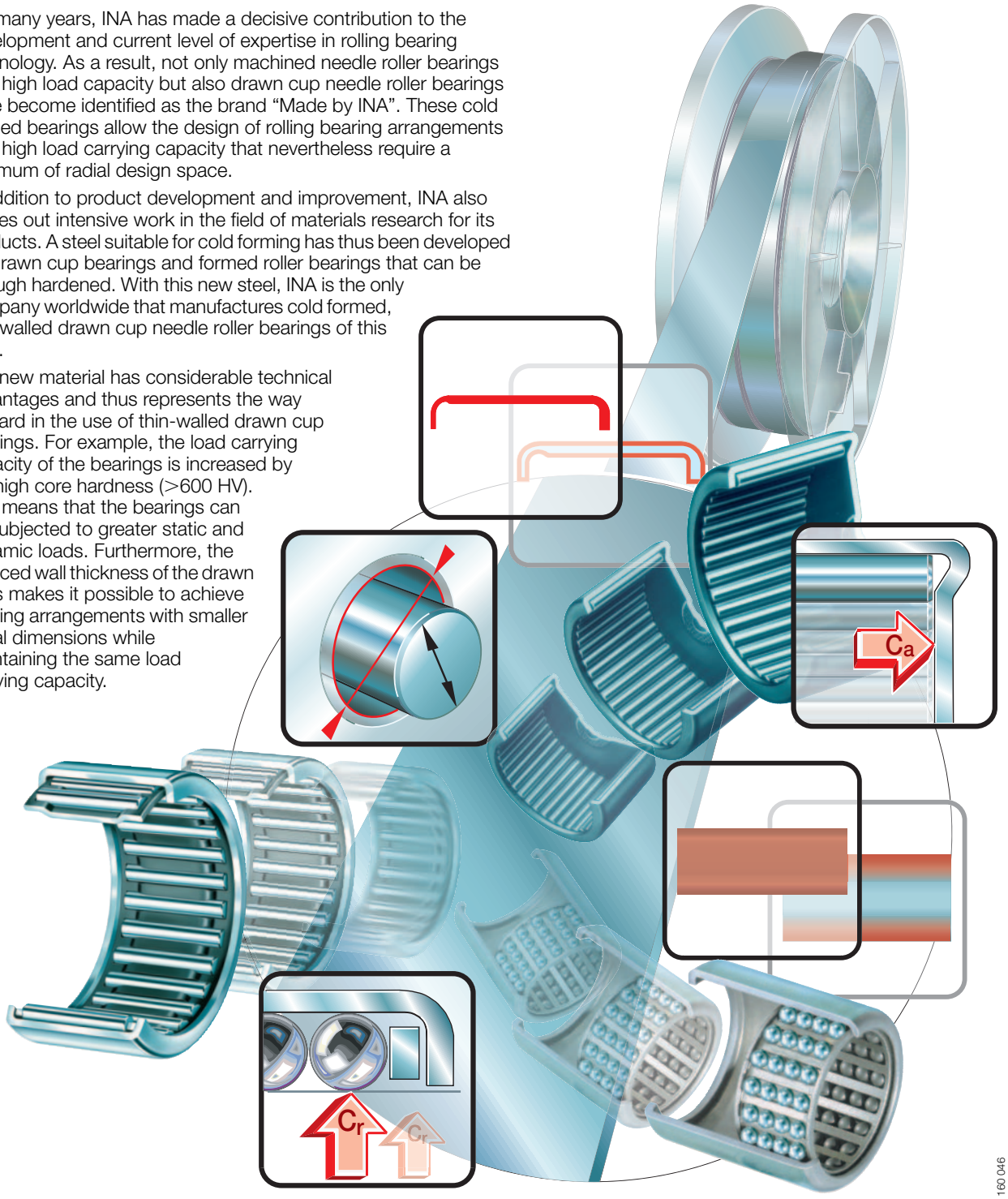
New material for drawn cup bearings and roller bearings

Drawn cup bearings now with higher load capacity

For many years, INA has made a decisive contribution to the development and current level of expertise in rolling bearing technology. As a result, not only machined needle roller bearings with high load capacity but also drawn cup needle roller bearings have become identified as the brand “Made by INA”. These cold formed bearings allow the design of rolling bearing arrangements with high load carrying capacity that nevertheless require a minimum of radial design space.

In addition to product development and improvement, INA also carries out intensive work in the field of materials research for its products. A steel suitable for cold forming has thus been developed for drawn cup bearings and formed roller bearings that can be through hardened. With this new steel, INA is the only company worldwide that manufactures cold formed, thin-walled drawn cup needle roller bearings of this type.

The new material has considerable technical advantages and thus represents the way forward in the use of thin-walled drawn cup bearings. For example, the load carrying capacity of the bearings is increased by the high core hardness (>600 HV). This means that the bearings can be subjected to greater static and dynamic loads. Furthermore, the reduced wall thickness of the drawn cups makes it possible to achieve bearing arrangements with smaller radial dimensions while maintaining the same load carrying capacity.



New material for drawn cup bearings and roller bearings

Current materials

The standard materials used for the formed, thin-walled outer rings of drawn cup needle roller bearings and linear ball bearings are steels such as DC04M, SAE1015 and 16MnCr5. These steels can be cold formed and are suitable for the case hardening conventionally used.

The characteristics of these steels include:

- their purity and cold drawing capability
- the need for case hardening
- the relative dimensional and geometrical changes in heat treatment
- the material thickness required due to the case hardness depth Eht and the soft core required for these materials.

New generation of materials

The new, cold forming steel for thin-walled rolling bearings is defined in terms of its technological characteristics and the chemical composition as C45M in accordance with the INA specification.

C45M is an isotropic fine-grained steel with high purity and specially matched to the requirements of rolling bearing technology.

Its deep drawing capability and forming capacity is comparable with the cold strip materials currently used, but its hardenability is significantly higher than that of conventional steels (see Figure 1).

Due to its optimised hardenability, which is matched to the component geometry and material loading, the steel has a high core strength, toughness and elasticity.

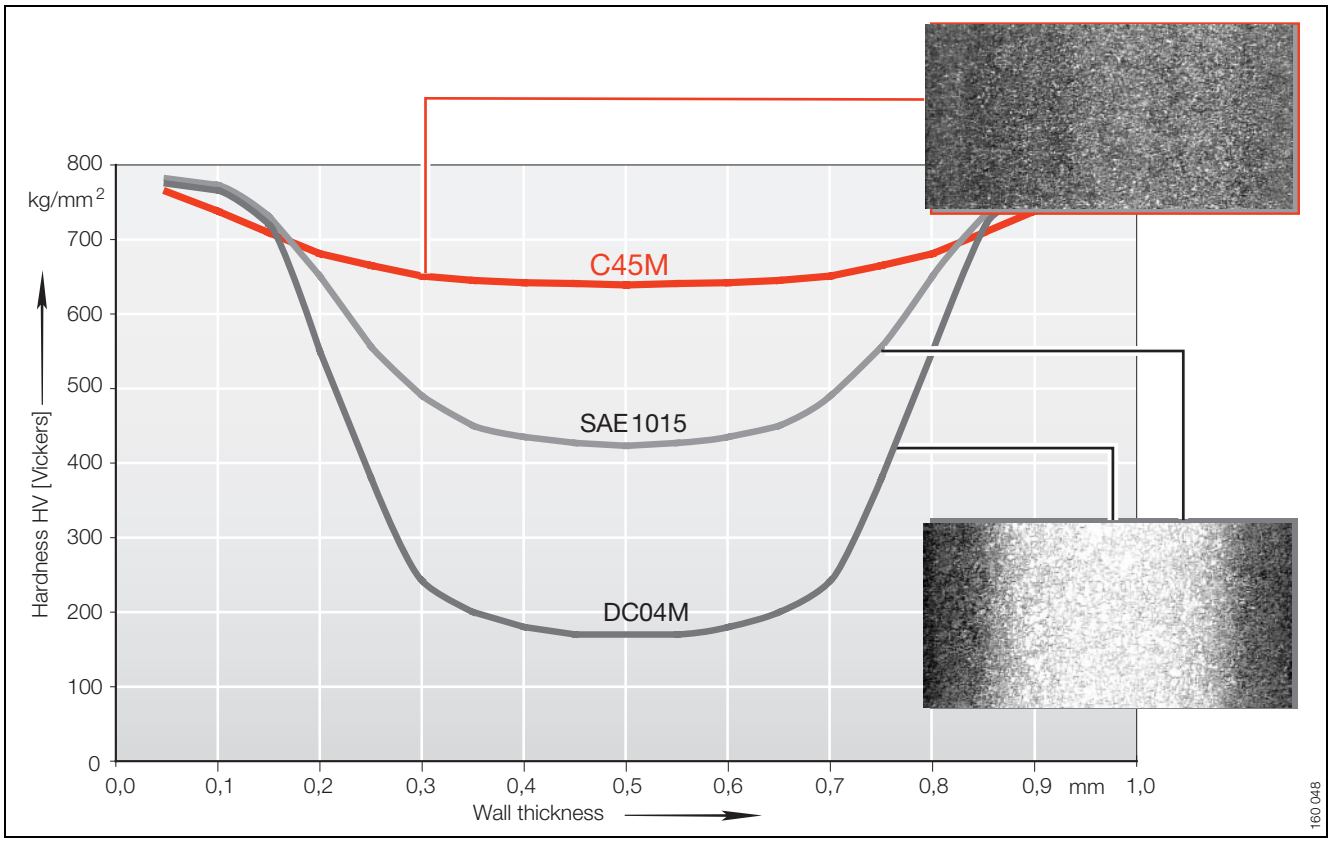


Figure 1 · Hardness and structure of classic material und C45M steel – comparison

Plastic deformation of the raceway

Figure 2 shows the plastic deformation of drawn cup raceways made from DC04M and C45M under the same load. Due to its high core hardness, bearings made from the new material have a higher static and dynamic load carrying capacity than comparable bearings made from conventional steel. This reduces the plastic deformation of the raceways under high static load.

The new steel achieves its high performance capacity due to the material composition and a special heat treatment. Bearings made from C45M can therefore even be designed with a significantly reduced wall thickness compared to drawn cups made from conventional steels.

Elasticity of the drawn cup base

Figure 3 shows deflection curves for the bases of universal joint bearings made from DC04M and C45M. The base of the drawn cup made from DC04M undergoes plastic deformation starting at a particular force value; the base of the drawn cup made from C45M shows fully elastic behaviour over a significantly wider range of force values.

This elastic behaviour gives advantages relating to assembly in certain applications.

Advantages for application

Drawn cup needle roller bearings, linear ball bearings and roller bearings made from drawn C45M (see page 5):

- can be subjected to higher static loads, while occupying the same design envelope, than bearings made from conventional steels
- allow smaller design envelopes under the same loads
- allow designs that lead to longer life while occupying the same design envelope
- give advantages relating to assembly of universal joint bearings in certain applications.

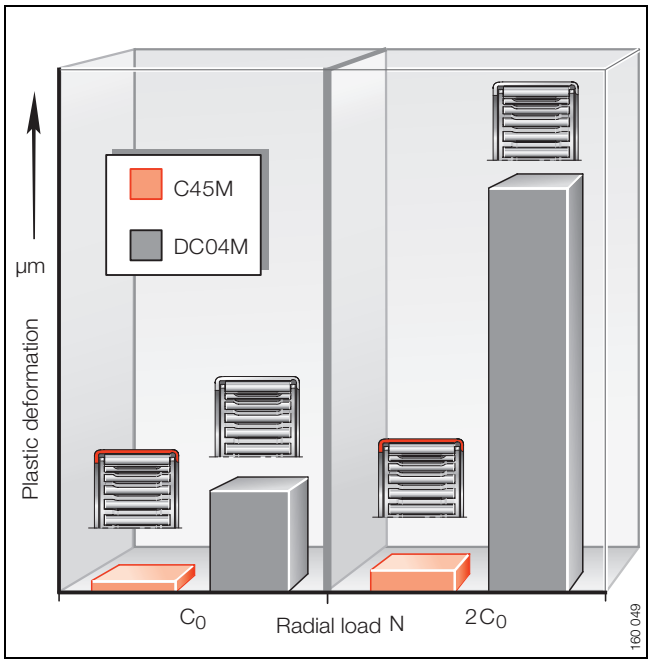


Figure 2 · Plastic deformation under radial load – drawn cup material DC04M and C45M

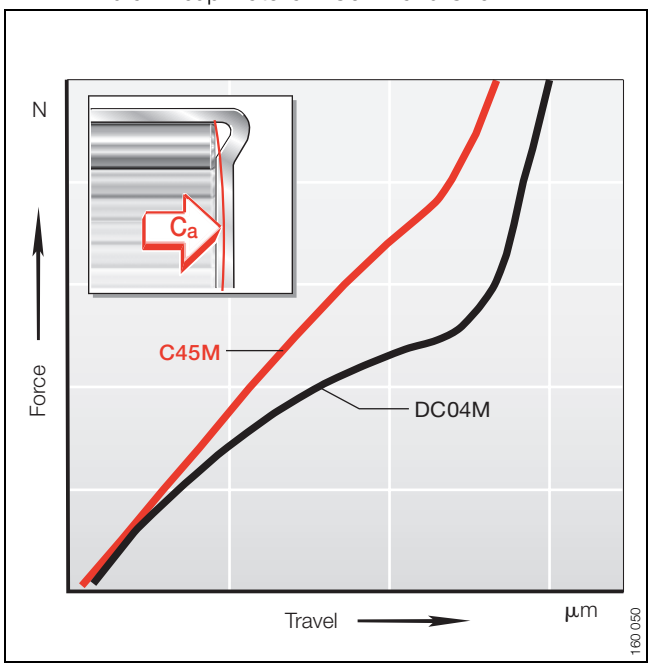


Figure 3 · Deflection curves of drawn cup base – material DC04M and C45M

Design of bearing arrangements

⚠ These statements are not valid for universal joint bearings!

The shaft must be designed as a rolling bearing raceway.

In order to make full use of the load carrying capacity, rigid support should be provided for thin-walled outer rings.

The bearing outer rings may become slightly out of round due to the manufacturing process. They will adopt their final dimensional and geometrical accuracy only once they are pressed into the housing bore.

The outer ring is designed with an oversize in relation to the housing bore. The bearings therefore require no additional axial location such as shoulders or snap rings.

The position of the enveloping circle and the quality of the fitted bearing arrangement are determined by the the material and wall thickness of the adjacent construction as well as the dimensional and geometrical accuracy of the bore.

Mounting tolerances

If the bore tolerances in Table 1 are adhered to, the needle enveloping circle in rigid housings is approximately in tolerance zone F8. In conjunction with the stated shaft tolerances, a normal operating clearance is achieved.

Table 1 · Shaft and housing design

Housing material		Bore tolerance	Shaft tolerance for bearings without inner ring
Steel or cast iron		N6	h6
Light metal[1)]		R6	
Roughness	max.	R_a0,8 (R_z4)	R_a0,2 (R_z1)
Roundness	max.	IT 5/2	25% of h6
Parallelism	max.	IT 5/2	50% of h6

[1)] Check the strength of the housing.

Fitting

⚠ These statements are not valid for universal joint bearings!
Further information on dimensions and load carrying capacity is available on request.

Bearings with grease lubrication should be greased before fitting.

Bearings should be fitted with a special fitting mandrel (Figure 4). The fitting mandrel shoulder should rest on the bearing end face marked with the designation.

A round section seal ① should be used to retain the bearing.

The bearing and fitting mandrel must not be tilted!

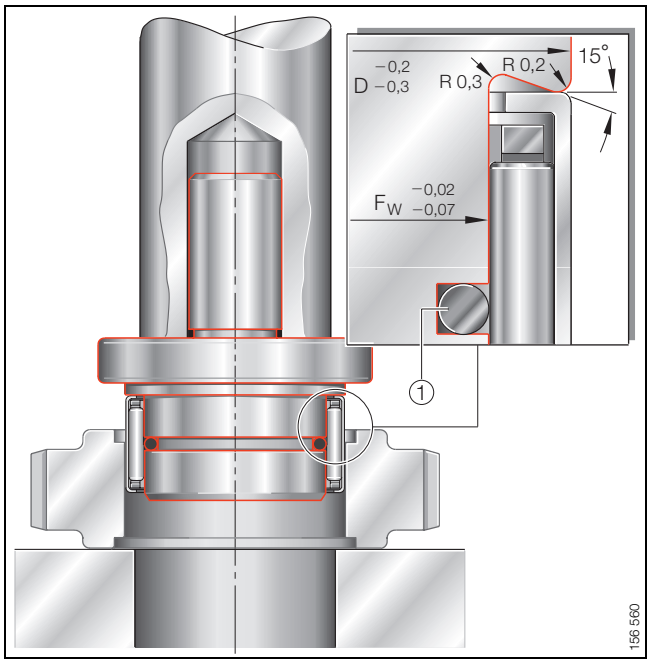
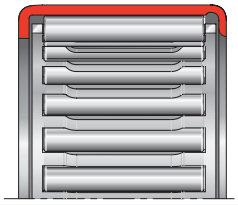
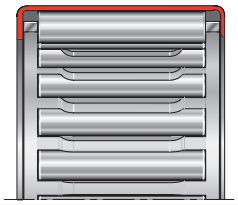


Figure 4 · Fitting using a fitting mandrel

Drawn cup needle roller bearing HK made from DC04M and C45M – comparison

The comparison (Figure 5) shows the advantages of the new steel over conventional materials. This results in significant application advantages that, in turn, increase the customer benefits of the products.

⚠ In contrast to use in steel, the stresses in the bearing bore must be taken into consideration if it is to be used in light metal!

		HK 3020/steel DC04M	HK 3020/ steel C45M	
	Features			Potential due to redesign Δ
	Wall thickness			–50%
	Rolling element diameter			20%
	Rolling element length			5%
	Number of rolling elements			–12%
	Basic dynamic load rating C_r			18%
	Basic static load rating C_{0r}			9%
	Dynamic life			75%
	Total mass			–7%

160 047

Figure 5 · Drawn cup needle roller bearing HK made from DC04M and C45M – comparison

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