Engine Bearing Failure Analysis
By Clevite 1965
RECOMMENDED BEARING INSTALLATION TOLERANCES

CRANKCASE TOLERANCES

Finish of main bores—80 micro inch or better.
Bore Tolerance—.001" up to 10" bore,
—.002" over 10" bore.
Out-of-round —.001" max. if horizontal is larger than vertical.
Alignment—.002" max. overall misalignment.
—.001" max. misalignment on adjacent bores.

CRANKSHAFT TOLERANCES

MAIN BEARING AND CRANKPIN JOURNALS

Finish—20 micro inch or better.
Diameter tolerance—.0005" up to 1 \(\frac{3}{8}\)" journal.
—.001" for 1 \(\frac{3}{8}\)" to 10" journal,
—.002" for 10" journal and over.
Out-of-round —.002" max. (never use a max. out-of-round journal with a max. out-of-round bore).
Taper—.0002" max. up to 1" long journal,
—.0004" max. for 1" to 2" long journal,
—.0005" max. for 2" or longer journal.
Hour-glass or barrel shape condition—same as Taper.
Oil holes must be well blended into journal surface.

CONNECTING ROD TOLERANCES

Finish of rod bores—80 micro inch or better.
Bore Tolerance—.0005" up to 3\(\frac{3}{8}\)" diameter,
—.001" from 3\(\frac{3}{8}\)" to 10" diameter.
Out-of-round —.001" max. if larger horizontally.
Taper—.0002" up to 1" length,
—.0004" for 1" to 2" length,
—.0005" for 2" or longer.
Hour-glass or barrel shape condition—same as Taper.
Parallelism between rod bore and wrist pin hole .001" in 6".
Twist .001" in 6 inches.
As you know, every automotive engine part will eventually wear out. And if every part always performed for the full length of its expected life, your job would be fairly simple — to replace parts that have worn.

Unfortunately, we cannot always count on an engine part failing only because its normal life span is exceeded. If this were true, there would be no premature failure of rings, pistons, bearings and other engine components — things we know actually do happen. Thus, a mechanic must not only be a "replacer of parts," but, like a doctor, he must be capable of diagnosing his "patient" to determine why a part failed prematurely.

The table below lists the eight major causes of premature engine bearing failure, along with percentage figures which indicate how often each has been found to be the prime contributor to a bearing's destruction. However, it is important to note that in many cases a premature bearing failure is due to a combination of several of these causes.

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<th>MAJOR CAUSES OF PREMATURE BEARING FAILURE</th>
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<tr>
<td>Dirt</td>
<td>44.9%</td>
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<tr>
<td>Misassembly</td>
<td>13.4%</td>
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<tr>
<td>Misalignment</td>
<td>12.7%</td>
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<tr>
<td>Insufficient Lubrication</td>
<td>10.8%</td>
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<tr>
<td>Overloading</td>
<td>9.5%</td>
</tr>
<tr>
<td>Corrosion</td>
<td>4.2%</td>
</tr>
<tr>
<td>Other</td>
<td>4.5%</td>
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Thus, we can reason that if a mechanic merely replaces a damaged bearing in an automotive engine, without determining the cause of its failure, more than 99% of the time he will be subjecting the replacement bearing to the same cause that was responsible for the original failure. What this all means is that just as a doctor cannot cure a patient until he has determined what ails him, so, too, a mechanic cannot correct the cause of premature bearing failure until he first determines what causes the failure.

The pages of this manual are organized, for your convenience, into four major subjects:

1. **Appearance** — an illustration and brief description of a bearing that has failed due to a specific cause.

2. **Damaging Action** — what actually damaged the bearing under the conditions which were present.

3. **Possible Causes** — a listing of those factors capable of creating the particular damaging action.

4. **Corrective Action** — the action that should be taken to correct the cause of failure.

We believe you will find this reference manual easy to read and use, and that it will be very helpful to you on future bearing replacement jobs.
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<td>INSUFFICIENT CRUSH</td>
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<td>OIL STARVATION</td>
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<td>OUT-OF-ROUND BORE</td>
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<td>EXCESSIVE CRUSH</td>
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<td>APPEARANCE</td>
<td>CAUSE</td>
<td>REFERENCE NUMBER</td>
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**DAMAGING ACTION**

Heavy pulsating loads imposed upon the bearing by reciprocating engine cause the bearing surface to crack due to metal fatigue, as illustrated below.

**APPEARANCE**

Small irregular areas of surface material missing from the bearing lining.

**POSSIBLE CAUSES**

Bearing failure due to surface fatigue is usually the result of the normal life span of the bearing being exceeded.

**CORRECTIVE ACTION**

1. If the service life for the old bearing was adequate, replace with the same type of bearing to obtain a similar service life.
2. If the service life of the old bearing was too short, replace with a heavier duty bearing to obtain a longer life.
3. Replace all other bearings (main connecting rod and cam shaft) as their remaining service life may be short.
4. Recommend that the operator avoid "hot rodding" and lugging as these tend to shorten bearing life.
**APPEARANCE**

Foreign particles are embedded in the lining of the bearing. Scrape marks may also be visible on the bearing surface.

**DAMAGING ACTION**

Dust, dirt, abrasives and/or metallic particles present in the oil supply embed in the soft babbit bearing lining, displacing metal and creating a high-spot.

The high spot may be large enough to make contact with the journal causing a rubbing action that can lead to the eventual breakdown and rupture of the bearing lining. Foreign particles may embed only partially and the protruding portion may come in contact with the journal and cause a grinding wheel action.

**POSSIBLE CAUSES**

Three factors can lead to bearing failure due to foreign particles:

1. Improper cleaning of the engine and parts prior to assembly.
2. Road dirt and sand entering the engine through the air-intake manifold.
3. Wear of other engine parts, resulting in small fragments of these parts entering the engine's oil supply.

**CORRECTIVE ACTION**

1. Install new bearings, being careful to follow proper cleaning procedures.
2. Grind journal surfaces if necessary.
3. Recommend that the operator...

   - have the oil changed at proper intervals
   - have air filter, oil filter and crankcase breather-filter cleaned as recommended by the manufacturer.
© foreign particles on bearing back

APPEARANCE
A localized area of wear can be seen on the bearing surface. Also, evidence of foreign particle(s) may be visible on the bearing back or bearing seat directly behind the area of surface wear.

DAMAGING ACTION
Foreign particles between the bearing and its housing prevent the entire area of the bearing back from being in contact with the housing base. As a result, the transfer of heat away from the bearing surface is not uniform causing localized heating of the bearing surface which reduces the life of the bearing.

Also, an uneven distribution of the load causes an abnormally high pressure area on the bearing surface, increasing localized wear on this material.

POSSIBLE CAUSES
Dirt, dust, abrasives and/or metallic particles either present in the engine at the time of assembly or created by a burr removal operation can become lodged between the bearing back and bearing seat during engine operation.

CORRECTIVE ACTION
1. Install new bearings following proper cleaning and burr removal procedures for all surfaces.
2. Check journal surfaces and if excessive wear is discovered, regrind.

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**APPEARANCE**
Localized excessive wear areas are visible near the parting line on both sides of both top and bottom shells.

**DAMAGING ACTION**
Oil clearance near the parting line is decreased to such an extent that metal-to-metal contact between bearing and journal takes place, resulting in areas of above-normal wear.

Also, improper seating between the bearing back and the housing bore may be present . . . hinders proper heat transfer causing localized heating of the bearing surface and thus reducing fatigue endurance.

**POSSIBLE CAUSES**
Alternating loading and flexing of the connecting rod can cause the bearing seats to become elongated. And because replacement bearing shells, when installed, tend to conform to the shape of the bearing seat, this can result in an out-of-round bearing surface.

**CORRECTIVE ACTION**
1. Check the roundness of bearing seats before installing the new bearings. If they are found to be out-of-round, recondition the bearing housings (or replace connecting rod).
2. Check the journal surfaces for excessive wear and regrind if necessary.
3. Install new bearings.
APPEARANCE

Extreme wear areas visible along the bearing surface adjacent to one or both of the parting faces.

DAMAGING ACTION

Before the bearing cap is assembled, a small portion of the bearing extends just a little beyond the edge of the bearing seat. Thus when the bearing cap is tightened into place, the bearing is forced against the bearing seat. That portion of the bearing which extends beyond the seat is called "crush."

When there is too much crush, however, the additional compressive force created by the surplus crush that still remains after the bearing is fully seated causes the bearing to bulge inward at the parting faces. This bearing distortion is called "side pinch."

POSSIBLE CAUSES

There are three possible causes of excessive crush:
1. The bearing caps were filed down in an attempt to reduce oil clearance.
2. The bearing caps were assembled too tightly due to excessive torquing.
3. Not enough shims were utilized (if shims were specified).

CORRECTIVE ACTION

1. Rework the bearing housing of the engine block if it has been filed down.
2. Replace the connecting rod if its bearing cap has been filed down.
3. Install the new bearing.
4. Check journal surfaces and regrind if necessary.
5. Follow proper installation procedures by never filing down bearing caps and using the recommended torque wrench setting.
6. Correct the shim thickness (if applicable).
7. Check for out-of-roundness of the inside diameter of the assembled bearing by means of an out-of-roundness gauge, inside micrometer, calipers or prussian blue to assure that any out-of-roundness is within safe limits.

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**APPEARANCE**

Highly polished areas are visible on the bearing back and or on the edge of the parting line.

**DAMAGING ACTION**

When a bearing with insufficient crush is assembled in an engine, it is loose and therefore free to work back and forth within its housing.

Because of the loss of radial pressure, there is inadequate contact with the bearing seat, thus impeding heat transfer away from the bearing. As a result, the bearing overheats causing deterioration of the bearing surface.

**POSSIBLE CAUSES**

There are five possible causes of insufficient crush:

1. Bearing parting faces were filed down in a mistaken attempt to achieve a better fit, thus removing the crush.
2. Bearing caps were held open by dirt or burrs on the contact surface.
3. Insufficient torquing during installation (be certain bolt doesn't bottom in a blind hole).
4. The housing bore was oversize or the bearing cap was stretched, thus minimizing the crush.
5. Too many shims were utilized (if shims are specified).

**CORRECTIVE ACTION**

1. Install new bearings using correct installation procedures (never file parting faces).
2. Clean mating surfaces of bearing caps prior to assembly.
3. Check journal surfaces for excessive wear and regrind if necessary.
4. Check the size and condition of the housing bore and recondition if necessary.
5. Correct shim thickness (if applicable).
© bent or twisted connecting rod

APPEARANCE
Excessive wear areas can be seen on opposite ends of the upper and lower connecting rod bearing shells. The wear is localized on one portion of the bearing surface with little or no wear on the remainder.

DAMAGING ACTION
A bent or twisted connecting rod results in misalignment of the bore, causing the bearing to be cocked so the bearing edge makes metal-to-metal contact with the journal.

POSSIBLE CAUSES
Three factors can contribute to connecting rod distortion:
1. Extreme operating conditions such as "hot rodding" and "lugging."
2. Improper installation of the connecting rod.
3. Dropping or abusing the connecting rod prior to assembly.

CORRECTIVE ACTION
1. Inspect connecting rod and recondition or replace if bent or twisted.
2. Check journal surfaces for excessive wear and reground if necessary.
3. Install bearing.
4. Avoid dropping or abusing the connecting rod prior to assembly.
5. Use proper installation techniques.
6. Check related upper cylinder parts and replace if necessary.
APPEARANCE
Excessive wear areas can be seen near the parting lines on opposite sides of the upper and lower bearing shells.

DAMAGING ACTION
The bearing cap has been shifted, causing one side of each bearing half to be pushed against the journal at the parting line.

POSSIBLE CAUSES
These are five factors which can cause a shifted bearing cap:
1. Using too large a socket to tighten the bearing cap. In this case, the socket crowds against the cap causing it to shift.
2. Reversing the position of the bearing cap.
3. Inadequate dowel pins between bearing shell and housing (if used), allowing the shell to break away and shift.
4. Improper torquing of cap bolts resulting in a "loose" cap that can shift positions during engine operation.
5. Enlarged cap bolt holes or stretched cap bolts, permitting greater than normal play in the bolt holes.

CORRECTIVE ACTION
1. Check journal surfaces for excessive wear and regrind if necessary.
2. Install the new bearing being careful to use the correct size socket to tighten the cap and the correct size dowel pins (if required).
3. Alternate torquing from side to side to assure proper seating of the cap.
4. Check the bearing cap and make sure it’s in its proper position.
5. Use new bolts to assure against overplay within the bolt holes.
APPEARANCE
A wear pattern is visible on the upper or lower halves of the complete set of main bearings. The degree of wear varies from bearing to bearing depending upon the nature of the distortion. The center bearing usually shows the greatest wear.

DAMAGING ACTION
A distorted crankcase imposes excessive loads on the bearings, with the point of greatest load being at the point of greatest distortion. These excessive bearing loads cause excessive bearing wear. Also, oil clearance is reduced and metal-to-metal contact is possible at the point of greatest distortion.

POSSIBLE CAUSES
Alternating periods of engine heating and cooling during operation is a prime cause of crankcase distortion. As the engine heats the crankcase expands, and as it cools the crankcase contracts. This repetitive expanding and contracting causes the crankcase to distort in time.

Distortion may also be caused by:
- Extreme operating conditions (for example “hot-rod Turing” and “lugging”).
* Improper torquing procedure for cylinder head bolts, particularly with overhead valve V-8 engines.

CORRECTIVE ACTION
1. Determine if distortion exists by use of Prussian blue or visual methods.
2. Align bore the housing (if applicable).
3. Install new bearings.
DAMAGING ACTION

A distorted crankshaft subjects the main bearings to excessive loads, with the greatest load being at the point of greatest distortion. The result is excessive bearing wear. Also, the oil clearance spaces between journals and bearings are reduced, making it possible for metal-to-metal contact to occur at the point of greatest distortion.

APPEARANCE

A wear pattern is visible on the upper and lower halves of the complete set of main bearings. The degree of wear varies from bearing to bearing depending upon the nature of the distortion. The center bearing usually shows the greatest wear.

POSSIBLE CAUSES

A crankshaft is usually distorted due to extreme operating conditions, such as “hot-rodding” and “lugging.”

CORRECTIVE ACTION

1. Determine if distortion exists by means of Prussian blue or visual methods.
2. Install a new or reconditioned crankshaft.
3. Install new bearings.
An out-of-shape journal imposes an uneven distribution of the load on the bearing surface, increasing heat generated and thus accelerating bearing wear. An out-of-shape journal also affects the bearing's oil clearance, making it insufficient in some areas and excessive in others, thereby upsetting the proper functioning of the lubrication system.

**Appearance**
In general, if a bearing has failed because of an out-of-shape journal, an uneven wear pattern is visible on the bearing surface. Specifically, however, these wear areas can be in any one of three patterns: Photo A above shows the wear pattern caused by a **tapered** journal. Photo B shows the wear pattern caused by an **hour-glass** shaped journal. Photo C shows the pattern of a **barrel-shaped** journal.

**Possible Causes**
If the journal is tapered, there are two possible causes:
1. Uneven wear of the journal during operation (misaligned rod).
2. Improper machining of the journal at some previous time.

If the journal is **hour glass** or **barrel** shaped, this is always the result of improper machining.

**Corrective Action**
Regrinding the crankshaft can best remedy out-of-shape-journal problems. Then install new bearings in accordance with proper installation procedures.
**APPEARANCE**

When fillet ride has caused a bearing to fail, areas of excessive wear are visible on the extreme edges of the bearing surface.

**DAMAGING ACTION**

If the radius of the fillet at the corner where the journal blends into the crank is larger than required, it is possible for the edge of the engine bearing to make metal-to-metal contact and ride on this oversize fillet.

This metal-to-metal contact between the bearing and fillet causes excessive wear, leading to premature bearing fatigue.

**POSSIBLE CAUSES**

Fillet ride results if excessive fillets are left at the edges of the journal at the time of crankshaft machining.

**CORRECTIVE ACTION**

1. Regrind the crankshaft paying particular attention to allowable fillet radii.

   **NOTE:** be careful not to reduce fillet radius too much, since this can weaken the crankshaft at its most critical point.

2. Install new bearings.
When a bearing has failed due to oil starvation, its surface is usually very shiny. In addition, there may be excessive wear of the bearing surface due to the wiping action of the journal.

The absence of a sufficient oil film between the bearing and the journal permits metal-to-metal contact. The resulting wiping action causes premature bearing fatigue.

Any one of the following conditions could cause oil starvation:

1. Insufficient oil clearance — usually the result of utilizing a replacement bearing that has too great a wall thickness. In some cases, the journal may be oversize.
2. Broken or plugged oil passages, prohibiting proper oil flow.
3. A blocked oil suction screen or oil filter.
4. A malfunctioning oil pump or pressure relief valve.
5. Misassembling main bearings metering off an oil hole.

1. Double check all measurements taken during the bearing selection procedure to catch any errors in calculation.
2. Check to be sure that the replacement bearing you are about to install is the correct one for the application (that it has the correct part number).
3. Check the journals for damage and regrind if necessary.
4. Check engine for possible blockage of oil passages, oil suction screen and oil filter.
5. Check the operation of the oil pump and pressure relief valve.
6. Be sure that the oil holes are properly indexed when installing the replacement bearings.
7. Advise the operator about the results of engine lugging.

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Engine bearings will not function properly if they are installed wrong. In many cases (disassembly will result in premature failure of the bearing.

The following are typical assembly errors most often made in the installation of engine bearings:

- Position of offset connecting rod reversed
- Shims improperly installed
- Bearing caps in wrong or reversed position
- Locating lugs not nested
- Bearing halves reversed
- Bearing oil hole not aligned with oil passage hole