ISSN 0111-6711

LOGGING INDUSTRY RESEARCH ASSOCIATION
NEW ZEALAND

REPORT

Vol. 13 No. 21 1988

DIESEL ENGINE LUBRICATION

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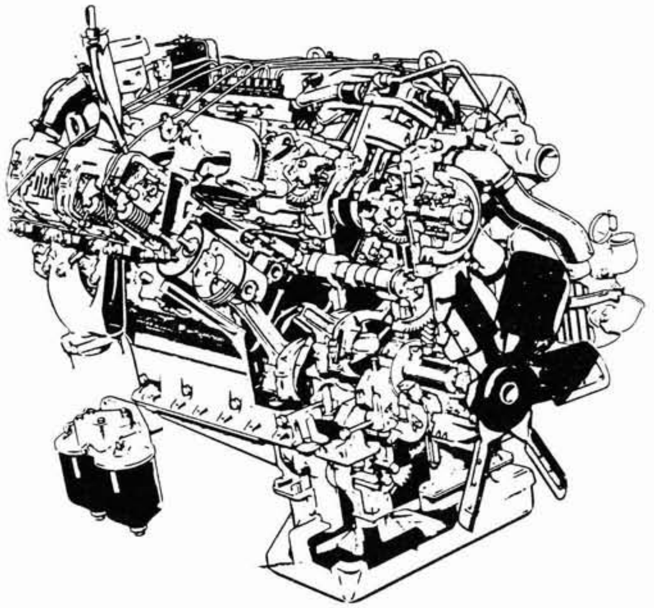

Figure 1 - Cut away Diesel Engine

ABSTRACT

Diesel engines working in the logging industry are subjected to harsh working conditions. When dust and other airborne particles enter the engine oil, the damage they cause is lasting and expensive. Details of the different types of contamination and some simple maintenance action to avoid these problems are given.

This Report incorporates the findings of Pall Scientific and Laboratory Service (USA). LIRA acknowledges their permission to publish this information.

INTRODUCTION

The diesel engine is an integral part of New Zealand's logging industry and is receiving greater attention as a power plant due to its fuel efficiency and life advantages. For an engine to operate efficiently and economically, it needs lubrication.

The major function of engine oil includes cooling, friction control and wear reduction. The oil develops a lubricating film between moving surfaces which reduces friction and wear. The oil also collects impurities which are in the form of solids, liquids and gaseous contaminants. High levels of lubricant contamination cause wear of mechanical components as well as oil breakdown. The result is reduced performance, engine life and short oil service life.

OIL CONTAMINATION

Contamination enters the engine by four routes :

- built-in from manufacture and assembly
- external entry
- internal generation
- maintenance actions

Built-In Contamination

Diesel engine manufacturers take great care during the manufacture and assembly processes to ensure high standards of cleanliness and quality control. However, casting materials, machine swarf, abrasives, polishing compounds, and even dirt can remain after manufacture or overhaul. These built-in contaminants rapidly damage moving engine parts.

External Entry

External entry is a major source of hard particle contamination. Airborne particles in the form of sand, salt, pumice dust and minerals enter through the engine intake system, mix with the atomised fuel which is compressed and then burned. Since most of

Type	*Primary Sources*	*Major Problems*
Metallic Particles	*Engine Wear*	*Abrasion, Fatigue, Lubricant Breakdown*
Metal Oxides	*Engine Wear and Corrosion*	*Abrasion and Fatigue*
Sand	*Combustion Blowby*	*Abrasion and Fatigue*
Soot	*Combustion Blowby*	*Lubricant Breakdown*
Exhaust Gases	*Combustion Blowby*	*Lubricant Breakdown*
Fuel	*Combustion Blowby*	*Lubricant Breakdown*
Water	*Combustion Blowby*	*Corrosion and Lubricant Breakdown*
Acids	*Combustion Blowby and Lubricant Breakdown*	*Corrosion*

Figure 2 - Contamination of Diesel Engine Oil

these particles have melting points higher than the temperatures reached in the diesel combustion process, they remain hard abrasive solids.

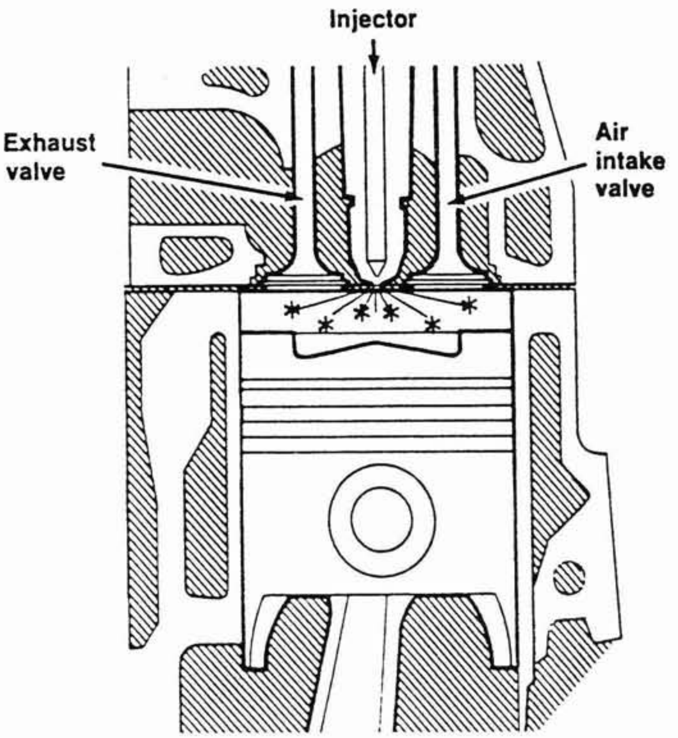

Figure 3 - During combustion, particles are forced through the piston ring clearances and into the oil

The strong pressure shock wave created during combustion forces gases through the piston ring clearances. This process, known as blowby, carries particles into the engine oil. Particles may also be retained in the oil film. They are then wiped by the rings into the oil sump on the next down stroke of the piston (Figure 3). <u>In fact, airborne contamination has been shown to be the greatest cause of ring-to-cylinder wear</u>.

Exhaust gases are similarly driven into the oil as blowby gases. These exhaust gases include unburned fuel, water, nitrous oxide, soot and other partially burned hydrocarbons. Higher levels of exhaust gas recirculation have been shown to increase oil contamination. New ceramic combustion technologies are under development and it is likely that these advances will lead to higher percentages of exhaust gas recirculation, resulting in further deterioration of oil properties.

Other paths of external entry of contaminants into the engine oil include crankcase breathers which can admit large quantities of dust and water directly into the oil sump and replenishment oils and diesel fuels which can be contaminated. In addition, water combined with anti-freeze compounds such as glycol, can be forced into the oil cavity under pressure through defective head gaskets, or occasionally through a cracked block.

Internal Generation

Internal generation of contaminants in the lubrication system is by wear of mechanical component parts and by lubricant breakdown. Mechanical component wear from abrasion, fatigue, adhesion, and corrosion releases harmful particles into the oil. The wear debris is in the form of hard metal particles and of abrasive metal oxides. Particle sizes, not controlled by standard filtration, can build up to grossly contaminate the oil. More than 99% of these particles are less than 20 microns in size.

Lubricant breakdown is the loss of important properties of the oil plus accumulation of harmful materials derived from the oil. These materials include acids, sludges, gels and additive precipitates. These contaminants wear moving component parts as well as clog flow passages and cooling surfaces.

If wear debris and materials from lubricant breakdown accumulate in the oil, the result is more wear, generating more contaminants. The process of particles wearing surfaces and generating new particles that, in turn, cause more wear is known as the "chain reaction of wear".

Maintenance Actions

During maintenance activities, contaminants are introduced into the lubrication system. The opening of rocker covers, removal of engine heads, and even the oil filler cap allow entrance of dust and water. Simply making or breaking a fitting generates tens of thousands of damaging particles.

MECHANISM OF WEAR

There are five forms of wear that occur in diesel engine components:

- abrasion) mechanical
- fatigue) damaging of
- adhesion) surfaces
- corrosion) chemical
- lubricant) reactions
  breakdown)

Abrasion

Abrasive wear by particle contamination includes the rapid cutting away of component material. Material is cut away in a single pass. The rate of abrasive wear is proportional to the number of contaminant particles greater than the dynamic lubricant film. The results of abrasive wear are roughened surfaces, loss of clearance, misalignment and generation of fresh wear debris.

Component	*Oil Film Thickness (microns)*
Rings/Cylinders	*0.3 - 7*
Rod Bearings	*0.5 - 20*
Main Shaft Bearings	*0.8 - 50*
Turbocharger Bearings	*0.5 - 20*
Piston Pin Bushings	*0.4 - 15*
Valve Train	*0.0 - 1.0*
Gearing	*0.0 - 1.5*

Figure 3 - Diesel Engine Component Oil Film Thickness

Fatigue

Fatigue of a component surface is due to an accumulation of microscopic cracks at, or just below, the component surface. Over a period of time these cracks accumulate, eventually combining to form holes. Large quantities of material then break away leaving a cratered surface and releasing work-hardened particles into the oil.

Adhesion

Adhesive wear occurs when the boundary layer lubricant film between the two opposing surfaces is displaced. Metal to metal contact between surfaces can lead to spot welding of the high points. As the two surfaces move in relation to one another these spot welds often break removing material from the surface with the lower yield strength. The result is high friction, wear and heat produced simultaneously, the surfaces can no longer move apart and seizure occurs.

Corrosion

Corrosion is a reaction between aggressive chemicals and component surfaces. These chemicals include water, dissolved oxygen and nitrogen dioxide from the combustion gases. Corrosion is often accelerated on surfaces damaged by contaminant particles.

Lubricant Breakdown

Lubricant breakdown is the loss of important oil properties, such as viscosity, and the build-up of harmful materials derived from the lubricant. Lubricant breakdown can be caused by several mechanisms. Fuel and water can mix with the oil to form precipitants and gels. Soot particles, carried into the oil with blowby gases along with wiping of the piston rings can combine with anti-wear and viscosity additives to reduce wear tolerances and increase viscosity.

CONTROLLING CONTAMINANT BUILD-UP

Air Filters

An internal combustion engine burns up to 10,000 litres of air for every litre of fuel it consumes and this entire volume of air must pass through the air cleaner. Although most air cleaners are more than 99% efficient - when properly serviced - unfiltered air can enter the system at a number of points, wherever there are loose clamps, cracks in hoses or pipes, poorly connected slip points, defective O rings, etc. When these problems occur, dirt and other particles enter the combustion chamber and cause the rapid deterioration of the oil resulting finally in engine damage. Worn crankshafts and bearings are frequently caused by air system leakage, as are broken piston rings, scuffed cylinder sleeves or failed turbochargers.

There is a simple procedure for checking the air induction system on a diesel engine. The difference in plumbing from one type of engine to another does not influence the basic checking procedure but it does prompt the emphasis of certain points. On turbo charged units, connections at the suction side of the air cleaner, the turbo and the air compressor are of prime concern. On naturally aspirated engines connections between the air cleaner and the intake manifold are most important. In all cases, the entire air induction system - suction and pressure side - must be tested. Testing can be carried out simply by pressurising the air system and either listening for air leaks or painting the joints with soapy water and watching for bubbles.

Oil Filters

The concentrations of wear metal elements can be partially controlled by the filter and as Figure 4 shows, different filter types are more effective than others; filters need to be changed and inspected regularly.

It is important to monitor and change the oil in a diesel engine at regular intervals. Failure to do this will cause excessive contamination build up leading to loss of performance, increased maintenance and overhaul costs, lower fuel efficiency and shorter oil service life.

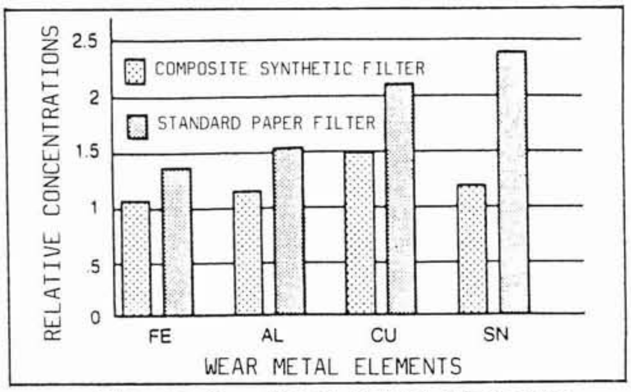

Figure 4 - Wear Metal Elements (Concentrations at 500 hours)

CONCLUSION

To get the best from a diesel engine and to extend its life, it is important to monitor the condition of vital components and take the appropriate action when warning signs appear.

The importance of checking the condition the condition of external components is easily done but is often overlooked. Monitoring the contamination build up internally is more difficult and requires technical assistance. To monitor the internal condition of a diesel engine, the oil needs to be analysed.

Abnormal concentrations of contaminants such as diesel fuel, coolant of airborne dirt cannot be tolerated for prolonged periods. Their presence will result in accelerated engine wear resulting in reduced engine life. The oil should be changed immediately if contaminants are present and the appropriate action taken, depending on concentration.

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