a reading takes a very short period of time. Zahn cup time is generally measured in seconds.
- **Easy:** it is simple to use and easy to train someone else to use.
- **Benchmark:** Cup seconds is a common language in the printing industry. It is often the go-to measurement when discussing viscosity and viscosity issues.

Weaknesses

- **People:** While easy to use and easy to train others, efflux cups introduce the human element. We have seen as much as a 30 percent variance in viscosity reported by operators using Zahn cups. Simply stated, Zahn cups leave an awful lot open to interpretation, attention, and personal preference.
- **Time:** If you are taking cup measurements every 15-20 minutes, you are considered to be "staying on top of it." The reality is, much can change in a printing process in that time, leaving you exposed to quality defects.
- **Temperature:** A temperature increase of 5.5°C can reduce the viscosity of a printing ink by 50 percent or more (DeJidas and Destree, 2005). By taking ink out of the process and subjecting it to a temperature change, (due to ambient conditions or to the temperature of the cup itself), you eliminate the possibility of getting a true process reading.
- **Shear:** Shear occurs when certain gels or fluids that are thick (viscous) under static conditions become thin (less viscous) over time when shaken, agitated, or otherwise stressed.

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EFFLUX CUP

Inks are highly viscous under normal conditions, but will gradually become less viscous as force or stress is applied. Removing ink from the process eliminates the effects of shear. This ultimately ensures that you will not get an accurate process reading.

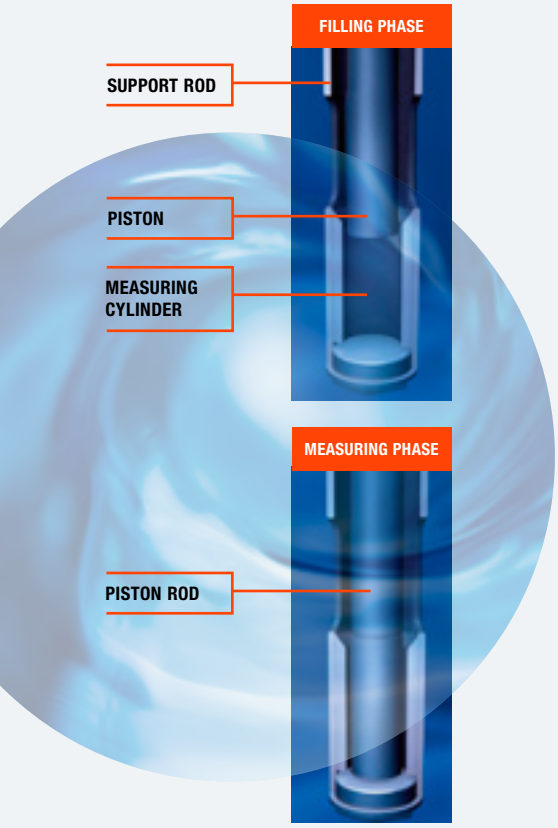
- **Easily inaccurate:** Efflux cup accuracy depends on the consistency of the cup and the hole size. The problem is that these cups are used in an industrial environment; any ding or dent that alters the cup or hole will affect the measurement. Additionally, there are many inexpensive cups available from online resources, but these cups are not always manufactured to the standard required to ensure accuracy.

Summary

Get an efflux cup, but don't rely on that alone for process accuracy. You will find that you will use your cup frequently and it will come in handy when you are spot checking during runs to ensure everything is functioning properly. Also use the following link to download our Viscosity Conversion Table to make sure you get the right cup for your fluid: https://www.viscosity.com/viscosity-markets/printing-industries-ink-viscosity

Relying on just the cup to ensure accuracy during your print runs can be risky, though. Unless your customer allows you a lot of latitude with your color, the weaknesses detailed in this guide introduce too many variables to make the efflux cup a foolproof, reliable viscometer. Even if money is an issue (and it always is), contact a viscosity control expert and let him or her help you determine your true cost of ineffective process viscosity control.

FALLING PISTON VISCOMETER



Overview

Wikipedia describes the Falling Piston Viscometer as follows:

Also known as the Norcross viscometer after its inventor, Austin Norcross. The principle of viscosity measurement in this rugged and sensitive industrial device is based on a piston and cylinder assembly.

The piston is periodically raised by an air lifting mechanism, drawing the material being measured down through the clearance (gap) between the piston and the wall of the cylinder into the space which is formed below the piston as it is raised.

The assembly is then typically held up for a few seconds, then allowed to fall by gravity, expelling the sample out through the same path that it entered. This creates a shearing effect on the measured liquid, which makes this viscometer particularly sensitive and good for measuring certain thixotropic liquids.

The time of fall is a measure of viscosity, with the clearance between the piston and inside of the cylinder forming the measuring orifice. The viscosity controller measures the time of fall (time-of-fall seconds being the measure of viscosity) and displays the resulting viscosity value.

The controller can calibrate the time-of-fall value to cup seconds (known as efflux cup), Saybolt universal seconds (SUS), or centipoise.

Common applications

Due to the scalability of using different piston and cylinder sizes, falling piston viscometers are used to measure the viscosity of a large variety of fluids; however, the primary discussion of this document will be printing ink.

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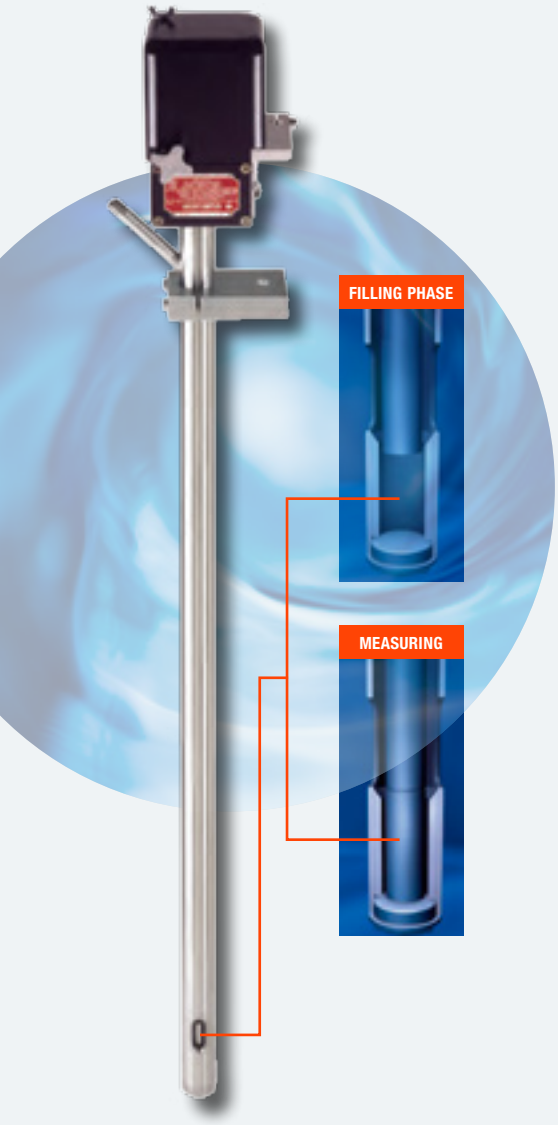
FALLING PISTON VISCOMETER



Strengths

- **Sensitive:** The falling piston viscometer detects small changes in viscosity and is excellent for processes requiring very sensitive readings.
- **Shear:** The shear effect activates the thixotropic properties of the fluid and provides increased accuracy. This makes this the most accurate device for measuring non-Newtonian fluids.
- **Robust:** The falling piston viscometer is designed for industrial use. Many of this type have been in use for several years.
- **Economical:** While not nearly as inexpensive as an efflux cup, the falling piston viscometer is an economical choice compared to other viscometers providing similar control.
- **Repeatable:** The design allows the falling piston viscometer to measure viscosity with minimal variation. Not much in a manufacturing environment disturbs either its function or its readings.

Weaknesses

- **Moving parts:** Although robust, the falling piston viscometer still has moving parts and, as a result, has pieces that are subject to wear. While not difficult to monitor or to replace, this type of viscometer works best in environments where preventive or predictive maintenance is part of the culture.
- **Cleaning:** Measuring parts that are exposed to the atmosphere (which causes ink to dry) need to be cleaned periodically, especially during color changes.

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FALLING PISTON VISCOMETER

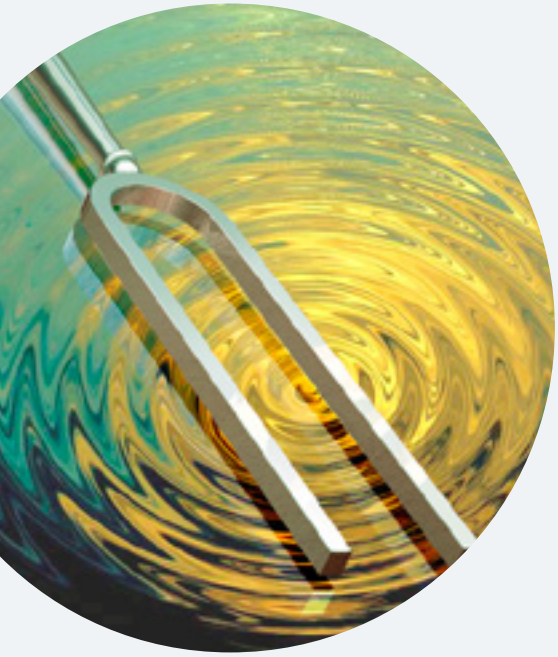
- **In-tank attachment:** Typically operated as an in-tank attachment, and often attached to the lid, the falling piston viscometer can be cumbersome and harder to work with.
- **Maintenance:** The unit routinely needs to be physically removed for visual inspection and part replacement.
- **Installation:** The system requires air lines to lift the piston. This can create additional installation time and cost, and contribute to additional clutter in the work area.
- **Temperature:** The falling piston viscometer does not come with a temperature sensor. While not applicable to all processes, temperature will become the next big variable to control in printing.

Summary

It's difficult to call the falling piston viscometer the wrong choice for a printing application. With an enormous installed base, the falling piston viscometer is still perhaps the most widely used process viscometer in the world. While a handful of weaknesses exist, none of them are severe enough to warrant avoiding this technology. For either a gravure or flexographic printing operation, the repeatability and the longevity make a falling piston viscometer a reliable, cost-effective selection.

That being said, there are some weaknesses to consider before making the decision. Most notably, the moving parts create additional maintenance and wear items.

VIBRATIONAL (Tuning Fork) VISCOMETER



Overview

Wikipedia describes the vibrational viscometer as follows:

Vibrational viscometers are of a class that operates by measuring the damping of an oscillating electromechanical resonator immersed in a fluid whose viscosity is to be determined. The resonator generally oscillates transversely as a tuning fork. The higher the viscosity, the larger the damping imposed on the resonator. The resonator's damping may be measured by one of several methods:

Measuring the power input necessary to keep the oscillator vibrating at a constant amplitude. The higher the viscosity, the more power is needed to maintain the amplitude of oscillation.

Measuring the decay time of the oscillation once the excitation is switched off. The higher the viscosity, the faster the signal decays.

Vibrating viscometers are rugged industrial systems used to measure viscosity in the process condition. The active part of the sensor is a vibrating rod. The vibration amplitude varies according to the viscosity of the fluid in which the rod is immersed.

Currently, many industries around the world consider these viscometers to be the most efficient system with which to measure the viscosities of a wide range of fluids. Vibrating viscometers have no moving parts, no weak parts and the sensitive part is very small.

Common applications

Vibrational viscometers are widely used in flexographic printing, gravure printing and in some aqueous coating applications.

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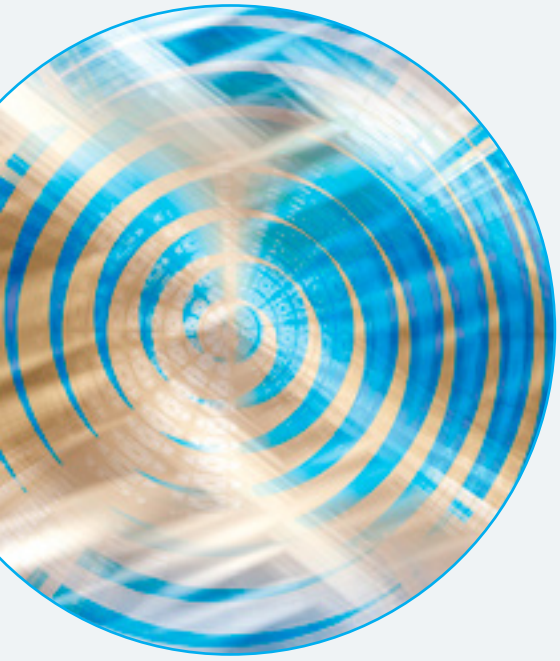
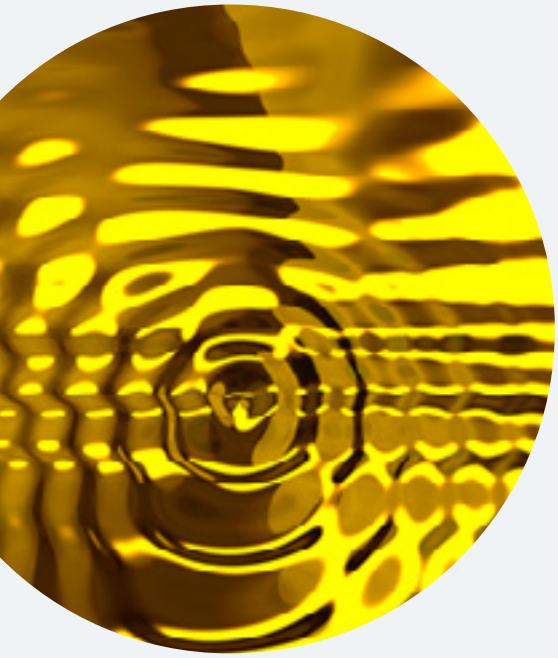
VIBRATIONAL (Tuning Fork) VISCOMETER



Strengths

- **Sensitive:** The vibrational viscometer detects small changes in viscosity and is excellent for processes requiring very sensitive readings.
- **Repeatable:** The design allows the vibrational viscometer to measure viscosity with minimal variation.
- **Self-cleaning:** As a process controller, the vibrational viscometer cleans easily with the normal cleaning of the press and its accessories.
- **In-line:** There is no reason to remove ink from the process. This viscometer takes the reading as it is in use.
- **Compact:** Vibrational viscometers are relatively small. This makes finding a place for mounting and installation relatively simple.
- **Real time:** Although the time lag in a falling piston viscometer is relatively short, the vibrational viscometer reads in milliseconds.
- **Other:** The items listed below are differences that may exist between different vibrational viscometers. If these are important to you, please investigate with the manufacturers directly:
  - In-line temperature reading: Good for expanding your system to incorporate temperature control or simply for monitoring.
  - Calibration: Some vibrational viscometers can be trained to recognize inks and calibrate automatically.
  - High frequency: Some vibrational viscometers vibrate at a frequency that can be subject to interference by machine vibration. Those models have special mounting requirements. Others operate at a higher frequency and do not give inaccurate readings when exposed to machine vibration.

VIBRATIONAL (Tuning Fork) VISCOMETER



Weaknesses

- **Mounting:** As mentioned above, some vibrational viscometers vibrate at a frequency that can be subject to interference by machine vibration. If you select one of these models, you must adhere to strict rigid mounting requirements.
- **Shear:** Vibrational viscometers do not generate shear and therefore may not accurately measure non-Newtonian fluids.
- **Replacement cost:** Premature failure of the vibrational viscometer sensor generally means replacement of the entire unit.

Summary

With many strengths and very few weaknesses, it is not surprising that the vibrational viscometer has become the highest selling viscometer in the printing industry. There is much to like about the vibrational viscometer. Just make sure that when you are making your decision, you get the right model for your application. At a minimum, we recommend that you consider temperature readings to allow for expansion of your system for even tighter control.

Additionally, look for models that operate at a higher frequency to ensure that you do not get false readings due to machine vibration. Finally, make sure that the Newtonian characteristics of the ink(s) you are measuring are compatible with the sensor that is chosen.

FINAL THOUGHTS

Be informed

There are many ways to control ink viscosity in the printing process. We chose to discuss only three here as they are currently the most widely used. As new technology develops, we will investigate and write about it on our blog.

No one technology is sufficient for all applications but understanding the cost of the solution as well as the cost of not implementing a solution is vital. We have resources dedicated to understanding those costs and guiding you in the right direction.

Our Company

Norcross has been in business for over 75 years, helping gravure printers solve their printing problems. Norcross provides a wide range of viscometers, controllers and accessories, along with technical expertise, technical advice and troubleshooting to help you increase your bottom line.

Need Assistance with your Viscosity Issues?

Contact us for a free consultation, or find out what sorts of custom solutions we offer.

CLICK FOR A CONSULTATION >

DOWNLOAD OUR VISCOSITY CONVERSION TABLE

Make accurate conversions between different units of viscosity.

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12427 31 Mile Road, Washington, Michigan 48095, +1 (617) 969-7020
www.viscosity.com