Basics of Oil Condition Monitoring Through Oil Analysis

Vibration Institute

INTERNATIONAL REPRESENTATIVE

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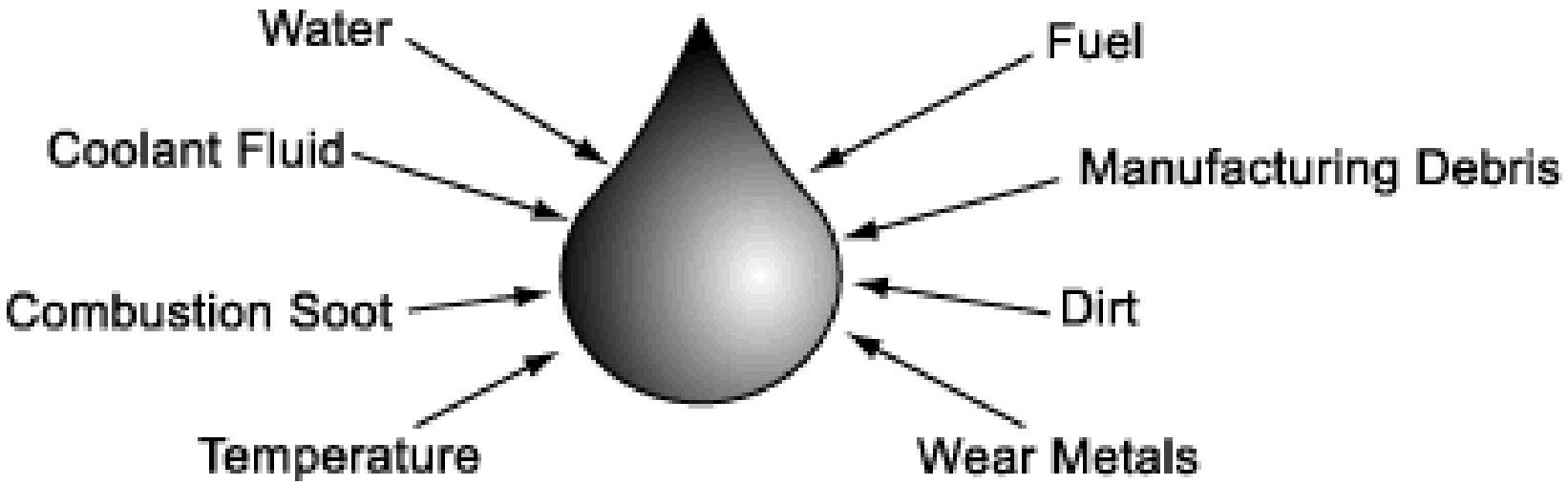
What is Oil Analysis

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!



Analysts' Testing Capabilities

DIESEL FUELS

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

GREASES

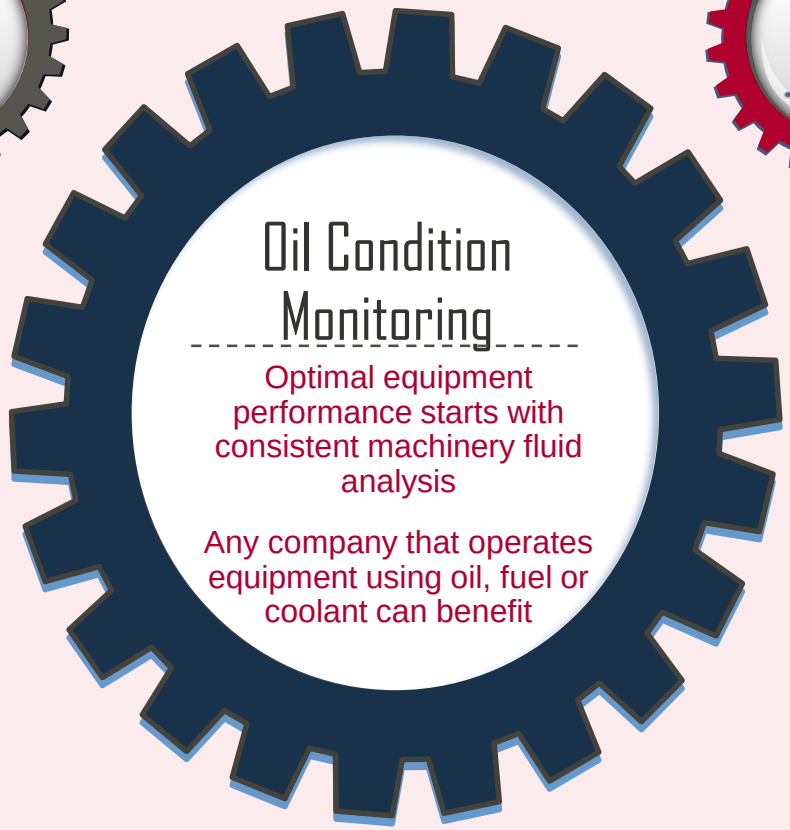
Grease testing can evaluate wear, consistency, contamination and oxidation in grease lubricated systems

COOLANTS

Coolant analysis takes the guesswork out of cooling system maintenance

MWF's

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



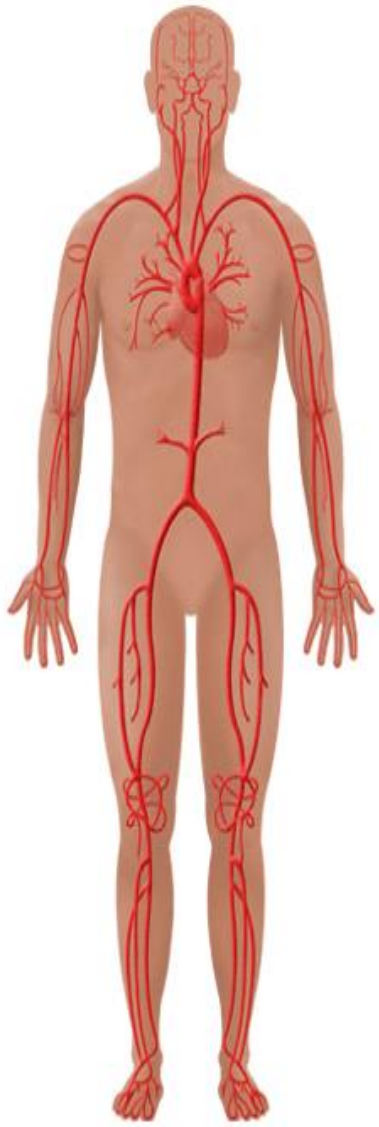
LUBE OILS

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

DEF's

Ensure SCR systems operate efficiently with DEF Testing

What your doctor needs



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:

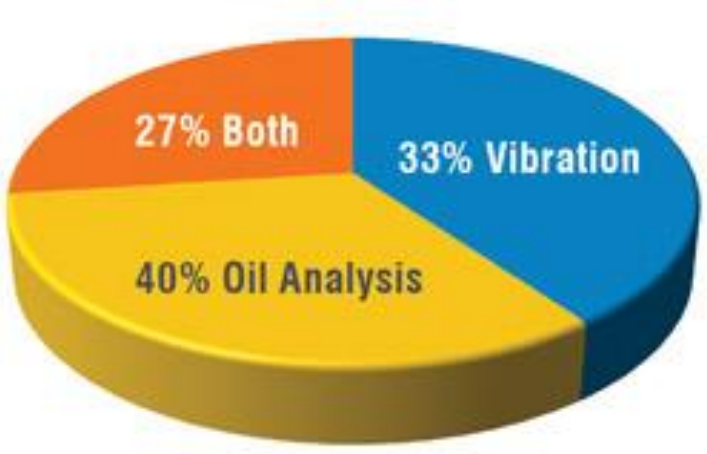
- Recognize How Well Equipment Components are Operating
- Distinguish Different Causes of Wear
- Diagnose Fluid Degradation
- Identify RISKS for Known Conditions
- Confirm if Corrective Maintenance Actions are Working

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

- ✓ Machine Mfg/Model
- ✓ Component Type
- ✓ Oil Type
- ✓ Symptoms
- ✓ Hours on Machine & Oil

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



Bearing fault detection of early bearing failure (750 machines)

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.

Oil Sampling Program Goals & Objectives

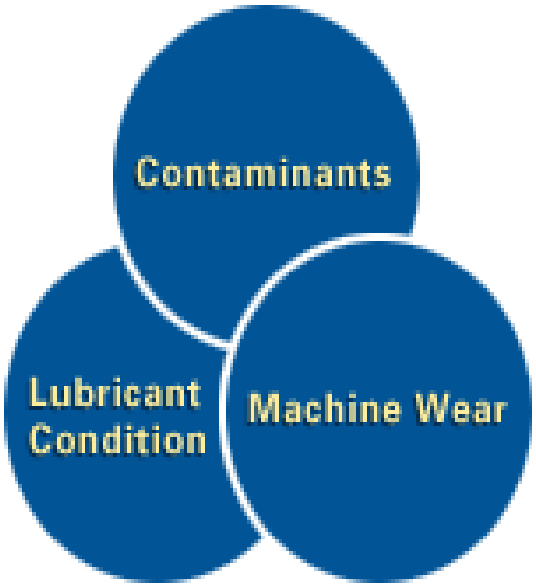
Oil Analysis GOALS

- 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



Equipment Selection

SELECTING EQUIPMENT

- Start Small
  - Based on Equipment Criticality
- Sample Frequently
  - Monthly / Quarterly
- Review and Act on Reports
- Expand Program to Additional Equipment

Equipment Information

CRUCIAL INFORMATION

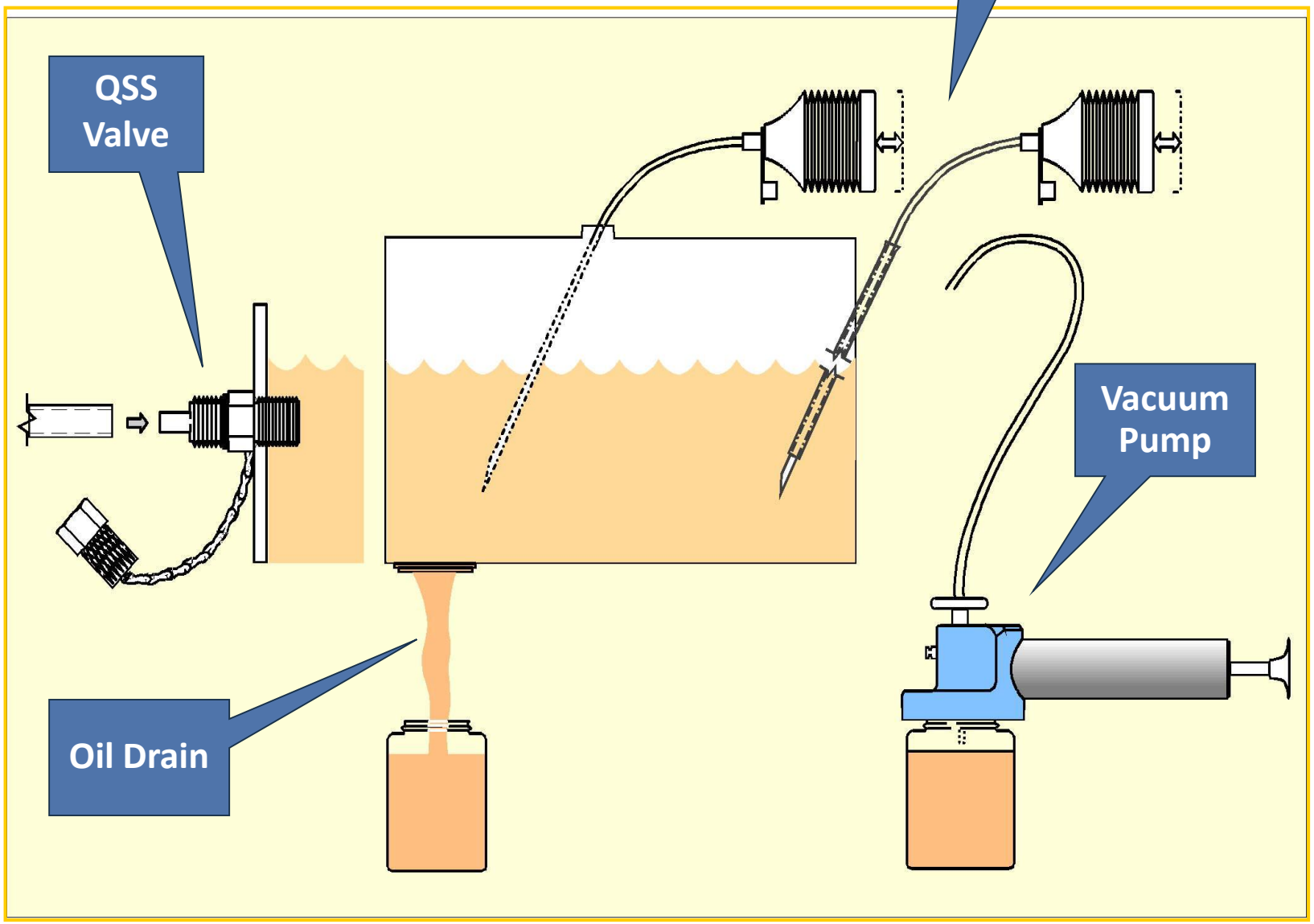
- Unit / Compartment ID
- Mfg. Make & Model
- Oil Information
  - Manufacturer
  - Brand
  - ISO Grade
- Equipment Type / Application
- Feedback
- Service Hours
  - Equipment & Oil

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



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, contaminates and additives
- **Viscosity and Equivalent ISO grade**
  - ✓ Measures a lubricants 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)

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

Spectrochemical Metals Analysis (ppm)

Non-Wear Metals: Typical Sources of Elements	Silicon (Si)	Sodium (Na)	Boron (B)	Phosphorus (p)	Zinc (Zn)	Calcium (Ca)	Magnesium (Mg)	Molybdenum (Mo)
ADDITIVES:								
- Anti-Foam	✓							
- Anti-Oxidant			✓		✓			
- Anti-Wear			✓	✓	✓	✓	✓	✓
- Corrosion Inhibitor		✓		✓	✓	✓	✓	✓
- Detergent			✓	✓		✓	✓	
- Dispersant			✓			✓	✓	
- Extreme Pressure								✓
- Reserve Alkalinity						✓	✓	
- Rust Inhibitor		✓				✓	✓	
- Thickener (Grease)	✓	✓						
Atmospheric / Process	✓	✓	✓	✓		✓	✓	
Brine / Saltwater	✓	✓				✓	✓	
Coolant Inhibitor	✓	✓	✓	✓				✓

VISCOSITY - Measures a lubricants resistance to flow

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

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

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

Presence of Water

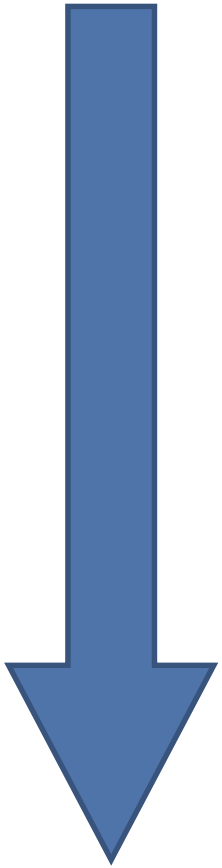
- ✓ Reported in %
- ✓ Reported in ppm

Base Number

Base Number / BN

Monitors the Reserve Alkalinity of the lubricant

Measured against new oil for % of **depletion**



Typical causes of BN decrease:

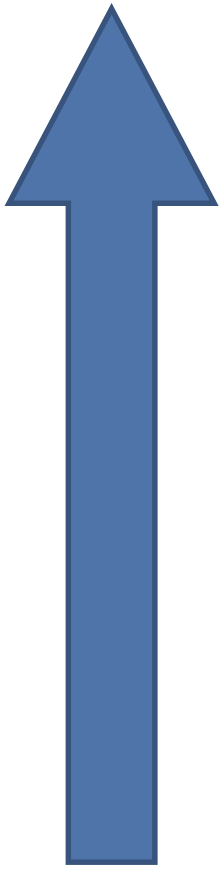
- Elevated Operating Temperature
- Oxidation / Nitration Acids
- Inadequate Combustion
- High Sulfur Fuels
- Over-Extended Service Time

Acid Number / AN

Monitored for increased level Evaluated against increase above new oil level

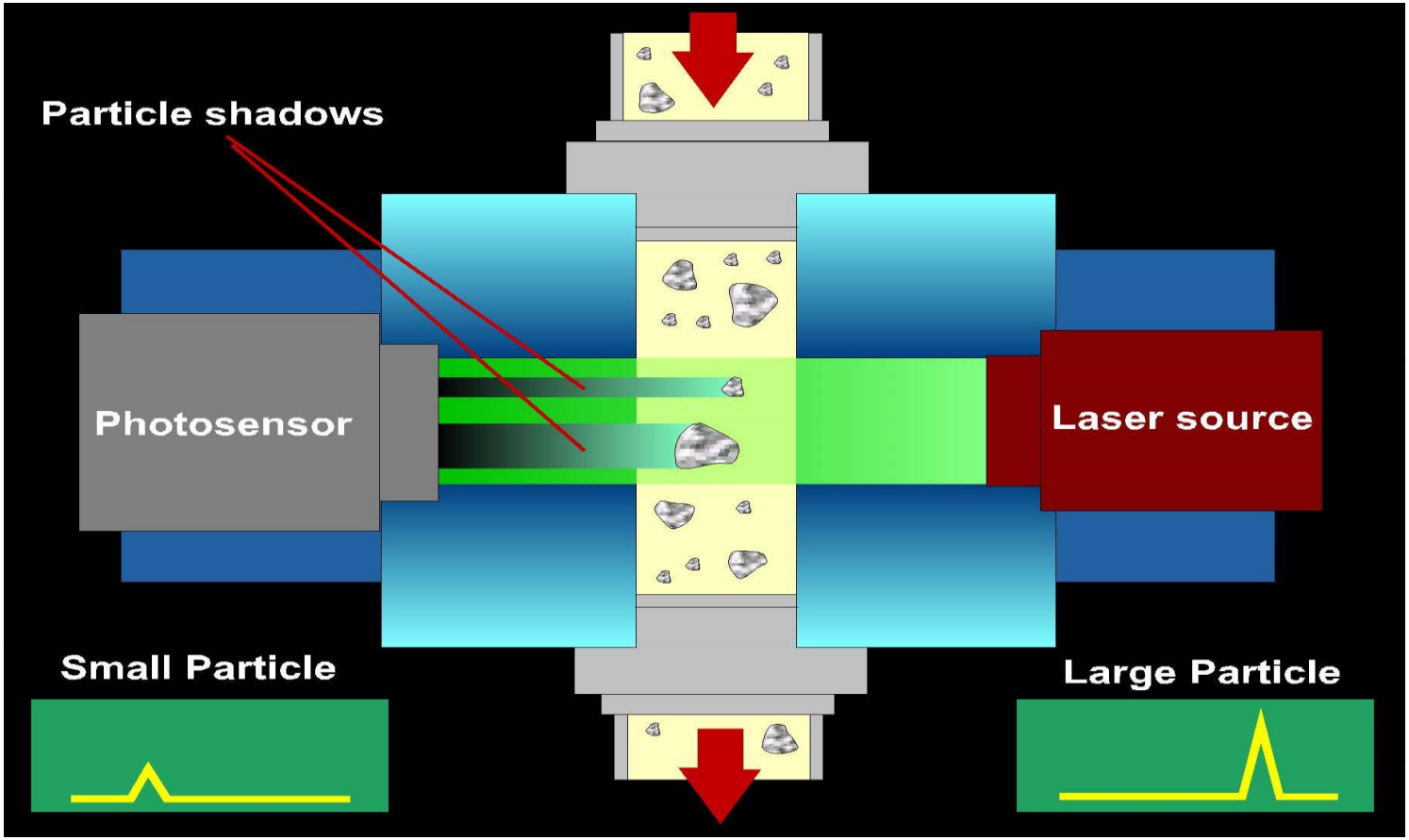
Typical Causes AN Increase:

- Elevated operating temperature
- Oxidative degradation
- Additive transformations
- Environmental contamination
- Improper oil type or mixture
- Over-extended service time



ISO Particle Count

PARTICLE COUNT Measures particle size and volume



ISO Cleanliness Code

Total >4µ = 6720

Total >6µ = 432

Total >14µ = 52

ISO CODE: 20/16/13

ISO 4406 - Number of particles per ml		
More than	Up to & Including	ISO Number
2,500,000	-	>28
1,300,000	2,500,000	28
640,000	1,300,000	27
320,000	640,000	26
160,000	320,000	25
80,000	160,000	24
40,000	80,000	23
20,000	40,000	22
10,000	20,000	21
5,000	10,000	20
2,500	5,000	19
1,300	2,500	18
640	1,300	17
320	640	16
160	320	15
80	160	14
40	80	13
20	40	12
10	20	11
5	10	10
2.5	5	9
1.3	2.5	8
0.64	1.3	7
0.32	0.64	6
0.16	0.32	5
0.08	0.16	4
0.04	0.08	3
0.02	0.04	2
0.01	0.02	1
0.00	0.01	0

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 ± Change
- ✓ Combinations of the Above

Set Value Limits

Rules / Qualifications

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

Minimum	**Vis @ 40 C, cSt**	**- 10% ~ New Oil**	**Abnormal**
Maximum	**Vis @ 40 C, cSt**	**+ 15% ~ New Oil**	**Abnormal**
Maximum	**Water, ppm**	**500 (.05+)**	**Abnormal**
Maximum	**Silicon, ppm**	**+ 15 ppm ~ New Oil**	**Abnormal**
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)

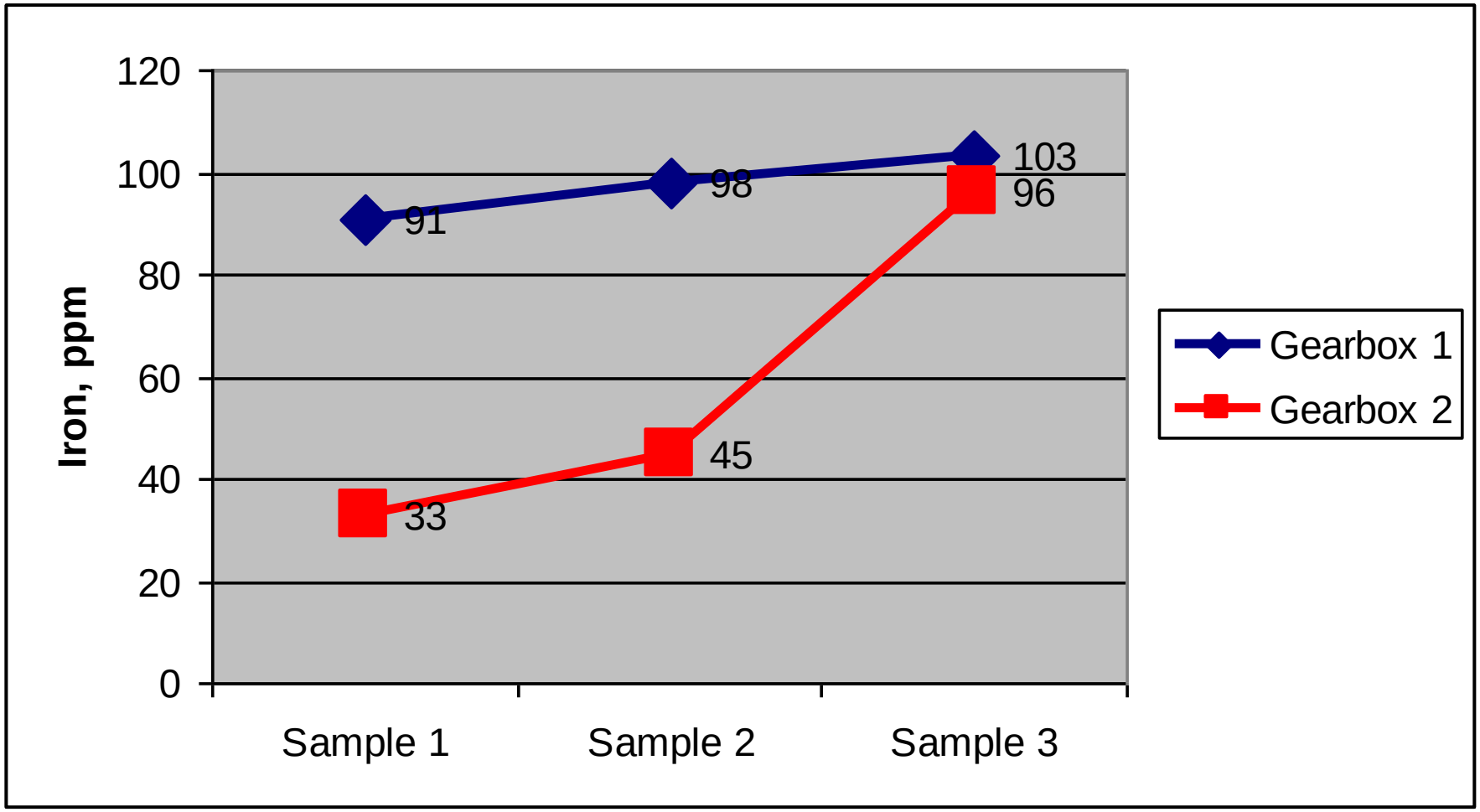
Gearbox Number 1			
Sample	**Iron**	**Set Limit**	**Trend**
1	91	Normal	Normal
2	98	Normal	Normal
3	105	Abnormal	Normal

Set Limit vs. Trend

Evaluate Against 100 ppm Maximum (Iron)

Gearbox Number 2			
Sample	**Iron**	**Set Limit**	**Trend**
1	33	Normal	Normal
2	45	Normal	Normal
3	96	Normal	Abnormal

Trend Comparison



What Is A PPM?

#1 (standard size)

Steel paper clip

Wt.: 419 mg

+

1 mg/L = 1ppm

1 Liter

ISO 68 Turbine Oil

Sp. gr: 0.866

= **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

Major Change Without a Corresponding Reason…

RESAMPLE !

1. Confirm Analysis Results
2. Ensure Component Identification
3. Ensure Representative Sample

The Abnormal Report

ANALYSTS, INC.
A Bureau Veritas Group Company

Analysis Report

Status: ABNORMAL on Mar 16 2016

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Phone: 800-241-6315

Analysts, Inc.
Marian Kiley
3385 Martin Farm Rd -
Suwanee, GA, 30024

Unit ID: **LINE 27 EXTRUDER** Unit Worksite: **PLANT SI** Comp. Ref NO.: **4393104**

Component Type: **GEARBOX** Component: **GEARBOX**

Unit Manufacturer and Model: **Davis Standard 60IN60 TPI** Oil Type: **SHELL TELLUS ISO 320**

Component Manufacturer and Model: **Davis Standard 60IN60TPI** Component Serial Number: **CD-053**

Maintenance Recommendations for Lab No. 201603221898 Reported On: **Mar 24 2016**

From: **Shaw Industries - Plant SI, PLANT SI**

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

LAB NO.	Iron	Chromium	Nickel	Aluminum	Lead	Copper	Tin	Silver	Titanium	Silicon	Boron	Sodium	Potassium	Molybdenum	Phosphorus	Zinc	Calcium	Barium	Magnesium	Antimony	Vanadium	Sample Drawn
1898	28 *	1	2	1	<1	27 *	1	<0.1	1	2	2	2	2	1	250	7	1	1	1	1	1	03/16/16
1474	25	<1	<1	<1	<1	25	<1	<0.1	<1	2	<1	1	1	<1	232	4	<1	<1	<1	<1	<1	-
1311	29	<1	<1	<1	<1	27	<1	<0.1	<1	2	<1	1	<10	<5	276	19	<10	<10	<1	<30	<1	-
0687	24	<1	<1	1	1	26	2	<0.1	<1	2	1	1	<10	<5	262	15	<10	<10	<1	<30	<1	12/02/13
0026	17	<1	<1	1	1	23	<1	0.1	<1	1	2	2	<10	<5	265	14	<10	<10	<1	<30	<1	10/16/12
2970	5	<1	<1	2	1	15	1	<0.1	<1	2	1	1	<10	<5	258	8	<10	<10	<1	<30	<1	09/21/11

SAMPLE INFORMATION

LAB NO.	MI/HR Unit	MI/HR Oil	Oil Add	FLTR CHG	Oil CHG
1898	0	0	0	No	S
1474	0	0	0	-	
1311	0	0	0	-	
0687	0	0	0	-	
0026				-	
2970	1	1		Yes	Y

PHYSICAL TEST RESULTS

LAB NO.	Water(KF)	Viscosity 40 °C	TAN	Particles >4µm	Particles >6µm	Particles >14µm	Particles >21µm	Particles >38µm	Particles >70µm	ISO Code
1898	35	143.0	0.67	3290	937	90	20	2	<1	19/17/14 *
1474	59	142.0	0.39	3571	578	26	6	<1	<1	19/16/12 *
1311	38	151.0	0.56	7415	1532	96	20	1	<1	20/18/14 *
0687	28	153.0	0.45	6915	1186	66	15	4	<1	20/17/13
0026	31	147.9	0.73	18012	4539	167	28	4	<1	21/19/15
2970	41	152.8	0.34	15729	1021	23	6	1	<1	21/17/12

Machine Condition Monitoring Through Oil Analysis

Questions ?

Vibration Institute
INTERNATIONAL REPRESENTATIVE