

Symptoms

Cylinder head gasket sealing can fail for many reasons. A minor leak if left unattended, will become progressively worse, affect other engine functions and eventually lead to a catastrophic engine failure. One symptom rarely appears independently of another, although the following chart will assist diagnosis.

General effects

When a damaged cylinder head gasket is examined, it will invariably show oil and water stains, discolouration due to the effects of heat, carbon deposits, compression marks and possibly areas of burning and erosion. To determine the cause of the problem, close attention must be paid to determine the key effect, otherwise an incorrect diagnosis is possible. Experience, and a specific knowledge of the engine being considered (oil and water flowpaths, manufacturers' service bulletins etc.) will assist the analysis. Well over 80% of gasket sealing failures are caused by; incorrect bolt tightening (which leaves the gasket insufficiently compressed), failure to check the bolts after a specified mileage, general engine overheating or abnormal engine combustion.

Water	Low/falling water level in radiator plus:	Overheating plus:
1. Water leaks externally.	Wet engine. Evaporation stains. Water on chassis/floor.	Hot engine smell, combustion knock, contraction noises on shut down.
2. Water leaks to oil-way.	White emulsion in rocker cover and sump. Oil level appears to increase.	As above plus rapid engine wear leading to bearing noises and increased blowby to crankcase.
3. Water leaks to cylinder.	As above plus evaporation stains around radiator cap and wet exhaust.	As above plus power loss, steam from exhaust and radiator cap.
Oil	Falling oil level plus:	Slow overheating as oil level falls plus:
1. Oil leaks externally.	Oil engine. Dirt adhesion. Oil on chassis/floor.	Bearing knock and piston seizure if oil depleted.
2. Oil leaks to water passage.	White emulsion in radiator.	As above with faster overheating due to radiator core blocking.
3. Oil leaks to cylinder.	Fouled spark plugs/injectors.	Poor starting. Power loss. Blue smoke from exhaust
Combustion gas	High fuel consumption plus:	Poor starting & power loss plus:
1. Gas leaks externally.	Burnt surfaces and carbon around leak.	Exhaust fumes in engine bay. Hissing/whistling noise in time with engine.
2. Gas leaks to water passage.	Evaporation marks around radiator cap and generally around engine bay.	Overheating. Pressurisation and water loss from radiator.
3. Gas leaks to oilway.	Valve gear may appear dry due to oil flow disruption to cylinder head.	Valve gear noise. Possible crankcase pressurisation.
4. Gas leaks to next cylinder.	Black carbon deposits in exhaust pipe.	Overheating. Severe power loss. Possible backfiring. Fuel rich exhaust smell Black smoke. Hissing noise.

Overheating



Symptom: Gasket materials are hard and carbonised. Surface cracks are evident. Bore eyelets are discoloured.
Cause: Overheating causes hardening of the gasket materials and possible material degradation. This will reduce the sealing effectiveness of the gasket.
Remedy: Maintain cooling systems in good order. Rectify leaks immediately. Replace cylinder head gasket if engine has been severely overheated. A planned repair is better than an unexpected failure. or replace damaged cylinder components. Ensure any piston under crown cooling jets are functioning correctly.

Loose assembly

Symptom: There will be no or few compression marks on the gasket faces. The thickness of the gasket will be almost the same as a new un-compressed gasket. Leakage occurs in first few hours.

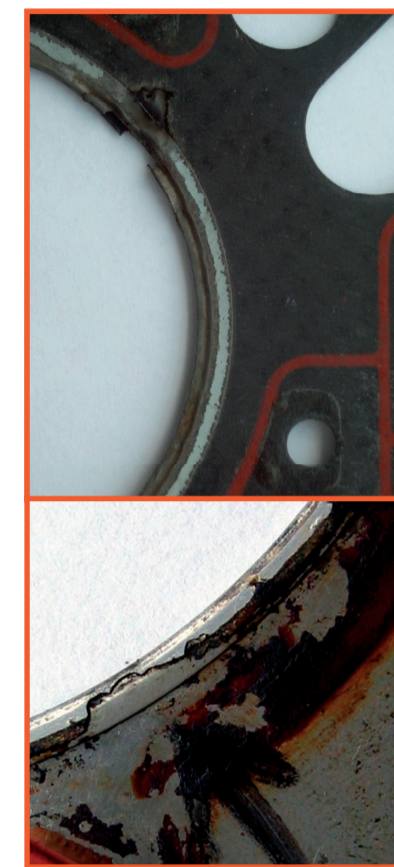
Cause: Cylinder head bolts insufficiently tightened.

- Damaged or dirty threads.
- Excess oil or water in bolt holes.

(In the above cases, the correct torque may be applied, but insufficient load is generated). Old bolts re-used ('Stretch' or 'yield tightened' bolts should always be replaced).

Remedy: Always follow the engine manufacturers' procedures for the replacement and tightening of cylinder head bolts, particularly the torque setting and the tightening sequences. Ensure that threads are not damaged and that bolt holes are clear. When a bolt is tightened, about 90% of the applied torque is used to overcome friction. The remaining 10% provides the actual bolt tension. It is therefore most important to know and to follow the manufacturers' recommendations for cylinder head bolt lubrication. Be aware that some manufacturers pre-coat bolts and recommend their installation in a 'dry' condition.

Abnormal combustion



Symptom: Gasket material is burnt away, often between cylinders, or at a location where detonation or pre-ignition occurs. Discolourations are indicative of elevated temperatures around the bore eyelets and combustion gas leakage paths are evident.

Cause: Detonation and pre-ignition increase the localised surface temperatures in the combustion chamber and damage the gasket by burning away the gasket material. In addition, the excessive cylinder pressures are generated which counteract the clamping load leading to a fatigue failure of the gasket bore seal.

Remedy: Keep the ignition system in good order. Ensure the spark plugs have both the correct heat rating and electrode gap. Use the correct grade of fuel specified for the engine and check the compression ratio if major engine machining operations have been undertaken.

Retorque omitted



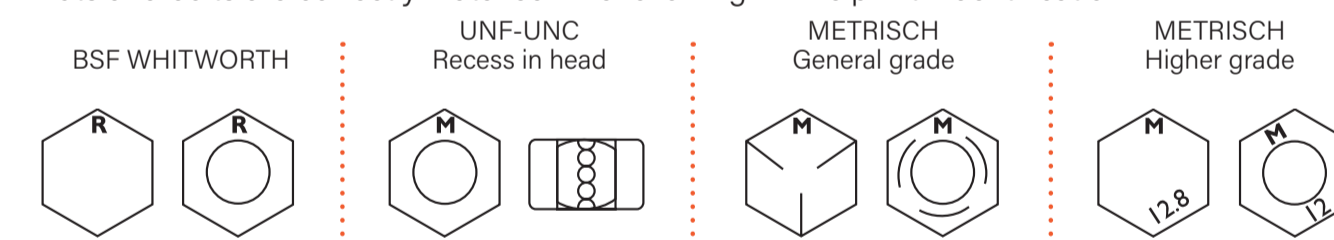
Symptom: Displacement of the gasket material and cracking of the bore eyelets due to the clamping force reduction. Leakage occurs within the first few thousand miles.

Cause: Depending upon the type of material and construction, some cylinder head gaskets settle slightly when exposed to heat and vibration. If the cylinder head bolts are not retorqued after an initial period of engine operation, the clamping load is reduced and leakage occurs.

Remedy: Always follow the manufacturers' instructions about retorquing cylinder head bolts after a specified mileage. If the engine is to pass out of your control, clearly label it that a retorque will be required.

Bolt identification

Threads in today's modern vehicles are almost without exception metric. However, many older vehicles are still to be found with a mixture of thread systems. It is extremely important that nuts and bolts are correctly matched. The following will help with identification.



Surface finish



Recommendations: To ensure an effective seal between the cylinder head gasket and the joint face is obtained, the surface finish of the cylinder head must be taken into consideration. Too smooth a finish may allow gasket movement, resulting in failure. Too rough a finish will prevent adequate surface sealing between the gasket and the engine surfaces, allowing seepage to occur. The table below gives the approximate surface finish requirements in micromillimetres from the various types of gasket available. These are general guidelines but should be used when alternative OE specifications are unavailable.

Surface Feature	Gasket Type			
	Fibre	Graphite	Multi-Layer Steel	Steel-Elastomer
Maximum Roughness Rz (Sampling Length)	12µm - 15µm (0.80mm)	12µm - 15µm (0.80mm)	< 12.5µm Depending on Coating thickness (0.80mm)	12µm - 15 µm (0.80mm)
Waviness Wt (Sampling Length)	< 10µm (2.5mm)	< 10µm (2.5mm)	< 10µm (2.5mm)	< 10µm (2.5mm)
Flatness	80µm over 150 mm	50 µm over 150 mm	<25µm over 150 mm <25µm overall	50 µm over 150 mm

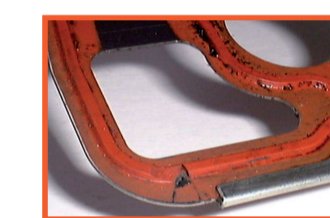
Torque conversion chart

Unit	Nm	Kgf.m	Kgf.cm	Lbf.ft	Lbf.in
1 Nm =		0.102	10.20	0.738	8.85
1 Kgf.m =	9.806		100	7.233	86.79
1 Kgf.cm =	0.098	0.01		0.072	0.868
1 Lbf.ft =	1.356	0.138	13.80		12.00
1 Lbf.in =	0.113	0.011	1.152	0.083	

Other problems



Entrapment: Gaskets and components must be thoroughly cleaned before assembly. Any foreign material trapped between the mating surfaces will seriously impair the gaskets sealing performance.



Damage: A cylinder head gasket is a delicate component and easily damaged. Always inspect a gasket before assembly and never install one that has been folded or creased. Never re-use a cylinder head gasket.



Distortion: Cylinder head gaskets are designed to seal flat surfaces. Distorted cylinder heads and engine blocks will impair gasket sealing performance. Always check that surfaces are within the manufacturer's specification for flatness, particularly with aluminium components. It is difficult to give a figure for all engines but a distortion of 0.1 mm over the length of the average cylinder head should be considered the maximum allowable.



Sealants: In general, sealants should never be used when fitting a cylinder head gasket. If a sealant is considered necessary at, for example, 'T' Joints, then avoid overuse. Excess sealant can block passageways and cause bolts to lock hydraulically in blind holes.

