Drew Marine®

DREW XP Lube Analysis Program Guide

DREW XP LUBE ANALYSIS PROGRAM

Benefits

Routine lube oil analysis is a critical component for managing asset reliability in any marine application. High expectations and harsh environmental operating conditions present constant obstacles. Monitoring the condition of both the unit and fluid, through analysis, identifies wear-causing contaminants and their effect on performance. As a result, you can:

- **Maximize asset reliability**
- **Optimize equipment performance**
- **Achieve peak efficiency**
- **Extend drain intervals safely**
- **Improve onboard oil purification process**

The **DREW XP Lube Analysis Program** is a maintenance tool that gives you a look at exactly what's going on inside a diesel engine, gearbox or hydraulic system. The program tells you the condition of both the unit and the lube oil without having to disassemble the unit. Since lube oil replacement can be costly and difficult to achieve while underway, lube oil analysis is a unique opportunity that can help you identify small problems before they become costly failures.

DO YOU KNOW WHAT YOUR OIL IS TRYING TO TELL YOU?

High Quality Testing

With the Drew XP Lube Analysis Program, you can be confident you're testing with a laboratory that knows your equipment better than anyone. Drew Marine's independent testing laboratories are ISO 17025 accredited, which is the highest level of quality attainable by a testing laboratory backed by stringent accreditation bodies. This means your Lube Analysis Program is supported by a documented quality system you can depend on to deliver superior testing and customer services.

YOU ARE TESTING WITH MORE THAN JUST A LABORATORY – DREW MARINE KNOWS MARINE EQUIPMENT.

TAKING SAMPLES

When determining sampling frequency, you should always take into consideration whether the equipment is critical to productivity.

Lube Analysis is most effective when samples are representative of typical operating conditions. Dirt, system debris, water, and light fuels tend to separate from lubricants and coolants when system temperatures cool. For optimum results, consider the following best practices:

- Identify appropriate sampling points
- Take samples from the same sampling points each time
- Determine proper sampling intervals
- Take samples while systems are operating under normal conditions or immediately after shutdown while they are still at operating temperature
- Select sampling points where the oil is “LIVE” and in motion – avoid sampling from “DEAD” spaces
- Review sampling strategy onboard with your Drew Marine service engineer.

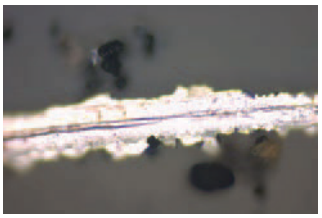
Suggested Sampling Intervals

System	Sampling Interval
Diesel Engine	Monthly or at 250 hours
Hydraulics	250 – 500 hours
Gearboxes	750 hours
Bearings	750 hours
Compressors	250-500 hours

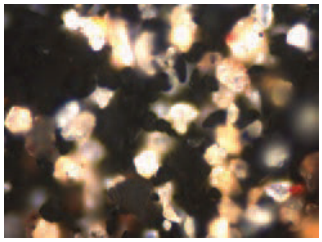
STANDARD OIL ANALYSIS TEST PACKAGE

The **DREW XP Lube Analysis Program** provides diagnostic testing designed to evaluate lubricant condition, component wear, and contamination. Additional test packages such as particle count, ferrography, and micropatch are also available. Contact your Drew Marine representative to learn how to add these as routine tests.

Tests	Method	Engine	Non-Engine
Additive Elements, Wear Metals, and Contaminants	mod. ASTM D5185 ICP-AES	•	•
Water %	Visual Crackle	•	•
Viscosity at 40°C or 100°C	mod. ASTM D445	•	•
Fuel Dilution	Gas Chromatography	•	
Soot %	ASTM E2412, FTIR	•	
Oxidation/Nitration	ASTM E2412, FTIR	•	•
Total Acid Number	mod. ASTM D664		•
Total Base Number	mod. ASTM D4739	•	



500x photomicrograph of ferrography



500x photomicrograph of micropatch

Reading a lubricant analysis report can be a challenging and sometimes seemingly impossible task without an understanding of the basic fundamentals necessary to interpret laboratory results and recommendations. Referring to the report descriptions and explanations below will help you better understand your results and, ultimately, better manage a productive, cost-saving lubricant oil analysis program.

Drew Marine

Lubricant Analysis Report

866-211-7271

0	1	2	3	4
NORMAL		ABNORMAL		CRITICAL

Overall report severity based on comments.

Account Information	Component Information	Sample Information
Account Number: DRWMRN-0000-0000 Company Name: ABC COMPANY Contact: BOB SMITH Address: 123 ANYWHERE STREET ANYWHERE, NJ Phone Number: 123-456-7890	IMO#: 0012345 Call Sign: BLUE MARLIN Component Type: STERN TUBE JOURNAL BEARING Manufacturer: WARTSILA Model: WCS-P-M Application: MARINE Sump Capacity: 0 gal	Tracking Number: Lab Number: I-593938 Lab Location: Indianapolis Data Analyst: JUK Sampled: 25-Jan-2012 Received: 23-Feb-2012 Completed: 24-Feb-2012
Filter Information	**Miscellaneous Information**	**Product Information**
Filter Type: Missing Information Micron Rating: 0	Miscellaneous:	Product Manufacturer: SHELL Product Name: TURBO T Viscosity Grade: ISO 68
Comments	We suggest that a Micropatch be performed to clarify the type of wear and/or contamination that is present; Copper is at a SIGNIFICANT LEVEL; Possible bearing metal;	

	Wear Metals (ppm)										Contaminant Metals (ppm)			Multi-Source Metals (ppm)						Additive Metals (ppm)				
Sample #	Iron	Chromium	Nickel	Aluminum	Copper	Lead	Tin	Cadmium	Silver	Vanadium	Silicon	Sodium	Potassium	Titanium	Molybdenum	Antimony	Manganese	Lithium	Boron	Magnesium	Calcium	Barium	Phosphorous	Zinc
19	4	0	0	0	67	1	1	0	0	0	0	13	0	0	0	0	0	0	0	4	25	0	140	159
20	2	0	0	0	54	0	0	0	0	0	0	4	0	0	0	0	0	0	0	3	19	0	116	134
21	0	0	0	0	32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	13	0	66	70
22	2	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	17	0	86	95
23	0	0	0	1	85	1	0	0	0	0	5	0	6	0	0	1	0	0	3	2	13	1	70	70

	Sample Information						Contaminants			Fluid Properties					
Sample #	Date Sampled	Date Received	Lube Time h	Unit Time h	Lube Change	Lube Added gal	Filter Change	Fuel Dilution % Vol	Soot % Vol	Water % Vol	Viscosity 40°C cSt	Viscosity 100 °C cSt	Acid Number mg KOH/g	Base Number mg KOH/g	Oxidation abs/cm	Nitration abs/cm
19	03-Aug-2011	19-Aug-2011			Unk		Unk			<.1 - Hotplate	67.0		0.29			
20	N/A	26-Aug-2011			Unk		Unk			<.1 - Hotplate	66.6		0.19			
21	08-Sep-2011	23-Sep-2011			Unk		Unk			<.1 - Hotplate	67.6		0.09			
22	23-Dec-2011	22-Feb-2012			Unk		Unk			<.1 - Hotplate	67.0		0.09			
23	25-Jan-2012	23-Feb-2012			Unk		Unk			<.1 - Hotplate	66.6		0.15			

	Particle Count (particles/mL)										Additional Testing
Sample #	ISO Code Based On 4/6/14	> 4 µm	> 6 µm	> 10 µm	> 14 µm	> 21 µm	> 38 µm	> 70 µm	> 100 µm	Test Method	
19											
20											
21											
22											
23											

Comments are advisory only and are based on the assumption that the sample and data submitted are valid. Missing fluid or component information limits the evaluation. No warranty is expressed or implied.

MINIMIZE UNSCHEDULED DOWNTIME TO ELIMINATE COSTLY DISRUPTIONS.

HOW TO READ THE DREW MARINE LUBRICANT ANALYSIS REPORT

Equipment and Sample Information

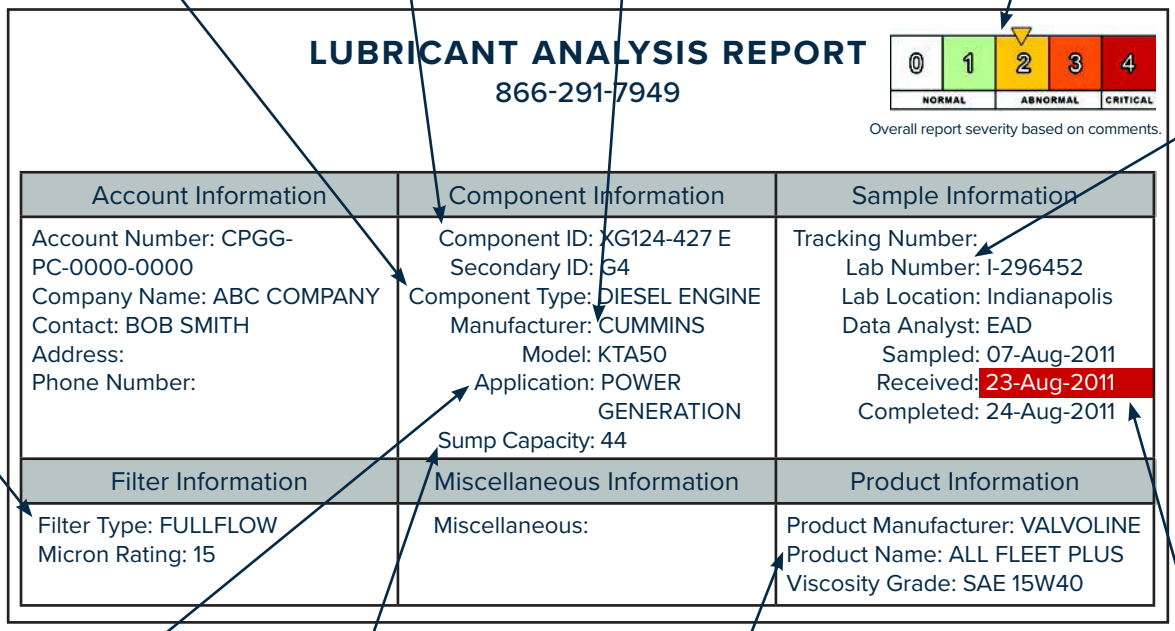
The information submitted with a sample is as important to the one reading the report as it is to the analyst interpreting the test results and making recommendations. Properly document your equipment, and share this knowledge with your laboratory. Implement a sampling process for every piece of equipment in your oil analysis program that can be followed consistently each time the component is sampled. Accurate, thorough, and complete lube and equipment information not only allows for in-depth analysis, but can eliminate confusion and the difficulties that can occur when interpreting results.

Component Type should give as much detail as possible. **What kind** of compressor, gearbox, engine, etc., influences flagging parameters and depth of analysis. Different metallurgies require different lubrication and have great impact the interpretation of results.

Component ID is **each customer's** opportunity to uniquely identify components being tested and their location.

Manufacturer and Model can also identify metallurgies involved as well as the OEM's standard maintenance guidelines and possible wear patterns to expect

Severity Status Levels:
0- Normal.
1- At least one or more items have violated initial flagging points yet are still considered minor.
2- A trend is developing.
3- Simple maintenance and/or diagnostics are recommended.
4- Failure is eminent if maintenance is not performed.



LUBRICANT ANALYSIS REPORT
866-291-7949

0 1 2 3 4
NORMAL ABNORMAL CRITICAL
Overall report severity based on comments.

Account Information	Component Information	Sample Information
Account Number: CPGG-PC-0000-0000 Company Name: ABC COMPANY Contact: BOB SMITH Address: Phone Number:	Component ID: XG124-427 E Secondary ID: G4 Component Type: DIESEL ENGINE Manufacturer: CUMMINS Model: KTA50 Application: POWER GENERATION Sump Capacity: 44	Tracking Number: Lab Number: I-296452 Lab Location: Indianapolis Data Analyst: EAD Sampled: 07-Aug-2011 Received: 23-Aug-2011 Completed: 24-Aug-2011
Filter Information	**Miscellaneous Information**	**Product Information**
Filter Type: FULLFLOW Micron Rating: 15	Miscellaneous:	Product Manufacturer: VALVOLINE Product Name: ALL FLEET PLUS Viscosity Grade: SAE 15W40

Application identifies the type of environment in which the equipment operates and is useful in determining exposure to possible contaminants.

The laboratory at which testing was completed. The following **Lab #** is assigned to the sample upon entry for processing and should be the reference number used when contacting the lab with questions, concerns or feedback.

Filter Types and their **Micron Ratings** are important in analyzing particle count (available for an additional fee) – the higher the micron rating, the higher the particle count results.

Sump Capacity identifies the total volume of oil in which wear metals are suspended and is critical to trending wear metal concentrations.

Product Information identifies a lube's properties and its viscosity and is critical in determining if the right lube is being used

Make note of the difference between the **Date Sampled** and the **Date Received** by the lab. Turnaround issues may point to storing samples too long before shipping or shipping agent problems. Also noted is testing **Date Completed**.

RECOMMENDATIONS

A technical analyst's job is to explain and, if necessary, recommend corrective action when significant changes are found in the lubricant or the unit's condition. Reviewing comments before analyzing actual test results will provide a road map to the report's most important information. Actions that need to be taken are listed in order of severity. Justifications for recommending those actions immediately follow.

Comments	VANADIUM and NICKEL are most likely contaminates from the #6 fuel oil (Bunker-C) used in this application. Water is at a MODERATE LEVEL. Viscosity result is invalid due to water contamination. IR (OXIDATION/NITRATION) RESULTS may be skewed due to excess water; Sample information has been added or tests have been rerun or additional testing was added and the report has been regenerated; SIGNIFICANT FINDINGS from analytical ferrography study. Please refer to analytical ferrography report; SIGNIFICANT FINDINGS from micropatch study. Please refer to micropatch report. Sample RUSHED per customer request.

	Wear Metals (ppm)										Contaminant Metals (ppm)			Multi-Source Metals (ppm)						Additive Metals (ppm)				
Sample #	Iron	Chromium	Nickel	Aluminum	Copper	Lead	Tin	Cadmium	Silver	Vanadium	Silicon	Sodium	Potassium	Titanium	Molybdenum	Antimony	Manganese	Lithium	Boron	Magnesium	Calcium	Barium	Phosphorous	Zinc
1	24	0	32	4	2	1	0	0	0	88	18	57	7	1	0	0	3	0	31	37	17361	1	393	415

	Sample Information							Contaminants			Fluid Properties					
Sample #	Date Sampled	Date Received	Lube Time	Unit Time	Lube Change	Lube Added	Filter Change	Fuel Dilution % Vol	Soot % Vol	Water % Vol	Viscosity 40°C cSt	Viscosity 100 °C cSt	Acid Number mg KOH/g	Base Number mg KOH/g	Oxidation abs/cm	Nitration abs/0.1 mm
1	N/A	18-Jul-2012			Unk		Unk	0.1 - GC	0.4 - FTIR	0.3 - Hotplate		WAT		26.3	13	35

ELEMENTAL ANALYSIS

Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES) identifies the type and amount of wear particles, contamination and oil additives. Determining metal content can alert you to the type and severity of wear occurring in the unit. Measurements are expressed in parts per million (ppm).

Combinations of these **Wear Metals** canidentify components within the machine that are wearing. Knowing what metal a unit is made of can greatly influence an analyst's recommendations and determine the value of elemental analysis.

Knowledge of the environmental conditions under which a unit operates can explain varying levels of **Contaminant Metals.** Excessive levels of dust and dirt can be abrasive and accelerate wear.

Additive and **Multi-Source Metals** may turn up in test results for a variety of reasons. Molybdenum, antimony and boron are additives in some oils. Magnesium, calcium and barium are often used in detergent/dispersant additives. Phosphorous is used as an extreme pressure additive in gear oils. Phosphorous, along with zinc, are used in anti-wear additives.

	Wear Metals (ppm)										Contaminant Metals (ppm)			Multi-Source Metals (ppm)						Additive Metals (ppm)				
Sample #	Iron	Chromium	Nickel	Aluminum	Copper	Lead	Tin	Cadmium	Silver	Vanadium	Silicon	Sodium	Potassium	Titanium	Molybdenum	Antimony	Manganese	Lithium	Boron	Magnesium	Calcium	Barium	Phosphorous	Zinc
3	6	0	0	0	9	0	0	0	0	0	4	0	1	0	0	0	0	0	0	0	20	0	250	212
4	8	0	0	0	12	0	0	0	0	0	3	1	0	0	0	0	0	0	0	1	26	0	259	252
5	7	0	0	0	11	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	19	0	260	242
6	8	0	0	0	11	0	0	0	0	0	3	2	2	0	0	0	0	0	0	0	25	0	239	231
7	7	0	0	0	12	0	0	0	0	0	3	0	0	0	0	0	0	0	2	0	19	0	250	229

	Sample Information	Contaminants	Fluid Properties

HISTORICAL TRENDING

Test results are listed according to age of the sample – oldest to most recent, top to bottom – so that trends are apparent. Significant changes are flagged and printed in the gray areas of the report.

Samples are listed by **Date Received** in the lab-oldest first. They are also assigned a **Lab Number** for easy internal tracking. Important to also note is whether or not the **Lube** has been **Changed** since the last sample was taken.

Viscosity measures a lubricant's resistance to flow and is considered its most important physical property Depending on lube grade, it is tested at 40 and/or 100 degrees Centigrade and reported in Centistokes.

	Sample Information							Contaminants			Fluid Properties					
Sample #	Date Sampled	Date Received	Lube Time	Unit Time	Lube Change	Lube Added	Filter Change	Fuel Dilution % Vol	Soot % Vol	Water % Vol	Viscosity 40°C cSt	Viscosity 100 °C cSt	Acid Number mg KOH/g	Base Number mg KOH/g	Oxidation abs/cm	Nitration abs/cm
3	08-Jul-2008	21-Jul-2008			Unk		Unk			<.1 - FTIR	87.1		0.32		3	6
4	15-Jun-2011	21-Jun-2011			No		Yes			<.1 - FTIR	87.3		0.35		3	7
5	30-Aug-2011	06-Sep-2011			No		Yes				88.6		0.44		2	6
6	09-Sep-2011	27-Sep-2011	1000		Unk		No			<.1	84.3		0.38		2	6
7	16-Dec-2011	16-Jan-2012			Unk		Yes			<.1 - FTIR	88.6		0.39		3	5

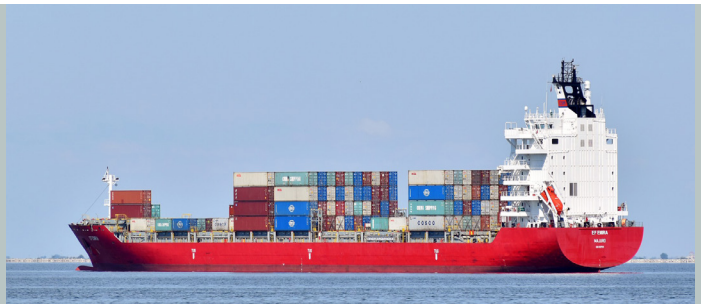
	Particle Count (particles/mL)										Additional Testing
Sample #	ISO Code Based On 4/6/14	> 4 µm	> 6 µm	> 10 µm	> 14 µm	> 21 µm	> 38 µm	> 70 µm	> 100 µm	Test Method	Water by Karl Fischer %
3	23/19/13	58148	4318	316	72	24	2	2	0	Pore	
4	22/21/18	28918	13287	4168	2009	778	123	18	5	Laser	
5	22/17/12	23983	1176	107	33	13	1	0	0	Laser	0.029
6	23/16/13	58347	371	108	60	17	4	2	1		
7	22/21/18	28284	11282	3199	1439	576	81	12	3	Laser	

The **ISO Code** is an index numberthat represents a range of particles within a specific micron range, i.e., 4, 6, 14. Each class designates a range of measured particles per one mL of sample.

The **Particle Count** is a cumulative range between 4 and 100 microns. This test is valuable in determining large particle wear in filtered systems. Contact your Drew Marine representative to add Particle Count to your prepaid testing package.

Fuel and **Soot** are reported in % of volume. Tested by Fourier Transform Infra-Red (FTIR), High fuel dilution decreases unit load capacity. Excessive soot is a sign of reduced combustion efficiency. Applicable to engine oil samples only.

Water in oil decreases lubricity, prevents additives from working, and furthers oxidation. Its presence can be determined by crackle and is reported in % of volume. Water by Karl Fischer method determines the amount of water present. These results appear in the Additional Testing section of your report.



PROACTIVELY IDENTIFY PROBLEMS IN THEIR EARLIEST STAGES TO AVOID UNNECESSARY BREAKDOWNS AND FAILURES.

STEP 1

SAMPLE INFORMATION & COMPONENT REGISTRATION

Complete the Required Sample Information section of your fluid analysis form for every sample submitted to the laboratory, unless the sample is registered and pre-submitted online. Be sure to fill it out completely and accurately to ensure proper testing and accurate, in-depth analysis.

Fill out the Component Registration section ONLY when sampling a new component for the first time or to notify the laboratory of a change in component and/or fluid information already registered with the laboratory.

- Enter the email address of the individual that will receive the Lubricant Analysis Report
- Include all component and fluid information requested including component ID, type of component and position, time on both the fluid and the component, and whether or not the fluid and/or filter has been changed
- Attach one barcode sticker label to sample jar
- Retain one barcode sticker label for your records

STEP 2

SHIPPING SAMPLES

Attach the return address label to the black mailer. If sending all ten samples, use the original packaging with a single return address label attached.

- Include sample jar and sample information form, if applicable, in black mailer
- Dispatch prepared samples by trackable delivery service such as UPS, FedEx, or DHL

STEP 3

SAMPLE REPORTS & ONLINE DATA MANAGEMENT

Lubricant Analysis Reports are emailed within 24-48 hours after the laboratory receives the sample. Drew Marine's free online reporting option – HORIZON® – is fast. After testing is complete, HORIZON provides you access to your results.

Utilize HORIZON® daily to:

- Track the progress of your samples while they are being tested
- Create monthly fluid analysis management reports for each of your vessels
- Place critical components on asset watch and receive email alerts on high severities
- Document maintenance action taken to ensure maintenance personnel act on laboratory recommendations
- Estimate cumulative savings to bring visibility to program value

HORIZON® Login: www.drew-marine.com/horizon.html

Drew Marine.

EXPERIOR PROGRAMME

0 0 0 0 0 A 0 0 0 0 0

Customer Service: 1-866-211-7271
www.drew-marine.com/horizon.html

1 Apply barcode to bottle

2 Submit sample online via HORIZON®
OR complete this form

3 Place form in mailer (unless sample info is submitted online) and ship sample

4 Receive report by email

SAMPLE INFORMATION

Acct # DRWMRN	Customer	INTERNAL USE ONLY
Vessel	Contact	
Address	City - State/Province - Postal Code - Country	
Phone	Email Address	

Sample Point
❑ Engine ❑ Propulsion ❑ Auxiliary
❑ Compressor ❑ Bearing ❑ Gear ❑ Hydraulic
❑ Other_____

Position *(If Applicable)*
❑ Port ❑ Forward ❑ Center
❑ Aft ❑ Starboard ❑ Number_____

IMO # | Call Sign | Date Sampled

New Lube Reference ❑

Lube Time ❑ Hr ❑ Day ❑ Mo ❑ Yr

Component Time ❑ Hr ❑ Day ❑ Mo ❑ Yr

Lube Added ❑ Qt ❑ Gal ❑ Ltr | Lube Changed ❑ Yes ❑ No

Misc | Filter Changed ❑ Yes ❑ No

Comments

COMPONENT REGISTRATION *(Required **ONLY** for registering new components or to request changes.)*

Component Manufacturer | Component Model

Component Type (Check One)

Engine:
❑ Propulsion ❑ Auxiliary
❑ Diesel (AA)
❑ Other_____

Compressor:
❑ Reciprocating (BCREC)
❑ Rotary Screw (BCRSC)
❑ Rotary Vane (BCRVN)
❑ Centrifugal (BCCEN)
❑ Refrigeration (BR)
❑ Turbo Compressor (BTTC)
❑ Other_____

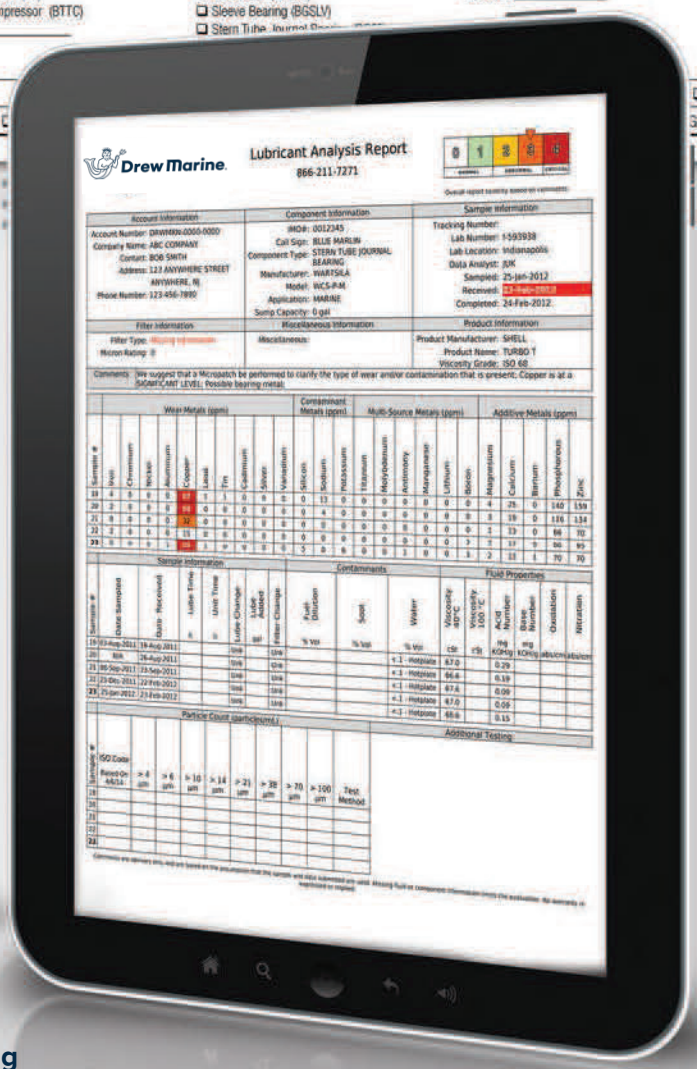
Marine Gear/Bearing:
❑ Journal (BBJRL)
❑ Main Reduction (BBMRD)
❑ Reversing Gear (BBREV)
❑ Turning Gear (BBTUR)
❑ Bevel Gear (BBBVL)
❑ Sleeve Bearing (BGSLV)
❑ Stern Tube Journal Bearing

Hydraulic:
❑ Piston Pump (BHPIP)
❑ Gear Pump (BHGP)
❑ Vane Pump (BHVAN)
❑ Screw Pump (BHRSP)
❑ Other_____

Lube Manufacturer ❑ AGMA

Filter ❑ Full-Flow ❑ By-Pass ❑ Kidney Loop ❑ None ❑ Gal ❑ Ltr

DREW MARINE LABORATORIES
10910 W. SAM HOUSTON PKWY N
SUITE 700
HOUSTON, TX 77064-9903



Note: Component updates can be made online using the Equipment Management feature in HORIZON®

OUR VISION

Drew Marine is the most trusted brand and preferred global resource for marine solutions that enhance the longevity and operating efficiency of ocean vessels.

OUR MISSION

To sustain the superiority of the Drew Marine brand by bringing environmentally and technologically superior products and services for the benefit of vessel owners and operators while increasing shareholder value.

Drew Marine®

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