TECHNI/TIPS

A Publication of the Lubrication Engineers Technical Department

LEADERS IN LUBRICANTS NUMBER 72

PISTON RING AND CYLINDER WEAR AND FAILURES

Engines have changed greatly during the last 25 years. New, high-powered engines require rigid maintenance procedures, much more so than older engines. Basic procedures for overhauls remain about the same, but each portion of maintaining and rebuilding is more critical.

High output engines are linked closely with improved engine parts. There are better designs, stronger and lighter materials and closer tolerances on all engine parts. These have helped to obtain longer life from new engines than could be obtained 25 years ago.

New tighter ring designs for lower particulate emission requirements make ring/cylinder failures even more critical.

In spite of improvements, many engines fail too early. In each case of premature failure, there is a reason. The reason may have occurred during the last overhaul, or it may be the result of operating conditions. Whatever the cause, engine life after a rebuild will not improve and reach a reasonable level of performance unless the reason for failure has been found and corrected.

Failure in the piston, ring cylinder areas is normally indicated by high blow-by and/or high oil consumption. When either reaches too high a level, the engine is scheduled for work. Both blow-by and consumption can be caused by a failure in some other part of the engine. If a failure has occurred elsewhere, then obviously re-ringing or overhaul may not restore the engine to satisfactory performance. Since a failure in other than the piston, ring and cylinder area will almost invariably be cheaper and involve less downtime than re-ringing or overhaul, the other possible failures should be investigated prior to engine teardown.

High oil consumption and blow-by can be caused by any one of the following:

A. External leaks
B. Failure of accessories C. Valve guides
D. Internal leaks
E. Piston ring and cylinder combination

A. EXTERNAL LEAKS May be checked visually. If the source is not apparent, leaks should be checked by running the engine and inspecting all joints. When oil appears to be leaking at every joint, undoubtedly the crankcase ventilating system is clogged or faulty, or there is a high blow-by due to ring failure or an accessory 'failure.

B. FAILURE OF ACCESSORIES-Accessories may consume oil by allowing oil to pass into the air intake system of the engine and thus be consumed. The accessories that can cause abnormal oil consumption and that should be inspected are:

1. Fuel pump vacuum booster diaphragm.

2. Mechanical crankcase breather valve.
3. Clogged air filter (resulting in intake manifold depression).
4. Ventilating tube connecting rocker box area to intake manifold.
5. Supercharger and turbocharger seals.
6. Air compressors utilizing engine sump.
7. Starting engines utilizing engine sump.

C. WORN VALVE GUIDES-Allow oil to travel from the rocker box area to either the exhaust manifold or the combustion chamber. Where a pressurized intake or intake and exhaust system exists, worn guides can cause high blow-by which, in turn, can cause excessive leakage.

D. INTERNAL LEAKS-Oil passages from block to head sometime leak oil either to a nearby cylinder or to the cooling system. Spark plug fouling or oil in the coolant indicates this type of leakage. Leaking, corroded oil coolers will also result in the mixing of oil and coolant. Intake manifold-to-head gaskets can be a source of leakage in gasoline engines where the manifold covers the tappet chamber. If this type of leakage is occurring, engine idle is rough and cannot be corrected by tune up procedures. Intake valve stems and ports wet with oil following removal of the manifold also indicate a leaking gasket.

E. PISTON RING AND CYLINDER COMBINATION If analysis has not revealed a reason for high oil consumption or high blow-by, it can be assumed that the failure exists in the piston ring, piston and cylinder combination. It is extremely important that a careful step-by-step analysis be carried on during teardown so that the cause for failure can be determined. Again, if this cause is not found and corrected during overhaul, then performance following the rebuild will be unsatisfactory.

Check for existence of these conditions during disassembly:

1. Improper ring installation.

    - Compression rings upside down.
    - Cut off expander space.
    - Compression rings incorrect width.
    - Excess back clearance for hump type oil ring expanders.
    - Oil rings incorrect width.
    - Rings with incorrect diameter.

2. Abnormal wear patterns on the pistons or physical damage to pistons.
3. Compression ring sticking and oil ring plugging and unitizing (rails and expanders sticking together).
4. Top groove wear and top ring breakage.
5. Overall ring, piston and cylinder wear.
6. Abrasive wear, scuffing and scoring and corrosive wear.

These conditions are the most prevalent reasons for high oil consumption and blow-by. Each will now be discussed in detail.

IMPROPER RING INSTALLATION--Can increase oil consumption many times. For this reason, the following conditions should be checked as the engine is tore down:

1. Compression Rings Upside Down - Will tend to scrape oil up into the combustion chamber instead of down into the crankcase. Rings with an inside groove counterbored should be installed with the groove to the top of the piston (see Fig. I). Rings having an outside groove should be installed with the groove toward the bottom of the piston (see Fig. 2).

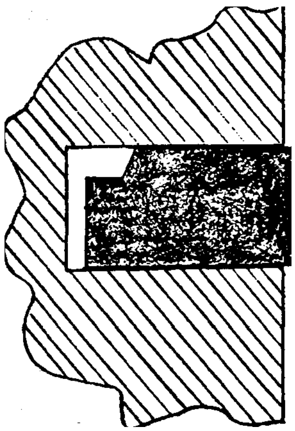


Fig. 1

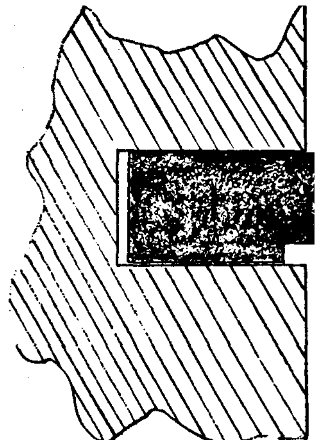


Fig. 2

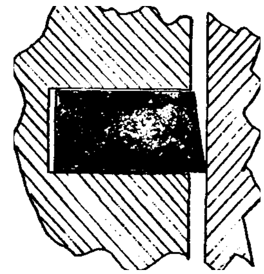


Fig. 3

Tapered face rings should be installed with the face edge touching the cylinder toward the bottom of the piston (see Fig. 3). Where there has been little ring side wear, it may be possible to tell when rings have been incorrectly installed, even if they become separated from the piston by inspecting the sides and faces.

Rings normally ride on the bottom land for three strokes out of four in the engine cycle; therefore, the lower side of a compression ring is often more polished than the top side. If the ring has been installed upside down, the more polished area will be observed on the top side of the ring. The correct top and bottom sides of a tapered face ring can be determined by inspecting the wear pattern on the face of the ring.

2. Compression Rings Incorrect Width - Compression rings are furnished in fractions of an inch and in millimeter widths. If a 5/64 ring has been installed in a piston groove made for a 3/32 ring, the side clearance will have been too great for proper operation. Generally, top rings with too much side clearance result in poor initial performance and ultimate top groove wear and ring breakage. (see Fig. 13). Rings installed with not enough side clearance will not give satisfactory performance and will be much more susceptible to ring sticking.

3. Oil Rings Incorrect Width - Expandable side seal oil rings are designed to force the two rails against the sides of the groove and out against the cylinder wall (see Fig. 4). If the ring was too narrow for the groove or the groove too wide for the ring, the rails may have slid off the ends of the expander ears and wedged the ring assembly in the groove or allowed complete loss of unit pressure, side seal and oil control.

(4) Cut Off Expander Spacer - The spacer used with the rings in Fig. 4 must be compressed when the ring is installed. Sometimes part of the expander is cut off to make installation easier. The reduced expander tension doesn't exert sufficient force on the rails to assure proper performance. Little or no wear on the face of the rails indicates that the spacer was cut off or the wrong length was used.

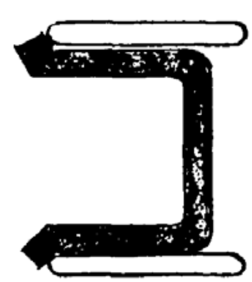


Fig. 4

(5) Wrong Diameter Rings - Rings up to five inches in diameter that have operated in cylinders 0.020 inches or more larger than the ring size itself, can be identified by carbon deposits on the ring face near the gap and by the excessive gap clearance the rings will have when installed. The ring face close to the gap does not touch the cylinder. (see Fig. 5).

(6) Excess Back Clearance For Hump Type Oil Ring Expanders - The hump type expander is used to increase the oil ring pressure to provide conformability and oil control. It is designed to operate within precise back clearances. With the omission of a specified shim, installation in too deep a groove, or using an oil ring of incorrect radial wall thickness will increase the back clearance beyond the working range.

This condition may be recognized by carefully examining the worn rings. There has been too much back clearance for the expander when very little face wear is found on the oil ring and the compression rings show normal wear.

Unusual Piston Wear And Physical Damage - Pistons showing contact with the cylinder wall on the bottom of the skirt at one side and the upper ring lands on the other, indicate a bent or twisted connecting rod or a cylinder bored at an angle to the crankshaft (see Fig. 6).

Damage caused by the loss of a wrist pin lock may be due to: (see Fig. 7)

- Worn thrust bearings
- Piston pins too long
- Crank pin taper
- Weak pin locks
- Cylinder bored out of alignment
- Rod misalignment
- Piece of metal left inside pin
- Incorrect pin locks
- Incorrect pin lock installation

Fig. 5

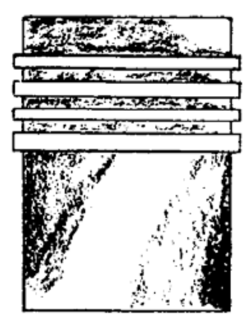


Fig. 6

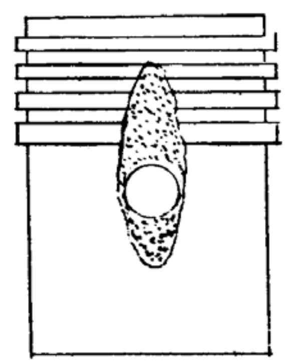


Fig. 7

RING STICKING AND OIL PLUGGING-Deposits are formed by a combination of blow-by, lube oil and heat. Soft deposits can reduce clearances while hard deposits can transmit loads as well as reduce clearances.

Where deposits have reduced clearances essentially to zero, the ring sticks and usually ring breakage occurs (See Fig. 13). The effect of deposits in the oil ring is plugging, and as the deposits harden, this results in loss of unit pressure on the cylinder wall, sticking together of multiple piece oil rings (see Fig. 8) and finally sticking in the groove.

Deposit formation can be caused by:

- Top groove failure.
- Liner distortion due to improper clearances.
- Cylinder distortion due to wear, improper head bolt torquing or improper boring and honing.
- Combustion knock.
- Preignition (see Fig. 13)
- Overloading.
- Cooling system failure.
- Using straight mineral or too low detergent oils.
- Too long oil drain periods.
- Oil cooler failure.
- Low engine temperature (stop-and-go service.)

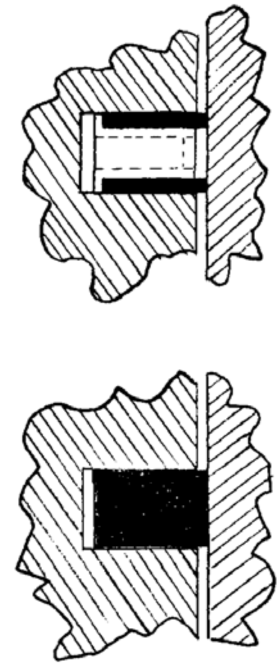


Fig. 8

TOP GROOVE WEAR AND TOP RING BREAKAGE-The top groove shows the most wear since it is exposed to the highest temperatures and pressures and also it has the greatest exposure to airborne abrasives that may come in through the intake system. As wear occurs, the clearance between the ring and groove increases and the rate of wear accelerates (see Fig. 9).

The sides of a new ring groove are flat, parallel and smooth and with proper clearance of the ring. The combustion gases on the power stroke force the ring down against the lower side of the groove and at the same time, the gases pass behind the ring and force it out against the cylinder wall. The result is a good seal.

Fig. 9

If a new ring is installed in a worn groove, it permits the ring to sag and allows the upper corner of the ring face to contact the cylinder wall, resulting in oil being wiped up into the combustion chamber instead of down into the crankcase. The flat new ring cannot mate with the irregular worn groove sides and, consequently, a proper seal is not formed at either ring face or side, and poor performance results.

In addition, the constant deflection will result in early ring fatigue and breakage. (see Fig. 10). Top groove wear may also be a reason for poor performance before it has progressed to the stage of obvious physical damage. For this reason, the top groove area should always be a prime suspect when initial performance is poor after rebuild.

Following is a list of conditions that may cause top groove failure: •

- Airborne abrasives
- Excessive deposits
- Peignition (see Fig. 13)
- Combustion knock Installation of a new ring in a worn groove
- Assembly of new rings without removing the wear ridge at the top of the cylinder.

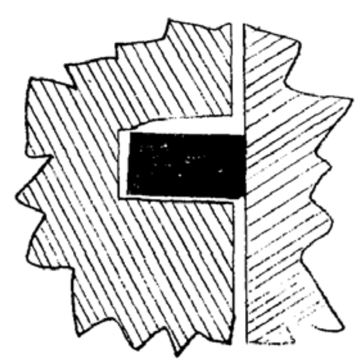


Fig. 10

Many heavy-duty pistons have iron or steel top groove ring inserts to fight top groove failure. The life of top grooves in engines so equipped may be increased to where second groove failure may occur at the same time or prior to top groove failure.

OVERALL WEAR--Perfect Circle Corporation reports the following analysis of premature engine failures as follows:

- Abrasive wear – 44%
- Scuffing and scoring – 18.5%
- Improper ring installation – 9.5%
- New rings installed in worn grooves – 10.5%
- Other causes – 2.5%
- Unknown – 15%

This analysis indicates that time could be saved by first looking for evidence of abrasive wear or scuffing and scoring. Abrasive wear can be identified by examining the faces and sides of the worn rings. Abrasive wear is indicated by ring faces covered with fine vertical scratches and having a dull gray satiny appearance and excessive ring gap. The tool marks or chrome plate are worn off the faces of rings after short mileage (see Fig. 11). Fine dull gray vertical scratches are visible on piston skirts. Cylinder bores are scratched. There may be an excessive ridge at the top of the cylinder, a loose piston fit or badly scratched rod and main bearings.

Abrasive wear is the result of abrasives that have entered the engine during operation or abrasives that were left in the engine from previous work. Abrasives may enter an engine via:

- Air intake system
- Vacumm brake system
- Engine assembly
- Fuel system
- Crankcase breathing system

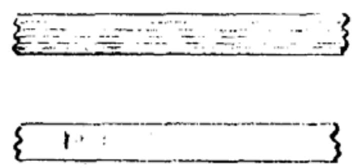


Fig. 11

Proper air cleaner maintenance is essential to prevent airborne abrasives from entering the engine. Any leaks in the intake sir system between the air filter and the engine are a source of abrasives. Check for cracks, rotted hose or loose connections. Accumulations of dirt in the air intake system and occasionally on the outside of the system may indicate leaks.

Check for proper installation of filter elements and for cracked or faulty gaskets, including the intake manifold gaskets on diesels. Dirt may also enter the intake system as a result of excessive oil pull-over to and from the air cleaner in an engine equipped with a breather tube from the valve cover to the inlet side of an oil bath air cleaner. Inspect manifolds, carburetor throats and the like for dirt.

Dirt left in an engine during assembly can wear out a set of new rings within a few hundred miles. Special care should be exercised when honing cylinder, grinding valves or any similar type operation to be sure all abrasives are cleaned from the -engine prior to assembly. An engine worn out for this reason usually does not contain any evidence indicating this condition.

Proper air cleaner maintenance on the crankcase breathing system again is essential. If maintenance has been lacking, dirt will be found along the walls of the pipe leading from the breather element. Vacuum brake boosters use a cylinder that is powered by atmospheric pressure on one side and manifold vacuum on the other. Each time the brakes are applied, sir passes from the brake unit into the intake manifold to the engine. If the air cleaner on the brake unit is not properly maintained, abrasive air can enter the engine via the intake system. Abrasives in fuel will wear out the fuel system and cause wear of pistons, rings and cylinders. Worn carburetor parts, such as the throttle shaft, will allow air-carrying abrasives to enter the engine.

SCUFFING AND SCORING-Scuffing is invariably the result of excessive heat. It occurs when the surface temperature of one or both of two rubbing metal surfaces reaches the melting point of the material, allowing a small dab of the melted material to pull out. This leaves a void on one surface and a deposit cold-welded to the other surface (see Fig. 12). Scoring may be considered simply as a severe case of scuffing where the voids and scratches are much more apparent.

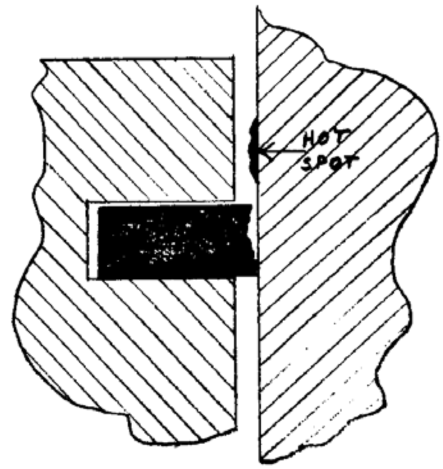


Fig. 12

Scuffing may be identified by discolored metal. When magnified, the metal will be burnished and smeared in the direction of motion.

The starting point may be difficult to see, because it invariably spreads to a larger area because of the additional heat generated by scuffing action itself. Following is a list of possible causes of scuffing and scoring:

1. Lubricating system-worn oil pump, clogged screen or passage, oil pressure relief valve stuck open, incorrect bearing clearances, dirty lubricating oil, incorrect oil for the engine or service, low oil level, malfunctioning piston cooling pipes.

2. Cooling system-external leaks, internal leaks, clogged radiator, deposits in block water passages, defective or incorrectly installed thermostat, defective radiator pressure cap, worn or broken fan belt, corroded water pump impeller, corroded oil cooler core, radiator cooling air restriction.

3. Fuel system-rich mixture, lean mixture, malfunctioning choke, overfueling and incorrect fuel.

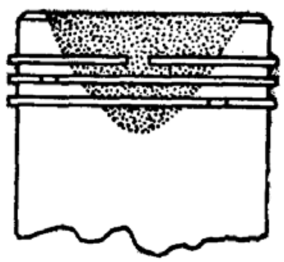
4. Incorrect timing-wrong adjustment, worn distributor altering spark advance, worn fuel system parts.

5. Combustion knock and preignition (see Fig. 13)

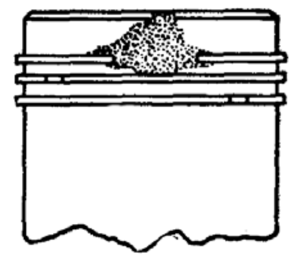
6. Improperly fitted parts-insufficient piston clearance, wrong piston shape, tight piston pin fit, rings with insufficient gap and improper cylinder liner fit.

7. Improper break-in, slow idle and coolant not permitted to reach or be maintained at operating temperature.

8. Lugging and overloading.



Typical failure due to preignition.



Typical failure due to ring breakage.

Fig. 13

Correction of the above difficulties, of course, is obvious in each case.

CORROSIVE WEAR-Corrosion may be another cause of excessive engine wear. Pistons severely corroded by coolant leaking into the cylinders are easily identified. They have a mottled grayish, pitted appearance; however, other types of corrosion are difficult or impossible to identify by appearance alone. Low engine temperatures, stop-and-go driving and coolant leakage are the causes of corrosive

To summarize, premature engine failures have assignable causes. That cause must be found and corrected if performance is to be restored to a satisfactory level.

Generally speaking, lubricating oils can do very little for the type of failures discussed above. It might be pointed out, however, that LE's MONOLEC Engine Oils can improve certain aspects of these failures. They will reduce wear attributable to airborne abrasives and wear which is attributable to corrosion. They can also help to reduce compression ring sitcking and oil ring plugging and unitizing and control deposits throughout the engine by its improved cleanliness.

The patented MONOLEC additive essentially lays down a mono-molecular film on all moving surfaces, which tends to help metal high points flow and smooth out, rather than welding and tearing off. The ultimate result is a smoother metal finish, reduction of scuffing and scoring and longer engine life. If LE's MONOLEC Engine Oils are coupled with first-class maintenance and rebuild procedures, they will result in the maximum useful life of any engine.

TT-924
Rev. 02-94

LUBRICATION ENGINEERS,® Inc.
300 Bailey Ave, Fort Worth, TX 76107 | 817-834-6321 | 800-537-7683
fax 817-834-2341 | http://www.le-inc.com