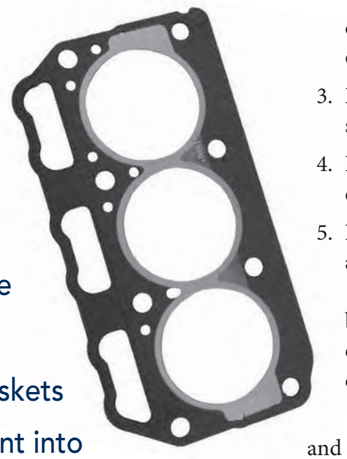
Head Gaskets

By Bill Hancock, Assistant Editor



Head Gaskets wear out or simply age. When they fail, usually the first sign is overheating. However, since many of us use water from the lake, we do not notice the failure because, unlike a car, there is no apparent overheating. When the gaskets initially fail, they begin to leak coolant into the combustion chamber. Once the engine is shut off, water sometimes continues to enter the combustion chamber where it may lay for months before your next outing. By that time, rust corrosion and perhaps a seized piston may have occurred.

When faced with a head gasket failure however, many mechanics and DIY types simply remove the gasket, clean the surface and replace the gasket without finding the root cause of the failure. All they have done is to delay the solution and set-up the next failure.

Recently, there has been a lot of concern about blown head gaskets. Before we begin with the repair let's examine why head gaskets typically fail. In no particular order, here are some of the reasons:

1. **Overheating**-Here are the most prevalent reasons for overheating
   a. Poor or old fuel causing detonation
   b. Improper spark timing causing pre-ignition
   c. Poor fuel distribution causing a hot cylinder
   d. Bad water pump or blocked cooling passages, or plugged water inlet
   e. Leaking gaskets
2. **Uneven mating surfaces** typically caused by
   a. Overheating
   b. Poor surface machining during a prior rebuild
   c. Rusted or worn parts
   d. Loose head fasteners
3. **Pits and porosity** in mating surfaces causing leaks
4. **Incorrect head gasket** or wrong orientation during reassembly
5. **Improper assembly**
   a. Failed to follow torque sequence
   b. Wrong torque
   c. Incorrect or worn out fasteners
   d. Wrong application of sealer

Let's take a look at the issues and explore how to ensure a lasting repair.

To begin, let's look at the functions of the head gasket. Obviously, the first and foremost duty of the head gasket is to seal the cylinder head to the block so no hot gases escape. The secondary function is to create a seal which keeps the coolant inside the engine's coolant passages, and the oil within the oil passages.

Coolant

Let's take a moment here to define coolant. Coolant can be water or in a closed system a 50-50 mixture of water and ethylene glycol. Most of us here in Florida use an **open** system in which our engine draws lake water into the block which then flows through the cooling passages where it absorbs the heat and then is routed into the downstream exhaust system where it cools the hot exhaust gases before exiting into the lake. In a **closed** system, the engine utilizes coolant which stays in a closed loop and continually circulates between the engine where it absorbs heat and the heat exchanger where it transfers the heat from the engine back into the lake. The real benefit of a closed system is not having to drain the engine during the winter lay-up to prevent freezing. For this article, I will use the term coolant to cover both plain water and a mixture of water and ethylene glycol.

Next, the head gasket must prevent the coolant from leaking out of the engine and ending up in the bilge as well as preventing the coolant from leaking into the cylinders or the internal engine oil passages or into the crankcase.

The third function of the head gasket is to proportionately meter or direct the coolant flow to various regions of the engine, so the engine maintains equalized cooling capability throughout. The coolant typically enters the engine in one location, circulates through the engine collecting heat then exits to either a cooler or is dumped back into the lake through the exhaust system.

Creating and maintaining a successful seal in all of these areas is one of those exercises where the Devil is in the details. Let's start with the basic principles of sealing. The head gasket can be divided into two basic types. Either a shim gasket which is a relatively thin piece of soft metal such as copper or mild steel, or a composite gasket which is a sandwich affair comprised of thin layers of heat resistant relatively soft material sometimes clad by thin metal on both sides. The composite gaskets always have a metal fire ring which surrounds the perimeter of the combustion chamber to prevent the blow out and burning from the intense heat and high pressure encountered in the combustion chamber. The remainder of the composite gasket may be comprised of a heat resistant material capable of sealing hot oil and water.

Figure 1 - Using a machinist's precision straight edge you should not be able to slide a feeler gage larger than .003" between the straight edge and the cylinder head deck surface. A carpenter's square does not qualify as a precision straightedge.

For the head gasket to perform its job, three things must occur: First the adjacent mating surfaces, which in this case are the head and the cylinder block, must be **absolutely flat and parallel** over their entire contact area. Second, there can be no pits or voids in the mating surfaces. And finally, there must be adequate and equal clamping load over the entire joint.

Clamping Load

This is a term engineers like to use when talking about fasteners. Not unlike a 'C' Clamp, as the screw is tightened, the subject matter is squeezed between the two adjacent surfaces. In everyday practice we apply the same principle and rate the amount of clamping force by measuring the torque or twisting effort to tighten the fastener/s.

Here's where that theory falls apart. Suppose the threads holding the joint together are slightly damaged. It would be possible to reach the desired torque, because the threads jammed, before we created any clamping action. For this reason, we always insist on inspecting both the internal and the external mating threads to make sure the fastener turns freely over the entire length. In other words, it is entirely possible to achieve the proper torque number because of jammed threads, but not have the correct clamping load.

Now let's take these requirements and examine them one at a time. First let's define *flat*. Typical engine service manuals define flatness as the surface flatness not varying more than .003" over the entire length of the head in the case of a small block V8. This means that if you place a straight edge on the gasket surface of a cylinder head you cannot slip a .004" feeler gage under it at any point while it is resting on the head, no matter how it is aligned with the head.

If there is one key to this job, it is not to get in a hurry or decide to skip some steps such as surfacing the block because it is too hard or time consuming. This will only come back to haunt you later and you will be forced to repeat the process when the next gasket blows. Unless BOTH surfaces are perfectly flat, you WILL have head gasket problems!

To check the block deck surface for flatness, first you must remove the head studs if the engine is so equipped. Removing the studs can sometimes be

Figure 2 - Snap-On Stud installer/Remover

Figure 3 - This is the perfect water squirter. It has a small stream that can be accurately aimed at the precise location.

a little difficult so here are a few tricks. Typically, on older engines, especially those which have been exposed to untreated or salt water, the studs may have rusted into the block. Before you begin the removal procedure, you might want to make sure you can get replacement studs, since you may inadvertently destroy a weakened or rusted stud or two during the removal process. The real trick here is to have the proper stud removal tool. The typical Neanderthal mechanic uses a set of Vise Grip pliers or a pipe wrench and grabs the stud and starts turning until either the pliers slip and gouge the stud, or the stud is twisted off in the block. There are several dedicated stud removal tools available, and I have tried them all. The best one is made by Snap-On tools, (Fig 2) and utilizes a threaded collet which contacts the stud by all of the threads evenly and will not damage the threads. To use it, simply thread it onto the stud, tighten it up, and then give it a twist with a wrench.

Stud removal is one of those areas where, after years of experience, we come to realize that brute force only works well in certain applications. This is an area where PATIENCE and FINESSE are the key. Before you attempt to remove the studs, use a penetrant, and spray it around the stud then leave it overnight so it has time to sink into the threads. My favorite penetrant is actually a home brew comprised of a 50/50 mixture of transmission oil and acetone. Install the stud removal tool and gently rotate the stud back and forth.

If the stud does not move with a fair amount of torque: **STOP!** Use an Oxy-Acetelyene torch; not a propane torch because they don't produce enough heat. Next, have a small squirt bottle (see Fig 3) filled with water handy before you start to heat the parts.

Using a neutral flame, apply heat to the block gently around the base of the stud where it meets the block. When the stud starts to heat up and reaches a dull red or dark maroon color, hand the torch to a friend to hold, place a wrench on the stud removal tool, pick up the squirt bottle and quickly squirt the base of the stud with water, as you quickly turn the stud removal tool. What you are doing is temporarily shrinking the stud diameter by a very small amount while the metal surrounding it is slightly expanded. *Note, this extra clearance only lasts a few seconds before it returns to normal.* **RESIST the urge to keep on twisting when it gets difficult to turn.** STOP……. repeat the process. Sometimes you may only get ¼ to ½ a turn before the stud tightens up again. Keep on doing the gentle heat, quench, turn, heat, quench, etc. routine and eventually you will be able to remove the stud without damaging the threads or the stud.

Figure 4 - A few strokes with long sanding board with 60 grit paper works well to remove the remaining bits of material from the surface after you first clean the surface with a razor blade scraper. This may also show some low spots.

DO NOT GET IN A HURRY HERE!

Remember Patience and Finesse!

Warning – If you get the head studs too hot, they will lose their strength and become soft. They will no longer be able to produce the correct clamping load and will need to be replaced, so don't overheat them. If they get any hotter than dark maroon you will have probably overheated and softened them.

Once you remove all the studs, clean up the deck surface. Gently scrape the surface using a single edge razor blade and follow-up with a long flat sanding board (Fig. 4) with 60 grit paper to lightly sand the surface and get rid of the prior gasket, carbon, and sealer remnants.

If you don't have a good straightedge, don't worry. In our everyday life the flattest thing we all encounter is a piece of plate glass. Go to the local glass cutter and get a piece of 3/8 thick glass at least 20" long x 6 inches wide and then get some rubbing compound or valve grinding compound. Smear the abrasive over the deck surface and lay the glass on the deck surface. Wear some work gloves and rub the glass back and forth about twenty times then remove the abrasive and look at the resulting pattern. You will be able to see just exactly where the high and the low spots are.

Depending on how flat the surface is, it may need to be ground or milled flat again. You will have to take the parts to an automotive machine shop to get this done. Before reassembly, run a bottom tap, which has full threads for its entire length, into all of the bolt holes to remove any built-up debris in the thread area. Clean the threaded portions of the bolts and studs with a wire wheel or die to ensure the fastener threads are clean. Reinstall the studs or bolts with the proper sealer or thread locker if called for.

If the block needs to be surfaced, it will require complete disassembly. After the surfacing, the parts, especially the internal oil passages, must be carefully cleaned to ensure they are free from machining debris and abrasive. Check carefully to be sure the parts are clean before reassembly, otherwise the engine bearings will fail prematurely due to wear from debris.

Before you assemble the head to the block, coat the gasket with gasket sealer if required. Place the gasket on the block with the correct side up. Proper gasket orientation is a critical detail since it determines how the cooling holes are aligned with the corresponding holes in the block. Read and follow the instructions and service manual for your engine. Some gaskets are stamped with the word "TOP" or "THIS SIDE UP" indicating that that face should be faced away from the block.

Next, using the proper lubricant or sealant on the threads, place the head/s on the engine, loosely install the fasteners and be sure to follow the torque pattern and sequence utilizing the recommended incremental torque steps. Do not use the Neanderthal method of just running them down with an air impact wrench and calling it good. Threat your engine fasteners with the care and respect they deserve.

Reinstall the remainder of the parts and fill your engine with coolant and check for leaks. Once there are no leaks, fire the engine up and continue to look for leaks. Let it run and warm up to operating temperature, then turn it off and let it fully cool. Go back and retorque the head/s. Now there will be a good chance your new head gasket will last for a long time.

Happy Boating!