



Vacrodur

The material for maximum performance and excellent operational reliability (X-life)

X-life spindles made from Vacrodur



X-life high-speed spindle bearing made from Vacrodur

Excellent bearing operating life under the most challenging operating conditions

In the field of machine tools, innovative spindle drives must make an essential contribution towards achieving the continuous increase required in productivity. In addition, they must fulfil the increasing performance requirements at the same time as the lowest operational and maintenance costs.

Requirements for spindle bearings

A high proportion of all cases of spindle damage leading to failure can be attributed to the spindle bearing arrangement and is caused primarily by wear or collision. Other causes of damage include lubricant starvation and contamination.

In order to increase productivity and reduce machine downtime, spindle bearings must meet ever-increasing requirements in relation to:

- speed level,
- thermal robustness,
- load carrying capacity,
- lubrication conditions.

Vacrodur as a solution

Schaeffler has developed spindle bearings made from the innovative material Vacrodur.

Vacrodur is proven to be capable of giving significant increases in the operating life of spindle bearings under the most challenging conditions as well as clear reductions in operational and maintenance costs.

As a result, extremely robust spindle drives can be achieved that can make a considerably increased contribution to cost reduction in comparison with established solutions, Figure 1.

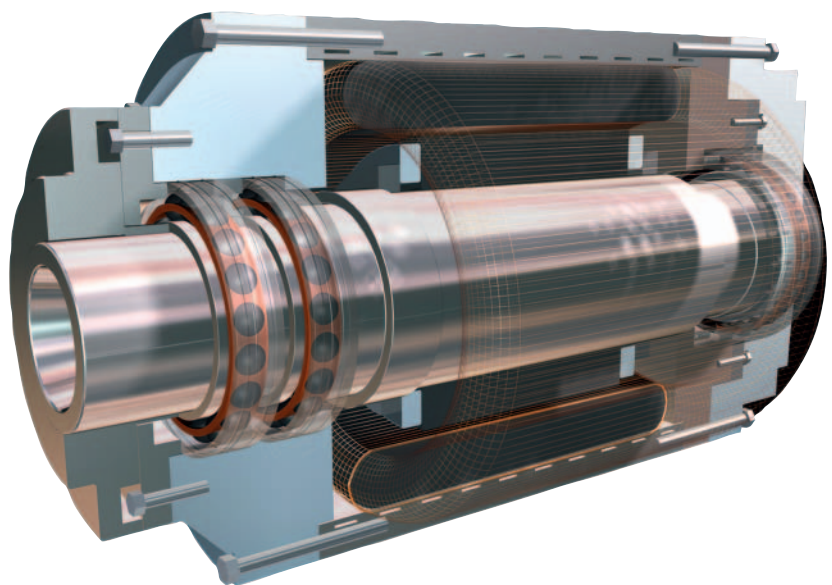


Figure 1: Motor spindle

Characteristics and advantages of Vacrodur

The material Vacrodur possesses, due to its alloy concept as well as the associated specific production process, outstanding characteristics that are beneficial for application in the field of spindle bearings.

- The material production process, which is based on powder metallurgy, gives exceptional homogeneity of material characteristics, which is reflected in the high quality of components, Figure 2 and Figure 3.
- The multiple-stage heat treatment of the material gives exceptionally high hardness values of up to 66 HRC which, in the case of lubricant contamination, leads to a reduction in initial damage caused by overrolling of foreign particles.

- The high hardness is achieved by a homogeneous material structure which has not only a tough material matrix but also contains large quantities of fine, uniformly distributed carbides. These carbides also lead to the outstanding wear resistance of Vacrodur.

- A further positive aspect of the heat treatment processes is the resulting thermal stability of Vacrodur. In contrast to conventional rolling bearing steels, the increased thermal stability of Vacrodur is not associated with reduced hardness values. The characteristics are stable up to exceptionally high application temperatures of 400 °C.

The associated robustness of a Vacrodur bearing is apparent particularly in cases of inadequate lubrication or a complete failure of lubrication. Such undesirable operating conditions are normally associated with considerably increasing temperatures at the rolling contact, with the potential for thermal influences on the structure and dimensional changes. The situation is different in the case of Vacrodur, where the thermal stability provides an additional safety margin to prevent spindle failures.



Figure 2: 100Cr6



Figure 3: Vacrodur

Comparison of Vacrodur – demonstrable and significant increase in operating life under mixed friction

Achieving the objective of increased operating life is based on the excellent rolling strength of Vacrodur. With the aid of a procedure certified by Germanischer Lloyd, Schaeffler is in a position to demonstrate the increased load carrying capacity of Vacrodur in comparison with standard rolling bearing steel.

This shows that Vacrodur achieves a rating life greater by a factor of more than 25 in a rating life test under mixed friction conditions, Figure 4.

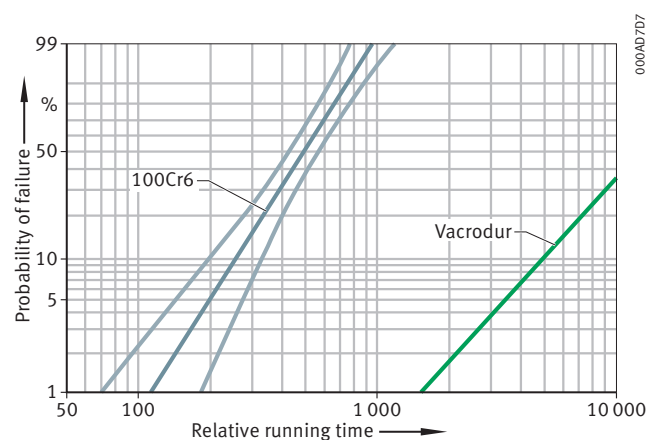


Figure 4: Rating life under mixed friction

Comparison of Vacrodur – demonstrable and significant increase in dynamic load carrying capacity

In the rating life test, Vacrodur was proven to have a rating life longer by a factor of more than 13 under elasto-hydrodynamic (EHD) lubrication conditions. The dynamic load carrying capacity is thus greater by a factor of 2,4 than for 100Cr6.

Comparison of Vacrodur – significant increase in resistance to brinelling

Failure by collision is one of the most common causes of failure. Due to its high hardness, Vacrodur gives significantly more robust behaviour in comparison with 100Cr6. In testing, the limiting contact pressure was shown to be higher by 15%, Figure 5. As a result, Vacrodur spindle bearings have a 40% higher static load carrying capacity (C_0).

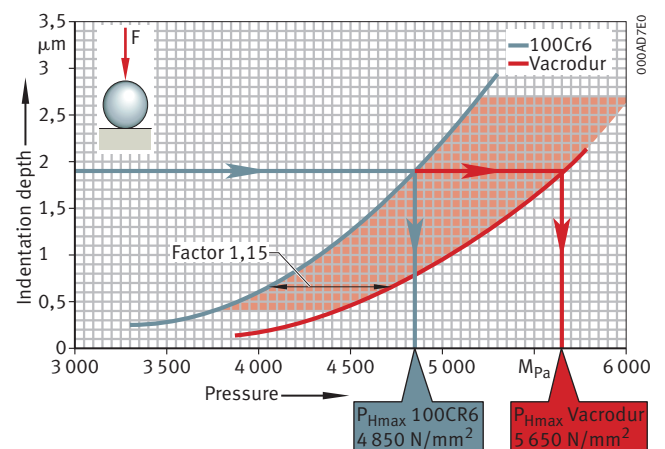


Figure 5: Indentation depth as a function of pressure

Comparison of Vacrodur – demonstrable and significant increase in operating life with contamination

Contamination of the lubricant or the ingress of contamination represents one of the main limiting factors on the operating life. Even under these boundary conditions, Vacrodur is capable of a significant increase in operating life. In a test under controlled contamination conditions, described as defined contamination of the lubricant by mineral particles, an increase by a factor of almost 24 in the operating life was demonstrated in comparison with the previous benchmark material Cronidur, Figure 6.

Comparison of Vacrodur – demonstrable and significant increase in resistance to adhesive/abrasive wear mechanisms under boundary friction

In spindle bearing applications, highly unfavourable lubrication conditions may occur in combination with slippage and solid body contamination, which have a negative influence on the operating life. In this case, the operating life can be reduced to a considerable extent in some cases by adhesive and abrasive wear mechanisms.

The excellent characteristics of Vacrodur – in particular its combination of very high hardness together with good toughness, in conjunction with its low adhesion tendency attributable to the alloy composition and the almost perfect homogeneity of the structure – play a decisive role in giving resistance to adhesive and abrasive wear mechanisms.

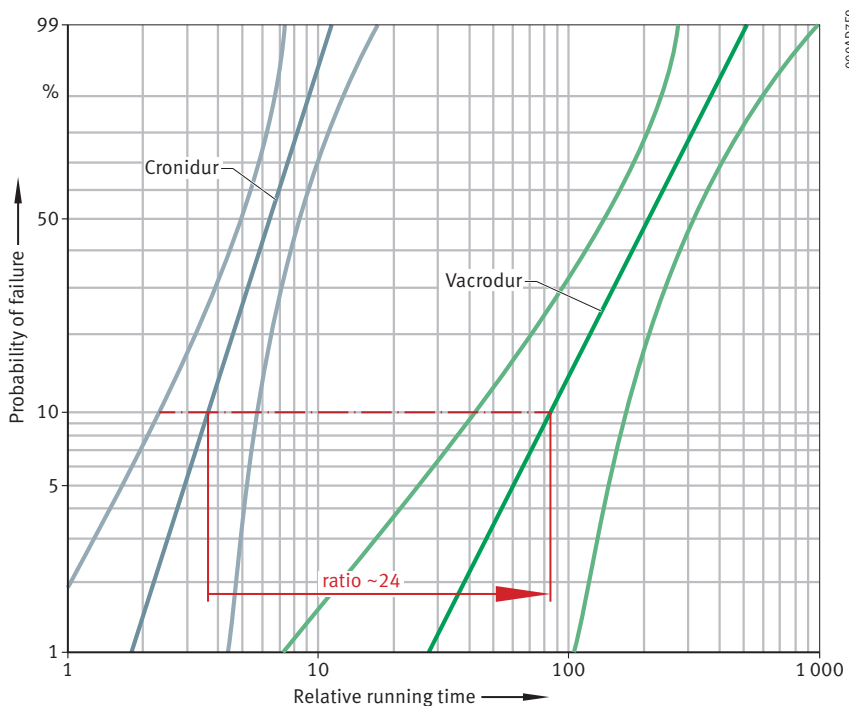


Figure 6: Rating life under the influence of contamination

X-life high-speed spindle bearings made from Vacrodur – measurable progress in the field of motor spindles

In a special test apparatus on the tribology test rig FE8 at Schaeffler, the excellent wear resistance of Vacrodur compared to the standard rolling steel made from 100Cr6 was demonstrated. The steel variants were compared with each other under boundary friction conditions together with high pressures under heavily wear-promoting operating conditions in a rolling bearing subjected to slippage. This test scenario is particularly representative of the operating conditions liable to slippage and wear, such as those which can occur in motor spindles, for example with load cycles. The result achieved with Vacrodur in relation to its wear-resistant characteristics proved completely convincing in a direct comparison, as is shown impressively in the following diagram, Figure 7.

The results emphasize that the excellent wear resistance of Vacrodur, not least in the presence of boundary conditions subject to slippage and exposed to contamination, represent the first choice in spindle bearing arrangements.

Due to their outstanding performance capability, spindle bearings made from Vacrodur are in a superior position for fulfilling the increased requirements in relation to operating life or the preference for previously unattained machining volume.

Schaeffler offers Vacrodur in the new X-life high-speed spindle bearing range under the designation VCM.

High-speed spindle bearings of series VCM are characterised, due to their optimised X-life internal construction, by very high speed capacity and high tolerance to rapidly changing thermal conditions. At the same time, they have load-bearing characteristics that were previously only achievable using ball bearings with large size balls.

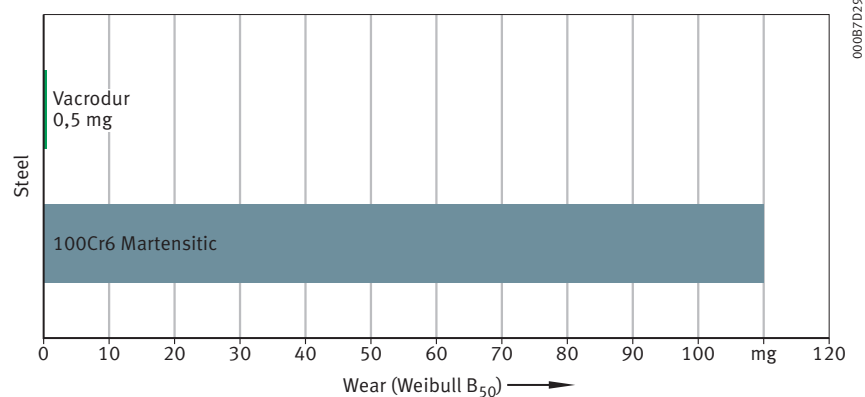


Figure 7: Comparison of wear resistance

In comparison with conventional spindle bearings, X-life high-speed spindle bearings made from Vacrodur permit significantly greater design flexibility in motor spindle design and thus offer the customer the opportunity to make discernible cost reductions.

Further information on spindle bearings made from Vacrodur can be found in the corresponding publication on the new X-life high-speed spindle bearing series.

With Vacrodur spindle bearings, significant potential savings are possible in comparison with all the established solution approaches, Figure 8.

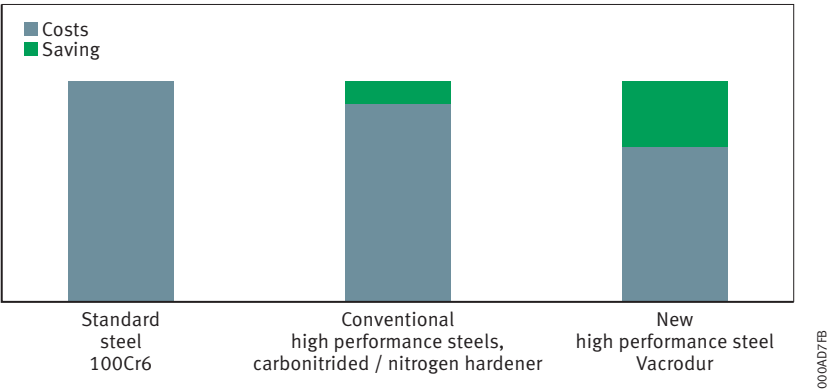


Figure 8: Comparison of cost saving potential

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