TOYO TANSO CARBON PRODUCTS

Carbon Products for Mechanical applications

TOYO TANSO

Inspiration for Innovation

People and carbon
An everlasting relationship.

Carbon has been a part of our life since ancient times. The benefits of carbon have never been far away from humans, making our lives more plentiful and comfortable. In 1974, we were the first company in Japan to successfully develop isotropic graphite, and thereafter rapidly expanding its possibilities. Isotropic graphite become a crucial material of state-of-the-art technologies in industries such as semi-conductors and aerospace. Currently, this material is being used in a wide range of applications over an ever-increasing number of fields. Toyo Tanso is dedicated to unlocking the unlimited potential of carbon and aims to ensure that the beneficial relationship between people and carbon is one that lasts forever.

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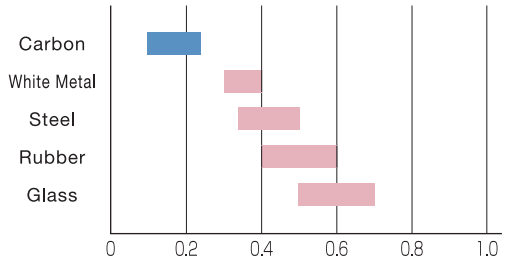
Features of Carbon Products for Mechanical applications

Carbon sliding materials have excellent self-lubricating properties, heat resistance and chemical resistance. This means they can be used in high-temperature atmospheres where ordinary metal sliding materials cannot be used, and in fields where fluids and lubricants are inappropriate. Toyo Tanso's IG, KC and TUG product series bring together the technical and development capabilities in the field of sliding materials that have been cultivated over many years, to meet the various demands of our customers.

Excellent Self-Lubrication

Carbon has self-lubricating properties due to its layered crystal structure, making it appropriate for use in high-temperature atmospheres and in fields where fluids and lubricants are avoided. In particular, its coefficient of friction in an unlubricated condition is low compared with other materials, making adhesion difficult to occur.



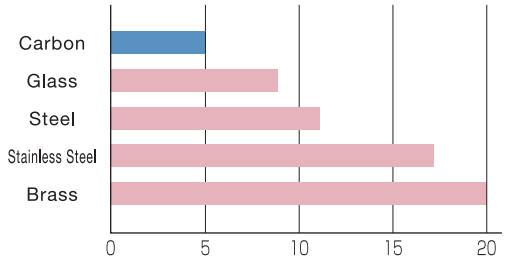
Dynamic Coefficient of Friction on a Steel Surface [Atmospheric Room Temperature]

Excellent Thermal Durability

There are virtually no changes in the mechanical strength and slide properties due to heat. Refer to the table on page 6 for the thermal durability of each material.

Excellent Chemical Resistance

With the exception of inorganic chemicals (strong oxidizers), carbon has excellent chemical resistance. The chemical resistance of each material is shown in the table on page 15.



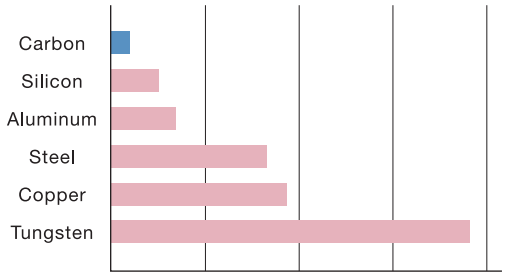
Coefficient of Thermal Expansion [10^{-6}/K]

Thermal Shock Resistance

The coefficient of thermal expansion is lower than metal materials, and it has good thermal conductivity. This means that the material hardly ever cracks, even during rapid temperature changes.

Supports Lightweight Designs

The bulk density is low compared to metal materials, which support lightweight machinery designs and a reduction in friction noise.



Bulk Density [Mg/m³]

① Rod Packing
② Labyrinth Seal
③ Radial Bearing
④ Thrust Bearing
⑤ Shoe
⑥ Slider
⑦ Joint Seal
⑧ Trolley Wheel
⑨ Valve Sheet
⑩ Vane
⑪ Rotor
⑫ Piston Ring
⑬ Mechanical Seal
⑭ Bearing

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Typical Properties

We provide many different kinds of carbon products for sliding materials for mechanical applications, including graphite, carbon graphite, resin-impregnated carbon, metal-impregnated carbon, SiC/C composites, inorganic-compound impregnated carbon, B_4C/C composites, impermeable graphite, resin-bonded carbon and metal-bonded carbon. Select the product most appropriate for your application.

Graphite
It has excellent heat and chemical resistant characteristics compared with other compositions, and virtually no change in factors such as the slide properties.

Carbon Graphite
It is a general carbon sliding material composed of carbon and graphite. We provide products suitable for your applications.

Resin-Impregnated Carbon and Metal-Impregnated Carbon
Resin or metal is impregnated in the pores in carbon to improve strength, impermeability and slide properties.

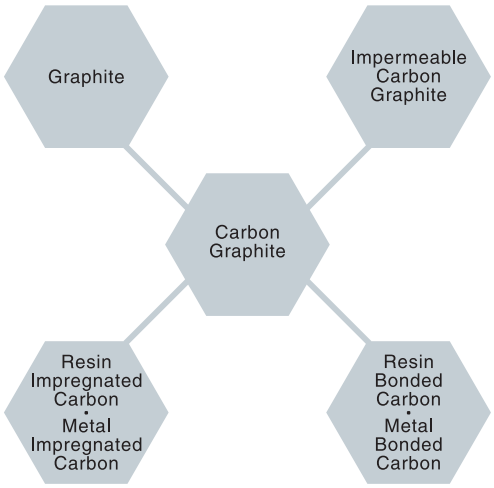
SiC/C Composites
It has excellent slurry and blister resistance. The composite layer depth can be 2 to 4mm from the surface layer.

Inorganic Compound-Impregnated Carbon
Inorganic compound is impregnated into isotropic graphite.
It has anti-oxidizing properties in high-temperature atmospheres.

Impermeable Carbon Graphite
It is a non-impregnated material with excellent impermeability. It is easily mass-produced by die-molding to any desirable shape.

Resin-Bonded Carbon
It is a carbon and resin bonded material. It is easily mass-produced by die-molding to any desirable shape.

Metal-Bonded Carbon
It is a sintered material with carbon and metal. It has self-lubricating properties, and is appropriate for fields where lubricants are avoided.



The slide properties of carbon are greatly affected by the usage conditions (e.g. pressure, circumferential velocity, contacting materials, atmosphere, temperature, etc.).
Toyo Tanso has a wide range of carbon grades available to meet every kind of need.
Before actually using one of our products, please be sure to contact our sales department to consult on selecting the most appropriate grade.

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Composition	Grade	Bulk Density	Hardness	Flexural Strength	Compressive Strength	Young's Modulus	Coefficient of Thermal Expansion	Thermal Conductivity	Thermal Durability
		Mg/m^3	HSD	MPa	MPa	GPa	$10^{-6}/K$	W/(m·K)	℃
Graphite	IG-11	1.77	51	39	78	10	4.5 a)	120	450
	ISO-68	1.82	80	76	172	13	5.6 a)	70	450
Carbon Graphite	KC-36	1.72	65	48	135	15	3.5	15	350
	KC-57	1.78	105	70	270	20	4.0	5	350
	KC-67	1.77	72	60	185	20	3.5	10	350
	KC-83K	1.74	80	55	160	15	4.0	10	350
	KP-001	1.72	90	70	240	17	5.0	4	350
	KP-002	1.73	60	58	170	17	3.5	7	350
Resin-Impregnated Carbon	KC-360	1.78	75	58	165	17	4.0	15	300
	KC-570*	1.85	110	84	370	22	5.0	5	300
	KC-573*	1.85	110	85	370	22	5.5	5	250
	KC-670*	1.87	87	78	240	22	5.0	10	300
	KC-673*	1.87	87	78	245	22	5.5	10	250
	KC-830K	1.84	90	70	205	17	5.0	10	250
Metal-Impregnated Carbon	KC-5709*	2.25	110	100	430	27	5.0	5	500
	KC-6707*	2.35	80	73	240	25	5.0	13	250
	KC-6709*	2.30	88	90	300	27	5.0	13	500
	IKC-6809	2.67	88	105	300	21	6.0	80	500
	PC-78A	2.90	95	110	410	27	6.5	13	350
SiC/C Composites	TS-002	2.31/2.75	63/70	113/78	300/205	18/16	4.5/5.2	80/80	500
	TS-003	2.28/1.82	83/80	116/76	410/172	30/13	5.4/5.6	70/70	400
	TS-004	2.28/1.92	83/86	116/88	410/235	30/15	5.4/7.5	70/60	200
	TS-005	2.28/2.67	83/88	116/105	410/300	30/21	5.4/6.0	70/80	500
Inorganic Compound-Impregnated Carbon	IG-11R1	1.85	55	46	92	11	5.5	120	500
	ISO-68R1	1.87	84	83	190	15	5.0	70	500
Impermeable Carbon Graphite	TUG-105	1.67	90	60	250	20	4.0	—	350
	TUG-110	1.78	105	90	290	20	4.0	—	350
	TUG-120	1.68	95	70	245	20	4.0	—	350
	TUG-307	1.91	90	75	235	25	3.5	—	350
	TUG-308	1.87	90	65	215	23	3.5	—	350
	TUG-309	1.85	80	55	185	20	3.5	—	350
	TUG-3095	1.81	75	50	170	20	3.5	—	350
	TUG-505	1.89	80	68	185	20	3.0	—	350
Resin-Bonded Carbon	W-1500	1.77	70	75	175	15	23.0 b)	—	150
	W-3500*	1.63	85	90	250	12	30.0 b)	—	200
	LS	1.77	60	70	100	15	15.0 b)	—	150
	NLA	1.70	75	85	175	15	23.0 b)	—	150
	MR-10*	1.43	78	100	230	10	35.0 b)	—	220
Metal-Bonded Carbon	GM-1	4.60	18	25	55	—	12.0	—	200
	GM-5	6.20	18	205	350	—	12.0	—	400

※The figures above are typical values, and are not guaranteed. **Patent No. 2635996. *Patent pending.

※The SiC/C composite values show both of the "SiC/C composite layer" and "substrate(+ impregnation)".

※The SiC/C composite thermal durability shows that of the "substrate (+ impregnation)".

※Thermal durability varies with usage conditions. Values provided for reference purposes only.

※The measurement temperature range for the coefficient of thermal expansion is: a) 350 to 450°C, b) 50 to 150°C, and others: 100 to 200°C.

※Unit conversion: MPa=kgf/cm^2×0.098 GPa=kgf/mm^2×0.0098 W/(m·K)=kcal/h·m·℃×1.16

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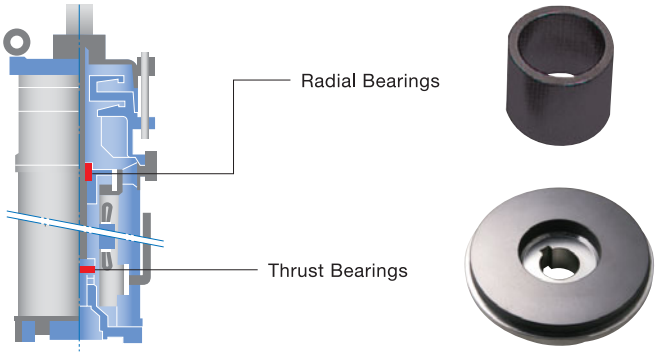
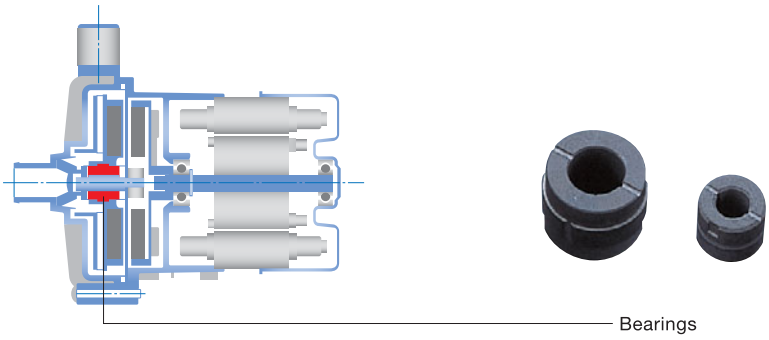
Application

■Bearings

Deep well underwater motor pumps
Pumps for oil refining and petrochemical processes
Pumps for power station processes
Pumps for general industries
Chemical pumps
Marine pumps
Flowmeter pumps

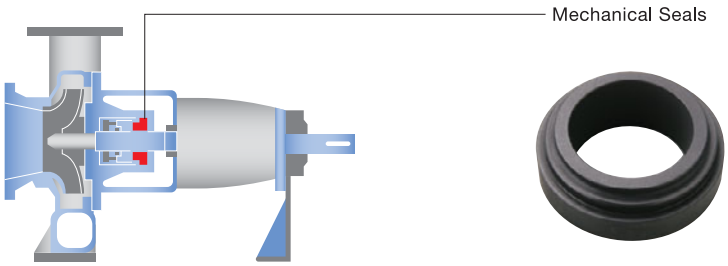


Household hot water circulation pumps
Vending machine circulation pumps
Dishwashers
Plywood dryer

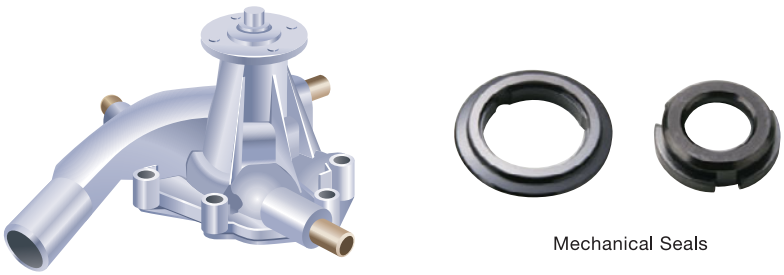


■Seal rings

Pumps for oil refining and petrochemical processes
Pumps for power station processes
Pumps for general industries
Chemical pumps
Agitator
Marine pumps



Automobile water pumps
Household hot water circulation pumps
Refrigerator compressors



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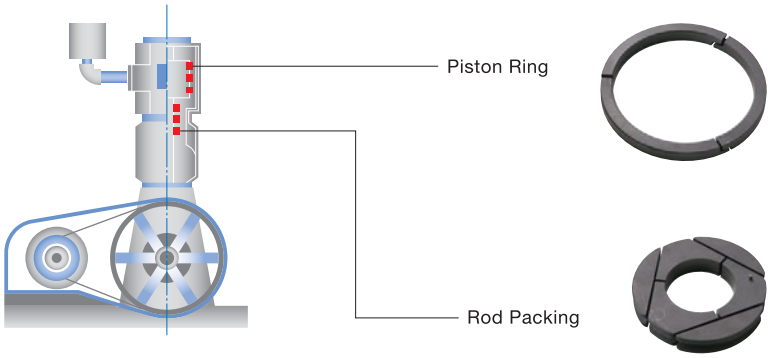
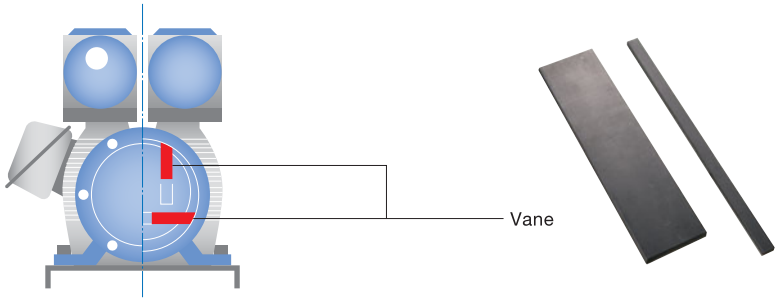
Packing

Reciprocal compressors
Screw compressors
Steam turbines
hydroelectric power generators



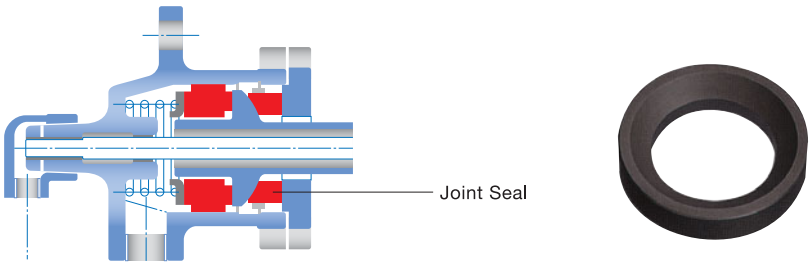
Vanes

Various vacuum pumps
Air blowers
Flow meters
Oscillating compressors
Jet heaters



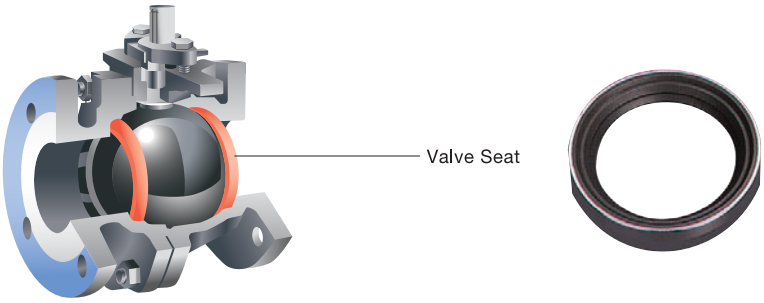
Joint Seals

Papermaking dryers
Drum dryers
Mixing mills
Printers



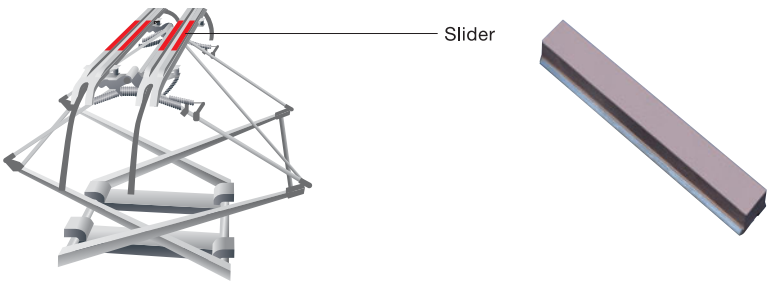
Valve Seats

Ball valves



Pantograph Sliders

JR regular lines
Japanese private railways



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Product Selection Table by Usage

Composition	Grade	Bearings										Seal Rings					
		Non-Lubricated					Lubricated					Mechanical Seal					
		For high temperatures	For high loads	For low loads	For high load mass production	For low load mass production	For high loads	For low loads	For high load mass production	For low load mass production	For slurry resistance	For high loads	For low loads	For high load mass production	For low load mass production	For blister resistance	
Graphite	IG-11	○															
	ISO-68	○															
Carbon Graphite	KC-36			◎													
	KC-57						○	◎									
	KC-67			○				○									
	KC-83K			○				○									
	KP-001								◎								
	KP-001									◎							
Resin-Impregnated Carbon	KC-360		○	◎													
	KC-570, KC-573						◎					◎					
	KC-670, KC-673							◎					◎				
	KC-830K							◎					○				
Metal-Impregnated Carbon	KC-5709						◎				○	◎				○	
	KC-6707						○	◎									
	KC-6709						○	◎					○				
	IKC-6809						○										
	PC-78A																
SiC/C Composites	TS-002						◎				◎	◎				◎	
	TS-003						◎				◎						
	TS-004											◎				◎	
	TS-005						◎				◎	◎				◎	
Inorganic Compound-Impregnated Carbon	IG-11R1	○															
	ISO-68R1	◎															
Impermeable Carbon Graphite	TUG-105								◎								
	TUG-110													◎		○	
	TUG-120								◎								
	TUG-307															◎	
	TUG-308													◎		○	
	TUG-309								○					○			
	TUG-3095				○												
	TUG-505													○			
Resin-Bonded Carbon	W-1500					○				○					○		
	W-3500					◎				◎					◎		
	LS					○											
	NLA									◎							
	MR-10																
Metal-Bonded Carbon	GM-1																
	GM-5				◎												

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	Seal Rings											Vanes		Slider			Special Applications	
	Joint Seal					Compressors			Shaft Seals		Valve Sheet	Non-Lubricated	Lubricated	Trolley wheels and shoes	For trains	For brakes	Jigs for glass production	Structural materials for high temperatures
	For high loads	For low loads	For high load mass production	For low load mass production	For large sizes	For air	For special gas	For dry gas	For steam	For hydropower								
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※◎… Most appropriate　○…Appropriate
※Many material block dimension types are available. Please feel free to contact Toyo Tanso.
※The maximum dimensions are subject to change due to manufacturing technology developments.
※There are additional products for special applications that are not shown in the table.

Toyo Tanso has a wide range of carbon grades to meet every kind of need. Before actually using one of our products, please be sure to contact our sales department to consult on selecting the most appropriate grade.

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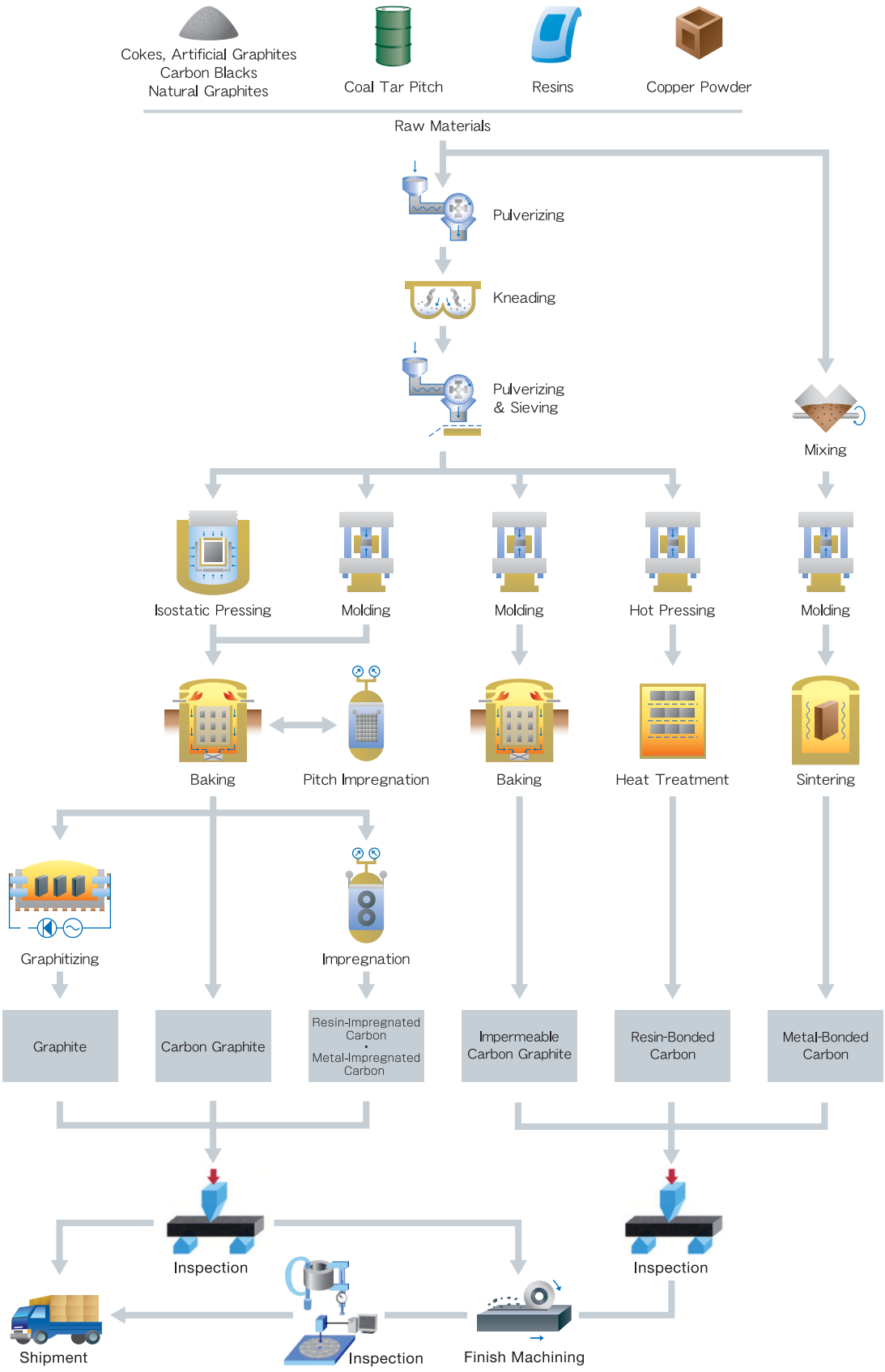
Manufacturing Process



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Long Size

The length of molded materials in design and production is limited to about 80 to 120mm. Long size increase this length to 600mm, with uniform characteristics in the length direction.

Excellent uniformity in the bulk density distribution

Density and characteristics are uniform even in long materials.

Excellent airtightness after resin impregnation.

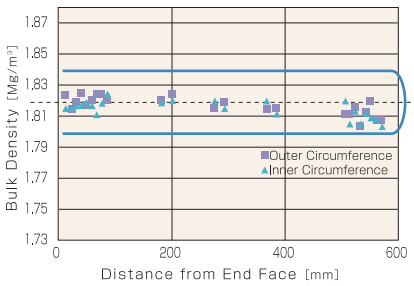
The density is uniform, so there is excellent airtightness after resin impregnation.

Excellent design flexibility.

Long size can be produced in the range: OD30 / ID12 to OD170 / ID125 × 600mm. Furthermore, solid cylinder and hollow cylinder materials can be produced. A wide range of lengths and sizes are available, enabling the selection of materials with a good yield. The material can be cut and processed at the required length, facilitating storage.

※Please contact our sales department to consult on the sizes.

■ Density Distribution



Solid Cylinder Long Size

Hollow Cylinder Long Size

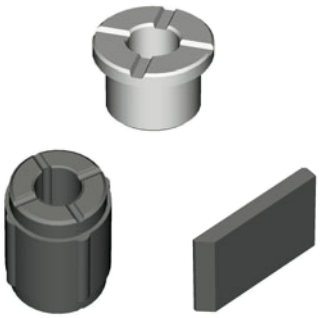
PTS Products (KP Series)

PTS products differ from conventional products that are cut from carbon (bulk) material in that they are pressed into a shape that closely approximates the finished product (“pressed to size”), helping to lower costs.

Possible shapes

Customers enjoy an exceptional degree of freedom when it comes to shape thanks to capabilities that include exterior fluting, interior fluting, grooving, and chamfering. It is generally possible to manufacture parts with an outer diameter of up to 30 mm and a thickness of up to 20 mm, and even thin-walled parts with wall thicknesses of 1.5 to 2 mm can be pressed.

※For more information about dimensions and shapes, please contact the Toyo Tanso Sales Department.



PTS product features

(1) The ability to press material into the product shape allows subsequent steps to be eliminated from the manufacturing process.
(2) An automated pressing process reduces the amount of labor needed to manufacture parts. Please note that a dedicated mold is required for each product.
(3) Parts can be baked in a short period of time, making mass production feasible and allowing quick delivery.
(4) Only the portions of each part requiring a high level of precision need to be machined, lowering costs.
(5) Absent finish machining, a dimensional accuracy (tolerance) of about ±0.4% of the basic dimensions is required.

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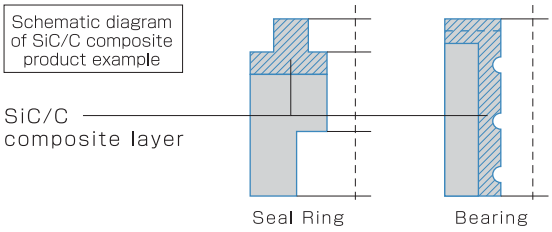
Special Materials

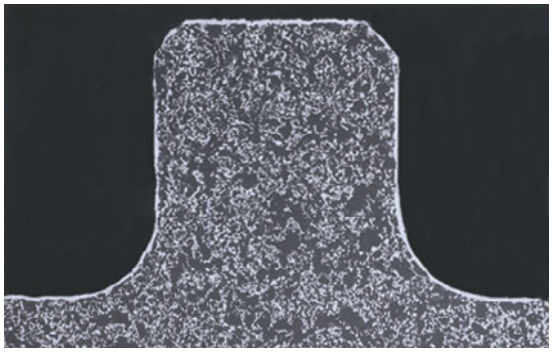
We have SiC/C composites, Inorganic compound impregnated carbon and B_4C/C composites as special materials.

SiC/C composites have excellent slurry resistance and blister resistance

SiC/C composites have the strength of silicon carbide and the self-lubricating properties of graphite in the composite layer, ensuring excellent slurry resistance. The mechanical strength is high and an appropriate surface roughness is maintained for sliding surface, which allow a lubricating film to form easily and ensures excellent blister resistance. It is also possible to perform the SiC/C composite treatment only for the required section. The composite layer can be formed at a depth of 2 to 4mm from the surface layer.



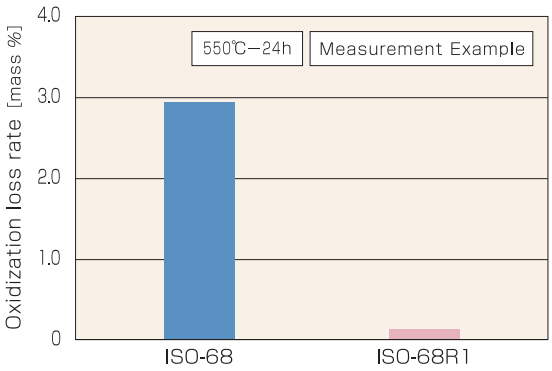
Structure of SiC/C composite layer



Inorganic Compound-Impregnated carbon has excellent oxidation resistance.

The material is isotropic graphite which has been impregnated with inorganic compound. It has anti-oxidation property in high temperature atmospheres.

■ Oxidization loss for inorganic compound-impregnated carbon



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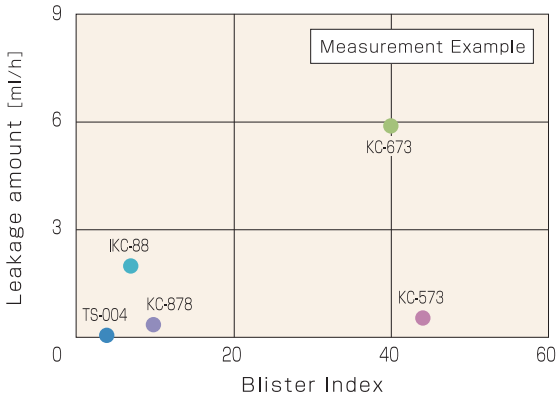
Test Data

Blister Test



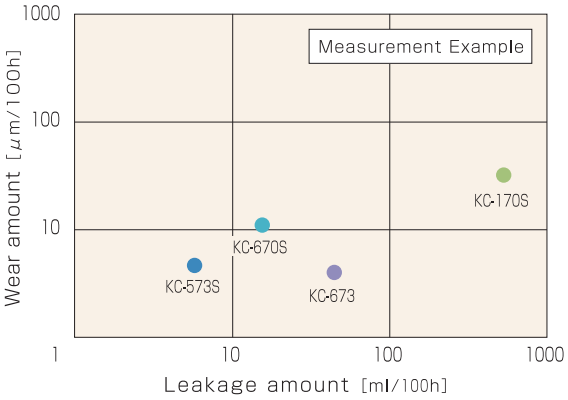
※ Blister Test Conditions

Contacting material:WC
Circumferential Velocity:8.6m/s
Fluid pressure:0.49MPa
PV value:4.2MPa·m/s
Balance ratio:0.75
Fluid: Mechanical oil VG#68
Fluid temperature:45℃
Test time:100h

Example of a blister on slide surface

Example of improved surface using TS-004

Water Circulation Mechanical Seal Test



※ Water Circulation Mechanical Seal Test Conditions

Contacting Material:WC
Slide surface dimensions:φ49.5×φ43.5
Rotation speed:3,600 rpm
Circumferential Velocity:8.76m/s
Fluid:Water
Fluid pressure:1.96MPa
PV value:27.79MPa·m/s
Fluid temperature:35℃
Flushing amount:0.18m³/h
Test time:100h

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Chemical Resistance

With the exception of some inorganic chemicals (strong oxidizers), carbon is resistant to chemical corrosion. Carbon has excellent chemical resistance when compared to general metal materials, and so is used in a wide variety of applications. Refer to the table below for the chemical resistance of carbon for mechanical application, as compared to general chemicals. The chemical resistance varies according to the chemical density, temperature and carbon composition, so please contact Toyo Tanso for further details.

Chemical Name	Chemical Formula	Concentration (mass %)	Temperature	Composition				
				Graphite	Carbon Graphite			Resin Bonded
					Non-Impregnated	Resin-Impregnated	Metal-Impregnated	
Ammonia (Gas)	NH_3	100	H	○	○	○	○	○
Chlorine (Gas)	Cl_2	100	H	○	○	○	×	×
Hydrogen Chloride (Gas)	HCl	100	H	○	○	○	×	×
Bromine (Gas)	Br_2	100	C	×	×	×	×	×
Hydrogen Bromide (Gas)	HBr	100	H	○	○	○	×	×
Sulfur Dioxide (Gas)	SO_2	100	H	○	○	○	×	×
Fluorine (Gas)	F_2	100	C	×	×	×	×	×
Hydrogen Fluoride (Gas)	HF	100	W	○	○	○	×	×
Ammonium Hydroxide	NH_4OH	25	W	○	○	○	○	○
Potassium Hydroxide	KOH	60	C	○	○	○	○	○
		60	H	○	○	×	×	×
Sodium Hydroxide	NaOH	60	C	○	○	○	○	×
		60	H	○	○	×	×	×
Sodium Chlorite	$NaClO_2$	20	H	×	×	×	×	×
Sulfurous Acid	H_2SO_3	100	C	○	○	○	○	×
Hydrochloric Acid	HCl	36	H	○	○	○	×	×
Aqua Regia (Hydrochloric Acid/Nitric Acid)	HCl/HNO_3	100	C	○	○	○	×	×
Potassium Permanganate	$KMnO_4$	7	C	○	○	○	○	○
		7	H	×	×	×	×	×
Chromic Acid	H_2CrO_4	20	C	○	○	○	×	×
		20	H	○	○	○	×	×
		40	C	○	○	○	×	×
		40	H	○	×	×	×	×
		60	C	×	×	×	×	×
Mixed Acid (Nitric Acid/Sulfuric Acid)	HNO_3/H_2SO_4	100	C	×	×	×	×	×
Nitric Acid	HNO_3	38	H	○	○	○	×	×
		65	C	○	×	×	×	×
		65	W	○	×	×	×	×
		65	H	×	×	×	×	×

Chemical Name	Chemical Formula	Concentration (mass %)	Temperature	Composition				
				Graphite	Carbon Graphite			Resin Bonded
					Non-Impregnated	Resin-Impregnated	Metal-Impregnated	
Sodium Hypochlorite	NaClO	7	H	○	×	×	×	×
		13	W	○	×	×	×	×
		23	C	×	×	×	×	×
Hydrofluoric Acid	HF	40	W	○	×	×	×	×
		60	C	×	×	×	×	×
Fuming Sulfuric Acid	$H_2SO_4+SO_3$	98	C	×	×	×	×	×
Sulfuric Acid	H_2SO_4	48	H	○	○	○	×	×
		98	H	×	×	×	×	×
Phosphoric Acid	H_3PO_4	85	C	○	○	○	○	○
		85	H	○	○	○	×	×
Acetone	CH_3COCH_3	100	C	○	○	○	○	×
Aniline	$C_6H_5NH_2$	100	C	○	○	○	○	○
Ether	R-O-R	100	C	○	○	○	○	○
Formic Acid	HCOOH	100	C	○	○	○	×	×
Citric Acid	$C_6H_8O_7$	100	C	○	○	○	○	○
Glycerin	$C_3H_5(OH)_3$	100	C	○	○	○	○	×
Chloroform	$CHCl_3$	100	C	○	○	○	×	○
Carbon Tetrachloride	CCl_4	100	C	○	○	○	○	○

※H…100℃ W…50℃ C…20℃ ○…Resistant ×…Infused

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Design Data

PV Value Selection

When using carbon as a bearing, the most important thing is to design so that the product of the bearing pressure and rim speed (PV value) is below a certain value. If there is an error in this design, problems such as abnormal abrasion and bearing damage could occur. It is preferable that carbon bearings are used in the lubricated condition, because a larger PV value than the non-lubricated condition can be maintained. We recommend that it is used when the bearing pressure is under approximately 3MPa.

●Rough Calculation Method for the Radial Bearing PV Value

$$\text{Bearing Pressure (MPa)} = \frac{\text{Bearing Load (N)}}{\text{Shaft Diameter (m)} \times \text{Bearing Length (m)} \times 10^6}$$

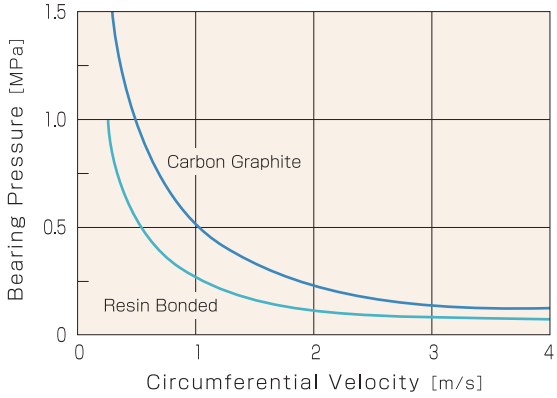
$$\text{Circumferential Velocity V (m/s)} = \frac{\pi \times \text{Shaft Diameter (m)} \times \text{Rotation Speed (rpm)}}{60}$$

① Boundary PV Value

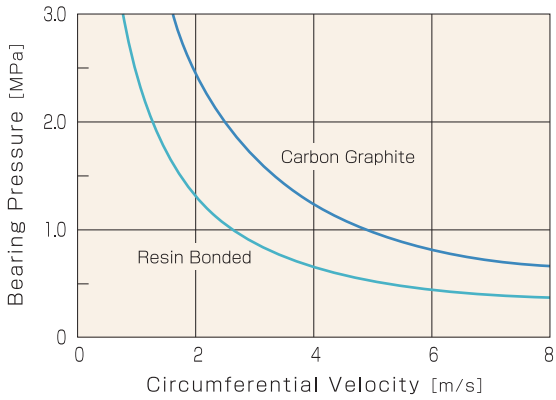
Unit:MPa·m/s

Atmosphere	Resin Bonded	Carbon Graphite
Non-Lubricated Condition	0.25	0.5
Lubricated Condition	2.5	5.0

② Acceptable Bearing PV Values under the Non-Lubricated Condition



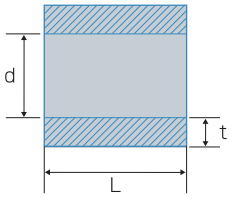
③ Acceptable Bearing PV Values under the Lubricated Condition



Carbon Bearing Shape

d:Bearing Inner Diameter

Refer to JIS B 0901 for the nominal dimensions. Note that the actual dimensions may differ a little because the operational clearance must also be taken into account. Refer to the H7 dimension allowance of JIS B 0401 for the dimension tolerance.



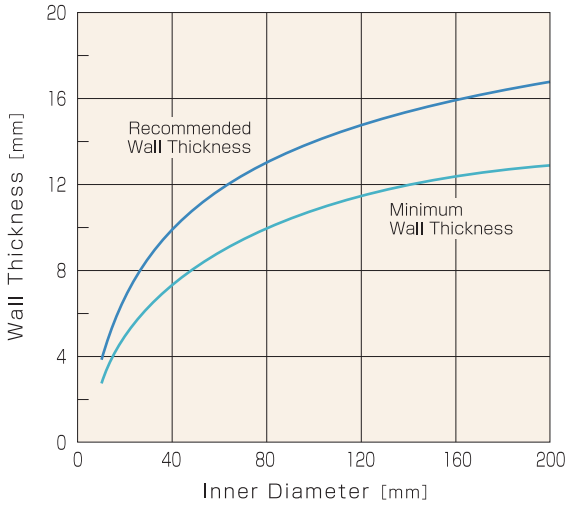
L:Bearing Length

As a rule we recommend L = d. This may vary according to the bearing pressure, but please design within a range of 2d ≧ L ≧ 0.5d.

t:Wall Thickness

Refer to diagram ④ on the right. However, if the bearing pressure is high or there is vibration, we recommend the use of a housing.

④ Relationship Between the Bearing Inner Diameter and Wall Thickness



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Operational Clearance

In order for the shaft to rotate in the bearing, there must be a "clearance" between both parts. If this "clearance" does not exist, rotation could be prevented by problems such as seizures, caused by the accumulation of abrasion powder and temperature increases in the contact area. If a temperature increase during usage seems likely, the amount of change due to the difference in the thermal expansion between the shaft and bearing must be considered at the initial stage.

●Initial Clearance ＝Operational Clearance
＋
Change Amount Due to Thermal Expansion

＝Operational Clearance
＋
$(d \times \Delta\alpha \times \Delta t)$

d：Shaft diameter

$\Delta\alpha$：Difference between the shaft and bearing thermal expansion coefficient

Δt：Temperature increase

Surface Roughness Standards

Since carbon products are porous, it is difficult to obtain a surface finish that is equivalent to metal. The table on the right shows the correspondence of the "Surface Finish Symbol" and surface roughness standards, Rz & Ra.

Machining Dimension Tolerance

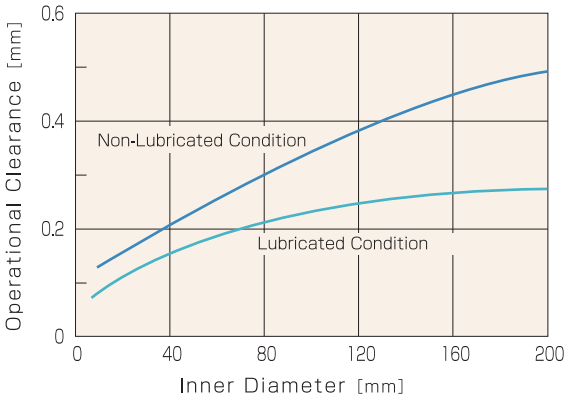
If the tolerance is not specified on the customer drawing, apply the intermediate grade of JIS B 0405.

⑧ Tolerance for Length

Unit:mm

Nominal Dimension Category		Tolerance
0.5 or more	6or less	±0.1
Exceeding 6	30or less	±0.2
Exceeding 30	120or less	±0.3
Exceeding 120	400or less	±0.5
Exceeding 400	1000or less	±0.8

⑤ Relationship Between the Bearing Inner Dimension and Operational Clearance



⑥ Coefficient of Thermal Expansion of Various Materials

Unit:10^{-6}/K

Materials	Coefficient of Thermal Expansion
Cast Iron	12
Stainless Steel	17
Carbon Steel	11
Chrome Steel	11
Aluminum	23
Zinc Bronze	18
Brass	20

⑦ Surface Roughness Standards

Finish Symbol	Surface Roughness for Carbon		Finishing Method	Machining Surface Roughness for Metal	
	Rz	Ra		Rz	Ra
▽▽▽▽	√Rz3	√Ra0.75	Honing Lapping	√Rz0.8	√Ra0.2
▽▽▽	√Rz12	√Ra3.0	Grinder, Lathe Miller	√Rz6.3	√Ra1.6
▽▽	√Rz35	√Ra8.75	Lathe Miller	√Rz25	√Ra6.3
▽	√Rz100	√Ra25	Lathe Miller	√Rz100	√Ra25
～	No particular standard		Saw Machine	No particular standard	

※√Ra3.0 means that Ra 3.0 is the maximum.

⑨ Geometric Tolerance for Shape

Unit:mm

Nominal Dimension Category		Tolerance	
		Straightness Flatness	Perpendicularity
	10 or less	0.05	0.4
Exceeding 10	30 or less	0.1	0.4
Exceeding 30	100 or less	0.2	0.4
Exceeding 100	300 or less	0.4	0.6
Exceeding 300	1000 or less	0.6	0.8
Exceeding1000	3000 or less	0.8	1

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