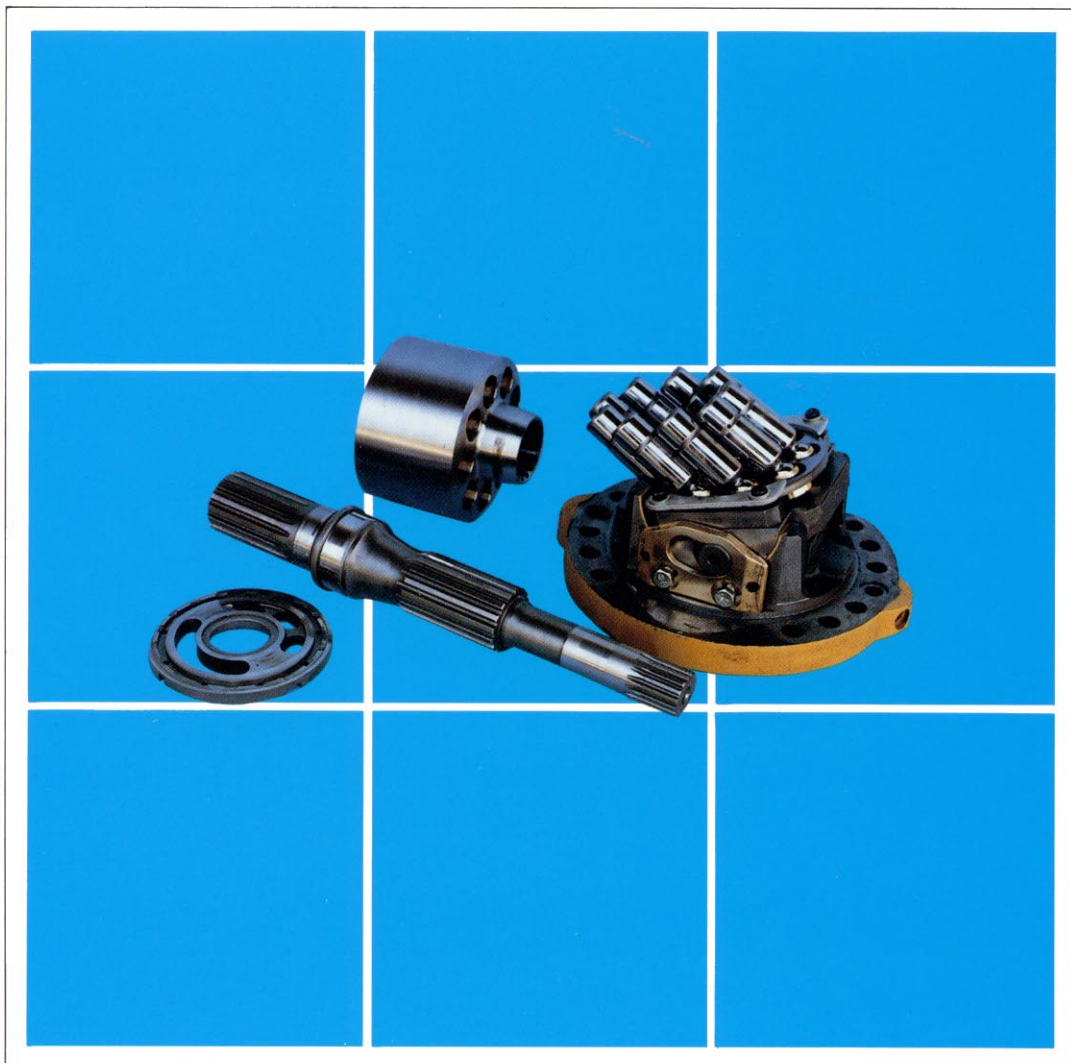


SHOP MANUAL



GUIDANCE FOR REUSABLE PARTS

SWASH PLATE TYPE PISTON PUMPS



KOMATSU

GUIDANCE FOR REUSABLE PARTS
KOMATSU

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INTRODUCTION

This Guidance for Reusable Parts provides basic knowledge and explanation of the causes of damage needed when disassembling, assembling or repairing swash plate type piston pumps.

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 piston pumps. 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.

Note: This publication is intended for guidance only and KOMATSU LTD. hereby expressly denies and excludes any representation, warranty or implied warranty for the reuse of piston pumps.

TYPE OF HYDRAULIC PUMPS

Hydraulic pump	Rotating type	Gear pump Vane pump Screw pump
	Double acting type	Axial piston pump (bent axis type, swash plate type) Radial piston pump Reciprocating piston pump

- ★ Hydraulic pumps are categorized according to their form into fixed displacement pumps and variable displacement

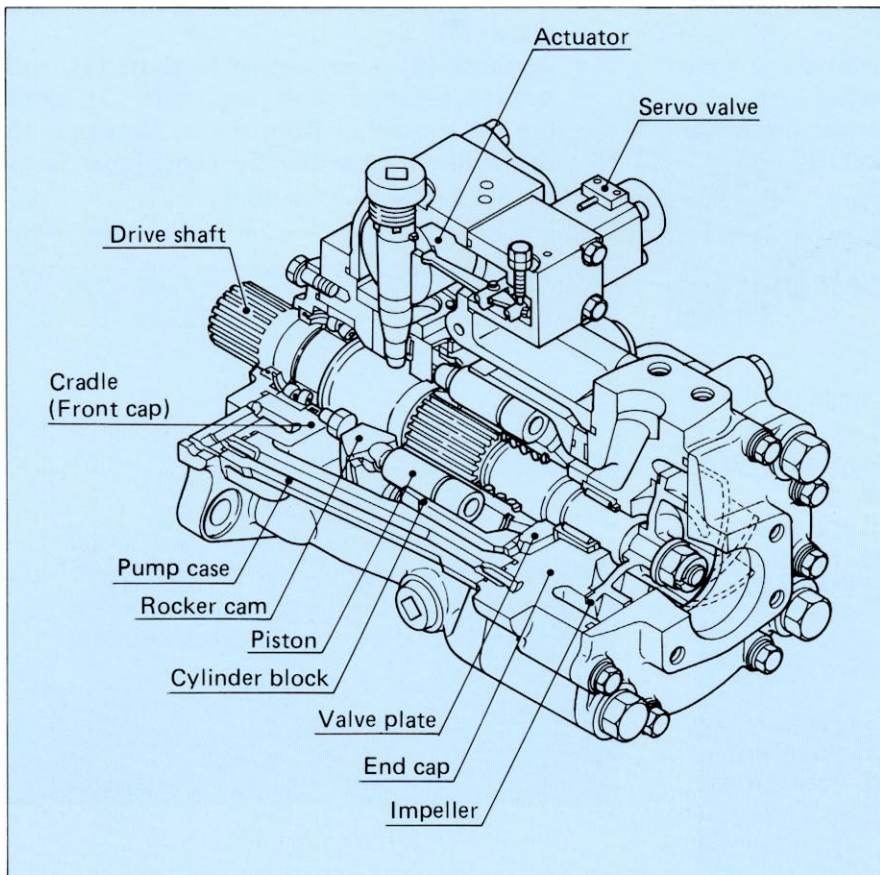
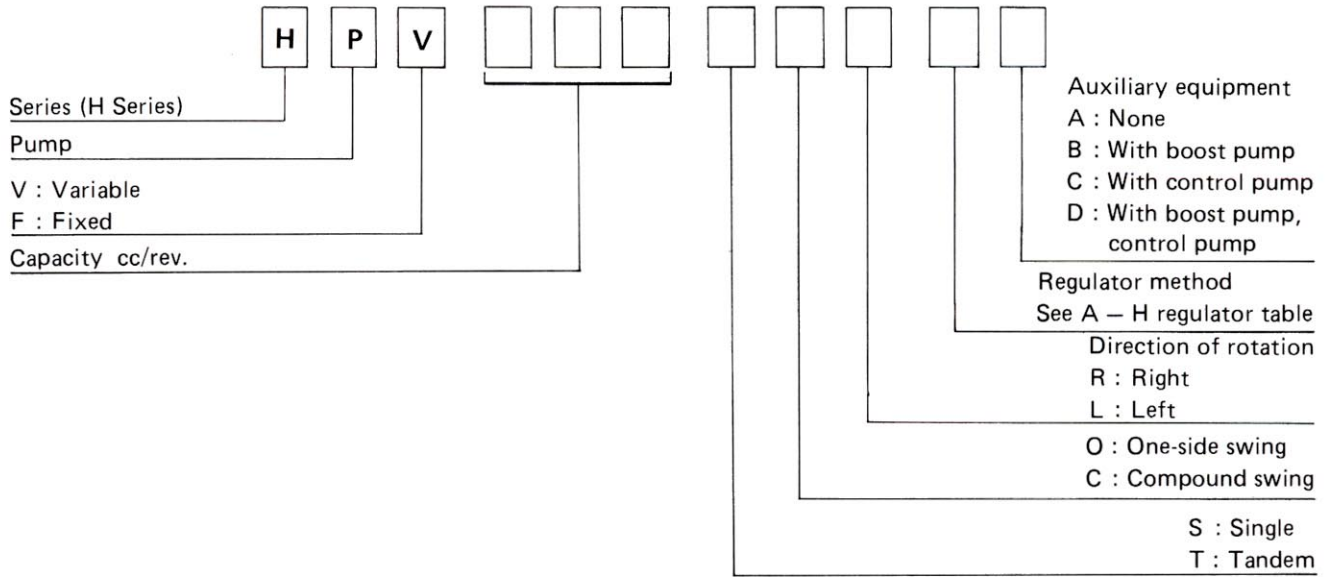
Specifications of hydraulic pumps

The main specifications used to describe hydraulic pumps are as follows.

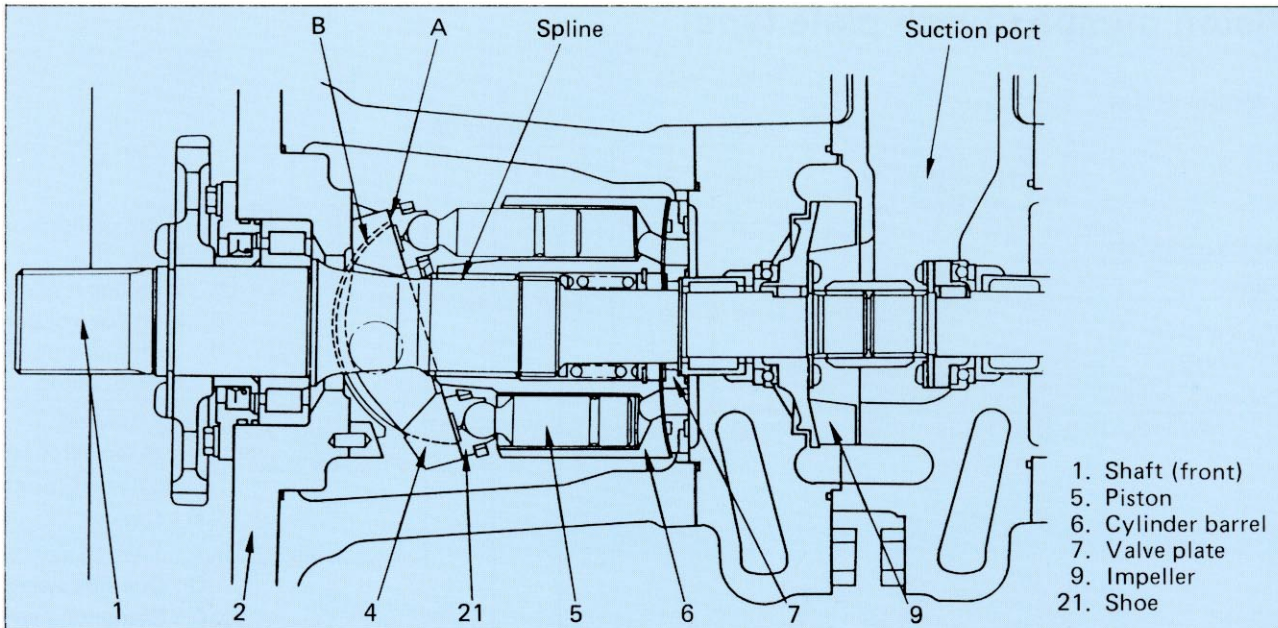
1. Displacement volume (per rotation) Unit : cc/rev
This shows the displacement for one revolution of the hydraulic pump.
2. Delivery (per minute) Unit : litre/min
This shows the amount of oil delivered in one minute when the hydraulic pump is rotating at the specified speed.
3. Max. speed Unit : rpm
This shows the maximum permissible speed of the hydraulic pump.
4. Rated pressure Unit : kg/cm²
This shows the maximum pressure at which the hydraulic pump can be used continuously for a fixed time.
5. Peak pressure (momentary maximum pressure) Unit : kg/cm²
This shows the maximum momentary pressure which is generated when a load is applied to the hydraulic pump.

Piston pumps (swash plate type)

Model codes



STRUCTURE AND FUNCTION



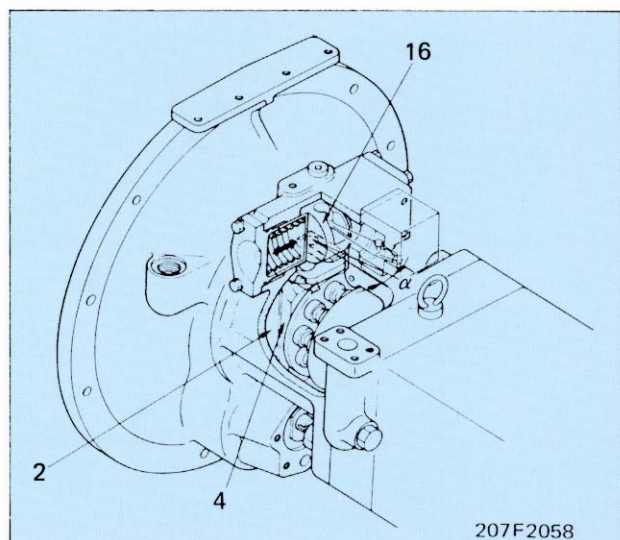
- The tip of piston (5) is spherical. Shoe (21) is swaged around the ball at the piston tip to form one unit with the piston. Piston (5) and shoe (21) from a spherical bearing.
- Swash plate (4) has surface A. Shoe (21) is always pushed against this surface and slides in a circle on surface A. Swash plate (4) slides on the concave face of cradle (2) which is fixed to the case.
- Pistons (5) move in an axial direction inside each cylinder of cylinder barrel (6).
- Cylinder barrel (6) rotates while pushing valve plate (7). This seals the oil while rotating. The oil inside each cylinder chamber on the rotating side (cylinder barrel (6)) goes in and out of the ports on the fixed side (valve plate (7)).
- Impeller (9) is connected to shaft (1), and rotates together with the shaft. It sends the oil sucked in from the suction port to the cylinder chamber by centrifugal force to make it easier to suck in.

Delivery control (swash plate angle control α)

Servo piston (16) changes the angle of the swash plate. Servo piston (16) moves in a reciprocal linear movement according to the commands of the servo valve. (\leftrightarrow)

This linear movement moves rod and swings swash plate (4). Swash plate (4) slides around the spherical surface of cradle (2). (\curvearrowright)

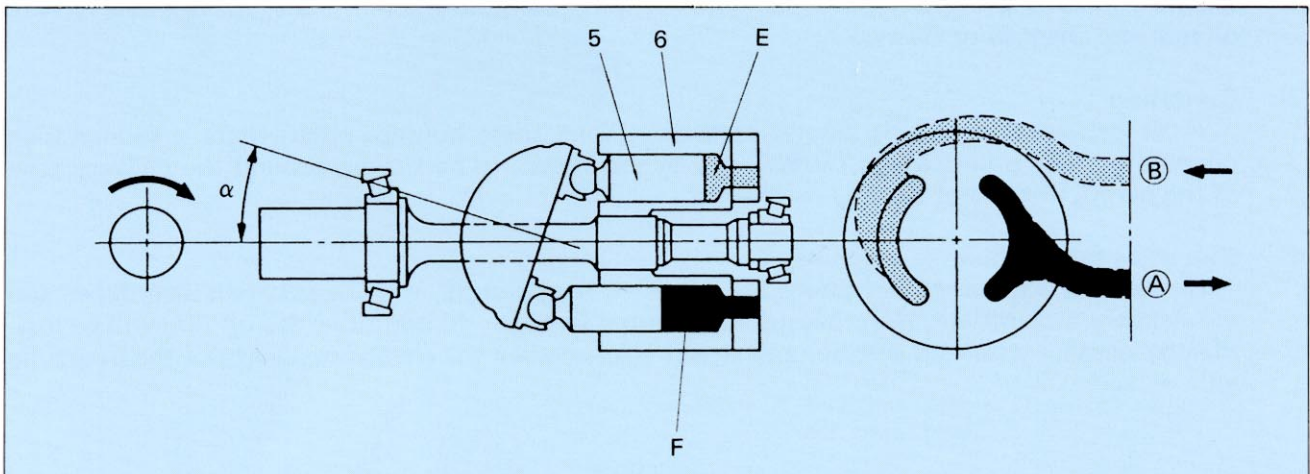
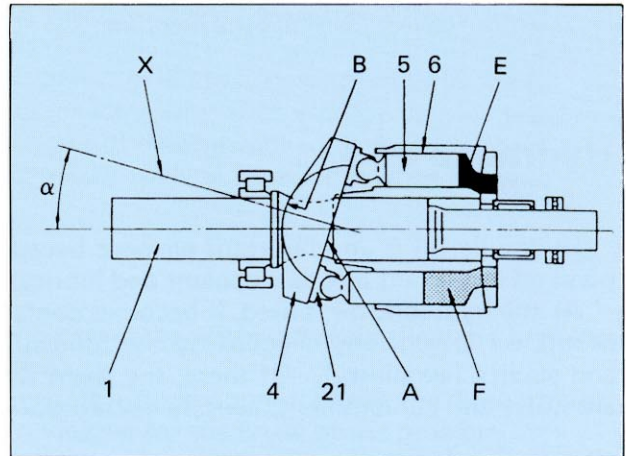
2. Cradle (front)
 4. Swash plate
 16. Servo piston



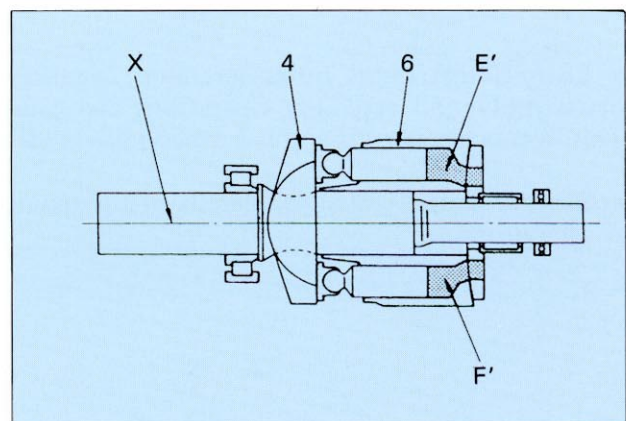
Operation of pump

- When shaft (1) rotates because of the engine, cylinder barrel (6) also rotates. Shoe (21) rotates on face A of swash plate (4). When swash plate (4) moves on concave face B, the angle α of swash plate (4) changes. α is called the swash plate angle.

- When swash plate (4) has a swash plate angle α , piston (5) reciprocates inside cylinder barrel (6). As a result, a difference between volume E and volume F inside cylinder barrel (6) appears. When this happens, an amount of oil equal to this difference in volume is sucked in from port B, and the same amount of oil is pumped out from port A. In other words, cylinder barrel (6) rotates and volume F gradually becomes smaller. While the volume F approaching volume E, oil is pumped out. After it passes the situation in volume E and approaches volume F, the oil is sucked in.



- When the angle of swash plate (4) is 0, there is no difference between volume E' and volume F', so no oil is sucked in or pumped out. (no pumping action)



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 or 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

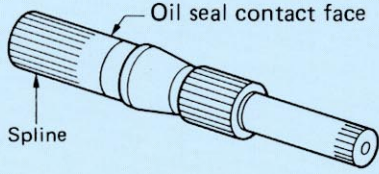
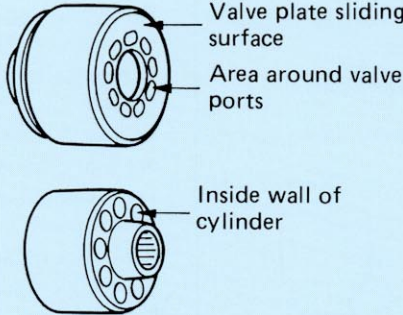
The piston pump is the heart of the hydraulic equipment. If there is wear, scuffing, dents, or seizure of the piston pump, the performance of the hydraulic equipment will drop and other problems will occur. Therefore, it is important to exercise extreme care when making judgements about the reuse of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

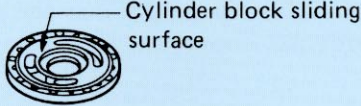
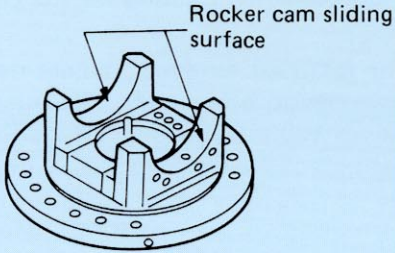
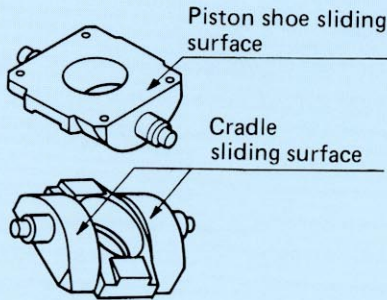
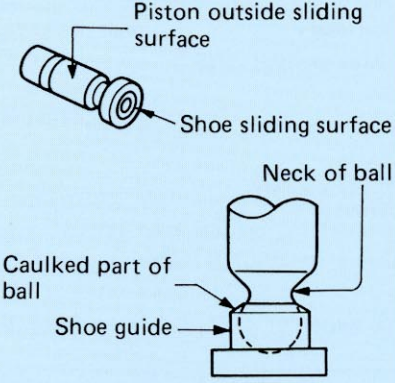
When making judgements about the reuse of parts, it is important to consider daily maintenance and operating conditions to find out exactly why that kind of damage was caused. In this Guidance Manual, there are photographs of damage ranked A, B or C. These photographs should be used together with the 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, check the discoloration of the hydraulic oil and use the results as reference when looking for the cause of the problem.

	Part Name	Check position	Check point
1	Drive shaft		<ul style="list-style-type: none"> • Wear of spline • Wear of oil seal lip contact face • Wear or seizure of shaft bearing mount
2	Cylinder block		<ul style="list-style-type: none"> • Scratches, seizure, or wear of valve plate sliding surface • Scratches or erosion of area around valve ports • Scratches, wear, or erosion of inside wall of cylinder

	Part Name	Check position	Check point
3	Valve plate		<ul style="list-style-type: none"> • Scratches, seizure, or discoloration of cylinder block sliding surface • Erosion around escape grooves
4	Cradle		<ul style="list-style-type: none"> • Scratches or wear of rocker cam sliding surface <p>Proper contact of sliding-surface.</p>
5	Rocker cam		<ul style="list-style-type: none"> • Scratches, seizure, or wear of piston shoe sliding surface • Proper contact of cradle sliding surface
6	Piston sub-assembly		<ul style="list-style-type: none"> • Scratches, seizure, or wear of piston outside circumference sliding surface • Scratches or wear of shoe sliding surface • Cracks in neck of ball • Wear or play in caulked part of ball • Is movement of ball smooth or free of stiffness? • Scratches or wear of ball • Scuffing or wear of shoe guide • Scuffing or wear of shoe collar

LEVEL OF FAILURE AND JUDGEMENT ON REUSE

The level of damage for piston pumps 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.

Judgement standards for reuse

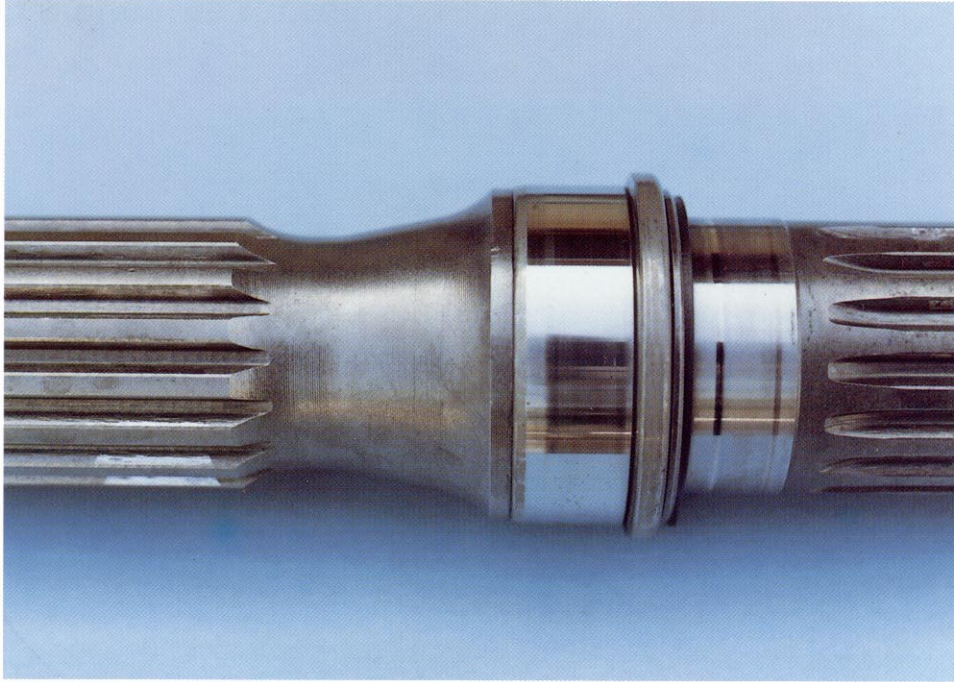
Part Name	Damaged Name		Judgement category		
			A	B	C
Drive shaft	1	Spline	No wear of tooth face	/	Marked wear of tooth face
	2	Oil seal lip contact surface	No scratch or wear		Wear causes fingernail to catch slightly
Cylinder block	1	Valve plate sliding surface	<ul style="list-style-type: none"> • No scratches, seizure, or wear • No erosion of area around valve ports 	Scratches or slight stepped wear which can be corrected easily by lapping together with valve plate. * Use #2000 lapping compound or equivalent, and finish with chromium oxide, or wash off the lapping compound and repeatedly slide the parts using only oil to remove the oil groove on the plate side and give total face contact. Completely remove all the lapping compound burried in the sliding surface.	<ul style="list-style-type: none"> • Marked stepped wear, seizure, or scratches which cannot be removed by lapping together. • Deep scratches or erosion between the valve ports
	2	Cylinder inside wall	<ul style="list-style-type: none"> • No seizure, wear, or erosion • When the piston is inserted, it goes down smoothly to the bottom. 	Slight scratches, wear, or uneven contact	<ul style="list-style-type: none"> • Deep scratches extending to the skirt • Seizure, erosion, or excessive stepped wear • When the piston is inserted, it does not go smoothly down to the bottom.
Valve plate	1	Cylinder block sliding surface	No scratches, seizure, or discoloration	Slight scratches which can be easily removed by lapping together with the cylinder block	<ul style="list-style-type: none"> • Marked discoloration or seizure • Scratches or erosion between the ports which cannot be removed by lapping together
Cradle	1	Sliding surface.	<ul style="list-style-type: none"> • No scratches or wear • Good contact 	<ul style="list-style-type: none"> • Scratches which can be easily removed by lapping together with the rocker cam, or which can be repaired by repair of the scratched part • Parts with improper contact * Correct the contact by lapping together with the rocker cam. For the lapping compound, use #1200 – #2000. For the repair limit for contact, see the Shop Manual.	<ul style="list-style-type: none"> • Marked wear • Deep scratches around oil holes or oil grooves (These cause problems with maintaining oil-tightness, so do not use.)

Part Name	Damaged Name	Judgement category			
		A	B	C	
Rocker cam	1	Piston shoe sliding surface	No scratches, seizure, or wear	<ul style="list-style-type: none"> Scratches or seizure which can be removed easily by surface lapping Stepped wear which can be corrected by surface grinding and lapping * The lapping compound is selected according to the depth of the scratch, but for finishing, use #1200. For repair limits for wear, see the Maintenance Standards in the Shop Manual. 	Damage other than B which cannot be corrected.
	2	Sliding surface with cradle	Good contact	Poor contact <ul style="list-style-type: none"> * Correct using lapping together with the cradle. For the lapping compound, use #1200 – #2000. For the repair limit for contact, see the Shop Manual. 	Contact cannot be corrected because of wear
Piston sub-assembly	1	Piston outside circumference sliding surface	<ul style="list-style-type: none"> No wear, scratches, or seizure Moves smoothly when inserted into cylinder 	Fine scratches which catch fingernail slightly <ul style="list-style-type: none"> * Remaining scratches which can be removed easily with smooth #200 sandpaper 	<ul style="list-style-type: none"> Many deep scratches other than B Piston does not move smoothly when inserted in cylinder
	2	Ball caulking	<ul style="list-style-type: none"> Ball moves smoothly No wear or play * Wear must be within 0.2 mm in direction of pull For details, see the Shop Manual.	* For limits of use for wear in items 1 – 5, decide the category according to the Maintenance Standards in the Shop Manual.	* For items 1 – 5 for the piston sub-assembly, if one item in a set is to be replaced, replace the whole set.
	3	Neck of ball	No cracks		
	4	Shoe sliding surface	No scratches or wear		
	5	Shoe guide	No wear		

EXAMPLES OF FAILURES

Drive shaft

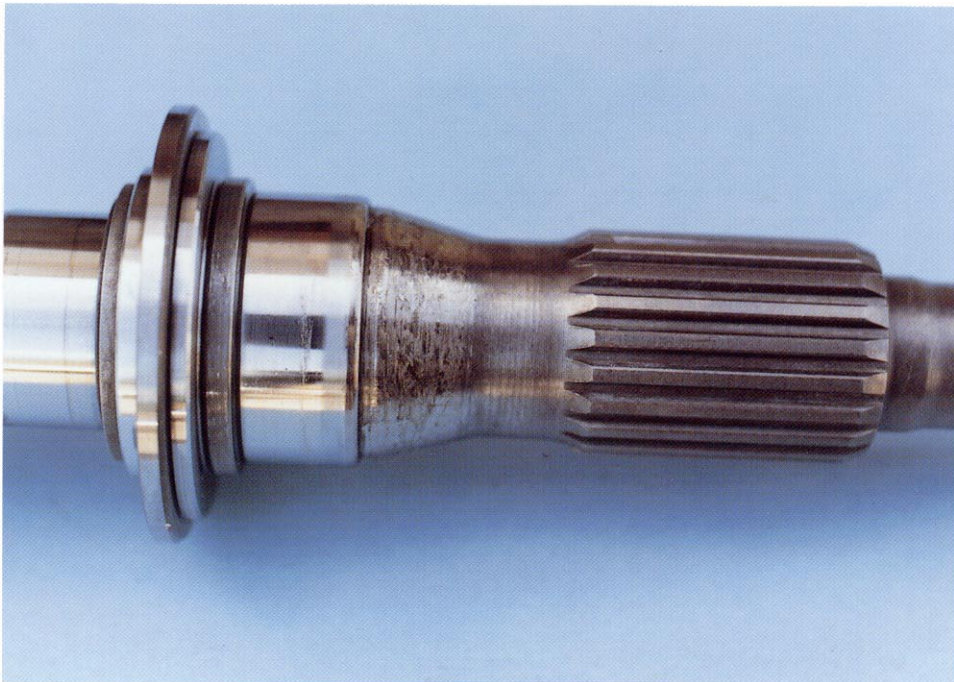
1



Category : A

Condition : Good condition. No wear of spline, no scratches or wear on bearing inner race and oil seal contact surface

2



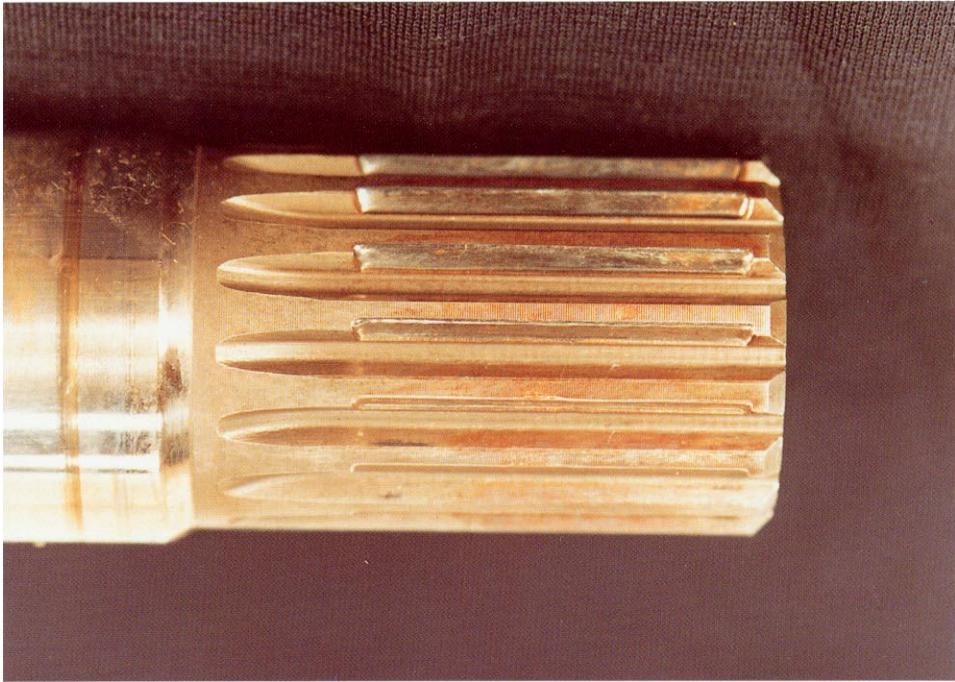
Category : B

Condition : Good condition, but scuffing on shaft, dents or scratches in machined surface and scratches on bearing roller rolling surface

Cause : Broken part of internal parts of pump caught between other parts

Remedy : The scratches in the shaft are shallow so repair is unnecessary. Reuse is possible after removing the bearing inner race and replacing the assembly.

3



Category : C

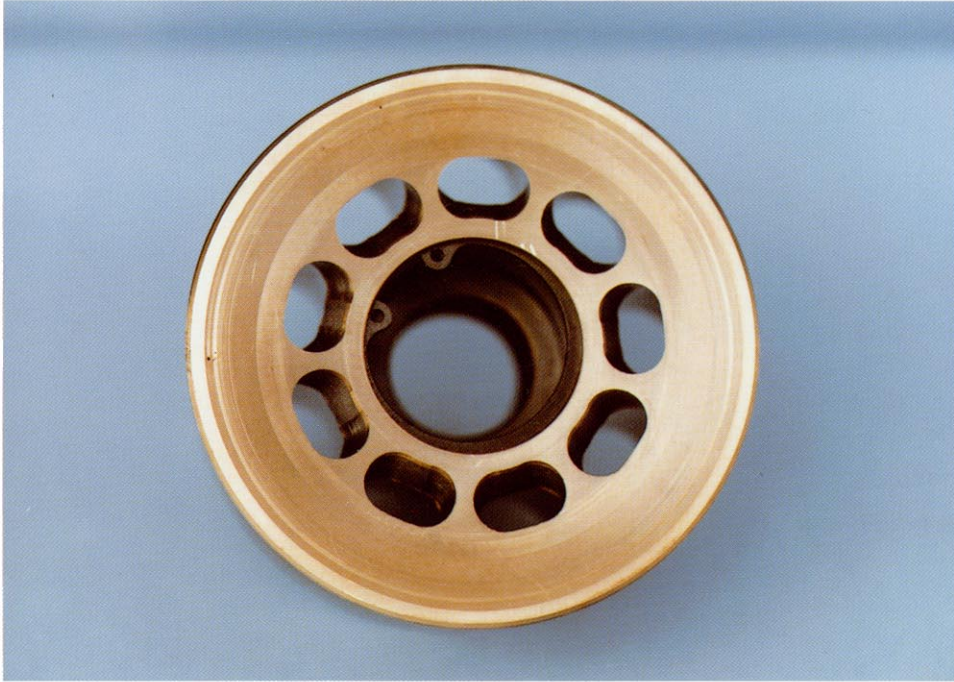
Condition : Progress of marked wear in spline

Cause : Excessive load caused by abnormality, such as dirty oil or defective lubrication.

Remedy : Take action according to the wear repair limit given in the Maintenance Standards in the Shop Manual.

Cylinder block

4



Category : A

Condition : Good condition. No scratches, seizure, or wear of valve plate sliding surface

5



Category : B

Condition : Slight discoloration (oil burn, initial signs of seizure) on valve plate sliding surface, but no scratches or wear.

Cause : Loss of oil film due to defective contact, etc.

Remedy : Correct the contact by lapping together with the valve plate (for the lapping compound, use #2000 or equivalent). (Except the oil groove on the valve plate to give total face contact.)

6



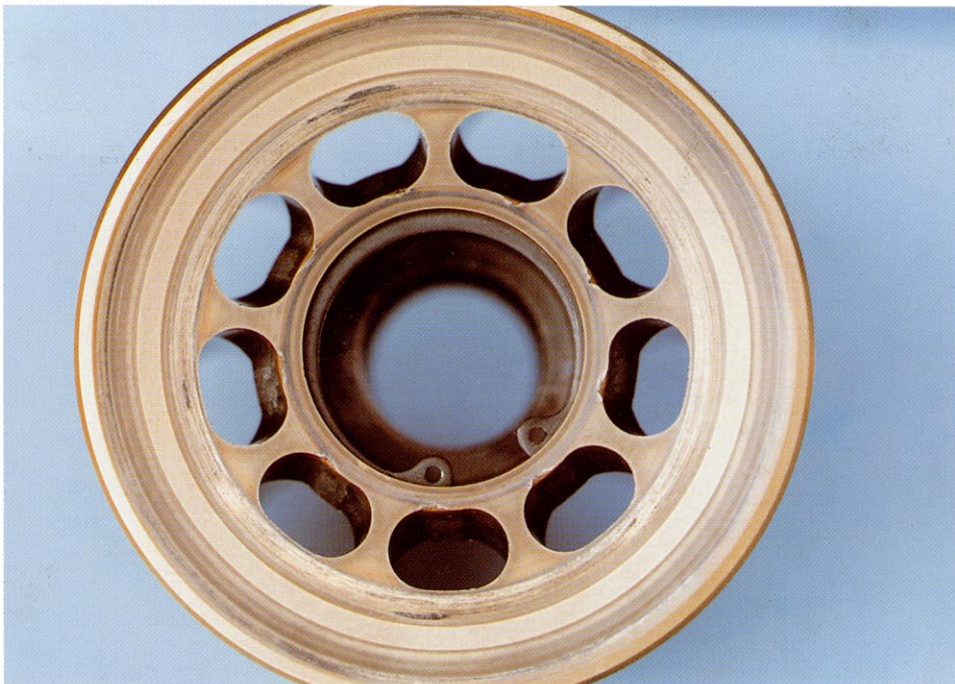
Category : B

Condition : Slight seizure and initial wear can be seen on valve plate sliding surface.

Cause : Loss of oil film due to dirty oil or defective lubrication.

Remedy : Correct by lapping together with the valve plate, and reuse. (For lapping compound, use #2000 or equivalent)

7



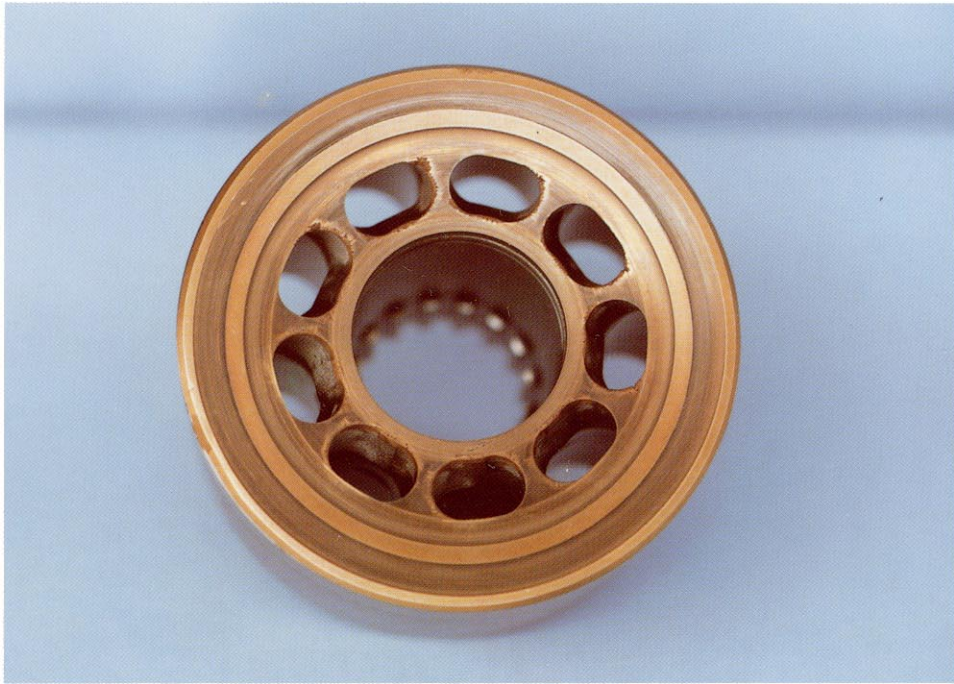
Category : B

Condition : Slight erosion from the valve ports in the valve plate sliding surface towards the center of the shaft hole, and slight seizure on the surface can be seen.

Cause : Air in the oil has caused erosion or loss of the oil film.

Remedy : Correct by lapping together with the valve plate. If total face contact is obtained, a slight amount of the traces of erosion can be left.

8



Category : C

Condition : Discoloration, and advanced wear and erosion between the valve ports can be seen in the valve plate sliding surface.

Cause : Rise in oil temperature caused by air in the oil.

9



Category : C

Condition : Discoloration, and advanced wear and erosion between the valve ports can be seen in the valve plate sliding surface.

Cause : Rise in oil temperature caused by air in the oil.

10

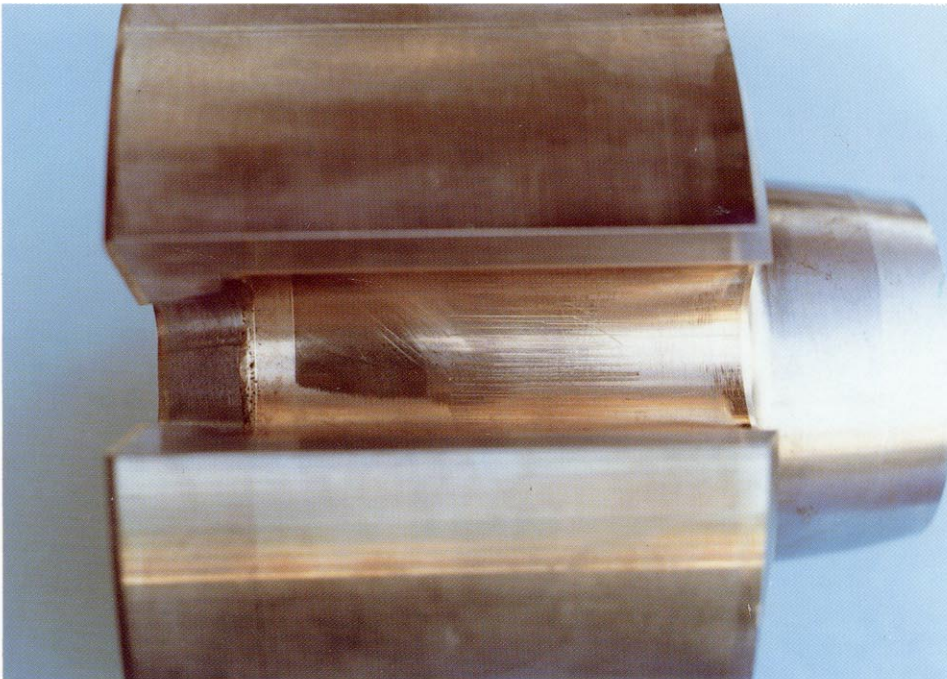


Category : C

Condition : Marked stepped wear and discoloration can be seen on the valve plate sliding surface.

Cause : Powder from broken parts inside the cylinder has entered the pump.

11



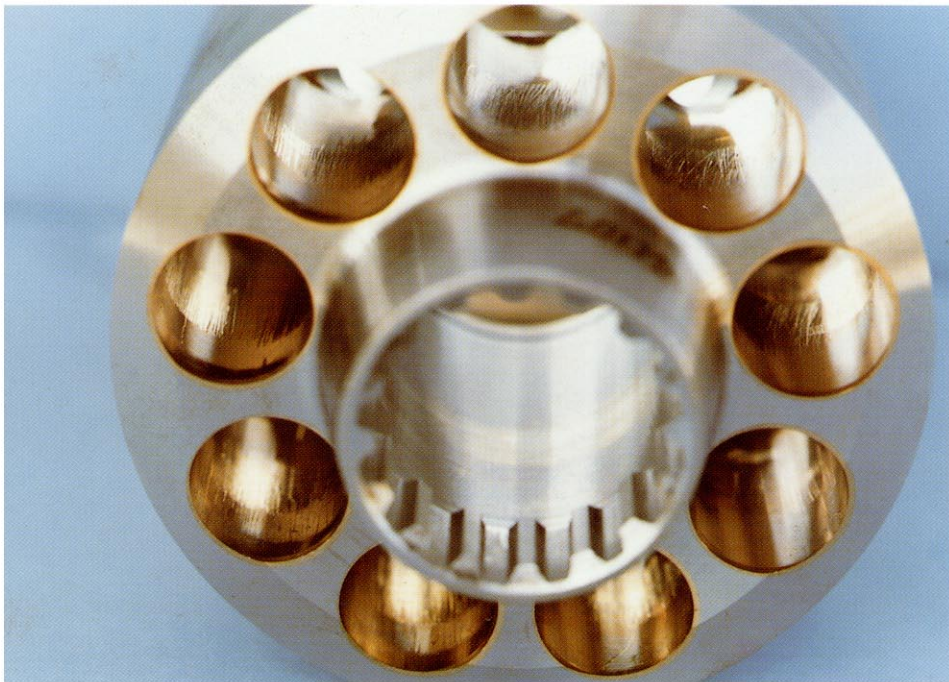
Category : A

Condition : No wear, but strong contact at one side of the top of the inner wall of the cylinder and slight scratches in the center.

Cause : Scratches caused by dirt getting caught, and sliding at an angle caused by defective follow-up of the piston rotation.

Remedy : Insert the piston alone. If it moves smoothly it can be used as it is; if it catches, judge it as category B. Correct damaged parts by using smooth #200 sandpaper.

12



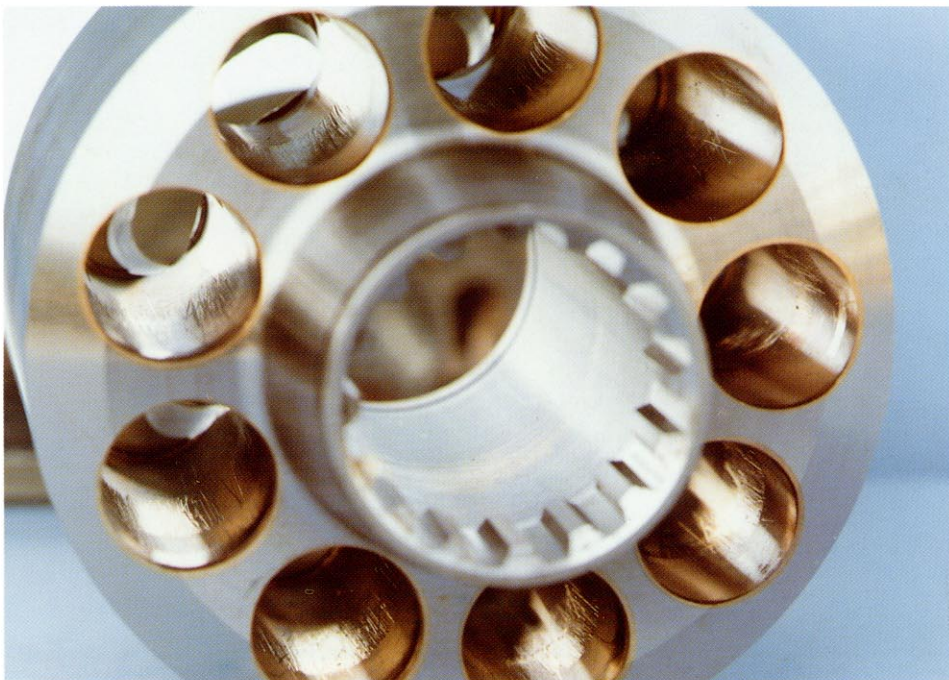
Category : B

Condition : No wear, but scratches on the inside walls of each hole in the cylinder and several vertical scratches which can be felt with the finger tip.

Cause : Catching of fine powder from broken part, etc.

Remedy : Correct by lightly removing the scratches with #200 sandpaper. Insert the piston alone and check again, then reuse.

13



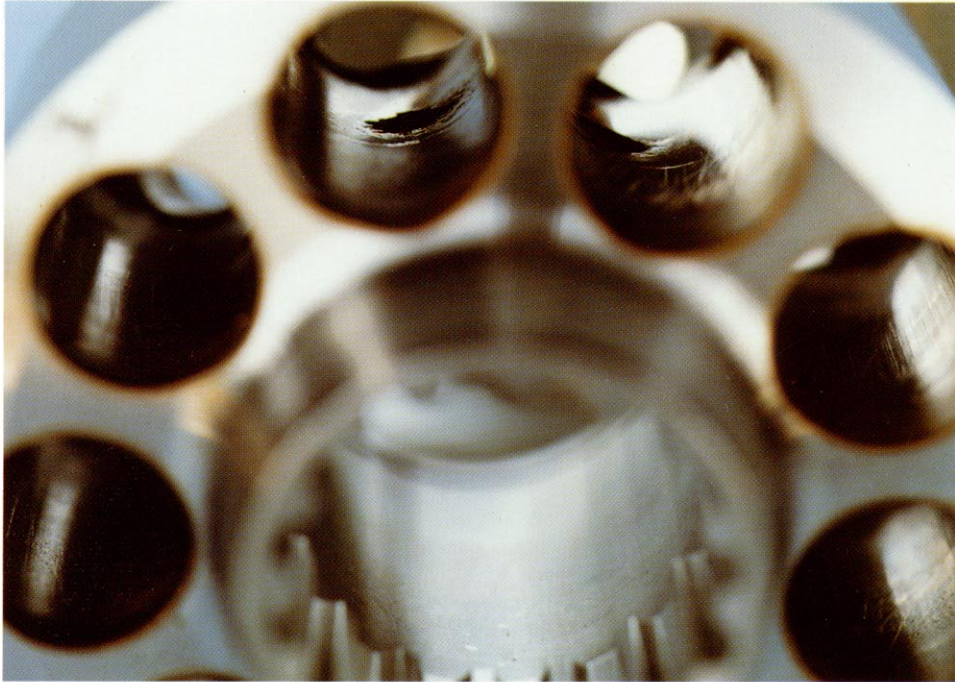
Category : B

Condition : No wear, but scratches on the inside walls of each hole in the cylinder and several vertical scratches which can be felt with the finger tip.

Cause : Catching of fine powder from broken part, etc.

Remedy : Correct by lightly removing the scratches with #200 sandpaper. Insert the piston alone and check again, then reuse.

14

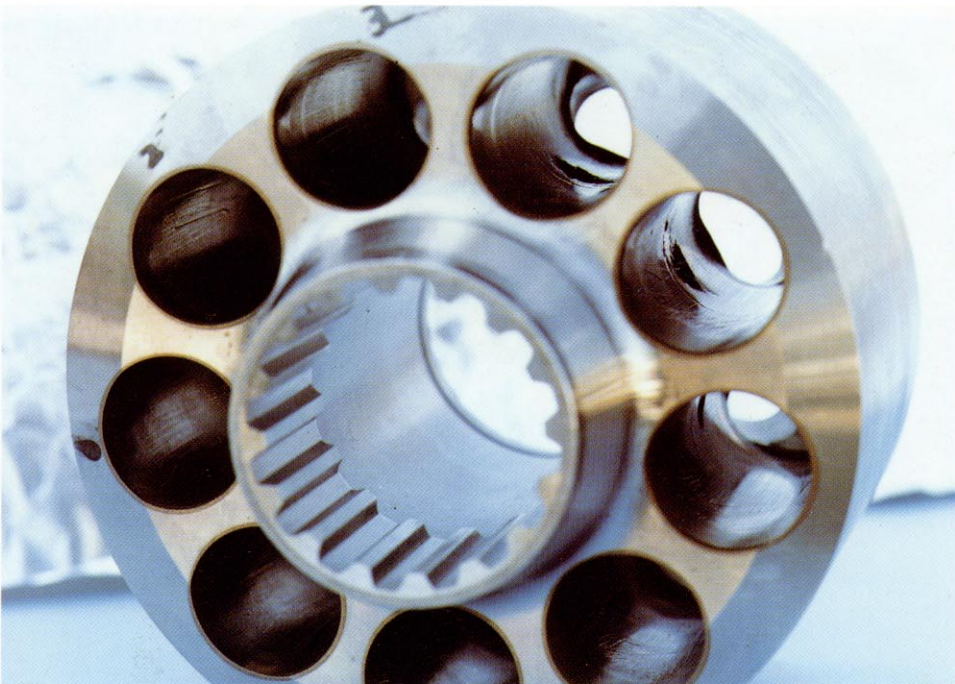


Category : C

Condition : Scratches and extreme erosion of the inside walls of the cylinder.

Cause : Erosion caused by cavitation due to air in the oil.

15

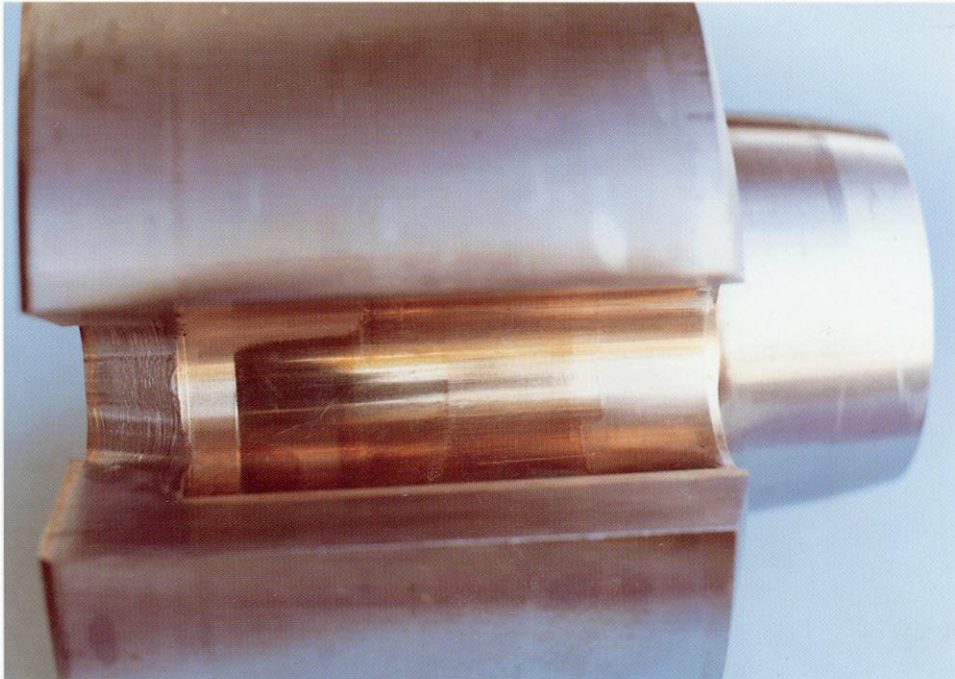


Category : C

Condition : Scratches and extreme erosion of the inside walls of the cylinder.

Cause : Erosion caused by cavitation due to air in the oil.

16



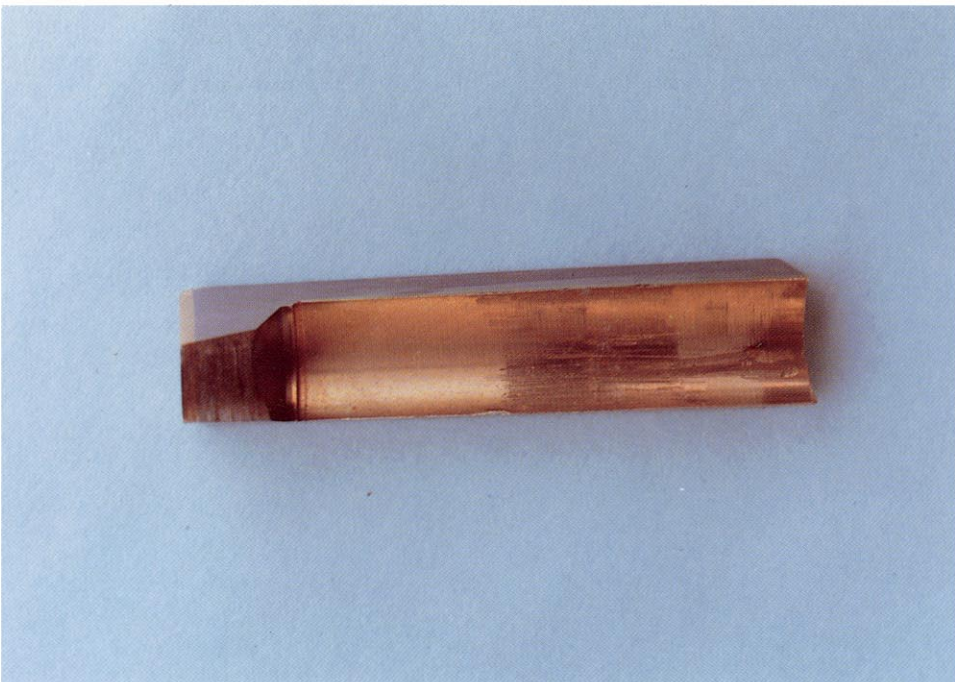
Category : C

Condition : Extreme one-side contact on inside wall of cylinder, and stepped wear can be seen at the top.

Cause : The piston is sliding at an angle because of excessive load or catching by dirt.

Remedy : Take action according to the wear repair limit given in the Maintenance Standards in the Shop Manual.

17

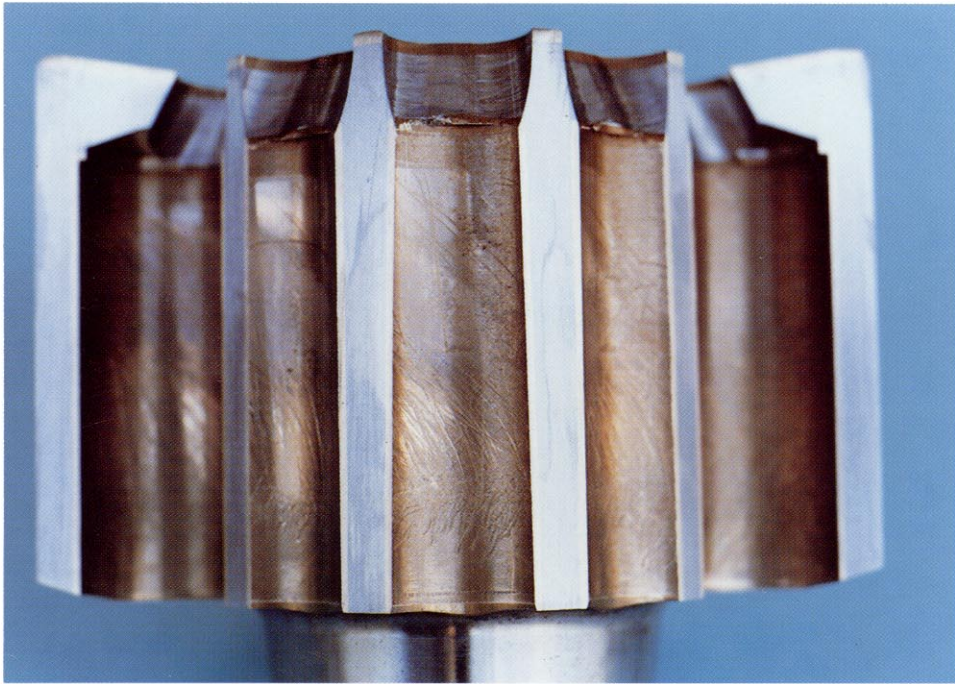


Category : C (matching part of cut-away part shown above)

Condition : Same as above. Scuffing is caused as far as the skirt.

Cause : Same as above

18

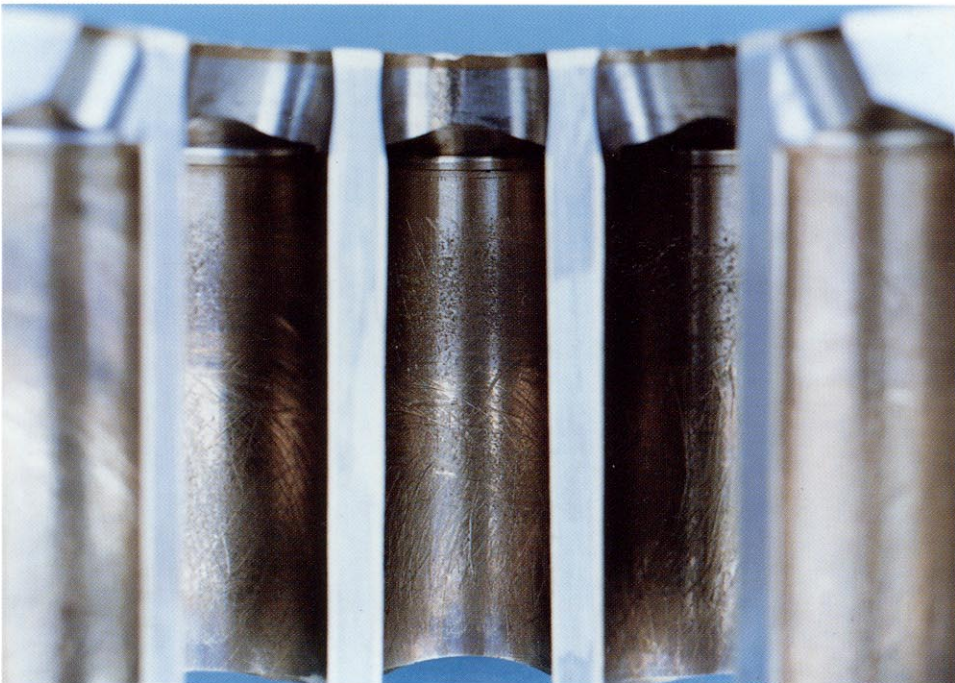


Category : C

Condition: Many spiral scratches on the inside wall of the cylinder, and granular scratches can be seen extending to the skirt.

Cause : Powder from a broken part inside the cylinder has entered the pump.

19



Category : C (Photograph shows cut-away of mating part for part shown above)

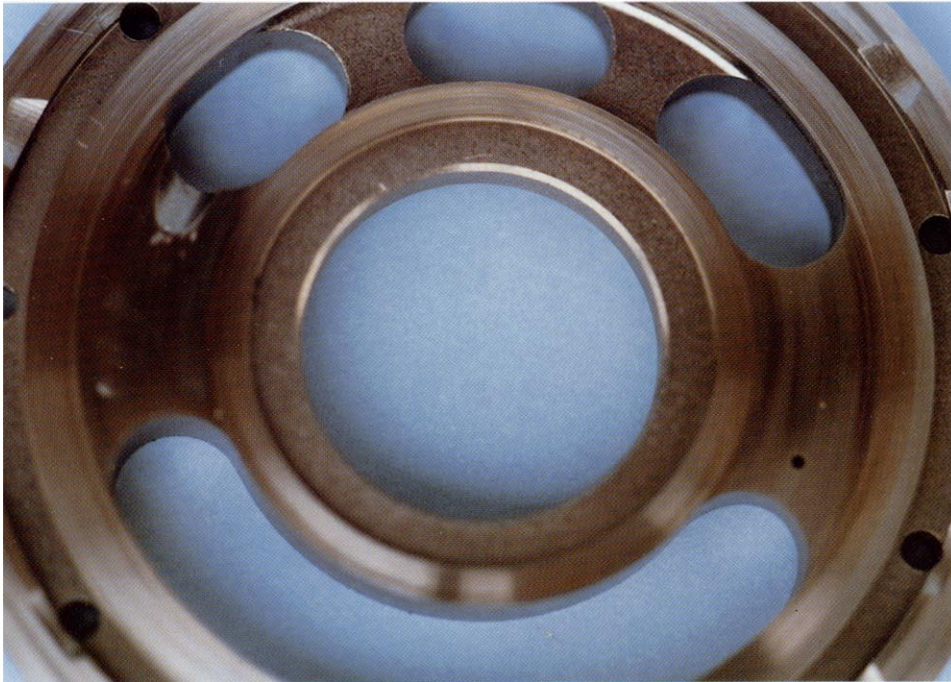
Condition: Same as above. Scratches and many granular dents caused by powder from broken parts getting caught.

Cause : Same as above.

* This example can be easily checked visually, but the part was cut away to enable photographs to be taken of the inside of the hole.

Valve plate

20



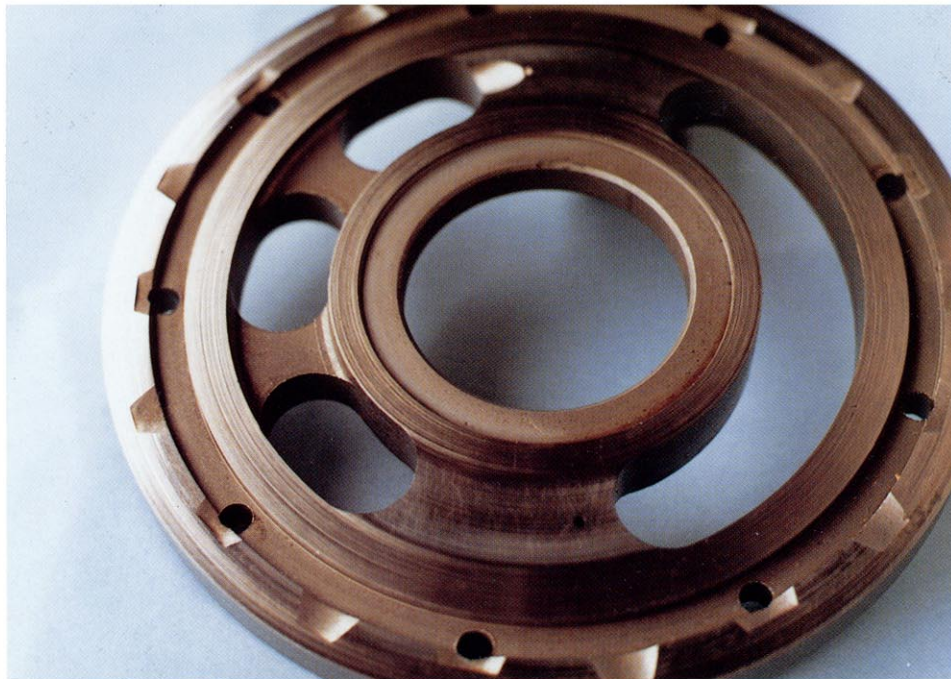
Category : B

Condition : Slight cavitation on sliding surface in contact with the cylinder block, and scratches like grooves on a record on the temper collar (enough to catch the fingernail).

Cause : Loss of oil film caused by air in the oil.

Remedy : Correct by lapping together with the cylinder block (for lapping compound, use #2000 or equivalent) to give total contact, then reuse.

21



Category : B

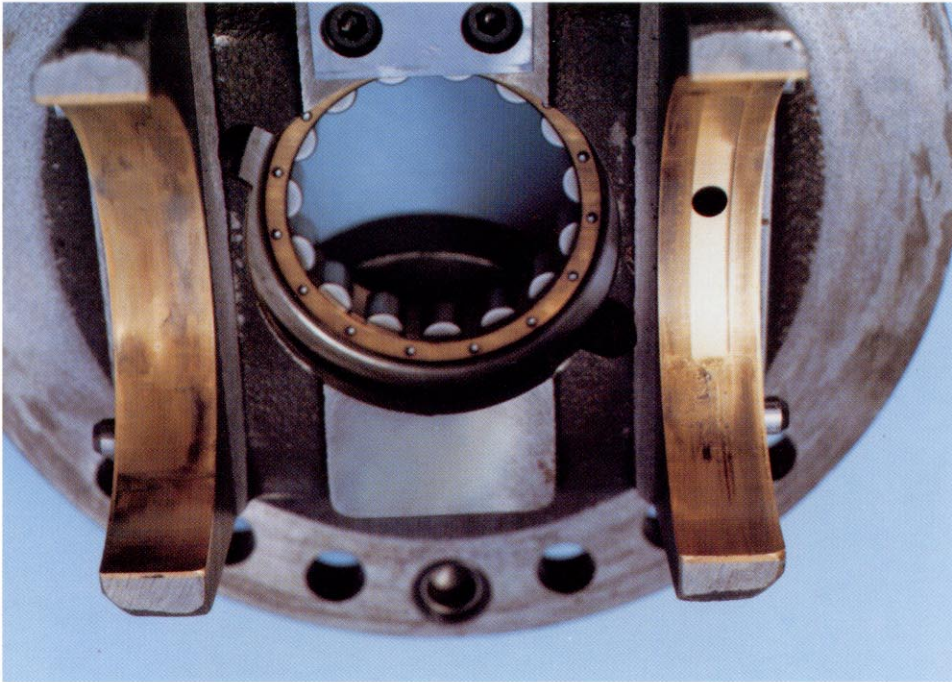
Condition : Slight cavitation on sliding surface in contact with the cylinder block, and scratches like grooves on a record on the temper collar (enough to catch the fingernail).

Cause : Loss of oil film caused by air in the oil.

Remedy : Same as above.

Cradle

22



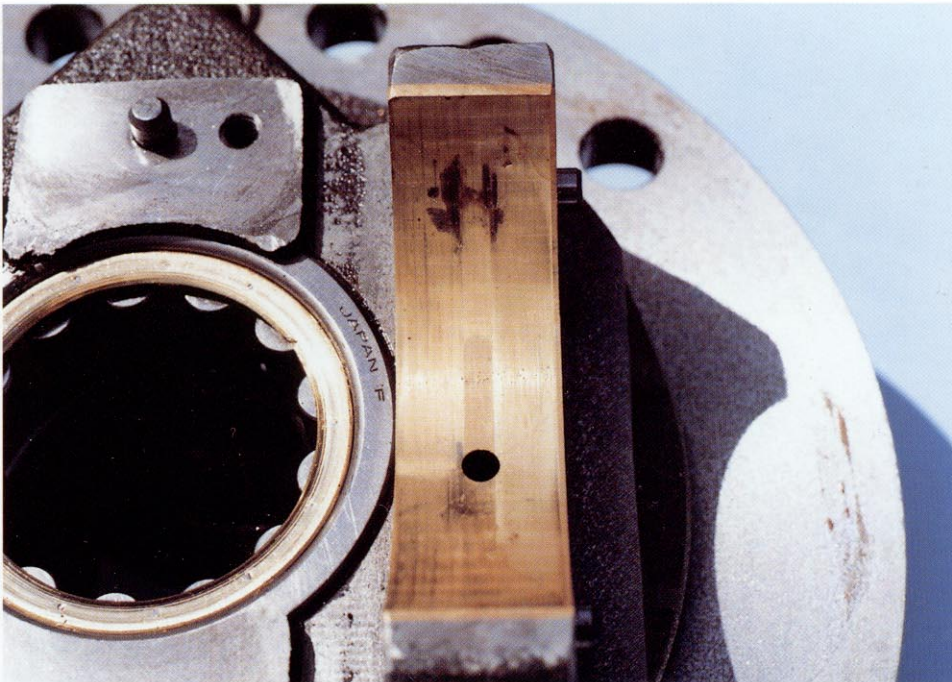
Category : B

Condition : Slight granular dents in the rocker cam sliding surface and slight vertical scratches can be seen, but condition of contact is mostly good.

Cause : The scratches are caused by granules of broken parts getting caught.

Remedy : Correct by lapping together with the rocker cam (for lapping compound, use #2000 or equivalent). For details, see the Shop Manual.

23



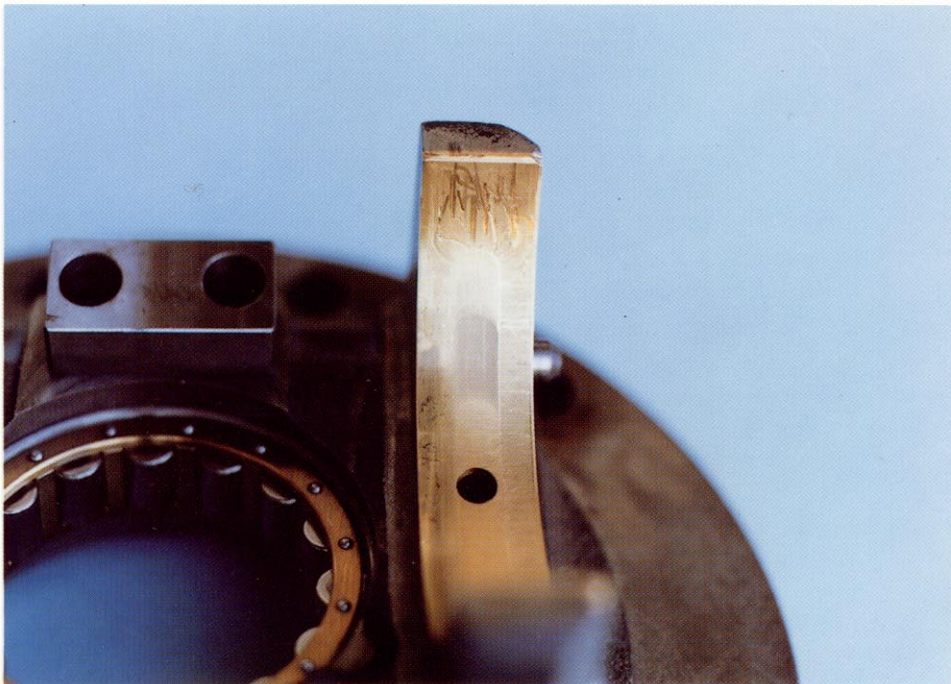
Category : B

Condition : There is strong contact in places and granular dents in the end of the oil groove in the rocker cam sliding surface.

Cause : Broken pieces have got caught.

Remedy : After finishing the protruding part of the contact with a scraper, correct by lapping. For lapping compound, use #2000 or equivalent. For details see the Shop Manual.

24



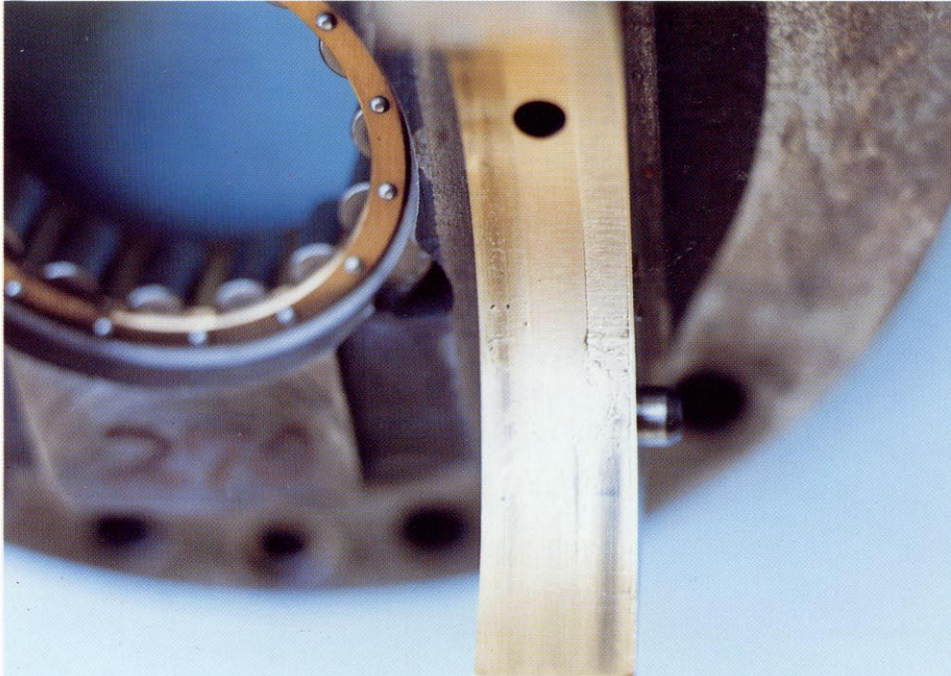
Category : C

Condition : Scratches on the end of the rocker cam sliding surface and many scratches extending from the traces of the oil groove to the outside.

Cause : Broken particles getting caught, and contaminated oil being blown through.

Remedy : The traces of contact of the oil groove have made stepped wear, so it is impossible to correct by lapping.

25



Category : C

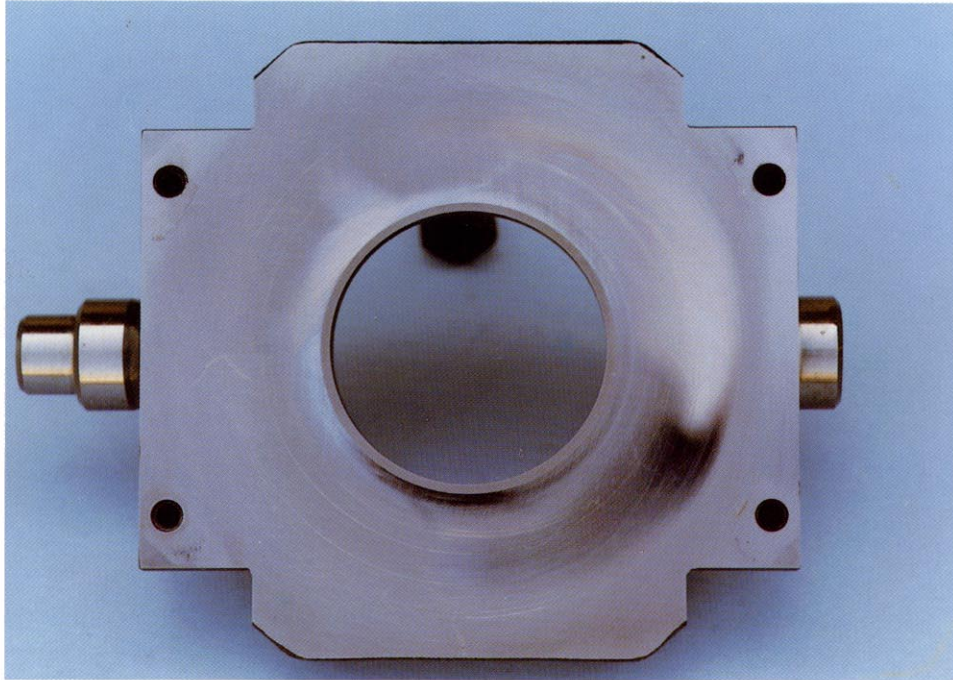
Condition : Scratches on the end of the bearing at the rocker cam sliding surface and many scratches extending from the traces of the oil groove to the outside.

Cause : Broken particles getting caught, and contaminated oil being blown through.

Remedy : Same as above

Rocker cam

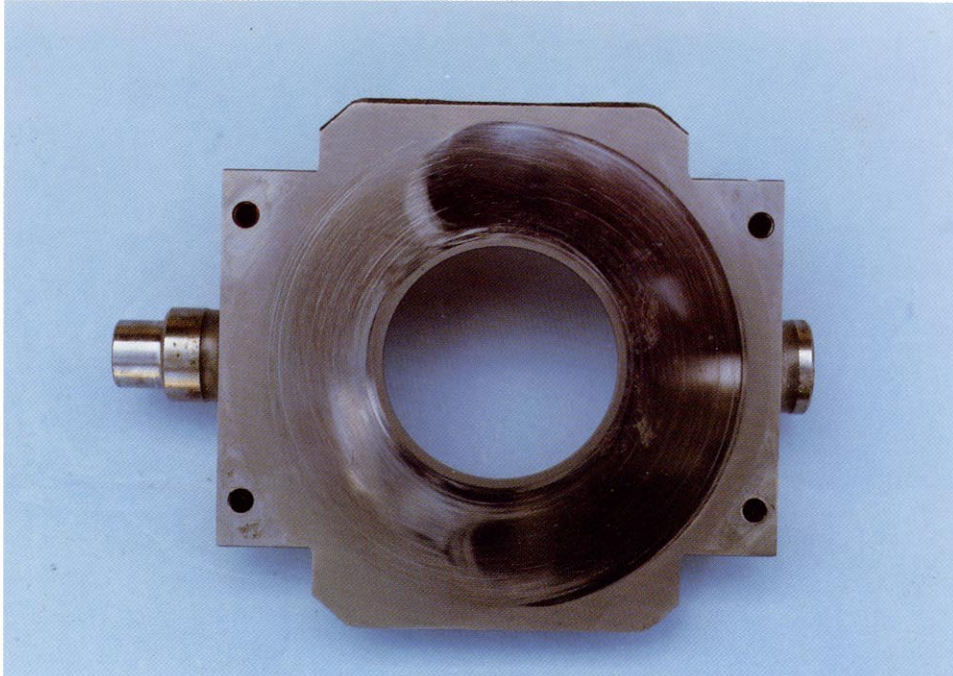
26



Category : A

Condition : No scratches on the piston shoe sliding surface and contact area at pressure side is shining. This is the normal condition for initial operation.

27



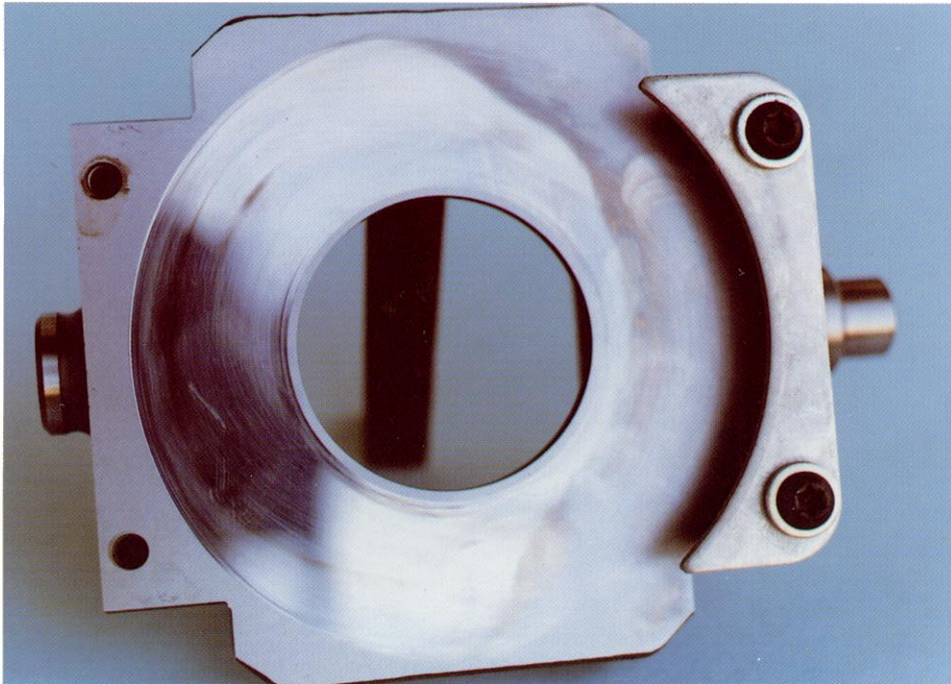
Category : B

Condition : Light scratches on the piston shoe sliding surface, but the contact surface on the pressure side is like a mirror. Slight wear is shown.

Cause : Contaminated oil, etc.

Remedy : Correct by surface lapping (for the final lapping compound, use #1200 or equivalent) to remove the scratches.

28



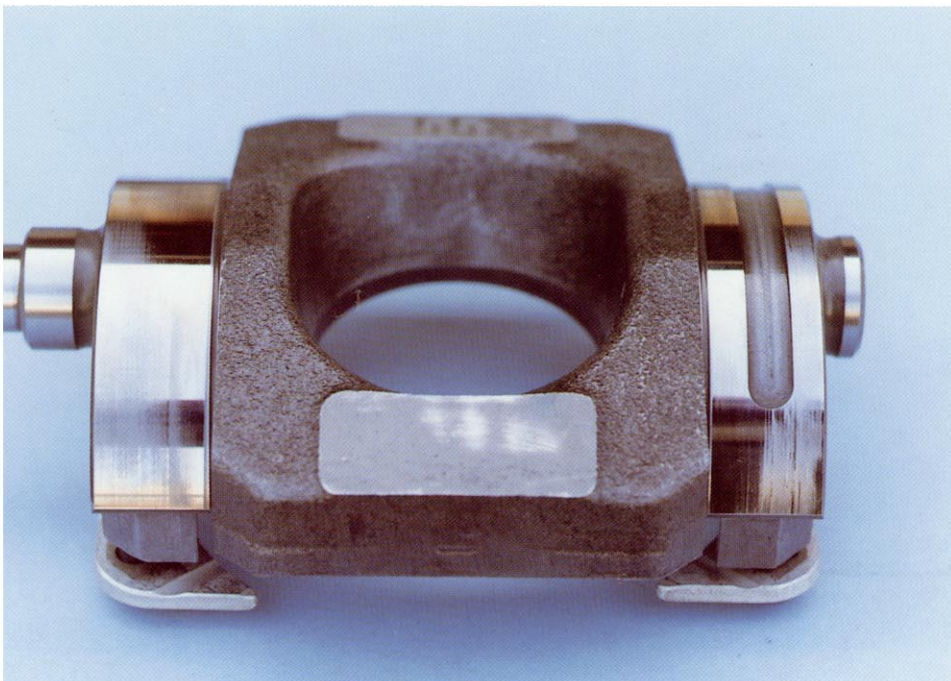
Category : B

Condition : Good condition. No scratches or seizure on piston sliding surface, but the contact area is like a mirror. Wear is progressing and stepped wear can be seen at the pressure side. (Normal wear)

Reference : The maximum wear in the part photograph is approx. 0.07 mm

Remedy : After surface grinding and finishing by lapping, reuse is possible.
Grinding repair limit : Maximum 0.1 mm.
For details of the lapping skill, see SEBG4240-1.

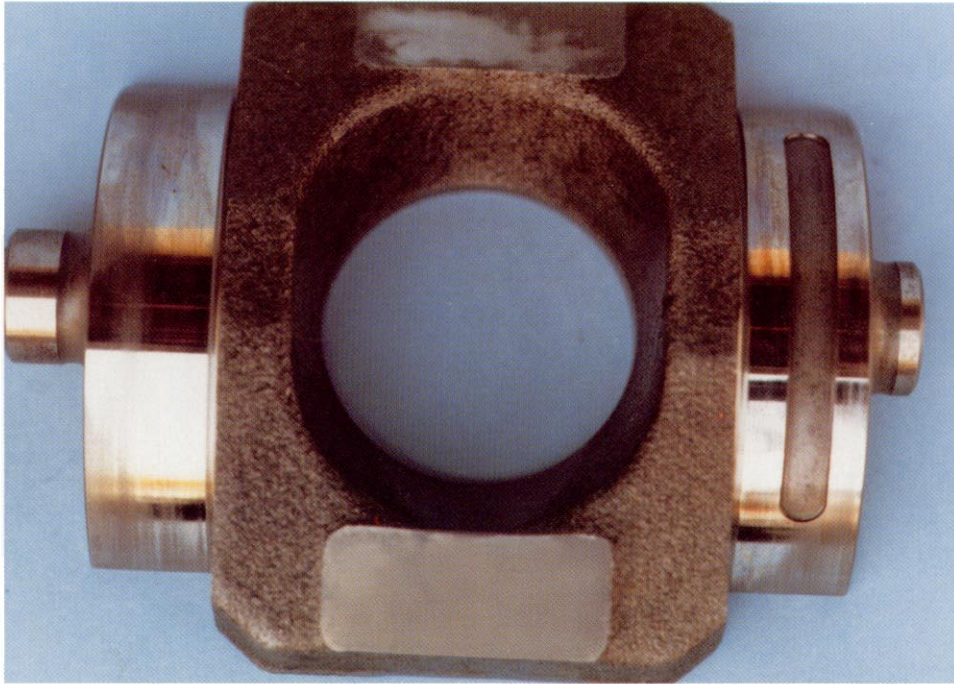
29



Category : A

Condition : Good condition. Lapping surface still remains on crank sliding surface, but the contact area is like a mirror.

30



Category : B

Condition : Contact of cradle sliding surface is somewhat defective.

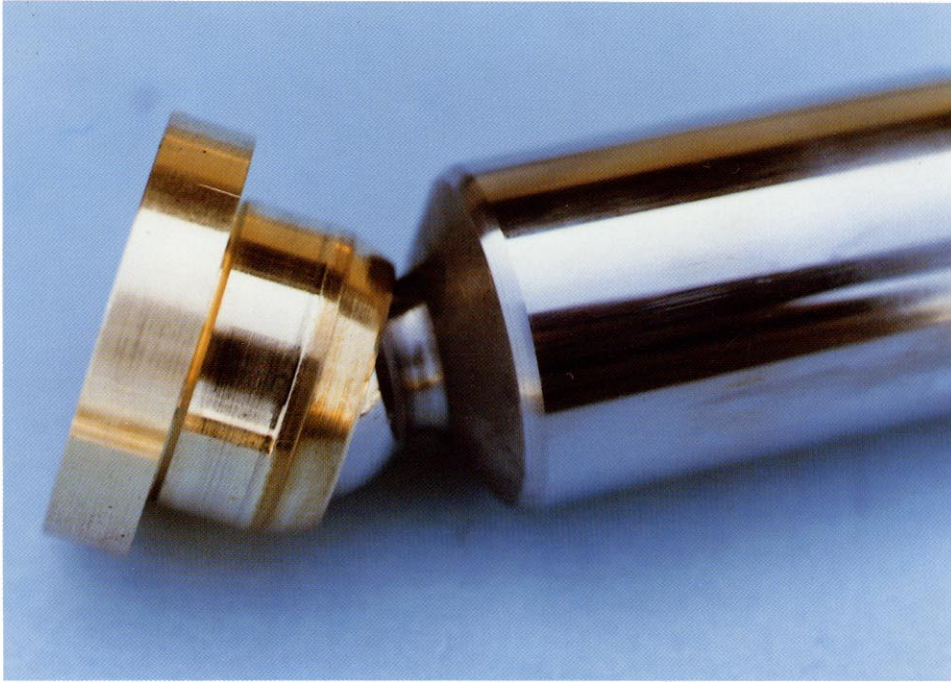
Remedy : Correct contact by lapping together with cradle.

For details of the lapping skill, see SEBG4240-1.

For details of the repair limit for contact, see the Shop Manual.

Piston sub-ass'y

31

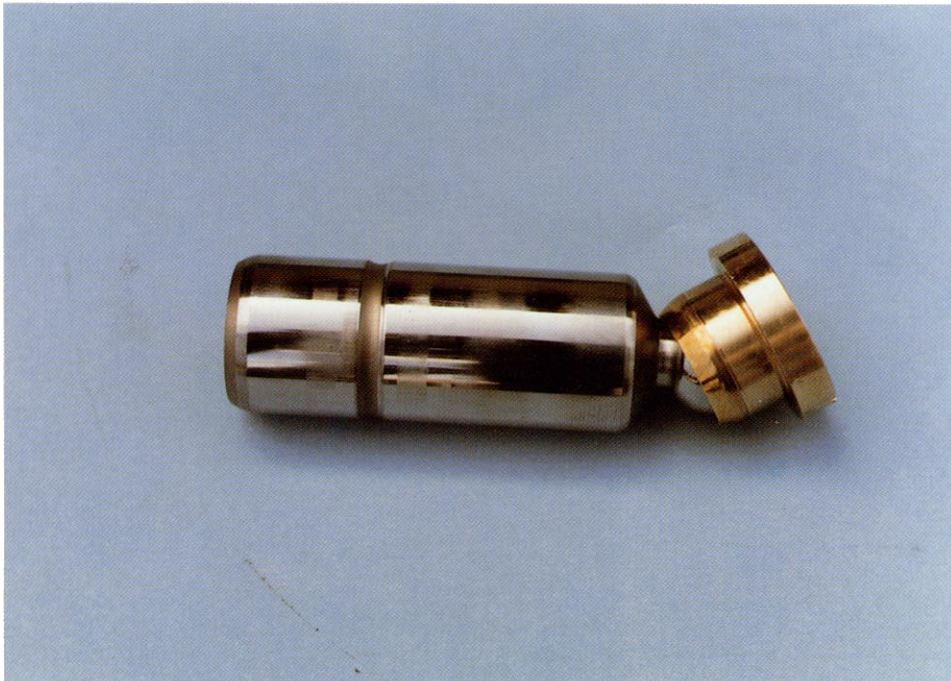


Category : A

Condition : Good condition, no scratches, seizure, or wear in the piston outside the circumference sliding surface, but contact area is like a mirror. The shoe guide area is also in good condition with no scratches or wear.

Cause : None.

32



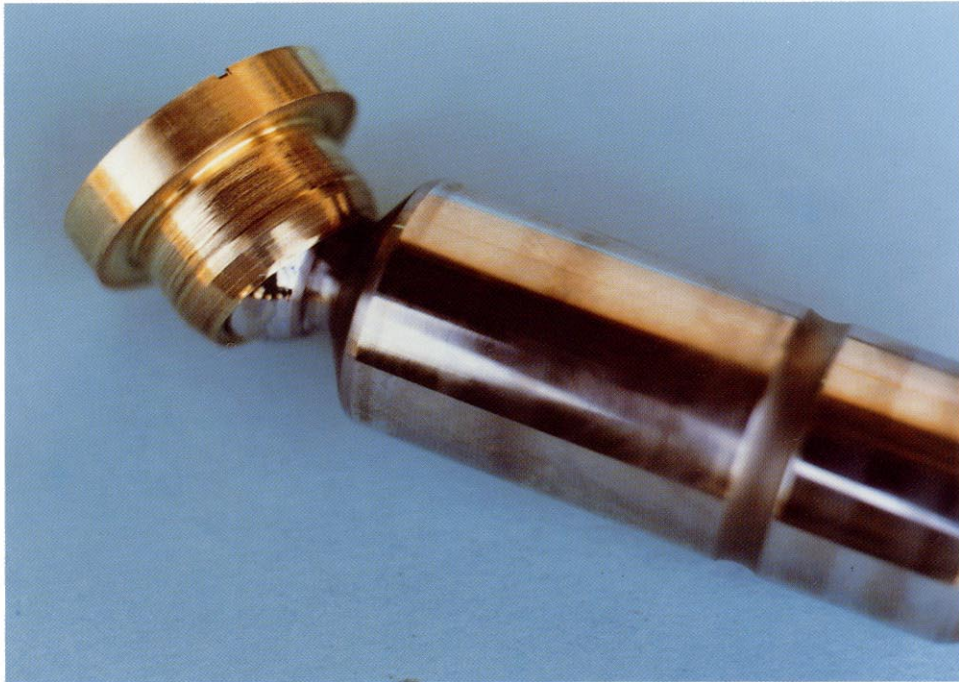
Category : B

Condition : Scratches which catch the fingernail near the oil groove on the piston outside circumference sliding surface, and belt-like scratches.

Cause : Contaminated oil, wear particles getting caught.

Remedy : Correct with smooth sandpaper #200 until the fingernail does not catch.

33

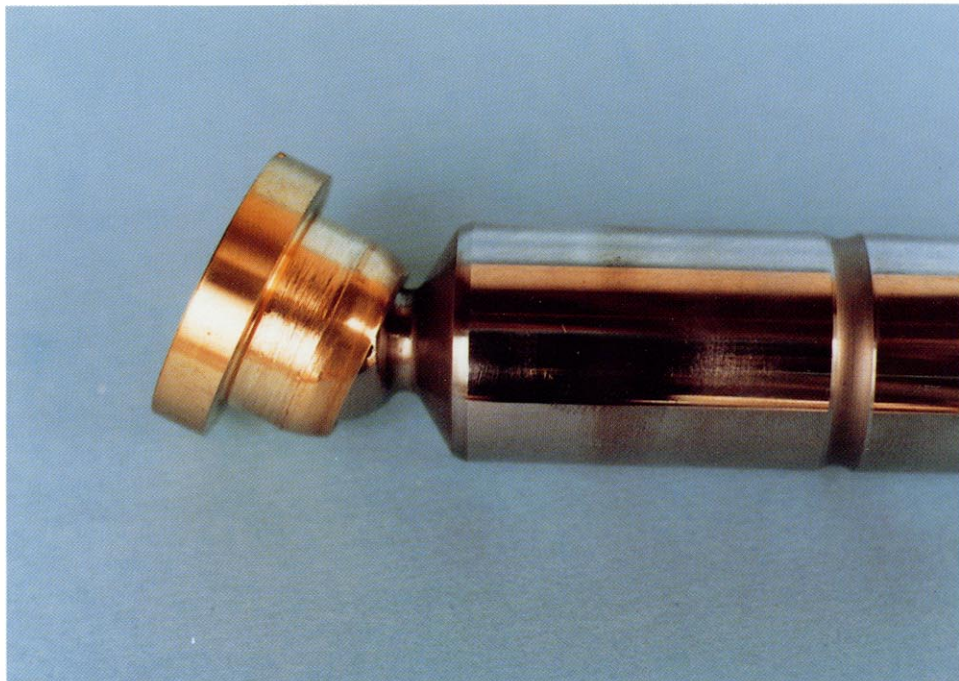


Category : (Check if ball moves smoothly or if wear is within repair limit to make judgement)

Condition: Scratches on the outside surface of the shoe guide.

Cause : Stiff follow-up of rotation caused by dirt getting caught in the ball surface.

34

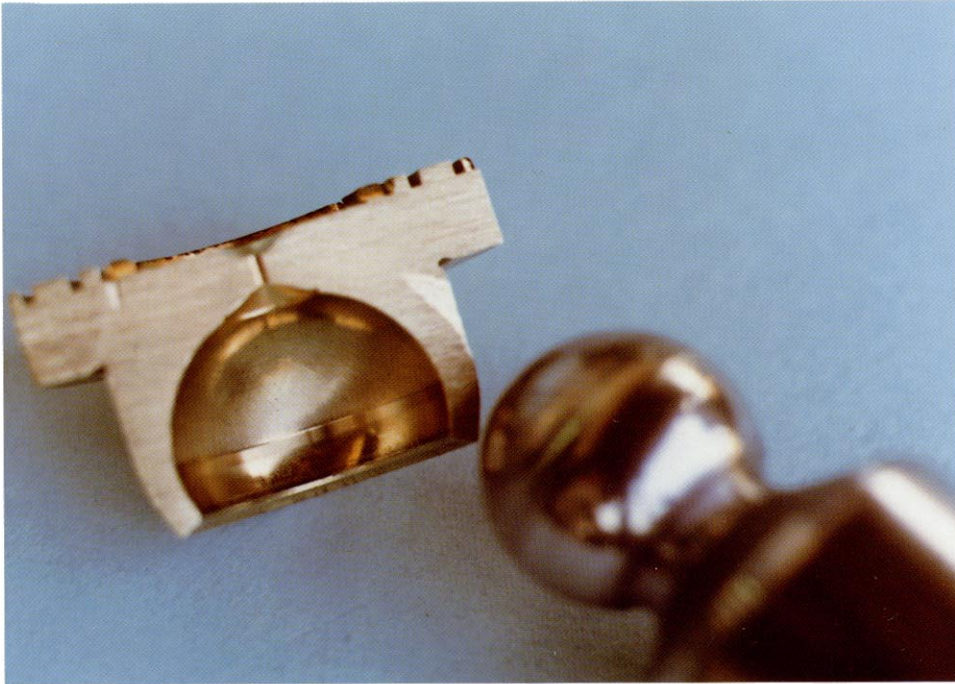


Category : C

Condition: Scratches around the circumference of the shoe guide; wear causing a hollow progressing in center part of circumference.

Cause : Stiff follow-up of rotation caused by dirt getting caught in the ball surface.

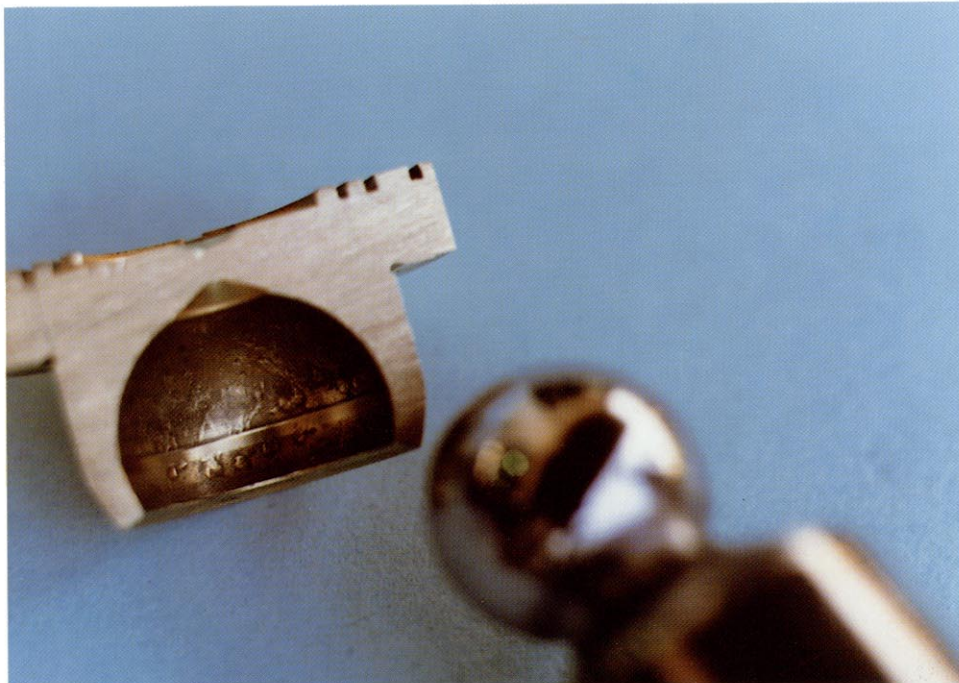
35



Category : A

Condition: Good condition (normal part). No scratches on caulked part of ball.

36



Category : C

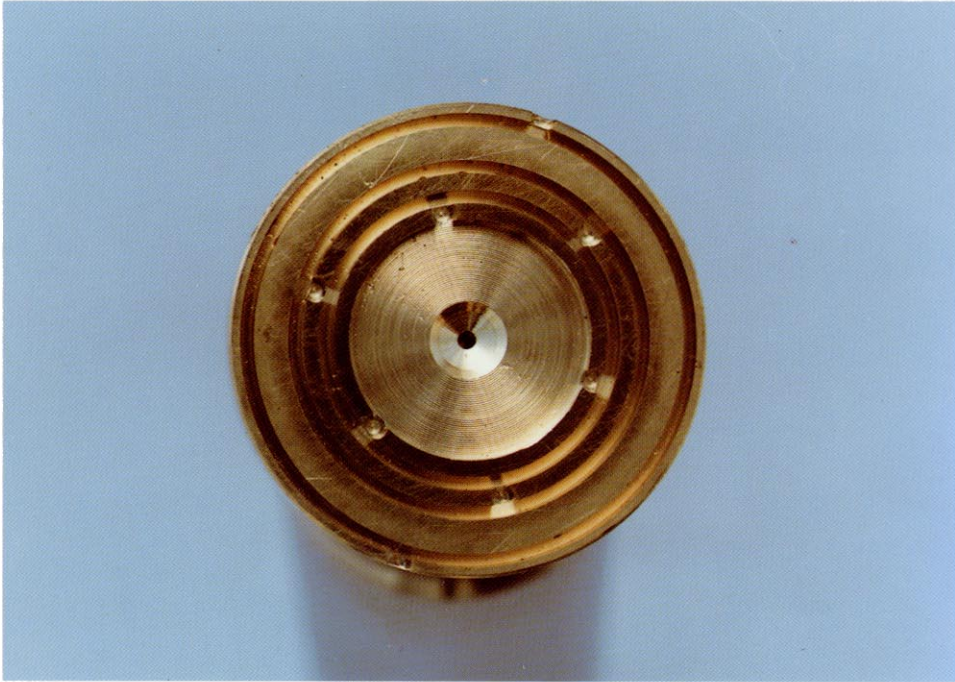
Condition: The photograph shows a cut-away of the shoe portion of a part with play in the pulling direction of the caulked part of the ball and wear of approximately 0.45. There are many dents and scratches in the spherical surface of the shoe.

Cause : Fine broken pieces from breakage inside the cylinder has entered the clearance at the ball and has become caught.

Remedy : For details of the wear limit for play and wear, see the shop manual.

* Normally, the ball part is caulked, so it is impossible to carry out visual checks of the ball surface, for this reason the shoe has been cut to provide a photograph for reference.

37



Category : A

Condition : Good condition, no scratches or wear in shoe sliding surface.

38

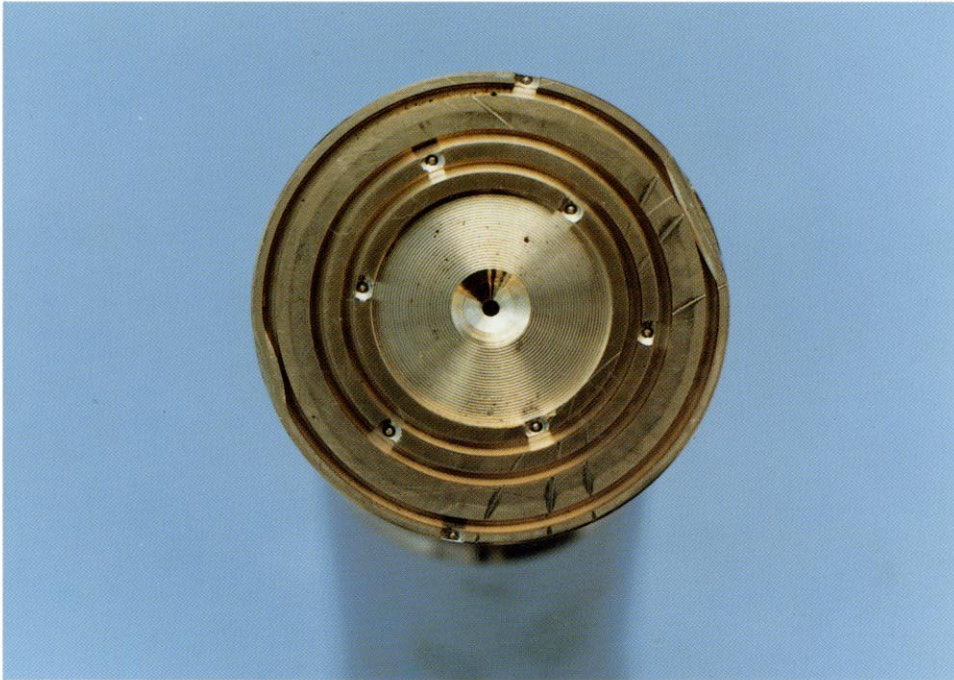


Category : C

Condition: Many deep scratches in shoe sliding surface.

Cause : Broken particles getting caught.

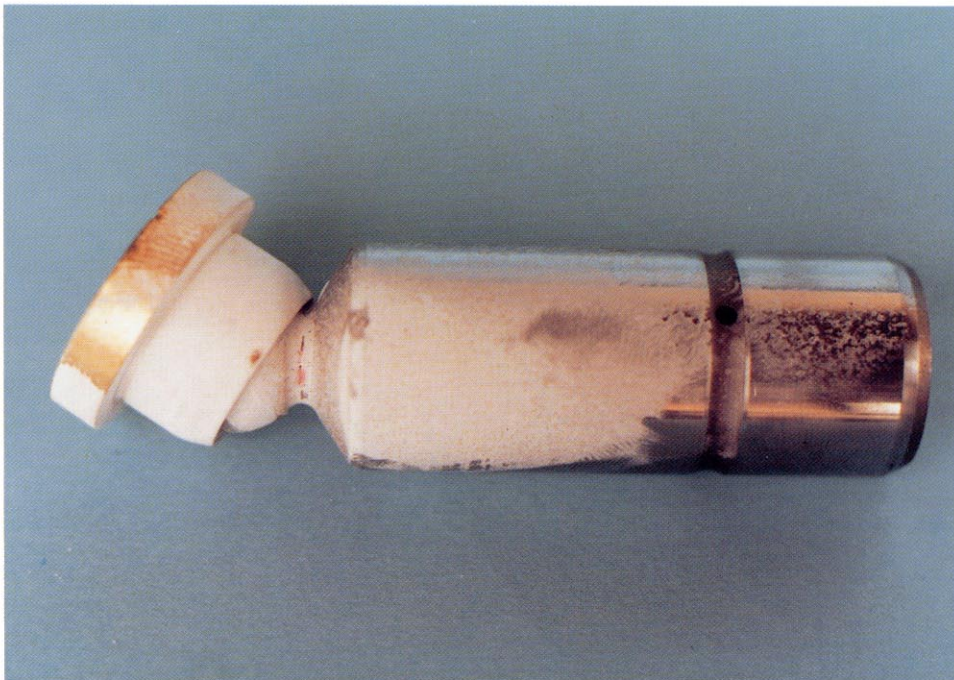
39



Category : C

Condition: Pressure dents at end of shoe sliding surface, and oil groove blocked.

40



Category : C

Condition: Cracks in neck of ball.

Cause : Defect in material, etc.

PREVENTIVE MAINTENANCE

To prevent failures in the machine before they occur, and to allow the machine to demonstrate its function 100% it is necessary always to know the condition of the machine, in particular to be aware of abnormal noise, particles of worn metal in the lubricating oil, and the level of the lubricating oil. In addition, by carrying out maintenance correctly as listed in the operation manual, most damage can be prevented, but be particularly sure to have the user carry out the following points properly.

- Always use genuine Komatsu lubricating oil, keep to the prescribed change intervals, and use lubricating oil to correspond with changes in the ambient temperature.
- Always warm up the engine thoroughly. Avoid as far as possible applying sudden excessive loads, accelerating suddenly or stopping suddenly.
- When the operator feels there is some abnormality, he should stop using the machine immediately and look for the cause.
- Carry out oil analysis periodically, and make every effort to prevent failure in the machine.

