

# SLIDE SHAFT

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# SLIDE SHAFT

The NB slide shaft is used with bearings such as a slide bush in order to obtain highly accurate linear motion. When used in combination with a slide bush, the shaft performs as the inner race of the bearing system. The quality and accuracy of the shaft directly affect the performance of the slide bush. NB slide shaft is manufactured with an emphasis on quality and accuracy to ensure stable functionality under many operating conditions. Superior performance is guaranteed for both rotational motion and combined rotation and linear motion.

## ADVANTAGES

### Advanced Machining Technology:

NB will perform 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 perform special grinding and bore machining requirements.

### Excellent Wear Resistance:

High wear resistant carbon-chromium bearing steel (SUJ2) and Martensite stainless steel (equivalent to SUS440C) materials are most commonly used. These materials are annealed and tempered to achieve a reliably uniform hardened layer in both the circumferential and axial directions. A cross-sectional photograph illustrating the hardened layer depth of the NB slide shaft is shown below.

### Surface Roughness:

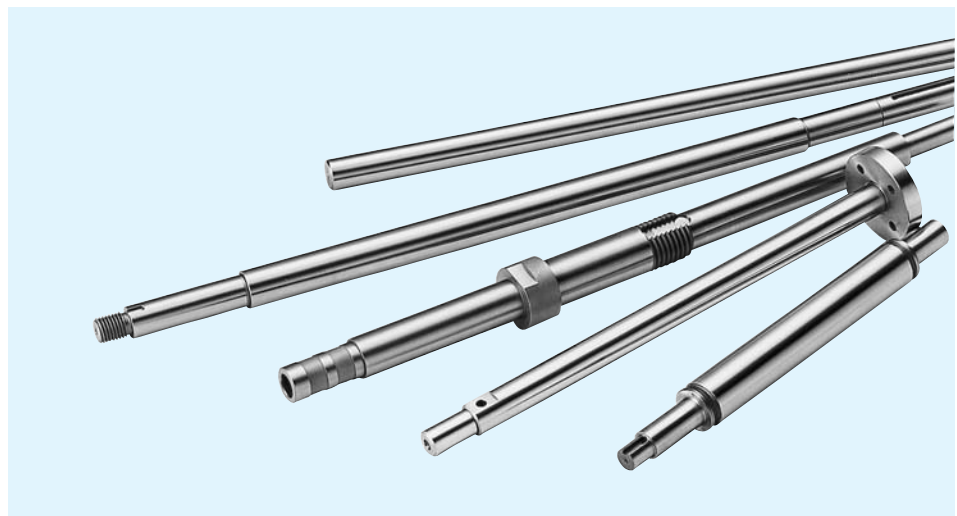
Precision grinding results in a surface roughness of less than 0.4 Ra.

### Wide Selection of Shaft Types:

SN type  
SNS type  
SNT type  
Tapped shaft type (SNB/SNSB type)  
SNW/SNWS(Inch type)  
SNW-PD/SNWS-PD(Inch type pre-drilled shaft)

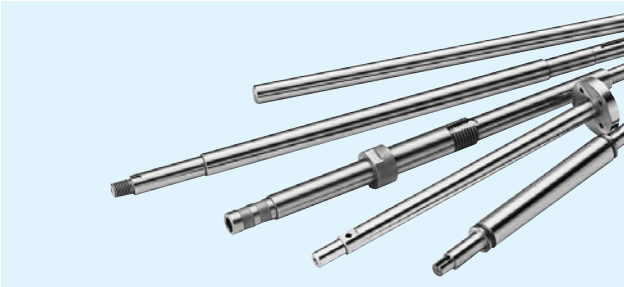
### Special requirements:

NB will provide slide shafts meeting special requirements (including special shapes and materials).



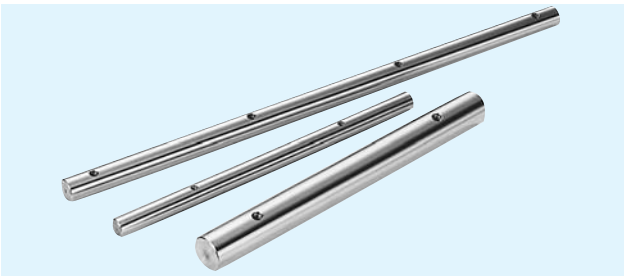
## TYPES

### SN/SNS/SNT Type (NB Shaft)



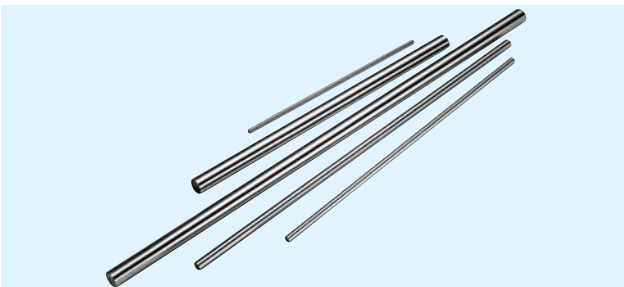
P.G-6,7,8

### SNB/SNSB (NB Center-Lined Tapped Shaft)



P.G-9

### SNW/SNWS Type



P.G-10,11

NB's SN/SNS slide shaft is a high-precision, straight, machined shaft series that may be used with a slide bush or as material in other applications.

Table G-1 SN/SNS Specifications

type	SN Type	SNS Type	SNT Type
material	SUJ-2	equivalent to SUS440C	SUJ-2
outer diameter tolerance	g6 or to be specified		
hardness	60HRC or more	56HRC or more	60HRC or more
surface roughness	less than 0.4Ra		
page	page G-6	page G-7	page G-8

The SNT pipe shaft may be used to reduce weight without reducing the material's rigidity. It may also be used for channeling electrical wires, hydraulic, or pneumatic sources.

Table G-2 SNB/SNSB Specifications

type	SNB type	SNSB type
material	SUJ-2	equivalent to SUS440C
outer diameter tolerance	g6 or to be specified	
hardness	60 HRC or more	56 HRC or more
surface roughness	less than 0.4Ra	
page	page G-9	

The SNW series are inch dimension shafts with the same quality level as SN/SNS type.

PD (center-lined tapped hole) type is available for relatively long shafts.

PD type can be used with WA shaft support rail (page E-46) for better performance.

SNW/SNWS type

SNW-PD/SNWS-PD type



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## CALCULATION OF DEFLECTION AND DEFLECTION ANGLE

The following formulas can be used to obtain the deflection and its angle of a linear slide shaft. Some typical conditions are listed in Table G-3.

Table G-3 Formulas for Calculating Deflection and Deflection Angle

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

$\delta_1$ : deflection when load is applied(mm)  $\delta_{\max}$ : maximum deflection(mm)  $i_1$ : deflection angle when load is applied(rad)  $i_2$ : deflection angle at the support(rad) Mo: moment(N·mm) P: concentrated load(N) p: uniformly distributed load(N/mm) a,b: loading point distance l: span(mm) I: geometrical moment of inertia(mm<sup>4</sup>) E: modulus of direct elasticity  $2.06 \times 10^5$ (N/mm<sup>2</sup>) C:  $1/48EI$ (1/N·mm<sup>3</sup>)



The Geometrical moment of inertia (I) is obtained using the following formula:

● For solid shaft

● For hollow shaft

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

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

I : geometrical moment of inertia (mm<sup>4</sup>) D : outer dia. (mm)  
d : inner dia. (mm)

The values of the geometrical moment of inertia and C (=1/48 I) for NB slide shafts are listed in Table G-4 and G-5.

### Calculation Examples:

1. Calculate the maximum deformation of a shaft with an outer diameter of 30 mm and a span of 500 mm when a concentrated load of 980 N is applied at the mid-point of the shaft (neglecting the weight of the shaft).

① support-support :

From the given conditions, P is 980 N and  $\ell$  is 500 mm

From Table G-4, C for an outer diameter of 30 mm is  $2.54 \times 10^{-12}$  (1/N mm<sup>2</sup>).

Substituting these values into the corresponding formula in Table G-3,

$$\delta_{\max} = P \ell^3 C = 0.31 \text{ mm.}$$

② fixed-fixed :

Substituting the values into the corresponding formula given in Table G-3,

$$\delta_{\max} = \frac{1}{4} P \ell^3 C = 0.08 \text{ (mm)}$$

2. Calculate the maximum deformation of a shaft with an outer diameter of 60 mm, an inner diameter of 32 mm, and a span of 2000 mm due to its own weight.

From Table G-5, C for an outer diameter of 60 mm is

$$C = 1.73 \times 10^{-13} \text{ (1/N mm}^2\text{)}$$

The mass per unit length of a shaft with an outer diameter of 60 mm and an inner diameter of 32 mm is 15.9 kg/m. Therefore, a uniformly distributed load of 0.156 N/mm is applied. Substituting these values into the most appropriate formula for your application given in Table G-3.

$$\delta_{\max} = \frac{5}{8} p \ell^4 C = 0.27 \text{ (mm).}$$

Table G-4 Geometrical moment of inertia and C for NB Slide Shafts

outer diameter D(mm)	Geometrical moment of inertia I(mm <sup>4</sup> )	C=1/48EI (1/Nmm <sup>2</sup> )
3	3.98	$2.54 \times 10^{-8}$
4	$1.26 \times 10$	$8.03 \times 10^{-9}$
5	$3.07 \times 10$	$3.29 \times 10^{-9}$
6	$6.36 \times 10$	$1.59 \times 10^{-9}$
8	$2.01 \times 10^2$	$5.03 \times 10^{-10}$
10	$4.91 \times 10^2$	$2.06 \times 10^{-10}$
12	$1.02 \times 10^3$	$9.91 \times 10^{-11}$
13	$1.40 \times 10^3$	$7.22 \times 10^{-11}$
15	$2.49 \times 10^3$	$4.06 \times 10^{-11}$
16	$3.22 \times 10^3$	$3.14 \times 10^{-11}$
20	$7.85 \times 10^3$	$1.29 \times 10^{-11}$
25	$1.92 \times 10^4$	$5.27 \times 10^{-12}$
30	$3.98 \times 10^4$	$2.54 \times 10^{-12}$
35	$7.37 \times 10^4$	$1.37 \times 10^{-12}$
40	$1.26 \times 10^5$	$8.03 \times 10^{-13}$
50	$3.07 \times 10^5$	$3.29 \times 10^{-13}$
60	$6.36 \times 10^5$	$1.59 \times 10^{-13}$
80	$2.01 \times 10^6$	$5.03 \times 10^{-14}$
100	$4.91 \times 10^6$	$2.06 \times 10^{-14}$
120	$1.02 \times 10^7$	$9.91 \times 10^{-15}$
150	$2.49 \times 10^7$	$4.06 \times 10^{-15}$

Table G-5 Geometrical moment of inertia and C for NB Pipe Shafts

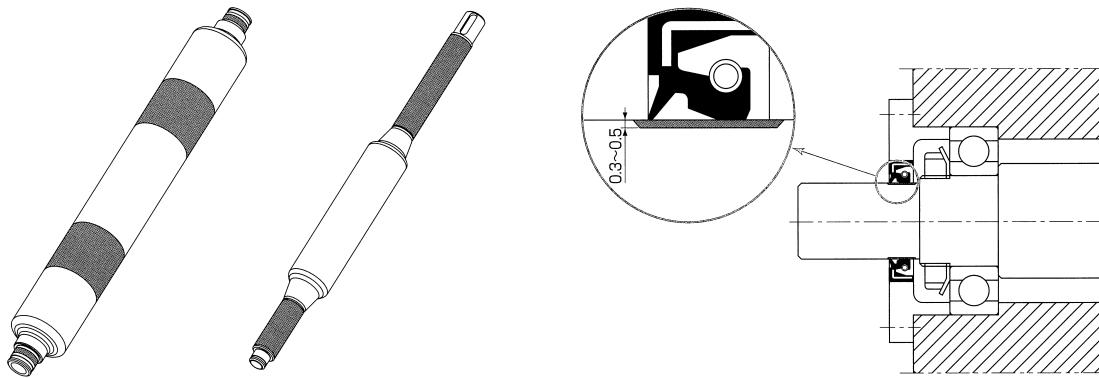
outer diameter D(mm)	inner diameter d(mm)	Geometrical moment of inertia I(mm <sup>4</sup> )	C=1/48EI (1/Nmm <sup>2</sup> )
6	2	$6.28 \times 10$	$1.61 \times 10^{-9}$
8	3	$1.97 \times 10^2$	$5.13 \times 10^{-10}$
10	4	$4.78 \times 10^2$	$2.11 \times 10^{-10}$
12	5	$9.87 \times 10^2$	$1.02 \times 10^{-10}$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

## THERMAL-SPRAYING CERAMIC-COATING SPECIFICATION

### ADVANTAGES:

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

### APPLICATION EXAMPLES:



Application of a ceramic coating to oil-sealing parts, rollers, and 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 Coated 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)	Steel alloy for tools (SKS3, SK4)

Proper heat treatment is done on your request. Thermal-spraying ceramic-coating is also available to be applied to other materials.

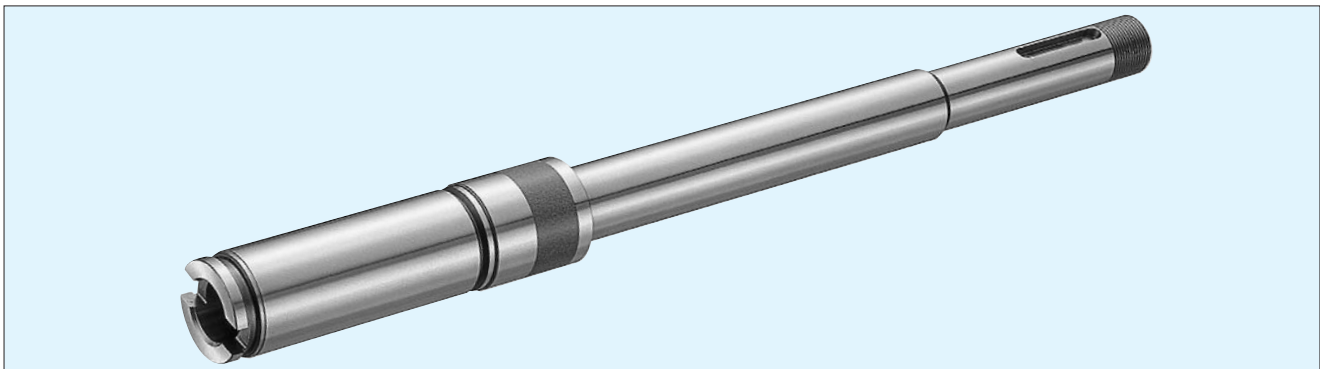
Standard Ceramic for Melt-Spray

main component	specific gravity	hardness	characteristics
TiO <sub>2</sub> titanium dioxide	4.7	60HRC	max. temp. 540°C 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



## SPECIAL REQUIREMENTS

### MACHINING EXAMPLE

NB can fabricate shafts to fit specific customer requirements.

#### Machining/Grinding:

Shafts can be machined or ground up to a diameter of 400mm and a length of 6000mm.

#### Internal Surface Grinding:

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

#### Deep Hole Machining:

Non-standard holes can be machined using a gun drill and BT machining methods. (Ref. to Table G-6.)

#### Screw Machining:

Triangular and trapezoidal screws can be handled.

#### Compatible Parts:

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

#### Material and Heat Treatment:

Non-NB material and non-NB shape parts can be heat treated. Please specify the heat treatment method and hardness.

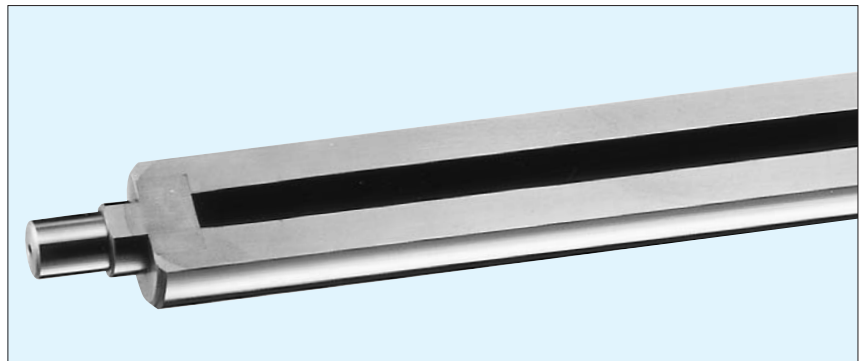
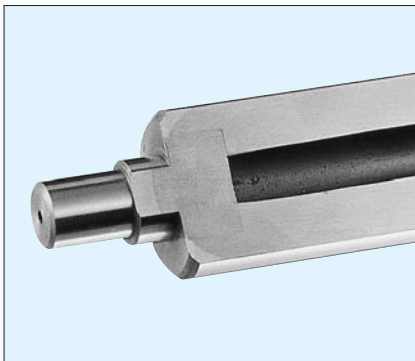
Table G-6 Deep Hole Machining Range

unit/mm

	hole diameter	maximum length
gun drill machining	$\phi 2\sim$	850(single-side machining)
BT machining	$\phi 30\sim$	2000(single-side machining)

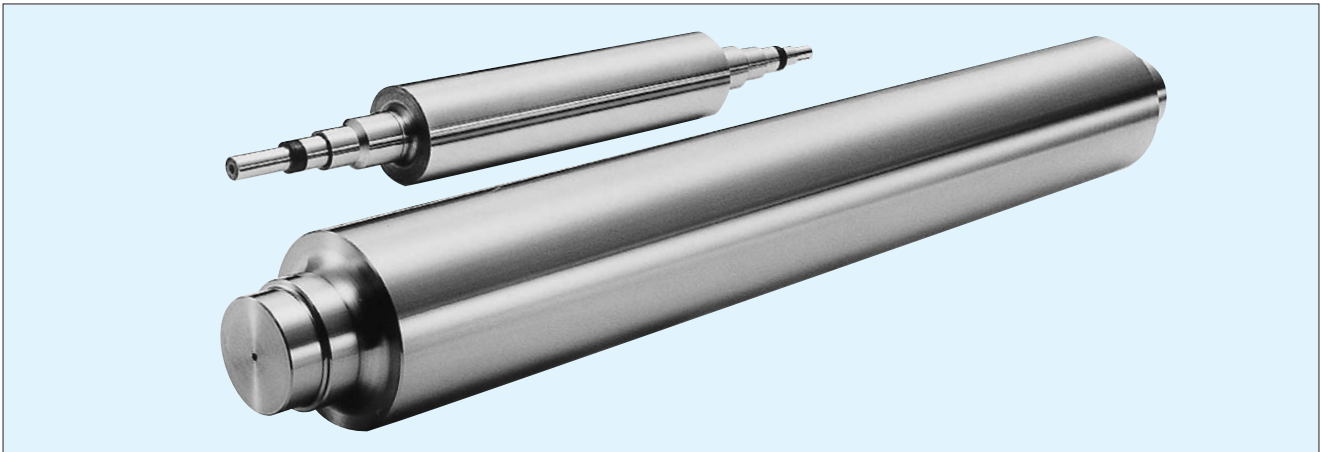
Contact NB for maximum length versus hole diameter information.  
Machining of up to twice the maximum length listed above for double-side machining.

### Gun Drill Machining

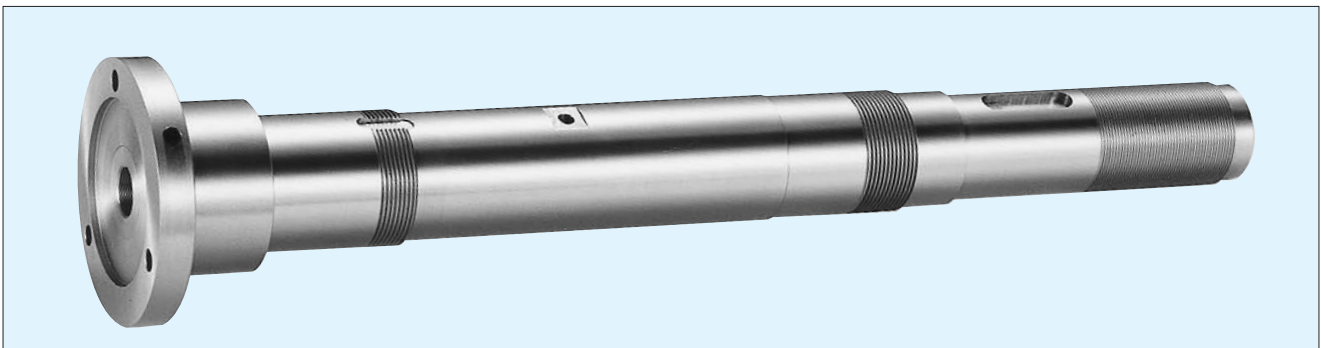
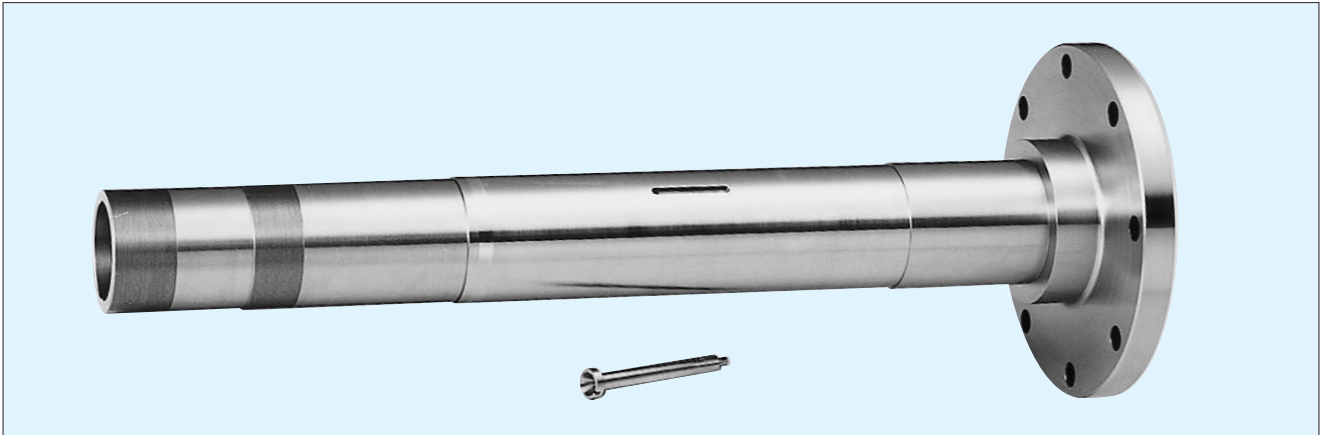


## MACHINING EXAMPLES

Roll Shaft



Flanged Shaft

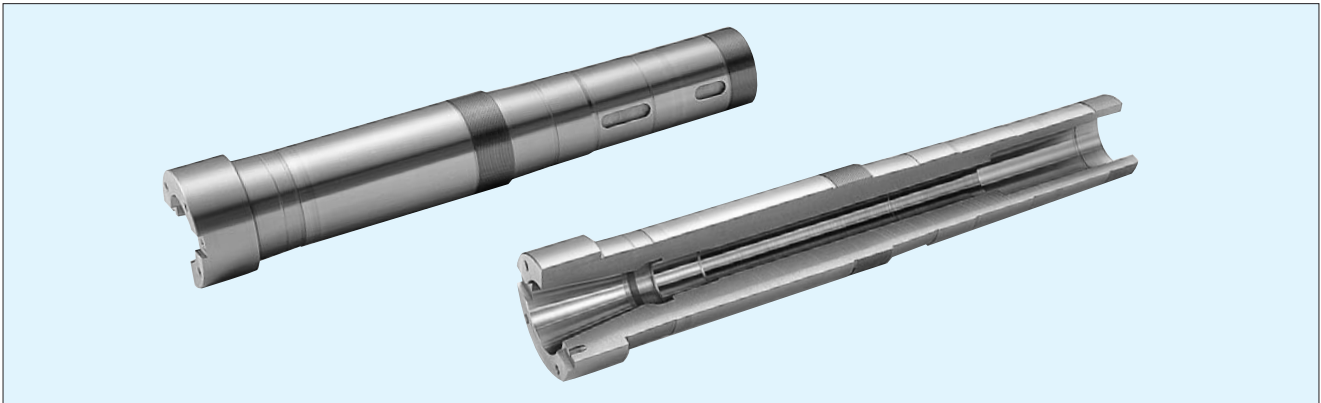
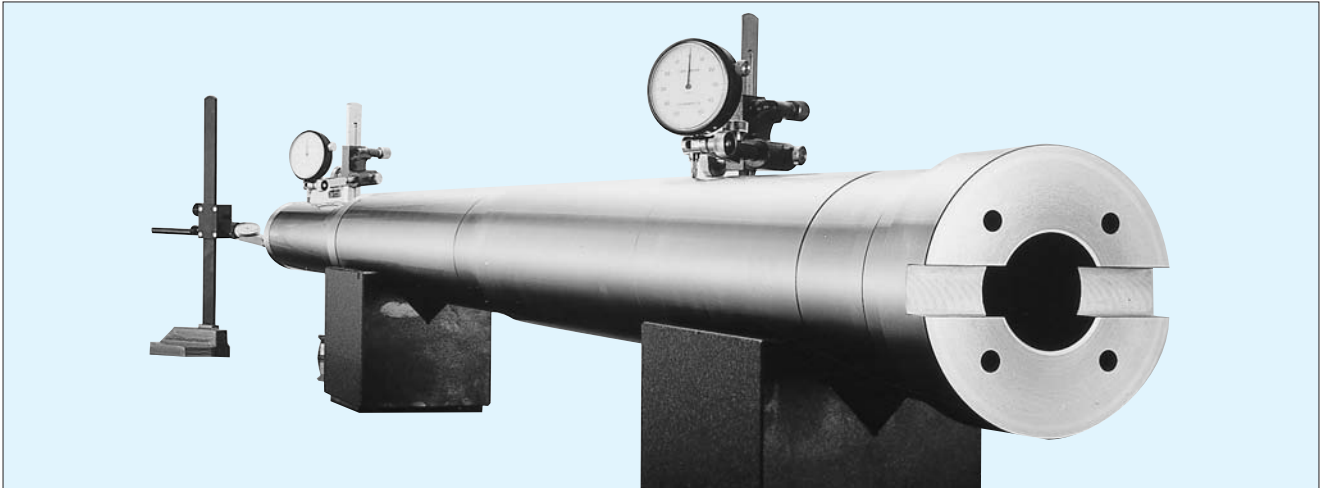




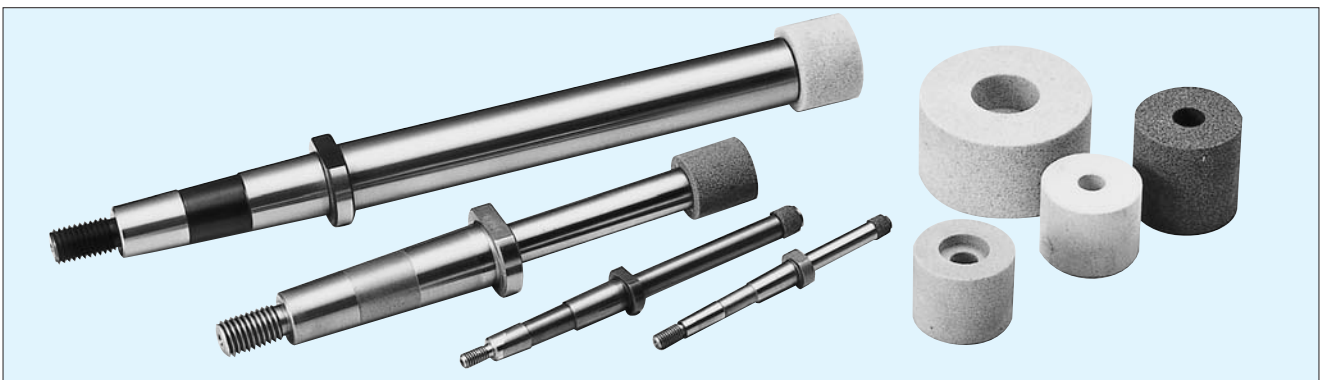


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## Shaft (spindle)



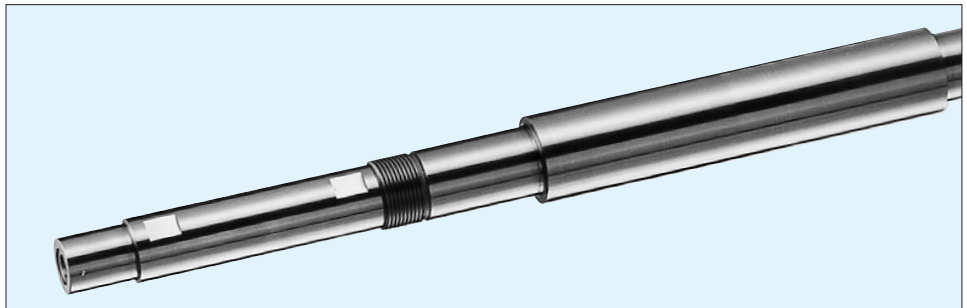
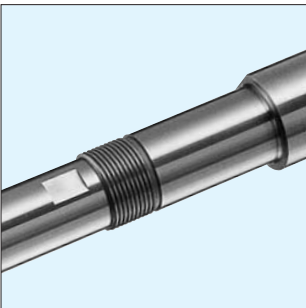
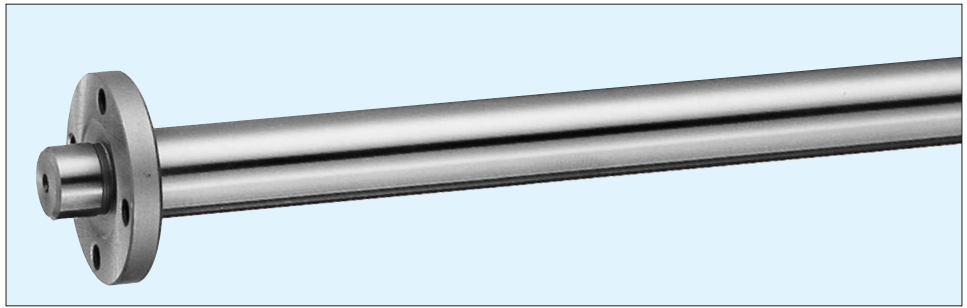
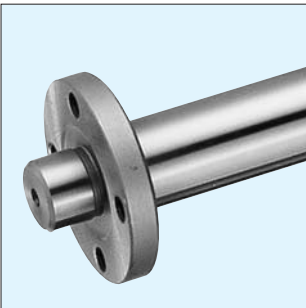
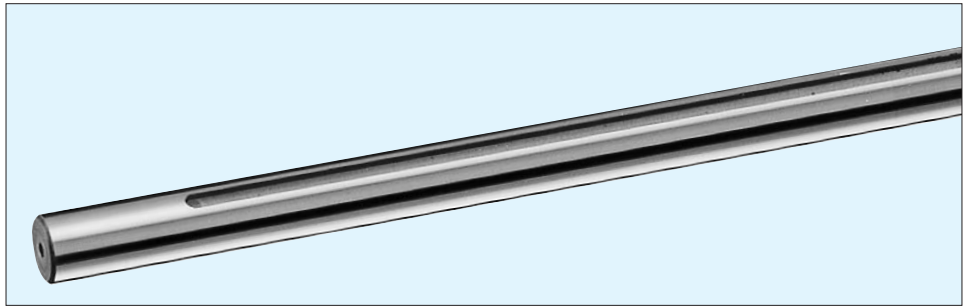
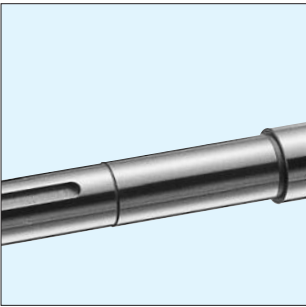
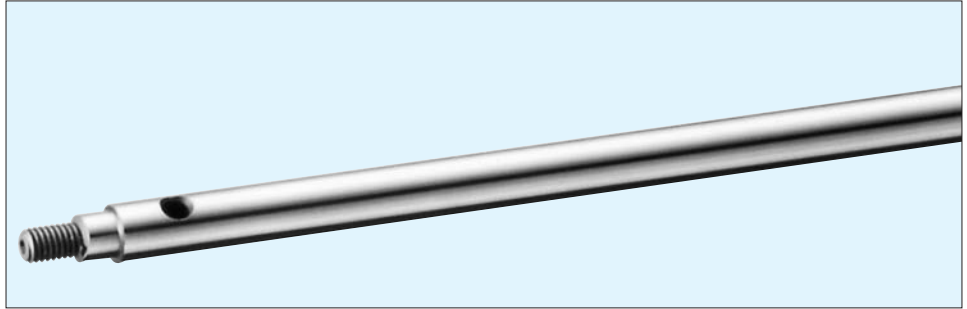
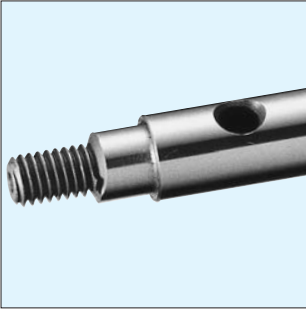
## Shaft (Quill)



Please send drawing for quotation on custom configurations.

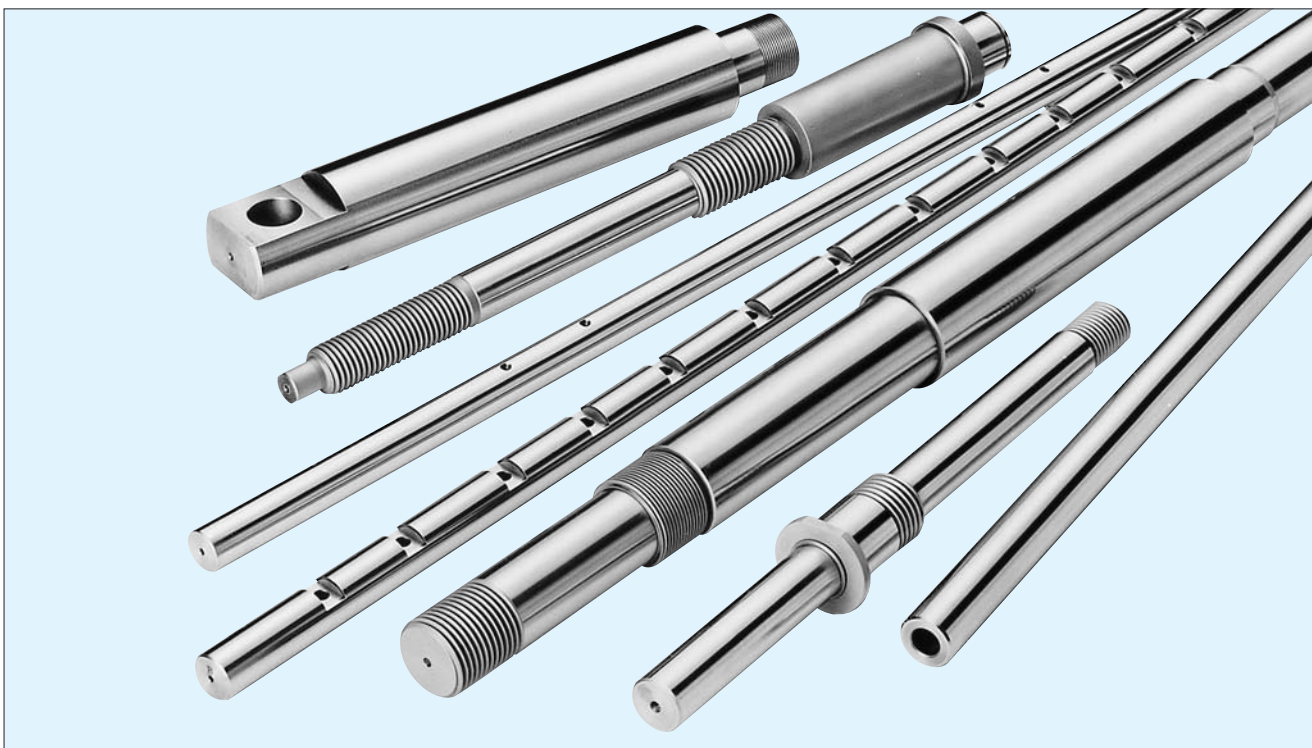
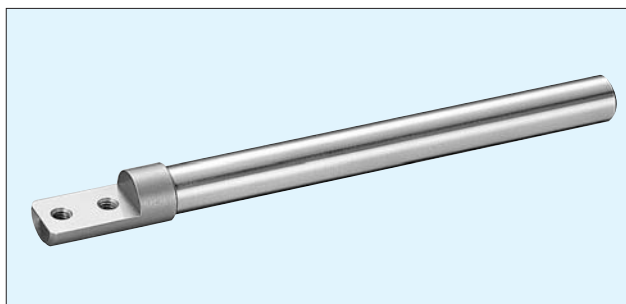
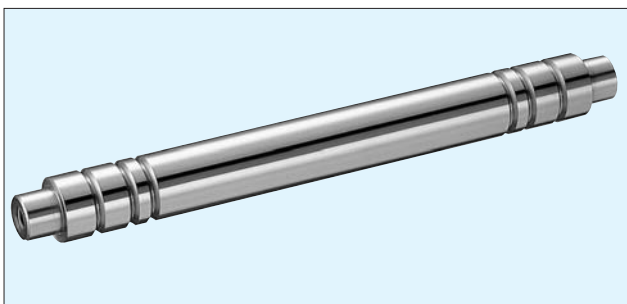
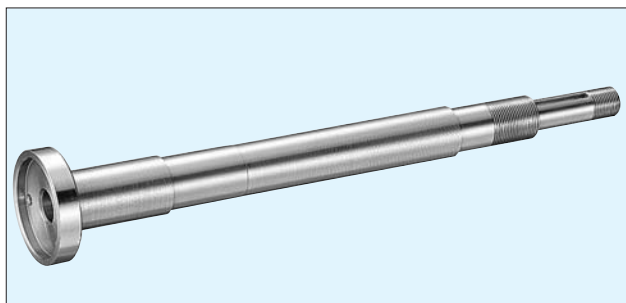
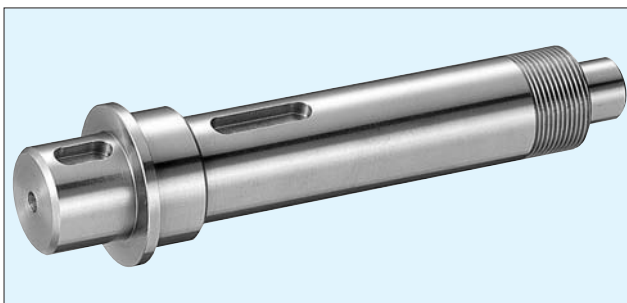


## MACHINING EXAMPLES





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