# Example of Test Layout:


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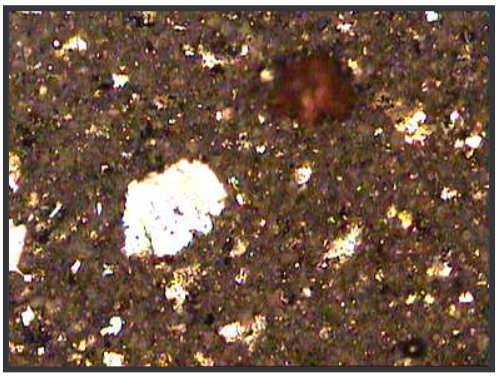
DATE: 00/00/0000

**No 000 Wear Mode Explanation Example**

**Name**

**Objective.** OOOOOOOO, Check oil for Wear Metal Particles and any possible contamination, Information found used to establish machine condition and future maintenance requirements.

**Method**. Sample of approx 100 mil received. Sample preparation in accordance with I.L.S. standard laboratory practices. One sample processed **1 mil in volume, therefore the amount seen in the video pictures is the actual debris filtered from 1 mil of oil.**



**Overview density of dirt,**
**Wear Metal Chunks and debris particles @ 100X.**

**One mil of the oil sample has been forced through a 13-mm diameter 0.3-micron membrane filter @ 150 P.S.I. trapping any dirt, metal chunks and debris present.** This shot is a 0.25-mm diameter circle photographed from that filter.

**Red Iron Oxide Crystal**
**10-40 Microns @ 600X**

Red Iron Oxide Particles (Rust) are formed when water is present in the system. The formation of the Red Iron Oxide Particles causes corrosion damage to wear surfaces and a loss of load carrying area.

These spalling metal particles are carried by the oil flow through other load zones, snowballing the effect and further damaging the load bearing surfaces.

The entry of water must be prevented and the fitting of a Mainlube Breather/Bladder and water drain system will assist with water removal. Damage will continue to this machine until the contamination is completely removed

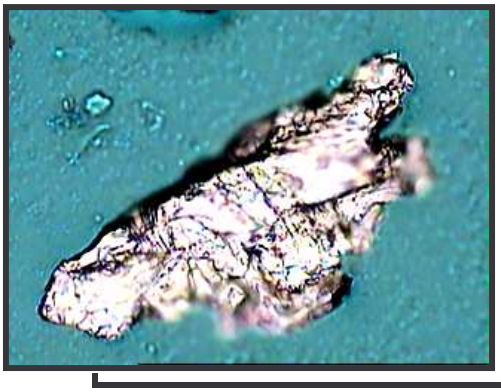
**Cutting Wear Particle**
**80 Microns, @ 500X**

Cutting Wear Particles are caused by hard contamination, usually Silica (Sand) or hard contaminant being present in the machine.

Cutting Wear Particles are formed when the lubricating film has been penetrated, by the hard contaminant, gouging off the load bearing surfaces, producing the distinctive swarf shape from machined metal components.

These metal particles are carried by the oil flow through other load zones, snowballing the effect and further damaging load-bearing surfaces.

Damage will continue to this machine until the contamination is completely removed



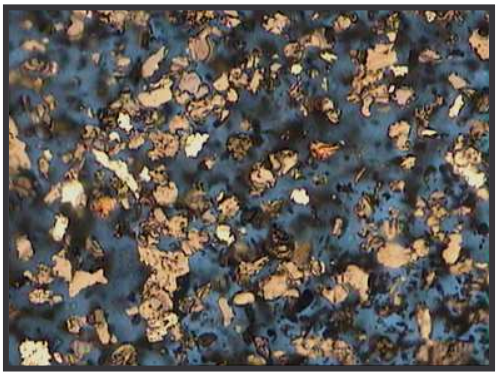
**2 Body Fatigue Wear Particle**
**50 Microns, @ 500X**

2 Body Fatigue chunks occur when the machine's cyclic application of the stress, is in excess of the design value.

The machine has been overloaded, past the capabilities of the metals surface, creating a crack or dent. Repetitive bruising in this area fractures the metals sub-surface causing the area to eventually spall out. This creates the familiar deep pitting and scaring damage observed on load bearing surfaces.

These spalling metal particles are carried by the oil flow through other load zones, snowballing the effect and further damaging load-bearing surfaces.

Damage will continue to this machine until the contamination is completely removed



**3 Body Fatigue Wear Particles**
**50 Microns @ 500X**

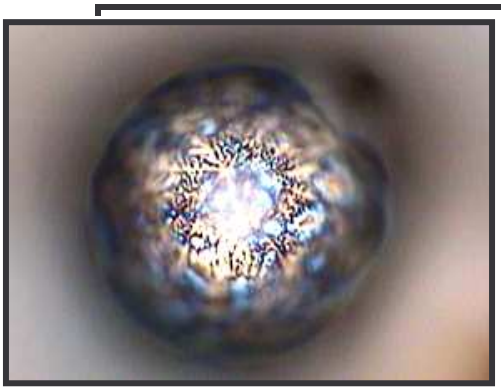
3 Body Fatigue Chunks are wear metal Particles that began when a foreign body was forced through the load zone creating a crack or dent.
Repetitive bruising in this area fractures the metals subsurface causing the area to eventually spall out. This creates the familiar scaring and light-pitting damage observed on load bearing surfaces.
These spalling metal particles are carried by the oil flow through other load zones, snowballing the effect and further damaging load-bearing surfaces.

Damage will continue to this machine until the contamination is completely removed

**Cutting Wear Generated by 2Body Fatigue**
**60x50 Microns @100x**

Cutting Wear Larger then 2.5 microns in width and 30 microns in Length are generated by 2 body Fatigue Abrasive Wear, i.e. one surface penetrating another along with sliding or overheating wear particles.

Damage will continue to this machine until the contamination is completely removed



**Steel Sphere Wear Particle**
**10 Microns @ 600X**

Spherical Wear Particles are formed through entrapment, then repeated compression of metal particles in a dent or crack. Spheres build in size until escaping; the repetitive formation of Spheres eventually spalls the area out as 3 body Fatigue Wear.

Spheres sized below 5 microns are from rolling bearings while Spheres 10 microns and above are from gears.

These spalling metal particles are carried by the oil flow through other load zones, snowballing the effect and further damaging load-bearing surfaces.

As a bearing is failing, thousands of spheres are released as pre-warning of an eminent bearing failure.

Damage will continue to this machine until the contamination is completely removed

**Dark Metallo Oxide Particle**
**60 Microns @ 500X**

Note fine pieces of metal imbedded in surface of particle.

Dark Metallo-Oxide and Black Oxide Particles are formed when machine is being over driven beyond the capability of the lubricant. The heat and pressure generated causes lubricant starvation. When Red Iron Oxide (rust), is forced through the load zone it Polymerises and forms Dark Metallo-Oxide and Black Oxide Particles. There are many forms of Iron Oxides FeO, $Fe_2O_3$ and $Fe_3O_4$ . To rectify this wear mode the lubricant should be up graded to a product more suitable to the machines operating environment

Damage will continue to this machine until the contamination is completely removed

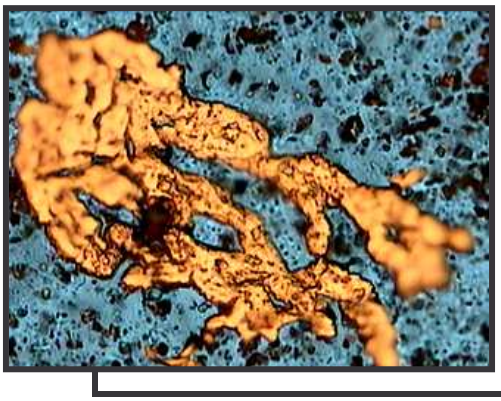
**Steel Sliding Wear Particle**
**100 Microns @ 200X**

Sliding Wear occurs when the lubricants film strength has been insufficient in providing separation between two wear surfaces, allowing metal-to-metal contact.

Sliding Wear is like a glacier sliding down a hill, bulldozing along rupturing the surface.

These spalling metal particles are carried by the oil flow through other load zones, snowballing the effect and further damaging load-bearing surfaces.

Damage will continue to this machine until the contamination is completely removed

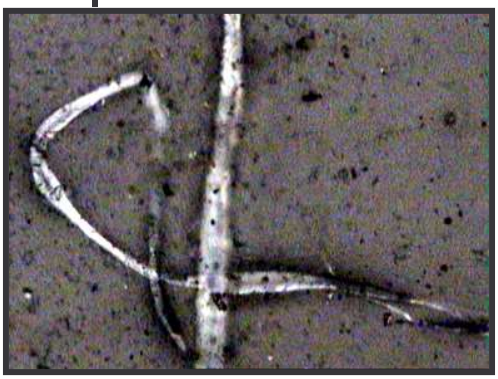


**Laminar Wear Metal Particles**
**5-30 Microns @ 500X**

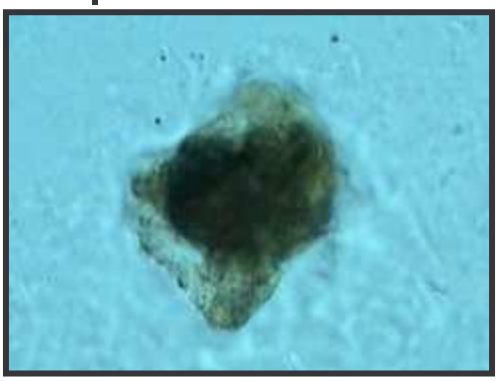
Laminar Wear is a secondary wear mode that is the end result of all wear modes being forced through the load zone by the lubricant flow. Their passage damages load bearing surfaces, forming large “rolled out” particles that contain all wear modes created earlier.

These metal particles are carried by the oil flow through other load zones, snowballing the effect and further damaging load-bearing surfaces.

Damage will continue to this machine until the contamination is completely removed

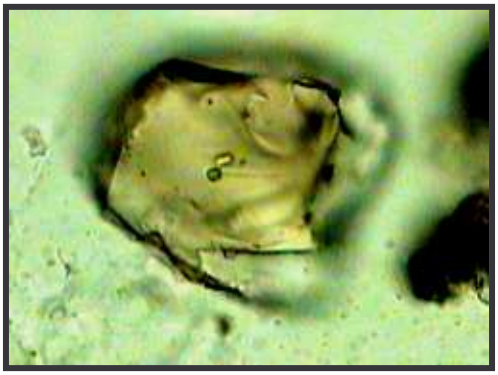


**Organic Debris,**
**1500 microns long @ 200X**



**Friction Polymer**
**40 microns long @ 600X**

Show the lubricant is under pressure.



**Silica Crystal**
**60 Microns @ 500**

This application is contaminated with silica crystals (Sand).
The lubricant flow forces the Silica the through the gears and bearings, easily penetrating the lubricating film, cutting the load bearing surfaces.

The entry of Silica must be prevented and the fitting of a Mainlube Breather/Bladder and water drain system will assist with water removal. Damage will continue to this machine until the contamination is completely removed

**Filter Fibre**
**55 Microns @ 100X**

Fibres in used oils may be from Internal filter damage and/or textile matter ingression. The occurrence of the filter fibre material is an indicative of a filter failure. The fibres can clog filters and the flow path of bearings, resulting in bearing overheating and potential failure.

Damage will continue to this machine until the contamination is completely removed

**Recommendations**

Cleanliness

The sample is of ISO Contamination 21/18 level 8, the 21 means there are between 10,000 to 20,000 particles per ml of oil bigger then 5 microns. The 18 means there are between 1,300 to 2,500 particles per ml of oil bigger then 15 microns. The cleanliness and contamination level is High.

Appearance

Appearance/Discoloration has elevated to 70 indicating oxidation, emulsification is evident possibly due to escalated running temperature then cooling creating condensation. Over 2000 ppm, 0.2% of moisture content. Acceptable limit 700 to 800 ppm @0.07%.

Particles

1) - Running in/scuffing wear that developed on initial running in of unit that was never eliminated.

2) - 3 Body Fatigue/cutting wear; these particles are small in size less then 30 microns in length and 1 micron in width and are in abundance. They are generated as a result of 3 – body abrasive wear i.e. hard abrasive particle (or from cavitation erosion) penetrating softer surface accompanying with small solid dust particles in lube oil. These wear modes are being forced through the load zone by the lubricant flow causing damage by generating further 3 Body Fatigue wear and finally rolled out flat to form Laminar Wear Metal particles.

3) Some 3 Body fatigue has progressed into hybrid laminar wear particles, this form of abrasive wear is very aggressive and must be eliminated.

Comments

This contamination should be removed before the wear mode has chance to progress to the next stage. Thus preventing further damage.

I.L.S. recommends that the gearbox be flushed to assist with the debris removal. If after flushing there is a possibility that debris still remains, then repeat the process until unit is clean. The source of the contamination should be established and prevented from recurring with a Filter or Bladder Vent and Water Drain System.

These recommendations and suggestions serve merely as a guide and in no way imply liability.

Mark O'Brien
Tribologist