SENGENUITY
Sensor Engines by Vectron International

Detecting Change in Viscosity Due to Water Contamination with the ViSmart™ Sensor

Customer Application Challenges

Under most circumstances the presence of water in lubrication oil is undesirable as its destructive effects on mechanical components have been well documented. Water can cause damage to machinery in a number of ways including but not limited to corrosion, cavitation, and the change in viscosity of critical lubricants. The ability to sense water intrusion into lubricating oils as soon as possible is the key to preventing machine wear and premature failure.

Factors that contribute to a machine's sensitivity to water in oil:

- **The sensitivity of the machine and its lubricant to water** – The design of the components of the machine that come into contact with the lubricant makes a difference in the level of damage they receive from water. The lubricants as well vary in their susceptibility to water induced breakdown factors such as hydrolysis and oxidation

- **How long the water stays in the oil** – It stands to reason that the longer a machine is exposed to the damaging nature of water the more damage will be inflicted on the machine. The best way to counteract this is the early detection of water incursion.

- **Amount of oil/water interfacial surface area** – The surface are of the water in the oil determines the number of chances that the water has to react with the oil or the machine. Every time the size of the droplets is divided by two by volume the surface area increases by 59% so the smaller the droplet size and the closer to emulsification the more damage potential for the machine.

- **The mobility of water within the machine** – Water that is settled on the bottom of an oil reservoir will cause less damage than water that is circulating through the machine. If, through the turbulent flow of the lubricant, water is allowed to emulsify into the oil then it can be carried to any part of the machine that is lubricated and do damage there.

- **Heat** – As heat increases so does the potential for machine and lubricant damaging chemical reactions to occur.

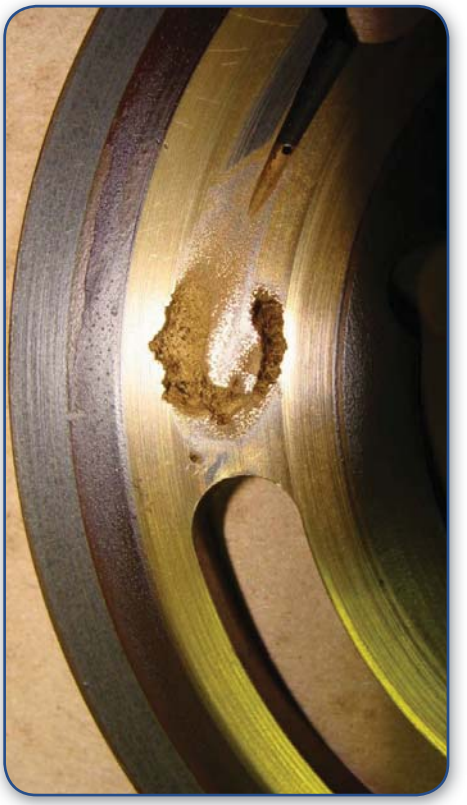

Figure 1 – Cavitation damage on a valve plate for an axial piston hydraulic pump.

The chart below (Figure 2) illustrates the different factors that contribute towards machine damage when water is involved.

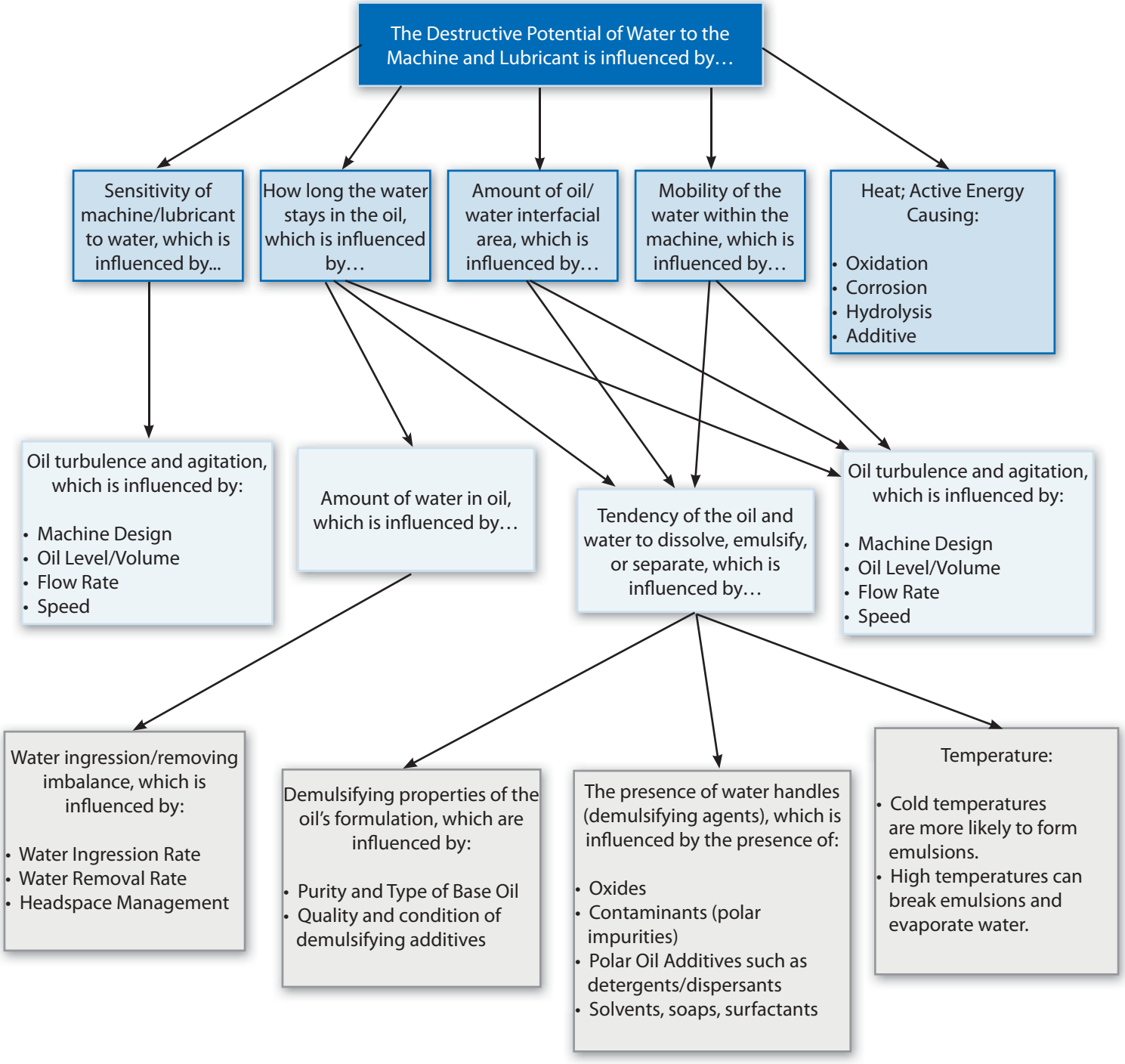

Figure 2: The effect of water contamination on machinery. Chart Reproduced from "The Hazards of Water Handles" by Jim Fitch, Practicing Oil Analysis Magazine. November 2004

Using SenGenuity's Online Viscometer to Sense Water Contamination

Testing has been done by SenGenuity and its customers to determine the effectiveness of using the ViSmart™ Low Shear Viscometer as an alert indicator of water intrusion into lubricating oil. Marine 75W90 diesel engine oil was tested with new and 10% water contaminated oil samples at the industry standard temperatures of 40 and 100°C. The water contaminated sample due to the nature of the application was mixed thoroughly and was emulsified with little settling. This would be the worst case scenario when using interfacial surface area as a metric for damage potential.

Below are the results of this test (see Table 1). SenGenuity's sensors have a built in temperature measurement that they are calibrated to. This allows the customer to monitor both viscosity (AV; Acoustic Viscosity units) and temperature with the same device. The difference between the temperature set point and the measured temperature are minimal and well within error bounds.

Marine 75W90					
	Pure Oil		10% Water in Oil		% Change
Temperature set Point (C)	Sensor Temperature (C)	Viscosity (AV)	Sensor Temperature (C)	Viscosity (AV)	Viscosity
40	41.07	52.32	41.73	45.988	-13.77%
100	99.485	9.927	99.35	9.16	-8.37%

Table 1 – Test data for Marine 75W90 with ViSmart™ viscosity sensor.

Changes in viscosity of 13.77% at 40°C and 8.37 at 100°C were detected by the ViSmart™ sensor and show that the effectiveness of the oil as a lubricant has been reduced from its original specifications. It is easily conceivable the amount of damage that this level of water intrusion could cause to valuable machinery if left unchecked and unnoticed.

A second application customer test was performed under different circumstances using 30W engine oil. During this experiment oil was placed in a container with a magnetic induction stirrer at the bottom to closely replicate the actual application conditions. The sensor was mounted in the center of the container and water was introduced in small increments over the course of a little more than an hour. The incremental changes in water percentage were exactly measured to correspond to 1, 5, 10, 15, and 20% water in oil. The mixing was continuous as the samples were added, but did not emulsify as much as the Marine 75W90 oil.

As can be seen in the chart (see Figure 3) little change was seen with the 1% water addition. If the data is examined closely there is a 1% corresponding change in the viscosity from 1.06 to 1.07 AV (Acoustic Viscosity Units). This change can be seen as the fist indication of a change in the lubricating quality of the oil. Upon the 5% water addition there was a dramatic shift in viscosity of 150% of the original value. This would be a definite indicator of lubricant failure and if seen on machinery would cause a shutdown to investigate the problem.

Interestingly, at the 10% water addition the viscosity reading shifted back to 40% higher than the baseline reading. This is attributable to the method the test which was performed by dropping water into the moving oil. Since SenGenuity's ViSmart™ sensors sample the viscosity of the few microliters of liquid that is in contact with the sensor's surface they will see changes in viscosity based on the individual fluids touching that surface. At the 5% level water droplets attached to the surface and were part of the bulk viscosity measurement. With the 10% water addition the percentage of water in the fluid was high enough that it knocked the large water bubbles off the surface of the sensor and started to emulsify. The last two water additions continued the upward viscosity trend.

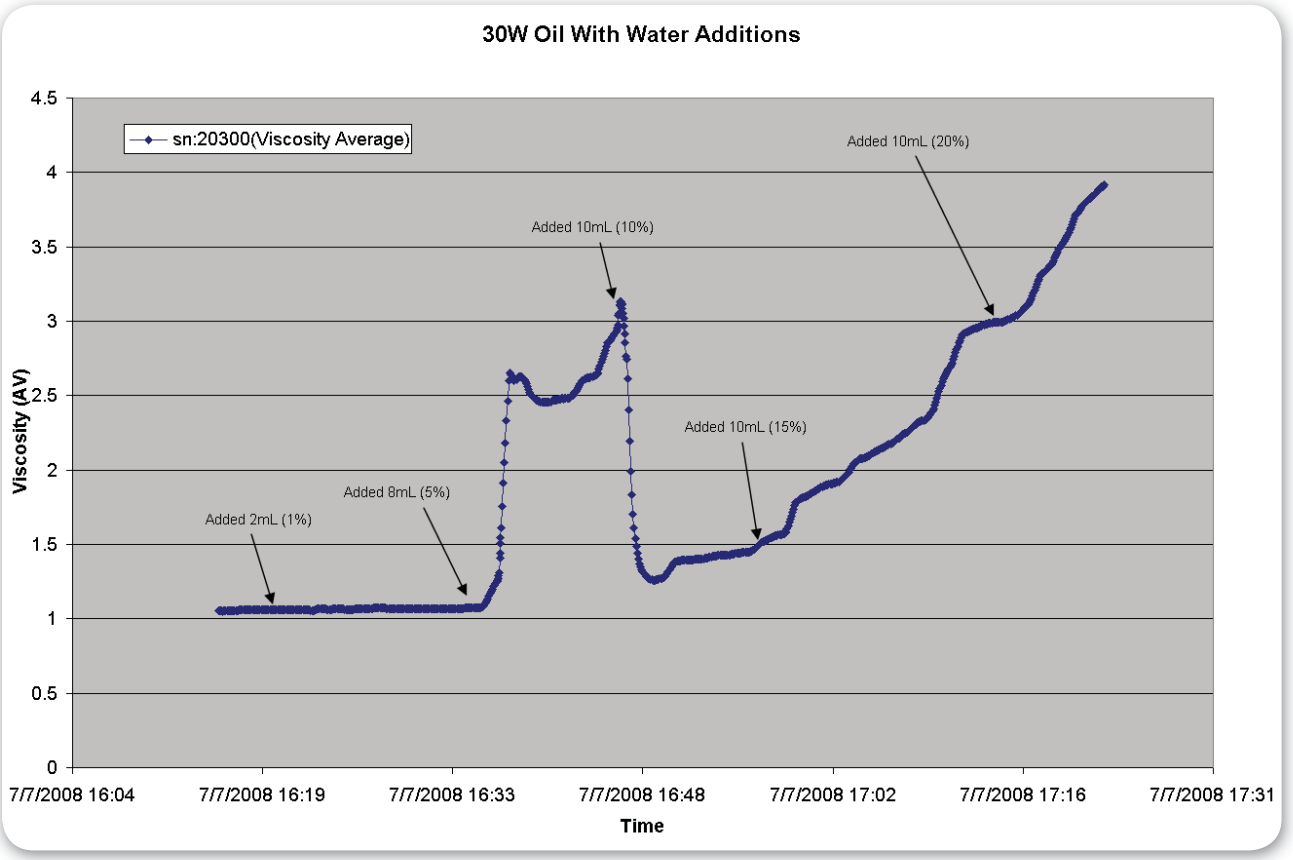

Figure 3 –ViSmart™ viscosity sensor tracking viscosity changes due to water contamination.

The most telling shift recorded in the data stream was the 5% water addition. This shift is similar to what would be recorded if the ViSmart™ sensor was mounted in a machine that had a sudden influx of water into the oil system. It can easily be imagined the amount of damage that would be avoided if this type of contamination was allowed to go unchecked.

While viscosity is not a direct measurement of the percentage of water in oil, it has been shown that SenGenuity's ViSmart™ sensors can be used to detect changes in viscosity based on water contamination. Having a live indication of the condition of the machinery's lubricant can be the difference between normal operation and catastrophic failure involving the loss of time and the replacement of expensive mechanical components. Early warning is the key to failure prevention and mechanical longevity.

Contact Information

If you would like to learn more about our sensors, the markets we serve and customer applications we strive to address, please do not hesitate to contact our Application Engineering group at support@sengenuity.com.

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