Head Gasket Sealing

BY **Brian Roberts**

Today's head gaskets have come a long way in design and function over the last five or six decades. The requirements for them have driven these changes and we will look at this evolution to help explain for those who are new to this industry or brush up for those who have been around a long time.

Early Generation Head Gaskets

The early head gasket was often referred to as a sandwich style gasket. They were a fiber-based material that had excellent thermal properties that was sandwiched between to layers of copper or steel and then eyelets were closed around all the coolant and oil openings to keep the fluid from getting to the fiber material within. The combustion openings had metal armors that formed around the top and bottom like an eyelet to contain the combustion process. This gasket style was very soft and conformable to accommodate very loose manufacturing tolerances of the day. Although many were installed dry, these gaskets were often covered by the installer in a copper coat or some other coating to enhance micro sealing of the surface finishes. One of the early head gaskets was a shim gasket for the small block Chevy. It had embossments like what you see on current MLS head gaskets. The difference is the material back then was a mild steel with no recovery to it. The embosses give a high initial load to seal and then as the head lifts the gasket does not recover with it like it does on later generation MLS gaskets.

Composite Head Gaskets

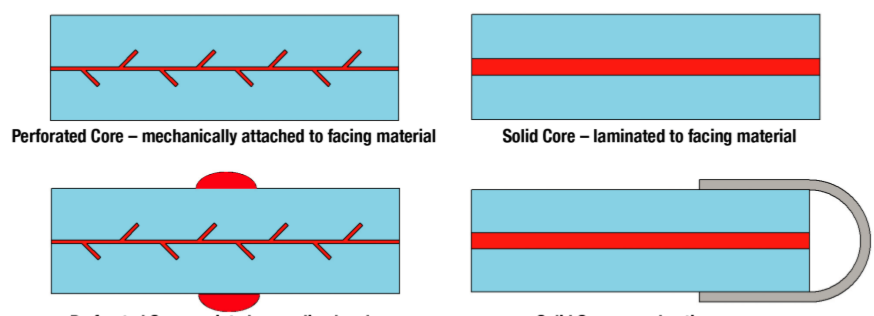
The next generation head gasket was known as composite, these are a combination of fiber based or graphite-based materials and rigid cores like steels or stainless steels. These materials were also enhanced with coatings and screen-printed sealing beads strategically placed to improve fluid sealing. The combustion pressure was sealed using a wrap around armor to protect the composite material from the higher temps seen at combustion. Let's look at the details of this generation of head gaskets…

The body of a composite gasket is either a perforated core or a laminated core. The perforated core provided a mechanical attachment of the fiber based or graphite-based facing materials used to seal fluids.

These fiber and graphite materials are densified to a pre-determined amount to provide the best sealing capabilities possible. Aftermarket manufactures spent countless hours and money static and dyno testing to prefect this process. Once the material is densified it needs to be blanked out to produce all the bolt holes, combustion opening, fluid metering holes for oil and coolant and the outside contour profile. This is achieved by either simple rule die blanking or steel die blanking process. The important portion of this blanking process is the locations of the dowel pin holes in relation to the combustion openings. If this relationship is not accurate, the combustion openings can be out of position and unload the combustion seal. For composite gaskets, manufacturers utilize an armor to wrap around the body. This material is usually a tin plate or more likely a stainless steel. The material sits on top and bottom of the body material and when compressed it densifies the body material more and creates a high concentrated load to handle the firing pressures. The screen-printed materials are placed in specific areas to seal fluids. This material is usually a silicone or nitrile and like the armor creates a more densified area to increase loading

to seal the fluids. The screen-printing is not always needed as the body material is more than capable of sealing fluids but on certain applications the beads are a benefit. The last part of a composite gasket is the coating. The head gasket is usually coated on both sides to serve two functions. One is to provide a micro seal that helps fill in the tiny peaks and valleys of the surface finishes on the flanges.

The other is to provide a release agent for disassembly. The coatings can be formulations of Silicone, Moly or Teflon. These constructions served the industries very well for decades, but the modern engine designs and function evolved to a point where these gaskets could no longer perform to those demands. This led to the next generation of head gaskets.



Perforated Core – mechanically attached to facing material

Solid Core – laminated to facing material

Perforated Core – printed on sealing beads

Solid Core – combustion armor

MLS (Multi-Layered Steel)

This is the current head gasket construction is used by almost all passenger car and light duty vehicle manufactures today. The demands of higher combustion temperatures, firing pressures and lighter components created the need for a new breed of gasket. The MLS construction accommodates these demands. These head gaskets usually consist of two functional outer layers and a middle (distance) layer, creating a three-layer gasket. There are MLS gasket with five or more layers and the number of layers is dependent on the amount of head lift that occurs each time the cylinder fires. This micro movement is measured by manufacturers to help determine the number of layers needed. MLS gasket acts like a spring and always travels up

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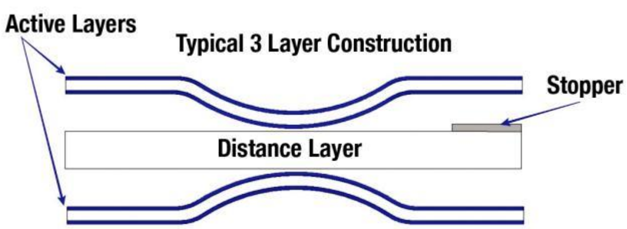
and down to maintain a sealing load on the flanges while in motion. The outer layers have pre-determined embossed beads to seal combustion and fluids. The full emboss primarily for combustion and high-pressure oil sealing. The half emboss is reserved to seal non-high-pressure fluids. These outer layers are also either fully coated with a very thin coating or screen printed on very thin coating. Most coating are no more than .001" thick. This coating is or micro sealing of the peaks a valley in the surface finish. The coating is applied with a curtain coater or screen printed on is a particular pattern. Both methods require very precise thickness application control. Since the coating is very thin the need for smoother surface finishes is required. The distance layer is used to make up the difference of machining processes used in our industry. Aftermarket manufacturers try to design in a thicker distance layer to return the stack up height of the head after surfacing it. This distance layer can also serve as a mounting point for the stopper design aids in reducing bore distortion and provide a very strong combustion seal that is inside the primary sealing emboss ring.

Full Emboss – Used to seal combustion and high-pressure fluids.

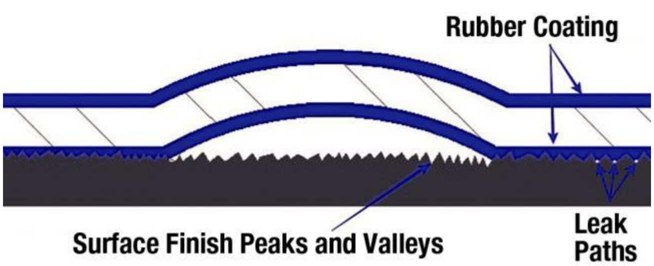
Half Emboss – Used to seal fluids.



MLS with Stopper – Stopper is the primary sealing bead with the traditional emboss bead as the backup.

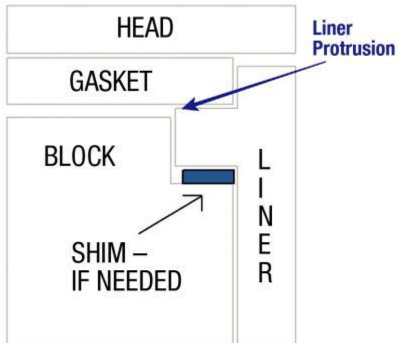
Surface Finish Importance

The surface finish has always been critical to head gasket sealing success but today it is more important than ever. Today's materials require a smoother finish due to the thickness of the coatings. These rubber coatings applied to the surface of the steels used is only about .001" thick. This thin coating needs to seal the micro peaks and valleys left behind during the machining processes. The finish you need for most MLS head gaskets by aftermarket suppliers is 40-60 Ra.



Diesel Head Gaskets

Many diesel applications with their higher compression ratios and firing pressures require a special head gasket design. Some of these engines have a cylinder liner in the block that protrudes from the deck surface. This protrusion produces extra load on the cylinder ring or fire ring as it is commonly called. This extra load/squeeze provides the clamping force needed to ensure the combustion seal can withstand those higher firing pressures. The machining processes to install the cylinder liner are critical to establish the correct liner protrusion. As an example, this critical protrusion height may be .002-.004" above the block deck. Too little protrusion and not enough load to seal and or too much protrusion can over compress the fire ring and then unload the body material to the point of fluid leaks.



Head Bolts

The success on the sealing capability of any head gasket discussed from Sandwich to MLS relies on the fasteners. Head bolts can be multi-use or single use as seen with TTY (Torque to Yield Bolts). Older engines used bolts that could be used over and over (unless damaged) and were torqued in steps to a desired FT/LB rating. Later engines utilize TTY bolts, these bolts are engineered to stretch and provide a more uniform load on the gasket. Some TTY bolts can be used a few times while other can only be used once. Follow the manufacturers recommendations on use for those bolts. The TTY bolts stretch and once that stretch reaches the yield point, the fastener breaks.

Regardless of the type of bolt being used the threads need to be clean and free of debris. Any dirt or debris will increase the coefficient of friction and you will reach your torque value but have a reduced clamp load, which could lead to a head gasket failure. Threads should also be lubricated with oil or a recommended lubricant to reduce the friction which will result in more load at the factory torque specification. New bolts with pre-applied coatings should not be cleaned or oiled before installation, install as recieved. Torque wrench calibration is also something that should be looked at periodically to ensure you are producing the desired torque. Following these simple guidelines will help ensure you have a good head gasket seal.n

AERA Technical Specialist Brian Roberts has over 20 years of experience in the automotive aftermarket, including time at Federal-Mogul (Fel-Pro), Modern Silicone Technologies and Dana Corporation as a Product Engineer and Product Manager. He has a wealth of information in gasket development, production and distribution; in particular, the engine sealing process and solving problem applications. For more information, email: brian@aera.org.