GETTING RESULTS FAST

A guide to Shell Rapid Lubricants Analysis

Shell Marine Products

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INTRODUCTION TO SHELL RAPID LUBRICANTS ANALYSIS

Shell RLA is an oil condition monitoring service that helps you to keep your vessels running smoothly by identifying potential oil or equipment failures before they become critical.

It acts an early-warning system that aims to give you peace of mind knowing that your equipment and lubricants are in optimum working order.

The Shell RLA service is available to all Shell Marine Products customers worldwide.

SHELL RLA

- Approved in accordance with the requirements of Lloyd's Register Procedures for Approval of Service Suppliers for the provision of used and new oil analysis services for a machinery condition monitoring service.
- Over 30 years of sample analysis, with more than 170,000 samples per year
- The Shell RLA service has been used by over 1,200 customers and more than 9,000 vessels
- Six ISO-accredited laboratories worldwide utilising ASTM and in-house test methods
- Analysis available for all machinery types on board a vessel
- Proven logistics and report response lead times to give an accurate and timely worldwide service
- Easy access via the Internet to a consolidated global database
- Diagnosis by a multidisciplinary team of marine engineering and lubricants experts

BENEFITS AT A GLANCE

Analysing used oil is widely acknowledged as a key tool to help manage preventive and predictive maintenance. Many leading shipping companies utilise Shell RLA as an important part of their planned and predictive maintenance strategies to help deliver

- greater equipment reliability and reduced downtime through early diagnosis of potential faults
- quick and timely results
- lower machine repair costs
- high standards of safety
- precise monitoring of operating efficiency.

Industry analysis suggests that the return on investment within the industry sector can be up to 14 times the investment spent on an oil condition monitoring service.

WHAT OUR SHELL RLA CUSTOMERS SAY

"By implementing the recommendations from Shell's lubricant experts, we have been able to run trouble-free operations on the flash gas compressor over the past two years. The main bearings of the flash gas unit have not failed, and we are fully satisfied with the technical services and support provided by Shell Marine Products." Japan Vietnam Petroleum Co. Ltd

"INDUSTRY ANALYSIS SUGGESTS THAT THE RETURN ON INVESTMENT WITHIN THE INDUSTRY SECTOR CAN BE UP TO 14 TIMES THE INVESTMENT SPENT ON AN OIL CONDITION MONITORING SERVICE."

SAMPLE KIT

A Shell RLA sample kit contains

- 20 empty sample bottles to collect the samples from the equipment
- 20 sample labels in a chequebook format
- 20 mailing envelopes
- 6 sheets of address labels for all the Shell RLA laboratories
- a step-by-step guide to sampling and a world map showing the laboratories and addresses.

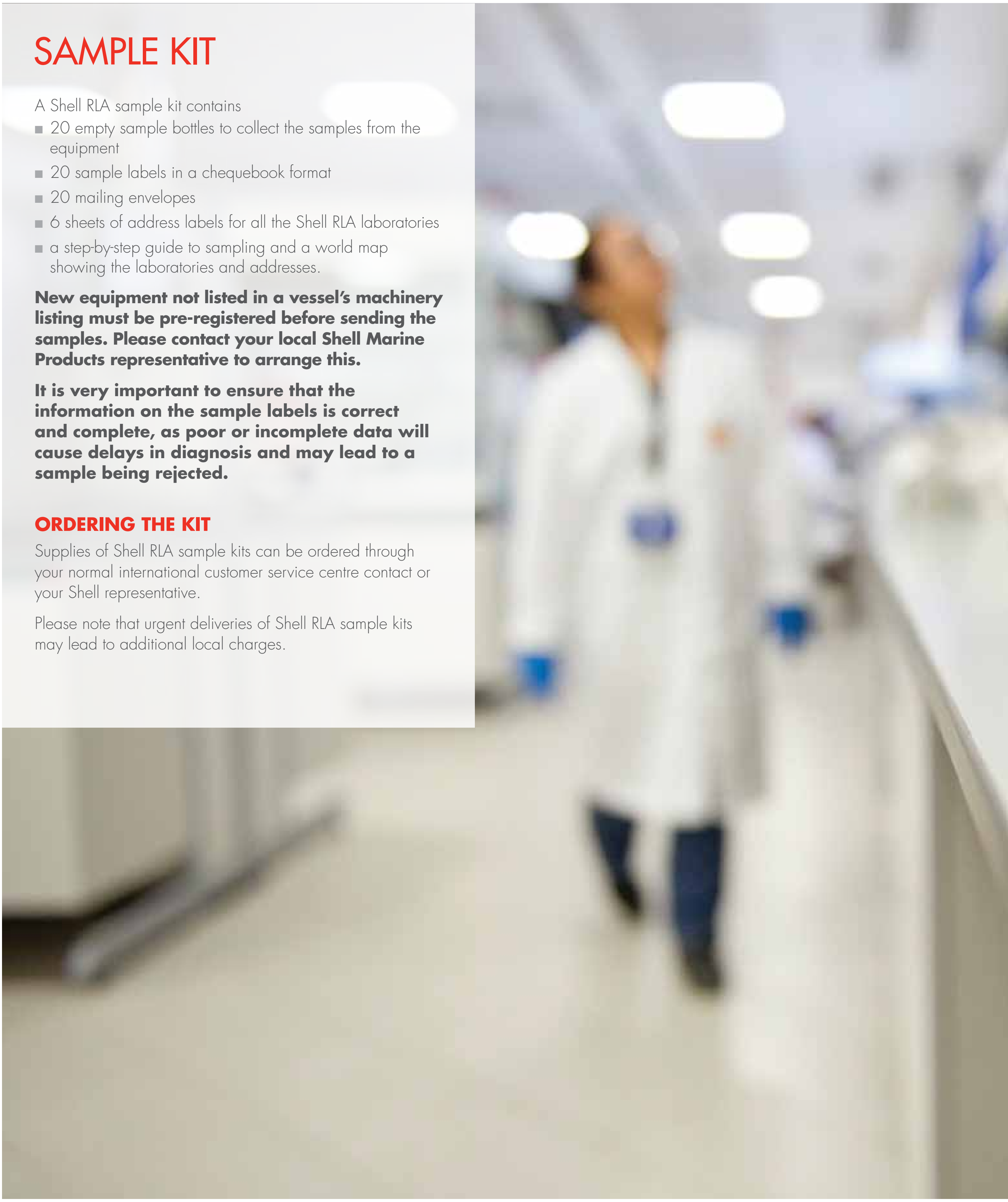
New equipment not listed in a vessel's machinery listing must be pre-registered before sending the samples. Please contact your local Shell Marine Products representative to arrange this.

It is very important to ensure that the information on the sample labels is correct and complete, as poor or incomplete data will cause delays in diagnosis and may lead to a sample being rejected.

ORDERING THE KIT

Supplies of Shell RLA sample kits can be ordered through your normal international customer service centre contact or your Shell representative.

Please note that urgent deliveries of Shell RLA sample kits may lead to additional local charges.



“TRENDS IN OIL CONDITION WILL INDICATE IF THE STATE OF LUBRICATING OIL IS STAYING SAFELY IN EQUILIBRIUM OR IF IT IS MOVING TOWARDS CONDEMNING LIMITS.”

WHEN TO SAMPLE

Regular oil analysis enables trends in oil condition to be determined:

- Trends will indicate if the state of lubricating oil is staying safely in equilibrium or if it is moving towards condemning limits.
- Before condemning limits are reached, recommendations will often be given for corrective action.

Regular oil analysis facilitates equipment condition monitoring; for example:

- a sudden increase in trends of wear metals may indicate component failure
- the presence of cooling water treatment additives may indicate leakage
- poor air filtration may also be detected.

Original equipment manufacturers usually prescribe the oil sampling frequency in their equipment documentation, so following these sampling frequency guidelines is recommended.

In the absence of an original equipment manufacturer’s guide for the required oil sampling frequency, the general guidelines shown in Table 1 should be followed. These are based on actual operational hours or a time-elapsed schedule (months).

Equipment	Suggested sampling points	Sample frequency (hours or months)
Low-speed engine-system oil	■ Oil pump delivery ■ Oil cooler outlet ■ Engine inlet line	1,500/three months
Medium-speed diesel engine oil		1,500/three months
High-speed diesel engine oil		500/six months
Gas engines (LNG or LPG)		2,000/three months
Hydraulic system	■ Returning line to hydraulic oil reservoir ■ Oil pump delivery	2,000/three months
Heat transfer system		2,000/three months
Gears	■ Fitted sampling device ■ Sump ■ Inspection door	2,000/six months
Thrusters		1,000/three months
Stern tubes	■ Fitted sampling device ■ Return to gravity compensation tank	1,500/three months

Table 1: Guidelines for oil sampling frequency

SAMPLING FREQUENCY

The following factors will affect sampling frequency:

- The fluid environment's severity, for example, high loads, temperatures and speeds, continuous operation, duty cycle and moisture (start–stop) will influence sampling frequency.
- New or near to overhaul machinery requires more samples.
- If the probability of failure is high, more samples should be taken.
- As the oil approaches the end of its useful life, the rate of degradation increases, which means more samples should be taken.
- To ensure safe operation of the vessel, critical equipment should be regularly sampled to reduce the risk of failure.

ALWAYS TAKE A REPRESENTATIVE SAMPLE

The quality of the oil sample and the information on the sample label are critical to the accuracy of the Shell RLA report.

We therefore recommend

- drawing samples from a connection that comes directly out of the main oil supply or the return line from the machine
- always taking samples from the same point. Adhesive labels for sample point identification are available from your Shell Marine Products representative.
- ensuring that the total quantity of oil in circulation is approximately the same during each sampling
- sampling only when the oil is at its operating temperature and the machine is running
- purging the sample connection thoroughly until hot oil flows before taking a sample
- drawing samples into a clean container
- filling the Shell RLA sample bottle 80% full, thereby leaving an air space, and sealing the bottle tightly
- always observing the appropriate safety guidelines.

ISO4406 particle counting

Make sure that a second sample bottle is used for oil samples that need the ISO 4406 cleanliness test. Use the label from the lower half of Section 3 for this sample bottle.

SAMPLING TIPS

- Areas where lubricant flow is restricted or where contaminants and wear products tend to settle or collect should be avoided as sampling points.
- Always take the sample in the cleanest conditions to avoid contaminating the sample.
- Always use the Shell RLA sample bottles supplied by Shell and make sure that they are unopened and that the exterior is clean.
- Always clean the sampling kit immediately after use.
- After taking samples, check to make sure that the bottles are tightly closed.
- Avoid direct sampling from the engine oil sump.
- Avoid sampling from the purifier suction or discharge lines unless you intend to check purifier efficiency.
- Avoid sampling from places where the oil may be stagnant or have little or no flow such as small auxiliary pipelines, sumps, the drain cocks of filters and coolers.
- Avoid sampling while the machinery is stopped.

SAMPLING FROM CIRCULATION SYSTEMS

- For circulating systems, one of the best sampling locations is a live zone before the filters where contaminants and wear debris are most concentrated. This usually means sampling from fluid return or drain lines.
- For systems where the oil drains back to a sump without being directed through a line (such as in engines), draw from the pressure line downstream of the pump (before the filter).
- Permanent sampling points should be at elbows in pipe runs in preference to straight sections. This will help to ensure that the flow regime at the sample point is turbulent and that wear and contaminant particles do not drop out of suspension.

RECOMMENDED SAMPLING POINTS

Engines

- Before the lubricating oil filters on the main supply line

Hydraulic systems

- The middle of the main reservoir or system return line

Steam turbines

- The main supply line before the turbine (preferably after the cooler)

Compressors

- Take samples just after shutdown with the compressors isolated from the system or use a designated sample valve.

Gear cases

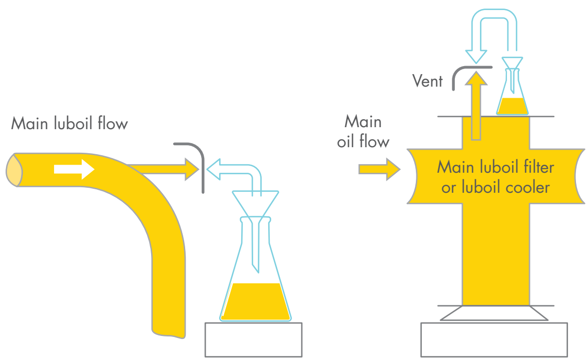
- The main supply line before the turbine (preferably after the cooler)

Stern tubes

- The drain valve or sample cock. Make sure that all free water or sediment/debris is flushed out before taking the sample.

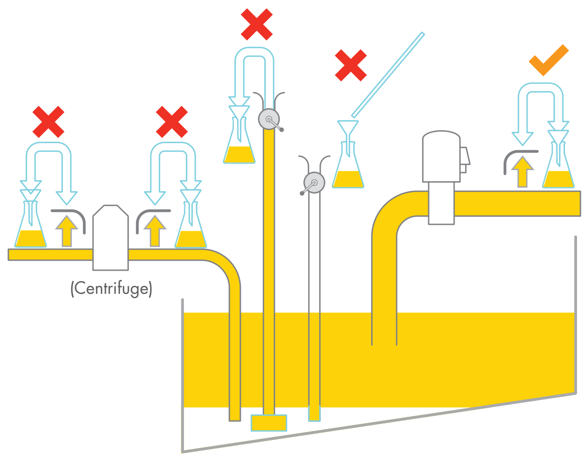
Splash-lubricated systems

- The mid-point of the reservoir
- Splash-lubricated systems, and slinger-ring and flood-lubricated components are best sampled from drain plugs but only after considerable flushing.
- Similarly, permanent valves should be wiped clean and then flushed before sampling to ensure that any dead-leg debris is excluded from the sample.



Preferred method

Alternative method



SAMPLE LABELS

All machinery must be pre-registered to avoid delaying sample analysis. Shell RLA vessel and machinery codes can only be issued by Shell.

Complete the sample label in full with all the relevant information, as detailed in the section "Sample label identification". Ensure that the machine details are exactly as written in the lubrication survey or the Shell RLA machinery list.

1. Check that an air space has been left above the sample and that the seal is tight.
2. Detach the sample label from top of Section 3 and attach to the sample bottle.
3. A second sample bottle is required for oil samples that need the ISO 4406 cleanliness (particle counting) test. Use the label from the lower half of Section 3 for this sample bottle.
4. Put Section 2 of the label and the sample bottle into the envelope.
5. Seal the envelope using the two sealing strips.
6. Using the map from the step-by-step guide, select the relevant laboratory coloured address label to attach to the envelope, for example, if the vessel is in Europe use a yellow label.
7. Dispatch by a reliable courier is strongly recommended, preferably an international courier service provider. Keep or record the airway bill number for tracking.
8. All courier charges must be paid by the vessel's staff or agent on dispatch, as Shell will not accept charges for sample transportation to Shell RLA laboratories.

COMPLETING THE LABEL

Sample label identification

To reduce delays in processing used oil samples, Shell Marine Products has created a label that aims to reduce the information required to the bare minimum while enabling customers to build up a meaningful database of used oil analysis results for their machinery.

Missing vessels names, Shell RLA vessel and machine codes will cause delays in analysis.

Filling in the label

- To complete the sample labels, follow the directions shown on the sample label (Figure 1).
- For routine samples, please use the top label of Section 3.
- Only use the lower label in Section 3 for sample requiring cleanliness testing (particle counting) according to ISO 4406.
- Sections 2 and 3 are vital to ensuring the correct identification of your sample.

Note that incorrectly completed labels will lead to samples being registered in the laboratories as "unidentified". An unidentified sample cannot be analysed.

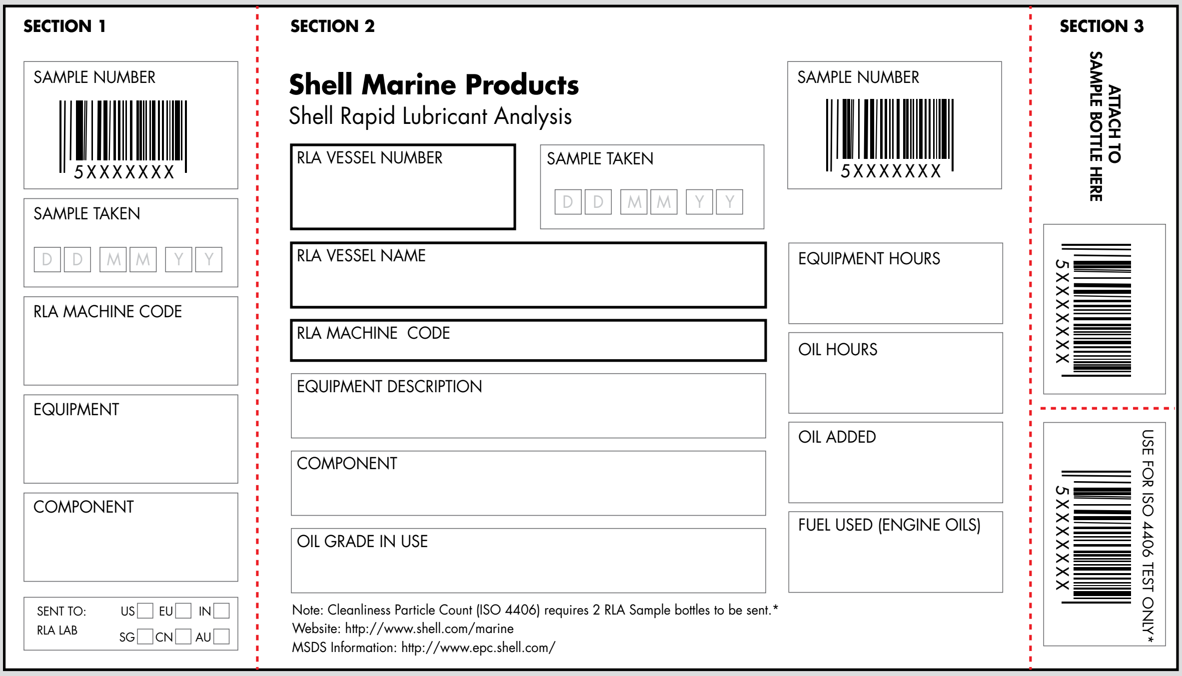


Figure 1: Filling in the sample label

TEST SUITES

SIMPLIFIED TEST SUITES

Shell RLA offers the test suites shown in Table 2.

This arrangement provides good flexibility and enables you to select best test suites for your machinery:

- **Check** test suites are suitable for most equipment with a medium impact of failure.
- **Check Plus** test suites offer advanced diagnosis at equipment level and an enhanced test sequence suitable for equipment that is critical to the safe operation of a vessel.

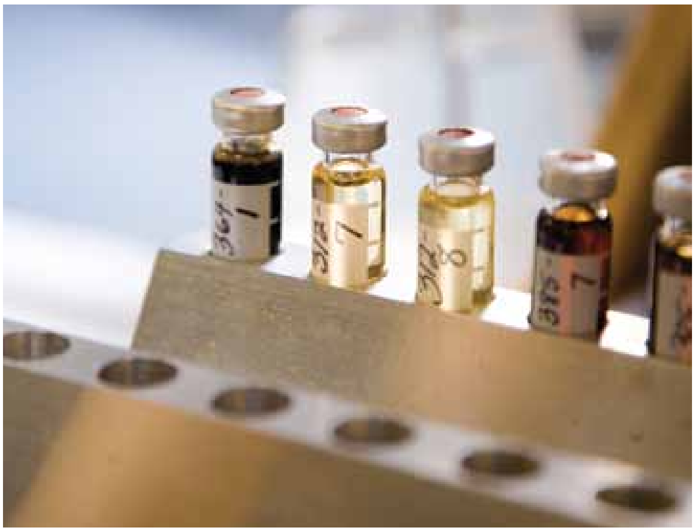


Table 2: Shell RLA test suites

	Viscosity at 40°C	Viscosity at 100°C	TBN	TAN	Clean ISO 4406	Water (%vol)	Water (ppm)	Flash point (°C)	ICP	Dispersancy (IC/DP/MD)	WPI
Engine Check		✓	✓			✓		✓	✓	✓	✓
Shaft Check[1]	✓			✓		✓			✓[2]		✓
System Check	✓			✓		✓			✓		✓
Fridge Check[3]	✓			✓			✓		✓		
Gas Engine Check[4]		✓	✓	✓		✓		✓	✓	✓	
Turbine Check	✓			✓		✓			✓[5]		✓
EMD Engine Check		✓	✓			✓		✓	✓[6]	✓	✓
Cylinder Check			✓			✓			✓[7]		✓
Hydraulic Check	✓			✓		✓			✓		✓
Gear Check	✓			✓		✓			✓		✓
Thruster Check	✓			✓			✓		✓		✓
Thermal Check	✓			✓		✓		✓	✓		✓
Grease Check									✓		✓
Engine Check Plus		✓	✓				✓	✓	✓	✓	✓
System Check Plus	✓			✓			✓		✓		✓
Hydraulic Check Plus[1]	✓			✓	✓	✓			✓		✓
Gear Check Plus[1]	✓			✓		✓			✓		✓
Thruster Check Plus	✓			✓	✓		✓		✓		✓
NK Stern Tube Check Plus[8][9]	✓			✓		✓			✓[2]		

[1]Also includes heptane insolubles [2]ICP with nickel [3]Includes degas [4]Includes oxidation and nitration by infrared spectroscopy [5]Calcium in ppm [6]Zinc in ppm [7]Zinc and phosphorus in ppm [8]Oxidation using infrared spectroscopy [9]Direct-reading ferrography

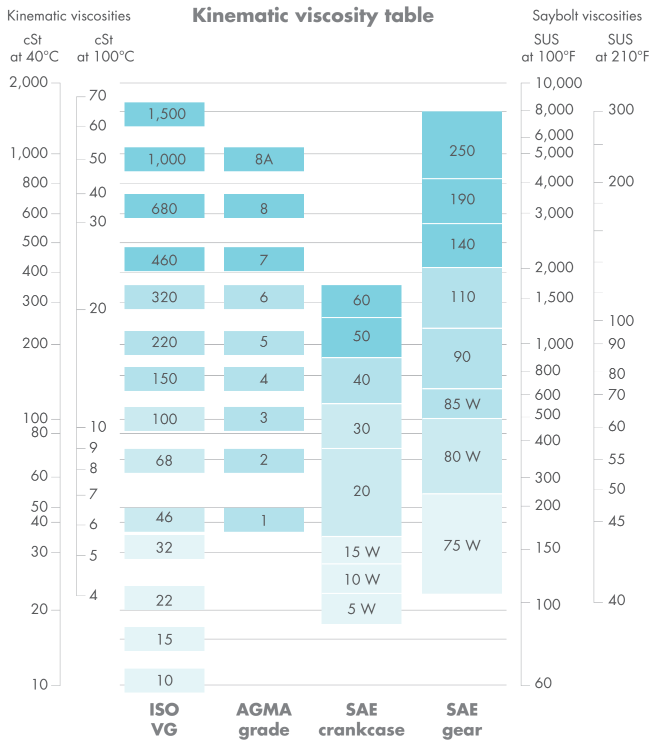
EXPLAINING THE SHELL RLA TESTS

VISCOSITY

The viscosity of a fluid is a measure of its resistance to flow and is directly affected by its temperature. Oil viscosity decreases with an increase in temperature and increases with a drop in temperature. Kinematic viscosity is expressed in millimetres squared per second (mm^2/s) and is measured at 100°C for diesel engine oils and 40°C for other applications.

The viscosity of lubricating oil may change in service as a result of deterioration, contamination or both. Insolubles, oxidation and mixing with a higher viscosity grade oil will increase oil viscosity. Fuel or water contamination may either increase or decrease oil viscosity.

A decrease in oil viscosity is of greater significance than an increase because full film lubrication may not be achieved if the viscosity is too low. For engine oil, the limiting value is normally 25% of the nominal recommended value of the fresh oil. The upper limit for engine oil is generally not so critical and viscosity may be allowed to increase by as much as 50% above the fresh oil's value in certain applications. It should be noted that if systems run with high-viscosity oils, there might be an increase in system pressure that could result in component failure, for example, of the seals. Increased temperatures may also be noted.



FLASH POINT IN ENGINE AND THERMAL OILS

The flash point is the temperature at which a vapour above a liquid will ignite when a flame is applied under standard conditions. The standard method used in Shell RLA is the closed cup method. The flash point is reported in degrees Celsius.

A drop in the closed flash point indicates that the oil is contaminated. This may be accompanied by a corresponding drop in viscosity, though with heavy fuel no significant change may be apparent.

As a general guide, it is advisable to check for fuel leaks when the lubricant's flash point drops to less than 190°C. If the sample contains water, it may not be possible to obtain a flash point figure.

The likelihood of a low flash point and therefore the risk of ignition are greatest in used engine oils, particularly for those engines operating on distillate fuels.

Fuel samples must not be sent using Shell RLA sample bottles or labels owing to the potential risks of lubricants testing facilities being unused to handling low flash point flammable products.

TOTAL BASE NUMBER (TBN) – ENGINE OILS

The TBN, which is expressed in milligrams of potassium hydroxide per gram of oil (mg KOH/g), is the alkaline reserve formulated into an oil to neutralise the acidic products of combustion derived from the sulphur in the fuel.

With Shell Rapid Lubricants Analysis, the TBN determined by the perchloric acid method provides a measure of the effective additive content and the oil's ability to neutralise acids.

In service, the TBN of lubricating oil will fall from its original value to an equilibrium value, where it normally remains unless conditions change.

The factors that influence the equilibrium level are mainly changes in the fuel sulphur content: a high-sulphur fuel will cause a drop in TBN.

If the rate of TBN depletion is too great and the oil charge requires changing, consideration should be given to replacing the charge with a lubricating oil of a higher initial TBN or using a higher TBN oil for top-up.

A decrease in lubricating oil consumption will cause a fall in the equilibrium TBN, whereas a rise in lubricating oil consumption results in a rise in the equilibrium TBN. Different original equipment manufacturers specify minimum levels of TBN for their equipment, but as a general guide, the TBN should not be allowed to fall below 50% of that of new oil.

The system oil in cross-head engines may suffer from an increase in TBN. This can be attributed to cylinder oil draining into the crankcase.

WATER CONTENT

Water contamination is initially determined by a hot plate crackle test. If this gives positive results, the oil is analysed to quantify the water content. Traces of water in lubricating oil are inevitable, for example, there may be salt water from leaking oil coolers or fresh water from separator water seal malfunctions, coolers, cylinder cooling jackets or atmospheric condensation. Water affects the viscosity of oil and may form an emulsion with the oil. Water in oil may cause lubrication failures and corrosion problems. In reciprocating machinery, it will cause bearing fatigue that may result in bearing damage or failure.

It is therefore desirable to minimise the water content in lubricant by settling and draining or centrifuging. In general, if the levels in Table 3 are exceeded, action should be considered to identify and stem the ingress of water and to reduce the overall water content.

It should be noted that stern tubes may tolerate up to 5% water for short periods when normal mineral-oil-based lubricants are used and up to 20% when emulsifying lubricants are used. IACS and class limits are used in Shell stern tube analysis.

Water screening crackle test

Location of oil	Water content limit (%)
System oil	<0.5
Hydraulic oil systems	<0.2
Stern tube oil systems	<0.5
Crankcase in trunk-piston engines	<0.2
Steam turbine and gearing systems	<0.1

Table 3: Limits for water in lubricant

TAN measuring equipment

TOTAL ACID NUMBER (TAN) – USUALLY NON-ENGINE OILS

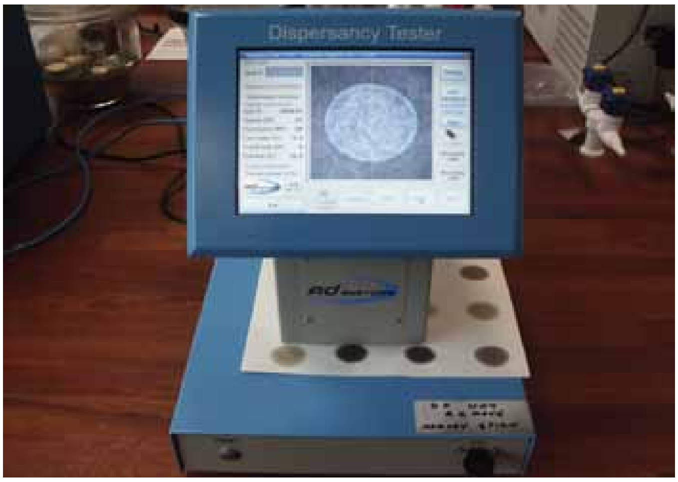
The TAN is a measure of the total acids present in the lubricating oil. In non-engine oil, these are normally derived from oxidation of the oil (weak acids). In diesel engine oil, however, acidic products of fuel combustion (strong acids) may also be present.

The rate at which the TAN changes is more important than the absolute value and can indicate whether the system oil is liable to deteriorate rapidly and consequently form sludge and lacquer. Where a straight mineral oil or a rust-and-oxidation-inhibited oil is used, the TAN should not be allowed to exceed 3.0 mg KOH/g.

The weak acids formed by the oxidation of oil do not attack ferrous metals or white metal but can cause corrosion of copper or lead bearings.

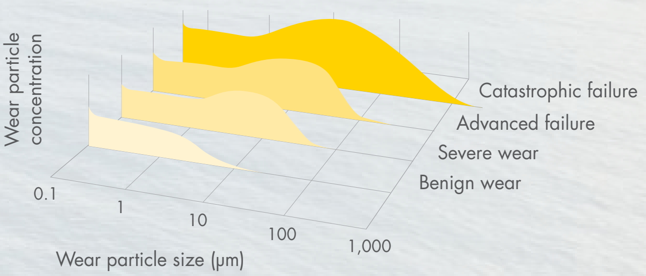
INDUCTIVELY-COUPLED PLASMA (ICP) SPECTROSCOPY

Elemental analysis using ICP spectroscopy can detect up to 24 different elements, from particles measuring less than 5 µm in diameter, which be present in used oil through wear, contamination or additives. Wear metals include iron, chromium, nickel, copper, lead and tin. Contaminant elements include silicon, sodium and vanadium. Multi-source metals include aluminium, molybdenum and manganese. Additive elements include boron, magnesium, calcium, barium, phosphorous and zinc. Such elemental analysis is instrumental in determining the type and severity of the wear occurring within a unit.



WEAR PARTICLE INDEX (WPI)

The WPI is determined using a test that measures the amount of ferromagnetic material in a sample. The most common ferromagnetic material found in oil samples from marine machinery is iron; therefore, the WPI correlates very closely to the total iron content in a sample. The WPI test can be beneficial, as one of the weaknesses of ICP spectroscopy is that its sensitivity to particles starts to diminish as the particle size increases. Particles larger than 5 µm are virtually undetectable by ICP but if magnetic are readily detected using the WPI test.



DISPERSANCY

Additives called dispersants are used in engine oil to hold carbon particles in suspension. They do this by enveloping the carbon particles and preventing them from joining together to form sludge. The rate of depletion of these additives is related to time and the rate of carbon generation by the engine, i.e., engine health, degree of blow-by, fuel injection rates, etc.

To understand the impact of fuel quality and the operating condition of engines, Shell has developed unique technology to identify the level of contamination in oil and the oil dispersancy. This helps the engine users to take immediate corrective action if an abnormality is observed.

The index of contamination (IC) is the concentration of insoluble soot loading in a diesel engine oil charge and is expressed as weight percent. Such contaminants cause a rise in the viscosity of system oil and may result in the formulation of sludge, which can lead to excessive component wear.

The merit of dispersancy (MD) indicates the ability of the lubricant in a diesel engine to carry combustion contaminants in suspension. It is expressed as a number from zero to 100. Providing an adequate dispersancy level is maintained, the amount of insoluble soot that can be tolerated increases and the diagnostician can make informed recommendations to the vessel's engineer about the treatment of the remaining oil charge. The lubricant's inability to maintain the contaminants in suspension may lead to deposits accumulating in the bottom of the crankcase and cause problems with filtration and/or purification equipment.

Example

MD = 0 = poor dispersion: the insolubles are all concentrated in the centre of the oil spot in the test; the residues are flocculated.
MD = 100 = excellent dispersion: the distribution of the insolubles on the filter paper is homogeneous.

The demerit points (DP) figure reflects the overall condition of the oil, as it is a combination of the IC and the MD derived from the calculation DP = (100 – MD) × IC. A low DP (0 or close to 0) indicates slight contamination and excellent dispersancy. A high DP (approaching 100 or more) indicates heavy contamination and/or a poor dispersancy.

METAL ANALYSIS BY ICP SPECTROSCOPY

Guidelines for wear metals

Normal wear metal levels may vary significantly between different types of equipment and different applications. The true value of oil analysis is in establishing a wear trend for each piece of machinery that is specific to that item of machinery, its operating cycle and its operating environment. Remember, the absolute value of wear metals will vary with the oil-drain interval and oil top-up rate.

Spectroscopy

Spectrographic analysis is used to determine the elements in the oil. The presence of certain elements can uniquely identify additives and contaminants in the oil. It is, therefore, possible to deduce the identity of the oil, the type of any contamination and the condition of the machinery.

The elements measured using spectroscopy are described below.

Additives

The concentration of calcium, barium, phosphorus and zinc can serve as confirmation of the lubricant grade in use or as an indication of the addition of or contamination by other oil grades.

Phosphorus and zinc are normally associated with extreme-pressure or anti-wear additives. These additives rarely deplete before the oil becomes unfit for further use and, therefore, significant variations in their levels normally indicate that a different oil grade has been added.

Calcium and magnesium are normally associated with BN additives. These additives provide alkalinity, detergency and resistance to oxidation. Magnesium may also be present owing to water ingress. If this contamination is seawater, the ratio of magnesium to sodium will be approximately 1:9.

Barium is not used in Shell marine lubricants. It is, however, used in some diesel engine oils manufactured in Eastern Europe.

Wear metals

Iron, chromium, molybdenum and aluminium are found in the metal alloys used to manufacture components for the upper part of the engine. Lead, tin and copper are metals used in bearing materials in the lower part of the engine. See also Table 4.

Contaminants

Sodium, vanadium, aluminium and silicon are contaminants that may be related to fuel oil. The presence of silicon may also indicate contamination by airborne particles or dust due to a breakdown in air filtration systems. Sodium in conjunction with magnesium can be used to determine whether water contamination is seawater, cooling water or fresh water.

Boron is found in some types of inhibitor used in water cooling systems. Boron in a Shell lubricant may point to a coolant leak. However, certain Shell oils for high-speed diesel engines contain boron as part of the performance enhancement package.

Metal	Potential source
Iron (Fe)	Cylinder walls and liners; crank and cam shafts; valve guides; rockers; rings; bearings; gears; shafts
Lead (Pb)	Generally used as an alloy (Babbitt, copper–lead) in bearings. Big-end and crankshaft bearings; and thrust washers
Copper (Cu)	Usually alloyed in the form of brass, bronze or as sintered copper–lead. Big-end and crankshaft bearings; bushings; oil coolers and cooler core tubes; thrust washers; fuel transfer pumps; and governor and wrist pin bushings. Copper-type anti-seize compounds
Chromium (Cr)	Commonly used as plating metal. Chrome-plated piston rings and valve stems. Chromate-treated cooling systems
Silicon (Si)	Dirt. Highly abrasive. Sources include inadequately filtered air due to cracked induction piping or hoses, or defective or incorrectly fitted air filters and gaskets. Dirty oil filling or sampling equipment. Incorrectly fitted or missing oil filler caps. Ineffective reservoir breathers. Also silicon-based gasket/joining compound and antifoaming additive in some engine oils
Sodium (Na)	Coolant leakage, water or using the same container for coolant as for oil
Aluminium (Al)	Pistons (scuffing, scoring or burning); aluminium bearings; alloy housing wear; and housing or rotor wear in turbochargers. May also be associated with high silicon levels in the form of clay or stone dust contamination
Tin (Sn)	Bearings; bushings; and thrust washers
Note that upper engine wear is characterised by high levels of iron, chromium, aluminium or silicon. Lower engine wear is characterised by lead, tin or copper.	

Table 4: The origin of metals in engine oils

INTERPRETATION OF SHELL RLA RESULTS

The possibility of extending the period between classification surveys is enhanced by regular oil analysis using Shell RLA. A satisfactory series of Shell RLA reports can help to satisfy the surveyor that all is well and that visual inspection can be deferred for a specified time. The time and cost savings will be readily apparent to the operator.

Shell's team of marine diagnosticians draws on years of experience and knowledge in the interpretation of analysis results. The regular submission of samples enables historical data trends to be established. Close scrutiny of trend data identifies changes in the underlying condition of the lubricant. This enables the diagnostician to determine whether the trend is normal or otherwise.

Variations in the underlying trends of a lubricant's measured properties give vital clues to its condition and of the equipment it lubricates. Trend analysis can be vital in preventing failure by means of early warning of detrimental machinery condition.

CONTINUING THE TREND

The use of used oil analysis to determine the condition of both the oil and machinery is not a new concept. The Shell RLA service began in 1980 and the principal tests remain the same today. The introduction of modern computerised analysis equipment and data handling systems has made regular routine sampling more economically viable, and the trending of results forms a good basis for ISM and IACS and classification society condition monitoring programmes.

Lubricants are integral parts of all engines and most machinery. The very specialised nature of these machines and the harsh conditions under which they frequently operate put considerable demands on a lubricant.

As the lubricant is in contact with most of the highly stressed areas of a machine, it can provide information that, when correctly interpreted, can assist in the identification of deteriorating components and reduce the risk of untimely breakdown.

DIAGNOSIS AND REPORTING

DIAGNOSIS

Shell Marine Products use a multidisciplinary team of specialist diagnosticians with expertise in marine engineering and lubricants to interpret the analysis results reported by the Shell RLA laboratories. However, remember that the advice given by the Shell Marine Products diagnosticians is reliant on two-way communication between Shell Marine Products and the customer, site or vessel.

Shell Marine Products uses advanced algorithms with a database containing over 30 years of data to identify samples requiring human intervention. These data, along with the information on maintenance, etc., provided by the customer, enable Shell Marine Products to make an informed assessment on the health of a particular machine/lubricant combination.

REPORTS

Shell RLA reports indicate the condition of oil or equipment of a particular sample through traffic light signals:

Normal – no action

Attention – monitor and consider taking action

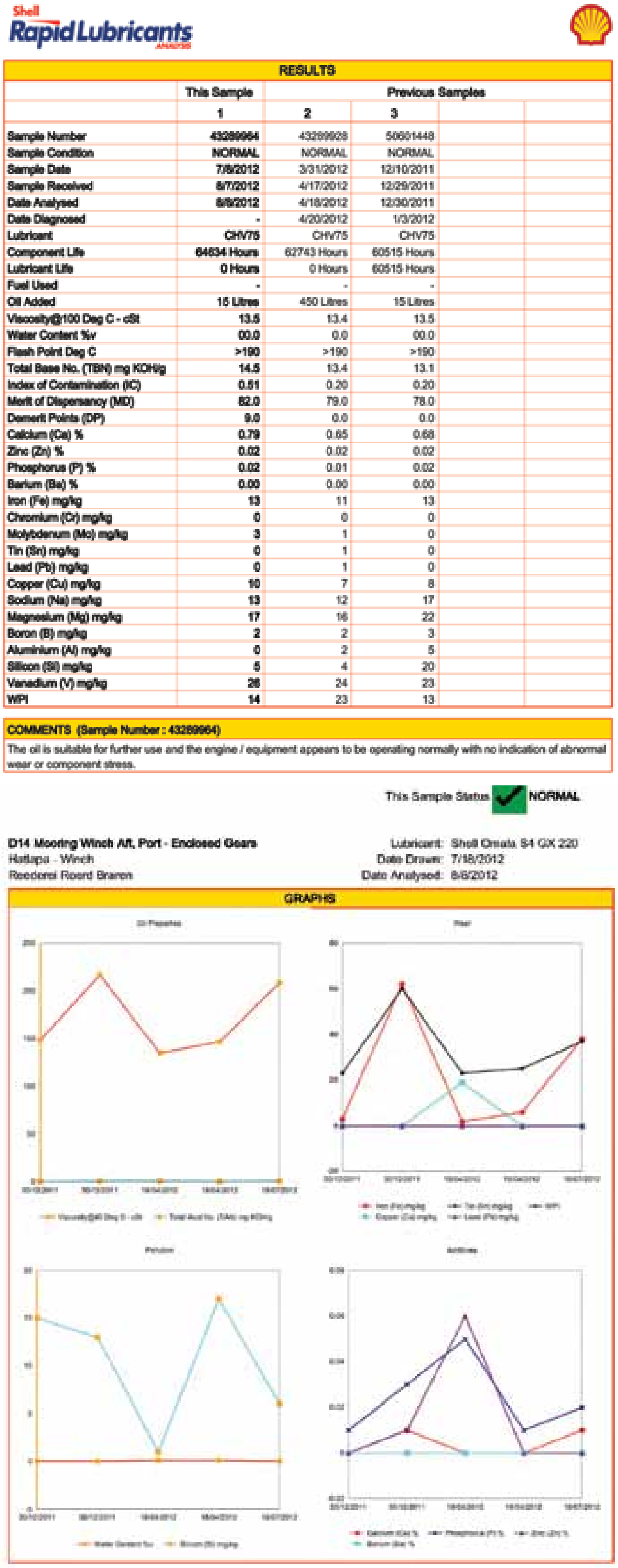
Action – needs immediate action

THE SHELL RLA REPORT

Shell RLA reports include

- customer and equipment details
- equipment and oil running hours
- physicochemical parameters
- contaminants
- wear metal analysis
- additive levels
- trends of the past five reports
- graphical trends
- comments from the marine expert on all the reports that need action.

Shell RLA reports for all "normal" samples will be available within two workng days of sample receipt at the laboratory. Samples requiring retests are excluded.



Shell Rapid Lubricants Analysis

RESULTS

	This Sample	Previous Samples			
	1	2	3		
Sample Number	43289964	43289928	50601448		
Sample Condition	NORMAL	NORMAL	NORMAL		
Sample Date	7/8/2012	3/31/2012	12/10/2011		
Sample Received	8/7/2012	4/17/2012	12/29/2011		
Date Analysed	8/8/2012	4/18/2012	12/30/2011		
Date Diagnosed	-	4/20/2012	1/3/2012		
Lubricant	CHV75	CHV75	CHV75		
Component Life	64634 Hours	62743 Hours	60515 Hours		
Lubricant Life	0 Hours	0 Hours	60515 Hours		
Fuel Used	-	-	-		
Oil Added	15 Litres	450 Litres	15 Litres		
Viscosity@100 Deg C - cSt	13.5	13.4	13.5		
Water Content %v	00.0	0.0	00.0		
Flash Point Deg C	>190	>190	>190		
Total Base No. (TBN) mg KOH/g	14.5	13.4	13.1		
Index of Contamination (IC)	0.51	0.20	0.20		
Merit of Dispersancy (MD)	82.0	79.0	78.0		
Demerit Points (DP)	9.0	0.0	0.0		
Calcium (Ca) %	0.79	0.65	0.68		
Zinc (Zn) %	0.02	0.02	0.02		
Phosphorus (P) %	0.02	0.01	0.02		
Barium (Ba) %	0.00	0.00	0.00		
Iron (Fe) mg/kg	13	11	13		
Chromium (Cr) mg/kg	0	0	0		
Molybdenum (Mo) mg/kg	3	1	0		
Tin (Sn) mg/kg	0	1	0		
Lead (Pb) mg/kg	0	1	0		
Copper (Cu) mg/kg	10	7	8		
Sodium (Na) mg/kg	13	12	17		
Magnesium (Mg) mg/kg	17	16	22		
Boron (B) mg/kg	2	2	3		
Aluminium (Al) mg/kg	0	2	5		
Silicon (Si) mg/kg	5	4	20		
Vanadium (V) mg/kg	26	24	23		
WPI	14	23	13		

COMMENTS (Sample Number : 43289964)

The oil is suitable for further use and the engine / equipment appears to be operating normally with no indication of abnormal wear or component stress.

This Sample Status NORMAL

D14 Mooring Winch Aft, Port - Enclosed Gears
Hatlapa - Winch
Reederei Roerd Braren

Lubricant: Shell Omala S4 GX 220
Date Drawn: 7/18/2012
Date Analysed: 8/8/2012

GRAPHS

TYPICAL FAILURES AND CAUSES

ENGINES

Failure	Symptoms	Potential cause	Effect	Recommendation
Degraded lubricant	High level of oxidation/nitration in gas engines; additive depletion	Overheating; low oil consumption; increased contamination (cooling system problem, mechanical problem)	Increased wear; potential failure	Check cooling system;
Contamination by abrasive particles	High silicon; high particle count; high wear metals	Problem with air filter; poor storage and handling of lubricant	Increased wear (especially bearings, piston/cylinder); potential failure	Change oil filter
Excessive wear	High wear metals (Al, Cr, Fe, Cu, Pb, Sn)	Effect of another failure type (water ingress, contamination, fuel dilution, overheating)	Shorter engine life	Check whole system
Excessive soot contamination	High soot content (IC/MD/DP test)	Problem with fuel system; incomplete combustion; exhaust gas recirculation	Increased wear; potential failure	Check fuel system; check purifier operation
Water ingress	High water content; sodium, magnesium present	Head gasket leak; oil cooler leak	Water displacing lubricant; increased wear; potential failure	Repair leak; check purifier operation
Fuel dilution (distillates)	Low viscosity; low flash point; fuel present	Problems with fuel system (incomplete combustion)	Increased wear; potential failure	Repair fuel system
Fuel dilution (residues)	High viscosity; vanadium and nickel present	Problems with fuel system (incomplete combustion)	Increased wear; potential failure	Repair fuel system; change oil; check purifier operation

GEARS

Failure	Symptoms	Potential cause	Effect	Recommendation
Contamination by abrasive particles	High silicon; high particle count; high wear metals	Clogged or damaged air breather	Increased wear; potential failure	Replace air breather or filter; change oil
Excessive wear	High wear metal content	Effect of another failure type (water ingress, pollution, wrong product and/or overheating)	Increased wear; potential failure	Check whole system; Change oil
Degraded lubricant	Increased viscosity; increased TAN	Overheating; oil thermally degraded and at the end of its useful life	Increased wear; potential failure	Change oil
Wrong lubricant	Product out of viscosity grade and/or additive metals not typical	Wrong lubricant for application or product mixed with another product	Increased wear; potential failure	Check lubricant used; Change oil

HYDRAULICS

Failure	Symptoms	Potential cause	Effect	Recommendation
Contamination by abrasive particles	High silicon; high particle count; high wear metals	Clogged or damaged air breather; worn or damaged rod seal end	Increased wear; potential failure	Replace air breather or seal; change oil
Degraded lubricant	Increased TAN; increased viscosity	Overheating; oil thermally degraded and at the end of its useful life; problem with oil cooler	Increased wear (due to increased viscosity)	Check system for overheating; check oil cooler; change oil
Wrong lubricant	Product out of viscosity grade and/or additive metals not typical	Wrong lubricant for application or product mixed with another product	Increased wear (due to inappropriate viscosity grade)	Check lubricant used; change oil
Excessive wear	High wear metals (Al, Cr, Fe, Cu, Pb, Sn)	Effect of another failure type (water ingress, contamination, wrong product and/or overheating)	Shorter equipment life	Check whole system; change oil

SHELL LABORATORIES

Shell Laboratories are available in six key locations to ensure customers worldwide can benefits from Shell RLA and get the fastest analysis of their oil and equipment condition.

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TECHNICAL SERVICE	DESCRIPTION
Shell LubeAdvisor	Technical support services, lubrication surveys and audits, storage and handling advice
Shell LubeCoach	Empower your staff with our training
Shell LubeExpert	Specialist on-site critical application support and inspections by application, marine and product experts
Shell Lube Monitor	Cylinder condition monitoring
Shell Rapid Lubricants Analysis	Laboratory oil condition monitoring tools service
Shell Rapid Lubricants Onboard Plus	Onboard oil condition monitoring tools
Shell Rapid Lubricants Onboard Alert	

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For product technical data sheets (TDS) or material safety data sheets (MSDS), please visit www.epc.shell.com