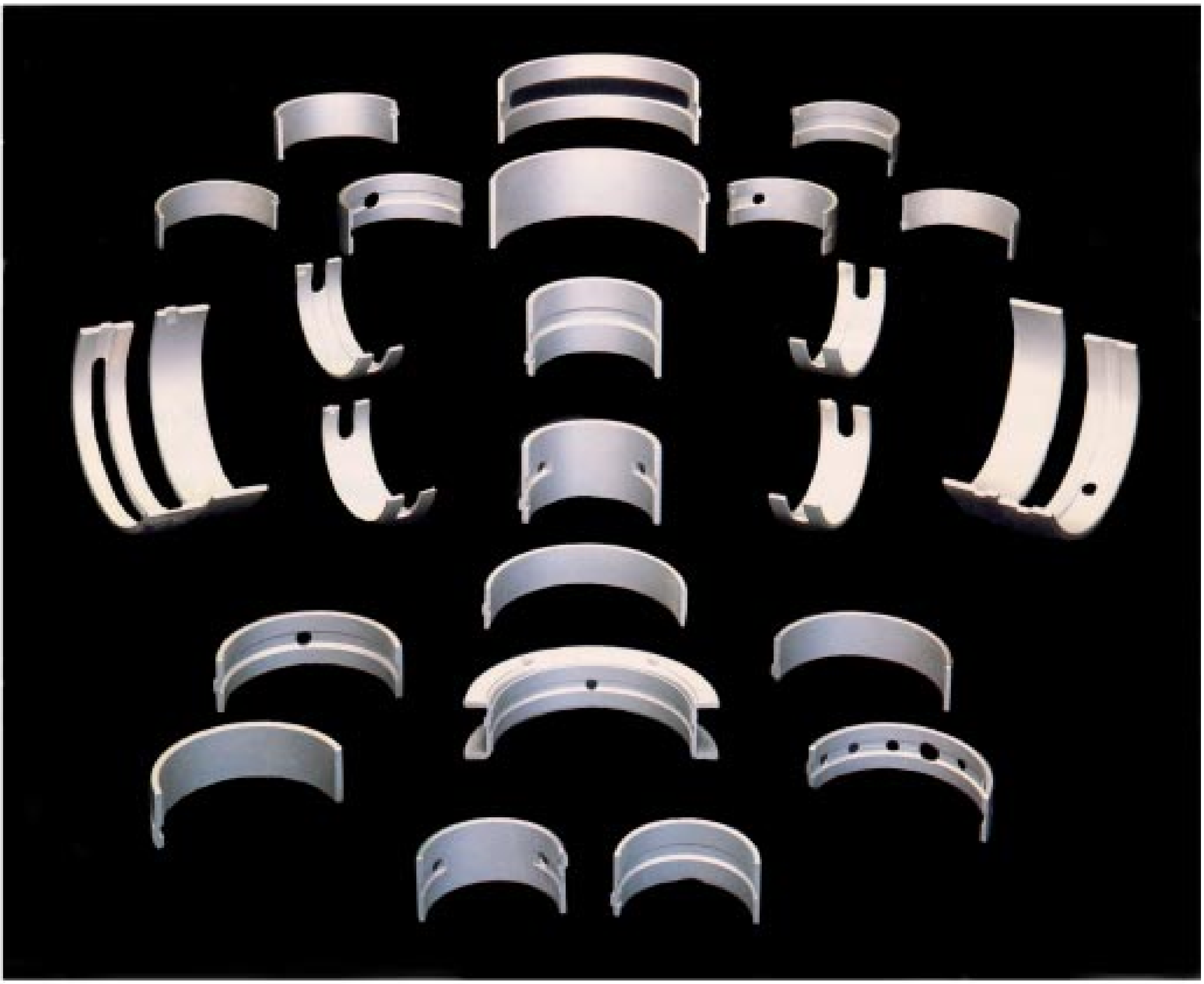
DETROIT DIESEL

Bearings - Technician's Guide



Inspection/Analysis

Reusable Parts Guide

ATTENTION

This bulletin is a guideline for qualified personnel. The information contained in this bulletin may not be complete and is subject to change without notice.

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1 INTRODUCTION

The purpose of this guide is to illustrate variations of crankshaft main bearing and connecting rod bearing wear after use in an engine. Bearings removed from an engine can be compared to photographs in this guide to determine the cause of the bearing condition and old bearing usability.

The service life of the bearings are expected to be the same as the overhaul life of the engine under normal operating conditions and recommend maintenance practices.

1.1 MAINTENANCE

An effective preventative maintenance program for the engine and its supporting systems will maximize the engine bearing life. Preventative maintenance starts with a **daily inspection of the engine by the operator for correct fluid levels** and replenishment of any low fluids, refer to section 6. Periodic maintenance inspection of the **engines air inlet, cooling, fuel, and exhaust systems** must be scheduled as each of the related systems can affect engine bearing life. This periodic inspection schedule is available in the appropriate Detroit Diesel® engine service manual.

Maximum bearing life, as well as long engine life, will depend upon an established maintenance program that is followed on a regular basis.

The major cause of bearing damage is dirt and foreign particles which can come from careless handling, poor cleanliness, and failure to follow a maintenance program.

Ensure the engine oil used in the engine meets Detroit Diesel lubricating oil requirements. The requirements for proper lubricating oil are based on SAE Viscosity Grade and API Service Designation. The requirements are covered in Detroit Diesel *Lubricating Oil, Fuel and Filters* bulletin, 7SE270.

Filters make up integral part of fuel and lubricating systems. Proper filter selection and maintenance are important to satisfactory engine operation and service life. Filters, however, should be used to maintain a clean system, not to clean up a contaminated one. Filter performance and test specifications very between manufacturers. The filters recommended by Detroit Diesel have been qualified to appropriate SAE performance specifications and meet manufacturer's requirements. Refer to Specifications for Detroit Diesel Maintenance Products in Detroit Diesel *Lubricating Oil, Fuel and Filters* bulletin, 7SE270. Other brands may be used, provided they have demonstrated equivalent performance.

2 INVESTIGATION

Determining the primary cause of engine bearing damage is critical to the continuing successful operation of any Detroit Diesel engine. It is important to examine all engine components as the engine is disassembled. The parts should be cleaned and laid out in such a manner so that the primary cause of the damage can be determined while noting which bearings are damaged. In some instances, due to extensive secondary damage, it is difficult to determine the exact primary cause. If the reasons are not determined, the rebuilt engine may experience a repeat failure.

Examination of the parts is only one step in determining bearing damage. The investigation of bearing damage should consider the facts and conditions related to the damage.

1. When did the damage happen?
    - [a] At start-up?
    - [b] During operation?
    - [c] At shutdown?
    - [d] At idle?
    - [e] During cruise?
2. What identified the problem?
    - [a] Operator complaint?
    - [b] Unusual engine noise?
    - [c] Engine stopped?
    - [d] Engine alarms?
    - [e] Excess smoke?
3. What past complaints did the engine have?
    - [a] Recent engine rebuild?
    - [b] Are the replacement parts genuine Detroit Diesel reliabilt®?

2.1 OIL ANALYSIS

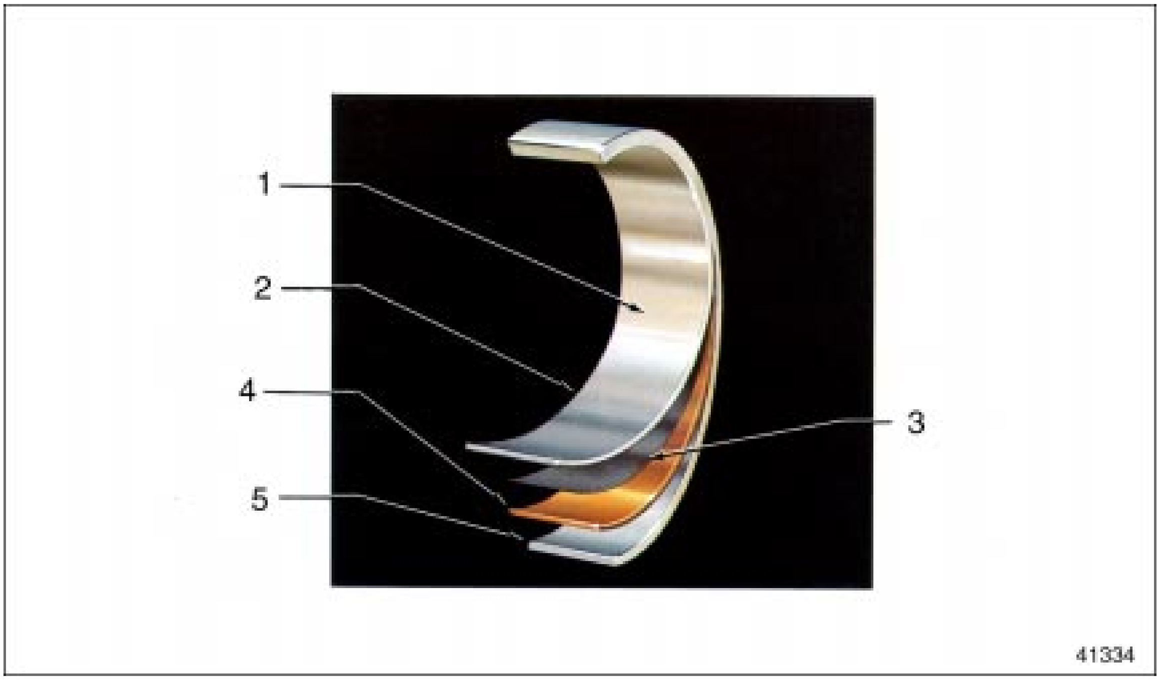
Obtain an oil sample from the engine prior to disposal of the lubricating oil. The oil analysis should help provide key clues to the exact cause of the problem. Oil analysis consists of a series of laboratory tests conducted on the engine lubricant. The tests can reveal conditions of the engine as well as the condition of the oil. It also can tell what contaminates were in the oil, such as fuel or coolant.

2.2 TRENDS

Inspect all of the bearings. Do they all share the same wear? Is it localized to one bearing? A detailed inspection of the damaged parts will determine the primary cause.

3 GENERAL CONSTRUCTION

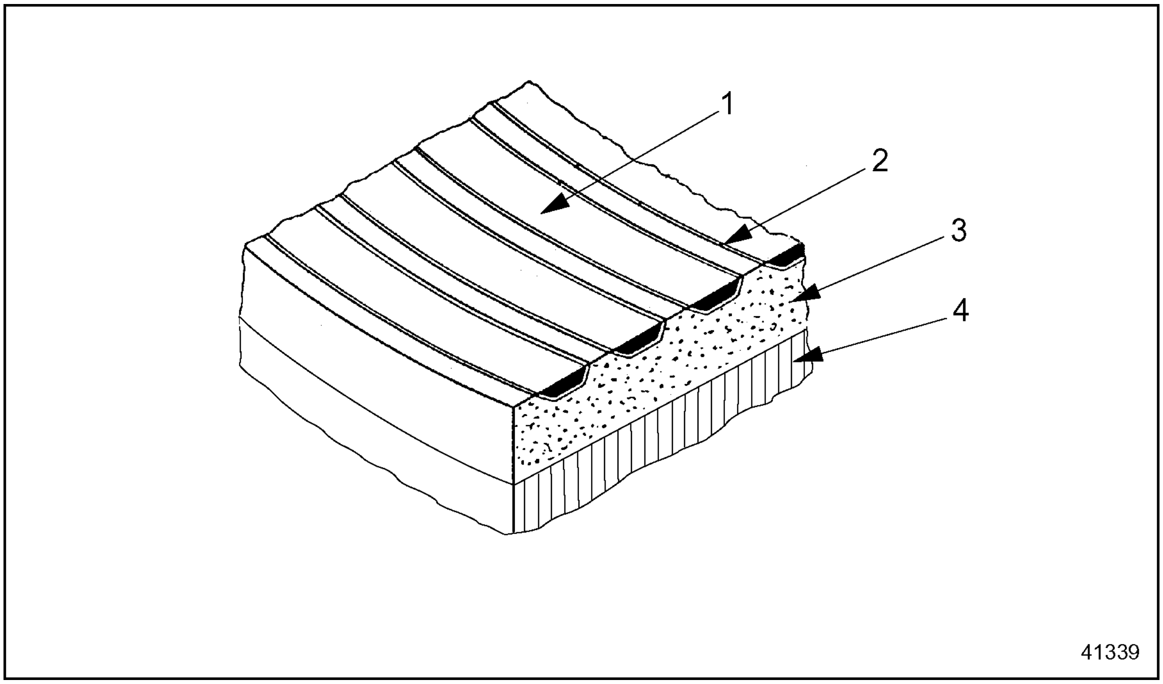
It is important to have a familiarity of the engine bearing construction, when trying to determine the primary cause of bearing damage. There are three basic constructions for the connecting rod and crankshaft bearings. They are trimetal (see Figure 3-1), rillenlager (see Figure 3-2), and sputtered (see Figure 3-3).



1. Flashing
2. Overlay
3. Barrier
4. Lining
5. Backing

Figure 3-1 Trimetal Bearing Construction

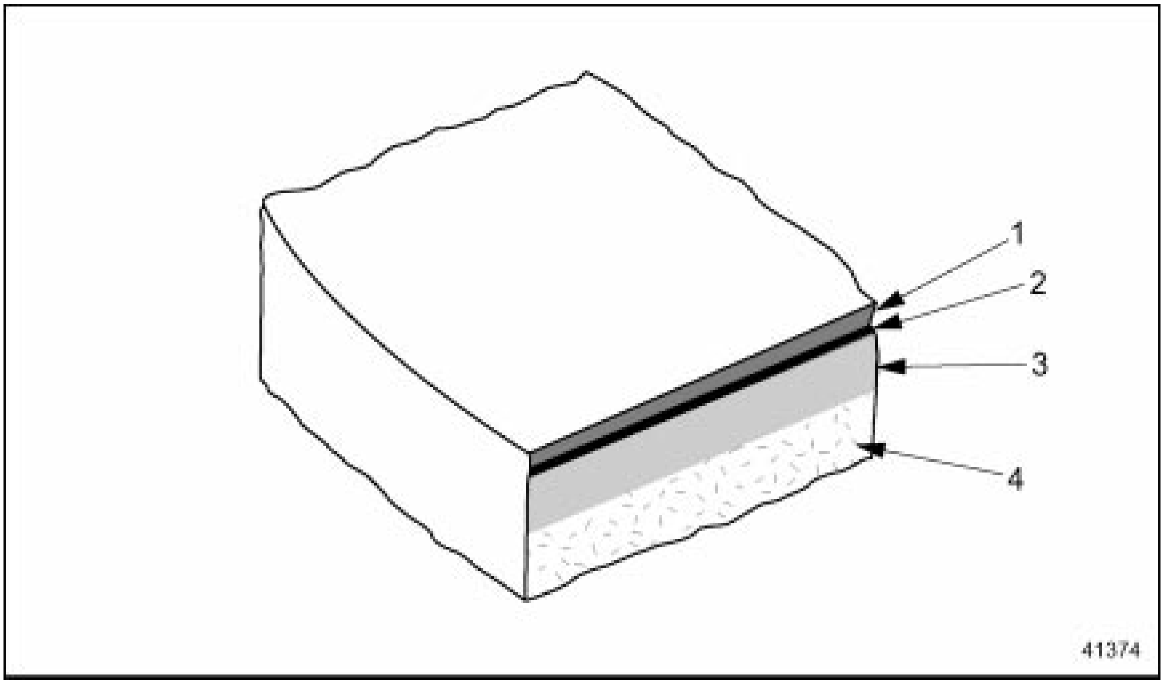
- **Flashing** - Tin plating covering the entire bearing for the protection prior to installation.
- **Overlay** - Alloy mainly of lead with tin to provide embedability, conformability, and protection against marginal lubrication.
- **Barrier** - Nickel layer plated over the lining to prevent chemical reaction between the lining and overlay.
- **Lining** - Alloy mainly of copper and lead for maximum fatigue strength.
- **Backing** - Made of steel to provide support for the bearing lining.



1. Overlay
2. Barrier
3. Aluminum Alloy
4. Backing

Figure 3-2 Rillenlager Bearing Construction

- ☐ **Overlay** - Provides embedability and lubricity (approximately 75% of surface area).
- ☐ **Barrier** - Nickel layer plated over the lining to prevent chemical reaction between the lining and overlay (maximum 5% of surface area).
- ☐ **Aluminum Alloy** - Bearing material with excellent strength and durability used as a substrate for the overlay (approximately 25% of surface area).
- ☐ **Backing** - Made of steel to provide support for the bearing.



1. Sputtered Overlay
2. Barrier
3. Lining
4. Backing

Figure 3-3 Sputtered Bearing Construction

- **Sputtered Overlay** - Made of an aluminum-tin alloy.
- **Barrier -** Nickel layer plated over the lining to prevent chemical reaction.
- **Lining** - Alloy mainly of copper and lead for maximum fatigue strength.
- **Backing -** Made of steel to provide support for the bearing.

The main bearings have an upper and lower shell. The lower shell, which fits in the removable cap, supports the crankshaft. For maximum load capacity, the lower shell has no oil hole or grooves. The upper shell fits into the engine block saddle bores. The upper main shell is grooved or slotted. Oil is directed though the grooves and holes from the crankshaft main journals.

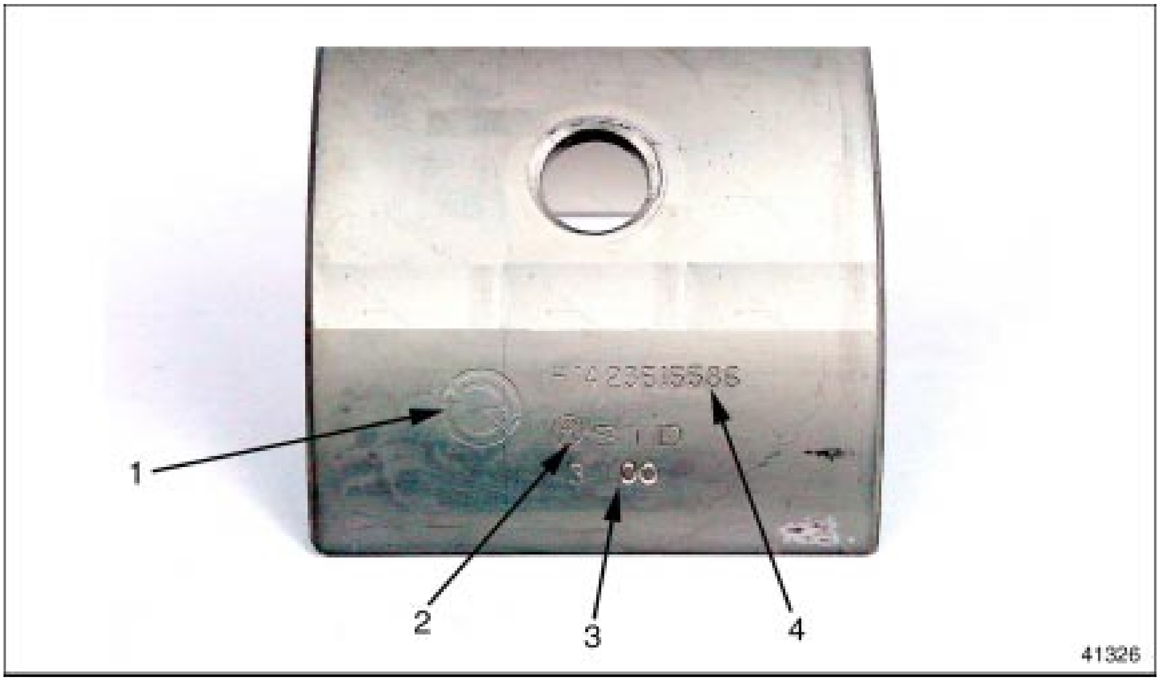
Upper and lower main bearing must not be reversed in their position in the engine. To prevent an incorrect installation from happening, the locating tang on the upper and lower shells are normally in different positions.

The connecting rod bearings have an upper and lower shell. As with main bearings, the lower connecting rod shell fits into a removable rod cap. The upper shell may or may not have a means of supplying lubricating oil to further lubricate the piston pin/bushings and cool the underside of the piston. The locating tangs are provided in order to assist in installing the shells correctly in the bore of the connecting rod.

4 IDENTIFICATION

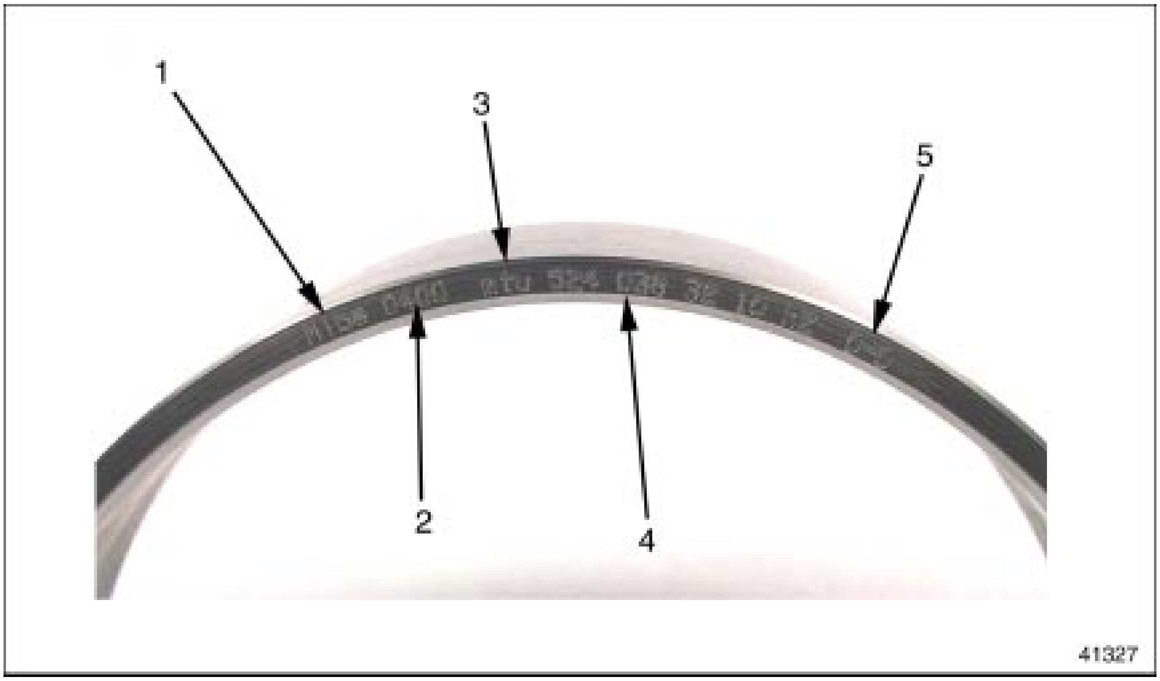
When conducting a bearing analysis, proper identification of the component location is key. When there is more than one part, mark or etch the part location. On the bearing shells, mark the location for the upper and lower bearing if necessary. Remember to mark each bearing with its exact location and piston number. Mark each cap with its location. The caps cannot be interchanged with each other.

Ensure to identify the stamping on each bearing. Each bearing should be stamped with its part number, size classification, manufacturing date, and manufacturer. See Figure 4-1 for Detroit Diesel bearings and see Figure 4-2 for MTU® bearings.



1. Detroit Diesel Logo
2. Size Classification
3. Manufacturing Date
4. Part Number

Figure 4-1 Detroit Diesel Bearing Stampings



1. Manufacturer
2. Manufacturing Date
3. MTU Logo
4. Part Number
5. Size Classification

Figure 4-2 MTU Bearing Stampings

5 NORMAL WEAR

Not all bearings will wear exactly alike, but the normal wear patterns are similar. See Figure 5-1.

NOTE:
These bearings are not suitable for continued service and should be replaced.

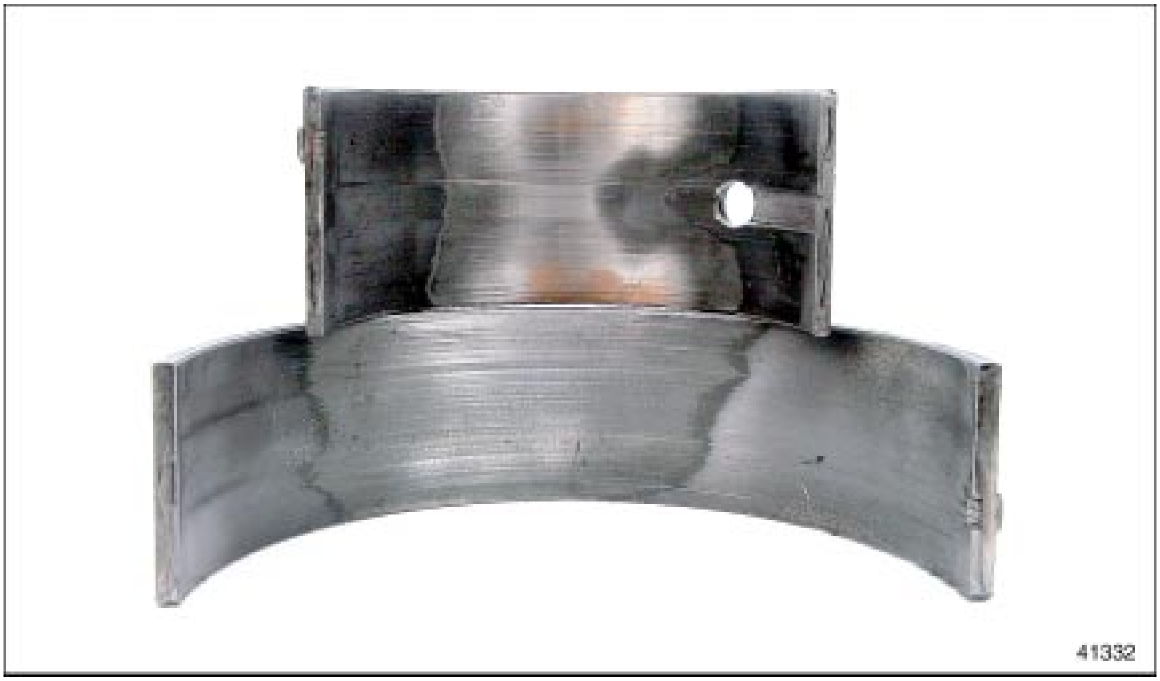


Figure 5-1 Bearing Wear under Normal Operation

6 TYPES OF FAILURE

Bearing failure can usually be traced to the following causes:

- ☐ Oil Contamination
- ☐ Assembly Contamination
- ☐ Cavitation
- ☐ Improper Assembly
- ☐ Corrosion
- ☐ Overlay Fatigue
- ☐ Wiping
- ☐ Lack of Lubrication

6.1 OIL CONTAMINATION

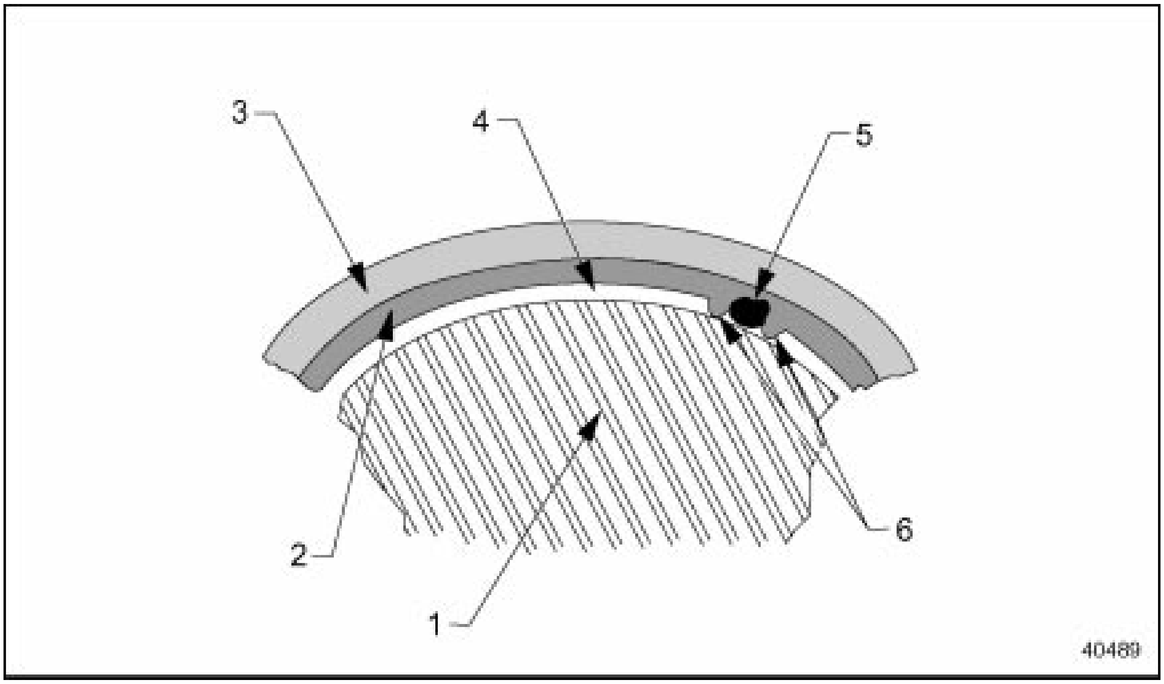
6.1.1 APPEARANCE

The bearing appears to have lines of light scratches or deep grooves. Speckles from embedded particles my be present. Spots of exposed copper layer would show in the lining. See Figure 6-1.

Figure 6-1 Example of Oil Contamination

6.1.2 DAMAGE

Oil contamination occurs when foreign particles enter the oil. Normally the oil filter will filter out a great majority of the particles. When there are excessive particles, they can do damage to the bearings. See Figure 6-2.



1. Journal
2. Bearing Lining
3. Bearing Backing
4. Oil Clearance
5. Dirt Particle
6. Displaced Bearing Material

Figure 6-2 Elements of Bearing Damage from Oil Contamination

Smaller particles can become embedded in the soft bearing lining, causing the adjacent material to surround the material forming a halo. The larger particles circulate through the clearance between the bearing and the journal, grooving the surface of the bearing in a circumferential manner. The grooves can range from light scratches to deep gouges.

6.1.3 POSSIBLE CAUSES

There are several possible causes for this damage:

1. Failure to follow the correct cleaning procedure after rebuild.
2. Not performing the daily maintenance practice on the engine.
3. Wear of the engine parts.
4. Failure to change the lubricating oil within the recommended schedule.

6.1.4 RECOMMENDATION

The recommended maintenance procedures after oil contamination are:

1. Replace bearings.
2. Check all other engine bearings for similar wear.
3. Use recommended maintenance practices.

6.2 ASSEMBLY CONTAMINATION

6.2.1 APPEARANCE

The bearing appears to have a localized area of wear. The appearance of a foreign material is found on the backside of the bearing. See Figure 6-3.

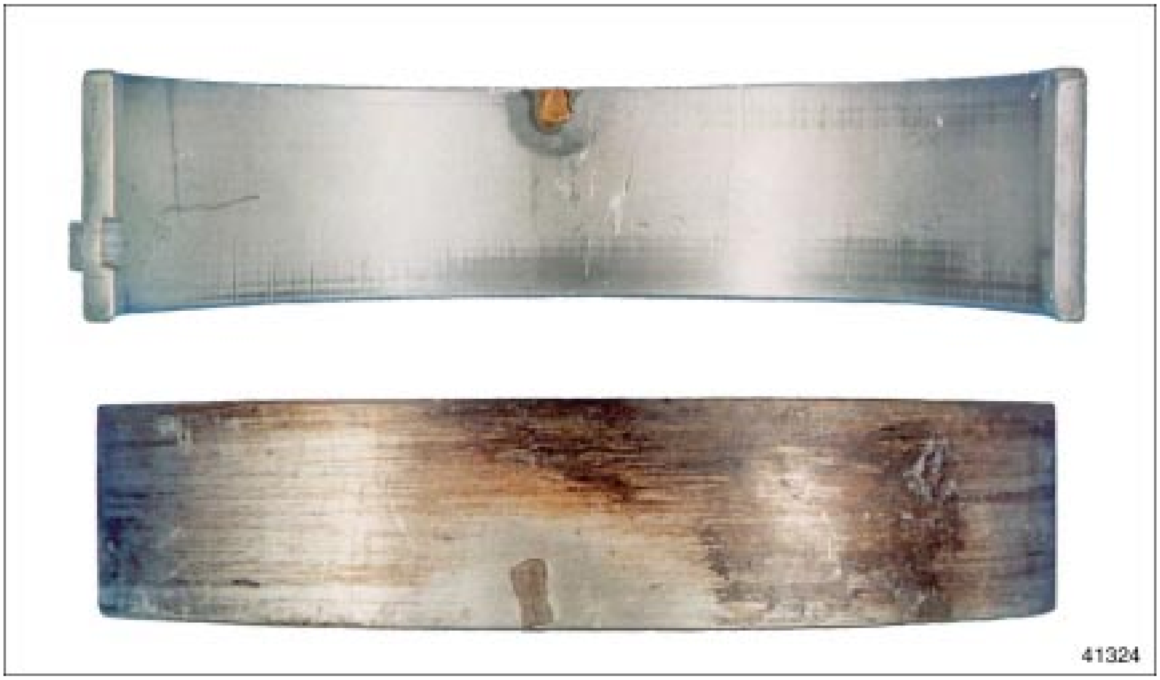
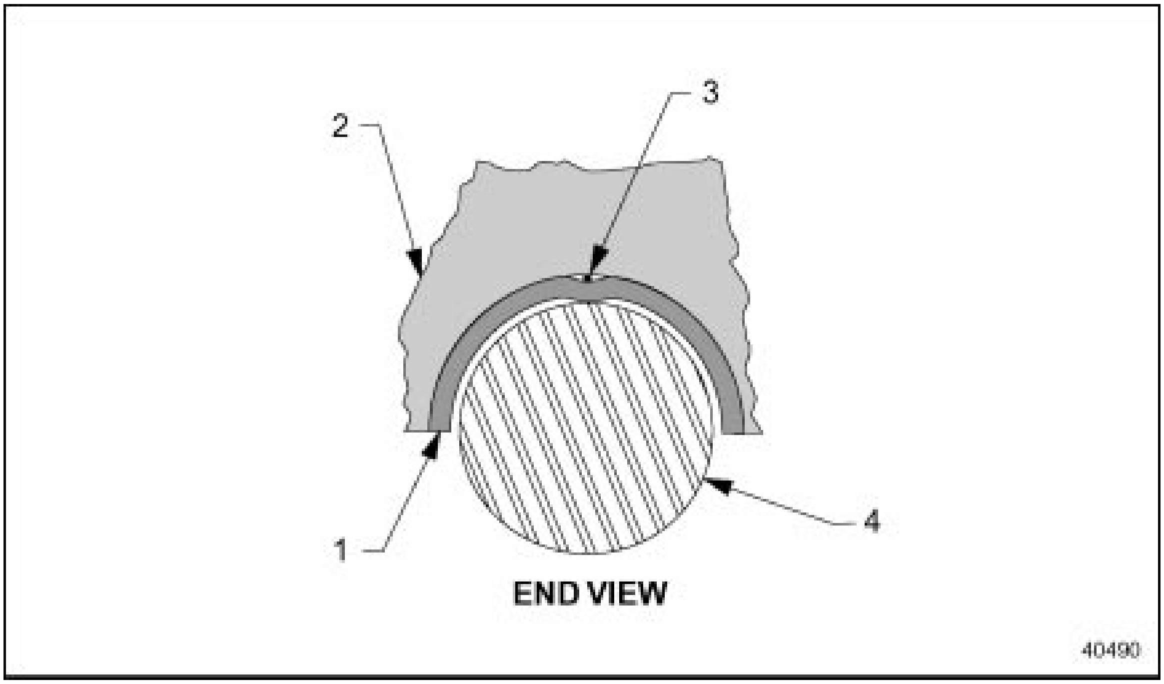


Figure 6-3 Example of Assembly Contamination

6.2.2 DAMAGE

Damage normally occurs when the bearings are being installed and contamination is introduced to the backside of the bearing, trapping it between the bearings back and the caps. See Figure 6-4.



1. Bearing
2. Housing
3. Foreign Material
4. Shaft

Figure 6-4 Elements of Bearing Failure from Assembly Contamination

The contamination creates a high spot on the inside diameter which can cause wear to the bearing.

6.2.3 POSSIBLE CAUSES

Assembly contamination occurs when foreign material enters the engine during engine assembly. It can also occur when an engine is being rebuilt and proper cleaning procedures are not followed, allowing contamination upon assembly.

6.2.4 RECOMMENDATION

The recommended maintenance procedures after assembly contamination are:

1. Replace bearings.
2. Check all other engine parts for similar wear.
3. Use recommended maintenance practice.

6.3 CAVITATION

6.3.1 APPEARANCE

White looking bubble-shaped features etched in the bearing surface. Normally in, but not limited to, the overlay layer of the bearing. See Figure 6-5.

Figure 6-5 Example of Bearing Cavitation

6.3.2 DAMAGE

The damage is caused by the collapse of vapor bubbles due to different oil pressures that occur in the engine during operation. This process is considered a form of erosion. Bearing cavitation can occur during normal engine operation.

6.3.3 POSSIBLE CAUSES

There are several possible causes for the damage:

1. Using the wrong weight of oil.
2. Not using oil with the right additives.
3. Oil dilution by fuel, air, or water.
4. Improper bearing clearance.

6.3.4 RECOMMENDATION

The recommended maintenance procedures after bearing cavitation are:

1. Reuse if bearing surface is not damaged and within specifications.
2. Use correct oil.
3. Use recommended maintenance practices.
4. Ensure the bearings have the correct clearances.

6.4 IMPROPER ASSEMBLY

6.4.1 APPEARANCE

Bearings can be deformed, bent, crushed, or wear unevenly. Not all examples of improper assemblies look alike. See Figure 6-9, see Figure 6-10, and see Figure 6-8.

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Figure 6-6 Example of Locating Lugs Improperly Nested Shown on Engine

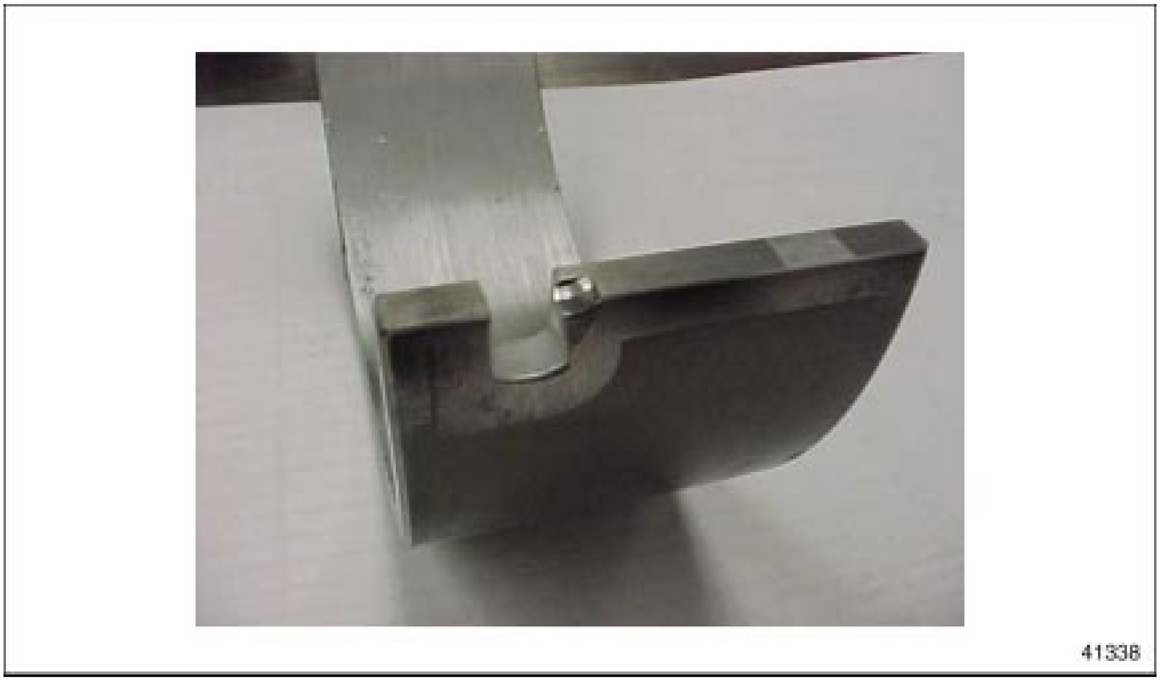

Figure 6-7 Example of Locating Lugs Improperly Nested Shown off Engine

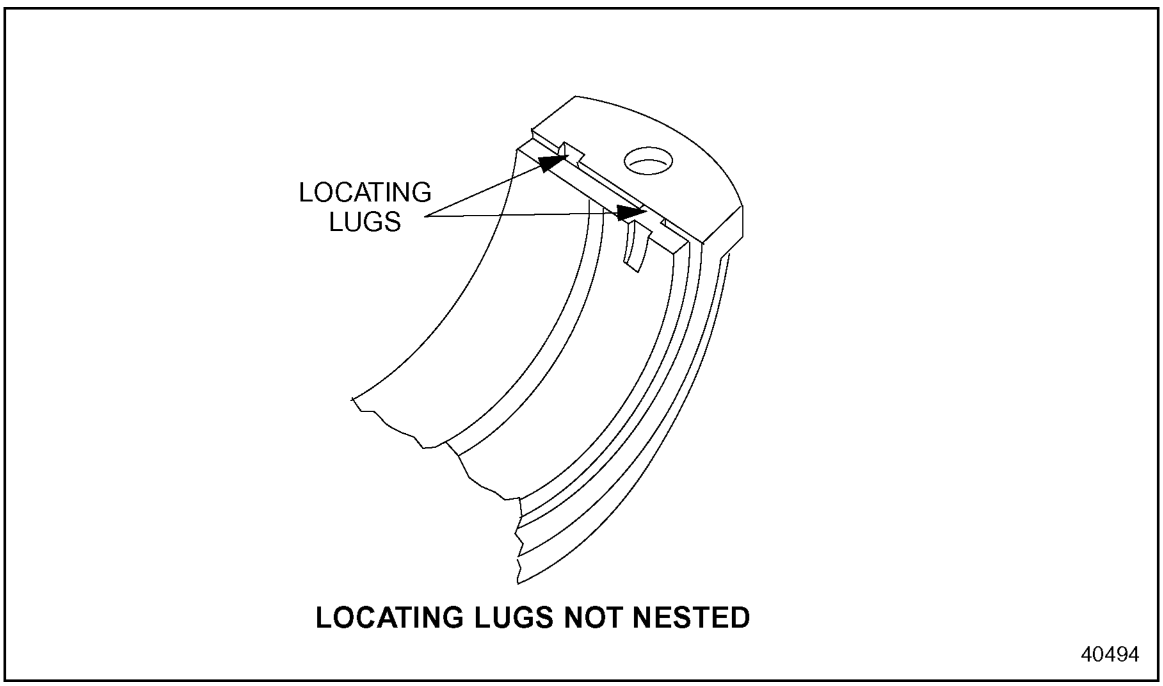

Figure 6-8 Incorrectly Installed Locating Lugs

6.4.2 DAMAGE

Types and results of improper assembly are:

1. A shifted bearing cap causes the side of the bearing to push against the journal.
2. Bent or twisted connecting rod results in the misalignment of the bore with the journal.
3. Insufficient crush allows for the movement of the bearing within the housing.
4. Excessive crush causes the bearing to bulge inward at the edges. See Figure 6-9.

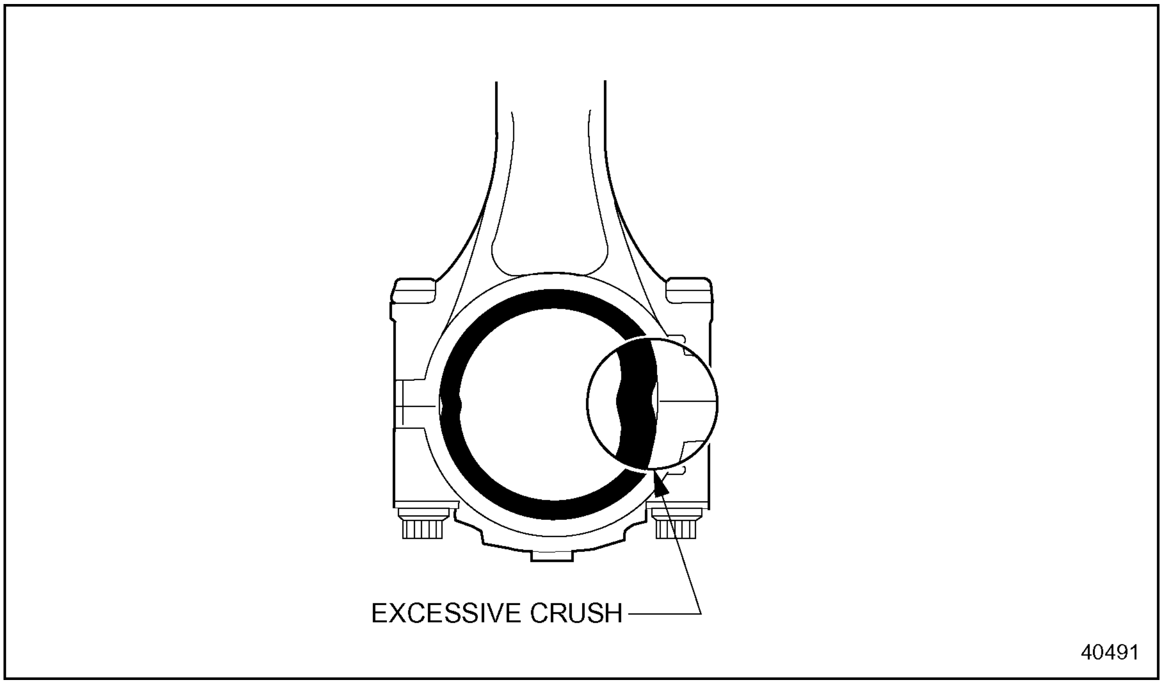

Figure 6-9 Damage from Excessive Crush

6.4.3 POSSIBLE CAUSES

Some possible causes for the damage are:

1. Bearing caps assembled to tightly or not tight enough.
2. Extreme operating conditions.
3. Improper installation. See Figure 6-10 and see Figure 6-11.

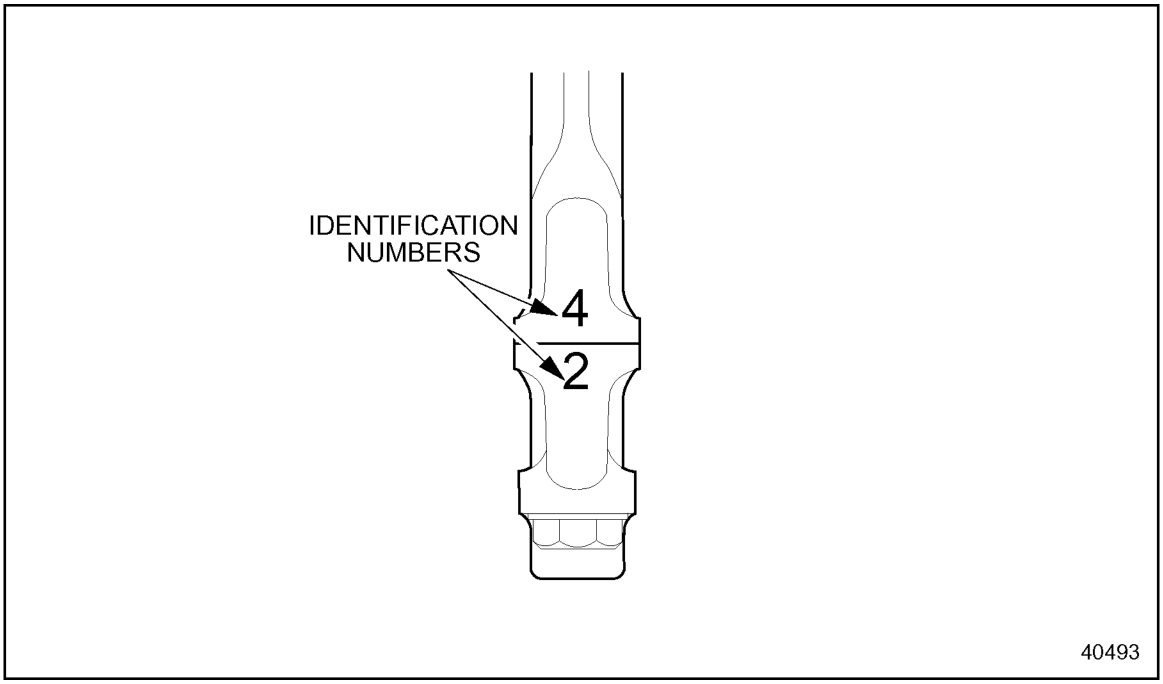

Figure 6-10 Installation with Bearing Caps in Wrong or Reversed Position

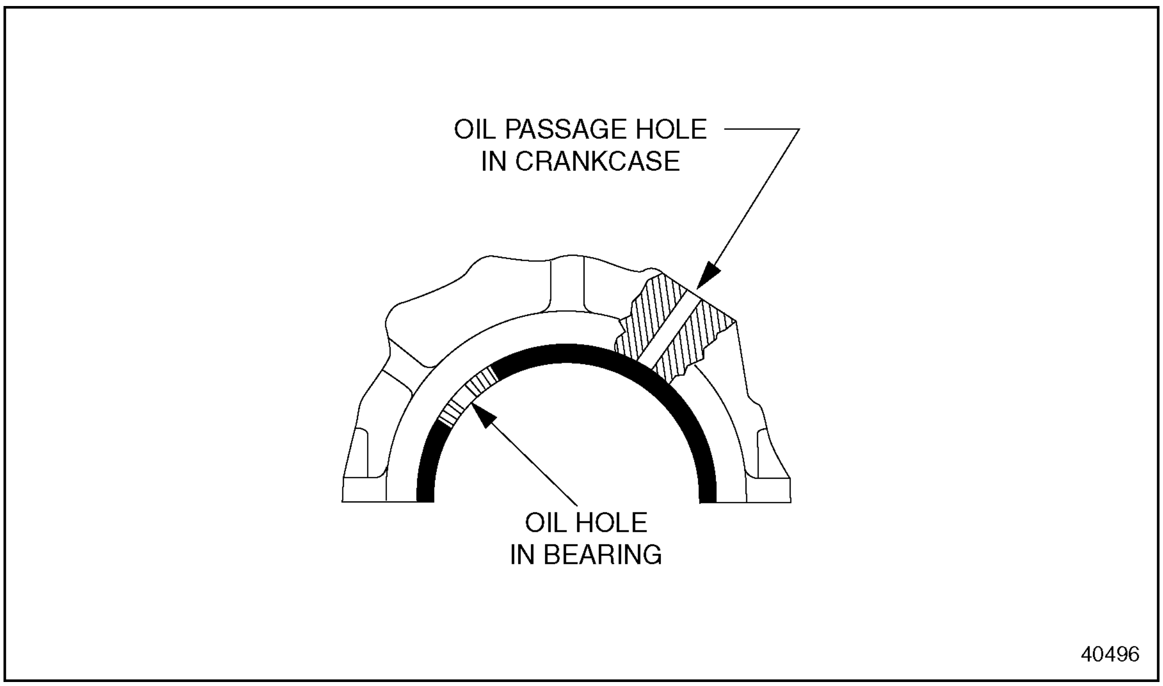

Figure 6-11 Installation with Oil Hole not Aligned with Oil Passage

6.4.4 RECOMMENDATION

The recommended maintenance procedures after finding improper assembly are:

1. Replace bearings.
2. Install new engine components.
3. Ensure the correct torque is applied to the caps.
4. Use correct installation procedures.

6.5 CORROSION

6.5.1 APPEARANCE

The bearing surfaces appear to have holes burned in them by acid. See Figure 6-12

Figure 6-12 Example of Bearing Corrosion

6.5.2 DAMAGE

Corrosion is a chemical attack on the bearing layers by the lubricating oil. The appearance can change depending on the alloy of bearing and the type of corrosive agent involved. Lubricating oil has an oxidation inhibitor added, but after extended periods, the additive is depleted.

Corrosion can develop during operation when a foreign agent such as fuel, air, coolant, or combustion by-products are introduced to the lubricating oil.

6.5.3 POSSIBLE CAUSES

There are several possible causes for the damage:

1. Using the wrong type of oil.
2. Not performing the daily maintenance practice on the engine.
3. Overloading of the engine.
4. Failure to change the lubricating oil on recommended schedule.

6.5.4 RECOMMENDATION

The recommended maintenance procedures after finding corrosion are:

1. Replace bearings.
2. Use recommended oil and additives.
3. Use recommended maintenance practices.
4. Change lubricating oil within the recommended intervals.

6.6 OVERLAY FATIGUE

6.6.1 APPEARANCE

The bearing appears to have part of the overlay, or top layer, missing in sections. See Figure 6-13

Figure 6-13 Example of Overlay Fatigue

6.6.2 DAMAGE

The overlay is a soft material used for embedding foreign material. The material begins to form small cracks which break off. Small pieces of the layer flake away exposing the harder layers. See Figure 6-14.

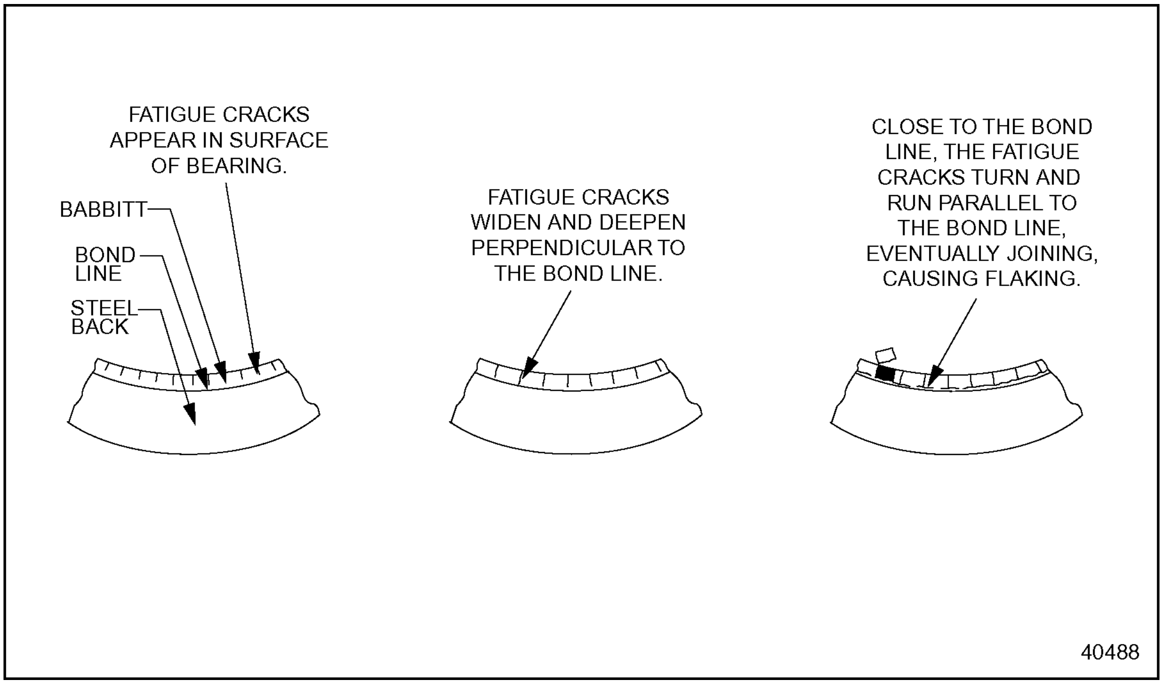

Figure 6-14 Progression of Overlay Fatigue

6.6.3 POSSIBLE CAUSES

There are several possible causes for the damage:

1. High internal oil pressure during normal engine operation.
2. An unintentional load concentration.
3. Exceeding normal bearing life.

6.6.4 RECOMMENDATION

When overlay fatigue occurs, replace bearings.

6.7 WIPING

6.7.1 APPEARANCE

The bearing surface is severely gouged and distorted. Discoloration of the surface may also be present. The surface also has a colored streaking appearance. See Figure 6-15

Figure 6-15 Example of Bearing Wiping

6.7.2 DAMAGE

Wiping occurs when the bearing and journal have come into direct contact with each other from lack of oil film. Wiping produces high heat from friction between the two surfaces. This condition may be from fuel or coolant diluting of lubricating oil. See Figure 6-16.

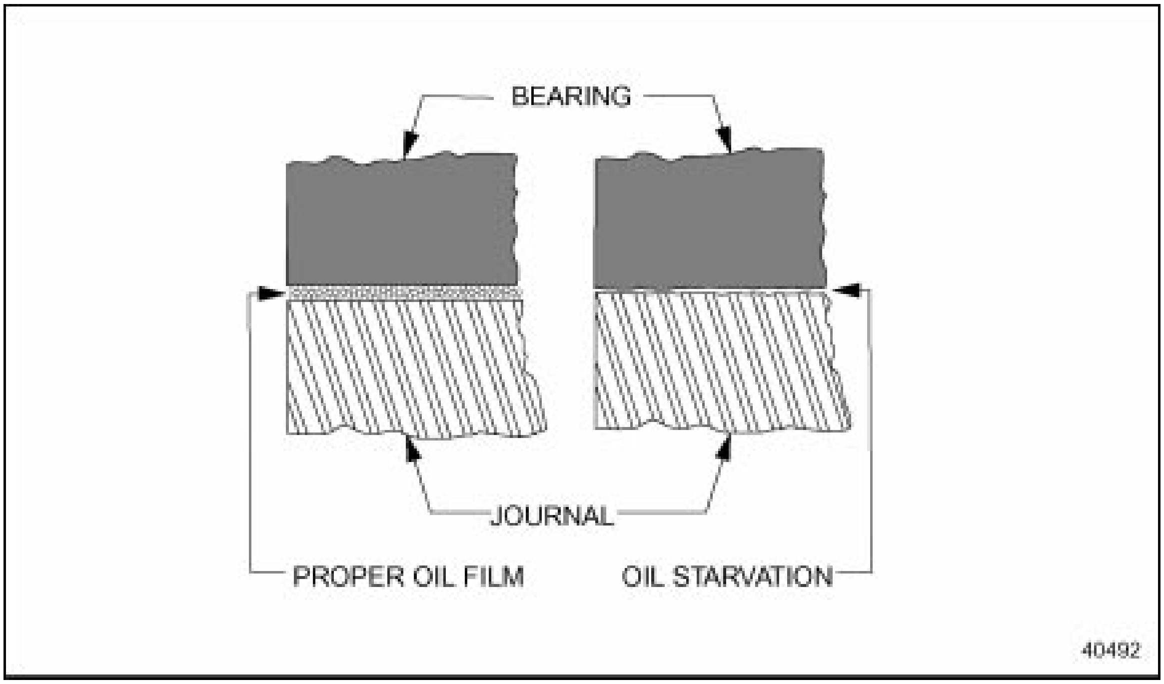

Figure 6-16 Illustration of Oil Film Levels

Overloading can cause wiping. Wiping can also occur when the oil galleries become plugged from foreign debris.

6.7.3 POSSIBLE CAUSES

There are several possible causes for the damage:

1. Dilution of the oil by fuel or coolant.
2. Failure to change the lubricating oil within the recommended schedule.
3. Lack of oil pressure from pump, bearing clearance, or plugged oil galleries.
4. Overloading of the engine.

6.7.4 RECOMMENDATION

The recommended maintenance procedures after finding corrosion are:

1. Replace bearings.
2. Change the lubricating oil and fix leaks in coolant of fuel.
3. Use recommended maintenance practices.
4. Clean and flush all oil galleries.

6.8 LACK OF LUBRICATION

6.8.1 APPEARANCE

The bearing layer appears to have been melted with the layer material streaking together. See Figure 6-17.

Figure 6-17 Example of Lack of Lubrication

6.8.2 DAMAGE

The damage is caused by oil flow disruption to the bearing. When the oil flow is disrupted, the bearing and journal come into contact with one another and creates high heat. Without the oil barrier, the bearing layers are melted away. See Figure 6-16.

6.8.3 POSSIBLE CAUSES

There are several possible causes for the damage:

1. Using the wrong type of oil.
2. Not performing the daily maintenance practice on the engine.
3. Failing to change the lubricating oil within the recommended schedule.

6.8.4 RECOMMENDATION

When lack of lubrication occurs, replace bearings.

1. Replace bearings.
2. Check all other engine parts for similar wear.
3. Use recommended maintenance practices.
4. Change lubricating oil within the recommended interval.

GLOSSARY

Aluminum Contamination	Failure of aluminum components in an engine, contributing aluminum debris into the lubrication system; i.e. blower(s), intermediate camshaft bearings, flywheel housing, turbochargers, piston skirts, oil pump housings, and governor housings.
Bearing Alloy	Any alloy that is used as a bearing lining surface.
Bearing Cap	The removable half of the housing that holds the bearing shells in place.
Bearing Corrosion	Chemical attack evident on bearing surfaces by metal loss or discoloration.
Bearing Material Fatigue	The cracking and eventual "chunking out" of bearing material associated with repeated loading in excess of the fatigue strength for the material.
Bearing Lining Material	Trimetal alloy mainly of copper with lead and tin for maximum fatigue strength.
Bearing Lower (Half Shell)	The bearing half that is made for assembly in the bearing cap.
Bearing Housing Bore	The housing into which the bearing shells are assembled.
Bearing Upper (Half Shell)	The bearing half that is made for assembly in the engine block or connecting rod as opposed to the bearing cap.
Bearing Wall Thickness	The dimension of the bearing shell through the radial cross section as measured by a micrometer with ball attachment.
Bore (Housing)	The inside diameter of the main bearing/connecting rod bore into which the bearing shells are assembled.
Bore Geometry	Bore diameter, roundness, taper, and alignment (main bearing).
Cavitation Erosion	Cavitation is the formation of bubbles in a fluid (lubrication oil) which may occur when the fluid is subjected to low pressures. The high energy dissipated when these bubbles collapse near the bearing surface causes gradual erosion and pitting of the surface. This

condition is called cavitation erosion and is generally not harmful to bearing performance.

Clearance (Diametral Bearing) The difference between the bearing housing bore ID and the bearing journal OD.

Connecting Rod The structural member that transfers the force from the piston to the crankpin.

Connecting Rod Bearing The bearing at the big end of the connection rod in which the crankpin rotates.

Copper Exposed A condition where the bearing shell has been worn through the overlay and into the copper bearing lining as evidenced by a copper color.

Corrosion See Bearing Corrosion.

Crankcase The enclosure for the crankshaft formed by the oil pan and the lower portion of the engine block.

Crankpin The crankshaft journal around which the connecting rod bearing shells are installed.

Crankshaft The main shaft of an engine; contains the main bearing journals and crankpins.

Crown The center area of a bearing shell.

Crush The circumferential interference fit necessary to hold two bearing halves securely in the housing bore. In a bearing half, the amount of circumference in excess of a half circle.

Crush Relief Metal removed on the bearing surface at the parting faces extending the full width of the bearing.

Debris See Foreign Material.

Dirt See Foreign Material.

Dilution Either fuel or coolant in the lubrication system mixing with the lubrication oil.

Edge Loading Unequal loading of a bearing shell evidenced by taper wear across the length of the bearing.

Embedability The ability of the bearing material to absorb foreign material without causing serious bearing damage.

Embedded The enclosure of solid particles into the surface of a bearing shell; i.e., dirt, shavings, metal grinding dust.

End Clearance (End Play) The possible forward and backward movement of the crankshaft in the main bearing fore or connecting rods on the crankpin.

Engine Block The main casting of an internal combustion engine containing the cylinder bores and main bearing bores.

Fatigue See Bearing Material Fatigue.

Fatigue Strength The ability of a bearing material to withstand the repeated loads during engine operation.

Foreign Material Any extraneous material not intended to be present, i.e., particles of steel, cast iron, dirt sand, etc.

Free Spread Diameter See Spread.

Hot Short This term is used to describe a condition where the bearing lining becomes unbonded from the steel bearing back because of an excessively high bearing temperature. The high bearing temperature is almost always a result of the heat generated during a scoring failure. This condition does not indicate an initial defective bearing lining to steel back bond. It merely indicates that a high bearing temperature was reached during a scoring failure to "hot short" or "melt" the bond layer.

Hydraulic Erosion The eating away of the bearing overlay by the action of the oil flow past the surface.

Insufficient Lubrication Inadequate flow rate of the lubrication oil for satisfactory performance.

Journal The part of a shaft that revolves in a bearing.

Limit A size dimension either plus or minus the tolerance (high or low limit).

Line Bore To machine the crankshaft main bearing bores, creating bore centers which fall on a true center line.

Lining	See Bearing Lining Material.
Lining Fatigue	See Bearing Material Fatigue
Locating Tang	A projection on a bearing back that locates in a machined slot in the bearing seat, used to locate the bearing in the housing bore and keep it from moving laterally.
Lubricant	A substance capable of reducing friction between mating surfaces in a relative motion through separation by an oil film.
Main Bearing	A bearing that is used to support the crankshaft in the cylinder block.
Main Bearing Journal	A crankshaft journal that is supported by a main bearing.
Main Bearing Saddle	The area in the cylinder block machined to receive the upper main bearing.
Normal Wear	The amount of bearing wear experienced during normal engine operation.
Oil	A viscous fluid, insoluble in water.
Oil Clearance	See Clearance — Diametral Bearing.
Oil Film	The thin layer of oil that protects the journal and bearing surfaces by separating them and preventing journal to bearing contact while the engine is in operation.
Oil Gallery (Main)	The main oil supply line in the engine block, often referred to as the header. Oil flows from this major supply route under pressure to the many parts that are to be lubricated.
Oil Groove	A canal machined in the surface of a bearing to spread oil on a friction area or to permit the transfer of oil to another part.
Oil Hole	A hole drilled through the bearing wall or crankshaft journal to allow the passage of the oil.
Oil Starvation	A condition of inadequate oil flow or supply.

Out of Round	An inside or outside diameter, designed to be perfectly round, having varying diameters when measured at different points across the diameter.
Overlay Checking	The bearing overlay cracking which indicates the beginning stages of overlay fatigue.
Overlay Fatigue	The cracking and eventual lose of overlay material associated with repeated loading in excess of the fatigue strength of the overlay material.
Overload	A bearing load in excess of the load the bearing was designed to carry.
Oversize	Either an inside or outside diameter that is greater than the standard size.
Parting Edge	The edge formed where the inside or outside surface of the bearing joins at the parting face.
Parting Face	The surface that is in contact with the other bearing half when the bearing is assembled.
Parting Line	The theoretical line formed by the contacting parting faces.
Spread	The excess of diameter at the outside parting edges in the free state over the housing bore into which the bearing is to be installed.
Spun Bearing	A bearing set which has adhered to the journal and turned in the bore for various reasons, i.e. dirt, lack of lubrication, or improper lubrication.
Tolerance	An acceptable range of dimensions to provide accuracy in finished parts.
Thrust Bearing	A flat bearing used to control the crankshaft end play.
Undersize	Either an inside or outside diameter that is less than the standard size.
Wear	The gradual decrease in bearing thickness.