OilSTest

PROACTIVE MACHINE ANALYSIS

CAPABILITY STATEMENT

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OIL TEST PROFILE

MISSION STATEMENT

"To generate a long-lasting partnership with our customers providing quality and reliable oil testing services, support, and consulting of lubrication and maintenance practices to increase the productive life of our customer's equipment while decreasing maintenance cost and downtime."

BACKGROUND

Oil Test has established itself as a truly independent used oil-testing laboratory. We are not owned by or are not influenced by lubricant or OEM componentry supply companies. Our focus is to serve our clients and not to generate revenue from the supply of oils or componentry as we are in the business of saving componentry and reducing lubricant usage.

Our efficient and highly automated laboratory is designed to generate and report data quickly to minimise the time taken to provide information to our clients. Laboratory turnaround times are typically around 4-6 hours from receipt of samples.

We guarantee a maximum turnaround of 24 hours from receipt of wear metal analysis samples seven days a week

Our used oil analysis condition monitoring service is aimed at reducing our customer's maintenance budgets via proactive oil condition monitoring techniques, which have the following added benefits to maintenance managers and supervisors;

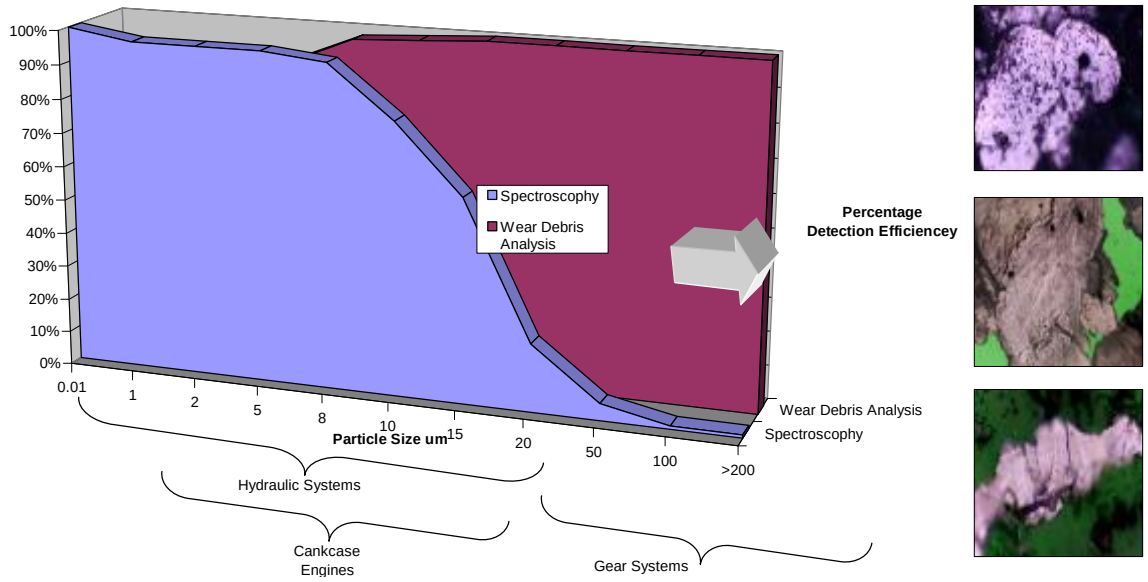
- Increased safety
- Machine condition monitoring and diagnosis for warranty purposes
- Adding value to the service book for better equipment resale value
- Extending machine & component life
- Assisting maintenance scheduling and reducing unscheduled downtime
- Fault cause and prevention diagnosis
- Determination of optimum oil change interval and reducing the environmental impact through waste reduction

TESTING METHODS

Oil Test has equipped its laboratory with the latest oil testing equipment from around the globe to meet your condition monitoring requirements. We have provided for your reference a dossier of our standard tests and their use in monitoring your plant and equipment.

The Oil Test Difference

We continue to have considerable success in monitoring both small and large particle wear using both elemental spectroscopy and microscopic wear debris analysis particularly on gearcases, final drives & hubs and transmissions, which have traditionally, been poorly monitored via elemental spectroscopy which has particle size detection limitations. As a result we have built into our pricing routine oil wear debris analysis, which provides an excellent method of monitoring large wear and contaminant particles.



Wear Debris Analysis immediately registers and indicates the severity of any particles from fatigue breakage or environmental contamination. This enables all abnormal wear modes to be quickly identified and corrected. In difficult maintenance areas the commencement of Wear Debris Analysis testing and the resulting removal of abnormal wear situations can provide significant equipment life extensions.

PHYSICAL ANALYSIS

Of most importance are the physical analysis techniques that Oil Test uses when your oil samples first arrive at the laboratory. These initial indicators, in particular fuel dilution, water content and PQ, can provide early warning signals of an imminent failure, which is why rapid turnaround is key to maximising your oil analysis program.

Fuel Dilution

Fuel dilution indicates the relative amount of unburned diesel fuel or gasoline present in an engine lubricant. This dilution is associated with improperly adjusted or malfunctioning fuel system assemblies. Excessive fuel dilution lowers lubricant load-carrying capacities, promotes lubricant breakdown and increases the risk of fire or explosion. Fuel dilution is determined by FTIR analysis or plotting the flash point of the oil and is reported in percent (%) volume.

Water

The presence of water in a non-water-base fluid indicates contamination from an outside source or from condensation. Not only does water have a direct harmful affect on machine components, but it also plays a direct role in the aging rate of lubricating oils. The presence of water in lubricating oil can cause the progress of oxidation to increase tenfold, resulting in premature aging of the oil, particularly in the presence of catalytic metals such as copper, lead and tin. In addition, certain types of synthetic oils such as phosphate esters and dibasic esters are known to react with water, resulting in the destruction of the base stock and the formation of acids. Results are reported in percent (%) volume.

PQ – Ferrous Particle Quantification

PQ measurement is recognised as an essential tool in any used oil analysis programme to identify the bigger debris particles missed by other analytical techniques. There is very seldom any correlation between the PQ and the Fe readings obtained by spectrographic methods. This is why the PQ is so valuable and why we do a PQ on every sample that comes into the laboratory so we can get a quantitative measurement of ferrous metal debris in used oil samples.

Viscosity

Viscosity is a lubricant's internal resistance to flow at a given temperature in relation to time, and is considered to be the single most important physical property of a lubricant. Changes in viscosity indicate improper servicing, dilution, and contamination or lubricant breakdown in service. Viscosity is usually determined with a kinematic method and the results are reported in centistokes (cSt) and compared to the lubricant manufacturer's new oil specification. Oil Test provides as a standard part of its service to all its clients, viscosity measurement at 40°c, 100°c and a viscosity index measurement.

TAN – Total Acid Number

A titration method designed to indicate the relative acidity in a lubricant. The acid number is used as a guide to follow the oxidative degeneration of an oil in service. Oil changes are often indicated when the TAN value reaches a predetermined level for a given lubricant and application. An abrupt rise in TAN would be indicative of abnormal operating conditions (e.g. overheating) that require investigation. Most lubricant suppliers give TAN condemnation limits in their product data sheets.

- ASTM D2974 Total Acid Number for Hydraulic Oils \ Gear systems

TBN – Total Base Number

The converse of the TAN, this titration is used to determine the reserve alkalinity of a lubricant. The TBN is generally accepted as an indicator of the ability of the oil to neutralize harmful acidic by-products of engine combustion.

- ASTM D2896 Total Base Number for Engine Oils

Visual Inspection

Looking at the oil through a clear sample container can reveal imminent signs of its condition. Visible wear debris can be noted, colour and odour are also evaluated to determine the level of emulsification and oxidisation or to identify contaminants.

Figure 1: Oil Colour Chart

Guide to Typical Oil Odours:

Oxidation - sour or pungent odour, acrid (rotten egg) smell or something similar to stale cheese

Thermal Failure - smell of burnt food

Bacteria - stench, road-kill smell

Running High Temperatures - no odour

Contaminants - solvents, refrigerants, degreasers, hydrogen sulphide, gasoline, diesel, kerosene and process chemicals

Amino Acids - fish odour

Nitro Compounds - almond-like scent

Esters (Synthetic Lubricants) and Ketones - perfume odour

SPECTROMETRIC ANALYSIS

Spectrometric Analysis is the technology that is most commonly used for trending the concentrations of wear-metals. The main focus of this technology is to trend the accumulation of small wear metals, elemental constituents of additives, and identification of possible introduction of contaminants. The results are reported in parts per million (PPM).

NOTE: It is important to remember that these technology only monitors the smaller particles present in the oil up to 10µm in size. Any large wear metal particles present will not be detected or reported. We utilise wear debris analysis to monitor wear and contamination particles.

Spectroil-M

The Spectroil M uses the time tested and well established rotating disk electrode (RDE) method, still the best means available to analyse wear metals, contaminants and additives in lubricants and greases and most fuels. The method, which undergoes continual improvement, is key to Spectroil's many features. The model purchased by Oil Test has the most advanced optics for an oil analysis spectrometer in the country at present. With precision analysis of 21 elements (19 reported on our analysis sheets), we are able to give our clients precise and accurate results.

Spectrographic Element Guide – General

There are many special situations and conditions that must be considered when interpreting elemental oil analysis data. It is always beneficial to have detailed knowledge of the machine's metallurgical makeup if possible. It is also important to be familiar with the operating environment, common contaminants other close proximity materials that may enter the oil system. Below is a general guide to the source of elements measured by Oil Test.

WEAR METALS

Lead	Overlay of most main/rod bearings.
Iron	Wear originating from rings, shafts, gears, valve train, cylinder walls, and pistons in some engines
Aluminium	Indicates wear of pistons, rod bearings and certain types of bushings. Can be a component of silicon
Copper	Wear from bearings, rocker arm bushings, wrist pin bushings, thrust washers, other bronze and brass parts. In some transmission, wear from discs and clutch plates. Oil additive or anti-seize compound
Chromium	Primary sources are chromed parts such as rings, liners, etc., and some coolant additives.
Tin	Indicates wear from bearings when babbitt overlays are used. Also an indicator of piston wear in some engines.
Nickel	Secondary indicator of wear from certain types of bearings, shafts, valves and valve guides.

Silver	Wear of bearings which contain silver. In some instances, a secondary indicator of oil cooler problems.
Titanium	Alloy in high quality steel for gears and bearings.
	CONTAMINANTS
Silicon	A measure of airborne dust and dirt contamination, usually indicating improper air cleaner service
Sodium	Coolant additive; used as an additive in some oils. Can also indicate water ingress or condensation due to prolonged periods of shutdown.
Vanadium	Heavy fuel contaminant - trace element.
	OIL ADDITIVES
Magnesium	Dispersant, detergent additive, alloying metal.
Zinc	Antioxidants, corrosion inhibitors, anti-wear additives, detergents, extreme pressure additives.
Molybdenum	Indicates ring wear. Used as an additive in some gear oils.
Calcium	Detergents, dispersants, acid neutralizers.
Phosphorous	Antirust agents, spark-plug and combustion chamber deposits.
Boron	Coolant additive; used as an EP additive in some gear oils to improve load handling characteristics.
Barium	Corrosion inhibitors, detergents, rust inhibitors

For a more detailed reference on elemental sources for used oil analysis, we can provide further information and training to your maintenance personnel.

INFRARED ANALYSIS

When an organic compound, such as lubricating oil, is exposed to infrared light, the substances present in the compound will absorb the light at specific wavelengths. The amount of absorbance at a particular wavelength is related to both the type and quantity of absorbing material. When the infrared absorbance spectrum of unused oil provided by the customer is compared to the spectrum of the same type of used lubricant, certain contaminants and physical changes in the lubricant can be directly measured. Although infrared analysis can detect and measure an extremely wide range of organic compounds, it is most frequently used in oil analysis to monitor:

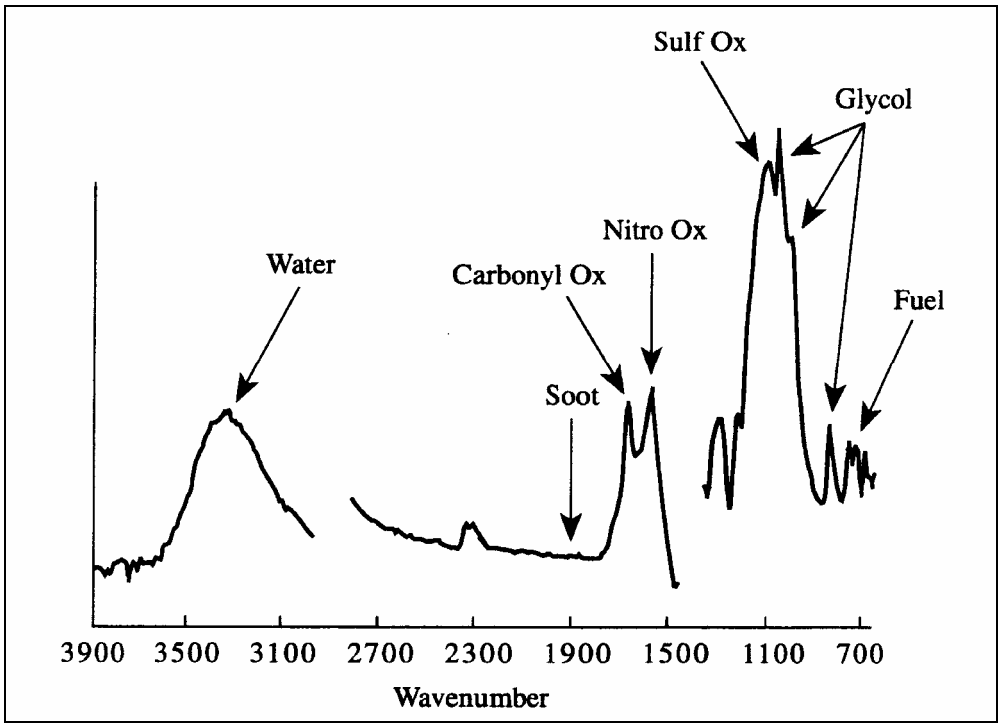


Figure 2: Used-oil difference spectrum

Soot

The amount of fuel soot carbon suspended in the engine lubricant. Higher values indicate reduced combustion efficiency due to such conditions as air intake or exhaust restrictions, injector malfunctions or excessive idling. Test results are reported on an absorbance scale and trended.

Fuel Dilution

Fuel residue in the oil indicates that the engine has worn piston rings or internal leaking fuel lines. Fuel decreases the oil's viscosity, thus reducing its ability to lubricate and protect the engine. In addition fuel in the oil poses a fire hazard. Test results are reported in % volume.

Oxidation

The chemical incorporation of oxygen into and subsequent loss of lubricant performance due to aging, adverse or abnormal operating conditions or internal overheating. Test results are reported on an absorbance scale and trended.

Nitration

The organic nitrates formed when combustion by-products enter the engine oil during normal service or as a result of abnormal 'blow-by' past the compression rings. Test results are reported on an absorbance scale and trended.

Sulfation

Sulfur reaction products are present as a result of sulfur-containing fuel that forms sulfates upon combustion and the incorporation of these sulfates in the oil. These materials lead to acidic precipitates that react with the base reserve additive in the oil. Sulfation is a fairly specific measure of base additive composition and is likely more reliable that the normal TBN evaluation. Test results are reported on an absorbance scale and trended.

Water Contamination

Water contamination produces a characteristic peak in most oils, which can be easily measured. Test results are reported in % volume and are confirmed by crackle testing and chemical determination of the exact volume.

Glycol

Used to confirm is coolant leakage is taking place (if a glycol based coolant is being used). Test results are reported in % volume from 0.1% and above.

ZnDTP – Antiwear Depletion

As oil ages the reserve of phosphate antiwear additive will decrease over the life of the lubricant in service. By trending ZnDTP we can evaluate the rate of antiwear additive depletion. Results are typically represented as negative values, the lower the result the higher the rate of additive depletion detected.

- At Oil Test we analyse and trend all of the above FTIR indicators within our laboratory-reporting environment to determine oil condition.
- To conduct FTIR analysis accurately we require a “new” oil sample to base the analyses on. We have an extensive library of “new” oil samples on hand for this purpose, however a sample of oil from your site provides the most accurate reference point.

PARTICLE COUNT ANALYSIS

Abnormal particle contamination levels are associated with increased wear, operational problems, with close tolerance components, fluid contamination or degradation and loss of filter efficiency. Oil Test uses a special detector, which counts and sizes particles present in the fluid. Results are reported as numbers of particles in a specific size range per a given volume of sample. We have customisable particle analysis reports to monitor oil cleanliness, filter effectiveness and particle generation.

ISO 4406 Cleanliness Analysis

The ISO 4406 Particle Contamination Code simplifies the reporting of particle count data by converting the particle count results into classes or codes. An increase from one code number to the next generally indicates a doubling of the particle contamination level. The ISO Code scale numbers are based on total particles equal to or greater than a given size range as detailed in the table below.

Originally designed to monitor hydraulic and turbine oil system cleanliness, this method is now being used to monitor a range of componentry and to establish and maintain a level of cleanliness of new lubricants from the manufacturer. In 2000 the international standards committee updated the size ranges to 4, 6, and 14 microns, which is now the lubricant industry default. Previous ranges used by other laboratories with older equipment are 2 (unofficial), 5, and 15 microns to the 1994 standard.

Oil Test reports particle counts per millilitre of sample to the 2000 ISO 4406 Standard. Studies have shown that, an improvement in particle contamination by one ISO Cleanliness Code can result in a 10 to 30 percent increase in the life of contamination-sensitive components such as hydraulic valves, pumps, and journal and rolling element bearings.

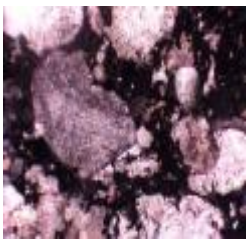
ISO Class	Particle Range
1	0 - 2
2	2 - 4
3	4 - 8
4	8 - 16
5	16 - 32
6	32 - 64
7	64 - 130
8	130 - 250
9	250 - 500
10	500 - 1000
11	1000 - 2000
12	2000 - 4000
13	4000 - 8000
14	8000 - 16,000
15	16,000 - 32,000
16	32,000 - 64,000
17	64,000 - 130,000
18	130,000 - 250,000
19	250,000 - 500,000
20	500,000 - 1,000,000
21	1,000,000 - 2,000,000
22	2,000,000 - 4,000,000
23	4,000,000 - 8,000 000
24	8,000,000 - 16,000,000
25	16,000,000 - 32,000,000
26	32,000,000 - 64,000,000

Oil Wear Debris Analysis

As spectrometric analysis carried out on the oil sample can only detect up to a maximum size of 8 to 10µm (microns), further tests are better suited to detected particles greater than 10 microns.

Typically suited larger componentry on equipment such as Fixed Plant, Shovels and Draglines, Wear Debris Analysis has proven to be also an effective fault diagnosis tool for monitoring Gear Cases, Transmissions, Final Drives and Hubs on mobile earthmoving equipment. Wear Debris Analysis performed on an oil sample involves removing the debris contained in the oil and depositing it on a filter medium to carry out a microscopic examination of the wear and contamination debris.

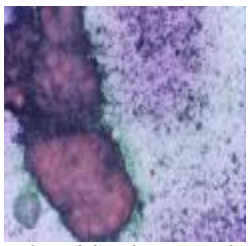
Utilising a microscope equipped with a digital camera, our condition monitoring engineers can monitor the condition of your equipment and can provide a very early indication of possible critical wear damage and help assess the root cause of the failure. An image is captured and store in our database or each sample examined for trending purposes.



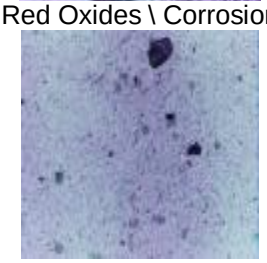
Fatigue Chunks

Non-Ferrous Bearing Wear

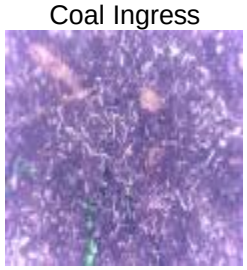
Gear Spalling



Red Oxides \ Corrosion



Coal Ingress



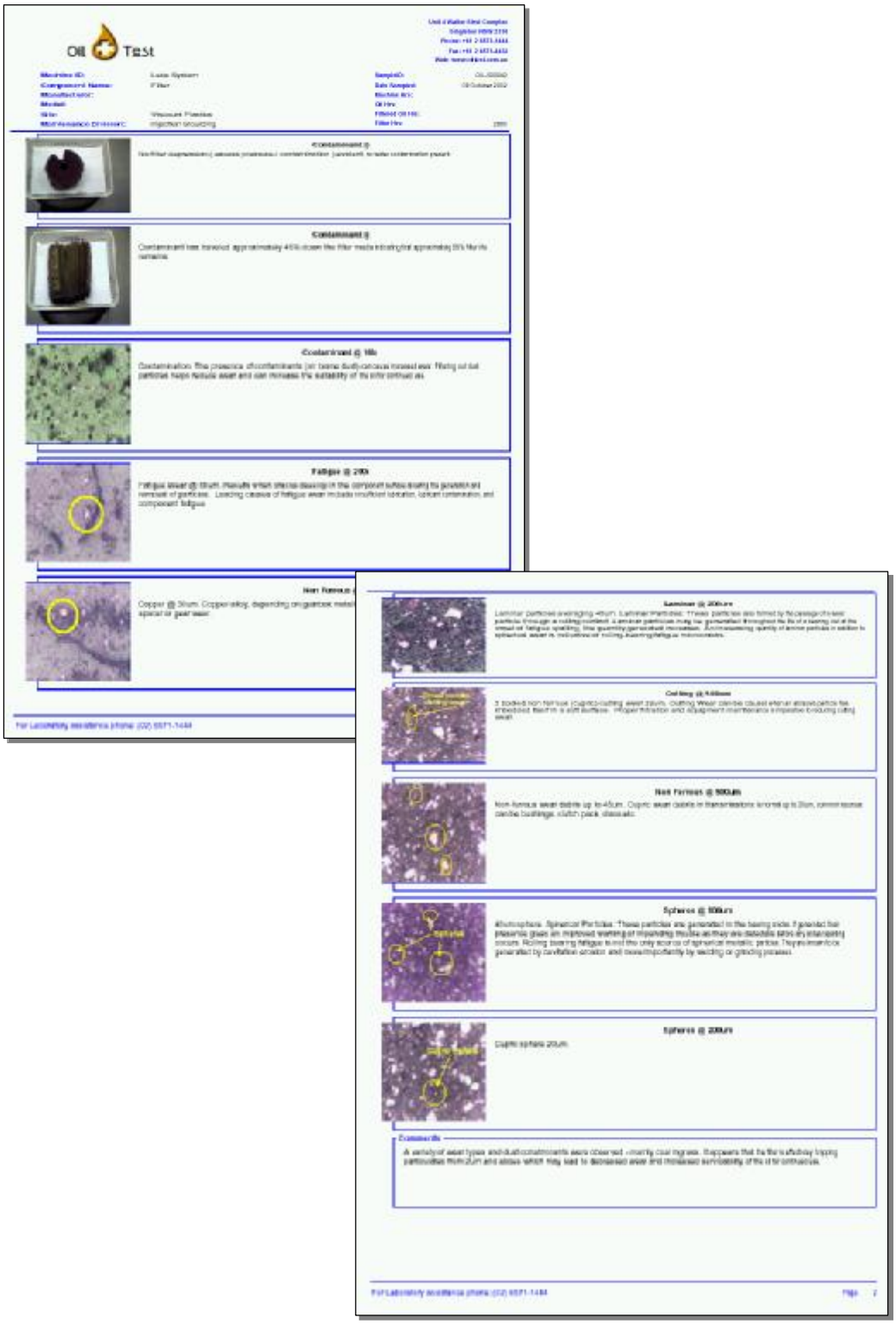
Filter Failure - Fibres & Contamination

Grease Wear Debris Analysis

Wear Debris analysis on greased bearings is also available to give you an indication of condition and remaining useful life.

Filter Examination Analysis

We regularly examine oil and fuel filters for signs of contamination ingress (water, bacteria and solid particles), wear generation, and filter integrity.



Additional Services:

- Oil Filter Debris Analysis
- Magnetic Plug Particle Analysis
- Grease Wear Debris Analysis
- New Oil Quality Checks for lubricants delivered to site
  - Oil Cleanliness Analysis, reported to ISO4406
  - Water Content %
  - TBN (Engine Oils)
  - TAN (Gear & Hydraulic Oils)
  - Additive levels (ppm)
  - Contamination levels (ppm)
- Coolant Analysis
- Scanning Electron Microscope Analysis (failure investigation)
- Hydrocarbon Cleanliness Analysis to ISO4407 and ISO11500 standards.
- Diesel Fuel Testing
- Oil Analysis Training (complementary)

Additional Testing Capability

D482	Ash% *
D524	Carbon Residue, 10% Residue *
D4737	Cetane Index (calc) *
D1317 (Modified)	Chloride
D2500	Cloud Point *
D1500	Colour *
D130	Copper Strip Corrosion *
D1401	Demulsibility
D1298	Density @ 15 degrees C *
D877	Dielectric Strength *
D3612-85	Dissolved Gas Analysis
D86	Distillation *
D2265	Dropping Point of Grease
OTM04.1	Ferrography (Analytical)
OTM04.2	Ferrography (Analytical) on Grease
OTM04.3	Ferrography (Direct Reading)
OTM04.0	Filter Patch Analysis
D92	Fire Point (Flash Point Required)
D92	Flash Point *
D892	Foam Test
OTM03	Fuel %
D2982	Glycol (Positive/Negative)
D4898	Gravimetric Solids
OTM09	Infrared (Fixed Points/Single Beam)
D893	Insolubles-Pentane (Coagulated or Uncoagulated)
D893	Insolubles-Toluene (Coagulated or Uncoagulated)
	Micro-Organism (Positive/Negative) *
D2272	Oxidation Stability (RBOT)
	Particle Count
D2276	Particle Contamination *
D4059	PCB Detection
D1403	Penetration of Grease
D97	Pour Point *
D924	Power Factor
D1169	Resistivity
D665	Rust Preventing Characteristics
Modified D96S	Solids & Water % (Centrifugation)
Sartorius Balance Method	Specific Gravity
D5185 and D4951	Spectrometric Metals (21 Metals) *
Modified D5185 & D4951	Spectrometric Metals on Ethylene Glycol
Modified D5185 & D4951	Spectrometric Metals on Grease
D1522/D4294	Sulfur Content *
D974 or D664	Total Acid Number
D664	Total Base Number
D4768	Transformer Oil Oxidation Inhibitor (DBPC & DBP)
D2270	Viscosity Index (Incl. Viscosity @ 40 and 100)
D445	Viscosity @ 40 degrees * and 100 degrees C
D1796, D96	Water and Sediment % *
D95	Water % by Distillation *
D1744	Water-Part per million (Karl Fischer) *

Grease Analysis

D1403	Penetration of Grease
D2265	Dropping Point of Grease
Modified D5185 and D4951	Spectrometric Analysis
OTM04.2	Ferrography (Analytical)

Sundry Analysis

D877	Dielectric Strength
D1524	Visual/Colour
D1298	Specific Gravity
D974	Total Acid Number
D971	Interfacial Tension
D3612	Dissolved Gas
D924	Power Factor
D4768	Oxidation Inhibitor (DBPC & DBP)
D1533	Karl Fischer Water
D4059	PCB Detection
D877	Dielectric Strength

* - Indicates tests that are applicable on fuel sample

Reporting

Oil Test has a variety of reporting options to meet your requirements.

- ü Batch Summary Reporting
- ü Chemical Analysis Report
- ü Wear Debris Analysis Report
- ü Filter Examination Report
- ü Particle Analysis Report
- ü ASTM Method Report
- ü Custom report formats to suit your requirements

Condition Codes

They key to our reporting system is the four-stage icon condition coding system that quickly identifies the sample condition.

J OKAY	Oil and Machine condition normal.
$ MONITOR	Minor defect detected – monitor trend.
K WARNING	Defect detected action is required at next service interval.
L PROBLEM	Major defect detected, immediate action required.

Delivery Methods

We have a number of report delivery methods to suit your operation. The majority of our clients receive their reports via e-mail within hours of us receiving their samples.

Phone - Immediate alert raised on problem samples
E-Mail - Full colour reports in Adobe Acrobat format
Fax - Reports faxed to your office at your request
Printed - Reports posted to your office at your request

Feedback Loop

The key to making your oil analysis program pay for itself is to implement a mechanism of regular feedback to the laboratory. Within our laboratory control system we have the ability to record maintenance actions in a history file. When an alert or problem sample is detected the maintenance history can be reviewed before making the final evaluation and recommendation.

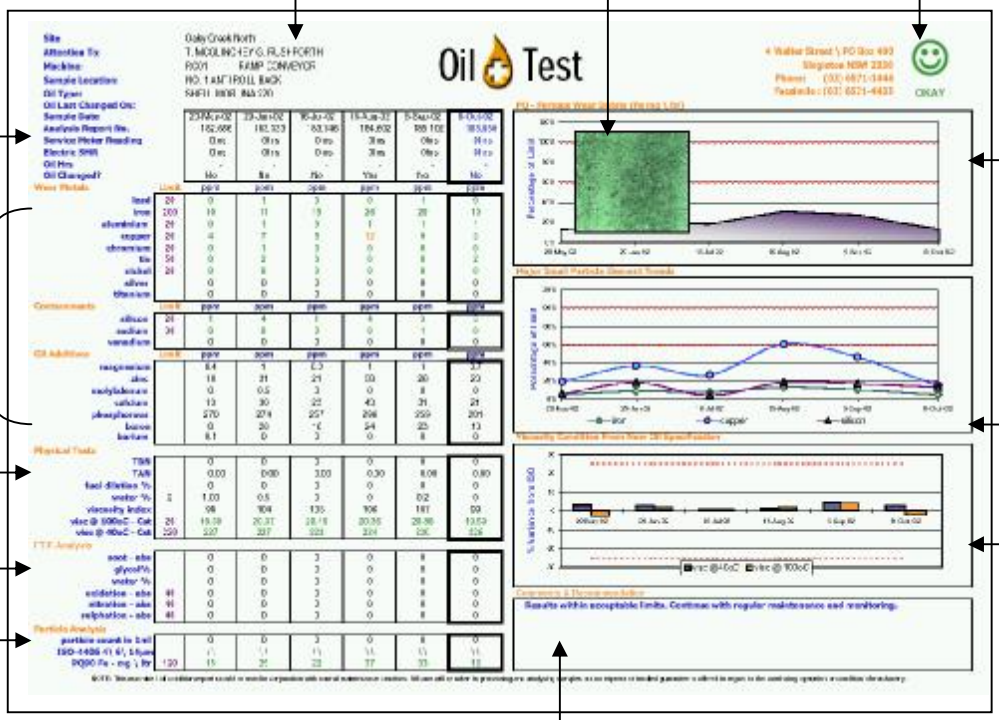
Wear Metal Analysis - Report Layout

Sample Date
Report No
Meter Reading
Oil Hours
Oil Changed

Client Details
Machine Details
Sample Location
Oil Type

Digital Pictogram – displaying contaminants and wear debris observed.

Oil & Machine Evaluation – 4 level condition Reporting.
- J Normal
- $ Monitor
- K Warning
- L Problem



Particle Analysis detailing particle count, ISO 4406 Count and PQ Ferrous Quantity result.

Maintenance based recommendation detailing elevated results, source and appropriate course of action to be taken.

Viscosity Trends Graph - 40°c and 100°c trended against new oil specification.

FTIR Analysis – Soot, Glycol, Oxidation, Nitration and Sulphation levels.

Spectrometric Analysis – 19 elements tested and true results displayed to two decimal places. Results are broken into the three categories of;

- ü **Wear Metals**
- ü **Contaminants**
- ü **Oil Additives**

Colour coded against a maximum limit, problem results can quickly be identified.

GREEN {0-60% of limit}
ORANGE {60-99% of limit}
RED {>=100% of Limit}

Element Trend Graph – Iron, Copper and Silicon trended against maximum limit. Includes Orange Warning and Red Action limit lines.

Physical Test Results – TAN, TBN, Fuel Dilution, Water Content, Viscosity @ 40°c, Viscosity @ 100°c and VI (Viscosity Index).

PQ Trend Graph – Displays Mg \ Ltr of Iron (Including large wear particles) trended against maximum limit.

Trending Software Options

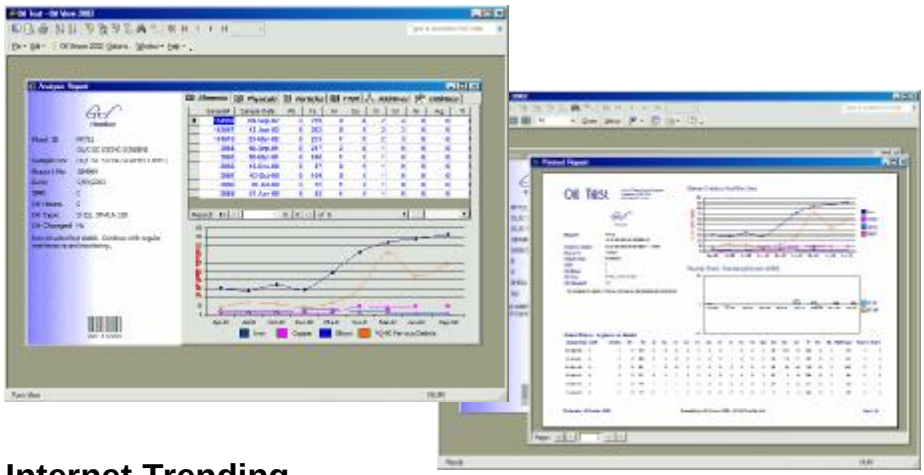
At Oil Test we believe that the data belongs to the client and to facilitate this we have a variety of solutions to help our client maintain a complete historical record of their oil condition monitoring.

Oilview 2002

Oil Test offers a complementary Microsoft Access Database trending package to its clients – "Oilview 2002". Used to review past analysis history, trends and reporting comments, this simple to use package provides an effective maintenance-planning tool.

Data is updated for each batch of samples processed by simply saving an update file into a specified directory and pressing a button within "Oilview 2002", which ensures that your database is kept up-to-date at all times.

Versions available for Access 97, 2000 and XP.



Internet Trending

Internet reporting and trending is an exciting new innovation available to our clients with our in-house web systems and external packages including a module for Dingo Maintenance Guy. Break down the barriers, which exist to information sharing. Consolidate all types of condition monitoring data in one robust central database. Each site can access its own data, and compare that with data from other parts of the organisation nation wide.

Third Party Trending \ Maintenance Packages

Results can be sent to you in ASCII text or CSV file format for automatic input into third party trending tools or your maintenance management system. We have export routines in operation for;

- Monitor \ Monitor 2
- Dingo Lube Explorer
- Dingo Fleetoil
- Dingo Maintenance Guy
- CSI RBMWare
- Entek Odsey
- CPM, CPM/2 & QM Maintenance Management Systems
- And other proprietary systems as requested by our clients

Turnaround

Laboratory turnaround times are typically around 4-6 hours from receipt of samples. We guarantee a maximum turnaround of 24 hours from receipt of samples seven days a week including public holidays.

Laboratory - Ph: (02) 6571-1444
Mike O'Brien - 0405 144232
Graeme Vivian - 0410 329950

Training

At Oil Test we encourage our clients to visit our laboratory and equally encourage our personnel to visit client sites to appreciate the environment that the equipment works in. We have a range of training modules available including;

- Laboratory Tours
- Result Reading and Interpretation
- Oil Analysis Basics – Mobile Equipment
- Oil Analysis Basics – Fixed Plant
- Advanced Oil Analysis techniques (statistical analysis)
- Best Sampling Practises