



R&D Center



March 23, 2001

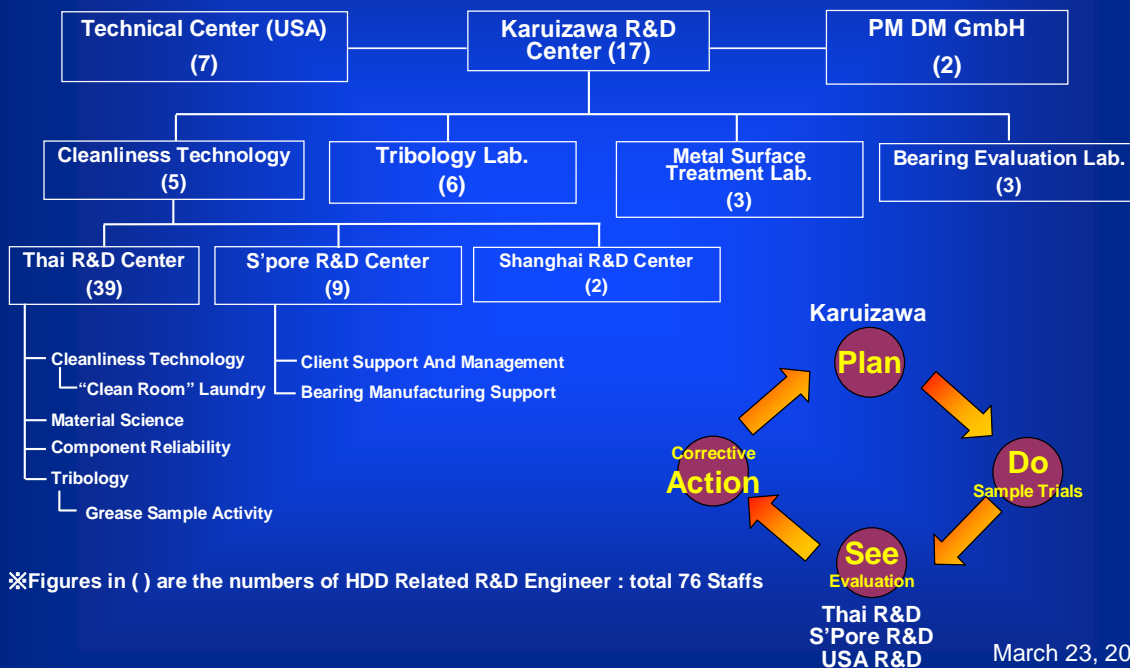
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- 1. Collaborated Organization and Its Major Activity Fields.**
- 2. HDD Major Technology.**
- 3. Sustaining The HDD Technology Innovation
(Spindle Motor and Pivot Assy.).**
 - Grease Development for RO (Ball) Bearing
 - Steel Alloy Development
(Free-Machining Stainless Steel)
- 4. Chemical Integration (Spindle Motor)**
- 5. Summary.**

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7. R&D Center
 1. Collaborated Organization and It's Major Activity Fields.



Minebea bases its R&D activities on the R&D Center in Karuizawa, which works in collaboration with the R&D Center in Germany and the Technical Center in the U.S. Four areas of activities in the Karuizawa R&D Center are cleanliness technology, tribology, metal surface treatment, and bearing evaluation.

With respect to cleanliness technology and tribology, Minebea has R&D centers in Thailand, Singapore, and Shanghai to directly support manufacturing divisions.

As the diamond diagram on the bottom right in the above chart shows, the Karuizawa R&D Center undertakes product development processes such as planning, trial production, and working out countermeasures, while R&D centers in Thailand, Singapore, and the U.S. undertake evaluation that requires engineers with highly specialized expertise.

●CHANNEL INTEGRATION

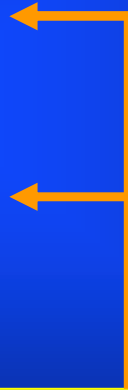
- R/W CHANNEL
- CODING
- SERVO

●MECHANICAL INTEGRATION

- HEAD/DISK TECHNOLOGY
- OTP/TMR

●CHEMICAL INTEGRATION

- RELIABILITY
- CLEAN TECHNOLOGY



Spindle Motor/Pivot Assembly

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Mechanical integration and chemical integration are factors of vital importance in the manufacture of spindle motors and pivot assemblies.

Hard Disk Interface (HDI), Off Track Performance (OTP), and Track Miss Registration (TMR) are important factors in mechanical integration. Significant elements in chemical integration are reliability and cleanliness.

SPINDLE MOTOR	PIVOT
<ul style="list-style-type: none"> ● Higher Rotational Bearing <ul style="list-style-type: none"> Steel Ball (Grease Development) Ceramic Ball ● Less Noise <ul style="list-style-type: none"> Bearing Cleanliness Improvements ● Less NRRO (Lower Than 0.3 μ m) <ul style="list-style-type: none"> RO Bearing rather than Conventional (Discrete) Bearing ● Less Friction Torque And Anti-Fretting <ul style="list-style-type: none"> Grease Development ● Less Outgassing <ul style="list-style-type: none"> Polymers Sulfur Contained Free-Machining Steel Improvement 	<ul style="list-style-type: none"> ● Less Access Time <ul style="list-style-type: none"> Less Hysteresis Thermal Expansion Matching ● Less Friction Torque <ul style="list-style-type: none"> Grease → Oil ● Outgassing Improvement <ul style="list-style-type: none"> Sulfur Contained Free-Machining Steel Improvement Less Outgassing Adhesions Less Outgassing Grease Development ● Less Weight <ul style="list-style-type: none"> Stainless Steel → Non-Ferric Metals

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This chart shows how Minebea has pursued technological innovation for spindle motors and pivot assemblies to cope with the increasing sophistication of HDDs.

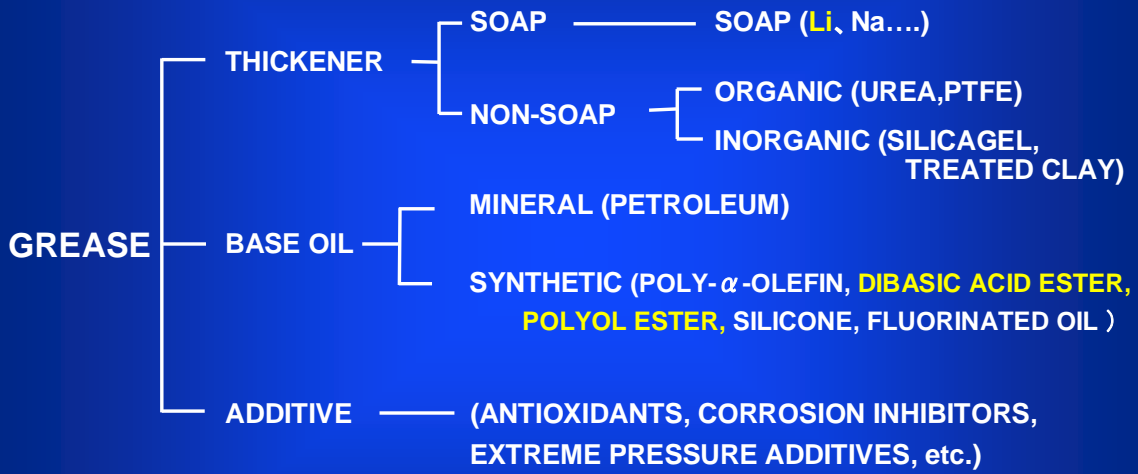
With regard to spindle motors, Minebea has introduced grease of its own make and developed ceramic balls to meet the need for high-speed rotation. The Bang Pa-in Plant in Thailand makes in its clean room seven kinds of grease to be applied to different types of spindle motors. The cleanliness of bearings has been improved to reduce noise. RO bearings have been developed for lower NRRO, while newly developed grease has lowered friction torque.

For lower outgassing that directly affects product reliability, Minebea works with materials makers to develop polymers and sulfur-contained free-machining steels that generate no hazardous gas.

With regard to pivot assemblies, Minebea has taken measures as shown above for improved performance.

To exemplify Minebea's efforts toward further improvement in performance, let us explain about the development of sulfur-contained free-machining steels and RO bearing grease for high-speed rotation and low friction torque.

LUBRICATING GREASE STRUCTURE



GREASE CONSISTS OF APPROX. 80% TO 90% OIL, APPROX. 10% TO 20% THICKENER AND APPROX. 1% TO 5% STIFFENER ADDITIVES.

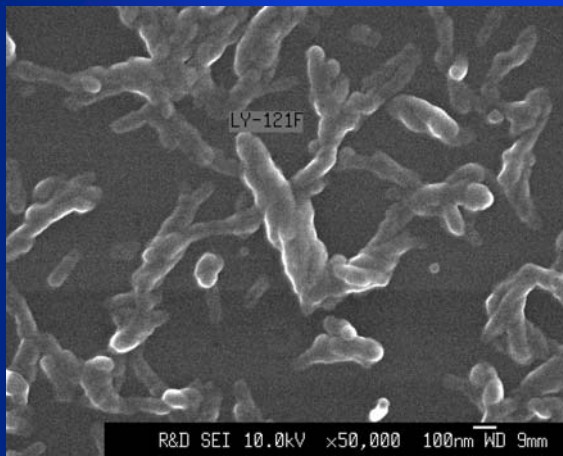
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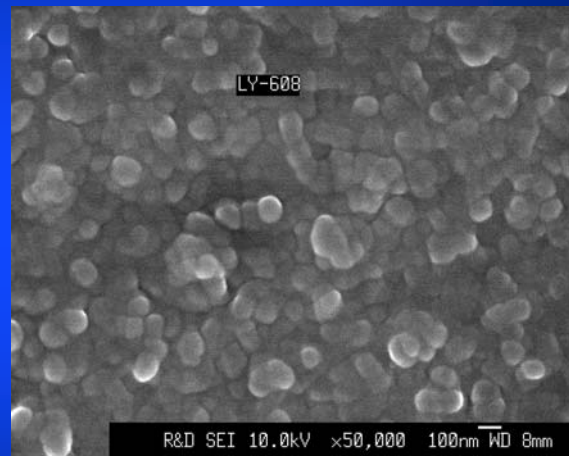
Grease is made of 80% to 90% base oil that serves as lubricant, 10% to 20% of thickner, and several percent of additives.

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- 3. Sustaining The HDD Technology Innovation (Spindle Motor and Pivot Assy.).

Old and Current Li Soap



New Li Soap



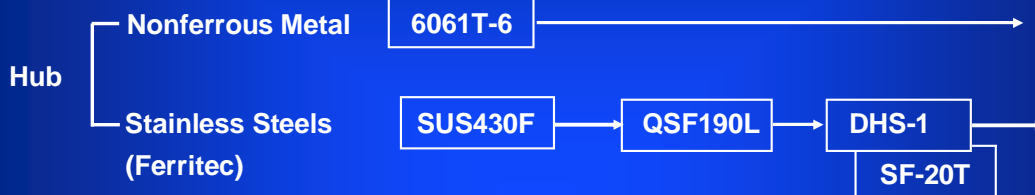
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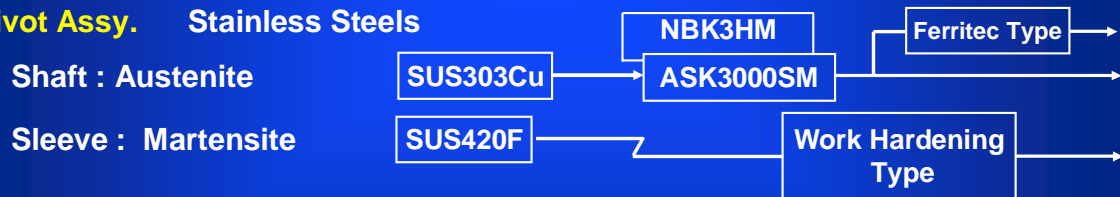
As thickener in the grease for high-speed rotation RO bearings, Minebea changed lithium soap from 12-hydro stearic acid lithium to stearic acid lithium. We have also changed the combination of base oil and additives.

Steel Alloy Development (Spindle Motor And Pivot Assy.)

Spindle Motor



Pivot Assy.



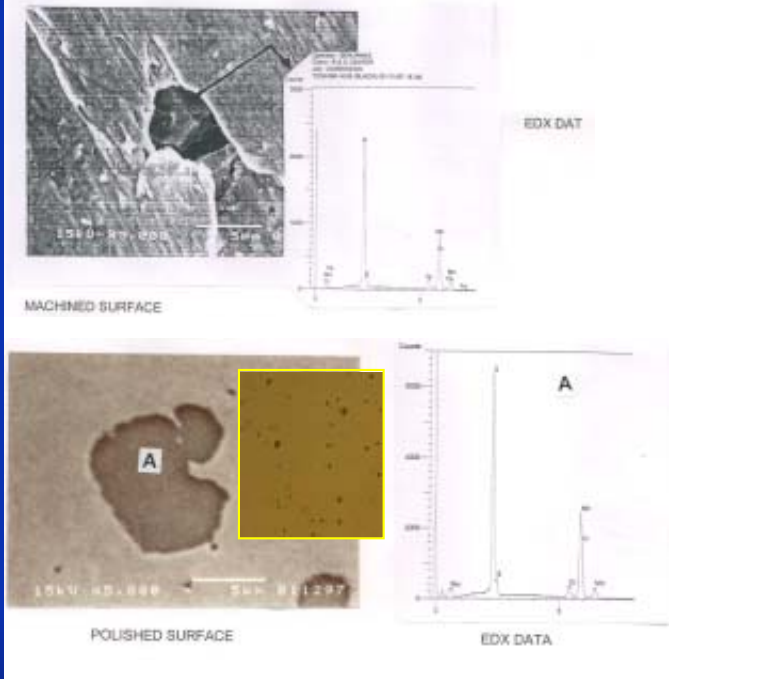
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The chart shows a development roadmap for ferrite stainless steel for spindle motor hubs, austenite stainless steel for pivot shafts, and martensite stainless steel for pivot sleeves.

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SUS 430F (Mn/S Ratio ; 4.43)



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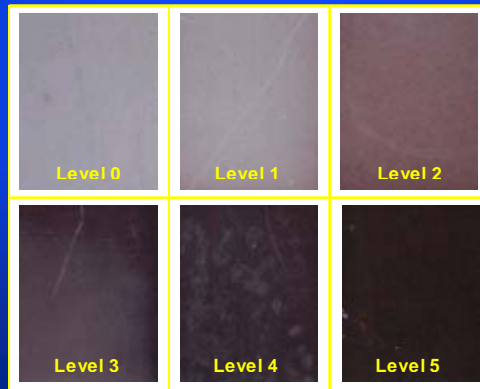
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The photos show an electron microscopic view of the surface of SUS430F. The black dots are manganese sulfide.

IMPROVEMENT OF SULFUR OUTGAS ON ALLOY STEEL

SILVER COUPON CORROSION TEST

<u>MATERIAL</u>	<u>SULFUR LEVEL</u>	<u>Mn/S</u>	<u>Cr(%)</u>
Ferritec			
SUS430F	5	4.5	17
DHS-1	0	1.2	19
Austenitec Stainless Steel			
SUS303Cu	2	5.0	17.8
ASK3000SM	1	5.0	18.7



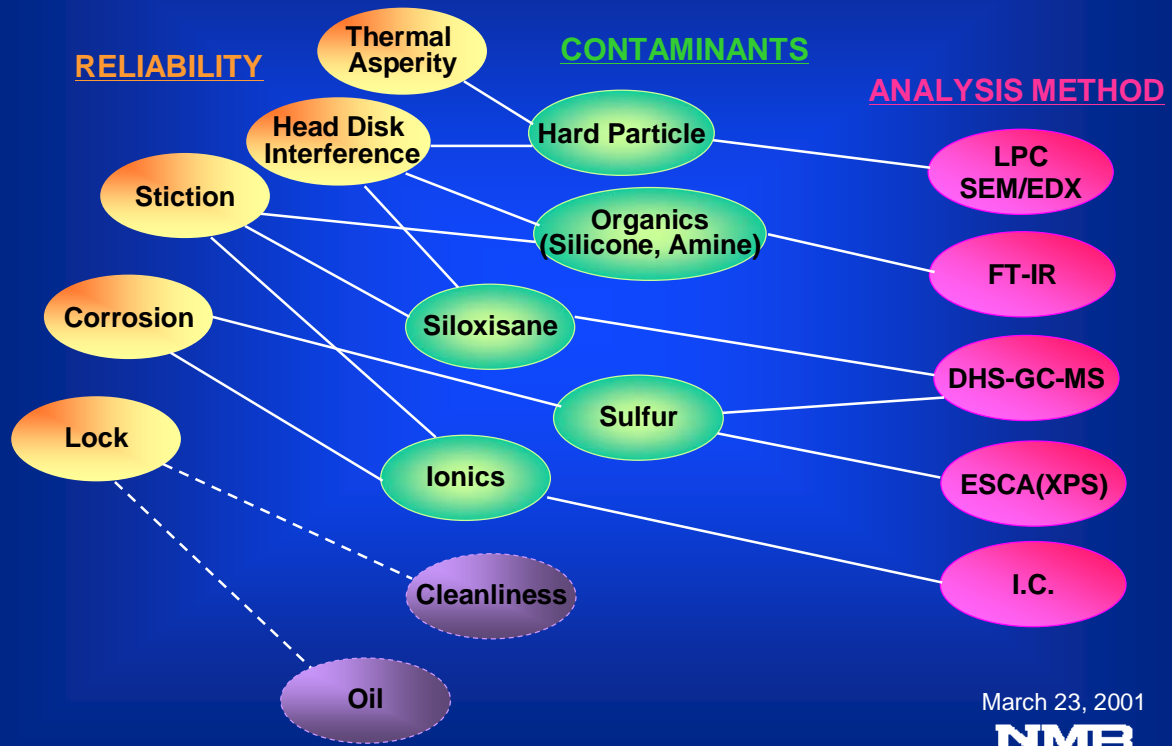
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These photos show levels of sulfur content by color changes on silver plates.

Generally, outgassing of sulfur and hydrogen sulfide easily occurs when the ratio of manganese and sulfur content is large. Also the possibility of sulfur outgassing varies according to chromium content. Important points for improvement, therefore, are the ratio of

CHEMICAL INTEGRATION AND SPINDLE MOTOR



This chart shows primary items of chemical integration that affect reliability of HDD spindle motors, major related contaminants, and quantitative analyzers of minute elements of the contaminants.

- 7. R&D Center
- 4. Chemical Integration (Spindle Motor)

CHEMICAL INTEGRATION AND SPINDLE MOTOR



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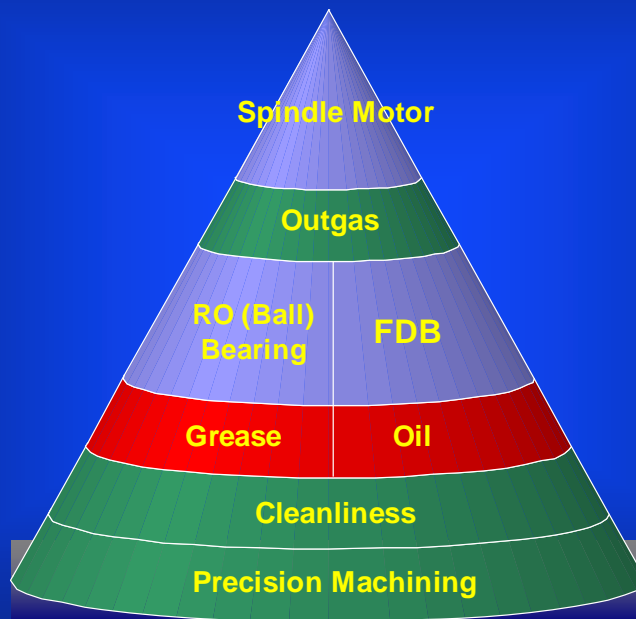
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The photo on the left shows an electrostatic spectroscopy for chemical analysis of an extremely thin surface of up to 50 angstrom in thickness.

The photo on left shows an outgassing analyzer, a Fourier transform infrared spectrophotometer (FT-IR), an ion chromatograph, and a liquid-borne particle counter (LPC).

It is important to detect by these analyzers and control the minutest amount of contaminants in order to ensure reliability of HDD spindle motors.

Chemical Integration Supports HDD Components Technology



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For mass-production of high-performance and highly reliable spindle motors, it is essential to integrate outgassing control technology with Minebea's expertise in miniature ball bearing production and its proprietary ultra-precision machining technology.