

GUIDANCE FOR REUSABLE PARTS

ENGINE

**CYLINDER HEADS
AND VALVES**



GUIDANCE FOR REUSABLE PARTS
KOMATSU

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INTRODUCTION

This publication contains colored photographs of typical failures encountered with cylinder heads and valves, at the time of engine disassembling and inspection, and is intended to provide guidelines for determining by visual inspection whether the parts are fit to be reused or not, prior to reassembly. This guide also contains basic information on the parts and explanations of the failures and their causes.

Because engine parts of construction equipment are usually operated at high speeds under heavy loads, heat and exhaust gas, and the condition of the coolant, engine oil, and fuel have profound effects on the failures. Thus, failure symptoms of engine parts are quite different to those appearing in other components.

Moreover, engine parts failures in general are caused by a single cause, multiple causes, or their combined effects and so are varied in nature, so that this publication should be useful for anybody engaged in the diagnosis and repairs of construction equipment engines.

The writers will be gratified if, "lowering of repair costs" through appropriate reuse of parts, as well as, "prevention of reoccurrence of failures" through correct diagnosis of their causes, is achieved.

This publication is intended for guidance only and KOMATSU LTD. hereby expressly denies and excludes any representation, warranty or implied warranty of the reuse of cylinder heads, or valves.

FAILURE SIGNS, THEIR CAUSES AND DIAGNOSIS FOR REUSAGE

When determining whether engine parts can be reused or not, it is important to consider daily maintenance and work conditions, and search for “what caused the very failure”, and how to eliminate it. Combined with the distributor’s acquired experience, the photographs of typical failures ranked by three should be used as guidelines to determine reusage of each part.

Moreover, the extent of the failure is an important factor in determining whether that part is reusable or not, however, full consideration should be paid to the risk against damage borne in the engine as a result of reusing a failed part.

Inspection Points for Parts Reusage Diagnosis

To inspect failed parts, correctly wash and clean the parts and then inspect them by referring to the following inspection points.

Part name	Inspection points
Cylinder head	<ul style="list-style-type: none">● Cracks in the intake and exhaust valve port area● Cracks, deformations
Valve seat	<ul style="list-style-type: none">● Cracks in the valve seat surface● Damage and wear on valve seat surface
Valve guide	<ul style="list-style-type: none">● Wear to inner surface of valve guide● Damage on upper end surface of valve guide
Valve	<ul style="list-style-type: none">● Damage and wear on valve stem face● Damage and wear to cotter groove● Stepped wear on valve stem top surface

Note: When using a wire brush to remove carbon and other accumulations, care should be taken so as not to scratch the surface.

Standards for Failure Determination

Rank	Failure degree
Use again (As is)	<ul style="list-style-type: none"> ● The failure does not affect engine performance, and will not cause secondary failures.
Use after reconditioning	<ul style="list-style-type: none"> ● The failure does not immediately affect engine performance but is liable to cause secondary failures. ● If part is reconditioned part can be reused.
Do not use again	<ul style="list-style-type: none"> ● Performance of the engine is clearly affected by the failure, and further use of the part will surely cause severe damage.

Note: To determine the amount of wear, refer to the Repair limit and Maintenance standards' in the Shop Manual.

Cylinder Heads : Determination for Reusage

Location of failure	Rank	Failure degree
Injector sleeve and Pre-combustion chamber	Use again (As is)	<ul style="list-style-type: none"> ● Slightly scratched
	Use after reconditioning	<ul style="list-style-type: none"> ● Dents 0.5 mm or less in depth ● Cracks 3 mm or less in length, that are discernable by 'color check'.
	Do not use again	<ul style="list-style-type: none"> ● Dents deeper than the above or: ● Damage through melting
Intake and exhaust port	Use again (As is)	<ul style="list-style-type: none"> ● No cracks are seen.
	Do not use again	<ul style="list-style-type: none"> ● Cracks become discernable using the 'color check' method.

Valve Seats: Determination for Reusage

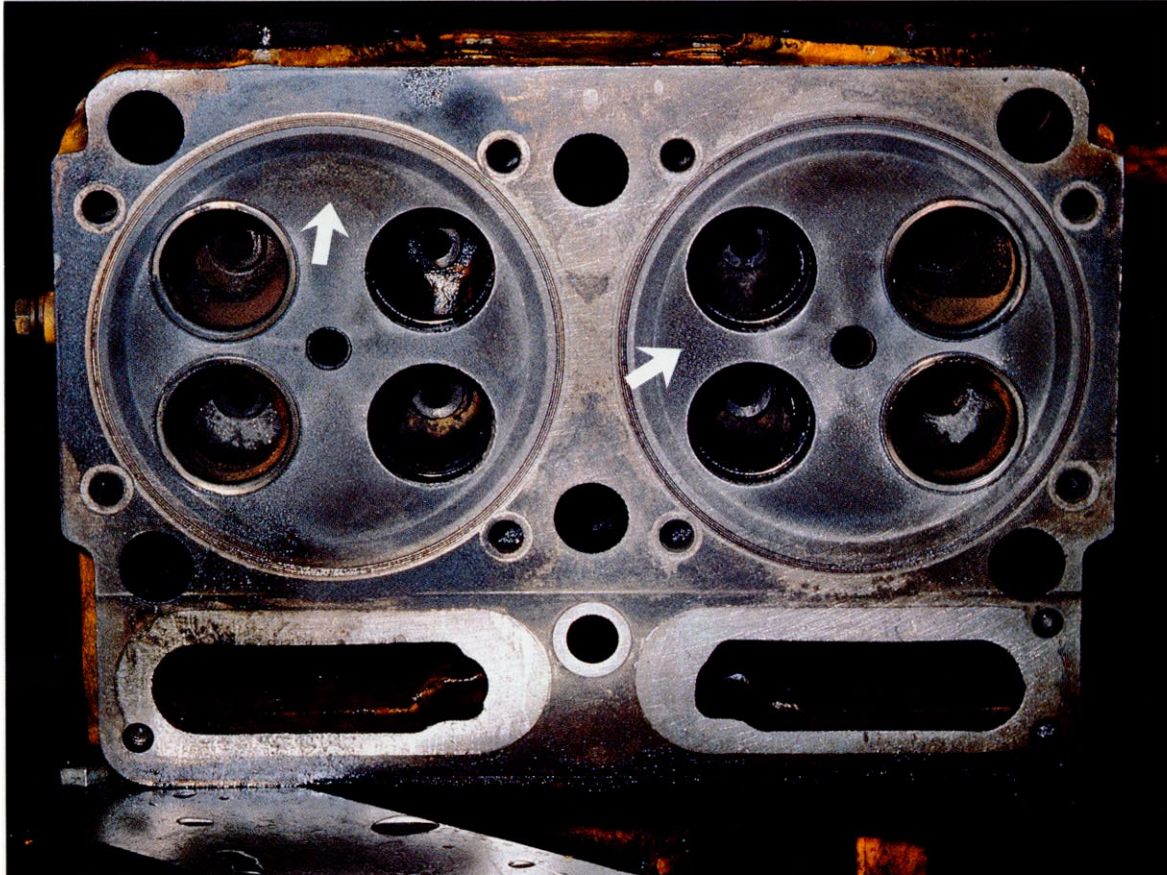
Location of failure	Rank	Failure degree
Valve seat cracks	Use again (As is)	<ul style="list-style-type: none"> No cracks are found.
	Use after reconditioning	<ul style="list-style-type: none"> No cracks are found.
	Do not use again	<ul style="list-style-type: none"> Cracks become discernable with the color check.
Valve seat dents, and wear	Use again (As is)	<ul style="list-style-type: none"> Slight scratches
	Use after reconditioning	<ul style="list-style-type: none"> Dents 0.5 mm or less Noticeable wear
	Do not use again	<ul style="list-style-type: none"> Dents or wear in excess of the above.

Valve Guides: Determination for Reusage

Clearance between the valve guide and the valve stem should be determined according to the repair limit and 'maintenance standard' outlined in the Shop Manual.

Valves: Determination for Reusage

Location of failure	Rank	Failure degree
Valve stem	Use again (As is)	<ul style="list-style-type: none"> No scratches, scuffing or step-wear
	Use after reconditioning	<ul style="list-style-type: none"> Slight scratches Slight step-wear (not felt with finger-nail)
	Do not use again	<ul style="list-style-type: none"> Scratches or step-wear in excess to the above
Valve stem (end)	Use again (As is)	<ul style="list-style-type: none"> Roughness or step-wear not felt by the finger-nail
	Use after reconditioning	<ul style="list-style-type: none"> Scratches or wear slightly felt by the finger-nail
	Do not use again	<ul style="list-style-type: none"> Scratches 0.3 mm or more deep damage in excess to the above
Valve face	Use again (As is)	<ul style="list-style-type: none"> No nicks, cracks, or melting
	Use after reconditioning	<ul style="list-style-type: none"> No nicks, cracks, or channeling
	Do not use again	<ul style="list-style-type: none"> Discernible nicks, or channeling and cracks by 'color check'.



USE AGAIN

Failure Signs

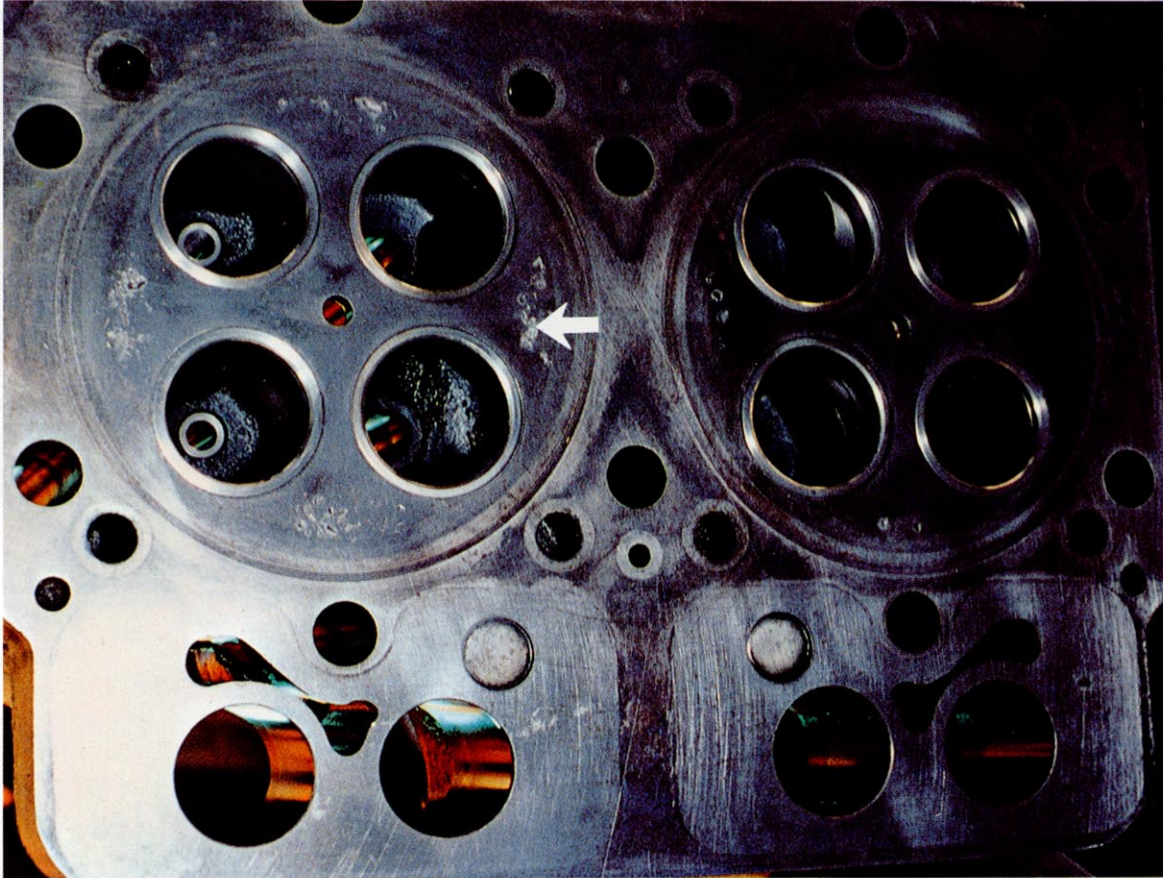
- Slight scratches and corrosion on bottom surface of the cylinder head.

Causes

- Dust and foreign matter entering with intake air.

Note:

Corrosion is caused by combustion gases, and moisture etc. slight corrosion is no problem.



USE AFTER RECONDITIONING

Failure Signs

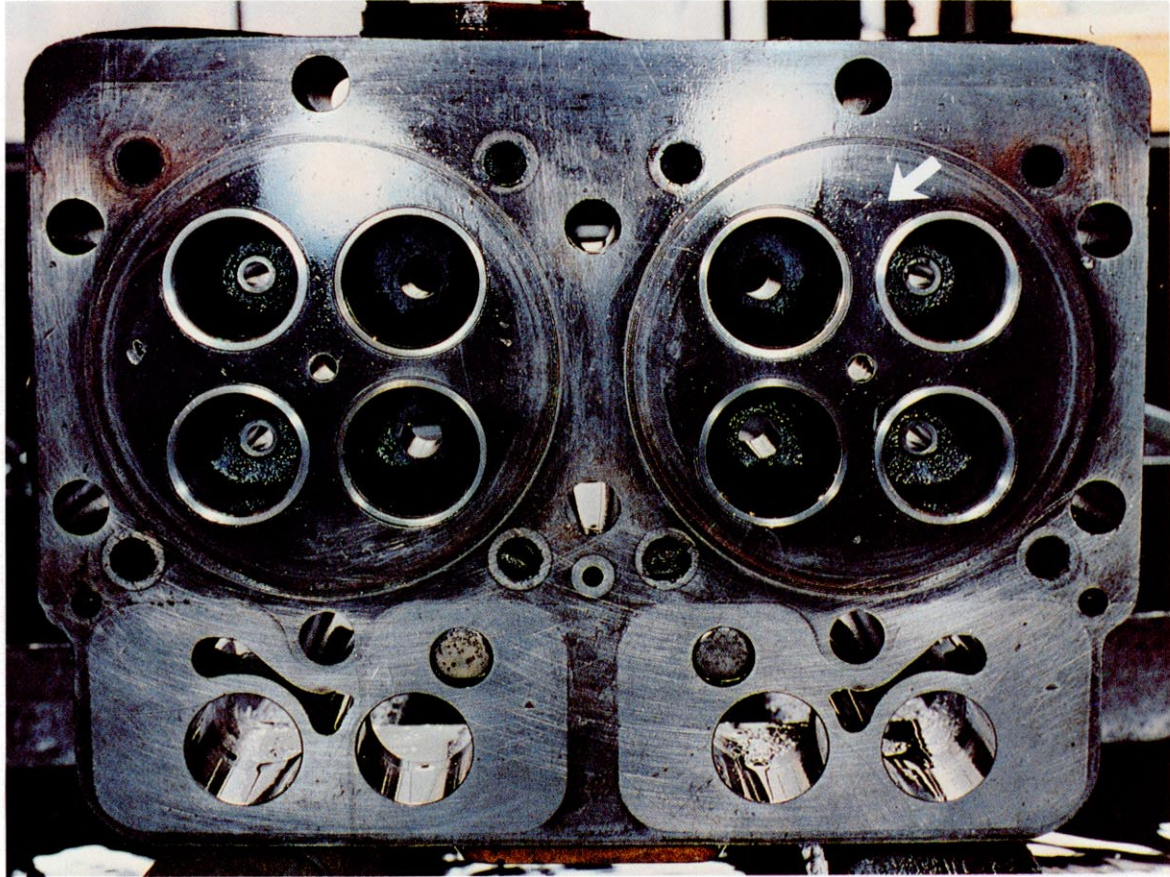
- Slight dents and scratches are discernible.

Causes

- Dust and foreign matter entering with intake air.

Reconditioning Method

- Refinish by lightly rubbing with sand paper, and reuse.



USE AFTER RECONDITIONING

Failure Signs

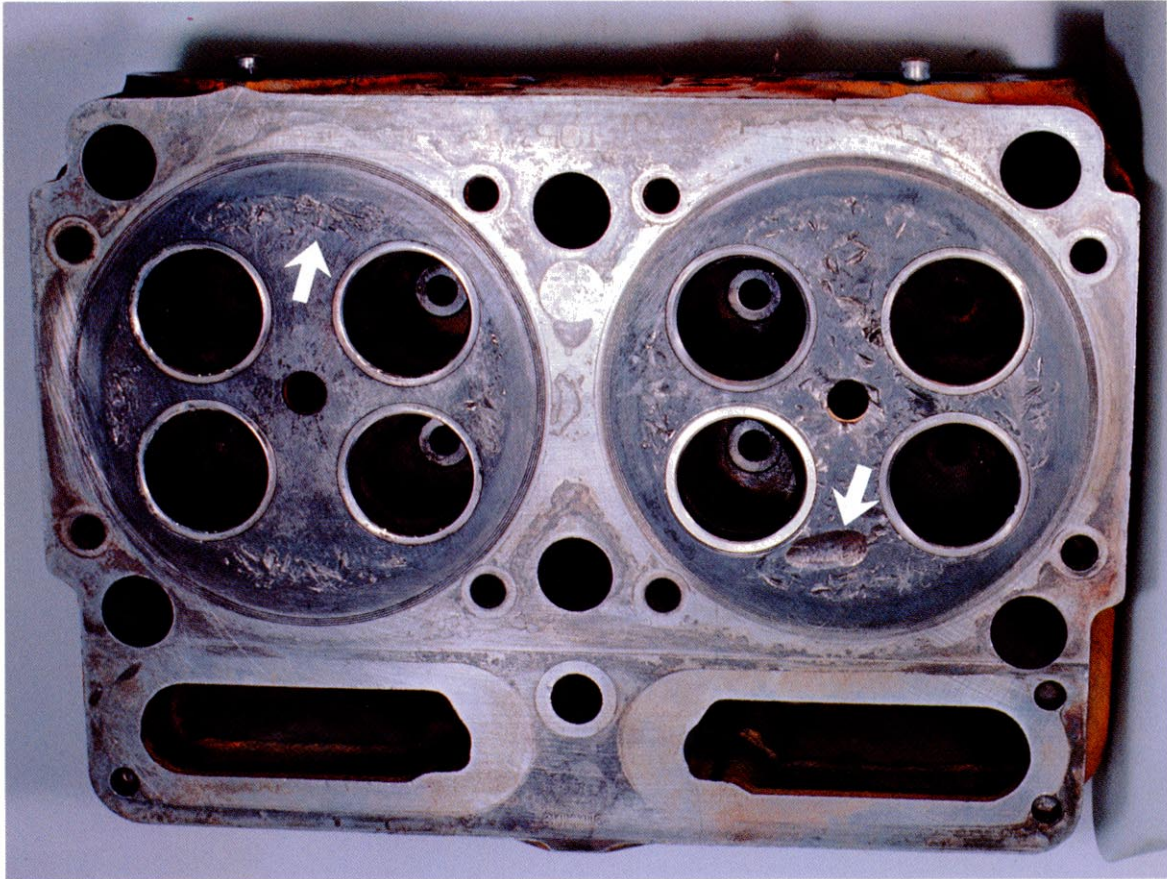
- Cylinder head bottom surface has slight scratches and dents (0.3 mm or less in depth)

Causes

- Overfueling, engine over running, etc. causes damage to the valve and valve seat, and loosened metal pieces cause secondary failures.
- Foreign matter in the air intake.

Reconditioning Method

- Remove burrs etc. with sand paper and reuse.



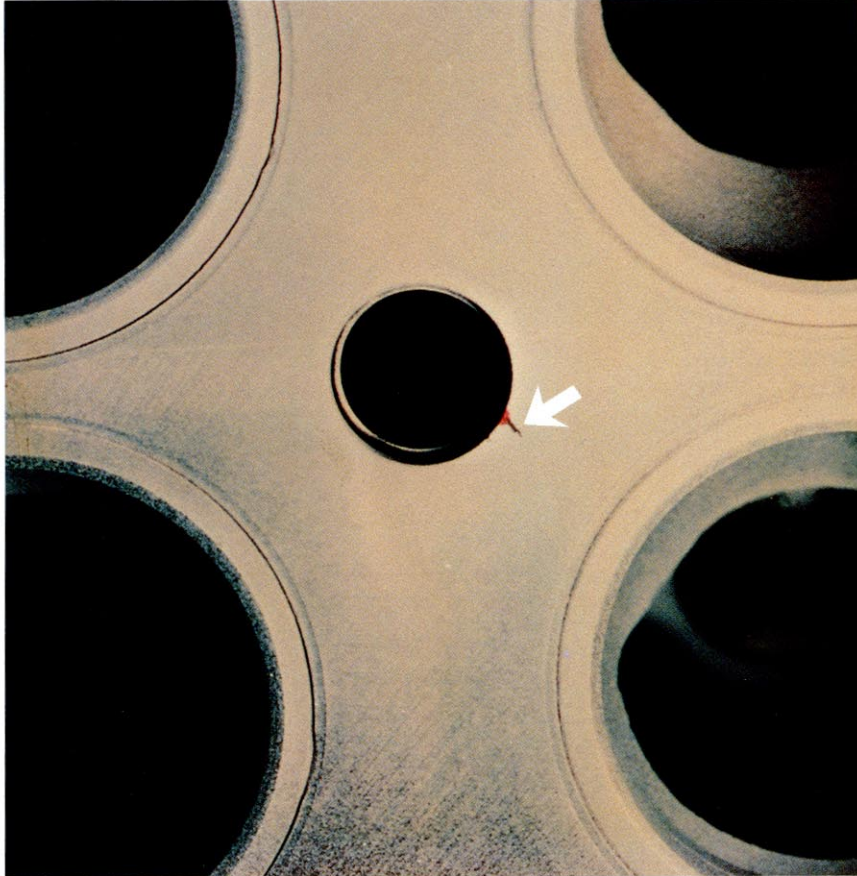
DO NOT USE AGAIN

Failure Signs

- Large and deep dents (0.3 mm or more in depth) are observed on the bottom surface.

Causes

- Small parts or broken pieces in the cylinder have caused secondary damage by hitting the cylinder head bottom surface.



USE AFTER RECONDITIONING

Failure Signs

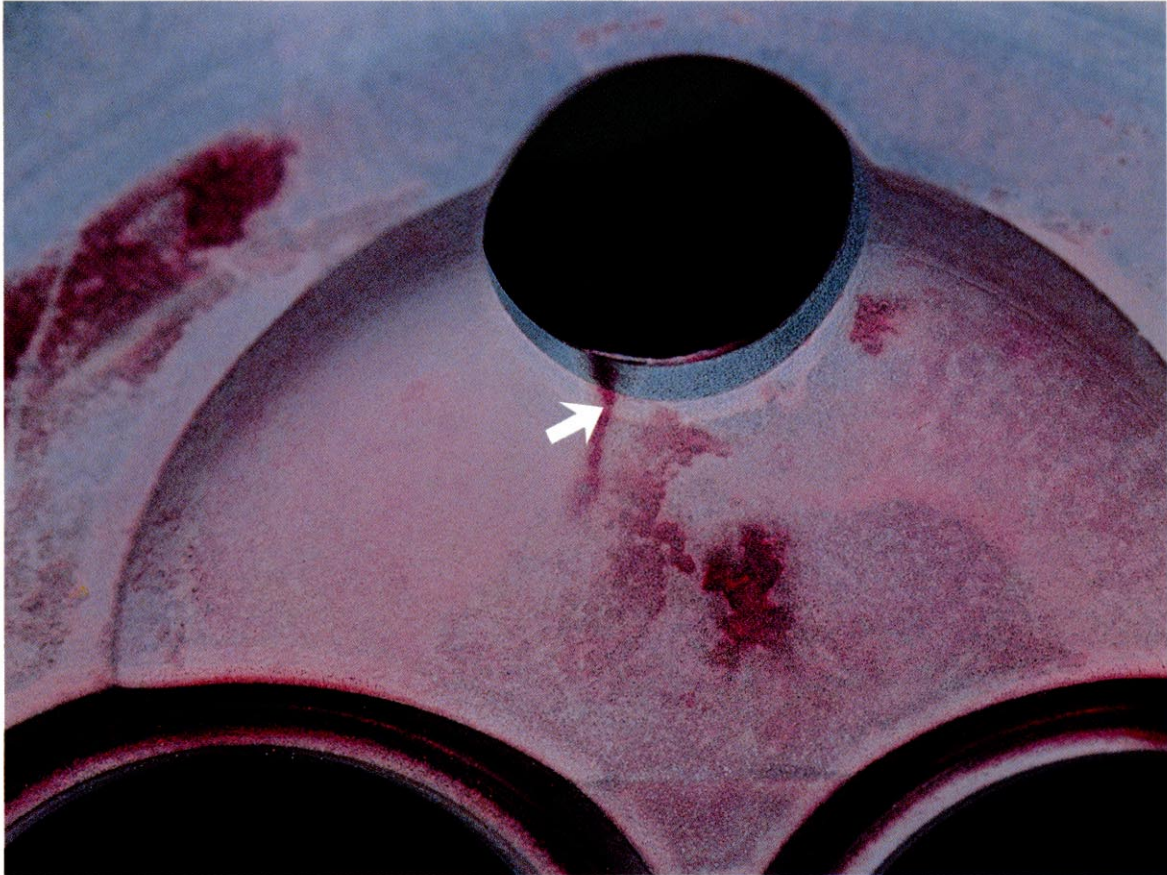
- Area around fuel injector bore has fine cracks. (less than 3.0 mm in length) only revealed by 'color check'.

Causes

- Overheating (running with insufficient coolant)
- Overfueling
- Incorrect injection timing
- Sudden engine stopping
- Water fur collected on cylinder head bottom surface
- Air cleaner is clogged.

Reconditioning Method

- After refinishing the cracked area with a small grinder, finish off with sand paper and reuse the cylinder head.



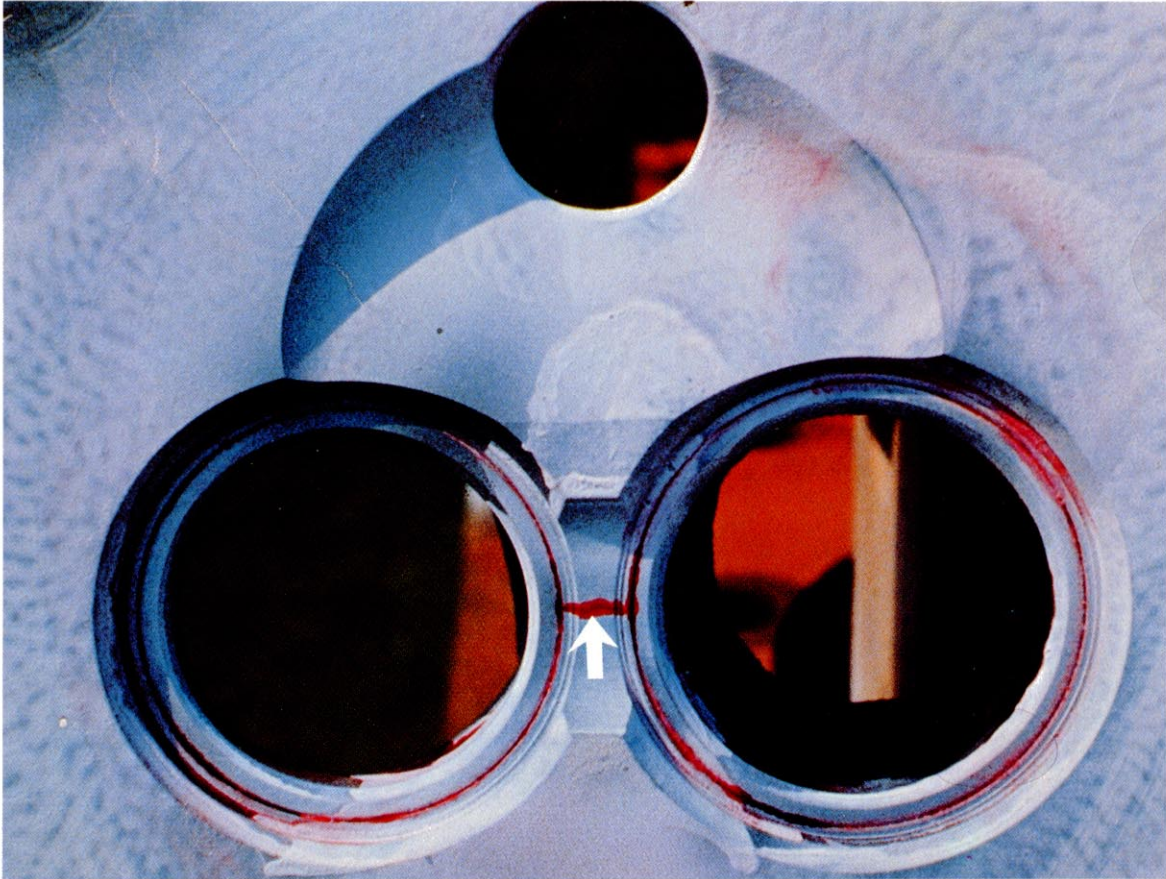
DO NOT USE AGAIN

Failure Signs

- Cracks (3.0 mm or over in length) appear around the combustion chamber when 'color check' is applied.

Causes

- Overheating (running with insufficient coolant)
- Overfueling
- Incorrect injection timing
- Sudden engine stopping
- Water fur collected on cylinder head bottom surface
- Air cleaner is clogged.



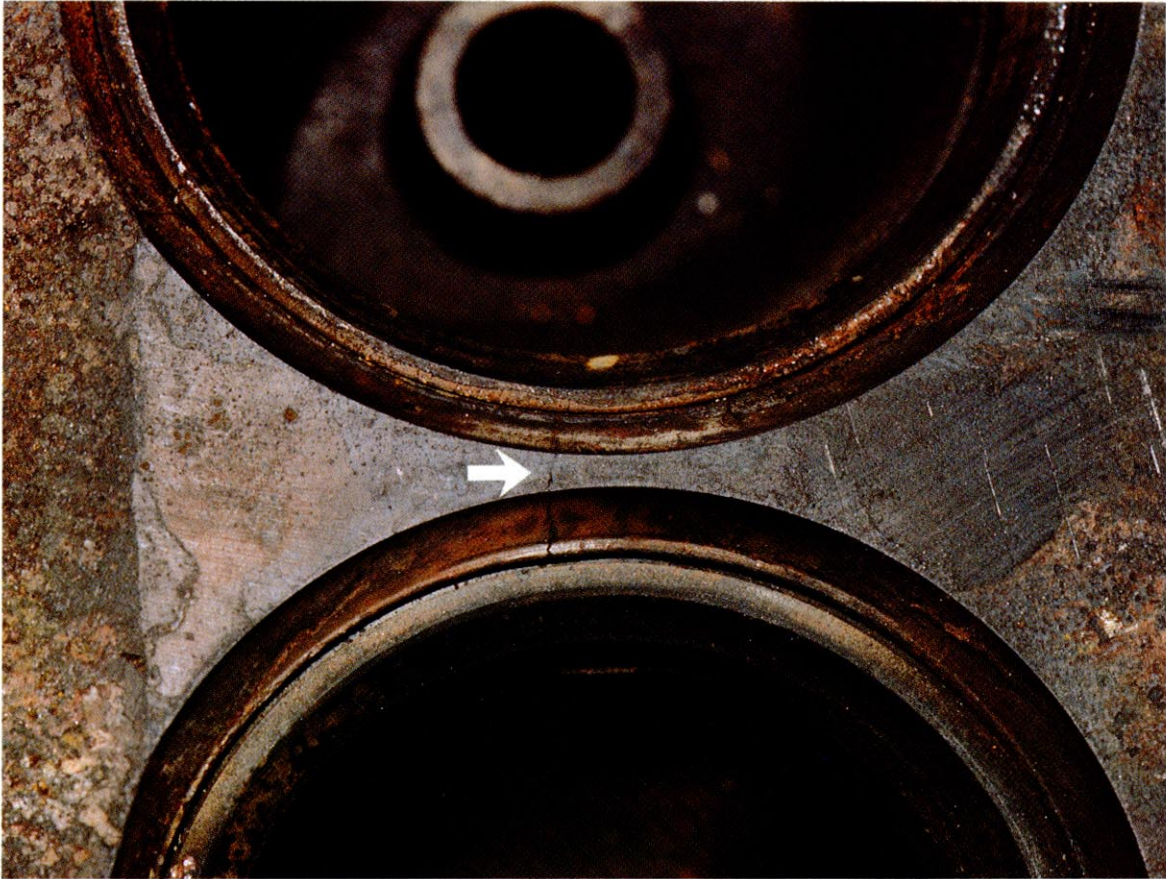
DO NOT USE AGAIN

Failure Signs

- Cracks appear between the valve ports when 'color check' is applied.

Causes

- Overheating (running with insufficient coolant)
- Overfueling
- Incorrect injection timing
- Sudden engine stopping
- Water fur collected on cylinder head bottom surface
- Air cleaner is clogged.



DO NOT USE AGAIN

Failure Signs

- Cracks are visible between the valve ports.

Causes

- Overheating (running with insufficient coolant)
- Overfueling
- Incorrect injection timing
- Sudden engine stopping
- Water fur collected on cylinder head bottom surface
- Air cleaner is clogged.



DO NOT USE AGAIN

Failure Signs

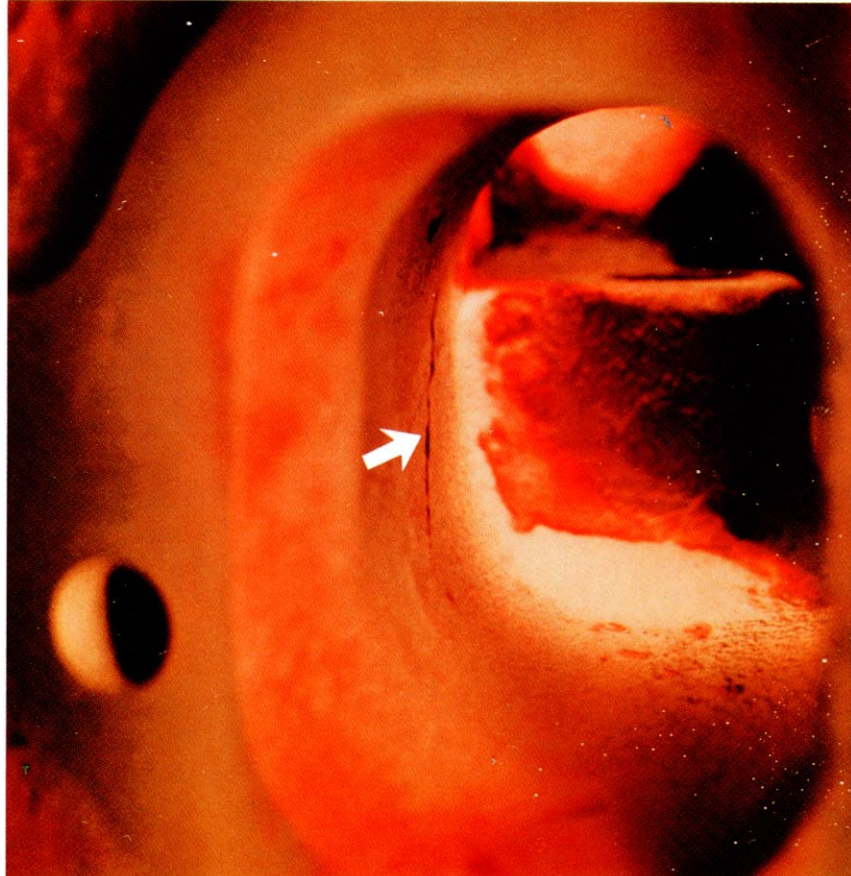
- Cracks and rust are visible around the valve ports.

Causes

- Water leakage into the cylinder.

Note:

When water leakage into the cylinder is observed, check the seat area carefully, visually and also by 'color check'.



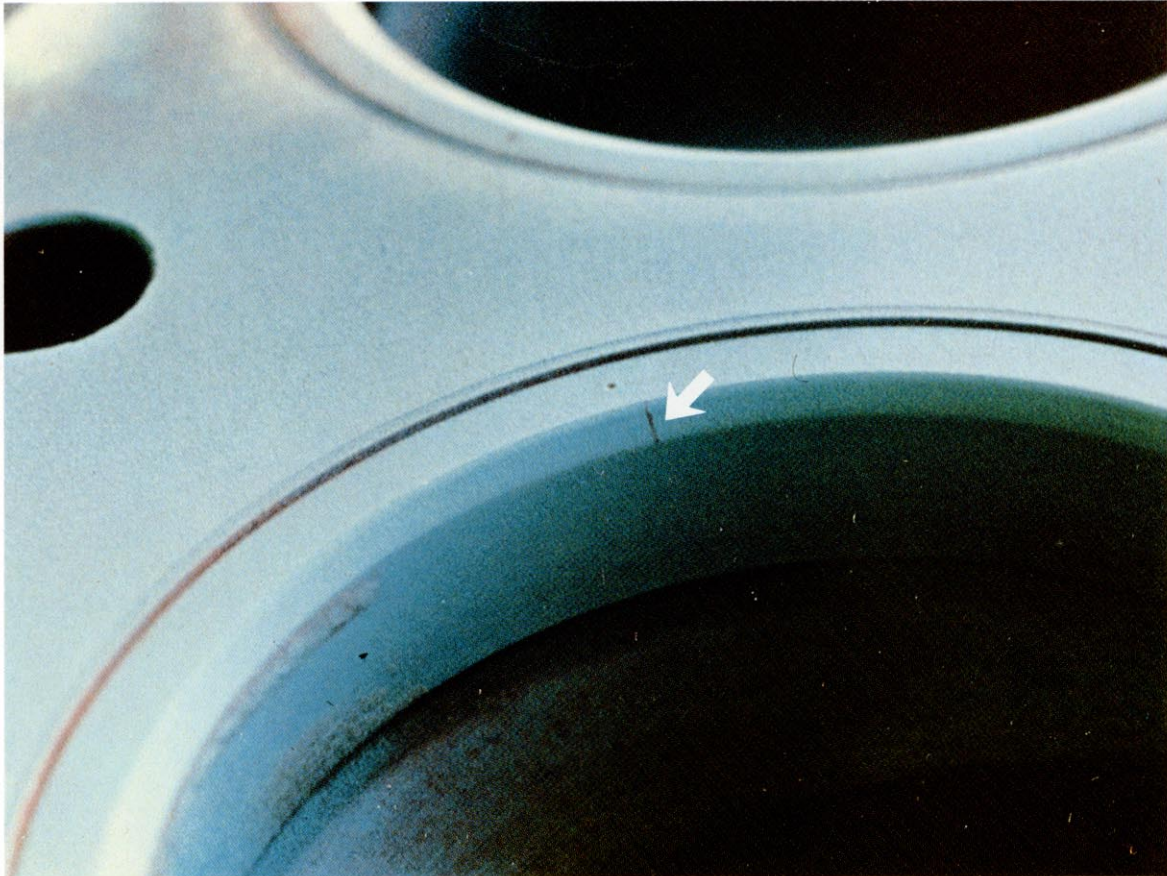
DO NOT USE AGAIN

Failure Signs

- Cracks are observed inside the air intake port or the exhaust port.

Causes

- Over-torquing of the cylinder head bolts
- Overheating (running with insufficient coolant)
- Overfueling
- Incorrect injection timing
- Sudden engine stopping
- Water fur collected on cylinder head bottom surface
- Air cleaner is clogged.



DO NOT USE AGAIN

Failure Signs

- Fine cracks appear on the valve seat inner surface when 'color check' is applied.

Causes

- Overheating
- Overfueling
- Air cleaner is badly clogged.
- Mal-contacting between valve and valve seat (blow-through of exhaust gases)
- Water leakage from around injector sleeve.
- Water leakage from after cooler area



USE AGAIN

Failure Signs

- Valve face seating is proper and only slight wear is visible.



USE AFTER RECONDITIONING

Failure Signs

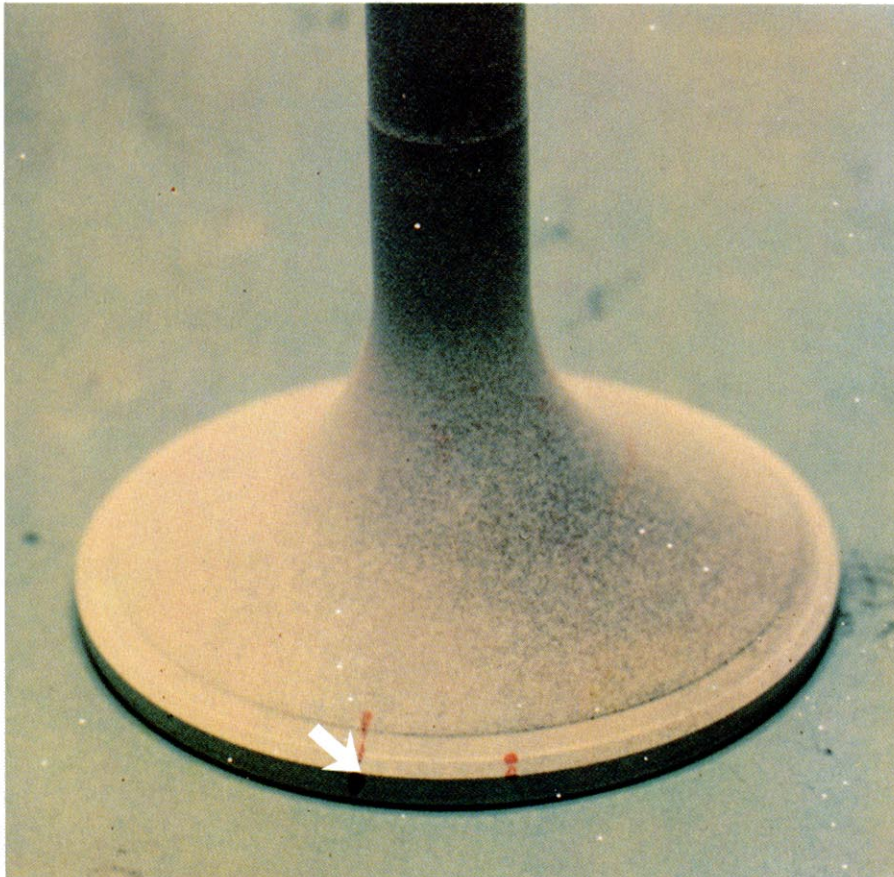
- Valve face seating is proper but visible wear is fairly considerable.

Causes

- Normal wear caused by usage over a fairly long time.

Reconditioning Method

- Regrind the valve face and reuse the part.



DO NOT USE AGAIN

Failure Signs

- Fine cracks appear on the valve face area when 'color check' is applied.

Causes

- Foreign matter chewed by the valve.
- Valve clearance is too much.
- Overfueling
- Engine over running
- Improper injection timing



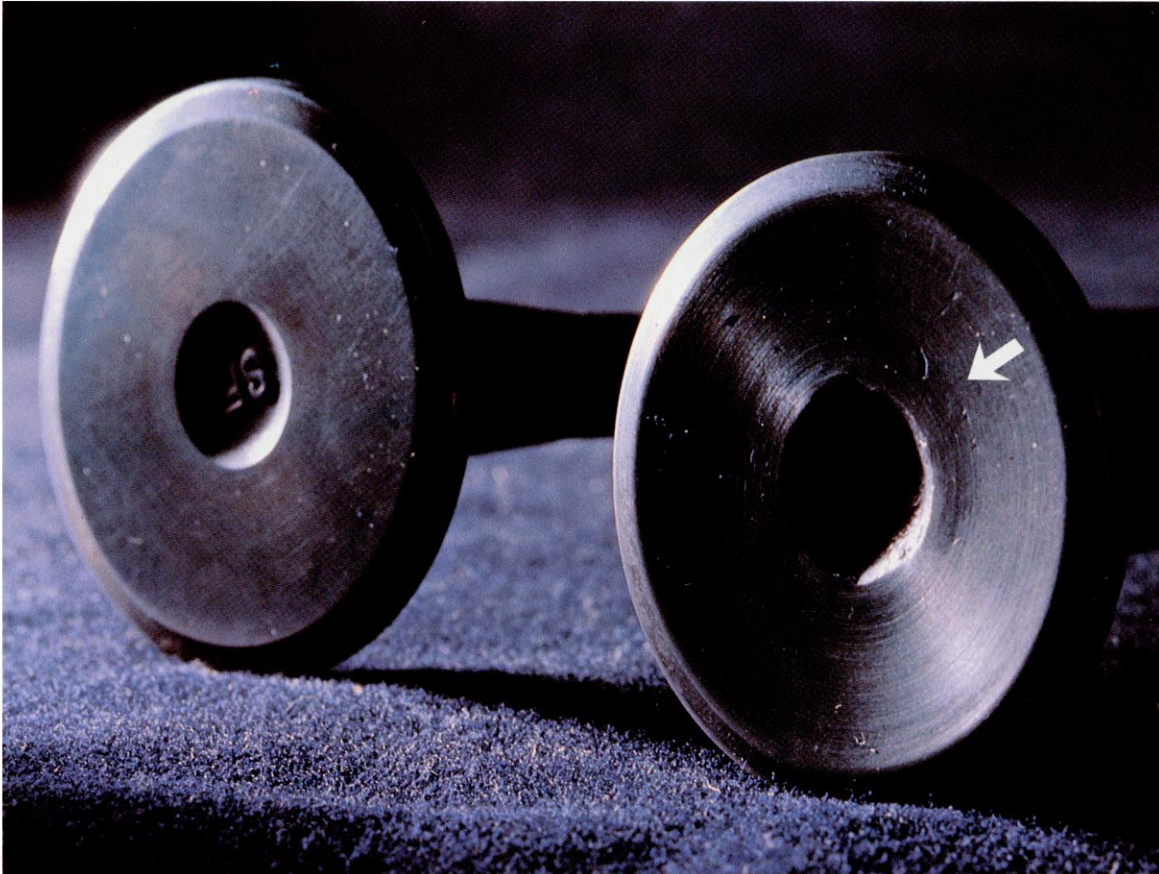
DO NOT USE AGAIN

Failure Signs

- A large crack and nick is observed on the valve face.

Causes

- Foreign matter chewed by the valve.
- Valve clearance is too much.
- Overfueling
- Engine over running
- Improper injection timing



DO NOT USE AGAIN

Failure Signs

- Valve head bottom surface has deformed and become concave. (on right)

Causes

- Overheating
- Engine over running
- Overfueling

Note:

Even a slight deformation of the valve head bottom surface renders the valve useless.



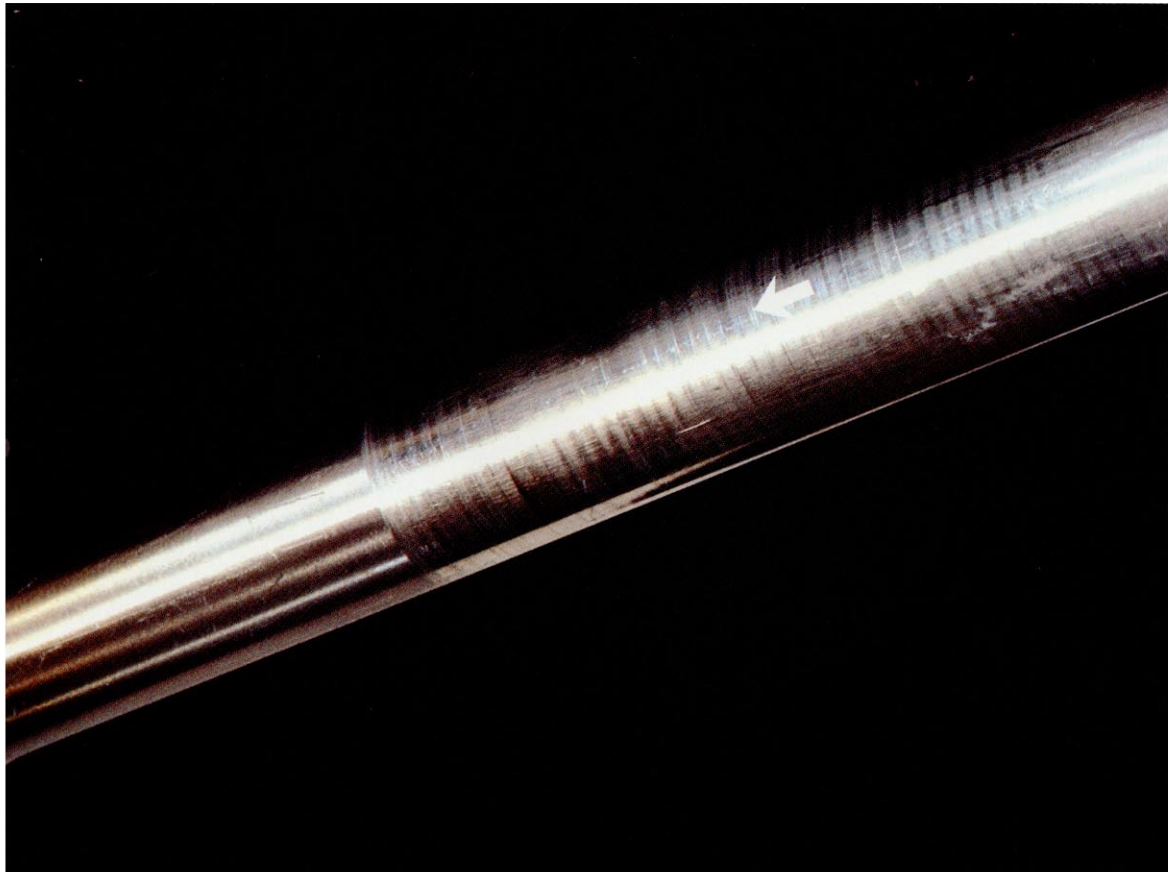
USE AGAIN

Failure Signs

- The valve stem outer surface has slight cylindrical wear bands, however step-wear is not felt by running the finger-nail over the wear bands.

Causes

- Foreign matter entering through the air intake system.
- Carbon accumulations on the valve guides.
- Excessive clearance or poor concentricity, between valve stem and valve guide.



USE AFTER RECONDITIONING

Failure Signs

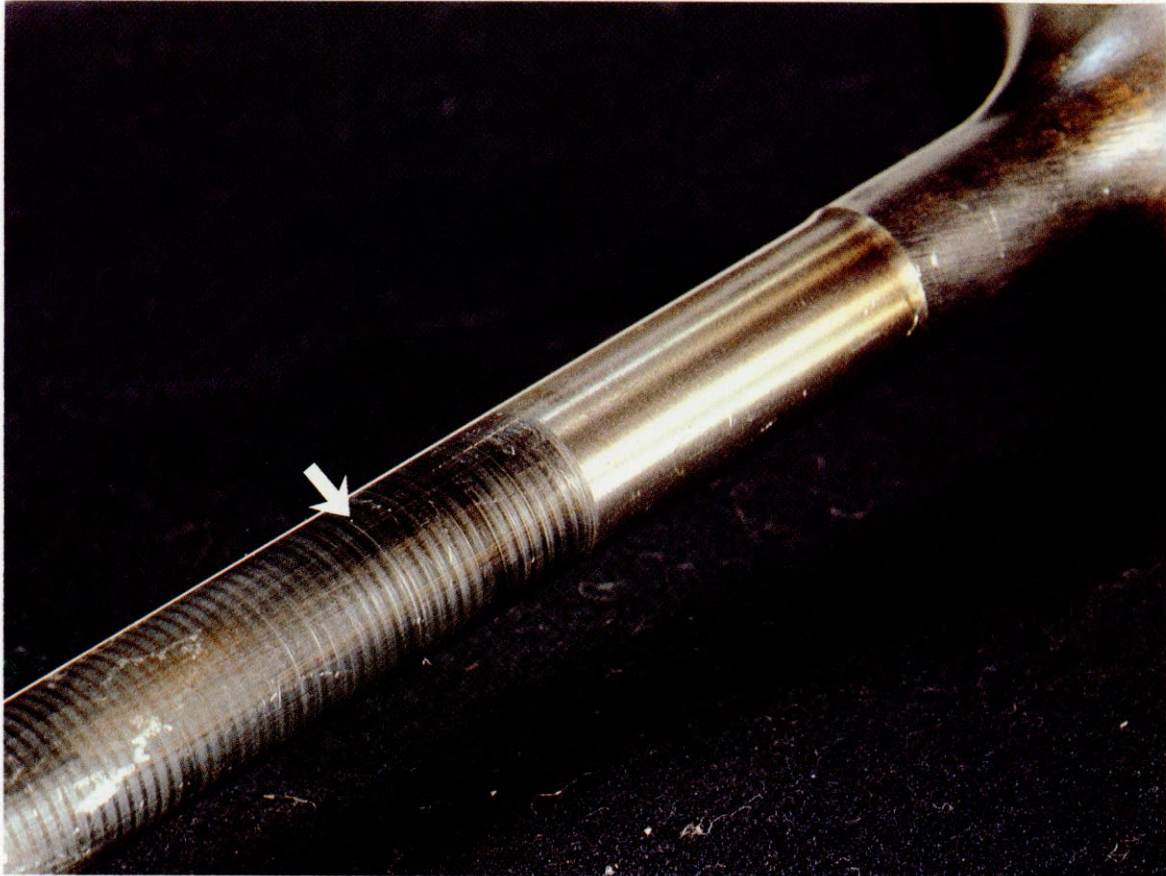
- Stem outer surface has cylindrical wear bands, and stepped wear is visible but cannot be felt by running the finger-nail over the stepped areas.

Causes

- Water and/or fuel has mixed with the engine oil, and its properties have deteriorated.
- Foreign matter entering through the air intake system.
- Carbon accumulations on the valve guides.
- Excessive clearance or poor concentricity, between valve stem and valve guide.

Reconditioning Method

- Lightly and carefully refinish the stepped wear by rubbing with 'fine' grade sand paper.
- Check for failure signs in the valve guide, and if necessary replace it.



DO NOT USE AGAIN

Failure Signs

- The valve stem outer surface has cylindrical wear bands, and in addition, fine scratches on the surface along the stem axis. The stepped wear is evident with the 'finger-nail' check.

Causes

- Foreign matter entering through the air intake system.
- Carbon accumulations on the valve guides.
- Excessive clearance or poor concentricity, between valve stem and valve guide.

Note:

Also replace the valve guide.



DO NOT USE AGAIN

Failure Signs

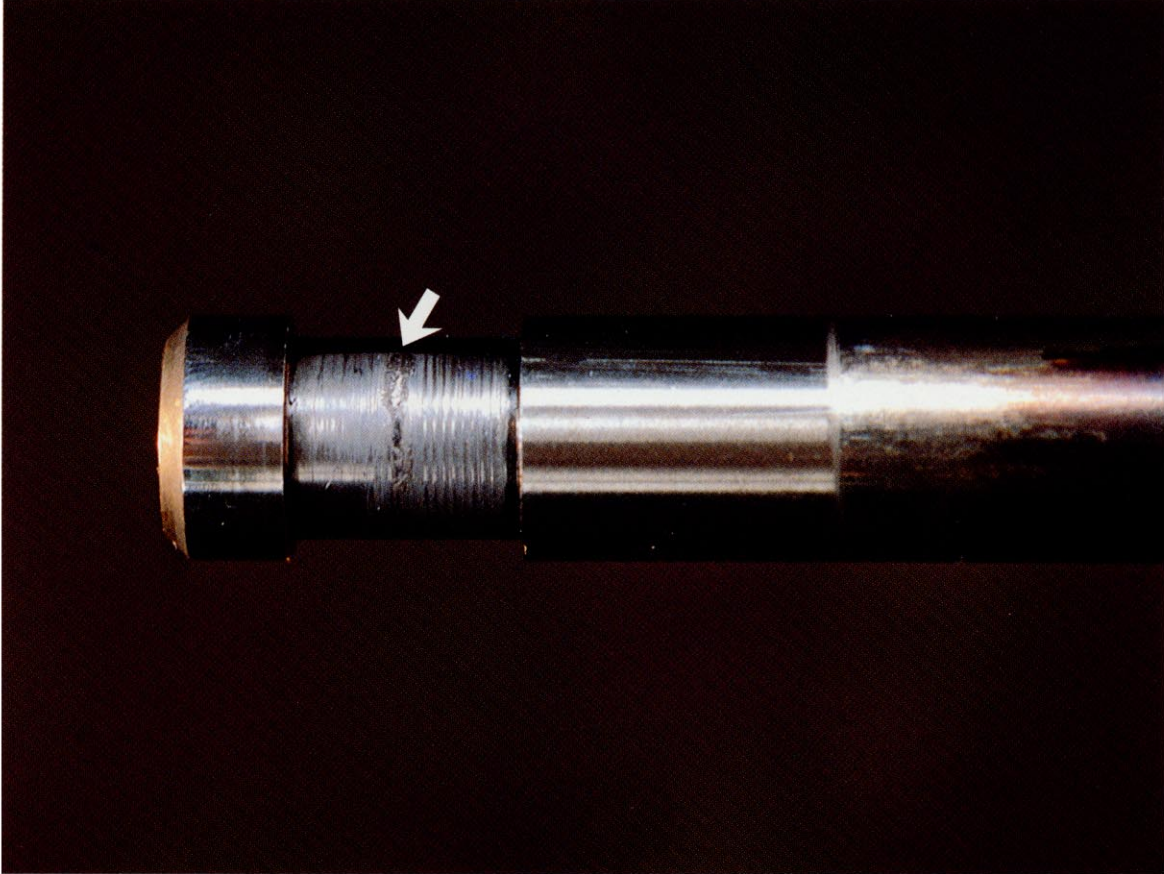
- Corrosion is visible on the valve stem and the valve head surfaces.

Causes

- Use of poor quality fuel containing sulfur.
- Use of heavy oil or, fuel mixed with heavy oil.

Note:

Check fuel and use normal designated fuel.



DO NOT USE AGAIN

Failure Signs

- The 'cutter' part of the valve shows ring-like wear, and a part of it shows signs of jamming.

Causes

- Engine over running repeatedly.

Note:

Abnormalities in the 'cutter' area renders the part unuseable.



USE AGAIN

Failure Signs

- The stem top surface shows signs of slight wear.

Causes

- Cylinder head oil passage line clogging.
- Overheating (to abnormally high engine oil temperatures)
- Overloading the stem top surface by engine over running.



USE AFTER RECONDITIONING

Failure Signs

- The stem top surface has shallow scratch marks.

Causes

- Cylinder head oil passage line clogging.
- Overheating (to abnormally high engine oil temperatures)
- Overloading the stem top surface by engine over running.

Reconditioning Method

- Refinish by grinding the top surface of the valve stem and reuse. However, reuse is possible only while the chamfered edge remains.
- If the depth of the scratch marks are more shallow than shown, refinishing with sand paper will be sufficient.



DO NOT USE AGAIN

Failure Signs

- The valve stem top surface shows wear and fairly deep scratch marks.

Causes

- Cylinder head oil passage line clogging.
- Overheating (to abnormally high engine oil temperatures)
- Overloading the stem top surface by engine over running.

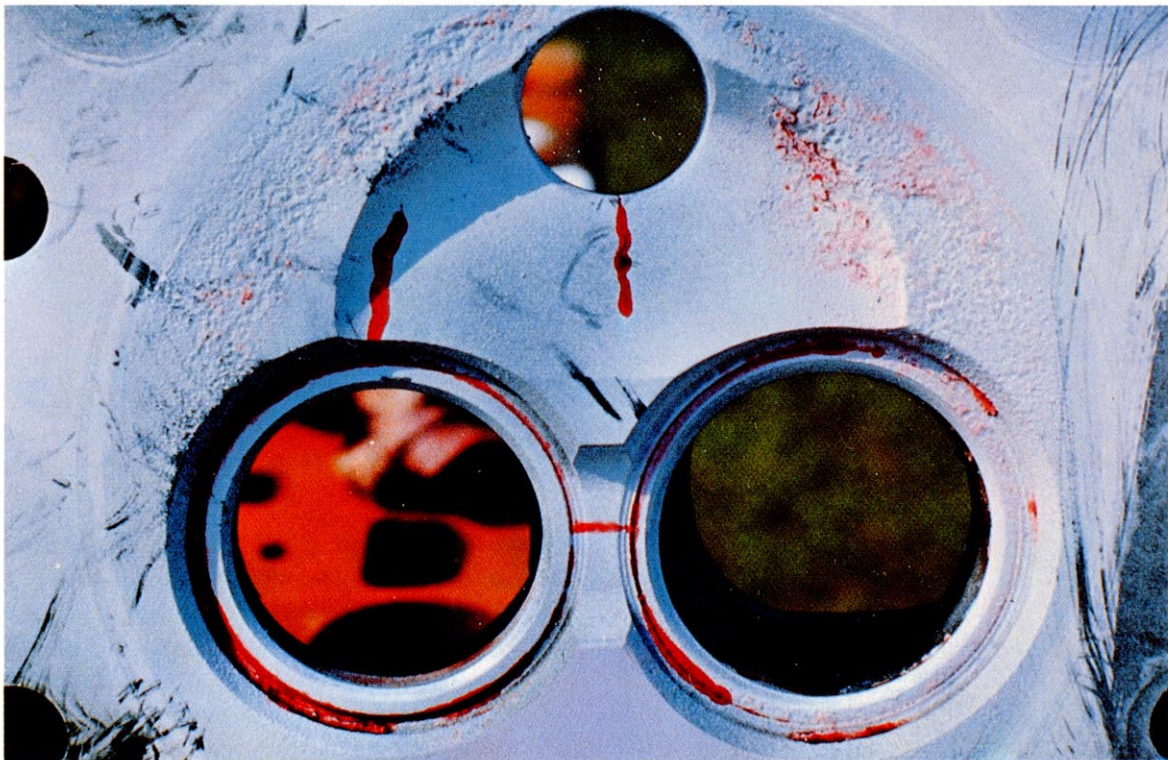
TYPICAL EXAMPLES OF FAILURES

Cylinder Head Failures

Crack Development

Improper combustion due to overfueling, incorrect injection timing, as well as, inadequate cooling or use of unsuitable water, will cause overheating of the combustion chamber of the cylinder head, and as a result will induce the development of cracks.

Normally, most of the cracks develop around the valve port and injector bore; areas most exposed to the excessive heat.



Causes

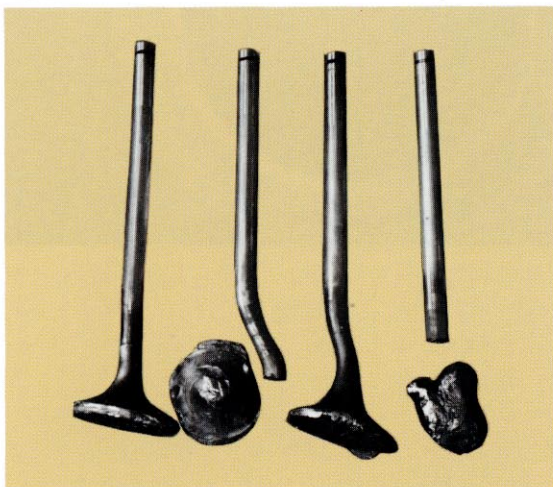
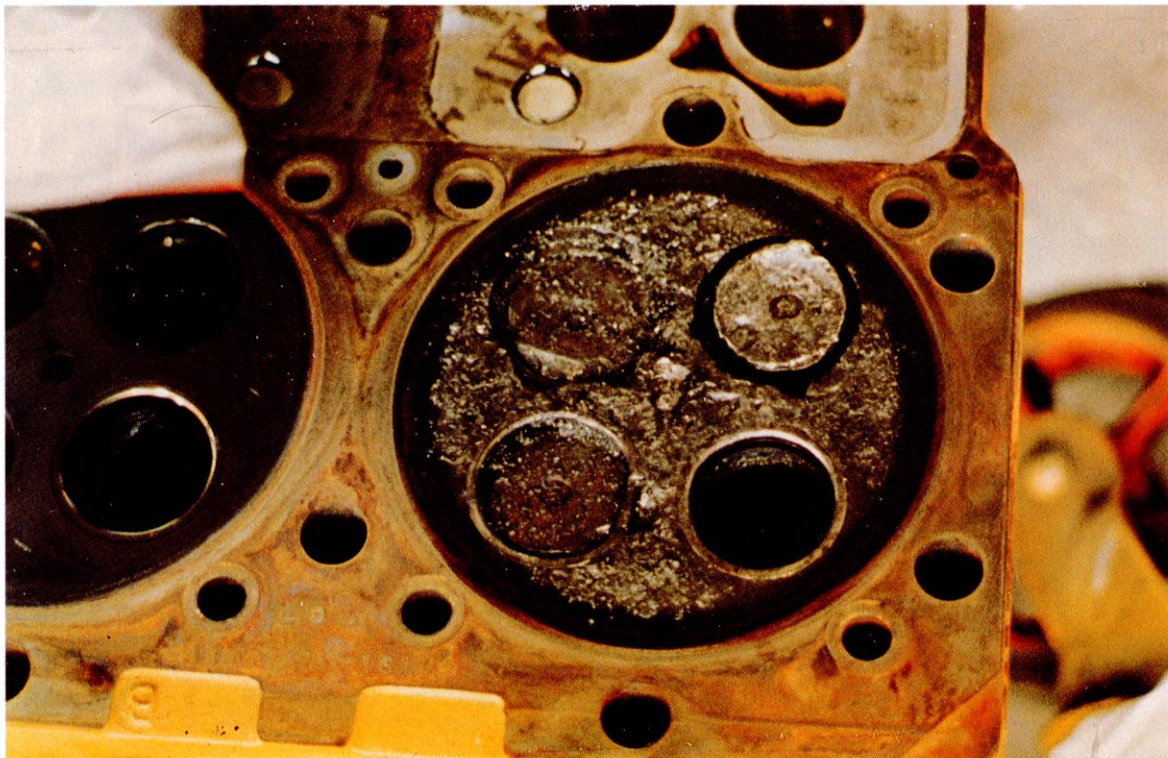
- Overfueling
- Improper injection timing
- Overheating
- Water leakage into the combustion chamber

Note:

To check for water leakage, use a 'cylinder head hydraulic tester'.

Failure from Foreign Matter

Secondary failures result when foreign matter enter through the air intake and cause damage to the valve and valve seat, broken parts of which are hit by the piston head and bottom surface of the cylinder head.

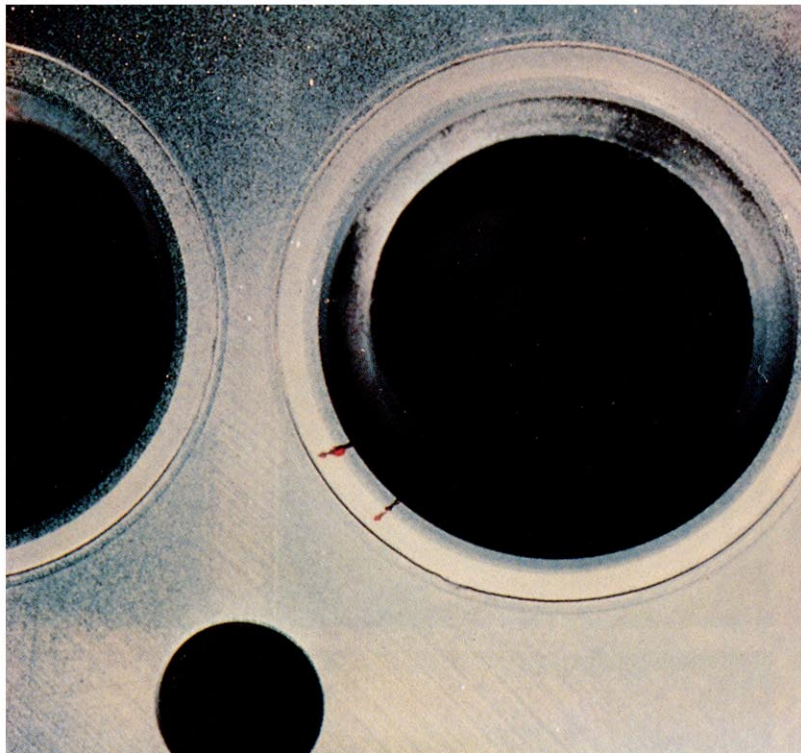


Causes

- Valve falls down.
- Valve seat falls down.
- Foreign matter enters from the air intake system.
- Turbocharger or blower impeller is damaged.

Valves Seat Crack Development

Improper combustion due to overfueling, incorrect injection timing, as well as, inadequate cooling or use of unsuitable water, will cause overheating, also, carbon will become lodged between the valve seat and valve face, and will cause cracks and abnormal wear to develop.



Causes

- Foreign matter enters from the air intake system.
- Overfueling
- Overheating
- Water leaks into the combustion chamber

Valve Failures

Valve Melting and Crack Development

Melting of the valve face may result from rapid and excessive heating caused by overfueling or improper injection timing. Also, cracks and abnormal wear may result from foreign matter passed through the air intake, and or carbon deposits becoming jammed between the valve and its seat.



Causes

- Foreign matter mixed with the air intake.
- Overfueling
- Improper injection timing.

Abnormal Wear of the Valve Stem

Abnormal wear and seizing may result from the mixing of dirt, water and fuel in the engine oil, causing lowering of its viscosity and lubricating properties, to in turn cause metal-to-metal contacting leading to this type of failure.



Causes

- Foreign matter mixed in the intaken air.
- Water and fuel leakage
- Insufficient engine oil

FAILURES AND THEIR CAUSES

Parts facing the combustion chamber such as, the cylinder head bottom surface, valve seats, and valves, in particular, are exposed to high temperatures (from 500°C to 700°C) while sustaining high pressures under repeated severe load conditions.

Failures to these parts are the result of multiple causes, however, whether conditions such as; maintenance of cooling water, lubricating oil, and fuel, entrance of foreign matter through the air intake system, and machine work operations etc. are proper or not will seriously affect failure development.

Cooling Water

Cooling water surrounding the cylinder head prevents excessive heat rise in the combustion chamber. Cracks and water leakage may develop in the cylinder head as a result of overheating caused by rust and scale accumulations.

Use of unsuitable water (hard water or water containing contaminants), insufficient cooling water, ineffective corrosion resistor etc. will result in rust and scale accumulations and consequent overheating and development of cylinder head cracks and water leakage.

Lubricating Oil

The valve stem and guide are lubricated by the engine oil, however, seizing and scoring of the parts may result through: oxidizing of the oil due to overheating, oil contamination by blow-by gases, oil deterioration and lowered viscosity caused by water and fuel mixing.

Fuel

Highly compressed fuel is injected into the combustion chamber, so that poor quality fuel may cause: seizing of the plunger; poor misting, due to nozzle clogging, and result in abnormal combustion. Abnormal combustion will cause carbon deposit at valve fillet area or valve seat, resulting in valve stick, bending, melting and cracks.

Air Intake

Dust and foreign matter mixed in the intaken air, are separated and filtered in the air cleaner, and clean air is sucked into the combustion chamber. Damage to the filter element, and gaskets in the intake manifold system, or loose clamping devices may cause dirt and foreign objects to be sucked directly into the intake system and be chewed between a valve face and seat, resulting in abnormal wear and cracks in these parts.

PREVENTIVE MAINTENANCE

Constant checking and a good grasp of the engine condition are important factors for sustaining full work efficiency and preventing the occurrence of failures beforehand. In particular, color of the exhaust gas, blow-by pressure, overheating, abnormal engine oil pressure, unusual engine noise etc. should be observed carefully for failure signs.

Accurately following the maintenance procedures outlined in the "operation & maintenance manual" will prevent most of the usually encountered failures, however, the customer is requested to pay particular attention to the following items.

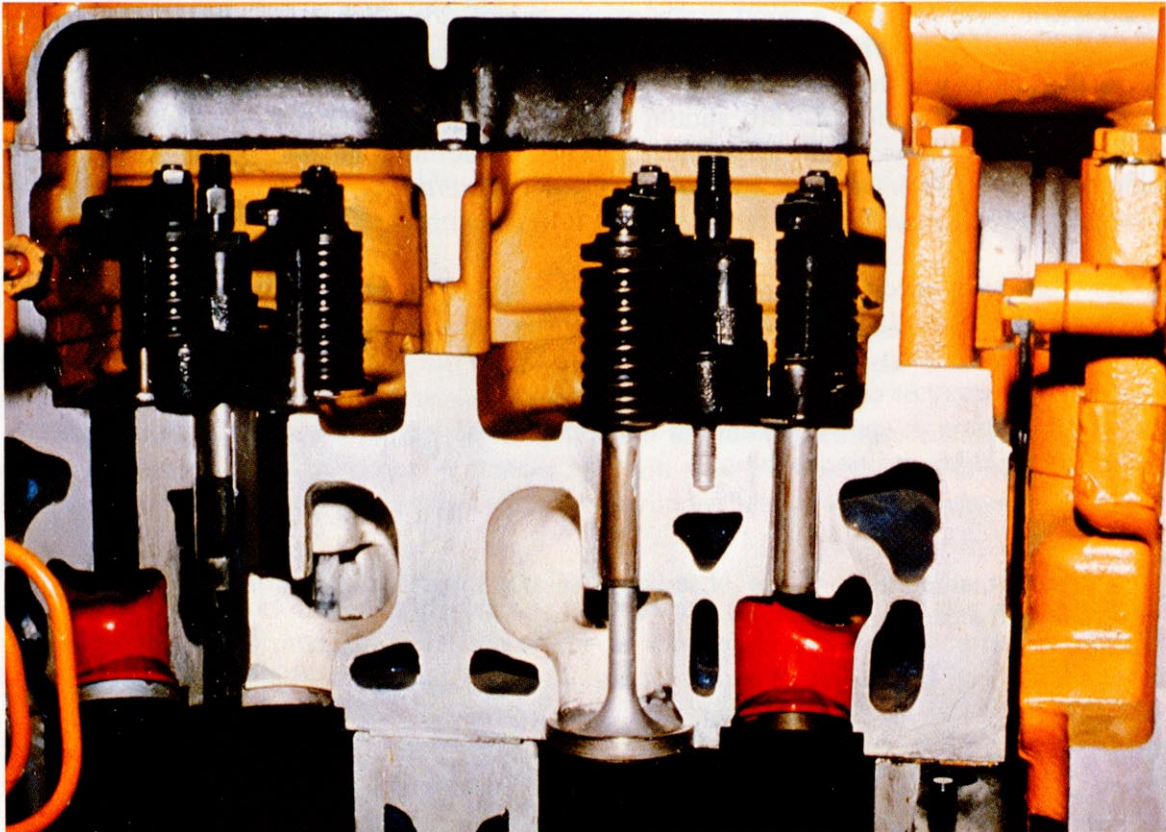
- Use Komatsu's specified lubricating oil, change the oil at the designated intervals, and use the specified oil type matched to ambient temperature.
- Use soft water (tap water or boiled water). Never run the engine with insufficient or unsuitable (dirty or contaminated) cooling water.
- Take your time in warm up running the engine. Avoid, sudden overloads, rapid acceleration, and sudden engine-stopping.

If abnormal conditions are observed, use the tabulated measuring instruments and search for the causes.

Measuring Instrument	Part Number	Measuring items
Blow-by Checker	799-201-1502	Blow-by pressure
Hydraulic Tester	790-301-1102	Engine oil pressure
Thermister Kit	790-500-1300	Cooling water & oil temperature
Engine oil Checker	799-201-6000	Water and/or fuel mixing in the oil.
Water Tester	799-202-7000	Quality of cooling water
Smoke Tester	Locally available	Exhaust gas condition

Refer to the section on "Testing and adjusting", in the Shop Manual.

CONSTRUCTION AND FUNCTION



The cylinder head in conjunction with the cylinder liner and piston, forms the combustion chamber — the part of an engine most exposed to extremely severe working conditions.

The air in the combustion chamber is compressed during the rising stroke of the piston, developing high temperature and compression. Fuel is injected into this highly compressed air, so that combustion takes place and the explosive rise in temperature and pressure forces the piston downward to turn the engine.

The valve seats are press-fitted into the cylinder head to form an air tight contact with the valve face. The valves open and close in sequence with the movement of the piston, to intake the air necessary for combustion, and to exhaust the spent gas. Opening and closing of the valves is performed through push-rods and rocker-levers driven by the cams on the cam shaft.

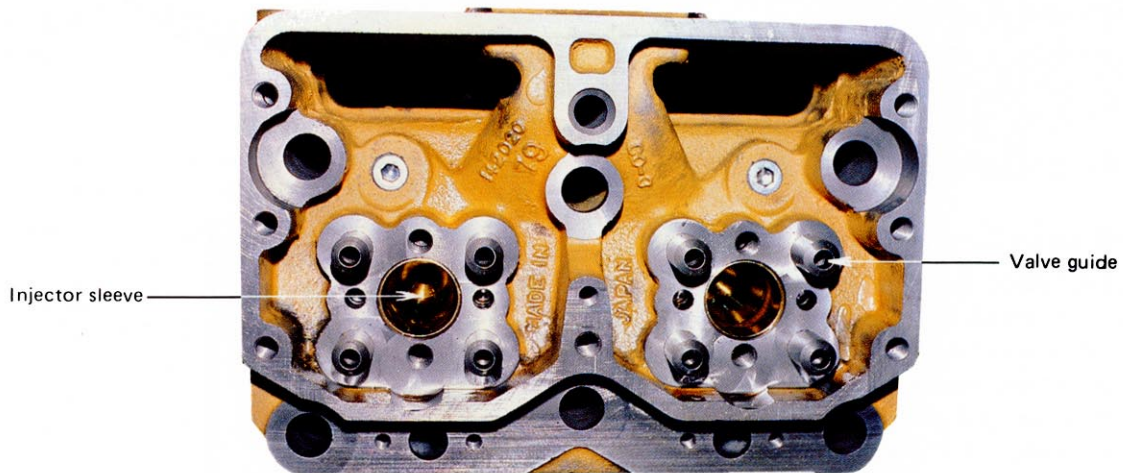
Cylinder Heads

Construction of the Cylinder Head

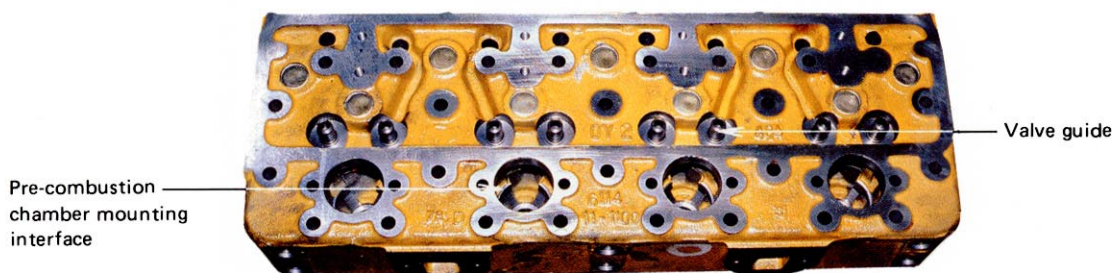
Cylinder heads are classified according to the engine's combustion system or the shape of the cylinder head, as: Direct injection type or precombustion chamber type, 2-valve or 4-valve, separate or single block type.

The separated cylinder head is commonly used in large-size engines while single block head are employed in small to medium size engines. Basic shape and parts used in a direct injection type and a pre-combustion chamber type head are shown in the photographs.

Direct injection type



Pre-combustion chamber type



Function of the Cylinder Head

The cylinder head retains the combustion pressure and also transfers and dissipates the generated heat from the combustion chamber. For performing these functions the cylinder head must:

- 1) Have sufficient strength and durability to withstand and the high pressures of combustion.
- 2) Effectively cool the heads essential parts.
- 3) Completely seal the combustion chamber against leakage of combustion pressure.

Valve Seat

Construction of the Valve Seat

The valve seat is a heat-proof and wear-proof ring, press-fitted into the cylinder head to form the air tight seal with the valve face, and the valve seat constantly receives repeated shocks under high temperature and high pressure conditions. As a result, the valve seat can be replaced if the seat surface develops cracks or flaws, and becomes excessively worn.

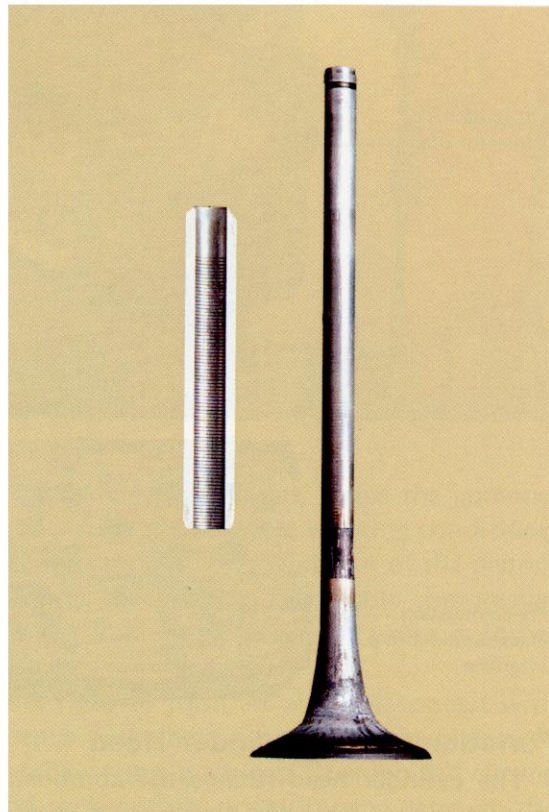


Valve Guides

Construction of Valve Guide

The valve guide is press-fitted into the cylinder head, and guides the valve stem in its reciprocating motion. In addition, oil grooves are machined on its inner sliding surface to retain the oil film and prevent the valve stem from seizing or scoring with the valve guide.

If the valve guide becomes excessively worn, it can be replaced with a new part.



Valves

Construction of the Valve

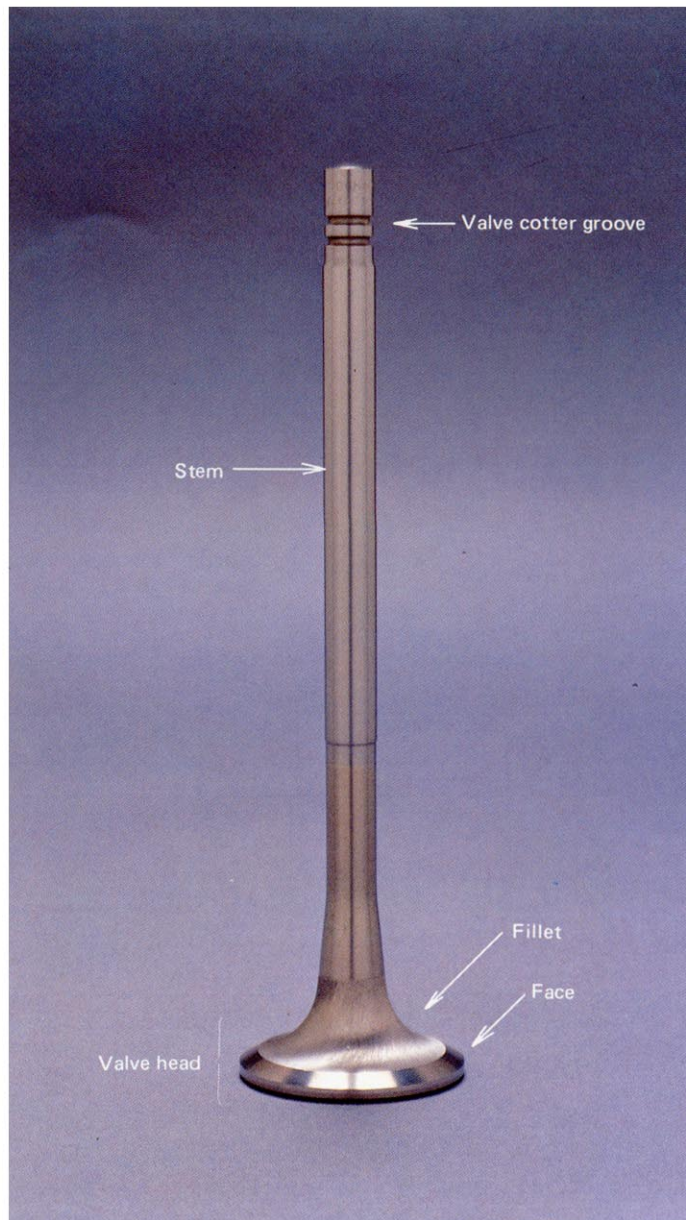
The valve is inserted in the valve guide, and is assembled in the cylinder head together with the valve seat, valve spring and cotter.

Usually there are two valve face angles, 30° and 45° . The 45° is used for the intake valve and the 30° is for the exhaust valve.

Nomenclature of the valve is shown in the illustration.

Valves maintain the combustion pressure caused by the high temperature and high pressure gas. Furthermore, the valves continuously and repeatedly reciprocate. To perform these functions valves must fulfill the following conditions.

- 1) Must be unaffected by intense heat and durable against shocks and wear.
- 2) Must be able to transfer and dissipate heat rapidly.
- 3) Must have good air tight sealing characteristics.



BASIC MATERIALS

Cylinder heads, valve seats, valve guides and valves are engine parts that operate under extremely severe conditions. Basic materials for these parts, thus are called upon to fulfill various requirements. Typical materials employed are listed below.

Part name	Materials	Requirements
Cylinder head	Cast iron (FC 25– ©)	<ul style="list-style-type: none">● Strength● Low-wear
Valve seat	Special alloy steel (Heat-resistant)	<ul style="list-style-type: none">● Heat-resistant● Low-wear
Valve guide	Cast iron (FC 20–VC)	<ul style="list-style-type: none">● Low-wear● Oil retaining
Valve	Special alloy steel (Heat-resistant)	<ul style="list-style-type: none">● Heat-resistant● Low-wear

