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Analysis of SOS Results for Engine Lubricants Contaminated by the Fuel in The 3516 TA Diesel Engine Generator Set

Wilurso(1), Aswin Domodite(1), Hilman Sholih (1), Mujiarto (2)

- 1) Sekolah Tinggi Teknologi Muhammadiyah Cileungsi, Bogor, Indonesia
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Abstract

Generator Set Unit that operates in the PLTD, during operation there is a knocking sound at cylinder position # 14, after checking and removing the injector there is diesel in the combustion chamber and indicated glowing in the exhaust manifold. The purpose of this study is to determine the root causes of knocking and diesel fuel in the combustion chamber. This research method uses oil sample testing to be tested in the laboratory. The results of the analysis of oil contaminated with diesel fuel are caused by diesel oil flowing into the pan oil and after checking the cylinder head crack (groove-shaped) is found on the side of the injector seal holder, when the unit is not operating the diesel flows into the combustion chamber and into the oil reservoir. The groove in the cylinder head is formed, caused by a hard injector seal caused by fuel temperature and high water temperature. The solution of this research is that the pressure on the fuel return from the engine should not exceed 27 kPa, while the maximum fuel temperature is 66 oC (150 oF), and what needs to be done is an improvement of diesel cooling and routine radiator maintenance. **(Approx. 199 words)**

Keywords: Diesel Engine, Glowing, Exhaust Manifold

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Dear Authors: Wilarso(1), Aswin Domodite(1), Hilman Sholih (1), Mujiarto (2)

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²Department of Mechanical Engineering, Universitas Muhammadiyah Tasikmalaya, Tasikmalaya, Indonesia

* wilarso@sttmcileungsi.ac.id

ABSTRACT. Generator Set Unit which operates in PLTD X, during operation there is a knocking sound from one of the units in cylinder # 14, after checking and releasing the injector, it is obtained diesel in the combustion chamber and also indicated glowing in the exhaust manifold. The purpose of this study is to determine the root cause of knocking and in the combustion chamber contaminated with diesel fuel. The method in this study uses schedule oil sample testing to be tested in a laboratory. The results of the analysis of lubricant contaminated with diesel fuel are caused by diesel lubricant flowing into the pan lubricant and after checking the cylinder head crack (groove-shaped) is found on the side of the injector seal holder, so that when the unit is not operating the diesel flows into the combustion chamber and into the lubricant reservoir. Groove on the cylinder head is formed, caused by a hard injector seal caused by fuel temperature and high water temperature. Pressure on the fuel return from the engine must not exceed 27 kPa, while the maximum temperature is 66 °C (150 °F), in research to reduce the temperature of fuel and water in the engine system. The solution in this research is to improve solar cooling and radiator routine maintenance, so that the cooling process in the engine is more optimal.

1. Introduction.

Generator Set which operates in one of the PLTD does not operate, due to experiencing engine oil mixed with diesel and indicated knocking when the unit is operating. The knocking indication occurs because the ratio of air to fuel is unbalanced, if left too long to operate will cause damage to the exhaust valve and intake valve [1]. After checking the engine, diesel fuel is found to flow from the inside of the cylinder liner and there is diesel fuel in the combustion chamber [2]. When the lubricating oil is mixed with the fuel, the viscosity (the ability of the oil to hold the flow rate decreases) will reduce the lubricating oil, this condition will damage the oil function which will cause damage to the engine components. The unit for reading viscosity is cSt (centistoke). Lubricant contaminating fuels also reduce the concentration of additives present in oil [3]. Excessive fuel contamination in oil can reduce the nature of the lubricating oil which will result in engine damage. Lubricating oil contaminated with diesel fuel will affect the decrease in oil pressure (low oil pressure) and increase the oil level. Fuel dilution decreases the ability of the oil film to protect moving parts [4]. In addition, due to the reduced concentration of additives, lubricating oils do not have adequate amounts of anti-wear additives and corrosion inhibitors [5].

To meet stringent standards, the Common Rail fuel injection system has been implemented, which increases fuel injection pressure and introduces multi-stage dosing. The cost of repairs is very high because of sophisticated parts and technology and to reduce the cost of repairs [6]. In figure 1, the damage to the injector is explained [7].

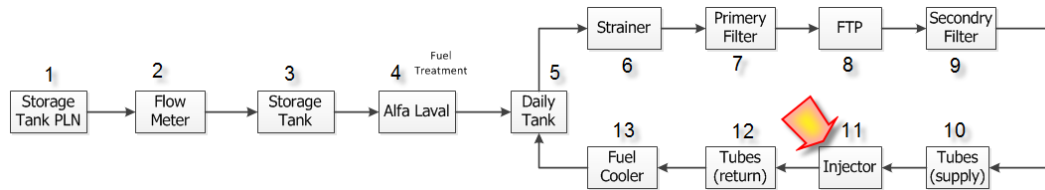


Figure 1. Position of damage to the injector

2. Literature Review.

Cracks in the injector seal holder cause fuel to flow into the combustion chamber [2]. In table 1 the standard readout of the oil test results is based on reference from manufacturing. Where diesel fuel is still recommended in tests below <4%. And if the value is above >4%, then it is immediately conditioned to the relevant parties regarding this matter [8].

Table 1. Guide to analyzing engine oil [9]

S·O·S Services - Oil Analysis Guidelines							18 December 2013	
Diesel Engine Oils			Gas Engine Oils					
Test	Parameters	Guideline	Test	Parameters	Guideline	Test	Parameters	Guideline
Wear Elements	Fe Cr Cu Si Al Sn Pb	Wear Tables ¹	Wear Elements	Fe Cr Cu Si Al Sn Pb	Wear Tables ¹			
Additive Elements	Ca Mg Zn P Mo Ba B	Help Sheet ²	Additive Elements	Ca Mg Zn P Mo Ba B	Help Sheet ²			
Coolant (monitor)	Na or K	25 ppm to 250 ppm	Coolant (monitor)	Na or K	25 ppm to 250 ppm			
Coolant (action required)	Na or K	>250 ppm	Coolant (action required)	Na or K	>250 ppm			
Oxidation (monitor)		24 UFM	Oxidation		20 UFM			
Oxidation (action required)		34 UFM	Nitration		12 UFM			
Sulfate (monitor)		28 UFM						
Sulfate (action required)		34 UFM						
Soot UFM	Absorbance	80	Viscosity change	cSt @ 100 C	+/- 3 cSt			
Soot TGA	%weight of soot	1.50%						
Viscosity change (monitor)	cSt @ 100 C	+/- 2 cSt						
Visc. change (action req.)	cSt @ 100 C	+/- 3 cSt	Water - Positive		>0.5%			
Fuel Dilution - Positive ¹	viscosity decrease	below SAE Grade	Water - Trace		0.1% to 0.5%			
	GC fuel dilution	>4%	Glycol - Positive (optional)		0.1% max			
Water - Positive		>0.5%						
Water - Trace		0.1% to 0.5%						
Glycol - Positive (optional)		0.1% max						

Viscosity, hotspot and flashpoints are chosen as the most important parameters to follow changes in the fuel-oil mixture. Lubricant is diluted based on the results of the maximum oil laboratory analysis recommended units to be stopped or by testing engine oil that is contaminated with diesel fuel [4], so as not to cause great damage.

3. Statement of Problem.

Diesel engine oil contaminated from the results of SOS testing (schedule oil sampling) and visual checking in the field.

4. The Objective of Work.

- Check the cylinder head holder.
- Link damage to the injector holder with oil sampling testing.

5. Problem Description.

Knocking sound when the diesel engine is operating, after checking there is a fluid leak from the inside of the cylinder liner. Diesel fuel is in the combustion chamber and contaminates engine oil, so that engine oil is low viscosity.

6. Observation of Field.

Based on the cylinder head inspection it was found that the diesel fluid was in the combustion chamber, which is explained in figure 2.

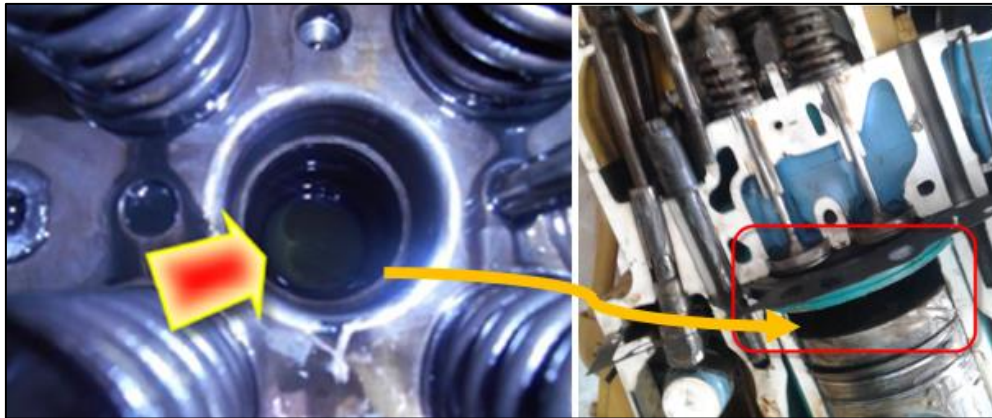


Figure 2. Diesel is in the combustion chamber.

The formation of a groove in the injector seal holder in the cylinder head resulting in leakage of fuel into the combustion chamber and diesel fuel flowing from the cylinder head to the oil pan.

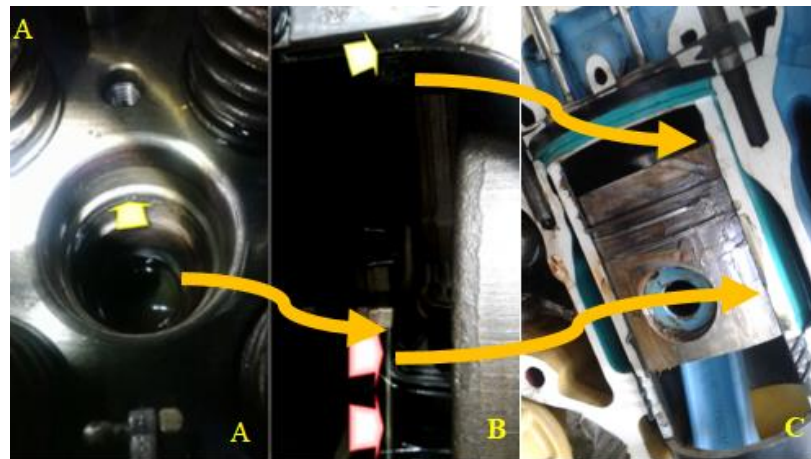


Figure 3. The formation of the groove on the cylinder head in the injector seal holder.

7. Result Analysis.

Fuel dilution will affect the engine lubrication system and its fatality results in the hydraulic lock and wear on the liner wall.

Lubricant performance:

- Viscosity decrease.
- Positive fuel on Set-a-flash (4% maximum)
- Fe (cylinder liner, crankshaft, camshaft, pushrods).
- PB & Sn (bearing overlay).
- Cr & Mo (piston rings).
- Cu, Pb, & Sn (bronze bushings).

Increased wear element Cu is found in bearing material, bushings, friction in engine components that come in contact with metal components with metals, causing wear on bearing or bushing elements. As for engine lubricant that is contaminated with diesel fuel causes thinning of the oil film, according to the data in figure 4, where on March 4 and March 30 2016 oil viscosity was recorded at 0.311 and 0.644, the condition of the lubricant being low viscosity. The rate of wear from January to November 2016, wear element Fe, Cu trending is quite high starting from January and followed by a decrease in viscosity from January to March 2016.

After March 2016 has been done to repair damaged components, so that the lubricant viscosity becomes stable.

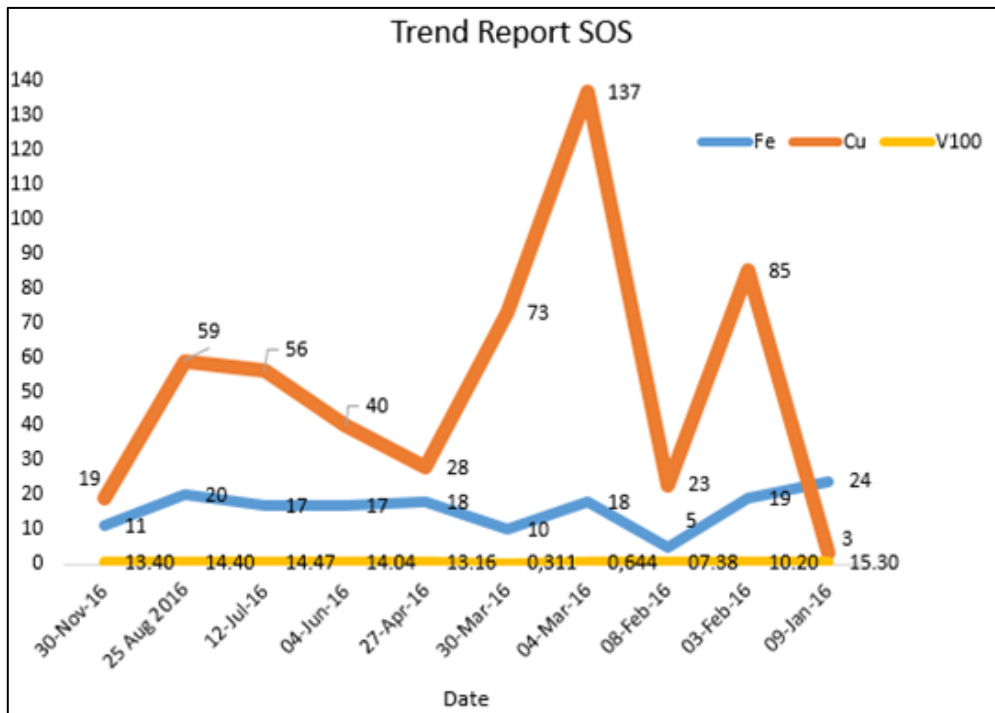


Figure 4. Graph of schedule oil sampling test results (Fe, Cu, and Viscosity)

In the explanation of figure 5 the increase in Fe is balanced by the addition of lubricant at each lubricant change interval at 500 hours [10], enough to increase and including the addition of oil up to 260 liters on January 9, 2016, and 280 liters on June 04, 2016. With the Fe trend, increasing wear occurs in the liner wall. The impact on shiny on the inner liner wall described in Figure 6 [11] [12], lubricant also burns during the process of movement of the piston from TMB to TDC and the combustion process in the combustion chamber occurs and causes the lubricant to decrease.

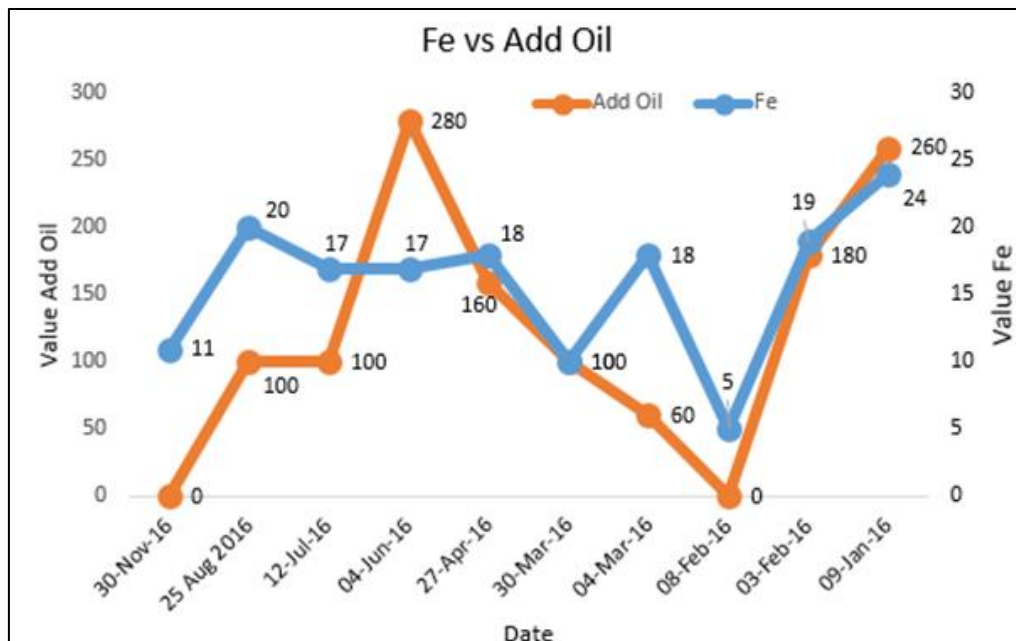


Figure 5. Graph of schedule oil sampling testing (Fe vs Add Oil Lubricant).

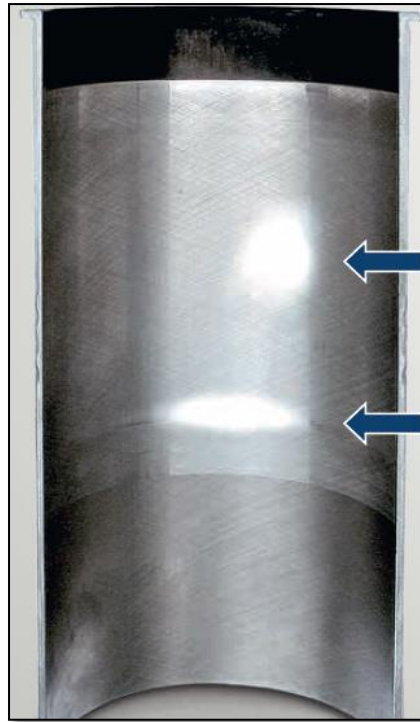


Figure 6. Shiny at liner [10].

8. Conclusion.

Engine lubricant mixed with diesel fuel results in reduced lubricant viscosity (fuel dilution) caused by damage to the hardened injector seal, with hardening of the injector seal friction, which occurs with the seal holder and shaped groove. When the unit is operating, the fuel will flow into the combustion chamber, causing abnormalities in the combustion process and when the unit is not operating, diesel will flow into the combustion chamber and then flow into the oil pan. This is affected by the high fuel temperature, damaging the injector seal holder in the cylinder head and not fitting the holder. Groove on the cylinder head wall a maximum of 2 millimeters in-depth, if it exceeds 2 milli it will cause fatality to other engine components. To prevent fuel dilution from occurring, care must be taken regarding the temperature of the fuel. treatment, preventing fuel temperatures from rising beyond 60 °C (150 °F). Preventing back pressure fuel return exceeds the maximum limit of 27 kPa (kilopascal) and perform maintenance in accordance with procedures, as well as routine engine lubricant testing, in order to find out the diesel content of engine lubricant.

9. Reference.

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In the explanation in Figure 1, 1) Daily tank functions to collect fuel after leaving the engine, 2) the strainer functions to filter large particles before entering the fuel system. 3) Primary filter functions to filter small particles in micron size, 4) Fuel transfer pump to transfer to the fuel system, 5) Secondary filter functions to filter particles under 5 microns, 6) tube (supply) to deliver fuel to the injector, 7) The injector functions to inject fuel into the fuel chamber, 8) Tube (return) distributes the material after the injector, 9) The fuel cooler functions to cool the fuel after the injection system, the damage that occurs at no. 7 (injector).

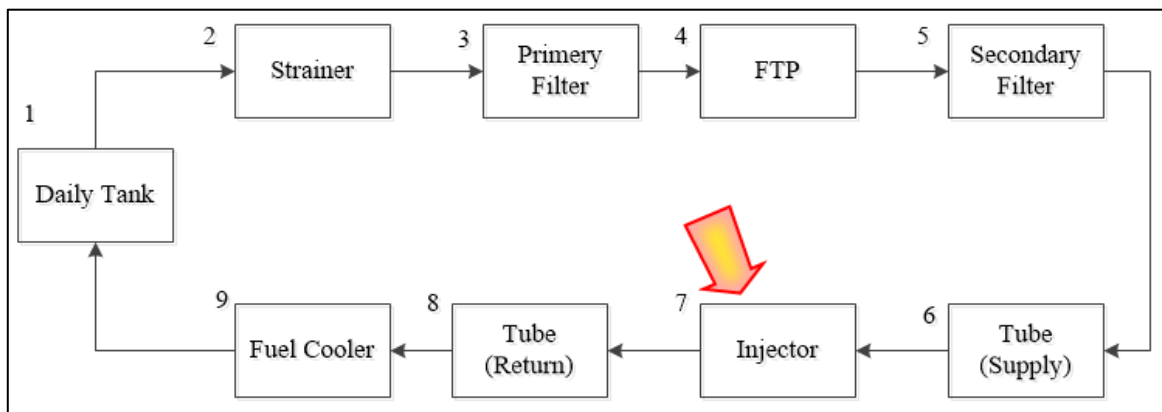


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Figure 2. Solar is in the combustion chamber.

The formation of a groove injector seal holder in the cylinder head resulting in leakage of fuel into the combustion chamber and diesel fuel flowing from the cylinder head to the oil pan.

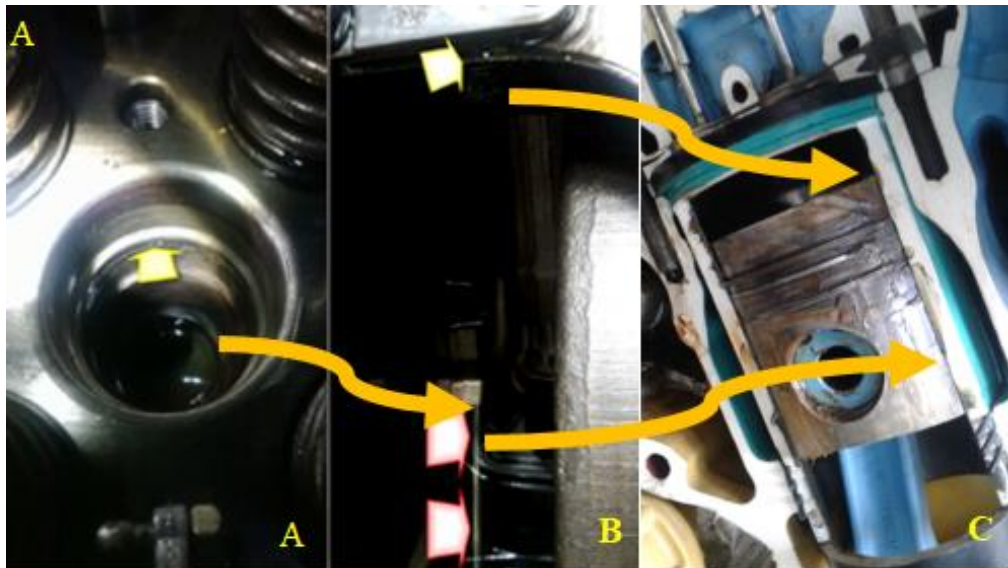


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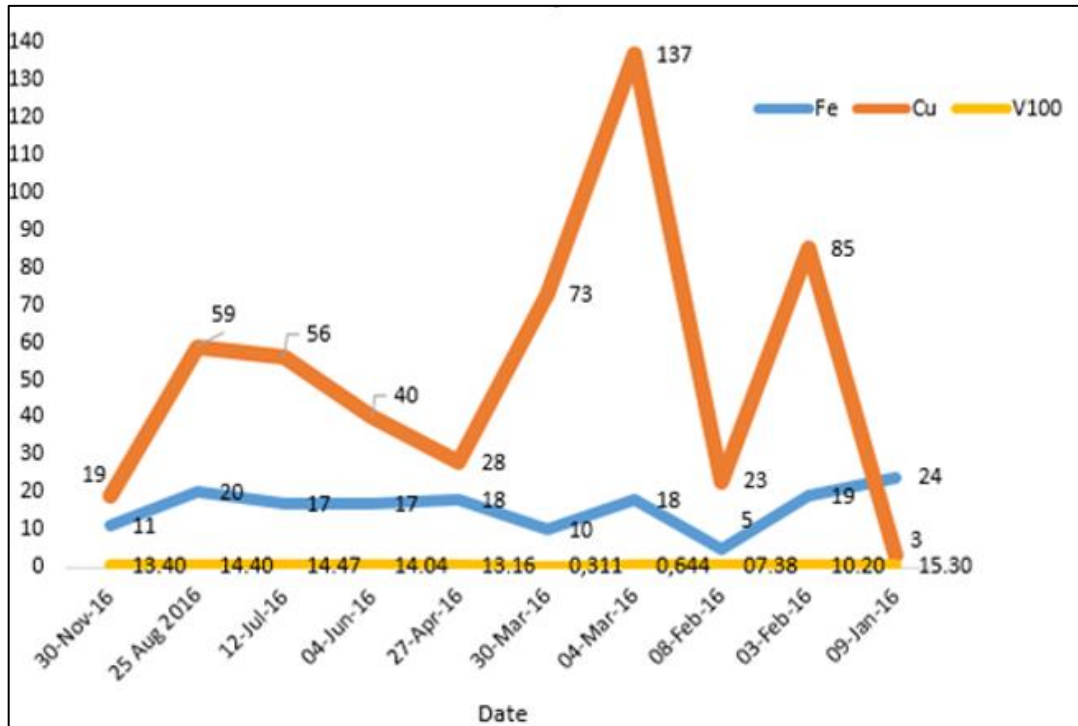


Figure 4. Graph of scheduled oil sampling test results (Fe, Cu, and Viscosity)

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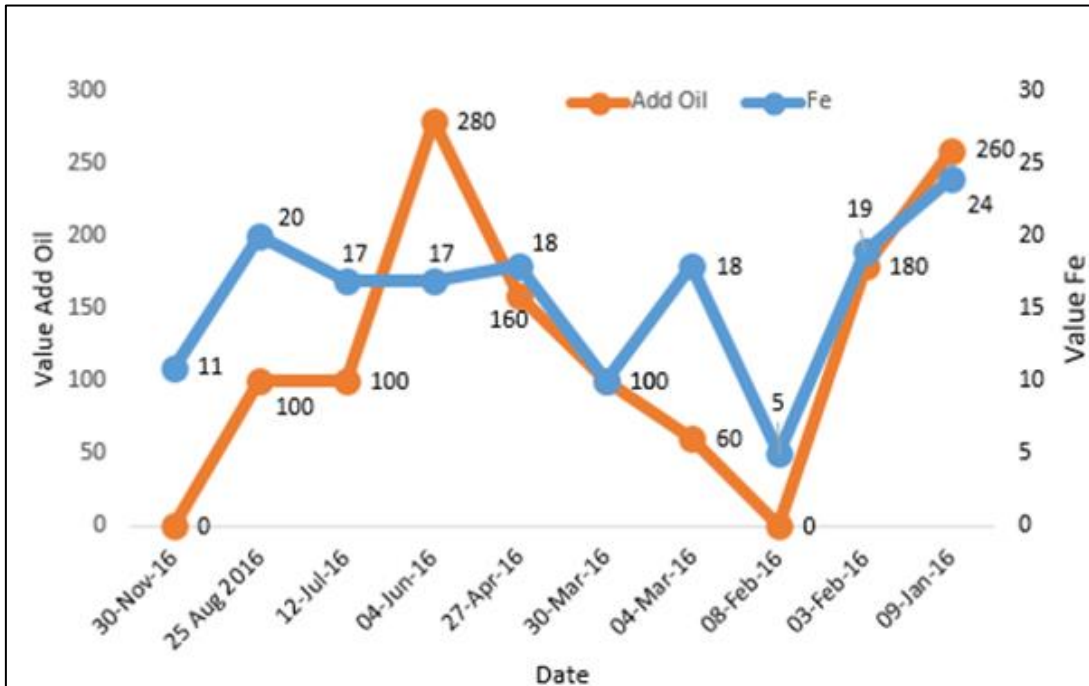


Figure 5. Graph of scheduled oil sampling testing (Fe vs Add Oil Lubricant).

Figure 6 explains the occurrence of shiny in the liner where there is friction between the piston ring and the liner wall in the shiny region of the surface of the liner caused by scale deposits [15] on the middle and bottom sides. Indications that occurred in oil testing indicated an increase in the Fe element.

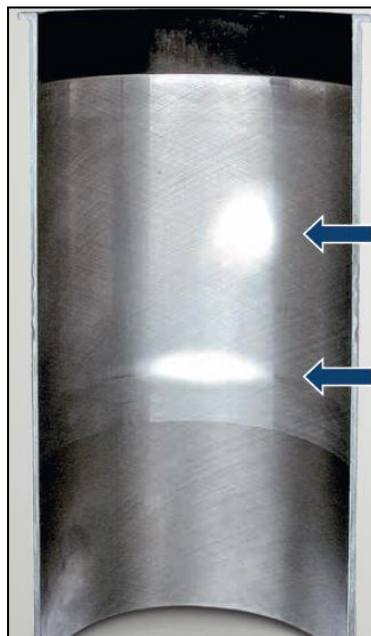


Figure 6. Shiny at liner [9].

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Engine lubricant mixed with diesel fuel results in reduced lubricant viscosity (fuel dilution) caused by damage to the hardened injector seal, with hardening of the injector seal friction, which occurs with the seal holder and shaped groove. When the unit is operating, the fuel will flow into the

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Analysis of SOS Results for Engine Lubricants Contaminated by the Fuel in The 3516 TA Diesel Engine Generator Set

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Abstract. Generator Set Unit that operates in the PLTD, during operation there is a knocking sound at cylinder position # 14, after checking and removing the injector there is diesel in the combustion chamber and indicated glowing in the exhaust manifold. The purpose of this study is to determine the root causes of knocking and diesel fuel in the combustion chamber. This research method uses oil sample testing to be tested in the laboratory. The results of the analysis of oil contaminated with diesel fuel are caused by diesel oil flowing into the pan oil and after checking the cylinder head crack (groove-shaped) is found on the side of the injector seal holder, when the unit is not operating the diesel flows into the combustion chamber and into the oil reservoir. The groove in the cylinder head is formed, caused by a hard injector seal caused by fuel temperature and high water temperature. The solution of this research is that the pressure on the fuel return from the engine should not exceed 27 kPa, while the maximum fuel temperature is 66 °C (150 °F), and what needs to be done is an improvement of diesel cooling and routine radiator maintenance.

1. Introduction.

Generator Set which operates in one of the PLTD does not operate, due to experiencing engine oil mixed with diesel and indicated knocking when the unit is operating. The knocking indication occurs because the ratio of air to fuel is unbalanced, if left too long to operate will cause damage to the exhaust valve and intake valve [1]. After checking the engine, diesel fuel is found to flow from the inside of the cylinder liner and there is diesel fuel in the combustion chamber [2]. When the lubricating oil is mixed with the fuel, the viscosity (the ability of the oil to hold the flow rate decreases) will reduce the lubricating oil, this condition will damage the oil function which will cause damage to the engine components. The unit for reading viscosity in cSt (centistoke). Lubricant contaminating fuels also reduce the concentration of additives present in oil [3]. Excessive fuel contamination in oil can reduce the nature of the lubricating oil which will result in engine damage. Lubricating oil contaminated with diesel fuel will affect the decrease in oil pressure (low oil pressure) and increase the oil level. Fuel dilution decreases the ability of the oil film to protect moving parts [4]. Also, due to the reduced concentration of additives, lubricating oils do not have adequate amounts of anti-wear additives and corrosion inhibitors [5].



To meet stringent standards, the Common Rail fuel injection system has been implemented, which increases fuel injection pressure and introduces multi-stage dosing. The cost of repairs is very high because of sophisticated parts and technology and to reduce the cost of repairs [6]. In figure 1, the damage to the injector is explained [7].

In the explanation in Figure 1, 1) Daily tank functions to collect fuel after leaving the engine, 2) the strainer functions to filter large particles before entering the fuel system. 3) Primary filter functions to filter small particles in micron size, 4) Fuel transfer pump to transfer to the fuel system, 5) Secondary filter functions to filter particles under 5 microns, 6) tube (supply) to deliver fuel to the injector, 7) The injector functions to inject fuel into the fuel chamber, 8) Tube (return) distributes the material after the injector, 9) The fuel cooler functions to cool the fuel after the injection system, the damage that occurs at no. 7 (injector).

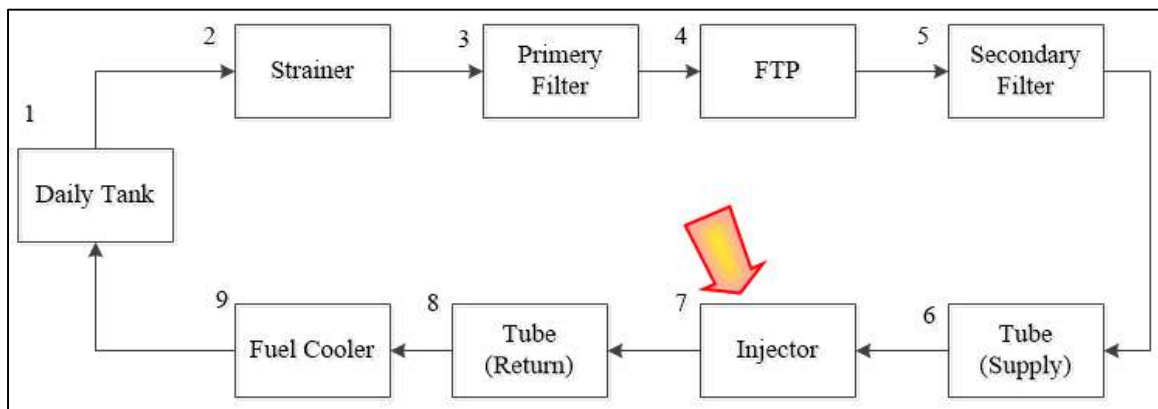


Figure 1. Position of damage to the injector

2. Literature Review.

Cracks in the injector seal holder causes fuel to flow into the combustion chamber [2]. In table 1 the standard readout of the oil test results is based on reference from manufacturing. Where diesel fuel is still recommended in tests below <4%. And if the value is above >4%, then it is immediately conditioned to the relevant parties regarding this matter [8]

Viscosity, hotspot and flashpoints are chosen as the most important parameters to follow changes in the fuel-oil mixture. Lubricant is diluted based on the results of the maximum oil laboratory analysis recommended units to be stopped or by testing engine oil that is contaminated with diesel fuel [4], so as not to cause great damage.

3. Statement of Problem.

Diesel engine oil contaminated from the results of SOS testing (schedule oil sampling) and visual checking in the field.

4. The Objective of Work.

- Check the cylinder head holder.
- Link damage to the injector holder with oil sampling testing.

5. Problem Description.

Knocking sound when the diesel engine is operating, after checking there is a fluid leak from the inside of the cylinder liner. Diesel fuel is in the combustion chamber and contaminates engine oil, so that engine oil is low viscosity.

6. Observation of Field.

Based on the cylinder head inspection it was found that the diesel fluid was in the combustion chamber, which is explained in figure 2.



Figure 2. Solar is in the combustion chamber.

The formation of a groove injector seal holder in the cylinder head resulting in leakage of fuel into the combustion chamber and diesel fuel flowing from the cylinder head to the oil pan.

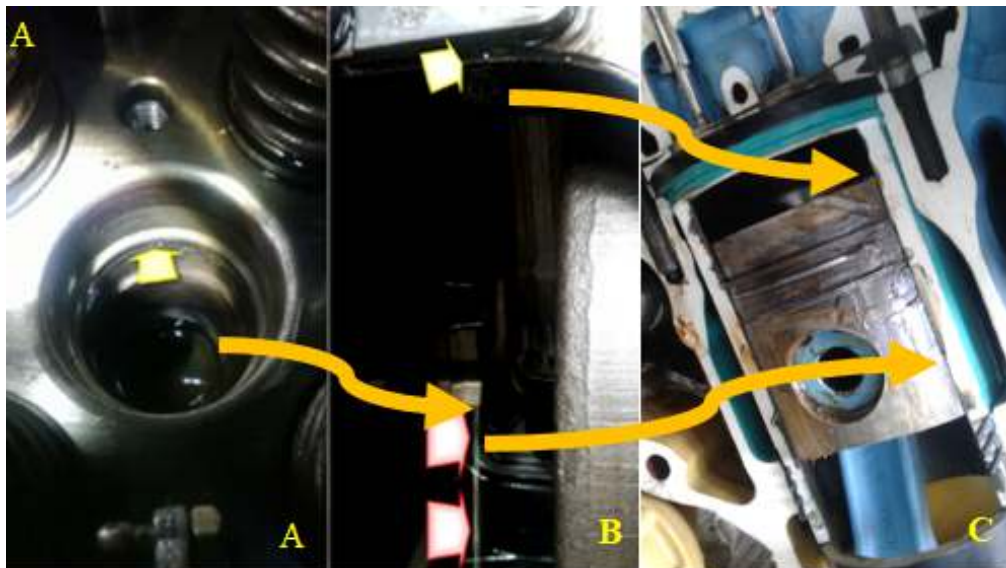


Figure 3. The formation of the groove on the cylinder head in the injector seal holder.

7. Result Analysis.

Fuel dilution will affect the engine lubrication system and its fatality results in the hydraulic lock and wear on the liner wall.

Lubricant performance:

- Viscosity decrease.
- Positive fuel on Set-a-flash (4% maximum)
- Fe (cylinder liner, crankshaft, camshaft, pushrods).
- PB & Sn (bearing overlay).
- Cr & Mo (piston rings).
- Cu, Pb, & Sn (bronze bushings).

Increased wear element Cu is found in bearing material, bushings, friction in engine components that come in contact with metal components with metals, causing wear on bearing or bushing elements. As for engine lubricant that is contaminated with diesel fuel causes thinning of the oil film, according to the data in figure 4, where on March 4 and March 30 2016 oil viscosity was recorded at 0.311 and 0.644, the condition of the lubricant being low viscosity. The rate of wear from January to November 2016, wear element Fe, Cu trending is quite high starting from January and followed by a decrease in viscosity from January to March 2016. After March 2016 has been done to repair damaged components so that the lubricant viscosity becomes stable.

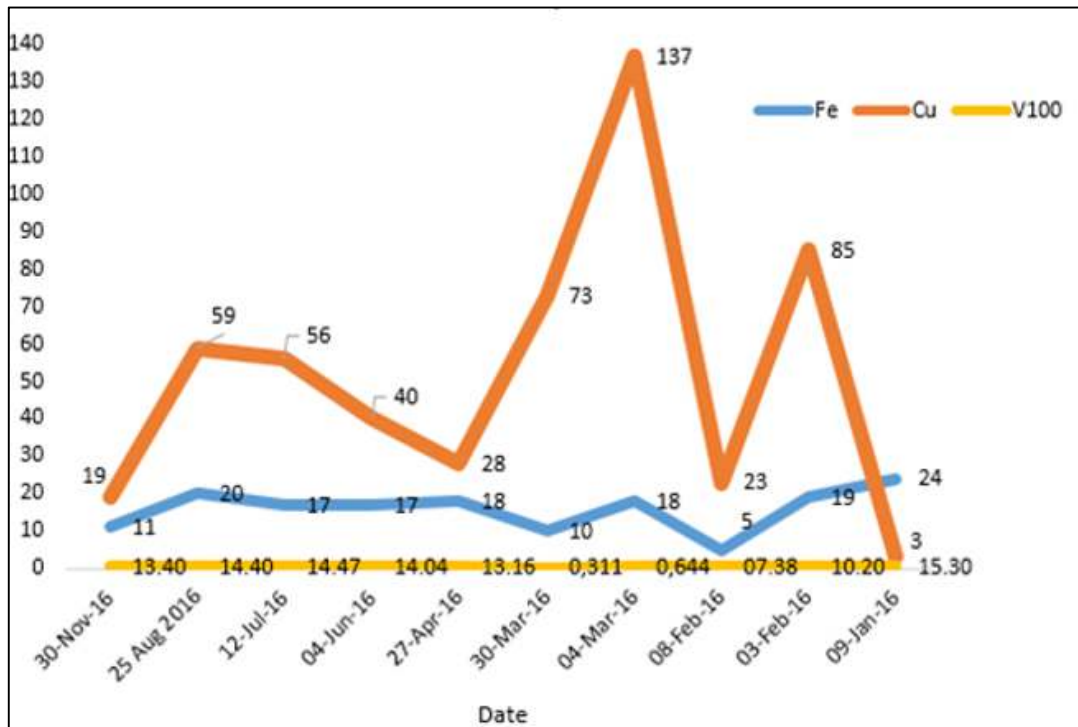


Figure 4. Graph of scheduled oil sampling test results (Fe, Cu, and Viscosity)

In the explanation of figure 5 the increase in Fe is balanced by the addition of lubricant at each lubricant change interval at 500 hours [9], enough to increase and including the addition of oil up to 260 liters on January 9, 2016, and 280 liters on June 04, 2016. With the Fe trend, increasing wear occurs in the liner wall. The impact on shiny on the inner liner wall described in Figure 6 [10] [11], lubricant also burns during the process of movement of the piston from BDC to TDC and the combustion process in the [12] combustion chamber occurs [13] and causes the lubricant to decrease, this will result in engine components will be damaged quickly, including bearings, shafts [14].

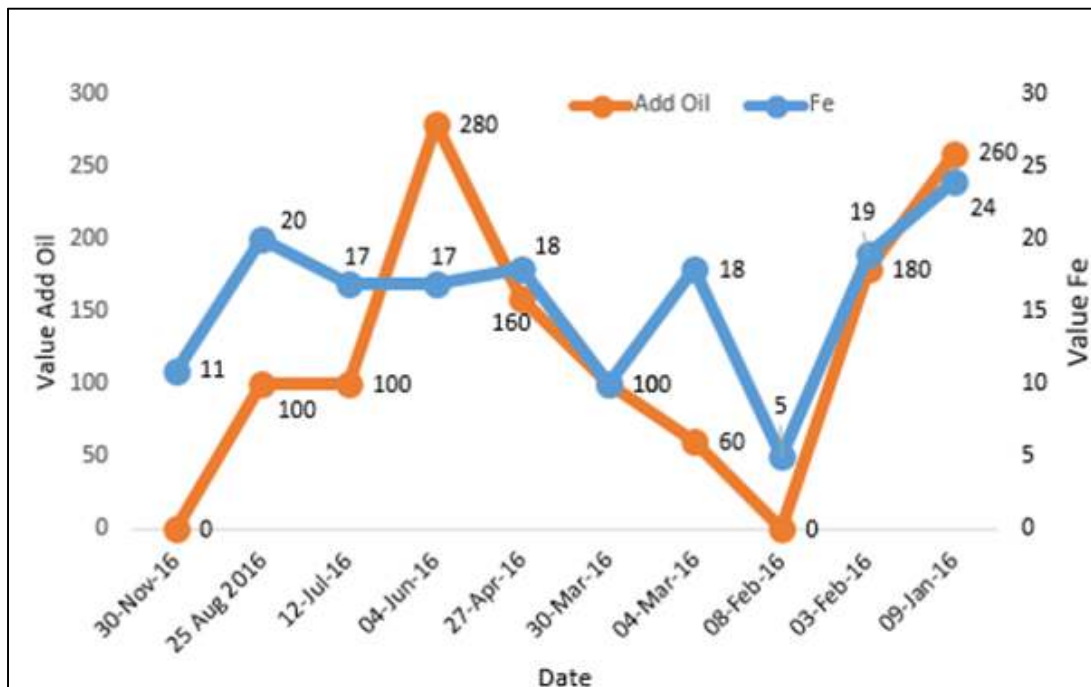


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