Analysis of wear and contamination particles from in-service oil and filter samples

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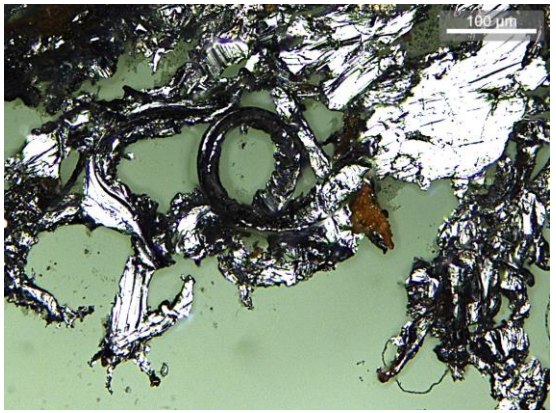
Oil Analysis Services

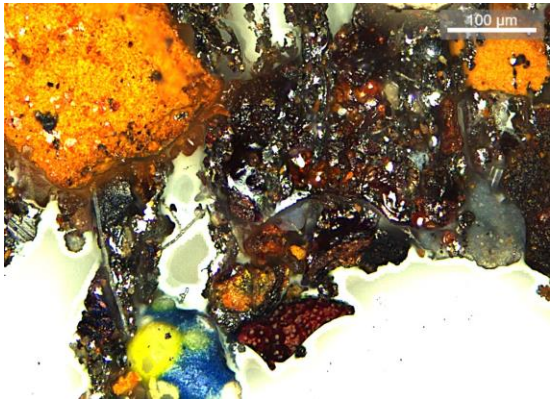
Swansea Tribology Services

Wear and Contamination Particles - Introduction

Wear particles are generated during both normal and abnormal wear of machine components. Their **quantity**, **size** and **morphology** are indicative of the wear regimen in operation.



Contamination particles may enter the system through many pathways and may include environmental dust and dirt, fibres, process specific dust, oxides/rust, etc.

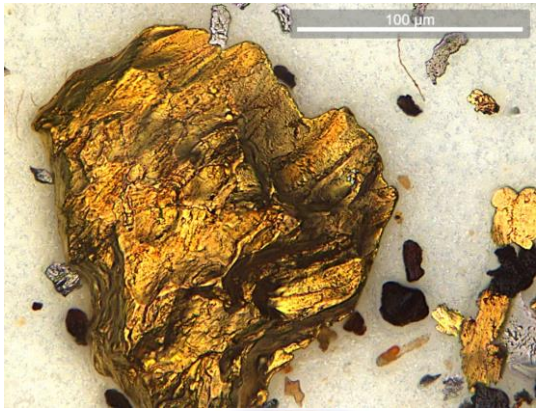


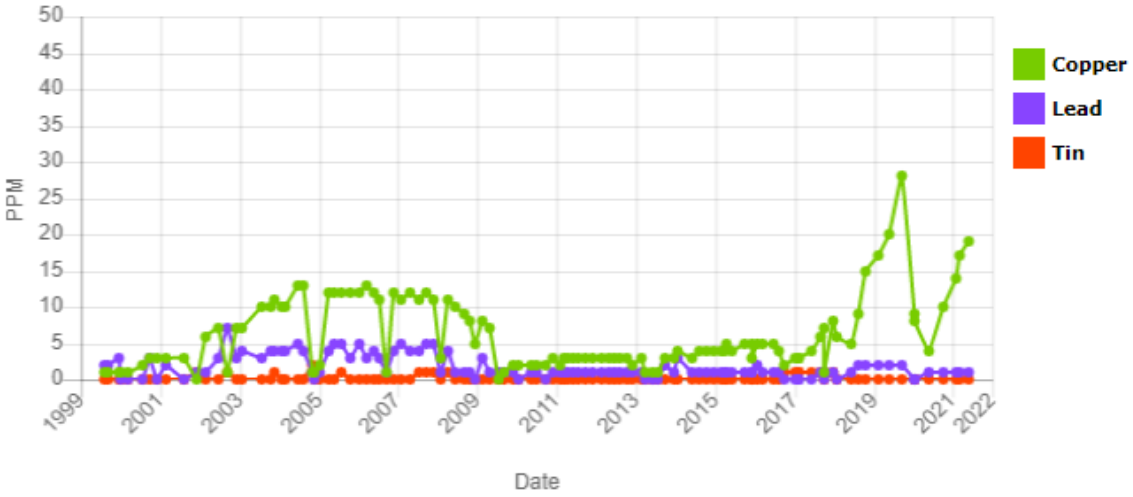
The particles may be suspended in oil, settled at the bottom of the oil sump or tank or captured by strainers, filters or magnetic plugs.

Analysis of Particles in Oil

There are many methods for analysis of wear debris.

Some can be performed on the fluid sample. These include particle counting and shape analysis through laser scanning (e.g., Lasernet Fines) and bulk elemental analysis (e.g., ICP/RDE spectroscopy – particle size limitations).

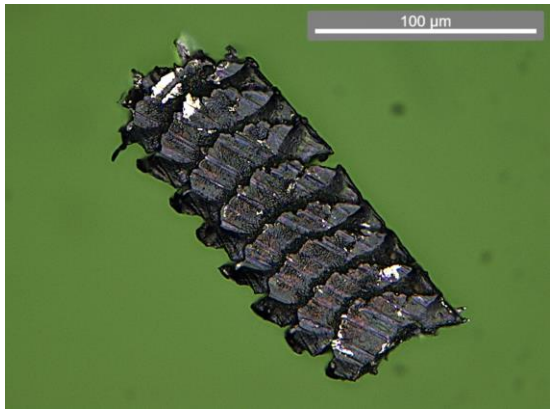


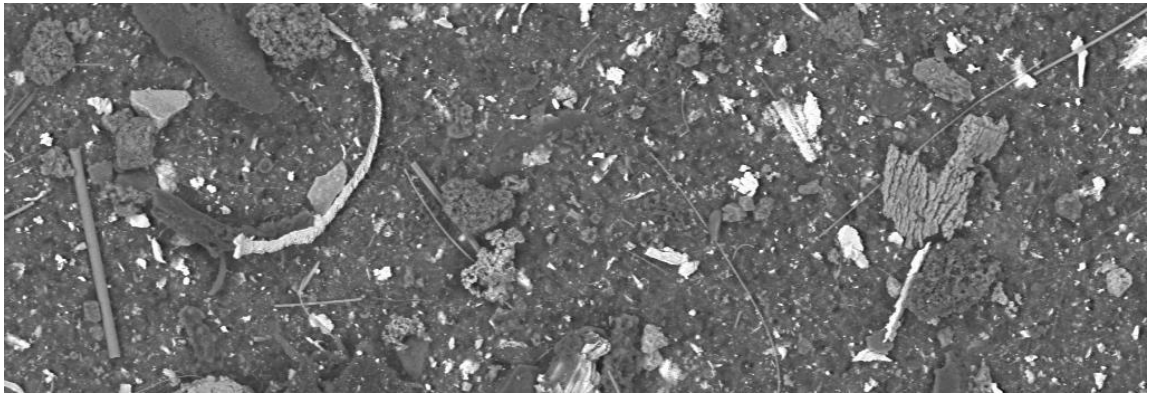


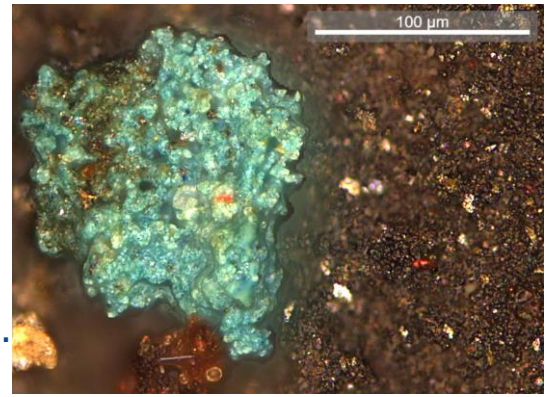
Wear and Contamination Particle Analysis

Other methods involve separation of particles from the fluid by means of filtration or magnetic deposition, with subsequent analysis by operator or computerised systems.

Elemental analysis can be carried out on specific particles, typically using Scanning Electron Microscopy (SEM).







Laser Induced Breakdown Spectroscopy (LIBS) is a new technology, which is now becoming available for this application.

FTIR microscopy may be used to identify organic contaminants.

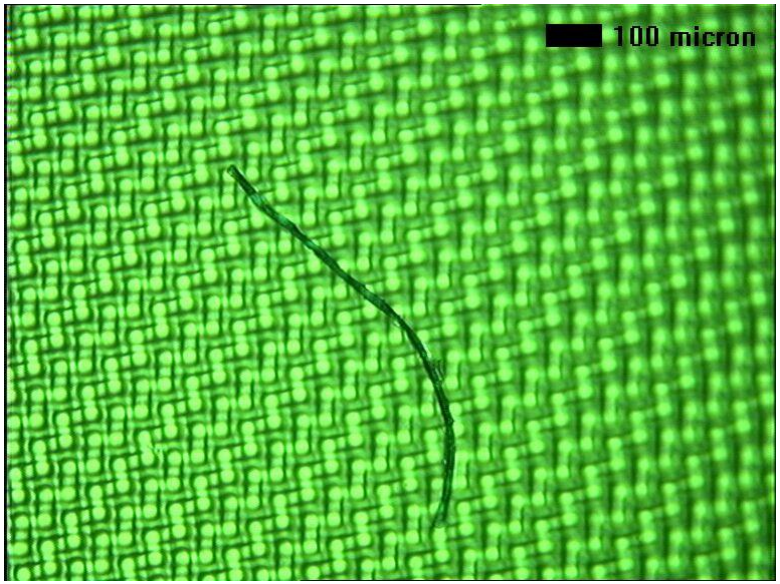
Wear Particle Deposition - Filtration

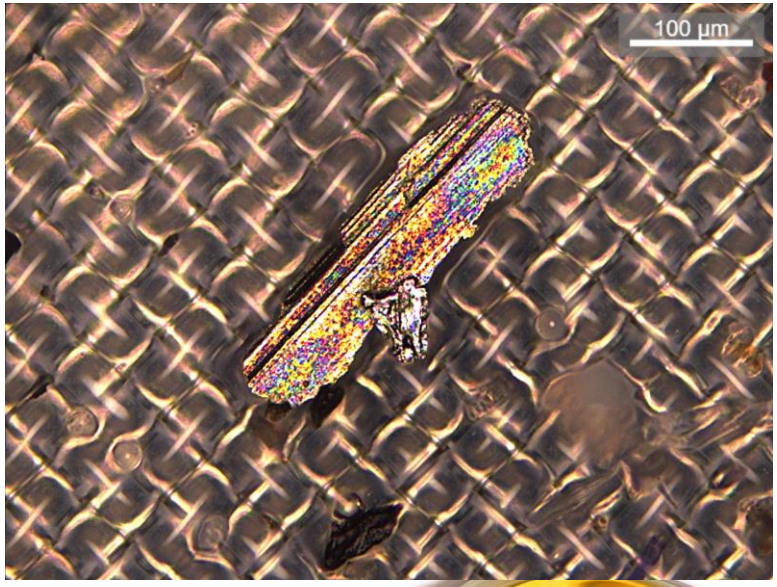
Filtration, often referred to as Patch Testing, involves passing a known quantity of the fluid through a membrane filter patch of a specified pore size.

Membrane Pore Size

Pore size selection can be used to specifically target the larger particles allowing most of the finer debris to go through.

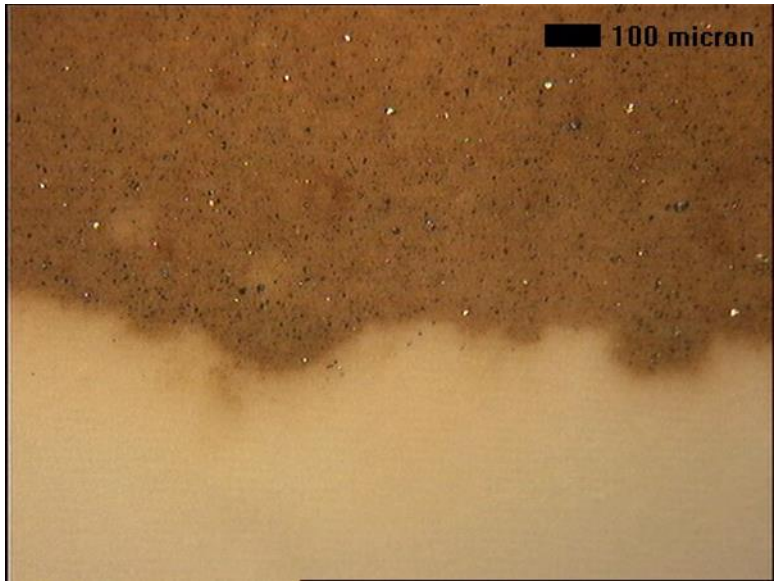
Also used for fibre counting.





Fine Particle Deposition - Varnish

Fine pore size patches (e.g. 0.45 µm) are used to capture sub-micron insolubles/silt. This is indicative of the oil's varnish potential and can be quantified by Membrane Patch Colorimetry.



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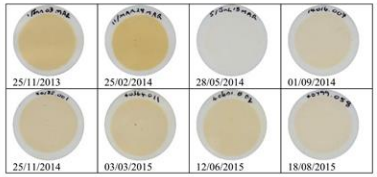
Sample ID: XXXXX.XXX
Sample Date: 18/08/2015
Machine number: ABC 1234
Machine description: Gas Compressor
Sample Point: Tank
Lubricant: XXXXXX XXX XX
System Volume: Ltr
Fill date:
Top ups:

Views of membranes



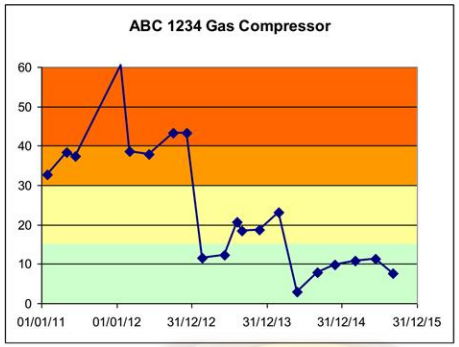
Results

Date	MPC Value
25/11/13	18.8
25/02/14	23.2
28/05/14	2.9
01/09/14	7.8
25/11/14	9.9
03/03/15	10.9
12/06/15	11.3
18/08/15	7.6

Comments

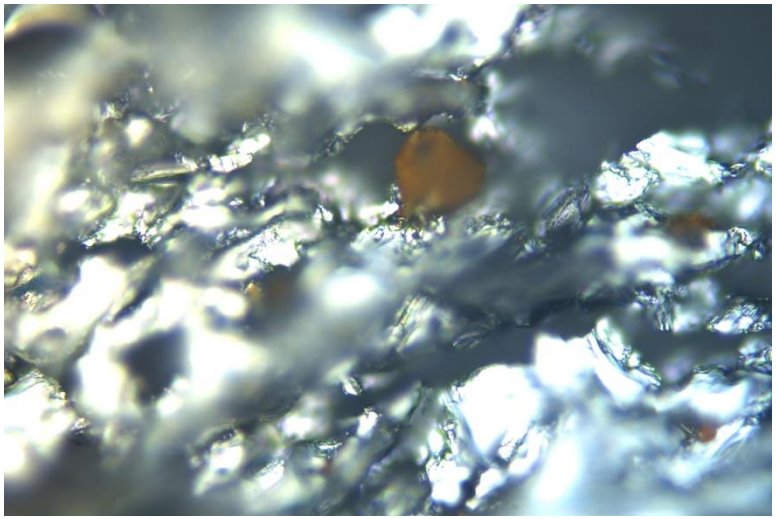
Test result indicates an MPC value of 7.6, which is an improvement when compared with the previous value. It remains in the category of 'Normal' (0-15). Based on the result the oil in this condition has a low risk of creating varnish.

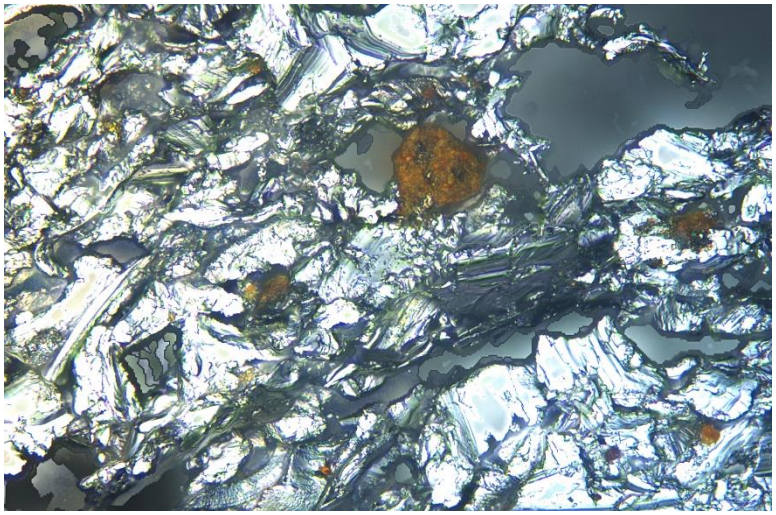
Trend



Wear Particle Analysis – Microscopy

Modern microscope systems offer many software tools for particle analysis. They cover particle counting and sizing as well as particle morphology. Vertical stitching improves image quality, while advanced lighting options offer new perspectives.





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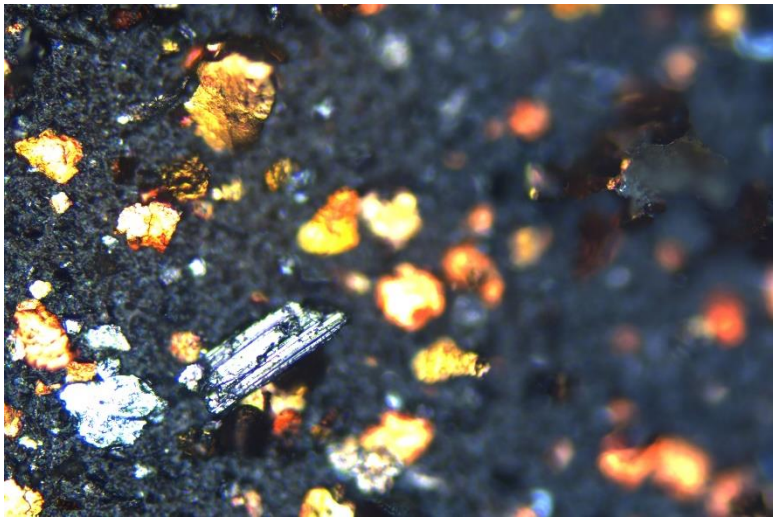

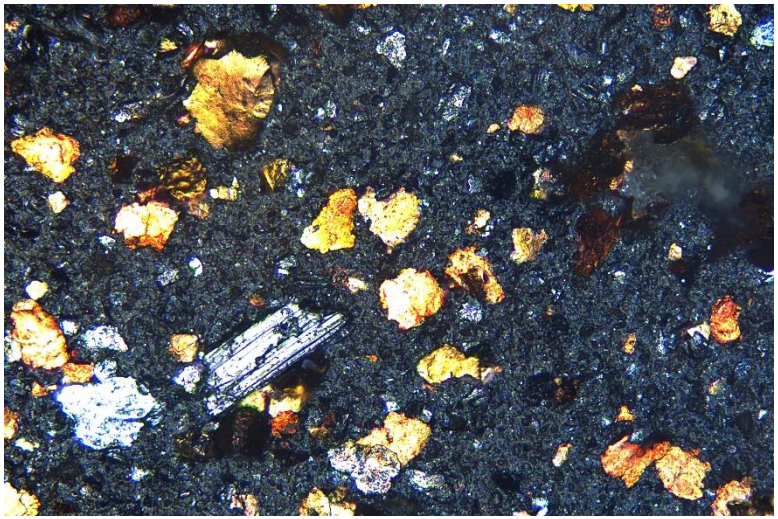

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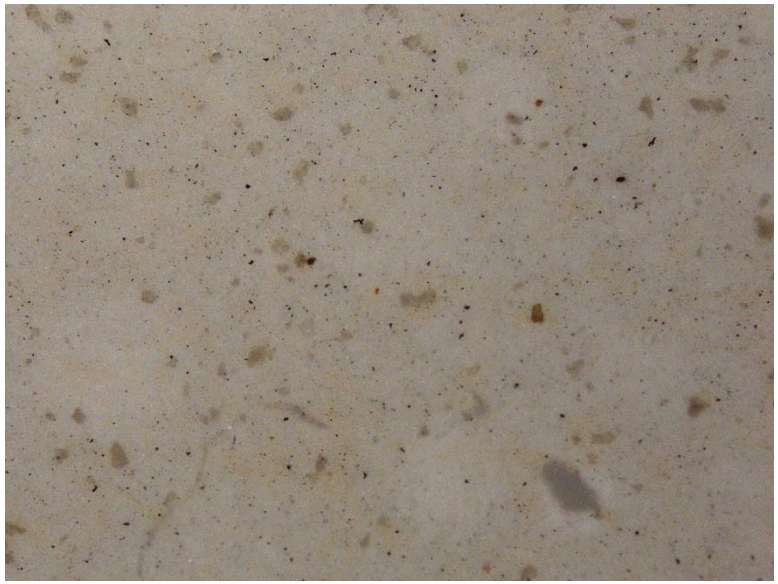
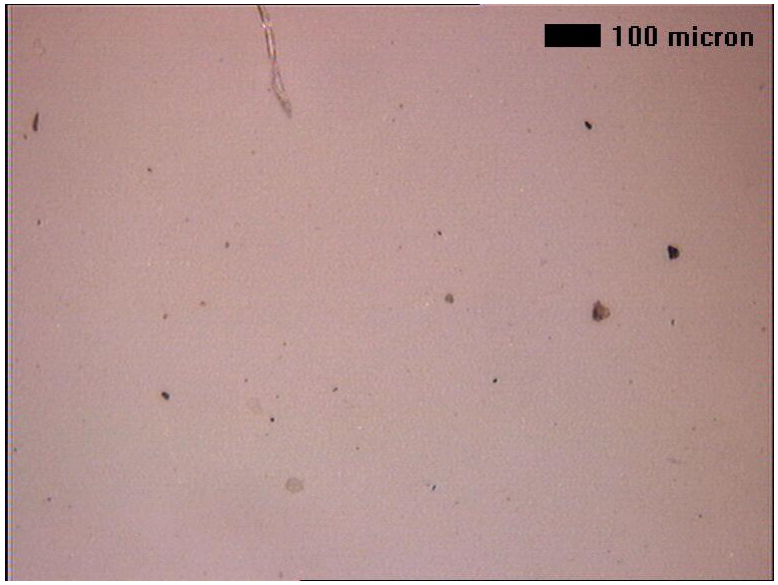
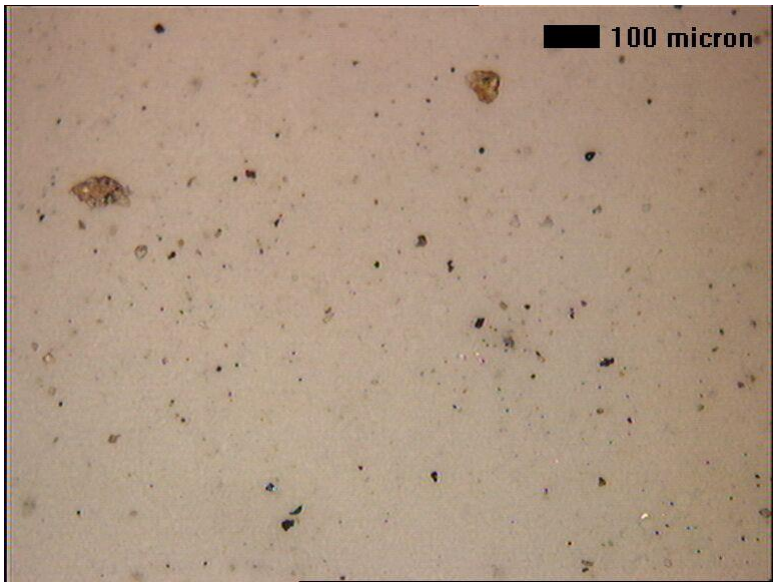



100 micron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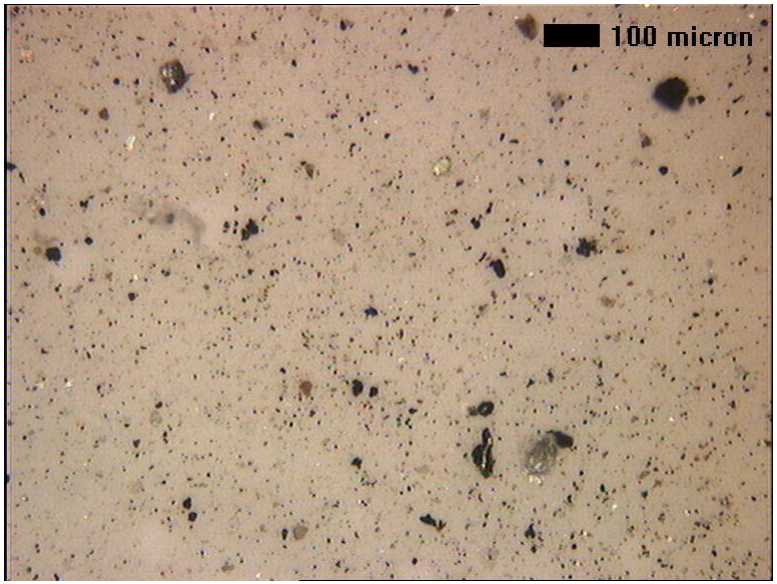
100 micron


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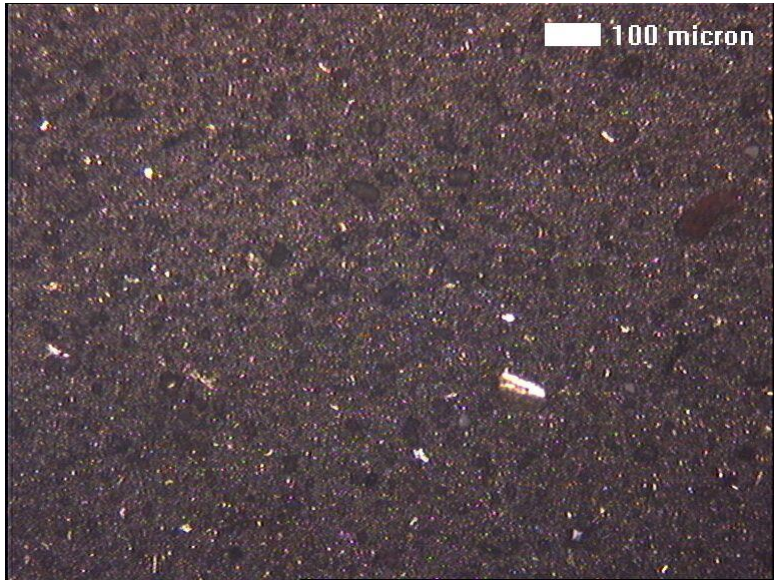
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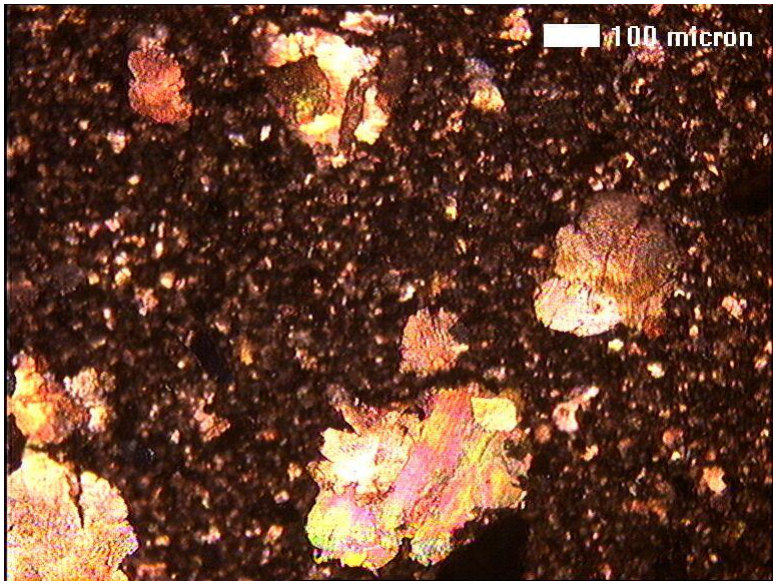
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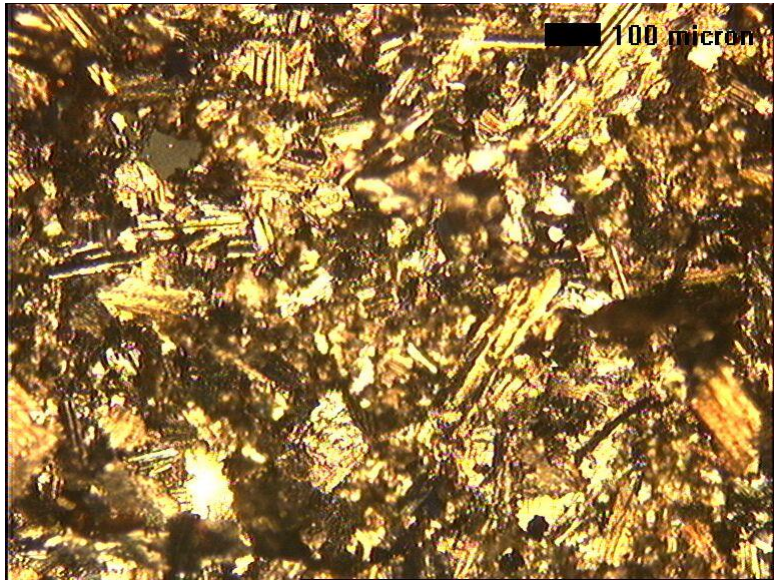
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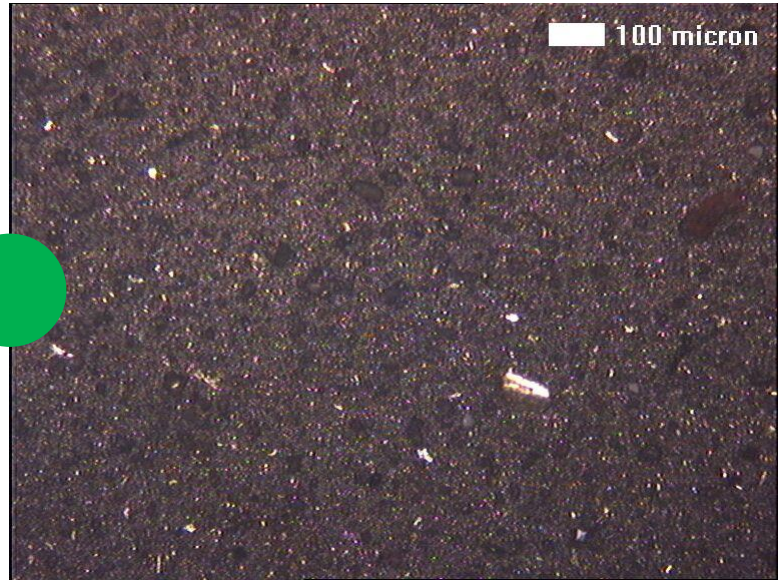
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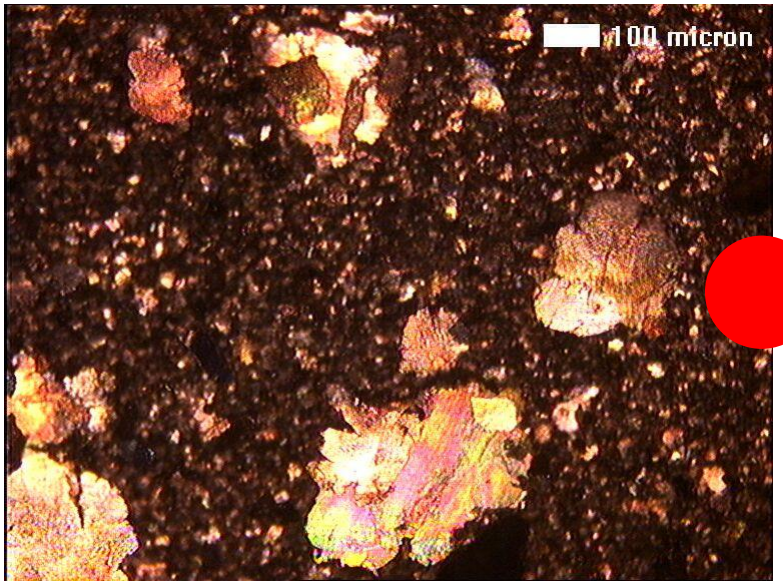
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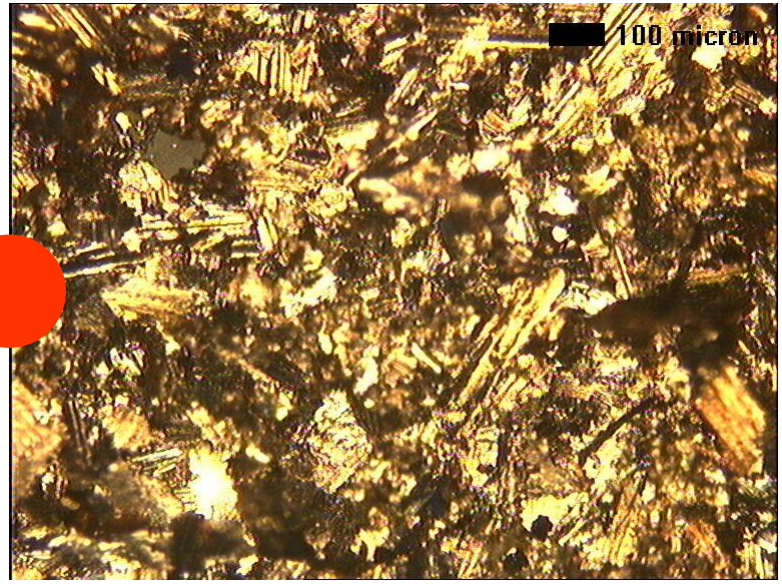
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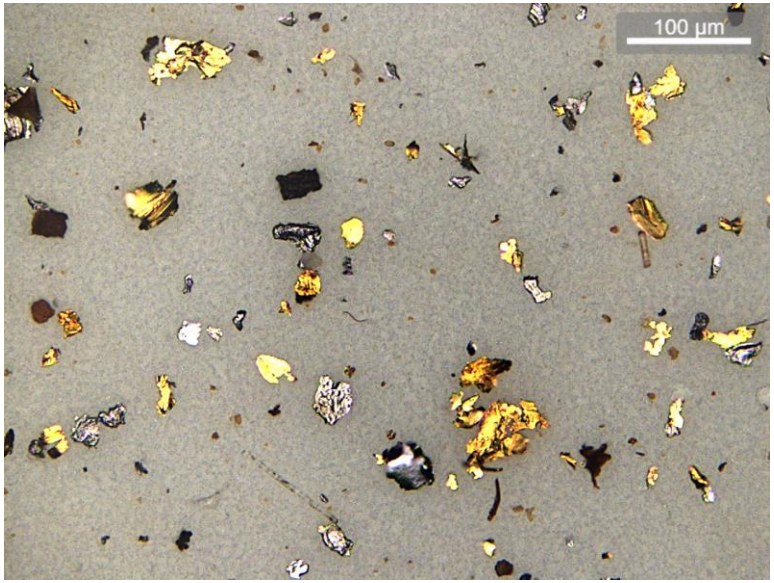
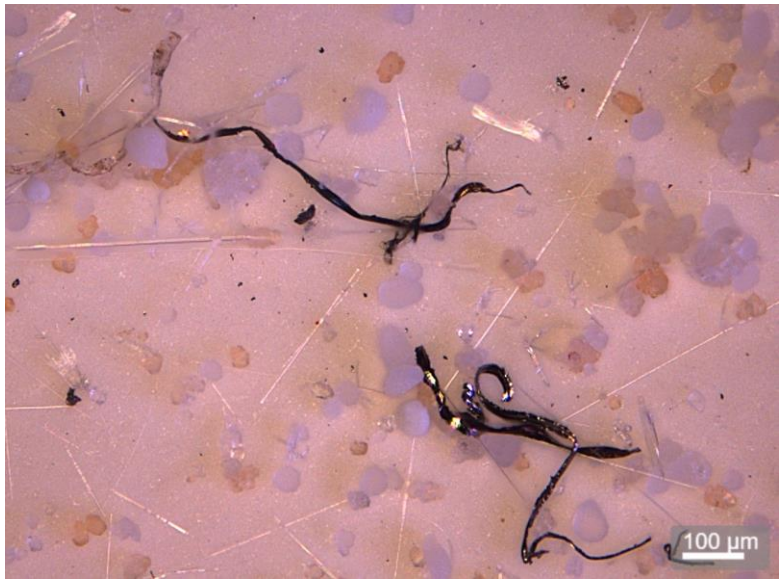

100 µm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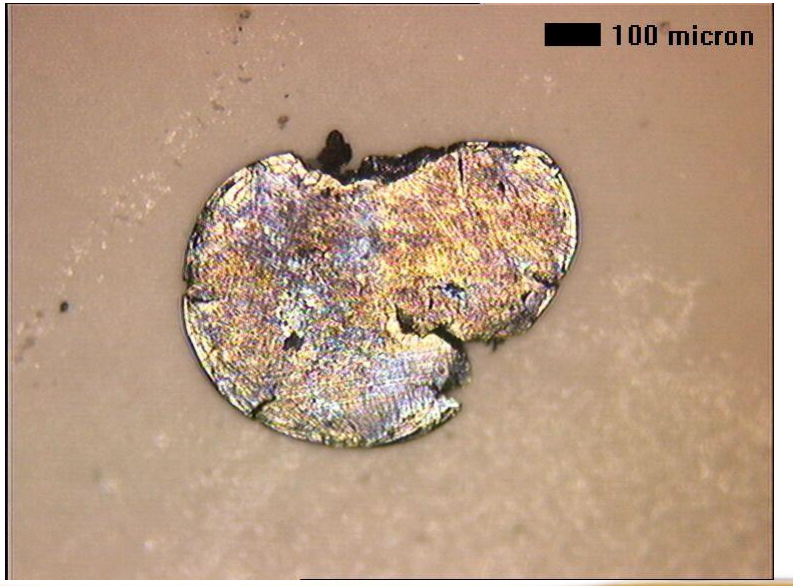
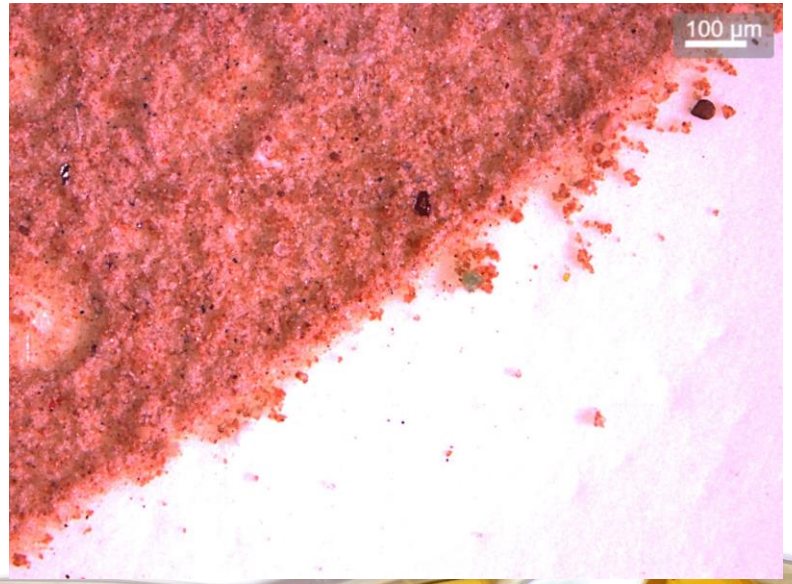
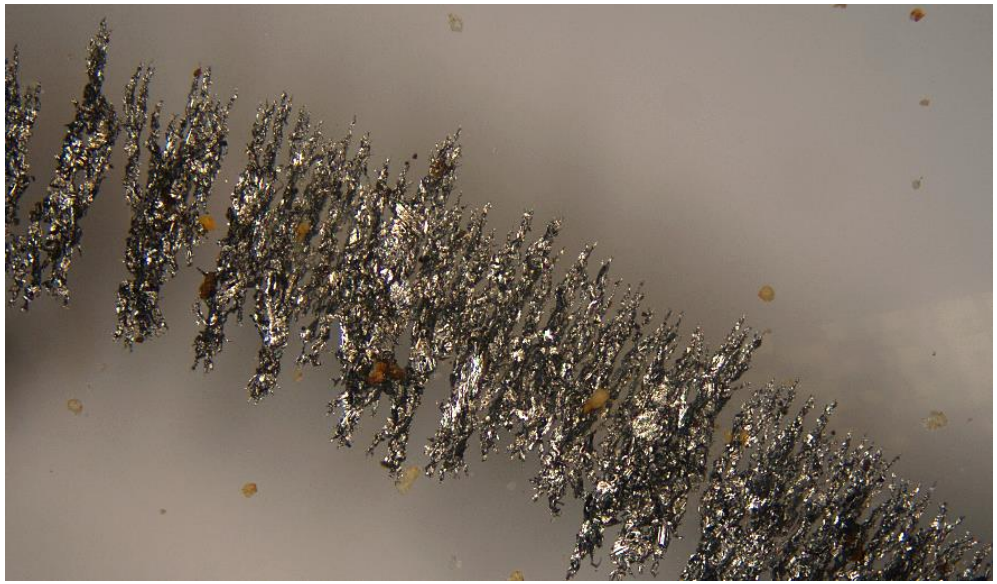

100 micron


100 µm

Wear Particle Deposition – Ferrography

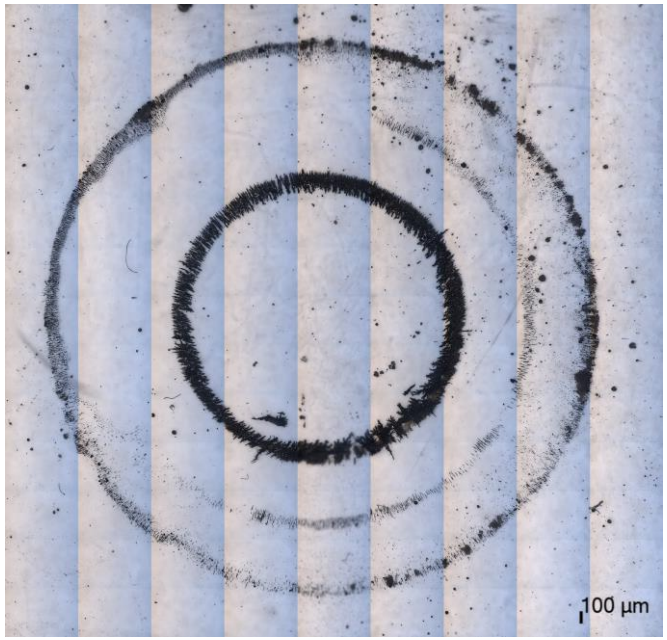
An alternative technique is employed for Analytical Ferrography, where magnets are used to capture ferrous debris on a glass slide and to arrange it based on size for ease of examination.

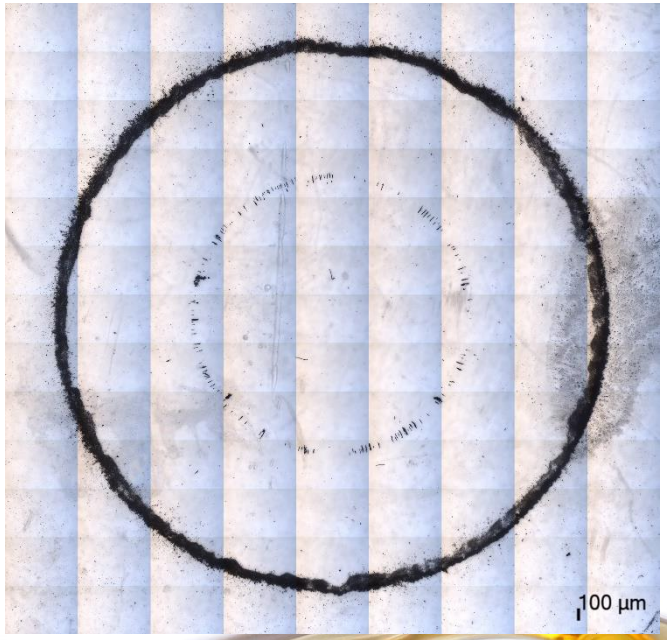


Rotary Particle Depositor (RPD)

Wear Particle Deposition – Ferrography

Concentric magnets align wear particles in three rings. The largest particles settle along the central ring and the fine particles and oxides settle out on the periphery, together with a small proportion of any other nonmagnetic particles (e.g. Copper containing wear particles).





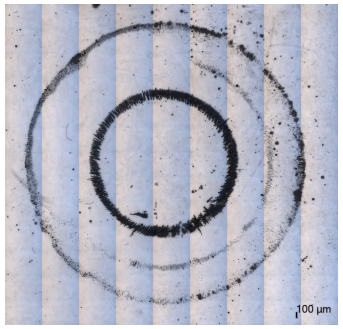
Wear Particle Analysis – Ferrography

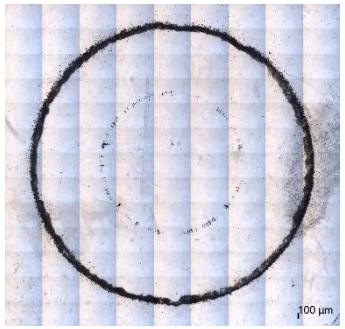
Ordered particle arrangement aids particle characterisation and analysis.

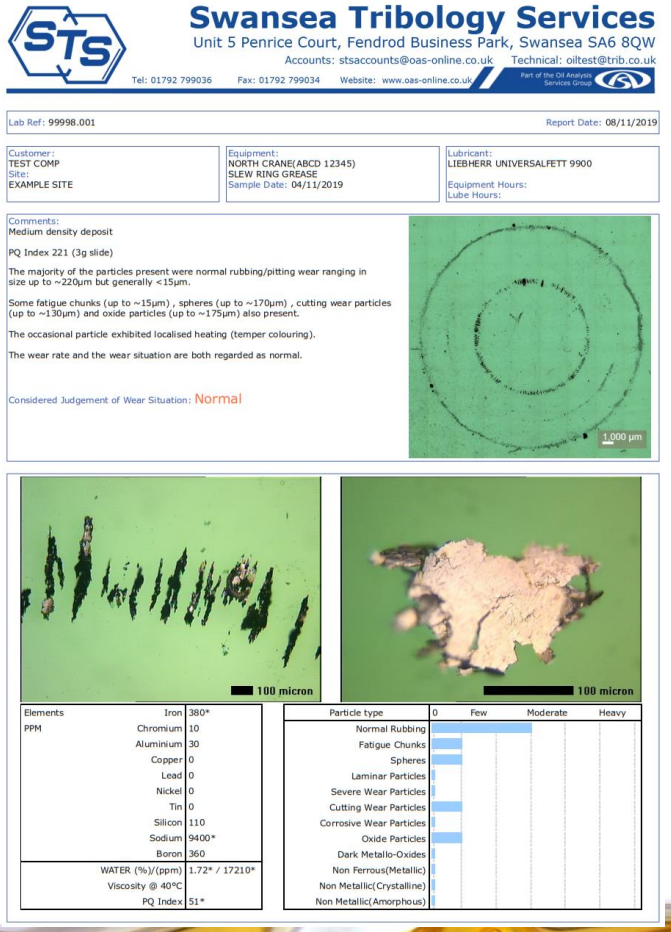
Relative quantity and size are recorded for each wear particle type.

Elemental analysis of bulk fluid is also included.

Report is concluded with considered judgement on the wear rate and situation.







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Tel: 01792 799036 Fax: 01792 799034 Website: www.oas-online.co.uk
Part of the Oil Analysis Services Group

Lab Ref: 99998.001 Report Date: 08/11/2019

Customer: TEST COMP
Site: EXAMPLE SITE

Equipment: NORTH CRANE(ABCD 12345) SLEW RING GREASE
Sample Date: 04/11/2019

Lubricant: LIEBHERR UNIVERSALFETT 9900
Equipment Hours:
Lube Hours:

Comments:
Medium density deposit

PQ Index 221 (3g slide)

The majority of the particles present were normal rubbing/pitting wear ranging in size up to ~220µm but generally <15µm.

Some fatigue chunks (up to ~15µm) , spheres (up to ~170µm) , cutting wear particles (up to ~130µm) and oxide particles (up to ~175µm) also present.

The occasional particle exhibited localised heating (temper colouring).

The wear rate and the wear situation are both regarded as normal.

Considered Judgement of Wear Situation: Normal

1,000 µm

100 micron

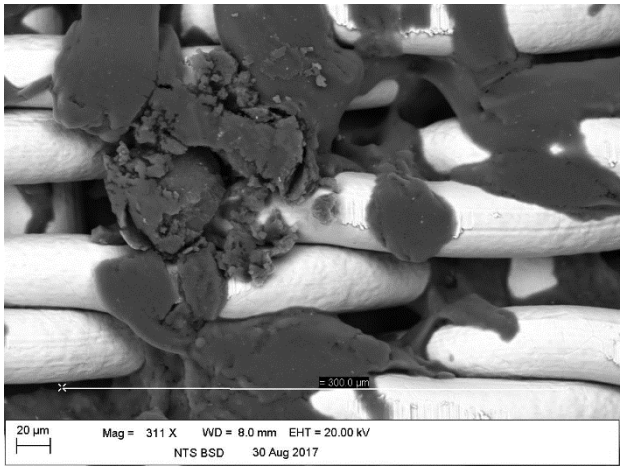
100 micron

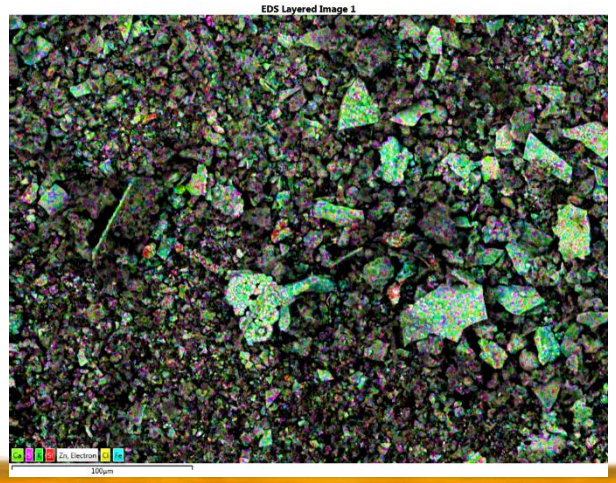
Elements		
PPM	Iron	380*
	Chromium	10
	Aluminium	30
	Copper	0
	Lead	0
	Nickel	0
	Tin	0
	Silicon	110
	Sodium	9400*
	Boron	360
	WATER (%)/(ppm)	1.72* / 17210*
	Viscosity @ 40°C	
	PQ Index	51*

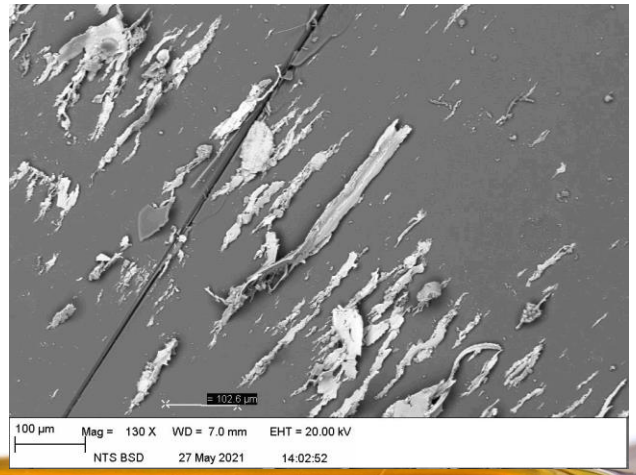
Particle type	0 Few Moderate Heavy
Normal Rubbing	
Fatigue Chunks	
Spheres	
Laminar Particles	
Severe Wear Particles	
Cutting Wear Particles	
Corrosive Wear Particles	
Oxide Particles	
Dark Metallo-Oxides	
Non Ferrous(Metallic)	
Non Metallic(Crystalline)	
Non Metallic(Amorphous)	

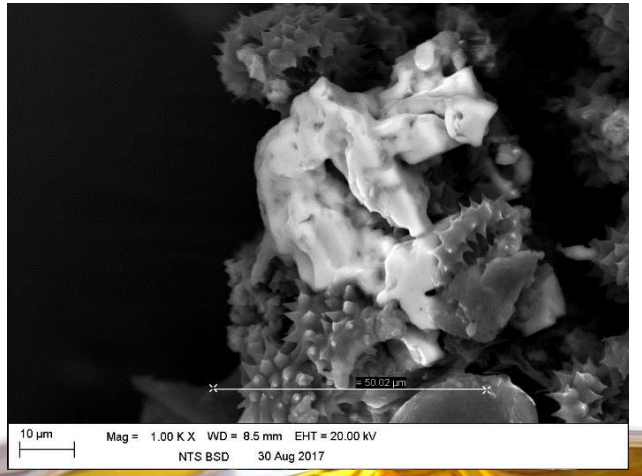
Elemental Analysis of Specific Particles – Scanning Electron Microscopy

+ Focused images at very high magnifications
+ Elemental analysis of individual particles or areas
+ Particle sizing and characterisation
+ Elemental analysis of particle populations
+ Elemental mapping
- Samples require preparation
- Time consuming









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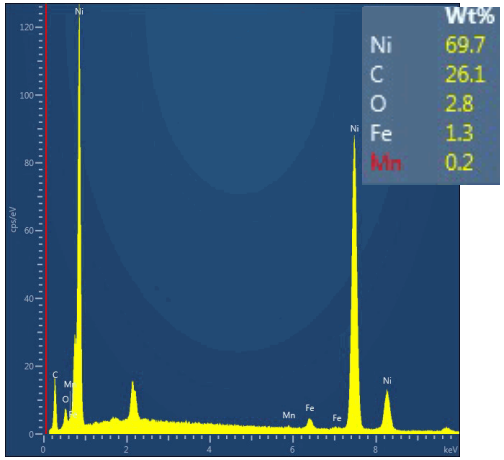
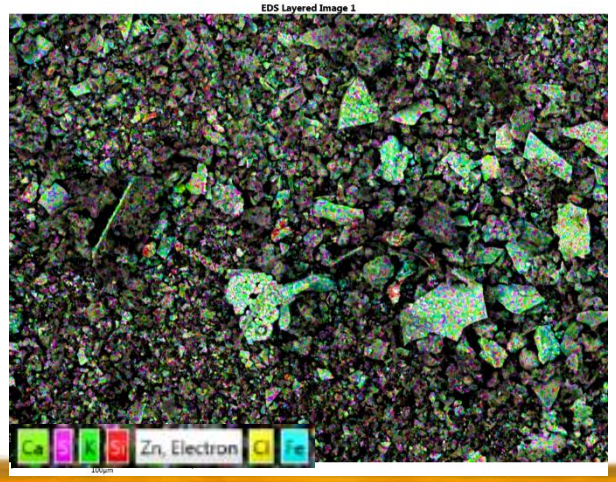
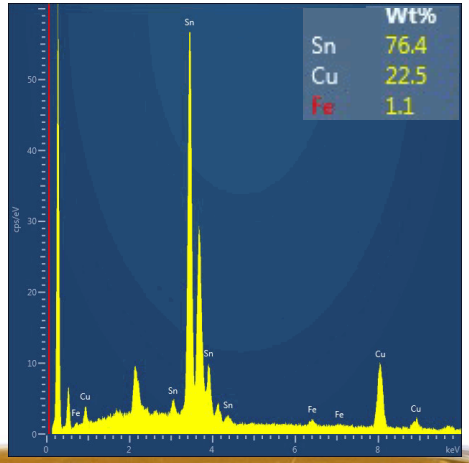
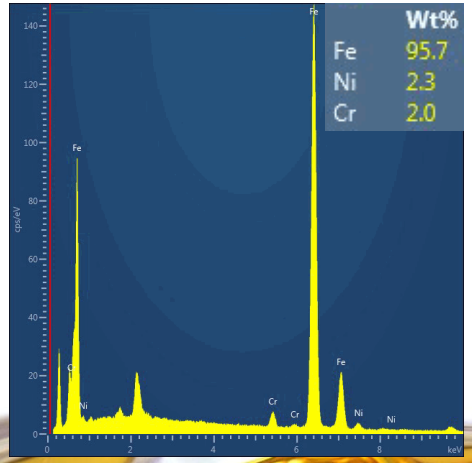


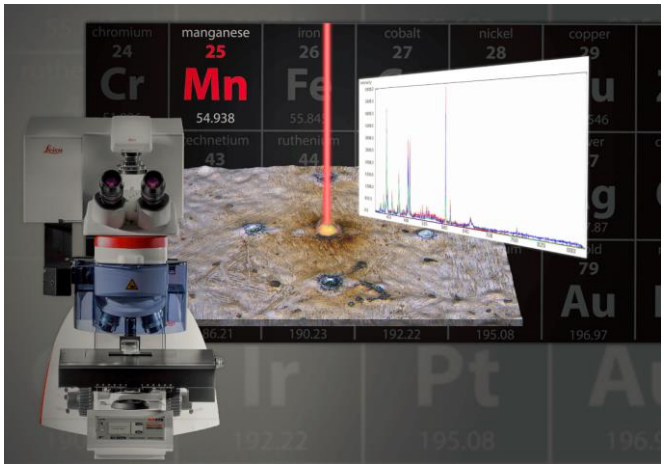


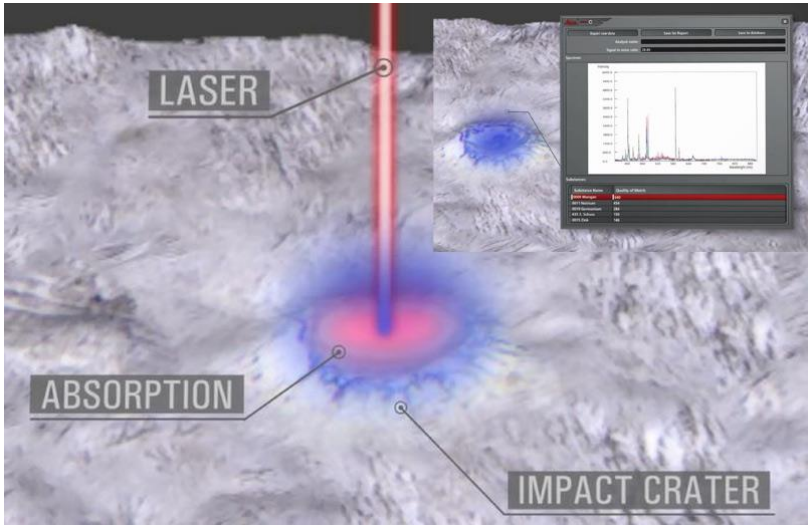




Elemental Analysis of Specific Particles – Laser Induced Breakdown Spectroscopy

- A laser pulse strikes the material surface;
- A plasma is induced and then breaks down, emitting light; and
- Characteristic atomic line spectral emissions allow the elements to be identified.

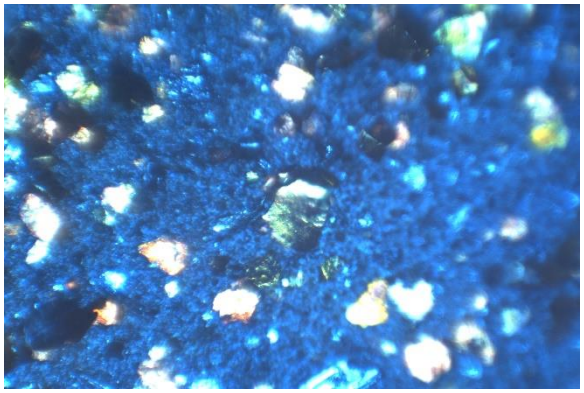


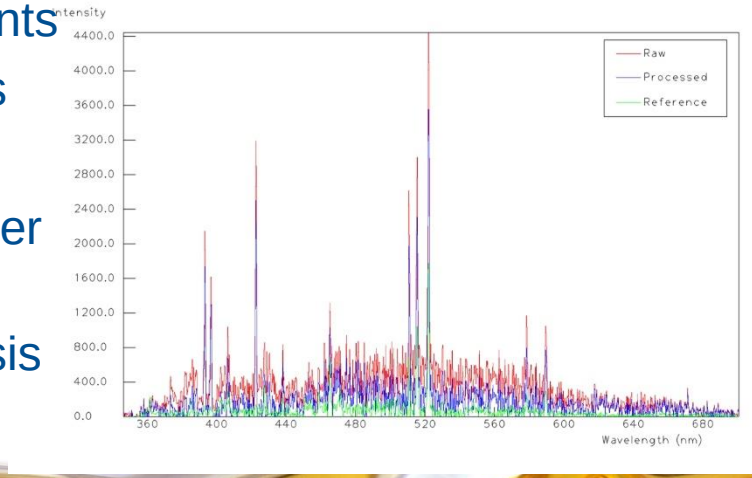


(source Leica)

Laser Induced Breakdown Spectroscopy – Advantages and Disadvantages

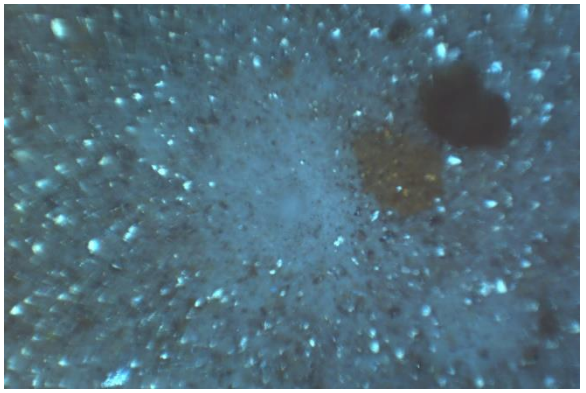
+ Upgrade module to a conventional microscope
+ Colour images of the field of view
+ Elemental analysis of individual particles or areas
+ Particle sizing and characterisation
+ In situ analysis during microscopy
+ No sample prep required and no consumables
+ Fast analysis speed for individual measurements
- Currently poor specificity of elemental analysis
- Requires libraries of candidate compounds
- Surrounding area included in analysis of smaller particles
- Particles thrown off or destroyed during analysis
- No mapping

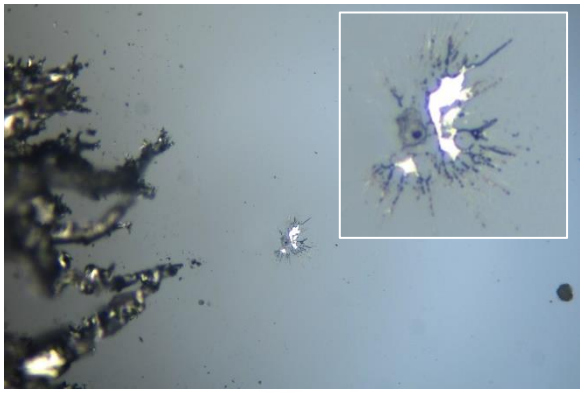




Laser Induced Breakdown Spectroscopy – Advantages and Disadvantages

+ Upgrade module to a conventional microscope
+ Colour images of the field of view
+ Elemental analysis of individual particles or areas
+ Particle sizing and characterisation
+ In situ analysis during microscopy
+ No sample prep required and no consumables
+ Fast analysis speed for individual measurements
- Currently poor specificity of elemental analysis
- Requires libraries of candidate compounds
- Surrounding area included in analysis of smaller particles
- Particles thrown off or destroyed during analysis
- No mapping





Thank You

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Oil Analysis Services

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