

SB017

Valve Stem Bending and Fatigue Fracture

Valve stem fracture (VSF) usually results in considerable and expensive engine damage - especially in the now common double overhead cam, four valve per cylinder design engines. The cause of VSF is rarely a manufacturing or materials fault and nearly always an operational fault. Table 1 below shows a summary of fracture faces of shafts and a valve stem is fundamentally a shaft. The majority of VSFs are due to one way bending, although two way bending and reversed bending by rotation can also occur. The most common stem fracture appears as a valve head to stem breakage in the region of the junction of the underhead radius and the stem (Photo 1). Even when the stem is a welded two piece design, this type of fracture does not occur at the weld, but typically closer down towards the head. The stem is often drawn up into the head and the fracture face remains undamaged, while the valve head typically drops into the cylinder and is too damaged for the fracture face to provide evidence.



Photo 1. Typical valve stem fracture at the underhead radius and stem junction. The stem fracture face is usually in good condition, while the valve head fracture face is typically too damaged to be of use.

STRESS CONDITION \ CASE	NO STRESS CONCENTRATION		MILD STRESS CONCENTRATION		HIGH STRESS CONCENTRATION	
	LOW OVERSTRESS	HIGH OVERSTRESS	LOW OVERSTRESS	HIGH OVERSTRESS	LOW OVERSTRESS	HIGH OVERSTRESS
ONE WAY BENDING						
TWO WAY BENDING						
REVERSED BENDING BY ROTATION						

Table 1. Summary of shaft fracture faces, stress conditions and mode.

..... continued over.

The most common causes of one way bending are:

1. Flexing: Off-square seating and high seating forces can cause stem flex. Worn valve guide bores, loose valve seat inserts, incorrectly cut valve seats and debris trapped under the valve face can cause stem flexing and bending. The alternating stress cycles result in cyclic fatigue fracture typified as no or mild stress concentration.

2. High Seating Forces: Excessive valve stem-to-guide clearance, out-of-square valve springs, excessive valve lash, and worn rocker arm faces can cause extra cocking and seating forces on valve stems. A broken stem or collet end is often the result. This is typified as mild stress concentration.

3. Impact Failure: This type of failure is often the result of high physical loads suddenly imposed on the valve. Faulty keeper installation, a timing chain or belt breakage, incorrect valve timing, operating an engine beyond its normal RPM range or weak valve springs resulting in valve bounce, or hitting a foreign object (e.g. the piston or debris in the cylinder) are common causes of impact damage. A malfunctioning exhaust breaking system can result in valve float and a piston/valve collision. This is typified as mild or high stress concentration. Sometimes the valve stems are not fractured, but bent.

Valve stem breakage through a single collet groove can be caused by any of a number of conditions. Some of these are faulty keeper installation, damaged collet groove, valve bouncing, valve spring coil bind and damage at assembly from 'bouncing' the valve on its seat after fitting - usually with a soft mallet. One example of fracture through the collet groove due to high overstress can be seen in Photo 2 below.



Photo 2. Valve stem fracture at the collet groove. The fracture shows no sign of cyclic fatigue, but the stem end is bent and the fracture face is typical of high overstress.