CARBON FOULING

FEATURES:

Heavy encrusted black deposit resembling "coke". Substance can be wet and oily to the touch.

CAUSES:

a) Loose or ineffective valve stem seals.

b) Worn valve guides.

GENERAL:

a) During an engine's life it is quite normal for valve stem seals to harden/perish and lose their ability to wipe excessive oil drain from the valve stem.

b) Excessive valve guide wear/valve stem wear, produces a side to side movement between the sliding surfaces and a pumping action can be produced. This is especially so on inlet valves. Similarly the side movement ovaliates the stem seal lip encouraging oil by pass and encourages stem seal wear. With added gravitational and induction pressures, excessive oil runs down the stem and although some enters the combustion cycle to be witnessed as "blue smoke", the residual flow bakes on the valve throat and solidifies. This invasive contamination will reduce the breathing ability of the engine and breakaway particles can become trapped between the valve face and seat. Some valve designs incorporate a "carbon breaker" groove on the stem which prevents carbon fouling but only at that point.

ACTION:

During engine overhauls it is of prime importance to measure valve stems and valve guide bores for size consistency and to ensure the valve guide clearance is held with the manufacturer’s specification or as per the size chart recommendations which can be found in our fitting suggestions for valves.

SEAT PITTING

FEATURES:

Valve and valve seat are peppered with tiny craters resembling the "moon's surface".

CAUSES:

Primarily contaminant fouling temporarily trapped between the valve face and seat which encourages hot gas blow by/acid etching/metal tongue detachment and adhesions.

GENERAL:

Basically there are many reasons which can instigate the failure of a valve and seat facing. These can include face damage due to incorrect valve lapping/valve and seat eccentricity/valve guide wear/ingress of excessive oil producing carbon fouling/overheating for whatever reason i.e. tuning/coolant deficiencies etc. Valve seatings in this condition can only deteriorate further with the possibility of a "vee" section burn out caused by a concentrated "gutter path".

ACTION:

Valve seating is of prime importance and we recommend strict adherence to our seating suggestions. The general use of lapping paste is to be strongly discouraged and all seating dimensions must be within manufacturer's tolerances. By following our seating suggestions natural face peening will produce a polished face with air tight sealing.

GUTTER PATH

FEATURES:

A "vee" section is missing from the valve head causing compression loss. The engine would be very "lumpy" and backfiring from the exhaust might be evident.

CAUSES:

Material loss has been caused by "melt" during attempted combustion/firing stroke. This gutter path failure could also initiate valve seat cracking.

GENERAL:

By referring to the previous two valve heads featuring "carbon fouling" and "seat pitting," it can be easily imagined that due to the lack of air tight sealing on the seat faces that hot gases can escape the combustion chamber and by pass the valve. In design, the head of the valve conducts combustion heat into the margin and the throat and then into the valve stem and guide. Similarly valve face heat is conducted to the cylinder head valve seat. Both of these component terms are adjacent to the coolant channellings, where the heat is finally absorbed. Where seating is damaged these hot gases can escape past the seat facings and temperatures as high as 1650 C degrees can be experienced. If gases are encouraged and channelled to one place i.e. the widest seal loss gap, then the valve and even the seat can gradually melt and tiny spheroidal molten metal is eroded away. A "gutter path" for the hot gases is thus formed and the metal loss will progress to a "vee" section. Pre-ignition due to tuning deficiencies will also accelerate this process.

DETACHED VALVE HEAD

FEATURES:

Valve head breaks adjacent to the stem and throat join.

CAUSES:

a) High seating forces.

b) Valve and piston collision.

GENERAL:

a) Although extremely rare, it is possible for high seating forces to initiate fatigue stresses at the true stem adjacent to the valve head throat. High seating forces can be simply due to over revving which encourages valve bounce, or by badly worn valve guides or thick seat contaminants which force the valve to double close. A valve that is constrained at an angle which is hostile to the valve guide centre line will hit one side of the valve seat and then bounce to attempted closure on the opposite side. This creates a side loading of the valve head. Accordingly the stem being the narrowest point will give rise to a natural fatigue point. Molecular movement and work hardening will result in a valve head detachment with massive consequential damages.

b) Valve and piston collision can be simply due to mistiming either by human error or for instance a timing belt break. A valve that is inclined at an angle to the piston travel will readily break due to the side impact imposed. Valves which operate in the same axis of the piston travel can sometimes escape breakage particularly if a rocker arm breaks, however the valve head and stem will have suffered some dimensional misalignment and must be replaced.

BENT VALVES

FEATURES:

Head is bent from the true stem axis.

CAUSES:

Piston and valve collision.

GENERAL:

A "safe" engine is one which in the event of a timing error/belt break, the valves and pistons DO NOT collide.

An "unsafe" engine is where designers do not accommodate the "safe" factor and valves and pistons will collide if and when timing errors occur.

Normally a timing failure will result in catastrophic damage within the combustion chamber i.e. Valve/piston/combustion chamber faces and even the cylinder bore wall. Consequential damage can also be transmitted to connecting rods, camshafts, camshaft housings and camshaft followers. During repair work for such a failure, valve guides must be checked thoroughly for chipped ends and longitudinal cracks and be replaced as necessary. A bent valve must never be straightened as invisible defects can give rise to fatigue failures resulting in a future engine breakdown.

DROPPED VALVE

FEATURES:

Entire valve drops into its respective engine cylinder.

CAUSES:

Various as follows;-

GENERAL:

A dropped valve is where the valve is not constrained by the valve cap and cotters. The retainer release allows the valve to gravitate and even be accelerated under camshaft lift into the cylinder bore where major damage is inevitable. There are several circumstances that can cause this including;-

1) Incorrectly fitted cotters allowing them to jump out on initial start-up.

2) Worn cotters and/or valve cap.

3) Cracked valve cap.

4) Seized valve stem in a valve open position which allows an unconstrained rocker arm to strike the side of the valve cap releasing the cotters.

5) Breakage of valve stem adjacent to underside of cotters due to excessive side way forces imposed on the stem i.e. worn valve guides, out of square valve springs or even excessive valve clearances which create valve stem hammer.

COTTER / STEM BREAKAGE

FEATURES:

Valve stem breaks immediately at the lowest cotter groove.

CAUSES:

Incorrectly seated valve spring.

GENERAL:

This phenomenon is particularly prevalent at present times with Audi/VW group 4 cylinder 20 valve engines. These engines have a history of suffering major engine damage which is evident very shortly following aftermarket repairs to the cylinder head. However the following principles applies to any cylinder head. During cylinder head overhauls/repairs, it is very important to be aware of the following assembly procedure;-

1) The valve springs sit and locate in recessed housings which are approximately 3mm deep compared to that of the surrounding oil bath casting. In fact, the raised casting is quite rough and in some instances we have witnessed casting irregularities as high as 5mm. The spring has very little side clearance when it is located in its recess and in view of the awkward accessibility and the inability to see properly, it is all too easy to misplace the spring on to the edge of the raised casting. In other words the spring attempts to seat partly in the proper recess but also partly on the high surrounding casting. When assembled we now have two constraints on the valve which are acting against one another. 1) The valve guide is constraining the stem to the centre line axis of the guide whereas 2) the valve spring is attempting to similarly constrain the valve stem to the centre line of the free spring. This results in a high side loading of the valve stem. The following diagrams illustrate the forces and effect which are dramatically increased during camshaft lift and valve open.

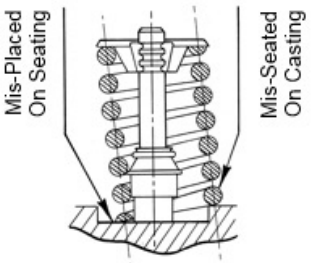


FIG. 1

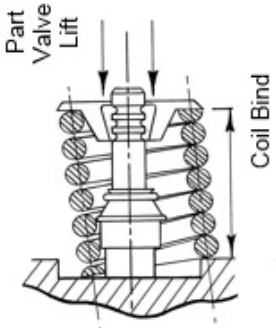


FIG. 2

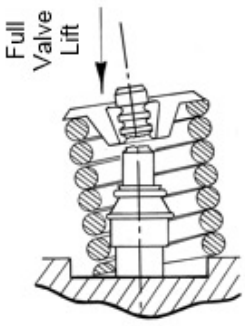


FIG. 3

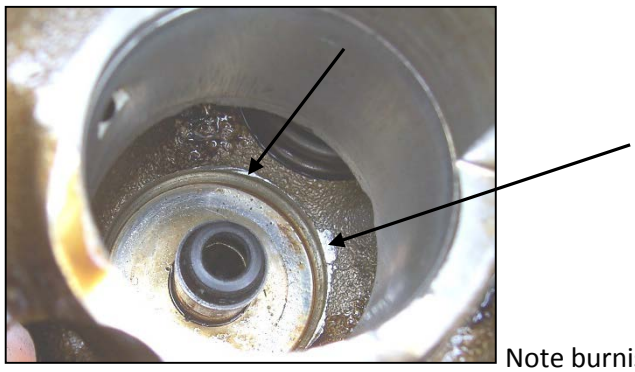

Note burnish/polish mark witnessing incorrect spring seating.

FIG. 1

The spring is misplaced half on the raised casting and half in its correct recess. This results in the spring sitting at an angle to the valve axis.

FIG. 2

During the valve opening sequence the spring (in the worst scenario) coil binds preventing further free valve lift.

FIG. 3

The coil bind acts as a pivot point for the valve cap and further camshaft lift still pushes the valve and free side of the spring down resulting in a tremendous bending moment. The lowest cotter groove being the closest minor diameter and being a natural fatigue point breaks the stem to complete shear.

VALVE GUIDE WEAR

FEATURES:

Valve and stem exhibit polished contact faces but tending to each end of the stem travel length.

CAUSES:

General wear and tear plus various causes

GENERAL:

Valve stem to guide clearance is critical in establishing a valves efficiency and long term service.

Excessive clearance will allow undesirable operating conditions which can lead to ultimate failures as follows;

a) Excessive oil by pass leading to valve and seat carbon fouling. Engine breathing and performance will be reduced and "blue smoke" will emit from the exhaust. Ultimately the valve will foul to the point of non-closure.

b) Since a worn guide allows valve freedom, the valve head is not constrained to its pre-determined axial direction and valve "cocking" will occur. As the valve approaches closing, it hits the seat on one side followed by closure on the opposite side i.e. it double hits and bounces. This puts enormous point loading on the valve head and throat and fatigue breakage is possible at the true stem start.

c) Valve "cocking" as above will ironically accelerate wear both to the valve stem and the guide. Side loading is now concentrated to both ends of the guides instead of the designed bore length. Although the oil film has increased, the oil barrier has to combat the hammering effect, as opposed to the designed sliding effect and metal to metal contact can occur. Additional wear will result on stem and guide.

VALVE GUIDE PICKUP

FEATURES:

Raised tongues of metal adhered to the stem with possible associated line scoring.

CAUSES:

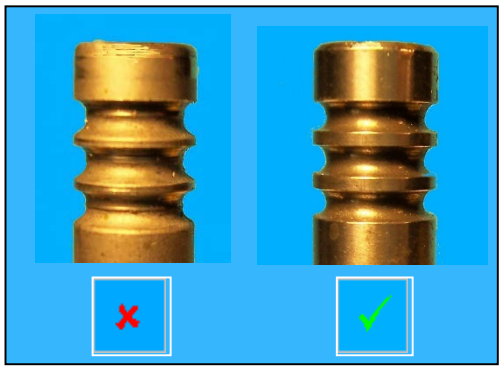
a) Insufficient clearance following an overhaul or b) Insufficient lubrication on assembly.

GENERAL:

a) Insufficient clearance will result in an immediate valve seizure/pickup, normally within two minutes of engine start up. As the valve expands the oil barrier is excluded and metal to metal contact ensues. The frictional effects will tear tongues of metal normally away from the valve guide bore and these will molecularly adhere to the valve stem. An overlapping of tear off tongues can cause an interference seizure in either open or closed position. Piston and valve collision might result or even rocker arm breakage, whatever, the engine will fail. If the adhesions act as a key and keyway and the valve doesn't seize, problems will still occur. Since the valve can no longer spin (which helps with load distribution and self-cleaning of the seat faces) then the non-spin factors will dramatically shorten the valve life.

b) During cylinder head assembly both valve stems and valve guide bore should be liberally coated with a high viscosity oil or with a pure graphite black grease like "Graphogen". DO NOT lubricate with light oil such as A.T.F. and DO NOT lubricate with white grease. Always attain oil pressure and visual flow of oil at starter revolutions before engine is fired. Allow sensible running in periods for all new components.

COTTER GROOVE WEAR



FEATURES:

Either valve or cotter male beads are worn. Thin cotters will move up and down the stem when "freely" assembled. Note the cotter beads on the left hand image are very thin compared to the good valve on the right.

CAUSES:

a) Normal wear and tear.

b) Valve hammer due to excessive valve clearance.

GENERAL:

Cotters are an important part of a valve assembly. By taper locking into the valve spring cap the cotter beads locate in the valve stem end grooves and prevent the valve "dropping" into the combustion chamber. The cotters shouldn't actually grip the valve stem as the desired effect is that the valve should be able to rotate freely during the valve "lift" cycle. Engines which employ over head camshafts with "bucket" followers actually offset the camshaft lobes away from the centre line of the followers. This directs a wiping effect on the follower and spinning results. Since the valve is in direct contact with the camshaft follower then the spinning effect is also passed to the valve. In reality a valve will spin at a very slow rate of say 5 or 6 times a minute at medium engine revolutions. Valve spinning has three main desired effects.

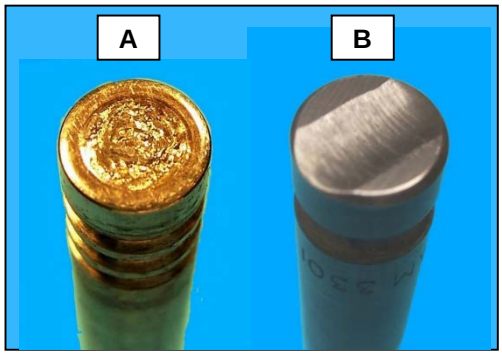
1) Valve seating is continually "wiped" and helps remove any carbon deposits.

2) Valve seating is improved by the variable contact which helps prevent sticking and evens the loading to encourage a round and consistent seat. Hot spots are also eliminated.

3) Valve stem and guide lubrication is more efficient as oil is circulated.

Valve cotter grooves and indeed the cotters themselves must be inspected for wear. Worn cotter clearance can impose shock loads which can lead to further rapid cotter wear and possible shear.

VALVE STEM ENDS



FEATURES:

Stem end is not flat

a) Fatigue pitting. Possible breakthrough of hardened surface.

b) Rocker arm trough preventing valve spin.

CAUSES:

Normal wear and tear.

GENERAL:

Valve stem ends are also an important part of the valve function. The stem end must be flat and in good face to face contact with the camshaft followers/rocker. The wiping effect of the camshaft follower helps rotate the valve and any wear or grooving of the stem will prevent and actually stop valve rotation to the detriment of the valve life.

It is acceptable for an engine repair shop to reface a stem end known as "topping" however care must be taken not to;

1) Grind off too much or the hardened surface can be removed.

2) By lowering the stem too far the camshaft follower or rocker arm can contact the valve cap rather than the stem end and a dropped valve might result.

3) In respect to hydraulically operated systems (i.e. hydraulic cam followers) particular detail to valve protrusion heights must be strictly observed and maintained.

WARNING! DO NOT strike valve stem ends with steel hammers to "set cotters". A light blow with a plastic faced hammer is acceptable.