SHAFT

The NB shaft can be used in a wide range of applications as a mechanical component from straight shaft to spindle shaft. NB's expertise in machining and heat-treatment turns into manufacturing spindle shaft, roll shaft, and general machinery shaft for rotational motion. NB's high accuracy technology answers various shaft machining requirements.

ADVANTAGES

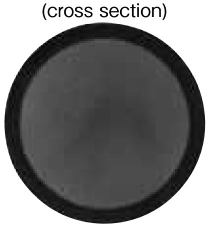
Advanced Machining Technology

NB performs a wide variety of highly accurate machining processes to provide custom shafting from relatively simple machining, such as tapping and shaft stepping to the more demanding high-speed rotating shafts and spindles. NB can also answer the special grinding and bore machining requirements.

Excellent Wear Resistance

Most commonly used materials are high-carbon chromium bearing steel (SUJ2) and martensite stainless steel (SUS440C or equivalent). NB's advanced heat-treatment technology gives these materials an excellent wear resistance by quenching and tempering to achieve a uniform hardened layer in the circumferential and axial directions. The cross-sectional picture below shows the hardened layer-depth of the NB shaft.

Hardened Layer
(cross section)



Surface Roughness

Precision grinding results in a surface roughness of less than Ra0.4.

Wide Selection of Shaft Types

- SN type, SNS type, SNT type,
- SNB, SNSB type (Center-lined tapped shaft)
- SNW, SNWS type (Inch shaft)
- SNW-PD, SNWS-PD type (Inch, pre-drilled shaft)
- Spindle shaft, roll shaft

Special Requirements

Based on the customer drawings and specifications NB will answer the customer requirements in material (SCM, SKS etc.), heat-treatment, surface treatment, etc.

Shaft Supporter and Shaft Support Rail

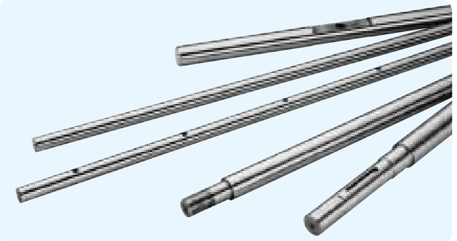
These components ease the shaft installation and help save the design/assembling time. (refer to page F-14)

FIT Series

This series is a set of NB slide bush and NB shaft. By precise shaft-grinding, FIT series achieves the best-fit clearance adjustment for a smooth, high accuracy linear motion. (refer to page F-24)

TYPES

SN/SNS/SNT type (NB Shaft)
SNW/SNWS type (Inch Shaft)



NB shaft is a high-precision shaft that can be used with slide bush or any other bearings. A wide range of machining is provided for customer drawings and requirements.

Table F-1 Specifications

type	SN type	SNS type	SNT type
material	SUJ2	equivalent to SUS440C	SUJ2 (hollow shaft)
outer diameter tolerance	g6 or to be specified		
hardness	60HRC or more	56HRC or more	60HRC or more
surface roughness	Ra0.4 or less		
page	page F-6	page F-7	page F-8

Center-lined tapped shafts are standardized series for easy selection that can be used with the SA shaft support rails. (refer to page F-18)

SNB/SNSB type (NB Center-lined Tapped Shaft)
SNW-PD/SNWS-PD type (Inch Shaft, Pre-drilled Shaft)

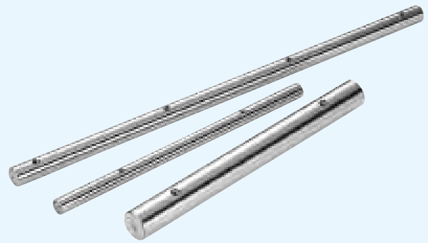


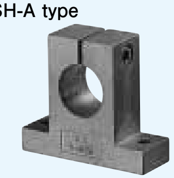
Table F-2 Specifications

type	SNB type	SNSB type
material	SUJ2	equivalent to SUS440C
outer diameter tolerance	g6 or to be specified	
hardness	60HRC or more	56HRC or more
surface roughness	Ra0.4 or less	
page	page F-9	

The SNW and SNWS types are inch dimensional shafts with the same specifications as SN/SNS type (refer to page F-10,11). SNW-PD and SNWS-PD types are standardized series that can be used with the WA shaft support rails. (refer to page F-12,13,22)

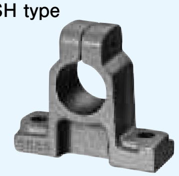
Shaft Supporter and Shaft Support Rail

SH-A type



P.F-15

SH type

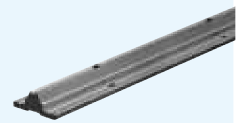


P.F-16

SHF type
SHF-FC type

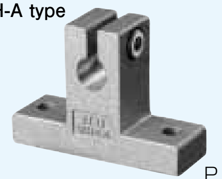
P.F-17

SA type



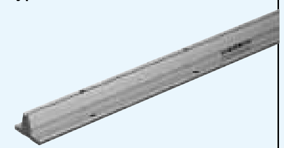
P.F-18

WH-A type



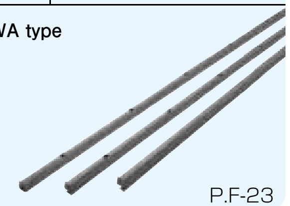
P.F-20

WA type



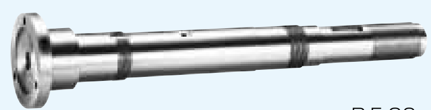
P.F-22

LWA type



P.F-23

Special Specifications



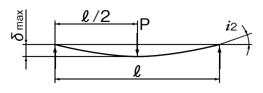
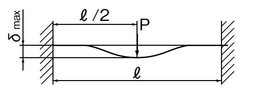
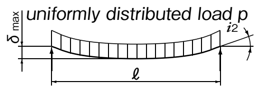
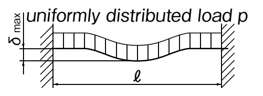
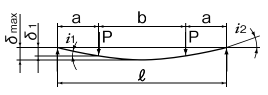
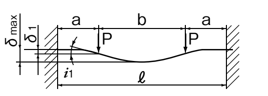
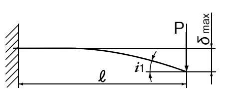
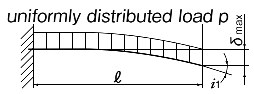
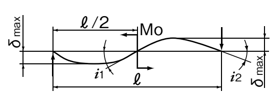
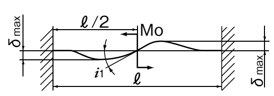
P.F-26

Based on drawings and specifications, NB manufactures spindle shafts, and roll shafts for the rotary motion application. Material, heat-treatment (hardening/tempering), surface treatment, etc, NB meets customer requirements. Please contact NB for details.

CALCULATION OF DEFLECTION AND DEFLECTION ANGLE

The following formulas are used to obtain the deflection and its angle of the shaft. Typical conditions are listed in Table F-3.

Table F-3 Formulas for Calculating Deflection and Deflection Angle

	support method	specification	formula for deflection	formula for deflection angle
1	support – support		$\delta_{max}=\frac{P\ell^3}{48EI}=P\ell^3C$	$i_1=0$ $i_2=\frac{P\ell^2}{16EI}=3P\ell^2C$
2	fixed – fixed		$\delta_{max}=\frac{P\ell^3}{192EI}=\frac{1}{4}P\ell^3C$	$i_1=0$ $i_2=0$
3	support – support		$\delta_{max}=\frac{5p\ell^4}{384EI}=\frac{5}{8}p\ell^4C$	$i_2=\frac{p\ell^3}{24EI}=2p\ell^3C$
4	fixed – fixed		$\delta_{max}=\frac{p\ell^4}{384EI}=\frac{1}{8}p\ell^4C$	$i_2=0$
5	support – support		$\delta_1=\frac{Pa^3}{6EI}\left(2+\frac{3b}{a}\right)=8Pa^3\left(2+\frac{3b}{a}\right)C$ $\delta_{max}=\frac{Pa^3}{24EI}\left(\frac{3\ell^2}{a^2}-4\right)=2Pa^3\left(\frac{3\ell^2}{a^2}-4\right)C$	$i_1=\frac{Pab}{2EI}=24PabC$ $i_2=\frac{Pa(a+b)}{2EI}=24Pa(a+b)C$
6	fixed – fixed		$\delta_1=\frac{Pa^3}{6EI}\left(2-\frac{3a}{\ell}\right)=8Pa^3\left(2-\frac{3a}{\ell}\right)C$ $\delta_{max}=\frac{Pa^3}{24EI}\left(2+\frac{3b}{a}\right)=2Pa^3\left(2+\frac{3b}{a}\right)C$	$i_1=\frac{Pa^2b}{2EI\ell}=\frac{24Pa^2bC}{\ell}$ $i_2=0$
7	fixed – free		$\delta_{max}=\frac{P\ell^3}{3EI}=16P\ell^3C$	$i_1=\frac{P\ell^2}{2EI}=24P\ell^2C$ $i_2=0$
8	fixed – free		$\delta_{max}=\frac{p\ell^4}{8EI}=6p\ell^4C$	$i_1=\frac{p\ell^3}{6EI}=8p\ell^3C$ $i_2=0$
9	support – support		$\delta_{max}=\frac{\sqrt{3}Mo\ell^2}{216EI}=\frac{2\sqrt{3}}{9}Mo\ell^2C$	$i_1=\frac{Mo\ell}{12EI}=4Mo\ell C$ $i_2=\frac{Mo\ell}{24EI}=2Mo\ell C$
10	fixed – fixed		$\delta_{max}=\frac{Mo\ell^2}{216EI}=\frac{2}{9}Mo\ell^2C$	$i_1=\frac{Mo\ell}{16EI}=3Mo\ell C$ $i_2=0$

δ_1: deflection at the concentrated load point (mm) δ_{max}: maximum deflection (mm) i_1: deflection angle at the concentrated load point (rad)
i_2: deflection angle at the support point (rad) Mo: moment (N・mm) P: concentrated load (N)
p: uniformly distributed load (N/mm) a,b: concentrated load point distance (mm) ℓ: span (mm) I: moment of inertia of area (mm^4)
E: modulus of longitudinal elasticity (SUJ2) 2.06×10^5 (N/mm^2) (SUS) 2.0×10^5 (N/mm^2) C: 1/48EI (1/N・mm^2)

The moment of inertia of area (I) is obtained using the following formulas:

● For solid shaft

$$I=\frac{\pi D^4}{64}$$

● For hollow shaft

$$I=\frac{\pi}{64}(D^4-d^4)$$

I: moment of inertia of area (mm^4)
D: outer diameter (mm) d: inner diameter (mm)

The values of the moment of inertia of area and C (=1/48 EI) for NB shafts are listed in Table F-4 and F-5.

Calculation Examples

1. Calculating the maximum deflection of a 30mm shaft with a 500mm span when a concentrated load of 980 N is applied at the mid-point of the shaft … (neglecting the shaft weight)

①In case the support method is support-support:
From the given conditions, P = 980 N, ℓ = 500mm
From Table F-4, C for an outer diameter of 30 mm, $C=2.54\times10^{-12}$ (N・mm^2).
Substituting these values into the corresponding formula (No. 1) in Table F-3,
$\delta_{max}=P\ell^3C=0.31$ (mm)

② In case the support method is fixed-fixed:
Substituting the values into the corresponding formula (No. 2) given in Table F-3,
$\delta_{max}=\frac{1}{4}P\ell^3C=0.08$ (mm)

2.Calculating the maximum deflection of a 60mm shaft with an inner diameter of 32 mm and a 2,000 mm span by its own weight …

From Table F-5, C for an outer diameter of 60 mm, $C=1.73\times10^{-13}$ (N・mm^2)
The mass per unit length of a shaft with an outer diameter of 60 mm and an inner diameter of 32 mm is 15.9kg/m. Therefore, a uniformly distributed load of 0.156 N/mm is applied. Substituting these values into the formula (No. 3) given in Table F-3.
$\delta_{max}=\frac{5}{8}p\ell^4C=0.27$ (mm)

Table F-4 Solid Shaft

outer diameter D (mm)	moment of inertia of area I (mm^4)	C=1/48EI (1/N・mm^2) SUJ2	equivalent to SUS440C
3	3.98	2.54×10^{-8}	2.62×10^{-8}
4	1.26×10	8.05×10^{-9}	8.29×10^{-9}
5	3.07×10	3.30×10^{-9}	3.40×10^{-9}
6	6.36×10	1.59×10^{-9}	1.64×10^{-9}
8	2.01×10^2	5.03×10^{-10}	5.18×10^{-10}
10	4.91×10^2	2.06×10^{-10}	2.12×10^{-10}
12	1.02×10^3	9.94×10^{-11}	1.02×10^{-10}
13	1.40×10^3	7.21×10^{-11}	7.43×10^{-11}
15	2.49×10^3	4.07×10^{-11}	4.19×10^{-11}
16	3.22×10^3	3.14×10^{-11}	3.24×10^{-11}
20	7.85×10^3	1.29×10^{-11}	1.33×10^{-11}
25	1.92×10^4	5.27×10^{-12}	5.43×10^{-12}
30	3.98×10^4	2.54×10^{-12}	2.62×10^{-12}
35	7.37×10^4	1.37×10^{-12}	1.41×10^{-12}
40	1.26×10^5	8.05×10^{-13}	8.29×10^{-13}
50	3.07×10^5	3.30×10^{-13}	3.40×10^{-13}
60	6.36×10^5	1.59×10^{-13}	1.64×10^{-13}
80	2.01×10^6	5.03×10^{-14}	5.18×10^{-14}
100	4.91×10^6	2.06×10^{-14}	–
120	1.02×10^7	9.94×10^{-15}	–
150	2.49×10^7	4.07×10^{-15}	–

Table F-5 Hollow Shaft

outer diameter D (mm)	inner diameter d (mm)	moment of inertia of area I (mm^4)	C=1/48EI (1/N・mm^2)
6	2	6.28×10	1.61×10^{-9}
8	3	1.97×10^2	5.13×10^{-10}
10	4	4.78×10^2	2.11×10^{-10}
12	5	9.87×10^2	1.02×10^{-10}
13	6	1.34×10^3	7.55×10^{-11}
16	8	3.02×10^3	3.36×10^{-11}
20	10	7.36×10^3	1.37×10^{-11}
25	15	1.67×10^4	6.06×10^{-12}
30	16	3.65×10^4	2.77×10^{-12}
35	19	6.73×10^4	1.50×10^{-12}
40	20	1.18×10^5	8.57×10^{-13}
50	26	2.84×10^5	3.56×10^{-13}
60	32	5.85×10^5	1.73×10^{-13}
80	48	1.75×10^6	5.78×10^{-14}
100	60	4.27×10^6	2.37×10^{-14}

FIT SERIES

Due to the combined tolerances of the bush's bore and the shaft's diameter, accuracy can be affected by clearance or increased dynamic friction caused by preloading.
NB's FIT Series takes advantages of the lower cost slide bush and the precision ground shaft to achieve a target clearance in order for the linear system to produce a smooth, high-accuracy performance.

part number structure

example **F– SMS25GUU ×1 ／ SNS25×550**

FIT series
slide bush part number
shaft part number
number of slide bush on one shaft

・Please refer to corresponding catalog pages for details.
・Please specify on the drawing about the shaft machining, radial clearance, match-marking, etc.

Recommended Radial Clearance

Depending on the type of application, the clearance range varies, please use the chart below as a guideline.

target	clearance (+) ← 0 → clearance (−)
light motion	
high accuracy	
no play	

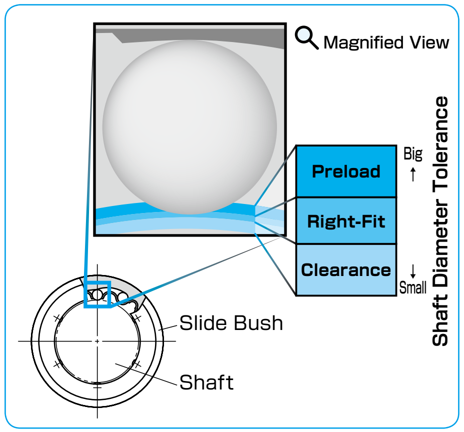
Slide Bush, Radial Clearance (−) , Negative Limit

Negative clearance is opted to reduce backlash. Please refer to the chart below for the negative clearance limits.

size	3~8	10~13	16~25	30~35	40	50~60
radial clearance limit	−3μm	−4μm	−6μm	−8μm	−10μm	−13μm

・The off-center of the housing causes uneven loading on the slide bush, please pay special attention to the centering of the housing especially when negative clearance is a requirement.
・Please contact NB for details on the extra preloading requirement or on other part numbers like SRE, SR, etc.

Figure F-3 Radial Clearance between Slide Bush and Shaft

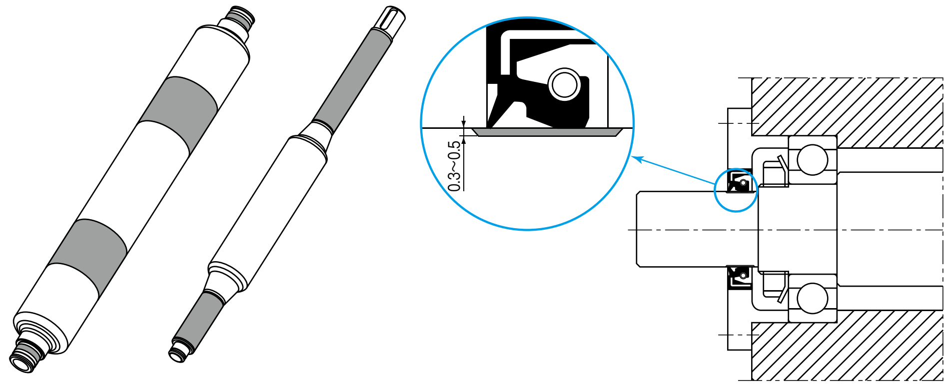


THERMAL-SPRAYING CERAMIC-COATING SPECIFICATIONS

ADVANTAGES

Parts that require wear and corrosion resistance can be thermal-sprayed with a ceramic material per NB's ceramic-coating specifications. Ceramic-coating can be applied to a wide variety of materials. The pores in the coated layer result in good lubrication characteristics and can be sealed to achieve high corrosion resistance.

APPLICATION EXAMPLE



Application of a ceramic coating to oil-sealing parts, rollers, and roll shafts results in good lubrication and high wear/corrosion resistance characteristics.
Note: Ceramic coated surface cannot be used as the inner race for a slide bush.

REFERENCE

Standard Coating Materials

High-carbon chromium bearing steel (SUJ2)	Martensite stainless steel (equivalent to SUS440C)
Chrome molybdenum steel (SCM415, 435)	Austenite stainless steel (SUS303, 304)
Carbon steel for machinery (S45C)	Tool steel (SKS3, SK4)

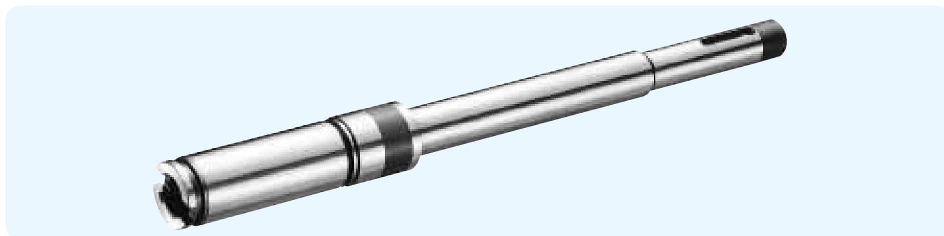
Proper heat treatment can be done on your request. Thermal-spraying ceramic-coating is applicable to other materials as well.

Standard Ceramic for Thermal-Spraying

main component	specific gravity	hardness	characteristics
TiO_2 titanium dioxide	4.7	58HRC	max. temp. 540℃ fine coating; color: black; wear resistant fine surface finish

thermal-spraying layer thickness: 0.3-0.5mm
Other types of ceramic materials can be thermal-sprayed. Contact NB for more information.

Example of Ceramic Coating



RANGE AND SPECIFICATIONS OF MACHINING

NB does shaft-machining based on the customer requirements.

Range Of Machining

maximum diameter —— 650mm
maximum length —— 6000mm
surface roughness —— Ra0.4 or less

straightness —— customer specification
concentricity —— customer specification
squareness —— customer specification
cylindricity —— customer specification

Internal Surface Grinding

The straight/tapered portion of the inner spindle can be ground.

Deep Hole Machining

hole diameter	maximum length of hole	
	non through hole	through hole
φ2～2.5mm	200	400
φ3～3.5mm	300	600
φ4～8mm	500	1000
φ9～10mm	750	1500
φ10～32mm	850	1700
φ30～80mm	2000	4000

Screw Grinding

Triangular and trapezoidal threading can be handled.

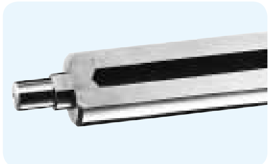
Compatible Parts

Special nuts compatible with a given shaft can be machined. The inner surface and outer diameter of the tapered portion can be ground.

Material and Heat Treatment

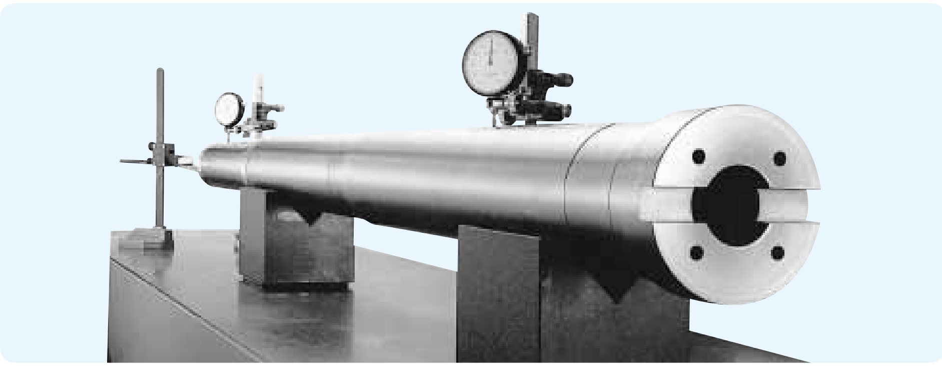
NB's non-standard material and non-standard shaped parts can be heat treated. Please specify the heat treatment method, hardness, and heat-treated area.

Gun Drill Machining

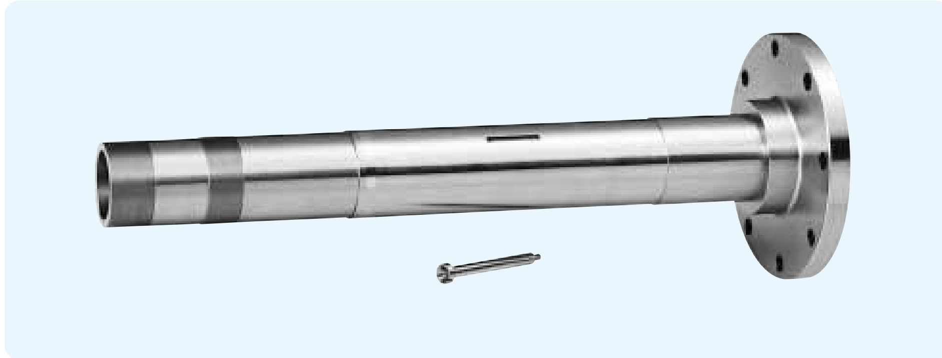


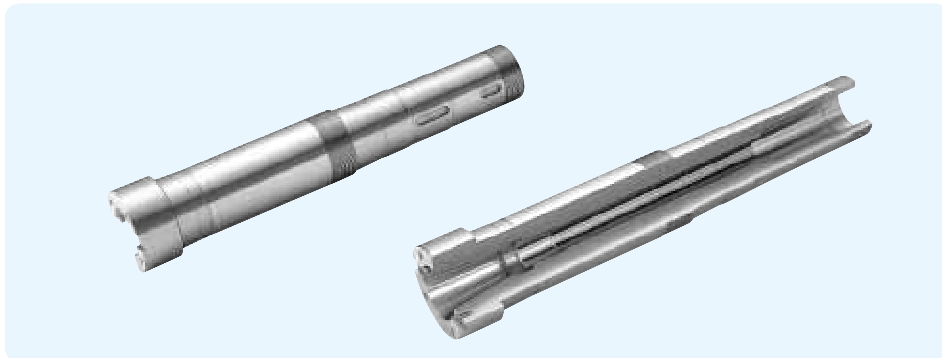
EXAMPLES OF MACHINING

Main Spindle



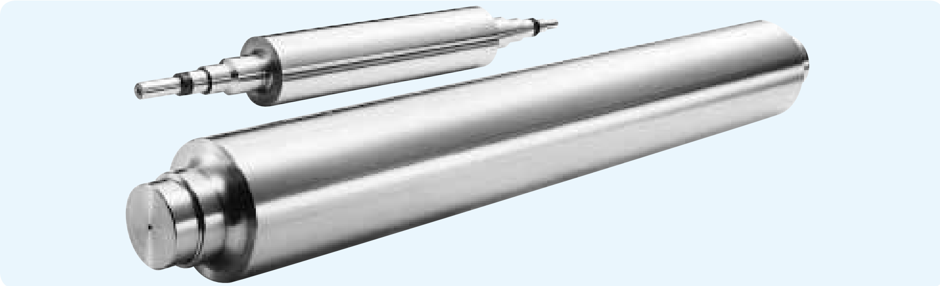
EXAMPLES OF MACHINING



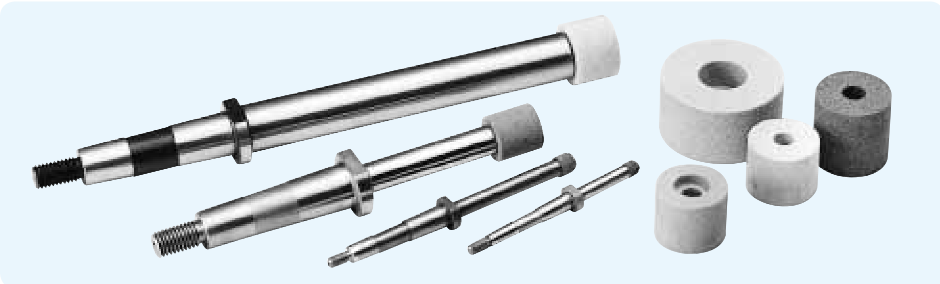


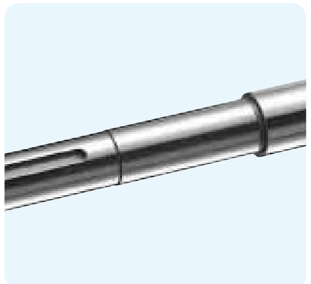
EXAMPLES OF MACHINING

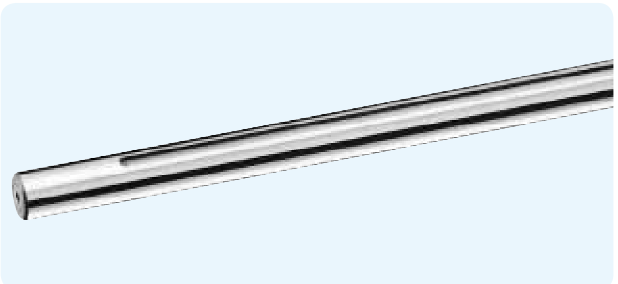
Roll Shaft

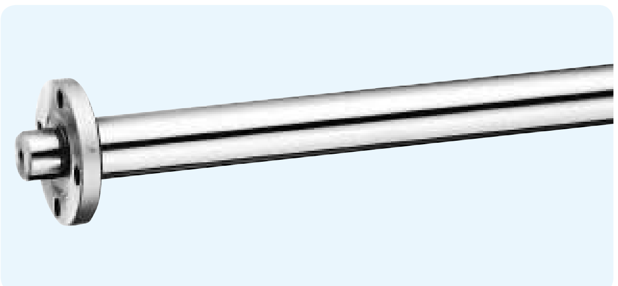


Quill Shaft

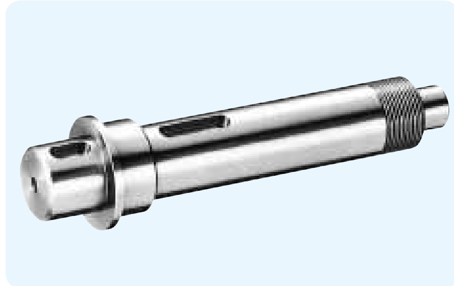


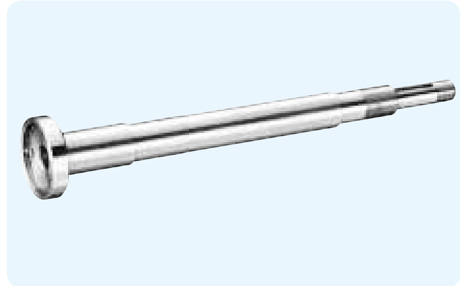


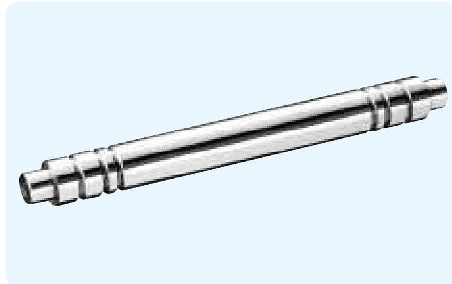


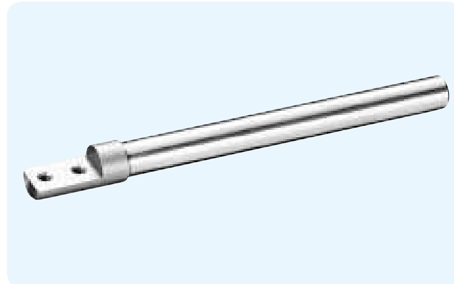


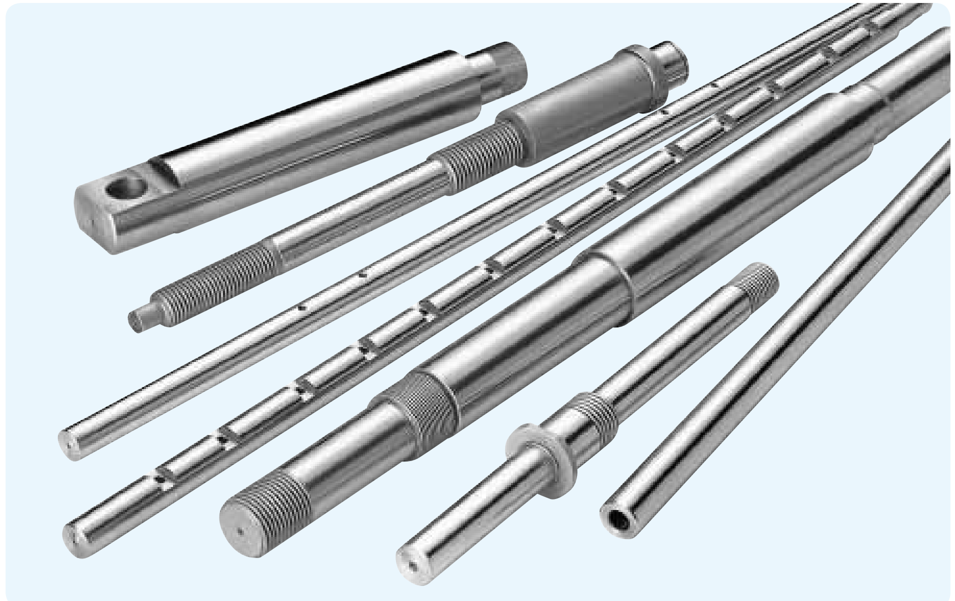
EXAMPLES OF MACHINING











Please visit at NB Website for more examples of machining.