FORM : SEBG4160-1

SHOP MANUAL

GUIDANCE FOR REUSABLE PARTS

HST (Hydrostatic Transmission)

Piston pumps and Motors

KOMATSU

GUIDANCE FOR REUSABLE PARTS

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INDEX

INTRODUCTION

This Guidance for Reusable Parts provides basic knowledge and explanation of the causes of damage needed when disassembling, assembling or repairing HST. (piston pumps and motors)

It includes photographs of various types of damage so that judgement can be made visually as to whether a part can be used again or not.

This Guidance for Reusable Parts is designed so that it can be used by a wide range of people in the repair and maintenance of HST.

We hope that it will be used to make suitable judgement about reuse or replacement of parts to reduce repair costs and to improve machine availability.

MAIN CAUSES OF FAILURE

About 70% of damage to hydraulic equipment is caused by problems in maintenance and in the selection of hydraulic oil. Therefore, to prevent damage, and to use the machine efficiently, it is important to give careful consideration to the selection of hydraulic oil and to the way of handling the machine.

Hydraulic oil

Hydraulic oil is an important element because it acts as the medium to transmit pressure. It also plays an important role as a coolant and lubricant for sliding parts.

As the hydraulic oil is used, it becomes contaminated by the entry of dirt of water, so the condition of the oil is generally checked by the following four items : discoloration, water content, viscosity, and acidity (alkalinity). Of these, the items which most frequently lead to damage of the equipment are water and contaminants causing discoloration.

1) **Discoloration**

Hard particles (contaminants), such as particles of worn metal, sand or dirt, cause wear or scuffing of the sliding surface. They also advance the change to acidity of the hydraulic oil.

Generally speaking, discoloration is expressed by NAS grade. The oil should be within grade 10; it must be changed if it is above grade 12. Grade 11 and grade 12 can often be reused if the oil is cleaned.

2) **Water content**

If water gets into the hydraulic oil, the oil does not lubricate properly. This leads to wear, seizure and rusting of parts. The standard for water content is within 0.2%; above this level, the oil must be changed or cleaned.

3) **Cavitation**

If air gets into the oil, it creates bubbles. When these bubbles burst, there is sudden high pressure at that point, which causes noise or vibration. In particular, around the delivery port of the pump, this causes damage by erosion.

4) **Rise in oil temperature**

If the oil is allowed to rise above the specified temperature, the viscosity will be reduced and the delivery amount will drop because of internal leakage. In addition, the oil film will be lost, thereby causing wear and seizure, and it will also advance the change to acidity of the hydraulic oil.

Disassembly and assembly

Entry of dirt, dents, burrs, scratches, catching of the O-ring, and abnormal tightening torque during disassembly and assembly operations can cause oil leakage, scuffing and seizure during operation. This lowers the output and has other adverse effects on performance.

★ See the Shop Manual for details of tightening torques and methods of adjustment during assembly operations.

JUDGEMENT ABOUT FAILURE

The piston pump and motor are the heart of the hydraulic equipment. If there is wear, scuffing, dents, or seizure of the piston pump or motor, the performance of the hydraulic equipment will drop and other problems will occur. Therefore, it is important to exercise extreme care when making judgements about the reuse of parts.

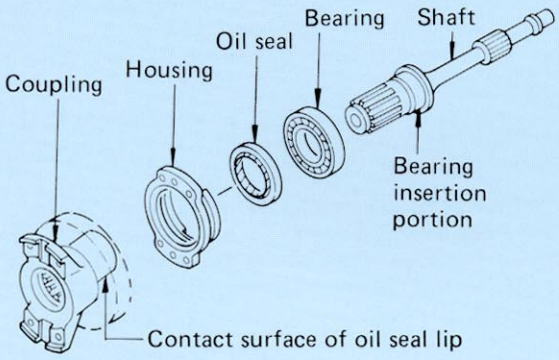
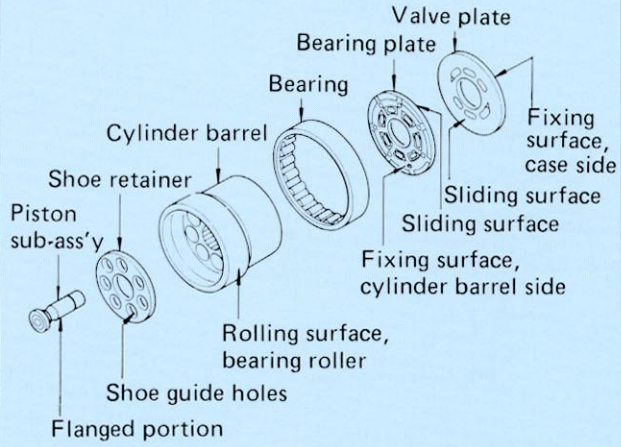
When making judgements about the reuse of parts, it is important to consider daily maintenance and operating conditions to find out exactly why that kind of damage was caused. In this Guidance Manual, there are photographs of damage ranked A, B or C. These photographs should be used together with the know-how derived from experience to make judgements about reuse of the part.

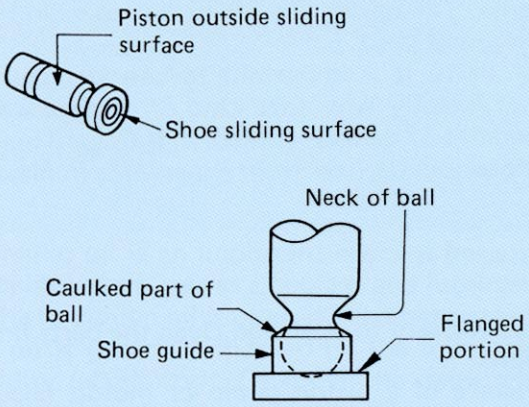
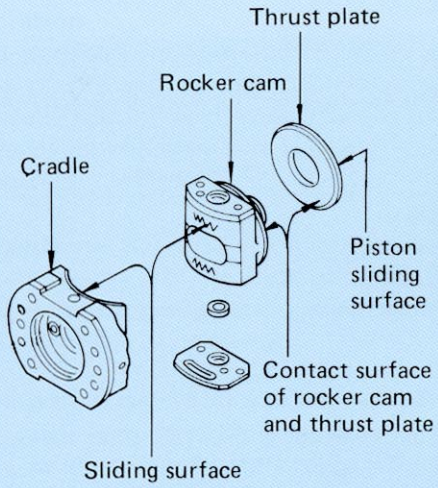
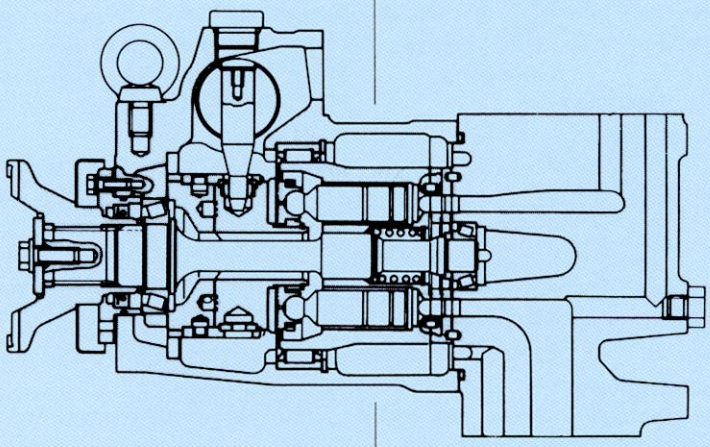
Check points when judging parts

To make accurate judgement on damaged parts, it is necessary to wash and clean the parts first and then to pay careful attention to the following check points.

If there is any malfunction or drop in the performance of a piston pump or motor, check the discoloration of the hydraulic oil and use the results as reference when looking for the cause of the problem.

Note: The check items, examples of damage, and photographs are explained for a pump. Since a motor has the same structure, make the same judgements.

Check position	Check point
	1. Shaft · Wear or scratches on bearing insertion portion. 2. Bearing · Indentations, dents, pitting, smearing, scratches or wear 3. Coupling · Scratches or wear on contact surface of oil seal ★ For details about the bearing, see the Guidance for Reusable Parts on Bearings.
	1. Valve plate · Scratches, seizure, or discoloration of sliding surface 2. Bearing plate · Scratches, seizure, discoloration, or hair cracks of sliding surface; erosion; uneven plating 3. Cylinder barrel · Indentations, dents, pitting, fretting, or scratches of rolling surface of bearing roller · Scuffing, wear or erosion on inside of cylinder bore 4. Shoe retainer · Scuffing or cracks in shoe retainer holes

Check position	Check point
	5. Piston sub-assembly • Scratches or seizure of piston sliding surface • Indentations or cracks in cylinder ball neck • Indentations, dents, scuffing, or wear of sliding surface of shoe thrust plate ★ If there are marked scratches on the shoe and you suspect that there are cracks on the ball neck, carry out a color check (penetration test). • Scuffing or wear of the flanged portion and the surface in contact with the shoe retainer holes • Play and indentations of caulked part of ball (endplay of piston) ★ Measure the play with a dial gauge.
	1. Thrust plate • Deposits of shoe material or scuffing of piston sliding surface • Seizure, scuffing, or discoloration of surface in contact with rocker cam 2. Rocker cam • Seizure, scuffing, or discoloration of surface in contact with thrust plate • Seizure or scuffing of sliding surface in contact with cradle; contact condition • Function of bearing (ball joint), wear 3. Cradle • Seizure, scuffing, wear, or indentations of sliding surface in contact with rocker cam; contact condition ★ To check the contact condition of the sliding surface between the rocker cam and cradle, apply a thin coat of red lead primer to one side, slide both sides together, and observe the contact condition.
	

LEVEL OF FAILURE AND JUDGEMENT ON REUSE

The level of damage for piston pumps and motors is categorized into three stages : A, B, C Judgement about reuse of parts is made according to these categories.

Category	Level of failure	Action
A	This category indicates slight or minor damage which creates no problem for the performance of the machine. There is no risk of this damage causing secondary damage.	Can be used as it is
B	This category indicates medium damage which at present is no problem to the performance of the machine, but there is a risk of secondary damage, so replacement is preferable if the part is used for heavy duty work.	Repair and reuse
C	This category indicates serious or critical damage, or that the part has reached the end of its life. If this part is used it may break and cause serious damage, so it must be replaced.;	Can not be reused

Damage to parts does not simply consist of one type of damage; it often consists of several types of damage occurring together. In such cases, take the most dangerous form of damage as a guide when making judgement, and always take the overall safety of the machine into consideration.

If the level of damage is ranked between category A and category B as shown in the photographs, the damage should be ranked at the more dangerous category, that is, category B.

This judgement frequently depends on the user's needs (does the part still have the demanded residual life ?), so it is impossible to make an unconditional judgement. However, it is necessary to consider what kind of operation it will be used in, what level of capacity it must display, what length of time it will be used and if it can be used continuously.

Therefore, judgement on the harmful effects or danger of the damage must be based on experience, so when ranking the damage, use the photographs as reference.

Part Name	Location of damage		Judgement category		
			A	B	C
Shaft	1	Bearing insertion portion	No sign of creeping	* If creeping is present, refer to the Guidance for reusable parts on bearings and classify the damage into B or C.	
Coupling	1	Contact surface of oil seal lip	No scratches or wear	Wear to the extent that the fingernails get caught, but the tracks of wear are smooth	Advanced stepped wear, tears
Valve plate	1	Sliding surface	No scratches, seizure, or discoloration; good contact condition	Light scratches or scuffing which can be removed easily by lapping. * If the scratches are slight but cannot be corrected by lapping, surface grinding may be tried. In this case, the precision of grinding must be within 0.002 flatness and 0.010 parallelism. Use #2000 lapping compound or equivalent, and finish with chromium oxide.	Marked scratches, seizure, discoloration (temper color) or deep scratches between the valve ports.
Bearing plate	1	Sliding surface	No temper color, hair cracks, erosion, peeling of plating, or injuries	Light scratches or scuffing which can be removed easily by lapping. * The plating is 5 microns thick, so do not carry out excessive lapping. It is OK if a few scratches remain. Use lapping compound #2000 or equivalent.	**Marked discoloration (temper color), hair cracks, peeling of plating, or deep scratches. Deep scratches between valve ports.**
Cylinder barrel	1	Cylinder inside wall	No scratches, wear, or erosion	Slight scratches, but when piston is inserted, it goes down smoothly to the bottom * If it feels scratchy to the fingertips, use #400 ~ 600 sandpaper, apply oil, and sand lightly to remove the burrs.	**Several deep scratches/Deep scratches extending to the skirt/Seizure or erosion/Marked wear/heat spot.**
	2	Rolling surface of bearing roller	No indentations, dents, pitching, or fretting	* To classify the rolling surface into B or C, see the Guidance for reusable parts on bearing of the same type as the roller bearing.	
Shoe retainer	1	Hole area	No scuffing or cracks	Very light scuffing * Use #400 ~ 600 sandpaper and finish gently.	Marked scuffing or cracks

Part Name	Location of damage		Judgement category		
			A	B	C
Piston subassembly	1	Piston sliding surface	No scratches or cracks	Fine scratches which catch the fingernails * Remove any protrusions with an oilstone, finish with #400 ~ 600 sandpaper, then give a final finish with chromium oxide.	Seizure or scuffing
	2	Neck of ball	No indentations or cracks		Indentations or cracks
	3	Piston shoe, piston plate sliding surface	No indentations, dents, imbedded marks, scuffing, or wear	Slight scratches or wear	Crushed oil grooves, deep scratches, advanced wear
	4	Piston/shoe retainer hole mating surface	No scratches or scuffing	Slight wear or scuffing	Marked scuffing, stepped wear
	5	Caulked part of ball	* Ball moves smoothly * No elongation of caulked portion * No dents or indentations		* Poor movement of ball * Dents or indentations

* The allowable limits for elongation of the caulking (play is direction) are 0.3 mm within the first 200 hours and 0.4 mm after 200 hours.

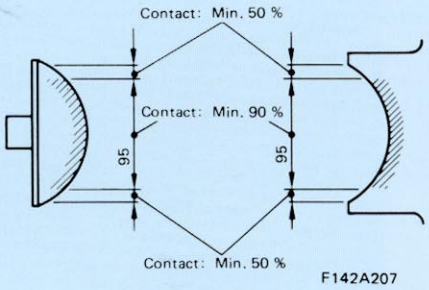
* If the judgement for the piston subassembly is that replacement is needed, replace all the piston subassemblies as sets.

Part Name	Location of damage		Judgement category		
			A	B	C
Thrust plate	1	Piston shoe sliding surface	No dents, seizure, deposits of shoe material, or scuffing	Shallow scratches which catch the fingernail lightly or light scuffing which can be repaired by lapping. * If there are protrusions because of deposits of shoe material or scuffing, first use a smooth oilstone to make local correction, then carry out lapping. Use #2000 lapping compound or equivalent, then finish with chromium oxide.	Dents, marked seizure, or severe scuffing
	2	Contact surface with rocker cam	No seizure, scuffing, or discoloration	Light seizure or scuffing, but protrusions can be removed easily. Local corrections can be made easily. * It is OK is a few small indentations remain, but the rocker cam contact surface must be sealed completely. No protrusions shall remain which create a rising gap.	Marked seizure, scuffing, or discoloration
	For correction of thrust plates in Category B, make sure that the flatness is 0.002 and the parallelism 0.030.				
Rocker cam	1	Mating surface with thrust plate	No seizure or scuffing	Same as Category B for No. 2 under 'Thrust plate.'	Marked seizure or scuffing
	2	Cylindrical sliding surface	* No seizure or scuffing * Good contact condition	Fine scratches which catch the fingernail or light deposits of shoe material which can be removed easily by lapping with the cradle. If there is build-up through deposits of shoe material, remove the built-up portion with an oilstone, polish with #400 ~ 600 sandpaper, and finish by lapping together.	* Marked scuffing or seizure * Deep scratches from the oil grooves towards the side < Reason > (Necessary condition for maintaining oil tightness.)

Part Name	Location of damage		Judgement category		
			A	B	C
Cradle	1	Sliding face with rocker cam (bearing portion)	* No seizure, scuffing, wear, or imbedded marks * Good mating condition * To determine whether the contact between the cradle and rocker cam is proper, use red lead primer and slide the cradle against the rocker cam several times even if the visual check showed the cradle to be in Category A.	* Slight seizure, scuffing, or imbedded marks which can be corrected easily. * Poor contact with rocker cam • Cradles which can be repaired easily by lapping together with the rocker cam. * Use #2000 lapping compound or the equivalent. The allowable limits for contact are shown in the figures below. Within the range of contact, marks caused by a small number of dents are OK as long as the lubricating oil remains tightly sealed.	* Marked wear or one-sided contact which is difficult to correct. * Deep scratches moving towards both the outside and inside. < Reason > (Not used because it would interfere with the tight sealing of the lubricating oil.)

★ Check contact between cradle and cylindrical surface of rocker cam.

• For motor
  i) Contact must be over 90% inside a width of 95 mm from center (center part).
  ii) Contact must be over 50% outside a width of 95 mm from center (outside part).



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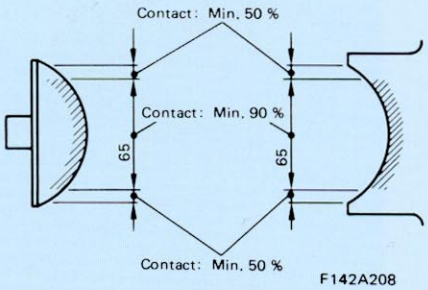
• For pump
  i) Contact must be over 90% inside a width of 65 mm from center (center part).
  ii) Contact must be over 50% outside a width of 65 mm from center (outside part).

★ It is not permitted if there is no contact in the center, and only contact on the outside.

★ In case of wrong contact, correct contact.



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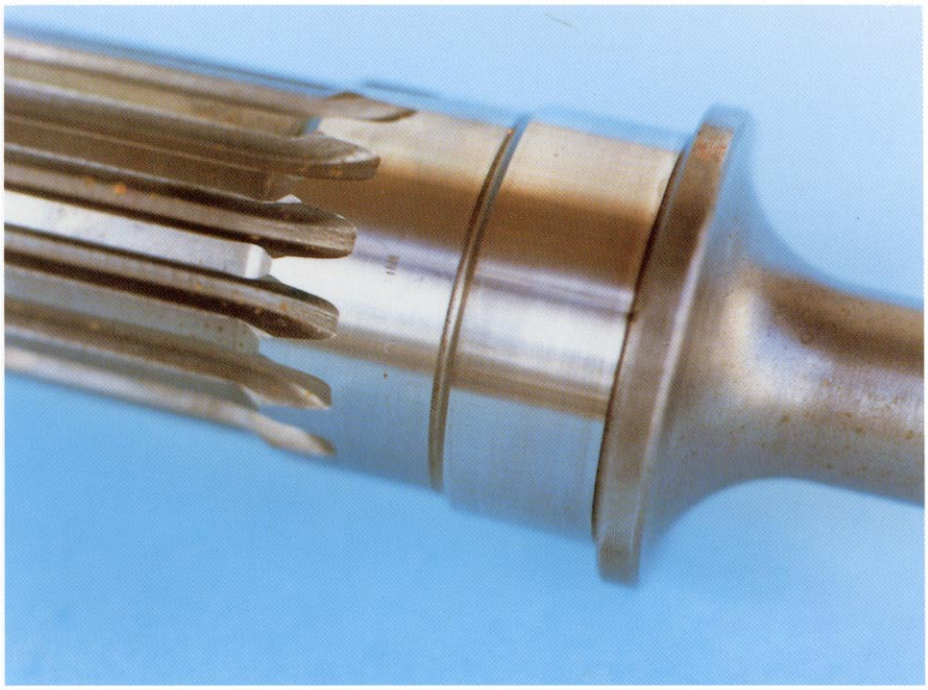
EXAMPLES OF FAILURES

Shaft : Insertion portion of bearing

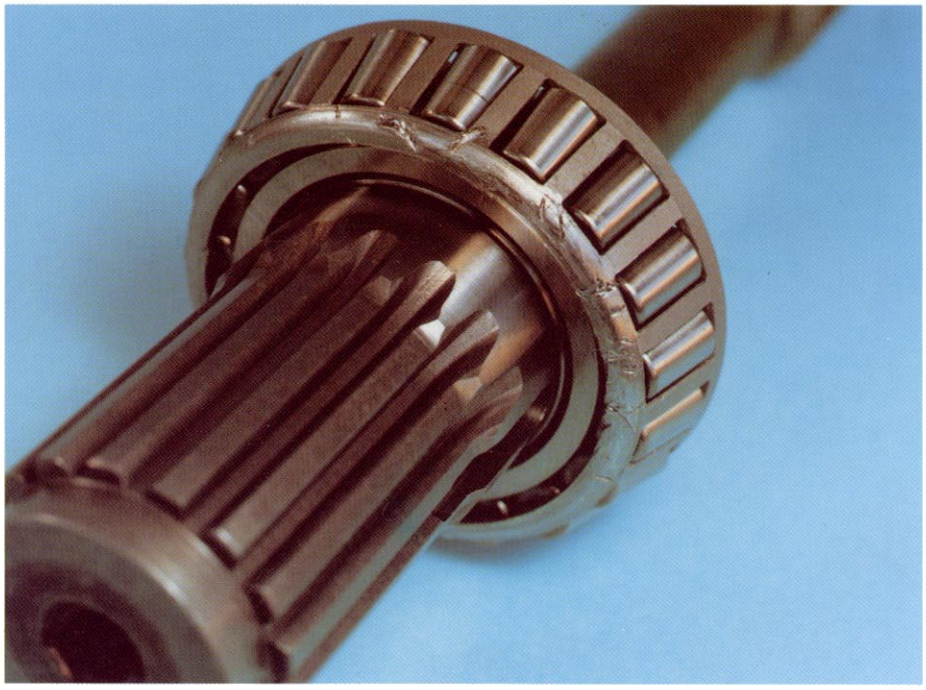
1



Category: A
Condition: Bearing insertion portion in good condition with no sign of creeping
Cause: Normal

Shaft and Bearing

2



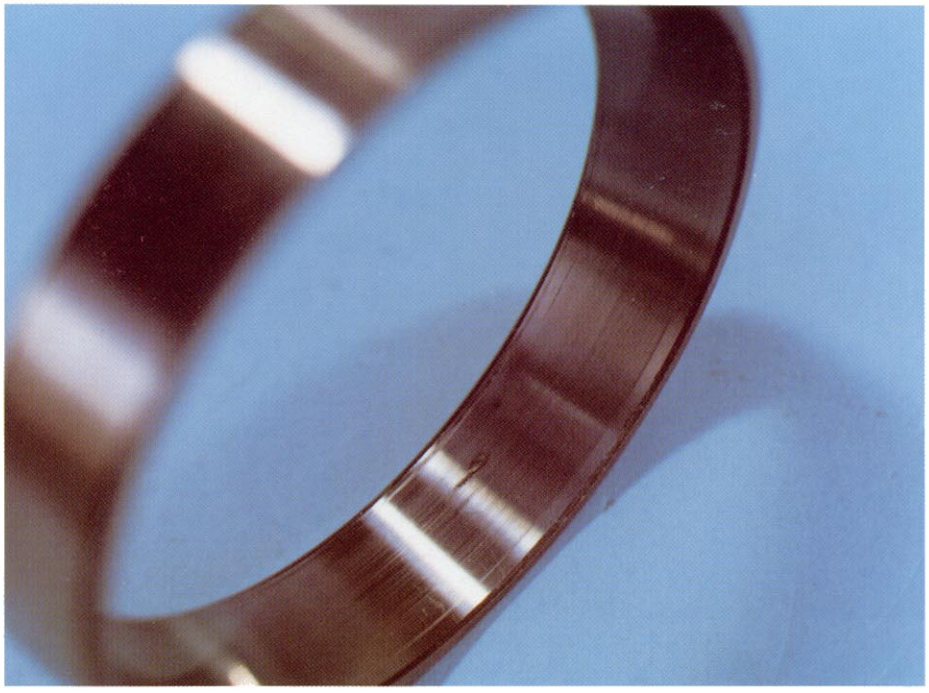
Category: Shaft A
Bearing C

Condition: *No wear in splines
*Deep scratch in bearing cage
★ The bearing can not be reused because there is a possibility that the cage will break.

Cause: The deep scratch in the bearing was caused by fragments resulting from breakage of internal parts.

Bearing outerrace

3



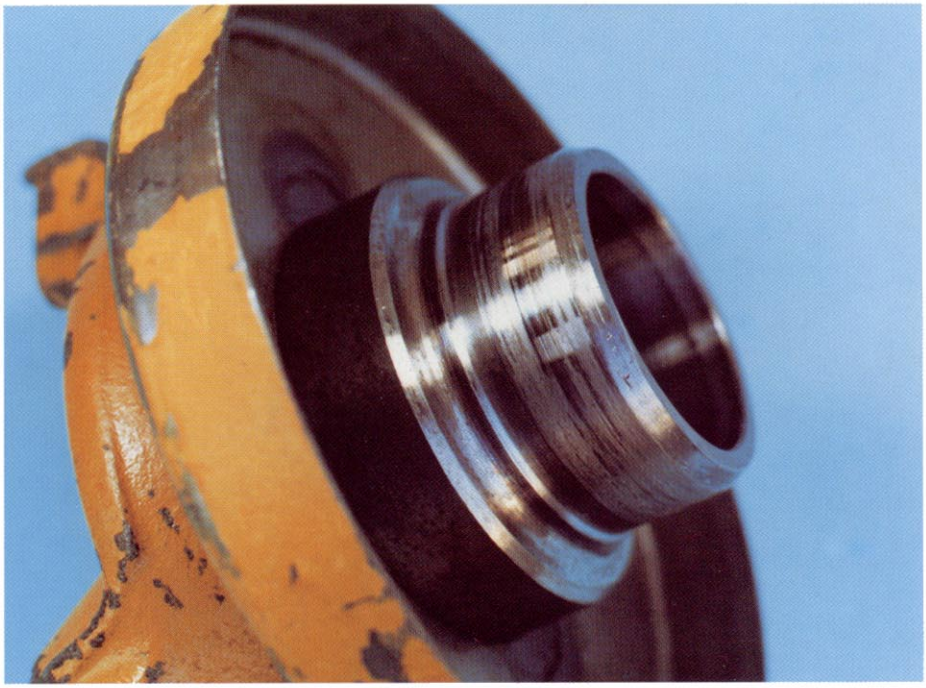
Category: C
For details about judgement of the bearings, see the Guidance for reusable parts on bearings.

Condition: Marked scuffing in the bearing race

Cause: Fragments got caught

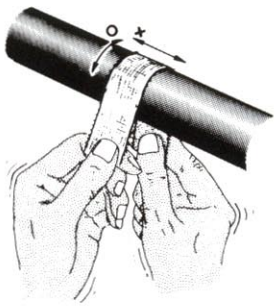
Coupling : Oil seal contact face

4



Category: C
After correcting the plating, if the accuracy of the dimensions can be maintained, rank it in Category B.

Condition: Numerous scuffing marks on overall oil seal contact surface.

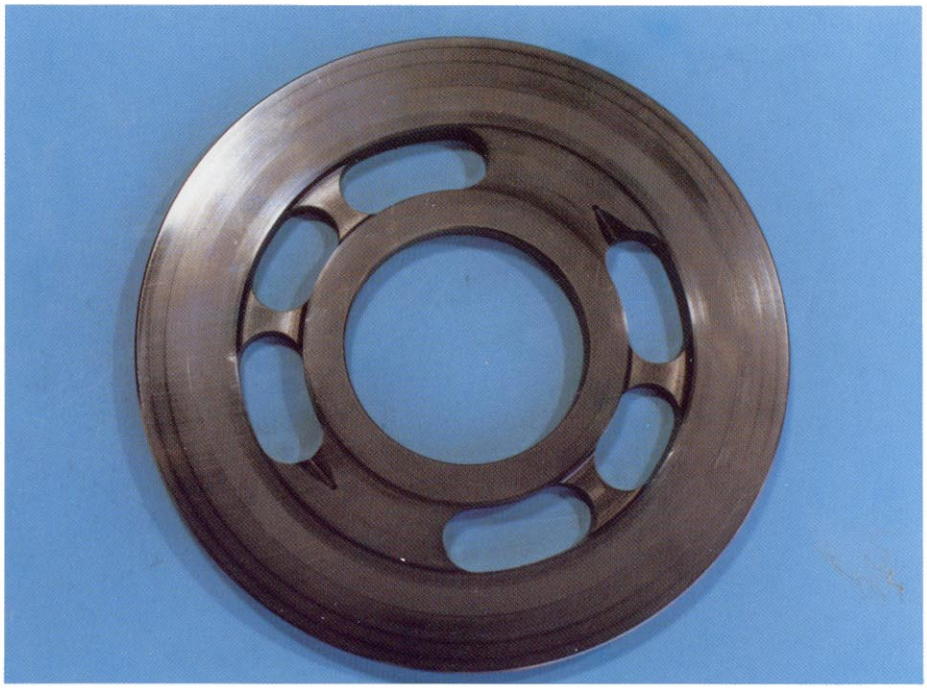


★ Correcting the oil seal contact surface

To correct the oil seal contact surface, polish the coupling with #240 sandpaper while rotating it on a lathe. During this time, keep the radial runout of the coupling to a minimum and do not move the sandpaper in the axial direction.
If the sandpaper is moved in the axial direction, oil may ooze out from the small grooves cut by the sandpaper, thus destroying the oil sealing function.
If there is rust or damage which can not be corrected with sandpaper, exchange the part or use a grinder and correct the hard chrome plating to a grinding allowance of 0.05 ~ 0.1 mm.

Valve plate : Sliding surface

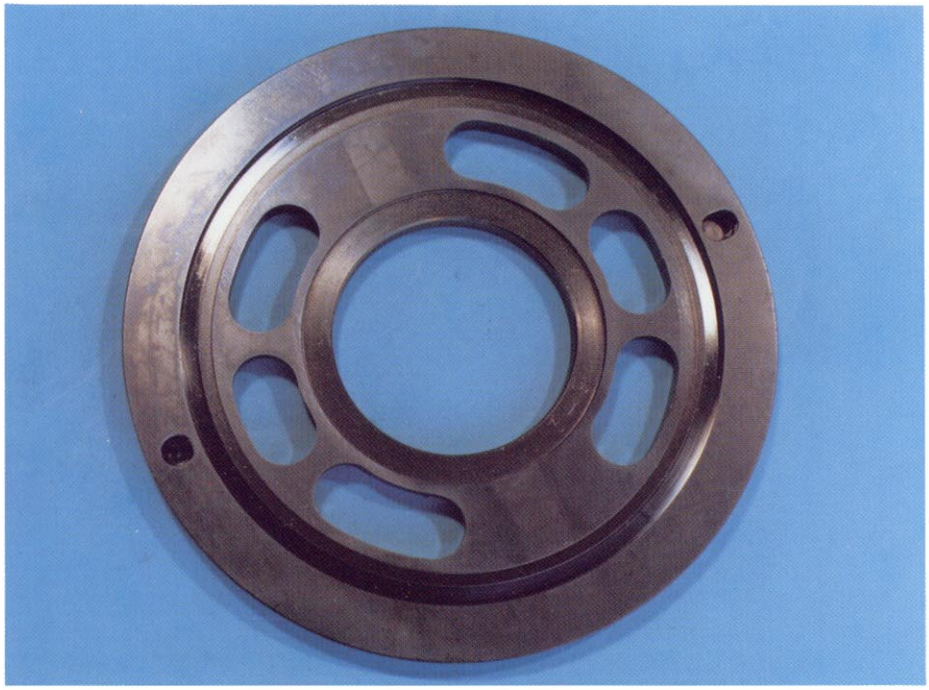
5



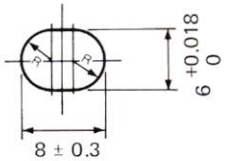
Category: A

Condition: There are small dents and scuff marks in the central and left hand side of the sliding surface, but the surface is smooth, the fingernail does not get caught on scratches, and the fit is good.

Cause: The dents were caused by carelessness in handling parts. Everything else is normal.

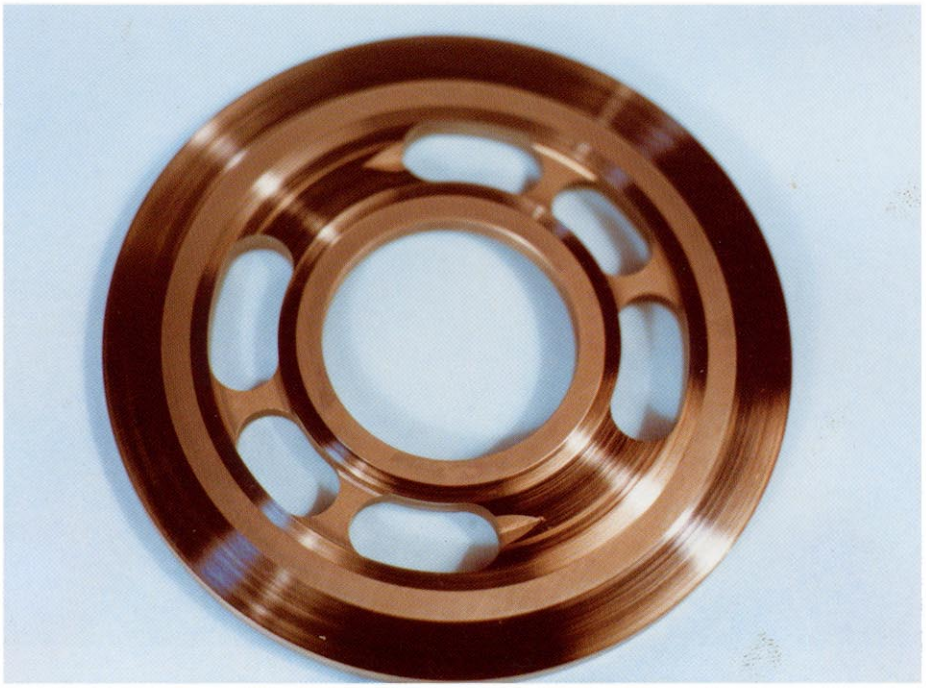


Reference: Shows the fixing surface on the case side of the valve plate. In good condition because there are no wrinkles in the knock holes and no traces of entry of foreign matter.



The R.H. knock holes are oblong.

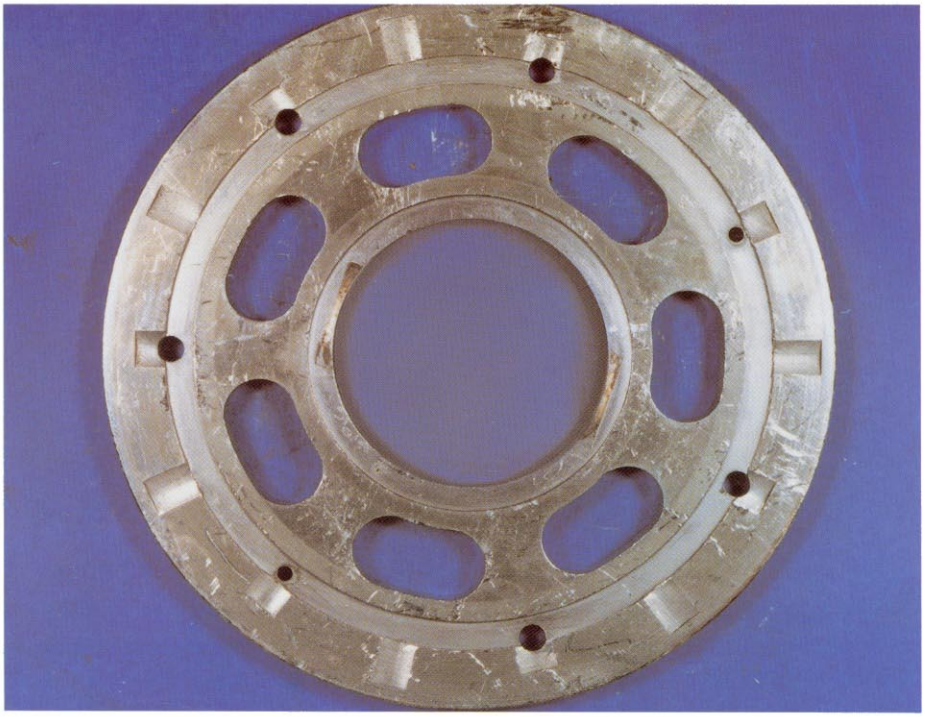
6



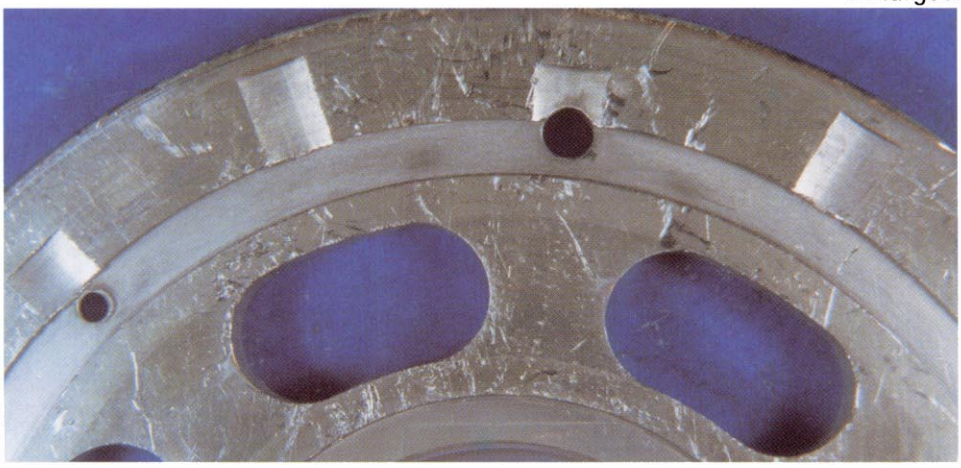
Category: B
Condition: The sliding surface has slight wear in which the fingernail catches on the 'record grooves,' but the wear condition is normal since there is no seizure or scuffing.
Cause: The scratches in the 'record grooves' are caused by contamination with oil from wear powder.
Remedy: Can be corrected with surface lapping.

Bearing plate : Sliding surface

7



Enlarged



Category: B

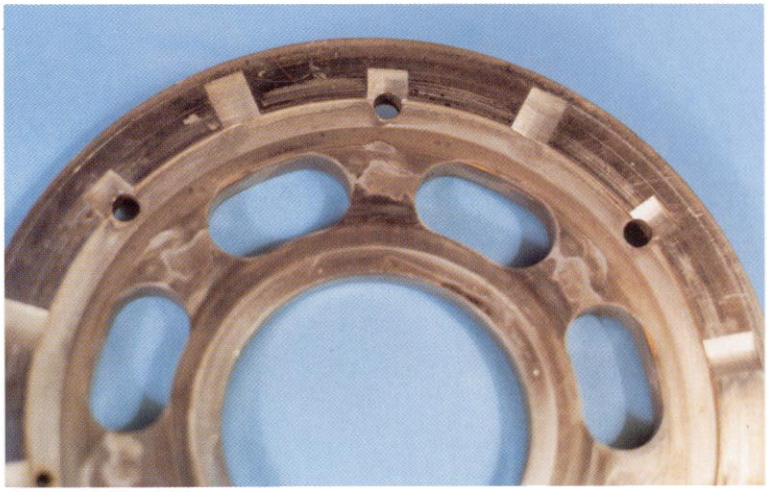
Condition: There are only a few scratches between and around the valve ports of the sliding surface but, as shown in the enlarged photograph, there are local dents and scuff marks on the outer side.

Cause: A secondary symptom in which fragments or particles from the hydraulic equipment flow into the pump and get caught between the plates.

Remedy: Can be corrected with surface lapping. The plating thickness on new parts is 5 microns, so it is not possible to remove a large amount by lapping. It is OK if a few dent marks remain. Ensure flatness against the surface.

8

Enlarged



Category: A

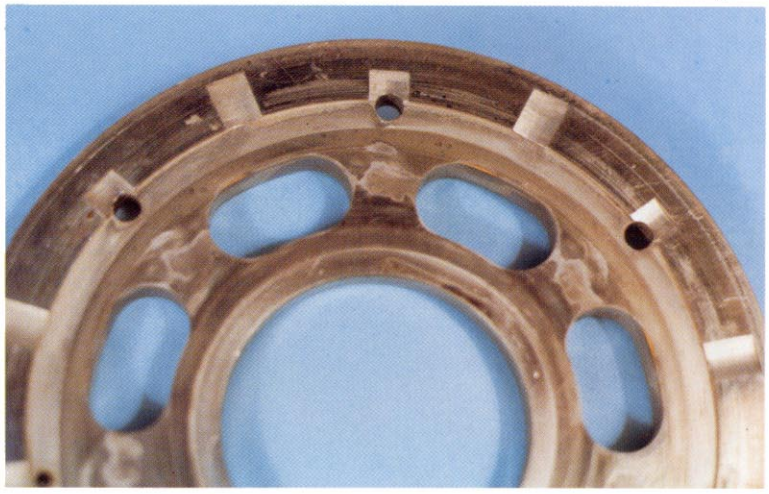
Condition: The plating between the ports has become thin in places. In some cases, the places where the plating has become thin may extend to the whole area between the ports, and the ports may be joined.

Cause: The cause of the plating becoming thin between ports is that hydraulic oil flows at high speed from the high pressure port to the low pressure port. There is no problem with the function.
(The plating on the sliding surface is to provide initial settling after assembly. Even if the plating becomes thin after the initial period of operation, it can be used again as it is.)

Note: The fixing surface and mating surface are in good condition as there is no sign of wrinkles in the knock holes or entry of foreign matter.

8 - 1

Enlarged



Category: B

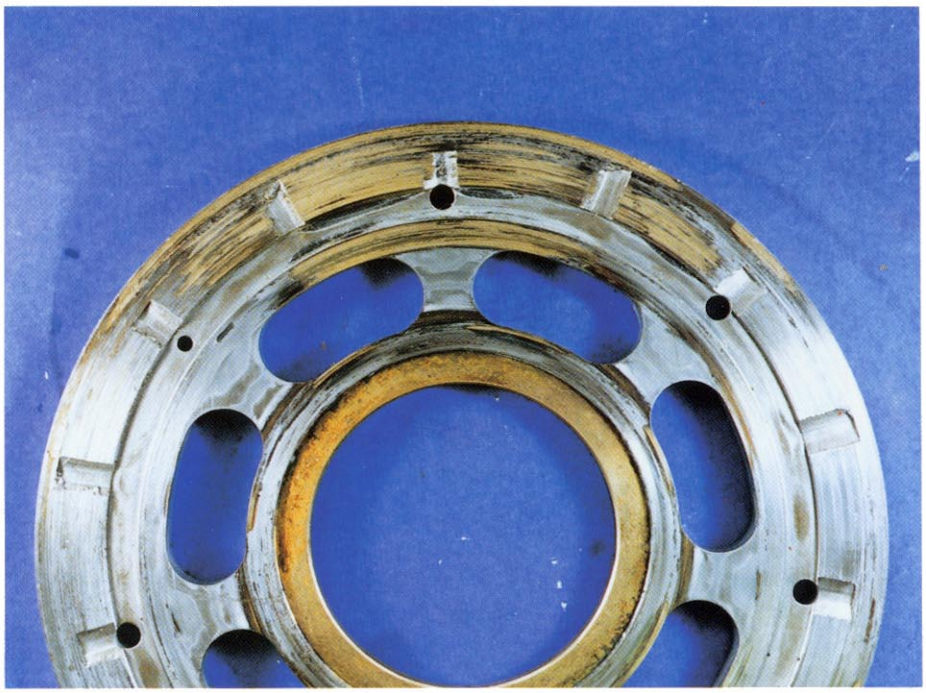
Condition: There are very fine scratches (too small to catch the fingernail) and discoloration (temper color) on the sliding surface.

Cause: Fine scratches or discoloration caused by temper color occur because of loss of the film of lubricating oil.

Repair: Repair is posible by surface lapping. However, the thickness of the lapping is only 5 microns, even for new parts, so after lapping extremely lightly with chromium oxide, finish with a piece of paper soaked in oil. (Do not use ordinary lapping power under any circumstances.)
After lapping, fine scratches can be left. Before using check the surface contact.

Note: The fixing surface and mating surface are in good condition as there is no sign of wrinkles in the knock holes or entry of foreign matter.

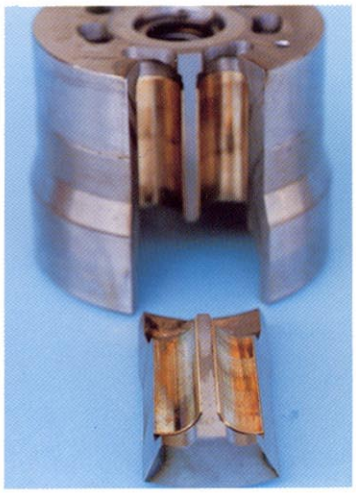
8 - 2



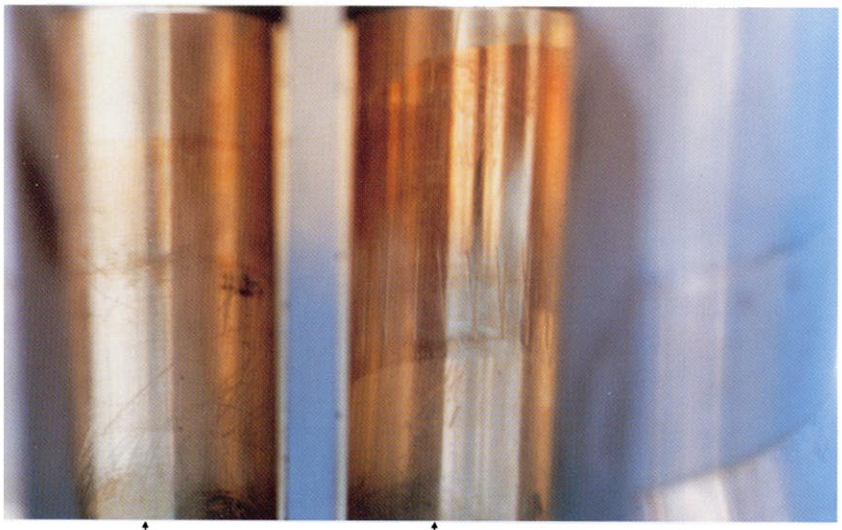
Category: C
Condition: The copper alloy of the bearing plate itself can be seen. Adhesion of metal has occurred, and tearing caused by relative movement can also be seen.
([Reference] The plating is gray, and the copper alloy for the body is yellow)
Cause: Lack of lubricating oil and abnormal external pressure on the cylinder barrel installed to this bearing plate has caused contact of metal between the sliding surfaces, resulting in abnormal heat and adhesion wear.

Cylinder barrel : Inside wall

9



Enlargement of inside of barrel

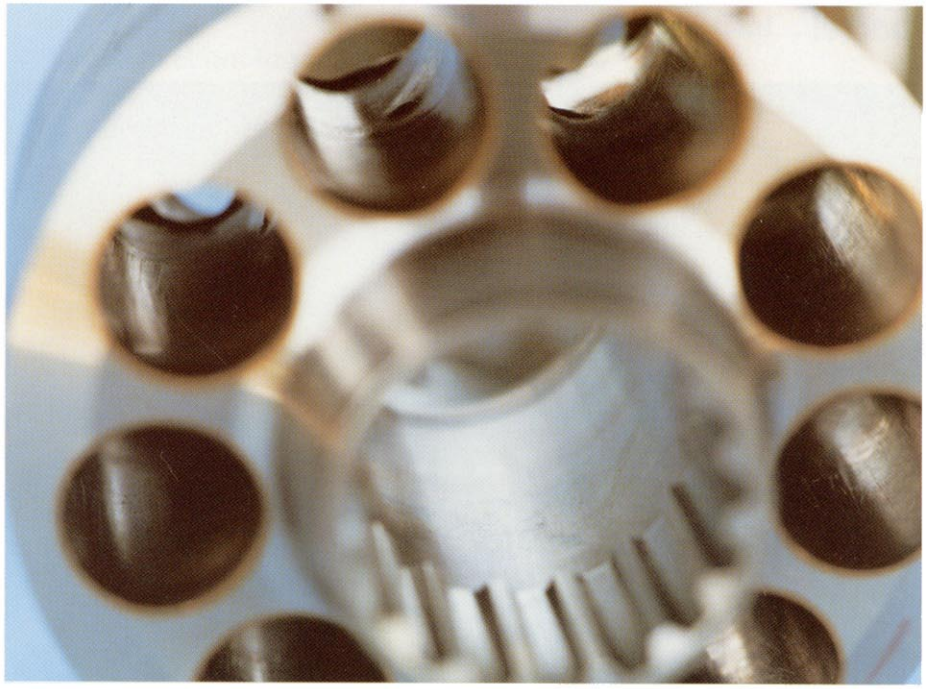


Category: A (L.H. wall)
Condition: There are extremely fine scratches on the lower side of the L.H. wall, indicating the early stage of wear. * No need for repair.
Category: B (R.H. wall)
Condition: Shallow vertical scratches have developed at the central portion of the R.H. wall and strong contact is evident at the top half, but this is normal.
* To correct, remove the burrs of the scratched portion by rubbing gently with #400 ~ 600 sandpaper.

Enlargement of inside of barrel

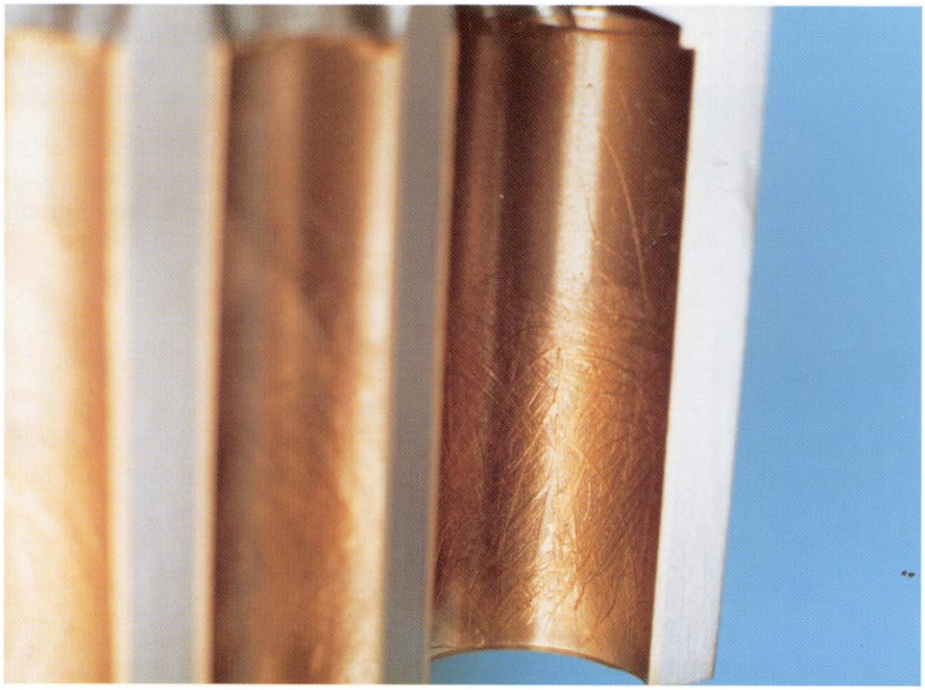
Category: C
Condition: Deep scratches and scuffs have developed along the whole wall.
Cause: Biting of fragmented particles.

10



Category: C
Condition: Extreme erosion has occurred along with scratches on the inner wall.
Cause: The erosion was caused by cavitation which occurred due to air in the oil.

11

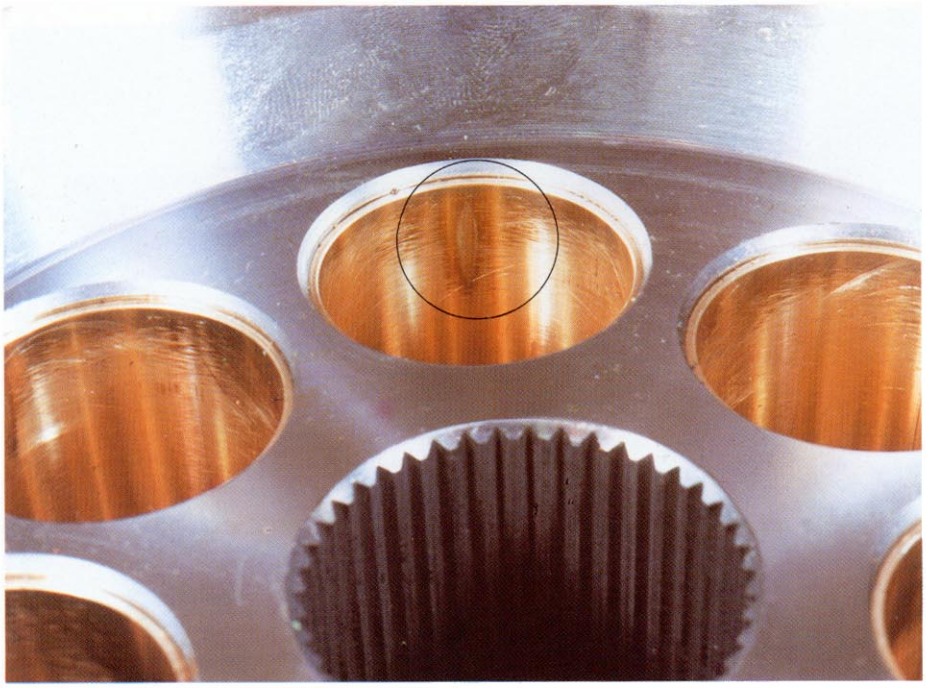


Category: C
Condition: Marked scuffing in many places from the central portion to the skirt of the inside wall.
Cause: Broken particles from the hydraulic equipment have entered the pump.

12

Category: C
Condition: Marked scuffing extending to the skirt and a large number of granular marks at the top portion.
Cause: Broken particles getting caught

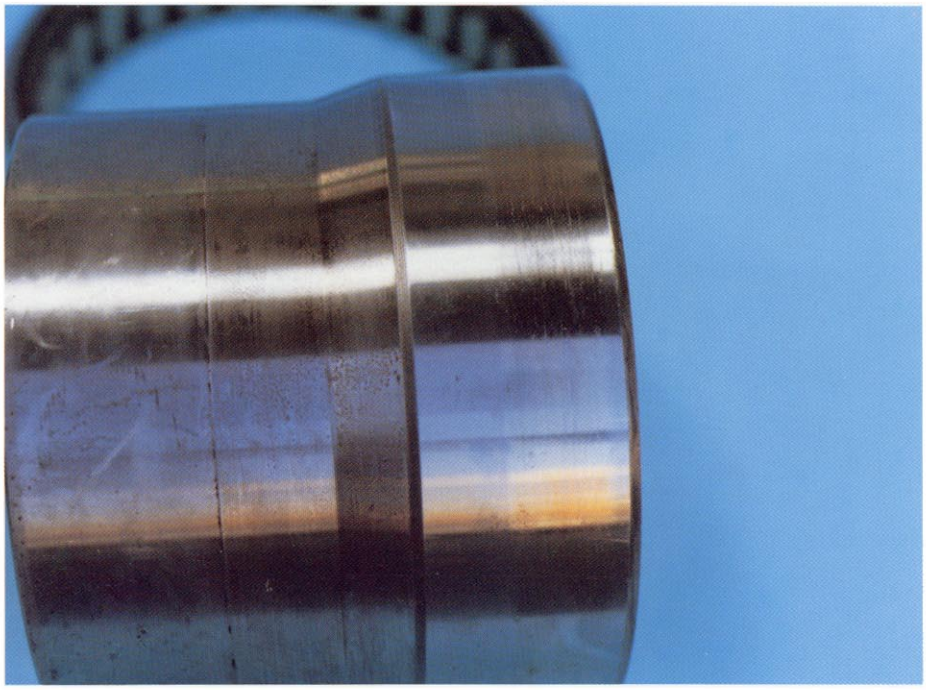
12 - 1



Category: C
Condition: Heat spot near opening of the cylinder bore.
Cause: Lack of lubrication/Excessive heat.

: Rolling surface of bearing roller

13



Category: A
Condition: Slight scratches on the rolling surface, but no dents, indentations, or pitting
Cause: Contamination with oil, wear particles getting caught

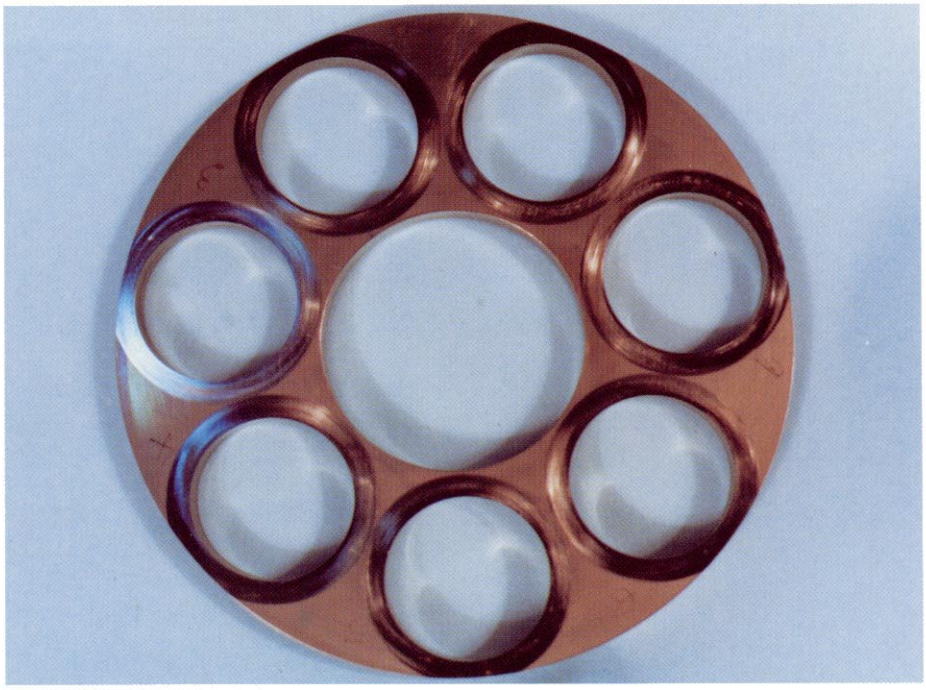
Reference: Roller bearing which matches the cylinder barrel

Note: (Good condition with no creeping, pitting, smearing, or scratches.)

★ For details regarding judgement of the cylinder barrel and the bearing, see the Guidance for Reusable Parts on bearings.

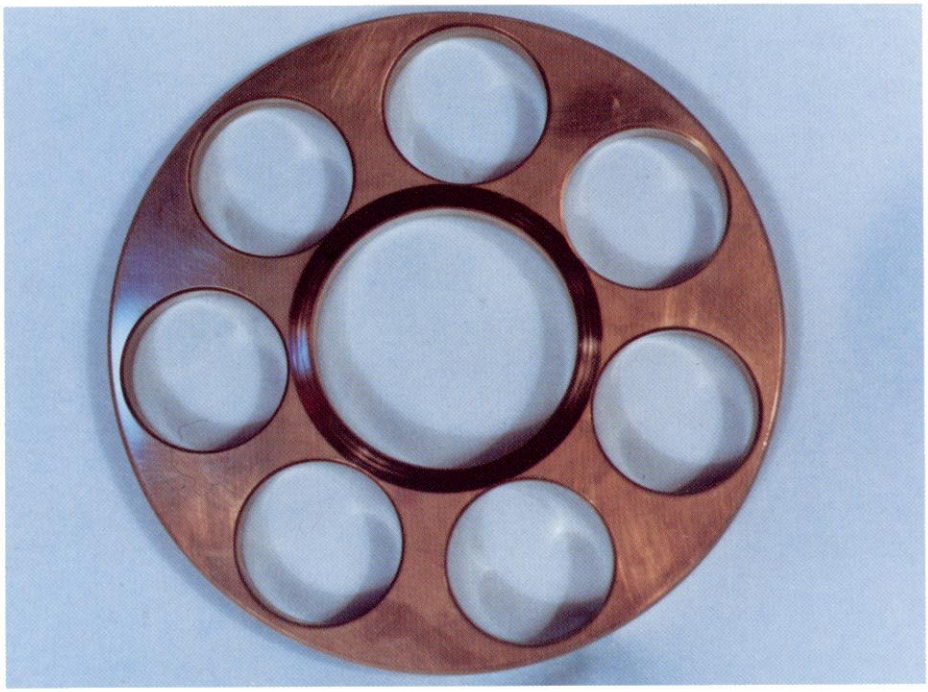
Shoe retainer : Periphery of holes

14

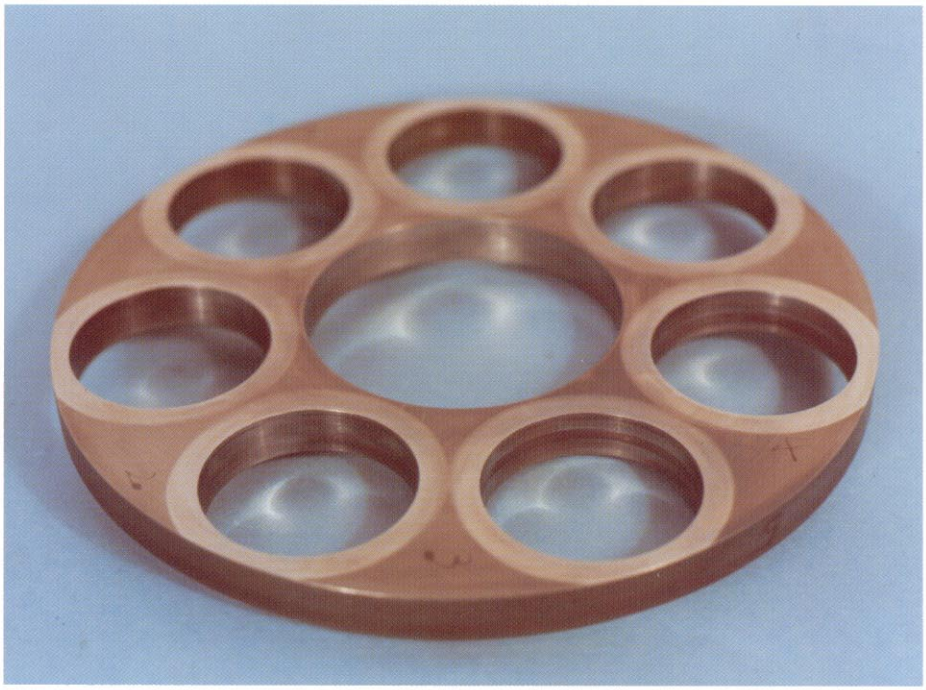


Category: A
Condition: The mating of the sliding surface with piston flanged portion is normal;good condition with no scuff marks or cracks.
Cause: Normal

Reference: Back side of shoe retainer shown below.

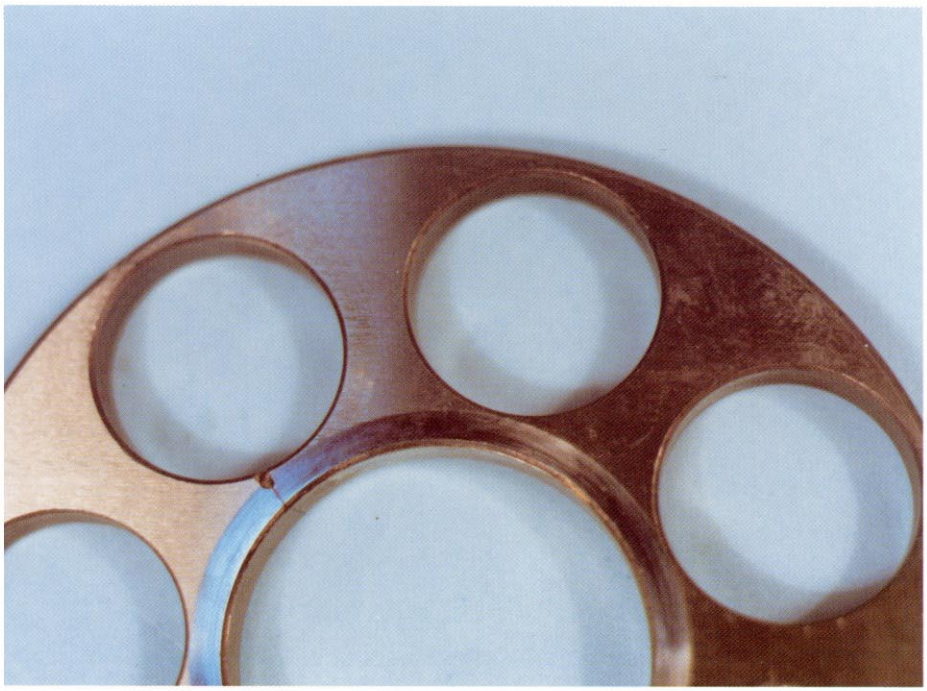


15



Category: A
Condition: Cood condition with no scuff marks or cracks on the mating surfaces of the piston shoe guide holes
Cause: Normal

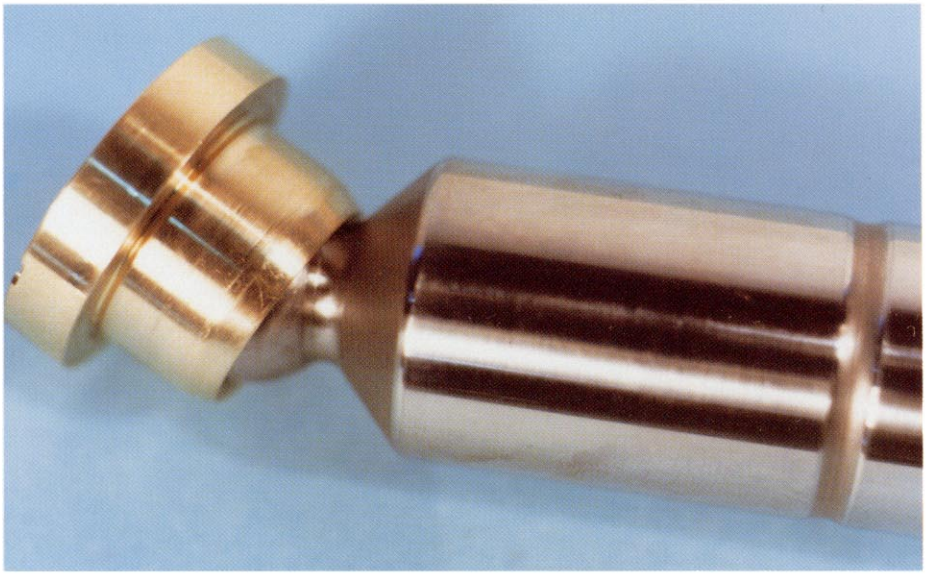
16



Category: C
Condition: Cracks
Cause: Breakage inside the pump

Piston sub-assembly : Sliding surface, and flanged portion

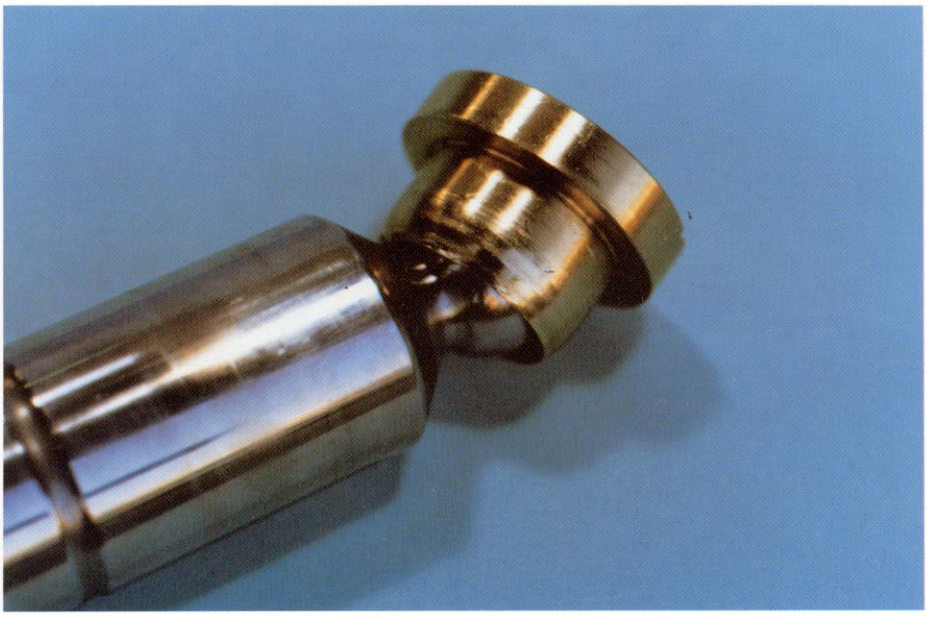
17



Category: A
Condition: Good condition with no scratches, seizure, or scuffing and contact surface is like a mirror.
The retainer contact surface of the shoe portion is also in good condition with no wear or scratches
Cause: Normal

: Sliding surface and caulked part of ball

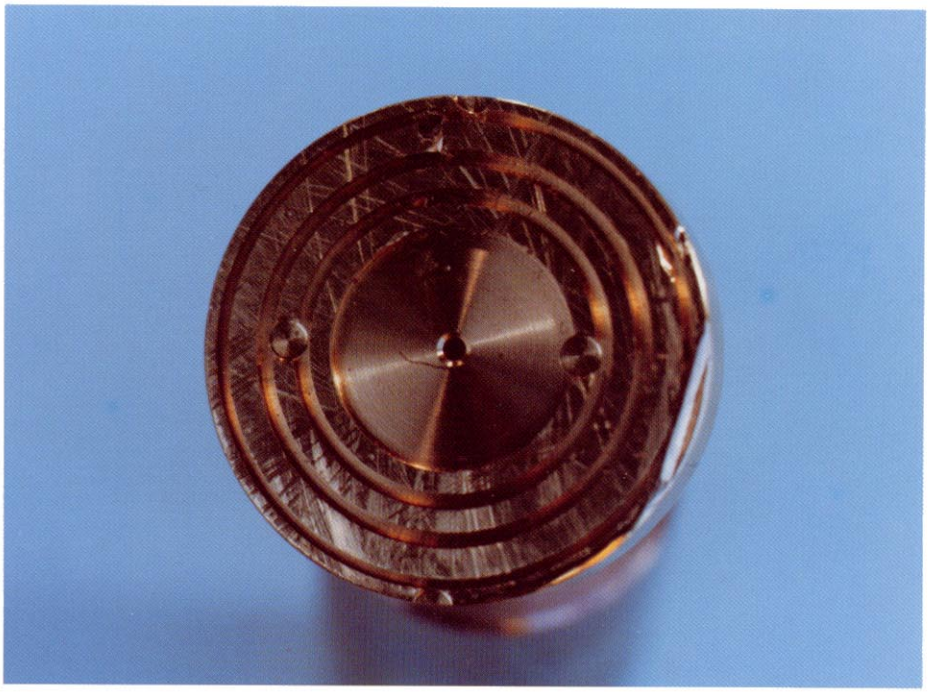
18



Category: B
Condition: Slight scratches which catch the fingernail on R.H. half of sliding surface
Light dent marks are on the tip of the caulked part of the ball.
Cause: Scratches on sliding surface are caused by broken particles getting caught; dents in caulked part are caused by broken particles.
Remedy: ★ Remove the protrusions with an oilstone, polish with #400 ~ 600 sandpaper, then finish the whole surface with chromium oxide.
Even if there are dents in the caulked portion of the ball, it can still be used if ball part moves smoothly and if elongation has not occurred in the caulking.

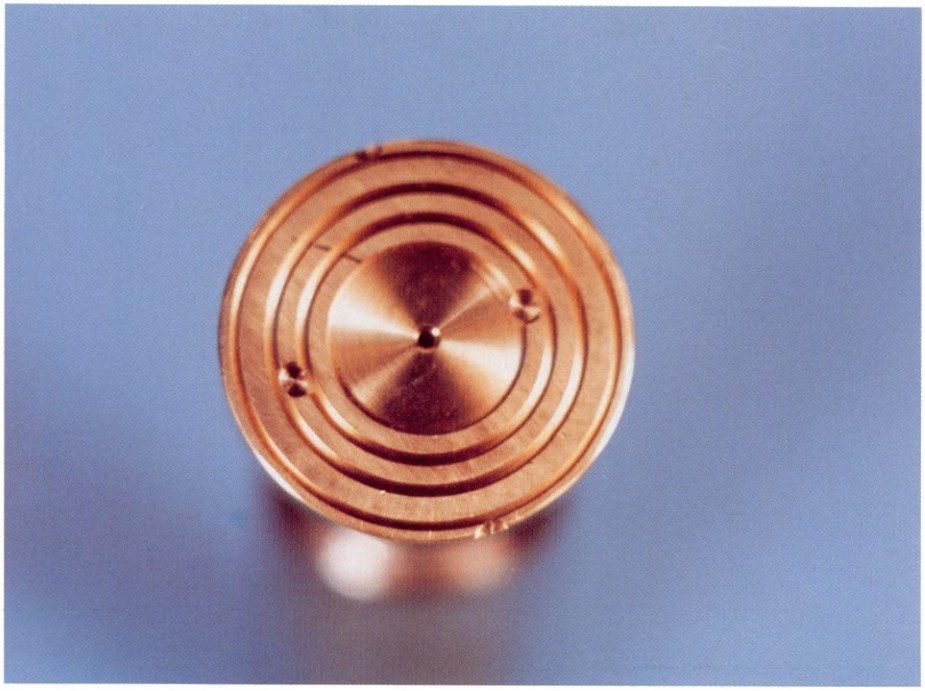
: **Sliding surface of piston shoe thrust plate**

19



Category: C
Condition: A broken particle is imbedded in the sliding surface at the upper part of the photograph and a dent has formed at the R.H. side, blocking the oil groove. In addition, there are numerous scratches in the radial direction which catch the fingernail.
Cause: The dent at the edge occurred because the shoe lost its stability and tilted because of breakage of the shoe retainer. The scratches were caused by broken particles getting caught and imbedded.

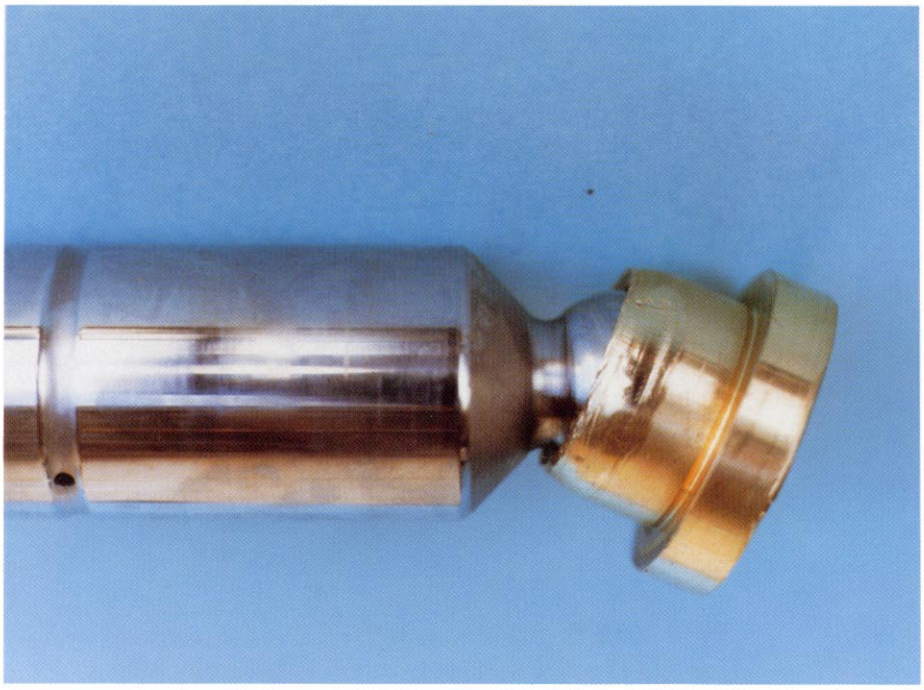
20



Category: A
Condition: The sliding surface is in good condition without signs of wear and with no dents, indentations, or scuffing.
Cause: Normal

: **Caulked part of ball**

21

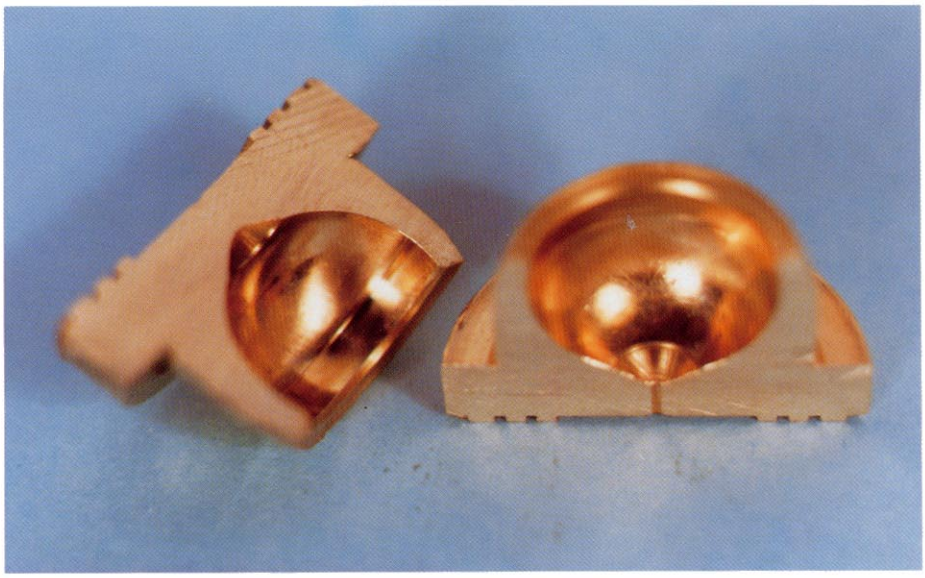


Category: C

Condition: There are marked dents and scratches on the caulked part.
*The piston sliding surface and shoe retainer hole contact surface are in good condition.

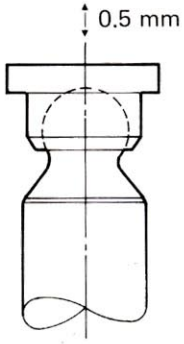
Cause: The dents were caused by indentations and scratches resulting from broken particles caused by breakage of the shoe retainer.

22



Reference:

An actual shoe in which an elongation (wear) with play of about 0.5 mm (limit: 0.2 mm) in the direction of tension in the caulked portion has been cut to provide a photograph for reference.



Piston subassembly

Category: C
If the play of the caulked part of the shoe is more than 0.2 mm, the judgement for the piston subassembly is Category C.

Category: B
If the play of the caulked part of the shoe is less than the limit of 0.2 mm, the judgement for the piston subassembly is Category B.

Condition: The inside wall of the shoe's ball has slight scratches, but nothing abnormal.
- The ball surface on the piston side is also free of scratches and in good condition.
- There are light scratches and belt-shaped stains on the sliding surface of the piston, but no seizure or scuffing.

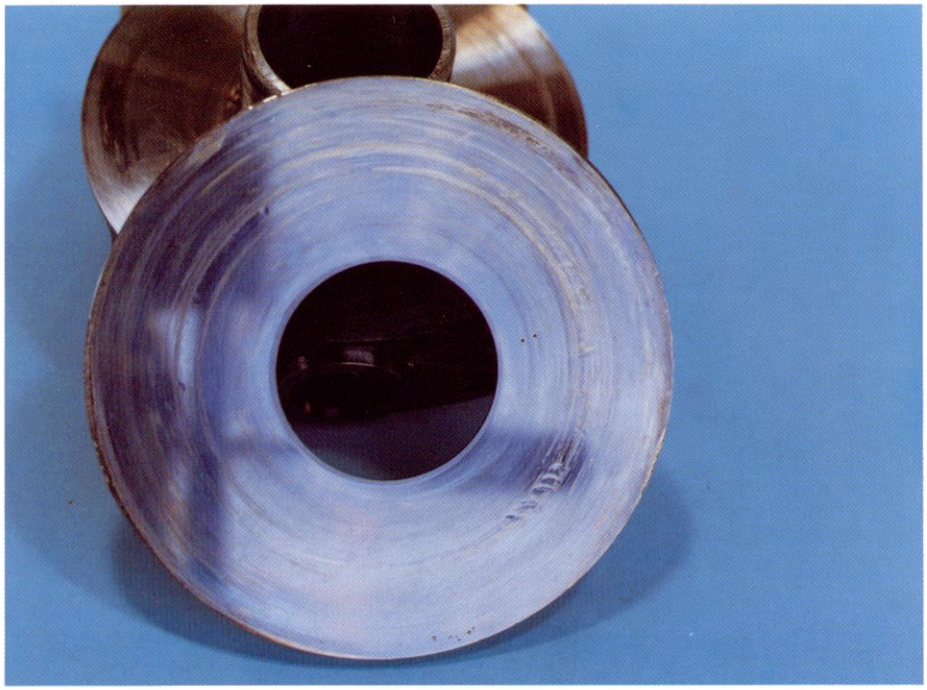
Cause: The cause of play in the caulked part is elongation of the caulked part accompanying an abnormality inside the pump. Otherwise, it can be regarded as normal wear if there is no particular abnormality on the piston sliding surface.

Thrust plate : Piston shoe sliding surface

23

Category: B
Condition: There are scratches in the 'record grooves' of the sliding surface.
*Can be corrected by surface lapping.
Cause: Oil contamination

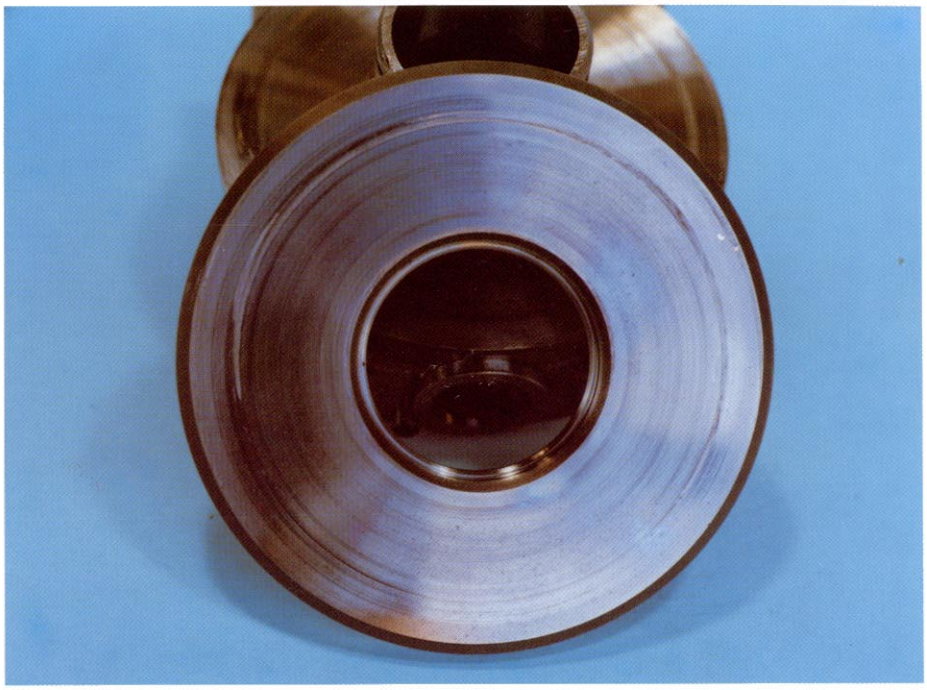
24



Category: C
Condition: There is an excessive amount of deposits of shoe material and deep dents on the sliding surface. Outside of the deposits and dents there are scratches which slightly catch the fingernail.
Cause: Fragmented granules caused by trouble in some other hydraulic equipment flowed into the pump and plugged up the piston lubricating holes, thus leading to a lack of lubrication at the sliding portion. It can be assumed that dents have occurred on the piston ball at the same time as a result of peeling of the caulked part of the shoe.

: **Installation surface with rocker cam**

25



Category: B

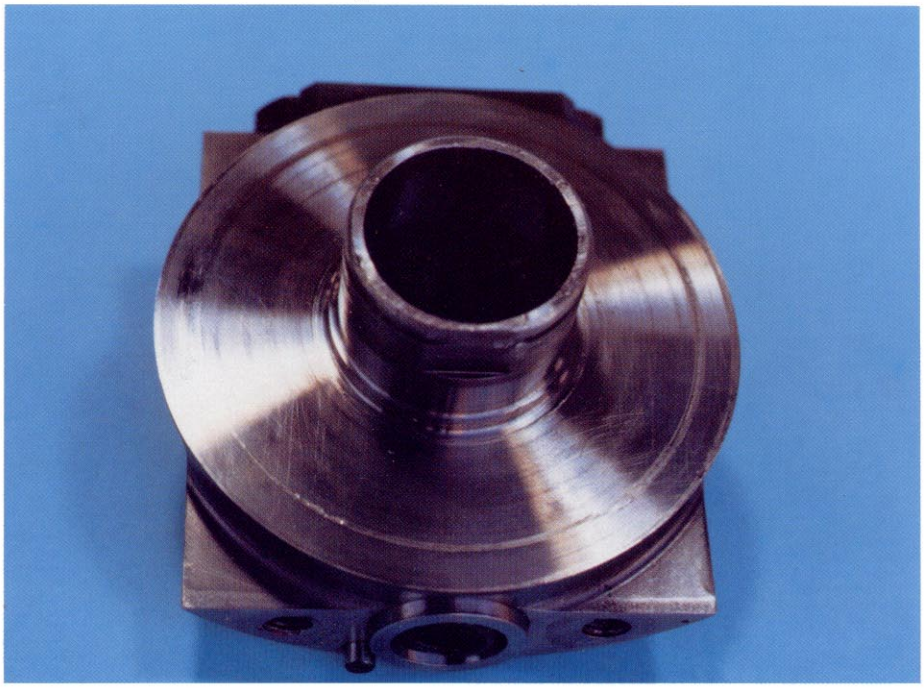
Condition: There are pit-shaped scuff marks which feel scratchy to the fingertips on the surface which mates to the rocker cam side, but the other places are smooth and no gaps occur on the mating surface.

Cause: Along with the lack of lubrication on the sliding surface described above, scuff marks occur because of drag turning.

Remedy:
1. To repair the sliding surface, carry out surface lapping to the extent that scratches can be removed.
2. If the rocker cam mating surface fits completly snugly against the mating part, it is OK even if small pit-scratches remain. Correct any local protrusions with a smooth oilstone, then carry out lapping.

Rocker cam : Thrust plate installation surface

26



Category: B

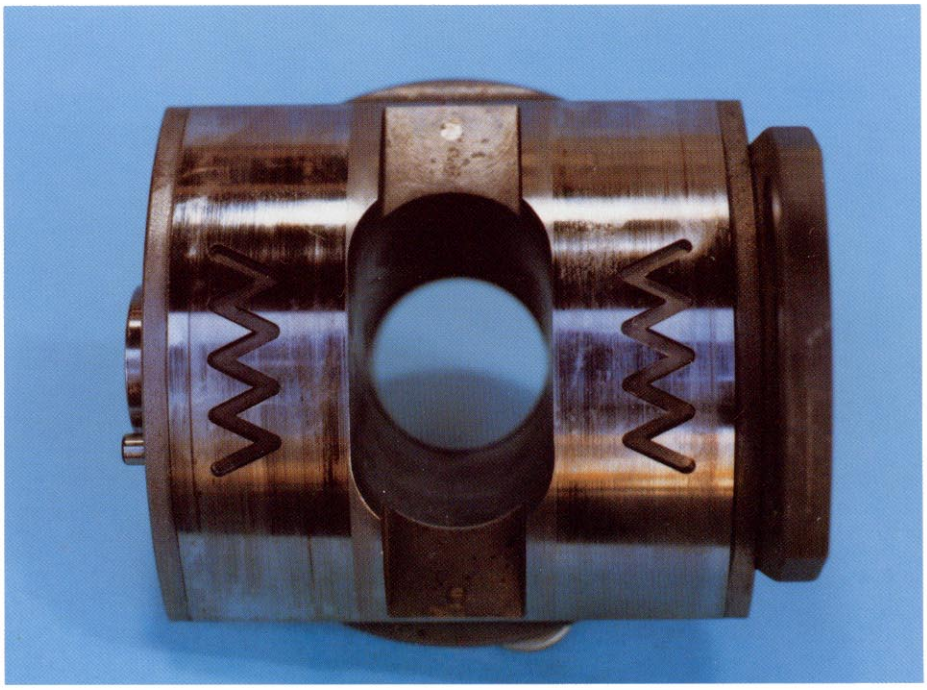
Condition: Similarly to the thrust plate shown on the previous page, there are pit-shaped scuff marks which feel scratchy to the fingertips on the mating surface with the thrust plate installation surface, but areas which are outside the scuff marks are smooth and there are no gaps in the mating surface.

Cause: Drag turning of the thrust plate as a result of breakage inside the pump.

Remedy: If there are protrusions on the scratches, smooth the local area gently with an oilstone. If it is confirmed that the thrust plate fits snugly, it can be used again. It is OK if small pit-scratches remain.

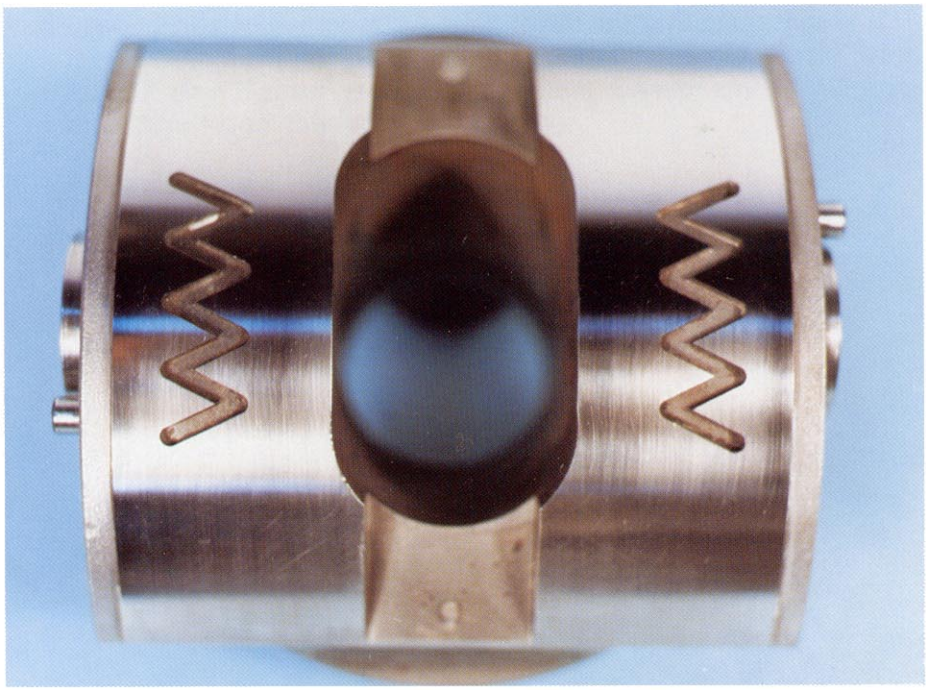
: Cylinder sliding surface

27



Category: B
Condition: There are scratches on the sliding surface which feel rough to the fingernail, but there is no seizure, scuffing, or deep scratches. The overall mating surface is bright and in good condition.
Cause: Deteriorated oil
*To correct the scratches, lap together with the cradle.

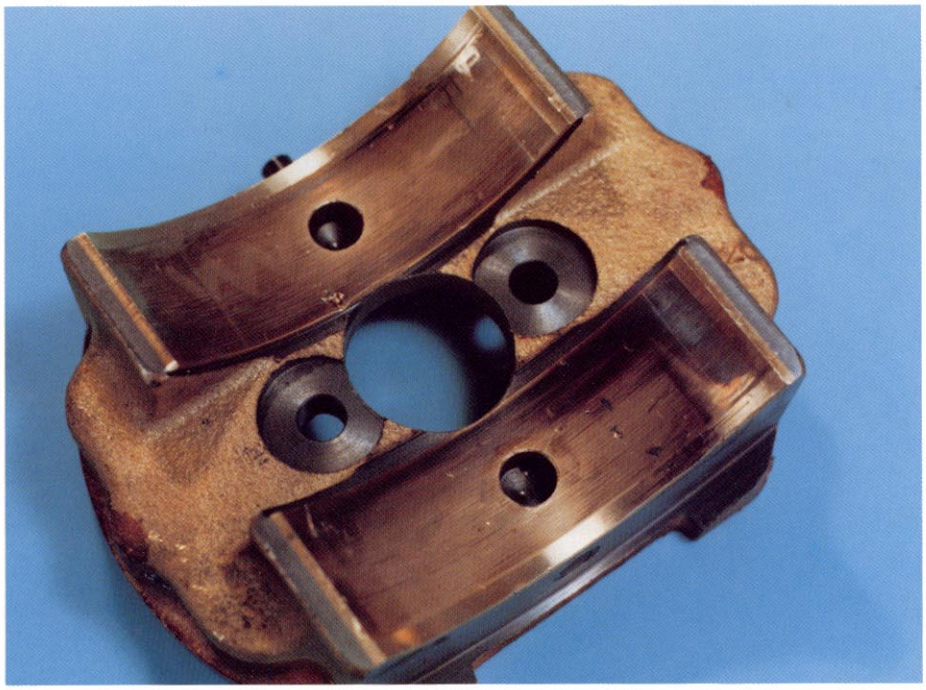
Reference



Note: This photograph shows the condition of the above part after it has been corrected lapping together with the cradle. The scratches have been removed and the contact surface is smoother so the overall surface makes contact.

Cradle : Rocker cam sliding surface

28

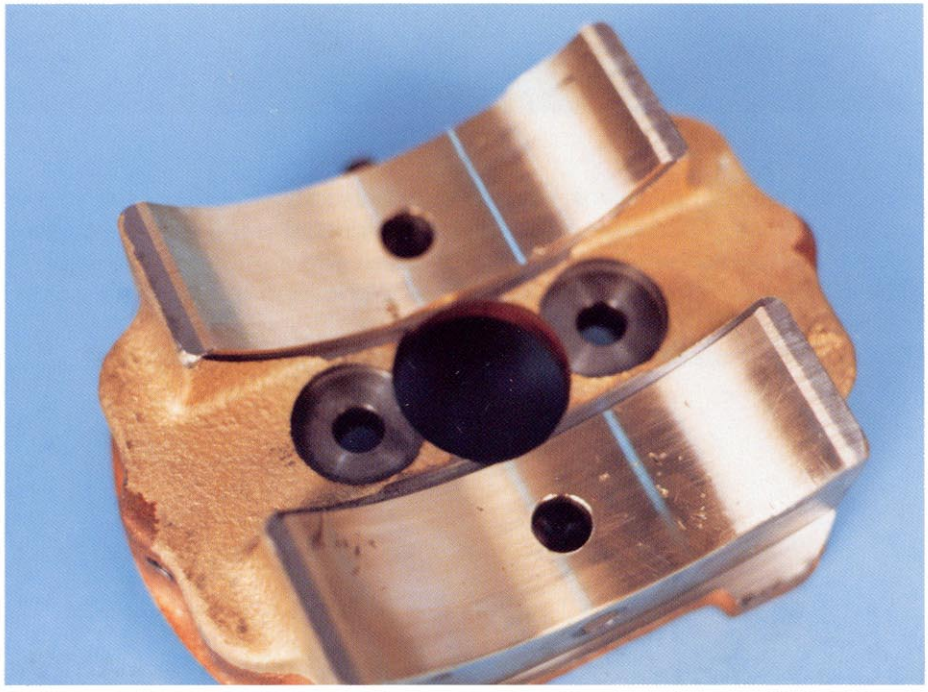


Category: B

Condition: At several places on the sliding surface there are traces of fragments getting caught and imbedded marks. On the outer side there are what appear to be newly formed belt-shaped cuts. There are also indications of eccentric wear and traces of oil burns.

Cause: A guide pin for the plate of the rocker cam broke because of an eccentric load resulting from breakage inside the pump, so the rocker cam lost its stability.

Reference



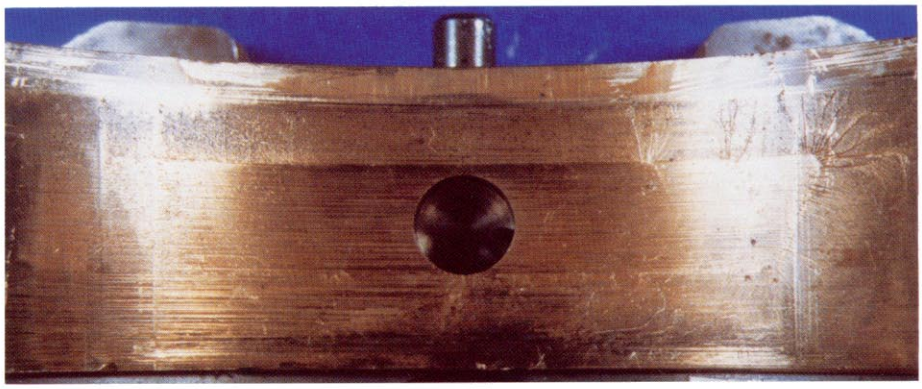
Note: This photograph shows the cradle after it has been corrected by lapping together with the rocker cam. There are several small dents on the sliding surface, but the lubricating oil is still sealed tight, so the cradle can be used again. The entire mating surface makes contact and is in good condition.

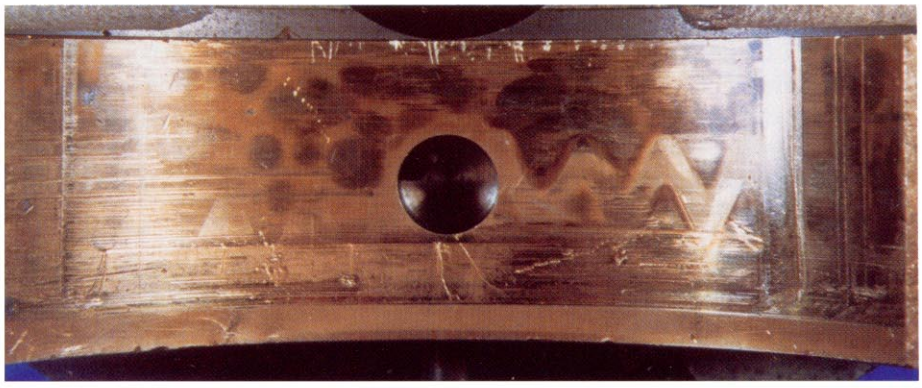
Remedy:

- To correct the contact, remove the imbedded marks, join the rocker cam to the sliding surface of the cradle, correct the contact surface with a scraper while checking the parallelism, then finish by lapping the rocker cam together with the cradle.
- If there is a minor defect in contact, it is possible to finish by lapping only.

: Rocker cam sliding surface (enlarged)

29





Category: C

Condition: There are signs of oil burns, strong dents caused by the tip of the rocker cam, and adhering traces. Granular scratches have occurred along the side surface at the top of the photograph, and scratches have developed along with the wear.

Cause: The oil film was broken because of poor lubrication or else there was biting of broken particles.

Remedy: Based on the condition of the wear and dents, repair is possible.

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