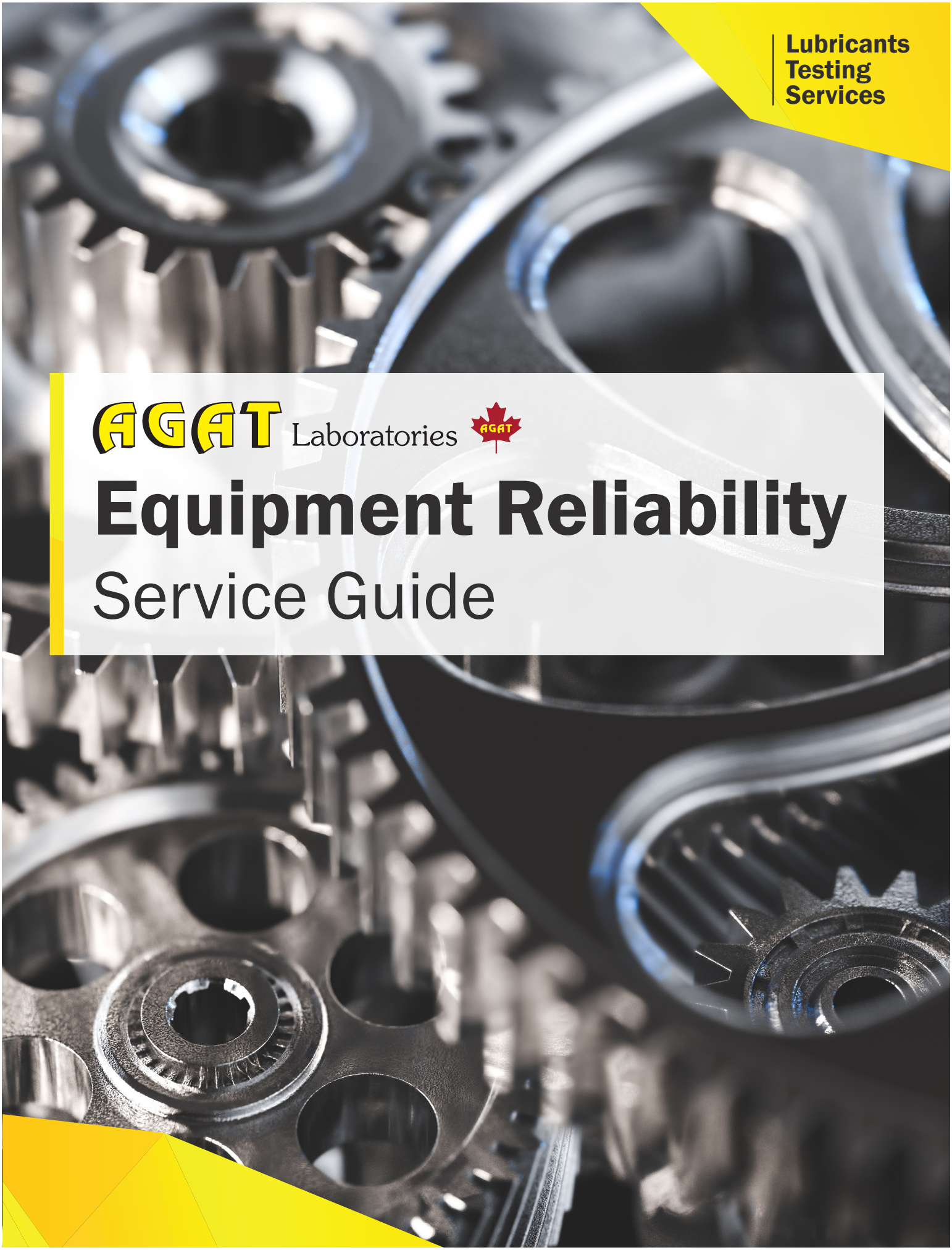


Lubricants
Testing
Services

AGAT Laboratories

Equipment Reliability

Service Guide

About AGAT Laboratories

AGAT Laboratories is a highly specialized Canadian company providing analytical solutions worldwide. As Canada's sole privately-owned laboratory network, AGAT Laboratories is renowned for providing accurate, timely and defensible solutions to complex analytical requests with a constant focus on ensuring "Service Beyond Analysis" to its national and international clients. With 43 locations and 1,200 employees coast to coast, AGAT Laboratories is comprised of 12 scientific divisions that service a wide spectrum of industries, namely, Environmental Chemistry, Mining Geochemistry, Petroleum Testing, Oil Sands Analysis, Rock Properties, Reservoir Characterization, Lubricant Testing, Air Quality Monitoring, Forensic Chemistry, Ultra-Trace and Toxicology, Food Testing, and Agricultural Analysis.

For more information, please visit **www.agatlabs.com**, follow us on **LinkedIn**, **Twitter** and **Instagram**, and subscribe to our **YouTube channel**.

AGAT Laboratories

Equipment Reliability and Lubricant Testing Laboratory Partnership Program

AGAT Laboratories has supported clients through a combination of services, visions and innovations for over 30 years. As a leader in the delivery of laboratory services, our business is highly diversified across a spectrum of scientific divisions, geographies and value-added services.

Our Partnership

As a valued client to AGAT Laboratories, we would like to remind you of your complementary value-added services offered through our Laboratory Partnership Program where we provide you the following benefits:

- **Client Project Managers:** Dedicated to your account is a highly-trained and qualified Client Project Manager who over sees all aspects of your laboratory program.
- **WebOAS:** Schedule a demo with your Business Development Representative to learn more about our WebOAS e-services program where all your reports are available online.
- **Technical Information Seminars:** Schedule your customized training seminars designed to provide your team with technical information on laboratory processes, quality control, equipment reliability improvements, and lubrication.
- **Pre-labeled Sampling Kits:** We will provide you with containers and jars for sampling. We also offer these supplies pre-labeled with client information and customized sample submission forms.
- **Oil Analysis Trouble Shooting Guide:** Find out useful information about your analysis and results by asking about our Oil Analysis Trouble Shooting Guide, and our Troubleshooting Equipment Problem Paper series.
- **Accreditation:** To ensure AGAT Laboratories provides you with service beyond the industry standard, our Equipment Reliability and Lubricant Testing division is accredited by ISO 9001:2015 and ISO/IEC 17025:2005.
- **Coast-to-Coast Locations:** AGAT Laboratories operates an extensive network of laboratories and branches across Canada, ensuring our clients have access to cost effective and timely analyses. We are proud to set the standard for the laboratory industry, pursuing creative, accurate and defensible solutions to your complex analytical requests. Visit our website or Branches and Depots manual for an up-to-date list of our locations.
- **Client Feedback and Continuous Improvement:** Client satisfaction and continuous improvement is our priority, please fill out our confidential online customer review form to submit your feedback at www.agatlabs.com/resources/client-forms.cfm
- **Research and Development:** As part of our Research and Development program we would like to identify any areas of your operations where new innovations are needed. Submit your ideas online at www.agatlabs.com/about/research-and-development-feedback.cfm.

Individual Lubricant, Fuel, and Coolant Tests		
Product Code	**Description**	**Method**
30-410	ISO Cleanliness	ASTM D7596
30-001	RULER View Test	ASTM D6971
30-002	Varnish Potential Test (MPC)	ASTM D7843
30-465	Cetane Rating	-
30-436	Copper Strip Corrosion	ASTM D130
30-432	Ferrography	-
30-440	Fire Point	ASTM D92
30-453	Flash Point - Cleveland Open Cup	ASTM D92
30-414	Flash Point - Closed Cup	ASTM D56
30-454	Freeze Point in Fuel	ASTM D2386
30-470	Fuel in Lubricating Oil by Gas Chromatography	-
30-471	Coolant in Lubricating Oil by Gas Chromatography	-
30-430	ICP Heavy Metal Scan of Lube Oil	ASTM D5185
30-442	ICP Metal Scan of Lube Oil	ASTM D5185
30-433	Infrared Scan	ASTM E2412
30-435	Moisture by Karl Fischer	ASTM D6304
30-464	R.P.V.O.T (Formerly RBOT)	ASTM D2272
30-437	Sediment and Water (Low Speed Centrifuge)	ASTM D1796
30-438	Total Acid Number	ASTM D664
30-439	Total Base Number	ASTM D2896
30-441	Viscosity at 40 °C and 100 °C	ASTM D445
30-431	Viscosity Index Calculation	ASTM D2270
30-475	Volatile Organic Phosphorous	ASTM D5185
30-877	Conductivity	-
30-482	Flash Point by SETA Flash	ASTM D56
30-876	WISM (Water Separation Index Modifier)	-
30-417	Density	ASTM D1298
30-414	Distillations	ASTM D86
30-480	HUMBUG – Hydrocarbon Utilizing Micro-Organisms	-
30-420	Octane Rating - Motor Method	ASTM D2700
30-418	pH	pH Meter
30-700	Conductivity of Coolant	Conductivity Meter
30-701	Ion Chromatography of Coolant	-
30-702	Boiling Point of Coolant	-
30-703	Glycol % in Coolant	-
30-704	Reserve Alkalinity of Coolant	-
30-707	Total Metal Scan in Coolant	-
30-730	Freezing Point of Coolant	-
30-416	Sediment in Lubricant Oil by Membrane Filtration (Patch Test)	ASTM D4807
30-468	Sediment by Membrane Filtration and Photography	ASTM D4807

Lubricant, Fuel and Coolant Individual Tests	
Product Code	**Description**
30-400	**Basic Wear Package -** ICP Metal Scan, Viscosities at 40C and 100C, Visual Inspection, Oxidation/Nitration/Sulfation/Soot (Full Infrared Scan), Crackle Test for Water, Fuel % by Gas Chromatography (If Fuel Dilution is Suspected)
30-401	**Diesel Engine Package -** ICP Metal Scan, Viscosities at 40C and 100C, Visual Inspection, Oxidation/Nitration/Sulfation/Soot (Full Infrared Scan), Crackle Test for Water, Fuel % by Gas Chromatography (If Fuel Dilution is suspected), Total Base Number
30-402	**Natural Gas Engine Package -** ICP Metal Scan, Viscosities at 40C and 100C, Visual Inspection, Oxidation/Nitration/Soot (Infrared Scan), Crackle Test for Water, Total Acid Number
30-403	**Recirculating Lubrication Systems Package -** ICP Metal Scan, Viscosities at 40C and 100C, Visual Inspection, Oxidation/Nitration/Sulfation (Infrared Scan), Moisture by Karl Fischer (If Crackle Test for Water is Positive), Total Acid Number, ISO Particle Count
30-404	**Complete Analysis Package -** ICP Metal Scan, Viscosities at 40C and 100C, Visual Inspection, Oxidation/Nitration/Sulfation/Soot (Full Infrared Scan), Crackle Test for Water, Fuel % by Gas Chromatography (If Fuel Dilution is Suspected), TBN and TAN, ISO Particle Count or Patch Test
30-003	**Turbine Analysis Package (250 hours) –** Membrane Patch Colorimetry, RULER Test (Remaining Useful Life Evaluation Routine), Ultracentrifuge Rating (Insoluble Contaminants), Total Acid Number, Particle Count, Water by Karl Fischer, Interpretation of Results
30-004	**Turbine Analysis Package (Annual) –** Kinematic Viscosity, Spectrographic Analysis (wear metals, additives and contaminants), Membrane Patch Colorimetry (varnish potential), RULER Test (Remaining Useful Life Evaluation Routine), Ultracentrifuge Rating (Insoluble Contaminants), Total Acid Number, Particle Count, Water by Karl Fischer, Membrane Filtration (Patch) Test and Photographs, Visual Inspection, RPVOT, Conductivity (recommended for group II and III base oils), Interpretation of Results
30-488	**Basic Gasoline Analysis Package -** Density, Distillation, Water Content, Particulate Content
30-489	**Basic Diesel Analysis Package -** Density, Distillation, Cetane Index, Flash Point, Water Content, Particulate Content
30-490	**Fuel Contamination Package -** Distillation, Flash Point (diesel only), Water Content, Particulate Content, HUMBUG
30-492	**Basic Coolant Package (Appearance (color, clarity, precipitate) -** pH, Conductivity, Freeze Point, Boiling Point, Glycol Strength (%), Ion Chromatography (chloride, nitrite, bromide, nitrate, sulfate)
30-493	**Advanced Coolant Package (Appearance (color, clarity, precipitate) -** pH, Conductivity, Freeze Point, Boiling Point, Glycol Strength (%), Ion Chromatography (chloride, nitrite, bromide, nitrate, sulfate), Reserve Alkalinity, Metals by ICP)
Failure Analysis / Root Cause Analysis Services	
30-200	**Component Failure Analysis -** Visual Inspection, Component Laser Cutting (if required), X-ray/Scanning Electron Microscopy Inspection, Root Cause Analysis Report and Interpretation
30-210	**Filter / Foreign Material Analysis -** Visual Inspection, Filter Cutting (if required), Filtration (if required), X Ray Emission and/or Scanning Electron Microscopy Inspection, Filter/Material Analysis Report and Interpretation

On-Site Training / Educational Seminars, On-Site Inspections and Equipment Reliability Program Review	
Location	Seminars can be provided on site or at an AGAT Facility
Choices	Seminar Topics can be taken at once, or 'mix and matched' as required
Certificate	Certificates of Completion available free of charge for Seminars upon request
Seminar Topics	
T1	**Lubrication and Lubrication Analysis Basics** • Lubrication terminology properly defined: alkalinity, acidity, conductivity, viscosity index, shear rate and more • Effective oil analyses of machinery, including engines, turbines, gear drives and hydraulics. • Oil analysis report interpretation and equipment condition analysis. • The significance of the P-F curve
T2	**On-Site Equipment Reliability** • Troubleshooting equipment problems using test and measurement techniques. • 15 economic reasons for using condition monitoring technologies. • Lubricant contamination: a major cause of equipment failure. • Understanding effective grease selection and application. • Unacceptable operating conditions that adversely affect equipment reliability • Effective combination of reliability improvement processes with corresponding predictive maintenance technologies
T3	**Root cause failure classifications and their initiating causes** • Equipment failure defined • Effective data collection for successful root causes of failure. • The seven step process for thorough root cause failure analysis. • Case histories of equipment failures that could have been prevented
T4	**Site-Specific (or Custom Topic) Education Seminar** • Customized Seminar revolving around site specific problems, questions, and equipment • Topics can range from Preventive Maintenance, Total Equipment Reliability, Planning and Scheduling, and more * For a Custom Seminar, you must provide AGAT with a list of questions / topics at least 3-4 weeks in advance, as well as answer basic questions about current reliability practices, to ensure a productive, educational seminar
On Site Inspections	
ON1	**Critical Equipment Identification** • Identify Critical Equipment on Site and select Critical Equipment Sampling Points • Provide Feedback on Sampling Requirements, Required Sampling Equipment, and Scheduling Samples
ON2	**Lubrication Selection and Storage Survey** • Provides feedback on current lubrication storage, selection, and handling procedures • Provides comments and recommendations based on industry best-practices to improve lubrication cleanliness
Value Added Services	
VA1	**Fuel Dilution by Gas Chromatography** - % Fuel in oil calculated when fuel dilution suspected
VA2	**Pre-Printed Labels -** Providing a complete equipment list to AGAT allows for the creation of pre-printed labels for components. This replaces the need for constant ordering of tags, or for writing out information on site.
VA3	**Critical Result Alerts -** Receive critical results quickly with Alert Emails
VA4	**Report Interpretation** - Call or Email during business hours to receive detailed interpretation of sample results
VA5	**Sourcing Sampling Equipment** - AGAT can help you fin-d the right sampling equipment such as valves and pumps

Legend	Legend Description
Required - R	Should be tested on every sample for this component type
Optional - O	Can be useful in certain circumstances, or when specific details are required
Triggered- T	Run free of charge by AGAT when normal testing indicates it is required for a sample
Varnish Specific- V	Should be tested Quarterly or 250 Hours to prevent varnish buildup in Turbine systems
Blank - Not Recommended	Not a recommended test for this component type

Component Type									
	Gasoline Engines	**Diesel Engine**	**Natural Gas Engine**	**Compressors**	**Pumps**	**Geardrives**	**Hydraulics**	**Oil Lubricated Electric Motors**	**Turbines**
Suggested Package	30-400	30-401	30-402	30-403	30-403	30-403	30-403	30-403	30-409
Visual Inspection	R	R	R	R	R	R	R	R	R
Water (Crackle) Test	R	R	R	R	R	R	R	R	R
Viscosity	R	R	R	R	R	R	R	R	R
ICP Metal Scan	R	R	R	R	R	R	R	R	R
FTIR Scan	R	R	R	T	T	T	T	T	T
Fuel % by G.C	T	T							
Total Base Number	O	R	O						
Total Acid Number		O	R	R	R	R	R	R	R
ISO Particle Count			R	R	R	R	R	R	R
Water by Karl Fischer	O		O	T	T	T	T	T	T
Sediment (Patch) Test		O	O	O	O	O	O	O	O
Patch Photography		O	O	O	O	O	O	O	O
RPVOT									O
RULER Test									V
MPC (Varnish Potential)									V
Centrifuge for Varnish									V

Steps to Getting the Most out of your Oil Analysis Program	
The keys to a successful oil analysis program is understanding the reports provided by your oil analysis laboratory, having a strong grasp of your equipment, taking consistent samples, and communication between your team and your oil analysis laboratory.	
1. Understand your Reports	Being able to read and understand the reports is critical. When your oil analysis provider warns you of abnormalities in your sample, it is important that you can identify them on your reports.
2. Know your Equipment	When your oil analysis tells you about an issue, it's important that you or your team knows the metallurgical makeup and operating conditions of that component to better identify the cause of the issue. With new or unfamiliar equipment, your OEM or oil analysis provider can help you translate what you see on your report to what is happening inside your machines.
3. Use the Data	Being able to read the reports and understand your equipment is important, but being able to use oil analysis results for real world decision-making is the entire point of an oil analysis program. Combine your understanding of the data, of the equipment, and of the operating conditions to stop failures, prevent down time, and reduce your operating costs.

WebOAS

Online Data Management System: Overview

WebOAS is an on-line data management system to allow clients to effectively manage their data received from AGAT's predictive maintenance program. This value-added system is a secure database that stores records of all current and historical analysis data, allowing for review, monitoring, and trending. Data can be exported from WebOAS into multiple formats so clients can upload and manipulate information within their own software systems. WebOAS is a web-based program that is integrated with AGAT Laboratories' internal Laboratory Information Management System (LIMS), providing clients with real-time access to analysis and reports while monitoring quality control.

Data Security

AGAT works hard to ensure the confidentiality and integrity of user data; only approved users can access and view data using their confidential Username and Password. The system features multiple-level, protected access for all authorized users. In addition, all data is backed up on AGAT servers on a daily basis, ensuring that your data will always be available for years to come.

Organized and Convenient

WebOAS is user-friendly with a powerful graphics package that sorts and compares all equipment analysis results and enables:

- Trending
- Critical analysis flagging
- Condemning limit notification
- Corrective maintenance recommendations

When WebOAS detects samples with anomalies in the data, the system automatically generates and sends ALERT notifications via email, notifying the assigned users of potential upcoming equipment issues. In addition, all completed analyses are e-mailed in PDF format for easy viewing.

Uploading Historical Data

If users are switching from one Oil Analysis provider to AGAT Laboratories they can provide historical oil analysis data, with the corresponding unit numbers and dates of analysis, to AGAT who will upload it into the WebOAS program.

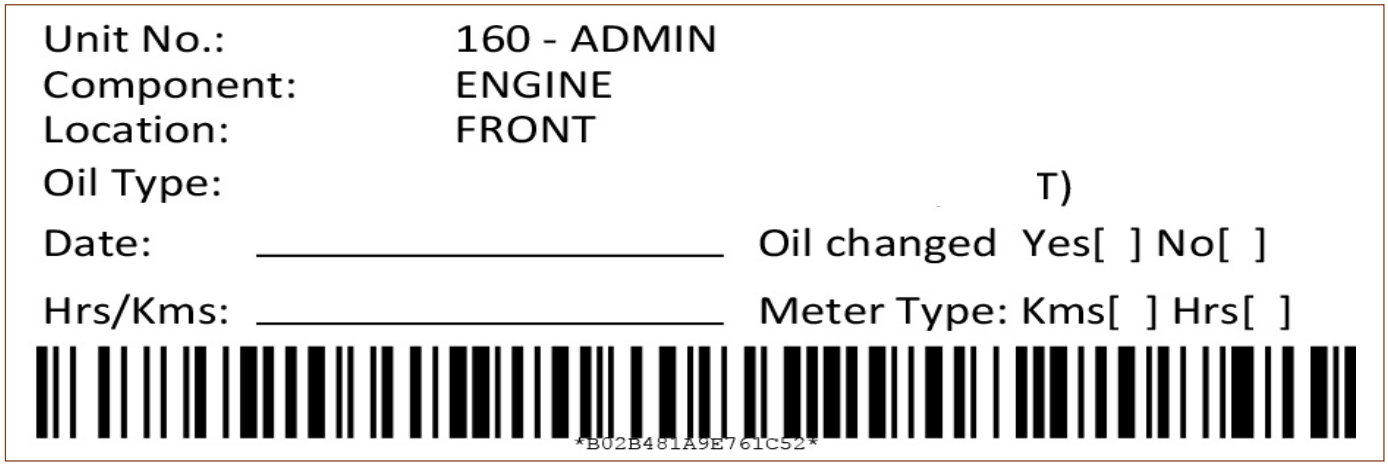
Comments and Document Uploads:

We now provide our clients with the full ability to upload PDF reports and photos of equipment and samples directly to WebOAS. Our clients now have the ability and freedom to make text comments within WebOAS, permitting time stamped comments to be recorded for work done on site, changes to equipment, or repairs made as a result of the analytical reports.

Editing Customization:

WebOAS provides our clients with the ability and ease of more customization, such as editing unit and component information.

Label Printing Feature:



Our software now prints out labels for clients at the press of a button. Clients can use the Dymo label writer, available at http://global.dymo.com/enAU/Products/LabelWriter_450.html to print a barcode label. The user simply adds hours or mileage and if the oil was changed onto the tag, applies the label to the oil sample bottle which is then sent directly to AGAT Laboratories. Not only does this make sample submission easier, but barcoded labels help get your samples to the lab sooner than ever before, ensuring that AGAT Laboratories maintains the fastest sample turnaround time in the industry.

Client: **123456**
ABC COMPANY INC.
100 ABC STREET
CALGARY, AB T2E6V6
ATTN: John Smith

Unit #: **254**
Unit Location: **RED DEER**
Component: **ENGINE**
Location:
Serial #: **123456789XYZ**
Make: **DETROIT DIESEL**
Model: **SERIES 60**
OAS #: **123456**

AGAT Laboratories
Equipment Reliability and Lubricants Testing Services
3650 21st Street N.E., Calgary, AB, T2E6V6
Phone:(403)299-2000 Fax:(403)299-2105

Date analyzed: **10/21/15**
Work order: **15C100000**
Oil brand & grade: **PETRO CANADA DURON E 15W40**
Client Ref #: **123ABC**

LEGEND - LC -Lower Critical LR -Lower Reportable UR -Upper Reportable UC -Upper Critical * Ital -Custom Limit

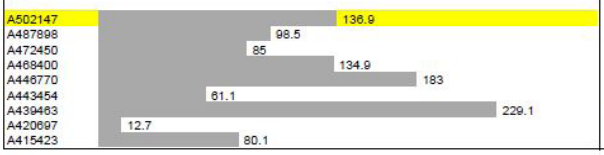
UNIT DATA / SPECTROGRAPHIC ANALYSIS (PPM)

Sample#	Date Sampled	Component Service	Oil Service	Oil Changed	Al Aluminum	Cr Chromium	Cu Copper	Fe Iron	Sn Tin	Pb Lead	Si Silicon	Mo Molybdenum	Ni Nickel	Ag Silver	K Potassium	Na Sodium	B Boron	Ba Barium	Ca Calcium	Mg Magnesium	Mn Manganese	P Phosphorus	Zn Zinc
New Oil					**0**	**0**	**0**	**0**	**0**	**0**	**6**	5	0	0	0	0	13	0	2407	9	0	1029	1247
A502147	06/13/15	mls	20000 mls	Y	**4**	**1**	**49 UR**	**60**	**2**	**7**	**14**	**7**	**0**	**0**	**1**	**4**	**11**	**0**	**2300**	**8**	**1**	**924**	**1090**
A487898	02/05/15	mls	20000 mls	Y	**4**	**2**	**9**	**56**	**3**	**9**	**16**	4	0	0	1	2	5	0	2470	7	1	987	1290
A472450	11/17/14	kms	20000 mls	Y	**3**	**1**	**3**	**54**	**1**	**4**	**18**	2	0	0	1	5	5	0	2320	7	1	1010	1227
A468400	07/11/14	8278 mls	20000 mls	Y	**3**	**2**	**4**	**67**	**3**	**5**	**50 UR**	4	0	0	1	4	9	0	2280	8	1	902	1110
A446770	10/24/13	mls	20000 mls	Y	**3**	**3**	**10**	**123 UC**	**6**	**11**	**27**	4	1	0	1	8	7	0	2250	8	1	963	1129
A443454	07/22/13	mls	4580 mls	N	**3**	**1**	**6**	**26**	**2**	**6**	**18**	4	2	0	1	5	10	0	2470	8	0	938	1077
A439463	06/13/13	mls	20000 mls	Y	**3**	**4**	**39 UR**	**88 UR**	**9**	**8**	**78 UC**	12	1	0	7	46	9	1	1990	10	1	823	984
A420697	09/27/12	43300 mls	20000 mls	Y	**2**	**0**	**1**	**7**	**0**	**1**	**2**	0	0	0	1	3	1	0	2100	8	0	922	1099
A415423	07/31/12	31896 mls	11000 mls	N	**4**	**1**	**16 UR**	**42**	**1**	**7**	**9**	5	1	0	2	5	8	0	2460	9	1	990	1257

PHYSICAL PROPERTIES / ISO CLEANLINESS / OIL DEGRADATION

Sample#	Glycol	H2O	% Fuel	Viscosity 40°C	Viscosity 100°C	% Solids	KF	°C Flash Point	Micron size 4	Micron size 6	Micron size 14	ISO Code	% SOOT	abs/cm-1 OXD	abs/cm-1 NOX	abs/cm-1 COX	abs/cm-1 SO4	abs/cm-1 ZDDP	TAN	TBN	Min. RPVOT
New Oil				105.4	14.5														2.02	8.1	
A502147	N	N		88.6 LC	12.6 LR								1.1	7	7	10	0	0			
A487898	N	N		98.5	13.8								1.0	14	15	16	9	0			
A472450	N	N		100.6	14.1								0.6	6	9	0	0	0			
A468400	N	N		92.0	13.3								1.1	10	14	14	8	0			
A446770	N	N		96.6	12.9								2.4	9	12	12	10	0			
A443454	N	N		95.8	13.3								0.7	5	6	0	0	0			
A439463	N	N		93.9	12.9								1.4	16	16	0	10	0			
A420697	N	N		94.6 LC	13.9								3.9 UR	17	17	17	13	0			
A415423	N	N		88.4	12.7								2.5	12	14	14	9	0			

WEAR CONTROL CHART



COMMENTS

Comments:

The VISCOSITY results were confirmed by rerun. REFER TO REVERSE FOR QUALITY CONTROL REPORT, EXPLANATION OF VARIANCE AND POSSIBLE CAUSES.

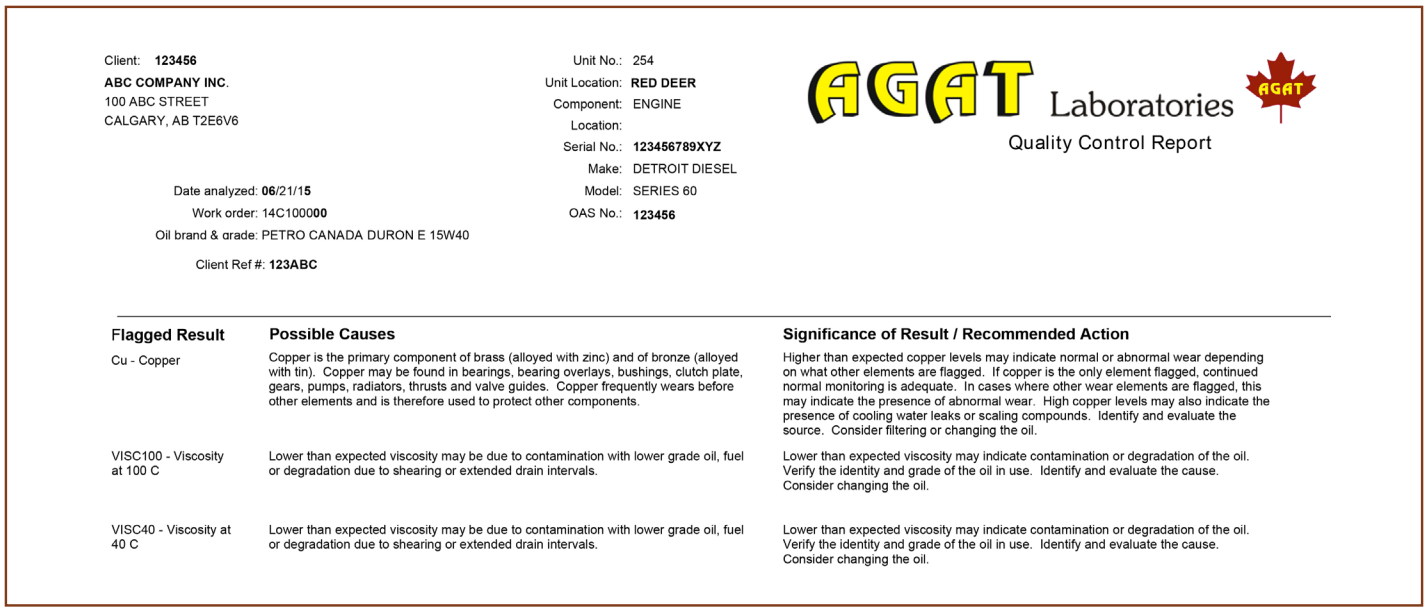
Should you wish to provide feedback to AGAT Laboratories, please access our Customer review form at www.agatlabs.com/review.htm. This input is extremely important to us because your well being and satisfaction is our number one priority.

* COMPONENT SERIAL NUMBER MUST BE GIVEN TO GENERATE HISTORY. Bold faced elements are included in Wear Control Chart.

Reports

Each and every sample analyzed by AGAT has a unique report generated, detailing all of the data collected, providing recommendations and possible suggestions if warning alarms are found, and providing a sample status and trend graphs for a quick review of the component history. Reports contain the following information:

- Unit, component and lubrication information.
- Interpretation of results and corrective action recommendations
- Sample information (date, component hours, oil added or changed, etc).
- Trend graphs for wear metals, as well as graphs displaying the analysis history of the equipment
- A Sample Status from 1 to 10 (from ‘Normal’ to ‘Critical’) indicating the overall severity of the sample
- Analysis results (metal scan results, physical property information, infrared, particle count, TBN, TAN, etc.) with reportable and critical values highlighted for easy identification.
- Field headers containing base-line values for new oil.



Client: **123456**
ABC COMPANY INC.
100 ABC STREET
CALGARY, AB T2E6V6

Unit No.: 254
Unit Location: **RED DEER**
Component: ENGINE
Location:
Serial No.: **123456789XYZ**
Make: DETROIT DIESEL
Model: SERIES 60
OAS No.: **123456**

AGAT Laboratories

Quality Control Report

Date analyzed: **06**/21/**15**
Work order: 14C100**000**
Oil brand & grade: PETRO CANADA DURON E 15W40
Client Ref #: **123ABC**

Flagged Result	Possible Causes	Significance of Result / Recommended Action
Cu - Copper	Copper is the primary component of brass (alloyed with zinc) and of bronze (alloyed with tin). Copper may be found in bearings, bearing overlays, bushings, clutch plate, gears, pumps, radiators, thrusts and valve guides. Copper frequently wears before other elements and is therefore used to protect other components.	Higher than expected copper levels may indicate normal or abnormal wear depending on what other elements are flagged. If copper is the only element flagged, continued normal monitoring is adequate. In cases where other wear elements are flagged, this may indicate the presence of abnormal wear. High copper levels may also indicate the presence of cooling water leaks or scaling compounds. Identify and evaluate the source. Consider filtering or changing the oil.
VISC100 - Viscosity at 100 C	Lower than expected viscosity may be due to contamination with lower grade oil, fuel or degradation due to shearing or extended drain intervals.	Lower than expected viscosity may indicate contamination or degradation of the oil. Verify the identity and grade of the oil in use. Identify and evaluate the cause. Consider changing the oil.
VISC40 - Viscosity at 40 C	Lower than expected viscosity may be due to contamination with lower grade oil, fuel or degradation due to shearing or extended drain intervals.	Lower than expected viscosity may indicate contamination or degradation of the oil. Verify the identity and grade of the oil in use. Identify and evaluate the cause. Consider changing the oil.

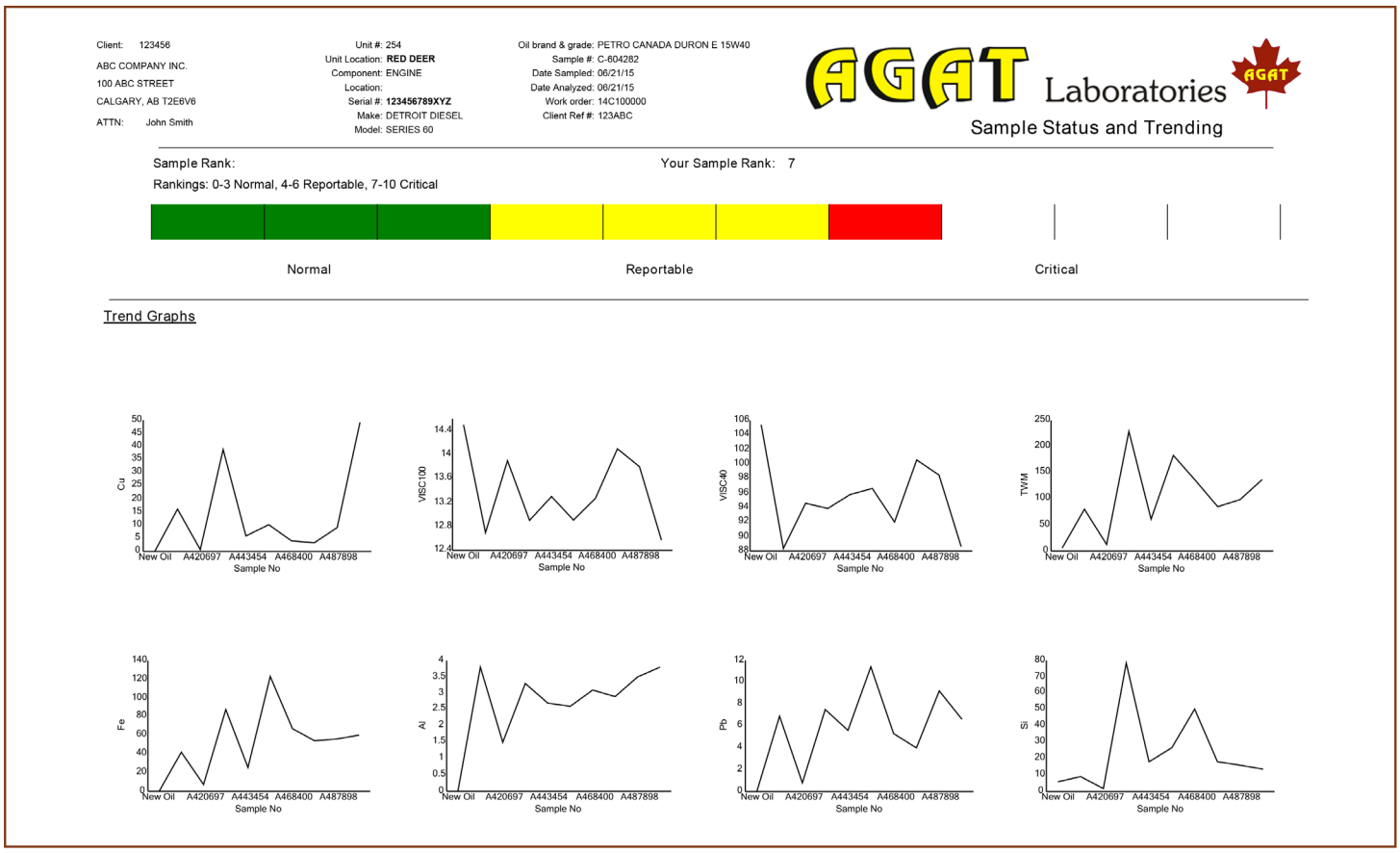
Taking Oil Samples

Frequently, oil samples are taken which are not representative of the oil in the lubrication system. It is important for the troubleshooter to follow several fundamental rules when obtaining oil samples:

- Take oil samples while the equipment is running or immediately after shutdown. This will ensure a representative oil sample from lubricant that has been allowed to reach its operating temperature with all contaminants suspended.
- Take oil samples before the oil has passed through a filter, particularly if the troubleshooter is concerned about particulate larger than 10-50 micrometers in size.
- Before taking the sample, flush the sampling valve or suction gun to ensure that the sample represents oil from the system and does not contain contaminants that may have been previously trapped in the sample valve or suction gun.
- Oil samples obtained carelessly will result in oil analysis reports that will be misleading and therefore useless to the troubleshooter.
- Oil samples should be taken at the “same interval” (hours or kms), at the “same location”, using the “same method”, and under the “same operating conditions”; if proper trend data, repeatability, and reliability of results are to be expected. Following these guidelines is critical if comparative data analyses (comparing engine wear within a fleet, contamination levels in hydraulic systems, or remaining oil life in industrial equipment) are to be accurate and repeatable.

Interpreting Oil Analysis Reports

Wear metal rates begin higher than expected when a new or rebuilt machine component is put into service and gradually decreases after two or three oil samples. This is due to a “breaking in” period. The wear rate “trend” will establish itself during this period and generally doesn’t increase unless contamination such as dirt, dust, water, anti-freeze, or other contaminants enter the machine through leaking seals or air intake systems. The resulting wear metals are the result of wear, not usually the cause of it.



Any sudden increase in two or more wear elements is cause for concern; for example, an increase in copper, lead, and/or iron suggests journal bearing wear in engines. An increase in silicon, iron, molybdenum (or chromium) suggests a contaminated air intake leak affecting piston rings. A combined increase of iron, chromium, and silicon in a hydraulic system indicates cylinder rod wear caused by dirt or dust contamination. When silicon and aluminum are increasing together, it suggests that contamination is an issue, (aluminum is not always a wear metal). Potassium, sodium, and "sometimes" boron of as little as 35-45 ppm indicates a coolant leak, even if the glycol test is negative.

A sudden decrease in any particular wear metal is not always a good sign. It could mean that the wear particles have increased in size beyond the capability of the spectrometer. Remember that the spectrographic instrument cannot usually detect particles larger than about 6-8 micrometers in size. Wear doesn't go away!

Whenever additive metal levels change significantly, either up or down, it suggests that the wrong lubricant has been added to the machine as a top-up or fill. The presence of additive elements does not mean that the additive remains active; it could be "used up" and no longer effective.

This explains why the tests for TAN 'acid number', (to monitor the remaining lubricant life in natural gas engines and recirculating systems like hydraulics, turbines, and compressors) and TBN 'base number', (to monitor the remaining lubricant life in diesel engines) are so important, as a part of the equipment reliability program.

Above all, remember these four important points:

1. Know the metallurgical make-up of the machine components in your care. (Common wear metals include iron, chromium, nickel, aluminum, copper, lead, tin, silver and sometimes molybdenum).
2. Understand the purpose of the additives in the lubricants used on your site. (Additive metals include boron, magnesium, manganese, calcium, barium, phosphorus, zinc and sometimes copper, molybdenum and sodium).
3. Understand the operating conditions that may affect your equipment; for example, contaminant metals include silicon (dust and dirt), sodium, potassium and sometimes boron (coolant additives) and sodium and aluminum, sometimes as contaminants in dirt, dust, or road salt.
4. Statistically, contaminant particles of dirt, dust, water, excessive levels of wear metals, soot, (in diesel engines) and varnish, (in turbines, natural gas engines and compressors) larger than component bearing clearances, cause over 70% of lubrication related failures.

Notes:

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