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# Cylinder Block and Cylinder Head Surface Finish

The cylinder block and cylinder head surface finishes required for successful gasket sealing and expected gasket life vary according to cylinder head and cylinder block materials, and gasket design, material and coatings. Head gasket materials have changed over the last two decades from asbestos based to various asbestos free materials to graphite composite and the current steel shim (MLS or multi-layer steel) designs. Each design requires different cylinder head and block surface finishes. Head gaskets must provide both *macro and micro sealing*. Macro sealing is provided by the gasket design and construction, typically giving surface pressures up to 10 kg/mm$^2$ for petrol combustion cylinders, up to 20 kg/mm$^2$ for turbocharged diesel combustion cylinders, up to 1 kg/mm$^2$ for oil drain-back holes, up to 1.5 kg/mm$^2$ for oil pressure-feed holes and up to 0.5 kg/mm$^2$ for water/coolant holes.

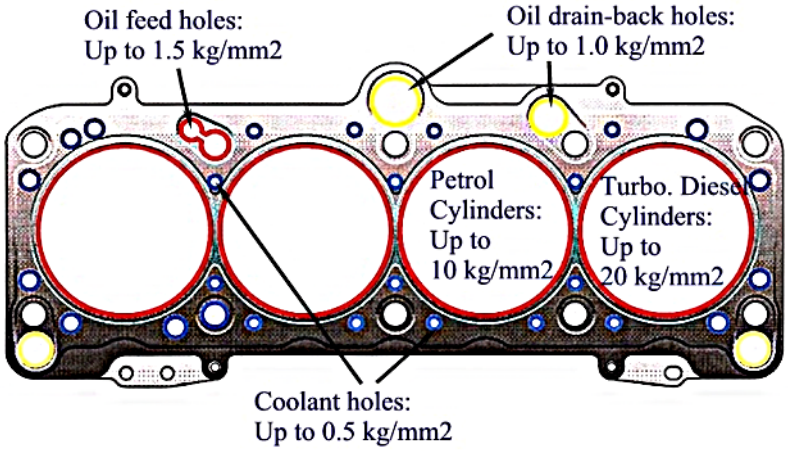


**Image 1.** Typical surface pressures required for head gaskets to macro seal.

The ability of the head gasket to seal with these pressures is governed by head bolt load and cylinder head and cylinder block finish, flatness and waviness. In linered engines, liner flange protrusion and variation between adjacent liner flange protrusions also have a large influence on the ability of the head gasket to successfully seal. These pressures are often achieved by the use of silicon beads on composite gaskets, pressed deformation beads on steel shim gaskets, and bore bindings and wire rings inside bore bindings. Micro sealing is the gasket's ability to seal small grooves, scratches and imperfections on the cylinder head and cylinder block surfaces and is usually achieved with 25 µm NBR (rubber), Silicon or FPM (Fluoropolymer/Viton) surface coatings. On MLS gaskets this may also include 10 µm NBR, Silicon or FPM surface coatings on intermediate layers. These surface coatings are also common on composite gaskets.

Each gasket design works best when matched with a suitable surface finish - usually specified by a Ra or Rz designation. Composite graphite gaskets are relatively fragile due to the inherit properities of the graphite and will fail if they experience excessive shearing forces. These gaskets will nearly always have solid stainless steel support/spacer rings inside the bore binding of each cylinder. Furthermore, the cylinder block and cylinder head surface finishes should be relatively smooth, minimising shear forces on the gasket and maximising heat transfer. If the head and/or block are of aluminium, the surface finish should be less than 1.5 µm Ra (60 µ Ra). Table 1 below shows the *general* recommendations for surface finish according to block and head material and the style of gasket. These are *only* a recommendation and the engine and gasket manufacter's specifications should be followed if they are available.

MLS gaskets also require very fine surface finishes, although not to minimise shearing forces. The steel layers cannot conform to block or head surface irregularities as composite gaskets do and rely exclusively on the gasket coatings and clamping loads for sealing. While the general recommendation for an aluminium head and/or block surface finish is less than 0.75 µm Ra (30 µ Ra), it is not uncommon to see the specification as less than 0.35 µm Ra (15 µ Ra). The traditional fear of too-fine surface finish is the susceptibility of cold sealability, however this is less a problem with composite graphite and MLS gaskets.

| | COMPOSITE GASKET | STEEL SHIM GASKET |
|---|---|---|
| ALUMINIUM | 1.0 – 1.5 µm Ra (40 – 60 µ) | 0.5 – 0.75 µm Ra (20 – 30 µ) |
| CAST IRON | 1.5 – 2.0 µm Ra (60 – 80 µ) | 1.5 – 1.75 µm Ra (60 – 70 µ) |

**Table 1.** General Recommendations for Surface Finish by Gasket Design
**Note:** 1 µ Ra = 0.0254 µm Ra

While successful head gasket sealing relies on getting the correct surface finish on the cylinder head and cylinder block, extra care must also be taken to ensure the surfaces are free of any nicks and scratches that lead to the edges of any combustion, coolant or oil holes. These can lead to leakages over time, or in the case of coolants, can result in immediate leakage. Glycol, one of the most common cooling additives, has high 'wicking' properties and any significant scratch or machining groove that leads from a coolant hole to a combustion hole, oil hole or the exterior of the engine, can result in the coolant tracking to that point. Once the surface of the 'groove' is coated with glycol and the many other additives in the coolant, it is unlikely the gasket coating will ever seal correctly at that point. This effect is sometimes evident as small beads of 'green' coolant forming at various locations around the edge of the head gasket after the engine is first started. Ideally, the engine should be filled with demineralised water initially and then after the engine has been warmed up to operating temperature and cooled down, and the head bolts re-tensioned (if required), the necessary cooling additive can be added.

Successful head gasket sealing also requires the other specifications of cylinder head and block flatness and cylinder head bolt tensions and sequences, as specified by the manufacturer, be followed. Extra sealants (e.g. Hylomar, CopperKote, Silastic, etc.) must not be applied to the head gasket unless specified by the manufacturer. Use of these sealants can affect a head gaskets ability in several ways:

- Cold-seal - the ability of the gasket to seal coolant until the engine is first started.
- Cold-flow - the characteristics of the coating material to creep as the gasket is loaded (clamped), to seal small scratches and imperfections on the head and block surfaces.
- Reduce the shearing forces that are applied to the gasket surfaces by thermal expansion of the cylinder head and block.
- The added thickness of an applied sealant on a head gasket can cause uneven loading and/or a loss of torque retention.
- Some sealants may react with the gasket's silicone coating, causing the gasket to deteriorate, and in some cases this can cause the deterioration of the added sealant itself.

Added sealants will only be necessary on gaskets that are not pre-coated. These are uncommon in the diesel world today and would only apply to older engines with copper faced sandwich design head gaskets and on the one side of the newer single steel layer 'Head Saver' style shims. Use of sealants on most other styles of head gaskets will typically lead to gasket failure and immediately void the manufacturer's warranty.

**Note:** Acceptable cylinder head and cylinder block surface finishes **cannot** be obtained using planer style surface grinders or hand-held disk grinders (e.g.. Scotchbrite pads).

For related topics, refer to:

**SB004 Angle Torque Cylinder Head Bolts**
**SB021 Surface Finish**