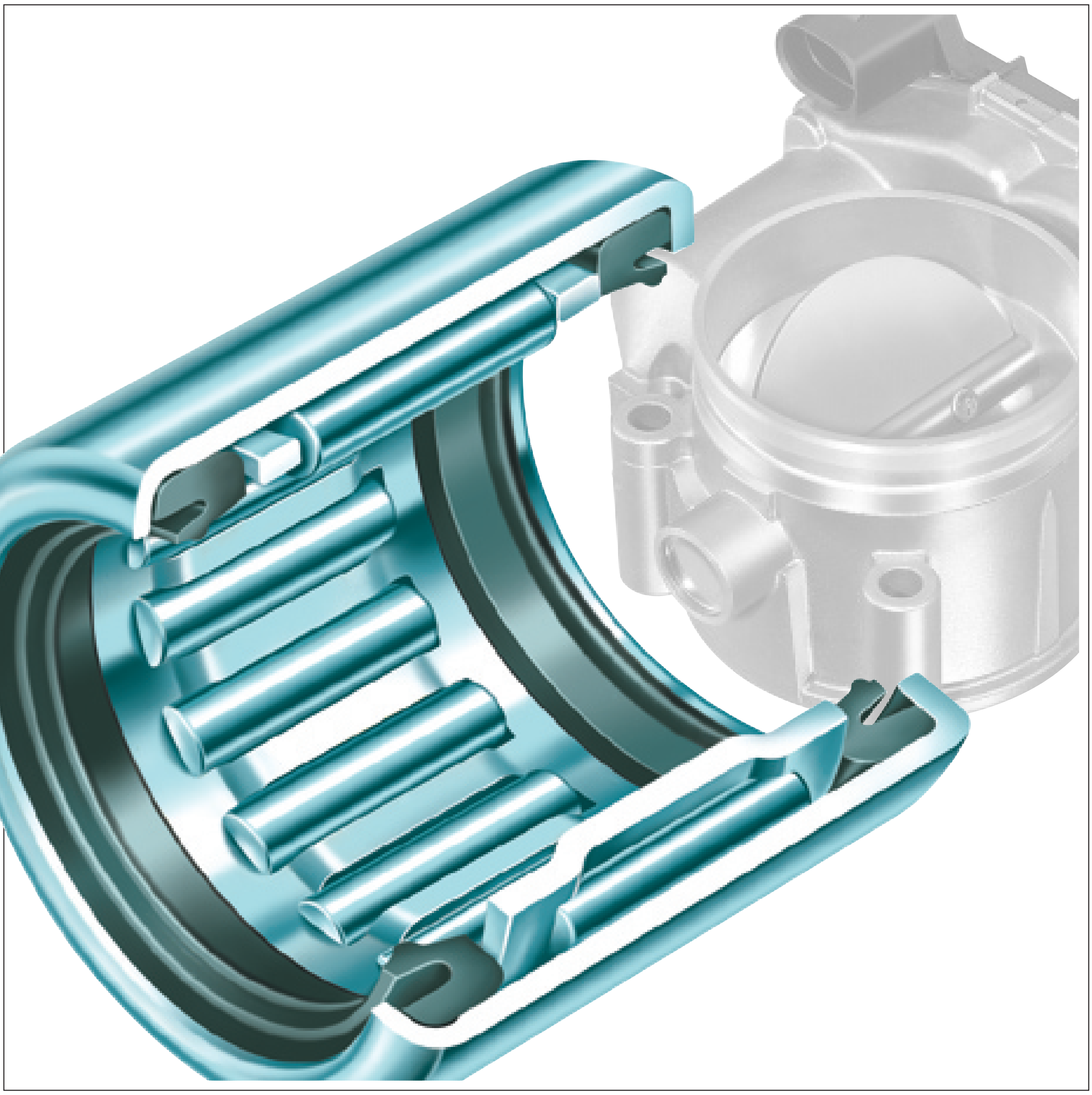

Throttle Valve Bearings

Automotive Product Information API 15

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Throttle Valve Bearings

Burning fossil fuels causes carbon dioxide to be released into the atmosphere. The CO_2 content present in pollutant emissions can be decreased by reducing fuel consumption. In gasoline engines, one way of achieving this is by stratified charging of the combustion chamber and a high excess of air in the partial-load range.

The air required to burn fuel enters the combustion chamber by means of an electronically controlled throttle valve (EGAS) with bearing supports on both sides. The engine management constantly adjusts the position of the throttle valve to the engine operating point.
In addition to the proper air flow in all load ranges, the throttle also regulates idle and cold-start behavior as well as safety systems such as ABS, ASR and ESP. To meter the exact amount of air, the throttle must be extremely precise and low in friction. However, this is only possible if high-quality bearing supports are used.

INA's throttle valve bearings are open end drawn cup needle roller bearings that are airtight, sealed on both sides and especially compact radially. These low-friction rolling bearings – proven in countless applications – are resistant to false brinelling and have a very low and constant radial clearance. They provide cost-effective solutions as their technical features clearly make them superior to ball bearings and plain bearings. They play a significant role in lowering CO_2 emissions, which increases engine efficiency throughout the service life of the unit.

This brochure provides all relevant information about INA's standard line of throttle valve bearings. INA's applications engineers and engineers in regional sales locations would be more than happy to assist you in selecting the right bearing or designing your bearing supports.

INA Wälzlager Schaeffler oHG
Herzogenaurach (Germany)

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Throttle Valve Bearings

Features

Throttle Valve Bearings

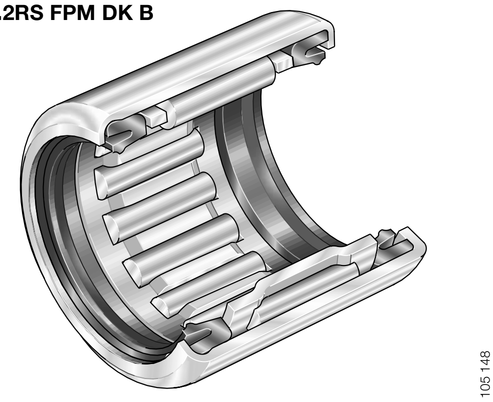
- consist of thin section, deep-drawn outer rings, needle roller and cage assemblies and **.**2RS FPM DK seals
- are leakproof in the presence of positive and negative pressure
  - The bearings are inspected for leaks without grease and sealed on both sides (max. permissible leakage 1 cm^3/min for 400 mbar)
- have optimized seals made from fluor elastomer FPM
  - FPM is particularly heat resistant and is also resistant to fuel, mineral oil, grease and blow-by condensate
- require no additional sealing of the mounting structure because of the integral seals
- have a very low frictional torque
  - for +20 °C max. 1.3 Ncm, for –40 °C max. 4 Ncm
- have a constant and small operating clearance throughout the entire service life
- require minimal radial design space
- provide excellent protection against false brinelling
- are silicone-free
- are sealed for life with a special grease
- can be installed near electronic components without any problems due to the grease-free under roller diameter
  - No grease enters the under roller diameter during installation due to splash lubrication and optimized grease amounts
- can also be used on unhardened shafts
- are significantly more cost-effective than ball bearings or plain bearings (see table below)

Comparison of throttle valve bearing design types

Evaluation Criteria	①	②	③
low wear/min. radial clearance	++	++	+
100% leak test	++	–	– –
integral contact seals	++	++	– –
frictional torque test	++	+	– –
low radial section height	+	– –	++
axial positioning of the shaft	–	+	–
resistant to false brinelling	+	–	++
price (including seals and mounting expense)	+	– –	+
Evaluation	+	❍	–

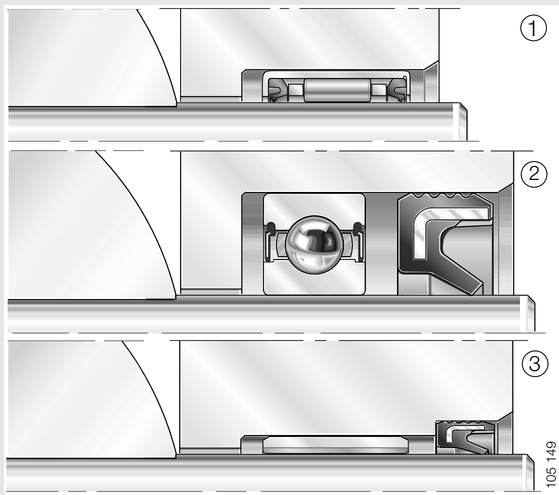
Throttle Valve Bearings

HK...2RS FPM DK B

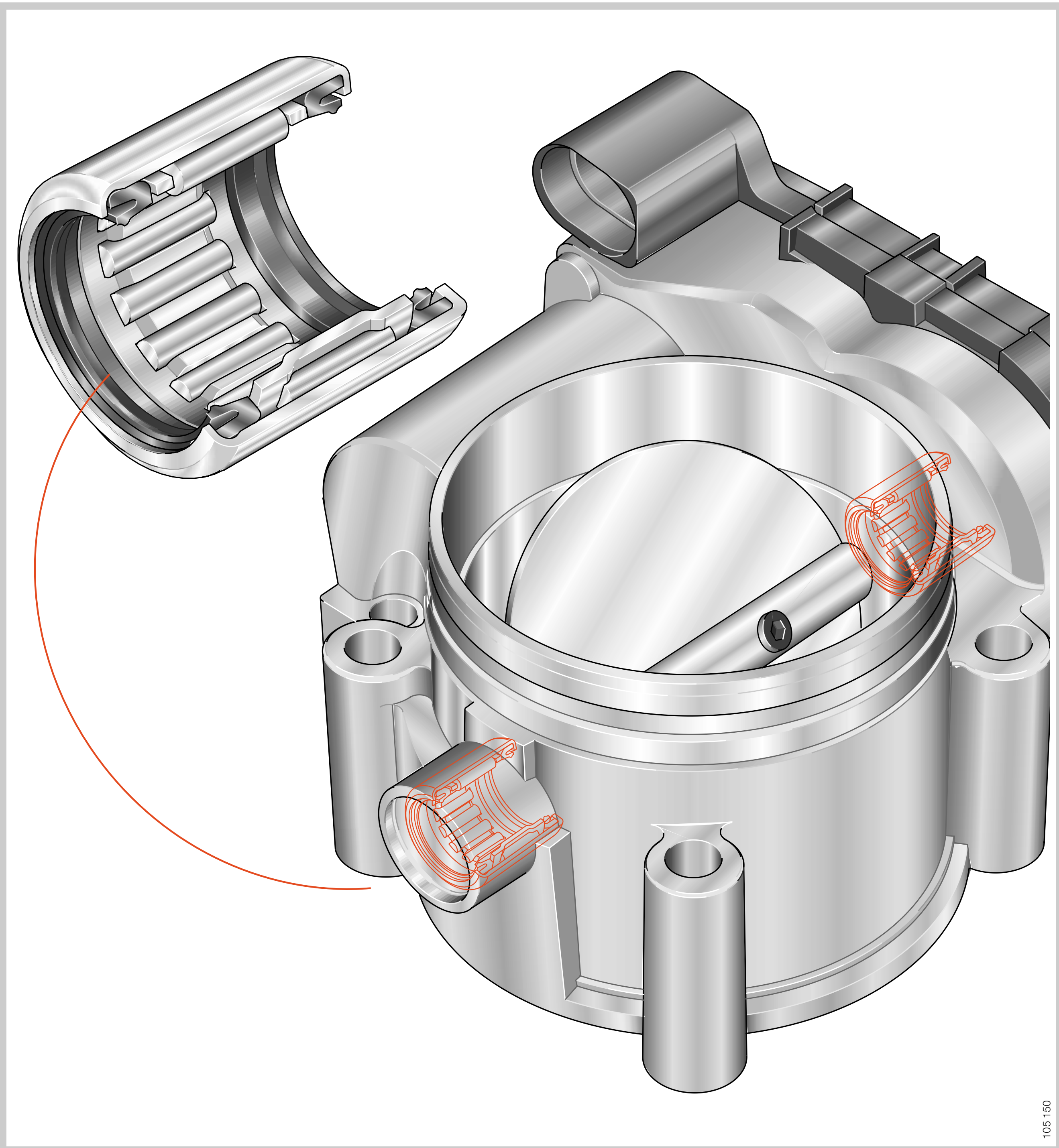


- designed like INA's open end drawn cup needle roller bearing HK
- needle rollers w/ special profile, case hardened steel cage
- FPM lip seals on both sides (suffix **.**2RS FPM DK), hardness 75 ±5 Shore A
- suitable for temperatures from –40 °C to +150 °C
- for 8 mm and 10 mm shaft diameters

Comparison of radial design space



- throttle valve bearing HK**..**2RS FPM DK B ①
- ball bearings ②
- plain bearings ③


105 150

Test Methods for Bearing Design

Pressure Testing during Vehicle Operation

Throttle valve bearings must be airtight in the presence of positive and negative pressure. That's why INA checks every bearing to ensure it is airtight.

A large number of specially designed instruments, test stands and test methods are available to perform these checks.
INA test standards as well as those specified by customers guarantee that accurate test results are obtained.

Important testing criteria used at INA for the leak test include:

- the pressure level on the bearing seals
- the pressure level in the bearing

In INA's vehicle test, pressure conditions are determined in order to provide the optimum bearing configuration.
The position of the throttle valve as well as the pressure in the body must be considered in order to obtain precise results.

Vehicle measurements

- provide the data required for proper bearing operation
- provide a basis for the specification sheet used to design bearings and seals

Vehicle Testing

Engine types and measuring parameters

The data were obtained for a self-induced engine and a turbocharged engine.

The following were measured (see Figure 1):

① the pressure in the body

② the pressure in front of the first seal

③ the pressure in the bearing

④ the angular position of the throttle valve

Bearing design

The shaft is supported by throttle valve bearings HK...2RS FPM DK B. The bearings are dry preserved, ungreased and have FPM seals on both sides with the sealing lips facing outward.

Seals have been optimized and now cause only minimal friction. They offer the best possible seal and have good dry-running properties.

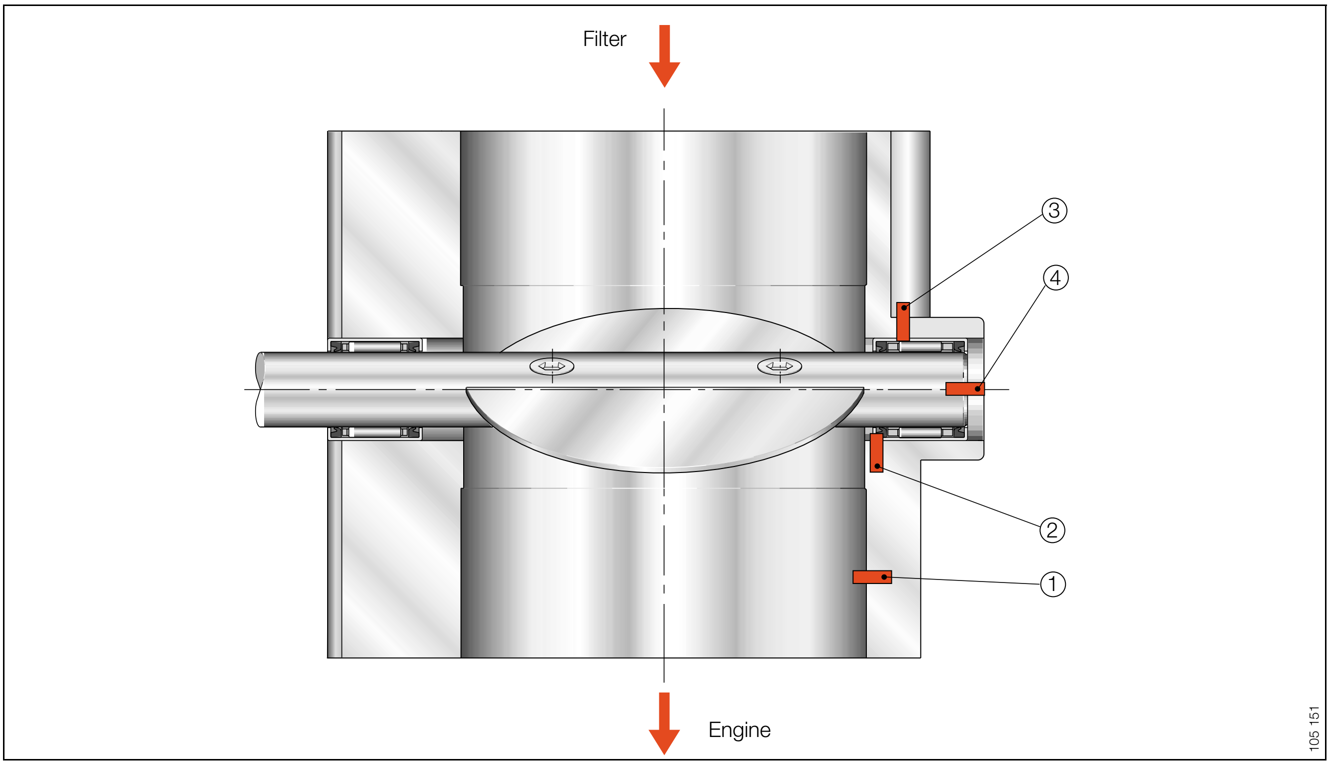


Figure 1 · Vehicle pressure testing – Points measured

Results for the Naturally Aspirated Engine

For the naturally aspirated engine, only negative pressure (vacuum) was present.

The pressure conditions can be seen in Figure 2.

① The negative pressure after the throttle valve is:
- a maximum of 800 mbar when the throttle valve is completely closed
- nearly 0 mbar when the throttle valve is wide open

② The negative pressure on the first seal is approx. 200 mbar and occurs at the same time as the vacuum after the throttle valve ①.

③ The low pressure level in the bearing fluctuates quite uniformly throughout operation near 0 mbar.

Evaluation

The constant pressure conditions in curve ③ show that the bearing is leakproof.

It can be seen that the seals selected provide a good sealing for the bearing position even before the bearing is greased.

Greasing prior to delivery increases the sealing effect and also improves protection against corrosion.

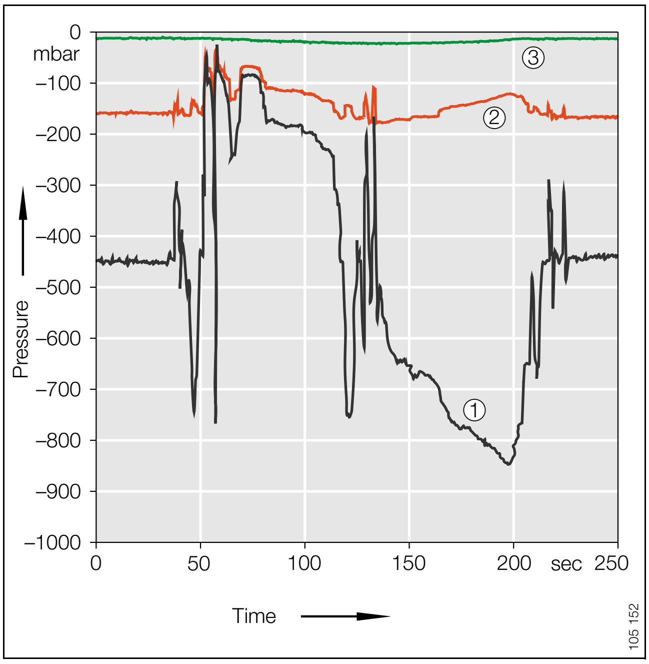


Figure 2 · Results for the naturally aspirated engine

Results for the Turbocharged Engine

For the turbocharged engine, both positive (overpressure) and negative pressure (vacuum) were present.
The pressure conditions can be seen in Figure 3.

① The pressure in the body fluctuates between 400 mbar positive pressure and 800 mbar negative pressure.

② The positive pressure on the first seal increases briefly to approx. 700 mbar when the throttle valve is quickly closed by the “push” from the turbocharger.

③ As in the case of the naturally aspirated engine, the pressure level in the bearing is uniform and constantly low.

Evaluation

The nearly constant pressure conditions in curve ③ show that the bearing is leakproof.

It can be seen that the seals selected provide a good sealing for the bearing position even before the bearing is greased.

Greasing prior to delivery increases the sealing effect and also improves protection against corrosion.

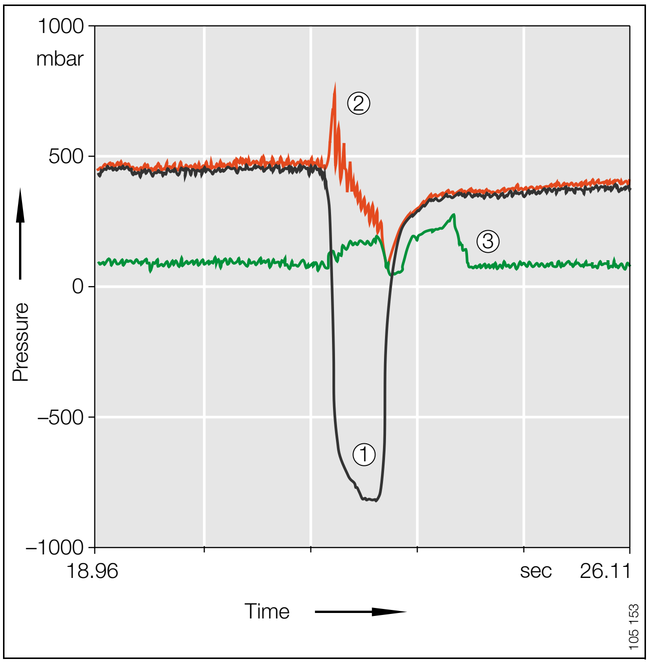


Figure 3 · Results for the turbocharged engine

To arrive at the optimum configuration, bearings of differing designs were tested and compared.

Tests were performed to determine for following:

① the bearing frictional torque

② the effects of temperature and methanol-containing liquids (to DIN 51 604-1 and -2) on FPM seals

③ the wear to ungreased seal lips in the bearing

Bearing Frictional Torque

The frictional loss of a bearing consists of several friction components:

- rolling friction
- the sliding friction of the rolling elements and cages
- grease friction
- seal friction

Figure 4 shows the frictional behavior of greased bearings with respect to bearing size, number of FPM seals and temperature. The curves at the top show the frictional torque when the throttle is opened, and those at the bottom, when the throttle is closed.

Evaluation

Frictional torque is the lowest in the bearing that is sealed on one side. This behavior changes only slightly with respect to size, the number of seals and increasing below-freezing temperatures. This is due to the friction components mentioned above and the fact that the operating viscosity of the lubricant changes at low temperatures.

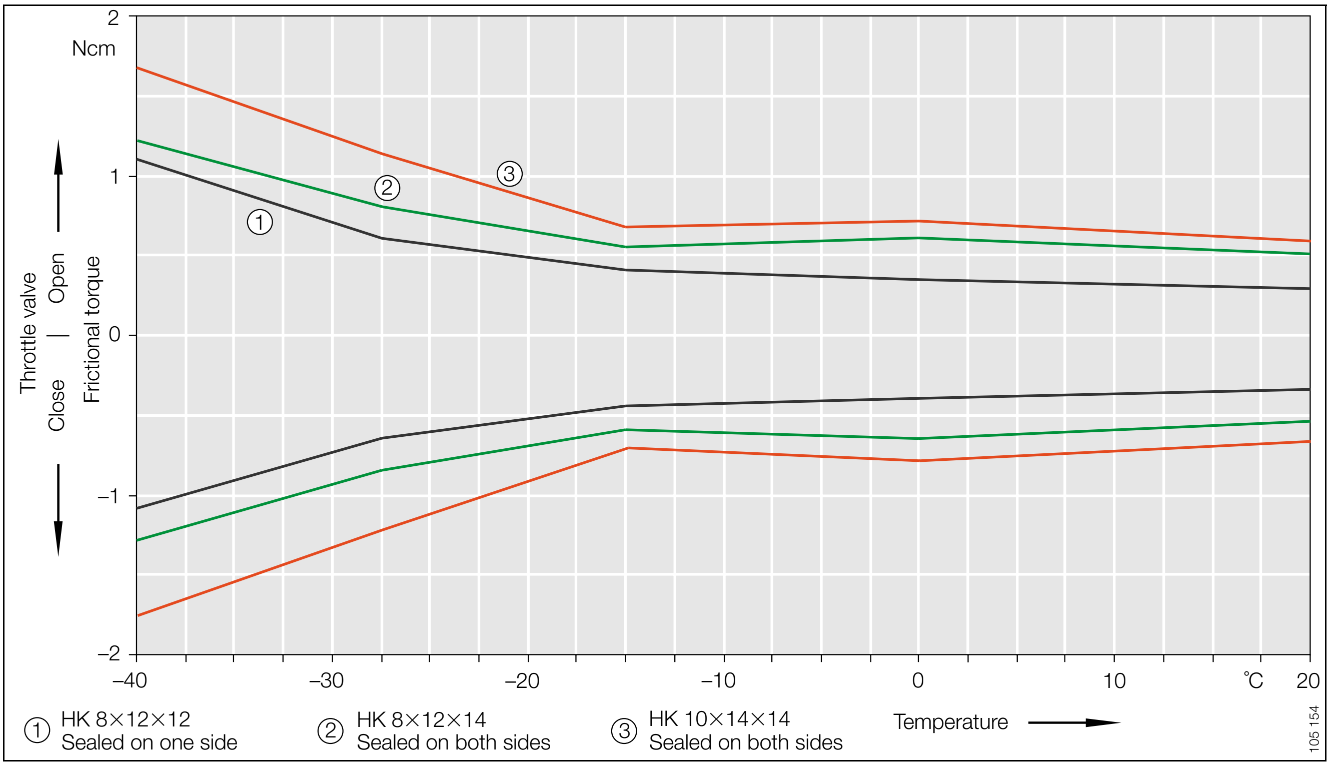


Figure 4 · Bearing frictional torque with respect to bearing size, number of seals and temperature

Effects of Temperature and Methanol-Containing Liquids on FPM Seals

Figure 5 shows the behavior of FPM seals for greased bearings with respect to bearing size and temperature.

To monitor temperature resistance, the bearings are subjected to an alternating temperature cycle (see Figure 5).
The bearings are also tested to DIN 51604-1 and -2 (bearings in methanol-containing liquids).

The curves at the top show the behavior when the throttle valve is opened, and those at the bottom, when the throttle valve is closed.

Evaluation

The frictional torque curve allows the functional operation of the bearing to be evaluated. Since FPM seals are especially heat resistant and resistant to fuels, mineral oils, greases and blow-by condensate, they display no irregularities or leaks during the alternating cycle test, nor in the test with methanol-containing liquids. Frictional torque thus remains very low overall.

Wear to Greased and Ungreased Seal Lips

In order to check the potential operational effects that wear might have, greased and ungreased seals were subjected to 1 million revolutions.

Evaluation

The wear to both the greased and ungreased seal lips is not significant, and it has no effect on the sealing function.
After run-in, wear to the lips no longer occurs. This means that the bearings are airtight throughout the service life.

During operation, the seal lips are lubricated by the grease in the bearing. In addition, additives provide the seal material with self-lubricating characteristics. These dry-running properties ensure that the edge of the lip always has a sufficient supply of lubricant.

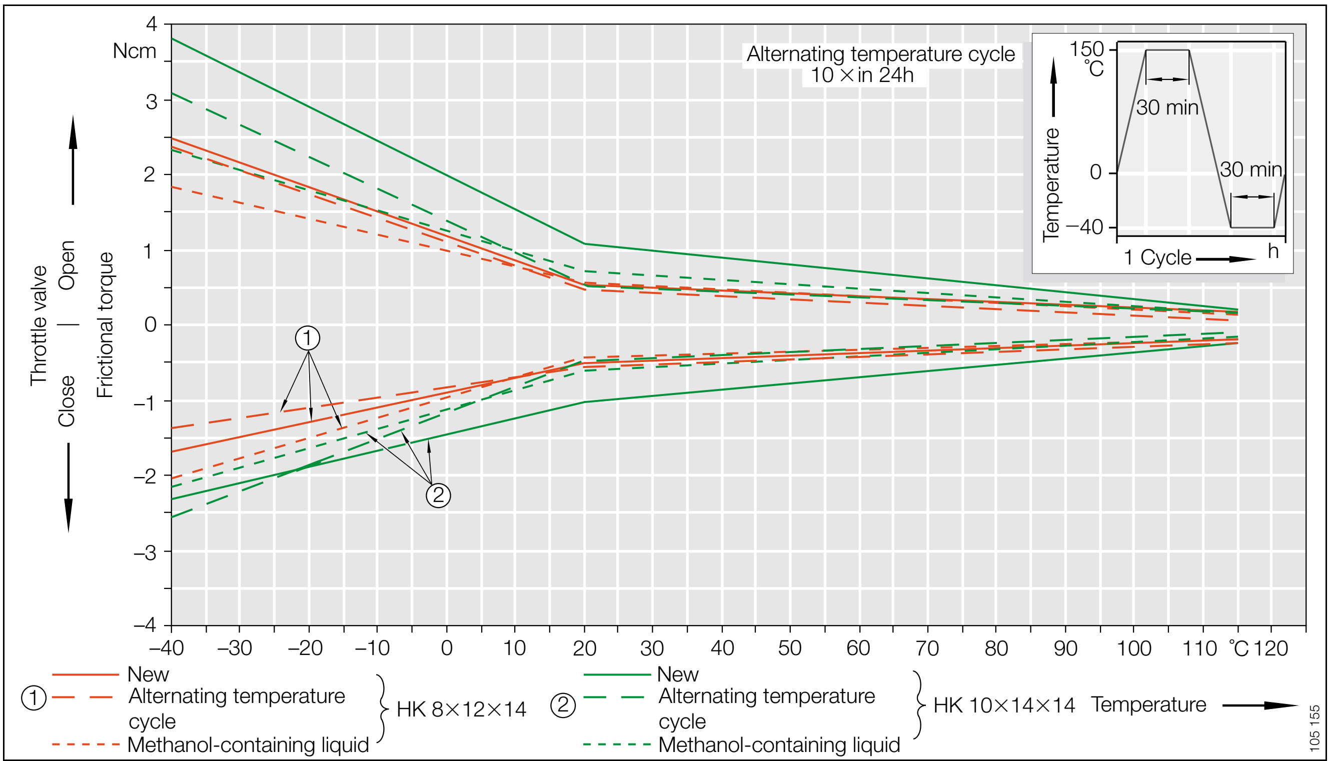


Figure 5 · Effects of temperature and methanol-containing liquids on FPM seals with respect to bearing under roller diameter F_W

Mating Component Design

Mating components – shaft and housing bores – play an important role in determining throttle valve function and service life.

The following design recommendations for housing bores and shafts pertain to standard bearing supports. Proper bearing operation can be guaranteed if these recommendations are followed and if the throttle valve bearings have been properly installed.

INA should be contacted if the values for the mating components are different than those given here.

Housing

Throttle valve bearings require dimensionally and geometrically accurate bores in the body since the thin section outer rings of the drawn cup bearing must match the dimensional and geometric accuracy of the housing bores. The geometric accuracy required for housing seats is shown in Figure 6.

Large fluctuations in the housing wall thicknesses and ribs near the bearing seats have an adverse effect on tight fits and runout accuracy.

Tolerance zones for housing bores

For aluminum housings, bores with tolerance zone N6 should be designed. The bearings will be axially secured in the bores if these dimensional tolerances are maintained. The runout accuracy will also be sufficient.

For optimized housing geometries (no stiffening ribs, cylindrical shoulders if possible, etc.), bores in tolerance zones R6 or S6 are possible. This is particularly necessary for bearings that have additional axial loads.

Shaft

Bearing raceways on the shafts must be of a quality typical for rolling bearings. The required geometric accuracy is shown in Figure 6.

Tolerance zones for shafts

For housing tolerance N6, tolerance zone m6 can be selected for shafts. If the zone deviates from N6, shaft tolerances must be adjusted to the tolerance zone for the bores, e.g. bore tolerance R6, shaft tolerance h6. Press-in tests must than be performed to check the bearing fit. INA can conduct these tests on request.

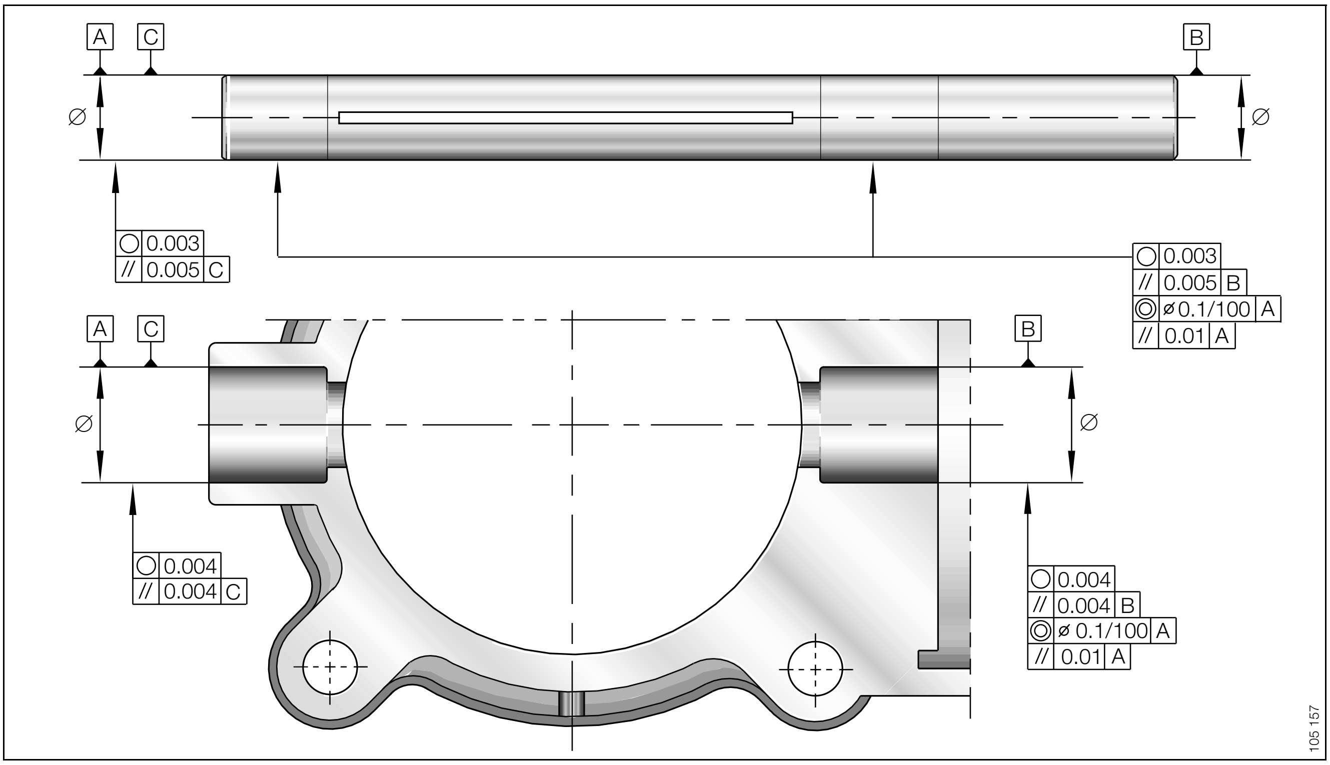


Figure 6 · Geometric accuracy of bearing seats for shaft and housing bores

Shaft materials and surface hardness

The following are suitable:

- through hardening steels to DIN 17 230 (similar to SAE J403 and SAE J404)
- carburizing steels to DIN 17 230 or DIN 17 210 (similar to SAE J403 and SAE J404)
- steels for flame and induction hardening to DIN 17 230 or DIN 17 212 (similar to SAE J403 and SAE J404)
- stainless steels such as SAE 51 430 F/J405, unhardened

The surface hardness of shafts should be $>$550 HV, and an effective case depth $>$0.1 mm should be present.

⚠ Stainless steel shafts have become the technical standard as they too have proven to be the more cost-effective solution. However, since these shafts cannot be hardened, their hardness can be significantly lower than 550 HV. Shafts must first be vibration tested before use in order to ensure the proper service life and adequate protection against false brinelling. Under engine-specific conditions, tests are conducted on the shaft to determine whether the lower hardness meets the raceway requirements and operating conditions.

Shaft design

In order for the bearing to remain airtight, the seal lips must not be damaged when the shaft is installed. For this reason and considering the assembly direction (see Figure 7) the following should be done :

- all sharp edges should be provided with lead chamfers
- all burrs on bores, recesses, grooves etc. should be removed
  - Suitable deburring methods include brushing or abrasive blasting (e.g. glass bead blasting).
- the thread diameter at the end of the shaft should be "topped"
  - It should be at least 0.5 mm smaller than the bearing bore diameter.

Raceway roughness should not exceed the value R_z 6.3 µm.

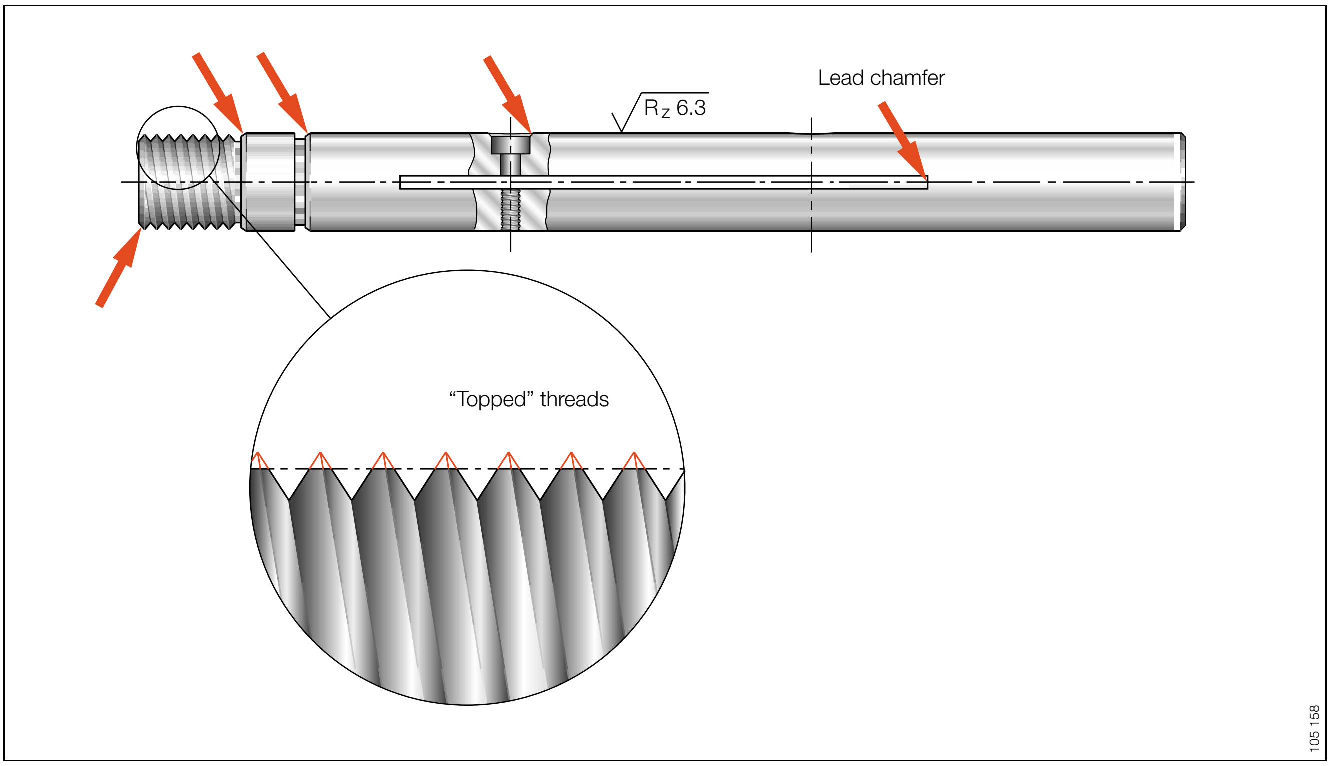


Figure 7 · Shaft design

Bearing Installation

Throttle valve bearings must be handled with care before and during installation. Their trouble-free operation especially depends on the care taken during installation.

Delivery Packaging

The bearings are delivered silicone-free and dry preserved with VCI paper.

Storage

Store bearings:

- only in the original packaging
- in dry, clean rooms at a constant temperature
- at a relative humidity of 65% or less

The storage period is limited by the life of the grease.

Unpacking

Sweat from the hands leads to corrosion. Keep hands clean and dry and wear protective gloves if necessary.

Do not remove the bearings from the factory packaging until you are ready to mount them. If bearings are removed from a larger batch packaged with dry preservation, close package immediately after removal: The protective vapor phase from the VCI paper can be maintained only if the package is closed.

Mounting Guidelines

For proper bearing operation, we recommend the following:

- Ensure that the bearings and mounting area are protected from silicone, dust, contaminants and dampness. Contaminants have a detrimental effect on bearing operation and service life. In electronic components, such as potentiometers, silicone can lead to serious interruptions of electric conductivity. These interruptions can lead to engine failure.
- Check the dimensional and geometric accuracy of the bearing seat on the shaft and in the housing (see Figure 6, page 12).
- Ensure that sharp edges on the shaft and all bores, recesses, grooves etc. are removed (see Figure 7, page 13).
- Press in the bearing with a press-in arbor. Drawn cups should not be tilted in the process (see Figure 8). The arbor must have a 15° chamfer for press-in. The bearings can be pressed in from either the marked or unmarked side.
- There should be no vertical shaft installation for throttle valve shafts. Condensate that forms at the butterfly valve can collect at the lower bearing and cause corrosion.

Provide for adequate protection against splash and contamination. Once installed, bearings must be adequately protected against splash water, cleaning media, the effects of high pressure cleaning etc. as well as outside contamination.

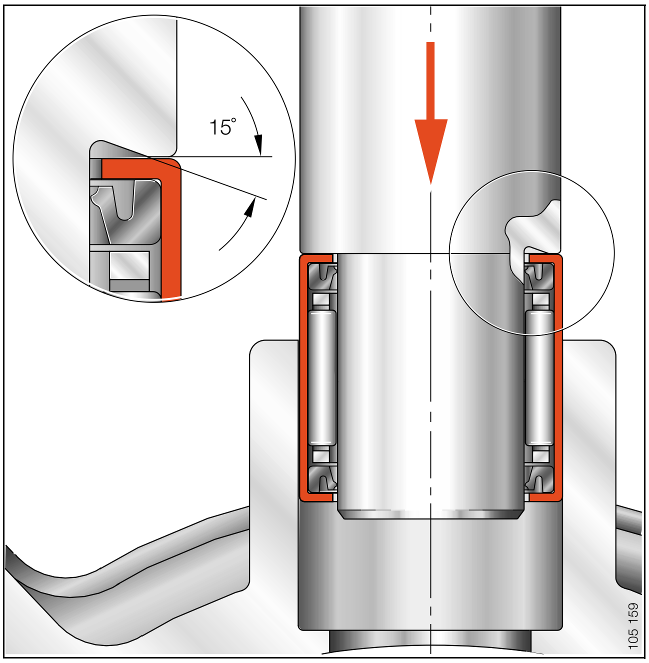


Figure 8 · Arbor for bearing press-in

Bearing-Support Variants and Axial Shaft Location

The following examples show how throttle valve bearing supports can be designed and axially located.

Installation and Axial Location – Variant 1 (Figure 9)

- Press both throttle valve bearings ① into the housing ②.
- Axially locate shaft ③ with potentiometer ④ or retaining ring ⑤.
- Position control lever ⑥ with return spring ⑦.

Advantages

The bearing support is preloaded by the return spring ⑦ and thus clearance-free axially.

- Friction is increased slightly due to the axial preload between the potentiometer ④ or retaining ring ⑤ and the bearing rib.

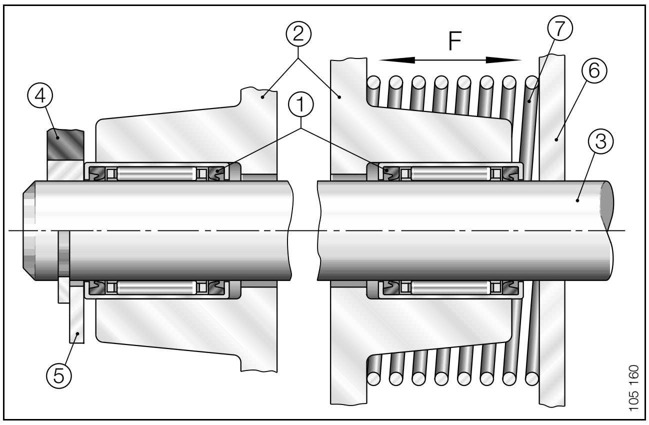


Figure 9 · Installation and axial location – Variant 1

Installation and Axial Location – Variant 2 (Figure 10)

- Press the right bearing ① into the housing ②.
- Press in the left bearing ③ with shaft ④ and retaining element ⑤ as far as it will go.

Advantages

Bearing friction will not increase.

- There is an axial clearance of 0.15 mm to 0.2 mm.

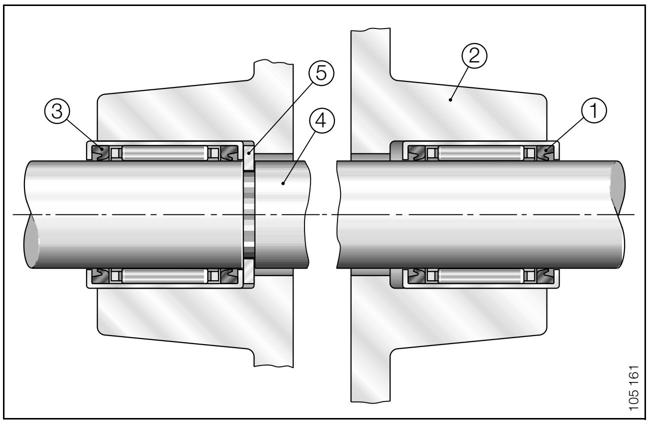


Figure 10 · Installation and axial location – Variant 2

Installation and Axial Location – Variant 3 (Figure 11)

- Press both bearings ① into the housing ②.
- Push in the shaft ③ with thrust washer ④ and retaining ring ⑤ as far as it will go.
- Press on potentiometer ⑥ as far as it will go – the shaft ③ can spring back lightly in the process.

Advantages

Bearing friction will not increase.

- The low axial clearance can be set during installation.

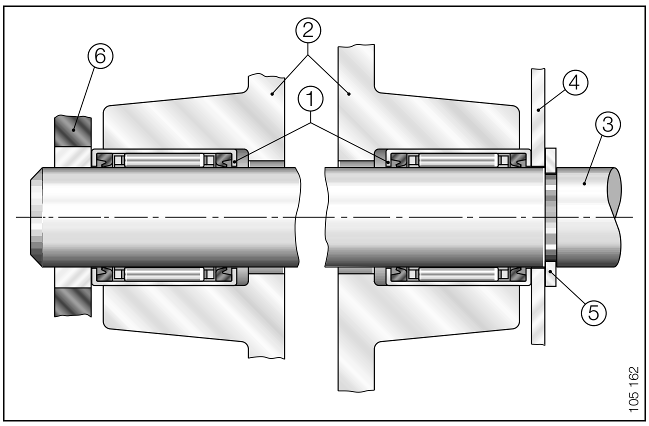
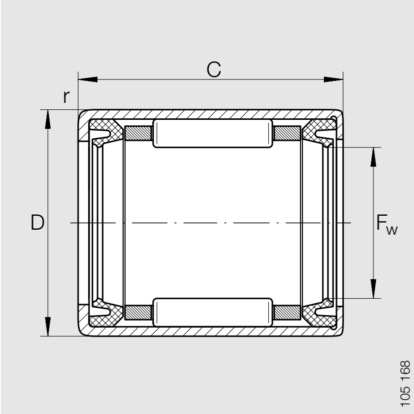


Figure 11 · Installation and axial location – Variant 3

Dimension Table

Throttle Valve Bearings

Series HK...2RS FPM DK B



HK...2RS FPM DK B

Dimension Table · Dimensions in mm

Shaft diameter	Designation	Weight	Dimensions				Load ratings	
			F_W	D	C	r	dyn. C	stat. C_0
		g			–0.3	±0.6	kN	kN
8	**HK 0812.2RS FPM DK B**	3	8	12	12	1	2.75	2.6
	HK 0814.2RS FPM DK B	4	8	12	14	1	3.8	3.95
10	**HK 1012.2RS FPM DK B**	4	10	14	12	1	3.2	3.35
	HK 1014.2RS FPM DK B	5	10	14	14	1	4.4	5.1

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Sach-Nr. 005-405-149/API 15 US-D 09002.5