Technical Information

Motorsport Engine Bearings

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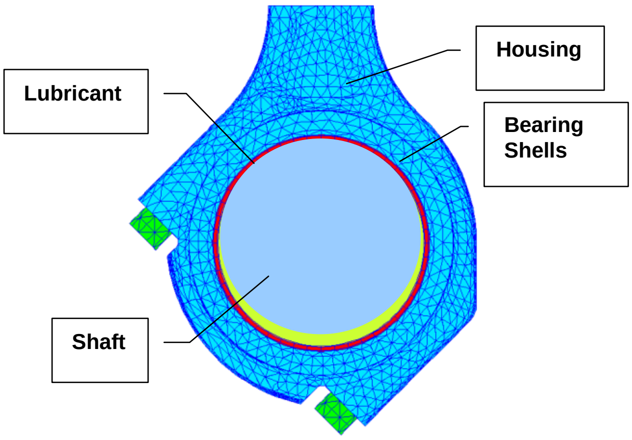
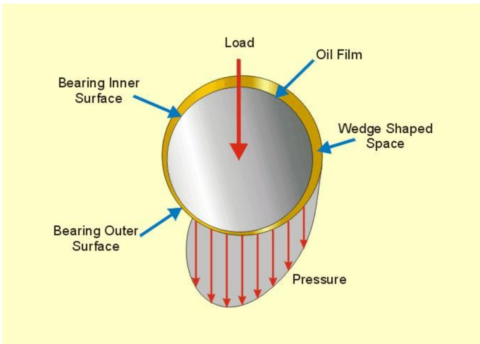
The Bearing System:

A bearing shell is one component in a system that includes a housing, shaft and lubricant. The reliability of the bearing shells are dependent on these other components and as such they must be designed in conjunction with the bearing shells as part of a bearing system.

The bearing system is designed to generate a ***hydrodynamic oil film*** in order to separate the bearing shell from the shaft during operation and the design of the bearing shell itself is crucial in achieving this. There are a number of critical features on the bearing shell but most important is the wall thickness which must be controlled, not only at the centreline, but around the entire bore profile. The bearing shell must also be able to achieve good contact with its housing in order to accept full support from the housing and efficiently transfer heat into it.



The Bearing System

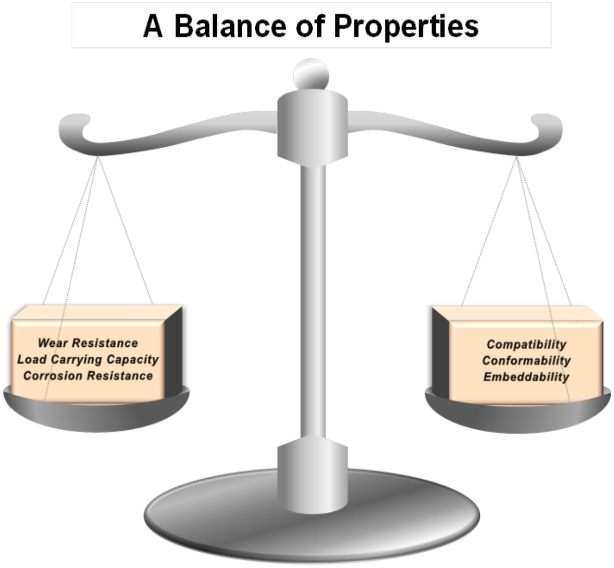


Generation of a hydrodynamic oil film

The inherent elasticity in the bearing system as well as imperfect geometry means that the bearing shells must exhibit properties of ***compatibility*** and ***conformability*** for successful operation. A further requirement is ***embeddability*** which enables the bearing to deal with particle contamination.

However, for motorsport bearings or indeed any heavy duty application the bearing shells must also exhibit good ***load carrying capacity***, ***wear resistance*** and ***resistance to cavitation erosion***.

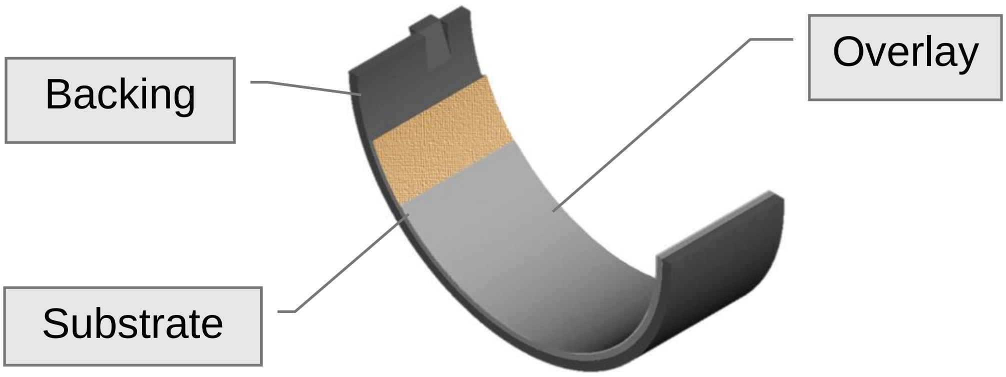
The bearing designer needs to achieve this balancing act by selecting the right combination of materials.



A Balance of Properties

Bearing Materials:

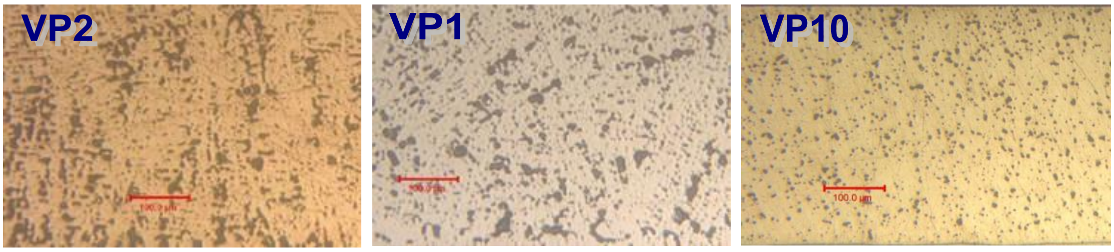
In motorsport the right balance of properties must be selected for each and every engine application. For example, in Formula 1 every make of engine has its own unique bearing design with its own balance of properties. Despite F1 engines being of a standard V6 configuration, the bearings are customised for each engine design.



Trimetal Bearing Construction

A trimetal construction is required for motorsport. The technology begins with the steel backing. This must be strong enough to allow a high interference fit in the housing without plastic deformation. The bearing fit is critical, not merely to hold the bearing in place during service, but to create intimate contact with the housing and minimise fretting damage. This increases the efficiency of the heat transfer into the housing – an aspect of bearing technology that is often overlooked. Even the identification stamping on a bearing backing can seriously inhibit heat transfer causing a bearing to run hotter.

The bronze substrate should be cast for maximum strength. The casting process provides a microstructure with ***vertically orientated bronze columns*** which offers a superior load carrying capacity. The level of conformability can be defined by the amount of lead in the substrate but even with a high lead composition, the substrate on its own is still too hard.



MAHLE Cast Bronze Microstructures

An overlay is required to increase the soft-phase properties and provides a further opportunity to fine tune the balance of properties. ***Lead-Indium*** has been proven at the highest level of motorsport to offer the optimum combination of hard-phase and soft-phase properties. The thickness and ***Indium*** content can be varied to suit the application.

Lead-indium does not contain tin and this means it does not require a nickel barrier: Tin migrates very quickly into the bronze substrate unless an intermediate nickel layer is applied over the substrate to act as a barrier. Nickel is not a bearing material and if it becomes exposed through wear of the overlay it could damage the crankshaft, or lead to overheating and even failure.

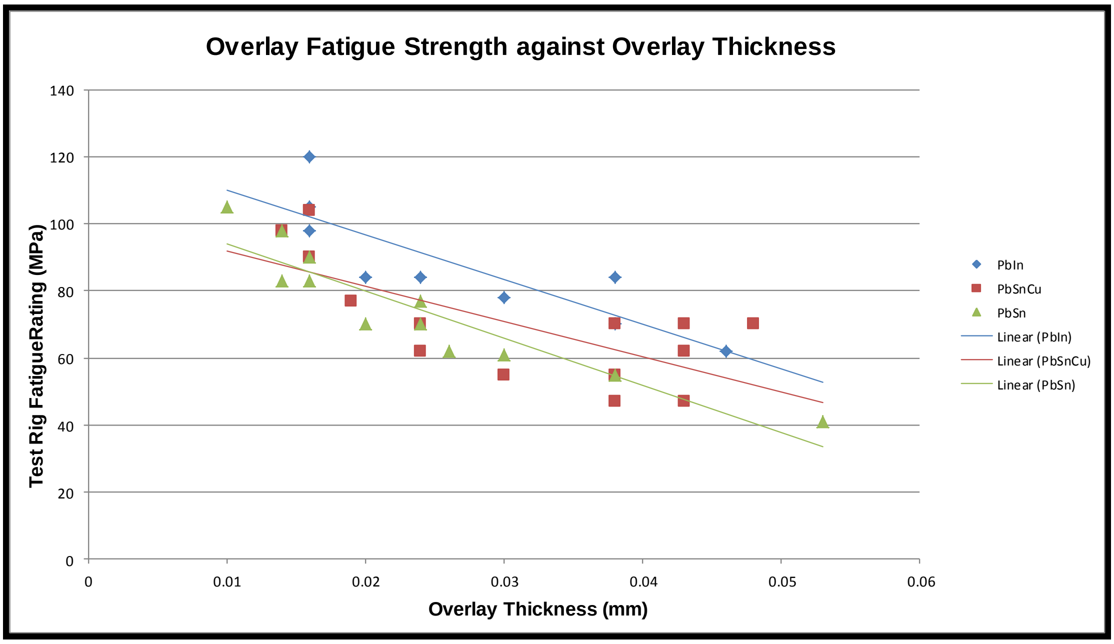
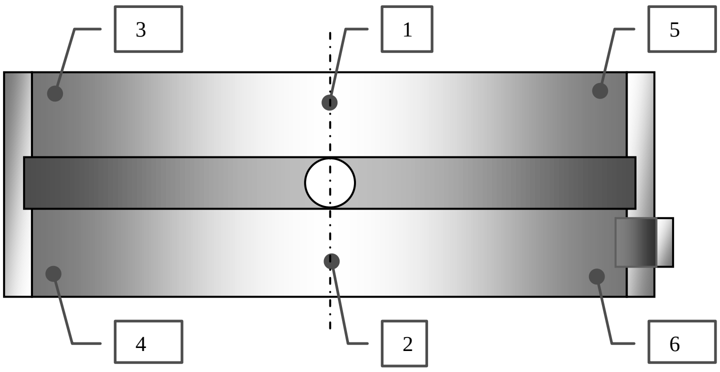


Chart Comparing Fatigue Strength of Common Overlay Materials

Bearing Geometry:

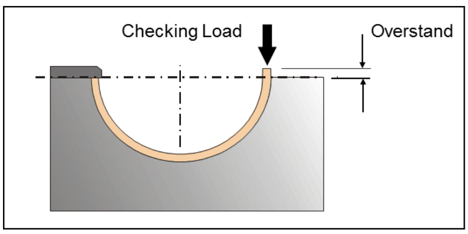
Most engine builders know how important the ***wall thickness*** of the bearing is as it defines the clearance of the engine which has a direct influence in the all-important oil film thickness. The wall thickness is usually measured across points 1 and 2 as shown in the diagram below but the thickness in positions 3 to 6 are just as important.



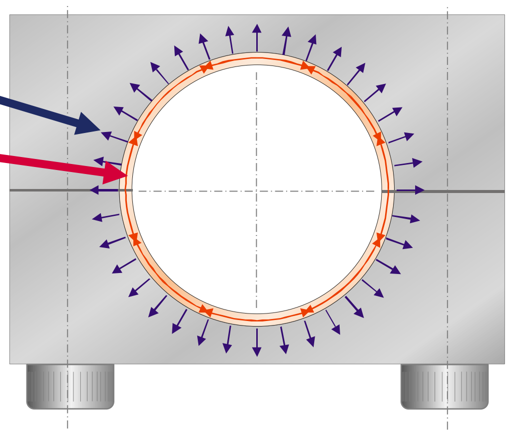
Bearing Wall Thickness

The wall is specifically machined thinner at points 3 to 6, how much thinner depends on the application. This feature is called ***eccentricity*** owing to the fact that bearing shells are bored eccentrically and it influences the oil film thickness and oil flow. The bore of a bearing shell has a further machined operation called ***bore relief*** which is usually visible close to the joint faces. This is additional clearance required to cope with potential poor alignment of the housing cap known as joint face stagger. Without relief the bearing shell could end up acting as an oil scraper. In many bearings, the amount of relief is excessive creating a larger oil leakage path.

The overstand of the bearing is the dimension which defines its peripheral length which in turn controls the interference fit of the bearing. Along with the steel backing the overstand specification is crucial in minimising fretting damage and maximising the efficiency of the heat transfer into the housing.



Bearing Overstand



Schematic of Fitting Loads

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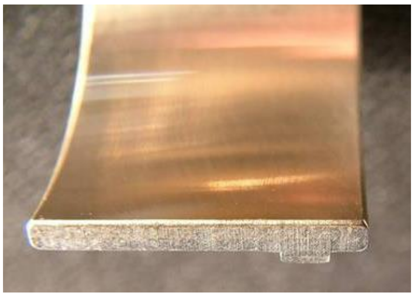
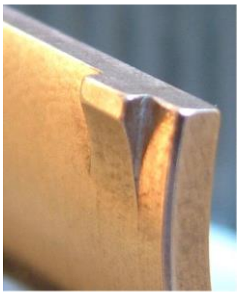
Bearing Features:

The sole purpose of the notch is for location during assembly. However, a conventional notch compromises the integrity of the bearing as it reduces the cross-sectional area of the bearing at the joint face which increases the hoop stress in the bearing and limits the interference fit that can be achieved.

The most critical motorsport applications use a ***racing notch*** which maximizes the cross-sectional area for good interference fit and eliminates disruption to the bearing bore and consequently to the oil film.





Various Types of Racing Notch

The cheapest method of identifying a bearing is by stamping. For motorsport applications where higher temperatures are experienced, the effectiveness of heat transfer into the housing should not be compromised. If the stamping is heavy and extends quite far round the bearing causing poor back contact then the heat transfer will be reduced.

Laser marking is an alternative method which creates smaller, more consistent marking and as such does not interfere with the back contact and subsequent heat transfer. The laser marking penetrates into the steel backing by only around 12µm.

Laser Marking

The Complete Package:

Just as bearing shells should not be designed in isolation of the other components that make up the bearing system, each material, dimension and feature of a bearing shell should not be specified independently of each other. There is a tendency amongst engineers to focus on the performance of the top layer of the bearing – the overlay, yet the damaged incurred by the overlay may have its root cause in the substrate or the steel backing or even the eccentricity specification.

Every detail on a bearing shell, however small, contributes to the performance of that bearing shell as it strives to protect the oil film. And every bearing shell contributes to the performance of the bearing system as it strives to protect the engine.

The simple appearance of a bearing shell hides a wealth of complexity and every detail must be given due attention during design, manufacture and assembly to ensure the package is complete for secure and reliable performance right in the heart of the engine.