Intrusion Detection & Oil Condition Monitoring: A Paper Industry Pilot Program

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Technical Contributions by:
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EXECUTIVE SUMMARY

A Pilot Program by IntelliStick Inc. and the Energy, Engineering and Maintenance Task Force of the Recycled Paperboard Technical Association evaluated the IntelliStick Intrusion & Oil Condition system in paper mill environments. For a period of five months in 2009, a total of five instruments were employed in three mills. The instruments were installed on two bearing lubrication systems, a pulper gearbox, and two generator engine oil reservoirs.

This IntelliStick Pilot Program Report concludes that the IntelliStick system reliably detects water intrusion, in addition to oil condition and temperature, in real time using a single sensor. The sensor must be installed in a location where the water is emulsified to detect it—water that has settled out away from the sensor location is not detected.

The Intellistick system is relativily inexpensive and easy to install. The information provided by the IntelliStick system has less detail than oil lab reports. Although IntelliStick is not seen as a replacement for lab analysis, it provides the advantage of real-time immediacy. This program also identified a limitation in the communications; accordingly Intellistick has added a 4-20mA communications option to better integrate with plant monitoring systems.

This evaluation concludes that the system is cost-effective in providing information for condition-based maintenance programs, helping protect critical equipment and assure maximum up-time. Since the completion of the trial, all of the participating mills have purchased more units.

INTRODUCTION

In early 2008, a paper industry technical group encountered a new product that appeared to hold potential benefit for industrial applications and the task force elected to investigate further.

The IntelliStick technology for real-time intrusion and oil condition monitoring in vehicles appeared to have potential use in stationary equipment. Although proven in development and vehicular applications, IntelliStick was new to the severe challenges of a paper mill environment.

Subsequently, the industry group and IntelliStick Inc. agreed to conduct a Pilot Program at three mill locations. The purpose of the program was to evaluate the technology in operating environments, using a real-time oil condition and intrusion monitor system to help protect critical equipment against failure (repair or replacement), and help assure maximum up-time. Further, the IntelliStick instrument design, features, capabilities and benefits would be evaluated with on-going feedback regarding performance and future design enhancements for this environment.

ABOUT THE INTELLISTICK INSTRUMENT

IntelliStick is a real-time electronic intrusion and oil condition monitor for oil management and maintenance in diesel and gasoline vehicles, heavy equipment, trucks, and in industrial manufacturing and plant process operations. IntelliStick products are based on a patented technology developed for the US military. Products use a single sensor to continuously monitor oil wear package depletion, oil oxidation, and detect intrusion. *The system is described in more detail in the separate document: THE INTELLISTICK OIL CONDITION MONITORING SYSTEM*

PILOT PROGRAM OUTLINE AND TIME LINE

This Pilot Program, begun in January 2009, includes a total five IntelliStick instruments installed in a variety of mill equipment at three recycled paper plants located in various parts of the nation. For purposes of this report, these are identified as:

SOUTHWEST MILL **UPPER MIDWEST MILL** **SOUTHEAST MILL**

A primary contact person was designated in each location; in each instance a maintenance or engineering supervisor or superintendent. Each individual would be responsible for identifying installation locations, and providing the manufacturer with ongoing feedback, data collection and evaluation. Further, participants would provide insight regarding related installations, operations and product design and performance.

The initial evaluation period—and the focus of this report—was January 2009 through May 2009. Initial installations were established and instrument data collection was underway by the first month, with industry and IntelliStick representatives meeting in person and by way of regular teleconferences periodically thereafter. Data collection was maintained through May when participants presented program findings to an industry technical meeting.

All five instruments remain installed and in use, and all three mills have subsequently upgraded and expanded their use of IntelliStick instruments in their operations.

PILOT PROGRAM INSTALLATIONS

SOUTHWEST MILL

Application Point: "COGEN" (1 of 1)
IntelliStick Device: *Industrial Analyzer, Dipstick Sensor, RS-232 Output* *Installed: DEC08*

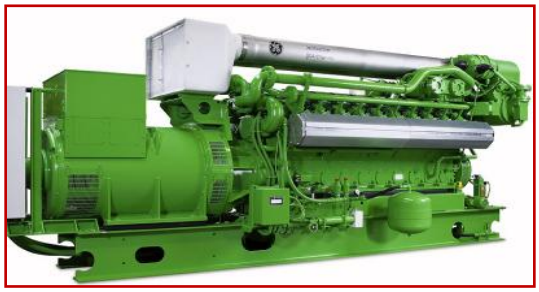
Fig. 1: Cogeneration Unit


Fig. 2: Data Collection


Fig. 3: Installation detail

Equipment: **GE Jenbacher 320; Natural Gas Cogeneration Unit; 998 kW output**
The cogeneration unit produces approximately one-quarter of the mill's power consumption, with exhaust used in drying paper. The unit is a 20-cylinder (2.43L/cylinder = 48.7 liter displacement) natural gas engine that operates 24/7 except for plant downtime and service/maintenance periods. The crankcase volume is 95 gallons, and consumes approximately 21 gallons of oil per month. The oil level is monitored and automatically topped-off between changes. The original oil was Mobil Pegasus 805/40 W; and is now using Shell Mysella 40W. Oil change interval is about 1,200 hours or to coincide with mill downtime.

Installation: On Nov. 3, 2008, representatives of IntelliStick and the plant surveyed several install options, and the cogeneration unit was selected as an appropriate location in vital equipment with ease of reach and power availability. The cogen is housed in a shipping container-like enclosure; the instrument was mounted immediately inside the door, with an access point for the dipstick sensor, and RS-232 connection for data acquisition. The installation occurred on December 31, 2008 during a plant down period.

Hurdles/Issues: One anticipated challenge was the ability to communicate with the plant's maintenance/ monitoring system. Accordingly, during the pilot program, this instrument was not connected to plant PC maintenance system, and periodic data downloads were done by direct connection. The device retains about 30 days of data, and factory representatives worked closely with plant personnel to collect data periodically. IntelliStick output will, in the future, be connected to the plant system using the 4-20mA loops.

Cogen IntelliStick Readings:

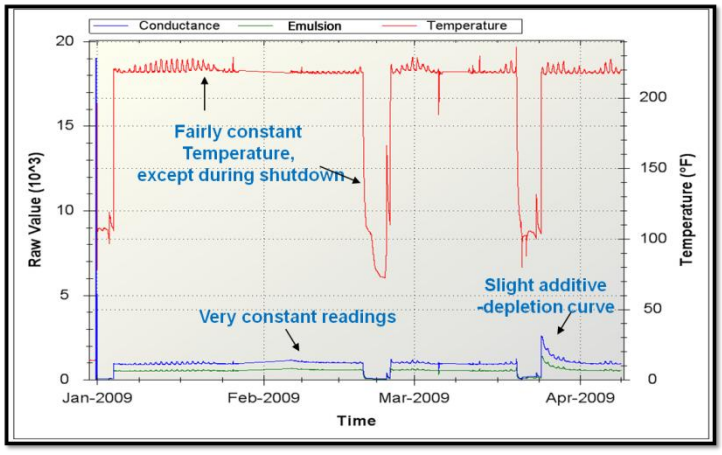

Fig 4: Cogen Data Example A—raw data

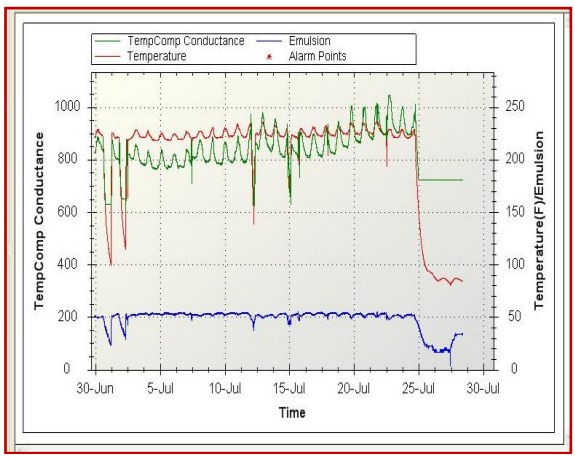

Fig 5: Cogen Data Example B processed data over 1 month

The COGEN data has been highly consistent throughout the program period, showing only slight variations in temperature and oil condition. There has been no indication of water or other intrusion. The automatic top-off with fresh oil results in only minor changes in additive level, and consequently normal data produces a relatively flat graph. Many of the minor variations in the reading relate to large temperature changes during startup and shutdowns.

[Figure 4 and Figure 5] No raised emulsion reading indicates that there is no water in the oil. No upwards slope on the conductance means no oxidation. The slight additive-depletion curve (noted Fig.4; 16 Mar) follows an oil change or large top-off. The renewed additive package declined relatively quickly over the following week.

Data vs. Lab Reports: Oil sample analysis reports from 23 Jan, 23 Feb and 19 Mar confirmed normal operations—the Total Acid Number (TAN) was not significantly elevated in any sample compared to the Total Base Number (TBN), no water or other contaminates were detected in the oil, and the level of metals in the oil was low.

This supports the conclusion from the IntelliStick data that everything is normal. Of note, while IntelliStick monitoring is continuous and real time, a typical lab analysis interval, between sample and report, was about 8-12 days.

UPPER MIDWEST MILL

Application Point: "CONTROLLED CROWN STACK RESERVOIR" *(initial; later changed)*
IntelliStick Device: Original Vehicular Analyzer, Dipstick Sensor, Bluetooth Output Installed: NOV08


Fig 6: GPI CC Stack


Fig 7: GPI CC Stack Reservoir


Fig 8: Battery

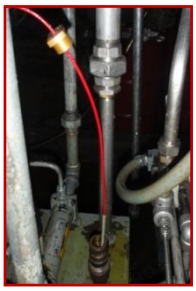
Fig 9: Dipstick Sensor

Equipment: Controlled Crown Stack Bearing lubrication 300 gal Reservoir
This application point was initially thought to be a good application test site as it is habitually prone to water contamination. The oil separates well in the reservoir, and water is routinely drained from the bottom and oil is added to the top of the reservoir. The system also tends to leak oil around the stack. Because water was separated from oil and not a lot of turbulence, the probe was extended to near the bottom of tank. Normal operating temperature: 145 degrees F; Flow to bearings 10-12 GPM.

Hurdles/Issues: This initial IntelliStick unit was the original vehicular version, with a dipstick sensor installed via the oil fill hole and powered by an enclosed motorcycle battery. It became clear that this configuration was not satisfactory—the battery would not hold a charge for the period required, and with intermittent power, the device software was not able to present that data correctly.

Adjustments: Both the application point and the IntelliStick device were changed in the pilot program. The device was upgraded to an Industrial Analyzer with Threaded Sensor and RS-232 output. The new application point and installation provided reliable source of power to eliminate the intermittent nature the battery. The OCC PULPER GEARBOX became the application point for the duration of the study.

CC Stack IntelliStick Readings:

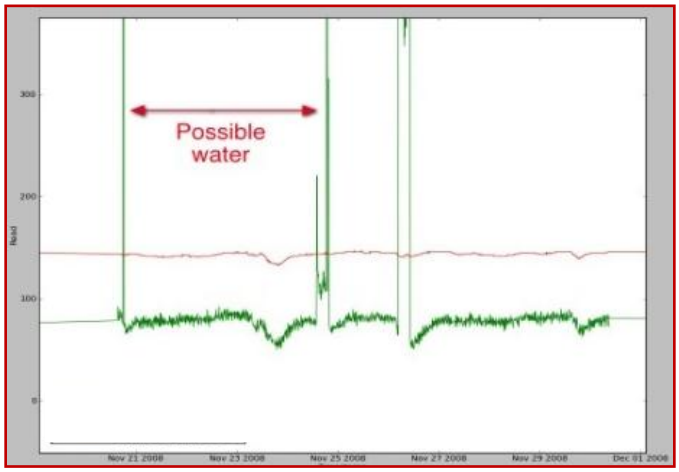

Fig 10: Emulsion reading - CC Stack Example

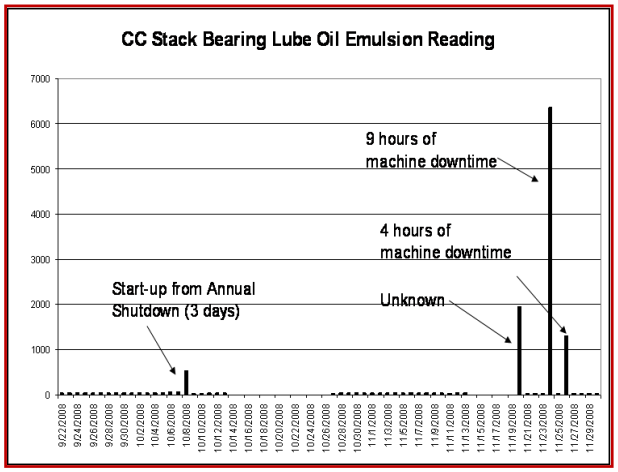

Fig 11: Emulsion reading - CC Stack Data (Excel graph)

[Figure 10 and Figure 11] The emulsion number only became elevated at startups. It is believed this is because startup was the only time when there was enough turbulence in the reservoir for emulsified water to become mixed throughout the oil reservoir. This highlights a feature of the IntelliStick system: the water must be emulsified into the oil to be detected. Un-emulsified water that sits at the bottom of the reservoir is not a risk to the equipment.

Application Point: OCC PULPER GEARBOX (1 of 1)

IntelliStick Device: Industrial Analyzer, Threaded Sensor, RS-232 Output Installed: FEB09

Fig 12: OCC Pulper Gearbox

Fig 13: Threaded Sensor detail

Fig 14: Installation detail

Equipment: Black Clawson #4 Gearbox for 20 ft OCC Pulper

This air-cooled system is one of the biggest gearboxes in this facility and has been prone to water intrusion in the past. The gearbox uses a non-synthetic 320 grade oil, which historically was changed on 3-month and 6-month PM cycles. Currently oil is changed on an as-needed basis, based on visual inspection.

Installation: The Industrial instrument—a new instrument in a new location—was installed in a protective box to keep from being damaged by passing equipment. The ½" NPT Threaded Sensor is located on the discharge of the lubrication pump as it comes out of the gearbox before filtering and cooling.

The one drawback of this installation is that the LED alarm lights cannot be seen; the alarm information, such as intrusion detection, needs to be communicated through the plant monitoring system without reliance on the visual LED in the case. The system was installed on February 27th.

OCC Pulper IntelliStick Readings:

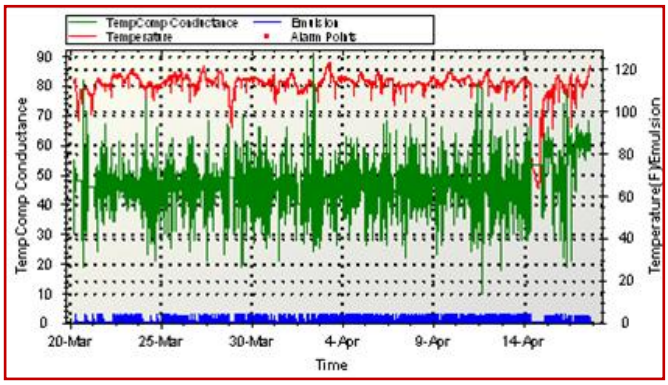

Fig 15: OCC Pulper Data Example

Initial data indicated what was determined to be a software configuration issue – the Temperature Compensated Conductance read zero continuously. This was corrected in subsequent data downloads by changing the user-defined temperature range to better match the operating range of the gearbox. The early temperature setting was near the minimum and easily remedied through the set-up adjustments. Once this was corrected, useful data could be collected [Figure 15].

On March 3, 2009, there was a planned maintenance shutdown, and the oil was changed at that time. The data indicates that the equipment is operating normal and the oil condition is consistent. The temperature is fairly steady between 100 and 120 F, the conductance and emulsion readings are effectively at zero. This indicates that there is no water contamination and no oxidation of the oil.

Data vs. Lab Reports: The IntelliStick instrument data was correlated with routine oil sample analysis reports, which subsequently confirmed normal operations. Laboratory reports are typically received approximately 8 days after sample submitted.

SOUTHEAST MILL

Application Point: "CRITICAL GENERATOR" (1 of 3)
IntelliStick Device: *Industrial Analyzer, Dipstick Sensor, RS-232 Output* *Installed: JAN09*

Fig 16: Standby Generator

Fig 17: Dipstick Sensor detail

Fig 18: Analyzer Installation detail

Equipment: **Caterpillar Diesel Generator**
This standby generator is a critical piece of equipment used as backup power for effluent pumps. The loss of city power could result in a mill shut-down. The city previously owned and maintained the equipment, but never ran it. They reportedly paid about $2,000 per year for oil tests and changes. Normally the generator runs for a minimum of about 2 hours per week.

Hurdles/Issues: IntelliStick unit is installed using a dipstick sensor that accesses the oil via the dip tube. At the time of this report, however, the transfer switch from city power was not in service and the generator was temporarily out of service. Accordingly, no data was available during the period of the pilot program.

Application Point: "WET END LUBRICATION SYSTEM" (2 of 3)
IntelliStick Device: *Industrial Analyzer, Threaded Sensor, RS-232 Output* *Installed: JAN09*


Fig 19: Gravity lubrication illustration

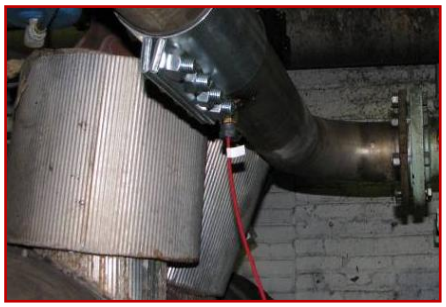
Fig 20: Threaded Sensor installation detail


Fig 21: Wet End installation detail

Equipment: **2,000 gallon Oil Reservoir Wet End Lubrication System**
This lubrication system serves the main paper machine. A gravity feed pipe, with a slope of .5 in/10 ft., is known to have water contamination, and has a flow rate of 10 gpm.

Installation: The installation of the threaded sensor was accomplished by a 4" pipe cut and nipple welded onto bottom of pipe [Fig. 20]. This may not be an ideal mounting location because it is picking up bulk water in the bottom of the pipe. A possible relocation is under consideration. This demonstrates that sensor installation location is important for obtaining a good sample, because the state of the water in the oil varies significantly according to turbulence and mixing conditions.

Wet End IntelliStick Readings:

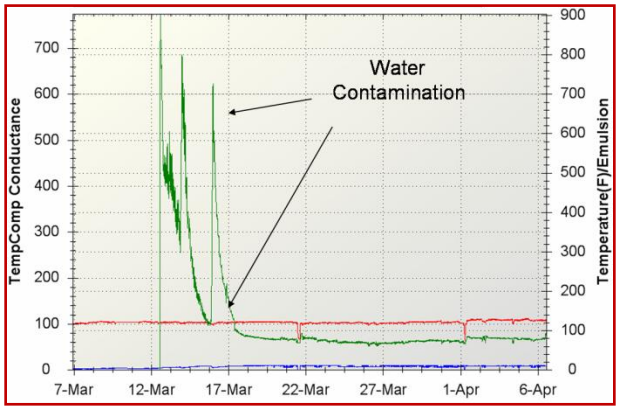

Fig 22: Wet End Data Example

[Figure 22] The fluid temperature operates at about 100F constantly. The conductance readings fluctuate significantly, possibly indicating that the water was not emulsified into the oil, but existed as large discrete droplets. After 18MAR, readings become flat indicating that water was no longer present in the same way.

Application Point: "DRY END LUBRICATION SYSTEM (3 of 3)
IntelliStick Device: Industrial Analyzer, Threaded Sensor, RS-232 Output *Installed: JAN09*

Fig 23: Dry End Reservoir

Fig 24: Threaded Sensor installation detail

Fig 25: Dry End installation detail

Equipment: 5,000 gallon Oil Reservoir Dry End Lubrication System
The threaded sensor was installed in a 6" pipe (cut and nipple welded onto bottom of pipe) where the gravity flow rate is about 30 gpm [Fig. 24]. This location is known to have water contamination, and an evaporator was installed at the dry end.

Dry End IntelliStick Readings:

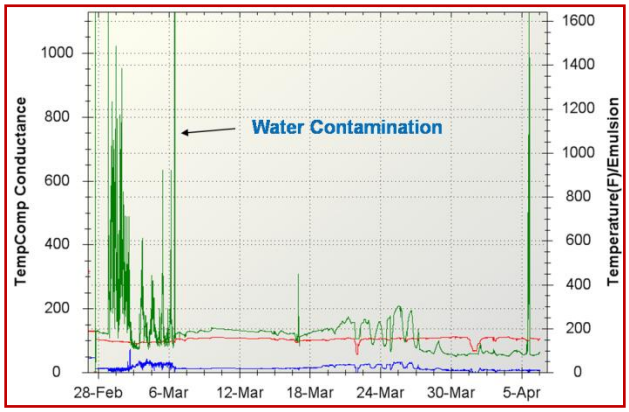

Fig 26: Dry End Data Example

[Figure 26] The lubricant at this end runs at a higher temperature of around 150 F. The IntelliStick reading shows conductance spikes that are particularly apparent before the evaporator was used. After the evaporator removed a large amount of water from the oil, the readings were normal in March; smaller fluctuations occurred with the occasional spike. This is likely to be because visual and lab samples show that there is still greater than 1% moisture in the oil.

This was perfect timing for a test of new piece of equipment. The difference in the readings between before-and-after the evaporator was used clearly demonstrate the device detecting water in the oil.

Future: The plant will continue to progress this technology for maintenance best practices. A new probe will be used for the discharge side of the pump that runs at 80 psig. The local gauge will be taken out and IntelliStick will be installed in its place. The control panel has a local pressure gauge for the system as well as the DCS.

PILOT PROGRAM PRINCIPAL FINDINGS

A number of conclusions can be drawn from the Pilot Program:

a. The Industrial IntelliStick instrument reliably detects water intrusion in an emulsified or well-mixed form in a mill environment.

b. IntelliStick is appropriate to critical equipment, such as generator and reservoirs, and continuous process operations.

c. IntelliStick systems help assure maximum plant up-time, protect equipment investment (reducing repair or replacement costs), and facilitate condition-based maintenance programs.

d. IntelliStick real-time data is useful in establishing oil change patterns.

e. The device provides immediate information without waiting for lab analysis results. The information provided by the IntelliStick system has less detail and precision than lab reports and is not seen as a replacement. However it may be possible to reduce the frequency of lab testing in situations where IntelliStick shows the oil condition is unchanging. Its use will facilitate or greatly enhance a real-time condition-based maintenance program.

f. The physical installation of the unit is straightforward. However the sensor installation location is important. The sensor must be located at the point where the oil and water mixing will exist. For example, the instrument will not detect water that has settled to the bottom of a reservoir.

g. For mill applications, a manual downloading of data from the instrument may not be practical, and the analyzer box status lights could be obscured in some locations. The instrument must be connected to the plant monitoring and control system. The RS232 output would require integration of the digital output from IntelliStick into the monitoring and control system, and this was not done for any of the pilot program installations.

h. As a result of this Pilot Program an enhanced IntelliStick Analyzer version was developed and manufactured with 4-20mA outputs to provide an option for integration that did not require customization. The factory provided an exchange/upgrade device for the Pilot Program devices, thus matching additional new model instruments that were subsequently purchased.

i. The cost of the instrument is significantly less than that of other online oil condition instruments and in-plant analysis equipment. In part this is due to IntelliStick combining several functions into one instrument which are traditionally purchased separately.

j. The temperature measurement feature alone has significant value for monitoring equipment condition.

It is worth noting that since the completion of this Pilot Program, the participating mills have purchased additional IntelliStick instruments, and the factory continues to work closely with these customers as they expand the work begun in the program.

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