Condition monitoring and analysis of hydraulic and lubrication fluids
Eaton combines sales, engineering, manufacturing, customer service and technical sales support with a focused business goal in mind: providing optimum filtration solutions for our customers.

Following a path of continuous improvement, Eaton has maintained quality as a fundamental corporate strategy and a hallmark of all products and services. Eaton is a leader in manufacturing filtration products and solutions that include measurement, diagnostic and analysis technology—as well as more than 4,000 hydraulic filter elements and corresponding filter housings.

**Condition monitoring and analysis of hydraulic and lubrication fluids**

- In-line measuring
- On-line/off-line measuring
- Laboratory analysis and measurement
Cleanliness is the measure of any solid or liquid contamination that is not part of a hydraulic system’s working fluid.

**Cleanliness may:**
- Ensure productivity at maximum efficiency
- Reduce service costs through preventative maintenance and monitoring
- Reduce equipment downtime through scheduled inspections
- Minimize safety hazards and prevent contamination-related outages
- Extend the service life of system components, which improves operating profitability by reducing maintenance costs
- Reduce repair costs and system downtime

**Support services**
In addition to precision equipment and accessories for condition monitoring and analysis of hydraulic and lubrication fluids, Eaton provides a wide range of services, such as:
- State-of-the-art laboratory testing services
- Maintenance, calibration with certificate, software updates, trials
- On-site services: training, commissioning, repairs, equipment replacement
- Extensive network of sales and customer representatives
- Product specialists for customer application support
- Global technical support

**Calibration services**
- Performance tests
- Device cleaning
- Secondary calibration
- Replacement of used and worn mechanical components
- Replacement of printing paper and ink ribbons
- Software updates
- 24-hour trials
- Calibration certification

**Laboratory services**
- Performed by certified specialists
- Employ the latest measuring instruments and testing devices
- Determination of contamination classes
- Contamination analysis
- Oil condition analysis
- Filter element inspection

Fluids are the lifeblood of every hydraulic system. Fluid analysis is an important factor for determining whether your hydraulic system can operate efficiently and effectively.

Inadequate fluid conditions are responsible for up to eighty percent of all hydraulic system failures. An effective fluid analysis program will help identify contamination and other problems not visible to the naked eye.
Solid contaminants are the main cause of failure and downtime in hydraulic and lubrication systems. Knowing the precise level of contamination is essential for the efficiency and functionality of a system. Contaminants can be introduced to a system during installation, accumulate inside during its operation, or introduced by external influences.

This knowledge enables the operator to influence the system and intervene with appropriate corrective measures.

**Effects of solid contamination**
- Increases system wear due to abrasion and erosion
- Shortens service life of system components and increases system failure
- Shortens service life of the fluid

**Contamination monitoring systems**
- Provide immediate and precise diagnosis of the condition of a hydraulic system
- Monitor of filter performance so that it can be compared with the standards required for specific system components
- Provide precise determination of the optimal time to replace filter elements
- Reliably monitor the commissioning of new systems
- Diagnose hydraulic components such as pumps, bearings or gaskets
- Determine the condition of new fluids during system start-up
- Verify the effectiveness of off-line filtration
- Document the effect of external conditions on the particle level of solid contaminants in the hydraulic system

**Advantages of immediate diagnosis**
- Rapid results, no need to wait for lab analysis
- Timely and appropriate corrective actions
- Improve quality control

**Measuring methods**
The measurement systems and sets for monitoring oil condition are equipped with laser sensors that detect particles in fluid using the light blockade principle.

Particles can be costly in a hydraulic system

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**Laser detector using the light blockade principle**

Particles

Laser diode

Photo diode

Measurement channel
The presence of water in hydraulic fluids is the second most common cause of failure and downtime in hydraulic and lubrication systems.

Effects of water in hydraulic fluids
- Shortened service life of the fluid
- Reduced performance of the lubrication fluid
- Deterioration of control characteristics
- Reduced filterability
- Increased wear to the components
- Increased noise levels
- Loss of polarizing additives
- Increased acidity
- Rust formation
- Increased contamination levels

How water enters a system
- Improper storage
- Residue from cleaning
- Humidity/condensation
- Through bearings or penetrable points (such as hair-line cracks, caps, faulty gaskets, etc.)

Types of water in a system
- Dissolved water (up to the saturation limit of the fluid)
- Emulsified and free water (above the saturation limit of the fluid)

Measuring principle
The WSPS 05 sensor is a capacitive sensor that uses a polymer foil as a dielectric between two electrodes. This foil can absorb water molecules due to its microporous structure. The absorption causes the capacity of the sensor and the frequency of the resonant circuit to change. The change in frequency is detected and converted into an electrical output signal.

What is measured
The WSPS 05 sensor measures the relative water content in a fluid. The result is expressed as a percent of water saturation of the fluid. A value of 100 percent means that the fluid is completely saturated and contains hazardous free water.

The measurement results of the WSPS 05 sensor are different from those of water content analysis using the Karl Fischer method, which specify the total amount of free and dissolved water in the fluid.

A theoretical relation to water content in ppm (mg/kg) according to the Karl Fischer method, can be established using the specific saturation curve and the temperature of the tested fluid.
Element spectral analysis – potential sources of metals in oil

### Aluminum
- abrasives, aluminum mill, bauxite, bearing metal, catalyst, coal contaminant, fly ash, foundry dust, granite, paint

### Antimony
- journal bearings, solder

### Arsenic
- antimony, bismuth, arsenic, bauxite, rosin, bitumen, copper, stannum

### Barium
- engine additives, grease

### Beryllium
- aircraft construction, bearings, mineral oil

### Bismuth
- journal bearings

### Boron
- EP additives, coolant inhibitor

### Cadmium
- journal bearings, plate

### Calcium
- cement dust, detergent, fuller's earth, grease, gypsum, hard water, lubricant, lime, mining dust, oil additive, road dust, rubber, salt, water, slag

### Carbon
- abrasives, carbides, carbon steel, graphite, hard metal, mineral oil, coal,arat, synthetic material

### Chromium
- chrome plating, hardcoat, paint, ring plating, stainless steel, tooling steels

### Cobalt
- additives, hard metal, tooling steels

### Cesium
- nuclear technology

### Iron
- asbestos, cast iron, catalyst, cleaning detergent, fly ash, mill scale, ore dust, paint, rust, talc, zeolite

### Lead
- babbitt, bearing overcase, gasoline additive, solder, paint

### Lithium
- crustal dust, grease, salt water

### Magnesium
- aluminum alloy, engine additives, fuller's earth, hard water, road dust, salt, water, turbinic acid

### Mercury
- bactericide, batteries

### Molybdenum
- metal alloys, EP additives, MoS, rings

### Nickel
- hard steel, plating, stainless steel, steatite

### Niobium
- turbine blades

### Phosphorus
- in AW/EV additives, cleaning detergent, oil additives, surface finish

### Platinum
- catalyst, mineral oil

### Potassium
- additives, coolant inhibitor, fertilizer, fly ash, granite, paper mill dust

### Scandium
- ICP reference

### Silicon
- anti-foam additives, asbestos, cement dust, coolant additives, fly ash, foundry dust, glass, granite, limestone, mica, road dust, slag, steel, synthetic lubricant, talc, wax, clutch

### Silver
- bearing overcase, needle bearings, solder

### Sodium
- additives, base stocks, coolant inhibitor, dirt, fly ash, grease, paper mill dust, road dust, salt, salt water

### Sulfur
- gypsum, mineral oil, MoS2, rubber

### Tantalum
- hard metals, tooling steels

### Tellurium
- mineral oil

### Titanium
- hard metal, paints, turbine bearings, turbine blades

### Tungsten
- hard metals, tooling steels

### Uranium
- ore dust, road dust (some types)

### Vanadium
- mineral oil, turbine blades, valves

### Yttrium
- ICP reference

### Zinc
- AW additives, brass, galvanizing, grease, hard steel, oil additives, plating, solder

### Zirconium
- abrasives, nuclear technology

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### Monitoring of Hydraulic and Lubrication Fluids

#### In-line systems

- **CCM 07 set**
  - Contamination control and monitoring system
  - ISO 4406:99, NAS 1638

- **WSPS 05 sensor**
  - Diagnostic system for determining the saturation level of water in oil

- **CCT 01 set**
  - Transmitter system for contamination control
  - ISO 4406:99

#### Off-line systems

- **WSPS 05 sensor**
  - Diagnostic system for determining the saturation level of water in oil

- **CCT 01 set**
  - Transmitter system for contamination control
  - ISO 4406:99

#### On-line systems

- **ISO 4406:99, NAS 1638**

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Note: 1 Severe conditions may include high flow surges, pressure spikes, frequent cold starts, extremely heavy duty use or the presence of water. 2 Two or more system filters of the recommended filter micron rating may be required to achieve and maintain the desired cleanliness level.
CCM 01 set
Contamination control and monitoring system

Features
• Cost-effective in-line monitoring solution for continuous operations
• Particle counter consisting of PFS 01 laser sensor for hydraulic and lubrication fluids and CCM 01 display unit
• Reliable determination of contamination classes according to ISO 4406:99 or NAS 1638 (switchable)
• Installation in new and existing systems
• Internal memory for storing results (100 measured values)
• Automatic monitoring function with control signal output when thresholds are exceeded (programmable)
• RS-232 interface
• LabVIEW data manager software (export to Microsoft Excel) for data management on an external computer
• CAN bus interface (CANopen compatible)
• Alphanumerical display
• Sturdy case

Technical data

<table>
<thead>
<tr>
<th>Operating parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply:</td>
</tr>
<tr>
<td>Power supply (external unit):</td>
</tr>
<tr>
<td>Protection class:</td>
</tr>
<tr>
<td>Max. operating pressure:</td>
</tr>
<tr>
<td>Viscosity:</td>
</tr>
<tr>
<td>Fluid temperature:</td>
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<tr>
<td>Ambient temperature:</td>
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<tr>
<td>Connection:</td>
</tr>
<tr>
<td>Max. volume flow:</td>
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<tr>
<td>Min. volume flow:</td>
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<table>
<thead>
<tr>
<th>Measurement parameters</th>
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</thead>
<tbody>
<tr>
<td>Automatic particle counting in 4 channels:</td>
</tr>
<tr>
<td>Contamination classes:</td>
</tr>
<tr>
<td>Accuracy:</td>
</tr>
</tbody>
</table>

CCT 01 set
Transmitter system for contamination control

Features
• Cost-effective in-line monitoring solution for continuous operations
• Contamination class transmitter consisting of PFS 01 laser sensor for hydraulic and lubrication fluids and CCT 01 transmitter system for contamination control
• Reliable determination of contamination classes according to ISO 4406:99
• Output of contamination classes as per ISO 4406:99 as electrical signal (3 x 4 to 20 mA)
• Installation in new and existing systems
• Internal memory for storing results (1,000 measured values)
• USB interface for configuration and data transfer of current and saved measured values
• LabVIEW data manager software (export to Microsoft Excel) for data management on an external computer
• CAN bus interface (CANopen compatible)
• Sturdy case

Technical data

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<tr>
<td>Viscosity:</td>
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<tr>
<td>Fluid temperature:</td>
</tr>
<tr>
<td>Ambient temperature:</td>
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<tr>
<td>Connection:</td>
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<tr>
<td>Max. volume flow:</td>
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<tr>
<td>Min. volume flow:</td>
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<table>
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<tbody>
<tr>
<td>Automatic particle counting in 3 channels:</td>
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<tr>
<td>Contamination classes:</td>
</tr>
<tr>
<td>Accuracy:</td>
</tr>
<tr>
<td>Output data:</td>
</tr>
</tbody>
</table>
WSPS 05 sensor

The WSPS 05 sensor is an effective diagnostic system for determining the saturation level of water in oil. The sensor detects the presence of free or emulsified water in hydraulic or lubrication systems, thereby enabling the user to prevent accelerated oil aging, increased wear, malfunctions and failure of components. The saturation of the fluid with water displays as a percentage. Saturation values of fluid are influenced by temperature. The WSPS 05 sensor includes an integrated thermal sensor that determines the exact temperature of the fluid during a measurement.

Technical data

Operating parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
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</thead>
<tbody>
<tr>
<td>Power supply</td>
<td>12 to 30 VDC/0.1 A/max. 3 VA</td>
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<tr>
<td>Protection class</td>
<td>IP 67</td>
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<tr>
<td>Max. operating pressure</td>
<td>≤ 363 psi (25 bar)</td>
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<tr>
<td>Viscosity</td>
<td>45 to 1,854 SUS (10 to 400 mm²/s)</td>
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<tr>
<td>Fluid temperature</td>
<td>-40 to 194 °F (-40 to 90 °C)</td>
</tr>
<tr>
<td></td>
<td>(briefly 212 °F (100 °C))</td>
</tr>
<tr>
<td>Ambient temperature</td>
<td>-13 to 185 °F (-25 to 85 °C)</td>
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<tr>
<td>Max. flow velocity</td>
<td>≤ 797/s (2 m/s)</td>
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<tr>
<td>Connection</td>
<td>G ¾” threaded</td>
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</table>

Measurement parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>-13 to 212 °F (-25 to 100 °C)</td>
</tr>
<tr>
<td>Water saturation</td>
<td>0 to 100%</td>
</tr>
<tr>
<td>Accuracy (water saturation)</td>
<td>± 2%</td>
</tr>
<tr>
<td>Accuracy (temperature)</td>
<td>± 0.4%</td>
</tr>
<tr>
<td>Output data</td>
<td>2 x 4 to 20 mA</td>
</tr>
</tbody>
</table>
CCS 4 Contamination control system

The mobile CCS 4 contamination control system determines the solid contamination particle size distribution, water saturation and fluid temperature.

The CCS 4 contamination control system measurement results provide a basis for analyzing the wear on hydraulic components, observing standards and detecting damage early.

The system can be used both in pressurized operating modes and for unpressurized sampling (such as from a tank).

Features:
- Optical particle counting via laser sensor
- Precise evaluation of contamination classes according to ISO 4406:99, ISO 4406:87, NAS 1638 and SAE AS 4059
- Measurements are displayed as particle numbers according to contamination classes, water saturation, temperature and theoretical water content (ppm)
- Different automated measuring programs for single, continuous, cyclical and on-line measurements
- Rechargeable lithium polymer battery
- Internal memory for storing results (capacity for 4 x 100 measurements)
- Display of current and saved measured values via USB or RS-232 interface
- LabVIEW data manager software (export to Microsoft Excel) for data management on an external computer

Technical data

Operating parameters
- Power supply: 15 VDC/5 A/75 VA
- Power supply (external unit): 100 to 240 VAC/50/60 Hz/15 VDC/5.3 A
- Protection class: IP 67 (when cover is closed)
- Operating suction range: -2.9 to 2.9 psi (-0.2 to 0.2 bar)
- Operating pressure range: 22 to 6,000 psi (1.5 to 420 bar)
- Viscosity: 45 to 1,854 SUS (10 to 400 mm²/s)
- Fluid temperature: 32 to 158 °F (0 to 70 °C)
- Ambient temperature: 32 to 122 °F (0 to 50 °C)

Measurement parameters
- Automatic particle counting in 8 channels: ≥ 4.0 µm, ≥ 4.6 µm, ≥ 6.0 µm, ≥ 6.4 µm, ≥ 10 µm, ≥ 14 µm, ≥ 21 µm, ≥ 38 µm
- Contamination classes: ISO 4406:99, NAS 1638, SAE AS 4059
- Accuracy: ±1 (contamination class)
- Water saturation: 0 to 100%
- Temperature: 32 to 158 °F (0 to 70 °C)
Oil analysis

PAS 01 kit for sampling and oil analysis
Mobile mini-laboratory for conducting fluid analysis.

Static sampling
Vacuum pump, tubes and telescopic stick for sampling fluids from tanks or packing drums.

Disposable pipette
For sampling fluids with severe levels of contamination.

Dynamic sampling
Mini-measuring connections and tubes for dynamic sampling from pressurized pipes.

Vacuum filtration set
Includes an electric vacuum pump for preparing membrane samples for microscopic particle counting, gravimetric analysis and analysis of contamination types using the supplied micro magnifier.

Water analysis

Technical data

<table>
<thead>
<tr>
<th>Membrane filter</th>
<th>0.45 µm</th>
<th>5 µm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other consumables</td>
<td>Transparent fluid</td>
<td>Petri slides</td>
</tr>
</tbody>
</table>

For WAS 01 water analysis kit
Cleaning spray
WIO solution

WAS 01 kit for water analysis
Mobile analysis kit for determining the water content percentage in mineral oils using the calcium hydride method.
Optional Accessories

For oil and water analysis

Microscope
Equipped with an ocular micrometer, 3 lenses with 40x, 100x, and 400x enlargement, transmitted light source and cross table for particle counting

Bottle sampling set
Two high-purity glass bottles (8 fl. oz. (200 ml); cleaned according to ISO 3722) with self-adhesive labels and shipping box.

Drop-ball viscometer
Mobile device for determining dynamic viscosity, consisting of a graduated tube with integrated thermometer, 3 measuring balls, mirror and an electronic stopwatch.

CONDITION MONITORING AND ANALYSIS OF HYDRAULIC AND LUBRICATION FLUIDS

In-line measuring systems
- Particle counter
  - CCM 01 set
  - CCT 01 set

On-line/off-line measuring systems
- Particle counter
  - CCS 4
    Particle counting, water saturation

Sensors
- Water contamination
  - WSPS 05
    Water saturation, temperature

Laboratory analysis and measurement systems
- Oil analysis
  - PAS 01 kit

Water analysis
- WAS 01 kit

Optional accessories
- Microscope
- Bottle sampling set
- Drop-ball viscometer