

# MINEBEA

## Technical Conference

~HDD Spindle Motor & Bearing~

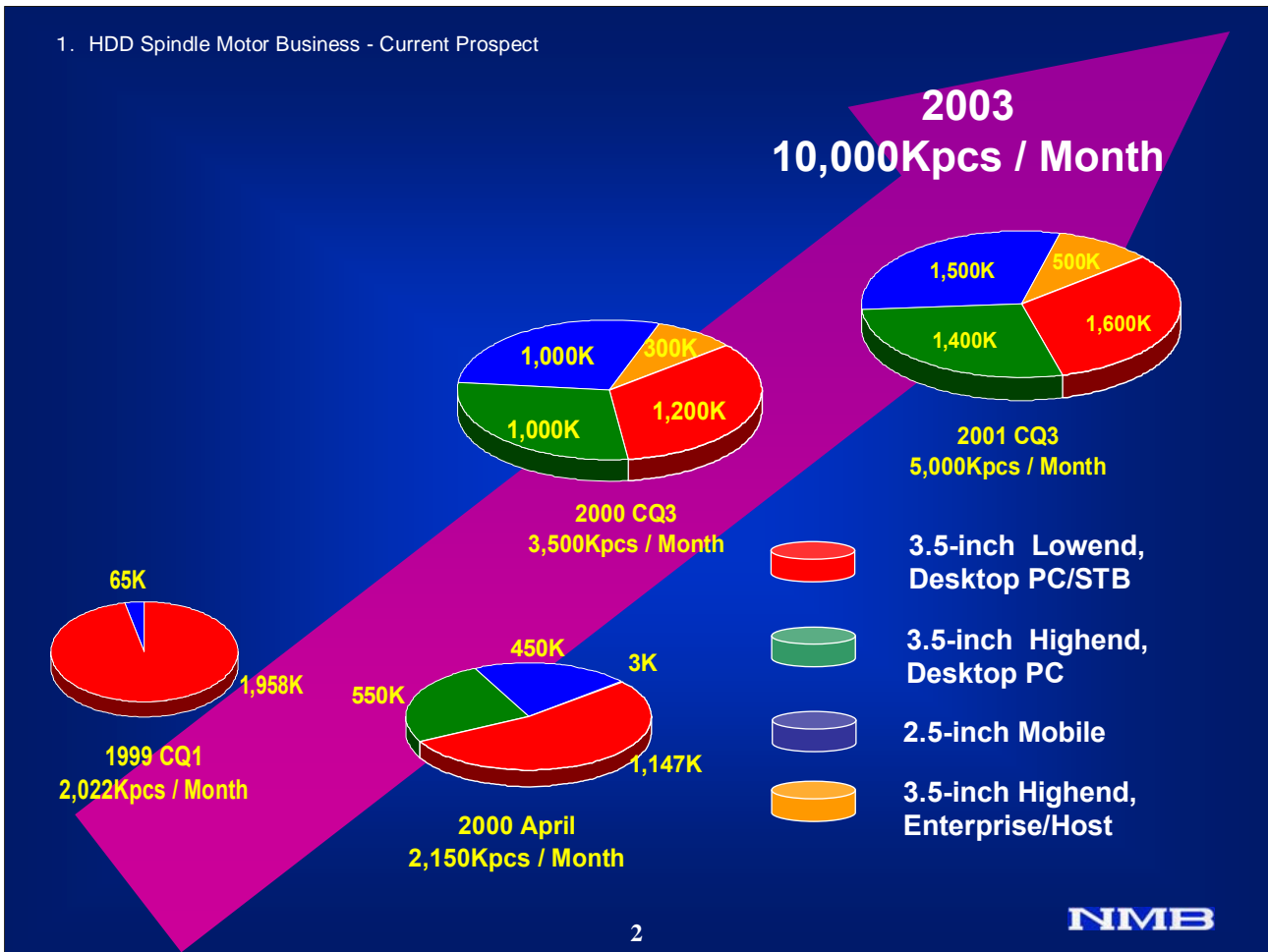
March 24, 2000

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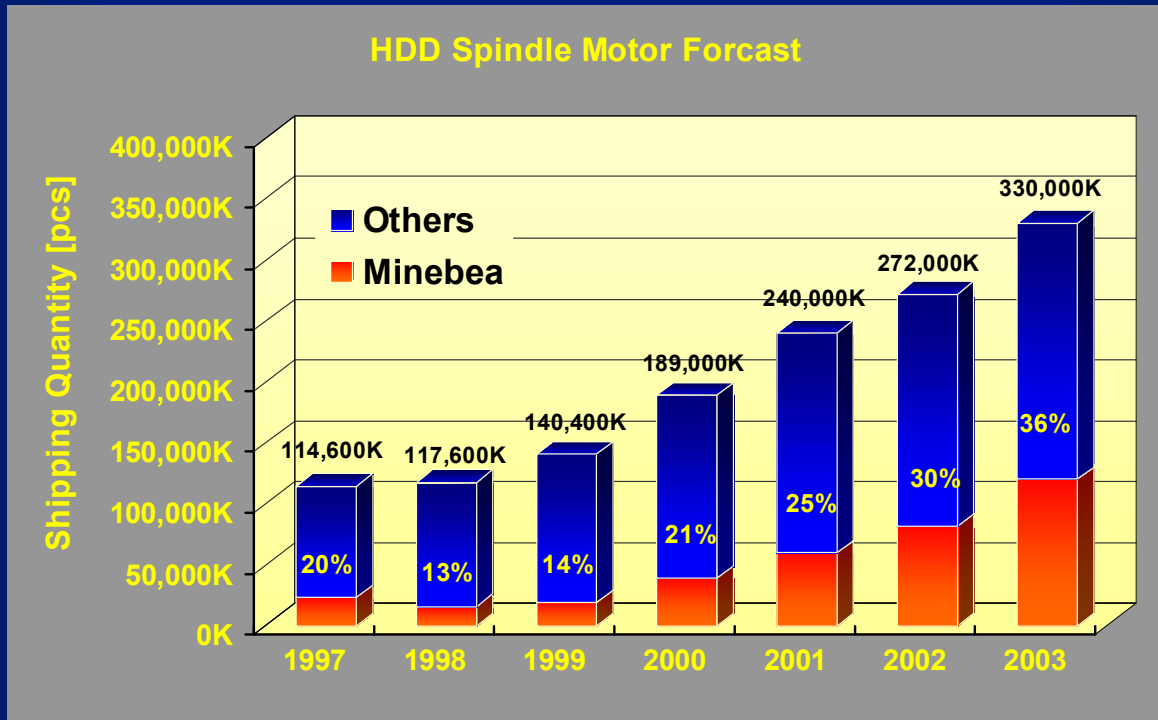
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7. Summary

In accordance with the table of contents, I would like to provide you with a technical profile of Minebea's businesses concerning HDD spindle motors and bearings including fluid dynamic bearings.



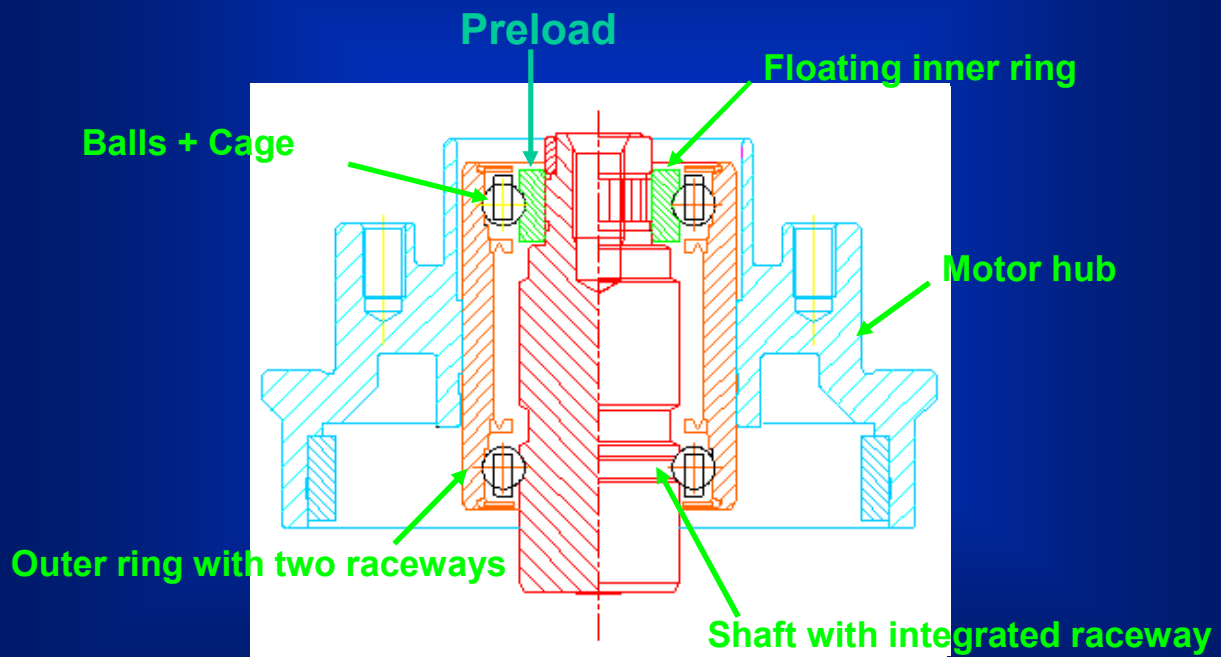
As of April 2000, our monthly production volume of HDD spindle motors stood at 2,150,000, but we expect this level to reach 3.5 million during the third quarter of 2000 and 5 million during the third quarter of 2001. The "3.5-inch highend, desktop" shown in Figures refers to spindle motors for 3.5-inch HDDs that are now said to have the largest storage capacity in the world. We expect to produce 10 million HDD spindle motors each month during 2003.



Annual production quantity K=1,000pcs  
Excluding Minebea, Other Manufacturers total, referenced from Pixie Pinnacle Corporation

Our market share of HDD spindle motors is expected to rise from 21% in 2000 to 36% in 2003. We have calculated the market size by adding about 10% to Pixie Pinnacle Corporation's estimate.

## Structure of RO Bearing

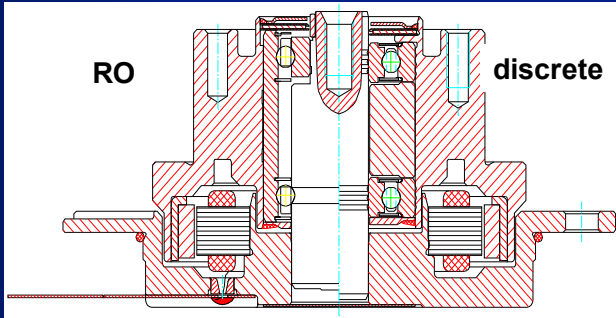


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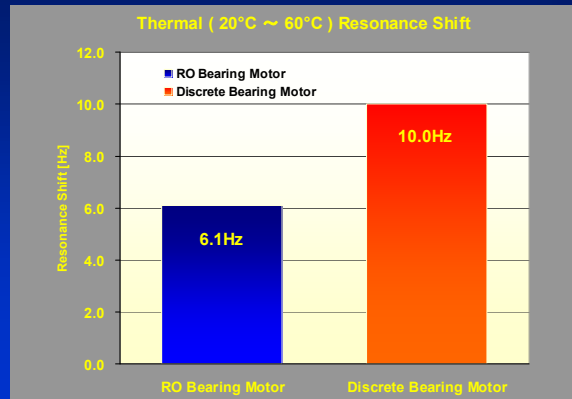
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An RO bearing is composed of one outer ring with two raceways, one shaft with one raceway, and one inner ring with one raceway.

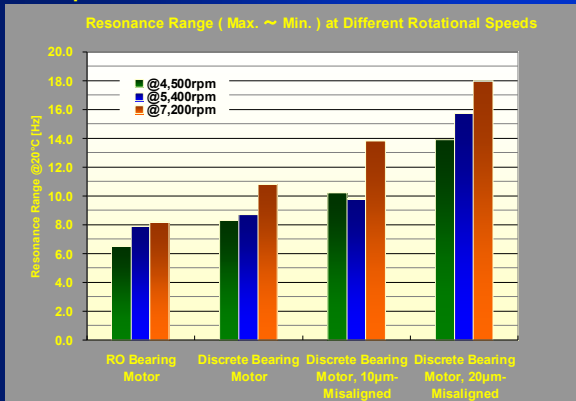
2. RO Bearing Motor – Performance and Advantage



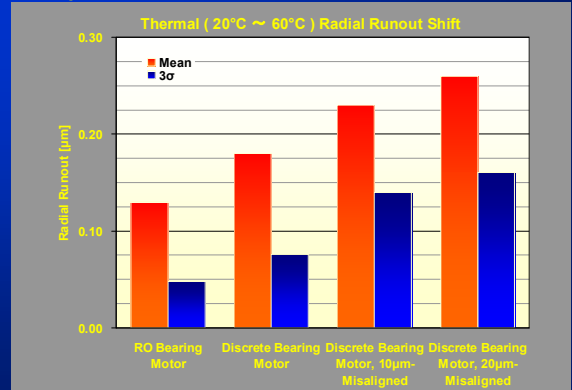
Graph A



Graph B

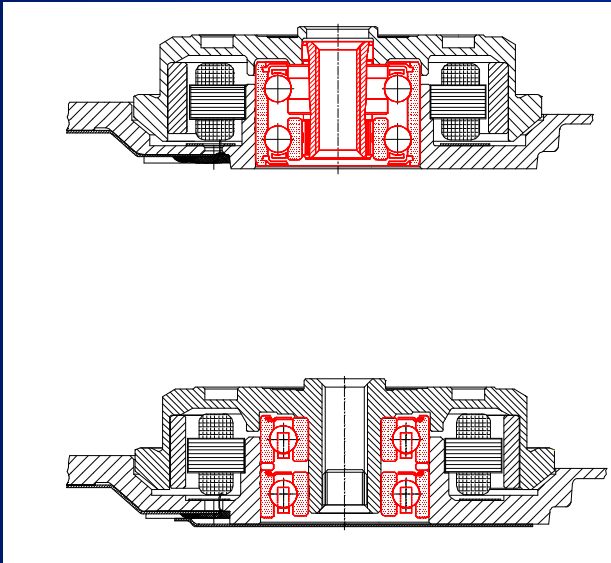


Graph C

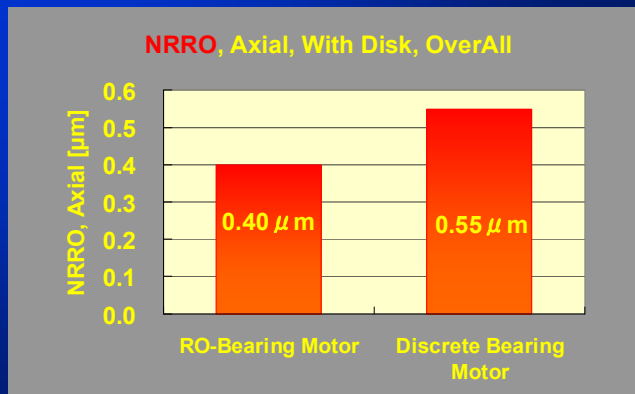
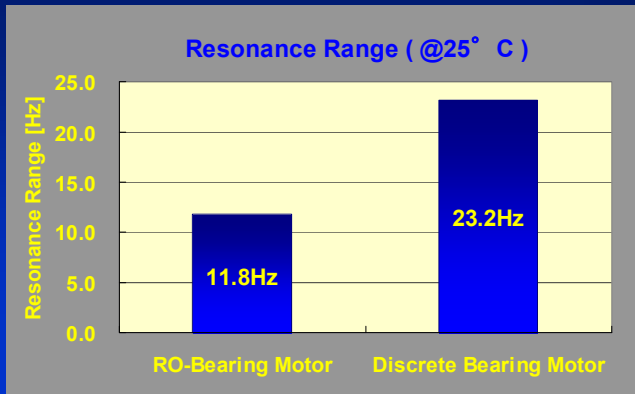


The key features of RO bearing motors are that they are less affected by temperature variation and that they suffer no misalignment. The advantages of RO bearings over discrete bearings are evident as shown in Graphs A (Thermal Resonance Shift) and B (Resonance Range at different Rotational Speed), and Graph C (Thermal Radial Runout Shift).

### 2.5 inch Spindle Motor Performance



~RO Bearing stiffness results in smaller NRRO and narrower Resonance range. ~



RO bearings have advantages in NRRO and resonance range. They have a high reputation as bearings for use in spindle motors for 2.5-inch, notebook type HDDs which require higher accuracy.

## Technical Problem of Ball Bearings with Ceramic Balls

### Loosing of Preload

#### Ball Bearing with Steel Balls:

Same Ball and Ring Materials

=> Same Thermal Expansion

No Preload Loosing Problem in Temperature Variation

#### Ball Bearing with Ceramic Balls:

Different Ball and Ring Material

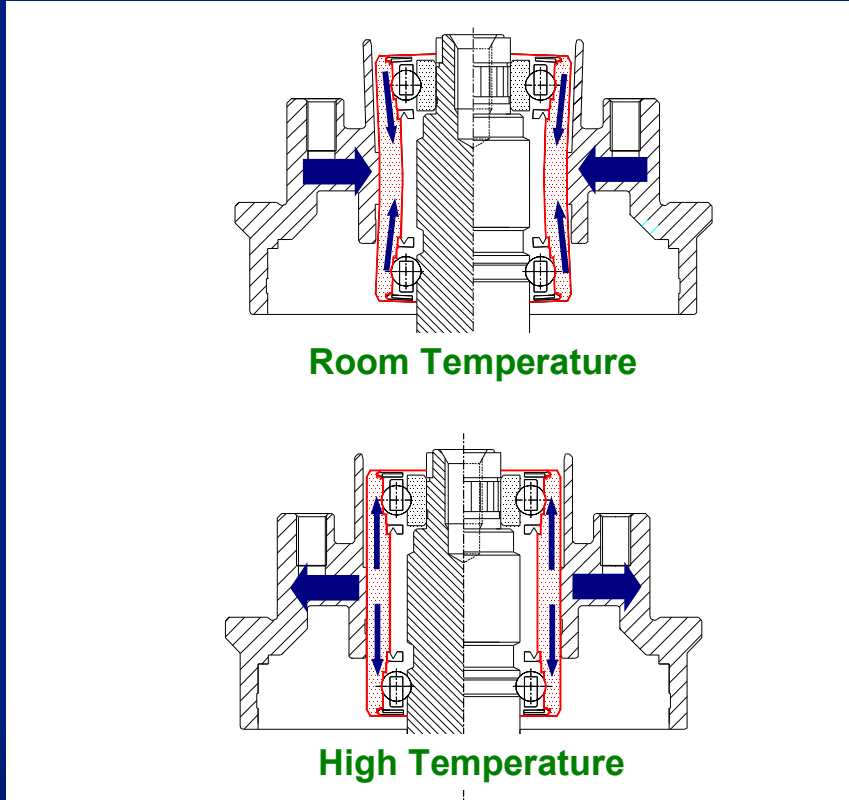
=> Different Thermal Expansion

Preload Loosing Problem in Temperature Variation

Generally speaking, in discrete ball bearings, when we use ceramic balls that have different thermal expansion rate from steel rings a technical problem of the preload loosing occurs.

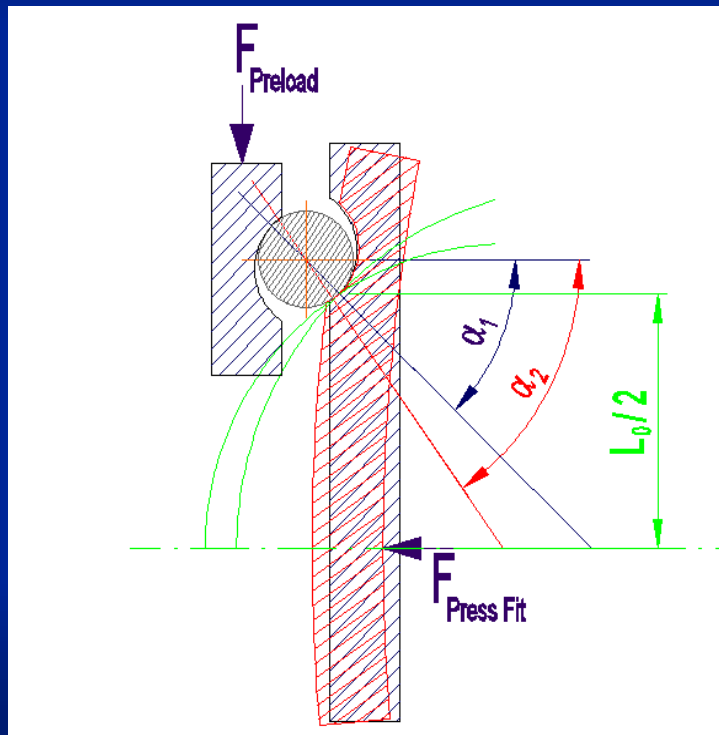


## Prevention of the Loosing Preload in RO Bearing with Ceramic Balls



When assembled into a motor, the outer ring of RO Bearing is compressed as shown in the above figure. This assembling method prevents the problem of the preload loosing at high temperature. We have applied for a patent for this structure.

## Principle of Compensating the Preload

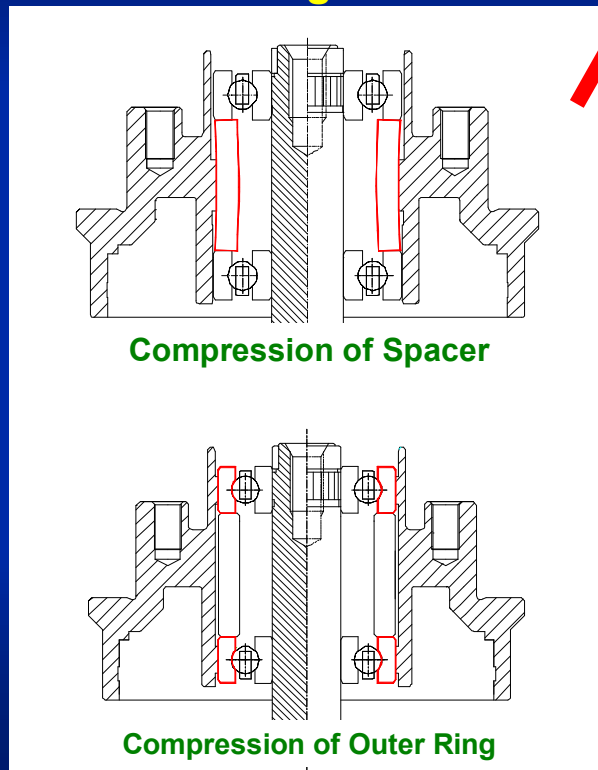


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In the case of RO bearing, pre-load is retained even when its outer ring is elongated due to a rise of temperature, since the compression of the outer ring is released to the longitudinal direction. The contact angle only changes slightly.

## Difficulty of Retaining the Preload in Discrete Ball Bearings with Ceramic Balls

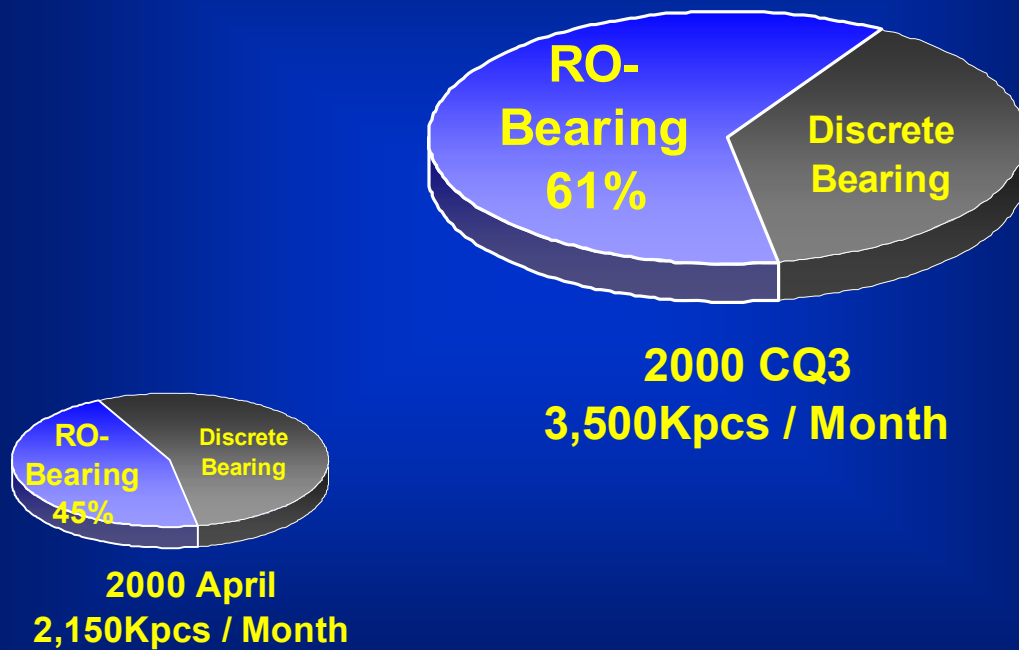


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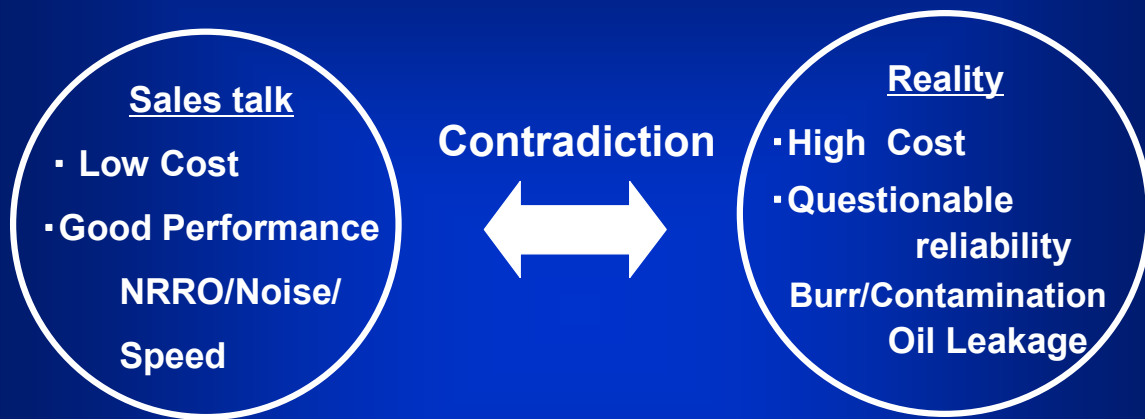
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In the case of discrete ball bearings with Ceramic Balls, the same principle to prevent the losing of preload is not applicable.

## Projection of RO Bearing Motor Production



All of our spindle motors for 2.5-inch and 3.5-inch, highend desktop HDDs use RO bearings. Production of RO bearing motors is expected to grow further in the future.



**Cost is a Key to the Success  
in FDB Business.**

The number of components used in fluid dynamic bearings are fewer than those used in other types of bearing. Thus, the price of fluid dynamic bearings should be lower by that count.

## **FDB developed by Seagate**

**Capital expenditure:**

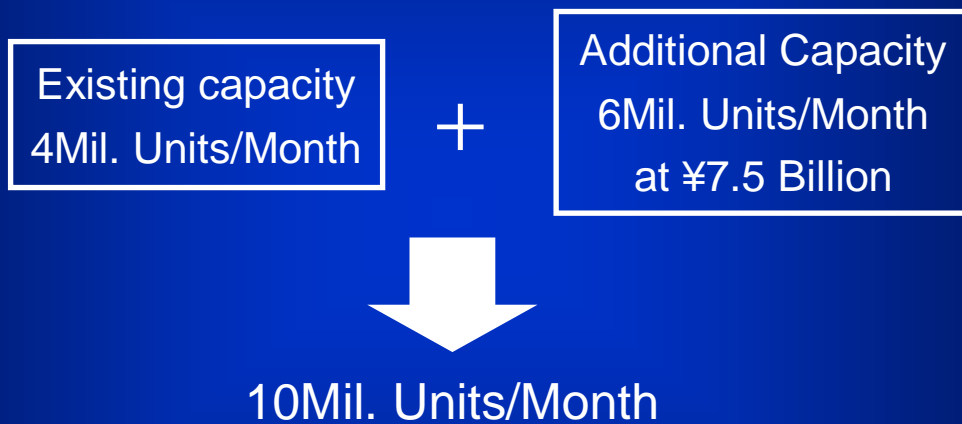
**2 Ball Bearings + 1 Shaft > 1 FDB**  
(Greater than)

**Reliability: Excellent Design and know-how**

(Burr Free, less Contamination and No Oil Leakage)

The fluid dynamic bearing developed by Seagate Technologies Inc. satisfies our requirements with regards to both cost and reliability.

## Capital expenditure for Additional HDD Spindle Motor Production Capacity



FDB Mass production starts within year 2000

We will start the mass production of fluid dynamic bearings by the end of 2000. We will invest 7.5 billion yen in Bang Pa-in, Thailand to build a HDD spindle motor plant with a monthly production capacity of 6 million units. After the completion of the new plant, our monthly production capacity of HDD spindle motor, including the existing production lines, will be 10 million units.

## Spindle Motor Performance Comparison by Bearing Types

	Discrete	RO	Non Minebea's FDB
NRRO	△	○	◎
Life, High Speed Rotation	△	○	◎
Acoustic Noise	○	○	◎
Load Carrying Capacity	◎	◎	△
Torque	○	○	?
Shock Torrelance	○	○	?
Thermal Characteristics	○	◎	?
Cost Advantage	◎	◎	?
Rotating Direction	<b>Both</b>	<b>Both</b>	<b>Specific</b>
Ease of Assembly	○	◎	?

(Note) RO : Ceramic Ball Type

The question mark placed on fluid dynamic bearings means that they will vary depending upon FDB's, design and manufacturing process. The above comparison clearly shows that RO bearings have certain advantages over discrete bearings.

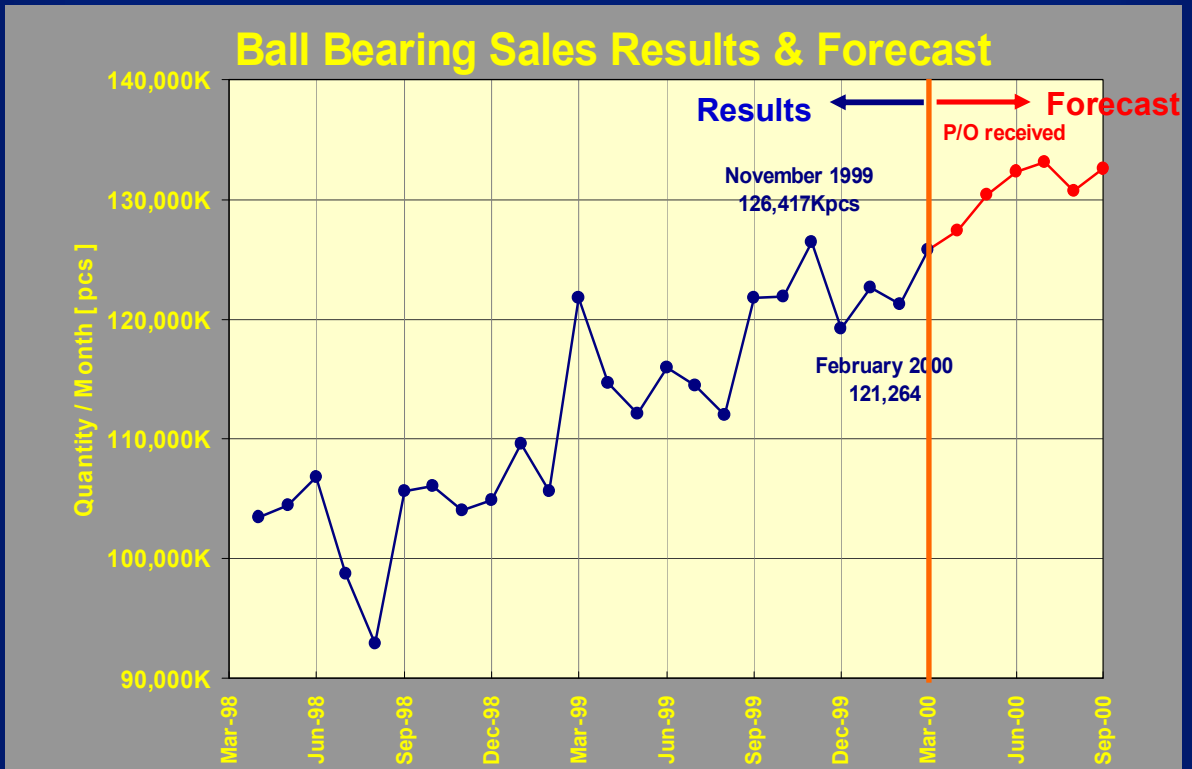


## Spindle Motor Performance Comparison by Bearing Types

	Discrete	RO	Minebea's FDB
NRRO	△	○	◎
Life, High Speed Rotation	△	○	◎
Acoustic Noise	○	○	◎
Load Carrying Capacity	◎	◎	△
Torque	○	○	○
Shock Torrelance	○	○	○
Thermal Characteristics	○	◎	○
Cost Advantage	◎	◎	◎
Rotating Direction	Both	Both	Specific
Ease of Assembly	○	◎	○

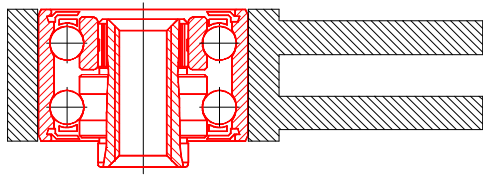
(Note) RO : Ceramic Ball Type

In the case of Minebea's fluid dynamic bearings, the question mark will turn to O or ◎. The fluid dynamic bearings have an NRRO and noise advantage over ball bearings. However, at highspeed rotation, the fluid dynamic bearings lose these advantages due to the disc dynamics and wind noises. Minebea's fluid dynamic bearings include fluid dynamic bearings designed for the highspeed rotation type HDDs and those designed for 2.5-inch HDDs. At present, however, we believe that the immediate area in which we can make the best use of the features of fluid dynamic bearings is the area of lowend HDDs, including HDDs for AV application. The best advantage of Minebea's fluid dynamic bearings is their low cost. With this in mind, we believe that Minebea's fluid dynamic bearings best suit lowend HDDs.

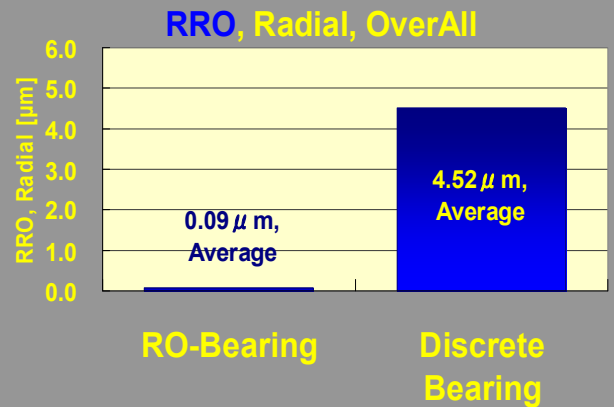
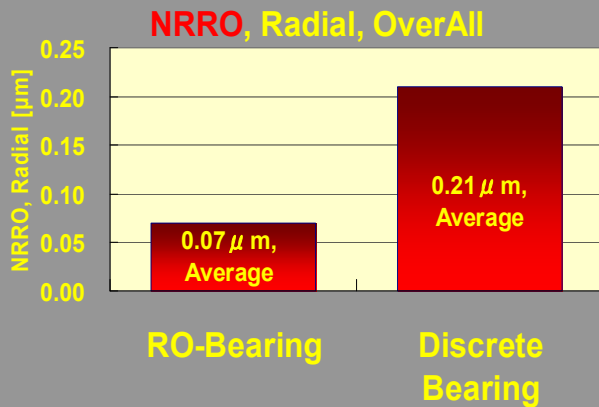


Since fluid dynamic bearings have a weakness in load carrying capacity and the limitation of rotational direction, while having an NRRO and noise advantage over ball bearings, their applications will be limited. However, even if all bearings for HDD spindle motors are replaced by fluid dynamic bearings, our ball bearing businesses will not be overly affected.

**Eg.1 : Precision Pivot Assy.**



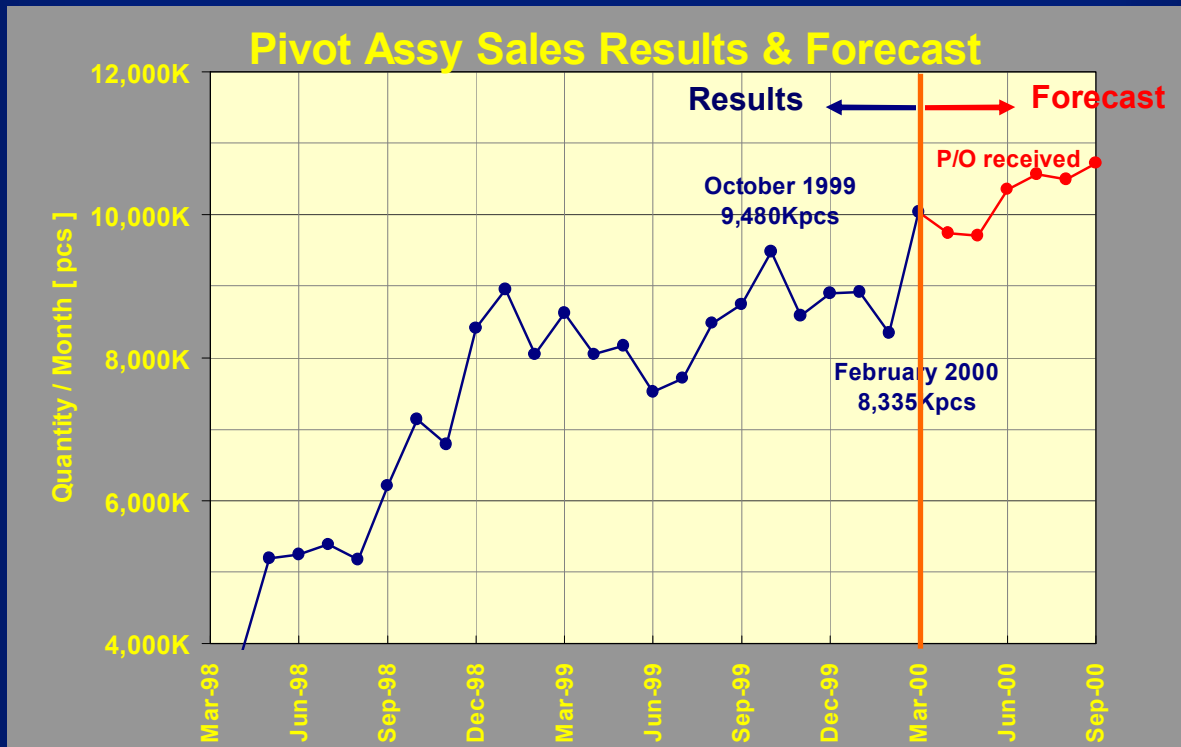
Though we now have a strong demand of RO Bearing for HDD Spindle Motors, we will explore new applications.



Rotating accuracy comparison between RO bearing and Discrete Bearing for Pivot Assy.

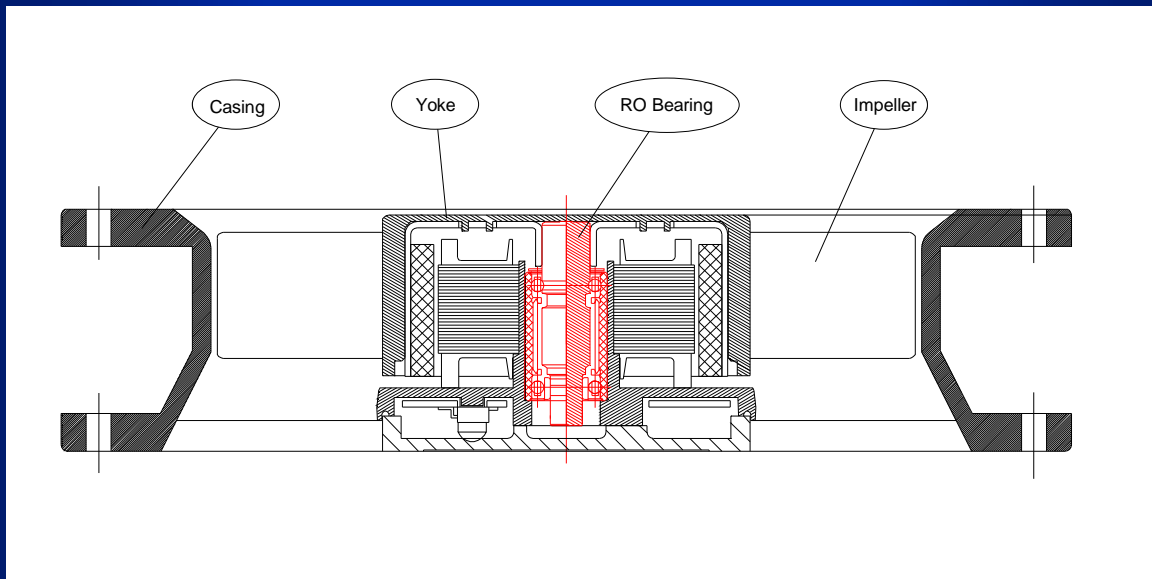


We consider high precision pivot assembly as a new application area for RO bearings. In the case of HDDs, higher accuracy is required not only for the HDD spindle motors that function to rotate the disks, but also for the pivot assemblies that function to control the position of heads.

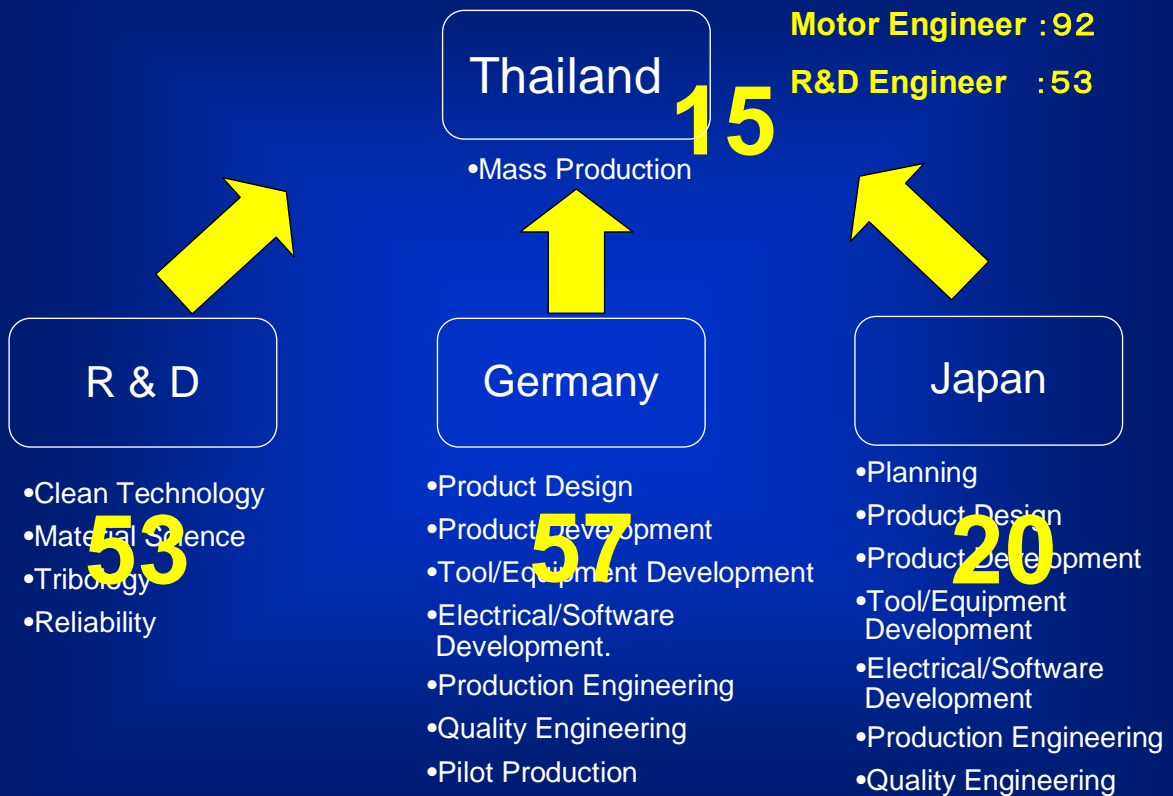


We expect that market demand for our pivot assemblies will increase further in the future.

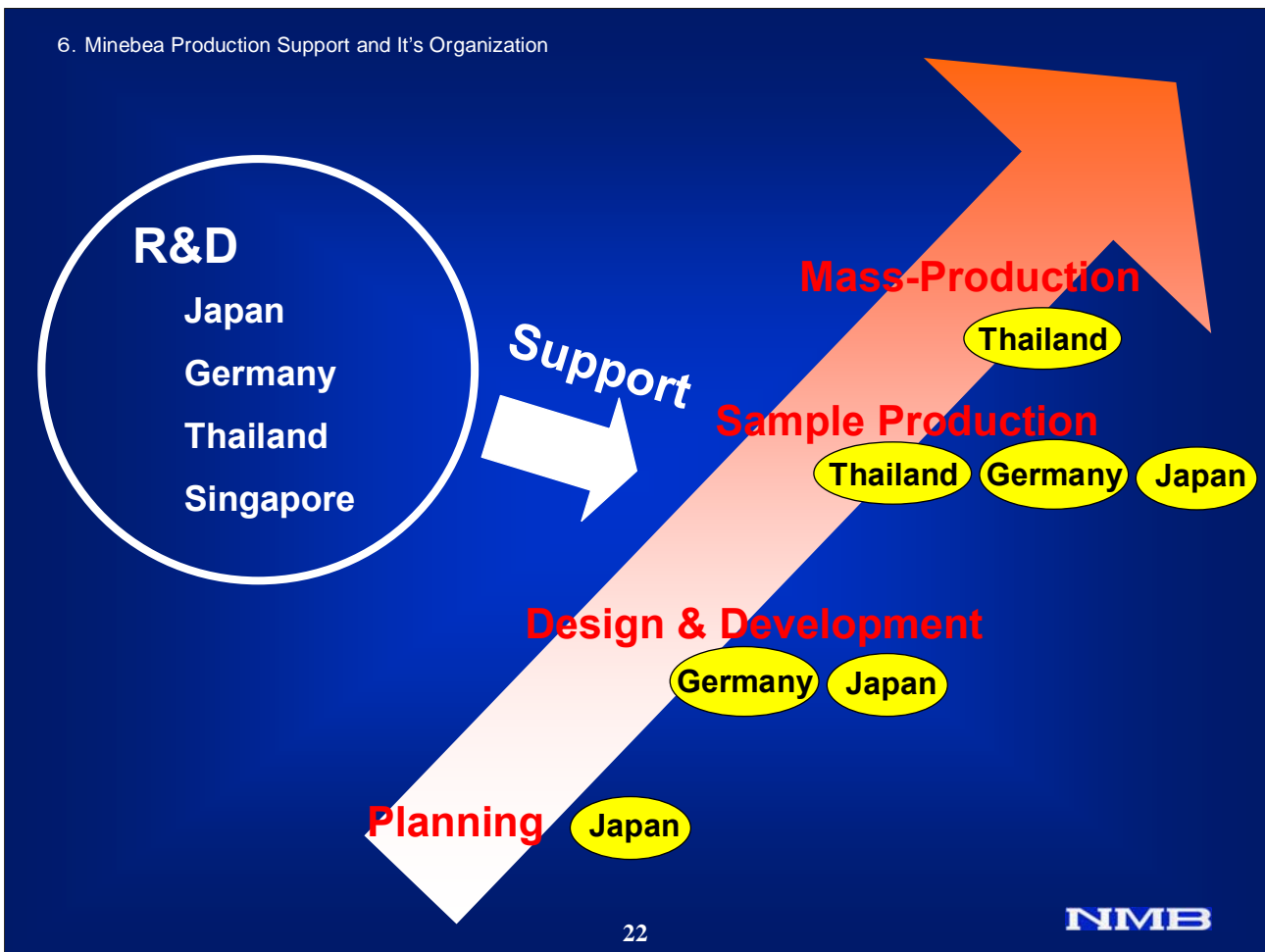
## RO Bearing Fan Motor - Ultra High Performance & High Reliability -



We consider ultrahigh performance, highly reliable fan motors as the next application area for RO bearings. We can obtain the stable rotation of fan motors by using RO bearings. In addition, we can multiply the operating life by three times or more if ceramic balls are used. High performance, highly reliable fan motors are expected to be used in a wide variety of areas, including the aerospace, information and telecommunication industries.



At present, Minebea has 92 HDD spindle motor engineers and 53 R&D engineers.



We are engaged in the design and development of HDD spindle motors in both Japan and Germany. We mass-produce HDD spindle motors in Thailand. Our R&D centers in various parts of the world support these operations.

1. Minebea HDD Spindle Motor expects Strong Demand and Steep Growth.
2. Minebea HDD Spindle Motor continues to use RO Bearing because of its Superior Performance.
3. Minebea FDB has Advantages in both Cost and Reliability.
4. FDB does not Affect has Minebea's Current Ball Bearing Business.
5. RO Bearing will be used not only for HDD Spindle Motors but also for Other High Value Added Products.
6. Globalized R&D Production set up will enhance Minebea's Further Growth.