CONDITION REPORT GUIDE

Extending the life and productivity of your equipment

ORBITAL

Orbital combines the concept of the Journey of the Lubricant, oil sampling data, peripheral equipment, and environmental information to provide you with the most comprehensive oil analysis program. Orbital allows you to compare, combine, analyze, and report on all data points surrounding the health of your equipment and lubricant. Welcome to the new era of oil analysis...**Oil Intelligence.**

TRICO O

LUBRICOLOGY N

CONDITION REPORT

IMMEDIATE ACTION REQUIRED C

XYZ Manufacturing

A Pewaukee, WI

Change Oil B

NAME: XYZ Manufacturing
DESCRIPTION: CRANE BRIDGE NORTH
LUBRICANT: Mobil Teresstic ISO 220 D
RESERV CAP: 2-5 Gallons
LUBE TIME: Not Provided
SPID #: 355786 P
COMPONENT: Gearbox
E

SAMPLE DATE: 10/04/2019 G
TEST SUITE: H002T
H CNTL#: 5322467
BATCH #: T191010-014

AREAS OF CONCERN F

particle
Si 14 Silicon
silicon

Analyst Summary: Q

Data of Concern:

- The iron concentration is higher than expected. This indicates that equipment wear is taking place.
- Silicon is present in higher than expected quantities. Silicon is related to dirt and dust ingression.
- The high particle count is reflective of the two above concerns - the oil is unclean.

Actions Needed:

- The oil should be filtered in order to remove the contamination and wear particles.
- This equipment is equipped only with an OEM vent which may be the source of ingression. Consider alternative methods for closing this system off.
- Continue sampling quarterly to monitor the wear rate of this equipment.

Customer Comments: J

On 10/15/2019 filtered oil to remove contamination and installed a desiccant breather on the system.

REPORT RATINGS:

I					K			L			
Sample Date	02/11/2019	04/02/2019	07/19/2019	10/04/2019		02/08/2019		LIMITS			
Ratings	Critical	Critical	Critical	Critical	Reference Transfer	Reference Storage	Reference Arrival	Upper Alert	Upper Alarm	Lower Alert	Lower Alarm
VISCOSITY (ASTM D445)											
M Viscosity 40C (cSt)	215.71	217.11	216.68	212		**220**			264.00		187.00
PHYSICAL/CHEMICAL PROPERTIES:											
Acid Number (ASTM D664)											
TAN (mg KOH)	0.08	0.02	0.00	0.05		**0.06**					
FT-IR (ASTM E2412)											
Anti-Wear (abs)	12	12	12	12		**12**					
Glycol (FTIR) (abs)	1	1	1	1		**1**					
Hydroxide (abs)	10	10	8	7		**7**					
Nitration (abs)	3	3	4	4		**4**					
Oxidation (abs)	4	4	5	4		**5**					
Sulfur (abs)	12	13	14	13		**13**					
Karl Fischer (ASTM D6304)											
Karl Fischer % (%)	0.00	0.00	0.03	0.01		**0.00**		0.05	0.2		
Karl Fischer (ppm)	51.6	22	260.6	85.8		**13.8**		500	2000		

REC'D DATE: 10/08/2019 G REPORT DATE: 10/10/2019 H ANALYST: Smith

A **Customer Name, City, State, Facility/Area**

B **Next Steps Icons:** These icons are meant to provide at-a-glance next steps in order to help you to maintain your equipment.

- **Bleed and Feed:** It is recommended that a portion of the lubricant be replaced with fresh lubricant in order to improve the chemical properties of the oil. This is also sometimes referred to as “sweetening” the oil.
- **Oil Change:** The lubricant is no longer viable and must be replaced. A high-velocity flush is recommended as a part of this maintenance action.
- **Check Bearings:** An inspection of the bearings on this equipment is recommended at the next possible opportunity.
- **Equipment Concern:** Maintenance is warranted for this equipment.
- **Filtration:** Filtration of this lubricant is recommended. If an on-line filter is already present, then it is recommended that it be checked for bypass mode, or a smaller micron size/better quality filter be used.
- **Information Needed:** More information is needed about this sample in order to provide an appropriate maintenance action. Please use the online customer portal to complete the information requested by the analysts.
- **No Action Needed:** No action needs to be taken at this time.
- **Reference Sample Needed:** Please supply a 4 ounce bottle of unused lubricant for this equipment to be used as a baseline reference for this sample.
- **Resample:** Another sample from the same equipment is requested in order to confirm the test results.
- **Dehydrate:** Water removal via vacuum dehydration or coalescent filter is recommended.
- **Equipment Inspection:** The data shows that components are wearing significantly or abnormally and inspection of this equipment is warranted.
- **Purge Grease:** The analyst has determined that the grease in use is no longer viable and should be purged from he component and refilled.
- **More Frequent Sampling Needed:** Developing patterns and trends with regular sampling frequency, either monthly or quarterly, is the most powerful way to see problems with your equipment through oil analysis.
- **Eliminate Water Source:** The source of water must be determined and eliminated. Possible points of water ingression include leaking seals and open vents.
- **Check Seals:** An inspection of the seals on this equipment is recommended at the next possible opportunity.
- **Purge Grease:** The analyst has determined that the grease in use is no longer viable and should be purged from he component and refilled.
- **Maintenance Activity:** Data indicates maintenance activity was performed on equipment. Please confirm.
- **Consider/Request WPA:** Wear metals have been detected in this equipment and further testing is required to pinpoint the severity and source of the concern.
- **Check Label:** Please check label as the incorrect label is used, no label on sample is provided, or more information is needed on the label about this sample.
- **Continue Regular Sampling:** Continue with regular oil sampling frequency for data trending and diagnostics.
- **Install Sampling Ports:** For consistent and representative oil analysis install sampling ports in the appropriate areas.
- **Contact:** Please contact Trico regarding your oil analysis results at 262.691.9336.
- **Reference Not Suitable:** Please supply a new 4 ounce bottle of unused lubricant for this equipment as current reference sample is not suitable.
- **Verify Lubricant:** The lubricant provided does not represent the information on file. Please verify lubricant.
- **Remove Contaminants:** High levels of contaminants are present in lubricant. It is recommended to remove them with the appropriate method.
- **Increase Sample Volume:** Too low of sample volume provided. Please supply a full 4 ounce bottle of oil sample for oil analysis.
- **Thermography/Vibration:** The data shows that the components are wearing and inspection of this equipment is warranted with Thermography/Vibration.

C **Timeframe for Action Recommendation:** This part of the report is designed to help you understand the urgency of the rating and is tied to the criticality rating of the report.

D **Equipment and Lubricant Information**

E **Component Image:** This image shows the equipment type described in the report and is identical to the image that is used for identification on the Orbital Portal.

Bearing/Bearing Housing	Compressor
Engine	Fan
Gearbox	Hydraulic Component
Pump	Reference Sample
Reservoir/Sump	Transformer
Transmission	Turbine/Generator
Unknown	

F **Areas of Concern:** These images are designed to allow you to determine the major equipment issues at-a-glance.

Acid Number Concern	Base Number Concern
Biological Contamination	Foam
Oxidation	High Particulate Contamination
High Soot	Change in Viscosity
High Water Contamination	Elements of Concern*
Color	Varnish
Coolant	Fuel Contamination
Chemistry	

See page 8 for more detail regarding sources of these elements.

G **Sample Tracking Information:**

Sample Date – Date sample was taken from equipment
Received Date – Date sample was delivered to Trico
Report Date – Date analysis was completed

H **Machine Condition Analyst Report Identification Codes:**

SPID # – Sample point identification number for all samples from this equipment.
CNTL # – Identification number for this sample for this SPID.
Analyst – Machine Condition Analyst's name.
Batch # – Specific number assigned to a group of samples for processing.

I **Report Ratings:** Date of sample and sample rating determined by the analyst. Condition ratings are one of four levels:

1. Normal – Both the lubricant and the equipment are within acceptable limits.
2. Caution – A condition of the lubricant or equipment is abnormal, but not yet to a level of concern.
3. Serious – One or more conditions of the lubricant or equipment is beyond acceptable limits.
4. Critical – One or more conditions of the lubricant or equipment is well beyond acceptable limits, at this point either the lubricant or equipment is compromised.

J **Customer Comments:** Area designated for comments entered by the customer.

K **Lubricant Reference Table:** These columns show the test values for a new lubricant as provided by customer from three distinct stages of The Journey of the Lubricant®; Arrival, Storage, and Transfer. The sample date, physical/chemical properties and trace elements are displayed. New, unused oil references should be submitted once a year in order to maintain a proper baseline for comparison.

L **Limits:** Low-end or high-end range limits are set by industry standards but can also be adjusted based on your internal standards for cleanliness or OEM requirements. A lubrication program advisor can meet with you to discuss any limit setting and changes you would like to see on your account. Limits that are out of the specified range are shaded based on the significance of the change to make it easier to see where issues are occurring in your equipment.

ALERT – When a test moves beyond this first limit only the test result will be shaded YELLOW. These are designed to indicate a possible problematic condition.

ALARM –This is the second set of limit values that is designed to indicated that a significant change has occurred. Any result that is beyond this limit will be shaded RED.

M **Data:** Test result values of the current and previous samples. Results include physical and chemical properties, particulates, and trace elements.

N **Lubricology:** Direct link to article resource that provides valuable insights, experiences and practical approach to lubrication (www.lubricology.com).

O **Trico Logo:** Direct link to Trico's website (www.tricocorp.com).

P **Enterprise Dashboard Link**: Clicking on the graph icon provides a direct link to the Enterprise Dashboard.

Q **Analyst Summary:** Provides a meaningful, clear summation of the numerical data along with the best course of action to address any concerns demonstrated in the test results.

TRACE ELEMENTS (ASTM 5185) ®

Equipment	Iron (ppm)		141	138	136		**0**		100	300		
	Chromium (ppm)		1	1	1		**0**		4	15		
	Aluminum (ppm)		9	7	8		**0**		10	30		
	Copper (ppm)		1	1	1		**0**		30	80		
	Lead (ppm)		1	1	2		**1**		30	80		
	Tin (ppm)		1	0	0		**1**					
	Silver (ppm)		0	0	0		**0**					
	Nickel (ppm)		0	0	0		**0**					
Contaminants	Silicon (ppm)		35	28	28		**1**		20	60		
	Sodium (ppm)		3	3	1		**0**		30	80		
	Potassium (ppm)		3	4	2		**1**					
	Boron (ppm)		0	0	0		**0**					
Additives	Molybdenum (ppm)		1	1	1		**0**					
	Magnesium (ppm)		4	2	3		**0**					
	Calcium (ppm)		52	36	39		**2**					
	Barium (ppm)		0	0	0		**0**					
	Phosphorus (ppm)		5	3	4		**3**					
	Zinc (ppm)		4	3	4		**2**					
Other	Vanadium (ppm)		0	0	0		**0**					
	Titanium (ppm)		1	1	1		**0**					

® **Trace Elements:** Trace Elements results are obtained by Inductively Coupled Plasma (ICP) Spectroscopy and are reported in parts per million (ppm) for the lubricant and wear particles ranging in size up to approximately 5-8 microns.

Please see page 8 for a detailed description of each element.

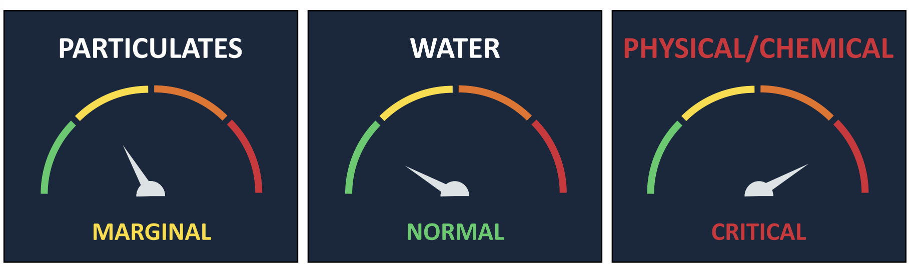
Orbital Trending and Diagnostics

Orbital...where oil analysis ends, and oil intelligence begins.

Orbital allows you to compare variables across your process including environment, practices, and equipment setups to identify the factors compromising your oil's condition and equipment's performance.

Doing dimensional sampling at predefined locations across your oil's journey and paired with mobile application data input provides you variable filters within Orbital to evaluate and pinpoint where and what is having the greatest impact on your program. You’re able to evaluate sample results from equipment inside compared to outside, by equipment or lubricant type, or by sample methods and locations creating clarity about where to focus initiatives to address your greatest problems.

It's not just oil analysis anymore; it's oil intelligence.



Orbital helps you see the commonality between small and vast amounts of information.

CORRELATION

See the relationship between data using factors such as environment, your practices, equipment type, and lubricant type.

VISUALIZATION

The data is displayed in simple visual formats such as charts, graphics, and tables for ease of analysis and interpretation.

ANALYSIS

Provides the capability to categorize, manipulate, and summarize data to find trends and relationships.

INTERPRETATION

Allows you to see the meaning of your data to make the necessary decisions needed for action.

DETECT
Problem areas

ANALYZE
Deviations from the norm

DIAGNOSE
Issues and risks

ACT
With insights to make decisions

PHYSICAL PROPERTIES

FT-IR (Fourier Transform Infrared) – Infrared (invisible) light is absorbed at different wavelengths by certain molecules. The Fourier Transform then measures the amounts of absorbed light to determine which chemicals are present in the lubricant. The amount of light absorbed can indicate the relative amount of a substance present in the lubricant. This test functions best when a baseline of comparison is present, therefore an up-to-date unused portion of lubricant should be submitted once a year.

Hydroxides – One of the groups that is picked up by the FT-IR is a hydroxyl group. This group is commonly found in water so this band is typically reported as such. However, many other substances (such as peroxides or carboxylic acids) share this hydroxyl group, so it is possible to see this represented when no water is detected by the Karl Fischer or the crackle test.

Oxidation – Oxidation indicates the amount of oxygen-containing compounds present in the sample. As a lubricant ages, the amount of oxidation increases. Eventually this compromises the oil and indicates that it needs to be changed. If oxidation levels continue to be elevated sludge, varnish, and lacquer deposits are all possible consequences.

Nitration – Nitration by-products are formed by the combustion of fuel and air during normal operation or as a result of abnormal “blowby” past compression rings on an engine. The by-products are highly acidic, create deposits, and accelerate the oxidation process.

Sulfates – Indicates the amount of metal sulfates that are present within the lubricant above the amount normally found in an unused lubricant sample. Metal sulfates are typically additives used in the design of oxidation inhibitors and detergents. Excessive levels of sulfates can lead to combustion chamber deposits and top ring wear (internal combustion engines).

Fuel – Any presence of solvents, i.e. fuel dilution, in a lubricant seriously reduces the lubricant’s effectiveness. The resulting decrease in viscosity can lead to decreased lubricant film strength, adding to the risk of abnormal wear.

Insolubles – Measurement of the excess amount of carbon and solid-like particles within the lubricant. Normal operating range is determined by trend.

AN (Acid Number) /BN (Base Number) – Titration test measuring the acidity or alkalinity of the lubricant. The acid number reflects the amount of a basic substance (Potassium hydroxide or KOH) that is needed to neutralize the sample. While the base number is the equivalent amount of potassium hydroxide (KOH) that would be neutralized by the amount of hydrochloric acid that was used to neutralize the sample. This number is affected by additive depletion, lubricant oxidation, and/or acidic contamination. The acid number test is best when used as a trending tool and is an essential test in order to determine lubricant health. The base number is the amount of reserve alkalinity that is left in the lubricant and is an essential test for engine oils. As an engine runs acidic byproducts are created and the reserve alkalinity is necessary to protect the equipment from the corrosive acids. This test functions best when a baseline of comparison is present, therefore an up-to-date unused portion of lubricant should be submitted once a year.

Wear Particle Concentration (WPC) – WPC indicates the relative amount of all magnetic particles present in the sample 0.1 to 300+ microns in size. Magnitude of the WPC is important, but the trend of values is the indicator of machine wear condition. This is a trending mechanism and not a particle count. WPC = DL + DS

Density Large (DL) – The trend data read from the “large” channel representing the trend of magnetic particles >5 microns in maximum dimension. This value is not a particle count.

Density Small (DS) – The trend data read from the “small” channel representing the trend of magnetic particles <3 microns. This value is not a particle count.

TRACE ELEMENTS

These results are obtained by Inductively Coupled Plasma (ICP) Spectroscopy and are reported in parts per million (ppm) for the lubricant and wear particles ranging in size up to approximately 5-8 microns. Below is a brief description of the elements and their importance to the equipment and lubricant.

Iron – Indicates steel or iron wear originating from rings, shafts, gears, bearings, valve trains, cylinder walls and pistons in some engines. Will be called out in wear particle analysis as ferrous wear particles.

Chromium – Commonly just called "chrome" the primary sources are chrome plated parts such as rings, liners, etc. With ferrographic analysis it also be identified as white nonferrous metal.

Aluminum – This element can be a metal and soap complex for greases. It can also be due to the wear of pistons, valves, seals, plain bearing and certain types of bushings. Can also be identified in ferrography as white nonferrous metal.

Copper – Generally seen along with zinc indicating brass or with tin indicating bronze, the presence of this metal can indicate wear from oil slinger rings, screw compressors, bearing retainers, plain and thrust bearings, rocker arm bushings, wrist pin bushings, thrust washers, transmission discs, and clutch plates. Copper has also been historically used as an anti-corrosive additive.

Lead – This is an overlay metal in most bearings. This can also be called out as nonferrous or babbitt metal (with tin).

Tin – This can indicate wear from bearings when babbitt overlays are used. Tin is also an indicator of piston wear in some engines and can be identified as white nonferrous or babbitt metal (with lead).

Silver – This indicates wear of bearings which contain silver alloy. In some instances, a secondary indicator of oil cooler problems, especially when coolant is detected. Identified as white nonferrous metal.

Nickel – This metal is used as a part of many different alloys. It can also be a secondary indicator of wear from certain types of bearings, shafts, valves, and valve guides.

Sodium – This element can be a detergent or EP additive, indicate the presence of a coolant, or show up as contamination from water sources or process materials. An up-to-date baseline in the form of an unused portion of lubricant is needed in order to determine which scenario is more likely.

Silicon – This non-metal element is a common anti-foaming agent but can also be a sign of dirt or dust contamination that can indicated improper intake filtration. An up-to-date baseline sample is needed in the form of an unused portion of lubricant in order to determine which is the more likely scenario as excessive dirt and silicon-based abrasives can greatly accelerate component wear.

Potassium – This element has several sources including a detergent or EP additive, coolant contamination or process contamination. An up-to-date baseline in the form of an unused portion of lubricant is needed in order to determine which scenario is more likely.

Boron – This is a commonly found in oil as a detergent, dispersant, or EP additive.

Molybdenum – This metal can either be part of an alloy especially for piston rings or exist as a friction-modifier additive. An up-to-date baseline in the form of an unused portion of lubricant is needed in order to determine which scenario is more likely.

Magnesium – This element can also come from a variety of sources – as an dispersant or detergent additive or as wear as part of a metal alloy. An up-to-date baseline in the form of an unused portion of lubricant is needed in order to determine which scenario is more likely. This can also be identified as white nonferrous metal with analytical ferrography.

Calcium – Calcium is generally used as a lubricant additive. It can be added as a detergent, dispersant, or an acid neutralizer.

Barium - Barium is generally used as a lubricant additive. It is used as a corrosion inhibitor, detergent, or a rust inhibitor.

Phosphorus – This is one of the most common anti-wear additives in lubricating oil. Its presence can be due ZDDP (zinc dithiophosphate) or a common EP additive in the case of phosphate-ester lubricant.

Zinc – This is also one of the most common anti-wear additives as it is also found in ZDDP (zinc dithiophosphate). Another source of this metal is as wear from copper alloys. An up-to-date baseline in the form of an unused portion of lubricant is needed in order to determine which scenario is more likely.

Vanadium – This is generally an indicator of heavy fuel contamination. It can also be seen as a white non-ferrous metal.

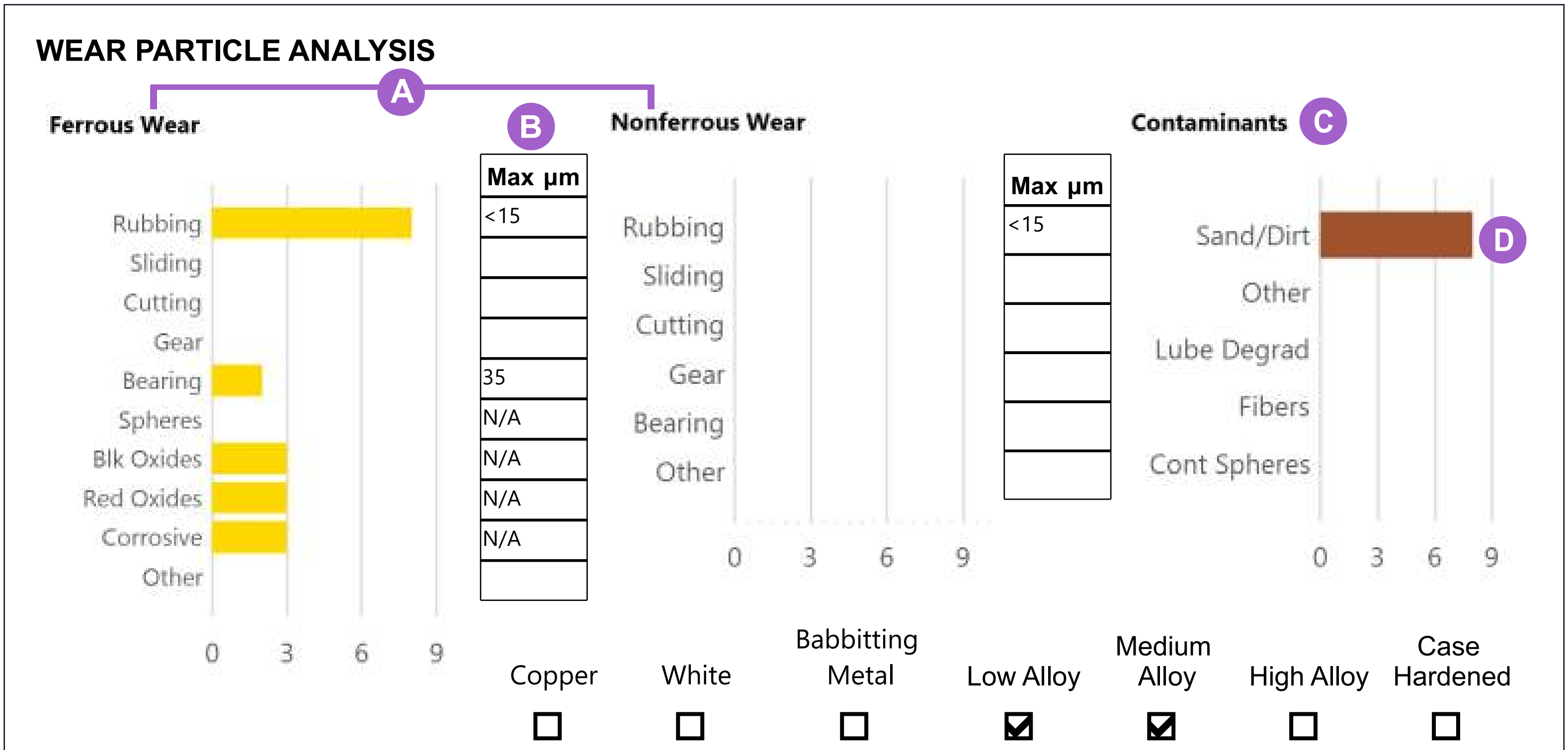
Titanium – This metal is extremely durable and therefore is generally seen in shafts and high-quality steel gears and bearings.

A Analytical results can be ferrous wear particles (containing iron) or non-ferrous wear particles (non-iron containing).

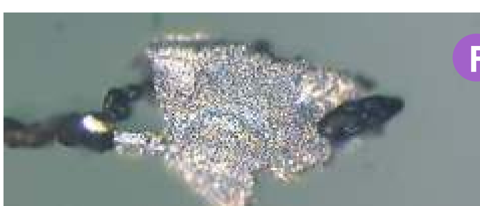
B MAX µm – Indicates the largest particle in microns measured in each particle category. By definition, normal rubbing wear particles are less than 15 microns in size.

C Analytical results can also be various contaminants. A detailed list of contaminants can be found on page 10 of the report guide.

D Gradient Bar – Graph displays the ratings (bottom) assigned by the analyst for each of the categories listed on the left.



E Particle Composition – If the square next to the particle composition is black, the material has been identified in the sample by the ferrography test method.



The image above depicts a large bearing wear particle composed of lead/tin babbitt.

F All Images are taken allowing for identification of wear particle details such as babbitt, sand, and dirt. The image below is of 100 micron bearing wear particles.

Large particles are the result of abnormal wear condition. If they remain in the lubricant, they will cause the most damage.

Condition Report Key - Particles

WEAR PARTICLES – Ferrous and Nonferrous

Normal Rubbing – Wear particles that are continuously generated in all equipment. Sizes range from 1 to 15 microns and are typically smaller than 5 microns.

Severe Sliding – Wear particles that are generally produced from the sliding contact surfaces undergoing high stress. Particles are >15 microns in size and are produced when gears/bearings/cylinders are operated with incorrect lubrication or under sever load and/or speed conditions.

Cutting – Wear particles generated as a result of one surface penetrating another. Sizes can range from 5 to >400 microns. There are two sources of these particles: misalignment of components and/or abrasive contamination. Sometimes observed when equipment is undergoing a break-in operating period.

Gear – Wear particles generated from the gear tooth pitch line (laminar) and/or tip and root (sliding). Sizes range from 15 to >500 microns. This type of wear is generally the result of improper load to speed ratio applied to gear teeth and incorrect lubrication.

Bearing – Wear particles generated as a result of fatigue in the rolling elements and races of antifriction bearing and the planer surfaces of friction type journal bearings. Journal bearings include babbitted and unbabbitted bearings. Sizes range from 15 to >500 microns. Common causes of generation include contamination, excessive load, and incorrect lubrication.

Spheres – The onset of rolling contact fatigue is indicated by the presence of spherical wear particles. Sizes are generally <5 microns. Spheres normally precede rolling element fatigue spalling or brinelling.

FERROUS OXIDES

Black Oxides – These particles are associated with insufficient lubrication between metal surfaces and are formed under high temperatures. This is a results of low oil pressure, low oil level, restrictions in oil feed lines (bent, twisted, etc.). Size range varies.

Red Oxides – This is another word for rust. These particles are associated with water contamination and historical debris as well as improper sampling. Water could have been present in the lube system at some time for red oxides to form even though the current sample does not contain water. Particle size varies. Water contamination is a common cause of equipment failure.

Corrosive Wear – Corrosive or chemical wear results from chemical action on metal surfaces combined with running action of those surfaces. The lubricant becomes acidic. Circulating metal particles in the lubricant, as well as the outer wear surfaces, become dissolved to sub-micron proportions. Size ranges are <0.1 micron.

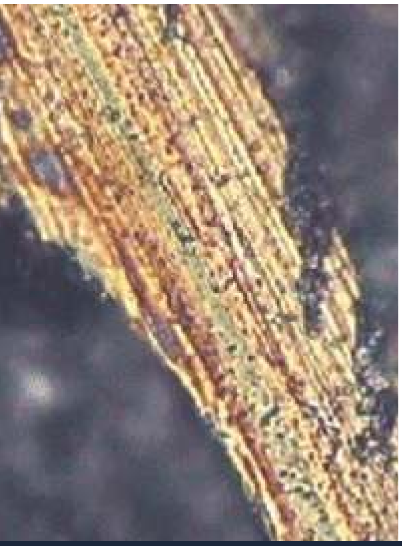
CONTAMINANTS

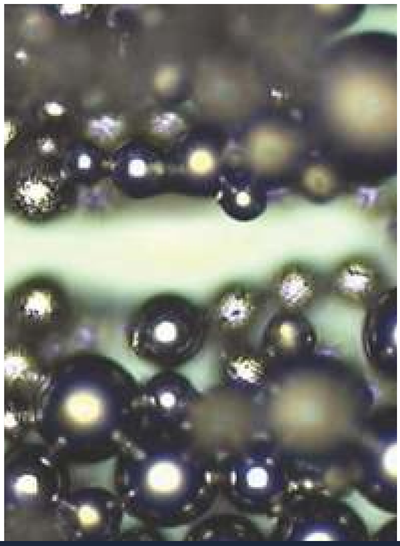
Lubricant Degradation – High concentration of friction polymers which indicates extreme pressure and/or temperature and over-stressing of the lubricant. No particular size ranges. In some specialty lubricants, degradation indicates additive depletion.

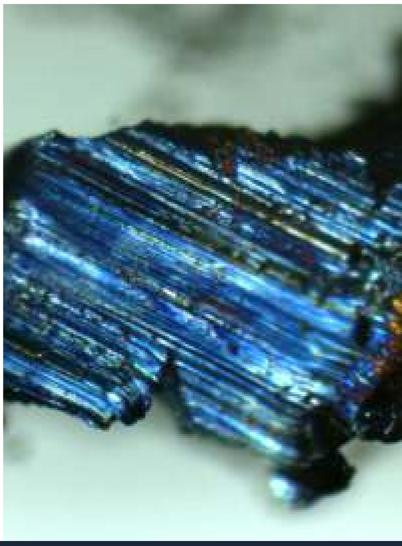
Sand/Dirt – External contamination in the lubricant. Sources can be from rebuilt units, improperly cleaned new machinery, perforated air filters, poorly installed or poorly functioning breathers (such as OEM vents). Particle size is generally >5 microns.

Contaminant Fibers – These indicate filter element breakdown of either internal or external oil filtration units. Other sources may be process or outside contamination, including cleaning rags.

Contaminant Spheres – Welding, grinding, sandblasting, and combustion processes produce spheres which can contaminate lube systems. Sizes range from 5 to 15 microns.







ORBITAL

BRINGING OIL INTELLIGENCE TO LIFE

ISO 9001:2015 Certified
ISO/IEC 17025:2017 Accredited

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