CATERPILLAR®

SEBF9050-01

Applied Failure Analysis

Engine Valve Failure Modes

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Engine Valve Failure Modes{1100, 1105}
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SMCS - 1100; 1105

Caterpillar Products: Engines with ACERT Technology Machine Engines with ACERT Technology
Industrial Engine:with Turbochargers All
Marine Engine:with Turbochargers All
Engine:Truck All
Engine: All Commercial Gas Engines
Machine Engines: All

Introduction

This Reuse and Salvage Guideline contains the necessary information in order to allow a dealer to establish a parts reusability program. Reuse and salvage information enables Caterpillar Dealers and customers to benefit from cost reductions. Every effort has been made in order to provide the most current information that is known to Caterpillar. Continuing improvement and advancement of product design might have caused changes to your product which are not included in this publication. This Reuse and Salvage Guideline must be used with the latest technical information that is available from Caterpillar.

For additional information about this guideline, consult Repair Process Engineering of the Marketing & Product Support Division at 1 (309) 675-5434.

Summary

These instructions give failure modes of valves for engines using the basic principles of wear and fracture to determine the most probable root cause of failure. This guide should be used with the additional documents in the reference section to define the reusability of valves.

References

ReferenceSee Guideline for Reusable Parts and Salvage Operations, SEBF8002-05, "Valves, Valve Springs, Valve Rotators and Locks".

ReferenceSee Guideline for Applied Failure Analysis, SEBV0554, "Principles of Wear".

ReferenceSee Guideline for Applied Failure Analysis, SEBV0552, "Principles of Fracture".

ReferenceSee Guideline for Applied Failure Analysis, SEBV0551, "Engine Valves".

Nomenclature for Valves

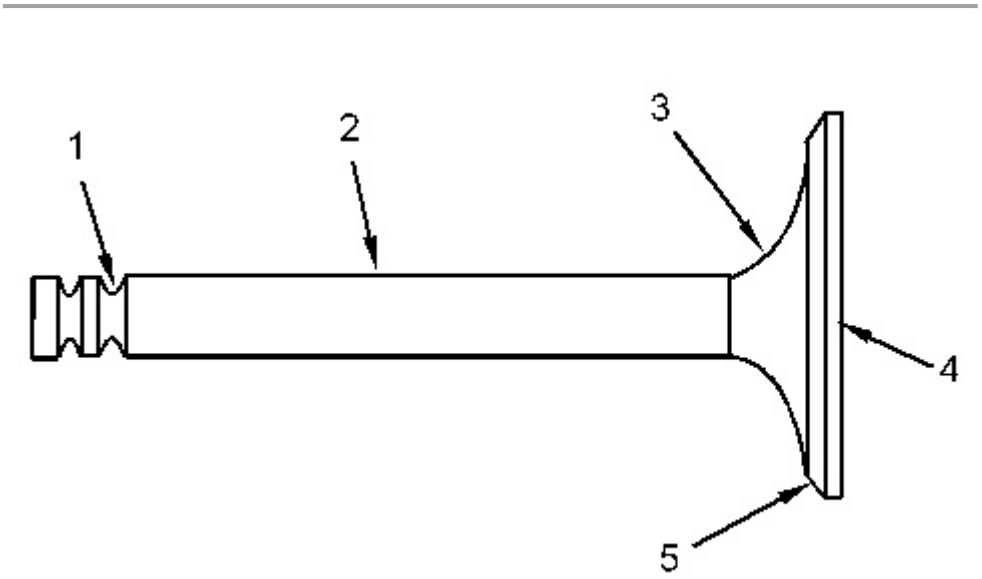

Illustration 1 g01184370

(1) Groove for Retaining Valve Spring

(2) Stem

(3) Fillet

(4) Head

(5) Face

Note: The valve seat is the sealing surface between the valve face and the seat in the cylinder head.

Tools and Equipment

Table 1

Required Tools	
Part Number	**Part Description**
9U-7231	Flashlight
8S-2257	Eye Loupe

1U-7262	Magnet
	Digital ProScope Microscope optional
	Straight Edge

Fretting

Fretting indicates repeated movement in a tight joint. Movement should not occur in the retaining area of the valve. Typically fretting is a result of the following items.

- Loose valve lash
- Engine over speed
- Sticking valves in guides
- Broken valve spring

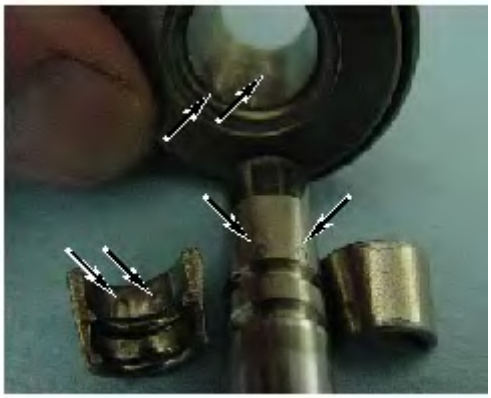

Illustration 2 g01183438

Fretting

Fractures will typically be brittle and/or fractures will be low cyclic fatigue due to an overloading in shock that is caused by excess velocities in seating of loose valve lash.Beach marks are clearly evident in the photo below indicating cyclic overloads.

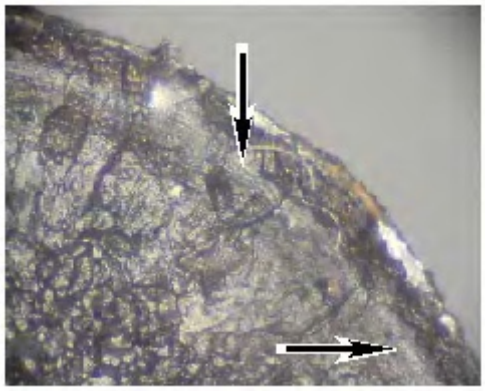

Illustration 3 g01183441

Beach Marks

Wear at the valve stems and/or valve bridges' interface may also be present.

Illustration 4 g01183442

Wear on valve stem and/or bridge

Tight Lash

Valves may not display oil degradation, adhesive wear, or fretting if valve lash was too tight. Also if valve lash was too tight valve heads may show repeated contact with the piston. Tight lash may affect only one valve in a cylinder or all the valves within the engine.

Illustration 5 g01183449

Piston contact on valve

If the valve lash is too tight, compression and combustion gases may leak past the valve face and the valve seat. This will cause the visual signs of gas to be left behind on the valves' face and valves' fillet. The gas leaks may overheat the valve head and the valve stem which will cause the material of the valve to weaken.

Carbon buildup or thick oxide coatings on the valve face or the sealing area of the seat can crack causing gases to leak past the valve face. When the coating cracks, the hot gases have a path to escape.

Illustration 6 g01183459

Traces of gas

Piston Contact

Multiple cylinders displayed outlines of the piston crown and the piston crater on the valve heads. This intermittent contact indicated a valve to a piston contact. This contact can be seen in the following picture. Look at the valve stems for the following items.

- Oil coking problem on sticky valves
- Adhesive wear
- Bent valve stem or stems
- ECM for logged conditions over speed

Illustration 7 g01183476

Piston contacts on valves

High Temperature

Valves for engines that operate in an overheated system will typically have a narrow band of oil coking near the bottom area of the valve guides' travel. Mild adhesive and/or abrasive wear may be present. Valves in overheated systems may have deposits of oil coking on the remainder of the valve head and associated parts.

The following items are sometimes associated with high temperatures.

- Temper colors.
- Adhesive wear
- Oil coking
- Piston contact

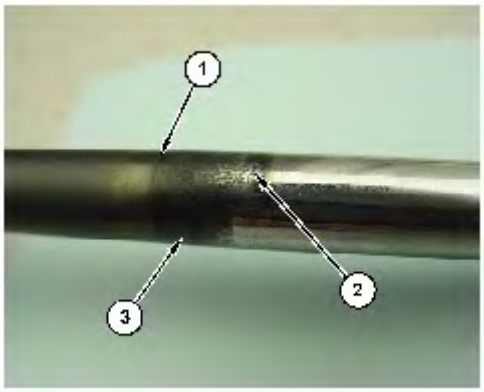

Illustration 8 g01183488

High temperature on valve stem

(1) Bottom of Guides' Contact

(2) Initial Adhesive Wear

(3) Oil coking

Valves in overheated systems may lose some of the alloys due to the high temperatures. If alloys have been drawn out of the valves' material, the valve may attract a magnet.

The following items are reasons of high temperatures.

- Overload from combustion
- Inlet and/or exhaust system restrictions
- Problems of efficiency in aftercooler
- Extreme applications
- Extreme high temperature environment

Illustration 9 g01183494

A valve attracts a magnet.

(1) Magnet

High pressures and temperatures during combustion can create damage. The system restrictions for the inlet air and/or exhaust gas temperatures can also create similar types of damage. Combustion usually creates higher pressures and temperatures that will cause greater amounts of damage to the valve and surrounding system. Plastic deformation to the valve head is known as tuliping. Tuliping is the result of higher than expected temperatures and pressures.

Illustration 10 g01183500

Valve Tuliping

High temperatures may also reduce the viscosity of the oil that allows metal to metal contact with the valve guide. Metal-to-metal contact can create adhesive wear.

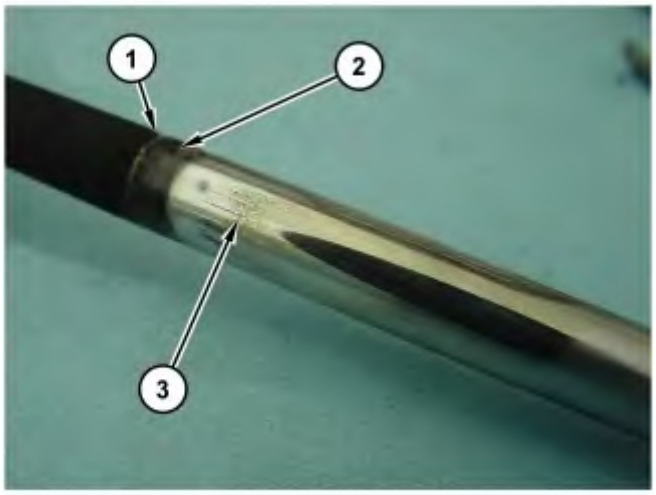

Illustration 11 g01183506

Metal-to-metal wear

(1) Bottom of Guides' Contact

(2) Oil coking

(3) Adhesive wear

Oil Quality

Varnished oil can accumulate on the valve stem near the bottom of the valve guides' contact. This accumulation of varnish is similar to the happenings of valves at high temperature. The buildup of varnish can cause the valve to stick in the guide. Valves that stick in the guides are likely to contact the pistons.

The following items should be examined when a problem with the quality of oil is suspected.

- Quality of oil
- Oil change intervals
- Application of Machine
- Operating conditions

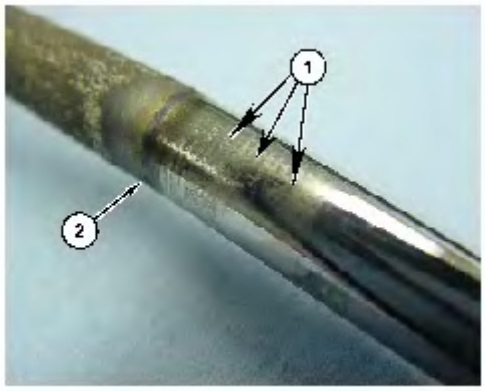

Illustration 12 g01183511

Effects of various qualities of oil

(1) Corrosive Pitting

(2) Bottom of Guides' Contact

The magnified view shows the surface of the valve stem to be pitted from corrosion. Pitting from corrosion is often confused as adhesive wear. Pitting that occurs in one valve stem usually will display the similar characteristics in all valves.

Illustration 13 g01183516

Surface pitting on valve stem

As the oil condition continues to degrade, consumption will usually increase leaving deposits on the valves' fillet and the valves' face. Corrosion may occur in any areas in contact with oil.

Illustration 14 g01183522

Deposits of oil on a valve

(1) Build up of oil coking.

(2) Corrosive pitting

Chordal fractures are the results of cyclic overloading. The chordal fractures usually begin in the area of the valves' fillet. The overloading is localized to one side of the valve head. The following items are causes for chordal fractures.

- Valve, seat, and/or misalignment of guides
- Bent valve
- Foreign debris on valve face
- High temperatures of combustion

Illustration 15 g01183525

Chordal fractures

Issues with Parts

Valves seldom fail due to problems with materials. Some failure modes that may occur are listed below.

- Faulty inertia welds
- Inclusions in the metal
- TIR of seat to guide (misalignment of guide to port hole in the fire deck)

Illustration 16 g01183528

Fractured material

When the inertia weld is excessively hot, the face of the fracture will have a twisted appearance. The valve stem at the inertia weld may be attracted by a magnet.

Illustration 17 g01183531

Twisted appearance on the face of the fracture

If the inertia weld is excessively cold, the face of fracture will have an appearance of a star and a magnet should not be attracted to the fractured head half of the valve.

Illustration 18 g01183533

Appearance of a star on the face of the fracture

The magnified picture of the face of fracture below started at an inclusion.

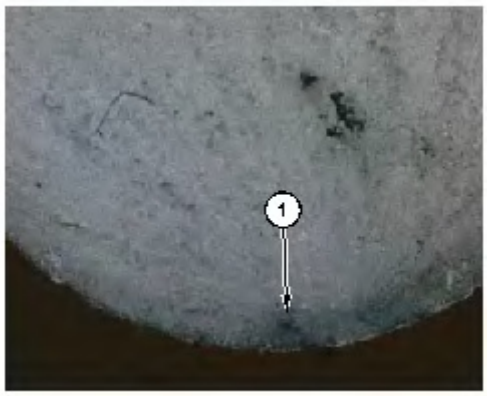

Illustration 19 g01183534

(1) Inclusion

Glossary

Fretting - Fretting causes a worn spot on metals by micro welding.

Lash - Lash is the distance between the rocker and the valve.

Adhesive wear - Adhesive wear is also known as an adhesive metal transfer.

Beach marks - Beach marks are markings on the face of fracture that are associated with the propagation of cracks due to fatigue.

ECM - Electronic Control Module

Plastic deformation - Plastic deformation is the permanent change in shape or size of an object without fracture. This is produced by a stress that is sustained beyond the elastic limit of a material.

Tuliping - Tuliping is plastic deformation of the valve head.

Oil coking - Oil coking is the solid residue that remains when oils undergo severe oxide and thermal breakdown.

Chordal fractures - Chordal fractures are propagating fractures from the circumference of an object.

TIR - Total Indicated Runout

Fire deck - The fire deck is the surface on the cylinder head that experiences the heat and pressures during combustion.

Inertia weld - Inertia welding connects two metals together by spinning one object and applying an axial pressure in order to join the two.

Technical Library

http://engine.od.ua