Measurement, Diagnostic, and Analysis Technology for Monitoring of Hydraulic and Lubrication Fluids
Hydraulic Filtration Product Families:

- Hydraulic & Lubrication Systems
- Hydraulic & Lubrication Filters
- Condition Monitoring
- Hydraulic Filter Accessories

Hydraulic System Cleanliness

Cleanliness is the measure of solid and liquid contamination found in hydraulic systems. Contamination is defined as any substance not part of a hydraulic system’s working fluid.

The Importance of Cleanliness

- Provides maximum efficient productivity
- Improves control of spare parts through preventive maintenance and monitoring
- Reduces equipment downtime through scheduled inspections
- Minimizes safety hazards and prevents contamination-related failure
- Increases the life of system components, which both increases operating profitability and decreases maintenance costs
- Reduces repair costs and system downtime

Occurrence of Contamination

There are three principal means through which contamination can occur in a typical hydraulic system.
- Incorporated during system assembly
- Generated during system operation
- Ingested by the system during operation

Eaton’s Filtration business is a leader in manufacturing filtration products and solutions that include measurement, diagnostic and analysis technology. Following a path of continuous improvement, Eaton has maintained quality as a fundamental corporate strategy and a hallmark of all products and services. Eaton’s Internormen Product Line currently includes more than 4,000 hydraulic filter elements and corresponding filter housings.

**Eaton Filtration Services**

- State-of-the-art testing lab facilities
- Equipment rentals
- Field service—inspections, field trials, start-up, repair, replacement, and maintenance
- Extensive network of sales and service representatives
- Worldwide technical support
- Product specialists dedicated to providing application engineering

Eaton Sustainability Commitment

Eaton is unwavering in our commitment to being sustainable by design—in the way we operate, through the design of our products, and through the energy and climate saving benefits our products deliver. Eaton issues a Sustainability Report as part of its Annual Report, available on www.eaton.com.
Particulate Contamination

Particulate contamination is the most common reason for failure and downtime of hydraulic and lubrication systems. Knowing the precise level of contamination can be essential for the efficiency and functionality of a system.

This knowledge enables the operator to influence the system or intervene with appropriate counteractive measures when necessary.

Effects of Particulate Contamination

- Accelerated oil aging
- Shortened fluid lifetime
- Failure of additives
- Corrosion, cavitation, abrasion, erosion
- Increased system wear

Contamination Monitoring Systems

- Immediate and precise diagnosis of a hydraulic system’s condition
- Monitoring of filter performance so it can be compared with the standards required for certain system components
- Accurate determination of the optimal time for performing filter element changes
- Reliable monitoring of the running-in or start-up time of new systems
- Diagnosis of hydraulic components, such as pumps, bearings, or seals
- Defining the condition of new fluids during system start up
- Verification of effective off-line filtration
- Record influence of changed external conditions on the particle level in a hydraulic system

Benefit from Immediate Diagnosis

- Rapid results
- Timely and appropriate corrective actions
- Improved quality control
- Less time waiting for lab results

Sensor Selection

Eaton’s Internormen particle counters operate with different sensors. The CCS 4, CCM 01-Set, and CCT 01-Set are equipped with laser sensors, which, based on the light blockade principle, detect particles in a fluid. For example, the sensor integrated in the CCS 4 determines the current particulate level of the pressure or lubrication fluid in combination with an integrated dosing system, which automatically adjusts the pressure of the connected system. Both the CCM 01-Set and CCT 01-Set generate results by an additional measurement of the volume flow rate. The MPS sensors detect coarse metal particles using an inductive measuring technique.

Water-In-Oil Contamination

After particulate contamination, water is the most common reason for breakdowns and failures of hydraulic and lubrication systems.

Consequences of Water in Hydraulic Fluids

- Accelerated oil aging
- Shortened fluid life
- Deteriorated lubrication performance
- Loss of control characteristics
- Reduced filterability
- Increased component wear
- Noise
- Failure of polarizing additives
- Increased acidity
- Rust
- Higher contamination levels

Particles like this in a hydraulic system can be costly

Laser detector operating on the principle of light barrier

Microscopic photo of water in oil

Filtered rust particles
## Monitoring Hydraulic and Lubrication Fluids

### Element Spectral Analysis – Potential Sources of Metals in Oil

<table>
<thead>
<tr>
<th>Metal</th>
<th>Potential Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium</td>
<td>abrasives, aluminium mill, bauxite, bearing metal, catalyst, coal contaminant, fly ash, foundry dust, granite, paint</td>
</tr>
<tr>
<td>Antimony</td>
<td>journal bearings, solder</td>
</tr>
<tr>
<td>Arsenic</td>
<td>antioxidants, bactericide, mineral oil</td>
</tr>
<tr>
<td>Barium</td>
<td>engine additive, grease</td>
</tr>
<tr>
<td>Beryllium</td>
<td>aircraft construction, bearings, mineral oil</td>
</tr>
<tr>
<td>Bismuth</td>
<td>journal bearings</td>
</tr>
<tr>
<td>Boron</td>
<td>EP additives, coolant inhibitor</td>
</tr>
<tr>
<td>Cadmium</td>
<td>journal bearings, plantings</td>
</tr>
<tr>
<td>Calcium</td>
<td>cement dust, detergent, fuller’s earth, grease, gypsum, hard water, lignite, limonite, mining dust, oil additive, road dust, rubber, salt water, sludge</td>
</tr>
<tr>
<td>Carbon</td>
<td>abrasives, carbides, carbon steel, hard metal, mineral oil, soot, synthetic material</td>
</tr>
<tr>
<td>Chromium</td>
<td>chrome plating, hardcoat, paint, ring plating, stainless steel, tooling steels</td>
</tr>
<tr>
<td>Cobalt</td>
<td>additives, hard metal, tooling steels</td>
</tr>
<tr>
<td>Cobalt</td>
<td>reactor technique</td>
</tr>
<tr>
<td>Iron</td>
<td>asbestos, cast iron, catalyst, cleaning detergent, fly ash, mill scale, one dust, paint, rust, tactile, zeolite</td>
</tr>
<tr>
<td>Lead</td>
<td>lithium, lead, gasoline additive, soilder, paint</td>
</tr>
<tr>
<td>Lithium</td>
<td>dust, grease, salt water</td>
</tr>
<tr>
<td>Magnesium</td>
<td>alloy of aluminium, engine additives, fuller’s earth, hard water, road dust, salt water, turbine</td>
</tr>
<tr>
<td>Mercury</td>
<td>bactericide, batteries</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>alloying metal, EP additives, MoS2, rings</td>
</tr>
<tr>
<td>Nickel</td>
<td>hard steel, plating, stainless steel, stellite</td>
</tr>
<tr>
<td>Nickel</td>
<td>turbine blades</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>AW/EP additives, cleaning detergents, oil additives, surface finish</td>
</tr>
<tr>
<td>Platinum</td>
<td>catalyst, mineral oil</td>
</tr>
<tr>
<td>Potassium</td>
<td>additives, coolant inhibitor, fertilizer, fly ash, granite, paper mill dust</td>
</tr>
<tr>
<td>Scandium</td>
<td>ICP-reference</td>
</tr>
<tr>
<td>Silicium</td>
<td>antifouling additives, asphalt, cement dust, coolant additives, fly ash, foundry dust, glass, granite, limonite, mica, road dust, slag, steel, synthetic lubricant, talc, wet clutch</td>
</tr>
<tr>
<td>Silver</td>
<td>bearing overlay, needle bearings, solder</td>
</tr>
<tr>
<td>Sodium</td>
<td>additives, base stocks, coolant inhibitor, dirt, fly ash, grease, paper mill dust, road dust, salt, salt water</td>
</tr>
<tr>
<td>Sulphur</td>
<td>gypsum, mineral oil, MoS2, rubber</td>
</tr>
<tr>
<td>Tantal</td>
<td>hard metals, tooling steels</td>
</tr>
<tr>
<td>Tellerium</td>
<td>mineral oil</td>
</tr>
<tr>
<td>Titanium</td>
<td>hard metal, paints, turbine bearings, turbine blades</td>
</tr>
<tr>
<td>Tungsten</td>
<td>hard metal, tooling steels</td>
</tr>
<tr>
<td>Uranium</td>
<td>one dust, road dust (some)</td>
</tr>
<tr>
<td>Vanadium</td>
<td>mineral oil, turbine blades, valves</td>
</tr>
<tr>
<td>Yttrium</td>
<td>ICP-reference</td>
</tr>
<tr>
<td>Zinc</td>
<td>AW additives, brass, galvanizing, grease, hard steel, oil additives, plating, solder</td>
</tr>
<tr>
<td>Zircon</td>
<td>abrasives, reactor technique</td>
</tr>
</tbody>
</table>

### Guidelines for Determining, Achieving, and Maintaining Target Cleanliness Levels with High Performance Filtration (Beta Ratio ≥ 200)

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Target Levels</td>
<td>Filter Micron Ratings</td>
<td>Target Levels</td>
<td>Filter Micron Ratings</td>
<td>Target Levels</td>
<td>Filter Micron Ratings</td>
</tr>
<tr>
<td>PUMPS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixed External Gear</td>
<td>22/18/14</td>
<td>25VG</td>
<td>20/16/13</td>
<td>10VG</td>
<td>20/16/13</td>
<td>10VG</td>
</tr>
<tr>
<td>Fixed Piston</td>
<td>22/18/14</td>
<td>25VG</td>
<td>20/16/13</td>
<td>10VG</td>
<td>20/16/13</td>
<td>10VG</td>
</tr>
<tr>
<td>Variable Piston</td>
<td>20/16/13</td>
<td>6VG</td>
<td>19/15/11</td>
<td>3VG</td>
<td>18/14/10</td>
<td>3VG</td>
</tr>
<tr>
<td>VALVES</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Check Valve</td>
<td>22/18/14</td>
<td>25VG</td>
<td>20/16/13</td>
<td>10VG</td>
<td>20/16/13</td>
<td>10VG</td>
</tr>
<tr>
<td>Directional (solenoid)</td>
<td>22/18/14</td>
<td>25VG</td>
<td>20/16/13</td>
<td>10VG</td>
<td>20/16/13</td>
<td>10VG</td>
</tr>
<tr>
<td>Cartridge Valve</td>
<td>20/16/13</td>
<td>6VG</td>
<td>19/15/11</td>
<td>3VG</td>
<td>18/14/10</td>
<td>3VG</td>
</tr>
<tr>
<td>Proportional Valve</td>
<td>19/15/11</td>
<td>3VG</td>
<td>19/15/11</td>
<td>3VG</td>
<td>17/13/9</td>
<td>3VG</td>
</tr>
<tr>
<td>Servo Valve</td>
<td>18/14/10</td>
<td>3VG</td>
<td>17/13/9</td>
<td>3VG</td>
<td>16/12/8</td>
<td>3VG</td>
</tr>
<tr>
<td>ACTUATORS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cylinders, Vane &amp; Gear Motors</td>
<td>23/18/15</td>
<td>25VG</td>
<td>20/16/14</td>
<td>16VG</td>
<td>26/16/13</td>
<td>6VG</td>
</tr>
<tr>
<td>Piston &amp; Swash Plate Motors</td>
<td>20/16/13</td>
<td>20/16/13</td>
<td>6VG</td>
<td>19/15/11</td>
<td>6VG</td>
<td></td>
</tr>
<tr>
<td>Hydraulic Drives</td>
<td>19/15/11</td>
<td>6VG</td>
<td>19/14/10</td>
<td>3VG</td>
<td>17/13/9</td>
<td>3VG</td>
</tr>
<tr>
<td>TEST STANDS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11/17/7</td>
<td>1VG</td>
<td>11/17/7</td>
<td>1VG</td>
<td>11/17/7</td>
<td>1VG</td>
<td></td>
</tr>
<tr>
<td>LUBRICATION OILS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paper Machine Oils</td>
<td>20/16/13</td>
<td>10VG</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Steam Turbine Oils</td>
<td>20/16/13</td>
<td>10VG</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Diesel Engine</td>
<td>20/16/13</td>
<td>10VG</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Mobile Gear Box</td>
<td>20/16/13</td>
<td>10VG</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Industrial Gear Box</td>
<td>19/15/11</td>
<td>6VG</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>
| Notes: 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 rating may be required to achieve and maintain the desired Target Cleanliness Level. For more details and accuracy, use our filter simulation software.
**CCS 4 - Contamination Control System**

The CCS 4 mobile measuring system determines the exact particle size distribution of the contamination plus water saturation and fluid temperature.

Measurement results obtained by the CCS 4 are meant to be a base for evaluating the wear condition of hydraulic components, adherence to norms, and early detection of damage.

It can be handled in on-line pressurized operating modes as well as for depressurized samplings (e.g., tank sampling).

**Features:**

- Optical particle counting performed by a laser sensor
- Counting system: > 4 µm(c), > 4.6 µm(c), > 6.0 µm(c), > 6.4 µm(c), > 10 µm(c), >14 µm(c), > 21 µm(c), > 38 µm(c)
- Exact 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 the above-mentioned contamination classes, water saturation, and temperature; theoretical water content in ppm
- Multiple measuring programs: special automatic measuring and conditioning operations, such as: single, continuous, cyclic, and off-line
- Lithium-polymer rechargeable battery
- Internal measurement storage (capacity of 4 x 100 measurements)
- Output of current and saved measurement values by an RS-232 interface
- Output of saved measurements by a USB interface on a USB flash drive (TXT file)
- Data management using an external computer (export in MS-Excel)
- Data management using an external computer and the LabVIEW Data Manager Software (export in MS-Excel)

Because external factors have extensive influence on the lubricant during operation, knowing the particle size distribution of the contamination plus water saturation and fluid temperature enables the user to evaluate the precise condition of a system. This information will help to promptly initiate actions and cost-saving measures before any failures can occur.
### OCM 01 - Oil Condition Monitor

**Features**
- Mobile diagnostic system for determining the aging condition of oil in hydraulic and lubrication systems by measuring solid contamination, water saturation, temperature, viscosity, and relative dielectricity.
- Theoretical water content in ppm.
- Applicable for both pressure and suction lines (can be used when working with foamed oils in gears).
- Enables the user to make a precise assessment of the condition of a system and perform timely, cost-effective maintenance.

**Technical Data**

<table>
<thead>
<tr>
<th>Operating parameters:</th>
<th>90 to 230 V, 50/60 Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating pressure:</td>
<td>-2.9 to 580 psi (-0.2 to 40 bar)</td>
</tr>
<tr>
<td>Viscosity:</td>
<td>92 to 3615 SUS (20 to 780 mm²/s)</td>
</tr>
<tr>
<td>Permitted oil temperature:</td>
<td>32 to 158 °F (0 to 70 °C)</td>
</tr>
<tr>
<td>Ambient temperature:</td>
<td>32 to 122 °F (0 to 50 °C)</td>
</tr>
<tr>
<td>Protection class:</td>
<td>IP 67 (with cover closed)</td>
</tr>
</tbody>
</table>

**Measurement parameters:**

- Automatic particle counting according to ISO 4406:99, NAS 1638, SAE AS 4059
  - in 8-channels: 4.0 µm(c), 4.6 µm(c), 6.0 µm(c), 6.4 µm(c), 10 µm(c), 14 µm(c), 21 µm(c), 37 µm(c)
  - Coincidence limit: 10,000 particle/ml
  - Accuracy: ±1 (contamination class)
  - Water saturation: 0 to 100%
  - Dynamic viscosity: 18 to 700 mPas
  - Temperature: 32 to 158 °F (0 to 70 °C)
  - Relative dielectricity constant: 1 to 10

### IVS 01 - In-line Multifunction Oil Condition Sensor

**Features**
- In-line multifunction sensor meant for oil condition monitoring in hydraulic and lubrication systems.
- Able to determine the aging condition and evaluate the kinds of mixtures in the oil by measuring and detecting changes of viscosity, temperature, and relative dielectricity before system failures can occur.
- Enables the user to program an automatic oil condition monitoring function, make a precise assessment of the condition of a system, and perform accurately timed maintenance.
- Simple screw-in assembly (G 3/4 threaded).

**Technical Data**

<table>
<thead>
<tr>
<th>Sensor measurement range:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamic viscosity:</td>
</tr>
<tr>
<td>Temperature:</td>
</tr>
<tr>
<td>Relative dielectricity constant:</td>
</tr>
<tr>
<td>Protection class:</td>
</tr>
</tbody>
</table>

**Operating parameters:**

| Maximum pressure:       | ≤ 362 psi (25 bar) |
| Ambient temperature:    | 32 to 158 °F (0 to 70 °C) |
| Connection:             | G 3/4 threaded |
| Protection class:       | IP 67 |
| Power supply:           | 24 V DC |
| Output data:            | 4 x 4 to 20 mA (dyn. viscosity, temperature, relative dielectric constant, oil quality) or CANopen |
In-line Measuring Systems

MPM 01-Set - Metal Particle Monitor System

Features
- Consists of a metal particle sensor (MPS) based on an inductive measurement technique for hydraulic and lubrication fluids, and control and display unit (MPM 01) for direct measurement survey
- The MPM 01-Set can be delivered with the MPS 01.2, MPS 02.1, or MPS 03.1 sensor
- Designed as an inexpensive in-line monitoring solution for stationary and permanent operations
- Suitable for installation in new or existing systems
- Internal storage of measurements
- Automatic monitoring function with control signal output if set thresholds are exceeded
- RS-232 interface
- Data transfer to an external PC
- User-friendly data management using LabVIEW Data Manager software
- Alpha-numeric display
- Sturdy case

MPS 01.2 - Metal Particle Sensor

Features
- Metal particle sensor based on an inductive measurement technique for hydraulic and lubrication fluids
- Detects metal particles >200 µm
- Designed as an inexpensive in-line monitoring solution for stationary and permanent operations
- Suitable for installation in new or existing systems
- Two output signals: counting impulses (24 V, 7 ms) and a diagnostic signal
- The MPS 01.2 can be used with or without the MPM 01 display unit

Technical Data

<table>
<thead>
<tr>
<th>Fluid compatibility</th>
<th>Hydraulic and lubrication fluids, as well as synthetic esters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measuring principle</td>
<td>Inductive method</td>
</tr>
<tr>
<td>Detection Limit</td>
<td>≥200 µm Fe</td>
</tr>
<tr>
<td>Maximum detection rate</td>
<td>100 particles/sec</td>
</tr>
<tr>
<td>Operating pressure</td>
<td>≤290 psi (20 bar)</td>
</tr>
<tr>
<td>Ambient temperature</td>
<td>-40 to 158 °F [-40 to 70 °C]</td>
</tr>
<tr>
<td>Fluid temperature</td>
<td>-22 to 185 °F [-30 to 85 °C]**</td>
</tr>
<tr>
<td>Survival temperature</td>
<td>-40 to 185 °F [-40 to 85 °C]</td>
</tr>
<tr>
<td>Max. volume flow</td>
<td>13.2 gpm (50 l/min)</td>
</tr>
<tr>
<td>Min. volume flow</td>
<td>2.64 gpm (10 l/min)</td>
</tr>
<tr>
<td>Power supply</td>
<td>+24 V DC</td>
</tr>
<tr>
<td>Elec. power consumption</td>
<td>5 W (maximum)</td>
</tr>
<tr>
<td>Output data</td>
<td>1x signal (24 V impulses - 7ms)</td>
</tr>
<tr>
<td></td>
<td>1x diagnostic output (24 V, if no malfunction)</td>
</tr>
<tr>
<td>Max. load on elec. outlet</td>
<td>10 mA</td>
</tr>
</tbody>
</table>

**The minimum flow rate must be ensured**
MPS 02.1 – Metal Particle Sensor

Features

• For detecting metal particles in moving hydraulic and lubricant fluids
• Typical application areas: inexpensive, continuous monitoring of large-scale gearboxes for incipient heavy wear with the increasing number of particles per time unit, as well as monitoring component cleanliness e.g., on flushing test stands.

Technical data (EU metrics)

| Detection limit: | ≥ 260 µm Fe |
| Max. detection rate: | 100 particles/s |
| Operating pressure: | ≤ 290 psi (20 bar) |
| Ambient temperature: | -40 to 158 °F (-40 to 70 °C) |
| Fluid temperature range: | -22 to 185 °F (-30 to 85 °C)** |
| Survival temperature range: | -40 to 185 °F (-40 to 85 °C) |
| Max. volume flow: | 36.99 gpm (140 l/min) |
| Min. volume flow: | 7.83 gpm (30 l/min) |
| Power supply: | +24 V DC |
| Electrical power consumption: | max. 5 W |
| Outputs: | 1 x signal (24 V impulses ~ 7 ms) |
| | 1 x diagnostic output (24 V, if no malfunctions) |
| Max. load on electric output: | 10 mA |
| Connection size: | SAE-flange 1” |

MPS 03.1 - Metal Particle Sensor

Features

• Inexpensive metal particle sensor for monitoring large-scale gear boxes and detecting initial heavy wear by identifying an increasing number of particles within a given time frame
• Also applicable for component cleanliness monitoring (e.g., on flushing test stands)
• Accurately detects metal particles in moving hydraulic and lubrication fluids, independent of size and metal type. The defined minimum particle size, which can be detected is an iron ball with a diameter of 350 µm at a volume flow (through the channel) of 15.8 gpm (60 l/min)
• The sensor is permanently installed into the hydraulic or lubrication circuit so that the monitored fluid flows through the sensor’s measuring channel.

Technical data

| Detection limit: | ≥ 350 µm Fe |
| Maximum detection rate: | 100 particles/sec |
| Operating pressure: | ≤ 290 psi (20 bar) |
| Ambient temperature: | -40 to 158 °F (-40 to 70 °C) |
| Fluid temperature: | -22 to 185 °F (-30 to 85 °C)** |
| Survival temperature: | -40 to 185 °F (-40 to 85 °C) |
| Max. volume flow: | 84.5 gpm (320 l/min) |
| Min. volume flow: | 15.8 gpm (60 l/min) |
| Power supply: | +24 V DC |
| Electric power consumption: | 5 W (max.) |
| Output data: | 1x signal (24 V impulses ~ 7ms) |
| | 1x diagnostic output (24 V, if no malfunction) |
| Max. load on electric output: | 10mA |
| Connection: | SAE-flange 1-1/2” |

** The minimum flow rate must be ensured
Note: The working temperature range of the MPS 0X also depends on the VT behavior of the fluid. For applications with very high viscosity fluids, regular operation of the sensor is only possible within a temperature range in which sufficient oil flow (“minimum volume flow”) can be ensured.
CCM 01-Set - Contamination Control Monitor System

**Features**
- Particle counter with a laser sensor for hydraulic and lubrication fluids (PFS 01) and a monitoring and display unit (CCM 01)
- Designed as an inexpensive in-line monitoring solution for stationary and permanent operations
- Reliable determination of contamination classes according to ISO 4406:99 or NAS 1638 (switchable)
- CAN-interface according to ISO 11898, CAN 2.0A; CANopen compatible
- Suitable for installation in new or existing systems
- Results displayed immediately
- Internal measurement storage
- Automatic monitoring function with control signal output if set thresholds are exceeded
- RS-232 interface
- Data transfer to an external PC
- Data management using LabVIEW Data Manager software
- User-friendly and easy to learn software
- Alpha-numeric display
- Sturdy case

**Technical Data**
- Fluid compatibility: Hydraulic and lubrication fluids, and synthetic esters
- Laser: 650 nm
- Counting channels: 4; sizes (switchable): ≥4 µm(c), ≥6 µm(c), ≥14 µm(c), ≥21 µm(c) or ≥6.4 µm(c), ≥14 µm(c), ≥21 µm(c), ≥37 µm(c)
- Accuracy: ± 1 (contamination class)
- Operating pressure: up to 725 psi (50 bar)
- Temperature: 32 to 158 °F (0 to 70 °C)
- Calibration: ISO MTD in oil
- Connection: 1” or ¾” pipes
- Power supply: 24 V DC

PFS 01 - Laser Sensor

**Features**
- Consists of two sensor elements: a laser sensor for particle counting and a flow sensor for volume flow measurements
- Advantages of the thermal volume flow sensor: no mobile component parts, no abrasion, simple electronic evaluation procedures, insensitive to contamination
- Integrated laser sensor operates on the principle of light blockage
- Advantages over precision sensors: compact construction, lower costs, applicable for permanent or periodic monitoring
- Calibrated according to ISO 11171:99
- Suitable for installation in new or existing systems
- The PFS 01 sensor cannot be used without a display unit (CCM 01 or CCT 01)

**Technical Data**
- Coincidence limit: 10,000 particles/ml
- Operating pressure: ≤ 725 psi (50 bar)
- Max. oil temperature (short term): 158 °F (70 °C)
- Viscosity: 46 to 1854 SUS (10 to 400 mm²/s)
- Ambient temperature: 32 to 158 °F (0 to 70 °C)
- Maximum volume flow: 13.2 gpm (50 l/min)
- Minimum volume flow: 0.13 gpm (500 ml/min)
- Connection: 1” or ¾” pipe
- Protection class: IP 65
- Weight: 3.3 lbs (1.5 kg)
CCT 01-Set - Contamination Control Transmitter System

Features
- Particle counter with the PFS 01 laser sensor for hydraulic and lubrication fluids
- Consists of the contamination class transmitter (CCT 01) with an integrated three-channel particle counter, combined with the particle flow sensor (PFS 01)
- Contamination monitoring at different test stands for hydraulic components, filter service devices, wind energy plants, and a variety of mobile and stationary hydraulic systems
- Inexpensive and reliable in-line system for contamination class control
- CAN-interface according to ISO 11898, CAN 2.0A; CANopen compatible
- When used as a contamination class transmitter, the CCT 01 transforms measurement signals received from the laser sensor into contamination classes displayed as analog outputs
- Reliable determination of contamination classes according to ISO 4406:99
- Measurements can be saved in user-defined intervals (up to 1000 measurements)
- May be PC-configured using a USB interface; calibration values can be set, and current or saved particle numbers transmitted to a PC

Technical Data
- Particle size: >4 µm(c), >6 µm(c), >14 µm(c)
- Representation of the contamination class: ISO 4406 (4 - 25)
- Accuracy: ± 1 (contamination class)
- Ambient temperature: 32 to 158 °F (0 to 70 °C)
- Power supply: 24 V DC
- Output data: 3 x 4 to 20 mA
- Max. burden: 450 Ω
- Protection class: IP 65
- Storage capacity: up to 1000 measurements
- Interfaces: 4 to 20 mA (3x) CAN: ISO 11898, CAN 2.0A, CANopen compatible USB
- Dimensions (mm): 7.91 in x 3.35 in x 1.38 in (201 mm x 85 mm x 35 mm)
- Weight: .83 lbs (380 g)

In-line Measuring Systems

CSM 02 - Contamination Sensor Monitor

Features
- Use as a stationary or mobile oil condition monitoring system
- Operates off-line, independent of the system being measured
- Analyzes the amount and size of solid contamination in hydraulic and lubrication fluids
- Easily upgraded with additional sensor modules to measure other important fluid parameters
- Measures foamed oils accurately
- Effective for early detection of changes in fluid cleanliness and oil composition as well as contamination increases
- Useful for quality control, maintenance, and during initial operations
- Software updatable through SD card
- Remote control via Internet or Intranet
- Graphic display of stored measurements
- Storage capacity 8 x 100 measurement results
- English and German languages available

Technical Data:
- Voltage supply: 230 V, 50 Hz / 110 V, 60 Hz
- Pressure operating range: -2.9 to 2.9 psi (-0.4 to 0.5 bar)
- Viscosity: 92.7 to 4635 SUS (20 to 1000 mm ²/s)
- Max. oil temperature: 32 to 158 °F (0 to 70 °C)
- Ambient temperature: 32 to 122 °F (0 to 50 °C)
- Protection class: IP 54
- Output signals: Two alarm signals; limit values programmable RS232 / RS485 output, USB, Ethernet
- Alarm through e-mail via Internet
- Measurement results displayed on monitor
- Printing function with optional thermal printer
- Operation: On touch-screen

Measuring Parameters:
- Particle counting: Contamination classes - acc. to ISO 4406:99
- Water saturation: 0 to 100%
- Temperature: 32 to 158 °F (0 to 70 °C)
- Dynamic viscosity: 9 to 900 mPas
- Relative dielectric constant: 1 to 10
- Weight: 72.8 lbs (33 kg) approximately
LPC 02-Set - Laboratory Particle Counter

Features

• The LPC 02 - Set is meant for counting solid contaminants and precise determination of contamination classes in hydraulic and lubrication oils
• Consists of the Laboratory Particle Counter (LPC 02), the Laser Sensor (LS 01), and Bottle Sampling System (BSS 2)
• 4096 easily selectable counting channels are available for determining particle size progression
• Integrated evaluation software enables the user to obtain data analysis and graphic diagrams of performed measurements
• Compatible with MS-Excel

Technical Data (LS 01)

<table>
<thead>
<tr>
<th>Measuring principle:</th>
<th>Light blockage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating pressure:</td>
<td>1.45 to 725 psi (0.1 to 50 bar)</td>
</tr>
<tr>
<td>Viscosity: 0.2 to .62 in²/s (130 to 400 mm²/s) pressure 58 psi (4 bar)</td>
<td></td>
</tr>
<tr>
<td>Maximum flow rate: 0.05 gpm (20 to 200 ml/min)</td>
<td></td>
</tr>
<tr>
<td>Coincidence limit: 24,000 particles/ml</td>
<td></td>
</tr>
</tbody>
</table>

Technical Data (LPC 02)

| Output data: | Particle numbers, contamination classes according to ISO 4406:99, NAS 1638, and SAE AS 4059 |
| Counting system: | Theoretical 4096 channels, 12 Bit |
| Operating pressure: | 0 to 58 psi (0 to 4 bar) |
| Viscosity: 603 to 1854 SUS (130 to 400 mm²/s) pressure 58 psi (4 bar) |
| Volume of measurement: 0.34 oz (10 ml) |
| Connection: 1 x mini measuring screwed joint M 16 x 2 |
| 1 x plug-in coupling for hose DN 6 |
| Power supply: External adaptor; 100 to 250 VAC 50-60 Hz / 12 V DC |
| Interface: USB |
| Weight: 8.2 lbs (3.7 kg) approximate |
| Dimensions: 12.6 in x 6.90 in x 7.87 in (320 mm x 175.2 mm x 200 mm) |

Engineering precision, technological innovation, manufacturing know-how, and customer focus come together to create solutions that are:
• accurate and immediate
• mobile and stationary
• fluid monitoring and particle counting
• according to ISO, NAS, and SAE standards
...to help keep your systems operating at maximum capacity.
Laboratory Analysis and Measurement Systems

Static Sampling
Vacuum pump, tubes, and telescopic stick for dynamic sampling out of pressurized pipes

Static Sampling
Vacuum pump, tubes, and telescopic stick for static sampling out of tanks or packing drums

One-way Pipette
For static sampling of heavily contaminated fluids

Dynamic Sampling
Mini-measuring connections and tubes for dynamic sampling out of pressurized pipes

PAS 01 - Sampling and Oil Analysis Kit
For on-site vendor inspection and condition control of operating fluids

Vacuum Filtration Set
Includes an electric vacuum pump to prepare membrane samples for microscopic particle counting (with the attached micro pocket lens), analysis of contamination types, or gravimetric analysis

WAS 01 - Water Analysis Kit
Uses the calcium hydride method to determine the content of water in mineral oils

Supplementary Sets for Oil Analysis

Bottle Sampling Set
2 high-purity glass bottles (8 oz) with self-adhesive labels and shipping box

Drop-ball Viscosimeter
Graduated tube with integrated thermometer, 3 measuring balls, mirror, and electronic stop-watch
Supplementary Sets for Oil Analysis

Consumables and Reagents

<table>
<thead>
<tr>
<th>Product</th>
<th></th>
<th></th>
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</tr>
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<tbody>
<tr>
<td>Membrane Filters</td>
<td>0.45 µm</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5 µm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Consumables</td>
<td>Of equal weight</td>
<td>Transparent fluid</td>
<td>Petri slides</td>
</tr>
<tr>
<td>For WAS 01</td>
<td>Reagent A and B</td>
<td>Cleaning spray</td>
<td></td>
</tr>
</tbody>
</table>

Microscope

Equipped with eyepiece micrometer, 3 lenses (40, 100, 400 x magnification), transmitted light source, and compound table for microscopic particle counting

Contamination Monitoring Accessories

BSS 2 - Bottle Sampling System

Features
- Optional auxiliary unit for the CCS 4 measuring system; ensures optimal bottle sampling processing and sample preparation to obtain lab-quality results
- Essential degasification performed by generating a vacuum
- Variable adjustable pressure can be applied to feed the fluid to the CCS 4 system

Technical Data

- Pressure: 0 to 58 psi (0 to 4 bar)
- Suction: 0 to 13.8 psi (0 to -0.95 bar) (-95 kPa)
- External supply pressure: 72 to 145 psi (5 to 10 bar) (air volume Q min = 10.6 gpm (40 l/min))
- Supply pressure connection: Quick-coupling NW 7.2
- Hose connection: Miniature measuring connection with screw coupling M16x2
- Power supply: 110 to 230 V AC, 12 V DC

Optional compressor available

Secondary Calibration

CALSUS 01 + CALSOFT 01

Features
- This set, in combination with the BSS 2, allows a secondary calibration of the CCS 4 laser sensor according to ISO 11171:99
- Necessary solutions and certificates are included
- Calibration can be performed automatically using CALSOFT 01 software

Consumables and Reagents

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<tr>
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</table>
Water Contamination Diagnostic Technology

How Water Enters a System
- Inappropriate storage
- Residue from cleaning
- Humidity/condensation
- Through bearings or permeable spots (e.g., hairline cracks, caps, defective seals, etc.)

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

Measuring Principle
Eaton’s Internormen WSPS systems are capacitive sensors and utilize a polymer foil as a dielectric between two electrodes. This foil is capable of absorbing water molecules due to its microporous structure. The absorption changes the capacity of the sensor element, altering the frequency of the resonant circuit. The frequency change is detected, converted to data, and displayed.

What is being measured
The WSPS’ sensors measure the relative humidity of a fluid. The result is the saturation level of the fluid with water as a percentage. A result of 100% means total saturation and the presence of dangerous free water in a fluid.

The WSPS result is different from water content analysis using the Karl Fischer Method, which calculates the total amount of free and dissolved water in the fluid.

A theoretic relation to the ppm (mg/kg) water content (determined by the Karl-Fischer method) can be made if both the characteristic curve of the saturation level and the temperature of the fluid being measured are known.

Characteristic curves for various fluids are pre-programmed in the WSTM 01 display unit. When operated with the WSPS 05, results also can be displayed in ppm. Characteristic curves for additional oils can also be implemented.
**WSPS 01 Sensor**

The WSPS 01 is a monitoring and diagnostic sensor used for hydraulic and lubrication fluids. It is designed for quick and reliable off-line measurements of saturated water in oil. It provides analog output of water saturation in volts. The unit is simple to use and easy to clean.

**Technical Data**

<table>
<thead>
<tr>
<th>Measuring range</th>
<th>0 to 100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy</td>
<td>± 2%</td>
</tr>
<tr>
<td>Ambient temperature</td>
<td>-40 to +176 °F (-40 to +80 °C)</td>
</tr>
<tr>
<td>Flow velocity</td>
<td>79&quot;/s (2 m/s) max</td>
</tr>
<tr>
<td>Power supply</td>
<td>6 to 30 V DC</td>
</tr>
<tr>
<td>Analog output</td>
<td>0 to 1 V</td>
</tr>
<tr>
<td>Cable length</td>
<td>59&quot; (1.5 m)</td>
</tr>
<tr>
<td>Protection class</td>
<td>IP 67</td>
</tr>
</tbody>
</table>

**Recommended display unit**: WSH 01 with colored LED display for mobile off-line applications.

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**WSPS 05 Sensor**

The WSPS 05 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 is shown as a percentage. An indication of 100% means the fluid is completely saturated.

Saturation values of fluid are influenced by temperature. The WSPS 05 includes an integrated thermal sensor, which determines the exact temperature of the fluid during a measurement.

**Technical Data**

<table>
<thead>
<tr>
<th>Measuring range</th>
<th>Saturation level: 0 to 100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy</td>
<td>Saturation level: ± 2%</td>
</tr>
<tr>
<td>Temperature</td>
<td>Temperature: ± 0.4%</td>
</tr>
<tr>
<td>Operating pressure</td>
<td>0 to 363 psi (25 bar)</td>
</tr>
<tr>
<td>Flow velocity</td>
<td>≤ 79&quot;/s (2 m/s)</td>
</tr>
<tr>
<td>Ambient temperature</td>
<td>-13 to +185 °F (-25 to +85 °C)</td>
</tr>
<tr>
<td>Temp. range of fluid</td>
<td>-40 to +194 °F (temporary 212 °F (100 °C)) (-40 to +90 °C)</td>
</tr>
<tr>
<td>Power supply</td>
<td>12 to 30 VDC</td>
</tr>
<tr>
<td>Analog outputs</td>
<td>2 x 4 to 20 mA</td>
</tr>
<tr>
<td>Protection class</td>
<td>IP 65</td>
</tr>
</tbody>
</table>

**Recommended display unit**: WSTM 01 - Set with an alpha-numeric display and a simple menu. Results can be shown in either percent saturation level or theoretical ppm.

The WSTM - Set features an RS-232 serial interface and a CAN-bus interface according to ISO 11898, CAN 2.0A; CANopen compatible.

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**WSSB**

Water sensor sample bottle for direct measurements when using the Contamination Control System (CCS).

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**WSH 01 - Set**

The WSH 01 - Set is a convenient handheld measuring device consisting of a WSPS 01 sensor and a WSH 01 unit with a colored LED display.

It is used for quick, simple, and reliable mobile off-line measurements of saturated water in oil.

The unit is battery powered and easy to clean.

---

**WSTM 01 - Set**

The WSTM 01 - Set is designed for reliable, stationary in-line measurements of saturated water in oil. It also measures the fluid’s temperature.

The set consists of a WSPS 05 sensor and a WSTM 01 display unit with an alpha-numeric display and a simple menu. Results can be shown in either percent saturation level or theoretical ppm.

**MSS 01**

This device allows up to eight WSPS sensors to operate with one WSTM 01 display unit.

Fluid compatibility of Eaton sensors include mineral oil-based fluids as well as synthetic fluids such as: hydraulic, lubrication, transformer, and ester-based oils.

Pre-programmed fluids in the WSTM 01 include: HLP 22 (Shell), HLP 46 (Shell), HLP 68 (Shell), MIL-H 5606 (Shell), CLP 220 (Shell), and HEES 46 (Fuchs).
Measurement, Diagnostic, and Analysis Technology

Laboratory Analysis and Measurement Systems
- Particle Counter
  - LCP 02
- Oil Analysis
  - PAS 01
  - Microscope Set
  - Drop-ball Viscosimeter
- Water Analysis
  - WAS 01

Sensors
- Metal Particles
  - MPS 01.2
  - MPS 02.1
  - MPS 03.1
- Water Contamination
  - WSPS 01
    - % saturation
  - WSPS 05
    - % saturation, temperature

In-line Measuring Systems
- Particle Counter
  - CCM 01-Set
  - CCT 01-Set
  - CSM 02
  - MPM 01-Set metal particle counter
- Water Contamination
  - WSTM 01
- Oil Condition
  - IVS 01
    - viscosity, temperature, relative dielectricity

On-line/Off-line Measuring Systems
- Particle Counter
  - CCS 2
  - CCS 4
- Accessories
  - BSS 2
    - bottle sampling system
  - TSS 1
    - tank sampling system
  - WSSB
    - water saturation bottle
  - MWS 01/02
    - mini web server
  - Secondary Calibration
- Mult-analyses Systems
  - DCM 01
    - particle counting, viscosity, water content, % saturation, temperature, relative dielectricity

Accessories
- BSS 2
- TSS 1
- WSSB
- MWS 01/02

Multi-analyses Systems
- DCM 01
  - particle counting, viscosity, water content, % saturation, temperature, relative dielectricity

Laboratory Services
- Performed by certified experts
- Employing the latest measuring and testing equipment
- Determination of contamination classes
- Contamination analysis
- Oil condition analysis

Calibration Services
- Performance tests
- Secondary calibration
- Exchange worn mechanical components
- Print paper and ink ribbon exchanges
- Equipment cleaning
- Software updates
- 24-hour test runs
- Calibration certification

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