What is Oil Analysis

Oil analysis is the sampling and laboratory analysis of a lubricant's properties, suspended contaminants, and wear debris. Oil analysis is performed as part of a routine condition monitoring program to provide meaningful and accurate information on the lubricant and overall condition of the machine. Oil analysis provides a view of the condition of the oil along with the machine wear!
Oil Condition Monitoring

Optimal equipment performance starts with consistent machinery fluid analysis

Any company that operates equipment using oil, fuel or coolant can benefit

---

**DIESEL FUELS**

Fuel analysis programs enable you to anticipate problems and ensure reliable equipment operations

---

**GREASES**

Grease testing can evaluate wear, consistency, contamination and oxidation in grease lubricated systems

---

**COOLANTS**

Coolant analysis takes the guesswork out of cooling system maintenance

---

**LUBE OILS**

Monitoring equipment condition with oil analysis controls maintenance planning; impacting the bottom line

---

**MWF’s**

Metalworking fluids can be complex formulations that require analysis to monitor multiple critical fluid properties

---

**DEF’s**

Ensure SCR systems operate efficiently with DEF Testing

---

**Analysts’ Testing Capabilities**
Blood Testing Can:

- Recognize How Well Organs are Functioning
- Distinguish Different Causes of Complaints
- Diagnose Diseases
- Identify RISKS for Known Conditions
- Confirm if Prescribed Medication is Working

Your doctor can only diagnose the above if you provide the necessary information:

- ✓ Height
- ✓ Gender
- ✓ Weight
- ✓ Symptoms
- ✓ Age
What the laboratory needs

Oil Analysis Can:

- Recognize How Well Equipment Components are Operating
- Distinguish Different Causes of Wear
- Diagnose Fluid Degradation
- Identify RISKS for Known Conditions
- Confirm if Corrective Maintenance Actions are Working

The laboratory can only diagnose the above if you provide crucial information:

- Machine Mfg/Model
- Component Type
- Oil Type
- Symptoms
- Hours on Machine & Oil
Machine Condition Monitoring Through Oil Analysis

Oil Analysis + Vibration

- Oil Condition Monitoring (OCM) & Vibration are Complimentary Predictive Tools
- Depending on the Failure Mode, One Technique May Provide Earlier Warning
- Combined, OCM and Vibration Increase Equipment Reliability

The pie chart shows the impressive results. Of the 750 machines in the condition monitoring program, bearing faults were first detected 67 percent of the time using oil analysis and 60 percent of the time with vibration analysis.

Both technologies converged to catch bearing faults 27 percent of the time. It was noted that while oil analysis caught the faults 40 percent of the time ahead of vibration, eventually vibration analysis would have detected many of these faults as the issue progressed.

Bearing fault detection of early bearing failure (750 machines)
Oil Sampling Program Goals & Objectives

Oil Analysis GOALS

- Condition Monitoring
- Fluid Selection
  - Comparison
  - Quality Control
- Establish Safe & Proper Drain Intervals
- Filtration Monitoring
- Special Requirements
Oil Sampling Program Goals & Objectives

Oil Analysis Objectives

- Prevent Lubrication and Wear Related Failures
- Reduce Maintenance Costs
- Decrease Unplanned Shutdowns
- Increase Equipment Life
SELECTING EQUIPMENT

► Start Small
  ● Based on Equipment Criticality
► Sample Frequently
  ● Monthly / Quarterly
► Review and Act on Reports
► Expand Program to Additional Equipment
CRUCIAL INFORMATION

- Unit / Compartment ID
- Mfg. Make & Model
- Oil Information
  - Manufacturer
  - Brand
  - ISO Grade
- Equipment Type / Application
- Feedback
- Service Hours
  - Equipment & Oil
THE SAMPLING PROCESS
Recommended Sampling Methods

- Petcock or sampling valve (QSS®) prior to oil filter
- Vacuum pump/tubing at dipstick or oil fill
- Sump reservoir or drain
Recommended Sampling Methods

- QSS Valve
- Bellow Bottle
- Oil Drain
- Vacuum Pump
Sampling Precautions

- Avoid points where lube flow is restricted or where contaminants and wear debris settle out or are filtered out.
- Sample component while operating or within 30 minutes after shutdown.
- Visually check sampling materials for any contamination before use.
- Containers are shipped clean and should be stored and transported with cleanliness in mind.
- Assure clean technique when using sampling pumps.
ROUTINE TESTING
Routine Industrial Equipment Oil Testing

- **Spectrochemical Analysis**
  - 21 elements including wear metals, contaminants and additives

- **Viscosity and Equivalent ISO grade**
  - Measures a lubricant's resistance to flow

- **Water**
  - Reported in % (non-critical applications)
  - Reported in ppm (sensitive / critical applications)

- **Acid Number (AN) / Base Number (BN)**
  - Lubricant Degradation
  - Service Life

- **ISO Particle Count**
  - System Cleanliness
  - Contamination Control
### Spectrochemical Metals Analysis (ppm)

<table>
<thead>
<tr>
<th>Wear Metals:</th>
<th>Iron (Fe)</th>
<th>Chrome (Cr)</th>
<th>Nickel (Ni)</th>
<th>Aluminum (Al)</th>
<th>Lead (Pb)</th>
<th>Copper (Cu)</th>
<th>Tin (Sn)</th>
<th>Molybdenum (Mo)</th>
<th>Titanium (Ti)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical Sources of Elements</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Atmospheric</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bearings</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Blocks / Housings</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Blowers</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Brakes</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Bushings</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Chain Drives</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Clutches / Discs</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Crankshaft / Camshaft</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cylinder / Liners</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gears</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Impellers</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Oil Pumps</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Pistons</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Rings</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Rods</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Screws</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Shafts</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Spools</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Surface Rust / Oxides</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tubing / Piping</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valves / Valve Train</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vanes</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Wrist Pins</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>
## Spectrochemical Metals Analysis (ppm)

<table>
<thead>
<tr>
<th>Non-Wear Metals:</th>
<th>Silicon (Si)</th>
<th>Sodium (Na)</th>
<th>Boron (B)</th>
<th>Phosphorus (P)</th>
<th>Zinc (Zn)</th>
<th>Calcium (Ca)</th>
<th>Magnesium (Mg)</th>
<th>Molybdenum (Mo)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Typical Sources of Elements</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ADDITIVES:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Anti-Foam</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Anti-Oxidant</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Anti-Wear</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Corrosion Inhibitor</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>- Detergent</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Dispersant</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Extreme Pressure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>- Reserve Alkalinity</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Rust Inhibitor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>- Thickener (Grease)</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td><strong>Atmospheric / Process</strong></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td><strong>Brine / Saltwater</strong></td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td><strong>Coolant Inhibitor</strong></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
VISCOSITY - Measures a lubricants resistance to flow

**VISCOSITY RANGES, 100C (SAE grade and stated limits)**

<table>
<thead>
<tr>
<th>SAE GRADE</th>
<th>LOW @</th>
<th>Min</th>
<th>TYP</th>
<th>Max</th>
<th>+25%</th>
<th>+35%</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>&lt;5.6</td>
<td>5.6</td>
<td>8.8</td>
<td>9.3</td>
<td>11.0</td>
<td>11.9</td>
</tr>
<tr>
<td>30</td>
<td>&lt;9.3</td>
<td>9.3</td>
<td>11.2</td>
<td>12.5</td>
<td>14.0</td>
<td>15.1</td>
</tr>
<tr>
<td>40</td>
<td>&lt;12.5</td>
<td>12.5</td>
<td>14.5</td>
<td>16.3</td>
<td>18.1</td>
<td>19.6</td>
</tr>
<tr>
<td>50</td>
<td>&lt;16.3</td>
<td>16.3</td>
<td>17.8</td>
<td>21.9</td>
<td>22.3</td>
<td>24.0</td>
</tr>
<tr>
<td>60</td>
<td>&lt;21.9</td>
<td>21.9</td>
<td>24.5</td>
<td>26.1</td>
<td>30.6</td>
<td>33.1</td>
</tr>
<tr>
<td>5W30</td>
<td>&lt;9.3</td>
<td>9.3</td>
<td>10.2</td>
<td>12.5</td>
<td>12.8</td>
<td>13.8</td>
</tr>
<tr>
<td>5W40</td>
<td>&lt;12.5</td>
<td>12.5</td>
<td>15.1</td>
<td>16.3</td>
<td>18.9</td>
<td>20.4</td>
</tr>
<tr>
<td>5W50</td>
<td>&lt;16.3</td>
<td>16.3</td>
<td>18.1</td>
<td>21.9</td>
<td>22.6</td>
<td>24.4</td>
</tr>
<tr>
<td>10W30</td>
<td>&lt;9.3</td>
<td>9.3</td>
<td>10.8</td>
<td>12.5</td>
<td>13.5</td>
<td>14.6</td>
</tr>
<tr>
<td>10W40</td>
<td>&lt;12.5</td>
<td>12.5</td>
<td>13.6</td>
<td>16.3</td>
<td>17.0</td>
<td>18.4</td>
</tr>
<tr>
<td>15W40</td>
<td>&lt;12.5</td>
<td>12.5</td>
<td>14.3</td>
<td>16.3</td>
<td>17.9</td>
<td>19.3</td>
</tr>
<tr>
<td>15W50</td>
<td>&lt;16.3</td>
<td>16.3</td>
<td>17.7</td>
<td>21.9</td>
<td>22.1</td>
<td>23.9</td>
</tr>
<tr>
<td>20W50</td>
<td>&lt;16.3</td>
<td>16.3</td>
<td>17.2</td>
<td>21.9</td>
<td>21.5</td>
<td>23.2</td>
</tr>
</tbody>
</table>

(Multigrade min / max extrapolated at 100C only for 30, 40, 50 portion of viscosity)
Water

Presence of Water

✓ Reported in %

✓ Reported in ppm
Base Number

Base Number / BN

Monitors the Reserve Alkalinity of the lubricant
Measured against new oil for % of **depletion**

**Typical causes of BN decrease:**

- Elevated Operating Temperature
- Oxidation / Nitration Acids
- Inadequate Combustion
- High Sulfur Fuels
- Over-Extended Service Time
Acid Number

Acid Number / AN

Monitored for increased level Evaluated against increase above new oil level

Typical Causes AN Increase:

- Elevated operating temperature
- Oxidative degradation
- Additive transformations
- Environmental contamination
- Improper oil type or mixture
- Over-extended service time
PARTICLE COUNT Measures particle size and volume

ISO Particle Count

Particle shadows

Photosensor

Small Particle

Large Particle

Laser source
ISO Cleanliness Code

Total >4µ = 6720
Total >6µ = 432
Total >14µ = 52

ISO CODE: 20/16/13
Data Interpretation

In the Laboratory
Interpretation Objectives

Sample Results / Data Interpretation:

- Classify overall condition and severity
- Monitor & reflect wear and corrosion modes
- Verification of proper lubricant in service
- Degree and Identity of contaminants
- Assess lubricant serviceability
- Assess filtration effectiveness
- Suggest condition causes and reasons
- Recommend diagnostic or corrective actions
- Answer specific questions from customer
Oil Sample Condition Classifications

Sample Status:

**NORMAL:** Lubricant and equipment conditions are acceptable. Continue routine sampling schedule.

**MONITOR:** Noteworthy presence or change; action usually not warranted.

**ABNORMAL:** Atypical results. Consideration, diagnostics and/or corrective action is necessary.

**CRITICAL:** Conditions present which will reduce system life. Immediate corrective action is necessary.
Evaluations Require Data Input...

**Evaluation Considerations:**

- **Individual Equipment Specifics:**
  - Make, Model, Application, and Fluid Capacity
- **Operating Environment & Duty Cycles**
- **Sample Operating Data:**
  - (Unit and Lube Service Times, Oil Added, etc.)
- **Customer Specific Requirements**
- **Customer Notations and Feedback**
- **Historical Trends**
- **Comparison with Similar Equipment.**
What Are My Guidelines / Limits?

Sources For Applied Evaluations:

- Equipment (OEM) Guidelines
- Lubricant Mfg Recommendations
- Customer Specific Requirements
- Legislated Environmental Limits
- Experience
- Historical Data of Similar Equipment

Types Of Applied Limits:

- Set Values - Minimum or Maximum
- Defined Ranges with Severity Assigned
- Trend Analysis for $\pm$ Change
- Combinations of the Above
## Rules / Qualifications

1. **Mfg, Model, Application**
2. **Lubricant Required = ISO 150**
3. **Frequency = 2500 Hours**

<table>
<thead>
<tr>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vis @ 40 C, cSt</strong></td>
<td><strong>Vis @ 40 C, cSt</strong></td>
</tr>
<tr>
<td><strong>- 10% ~ New Oil</strong></td>
<td><strong>+ 15% ~ New Oil</strong></td>
</tr>
<tr>
<td><strong>Abnormal</strong></td>
<td><strong>Abnormal</strong></td>
</tr>
<tr>
<td><strong>Water, ppm</strong></td>
<td><strong>500 (.05+)</strong></td>
</tr>
<tr>
<td><strong>Abnormal</strong></td>
<td><strong>Abnormal</strong></td>
</tr>
<tr>
<td><strong>Silicon, ppm</strong></td>
<td><strong>+ 15 ppm ~ New Oil</strong></td>
</tr>
<tr>
<td><strong>Abnormal</strong></td>
<td><strong>Abnormal</strong></td>
</tr>
<tr>
<td><strong>Chlorine, ppm</strong></td>
<td><strong>1000 maximum</strong></td>
</tr>
<tr>
<td><strong>Hazardous</strong></td>
<td><strong>Hazardous</strong></td>
</tr>
</tbody>
</table>

**Environmental Chlorine, ppm**

1000 maximum

Hazardous
Why Use Trend Analysis?

Compare Set Limits vs. Trend Analysis

1) Two Identical Gearboxes
2) Same Age and Operating Modes
3) Samples Taken at Same Intervals
4) Use Set Limit 100 ppm for Iron
### Set Limit vs. Trend

Evaluate Against 100 ppm Maximum (Iron)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Iron</th>
<th>Set Limit</th>
<th>Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>91</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td>2</td>
<td>98</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td>3</td>
<td>105</td>
<td>Abnormal</td>
<td>Normal</td>
</tr>
</tbody>
</table>
Set Limit vs. Trend

Evaluate Against 100 ppm Maximum (Iron)

<table>
<thead>
<tr>
<th>Sample</th>
<th>Iron</th>
<th>Set Limit</th>
<th>Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>33</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td>2</td>
<td>45</td>
<td>Normal</td>
<td>Normal</td>
</tr>
<tr>
<td>3</td>
<td>96</td>
<td>Normal</td>
<td>Abnormal</td>
</tr>
</tbody>
</table>
Trend Comparison

Iron, ppm

Sample 1 Sample 2 Sample 3

Gearbox 1 Gearbox 2

© - Copyright Bureau Veritas
What Is A PPM?

#1 (standard size)
Steel paper clip
Wt.: 419 mg

1 Liter
ISO 68 Turbine Oil
Sp. gr: 0.866

1 mg/L = 1 ppm

+ 483 ppm Fe
Data Interpretation

When A Change Occurs:

✓ Look for Corresponding Cause or Reason
  - Increased wear: Is dirt or water present?

✓ Look for a Confirming Related Change
  - Increased viscosity: Has oxidation or acid level also increased? Check additives for mixture...

✓ Look for Identifying Components
  - Water + Na (Sodium) + Mg (Magnesium) = Brine
  - Water + Na (Sodium) + B (boron) or K (Potassium) = Cooling System Leak
RESAMPLE!

1. Confirm Analysis Results
2. Ensure Component Identification
3. Ensure Representative Sample
## The Abnormal Report

### Analysis Report

#### UNIT INFORMATION

<table>
<thead>
<tr>
<th>Unit ID</th>
<th>LINE 27 EXTRUDER</th>
<th>Unit Worksite</th>
<th>PLANT SI</th>
<th>Component Type</th>
<th>GEARBOX</th>
<th>Component Serial Number</th>
<th>CD-053</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit Manufacturer and Model</td>
<td>Davis Standard 60IN60 TPI</td>
<td>Oil Type</td>
<td>SHELL TELLUS ISO 320</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Component Manufacturer and Model</td>
<td>Davis Standard 60IN60 TPI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Maintenance Recommendations

**From:** Shaw Industries - Plant SI, PLANT SI  
**Reported On:** Mar 24 2016

**ANALYSIS INDICATES ABNORMAL CONDITIONS!** PARTICLE COUNT level(s) are HIGH. PERFORM system filtration per manufacturer's guidelines. NOTED ELEMENTS are generally associated with: Gear or bearing wear. RESAMPLE at 1/2 normal interval.

### SPECTROCHEMICAL ANALYSIS IN PARTS PER MILLION

<table>
<thead>
<tr>
<th>LAB NO</th>
<th>Zn</th>
<th>Mg</th>
<th>Si</th>
<th>Ti</th>
<th>Al</th>
<th>Cr</th>
<th>Mn</th>
<th>Fe</th>
<th>Ni</th>
<th>Cu</th>
<th>P</th>
<th>Cl</th>
<th>Br</th>
<th>S</th>
<th>P</th>
<th>Mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>1858</td>
<td>28</td>
<td></td>
<td>1</td>
<td></td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>&lt;1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1474</td>
<td>25</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>1</td>
<td>&lt;1</td>
<td>1</td>
<td>&lt;1</td>
<td>1</td>
<td>&lt;1</td>
<td>1</td>
<td>1</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1311</td>
<td>29</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>1</td>
<td>&lt;1</td>
<td>1</td>
<td>&lt;1</td>
<td>1</td>
<td>&lt;1</td>
<td>1</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>1</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
<tr>
<td>607</td>
<td>24</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>1</td>
<td>1</td>
<td>&lt;1</td>
<td>2</td>
<td>1</td>
<td>&lt;1</td>
<td>1</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>1</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
<tr>
<td>6026</td>
<td>17</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>1</td>
<td>1</td>
<td>&lt;1</td>
<td>2</td>
<td>1</td>
<td>&lt;1</td>
<td>1</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>1</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
<tr>
<td>25070</td>
<td>5</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>1</td>
<td>1</td>
<td>&lt;1</td>
<td>2</td>
<td>1</td>
<td>&lt;1</td>
<td>1</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>1</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
</tbody>
</table>

### SAMPLE INFORMATION

| LAB NO | MFR Date | MFR Blend | Oil Type | GEARBOX | GEARBOX | GEARBOX | GEARBOX | GEARBOX | GEARBOX | GEARBOX | GEARBOX | GEARBOX | GEARBOX | GEARBOX | GEARBOX |
|--------|----------|-----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| 1858   | 15/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 |
| 1474   | 15/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 |
| 1211   | 15/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 |
| 607    | 15/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 |
| 6026   | 15/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 |
| 25070  | 15/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 | 14/07/14 |

#### PHYSICAL TEST RESULTS

<table>
<thead>
<tr>
<th>LAB NO</th>
<th>Water [ppm]</th>
<th>Viscosity @50°C</th>
<th>TAN</th>
<th>Particles 4μm</th>
<th>Particles 1μm</th>
<th>Particles 0.8μm</th>
<th>Particles 0.6μm</th>
<th>Particles 0.4μm</th>
<th>Particles 0.2μm</th>
<th>ISO Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>1858</td>
<td>35</td>
<td>143.0</td>
<td>0.87</td>
<td>3290</td>
<td>837</td>
<td>80</td>
<td>52</td>
<td>20</td>
<td>3</td>
<td>131171413</td>
</tr>
<tr>
<td>1474</td>
<td>59</td>
<td>142.0</td>
<td>0.50</td>
<td>36771</td>
<td>758</td>
<td>26</td>
<td>0</td>
<td>&lt;1</td>
<td>131171413</td>
<td></td>
</tr>
<tr>
<td>1211</td>
<td>30</td>
<td>151.0</td>
<td>0.50</td>
<td>17416</td>
<td>1832</td>
<td>85</td>
<td>20</td>
<td>5</td>
<td>1</td>
<td>20131713</td>
</tr>
<tr>
<td>607</td>
<td>28</td>
<td>153.0</td>
<td>0.45</td>
<td>16945</td>
<td>1188</td>
<td>68</td>
<td>15</td>
<td>4</td>
<td>1</td>
<td>2011713</td>
</tr>
<tr>
<td>6026</td>
<td>31</td>
<td>147.0</td>
<td>0.73</td>
<td>18012</td>
<td>4539</td>
<td>16</td>
<td>4</td>
<td>&lt;1</td>
<td>2111715</td>
<td></td>
</tr>
<tr>
<td>25070</td>
<td>41</td>
<td>152.8</td>
<td>0.34</td>
<td>15720</td>
<td>1021</td>
<td>23</td>
<td>0</td>
<td>1</td>
<td>&lt;1</td>
<td>2111712</td>
</tr>
</tbody>
</table>
Machine Condition Monitoring Through Oil Analysis

Questions ?