



## PAPER NO.: 74

# No Need of Additives in A New System for Semi-permanent Use of Lubricating Oil without Oil Renewal

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**Abstract:** The authors have developed a new technology that enables it to use lubricating oil (LO) semi-permanently and reduces LO consumption. The technology always keeps LO clean as the kidney of animals always keeps their blood clean. It is, therefore, called kidney system. There is no need of oil renewal forever and it is enough to supply only a small amount of fresh oil sometimes to compensate for the lost oil. No waste oil is, therefore, generated in the kidney system. The system has been working well in about 1000 units of marine and cogeneration diesel engines and in many hydraulic machines for many years. The results also show that the technology remarkably improves reliability of machines. Kidney system has another feature that it needs no additives and they are even harmful.

All the features mentioned above come from the fact that kidney system is able to remove LO sludge soon after it is generated, and that it is able to remove not only large sludge particles but also very fine ones. The high cleaning performance is based on the unique idea of removing LO sludge. In the kidney system, the key element of the system is a new type filter. In the

case of the conventional filter, contaminated LO flows through the filter meshes and large sludge particles are caught and removed by the filter meshes. In the case of the new type filter, however, many sheets of filter paper are arranged parallel and contaminated LO flows between the filter paper sheets. In the course of flowing between them, sludge particles sit on the surface of the filter paper and, thus, they are removed from LO. This mechanism of removing sludge particles is an exclusive feature of the new type filter.

The results of the practical use of the kidney system are as follows; (1) LO is always kept clean in the kidney system, (2) no oil renewal, (3) no waste oil, (4) reduction of LO consumption, (5) improvement of engine reliability due to clean LO, (6) only the kidney system may be able to obtain optimum contamination which minimizes engine wear and (7) the kidney system needs no additives and they are even harmful. Concerning the features (1) ~ (5), the authors published some reports in the past. In this paper, therefore, it is reported mainly based on the field data why no additives are needed and harmful to the kidney system. Also, optimum contamination is briefly discussed.

## INTRODUCTION

Nowadays, a lot of waste lubricating oil (LO) is generated every day in the world, which comes from the old and conventional wrong belief that LO is oxidised and deteriorated in engines. The authors have developed a new technology, which enables it to use lubricating oil semi-permanently with no oil change and no waste oil. The development of a new type filter has led to the successful new technology. The new LO system has been working well in more than 1000 units of marine and cogeneration diesel engines, about 50 hydraulic machine companies and about 60 machine workshops [1] [2]. The field data show that engine reliability and LO consumption are much improved by using the new system[1] [3].

The new system has the other two remarkable features. One is that it needs no LO additives and that they are even harmful. The other is that only the new system may be able to obtain optimum LO contamination which minimizes engine wear and remarkably elongate engine overhaul period. LO additives are considered to be harmful also in obtaining the optimum contamination. In this paper, the outline of the new LO system is described first. Then based mainly on field data, it is discussed that no additives are needed in the new system and why they are harmful. Optimum contamination is briefly discussed last. Some Data were already presented in the paper of CIMAC 2001 [1].

### OUTLINE OF NEW LUBE SYSTEM

#### New Type Lubricating System.

##### (1) Outline of the new system.

Figure 1 (a) shows the newly developed LO system. It is composed of a new type filter and a centrifugal sludge separator. The sludge separator is much smaller and of simpler structure than the centrifugal purifier in the conventional type LO system. In the new system, LO is circulated through the bypass system of the sludge solidifier and the new type filter. The idea of LO cleaning of the new system comes from the kidney of animals which cleans their blood and always keeps it clean. Therefore, the new system in figure 1 (a) is called kidney system.

LO is kept clean in the kidney system as shown in figure 1 (a). This is because the new type filter which is called nephron filter removes almost all fine sludge particles and because the sludge solidifier removes large sludge particles of relatively high density changing the liquid sludge into solid. This leads to reduction of LO consumption.

Figure 1 shows the structure of the nephron filter. Many sheets of the filter paper are piled up in a cylindrical case. Each of them is of circular shape with a hole at the center. Contaminated LO flows into the filter from the top side, then strikes the support plate at the right angle and flows into the outer space of the case. Then, LO flows between the filter paper from outer periphery towards holes at the center. It is expected that the nephron filter removes very fine sludge particles which are as small as  $0.001\mu\text{m}$  diameter. This is because fine particles ranging from  $0.001 \sim 1\mu\text{m}$  are considered to make Brownian motion and sit on the filter paper in the course of LO flow between the filter paper. This is a very important feature of the nephron filter because the mass of sludge smaller than  $1\mu\text{m}$  diameter is considered to account for almost all of the total sludge in LO. One of the authors' measurements shows that the mass of sludge particles larger than  $5\mu\text{m}$  diameter accounts for only about 1% of the total sludge mass [4]. Also, another report shows almost the same measurement [5].

##### (2) Defects of the conventional system.

The conventional system of marine and cogeneration diesel engines is usually composed of the pump and the centrifugal purifier, not paper filter, as shown in figure 1 (b). Paper filter is widely used in small engines such as automobile engines. The centrifugal purifier in the conventional LO system removes only large sludge particles. If soot particles and the soft groups of soot particles smaller than  $1\mu\text{m}$  diameter remain unremoved in LO, almost all the sludge remains and it is accumulated and LO gets contaminated more and more. This is considered to be the process of LO degradation in the conventional LO system. Furthermore, the centrifugal purifier throws out a lot of LO together with sludge and this is responsible for increasing LO consumption.

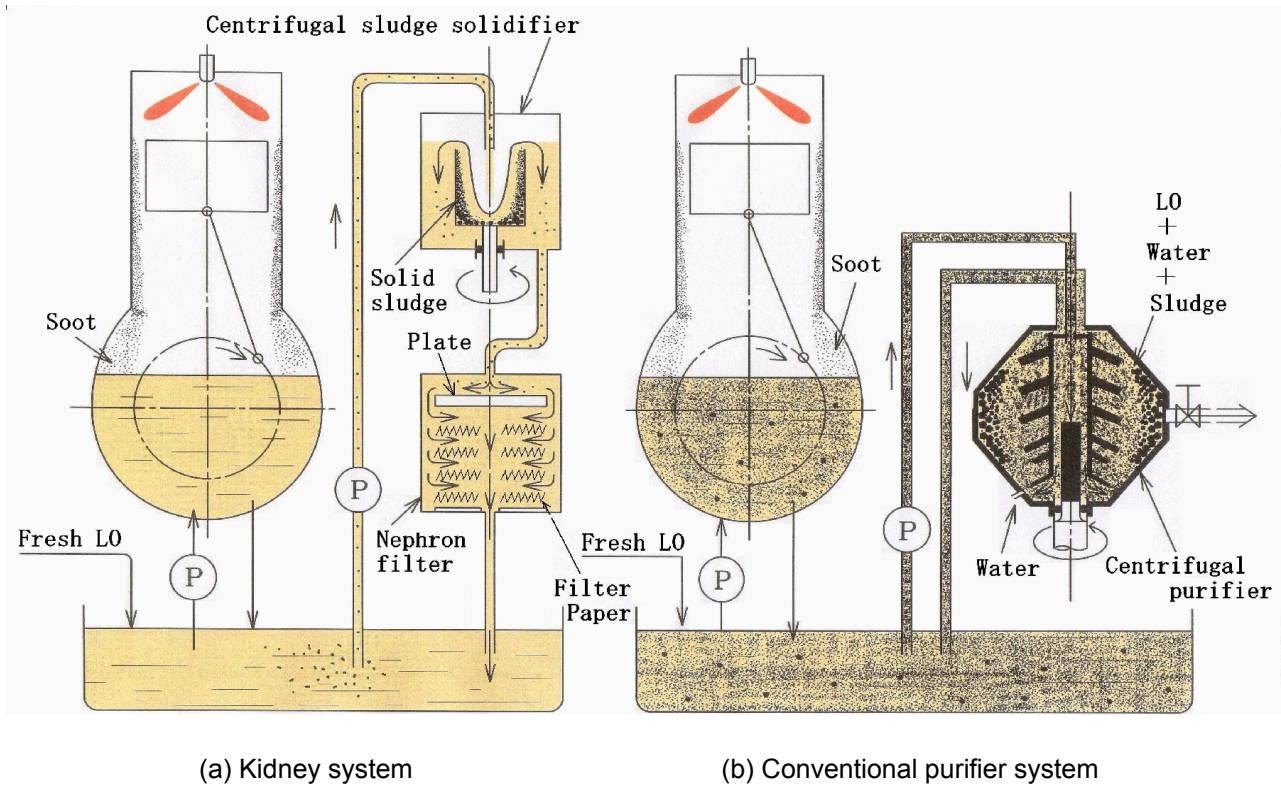


Figure 1 – Comparison of LO cleaning system

Field Data of Fundamental Performance

Figure 2 shows the result of a comparison test on fundamental performance of the kidney system [1]. It was carried out on three ships of the same type equipped with the engines of the same type. No cleaning system, the conventional and the kidney system were compared. In general, normal pentane (n-p) insoluble is used as an index of LO contamination. As shown in figure 2, n-p insoluble was kept below 0.1% in the kidney system during 10,000 hour running. In other two systems, however, n-p insoluble increased rapidly and LO was renewed with fresh oil in 4,000 ~6,000 running hours.

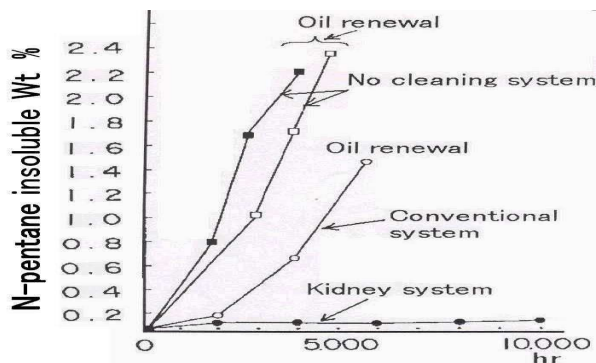


Figure 2 – Comparison test

The test verifies that the kidney system always keeps LO clean.

THEORY AND FIELD DATA ON NO NEED OF ADDITIVES

No Need of Antioxidant

Table 1 shows an analysis of sludge in the engines 1, 2 and 3. As discussed in the previous paper [1], LO is oxidised by less than 0.1% (0.01 ~ 0.1 %)/1000 hrs out of the circulating LO. This is negligibly small and nearly non-oxidation of LO is verified.

It is known that the oxidised LO strongly absorbs waves at  $1710\text{ cm}^{-1}$  in infrared radiation analysis (IR). Figure.3 shows that the kidney system removes the oxidised LO almost completely [1].

Oxidised LO is so sticky [6] that it is considered to be removed by adhering on the nephron filter. The amount of sludge on the filter is very small in comparison with that of LO circulating in an engine. Figure 3 also shows, therefore, that oxidised LO is negligible in amount and that antioxidant is not needed in the kidney system.

Table1 – Oxidised LO in sludge

4 cycle engines		1	2	3
Power kW		3675	1000	1000
FO		A	A	C
Sludge g/kW/1,000hrs		2.7	1.35	6.9
FO,LO in sludge	%		29.4	24.2
Toluene insoluble	%		63.7	69.9
Oxidised FO,LO	%		6.9	5.9
Total	%		100	100
N-pentan insoluble in LO	%	0.28	0.18	0.35

A; Marine diesel fuel oil of good quality  
C; Low grade fuel oil.

No Need of Antifoamer

Oxidised LO is considered to be one of the main foaming elements. Figure 3, therefore, shows almost no need of antifoaming agent, which is also confirmed by the experience in practical use of the kidney system for many years.

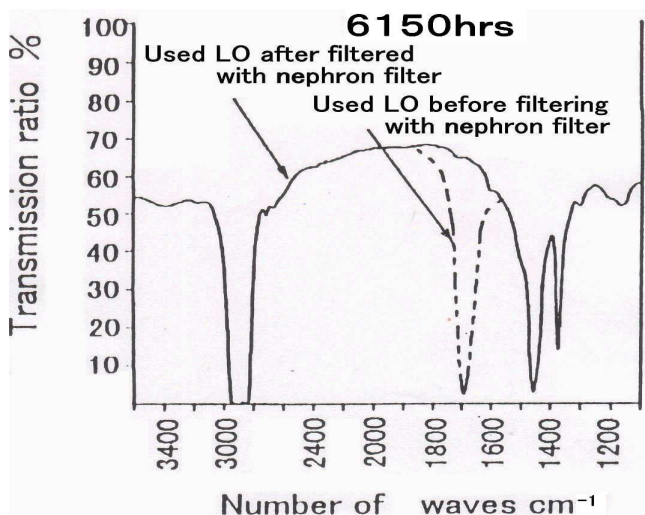


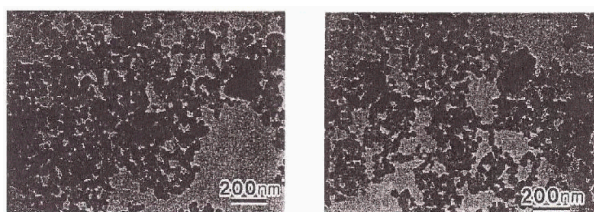
Figure 3 – Oil analysis with infrared spectrometer

No Need of Detergent Dispersant

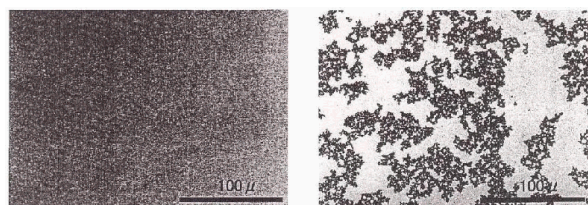
(1) Research example

Figure 4 and figure 5 show experimental results on performance of detergent dispersants [7]. Figure 4 (a) and (b) show coagulated soot in LO without

dispersant. On the other hand, figure 5 (a) shows sludge which was dispersed into very fine particles by a very strong dispersant. Figure 5 (b) shows, however, soot is coagulated in LO with a moderate dispersant. Figure 4 (a) and (b), and figure 5 (b) suggest that sludge may be removed by the nephron filter if there is no dispersant or it is not too strong. On the other hand, figure 5 (a) suggests that sludge may not be removed from LO with strong dispersant.



(a) LO (A) (b) LO (B)  
Figure 4 - Sludge from soot (LO without additive)

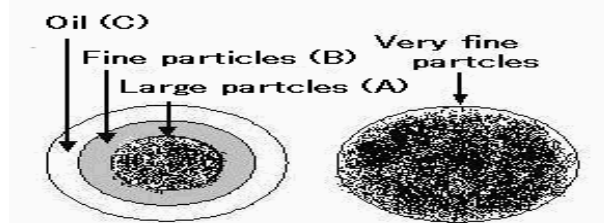


(a) High duty LO (b) Medium duty LO

Figure 5 – Sludge from soot

(2) Spot test

Spot test is a very simple and convenient way to get information of contamination degree and detergent dispersant. In the spot test, some LO sample is dropped on a sheet of filter paper. If there is no dispersant or it is not strong, three circles are formed as schematically shown in figure 6 (a). Large sludge particles form the very black circle (A) around the center because they can not diffuse into the paper. Fine particles form the circle (B) and oil



(a) Medium duty oil (b) High duty oil

Figure 6 – Schematic diffusion of sludge over paper

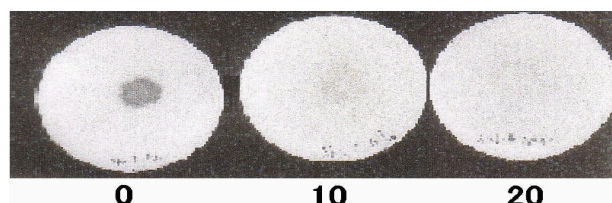
form the circle (C). If dispersant is very strong, sludge particles are dispersed into very fine particles and they can easily diffuse outwards to form the one black circle as shown in figure 6 (b).

### (3) Experiment of Model Contaminant

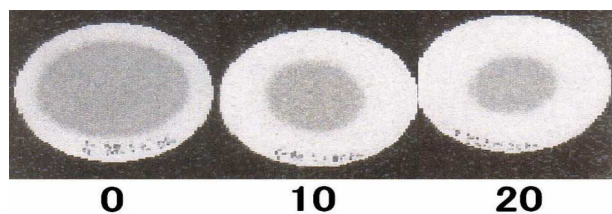
An experiment was conducted by using a model contaminant which simulates engine soot in particle size and distribution. The model contaminant was solved in an LO with no additives and in another LO with additives. The two contaminated LOs were filtered by the nephron filter. In the course of filtering, oil samples were taken from the two LOs and they were dropped on filter papers to see how much they were cleaned. Figure 7 (a) and (b) show the comparison. Figure 7 (a) shows that contaminated LO with no additives became cleaner as filtering time went on. This is because there was no dispersant and the contaminant particles were coagulated to be removed. On the contrary, figure 7 (b) shows that LO with additives was not cleaned by the nephron filter. This is because the contaminant was dispersed into fine particles by a strong dispersant.

### (4) Field Data

Figure 8 shows field data. Figure 8 (a) is the result of a filtering test on the LO with additives of medium



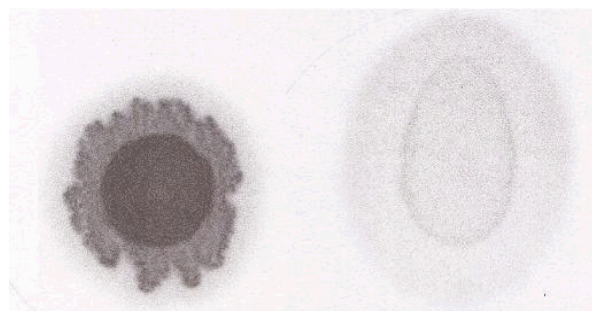
Filtering time hr  
(a) No additives



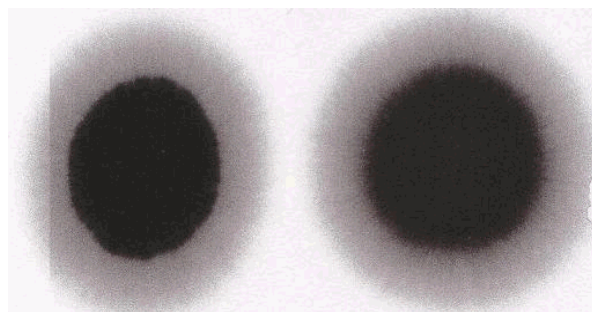
Filtering time hr  
(b) With additives

Figure 7 – Model contaminant

duty type. As is shown, the contaminant at the center was removed by the nephron filter. In figure 8 (b), however, the contaminant was so strongly dispersed by the heavy duty additives that LO was not cleaned by the nephron filter.



Not filtered      Filtered  
(a) Medium duty



Not filtered      Filtered  
(b) Heavy duty

Figure 8 – Spot test

### (5) No need of dispersant

Discussion and Experiments (1)~(4) above show that detergent dispersant is not needed in the kidney system.

### No Need of Extreme Pressure Agent

A company made a test to decide whether the kidney system should be adopted or not. Table 2 shows that load carrying capacity of the waste oil cleaned with the nephron filter is about 25% higher than that of both the fresh oil and the waste oil. There may be two reasons for the result. One is that oil soluble interim products may form a strong boundary layer over the metal [6]. The other is that very fine sludge particles may be working as ball bearings in the LO cleaned by the nephron filter, as discussed in the following chapter.

Table2 – Four ball test (1986-8)

Items \ LO	A Fresh oil	B Waste oil in conv. system	C Waste oil filtered with nephron filter
Vis. mm <sup>2</sup> /s,40°C	142.5	160.9	161.9
Water Vol. %	0.00	0.05	0.00
Total acid No. mgKOH/g		4.36	4.17
Total alkali No. mgKOH/g	22.0	18.3	18.4
N-pentane insoluble Wt%(B)	0.00	0.22	0.18
4 ball test seizing load 1800rpm, 2hr,491N,75°C	1961N	1961N	2452N

(1) Cogeneratin diesel engine ; MHI, 18KU-30  
5000kW × 720rpm

(2) LO ; CE grade, fresh LO viscosity  
130mm<sup>2</sup>/s,40°C, TBN 20

(3) FO ; Low grade heavy FO

Harmfulness of Additives

Additives are harmful in the kidney system in the following points.

(1) Additives are not needed in the kidney system. It is, therefore, uneconomical to pay money for unnecessary chemicals.

(2) All additives are finally deteriorated and turn into sludge. Sludge from additives contain metals such as Ca, Zn and Mg, which turn into harmful abrasives to wear engine.

(3) Deteriorated additives are finally thrown out into the environment. It is, therefore, not only waste of natural resources but also harmful to the environment.

(4) Strong detergent dispersant makes it difficult or impossible for the nephron filter to remove sludge. This is very harmful not only to the kidney system but also to the optimum contamination discussed in the following.

Only some detergent dispersant is used in the kidney system when fuel oil of some sulpher content is used. The dispersant is used to disperse alkali in LO which is used in order to neutralize sulpher acid in the combustion chamber.

OPTIMUM CONTAMINATION

Engine Speed and Optimum Contamination

The kidney system speedily removes contaminant and always keeps LO clean. One of the results is that engine reliability is also improved. The authors have believed, however, that there exists optimum contamination which minimizes wear of engines. Contamination may be represented by normal pentane insolubles because most part of it is hard solid such as wear debris. Therefore, n-pentane insoluble is abrasives in engine wear, so to speak.

It is considered that optimum contamination depends on engine speed. High speed engines are small and light in weight. On the other hand, slow speed engines are large and heavy. Therefore, lubricating surface is considered to be smoother in high speed engines than in slow speed engines as schematically shown in figure 9.

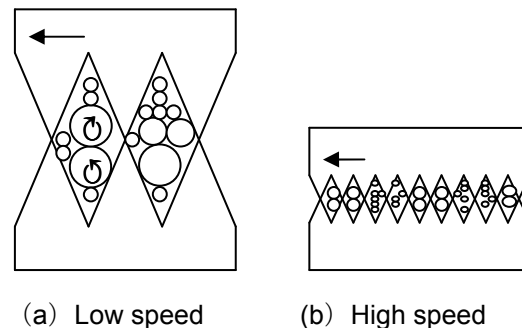


Figure 9 – Surface roughness

The authors' assumptions are as follows. (1) Optimum amount of contaminant particles reduces wear because of their function of ball bearing as shown in figure 9. (2) In the optimum condition, particle size must be large in slow speed engines while they must be small in high speed engines. (3) Only the nephron filter is able to remove very fine particles and obtain the optimum contamination.

#### Field Data of Optimum Contamination

Figure 10 shows an example of optimum contamination of n-pentane insoluble obtained from field tests. There have been almost no wear or very little wear of piston rings and liners, and bearing metals in the engines whose LO contaminations have been around the optimum shown in Figure 10. For example, wear of piston rings is less than measurable after 8,000 hour running in case of the cogeneration diesel engine, 1,200 rpm. On the contrary, engine wear was very serious in the engines A, B and C whose contaminations were far out of the optimum. Further research has been going on and detail report will be made in the near future.

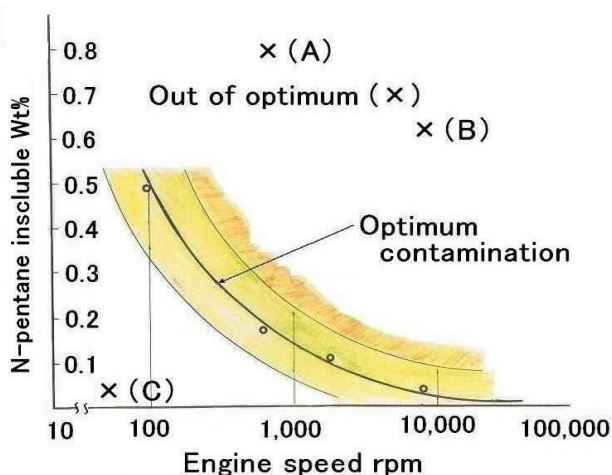


Figure 10 – Optimum contamination

## CONCLUSIONS

(1) A new LO system for semi-permanent use of LO, no waste LO and no LO change has been developed and in practical use in many engines.

(2) It is discussed why the new LO system needs no additives and they are even harmful. The discussion is verified by the field data.

(3) Optimum contamination of LO which minimizes engine wear is discussed and an example of the field data is presented.

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