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[1.] Diana Miruna ARMIONI

LUBRICATION SYSTEM FAILURES IN DIESEL ENGINES DUE TO IMPROPER OIL CHANGES

[1.] Politehnica University of Timişoara, Doctoral School of Engineering Studies, Piaţa Victoriei 2, 300006, Timişoara, ROMANIA

Abstract: Diesel engines operate under high thermal and mechanical stress, making effective lubrication essential for reliability and durability. This study analyses lubrication system failures caused by improper oil maintenance, including extended oil change intervals, incorrect viscosity grades, and contamination during servicing. Findings show that degraded or unsuitable oil accelerates oxidation, additive depletion, sludge formation, and abrasive soot accumulation, which result in oil starvation, bearing wear, clogged passages, and turbocharger or valve train damage. Oil pump failures and catastrophic engine seizures were also linked to neglected maintenance. The analysis demonstrates that such failures are preventable through adherence to recommended service intervals, correct oil specifications, and proper servicing practices, highlighting the critical role of preventive oil management in extending diesel engine life.
Keywords: used engine oil, diesel engine, lubrication system, oil change

INTRODUCTION

Diesel engines rely on a robust pressurized lubrication system to minimize friction and dissipate heat from moving parts such as bearings, pistons, camshafts, and turbochargers. Unlike gasoline engines, diesel engines operate at higher compression ratios and loads, generating intense pressures and temperatures that place heavy demands on the engine oil [1].

Proper maintenance of the lubrication system, especially regular engine oil and filter changes with the correct oil grade, is critical for engine longevity. Improper oil change practices (infrequent oil changes, use of incorrect oil viscosity or specification, or introducing contaminants during oil service) can undermine the oil's ability to protect the engine. Over time, degraded or wrong oil can lead to oil starvation, excessive component wear, sludge deposits, and even catastrophic failures.

Modern diesel engines use a forced–feed lubrication system driven by an oil pump. The oil pump is often described as "the heart of a lubrication system," sucking oil from the sump and pressurizing it through oil galleries to reach all moving components [2]. After circulating through bearings, valve train components, and pistons (including cooling jets under piston crowns in many diesels), the oil drains back to the sump for recirculation. The system includes an oil filter to remove contaminants, and often an oil cooler to manage oil temperature. Diesel engines typically have larger oil capacities and robust oil filtration compared to gasoline engines, reflecting the diesel's heavier soot and contaminant loads and longer service intervals. Critical points in the system – main bearings, connecting rod bearings, camshaft bearings, and turbocharger bearings – depend on a continuous film of oil of appropriate viscosity. Any interruption or degradation in this oil film can cause metal–to–metal contact and rapid wear [2].

This paper focuses on diesel engines and presents a technical root cause analysis of lubrication system failures caused by improper oil change practices. Common failure modes, including oil starvation, bearing wear, sludge buildup, and oil pump or turbocharger failures, are examined.

IMPROPER ENGINE OIL MAINTENANCE

Improper engine oil maintenance can take several forms [3]:
- running oil far beyond its recommended service interval
- using the wrong oil viscosity or specification
- allowing contaminants to enter during oil changes or neglecting filter replacement.

These practices can each induce different failure mechanisms, which often overlap.

Infrequent or extended oil change intervals

Over time, engine oil oxidizes and its additives (detergents, dispersants, anti–acids, anti–wear agents) get consumed. The oil's Total Base Number (TBN), which indicates its ability to neutralize acidic combustion products, steadily drops. If oil changes are infrequent, the TBN can fall below safe levels, allowing acidic compounds (from sulfur and nitrogen in diesel fuel combustion) to corrode bearings and other surfaces [1]. Prolonged intervals also exhaust anti–oxidant additives, causing the oil to thicken and form deposits. A study on extended drains showed that doubling a diesel truck's oil drain interval from 15 000 to 30 000 kilometers (especially with a reduced oil sump capacity) led to a significant loss of engine power and increased wear, due to piston ring and groove wear and increased blow–by from deposit formation [4].

Diesel engines naturally produce soot (carbonaceous particles) from combustion. Normally, detergents and dispersants keep soot finely suspended so it can be carried to the filter. However, as oil ages and dispersant additives deplete, soot aggregates into sludge. High soot loading is especially a concern in modern diesels with EGR (exhaust gas recirculation) and high–pressure fuel injection, which tend to produce finer, more abrasive soot [5]. If oil is not changed, soot concentration can exceed the oil's carrying capacity, causing several problems:

1) Abrasive wear: soot particles (especially aggregates ~1 μm) can act like fine lapping compound. They polish away protective films on cam lobes and followers and abrade metal surfaces [6]. Studies describe soot's "pro–wear" behavior: larger soot particles scouring surfaces and even removing anti–wear additive layers [6].

2) Oil thickening: Soot and oxidation products increase oil viscosity and can even form gel–like masses. Excessively thick oil flows poorly, especially during cold starts, which can lead to low oil pressure and oil starvation in parts of the engine [6].

3) Sludge deposits: At high concentrations, soot combines with other contaminants to form deposits in the crankcase, head, and oil pan [6]. These tar–like sludge deposits cling to surfaces and can block oil return passages and filters.

Other contaminants also accumulate when oil changes are delayed. Fuel dilution is a known issue in diesel oils: small amounts of diesel fuel wash past rings (especially with frequent cold starts, idling, or injector issues) and mix with the oil. Normally, light fuel fractions may evaporate out, but continuous dilution lowers oil viscosity and can form varnish. Severe fuel dilution (>2% fuel in oil) drastically thins the oil (e.g. turning a 15W–40 oil effectively into a 5W–20), collapsing the hydrodynamic oil film that protects bearings and cylinder walls. This leads to metal contact wear on pistons, rings, liners, and crank bearings. Fuel in oil also contributes to soot and deposit formation (unburned aromatics) and depletes dispersants [1]. Similarly, coolant leaks (glycol from a head gasket or cooler failure) are especially lethal to engine oil. Even a 0.4% glycol contamination can trigger massive sludge formation by coagulating soot and reacting with oil additives. Glycol in the oil forms acidic compounds and gelatinous "oil balls" that plug filters and oil passages, leading to rapid bearing damage [6]. In short, skipping oil changes allows fuel, coolant, water (condensation), and wear metals to accumulate in the oil, each contributing to lubrication failure if unchecked.

A crucial but often overlooked aspect of extended oil use is oil filter saturation. As the oil carries more soot and debris, the filter can become clogged. Eventually, the filter element reaches capacity and the pressure drop triggers the bypass valve to open, sending unfiltered oil through the engine. An overloaded filter thus reduces filtration efficiency and allows abrasive particles to circulate freely [7]. Additionally, sludge can coat the filter element and further restrict flow.

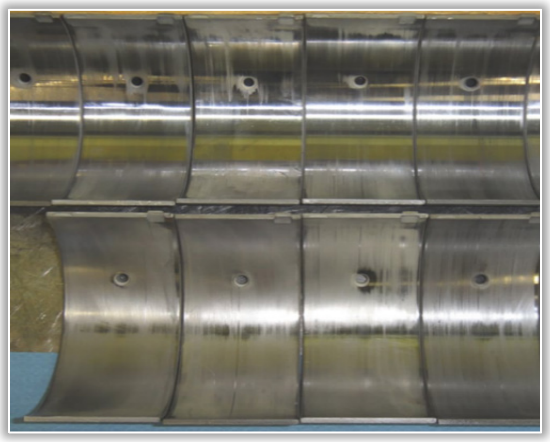


Figure 1. Polished appearance and streaking of main bearing shells from a diesel engine due to oil starvation from improper lubrication

In severe cases, sludge and debris can block the oil pickup screen or small oil passages. The net result is oil starvation in one or more components even if there is oil in the pan. Indeed, one field test found that doubling the oil drain interval (with inadequate sump capacity) led to heavy sludge on rocker covers and head decks, clogging oil return paths and filters [7]. Oil starvation is among the most dangerous failure modes because it can cause sudden seizure of bearings or turbochargers. Figure 1 illustrates the main bearings from a diesel engine that suffered lubrication failure due to extended oil use.

Use of incorrect oil viscosity or specification

Using the wrong type of oil for a diesel engine can cause serious lubrication problems, even if oil change intervals are on schedule. Diesel engines are typically designed for multigrade oils of a certain viscosity range (e.g. 15W–40 or 5W–40 for heavy–duty diesels in moderate climates) and must meet API or ACEA diesel specifications for sufficient detergency, dispersancy and load–carrying capacity. Deviating from the recommended viscosity or using an oil not rated for diesel service can lead to several failure modes [8]:

— Oil too thin (lower viscosity than required): if an oil of too low viscosity (or a passenger–car gasoline oil with insufficient high–temperature thickness) is used, the oil film may not be thick enough to withstand the high loads in components like main bearings or cam lobes. Oil pressure may run low, especially at operating temperature, triggering warning lights. A thinner oil can also be more prone to getting past seals, paradoxically causing leaks in an engine designed for a thicker oil. Premature bearing wear or even a spun bearing can result from persistent use of excessively low viscosity oil under heavy diesel loads. In cold climates a slightly thinner oil may aid starting, but it must still have adequate high–temperature viscosity once the engine is hot [8].

— Oil too thick (higher viscosity than specified): using a heavier–than–recommended oil can impede oil flow, particularly at low temperatures. Thick oil moves sluggishly through narrow passages and takes longer to reach valve train and turbocharger on startup. This can cause transient oil starvation in those components during cold starts [8]. A viscosity that is too high can also run hotter (due to fluid friction) and may not remove heat as effectively, risking localized overheating. Additionally, pumping losses increase: the engine expends more energy to circulate a highly viscous oil, possibly dropping fuel economy. While a slightly higher viscosity might not cause immediate harm, persistently using a much thicker oil can accelerate wear on the oil pump (working against higher resistance) and lead to inadequate lubrication of tight–clearance areas (like hydraulic lifters or cam journals), especially during cold operation [8].

— Incorrect oil specification or quality: beyond viscosity grade, oil formulated for gasoline engines (API "S" categories) should not be used in diesel engines which require API "C" category oils. Diesel–rated oils contain crucial additives: e.g. dispersants to handle soot, higher detergent levels to prevent deposits, and generally a higher TBN to combat acids. Using a non–diesel oil (or an obsolete diesel specification in a modern engine) can result in rapid sludge and deposit formation. For instance, a lower–spec oil may not keep soot finely suspended, leading to sludge that clogs filters and piston ring grooves [3]. It may also lack the anti–wear levels needed for diesel valve trains – modern low–emission diesels have very high camshaft loads, and oils are formulated to protect against scuffing. If the wrong oil is used, vital additives (like ZDDP, molybdenum, borate esters, etc.) might be insufficient, causing moving parts to wear prematurely [3]. Manufacturer oil specifications (such as ACEA E7/E9, Cummins CES, etc.) often include tests for piston cleanliness, bearing corrosion, wear and soot handling; using an oil that doesn't meet these can create serious engine issues [4], potentially leading to ring sticking, clogged diesel particulate filters (from high ash oil), or corrosion of bearings.

— Additive incompatibility: in some cases, using an incorrect oil type can chemically react with leftover oil or contaminants. For example, mixing certain additive chemistries might lead to precipitation of additives [3].

FAILURE MODES AND TECHNICAL ROOT CAUSES

When the lubrication system is compromised by degraded oil, wrong oil, or contamination as described, several failure modes can result. These modes often interrelate (e.g. sludge can cause starvation, which causes wear, etc.), but they should be discussed them separately for clarity.

Oil starvation and low oil pressure

Oil starvation refers to a condition where the engine's moving parts are not receiving sufficient oil flow or pressure. In a diesel engine, oil starvation typically manifests as dangerously low oil pressure readings, flickering oil warning lights (especially at idle), or audible signs like valvetrain ticking due to lack of oil. Starvation can be global (entire engine has lost oil pressure) or localized (one part is starved while others still get oil, due to a blockage or distribution issue). Improper oil changes can lead to starvation through several pathways:

- Critically low oil level: not refilling the proper quantity of oil or neglecting to top up oil consumption can cause the sump level to fall below the oil pickup. If an engine leaks or burns oil and oil changes are infrequent, the level might become low enough that the pump sucks air, especially during cornering or braking. Low oil level forces the pump to work harder with less oil, leading to cavitation and "additional friction resulting from insufficient lubrication," which can warp pump components and cause pump failure. This eventually causes a drop in oil pressure and intermittent starvation [9].
- Clogged oil pickup or passages: extended oil use can create sludge that settles in the oil pan or forms in narrow passages. Sludge, as discussed, can clog the oil pickup screen in the sump. Water contamination that emulsifies with oxidized oil can form "globular pools of sludge" that, when mobilized, knock out filters and restrict oil flow to bearings, pistons and the valve deck. Thus, an engine with thick sludge deposits can suddenly lose oil pressure if a chunk dislodges and plugs the pickup. One telltale sign is an oil pressure drop after running the engine hard (which might circulate sludge). This failure mode is directly tied to infrequent oil changes, sticky tar–like sludge is a product of neglected maintenance and can shut off oil circulation [9]. Additionally, as mentioned, if the oil filter is fully blocked with deposits, the bypass may open but still not allow full flow (or in worst case, sludge blocks oil galleries downstream). A blocked filter or pickup will quickly cause main gallery pressure to drop and starve critical components.
- High viscosity or cold oil starvation: using oil that is too thick (or oil that has thickened with soot/oxidation) can cause starvation, particularly at cold start. When oil is very viscous, the pump may struggle to draw it through the pickup (potentially causing cavitation), and flow through narrow passages is sluggish. In cold weather, improper oil choice (e.g. using a 15W–40 in sub–zero temperatures without block heating) can mean that the oil pump's relief valve opens (due to high pressure near the pump), but remote parts like overhead cams still temporarily get little flow. Over time, repeated cold start starvation contributes to camshaft and turbocharger wear. This mode is exacerbated if the oil is old and partially gelled, another reason timely changes are needed. Diesel engine turbos are very sensitive: insufficient oil supply for even a few seconds can overheat the turbo's bearings. Turbocharger manufacturer data and analyses show that poor oil supply (whether from obstructions, low oil, or high viscosity in cold weather) is a leading cause of turbo failure [9].

When oil starvation occurs, the immediate effect is boundary lubrication or metal contact in bearings and other surfaces. Bearings that have run without oil show a very characteristic appearance: they may be glossy or bluish from heat, with wiped areas. Figure 1 showed shiny main bearings from oil starvation. Additionally, engine components will overheat rapidly. Lack of oil film means friction skyrockets; as a result, temperatures rise, sometimes causing discoloration of metal (e.g. a bluish crank journal or blackened cam lobe). In extreme cases, components will seize or weld together. For example, a connecting rod bearing starved of oil can overheat and lock onto the crankshaft (a "spun" bearing), often leading to rod breakage [9].

Other evidence includes severely polished wear surfaces. As one technical guide describes, when a bearing fails due to oil starvation, its surface becomes "very shiny" from the wiping action of the journal, often with excessive wear where the oil film was lost. This polished appearance, as seen in the main bearings earlier, is a direct visual confirmation that metal–to–metal contact occurred because of insufficient oil film [9].

Oil starvation also often triggers engine warnings: low oil pressure alarms or lights. If an operator ignores these warnings (or if the sensor is faulty or absent, as can happen in older equipment), the first sign of trouble might be a catastrophic failure. Diesel engines can sometimes suffer a chain reaction, for instance, loss of oil pressure to a turbo will destroy it, and debris from the turbo (or a sudden power loss) might then damage the engine further.

Excessive bearing wear and failure

Engine bearings (primarily the plain bearings: connecting rod bearings, main crankshaft bearings, and camshaft bearings) are highly sensitive to oil condition. Under normal conditions, they operate with full–film hydrodynamic lubrication, meaning a pressurized oil wedge prevents metal contact.

Improper oil maintenance undermines this lubrication, leading to bearing distress ranging from accelerated wear to total failure [10].

The mechanisms of bearing wear from improper oil are [10]:
- abrasive wear from contaminants;
- loss of oil film (mixed/boundary lubrication);
- chemical wear and corrosion;
- bearing overlay removal by sludge and deposits.

Chronic wear will first increase bearing clearances (leading to lower oil pressure and heavy knocking under load). In advanced stages, bearing fatigue can occur, the overlay and lining may develop cracks from over–stress, or the bearing may overheat and wipe. In diesel engines, main and rod bearing failures due to poor lubrication can lead to catastrophic failures (connecting rod through the block, etc.). Even if catastrophic failure is avoided, worn bearings reduce engine efficiency (blow–by due to poor ring seal from vibration, lower oil pressure, etc.) and can throw off timing of moving parts [10].

It is also worth noting camshaft bearings and tappets/followers, which often receive oil last. These can suffer scoring and wear if oil is dirty or delayed. The cam–to–follower contact in many diesels is a highly stressed sliding interface with thin oil films. Tiny particles can "bridge" the oil film there and produce abrasive wear on the cam lobes [2]. Over extended oil life, cam lobes may show accelerated wear or pitting from these effects.

Sludge build–up and deposits

Engine sludge is a thick, gel–like or tar–like deposit that forms from degraded oil, combustion byproducts, fuel, water, and other contaminants. It appears as black or brown goo coating engine parts (often seen under the valve cover or in the oil pan).

Sludge is sometimes called the "black death" of engines because it can literally choke off oil flow and destroy an engine [11]. Diesel engines, due to soot and heavy fuel ends, are very prone to sludge if not properly maintained with high–detergent oils and frequent changes.

The effects of sludge on lubrication are [11]:
- Clogged oil passages;
- Restricted oil pickup and filter;
- Overheating and oil breakdown;
- Mechanical interference.

The image in Figure 2 shows a diesel car engine with components covered in sludge.

Figure 2. Example of engine oil sludge

Oil pump failure

Oil pumps in diesels are typically gear or rotor pumps with tight clearances. They rely on the oil for lubrication and cooling of the pump gears/rotors and can be damaged by wear or lack of lubrication. An oil pump failure is catastrophic because it instantly causes oil pressure to drop to zero [12].

The causes of oil pump issues from improper oil changes are:
- "bad" oil and lack of lubrication to pump;
- clogged pump pickup (cavitation);
- oil contamination and corrosion;
- bypass valve issues;
- overwork from thick oil.

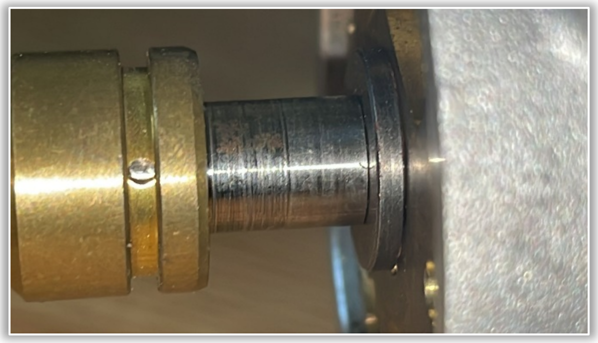
An oil pump that is failing might give warning signs like intermittent low oil pressure (especially at idle when a worn pump struggles to maintain pressure). Noisy hydraulic lifters or timing chain tensioners can also hint that the pump is weak or oil flow is compromised [12].

Ultimately, once the pump fails or cannot supply pressure, the engine's fate is sealed if not shut down immediately. Within seconds, bearings will start to seize. Often the pump failure is only discovered after engine teardown because the immediate symptom is just zero oil pressure.

Turbocharger and valve train failures

Most modern diesel engines are turbocharged, and the turbo depends entirely on engine oil for its journal or ball bearings. Turbos operate under extreme conditions: turbine shaft speeds can exceed 100 000 RPM and the bearing housing can see exhaust temperatures hundreds of degrees Celsius. Clean, correct oil is the only thing preventing the turbo shaft from contacting its bearing surfaces. When oil changes are skipped or wrong oil is used, two major threats arise for turbos: oil starvation and oil contamination/coking [13]. Turbos also suffer if engine shutdown procedure is improper (hot shutdowns can bake oil into coke because the oil stops flowing). While that is an operational issue, it becomes worse if the oil itself is already full of deposits or lacks anti–coking additives (some diesel oils have specific additives to reduce deposit formation in turbo bearings) [13]. The signs of oil starvation in a turbo include discoloration (bluish or dark heat marks) on the shaft or bearings and evidence of metal transfer or scoring on the shaft and bearing surfaces (Figure 3).

(a)



(b)

Figure 3. Effects of oil starvation in a turboshaft
a. discoloration on the shaft on the turbine side;
b. metal transfer and scoring on the compressor side.

The valve train (camshaft, lifters/tappets, pushrods, rocker arms, valves) relies on both pressurized oil (for cams and rockers) and splash/mist lubrication. Improper oil maintenance can cause [13]:

- Cam lobe and lifter wear or pitting;
- Hydraulic lifter and timing chain tensioner problems;
- Valve sticking.

BEST PRACTICES TO PREVENT LUBRICATION SYSTEM FAILURES

- Change oil and filter at or before recommended intervals. Use severe service schedule if applicable.
- Always use the correct oil grade and spec. Don't use outdated or wrong spec oils in modern diesels.
- Keep the oil system clean: avoid introducing dirt when servicing; use clean tools and containers.
- Inspect and maintain the crankcase breather, as a clogged breather can accelerate oil degradation (by moisture and acid build-up).
- Monitor oil level and quality regularly; top up as needed with correct oil. An engine should never run chronically low on oil.
- Fix any coolant or fuel leaks promptly. If such a leak occurs, perform an oil change immediately after the repair (don't leave contaminated oil in).
- If the engine has been overheated or subjected to harsh conditions, consider shortening the oil change interval as a precaution.
- Educate operators: Many failures occur because an operator ignored the oil pressure light or was unaware of maintenance needs. Training and checklists can ensure oil is checked and changed on schedule, especially in fleet environments [14].

By following these measures, the risk of lubrication–related engine failure drops dramatically. Practically, most diesel engines that receive regular oil changes with the right oil will wear very slowly and can reach very high hours or mileage before any major overhaul is needed [14]. As the evidence presented shows, it is largely improper maintenance that causes lubrication system breakdowns, not inherent design flaws. Thus, adhering to best practices not only prevents failures but also maximizes engine service life and reliability.

CONCLUSIONS

Improper engine oil maintenance in diesel engines, such as neglecting oil changes, using incorrect oil, or poor service practices, has been shown to lead to a cascade of lubrication system failures.

Through detailed root cause analysis, these maintenance lapses can be linked to technical failure modes: oil starvation from sludge–clogged passages or low oil levels, accelerated bearing wear from abrasive contaminants and thin oil films, sludge build-up that chokes oil flow and causes overheating, oil pump failures from pumping dirty or insufficient oil and turbocharger / valvetrain damage from both oil starvation and contamination.

Diesel engines are highly reliant on oil quality, perhaps even more so than gasoline engines, due to diesels' higher soot production and loads. However, the flipside is that these failures are largely preventable. Adhering to manufacturer–recommended oil change intervals (or using oil analysis for any extended interval programs) keeps the oil's protective chemistry intact and contaminants at safe levels. Using the specified oil grade and quality ensures proper lubrication under all operating conditions, preventing both the subtle long–term damage and the sudden catastrophic failures that the wrong oil can cause.

Good maintenance practices, especially regarding cleanliness and filter changes, avoid introducing new threats during service. Engine designers have provided better materials, filtration, and monitoring tools to support longer and safer operation, but these are aids, not replacements, for fundamental maintenance.

The correlation between improper oil changes and engine failure is supported by tribological research, field studies, and forensic analyses of failed components. The evidence repeatedly points to the same conclusion: proactive, quality maintenance is critical to diesel engine lubrication health. Preventive measures like timely oil changes, correct oil usage, and attention to warning signs form a multi–layer defence against the failure modes described. Meanwhile, ignoring oil maintenance is an invitation to engine failure, with the lubrication system being the first line of collapse.

References

[1] *** https://www.machinerylubrication.com/Read/1033/diesel–engine–oil–contaminants.
[2] *** https://dieselpro.com/blog/oil–pump–failure–and–what–causes–it
[3] Rațiu S and Alexa, V: Sisteme auxiliare ale autovehicule rutiere, Editura Politehnica, Timişoara, 2017.
[4] Green, D A and Lewis, R: The effects of soot–contaminated engine oil on wear and friction: a review, Proceedings of the IMechE, Part D: Journal of Automobile Engineering, **222**(D9), 1669–1689, 2008.
[5] Li, X et al.: Impact of exhaust gas recirculation (EGR) on soot reactivity from a diesel engine operating at high load, Applied Thermal Engineering, **68**(s 1–2), 100–106, 2014.
[6] Needleman, W M and Madhavan, P: Review of Lubricant Contamination and Diesel Engine Wear, SAE Technical Paper Series, 1988.
[7] The International Council on Combustion Engines (CIMAC): Guidelines for Diesel Engines Lubrication (Recommendation 22), 2004.
[8] Challen, B and Baranescu, R (Eds.): Diesel Engine Reference Book (2nd ed.), Butterworth–Heinemann/SAE, 1999.
[9] Gangopadhyay, A K et al.: The Effect of Oil Drain Interval on Valvetrain Friction and Wear, SAE Technical Paper, 2007.
[10] Niu, P et al.: Numerical analysis on lubrication failure of main bearings in a high–power 6V diesel engine, Engineering Failure Analysis, **163**(B), 108575, 2024.
[11] *** https://maxodyne.com/black–death–of–engines–sludge/.
[12] Salehi, F M: The Effect of Oil Properties on Engine Oil Pump Failure Mechanisms, PhD thesis, University of Leeds, 2016.
[13] Gangopadhyay, A K et al.: The Effect of Oil Drain Interval on Valvetrain Friction and Wear, SAE Technical Paper, 2007.
[14] *** https://www.machinerylubrication.com/Read/31888/lubrication–best–practices.

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