



KMP BRAND TECHNICAL BULLETIN

Valve Failures

KB-15004

In this bulletin reference will be made to the types of damage that could occur when valve and valve train components are subjected to abnormal operating conditions.

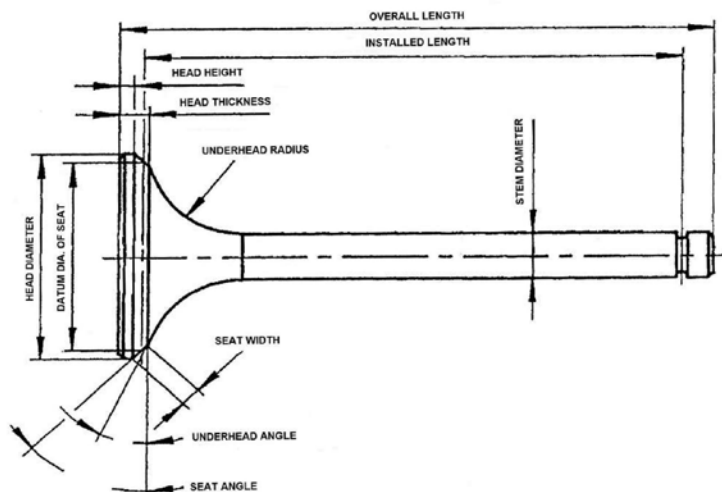
The most important point to remember when diagnosing a failure is to establish the cause of the problem and this may not always be clear and obvious.

All too often repairs are carried out, and then when the engine is returned to service, the same failure occurs again, because the **actual cause** of the initial failure was not identified and rectified.

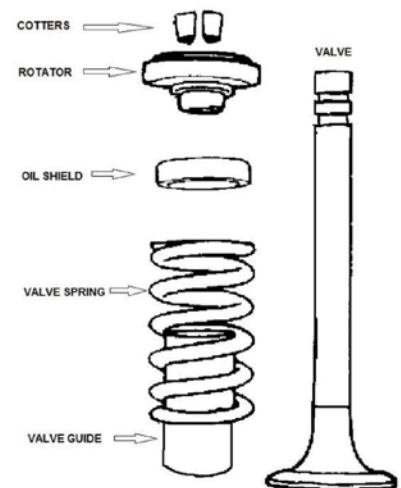
It is therefore inevitable that some "detective work" is needed, gather and organise the facts, observe the facts, think logically with the facts, and finally, identify the most logical cause.

- Replacing a valve which has broken will not fix the problem if the cause was misalignment between the seat and valve guide – the new valve will ultimately fail by the "flexing" action if the misalignment is not corrected.
- Replacing a burnt (guttered) valve will not remedy a lack of compression if the cause of the damage is not rectified – the new valve will also burn.
- Replacing a worn valve guide with a new one will not rectify an oil consumption problem if the wear was the result of lateral forces created by incorrect rocker arm geometry – the new guide will also wear prematurely.

It is imperative to analyse the true cause of the failure before the problem can be rectified because a broken or burnt valve, loose or cracked valve seat, worn or loose valve guides or other similar valve train damage may well be the final result of a chain reaction.



Valve terminology



Typical configuration

Types of failures that can occur



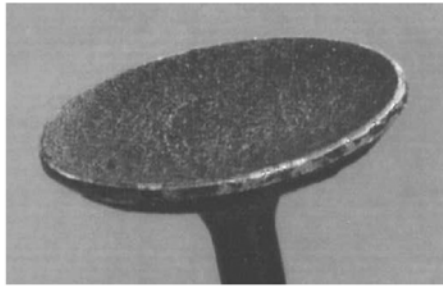
Head breakage



Stem breakage



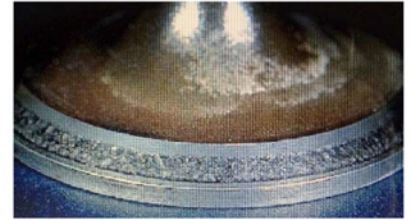
Valve face burning



Distortion



Wear



Erosion



Seat recession

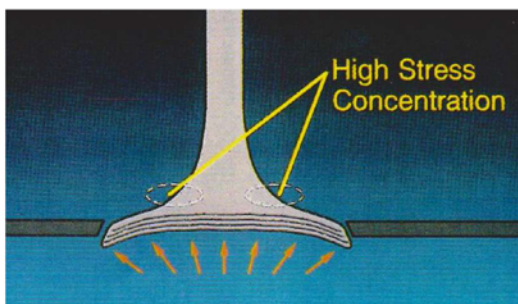


Valve stem seizure

In a diesel engine valves can fail in a number of ways but the most common cause is fatigue. The valves are subjected to cyclic loading, high temperatures (650°C to 735°C), impact loading, erosion type corrosion and high combustion pressures - all these can contribute to fatigue of the valve material, especially the exhaust valves, and it must be considered that a fatigue failure occurs at stresses which are well below the yield point of the material.

BREAKAGE

Head breakage can result when the valve head temperature rises above 650°C as this can allow cracks to develop in the areas of stress concentration



These cracks are referred to as chordal fractures and they originate in the lower portion of the underhead radius where they gradually progress through the valve head until a piece/pieces of the head become detached as a result of fatigue which is characterised by the presence of beachmarks across the fracture face. Some possible causes of the high temperatures are, abnormal combustion, inlet air restrictions, high inlet air temperatures or exhaust restrictions. A chordal fracture can also result from misalignment or from impact damage.

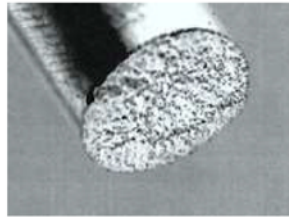
Stem breakage can occur as the result of misalignment or impact, but in each case the fracture face will be different.

Misalignment normally results in a fatigue fracture which has been created by cyclic bending of the head and stem and the fracture face will evidence the characteristic beachmarks. Possible causes are worn valve guide, bent valve, misaligned valve seat or foreign material trapped between valve and seat.

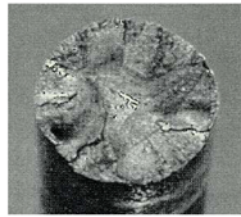
An impact fracture normally occurs when the valve has been subjected to a sudden impact or shock load, and in this instance the fracture face normally has a bright, sparkling appearance indicative of a ductile or brittle fracture.

This type of fracture normally occurs when the valve is struck by the piston in a single event.

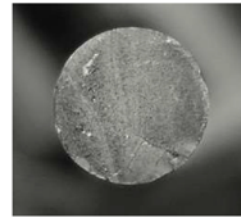
The characteristic appearance of the different fractures are shown in the following illustrations.



Ductile/Brittle fracture



Rotating bending fatigue



Bending fatigue

VALVE FACE BURNING



This type of damage can be referred to as channeling, guttering or torching and results from the leakage of burning combustion gases passing between the valve face and valve seat.

The leakage results in elevated temperatures which exceed the melting point of the valve and seat and erosion of the material takes place.

The poor seating of the valve can result from a number of causes, carbon buildup, misaligned or worn valve guide, cracked valve seat or valve, incorrect lash setting, or insufficient stem to guide clearance.

DISTORTION



The valve head is distorted in a manner referred to as cupping or tuliping and results from very high combustion temperatures and pressures.

Some of the possible causes for this type of failure are, a combustion irregularity, excessive valve spring pressure or a cooling system malfunction.

WEAR



Some possible causes of valve guide wear are, misalignment of the valve seat and the valve guide, insufficient stem to guide clearance (lubrication breakdown), side thrusting of valve due to rocker arm geometry, abrasive contamination, too much clearance between stem/guide (poor heat transfer), excessive carbon deposits or incorrectly seated valve springs causing side thrusting on the valve stem.

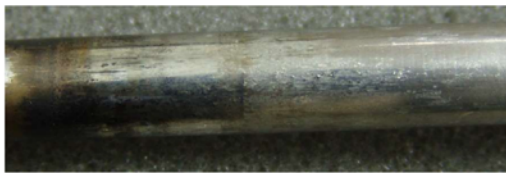


Valve face wear as the result of erosion can normally be attributed to carbon particles which are trapped between the seating faces of the valve and seat; the carbon accumulation could have originated from worn or broken piston rings, worn valve guides or damaged/missing valve stem seals.



Valve seat recession is another form of wear because when the valve is closing there is a combination of impact and sliding and these result in valve seat wear. As the wear progresses the valve recedes deeper into the insert and this results in the loss of the lash setting and incorrect valve seating.

VALVE STEM SEIZURE



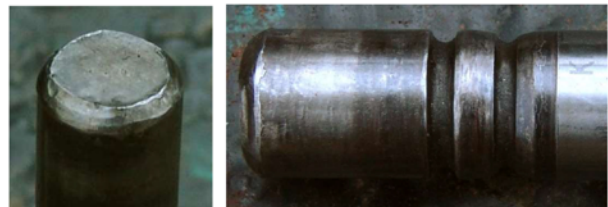
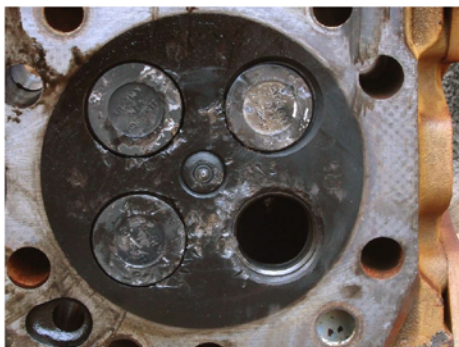
Seizure or scuffing occurs when there is insufficient lubrication which could have originated because there was a lack of clearance between the stem and guide, overheating had resulted in thermal expansion, carbon buildup on the underhead and valve neck, abrasive contamination bridging the oil film or a bent valve stem.

The following are some examples of valve failures, their appearance and the cause.

Failure 1



The customer removed and returned the complete cylinder head because it had "dropped" a valve. Initial inspection indicated abnormal wear on the tip of the valve stem and in the cotter grooves and it was concluded that valve geometry was the primary cause of the failure because it had resulted in the valve stem thrusting against the bore of the valve guide causing the seizure that was evidenced on the stem. Piston crown and valve head contact would explain the damage to the cotter grooves and also the eventual separation of the valve head from the stem.

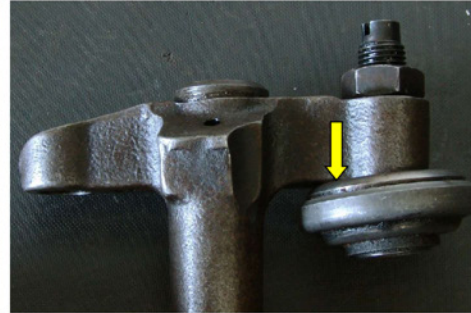
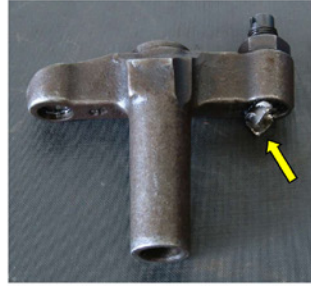


After the initial report, and rejection of the claim, an opportunity arose to inspect **all** the components of the engine. This inspection confirmed the reason for the failure, *the failure was directly attributed to the abnormalities that were present with the valve operating mechanism.*

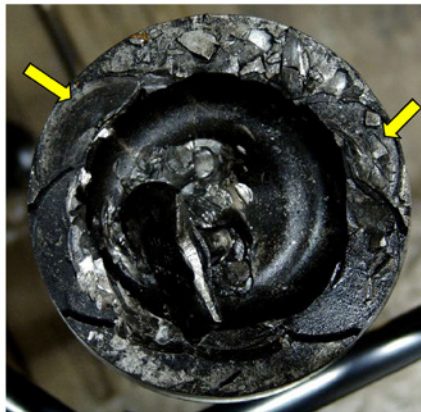
The valve had definitely contacted the piston crown as arrowed in the photograph.

The valve bridge had a cotter lodged into the recess, the arrow indicates an abnormal contact pattern on the rotator, the underside of the bridge has a corresponding contact pattern.

When the wear patterns were aligned the valve operating mechanism abnormalities were confirmed.



Failure 2



The customer complained of an inlet valve failure, the head of the valve was embedded into the piston crown.

The two yellow arrows indicate where the valve heads were making contact with the piston crown prior to the failure.

It was evident from these two indentations that the piston had been installed 180° out of position, which meant that the valve pockets in the piston crown were not aligned with the valve heads.

From the appearance of the remaining seven valves it was evident that the crowns of the other three pistons would also show signs of contact with the valve heads.

As a consequence it was strongly recommended that all the valves be replaced as a precautionary measure.



To summarise, replacing a failed valve/valves will not necessarily resolve the problem if the underlying problem has not been corrected. It is important that the correct valve and seat installation and finishing techniques are followed, make sure the installed stem heights and spring heights are correct, the stem to guide clearance is adequate, seat width and contact is correct, and that the valve lash settings are correct. It is also important to rule out any other engine problems that may exist such as overheating, timing problems and detonation irregularities – these precautionary checks will go a long way in preventing repeated valve failures.