

September 21, 2005

Latest measurement technology for contamination monitoring of hydraulic and lubricating systems

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Innovation in hydraulics is not limited on more effective component design and their ideal installation and control. Developing and applying sensors to diagnose systems in order to monitor and analyse the condition of these components is another important premise for the efficient and profitable application of modern systems.

One of these important components of a hydraulic system is the hydraulic fluid, of course. The state of contamination of the fluid does not only influence the characteristics of the entire system critically, also, it is an indicator for the momentary wear situation within the system. Therefore, it allows conclusions regarding the life expectancy of systems.

During the last few years - as far as fluid monitoring is concerned - there was a shift from offline measuring systems to online solutions. Today, the attention of the developers is directed towards all sorts of inline measuring systems.

The new inline monitoring systems developed by INT include sensors and display units for inline measurements. They are able to classify the contamination level with fine particles according to ISO 4406 and NAS 1638, they can detect metal particles > 200 µm, and they are able to monitor the saturation of the fluid with water and determine theoretic water contents of hydraulic and lubricating fluids.

The application of this technology is manifold. Depending on the different configurations, it enables continuous monitoring and analysis of the current condition of hydraulic systems and test stands, as well as the monitoring of wear. Furthermore, the early detection of damages within larger gears and lubricating systems is possible. Generally, these sensors can be used in all mineral oils and synthetic esters.

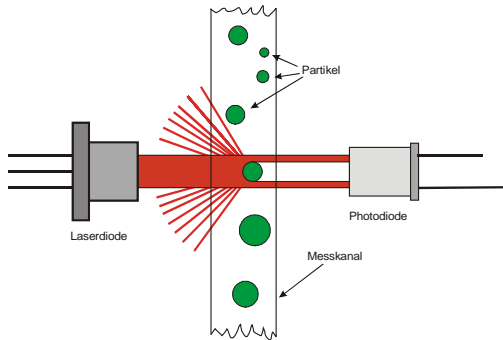
These new monitoring assortments are developed to realise inexpensive stationary solutions for stationary and mobile systems. They are the ideal completion for INTERNORMEN's Contamination Control System CCS2, equipped with bottle sampling and web control and intended for mobile and stationary applications.

The inline monitoring system includes the following components:

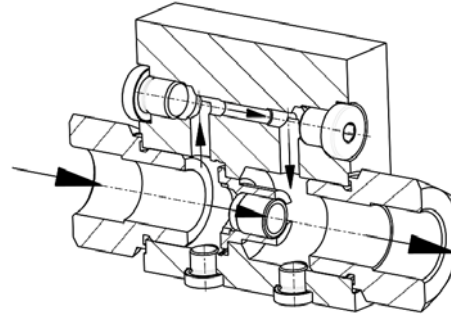
- 1. CCM 01 – system:** Measuring system for inline detection of fine particles and contamination level determination, consisting of the sensor PFS 01 as well as the display and control unit CCM 01.



The sensor PFS 01 consist of two sensor elements: A laser sensor to optically detect particles, which has a output voltage signal that is proportional to the particle size, and a flow rate sensor with an output signal between 4...20 mA. Particle counting is realised off line. A partial flow of the oil coming through the PFS 01 is guided through the particle counting laser sensor and the flow rate sensor using a counter balance valve. The laser sensor is calibrated using ISO-MTD.



Picture 2: optical particle detection



Picture 3: mechanical setup of the PSF 01

Technical Data PSF01:

Operating pressure:	1 ...50 bars
Flow rate:	0.1...50 l / min
Viscosity:	10 ...400 mm ² /s
max. oil temperature (continuous operation):	50°C
max. particle concentration:	10 000 particles per ml
Supply voltage:	+/-12 VDC, 5VDC
Output signal (laser sensor):	0...10 V
Output signal (flow rate sensor):	4...20 mA

The display unit CCM 01 can count particles per unit volume for the following particle sizes: Optionally for either > 4µm(c) , > 6µm(c) > 14µm(c) , > 21µm(c) or > 6,4µm(c) , > 14µm(c) > 21µm(c) , > 37µm(c). The results can be classified and displayed according to ISO 4406, respectively NAS 1638. Measurements can not only be displayed immediately, they can also be stored. Pre-programmed threshold values can be monitored and the possibility of certain control functions is given, due to potential-free relay contacts. Current or stored measurements can be transferred to external computer systems using the RS232 interface. Results can be managed using the data manager software, which is based on Microsoft-Excel. In addition to that, the CCM 01 has a CAN-BUS interface.

Typical applications:

Test stand monitoring, devices for filter support,
wind power plants,
mobile and stationary hydraulic- and lubricating systems in general.

2. MPM 01 - Set

Inline measuring system for the detection of metal wear debris, consisting of the metal particle sensor MPS 01, as well as the display and control unit MPM 01.



Picture 4: Display unit MPM 01 & metal particle sensor MPS 01

The metal particle sensor MPS 01 detects metal particles $> 200 \mu\text{m}$ based on an inductive measuring principle. As a result, an output signal is generated if a particle is detected. The signal is a standardised impulse, independent from the size of the detected particle.

The installation of the sensor in hydraulic circuits is realised by plate mounting. The device can also be installed in combination with a separate plate as conducting device with a nominal width of 1".

Up to a flow rate of approximately 50 l/min, the sensor operates at full flow. Higher flow rates will cause the division of the volume flow, using a counter balance valve, which is integrated in the plate. Counting these impulses and monitoring a certain threshold is realised by the MPM 01. This could also be performed by a different central control unit.

Technical data – MPS 01:

Operating pressure:	0.5...20 bars
Range of detection:	$> 200 \mu\text{m}$ - Fe
Flow rate (full flow): (larger flow rates will cause the division of the flow)	10... 50 l / min
Supply voltage:	24 VDC
Max. number of particles to be measured:	100 particles/s
Acceptable fluid temperature:	-40°C... + 85° C
Acceptable ambient temperature:	-40°C ...+ 70° C
Output signal:	23V / ~7ms impulses
Diagnostic output signal:	23 VDC

The purpose of the display unit MPM 01 is to display the number of particles counted.

The number displayed is a total particle number for each day.

Measurements can not only be displayed immediately, they can also be stored. Pre-programmed threshold values can be monitored and the possibility of certain control functions is given, due to potential-free relay contacts.

Current or stored measurements can be transferred to external computer systems using the RS232 interface. Results can be managed using the data manager software, which is based on Microsoft-Excel. In addition to that, the MPM 01 has a CAN-BUS interface.

Typical applications:

Early detection of wear in larger gears (vessel gears, wind power plant gears, turbines)

Monitoring the cleanliness of components in test stands and flushing stands and the detection of contamination from production, such as metal chips.

3. WSTM 01 – Set: Inline measuring system for monitoring the water content in oil-operated hydraulic and lubricating systems, consisting of WSPS 03 sensor as well as the display and control unit WSTM 01.

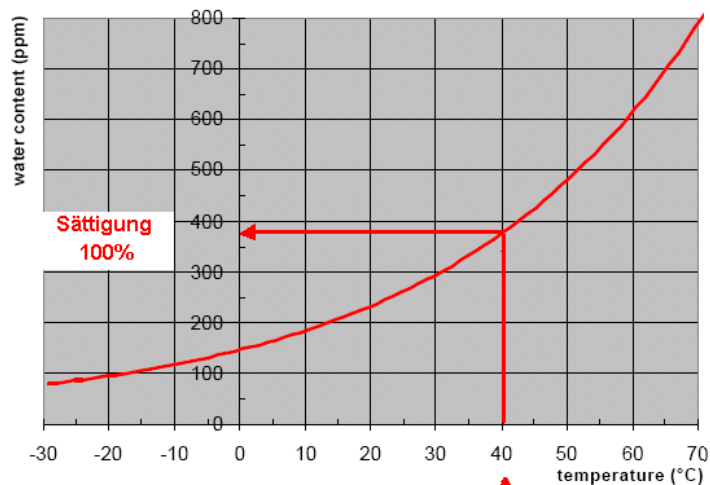


Picture 5: Display unit WSTM 01 & water saturation sensor WSTS 01

The sensor WSPS 03 consists of a water sensor element and a temperature sensor. The water saturation sensor works due to a polymer foil functioning as capacitive sensor. The saturation sensor measures the relative humidity of a fluid, not the total water content (free and emulsified water) as the Karl-Fisher titration method does.

The result of a measurement is the saturation of the fluid with water in %. Practically, emulsified water is less dangerous than free water for any hydraulic system. Therefore, knowing the saturation level is a much more valuable information than actually knowing the total amount of water contamination. In addition to that, the saturation depends on the fluid's temperature. Furthermore, measuring the saturation helps to determine different dangerous situations for a hydraulic system under different operating conditions. A saturation level of approximately 70% already indicates the possibility of the presence of small amounts of free water. In addition to that, the saturation level can be related to the actual water content (mg/kg), if the saturation can be linked to the temperature. For this purpose, the saturation-temperature curve of a fluid has to be known.

Temp. °C	water content ppm
-30	60
-20	80
-10	100
0	130
10	170
20	220
30	280
40	360
50	470
60	610
70	780



Picture 6: Example of a water saturation curve, in this case of HLP 46 mineral oil

Parameter
Temperatur

Knowing the temperature and the specific saturation curve of a certain oil, the water content of 100% saturation can be determined. This allows the calculation of the water content for the measured saturation level. The water content in oil is measured in PPM (parts per million) of water instead of mg/kg.

The calculation of "theoretic water contents" is possible up to the saturation level of 100%.

Evaluating the output signals as well as threshold monitoring can be realised with the WSTM 01 or any other centralised control unit.

Technical Data WSPS 03:

Measuring range (humidity):	Water saturation 0...100 %
Measuring range temperature:	-30 ...+70°C
max. operating pressure:	10 bars
max. flow rate on sensor:	app. 2m/s
Error (humidity):	+/- 2%
Supply voltage:	12...30 VDC
Output signal-humidity:	4...20 mA
Output signal-temperature:	4...20 mA
Connection thread:	G 3/4
Protection class:	IP 67

The purpose of the WSTM 01 is to display the measured saturation level of the fluid with water, as well as to display the measured temperature of the fluid.

The internal fluid library enables to calculate theoretic water contents in PPM for fluids if this fluid is included.

(Examples of implemented fluids: HLP 22, HLP 32, HLP46, HLP68, HEES 46, CLP 220)

Measurements can not only be displayed immediately, they can also be stored. Pre-programmed threshold values can be monitored and the possibility of certain control functions is given, due to potential-free relay contacts.

Current or stored measurements can be transferred to external computer systems using the RS232 interface. Results can be managed using the data manager software, which is based on Microsoft-Excel. In addition to that, the MPM 01 has a CAN-BUS interface.

Typical applications:

Wind power gears, vessel gears,

Stationary and mobile hydraulic- and lubricating systems in general.

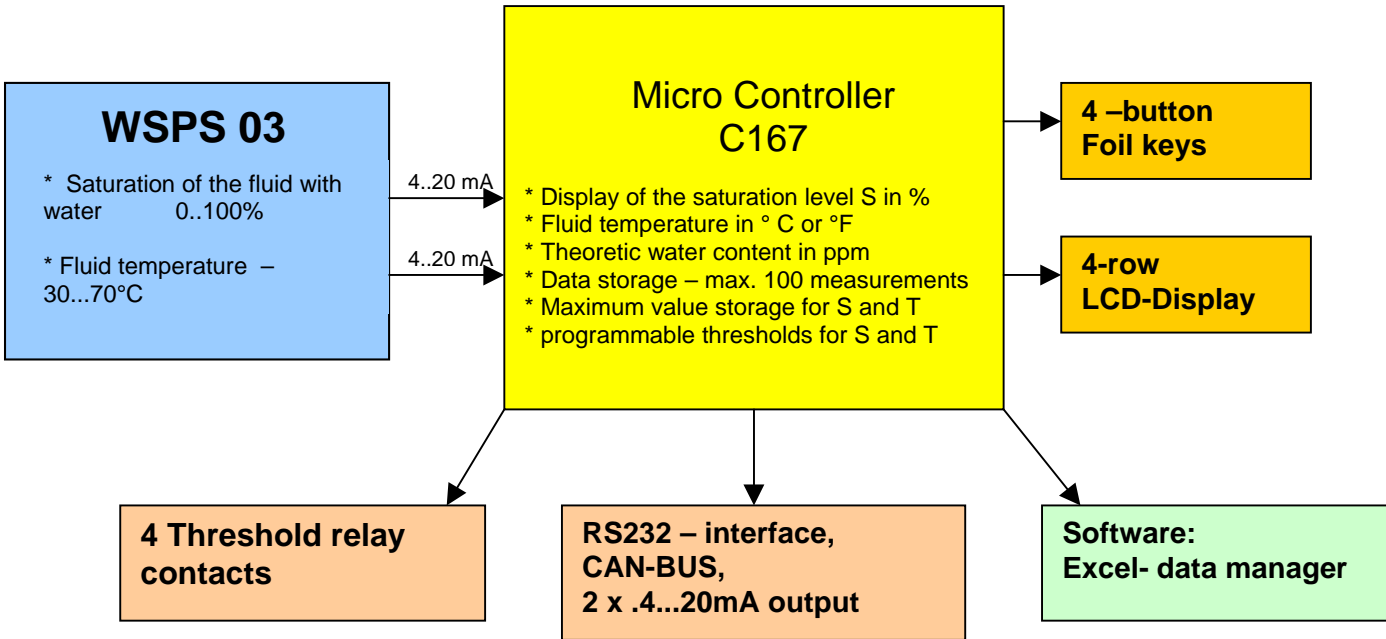
Technical Data CCM 01, WSTM 01, MPM 01:

The display and control units CCM 01, MPM 01, WSTM01 utilise the same micro processor and similar case design with foil keys and a 4-row display. They are intended for a supply voltage of 24V DC, their protection class is IP 65 and they can be mounted on a wall.

The stated technical data refer to all three units. Each unit is equipped with proper electronic and software needed for the intended sensors.

Supply voltage:	24 VDC
Acceptable ambient temperature:	0...+70°C
Interfaces:	RS 232 CAN-Bus
Internal storage:	100 measurements
Display:	4 rows, 16 digits each
Controls:	4 buttons
Dimensions:	160mm x 185mm x 110mm
Weight:	1.3 Kg
Protection class:	IP65

Picture 7: Diagram of the WSTM 01 – Set



Summary:

The inline measuring systems CCM 01-Set, MPM 01-Set and WSTM 01-Set make permanent and inexpensive monitoring of fluid contamination with dirt, wear debris and water possible, due to their modern sensors and display units.

The results of the measurements can be displayed immediately on location, and they can be used to steer the systems utilising threshold relay contacts. Transferring measurements to centralised display and control units is possible in many different ways. The measuring system is an effective tool for diagnosis and analysis of the current condition of hydraulic and lubricating systems.