Upgrade Fluid System Filter Element Monitoring to Increase Operational Reliability and Support Condition Based Maintenance Capability

Presented by
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Why the filter element?
Filters are already incorporated in all important systems to provide operational reliability.

Fluid systems such as; Transmission, Lubrication, Hydraulic, Fuel and Electronic Cooling can utilize this effective CBM process.
Filter Monitoring Supports CBM

In-System Filter Element Monitoring can support the following major levels of Condition Based Maintenance:

1. Identify when filter element service is required.
2. Determine the remaining filter element service life, the asset’s mission availability and establish a schedule for filter element service.
3. Provide an early indication of a system fault.
Filter Monitoring Supports CBM

Basic Transmission Lubrication System

- Pressure Regulator
- Filter
- Heat Exchanger
- Pump
- Rotor Output
- Turbine Input
Filter Monitoring Supports CBM

System Simplification

System Components
Valves, Bearings, Gears, Pump

System Filter

Lubrication Fluid Flow
Filter Monitoring Supports CBM

Fluid Cleanliness (Particles / Fluid Volume)

Fluid Volume Passing through the System

System Components
Valves, Bearings, Gears, Pump

System Filter

Lubrication Fluid Flow
Filter Monitoring Supports CBM

Cleanliness Equilibrium

Fluid Volume Passing through the System

System Components
Valves, Bearings, Gears, Pump

System Filter

Lubrication Fluid Flow
Filter Monitoring Supports CBM

Cleanliness Equilibrium

Fluid Volume Passing through the System

System Components
Valves, Bearings, Gears, Pump

System Filter

Filter Loading
Filter Monitoring Supports CBM

- Single Pass of Fluid Through The System
- Fluid Cleanliness
- Fluid Volume Passing through the System
- Filter Loading Curve
- Terminal Pressure Drop
- Filter Service Life
- Sum of Filter Element Loadings Over Time
- Filter Pressure Drop
- Cleanliness Equilibrium
- Filter Loading
Filter Monitoring Supports CBM

- **Cleanliness Equilibrium**
- **Filter Loading**
- **Terminal Pressure Drop**
- **CBM Level 1**

**Single Pass of Fluid Through The System**

**Fluid Volume Passing through the System**

**Sum of Filter Element Loadings Over Time**

**Filter Service Life**

**Fluid Cleanliness**

**Filter Pressure Drop**
Filter Monitoring Supports CBM

- Single Pass of Fluid Through The System
- Fluid Cleanliness
- Fluid Volume Passing through the System
- Filter Loading Curve
- Terminal Pressure Drop
- Filter Loading
- Current Pressure Drop
- Sum of Filter Element Loadings Over Time
- Cleanliness Equilibrium
Filter Monitoring Supports CBM

Single Pass of Fluid Through The System

Fluid Volume Passing through the System

Cleanliness Equilibrium

Filter Loading

Filter Loading Curve

Terminal Pressure Drop

Current Pressure Drop

Sum of Filter Element Loadings Over Time

Remaining Filter Service Life

Fluid Cleanliness

Filter Pressure Drop

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Filter Monitoring Supports CBM

- Single Pass of Fluid Through The System
- Fluid Volume Passing through the System
- Fluid Cleanliness
- Sum of Filter Element Loadings Over Time
- Current Pressure Drop
- Remaining Filter Service Life
- Terminal Pressure Drop
- Filter Loading Curve
- Cleanliness Equilibrium
- Filter Loading
- CBM Level 2
Filter Monitoring Supports CBM

Single Pass of Fluid Through The System

Fluid Volume Passing through the System

Fluid Cleanliness

Abnormal Equilibrium

Normal Filter Loading

Normal Filter Loading Curve

Terminal Pressure Drop

Filter Pressure Drop

Sum of Filter Element Loadings Over Time

Normal Filter Service Life
Filter Monitoring Supports CBM

Single Pass of Fluid Through The System

Fluid Cleanliness

Abnormal Equilibrium

Abnormal Filter Loading

Fluid Volume Passing through the System

Sum of Filter Element Loadings Over Time

Filter Pressure Drop

Abnormal Loading Curve

Terminal Pressure Drop

Normal Filter Service Life
Filter Monitoring Supports CBM

Single Pass of Fluid Through The System

Abnormal Equilibrium

Abnormal Filter Loading

Fluid Volume Passing through the System

Fluid Cleanliness

Abnormal Loading Curve

Filter Pressure Drop

Terminal Pressure Drop

Sum of Filter Element Loadings Over Time

Abnormal Filter Service Life

Lost Filter Service Life

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Filter Monitoring Supports CBM

Single Pass of Fluid Through The System

Fluid Volume Passing through the System

Abnormal Equilibrium

Abnormal Filter Loading

Terminal Pressure Drop

Abnormal Loading Curve

Deviation from normal loading curve provides an Early Indication of System Fault
Filter Monitoring Supports CBM

- **Single Pass of Fluid Through The System**
- **Fluid Cleanliness**
- **Fluid Volume Passing through the System**
- **Abnormal Equilibrium**
- **Abnormal Filter Loading**
- **Sum of Filter Element Loadings Over Time**
- **Filter Pressure Drop**
- **Terminal Pressure Drop**
- **Abnormal Loading Curve**
- **CBM Level 3**
- Deviation from normal loading curve provides an Early Indication of System Fault
### Comparison of Differential Pressure Monitors

<table>
<thead>
<tr>
<th>Monitor Capability</th>
<th>Indicator</th>
<th>Switch</th>
<th>Indicator/Switch</th>
<th>Sensor</th>
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<tbody>
<tr>
<td>Port Mounting Compatible</td>
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<tr>
<td>Validate Operation</td>
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<td>Remaining Life</td>
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<td>Schedule Service</td>
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<td>yes&lt;sup&gt;3&lt;/sup&gt;</td>
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<td>Early Fault Indication</td>
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<td>System In Bypass</td>
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</tbody>
</table>

1. Only on systems having high pressure drop during cold start without thermal lockout
2. No validation, Poor operational reliability, Possibly system fault
3. Possible validation, Poor operational reliability, Possibly system fault
Filter Monitoring Supports CBM

Upgrading to a Differential Pressure Sensor to provide real-time in-system monitoring of the filter element’s performance can support CBM in addition to providing:

- Improved indication tolerance
- No moving parts, robust design
- An integrated temperature sensor output
- Full utilization of the filter element
- Reduction of required filter changes
- Improved reliability and operational readiness
Any Questions?

Filter Monitoring Supports CBM