Technical Information overview

General Technical Information

Materials

Technical Information by Product

General Technical Information
SI (International System of Units)

1. International System of Units(SI)and Usage.

1-1. Scope of Application This standard specifies how to use the International System of Units(SI) and other international unitary systems, as well as units used in correlation with units from international systems, and other units which may be used.

1-2. Terms and Definitions Terminology used in this specification and definitions thereof are as follows.

(1) International System of Units(SI) Coherent system of units adopted and recommended by the International Committee on Weights and Measures. It contains base units and supplementary units, units derived from them and their integral exponents to the 10th power.

(2) SI Unit Generic term used to describe base units, supplementary units or derived units of the International System of Units(SI).

(3) Base Unit Those units are given in **Table 1**.

(4) Supplementary Units Those supplementary units are given in **Table 2**.

Table 1. Base Units

Base Quantity	Unit	Symbol	Definition
Length	Meter	m	A meter is the length of the path traveled by light in a vacuum during a time interval of $\frac{1}{299\ 792\ 458}$ of a second.
Mass	Kilogram	kg	A kilogram is a unit of mass(neither weight nor force), it is equal to the mass of the international prototype of the kilogram.
Time	Second	s	A second is the duration of 9 192 631 770 periods of radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium 133 atom.
Current	Ampere	A	An ampere is that constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross-section, and placed 1 meter apart in a vacuum, would produce between these conductors a force equal to 2×10^{-7} Newton per meter of length.
Thermodynamic Temperature	Kelvin	K	Kelvin, a unit of thermodynamic temperature, is the fraction $\frac{1}{273.16}$ of the thermodynamic temperature of the triple point of water.
Amount of Substance	Mole	mol	A mole is the amount of substance of a system that contains as many elementary particles(1) or aggregation of elementary particles as there are atoms in 0.012 kilogram of carbon 12 and when the mole is used, the elementary particles must be specified.
Luminance Intensity	Candela	cd	A candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540×10^{12} hertz and that has a radiant intensity in that direction of $\frac{1}{683}$ watt per steradian.

Note (1) The elementary particles here must be atoms, molecules, ions, electrons or other particles.

Table 2. Supplementary Units

Base Quantity	Unit	Symbol	Definition
Plane Angle	Radian	rad	A radian is the plane angle between two radii of a circle that cuts off an arc on the circumference equal in length to the radius.
Solid Angle	Steradian	sr	A steradian is the solid angle which, having its vertex in the center of a sphere, cuts off an area of the surface of the sphere equal to that of a square with sides equal in length to the radius of the sphere.

(5) Derived Units The supplementary units algebraically expressed using mathematical symbols such as plus, minus, etc. The SI derived units with special names and symbols are given in Table 3.

Examples of SI Derived Units Expressed in Terms of Base Units

Base Quantity	Base Quantity	
	Name	Symbol
Area	Square Meter	m^2
Volume	Cubic Meter	m^3
Velocity	Meter/Second	m/s
Acceleration	Meter/Second^2	m/s^2
Wave Number	Every Meter	m^{-1}
Density	Kilogram Every Cubic Meter	kg/m^3
Current Density	Ampere Every Square Meter	A/m^2
Magnetic Field Strength	Ampere Every Meter	A/m
Concentration (of Substance)	Mole Every Cubic Meter	mol/m^3
Specific Volume	Cubic Meter Every Kilogram	m^3/kg
Luminance	Candela Every Square Meter	cd/m^2

Table 3 SI Derived Units with Special Names and Symbols

Base Quantity	Base Quantity		Expression in Terms of Base Units or Supplementary Units, Supplementary Units or Other SI Units
	Name	Symbol	
Frequency	Hertz	Hz	1 Hz =1 s^{-1}
Force	Newton	N	1 N =1 kg·m/s^2
Pressure, Stress	Pascal	Pa	1 Pa =1 N/m^2
Energy, Work, Heat Quantity	Joule	J	1 J =1 N·m
Work Rate, Process Rate, Power, Electric Power	Watt	W	1 W =1 J/s
Electric Charge, Quantity of Electricity	Coulomb	C	1 C =1 A·s
Electric Potential, Potential Difference, Voltage, Electromotive Force	Volts	V	1 V =1 J/C
Electrostatic Capacity, Capacitance	Farad	F	1 F =1 C/V
Electric Resistance	Ohm	Ω	1 Ω =1 V/A
Conductance	Siemens	S	1 S =1 $Ω^{-1}$
Magnetic Flux	Weber	Wb	1 Wb =1 V·s
Magnetic Flux Density	Tesla	T	1 T =1 Wb/m^2
Inductance	Henry	H	1 H =1 Wb/A
Celsius Temperature	Degree Celsius	˚C	1 t˚C =(t+273.15)k
Luminous Flux	Lumen	lm	1 lm =1 cd·sr
Illuminance	Lux	lx	1 lx =1 lm/m^2
Radioactivity	Becquerel	Bq	1 Bq =1 s^{-1}
Absorbed Dose	Gray	Gy	1 Gy =1 J/kg
Dose Equivalent	Sievert	Sv	1 Sv =1 J/kg

1-3. Multiples of 10 of SI Units

(1)Prefix The multiples and the names and symbols of prefixes to express integer multiples of 10 of SI Units are shown in Table 4.

Table 4 Prefix.

Multiples of Unit	Prefix		Multiples of Unit	Prefix		Multiples of Unit	Prefix	
	Name	Symbol		Name	Symbol		Name	Symbol
10^{18}	Exsa	E	10^{2}	Hecto	h	10^{-9}	Nano	n
10^{15}	Peta	P	10^{1}	Deca	da	10^{-12}	Pico	p
10^{12}	Tera	T	10^{-1}	Deci	d	10^{-15}	Femto	f
10^{9}	Giga	G	10^{-2}	Centi	c	10^{-18}	Atto	a
10^{6}	Mega	M	10^{-3}	Milli	m			
10^{3}	Kilo	k	10^{-6}	Micro	μ			

2. Conversion Tables for SI and Conventional Units

(The units enclosed by thick lines are the SI units.)

	N	dyn	kgf
Force	1	1×10^{5}	$1.019\ 72\times10^{-1}$
	1×10^{-5}	1	$1.019\ 72\times10^{-6}$
	9.806 65	$9.806\ 65\times10^{5}$	1

	Pa·s	cP	P
Viscosity	1	1×10^{3}	1×10
	1×10^{-3}	1	1×10^{-2}
	1×10^{-1}	1×10^{2}	1

Note) 1P=1dyn·s/cm^2=1g/cm·s
1Pa·s=1N·s/m^2, 1cP=1mPa·s

	Pa or N/m²	MPa or N/mm²	kgf/mm²	kgf/cm²
Stress	1	1×10^{-6}	$1.019\ 72\times10^{-7}$	$1.019\ 72\times10^{-5}$
	1×10^{6}	1	$1.019\ 72\times10^{-1}$	$1.019\ 72\times10$
	$9.806\ 65\times10^{6}$	9.806 65	1	1×10^{2}
	$9.806\ 65\times10^{4}$	$9.806\ 65\times10^{-2}$	1×10^{-2}	1

Note) 1Pa=1N/m^2, 1MPa=1N/mm^2

	m²/s	cSt	St
Kinematic Viscosity	1	1×10^{6}	1×10^{4}
	1×10^{-6}	1	1×10^{-2}
	1×10^{-4}	1×10^{2}	1

Note) 1St=1cm^2/s, 1cSt=1mm^2/s

	Pa	kPa	MPa	bar	kgf/cm²	atm	mmH2O	mmHg or Torr
Pressure	1	1×10^{-3}	1×10^{-6}	1×10^{-5}	$1.019\ 72\times10^{-5}$	$9.869\ 23\times10^{-6}$	$1.019\ 72\times10^{-1}$	$7.500\ 62\times10^{-3}$
	1×10^{3}	1	1×10^{-3}	1×10^{-2}	$1.019\ 72\times10^{-2}$	$9.869\ 23\times10^{-3}$	$1.019\ 72\times10^{2}$	7.500 62
	1×10^{6}	1×10^{3}	1	1×10	$1.019\ 72\times10$	9.869 23	$1.019\ 72\times10^{5}$	$7.500\ 62\times10^{3}$
	1×10^{5}	1×10^{2}	1×10^{-1}	1	1.019 72	$9.869\ 23\times10^{-1}$	$1.019\ 72\times10^{4}$	$7.500\ 62\times10^{2}$
	$9.806\ 65\times10^{4}$	$9.806\ 65\times10$	$9.806\ 65\times10^{-2}$	$9.806\ 65\times10^{-1}$	1	$9.678\ 41\times10^{-1}$	1×10^{4}	$7.355\ 59\times10^{2}$
	$1.013\ 25\times10^{5}$	$1.013\ 25\times10^{2}$	$1.013\ 25\times10^{-1}$	1.013 25	1.033 23	1	$1.033\ 23\times10^{4}$	$7.600\ 00\times10^{2}$
	9.806 65	$9.806\ 65\times10^{-3}$	$9.806\ 65\times10^{-6}$	$9.806\ 65\times10^{-5}$	1×10^{-4}	$9.678\ 41\times10^{-5}$	1	$7.355\ 59\times10^{-2}$
	$1.333\ 22\times10^{2}$	$1.333\ 22\times10^{-1}$	$1.333\ 22\times10^{-4}$	$1.333\ 22\times10^{-3}$	$1.359\ 51\times10^{-3}$	$1.315\ 79\times10^{-3}$	$1.359\ 51\times10$	1

Note) 1Pa=1N/m^2

	J	kW·h	kgf·m	kcal
Work, Energy, Heat Quantity	1	$2.777\ 78\times10^{-7}$	$1.019\ 72\times10^{-1}$	$2.388\ 89\times10^{-4}$
	3.600×10^{6}	1	$3.670\ 98\times10^{5}$	$8.600\ 0\times10^{2}$
	9.806 65	$2.724\ 07\times10^{-6}$	1	$2.342\ 70\times10^{-3}$
	$4.186\ 05\times10^{3}$	$1.162\ 79\times10^{-3}$	$4.268\ 58\times10^{2}$	1

Note) 1Pa=1N/m^2, 1MPa=1N/mm^2

	W	kgf·m/s	PS	kcal/h
Power Heat Flow	1	$1.019\ 72\times10^{-1}$	$1.359\ 62\times10^{-3}$	$8.600\ 0\times10^{-1}$
	9.806 65	1	$1.333\ 33\times10^{-2}$	8.433 71
	7.355×10^{2}	7.5×10	1	$6.325\ 29\times10^{2}$
	1.162 79	$1.185\ 72\times10^{-1}$	$1.580\ 95\times10^{-3}$	1

Note) 1W=1J/s, PS: French Horsepower

	W/(m·K)	kcal/(h·m·˚C)
Thermal Conductivity	1	$8.600\ 0\times10^{-1}$
	1.162 79	1

	W/(m²·K)	kcal/(h·m²·˚C)
Coefficient of Heat Transfer	1	$8.600\ 0\times10^{-1}$
	1.162 79	1

	J/(kg·K)	kcal/(kg·˚C) cal/(g·˚C)
Specific Heat	1	$2.388\ 89\times10^{-4}$
	$4.186\ 05\times10^{3}$	1

Greek Symbols

Uppercase	Lowercase	Pronunciation	Conventional Usage
Α	α	alpha	Angle, Coefficient
Β	β	beta	Angle, Coefficient
Γ	γ	gamma	Angle, Weight Per Unit Area, Relationship(Uppercase)
Δ	δ	delta	Small Change, Density, Displacement
Ε	ε	epsilon	Small Amount, Distortion
Ζ	ζ	zeta	Variable
Η	η	eta	Variable
Θ	θ	theta	Angle, Temperature, Time
Ι	ι	iota	
Κ	κ	kappa	Radius of Gyration
Λ	λ	lambda	Wavelength, Characteristic Value
Μ	μ	mu	Friction Coefficient 10^{-6} (Micro)
Ν	ν	nu	Frequency
Ξ	ξ	xi	Variable
Ο	ο	omicron	
Π	π	pi	Circle Ratio (3.14159...) Angle Symbol of Product(Uppercase)
Ρ	ρ	rho	Radius, Density
Σ	σ	sigma	Stress, Standard Deviation Summation(Uppercase)
Τ	τ	tau	Time Constant, Time, Torque
Υ	υ	upsilon	
Φ	φ, φ	phi	Angle, Function, Diameter
Χ	χ	chi	
Ψ	ψ	psi	Angle, Function
Ω	ω	omega	Angular Verocity=2πf Ohm:Unit of Electric Resistance (Uppercase)

Reference Unless otherwise specified, lowercase letters are the norm.

Characteristics of Materials

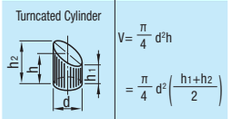
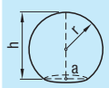
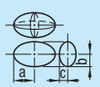
Material	Specific Gravity	Thermal Expansion Coefficient	Young's Modulus	
		$\times10^{-6}$/°C	N/mm²	{Kgf/mm²}
Mild Steel	7.85	11.7	205800	21000
NAK80	7.8	12.5	200900	20500
SKD11	7.85	11.7	205800	21000
SKD61	7.75	10.8	205800	21000
SKH51	8.2	10.1	218540	22300
Carbide V30	14.1	6.0	548800	56000
Carbide V40	13.9	6.0	529200	54000
Cast Iron	7.3	9.2~11.8	73500~102900	7500~10500
SUS304	8.0	17.3	193060	19700
SUS440C	7.78	10.2	199920	20400
Oxygen Free Coppers C1020	8.9	17.6	114660	11700
6/4 Brass C2801	8.4	20.8	100940	10300
Beryllium Copper C1720	8.3	17.1	127400	13000
Aluminum A1100	2.7	23.6	67620	6900
Duralumin A7075	2.8	23.6	70560	7200
Titanium	4.5	8.4	103880	10600

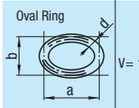
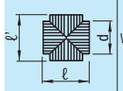
Name of Elements and Atomic Symbols

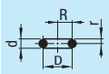
Atomic Number	Name	Symbol	Atomic Number	Name	Symbol
1	Hydrogen	H	53	Iodine	I
2	Helium	He	54	Xenon	Xe
3	Lithium	Li	55	Cesium	Cs
4	Beryllium	Be	56	Barium	Ba
5	Boron	B	57	Lanthanum	La
6	Carbon	C	58	Cerium	Ce
7	Nitrogen	N	59	Praseodymium	Pr
8	Oxygen	O	60	Neodymium	Nd
9	Fluorine	F	61	Promethium	Pm
10	Neon	Ne	62	Samarium	Sm
11	Sodium	Na	63	Europium	Eu
12	Magnesium	Mg	64	Gadolinium	Gd
13	Aluminum	Al	65	Terbium	Tb
14	Silicon	Si	66	Dysprosium	Dy
15	Phosphorous	P	67	Holmium	Ho
16	Sulfur	S	68	Erbium	Er
17	Chlorine	Cl	69	Thulium	Tm
18	Argon	Ar	70	Ytterbium	Yb
19	Potassium	K	71	Lutetium	Lu
20	Calcium	Ca	72	Hafnium	Hf
21	Scandium	Sc	73	Tantalum	Ta
22	Titanium	Ti	74	Tungsten	W
23	Vanadium	V	75	Rhenium	Re
24	Chromium	Cr	76	Osmium	Os
25	Manganese	Mn	77	Iridium	Ir
26	Iron	Fe	78	Platinum	Pt
27	Cobalt	Co	79	Gold	Au
28	Nickel	Ni	80	Mercury	Hg
29	Copper	Cu	81	Thallium	Tl
30	Zinc	Zn	82	Lead	Pb
31	Gallium	Ga	83	Bismuth	Bi
32	Germanium	Ge	84	Polonium	Po
33	Arsenic	As	85	Astatine	At
34	Selenium	Se	86	Radon	Rn
35	Bromine	Br	87	Francium	Fr
36	Krypton	Kr	88	Radium	Ra
37	Rubidium	Rb	89	Actinium	Ac
38	Strontium	Sr	90	Thorium	Th
39	Yttrium	Y	91	Protactinium	Pa
40	Zirconium	Zr	92	Uranium	U
41	Niobium	Nb	93	Neptunium	Np
42	Molybdenum	Mo	94	Plutonium	Pu
43	Technetium	Tc	95	Americium	Am
44	Ruthenium	R	96	Curium	Cm
45	Rhodium	Rh	97	Berkelium	Bk
46	Palladium	Pd	98	Californium	Cf
47	Silver	Ag	99	Einsteinium	Es
48	Cadmium	Cd	100	Fermium	Fm
49	Indium	In	101	Mendelevium	Md
50	Tin	Sn	102	Nobelium	No
51	Antimony	Sb	103	Lawrencium	Lr
52	Tellurium	T			

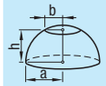
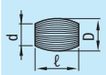
Reference This table is based on Appendix A(Names and Symbols of Elements)of ISO 31/8-1980 (Amounts and Units of Physical Chemistry and Molecular Physics) and Appendix C (Names and Symbols of Radionuclides) of ISO 31/9-1980 (Amounts and Units of Atomic Physics and Nuclear Physics).

How to Calculate the Volume

Solid	Volume V
Turncated Cylinder 	$V=\frac{\pi}{4}d^2h$ $=\frac{\pi}{4}d^2\left(\frac{h_1+h_2}{2}\right)$
Pyramid 	$V=\frac{h}{3}A=\frac{h}{6}arn$ A=Area of Base r=Radius of inscribed circle a=Length of a side of a regular polygon n=Number of the sides of a regular polygon
Spherical Crown 	$V=\frac{\pi h^2}{3}(3r-h)$ $=\frac{\pi h}{6}(3a^2+h^2)$ a is the radius.
Ellipsoid 	$V=\frac{4}{3}\pi abc$ In case of spheroid (b=c) $V=\frac{4}{3}\pi ab^2$

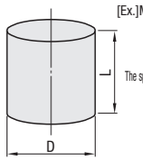
Solid	Volume V
Oval Ring 	$V=\frac{\pi^2}{4}d^2\frac{\sqrt{a^2+b^2}}{2}$
Cross Cylinder 	$V=\frac{\pi}{4}d^2(\ell+\ell'-\frac{d}{3})$
Hollow(Cylinder) 	$V=\frac{\pi}{4}h(D^2-d^2)$ $=\pi th(D-t)$ $=\pi th(d+t)$
Turncated Pyramid 	$V=\frac{h}{3}(A+a+\sqrt{Aa})$ A.a=Area of both ends

Solid	Volume V
Spherical Segment 	$V=\frac{2}{3}\pi r^2h$ $=2.0944r^2h$
Torus 	$V=2\pi^2Rr^2$ $=19.739Rr^2$ $=\frac{\pi^2}{4}Dd^2$ $=2.4674Dd^2$
Circular Cone 	$V=\frac{\pi}{3}r^2h$ $=1.0472r^2h$
Sphere 	$V=\frac{4}{3}\pi r^3=4.1888r^3$ $=\frac{\pi}{6}d^3=0.5236d^3$

Solid	Volume V
Spherical Belt 	$V=\frac{\pi h}{6}(3a^2+3b^2+h^2)$
Barrel 	When the circumference makes a curve equal to the circular arc, $V=\frac{\pi\ell}{12}(2D^2+d^2)$ When the circumference makes a curve equal to a parabolic line, $V=0.209\ell(2D^2Dd+1/4d^2)$

How to Calculate the Weight

Weight W[g]= Volume[cm³]× Specific Gravity



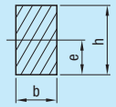
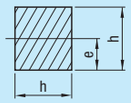
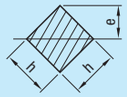
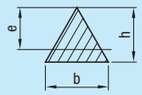
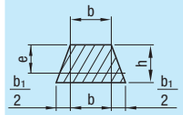
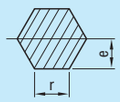
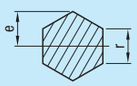
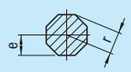
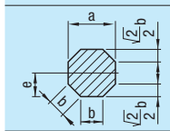
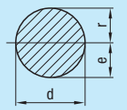
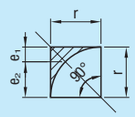
[Ex.]Material: Mild Steel

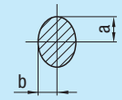
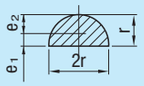
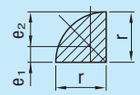
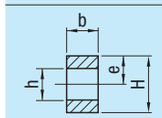
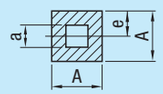
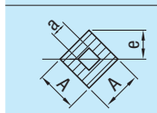
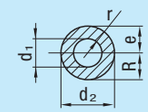
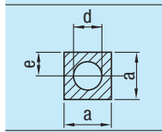
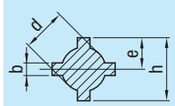
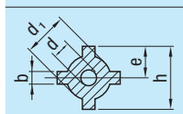
When D=Ø16 and L=50mm, the weight is:

The specific gravity of $W=\frac{\pi}{4}D^2\times L\times W$

$=\frac{\pi}{4}\times1.6^2\times5\times7.85$

≈79[g]

Cross Section	A	e	I	Z=I/e
	bh	$\frac{h}{2}$	$\frac{bh^3}{12}$	$\frac{bh^2}{6}$
	h^2	$\frac{h}{2}$	$\frac{h^4}{12}$	$\frac{h^3}{6}$
	h^2	$\frac{h}{2}\sqrt{2}$	$\frac{h^4}{12}$	$0.1179h^3=\frac{\sqrt{2}}{12}h^3$
	$\frac{bh}{2}$	$\frac{2}{3}h$	$\frac{bh^3}{36}$	$\frac{bh^2}{24}$
	$(2b+b_1)\frac{h}{2}$	$\frac{1}{3}\times\frac{3b+2b_1}{2b+b_1}h$	$\frac{6b^2+6bb_1+b_1^2}{36(2b+b_1)}h^3$	$\frac{6b^2+6bb_1+b_1^2}{12(3b+2b_1)}h^2$
	$\frac{3\sqrt{3}}{2}r^2$ $=2.598r^2$	$\sqrt{\frac{3}{4}}r=0.886r$	$\frac{5\sqrt{3}}{16}r^4=0.5413r^4$	$\frac{5}{8}r^3$
		r		$\frac{5\sqrt{3}}{16}r^3=0.5413r^3$
	$2.828r^2$	$0.924r^2$	$\frac{1+2\sqrt{2}}{6}r^4$ $=0.6381r^4$	$0.6906r^3$
	$0.8284a^2$	$b=\frac{a}{1+\sqrt{2}}$ $=0.4142a$	$0.0547a^4$	$0.1095a^3$
	$\pi r^2=\frac{\pi d^2}{4}$	$\frac{d}{2}$	$\frac{\pi d^4}{64}=\frac{\pi r^4}{4}$ $=0.0491d^4$ $\approx0.05d^4$ $=0.7854r^4$	$\frac{\pi d^3}{32}=\frac{\pi r^3}{4}$ $=0.0982d^3$ $\approx0.1d^3$ $=0.7854r^3$
	$r^2\left(1-\frac{\pi}{4}\right)$ $=0.2146r^2$	e_1 $=0.2234r$ e_2 $=0.7766r$	$0.0075r^4$	$\frac{0.0075r^4}{e_2}$ $=0.00966r^3$ $\approx0.01r^3$

Cross Section	A	e	I	Z=I/e
	πab	a	$\frac{\pi}{4}ba^3=0.7854\,ba^3$	$\frac{\pi}{4}ba^2=0.7854\,ba^2$
	$\frac{\pi}{2}r^2$	e_1 $=0.4244r$ e_2 $=0.5756r$	$\left(\frac{\pi}{8}-\frac{8}{9\pi}\right)r^4$ $=0.1098r^4$	$Z_1=0.2587r^3$ $Z_2=0.1908r^3$
	$\frac{\pi}{4}r^2$	e_1 $=0.4244r$ e_2 $=0.5756r$	$0.055r^4$	$Z_1=0.1296r^3$ $Z_2=0.0956r^3$
	b(H−h)	$\frac{H}{2}$	$\frac{b}{12}(H^3-h^3)$	$\frac{b}{6H}(H^3-h^3)$
	A^2-a^2	$\frac{A}{2}$	$\frac{A^4-a^4}{12}$	$\frac{1}{6}\frac{A^4-a^4}{A}$
	A^2-a^2	$\frac{A}{2}\sqrt{2}$	$\frac{A^4-a^4}{12}$	$\frac{\frac{A^4-a^4}{12A}\sqrt{2}}{}$ $=\frac{0.1179(A^4-a^4)}{A}$
	$\frac{\pi}{4}(d_2^2-d_1^2)$	$\frac{d_2}{2}$	$\frac{\pi}{64}(d_2^4-d_1^4)$ $=\frac{\pi}{4}(R^4-r^4)$	$\frac{\pi}{32}\left(\frac{d_2^4-d_1^4}{d_2}\right)$ $=\frac{\pi}{4}\times\frac{R^4-r^4}{R}$
	$a^2-\frac{\pi d^2}{4}$	$\frac{a}{2}$	$\frac{1}{12}\left(a^4-\frac{3\pi}{16}d^4\right)$	$\frac{1}{6a}\left(a^4-\frac{3\pi}{16}d^4\right)$
	2b(h−d) $+\frac{\pi}{4}d^2$	$\frac{h}{2}$	$\frac{1}{12}\left\{\frac{3\pi}{16}d^4+b(h^3-d^3)+b^3(h-d)\right\}$	$\frac{1}{6h}\left\{\frac{3\pi}{16}d^4+b(h^3-d^3)+b^3(h-d)\right\}$
	2b(h−d)+ $\frac{\pi}{4}(d_1^2-d^2)$	$\frac{h}{2}$	$\frac{1}{12}\left\{\frac{3\pi}{16}(d_1^4-d^4)+b(h^3-d_1^3)+b^3(h-d_1)\right\}$	$\frac{1}{6h}\left\{\frac{3\pi}{16}(d_1^4-d^4)+b(h^3-d_1^3)+b^3(h-d_1)\right\}$

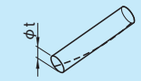
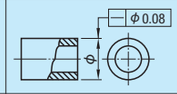
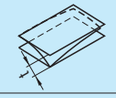
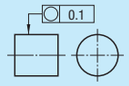
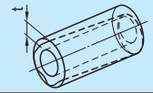
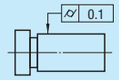
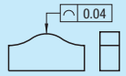
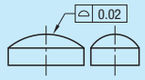
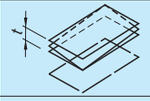
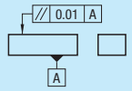
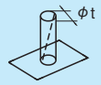
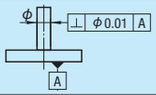
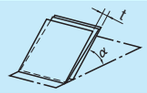
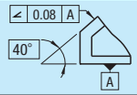
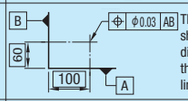
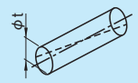
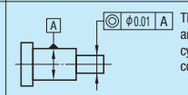
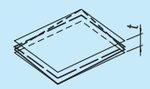
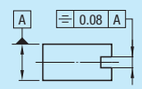
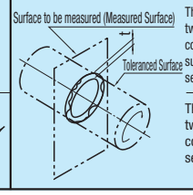
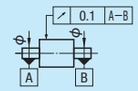
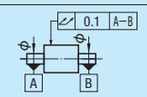
A: Sectional area e: Distance of Center of Gravity I: Geometrical Moment of Inertia
Z=I/e: Cross Section Coefficient

General Technical Information
Roughness Ranges by Various Processes

Arithmetic Average Roughness Ra		0.025	0.05	0.1	0.2	0.4	0.8	1.6	3.2	6.3	12.5	25	50	100
Traditional Roughness Notations	Maximum Height Rmax.	0.1 –S	0.2 –S	0.4 –S	0.8 –S	1.6 –S	3.2 –S	6.3 –S	12.5 –S	25 –S	50 –S	100 –S	200 –S	400 –S
	Reference Value of Standard Length (mm)	0.25				0.8			2.5		8		25	
	Finish Symbol	▽▽▽▽				▽▽▽			▽▽		▽		–	
Processes	Forging								Precise					
	Casting								Precise					
	Die Casting													
	Hot Rolling													
	Cold Rolling													
	Drawing													
	Extruding													
	Tumbling													
	Sand Blasting													
	Rolling													
	Face Milling						Precise							
	Planing													
	Carving / Slotting													
	Milling						Precise							
	Precision Boring													
	Filing						Precise							
	Round Turning			Precise			Fine		Medium			Coarse		
	Boring						Precise							
	Drilling													
	Reaming					Precise								
	Broaching					Precise								
	Shaping													
	Polishing			Precise	Fine		Medium			Coarse				
	Honing			Precise										
	Stone Lapping	Precise												
	Buff Finishing			Precise										
	Fine Sanding			Precise										
	Lapping	Precise												
	Hydro Honing			Precise										
	Burnishing													
	Roller Finishing													
	Sinker EDM													
	Wire Cut, EDM													
	Chemical Polishing						Precise							
	Electropolishing		Precise											

General Technical Information
Geometric Tolerance Indications

Geometric Tolerances and Symbols

Tolerance Types		Symbols	Definition of Tolerance Zones		Illustrated Examples and Interpretations	
Form Tolerance	Straightness	—		If the tolerance value is preceded by a Ø symbol, this tolerance zone is the range within a cylinder of diameter t.		If a tolerance frame is connected to a dimension that indicates the diameter of a cylinder, the axis line of the cylinder shall be contained within a cylinder of 0.08mm diameter.
	Flatness	▱		The tolerance zone is the area between two parallel planes separated by distance t.		This surface shall be contained within two parallel planes separated by 0.08mm.
	Circularity	○		The tolerance zone in the subject plane is the area between two concentric circles separated by distance t.		The circumference of arbitrary axis perpendicular cross sections shall be contained between two concentric circles separated by 0.1mm on the same plane.
	Cylindricity	⌭		The tolerance zone is the range between two coaxial cylinder surfaces separated by distance t.		The subject surface shall be contained between two coaxial cylinder surfaces separated by 0.1mm.
	Profile of Line	⌒		The tolerance zone is the range between the two enveloping lines formed by a circle with diameter t with the center located on the theoretically correct profile curve.		On arbitrary cross-sections parallel to the projection plane, the subject profile shall be contained between the two envelope lines formed by a 0.04mm diameter circle with the center located on the theoretically correct profile curve.
	Profile of Surface	⌓		The tolerance zone is the range between the two enveloping surfaces formed by a sphere with diameter t with the center located on the theoretically correct profile surface.		The subject surface shall be contained between the two enveloping surfaces formed by a 0.02mm diameter sphere with the center located on the surface containing the theoretically correct profile.
Orientation Tolerance	Parallelism	//		The tolerance zone is the range between two planes parallel to the datum plane separated by distance t.		The surface indicated by the arrow leader shall be contained between two planes parallel to the datum plane A separated by 0.01mm in the direction of the arrow leader.
	Perpendicularity Tolerance	⊥		If the tolerance value is preceded by a Ø symbol, the tolerance zone is the range within a cylinder of diameter t perpendicular to the datum plane.		The axis of the cylinder indicated by the arrow leader shall be contained within a 0.01mm cylinder perpendicular to the datum plane A.
	Angularity	∠		The tolerance zone is the range between two parallel planes inclined at a specified angle to the datum plane and separated from each other by distance t.		The surface indicated by the arrow leader shall be contained between two parallel planes inclined theoretically exactly by 40 degrees to the datum plane A, and separated by 0.08mm in the direction of the arrow of the leader.
Positional Tolerance	Positional Tolerance	⌖		The tolerance zone is the range within a circle or sphere of diameter t with its center located at theoretically true location of the subject point (True Position).		The point indicated by the arrow leader shall be contained within a 0.03mm diameter circle with its center located at the true location 60mm from the datum line A, and 100mm from the datum line B.
	Coaxiality or Concentricity	◎		If the tolerance value is preceded by a Ø symbol, the tolerance zone is the range within a cylinder of diameter t with axis coinciding with the datum axis line.		The axis of the cylinder indicated by the arrow leader shall be contained within a cylinder of diameter 0.01mm with axis coinciding with the datum axis line A.
	Symmetry	⌯		The tolerance zone is the range between two parallel planes separated by distance t and located symmetrically with relation to the datum plane.		The central plane indicated by the arrow leader shall be contained between two parallel planes separated by 0.08mm and located symmetrically in relation to the datum plane A.
Runout Tolerance	Runout Tolerance	↗		The tolerance zone is the range between two concentric circles having their centers common with the datum axis on any arbitrary surface perpendicular to this datum axis and separated by the distance t in radial direction.		The radial run-out of the cylinder surface indicated by the arrow leader shall not exceed 0.1mm on any measuring plane perpendicular to the datum axis line when the cylinder is rotated about the datum axis A-B.
	Total Runout	⌰		The tolerance zone is the range between two concentric cylinders having centers common with the datum axis, and separated in radial direction by distance t.		The total radial runout of the cylinder surface indicated by the arrow leader shall not exceed 0.1mm at any point on the cylinder surface when the cylinder is rotated about the datum axis A-B.

The lines used in the Tolerance Zone definitions mean the following.
Thick solid or broken line: Shape Thin dash-dot line: Center line Thick dash-dot line: Datum
Thin alternating long and two short dashed line: Supplementary projection plane or cross section plane Thin solid or broken line: Tolerance range
Thick alternating long and two short dashed line: Projection of shape onto supplementary plane or cross section plane

1. Regular Cut Dimension Tolerance B 0405—1991

Tolerances in Respect of Length Excluding Chamfered Portion

Unit: mm

Tolerance Class		Classification of Reference Dimension							
Symbol	Description	0.5 ([1]) or More 3 or Less	More than 3 6 or Less	More than 6 30 or Less	More than 30 120 or Less	More than 120 400 or Less	More than 400 1000 or Less	More than 1000 2000 or Less	More than 2000 4000 or Less
		Tolerance							
f	Precision Grade	±0.05	±0.05	±0.1	±0.15	±0.2	±0.3	±0.5	–
m	Medium	±0.1	±0.1	±0.2	±0.3	±0.5	±0.8	±1.2	±2
c	Coarse	±0.2	±0.3	±0.5	±0.8	±1.2	±2	±3	±4
v	Extremely Coarse	–	±0.5	±1	±1.5	±2.5	±4	±6	±8

Note ([1]) : A reference dimension less than 0.5 mm is followed by a tolerance.

2.Tolerances in Respect of the Length of the Chamfered Portion (Radius of rounding for edges and edge chamfering dimension)

Unit: mm

Tolerance Class		Classification of Reference Dimension		
Symbol	Description	0.5 ([2]) or More 3 or Less	More than 3 6 or Less	More than 6
		Tolerance		
f	Precision Grade	±0.2	±0.5	±1
m	Medium			
c	Coarse	±0.4	±1	±2
v	Extremely Coarse			

Note ([2]) : A reference dimension less than 0.5 mm is followed by a tolerance.

3. Angle Tolerance

Tolerance Class		Length of Shorter Side (Unit: mm)				
Symbol	Description	10 or Less	More than 10 50 or Less	More than 50 120 or Less	More than 120 400 or Less	More than 400
		Tolerance				
f	Precision Grade	±1°	±30'	±20'	±10'	± 5'
m	Medium					
c	Coarse	±1°30'	± 1°	±30'	±15'	±10'
v	Extremely Coarse	±3°	± 2°	± 1°	±30'	±20'

4.Regular Perpendicularity Tolerance B 0419—1991

Unit: mm

Tolerance Class	Nominal Length of Shorter Side			
	100 or Less	More than 100 300 or Less	More than 300 1000 or Less	More than 1000 3000 or Less
	Perpendicularity Tolerance			
H	0.2	0.3	0.4	0.5
K	0.4	0.6	0.8	1
L	0.6	1	1.5	2

5. Regular Straightness and Flatness Tolerance

Unit: mm

Tolerance Class	Nominal Length					
	10 or Less	More than 10 30 or Less	More than 30 100 or Less	More than 100 300 or Less	More than 300 1000 or Less	More than 1000 3000 or Less
	Regular Straightness and Flatness Tolerance					
H	0.02	0.05	0.1	0.2	0.3	0.4
K	0.05	0.1	0.2	0.4	0.6	0.8
L	0.1	0.2	0.4	0.8	1.2	1.6

6.Regular Symmetry Tolerance

Unit: mm

Tolerance Class	Nominal Length			
	100 or Less	More than 100 300 or Less	More than 300 1000 or Less	More than 1000
	Symmetry Tolerance			
H	0.5			
K	0.6		0.8	1
L	0.6	1	1.5	2

		H6	H7	H8	H9	Applicable Part	Functional Classification		Application Example
Can be Moved Relatively	Clearance Fit: Loose Fit				c9	Part which accommodates a wide gap or movable part which needs a gap. Part which accommodates a wide gap to facilitate assembling. Part which needs an appropriate gap even at a high temperature.	Part whose structure needs a gap. {Inflates. Large position error {Fitting length is long.		Piston Ring and the Ring Groove Fitting by means of a loose set pin.
	Clearance Fit: Light Roll Fit			d9	d9	Part which accommodates or needs a gap.	Cost needs to be reduced. {Manufacturing Cost {Maintenance Cost		Crank Web and Pin Bearing(Side) Exhaust Valve Box and the Sliding Part of a Spring Bearing Piston Ring and the Ring Groove
	Clearance Fit: Light Roll Fit		e7	e8	e9	Part which accommodates a wide gap or needs a gap. Fairly wide gap, well greased bearing. Bearing subjected to a high temperature, high speed and heavy load (high-degree forced lubrication).	Regular Rotary or Sliding Part (Must be well greased.)		Fitting of the Exhaust Valve Box Main Bearing for the Crank Shaft Regular Sliding Part
	Clearance Fit: Roll Fit	f6	f7	f7 f8		Fitting so as to provide an appropriate gap to permit movement (high-quality fitting). Regular normal temperature bearing lubricated with grease or oil.	Regular Fitting (Often comes apart.)		Part in which a cooled exhaust valve box is inserted. Regular Shaft and Bushing Link Device Lever and Bushing
	Clearance Fit: Fine Roll Fit	g5	g6			Continuously revolving part of a precision machine under a light load. Fitting with a narrow gap so as to permit movement (spigot and positioning). Precision sliding part.	Part required to make a precision motion with virtually no play.		Link Device Pin and Lever Key and its Groove Precision Control Valve Rod
Cannot be Moved Relatively	Transition Fit: Sliding Fit	h5	h6	h7 h8	h9	Fitting so as to permit movement by hand, with a lubricant applied. (high-quality positioning) Special High Precision Sliding Part Unimportant Stationary Part	Can be disassembled, reassembled without damaging component parts.	Force cannot be transmitted by the fitting force alone.	Fitting a rim and a boss together Fitting the gear of a precision gear device
	Transition Fit: Push Fit	h5 h6	js6			Fitting which accommodates a light gap. Precision fitting which locks both parts while the unit is used. Fitting which allows assembling and disassembling with a wooden or lead hammer.			Fitting Coupling Flanges Together Governor Path and Pin Fitting a Gear Rim and a Boss Together
	Transition Fit: Driving Fit	js5	k6			Fitting which requires an iron hammer or hand press for assembling, disassembling (a key or the like is necessary to prevent inter-part shaft rotation). Precision positioning.			Fixing the Shaft of a Gear Pump and a Casing Together Reamer Bolts
	Transition Fit: Driving Fit	k5	m6			Same as the above for assembling and disassembling. Precision positioning which allows no gap.			Reamer Bolts Fixing the piston of hydraulic equipment and a shaft together Fitting a Coupling Flange and a Shaft Together
	Transition Fit: Light Press Fit	m5	n6			Fitting which requires considerable force for assembling, disassembling. Precision stationary fitting (a key or the like is necessary for high torque transmission purposes)		Slight force can be transmitted by the fitting force alone.	Shaft of a Flexible Coupling and Gear(Passive Side) Precision Fitting Insertion of a Suction Valve and Valve Guide
	Interference Fit: Press Fit	n5 n6	p6			Fitting which requires much force for assembling, disassembling(a key or the like is necessary for high torque transmission). Light press fitting or the like is necessary for non-ferrous component parts. Standard press fitting is required for iron component parts and a bronze part and a copper part.	Hard to disassemble without damaging component parts.		Insertion of a Suction Valve and Valve Guide Fixing a Gear and a Shaft Together(Low Torque) Shaft of a Flexible Coupling and a Gear(Drive Side)
	Interference Fit: Press Fit	p5	r6			Same as the above for assembling and disassembling Shrinkage press fitting, cold press fitting or forced press fitting is required for large component parts.			Coupling and Shaft
	Interference Fit: Strong Press Fit, Shrinkage Fit, Freeze Fit	r5	s6 t6 u6 x6			Firmly coupled together and requires shrinkage press fitting, cold press fitting or forced press fitting. Permanent assembly, which can not be disassembled any further. Press fitting or the like is required for light alloy members.		Considerable force can be transmitted by the fitting force alone.	Attaching and Fixing a Bearing Bushing Insertion of a Suction Valve and Valve Box Fixing a Coupling Flange and a Shaft Together(High Torque) Fixing the Rim of a Drive Gear and a Boss Together Attaching and Fixing a Bearing Bushing

1.1 Generally Used Hole-basis System of Fits

Reference Hole	Class of Tolerance Range for Shafts: Clearance Fit						Transition Fit				Interference Fit					
H6					g5	h5	js5	k5	m5							
					f6	g6	h6	js6	k6	m6	n6*	p6*				
H7					f6	g6	h6	js6	k6	m6	n6	p6*	r6*	s6	t6	u6	x6
				e7	f7		h7	js7								
H8					f7		h7									
				e8	f8		h8									
			d9	e9												
H9			d8	e8			h8									
		c9	d9	e9			h9									
H10	b9	c9	d9													

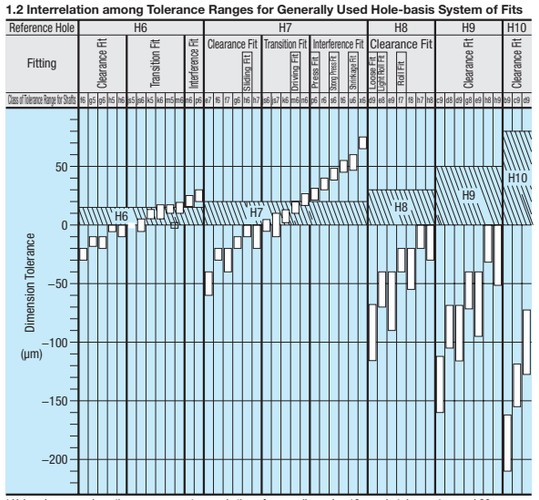
[Note]* An exception may arise according to the dimensional sectioning scheme.

2.1 Generally Used Shaft-basis System of Fits

Reference Shaft	Class of Tolerance Range for Holes: Clearance Fit						Transition Fit				Interference Fit					
h5							H6	JS6	K6	M6	N6*	P6				
h6					F6	G6	H6	JS6	K6	M6	N6	P6*				
					F7	G7	H7	JS7	K7	M7	N7	P7*	R7	S7	T7	U7	X7
h7				E7	F7		H7									
					F8		H8									
h8			D8	E8	F8		H8									
			D9	E9			H9									
h9			D8	E8			H8									
		C9	D9	E9			H9									
	B10	C10	D10													

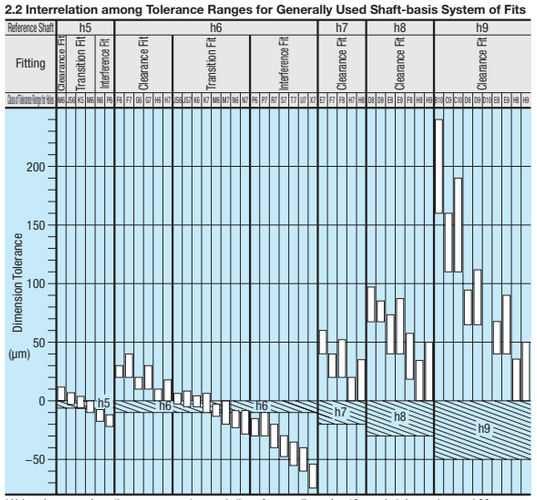
[Note]* An exception may arise according to the dimensional sectioning scheme.

1.2 Interrelation among Tolerance Ranges for Generally Used Hole-basis System of Fits



* Values in cases where the measurement exceeds the reference dimension 18 mm, but does not exceed 30 mm.

2.2 Interrelation among Tolerance Ranges for Generally Used Shaft-basis System of Fits



* Values in cases where the measurement exceeds the reference dimension 18 mm, but does not exceed 30 mm.

General Technical Information
Dimension Tolerance for Regularly Used Fitting

Dimension Tolerance for Generally Used Hole Fits

Reference Dimension (mm)		Class of Tolerance Range for Shafts																														Unit μm
More than	or Less	b9	c9	d8	d9	e7	e8	e9	f6	f7	f8	g5	g6	h5	h6	h7	h8	h9	js5	js6	js7	k5	k6	m5	m6	n5*	n6	p6	r6	s6	t6	u6	x6
–	3	−140 −165	−60 −85	−20 −34	−20 −45	−14 −24	−14 −28	−14 −39	−6 −12	−6 −16	−6 −20	−2 −6	−2 −8	0 −4	0 −6	0 −10	0 −14	0 −25	±2	±3	±5	+4 0	+6 0	+6 +2	+8 +2	+8 +4	+10 +4	+12 +6	+16 +10	+20 +14	–	+24 +18	+26 +20
3	6	−140 −170	−70 −100	−30 −48	−30 −60	−20 −32	−20 −38	−20 −50	−10 −18	−10 −22	−10 −28	−4 −9	−4 −12	0 −5	0 −8	0 −12	0 −18	0 −30	±2.5	±4	±6	+6 +1	+9 +1	+9 +4	+12 +4	+13 +8	+16 +8	+20 +12	+23 +15	+27 +19	–	+31 +23	+36 +28
6	10	−150 −186	−80 −116	−40 −62	−40 −76	−25 −40	−25 −47	−25 −61	−13 −22	−13 −28	−13 −35	−5 −11	−5 −14	0 −6	0 −9	0 −15	0 −22	0 −36	±3	±4.5	±7.5	+7 +1	+10 +1	+12 +6	+15 +6	+16 +10	+19 +10	+24 +15	+28 +19	+32 +23	–	+37 +28	+43 +34
10	14	−150 −193	−95 −138	−50 −77	−50 −93	−32 −50	−32 −59	−32 −75	−16 −27	−16 −34	−16 −43	−6 −14	−6 −17	0 −8	0 −11	0 −18	0 −27	0 −43	±4	±5.5	±9	+9 +1	+12 +1	+15 +7	+18 +7	+20 +12	+23 +12	+29 +18	+34 +23	+39 +28	–	+44 +33	+51 +40 +56 +45
14	18																																
18	24	−160 −212	−110 −162	−65 −98	−65 −117	−40 −61	−40 −73	−40 −92	−20 −33	−20 −41	−20 −53	−7 −16	−7 −20	0 −9	0 −13	0 −21	0 −33	0 −52	±4.5	±6.5	±10.5	+11 +2	+15 +2	+17 +8	+21 +8	+24 +15	+28 +15	+35 +22	+41 +28	+48 +35	–	+54 +41	+67 +54
24	30																														+54 +41	+61 +48	+77 +64
30	40	−170 −232	−120 −182	−80	−80 −142	−50 −75	−50 −89	−50 −112	−25 −41	−25 −50	−25 −64	−9 −20	−9 −25	0 −11	0 −16	0 −25	0 −39	0 −62	±5.5	±8	±12.5	+13 +2	+18 +2	+20 +9	+25 +9	+28 +17	+33 +17	+42 +26	+50 +34	+59 +43	–	+64 +48	+76 +60
40	50	−180 −242	−130 −192																													+70 +54	+86 +70
50	65	−190 −264	−140 −214	−100	−100	−60	−60	−60	−30	−30	−30	−10	−10	0	0	0	0	0	±6.5	±9.5	±15	+15 +2	+21 +2	+24 +11	+30 +11	+33 +20	+39 +20	+51 +32	+60 +41	+72 +53	–	+85 +66	+106 +87
65	80	−200 −274	−150 −224	−146	−174	−90	−106	−134	−49	−60	−76	−23	−29	−13	−19	−30	−46	−74											+62 +43	+78 +59		+94 +75	+121 +102
80	100	−220 −307	−170 −257	−120	−120	−72	−72	−72	−36	−36	−36	−12	−12	0	0	0	0	0	±7.5	±11	±17.5	+18 +3	+25 +3	+28 +13	+35 +13	+38 +23	+45 +23	+59 +37	+73 +51	+93 +71	–	+113 +91	+146 +124
100	120	−240 −327	−180 −267	−174	−207	−107	−126	−159	−58	−71	−90	−27	−34	−15	−22	−35	−54	−87											+76 +54	+101 +79		+126 +104	+166 +144
120	140	−260 −360	−200 −300	−145 −208	−145 −245	−85 −125	−85 −148	−85 −185	−43 −68	−43 −83	−43 −106	−14 −32	−14 −39	0 −18	0 −25	0 −40	0 −63	0 −100	±9	±12.5	±20	+21 +3	+28 +3	+33 +15	+40 +15	–	+52 +27	+68 +43	+88 +63	+117 +92	+147 +122	–	–
140	160	−280 −380	−210 −310																										+90 +65	+125 +100	+159 +134		
160	180	−310 −410	−230 −330																										+93 +68	+133 +108	+171 +146		
180	200	−340 −455	−240 −355	−170 −242	−170 −285	−100 −146	−100 −172	−100 −215	−50 −79	−50 −96	−50 −122	−15 −35	−15 −44	0 −20	0 −29	0 −46	0 −72	0 −115	±10	±14.5	±23	+24 +4	+33 +4	+37 +17	+46 +17	–	+60 +31	+79 +50	+106 +77	+151 +122	–	–	–
200	225	−380 −495	−260 −375																										+109 +80	+159 +130			
225	250	−420 −535	−280 −395																										+113 +84	+169 +140			
250	280	−480 −610	−300 −430	−190 −271	−190 −320	−110 −162	−110 −191	−110 −240	−56 −88	−56 −108	−56 −137	−17 −40	−17 −49	0 −23	0 −32	0 −52	0 −81	0 −130	±11.5	±16	±26	+27 +4	+36 +4	+43 +20	+52 +20	–	+66 +34	+88 +56	+126 +94	–	–	–	–
280	315	−540 −670	−330 −460																										+130 +98				
315	355	−600 −740	−360 −500	−210 −299	−210 −350	−125 −182	−125 −214	−125 −265	−62 −98	−62 −119	−62 −151	−18 −43	−18 −54	0 −25	0 −36	0 −57	0 −89	0 −140	±12.5	±18	±28.5	+29 +4	+40 +4	+46 +21	+57 +21	–	+73 +37	+98 +62	+144 +108	–	–	–	–
355	400	−680 −820	−400 −540																										+150 +114				
400	450	−760 −915	−440 −595	−230 −327	−230 −385	−135 −198	−135 −232	−135 −290	−68 −108	−68 −131	−68 −165	−20 −47	−20 −60	0 −27	0 −40	0 −63	0 −97	0 −155	±13.5	±20	±31.5	+32 +5	+45 +5	+50 +23	+63 +23	–	+80 +40	+108 +68	+166 +126	–	–	–	–
450	500	−840 −995	−480 −635																										+172 +132				

Dimension Tolerance for Generally Used Shaft Fits

Reference Dimension (mm)		Class of Tolerance Range for Holes																															Unit μm
More than	or Less	B10	C9	C10	D8	D9	D10	E7	E8	E9	F6	F7	F8	G6	G7	H6	H7	H8	H9	H10	JS6	JS7	K6	K7	M6	M7	N6	N7	P6	P7	R7	S7	T7	U7	X7
–	3	+180 +140	+85 +60	+100 +60	+34 +20	+45 +20	+60 +20	+24 +14	+28 +14	+39 +14	+12 +6	+16 +6	+20 +6	+8 +2	+12 +2	+6 0	+10 0	+14 0	+25 0	+40 0	±3	±5	0 −6	0 −10	−2 −8	−2 −12	−4 −10	−4 −14	−6 −12	−6 −16	−10 −20	−14 −24	–	−18 −28	−20 −30
3	6	+188 +140	+100 +70	+118 +70	+48 +30	+60 +30	+78 +30	+32 +20	+38 +20	+50 +20	+18 +10	+22 +10	+28 +10	+12 +4	+16 +4	+8 0	+12 0	+18 0	+30 0	+48 0	±4	±6	+2 −6	+3 −9	−1 −9	0 −12	−5 −13	−4 −16	−9 −17	−8 −20	−11 −23	−15 −27	–	−19 −31	−24 −36
6	10	+208 +150	+116 +80	+138 +80	+62 +40	+76 +40	+98 +40	+40 +25	+47 +25	+61 +25	+22 +13	+28 +13	+35 +13	+14 +5	+20 +5	+9 0	+15 0	+22 0	+36 0	+58 0	±4.5	±7.5	+2 −7	+5 −10	−3 −12	0 −15	−7 −16	−4 −19	−12 −21	−9 −24	−13 −28	−17 −32	–	−22 −37	−28 −43
10	14	+220 +150	+138 +95	+165 +95	+77 +50	+93 +50	+120 +50	+50 +32	+59 +32	+75 +32	+27 +16	+34 +16	+43 +16	+17 +6	+24 +6	+11 0	+18 0	+27 0	+43 0	+70 0	±5.5	±9	+2 −9	+6 −12	−4 −15	0 −18	−9 −20	−5 −23	−15 −26	−11 −29	−16 −34	−21 −39	–	−26 −44	−33 −51 −38 −56
14	18																																		
18	24	+244 +160	+162 +110	+194 +110	+98 +65	+117 +65	+149 +65	+61 +40	+73 +40	+92 +40	+33 +20	+41 +20	+53 +20	+20 +7	+28 +7	+13 0	+21 0	+33 0	+52 0	+84 0	±6.5	±10.5	+2 −11	+6 −15	−4 −17	0 −21	−11 −24	−7 −28	−18 −31	−14 −35	−20 −41	−27 −48	–	−33 −54	−46 −67
24	30																																−33 −54	−40 −61	−56 −77
30	40	+270 +170	+182 +120	+220 +120	+119 +80	+142 +80	+180 +80	+75 +50	+89 +50	+112 +50	+41 +25	+50 +25	+64 +25	+25 +9	+34 +9	+16 0	+25 0	+39 0	+62 0	+100 0	±8	±12.5	+3 −13	+7 −18	−4 −20	0 −25	−12 −28	−8 −33	−21 −37	−17 −42	−25 −50	−34 −59	–	−39 −64 −45 −70	−51 −76 −61 −86
40	50	+280 +180	+192 +130	+230 +130																															
50	65	+310 +190	+214 +140	+260 +140	+146 +100	+174 +100	+220 +100	+90 +60	+106 +60	+134 +60	+49 +30	+60 +30	+76 +30	+29 +10	+40 +10	+19 0	+30 0	+46 0	+74 0	+120 0	±9.5	±15	+4 −15	+9 −21	−5 −24	0 −30	−14 −33	−9 −39	−26 −45	−21 −51	−30 −60	−42 −72	−55 −85	−76 −106	–
65	80	+320 +200	+224 +150	+270 +150																											−32 −62	−48 −78	−64 −94	−91 −121	
80	100	+360 +220	+257 +170	+310 +170	+174 +120	+207 +120	+260 +120	+107 +72	+126 +72	+159 +72	+58 +36	+71 +36	+90 +36	+34 +12	+47 +12	+22 0	+35 0	+54 0	+87 0	+140 0	±11	±17.5	+4 −18	+10 −25	−6 −28	0 −35	−16 −38	−10 −45	−30 −52	−24 −59	−38 −73	−58 −93	−78 −113	−111 −146	–
100	120	+380 +240	+267 +180	+320 +180																											−41 −76	−66 −101	−91 −126	−131 −166	
120	140	+420 +260	+300 +200	+360 +200	+208 +145	+245 +145	+305 +145	+125 +85	+148 +85	+185 +85	+68 +43	+83 +43	+106 +43	+39 +14	+54 +14	+25 0	+40 0	+63 0	+100 0	+160 0	±12.5	±20	+4 −21	+12 −28	−8 −33	0 −40	−20 −45	−12 −52	−36 −61	−28 −68	−48 −88	−77 −117	−107 −147	–	–
140	160	+440 +280	+310 +210	+370 +210																											−50 −90	−85 −125	−119 −159		
160	180	+470 +310	+330 +230	+390 +230																											−53 −93	−93 −133	−131 −171		
180	200	+525 +340	+355 +240	+425 +240	+242 +170	+285 +170	+355 +170	+146 +100	+172 +100	+215 +100	+79 +50	+96 +50	+122 +50	+44 +15	+61 +15	+29 0	+46 0	+72 0	+115 0	+185 0	±14.5	±23	+5 −24	+13 −33	−8 −37	0 −46	−22 −51	−14 −60	−41 −70	−33 −79	−60 −106	−105 −151	–	–	–
200	225	+565 +380	+375 +260	+445 +260																											−63 −109	−113 −159			
225	250	+605 +420	+395 +280	+465 +280																											−67 −113	−123 −169			
250	280	+690 +480	+430 +300	+510 +300	+271 +190	+320 +190	+400 +190	+162 +110	+191 +110	+240 +110	+88 +56	+108 +56	+137 +56	+49 +17	+69 +17	+32 0	+52 0	+81 0	+130 0	+210 0	±16	±26	+5 −27	+16 −36	−9 −41	0 −52	−25 −57	−14 −66	−47 −79	−36 −88	−74 −126	–	–	–	–
280	315	+750 +540	+460 +330	+540 +330																											−78 −130				
315	355	+830 +600	+500 +360	+590 +360	+299 +210	+350 +210	+440 +210	+182 +125	+214 +125	+265 +125	+98 +62	+119 +62	+151 +62	+54 +18	+75 +18	+36 0	+57 0	+89 0	+140 0	+230 0	±18	±28.5	+7 −29	+17 −40	−10 −46	0 −57	−26 −62	−16 −73	−51 −87	−41 −98	−87 −144	–	–	–	–
355	400	+910 +680	+540 +400	+630 +400																											−93 −150				
400	450	+1010 +760	+595 +440	+690 +440	+327 +230	+385 +230	+480 +230	+198 +135	+232 +135	+290 +135	+108 +68	+131 +68	+165 +68	+60 +20	+83 +20	+40 0	+63 0	+97 0	+155 0	+250 0	±20	±31.5	+8 −32	+18 −45	−10 −50	0 −63	−27 −67	−17 −80	−55 −95	−45 −108	−103 −166	–	–	–	–
450	500	+1090 +840	+635 +480	+730 +480																											−109 −172				

Reference In each column, the upper value is the upper dimensional tolerance, and the lower figure is the lower one. [Note]*:n5 is the previous version of JIS. Presented here because many MISUMI products conform to this version.

General Technical Information
Surface Roughness

1. Varieties of Surface Roughness Indicators

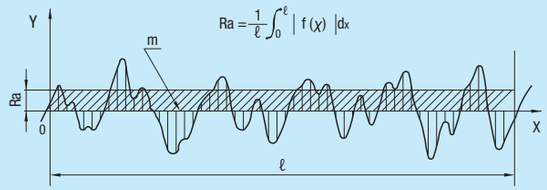
Definitions and presentations of arithmetic average roughness (Ra), maximum height (Ry), 10 spot average roughness (Rz), average concave to convex distance (Sm), average distance between local peaks S and load length rate tp are given as parameters indicating the surface roughness of an industrial product. Surface roughness is the arithmetical average of values at randomly extracted spots on the surface of an object.

[Centerline average roughness (Ra_{75}) is defined in the supplements to JIS B 0031 and JIS B 0601.]

■Typical calculations of surface roughness

Arithmetic Average Roughness Ra

Some portion is extracted from the roughness curve in the direction of the reference line and by the reference length. This portion is presented in a new graph with the X axis extending in the same direction as the average line and the Y axis representing the magnitude. Ra is represented by the equation shown at right, in microns (μm).

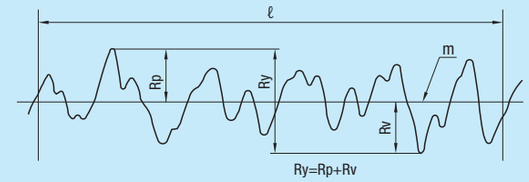


$$Ra = \frac{1}{\ell}\int_0^{\ell} |f(x)|\,dx$$

Maximum Height Ry

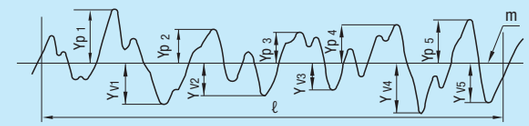
Some portion is extracted from the roughness curve in the direction of the reference line and by the reference length. The gap between the peak line and the trough line is measured in the direction in which the magnitude axis extends, in microns (μm).

Remarks: For Ry, find an area which has no extremely high peak or extremely low trough as the mark of flaw, and then extract the above reference length portion from this area.



Ten-spot Average Roughness Rz

Some portion is extracted from the roughness curve in the direction of the reference line and by the reference length. The average of the levels (Yp) of the highest peak to the fifth highest peak as measured from the average line and the average of the levels (Yp) of the lowest trough to the fifth lowest trough similarly measured in the said portion are added together. Rz is this sum, in microns (μm).



$$Rz = \frac{|Yp_1 + Yp_2 + Yp_3 + Yp_4 + Yp_5| + |Yv_1 + Yv_2 + Yv_3 + Yv_4 + Yv_5|}{5}$$

$Yp_1, Yp_2, Yp_3, Yp_4, Yp_5$: Levels of the highest peak to the fifth highest peak in the said portion with the reference length ℓ.

$Yv_1, Yv_2, Yv_3, Yv_4, Yv_5$: Levels of the lowest trough to the fifth lowest trough in the said portion with the reference length ℓ.

Reference Relation between Arithmetic Average Roughness (Ra) and Conventional Parameters

Arithmetic Average Roughness Ra: Standard Series	Cut-off Value c(mm)	Graphical Representation of Surface Texture	Maximum Height Ry: Standard Series	Ten-spot Average Roughness Rz: Standard Series	Reference Length of Ry (Rz) ℓ (mm)	Conventional Finish Symbol
0.012 a 0.025 a 0.05 a 0.1 a 0.2 a	0.08	0.012 ~ 0.2	0.05 s 0.1 s 0.2 s 0.4 s 0.8 s	0.05 z 0.1 z 0.2 z 0.4 z 0.8 z	0.08	▽▽▽▽
	0.25				0.25	
	0.8				0.8	
0.4 a 0.8 a 1.6 a		0.4 ~ 1.6	1.6 s 3.2 s 6.3 s	1.6 z 3.2 z 6.3 z		▽▽▽
3.2 a 6.3 a	2.5	3.2 ~ 6.3	12.5 s 25 s	12.5 z 25 z	2.5	▽▽
12.5 a 25 a	8	12.5 ~ 25	50 s 100 s	50 z 100 z	8	▽
50 a 100 a	–	50 ~ 100	200 s 400 s	200 z 400 z	–	~

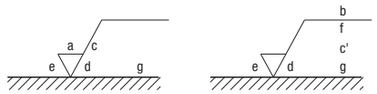
* Interrelations among the three types shown here are not precise, and are presented for convenience only.

* Ra:The evaluation values of Ry and Rz are the cut-off value and the reference length each multiplied by five, respectively.

1. Positions of Auxiliary Symbols for Surface Symbol

A surface roughness value, cut-off value or reference length, machining method, grain direction, surface undulation, etc. are indicated with the surface symbol as shown in Fig. 1 below.

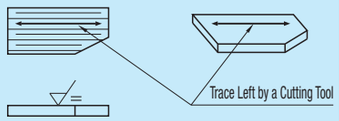
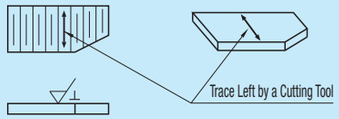
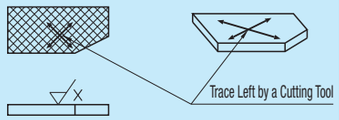
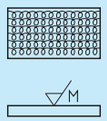
Fig. 1 Positions of Auxiliary Symbols



a : Ra Value
b : Machining Method
c : Cut-Off Value, Evaluation Length
c' : Reference Length, Evaluation Length
d : Grain Direction
f : Parameter other than Ra (tp:Parameter/Cut-Off Level)
g : Surface Undulation (JIS B 0610)

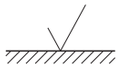
Reference These symbols except a and f are provided when they are needed.

Reference Under ISO 1302, a finish range should be indicated as e in Fig. 1.

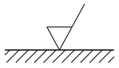
Code	Meaning	Illustration
=	The trace left by a cutting tool is parallel to the projection plane in the drawing. Ex. Shaped Surface	
⊥	The trace left by a cutting tool is perpendicular to the projection plane in the drawing. Ex. Shaped Surface(Side View) Circular Cut, Cylindrical Cut	
X	The pattern left by a cutting tool diagonally crosses the projection plane in the drawing. Ex. Honed Surface	
M	The pattern left by a cutting tool crosses in various directions or has no grain direction. Ex. Lapped Surface, Superfinished Surface and Surface Finished with a Front Mill or End Mill	
C	The pattern left by a cutting tool is virtually concentric around the center of the plane in the drawing. Ex. Faced Surface	
R	The pattern left by a cutting tool is virtually radial around the center of the plane in the drawing.	

Examples of Graphical Representation of Surface Texture

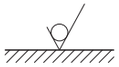
Surface Symbol



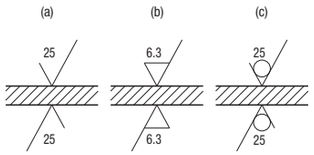
Removal of Material by Machining is required



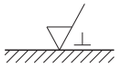
Removal of Material is Prohibited



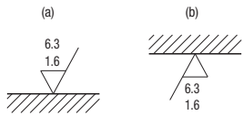
Upper Limit of Ra



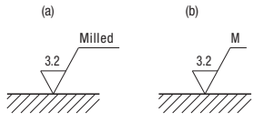
Grain Direction



Upper and Lower Limits of Ra



Machining Method

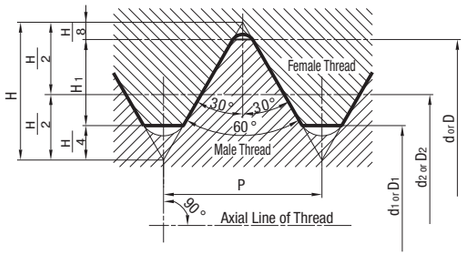


Approximate Conversion of Rockwell C Hardness Values for Steel(1)

(HRC) Rockwell C-Scale Hardness	(HV) Vickers Hardness	Brinell Hardness (HB) 10mm Ball , Load 3000kgf		Rockwell Hardness(3)			Rockwell Superficial Hardness Diamond Cone Indenter			(Hs) Shore Hardness	Tensile Strength (Approximated Value) Mpa (kgf/mm²) (2)	Rockwell C-Scale Hardness (3)
		Standard Sphere	Tungsten Carbide Sphere	(HRA) A Scale, Load 60kgf, Diamond Cone Indenter	(HRB) B Scale, Load100kgf, Diameter1.6mm (1/16in) Sphere	(HRD) D Scale, Load 100kgf, Diamond Cone Indenter	15-N Scale Load 15kgf	30-N Scale Load 30kgf	45-N Scale Load 45kgf			
68	940	–	–	85.6	–	76.9	93.2	84.4	75.4	97	–	68
67	900	–	–	85.0	–	76.1	92.9	83.6	74.2	95	–	67
66	865	–	–	84.5	–	75.4	92.5	82.8	73.3	92	–	66
65	832	–	(739)	83.9	–	74.5	92.2	81.9	72.0	91	–	65
64	800	–	(722)	83.4	–	73.8	91.8	81.1	71.0	88	–	64
63	772	–	(705)	82.8	–	73.0	91.4	80.1	69 9	87	–	63
62	746	–	(688)	82.3	–	72.2	91.1	79.3	68.8	85	–	62
61	720	–	(670)	81.8	–	71.5	90.7	78.4	67.7	83	–	61
60	697	–	(654)	81.2	–	70.7	90.2	77.5	66.6	81	–	60
59	674	–	(634)	80.7	–	69.9	89.8	76.6	65.5	80	–	59
58	653	–	615	80.1	–	69.2	89.3	75.7	64.3	78	–	58
57	633	–	595	79.6	–	68.5	88.9	74.8	63.2	76	–	57
56	613	–	577	79.0	–	67.7	88.3	73.9	62.0	75	–	56
55	595	–	560	78.5	–	66.9	87.9	73.0	60.9	74	2075(212)	55
54	577	–	543	78.0	–	66.1	87.4	72.0	59.8	72	2015(205)	54
53	560	–	525	77.4	–	65.4	86.9	71.2	58.5	71	1950(199)	53
52	544	(500)	512	76.8	–	64.6	86.4	70.2	57.4	69	1880(192)	52
51	528	(487)	496	76.3	–	63.8	85.9	69.4	56.1	68	1820(186)	51
50	513	(475)	481	75.9	–	63.1	85.5	68.5	55.0	67	1760(179)	50
49	498	(464)	469	75.2	–	62.1	85.0	67.6	53.8	66	1695(173)	49
48	484	451	455	74.7	–	61.4	84.5	66.7	52.5	64	1635(167)	48
47	471	442	443	74.1	–	60.8	83.9	65.8	51.4	63	1580(161)	47
46	458	432	432	73.6	–	60.0	83.5	64.8	50.3	62	1530(156)	46
45	446	421	421	73.1	–	59.2	83.0	64.0	49.0	60	1480(151)	45
44	434	409	409	72.5	–	58.5	82.5	63.1	47.8	58	1435(146)	44
43	423	400	400	72.0	–	57.7	82.0	62.2	46.7	57	1385(141)	43
42	412	390	390	71.5	–	56.9	81.5	61.3	45.5	56	1340(136)	42
41	402	381	381	70.9	–	56.2	80.9	60.4	44.3	55	1295(132)	41
40	392	371	371	70.4	–	55.4	80.4	59.5	43.1	54	1250(127)	40
39	382	362	362	69.9	–	54.6	79.9	58.6	41.9	52	1215(124)	39
38	372	353	353	69.4	–	53.8	79.4	57.7	40.8	51	1180(120)	38
37	363	344	344	68.9	–	53.1	78.8	56.8	39.6	50	1160(118)	37
36	354	336	336	68.4	(109.0)	52.3	78.3	55.9	38.4	49	1115(114)	36
35	345	327	327	67.9	(108.5)	51.5	77.7	55.0	37.2	48	1080(110)	35
34	336	319	319	67.4	(108.0)	50.8	77.2	54.2	36.1	47	1055(108)	34
33	327	311	311	66.8	(107.5)	50.0	76.6	53.3	34.9	46	1025(105)	33
32	318	301	301	66.3	(107.0)	49.2	76.1	52.1	33.7	44	1000(102)	32
31	310	294	294	65.8	(106.0)	48.4	75.6	51.3	32.7	43	980(100)	31
30	302	286	286	65.3	(105.5)	47.7	75.0	50.4	31.3	42	950 (97)	30
29	294	279	279	64.7	(104.5)	47.0	74.5	49.5	30.1	41	930 (95)	29
28	286	271	271	64.3	(104.0)	46.1	73.9	48.6	28.9	41	910 (93)	28
27	279	264	264	63.8	(103.0)	45.2	73.3	47.7	27.8	40	880 (90)	27
26	272	258	258	63.3	(102.5)	44.6	72.8	46.8	26.7	38	860 (88)	26
25	266	253	253	62.8	(101.5)	43.8	72.2	45.9	25.5	38	840 (86)	25
24	260	247	247	62.4	(101.0)	43.1	71.6	45.0	24.3	37	825 (84)	24
23	254	243	243	62.0	100.0	42.1	71.0	44.0	23.1	36	805 (82)	23
22	248	237	237	61.5	99.0	41.6	70.5	43.2	22.0	35	785 (80)	22
21	243	231	231	61.0	98.5	40.9	69.9	42.3	20.7	35	770 (79)	21
20	238	226	226	60.5	97.8	40.1	69.4	41.5	19.6	34	760 (77)	20
(18)	230	219	219	–	96.7	–	–	–	–	33	730 (75)	(18)
(16)	222	212	212	–	95.5	–	–	–	–	32	705 (72)	(16)
(14)	213	203	203	–	93.9	–	–	–	–	31	675 (69)	(14)
(12)	204	194	194	–	92.3	–	–	–	–	29	650 (66)	(12)
(10)	196	187	187	–	90.7	–	–	–	–	28	620 (63)	(10)
(8)	188	179	179	–	89.5	–	–	–	–	27	600 (61)	(8)
(6)	180	171	171	–	87.1	–	–	–	–	26	580 (59)	(6)
(4)	173	165	165	–	85.5	–	–	–	–	25	550 (56)	(4)
(2)	166	158	158	–	83.5	–	–	–	–	24	530 (54)	(2)
(0)	160	152	152	–	81.7	–	–	–	–	24	515 (53)	(0)

Note(1): Blue figures: Based on ASTM E 140, Table 1 (Jointly coordinated by SAE, ASM and ASTM).
(2): The units and figures shown in brackets are the results of conversion from psi figures by reference to JIS Z 8413 and Z 8438 conversion tables. Moreover, 1MPa=1N/mm²
(3): The figures in brackets are in ranges not frequently used. They are given as referential data.

General Technical Information
Metric Coarse Screw Threads



$H = 0.866025P$ $\quad D = d$

$H_1 = 0.541266P$ $\quad D_2 = d_2$

$D_1 = d_1$

$d_2 = d - 0.649519P$

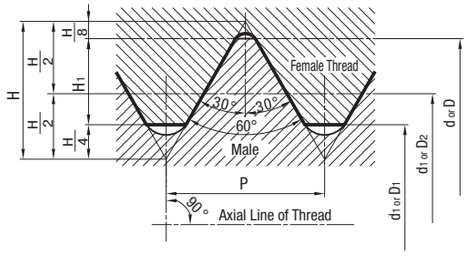
$d_1 = d - 1.082532P$

Unit:mm

Nominal of Thread (1)*			Pitch P	Height of Engagement H_1	Female Thread		
					Minor Dia. D	Effective Dia. D_2	Inner Dia. D_1
					Male Thread		
Column 1	Column 2	Column 3			Outer Dia. d	Effective Dia. d_2	Inner Dia. d_1
M 1			0.25	0.135	1.000	0.838	0.729
	M 1.1		0.25	0.135	1.100	0.938	0.829
M 1.2			0.25	0.135	1.200	1.038	0.929
	M 1.4		0.3	0.162	1.400	1.205	1.075
M 1.6			0.35	0.189	1.600	1.373	1.221
	M 1.8		0.35	0.189	1.800	1.573	1.421
M 2			0.4	0.217	2.000	1.740	1.567
	M 2.2		0.45	0.244	2.200	1.908	1.713
M 2.5			0.45	0.244	2.500	2.208	2.013
M 3			0.5	0.271	3.000	2.675	2.459
	M 3.5		0.6	0.325	3.500	3.110	2.850
M 4			0.7	0.379	4.000	3.545	3.242
	M 4.5		0.75	0.406	4.500	4.013	3.688
M 5			0.8	0.433	5.000	4.480	4.134
M 6			1	0.541	6.000	5.350	4.917
		M 7	1	0.541	7.000	6.350	5.917
M 8			1.25	0.677	8.000	7.188	6.647
		M 9	1.25	0.677	9.000	8.188	7.647
M10			1.5	0.812	10.000	9.026	8.376
		M11	1.5	0.812	11.000	10.026	9.376
M12			1.75	0.947	12.000	10.863	10.106
	M14		2	1.083	14.000	12.701	11.835
M16			2	1.083	16.000	14.701	13.835
	M18		2.5	1.353	18.000	16.376	15.294
M20			2.5	1.353	20.000	18.376	17.294
	M22		2.5	1.353	22.000	20.376	19.294
M24			3	1.624	24.000	22.051	20.752
	M27		3	1.624	27.000	25.051	23.752
M30			3.5	1.894	30.000	27.727	26.211
	M33		3.5	1.894	33.000	30.727	29.211
M36			4	2.165	36.000	33.402	31.670
	M39		4	2.165	39.000	36.402	34.670
M42			4.5	2.436	42.000	39.077	37.129
	M45		4.5	2.436	45.000	42.077	40.129
M48			5	2.706	48.000	44.752	42.587
	M52		5	2.706	52.000	48.752	46.587
M56			5.5	2.977	56.000	52.428	50.046
	M60		5.5	2.977	60.000	56.428	54.046
M64			6	3.248	64.000	60.103	57.505
	M68		6	3.248	68.000	64.103	61.505

*Priority should be given to Column 1. If required, select items in the order from Column 2 to Column 3.

General Technical Information
Metric Fine Screw Threads



$H = 0.866025P$ $\quad D = d$

$H_1 = 0.541266P$ $\quad D_2 = d_2$

$D_1 = d_1$

$d_2 = d - 0.649519P$

$d_1 = d - 1.082532P$

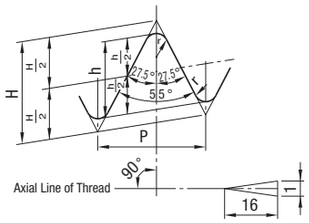
Unit: mm

Nominal of Thread	Pitch P	Height of Engagement H_1	Female Thread		
			Minor Dia. D	Effective Dia. D_2	Inner Dia. D_1
			Male Thread		
			Outer Dia. d	Effective Dia. d_2	Inner Dia. d_1
M 1 ×0.2	0.2	0.108	1.000	0.870	0.783
M 1.1×0.2	0.2	0.108	1.100	0.970	0.883
M 1.2×0.2	0.2	0.108	1.200	1.070	0.983
M 1.4×0.2	0.2	0.108	1.400	1.270	1.183
M 1.6×0.2	0.2	0.108	1.600	1.470	1.383
M 1.8×0.2	0.2	0.108	1.800	1.670	1.583
M 2 ×0.25	0.25	0.135	2.000	1.838	1.729
M 2.2×0.25	0.25	0.135	2.200	2.038	1.929
M 2.5×0.35	0.35	0.189	2.500	2.273	2.121
M 3 ×0.35	0.35	0.189	3.000	2.773	2.621
M 3.5×0.35	0.35	0.189	3.500	3.273	3.121
M 4 ×0.5	0.5	0.271	4.000	3.675	3.459
M 4.5×0.5	0.5	0.271	4.500	4.175	3.959
M 5 ×0.5	0.5	0.271	5.000	4.675	4.459
M 5.5×0.5	0.5	0.271	5.500	5.175	4.959
M 6 ×0.75	0.75	0.406	6.000	5.513	5.188
M 7 ×0.75	0.75	0.406	7.000	6.513	6.188
M 8 ×1	1	0.541	8.000	7.350	6.917
M 8 ×0.75	0.75	0.406	8.000	7.513	7.188
M 9 ×1	1	0.541	9.000	8.350	7.917
M 9 ×0.75	0.75	0.406	9.000	8.513	8.188
M 10 ×1.25	1.25	0.677	10.000	9.188	8.647
M 10 ×1	1	0.541	10.000	9.350	8.917
M 10 ×0.75	0.75	0.406	10.000	9.513	9.188
M 11 ×1	1	0.541	11.000	10.350	9.917
M 11 ×0.75	0.75	0.406	11.000	10.513	10.188
M 12 ×1.5	1.5	0.812	12.000	11.026	10.376
M 12 ×1.25	1.25	0.677	12.000	11.188	10.647
M 12 ×1	1	0.541	12.000	11.350	10.917
M 14 ×1.5	1.5	0.812	14.000	13.026	12.376
M 14 ×1.25	1.25	0.677	14.000	13.188	12.647
M 14 ×1	1	0.541	14.000	13.350	12.917
M 15 ×1.5	1.5	0.812	15.000	14.026	13.376
M 15 ×1	1	0.541	15.000	14.350	13.917
M 16 ×1.5	1.5	0.812	16.000	15.026	14.376
M 16 ×1	1	0.541	16.000	15.350	14.917
M 17 ×1.5	1.5	0.812	17.000	16.026	15.376
M 17 ×1	1	0.541	17.000	16.350	15.917
M 18 ×2	2	1.083	18.000	16.701	15.835
M 18 ×1.5	1.5	0.812	18.000	17.026	16.376
M 18 ×1	1	0.541	18.000	17.350	16.917
M 20 ×2	2	1.083	20.000	18.701	17.835
M 20 ×1.5	1.5	0.812	20.000	19.026	18.376
M 20 ×1	1	0.541	20.000	19.350	18.917
M 22 ×2	2	1.083	22.000	20.701	19.835
M 22 ×1.5	1.5	0.812	22.000	21.026	20.376
M 22 ×1	1	0.541	22.000	21.350	20.917
M 24 ×2	2	1.083	24.000	22.701	21.835
M 24 ×1.5	1.5	0.812	24.000	23.026	22.376
M 24 ×1	1	0.541	24.000	23.350	22.917

Nominal of Thread	Pitch P	Height of Engagement H_1	Female Thread		
			Minor Dia. D	Effective Dia. D_2	Inner Dia. D_1
			Male Thread		
			Outer Dia. d	Effective Dia. d_2	Inner Dia. d_1
M 25×2	2	1.083	25.000	23.701	22.835
M 25×1.5	1.5	0.812	25.000	24.026	23.376
M 25×1	1	0.541	25.000	24.350	23.917
M 26×1.5	1.5	0.812	26.000	25.026	24.376
M 27×2	2	1.083	27.000	25.701	24.835
M 27×1.5	1.5	0.812	27.000	26.026	25.376
M 27×1	1	0.541	27.000	26.350	25.917
M 28×2	2	1.083	28.000	26.701	25.835
M 28×1.5	1.5	0.812	28.000	27.026	26.376
M 28×1	1	0.541	28.000	27.350	26.917
M 30×3	3	1.624	30.000	28.051	26.752
M 30×2	2	1.083	30.000	28.701	27.835
M 30×1.5	1.5	0.812	30.000	29.026	28.376
M 30×1	1	0.541	30.000	29.350	28.917
M 32×2	2	1.082	32.000	30.701	29.835
M 32×1.5	1.5	0.812	32.000	31.026	30.376
M 33×3	3	1.624	33.000	31.051	29.752
M 33×2	2	1.083	33.000	31.701	30.835
M 33×1.5	1.5	0.812	33.000	32.026	31.376
M 35×1.5	1.5	0.812	35.000	34.026	33.376
M 36×3	3	1.624	36.000	34.051	32.752
M 36×2	2	1.083	36.000	34.701	33.835
M 36×1.5	1.5	0.812	36.000	35.026	34.376
M 38×1.5	1.5	0.812	38.000	37.026	36.376
M 39×3	3	1.624	39.000	37.051	35.752
M 39×2	2	1.083	39.000	37.701	36.835
M 39×1.5	1.5	0.812	39.000	38.026	37.376
M 40×3	3	1.624	40.000	38.051	36.752
M 40×2	2	1.083	40.000	38.701	37.835
M 40×1.5	1.5	0.812	40.000	39.026	38.376
M 42×4	4	2.165	42.000	39.402	37.670
M 42×3	3	1.624	42.000	40.051	38.752
M 42×2	2	1.083	42.000	40.701	39.835
M 42×1.5	1.5	0.812	42.000	41.026	40.376
M 45×4	4	2.165	45.000	42.402	40.670
M 45×3	3	1.624	45.000	43.051	41.752
M 45×2	2	1.083	45.000	43.701	42.835
M 45×1.5	1.5	0.812	45.000	44.026	43.376
M 48×4	4	2.165	48.000	45.402	43.670
M 48×3	3	1.624	48.000	46.051	44.752
M 48×2	2	1.083	48.000	46.701	45.835
M 48×1.5	1.5	0.812	48.000	47.026	46.376
M 50×3	3	1.624	50.000	48.051	46.752
M 50×2	2	1.083	50.000	48.701	47.835
M 50×1.5	1.5	0.812	50.000	49.026	48.376
M 52×4	4	2.165	52.000	49.402	47.670
M 52×3	3	1.624	52.000	50.051	48.752
M 52×2	2	1.083	52.000	50.701	49.835
M 52×1.5	1.5	0.812	52.000	51.026	50.376
M 55×4	4	2.165	55.000	52.402	50.670
M 55×3	3	1.624	55.000	53.051	51.752
M 55×2	2	1.083	55.000	53.701	52.835
M 55×1.5	1.5	0.812	55.000	54.026	53.376

■Reference Thread Shape and Reference Dimension

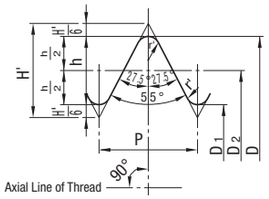
Reference Thread Shape and Basic Dimension for a Tapered Male/Female Thread



Thick Solid Lines: Reference Thread Shape

$P=\frac{25.4}{n}$
H=0.960237P
h=0.640327P
r =0.137278P

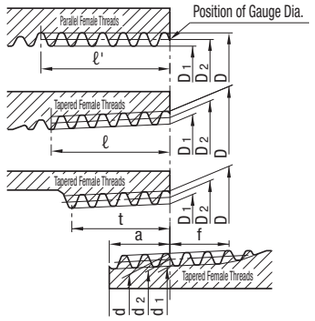
Reference Thread Shape for a Parallel Female Thread



Thick Solid Lines: Reference Thread Shape

$P=\frac{25.4}{n}$
H'=0.960491P
h =0.640327P
r' =0.137329P

Fitting together a tapered female thread or parallel female thread and a tapered male thread.



Unit: mm

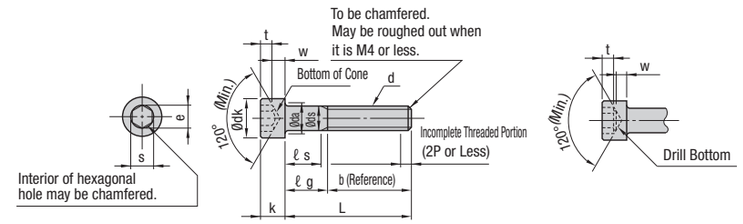
Nominal of Thread (1)	Thread: Number of Threads n (in 25.4 mm)	Thread: Pitch P (Reference)	Thread: Thread Height h	Thread: Roundness r or r'	Gauge Dia. Male Thread: Outer Dia. d	Gauge Dia. Male Thread: Effective Dia. d2	Gauge Dia. Male Thread: Minor Dia. d1	Gauge Dia. Female Thread: Minor Dia. D	Gauge Dia. Female Thread: Effective Dia. D2	Gauge Dia. Female Thread: Inner Dia. D1	Position of Gauge Dia. Male Thread From Pipe End: Reference Length a	Position of Gauge Dia. Male Thread From Pipe End: Axial Tolerance b	Position of Gauge Dia. Male Thread Pipe End / Female Thread From Pipe End: Axial Tolerance c	D, D2 and D1 Tolerances of Parallel Female Threads	Length of Effective Thread (Min.) Male Thread: From Position of Gauge Dia. Spot to Major Dia. Spot f	Length of Effective Thread (Min.) Female Thread With Incomplete Threaded Portion: Tapered Female Threads: From Position of Gauge Dia. Spot to Minor Dia. Spot ℓ	Length of Effective Thread (Min.) Female Thread With Incomplete Threaded Portion: Parallel Female Threads: From pipe end or pipe fitting end ℓ' (Reference)	Length of Effective Thread (Min.) Female Thread Without Incomplete Threaded Portion: Tapered Female Threads, Parallel Female Threads t(2)	Carbon Steel for Piping Size of Steel Pipe (Reference): Outer Diameter	Carbon Steel for Piping Size of Steel Pipe (Reference): Thickness
R1/16	28	0.9071	0.581	0.12	7.723	7.142	6.561	3.97	±0.91	±1.13	±0.071	2.5	6.2	7.4	4.4	–	–
R1/8	28	0.9071	0.581	0.12	9.728	9.147	8.566	3.97	±0.91	±1.13	±0.071	2.5	6.2	7.4	4.4	10.5	2.0
R1/4	19	1.3368	0.856	0.18	13.157	12.301	11.445	6.01	±1.34	±1.67	±0.104	3.7	9.4	11.0	6.7	13.8	2.3
R3/8	19	1.3368	0.856	0.18	16.662	15.806	14.950	6.35	±1.34	±1.67	±0.104	3.7	9.7	11.4	7.0	17.3	2.3
R1/2	14	1.8143	1.162	0.25	20.955	19.793	18.631	8.16	±1.81	±2.27	±0.142	5.0	12.7	15.0	9.1	21.7	2.8
R3/4	14	1.8143	1.162	0.25	26.441	25.279	24.117	9.53	±1.81	±2.27	±0.142	5.0	14.1	16.3	10.2	27.2	2.8
R1	11	2.3091	1.479	0.32	33.249	31.770	30.291	10.39	±2.31	±2.89	±0.181	6.4	16.2	19.1	11.6	34	3.2
R1 1/4	11	2.3091	1.479	0.32	41.910	40.431	38.952	12.70	±2.31	±2.89	±0.181	6.4	18.5	21.4	13.4	42.7	3.5
R1 1/2	11	2.3091	1.479	0.32	47.803	46.324	44.845	12.70	±2.31	±2.89	±0.181	6.4	18.5	21.4	13.4	48.6	3.5
R2	11	2.3091	1.479	0.32	59.614	58.135	56.656	15.88	±2.31	±2.89	±0.181	7.5	22.8	25.7	16.9	60.5	3.8
R2 1/2	11	2.3091	1.479	0.32	75.184	73.705	72.226	17.46	±3.46	±3.46	±0.216	9.2	26.7	30.1	18.6	76.3	4.2
R3	11	2.3091	1.479	0.32	87.884	86.405	84.926	20.64	±3.46	±3.46	±0.216	9.2	29.8	33.3	21.1	89.1	4.2
R4	11	2.3091	1.479	0.32	113.030	111.551	110.072	25.40	±3.46	±3.46	±0.216	10.4	35.8	39.3	25.9	114.3	4.5
R5	11	2.3091	1.479	0.32	138.430	136.951	135.472	28.58	±3.46	±3.46	±0.216	11.5	40.1	43.5	29.3	139.8	4.5
R6	11	2.3091	1.479	0.32	163.830	162.351	160.872	28.58	±3.46	±3.46	±0.216	11.5	40.1	43.5	29.3	165.2	5.0

Note(1): The nominal of a tapered male thread is given here. For a taper female thread or parallel female thread, R should be replaced with Rc or Rp. (Refer to*)
(2): Tapered thread: length from position of gauge dia. spot to a minor dia. spot.; Parallel female thread: length from a pipe end or pipe fitting end.

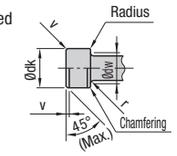
Reference 1. The threads should be at right angles to the central axial line, and the pitch should be measured along the central axial line.
2. The length of the effective thread means the length over which threads are fully provided. A pipe or a pipe fitting may be left in place on the crests of the last few threads. A chamfered end, if any, of a pipe or a pipe fitting should be included in the length of the effective thread.
3. When the value of a, f and t do not meet the requirements, the criteria of other standard is provided.

(*) Tapered threads type for a pipe are specified as taper male thread for a pipe, taper female thread and parallel female thread for a pipe.
The parallel female thread for a pipe should be mated with a tapered male thread for a pipe, and differs in dimension tolerances from the parallel female thread specified by JIS B 0202.

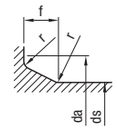
1. Dimensions of Sections



Rounded or Chamfered Head



Max. Rounding Beneath Neck



f (Max.)=1.7r (Max.)

$r\ (Max.)=\frac{da\ (Max.) - ds\ (Max.)}{2}$

r (Min.)= Value in the Attached Table

Unit: mm

Nominal of Thread (d)(2)		M2	M2.5	M3	M4	M5	M6	M8	M10	M12	(M14)	M16	(M18)	M20	(M22)	M24	(M27)	M30
Pitch of Thread (P)		0.4	0.45	0.5	0.7	0.8	1	1.25	1.5	1.75	2	2	2.5	2.5	2.5	3	3	3.5
b	Reference	16	17	18	20	22	24	28	32	36	40	44	48	52	56	60	66	72
dk	Max. (Basis)*	3.8	4.5	5.5	7	8.5	10	13	16	18	21	24	27	30	33	36	40	45
	Max.**	3.98	4.68	5.68	7.22	8.72	10.22	13.27	16.27	18.27	21.33	24.33	27.33	30.33	33.39	36.39	40.39	45.39
	Min.	3.62	4.32	5.32	6.78	8.28	9.78	12.73	15.73	17.73	20.67	23.67	26.67	29.67	32.61	35.61	39.61	44.61
da	Max.	2.6	3.1	3.6	4.7	5.7	6.8	9.2	11.2	13.7	15.7	17.7	20.2	22.4	24.4	26.4	30.4	33.4
ds	Max. (Basis)	2	2.5	3	4	5	6	8	10	12	14	16	18	20	22	24	27	30
	Min.	1.86	2.36	2.86	3.82	4.82	5.82	7.78	9.78	11.73	13.73	15.73	17.73	19.67	21.67	23.67	26.67	29.67
e	Min.	1.73	2.30	2.87	3.44	4.58	5.72	6.86	9.15	11.43	13.72	16.00	16.00	19.44	19.44	21.73	21.73	25.15
f	Max.	0.51	0.51	0.51	0.60	0.60	0.68	1.02	1.02	1.45	1.45	1.45	1.87	2.04	2.04	2.04	2.89	2.89
k	Max. (Basis)	2	2.5	3	4	5	6	8	10	12	14	16	18	20	22	24	27	30
	Min.	1.86	2.36	2.86	3.82	4.82	5.70	7.64	9.64	11.57	13.57	15.57	17.57	19.48	21.48	23.48	26.48	29.48
r	Min.	0.1	0.1	0.1	0.2	0.2	0.25	0.4	0.4	0.6	0.6	0.6	0.6	0.8	0.8	0.8	1	1
s	Nominal (Basis)	1.5	2	2.5	3	4	5	6	8	10	12	14	14	17	17	19	19	22
	Min.	1.52	2.02	2.52	3.02	4.02	5.02	6.02	8.025	10.025	12.032	14.032	14.032	17.05	17.050	19.065	19.065	22.065
	Max. (1) Column 1	1.560	2.060	2.580	3.080	4.095	5.140	6.140	8.175	10.175	12.212	14.212	14.212	17.230	17.230	19.275	19.275	22.275
	Max. (1) Column 2	1.545	2.045	2.560	3.080	4.095	5.095	6.095	8.115	10.115	12.142	14.142	14.142					
t	Min.	1	1.1	1.3	2	2.5	3	4	5	6	7	8	9	10	11	12	13.5	15.5
v	Max.	0.2	0.25	0.3	0.4	0.5	0.6	0.8	1	1.2	1.4	1.6	1.8	2	2.2	2.4	2.7	3
dw	Min.	3.40	4.18	5.07	6.53	8.03	9.38	12.33	15.33	17.23	20.17	23.17	25.87	28.87	31.81	34.81	38.61	43.61
w	Min.	0.55	0.85	1.15	1.4	1.9	2.3	3.3	4	4.8	5.8	6.8	7.7	8.6	9.5	10.4	12.1	13.1

Note (1): Column 1 for s (max.) is applicable to strength class 8.8, 10.9, A 2-50 and A 2-70; Column 2 should be applied to strength class 12.9.
Column 1 may be applicable to strength class 12.9 in accordance with an agreement made between the delivering and receiving parties.
When the nominal of thread is M20 or larger, s (max.) should be applied to all strength classes.

Note (2): Nominal of thread in brackets should not be used unless it is absolutely necessary.

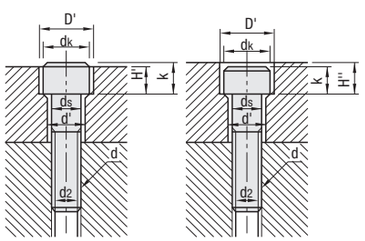
Reference 1. A side of the head should be knurled into a straight line or crisscross pattern [refer to JIS B 0951 (knurling pattern)]. dk (max.) should be the value marked with**.
If no knurled pattern is needed, purchasers can so specify. However, dk (max.) should be the value marked with*.
2. Recommended nominal lengths (L) for individual nominal of thread are shown within the bold lines.
If L is shorter than the dotted line, the thread should be fully threaded, and the incompletely threaded part length beneath the neck should be approximately 3P.
3. ℓg (max.) and ℓg (min.) for a screw, whose length (L) exceeds the dotted line, are obtained by the equations below:
ℓg(Max)=Nominal Length(L)-b
ℓs(Min)=ℓg(Max)-5P

2. L, s and g of Hexagon Socket Head Cap Screws

Unit: mm

Nominal of Thread (d)			M2		M2.5		M3		M4		M5		M6		M8		M10		M12		M14		M16		(M18)		M20		(M22)		M24		(M27)		M30	
L			ℓs min and ℓg max																																	
Nominal Length	min	max	ℓs min	ℓg max	ℓs min	ℓg max	ℓs min	ℓg max	ℓs min	ℓg max	ℓs min	ℓg max	ℓs min	ℓg max	ℓs min	ℓg max	ℓs min	ℓg max	ℓs min	ℓg max	ℓs min	ℓg max	ℓs min	ℓg max	ℓs min	ℓg max	ℓs min	ℓg max	ℓs min	ℓg max	ℓs min	ℓg max	ℓs min	ℓg max	ℓs min	ℓg max
5	4.76	5.24																																		
6	5.76	6.24																																		
8	7.71	8.29																																		
10	9.71	10.29																																		
12	11.65	12.35																																		
16	15.65	16.35																																		
20	19.58	20.42	2	4																																
25	24.58	25.42			5.75	8	4.5	7																												
30	29.58	30.42					9.5	12	6.5	10	4	8																								
35	34.5	35.5							11.5	15	9	13	6	11																						
40	39.5	40.5							16.5	20	14	18	11	16	5.75	12																				
45	44.5	45.5									19	23	16	21	10.75	17	5.5	13																		
50	49.5	50.5									24	28	21	26	15.75	22	10.5	18																		
55	54.4	55.6											26	31	20.75	27	15.5	23	10.25	19																
60	59.4	60.6											31	36	25.75	32	20.5	28	15.25	24	10	20														
65	64.4	65.6													30.75	37	25.5	33	20.25	29	15	25	11	21	4.5	17										
70	69.4	70.6													35.75	42	30.5	38	25.25	34	20	30	16	26	9.5	22										
80	79.4	80.6													45.75	52	40.5	48	35.25	44	30	40	26	36	19.5	32	15.5	28	11.5	24						
90	89.3	90.7															50.5	58	45.25	54	40	50	36	46	29.5	42	25.5	38	21.5	34	15	30	9	24		
100	99.3	100.7															60.5	68	55.25	64	50	60	46	56	39.5	52	35.5	48	31.5	44	25	40	19	34		
110	109.3	110.7																	66.25	74	60	70	56	66	49.5	62	45.5	58	41.5	54	35	50	29	44	20.5	38
120	119.3	120.7																	75.25	84	70	80	66	76	59.5	72	55.5	68	51.5	64	45	60	39	54	30.5	48
130	129.2	130.8																			80	90	76	86	69.5	82	65.5	78	61.5	74	55	70	49	64	40.5	58
140	139.2	140.8																			90	100	86	96	79.5	92	75.5	88	71.5	84	65	80	59	74	50.5	68
150	149.2	150.8																					96	106	89.5	102	85.5	98	81.5	94	75	90	69	84	60.5	78
160	159.2	160.8																					106	116	99.5	112	95.5	108	91.5	104	85	100	79	94	70.5	88
180	179.2	180.8																							119.5	132	115.5	128	111.5	124	105	120	99	114	90.5	108
200	199.05	200.95																									135.5	148	131.5	144	125	140	119	134	110.5	128
220	219.05	220.95																															139	154	130.5	148
240	239.05	240.95																															159	174	150.5	168
260	258.95	261.05																															179	194	170.5	188
280	278.95	281.05																															199	214	190.5	208
300	298.95	301.05																															219	234	210.5	228

Reference: Dimensions of Counterbore and Bolt Hole for the Hexagon Socket Head Cap Screws



Unit: mm

Nominal of Thread (d)	M3	M4	M5	M6	M8	M10	M12	M14	M16	M18	M20	M22	M24	M27	M30
ds	3	4	5	6	8	10	12	14	16	18	20	22	24	27	30
d'	3.4	4.5	5.5	6.6	9	11	14	16	18	20	22	24	26	30	33
dk	5.5	7	8.5	10	13	16	18	21	24	27	30	33	36	40	45
D'	6.5	8	9.5	11	14	17.5	20	23	26	29	32	35	39	43	48
k	3	4	5	6	8	10	12	14	16	18	20	22	24	27	30
H'	2.7	3.6	4.6	5.5	7.4	9.2	11	12.8	14.5	16.5	18.5	20.5	22.5	25	28
H''	3.3	4.4	5.4	6.5	8.6	10.8	13	15.2	17.5	19.5	21.5	23.5	25.5	29	32
d2	2.6	3.4	4.3	5.1	6.9	8.6	10.4	12.2	14.2	15.7	17.7	19.7	21.2	24.2	26.7

Axial Tightening Force for Bolt and Fatigue Limit

- The proper axial tightening force for a bolt should be calculated within an elasticity range up to 70% of the rated yield strength when the torque method is used.
- The fatigue strength of bolt under repeated load should not exceed the specified tolerance.
- Do not let the seat of a bolt or nut dent the contact area.
- Do not break the tightened piece by tightening.

A bolt is tightened by torque, torque inclination, rotating angle, stretch measurement and other methods. The torque method is widely used due to its simplicity and convenience.

Calculation of Axial Tightening Force and Tightening Torque

The relation between the axial tightening force and Ff is represented by Equation (1) below:

$Ff=0.7\times\sigma y\times As$……(1)

Tightening torque TfA can be obtained by using the following formula (2).

$T_{fA}=0.35k(1+1/Q)\sigma y\cdot As\cdot d$……(2)

k : Torque Coefficient
d : Nominal Diameter of Bolt[cm]
Q : Tightening Coefficient
σy : Tensile strength (When the strength class is 12.9, it is 112kgf/mm^2)
As : Effective Sectional Area of the Bolt [mm^2]

Calculation Example

Proper torque and axial force for Mild steel pieces tightened together by means of a hexagon socket head cap screw, M6 (strength class 12.9), with the pieces lubricated with oil, can be calculated as follows.

· Proper Torque, by using Equation(2)

$T_{fA}=0.35k\ (1+1/Q)\ \sigma y\cdot As\cdot d$
$=0.35\times0.17\ (1+1/1.4)\ 1098\times20.1\times0.6$
$=1351$[N · cm] {138[kgf · cm]}

· Axial Force Ff, by using Equation(1)

$Ff=0.7\times\sigma y\times As$
$=0.7\times1098\times20.1$
$=15449$[N] {1576[kgf]}

Surface Treatment for Bolt and Torque Coefficient Dependent on the Combination of Material for Area to be Fastened and Material of Female Thread

Bolt Surface Treatment Lubrication	Torque Coefficient k	Combination of material for area to be fastened and material for female thread (a) (b)
Steel Bolt Black Oxided Film Oil Lubrication	0.145	SCM–FC FC–FC SUS–FC
	0.155	S10C–FC SCM–S10C SCM–SCM FC–S10C FC–SCM
	0.165	SCM–SUS FC–SUS AL–FC SUS–S10C SUS–SCM SUS–SUS
	0.175	S10C–S10C S10C–SCM S10C–SUS AL–S10C AL–SCM
	0.185	SCM–AL FC–AL AL–SUS
	0.195	S10C–AL SUS–AL
	0.215	AL–AL
Steel Bolt Black Oxided Film Unlubricated	0.25	S10C–FC SCM–FC FC–FC
	0.35	S10C–SCM SCM–SCM FC–S10C FC–SCM AL–FC
	0.45	S10C–S10C SCM–S10C AL–S10C AL–SCM
	0.55	SCM–AL FC–AL AL–AL

S10C: Mild steel not thermally refined SCM:Thermally Refined Steel(35HRC) FC:Cast Iron(FC200)AL:Aluminum SUS:Stainless Steel

Standard Value of Tightening Coefficient Q

Tightening Coefficient Q	Tightening Method	Surface Condition: Bolts	Surface Condition: Nuts	Lubrication
1.25	Torque Wrench	Manganese Phosphate	Not treated or Treated with Phosphate.	Lubricated with oil or MoS2 paste
1.4	Torque Wrench	Not treated or Treated with Phosphate.		
	Limited-Torque Wrench			
1.6	Impact Wrench			
1.8	Torque Wrench	Not treated or Treated with Phosphate.	No Treatment	Unlubricated
	Limited-Torque Wrench			

Strength Class

Ex. 12.9

Tensile Strength (Yield Stress): 90% of the minimum value of tensile strength
The minimum value of tensile strength is 1220N/mm^2 { 124kgf/mm^2 }

10.9

Tensile Strength (Yield Stress): 90% of the minimum value of tensile strength
The minimum value of tensile strength is 1040N/mm^2 { 106kgf/mm^2 }

Initial Tightening Force and Tightening Torque

Nominal of Thread	Effective Sectional Area As mm^2	Strength Class 12.9: Yield Load N {kgf}	12.9: Initial Tightening Force N {kgf}	12.9: Tightening Torque N · cm {kgf · cm}	10.9: Yield Load N {kgf}	10.9: Initial Tightening Force N {kgf}	10.9: Tightening Torque N · cm {kgf · cm}	8.8: Yield Load N {kgf}	8.8: Initial Tightening Force N {kgf}	8.8: Tightening Torque N · cm {kgf · cm}
M 3×0.5	5.03	5517{ 563}	3861{ 394}	167{ 17}	4724{ 482}	3312{ 338}	147{ 15}	3214{ 328}	2254{ 230}	98{ 10}
M 4×0.7	8.78	9633{ 983}	6742{ 688}	392{ 40}	8252{ 842}	5772{ 589}	333{ 34}	5615{ 573}	3930{ 401}	225{ 23}
M 5×0.8	14.2	15582{ 1590}	10907{ 1113}	794{ 81}	13348{ 1362}	9339{ 953}	676{ 69}	9085{ 927}	6360{ 649}	461{ 47}
M 6×1	20.1	22060{ 2251}	15445{ 1576}	1352{ 138}	18894{ 1928}	13220{ 1349}	1156{ 118}	12867{ 1313}	9006{ 919}	784{ 80}
M 8×1.25	36.6	40170{ 4099}	28116{ 2869}	3273{ 334}	34398{ 3510}	24079{ 2457}	2803{ 286}	23422{ 2390}	16395{ 1673}	1911{ 195}
M10×1.5	58	63661{ 6496}	44561{ 4547}	6497{ 663}	54508{ 5562}	38161{ 3894}	5557{ 567}	37113{ 3787}	25980{ 2651}	3783{ 386}
M12×1.75	84.3	92532{ 9442}	64768{ 6609}	11368{ 1160}	79223{ 8084}	55458{ 5659}	9702{ 990}	53949{ 5505}	37759{ 3853}	6605{ 674}
M14×2	115	126224{ 12880}	88357{ 9016}	18032{ 1840}	108084{ 11029}	75656{ 7720}	15484{ 1580}	73598{ 7510}	51519{ 5257}	10486{ 1070}
M16×2	157	172323{ 17584}	117982{ 12039}	28126{ 2870}	147549{ 15056}	103282{ 10539}	24108{ 2460}	100470{ 10252}	70325{ 7176}	16366{ 1670}
M18×2.5	192	210739{ 21504}	147519{ 15053}	38710{ 3950}	180447{ 18413}	126312{ 12889}	33124{ 3380}	126636{ 12922}	88641{ 9045}	23226{ 2370}
M20×2.5	245	268912{ 27440}	188238{ 19208}	54880{ 5600}	230261{ 23496}	161181{ 16447}	46942{ 4790}	161592{ 16489}	113112{ 11542}	32928{ 3360}
M22×2.5	303	332573{ 33936}	232799{ 23755}	74676{ 7620}	284768{ 29058}	199332{ 20340}	63896{ 6520}	199842{ 20392}	139885{ 14274}	44884{ 4580}
M24×3	353	387453{ 39536}	271215{ 27675}	94864{ 9680}	331759{ 33853}	232231{ 23697}	81242{ 8290}	232819{ 23757}	162974{ 16630}	57036{ 5820}

(Note) · Tightening Conditions: Use of a torque wrench (Lubricated with Oil, Torque Coefficient k=0.17, Tightening Coefficient Q=1.4)
· The torque coefficient varies with the conditions of use. Values in this table should be used as rough referential values.
· The table is an excerpt from a catalog of Kyokuto Seisakusho Co., Ltd.

General Technical Information
Strength of Bolts, Screw Plugs and Dowel Pins

■Strength of Bolt

1)Tensile Load Bolt

$P=\sigma t \times As$ ·····(1)

$=\pi d^2 \sigma t/4$ ·····(2)

Pt : Tensile Load in the Axial Direction [N]
σb : Yield Stress of the Bolt [N/mm²]
σt : Allowable Stress of the Bolt [N/mm²] ($\sigma t=\sigma b$/Safety Factorα)
As : Effective Sectional Area of the Bolt [mm²] $As=\pi d^2/4$
d : Effective Dia. of the Bolt (Core Dia.) [mm]

(Ex.)The proper size of a hexagon socket head cap screws, which is to bear a repeated tensile load (pulsating) at P=1960N {200 kgf} , should be determined. (The hexagon socket head cap screws are SCM435, 38 to 43 HRC, strength class 12.9)

(1) Using Equation

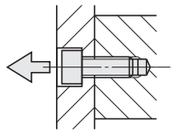
$As=Pt/\sigma t$

$=1960/219.6$

$=8.9$ [mm²]

∴By finding a value greater than the result of the equation in the Effective Sectional Area column in the table on the right, M5, 14.2 [mm²], should be selected.

M6, allowable load of 2087N {213 kgf} , should be selected from the column for strength class 12.9, if the fatigue strength is considered.



2) If the bolt, like a stripper bolt, is to bear a tensile impact load, the right size should be selected from the fatigue strength column. (Under a load of 1960N {200kgf}, stripper bolt made of SCM435, 33 to 38 HRC, strength class 10.9)

By finding a value greater than the allowable load of 1960N {200 kgf} in the Strength Class 10.9 column in the table on right, M8, 3116[N] {318[kgf]} , should be selected. Hence, MSB10 with the M8 threaded portion and an axial diameter of 10 mm should be selected.

If it is to bear a shearing load, a dowel pin should also be used.

■Strength of Screw Plug

When screw plug MSW30 is to bear an impact load, allowable load P should be determined. (The materials of MSW30 are S45C, 34 to 43 HRC, tensile strength σt 637N/mm² {65kgf/mm².})

If M S W is shorn at a spot within the root diameter section and is broken, allowable load P can be calculated as shown below.

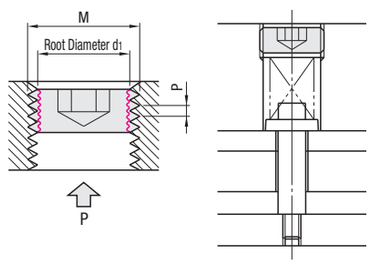
Allowable Load $P=\tau t \times A$

$=3.9\times107.4$

$=40812$[N] {4164[kgf]}

Find the allowable shearing force base on the core diameter of female thread if a tap is made of soft material.

Area A=Root Diameter $d_1\times\pi\times L$
(Root Diameter $d_1\approx M-P$)
$A=(M-P)\pi L=(30-1.5)\pi\times12$
$=1074$ [mm²]
Yield Stress≈0.9×Tensile Strength $\sigma b=0.9\times637=573$[N/mm²]
Shearing Stress≈0.8×Yield Stress
=459 [N/mm²]
Allowable Shearing Stress τt=Shearing Stress/Safety Factor 12
=459/12=38 [N/mm²] {3.9 [kgf/mm²]}



■Strength of Dowel Pins

The proper size of a dowel pin under repeated shearing load of 7840N {800 kgf} (Pulsating) should be determined as follows. (The material of Dowel Pins is SUJ2. Hardness 58HRC~)

$P=A\times\tau$

$=\pi D^2\tau/4$

$D=\sqrt{(4P)/(\pi\tau)}$

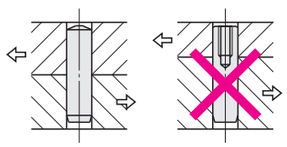
$=\sqrt{(4\times7840)/(3.14\times188)}$

≈7.3

∴D8 or a larger size should be selected for MS.

If the dowel pins are of a roughly uniform size, the number of the necessary tools and extra pins can be reduced.

Yield Stress for SUJ2 σb=1176 [N/mm²] {120 [kgf/mm²]}
Allowable Shearing Strength $\tau=\sigma b\times0.8$/Safety Factor α
=1176×0.8/5
=188 [N/mm²] {19.2 [kgf/mm²]}



The dowel pin must not be loaded.

■Safety Factor α of Unwin Based on Tensile Strength

Materials	Static Load	Repeated Load		Impact Load
		Pulsating	Reversed	
Steel	3	5	8	12
Cast Iron	4	6	10	15
Copper, Soft Metal	5	5	9	15

Reference Strength: Yield Stress for Ductile Material
Fracture Stress for Fragile Material

$$\text{Allowable Stress} = \frac{\text{Reference Strength}}{\text{Safety Factor}\alpha}$$

The yield stress, strength class 12.9, is σb=1098[N/mm²] {112[kgf/mm²]}.
Allowable Stress $\sigma t=\sigma b$/Safety Factor(from the above table Safety Factor 5)
=1098/5
=219.6[N/mm²] {22.4[kgf/mm²]}

■Fatigue Strength of Bolt (Thread:Fatigue Strength is 2 million times)

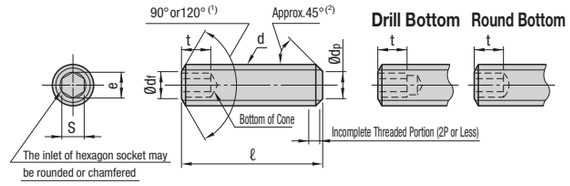
Nominal of Thread	Effective Sectional Area As mm²	Strength Class 12.9 Fatigue Strength† N/mm² [kgf/mm²]	Strength Class 12.9 Allowable Load N {kgf}	Strength Class 10.9 Fatigue Strength† N/mm² [kgf/mm²]	Strength Class 10.9 Allowable Load N {kgf}
M 4	8.78	128{ 13.1}	1117{ 114}	89{ 9.1}	774{ 79}
M 5	14.2	111{ 11.3}	1568{ 160}	76{ 7.8}	1088{ 111}
M 6	20.1	104{ 10.6}	2087{ 213}	73{ 7.4}	1460{ 149}
M 8	36.6	87{ 8.9}	3195{ 326}	85{ 8.7}	3116{ 318}
M10	58	73{ 7.4}	4204{ 429}	72{ 7.3}	4145{ 423}
M12	84.3	66{ 6.7}	5537{ 565}	64{ 6.5}	5370{ 548}
M14	115	60{ 6.1}	6880{ 702}	59{ 6}	6762{ 690}
M16	157	57{ 5.8}	8928{ 911}	56{ 5.7}	8771{ 895}
M20	245	51{ 5.2}	12485{ 1274}	50{ 5.1}	12250{ 1250}
M24	353	46{ 4.7}	16258{ 1659}	46{ 4.7}	16258{ 1659}

Fatigue strength* is a revision of an excerpt from "Estimated Fatigue Limits of Small Screws, Bolts and Metric Screws for Nuts" (Yamamoto).

Typical strength calculations are presented here. In practice, further conditions including hole-to-hole pitch precision, hole perpendicularity, surface roughness, circularity, plate material, parallelism, quenching or non-quenching, precision of the press, product output, wear of tools should be considered. Hence the values in these examples are typical but not guaranteed values.

General Technical Information
Hexagon Socket Set Screws Flat Type

1. Shape and Dimension of Hexagon Socket Set Screws and Its Flat End (JIS B 1177-1997)



Note (1): Should be chamfered to 120° if ℓ is shorter than values indicated with dotted line in a stair case pattern
(2): 45° is applied to the slanted portion below the trough diameter line of the male thread.

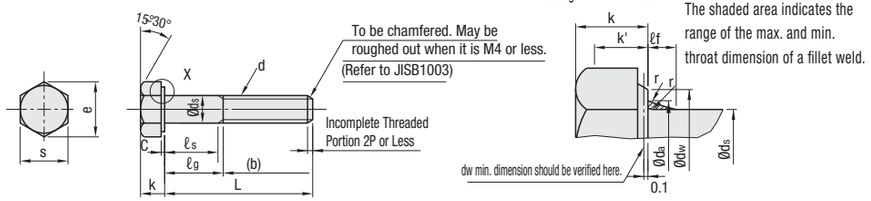
Nominal of Thread(d)			M2	M3	M4	M5	M6	M8	M10	M12	M16	M20	M24
Pitch(P)			0.4	0.5	0.7	0.8	1.0	1.25	1.5	1.75	2.0	2.5	3.0
d_p	Max.(Reference Dimension)		1.0	2.0	2.5	3.5	4.0	5.5	7.0	8.5	12.0	15.0	18.0
	Min.		0.75	1.75	2.25	3.2	3.7	5.2	6.64	8.14	11.57	14.57	17.57
d_f	Approx.		Thread Bottom Diameter of Male Thread										
e	Min.(3)		1.003	1.73	2.30	2.87	3.44	4.58	5.72	6.86	9.15	11.43	13.72
s	Nominal(Reference Dimension)		0.9	1.5	2.0	2.5	3.0	4.0	5.0	6.0	8.0	10.0	12.0
	Max.		0.902	1.545	2.045	2.560	3.080	4.095	5.095	6.095	8.115	10.115	12.142
	Min.		0.889	1.520	2.020	2.520	3.020	4.020	5.020	6.020	8.025	10.025	12.032
t	Min.(4)	Column 1	0.8	1.2	1.5	2.0	2.0	3.0	4.0	4.8	6.4	8.0	10.0
		Column 2	1.7	2.0	2.5	3.0	3.5	5.0	6.0	8.0	10.0	12.0	15.0
ℓ(5)			Approx. Mass Per 1000 Units										
Nominal Length (Reference Dimension)	Min.	Max.	Unit:kg (Density:7.85kg/dm³)										
2	1.8	2.2	0.029	0.059									
2.5	2.3	2.7	0.037	0.08	0.099								
3	2.8	3.2	0.044	0.1	0.14	0.2							
4	3.7	4.3	0.059	0.14	0.22	0.32	0.41						
5	4.7	5.3	0.074	0.18	0.3	0.44	0.585	0.945					
6	5.7	6.3	0.089	0.22	0.38	0.56	0.76	1.26	1.77				
8	7.7	8.3	0.119	0.3	0.54	0.8	1.11	1.89	2.78	4			
10	9.7	10.3	0.148	0.38	0.7	1.04	1.46	2.52	3.78	5.4	8.5		
12	11.6	12.4		0.46	0.86	1.28	1.81	3.15	4.78	6.8	11.1	15.8	
16	15.6	16.4		0.62	1.18	1.76	2.51	4.41	6.78	9.6	16.3	24.1	30
20	19.6	20.4			1.49	2.24	3.21	5.67	8.76	12.4	21.5	32.3	42
25	24.6	25.4				2.84	4.09	7.25	11.2	15.9	28	42.6	57
30	29.6	30.4					4.97	8.82	13.7	19.4	34.6	52.9	72
35	34.5	35.5						10.4	16.2	22.9	41.1	63.2	87
40	39.5	40.5						12	18.7	26.4	47.7	73.5	102
45	44.5	45.5							21.2	29.9	54.2	83.8	117
50	49.5	50.5							23.7	33.4	60.7	94.1	132
55	54.4	55.6								36.8	67.3	104	147
60	59.4	60.6								40.3	73.7	115	162

Note (3): when **e** min.=1.14×s(min.) Excluding nominal of thread M25 or less for screws.
(4): The values in Column 1 for **t** min. are applicable to the nominal lengths (ℓ) shorter than values indicated with the dotted border, and the values in Column 2 to the nominal lengths beyond the border.
(5): Min.rand max. are based on JIS B 1021. They are rounded to the first digit below zero.

Reference
1. Recommended nominal lengths (ℓ) for individual nominal of thread are enclosed with thick lines. If the required ℓ-value is not given in the table, it should be specified by the ordering side.
2. The shape and dimensions of the flat end of the screw are based on JIS B 1003 (shape and dimensions of the end of the screw).
3. The shape of the hexagon socket bottom may be a conical, drill or round bottom.

The shape and dimensions indicated in the reference table are based on ISO 4026-1977.

1. Shape and Dimensions of Hexagon Bolt (Parts Grade A)



Unit: mm

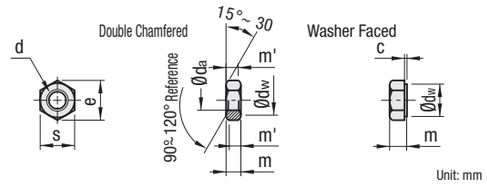
Nominal of Thread d		M2	M3	M4	M5	M6	M8	M10	M12	–	M16	M20	M24
	Coarse Thread Column Ⅰ	M2	M3	M4	M5	M6	M8	M10	M12	–	M16	M20	M24
	Coarse Thread Column Ⅱ	–	–	–	–	–	–	–	–	M14	–	–	–
	Coarse Thread Pitch P	0.4	0.5	0.7	0.8	1	1.25	1.5	1.75	2	2	2.5	3
	Fine Thread Column Ⅰ	–	–	–	–	–	M8×1	M10×1	M12×1.5	–	M16×1.5	M20×1.5	M24×2
	Fine Thread Column Ⅱ	–	–	–	–	–	–	M10×1.25	M12×1.25	M14×1.5	–	M20×2	–
b (Reference)	L≤125mm	10	12	14	16	18	22	26	30	34	38	46	54
	125<L≤150mm	–	–	–	–	–	–	–	–	40	44	52	60
c	Min.	0.1	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.2	0.2	0.2
	Max.	0.25	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.6	0.8	0.8	0.8
da	Max.	2.6	3.6	4.7	5.7	6.8	9.2	11.2	13.7	15.7	17.7	22.4	26.4
ds	Reference Dimension=Max.	2	3	4	5	6	8	10	12	14	16	20	24
	Min.	1.86	2.86	3.82	4.82	5.82	7.78	9.78	11.73	13.73	15.73	19.67	23.67
dw	Min.	3.07	4.57	5.88	6.88	8.88	11.63	14.63	16.63	*19.64	22.49	28.19	33.61
e	Min.	4.32	6.01	7.66	8.79	11.05	14.38	17.77	20.03	23.36	26.75	33.53	39.98
ℓf	Max.	0.8	1	1.2	1.2	1.4	2	2	3	3	3	4	4
k	Reference Dimension=Nominal	1.4	2	2.8	3.5	4	5.3	6.4	7.5	8.8	10	12.5	15
	Min.	1.275	1.875	2.675	3.35	3.85	5.15	6.22	7.32	8.62	9.82	12.285	14.785
	Max.	1.525	2.125	2.925	3.65	4.15	5.45	6.58	7.68	8.98	10.18	12.715	15.215
k'	Min.	0.89	1.31	1.87	2.35	2.7	3.61	4.35	5.12	6.03	6.87	8.6	10.35
r	Min.	0.1	0.1	0.2	0.2	0.25	0.4	0.4	0.6	0.6	0.6	0.8	0.8
s	Reference Dimension=Max.	4	5.5	7	8	10	13	16	18	21	24	30	36
	Min.	3.82	5.32	6.78	7.78	9.78	12.73	15.73	17.73	20.67	23.67	29.67	35.38

Length of Bolt L			ℓs and ℓg																							
Nominal Length (Reference Dimension)	Min.	Max.	ℓs Min.	ℓg Max.	ℓs Min.	ℓg Max.	ℓs Min.	ℓg Max.	ℓs Min.	ℓg Max.	ℓs Min.	ℓg Max.	ℓs Min.	ℓg Max.	ℓs Min.	ℓg Max.	ℓs Min.	ℓg Max.	ℓs Min.	ℓg Max.	ℓs Min.	ℓg Max.	ℓs Min.	ℓg Max.	ℓs Min.	ℓg Max.
16	15.65	16.35	4	6																						
20	19.58	20.42	8	10	5.5	8																				
25	24.58	25.42			10.5	13	7.5	11	5	9																
30	29.58	30.42			15.5	18	12.5	16	10	14	7	12														
35	34.5	35.5					17.5	21	15	19	12	17														
40	39.5	40.5					22.5	26	20	24	17	22	11.75	18												
45	44.5	45.5							25	29	22	27	16.75	23	11.5	19										
50	49.5	50.5							30	34	27	32	21.75	28	16.5	24	11.25	20								
55	54.4	55.6									32	37	26.75	33	21.5	29	16.25	25								
60	59.4	60.6									37	42	31.75	38	26.5	34	21.25	30	16	26						
65	64.4	65.6											36.75	43	31.5	39	26.25	35	21	31	17	27				
70	69.4	70.6											41.75	48	36.5	44	31.25	40	26	36	22	32				
80	79.4	80.6											51.75	58	46.5	54	41.25	50	36	46	32	42	21.5	34		
90	89.3	90.7													56.5	64	51.25	60	46	56	42	52	31.5	44	21	36
100	99.3	100.7													66.5	74	61.25	70	56	66	52	62	41.5	54	31	46
110	109.3	110.7															71.25	80	66	76	62	72	51.5	64	41	56
120	119.3	120.7															81.25	90	76	86	72	82	61.5	74	51	66
130	129.2	130.8																	80	90	76	86	65.5	78	55	70
140	139.2	140.8																	90	100	86	96	75.5	88	65	80
150	149.2	150.8																			96	106	85.5	98	75	90

Reference
1. Priority should be given to the nominal of thread in Column Ⅰ. The screw size codes are based on JIS B 0123.
2. Recommended nominal lengths (L) for individual nominal of thread are enclosed by thick lines.
3. When the thread part length (b) of a bolt exceeds the max. nominal value given within the thick lines, the tolerance of the thread part length should be agreed upon by the delivering and receiving sides, corresponding to JIS B 1021.
4. Max. value ℓg and Min. value ℓs as follows: ℓg max Nominal Length(L)-b, ℓs min.=ℓg max-5P(P=Coarse Thread Pitch)
5. da and r in this table are based on JIS B 1005.
6. "Chamfered" and "Unpointed", the shape of the end screw should be decided according to JIS B 1003.
7. The asterisked figures in the table are values after being corrected with the relevant international standard.

*With some of the hexagon bolts and hexagon nuts for M10 and M12 distributed at present, the opposite side S is based on JIS prior to the revision.

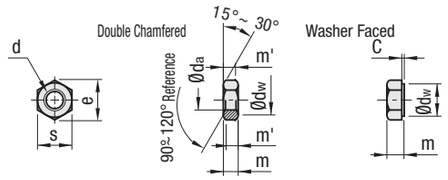
1. Shape and Dimensions of Hexagon Nuts Style Ⅰ (Parts Grade A)



Unit: mm

Nominal of Thread d		M2	M3	M4	M5	M6	M8	M10	M12	(M14)	M16
Pitch P		0.4	0.5	0.7	0.8	1	1.25	1.5	1.75	2	2
c	Max.	0.2	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.6	0.8
	Min.	0.1	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.2
da	Min.(Reference Dimension)	2	3	4	5	6	8	10	12	14	16
	Max.	2.3	3.45	4.6	5.75	6.75	8.75	10.8	13	15.1	17.3
dw	Min.	3.07	4.6	5.9	6.9	8.9	11.6	14.6	16.6	19.6	22.5
e	Min.	4.32	6.01	7.66	8.79	11.05	14.38	17.77	20.03	23.35	26.75
m	Max.(Reference Dimension)	1.6	2.4	3.2	4.7	5.2	6.8	8.4	10.8	12.8	14.8
	Min.	1.35	2.15	2.9	4.4	4.9	6.44	8.04	10.37	12.1	14.1
m'	Min.	1.08	1.72	2.32	3.52	3.92	5.15	6.43	8.3	9.68	11.28
s	Max.(Reference Dimension)	4	5.5	7	8	10	13	16	18	21	24
	Min.	3.82	5.32	6.78	7.78	9.78	12.73	15.73	17.73	20.67	23.67

2. Shape and Dimensions of Hexagon Nuts Style Ⅱ (Parts Grade A)



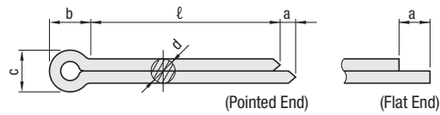
Unit: mm

Nominal of Thread d		M5	M6	M8	M10	M12	(M14)	M16
Pitch P		0.8	1	1.25	1.5	1.75	2	2
c	Max.	0.5	0.5	0.6	0.6	0.6	0.6	0.8
	Min.	0.15	0.15	0.15	0.15	0.15	0.15	0.2
da	Min.(Reference Dimension)	5	6	8	10	12	14	16
	Max.	5.75	6.75	8.75	10.8	13	15.1	17.3
dw	Min.	6.9	8.9	11.6	14.6	16.6	19.6	22.5
e	Min.	8.79	11.05	14.38	17.77	20.03	23.35	26.75
m	Max.(Reference Dimension)	5.1	5.7	7.5	9.3	12	14.1	16.4
	Min.	4.8	5.4	7.14	8.94	11.57	13.4	15.7
m'	Min.	3.84	4.32	5.71	7.15	9.26	10.7	12.6
s	Max.(Reference Dimension)	8	10	13	16	18	21	24
	Min.	7.78	9.78	12.73	15.73	17.73	20.67	23.67

Reference
1. Nominal of thread in brackets should not be used unless it is absolutely necessary.
2. The shape of nuts, unless otherwise designated, shall be "double chamfered", and the "washer faced" option shall be as designated by the purchaser. Chamfering for the "washer faced" threads shall be based on the chamfered dimensions for "double chamfered".

* With some of the hexagon bolts and hexagon nuts for M10 and M12 distributed at present, the opposite side S is based on JIS prior to the revision.

3.Shape and Dimensions of Cotter Pins

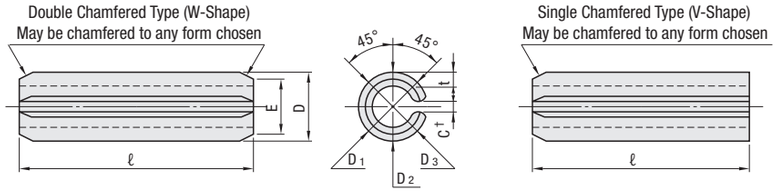


Unit: mm

Nominal Diameter		0.6	0.8	1	1.2	1.6	2	2.5	3.2	4	5	6.3	8	10	13	16	20
d	Reference Dimension	0.5	0.7	0.9	1	1.4	1.8	2.3	2.9	3.7	4.6	5.9	7.5	9.5	12.4	15.4	19.3
	Tolerance	0 −0.1						0 −0.2							0 −0.3		
c	Reference Dimension	1	1.4	1.8	2	2.8	3.6	4.6	5.8	7.4	9.2	11.8	15	19	24.8	30.8	38.6
	Tolerance	0 −0.1	0 −0.2		0 −0.3	0 −0.4		0 −0.6	0 −0.7	0 −0.9	0 −1.2	0 −1.5	0 −1.9	0 −2.4	0 −3.1	0 −3.8	0 −4.8
b	Approx.	2	2.4	3	3	3.2	4	5	6.4	8	10	12.6	16	20	26	32	40
a	Approx.	1.6	1.6	1.6	2.5	2.5	2.5	2.5	3.2	4	4	4	4	6.3	6.3	6.3	6.3
Diameter of Applicable Bolts and Pins: Bolts	Over than	–	2.5	3.5	4.5	5.5	7	9	11	14	20	27	39	56	80	120	170
	or Less	2.5	3.5	4.5	5.5	7	9	11	14	20	27	39	56	80	120	170	–
Diameter of Applicable Bolts and Pins: Clevis Pin	Over than	–	2	3	4	5	6	8	9	12	17	23	29	44	69	110	160
	or Less	2	3	4	5	6	8	9	12	17	23	29	44	69	110	160	–
Dia. of Pin Hole	(Reference)	0.6	0.8	1	1.2	1.6	2	2.5	3.2	4	5	6.3	8	10	13	16	20
ℓ	4	±0.5															
	5																
	6																
	8		±0.5														
	10			±0.5													
	12				±0.5												
	14					±0.8											
	16						±0.8										
	18							±0.8									
	20								±0.8								
	22									±1.2							
	25										±1.2						
	28											±1.2					
	32												±2				
	36													±2			
	40														±2		
	45															±2	
	50																±2
	56																
	63																
	71																
	80																
	90																
	100																
	112																
	125																
	140																
	160																
	180																
	200																
	224																
	250																
	280																

Reference
1. The nominal diameter is dependent on the diameter of the pin hole.
2. d is a value for a spot somewhere between the end and the ℓ/2 spot.
3. The end may be pointed or flat. If a pointed end or a flat one is needed, it should be specified.
4. The length (ℓ) should be one enclosed by thick lines. The value in an enclosed area is a tolerance. If the required r-value is not given in the table, it should be specified by customers.
5. The head must not tilt excessively from the axial center.

Shape and Dimensions of Spring Pins



*The size of Gap C should be able to avoid the contact between the spring pin and the hole in which the pin is to be inserted.

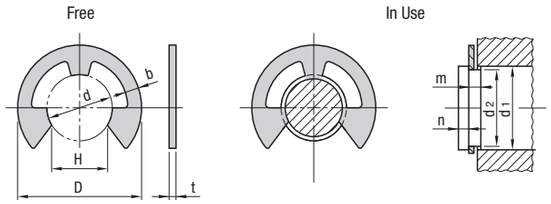
Unit: mm

Nominal Diameter			1	1.2	1.4	1.5	1.6	2	2.5	3	4	5	6	8	10	13
Spring Pins	D(1)	Max.	1.2	1.4	1.6	1.7	1.8	2.25	2.75	3.25	4.4	5.4	6.4	8.6	10.6	13.7
		Min.	1.1	1.3	1.5	1.6	1.7	2.15	2.65	3.15	4.2	5.2	6.2	8.3	10.3	13.4
	t (Reference)	For General Use	0.2	0.25	0.28	0.3	0.3	0.4	0.5	0.6	0.8	1	1.2	1.6	2	2.5
		Light Load	0.1	0.12	0.15	0.15	0.15	0.2	0.25	0.3	0.4	0.5	0.6	–	–	–
	E (Max.)		0.9	1.1	1.3	1.4	1.5	1.9	2.4	2.9	3.9	4.8	5.8	7.8	9.8	12.7
	Double Shearing Load kN{kgf} Minimum Value	For General Use	0.69 {70}	1.02 {104}	1.35 {138}	1.55 {158}	1.68 {171}	2.76 {281}	4.31 {440}	6.20 {633}	10.80 {1130}	17.25 {1760}	24.83 {2532}	44.13 {4500}	68.94 {7030}	112.78 {11500}
		Light Load	0.38 {39}	0.56 {57}	0.80 {82}	0.87 {89}	0.93 {95}	1.55 {158}	2.42 {247}	3.49 {356}	6.21 {633}	9.70 {989}	13.96 {1424}	– –	– –	– –
Applicable Holes		Diameter	1	1.2	1.4	1.5	1.6	2	2.5	3	4	5	6	8	10	13
		Dimensional Tolerance	+0.08 0					+0.09 0			+0.12 0			+0.15 0		+0.2 0

ℓ	Dimensional Tolerance	Nominal Diameter 1	1.2	1.4	1.5	1.6	2	2.5	3	4	5	6	8	10	13
4	+0.5 0	0	0	0	0	0									
5		0	0	0	0	0	0	0							
6		0	0	0	0	0	0	0	0						
8		0	0	0	0	0	0	0	0	0					
10		0	0	0	0	0	0	0	0	0	0				
12	+1.0 0		0	0	0	0	0	0	0	0	0	0			
14				0	0	0	0	0	0	0	0	0			
16						0	0	0	0	0	0	0	0		
18							0	0	0	0	0	0	0	0	
20							0	0	0	0	0	0	0	0	
22								0	0	0	0	0	0	0	0
25								0	0	0	0	0	0	0	0
28									0	0	0	0	0	0	0
32									0	0	0	0	0	0	0
36										0	0	0	0	0	0
40										0	0	0	0	0	0
45											0	0	0	0	0
50											0	0	0	0	0
56	+1.5 0											0	0	0	0
63												0	0	0	0
70													0	0	0
80													0	0	0
90														0	0
100														0	0
110															0
125															0
140															0

Note(1): Maximum value for D is the maximum value on the pin's circumference, and the minimum value for D is the average of D_1, D_2 and D_3.
Reference: t is in accordance with JSMA (Japan Spring Manufactures Association Standard)No.6.

Shape and Dimensions of Retaining Ring-E Type



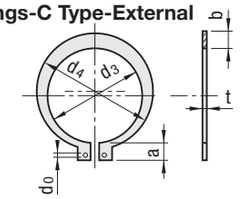
Reference: Typical shape is shown.

Unit: mm

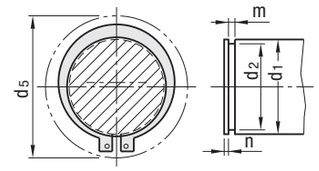
Nominal	Retaining Rings d(1) Reference Dimension	d(1) Tolerance	D Reference Dimension	D Tolerance	H Reference Dimension	H Tolerance	t Reference Dimension	t Tolerance	b Approx.	Applicable Shaft (Reference) Classification of d_1 More than	d_1 or Less	d_2 Reference Dimension	d_2 Tolerance	m Reference Dimension	m Tolerance	n Min.
0.8	0.8	-0.05	2	±0.1	0.7	0 −0.25	0.2	±0.02	0.3	1	1.4	0.8	$+0.05$	0.3	+0.05 0	0.4
1.2	1.2	0 −0.09	3		1		0.3	±0.025	0.4	1.4	2	1.2	+0.06 0	0.4		0.6
1.5	1.5		4	±0.2	1.3		0.4	±0.03	0.6	2	2.5	1.5		0.5		0.8
2	2		5		1.7		0.4		0.7	2.5	3.2	2				1
2.5	2.5		6		2.1		0.4		0.8	3.2	4	2.5				
3	3		7		2.6		0.6	±0.04	0.9	4	5	3		0.7	+0.1 0	
4	4	0 −0.12	9		3.5	0 −0.3	0.6		1.1	5	7	4	+0.075 0			1.2
5	5		11		4.3		0.6		1.2	6	8	5				
6	6		12		5.2		0.8		1.4	7	9	6		0.9		
7	7	0 −0.15	14		6.1	0 −0.35	0.8		1.6	8	11	7	+0.09 0			1.5
8	8		16		6.9		0.8		1.8	9	12	8				1.8
9	9		18		7.8		0.8		2.0	10	14	9				2
10	10		20		8.7		1.0	±0.05	2.2	11	15	10		1.15	+0.14 0	
12	12	0 −0.18	23	±0.3	10.4	0 −0.45	1.0		2.4	13	18	12	+0.11 0			2.5
15	15		29		13		1.6(2)	±0.06	2.8	16	24	15		(2)		3
19	19	0 −0.21	37		16.5		1.6(2)		4.0	20	31	19	+0.13 0	1.75		3.5
24	24		44		20.8	-0.15	2.0	±0.07	5.0	25	38	24		2.2		4

Note(1): d should be measured with a limit plug gauge.
Note(2): For thickness (t) = 1.6mm, the value of 1.5mm may be substituted for on the right side of the formula, for the time being. In this case, m must be 1.65mm.
Reference: The recommended dimensions of the applicable shaft are given here for reference.

1. Retaining Rings-C Type-External



The hole with diameter d_0 should be so positioned to protrude out of the groove when the retaining ring is inserted in the shaft.



d_5 is the max. outer diameter when the retaining ring is fitted onto the shaft.

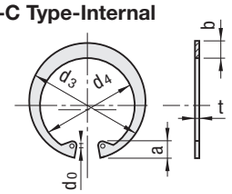
Retaining Rings-C Type-External

Unit: mm

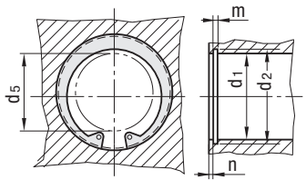
Nominal(1)	Retaining Rings d_3 Reference Dimension	d_3 Tolerance	t Reference Dimension	t Tolerance	b (Approx.)	a (Approx.)	d_0 (Min.)	Applicable Shaft (Reference) d_5	d_1	d_2 Reference Dimension	d_2 Tolerance	m Reference Dimension	m Tolerance	n (Min.)
10	9.3	±0.15	1	±0.05	1.6	3	1.2	17	10	9.6	-0.09	1.15	+0.14 0	1.5
(11)	10.2				1.8	3.1		18	11	10.5	0 −0.11			
12	11.1	±0.18			1.8	3.2	1.5	19	12	11.5				
(13)	12				1.8	3.3		20	13	12.4				
14	12.9				2	3.4	1.7	22	14	13.4				
15	13.8				2.1	3.5		23	15	14.3				
16	14.7				2.2	3.6		24	16	15.2				
17	15.7				2.2	3.7		25	17	16.2				
18	16.5		1.2	±0.06	2.6	3.8		26	18	17		1.35		
(19)	17.5				2.7	3.8	2	27	19	18				
20	18.5	±0.2			2.7	3.9		28	20	19	0 −0.21			
(21)	19.5				2.7	4		30	21	20				
22	20.5				2.7	4.1		31	22	21				
(24)	22.2				3.1	4.2		33	24	22.9				
25	23.2				3.1	4.3		34	25	23.9				
(26)	24.2				3.1	4.4		35	26	24.9				
28	25.9		1.6(2)		3.1	4.6		38	28	26.6		1.75		
(29)	26.9				3.5	4.7		39	29	27.6				
30	27.9				3.5	4.8		40	30	28.6				
32	29.6				3.5	5	2.5	43	32	30.3	0 − 0.25			
(34)	31.5	±0.25			4	5.3		45	34	32.3				
35	32.2				4	5.4		46	35	33				
(36)	33.2		1.8	±0.07	4	5.4		47	36	34		1.95		2
(38)	35.2				4.5	5.6		50	38	36				
40	37	±0.4			4.5	5.8		53	40	38				
(42)	38.5				4.5	6.2		55	42	39.5				
45	41.5				4.8	6.3		58	45	42.5				
(48)	44.5				4.8	6.5		62	48	45.5				
50	45.8		2		5	6.7		64	50	47		2.2		
(52)	47.8				5	6.8		66	52	49				
55	50.8	±0.45			5	7		70	55	52	0 −0.3			
(56)	51.8				5	7		71	56	53				
(58)	53.8				5.5	7.1		73	58	55				
60	55.8				5.5	7.2		75	60	57				
(62)	57.8				5.5	7.2		77	62	59				
(63)	58.8				5.5	7.3		78	63	60				
65	60.8		2.5	±0.08	6.4	7.4		81	65	62		2.7		2.5
(68)	63.5				6.4	7.8		84	68	65				
70	65.5				6.4	7.8		86	70	67				
(72)	67.5				7	7.9		88	72	69				
75	70.5				7	7.9		92	75	72				
(78)	73.5				7.4	8.1		95	78	75				
80	74.5				7.4	8.2		97	80	76.5				

Note(1): Priority should be given to values other than included in ( ). A value in ( ) may be used if necessary.
Note(2): For thickness (t) = 1.6mm, the value of 1.5mm may be substituted for on the right side of the formula, for the time being. In this case, m must be 1.65mm.
Reference: 1. The minimum width of the ring of the retaining ring should be less than the plate thickness t.
2. The recommended dimensions of the applicable shaft are given here for reference.
3. d_4 (mm) should preferably be equal to $d_4=d_3+(1.4\sim1.5)b$.
Reference: The thickness t, conforms to the Japan Spring Manufactures Association Standard, JSMA No. 6-1976 (steel belt for a spring).

2. Retaining Rings-C Type-Internal



The hole with diameter d0 should be so positioned to protrude out of the groove when the retaining ring is inserted in the hole.



d5 is the minimum diameter of the internal circumference when the retaining ring is fitted.

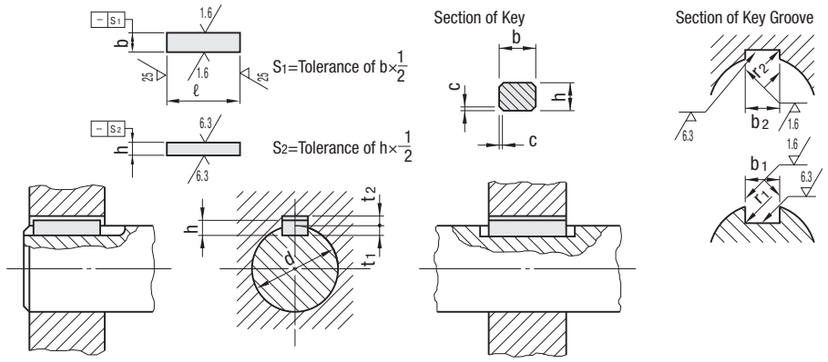
Retaining Rings-C Type-Internal

Unit: mm

Nominal(1)	Retaining Rings							Applicable Shaft (Reference)						
	d3		t		b	a	d0	d5	d1	d2		m		n
	Reference Dimension	Tolerance	Reference Dimension	Tolerance	(Approx.)	(Approx.)	(Min.)			Reference Dimension	Tolerance	Reference Dimension	Tolerance	(Min.)
10	10.7	±0.18	1	±0.05	1.8	3.1	1.2	3	10	10.4	+0.11 0	1.15	2.5	1.5
11	11.8				1.8	3.2		4	11	11.4				
12	13				1.8	3.3	1.5	5	12	12.5				
(13)	14.1				1.8	3.5		6	13	13.6				
14	15.1				2	3.6	1.7	7	14	14.6				
15	16.2				2	3.6		8	15	15.7				
16	17.3				2	3.7		8	16	16.8				
(17)	18.3	±0.2			2	3.8		9	17	17.8				
18	19.5				2.5	4	2	10	18	19	+0.21 0			
19	20.5				2.5	4		11	19	20				
20	21.5				2.5	4		12	20	21				
(21)	22.5				2.5	4.1		12	21	22				
22	23.5				2.5	4.1		13	22	23				
(24)	25.9		1.2	±0.06	2.5	4.3		15	24	25.2		1.35		
25	26.9				3	4.4		16	25	26.2				
(26)	27.9				3	4.6		16	26	27.2				
28	30.1	±0.25			3	4.6		18	28	29.4				
30	32.1				3	4.7		20	30	31.4	+0.25 0			
32	34.4				3.5	5.2		21	32	33.7				
(34)	36.5		1.6(2)		3.5	5.2		23	34	35.7		1.75	+0.14 0	
35	37.8				3.5	5.2		24	35	37				
(36)	38.8				3.5	5.2		25	36	38				
37	39.8				3.5	5.2		26	37	39				
(38)	40.8				4	5.3		27	38	40				
40	43.5	±0.4	1.8	±0.07	4	5.7		28	40	42.5		1.95		
42	45.5				4	5.8		30	42	44.5				
45	48.5				4.5	5.9		33	45	47.5				
47	50.5	±0.45			4.5	6.1		34	47	49.5				2
(48)	51.5				4.5	6.2		35	48	50.5	+0.3 0			
50	54.2		2		4.5	6.5		37	50	53		2.2		
52	56.2				5.1	6.5		39	52	55				
55	59.2				5.1	6.5		41	55	58				
(56)	60.2				5.1	6.6		42	56	59				
(58)	62.2				5.1	6.8		44	58	61				
60	64.2				5.5	6.8		46	60	63				
62	66.2				5.5	6.9		48	62	65				
(63)	67.2				5.5	6.9		49	63	66				
(65)	69.2		2.5	±0.08	5.5	7		50	65	68		2.7		2.5
68	72.5				6	7.4		53	68	71				
(70)	74.5				6	7.4		55	70	73				
72	76.5				6.6	7.4		57	72	75				
75	79.5				6.6	7.8		60	75	78				
(78)	82.5	±0.55			6.6	8		62	78	81	+0.35 0			
80	85.5				7	8		64	80	83.5				

Note(1): Priority should be given to values other than included in( ). A value in( )may be used if necessary.
Note(2): For thickness (t) = 1.6mm, the value of 1.5mm may be substituted for on the right side of the formula, for the time being. In this case, m must be 1.65mm.
Reference: 1. The minimum width of the ring of the retaining ring should be less than the plate thickness t.
2. The recommended dimensions of the applicable shaft are given here for reference.
3. d_4(mm)should preferably be equal to $d_4=d_3-(1.4\sim1.5)b$.
Reference: The thickness t, conforms to the Japan Spring Manufactures Association Standard, JSMA No. 6-1976 (steel belt for a spring).

1. Parallel Keys and Key Grooves

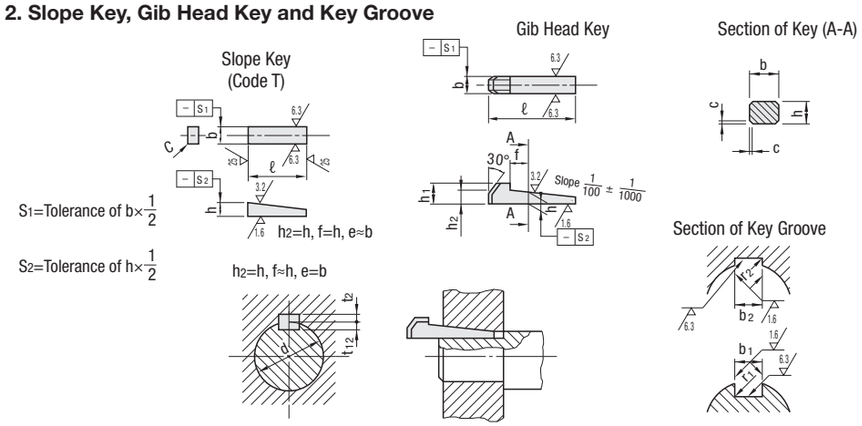


Unit: mm

Key Nominal Dimension b×h	Dimension of Key Groove										Reference
	Reference Dimension of b1, b2	(Sliding Type) b1 Tolerance (H9)	(Sliding Type) b2 Tolerance (D10)	Standard b1 Tolerance (N9)	Standard b2 Tolerance (Js9)	Precision Class b1 and b2 Tolerance (P9)	r1 and r2	Reference Dimension of t1	Reference Dimension of t2	Reference Dimension of t2, t1	Applicable Shaft Dia.(1) d
2×2	2	+0.025 0	+0.060 +0.020	−0.004 −0.029	±0.0125	−0.006 −0.031	0.08~0.16	1.2	1.0	+0.1 0	6~8
3×3	3							1.8	1.4		8~10
4×4	4	+0.030 0	+0.078 +0.030	0 −0.030	±0.0150	−0.012 −0.042		2.5	1.8		10~12
5×5	5						0.16~0.25	3.0	2.3		12~17
6×6	6							3.5	2.8		17~22
(7×7)	7	+0.036 0	+0.098 +0.040	0 −0.036	±0.0180	−0.015 −0.051		4.0	3.0	+0.2 0	20~25
8×7	8							4.0	3.3		22~30
10×8	10						0.25~0.40	5.0	3.3		30~38
12×8	12	+0.043 0	+0.120 +0.050	0 −0.043	±0.0215	−0.018 −0.061		5.0	3.3		38~44
14×9	14							5.5	3.8		44~50
(15×10)	15							5.0	5.0		50~55
16×10	16							6.0	4.3		50~58
18×11	18							7.0	4.4		58~65
20×12	20	+0.052 0	+0.149 +0.065	0 −0.052	±0.0260	−0.022 −0.074	0.40~0.60	7.5	4.9		65~75
22×14	22							9.0	5.4		75~85
(24×16)	24							8.0	8.0		80~90
25×14	25							9.0	5.4		85~95
28×16	28							10.0	6.4		95~110
32×18	32	+0.062 0	+0.180 +0.080	0 −0.062	±0.0310	−0.026 −0.088		11.0	7.4		110~130
(35×22)	35						0.70~1.00	11.0	11.0	+0.3 0	125~140
36×20	36							12.0	8.4		130~150
(38×24)	38							12.0	12.0		140~160
40×22	40							13.0	9.4		150~170
(42×26)	42							13.0	13.0		160~180
45×25	45							15.0	10.4		170~200
50×28	50							17.0	11.4		200~230
56×32	56	+0.074 0	+0.220 +0.100	0 −0.074	±0.0370	−0.032 −0.106	1.20~1.60	20.0	12.4		230~260
63×32	63							20.0	12.4		260~290
70×36	70							22.0	14.4		290~330
80×40	80						2.00~2.50	25.0	15.4		330~380
90×45	90	+0.087 0	+0.260 +0.120	0 −0.087	±0.0435	−0.037 −0.124		28.0	17.4		380~440
100×50	100							31.0	19.5		440~500

Note(1) The applicable shaft diameter is calculated from the torque corresponding to the strength of the key, for presentation of referential data for general-purpose use. When the key is of an appropriate size relative to the torque to be transmitted, a shaft thicker than the applicable shaft diameter may be used. In some cases, t_1 and t_2 should be adjusted so that a side of the key will come into uniform contact with the shaft and the hub. A shaft narrower than the applicable shaft diameter should not be used.
Reference: The nominal sizes given in ( ) do not conform to the relevant international standard and must not be used in new design.

2. Slope Key, Gib Head Key and Key Groove



Unit: mm

Key Nominal Dimension b×h	Dimension of Key Groove								Dimension of Key Groove						Reference
	b		h			h1	c	ℓ(1)	b1 and b2		r1 and r2	Reference Dimension of t1	Reference Dimension of t2	Reference Dimension of t2, t1	Applicable Shaft Dia.(2) d
	Reference Dimension	Tolerance (h9)	Reference Dimension	Tolerance					Reference Dimension	Tolerance (D10)					
2×2	2	0 −0.025	2	0 −0.025	h9	–	0.16 ~0.25	6~30	2	+0.060 +0.020	0.08 ~0.16	1.2	0.5	+0.05 0	6~8
3×3	3		3			–		6~36	3			1.8	0.9		8~10
4×4	4	0 −0.030	4	0 −0.030		7		8~45	4	+0.078 +0.030		2.5	1.2	+0.1 0	10~12
5×5	5		5			8	0.25 ~0.40	10~56	5		0.16 ~0.25	3.0	1.7		12~17
6×6	6		6			10		14~70	6			3.5	2.2		17~22
(7×7)	7	0 −0.036	7.2	0 −0.036		10		16~80	7	+0.098 +0.040		4.0	3.0		20~25
8×7	8		7	0 −0.090	h11	11		18~90	8			4.0	2.4	+0.2 0	22~30
10×8	10		8			12	0.40 ~0.60	22~110	10		0.25 ~0.40	5.0	2.4		30~38
12×8	12	0 −0.043	8			12		28~140	12	+0.120 +0.050		5.0	2.4		38~44
14×9	14		9			14		36~160	14			5.5	2.9		44~50
(15×10)	15		10.2	0 −0.070	h10	15		40~180	15			5.0	5.0	+0.1 0	50~55
16×10	16		10	0 −0.090	h11	16		45~180	16			6.0	3.4	+0.2 0	50~58
18×11	18		11	0 −0.110		18		50~200	18			7.0	3.4		58~65
20×12	20	0 −0.052	12			20	0.60 ~0.80	56~220	20	+0.149 +0.065	0.40 ~0.60	7.5	3.9		65~75
22×14	22		14			22		63~250	22			9.0	4.4		75~85
(24×16)	24		16.2	0 −0.070	h10	24		70~280	24			8.0	8.0	+0.1 0	80~90
25×14	25		14	0 −0.110	h11	22		70~280	25			9.0	4.4	+0.2 0	85~95
28×16	28		16			25		80~320	28			10.0	5.4		95~110
32×18	32	0 −0.062	18			28		90~360	32	+0.180 +0.080		11.0	6.4		110~130
(35×22)	35		22.3	0 −0.084	h10	32	1.00 ~1.20	100~400	35		0.70 ~1.00	11.0	11.0	+0.15 0	125~140
36×20	36		20	0 −0.130	h11			–	36			12.0	7.1	+0.3 0	130~150
(38×24)	38		24.3	0 −0.084	h10	36		–	38			12.0	12.0	+0.15 0	140~160
40×22	40		22	0 −0.130	h11	36		–	40			13.0	8.1	+0.3 0	150~170
(42×26)	42		26.3	0 −0.084	h10	40		–	42			13.0	13.0	+0.15 0	160~180
45×25	45		25	0 −0.130	h11	40		–	45			15.0	9.1	+0.3 0	170~200
50×28	50		28			45		–	50			17.0	10.1		200~230
56×32	56	0 −0.074	32	0 −0.160		50	1.60 ~2.00	–	56	+0.220 +0.100	1.20 ~1.60	20.0	11.1		230~260
63×32	63		32			50		–	63			20.0	11.1		260~290
70×36	70		36			56		–	70			22.0	13.1		290~330
80×40	80		40			63	2.50 ~3.00	–	80		2.00 ~2.50	25.0	14.1		330~380
90×45	90	0 −0.087	45			70		–	90	+0.260 +0.120		28.0	16.1		380~440
100×50	100		50			80		–	100			31.0	18.1		440~500

Note(1): From the values for ℓ given below, which are in the appropriate range in the table, one should be selected.
The tolerance for ℓ should be h12 under JIS B0401 (dimension tolerance and fitting), in principle.
6, 8, 10, 12, 14, 16, 18, 20, 22, 25, 28, 32, 36, 40, 45, 50, 56, 63, 70, 80, 90, 100, 110, 125, 140, 160, 180, 200, 220, 250, 280, 320, 360, 400
Note(2): The appropriate shaft diameter should be matched with the torque corresponding to the strength of the key.
Reference: The nominal sizes given in ( ) should not be used unless they are absolutely necessary.
The groove for the boss should be slanted to 1/100, in principle.

1. General Steel Materials

Type	Material Code	Applications	Comment	JIS	Flat Bar	Square Bar	Hexagonal Bar	Round Bar	Steel Plate	Section Steel
Rolled Steel for General Structure	SS400	General Machine Parts	Fine Workability and Weldability	JIS G 3101	0	0		0	0	0
Polished Steel Bar (Cold-Drawn)	SS400D	General Machine Parts	Excellent Precision and Surface Roughness. Ready for use directly after slight cutting.	–	0	0	0	0		
Carbon Steel for Machine Structural Use	S45C	General Machine Parts	Fit for Hardening Tensile Strength 58kgf/mm²	JIS G 4051	0	0	0	0	0	
	S50C		Fit for Hardening Tensile Strength 66kgf/mm²							
Carbon Tool Steel	SK4	Shafts, Pins, etc.	For Drill Rod (Round Bar) SK4 surface-finished after cold drawing. Class 7(−DG7)=h7 Class 8(−DG8)=h8 Class 9(−DG9)=h9.	JIS G 4401	0			0		
	SK5				0			0	0	
Alloy Tool Steel	SKS93	Hardening Parts	Deformation caused by Hardening is much less than that of SK material.	JIS G 4404	0	0		0		
	SKS3									
Chrome Molybdenum Steel	SCM435	General machine Parts requiring strength. Screws, etc.	Tensile Strength 70kgf/mm², Tensile Strength after Hardening & tempering: 95 kgf/mm² or more. Hardness: HB270 or more. Hardening: HRC50 or more.	JIS G 4105	0	0	0	0	0	
	SCM415									
	SCM420									
Sulfuric and Sulfur Compound Free Cutting Steel	SUM21	General Machine Parts (Free-Cutting steel)	Made of carbon steel plus sulfur to enhance machinability.	JIS G 4804		0	0	0		
	SUM22L		Free-Cutting Steel containing sulfur and lead.							
	SUM24L									
High Carbon Chrome Bearing Steel	SUJ2	Roller bearings, etc.	Bearing Steel	JIS G 4805				0		
Cold-Rolled Steel Plate	SPCC	Covers, cases, etc.	Rolled at an almost ambient temperature. High dimensional precision and fair texture. Fine machinability. Easy to bend, wring and cut. Fine Weldability.	JIS G 3141					0	
Hot-Rolled Steel Plate	SPHC	General machine structural parts.	Plates for general use are 6 mm or less in thickness.	JIS G 3131					0	

2. Stainless Steel Materials

Type	Material Code	Applications	Comment	Magnetism	JIS	Flat Bar	Square Bar	Hexagonal Bar	Round Bar	Steel Plate	Section Steel
Austenite	SUS303	Machine parts requiring antirusting	18-8 Free-Cutting Stainless Steel, Non-Magnetic. More Machinable than SUS304	None*	JIS G 4303~	Good			Good		
Austenite	SUS304	Machine parts requiring antirusting	Most Versatile Antirusting and Heat-Resisting Steel for General Use	None*		Good	Good	Good	Good	Good	Good
Austenite	SUS316	Machine parts requiring antirusting	More resisting to seawater and other media than SUS304.	None*		Good			Good	Good	
Martensite	SUS440C	Machine parts requiring antirusting (Less corrosion resistant than austenite.)	Fit for Hardening.	Available					Good		
Martensite	SUS410	Machine parts requiring antirusting (Less corrosion resistant than austenite.)	Fit for Hardening. Fine Machinability.	Available					Good		

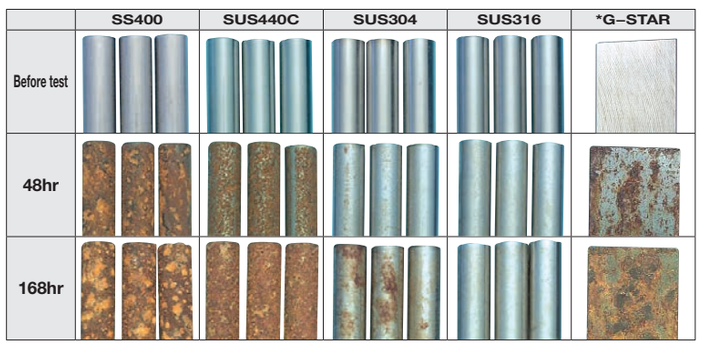
*Martensite exhibits magnetic properties. Machining of Austenite may cause magnetic properties.

<Reference: Corrosion Resistance of Stainless Steel>

Testing Method
Conforms to the JIS H 8502 Cycle Test Method as a complex corrosion test

Test Conditions
(1) Salt water spray test (5%NaCl. 35˚C) 2hr
(2) Drying (60˚C) 4hr
(3) Wetting (95%RH. 35˚C) 2hr
One cycle takes 8 hr.

Appearance of test piece 48 hr, 168 hr before test.



* G-STAR is martensite stainless steel (pre-hardened steel) manufactured by the Daido Special Steel Co., Ltd.

Materials
Varieties and Applications

3. Aluminum Alloy Materials

Type	Material Code	Applications	Comment	JIS	Flat Bar	Square Bar	Hexagonal Bar	Round Bar	Section Steel
Al–Cu Alloy	A2011	General-Use Strength Materials	Free-Cutting Alloy. It excels in machinability but has worse corrosion resistance.	JIS H 4000			Good		
Al–Cu Alloy	A2017	General-Use Strength Materials	High Strength and Machinability Duralumin		Good		Good	Good	
Al–Mg Alloy	A5052	General Machine Parts Covers, cases, etc.	Most typical aluminum alloy with medium strength. With high fatigue strength in comparison with its strength and high corrosion resistance to seawater.		Good			Good	
Al–Mg Alloy	A5056	General Machine Parts	It has fine machined surface and high corrosion resistance to seawater. It has fine machined surface and high corrosion resistance to seawater.				Good		
Al–Mg–Si Alloy	A6061	General Machine Parts	Heat-treated corrosion resisting alloy. High durability owing to T6 treatment.		Good		Good		
Al–Mg–Si Alloy	A6063	General Machine Parts and Structural Material	Weaker than 6061, but more extrudable. Applicable to complex cross-sections shapes. Good corrosion resistance and surface treatment.		Good	Good			Good
Al–Zn–Mg Alloy	A7075	Jigs and Dies	It is one of the strongest aluminum alloys but has worse corrosion resistance. Extra Super Duralumin		Good				

JIS Acronyms for Non-Ferrous Metal

P	Plate, Strip, Disk
PC	Laminate
BE	Extruded Bar
BD	Drawn Bar
W	Drawn Wire
TE	Seamless Extruded Tube
TD	Seamless Drawn Tube

TW	Welded Tube
TWA	Arc-Welded Tube
S	Extruded Section
BR	Riveted Bar
FD	Die-Forged Part
FH	Free-Forged Part

Quality Codes for Aluminum and Aluminum Alloys

Code		Definition	Description
F		Plain Manufactured Material	Completed as a product, without any order for thermal refining. Extruded or forged material, not thermally refined.
H112		Wrought material, for which certain mechanical properties are guaranteed without the need of hardening.	
O		Brought into the softest state by annealing.	Completely re-crystallized by annealing. A thermally treated alloy should be cooled at a temperature below the annealing temperature to prevent the effect of annealing completely.
H	H1n	Hardened by cold working.	n is a numeral from 1 to 9, representing the degree of hardening. "8" represents hard material, and "4" represents the state halfway 1/2 between 0 and hard material. "2" represents the level halfway between 0 and 1/2 hardness, and "6" the state halfway between 1/2 hardness and hard material.
	H2n	Hardened and then properly softened by heat.	
	H3n	Stabilized after cold working.	
T	T1	Cooled after high-temperature working and then allowed to age naturally.	Quenched at the end of a cold working process and allowed to age and harden at ambient temperature. Extruded material is typical material processed in this way. Cold working such as correction may be conducted unless it affects the strength. Used for an alloy such as 6063, for which the effect of quenching can be realized by cooling after hot working (extrusion).
	T3	Allowed to age naturally after solution treatment and cold working.	Cold working is conducted for plates, rods, tubes, etc. to enhance the strength in some cases, and to improve the corrective dimension precision in other cases, with an obvious effect. T361 when cold working is performed to a higher degree than that for T3.
	T351	Allowed to age naturally after solution treatment and cold working.	Cold working is conducted to enhance the strength after solution treatment, and then it is tension processed to give 1.5% to 3% permanent distortion to remove residual tension, and allowed to age naturally.
	T4	Natural aging after solution treatment	Aging is usually completed after exposure to ambient temperature for approx. 4 days. In the case of 7N01, however, aging is a longer process. The tensile property upon the elapse of one month is adopted as referential data. The variety that is given T4 treatment by a user under specified conditions is called T42.
	T5	Hardened through artificial aging after high-temperature processing and quenching	Hardened through artificial aging to improve the mechanical properties and stabilize the dimensions. Used for an alloy or casting such as 6063, for which the effect of quenching can be realized by cooling after hot working (extrusion).
	T6	Hardened through artificial aging after solution treatment.	Excellent strength can be attained for a thermally treated alloy without cold working in the typical heat treatment process. An item that is given T6 treatment by a user under specified conditions is called T62.
	T61	Wrought Materials: Hardened through artificial aging after solution treatment by quenching with lukewarm water. Casting:Tempered after hardening	Quenched with lukewarm water to prevent distortion due to the main hardening. The conditions for hardening through artificial aging are adjusted to attain strength exceeding that accomplished by regular T6 treatment.
	T7	Stabilized after solution treatment	Overaging surpassing those needed for hardening through artificial aging is carried out to attain the maximum strength, because special properties are adjusted somewhat at the expense of strength.
	T73	Overaging after solution treatment.	Overaging after solution treatment to rectify the tendency to crack due to corrosion under stress. Specified in 7075, forgings, of JIS.
	T7352	Overaging after removal of residual stress after solution treatment.	Overaging after removal of residual stress by compression to retain 1% to 5% permanent deformation subsequent to solution treatment, in order to rectify the tendency to crack due to corrosion under stress. Included in free-forged part, 7075.
	T8	Hardened through artificial aging after cold working subsequent to solution treatment.	Cold working performed, with a noticeable effect, to improve the mechanical properties or to rectify drawbacks or improve dimension precision. Called T83 when the sectional area is reduced 3%through cold working. Called T86 when the reduction rate is 6%. These procedures are performed to enhance the strength.
	T9	Cold working after hardening through artificial aging subsequent to solution treatment.	Cold working is necessary to enhance the strength.

4. Copper Alloy Materials

Type	Material Code	Applications	Comment	JIS	Square Bar	Hexagonal Bar	Round Bar	Steel Plate
Brass Plate	C2801P	For Regular Sheet Metal Machining Name Plates and Instrument Panels	Used in high strength and ductile sliding parts. Brass	JIS H 3100				Good
Free-Cutting Brass (Extruded Bar)	C3604BD	General turming bolts screws, nuts, etc.	Good Machinability	JIS H 3250	Good	Good	Good	

5. Cast and Forged Products, Copper Alloy Castings

Type	Material Code	Applications	Comment	JIS
Gray Cast Iron, Class3	FC200	Cast Machine Parts	–	JIS G 5501
Gray Cast Iron, Class4	FC250		–	JIS G 5501
Spheroidal Graphite Cast Iron, Class4	FCD600		–	JIS G 5502
Bronze Casting, Class 6	BC6	Bearings, sleeves, bushings and general machine parts.	High pressure resistance and abrasion resistance, and good machinability.	JIS H 5111

6. Steel Pipe Materials

Type	Material Code	Applications	Comment	JIS
Carbon Steel Pipe for Ordinary Piping	White Pipe(Zinc Galvanizing) SGP Black Pipe(No Plating)	Piping Parts	At ambient temperature (Gas pipe). A is metric specification. B is inch specification.	JIS G 3452
Carbon Steel Pipe for Machine Pressure Service	STPG370 (STPG38)	Piping Parts	Operation temperature 350˚C. A is metric specification. B is inch specification.	JIS G 3454
Carbon Steel Pipe for Machine Structural Use	STKM	General Machine Parts Hollow Shafts.	Available for class 11 to class 20.	JIS G 3445
Seamless Brass Pipe (Regular class)	C2700T	–	Easy Flaring, Bending, Wringing and Plating	JIS H 3300

7. Spring Materials

Type	Material Code	Applications	Allowable Operating Temperature ˚c	JIS
Piano Wire	SWP-A SWP-B	High strength, homogenous cold-drawn wire. For high quality springs and forming.	110	JIS G 3522
Hard Steel Wire	SWB	Applicable to universal stress. For low priced springs and forming.	110	JIS G 3521
	SWC	For high quality springs and forming.	110	
Carbon Steel for Spring Oil Tempered Wire Oil Tempered Steel Wire	SWO-A SWO-B	Hardening and tempered. For general-purpose springs.	120	JIS G 3560
Carbon Steel for Valve-Spring Oil Tempered Wire. Oil Tempered Steel Wire	SWO-V	Hardening and tempered. With a fine surface and uniform tensile strength	120	JIS G 3561
Cr-V Steel for Valve-Spring Oil Tempered Steel Wire	SWOCV-V	Hardening and tempered. Loads and slightly high Temperatures.	220	JIS G 3565
Ci-Cr Steel for Valve-Spring Oil Tempered Steel Wire	SWOSC-V	Hardening and tempered. Loads and slightly high Temperatures.	245	JIS G 3566
For Springs Stainless Steel Wire	SUS302 (–WPA) (–WPB)	For general corrosion and heat resistance Available for magnetic spring.	290	JIS G 4314
	SUS316 (–WPA) (–WPB)	Heat Resistance is good. Higher corrosion resistance than SUS302. Available for magnetic spring.	290	
	SUS631 J1-WPC	Precipitation hardening after spring processing. High strength and general corrosion resistance. Available for magnetic spring.	340	

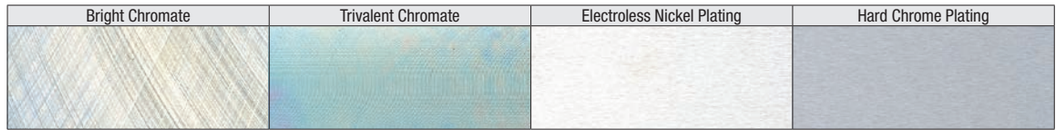
Materials
Types and Apparent Colors of Surface Treatment

Types of Surface Treatment

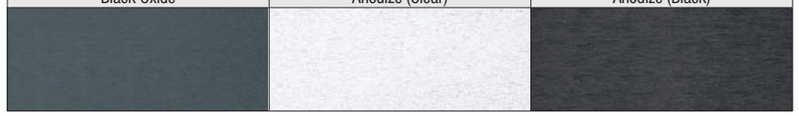
Name	Vickers Hardness (HV)	Layer Thickness (μm)	Applicable Materials	Example	Purpose, Features	Reference
Zinc Plating	–	3~20	Steel	Thin Plate Wire	·Antirust, low price. ·Poor appearance.	–
Chromate Plating	–	1~2	Steel	Plate Work Bolts and Nuts.	·Antirust, low price. ·Fit for mass production. ·Poor appearance, however, can work instead of nickel plating.	–
Bright Chromate	–	1~2	Steel	–		
Trivalent Chromate	–	1~2	Steel	Bolts and Nuts	·Antirust, low price. ·Do not contain hexavalent chrome.	–
Nickel Plating	–	–	Steel Copper Brass	–	·Improvement of corrosion resistance and decoration ·Chrome plating has more corrosion resistance in the atmosphere.	·Copper base plating as appropriate. ·Not applicable to deep indentations.
Class 1 Plating	500	5~20			·Better appearance than Class 3 plating.	·Material…Buff…Plating…Buff
Class 3 Plating					–	·Material…Plating
Satin Finish Plating	–	–			·Fatigue resistance. ·Minor flaws remain inconspicuous.	·Material…Satin finish…Plating
Electroless Nickel Plating	500	Specifiable	Steel Stainless Steel Copper Aluminum Alloy Glass Plastic	Parts Unsuitable for Nickel Plating.	·Approx.10 times more expensive than nickel plating. ·Easy film thickness control. ·High corrosion resistance, abrasion resistance. ·Give Conductivity to Non-Metals	–
Kanigen Plating	Up to 1000			Parts hardened after Plating.	·Same as the features of electroless nickel plating. ·Can be hardened by heat treatment after plating.	
Chrome Plating	–	–	Steel Copper Brass	–	·Appearance with gloss ·Good corrosion resistance ·Sliding chrome plating surfaces are easy to stick together.	·Nickel base plating as appropriate. ·Not applicable to deep indentations.
Class 1 Plating	500	5~20			·Better appearance than Class 3 plating.	·Material…Buff…Plating…Buff
Class 3 Plating					–	·Material…Plating
Satin Finish Plating	–	–			·Fatigue resistance. ·Minor flaws remain inconspicuous.	·Material…Satin finish…Plating
Hard Chrome Plating	1000	10~30		Cylinder Liners	·Excellent abrasion resistance. ·More expensive than other chrome plating.	·Material…Plating (Class 3 Plating)
Black Oxide (Blackening)	–	–	Steel	Bolts Nuts Instruments	·Base coating. ·Appearance(with gloss). ·Rusts more easily than Tufftride	·General Black Oxide
Low Temperature Black Chrome Plating	–	1~2	Steel Copper Stainless Steel	Items requiring high precision, items requiring higher corrosion resistance than blackening.	·Long term antirust performance. ·High corrosion resistance. ·Ultra thin film.	·Low-Temperature Preliminary Treatment. No thermal effect on raw material. Parts coupled with plastic matter, rubber, etc.
Anodize – Clear	–	3~5	Aluminum Alloy	–	·Corrosion and abrasion resistance. ·No electric conductivity. ·Heat Resistance	·Some anodize pieces are colored through fine holes in the hard, oxidized film formed on the surface.
Anodize – Black	–	5~10				

Apparent Colors of Surface Treatment

Bright Chromate	Trivalent Chromate	Electroless Nickel Plating	Hard Chrome Plating



Black Oxide	Anodize (Clear)	Anodize (Black)



Materials
Hardening and Hardness Test Methods

Heat Treatment for Steel Materials

Name	Vickers Hardness (HV)	Hardening Depth (mm)	Strain	Applicable Materials	Typical Material	Reference
Through hardening	750 or Less	Full Depth	Varies according to materials.	High Carbon Steel C>0.45%	SKS3 SKS21 SUJ2 SKH51 SKS93 SK4 S45C	·Operation of heating copper to an appropriate temperature over transformation point and quickly cooling it in an appropriate medium in order to increase hardness or improve strength. ·Not applicable to long or precision parts, such as spindles, etc.
Carburization	500 or Less	Standard 0.5 Up to 2	Moderate	Low Carbon Steel C<0.3%	SCM415 SNCM220	·Applicable to partial hardening ·Hardening depth should be specified on drawings. ·Applicable to precision parts.
Induction Hardening	750 or Less	1~2	High	Medium Carbon Steel C 0.3~0.5%	S45C	·A surface hardening method that uses high frequency induction current to quickly heat and cool the steel surface. ·Applicable to partial hardening ·Expensive in small-volume lots. ·High fatigue resistance.
Nitriding	900~1000	0.1~0.2	Low	Nitriding Steel	SACM645	·A surface hardening method that forms hardening layer of hard nitride compounds on the steel surface ·Obtains highest degree of hardness among all hardening techniques. ·Fit for mass production. ·Applicable to spindles for sliding bearing.
TUFFTRIDE is the trademark of Durferrit GmbH, Germany (salt bath process).	Carbon Steel 500 Stainless Steel 1000	0.01~0.02	Low	Steel Material	S45C SCM415 SK3 Stainless Steel	·Tufftride is one of the nitriding methods called soft-nitriding (salt bath process). ·High fatigue resistance and abrasion resistance ·Same corrosion resistance as zinc plating. ·Not applicable to precision parts because of incapability of polishing after heat treatment. ·Applicable to oil free bearings.
Bluing	–	–	–	Wire Rod	SWP-B	·Low temperature annealing. ·Removes internal stress during forming to enhance elasticity.

Hardness Test Methods and Applicable Parts

Testing Method	Principle	Applicable Heat-Treated Parts	Features	Reference
Brinell Hardness	·A (steel or super hard alloy) ball indenter is used to indent the test surface. Hardness is given as a quotient divided by the surface area of the dent, computed from the diameter.	·Annealing ·Normalized parts ·Anchored materials	·Applicable to uneven materials and forged products because indent is large. ·Not applicable to small or thin specimens.	JIS Z2243
Rockwell Hardness	·This standard or test load is applied via a diamond or ball indenter. Hardness is read on a tester.	·Hardening tempered parts ·Carburized surfaces ·Nitrided parts ·Thin sheets such as copper, brass, bronze, etc.	·Hardness value obtained quickly. ·Applicable to intermediate testing of actual products. ·Caution is required as there are 30 types.	JIS Z2245
Shore Hardness	·The specimen is set on a table. A hammer is dropped from a uniform height. Hardness is based on how height the hammer bounces.	·Hardening tempered parts ·Nitrided parts ·Large carburized parts, etc.	·Extremely easy to operate and data can be obtained quickly. ·Applicable to large parts. ·Indent is kept shallow, therefore is applicable to actual products. ·Portable, because of compactness and light weight.	JIS Z2246
Vickers Hardness	·Uses a diamond 136°square pyramid indenter. Hardness value is obtained from the surface area of the dent, computed from the experimental load and the length of the diagonal lines of the dent. (Automatically calculated)	·This hardening layers by induction hardening, carburizing, nitriding, electrolytic plating, ceramic coating, etc. ·Hardening layer depth in carburized and nitrided parts.	·Applicable to small and thin specimens. ·Applicable to all materials because of diamond indenter.	JIS Z2244

Materials
Standard Material Sizes

General Steel Materials

Type	Material Code	Shapes	Unit	Standard Dimensions
Rolled Steel for General Structure	SS400	Flat Bar	t	6, 9, 12, 13, 14, 16, 19, 22, 25, 28, 30, 32, 35, 38, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 105
		Square Bar	_	9, 13, 16, 19, 22, 25, 32, 38, 44, 50, 65, 75, 90, 100
Polished Steel Bar (Cold-Drawn)	SS400D	Flat and Square Steel Bar	t	Width W
			2	6, 8, 10, 12, 16, 20
			3	6, 8, 9, 10, 12, 13, 16, 19, 22, 25, 32, 38, 50
			4	10, 13, 16, 19, 20, 22, 25, 32
			4.5	11, 13, 16, 19, 22, 25, 32, 38, 50
			5	8, 10, 13, 16, 19, 20, 22, 25, 30, 32, 38, 50
			6	9, 10, 13, 16, 19, 20, 22, 25, 32, 38, 44, 50, 60, 65, 75, 90, 100, 125
			8	10, 12, 13, 16, 19, 22, 25, 30, 32, 38
			9	12, 13, 16, 19, 22, 25, 32, 38, 44, 50, 60, 65, 75, 90, 100, 125
			10	13, 15, 16, 20, 22, 25, 30, 32, 38, 40, 50, 60, 65, 100
			12	16, 19, 22, 32, 38, 44, 45, 50, 60, 65, 75, 90, 100, 125
			16	19, 22, 25, 32, 38, 44, 50, 60, 65, 75, 90, 100, 125
			19	22, 25, 32, 38, 44, 50, 60, 65, 75, 90, 100, 125
			22	25, 32, 38, 44, 50, 60, 65, 75, 90, 100, 125
			25	32, 38, 44, 50, 60, 65, 75, 90, 100, 125
			30	50, 65, 75, 100, 125
			32	50, 65, 75, 100, 125
			38	50, 65, 75, 100, 125
		Square Bar	_	2.5, 3, 4, 4.5, 5, 5.5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 24, 25, 28, 30, 32, 34, 35, 36, 38, 40, 42, 44, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 100, 110, 120, 130
		Hexagonal Bar	Opposite side H	3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 17, 19, 21, 22, 23, 24, 26, 27, 29, 30, 32, 35, 36, 38, 41, 46, 50, 54, 55, 58, 60, 63, 65, 67, 70, 71, 75, 77, 80, 85, 90, 95, 100, 115
		Round Bar	D	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 40, 42, 43, 44, 45, 46, 48, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 105, 110, 115, 120, 130, 140, 150, 160, 170, 180, 190, 200
Cold-Rolled Steel Plate	SPCC	Steel Plate	t	0.4, 0.5, 0.6, 0.7, 0.8, 1, 1.2, 1.6, 2, 2.3, 3.2
Hot-rolled Steel Plate	SPHC	Steel Plate	t	(1.2), 1.6, 2.3, 2.6, 3.2, 4.5
Carbon Steel for Machine Structural Use	S45C-D (Polished)	Round Bar	D	2, 2.5, 3, 3.5, 4, 4.5, 6, 7, 8, 9, 9.5, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 32, 33, 34, 35, 36, 38, 40, 42, 44, 45, 46, 48, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 105, 110, 115, 120, 125, 130
	S50C	Flat Bar	t	6, 9.5, 12.7, 13, 16, 19, 22, 25, 27, 32, 38, 45, 50, 55, 65, 75, 85, 95, 105, 115, 125, 135, 145, 155, (165), (175), (185), (205)
		Square Bar	_	12.7, 13, 16, 19, 25, 28, 32, 38, 44, 50, 55, 65, 75, 90, 100, 110, 120, 130, 155
Carbon Tool Steel	SKS93	Flat Bar	t	2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 16, 19, 22, 25, 27, 32, 38, 43, 50, 53, 65, 75, 90, 105, 130, 155
	SKS93	Square Bar	_	10, 13, 16, 19, 22, 25, 28, 32, 38, 45, 50, 55, 65, 75, 90, 105, 130, (155), (210)
	SK4-DG8	Round Bar	D	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 23, 24, 25, 26, 28, 30, 32, 36, 38, 40, 42, 45, 48, 50, 55, 60, 65, 70, 75, 80
Alloy Tool Steel	SKS3	Flat Bar	t	2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 16, 19, 22, 25, 27, 32, 38, 43, 50, 53, 65, 75, 90, 105, 130, 155, (160)
		Square Bar	_	10, 13, 16, 19, 22, 25, 28, 32, 36, 38, 45, 50, 55, 65, 75, 90, 105, 130, (155), (210)
		Round Bar	D	13, 16, 19, 22, 25, 28, 32, 38, 42, 46, 50, 55, 60, 65, 70, 80, 85, 90, 100, 110, 120, 130, 150, 160, 180
Chrome Molybdenum Steel	SCM435	Hexagonal Bar	Opposite side H	6, 7, 8, 9, 10, 11, 12, 13, 14, 17, 19, 21, 22, 23, 24, 26, 27, 30, 32, 35, 36, 38, 41, 46, 50, 54, 55
		Round Bar	D	4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 30, 32, 34, 35, 36, 38, 40, 42, 45, 46, 48, 50
Sulfuric and Sulfur Compound Free Cutting Steel	SUM24L	Round Bar	D	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 20, 22, 23, 24, 25, 26, 28, 30, 32, 34, 35, 36, 38, 40
High Carbon Chrome Bearing Steel	SUJ2	Round Bar	D	13, 16, 19, 22, 25, 28, (30), 32, (34), 36, 38, 42, (44), 46, (48), 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 110, 120, 130, 140, 150, (160), (170), (180), (190), (200), (210), (220), (230), (240), (250)

Stainless Steel Materials

Type	Material Code	Shapes	Unit	Standard Dimensions
Austenite	SUS303	Round Bar	D	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 25, 26, 28, 30
Austenite	SUS304	Flat Bar	t	3, 4, 5, 6, 8, 9, 10, 12, 14, 15, 16, 19, 20, 22, 25, 28, 30, 35, 40, 45, 50, 55, 60, 70
		Square Bar	_	5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 19, 20, 22, 25, 28, 30, 32, 36, 38, 40, 45, 50, 60
		Hexagonal Bar	Opposite side H	8, 10, 14, 17, 19, 21, 22, 23, 24, 26, 29, 30, 32, 35, 36, 38, 41, 46
		Round Bar	D	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 28, 30, 32, 34, 35, 36, 38, 40, 42, 45, 46, 48, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 110, 120, 130, 140, 150, 160, 170, 180, 190, 200, 210, 220, 230
		Steel Plate	t	0.3, 0.4, 0.5, 0.6, 0.8, 1, 1.2, 1.5, 2, 2.5, 3, 4, 5, 6, 7, 8, 9, 10, 12, 15, 20

Copper Alloy Materials

Type	Material Code	Shapes	Unit	Standard Dimensions
Brass Plate	C2801P	Steel Plate	t	0.1, 0.15, 0.2, 0.3, 0.4, 0.5, 0.8, 1, 1.2, 1.5, 1.6, 2, 2.3, 2.5, 3, 3.5, 4, 5, 6, 7, 8, 9, 10, 12, 15, 20, 25, 30, 40, 50
Free-Cutting Brass (Extruded Bar)	C3604BD	Square Bar	_	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 28, 30, 32, 35, 36, 38, 40, 42, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100
		Hexagonal Bar	Opposite side H	5, 5.5, 6, 7, 8, 9.5, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 32, 34, 35, 36, 38, 40, 41, 42, 44, 45, 46, 50, 54, 55, 58, 60, 65, 70, 75, 80
		Round Bar	D	3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 32, 33, 34, 35, 36, 38, 40, 42, 45, 46, 47, 48, 50, 51, 52, 53, 54, 55, 56, 57, 58, 60, 65, 70, 75, 80, 85, 90, 95, 100, 105, 110, 115, 120, 125, 130, 135, 140, 145, 150, 160, 170, 180, 190, 200, 210, 220, 230, 240, 250, 270, 280, 300, 320, 350

Aluminum Alloy Materials

Type	Material Code	Shapes	Unit	Standard Dimensions
Al-Cu Alloy	A2017	Flat Bar	t	0.5, 0.6, 0.8, 1, 1.2, 1.5, 1.6, 2, 2.5, 3, 4, 5, 6, 8, 10, 12, 15, 20, 25, 30, 40, 45, 50, 60, 70, 80, 90, 100
		Round Bar	D	5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 70, 75, 80, 85, 90, 95, 100, 105, 110, 115, 120, 125, 130, 135, 140, 150, 160, 170, 180, 190, 200, 210, 220, 230, 240, 250, 260, 280, 300
Al-Mg Alloy	A5052	Flat Bar	t	0.4, 0.5, 0.6, 0.7, 0.8, 1, 1.2, 1.5, 1.6, 2, 3, 3.2, 4, 5, 6, 7, 8, 10, 12, 15, 16, 18, 20, 22, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 105, 110, 120, 130, 150, 160, 170, 180, 200
Al-Mg Alloy	A5056	Round Bar	D	5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 70, 75, 80, 85, 90, 95, 100, 105, 110, 115, 120, 125, 130, 135, 140, 150, 160, 170, 180, 190, 200, 210, 220, 230, 240, 250, 260, 270, 280, 290, 300, 310, 320, 330, 340, 350, 360, 370, 380, 390, 400, 420
Al-Mg-Si Alloy	A6063	Square Bar	_	6, 8, 10, 12, 14, 15, 16, 18, 19, 20, 22, 25, 30, 32, 35, 40, 45, 50, 60, 70, 80, 100

Resin Type Materials

Type	Material Code	Shapes	Unit	Standard Dimensions
Laminated Sheet	Bakelite	Plate	t	(0.5), (0.6), 0.8, 1, 1.2, 1.5, 1.6, 2, 2.5, 3, 4, 5, 6, 8, 10, 12, 15, 16, 20, 25, 30, 35, 40, 50 Sizes in( )for cloth base only.
Polyamide Resin	Nylon 6, 66	Plate	t	5, 10, 15, 20, 25, 30, 40, 50
		Bar	D	6, 8, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 90, 100, 120, 140, 160, 180, 200
(MC Nylon)	MC Nylon	Plate	t	5, 7, 10, 12, 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 110, 120
		Bar	D	20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 110, 120, 130, 140, 150, 160, 170, 180, 190, 200, 225, 250, 275, 300, 325, 350, 375, 400, 450, 500, 600
Acetal Resin	Polyacetal	Plate	t	5, 6, 8, 10, 12, 15, 20, 25, 30, 35, 40, 50, 60, 70, 80, 90, 100
		Bar	D	4, 5, 6, 7, 8, 9, 10, 12, 12.5, 13, 15, 16, 17.5, 20, 22.5, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 100, 110, 120, (130), (140), 150, (160), (180), 200
General Methacrylic Resin Plate	Acrylic	Plate	t	0.8, 1, 1.5, 2, 3, 4, 5, 6, 8, 10, 15, 20, 25, 30

Materials
Comparisons of Materials between JIS and Foreign Standards

Carbon Steel for Machine Structural Use, Alloy Steel

Japan Industrial Standards		Steel Type Related to Foreign Standards					
Standard Number Name	Symbol	ISO 683/1,10,11[5]	AISI SAE	BS 970 Part1,3 BS EN 10083-1,2	DIN EN 10084 DIN EN 10083-1,2	NF A35-551 NF EN 10083-1,2	Γ OCT 4543
JIS G 4051 Carbon Steel for Machine Structural Use	S10C	C10	1010	040A10 045A10 045M10	C10E C10R	XC10	–
	S12C	–	1012	040A12	–	XC12	–
	S15C	C15E4 C15M2	1015	055M15	C15E C15R	–	–
	S17C	–	1017	–	–	XC18	–
	S20C	–	1020	070M20 C22 C22E C22R	C22 C22E C22R	C22 C22E C22R	–
	S22C	–	1023	–	–	–	–
	S25C	C25 C25E4 C25M2	1025	C25 C25E C25R	C25 C25E C25R	C25 C25E C25R	–
	S28C	–	1029	–	–	–	25Γ
	S30C	C30 C30E4 C30M2	1030	080A30 080M30 C30 C30E C30R	C30 C30E C30R	C30 C30E C30R	30Γ
	S33C	–	–	–	–	–	30Γ
	S35C	C35 C35E4 C35M2	1035	C35 C35E C35R	C35 C35E C35R	C35 C35E C35R	35Γ
	S38C	–	1038	–	–	–	35Γ
	S40C	C40 C40E4 C40M2	1039 1040	080M40 C40 C40E C40R	C40 C40E C40R	C40 C40E C40R	40Γ
	S43C	–	1042 1043	080A42	–	–	40Γ
	S45C	C45 C45E4 C45M2	1045 1046	C45 C45E C45R	C45 C45E C45R	C45 C45E C45R	45Γ
	S48C	–	–	080A47	–	–	45Γ
	S50C	C50 C50E4 C50M2	1049	080M50 C50 C50E C50R	C50 C50E C50R	C50 C50E C50R	50Γ
	S53C	–	1050 1053	–	–	–	50Γ
	S55C	C55 C55E4 C55M2	1055	070M55 C55 C55E C55R	C55 C55E C55R	C55 C55E C55R	–
	S58C	C60 C60E4 C60M2	1059 1060	C60 C60E C60R	C60 C60E C60R	C60 C60E C60R	60Γ
	S09CK	–	–	045A10 045M10	C10E	XC10	–
	S15CK	–	–	–	C15E	XC12	–
	S20CK	–	–	–	–	XC18	–
JIS G 4106 Manganese Steel and Chrome-Manganese Steel for Machine Structural Use	SMn420	22Mn6	1522	150M19	–	–	–
	SMn433	–	1534	150M36	–	–	30Γ 2 35Γ 2
	SMn438	36Mn6	1541	150M36	–	–	35Γ 2 40Γ 2
	SMn443	42Mn6	1541	–	–	–	40Γ 2 45Γ 2
	SMnC420	–	–	–	–	–	–
	SMnC443	–	–	–	–	–	–
JIS G 4202 Aluminum Chrome Molybdenum Steel	SACM645	41CrAlMo74	–	–	–	–	–
JIS G 4052 Structural Steel with Guaranteed Hardenability (H Steel)	SMn420H	22Mn6	1522H	–	–	–	–
	SMn433H	–	–	–	–	–	–
	SMn438H	36Mn6	1541H	–	–	–	–
	SMn443H	42Mn6	1541H	–	–	–	–
	SMnC420H	–	–	–	–	–	–
	SMnC443H	–	–	–	–	–	–
	SCr415H	–	–	–	17Cr3 17CrS3	–	15X
	SCr420H	20Cr4 20CrS4	5120H	–	–	–	20X
	SCr430H	34Cr4 34CrS4	5130H 5132H	34Cr4 34CrS4	34Cr4 34CrS4	34Cr4 34CrS4	30X
	SCr435H	34Cr4 34CrS4 37Cr4 37CrS4	5135H	37Cr4 37CrS4	37Cr4 37CrS4	37Cr4 37CrS4	35X
	SCr440H	37Cr4 37CrS4 41Cr4 41CrS4	5140H	41Cr4 41CrS4	41Cr4 41CrS4	41Cr4 41CrS4	40X
	SCM415H	–	–	–	–	–	–
	SCM418H	18CrMo4 18CrMoS4	–	–	18CrMo4 18CrMoS4	–	–
	SCM420H	–	–	708H20	–	–	–
	SCM435H	34CrMo4 34CrMoS4	4135H 4137H	34CrMo4 34CrMoS4	34CrMo4 34CrMoS4	34CrMo4 34CrMoS4	–
	SCM440H	42CrMo4 42CrMoS4	4140H 4142H	42CrMo4 42CrMoS4	42CrMo4 42CrMoS4	42CrMo4 42CrMoS4	–
	SCM445H	–	4145H 4147H	–	–	–	–
	SCM822H	–	–	–	–	–	–
	SNC415H	–	–	–	–	–	–
	SNC631H	–	–	–	–	–	–
	SNC815H	15NiCr13	–	655H13	15NiCr13	–	–
	SNCM220H	20NiCrMo2 20NiCrMoS2	8617H 8620H 8622H	805H17 805H20 805H22	–	20NCD2	–
	SNCM420H	–	4320H	–	–	–	–

Japan Industrial Standards		Steel Type Related to Foreign Standards					
Standard Number Name	Symbol	ISO 683/1,10,11[5]	AISI SAE	BS 970 Part1,3 BS EN 10083-1,2	DIN EN 10084 DIN EN 10083-1,2	NF A35-551 NF EN 10083-1,2	Γ OCT 4543
JIS G 4102 Nickel-Chromium Steel	SNC236	–	–	–	–	–	40XH
	SNC415	–	–	–	–	–	–
	SNC631	–	–	–	–	–	30XH3A
	SNC815	15NiCr13	–	655M13	15NiCr13	–	–
	SNC836	–	–	–	–	–	–
JIS G 4103 Nickel Chrome Molybdenum Steel	SNCM220	20NiCrMo2 20NiCrMoS2	8615 8617 8620 8622	805A20 805M20 805A22 805M22	20NiCrMo2 20NiCrMoS2	20NCD2	–
	SNCM240	41CrNiMo2 41CrNiMoS2	8637 8640	–	–	–	–
	SNCM415	–	–	–	–	–	–
	SNCM420	–	4320	–	–	–	20Н2М(20ХНМ)
	SNCM431	–	–	–	–	–	–
	SNCM439	–	4340	–	–	–	–
	SNCM447	–	–	–	–	–	–
	SNCM616	–	–	–	–	–	–
	SNCM625	–	–	–	–	–	–
	SNCM630	–	–	–	–	–	–
	SNCM815	–	–	–	–	–	–
JIS G 4104 Chrome Steel	SCr415	–	–	–	17Cr3 17CrS3	–	15X 15XA
	SCr420	20Cr4 20CrS4	5120	–	–	–	20X
	SCr430	34Cr4 34CrS4	5130 5132	34Cr4 34CrS4	34Cr4 34CrS4	34Cr4 34CrS4	30X
	SCr435	34Cr4 34CrS4 37Cr4 37CrS4	5132	37Cr4 37CrS4	37Cr4 37CrS4	37Cr4 37CrS4	35X
	SCr440	37Cr4 37CrS4 41Cr4 41CrS4	5140	530M40 41Cr4 41CrS4	41Cr4 41CrS4	41Cr4 41CrS4	40X
	SCr445	–	–	–	–	–	45X
JIS G 4105 Chrome Molybdenum Steel	SCM415	–	–	–	–	–	–
	SCM418	18CrMo4 18CrMoS4	–	–	18CrMo4 18CrMoS4	–	20XM
	SCM420	–	–	708M20	–	–	20XM
	SCM421	–	–	–	–	–	–
	SCM430	–	4131	–	–	–	30XM 30XMA
	SCM432	–	–	–	–	–	–
	SCM435	34CrMo4 34CrMoS4	4137	34CrMo4 34CrMoS4	34CrMo4 34CrMoS4	34CrMo4 34CrMoS4	35XM
	SCM440	42CrMo4 42CrMoS4	4140 4142	708M40 709M40 42CrMo4 42CrMoS4	42CrMo4 42CrMoS4	42CrMo4 42CrMoS4	–
	SCM445	–	4145 4147	–	–	–	–
	SCM822	–	–	–	–	–	–
JIS G 4107 High-Temperature Alloy Steel for Bolts	SNB5	–	501	–	–	–	–
	SNB7	42CrMo4 42CrMoS4	4140 4142 4145	708M40 709M40 42CrMo4[1)]	42CrMo4[3)]	42CrMo4[4)]	–
	SMB16	–	–	40CrMoV4–6[1)]	40CrMoV47[2)]	40CrMoV4–6[6)]	–
JIS G 4108 Steel Bar for Special-Purpose Alloy Bolts	SNB21–1–5	–	–	40CrMoV4–6[1)]	40CrMoV47[2)]	40CrMoV4–6[6)]	–
	SNB22–1–5	42CrMo4 42CrMoS4	4142H	–	42CrMo4[3)]	–	–
	SNB23–1–5	–	E4340H	–	–	–	–
	SNB24–1–5	–	4340	–	–	–	–

Cautions 1) BS EN 10259
2) DIN 1654 Part 4
3) DIN 17240
4) NF EN 10259
5) ISO683-1, 10 and 11 have been translated into JIS as JIS G 7501, G 7502 and G 7503.

ISO: International Organization for Standardization
AISI: American Iron and Steel Institute
SAE: Society of Automotive Engineers
BS: British Standards
DIN: Deutsches Institut für Nörmung
EN: European Standards
NF: Norme Francaise
Γ OCT: National Standards of Former USSR

Names of Tool Steels

Rolled Steel for General Structure	SS400	Steel, Structure, 400N/mm²
Carbon Steel for Mechanical Structure	S45C	Steel, 0.45%C
Chrome Molybdenum Steel	SCM435	Steel, Cr, Mo 435
Nickel Chrome Molybdenum Steel	SNCM220	Steel, Ni, Cr, Mo 220
Carbon Tool Steel	SK105 (Old SK3)	Steel, Tool (Kogu, in Japanese), Type105
Alloy Tool Steel	SKS3	Steel, Tool (Kogu, in Japanese), Special, Type 3
Alloy Tool Steel	SKD11	Steel, Tool (Kogu, in Japanese), Dies, Type 11
High-Speed Tool Steel	SKH51	Steel, Tool (Kogu, in Japanese), High Speed, Type 51
High Carbon Chrome Bearing Steel	SUJ2	Steel, Use, Bearing, Type 2
Stainless Steel	SUS304	Steel, Use, Stainless, Type 304
Gray Cast Iron	FC250	Ferrum (Iron), Cast, 250N/mm²

Stainless Steel, Heat-Resisting Steel

Japan Industrial Standards		International Standard	Foreign Standards						European Standard	
Standard Number, Name (Stainless Steel)	JIS	ISO TR 15510 L-No.	US		UK	Germany	France	Russia(Former USSR)	EN	
			UNS	AISI	BS	DIN	NF	Γ OCT	Type	No.
JIS G 4303~4305 Bar	**SUS 201**	12	S20100	201			Z12CMN17-07Az		X12CrMnNiN17-7-5	1.4372
	SUS 202		S20200	202	284S16			12Х17 Г 9АН4	X12CrMnNiN18-9-5	1.4373
	SUS 301	5	S30100	301	301S21	X12CrNi17 7	Z11CN17-08	07Х16Н6	X5CrNi17-7	1.4319
Hot-Rolled Plate and Band	**SUS 301L**	4				X2CrNiN18-7			X2CrNiN18-7	1.4318
Cold-Rolled Plate and Band	**SUS 301J1**					X12CrNi17 7				
JIS G 4308~4309 Wire Rod	**SUS 302**		S30200	302	302S25		Z12CN18-09	12Х18Н9		
	SUS 302B		S30215	302B						
	SUS 303	13	S30300	303	303S21	X10CrNiS18 9	Z8CNF18-09		X8CrNiS18-9	1.4305
Wire	**SUS 303Se**		S30323	303Se	303S41			12Х18Н10Е		
	SUS 303Cu									
JIS G 4313~4315 Band for Spring	**SUS 304**	6	S30400	304	304S31	X5CrNi18 10	Z7CN18-09	08Х18Н10	X4CrNi18-10	1.4301
	SUS 304L	1	S30403	304L	304S11	X2CrNi19 11	Z3CN19-11	03Х18Н11	X2CrNi19-11	1.4307
		2								1.4307
	SUS 304N1	10	S30451	304N			Z6CN19-09Az		X2CrNi18-9	1.4306
Wire for Spring	**SUS 304N2**		S30452							
Wire for Cold Forging	**SUS 304LN**	3	S30453	304LN		X2CrNiN18 10	Z3CN18-10Az		X2CrNiN18-10	1.4311
JIS G 4317~4320 Hot-Rolled Equal-Leg Angle	**SUS 304J1**									
	SUS 304J2									
	SUS 304J3		S30431	S30431						
Cold-Finished Bar	**SUS 305**	8	S30500	305	305S19	X5CrNi18 12	Z8CN18-12	06Х18Н11	X4CrNi18-12	1.4303
Steel Piece for Forged Article	**SUS 305J1**									
Cold-Rolled Equal-Leg Angle	**SUS 309S**	X6CrNi23-14	S30908	309S			Z10CN24-13			
	SUS 310S	X6CrNi25-21	S31008	310S	310S31		Z8CN25-20	10Х23Н18	X6CrNi25-20	
	SUS 315J1									
	SUS 315J2									
	SUS 316	26	S31600	316	316S31	X5CrNiMo17 12 2	Z7CND17-12-02		X4CrNiMo17-12-2	1.4401
	SUS 316F	27				X5CrNiMo17 13 3	Z6CND18-12-03		X4CrNiMo17-13-3	1.4436
	SUS 316L	19	S31603	316L	316S11	X2CrNiMo17 13 2	Z3CND17-12-02		X2CrNiMo17-12-2	1.4404
		20				X2CrNiMo17 14 3	Z3CND17-13-03	03Х17Н14М3	X2CrNiMo17-13-3	1.4432
									X2CrNiMo18-14-3	1.4435
	SUS 316N		S31651	316N						
	SUS 316LN	22	S31653	316LN		X2CrNiMoN17 12 2	Z3CND17-11Az		X2CrNiMoN17-11-2	1.4406
		23				X2CrNiMoN17 13 3	Z3CND17-12Az		X2CrNiMoN17-13-3	1.4429
	SUS 316Ti	28	S31635			X6CrNiMoTi17 12 2	Z6CNDT17-12	08Х17Н13М2Т	X6CrNiMoTi17-12-2	1.4571
	SUS 316J1									
	SUS 316J1L									
	SUS 317		S31700	317	317S16					
	SUS 317L	21	S31703	317L	317S12	X2CrNiMo18 16 4	Z3CND19-15-04		X2CrNiMo18-15-4	1.4438
	SUS 317LN	24	S31753				Z3CND19-14Az		X2CrNiMoN18-12-4	1.4434
	SUS 317J1								X2CrNiMoN17-13-5	1.4439
	SUS 317J2									
	SUS 317J3L									
	SUS 836L		N08367							
	SUS 890L	31	N08904	N08904	904S14		Z2NCDU25-20		X1CrNiMoCuN25-25-5	1.4539
	SUS 321	15	S32100	321	321S31	X6CrNiTi18 10	Z6CNT18-10	08Х18Н10Т	X6CrNiTi18 10	1.4541
	SUS 347	17	S34700	347	347S31	X6CrNiNb18 10	Z6CNNb18-10	08Х18Н12 Б	X6CrNiNb18 10	1.4550
	SUS 384	9	S38400	384			Z6CN18-16			
	SUS XM7	D26([1])	S30430	304Cu	394S17		Z2CNU18-10		X3CrNiCu18-9-4	1.4587
	SUS XM15J1		S38100				Z15CNS20-12		X1CrNiSi18-15-4	1.4381
	SUS 329J1		S32900	329						
	SUS 329J3L	33	S39240	S31803			Z3CND22-05Az	08Х21Н6М2Т	X2CrNiMoN22-5-3	1.4462
	SUS 329J4L	34	S39275	S31260			Z3CNDU25-07Az		X2CrNiMoCuN25-6-3	1.4507
	SUS 405	40	S40500	405	405S17	X6CrAl13	Z8CA12		X6CrAl13	1.4002
	SUS 410L						Z3C14			
	SUS 429		S42900	429						
	SUS 430	41	S43000	430	430S17	X6Cr17	Z8C17	12Х17	X6Cr17	1.4016
	SUS 430F	42	S43020	430F		X7CrMoS18	Z8CF17		X6CrMoS17	1.4105
	SUS 430LX	44	S43035			X6CrTi17	Z4CT17		X3CrTi17	1.4510
						X6CrNb17			X2CrTi17	1.4520
	SUS 430J1L						Z4CNb17		X3CrNb17	1.4511
	SUS 434	43	S43400	434	434S17	X6CrMo17 1	Z8CD17-01		X6CrMo17-1	1.4113
	SUS 436L		S43600	436					X1CrMoTi16-1	1.4513
	SUS 436J1L									
	SUS 444	46	S44400	444			Z3CDT18-02		X2CrMoTi18-2	1.4521
	SUS 445J1									
	SUS 445J2									
	SUS 447J1		S44700							
	SUS XM27		S44627				Z1CD26-01			
	SUS 403		S40300	403						
	SUS 410	48	S41000	410	410S21	X10Cr13	Z13C13		X12Cr13	1.4006
	SUS 410S	39	S41008	410S	403S17	X6Cr13	Z8C12	08Х13	X6Cr13	1.4000
	SUS 410F2									
	SUS 410J1		S41025							
	SUS 416	49	S41600	416	416S21		Z11CF13		X12CrS13	1.4005
	SUS 420J1	50	S42000	420	420S29	X20Cr13	Z20C13	20Х13	X20Cr13	1.4021
	SUS 420J2	51	S42000	420	420S37	X30Cr13	Z33C13	30Х13	X30Cr13	1.4028
	SUS 420F		S42020	420F			Z30CF13		X29CrS13	1.4029
	SUS 420F2									
	SUS 423J1									
	SUS 431	57	S43100	431	431S29	X20CrNi17 2	Z15CN16-02	20Х17Н2	X19CrNi17 2	1.4057
	SUS 440A		S44002	440A			Z70C15		X70CrMo15	1.4109
	SUS 440B		S44003	440B						
	SUS 440C		S44004	440C			Z100CD17	95Х18	X105CrMo17	1.4125
	SUS 440F		S44020	S44020						
	SUS 630	58	S17400	S17400			Z6CNU17-04		X5CrNiCuNb16-4	1.4542
	SUS 631	59	S17700	S17700		X7CrNiAl17 7	Z9CNA17-07	09Х17Н7 І0	X7CrNiAl17-7	1.4568
	SUS 632J1									
JIS G 4311~4315 Heat Resisting Steel Bar Heart Resisting Steel Plate	SUH 31						Z35CNWS14-14		45Х14Н14В2М	
	SUH 35	X53CrMnNi21 4 ([7])					Z52CMN21-09Az			
	SUH 36		S63008				349S54	X53CrMnNi21 9	Z55CMN21-09Az	55Х20 Г 9АН4
	SUH 37		S63017				381S34			
	SUH 38									
	SUH 309		S30900	309	309S24		Z15CN24-13			
	SUH 310		S31000	310	310S24	CrNi2520	Z15CN25-20	20Х25Н20С2		
	SUH 330		N08330	N08330			Z12NCS35-16			
	SUH 660		S66286				Z6NCTV25-20			
	SUH 661		R30155							
	SUH 21					CrAl1205				
	SUH 409	37	S40900	409	409S19	X6CrTi12	Z6CT12			
	SUH 409L	36					Z3CT12		X2CrTi12	1.4512
	SUH 446	X15CrN26([7])	S44600	446			Z12C25	15Х28		
	SUH 1	X45CrSi9 3([7])	S65007		401S45	X45CrSi9 3	Z45CS9			
	SUH 3						Z40CSD10	40Х10С2М		
	SUH 4				443S65		Z80CSN20-02			
	SUH 11	X5CrSi18-2([7])						40Х9С2		
	SUH 600							20Х12ВНМ Б φ г		
	SUH 616		S42200							

Reference 1. ISO:ISO TR 15510:1997. EN Symbols. ([1]) ISO 4954, ([2]) ISO 683, 15.
2. US:UNS registration numbers and the AISI Steel Manual
3. European Standard:EN 10088-1:1995
4. European countries:BS, DIN, NF, etc. These national standards are to be abolished in favor of EN.
5. Γ OCT: 5632

Tool Steel

Japan Industrial Standards		Steel Type Related to Foreign Standards					
Standard Number Name	Code	ISO	AISI ASTM	BS	DIN VDEh	NF	Γ OCT
JIS G 4401 Carbon Tool Steel	SK140(Old SK1)	TC140	–	–	–	C140E3U	Y13
	SK120(Old SK2)	TC120	W1–11 1/2	–	–	C120E3U	Y12
	SK105(Old SK3)	TC105	W1–10	–	C105W1	C105E2U	Y11
	SK95(Old SK4)	TC 90	W1–9	–	–	C90 E2U	Y10
	SK85(Old SK5)	TC 90 TC 80	W1–8	–	C 80W1	C90 E2U C80 E2U	Y8 Γ Y9
	SK75(Old SK6)	TC 80 TC 70	–	–	C 80W1	C80 E2U C70 E2U	Y8
	SK65(Old SK7)	–	–	–	C 70W2	C70 E2U	Y7
JIS G 4403 High-Speed Tool Steel	SKH 2	HS18–0–1	T 1	BT 1	–	HS18–0–1	P18
	SKH 3	HS18–1–1–5	T 4	BT 4	S18–1–2–5	HS18–1–1–5	–
	SKH 4	HS18–0–1–10	T 5	BT5	–	HS18–0–2–9	–
	SKH10	HS12–1–5–5	T15	BT15	S12–1–4–5	HS12–1–5–5	–
	SKH51	HS 6–5–2	M2	BM2	S 6–5–2	HS 6–5–2	–
	SKH52	–	M3–1	–	–	–	–
	SKH53	HS 6–5–3	M3–2	–	S 6–5–3	HS 6–5–3	–
	SKH54	–	M4	BM4	–	HS 6–5–4	–
	SKH55	HS 6–5–2–5	–	BM35	S 6–5–2–5	HS 6-5-2-5Н[C]	Р6М5К5
	SKH56	–	M36	–	–	–	–
	SKH57	HS10–4–3–10	–	BT42	S10–4–3–10	HS10–4–3–10	–
	SKH58	HS 2–9–2	M7	–	–	HS 2–9–2	–
	SKH59	HS 2–9–1–8	M42	BM42	S 2–10–1–8	HS 2–9–1–8	–
JIS G 4404 Alloy Tool Steel	SKS11	–	F2	–	–	–	XB4
	SKS 2	105WCr1	–	–	105WCr6	105WCr5	XB Γ
	SKS21	–	–	–	–	–	–
	SKS 5	–	–	–	–	–	–
	SKS51	–	L6	–	–	–	–
	SKS 7	–	–	–	–	–	–
	SKS 8	–	–	–	–	C140E3UCr4	13X
	SKS 4	–	–	–	–	–	–
	SKS41	–	–	–	–	–	–
	SKS43	TCV105	W2–9 1/2	BW2	–	100V2	–
	SKS44	–	W2–8	–	–	–	–
	SKS 3	–	–	–	–	–	9XB Γ
	SKS31	105WCr1	–	–	105WCr6	105WCr5	XB Γ
	SKS93	–	–	–	–	–	–
	SKS94	–	–	–	–	–	–
	SKS95	–	–	–	–	–	–
	SKD 1	210Cr12	D3	BD3	X210Cr12	X200Cr12	X12
	SKD11	–	D2	BD2	–	X160CrMoV12	–
	SKD12	100CrMoV5	A2	BA2	–	X100CrMoV5	–
	SKD 4	30WCrV5	–	–	–	X32WCrV3	–
	SKD 5	30WCrV9	H21	BH21	–	X30WCrV9	–
	SKD 6	–	H11	BH11	X38CrMoV51	X38CrMoV5	4Х5МØС
	SKD61	40CrMoV5	H13	BH13	X40CrMoV51	X40CrMoV5	4Х5МØ1С
	SKD62	–	H12	BH12	–	X35CrWMoV5	3Х3М3Ø
JIS G 4404 (Continued)	**SKD 7**	30CrMoV3	H10	BH10	X32CrMoV33	32CrMoV12–18	–
	SKD 8	–	H19	BH19	–	–	–
	SKT 3	–	–	–	–	55CrNiMoV4	–
	SKT 4	55NiCrMoV2	–	BH224/5	55NiCrMoV6	55NiCrMoV7	5ХНМ

Special Purpose Steels

Japan Industrial Standards		Steel Type Related to Foreign Standards					
Standard Number Name	Code	ISO	AISI SAE	BS	DIN	NF	Γ OCT
JIS G 4801 Spring Steel	**SUP 3**	–	1075 1078	–	–	–	75 85 80
	SUP 6	59Si7	–	–	–	60Si7	60С2
	SUP 7	59Si7	9260	–	–	60Si7	60С2 Γ
	SUP 9	55Cr3	5155	–	55Cr3	55Cr3	–
	SUP 9A	–	5160	–	–	60Cr3	–
	SUP10	51CrV4	6150	735A51,735H51	50CrV4	51CrV4	ХØА50Х Γ ØА
	SUP11A	60CrB3	51B60	–	–	–	50Х Γ Р
	SUP12	55SiCr63	9254	685A57,685H57	54SiCr6	54SiCr6	–
	SUP13	60CrMo33	4161	705A60,705H60	–	60CrMo4	–
JIS G 4804 Sulfuric and Sulfur Compound Free Cutting Steel	**SUM11**	–	1110	–	–	–	–
	SUM12	–	1108	–	–	–	–
	SUM21	9 S20	1212	–	–	–	–
	SUM22	11SMn28	1213	(230M07)	9 SMn28	S250	–
	SUM22L	11SMnPb28	12L13	–	9 SMnPb28	S250Pb	–
	SUM23	–	1215	–	–	–	–
	SUM23L	–	–	–	–	–	–
	SUM24L	11SMnPb28	12L14	–	9 SMnPb28	S250Pb	–
	SUM25	12SMn35	–	–	9 SMn36	S300	–
	SUM31	–	1117	–	15S10	–	–
	SUM31L	–	–	–	–	–	–
	SUM32	–	–	210M15,210A15	–	(13MF4)	–
	SUM41	–	1137	–	–	(35MF6)	–
	SUM42	–	1141	–	–	(45MF6.1)	–
	SUM43	44SMn28	1144	(226M44)	–	(45MF6.3)	–
JIS G 4805 High Carbon Chrome Bearing Steel	**SUJ 1**	–	51100	–	–	–	–
	SUJ 2	B1 or 100Cr6	52100	–	100Cr6	100Cr6	ШХ15
	SUJ 3	B2 or 100CrMnSi4-4	ASTM A 485 Grade 1	–	–	–	–
	SUJ 4	–	–	–	–	–	–
	SUJ 5	–	–	–	–	–	–

Materials
Steel Brand Comparative Table / Hardness of Materials and Corresponding Tools

■Steel Brand Comparative Table

Type	Steel Types Related to the Foreign Standards			
	JIS	AISI	DIN	ISO
Carbon Tool Steel	SK105(Old SK3)	W1-10		TC105
Alloy Tool Steel	SKS93			
	SKS3			
	SKD1	D3		X210Cr12
	SKD11	D2	X210Cr12	X210Cr12W12
	SKD11(Modification)			
	Matrix Group CrSKD			
	SKD12			X100CrMoV5
	Pre-Hardened 40HRC	A2		
	Pre-Hardened 50HRC or more			
	Flame-Hardened Steel			
	Low Temperature Air Cooled Steel			
	Shock Resistance Steel			
	Others			
High-Speed Tool Steel	SKH51	M2	H6.5.2	HS6–5–2
	SKH55 Group		S6.2.5	HS6–5–2–5
	SKH57 Group		S10–4–3–10	HS10–4–3–10
	Matrix Group			
P/M High Speed Tool Steel	SKH40			HS6–5–3–8
	Matrix Group			
	Others			

Hitachi Metals, Ltd.	Aichi Steel Works, Ltd.	Kobe Steel Co., Ltd.	Sanyo Special Steel Co., Ltd.	Daido Steel Co., Ltd.	Nippon Koshuha Steel Co., Ltd.	Nachi-Fujikoshi	Riken Steel	Uddeholm (Sweden)	Bohler (Germany)
YC3	SK3		QK3	YK3	K3				K990
YCS3	SK301		QKSM	YK30	K3M	SK3M			
SGT	SKS3		QKS3	GOA	KS3	SKS3	RS3	ARNE	K460
CRD	SKD1		QC1	DC1	KD1			SVERKER3	K100 K107
SLD	SKD11		QC11	DC11	KD11	CDS11	RD11	SVERKER21	K105 K110
SLD8 SLD10	AUD15		QCM8 QCM10	DC53	KD11S KD21	MDS9		SLEIPNER	K340
ARK1	SXACE		QCM7	DCX					
SCD	SKD12			DC12	KD12			RIGOR	K305
HPM2T				GO40F	KAP65			IMPAX	
PRE2				CX1	RC55				
HMD5 HMD1	SX105V SX4		QF3	GO5	FH5			FERNO	
ACD37	AKS3			GO4	KSM				
YSM	AKS4		QF1	GS5	KTV5	SRS6		PREGA COMPAX	K630
ACD8	AUD11 SX5 SX44					ICS22 MCR1		CALMAX VIKING ELMAX VANADIS4 VANADIS6 VANADIS10	K190
YXM1			QH51	MH51	H51	SKH9	RHM1		S600
YXM4				MH55	HM35	HM35 HS53M	RHM5		S705
XVC5				MH8	MV10	HS93R HS98M FM38V	RHM7		S700
YXR33 YXR3 YXR7			QHZ	MH85 MH88	KXM KMX2 KMX3	MDS1 MDS3 MDS7 MATRIX2 ATM3			
HAP40		KHA30		DEX40		FAX38		ASP30	S590
HAP5R		KHA3VN		DEX–M1 DEX–M3					
HAP10									S690
		KHA32	SPM23	DEX21		FAX31		ASP23	S790
HAP50				DEX60					S390
				DEX61		FAX55			
HAP72		KHA60	SPM60	DEX80		FAXG1		ASP60	
		KHA77				FAX18			
						FAXG2			
		KHA30N							
		KHA33N							
		KHA3NH							
		KHA5NH							

Reference: "Special Steel", Nov. 2001

Matrix Group: This Tool Steel has cutting-machinability and toughness enhanced by reducing the ratio occupied by the carbide which facilitates the tool abrasion during the cutting process and thereby, causes toughness of the tool to be degraded.

Machining Method		Equipment	Required Tool
Machining	Hole Machining on Side and Bottom	General Purpose Milling Cutter NC Milling Cutter Machining Center	Drills Reamer End Mills Cutting Tools
	Hole Machining	Drilling Machine Drill Press Boring Machine Jig Borer	Drills Tapped Reamer Cutting Tools
	Machining Cylinders	General Purpose Lathe NC Lathe Turning Center	Drills Reamer Tapped Cutting Tools
Grinding		Surface Grinder Cylindrical Grinder Jig Grinder Profile Grinder Forming Grinder	Grindstone
Electric Discharging		EDM	Electrode Master
		WEDM	Wire

Tool	Tool Material	Parts Material
Drills Reamer	High-Speed Steel	SKH–
	Carbide	Wn–Co
Tapped	High-Speed Steel	SKH–
	Carbide	Wn–Co
End Mills Cutting Tools	High-Speed Steel	SKH–
	Carbide	Wn–Co
	Boron	CBN
	Diamond	D
Grindstone	White Fused Alumina	WA
	Brown Fused Alumina	A
	Pink Fused Aluminum	PA
	Green Silicon Carbide	GC
	Black Silicon Carbide	C
	Electrodeposited Boron	CBN
	Electrodeposited Diamond	D
Electrode Master	Electrolytic Copper, Brass	CU–
	Copper Tungsten, Silver Tungsten	–Wn
Wire	Brass	CU–Zn
	Tungsten	Wn

Machined Material

	Non-Ferrous Metal	Untreated	Thermal Refined	Hardening/Tempered
For Press Die	(Al)	(Al–alloi) SS400(SS41) SKD11 S45C S50C DC53	(Be–Cu) SCM435 HPM2T	DC53(Carbide) S45C SKS3 SKD11 SUJ2 SKH51
For Plastic Mold	CU BsBM2	SKD61 STAVAX ESR RIGOR(SKD12 Group)	HPM7 NAK55 PX5 HPM1 NAK80 HPM38 HPM50 S–STAR FDAC STAVAX ESR DH2F	(Electroforming-Outside) (Electroforming-Inside) ORAVAR SUPREME (Age-Hardened)MAS1C HPM38 S–STAR SKD61 STAVAX ESR RIGOR (SKD12 Group)

HRC 10 20 30 40 50 60 70

(Non-Ferrous Metal)

(Non-Ferrous Metal)

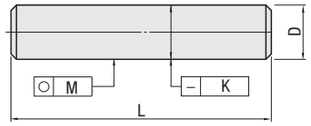
(Non-Ferrous Metal)

(Carbide)

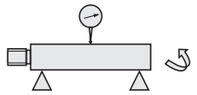
Lineart Shaft
Precision Standards

Accuracy Standards

Circularity, Straightness, L Dimension Accuracy



Straightness Measurement Method



Shaft ends are supported on V-blocks and turned 360 degrees to measure shaft runout using a dial indicator.
1/2 of measured runout is defined as the straightness.

O.D. g6, h5 Shafts (Hardened)

D Section Circularity Unit: mm

D Over	D or Less	Circularity M
2	13	0.004
13	20	0.005
20	40	0.006
40	50	0.007

L, Y Dimension Tolerances Unit: mm

Dimension Over	Dimension or Less	Dimension Tolerance
2	6	±0.1
6	30	±0.2
30	120	±0.3
120	400	±0.5
400	1000	±0.8
1000	1500	±1.2

Straightness Unit: mm

D	L	Straightness K
3, 4	N/A	(L/100)x0.05 or Less
5	N/A	(L/100)x0.03 or Less
6~50	100 or Less	0.01 or Less
	Over 100	(L/100)x0.01 or Less

O.D. f8 Shafts (Not Hardened)

D Section Circularity Unit: mm

D Over	D or Less	Circularity M
5	10	0.011
10	18	0.014
18	30	0.017
30	50	0.020

L, Y Dimension Tolerances Unit: mm

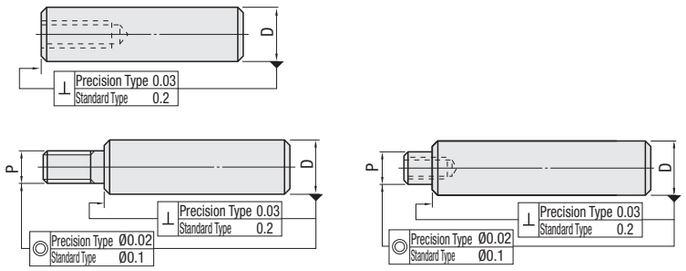
Dimension Over	Dimension or Less	Dimension Tolerance
3	6	±0.1
6	30	±0.2
30	120	±0.3
120	400	±0.5
400	1000	±0.8
1000	1500	±1.2

Straightness Unit: mm

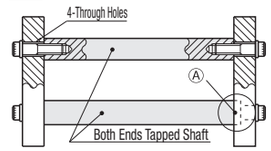
Condition L	Straightness K
L≤100	0.025 or Less
L>100	(L/100)x0.025 or Less

Concentricity, Perpendicularity

Features of Precision Shafts: Perpendicularity is ⊥ 0.03 , Concentricity (Threaded and Stepped) is ◎ Ø0.02.



Example



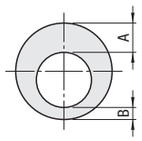
•Precision Type does not require stepped machining as Ⓐ, which enables effective assembly.

About Hollow Shaft Wall Thickness Deviations

Unit: mm

O.D. (D)	SUJ2 Wall Thickness Deviation Value	SUS440C Equivalent Wall Thickness Deviation Value
6	0.3 or Less	-
8	0.4 or Less	1.5 or Less
10		4.0 or Less
12		
13		
16		
20		
25	0.6 or Less	
30	1.0 or Less	
35		-
40	1.5 or Less	
50		

Hollow shaft interior surfaces are not plated, which causes rust.



Deviation Value = A-B

Thread Undercut Dimensions (PC, QC) (Reference Values)

O.D. Tolerance g6, h5 Shafts (Hardened), O.D. Tolerance f8 Shafts (Plated)

When specifying Shafts with thread undercuts or adding thread undercut alterations (PC, QC), PC and QC dimensions are as the table below. When B(S) is specified, undercut width (g) is F-B (T-S).
Refer to the table below for the dimensions of PC and QC when combined with Fine Thread alterations (PMC, PMS, QMC, QMS, MMC, MMS, NMC, and NMS).

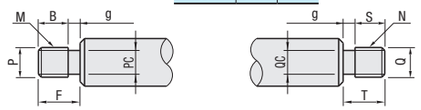
•For Coarse Threads

P(=M) Q(=N)	PC QC	F-B (T-S)
6	4.4	2
8	6.0	3
10	7.7	
12	9.4	4
16	13.0	
20	16.4	5
24	19.6	
30	25.0	

•When combined with Fine Thread Alterations

PMC, MMC QMC, NMC	PC QC	F-B (T-S)
6	4.8	2.0
8	6.4	
10	8.4	
12	10.4	
15	13.4	
17	15.4	
20	18.4	
25	22.7	3.0
30	27.7	

PMS, MMS QMS, NMS	PC QC	F-B (T-S)
10	8.0	3.0
12	9.7	
14	11.7	
18	15.7	



Shaft Material, Hardness, Surface Treatment

M Material	O.D. Tolerance	H Hardness	S Surface Treatment
EN 1.3505 Equiv.	g6, h5	Induction Hardening EN 1.3505 Equiv. 58HRC~ EN 1.4125 Equiv. 56HRC~	-
EN 1.4125 Equiv.			
EN 1.3505 Equiv.			Hard Chrome Plating Plating Hardness HV750 ~ Plating Thickness: 5μ or More
EN 1.4125 Equiv.			
EN 1.3505 Equiv.	g6		Low Temp. Black Chrome Plating Plating Thickness: 1 ~ 2μ
EN 1.4125 Equiv.			
EN 1.1191 Equiv.	f8	-	Hard Chrome Plating Plating Hardness HV750 ~ Plating Thickness 10μ or More
EN 1.4301			

Effective Hardened Layer Depth of Shafts (hardened) with O.D. Tolerance g6, h5

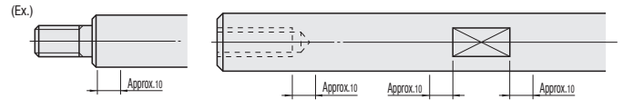
Unit: mm

O.D. (D)	Effective Hardened Depth EN 1.3505 Equiv.	Effective Hardened Depth EN 1.4125 Equiv.
3	0.5 or More	0.5 or More
4		
5		
6~10		
12, 13	0.7 or More	0.5 or More
15~20		0.7 or More
25~50	1.0 or More	

Notes on Hardening and Surface Treating

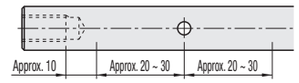
Reduced Hardness around Machined Areas

Machining is applied after base materials are case hardened.
In the example below, annealing caused by machining may result in reduced hardness of the machined area + 10mm fore and aft.



Annealing caused by machining may lower hardness of following areas:
- All threaded shafts
- All stepped shafts
- Tapped Holes: when M≥D/2, RC threads, two tapped holes on ends, hard chrome plated SUS440C products
- Retaining ring grooves, keyway, tapers, hex socket holes, wrench flats, tapped pilot, set screw grooves
- Keyway, Flats, 90-deg. Flats, V-grooves
- Shaft Ends Configurable Type (G, H shape), Hollow Shafts (Lateral Hole on One Side)

(Note) Excluding "Full Length Hardness Guaranteed Type"



•For Shafts with Cross-Drilled Hole, annealing may lower hardness in the range of 20mm and 30mm around machined area for SUJ2 and SUS440C respectively.

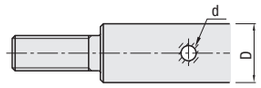
Surface Treatment Plating Layers

Machining is applied after base materials are surface treated.
In the example below, only ▨ D area is treated with hard chrome plating/low temp. black chrome plating.
Hard chrome plating, low temp. black chrome plating will not remain on cut-ends, stepped. tapered, and altered sections.
For Features of Low Temp. Black Chrome Plating, see P.292.
Hollow shaft interior surfaces are not plated, which causes rust.

Other plating finished shapes are:
- Threaded, Stepped and Tapped
- Retaining ring grooves, keyway, tapers, hex socket holes, wrench flats, set screw grooves
- Keyway, Flats, 90-deg. Flats, V-grooves

Surface Treatment Fully Plated Shafts will have the plating on the entire shaft except centering holes and tapped sections.

Cross-Drilled Hole Dimension Details

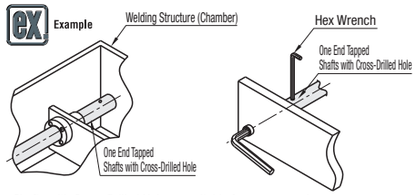


Cross-drilled hole areas may be out of O.D. tolerances due to annealing-induced deformation.
Hard chrome plating layers around machined area may be flaked by deburring. (▨ Areas)
Orientation in relation to other features will be random.

D	d
8	3
10	
12	
13	4
15	
16	

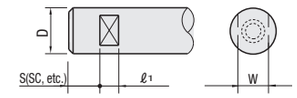
D	d
18	6
20	
25	7
30	

Example



•Shafts with Cross-Drilled Hole are suitable for narrow work space.

Shafts: Detailed Wrench Flats Dimensions



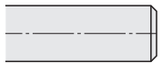
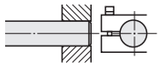
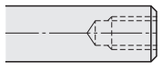
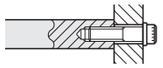
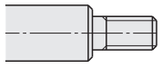
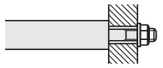
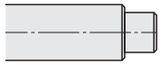
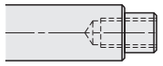
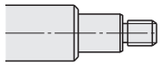
S(SC, etc.) =1mm Increment
S (SC, etc.) +ℓ1≤L
S(SC etc.) =0 or S(SC etc.) ≥1
Cannot be machined coplanar.
Orientation in relation to other features will be random.

D	W	ℓ1
6	5	8
8	7	
10	8	
12	10	10
13	11	
15	13	
16	14	

D	W	ℓ1
18	16	10
20	17	
25	22	
30	27	15
35	30	
40	36	20
50	41	

Not applicable to D=3, 4, 5

List of Features by Shapes

Shape	Figures	Mounting Examples	Features
Straight			• Simple Shape • Used in combination with Shaft Supports
Female Thread			• Can be easily mounted only with screw through holes. • Mounting position accuracy is low. • Horizontal mountings are for light load applications.
Male Thread			• High accuracy assembly is possible with threaded shaft and mating bore fits. • Stable when used for heavy loads, horizontally, and in long lengths.
Stepped			• High accuracy assembly is possible with stepped shaft section and mating bore fits. • Stable when used for heavy loads, horizontally, and in long lengths. • The step enables axial direction constraining. • Shaft diameters can be freely set to match the mating bores.
Stepped and Female Thread			
Stepped and Male Thread			

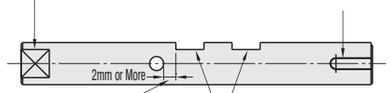
Cautions for Alteration Selections

- Alterations may lower hardness.
- When selecting multiple alteration additions, the distance between machined areas should be greater than 2mm. (See below)

Ex. 1

Wrench Flats (SC)
- When the flats are to start from the ends, specify as "SC0".

Keyway (KC)
- See Rotary Shaft pages for more variations.

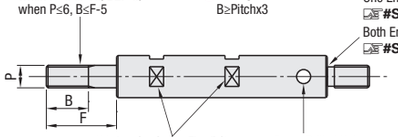


When Selecting Multiple Alterations
- The distance between machined areas should be greater than 2mm.

Set Screw Flat
- Orientation between two set screw flats is not coplanar.
  - ・WFC (Set Screw Flats at Two Locations)
  - ・WSC (Wrench Flats at Two Locations)
  - ・WRC (90-deg. Set Screw Flats at Two Locations)
  - ・WKC (Keyways at Two Locations)

Ex. 2

Threads
- Correlation between F and B:
  When P≤6, B≤F-2;
  when P=8 or 10, B≤F-3;
  when P≤6, B≤F-5
- F Length: 5≤F≤Px5
- B Length: B≥Pitchx3



90-deg. Set Screw Flat (RC)
- Orientation between two set screw flats is not coplanar.
- Recommended to be used with Shaft Collar **#SCC**.

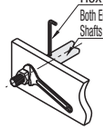
Cross-Drilled Hole

Undercut (PC, QC)
- For the following types, PC and QC alterations are no longer available. Please see pages below.

One End Threaded with Undercut
#SAFN

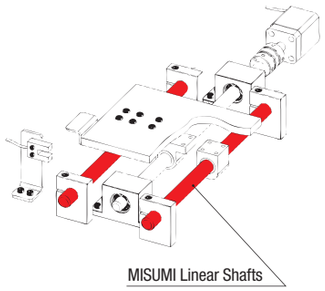
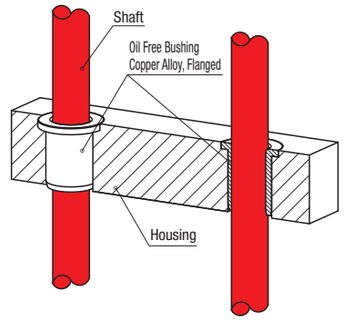
Both Ends Threaded with Undercuts
#SAFM

Hex Wrench
Both Ends Threaded Shafts with Cross-Drilled Hole



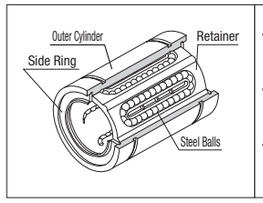
・Shafts with Cross-Drilled Hole are suitable for narrow work space.

Selective Shaft Use

		High Precision		For Oil Free Bushing
		g6/g6 Precision Grade /h5		f8
App. Example				
Recommended Apps.		• For high accuracy applications (Outer diameter, Straightness and Circularity) • for high load/high durability purposes - For horizontal use and heavy load applications - Extensive sliding distance, frequency and speed.		• For use with oil-free bushings • Sufficient clearance for surface contact sliding can be obtained.
Standards	Material	EN1.3505 Equiv.	EN1.4125 Equiv.	EN1.1191 Equiv.
	Hardness	58HRC~	56HRC~	No hardening
	Surface treatment	None/ Hard Chrome Plating Plating hardness HV750~ Plating thickness 5μ or more		Hard Chrome Plating Plating Hardness HV750 ~ Plating Thickness 10μ or More
	O.D.	Ø3~50		Ø6~50
	Length	L10~1500		L20~1500
Accuracy	Circularity	Ø3~13: 0.004 Ø15~20: 0.005 Ø20~30: 0.006 Ø40~50: 0.007		Ø6~10: 0.011 Ø12~18: 0.014 Ø20~30: 0.017 Ø40~50: 0.020
	Straightness	Ø3, 4: N/A: (L/100)x0.05 or Less Ø5: N/A: (L/100)x0.03 or Less Ø6~50: 100 or Less: 0.01 or Less Ø6~50: Over 100: (L/100)x0.01 or Less		L≤100: 0.025 or Less L>100: (L/100)x0.025 or Less
Related Products		■Linear Bushings **#LHFC** 		■Oil Free Bushing **#MPBZ** 
		■Shaft Support **#STH3** 		■Shaft Collar **#SCC** 

Linear Bushing
Cautions on Selection and Usage / Various Greases

Structure of Linear Bushings

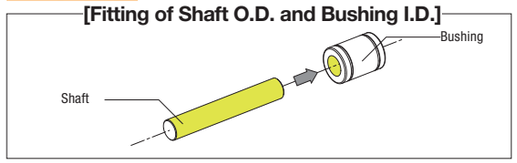


- Linear Bushings are used in combination with Linear Shafts, and it is the linear motion mechanism utilizing rolling steel balls for unlimited linear motion.
- Linear bushings imparts unlimited stroke linear motion on shafts by steel balls recirculating within the raceway grooves formed by the outer cylinder and retainer.
- Can obtain linear motion with lower friction and high accuracy compared to slide bearings, and used for many applications such as transfer equipment and semiconductor manufacturing systems.

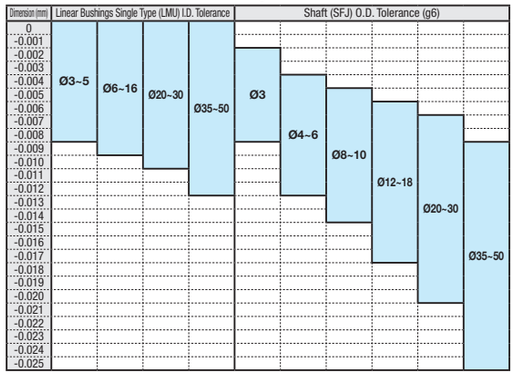
Cautions on Selection and Usage

Fitting Design

[Fitting of Shaft O.D. and Bushing I.D.]

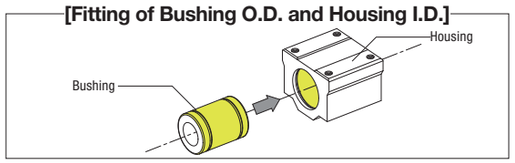


Reference: Tolerance range of I.D. of linear bushings and O.D. of shafts made by MISUMI



For MISUMI linear bushings, use in combination with MISUMI shafts (hardened with g6 tolerance) is recommended.

[Fitting of Bushing O.D. and Housing I.D.]



Reference: Tolerance range of O.D. of linear bushings and diameter of housing made by MISUMI

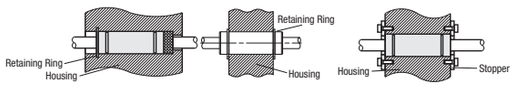
	Product		Customer's design	
I.D. dr	O.D. (D)	Tolerance	Housing Dia.	Tolerance H7
3	7	0 - 0.009	7	+0.015 0
4	8		8	
5	10		10	
6	12	0 - 0.011	12	+0.018 0
8	15		15	
10	19	0 - 0.013	19	+0.021 0
12	21		21	
13	23		23	
16	28		28	
20	32	0 - 0.016	32	+0.025 0
25	40		40	
30	45		45	
35	52	0 - 0.019	52	+0.030 0
40	60		60	
50	80		80	

For MISUMI Linear Bushings, mounting Housing of H7 tolerance is recommended. Bushing and Housing will be clearance fit.

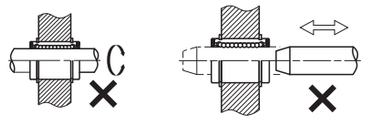
Selection / Assembly

①Use Retaining Ring (Snap Ring), Stoppers, etc., when mounting Linear Bushings and Housing.

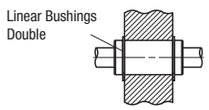
■ Mounting with Retaining Ring ■ Mounting with Stoppers



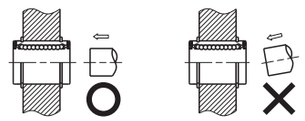
②Linear Bushings are not suitable for rotating motion and uses that need repetitive insertion and extraction from shafts.Forced use may prove to be the cause of damage.



③If large moment load (offset load) is to be applied, Short/Single Type Linear Bushings are not suitable. Use of Double Type or Multiple Linear Bushings is recommended.



④When assembling with linear shafts, forcing the shaft into the bushing with angular misalignment may cause the ball retainers to deform and balls to fall out. Be sure to align the centers and insert the shaft gently.



Lubrication and Maintenance

- **At the time of delivery**
  Other than the MX Lubrication Units, MISUMI Linear Bushings are applied with Anti-rust Oil harmless to the bearing lubrication greases. After de-greasing the Antirust Oil, application of grease is recommended.
  L, G, and H Grease filled types are also available. The MX Lubrication Units are filled with lithium soap-based grease.

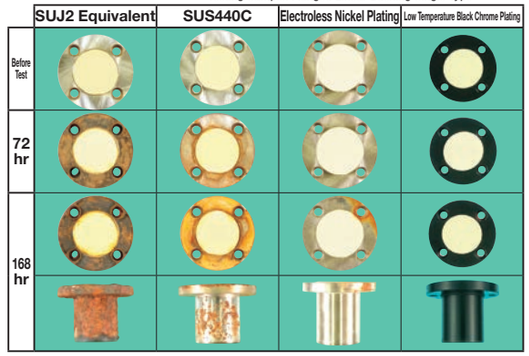
- **Maintenance**
  Before usage, apply grease to the ball rows within the Linear bushings, then periodically apply grease during the use. The grease has an effect of reducing friction by forming a layer between the balls and shaft rolling surfaces, preventing seizures. Grease loss and deterioration will cause shorter life of linear guides.

  Recommended Grease: Lithium soap based grease (Alvania Grease S2 by Showa Shell Sekiyu).
  Recommended Greasing Interval: Normally 6 months
  * Every 3 month when travel distance is extensive, or every 1000km.

Antirust Performance

(Ref. Data)
Antirust Performance Comparison Test

Salt water spray testing method conforms to JIS H8502.
Testing Sample: Flanged Linear Bushing Single Type



■Linear Bushing Models Applicable to Low Temperature Black Chrome Plating

Straight	Applicable I.D.	TYPE CODE
Single LMUR	Ø3~Ø30	#LHU
Double LMUWR	Ø5~Ø30	#LMUW

Flanged Type	Applicable I.D.	TYPE CODE
Single LHF□R	Ø6~Ø30	#LHFC
Double LHF□WR		#LHFCW

* For details, refer to each page.

Low Temperature Black Chrome Plating

- Low temperature black chrome plating on linear bushings is 5μm of fluoropolymer layer chemically deposited as a black film, and it has a long-lasting rust prevention effect.
- Additionally, the coating is resistant to cracking from extreme and repeated bending.
- Low temperature black chrome plated shafts are suitable for places where rusting or reflection of light is undesirable.

(Note) No surface treatment is applied to I.D. surface of low temperature black chrome plated linear bushings.
* Photograph shows the condition of Linear Bushing after Sliding Test
(Sliding Test Conditions)
50km sliding test was conducted with a 412N load on the linear bushing.
No performance degradation after the test.

Grease Service

Service to apply greases shown below at the time of shipping.

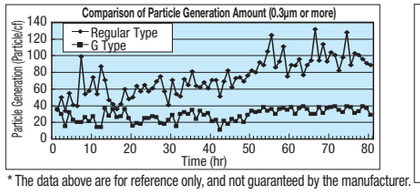
Type	Product Name	Main Features
L Type	ET–100K (Made by Kyodo Yushi)	Superior heat resistance and oxidation stability. Also high adhesion and cohesion with limited splash or leakage.
G Type	LG2 (Made by NSK Ltd.)	Suitable for clean environment due to low particle generation grease. Also good anti-rusting characteristics.
H Type	FGL(Lubriplate®)	Suitable for food, beverage and pharmaceutical industries. (NSF H-1 Reg. NO.043534)

Ordering Example Part Number
LMU12L (L Type Greased)
LMU12G (G Type Greased)
LMU12H (H Type Greased)
To place an order, add L, G, or H after Part Number of Regular Type.

■Grease Performance

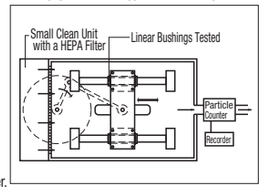
	Item	Conditions	Unit	Measurement Method	L Type	G Type	H Type
Grease Performance	Thickener	-	-	-	Aromatic Diurea	Lithium Type	Aluminum Complex Soap
	Base Oil	-	-	-	Ether Synthetic Oil	Mineral Oil + Synthetic Hydrocarbon Oil	USP White Oil
	Base Oil Kinetic Viscosity	40°C	mm²/s	JIS K2220 5.19	103	30	105
		100°C			12.8	-	11.5
	Miscible Consistency	-	-	JIS K2220 5.3	280	207	310
	Dropping Point	-	°C	JIS K2220 5.4	<260	200	238
	Evaporation Amount	99°Cx22hr	wt%	-	0.15%	1.40%	0.27%(ASTMD-972)
	Oil Separation	100°Cx24hr	wt%	JIS K2220 514	1.2%	0.8%	2.1%(ASTMD-1742)
	Operating Temp.	In Air	°C	-	-40~200	-10~80	-12~170

■Comparison of Particle Generation



* The data above are for reference only, and not guaranteed by the manufacturer.

<Test Equipment for G Type Grease Comparison>



<Testing Condition>

Linear Bushing Used	LHFS16 (Regular Type) LHFS16G (G Type)
Liner Motion Speed	20m/min
Stroke	100mm
Environment	Inside Clean Booth (Class100)
Temperature	22.5°C±2°C
Humidity	50wt%
Particle Counter	Made by Rion Co. Ltd. KC03A1

Ball Splines
Overview

Features

1 Capable of Highly Accurate Linear Motion

Shafts and nuts are offered as sets. This ensures accuracy with rotational clearance adjustment allowing for highly accurate linear motion.

2 Capable of Transmission of Torque

Rotary motion of balls on grooves fine-grinding machined into spline shaft in R Shape makes ball spline capable of linear motion while transmitting torque.

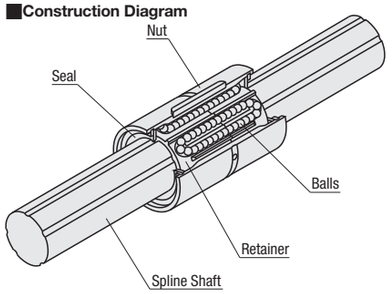
3 Enables Compact Designs

Rotary motion of balls along the line of groove allows for linear motion of ball spline without generating misalignment of nuts toward rotary motion even based on a single shaft.

4 High Load Capability and Long Life

High load capacity and long running life due to presence of R-shaped grooves of splines tailored to ball dia. on the rolling surface where loads are applied.

■Construction Diagram



Balls do not fall out even if the spline shaft is pulled out.

Lineup

27 variations (3 Nut Shapes x 9 Machined Shaft End Shapes)

Nut Shape	
Straight	
Round Flange	
Compact Flange	

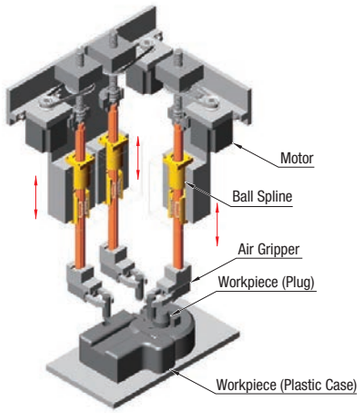
×

Shaft End Shape		
Straight	One End Tapped	Both Ends Tapped
		
One End Stepped	Both Ends Stepped	Both Ends Stepped and Threaded
		
One End Stepped and Threaded	One End Stepped and Threaded, One End Tapped	Both Ends Stepped and Threaded
		

Application Examples

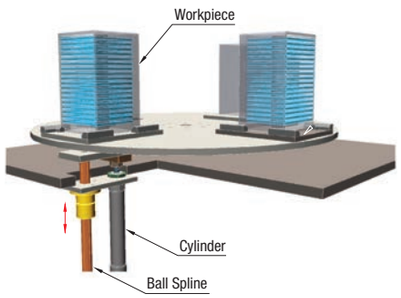
1 Pick and Place Application Unit

When linear motion on each axis is needed in limited spaces, ball splines that can be used in single shaft configuration are effective.



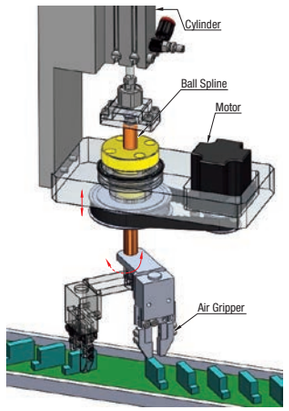
2 Magazine Lifter Mechanism

Space saving is enabled as there is no misalignment of nuts toward rotary motion even based on a single shaft.



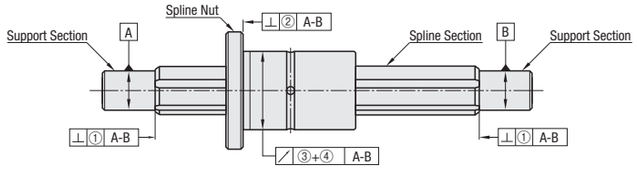
3 Pick and Place Application Unit

Since ball splines can also provide torque transmission, linear motion and rotary motion in one axis is enabled by providing rotation mechanism.



In addition, ball splines are used in many machines, such as coil winders, honing machines, optical measuring instruments, loaders, automatic filling machines, industrial robot arms, etc.

Accuracy



Note: Supporting portion is the part to mount the bearing and support the spline shaft.

■Spline Shaft: Raceway Twist Tolerance (Max.)

Unit: μm

Material	Tolerance
EN 1.3505 Equiv.	13
EN 1.4125 Equiv.	33

Spline groove twist is measured at an arbitrary 100mm section of the effective shaft length. If the length to be evaluated is longer or shorter than 100mm, proportionally add or subtract from the standard values in the table.

■Rotational Clearance Unit: μm

No.	Standard Preload EN 1.3505 Equiv.	Standard Preload EN 1.4125 Equiv.
6	-2~+1	-1~+4
8		
10	-3~+1	
13		-2~+5
16		
20	-4~+2	-
25		
30		

■Tolerance (Max) of Accuracies against Spline Shaft Supporting Sections Unit: μm

No.	①Spline Section Perpendicularity of End Face of the Shafts	②Flange Mounting Surface Perpendicularity
6	9(22)	11(27)
8		
10		13(33)
13	11(27)	16(39)
16		
20		
25	13	19
30		

Values in ( ) are for EN 1.4125 Equiv.

No.	③Max. Runout of Spline Axis Line ~200	201~	316~	401~	501~	631~	801~	1001~
6	46(72)	89	126	163	-	-	-	-
8								
10	36(59)	54(83)	68(103)	82	102	-	-	-
13	34(56)	45(71)	53(83)	62	75	-	-	-
16								
20	32	39	44	50	57	68	83	102
25								
30								

Values in ( ) are for EN 1.4125 Equiv.

No.	④Max. Runout of Spline Nut Outer Surface
6	11(27)
8	
10	13(33)
13	16(39)
16	
20	
25	19
30	

Values in ( ) are for EN 1.4125 Equiv.

Calculation of Life

Running Life

Radial Load

$$L=\left(\frac{ft \cdot fh \cdot fp}{fw} \cdot \frac{C}{F}\right)^3 \cdot L_0$$

Torque Load

$$L=\left(\frac{ft \cdot fh}{fw} \cdot \frac{Ct}{T}\right)^3 \cdot L_0$$

L: Running Life (km)
ft: Temperature Factor
fh: Hardness Factor
fp: Ratio of Rated Load
fw: Load Factor
L0: Rated Life (50km)
C: Basic Dynamic Load Rating (N)
F: Applied Radial Load (N)
Ct: Basic Dynamic Torque (N · m)
T: Applied Torque (N · m)

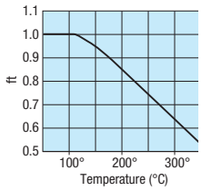
For values and factors, see below.

Life Hours

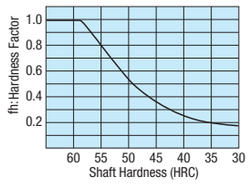
$$Lh=\frac{106 \cdot L}{120 \cdot St \cdot n}$$

Lh: Running Time (hr)
L: Running Life (km)
St: Stroke Length (mm)
n: Reciprocating Cycles per Minute (cpm)

■Temperature Factor (ft)

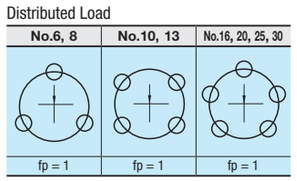


■Hardness Factor (fh)

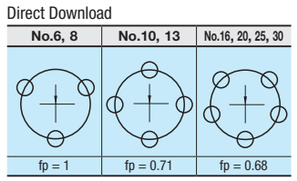


■Ratio of Rated Load (fp)

Distributed Load



Direct Download



■Load Factor (fw)

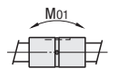
Conditions of Use	Load Factor (fw)
Minimal vibrations / shocks (Low speed 15m/min. or less)	1~2
Some vibrations / shocks (Medium speed 60m/min. or less)	2~3
Significant vibrations / shocks (High speed over 60m/min.)	3 or more

■Load Rating

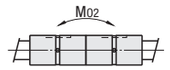
No.	Basic Rated Torque Dynamic C_t N · m	Basic Rated Torque Static C_{0t} N · m	Basic Load Rating Dynamic C kN	Basic Load Rating Static C_0 kN	Allowable Static Moment M_{01} N · m	Allowable Static Moment M_{02} N · m	Cross Sectional Moment of Inertia mm^4
6	3.8	7	1.2	2.1	5	36	6.2 x10
8	4.8	8.7	1.2	2.1	5	36	$1.97x10^2$
10	19(11)	34(21)	3.8(2.4)	6.9(4.3)	26(15)	181(102)	$5.57x10^2$
13	28(20)	52(37)	4.6(3.3)	8.3(5.9)	36(22)	251(148)	$1.55x10^3$
16	51	93	6.2	11.1	56	386	$3.61x10^3$
20	85	154	8.5	15.3	83	611	$8.74x10^3$
25	193	348	15.4	27.7	173	1248	$2.13x10^4$
30	272	490	18.5	33.3	212	1581	$4.373x10^4$

Values in ( ) are for EN 1.4125 Equiv.

If the number of nuts is 1, check the M_{01} column; if the said number is 2, check the M_{02} column.



When 1 nut is used



When 2 nuts are used in contacting tandem

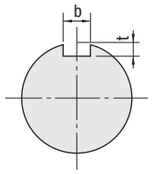
Operating Temp.

Plastic components are used in ball spline assemblies. Avoid using in high temperature environments, keep below 80°C.

Ball Splines
Alterations / Grease Application Services

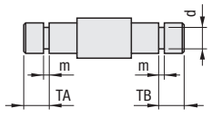
Alteration Overview

■Dimensions of Keyways on the Shaft Ends (P and Q)



P, Q	b	Tolerance (N9)	t	Tolerance
8, 10	3	-0.004 / -0.029	1.8	+0.1 / 0
12	4	0 / -0.030	2.5	
13~16	5		3.0	
20	6		3.5	
25	8	0 / -0.036	4.0	+0.2 / 0

■Dimensions of the Retaining Ring Grooves on the Shaft Ends (P and Q)



P, Q	Tolerance	m	Tolerance	d	Tolerance	Applicable Retaining Ring
3	0 / -0.010	0.5	+0.05 / 0	2	+0.06 / 0	JIS E Type 2
4	0 / -0.012	0.7	+0.1 / 0	3		JIS E Type 3
5				4	+0.075 / 0	JIS E Type 4
6				5.05		JIS E Type 5
8	0 / -0.015	0.9		6.05		JIS E Type 6
10		1.15	+0.14 / 0	9.6	0 / -0.09	JIS C Type 10
12	0 / -0.018			11.5	0 / -0.11	JIS C Type 12
13				12.4		JIS C Type 13
15				14.3		JIS C Type 15
16				15.2		JIS C Type 16
20	0 / -0.021	1.35		19	0 / -0.21	JIS C Type 20
25				23.9		JIS C Type 25

Lubrication

Ball splines are shipped greased.
Administer lubrication maintenance with lithium soap based grease (Alvania Grease S2 by Showa Shell Sekiyu K.K), etc. for a mileage of 100km.

Various Grease Application Services

The Lubricant used for Ball Splines can be changed to any of the following Special Greases.
Service is provided to apply grease on nuts and shafts. For performance of each grease, refer to the table below.

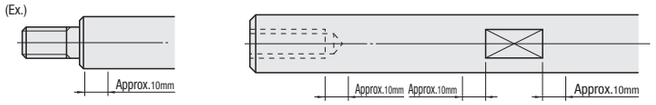
Type	Grease Product Name	Main Features
● L Type	ET–100K (Made by Kyodo Yushi)	High heat resistance and oxidation stability. Also high adhesion and cohesion with limited splash or leakage.
● G Type	LG2 (Made by NSK Ltd.)	Suitable for clean environment due to low particle generation grease. Highly resistant to corrosion.

■Precautions for Use
For Particle Generation Amount upon grease application, refer to the "Comparison of Particle Generation (Experimental Values)" section of "Linear Bushings."
If G Type grease, Low Miscible Consistency grease, is applied onto the small dia. portion (No. 6, 8, or 10), resistance may be increased, and thus, sliding motion may be degraded.

Annealing Range

Spline Shafts are already hardened, and must be annealed before machining.
Annealing may lower hardness on the machined area +10mm fore and aft. (See the examples below). Furthermore, the annealing portions are out of the guaranteed range of O.D. Tolerance.
When calculating stroke, count out the dimensions of annealing portions.

(Ex.)



Annealing may lower hardness of the following sections:
· Threaded Ends
· Stepped Parts
· Tapped Ends
· Wrench flats, set screw flats, retaining ring grooves, tap alteration

Ordering Example

Part Number

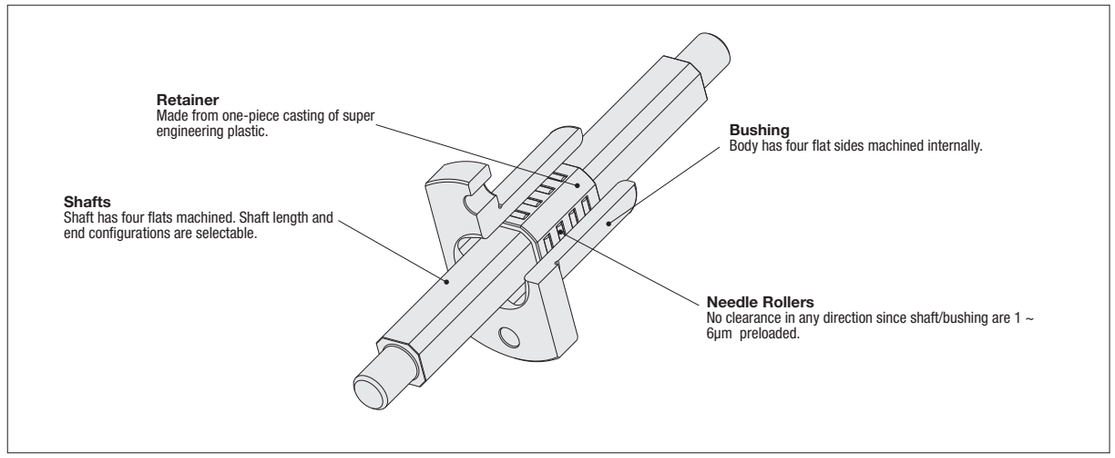
●BSSS8L-300 (L Type Greased)
●BSSS8G-300 (G Type Greased)

Please add L or G after part number of Regular Type when placing an order.

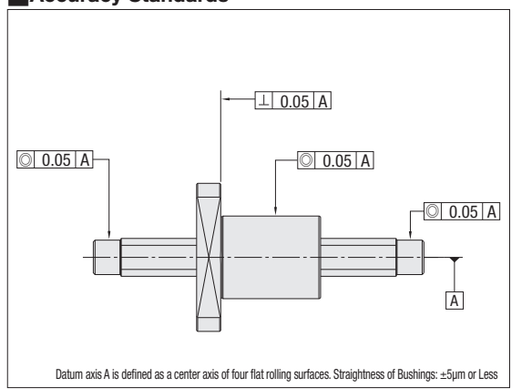
Needle Guide
Overview

■Features

High accuracy needle rollers are arranged in four directions against the square shafts. Shafts/bushings are designed to be 1 ~ 6μm preloaded.
Widely used in parts of semiconductor, liquid crystal manufacturing equipment and inspection device, lift/slide stages, robotic systems, press machines and transfer mechanism as the guide with high rigidity, straightness and high speed. Capable of torque loading without rotation due to square cross section with low yawing and pitching, maintaining smooth rotation and stable accuracy.



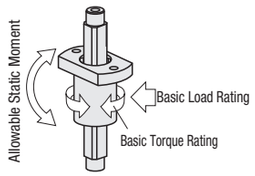
■Accuracy Standards

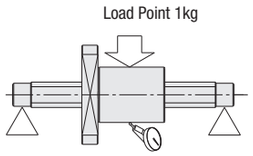


Datum axis A is defined as a center axis of four flat rolling surfaces. Straightness of Bushings: ±5μm or Less

■Load Rating Table

D	Basic Rated Torque		Basic Load Rating		Allowable Static Moment
	CT Dynamic (N·m)	CoT Static (N·m)	C Dynamic (kN)	Co Static (kN)	Mo(N·m)
6	12.3	21.0	3.4	5.0	10.6
10	48.7	84.4	6.8	10.0	23.0
12	91.3	162.9	11.9	17.4	76.4
16	115.7	212.0	11.9	17.4	83.6

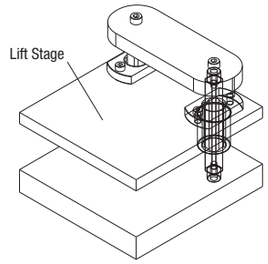




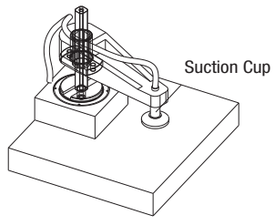
Displacement Measuring Point

D	Deflection (L is max.)
6	6μm
10	2μm
12	2μm
16	1μm

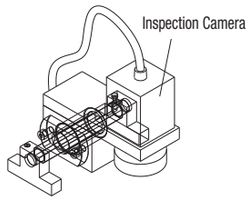
■App. Example



Lift Stage



Swiveling Arm



Slide Stage

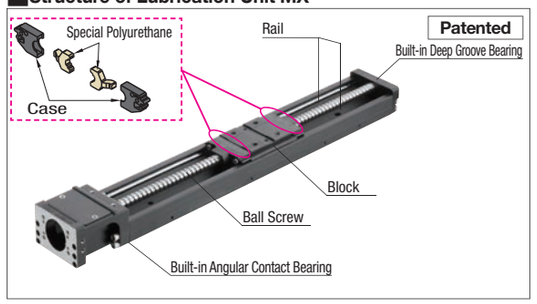
■Notes on handling

- Anti-rust oil is applied to the products when they are shipped. Administer lubrication maintenance with high-pressure grease (AFC Grease by THK), etc. as needed.
- When designing, position the bushing where the retainer does not fall out from the bushing at stroke ends.
- As a preload is applied, assemble slowly without any prying when inserting retainers. (It may cause damages to the retainers as well as damages on the rolling surfaces).
- Use covers, etc. if any foreign objects or dust may fall on the rolling surfaces.
- Avoid using in high temperature environments, keep below 80°C.
- Do not cold shrink fit the bushings and shafts. Residual austenite will transform into martensite and will expand I.D./O.D. of bushings and shafts, rendering them unusable.

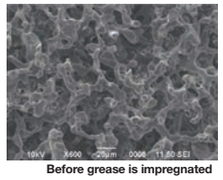
Single Axis Actuators (LX) Lubrication Unit Series

MX Maintenance Free

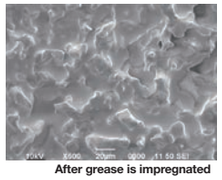
Structure of Lubrication Unit MX



Enlarged Photos of Special Polyurethane Pores



Before grease is impregnated



After grease is impregnated

Grease impregnated special polyurethane provides appropriate supply of grease on ball screws and rails.

Features

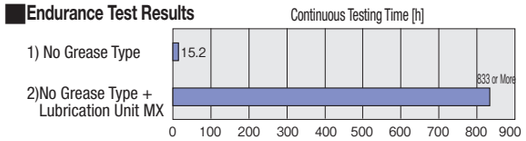
1 Long Term Maintenance-free Condition

- Lubrication Unit MX is a self-lubrication unit constructed of grease impregnated special polyurethane. Capillary action provides appropriate supply of grease.
- Oil film is always formed on the ball screws and rails, providing long term maintenance-free operations.

2 Cost Advantages

- MX unit-equipped products significantly reduce lubrication frequency, which significantly saves maintenance time and costs.

Endurance Test Results

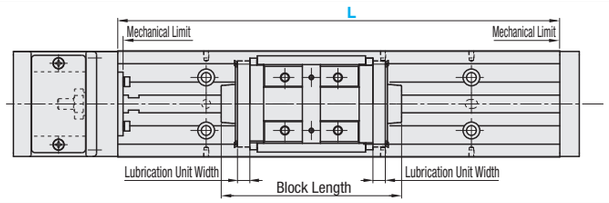


MX unit-equipped products showed good lubrication conditions even after exceeding 800 hrs, while part seizure was observed with non-greased samples within 20 hrs.
* These are not guaranteed values but reference values.

Test Conditions

(1) Part Number	LX2605-B1-300
(2) Installation Orientation	Vertical Test
(3) Load Condition	15kgf Load
(4) Test Stroke	200mm
(5) Travel Speed	136mm/s

Specifications of MX Series



MX Series Specifications

Part Number	Block Qty.	Base Length (L)	Effective Stroke	Block Length	Lubrication Unit Width
LX15□□-MX	(1 pc.) B1	100	43.9	49.6	4
		125	68.9		
		150	93.9		
		175	118.9		
		200	143.9		
LX20□□-MX	(1 pc.) B1	150	76.5	67	5
		200	126.5		
		250	176.5		
		300	226.5		
LX26□□-MX	(1 pc.) B1	200	105	88	6
		250	155		
		300	205		
		350	255		
		400	305		
LX(R)30□□-MX	Long Block (1 pc.) B1	200	90	102	7
		250	140		
		300	190		
		350	240		
		400	290		
		450	340		
		500	390		
		550	440		
		600	490		
	Short Block (1 pc.) S1	150	65.5	76.5	
		200	115.5		
		250	165.5		
		300	215.5		
		350	265.5		
		400	315.5		
		450	365.5		
		500	415.5		
		550	465.5		
		600	515.5		
LX(R)45□□-MX	Long Block (1 pc.) B1	340	194.4	137.6	8
		390	244.4		
		440	294.4		
		490	344.4		
		540	394.4		
		590	444.4		
	Short Block (1 pc.) S1	340	231.9	100.1	
		390	281.9		
		440	331.9		
		490	381.9		
		540	431.9		
		590	481.9		

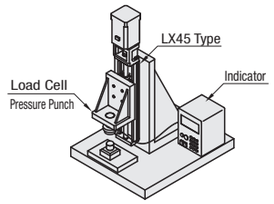
Effective stroke is indicated in dimensions with a margin of 2.5mm each from the ends.

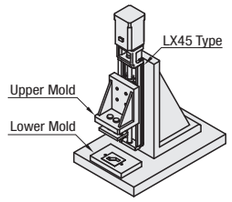
Single Axis Actuators (LX) Application Examples

The Actuator LX is a ball screw and linear guide integrated actuator essential to high precision manufacturing processes.
- **High Accuracy Positioning Type and High Accuracy & High Load Capacity Type are available.**
- **Standard leads for precise positioning and large leads for high-speed operations are available.**
- **Manufactured by SURUGA Production Platform Co., Ltd., MISUMI GROUP, reputable XY Stage producer.**

Servo Press Machine

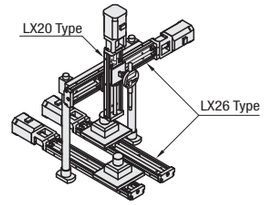
Utilize as press axis for servo press device.
- High rigidity frame is highly reliable
- Dowel holes indispensable for high load applications are standardized (The dowel pins are used for locating, but also serve to to receive shear loads)





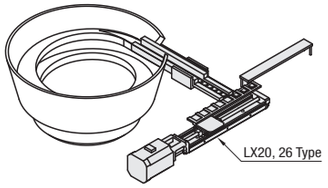
Measurement Unit

Use in combination with Servo Motor for measuring process.
- System possible due to product's high precision
- Compact structure provides high degree of integration freedom



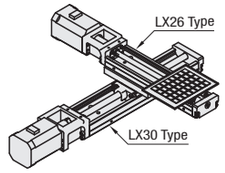
Precision Conveyance

Best suited for high precision conveyance.
- Accuracies higher than the High Grade assures reliable motion



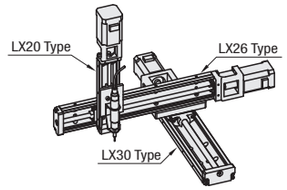
Part Supply Table

Part supply by connecting two axes.



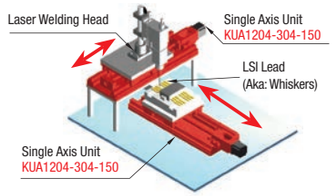
Painting Unit

Painting Unit by connecting three axes.
- Customers have liberation of designs



Single Axis Unit KU is a ball screw and linear guide integrated unit.
- **Usable for small robots and movable table of loaders excluding heavy loads.**
- **Cover Type is available as operating environment countermeasures.**
- **Single Axis Units are manufactured by SURUGA Production Platform Co., Ltd., MISUMI GROUP, reputable XY Stage provider.**

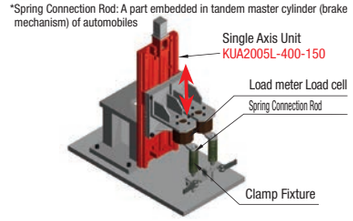
Laser Welding Head Unit (Workpiece Weight: 5~10kg)



For XY mechanisms where stability of the base is required

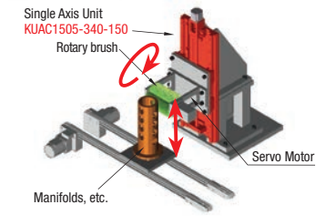
Spring Adjusting Unit (Workpiece Weight: 15~20kg)

*Spring Connection Rod: A part embedded in tandem master cylinder (brake mechanism) of automobiles



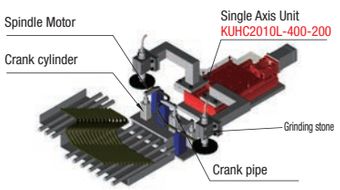
Preset point positioning made easy by external signals

Deburring Unit (Workpiece Weight: 15~20kg)



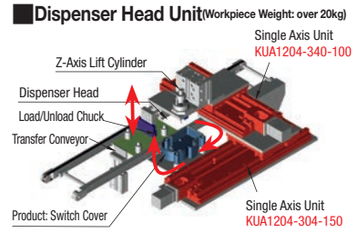
For Mechanisms where rigidity against vibration is required

Moving Polishing Head Unit (Workpiece Weight: over 20kg)



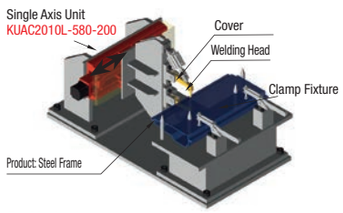
For structures with offsets from the base

Dispenser Head Unit (Workpiece Weight: over 20kg)



For dedicated designs where space limitations are critical

Laser Welding Head Unit (Workpiece Weight: 20~30kg)



For Mechanisms where rigidity against clamps is required

Single Axis Actuators (LX)
Stroke / Load Rating / Allowable Moment

Stroke

(mm)

Type	Lubrication Unit MX-equipped	Block	Rail Length L (mm)														
			75	80	100	125	150	175	200	250	300	350(340)*	400(390)*	450(440)*	500(490)*	550(540)*	600(590)*
LX15	-	Long 1 pc.	26.9	-	51.9	76.9	101.9	126.9	151.9	-	-	-	-	-	-	-	-
	MX	Long 1 pc.	-	-	43.9	68.9	93.9	118.9	143.9	-	-	-	-	-	-	-	-
LX20	-	Long 1 pc.	-	16.5	36.5	-	86.5	-	136.5	186.5	236.5	-	-	-	-	-	-
	MX	Long 1 pc.	-	-	-	-	76.5	-	126.5	176.5	226.5	-	-	-	-	-	-
	-	Long 2 pcs.	-	-	-	-	-	-	79.5	129.5	179.5	-	-	-	-	-	-
LX26	-	Long 1 pc.	-	-	17	-	67	-	117	167	217	267	317	-	-	-	-
	MX	Long 1 pc.	-	-	-	-	-	-	105	155	205	255	305	-	-	-	-
	-	Long 2 pcs.	-	-	-	-	-	-	-	91	141	191	241	-	-	-	-
LX30	-	Long 1 pc.	-	-	-	29	54	-	104	154	204	254	304	354	404	454	504
	-	Short 1 pc.	-	-	-	54.5	79.5	-	129.5	179.5	229.5	279.5	329.5	379.5	429.5	479.5	529.5
	MX	Long 1 pc.	-	-	-	-	-	-	90	140	190	240	290	340	390	440	490
	MX	Short 1 pc.	-	-	-	-	65.5	-	115.5	165.5	215.5	265.5	315.5	365.5	415.5	465.5	515.5
	-	Long 2 pcs.	-	-	-	-	-	-	-	-	116	166	216	266	316	366	416
	-	Short 2 pcs.	-	-	-	-	17	-	67	117	167	217	267	317	367	417	467
LX45	-	Long 1 pc.	-	-	-	-	-	-	-	-	-	210.4	260.4	310.4	360.4	410.4	460.4
	-	Short 1 pc.	-	-	-	-	-	-	-	-	-	247.9	297.9	347.9	397.9	447.9	497.9
	MX	Long 1 pc.	-	-	-	-	-	-	-	-	-	194.4	244.4	294.4	344.4	394.4	444.4
	MX	Short 1 pc.	-	-	-	-	-	-	-	-	-	231.9	281.9	331.9	381.9	431.9	481.9
	-	Long 2 pcs.	-	-	-	-	-	-	-	-	-	88.8	138.8	188.8	238.8	288.8	338.8
	-	Short 2 pcs.	-	-	-	-	-	-	-	-	-	163.8	213.8	263.8	313.8	363.8	413.8

Effective stroke is indicated in dimensions with a margin of 2.5mm each from the ends.
* ( ) is the length of LX45 rail.

Load Rating

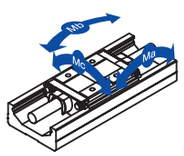
Type	Block	Rail			Ball Screw						Bearing (fixed side) Axial Direction	
		Basic Dynamic Load Rating C (N)	Basic Static Load Rating C0 (N)	Radial Clearance (μm)	Basic Dynamic Load Rating Ca (N)	Basic Static Load Rating C0a (N)	Shaft Dia. (mm)	Lead (mm)	Root Dia. (mm)	Ball Center Dia. (mm)	Basic Dynamic Load Rating Ca (N)	Allowable Static Load P0a (N)
LX1502	Long	2072	3701	-3~0	208	265	5	2	4.534	5.15	678	415
LX2001	Long	3277	6199	-3~0	482	642	6	1	5.3	6.15	730	461
LX2005					822	1026		5	4.918	6.3		
LX2602	Long	6522	11871	-4~0	1712	2251	8	2	6.4	8.3	1637	1205
LX2605					1600	2097		5	6.46	8.3		
LX2610					782	961		10	6.46	8.3		
LX3005	Long	9732	17218	-4~0	1831	2389	10	5	8.2	10.3	2702	2197
LX3010					1129	1386		10	8.2	10.3		
LX3005	Short	6305	9271	-4~0	1831	2389	10	5	8.2	10.3	2702	2197
LX3010					1129	1386		10	8.2	10.3		
LX4510	Long	18450	32441	-6~0	4167	5945	15	10	11.7	15.5	4355	4106
LX4520					2499	3381		20	11.7	15.75		
LX4510	Short	11826	17175	-6~0	4167	5945	15	10	11.7	15.5	4355	4106
LX4520					2499	3381		20	11.7	15.75		

Load ratings shown in Rail columns are for one block.
For actual life calculations, please use our Technical Calculation Software.

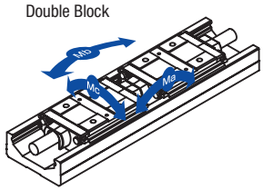
Allowable Moment

Moment loads can be applied in all three directions.

Single Block



Double Block



Ma: Pitch Moment

Mb: Yaw Moment
Mc: Roll Moment

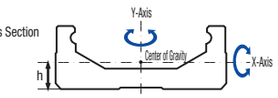
Type	Block Qty.	Block Qty.	Allowable Static Moment (N · m)		
			Ma	Mb	Mc
LX15	1	Long	13	13	41
LX20	1	Long	27	27	93
	2		353	353	186
LX26	1	Long	70	70	225
	2		902	902	450
LX30	1	Long	126	126	387
	2		1515	1515	774
	1	Short	63	63	208
	2		579	579	417
LX45	1	Long	291	291	972
	2		3945	3945	1944
	1	Short	145	145	515
	2		1444	1444	1029

* Double Block Type values are those when two blocks contact with each other.
The table above lists reference values in static state.
For actual life calculations, please use our Technical Calculation Software.

Rail Rigidity

Rails with low center of gravity and high rigidity.

Rail Cross Section



Type	Cross Sectional Moment of Inertia (mm⁴)		Center of Gravity (mm)	Mass (kg/100mm)
	Ix	Iy	h	W
LX15	1.0×10^3	1.7×10^4	3.4	0.13
LX20	3.2×10^3	5.2×10^4	4.4	0.22
LX26	1.0×10^4	1.4×10^5	6.1	0.37
LX30	2.5×10^4	3.1×10^5	7.8	0.60
LX45	8.8×10^4	10.4×10^5	11.0	1.10

IX: Cross Sectional Moment of Inertia around X-axis IY: Cross Sectional Moment of Inertia around Y-axis

Material

Components	Base (Rail)		Block	Motor Bracket	Support Side Bearing with Housing	Cover	Stopper	Precision Ball Screw (Ground)
	LX15	LX20/26/30/45						
M Material	Stainless Steel	Carbon Steel	SCM Material	ADC12	A5052	A6063	NBR	SCM415
S Surface Treatment	Low Temperature Black Chrome Plating		Low Temperature Black Chrome Plating	Black Baked Paint	Black Anodize	Black Anodize	-	-
H Hardness	-	Induction Hardened HRC58 ~ 64	HRC58~62	-	-	-	-	HRC58~62

Single Axis Actuators (LX)
Total Mass / Moment of Inertia

Total Mass

(kg)

Type	Block	Rail Length L (mm)														
		75	80	100	125	150	175	200	250	300	350(340)*	400(390)*	450(440)*	500(490)*	550(540)*	600(590)*
LX15	Long 1 pc.	0.13	-	0.17	0.22	0.29	0.35	0.38	-	-	-	-	-	-	-	-
LX15C	Long 1 pc.	0.18	-	0.22	0.28	0.35	0.41	0.45	-	-	-	-	-	-	-	-
LX20	Long 1 pc. / 2 pcs.	-	0.40	0.45	-	0.58	-	0.71/0.79	0.83/0.92	0.96/1.05	-	-	-	-	-	-
LX20C	Long 1 pc. / 2 pcs.	-	0.51	0.56	-	0.69	-	0.81/0.97	0.94/1.10	1.07/1.23	-	-	-	-	-	-
LX26	Long 1 pc. / 2 pcs.	-	-	0.87	-	0.95	-	1.16	1.37/1.57	1.58/1.78	1.79/1.99	2.00/2.20	-	-	-	-
LX26C	Long 1 pc. / 2 pcs.	-	-	1.07	-	1.15	-	1.36	1.57/1.89	1.78/2.10	1.99/2.31	2.20/2.52	-	-	-	-
LX30	Long 1 pc. / 2 pcs.	-	-	-	1.30	1.47	-	1.81	2.14	2.48/2.79	2.81/3.12	3.15/3.46	3.49/3.79	3.82/4.13	4.16/4.47	4.49/4.80
	Short 1 pc. / 2 pcs.	-	-	-	1.18	1.35/1.53	-	1.68/1.86	2.02/2.20	2.35/2.53	2.69/2.87	3.02/3.21	3.36/3.54	3.70/3.88	4.03/4.21	4.37/4.55
LX30C	Long 1 pc. / 2 pcs.	-	-	-	1.75	1.92	-	2.25	2.59	2.92/3.49	3.26/3.83	3.60/4.16	3.93/4.50	4.27/4.83	4.60/5.17	4.94/5.51
	Short 1 pc. / 2 pcs.	-	-	-	1.50	1.67/1.98	-	2.00/2.32	2.34/2.66	2.67/2.99	3.01/3.33	3.35/3.66	3.68/4.00	4.02/4.33	4.35/4.67	4.69/5.01
LX45	Long 1 pc. / 2 pcs.	-	-	-	-	-	-	-	-	-	5.77/6.69	6.37/7.29	6.97/7.90	7.57/8.50	8.18/9.10	8.78/9.70
	Short 1 pc. / 2 pcs.	-	-	-	-	-	-	-	-	-	5.37/5.91	5.98/6.51	6.58/7.11	7.18/7.71	7.78/8.31	8.39/8.92
LX45C	Long 1 pc. / 2 pcs.	-	-	-	-	-	-	-	-	-	6.59/8.09	7.23/8.73	7.86/9.36	8.49/9.99	9.13/10.63	9.76/11.26
	Short 1 pc. / 2 pcs.	-	-	-	-	-	-	-	-	-	5.94/6.78	6.57/7.41	7.20/8.04	7.84/8.68	8.47/9.31	9.10/9.94

* ( ) is the length of LX45 rail.

Additional Mass of Lubrication Unit MX-equipped Type

Type	Additional Mass (kg)
LX15(C)	0.002
LX20(C)	0.004
LX26(C)	0.007
LX30(C)	0.011
LX45(C)	0.024

Moment of Inertia

(10^{-4}kg · cm²)

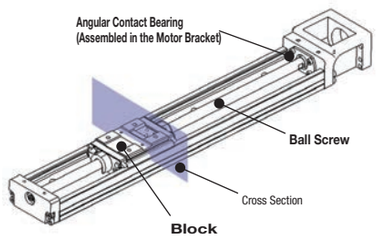
Type	Lead Cover or No Cover (c)	Block	Rail Length L (mm)														
			75	80	100	125	150	175	200	250	300	350(340)*	400(390)*	450(440)*	500(490)*	550(540)*	600(590)*
LX15	02/02C	Long 1 pc.	23/23	-	24/24	25/25	26/26	27/27	28/28	-	-	-	-	-	-	-	-
LX20	01/01C	Long 1 pc.	-	47/47	49/49	-	53/53	-	58/58	-	-	-	-	-	-	-	-
	01/01C	Long 2 pcs.	-	-	-	-	-	-	58/58	-	-	-	-	-	-	-	-
	05/05C	Long 1 pc.	-	-	54/59	-	59/63	-	63/68	68/73	73/77	-	-	-	-	-	-
	05/05C	Long 2 pcs.	-	-	-	-	-	-	69/78	74/83	78/88	-	-	-	-	-	-
LX26	02/02C	Long 1 pc.	-	-	140/141	-	155/156	-	169/170	184/185	198/199	-	-	-	-	-	-
	02/02C	Long 2 pcs.	-	-	-	-	-	-	-	186/188	200/202	-	-	-	-	-	-
	05/05C	Long 1 pc.	-	-	-	-	166/173	-	180/188	194/202	209/216	223/231	238/245	-	-	-	-
	05/05C	Long 2 pcs.	-	-	-	-	-	-	-	207/222	222/237	236/251	251/266	-	-	-	-
	10/10C	Long 1 pc.	-	-	-	-	204/234	-	219/249	233/263	248/278	262/292	277/307	-	-	-	-
LX30	05/05C	Long 1 pc.	-	-	-	436/452	454/471	-	491/507	528/544	565/581	602/618	638/655	675/692	712/729	749/765	786/802
	05/05C	Long 2 pcs.	-	-	-	-	-	-	-	-	584/617	621/654	658/691	695/728	732/764	768/801	805/838
	05/05C	Short 1 pc.	-	-	-	428/436	446/455	-	483/492	520/528	557/565	594/602	630/639	667/676	704/713	741/750	778/787
	05/05C	Short 2 pcs.	-	-	-	-	474/475	-	494/512	531/548	568/585	605/622	642/659	679/696	716/733	753/770	789/807
	10/10C	Long 1 pc.	-	-	-	-	513/579	-	550/616	587/653	624/690	661/727	698/764	735/800	772/837	808/874	845/911
	10/10C	Long 2 pcs.	-	-	-	-	-	-	-	-	702/833	739/870	776/907	812/944	849/981	886/1018	923/1054
	10/10C	Short 1 pc.	-	-	-	-	482/516	-	518/553	555/590	592/626	629/663	666/700	703/737	740/774	777/811	813/848
	10/10C	Short 2 pcs.	-	-	-	-	591/596	-	564/633	601/670	638/707	675/743	712/780	749/817	785/854	822/891	859/928
LX45	10/10C	Long 1 pc.	-	-	-	-	-	-	-	-	-	2528/2674	2723/2869	2918/3064	3113/3259	3308/3454	3503/3649
	10/10C	Long 2 pcs.	-	-	-	-	-	-	-	-	-	2762/3053	2957/3249	3152/3444	3347/3639	3543/3834	3738/4029
	10/10C	Short 1 pc.	-	-	-	-	-	-	-	-	-	2429/2507	2624/2702	2820/2897	3015/3092	3210/3287	3405/3482
	10/10C	Short 2 pcs.	-	-	-	-	-	-	-	-	-	2565/2720	2760/2915	2955/3110	3150/3305	3345/3500	3540/3695
	20/20C	Long 1 pc.	-	-	-	-	-	-	-	-	-	3242/3825	3437/4020	3632/4215	3827/4410	4022/4605	4217/4800
	20/20C	Long 2 pcs.	-	-	-	-	-	-	-	-	-	4179/5344	4374/5539	4569/5734	4764/5929	4959/6124	5154/6319
	20/20C	Short 1 pc.	-	-	-	-	-	-	-	-	-	2847/3157	3042/3352	3237/3547	3432/3742	3627/3937	3823/4132
	20/20C	Short 2 pcs.	-	-	-	-	-	-	-	-	-	3389/4008	3584/4203	3779/4399	3974/4594	4169/4789	4364/4984

* ( ) is the length of LX45 rail.

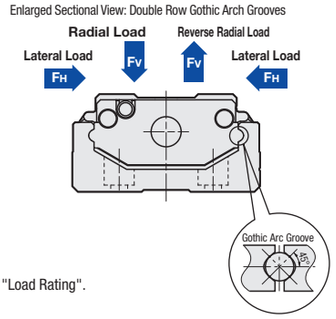
Load Directions

The Rails employ Double Row Gothic Arch Grooves, and are compact and low-profile.

Outline View



Enlarged Sectional View: Double Row Gothic Arch Grooves



• Rail
Equal basic load rating in all four directions: radial, reverse radial and lateral directions. For values, see "Load Rating".

• Ball Screw
Preload is applied to precision (ground) ball screw. Integrating structure of the block and ball screw nut allows axial loads to be applied.
For Basic Load Rating in axial directions, see "Load Rating".

• Bearing (Fixed Side)
Angular contact bearings are integrated in the motor bracket, allowing loads in the axial direction to be applied. For Basic Load Rating in axial directions, see "Load Rating".

Single Axis Actuators (LX)
Maximum Travel Speed / Accuracy Standards

Maximum Travel Speed

■Max. Velocity (mm/sec)

Type	Lead (mm)	Rail Length L (mm)														
		75	80	100	125	150	175	200	250	300	350	400	450	500	550	600
LX15	2	330	-	330	330	330	330	330	-	-	-	-	-	-	-	-
LX20	1	-	190	190	-	190	-	190	-	-	-	-	-	-	-	-
	5	-	-	694	-	694	-	694	694	633	-	-	-	-	-	-
LX26	2	-	-	290	-	290	-	290	290	290	-	-	-	-	-	-
	5	-	-	-	-	521	-	521	521	521	521	446	-	-	-	-
	10	-	-	-	-	1040	-	1040	1040	1040	1040	890	-	-	-	-
LX30	5	-	-	-	410	410	-	410	410	410	410	410	410	370	300	250
	10	-	-	-	-	830	-	830	830	830	830	830	830	740	600	500

Type	Lead (mm)	Rail Length L (mm)					
		340	390	440	490	540	590
LX45	10	550	550	550	550	550	550
	20	1110	1110	1110	1110	1110	1110

* Values in the table are calculated on basis of critical speed and DN value of ball screws.
Note that these are not guaranteed data considering motor rotational speed, operating conditions, etc.

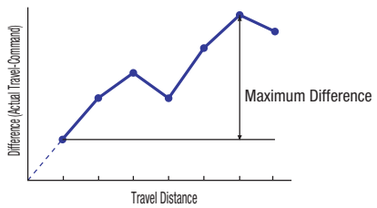
■Accuracy Standards Table

Accuracy Standard Items	LX15		LX20		LX26		LX30(L≤400)		LX30(L≥450)		LX45	
	High Grade	Precision Grade	High Grade	Precision Grade	High Grade	Precision Grade	High Grade	Precision Grade	High Grade	Precision Grade	High Grade	Precision Grade
Positioning (mm)	0.04	0.02	0.06	0.02	0.06	0.02	0.06	0.02	0.1	0.025	0.1	0.025
Positioning Repeatability (mm)	±0.004	±0.003	±0.005	±0.003	±0.005	±0.003	±0.005	±0.003	±0.005	±0.003	±0.005	±0.003
Backlash (mm)	0.01	0.002	0.01	0.003	0.01	0.003	0.02	0.003	0.02	0.003	0.02	0.003
Parallelism (mm)	0.02	0.01	0.025	0.01	0.025	0.01	0.025	0.01	0.035	0.015	0.035	0.015
Starting Torque (N · cm)	0.8		1.2		2		4		4		10	

Accuracy Standards

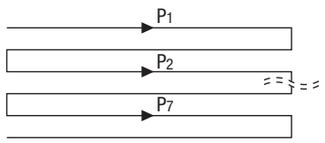
• Positioning Accuracy

Positioning is performed from a reference position incrementally in one direction, and measured.
Measurement values are the maximum difference between actual travel distance and commanded distance.
See Accuracy Standards Table for Standard values.



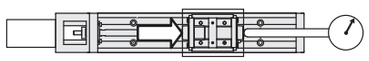
• Repeatability

Repeat positioning and measurement seven times at the same point in a specified direction.
1/2 of the maximum difference with "±" in front is defined as the measurement value.
See Accuracy Standards Table for design values.



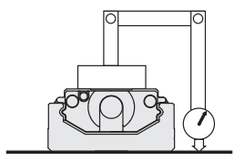
• Backlash

Loads are applied to the block from the reference position, and then released.
The difference between the reference position and returned value is the measurement value.
See Accuracy Standards Table for design values.



• Running Parallelism

A dial indicator is installed from the block to the reference surface. Measurements are taken while traveling with the rail mounted to a standard reference surface base.
The maximum difference taken by the measurement is the measurement value.
See Accuracy Standards Table for design values.



Single Axis Actuators (LX)
Low Dust Generation Grease Specifications

■Maintenance

• **Routine Inspections:**
Perform inspection once per 3 to 6 months.
Check for proper lubrication conditions, clean-up and grease refill.
Check on mounting screws for looseness.

• **Lubrication:**
The recommended lubricants are shown as below.
LX15, LX20, LX26 Series → Showa Shell Sekiyu-made Alvania Grease S No.2
LX30, LX45 Series → Showa Shell Sekiyu-made Cartridge Grease EP2
Low Dust Generation Grease Type → NSK LG2
Recommended greasing cycle is per 6 months or 1,000km under normal operating conditions.
* Lubrication intervals, however, depend on usage conditions and environments.

■Cautions for Operating Environments:
Ensure that it is used at an ambient temperature of 50°C or less. It is recommended to provide mechanical stoppers to prevent overrun.

• **Allowable Rotational Speed**
Size-specific allowable rotational speed is indicated below.

Part Number	Lead	Rail Length	Allowable Rotational Speed (min^{-1})
LX15	2	75~200	6000
LX20	1	80~200	6000
	5	100~300	
LX26	2	100~300	6000
	5/10	150~350	6000
		400	5350
LX45	10	340~590	3300
	20	340~590	3330

Part Number	Lead	Rail Length	Allowable Rotational Speed (min^{-1})
LX30	5	125~450	4920
		500	4440
		550	3600
		600	3000
	10	150~450	4980
		500	4440
		550	3600
		600	3000

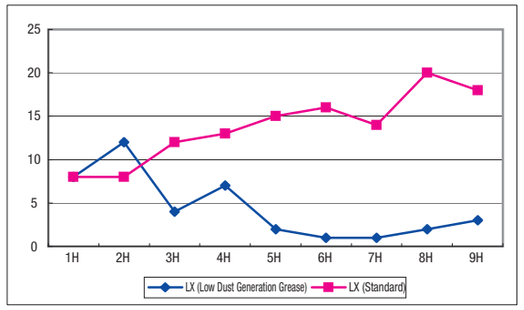
■About Single Axis Actuator LX Low Dust Generation Grease

The products are shipped with low particle generation grease applied for high cleanliness environments.
LG2 (Made by NSK Ltd.) generates less particles and exhibits excellent corrosion resistance.
For part number selections, please see each product page.

■Low Dust Generation Grease Performance Table

	Item	Conditions	Unit	Measurement Method	LG2 (Made by NSK Ltd.)
Grease Performance	Thickener	-	-	-	Lithium Type
	Base Oil	-	-	-	Mineral Oil + Synthetic Hydrocarbon Oil
	Base Oil Kinetic Viscosity	40°C	mm^2/s	JIS K2220 5.19	30
	Worked Penetration	-	-	JIS K2220 5.3	207
	Dropping Point	-	°C	JIS K2220 5.4	200
	Evaporation	99°Cx22hr	wt%	-	1.40%
	Oil Separation	100°Cx24hr	wt%	JIS K2220 514	0.80%
	Operating Temp.	In Air	°C	-	-10~80

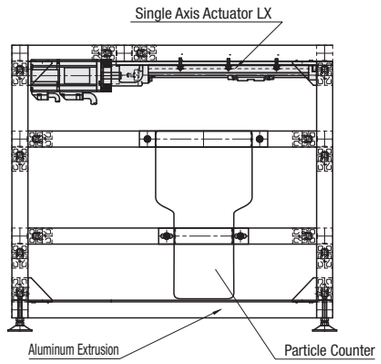
■Particle Generation Comparison



0.3μm or larger particle count (m^3)

Measuring Time	1H	2H	3H	4H	5H	6H	7H	8H	9H
LX (Low Dust Generation Grease)	8	12	4	7	2	1	1	2	3
LX (Standard)	8	8	12	13	15	16	14	20	18

■Particle Generation Test Evaluation Equipment - Overview



<Evaluation Conditions>
Clean Room Class 100 (in a clean room)
Room Temperature: 24°C±2°C, Humidity: 45%±5%
(Particle Counter Name)
Hand-held Particle Counter KR-12A (Rion Co., Ltd.)
Tested Actuator: LX2001-B1-A2040-200
Motor Speed: 3000rpm

Clean Room Class 100/ISO Class 5
The measurement results meet the conditions above.
* These are not guaranteed values but reference values.
Values considerably vary depending on operating environment.

Single Axis Actuators (LX)
Selection of Single Axis Actuators 1

Select the nominal LX actuator from the travel and the rating list below. ➡ Determine the ball screw lead so that the operation speed will be within the maximum speed shown in (Table 2). At this stage, the selection is temporary. ➡ Examine the load applied to the rail part and assign the resulting value to the Formula ① or ② on **P.304** to calculate the load equivalent among processes (Fe). Assign the resulting value to the Formula ③ on **P.304** to calculate the average load (Fm) and apply the resulting value to calculation of the average life span. ➡ Examine the load applied to the ball screw and the support bearing. Assign the resulting value to the Formula ③ on **P.304** to calculate the average load (Fm) and apply the resulting value to calculation of the average life span.

■Rated load (Table 1)

	Type		LX1502	LX2001	LX2005	LX2602	LX2605	LX2610	LX3005–B	LX3010–B	LX3005–S	LX3010–S	LX4510–B	LX4520–B	LX4510–S	LX4520–S
	Block		Long	Long		Long			Long		Short		Long		Short	
Rail	Dynamic load rating C (N)		2072	3277		6522			9732		6305		18450		11826	
	Static load rating Co (N)		3701	6199		11871			17218		9271		32441		17175	
	Radial clearances (mm)		–3~0	–3~0		–4~0			–4~0		–4~0		–6~0		–6~0	
Ball screw	Dynamic load rating C (N)	Advanced	208	482	822	1712	1600	782	1831	1129	1831	1129	4167	2499	4167	2499
	Static load rating Co (N)	Advanced	265	642	1026	2251	2097	961	2389	1386	2389	1386	5945	3381	5945	3381
	Thread shaft diameter (mm)		5	6	6	8	8	8	10	10	10	10	15	15	15	15
	Lead (mm)		2	1	5	2	5	10	5	10	5	10	10	20	10	20
	Core diameter		4.534	5.3	4.918	6.4	6.46	6.46	8.2	8.2	8.2	8.2	11.7	11.7	11.7	11.7
	Ball center diameter		5.15	6.15	6.3	8.3	8.3	8.3	10.3	10.3	10.3	10.3	15.5	15.75	15.5	15.75
Bearing (Axial direction)	Basic dynamic load rating Ca (N)		678	730		1637			2702		2702		4355		4355	
	Allowable static load P0a (N)		415	461		1205			2197		2197		4106		4106	

*The load ratings shown on the Rail Section are load ratings for one block. * Please utilize our Technical Calculation Software for the actual life calculations.

■Moment equivalent coefficient at rail (Table 2)

Max. Velocity (mm/sec)

Type	Lead (mm)	Rail length (mm) 75	80	100	125	150	175	200	250	300	350	400	450	500	550	600
LX15	2	330	–	330	330	330	330	330	–	–	–	–	–	–	–	–
LX20	1	–	190	190	–	190	–	190	–	–	–	–	–	–	–	–
	5	–	–	694	–	694	–	694	694	633	–	–	–	–	–	–
LX26	2	–	–	290	–	290	–	290	290	290	–	–	–	–	–	–
	5	–	–	–	–	521	–	521	521	521	521	446	–	–	–	–
LX30	5	–	–	–	410	410	–	410	410	410	410	410	410	370	300	250
	10	–	–	–	–	830	–	830	830	830	830	830	830	740	600	500

Type	Lead (mm)	Rail length (mm) 340	390	440	490	540	590
LX45	10	550	550	550	550	550	550
	20	1110	1110	1110	1110	1110	1110

*The values in the table are reference values calculated based on ball screw critical speeds and DN values.
Please note that the values are not guaranteed with considerations given to motor RPM and operating conditions.

■Moment equivalent coefficient at rail (Table 3)

Type	Block	Kp	Ky	Kr
LX15_ _	1 piece	0.2762	0.2762	0.0894
LX20_ _	1 piece	0.228	0.228	0.0667
	Close contact between 2 pcs.	0.144	0.144	0.0667
LX26_ _	1 piece	0.17	0.17	0.0527
	Close contact between 2 pcs.	0.114	0.114	0.0527
LX30_ _	1 piece	0.137	0.137	0.0445
	Close contact between 2 pcs.	0.0917	0.0917	0.0445
LX45_ _	1 piece	0.1115	0.1115	0.0334
	Close contact between 2 pcs.	0.0840	0.0840	0.0334

■Cross Sectional Moment of Inertia at Rail (Table 5)

Type	Cross sectional moment of inertia (mm^4) Ix	Iy	Center of gravity (mm) h	Mass (kg/100mm) W
LX15	1.0×10^3	1.7×10^4	3.4	0.13
LX20	3.2×10^3	5.2×10^4	4.4	0.22
LX26	1.0×10^4	1.4×10^5	6.1	0.37
LX30	2.5×10^4	3.1×10^5	7.8	0.60
LX45	8.8×10^4	10.4×10^5	11.0	1.10

IX: Cross sectional moment of inertia around X axis.
IY: Cross sectional moment of inertia around Y axis.

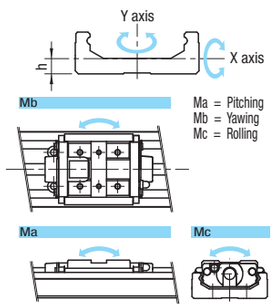
■Allowable Static Load / Allowable Static Moment (Table 4)

Type	No. of blocks	Block Type	Allowable Static Load (kg) Horizontal	Allowable Static Moment (N·m) Ma	Mb	Mc
LX15	1	Long	3701	13	13	41
LX20	1	Long	6199	27	27	93
	2		12398	353	353	186
LX26	1	Long	11871	70	70	225
	2		23742	902	902	450
LX30	1	Long	17218	126	126	387
	2		34436	1515	1515	774
	1	Short	9271	63	63	208
	2		18542	579	579	417
LX45	1	Long	32441	291	291	972
	2		64882	3945	3945	1944
	1	Short	17175	145	145	515
	2		34350	1444	1444	1029

*Double Block Type values are those measured when two blocks contact with each other.
The values above are for reference in static conditions,
Please utilize our Technical Calculation Software for the actual life calculations.

■Load coefficient fw (Table 6)

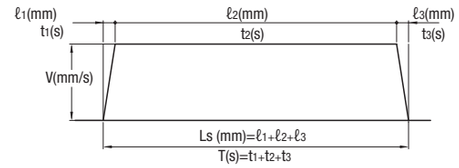
Vibration/ impact	Speed	fw
Subtle	Super-low speed V≤ 0.25m/s	1~1.2
Small	Low speed 0.25m/s<V≤ 1m/s	1.2~1.5
Medium	Medium speed 1m/s <V≤ 2m/s	1.5~2
Large	High speed 2m/s<V	2~3.5



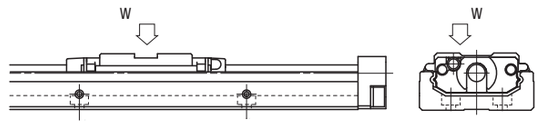
Life Span

For the LX actuator, calculate the life span of the rail, ball screw and support bearing.
The actuator life span is determined to be the smallest value from among these results.

Load mass : W kg
Stroke : Ls mm
Acceleration : a mm/s²
Maximum speed : v mm/s
Gravity : g=9.81m/s²
acceleration : Horizontal
Speed diagram : (Fig. 1)
Operating conditions : (Fig. 2)



Speed diagram (Fig. 1)



Status of load applied (Fig. 2)

Examination Selection

Select the temporary model number based on the load mass W (kg) and the maximum speed V (mm/s). Then prepare a speed diagram based on the acceleration, maximum speed and travel. The conditions that can develop this speed diagram will serve as the basis for the selection calculation.

Calculation Lifetime Calculation Example

Examine the status of the load applied (Fig. 2) to the rail of the LX actuator. Put each load in the formula below (formula (1) for single nut block specifications and formula (2) for double nut block specifications), and obtain the equivalent load Fe.

Equivalent Load

•In the case of single block

$$Fe=Y_HF_H+Y_VF_V+Y_PK_PMa+Y_YK_YMb+Y_RK_RMc \quad -①$$

•In the case of double block

$$Fe=Y_HF_H/2+Y_VF_V/2+Y_RK_RMa+Y_PK_PMb+Y_YK_YMc \quad -②$$

F_e : Equivalent Load
F_H : Horizontal load acting on blocks
F_V : Vertical load applied to the block
Ma : Pitching direction moment applied to the block
Mb : Yawing direction moment applied to the block
Mc : Rolling direction moment applied to the block
Kp : Equivalent coefficient for pitching direction moment
Ky : Equivalent coefficient for yawing direction moment
Kr : Equivalent coefficient for rolling direction moment
Y_H, Y_V, Y_P, Y_Y, Y_R: 1.0 or 0.5

When using with moment loads applied, multiply by Table 3 Rail Section Moment Equivalent coefficient to calculate the Load. In formulas ① and ②, in order to obtain the equivalent load Fe, the maximum value among FH, Fv, KpMa, KyMb and KrMc is regarded to be 1.0, and the remaining values are regarded to be 0.5.

Average Load

As Ma and Mb for the LX actuator vary with acceleration and deceleration, obtain the average load Fm from formula (3).

$$Fm=\sqrt[3]{\frac{1}{Ls}\left(Fe_1^3\cdot L_1+Fe_2^3\cdot L_2+Fe_3^3\cdot L_3\cdots Fe_n^3\cdot L_n\right)} \quad -③$$

Fm: Average load for fluctuating loads (N) L: Total travel distance (km)

Rail Life Span

Obtain the rail life span for the LX actuator from formula ④.

$$L=La\times\left(\frac{C}{fw\cdot Fm}\right)^3 \quad -④$$

L: Rail lifetime (km) La: Travel distance (km) fw: Load coefficient
C: Basic dynamic load rating (N)

When the travel length and the number of reciprocal motions per minute are constant, the number of life span hours can be calculated from formula ⑤.

$$Lh=\frac{L\times10^6}{2\cdot\ell s\cdot n1\times60} \quad -⑤$$

Lh: Life span hours (h) ℓs: Travel (mm) n1: Reciprocal motions per minute

Life span of ball screw and support areas

Obtain the average load from the load applied in the axial direction. Calculate life span for both ball screws and bearings from formula ⑥. Obtain the average load from formula ③.

$$Lr=\left(\frac{Ca}{fw\cdot Fm}\right)^3\cdot\ell\times10^6 \quad -⑥$$

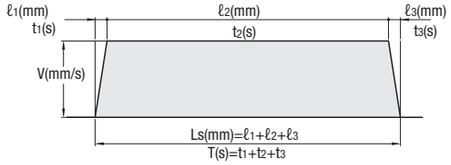
Lr: Life span of ball screw (km) ℓ: Ball screw lead (mm))
fw: Load coefficient Ca: Basic dynamic load rating of screw and support (N)

Rated lifetime calculation example

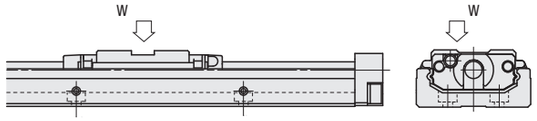
1 Model number for examination

Operating conditions : LX2602
Rail : C (Basic dynamic load rating)=6522N Co (Basic static load rating)=11871N
Ball screw : Ca (Basic dynamic load rating)=1712N Coa (Basic static load rating)=2251N
Support bearings : Ca (Basic dynamic load rating)=1637N Poa (Basic static load rating)=1205N

Load mass : 10kg
Maximum speed : 250mm/s
Acceleration : 833mm/s²
Stroke : 200mm
Gravity : g=9.81m/s²
Position : Horizontal
Speed diagram : (Fig. 1)
Operating Conditions : (Fig. 2)



Speed diagram (Fig. 1)



Status of load applied (Fig. 2)

2 Examination

Temporary selection

Use a travel distance of 200 mm with an acceleration of 833 mm/s² and a maximum speed of 250 mm/s. Based on these conditions, assume that the LX26 series is used. (The selection software can be used on the Misumi website after customer registration has been completed.)

3 Calculation

3–1 Examination of rail

In accordance with the usage conditions whereby the number of nut blocks used is one piece, multiply the load by the moment equivalent coefficient in the table.

Load for nut block

1) At constant speed

$Fe_1=Yv\ Fv=Yv\cdot W\cdot g=1\cdot 10\cdot 9.81=98.1(N)$

2) At acceleration

$Fe_2=Yv\ Fv+Yp\ Kp\ Ma=0.5\cdot 98.1+1\cdot 0.17\cdot 70\cdot 0=60.95(N)$

3) At deceleration

$Fe_3=Yv\ Fv+Yp\ Kp\ Ma=0.5\cdot 98.1+1\cdot 0.17\cdot 70\cdot 0=60.95(N)$

Static safety coefficient

$$fs=\frac{Co}{Femax}=\frac{Co}{w\cdot g}=\frac{11871}{98.1}=121.1$$

Rated life span

Axial average load

$$Fm=\sqrt[3]{\frac{1}{Ls}\left(Fe_1^3\cdot L_1+Fe_2^3\cdot L_2+Fe_3^3\cdot L_3\cdots Fen^3\cdot Ln\right)}=100.41(N)$$

Rated life span

$$L=\left(\frac{C}{fw\cdot Fm}\right)^3\times 50=1.6\times 10^6$$

fw: Load coefficient 1.2
L : Travel distance

3–2 Examination of ball screw

Obtain the axial loads for the parts and the average load from the speed diagram.

Lifetime of ball screw

Axial load
1) At constant speed

$Fe_1=\mu\cdot W\cdot g=0.01\times 10\times 9.81=0.981(N)$

2) At acceleration

$Fe_2=Fe_1+W\cdot a\times 10^{-3}=0.981+10\cdot 0.833=9.311(N)$

3) At deceleration

$Fe_3=Fe_1-W\cdot a\times 10^{-3}=7.352(N)$

Static safety coefficient

$$fs=\frac{Coa}{Femax}=\frac{Coa}{Fe_2}=\frac{2251}{9.311}=241.76$$

Buckling load

$$P_1=\frac{n\cdot\pi^2\cdot E\cdot I}{\ell a^2}\times 0.5=5562.02(N)$$

P_1 : Buckling load
ℓa : Distance between support and nut 250(mm)
E : Young's modules $2.06\times 10^5(N/mm^2)$
n : Coefficient according to mounting method
0.5: Safety factor
I : Minimum geometrical moment of inertia of screw shaft

$$I=\frac{\pi\cdot d_1^4}{64}=85.49(mm^4)$$

d_1 : Root diameter of screw shaft 6.46(mm)

Allowable tension/compression load

$$P_2=\frac{\delta\cdot\pi\cdot d_1^2}{4}=4818.06$$

P_2 : Allowable tension/compression load (N)
δ : Allowable tension/compression stress 147(N/mm²)
d_1 : Root diameter of screw shaft 6.46(mm)

Critical speed

$$N1=\frac{60\cdot\lambda^2}{2\pi\cdot\ell b^2}\cdot\sqrt{\frac{E\times 10^3\cdot I}{\gamma\cdot A}}\times 0.8=12485(min^{-1})$$

N1 : Critical speed
ℓb : Distance between mounting points
E : Young's modules $2.06\times 10^5(N/mm^2)$
λ : Coefficient according to mounting method (Fixed-Support 3.927)
γ : Density ($7.85\times 10^{-6}kg/mm^3$)
0.8: Safety factor

DN value

DN=62250(≤70000)

D : Ball center to center diameter (8.3mm)
N : Maximum number of operating revolutions (min^{-1})

Rated life span

Axial average load

$$Fm=\sqrt[3]{\frac{1}{Ls}\left(Fe_1^3\cdot L_1+Fe_2^3\cdot L_2+Fe_3^3\cdot L_3\cdots Fen^3\cdot Ln\right)}=6.096(N)$$

Rated life span

$$L=\left(\frac{Ca}{fw\cdot Fm}\right)^3\cdot\ell\times 10^6=25.64\times 10^6(km)$$

fw : Load coefficient 1.2
ℓ : Ball screw lead 2 (mm)

3–3 Examination of support bearing

Axial load

$Fe_1=0.981(N)$
$Fe_2=9.311(N)$
$Fe_3=7.352(N)$

Static safety coefficient

$$fs=\frac{Poa}{Femax}=\frac{Poa}{Fe_2}=129.42$$

Equivalent load

Axial average load

$$Fm=\sqrt[3]{\frac{1}{Ls}\left(Fe_1^3\cdot L_1+Fe_2^3\cdot L_2+Fe_3^3\cdot L_3\cdots Fen^3\cdot Ln\right)}=6.096(N)$$

Rated lifetime

$$L=\left(\frac{Ca}{fw\cdot Fm}\right)^3\cdot\ell\times 10^6=22.41\times 10^6(km)$$

fw : Load coefficient 1.2
ℓ : Ball screw lead 2 (mm)

LX2602	Rail	Ball screw	Support bearing
Static safety factor	114.09	241.76	129.42
Buckling load (N)	–	5562.02	–
Allowable tension/compression load (N)	–	4818.06	–
Critical speed (min^{-1})	–	12485	–
DN value	–	62250	–
Rated lifetime (km)	1.6×10^6	25.64×10^6	22.41×10^6
Maximum axial load (N)	–	9.311	–
Maximum number of operating revolutions	–	7500	–

Single Axis Robot (RS)
Lineup / Spec List

Slapping Motor Specifications

■Slider Type

Motor Direction	Type	Lead	Maximum Load Capacity Mass (kg) Horizontal	Maximum Load Capacity Mass (kg) Vertical	Max. Push Force (N)	Max. Velocity (mm/sec) * Values in the list are the Max. Velocity Stroke (mm) 50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	Environmental Spec.	Position Detector	Controller Input Power Supply
Straight	RS1 RS1C	2	6	4	150	100																Standard / Clean	Resolver Incremental Type	DC24V (±10%)
		6	4	2	90	300																		
		12	2	1	45	400~600																		
	RS2 RS2C	6	10	2	90	300												280	250	220	190			
		12	6	1	45	400~ 600												560	500	440	380			
		20	4	-	27	350~1000												933	833	733	633			
	RS3 RS3C	6	12	4	120	300												280	250	220	190			
		12	8	2	60	420~ 600												560	500	440	380			
		20	6	-	36	350~1000												933	833	733	633			
Folded	RS1	2	6	4	150	100																Standard		
		6	4	2	90	300																		
		12	2	1	45	400~600																		
	RS2	6	10	2	90	300												280	250	220	190			
		12	6	1	45	400~ 600												560	500	440	380			
		20	4	-	27	350~1000												933	833	733	633			
	RS3	6	12	4	120	300												280	250	220	190			
		12	8	2	60	420~ 600												560	500	440	380			
		20	6	-	36	350~1000												933	833	733	633			

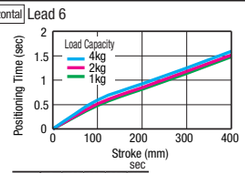
■Rod Type

Motor Direction	Support Guide	Type	Lead	Maximum Load Capacity Mass (kg) Horizontal	Maximum Load Capacity Mass (kg) Vertical	Max. Push Force (N)	Max. Velocity (mm/sec) * Values in the list are the Max. Velocity Stroke (mm) 50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	Environmental Spec.	Position Detector	Controller Input Power Supply
Straight	None	RSD1	6	20	8	100	250																Standard	Resolver Incremental Type	DC24V (±10%)
			12	10	4	75	500																		
		RSD2	2	45	25	600	80																		
			6	40	12	300	250																		
			12	25	5	150	500																		
		RSD3	2	60	30	900	50																		
			6	55	20	550	150																		
			12	50	10	250	300																		
	Included	RSDG1	6	20	7.5	100	250																		
			12	10	3.5	75	500																		
		RSDG2	2	45	24	600	80																		
			6	40	11	300	250																		
			12	25	4	150	500																		
		RSDG3	2	60	28.5	900	50																		
			6	55	18.5	550	150																		
			12	50	8.5	250	300																		
Folded	None	RSD1	6	20	8	100	250																		
			12	10	4	75	500																		
		RSD2	2	45	25	600	80																		
			6	40	12	300	250																		
			12	25	5	150	500																		
		RSD3	2	60	30	900	50																		
			6	55	20	550	150																		
			12	50	10	250	300																		
	Included	RSDG1	6	20	7.5	100	250																		
			12	10	3.5	75	500																		
		RSDG2	2	45	24	600	80																		
			6	40	11	300	250																		
			12	25	4	150	500																		
		RSDG3	2	60	28.5	900	50																		
			6	55	18.5	550	150																		
			12	50	8.5	250	300																		

■Cycle Time Graph (for reference)

RS1

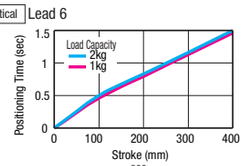
Horizontal Lead 6



sec

st	O	100	200	300	400
4kg	O	0.59	0.92	1.25	1.59
2kg	O	0.51	0.85	1.18	1.51
1kg	O	0.48	0.81	1.14	1.48

Vertical Lead 6

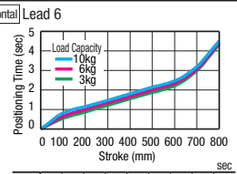


sec

st	O	100	200	300	400
2kg	O	0.50	0.83	1.16	1.50
1kg	O	0.46	0.79	1.13	1.46

RS2

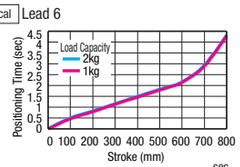
Horizontal Lead 6



sec

st	O	100	200	300	400	500	600	700	800
10kg	O	0.83	1.14	1.47	1.81	2.14	2.47	3.20	4.51
6kg	O	0.66	0.99	1.33	1.66	1.99	2.33	3.07	4.42
3kg	O	0.55	0.88	1.22	1.55	1.88	2.22	2.98	4.35

Vertical Lead 6



sec

st	O	100	200	300	400	500	600	700	800
2kg	O	0.50	0.83	1.16	1.50	1.83	2.16	2.94	4.32
1kg	O	0.46	0.79	1.13	1.46	1.79	2.13	2.91	4.29

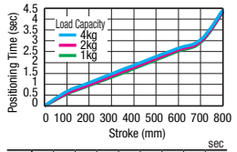
RS3

Horizontal Lead 6

sec

st	O	100	200	300	400	500	600	700	800
12kg	O	0.90	1.21	1.55	1.88	2.21	2.55	3.26	4.56
8kg	O	0.74	1.07	1.40	1.73	2.07	2.40	3.13	4.46
4kg	O	0.59	0.92	1.25	1.59	1.92	2.25	3.01	4.37

Vertical Lead 6



sec

st	O	100	200	300	400	500	600	700	800
4kg	O	0.67	1.07	1.47	1.87	2.27	2.67	3.07	4.42
2kg	O	0.58	0.98	1.38	1.78	2.18	2.58	2.98	4.35
1kg	O	0.53	0.93	1.33	1.73	2.13	2.53	2.93	4.31

Servo Motor Specifications

■Slider Type

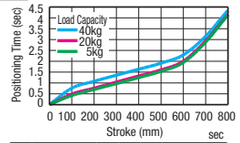
Driving	Type	Lead	Maximum Load Capacity Mass (kg) Horizontal	Maximum Load Capacity Mass (kg) Vertical	Max. Push Force (N)	Max. Velocity (mm/sec) * Values in the list are the Max. Velocity Stroke (mm) 150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000	1050	Environmental Spec.	Position Detector	Controller Input Power Supply
Ball Screw	RSH1 RSH1C	6	40	8	238	360									324	270	234	216	180						Standard / Clean	Resolver Absolute Incremental Type	AC Single Phase 100~115V 200~230V (±10%)
		12	20	4	141	720									648	540	468	432	360								
		20	12	-	84	780~1200									1080	900	780	780	600								
	RSH2 RSH2C	5	50	16	339	300										255	225	195	180	165	150	135	120				
		10	40	8	169	600										510	450	390	360	330	300	270	240				
		20	20	4	84	1020~1200										1020	900	780	720	660	600	540	480				
		30	7	-	56	774~1800										1530	1350	1170	1080	990	900	810	720				
	RSH3 RSH3C	5	80	-	339	300									255	225	195	180	165	150	135	120	105				
		10	60		169	600									510	450	390	360	330	300	270	240	210				
		20	30		84	1020~1200									1020	900	780	720	660	600	540	480	420				
	RSH4	5	60	20	399	300											240	195	150	135				Standard			
		10	40	10	169	600											480	390	300	270							
		20	20	4	84	800~1200											960	780	600	540							
		30	15	-	56	800~1800											1440	1170	900	810							
	RSH5	5	80	20	399	300											240	195	150	135							
		10	55	10	169	600											480	390	300	270							
		20	30	4	84	1000~1200											960	780	600	540							
		30	15	-	56	900~1800											1440	1170	900	810							
	RSF4	5	80	20	399	300											240	195	150	135							
		10	55	10	169	600											480	390	300	270							
		20	30	4	84	1100~1200											960	780	600	540							
		30	15	-	56	800~1800											1440	1170	900	810							

Driving	Type	Maximum Load Capacity Mass (kg) Horizontal	Maximum Load Capacity Mass (kg) Vertical	Max. Push Force (N)	Max. Velocity (mm/sec) * Values in the list are the Max. Velocity. Stroke (mm)	Environment Specifications	Position Detector	Controller Input Power Supply
Belt	RSB1	10	-	-	150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000 1050 1100 1150 1200 1250 1300 1350 1400 1450 1500 1550 1600 ~1750 1875 1650 1700 1750 1800 1850 1900 1950 2000 2050 2100 2150 2200 2250 2300 2350 2400 2450 2500 2550 1875	Standard	Resolver Absolute Type Incremental Method	AC Single Phase 100~115V 200~230V (±10%)
	RSB2	20	-	-	150 200 250 300 350 400 450 500 550 600 650 700 750 800 850 900 950 1000 1050 1100 1150 1200 1250 1300 1350 1400 1450 1500 1550 1600 ~1750 1875 1650 1700 1750 1800 1850 1900 1950 2000 2050 2100 2150 2200 2250 2300 2350 2400 2450 2500 2550 2600 2650 2700 2750 2800 2850 2900 2950 3000 3050 1875			

■Cycle Time Graph (for reference)

RSH1

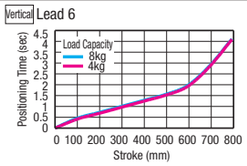
Horizontal Lead 6



sec

st	O	100	200	300	400	500	600	700	800
40kg	O	0.76	1.08	1.36	1.63	1.91	2.29	3.15	4.34
20kg	O	0.49	0.76	1.04	1.32	1.60	2.00	2.93	4.16
5kg	O	0.42	0.70	0.97	1.25	1.53	1.94	2.88	4.13

Vertical Lead 6

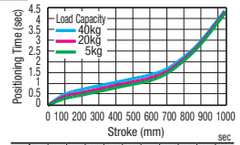


sec

st	O	100	200	300	400	500	600	700	800
8kg	O	0.46	0.73	1.01	1.29	1.57	1.98	2.91	4.15
4kg	O	0.42	0.69	0.97	1.25	1.53	1.94	2.88	4.13

RSH2

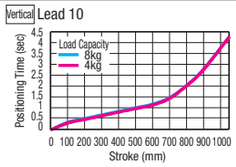
Horizontal Lead 10



sec

st	O	100	200	300	400	500	600	700	800	900	1050
40kg	O	0.51	0.73	0.90	1.06	1.23	1.40	1.67	2.20	2.92	4.40
20kg	O	0.41	0.58	0.75	0.92	1.08	1.25	1.54	2.10	2.84	4.33
5kg	O	0.31	0.47	0.64	0.81	0.97	1.14	1.45	2.03	2.78	4.27

Vertical Lead 10

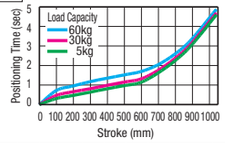


sec

st	O	100	200	300	400	500	600	700	800	900	1050
8kg	O	0.35	0.51	0.68	0.85	1.01	1.18	1.48	2.05	2.80	4.29
4kg	O	0.31	0.47	0.64	0.81	0.97	1.14	1.45	2.03	2.78	4.27

RSH3

Horizontal Lead 10



sec

st	O	100	200	300	400	500	600	700	800	900	1050
60kg	O	0.73	0.96	1.18	1.36	1.53	1.70	2.04	2.59	3.35	4.93
30kg	O	0.47	0.66	0.82	0.99	1.16	1.32	1.75	2.36	3.15	4.74
5kg	O	0.31	0.47	0.64	0.81	0.97	1.14	1.61	2.24	3.05	4.64

Notes on CE Marking

MISUMI Robot Series provide parts to be incorporated into customers' device and equipment. According to EC Directive, it is declared that these are supplied in an incomplete state. Therefore, no CE marks are attached.
Please check for EC Directive compatibility with actuator built-in device or equipment (finished products). For details, please see the Instruction Manual.

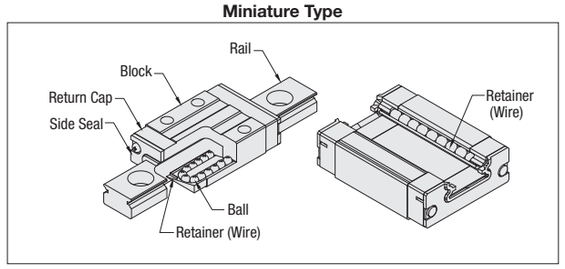
Warranty

■Warranty Terms Comply with "Warranty Standards" printed on "Mechanical Standard Components for Factory Automation" catalog.
■Warranty Period One year from shipment date or within the first 2400 hours of operation whichever comes first

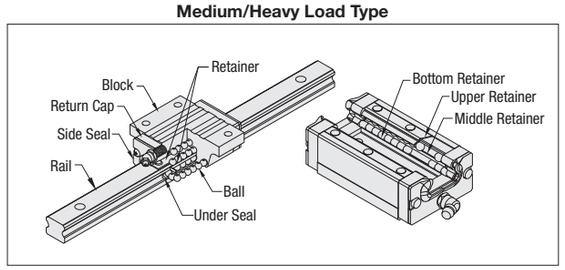
Linear Guide
Structure and Precision

Linear Guide - Structure and Features

Miniature Type



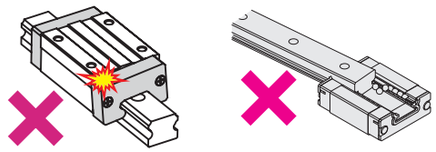
Medium/Heavy Load Type



- Linear guides utilize steel balls rolling on precisely ground raceways, and the balls are recirculated by plastic return caps.
- End seals prevent foreign substances from intruding into the blocks.
- Miniature Type has two rows of contacting steel balls in a 4-point raceway contact design.
- Medium/Heavy Load Types have four rows of contacting steel balls in a 2-point raceway contact design.
- Load ratings are the same for all four directions (radial, reverse-radial, and lateral directions). Can be used in any orientation.
- Cautions

Do not apply a shock to the return cap. Doing so will affect the ball circulation and may cause sliding defects.

Balls do not fall out of MISUMI linear guides when removed from rails as the blocks are equipped with ball-retainers. However, the balls may fall out by rapidly removing blocks from the rail or inserting the rail into the block at a slant. Remove and install the blocks with caution.



Precision

• Dimensional Accuracy

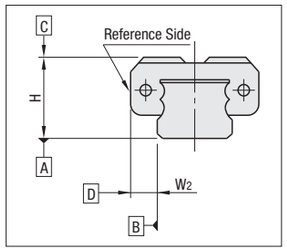
Type	Accuracy Standards		Existing Products			C-VALUE Products
			Precision Grade	High Grade	Standard Grade	Standard Grade
Miniature Type	Height H Tolerance		±10	±20	±20	±40
	Pair Variation of Height H		7	15	40	30
	Width W_2 Tolerance		±15	±25	±25	±40
	Pair Variation of Width W_2		10	20	40	30
Medium/ Heavy Load Type	**Accuracy Standards**		**High Grade**	**Interchangeable**	**Standard Grade**	**Standard Grade**
	Height H Tolerance		±40	±20	±100	±120
	Pair Variation of Height H		15	15	20	40
	Width W_2 Tolerance		±20	±30	±100	±100
	Pair Variation of Width W_2	24, 28	15	25	20	40
		33, 42	15	25	30	40
		30, 36, 40, 42	-	25	-	40

• Running Parallelism Unit: μm

Rail Length (mm)		Miniature				Medium/Heavy Load			
		Existing Products			C-VALUE	Existing Products			C-VALUE
over	or Less	Precision Grade	High Grade	Standard Grade	Standard Grade	High Grade	Interchangeable	Standard Grade	Standard Grade
	50	2	3	13	13	7	6	7	10
50	80	2	3	13	13	7	6	7	10
80	125	3	7	15	15	7	6.5	7	10
125	200	3	7	15	15	7	7	7	10
200	250	3.5	9	17	17	7	8	7	10
250	315	4	11	18	18	8	9	12	10
315	400	5	11	18	18	8	11	12	12
400	500	5	12	19	19	9	12	14	13
500	630	6	13.5	21	21	11	14	18	15
630	800	6	14	21.5	21.5	13	16	21	17
800	1000	-				14.5	18	23	19
1000	1250	-				16	20	25	22
1250	1600	-				-	23	27	23
1600	2000	-				-	26	28.5	24

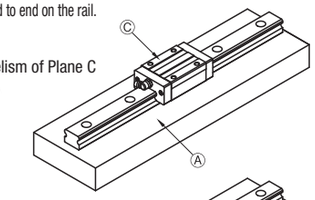
[Pair Variation of Height H]
Difference between the min./max. values of Height (H) Dimension for a number of blocks combined on one rail.

[Pair Variation of Width W_2]
Difference between the min./max. values of Width (W) Dimension for a number of blocks combined on one rail.

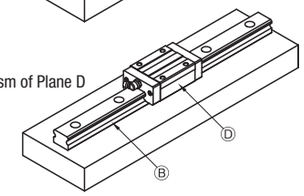


[Running Parallelism]
Measured while the rail is bolted firmly to a standard datum surface base.
A relative variation of block's top surface C against the rail's bottom surface A, and a relative variation of block's datum surface D against the rail's datum surface B are measured, as the block is run from end to end on the rail.

•Running Parallelism of Plane C against Plane A



•Running Parallelism of Plane D against Plane B



Linear Guide
Preload and Allowable Load

Selection of Radial Clearance (Preload)

Type		Preload	Size (Height H Dimension)	Radial Clearance (μm)
Miniature	Existing Products	Light Preload	6~20	-3~0
		Slight Clearance		0~+15
Medium/ Heavy Load	Existing Products	Normal Clearance	24	-4~+2
			28	-5~+2
			33	-6~+3
		Interchangeable, Light Preload	24, 28	-4~0
			30, 36, 40, 42	-5~0
			*42	-7~0
	Cost Efficient Products	Normal Clearance	24	-4~+4
			28, 30	-5~+5
			33, 36, 40	-6~+6
			45	-7~+7

* marked size is for Super Heavy / Extra Super Heavy Load.

- Clearance and preload of MISUMI Linear Guides are controlled with minute ball size adjustments.
- Increased rigidity and reduced elastic deformation will result by preloading (negative clearance).
- Generally, selecting some preloads would cause favorable effects on accuracy and life of Linear Guides.
- MISUMI-manufactured Blocks and rails guarantee their own radial clearances (preload) and accuracies as sets of blocks and rails. Be sure to use the blocks and rails in sets.

Friction Force (Required Thrust Force)

Linear Guide friction force (required thrust) varies depending on load, speed and lubricant property. Especially when moment load is applied, Preload Type friction force increases.
Although seal resistance varies according to seal lip press-fit allowance and lubrication conditions, it is not proportionate to load and keeps a constant value.
Friction force is obtained by the following formula.

$$F = \mu \cdot W + f$$

F : Friction (N)
μ : Dynamic Friction Coefficient
W : Applied Load
f : Seal Resistance (2N ~ 5N)

Table-1. Dynamic Friction Coefficient

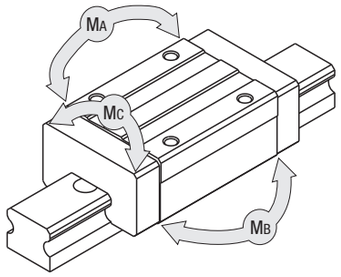
Type	Dynamic Friction Coefficient (μ)
Miniature Linear Guides	0.004~0.006
Linear Guides for Medium Load	0.002~0.003

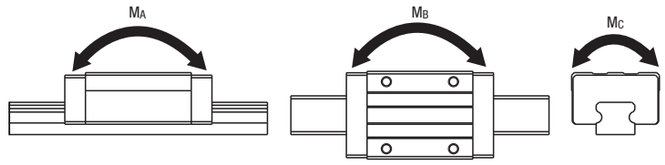
Allowable Load

- Basic Dynamic Load Rating (C)
  Basic dynamic load rating is defined as: a load applied in a constant direction and ran under equal condition on a group of linear guide specimen where 90% of specimen will reach 50×10^3m without experiencing any damages due to rolling fatigues.
- Basic Static Load Rating (Co)
  Basic static load rating is defined as: a load applied on non-moving linear guides where a sum of rolling element plastic deformation amount and rolling surface plastic deformation amount becomes equal to 0.0001 times that of the diameter of the rolling element (balls).
- Allowable Static Moment (M_A, M_B, M_C)
  Allowable static moment is a critical static moment load defined by permanent deformation value similar to basic static load rating Co.

Allowable Load (N) ≤ Co/fs
Allowable Moment (N · m) ≤ (M_A, M_B, M_C)/fs

fs: Static Safety Factor Co: Basic Static Load Rating (N)
M_A, M_B, M_C: Allowable Static Moment (N · m)





Pitch Direction Yaw Direction Roll Direction

- Static Safety Factor (fs)
  Basic Static Load Rating Co, in the static state or in low speed, is divided by Static Safety Factor fs in **Table - 2** depending on operating conditions.

Table-2. Static Safety Factor (fs Lower Limit)

Condition of Use	Lower Limits of fs
For normal operating condition	1~2
When smooth running performance is required	2~4
When vibrations and impacts exist	3~5

Linear Guide
Operating Life Calculation for Linear Guides

■Operating Life

When Linear Guide is loaded in linear reciprocating motion, scaly damages called flaking appear due to material fatigue as the stress works on the rolling elements and rolling contact surfaces constantly. Total travel distance until the first flaking occurs is called Life of Linear Guides.

■Rated Life

Rated life is the total travel distance that 90% of linear guides of the same type can reach, under the same conditions, with no occurrence of flaking damage. Rated life can be obtained from the Basic Dynamic Load Rating and the actual load applied on the linear bushings, as shown below.

$$L=\left(\frac{C}{P}\right)^3\cdot 50$$

Load must be calculated before actually using Linear Guides. To obtain load during linear reciprocating motion, it is necessary to fully consider vibration and impact during motion, and also distribution status in relation to Linear Guides. So, it is not easy to obtain load by calculation. Operating temperature also critically affects life. All these conditions considered, the above-mentioned calculation formula is as follows.

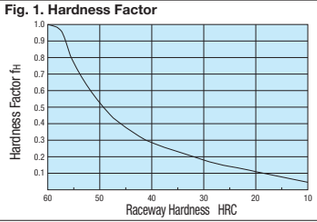
$$L=\left(\frac{f_H\cdot f_T\cdot f_C}{f_W}\cdot\frac{C}{P}\right)^3\cdot 50$$

L : Rated Life (km)
f_H : Hardness Factors (See Fig. 1)
f_T : Temperature Factors (See Fig. 2)
f_C : Contact Factors (See Table-1)
f_W : Load Factors (See Table-2)
C : Basic Dynamic Load Rating (N)
P : Applied Load (N)

• Hardness Factor (f_H)

For Linear Guide applications, sufficient hardness is required for ball contact shafts. Insufficient hardness causes less allowable load, resulting in shorter life.
Please correct the rated life according to the hardness factors.

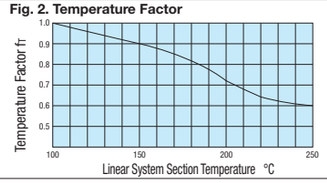
Fig. 1. Hardness Factor



• Temperature Factor (f_T)

If the Linear Guide temperature exceeds 100°C, the Linear Guide and shaft hardness decreases, resulting in less allowable load and shorter life than used at a room temperature.
Please correct the rated life according to the temperature factors.
* Please use Linear Guides under the allowable temperature shown on each product page.

Fig. 2. Temperature Factor



• Contact Factor (fc)

For actual applications, more than 2 blocks are generally used per shaft. In this case, load applied to each block varies depending on machining precision but is not uniformly distributed. As a result, per-block allowable load varies depending on per-shaft Linear Guide quantity.
Please correct the rated life according to Table-1 Contact Factor.

Table-1. Contact Factor

Number of Linear Guide on One Shaft	Contact Factor fc
1	1.00
2	0.81
3	0.72
4	0.66
5	0.61

• Load Factor (fw)

To calculate load applied to the Linear Guides, in addition to object weight, it requires inertia force attributed to motion velocity or moment loads. Further, it is necessary to accurately determine the temporal change of each. It, however, is difficult to attain accurate calculations due to potential vibration and impacts caused during reciprocating motion, other than repeated start-stop motions. Table-2 Load Factor helps simplify operating life calculation.

Table-2. Load Factor

Condition of Use	fw
No shocks/vibrations, low speed: 15m/min. or less	1.0~1.5
No significant shocks/vibrations, medium speed: 60m/min. or less	1.5~2.0
With shocks/vibrations, high speed: 60m/min. or more	2.0~3.5

• Applied Load P Calculation Method

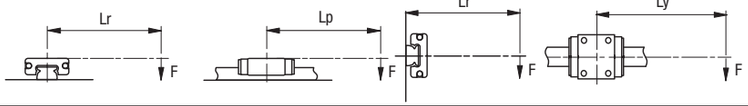
When load is applied to the a block, convert moment load into applied load by the following formula.

・Horizontal Installation

$$P=F+\frac{C_O}{M_C}\times(F\times L_r)+\frac{C_O}{M_A}\times(F\times L_p)$$

・Lateral Installation

$$P=F+\frac{C_O}{M_C}\times(F\times L_r)+\frac{C_O}{M_B}\times(F\times L_y)$$

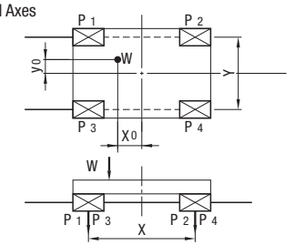
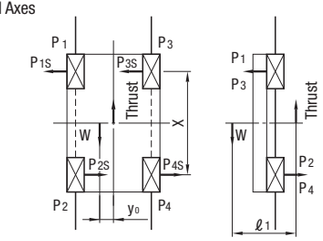
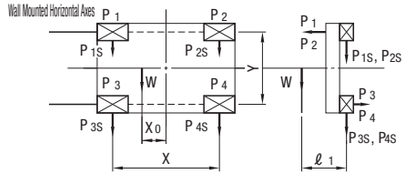
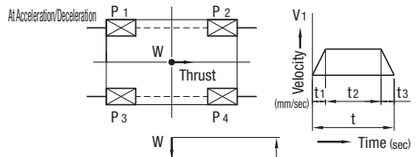
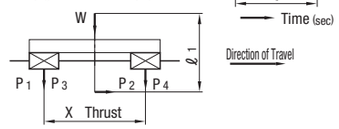


P: Applied Load (N)
F: Downward Load (N)
Co: Static Load Rating (N)
M_A: Allowable Static Moment - Pitch Direction (N・m)
M_B: Allowable Static Moment - Yaw Direction (N・m)
M_C: Allowable Static Moment - Roll Direction (N・m)
Lp: Distance from Block Center to Load Center in Pitch Direction (m)
Ly: Distance from Block Center to Load Center in Yaw Direction (m)
Lr: Distance from Block Center to Load Center in Roll Direction (m)

■Load Calculation

Linear Guides perform linear reciprocating motion while supporting object weight. Therefore, load applied to Linear Guides varies depending on the center of gravity of the object, thrust force applied position or changes in speed at start, stop, acceleration and deceleration. For Linear Guide selections, these conditions must be fully considered.

Table-3. Condition of Use and Load Calculation Formula

Classification	Operating Condition and Load
1	Horizontal Axes  $P_1=\frac{1}{4}W+\frac{X_0}{2X}W+\frac{y_0}{2Y}W$ $P_2=\frac{1}{4}W-\frac{X_0}{2X}W+\frac{y_0}{2Y}W$ $P_3=\frac{1}{4}W+\frac{X_0}{2X}W-\frac{y_0}{2Y}W$ $P_4=\frac{1}{4}W+\frac{X_0}{2X}W-\frac{y_0}{2Y}W$
2	Vertical Axes  $P_1=P_2=P_3=P_4=\frac{\ell_1}{2X}W$ $P_{1S}=P_{2S}=P_{3S}=P_{4S}=\frac{y_0}{2X}W$
3	Wall Mounted Horizontal Axes  $P_1=P_2=P_3=P_4=\frac{\ell_1}{2Y}W$ $P_{1S}=P_{3S}=\frac{1}{4}W+\frac{X_0}{2X}W$ $P_{2S}=P_{4S}=\frac{1}{4}W-\frac{X_0}{2X}W$
4	At Acceleration/Deceleration   • When accelerating from a start $P_1=P_3=\frac{1}{4}W\left(1+\frac{2V_1\cdot\ell_1}{g\cdot t_1\cdot X}\right)$ $P_2=P_4=\frac{1}{4}W\left(1-\frac{2V_1\cdot\ell_1}{g\cdot t_1\cdot X}\right)$ • When decelerating to a stop $P_1=P_3=\frac{1}{4}W\left(1-\frac{2V_1\cdot\ell_1}{g\cdot t_3\cdot X}\right)$ $P_2=P_4=\frac{1}{4}W\left(1+\frac{2V_1\cdot\ell_1}{g\cdot t_3\cdot X}\right)$ • At constant speed $P_1=P_2=P_3=P_4=\frac{1}{4}W$ g: Gravitational Acceleration $=9.8\times10^3$mm/sec^2

W : Applied Load (N) P_1, P_2, P_3, P_4: Load applied to Linear Guides (N)
X,Y: Linear Guide Span (mm) V: Travel Speed (mm/sec) t_1: Acceleration Time (sec) t_3: Deceleration Time (sec)

■Average of Fluctuating Loads

In general, load applied to Linear Guides varies depending on their applications. For example, there are cases at the start and stop of reciprocating motion, during constant motion or transfer with/without a workpiece. Therefore, it requires average load under which the life equals to the one under these fluctuating loads.

①When load changes in stages according to the distance (Fig. 3)
Travel distance ℓ_1 under load P_1
Travel distance ℓ_2 under load P_2
⋮ ⋮
For travel distance ℓ_n under load P_n,
average load Pm is obtained by the following formula.

$$P_m=\sqrt[3]{\frac{1}{\ell}\left(P_1^3\ell_1+P_2^3\ell_2\cdots+P_n^3\ell_n\right)}$$

Pm: Average of Fluctuating Loads (N) ℓ : Total Travel Distance (m)

②When load changes almost linearly (Fig. 4),
average load Pm is approximately obtained by the following formula.

$$P_m\approx\frac{1}{3}(P_{min}+2\cdot P_{max})$$

Pmin: Minimum Fluctuating Load (N)
Pmax: Maximum Fluctuating Load (N)

③When load changes in a sine curve as shown on Fig. 5 (a) and (b), average load Pm is approximately obtained by the following formula.

Fig. 5 (a) Pm≈0.65Pmax
Fig. 5 (b) Pm≈0.75Pmax

Fig. 3 Staged Fluctuating Loads

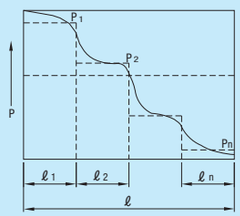


Fig. 4 Constant Fluctuating Loads

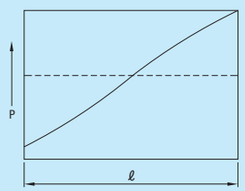
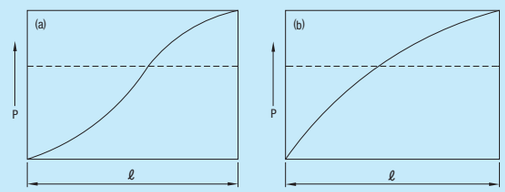


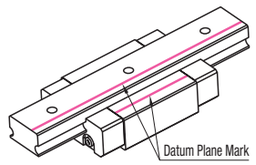
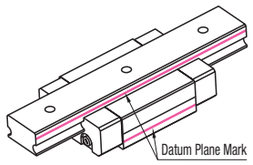
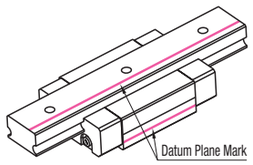
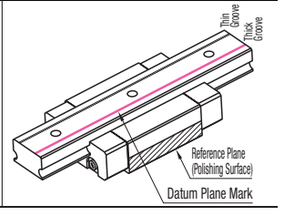
Fig. 5 Sine Curve Formed Fluctuating Loads



Linear Guide
Installation and Maintenance

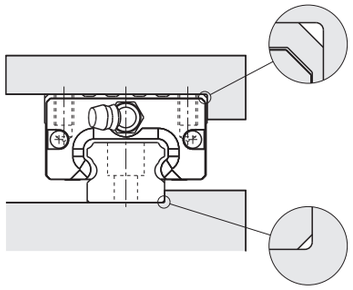
Installation Method of Linear Guides

MISUMI Linear Guides have a datum surface (a surface with a straight groove) on both the rail and block. (See the diagram below.)
When installing Linear Guides, correctly match the datum of the guides and installation bases.

Miniature Linear Guides	Linear Guides for Medium/Heavy Load		
Common to Existing Products	Existing Products	Existing Products (with Plastic Retainer)	Cost Efficient Products
			

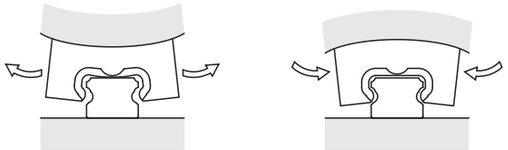
Mounting Surface Shape

Linear Guides are designed to obtain accuracies when mounted on base plates. Generally, the datum plane is placed against the shoulder on the mounting surface. In that case, corners should have reliefs or corner radius should be machined smaller than chamfering of rails and blocks. See each product page for chamfering dimensions of products.



Block Mounting Surface Flatness

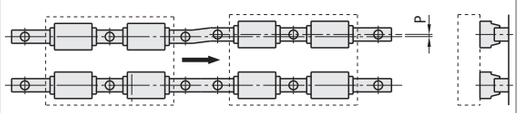
Blocks may be deformed depending on its mounting surface flatness. Block deformation may cause clearance, which might give less/more preload and cause sliding defects. Securing 5μ mounting surface flatness is recommended.



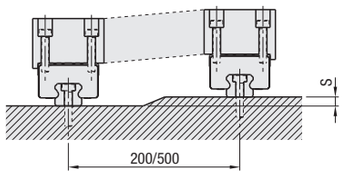
Installation Error Tolerance

•Installation Error Tolerance is the value which does not influence operating life under common usage.

Running Parallelism Error Tolerance



Height Error Tolerance



Installation Error Tolerance

Type		Radial Clearance	Parallelism Error Tolerance of 2 Axes (P)	Height Error Tolerance of 2 Axes (S)
Existing Products	Medium/Heavy Load Type	Light Preload, Normal Clearance	20μm or Less	330μm or Less / 500mm
Cost Efficient Products	H24 H28 H30	Normal Clearance	25μm or Less	130μm or Less / 500mm
	H33 H36 H40		30μm or Less	130μm or Less / 500mm
	H42 H45		40μm or Less	170μm or Less / 500mm
Miniature Type (Common to Existing Products)		Light Preload	6μm or Less	15μm or Less / 200mm
		Slight Clearance	10μm or Less	30μm or Less / 200mm

Rail Installation

•When datum is provided on installation bases

①Remove burrs and dusts on the mounting surfaces before installation.
②Place a rail on the installation side of the base gently, and tighten the screws temporarily while pushing the rail against the datum shoulder.
③Installation methods Fig. 1-3 are recommended when using linear guides where shocks, vibrations and heavy loads may exist, and high precision is required.
④Fully tighten the rail mounting screws to specified torque with a torque wrench. (For torque standards, see Table-1.)

Fig.1: Push Plate Method

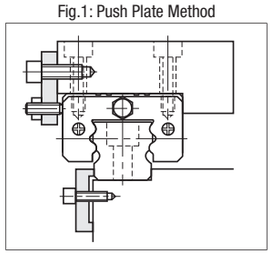


Fig.2: Taper Gib Method

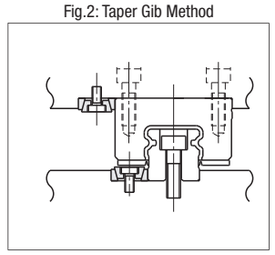
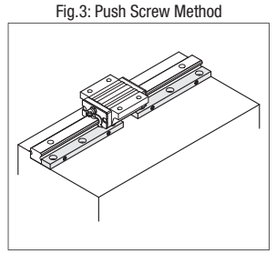


Fig.3: Push Screw Method



•When datum is not provided on installation bases

Straight Gauge
①Place a rail on the installation side of the base gently, and tighten the screws temporarily.
②Place a straightedge parallel to the temporarily tightened rail.
③Use the straightedge as a reference, snug down the screws while measuring the parallelism of the rail with a dial indicator as shown in Fig.4.
④Fully tighten the rail mounting screws to specified torque with a torque wrench.
⑤The secondary rail can be installed in the same straightedge method as the primary master rail, or by using the primary rail as a datum reference. In either method, use a dial indicator to measure the parallelism while the rail is being fastened down.

Fig.4: Straightedge Method

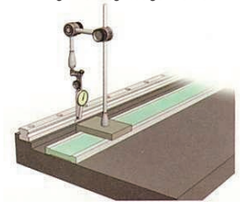


Fig.5: Secondary Rail Mounting Method

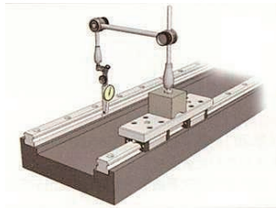


Table-1: Screw Tightening Torque (for SCM Material)

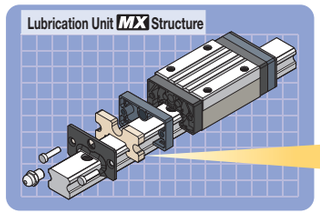
Type	Nominal of Thread	Recommended Torque (N・m)
Medium/Heavy Load Type	M3	2.0
	M5	8.8
	M6	12.7
	M8	29.4
Miniature Type	M2	0.4
	M2.5	0.6
	M3	1.0
	M4	2.5

Maintenance (Grease Application)

•Grease forms lubricating film between steel balls and rolling surface of linear guides. This reduces friction and prevents seizures.
Grease loss and deterioration will cause shorter life of linear guides. Apply grease appropriately depending on your condition of use.
Grease listed below is applied to MISUMI Linear Guides before shipping, and the products can be used out of box.
•Miniature Type: Filled with Lithium soap based grease (Multemp Grease PS2 by Kyodo Yushi Co., Ltd.).
•Medium/Heavy Load Type: Filled with Lithium soap based grease (Alvania Grease S2 by Showa Shell Sekiyu K.K.).
•Recommended Lubrication Intervals: Every 6 month
Every 3 month when travel distance is extensive, or every 1000km.
*Recommended above is the lubrication interval based on travel distance. If the grease degrades or gets contaminated faster depending on the operating environment, you will need to shorten the lubrication interval as needed.
•Lubrication Unit MX significantly extends lubrication intervals.

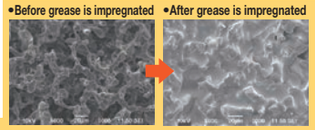
Lubrication Units Which Provide Long-term Maintenance-free Operation MX

Lubrication Unit MX Structure



Enlarged Photos of Special Polyurethane Pores

•Before grease is impregnated •After grease is impregnated



Special polyurethane, which is formed by continuous pore evenly distributed, highly excels in water-holding capability.
Thus, it is possible to impregnate a large amount of grease.

Features

1 Long Term Maintenance-free Condition

Lubrication Unit MX is a self-lubrication unit constructed of grease impregnated special polyurethane.
Capillary action provides appropriate supply of grease to the track surface of the linear guide.
Oil film is always formed between the steel ball and the rail and provides long term maintenance-free operation.

2 Cost Advantages

Since lubrication frequency can be significantly reduced, you can save maintenance cost.

Linear Guide
Calculation of Life Span of Linear Systems 1

■Allowable Load

•Basic Dynamic Load Rating (C)

Basic dynamic load rating is a constant load applied in a constant direction that enables each linear system of the same series to travel 50×10^3m under the same conditions, without 90% of the material suffering damage from rolling contact fatigue.

•Basic Static Load Rating (Co)

Basic static load rating is the static load exerted on contacting parts under maximum stress, at which the sum of the permanent deformation in the rolling element and rolling contact surface equals 0.0001 times the diameter of the rolling element.

•Allowable Static Moment (M_P, M_Y, M_R)

Allowable static moment is a critical static moment load that acts upon a system at the loading moment. It is set in accordance with the permanent deformation as in basic static load rating Co.

•Static Safety Factor (fs)

Static safety factors are given in Table-1. When a linear system is still or moving at low speed, basic static load rating Co must be divided by fs in accordance with the conditions of use.

Table-1. Static Safety Factor(Lower Limit of f_s)

Condition of Use	Lower Limit of f_s
Under Normal Operating Conditions	1~2
When Smooth Travel is Required	2~4
When Subjected to Vibrations, Impacts	3~5

Allowable Load (N) ≤ Co/fs

Allowable Moment (N·m) ≤ (M_P, M_Y, M_R)/fs

fs: Static Safety Factor Co: Basic Static Load (N)

M_P, M_Y, M_R : Static Allowable Moment (N·m)

■Life Span

When a load is applied to a linear system, the system moves back and forth in a linear direction. In the process, repeated stress acts upon rolling elements and rolling contact surfaces, causing damage referred to as flaking from material fatigue. The life span of a linear system is measured in terms of the total travel distance covered by the system up until initial flaking occurs.

•Rated Life Span (L)

Rated life span is the total travel distance that each linear system of the same series can endure under the same conditions, without the occurrence of flaking in 90% of the system.

Rated life span can be obtained as follows from the basic dynamic load rating and various loads exerted on the linear system.

For Ball Bearings $L=\left(\frac{C}{P}\right)^3\cdot50$

For Roller Bearings $L=\left(\frac{C}{P}\right)^{10/3}\cdot50$

L: Rated Life Span (km)

C: Basic Dynamic Load Rating (N)

P: Acting Load (N)

When actually using a linear system, the first thing you must do is to calculate the load. It is necessary to consider load also in terms of vibration and impact that occur during operation, as well as its distribution across the entire linear system as it moves back and forth in a linear direction. Calculations are not simple. Operating temperature also significantly influences useful life. When these parameters are taken into consideration, the above formula is transformed as follows:

For Ball Bearings $L=\left(\frac{f_H\cdot f_T\cdot f_C}{f_W}\cdot\frac{C}{P}\right)^3\cdot50$

For Roller Bearings $L=\left(\frac{f_H\cdot f_T\cdot f_C}{f_W}\cdot\frac{C}{P}\right)^{10/3}\cdot50$

L: Rated Life Span (km)

f_H: Hardness Coefficient (See Fig.1)

C: Basic Dynamic Load Rating (N)

f_T: Temperature Coefficient (See Fig.2)

P: Acting Load (N)

f_C: Contact Coefficient (See Table 3)

f_W: Load Coefficient (See Table 4)

The Life span can be computed as a number of hours by obtaining the travel distance for a unit of time.

It can be obtained by using the following formula, in which stroke length and stroke cycles are assumed to be constant.

$$L_h=\frac{L\cdot10^3}{2\cdot\ell s\cdot n_1\cdot60}$$

L_h: Life Span Hours (hr)

ℓs: Stroke Length (m)

L: Rated Life Span (km)

n_1: Reciprocating Times per Minute (cpm)

■Friction Resistance and Required Thrust

Using the following formula, the friction resistance (required thrust) can be obtained from the load and the seal resistance specified by the system.

$$F=\mu\cdot W+f$$

F: Friction Resistance (N)

μ: Dynamic Friction Coefficient

W: Weight Loaded

f: Seal Resistance (2N~5N)

Table-2. Dynamic Friction Coefficient

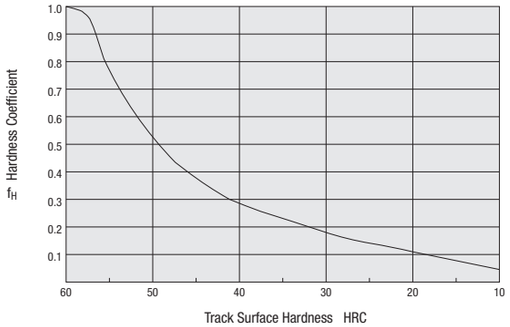
Type	Dynamic Friction Coefficient (μ)
Miniature Slide Guides	0.004~0.006
Medium Load Slide Guides	0.002~0.003
Slide Ways	0.001~0.003
Slide Tables	0.001~0.003
Linear Bushings	0.002~0.003
Linear Ball Bushings	0.0006~0.0012

•Hardness Coefficient(f_H)

In a linear system, the shaft must be hard enough to withstand contact with the ball bearings. Unless sufficient hardness is provided, the allowable load can decrease, resulting in a short useful life.

Compensate the rated life span with the hardness coefficient.

Fig-1. Hardness Coefficient



•Contact Coefficient (fc)

In general, two or more linear systems are used with each shaft. Depending on the machining precision, the load exerted on each of the respective systems can vary. In this case, the load applied on each linear system changes depending on the machining precision, therefore it cannot be uniformly applied. As a result, allowable load per linear system changes depending on the number of linear systems on one axis.

Compensate the rated life span with the contact coefficient in Table-3.

•Load Coefficient (fw)

When calculating the load that acts on a linear system, it is necessary to work with precise figures for material weight, the force of inertia resulting from operating speed, load moment, various changes that occur over time, and so on. However, it is difficult to have accurate calculation for oscillating movement as beside the normal repetition of start and stop, other factors such as vibration and impact also need to be considered.

Therefore, the life span calculation needs to be simplified using the load coefficient in Table-4.

■Linear Bushings

Rated life span can be obtained as follows from the basic dynamic load rating and the load to the linear bushing.

$$L=\left(\frac{f_H\cdot f_T\cdot f_C}{f_W}\cdot\frac{C}{P}\right)^3\cdot50$$

L: Rated Life Span (km) f_H: Hardness Coefficient (See Fig.1)

C: Basic Dynamic Load Rating (N) f_T: Temperature Coefficient (See Fig.2)

P: Working Load (N) f_C: Contact Coefficient (See Table3)

fw: Load Coefficient (See Table4)

The Life span can be computed as a number of hours by obtaining the travel distance for a unit of time. It can be obtained using the following formula, in which stroke length and stroke cycles are assumed to be constant.

$$L_h=\frac{L\cdot10^3}{2\cdot\ell s\cdot n_1\cdot60}$$

L_h: Life Span Hours (hr) ℓs: Stroke Length (m) L: Rated Life Span (km)

n_1: Reciprocating Times per Minute (cpm)

•Temperature Coefficient (f_T)

When temperature in a linear system exceeds 100˚C, the hardness of the system and the shaft become degraded. This decreases the allowable load to a greater extent than when the system is used at ambient temperature, and can shorten the life span.

Compensate the rated life span with the temperature coefficient.

Fig.-2 Temperature Coefficient

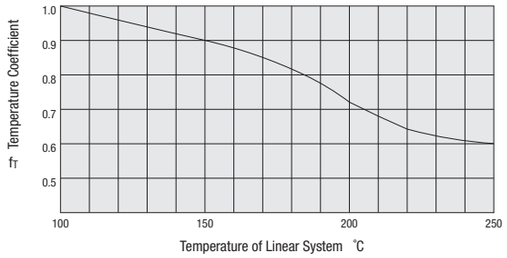


Table-3. Contact Coefficient

Number of Bearings per Shaft	Contact Coefficient fc
1	1.00
2	0.81
3	0.72
4	0.66
5	0.61

Table-4. Load Coefficients

Condition of Use	fw
Low speed with no external vibration or impact (Max. 15m/min)	1.0~1.5
Middle range speed with no exerted vibration or impact of considerable force(Max. 60m/min)	1.5~2.0
High speed with no external vibration or impact (Over 60m/min)	2.0~3.5

■Linear Ball Bushings

Rated life span can be obtained as follows from the basic dynamic load rating and the load to the linear ball bushing.

$$L=\left(\frac{f_H\cdot f_T\cdot f_C}{f_W}\cdot\frac{C}{P}\right)^3\cdot50$$

L: Rated Life Span (km) f_H: Hardness Coefficient (See Fig.1)

C: Basic Dynamic Load Rating (N) f_T: Temperature Coefficient (See Fig.2)

P: Working Load (N) f_C: Contact Coefficient (See Table 3)

fw: Load Coefficient (See Table 4)

Life Span Hours

·For revolution and reciprocating motion

$$L_h=\frac{10^6\cdot L}{60\sqrt{(dm\cdot n)^2+(10\cdot S\cdot n_1)^2}/dm}$$

·For reciprocating motion

$$L_h=\frac{10^6\cdot L}{600\cdot S\cdot n_1/(\pi\cdot dm)}$$

L_h: Life Span Hours(hr) S: Stroke Length(mm) n: Revolutions per Minute(rpm)

n_1: Strokes Per Minute(cpm)

dm: Pitch Diameter of Ball(mm)≈1.15dr

·Revolution and reciprocal motion allowable values

$$DN\geq dm\cdot n+10\cdot S\cdot n_1$$

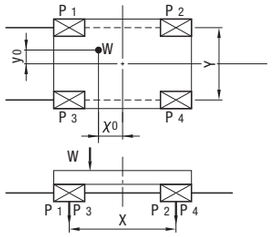
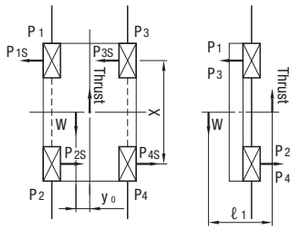
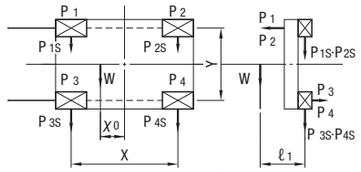
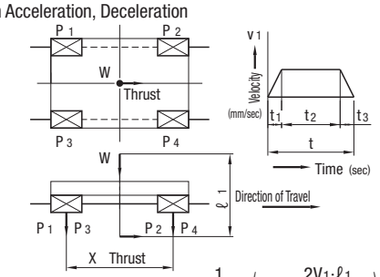
Linear Guide
Calculation of Life Span of Linear Systems 2

•Load Calculations

Since a linear system bears the weight of the work while it performs a reciprocating linear motion, the load exerted on the system can vary depending on the work's center of gravity, thrust acting position change, and the speed changes by starting, stopping and acceleration, deceleration.

It is necessary to take these conditions into consideration when selecting a linear system.

Table-5. Use Conditions and Load Calculation Formulas

Type	Condition of Use and Load
1	Horizontal Axis  $P_1=\frac{1}{4}W+\frac{x_0}{2X}W+\frac{y_0}{2Y}W$ $P_2=\frac{1}{4}W-\frac{x_0}{2X}W+\frac{y_0}{2Y}W$ $P_3=\frac{1}{4}W+\frac{x_0}{2X}W-\frac{y_0}{2Y}W$ $P_4=\frac{1}{4}W-\frac{x_0}{2X}W-\frac{y_0}{2Y}W$
2	Vertical Axis  $P_1=P_2=P_3=P_4=\frac{\ell_1}{2X}W$ $P_{1S}=P_{2S}=P_{3S}=P_{4S}=\frac{y_0}{2X}W$
3	Perpendicular to Horizontal Axis  $P_1=P_2=P_3=P_4=\frac{\ell_1}{2Y}W$ $P_{1S}=P_{3S}=\frac{1}{4}W+\frac{x_0}{2X}W$ $P_{2S}=P_{4S}=\frac{1}{4}W-\frac{x_0}{2X}W$
4	In Acceleration, Deceleration  •Acceleration at Starting $P_1=P_3=\frac{1}{4}W\left(1+\frac{2V_1\cdot\ell_1}{g\cdot t_1\cdot X}\right)$ $P_2=P_4=\frac{1}{4}W\left(1-\frac{2V_1\cdot\ell_1}{g\cdot t_1\cdot X}\right)$ •Deceleration at Stopping $P_1=P_3=\frac{1}{4}W\left(1-\frac{2V_1\cdot\ell_1}{g\cdot t_3\cdot X}\right)$ $P_2=P_4=\frac{1}{4}W\left(1+\frac{2V_1\cdot\ell_1}{g\cdot t_3\cdot X}\right)$ •Constant Speed $P_1=P_2=P_3=P_4=\frac{1}{4}W$ g:Gravitational Acceleration=9.8×10^3mm/sec^2

W: Acting Load(N) P_1,P_2,P_3,P_4: Load applied to the Linear System(N)
X,Y: Linear System Span (mm) V:Moving Speed (mm/sec)
t_1: Acceleration Time(sec) t_3: Deceleration Time(sec)

Fig-3. Stepped Load Fluctuation

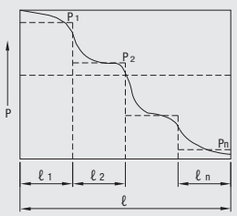


Fig-4. Flat Fluctuation Load

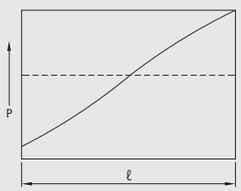
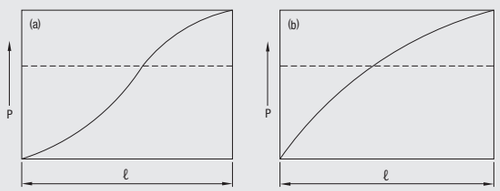


Fig-5. Sinusoidal Load Fluctuation



•Mean Load Derived from Fluctuating Loads

In general, the load acting upon a linear system can change according to how the system is used.This happens for example when the reciprocating motion is started, stopped as compared to constant speed motion, and whether or not work is present during transfer, etc. Therefore, in order to correctly design the life span under various conditions and fluctuating loads, it is necessary to obtain a mean load and apply it to the life span calculations.

(1) When load changes in steps by a travel distance(Fig-3)

Travel distance ℓ_1 subjected to load P_1
Travel distance ℓ_2 subjected to load P_2
⋮ ⋮
Travel distance ℓn subjected to load Pn

Mean load Pm can be obtained by using the following formula:

$$P_m=\sqrt[3]{\frac{1}{\ell}\left(P_1^3\ell_1+P_2^3\ell_2\cdots+P_n^3\ell_n\right)}$$

P_m: Mean Load Derived from Fluctuating Loads (N) ℓ : Total Travel Distance (m)

(2) When load changes almost linearly (Fig-4)

Mean load P_m can be approximated by the following formula:

$$P_m\approx\frac{1}{3}(P_{min}+2\cdot P_{max})$$

P_{min}: Min. Fluctuating Load (N)
P_{max}: Max. Fluctuating Load (N)

(3) When the load change resembles a sinusoidal curve as shown in Fig-5 (a), (b), Mean Load Pm can be approximated by the following formula:

Fig-5(a) $P_m\approx0.65P_{max}$
Fig-5(b) $P_m\approx0.75P_{max}$

■Slide Guides

Rated life span is the total travel distance each linear guide of the same series can endure under the same conditions, without the occurrence of flaking in 90% of the system.

Rated life span can be obtained as follows from the basic dynamic load rating and the load to the slide guide.

$$L=\left(\frac{f_T}{f_w}\cdot\frac{C}{P}\right)^3\cdot50 \qquad (1)$$

L: Rated Life Span (km) C : Basic dynamic load rating (N)
f_T: Temperature Coefficient (See Fig-2) P : Acting Load (N)
fw: Load Coefficient (See Fig-4)

The life span hours can be computed as a number of hours by obtaining the travel distance for a unit of time.It can be obtained by using the following formula, in which stroke length and stroke cycles are assumed to be constant.

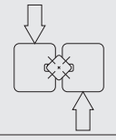
$$L_h=\frac{L\cdot10^3}{2\cdot\ell_s\cdot n_1\cdot60} \qquad (2)$$

Lh: Life Span Hours (hr) ℓ_s: Stroke Length (m)
L: Rated Life Span (km) n_1 : Reciprocating Times per Minute (cpm)

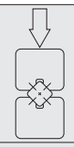
■Slide Ways

Rated load for slide ways is determined by the rolling elements(numbers of rollers). It can be calculated by using the following formulas:

One shaft is used

Load Direction	
Dynamic Load Rating (N)	$C=\left(\frac{Z}{2}\right)^{3/4}\cdot C_1$
Static Load Rating (N)	$C_0=\left(\frac{Z}{2}\right)\cdot C_{01}$

One shaft is used vertically

Load Direction	
Dynamic Load Rating (N)	$C=\left(\frac{Z}{2}\right)^{3/4}\cdot C_1\cdot2^{7/9}$
Static Load Rating (N)	$C_0=\left(\frac{Z}{2}\right)\cdot C_{01}\cdot2$

Two shafts are used in parallel

Load Direction	
Dynamic Load Rating (N)	$C=\left(\frac{Z}{2}\right)^{3/4}\cdot C_1\cdot2^{7/9}$
Static Load Rating (N)	$C_0=\left(\frac{Z}{2}\right)\cdot C_{01}\cdot2$

C_1: Basic Dynamic Load Rating per Roller (N)
C_{01}: Basic Static Load Rating per Roller (N)
Z: Number of Rolling Elements

The life span for slide ways is calculated by using the following formula.

$$L=\left(\frac{f_T\cdot C}{f_w\cdot P}\right)^{10/3}\cdot50$$

L: Life Span Hours(km) C: Dynamic Load Rating (N)
f_T: Temperature Coefficient (See Fig-2) P: Acting Load (N)
fw: Load Coefficient (See Fig-4)

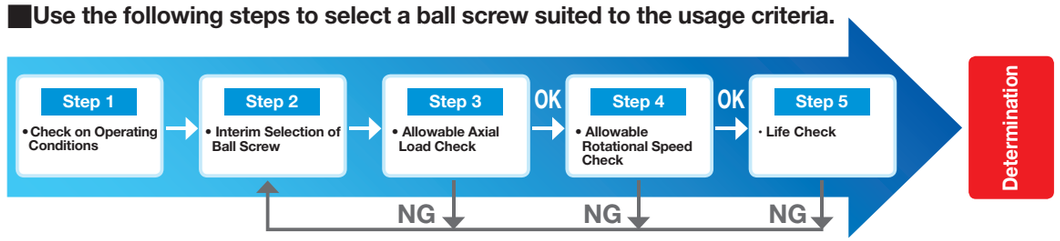
Life Span Hours

$$L_h=\frac{L\cdot10^3}{2\cdot\ell_s\cdot n_1\cdot60}$$

Lh: Life Span Hours (hr) ℓ_s: Stroke Length (m)
L: Life Span Hours (km) n_1: Reciprocating Times per Minute (cpm)

Ball Screws
Selection Guide

■Use the following steps to select a ball screw suited to the usage criteria.



Step 1 Check on Operating Conditions

Refer to Operating Conditions below.

NO	Item	Unit
①	Positioning Accuracy	mm
②	Stroke	mm
③	Travel Speeds	mm/s
④	Drive Motor Speed	min^{-1}
⑤	Weight of Workpiece and Table	Kg
⑥	Mounting Orientation (horizontal or vertical)	-
⑦	Life Hours	Time
⑧	Motion pattern (Duty Cycle Line Diagram) (See Figure 1)	-

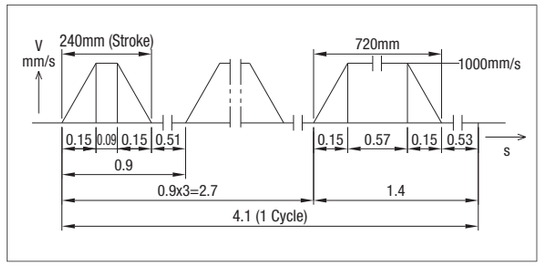


Figure 1 (Ex.) Duty Cycle Line Diagram

Step 2 Interim Selection of Ball Screw

Consider the applicability of the following items to the conditions confirmed in step 1 and provisionally decide the ball screw.

1. Selection of Lead Accuracy of Ball Screws

① Select the ball screw that satisfies the positioning precision. Check the following two points.

Lead Accuracy : For details, see **P.321** on the catalog.

Axial Clearance: For details, see **P.322** on the catalog.

2. Selection of Ball Screw Shaft Length

Generally, the shaft length should be ② stroke + shaft end of 50~ 150 mm + allowance.

The allowance is to prevent detachment, and one end should be (lead x 1.5~ 2) mm or more.

3. Provisional positioning of lead

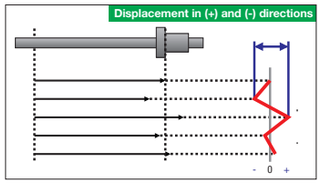
③ Travel speeds, and ④ speed of the drive motor should be used to select the lead.

4. Temporary selection of the shaft diameter

⑤ Weight of work and table, and .⑥ mounting position, and provisionally decided lead should be used to select the shaft diameter.

<Impact on Positioning Precision of Axial Clearance>

If the ball screw has axial clearance, when positioning operation is performed from the positive direction, because the work does not move even when the screw shaft rotates, a difference occurs in the clearance interval between the theoretical movement amount obtained from the revolution speed of the screw shaft and the actual movement amount.



Step 3 Allowable Axial Load Check

The max. axial load to the ball screw must be equal to or less than the allowable axial load value. If a load exceeding the allowable axial loading is applied, it is possible that the ball screw's screw shaft will buckle. (Figure 2)

Allowable Axial Load

The allowable axial load represents an allowed maximum load, including a safety margin, to prevent shaft buckling from occurrence.

The finer the shaft diameter or the longer the shaft the easier it is for buckling to occur.

For details, see P.323 on the catalog.

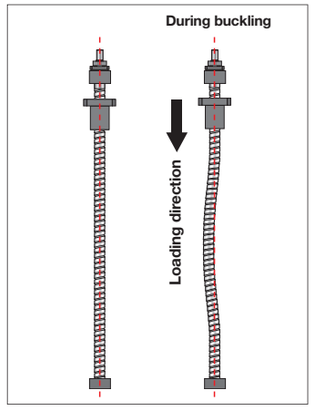


Figure 2 Buckled Ball Screw

Step 4 Allowable Rotational Speed Check

The rotational speed of the ball screw must be less than the allowable rotational speed. If it exceeds the allowed rotational speed, the thread and the nut will be affected in the following way.

Screw Shaft: When the allowable rotational speed is exceeded, resonance will begin at a unique oscillating frequency and this might disable operation. (Figure 3)

Nut : If the orbital speed of the steel balls inside the nut becomes large, it is possible that the circulation components will be damaged by the impact force. (Figure 4)

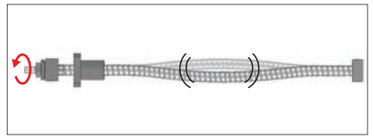


Figure 3 Resonating Ball Screw

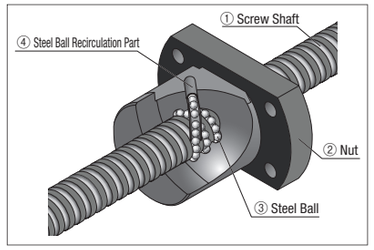


Figure 4 Ball Screw Circulation Structure (Tube Style)

Allowable Rotational Speed

Refers to the allowable rotational speed that is 80% or less of the critical speed that matches the rotational speed of a ball screw at which there is a unique oscillation possessed by the screw shaft. The ball screw rotational speed is decided by the necessary travel speed and ball screw lead.

To decide the allowable rotational speed, it is necessary to consider the following two elements.

1. Critical speed for the rotating shaft
2. Limit rotational speed of the balls circulating inside the nut

For details, see P.324 on the catalog.

Step 5 Life Check

In order to use the equipment beyond the expected life, life calculations are required.

Figure 5 Thread Inside Nut

Operating Hours of Ball Screws

This refers to the total revolutions, time, or distance up until chipping begins to occur due to fatigue causes by some kind of repetitive stress on the ball rolling surface or balls. The lifespan of the ball screw is calculated from the basic dynamic load rating. See Figures 5 and 6 for expired parts that have chips.

When a certain group of the same ball screws are operated with a certain axial load and 90% of the screws achieve 1 million rotations (10^6) without flaking in its operating life, such axial load is defined as a basic dynamic load rating.

For details, see P.325 on the catalog.

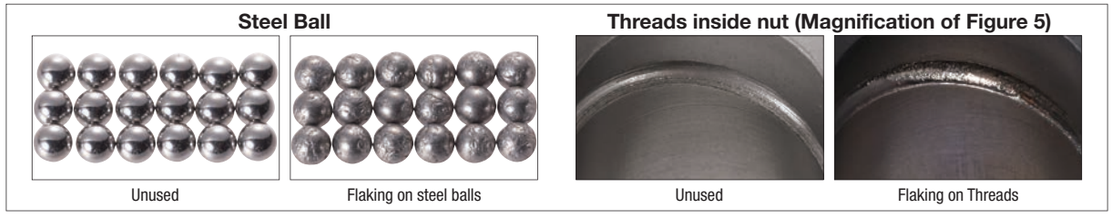


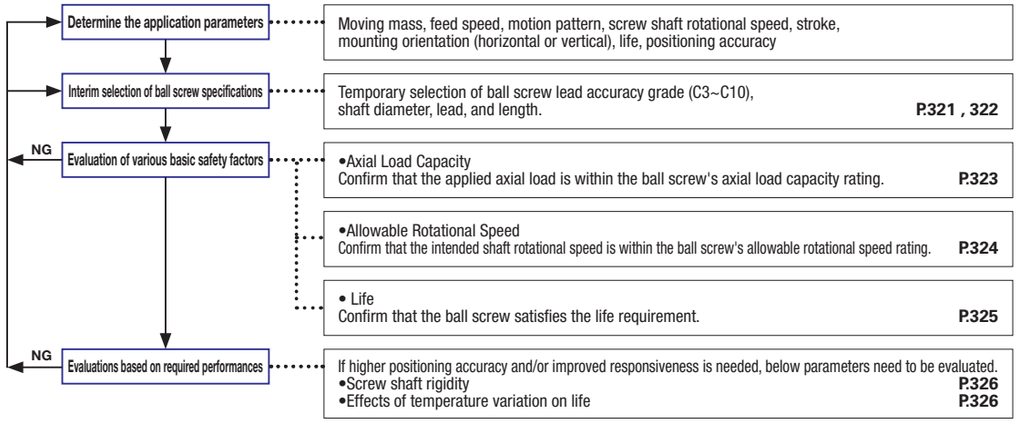
Figure 6 Flaking on Ball Screw Components

■When choosing, it is necessary to ensure the temperature impact and rigidity is suitable for the usage environment and selection criteria. For details, see P.76~83 of the catalog technical pages and choose a ball screw that is suitable for the purpose of use.

Ball Screws
Selection of Ball Screws 1

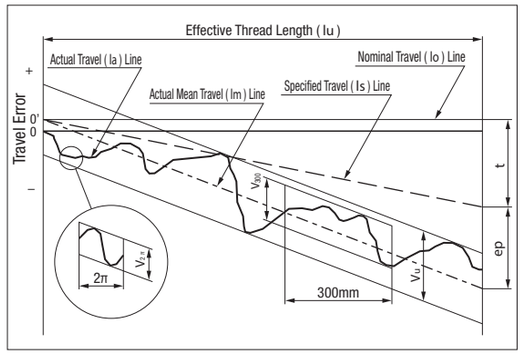
1. Ball Screw Selection Procedure

Basic ball screw selection procedure and required evaluation items are shown below.



2. Ball Screw Lead Accuracy

Ball screw lead accuracy is defined by JIS Standards property parameters (e_p, V_u, V_{300}, $V_{2\pi}$).
Parameter definitions and allowable values are shown below.
In general, a ball screw lead accuracy grade is selected by evaluating if the Actual Mean Travel Error of a candidate is within the allowable positioning error.



Terms	Symbols	Meaning
Actual Mean Travel Error	ep	A value that is Specified Travel subtracted from Actual Mean Travel.
Variation		The maximum difference of the actual travel contained between two lines drawn parallel to the actual mean travel, and is defined by three parameters below.
	V_u	Variation for the effective thread length of screw shaft.
	V_{300}	Variation for an arbitrarily taken length of 300mm within the effective thread length of screw shaft.
	$V_{2\pi}$	Variation for an arbitrary one revolution (2πrad) taken within the effective thread length of screw shaft.
Specified Travel	Is	Axial travel compensated for temperature rise and loading conditions, in relation to the Nominal Travel (Lead).
Specified Travel Target Value	t	A value that is Nominal Travel subtracted from Specified Travel, over the effective thread length. This value is set to compensate for possible screw shaft expansion and contraction due to temperature changes and applied loads. The value is to be determined based on experiments or experiences.
Actual Travel	Ia	Actually measured travel distance
Actual Mean Travel	Im	A straight line representing the actual travel trend. A straight line obtained by the least-squares method or other approximation methods from the curve representing the actual travel.

Table 1. Positioning Screw (C Class) Actual Mean Travel Error ($\pm e_p$) and Variation (V_u) allowances Unit : μm

Thread Effective Length (mm)		Accuracy Grade			
		C3		C5	
over	or less	Actual Mean Travel Error	Variation	Actual Mean Travel Error	Variation
	315	12	8	23	18
315	400	13	10	25	20
400	500	15	10	27	20
500	630	16	12	30	23
630	800	18	13	35	25
800	1000	21	15	40	27
1000	1250	24	16	46	30
1250	1600	29	18	54	35

Table 2. Positioning Screws (C Class) variation per 300mm (300) Variation per rotation (2π) standard values Unit : μm

Accuracy Grade	C3		C5	
Parameters	V_{300}	$V_{2\pi}$	V_{300}	$V_{2\pi}$
Standard Values	8	6	18	8

Table 3. Transfer Screw (Ct Class) variation per 300mm (V_{300}) Standards Unit : μm

Accuracy Grade	Ct7	Ct10
V_{300}	52	210

Actual Mean Travel Error (ep) for Transfer Screws (Ct Class) is calculated as $e_p = 2 \cdot L_u / 300 \cdot V_{300}$

3. Axial Clearances of Ball Screws

Axial clearance does not affect positioning accuracy if the feed is unidirectional, but will generate backlash and negatively affect on positioning accuracy if the direction or the axial load is reversed.
Select the axial clearance in such a way that the current requirement for positioning accuracy are met.

Table 4. Axial Clearances of Rolled Ball Screws

Types	Prod. Example	Screw Shaft Dia.	Lead	Axial Clearance (mm)	Screw Shaft Length (mm) MIN	MAX
Existing Products Compact Nut Accuracy Grade C10	BSSC	8	2	0.05 or less	100	400
		10	4		150	600
		12	4		150	800
		15	5	0.10 or less	150	1200
			10		200	1200
		20	5		200	2000
			10	0.15 or less	250	2000
		25	5	0.10 or less	200	2000
Existing Products Standard Nut Accuracy Grade C10	BSSZ BSSR	8	2	0.05 or less	100	400
			4		100	380
		10	2		150	585
			4		150	600
			10		150	585
		12	4		150	800
			10	0.10 or less	150	800
		14	5		150	800
		15	5		150	1200
			10		200	1200
			20		200	1200
		20	5		200	2000
			10	0.15 or less	250	2000
			20	0.10 or less	250	2000
		25	5		200	2000
			10	0.20 or less	300	2000
			25	0.12 or less	300	2000
		28	6	0.10 or less	250	2000
		32	10	0.20 or less	300	2000
			32	0.15 or less	300	2000
C-VALUE Products Standard Nut Accuracy Grade C10	C-BSSC	8	2	0.05 or less	100	400
		10	2		150	585
			4		150	600
		12	5		150	800
			10	0.10 or less	150	800
		15	5		150	1200
			10		200	1200
			20		200	1200
		20	5		200	2000
			10	0.15 or less	250	2000
			20	0.10 or less	250	2000
		25	5		200	2000
			10	0.20 or less	300	2000
			25	0.12 or less	300	2000
Existing Products Block Nut Accuracy Grade C10	BSBR	15	5	0.10 or less	150	1200
		20			200	1200
		25			200	1500
		15	10		150	1200
		20		0.15 or less	200	1200
		25		0.20 or less	200	1500
Existing Products Standard Nut Accuracy Grade C7	BSST	8	2	0.03 or less	100	380
		10	4		150	585
		12	4		150	795
		15	5		150	1200
			10		200	1200
			20		200	1200
		20	5		200	1200
			10	0.05 or less	250	2000
			20	0.03 or less	250	2000
		25	5		200	2000
			10	0.07 or less	300	2000

Table 5. Axial Clearances of Precision Ball Screws

Types	Prod. Example	Screw Shaft Dia.	Lead	Axial Clearance (mm)	Screw Shaft Length (mm) MIN	MAX
Existing Products Standard Nut Accuracy Grade C5	BSS	8	2	0.005 or less	100	210
		10	2		100	315
			4		150	380
			10		150	450
		12	2		150	445
			4		150	400
			5		150	450
			10		200	600
		15	5		150	1095
			10		200	1095
			20		230	1095
		20	5		200	1000
			10		250	1500
			20		250	1500
		25	5		300	995
			10		300	1500
			20		300	1500
C–Value Standard Nut Accuracy Grade C5	C-BSS	8	2	0.008 or less	100	210
		10	2		100	315
			4		150	380
		12	2		150	445
			5		150	450
			10		200	600
		15	5	0.015 or less	150	1095
			10		200	1095
			20		230	1095
		20	5		200	1000
			10		250	1500
			20		250	1500
		25	5		300	995
			10		300	1500
			25		300	1500
Existing Products Standard Nut Accuracy Grade C3	BSX	6	1	0 (Preloaded)	80	205
		8	1		80	255
			2		100	240
		10	2		100	310
		12	2		150	390
			5		150	440
		15	5		150	590
Existing Products Standard Nut Accuracy Grade C7	BSSE	8	2	0.030 or less	100	210
		10	2		100	315
			4		150	380
		12	2		150	445
			5		150	450
			10		200	600
		15	5		150	1095
			10		200	1095
			20		230	1095
		20	5		200	1000
			10		250	1500
			20		250	1500
		25	10		300	1500
			20		300	1500

Selection Example of Lead Accuracy

<Requirements>
· Ball screw diameter Ø15, lead 20.
· Stroke 720mm
· Positioning accuracy ±0.05mm/720mm

<Selection Details>
Select an appropriate lead accuracy grade based on the application requirements.

(1) Evaluating the screw thread length
Stroke+Nut Length+Margin=720+62+60=842
*The Margin shown above is an overrun buffer, and normally determined as 1.5~2 times the screw lead.
Lead 20x1.5x2 (both ends)=60

(2) Evaluating the lead accuracy
Verify the actual mean travel error $\pm e_p$ for 842mm ball screw thread by referencing the Table 1. on **P.321**.
C3 · · · ±0.021mm/800~1000mm
C5 · · · ±0.040mm/800~1000mm

(3) Determining the lead accuracy
It can be determined that a C5 grade (±0.040/800~1000mm) ball screw can satisfy the required positioning accuracy of ±0.05/720mm.

Selection Example of Axial Clearance

<Requirements>
· Ball screw diameter Ø15, lead 5.
· Allowable backlash ±0.01mm

<Selection Details>
From Table 5., it can be determined that C5 grade with 0.005mm or less axial clearance satisfies the allowable backlash amount of 0.01mm for the Ø15 group.

4. Allowable Axial Load

Allowable Axial Load is a load with a safety margin built-in against a shaft bucking load.
Axial load that applies to a ball screw needs to be less than Allowable Maximum Axial Load.
Allowable Axial Load can be obtained by the following formula.
Additionally, approximate Allowable Axial Load can be obtained from Table 1. Allowable Axial Load Graph.

•Allowable Axial Load (P)

$$P=\frac{n\pi^2 EI}{\ell^2}\alpha = m\frac{d^4}{\ell^2}\times 10^4 (N)$$

Where:
P: Allowable Axial Load (N)
ℓ: Distance between Points of Buckling Load (mm)
E: Young's Modulus (2.06×10^5N/mm²)
I: Min. Geometrical Moment of Inertia of Across Root Thread Area (mm⁴)

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

d : Thread Root Diameter (mm)
n, m : Coefficient Determined by Method of Screw Support

Method of Screw Support	n	m
Support - Support	1	5
Fixed - Support	2	10
Fixed - Fixed	4	19.9
Fixed- Free	0.25	1.2

α : Safety Factor = 0.5
For higher safety, a higher safety factor should be required.

Allowable Axial Load Calculation Example

Find the Allowable Axial Load for Fig.1

<How to use>
· Thread shaft diameter Ø15, Lead 5
· Mounting method Fixed - Support
· Distance between Points of Buckling Load ℓ_1 820mm
· Screw Shaft Root Diameter d 12.5

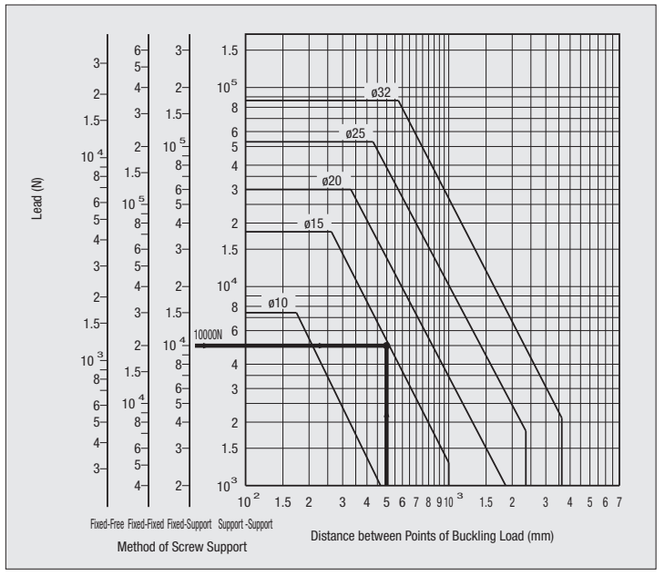
<Calculations>
g=15.1 since the mounting method is Fixed-Supported,
the Allowable Rotational Speed (Nc) is,

$$P=m\frac{d^4}{\ell^2}\times10^4 = 10\times\frac{12.5^4}{820^2}\times10^4 = 3630(N)$$

Therefore, the rotational speed will need to be 3024rpm or less.

Table.1

•Figure1. Allowable Axial Load Curve



Screw Shaft Dia. Calculation Example

<Requirements>
· Distance between Points of Buckling Load 500mm
· Mounting method Fixed - Support
· the max. axial load 10000N

<Calculations>
(1) Find the intersection between a distance of 500mm between load acting points and the axial load of 10000N(from the fixed-support graduation).[Figure 1]

(2) Read the shaft diameter of the diagonal line nearest to the intersection on the outside. The shaft diameter can be a min. 15mm.

5. Allowable Rotational Speed

Ball screw rotational speed is determined by required feed speed and the given screw lead, and needs to be less than the Allowable Maximum Rotational Speed.
Ball screw rotational speed is evaluated based on the shaft's critical speed and ball recirculation speed limitation DmN value.

5-1. Critical Speed

Allowable rotational speed is defined as a speed 80% or less of the Critical Speed where the rotational speed coincides with a natural resonant frequency of the screw shaft.
The Allowable Rotational Speed can be obtained by the following formula.
Additionally, approximate Allowable Rotational Speeds can be obtained from Table 2. Allowable Maximum Rotational Speed Graph.

•Allowable Rotational Speed (rpm)

$$N_C=fa\frac{60\lambda^2}{2\pi\ell^2}\sqrt{\frac{EI\times10^3}{\gamma}} = g\frac{d}{\ell^2}10^7 (min^{-1})$$

Where:
ℓ: Distance of Supports (mm)
fa: Safety Factor (0.8)
E: Young's Modulus (2.06×10^5N/mm²)
I: Min. Geometrical Moment of Inertia of Across Root Thread Area (mm⁴)

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

d: Thread Root Diameter (mm)
γ: Specific Gravity (7.8×10^{-6}kg/mm³)
A: Root Thread Section Area (mm²)

$$A=\frac{\pi}{4}d^2$$

g, λ: Coefficient Determined by Method of Screw Support

Method of Screw Support	g	λ
Support - Support	9.7	π
Fixed - Support	15.1	3.927
Fixed - Fixed	21.9	4.73
Fixed- Free	3.4	1.875

Allowable Rotational Speed Calculation Example

Find the Allowable Maximum Rotational Speed for Fig.2

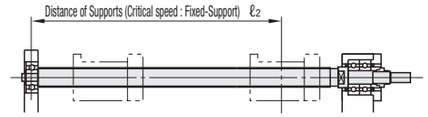
<How to use>
· Thread shaft diameter ø15, Lead 5
· Mounting method Fixed - Support
· Distance between Points of Buckling Load ℓ_1 790mm

<Calculations>
g=15.1 since the mounting method is Fixed-Supported,
the Allowable Rotational Speed (Nc) is,

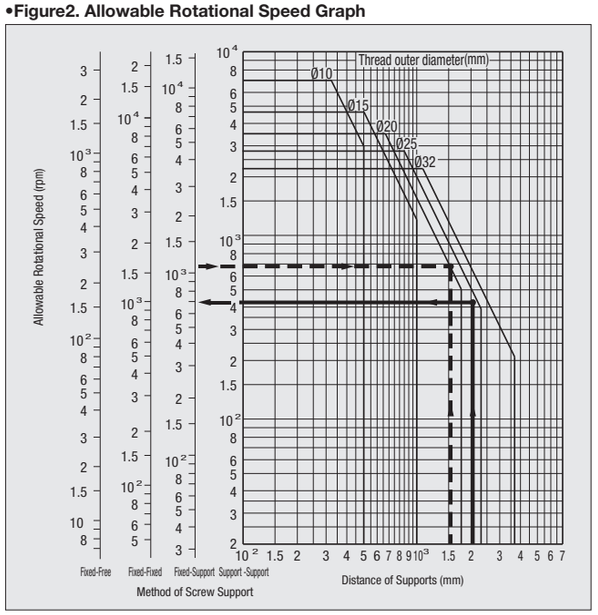
$$N_C=g\frac{d}{l^2}10^7(rpm) = 15.1\times\frac{12.5}{790^2}\times10^7(rpm) = 3024(rpm)$$

Therefore, the rotational speed will need to be 3024rpm or less.

Table.2



•Figure2. Allowable Rotational Speed Graph



Allowable Rotational Speed Calculation Example

<Requirements>
· Thread outer diameter 20
· Distance of Supports 1500mm
· Mounting method Fixed - Support

<Calculations>
(1) From Table 2., find an intersection of a vertical line from Supported Span Distance 1500mm and Screw Shaft O.D. Ø20 line.

(2) The value 1076rpm on the Fixed-Supported scale (Y-Axis) that corresponds to the intersection of (1) above is the Allowable Maximum Speed.

Screw Shaft Dia. Calculation Example

<Requirements>
· Distance of Supports 2000mm
· Maximum Rotational Speed 1000rpm
· the max. axial load Fixed - Fixed

<Calculations>
(1) From Table 2., find a intersection of a vertical line from Supported Span Distance 2000mm and a horizontal line from Fixed-Fixed max. speed scale (Y-Axis) at 1000rpm.

(2) A line that reaches down to the intersection in (1) is the Ø25 ball screw that satisfies the required speed of 1000rpm.

5-2. DmN Value

The DmN value represents a ball recirculation (orbit) speed limit within a ball nut.
If this vale is exceeded, the recirculation components will be damaged.
The DmN value can be calculated with the following formula.

•Allowable Rotational Speed (min⁻¹)

DmN≤70000 (Precision Ball Screws)
DmN≤50000 (Rolled Ball Screws)

Where:
Dm: Thread outer diameter (mm)+A Value
N: Maximum Rotational Speed (min⁻¹)

Ball Dia.	A Value
1.5875	0.3
2.3812	0.6
3.175	0.8
4.7625	1.0
6.35	1.8

6. Life Span

Ball screw's life is defined as: Total number of rotations, time, or distance where either the ball rolling surfaces or the balls begin to exhibit repetitive stress caused flaking.
Ball screw's life can be calculated based on Basic Dynamic Load Rating with the following formula.

6-1. Life Hours (Lh)

$$L_h = \frac{10^6}{60N_m}\left(\frac{C}{P_m f_w}\right)^3 \text{(hrs)}$$

Where:
L_h: Life Span Hours (hrs)
C: Basic Dynamic Load Rating (N)
P_m: Mean Axial Load (N)
N_m: Mean Rotational Speed (min^{-1})
f_w: Work Factor

Impactless Run	f_w = 1.0~1.2
Normal Run	f_w = 1.2~1.5
Run with Impact	f_w = 1.5~2.0

•Basic Dynamic Load Rating : C
Basic Dynamic Load Rating (C) is defined as: An axial load which a group of same ball screws are subjected and 90% of the specimen will reach 1 million rotations (10^6) without experiencing any flaking of the rolling surfaces. See product catalog pages for the Basic Dynamic Load Ratings.

*Setting life span hours longer than what is actually necessary not only requires a larger ball screw, but also increases the price.
In general, the following standards are used for life span hours:

Machine Tools: 20,000hrs	Automatic Control Equipment:15,000hrs
Industrial Machinery:10,000hrs	Measuring Instruments:15,000hrs

*The basic dynamic load rating that satisfies the set life span hours is expressed by the following formula.

$$C = \left(\frac{60L_hN_m}{10^6}\right)^{\frac{1}{3}} P_m f_w \text{(N)}$$

Life Calculation Example

<Requirements>

· Ball Screw Model	BSS1520 (Ø15 Lead 5)
· Mean Axial Load Pm	250N
· Mean Rotational Speed Nm	2118 (min^{-1})
· Work Factor fw	1.2

<Calculations>
Since Basic Dynamic Load Rating C for BSS1520 is 4400N,

$$L_h = \frac{10^6}{60\times2118}\left(\frac{4400}{250\times1.2}\right)^3 = 24824 \text{ (hr)}$$

Therefore, Life will be 24824 hours.

6-2. Axial Load

Axial loads that apply on the screw shafts will vary depending on applicable motion profile such as acceleration, constant velocity, and deceleration phases. Following formula can be used.

-Axial Load Formula-
Constant Velocity · · · Axial Load (Pb)=μWg
Acceleration · · · Axial Load (Pa)=Wα+μWg
Deceleration · · · Axial Load (Pc)=Wα-μWg

* Omit the "μ" for vertical applications.

μ: Linear motion guide friction coefficient (0.02)
W: Load Mass N
g: Gravitational Acceleration 9.8m/s²
α: Acceleration (*) m/s²

(*) Acceleration (α)=(Vmax/t)x10^{-3}
Vmax: Rapid Feed Rate mm/s
t: Acceleration/Deceleration Time s

6-3. Formulas for Average Axial Load and Average Rotational Speed

Average Axial Load and Average Rotational Speed are calculated based on proportions of motion profiles.
Average Axial Load and Average Rotational Speed for Motion profiles in Table 1. can be calculated with the formula 2.

[Table 1. Motion Profile] ($t_1+t_2+t_3$=100%)

Motion Profile	Axial Load	Rotational Speed	Hours Ratio
A	P_1 (N)	N_1 (min^{-1})	t_1 (%)
B	P_2 (N)	N_2 (min^{-1})	t_2 (%)
C	P_3 (N)	N_3 (min^{-1})	t_3 (%)

[Formula 2. Average Axial Load Calculation]

$$P_m = \left(\frac{P_1^3N_1t_1+P_2^3N_2t_2+P_3^3N_3t_3}{N_1t_1+N_2t_2+N_3t_3}\right)^{\frac{1}{3}} \text{(N)}$$

$$N_m = \frac{N_1t_1+N_2t_2+N_3t_3}{t_1+t_2+t_3} \text{ (min}^{-1}\text{)}$$

For machine tool applications, max. load (P1) is applicable for the "Heaviest cutting". Regular Load (P2) is for the general cutting conditions, and Minimum Load (P3) is for the non-cutting rapid feeds during positioning moves.

Average Axial Load and Average Rotational Seed Calculation Example

<Requirements>

Motion Profile	Axial Load	Rotational Speed	Hours Ratio
A	343N	1500rpm	29.4%
B	10N	3000rpm	41.2%
C	324N	1500rpm	29.4%

<Calculations>

(1) Average Axial Load

$$P_m = \left(\frac{343^3\times1500\times0.294+10^3\times3000\times0.412+324^3\times1500\times0.294}{1500\times0.294+3000\times0.412+1500\times0.294}\right)^{\frac{1}{3}} = 250 \text{ (N)}$$

Therefore, the Average Axial Load Pm will be 250N.

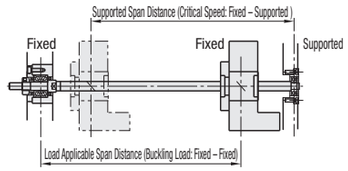
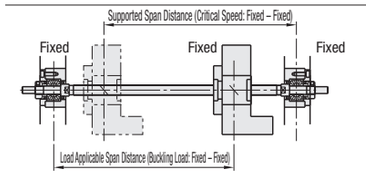
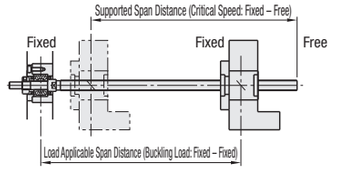
(2) Average Rotational Speed

$$N_m = \left(\frac{1500\times0.294+3000\times0.412+1500\times0.294}{0.294+0.412+0.294}\right) = 2118 \text{ (min}^{-1}\text{)}$$

Therefore, the Average Rotational Speed Nm will be 2118rpm.

7. Screw Shaft Mounting Arrangements

Representative ball screw mounting arrangements are shown below.

Mounting Methods	Application Example
	· Typical method · Medium~ High Speeds · Medium~High Accuracy For Support Units, Standard Type BRW / BUR is selected.
	· Medium Speeds · High Accuracy · For Support Units, Standard Type BRW is selected.
	· Low Speeds · For Short Screw Shafts · Medium Accuracy · For Support Units, Economy Type BRWE is selected

8. Temperature and Life

When ball screws are continuously used at 100°C or higher, or used momentarily at very high temperatures, Basic Dynamic/Static Load Ratings will be reduced according to the temperature rise due to changes in material compositions.
However, there will be no effects up to 100°C. Basic Dynamic Load Rating C" and Basic Static Load Rating Co" at 100°C or higher with the temperature factors ft and ft' can be expressed with the following formula.

C"=ftC (N)
Co"=ft'Co (N)

Temperature ℃	100 or less	125	150	175	200	225	250	350
ft	1.0	0.95	0.90	0.85	0.75	0.65	0.60	0.50
ft'	1.0	0.93	0.85	0.78	0.65	0.52	0.46	0.35

For high temperature applications, the current grease should be replaced with the heat resistant type and the current components should be checked for the heat resistant temperature.

9. Rigidity

To improve positioning accuracy and control response of a machine, considerations must be given to the rigidity of feed screw elements. Rigidity (K) of feed screw system can be expressed with the following formula.

$$K = \frac{P}{\delta} \text{ (N/μm)}$$

Where:
P: Axial Loads Applied on Feed Screw System (daN)
δ: Elastic Deformation of Feed Screw System (μm)
Additionally, the following relationship exists between the feed screw system rigidity and other various construction element rigidity.

$$\frac{1}{K} = \frac{1}{K_\ell} + \frac{1}{K_n} + \frac{1}{K_b} + \frac{1}{K_h}$$

Where:
K_ℓ: Screw Shaft Compressive, Tensile Rigidity
K_n: Nut Rigidity
K_b: Support Bearing Rigidity
K_h: Nut and Bearing Mount Rigidity

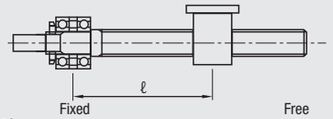
•Screw Shaft Compressive/Tensile Rigidity : Kℓ

$$K_\ell = \frac{P}{\delta_\ell} \text{ (N/μm)}$$

Where:
P: Axial Load (N)
δ_ℓ: Screw Shaft Expansion/Contraction (μm)

The expansion and contraction are expressed in the following formula. The expansion and contraction will directly appear as ball screw backlash.

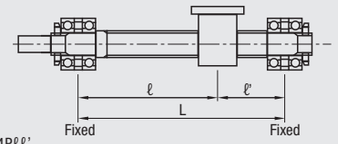
(1) Fixed-Free Arrangement



$$\delta_\ell = \frac{4P\ell}{E\pi d^2}\times10^3 \text{ (μm)}$$

Where:
P: Axial Load (N)
E: Young's Modulus (2.06x10^5N/mm²)
d: Screw Shaft Root Diameter (mm)
ℓ: Load Applicable Span Distance (mm)

(2) Fixed-Fixed Arrangement



$$\delta_\ell = \frac{4P\ell\ell'}{E\pi d^2 L}\times10^3 \text{ (μm)}$$

Where:
P: Axial Load(N)
E: Young's Modulus (2.06x10^5N/mm²)
d: Screw Shaft Root Diameter (mm)
ℓ, ℓ': Load Applicable Span Distance (mm)
L: Mounting Span Distance (mm)

The formula produces the max. value when $\ell = \ell' = \frac{L}{2}$

$$\left(\delta_\ell = \frac{PL}{E\pi d^2}\times10^3\right)$$

Therefore, the max. shaft expansion and contraction will be 1/4 of Fixed-Free arrangement.

10. Driving Torque

This selection provides a guide for selecting ball screw frictional properties and the driving motor.

10-1. Friction and Efficiency

When the friction coefficient is μ , and lead angle is β , ball screw's efficiency η is indicated by the following formulas.

When rotational force is converted into axial force (Forward Action)

$$\eta = \frac{1-\mu \tan\beta}{1+\mu/\tan\beta}$$

When axial force is converted into rotational force (Reverse Action)

$$\eta' = \frac{1-\mu/\tan\beta}{1+\mu\tan\beta}$$

10-2. Load Torque

The load torque (constant velocity torque) required for the drive power source (motor, etc.) selection is as follows.

(1) Forward Action

Torque required when converting rotational force into axial force

$$T = \frac{PL}{2\pi\eta} \ (N \cdot cm)$$

Where:

T: Load Torque (N·cm)

P: External Axial Load (N)

L: Ball Screw Lead (cm)

η: Ball Screw Efficiency (0.9)

(2) Reverse Action

External axial load when converting axial force into rotational

$$P = \frac{2\pi T}{\eta' L} \ (N)$$

Where:

P: External Axial Load (N)

T: Load Torque (N·cm)

L: Ball Screw Lead (cm)

η': Ball Screw Efficiency (0.9)

(3) Friction Torque Caused by Preloading

This is a torque generated by preloading. As external loads increase, the preload of the nut is released and therefore the friction torque by preloading also decreases.

Under No load

$$T_P = K\frac{P_L L}{2\pi} \ (N \cdot cm)$$

$$K = 0.05(\tan\beta)^{-\frac{1}{2}}$$

Where:

P_L: Preload (N)

L: Ball Screw Lead (cm)

K: Coefficient of Internal Friction

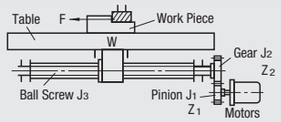
β: Lead Angle $\beta \approx \tan^{-1}\left(\frac{L}{\pi D}\right)$

D: Thread Outer Diameter

11. Selecting the Driving Motors

When selecting a driving motor, it is necessary to satisfy the following conditions:

1. Ensure a marginal force sufficient to counter the load torque exerted on the motor's output thread.
2. Enable starting, stopping at prescribed pulse speeds, sufficiently powered to counter the moment of inertia exerted on the motor's output thread.
3. Obtain the prescribed acceleration and deceleration constants, sufficient to counter the moment of inertia exerted on the motor's output thread.



(1) Constant Speed Torque Exerted on the Motor Output Thread

This is the amount of torque required to drive the output thread against the applied external load, at a constant speed.

$$T_1 = \left(\frac{PL}{2\pi\eta} + T_P\frac{(3P_L - P)}{3P_L}\right)\frac{Z_1}{Z_2} \ (N \cdot cm)$$

Where: $P \leqq 3P_L$

T_1: Driving Torque at Constant Speed (N·cm)

P: External Axial Load (N)

$P = F + \mu Mg$

F: Thrust Reaction Produced in Cutting Force (N)

M: Masses of Table and Work Piece (kg)

μ: Coefficient of Friction on Sliding Surfaces

g: Gravitational Acceleration (9.8m/s^2)

L: Ball Screw Lead (cm)

η: Mechanical Efficiency of Ball Screw or Gear

T_P: Friction Torque Caused by Preloading (N·cm) Referto Formula 10-2-(3)

P_L: Preload (N)

Z_1: Number of Pinion's Teeth

Z_2: No. of Gear's Teeth

(2) Acceleration Torque Exerted on the Motor Output Thread

This is the amount of torque required to drive the output shaft against the external load during acceleration.

$$T_2 = J_M\omega = J_M\frac{2\pi N}{60t} \times 10^{-3} \ (N \cdot cm)$$

$$J_M = J_1 + J_4 + \left(\frac{Z_1}{Z_2}\right)^2\left\{(J_2 + J_3 + J_5 + J_6)\right\} \ (kg \cdot cm^2)$$

Where:

T_2: Driving Torque in Acceleration (N·cm)

ω: Motor Thread Angular Acceleration (rad/s^2)

N: Motor Thread Rotational Speed (rpm)

t: Acceleration Time (s)

J_M: Moment of Inertia Exerted on the Motor (kg·cm^2)

J_1: Moment of Inertia Exerted on Pinion (kg·cm^2)

J_2: Moment of Inertia Exerted on Gear (kg·cm^2)

J_3: Moment of Inertia Exerted on Ball Screw (kg·cm^2)

J_4: Moment of Inertia Exerted on Motor's Rotor (kg·cm^2)

J_5: Moment of Inertia of Moving Body (kg·cm^2)

J_6: Moment of Inertia of Coupling (kg·cm^2)

M: Masses of Table and Work Piece (kg)

L: Ball Screw Lead (cm)

Moment of inertia exerted on cylinders as screws and cylinders such as Gears (Calculation of $J_1 \sim J_4$, J_6)

$$J = \frac{\pi\gamma}{32}D^4\ell \ (kg \cdot cm^2)$$

Where:

D: Cylinder Outer Diameter (cm)

ℓ: Cylinder Length (cm)

γ: Material Specific Gravity

$\gamma = 7.8 \times 10^{-3}$ (kg/cm^3)

$$J_5 = M\left(\frac{L}{2\pi}\right)^2 \ (kg \cdot cm^2)$$

(3) Total Torque Exerted on the Motor Output Thread

Overall torque can be obtained by adding results from formulas (1) and (2).

$$T_M = T_1 + T_2 = \left(\frac{PL}{2\pi\eta} + T_P\frac{(3P_L - P)}{3P_L}\right)\frac{Z_1}{Z_2} + J_M\frac{2\pi N}{60t} \times 10^{-3} (N \cdot cm)$$

Where:

T_M: Total Torque Exerted on the Motor Output Thread (N·cm)

T_1: Driving Torque at Constant Speed (N·cm)

T_2: Driving Torque at In Acceleration (N·cm)

Once you have temporarily found the type of motor you need, check

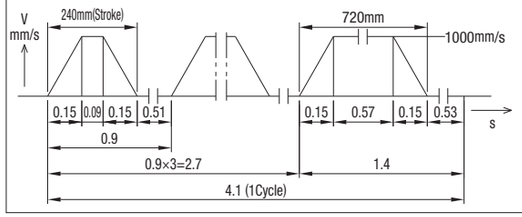
1. effective torque,
2. acceleration constant and
3. motor overload properties and heat tolerance during repeated starting, stopping.

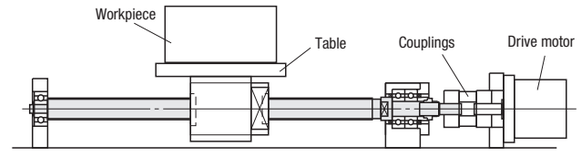
It is necessary to ensure a sufficient margin for these parameters.

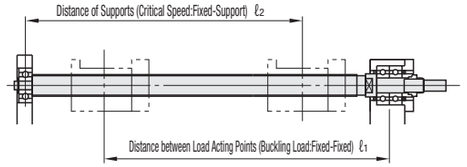
12. Example of Selection of Ball Screws (in case of X-axis)

Condition of Use

•Work & Table Mass	W=40(kg)
•Maximum Strokes	Smax.=720 (mm)
•Threading Speed	Vmax.=1000 (mm/s)
•Acceleration Constant	t=0.15(s)
•Positioning Precision	±0.1/720(mm)
•Repeat Accuracy	±0.01(mm)
•Life Span	Lh=30000Hours
•Linear Motion Guide Friction Coefficient	μ=0.02
•Driving Motor	Nmax.=3000 (min^{-1})
•Duty Cycle Model Diagram	







1. Setting Lead (L)

Set lead based on maximum motor revolutions and threading speed. Use the following formula.

$$L \geqq \frac{Vmax \times 60}{Nmax} = \frac{1000 \times 60}{3000} = 20(mm)$$

Required lead is 20mm or higher.

2. Nut selection

(1) Calculating Axial Load

The axial load calculation formula on Clause 6-2, **P.325** is used to calculate the axial loads for each segment of a motion profile.

· At Constant Speed

Axial Load (Pb) $= \mu Wg = 0.02 \times 40 \times 9.8 \approx 8$ (N)

· In Acceleration

Acceleration(α) $= (Vmax/t) \times 10^{-3} = (1000/0.15) \times 10^{-3} = 6.67$ (m/s^2)

Axial Load (Pa) $= W\alpha + \mu Wg = 40 \times 6.67 + 0.02 \times 40 \times 9.3 \approx 274$ (N)

· In Deceleration

Axial Load (Pc) $W\alpha - \mu Wg = 40 \times 6.67 - 0.02 \times 40 \times 9.8 \approx 260$ (N)

(2) Actual moving time during each segment in a motion profile

Below derived from Duty Cycle Model Diagram.

Operating Pattern	In Acceleration	At Constant Speed	In Deceleration	Total Operating Time
Operating Time	0.60	0.84	0.60	2.04

(3) Summary of Axial Loads, Rotational Speeds, and Operation Time for Each Motion Profile

Operating Pattern	In Acceleration	At Constant Speed	In Deceleration
Axial Load	274N	8N	260N
Rotational Speed	1500min^{-1}	3000min^{-1}	1500min^{-1}
Operating Time Ratio	29.4%	41.2%	29.4%

(4) Calculating the Average Axial Load with a formula in **P.325**, 6-3.

$$\text{Mean Axial Load}(Pm) = \left(\frac{P_1^3N_1t_1 + P_2^3N_2t_2 + P_3^3N_3t_3}{N_1t_1 + N_2t_2 + N_3t_3}\right)^{\frac{1}{3}} = 200(N)$$

(5) Calculating the mean turns

$$\text{Mean Turns } (Nm) = \frac{N_1t_1 + N_2t_2 + N_3t_3}{t_1 + t_2 + t_3} = 2118(min^{-1})$$

(6) Calculation of the required basic dynamic load rating

(1) Calculating Continuous Operational Life (Lho)

A Continuous Operational Life which is derived by subtracting Resting time from Desired Life while a motion profile of 4.01s with a moving time of 2.04s can be calculated as follows.

$$Lho = \text{Desired Life } (Lh) \times \left(\frac{2.04}{4.1}\right) = 14927 \text{ (Hours)}$$

(2) Calculating Required Basic Dynamic Load Rating

The formula on Clause 6-1., **P.325** is used to calculate the basic dynamic load rating required to retain the net operational life of ball screw.

$$C = \left(\frac{60LhoNm}{10^6}\right)^{\frac{1}{3}} \times Pm \times fw = \left(\frac{60 \times 14927 \times 2118}{10^6}\right)^{\frac{1}{3}} \times 200 \times 1.2 = 2970 \text{ (N)}$$

(7) Tentative Ball Screw Selection

A ball screw to satisfy the requirements of Lead 20 and Basic Dynamic Load Rating of 2970N, BSS1520 is tentatively selected.

3. Accuracy Evaluation

(1) Evaluating Accuracy Grades and Axial Clearances

By referencing the "Ball Screw Lead Accuracy" table on Section 2., **P.321**, it is found that the Accuracy Grade C5 with ±ep0.040 / 800~1000m of actual mean travel error satisfies the positioning accuracy: ±0.1/720mm and therefore, that BSS1520 is fully applicable.

Additionally, the Precision Screws axial clearance table on **P.322** shows that axial clearance of BSS1520 is 0.005 or less.

The required positioning repeatability is ±0.01mm, and it can be confirmed that BSS1520 satisfies the requirement.

4. Screw Shaft Selection

(1) Determining the Overall Length

Screw Shaft O.A.L. (L)=

Max. Stroke+Nut Length+Margin+Shaft End Terminations (both sides). Therefore,

Max Stroke:	720mm
Nut Length:	62mm
Margin:	Lead×1.5=60mm
Shaft End Termination Dims.: 72	

Screw Shaft O.A.L. (L)=720+62+60+72=914 (mm)

* The Margin is provided as a countermeasure against overruns, and the amount is typically set as 1.5~2 times as much as the screw lead.
  Lead 20×1.5×2(Both Ends)=60(mm)

(2) Evaluating the Allowable Axial Load

Load Applicable Span Distance l1 is 820mm, and the Axial Load can be obtained by the formula on **P.323**, "4. Allowable Axial Load" as indicated below.

$$P = m\frac{d^4}{\ell^2}10^4 = 10 \times \frac{12.5^4}{820^2} \times 10^4 = 3660 \text{ (N)}$$

The above formula produces an Axial Load value of 343N which is well within the Allowable Max. Axial Load 3660N, and suitability is confirmed.

(3) Evaluating the Allowable Max. Rotational Speed

Shaft supported span is 790mm, and the Critical Speed Nc value is calculated as follows by using the formula on "5-1. Critical Speed" in **P.324**:

$$Nc = g\frac{d}{\ell^2}10^7 = 15.1 \times \frac{12.5}{790^2} \times 10^7 = 3024 \text{ (min}^{-1})$$

The max. speed requirement of 3000rpm is within the Critical Speed of 3024min^{-1}, and the suitability is confirmed.

Additionally, the DmN value can be calculated by using the formula in **P.324**, "5-2. DmN Value" as:

DmN=(Shaft O.D.+A value)×Max Rotational Speed=15.8×3000=47400≤70000

and the suitability is confirmed.

5. Selection Result

From the above, it is determined that a suitable ball screw model is BSS1520-914.

Ball Screw Lineup

List of Type, Accuracy Grade, Shaft Dia., Lead, Axial Play and Shaft Length of MISUMI Ball Screws
Provisionally select the ball screw suitable for the purpose of use from the list and select the product following the selection procedure.

Rolled Ball Screw Lineup

Type	Standard Type	Shaft Dia.	Lead	Axial Play (mm)	Shaft Length (mm) MIN	Shaft Length (mm) MAX
Existing Product Compact Nut Accuracy Grade C10	BSSC	8	2	0.05 or Less	100	400
		10	4		150	600
		12	4		150	800
		15	5	0.10 or Less	150	1200
			10		200	1200
		20	5		200	2000
			10	0.15 or Less	250	2000
		25	5	0.10 or Less	200	2000
Existing Product Standard Nut Accuracy Grade C10	BSSZ BSSR	8	2	0.05 or Less	100	400
			4		100	380
		10	2		150	585
			4		150	600
			10		150	585
		12	4		150	800
			10	0.10 or Less	150	800
		14	5		150	800
		15	5		150	1200
			10		200	1200
			20		200	1200
		20	5		200	2000
			10	0.15 or Less	250	2000
			20	0.10 or Less	250	2000
		25	5		200	2000
			10	0.20 or Less	300	2000
			25	0.12 or Less	300	2000
		28	6	0.10 or Less	250	2000
		32	10	0.20 or Less	300	2000
			32	0.15 or Less	300	2000
Cost Efficient Products Standard Nut Accuracy Grade C10	C-BSSC	8	2	0.05 or Less	100	400
		10	2		150	585
			4		150	600
		12	5		150	800
			10	0.10 or Less	150	800
		15	5		150	1200
			10		200	1200
			20		200	1200
		20	5		200	2000
			10	0.15 or Less	250	2000
			20	0.10 or Less	250	2000
		25	5		200	2000
			10	0.20 or Less	300	2000
			25	0.12 or Less	300	2000
Existing Product Block Nut Accuracy Grade C10	BSBR	15	5	0.10 or Less	150	1200
		20			200	1200
		25			200	1500
		15	10		150	1200
		20		0.15 or Less	200	1200
		25		0.20 or Less	250	1500
Existing Product Standard Nut Accuracy Grade C7	BSST	8	2	0.03 or Less	100	380
		10	4		150	585
		12	4		150	795
		15	5		150	1200
			10		200	1200
			20		200	1200
		20	5		200	1200
			10	0.05 or Less	250	2000
			20	0.03 or Less	250	2000
		25	5		200	2000
			10	0.07 or Less	300	2000

Precision Ball Screw Lineup

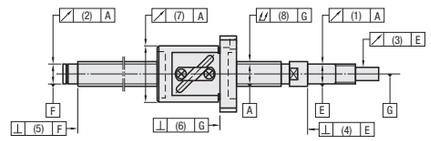
Type	Standard Type	Shaft Dia.	Lead	Axial Play (mm)	Shaft Length (mm) MIN	Shaft Length (mm) MAX
Existing Product Standard Nut Accuracy Grade C5	BSS	8	2	0.005 or Less	100	210
		10	2		100	315
			4		150	380
			10		150	450
		12	2		150	445
			4		150	400
			5		150	450
			10		200	600
		15	5		150	1095
			10		200	1095
			20		230	1095
		20	5		200	1000
			10		250	1500
			20		250	1500
		25	5		300	995
			10		300	1500
			20		300	1500
Cost Efficient Product Standard Nut Accuracy Grade C5	C-BSS	8	2	0.008 or Less	100	210
		10	2		100	315
			4		150	380
		12	2		150	445
			5		150	450
			10		200	600
		15	5	0.015 or Less	150	1095
			10		200	1095
			20		230	1095
		20	5		200	1000
			10		250	1500
			20		250	1500
		25	5		300	995
			10		300	1500
			25		300	1500
Existing Product Standard Nut Accuracy Grade C3	BSX	6	1	0 (Preloaded)	80	205
		8	1		80	255
			2		100	240
		10	2		100	310
		12	2		150	390
			5		150	440
		15	5		150	590
Existing Product Standard Nut Accuracy Grade C7	BSSE	8	2	0.030 or Less	100	210
		10	2		100	315
			4		150	380
		12	2		150	445
			5		150	450
			10		200	600
		15	5		150	1095
			10		200	1095
			20		230	1095
		20	5		200	1000
			10		250	1500
			20		250	1500
		25	10		300	1500
			20		300	1500

Meaning of Terms

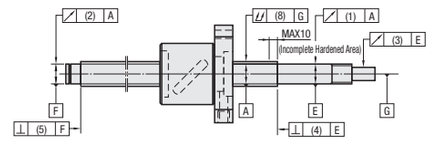
- **Accuracy Grade** Lead Accuracy of Ball Screws defined by JIS Standards. Smaller numbers mean higher lead precision.
- **Shaft Dia.** Screw O.D.
- **Lead** Refers to the distance a nut moves when the screw shaft makes a full rotation.
- **Axial Play** Axial play between the screw shaft and nuts.

Mounting Interface Accuracies

Precision Ball Screws



Rolled Ball Screws



Unit: mm

Part Number Type	Screw Shaft O.D.	(1) (2) Run-out Tolerance (Max.)	(3) Run-out Tolerance (Max.)	(4) (5) Perpendicularity Tolerance (Max.)	(6) Perpendicularity Tolerance (Max.)	(7) Run-out Tolerance (Max.)
BSX	6	0.008	0.008	0.004	0.008	0.008
	8					
	10					0.010
	12					
	15	0.009	0.009			0.012
BSS C-BSS	8	0.011	0.011	0.005	0.010	0.012
	10					
	12					
	15	0.012	0.012		0.011	0.015
	20					
	25	0.013	0.013		0.013	0.019
BSSE BSST	8	0.014	0.014	0.007	0.014	0.020
	10					
	12				0.018	0.030
	15					
	20					
	25	0.020	0.020			
BSSR□ BSSZ□ BSSC□ C-BSSC□	8	0.040	0.040	0.010	-	-
	10					
	12					
	14					
	15					
	20					
	25	0.060	0.060			
	28	0.060	0.060	0.010	-	-
	32					
BSBR□	15	0.040	0.040	0.010	-	-
	20					
	25	0.060	0.060			

(1), (2) Radial Run-out of the thread surface against the shaft support axis.
These parameters are affected by "(8) Shaft's total radial run-outs" and may be subject to compensation.

(3) Radial run-out of drive component interface surface in relation to screw shaft support axis.

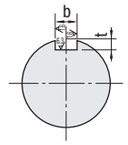
(4), (5) Perpendicularity of shaft's bearing shoulders in relation to screw shaft support axis.

(6) Perpendicularity of ball nut mounting flange surface (datum) in relation to screw shaft axis.

(7) Radial run-out of ball nut body outer circumference in relation to screw shaft axis.

(8) Shaft's total radial run-outs.

Keyway Dimension Details Located at P on Fixed Side Shaft End



Shaft Dia.	b Reference Dim.	b Tolerance (N9)	t Reference Dim.	t Tolerance
6~7	2	-0.004 -0.029	1.2	+0.1 0
8~10	3		1.8	
11~12	4	0 -0.03	2.5	
13~17	5		3.0	
18~20	6		3.5	

Unit: mm

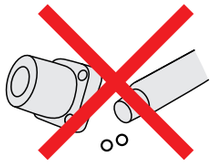
Part Number Type	Screw Shaft O.D.	(8) Run-out Tolerance (Max.) Screw Shaft Length ~125	126~200	201~315	316~400	401~500	501~630	631~800	801~1000	1001~1250	1251~1600	1601~2000
BSX	6	0.025	0.035	0.050	-	-	-	-	-	-	-	-
	8											
	10			0.040	0.050	0.065	-	-	-	-	-	-
	12											
	15	-	0.025	0.030	0.040	0.050	0.055	-	-	-	-	-
BSS C-BSS	8	0.035	0.050	0.065	-	-	-	-	-	-	-	-
	10		0.040	0.055	0.065	0.080	0.090	-	-	-	-	-
	12											
	15	-		0.045	0.055	0.060	0.075	0.090	0.120	0.150	0.190	-
	20											
	25	-	-	0.040	0.045	0.050	0.060	0.070	0.085	0.100	0.130	-
BSSE BSST	8	0.060	0.075	0.100	-	-	-	-	-	-	-	-
	10	0.055	0.065	0.080	0.100	0.120	0.150	-	-	-	-	-
	12											
	15	-	0.060	0.070	0.080	0.095	0.110	0.140	0.170	0.210	0.270	-
	20											
	25	-	-	0.060	0.070	0.080	0.090	0.100	0.130	0.150	0.190	-
BSSR□ BSSZ□ BSSC□ FBS□□ BSBR□ C-BSSC□	8	0.100	0.140	0.210	(0.270)	-	-	-	-	-	-	-
	10	-	0.120	0.160	0.210	0.270	0.350	-	-	-	-	-
	12											
	14	-	0.110	0.130	0.160	0.200	0.250	-	-	-	-	-
	15	-	0.110	0.130	0.160	0.200	0.250	0.320	0.420	0.550	0.730	0.730
	20											
	25	-	-	0.110	0.130	0.160	0.190	0.230	0.300	0.380	0.500	0.690
	28	-	-	0.110	0.130	0.160	0.190	0.230	0.300	0.380	0.500	0.690
	32											

Precautions on handling Ball Screws

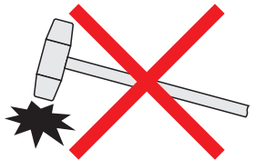
• Precautions on Handling

(1) Removing the ball nut from the screw shaft causes the ball to fall out rendering the ball screw unusable. Do not disassemble Ball Screws. It may attract dusts and degrade assembly accuracy. Use dedicated temporary shafts when removing Ball Nuts.
(2) Do not give an external impact to a screw shaft outer diameter, thread and recirculation parts. It may cause recirculation failure and a malfunction.
(3) Do not tilt the ball screw assembly since a ball screw nut may spin off from a screw shaft due to its own weight. Especially when using a ball screw vertically, place a fall-off prevention mechanism since a ball screw nut may spin off due to its own weight.
(4) When inspecting the sliding, fix the nut and cause the shaft to rotate, or fix the shaft and cause the nut to rotate.

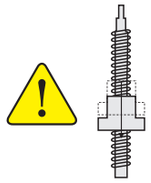
(1) Do not remove the Nuts



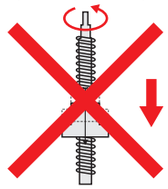
(2) Application of impacts to Nuts is prohibited



(3) Caution for free fall



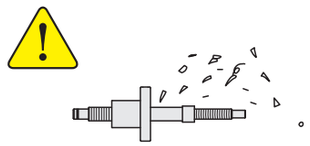
(4) Inspection by reverse operation



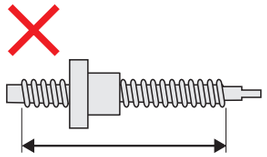
• Cautions on use

(1) Use Ball Screws in clean environments. Use covers, etc. to prevent intrusion of dusts and chips that may cause damages and performance degradations to ball recirculation components.
(2) Do not let a ball screw nut overrun. It may cause the balls to fall out or damage the ball recirculation parts.
(3) Avoid using Ball Screws at a temperature of more than 0~80°C. It may damage recirculation parts or seal parts.
(4) Do not misalign or tilt ball screws shaft support side and a ball screw nut. Life hours may become extremely short due to an offset load to a ball screw nut.

(1) Caution on Contaminations

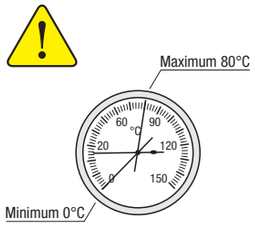


(2) Do not let a nut overrun



If the nut edges exceed this range, the balls will fall out causing malfunctions.

(3) Caution of temperature of usage environment



Rolled Ball Screws · About Removing Ball Screws

If the nut is removed from the shaft, the balls contained in the nut will fall out and the ball screw will become unusable
Use dedicated temporary shafts when removing Ball Nuts.
MISUMI provides various temporary shafts as option.
To order a dedicated temporary shaft together with Ball Screws, add alterations code "-TAS" to the end of a part number.
⊗Nuts cannot be removed using the temporary shafts with Precision Ball Screw BSX, BSS, BSSE, C-BSS and Rolled Ball Screw C-BSSC.

Alterations

Part Number	-	L	-	F	-	P	-	(TAS)
BSSZ1510	-	300					-	TAS
BSSR2005	-	700	-	F30	-	P12	-	TAS

• Caution on use of Temporary Shaft

When Taking Out Ball Screws Nut from Screw Shaft
• Stand a screw shaft vertically and place a temporary shaft to the screw shaft support side edge in consistent with screw shaft center. (Refer to Fig. 2)(*)
• Lightly rotate the nut and install it onto the temporary shaft. (Refer to Fig. 4)
• After confirming that both nut edges are on the temporary shaft, take out the temporary shaft from the screw shaft.
• Store the assembly while ensuring that the nut does not fall off of the temporary shaft.

When Installing Ball Screws Nut to Screw Shaft
• Stand a ball screw shaft vertically and place a temporary shaft to the screw shaft support side edge in consistent with screw shaft center.
• Rotate the nut with pressing the screw shaft lightly and install it into the shaft.
• In case there is any interference, do not insert the ball screw forcibly. Try reassembling.
(*) In BSSZ, BSSR0802, BSSR0804, BSSR1002, BSSR2510, BSST0802 and BSST2510, the screw shaft support side and the temporary shaft are placed as shown in the following Figure 3. Since TAS is unstable, grip TAS firmly from the above until the installation is finished.

Fig. 1

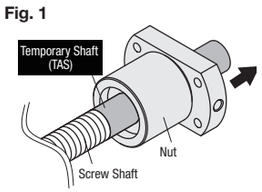


Fig. 2

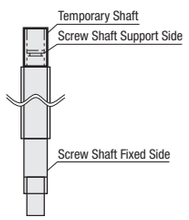


Fig. 3

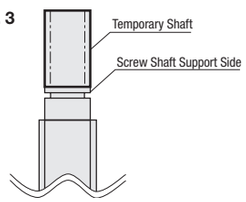
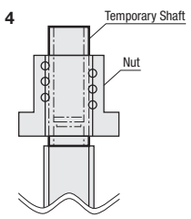


Fig. 4



Lubrication (grease inspection and replenishment)

The grease forms an oil film on the ball screw's screw shaft, rolling surface inside the nut, and surface of the balls and acts to reduce friction and prevent heat damage.
MISUMI ball screws are filled with grease before shipping, however after commencing use, it is necessary to perform regular and appropriate inspection and grease replenishment.
When adding grease, use the same grease that was used at shipment and do not mix with other greases.

• Guides for inspection and grease replenishment

After 2~ 3 months of operation, if the grease is very dirty, we recommend to remove the old grease and fill with new grease.
Subsequent inspection intervals are recommended to be every 6 months, however, we recommend this timing be adjusted to an interval appropriate for the usage environment.

Available Grease

Ball screw products are shipped with grease filled. If not otherwise indicated, lithium soap based grease (Alvania Grease S2 made by Showa Shell Sekiyu K.K) is the standard type that is used. (BSX0601, BSX0801, and BSX0802 are filled with Multemp Grease PS2 made by Kyodo Yushi Co., Ltd.)
Grease type can be changed from the standard to the following types.

Part Number	Product Name	Main Features
● L Type	ET-100K (Made by Kyodo Yushi)	Excels in heat resistance, oxidation stability, adhesion and adhesive power. In addition, splash or leakage is little.
● G Type	LG2 (Made by NSK Ltd.)	Special grease for linear guides, ball screws and etc. for clean-room use.

Item		Condition	Unit	Measurement Method	Standard	L Type	G Type
Grease Performance	Thickener	-	-	-	Lithium Type	Aromatic Diurea	Lithium Type
	Base Oil	-	-	-	Mineral Oil	Ether Synthetic Oil	Mineral Oil + Synthetic Hydrocarbon Oil
	Base Oil Viscosity	40°C	mm²/s	JIS K2220 5.19	131	103	30
		100°C			12.2	12.8	-
	Worked Penetration	-	-	JIS K2220 5.3	283	280	207
	Dropping Point	-	°C	JIS K2220 5.4	181	<260	200
	Evaporation Amount	99°Cx22h	wt%	-	-	0.15%	1.40%
	Oil Separation Rate	100°Cx24h	wt%	JIS K2220 514	2.8%	1.2%	0.8%
	Operating Temp.	In Air	°C	-	-25~+135	-40~200	-10~80

Usage temperature is for grease performance and not the usable temperature of the ball screw.
⊗Avoid using Ball Screws at a temperature of more than 0~80°C.

Available Ball Screws and Grease Types

Type	Accuracy Grade	Type	Unit Price (Add to the price of Standard Type) L≤1000	Unit Price (Add to the price of Standard Type) L>1000
Precision Ball Screws	C 5	BSS	● L Type ● G Type	● L Type ● G Type
	C 7	BSSE		
Rolled Ball Screws	C 7	BSST		
	C10	BSSR BSSZ		
		BSSRK BSSZK		

⊗Not applicable to Precision Ball Screw BSX, C-BSS, Rolled Ball Screw BSSC and C-BSSC.

Ordering Example

Part Number	-	L
● BSS2010L	-	700 (L Type Greased)
● BSS2010G	-	700 (G Type Greased)

Please add L or G after the part number of standard type when placing an order.

Design of Ball Screws and Peripherals, Caution when Assembling

Ball screws are parts that receive only axial load, when a radial load or moment load is received, it could cause sliding failure, vibration/abnormal noise and reduction in lifespan.
To prevent parallelism error and misalignment of peripherals that causes radial load and moment load on ball screws, it is important to appropriately design and assemble peripherals.

• Misalignment of Ball Screw and Support Unit (Figure 1)

- Misalignment occurs when the shaft center of the ball screw fixed to the fixed-side support unit is misaligned with the center of the shaft bearing of the support unit on the support side.
- Misalignment allowance value (reference)
• 20μ or Less
• When there is high precision usage criteria or when using preloaded ball screws, keep the value as low as possible.

• Parallelism of ball screw and linear guide (Figure 2)

- Parallelism error is where the ball screw is tilting toward up/down or left/right with respect to the linear guide or other references.
- Tilting allowable value (reference) (Figure 3)
• 1/2000 or Less
• When there is high precision usage criteria or when using preloaded ball screws, keep the value as low as possible.

• Caution During Design

Design/machining precision of ball screw peripherals can be factors that cause misalignment and tilting.
Particularly be cautious of the following two points.
• Flatness of base plate • Dimensional precision from edge of support unit to shaft center

• Precautions on Installation

• Mounting/assembly of ball screw peripherals can cause misalignments and tilting.
Particularly be cautious of the following four points.
- Error in left/right direction of support unit (Figure 1) - Parallelism error of linear guide and ball screw (Figure 2)
- Fixing of table and nut bracket - Fixing of ball screw nut and nut bracket
• If abnormal noise/sliding is being caused by the ball screw movement after assembly, loosen each of the fastened parts again and reassemble while ensuring smooth sliding.

Figure 1 Misalignment of Ball Screw and Support Unit

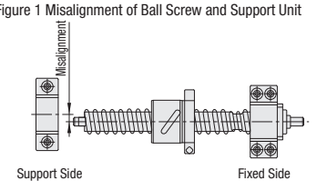


Figure 2 Parallelism Error of Linear Guide and Ball Screw

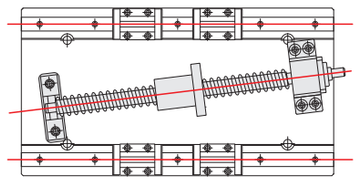
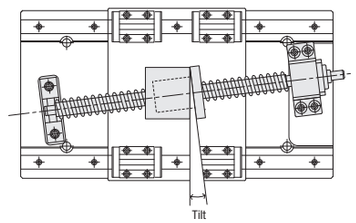


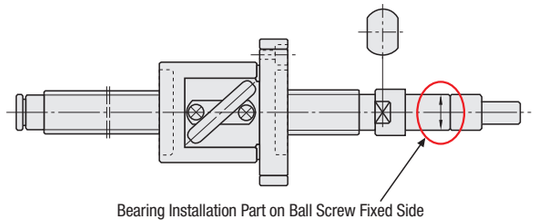
Figure 3 Tilt of Ball Screw and Nut Bracket



Combination of Ball Screws and Support Units

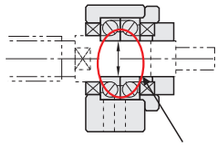
When selecting Support Units for Ball Screws, note that it can be combined if dimensions of bearing installation part on Fixed Side of the Ball Screw [Fig. 1] and bearing I.D. of the Support Unit [Fig. 2] are the same.

[Fig. 1] <Example of Ball Screw BSS1505>



Bearing Installation Part on Ball Screw Fixed Side

[Fig. 2] <Example of Support Unit BSW12>



Support Units Bearing I.D.

Ball Screw Part Number	Accuracy Grade C3	BSX0601	-	BSX0801 BSX0802 BSX1002	-	BSX1202 BSX1205	BSX1505	-	-	-
	Accuracy Grade C5	-	BSS1002 C-BSS1002	BSS0802 BSS1202	BSS1004 BSS1205 BSS1204 BSS1210	BSS1010	Step ① BSS15□□ C-BSS15□□	BSS20□□ C-BSS20□□	BSS25□□ C-BSS25□□	-
	Accuracy Grade C7	BSST0802	BSSE1002 BSST1004	BSSE0802 BSSE1202	BSSE1004 BSSE1205 BSSE1210 BSST1204	-	BSSE15□□ BSST15□□	BSSE20□□ BSST20□□	BSSE25□□ BSST25□□	
	Accuracy Grade C10	BSSR08□□ BSSZ08□□ BSSC08□□ C-BSSC08□□	BSSR10□□ BSSZ10□□ BSSC10□□ C-BSSC10□□	-	BSSR12□□ BSSZ12□□ BSSC12□□ C-BSSC12□□	BSSR14□□ BSSZ14□□	BSSR15□□ BSSZ15□□ BSSC15□□ BSBR15□□ C-BSSC15□□	BSSR20□□ BSSZ20□□ BSSC20□□ BSBR20□□ C-BSSC20□□	BSSR25□□ BSSZ25□□ BSSC25□□ BSBR25□□ BSSR28□□ BSSZ28□□ C-BSSC25□□	BSSR32□□ BSSZ32□□
Fixed Side Shaft Dia. of Ball Screws (Bearing Installation Part)		Ø6	Ø8		Ø10		Step ② Ø12	Ø15	Ø20	Ø25
Support Units (Bearing I.D.)		No.6 No.6L	No.8S	No.8	No.10S	No.1022 No.10	Step ③ No.12	No.152□ No.15*	No.20*	No.25

* Except C-BSFW15,20, C-BUFN15,20

[Example]
- Step ① Confirm that shaft diameter of the Ball Screw is 15.
- Step ② Confirm that dimension of the bearing installation part on fixed side of the Ball Screw is Ø12.
- Step ③ Determine that corresponding bearing I.D. of the Support Unit is No.12.

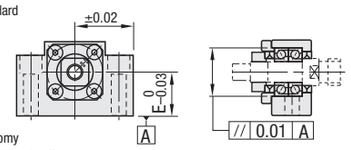
Combination of Fixed Side and Support Side Support Units

Type	Type	Fixed Side	Support Side
Square	Standard	BSW	BUN
		BSWN	BUNM
		BSWR	BUNR
	Cost Efficiency	C-BSW	C-BUN
		C-BSFW*	C-BUFN*
	Economy	BSWE	BUN
		BSWEM	BUNM
		BSWER	BUNR
	Radial Bearing Type	BSWZ	BUN
		BSWZM	BUNM
	Compact	BSQ	BUQ
		BSQM	BUQM
	Low Profile Type	BSV	BUV
		BSVM	BUVM
	Narrow Mounting Hole Pitch Type	BSA	BUA
		BSAM	BUAM
	with Dowel Holes	BSWG	BUN
		BSWGN	BUNM
	with Damper	BSWD	BUND
Round	Standard	BRW	BUR
		BRWN	BURM
		BRWR	BURR
	Cost Efficiency	C-BRW	C-BUR
	Economy	BRWE	BUR
		BRWEM	BURM
		BRWER	BURR
	Radial Bearing Type	BRWZ	BUR
		BRWZM	BURM

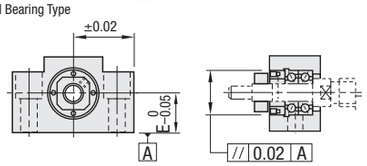
* Excludes C-BSFW15,20, C-BUFN15,20.

Support Units - Square (Fixed Side) Mounting Interface Accuracies

Standard

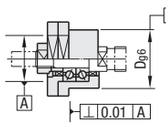


Economy
Radial Bearing Type

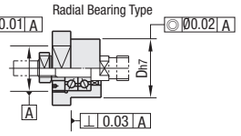


Support Units - Round (Fixed Side) Mounting Interface Accuracies

Standard



Economy
Radial Bearing Type



Critical Bearing Performances

Bearing Type	Existing Product			Cost Efficient Products		
	Japanese made JIS 5 Class Angular Contact Bearing			Japanese made JIS 5 Class Angular Contact Bearing		
Type	BSW/BRW/BSA/ BSV/BSWG/BSWD/BJS			C-BSW/C-BRW/C-BSFW		
d	Allowable Axial Load (N)	Basic Dynamic Load Rating (N)	Bearing Type	Allowable Axial Load (N)	Basic Dynamic Load Rating (N)	Bearing Type
6	1040	2670	70M6DF/P5	720	1880	70M6DF/P5
8	1450	4400	70M8DF/P5	1010	3090	70M8DF/P5
10	2730	6100	7000DF/P5	1910	4260	7000DF/P5
12	3040	6650	7001DF/P5	2120	4660	7001DF/P5
15	3370	7600	7002DF/P5	2350	5320	7002DF/P5
20	8260	17900	7204DF/P5	5780	12490	7204DF/P5
25	9960	20200	7205DF/P5	-	-	-

Bearing Type	JIS 0 Class Angular Contact Bearing			Radial Bearing		
Type	BSWE/BSQ/BRWE			BSWZ/BRWZ		
d	Allowable Axial Load (N)	Basic Dynamic Load Rating (N)	Bearing Type	Allowable Axial Load (N)	Basic Dynamic Load Rating (N)	Bearing Type
6	-	-	-	780	2190	606ZZ
8	-	-	-	1300	3350	608ZZ
10	2730	6100	7000DF/Standard Grade	2300	4550	6000ZZ
12	3040	6650	7001DF/Standard Grade	2600	5100	6001ZZ
15	3370	7600	7002DF/Standard Grade	2900	5600	6002ZZ
20	8260	17900	7204DF/Standard Grade	8100	12800	6204ZZ
25	9960	20200	7205DF/Standard Grade	-	-	-

Bearing's Accuracies

Outer Ring

Unit: μm

Nominal Bearing O.D.		Flat Surface Average O.D. Dim. Difference				Radial Run-out		Axial Play	
D		△Dmp				Kea		Sea	
mm		Class 5		Class 0		Class 5	Class 0	Class 5	Class 0
over	or Less	more than	or Less	more than	or Less	Max.		Max.	
6	18	0	-5	0	-8	5	15	8	-
18	30	0	-6	0	-9	6	15	8	-
30	50	0	-7	0	-11	7	20	8	-
50	80	0	-9	0	-13	8	25	10	-

Inner Ring

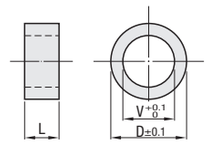
Unit: μm

Nominal Bearing I.D.		Flat Surface Average I.D. Dim. Difference				Radial Run-out		Axial Play	
d		△dmp				Kia		Sia	
mm		Class 5		Class 0		Class 5	Class 0	Class 5	Class 0
over	or Less	more than	or Less	more than	or Less	Max.		Max.	
2.5	10	0	-5	0	-8	4	10	7	-
10	18	0	-5	0	-8	4	10	7	-
18	30	0	-6	0	-10	4	13	8	-

(Extract from JIS B1514)

Both radial run-out and axial play stand for measurement method of bearing rotational accuracy.
Since Inner Ring Radial Run-out (Kia), Outer Ring Radial run-out (Kea), Inner Ring Axial Play (Sia), and Outer Ring Axial Play (Sea) are all different, contact us for more detail.

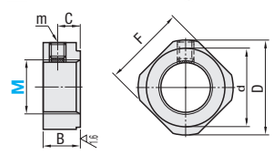
Included Collar Size



*For 8S and 10S, the I.D. of oil seal is smaller than the previous 8S and 10S versions. Use it in accordance with ball screw fixed side dimensions.

		No	D	V	L
Existing Product		6	9.5	6	5
		8S	10	8	5.5
		8	11.5	8	5.5
		10S	12	10	5.5
		10□□	14	10	5.5
		12□□	15	12	5.5
		15□□	20	15	10
		20	25	20	11
		25	31	25	14
Cost Efficient Product	C-BSW C-BRW	6	9.5	6	5
		8S	10	8	5.5
		8	11.5	8	5.5
		10S	12	10	5.5
		10	14.5	10	5.5
		12	15.5	12	5.5
		15S	19.5	15	10
		15	20	15	10
		20	25	50	11
	C-BSFW	10S	12	10	5
		10	14.5	10	5
		12	15.5	12	5
		15	19.5	15	6
		20	27.5	20	8

Included Bearing Nut Size

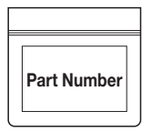


Tighten the set screw after inserting the Thread Protector.
EN 1.1191 Equiv. Thermal Refined excels in durability.

	No	M	Fine Thread	B	m	d	D
Existing Product	6	6	M6*0.75	5.5	M3	10	14.5
	8□	8	M8*1.0	6.5	M3	13	17
	10□□	10	M10*1.0	8	M4	16	20
	12□□	12	M12*1.0	8	M4	17	22
	15□□	15	M15*1.0	10	M4	21	25
	20	20	M20*1.0	13	M4	26	35
	25	25	M25*1.0	15	M5	33	43
Cost Efficient Product	6	6	M6*0.75	5	M3	10	14.5
	8□	8	M8*1.0	6.5	M3	13	17
	10□□	10	M10*1.0	8	M3	15	20
	12□□	12	M12*1.0	8	M3	17	22
	15□□	15	M15*1.0	8	M3	21	25
	20	20	M20*1.0	11	M4	26	35

Cautions on Accessories

Accessory packaging



Accessory contents <fixed side>

Collar | Bearing Nut

When used together with a MISUMI ball screw, there is one accessory collar spare.

Accessory contents <support side>

Bearing | Retaining Ring

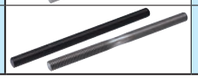
*** Store Accessories with care since they are required when assembling.**

Lead Screw
Overview

Feed Screw Comparison

Type	Slide Screw	Lead Screw	Rolled Ball Screw	Precision Ball Screw
Shape				
Features	Simple feed and adjust mechanisms, etc. Made of stainless steel shaft and plastic nut. No-grease operation is possible.	Optimal for the case where thrust loads and high loadings exist.	Can be applied at reasonable costs when precision ball screw accuracies are not required.	Optimal for the case where high positioning and velocity accuracy are required.
App. Example	Stoppers In/Out and Transfer pitch changeover	Transfer pitch changeover Jacks, Feed Screw for Lathes	Transfer Line	Measurement Instruments
Allowable Rotational Speed	Low Speed	Medium Speed	High Speed	High Speed
Accuracy	★★	★★	★★★★	★★★★★
Allowable Axial Load ( ) is for Reference.	(max540N)	(max30000N)	(max9960N)	(max9960N)

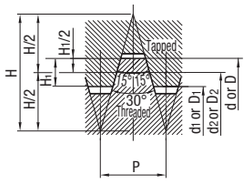
Lineup : Lead Screws

Lead Screw Type	Shape	Right-Hand Thread	Left-Hand Thread	Fine Pitch Right-Hand Thread	Right and Left-Hand Thread	Precision Right and Left-Hand Thread
Both Ends Stepped		✓	✓	✓	✓	✓
One End Stepped / One End Double Stepped		✓	✓	-	✓	✓
One End Stepped / One End Double Stepped		✓	-	-	-	-
Both Ends Double Stepped		✓	✓	-	-	-
Straight		✓	✓	-	✓	-

Lead Screw Accuracy Standards

Item	Content
Allowable Dimension and Tolerance	JISB0217 0218
Screw Accuracy	7e Grade
Nut Accuracy	7H Grade
Single Pitch Error	±0.02
Accumulated Pitch Error	±0.15/300mm
Shaft Maximum Runout	See table below
Length Tolerance	JIS B 0405 (Medium Class)

Lead Screw Thread Geometry Standards (JIS Tr)



$H=1.866P \quad H_1=0.5P \quad d_2=d-0.5P$
$d_1=d-P \quad D=d \quad D_2=d_2 \quad D_1=d_1$

Thread d: O.D d1: Root Dia. d2: Effective Dia.
Tapped D: Root Dia. D1: I.D. d2: Effective Dia.
P: Pitch H1: Engage Height

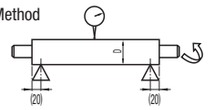
Pitch 3 of D Dimension 16, Pitch 5 of D Dimension 25 and Pitch 6 of D Dimension 40 conform to Tr Standard.

Lead Screw Specifications

Unit : mm

Shaft Dia.	Pitch	Screw Shaft Effective Dia.	Screw Shaft Minor Dia. (MIN.)	Screw Shaft Lead Angle	Screw Shaft Runout (Max.) Shaft Overall Length ~125	126~200	201~315	315~400	401~500	501~630	631~800	801~1000	1001~1250	1251~1600	1601~2000
8	1.5	7.25	(5.9)	3°46'	0.1	0.14	0.21	0.27	0.35	-	-	-	-	-	-
10	2	9	(7.2)	4°03'	0.09	0.12	0.16	0.21	0.27	0.35	0.46	0.58			
12	2	11	(9.2)	3°19'											
14	3	12.5	(10.1)	4°22'	0.09	0.11	0.13	0.16	0.2	0.25	0.32	0.42	-	-	-
16	2	15	(13.18)	2°25'									0.55	0.73	1
	3	14.5	(12.1)	3°46'											
18	4	16	(13.1)	4°33'	-										
20	2	19	(17.18)	1°55'											
	4	18	(15.1)	4°03'											
22	5	19.5	(16.1)	4°40'	-	0.09	0.11	0.13	0.16	0.19	0.23	0.3	0.38	0.5	0.69
25	5	22.5	(19)	4°03'											
28	5	25.5	(22)	3°34'											
32	6	29	(24.5)	3°46'											
36	6	33	(28.5)	3°19'	-	0.11	0.11	0.11	0.13	0.15	0.17	0.22	0.27	0.34	0.46
40	6	37	(32.5)	2°57'											
50	8	46	(40.4)	3°10'											

• Runout Measurement Method



Lead Screw
Specifications / Technical Calculations

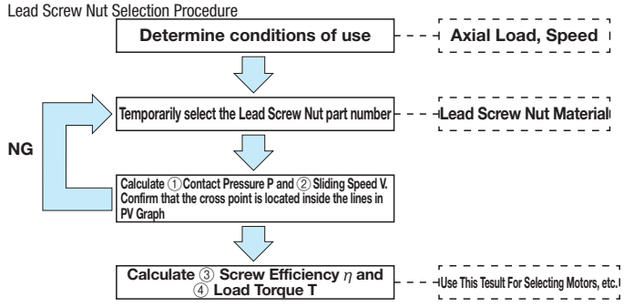
Nuts for Lead Screw Specifications

Shaft Dia.	Pitch	MTS□□/ Standard	MTSP□□/ Compact	MTSJR/ Pilot	MTSQR/ Slotted Holes	MTRFR / RoHS Compliant	MTBLR/ Anti-Backlash	MTSM□□/ Lubrication-Free	MTSR□□/ High Strength Plastic	MTSF□□/ Plastic Type
									
		Allowable Dynamic Thrust (N)								
8	1.5	1470	-	-	-	-	-	-	-	-
10	2	2550	2020	-	-	2550	2600	2550	278	255
12	2	3920	3140	-	-	3920	3390	3920	428	392
14	3	4900	3920	4900	4900	4900	-	4900	536	490
16	2	-	-	6670	6670	6670	-	-	-	-
	3	6670	5340	-	-	6670	6290	6670	686	628
18	4	8720	-	-	-	-	-	-	954	873
20	2	-	-	-	-	10100	-	-	-	-
	4	9810	7850	9810	9810	9810	9320	9810	1071	980
22	5	12360	9890	12360	12360	-	-	12360	-	-
25	5	14220	11380	14220	14220	14220	-	14220	-	1412
28	5	17950	14420	17950	17950	17950	-	17950	-	1765
32	6	21080	16940	21080	21080	21080	-	21080	-	2050
36	6	25780	-	-	-	-	-	25780	-	-
40	6	33830	-	-	-	-	-	33830	-	-
50	8	40310	-	-	-	-	-	-	-	-

Lead Screw Technical Calculations

Calculate Contact Pressure P and Sliding Velocity V based on conditions of use to check that no abnormal wear will occur.
Calculate cross point based on the calculated P and V values in PV Graph.
When the cross point is located inside the line ① or ② in PV Value Graph, it can be stated that no abnormal wear will occur.

Lead Screw Nut Selection Procedure



①Contact Pressure P (N/mm²)

$$P=\frac{Fs}{Fo}\times\alpha$$

Fs : Axial Load (N)
Fo : Allowable Dynamic Thrust (N) >> Nuts for Lead Screw Specifications
The thrust when the contact pressure acting on the screw shaft and nuts is 9.8 (0.98N)/mm²
α : 9.8 (Brass), 0.98 (Resin)

②Sliding Speed V (m/min)

$$V=\frac{\pi\cdot d_2\cdot n}{\cos(d)}\times10^{-3}$$

d_2 : Screw Shaft Effective Dia. >> Nuts for Lead Screw Specifications
d : Screw Shaft Lead Angle (Degree) >> Nuts for Lead Screw Specifications
n : Screw Shaft Revolution Frequency per Minute (min⁻¹)

③Screw Efficiency η

$$\eta=\frac{1-\mu\tan(d)}{1+\mu/\tan(d)}$$

μ : Dynamic Friction Coefficient
d : Screw Shaft Lead Angle (Degree)

Dynamic Friction Coefficient Reference Value

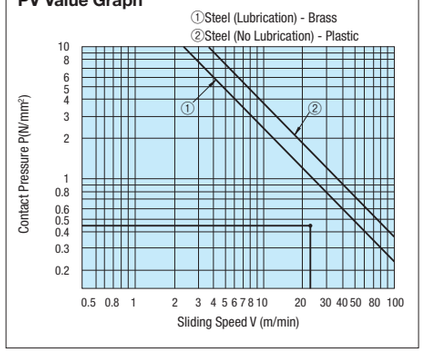
Thread Shaft	Nut	Dynamic Friction Coefficient μ
Steel (Lubrication)	Brass	0.21
Steel (Non Lubrication)	Polyacetal / PPS Resin with Sliding Property	0.13

④Load Torque T (N · cm)

$$T=\frac{FS\cdot R}{2\pi\cdot\eta}$$

Fs : Axial Load
η : Screw Efficiency
R : Lead (cm)

PV Value Graph



Calculation Example

In case of using MTSRW16 shaft, pitch 3 and MTSFR16 brass flanged nut when the axial load is 300N as rotational speed at 500min⁻¹.

①Contact Pressure P (N/mm²)

$$P=\frac{Fs}{Fo}\times\alpha=\frac{300}{6670}\times9.8=0.44(N/mm^2)$$

②Sliding Speed V (m/min)

$$V=\frac{\pi\cdot d2\cdot n}{\cos(d)}\times10^{-3}=\frac{\pi\times14.5\times500}{\cos(3°46')}\times10^{-3}=22.8(m/min)$$

When the PV Graph is viewed based on the calculated P and V values, the cross point V=22.8(m/min) when P=0.44(N/mm²) is located inside the line ① on the PV Graph, thus it can be stated that no abnormal wear will occur.

Calculation Example

Required Torque when using MTSRW16 shaft , pitch 3, and MTSFR16 brass (flanged nut.)

③Screw Efficiency η

$$\eta=\frac{1-\mu\tan(d)}{1+\mu/\tan(d)}=\frac{1-0.21\times\tan(3°46')}{1+0.21/\tan(3°46')}=0.24$$

Also, in a case of calculating for the Load Torque T (N · cm) when the axial load is 300N.

④Load Torque T (N · cm)

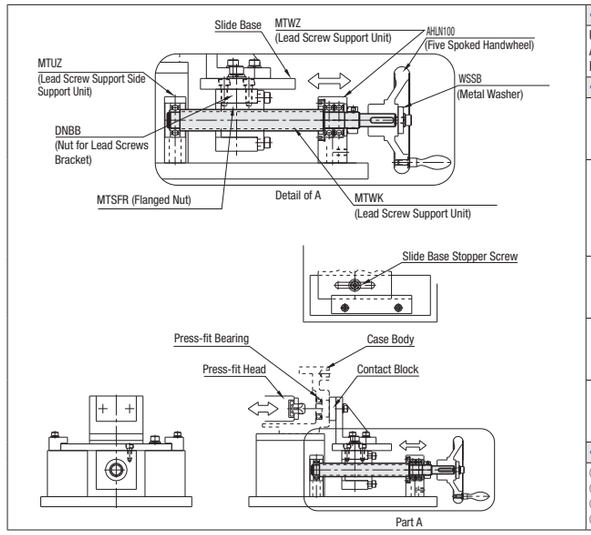
$$T=\frac{FS\cdot R}{2\pi\cdot\eta}=\frac{300\times0.3}{2\pi\times0.24}=59.7(N\cdot cm)$$

Lead Screw
Application Examples

Lead Screw Application Examples

App. Example 1 Machine Name Slide Base Feed Mechanism for Reference Shoulder Adjusting

Configuration comprised of Shaft Support Unit for Lead Screws, Lead Screw Shaft, and a Position Indicator.



• Applications

Used for transfer feeding, locating stoppers, and guiding of various workpieces.
Adjustments are relatively small, but shock loads in axial direction are considered.
In addition, the lead screw scheme is chosen for its low price.

• Selection Criteria

Lead Screw Shaft
A lead screw shaft configured specifically for MISUMI Shaft Supports with a Keyway is selected.
The configuration supports each end of the shaft with a bearing.

Lead Screw Support Units
Lead Screw Support Unit is selected for the fixed side of the shaft.
Selected support unit has two radial bearings in preloaded arrangement.
Selected since thrust loads can be supported.

Lead Screw Support Units
A Shaft Support Unit for Lead Screws is selected for the shaft support side.
Comes with two radial bearings in the set, and used as is.

Nuts for Lead Screws
Commonly used Round Flanged Lead Screw Nut is selected.

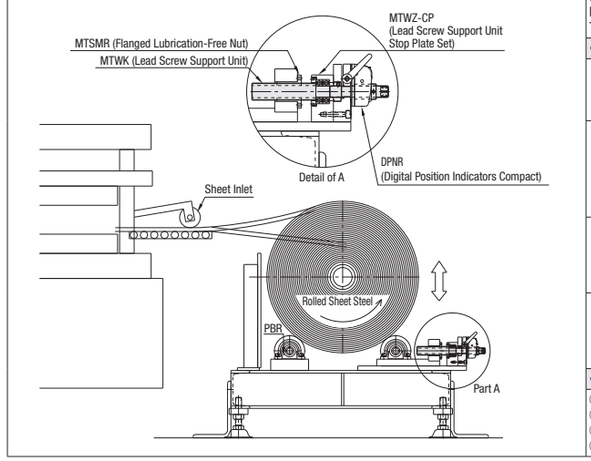
Nut Brackets
A Nut Bracket compatible with a lead screw nut is selected.

• Conditions of Use

①Applied Load 200N Material Mass : 300N
②Setup Change-over Frequency Once a day for rod changes, etc.
③Positioning Accuracy ±0.5mm
④Stroke 150mm

App. Example 2 Machine Name Sheet Steel Roll Base with Adjustment Mechanism

Configuration comprised of Shaft Support Unit for Lead Screws, Stop Plate Set, Lead Screw Shaft, and a Position Indicator.



• Applications

Sheet steel roll's remaining O.D. is measured at set intervals, and the roll is raised accordingly with a lead screw.
The lead screw feed amount is measured by a position indicator, instead of using a conversion table.

• Selection Criteria

Lead Screw Shaft
A lead screw shaft configured specifically for MISUMI Shaft Supports with no R machining on the support side (Alteration RC) is selected.

Lead Screw Support Units
Lead Screw Support Unit is selected for the fixed side of the shaft.
Selected since thrust loads can be supported, and a Digital Position Indicators Compact can be directly mounted.

Nuts for Lead Screws
Round Flanged Lubrication-Free Lead Screw Nut is selected.
Selected because the lubrication maintenance can be reduced to only once a year.

Position Indicators
A Digital Position Indicators Compact is selected for lead screw feed distance measurements.

• Conditions of Use

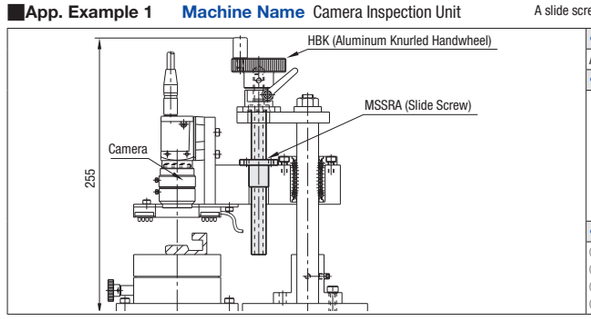
①Applied Load 20kN
②Maintenance Once a year
③Positioning Accuracy 1~2mm
④Stroke 150mm

Slide Screw Application Example

With a stainless steel thread shaft and a plastic nut, slide screws can be used without grease and are suitable for use with the screw feed mechanism in clean environments.
Slide screws are low cost and offer smooth movements due to their excellent tribological properties.

App. Example 1 Machine Name Camera Inspection Unit

A slide screw is utilized as the Z axis.



• Applications

A slide screw is chosen for fine adjustability, and can be used without lubrication maintenance.

• Selection Criteria

Slide Screw Shaft
One End Stepped Type in EN 1.4301 Equiv. is selected.
Nut
Tribological resin nut is selected for zero grease requirement and good corrosion resistance.

• Conditions of Use

①Applied Load 50N
②Setup Change-over Frequency Once a day for rod changes, etc.
③Positioning Accuracy ±0.5mm
④Stroke 100mm

Bearing
Tolerances and Allowances / IP Codes for Sensor Switches

Radial Bearing(Class 0) Tolerances and Allowances

(1) Inner Wheel

Unit μm

d (mm) Nominal Inner Diameter of Bearing		△dmp		Diameter Series 9 Vdp	Diameter Series 0,1 Vdp	Diameter Series 2, 3, 4 Vdp	Vdmp	Kia	Single Bearing △Bs		Bearings in Combinations △Bs		VBs
More	or Less	Above	Below	Max.	Max.	Max.	Max.	Max.	Above	Below	Above	Below	Max.
0.6(1)	2.5	0	–8	10	8	6	6	10	0	–40	–	–	12
2.5	10	0	–8	10	8	6	6	10	0	–120	0	–250	15
10	18	0	–8	10	8	6	6	10	0	–120	0	–250	20
18	30	0	–10	13	10	8	8	13	0	–120	0	–250	20
30	50	0	–12	15	12	9	9	15	0	–120	0	–250	20
50	80	0	–15	19	19	11	11	20	0	–150	0	–380	25
80	120	0	–20	25	25	15	15	25	0	–200	0	–380	25
120	180	0	–25	31	31	19	19	30	0	–250	0	–500	30
180	250	0	–30	38	38	23	23	40	0	–300	0	–500	30
250	315	0	–35	44	44	26	26	50	0	–350	0	–500	35
315	400	0	–40	50	50	30	30	60	0	–400	0	–630	40
400	500	0	–45	56	56	34	34	65	0	–450	–	–	50
500	630	0	–50	63	63	38	38	70	0	–500	–	–	60
630	800	0	–75	–	–	–	–	80	0	–750	–	–	70
800	1000	0	–100	–	–	–	–	90	0	–1000	–	–	80
1000	1250	0	–125	–	–	–	–	100	0	–1250	–	–	100
1250	1600	0	–160	–	–	–	–	120	0	–1600	–	–	120
1600	2000	0	–200	–	–	–	–	140	0	–2000	–	–	140

(1)0.6mm is included in this class. (2)Applies to each orbit ring made for bearing combination.

(2) Outer Ring

D(mm) Nominal Outer Diameter of Bearing		△Dmp		Open Bearing Diameter Series 9 VDP f	Open Bearing Diameter Series 0,1 VDP f	Sealed Bearing, Shielded Bearing Diameter Series 2,3,4 VDP f	Sealed Bearing, Shielded Bearing Diameter Series 2,3,4 VDP f	(4) VDmp	Kea	△Cs		VCs
More	or Less	Above	Below	Max.	Max.	Max.	Max.	Max.	Max.	Above	Below	Max.
2.5(3)	6	0	–8	10	8	6	10	6	15			
6	18	0	–8	10	8	6	10	6	15			
18	30	0	–9	12	9	7	12	7	15			
30	50	0	–11	14	11	8	16	8	20			
50	80	0	–13	16	13	10	20	10	25			
80	120	0	–15	19	19	11	26	11	35			
120	150	0	–18	23	23	14	30	14	40			
150	180	0	–25	31	31	19	38	19	45			
180	250	0	–30	38	38	23	–	23	50	Depends on △Bs tolerance against d of the same bearing.		Depends on △Bs tolerance against d of the same bearing.
250	315	0	–35	44	44	26	–	26	60			
315	400	0	–40	50	50	30	–	30	70			
400	500	0	–45	56	56	34	–	34	80			
500	630	0	–50	63	63	38	–	38	100			
630	800	0	–75	94	94	55	–	55	120			
800	1000	0	–100	125	125	75	–	75	140			
1000	1250	0	–125	–	–	–	–	–	160			
1250	1600	0	–160	–	–	–	–	–	190			
1600	2000	0	–200	–	–	–	–	–	220			
2000	2500	0	–250	–	–	–	–	–	250			

(3) 2.5mm is included in this class. (4)Applies when a retaining ring is not installed.

Dimensional Tolerance
△dmp : Tolerance of Mean Inner Diameter within the Plane
△Dmp: Tolerance of Mean Outer Diameter within the Plane
△Bs : Measured Inner Ring Tolerance or Height Tolerance of Center Orbiting Plate
△Cs : Measured Outer Ring Tolerance

Dimensional inequality
Vdp : Inner Diameter Inequality within the Plane
Vdmp : Mean Inner Diameter Inequality within the Plane
VDp : Outer Diameter Inequality within the Plane
VDmp: Mean Outer Diameter Inequality within the Plane
VBs : Inequality of Inner Ring Widths
VCs : Inequality of Outer Ring Widths

Rotation Precision
Kia : Radial Deviation of Inner Rings
Kea : Radial Deviation of Outer Rings

About IP Codes for Sensor Switches

·IP codes in this catalog are based on"Protection Statement for Equipments"of IEC 529:1989.
Sealing ability may be affected by the conditions or environment in which it is used, such as cutting oil, chemicals, or existence of dust.

IP 6 7
(International Protecion)
First Characteristic Numeral (0~6): Ingress of Solid Foreign Objects
Second Characteristic Numeral(0~8): Ingress of Water with Harmful Effects

Characteristic Numeral	Ingress of Solid Foreign Objects	Ingress of Water with Harmful Effects
0	Non-Protected	Non-Protected
1	Protected against solid foreign objects 50mm in diameter or greater.	Protected against vertically falling water drops.
2	Protected against solid foreign objects 12.5mm in diameter or greater.	Protected against vertically falling water drops angled within 15 degree.
3	Protected against solid foreign objects 2.5mm in diameter or greater.	Protected against spraying water.
4	Protected against solid foreign objects 1.0mm in diameter or greater.	Protected against splashing water.
5	Dust-protected: Prevents the penetration of dust in amounts interfering with equipment operation.	Protected against water jetting from any direction.
6	Dust-tight:No ingress of dust.	Protected against powerful water jetting from any direction.
7	–	Protected against ingress of water in quantities causing harmful effects when the enclosure is temporarily immersed.
8	–	Protected against ingress of water in quantities causing harmful effects when the enclosure is continuously immersed in water under conditions more severe than No. 7, as determined by the parties concerned.

Couplings
Selection Method

When Selection is Based on Motor

1 Please select appropriate coupling type based on the motor type and the application in which it is to be used.

* Motor type and Coupling type are not limited to the following combinations. Select after confirming each product page.
* When selection is by torque, start from 2.

Coupling Easy Selection Chart

	Coupling Characteristics			Motor		
Type	Zero Backlash	High Torque	Allowable Lateral Misalignment Allowable Angular Misalignment	Servo	Stepping Motor Compact Servo	General-purpose
Disc	++	++	+	++	+	--
Oldham	--	++	++	--	--	++
Slit	++	+	+	+	++	--

++ : Very good, + : Good, -- : Very Poor

Selection Example)

<Prerequisites>

Rotating Direction: One-way rotation
Applications: Transfer Conveyor (Positioning not required)
Motor: General-purpose Motor

<Selection>

As positioning is not required in one-way rotation, zero backlash is not required. General-purpose Motor is used and Oldham Couplings can be selected.

2 Calculate the compensation torque applied to coupling

Connection with Servo Motors / Stepping Motors

Calculate the Compensation Torque by multiplying Compensation Factor with the Motor's Peak Torque. For Compensation Factor, please see products page. Choose a coupling with the torque capacity (shaft slip torque) higher than the calculated compensation torque.

Compensation Torque = Motor's Peak Torque x Compensation Factor

Connection with General-purpose Motor

Calculate the load torque, and the compensation torque should be 1~5 times of the load torque. Choose a coupling with the torque capacity (shaft slip torque) higher than the calculated compensation torque.

$$\text{Load Torque (N · m)} = 9550 \times \frac{\text{Transmission Power (kW)}}{\text{Rotational Speed (r/min)}}$$

Compensation Torque = Load Torque (N · m) x 1~5

3 Check coupling tolerance

Check that the Tolerance (Angular and Lateral misalignments and Max. Rotational Speed) and the Moment of Inertia mentioned in the catalogue meet the conditions of the device.

4 Select shaft bore

Check if the outer diameter of the connecting shaft is included in the inner diameter range of the coupling. If the outer diameter is not included, select a large size.

5 Select shaft connection method

Select in accordance with the clamp, keyed locking, keyless clamping applications.

6 Final confirmation

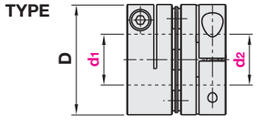
Finally check the dimension table to confirm that the coupling is compatible with the device.

How to Create Coupling Part Number

Part Number (Type, D)	-	I.D. 1 (d_1)	-	I.D. 2 (d_2)	$d_1 \leq d_2$

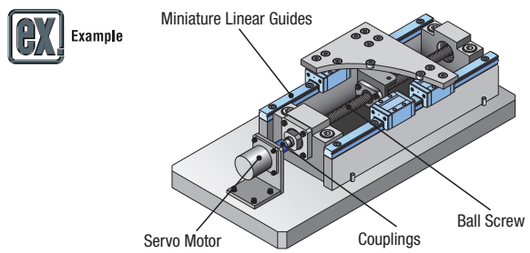
Ex.) TYPE: GCPS When D=33 d_1=10 d_2=11

GCPS33-10-11



Selection Example

Select on the basis of the following Example.



<Prerequisites>

Drive Motor: Servo Motor, Driven Side: Ball Screw
Rotational Direction: Reverse Rotary, Rotational Speed: 3000rpm
Lateral Misalignment: 0.1mm Angular Misalignment: 1° Axial Misalignment: 0.1mm
Shaft Bore Dia. Motor Side: 14mm, Ball Screw Side: 15mm
Coupling O.A.L.: 60mm or less

1. Select Coupling Type
   Required characteristics of coupling from the above conditions
   - Zero Backlash
   - Allow lateral/angular misalignments

   Refer to the above Coupling Easy Selection Chart, and select.

   Compatible Coupling Type ⇒ Disc Couplings: GCPW

2. Calculate the compensation torque applied to coupling
   Condition: Servo Motor's Peak Torque: 3.0N · m
   Servo Motor's Rated Torque: 1.0N · m
   Calculation of Compensation Torque
   Compensation Torque = Motor's Peak Torque (3.0N · m) x Compensation Factor (2.0) = 6.0N · m

   Select D(O.D.) with allowable torque 6.0N · m or more ⇒ GCPW39

* Compensation factor is for reference when using couplings with servo motors in general.
Please use the values as reference.

3. Check coupling tolerance
   Allowable Lateral Misalignment: 0.25mm Allowable Angular Misalignment: 1° Allowable Axial Misalignment: ±0.5mm
   Allowable Rotational Speed: 10000rpm
   ⇒ Conditions are met

4. Select shaft bore
   Check if 14mm and 15mm shaft bore can be selected in GCPW39.
   14mm and 15mm both fall under the category of D (O.D.) = 39 specification.

   d_1=14, d_2=15⇒ GCPW39-14-15

5. Selecting the method to fasten shaft bore

   ⇒ GCPW has only clamp, and need not be selected

6. Check that the dimension matches the device
   Overall Length: 49.6mm
   ⇒ Matches with the overall length 60mm or less

   Finally selected Part Number ⇒ GCPW38-14-15

Couplings
Terminology for Couplings·Assembly Procedure

Terminology

· Allowable Torque

A torque that a coupling can continuously transmit. Select a allowable torque according to selection method given on **P.339** which would ensure that using load torque is less than the allowable torque of the coupling. In couplings for Servo Motors, compensation factor recommended for each part number is set.

· Slip Torque

A torque which spins the fastened shaft and coupling, and slides out. Select the shaft slip torque when it is less than the allowable torque according to the selection method given on **P.339**, such that the load torque is less than the shaft slip torque of the coupling.

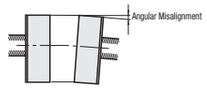
· Misalignment

An error between 2 coupling shaft centers. Misalignments are: Angular Misalignment, Lateral Misalignment and Axial Misalignment. Align (Centering) the shafts to ensure that misalignment between two shafts is less than the mentioned allowable misalignment. When two or more misalignments are combined, the allowable value for respective misalignment is 1/2. (Explanation regarding misalignment is as follows)

Angular Misalignment

Angle Error between two coupling shafts. (Fig. 1)

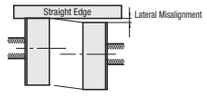
Fig. 1 Angular Misalignment
(Angle Error between Two Shaft Centers)



Lateral Misalignment

Angle Error between two coupling shafts. (Fig. 2)

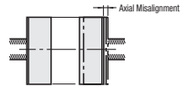
Fig. 2 Lateral Misali ent
(Parallelism Error between Two Shaft Centers)



Axial Misalignment

Displacement in the axial direction of various shafts. (Fig. 3): This misalignment occurs at the time of motor acceleration or, due to swelling at the time of rise in temperature.

Fig. 3 Axial Misalignment
(Shaft's Shift in the Axial Direction)



· Static Torsional Spring Constant (Torsional Rigidity)

Torsional rigidity of the coupling. It shows the phase difference between the rotating direction of input shaft and output shaft, when torque is applied to the coupling. The value given in the catalogue indicates the torsional rigidity for the whole coupling. The responsiveness increases as this value increases, and highly-precise rotation control becomes possible.

· Max. Rotational Speed

Highest available rotational speed. Balancing is necessary when using for high speed rotation, as dynamic balance is not considered in this value.

· Moment of Inertia

Inertia moment of the coupling. Rotatory inertia increases in respect to increase in the value of inertia moment.

· Zero Backlash

A rattling noise occurring in various parts of the coupling, corresponding to the rotating direction. When using Servo Motors, consider using disk coupling or slit couplings with zero backlash for the purpose of highly precise positioning, clock-wise and anti-clockwise rotation.

· Tightening Torque

A bolt tightening torque to fasten the coupling to the shaft. Use torque wrench to tighten the coupling to prescribed torque.

· Temperature Correction Factor

Resin spacer couplings such as Oldham and Jaw Types have allowable torque values that vary depending on the operating temperature. Select couplings by multiplying couplings Allowable Torque, Max. Rotational Speed, etc by Temperature Compensation Factor in the right hand table.

Operating Temperature (°C)	Temperature Correction Factor
-20~ 30	1.00
30~ 40	0.80
40~ 60	0.70
60~100	0.55

Assembly Procedure

1) Confirm that the clamping screws are loosened, and wipe clean the inner bore and shaft surfaces off dust and oils.
2) Insert the shaft into the coupling while taking care not to apply excessive compressive/tensile forces on the disc section.
3) Adjust the disk coupling in left-right hub concentration in precise manner, using the jig. Quickly check the angular and lateral misalignment using coupling as a base.

3-1)Quick Lateral Misalignment Check (Fig. 4): Slide the coupling in axial direction while the bolts are loosened and check that it is moving smoothly. Center the coupling properly as the single type coupling does not allow lateral misalignment.

3-2)Quick Angular Misalignment Check (Fig. 5): Rotate the coupling/shaft and visually check for smooth and even movement.

4)Final assembly: Adjust the shaft insertion as per the dimensions given in the catalogue (Fig. 6) and fasten it with prescribed torque by using the torque wrench.ℓDo not fasten till the prescribed torque at once. Alternate between left and right clamp and tighten it two or three times.

Fig. 4 Quick Lateral Misalignment Check

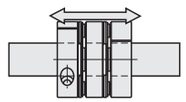


Fig. 5 Quick Angular Misalignment Check

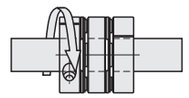
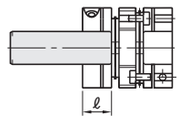


Fig. 6 Shaft Insertion Depth



What is Self Kit Conveyor?

A service to deliver only set of parts for belt conveyor unassembled.

Features of Self Kit Conveyor

- **Reduction in assembly man-hours shortens lead times and lowers costs!**
- **Customers can assemble the conveyor in a flexible and customized way!**

Highly flexible in designing because parts are not yet assembled.

Applicable Conveyors

SVKA Flat Belt Conveyor SV Series - Head Drive,
2-Slot Frame (Pulley Dia. 30mm)

How to Set

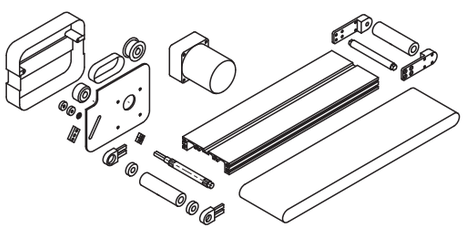
Ordering Example:

Part Number		B		L		Motor						Belt Specification		Motor Manufacturer Selection		Alterations
						Output		Voltage		Specification		Gearhead				
SVKA	-	50	-	500	-	25	-	T100	-	IM	-	12.5	-	H	-	B	-	SELF

Easily ordered just with an additionally specify SELF!

Alterations

Condition at Delivery



A complete set of belt conveyor components is delivered unassembled.
Each component is separately packaged by its classification.

Assembly Instruction Included

*Tools for assembly are not included

Access Now ▶ MISUMI Conveyors Search http://de.misumi-ec.com/contents/mech/product/cvs/

1. Calculating Effective Tension

1A. How to Calculate Pulley Mass on Return Side

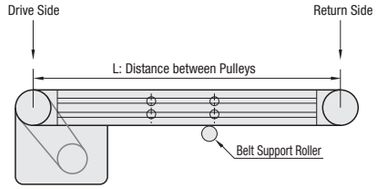
* Calculation formula for Flat Belt Head Drive Conveyor
* The calculation methods for Center Drive and other conveyors are different.

Formula 1

$$Wr=1/4[\pi\cdot(D^2-d^2)]\cdot Lr\cdot Wr1\cdot n/1000^2$$

Wr : Pulley Mass on Return Side (kg)
Wr1 : Pulley Unit Mass = 2.8 g/cm³

n : No. of Pulleys on Return Side (n)
π : Pi (3.14159)
D : Pulley O.D. on Return Side (mm)
d : Pulley I.D. on Return Side (mm)
Lr : Pulley Length on Return Side (mm)



Head Drive Conveyor Image

1B. How to Calculate Effective Tension of Belt

* The effect from belt support rollers is ignored.

Formula 2

$$Te=\{[(Wg+Wb\cdot L\cdot B/1000^2)\cdot\mu1]+(Wr+Wb\cdot L\cdot B/1000^2)\cdot\mu2]\}\cdot g$$

Te : Effective Tension (N)
Wg : Workpiece Mass (kg) Total mass of the workpiece loaded onto a flat belt
Wb : Belt Unit Mass (kg/m²) [Select from "Belt Specification"]
L : Length between Pulleys for Conveyor in Use (mm)
B : Belt Width (mm)
g : Gravitational Acceleration = 9.80665m/s²

μ1 : [Select from Table 1]
μ2 = 0.2* [From Table 1 on **P. 357**]
* For Head Drive Conveyor, Pulley + Steel Sheet Support

Table 1 - Friction Coefficient of Belt and Base Plate (Reference Value)

Table Material	Friction Coefficient μ1	
	Flat Belt	Timing Belt
Stainless Steel	0.40	0.30
Aluminum	-	-

2. Determining Allowable Tension and Safety Ratio of Belt

2A. How to Calculate Tight Side Tension of Belt

Formula 3

$$F_{M1}=[e^{\mu0\cdot\theta}/(e^{\mu0\cdot\theta}-1)]\cdot Te$$

F_{M1} : Tight Side Tension (N)
e : Base of Natural Logarithm (2.71828)
θ : Contact Angle of Belt and Pulley = 3.14 (rad) [Contact angle of the head drive conveyor should be 180°]
μ0 : [Select from Table 2]

Table 2 - Friction Coefficient of Drive Side Pulley and Belt

Pulley Surface Condition	μ0
Flat Belt and Pulley	0.20
Stainless Steel Belt and Pulley	0.20
Sprocket and Plastic Chain	1.00
Timing Belt and Pulley	1.00

2B. How to Calculate Initial Tension per Belt Unit

Formula 4

$$F_{M2}=Te+Tc\cdot B$$

F_{M2} : Initial Tension of Belt (N)
Te : Effective Tension of Belt (N)
Tc : Initial Tension per Belt Unit (N/mm) [Select from Table 3]
B : Belt Width (mm)

Table 3 - Initial Tension per Belt Unit

No. of Plies	N/mm
1	0.15
2	0.30
3	0.45

2C. How to Calculate Safety Ratio of Belt

Compare F_{M1} and F_{M2} and use the larger value as the maximum tension "F_M" to calculate maximum tension per belt unit "C".

$$C=F_M/B$$

Formula 5

$$S=\sigma/C$$

C : Max. Tension per Belt Unit (N/mm)
F_M : Max. Tension (N)
B : Belt Width (mm)
S : Safety Ratio of Belt (Determination of the safety ratio varies depending on your operating conditions, etc.)
σ : Allowable Tension of Belt (N/mm) [Select from "Belt Specification"]

3. Calculating Belt Speed

3A. Calculate the power requirement using Formula 6.

Formula 6

$$P = Pm \cdot \eta / 1000$$

P : Power Requirement (kW)
η : Machine Efficiency = 0.5
Pm : Motor Output (W)

3B. Calculate the maximum belt speed under load using Formula 7.

Formula 7

$$V = 102 \cdot 60 \cdot P \cdot g / Te$$

V : Belt Speed (m/min)
g : Gravitational Acceleration = 9.80665m/s^2

*1 The maximum rotation speed of the belt is the upper limit. This maximum speed varies depending on the conveyor type, power supply frequency, and gear head deceleration ratio.

3C. Max. Belt Speed at No-load

Formula 8

$$Vmax = [(Vm/i) \cdot (\pi \cdot DD/1000)] / (Pd1/Pd2)$$

Vmax : Max. Belt Speed (m/min)
Vm : Motor Synchronous Rotation Speed (rpm) [1500rpm@50Hz/1800rpm@60Hz]
i : Motor Gearhead Reduction Ratio
DD : Outer Diameter from Pulley Center to Belt Surface (mm)
Pd1/Pd2 : [Select from the gear ratio in unit for each conveyor model]

Calculation Example: As an example, calculate the safety ratio and the maximum speed of a belt for the conveyor "SVKA".

A. Calculate the pulley mass using Formula 1.

Pulley O.D. on Return Side =28.6mm
Pulley I.D. on Return Side =8.2mm
Pulley Length on Return Side =63mm
Wr ≈ 0.10 kg...From Formula 1

Pulley Unit Mass = 2.8g/cm^3
No. of Pulleys on Return Side =1
π: Pi (3.14159)

B. Calculate the effective tension of the belt using Formula 2.

Mass of Workpiece = 5kg
Belt Unit Mass = 1kg/m^2
Te = 20.42 N....From Formula 2

Unit Length =2000mm
Belt Width = 50mm

Friction Coefficient of Belt and Base Plate =0.4
Friction Coefficient of Belt and Pulley =0.2

C. Using Formula 3 and Formula 4, calculate the tight side tension of the belt "F_{M1}" and the initial tension by design "F_{M2}" to determine the maximum tension "F_M".

Friction Coefficient of Belt and Pulley =0.2
Initial Tension per Belt Unit = 0.15
F_{M1}≈43.76N F_{M2}≈27.92N
F_M = F_{M1} or F_{M2}, whichever is larger = F_{M1}
F_M ≈ 43.76 N...Determined from Formulae 3 and 4

Contact Angle of Belt and Pulley =3.14(rad)
Belt Width = 50mm

D. Calculate the safety ratio "S" from the maximum tension per belt unit "C" to compare the result with a given safety standard value.

C≈0.88
S ≈ 4.57...From Formula 5
When Safety Standard Value is "2", S > 2 ∴ Compliant

Safety Ratio S > Safety Standard Value: Compliant
Safety Ratio S < Safety Standard Value: NG

E. Calculate the belt speed under load using Formula 6 and Formula 7 and calculate the maximum belt speed at no-load using Formula 8 to verify that V is not greater than Vmax.

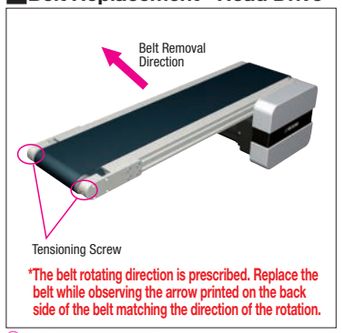
Motor Output = 6W
V = 8.41 m/min...From Formulae 6 and 7
Motor Synchronous Rotation Speed = 1500 rpm@50 Hz
Outer Diameter from Pulley Center to Belt Surface = 29.5 (Belt Thickness = 0.9)
Gear Ratio in Unit = 0.5
Vmax = 55.61 m/min ∴ V speed is compliant...Formula 8

Machine Efficiency = 0.5
Motor Gearhead Reduction Ratio = 5

Table 4 - Gear Ratio in Unit

Conveyor Type	Pd1/Pd2
SVKA	0.5
SVKB	0.5
SVKN	1
SVKR	1
CVGA	0.5
CVGB	0.5
CVGC	1
CVGD	1
CVGN	1
CVGP	1
CVGR	1
CVGW	1
CVSFA	0.5
CVSFC	0.5
CVSFB	1
CVSFD	1
CVSE	1
CVSF	1
CVSX	1
CVSY	1
CVMATM	2
CVMABM	2
CVMASM	1
CVMBTM	2
CVMBBM	2
CVMBSM	1
CVLSA	1
CVSJA	1
CVSMA	1
CVSMB	1
CVDSA	1
CVSTD	1
CVGTA	0.5
CVGTB	1
CVGTN	1
CVGTP	1
CVSTC	1
CVSTR	1
CVSPC	1
CVSPA	1
CVSSA	1
CVSA	0.5
CVSB	1
CVSC	0.5
CVSD	1
CVSN	1
CVSP	1
CVSR	1
CVSW	1
CVSTA	0.5
CVSTB	1
CVSTN	1
CVSTP	1

Belt Replacement ~Head Drive~

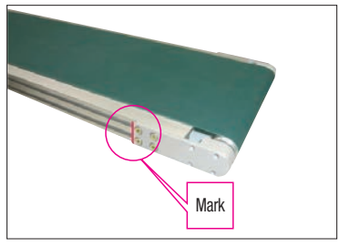


*The belt rotating direction is prescribed. Replace the belt while observing the arrow printed on the back side of the belt matching the direction of the rotation.

Applicable P/N: SVKA, SVKB

STEP1

Place a mark to note the existing tension condition. Do the same for the other side.

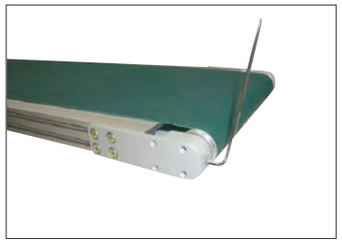


STEP2

Slightly loosen 4 pulley holder mounting screws. (Take caution that the pulley may fall off if the screws are completely loosened.) Do the same for the other side.

STEP3

Loosen the tensioning screws and completely remove. Do the same for the other side.

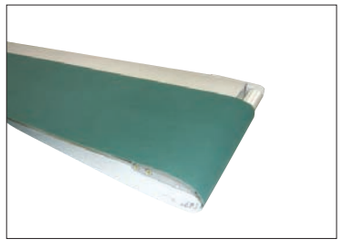


STEP4

Push both pulley holders towards the main body.

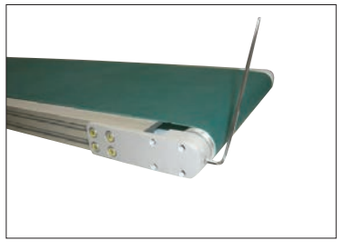
STEP5

Confirm the belt rotation direction and replace the belt.



STEP6

Tighten the tensioning screws (2 on both sides) to the position marked in Step 1 to adjust the tension. Perform this adjustment while checking for the parallelism between the pulley holder and the aluminum frame.



STEP7

Completely tighten 4 pulley holder screws. Tighten the 4 screws on the other side completely to complete.

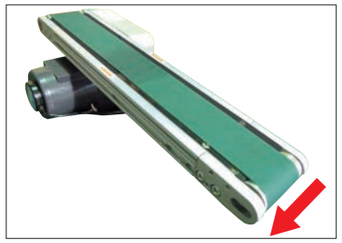
The belt will be stretched with use.
Perform maintenance on a periodic basis.

Belt Meandering Adjustment ~Head Drive~

Applicable P/N: CVGA, CVGB, SVKA, SVKB (CVGA in photo)

STEP1

While the belt is meandering to one side, start the conveyor. The meandering adjustment is done with the tensioning screw on the side the belt is deviated to.
Make sure to avoid contact of the side surface of the belt.

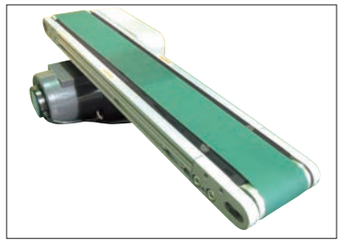


STEP2

First, loosen a nut on the tensioning screw, and gradually tighten the tension screw. If tighten excessively the unit will creep to the opposite side, then loosen.

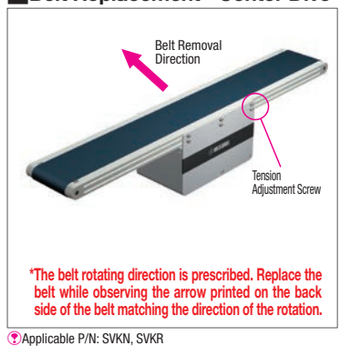
STEP3

Meandering will gradually disappear. Re-tighten the screws to complete. The belt will come to a stable state by leaving the conveyor in operation for a while after the adjustment.



Dedicated web site http://de.misumi-ec.com/contents/mech/product/cvs/
Conveyor selecting, component purchases, and easy search for maintenance parts are available.

■Belt Replacement ~Center Dive~



*The belt rotating direction is prescribed. Replace the belt while observing the arrow printed on the back side of the belt matching the direction of the rotation.

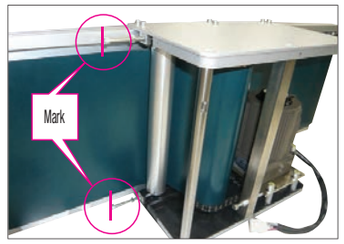
Applicable P/N: SVKN, SVKR

STEP1

Place the unit as the MISUMI logo faces downwards, and remove the 6 screws to remove the cover.

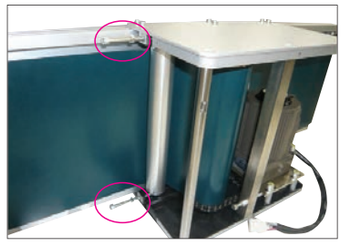
STEP2

Place a mark to note the existing tension condition.



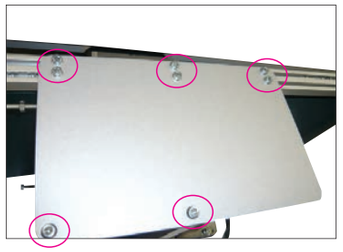
STEP3

Remove 2 tensioning screws and pull out the tensioning roller.



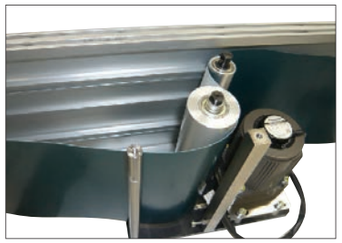
STEP4

Loosen 8 screws on the side plate, and lift the plate up straight to remove. (Take care that the pulley inside may fall)



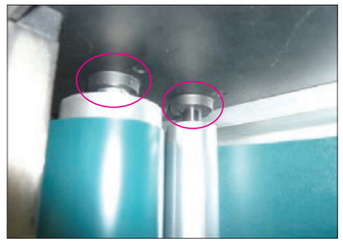
STEP5

Pull out the belt up, and replace the belt while confirming the correct rotation direction.



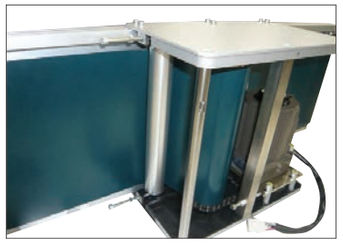
STEP6

After replacing the belt, replace the side plate from above. When mounting the side plate, ensure that 2 roller shafts are in the holes of the side plate.



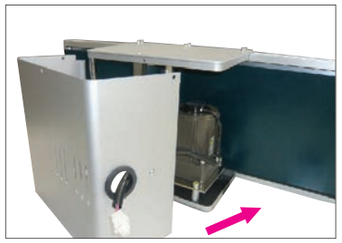
STEP7

Insert the tension adjustment rollers and return the 2 tensioning screws to the position marked in Step 2. Take care the belt does not deviate to one side.



STEP8

Run the wires through the wiring hole and replace the cover in the arrow direction, then tighten the 6 screws to complete.

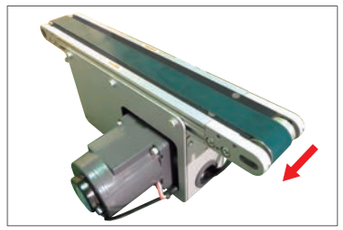


■Belt Meandering Adjustment ~Center Dive~

Applicable P/N: CVGN, CVGP, SVKN, SVKR (CVGN in photo)
No STEP3 for SVKN and SVKR.

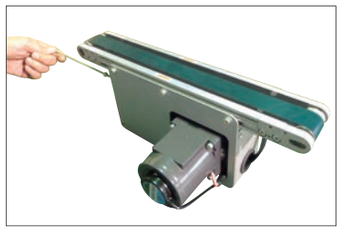
STEP1

While the belt is meandering to one side, start the conveyor. The meandering adjustment is done with the tensioning screw on the side the belt is deviated to.
Make sure to avoid contact of the side surface of the belt.



STEP2

First, loosen a nut on Center Drive tensioning screw, and gradually tighten the tension screw. If tighten excessively the unit will creep to the opposite side, then loosen.



STEP3

Next, adjust as shown previously with the Pulley Holder tensioning screw. As the belt meandering decreases and the parallelism is confirmed, re-tighten the nut to complete.

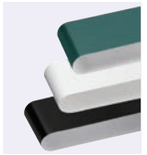
Conveyor Materials Overview

At MISUMI, conveyor parts are available for purchase as a separate item.

■ Conveyor parts represent the components that make up a conveyor.

Conveyor Parts Available from MISUMI

Conveyance Parts


■Flat Belt


■Stainless Steel Belts

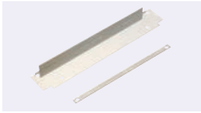

■Long Timing Belt Iron Rubber®


■Engineering Plastic Block Chains

Structural Parts


■Conveyor Aluminum Extrusion


■Pulley Holders for Conveyor


■Conveyor Belt Support Cover


■Motor Mounting Plates for Conveyor

Drive Parts


■Small Geared Motors / Gear Heads - Induction Motor


■Pulleys for Flat Belts


■High Torque Timing Pulleys - S3M


■Flanged Idlers with Teeth - S2M, S3M


■Sprocket Chains - 35B Series


■High Torque Timing Belts - S3M


■Rotating Shaft Straight Type


■Idlers for Flat Belts


■Coupling Oldham Set Screw Type

Internal Parts & Others


■Hex Posts - Both Ends Tapped


■Conveyor Connecting Blocks


■Conveyor Joint Plates


■Conveyor Belt Support Cover Reinforcements

Advantages of purchasing conveyor parts from MISUMI

Advantage 1 Maintenance

"Takes a long time to figure out the part numbers for maintenance."

➡ Part numbers can easily be searched on Conveyor Selection Site

Advantage 2 Remodeling

"We want to make the conveyor unit longer for the factory layout change"

➡ All the conveyor parts are available for separate item purchase on Conveyor Selection Site

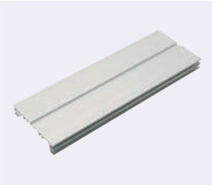
Advantage 3 In-house Manufacture of Conveyors

"Want to buy just the conveyor frame sections and manufacture the rest."

➡ Parts lineup available for conveyors manufactured in-house

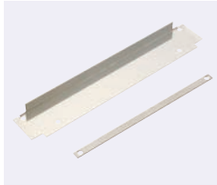
Lineup of Conveyor Parts

Conveyor Aluminum Extrusion

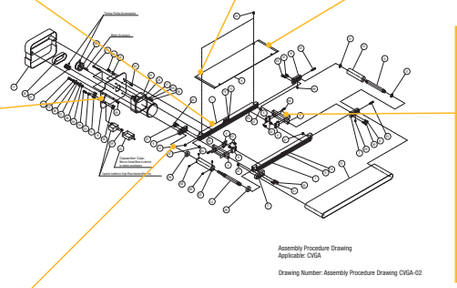


Motor Covers for Conveyor

Conveyor Belt Support Cover



Motor Mounting Plates for Conveyor



Conveyor Joint Plates

Pulley Holders for Conveyor

Pulleys, Idlers, Flat Belts, Round Belts Overview

■Pulleys and Idlers for Flat Belts

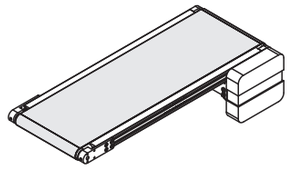
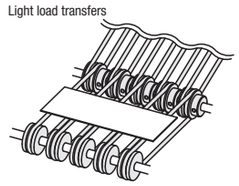
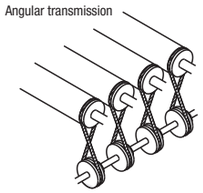
MISUMI pulleys and idlers for flat belts are offered in a wide variety of shapes and sizes.
You can choose the most suitable product for your needs, such as meandering and slip prevention.

[Pulleys and Idlers for Flat Belts List by Type]

	Belt Width (mm)		O.D. (mm)	Standard Type: Straight Type	Standard Type: Crowned	Standard Type: Crosspiece Groove Straight Type	Stainless Steel Belt: Crowned	Urethane Lined Type	Economy Type	Shaft Type
										
				Typical straight configuration. Flanged type can be selected.	Meandering preventing Crowned configuration. Flanged type can be selected.	Shape with groove for meandering prevention. Compatible with belt with crosspiece.	Crowned shape for meandering prevention.	Urethane lining is applied (partially press-fit) to prevent slip of the belt and the pulley.	Economical product with thin pipe.	Shaft integrated product. Contributes to reduction of the number of parts.
Pulley	Width Selection	6~32	15~100	P.√	P.√	-	-	P.√	-	-
	Width Configurable	25~100	15~80	-	P.√	P.√	-	P.√	-	P.√
		110~500	18~80	-	P.√	P.√	-	P.√	P.√	-
		40~160	50~100	-	-	-	P.√	-	-	-
Idler	Width Selection	6~32	15~50	P.√	P.√	-	-	-	-	-
	Width Configurable	25~100	15~80	P.√	P.√	P.√	-	-	-	-
		110~500	18~80	P.√	P.√	P.√	-	-	P.√	-
		40~160	50~100	-	-	-	P.√	-	-	-

■Flat Belts, Round Belts

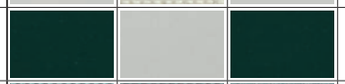
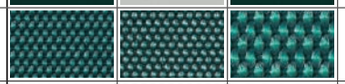
Flat Belts: 12 types of MISUMI flat belts are available - General Purpose, Sliding, Inclined Transfer, Grip Type, Oil Resistant, Heat Resistant, Non-Adhesive, Food Conveyor, Packaged Goods Conveyor, Electronic Parts Conveyor, Flat Belts with crosspieces, and Stainless Steel Types. Meandering Prevention Cross-piece Type is also available.
Round Belts: Five types of MISUMI round belts are available: Standard Type, High Tension Type, Conductive Type, Seamless Type and Hollow Rope Type.
Also, Welded Joint and Open End are selectable for Standard Type and High Tension Type.

	Flat Belts	Round Belts
App. Example		Light load transfers  Angular transmission 
	Flat Belts have rectangular cross section. These belts can transfer a variety of workpieces such as food / electronic parts / corrugated cardboard, etc.	Round Belts have cross section in round rope-form. These belts are easy to install and can be replaced without dismantling the machine thus making it easy to maintain.
Features	 General Purpose, Sliding, Inclined Transfer, Electronic Parts Transfer, Food Transfer, Heat Resistant, Oil Resistant, Non-Adhesive Wide range of specifications, ply count, colors, surface shapes are available	Welded Joint, Seamless, Open End  Standard, High Tensile Strength, Antistatic, Solid, Hollow
	Depending on applications, selection can be made from 12 types and 108 TYPEs.	Depending on applications, selection can be made from 5 types.
Applicable Belt Width/Dia.	5mm~500mm	Ø2~Ø15

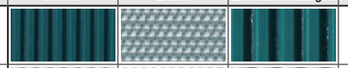
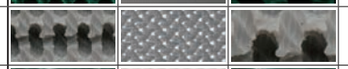
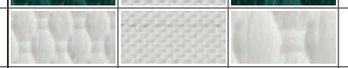
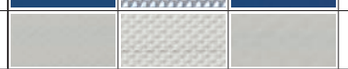
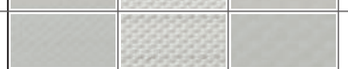
- **Cautions on Storing** (for safe use)
  - ・Avoid direct sunlight.
  - ・Store in a place with no rain fall.
  - ・Store in a place with humidity of less than 80%, temperature of 0 ~ 40°C.
  - ・Do not store in stacks and avoid hard bending during storage.
  - ・Do not place directly on the ground.
  - ・Avoid contact with oil and chemicals.

[Features of Round Belts]
Suitable for conveying lightweight objects. Flexible on designs such as multi-shafts transmission or right angle transmission.
High elasticity and hardness, and excels in abrasion resistance, oil resistance and weather resistance.
Not applicable to aromatic compounds (toluene, benzene, naphthalene, etc.). Avoid using or storing in humid locations.

Flat Belts
Belt Lineup

Usage	Type	Appearance			Min. Pulley Dia.	Material		Friction Coefficient (Ref. Against Polished Steel)	
		Front	Back	2x surface enlarged		Surface	Back	Front	Back
General Purpose	HBLT				25	Polyurethane	Polyester	0.2	0.1
	HBLTWH				25	Polyurethane	Polyester	0.15	0.1
	HBLTG HBLTDSG				15	Polyurethane	Polyester	0.8	0.2
	HBLTDSW				15	Polyurethane	Polyester	0.8	0.2
	HBLTDS				25	Polyurethane	Polyester	0.8	0.2
	HBLTGDN HBLTGSDSN				50	Thermoplastic Polyurethane	Polyester Canvas	0.6	0.2
	HBLBN HBLBDSN				15	Thermoplastic Polyurethane	Polyester Canvas	0.6	0.2
	HBLYGN HBLYGDSN				25(15)*1	Thermoplastic Polyurethane	Polyester Canvas	0.6	0.2
	HBLTGCN HBLTGCDSN				50	PVC	Polyester Canvas	1.0	0.2
	HBLTWCN HBLTWCDSN				50	PVC	Polyester Canvas	1.0	0.2
	HBLGT HBLGDST				120	PVC	Polyester Canvas	1.0	0.2
	HBLWT HBLWDST				120	PVC	Polyester Canvas	1.0	0.2
	HBTDST HBTDSTN				100	PVC	Polyester Canvas	1.0	0.2
Sliding	SHBLTG				25	Urethane Impregnated	Polyester	0.15	0.1
	SHBLT				25	Urethane Impregnated	Polyester	0.1	0.1
	SHBLTDSG				20	Polyester	Polyester	0.2	0.2
	SHBLTDSW				20	Polyester	Polyester	0.2	0.2
	SHBLTDS				40	Polyester	Polyester	0.2	0.2
	YSBLGN YSBLGDSN				30	Polyester Canvas	Polyester Canvas	0.2	0.2
	YSBLWN YSBLWDSN				30	Polyester Canvas	Polyester Canvas	0.2	0.2

*1: Number in ( ) is the value when allowable tension is 5N/mm.

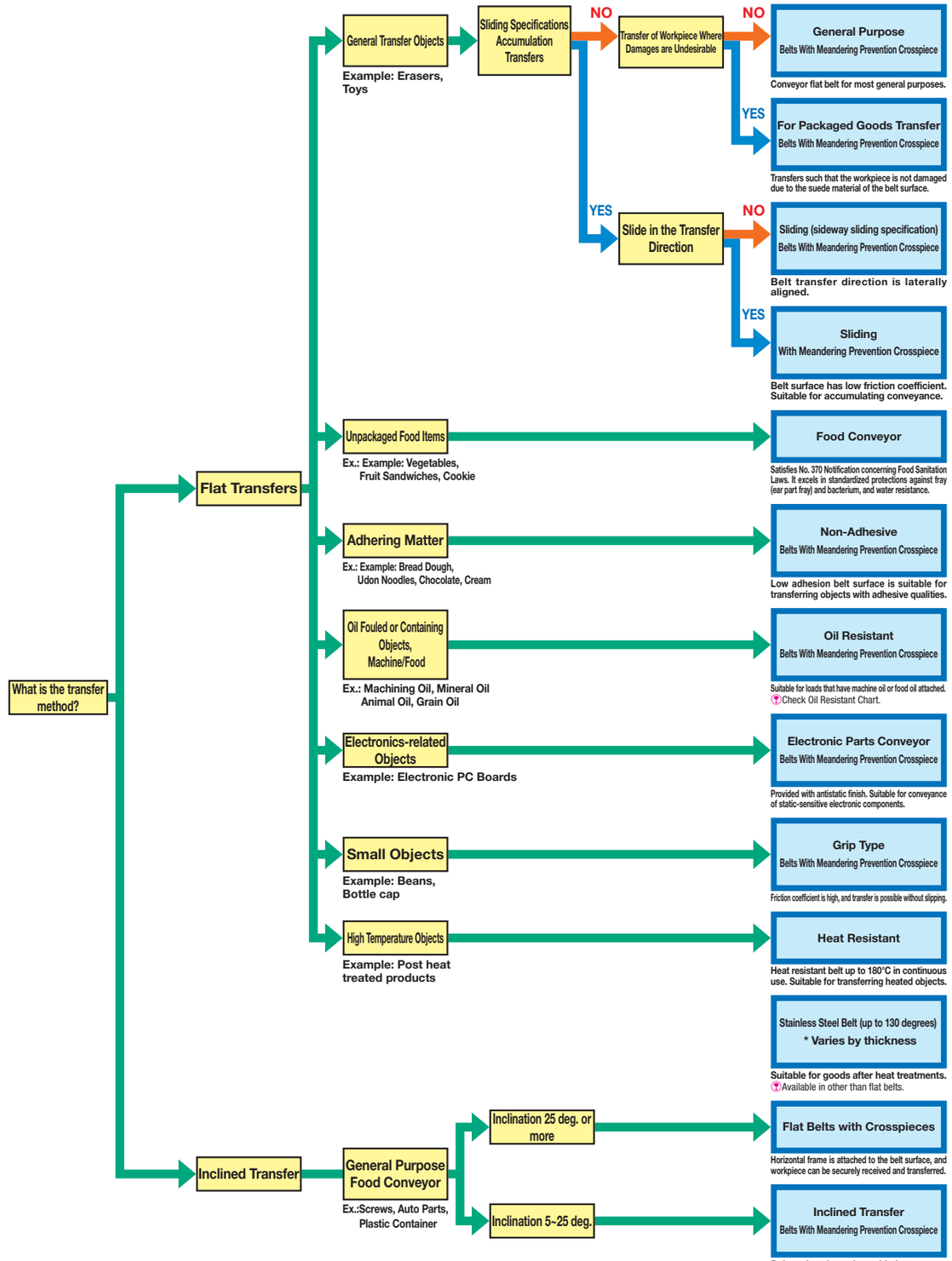
Usage	Type	Appearance			Min. Pulley Dia.	Material		Friction Coefficient (Ref. Against Polished Steel)	
		Front	Back	2x surface enlarged		Surface	Back	Front	Back
Inclined Transfer	LHBLT				30	Soft Polyurethane	Polyester	1.7	0.1
	LHBLTWH				30	Soft Polyurethane	Polyester	1.7	0.1
	LHBLTDSG				25	Polyurethane	Polyester	1.3	0.2
	LHBLTDSW				25	Polyurethane	Polyester	1.3	0.2
	LHBLWN LHBLWDSN				50(25)*1	Thermoplastic Polyurethane	Polyester Canvas	1.6	0.2
	LHBLYAN LHBLYADSN				80	PVC	Polyester Canvas	1.2	0.2
	LHBLGASN LHBLGDSN				100(70)*1	PVC	Polyester Canvas	1.1	0.2
	LHBLGAN LHBLGADSN				80	PVC	Polyester Canvas	1.2	0.2
	LHBLGTN LHBLGTDSN				80	PVC	Polyester Canvas	1.1	0.2
	LHBLYTN LHBLYTDSN				80	PVC	Polyester Canvas	1.1	0.2
	LHBLGYN LHBLGYDSN				50	Special Thermoplastic Elastomer	Polyester Canvas	2.0	0.2
	LHBLYFN LHBLYFDSN				75(50)*1	Special Thermoplastic Elastomer	Polyester Canvas	2.0	0.2
Grip Type	GBLG GBLDSG				15	Thermoplastic Polyurethane	Polyester Canvas	0.7	0.2
	GBLW GBLDSW				15	Thermoplastic Polyurethane	Polyester Canvas	0.7	0.2
	GBLGSN GBLGSDSN				25	Thermoplastic Polyurethane	Polyester Canvas	0.7	0.2
	GBLGDN GBLGDSN				50(20)*1	Thermoplastic Polyurethane	Polyester Canvas	0.7	0.2
	GBLWN GBLWDSN				50(20)*1	Thermoplastic Polyurethane	Polyester Canvas	0.7	0.2
Oil Resistant	OHBLTG OHBLTDSG				15	Oil Resistant Polyurethane	Polyester	0.8	0.2
	OHBLTGN OHBLTDS				25	Oil Resistant Polyurethane	Polyester	0.8	0.2
	OHBLT				25	Oil-Resistant Chloroethylene	Polyester	0.3	0.1
	OHBLTW OHBLTDSW				15	Thermoplastic Polyurethane	Polyester Canvas	0.6	0.2
	OHBLGN OHBLGDSN				25(15)*1	Thermoplastic Polyurethane	Polyester Canvas	0.6	0.2
	SOBLGN SOBLGDSN				15	Thermoplastic Polyurethane	Polyester Canvas	-	-
	KOBLGT KOBLGDST				20	Acrylonitrile-Butadiene Rubber	Cross-linked Polyurethane	-	-
Heat Resistant	HHBLT				75	Silicon Rubber	Polyester	1.5	0.1

*1: Number in ( ) is the value when allowable tension is 5N/mm.

Usage	Type	Appearance			Min. Pulley Dia.	Ⓜ Material		Friction Coefficient (Ref. Against Polished Steel)	
		Front	Back	2x surface enlarged		Surface	Back	Front	Back
Non-Adhesive	NSHBLT				25	Polyurethane	Polyester	0.2	0.15
	NSHBLTS NSHBLTDS				15	Polyurethane	Polyester	0.6	0.2
	NSHB NSHDSB				15	Thermoplastic Polyurethane	Polyester Canvas	0.6	0.2
	NSHBLG NSHBLGDS				15	Thermoplastic Polyurethane	Polyester Canvas	0.6	0.2
	NSHBWN NSHBWDSN				25(15)*1	Thermoplastic Polyurethane	Polyester Canvas	0.6	0.2
	NSHBN NSHBDSN				25(15)*1	Thermoplastic Polyurethane	Polyester Canvas	0.6	0.2
	NSHBLGN NSHBLGDSN				25(15)*1	Thermoplastic Polyurethane	Polyester Canvas	0.6	0.2
	HFHBG HFHBDSG				15	Thermoplastic Polyurethane	Polyester Canvas	0.4	0.2
	HFHBW HFHBDSW				15	Thermoplastic Polyurethane	Polyester Canvas	0.4	0.2
	HFHBGN HFHBGDSN				30(15)*1	Thermoplastic Polyurethane	Polyester Canvas	0.4	0.2
	HFHBWN HFHBWDSN				30(15)*1	Thermoplastic Polyurethane	Polyester Canvas	0.4	0.2
	BHFHBWN BHFHBWDSN				30(15)*1	Thermoplastic Polyurethane	Polyester Canvas	0.4	0.2
Food Conveyor	FHBLT				20	Polyurethane	Polyester	0.2	0.15
	KBLW KBLDSW				15	Thermoplastic Polyurethane	Polyester Canvas	0.6	0.2
	KBLT KBLTDSB				15	Thermoplastic Polyurethane	Polyester Canvas	0.6	0.2
	KBLWSN KBLWSDSN				25(15)*1	Thermoplastic Polyurethane	Polyester Canvas	0.6	0.2
	KBLWDN KBLWDSN				50	Thermoplastic Polyurethane	Polyester Canvas	0.6	0.2
	KBLWT KBLWDST				100	Thermoplastic Polyurethane	Polyester Canvas	0.6	0.2
	PHBLB PHBLDSB				20	Thermoplastic Polyurethane	Polyester Canvas	0.6	0.2
	PHBLBN PHBLBDSN				30	Thermoplastic Polyurethane	Polyester Canvas	0.6	0.2
	PHBLWN PHBLWDSN				30	Thermoplastic Polyurethane	Polyester Canvas	0.6	0.2
For Packaged Goods Transfer	FBLG FBLGDS				25	Suede Non-woven Fabric	Polyester Canvas	-	-
	FBLW FBLWDS				25	Suede Non-woven Fabric	Polyester Canvas	-	-
	FBLGN FBLGDSN				30	Suede Non-woven Fabric	Polyester Canvas	-	-
	FBLWN FBLWDSN				30	Suede Non-woven Fabric	Polyester Canvas	-	-
For Electronic Parts Transfer	DHBLT				25	Conductive Polyurethane	Polyester	0.2	0.1
	DHBLTS DHBLTDS				15	Conductive Polyurethane	Polyester	0.8	0.2
	DHBLGN DHBLGDSN				25(15)*1	Thermoplastic Polyurethane	Polyester Canvas	0.6	0.2

*1: Number in ( ) is the value when allowable tension is 5N/mm.

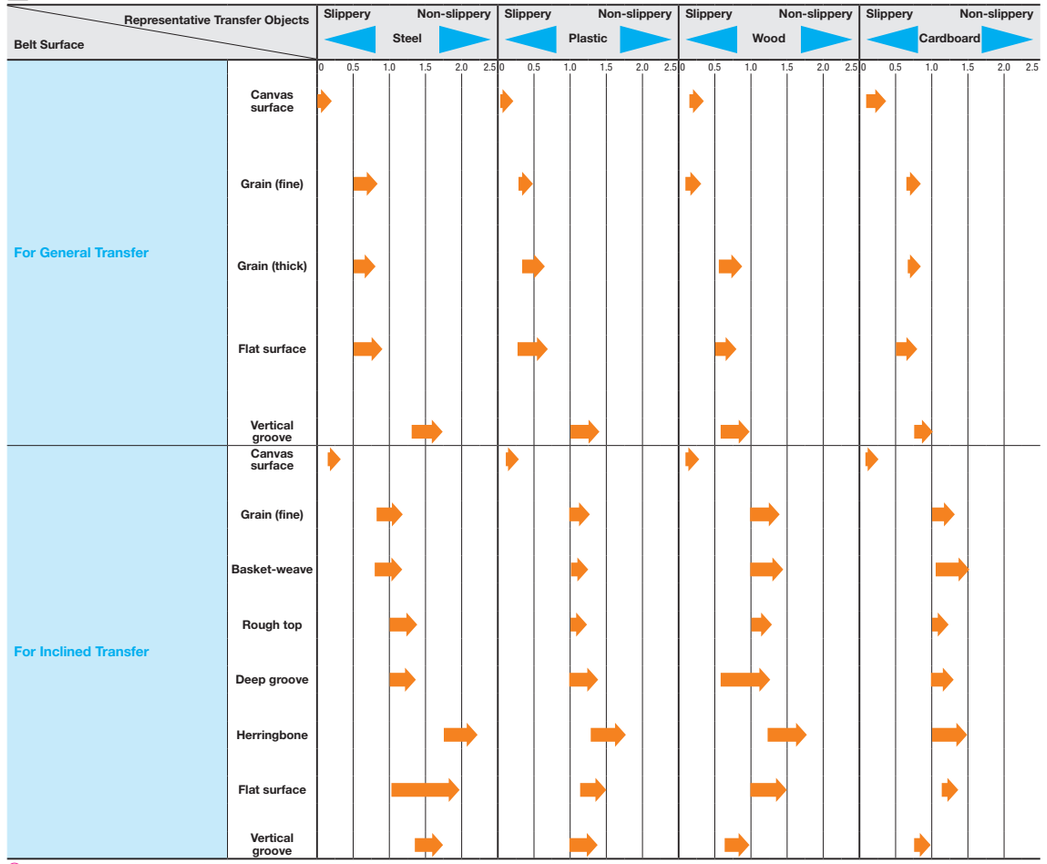
Flat Belts
Specification Selection Flow Chart



When the transfer weight is heavy (as a guide 10kg or more in width of 100mm), calculate the tension.
Example of transfer workpiece is a guide. For more information, check the Product page.
Performance Chart is mentioned on respective Product page. Determine if suitable to transfer workpiece.

Flat Belts
Technical Data1

Friction Coefficient Table



It is necessary to handle the above figures with care as the friction coefficient greatly varies with the surface condition (surface roughness), and, liquids such as water or adhesion degree of dust.

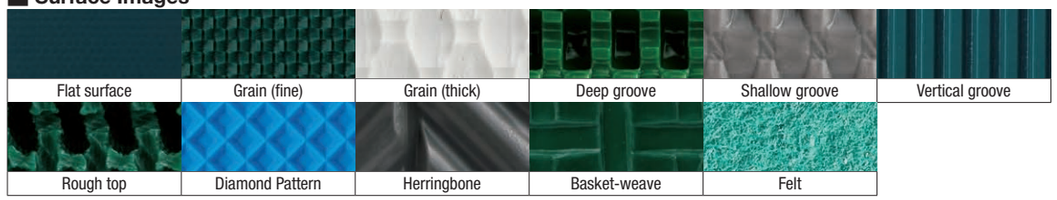
Max. Incline Angle

Unit (degree)

Surface Shape \ Load shape	Bulk goods: Powdered Objects	Bulk goods: Granulated Substances: Angulate	Bulk goods: Granulated Substances: Round	Bulk goods: Solid	Box: Cardboard: Empty	Box: Cardboard: 5kg	Bags: Paper	Bags: Plastic Bag
Flat surface	15	10	-	5	10 (20)	15 (25)	15 (25)	15 (15)
Canvas surface	15	10	-	5	10 (10)	10 (10)	10 (10)	10 (10)
Grain (fine)	20	15	-	5	25 (35)	30 (35)	25 (35)	25 (35)
Grain (thick)	25	15	5	5	30 (35)	30 (40)	30 (35)	30 (30)
Deep groove	30*	15	10	5	30 (40)	30 (40)	25 (40)	25 (45)
Shallow groove	30*	15	5	5	30 (40)	30 (40)	30 (35)	25 (25)
Vertical groove	20*	15	-	5	25 (40)	25 (40)	25 (40)	20 (35)
Rough top	30*	15	10	5	35 (40)	35 (40)	30 (40)	30 (30)
Diamond	20	15	-	5	10 (20)	15 (25)	15 (25)	10 (15)
Herringbone	30*	15	10	5	40 (50)	40 (50)	30 (40)	30 (30)
Basket-weave	20	15	-	5	25 (40)	25 (40)	25 (40)	20 (35)

* Data is presented on the assumption that belt surface is soiled with dust, etc.
For reference, data in case of clean belt surface is presented in ( ).
* Instances of being used for transfer of powdered objects are less, but are given for reference.

Surface Images

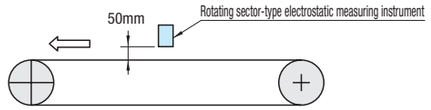


Flat Belts
Technical Data2

Antistatic Performance Chart

Electrostatic Charge Tendency

Small	←	Electrostatic Voltage	→	Large
Small	←	Tensile Strength of Belt	→	Large
Small	←	Belt Speed	→	Large
Large	←	Atmospheric humidity	→	Small



[Measurement Method]
Surface Resistance: ISO284 Compliant
Running Belt Electrostatic Voltage: ISO21179 Compliant

Item	Part Number	Surface Resistivity (Ω)	Running Belt Electrostatic Voltage (V) (Absolute value)
General Use Belts	HBLTDS	10^{12}~10^{14}	1000 or less
Antistatic Type Belts	DHBLTDS DHBLGN DHBLGDSN	10^{7} or less	50 or less
Other Belts	HBLTGCN HBLTGCDSN HBLTWCN HBLTWCDSN HBLGT HBLGDST HBLWT HBLWDST HBTDST HBTDSTN LHBLYAN LHBLYADSN LHBLGAN LHBLGADSN LHBLGYN LHBLGYDSN LHBLGTN LHBLGTDSN LHBLGASN LHBLGDSN LHBLYTN LHBLYTDSN	10^{12}~10^{14}	1000 or less

• DHBLT

Item		Unit	DHBLT
Electrical Resistance of Surface		Ω	10^{4}~10^{5}
Triboelectrical Voltage	* Test Condition A	V	10~20
	* Test Condition B		5~10

* Test Conditions
A: Belt Speed: 220m/min, Temperature: 21±0.5°C, Humidity: 70±1%
B: Belt Speed: 20m/min, Temperature: 18±0.5°C, Humidity: 50±1%
Listed values are not guaranteed values but an example set of measured values.

Minimum Pulley Diameter Selection Table

Minimum Pulley Dia., Driving Pulley Dia.

Identify the relevant pulley diameters by reading the width and length of the belt from the table below, and determine the smaller value as "minimum pulley diameter" and larger value as "drive pulley diameter".

[Table 1]
Minimum Pulley Diameter Selection Table (Belt Width)

Belt Width (mm)	Min. Pulley Dia. (Ømm): HBLT, HBLTWH SHBLTG, SHBLT DHBLT, FHBLT OHBLT, NSHBLT	LHBLT LHBLTWH	HHBLT
Less than 100	25	30	75
100~190	50	55	75
200~400	50	55	100
410~500	75	80	100

(Ex.) When the width is 150mm and the length is 5.00mm
Select from Width: 50 ··· Small Value → Min. Pulley Dia.
Select from Length: 75 ··· Large Value → Min. Driving Pulley Dia.

[Table 2]
Minimum Pulley Diameter Selection Table (Belt Length)

Belt Length (m)	Min. Pulley Dia. (Ømm): HBLT, HBLTWH SHBLTG, SHBLT DHBLT, FHBLT OHBLT, NSHBLT	LHBLT LHBLTWH	HHBLT
Less than 1.00	25	30	75
1.00~ 1.99	50	55	75
2.00~ 4.00	50	55	100
4.01~ 7.00	75	80	100
7.01~10.00	100	105	125
10.01~20.00	100	105	150

Flat Belt Tolerance Chart

Width tolerance

Width	Tolerance
~400	±2
401~500	±3

Thickness tolerance

Thickness	Tolerance	Joint tolerance
~1.0	±0.1	±0.3
1.1~1.5	±0.2	
1.6~2.0		
2.1~5.5	±0.4	

Length tolerance

Length	Tolerance
~ 2000	±10
2001~ 7000	±20
7001~10000	± 0.3%
10001~	± 0.3%

Permanent elongation of the belt is up to 1% for the overall length. (Reference value)

Flat Belts
Oil Resistance and Chemical Resistance

Type	Chemical Name	General Use / Sliding	Grip Type / Electronic Parts Conveyor	Non-Adhesive	Food Conveyor	Oil Resistant	Sliding	Inclined Transfer	General Use / Inclined Transfer	Inclined Transfer
		HBLTG HBLTDSG HBLW HBLTDSW HBLTDS HBLTGDN HBLTGSDSN HBLYGN HBLYGDSN HBLBN HBLBDSN SHBLTDSG SHBLTDS	GBLG GBLDSG GBLGSN GBLGSDSN GBLGDN GBLGDSN GBLW GBLDSW GBLWN GBLWDSN DHBLTS DHBLTDS DHBLGN DHBLGDSN	NSHBLTS NSHBLTDS NSHB NSHDSB NSHBLG NSHBLGDS NSHBWN NSHBWDSN NSHBN NSHBDSN NSHBLGN NSHBLGDSN HFHBG HFHBDSG HFHBW HFHBDSW HFHBGN HFHBGDSN HFHBWN HFHBWDSN	KBLW KBLDSW KBLT KBLTDSB KBLWSN KBLWSDSN KBLWDN KBLWDSN KBLWT KBLWDST PHBLB PHBLDSB PHBLBN PHBLBDSN PHBLWN PHBLWDSN BHFHBWN BHFHBWDSN	OHBLTG OHBLTDSG OHBLTGN OHBLTDS OHBLTW OHBLTDSW OHBLGN OHBLGDSN	YSBLGN YSBLGDSN YSBLWN YSBLWDSN	LHBLTDSG LHBLTDSW LHBLWN LHBLWDSN	HBLGT HBLGDST HBLWT HBLWDST HBLTGCN HBLTGCDSN HBLTWCN HBLTWCDSN HBTDST HBTDSTN LHBLGTN LHBLGTDSN	LHBLYAN LHBLYADSN LHBLGAN LHBLGADSN LHBLGYN LHBLGYDSN LHBLGASN LHBLGDSN LHBLYTN LHBLYTDSN LHBLGYN LHBLGYDSN
Cooking Oil	Linseed Oil	0				+	+	+	+	--
	Corn Oil	0				+	+	+	+	-
	Animal Oil	+				+	+	+	+	0
	Vegetable Oil	+				+	+	+	+	0
	Coconut Oil (Palm Oil)	0				+	+	+	+	0
Machine Oil	ASTM No.1 Oil	+				+	+	+	+	--
	ASTM No.2 Oil	+				+	+	+	+	--
	ASTM No.3 Oil	+				+	+	+	+	--
	DOS	0				+	0	+	+	--
	Grease	+				+	+	+	0	0
	Paraffin Oil	+				+	+	+	+	+
	Machining Oil	--				+	--	+	+	--
Others Fats	Glycerin	+				+	+	+	+	+
	Mineral Oil	+				+	+	+	+	--
	Dibutyl Phthalate	0				0	0	0	--	--
Antiseptic Solution	Sodium Chlorate	+				+	+	+	+	+
	Hydrogen Chloride	0				0	0	0	+	+
	Hypochlorite Soda 400ppm	+				0	+	+	+	0
	Electrolytic Hypochlorite Water 400ppm	+				0	+	+	+	0
Solvent	Acetaldehyde	--				--	--	--	0	0
	Acetone	--				--	--	--	--	--
	Amyl Alcohol	+				+	+	+	--	--
	Isooctane	+				+	+	+	0	0
	Isopropyl Alcohol	+				+	+	+	0	0
	Isopropyl Ether	0				0	0	0	--	--
	Ethyl Alcohol	+				+	+	+	0	0
	Ethylether (Ether)	--				--	--	--	--	--
	Gasoline	--				--	--	--	--	--
	Xylene (Xylol)	--				--	--	--	--	--
	Cresol	--				--	--	--	--	--
	Chloroform	--				--	--	--	--	--
	Kerosene	+				+	+	+	0	--
	Aluminium Acetate	--				--	--	--	--	--
	Ethyl Acetate	--				--	--	--	--	--
	Butyl Acetate	--				--	--	--	--	--
	Carbon Tetrachloride	0				0	0	0	--	--
	Cyclohexane	--				--	--	--	--	--
	Dimethylformamide (DMF)	--				--	--	--	--	--
	Petroleum	+				+	+	+	0	0
	Trichloroethylene	--				--	--	--	--	--
	Toluene (Triol)	--				--	--	--	--	--
	Nitrobenzene	--				--	--	--	--	--
	Carbon Disulfide	--				--	--	--	--	--
	Perchlorethylene	--				--	--	--	--	--
	Butyl Alcohol (Butanol)	+				+	+	+	0	0
	Hexane	0				+	+	+	--	--
	Heptane	+				+	+	+	0	0
	Benzene (Benzol)	--				--	--	--	--	--
	Benzaldehyde	--				--	--	--	--	--
	Formaldehyde (Formalin) 37%	--				--	--	--	+	+
	Methyl Alcohol (Methanol)	+				+	+	+	0	0
	Methylethylketone (MEK)	--				--	--	--	--	--
	Thinner (generic)	--				--	--	--	--	--
Acidic chemicals	Adipic Acid	+				+	0	+	+	+
	Benzoic Acid	--				-	--	--	-	-
	Zinc Chloride	+				+	+	+	+	+
	Acetyl Chloride	--				--	--	--	0	--
	Amyl Chloride	--				--	--	--	0	--
	Aluminum Chloride	+				0	0	0	0	0
	Chloroethane	--				--	--	--	--	--
	Calcium Chloride	+				+	+	+	+	+
	Ferrous Chloride*	+				+	+	+	+	+
	Ferric Chloride*	+				+	+	+	+	+
	Ethylene Chloride	+				+	+	+	+	+
	Hydrochloric Acid 5%	+				--	--	--	+	+
	Chlorine Gas	--				--	--	--	--	--
	Chlorine Water Solution	--				--	--	--	+	+
	Oleic Acid	+				+	+	+	+	0
	Formic Acid	--				--	--	--	+	--
	Citric Acid	+				+	+	+	+	--
	Glycolic Acid	+				+	+	+	+	--

* Not applicable when used as liquid.

+: Applicable, 0: May be applicable. --: Not applicable

Type	Chemical Name	General Use / Sliding	Grip Type / Electronic Parts Conveyor	Non-Adhesive	Food Conveyor	Oil Resistant	Sliding	Inclined Transfer	General Use / Inclined Transfer	Inclined Transfer
		HBLTG HBLTDSG HBLW HBLTDSW HBLTDS HBLTGDN HBLTGSDSN HBLYGN HBLYGDSN HBLBN HBLBDSN SHBLTDSG SHBLTDS	GBLG GBLDSG GBLGSN GBLGSDSN GBLGDN GBLGDSN GBLW GBLDSW GBLWN GBLWDSN DHBLTS DHBLTDS DHBLGN DHBLGDSN	NSHBLTS NSHBLTDS NSHB NSHDSB NSHBLG NSHBLGDS NSHBWN NSHBWDSN NSHBN NSHBDSN NSHBLGN NSHBLGDSN HFHBG HFHBDSG HFHBW HFHBDSW HFHBGN HFHBGDSN HFHBWN HFHBWDSN	KBLW KBLDSW KBLT KBLTDSB KBLWSN KBLWSDSN KBLWDN KBLWDSN KBLWT KBLWDST PHBLB PHBLDSB PHBLBN PHBLBDSN PHBLWN PHBLWDSN BHFHBWN BHFHBWDSN	OHBLTG OHBLTDSG OHBLTGN OHBLTDS OHBLTW OHBLTDSW OHBLGN OHBLGDSN	YSBLGN YSBLGDSN YSBLWN YSBLWDSN	LHBLTDSG LHBLTDSW LHBLWN LHBLWDSN	HBLGT HBLGDST HBLWT HBLWDST HBLTGCN HBLTGCDSN HBLTWCN HBLTWCDSN HBTDST HBTDSTN LHBLGTN LHBLGTDSN	LHBLYAN LHBLYADSN LHBLGAN LHBLGADSN LHBLGYN LHBLGYDSN LHBLGASN LHBLGDSN LHBLYTN LHBLYTDSN LHBLGYN LHBLGYDSN
Acidic chemicals	Chromic acid	--				--	--	--	0	0
	Acetic Acid 10%	--				--	--	--	0	0
	Bromine	--				--	--	--	--	--
	Oxalic acid 20%	+				0	+	0	+	+
	Tartaric acid	+				0	0	0	0	0
	Nitric Acid 5%	--				--	--	--	+	+
	Nitric Acid 20%	--				--	--	--	--	--
	Ammonium Nitrate	+				+	+	+	+	+
	Calcium Nitrate	+				+	+	+	+	+
	Stearic Acid	+				+	+	+	+	+
	Trichloroisocyanuric acid	--				--	--	--	0	--
	Lactic Acid	+				+	+	+	+	+
	Fuming Sulfuric Acid	--				--	--	--	--	--
	Picric acid 10%	--				--	--	--	--	--
	Phenol (Carbolic acid)	--				--	--	--	--	--
	Boric acid	+				+	+	+	+	+
	Maleic acid	0				--	--	--	0	0
	Iodine solution	+				+	+	+	+	+
	Sulfuric Acid 50%	--				--	--	--	0	0
	Phosphoric Acid 80%	--				--	--	--	0	0
Basic chemicals	Aniline	--				--	--	--	--	--
	Ammonia gas	+				0	+	0	+	+
	Ammonia water solution	+				0	+	0	+	+
	Sodium Hydroxide (Sodium Hydroxide) 10%	--				--	--	--	0	0
	Sodium Chromate	+				+	+	+	0	0
	Developer (Hydroquinone)	+				+	+	+	+	+
	Sodium Acetate	+				+	+	+	+	+
	Sodium Bicarbonate	+				+	+	+	+	+
	Ammonium Hydroxide	+				0	0	0	+	+
	Potassium Hydrate	--				--	--	--	0	0
	Urea	0				--	--	--	0	0
	Sodium Sulfide	--				--	--	--	--	--
	Trisodium Phosphate 10%	+				+	+	+	+	+
Others Chemical	Antimony Salt	+				+	+	+	+	+
	Sulfur	+				+	+	+	+	+
	Sodium Chloride (Salt)	+				+	+	+	+	+
	Ozone	+				+	+	+	+	+
	Zinc Acetate	+				+	+	+	+	+
	Ammonium Acetate	+				+	+	+	+	+
	Lead Acetate	+				+	+	+	+	+
	Oxygen	+				+	+	+	+	+
	Salt Water (Seawater)	+				+	+	+	+	+
	Sodium Acid Sulfate	+				0	+	0	+	+
	Silver Nitrate	+				+	+	+	+	+
	Ferrous Nitrate	+				+	+	+	+	+
	Sodium Sulfate	+				+	+	+	+	+
	Calcium Hydroxide	+				+	+	+	+	+
	Steam (80°C or less)	+				0	0	0	0	0
	Soap	+				+	+	+	+	+
	Ammonium Carbonate	+				+	+	+	+	+
	Sodium Carbonate	+				+	+	+	+	+
	Sodium Thiosulfate (Hypo)	+				+	+	+	+	+
	Neutral Salts	+				+	+	+	+	+
	Sulfur Dioxide	0				0	0	0	+	+
	Nickel Salt	+				+	+	+	+	+
	Fertilizer (general)	+				+	+	+	+	+
	Freon gas	0				--	--	--	--	--
	Propane	+				+	+	+	+	+
	Polystyrene	+				+	+	+	--	--
	Magnesium Salt	+				+	+	+	+	+
	Aluminum Sulfide	+				+	+	+	+	+
	Ammonium Sulfide	+				+	+	+	+	+
	Hydrogen Sulfide	--				--	--	--	+	+
	Zinc Sulfate	+				+	+	+	+	+
	Aluminum sulfate	+				+	+	+	+	+
	Ammonium Sulfate	+				+	+	+	+	+
	Calcium Sulfate	+				+	+	+	+	+
	Ferric Sulfate	+				+	+	+	+	+
	Sodium Sulfate	+				+	+	+	+	+
	Potassium Phosphate	+				+	+	+	+	+
	Sodium Acid Phosphate	+				+	+	+	+	+

If the belt is used in a condition wherein it comes in contact with salty water, for eg. sea water, and the belt repeatedly gets (wet ←→ dry), salt crystals are formed inside the belt and the belt contracts.
Same phenomenon can occur when any powder (flour, etc.) is rubbed over the reverse side of the belt.

+: Applicable, 0: May be applicable. --: Not applicable

Check the Core Body for Allowable Tension

Check the selected belt core body for adequacy of the corresponding allowable stress, by going through the following steps.

[Step 1] Calculating the Effective Tension

The effective tension of a belt can be calculated using Formula 1.

Formula1 $F=f(W_G+W_1+W_2)L+f(W_1+W_3)L\pm W_G \cdot H$

(Carrier Side) (Return Side) (Vertical Side)

F: Effective Tension

f: Rolling friction coefficient of rollers, or friction coefficient between belt and supports (Select from Table -1)

ωG: Weight of Carried Materials per Meter of Belt (kg/m)

ω1: Weight of belt per Meter (kg/m)

ω2: Carrier Roller Weight per 1m (kg/m) (Select from Table -2)

ω3: Return Roller Weight per 1m kg/m (Select from Table -2)

L: Conveyor Horizontal Length (m)

H: Vertical Height (+Up angle, -Down angle) (m)

Table of f Values (Table 1)

Belt Surface in Contact with Supports	Smooth	Cloth Surfaced
Roller Support	0.05	0.05
Roller+Steel Plate Support	0.2	0.3
Steel Supported (SUS·SS)	0.4	0.5
Plywood Support	0.5	0.6

(When knife edges are used, add 0.2 to the above values in Table -1.)

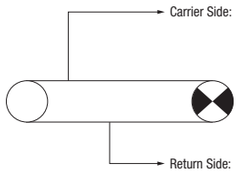


Table of Roller Weight (Table 2)

Roller Dia. (mm)	Single Roller (kg/roller)	Allowable Load (kg/roller)
28.6	0.2	50

Table-2 shows the weight of the revolving parts of a roller that meets (JISB8805-1965).
For accurate calculation, check the actual weight of the roller being used.

[Step 2] Power Requirement

Formula 2 $P=\frac{F \cdot V}{60000}$

P: Power Requirement kW
F: Effective Tension N
V: Belt Speed m/min
60000: 60×102 (Constant)

[Step 3] Motor Power

Formula 3 $Pm=\frac{P}{\eta}$

Pm: Motor Power kW
P: Power Requirement kW
η: Mechanical Efficiency
(Standard Mechanical Efficiency Range: 0.5~0.65)

The motor with 0.1kW or less output may encounter the power shortage phenomenon.
Thus, check the motor for its characteristics before use.

[Step 4] Using the Tension on the Loose Side to Calculate Maximum Tension

Formula 4 $F_{M1}=F \cdot K$

FM1: Maximum Tension N
F: Effective Tension N
K: Coefficient

Based on the value μ selected from Table-3 and the wrap angle (θ), select value K from Table-4.
(When the wrap angle (θ) is not listed in Table 4, calculate as follows)

$K=\frac{e^{\mu\theta'}}{e^{\mu\theta'}-1}$

μ: Friction coefficient between driving pulley and belt (Select from Table-3)
e: Base of Natural Logarithm (2.718)
θ': Radian ($\theta'=\theta\times\frac{2\pi}{360}$)

List of μ values (Table-3)

Pulley Surface \ Surface Shape in Contact with Pulley		Smooth	Cloth Surfaced
Bare Steel Pulley	Dry	0.2	0.3
	Wet	0.15	0.2
Rubber Ranking Pulley	Dry	0.3	0.35
	Wet	0.2	0.25

Table of Value K Based on Wrap Angle (θ) (Table-4)

θ° \ μ	0.1	0.15	0.2	0.25	0.3	0.35	0.5
180	3.8	2.7	2.2	1.9	1.7	1.5	1.3
190	3.6	2.6	2.1	1.8	1.6	1.5	1.3
200	3.4	2.5	2.0	1.8	1.6	1.5	1.3
210	3.3	2.4	2.0	1.7	1.5	1.4	1.2
220	3.2	2.3	1.9	1.7	1.5	1.4	1.2
230	3.1	2.3	1.9	1.6	1.4	1.4	1.2

[Step 5] Using Pretension to Calculate Maximum Tension

Formula 5 $F_{M2}=F+B \cdot T_C$

FM2: Maximum Tension (N)
B: Belt Width (mm)
TC: Initial Tension (N/mm)
(Select from Table-5)

Table of Tc Values (Table-5)

No. of Tension Members (No. of Plys)	1 Pc.	2 Pcs.	3 Pcs.
Initial Tension (N/mm)	0.15	0.30	0.45

Compare F_{M1} (Formula 4) and F_{M2} (Formula 5), and regard the larger as the Max. Tension FM.

[Step 6] Allowable Stress

Formula 6 $C\geq\frac{F_M}{B}$

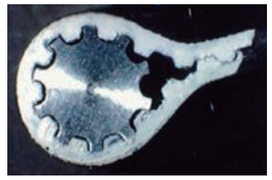
C: Allowable Stress for Belt N/mm
FM: Effective Tension kg
B: Belt Width mm

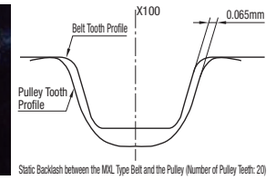
When the allowable stress for the belt being used is equal to or higher than the maximum tension per 1cm width of the belt as expressed by Formula 6 above, the belt is suitable for use.

Features of GT Belts

- The tooth engagements occur based on involute motion that closely assimilates the profiles of both teeth, thus minimizing backlash and making the scheme suitable for high accuracy positioning applications.
  * Backlash means the clearances between the belt tooth surface and the pulley tooth surface when engaged.

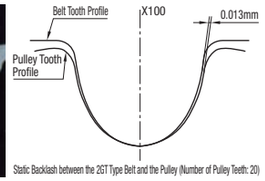
MXL (10 Toothed, Ø6.47mm)





Static Backlash between the MXL Type Belt and the Pulley (Number of Pulley Teeth: 20)

2GT (10 Toothed, Ø6.37mm)

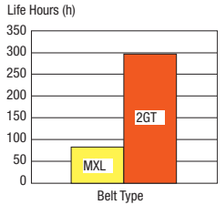


Static Backlash between the 2GT Type Belt and the Pulley (Number of Pulley Teeth: 20)

Performance Comparison between MXL and 2GT Belts

Reference①: Durability

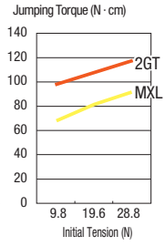
<Performance Conditions>
Number of belt teeth: 126
Belt Width: 9.5mm
Number of Pulley Teeth: 12 (2GT)
: 14 (MXL)
Speed: 7,900rpm
Load Torque: 24.3Nm



Reference②: Jumping Torque Capability

<Performance Conditions>
Number of belt teeth: 126
Belt Width: 4.8mm
Number of Pulley Teeth: 20 (2GT)
: 20 (MXL)
Speed: 1,130rpm
Tooth Height
MXL: 0.51mm 2GT: 0.75mm

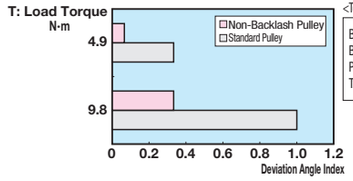
*Jumping Torque represents the max. torque when a jumping occurs.



Features of Non-backlash Pulleys (S8M)

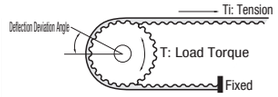
- Non-backlash pulley has reduced backlash compared to conventional type to work with high accuracy positioning mechanism.
- Backlash is significantly smaller than standard S8M pulleys. (The amount reduced depends on applications.)
- Use regular S8M timing belt.

Reference: Comparison of Deviation Angles between Non-Backlash Pulleys and Standard Pulleys

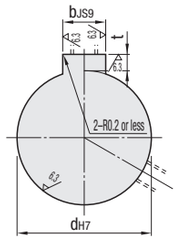


<Test Conditions>

Belt Type	:S8M
Belt Width	:25mm
Pulley Size	: 30 Toothed (P.D.76.39mm)
Tension Ti	:382N



Keyway Dimensions



N: New JIS (B1301) Keyway Dimensions

Nominal	dH7		bJS9		t Tolerance	
N 8	8	+0.015 0	3	±0.0125	1.4	+0.1 0
N10	10					
NK10	10					
N11	11	+0.018 0	4	±0.0150	1.8	
N12	12					
N13	13					
N14	14		5		2.3	
N15	15					
N16	16					
N17	17					
N18	18		6		2.8	
N19	19	+0.021 0				
N20	20					
N21	21					
N22	22					
N23	23		8	±0.0180	3.3	+0.2 0
N24	24					
N25	25					
N26	26					
N27	27					
N28	28					
N29	29					
N30	30					
N31	31	+0.025 0	10			
N32	32					
N33	33					
N34	34					
N35	35					
N36	36					
N37	37					
N38	38					

Nominal	dH7		bJS9		t Tolerance	
N39	39	+0.025 0	12	±0.0215	3.3	+0.2 0
N40	40					
N41	41					
N42	42					
N43	43					
N44	44		14		3.8	
N45	45					
N46	46					
N47	47					
N48	48					
N49	49					
N50	50					
N55	55	+0.030 0	16		4.3	
N60	60		18		4.4	
N61	61					
N62	62					
N63	63					
N64	64					
N65	65					
N66	66		20	±0.0260	4.9	
N67	67					
N68	68					
N69	69					
N70	70					

C: Old JIS Keyway Dimensions

DH7 Shaft Bore Dia. and Code	bF7		t Tolerance	
C10	4	+0.022 +0.010	1.5	+0.1 0
C12				
C15	5		2	
C16				
C18				
C19				
C20				
C30	7	+0.028 +0.013	3	
C33	10		3.5	
C34				
C35				
C36				
C37				
C38				
C39				
C40				
C41	12	+0.034 +0.016		
C42				
C43				
C44				
C45				
C50				
C55	15		5	
C60	18		6	
C61				
C62				
C63				
C64				
C65				
C66				
C67				
C68				
C69				
C70				

Cautions

- Do not bend belts too hard.
- When core wire is steel cord, avoid giving tension from the backside.
- Avoid using and storing the products in an environment of extremely high or low temperature (beyond the operating temperature) and high humidity.
- Avoid direct contact with water, solvent, oil, acid, alkali, ultra-violet light, ozone, etc. If the belt swells due to contact with oil, its service life will be considerably shortened.
- Make sure to shut down the machine and confrm the complete stop of its behavior before starting installation or maintenance check.
- Timing Pulleys and Belts (MXL XL, L, H) for general use are compliant with JIS and ISO Standards.
  Timing Pulleys: JIS B 1856(ISO5294)
  Timing Belts: JIS K6372 (ISO5296-1), JIS K6373 (ISO5296-2)
- S Type (S□M) timing pulleys and belts are compatible with S□M type from Mitsuboshi Belting Ltd. as well as Bando Chemical Industries Ltd.
- MTS Type (MTS8M) timing belts are compatible with MTS8M from Mitsuboshi Belting Ltd.
- P Type (P□M) timing pulleys and belts are compatible with P□M Type from Tsubakimoto Chain Co.
- UP Type (UP□M) timing belts are compatible with UP□M-HC Type from Tsubakimoto Chain Co.
- MA Type timing pulleys and belts are compatible with MA□Type from NOK Corporation.
- GT Type (□GT) and EV Type (EV5GT, EV8YU) timing pulleys and belts are compatible with□GT, EV5GT, EV8YU Types from Gates Unitta Asia Company.

Timing Belt
Selection of Transmission Timing Belts 1

[Step 1] Setting the Required Design Conditions

(1) Machine Type (2) Power Transmission (3) Load Variances (4) Operation Duration per Day (5) Small Pulley Rotational Speed
(6) Rotation Ratio (Lg. Pulley # of Teeth / Small Pulley # of Teeth) (7) Shaft Center Distance (Interim) (8) Pulley Diameter Limitation (9) Other Usage Conditions

[Step 2-a] Calculating Design Power……MXL/XL/L/H/S_M/MTS_M/T Series

•Design Power (Pd) =Transmission Power (Pt) x Overload Factor (Ks)
· Calculate Transmission Power at Motor Rated Power Output. (It is ideal to calculate from the actual load applied to the belt.)
· Overload Factor (Ks)=Ko+Kr+Ki
Overload Factor (Ks)=Lo+Kr+Ki

Ko : Overload Correction Factor (Table 1)
Kr : Rotation Ratio Correction Factor (Table 2)
Ki : Idler Correction Factor (Table 3)

* When converting the torque (Tq) into transmission power (Pd), calculate the applicable values by using the following expressions.
Torque (Tq) = tqxKs
Transmitting Power (Pd) = Tqxn/9550

Tq : Design Torque (N·m)
tq : Transmission Torque
Ks : Overload Factor
Pd : Design Power (kW)
n : Speed (rpm)

i. If the maximum torque is used once or twice per day,
calculate the design power by assigning "the load correction factor (Ko) = 1.0" to the expression for the overload factor and then, by multiplying the maximum torque by the overload factor (Ks) derived from the said expression.

ii. If the maximum torque is used very often,
calculate the design power by multiplying the maximum torque by the applicable overload factor (Ks).

<For Timing Belts based on Spindle Motor>
Calculate the design power by calculating the transmission power from the basic rotation speed and then, by multiplying it by the applicable overload factor (Ks).

<For Timing Belts based on Linear Drive>
Calculate the design power by using the following expressions.
$Te=m\times\alpha$
$Pt=Te\times V/1000$
$Pd=Pt\times Ks$

Te : Effective Tension (N)
m : Mass (g)
α : Acceleration (m/sec^2)
V : Belt Speed (m/sec)
Pt : Transmission Power (KW)
Pd : Design Power (kW)
Ks : Overload Factor

Table 1. Load Correction Factor (Ko)

Typical Machines Using a Belt	Motor					
	Max. Output not Exceeding 300% of Rated Value			Max. Output Exceeding 300% of Rated Value		
	AC Motor (Standard Motor, Synchronous Motor) DC Motor (Shunt), Engine with 2 or More Cylinders			Special Motor (High torque), Single-Cylinder Engine DC Motor (Series), Operation with Lye Shaft or Clutch		
	Operation Hours			Operation Hours		
	Intermittent use 1 Day 3 to 5 hrs	Regular Use 1 Day 8 to 12 hrs	Continuous Use 1 Day 8 to 12 hrs	Intermittent use 1 Day 3 to 5 hrs	Regular Use 1 Day 8 to 12 hrs	Continuous Use 1 Day 8 to 12 hrs
Exhibit Instrument, Projector, Measuring Instrument, Medical Machine	1.0	1.2	1.4	1.2	1.4	1.6
Cleaner, Sewing Machine, Office Machine, Carpentry Lathe, Belt Sawing Machine	1.2	1.4	1.6	1.4	1.6	1.8
Light Load Belt Conveyor, Packer, Sifter	1.3	1.5	1.7	1.5	1.7	1.9
Liquid Mixer, Drill Press, Lathe, Screw Machine, (Circular Sawing) Machine, Planer, Washing Machine, Paper Manufacturing Machine (Excluding Pulp Manufacturing Machine), Printing Machine	1.4	1.6	1.8	1.6	1.8	2.0
Mixer (Cement and Viscous Matter), Belt Conveyor (Ore, Coal and Sand), Grinder, Shaping Machine, Boring Machine, Milling Machine, Compressor (Centrifugal), Vibration Sifter, Textile Machine (Warper and Winder), Rotary Compressor, Compressor (Reciprocal)	1.5	1.7	1.9	1.7	1.9	2.1
Conveyor (Apron, Pan, Bucket and Elevator), Extraction, Fan, Blower (Centrifugal, Suction and Discharge), Power Generator, Exciter, Hoist, Elevator, Rubber Processor (Calender, Roll and Extruder), Textile Machine (Weaving Machine, Fine Spinning Machine, Twisting Machine and Weft Winding Machine)	1.6	1.8	2.0	1.8	2.0	2.2
Centrifugal Separator, Conveyor (Feed and Screw), Hammer Mill, Paper Manufacturing Machine (Pulpapitor)	1.7	1.9	2.1	1.9	2.1	2.3

Typical machines using a belt are listed above. For other machines using a belt, a load correction coefficient should be determined by reference to this table.
In the case of starts / stops over 100 times per day or rapid acceleration / deceleration, check the above values multiplied by 1.3. (MTS_M only)

Table 2. Speed Ratio Correction Coefficient (Kr)

Speed Ratio	Coefficient (Kr)
1.00 to 1.25	0
1.25 to 1.75	0.1
1.75 to 2.50	0.2
2.50 to 3.50	0.3
3.50 or more	0.4

Table 3. Idlers Correction Coefficient (Ki)

Position of Idler	Coefficient (Ki)
Outside the loose side of the belt	0
Inside the loose side of the belt	0.1
Outside the tensioned side of the belt	0.1
Inside the tensioned side of the belt	0.2

[Step 2-b] Calculating Design Power ……For P_M/UP_M Series

•Design Power (Pd) =Transmission Power (Pt) x Overload Factor (Ks)
· Calculate Transmission Power at Motor Rated Power Output. (It is ideal to calculate from the actual load applied to the belt.)
· Normal Motor Load Factor (Ks)=Ko+Ki+Kr+Kh

Ko : Application Coefficient (Table 4)
Ki : Idler Correction Factor (Table 5)
Kr : Speed Multiplication Correction Factor (Table 6)
Kh : Operation Time Correction Factor (Table 7)

Table 4. Service Coefficient (Ko)

Type of Motor / Type of Driven machine / Peak Output/Basic Output				Ⅰ	Ⅱ	Ⅲ
				200% or Less	200 to 300	300% or More
A	Extremely Smooth Transmission			1.0	1.2	1.4
B	Fairly Smooth Transmission			1.3	1.5	1.7
C	Transmission with Moderate Impact			1.6	1.8	2.0
D	Transmission with Considerable Impact			1.8	2.0	2.2
E	Transmission with Large Impact			2.0	2.2	2.5
Motor	AC Motor	Single-Phase		–	–	All Types
		Squirrel-Cage Induction	2 Poles	100kW or More	90~3.7kW	2.2kW or Less
			4 Poles	55kW or More	45kW or Less	–
			6 Poles	37kW or More	30kW or Less	–
			8 Poles	15kW or More	11kW or Less	–
		Wire-Wound	4 Poles	–	15kW or Less	11kW or Less
			6 Poles	–	11kW or Less	7.5kW or Less
			8 Poles	–	5.5kW or Less	3.7kW or Less
		Synchronous Motor		–	Average Torque	High Torque
	DC Motor			Shunt	Compound	Series
	Internal Combustion Engine			8 or More Cylinders	7 ~ 5 Cylinders	4 ~ 2 Cylinders
	Hydraulic Motor			–	–	All Types

Note) For transmission involving forward/reverse operation, a large moment of inertia, extremely large impact, etc., the basic service coefficient may be 2.5 or more.

Type	Typical Driven Machines
A	Measuring Instrument, Camera Device, Radar, Medical Machine, Projector
B	Belt Conveyor (For Light Load) Chain Conveyor (For Light Load) Driller Press, Lathe, Screw Machine Electric Typewriter, Calculator, Duplicator, Printing Press, Cutter, Paper Folder, Printer, Mixer, Calender-Dryer, Lathe, Belt Sawing Machine, Plane, Circular Sawing Machine, Planer, Mixer (Liquid), Bread Baking Machine, Flour Kneading Machine, Sifter (Drum and Cone), Sawing Machine
C	Belt Conveyor (Ore, Coal, Sand), Elevator, Boring Mill, Grinder, Milling Machine, Shaper, Metal Sawing Machine, Wind Hoist, Dryer, Washing Machine (Including a Wringer), Excavator, Mixer, Granulating Machine, Pump (Centrifugal, Gear and Rotary), Compressor (High-Speed Center), Stirrer, Mixer (Viscous Matter), Centrifugal Forced Blower, General Rubber Handling Machine, Power Generator, Sifter (Electric)
D	Conveyor (Apron, Bucket, Flight, Screw), Hoist, Cutting Press, Shattering Machine, Pulp Manufacturing Machine, Weaving Machine, Spinning Machine, Twisting Machine, Blender, Centrifugal Separator, Blower (Axial Flow, for Mining and Roots), General Construction Equipment, Hammer Mill, Rollgang
E	Crank Press, Pump (Reciprocal), Compressor (Reciprocating), Civil Engineering, Mining Equipment Including Crushing Machine (Ball, Rod, Gravel), Rubber Mixer

Table 5. Correction Coefficient when Idler is Used (Ki)

Location of Idler in Use	Inside	Outside
Loose Side of the Belt	0	+0.1
Tense Side of the Belt	+0.1	+0.2

Should be applied for each idler.

Table 6. Speed Increase Correction Coefficient (Kr)

Speed Increase Ratio	Correction Coefficient
1 to 1.25	0
1.25 to 1.75	+0.1
1.75 to 2.5	+0.2
2.5 to 3.5	+0.3
3.5 or more	+0.4

Table 7. Operating time Correction Coefficient (Kh)

Operation Hours	Correction Coefficient
Operated 10 or More Hours a Day	+0.1
Operated 20 or More Hours a Day	+0.2
Operated 500 Hours or Less (For Seasonal Operation)	–0.2

[Step 2-c] For 2GT/3GT Series

•Design Power (Pd) =Transmission Power (Pt) ×Overload Coefficient (Ks)

· Calculate the Transmission Power (Pt) from the motor rated power (Originally, it is ideal to calculate from the actual load applied to the belt)
· Normal Motor Load Factor (Ks)=Ko+Ki+Kr+Kh

Ko : Load Correction Factor (Table 8)
Ki : Idler Correction Factor (Table 9)
Kr : Speed Increase Correction Factor (Table 10)
Kh : Operation Time Correction Factor (Table 11)

<For Servo Motor Applications>
In the process of designing, apply Ko=2.5 for the rated torque and Ko=0.5 for the max. torque.
* If the max. torque is generated each time the belt system is started up or stopped, choose an applicable load correction factor Ko from the Table 8., "Load Correction Factors based on Frequency of Start/Stop (Ko) operation," and apply it to the above expression.

<For Spindle Motor Applications>
In the process of designing, apply Ko=2.2 for the rated output and the basic rotation speed.

Table 8. Load Correction Factor (Ko)

Type of Motor			Ⅰ	Ⅱ	Ⅲ
Peak Output/Basic Output			150% or Less	Over 150%~200% or Less	Over 250%
AC Motor	Single-Phase		–	–	All Types
	Squirrel Cage Type	2 Phase	–	–	All Types
		4 Phase	–	37Kw or More	30Kw or Less
		6 Phase · 8 Phase	–	–	All Types
	Wound Field Type	4 Phase	–	–	15Kw or Less
		6 Phase	–	–	11Kw or Less
		8 Phase	–	–	5.5Kw or Less
Synchronous Motor			–	Standard Torque Type	High Torque Type
DC Motor			Shunt	Wound Field	Series
Hydraulic Motor			–	–	All Types
Office Machinery	Printer · Fax Machine · Copy Machine		–	1.2	1.4
Home Appliance	Juicer		–	1.4	1.6
	Vacuum Cleaner		1	1.2	1.4
Finance Equipment	Money Exchanger · Ticket Machine · Ticket Gates · Bank Teller Machine		1.3	1.4	1.5
Food · Medicine · Medical Equipment	Bakery Equipment		1.2	1.4	1.6
	Mixer · Granulator		1.4	1.6	1.8
	Centrifuge		1.5	1.7	1.9
	Medical Machinery · Measurement Equipment		1	1.2	1.4
Machine Tool	Drill Press · Lathe		1.2	1.4	1.6
	Milling Machine		1.3	1.5	1.7
	Wood Lather		1.2	1.4	1.6
Printing Book Making	Printer · Book Making Machine · Cutter		1.2	1.4	1.6
Textile Machine	Textile · Knitting Machinery		1.3	1.5	1.7
Sawing Machine	Sawing Machine – Home Use		–	1.2	1.4
	Sawing Machine – Industrial		–	1.6	1.8
Belt Conveyor · Packaging Machine	Belt Conveyor – Light Objects		1.1	1.3	1.5
	Packaging Machine		1.2	1.4	1.6
Film · Wire Making Machine	Calender · Extruder		1.4	1.6	1.8
	Wire Making Machinery		1.4	1.6	1.8

Table 9. Idler Correction Factor (Ki)

Idler Position	Inside	Outside
Loose Side of the Belt	0	+0.1
Tense Side of the Belt	+0.1	+0.2

Table 10. Speed Multiplication Correction Factor (Kr)

Speed Increase Ratio	Correction Factor
1 or More Less than 1.25	0
1.25 or More Less than 1.75	+0.1
1.75 or More Less than 2.5	+0.2
2.5 or More Less than 3.5	+0.3
3.5 or More	+0.4

Table 11. Operation Time Correction Factor (Kh)

Operation Time	Correction Factor
Less than 10 hours (Everyday)	0
10~16 Hours Continuous (Everyday)	+0.2
16~24 Hours Continuous (Everyday)	+0.4
300 Hours/Year or Less (Seasonal operations etc.)	–0.2

Table 12. Special Motor Correction Factor (Kp)

Motor Type	Load Correction Factor
Servo Motor	Design as Kp=2.5 for Rated Output, and Kp=0.5 for Peak Output (Rational speed as applied speed)
Spindle Motor	Design as Kp=2.2 for Rated Output and Base Rotational Speed

Table 13. Load Correction Factor based on Frequency of Start/Stop (Ko) operation

When the frequency of Start/Stop is less than 100 times per day	Ko=1.5
When the frequency of Start/Stop is 100 times or more but less than 1,000 times per day	Ko=2.0
When the frequency of Start/Stop is more than 1,000 times per day	Ko=2.5

[Step 2-d] For EV5GT/EV8YU Series

•Design Power (Pd) =Transmission Power (Pt) x Overload Factor (Ks)

· Calculate Transmission Power at Motor Rated Power Output. (It is ideal to calculate from the actual load applied to the belt.)
· Overload Factor (Ks)=Ko+Ki+Kr+Kh+Km

Ko : Load Correction Factor (Table 14)
Ki : Idler Correction Factor (Table 15)
Kr : Speed Multiplication Correction Factor (Table 16)
Kh : Operation Time Correction Factor (Table 17)
Km : Start/Stop Correction Factor (Table 18)

· When converting the torque (Tq) into transmission power (Pd), calculate the applicable values by using the following expressions.
Torque (Tq)=tqxKs
Transmitting Power (Pd)=Tqxn/9550

Tq : Design Torque (N·m)
tq : Transmission Torque
Ks : Overload Factor
Pd : Design Power (kW)
n : Speed (rpm)

Table 14. Load Correction Factor (Ko)

Prime Motor Type		Induction Motor	Spindle Motor	Servo Motor (Peak Output/Rated Output)		
				200% or Less	201~299%	300% or More
Robot	Scara Type	2.0	2.0	1.6	1.7	1.8
Injection Mold Machine	Mold Fastening · Ball Screw Drive	1.8	1.8	1.3	1.4	1.5
Machine Tool	Lathe · Drill Press	1.6	1.3	1.2	1.3	1.4
Machine Tool	Milling Machine	1.7	1.3	1.2	1.3	1.4
Conveyor		1.8	1.8	1.4	1.5	1.6
Medical Machinery · Measurement Equipment		1.5	1.5	1.1	0.1	0.2
Packaging Machine		1.6	1.5	1.1	0.1	0.2
Agitator · Mixer	Liquid	1.6	1.6	1.2	1.3	1.4
	Viscous Material	1.7	1.7	1.3	1.4	1.5
Drilling Machine · Granulator		1.8	1.8	1.4	1.5	1.6
Centrifuge		1.9	1.9	1.5	1.6	1.7
Mills	Ball · Rods	2.2	2.2	1.7	1.8	1.9
Printing Machine · Book Making Machine		2.0	2.0	1.6	1.7	1.8
Paper Making Machine	Calender · Dryer	2.0	2.0	1.6	1.7	1.8
Textile Machine		2.0	2.0	1.6	1.7	1.8
Wire Related	Wire Drawing & Twisting Machine	2.1	2.0	1.6	0.1	0.2
Woodworking Machine		1.7	1.7	1.2	1.3	1.4
Pump		2.0	2.0	1.6	1.7	1.8
Compressor	Reciprocating · Rotating	2.0	2.0	1.6	1.7	1.8
Fan · Blower	Axial Flow · Roots	2.0	1.8	1.3	1.4	1.5
Generator · Exciter		1.8	1.8	1.4	1.5	1.6
Rubber Industry Machinery · Lumber Mill Machinery		2.0	2.0	1.6	1.7	1.8

Table 15. Idler Correction Factor (Ki)

No Idler	0
Inside Idler	0.1×(Qty-1)
Outside Idler	0.1×(Qty-1)

Table 16. Speed Multiplication Correction Factor (Kr)

Operation Duration (Hours/Day)	Correction Factor
1 or More Less than 1.25	0
1.25 or More Less than 1.75	0.1
1.75 or More Less than 2.5	0.2
2.5 or More Less than 3.5	0.3
3.5 or More	0.4

Table 17. Operation Time Correction Factor (Kh)

Operation Duration (Hours/Day)	Correction Factor
≤8	0.1
8<16	0.2
16≤	0.3

Table 18. Start/Stop Correction Factor (Km)

Start/Stop Frequency (Times/Day)	Correction Factor
≤10	0.1
11<100	0.2
101<500	0.3
501<	0.4

[Step 3] Temporarily Selecting the Type of Belt from Selection Guide Table

Table 19. Selection Guide Table 1 (MXL,XL,L,H,T5,T10)

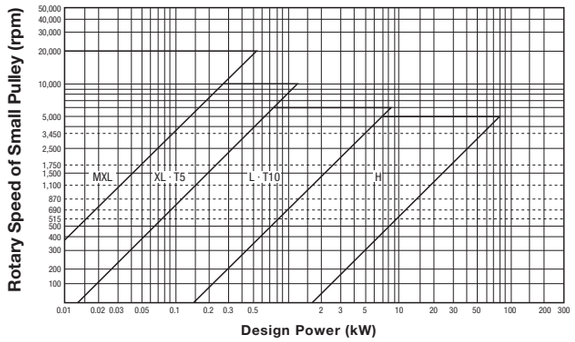


Table 20. Selection Guide Table 2 (S_M series)

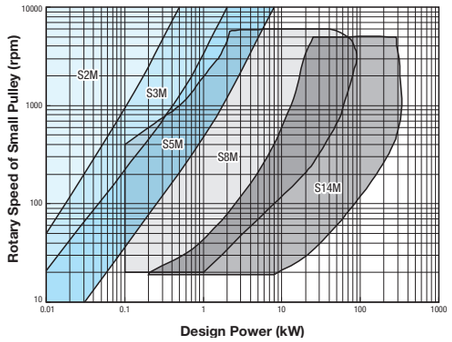


Table 21. Selection Guide Table 3 (P_M series)

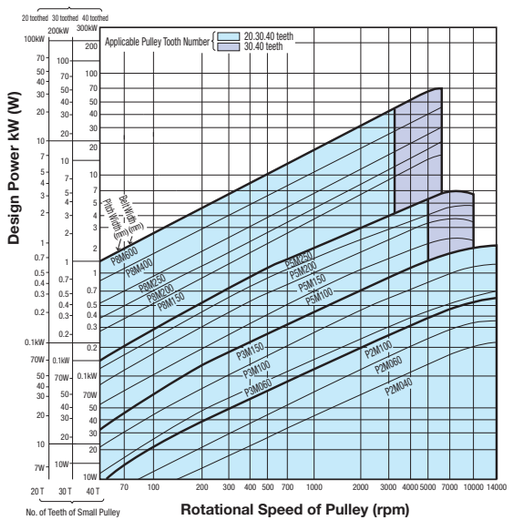


Table 22. Selection Guide Table 4 (MTS8M)

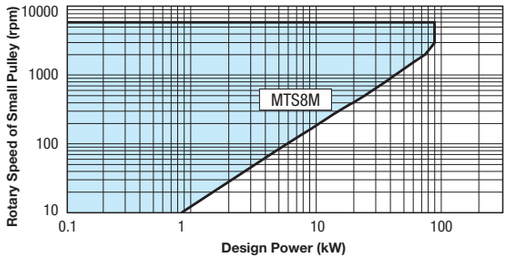


Table 23. Selection Guide Table 5 (UP_M series)

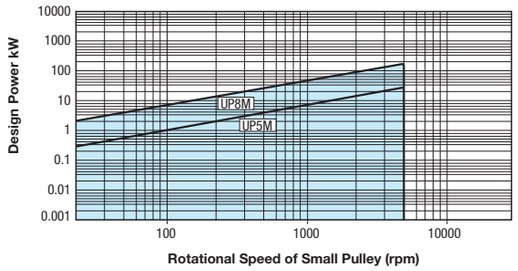


Table 24. Selection Guide Table (2GT·3GT series)

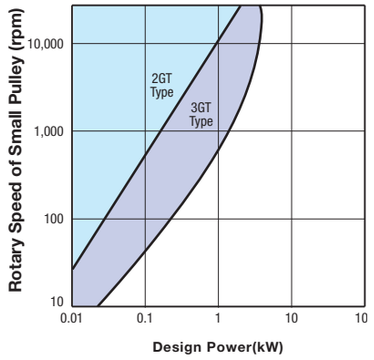
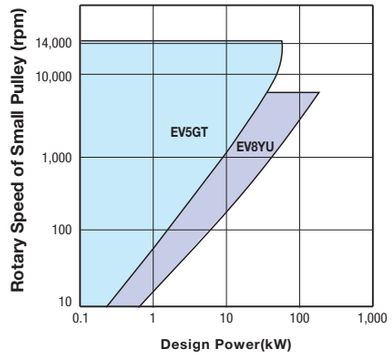


Table 25. Selection Guide Table (EV5GT·EV8YU series)



[Step 4] Determining Number of Teeth of Large and Small Pulley, Belt Length, Inter-Shaft Distance

(1) Select the number of teeth of large and small pulley from **P.125~135**, which can satisfy the predetermined speed ratio.
(However, select the small pulley with number of teeth more than Min. Number of Teeth on Table 26.)

$$\text{Speed Ratio} = \frac{\text{Number of Teeth of Large Pulley}}{\text{Number of Teeth of Small Pulley}}$$

Table 26. Allowable min. number of teeth

Rotary Speed of Small Pulley (rpm)	Type of Belt, Minimum Number of Teeth																					
	MXL	XL	L	H	S2M	S3M	S5M	S8M	S14M	P2M	P3M	P5M	P8M	UP5M	UP8M	MTS8M	T5	T10	2GT	3GT	EV5GT	EV8YU
900 or Less	12	11	14	16	16	16	16	24	–	14	14	18	22	18	22	24	12	16	12	14	18	26
Over 900 1200 or Less	15	11	14	18	16	16	20	25	40	14	14	20	24	20	24	24	14	18	14	14	20	28
Over 1200 1800 or Less	15	12	16	20	18	18	24	28	48	14	14	24	26	24	26	26	16	20	16	16	24	32
Over 1800 3600 or Less	16	16	19	24	20	20	24	30	–	16	18	28	28	28	28	28	18	22	18	20	28	36
Over 3600 4800 or Less	–	16	20	24	20	20	24	32	–	18	20	30	30	30	30	28	18	22	20	20	30	–
Over 4800 10000 or Less	–	–	–	–	20	20	26	–	–	20	28	40	–	40	–	–	–	–	–	–	–	–

(2) Determine approx. belt circum. length (Lp') in terms of temporary inter-shaft distance (C'), diameter of large pulley (Dp) and diameter of small pulley (dp).
(Calculate pulley diameter with P.D. dimensions.)

$$Lp' = 2C' + \frac{\pi(Dp+dp)}{2} + \frac{(Dp-dp)^2}{4C'}$$

C' : Temporary Inter-shaft Distance
dp : Pitch Diameter of Small Pulley (mm)
Dp : Pitch Diameter of Large Pulley (mm)
Lp' : Approx. Belt Circum. Length (mm)

(3) Determine a belt circum. length (Lp') that is the nearest value to approx. belt circum calculate the correct inter-shaft distance using the following formula.

$$C = \frac{b + \sqrt{b^2 - 8(Dp-dp)^2}}{8}$$

$$b = 2Lp - \pi(Dp+dp)$$

Dp : Pitch Diameter of Large Pulley (mm)
dp : Pitch Diameter of Small Pulley (mm)
Lp : Belt Circum. Length (mm)
C : Inter-shaft Distance

[Step 5] Determining Belt Width

(1)Calculate an approx. belt width using the following formula, and then select a belt width (Bw':mm) that is the nearest value to the approximated value.

$$Bw' = \frac{Pd}{Ps \cdot Km} \times Wp$$

Pd: Design Power
Ps: Reference Transmission Capacity……Use the Reference Transmission Capacity Table on **P.125~135.**
Km: Engagement Correction Coefficient (Table 27)
Wp: Reference Belt Width (Table 28)

Table 27. Engagement Correction Coefficient (Km)

No. of Teeth Engaged Zm	More than 6	5	4	3	2
Km	1.0	0.8	0.6	0.4	0.2
*Km	1.0	0.7	0.5	-	-

$$\text{No. of Teeth Engaged (Zm)} = \frac{Zd \cdot \theta}{360°}$$

$$\theta = 180° - \frac{57.3(Dp-dp)}{C}$$

Zd: No.of Teeth of Small Pulley
θ : Contact Angle (°)
Dp: Pitch Diameter of Large Pulley (mm)
dp: Pitch Diameter of Small Pulley (mm)
C:Inter-shaft Distance (mm)

Table 28. Reference Belt Width (Wp)

Type of Belt	MXL	XL	L	H	S2M	S3M	S5M	S8M	S14M	MTS8M
Reference Belt Width	6.4	25.4	25.4	25.4	4	6	10	60	120	60

Type of Belt	P2M	P3M	P5M	P8M	T5	T10
Reference Belt Width	4	6	10	15	10	10

(2)Check if Design Power (Pd) satisfies the following formula. (If not, select the belt width of one size larger again.)
For belt types P□M and UP□M, substitute *Km for meshing compensation factor

· Pd<Ps · Km · Kb
■2GT · 3GT · EV5GT · EV8YU
· Pd<Ps · Km · Kb · KL

Pd : Design Power
Ps : Reference Transmission Capacity
Km : Engagement Correction Coefficient
Kb : Width Correction Coefficient (Table 29)
KL : Length Correction Coefficient (Table 30)

Table 29. Width Correction Coefficient (Kb)

Type of Belt	Belt Width Nominal	Belt Width mm	Width Correction Coefficient Kb
MXL	019	4.8	0.72
	025	6.4	1.00
	037	9.5	1.57
	050	12.7	2.18
XL	025	6.4	0.15
	031	7.9	0.21
	037	9.5	0.28
	050	12.7	0.42
L	050	12.7	0.42
	075	19.1	0.71
	100	25.4	1.00
	150	38.1	1.56
H	075	19.1	0.71
	100	25.4	1.00
	150	38.1	1.56
	200	50.8	2.14

Type of Belt	Belt Width Nominal	Belt Width mm	Width Correction Coefficient Kb
S2M	040	4	1.00
	060	6	1.59
	100	10	2.84
S3M	060	6	1.00
	100	10	1.79
	150	15	2.84
S5M	100	10	1.00
	150	15	1.59
	250	25	2.84
S8M MTS8M	150	15	0.21
	250	25	0.37
	300	30	0.45
	400	40	0.63
S14M	400	40	0.29
	600	60	0.45

Type of Belt	Belt Width Nominal	Belt Width mm	Width Correction Coefficient Kb
P2M	40	4	1.00
	60	6	1.59
P3M	100	10	1.78
	150	15	2.84
P5M	100	10	1.00
	150	15	1.59
P8M	150	15	1.00
	250	25	1.79
T5	100	10	1.00
	150	15	1.60
	200	20	2.30
	250	25	2.90
T10	150	15	1.60
	200	20	2.30
	250	25	2.90
	300	30	3.50
	400	40	4.60
	500	50	5.80

Type of Belt	Belt Width Nominal	Belt Width mm	Width Correction Coefficient Kb
2GT	4	4	1.00
	6	6	1.67
	9	9	2.67
3GT	6	6	1.00
	9	9	1.66
	15	15	2.97
EV5GT	9	9	0.53
	12	12	0.76
	15	15	1.00
EV8YU	15	15	0.71
	20	20	1.00
	25	25	1.29

Table 30. Length Correction Coefficient(KL)

Length Correction Coefficient(KL)	0.80	0.90	1.00	1.10	1.20
2GT Belt Length(mm)	130 or less	131~182	183~280	281~419	420 or less
3GT Belt Length(mm)	190 or less	191~260	261~400	401~599	600 or less
EV5GT Belt Length(mm)	440 or less	441~550	551~800	801~1100	1001 or less
EV8YU Belt Length(mm)	600 or less	601~900	901~1250	1251~1799	1800 or less

[Step 6] Check if Inter-Shaft Distance Adjustment Range is Larger than that in Table 30

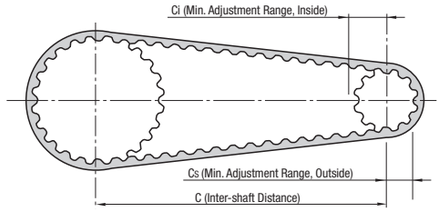


Table 31 Minimum Inter-Axial Distance Adjustment Range

Belt Length	Length Tolerance	Inter-Shaft Distance Tolerance	MXL		XL		L		H		S2M S3M S5M		S8M S14M		MTS8M		P2M P3M P5M		P8M		T5		T10	
			Ci	Cs	Ci	Cs	Ci	Cs	Ci	Cs	Ci	Cs	Ci	Cs	Ci	Cs	Ci	Cs	Ci	Cs	Ci	Cs	Ci	Cs
150 or Less	±0.35	±0.18		3		3		3		3		2		3		–		3		3		3		3
150 to 250	±0.41	±0.21		3		3		3		3		2		3		3		3		3		3		3
250 to 380	±0.46	±0.23		5		5		5		5		2		3		3		3		3		5		5
380 to 500	±0.51	±0.26		10		10		10		10		2		3		3		3		3		10		10
500 to 750	±0.60	±0.30	3	10	5	10	10	10	15	10	10	3	15	5	15	3	10	5	15	5	5	10	10	10
750 to 1000	±0.66	±0.33		15		15		15		15		3		5		5		5		5		15		15
1000 to 1250	±0.76	±0.38		15		15		15		15		5		10		5		10		10		15		15
1250 to 1500	±0.82	±0.41		25		25		25		25		5		10		10		10		10		25		25
1500 to 1750	±0.86	±0.43		25		25		25		25		5		10		10		10		10		25		25
1750 to 2000	±0.92	±0.46		30		30		30		30		5		10		10		10		10		30		30

Belt Length		Length Tolerance	Inter-Shaft Distance Tolerance	2GT		3GT		EV5GT		EV8YU	
				Ci	Cs	Ci	Cs	Ci	Cs	Ci	Cs
	150 or Less	± 0.40	± 0.20		3		3		3		3
Over 150	250 or Less	± 0.40	± 0.20		3		3		3		3
Over 250	380 or Less	± 0.46	± 0.23		3		3		3		3
Over 380	500 or Less	± 0.50	± 0.25		3		3		3		3
Over 500	750 or Less	± 0.60	± 0.30	4	5	5	5	10	5	20	5
Over 750	1000 or Less	± 0.66	± 0.33		5		5		5		5
Over 1000	1250 or Less	± 0.76	± 0.38		10		10		10		10
Over 1250	1500 or Less	± 0.82	± 0.41		10		10		10		10
Over 1500	1750 or Less	± 0.86	± 0.43		10		10		10		10
Over 1750	2000 or Less	± 0.92	± 0.46		10		10		10		10

■Precautions on Operation

1. Be careful to avoid the ingress of foreign particles.
   When solid foreign particles enter during operation, it can scratch the belt and adversely affect the engagement of the belt and the pulley.
   In some cases, the pulley may disengage, land on the teeth of the pulley, and be cut.
2. Avoid Adhesion of oil.
   Oil on the rubber timing belt may wet and expand it, drastically shortening its service life.
   (a)Take special care when using solvent type oil.
   (b)A small amount of lubricant or grease, however, rarely causes a trouble.
3. Do not use the belt in a humid atmosphere.
4. Please use a well-ventilated safety cover.
5. The service life of the belt, when used at a high temperature (80˚C or more), can be drastically shortened.

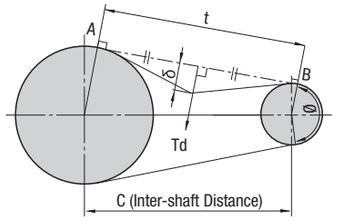
‹Reference›Belt Width Tolerance (Unit: mm)

Belt Width	Belt Length			
	351 or Less	351 to 840	840 to 1680	1680 or More
10 or Less	+0.3 −0.6	+0.3 −0.6	+0.3 −0.6	+0.6 −0.6
10 to 40	+0.6 −0.6	+0.6 −0.6	+0.6 −0.6	+0.6 −0.6
40 to 50	+0.6 −0.6	+0.6 −0.6	+1.0 −1.0	+1.0 −1.3

Cautions on Use of Belt

■How to Extend Belt

When the belt is too taut, its service life can be shortened, while when it is not taut enough, the belt may (jump off) the groove of the pulley due to an activating torque or shock load. Keep the belt stationary and optimize its tautness. The warp load necessary to provide the optimum tautness can be calculated from values representing the belt, its width and the span in equation A below. Apply deflection load between max. value and recommended value.



$$Td = \frac{Ti + \frac{t \times Y}{Lp}}{16} \quad \text{Equation A}$$

Td: Load N Needed for Deflection d at the Center of Span t

Ti : Initial Tension N — From Table 31

Y : Correction Coefficient — From Table 31

δ : Deflection (mm) — δ=0.016t

t : Span Length (mm) — $t = \sqrt{C^2 - \frac{(Dp-dp)^2}{4}}$

Lp : Length of the Belt (mm)

C : Inter-shaft Distance (mm)

dp : Diameter of the Pitch Circle of the Small Pulley (mm)

Dp : Diameter of the Pitch Circle of the Large Pulley (mm)

Table 32. Initial Tension (Ti) and Correction Coefficient (Y)

Type	Ti·Y	Belt Nominal Width / Belt Width mm	019 / 4.8	025 / 6.4	031 / 7.9	037 / 9.5	050 / 12.7	075 / 19.1	100 / 25.4	150 / 38.1	200 / 50.8
MXL	Ti (N)	Max. Value	9.8	13.7	–	21.6	29.9	–	–	–	–
		Recommended Value	5.8	8.2		12.9	18.0				
	Coefficient Y		–	–	–	–	–	–	–	–	–
XL	Ti (N)	Max. Value	–	29	37	44	67	–	–	–	–
		Recommended Value		18	25	32	51				
	Coefficient Y		–	3.8	5.4	7.6	11.8	–	–	–	–
L	Ti (N)	Max. Value	–	–	–	–	76	125	175	273	–
		Recommended Value					52	87	123	191	
	Coefficient Y		–	–	–	–	44.1	75.5	107	165	–
H	Ti (N)	Max. Value	–	–	–	–	–	293	421	646	889
		Recommended Value						222	312	486	668
	Coefficient Y		–	–	–	–	–	142	205	317	423

Type	Ti·Y	Belt Nominal Width / Belt Width mm	60 / 6	100 / 10	150 / 15	250 / 25
P2M	Ti (N)	Max. Value	13	–	–	–
		Recommended Value	9.8			
	Coefficient Y		0.9	–	–	–
P3M	Ti (N)	Max. Value	–	46	74	–
		Recommended Value		34	55	
	Coefficient Y		–	1.9	3.0	–
P5M	Ti (N)	Max. Value	–	147	225.4	–
		Recommended Value		107.8	166.6	
	Coefficient Y		–	56.9	82.4	–
P8M	Ti (N)	Max. Value	–	–	294	509.6
		Recommended Value			225.4	382.2
	Coefficient Y		–	–	135	239

Type	Ti·Y	Belt Nominal Width / Belt Width mm	40 / 4	60 / 6	100 / 10	150 / 15	250 / 25	300 / 30	400 / 40	600 / 60
S2M	Ti (N)	Max. Value	7.8	12.7	22.6	–	–	–	–	–
		Recommended Value	5.9	9.8	16.7					
	Coefficient Y		9.8	15.7	27.4	–	–	–	–	–
S3M	Ti (N)	Max. Value	–	26	46	73	–	–	–	–
		Recommended Value		20	34	54				
	Coefficient Y		–	26.5	46.1	75.5	–	–	–	–
S5M	Ti (N)	Max. Value	–	–	77	124	221	–	–	–
		Recommended Value			58	93	166			
	Coefficient Y		–	–	52.8	85.5	151.0	–	–	
S8M MTS8M	Ti (N)	Max. Value	–	–	–	294	510	628	873	
		Recommended Value				226	382	470	657	
	Coefficient Y		–	–	–	98	196	235	333	
S14M	Ti (N)	Max. Value	–	–	–	–	–	–	1226	1912
		Recommended Value							1108	1726
	Coefficient Y		–	–	–	–	–	–	686	1059

Type	Ti·Y	Belt Nominal Width / Belt Width mm	100 / 10	150 / 15	200 / 20	250 / 25	300 / 30	400 / 40	500 / 50
T5	Ti (N)	Max. Value	37.3	59	85	106	–	–	–
		Recommended Value	24.5	39	59	74			
	Coefficient Y		16.7	26.5	38.2	47.5	–	–	–
T10	Ti (N)	Max. Value	–	162	235	294	363	500	628
		Recommended Value		108	157	196	245	333	422
	Coefficient Y		–	71.6	104.9	130.4	163.8	222.6	281.5

Type	Ti·Y	Belt Nominal Width / Belt Width mm	4 / 4	6 / 6	9 / 9	12 / 12	15 / 15	20 / 20	25 / 25
2GT	Ti (N)	Max. Value	12.2	20.5	32.8	–	–	–	–
		Recommended Value	9.4	15.8	25.2				
	Coefficient Y		–	–	–	–	–	–	–
3GT	Ti (N)	Max. Value	–	38	57	–	96	–	–
		Recommended Value		29	44		74		
	Coefficient Y		–	–	–	–	–	–	–
EV5GT	Ti (N)	Max. Value	–	–	92	127	163	–	–
		Recommended Value			71	98	125		
	Coefficient Y		–	–	–	–	–	–	–
EV8YU	Ti (N)	Max. Value	–	–	–	–	273	364	455
		Recommended Value					210	280	350
	Coefficient Y		–	–	–	–	–	–	–

Timing Belt
Selection of Transmission Timing Belts 5

Table 33. Reference Transmission Capacity of MXL Ps -Nominal Width of Belts 025 (6.4mm)-

(W)

Rotary Speed of Small Pulley(rpm) \ No. of Teeth of Small Pulley	12	14	15	16	18	20	22	24	25	26	28	30	32	36	40
Diameter of the Pitch Circle(mm)	7.76	9.06	9.70	10.35	11.64	12.94	14.23	15.52	16.17	16.82	18.11	19.40	20.70	23.29	25.97
950	9.0	10.5	11.3	12.0	13.5	15.0	16.5	18.0	18.8	19.6	21.1	22.6	24.1	27.1	30.1
1160	11.0	12.8	13.8	14.7	16.5	18.4	20.2	22.0	23.0	23.9	25.7	27.6	29.4	33.1	36.7
1425		15.8	16.9	18.0	20.3	22.6	24.8	27.1	28.2	29.3	31.6	33.9	36.1	40.6	45.1
1750		19.4	20.8	22.2	24.9	27.7	30.5	33.3	34.7	36.0	38.8	41.6	44.3	49.9	55.4
2850			33.9	36.1	40.6	45.1	49.6	54.1	56.4	58.6	63.1	67.6	72.1	81.0	90.0
3450			41.0	43.7	49.2	54.6	60.1	65.5	68.2	70.9	76.3	81.7	87.1	97.9	108.6
100	0.9	1.1	1.1	1.2	1.4	1.5	1.7	1.9	1.9	2.0	2.2	2.3	2.5	2.8	3.1
200	1.9	2.2	2.3	2.5	2.8	3.1	3.4	3.8	3.9	4.1	4.4	4.7	5.0	5.7	6.3
300	2.8	3.3	3.5	3.8	4.2	4.7	5.2	5.7	5.9	6.1	6.6	7.1	7.6	8.5	9.5
400	3.8	4.4	4.7	5.0	5.7	6.3	6.9	7.6	7.9	8.2	8.8	9.5	10.1	11.4	12.6
500	4.7	5.5	5.9	6.3	7.1	7.9	8.7	9.5	9.9	10.3	11.1	11.9	12.6	14.2	15.8
600	5.7	6.6	7.1	7.6	8.5	9.5	10.4	11.4	11.9	12.3	13.3	14.2	15.2	17.1	19.0
700	6.6	7.7	8.3	8.8	10.0	11.1	12.2	13.3	13.8	14.4	15.5	16.6	17.7	19.9	22.2
800	7.6	8.8	9.5	10.1	11.4	12.6	13.9	15.2	15.8	16.5	17.7	19.0	20.3	22.8	25.3
900	8.5	10.0	10.7	11.4	12.8	14.2	15.7	17.1	17.8	18.5	19.9	21.4	22.8	25.7	28.5
1000	9.5	11.1	11.9	12.6	14.2	15.8	17.4	19.0	19.8	20.6	22.2	23.8	25.3	28.5	31.7
1100	10.4	12.2	13.0	13.9	15.7	17.4	19.2	20.9	21.8	22.6	24.4	26.1	27.9	31.4	34.8
1200	11.4	13.3	14.2	15.2	17.1	19.0	20.9	22.8	23.8	24.7	26.6	28.5	30.4	34.2	38.0
1300		14.4	15.4	16.5	18.5	20.6	22.6	24.7	25.7	26.8	28.8	30.9	32.9	37.1	41.2
1400		15.5	16.6	17.7	19.9	22.2	24.4	26.6	27.7	28.8	31.0	33.3	35.5	39.9	44.3
1500		16.6	17.8	19.0	21.4	23.8	26.1	28.5	29.7	30.9	33.3	35.6	38.0	42.8	47.5
1600		17.7	19.0	20.3	22.8	25.3	27.9	30.4	31.7	32.9	35.5	38.0	40.5	45.6	50.7
1700		18.8	20.2	21.5	24.2	26.9	29.6	32.3	33.7	35.0	37.7	40.4	43.1	48.5	53.8
1800		19.9	21.4	22.8	25.7	28.5	31.4	34.2	35.6	37.1	39.9	42.8	45.6	51.3	57.0
2000			23.8	25.3	28.5	31.7	34.8	38.0	39.6	41.2	44.3	47.5	50.7	57.0	63.3
2200			26.1	27.9	31.4	34.8	38.3	41.8	43.6	45.3	48.8	52.2	55.7	62.7	69.6
2400			28.5	30.4	34.2	38.0	41.8	45.6	47.5	49.4	53.2	57.0	60.8	68.3	75.9
2600			30.9	32.9	37.1	41.2	45.3	49.4	51.5	53.5	57.6	61.7	65.8	74.0	82.1
2800				35.5	39.9	44.3	48.8	53.2	55.4	57.6	62.0	66.4	70.8	79.6	88.4
3000				38.0	42.8	47.5	52.2	57.0	59.3	61.7	66.4	71.2	75.9	85.3	94.6
3200				40.5	45.6	50.7	55.7	60.8	63.3	65.8	70.8	75.9	80.9	90.9	100.9
3400				43.1	48.5	53.8	59.2	64.5	67.2	69.9	75.2	80.6	85.9	96.5	107.1
3600				45.6	51.3	57.0	62.7	68.3	71.2	74.0	79.6	85.3	90.9	102.1	113.3
3800					54.1	60.1	66.1	72.1	75.1	78.1	84.0	90.0	95.9	107.7	119.5
4000					57.0	63.3	69.6	75.9	79.0	82.1	88.4	94.6	100.9	113.3	125.6
4200					59.8	66.4	73.0	79.6	82.9	86.2	92.8	99.3	105.8	118.8	131.8
4400					62.7	69.6	76.5	83.4	86.8	90.3	97.1	104.0	110.8	124.4	137.9
4600					65.5	72.7	79.9	87.1	90.7	94.3	101.5	108.6	115.8	129.9	144.0
4800					68.3	75.9	83.4	90.9	94.6	98.4	105.8	113.3	120.7	135.4	150.0

* Endurance time will be reduced in ⬚ marked area. Please avoid if possible.

* Values in the table above are for nominal belt width 025(6.4mm). For other belt widths, those values should be multiplied by the width correction coefficient, Kb, shown in Table 29.

Table 34. Reference Transmission Capacity of XL Ps -Nominal Width of Belts 100 (25.4mm)-

(kW)

Rotary Speed of Small Pulley(rpm) \ No. of Teeth of Small Pulley	10	11	12	14	15	16	18	19	20	21	22	24	25	26	28	30
Diameter of the Pitch Circle(mm)	16.17	17.79	19.40	22.64	24.26	25.87	29.11	30.72	32.34	33.96	35.57	38.81	40.43	42.04	45.28	48.51
950	0.14	0.16	0.17	0.20	0.21	0.23	0.26	0.27	0.29	0.30	0.32	0.35	0.36	0.38	0.41	0.43
1160	0.17	0.19	0.21	0.25	0.26	0.28	0.32	0.33	0.35	0.37	0.39	0.42	0.44	0.46	0.50	0.53
1425			0.26	0.30	0.32	0.35	0.39	0.41	0.43	0.46	0.48	0.52	0.54	0.57	0.61	0.65
1750			0.32	0.37	0.40	0.43	0.48	0.51	0.53	0.56	0.59	0.64	0.67	0.69	0.75	0.80
2850			0.52	0.61	0.65	0.07	0.78	0.82	0.87	0.91	0.95	1.04	1.08	1.12	1.21	1.29
3450			0.63	0.74	0.79	0.84	0.94	1.00	1.05	1.10	1.15	1.25	1.30	1.35	1.45	1.55
100	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04
200	0.03	0.03	0.03	0.04	0.04	0.04	0.05	0.05	0.06	0.06	0.06	0.07	0.07	0.08	0.08	0.09
300	0.04	0.05	0.05	0.06	0.06	0.07	0.08	0.08	0.09	0.09	0.10	0.11	0.11	0.12	0.12	0.13
400	0.06	0.06	0.07	0.08	0.09	0.09	0.11	0.11	0.12	0.12	0.13	0.14	0.15	0.16	0.17	0.18
500	0.07	0.08	0.09	0.10	0.11	0.12	0.13	0.14	0.15	0.16	0.16	0.18	0.19	0.20	0.21	0.23
600	0.09	0.10	0.11	0.12	0.13	0.14	0.16	0.17	0.18	0.19	0.20	0.22	0.23	0.24	0.25	0.27
700	0.10	0.11	0.12	0.15	0.16	0.17	0.19	0.20	0.21	0.22	0.23	0.25	0.27	0.28	0.30	0.32
800	0.12	0.13	0.14	0.17	0.18	0.19	0.22	0.23	0.24	0.25	0.27	0.29	0.30	0.32	0.34	0.37
900	0.13	0.15	0.16	0.19	0.20	0.22	0.25	0.26	0.27	0.29	0.30	0.33	0.34	0.36	0.38	0.41
1000	0.15	0.16	0.18	0.21	0.23	0.24	0.27	0.29	0.30	0.32	0.33	0.37	0.38	0.40	0.43	0.46
1100	0.16	0.18	0.20	0.23	0.25	0.27	0.30	0.32	0.33	0.35	0.37	0.40	0.42	0.44	0.47	0.50
1200	0.18	0.20	0.22	0.25	0.27	0.29	0.33	0.35	0.37	0.38	0.40	0.44	0.46	0.48	0.51	0.55
1300			0.24	0.28	0.30	0.32	0.36	0.38	0.40	0.42	0.44	0.48	0.50	0.52	0.56	0.59
1400			0.25	0.30	0.32	0.34	0.38	0.41	0.43	0.45	0.47	0.51	0.53	0.56	0.60	0.64
1500			0.27	0.32	0.34	0.37	0.41	0.43	0.46	0.48	0.50	0.55	0.57	0.59	0.64	0.69
1600			0.29	0.34	0.37	0.39	0.44	0.46	0.49	0.51	0.54	0.59	0.61	0.63	0.68	0.73
1700			0.31	0.36	0.39	0.41	0.47	0.49	0.52	0.54	0.57	0.62	0.65	0.67	0.73	0.78
1800			0.33	0.38	0.41	0.44	0.49	0.52	0.55	0.58	0.60	0.66	0.69	0.71	0.77	0.82
2000			0.37	0.43	0.46	0.49	0.55	0.58	0.61	0.64	0.67	0.73	0.76	0.79	0.85	0.91
2200			0.40	0.47	0.50	0.54	0.60	0.64	0.67	0.70	0.74	0.80	0.84	0.87	0.94	1.00
2400			0.44	0.51	0.55	0.59	0.66	0.70	0.73	0.77	0.80	0.88	0.91	0.95	1.02	1.09
2600			0.48	0.56	0.59	0.63	0.71	0.75	0.79	0.83	0.87	0.95	0.99	1.03	1.10	1.18
2800			0.51	0.60	0.64	0.68	0.77	0.81	0.85	0.89	0.94	1.02	1.06	1.10	1.19	1.27
3000			0.55	0.64	0.69	0.73	0.82	0.87	0.91	0.96	1.00	1.09	1.14	1.18	1.27	1.35
3200			0.59	0.68	0.73	0.78	0.88	0.92	0.97	1.02	1.07	1.16	1.21	1.26	1.35	1.44
3400			0.62	0.73	0.78	0.83	0.93	0.98	1.03	1.08	1.13	1.23	1.28	1.33	1.43	1.53
3600			0.66	0.77	0.82	0.88	0.98	1.04	1.09	1.14	1.20	1.30	1.35	1.41	1.51	1.61
3800					0.87	0.92	1.04	1.09	1.15	1.21	1.26	1.37	1.43	1.48	1.59	1.69
4000					0.91	0.97	1.09	1.15	1.21	1.27	1.33	1.44	1.50	1.55	1.67	1.78
4200					0.96	1.02	1.14	1.21	1.27	1.33	1.39	1.51	1.57	1.63	1.74	1.86
4400					1.00	1.07	1.20	1.26	1.33	1.39	1.45	1.58	1.64	1.70	1.82	1.94
4600					1.05	1.12	1.25	1.32	1.38	1.45	1.52	1.64	1.71	1.77	1.90	2.02
4800					1.09	1.16	1.30	1.37	1.44	1.51	1.58	1.71	1.78	1.84	1.97	2.10

* Endurance time will be reduced in ⬚ marked area. Please avoid if possible.

* Values in the table above are for nominal belt width 100(25.4mm). For other belt widths, those values should be multiplied by the width correction coefficient, Kb, shown in Table 29.

Table 35. Reference Transmission Capacity of L Ps -Nominal Width of Belts 100 (25.4mm)-

(kW)

Rotary Speed of Small Pulley(rpm) \ No. of Teeth of Small Pulley	12	14	15	16	18	19	20	21	22	24	25	26	28	30	32	36	40	48
Diameter of the Pitch Circle(mm)	36.38	42.45	45.48	48.51	54.57	57.61	60.64	63.67	66.70	72.77	75.80	78.83	84.89	90.96	97.02	109.15	121.28	145.53
725	0.33	0.39	0.42	0.44	0.50	0.53	0.56	0.58	0.61	0.67	0.70	0.72	0.78	0.83	0.89	1.00	1.11	1.33
870	0.40	0.47	0.50	0.53	0.60	0.63	0.67	0.70	0.73	0.80	0.83	0.87	0.93	1.00	1.07	1.20	1.33	1.59
950	0.44	0.51	0.55	0.58	0.66	0.69	0.73	0.77	0.80	0.87	0.91	0.95	1.02	1.09	1.16	1.31	1.45	1.73
1160	0.53	0.62	0.67	0.71	0.80	0.85	0.89	0.93	0.98	1.07	1.11	1.15	1.24	1.33	1.41	1.59	1.76	2.09
1425		0.77	0.82	0.87	0.98	1.04	1.09	1.14	1.20	1.31	1.36	1.41	1.52	1.62	1.73	1.93	2.13	2.52
1750		0.94	1.01	1.07	1.20	1.27	1.34	1.40	1.47	1.59	1.66	1.72	1.85	1.97	2.10	2.34	2.58	3.02
2850				1.73	1.93	2.03	2.13	2.23	2.33	2.52	2.62	2.71	2.89	3.07	3.24	3.56	3.84	4.31
3450				2.07	2.31	2.43	2.54	2.66	2.77	2.99	3.09	3.19	3.39	3.58	3.76	4.07	4.33	4.67
100	0.04	0.05	0.05	0.06	0.06	0.07	0.07	0.08	0.08	0.09	0.09	0.10	0.10	0.11	0.12	0.13	0.15	0.18
200	0.09	0.10	0.11	0.12	0.13	0.14	0.15	0.16	0.17	0.18	0.19	0.20	0.21	0.23	0.24	0.27	0.30	0.37
300	0.13	0.16	0.17	0.18	0.20	0.22	0.23	0.24	0.25	0.27	0.29	0.30	0.32	0.34	0.37	0.41	0.46	0.55
400	0.18	0.21	0.23	0.24	0.27	0.29	0.30	0.32	0.34	0.37	0.38	0.40	0.43	0.46	0.49	0.55	0.61	0.74
500	0.23	0.27	0.29	0.30	0.34	0.36	0.38	0.40	0.42	0.46	0.48	0.50	0.54	0.58	0.61	0.69	0.77	0.92
600	0.27	0.32	0.34	0.37	0.41	0.44	0.46	0.48	0.51	0.55	0.58	0.60	0.64	0.69	0.74	0.83	0.92	1.10
700	0.32	0.37	0.40	0.43	0.48	0.51	0.54	0.56	0.59	0.64	0.67	0.70	0.75	0.81	0.86	0.97	1.07	1.28
800	0.37	0.43	0.46	0.49	0.55	0.58	0.61	0.64	0.68	0.74	0.77	0.80	0.86	0.92	0.98	1.10	1.22	1.46
900	0.41	0.48	0.52	0.55	0.62	0.66	0.69	0.73	0.76	0.83	0.86	0.90	0.97	1.03	1.10	1.24	1.37	1.64
1000	0.46	0.54	0.58	0.61	0.69	0.73	0.77	0.81	0.84	0.92	0.96	1.00	1.07	1.15	1.22	1.37	1.52	1.81
1100	0.51	0.59	0.63	0.68	0.76	0.80	0.84	0.89	0.93	1.01	1.05	1.09	1.18	1.26	1.34	1.51	1.67	1.99
1200	0.55	0.64	0.69	0.74	0.83	0.87	0.92	0.97	1.01	1.10	1.15	1.19	1.28	1.37	1.46	1.64	1.81	2.15
1300		0.70	0.75	0.80	0.90	0.95	1.00	1.05	1.09	1.19	1.24	1.29	1.39	1.48	1.58	1.77	1.96	2.32
1400		0.75	0.81	0.86	0.97	1.02	1.07	1.12	1.18	1.28	1.34	1.39	1.49	1.59	1.70	1.90	2.10	2.48
1500		0.81	0.86	0.92	1.03	1.09	1.15	1.20	1.26	1.37	1.43	1.48	1.59	1.70	1.81	2.03	2.24	2.64
1600		0.86	0.92	0.98	1.10	1.16	1.22	1.28	1.34	1.46	1.52	1.58	1.70	1.81	1.93	2.15	2.38	2.80
1700		0.91	0.98	1.04	1.17	1.23	1.30	1.36	1.42	1.55	1.61	1.68	1.80	1.92	2.04	2.28	2.51	2.95
1800		0.97	1.03	1.10	1.24	1.31	1.37	1.44	1.51	1.64	1.70	1.77	1.90	2.03	2.15	2.40	2.64	3.10
1900				1.16	1.31	1.38	1.45	1.52	1.59	1.73	1.80	1.86	2.00	2.13	2.27	2.52	2.77	3.24
2000				1.22	1.37	1.45	1.52	1.59	1.67	1.81	1.89	1.96	2.10	2.24	2.38	2.64	2.90	3.38
2200				1.34	1.51	1.59	1.67	1.75	1.83	1.99	2.06	2.14	2.29	2.44	2.59	2.87	3.14	3.64
2400				1.46	1.64	1.73	1.81	1.90	1.99	2.15	2.24	2.32	2.48	2.64	2.80	3.10	3.38	3.87
2500				1.52	1.70	1.80	1.89	1.97	2.06	2.24	2.32	2.41	2.58	2.74	2.90	3.20	3.49	3.98
2600				1.58	1.77	1.86	1.96	2.05	2.14	2.32	2.41	2.50	2.67	2.84	3.00	3.31	3.59	4.09
2800				1.70	1.90	2.00	2.10	2.20	2.29	2.48	2.58	2.67	2.85	3.02	3.19	3.51	3.80	4.27
3000				1.81	2.03	2.13	2.24	2.34	2.44	2.64	2.74	2.84	3.02	3.20	3.38	3.70	3.98	4.43
3200				1.93	2.15	2.27	2.38	2.48	2.59	2.80	2.90	3.00	3.19	3.38	3.55	3.87	4.15	4.56
3400				2.04	2.28	2.40	2.51	2.62	2.73	2.95	3.05	3.16	3.35	3.54	3.72	4.04	4.30	4.65
3600				2.15	2.40	2.52	2.64	2.76	2.87	3.10	3.20	3.31	3.51	3.70	3.87	4.18	4.43	4.71
3800					2.52	2.65	2.77	2.89	3.01	3.24	3.35	3.45	3.66	3.84	4.02	4.31	4.54	4.73
4000					2.64	2.77	2.90	3.02	3.14	3.38	3.49	3.59	3.80	3.98	4.15	4.43	4.62	4.72
4200					2.76	2.89	3.02	3.15	3.27	3.51	3.62	3.73	3.93	4.11	4.27	4.53	4.69	4.66
4400					2.87	3.01	3.14	3.27	3.40	3.64	3.75	3.85	4.05	4.23	4.38	4.61	4.72	4.56
4600					2.99	3.13	3.26	3.39	3.52	3.76	3.87	3.97	4.17	4.33	4.48	4.67	4.73	4.42
4800					3.10	3.24	3.38	3.51	3.64	3.87	3.98	4.09	4.27	4.43	4.56	4.71	4.72	4.23

* Endurance time will be reduced in ⬚ marked area. Please avoid if possible.

* □ The circumferential speed of pulley is 33(m/s)or more; a dynamic balance for the pulley is essential.

* Values in the table above are for nominal belt width 100(25.4mm). For other belt widths, those values should be multiplied by the width correction coefficient, Kb, shown in Table 29.

Table 36. Reference Transmission Capacity of H Ps -Nominal Width of Belts 100 (25.4mm)-

(kW)

Rotary Speed of Small Pulley(rpm) \ No. of Teeth of Small Pulley	14	15	16	18	19	20	21	22	24	25	26	28	30	32	36	40	48
Diameter of the Pitch Circle(mm)	56.60	60.64	64.68	72.77	76.81	80.85	84.89	88.94	97.02	101.06	105.1	113.19	121.28	129.36	145.53	161.70	194.04
725	1.33	1.43	1.52	1.71	1.81	1.90	2.00	2.09	2.28	2.38	2.47	2.66	2.85	3.04	3.41	3.79	4.53
870	1.60	1.71	1.83	2.05	2.17	2.28	2.40	2.51	2.74	2.85	2.96	3.19	3.41	3.64	4.08	4.53	5.41
950			1.99	2.24	2.37	2.49	2.61	2.74	2.99	3.11	3.23	3.48	3.72	3.97	4.45	4.93	5.89
1160			2.43	2.74	2.89	3.04	3.19	3.34	3.64	3.79	3.94	4.23	4.53	4.82	5.41	5.99	7.12
1425				3.35	3.54	3.72	3.91	4.09	4.45	4.63	4.81	5.17	5.53	5.89	6.59	7.27	8.61
1750				4.11	4.33	4.55	4.78	5.00	5.44	5.66	5.87	6.31	6.73	7.16	7.98	8.79	10.32
2850						7.27	7.61	7.95	8.61	8.93	9.25	9.87	10.48	11.06	12.16	13.15	14.80
3450						8.68	9.07	9.45	10.19	10.55	10.91	11.59	12.24	12.85	13.95	14.87	16.09
100	0.18	0.19	0.21	0.23	0.25	0.26	0.27	0.28	0.31	0.32	0.34	0.36	0.39	0.42	0.47	0.52	0.63
200	0.36	0.39	0.42	0.47	0.50	0.52	0.55	0.57	0.63	0.65	0.68	0.73	0.79	0.84	0.94	1.05	1.26
300	0.55	0.59	0.63	0.71	0.75	0.79	0.83	0.86	0.94	0.98	1.02	1.10	1.18	1.26	1.42	1.57	1.89
400	0.73	0.79	0.84	0.94	1.00	1.05	1.10	1.15	1.26	1.31	1.36	1.47	1.57	1.68	1.89	2.10	2.52
500	0.92	0.98	1.05	1.18	1.25	1.31	1.38	1.44	1.57	1.64	1.71	1.84	1.97	2.10	2.36	2.62	3.14
600	1.10	1.18	1.26	1.42	1.50	1.57	1.65	1.73	1.89	1.97	2.05	2.20	2.36	2.52	2.83	3.14	3.76
700	1.29	1.38	1.47	1.65	1.75	1.84	1.93	2.02	2.20	2.30	2.39	2.57	2.75	2.93	3.30	3.66	4.38
800	1.47	1.57	1.68	1.89	1.99	2.10	2.20	2.31	2.52	2.62	2.73	2.93	3.14	3.35	3.76	4.17	4.99
900	1.65	1.77	1.89	2.13	2.24	2.36	2.48	2.60	2.83	2.95	3.06	3.30	3.53	3.76	4.22	4.68	5.59
1000			2.10	2.36	2.49	2.62	2.75	2.88	3.14	3.27	3.40	3.66	3.92	4.17	4.68	5.19	6.18
1100			2.31	2.60	2.74	2.88	3.02	3.17	3.45	3.59	3.74	4.02	4.30	4.58	5.14	5.69	6.77
1200			2.52	2.83	2.99	3.14	3.30	3.45	3.76	3.92	4.07	4.38	4.68	4.99	5.59	6.18	7.35
1300				3.06	3.23	3.40	3.57	3.74	4.07	4.24	4.40	4.73	5.06	5.39	6.03	6.67	7.91
1400				3.30	3.48	3.66	3.84	4.02	4.38	4.55	4.73	5.09	5.44	5.79	6.48	7.16	8.47
1500				3.53	3.72	3.92	4.11	4.30	4.68	4.87	5.06	5.44	5,81	6.18	6.91	7.63	9.01
1600				3.76	3.97	4.17	4.38	4.58	4.99	5.19	5.39	5.79	6.18	6.57	7.35	8.10	9.55
1700				3.99	4.21	4.43	4.64	4.86	5.29	5.50	5.71	6.13	6.55	6.96	7.77	8.56	10.07
1800				4.22	4.45	4.68	4.91	5.14	5.59	5.81	6.03	6.48	6.91	7.35	8.19	9.01	10.57
1900						4.93	5.17	5.41	5.89	6.12	6.35	6.82	7.27	7.73	8.61	9.46	11.06
2000						5.19	5.44	5.69	6.18	6.43	6.67	7.16	7.63	8.10	9.01	9.89	11.53
2100						5.44	5.70	5.96	6.48	6.73	6.99	7.49	7.98	8.47	9.41	10.32	11.99
2200						5.69	5.96	6.23	6.77	7.03	7.30	7.82	8.33	8.83	9.81	10.73	12.43
2300						5.94	6.22	6.50	7.06	7.33	7.61	8.15	8.68	9.19	10.19	11.14	12.85
2400						6.18	6.48	6.77	7.35	7.63	7.91	8.47	9.01	9.55	10.57	11.53	13.25
2500						6.43	6.73	7.03	7.63	7.93	8.22	8.79	9.35	9.89	10.94	11.91	13.63
2600						6.67	6.99	7.30	7.91	8.22	8.52	9.10	9.68	10.24	11.30	12.28	13.99
2800						7.16	7.49	7.82	8.47	8.79	9.10	9.72	10.32	10.90	11.99	12.99	14.65
3000						7.63	7.98	8.33	9.01	9.35	9.68	10.32	10.94	11.53	12.64	13.63	15.21
3200						8.10	8.47	8.83	9.55	9.89	10.24	10.90	11.53	12.14	13.25	14.22	15.67
3400						8.56	8.95	9.33	10.07	10.42	10.78	11.45	12.10	12.71	13.81	14.75	16.02
3600						9.01	9.41	9.81	10.57	10.94	11.30	11.99	12.64	13.25	14.33	15.21	16.26
3800								10.28	11.06	11.44	11.80	12.50	13.15	13.75	14.80	15.60	16.38
4000								10.73	11.53	11.91	12.28	12.99	13.63	14.22	15.21	15.92	16.37
4200								11.18	11.99	12.37	12.75	13.44	14.08	14.65	15.56	16.16	16.23
4400								11.61	12.43	12.81	13.19	13.87	14.49	15.03	15.86	16.31	15.94
4600								12.03	12.85	13.23	13.60	14.28	14.87	15.37	16.09	16.39	15.51
4800								12.43	13.25	13.63	13.99	14.65	15.21	15.67	16.26	16.37	14.93

* Endurance time will be reduced in ⬚ marked area. Please avoid if possible.

* □ The circumferential speed of pulley is 33(m/s)or more; a dynamic balance for the pulley is essential.

* Values in the table above are for nominal belt width 100(25.4mm). For other belt widths, those values should be multiplied by the width correction coefficient, Kb, shown in Table 29.

Timing Belt
Selection of Transmission Timing Belts 6

Table 37. Reference Transmission Capacity of S2M Ps -Belt Width 4mm-

(W)

No. of Teeth of Small Pulley	14	15	16	18	20	22	24	25	26	28	30	32	36	40	44	48	50	60
Rotary Speed of Small Pulley(rpm) / Diameter of the Pitch Circle(mm)	8.91	9.55	10.19	11.46	12.73	14.01	15.28	15.92	16.55	17.83	19.10	20.37	22.92	25.46	28.01	30.56	31.83	38.20
870	11	12	14	16	19	21	23	25	26	28	30	33	37	41	46	50	52	62
1160	13	15	17	20	23	26	29	31	32	35	38	41	46	52	57	62	65	77
1750	17	20	22	27	31	35	39	41	43	47	51	55	63	70	78	85	88	105
3500	26	30	34	41	49	56	63	67	70	77	83	90	102	115	126	138	143	170
50	1	1	1	2	2	2	2	2	2	3	3	3	3	4	4	5	5	6
100	2	2	2	3	3	4	4	4	4	5	5	6	6	7	8	8	9	11
150	3	3	3	4	5	5	6	6	6	7	7	8	9	10	11	12	12	15
200	4	4	4	5	6	7	7	8	8	9	9	10	11	13	14	15	16	19
250	4	5	5	6	7	8	9	9	10	10	11	12	14	15	17	18	19	23
300	5	5	6	7	8	9	10	11	11	12	13	14	16	18	19	21	22	26
350	6	6	7	8	9	10	11	12	13	14	15	16	18	20	22	24	25	30
400	6	7	8	9	10	11	13	13	14	15	16	18	20	22	25	27	28	33
450	7	8	8	10	11	13	14	15	15	17	18	19	22	25	27	30	31	37
500	7	8	9	11	12	14	15	16	17	18	20	21	24	27	29	32	33	40
550	8	9	10	11	13	15	16	17	18	20	21	23	26	29	32	35	36	43
600	8	9	10	12	14	16	18	18	19	21	23	24	28	31	34	37	39	46
650	9	10	11	13	15	17	19	20	21	22	24	26	30	33	36	40	41	49
700	9	10	12	14	16	18	20	21	22	24	26	28	31	35	39	42	44	52
750	10	11	12	14	17	19	21	22	23	25	27	29	33	37	41	44	46	55
800	10	12	13	15	17	20	22	23	24	26	28	31	35	39	43	47	49	58
850	11	12	13	16	18	21	23	24	25	28	30	32	36	41	45	49	51	61
900	11	13	14	16	19	22	24	25	26	29	31	34	38	43	47	51	53	63
950	12	13	14	17	20	22	25	26	28	30	33	35	40	44	49	53	56	66
1000	12	14	15	18	21	23	26	27	29	31	34	36	41	46	51	55	58	69
1100	13	14	16	19	22	25	28	29	31	34	36	39	44	50	55	60	62	74
1200	14	15	17	20	24	27	30	31	33	36	39	42	47	53	58	64	66	79
1300	14	16	18	22	25	28	32	33	35	38	41	44	50	56	62	68	71	84
1400	15	17	19	23	26	30	33	35	37	40	44	47	53	60	66	72	75	89
1500	16	18	20	24	28	31	35	37	39	42	46	49	56	63	69	75	79	94
1600	17	19	21	25	29	33	37	39	41	44	48	52	59	66	73	79	82	98
1700	17	19	22	26	30	34	39	41	43	46	50	54	62	69	76	83	86	103
1800	18	20	23	27	31	36	40	42	44	48	52	56	64	72	79	86	90	107
1900	18	21	23	28	33	37	42	44	46	50	55	59	67	75	82	90	94	111
2000	19	22	24	29	34	39	43	46	48	52	57	61	69	78	85	93	97	115
2200	20	23	26	31	36	41	46	49	51	56	61	65	74	83	92	100	104	124
2400	21	24	27	33	38	44	49	52	54	59	64	69	79	88	97	106	111	131
2600	22	25	28	35	40	46	52	55	57	63	68	73	84	93	103	112	117	139
2800	23	26	30	36	42	49	55	57	60	66	72	77	88	98	109	118	123	146
3000	24	28	31	38	44	51	57	60	63	69	75	81	92	103	114	124	129	153
3200	25	29	32	39	46	53	60	63	66	72	79	85	96	108	119	130	135	160
3400	26	30	33	41	48	55	62	65	69	75	82	88	100	112	124	135	140	167
3600	26	30	34	42	50	57	64	68	71	78	85	92	104	117	129	140	146	173
3800	27	31	35	44	51	59	67	70	74	81	88	95	108	121	133	145	151	179
4000	28	32	36	45	53	61	69	73	76	84	91	98	112	125	138	150	156	185
4500	29	34	39	48	57	66	74	78	82	90	98	106	121	135	149	162	168	199
5000	30	36	41	51	60	70	79	83	88	96	105	113	129	144	159	173	179	211
5500	32	37	43	53	63	74	83	88	93	102	111	119	136	152	168	183	190	223
6000	33	38	44	56	66	77	87	92	97	107	117	126	143	160	176	192	199	233
6500	33	40	46	58	69	80	91	97	102	112	122	132	150	168	184	200	208	243
7000	34	41	47	60	72	83	95	100	106	117	127	137	156	174	192	208	216	251
7500	34	41	48	61	74	86	98	104	110	121	132	142	162	181	198	215	223	259
8000	35	42	49	63	76	89	101	107	113	125	136	147	167	187	205	222	229	265
8500	35	43	50	64	78	91	104	110	116	128	140	151	172	192	210	227	235	270
9000	35	43	51	65	80	94	107	113	119	132	144	155	177	197	215	232	240	275

* Endurance time will be reduced in ⬚ marked area. Please avoid if possible.

* Values in the table above are for 4mm belt width. For other belt widths, those values should be multiplied by the width correction coefficient, Kb, shown in Table 29.

Table 38. Reference Transmission Capacity of S3M Ps -Belt Width 6mm-

(W)

No. of Teeth of Small Pulley	14	15	16	18	20	22	24	25	26	28	30	32	36	40	44	48	50	60
Rotary Speed of Small Pulley(rpm) / Diameter of the Pitch Circle(mm)	13.37	14.32	15.28	17.19	19.10	21.01	22.92	23.87	24.83	26.74	28.65	30.56	34.38	38.20	42.02	45.84	47.75	57.30
870	53	58	62	73	79	87	95	99	103	110	118	125	140	155	169	182	188	222
1160	67	72	78	92	99	110	119	124	129	139	148	158	176	194	212	229	238	279
1750	92	100	107	128	137	151	165	171	178	192	205	218	243	268	291	315	326	381
3500	154	167	180	215	230	255	277	289	300	322	344	365	407	446	484	521	539	624
50	5	5	6	7	7	8	8	9	9	10	11	11	13	14	15	17	17	20
100	9	9	10	12	13	14	15	16	17	18	19	21	23	25	28	30	31	37
150	12	13	14	17	18	20	22	23	24	26	27	29	33	36	39	43	44	52
200	16	17	18	22	23	26	28	29	30	33	35	37	42	46	50	54	56	67
250	19	21	22	26	28	31	34	35	37	39	42	45	50	55	61	66	68	80
300	22	24	26	31	33	36	39	41	43	46	49	52	58	65	71	76	79	94
350	25	27	29	35	37	41	45	47	49	52	56	59	66	73	80	87	90	106
400	28	31	33	39	42	46	50	52	54	58	62	66	74	82	90	97	101	119
450	31	34	36	43	46	51	55	58	60	64	69	73	82	90	99	107	111	131
500	34	37	39	47	50	55	60	63	65	70	75	80	89	99	108	117	121	143
550	37	40	43	51	54	60	65	68	71	76	81	86	97	107	116	126	131	154
600	39	43	46	54	58	64	70	73	76	82	87	93	104	114	125	135	140	165
650	42	46	49	58	62	69	75	78	81	87	93	99	111	122	133	144	150	176
700	45	48	52	62	66	73	79	83	86	92	99	105	118	130	142	153	159	187
750	47	51	55	65	70	77	84	87	91	98	105	111	124	137	150	162	168	198
800	50	54	58	69	73	81	89	92	96	103	110	117	131	145	158	171	177	208
850	52	57	61	72	77	86	93	97	101	108	116	123	138	152	166	179	186	218
900	55	59	64	76	81	90	97	101	105	113	121	129	144	159	173	187	194	228
950	57	62	66	79	84	94	102	106	110	118	127	135	150	166	181	196	203	238
1000	60	64	69	82	88	97	106	110	115	123	132	140	157	173	188	204	211	248
1100	64	69	75	89	95	105	114	119	124	133	142	151	169	186	203	220	228	267
1200	69	74	80	95	102	113	122	128	133	143	152	162	181	200	218	235	244	286
1300	73	79	85	101	108	120	130	136	141	152	162	173	193	213	232	250	260	304
1400	78	84	90	107	115	127	138	144	150	161	172	183	204	225	245	265	275	322
1500	82	89	95	113	121	134	146	152	158	170	182	193	216	238	259	280	290	340
1600	86	93	100	119	127	141	154	160	166	179	191	203	227	250	272	294	305	357
1700	90	98	105	125	134	148	161	168	174	187	200	213	238	262	285	308	319	373
1800	94	102	110	130	140	155	168	175	182	196	209	222	248	273	298	322	333	390
1900	98	106	114	136	146	161	175	183	190	204	218	232	259	285	310	335	347	406
2000	102	110	119	141	151	168	182	190	198	212	227	241	269	296	322	348	361	421
2200	110	119	128	152	163	180	196	204	212	228	244	259	289	318	346	374	387	452
2400	117	127	136	162	174	193	210	218	227	244	261	277	309	340	369	398	413	481
2600	124	135	145	173	185	205	223	232	241	259	277	294	328	360	392	422	437	509
2800	131	142	153	182	195	216	235	245	255	274	292	311	346	380	413	446	461	536
3000	138	150	161	192	205	228	248	258	268	288	308	327	364	400	435	468	484	562
3200	145	157	169	201	216	239	260	270	281	302	322	342	381	419	455	490	507	588
3400	151	164	177	210	225	250	272	283	294	316	337	358	398	437	475	511	528	612
3600	157	171	184	219	235	260	283	295	306	329	351	373	415	455	494	531	549	635
3800	164	177	191	228	244	271	294	306	318	342	365	387	431	473	513	551	570	658
4000	170	184	198	237	253	281	305	318	330	355	378	402	447	490	531	570	590	679
4500	184	200	216	257	275	305	332	345	359	385	411	436	484	530	574	616	636	729
5000	198	215	232	277	297	329	357	372	386	414	442	468	520	568	614	658	679	774
5500	211	230	248	296	317	351	381	396	412	442	471	499	553	603	651	696	717	813
6000	224	243	263	313	336	372	404	420	436	468	498	528	584	636	685	731	753	848
6500	236	256	277	331	354	392	426	443	460	492	524	555	613	667	717	763	784	876
7000	247	269	291	347	371	411	446	464	482	516	549	580	640	695	745	791	812	900
7500	259	281	304	363	388	430	466	485	503	538	572	604	665	721	771	816	836	917
8000	269	293	316	378	404	447	485	504	523	559	594	627	688	744	793	837	856	929
8500	279	304	328	392	419	464	503	522	542	579	614	648	710	765	813	855	873	935
9000	289	315	340	406	434	480	520	540	559	597	633	667	729	784	830	869	885	935

* Endurance time will be reduced in ⬚ marked area. Please avoid if possible.

* Values in the table above are for 6mm belt width. For other belt widths, those values should be multiplied by the width correction coefficient, Kb, shown in Table 29.

Table 39. Reference Transmission Capacity of S5M Ps -Belt Width 10mm-

(W)

No. of Teeth of Small Pulley	14	15	16	18	20	22	24	25	26	28	30	32	36	40	44	48	60
Rotary Speed of Small Pulley(rpm) / Diameter of the Pitch Circle(mm)	22.28	23.87	25.46	28.65	31.83	35.01	38.20	39.79	41.38	44.56	47.75	50.93	57.30	63.66	70.03	76.39	95.49
870	173	192	210	246	282	317	352	369	386	420	453	486	551	614	677	738	916
1160	216	239	263	309	355	399	443	465	487	529	572	613	695	775	854	931	1154
1750	293	326	359	425	488	551	613	643	673	733	792	849	963	1073	1181	1286	1587
3500	475	534	592	705	816	923	1029	1080	1131	1231	1330	1425	1611	1787	1955	2115	2544
50	16	18	19	22	25	28	31	33	34	37	40	43	48	54	59	64	80
100	30	32	35	41	46	52	57	60	62	68	73	78	88	98	108	118	147
150	42	46	50	58	66	73	81	85	89	96	104	111	125	140	154	168	209
200	53	58	63	74	84	94	104	108	113	123	132	142	161	179	197	215	268
250	64	70	76	89	101	113	125	131	137	149	160	172	194	217	239	260	324
300	74	81	89	103	118	132	146	153	160	173	187	200	227	253	279	304	378
350	84	92	101	118	134	150	166	174	182	198	213	228	259	288	318	346	431
400	93	103	112	131	150	168	186	195	203	221	238	255	289	323	355	388	482
450	103	113	124	145	165	185	205	215	224	244	263	282	319	356	392	428	532
500	112	123	135	158	180	202	224	234	245	266	287	308	349	389	428	467	581
550	121	133	146	170	195	218	242	254	265	288	311	333	378	421	464	506	629
600	129	143	156	183	209	235	260	272	285	310	334	358	406	453	499	544	676
650	138	152	167	195	223	250	278	291	304	331	357	383	434	484	533	581	722
700	146	161	177	207	237	266	295	309	323	351	379	407	461	514	566	618	767
750	154	171	187	219	250	281	312	327	342	372	401	431	488	544	599	654	812
800	162	179	197	231	264	296	329	345	361	392	423	454	514	574	632	689	856
850	170	188	206	242	277	311	345	362	379	412	445	477	541	603	664	724	899
900	178	197	216	253	290	326	362	379	397	432	466	500	566	632	696	759	941
950	185	205	225	264	303	341	378	396	415	451	487	522	592	660	727	793	983
1000	193	214	234	275	315	355	394	413	432	470	507	544	617	688	758	826	1025
1100	207	230	252	297	340	383	425	446	466	507	548	588	666	743	818	892	1106
1200	221	246	270	318	364	410	456	478	500	544	588	630	715	797	877	956	1185
1300	235	261	287	338	388	437	485	509	533	580	626	672	762	849	935	1019	1262
1400	248	276	304	358	411	463	515	540	565	615	664	713	808	901	992	1081	1338
1500	262	291	320	378	434	489	543	570	597	649	701	753	853	951	1047	1141	1411
1600	274	305	336	397	456	514	571	600	628	683	738	792	898	1001	1102	1200	1483
1700	287	319	352	415	478	539	599	629	658	716	774	830	941	1049	1155	1258	1553
1800	299	333	367	434	499	563	626	657	688	749	809	868	984	1097	1207	1314	1621
1900	311	347	382	452	520	587	653	685	717	781	844	905	1026	1144	1258	1370	1688
2000	323	360	397	470	541	611	679	713	746	813	878	942	1068	1189	1308	1424	1753
2200	346	386	426	504	581	656	730	767	803	874	944	1013	1148	1279	1406	1529	1879
2400	367	411	454	538	620	701	780	819	858	934	1009	1082	1226	1365	1500	1630	1998
2600	389	435	480	570	658	744	828	870	911	991	1071	1149	1301	1448	1590	1727	2111
2800	409	458	507	602	695	786	875	919	962	1048	1132	1214	1374	1528	1677	1820	2218
3000	429	481	532	633	731	826	920	967	1012	1102	1190	1277	1445	1606	1761	1910	2319
3200	448	502	556	662	765	866	965	1013	1061	1155	1247	1338	1513	1680	1841	1995	2414
3400	466	524	580	691	799	904	1008	1058	1108	1206	1303	1397	1579	1752	1918	2076	2502
3600	484	544	603	719	832	942	1049	1102	1154	1256	1356	1454	1642	1821	1992	2153	2584
3800	501	564	626	747	864	978	1090	1145	1199	1305	1408	1509	1704	1888	2062	2227	2659
4000	518	583	647	773	895	1014	1130	1186	1242	1352	1459	1563	1763	1951	2129	2296	2728
4500	558	629	699	837	970	1098	1224	1285	1345	1463	1578	1689	1901	2098	2282	2452	2870
5000	595	672	748	896	1039	1177	1312	1377	1441	1566	1688	1804	2025	2228	2414	2581	2966
5500	629	712	793	951	1104	1251	1393	1462	1530	1661	1788	1909	2135	2340	2523	2683	3014
6000	661	749	835	1003	1164	1319	1468	1540	1611	1747	1878	2002	2231	2434	2609	2756	3011
6500	690	783	874	1051	1220	1382	1537	1612	1685	1825	1958	2084	2312	2508	2672	2800	2955
7000	716	814	910	1096	1272	1440	1600	1677	1752	1895	2029	2154	2378	2563	2709	2812	2841
7500	741	843	943	1137	1320	1493	1657	1735	1811	1955	2090	2213	2428	2598	2720	2791	2666
8000	763	870	974	1174	1363	1540	1708	1787	1863	2007	2140	2260	2462	2611	2703	2735	2427
8500	783	894	1001	1208	1402	1583	1752	1831	1908	2050	2179	2294	2479	2602	2658	2643	2122
9000	801	915	1026	1239	1436	1620	1790	1869	1944	2084	2208	2315	2479	2570	2583	2513	1745

* Endurance time will be reduced in ⬚ marked area. Please avoid if possible.

* ▭ The circumferential speed of pulley is 33(m/s)or more; a dynamic balance for the pulley is essential.

* Values in the table above are for 10mm belt width. For other belt widths, those values should be multiplied by the width correction coefficient, Kb, shown in Table 29.

Table 40. Reference Transmission Capacity of S8M Ps -Belt Width 60mm-

(kW)

No. of Teeth of Small Pulley	20	21	22	24	25	26	28	30	32	34	36	38	40	44	48	50	60	72	84
Rotary Speed of Small Pulley(rpm) / Diameter of the Pitch Circle(mm)	50.93	53.48	56.02	61.12	63.66	66.21	71.30	76.39	81.49	86.58	91.67	96.77	101.86	112.05	122.23	127.32	152.79	183.35	213.90
870	6.38	6.70	7.02	7.66	7.98	8.29	8.93	9.56	10.20	10.83	11.47	12.10	12.73	14.00	15.25	15.88	19.01	22.73	26.41
1160	8.51	8.93	9.35	10.20	10.62	11.05	11.89	12.73	13.58	14.42	15.25	16.09	16.93	18.60	20.26	21.08	25.19	30.03	34.77
1750	12.81	13.44	14.07	15.34	15.97	16.61	17.86	19.12	20.37	21.62	22.86	24.10	25.33	27.78	30.20	31.40	37.29	44.09	50.52
3500	25.33	26.56	27.78	30.20	31.40	32.59	34.96	37.29	39.60	41.86	44.09	46.28	48.42	52.57	56.62	58.42	67.02	75.09	80.26
50	0.37	0.39	0.40	0.44	0.46	0.48	0.51	0.55	0.59	0.62	0.66	0.70	0.73	0.81	0.88	0.92	1.10	1.32	1.54
100	0.73	0.77	0.81	0.88	0.92	0.95	1.03	1.10	1.18	1.25	1.32	1.40	1.47	1.62	1.76	1.84	2.20	2.64	3.08
200	1.47	1.54	1.62	1.76	1.84	1.91	2.06	2.20	2.35	2.50	2.64	2.79	2.94	3.23	3.52	3.67	4.40	5.28	6.16
300	2.20	2.31	2.42	2.64	2.75	2.86	3.08	3.30	3.52	3.74	3.96	4.18	4.40	4.84	5.28	5.50	6.60	7.92	9.24
400	2.94	3.08	3.23	3.52	3.67	3.82	4.11	4.40	4.70	4.99	5.28	5.58	5.87	6.46	7.04	7.34	8.80	10.55	12.30
500	3.67	3.85	4.04	4.40	4.59	4.77	5.14	5.50	5.87	6.24	6.60	6.97	7.34	8.07	8.80	9.16	10.99	13.17	15.34
600	4.40	4.62	4.84	5.28	5.50	5.72	6.16	6.60	7.04	7.48	7.92	8.36	8.80	9.67	10.55	10.99	13.17	15.78	18.37
700	5.14	5.39	5.65	6.16	6.42	6.68	7.19	7.70	8.21	8.72	9.24	9.75	10.26	11.28	12.30	12.80	15.34	18.37	21.37
800	5.87	6.16	6.46	7.04	7.34	7.63	8.21	8.80	9.38	9.97	10.55	11.13	11.71	12.88	14.04	14.62	17.51	20.94	24.34
900	6.60	6.93	7.26	7.92	8.25	8.58	9.24	9.89	10.55	11.21	11.86	12.52	13.17	14.47	15.78	16.42	19.66	23.50	27.29
1000	7.34	7.70	8.07	8.80	9.16	9.53	10.26	10.99	11.72	12.44	13.17	13.89	14.62	16.06	17.51	18.22	21.80	26.03	30.20
1100	8.07	8.47	8.87	9.67	10.08	10.48	11.28	12.08	12.88	13.68	14.47	15.27	16.08	17.65	19.23	20.01	23.92	28.54	33.07
1200	8.80	9.24	9.67	10.55	10.99	11.42	12.30	13.17	14.04	14.91	15.77	16.64	17.51	19.23	20.94	21.80	26.03	31.02	35.90
1300	9.53	10.00	10.48	11.42	11.90	12.37	13.31	14.26	15.20	16.14	17.07	18.01	18.94	20.80	22.65	23.57	28.12	33.48	38.68
1400	10.26	10.77	11.28	12.30	12.80	13.31	14.33	15.34	16.35	17.36	18.37	19.37	20.37	22.37	24.35	25.33	30.20	35.90	41.41
1500	10.99	11.53	12.08	13.17	13.71	14.26	15.34	16.42	17.51	18.58	19.66	20.73	21.80	23.92	26.03	27.08	32.25	38.29	44.09
1600	11.71	12.30	12.88	14.04	14.62	15.20	16.35	17.50	18.66	19.80	20.94	22.08	23.22	25.47	27.71	28.82	34.29	40.64	46.71
1700	12.44	13.06	13.68	14.91	15.52	16.14	17.36	18.58	19.80	21.01	22.22	23.43	24.63	27.01	29.37	30.54	36.30	42.95	49.26
1800	13.17	13.82	14.47	15.78	16.42	17.07	18.37	19.66	20.94	22.22	23.50	24.77	26.03	28.54	31.02	32.25	38.29	45.22	51.75
1900	13.89	14.58	15.27	16.64	17.32	18.01	19.37	20.73	22.08	23.43	24.77	26.10	27.43	30.06	32.66	33.95	40.25	47.44	54.17
2000	14.62	15.34	16.06	17.51	18.22	18.94	20.37	21.80	23.22	24.63	26.03	27.43	28.82	31.57	34.29	35.63	42.18	49.62	56.52
2100	15.34	16.10	16.86	18.37	19.12	19.87	21.37	22.86	24.35	25.82	27.29	28.75	30.20	33.07	35.90	37.29	44.09	51.75	58.79
2200	16.06	16.86	17.65	19.23	20.01	20.80	22.36	23.92	25.47	27.01	28.54	30.06	31.57	34.56	37.49	38.94	45.96	53.83	60.98
2300	16.79	17.61	18.44	20.09	20.91	21.73	23.36	24.98	26.59	28.19	29.78	31.37	32.93	36.03	39.07	40.57	47.81	55.86	63.08
2400	17.51	18.37	19.23	20.94	21.80	22.65	24.34	26.03	27.71	29.37	31.02	32.66	34.29	37.49	40.64	42.18	49.62	57.83	65.10
2500	18.22	19.12	20.01	21.80	22.68	23.57	25.33	27.08	28.82	30.54	32.25	33.95	35.63	38.94	42.18	43.77	51.40	59.74	67.02
2600	18.94	19.87	20.80	22.65	23.57	24.49	26.31	28.12	29.92	31.71	33.48	35.23	36.96	40.38	43.71	45.34	53.15	61.59	68.84
2700	19.66	20.62	21.58	23.50	24.45	25.40	27.29	29.16	31.02	32.87	34.69	36.50	38.29	41.80	45.22	46.89	54.85	63.38	70.57
2800	20.37	21.37	22.36	24.35	25.33	26.31	28.26	30.20	32.12	34.02	35.90	37.76	39.60	43.20	46.71	48.42	56.52	65.10	72.19
2900	21.09	22.12	23.14	25.19	26.21	27.22	29.23	31.23	33.21	35.16	37.09	39.01	40.89	44.59	48.17	49.92	58.15	66.75	73.70
3000	21.80	22.86	23.92	26.03	27.08	28.13	30.20	32.25	34.29	36.30	38.28	40.25	42.18	45.97	49.62	51.40	59.74	68.33	75.09
3100	22.51	23.61	24.70	26.87	27.95	29.03	31.16	33.27	35.36	37.43	39.46	41.48	43.46	47.32	51.05	52.86	61.29	69.84	76.38
3200	23.22	24.35	25.47	27.71	28.82	29.92	32.12	34.29	36.43	38.55	40.63	42.69	44.72	48.66	52.45	54.29	62.79	71.27	77.54
3300	23.92	25.09	26.24	28.54	29.68	30.82	33.07	35.29	37.49	39.66	41.79	43.90	45.96	49.98	53.83	55.69	64.25	72.63	78.57
3400	24.63	25.82	27.01	29.37	30.54	31.71	34.02	36.30	38.55	40.76	42.95	45.09	47.20	51.29	55.19	57.07	65.66	73.90	79.48
3600	26.03	27.29	28.54	31.03	32.25	33.48	35.90	38.28	40.64	42.95	45.22	47.44	49.62	53.84	57.83	59.74	68.33	76.20	80.90
3700	26.73	28.02	29.30	31.85	33.10	34.36	36.83	39.27	41.67	44.02	46.33	48.60	50.81	55.08	59.11	61.03	69.60	77.22	81.41
3800	27.43	28.75	30.06	32.66	33.95	35.23	37.76	40.24	42.69	45.09	47.44	49.74	51.99	56.30	60.36	62.29	70.81	78.15	81.77
3900	28.12	29.48	30.82	33.48	34.79	36.10	38.68	41.21	43.71	46.15	48.54	50.87	53.15	57.51	61.59	63.52	71.96	78.98	81.98
4000	28.82	30.20	31.57	34.29	35.63	36.96	39.59	42.18	44.72	47.20	49.62	51.99	54.29	58.69	62.79	64.72	73.06	79.72	82.04
4200	30.20	31.64	33.07	35.90	37.29	38.68	41.41	44.09	46.71	49.26	51.75	54.18	56.52	60.98	65.10	67.02	75.09	80.90	
4400	31.57	33.07	34.56	37.50	38.94	40.38	43.20	45.96	48.66	51.28	53.83	56.30	58.69	63.18	67.29	69.18	76.89	81.68	
4600	32.93	34.49	36.03	39.08	40.57	42.05	44.97	47.81	50.58	53.26	55.86	58.37	60.78	65.29	69.35	71.20	78.43	82.02	
4800	34.29	35.90	37.49	40.64	42.18	43.71	46.71	49.62	52.45	55.19	57.83	60.37	62.79	67.29	71.27	73.06	79.72	81.92	
5000	35.63	37.30	38.94	42.18	43.77	45.34	48.42	51.40	54.29	57.07	59.74	62.30	64.72	69.18	73.06	74.77	80.74	81.34	
5200	36.96	38.68	40.37	43.71	45.34	46.95	50.10	53.14	56.08	58.90	61.59	64.15	66.57	70.96	74.71	76.32	81.47		
5400	38.29	40.05	41.79	45.22	46.89	48.54	51.75	54.85	57.83	60.67	63.38	65.94	68.33	72.63	76.20	77.69	81.91		
5600	39.60	41.41	43.20	46.71	48.42	50.10	53.37	56.52	59.53	62.39	65.10	67.64	70.00	74.18	77.54	78.89	82.04		
5800	40.89	42.76	44.59	48.18	49.92	51.64	54.96	58.15	61.19	64.05	66.75	69.27	71.58	75.60	78.71	79.91			
6000	42.18	44.09	45.96	49.63	51.40	53.15	56.52	59.74	62.79	65.66	68.33	70.81	73.06	76.89	79.72	80.73			

* Endurance time will be reduced in ⬚ marked area. Please avoid if possible.

* ▭ The circumferential speed of pulley is 33(m/s)or more; a dynamic balance for the pulley is essential.

* Values in the table above are for 60mm belt width. For other belt widths, those values should be multiplied by the width correction coefficient, Kb, shown in Table 29.

Table 41. Reference Transmission Capacity of S14M Ps -Belt Width 120mm- (kW)

Rotary Speed of Small Pulley(rpm) \ Number of Teeth of Small Pulley	28	30	32	34	36	40	42	44	48	50	56	60	64	72	84
Pitch Dia. (mm)	124.78	133.69	142.60	151.52	160.43	178.25	187.17	196.08	213.90	222.82	249.55	267.38	285.21	320.86	374.33
575	32.08	34.36	36.63	38.90	41.17	45.68	47.94	50.19	54.67	56.91	63.58	68.00	72.39	81.10	93.92
690	38.45	41.17	43.88	46.59	49.29	54.67	57.36	60.03	65.35	68.00	75.89	81.09	86.26	96.44	111.32
870	48.35	51.75	55.14	58.52	61.88	68.57	71.90	75.20	81.77	85.03	94.68	101.02	107.27	119.49	136.99
1160	64.12	68.57	73.00	77.40	81.77	90.41	94.69	98.92	107.27	111.39	123.46	131.27	138.87	153.39	173.25
1750	95.20	101.57	107.84	114.03	120.11	131.93	137.68	143.29	154.11	159.32	174.00	182.96	191.21	205.36	220.00
3450	172.13	181.10	189.39	196.95	203.72	214.76	218.93	222.13	225.47						
20	1.12	1.20	1.28	1.36	1.44	1.60	1.68	1.76	1.92	2.00	2.24	2.40	2.56	2.88	3.36
40	2.24	2.40	2.56	2.72	2.88	3.20	3.36	3.52	3.84	4.00	4.48	4.80	5.12	5.76	6.71
60	3.36	3.60	3.84	4.08	4.32	4.80	5.04	5.28	5.76	6.00	6.71	7.19	7.67	8.63	10.07
80	4.48	4.80	5.12	5.44	5.76	6.39	6.71	7.03	7.67	7.99	8.95	9.59	10.23	11.51	13.42
90	5.04	5.40	5.76	6.12	6.47	7.19	7.55	7.91	8.63	8.99	10.07	10.79	11.51	12.94	15.10
100	5.60	6.00	6.39	6.79	7.19	7.99	8.39	8.79	9.59	9.99	11.19	11.99	12.79	14.38	16.77
200	11.19	11.99	12.78	13.58	14.38	15.98	16.78	17.57	19.17	19.96	22.35	23.94	25.53	28.71	33.47
300	16.78	17.97	19.17	20.36	21.56	23.94	25.14	26.33	28.71	29.90	33.47	35.84	38.21	42.94	49.99
400	22.35	23.94	25.53	27.12	28.71	31.88	33.47	35.05	38.21	39.79	44.51	47.65	50.78	57.01	66.27
500	27.92	29.90	31.88	33.86	35.84	39.79	41.76	43.72	47.64	49.60	55.45	59.33	63.20	70.87	82.22
600	33.47	35.84	38.21	40.58	42.94	47.64	49.99	52.34	57.00	59.33	66.27	70.87	75.43	84.47	97.76
700	39.00	41.76	44.51	47.26	49.99	55.45	58.17	60.88	66.27	68.96	76.95	82.22	87.45	97.76	112.80
800	44.51	47.65	50.77	53.90	57.01	63.19	66.27	69.34	75.43	78.46	87.45	93.36	99.21	110.68	127.26
900	49.99	53.51	57.00	60.49	63.97	70.87	74.29	77.70	84.47	87.82	97.75	104.27	110.68	123.19	141.06
1000	55.45	59.33	63.19	67.04	70.87	78.46	82.22	85.96	93.36	97.03	107.84	114.90	121.82	135.23	154.11
1100	60.88	65.12	69.34	73.54	77.70	85.96	90.05	94.10	102.11	106.06	117.68	125.23	132.60	146.75	166.35
1200	66.27	70.87	75.43	79.97	84.47	93.36	97.76	102.11	110.68	114.90	127.26	135.23	142.97	157.70	177.67
1300	71.63	76.57	81.47	86.34	91.16	100.66	105.35	109.97	119.07	123.53	136.53	144.87	152.91	168.02	188.00
1400	76.95	82.22	87.45	92.63	97.76	107.84	112.80	117.69	127.26	131.94	145.49	154.12	162.37	177.67	197.26
1500	82.22	87.82	93.36	98.85	104.27	114.90	120.11	125.23	135.23	140.10	154.11	162.94	171.32	186.69	205.36
1600	87.45	93.36	99.21	104.99	110.68	121.82	127.26	132.60	142.97	148.00	162.36	171.31	179.72	194.73	212.22
1700	92.63	98.85	104.98	111.04	116.99	128.60	134.25	139.78	150.46	155.62	170.22	179.21	187.53	202.03	217.76
1800	97.76	104.27	110.68	116.99	123.19	135.23	141.06	146.75	157.70	162.94	177.67	186.59	194.73	208.45	221.89
1900	102.83	109.62	116.29	122.85	129.27	141.70	147.69	153.51	164.65	169.95	184.67	193.43	201.26	213.94	224.54
2000	107.85	114.90	121.82	128.61	135.23	147.99	154.12	160.05	171.31	176.63	191.21	199.69	207.11	218.44	225.62
2100	112.80	120.10	127.26	134.25	141.06	154.11	160.34	166.35	177.67	182.96	197.25	205.36	212.22	221.89	
2200	117.69	125.23	132.60	139.78	146.75	160.05	166.35	172.40	183.70	188.93	202.79	210.39	216.56	224.26	
2300	122.51	130.27	137.83	145.19	152.30	165.78	172.13	178.18	189.39	194.51	207.78	214.76	220.10	225.47	
2400	127.26	135.23	142.97	150.47	157.70	171.31	177.67	183.70	194.72	199.69	212.22	218.43	222.80	225.50	
2500	131.94	140.10	147.99	155.62	162.94	176.63	182.97	188.93	199.69	204.46	216.06	221.39	224.63		
2600	136.54	144.87	152.90	160.63	168.02	181.82	188.00	193.86	204.27	208.78	219.29	223.59	225.54		
2700	141.06	149.54	157.70	165.51	172.93	186.58	192.77	198.49	208.45	212.66	221.89	225.01	225.50		
2800	145.50	154.12	162.36	170.23	177.67	191.21	197.26	202.79	212.22	216.06	223.83	225.62			
2900	149.85	158.58	166.90	174.80	182.22	195.58	201.46	206.76	215.55	218.98	225.08				
3000	154.12	162.94	171.31	179.21	186.59	199.69	205.36	210.39	218.43	221.39	225.62				
3100	158.29	167.19	175.58	183.46	190.76	203.53	208.95	213.66	220.86	223.28					
3200	162.37	171.31	179.71	187.53	194.73	207.10	212.22	216.56	222.80	224.63					
3300	166.35	175.32	183.70	191.44	198.49	210.39	215.16	219.09	224.25	225.42					
3400	170.23	179.21	187.53	195.16	202.03	213.37	217.76	221.22	225.20	225.63					
3500	174.00	182.96	191.21	198.69	205.36	216.06	220.01	222.94	225.62						
3600	177.67	186.59	194.72	202.04	208.45	218.43	221.89	224.26							
3700	181.23	190.08	198.08	205.18	211.32	220.49	223.41	225.14							
3800	184.67	193.43	201.26	208.12	213.94	222.21	224.54	225.58							
3900	188.00	196.63	204.27	210.86	216.31	223.59	225.28	225.58							
4000	191.21	199.69	207.10	213.38	218.44	224.63	225.62								
4100	194.30	202.60	209.75	215.68	220.30	225.30									
4200	197.26	205.36	212.22	217.76	221.89	225.62									
4300	200.09	207.95	214.49	219.61	223.21										
4400	202.79	210.39	216.56	221.22	224.26										
4500	205.36	212.66	218.43	222.59	225.01										
4600	207.79	214.76	220.10	223.71	225.47										
4700	210.08	216.68	221.56	224.58	225.64										
4800	212.22	218.43	222.80	225.20											
4900	214.22	220.00	223.63	225.55											
5000	216.06	221.39	224.63	225.63											

* Endurance time will be reduced in [ ] marked area. Please avoid if possible.
* The circumferential speed of pulley is 33 (m/s) or more in the [ ] marked range; a dymanic balance for the pulley is essential.
* The above table assumes the reference belt width of 120mm. For belts other than 120mm wide, multiply the compensation factors Kb from Table 29.

Table 42. Reference Transmission Capacity of MTS8M Ps -Belt Width 60mm- (kW)

Rotary Speed of Small Pulley(rpm) \ Number of Teeth of Small Pulley	24	26	28	30	32	34	36	38	40	42	44	46	48	50	60	72	84
Pitch Dia. (mm)	61.12	66.21	71.30	76.39	81.49	86.58	91.67	96.77	101.86	106.95	112.05	117.14	122.23	127.32	152.79	183.35	213.90
50	1.35	1.47	1.58	1.70	1.82	1.93	2.05	2.17	2.27	2.37	2.46	2.56	2.66	2.75	3.21	3.75	4.27
100	2.71	2.94	3.17	3.40	3.63	3.87	4.11	4.35	4.54	4.74	4.93	5.12	5.31	5.50	6.42	7.50	8.54
200	4.91	5.32	5.73	6.15	6.57	6.99	7.42	7.85	8.20	8.54	8.89	9.22	9.56	9.89	11.52	13.41	15.23
300	6.91	7.48	8.06	8.64	9.23	9.83	10.43	11.04	11.52	12.00	12.47	12.94	13.41	13.87	16.12	18.71	21.20
400	8.77	9.50	10.23	10.98	11.73	12.48	13.25	14.02	14.63	15.23	15.82	16.41	16.99	17.57	20.38	23.62	26.72
500	10.53	11.40	12.29	13.18	14.08	14.99	15.92	16.85	17.57	18.28	18.99	19.69	20.38	21.07	24.40	28.22	31.88
600	12.20	13.22	14.24	15.28	16.33	17.39	18.46	19.55	20.38	21.20	22.02	22.82	23.62	24.40	28.22	32.59	36.76
700	13.80	14.95	16.11	17.29	18.48	19.69	20.91	22.15	23.09	24.01	24.92	25.82	26.72	27.60	31.88	36.76	41.39
800	15.32	16.61	17.91	19.23	20.56	21.91	23.28	24.66	25.70	26.72	27.72	28.72	29.70	30.68	35.39	40.74	45.81
900	16.79	18.21	19.64	21.09	22.56	24.05	25.56	27.10	28.22	29.34	30.44	31.52	32.59	33.65	38.77	44.57	50.04
1000	18.21	19.75	21.31	22.89	24.50	26.13	27.78	29.46	30.68	31.88	33.06	34.23	35.39	36.53	42.03	48.25	54.09
1100	19.57	21.24	22.92	24.64	26.38	28.14	29.94	31.76	33.06	34.35	35.62	36.87	38.10	39.32	45.19	51.80	57.98
1200	20.89	22.67	24.48	26.33	28.20	30.10	32.04	34.00	35.39	36.76	38.10	39.43	40.74	42.03	48.25	55.22	61.71
1300	22.16	24.06	26.00	27.97	29.97	23.01	34.08	36.19	37.66	39.10	40.52	41.93	43.31	44.67	51.21	58.52	65.29
1400	23.38	25.40	27.46	29.56	31.69	33.86	36.07	38.33	39.87	41.39	42.89	44.36	45.81	47.24	54.09	61.71	68.73
1500	24.57	26.71	28.88	31.10	33.37	35.67	38.02	40.41	42.03	43.62	45.19	46.73	48.25	49.74	56.88	64.79	72.03
1600	25.71	27.97	30.26	32.61	35.00	37.44	39.92	42.46	44.15	45.81	47.44	49.05	50.63	52.18	59.59	67.76	75.19
1700	26.82	29.19	31.60	34.07	36.59	39.16	41.78	44.46	46.22	47.95	49.64	51.31	52.95	54.56	62.23	70.63	78.22
1800	27.89	30.37	32.90	35.49	38.14	40.84	43.60	46.42	48.25	50.04	51.79	53.52	55.22	56.88	64.78	73.40	81.12
1900	28.92	31.51	34.16	36.87	39.65	42.48	45.38	48.35	50.23	52.08	53.90	55.68	57.43	59.15	67.27	76.07	83.89
2000	29.92	32.62	35.39	38.22	41.12	44.09	47.13	50.23	52.18	54.09	55.96	57.79	59.59	61.36	69.68	78.64	86.53
2100	30.89	33.70	36.57	39.53	42.55	45.65	48.83	52.08	54.09	56.05	57.97	59.86	61.71	63.51	72.03	81.12	89.05
2200	31.82	37.74	37.73	40.80	43.95	47.19	50.50	53.90	55.96	57.97	59.95	61.88	63.77	65.62	74.30	83.50	91.43
2300	32.72	35.74	38.85	42.04	45.32	48.68	52.14	55.68	57.79	59.86	61.88	63.85	65.79	67.68	76.51	85.79	
2400	33.59	36.72	39.93	43.25	46.65	50.15	53.74	57.43	59.59	67.71	63.77	65.79	67.76	69.68	78.64	87.98	
2500	34.42	37.66	40.99	44.42	47.95	51.58	55.31	59.15	61.36	63.51	65.62	67.68	69.68	71.64	80.72	90.08	
2600	35.23	38.57	42.01	45.56	49.21	52.98	56.85	60.83	63.09	56.29	67.43	69.52	71.56	73.55	82.72	92.09	
2700	36.00	39.44	43.00	46.67	50.45	54.34	58.36	62.48	64.78	67.02	69.21	71.33	73.40	75.41	84.66		
2800	36.75	40.29	43.96	47.74	51.65	55.68	59.83	64.11	66.45	68.73	70.94	73.09	75.19	77.23	86.53		
2900	37.46	41.11	44.89	48.79	52.82	56.99	61.28	65.70	68.08	70.39	72.64	74.82	76.94	78.99	88.34		
3000	38.15	41.90	45.78	49.80	53.96	58.26	62.70	67.27	69.68	72.03	74.30	76.50	78.64	80.71	90.08		
3200	39.44	43.39	47.49	51.75	56.16	60.72	65.44	70.31	72.79	75.19	77.51	79.76	81.93	84.02			
3400	40.61	44.76	49.08	53.57	58.23	63.07	68.07	73.25	75.78	78.22	80.58	82.85	85.04	87.14			
3600	41.67	46.02	50.55	55.28	60.19	65.30	70.59	76.07	78.64	81.12	83.50	85.79	87.98	90.08			
3800	42.63	47.17	51.92	56.88	62.04	67.42	73.00	78.78	81.39	83.89	86.29	88.58	90.76				
4000	43.47	48.21	53.17	58.36	63.78	69.42	75.30	81.39	84.02	86.53	88.93	91.21					
4200	44.21	49.14	54.31	59.73	65.41	71.32	77.49	83.89	86.53	89.04	91.43						
4400	44.85	49.96	55.35	61.00	66.92	73.11	79.57	86.29	88.93	91.43							
4600	45.38	50.68	56.27	62.16	68.33	74.80	81.55	88.57	91.21								
4800	45.81	51.29	57.09	63.21	69.64	76.37	83.42	90.76									
5000	46.14	51.80	57.81	64.15	70.83	77.84	85.18										
5200	46.36	52.20	58.41	64.99	71.92	79.20	86.84										
5400	46.48	52.51		65.72	72.90	80.46											
5600	46.51	52.70		66.34	73.78												
5800	46.43			66.86	74.54												
6000	46.25																

* Endurance time will be reduced in [ ] marked area. Please avoid if possible.
* Because the circumferential speed of pulley within the [ ] marked range is higher than 20m/sec, this range should be avoided whenever possible.
* Values in the table above is for nominal belt width 600(60mm). For other belt widths, those values should be multiplied by the width correction coefficient, Kb, shown in Table 29.

Table 43. Reference Transmission Capacity of P2M Ps -Belt Width 4mm- (W)

Rotary Speed of Small Pulley(rpm) \ No. of Teeth of Small Pulley	14	15	16	18	20	22	24	25	26	28	30	32	34	36	40	42	44	48
Diameter of the Pitch Circle(mm)	8.91	9.55	10.19	11.46	12.73	14.01	15.28	15.92	16.55	17.83	19.10	20.37	21.65	22.92	25.46	26.74	28.01	30.56
100	2	2	2	2	3	3	3	3	3	4	4	5	5	6	7	7	8	9
200	3	3	4	5	5	6	7	7	7	8	9	10	11	11	13	14	15	17
400	6	6	7	8	9	10	11	12	13	14	15	16	17	19	22	24	25	28
600	8	9	10	11	12	14	16	17	18	19	20	22	23	25	29	31	33	37
800	10	11	12	13	16	18	19	20	21	23	25	27	29	31	36	38	41	46
1000	12	13	14	16	18	20	23	24	25	27	30	32	34	37	42	45	48	54
1200	14	15	16	19	21	23	26	26	28	31	34	37	40	42	48	51	54	61
1400	16	17	18	21	24	26	29	30	32	35	38	41	44	47	54	57	61	68
1450	16	18	19	21	24	27	30	31	33	36	39	42	45	48	55	59	62	70
1500	16	18	19	22	25	28	31	32	34	37	40	43	46	50	57	60	64	71
1600	17	18	20	23	26	29	32	33	35	39	43	46	49	53	60	64	67	75
1750	19	20	22	25	28	31	35	37	38	42	45	49	53	56	64	68	71	79
1800	19	21	23	25	29	32	35	37	38	42	46	50	54	57	65	69	73	81
2000	21	22	24	28	31	34	38	40	42	46	50	54	58	62	70	74	78	87
2400	24	26	28	32	36	40	44	46	48	52	56	61	65	70	80	85	89	99
3000		30	32	37	42	46	52	54	57	62	67	72	77	82	93	98	102	115
3600		35	38	43	48	53	59	62	64	70	76	82	88	94	106	112	118	131
4000		38	41	47	52	58	64	67	70	76	82	88	94	101	114	120	127	140
5000			48	55	61	68	75	78	82	89	96	104	111	118	132	139	147	162
6000			55	63	70	78	86	90	93	101	109	117	125	133	149	157	164	180
8000				76	86	95	105	109	114	123	132	141	150	158	176	184	192	209
10000				91	101	111	122	127	132	142	151	161	170	178	196	203	210	224
12000					114	125	136	141	146	157	166	175	183	190	206	211	217	228
14000					125	136	148	153	158	168	176	185	190	196	208	214	220	232

* Endurance time will be reduced in [ ] marked area. Please avoid if possible. If the belt width changes, multiply the compensation factors Kb from Table 29.

Table 44. Reference Transmission Capacity of P3M Ps -Belt Width 6mm- (W)

Rotary Speed of Small Pulley(rpm) \ No. of Teeth of Small Pulley	10	12	14	15	16	18	20	22	24	25	26	28	30	32	34	36	40	42
Diameter of the Pitch Circle(mm)	9.55	11.46	13.37	14.32	15.28	17.19	19.10	20.01	22.92	23.87	24.83	26.74	28.65	30.56	32.47	34.38	38.20	40.11
100	4	5	6	6	7	8	9	10	12	12	13	14	15	17	19	20	22	23
200	8	11	12	13	14	16	18	20	23	24	25	28	31	34	36	38	45	47
400	14	17	20	22	24	27	32	35	39	41	43	47	51	56	61	65	75	79
600	19	23	28	30	33	37	42	47	53	55	58	63	69	75	81	87	100	105
800	24	29	35	38	41	46	53	59	65	68	72	79	85	92	99	107	123	129
1000	28	35	41	44	48	55	62	69	77	81	84	92	100	109	118	126	144	151
1200	33	40	47	51	55	63	71	79	88	92	97	106	115	125	135	144	164	172
1400	37	45	54	58	62	71	80	89	99	104	109	119	129	140	151	162	184	193
1450	38	46	55	59	64	72	82	90	102	106	111	122	133	144	155	166	188	197
1500	39	47	56	60	65	75	84	93	104	109	114	125	135	147	158	170	193	202
1600	41	49	59	63	68	79	88	98	109	114	120	131	142	154	166	178	202	212
1750	44	54	63	68	74	84	95	106	118	124	129	141	153	165	177	190	215	226
1800		55	65	70	75	86	97	108	120	126	131	143	155	168	181	193	219	230
2000		59	70	75	81	93	105	117	129	135	142	155	168	182	196	209	237	249
2400		68	81	87	93	107	121	134	148	155	162	177	192	207	223	238	270	284
3000			95	103	112	125	142	158	175	183	191	208	226	243	261	279	316	332
3600			110	118	127	145	163	182	201	210	219	238	258	278	298	318	359	377
4000			119	128	138	158	176	196	216	226	236	257	278	299	321	342	386	405
5000			141	152	163	186	208	231	255	267	278	302	326	351	375	399	448	470
6000				174	187	212	238	264	291	304	317	343	370	397	424	451	505	530
8000					232	263	293	324	356	371	387	418	448	479	508	538	597	627
10000						308	342	377	413	430	446	480	512	545	574	604	663	696
12000						349	386	423	460	477	495	530	562	594	620	646	699	734
14000							424	462	500	517	534	568	597	626	645	665	704	739

* Endurance time will be reduced in [ ] marked area. Please avoid if possible. If the belt width changes, multiply the compensation factors Kb from Table 29.

Table 45. Reference Transmission Capacity of P5M Ps -Belt Width 10mm- (W)

Rotary Speed of Small Pulley (rpm) \ No. of Teeth of Small Pulley	12	14	16	18	20	22	24	25	26	28	30	32	34	36	40	42	44	48	56
Diameter of the Pitch Circle (mm)	19.10	22.28	25.46	28.65	31.83	35.05	38.20	39.79	41.38	44.56	47.75	50.93	54.11	57.30	63.66	66.85	70.03	76.39	89.15
100	23	26	31	35	41	46	52	55	58	64	70	76	81	86	103	110	118	133	158
200	46	53	63	72	81	92	104	109	115	126	138	151	164	177	205	220	235	267	316
400	77	90	106	122	138	155	173	182	192	211	231	251	272	294	337	361	385	434	514
600	105	123	144	165	188	211	235	247	259	284	310	337	365	394	452	482	513	577	684
800	131	153	179	205	234	262	291	306	322	353	385	417	451	485	556	592	629	706	837
1000	156	182	212	243	276	309	343	361	379	415	453	491	530	570	651	694	738	825	977
1200	179	209	244	280	316	355	394	414	435	476	518	561	605	650	742	790	838	937	1110
1400	201	235	274	319	355	399	443	465	487	532	580	628	677	726	828	880	933	1040	1230
1450		242	282	323	365	409	453	476	499	546	594	643	694	745	850	903	957	1070	1260
1500		248	288	333	374	420	466	489	512	560	609	659	711	762	869	925	981	1090	1290
1600		261	303	348	393	441	489	514	538	588	639	691	745	799	910	970	1030	1140	1350
1750		278	325	372	420	471	522	548	575	628	683	738	795	852	970	1040	1100	1220	1430
1800			332	380	430	481	532	559	586	640	696	753	810	868	989	1050	1110	1240	1460
2000			360	412	465	520	576	605	633	691	751	812	874	937	1060	1130	1200	1330	1570
2400			413	472	532	595	658	691	723	789	857	925	992	1060	1210	1280	1350	1500	2030
3000				557	628	701	775	812	850	926	1000	1080	1150	1240	1400	1485	1570	1730	2120
3600				638	719	801	883	925	966	1050	1140	1230	1310	1400	1580	1670	1760	1940	2250
4000					776	865	953	997	1040	1130	1220	1320	1450	1500	1690	1785	1880	2060	2380
5000					911	1010	1110	1160	1210	1320	1420	1520	1620	1720	1920	2010	2110	2300	2610
6000						1140	1260	1310	1370	1480	1580	1690	1790	1900	2100	2190	2290	2460	2720
8000							1490	1550	1600	1720	1830	1930	2020	2120	2270	2330	2400	2480	2480
10000								1710	1760	1860	1940	2020	2080	2130	2170	2160	2150	2040	
12000								1770	1810	1880	1910	1940	1920	1900					
14000									1750	1760	1710	1660							

* Endurance time will be reduced in [ ] marked area. Please avoid if possible. If the belt width changes, multiply the compensation factors Kb from Table 29.

Table 46. Reference Transmission Capacity of P8M Ps -Belt Width 15mm- (kW)

Rotary Speed of Small Pulley (rpm) \ No. of Teeth of Small Pulley	20	22	24	26	28	30	32	34	36	38	40	44	48	50	56	60	64	72
Diameter of the Pitch Circle (mm)	50.93	56.02	61.12	66.21	71.30	76.39	81.49	86.58	91.67	96.77	101.86	112.05	122.23	127.32	142.06	152.79	162.97	183.35
100	0.16	0.17	0.19	0.21	0.23	0.26	0.31	0.41	0.44	0.48	0.51	0.56	0.60	0.63	0.70	0.74	0.78	0.89
200	0.32	0.35	0.39	0.42	0.45	0.50	0.59	0.69	0.78	0.85	0.91	0.99	1.07	1.14	1.23	1.35	1.40	1.57
400	0.65	0.71	0.77	0.84	0.90	0.95	1.09	1.25	1.37	1.48	1.59	1.72	1.86	1.94	2.16	2.30	2.43	2.71
600	0.96	1.06	1.16	1.25	1.35	1.45	1.53	1.70	1.86	2.02	2.17	2.37	2.55	2.66	2.95	3.12	3.30	3.66
800	1.29	1.41	1.54	1.67	1.80	1.93	2.06	2.18	2.31	2.51	2.69	3.02	3.16	3.27	3.64	3.83	4.08	4.75
870	1.40	1.54	1.68	1.82	1.96	2.10	2.24	2.38	2.51	2.66	2.86	3.16	3.36	3.48	3.90	4.13	4.44	4.98
1000	1.61	1.77	1.93	2.09	2.25	2.41	2.57	2.73	2.89	2.99	3.16	3.64	3.84	4.00	4.47	4.78	5.09	5.71
1160	1.86	2.05	2.24	2.42	2.61	2.79	2.98	3.16	3.35	3.53	3.84	4.08	4.44	4.62	5.17	5.52	6.48	7.28
1200	1.93	2.12	2.31	2.51	2.70	2.89	3.07	3.27	3.46	3.60	3.82	4.22	4.59	4.78	5.34	5.71	6.08	7.52
1400	2.25	2.45	2.70	2.94	3.15	3.37	3.59	3.80	4.03	4.25	4.47	4.90	5.34	5.55	6.20	6.62	7.04	8.68
1450	2.33	2.55	2.79	3.04	3.26	3.65	3.72	3.94	4.17	4.40	4.63	5.07	5.53	5.75	6.41	6.85	7.28	8.96
1500	2.41	2.64	2.89	3.15	3.37	3.72	3.84	4.07	4.31	4.55	4.78	5.25	5.71	5.94	6.62	7.07	7.51	9.25
1600	2.57	2.83	3.07	3.35	3.59	3.84	4.09	4.34	4.59	4.84	5.09	5.59	6.08	6.32	7.04	7.52	7.98	9.81
1750	2.81	3.08	3.36	3.64	3.92	4.20	4.47	4.74	5.01	5.28	5.56	6.09	6.63	6.88	7.68	8.17	8.70	10.6
1800	2.89	3.18	3.72	3.75	4.03	4.31	4.59	4.87	5.15	5.43	5.71	6.26	6.80	7.07	7.86	8.38	8.90	10.9
2000	3.20	3.52	4.01	4.15	4.47	4.78	5.09	5.40	5.71	6.01	6.32	6.93	7.52	7.81	8.68	9.24	9.81	11.9
2400	3.84	4.22	4.59	4.97	5.34	5.71	6.08	6.44	6.80	7.16	7.52	8.22	9.05	9.24	9.86	10.9	11.5	13.8
3000	4.63	5.20	5.62	6.02	6.52	6.81	7.32	7.76	8.22	8.71	9.02	9.84	10.7	11.1	12.2	12.6	12.9	14.6
3600		5.82	6.34	6.75	7.27	7.67	8.17	8.65	9.14	9.72	10.0	10.8	11.7	12.2	13.1	13.9	13.9	15.3
4000			7.06	7.48	8.14	8.46	9.00	9.60	10.0	10.7	11.0	11.7	12.7	13.2	14.0	14.7	14.9	15.8
5000				8.81	9.60	10.2	10.7	11.3	11.7	12.4	12.8	13.6	14.5	14.8	15.7			
6000				10.2	11.2	11.9	12.3	13.0	13.2	14.1	14.5	14.9	15.8	16.0				

* Endurance time will be reduced in [ ] marked area. Please avoid if possible. If the belt width changes, multiply the compensation factors Kb from Table 29.
* [ ] The circumferential speed of pulley is 33(m/s)or more; a dynamic balance for the pulley is essential.

Table 47. Reference Transmission Capacity of UP5M Ps -Belt Width 10mm- (W)

Rotary Speed of Small Pulley (rpm) \ No. of Teeth of Small Pulley	12	14	16	18	20	22	24	26	28	30	32	36	40	44	48	50	60	72
Diameter of the Pitch Circle (mm)	19.10	22.28	25.46	28.65	31.83	35.01	38.20	41.38	44.56	47.75	50.93	57.30	63.66	70.03	76.39	79.58	95.49	114.59
20	10	12	15	17	19	21	24	26	29	31	34	39	45	51	58	61	78	101
40	19	23	28	32	36	40	45	49	54	59	64	74	85	96	108	114	147	187
60	27	32	39	45	50	56	63	69	76	83	90	104	119	135	152	161	206	267
100	41	50	60	69	78	88	97	107	118	128	139	162	185	210	236	249	321	420
200	76	92	111	128	145	162	180	198	215	237	257	298	342	388	436	460	592	774
400	141	170	206	236	267	299	332	366	401	437	474	550	631	715	804	849	1092	1430
500	172	207	251	287	325	364	405	446	488	532	577	670	769	871	979	1034	1330	1741
600	202	243	295	338	382	428	475	524	574	625	678	788	903	1024	1151	1216	1563	2045
800	260	314	380	436	492	552	613	675	740	806	875	1016	1164	1320	1483	1567	2016	2637
1000	316	382	463	531	600	672	747	822	901	982	1065	1238	1418	1609	1806	1909	2454	3210
1200	376	453	550	630	713	799	887	977	1070	1167	1265	1470	1685	1910	2146	2266	2913	3811
1400	436	526	637	730	826	924	1026	1132	1240	1351	1466	1702	1951	2212	2484	2625	3372	4409
1450		544	658	755	854	957	1061	1171	1283	1397	1516	1760	2017	2288	2569	2714	3488	4559
1500		561	681	780	883	988	1098	1209	1324	1444	1566	1819	2084	2364	2654	2803	3601	4707
1600		599	724	831	940	1052	1169	1287	1410	1537	1667	1935	2218	2514	2823	2984	3833	5007
1750		652	790	907	1025	1147	1275	1405	1539	1677	1817	2111	2420	2743	3080	3254	4178	5455
1800			813	931	1053	1179	1309	1443	1582	1724	1868	2171	2486	2820	3165	3344	4293	5605
2000			902	1032	1169	1309	1453	1601	1754	1912	2071	2407	2757	3124	3508	3707	4687	6201
2400			1068	1222	1386	1552	1720	1897	2077	2262	2453	2849	3261	3695	4146	4378	5485	7293
3000				1517	1714	1918	2130	2348	2570	2798	3034	3520	4027	4559	5108	5389	6614	8885
3600				1794	2029	2272	2519	2774	3039	3307	3584	4151	4743	5361	5996	6320	7629	10250
4000					2245	2513	2785	3067	3358	3655	3956	4577	5226	5895	6583	6932	8040	11069
5000					2747	3072	3404	3747	4090	4446	4807	5542	6301	7066	7843	8229	9048	
6000					3217	3585	3969	4359	4757	5154	5559	6376	7185	7995	8776	9159		
8000							5002	5455	5908	6361	6795	7624	8366	8993	9465	9619		
10000								6313	6747	7156	7518	8072	8349	8253				
12000								6824	7142	7359	7475	7316						
14000								6848	6882	6730								

* Endurance time will be reduced in [ ] marked area. Please avoid if possible. If the belt width changes, multiply the compensation factors Kb from Table 29.

Table 48. Reference Transmission Capacity of UP8M Ps -Belt Width 15mm- (kW)

Rotary Speed of Small Pulley (rpm) \ No. of Teeth of Small Pulley	20	22	24	26	28	30	32	34	36	38	40	44	48	50	56	60	64	72
Diameter of the Pitch Circle (mm)	50.93	56.02	61.12	66.21	71.30	76.39	81.49	86.58	91.67	96.77	101.86	112.05	122.23	127.32	142.60	152.79	162.97	183.35
20	0.11	0.12	0.13	0.14	0.15	0.17	0.18	0.19	0.20	0.21	0.23	0.25	0.28	0.29	0.33	0.36	0.40	0.46
40	0.19	0.21	0.24	0.26	0.28	0.30	0.33	0.36	0.38	0.40	0.42	0.47	0.52	0.55	0.62	0.67	0.73	0.84
60	0.27	0.31	0.34	0.37	0.40	0.44	0.47	0.50	0.53	0.56	0.60	0.67	0.74	0.77	0.89	0.96	1.04	1.20
100	0.43	0.48	0.52	0.57	0.62	0.67	0.71	0.77	0.82	0.88	0.93	1.03	1.14	1.20	1.38	1.50	1.62	1.87
200	0.76	0.84	0.93	1.01	1.10	1.19	1.28	1.37	1.46	1.57	1.69	1.85	2.06	2.16	2.48	2.70	2.93	3.40
300	1.06	1.17	1.29	1.41	1.54	1.66	1.78	1.92	2.05	2.18	2.29	2.59	2.88	3.03	3.48	3.79	4.11	4.79
400	1.32	1.47	1.62	1.78	1.93	2.09	2.25	2.41	2.59	2.75	2.92	3.28	3.65	3.84	4.41	4.81	5.22	6.08
500	1.57	1.75	1.93	2.12	2.30	2.50	2.69	2.89	3.09	3.30	3.50	3.93	4.37	4.60	5.30	5.78	6.29	7.32
600	1.81	2.01	2.22	2.44	2.65	2.88	3.10	3.33	3.57	3.80	4.05	4.54	5.06	5.32	6.14	6.71	7.29	8.51
700	2.04	2.26	2.50	2.75	2.99	3.24	3.50	3.75	4.02	4.29	4.57	5.13	5.72	6.02	6.95	7.59	8.26	9.65
800	2.25	2.51	2.77	3.04	3.31	3.59	3.87	4.17	4.46	4.76	5.07	5.70	6.35	6.69	7.73	8.45	9.20	10.75
900	2.46	2.74	3.03	3.32	3.61	3.92	4.24	4.55	4.88	5.21	5.55	6.25	6.97	7.34	8.48	9.29	10.11	11.83
1000	2.66	2.96	3.28	3.58	3.91	4.24	4.58	4.93	5.28	5.64	6.02	6.78	7.56	7.96	9.22	10.08	10.99	12.88
1100	2.86	3.19	3.52	3.87	4.23	4.59	4.95	5.33	5.71	6.10	6.51	7.32	8.18	8.62	9.99	10.93	11.91	13.97
1200	3.06	3.42	3.78	4.15	4.53	4.92	5.31	5.72	6.13	6.55	6.98	7.87	8.79	9.26	10.74	11.76	12.83	15.05
1300	3.26	3.64	4.02	4.42	4.82	5.24	5.67	6.10	6.54	6.99	7.45	8.40	9.40	9.90	11.49	12.59	13.73	16.11
1400	3.46	3.86	4.27	4.69	5.12	5.57	6.01	6.47	6.95	7.43	7.92	8.94	9.99	10.53	12.23	13.40	14.62	17.17
1450	3.55	3.96	4.39	4.82	5.26	5.72	6.18	6.66	7.15	7.64	8.15	9.20	10.28	10.84	12.59	13.80	15.06	17.69
1500	3.65	4.07	4.51	4.95	5.41	5.87	6.35	6.85	7.35	7.85	8.38	9.46	10.58	11.15	12.95	14.20	15.50	18.22
1600	3.83	4.27	4.73	5.21	5.69	6.18	6.69	7.21	7.74	8.28	8.84	9.98	11.16	11.77	13.68	15.00	16.37	19.26
1750	4.11	4.59	5.08	5.59	6.12	6.64	7.19	7.75	8.32	8.91	9.50	10.74	12.03	12.69	14.75	16.19	17.68	20.81
1800	4.19	4.69	5.20	5.71	6.25	6.79	7.35	7.92	8.52	9.11	9.72	11.00	12.31	12.99	15.10	16.58	18.11	21.32
2000	4.56	5.09	5.65	6.21	6.79	7.39	8.00	8.63	9.28	9.93	10.61	11.99	13.44	14.18	16.51	18.14	19.82	23.37
2400	5.25	5.87	6.51	7.17	7.85	8.54	9.27	10.00	10.75	11.52	12.31	13.95	15.65	16.53	19.27	21.20	23.18	27.38
2800	5.91	6.61	7.34	8.09	8.87	9.66	10.48	11.32	12.18	13.06	13.97	15.84	17.81	18.81	21.97	24.19	26.49	31.35
3000	6.22	6.97	7.75	8.54	9.37	10.21	11.09	11.97	12.89	13.82	14.79	16.78	18.87	19.94	23.31	25.68	28.13	33.30
3600	6.93	7.79	8.66	9.56	10.49	11.45	12.44	13.46	14.50	15.57	16.66	18.94	21.33	22.56	26.44	29.15	31.97	37.94
4000	7.36	8.29	9.20	10.18	11.18	12.20	13.27	14.36	15.48	16.63	17.81	20.27	22.85	24.18	28.37	31.30	34.36	40.81
5000	8.29	9.34	10.41	11.52	12.68	13.87	15.10	16.38	17.68	19.02	20.40	23.26	26.29	27.84	32.75	36.20		
6000	9.05	9.05	11.41	12.65	13.95	15.28	16.66	18.08	19.55	21.06	22.61	25.85	29.24	31.02	36.56	40.46		

* Endurance time will be reduced in [ ] marked area. Please avoid if possible. If the belt width changes, multiply the compensation factors Kb from Table 29.
* [ ] The circumferential speed of pulley is 33(m/s)or more; a dynamic balance for the pulley is essential.

Timing Belt
Selection of Transmission Timing Belts 9

Table 49. Reference Transmission Capacity of T5 Ps -Belt Width 10mm-

(W)

Rotary Speed of Small Pulley(rpm) \ No. of Teeth of Small Pulley	12	14	16	18	20	22	24	28	30
Diameter of the Pitch Circle(mm)	19.10	22.28	25.46	28.65	31.83	35.01	38.20	44.56	47.75
1160	98.5	114.9	131.3	147.7	164.1	180.5	196.9	229.7	246.1
1750	134.3	156.7	179.1	201.5	223.9	246.3	268.7	313.5	335.9
3500	222.5	259.6	296.7	333.7	370.8	407.9	445.0	519.1	556.2
100	10.7	12.4	14.2	16.0	17.8	19.5	21.3	24.9	26.6
200	20.8	24.3	27.7	31.2	34.7	38.2	41.6	48.6	52.0
300	30.5	35.6	40.7	45.7	50.8	55.9	61.0	71.2	76.2
400	39.7	46.4	53.0	59.6	66.2	72.9	79.5	92.7	99.4
500	48.6	56.7	64.8	72.9	81.0	89.1	97.2	113.4	121.5
600	57.0	66.5	76.0	85.6	95.1	104.6	114.1	133.1	142.6
700	65.1	76.0	86.8	97.7	108.6	119.4	130.3	152.0	162.8
800	72.9	85.0	97.2	109.3	121.5	133.6	145.8	170.1	182.2
900	80.3	93.7	107.1	120.5	133.9	147.3	160.7	187.5	200.9
1000	87.5	102.1	116.7	131.3	145.9	160.5	175.0	204.2	218.8
1100	94.4	110.2	125.9	141.6	157.4	173.1	188.9	220.3	236.1
1200	101.1	117.9	134.8	151.6	168.5	185.3	202.2	235.9	252.7
1300	107.5	125.5	143.4	161.3	179.2	197.2	215.1	250.9	268.9
1400	113.8	132.8	151.7	170.7	189.7	208.6	227.6	265.5	284.5
1500	119.9	139.8	159.8	179.8	200.0	219.2	239.7	279.7	299.7
1600	125.8	146.7	167.7	188.6	209.6	230.6	251.5	293.4	314.4
1700	131.5	153.4	175.4	197.3	219.2	241.1	263.0	306.9	328.8
1800	137.1	160.0	182.9	205.7	228.6	251.4	274.3	320.0	342.8
1900	142.6	166.4	190.2	214.0	237.7	261.5	285.3	332.8	356.6
2000	148.0	172.7	197.4	222.1	246.7	271.4	296.1	345.4	370.1
2200	158.6	185.0	211.4	237.8	264.3	290.7	317.8	370.0	396.4
2400	168.8	196.9	225.1	253.2	281.4	309.5	337.6	393.9	422.0
2600	178.8	208.7	238.5	268.3	298.1	327.9	357.7	417.3	447.1
2800	188.7	220.2	251.6	283.1	314.5	346.0	377.4	440.4	471.8
3000	198.5	231.6	264.6	297.7	330.8	363.9	397.0	463.1	496.2
3200	208.2	242.8	277.5	312.2	346.9	381.6	416.3	485.7	520.4
3400	217.7	254.0	290.3	326.6	362.9	399.2	435.5	508.0	544.3
3600	227.2	265.1	303.0	340.8	378.7	416.6	454.4	530.2	568.1
3800	236.6	276.0	315.5	354.9	394.3	433.8	473.2	552.1	591.5
4000	245.8	286.8	327.7	368.7	409.7	450.7	491.6	573.6	614.5
4200	254.8	297.3	339.7	382.2	424.7	467.2	509.6	594.6	637.0
4400	263.5	307.4	351.4	395.3	439.2	483.1	527.1	614.9	658.8
4600	271.9	317.2	362.5	407.8	453.1	498.4	543.7	634.4	679.7
4800	279.7	326.4	373.0	419.6	466.2	512.8	559.5	652.7	699.3
5000	287.0	334.8	382.7	430.5	478.3	526.2	574.0	669.7	717.5
5500			402.2	452.4	502.7	553.0	603.2	703.8	754.1
6000			412.1	463.6	515.1	566.6	618.1	721.1	772.6
6500			408.2	459.2	510.2	561.2	612.2	714.3	765.3
7000			385.3	433.5	481.7	529.8	578.0	674.3	722.5
7500			337.7	379.9	422.1	464.3	506.6	591.0	633.2
8000				290.8	323.1	355.5	387.8	452.4	484.7
8500				157.7	175.3	192.8	210.3	245.4	262.9

* Endurance time will be reduced in ⬚ marked area. Please avoid if possible.

* The above table shows values for the nominal width 10 (10mm). Multiply a value in the table by correction coefficient Kb in the table 29 for other widths.

Table 50. Reference Transmission Capacity of T10 Ps - Belt Width 10mm-

(W)

Rotary Speed of Small Pulley(rpm) \ No. of Teeth of Small Pulley	12	14	16	18	20	22	24	26	28	30	32	36	40	44	48
Diameter of the Pitch Circle(mm)	38.20	44.56	50.93	57.30	63.66	70.03	76.39	82.76	89.12	95.49	101.86	114.59	127.32	140.06	152.79
870	254.9	297.4	339.9	382.4	424.9	467.4	509.9	552.4	594.9	637.4	679.8	764.8	849.8	938.8	1019.8
1160	321.2	374.8	428.3	481.8	535.4	588.9	642.4	696.0	749.5	803.0	856.6	963.7	1070.7	1177.8	1284.9
1750	438.3	511.3	584.4	657.4	730.5	803.5	876.6	949.6	1022.7	1095.7	1168.8	1314.9	1461.0	1607.1	1753.2
3500	725.8	846.8	967.8	1088.7	1209.7	1330.6	1451.6	1572.6	1693.6	1814.6	1935.5	2177.5	2419.4	2661.4	2903.3
100	34.8	40.6	46.4	52.1	57.9	63.7	69.5	75.3	81.1	86.9	92.7	104.3	115.9	127.5	139.1
200	67.9	79.2	90.5	101.9	113.2	124.5	135.8	147.1	158.4	169.8	181.1	203.7	226.3	249.0	271.6
300	99.5	116.1	132.7	149.3	165.8	182.4	199.0	215.6	232.2	248.8	265.3	298.5	331.7	364.9	398.0
400	129.7	151.3	172.9	194.5	216.1	237.7	259.4	281.0	302.6	324.2	345.8	389.0	432.3	475.5	518.7
500	158.5	184.9	211.3	237.8	264.2	290.6	317.0	343.4	369.8	396.3	422.7	475.5	528.3	581.2	634.0
600	186.1	217.1	248.1	279.1	310.1	341.1	372.2	403.2	434.2	465.2	496.2	558.2	620.3	682.3	744.3
700	212.5	247.9	283.3	318.7	354.2	389.6	425.0	460.4	495.8	531.2	566.6	637.5	708.3	779.1	850.0
800	237.8	277.5	317.1	356.7	396.4	436.0	475.6	515.3	554.9	594.5	634.2	713.4	792.7	872.0	951.3
900	262.1	305.8	349.5	393.2	436.9	480.6	524.3	568.0	611.7	655.3	699.0	786.4	873.8	961.2	1048.6
1000	285.5	333.1	380.7	428.3	475.9	523.5	571.1	618.7	666.2	713.8	761.4	856.6	951.8	1047.0	1142.1
1100	308.1	359.4	410.8	462.1	513.5	564.8	616.2	667.5	718.8	770.2	821.5	924.2	1026.9	1129.6	1232.3
1200	329.8	384.8	439.8	494.7	549.7	604.7	659.7	714.6	769.6	824.6	879.6	989.5	1099.4	1209.4	1319.3
1300	350.9	409.4	467.8	526.3	584.8	644.3	701.4	760.2	818.7	877.2	935.7	1052.6	1169.6	1286.5	1403.5
1400	371.3	433.1	495.0	556.9	618.8	680.6	742.5	804.4	866.3	928.1	990.0	1113.8	1237.5	1361.3	1485.0
1500	391.0	456.2	521.4	586.6	651.7	716.9	782.1	847.3	912.4	977.6	1042.8	1173.1	1303.5	1433.8	1564.2
1600	410.3	478.7	547.1	615.4	683.8	752.2	820.6	889.0	957.4	1025.7	1094.1	1230.9	1367.7	1504.4	1641.2
1700	429.1	500.6	572.1	643.6	715.1	786.6	858.1	929.6	1001.2	1072.7	1144.2	1287.2	1430.2	1573.3	1716.3
1800	447.4	522.0	596.5	671.1	745.7	820.2	894.8	969.4	1043.9	1118.5	1193.1	1342.2	1411.3	1640.5	1781.6
1900	465.4	542.9	620.5	698.0	775.6	853.1	930.7	1008.3	1085.8	1163.4	1240.9	1396.1	1551.2	1706.3	1861.4
2000	483.0	563.5	643.9	724.4	804.9	885.4	965.9	1046.4	1126.9	1207.4	1287.9	1448.9	1609.9	1770.9	1931.8
2200	517.3	603.5	689.7	776.0	862.2	948.4	1034.6	1120.8	1207.1	1293.3	1379.5	1551.9	1724.4	1896.8	2069.2
2400	550.7	642.5	734.3	826.1	917.9	1009.7	1101.4	1193.8	1285.0	1376.8	1468.6	1652.2	1835.8	2019.3	2202.9
2600	583.5	680.7	777.9	875.2	972.4	1069.7	1166.9	1264.1	1361.4	1458.6	1555.9	1750.4	1944.9	2139.3	2333.8
2800	615.7	718.3	820.9	923.5	1026.1	1128.7	1231.3	1333.9	1436.6	1539.2	1641.8	1847.0	2052.3	2257.5	2462.7
3000		755.4	863.4	971.3	1079.2	1187.1	1295.0	1402.9	1510.9	1618.8	1726.7	1942.5	2158.4	2374.2	2590.1
3200		792.2	905.4	1018.6	1131.8	1244.9	1358.1	1471.2	1584.5	1697.6	1810.8	2037.2	2263.5	2489.9	2716.2
3400		828.7	947.1	1065.5	1183.8	1302.2	1420.6	1539.0	1657.4	1775.8	1894.2	2130.9	2367.7	2604.5	2841.2
3600		864.8	988.4	1111.9	1235.4	1358.9	1482.5	1606.0	1729.6	1853.2	1976.7	2223.8	2470.9	2718.0	2965.1
3800		900.5	1029.1	1157.7	1286.4	1415.0	1543.6	1672.2	1800.9	1929.6	2058.2	2315.5	2572.8	2830.0	3087.3
4000			1069.2	1202.8	1336.5	1470.0	1603.7	1737.3	1871.1	2004.7	2138.4	2405.7	2673.0	2940.3	3207.6
4200			1108.3	1246.9	1385.4	1523.9	1662.4	1800.9	1939.6	2078.1	2216.7	2493.7	2770.8	3047.9	3325.0
4400			1146.2	1289.5	1432.8	1576.0	1719.2	1862.5	2005.9	2149.2	2292.5	2579.0	2865.6	3152.1	3438.7
4600			1182.5	1330.3	1478.1	1625.8	1773.6	1921.4	2069.4	2217.2	2365.0	2660.6	2956.3	3251.9	3547.5
4800			1216.7	1368.8	1520.9	1672.8	1824.9	1976.9	2129.2	2281.3	2433.4	2737.6	3041.8	3345.9	3650.1
5000			1248.3	1404.3	1560.4	1716.2	1872.2	2028.3	2184.5	2340.6	2496.6	2808.7	3120.8	3432.8	3744.9
5200			1276.7	1436.3	1595.9	1755.2	1914.8	2074.4	2234.2	2393.8	2553.4	2872.6	3191.8	3510.9	3830.1
5400			1301.3	1463.9	1626.6	1789.0	1951.6	2114.2	2277.2	2439.9	2602.5	2927.8	3253.2	3578.5	3903.8
5600			1321.2	1486.4	1651.5	1816.4	1981.5	2146.7	2312.2	2477.3	2642.5	2972.8	3303.1	3633.4	3963.7
5800			1335.8	1502.8	1669.8	1836.4	2003.4	2170.3	2337.7	2504.7	2671.7	3005.6	3339.6	3673.5	4007.5
6000			1344.2	1512.2	1680.2	1847.8	2015.8	2184.3	2352.3	2520.3	2688.3	3024.4	3360.4	3696.5	4032.5

* Endurance time will be reduced in ⬚ marked area. Please avoid if possible.

* Balance the traveling speed as wind velocity of pulley in the ▭ marked range reaches more than 33 (m/s)

* The above table shows values for the nominal width 10 (10mm). Multiply a value in the table by correction coefficient Kb in the table 29 for other widths.

Table 51. Reference Transmission Capacity of 2GT Ps -Belt Width 4mm-

(W)

Rotary Speed of Small Pulley(rpm) \ No. of Teeth of Small Pulley	12	14	16	18	20	22	24	26	28	30	32	36	40	44	48	50	60	72
Diameter of the Pitch Circle(mm)	7.64	8.91	10.19	11.46	12.73	14.01	15.28	16.55	17.83	19.10	20.37	22.92	25.46	28.01	30.56	31.83	38.20	45.84
20	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.7	1.9	2.2	2.5	2.6	3.4	4.0
40	0.8	1.0	1.1	1.3	1.5	1.7	1.8	2.0	2.2	2.4	2.7	3.1	3.6	4.1	4.6	4.9	6.3	7.6
60	1.1	1.4	1.6	1.8	2.1	2.3	2.6	2.9	3.2	3.5	3.8	4.4	5.1	5.8	6.6	7.0	9.1	10.9
100	1.7	2.1	2.4	2.8	3.2	3.6	4.0	4.5	4.9	5.4	5.9	6.9	8.0	9.1	10.3	11.0	14.3	17.2
200	3.0	3.6	4.3	5.0	5.7	6.4	7.2	8.0	8.8	9.7	10.6	12.5	14.5	16.6	18.9	20.1	26.4	31.7
300	4.2	5.0	5.9	6.9	7.9	8.9	10.0	11.1	12.3	13.6	14.9	17.6	20.4	23.5	26.8	28.5	37.7	45.3
400	5.2	6.3	7.4	8.6	9.9	11.2	12.6	14.1	15.6	17.2	18.8	22.3	26.0	30.0	34.3	36.5	48.5	58.2
500	6.1	7.4	8.8	10.2	11.8	13.4	15.1	16.8	18.7	20.6	22.6	26.8	31.4	36.2	41.4	44.1	58.8	70.6
600	7.0	8.5	10.1	11.8	13.5	15.4	17.4	19.4	21.6	23.8	26.2	31.2	36.5	42.2	48.3	51.5	68.9	82.6
700	7.8	9.5	11.3	13.2	15.2	17.4	19.6	21.9	24.4	27.0	29.6	35.3	41.4	48.0	55.0	58.7	78.6	94.4
800	8.6	10.5	12.5	14.6	16.8	19.2	21.7	24.3	27.1	30.0	33.0	39.4	46.2	53.6	61.5	65.6	88.2	105.8
870	9.1	11.1	13.3	15.5	17.9	20.5	23.2	26.0	28.9	32.0	35.2	42.1	49.5	57.5	66.0	70.4	94.7	113.7
900	9.3	11.4	13.6	15.9	18.4	21.0	23.8	26.7	29.7	32.9	36.2	43.3	50.9	59.1	67.9	72.4	97.5	117.0
1000	10.0	12.3	14.6	17.2	19.9	22.7	25.7	28.9	32.2	35.7	39.3	47.1	55.4	64.4	74.1	79.1	106.7	128.0
1160	11.1	13.6	16.3	19.1	22.1	25.4	28.8	32.3	36.1	40.0	44.2	53.0	62.5	72.7	83.7	89.5	121.0	145.2
1200	11.4	13.9	16.6	19.6	22.7	26.0	29.5	33.2	37.0	41.1	45.3	54.4	64.2	74.8	86.1	92.0	124.6	149.5
1400	12.6	15.4	18.5	21.8	25.3	29.1	33.0	37.2	41.6	46.2	51.1	61.4	72.6	84.7	97.7	104.5	141.9	170.3
1450	12.9	15.8	19.0	22.4	26.0	29.8	33.9	38.2	42.7	47.5	52.5	63.1	74.7	87.2	100.6	107.6	146.2	175.4
1600	13.7	16.8	20.3	23.9	27.8	32.0	36.4	41.1	46.0	51.2	56.6	68.2	80.8	94.4	109.0	116.6	158.8	190.6
1750	14.5	17.8	21.5	25.4	29.6	34.1	38.8	43.8	49.1	54.7	60.6	73.1	86.7	101.4	117.2	125.5	171.2	205.4
1800	14.7	18.2	21.9	25.9	30.2	34.8	39.6	44.7	50.2	55.9	61.9	74.7	88.6	103.7	119.9	128.4	175.3	210.3
2000	15.7	19.4	23.4	27.8	32.4	37.4	42.7	48.3	54.2	60.4	66.9	81.0	96.2	112.8	130.5	139.9	191.4	229.7
2400	17.4	21.7	26.3	31.2	36.6	42.3	48.4	54.9	61.8	69.0	76.6	93.0	110.9	130.2	151.1	162.1	222.8	267.3
2800	19.0	23.7	28.8	34.4	40.4	46.9	53.8	61.1	68.9	77.1	85.8	104.4	124.8	146.9	170.8	183.4	253.1	303.7
3200	20.3	25.5	31.1	37.3	43.9	51.1	58.8	66.9	75.6	84.7	94.4	115.2	138.1	162.9	189.8	204.0	282.4	338.9
3600	21.5	27.1	33.2	39.9	47.2	55.0	63.4	72.4	81.9	92.0	102.6	125.6	150.9	178.4	208.2	223.9	311.0	373.2
4000	22.6	28.6	35.1	42.4	50.2	58.7	67.8	77.5	87.9	98.9	110.5	135.6	163.2	193.3	225.9	243.2	338.9	406.7
5000	24.7	31.6	39.2	47.7	56.9	66.9	77.7	89.2	101.6	114.7	128.7	158.9	192.2	228.7	268.3	289.3	406.0	487.2
6000	26.2	33.8	42.4	52.0	62.5	73.9	86.3	99.6	113.8	129.0	145.1	180.2	219.1	261.7	308.1	332.7	469.8	563.8
7000	27.1	35.5	45.0	55.5	67.2	79.9	93.8	108.8	124.8	142.0	160.2	200.0	244.2	292.8	345.8	373.9	531.0	637.3
8000	27.6	36.6	46.9	58.4	71.1	85.2	100.4	117.0	134.7	153.8	174.1	218.4	267.8	322.2	381.6	413.2	590.0	708.0
10000	27.5	37.5	49.2	62.4	77.1	93.5	111.4	130.9	151.9	174.6	198.7	251.8	311.2	376.8	448.7	487.0	702.1	842.6
12000	26.0	36.9	49.8	64.4	81.0	99.5	119.8	142.0	166.1	192.1	220.0	281.4	350.3	426.8	510.7	555.6	807.9	969.5
14000	23.5	35.1	48.9	64.9	83.1	103.5	126.1	150.9	177.9	207.1	238.4	307.8	385.9	472.8	568.5	619.7	908.3	1090.0

* Endurance time will be reduced in ⬚ marked area. Please avoid if possible. If the belt width changes, multiply the compensation factors Kb from Table 29.

Table 52. Reference Transmission Capacity of 3GT Ps -Belt Width 6mm-

(W)

Rotary Speed of Small Pulley(rpm) \ No. of Teeth of Small Pulley	12	14	16	18	20	22	24	26	28	30	32	36	40	48	54	60	72	80
Diameter of the Pitch Circle(mm)	11.46	13.37	15.28	17.19	19.10	21.01	22.92	24.83	26.74	28.65	30.56	34.38	38.20	45.84	51.57	57.30	68.75	76.39
20	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	5.9	6.4	6.9	7.8	8.7	10.5	11.8	13.1	15.7	17.4
40	3.6	4.5	5.5	6.4	7.3	8.2	9.1	10.0	10.9	11.8	12.6	14.3	16.0	19.3	21.7	24.2	28.9	32.0
60	5.0	6.4	7.7	9.0	10.3	11.6	12.9	14.2	15.4	16.7	17.9	20.4	22.8	27.5	30.9	34.4	41.1	45.5
100	7.6	9.7	11.8	13.9	15.9	18.0	19.9	21.9	23.9	25.9	27.8	31.6	35.3	42.6	48.0	53.4	63.8	70.6
200	13.1	16.9	20.8	24.6	28.2	32.0	35.6	39.2	42.8	46.4	49.9	56.8	63.6	76.8	86.5	96.1	114.8	127.0
300	17.7	23.2	28.7	34.1	39.2	44.6	49.6	54.8	59.9	65.0	69.8	79.6	89.2	107.7	121.4	134.8	161.0	178.1
400	21.9	28.9	35.9	42.8	49.4	56.3	62.7	69.3	75.7	82.2	88.4	100.9	113.0	136.5	153.9	171.0	204.1	225.7
500	25.6	34.2	42.6	51.0	58.9	67.2	74.9	82.9	90.6	98.5	105.9	121.0	135.6	163.8	184.7	205.1	244.8	270.7
600	29.1	39.0	48.9	58.7	67.8	77.5	86.5	95.8	104.8	114.0	122.6	140.1	157.1	189.8	214.0	237.7	283.7	313.5
700	32.2	43.6	54.8	66.0	76.4	87.4	97.6	108.2	118.4	128.9	138.6	158.5	177.8	214.8	242.2	269.1	321.0	354.7
800	35.2	47.9	60.4	72.9	84.6	96.9	108.3	120.1	131.5	143.2	154.1	176.2	197.7	239.0	269.4	299.3	357.0	394.3
870	37.2	50.8	64.2	77.6	90.1	103.3	115.5	128.2	140.4	152.9	164.6	188.3	211.3	255.4	288.0	319.8	381.4	421.3
900	38.0	52.0	65.8	79.6	92.4	106.0	118.6	131.6	144.2	157.0	169.0	193.3	217.0	262.3	295.8	328.5	391.7	432.6
1000	40.6	55.9	71.0	86.0	100.0	114.9	128.5	142.7	156.4	170.4	183.4	210.0	235.7	285.0	321.3	356.8	425.4	469.8
1160	44.4	61.8	78.8	95.8	111.6	128.4	143.8	159.9	175.2	191.1	205.7	235.6	264.5	319.9	360.7	400.6	477.4	527.0
1200	45.4	63.2	80.7	98.2	114.4	131.7	147.5	164.0	179.8	196.1	211.1	241.9	271.6	328.4	370.3	411.2	490.0	540.9
1400	49.6	69.9	89.7	109.6	128.0	147.5	165.5	184.2	202.1	220.5	237.5	272.2	305.7	369.8	416.9	462.9	551.4	608.3
1450	50.6	71.5	91.9	112.3	131.2	151.4	169.8	189.0	207.4	226.4	243.9	279.5	314.0	379.8	428.3	475.5	566.2	624.6
1600	53.4	76.0	98.2	120.3	140.8	162.6	182.5	203.3	223.2	243.7	262.6	301.1	338.4	409.3	461.5	512.3	609.8	672.5
1750	56.0	80.4	104.2	128.0	149.9	173.4	194.8	217.2	238.5	260.5	280.8	322.1	362.0	437.9	493.7	548.0	652.0	718.7
1800	56.8	81.7	106.1	130.5	152.9	176.9	198.8	221.7	243.5	266.0	286.7	328.9	369.7	447.2	504.2	559.6	665.7	733.7
2000	59.9	87.1	113.6	140.1	164.5	190.6	214.4	239.3	263.0	287.4	309.8	355.7	399.8	483.7	545.3	605.1	719.3	792.3
2400	65.2	96.6	127.3	158.1	186.2	216.4	243.8	272.4	299.7	327.9	353.7	406.3	456.9	552.8	622.9	690.9	820.1	902.2
2800	72.9	105.0	139.7	174.4	206.1	240.2	271.0	303.3	334.0	365.8	394.6	453.7	510.4	617.2	695.3	770.7	913.1	1003.1
3200	80.8	112.3	150.9	189.4	224.5	262.4	296.4	332.2	366.2	401.3	433.1	498.2	560.6	677.7	763.0	845.1	999.1	1095.6
3600	88.4	118.7	161.0	203.2	241.6	283.1	320.3	359.3	396.4	434.7	469.3	540.2	607.8	734.5	826.3	914.4	1078.4	1180.2
4000	95.9	124.3	170.2	216.0	257.5	302.4	342.6	384.9	424.9	466.3	503.5	579.8	652.4	787.8	885.6	979.0	1151.3	1257.0
5000	113.8	135.2	189.6	243.9	292.7	345.8	392.9	442.6	489.4	537.9	581.1	669.6	753.3	907.4	1017.3	1120.7	1306.3	1415.8
6000	130.7	154.3	204.6	266.8	322.3	383.0	436.3	492.7	545.5	600.3	648.7	747.7	840.5	1008.6	1126.6	1235.3	1422.5	1526.3
7000	147.0	173.3	216.0	285.5	347.2	414.7	473.7	536.1	594.2	654.6	707.3	815.0	915.0	1092.4	1214.1	1323.1	1499.2	1586.5
8000	162.6	191.5	224.1	300.4	367.7	441.6	505.6	573.4	636.2	701.3	757.6	872.2	977.3	1159.1	1279.9	1383.5	1534.5	1593.4
10000	192.2	225.7	259.3	320.5	397.5	482.4	554.7	631.3	701.2	773.7	834.6	957.4	1066.1	1240.3	1343.8	1418.4	1471.0	1431.9
12000	219.7	257.3	294.6	331.6	413.4	507.3	585.4	668.1	742.3	818.9	880.9	1004.0	1106.6	1249.1	1312.0	1329.1	1209.3	1008.1
14000	245.5	286.4	326.7	366.1	416.7	517.2	598.6	684.8	760.0	837.2	896.5	1010.9	1096.9	1180.1	1175.5	1102.1		

* Endurance time will be reduced in ⬚ marked area. Please avoid if possible. If the belt width changes, multiply the compensation factors Kb from Table 29.

Table 53. Reference Transmission Capacity of EV5GT Ps -Belt Width 15mm- (W)

Rotary Speed of Small Pulley(rpm) \ No. of Teeth of Small Pulley	14	16	18	20	22	24	26	28	30	32	36	40	44	48	54	60	72	80
Diameter of the Pitch Circle(mm)	22.28	25.46	28.65	31.83	35.01	38.20	41.38	44.56	47.75	50.93	57.30	63.66	70.03	76.39	85.94	95.49	114.59	127.32
20	13	18	22	27	33	38	42	47	52	56	64	72	80	87	97	108	128	139
40	24	33	41	50	61	70	79	88	96	104	120	136	150	163	183	203	240	263
60	33	46	58	72	87	100	113	126	139	150	173	196	216	236	264	293	348	380
100	50	71	91	113	136	157	178	199	219	237	273	310	343	374	419	465	552	604
200	85	125	163	205	248	287	326	365	403	438	506	575	636	695	780	867	1031	1129
300	115	173	228	289	350	407	464	520	574	625	723	823	912	996	1119	1244	1482	1623
400	142	217	289	369	447	520	594	667	737	803	931	1060	1176	1285	1445	1607	1914	2096
500	166	258	347	445	539	629	718	808	894	974	1131	1289	1430	1564	1759	1957	2333	2555
600	188	297	402	518	627	733	839	944	1046	1141	1325	1511	1678	1836	2065	2298	2740	3002
700	208	333	454	589	712	834	956	1077	1193	1302	1514	1728	1919	2101	2364	2632	3139	3439
800	227	368	505	657	795	933	1069	1206	1337	1460	1699	1940	2156	2360	2657	2958	3529	3866
870	239	392	540	704	851	1000	1147	1294	1436	1569	1826	2086	2319	2539	2858	3183	3797	4161
900	244	402	554	724	875	1028	1180	1332	1478	1615	1880	2148	2388	2615	2944	3279	3912	4286
1000	260	434	602	789	954	1122	1289	1456	1616	1767	2058	2352	2616	2865	3227	3593	4288	4698
1160	284	483	675	890	1075	1268	1459	1649	1832	2004	2337	2672	2973	3257	3669	4087	4878	5343
1200	289	495	693	915	1105	1304	1500	1696	1885	2062	2405	2751	3061	3353	3778	4209	5023	5502
1400	315	551	780	1035	1251	1478	1704	1929	2145	2349	2742	3138	3493	3828	4314	4807	5736	6282
1450	321	565	801	1065	1286	1521	1754	1986	2209	2419	2825	3233	3599	3945	4446	4954	5912	6474
1600	338	605	863	1152	1391	1647	1901	2155	2397	2627	3070	3516	3914	4291	4837	5390	6430	7040
1750	354	643	923	1237	1494	1771	2046	2320	2583	2831	3311	3793	4224	4631	5221	5817	6939	7595
1800	358	655	943	1264	1527	1811	2093	2374	2644	2899	3390	3884	4326	4743	5347	5958	7106	7777
2000	376	703	1020	1374	1659	1971	2280	2589	2884	3164	3703	4244	4728	5185	5846	6513	7765	8494
2400	406	791	1165	1584	1911	2278	2641	3003	3349	3678	4309	4943	5509	6042	6812	7587	9034	9868
2800	440	872	1301	1783	2151	2571	2986	3400	3795	4171	4892	5615	6259	6865	7737	8613	10238	11165
3200	486	945	1429	1973	2380	2851	3318	3782	4225	4647	5455	6263	6982	7657	8625	9594	11379	12384
3600	529	1011	1550	2155	2598	3120	3636	4150	4640	5107	5998	6888	7679	8419	9477	10531	12456	13522
4000	571	1072	1665	2330	2808	3379	3944	4505	5041	5550	6522	7492	8350	9151	10291	11423	13466	14575
5000	667	1202	1925	2738	3296	3986	4667	5343	5985	6597	7758	8910	9920	10854	12167	13450	15686	16815
6000		1305	2153	3108	3737	4539	5330	6112	6853	7559	8889	10199	11335	12372	13803	15172	17429	18431
7000		1382	2352	3445	4136	5044	5936	6817	7648	8438	9915	11358	12590	13695	15183	16561	18641	19343
8000			2524	3749	4495	5501	6487	7459	8370	9235	10835	12383	13677	14812	16285	17586	19259	
9000			2671	4023	4815	5912	6984	8037	9018	9946	11645	13265	14586	15706	17086	18212		
10000				4266	5096	6277	7426	8550	9591	10570	12339	13998	15303	16361	17560			
12000				4660	5541	6865	8141	9375	10498	11541	13356	14976	16113	16883				
14000				4930	5825	7256	8617	9915	11067	12113	13831	15238						

* Endurance time will be reduced in [- - -] marked area. Please avoid if possible. If the belt width changes, multiply the compensation factors Kb from Table 29.

Table 54. Reference Transmission Capacity of EV8YU Ps -Belt Width 20mm- (kW)

Rotary Speed of Small Pulley(rpm) \ No. of Teeth of Small Pulley	20	22	24	26	28	30	32	34	36	38	40	44	48	54	60	64	72	80
Diameter of the Pitch Circle(mm)	50.93	56.02	61.12	66.21	71.30	76.39	81.49	86.58	91.67	96.77	101.86	112.05	122.23	137.51	152.79	162.97	183.35	203.72
10	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.07	0.07	0.08	0.08	0.09	0.10	0.12	0.13	0.14	0.16	0.18
20	0.07	0.08	0.09	0.10	0.10	0.11	0.13	0.13	0.14	0.15	0.16	0.18	0.20	0.23	0.26	0.28	0.32	0.36
40	0.13	0.14	0.16	0.18	0.20	0.22	0.24	0.26	0.28	0.30	0.32	0.36	0.40	0.46	0.52	0.56	0.64	0.72
60	0.18	0.21	0.23	0.26	0.29	0.32	0.35	0.38	0.41	0.44	0.48	0.54	0.60	0.69	0.78	0.84	0.96	1.08
100	0.28	0.33	0.37	0.42	0.47	0.52	0.57	0.62	0.67	0.72	0.78	0.88	0.99	1.14	1.30	1.40	1.60	1.80
200	0.52	0.60	0.69	0.79	0.89	0.99	1.10	1.20	1.29	1.39	1.52	1.73	1.96	2.27	2.58	2.79	3.19	3.60
300	0.74	0.86	0.99	1.13	1.29	1.45	1.62	1.76	1.90	2.05	2.25	2.57	2.92	3.38	3.85	4.18	4.78	5.40
400	0.94	1.10	1.28	1.47	1.67	1.89	2.12	2.30	2.50	2.70	2.97	3.40	3.86	4.48	5.12	5.56	6.37	7.20
500	1.13	1.34	1.56	1.80	2.05	2.32	2.61	2.84	3.08	3.33	3.68	4.23	4.81	5.59	6.38	6.94	7.95	8.99
600	1.32	1.57	1.83	2.12	2.42	2.75	3.10	3.38	3.67	3.97	4.38	5.04	5.75	6.68	7.64	8.31	9.53	10.78
700	1.50	1.79	2.10	2.43	2.79	3.17	3.58	3.90	4.24	4.59	5.08	5.86	6.68	7.77	8.89	9.68	11.10	12.57
800	1.68	2.00	2.36	2.74	3.15	3.59	4.05	4.43	4.81	5.22	5.78	6.66	7.61	8.86	10.14	11.04	12.67	14.34
870	1.80	2.15	2.54	2.95	3.40	3.87	4.38	4.79	5.21	5.65	6.26	7.23	8.26	9.62	11.01	11.99	13.76	15.58
900	1.85	2.21	2.61	3.04	3.50	4.00	4.52	4.94	5.38	5.83	6.47	7.47	8.54	9.95	11.39	12.40	14.23	16.11
1000	2.02	2.42	2.86	3.34	3.85	4.40	4.99	5.46	5.94	6.45	7.15	8.27	9.46	11.03	12.63	13.75	15.78	17.88
1160	2.28	2.74	3.26	3.81	4.41	5.05	5.73	6.27	6.83	7.42	8.24	9.54	10.92	12.75	14.60	15.91	18.26	20.68
1200	2.34	2.82	3.35	3.92	4.54	5.20	5.91	6.47	7.06	7.66	8.51	9.86	11.29	13.17	15.09	16.45	18.87	21.37
1400	2.65	3.21	3.83	4.50	5.22	5.99	6.82	7.48	8.16	8.86	9.86	11.43	13.11	15.30	17.54	19.11	21.93	24.83
1450	2.73	3.31	3.94	4.64	5.39	6.19	7.05	7.72	8.43	9.16	10.20	11.82	13.56	15.83	18.15	19.78	22.69	25.68
1600	2.95	3.59	4.29	5.06	5.88	6.77	7.72	8.47	9.24	10.05	11.20	12.99	14.91	17.41	19.96	21.75	24.95	28.23
1750	3.17	3.87	4.63	5.47	6.37	7.34	8.39	9.20	10.05	10.93	12.19	14.15	16.25	18.98	21.75	23.71	27.18	30.75
1800	3.24	3.96	4.75	5.61	6.53	7.53	8.61	9.44	10.31	11.22	12.52	14.54	16.69	19.50	22.35	24.36	27.93	31.58
2000	3.52	4.32	5.19	6.14	7.17	8.29	9.48	10.41	11.37	12.38	13.82	16.06	18.46	21.56	24.71	26.94	30.85	34.86
2400	4.06	5.01	6.05	7.19	8.43	9.76	11.20	12.30	13.45	14.65	16.39	19.07	21.93	25.61	29.34	31.97	36.55	41.21
2800	4.57	5.66	6.88	8.20	9.64	11.20	12.87	14.15	15.48	16.87	18.90	22.00	25.31	29.55	33.82	36.82	41.99	47.22
3200	5.05	6.29	7.67	9.18	10.82	12.59	14.50	15.95	17.46	19.03	21.35	24.86	28.60	33.35	38.12	41.46	47.14	52.83
3600	5.50	6.89	8.43	10.12	11.96	13.95	16.08	17.69	19.38	21.12	23.72	27.62	31.78	37.01	42.22	45.86	51.95	57.98
4000	5.94	7.47	9.17	11.03	13.06	15.26	17.62	19.39	21.23	23.15	26.02	30.30	34.84	40.50	46.10	50.00	56.39	
5000	6.91	8.79	10.87	13.16	15.65	18.34	21.24	23.37	25.59	27.88	31.39	36.50	41.90	48.40	54.68			
6000	7.75	9.94	12.38	15.05	17.97	21.12	24.52	26.95	29.47	32.08	36.16	41.92	47.96	54.90				
7000	8.44	10.92	13.68	16.70	20.00	23.57	27.39	30.06	32.82	35.65	40.22	46.41	52.84					
8000	8.99	11.72	14.76	18.09	21.72	25.63	29.82	32.65	35.55	38.52	43.45							

* Endurance time will be reduced in [- - -] marked area. Please avoid if possible. If the belt width changes, multiply the compensation factors Kb from Table 29.

Table 55. Allowable Tension Table/List

Belt Type	Allowable Tension (N)	Belt Width / Correction Factor						
MXL	23.4	-	4.8	6.4	9.5	12.7		
		-	0.72	1.00	1.57	2.18		
XL	182.4	6.4	7.9	9.5	12.7	-		
		0.15	0.21	0.28	0.42	-		
L	244.2	12.7	19.1	25.4	38.1			
		0.42	0.71	1.00	1.56			
H	622.7	19.1	25.4	38.1	50.8	-		
		0.71	1.00	1.56	2.14	-		
T5	See **P.138**.	-	10	15	20			
		-	1.00	1.60	2.30			
T10	See **P.138**.	-	15	20	25	30	40	50
		-	1.60	2.30	2.90	3.50	4.60	5.80
S2M	See **P.136**.	4	6	10				
		1.00	1.59	2.84				
S3M	See **P.137**.	6	10	15				
		1.00	1.79	2.84				
S5M	See **P.137**.	10	15	25				
		1.00	1.59	2.84				
S8M	2736.0	15	-	25	30	40	-	-
		0.21	-	0.37	0.45	0.63	-	-
S14M	8483.0	-	40	-	60	-	-	-
		-	0.29	-	0.45	-	-	-

Table 56. S2M Allowable Tension Table: Per 4.0mm of Belt Width (Unit: N) (kW)

Speed of Small Pulley (rpm) \ Number of Small Pulley Teeth	14	15	16	18	20	22	24	26	28	30	32	36	40	44	50	60
Pitch Circle Dia. (mm)	8.91	9.55	10.19	11.46	12.73	14.01	15.28	16.55	17.83	19.10	20.37	22.92	25.46	28.01	31.83	38.2
870	26.9	28.2	29.2	30.8	32.0	32.9	33.6	34.2	34.6	34.9	35.2	35.5	35.7	35.8	35.8	35.5
1160	24.7	25.9	26.9	28.5	29.7	30.7	31.4	31.9	32.3	32.6	32.9	33.2	33.4	33.5	33.5	33.2
1750	21.4	22.6	23.7	25.3	26.5	27.4	28.1	28.6	29.0	29.4	29.6	30.0	30.1	30.2	30.2	29.9
3500	15.9	17.1	18.1	19.8	21.0	21.9	22.6	23.1	23.5	23.8	24.1	24.4	24.6	24.6	24.6	24.2
50	49.6	50.8	51.9	53.5	54.7	55.6	56.3	56.8	57.3	57.6	57.8	58.2	58.4	58.5	58.4	58.2
100	44.1	45.3	46.4	48.0	49.2	50.1	50.8	51.3	51.8	52.1	52.4	52.7	52.9	53.0	52.9	52.7
150	40.9	42.1	43.2	44.8	46.0	46.9	47.6	48.1	48.6	48.9	49.1	49.5	49.7	49.7	49.7	49.5
200	38.6	39.8	40.9	42.5	43.7	44.6	45.3	45.8	46.3	46.6	46.9	47.2	47.4	47.5	47.4	47.2
250	36.9	38.1	39.1	40.7	41.9	42.8	43.5	44.1	44.5	44.8	45.1	45.4	45.6	45.7	45.7	45.5
300	35.4	36.6	37.7	39.3	40.5	41.4	42.1	42.6	43.1	43.4	43.6	44.0	44.2	44.2	44.2	44.0
350	34.2	35.4	36.4	38.0	39.2	40.2	40.9	41.4	41.8	42.2	42.4	42.8	42.9	43.0	43.0	42.8
400	33.1	34.3	35.4	37.0	38.2	39.1	39.8	40.3	40.8	41.1	41.4	41.7	41.9	42.0	41.9	41.7
450	32.2	33.4	34.4	36.1	37.3	38.2	38.9	39.4	39.8	40.2	40.4	40.8	40.9	41.0	41.0	40.8
500	31.4	32.6	33.6	35.2	36.4	37.3	38.0	38.6	39.0	39.3	39.6	39.9	40.1	40.2	40.2	39.9
550	30.6	31.8	32.8	34.5	35.7	36.6	37.3	37.8	38.2	38.6	38.8	39.2	39.3	39.4	39.4	39.2
600	29.9	31.1	32.2	33.8	35.0	35.9	36.6	37.1	37.6	37.9	38.1	38.5	38.7	38.7	38.7	38.5
650	29.3	30.5	31.5	33.1	34.3	35.3	36.0	36.5	36.9	37.2	37.5	37.8	38.0	38.1	38.1	37.9
700	28.7	29.9	30.9	32.5	33.7	34.7	35.4	35.9	36.3	36.7	36.9	37.3	37.4	37.5	37.5	37.3
800	27.6	28.8	29.9	31.5	32.7	33.6	34.3	34.8	35.3	35.6	35.8	36.2	36.4	36.5	36.4	36.2
900	26.7	27.9	28.9	30.6	31.8	32.7	33.4	33.9	34.3	34.7	34.9	35.3	35.4	35.5	35.5	35.3
1000	25.9	27.1	28.1	29.7	30.9	31.8	32.5	33.1	33.5	33.8	34.1	34.4	34.6	34.7	34.7	34.4
1100	25.1	26.3	27.3	29.0	30.2	31.1	31.8	32.3	32.7	33.1	33.3	33.7	33.8	33.9	33.9	33.7
1200	24.4	25.6	26.7	28.3	29.5	30.4	31.1	31.6	32.1	32.4	32.6	33.0	33.1	33.2	33.2	33.0
1300	23.8	25.0	26.0	27.6	28.8	29.8	30.5	31.0	31.4	31.7	32.0	32.3	32.5	32.6	32.6	32.3
1400	23.2	24.4	25.4	27.0	28.2	29.2	29.9	30.4	30.8	31.1	31.4	31.7	31.9	32.0	32.0	31.7
1500	22.7	23.9	24.9	26.5	27.7	28.6	29.3	29.9	30.3	30.6	30.9	31.2	31.4	31.4	31.4	31.2
1600	22.1	23.3	24.4	26.0	27.2	28.1	28.8	29.3	29.8	30.1	30.3	30.7	30.9	30.9	30.9	30.7
1700	21.7	22.9	23.9	25.5	26.7	27.6	28.3	28.9	29.3	29.6	29.9	30.2	30.4	30.4	30.4	30.2
1800	21.2	22.4	23.4	25.0	26.2	27.2	27.9	28.4	28.8	29.1	29.4	29.7	29.9	30.0	30.0	29.7
1900	20.8	22.0	23.0	24.6	25.8	26.7	27.4	28.0	28.4	28.7	29.0	29.3	29.5	29.6	29.5	29.3
2000	20.4	21.6	22.6	24.2	25.4	26.3	27.0	27.6	28.0	28.3	28.6	28.9	29.1	29.1	29.1	28.9
2200	19.6	20.8	21.8	23.5	24.7	25.6	26.3	26.8	27.2	27.5	27.8	28.1	28.3	28.4	28.3	28.1
2400	18.9	20.1	21.1	22.8	24.0	24.9	25.6	26.1	26.5	26.9	27.1	27.4	27.6	27.7	27.6	27.4
2600	18.3	19.5	20.5	22.1	23.3	24.2	24.9	25.5	25.9	26.2	26.5	26.8	27.0	27.0	27.0	26.7
2800	17.7	18.9	19.9	21.5	22.7	23.6	24.3	24.9	25.3	25.6	25.9	26.2	26.4	26.4	26.4	26.1
3000	17.1	18.4	19.4	21.0	22.2	23.1	23.8	24.3	24.7	25.1	25.3	25.6	25.8	25.9	25.8	25.5
3200	16.6	17.8	18.9	20.5	21.7	22.6	23.3	23.8	24.2	24.5	24.8	25.1	25.3	25.3	25.3	25.0
3400	16.1	17.4	18.4	20.0	21.2	22.1	22.8	23.3	23.7	24.1	24.3	24.6	24.8	24.8	24.8	24.5
3600	15.7	16.9	17.9	19.5	20.7	21.6	22.3	22.9	23.3	23.6	23.8	24.2	24.3	24.4	24.3	24.0
3800	15.3	16.5	17.5	19.1	20.3	21.2	21.9	22.4	22.8	23.2	23.4	23.7	23.9	23.9	23.9	23.5
4000	14.9	16.1	17.1	18.7	19.9	20.8	21.5	22.0	22.4	22.7	23.0	23.3	23.5	23.5	23.4	23.1
4500	13.9	15.1	16.1	17.7	18.9	19.8	20.5	21.1	21.5	21.8	22.0	22.3	22.5	22.5	22.4	22.1
5000	13.1	14.3	15.3	16.9	18.1	19.0	19.7	20.2	20.6	20.9	21.2	21.5	21.6	21.6	21.5	21.1
5500	12.3	13.5	14.5	16.1	17.3	18.2	18.9	19.4	19.8	20.1	20.4	20.7	20.8	20.8	20.7	20.3
6000	11.6	12.8	13.8	15.4	16.6	17.5	18.2	18.7	19.1	19.4	19.6	19.9	20.0	20.1	19.9	19.5
6500	11.0	12.2	13.2	14.8	16.0	16.9	17.5	18.1	18.5	18.7	19.0	19.2	19.4	19.3	19.2	18.7
7000	10.4	11.6	12.6	14.2	15.4	16.3	16.9	17.4	17.8	18.1	18.3	18.6	18.7	18.7	18.5	17.9
7500	9.8	11.0	12.0	13.6	14.8	15.7	16.4	16.9	17.3	17.5	17.7	18.0	18.1	18.0	17.8	17.2
8000	9.3	10.5	11.5	13.1	14.3	15.2	15.8	16.3	16.7	17.0	17.2	17.4	17.5	17.4	17.2	16.6
9000	8.3	9.5	10.5	12.1	13.3	14.2	14.8	15.3	15.7	16.0	16.1	16.4	16.4	16.3	16.0	15.3

* Try to avoid use of belts within the range enclosed with [- - -]. Otherwise, the durable time might be shortened.
* The above table is for 4.0mm of belt width. When the desired belt has the other width, multiply the value on the above table by the relevant width correction factor Kb provided on the Table 29.

Table 57. S3M Allowable Tension Table: Per 6.0mm of Belt Width (Unit: N)

Speed of Small Pulley (rpm) \ Number of Small Pulley Teeth	14	15	16	18	20	22	24	26	28	30	32	36	40	44	50	60
Pitch Circle Dia. (mm)	13.37	14.32	15.28	17.19	19.10	21.01	22.92	24.83	26.74	28.65	30.56	34.38	38.20	42.02	47.75	57.30
870	87	88	89	90	90	91	91	91	91	90	90	90	89	88	87	85
1160	82	83	84	85	85	86	86	86	85	85	85	84	84	83	82	80
1750	75	76	77	78	78	78	78	78	78	78	78	77	76	76	75	73
3500	63	64	64	65	66	66	66	66	66	66	65	65	64	63	62	59
50	138	139	139	140	141	141	141	141	141	141	140	140	139	138	137	136
100	126	126	127	128	128	129	129	129	129	128	128	128	127	126	125	123
150	118	119	120	121	121	122	122	122	121	121	121	120	120	119	118	116
200	113	114	115	116	116	116	117	117	116	116	116	115	115	114	113	111
250	109	110	111	112	112	113	113	113	112	112	112	111	111	110	109	107
300	106	107	108	109	109	109	109	109	109	109	109	108	108	107	106	104
350	103	104	105	106	106	107	107	107	107	106	106	106	105	104	103	101
400	101	102	103	104	104	104	104	104	104	104	104	103	103	102	101	99
450	99	100	101	101	102	102	102	102	102	102	102	101	100	100	99	97
500	97	98	99	100	100	100	100	100	100	100	100	99	99	98	97	95
550	96	96	97	98	98	99	99	99	99	98	98	98	97	96	95	93
600	94	95	95	96	97	97	97	97	97	97	97	96	95	95	94	92
650	93	93	94	95	95	96	96	96	96	95	95	95	94	93	92	90
700	91	92	93	94	94	94	95	95	94	94	94	93	93	92	91	89
800	89	90	90	91	92	92	92	92	92	92	92	91	90	90	89	87
900	87	88	88	89	90	90	90	90	90	90	90	89	88	87	86	85
1000	85	86	86	87	88	88	88	88	88	88	88	87	86	86	85	83
1100	83	84	85	86	86	86	87	87	86	86	86	85	85	84	83	81
1200	82	83	83	84	85	85	85	85	85	85	84	84	83	82	81	79
1300	80	81	82	83	83	84	84	84	83	83	83	82	82	81	80	78
1400	79	80	81	81	82	82	82	82	82	82	82	81	80	80	79	77
1500	78	79	79	80	81	81	81	81	81	81	80	80	79	78	77	75
1600	77	78	78	79	80	80	80	80	80	80	79	79	78	77	76	74
1700	76	77	77	78	79	79	79	79	79	79	78	78	77	76	75	73
1800	75	75	76	77	78	78	78	78	78	77	77	77	76	75	74	72
1900	74	75	75	76	77	77	77	77	77	77	76	76	75	74	73	71
2000	73	74	74	75	76	76	76	76	76	76	75	75	74	73	72	70
2200	71	72	73	73	74	74	74	74	74	74	74	73	72	72	70	68
2400	70	70	71	72	72	73	73	73	73	72	72	71	71	70	69	67
2600	68	69	70	71	71	71	71	71	71	71	71	70	69	68	67	65
2800	67	68	68	69	70	70	70	70	70	70	69	69	68	67	66	64
3000	66	66	67	68	68	69	69	69	69	68	68	67	67	66	65	62
3200	65	65	66	67	67	68	68	68	67	67	67	66	65	65	63	61
3400	63	64	65	66	66	66	67	66	66	66	66	65	64	63	62	60
3600	62	63	64	65	65	65	66	65	65	65	65	64	63	62	61	59
3800	61	62	63	64	64	64	65	64	64	64	64	63	62	61	60	58
4000	60	61	62	63	63	64	64	64	63	63	63	62	61	60	59	57
4500	58	59	60	61	61	61	61	61	61	61	61	60	59	58	57	54
5000	57	57	58	59	59	59	60	59	59	59	59	58	57	56	54	52
5500	55	56	56	57	58	58	58	58	57	57	57	56	55	54	52	49
6000	53	54	55	56	56	56	56	56	56	55	55	54	53	52	50	47
6500	52	53	53	54	54	55	55	54	54	54	53	52	51	50	48	45
7000	51	51	52	53	53	53	53	53	53	52	52	51	50	48	46	43
7500	49	50	51	51	52	52	52	52	51	51	50	49	48	47	45	41
8000	48	49	49	50	51	51	51	50	50	49	49	48	46	45	43	39
9000	46	47	47	48	48	48	48	48	47	47	46	45	44	42	39	35

* Try to avoid use of belts within the range enclosed with [- - -]. Otherwise, the durable time might be shortened.
* The above table is for 6.0mm of belt width. When the desired belt has the other width, multiply the value on the above table by the relevant width correction factor Kb provided on the Table 29.

Table 58. S5M Allowable Tension Table: Per 10.0mm of Belt Width (Unit: N)

Speed of Small Pulley (rpm) \ Number of Small Pulley Teeth	14	15	16	18	20	22	24	26	28	30	32	36	40	44	48	60
Pitch Circle Dia. (mm)	22.28	23.87	25.46	28.65	31.83	35.01	38.20	41.38	44.56	47.75	50.93	57.30	63.66	70.03	76.39	95.49
870	170	176	181	189	195	199	202	205	207	208	210	211	212	212	212	211
1160	159	165	170	178	183	188	191	194	196	197	198	200	201	201	201	199
1750	144	149	154	162	167	172	175	178	179	181	182	183	184	184	184	181
3500	116	122	127	134	140	144	147	149	151	152	153	153	153	152	151	145
50	280	286	291	299	304	309	312	315	317	318	319	321	322	322	322	321
100	254	259	264	272	278	282	285	288	290	292	293	294	295	296	296	294
150	238	244	249	256	262	267	270	272	274	276	277	279	280	280	280	279
200	227	233	238	245	251	255	259	261	263	265	266	268	269	269	269	268
250	218	224	229	237	243	247	250	253	255	256	258	259	260	260	260	259
300	211	217	222	230	236	240	243	246	248	249	251	252	253	253	253	252
350	205	211	216	224	230	234	237	240	242	243	245	246	247	247	247	246
400	200	206	211	219	224	229	232	235	237	238	240	241	242	242	242	241
450	196	202	206	214	220	224	228	230	232	234	235	237	237	238	238	236
500	192	198	202	210	216	220	224	226	228	230	231	233	233	234	234	232
550	188	194	199	206	212	217	220	223	225	226	227	229	230	230	230	229
600	185	191	195	203	209	213	217	219	221	223	224	225	226	227	227	225
650	182	187	192	200	206	210	214	216	218	220	221	222	223	224	223	222
700	179	185	189	197	203	207	211	213	215	217	218	220	220	221	221	219
800	174	179	184	192	198	202	206	208	210	212	213	214	215	215	215	214
900	169	175	180	188	193	198	201	204	205	207	208	210	211	211	211	209
1000	165	171	176	183	189	194	197	199	201	203	204	206	206	207	207	205
1100	161	167	172	180	186	190	193	196	198	199	200	202	203	203	203	201
1200	158	164	169	176	182	186	190	192	194	196	197	198	199	199	199	198
1300	155	161	166	173	179	183	187	189	191	193	194	195	196	196	196	194
1400	152	158	163	170	176	180	184	186	188	190	191	192	193	193	193	191
1500	149	155	160	168	173	178	181	184	186	187	188	190	190	190	190	188
1600	147	153	158	165	171	175	179	181	183	184	186	187	188	188	187	185
1700	145	150	155	163	169	173	176	179	181	182	183	185	185	185	185	183
1800	142	148	153	161	166	171	174	176	178	180	181	182	183	183	183	180
1900	140	146	151	159	164	169	172	174	176	178	179	180	181	181	180	178
2000	138	144	149	157	162	167	170	172	174	176	177	178	178	178	178	175
2200	135	140	145	153	159	163	166	168	170	172	173	174	174	174	174	171
2400	131	137	142	149	155	159	162	165	167	168	169	170	171	170	170	167
2600	128	134	139	146	152	156	159	162	163	165	166	167	167	167	166	162
2800	125	131	136	143	149	153	156	159	160	162	163	164	164	163	163	158
3000	122	128	133	141	146	150	153	156	157	159	160	161	161	160	159	155
3200	120	126	130	138	144	148	151	153	155	156	157	158	158	157	156	151
3400	118	123	128	136	141	145	148	150	152	153	154	155	155	154	153	147
3600	115	121	126	133	139	143	146	148	150	151	151	152	152	151	150	144
3800	113	119	123	131	136	140	143	146	147	148	149	149	149	148	147	140
4000	111	117	121	129	134	138	141	143	145	146	147	147	146	145	144	136
4500	106	112	117	124	129	133	136	138	139	140	141	141	140	138	136	128
5000	102	108	112	119	125	128	131	133	134	135	135	135	134	132	129	119
5500	98	104	108	115	120	124	127	128	129	130	130	129	128	125	122	110
6000	94	100	104	111	116	120	122	124	125	125	125	124	122	119	115	100
6500	91	96	101	108	113	116	118	120	120	121	120	119	116	112	108	91
7000	88	93	98	104	109	112	114	116	116	116	115	113	110	106	100	81
7500	85	90	94	101	106	109	110	111	112	111	111	108	104	99	93	71
8000	82	87	91	98	102	105	107	107	108	107	106	103	98	92	85	61
9000	76	81	86	92	96	98	99	100	99	98	96	92	86	78	70	39

* Try to avoid use of belts within the range enclosed with [- - -]. Otherwise, the durable time might be shortened.
* The above table is for 10.0mm of belt width. When the desired belt has the other width, multiply the value on the above table by the relevant width correction factor Kb provided on the Table 29.

Table 59. T5 Allowable Tension Table: Per 10.0mm of Belt Width (Unit: N)

Speed of Small Pulley (rpm) \ Number of Small Pulley Teeth	14	16	18	20	22	24	28	30
Pitch Circle Dia. (mm)	22.28	25.46	28.65	31.83	35.01	38.20	44.56	47.75
1160	85	85	85	85	85	85	85	85
1750	77	77	77	77	77	77	77	77
3500	64	64	64	64	64	64	64	64
100	106	107	106	106	106	106	106	106
200	104	104	104	104	104	104	104	104
300	102	102	102	102	102	102	102	102
400	99	99	99	99	99	99	99	99
500	97	97	97	97	97	97	97	97
600	95	95	95	95	95	95	95	95
700	93	93	93	93	93	93	93	93
800	91	91	91	91	91	91	91	91
900	89	89	89	89	89	89	89	89
1000	87	87	87	87	87	87	87	87
1100	86	86	86	86	86	86	86	86
1200	84	84	84	84	84	84	84	84
1300	83	83	83	83	83	83	83	83
1400	81	81	81	81	81	81	81	81
1500	80	80	80	80	80	80	80	80
1600	79	79	79	79	79	79	79	79
1700	77	77	77	77	77	77	77	77
1800	76	76	76	76	76	76	76	76
1900	75	75	75	75	75	75	75	75
2000	74	74	74	74	74	74	74	74
2200	72	72	72	72	72	72	72	72
2400	70	70	70	70	70	70	70	70
2600	69	69	69	69	69	69	69	69
2800	67	67	67	67	67	67	67	67
3000	66	66	66	66	66	66	66	66
3200	65	65	65	65	65	65	65	65
3400	64	64	64	64	64	64	64	64
3600	63	63	63	63	63	63	63	63
3800	62	62	62	62	62	62	62	62
4000	61	61	61	61	61	61	61	61
4200	61	61	61	61	61	61	61	61
4400	60	60	60	60	60	60	60	60
4600	59	59	59	59	59	59	59	59
4800	58	58	58	58	58	58	58	58
5000	57	57	57	57	57	57	57	57
5500	-	55	55	55	55	55	55	55
6000	-	51	51	51	51	51	51	51
6500	-	47	47	47	47	47	47	47
7000	-	41	41	41	41	41	41	41
7500	-	34	34	34	34	34	34	34
8000	-	-	24	24	24	24	24	24
8500	-	-	12	12	12	12	12	12

* Try to avoid use of belts within the range enclosed with [- - -]. Otherwise, the durable time might be shortened.
* The above table is for 10.0mm of belt width. When the desired belt has the other width, multiply the value on the above table by the relevant width correction factor Kb provided on the Table 29.

Table 60. T10 Allowable Tension Table: Per 10.0mm of Belt Width (Unit: N)

Speed of Small Pulley (rpm) \ Number of Small Pulley Teeth	12	14	16	18	20	22	24	26	28	30	32	36	40	44	48
Pitch Circle Dia. (mm)	38.20	44.56	50.93	57.30	63.66	70.03	76.39	82.76	89.12	95.49	101.86	114.59	127.32	140.06	152.79
870	147	147	147	147	147	147	147	147	147	147	147	147	147	147	147
1160	138	138	138	138	138	138	138	138	138	138	138	138	138	138	138
1750	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125
3500	-	104	104	104	104	104	104	104	104	104	104	104	104	104	104
100	174	174	174	174	174	174	174	174	174	174	174	174	174	174	174
200	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170
300	166	166	166	166	166	166	166	166	166	166	166	166	166	166	166
400	162	162	162	162	162	162	162	162	162	162	162	162	162	162	162
500	159	159	159	159	159	159	159	159	159	159	159	159	159	159	159
600	155	155	155	155	155	155	155	155	155	155	155	155	155	155	155
700	152	152	152	152	152	152	152	152	152	152	152	152	152	152	152
800	149	149	149	149	149	149	149	149	149	149	149	149	149	149	149
900	146	146	146	146	146	146	146	146	146	146	146	146	146	146	146
1000	143	143	143	143	143	143	143	143	143	143	143	143	143	143	143
1100	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140
1200	137	137	137	137	137	137	137	137	137	137	137	137	137	137	137
1300	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135
1400	133	133	133	133	133	133	133	133	133	133	133	133	133	133	133
1500	130	130	130	130	130	130	130	130	130	130	130	130	130	130	130
1600	128	128	128	128	128	128	128	128	128	128	128	128	128	128	128
1700	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126
1800	124	124	124	124	124	124	124	124	124	124	124	124	124	124	124
1900	122	122	122	122	122	122	122	122	122	122	122	122	122	122	122
2000	121	121	121	121	121	121	121	121	121	121	121	121	121	121	121
2200	118	118	118	118	118	118	118	118	118	118	118	118	118	118	118
2400	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115
2600	112	112	112	112	112	112	112	112	112	112	112	112	112	112	112
2800	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110
3000	-	108	108	108	108	108	108	108	108	108	108	108	108	108	108
3200	-	106	106	106	106	106	106	106	106	106	106	106	106	106	106
3400	-	104	104	104	104	104	104	104	104	104	104	104	104	104	104
3600	-	103	103	103	103	103	103	103	103	103	103	103	103	103	103
3800	-	102	102	102	102	102	102	102	102	102	102	102	102	102	102
4000	-	-	100	100	100	100	100	100	100	100	100	100	100	100	100
4200	-	-	99	99	99	99	99	99	99	99	99	99	99	99	99
4400	-	-	98	98	98	98	98	98	98	98	98	98	98	98	98
4600	-	-	96	96	96	96	96	96	96	96	96	96	96	96	96
4800	-	-	95	95	95	95	95	95	95	95	95	95	95	95	95
5000	-	-	94	94	94	94	94	94	94	94	94	94	94	94	94
5200	-	-	92	92	92	92	92	92	92	92	92	92	92	92	92
5400	-	-	90	90	90	90	90	90	90	90	90	90	90	90	90
5600	-	-	88	88	88	88	88	88	88	88	88	88	88	88	88
5800	-	-	86	86	86	86	86	86	86	86	86	86	86	86	86
6000	-	-	84	84	84	84	84	84	84	84	84	84	84	84	84

* Try to avoid use of belts within the range enclosed with [- - -]. Otherwise, the durable time might be shortened.
* For the range enclosed with [ ], be sure to provide some means to retain dynamic balance, because the pulley constant speed becomes 33 (m/s) or faster.
* The above table is for 10.0mm of belt width. When the desired belt has the other width, multiply the value on the above table by the relevant width correction factor Kb provided on the Table 29.

Timing Belt
Selection of Transmission Timing Belts 13

Table 61. 2GT Allowable Tension Table: Per 4.0mm of Belt Width (Unit: N)

Number of Small Pulley Teeth	12	14	16	18	20	22	24	26	28	30	32	36	40	44	48	50	60	72
Speed of Small Pulley (rpm) / Pitch Circle Dia. (mm)	7.64	8.91	10.19	11.46	12.73	14.01	15.28	16.55	17.83	19.10	20.37	22.92	25.46	28.01	30.56	31.83	38.20	45.84
20	56.09	57.27	58.45	59.63	60.80	61.98	63.16	64.33	65.51	66.69	67.86	70.22	72.57	74.92	77.28	78.45	84.34	84.34
40	50.60	51.78	52.96	54.13	55.31	56.49	57.66	58.84	60.02	61.20	62.37	64.73	67.08	69.43	71.79	72.96	78.85	78.85
60	47.39	48.57	49.75	50.92	52.10	53.28	54.45	55.63	56.81	57.98	59.16	61.51	63.87	66.22	68.57	69.75	75.64	75.64
100	43.35	44.52	45.70	46.88	48.05	49.23	50.41	51.58	52.76	53.94	55.11	57.47	59.82	62.17	64.53	65.70	71.59	71.59
200	37.85	39.03	40.21	41.38	42.56	43.74	44.92	46.09	47.27	48.45	49.62	51.98	54.33	56.68	59.04	60.21	66.10	66.10
300	34.64	35.82	37.00	38.17	39.35	40.53	41.70	42.88	44.06	45.23	46.41	48.76	51.12	53.47	55.82	57.00	62.89	62.89
400	32.36	33.54	34.72	35.89	37.07	38.25	39.42	40.60	41.78	42.95	44.13	46.49	48.84	51.19	53.55	54.72	60.61	60.61
500	30.60	31.77	32.95	34.13	35.30	36.48	37.66	38.83	40.01	41.19	42.36	44.72	47.07	49.42	51.78	52.96	58.84	58.84
600	29.15	30.33	31.51	32.68	33.86	35.04	36.21	37.39	38.57	39.74	40.92	43.27	45.63	47.98	50.33	51.51	57.39	57.39
700	27.93	29.11	30.28	31.46	32.64	33.81	34.99	36.17	37.34	38.52	39.70	42.05	44.41	46.76	49.11	50.29	56.17	56.17
800	26.87	28.05	29.23	30.40	31.58	32.76	33.93	35.11	36.29	37.46	38.64	40.99	43.35	45.70	48.06	49.23	55.12	55.12
870	26.21	27.39	28.56	29.74	30.92	32.09	33.27	34.45	35.62	36.80	37.98	40.33	42.68	45.04	47.39	48.57	54.45	54.45
900	25.94	27.12	28.29	29.47	30.65	31.82	33.00	34.18	35.35	36.53	37.71	40.06	42.41	44.77	47.12	48.30	54.18	54.18
1000	25.11	26.28	27.46	28.64	29.81	30.99	32.17	33.34	34.52	35.70	36.87	39.23	41.58	43.93	46.29	47.46	53.35	53.35
1160	23.93	25.11	26.28	27.46	28.64	29.81	30.99	32.17	33.34	34.52	35.70	38.05	40.40	42.76	45.11	46.29	52.17	52.17
1200	23.66	24.84	26.01	27.19	28.37	29.54	30.72	31.90	33.08	34.25	35.43	37.78	40.14	42.49	44.84	46.02	51.90	51.90
1400	22.44	23.62	24.79	25.97	27.15	28.32	29.50	30.68	31.85	33.03	34.21	36.56	38.91	41.27	43.62	44.80	50.68	50.68
1450	22.16	23.34	24.52	25.69	26.87	28.05	29.22	30.40	31.58	32.75	33.93	36.28	38.64	40.99	43.34	44.52	50.40	50.40
1600	21.38	22.56	23.74	24.91	26.09	27.27	28.44	29.62	30.80	31.97	33.15	35.50	37.86	40.21	42.56	43.74	49.62	49.62
1750	20.67	21.85	23.03	24.20	25.38	26.56	27.73	28.91	30.09	31.26	32.44	34.79	37.15	39.50	41.85	43.03	48.92	48.92
1800	20.45	21.63	22.80	23.98	25.16	26.33	27.51	28.69	29.86	31.04	32.22	34.57	36.92	39.28	41.63	42.81	48.69	48.69
2000	19.61	20.79	21.97	23.14	24.32	25.50	26.67	27.85	29.03	30.21	31.38	33.74	36.09	38.44	40.80	41.97	47.86	47.86
2400	18.17	19.35	20.52	21.70	22.88	24.05	25.23	26.41	27.58	28.76	29.94	32.29	34.65	37.00	39.35	40.53	46.41	46.41
2800	16.95	18.13	19.30	20.48	21.66	22.83	24.01	25.19	26.36	27.54	28.72	31.07	33.42	35.78	38.13	39.31	45.19	45.19
3200	15.89	17.07	18.24	19.42	20.60	21.77	22.95	24.13	25.31	26.48	27.66	30.01	32.37	34.72	37.07	38.25	44.13	44.13
3600	14.96	16.13	17.31	18.49	19.67	20.84	22.02	23.20	24.37	25.55	26.73	29.08	31.43	33.79	36.14	37.32	43.20	43.20
4000	14.12	15.30	16.48	17.65	18.83	20.01	21.18	22.36	23.54	24.71	25.89	28.24	30.60	32.95	35.31	36.48	42.37	42.37
5000	12.36	13.53	14.71	15.89	17.06	18.24	19.42	20.59	21.77	22.95	24.12	26.48	28.83	31.18	33.54	34.71	40.60	40.60
6000	10.91	12.09	13.26	14.44	15.62	16.80	17.97	19.15	20.33	21.50	22.68	25.03	27.39	29.74	32.09	33.27	39.15	39.15
7000	9.69	10.87	12.04	13.22	14.40	15.57	16.75	17.93	19.10	20.28	21.46	23.81	26.17	28.52	30.87	32.05	37.93	37.93
8000	8.63	9.81	10.99	12.16	13.34	14.52	15.69	16.87	18.05	19.22	20.40	22.75	25.11	27.46	29.81	30.99	36.88	36.88
10000	6.86	8.04	9.22	10.40	11.57	12.75	13.93	15.10	16.28	17.46	18.63	20.99	23.34	25.69	28.05	29.22	35.11	35.11
12000	5.42	6.60	7.77	8.95	10.13	11.30	12.48	13.66	14.83	16.01	17.19	19.54	21.90	24.25	26.60	27.78	33.66	33.66
14000	4.20	5.38	6.55	7.73	8.91	10.08	11.26	12.44	13.61	14.79	15.97	18.32	20.67	23.03	25.38	26.56	32.44	32.44

* Try to avoid use of belts within the range enclosed with ⬚. Otherwise, the durable time might be shortened.
* The above table is for 4.0mm of belt width. When the desired belt has the other width, multiply the value on the above table by the relevant width correction factor Kb provided on the Table 29.

Table 62. 3GT Allowable Tension Table: Per 6.0mm of Belt Width (Unit: N)

Number of Small Pulley Teeth	12	14	16	18	20	22	24	26	28	30	32	36	40	48	54	60	72	80
Speed of Small Pulley (rpm) / Pitch Circle Dia. (mm)	11.46	13.37	15.28	17.19	19.10	21.01	22.92	24.83	26.74	28.65	30.56	34.38	38.20	45.84	51.57	57.30	68.75	76.39
20	167.63	179.89	188.72	195.58	200.00	204.41	207.10	209.80	211.71	213.63	214.66	216.67	217.87	218.78	219.08	219.05	218.33	217.65
40	149.92	162.18	171.00	177.87	182.28	186.70	189.39	192.09	194.00	195.91	196.94	198.95	200.16	201.07	201.37	201.34	200.62	199.93
60	139.56	151.82	160.64	167.51	171.92	176.33	179.03	181.73	183.64	185.55	186.58	188.59	189.80	190.71	191.00	190.98	190.26	189.57
100	126.51	138.76	147.59	154.45	158.87	163.28	165.98	168.67	170.59	172.50	173.53	175.54	176.74	177.66	177.95	177.92	177.20	176.52
200	108.79	121.05	129.88	136.74	141.15	145.57	148.26	150.96	152.87	154.79	155.81	157.82	159.03	159.94	160.23	160.20	159.49	158.80
300	98.43	110.69	119.52	126.38	130.79	135.21	137.90	140.60	142.51	144.42	145.45	147.46	148.67	149.58	149.87	149.84	149.12	148.43
400	91.08	103.34	112.16	119.03	123.44	127.85	130.55	133.25	135.16	137.07	138.10	140.11	141.31	142.22	142.51	142.48	141.75	141.06
500	85.38	97.64	106.46	113.32	117.74	122.15	124.85	127.54	129.45	131.36	132.39	134.40	135.60	136.51	136.80	136.76	136.03	135.33
600	80.72	92.98	101.80	108.66	113.08	117.49	120.18	122.88	124.79	126.70	127.73	129.74	130.94	131.84	132.13	132.09	131.35	130.65
700	76.78	89.04	97.86	104.72	109.14	113.55	116.24	118.94	120.85	122.76	123.79	125.79	126.99	127.89	128.17	128.13	127.39	126.68
800	73.36	85.62	94.45	101.31	105.72	110.13	112.83	115.52	117.43	119.34	120.37	122.37	123.57	124.47	124.75	124.70	123.95	123.23
870	71.22	83.48	92.30	99.16	103.58	107.99	110.68	113.37	115.28	117.19	118.22	120.22	121.42	122.31	122.59	122.54	121.78	121.06
900	70.35	82.61	91.44	98.30	102.71	107.12	109.81	112.51	114.42	116.33	117.35	119.35	120.55	121.44	121.72	121.67	120.91	120.19
1000	67.66	79.92	88.74	95.60	100.01	104.42	107.12	109.81	111.72	113.63	114.65	116.65	117.85	118.73	119.01	118.95	118.18	117.45
1160	63.87	76.12	84.95	91.81	96.22	100.62	103.32	106.01	107.92	109.82	110.85	112.84	114.04	114.91	115.18	115.12	114.32	113.58
1200	63.00	75.26	84.08	90.94	95.35	99.76	102.45	105.14	107.05	108.95	109.98	111.97	113.16	114.04	114.30	114.24	113.44	112.69
1400	59.06	71.31	80.13	86.99	91.40	95.81	98.50	101.19	103.09	105.00	106.02	108.01	109.19	110.06	110.31	110.23	109.40	108.63
1450	58.16	70.41	79.24	86.10	90.50	94.91	97.60	100.29	102.19	104.10	105.12	107.11	108.29	109.15	109.40	109.31	108.48	107.70
1600	55.64	67.90	76.72	83.57	87.98	92.39	95.07	97.76	99.66	101.57	102.58	104.57	105.75	106.59	106.83	106.74	105.88	105.08
1750	53.35	65.60	74.42	81.28	85.68	90.09	92.77	95.46	97.36	99.26	100.28	102.26	103.43	104.26	104.49	104.38	103.49	102.67
1800	52.63	64.88	73.70	80.56	84.96	89.36	92.05	94.74	96.64	98.53	99.55	101.53	102.70	103.53	103.75	103.64	102.74	101.91
2000	49.93	62.18	71.00	77.86	82.26	86.66	89.34	92.02	93.92	95.82	96.83	98.80	99.96	100.77	100.98	100.85	99.91	99.05
2400	45.26	57.51	66.33	73.18	77.57	81.97	84.65	87.32	89.21	91.10	92.10	94.06	95.20	95.97	96.14	95.96	94.92	93.98
2800	43.40	53.56	62.37	69.21	73.60	77.99	80.66	83.33	85.21	87.09	88.09	90.02	91.14	91.86	91.98	91.76	90.59	89.56
3200	42.08	50.13	58.93	65.77	70.16	74.54	77.20	79.86	81.73	83.60	84.59	86.50	87.59	88.25	88.31	88.03	86.73	85.60
3600	40.94	47.10	55.90	62.73	67.11	71.48	74.14	76.79	78.65	80.51	81.48	83.36	84.43	85.01	85.02	84.67	83.21	81.96
4000	39.95	44.39	53.18	60.00	64.37	68.74	71.38	74.02	75.87	77.72	78.67	80.53	81.56	82.07	82.01	81.58	79.96	78.57
5000	37.92	38.62	47.39	54.20	58.54	62.88	65.49	68.10	69.91	71.72	72.64	74.41	75.34	75.62	75.36	74.71	72.57	70.79
6000	36.32	36.74	42.63	49.41	53.72	58.03	60.60	63.17	64.94	66.71	67.58	69.23	70.05	70.05	69.55	68.63	65.86	63.60
7000	35.00	35.36	38.57	45.32	49.60	53.86	56.40	58.92	60.64	62.35	63.16	64.69	65.36	65.03	64.24	63.01	59.50	56.66
8000	33.88	34.19	35.02	41.73	45.97	50.19	52.67	55.14	56.80	58.45	59.19	60.58	61.08	60.37	59.26	57.65	53.28	49.80
10000	32.03	32.24	32.41	35.61	39.75	43.86	46.22	48.56	50.08	51.58	52.16	53.19	53.31	51.68	49.77	47.28	40.86	35.80
12000	30.52	30.63	30.69	30.70	34.46	38.43	40.65	42.83	44.18	45.49	45.88	46.48	46.11	43.37	40.50	36.92	27.99	21.00
14000	29.22	29.23	29.17	29.06	29.77	33.59	35.64	37.63	38.78	39.87	40.03	40.12	39.18	35.12	31.10	26.24	-	-

* Try to avoid use of belts within the range enclosed with ⬚. Otherwise, the durable time might be shortened.
* The above table is for 6.0mm of belt width. When the desired belt has the other width, multiply the value on the above table by the relevant width correction factor Kb provided on the Table 29.

Table 63. EV5GT Allowable Tension Table: Per 15.0mm of Belt Width (Unit: N)

Number of Small Pulley Teeth	14	16	18	20	22	24	26	28	30	32	36	40	44	48	54	60	72	80
Speed of Small Pulley (rpm) / Pitch Circle Dia. (mm)	22.28	25.46	28.65	31.83	35.01	38.20	41.38	44.56	47.75	50.93	57.30	63.66	70.03	76.39	85.94	95.49	114.59	127.32
20	569.50	672.00	745.30	816.20	899.70	942.90	978.90	1009.40	1033.20	1046.90	1067.20	1085.40	1088.20	1085.60	1079.30	1076.30	1063.30	1046.20
40	508.10	610.60	684.30	755.50	832.50	875.30	910.90	941.20	964.80	978.90	999.80	1018.20	1021.90	1020.30	1015.30	1013.20	1001.90	986.10
60	472.20	574.70	648.70	720.00	793.20	835.80	871.20	901.20	924.70	939.10	960.40	978.90	983.10	982.10	977.90	976.30	966.00	951.00
100	427.00	529.50	603.80	675.20	743.70	785.90	821.10	850.90	874.20	889.00	910.70	929.40	934.30	934.00	930.70	929.80	920.70	906.70
200	365.60	468.00	542.90	614.50	676.50	718.30	753.10	782.70	805.80	820.90	843.20	862.30	868.00	868.70	866.80	866.70	859.30	846.70
300	329.70	432.10	507.20	579.00	637.10	678.80	713.40	742.80	765.70	781.10	803.80	823.00	829.30	830.50	829.30	829.80	823.40	811.60
400	304.20	406.60	481.90	553.80	609.20	650.70	685.10	714.40	737.30	752.90	775.80	795.10	801.80	803.40	802.80	803.60	797.90	786.60
500	284.40	386.90	462.30	534.20	587.60	628.90	663.30	692.50	715.20	731.00	754.10	773.50	780.40	782.40	782.20	783.30	778.20	767.30
600	268.30	370.70	446.30	518.30	569.90	611.10	645.40	674.50	697.20	713.10	736.30	755.90	763.00	765.30	765.40	766.70	762.00	751.50
700	254.60	357.10	432.70	504.80	555.00	596.10	630.30	659.30	682.00	698.00	721.30	740.90	748.30	750.70	751.10	752.60	748.40	738.10
800	242.80	345.20	421.00	493.10	542.00	583.10	617.20	646.20	668.80	684.90	708.40	728.00	735.50	738.20	738.80	740.50	736.50	726.60
870	235.40	337.80	413.60	485.70	533.90	574.90	609.00	637.90	660.50	676.60	700.20	719.90	727.50	730.30	731.10	732.90	729.10	719.30
900	232.40	334.80	410.60	482.70	530.60	571.60	605.60	634.60	657.20	673.30	696.90	716.60	724.20	727.10	727.90	729.80	726.10	716.40
1000	223.00	325.50	401.40	473.50	520.40	561.30	595.30	624.20	646.80	663.00	686.60	706.40	714.20	717.10	718.20	720.20	716.80	707.20
1160	209.90	312.30	388.30	460.50	506.00	546.80	580.80	609.60	632.10	648.40	672.20	692.00	700.00	703.20	704.50	706.70	703.60	694.40
1200	206.90	309.30	385.30	457.50	502.70	543.50	577.40	606.30	628.80	645.10	668.90	688.70	696.70	700.00	701.40	703.60	700.60	691.50
1400	193.20	295.70	371.80	444.00	487.80	528.50	562.30	591.10	613.50	629.90	653.90	673.80	682.00	685.40	687.20	689.50	687.00	678.10
1450	190.10	292.60	368.70	441.00	484.40	525.10	558.90	587.60	610.10	626.50	650.50	670.40	678.60	682.10	683.90	686.30	683.80	675.10
1600	181.40	283.80	360.10	432.30	474.80	515.50	549.20	577.90	600.30	616.80	640.90	660.80	669.20	672.90	674.80	677.40	675.10	666.50
1750	173.50	275.90	352.20	424.50	466.10	506.70	540.40	569.10	591.50	608.00	632.20	652.20	660.70	664.40	666.60	669.20	667.20	658.80
1800	171.00	273.40	349.70	422.00	463.40	504.00	537.70	566.30	588.70	605.30	629.50	649.40	658.00	661.80	664.00	666.70	664.70	656.30
2000	161.60	264.10	340.40	412.80	453.20	493.70	527.30	556.00	578.30	594.90	619.20	639.20	647.90	651.80	654.20	657.10	655.40	647.20
2400	145.50	247.90	324.40	396.80	435.50	475.90	509.50	538.00	560.30	577.00	601.50	621.60	630.50	634.70	637.40	640.50	639.20	631.40
2800	135.20	234.30	310.90	383.30	420.60	460.90	494.40	522.80	545.00	561.90	586.50	606.60	615.70	620.20	623.20	626.40	625.60	618.00
3200	130.90	222.40	299.10	371.60	407.60	447.80	481.30	509.70	531.90	548.80	573.50	593.70	603.00	607.60	610.80	614.30	613.70	606.50
3600	127.00	212.00	288.80	361.30	396.20	436.30	469.70	498.10	520.20	537.20	562.00	582.30	591.70	596.50	600.00	603.60	603.30	596.30
4000	123.50	202.70	279.50	352.10	386.00	426.10	459.40	487.70	509.80	526.90	551.80	572.10	581.60	586.60	590.30	594.00	594.00	587.10
5000	116.20	182.90	259.90	332.50	364.30	404.30	437.50	465.70	487.80	505.00	530.10	550.40	560.30	565.50	569.70	573.70	574.20	567.80
6000	-	166.70	243.90	316.50	346.70	386.50	419.60	447.80	469.70	487.10	512.30	532.80	542.90	548.40	552.80	557.10	558.10	552.00
7000	-	153.10	230.30	303.00	331.70	371.50	404.50	432.60	454.50	472.00	497.30	517.80	528.10	533.80	538.60	543.00	544.40	538.70
8000	-	-	218.60	291.30	318.80	358.40	391.40	419.50	441.30	458.80	484.30	504.90	515.40	521.30	526.30	530.90	532.60	-
9000	-	-	208.20	281.00	307.30	347.00	379.90	407.90	429.70	447.30	472.90	493.50	504.10	510.20	515.40	520.20	-	-
10000	-	-	-	271.80	297.10	336.70	369.50	397.50	419.30	436.90	462.60	483.30	494.00	500.30	505.70	-	-	-
12000	-	-	-	255.80	279.40	318.90	351.70	379.50	401.30	419.00	444.90	465.60	476.60	483.10	-	-	-	-
14000	-	-	-	242.30	264.50	303.90	336.60	364.40	386.00	403.90	429.90	450.70	-	-	-	-	-	-

* Try to avoid use of belts within the range enclosed with ⬚. Otherwise, the durable time might be shortened.
* The above table is for 15.0mm of belt width. When the desired belt has the other width, multiply the value on the above table by the relevant width correction factor Kb provided on the Table 29.

Table 64. EV8YU Allowable Tension Table: Per 20.0mm of Belt Width (Unit: N)

Number of Small Pulley Teeth	20	22	24	26	28	30	32	34	36	38	40	44	48	54	60	64	72	80
Speed of Small Pulley (rpm) / Pitch Circle Dia. (mm)	50.93	56.02	61.12	66.21	71.30	76.39	81.49	86.58	91.67	96.77	101.86	112.05	122.23	137.51	152.79	162.97	183.35	203.72
10	1379.15	1402.18	1425.20	1448.23	1471.25	1494.28	1517.31	1528.82	1540.33	1551.84	1574.87	1597.90	1620.92	1639.34	1655.46	1666.97	1678.49	1689.95
20	1285.58	1315.53	1345.49	1375.45	1405.40	1435.36	1465.32	1480.30	1495.28	1510.25	1540.21	1570.17	1600.13	1624.09	1645.06	1660.04	1675.02	1689.93
40	1192.00	1228.89	1265.78	1302.67	1339.55	1376.44	1413.33	1431.77	1450.22	1468.66	1505.55	1542.44	1579.33	1608.83	1634.65	1653.10	1671.54	1689.90
60	1137.26	1178.20	1219.15	1260.09	1301.03	1341.97	1382.92	1403.39	1423.86	1444.33	1485.27	1526.21	1567.15	1599.90	1628.56	1649.02	1669.49	1689.87
100	1068.29	1114.34	1160.39	1206.44	1252.49	1298.54	1344.59	1367.61	1390.64	1413.66	1459.71	1505.75	1551.79	1588.62	1620.84	1643.86	1666.86	1689.77
200	974.69	1027.67	1080.64	1133.62	1186.59	1239.56	1292.54	1319.02	1345.50	1371.98	1424.95	1477.90	1530.85	1573.18	1610.21	1636.66	1663.06	1689.34
300	919.91	976.93	1033.95	1090.97	1147.99	1205.00	1262.02	1290.51	1319.00	1347.49	1404.50	1461.47	1518.44	1563.95	1603.74	1632.16	1660.47	1688.64
400	881.01	940.90	1000.78	1060.66	1120.54	1180.41	1240.28	1270.20	1300.11	1330.01	1389.87	1449.67	1509.46	1557.18	1598.88	1628.66	1658.24	1687.66
500	850.81	912.91	975.01	1037.10	1099.19	1161.27	1223.35	1254.35	1285.35	1316.34	1378.40	1440.37	1502.31	1551.70	1594.83	1625.63	1656.12	1686.41
600	826.10	890.01	953.90	1017.79	1081.68	1145.56	1209.43	1241.31	1273.19	1305.06	1368.90	1432.61	1496.29	1546.99	1591.24	1622.83	1653.97	1684.87
700	805.18	870.60	936.01	1001.42	1066.81	1132.20	1197.58	1230.20	1262.80	1295.40	1360.75	1425.90	1491.02	1542.78	1587.91	1620.14	1651.74	1683.07
800	787.02	853.75	920.47	987.18	1053.87	1120.56	1187.23	1220.47	1253.70	1286.92	1353.55	1419.93	1486.26	1538.89	1584.73	1617.47	1649.38	1680.98
870	775.60	843.14	910.68	978.20	1045.71	1113.20	1180.68	1214.31	1247.92	1281.52	1348.95	1416.08	1483.16	1536.31	1582.56	1615.59	1647.65	1679.36
900	770.97	838.85	906.71	974.56	1042.40	1110.22	1178.02	1211.80	1245.57	1279.32	1347.07	1414.50	1481.88	1535.22	1581.64	1614.78	1646.88	1678.62
1000	756.59	825.48	894.36	963.22	1032.06	1100.89	1169.70	1203.95	1238.19	1272.40	1341.14	1409.49	1477.77	1531.70	1578.58	1612.04	1644.22	1675.98
1160	736.25	806.57	876.86	947.13	1017.38	1087.60	1157.80	1192.69	1227.57	1262.42	1332.52	1402.10	1471.59	1526.25	1573.65	1607.48	1639.59	1671.18
1200	731.59	802.23	872.84	943.43	1013.99	1084.53	1155.05	1190.08	1225.10	1260.09	1330.50	1400.35	1470.10	1524.91	1572.41	1606.31	1638.36	1669.87
1400	710.33	782.41	854.47	926.48	998.47	1070.41	1142.33	1177.99	1213.62	1249.21	1320.99	1392.00	1462.88	1518.23	1566.03	1600.15	1631.74	1662.65
1450	705.47	777.88	850.25	922.59	994.89	1067.15	1139.38	1175.18	1210.93	1246.66	1318.74	1390.00	1461.11	1516.56	1564.39	1598.53	1629.96	1660.67
1600	691.78	765.09	838.36	911.58	984.76	1057.89	1130.98	1167.14	1203.25	1239.32	1312.23	1384.14	1455.87	1511.50	1559.35	1593.48	1624.33	1654.32
1750	679.25	753.36	827.43	901.44	975.39	1049.30	1123.15	1159.61	1196.01	1232.37	1306.00	1378.45	1450.68	1506.35	1554.08	1588.12	1618.23	1647.34
1800	675.29	749.66	823.97	898.22	972.41	1046.55	1120.64	1157.19	1193.68	1230.12	1303.98	1376.57	1448.94	1504.61	1552.27	1586.26	1616.09	1644.88
2000	660.41	735.69	810.90	886.04	961.11	1036.12	1111.05	1147.91	1184.70	1221.42	1296.07	1369.17	1441.98	1497.48	1544.75	1578.46	1607.02	1634.32
2400	634.27	711.05	787.73	864.32	940.80	1017.18	1093.47	1130.73	1167.90	1204.97	1280.85	1354.48	1427.72	1482.34	1528.28	1561.00	1586.32	1609.89
2800	611.65	689.60	767.41	845.08	922.62	1000.02	1077.28	1114.73	1152.03	1189.20	1265.92	1339.59	1412.70	1465.79	1509.72	1540.98	1562.16	1581.02
3200	591.54	670.39	749.05	827.54	905.85	983.98	1061.94	1099.36	1136.61	1173.68	1250.92	1324.17	1396.70	1447.68	1488.98	1518.32	1534.51	1547.70
3600	573.28	652.81	732.11	811.19	890.04	968.66	1047.06	1084.30	1121.31	1158.09	1235.59	1308.03	1379.58	1427.88	1465.98	1492.98	1503.34	1509.94
4000	556.42	636.45	716.20	795.67	874.86	953.77	1032.41	1069.30	1105.91	1142.25	1219.77	1291.05	1361.22	1406.34	1440.66	1464.92	1468.63	-
5000	518.49	599.11	679.29	759.04	838.36	917.24	995.69	1031.12	1066.11	1100.67	1177.38	1244.34	1309.56	1344.51	1367.04	-	-	-
6000	484.33	564.77	644.58	723.77	802.33	880.27	957.58	990.77	1023.34	1055.28	1130.10	1190.86	1249.12	1270.93	-	-	-	-
7000	452.24	531.85	610.61	688.52	765.58	841.79	917.15	947.39	976.78	1005.32	1077.28	1130.10	1179.53	-	-	-	-	-
8000	421.20	499.42	576.52	652.51	727.39	801.16	873.82	900.43	925.94	950.33	1018.55	-	-	-	-	-	-	-

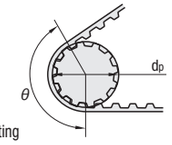
* Try to avoid use of belts within the range enclosed with ⬚. Otherwise, the durable time might be shortened.
* The above table is for 20.0mm of belt width. When the desired belt has the other width, multiply the value on the above table by the relevant width correction factor Kb provided on the Table 29.

Timing Belt
Selection of Synchronous Belt 1

Iron Rubber® Belts are selected based on applied Load Torque (Nm) or Transmission Capacity (kW).

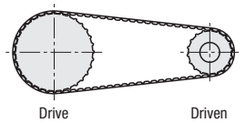
■ Selection Condition

Conditions Needed For Selecting
- · Pulley Pitch Diameter: d_p (mm)
- · Pulley Rotational Speed: n (rpm)
- · Pulley Wrap Angle: θ (°)
- · Load Torque: Md (Nm) or Transmission Capacity: P (kW)

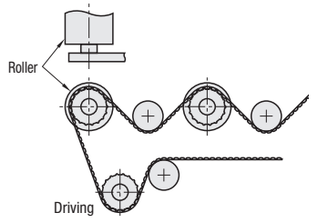


Fundamentally use the Drive side pulley for calculations. When the Driven side pulley is also transmitting torque, calculate for the Driven side also, and make the belt selection based on more severe side.

Ex. 1) When Drive Pulley Diameter > Driven Pulley Diameter, also calculate for the Driven side pulley.



Ex. 2) When the driven pulley is connected to a roller, also calculate for the Driven side.



■ Selection Method

[Step 1] Load Torque, Transmission Capacity Corrections

Back-side Idler Correction

• When a Transmission Capacity is given as a conditional parameter

$P = P_0 \times (1+0.1 \times f)$

P : Transmission Capacity Used for Selection (kW)
P_0 : Transmission Capacity Given as Conditional Parameter (kW)
f : Number of Back-side Idlers

• When a Load Torque is given as a conditional parameter

$Md = Md_0 \times (1+0.1 \times f)$

Md : Transmission Capacity Used for Selection (Nm)
Md_0 : Transmission Capacity Given as Conditional Parameter (Nm)
f : Number of Back-side Idlers

[Step 2] Selection of Belt Model

Select belt model using Simplified Selection Chart on **P.385**.

• When a Transmission Capacity is given as a conditional parameter
Select belt model based on Transmission Capacity and Pulley Speed (See Table 6)

• When a Load Torque is given as a conditional parameter
Select belt model based on Load Torque and Number of Sm. Pulley Tooth (See Table 7)

[Step 3] Selection of Pulley Tooth Count Z

Note the Min. Pulley Tooth Count when selecting the number of tooth. (See Table 1)

Table 1: Min. Pulley Tooth Count

Rotational Speed (rpm)	MA3	MA5	MA8	AT5	AT10	T5	T10	MXL	XL	L	H
600 or Less	18	15	20	15	15	12	14	12	10	10	14
720 or Less										12	
900 or Less			22								
1200 or Less		16	24		18		16				16
1800 or Less	20	20	26	16	20	14	18	14	12	14	18
3000 or Less	22	24	28	18	22	16	20	16		16	20

[Step 4] Selection of Belt Tooth Count ZB

<When pulley ratio is not 1:1>
Obtain belt tooth count from belt length.
Select belt loop length from shaft distance (C), Lg. Pulley Dia., and Sm. Pulley Dia.

$$Lp = 2C + \frac{\pi(Dp+dp)}{2} + \frac{(Dp-dp)^2}{4C}$$

C : Shaft Center Distance
dp : Small Pulley Pitch Circle Diameter (mm)
Dp : Large Pulley Pitch Circle Diameter (mm)
Lp : Belt length (mm)

Calculate number of tooth from belt length.

$$Z_B = \frac{Lp}{t}$$

Z_B : Number of Belt Tooth
t : Belt Pitch (exT10 → t=10)

<When pulley ratio is 1:1>

$$Z_B = \frac{2C}{t} + Z$$

C : Shaft Center Distance
t : Belt Pitch
z: Number of Pulley Tooth

[Step 5] Calculating Tooth Mesh Count

<When pulley ratio is not 1:1>

$$Z_E = \frac{z_1}{180} \times \cos^{-1}\frac{t(z_2-z_1)}{2\pi C}$$

z_1 : Small Pulley Number of Tooth
z_2 : Large Pulley Number of Tooth

<When pulley ratio is 1:1>

$$Z_E = \frac{z}{2}$$

z : Number of Pulley Tooth

However, Max. Number of Effective Meshed Teeth on the right table will be the upper limit.

Table 2: Max. Number of Effective Meshed Teeth

Belt Type	Max. Number of Effective Meshed Teeth
Long Synchronous Belt	6
Open End Belt	12

[Step 6] Calculating Minimum Belt Width bc

Calculate the minimum belt width from Allowable Transmission Capacity and Allowable Transmission Torque on **P.385**.

• When a Transmission Capacity is given as a conditional parameter
Allowable Transmission Capacity (Ps) in Table 8 (**P.385**) is used.

$$bc = \frac{P \times 10^4}{Ps \times Z_E \times z} \times fw$$

bc: Belt Width (mm)
P: Transmission Capacity (kW)
Ps: Allowable Transmission Capacity
Z_E: Number of Meshing Tooth
fw: Width Factor (Long Synchronous Belt T10150 : 1.5, Others : 1)
Z: Number of Pulley Tooth

• When a Load Torque is given as a conditional parameter
Allowable Transmission Torque (Mds) in Table 9 (**P.385**) is used.

$$bc = \frac{Md \times 10^3}{Mds \times Z_E \times z} \times fw$$

Md: Load Torque (Nm)
Mds: Allowable Transmission Torque
Z_E : Number of Meshing Tooth
fw: Width Factor (Long Synchronous Belt T10150 : 1.5, Others : 1)
Z: Number of Pulley Tooth

Select standard belt widths larger than the calculated minimum width bc.

[Step 7] Confirming Min. Shaft Center Distance Adjustment Range

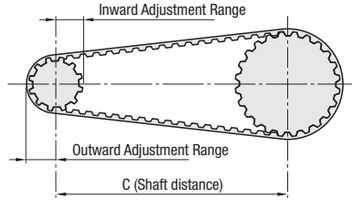
Refer to the table below for Min. Shaft Center Distance Adjustment Range by considering the mounting and adjustment range.

Table 3: Outside Adjustment Range

Outside Adjustment Range (mm)	Outside Adjustment Range (mm)
600 or Less	5
Over 600~1000 or Less	10
Over 1000~1500 or Less	15
Over 1500~2000 or Less	20
Over 2000~2500 or Less	25
Over 2500~3000 or Less	30
Over 3000	Shaft Center Distance × 0.01

Table 4: Inside Adjustment Range

Model	Inside Adjustment Range (mm)
MA3, T5, XL, MXL	5
MA5, AT5, L	10
MA8, AT10, T10, H	15

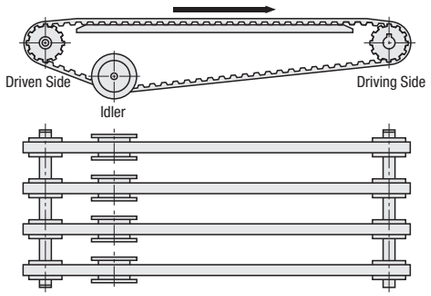


For flanged pulleys, allow ample adjustment margin by considering the flange dia .

■ Notes on Selection

• Load Torque and Transmission capability
Load torque and transmission capability should be calculated from absolute max. load values applicable to the belt for safety.

• For Multiple Belt Parallel Use
- · If each belt receives an equal load, calculate with a value of total load divided by the number of belts used. However, if the load on each belt may potentially become uneven, calculate with the max. load applicable on one belt.
- · The mechanism should be designed to facilitate individual belt tension adjustments.

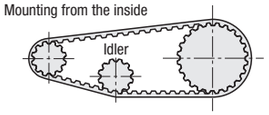


• When an Idler is used
- · If use of Idler is unavoidable, always use the Idler on the slack side.
- · Position the Idler on the inside if possible.
  When positioning an Idler on the inside, use one with more teeth than the smaller side pulley.
  For placing the Idler on the outside, use a flat pulley not crowned.

Table 5. Minimum Idler Diameter

Belt Type	Minimum Idler Diameter (mm)
MA3	30
MA5, AT5	40
MA8, AT10	80
T5	30
T10	70
MXL	15
XL	30
L	50
H	90

Mounting from the inside



Mounting from the outside

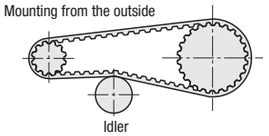
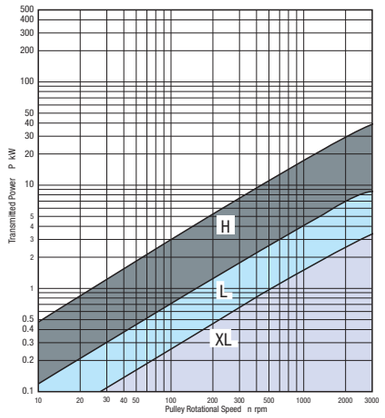


Table 6: Selection Guide Table 1 (Transmission Capacity)



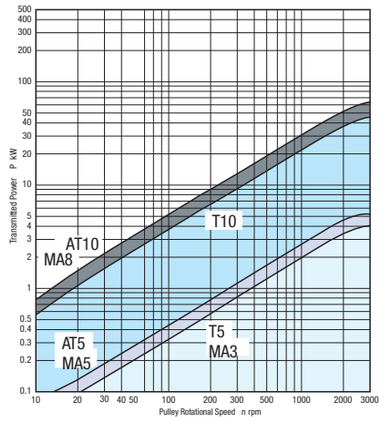
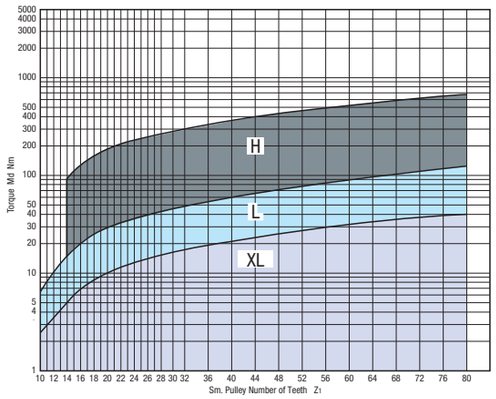


Table 7: Selection Guide Table 2 (Torque)



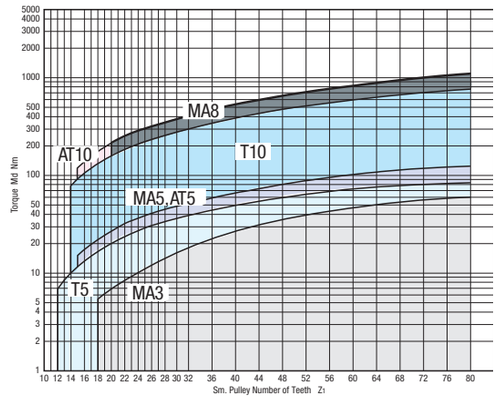


Table 8: Allowable Transmission Capacity (Ps)

Pulley Rotational Speed n (rpm)	MA3	MA5	MA8	AT5	AT10	T5	T10	MXL	XL	L	H
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20	0.026	0.052	0.181	0.052	0.226	0.043	0.181	0.007	0.044	0.129	0.206
40	0.050	0.101	0.351	0.101	0.439	0.084	0.351	0.014	0.085	0.250	0.401
60	0.074	0.147	0.511	0.147	0.639	0.123	0.511	0.020	0.124	0.364	0.583
80	0.096	0.192	0.661	0.192	0.826	0.160	0.661	0.026	0.161	0.471	0.753
100	0.116	0.233	0.800	0.233	1.000	0.194	0.800	0.032	0.196	0.572	0.910
200	0.211	0.422	1.423	0.422	1.779	0.351	1.423	0.058	0.354	1.019	1.616
300	0.296	0.592	1.984	0.592	2.480	0.494	1.980	0.082	0.498	1.419	2.250
400	0.376	0.753	2.496	0.753	3.120	0.627	2.490	0.104	0.632	1.789	2.830
500	0.452	0.905	2.976	0.905	3.720	0.754	2.980	0.126	0.760	2.140	3.370
600	0.525	1.050	3.432	1.050	4.290	0.875	3.430	0.147	0.881	2.470	3.880
700	0.593	1.187	3.864	1.187	4.830	0.989	3.870	0.168	0.999	2.780	4.370
800	0.662	1.324	4.280	1.324	5.350	1.104	4.280	0.188	1.113	3.080	4.830
900	0.728	1.456	4.664	1.456	5.830	1.213	4.680	0.208	1.223	3.370	5.280
1000	0.791	1.538	5.064	1.538	6.330	1.319	5.070	0.227	1.330	3.650	5.720
1100	0.854	1.708	5.440	1.708	6.800	1.423	5.440	0.247	1.434	3.920	6.130
1200	0.914	1.829	5.800	1.829	7.250	1.524	5.800	0.266	1.536	4.190	6.540
1300	0.974	1.947	6.152	1.947	7.690	1.623	6.150	0.285	1.636	4.440	6.930
1400	1.031	2.060	6.496	2.060	8.120	1.719	6.490	0.303	1.733	4.690	7.310
1500	1.088	2.180	6.824	2.180	8.530	1.814	6.830	0.322	1.829	4.930	7.680
1600	1.144	2.290	7.152	2.290	8.940	1.907	7.150	0.340	1.923	5.170	8.040
1700	1.199	2.400	7.464	2.400	9.330	1.998	7.460	0.358	2.010	5.400	8.390
1800	1.254	2.510	7.776	2.510	9.720	2.090	7.770	0.378	2.110	5.620	8.730
1900	1.308	2.610	8.072	2.610	10.090	2.180	8.070	0.394	2.190	5.840	9.060
2000	1.356	2.720	8.368	2.720	10.460	2.260	8.370	0.413	2.280	6.060	9.390
2200	1.458	2.920	8.936	2.920	11.170	2.430	8.940	0.448	2.450	6.480	10.020
2400	1.560	3.120	9.480	3.120	11.850	2.600	9.480	0.485	2.620	6.880	10.630
2600	1.656	3.310	10.008	3.310	12.510	2.760	10.010	0.520	2.780	7.270	11.210
2800	1.746	3.490	10.512	3.490	13.140	2.910	10.510	0.556	2.940	7.640	11.760
3000	1.838	3.680	11.000	3.680	13.750	3.060	11.000	0.590	3.090	8.000	12.300

Table 9: Allowable Transmission Torque (Mds)

Pulley Rotational Speed n (rpm)	MA3	MA5	MA8	AT5	AT10	T5	T10	MXL	XL	L	H
0	1.260	2.520	8.888	2.520	11.110	2.100	8.890	0.344	2.130	6.310	10.150
20	1.230	2.460	8.640	2.460	10.800	2.050	8.640	0.339	2.080	6.140	9.860
40	1.200	2.400	8.392	2.400	10.490	2.000	8.390	0.328	2.030	5.970	9.560
60	1.173	2.350	8.136	2.350	10.170	1.955	8.140	0.319	1.976	5.800	9.270
80	1.144	2.290	7.888	2.290	9.860	1.906	7.890	0.311	1.923	5.630	8.980
100	1.114	2.230	7.640	2.230	9.550	1.857	7.640	0.303	1.871	5.460	8.690
200	1.006	2.010	6.800	2.010	8.500	1.677	6.800	0.276	1.690	4.860	7.720
300	0.943	1.887	6.304	1.887	7.880	1.572	6.300	0.260	1.584	4.520	7.150
400	0.898	1.797	5.952	1.797	7.440	1.497	5.950	0.249	1.509	4.270	6.740
500	0.864	1.728	5.680	1.728	7.100	1.440	5.680	0.241	1.451	4.080	6.430
600	0.836	1.671	5.456	1.671	6.820	1.393	5.460	0.234	1.403	3.920	6.180
700	0.811	1.623	5.272	1.623	6.590	1.352	5.270	0.229	1.363	3.790	5.960
800	0.791	1.581	5.112	1.581	6.390	1.318	5.110	0.225	1.328	3.680	5.770
900	0.772	1.545	4.968	1.545	6.210	1.287	4.970	0.221	1.298	3.580	5.610
1000	0.756	1.512	4.840	1.512	6.050	1.260	4.840	0.217	1.270	3.490	5.460
1100	0.741	1.482	4.720	1.482	5.900	1.235	4.720	0.214	1.245	3.410	5.320
1200	0.728	1.456	4.616	1.456	5.770	1.213	4.620	0.211	1.223	3.330	5.200
1300	0.715	1.430	4.520	1.430	5.650	1.192	4.520	0.209	1.202	3.260	5.090
1400	0.704	1.407	4.432	1.407	5.540	1.173	4.430	0.207	1.182	3.200	4.980
1500	0.693	1.386	4.344	1.386	5.430	1.155	4.350	0.205	1.164	3.140	4.890
1600	0.683	1.366	4.264	1.366	5.330	1.138	4.270	0.203	1.148	3.080	4.800
1700	0.673	1.347	4.192	1.347	5.240	1.122	4.190	0.201	1.132	3.030	4.710
1800	0.665	1.329	4.120	1.329	5.150	1.108	4.120	0.200	1.117	2.980	4.630
1900	0.656	1.312	4.056	1.312	5.070	1.094	4.060	0.198	1.103	2.940	4.560
2000	0.648	1.296	3.952	1.296	4.940	1.080	4.000	0.197	1.089	2.890	4.480
2200	0.634	1.267	3.880	1.267	4.850	1.056	3.880	0.195	1.065	2.810	4.350
2400	0.620	1.240	3.776	1.240	4.720	1.033	3.770	0.193	1.042	2.740	4.230
2600	0.607	1.215	3.672	1.215	4.590	1.012	3.680	0.191	1.021	2.670	4.120
2800	0.596	1.192	3.584	1.192	4.480	0.993	3.590	0.190	1.002	2.610	4.010
3000	0.585	1.170	3.504	1.170	4.380	0.975	3.500	0.188	0.984	2.550	3.910

Allowable Tension

Table 10: Joint Processed Belt (Iron Rubber®) Allowable Tension Unit: N

Type of Belt	Belt Width						
	025	037	050	075	100	150	200
XL	90	135	175	–	–	–	–
L	–	–	320	480	640	–	–
H	–	–	–	480	640	960	1280

Unit: N

Type of Belt	Belt Width					
	100	150	200	250	400	500
T5	150	200	270	350	–	–
T10	–	320	440	640	960	1280
AT5	210	350	–	–	–	–
AT10	–	890	890	1070	–	–

Table 11: Open End Belt (Iron Rubber®) Allowable Tension Unit: N

Type of Belt	Belt Width						
	025	037	050	075	100	150	200
XL	180	270	350	–	–	–	–
L	–	–	640	960	1280	–	–
H	–	–	–	960	1280	1920	2560

Unit: N

Type of Belt	Belt Width						
	070	100	150	200	250	400	500
MA3	200	300	400	–	–	–	–
MA5	–	470	740	960	–	–	–
MA8	–	–	1620	2160	2700	–	–
T5	200	300	400	550	700	–	–
T10	–	–	640	880	1280	1920	2560
AT5	–	470	740	–	–	–	–
AT10	–	–	1620	2160	2700	–	–

Initial Tension Setup

Determine the Initial Tension based on the maximum tension that occurs during operation.
Initial tension is equal throughout the entire belt loop during non-running or idling states.
There are Tension and Slack sides on belts during operation. The differential of the tension is called Effective Tension.
This differential via the pulleys generates torque or transmission capacity.
For toothed belt applications, apply initial tension not to cause belt sags on the Slack side.
When a sag is evident during the start-up, it indicates that the initial tension is insufficient.

$$U = \frac{2 \times 10^3 \times Md}{dp} \quad \text{Or} \quad U = \frac{19.1 \times 10^6 \times P}{n \times dp}$$

Elasticity Guideline $0.5U < Fv < 0.5F + 0.2F$

However, if the value resulting from the calculation, "0.5U + 0.2F," exceeds 0.5F, regard "0.5F" as the maximum value.

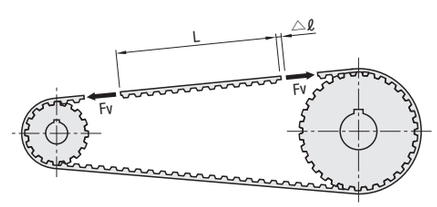
U: Effective Tension (N)
Md: Load Torque (Nm)
P: Transmission Capacity (kW)
dp: Pulley Diameter (mm)
n: Pulley Rotational Speed (rpm)
Fv: Initial Tension (N)
F: Allowable Tension (N)

Method for Checking Initial Tension

• Method by Checking Belt Elongation

Belt elongation (guideline) at Allowable Tension F,

Joint Process 0.2% = 2mm/m
Open End 0.4% = 4mm/m



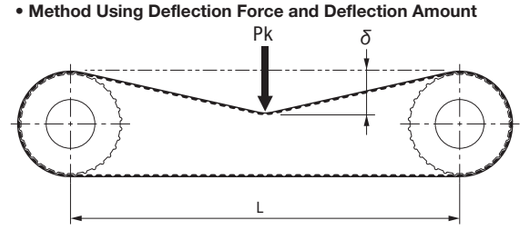
The relationship between force and elongation follows Hooke's Law (In proportional relationship), and the intermediate value can be obtained by calculations.

• Method Using Belt Vibrations

$Fv = 4 \times f^2 \times m \times \ell^2$

Fv: Belt Tension (N)
f: Vibration Frequency (Hz)
m: Belt Weight Per 1m (kg/m)
ℓ: Span Length (m)

• Method Using Deflection Force and Deflection Amount



Pk = Fv/16
Adjust in such a way that deflection meets the following criteria: [δ=L/64]

Pk: Deflection Force (N)
Fv: Desired Tension (N)
δ : Deflection Amount (mm)
L: Span Length (mm)

Timing Belt
Selection of Conveyor Timing Belts

■Conveyer belts selection procedure

The following steps for selection are provided by assuming that sizes of head pulley and tail pulley are same. (Follow the steps 1 -3 even when sizes of head pulley and tail pulley are different)
Use a head pulley as a driving pulley.
For belt installation and tension control, make the structure of the driven side to be adjustable for alignment and center distance with set screws.
*Head Pulley: The front of the pulley against traveling direction
Tail Pulley: The rear end of the pulley against traveling direction

[Step 1] Calculate effective tension (Te).

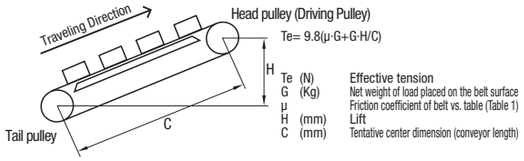


Table 1. Typical Friction Coefficient of Belt versus Table

Table Material	Steel	Stainless	Aluminium	UHMW	Teflon
Friction coefficient: μ	0.65	0.68	0.42	0.31	0.21

[Step 2] Calculate design tension (Td).

$$Td = K \cdot Te$$

Td (N) Design Tension
K Overload Coefficient
Te (N) Effective Tension

$$K = K1 + K2 + K3$$

K1 Correction factors for daily operation hours
K2 Belt length correction coefficient
K3 Belt speed correction coefficient

Table 2. K1 Correction Factors for Daily Operation Hours Unit: hour

~5	5~8	8~12	12~16	16~24
1.0	1.1	1.2	1.3	1.4

Table 3. K2 Belt Length Correction Factors Unit : mm

~1500	1501~3000	3001~4500	4501~
0.3	0.2	0.1	0.0

Table 4. K3 Belt Speed Correction Factors Unit : m/min

~60	61~90	91~120
0.0	0.1	0.2

[Step 3] Select belt type, belt width and pulley dimension.

(1) Select from Table 5 a belt type and a width which have a greater allowable tension than the designed tension.

Table 5. Allowable Tension of Joint Belts Unit : N

Belt Type	Belt width (mm)						
	10	15	20	25	30	40	50
S5M	120	180	–	300	–	–	–
S8M	–	235	–	392	471	627	–
T5	58	87	116	145	–	–	–
T10	–	180	240	300	360	481	601
AT5	74	110	–	–	–	–	–
AT10	–	234	312	391	–	–	–

Unit : N

Belt Type	Belt Nominal Width				
	050	075	100	150	200
L	92	138	184	276	–
H	–	163	216	324	432

(2) Select a pulley with a larger number of teeth than the minimum allowable number in Table 6 for both of driving and driven pulley.

Table 6. Number of Minimum Allowable Number of Teeth for Pulleys

Belt Type	L	H	S5M	S8M	T5	T10	AT5	AT10
Pitch (mm)	9.525	12.7	5	8	5	10	5	10
Min. No. of Pully Teeth	14	14	14	24	12	14	20	14
Pully Diameter (mm)	42.45	56.60	22.28	61.12	19.10	44.56	31.83	44.56

[Step 4] Determine belt length (no. of teeth) and center distance.

(1) Obtain approximate belt length from tentative center dimension (C') and approximate pulley diameter (Dp').

$$Lp' = 2 \cdot C' + \pi \cdot Dp'$$

Lp' (mm) Approx. belt length
C' (mm) Tentative center dimension
Dp' (mm) Approx. pully diameter

(2) Determine the number of teeth required from the approximate belt length (Lp') and pitch (P).
Round down the obtained number of teeth (N) to the nearest whole number.

$$N = Lp' / P$$

N No. of belt teeth
p (mm) Pitch

*Check the minimum teeth of belt which is available.

(3) Obtain the proper belt length from the number of teeth (N) and pitch (P).

$$Lp = P \cdot N$$

Lp (mm) Belt length

(4) Determine proper center distance with the following formula:

$$C = P \cdot (N - Dz)/2$$

C (mm) Center Distance
Dz No. of teeth of pulley

[Step 5] Confirm the ajustment margin for the center distance is larger than figures in Table7-a and 7-b.

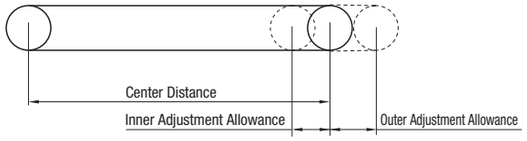


Table 7-a: Inner Adjustment Allowance (Attachment Allowance)

Belt Type	Inner Adjustment Allowance
L	More than 10mm
H	More than 15mm
S5M	More than 10mm
S8M	More than 15mm
T5	More than 5mm
T10	More than 10mm
AT5	More than 10mm
AT10	More than 15mm

Table 7-b: Outer Adjustment Allowance (Tension Allowance)

Distance between shafts (mm)	Outer Adjustment Allowance
~ 500	More than 5mm
501~1000	More than 10mm
1001~1500	More than 15mm
1501~2000	More than 20mm
2001~2500	More than 25mm
2501~	More than 1% of center distance

[Step 6] Install timing belt.

Install the belt with the installation tension in Table 8.
Axis weight at this time is twice the installation tension.

$$Fs = 2 \cdot Ti$$

Fs (N) Shaft load
Ti (N) Fixing Tension (Table 8)

Table 8. Installation Tension for Joint Belts Unit : N

Belt Type	Belt width (mm)						
	10	15	20	25	30	40	50
S5M	60	90	–	150	–	–	–
S8M	–	117	–	196	235	313	–
T5	29	43	58	72	–	–	–
T10	–	90	120	150	180	240	300
AT5	37	55	–	–	–	–	–
AT10	117	156	195	–	–	–	–

Unit : N

Belt Type	Belt Nominal Width				
	050	075	100	150	200
L	46	69	92	138	–
H	–	81	108	162	216

Reference: Table on Open-end belts Allowable Tension Unit : N

Belt Type	Material	Belt width (mm)							
		6	10	15	20	25	30	40	50
S3M	Polyurethane	127	–	–	–	–	–	–	–
S5M	Rubber	–	310	490	–	–	–	–	–
	Polyurethane		215	323		539			
S8M	Rubber	–	–	–	–	950	–	–	–
	Polyurethane			647		1176	1412	1882	
T5	Polyurethane	–	112	166	225	284	–	–	–
T10	Polyurethane	–	–	299	397	529	627	862	1064
AT5	Polyurethane	–	147	221	–	–	–	–	–
AT10	Polyurethane	–	–	469	625	781	–	–	–

Unit : N

Belt Type	Material	Belt Nominal Width (mm)						
		025	037	050	075	100	150	200
XL	Rubber	–	45	70	–	–	–	–
	Polyurethane	66	102	142				
L	Rubber	–	–	95	165	–	–	–
	Polyurethane			259	387	519		
H	Rubber	–	–	–	–	600	–	–
	Polyurethane				397	529	799	1093

When using belts for other purpose than conveyance (e.g. transmission), for polyurethane belt S3M; design with 1/2 of the allowable tension in the table; for XL, L, H, S5M, S8M, T5 and T10, design with approx. 2/3 of the allowable tension in the table.

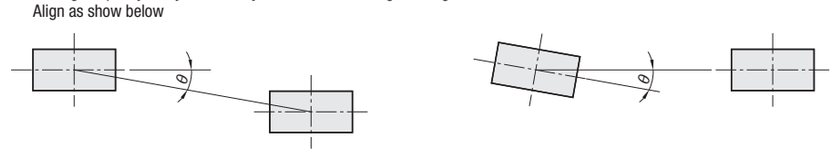
Timing Belt
Synchronous Belt Reference Information

■ Early failures and countermeasures

Abnormal Phenomena	Cause	Measures
Abnormal Wear of Belt Side Faces	· Pulley misalignment · Pulley shafts misalignments · Bent pulley flanges	· Realign · Correct shaft misalignments · Correct bent pulley flanges
Tooth Contact Pressure Surface Abnormal Wear	· Overload · Belt tension too high, too low	· Redesign with a wide belt or use larger belt pitch · Adjust initial belt tension
Belt abnormal wear on pulley contacting area	· Pulley tooth shape incorrect · Belt tension too high	· Adjust initial belt tension · Try to recreate belt systems by taking note of tooth tip radius
Broken/missing tooth	· Pulley diameter too small · Small pulley meshing 6 teeth or less · Shock loading exists	· Redesign · Increase small pulley tooth mesh or redesign · Avoid shock loading on belt · Increase belt width
Severed Core Wire	· Overload · Core wire decreased elasticity or corrosion · Induction of foreign matter · Excessive temperature	· Redesign · Check belt storage and shipping history/condision · Avoid shocks · Provide a belt cover · Lower environment temperature
Cracks on Backing Rubber	· Usage in low temperature · Pulley diameter too small	· Raise environment temp. · Increase pulley diameter
Heat Degradation of Rubber	· Rubber degradation due to high enviroment temperature	· Lower environment temperature
Rubber Swelling	· Contact with oils · Contact with water	· Avoid oil from contacting · Avoid water from contacting
Abnormal Wear of Pulley Teeth	· Overload · Belt tension too high · Pulley material too soft	· Redesign · Adjust initial belt tension · Apply surface hardening treatment on pulley or change pulley material
Pulley Circumference Wear	· Pulley service life has been reached · Belt tension too high (core wire visible on belt back side)	· Replace with a new pulley · Replace with new pulley and belt, and use lower belt tension
Abnormal Sound	· Belt tension too high · Overload · Pulley diameter too small · Pulley tooth shape incorrect	· Realign · Adjust initial belt tension · Redesign · Correct pulley tooth geometry
Apparent Belt Stretch	· Shaft center distance too small · Loose machine base	· Adjust to correct shaft distance · Reinforce machine base

■ About Pulley Alignments

Misaligned pulleys may cause early belt failure and flange damages.
Align as show below



•MXL/XL/L/H/S_M/MTS_M/T Series

Belt width (mm)	10	20	30≤
tanθ	5/1000	3/1000	2/1000

•P_M/UP_M

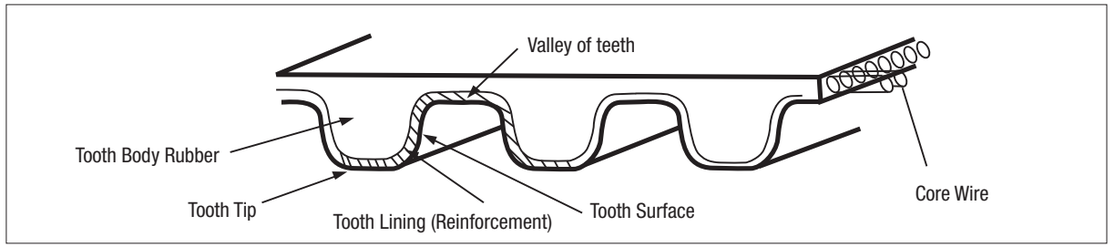
Belt width (mm)	≤30
tanθ	5/1000

•_GT/EV5GT/EV8YU

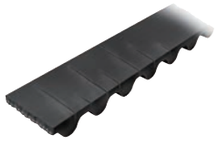
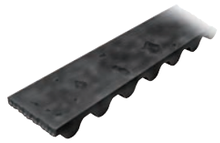
Belt width (mm)	≤20	20<40
tanθ	6/1000	3/1000

Timing Belt
Synchronous Belt Replacement Signs

Names of Belt Components



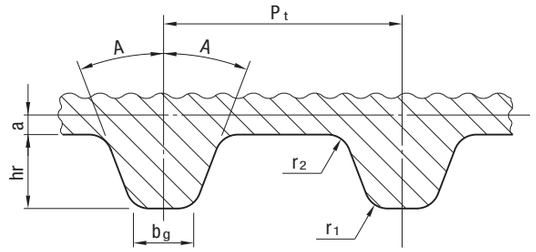
Examples of Belt Replacement Signs

Examples	Condition
1. When belt tooth reinforcement fabric is worn and rubber/core wire are exposed When tooth surface/grooves are worn and rubber/core wire are exposed	
2. When the backing rubber shows cracks due to hardening	
3. When cracks reaching the rubber are seen at tooth base	
4. Belt side faces are damaged due to wear	
5. When missing tooth can be seen	
6. When excessive wear can be seen on belt back side	
7. When belt or core wire are broken	

These are belt replacement timing guides. Early or periodical replacements are recommended even the signs shown above are not yet visible.

Timing Belt
Toothed Pulleys

1. Cutter Rack Dimensions and Tolerances



The pulley should have involute tooth, which are created and shaped by the cutter. For the cutter rack dimensions and tolerance, when the rack shape of the tooth profile generating cutter is measured by using a projector, shape measuring instrument, etc. the measurement results must meet the following conditions indicated on the table below:

Unit: mm

Type	Number of Teeth of the Pulley Z	Pt	A ±0.12	hr +0.05 0	bg +0.05 0	r_1 ±0.03	r_2 ±0.03	2a(1) (Reference)
MXL	10 ≤ Z ≤ 23	2.032 ± 0.008	28°	0.64	0.61	0.30	0.23	0.508
	24 ≤ Z		20°		0.67			
XL	10 ≤ Z	5.080 ± 0.010	25°	1.40	1.27	0.61	0.61	0.508
L	10 ≤ Z	9.525 ± 0.012	20°	2.13	3.10	0.86	0.53	0.762
H	14 ≤ Z ≤ 19	12.700 ± 0.016	20°	2.59	4.24	1.47	1.04	1.372
	20 ≤ Z						1.42	

Note (1) : a indicates the position equivalent to the pitch line (Centerline of the Core Line of the Belt) of the belt corresponding to the cutter rack shape.

2. Tolerance of Adjacent Pitch Error and Cumulative Pitch Error

Unit: mm

Addendum Circle Diameter of Pulley do	Allowable Value	
	Tolerance of Adjacent Pitch Error	Accumulated Pitch Error
5.96 ≤ do ≤ 25.40	0.03	0.05
25.40 < do ≤ 50.80	0.03	0.08
50.80 < do ≤ 101.60	0.03	0.10
101.60 < do ≤ 177.80	0.05	0.13
177.80 < do ≤ 304.80	0.05	0.15
304.80 < do ≤ 508.00	0.08	0.18
508.00 < do ≤ 762.00	0.08	0.20
762.00 < do ≤ 967.16	0.08	0.23

3. Tolerance of Side Deflection

Unit: mm

Addendum Circle Diameter of Pulley do	Tolerance of Deflection (TIR)(2)
5.96 ≤ do ≤ 101.60	0.10
101.60 < do ≤ 254.00	Addendum Circle Dia. do×0.001
254.00 < do ≤ 967.16	0.25+[(Addendum Circle Dia. do-254.00)×0.0005]

Note (2) : TIR is an abbreviation for Total Indicator Reading and refers to the difference between the max. deflection reading and the min. deflection reading.

4. Tolerances of Addendum Circle Diameter

Unit: mm

Addendum Circle Diameter of Pulley do	Tolerance
5.96 ≤ do ≤ 25.40	$^{+0.05}_{0}$
25.40 < do ≤ 50.80	$^{+0.08}_{0}$
50.80 < do ≤ 101.60	$^{+0.10}_{0}$
101.60 < do ≤ 177.80	$^{+0.13}_{0}$
177.80 < do ≤ 304.80	$^{+0.15}_{0}$
304.80 < do ≤ 508.00	$^{+0.18}_{0}$
508.00 < do ≤ 762.00	$^{+0.20}_{0}$
762.00 < do ≤ 967.16	$^{+0.23}_{0}$

5. Tolerance of Circumferential Deflection of Addendum Circle

Unit: mm

Addendum Circle Diameter of Pulley do	Tolerance of Circumferential Deflection
5.96 ≤ do ≤ 203.20	0.13
203.20 < do ≤ 967.16	0.13 + [(Addendum Circle Dia. do-203.20) × 0.0005]

6. Tolerance of Cylindricity and Parallelism

Unit: mm

Nominal Widths of Pulley	Cylindricity Tolerance	Parallelism Tolerance
025~050	0.01	0.03
075~150	0.02	
200 · 300	0.04	0.04
400 · 500	0.06	0.05

Selection of Power Transmission Efficiency

The table of transmission performance in this catalog (**P.394**) is based on the following conditions.

1) The chain drive mechanism is run in an atmosphere with a temperature of -10˚C~+60˚C and with no abrasive particles.
2) There is no adverse impact on the mechanism, such as corrosive gas or high humidity.
3) The two shafts between which power is transmitted are parallel with each other and correctly installed.
4) The recommended lubrication method and oil are used.
5) The power transmission is subjected to minimum load variation.

■Power Transmission Coefficient for Multiple Chains

On multiple row roller chains, the load is not shared evenly between each chain row. Therefore, the power transmission efficiency of multiple row roller chains cannot be obtained by simply multiplying the power transmission efficiency of a single chain by the number of chain rows. The power transmission efficiency of multiple row roller chains should be obtained by multiplying the power transmission efficiency of a single row chain by the multiple row chain power transmission coefficient.

Table 2. Power Transmission Coefficient for Multiple Row Chains

Number of Roller Chain Rows	Multiple Row Coefficient
2 lines	x1.7
3 lines	x2.5
4 lines	x3.3
5 lines	x3.9
6 lines	x4.6

■Service Coefficient Table

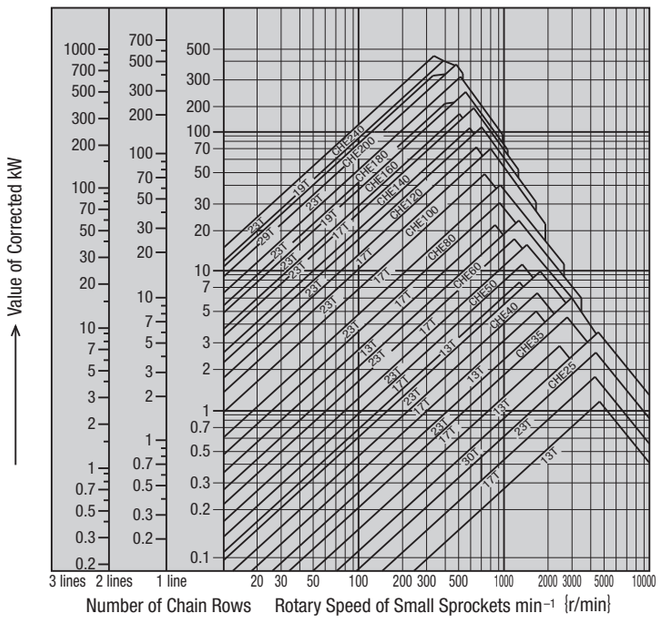
The power transmission efficiency table (**P.394**) is based on minimum load variation. The transmitted kW shown in the table should be corrected as follows depending on the actual magnitude of load variation.

Table 1. Service Coefficient Table

Impact Type	Prime Motor Type / Typical	Turbine Motor	Internal Combustion Engine: With Fluidic Mechanism	Internal Combustion Engine: Without Fluidic Mechanism
Smooth Transmission	Belt conveyor with small load variation, Chain conveyor, Centrifugal pump, Centrifugal blower, General textile machinery, General machinery with small load variation.	x1.0	x1.0	x1.2
Transmission with Moderate Impact	Centrifugal compressor, Marine propeller, Conveyor with moderate load variation, Automatic furnace, Drier, Pulverizer, General machine tools, Compressor, General earth-moving machinery, General paper manufacturing machinery	x1.3	x1.2	x1.4
Transmission with Large Impact	Press, Crusher, Construction and mining machinery, Vibrator, Oil well digger, Rubber mixer, Roll, Rollgang, General machinery with reverse or impact load	x1.5	x1.4	x1.7

■Selection Guide Table

Table 3. Selection Guide Table



How to Read The Table

Ex. Corrected kW=5kW
Rotary Speed of Small Sprockets=300r/min
when a single row chain is used

The intersection point of the vertical axis (corrected kW) and the horizontal axis (rotary speed 300r/min) is below CHE 60 23T (23 toothed) and above 17T (17 toothed). Based on the above intersection point, it can be determined that 19T is applicable.

■Specification Selection for Operation under Normal Conditions

1. Operating Conditions

When selecting roller chains, the following 7 parameters should be taken into account.

1. Machine to be used
2. Impact Type
3. Prime Motor Type
4. Power Transmission (kW)
5. Diameter and Rotary Speed of High-Speed Shaft
6. Diameter and Rotary Speed of Low-Speed Shaft
7. Inter-Shaft Distance

2. Service Coefficient

Select the application coefficient from the service table (Table 1) that is appropriate for the machine to be driven and the prime motor type.

3. Corrected Power Transmission(kW)

Correct the power transmission (kW) using the service coefficient.

- Single Row Chain…Corrected Power Transmission (kW)=Power Transmission (kW)×Service Coefficient
- Multiple Row Chains…Select the appropriate coefficient from the table for Power Transmission Coefficient for Multiple Row Chains (Table 2)

$$\text{Corrected Power Transmission(kW)} = \frac{\text{Power Transmission(kW)} \times \text{Application Coefficient}}{\text{Multiple Row Coefficient}}$$

4. Chain and Number of Sprocket Teeth

Using the selection guide table (Table 3) or the power transmission efficiency tables, select the chain and the number of small sprocket teeth that satisfy the rotary speed of the high-speed shaft and the corrected power transmission (kW). The chain pitch should be as small as possible. This should minimize noise and ensure smooth transmission of power. (If a single chain does not provide the required power transmission efficiency, use multiple chains instead. If the installation space requires that the inter-shaft distance as well as the outer diameter of sprocket be minimized, use small-pitch multiple chains.) There should be a minimum wrap angle of 120˚ between the small sprocket and the chain.

5. Number of Large Sprocket Teeth

Number of Large Sprocket Teeth = Number of Small Sprocket Teeth × Speed Ratio

Once the number of small sprocket teeth is determined, multiplying this by the speed ratio provides the number of large sprocket teeth. Generally, the appropriate number of small sprocket teeth is 17 or greater, or 21 or greater for high-speed operation, or 12 or greater for low speed operation. The number of large sprocket teeth should be 120 or less. Select the sprocket with as great a number of teeth as possible for a speed ratio of 1:1 or 2:1. The speed ratio should normally be 1:7 or less, and ideally 1:5.

6. Shaft Diameter

Ensure that the small sprocket selected above is compatible with the diameter of the existing shaft on which it is to be installed. Refer to the specification table on this page. When the shaft diameter is too large for the bore in the sprocket, select another sprocket with a greater number of teeth or a larger chain.

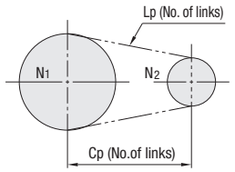
7. Inter-shaft Distance between Sprockets

The distance between the shafts can be reduced to the extent that the sprockets do not interfere with each other, but the wrap angle between the small sprocket and the chain should be 120˚ or more.

Generally, the inter-shaft distance should preferably be 30~50 times as much as the pitch of the chain used. Under pulsating load conditions, decrease the distance to 20 times the chain pitch or less.

8. Chain Length and Distance between Shaft Centers

Once the chain, the number of teeth on both sprockets, and the inter-shaft distance are determined, calculate the number of chain links as follows.



Lp: Chain Length Expressed in Number of Links
N_1 : Number of Large Sprocket Teeth
N_2 : Number of Small Sprocket Teeth
Cp: Distance between Shaft Centers Expressed in Number of Links
π : ≈3.14

(1) Calculating the chain length (when the number of sprocket teeth N_1 and N_2 and the distance between shaft centers Cp are identified)

$$Lp = \frac{N_1+N_2}{2} + 2Cp + \frac{\left(\frac{N_1-N_2}{2\pi}\right)^2}{Cp}$$

*Round up decimals of Lp to the next whole number.

Generally, when the chain length number of chain links obtained is an odd number, this should be raised to the next even number. When the inter-shaft distance demands the chain length to be an odd number, an offset link needs to be used. However, it should be avoided and an even number should be used as much as possible by adjusting the number of sprocket teeth or the inter-shaft distance.

(2) Calculating the distance between shaft centers (when the number of sprocket teeth N_1,and N_2 as the chain length Lp are identified)

$$Cp = \frac{1}{8}\left\{2Lp - N_1 - N_2 \pm \sqrt{(2Lp-N_1-N_2)^2 - \frac{8}{\pi^2}(N_1-N_2)^2}\right\}$$

The pitch number obtained by the chain length formula is, in most cases, only approximate and not identical with a given inter-shaft distance. Therefore, it will be necessary to calculate the exact distance between the shaft centers based on the required overall length.

■Example of Selection for Operation under Normal Conditions

The following is an example of selection when a 3.7 kW 1,000r/min electric (motor) is used to drive a compressor.

[1] Operating Conditions
1) Machine to be used……Compressor, 10 hours operation
2) Impact Type ……Smooth Transmission
3) Prime Motor Type……Electric Motor
4) Power Transmission ……3.7kW
5) Rotary Speed ……1000r/min

[2] Service Coefficient
From Table 1, an application coefficient of 1.2 is selected.

[3] Corrected Power Transmission(kW)
Corrected Power Transmission(kW)=Power Transmission(kW)×Service Coefficient
=3.7kW×1.2=4.44kW

[4] Chain and Number of Sprocket Teeth
If 1,000r/min/4.44kW is required as the rotary speed / power transmission efficiency, by referencing the selection guide table (Table 3), it can be guessed that the CHE40 Chain and the 17T Sprocket might be applied.
On the other hand, by referencing the power transmission efficiency table for the CHE40 Chain, it is found that 4.09kW of the power transmission efficiency is applicable for combination of 17T (number of teeth) and 1,000r/min (rotary speed) and does not meet the above requirements. By substituting 19T for 17T as the number of teeth, 4.6kW of power transmission efficiency becomes available. Thereby, it is found that combination of CHE40 and T19T fully satisfies the above requirements.

Results The CHE40 chain should be selected with the Number of Small Sprocket Teeth=19T

■Specification Selection for Low-Speed Operation

In operations using a chain speed of 50 m/min. or less, chain elongation due to wear can almost be ignored. Under such low-speed conditions, the service life of the chain largely depends on its fatigue strength. Low-speed operation is more economical than operation under "normal conditions". Low speed is recommended for operations with fewer startups and stops that enable smooth power transmission. Selection of ambient atmosphere, layout, lubrication, etc. for low-speed operation is the same as that for operation under normal conditions.
Selection should be made in accordance with the following formula.

Max. Allowable Tension of Chain ≥ Max. Tension N Working on Chain x Service Coefficient (Table 1) **P.391** x Speed Coefficient (Table 4)

Table 4. Speed Coefficients

Roller Chain Speed	Speed Coefficient
0~15 m/min	1.0
15~30	1.2
30~50	1.4
50~70	1.6

[1]Operating Conditions

Same as for "Specifications Selection for Operation under Normal Conditions"

[2] Chain and Number of Small Sprocket Teeth

From the selection guide table 3 (**P.391**), select a chain and a sprocket slightly undersized based on the rotary speed (r/min) and the design power (kW).

[3] Calculating the Chain Speed

Based on the sprocket selected (chain pitch, number of teeth) and the number of revolutions (r/min), calculate the chain speed as follows.

$$V=\frac{P\cdot N\cdot n}{1000}\ (m/min)$$

V : Chain Speed (m/min)
P: Chain Pitch (mm)
N: Number of Sprocket Teeth
n : Rotary of Sprocket Teeth (r/min)

[4] Calculating the Max. Working Load on Chain

Calculating the Maximum Working Load on the Chain

$$F=\frac{60\cdot kW}{V}\ (kN)$$

F : Load on Chain(kN)
V : Chain Speed(m/min)
kW: Power Transmission(kW)

[5] Service Coefficient

From the application coefficient table (Table 1), select the appropriate coefficient.

[6] Speed Coefficient

Based on the chain speed obtained in [3], calculate the appropriate speed coefficient.

[7] Maximum Allowable Tension of Chain

Apply the values calculated on [4]~[6] to on the right side element of the inequality formula provided on the top of this column and compare the resulting value against the Max. Allowable Tension for the chain selected on [2] to check whether the said inequality formula is satisfied or not.

If not, try again with another chain and sprocket set.

[8] Number of Large Sprocket Teeth, Shaft Diameter, and Chain Length same as for "Specification Selection for Operation under Normal Conditions".

■Specification Selection for Low-Speed Operation with Impact Load

For operations with a great amount of impact loading due to frequent startups, stops, reversing, or braking, the inertia (GD^2) of the motor and the driven machine needs to be taken into account.

Under such operational conditions, pay extreme caution, as the chain can be subjected to loads much greater than in operation under normal conditions.

Select the chain using the following formula.

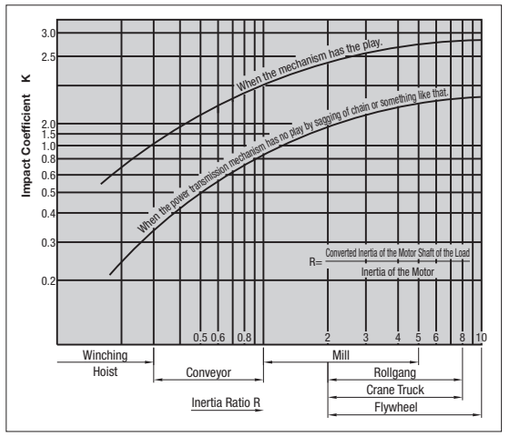
Max. Allowable Load of Chain N ≥ Load Acting on Chain as Calculated from the Starting Torque of the Prime Mover x Impact Coefficient (Table 5) x Speed Coefficient (Table 4)

Impact Coefficient

This is a constant determined by the inertia ratio (GD2 ratio) between the motor and the driven machine as well as by the amplitude of play on power transmission system and information about this is shown on the Table 5.

When the power transmission mechanism has excessive play, it loads greater impact than those in the table.

Table 5. Impact Coefficient



■Selection of Stainless Roller Chains (CHES)

Select Stainless Steel Roller Chains by following the same procedure as for operational conditions of low speed.

1). The maximum allowable tension for CHES (stainless type) is lower than that for CHE (steel type).

2). Avoid using offset links as much as possible.

■Selection based on temperature

Selection of Roller Chains Based on Temperature

The following table shows selection criteria for roller chains by size based on temperature and the associated reduction in strength.

1) Problems associated with roller chain operation at high temperature
   (1) Reduced hardness and resultant increase in wear
   (2) Elongation due to softening
   (3) Poor lubrication / flexing and increased wear due to oil deterioration and carbonization
   (4) Wear increase and poor flexing due to scale formation
2) Problems associated with roller chain operation at low temperature
   (1) Low-temperature brittleness and resultant reduction in impact strength
   (2) Solidification of lubricating oil
   (3) Poor flexing due to attachment of frost and ice

Guide Table for Roller Chain Power Transmission Efficiency at High, Low Temperature

Temperature	CHE Roller Chain	
	CHE60 or Less	CHE80 or Above
-60˚C or below	–	–
-60˚C ~ -50˚C	–	–
-50˚C ~ -40˚C	–	Cannot Be Used
-40˚C ~ -30˚C	Cannot Be Used	Catalog Value×1/4
-30˚C ~ -20˚C	Catalog Value×1/4	Catalog Value×1/3
-20˚C ~ -10˚C	Catalog Value×1/3	Catalog Value×1/2
-10˚C ~ 60˚C	Catalog Value	Catalog Value
60˚C ~ -150˚C	Catalog Value	Catalog Value
150˚C ~ 200˚C	Catalog Value×3/4	Catalog Value×3/4
200˚C ~ 250˚C	Catalog Value×1/2	Catalog Value×1/2
Above 250˚C	Cannot Be Used	Cannot Be Used

Selection of Stainless Roller Chains for High-Temperature Operation

(1) Follow the selection procedure for low-speed operation up to 400˚C. (Do not use the selection procedure for operation under normal conditions.)
(2) Above 400˚C, use the temperature coefficient described below.
(3) Formula

Max. Working Load on Chain × Application Coefficient (Table 1) × Speed Coefficient (Table 4) × Temperature Coefficient (Kt) ≤ Max. Allowable Tension of Chain

Temperature Coefficient (Kt)

Temperature	Coefficient(Kt)
400˚C Less	1.0
400˚C ~ 500˚C	1.2
500˚C ~ 600˚C	1.5
600˚C ~ 700˚C	1.8
Above 700˚C	Cannot Be Used

Take account of corrosion resistance, which begins to decline above 400˚C.

■Power and Torque

1kW=102kgf·m/sec 1PS=735.5W(Metric Power)
1kW=1000W 1HP=745.7W(Imperial Power) } ≈750W

*Torque : 1kg·m=100kg·cm
1kg·m=9.8N·m (newton metre)
1N·m=0.120kg·m
1r/min =1rpm

Obtaining Power from Torque and Rotary Speed

$$\text{Output (kW)}=\frac{\text{Torque((N·m)}\times\text{ Rotary speed(r/min)}}{9.55\times1000}$$

CHE35 (Single Chain)

■Power Transmission Efficiency Table

(kW)

Number of Small Sprocket Teeth	Rotary Speed of Small Sprockets min (r/min)																								
	50	100	300	500	700	900	1200	1500	1800	2100	2500	3000	3500	4000	4500	5000	5500	6000	6500	7000	7500	8000	8500	9000	10000
9	0.06	0.11	0.29	0.46	0.63	0.79	1.02	1.25	1.48	1.69	1.98	1.62	1.29	1.05	0.88	0.75	0.66	0.57	0.51	0.46	0.41	0.37	0.34	0.31	0.27
10	0.07	0.12	0.33	0.52	0.71	0.89	1.15	1.40	1.65	1.89	2.22	1.90	1.51	1.23	1.04	0.88	0.77	0.67	0.60	0.53	0.48	0.43	0.40	0.37	0.31
11	0.07	0.13	0.37	0.57	0.78	0.98	1.27	1.55	1.83	2.10	2.46	2.19	1.74	1.42	1.19	1.02	0.88	0.78	0.69	0.61	0.55	0.50	0.46	0.43	0.36
12	0.08	0.15	0.40	0.63	0.86	1.07	1.40	1.71	2.01	2.31	2.70	2.50	1.98	1.62	1.36	1.16	1.01	0.88	0.78	0.70	0.63	0.57	0.52	0.48	0.41
13	0.09	0.16	0.44	0.69	0.94	1.17	1.52	1.86	2.19	2.52	2.95	2.81	2.24	1.83	1.53	1.31	1.13	0.99	0.88	0.79	0.71	0.65	0.59	0.54	0.46
14	0.10	0.18	0.47	0.75	1.01	1.28	1.65	2.01	2.37	2.73	3.19	3.15	2.50	2.04	1.72	1.46	1.27	1.11	0.98	0.88	0.80	0.72	0.66	0.60	0.51
15	0.10	0.19	0.51	0.81	1.10	1.37	1.78	2.17	2.56	2.94	3.44	3.49	2.77	2.27	1.90	1.62	1.40	1.23	1.10	0.98	0.88	0.80	0.73	0.67	0.57
16	0.11	0.20	0.54	0.87	1.17	1.47	1.90	2.33	2.75	3.15	3.69	3.84	3.05	2.50	2.10	1.79	1.55	1.36	1.21	1.08	0.97	0.88	0.81	0.74	0.63
17	0.12	0.22	0.58	0.93	1.25	1.57	2.04	2.48	2.93	3.36	3.94	4.21	3.34	2.74	2.29	1.95	1.69	1.49	1.32	1.18	1.07	0.97	0.88	0.81	0.69
18	0.13	0.23	0.62	0.98	1.33	1.67	2.16	2.64	3.12	3.58	4.19	4.59	3.64	2.98	2.50	2.13	1.85	1.62	1.44	1.29	1.16	1.05	0.96	0.88	0.75
19	0.13	0.25	0.66	1.04	1.41	1.77	2.29	2.80	3.30	3.80	4.44	4.98	3.95	3.23	2.71	2.31	2.01	1.76	1.56	1.40	1.26	1.14	1.04	0.95	0.82
20	0.14	0.26	0.69	1.10	1.49	1.87	2.42	2.96	3.49	4.01	4.69	5.37	4.27	3.49	2.94	2.50	2.16	1.90	1.69	1.51	1.36	1.23	1.13	1.04	0.88
21	0.15	0.28	0.73	1.16	1.57	1.97	2.55	3.13	3.68	4.23	4.95	5.78	4.59	3.75	3.15	2.69	2.33	2.04	1.81	1.62	1.46	1.33	1.21	1.11	0.95
22	0.16	0.28	0.77	1.22	1.66	2.07	2.69	3.28	3.87	4.47	5.20	6.12	4.92	4.03	3.37	2.88	2.50	2.19	1.95	1.74	1.57	1.42	1.30	1.19	1.02
23	0.16	0.30	0.81	1.28	1.74	2.18	2.82	3.45	4.06	4.66	5.45	6.43	5.26	4.30	3.60	3.08	2.67	2.34	2.08	1.86	1.68	1.52	1.39	1.28	1.09
24	0.17	0.31	0.85	1.34	1.82	2.28	2.95	3.61	4.25	4.89	5.71	6.73	5.60	4.59	3.84	3.28	2.84	2.50	2.22	1.98	1.79	1.62	1.48	1.36	1.16
25	0.18	0.33	0.89	1.40	1.90	2.38	3.08	3.77	4.44	5.10	5.97	7.03	5.96	4.88	4.09	3.49	3.02	2.66	2.36	2.10	1.90	1.72	1.57	1.45	1.23
26	0.19	0.34	0.93	1.46	1.98	2.48	3.22	3.93	4.63	5.33	6.23	7.34	6.32	5.17	4.33	3.70	3.21	2.81	2.50	2.24	2.01	1.83	1.67	1.53	1.31
28	0.20	0.37	1.00	1.58	2.15	2.69	3.48	4.26	5.02	5.77	6.75	7.98	7.06	5.78	4.84	4.14	3.59	3.15	2.79	2.50	2.25	2.04	1.87	1.72	1.46
30	0.22	0.40	1.08	1.71	2.31	2.90	3.75	4.59	5.41	6.21	7.27	8.58	7.83	6.41	5.37	4.59	3.98	3.49	3.10	2.77	2.50	2.27	2.07	1.90	1.62
32	0.23	0.43	1.16	1.83	2.48	3.11	4.02	4.92	5.80	6.60	7.76	9.18	8.65	7.06	5.92	5.05	4.38	3.84	3.41	3.05	2.75	2.50	2.28	2.10	0
35	0.25	0.48	1.28	2.01	2.73	3.42	4.44	5.42	6.39	7.34	8.58	10.1	9.85	8.06	6.77	5.78	5.01	4.40	3.90	3.49	3.15	2.86	2.61	2.40	0
40	0.29	0.54	1.47	2.33	3.16	3.95	5.13	6.27	7.38	8.50	9.92	11.7	12.1	9.85	8.28	7.06	6.12	5.37	4.77	4.27	3.84	3.49	0		
45	0.34	0.62	1.67	2.65	3.58	4.49	5.82	7.11	8.36	9.62	11.3	13.3	14.4	11.8	9.85	8.43	7.30	6.41	5.68	5.09	0				
Lubrication Method	A		B							C															

Lubrication Method A: Drop Lubrication, B: Oil Bath Lubrication C: Forced Circulation Lubrication by Pump ☤Not applicable to selection of CHES-type chains.

CHE40 (Single Row Chain)

Power Transmission Efficiency Table (kW)

Number of Small Sprocket Teeth	Rotary Speed of Small Sprockets (r/min)																								
	10	25	50	100	200	300	400	500	700	900	1000	1200	1400	1600	1800	2100	2400	2700	3000	3500	4000	5000	6500	7000	8000
9	0.03	0.07	0.14	0.26	0.48	0.69	0.90	1.10	1.49	1.87	2.05	2.42	2.78	3.07	2.57	2.04	1.67	1.40	1.19	0.95	0.78	0.56	0.43	0.34	0.28
10	0.04	0.08	0.16	0.29	0.54	0.78	1.01	1.23	1.67	2.10	2.31	2.72	3.12	3.51	3.01	2.39	1.96	1.64	1.40	1.11	0.91	0.65	0.49	0.40	0.32
11	0.04	0.09	0.17	0.32	0.60	0.87	1.12	1.37	1.85	2.32	2.55	3.01	3.45	3.89	3.48	2.76	2.26	1.89	1.62	1.28	1.05	0.75	0.57	0.46	0.37
12	0.04	0.10	0.19	0.35	0.66	0.95	1.23	1.50	2.04	2.55	2.80	3.30	3.80	4.28	3.96	3.15	2.57	2.16	1.84	1.46	1.19	0.86	0.65	0.51	0.43
13	0.04	0.11	0.21	0.39	0.72	1.04	1.34	1.64	2.22	2.78	3.06	3.60	4.14	4.67	4.47	3.55	2.90	2.43	2.08	1.65	1.35	0.96	0.73	0.58	0.48
14	0.05	0.12	0.22	0.42	0.78	1.12	1.45	1.78	2.40	3.01	3.31	3.90	4.48	5.06	5.00	3.96	3.25	2.72	2.32	1.87	1.51	1.09	0.82	0.65	0.53
15	0.05	0.13	0.24	0.45	0.84	1.21	1.57	1.91	2.59	3.25	3.57	4.21	4.83	5.45	5.54	4.39	3.60	3.01	2.57	2.04	1.67	1.19	0.91	0.72	0.59
16	0.06	0.14	0.26	0.48	0.90	1.30	1.68	2.05	2.78	3.48	3.83	4.51	5.18	5.84	6.10	4.84	3.96	3.32	2.83	2.25	1.87	1.32	1.00	0.80	0.65
17	0.06	0.15	0.28	0.51	0.96	1.38	1.79	2.19	2.96	3.72	4.09	4.81	5.53	6.24	6.68	5.30	4.34	3.64	3.11	2.47	2.02	1.45	1.10	0.87	0.72
18	0.07	0.16	0.29	0.54	1.02	1.47	1.90	2.33	3.15	3.95	4.34	5.12	5.88	6.63	7.28	5.78	4.73	3.96	3.39	2.69	2.20	1.57	1.19	0.95	0
19	0.07	0.16	0.31	0.58	1.09	1.66	2.02	2.47	3.34	4.19	4.60	5.42	6.24	7.03	7.83	6.27	5.13	4.30	3.67	2.92	2.39	1.71	1.30	1.03	0
20	0.07	0.18	0.33	0.61	1.14	1.65	2.13	2.61	3.53	4.43	4.87	5.74	6.59	7.43	8.28	6.77	5.54	4.64	3.96	3.15	2.57	1.87	1.40	1.11	0
21	0.08	0.19	0.34	0.65	1.21	1.74	2.25	2.75	3.72	4.67	5.13	6.05	6.95	7.83	8.73	7.28	5.96	5.00	4.27	3.39	2.77	1.98	1.51	1.19	0
22	0.08	0.19	0.37	0.68	1.27	1.83	2.36	2.89	3.92	4.91	5.39	6.36	7.30	8.21	9.18	7.83	5.39	5.36	4.57	3.63	2.97	2.13	1.62	1.28	0
23	0.09	0.20	0.38	0.72	1.33	1.92	2.48	3.04	4.11	5.15	5.66	6.67	7.68	8.65	9.62	8.36	6.83	5.73	4.89	3.88	3.18	2.28	1.73	1.37	0
24	0.10	0.22	0.40	0.75	1.40	2.01	2.60	3.18	4.30	5.39	5.93	6.98	8.06	9.03	10.1	8.88	7.28	6.10	5.21	4.13	3.39	2.42	1.84	1.46	0
25	0.10	0.22	0.42	0.78	1.45	2.10	2.72	3.32	4.49	5.63	6.19	7.30	8.36	9.47	10.5	9.47	7.76	6.49	5.54	4.39	3.60	2.57	1.96	0	
26	0.10	0.23	0.43	0.81	1.52	2.19	2.83	3.46	4.68	5.88	6.46	7.61	8.73	9.85	11.0	10.1	8.21	6.89	5.88	4.66	3.82	2.73	2.08	0	
28	0.11	0.25	0.47	0.88	1.64	2.37	3.07	3.75	5.08	6.37	7.01	8.28	9.47	10.7	11.9	11.2	9.18	7.68	6.56	5.21	4.27	3.05	2.32	0	
30	0.12	0.28	0.51	0.95	1.78	2.55	3.30	4.04	5.47	6.66	7.53	8.88	10.2	11.5	12.8	12.5	10.1	8.50	7.28	5.78	4.73	3.39	2.57	0	
32	0.13	0.29	0.54	1.01	1.90	2.74	3.54	4.33	5.86	7.36	8.06	9.55	11.0	12.3	13.7	13.7	11.2	9.40	8.06	6.37	5.21	3.73	0		
35	0.14	0.32	0.60	1.12	2.10	3.01	3.91	4.77	6.46	8.13	8.88	10.5	12.1	13.6	15.1	15.7	12.8	10.7	9.18	7.28	5.96	4.27	0		
40	0.16	0.37	0.69	1.30	2.42	3.48	4.51	5.51	7.46	9.33	10.3	12.2	14.0	15.7	17.5	19.2	15.7	13.1	11.2	8.88	7.28	5.21	0		
45	0.19	0.43	0.79	1.47	2.75	3.95	5.13	6.27	8.50	10.6	11.7	13.8	15.8	17.8	19.8	22.8	18.7	15.7	13.4	10.6	8.73	0			
Lubrication Method	A				B								C												

Lubrication Method A: Drop Lubrication B: Oil Bath Lubrication C: Forced Circulation Lubrication by Pump

Not applicable to selection of CHES-type chains.

CHE50 (Single Row Chain)

Power Transmission Efficiency Table (kW)

Number of Small Sprocket Teeth	Rotary Speed of Small Sprockets (r/min)																								
	10	25	50	100	200	300	400	500	700	900	1000	1200	1400	1600	1800	2100	2400	2700	3000	3500	4000	4500	5000	5500	6000
9	0.07	0.14	0.27	0.50	0.94	1.35	1.75	2.14	2.90	3.64	4.00	4.71	4.49	3.67	3.08	2.44	2.00	1.68	1.43	1.13	0.93	0.78	0.66	0.57	0.51
10	0.07	0.16	0.31	0.57	1.05	1.51	1.69	2.40	3.25	4.07	4.48	5.28	5.26	4.30	3.60	2.86	2.34	1.96	1.68	1.33	1.09	0.91	0.78	0.67	0.59
11	0.08	0.18	0.34	0.63	1.16	1.68	2.18	2.66	3.60	4.52	4.97	5.86	6.06	4.96	4.16	3.30	2.70	2.27	1.93	1.54	1.25	1.05	0.90	0.78	0.69
12	0.09	0.19	0.37	0.69	1.28	1.84	2.39	2.92	3.96	4.96	5.45	6.43	6.91	5.65	4.74	3.76	3.08	2.58	2.20	1.75	1.43	1.20	1.02	0.89	0.78
13	0.10	0.22	0.40	0.75	1.40	2.01	2.61	3.19	4.31	5.41	5.95	7.01	7.76	6.38	5.34	4.24	3.47	2.91	2.48	1.97	1.61	1.35	1.16	1.00	0
14	0.10	0.23	0.43	0.81	1.51	2.18	2.83	3.45	4.68	5.86	6.45	7.61	8.73	7.12	5.98	4.74	3.88	3.25	2.76	2.20	1.81	1.51	1.29	1.12	0
15	0.11	0.25	0.47	0.87	1.63	2.35	3.04	3.72	5.04	6.32	6.95	8.21	9.40	7.91	6.62	5.26	4.30	3.60	3.08	2.44	2.00	1.68	1.43	1.24	0
16	0.12	0.27	0.50	0.94	1.75	2.52	3.26	3.99	5.40	6.77	7.45	8.80	10.1	8.73	7.30	5.79	4.74	3.97	3.39	2.69	2.20	1.84	1.57	1.37	0
17	0.13	0.29	0.54	1.00	1.87	2.69	3.48	4.26	5.77	7.23	7.98	9.40	10.7	9.55	7.98	6.34	5.19	4.35	3.72	2.95	2.41	2.02	1.72	1.50	0
18	0.13	0.31	0.57	1.07	1.98	2.86	3.71	4.53	6.13	7.68	8.43	10.0	11.4	10.4	8.73	6.91	5.65	4.74	4.04	3.21	2.63	2.20	1.88	0	
19	0.14	0.32	0.60	1.13	2.10	3.04	3.93	4.80	6.51	8.13	8.95	10.6	12.2	11.3	9.47	7.46	6.13	5.14	4.39	3.48	2.85	2.39	2.04	0	
20	0.15	0.34	0.64	1.19	2.22	3.21	4.16	5.07	6.87	8.58	9.47	11.2	12.8	12.2	10.2	8.06	6.62	5.55	4.74	3.76	3.08	2.58	2.20	0	
21	0.16	0.36	0.67	1.26	2.34	3.38	4.38	5.35	7.24	9.10	10.0	11.8	13.5	13.1	11.0	8.73	7.12	5.98	5.10	4.04	3.31	2.78	2.37	0	
22	0.16	0.38	0.71	1.37	2.47	3.55	4.60	5.62	7.61	9.55	10.5	12.4	14.2	14.0	11.8	9.33	7.61	6.41	5.47	4.34	3.55	2.98	2.54	0	
23	0.17	0.40	0.75	1.39	2.59	3.73	4.83	5.90	7.98	10.0	11.0	13.0	14.9	15.0	12.6	10.0	8.21	6.85	5.85	4.64	3.80	3.19	0		
24	0.19	0.42	0.78	1.45	2.71	3.90	5.06	6.18	8.36	10.5	11.6	13.6	15.6	16.0	13.4	10.7	8.73	7.30	6.23	4.95	4.04	3.39	0		
25	0.19	0.43	0.81	1.51	2.83	4.08	5.28	6.46	8.73	11.0	12.1	14.2	16.3	17.0	14.2	11.3	9.25	7.76	6.62	5.26	4.30	3.60	0		
26	0.20	0.46	0.85	1.58	2.95	4.25	5.51	6.74	9.10	11.4	12.6	14.8	17.0	18.1	15.1	12.0	9.85	8.21	7.03	5.57	4.57	3.83	0		
28	0.22	0.49	0.92	1.72	3.20	4.61	5.98	7.30	9.85	12.4	13.7	16.0	18.4	20.1	16.9	13.4	11.0	9.18	7.83	6.23	5.10	4.27	0		
30	0.23	0.53	0.99	1.85	3.45	4.97	6.44	7.83	10.70	13.5	14.7	17.3	19.8	22.4	18.7	14.8	12.2	10.2	8.73	6.91	5.65	0			
32	0.25	0.57	1.06	1.98	3.70	5.33	6.90	8.43	11.4	14.3	15.7	18.6	21.3	24.0	20.7	16.4	13.4	11.3	9.62	7.61	6.23	0			
35	0.28	0.63	1.17	2.19	4.07	5.86	7.61	9.33	12.6	15.7	17.3	20.4	23.5	26.5	23.6	18.7	15.4	12.8	11.0	8.73	7.12	0			
40	0.32	0.72	1.35	2.52	4.71	6.77	8.80	10.70	14.5	18.2	20.0	23.6	27.1	30.6	28.9	22.9	18.7	15.7	13.4	10.7	0				
45	0.36	0.82	1.54	2.86	5.34	7.68	10.0	12.2	16.5	20.7	22.8	26.8	30.8	34.6	34.4	27.3	22.4	18.7	16.0	0					
Lubrication Method	A				B					C															

Lubrication Method A: Drop Lubrication B: Oil Bath Lubrication C: Forced Circulation Lubrication by Pump

Not applicable to selection of CHES-type chains.

CHE60 (Single Row Chain)

Power Transmission Efficiency Table (kW)

Number of Small Sprocket Teeth	Rotary Speed of Small Sprockets (r/min)																								
	10	25	50	100	150	200	300	400	500	600	700	800	900	1000	1100	1200	1400	1600	1800	2000	2500	3000	3500	4000	4500
9	0.11	0.25	0.46	0.87	1.25	1.61	2.33	3.01	3.69	4.34	4.98	5.62	6.25	6.87	7.45	6.54	5.19	4.25	3.56	3.04	2.18	1.66	1.31	1.07	0.90
10	0.12	0.28	0.52	0.97	1.40	1.81	1.86	3.38	4.13	4.86	5.59	6.30	7.00	7.68	8.36	7.68	6.08	4.98	4.17	3.56	2.55	1.94	1.54	1.26	1.05
11	0.13	0.31	0.57	1.07	1.54	2.01	2.89	3.74	4.57	5.39	6.19	6.98	7.76	8.50	9.33	8.88	7.02	5.74	4.81	4.11	2.94	2.24	1.78	1.45	1.22
12	0.15	0.34	0.63	1.18	1.70	2.20	3.17	4.11	5.03	5.92	6.80	7.68	8.50	9.40	10.2	10.1	7.98	6.54	5.48	4.68	3.35	2.55	2.02	1.66	1.39
13	0.16	0.37	0.69	1.29	1.86	2.40	3.46	4.48	5.48	6.45	7.42	8.36	9.33	10.2	11.1	11.3	9.03	7.38	6.18	5.28	3.77	2.87	2.28	1.87	0
14	0.18	0.40	0.75	1.40	2.01	2.60	3.74	4.86	5.94	6.99	8.06	9.03	10.1	11.0	12.1	12.7	10.1	8.28	6.91	5.90	4.22	3.22	2.55	2.09	0
15	0.19	0.43	0.81	1.50	2.16	2.80	4.04	5.28	6.39	7.53	8.65	9.77	10.8	11.9	13.0	14.0	11.2	9.18	7.68	6.54	4.68	3.56	2.83	2.31	0
16	0.20	0.46	0.87	1.61	2.32	3.01	4.33	5.61	6.86	8.06	9.25	10.4	11.6	12.8	14.0	15.1	12.3	10.1	8.43	7.21	5.15	3.92	3.11	2.55	0
17	0.22	0.49	0.93	1.72	2.48	3.21	4.63	5.99	7.32	8.65	9.92	11.2	12.5	13.7	14.8	16.1	13.5	11.0	9.25	7.91	5.65	4.30	3.41	2.79	0
18	0.23	0.52	0.98	1.83	2.63	3.42	4.92	6.37	7.76	9.18	10.5	11.9	13.2	14.5	15.8	17.1	14.7	12.0	10.1	8.58	6.15	4.68	3.72	3.04	0
19	0.25	0.56	1.04	1.94	2.79	3.62	5.21	6.75	8.28	9.70	11.2	12.6	14.0	15.4	16.8	18.1	16.0	13.1	10.9	9.33	6.68	5.08	4.03	3.30	0
20	0.26	0.59	1.10	2.05	2.95	3.83	5.51	7.14	8.73	10.3	11.8	13.4	14.8	16.3	17.8	19.2	17.2	14.1	11.8	10.1	7.21	5.48	4.35	0	
21	0.27	0.62	1.16	2.16	3.11	4.03	5.80	7.53	9.18	10.8	12.5	14.0	15.6	17.2	18.7	20.2	18.5	15.1	12.7	10.8	7.76	5.90	4.68	0	
22	0.28	0.65	1.22	2.28	3.27	4.24	6.11	7.91	9.70	11.4	13.1	14.8	16.4	18.1	19.7	21.3	19.8	16.3	13.6	11.6	8.28	6.33	5.02	0	
23	0.30	0.69	1.28	2.38	3.43	4.45	6.41	8.28	10.1	11.9	13.7	15.5	17.2	18.9	20.7	22.3	21.2	17.4	14.5	12.5	8.88	6.77	5.36	0	
24	0.31	0.72	1.34	2.50	3.60	4.66	6.71	8.65	10.6	12.5	14.4	16.2	18.1	19.8	21.6	23.3	22.6	18.5	15.5	13.3	9.47	7.21	5.72	0	
25	0.33	0.75	1.40	2.61	3.76	4.86	7.01	9.10	11.1	13.1	15.0	16.9	18.9	20.7	22.6	24.4	24.0	19.7	16.5	14.1	10.1	7.68	6.08	0	
26	0.34	0.78	1.45	2.72	3.92	5.08	7.31	9.47	11.6	13.7	15.7	17.7	19.7	21.6	23.6	25.4	25.5	20.9	17.5	14.9	10.7	8.13	6.45	0	
28	0.37	0.84	1.58	2.95	4.24	5.50	7.91	10.3	12.5	14.8	17.0	19.2	21.3	23.4	25.5	27.6	28.5	23.3	19.5	16.7	11.9	9.10	0		
30	0.40	0.91	1.70	3.18	4.57	5.92	8.50	11.0	13.5	16.0	18.3	20.7	23.0	25.2	27.5	29.7	31.6	25.9	21.7	18.5	13.3	10.1	0		
32	0.43	0.98	1.83	3.40	4.90	6.36	9.18	11.9	14.5	17.1	19.6	22.2	24.6	27.1	29.5	31.9	34.8	28.5	23.9	20.4	14.6	11.1	0		
35	0.47	1.07	2.01	3.75	5.40	7.00	10.1	13.1	16.0	18.8	21.6	24.4	27.1	29.8	32.5	35.1	39.8	32.6	27.3	23.3	16.7	12.7	0		
40	0.54	1.25	2.32	4.33	6.24	8.06	11.6	15.1	18.4	21.7	25.0	28.1	31.3	34.4	37.5	40.6	46.6	39.8	33.3	28.5	20.4	0			
45	0.62	1.41	2.63	4.92	7.09	9.18	13.2	17.2	21.0	24.7	28.3	32.0	35.6	39.1	42.6	46.0	52.9	47.5	39.8	34.0	24.3	0			
Lubrication Method	A			B							C														

Lubrication Method A: Drop Lubrication B: Oil Bath Lubrication C: Forced Circulation Lubrication by Pump

Not applicable to selection of CHES-type chains.

CHE80 (Single Row Chain)

Power Transmission Efficiency Table (kW)

Number of Small Sprocket Teeth	Rotary Speed of Small Sprockets (r/min)																								
	10	25	50	100	150	200	300	400	500	600	700	800	900	1000	1100	1200	1400	1600	1800	2000	2200	2400	2700	3000	3400
9	0.25	0.58	1.08	2.02	2.91	3.77	5.43	7.03	8.58	10.1	11.6	13.1	12.7	10.8	9.40	8.21	6.53	5.35	4.48	3.83	3.32	2.91	2.44	2.08	1.73
10	0.28	0.65	1.22	2.26	3.26	4.22	6.09	7.91	9.62	11.3	13.1	14.7	14.8	12.7	11.0	9.62	7.68	6.27	5.25	4.48	3.89	3.41	2.86	2.44	2.02
11	0.31	0.72	1.34	2.51	3.61	4.68	6.74	8.73	10.7	12.6	14.5	16.3	17.2	14.6	12.7	11.1	8.80	7.23	6.06	5.17	4.48	3.93	3.30	2.81	1.27
12	0.35	0.79	1.48	2.75	3.97	5.14	7.41	9.62	11.7	13.8	15.9	17.9	19.5	16.6	14.5	12.7	10.1	8.21	6.90	5.89	5.11	4.48	3.76	3.21	0
13	0.38	0.87	1.61	3.01	4.33	5.61	8.06	10.4	12.8	15.1	17.3	19.5	21.7	18.8	16.3	14.3	11.3	9.33	7.76	6.65	5.76	5.06	4.24	3.62	0
14	0.41	0.93	1.75	3.25	4.69	6.07	8.73	11.3	13.9	16.3	18.7	21.2	23.5	21.0	18.2	16.0	12.7	10.4	8.73	7.43	6.44	5.65	4.74	4.04	0
15	0.44	1.01	1.88	3.51	5.05	6.54	9.40	12.2	14.9	17.6	20.2	22.8	25.4	23.3	20.2	17.8	14.1	11.5	9.62	8.21	7.14	6.27	5.25	4.48	0
16	0.47	1.08	2.01	3.76	5.42	7.02	10.1	13.1	16.0	18.9	21.6	24.5	27.2	25.7	22.2	19.5	15.5	12.7	10.6	9.10	7.83	6.90	5.79	4.94	0
17	0.51	1.16	2.15	4.01	5.78	7.46	10.8	14.0	17.1	20.1	23.1	26.1	29.0	28.1	24.4	21.4	16.9	13.9	11.6	9.92	8.58	7.53	6.33	5.41	0
18	0.54	1.22	2.29	4.27	6.15	7.98	11.5	14.8	18.2	21.4	24.6	27.8	30.9	30.7	26.6	23.3	18.5	15.1	12.7	10.8	9.40	8.21	6.90	5.89	0
19	0.57	1.30	2.42	4.53	6.52	8.43	12.2	15.7	19.2	22.7	26.1	29.4	32.7	33.2	28.8	25.3	20.1	16.4	13.7	11.7	10.1	8.95	7.46	6.39	0
20	0.60	1.37	2.57	4.78	6.89	8.95	12.8	16.6	20.4	24.0	27.6	31.1	34.5	35.9	31.1	27.3	21.6	17.8	14.8	12.7	11.0	9.62	8.06	0	
21	0.63	1.45	2.70	5.04	7.27	9.40	13.6	17.5	21.5	25.3	29.1	32.7	36.5	38.6	33.4	29.4	23.3	19.1	16.0	13.7	11.9	10.4	8.73	0	
22	0.67	1.52	2.84	5.30	7.61	9.92	14.2	18.5	22.6	26.6	30.6	34.5	38.3	41.4	35.9	31.5	25.0	20.4	17.2	14.6	12.7	11.1	9.33	0	
23	0.70	1.60	2.98	5.57	7.98	10.4	15.0	19.4	23.7	27.9	32.1	36.2	40.2	44.2	38.3	33.6	26.7	21.9	18.4	15.7	13.6	11.9	10.0	0	
24	0.73	1.67	3.13	5.83	8.43	10.9	15.7	20.3	24.8	29.2	33.6	37.9	42.1	46.3	40.9	35.9	28.5	23.3	19.5	16.6	14.5	12.7	10.6	0	
25	0.77	1.75	3.26	6.09	8.80	11.3	16.3	21.2	25.9	30.9	35.1	39.5	44.0	48.4	43.4	38.1	30.3	24.6	20.7	17.8	15.4	13.5	11.3	0	
26	0.80	1.83	3.40	6.36	9.18	11.9	17.1	22.2	27.0	31.9	36.6	41.3	45.9	50.4	46.1	40.4	32.1	26.3	22.0	18.8	16.3	14.3	12.0	0	
28	0.87	1.98	3.69	6.89	9.92	12.8	18.5	23.9	29.3	34.5	39.7	44.7	49.8	54.7	51.5	45.2	35.9	29.4	24.6	21.0	18.2	16.0	0		
30	0.93	2.13	3.98	7.42	10.7	13.8	19.9	25.8	31.6	37.2	42.7	48.2	53.6	58.9	57.1	50.1	39.8	32.5	27.3	23.3	20.2	17.8	0		
32	1.00	2.28	4.26	7.98	11.4	14.8	21.3	27.7	33.9	39.9	45.8	51.6	57.4	63.1	62.9	55.2	43.8	35.9	30.1	25.7	22.2	19.5	0		
35	1.10	2.51	4.69	8.73	12.6	16.3	23.6	30.5	37.3	43.9	50.4	56.9	63.3	69.6	72.0	63.2	50.1	41.0	34.4	29.4	25.4	0			
40	1.28	2.90	5.42	10.1	14.5	18.9	27.2	35.2	43.0	50.7	58.3	65.7	73.9	80.6	87.3	76.8	61.3	50.1	42.0	35.9	14.9	0			
45	1.45	3.30	6.15	11.5	16.6	21.4	30.9	40.0	48.9	57.6	66.2	74.6	82.8	91.0	99.2	91.8	73.1	59.8	50.1	40.3	0				
Lubrication Method	A			B					C																

Lubrication Method A: Drop Lubrication B: Oil Bath Lubrication C: Forced Circulation Lubrication by Pump

■Power Transmission Efficiency Table CHEM40 (Single Row Chain) (kw)

Number of Small Sprocket Teeth	Rotary Speed of Small Sprockets (r/min)											
	10	25	50	100	200	300	400	500	700	900	1000	1200
9	0.05	0.11	0.21	0.39	0.71	1.04	1.34	1.68	2.22	2.77	3.08	3.59
10	0.05	0.13	0.24	0.44	0.79	1.15	1.49	1.87	2.47	3.08	3.42	
11	0.06	0.15	0.26	0.48	0.87	1.27	1.64	2.05	2.72	3.39	3.80	
12	0.06	0.16	0.29	0.52	0.95	1.38	1.79	2.24	2.96	3.73		
13	0.07	0.18	0.31	0.57	1.03	1.50	1.94	2.43	3.27	4.05		
14	0.08	0.19	0.33	0.61	1.13	1.64	2.13	2.64	3.53			
15	0.08	0.20	0.36	0.65	1.21	1.76	2.29	2.83	3.78			
16	0.09	0.22	0.38	0.70	1.29	1.88	2.44	3.02	4.03			
17	0.09	0.23	0.41	0.74	1.37	2.00	2.59	3.21				
18	0.10	0.24	0.43	0.80	1.45	2.11	2.74	3.40				
19	0.10	0.26	0.45	0.86	1.57	2.28	2.95	3.65				
20	0.11	0.27	0.48	0.91	1.66	2.40	3.11	3.85				
21	0.11	0.28	0.50	0.95	1.74	2.52	3.26	4.04				
22	0.12	0.30	0.53	1.00	1.82	2.66	3.45	4.23				
23	0.12	0.31	0.55	1.04	1.92	2.81	3.61	4.42				
24	0.13	0.32	0.60	1.11	2.03	2.96	3.84					
25	0.13	0.34	0.63	1.15	2.11	3.08	4.00					
26	0.14	0.35	0.65	1.20	2.19	3.20	4.16					
27	0.15	0.36	0.68	1.25	2.28	3.33	4.32					
28	0.15	0.38	0.70	1.29	2.36	3.45	4.48					
30	0.16	0.40	0.75	1.40	2.53	3.70						
32	0.17	0.43	0.80	1.51	2.80	4.05						
35	0.19	0.47	0.88	1.65	3.06	4.43						
40	0.22	0.54	1.00	1.88	3.50							
45	0.24	0.61	1.13	2.12	3.94							

■Power Transmission Efficiency Table CHEM50 (Single Row Chain) (kw)

Number of Small Sprocket Teeth	Rotary Speed of Small Sprockets (r/min)											
	10	25	50	100	200	300	400	500	600	700	800	900
9	0.11	0.24	0.44	0.82	1.49	2.17	2.80	3.39	3.99	4.61	5.19	5.72
10	0.12	0.27	0.49	0.91	1.66	2.41	3.11	3.76	4.44	5.12	5.80	
11	0.14	0.29	0.54	1.00	1.83	2.65	3.42	4.14	4.88	5.63		
12	0.15	0.32	0.59	1.09	1.99	2.89	3.74	4.51	5.35	6.18		
13	0.16	0.35	0.64	1.18	2.16	3.14	4.07	4.91	5.80			
14	0.17	0.37	0.69	1.27	2.32	3.38	4.45	5.29	6.24			
15	0.19	0.40	0.74	1.36	2.49	3.62	4.76	5.67				
16	0.20	0.43	0.79	1.45	2.66	3.86	5.08	6.05				
17	0.21	0.45	0.84	1.54	2.82	4.10	5.40	6.43				
18	0.22	0.48	0.89	1.63	2.99	4.34	5.72					
19	0.24	0.51	0.97	1.79	3.31	4.81	6.21					
20	0.25	0.53	1.03	1.89	3.49	5.07	6.54					
21	0.26	0.56	1.08	1.98	3.66	5.32	6.86					
22	0.27	0.58	1.13	2.08	3.83	5.57						
23	0.29	0.61	1.18	2.17	4.01	5.83						
24	0.30	0.66	1.23	2.29	4.26	6.14						
25	0.31	0.68	1.28	2.38	4.44	6.39						
26	0.32	0.71	1.33	2.48	4.62	6.65						
27	0.34	0.74	1.38	2.57	4.80	6.90						
28	0.35	0.77	1.44	2.67	4.97	7.16						
30	0.37	0.82	1.54	2.86	5.33							
32	0.40	0.88	1.66	3.05	5.68							
35	0.44	0.97	1.81	3.34	6.22							
40	0.50	1.11	2.07	3.81	7.11							
45	0.56	1.24	2.33	4.29								

■Power Transmission Efficiency Table CHEM60 (Single Row Chain) (kw)

Number of Small Sprocket Teeth	Rotary Speed of Small Sprockets (r/min)											
	10	25	50	100	150	200	250	300	400	500	600	700
9	0.18	0.41	0.76	1.41	2.02	2.63	3.22	3.78	4.91	6.00	7.06	8.14
10	0.21	0.46	0.85	1.57	2.24	2.93	3.58	4.20	5.45	6.66	7.92	
11	0.23	0.51	0.93	1.73	2.47	3.22	3.94	4.62	6.00	7.33		
12	0.25	0.55	1.02	1.89	2.69	3.51	4.34	5.04	6.54	8.07		
13	0.27	0.60	1.10	2.04	2.97	3.88	4.75	5.46	7.23			
14	0.29	0.64	1.21	2.24	3.23	4.22	5.16	6.12	7.86			
15	0.31	0.69	1.30	2.41	3.46	4.52	5.53	6.56	8.43			
16	0.33	0.73	1.38	2.57	3.69	4.82	5.90	6.99				
17	0.35	0.78	1.47	2.73	3.92	5.12	6.27	7.43				
18	0.37	0.83	1.56	2.89	4.16	5.42	6.64	7.87				
19	0.39	0.89	1.69	3.17	4.51	5.89	7.21	8.46				
20	0.41	0.94	1.78	3.33	4.75	6.20	7.59	8.91				
21	0.43	0.98	1.87	3.50	4.99	6.51	7.97					
22	0.45	1.03	1.96	3.67	5.23	6.82	8.35					
23	0.47	1.08	2.05	3.83	5.46	7.13	8.73					
24	0.49	1.16	2.14	4.04	5.81	7.58	9.11					
25	0.51	1.21	2.23	4.20	6.05	7.90	9.67					
26	0.53	1.25	2.32	4.37	6.29	8.22						
28	0.58	1.35	2.49	4.71	6.78	8.85						
30	0.62	1.45	2.67	5.05	7.26	9.48						
32	0.66	1.56	2.93	5.53	7.96							
35	0.72	1.70	3.21	6.05	8.71							
40	0.82	1.95	3.66	6.92	9.95							
45	0.92	2.19	4.12	7.78								

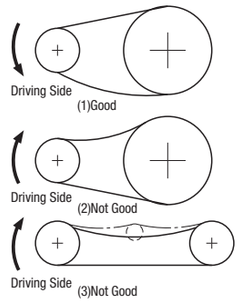
Installation Way

(A) Arrangement of Shafts

Horizontal Arrangement

Even when the shafts are arranged horizontally, the following points should be taken into account in terms of the rotary direction of the shafts. In (2) and (3) shown, elongation of the chain may prevent the chain links from leaving the sprocket teeth smoothly, resulting in biting. Especially for (3), use an idler, etc., because the upper side and lower side of chain are the most likely to come into contact with each other.

Horizontal Arrangement

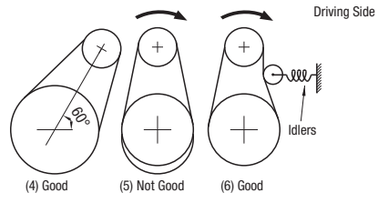


(Change the rotating direction or use an idler)

Vertical Arrangement

If a chain is elongated, it is deflected as shown in (5). In this case, if the smaller sprocket is arranged below the larger sprocket, the chain will come off. Therefore, restrict the vertical installation angle of chain to 60° or less. When the mechanism in question or the installation space requires a vertical arrangement, place the small sprocket above the large sprocket and use an idler, etc. on the outside or inside as shown in (6) .

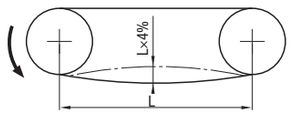
Vertical Arrangement



(B) Deflection

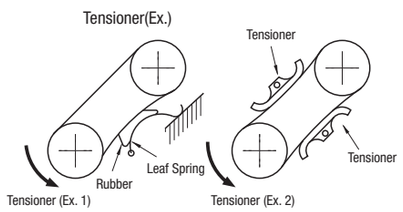
The deflection should normally be maintained at approximately 4% of the distance between the shafts, and approximately 2% in the following instances.

A. The shafts are arranged almost for vertical transmission.
B. The distance between the shafts is 1 m or more.
C. The chain needs to be started and stopped frequently under heavy load.
D. The chain needs to be run in the reverse direction.



(C) Load Fluctuation

When the load varies during operation, apply an appropriate initial tension either on the load or loose side of the chain. This can remove vibration and reduce the noise of the chain.



Lubrication

The service life of roller chains depends heavily on lubrication. Therefore, correct lubrication is extremely important. Today, as chains are increasingly run at higher speeds, they need to be lubricated more efficiently.

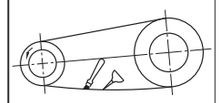
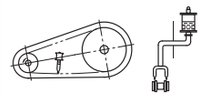
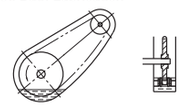
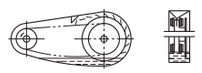
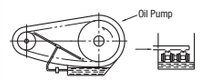
Benefits of Lubrication Oil

Oil applied into the space between pins, bushings and rollers forms oil film. That helps reduce wear of parts as well as absorbing impact. Oil also cools down heat generated in the chain. Use good quality mineral oil to lubricate roller chains.

Recommended Lubricating Oil

Lubrication Method	A , B				C			
Temperature(℃) / Chain No.	-10 ~ 0	0 ~ 40	40 ~ 50	50 ~ 60	-10 ~ 0	0 ~ 40	40 ~ 50	50 ~ 60
CHE25~50	SAE10	SAE20	SAE30	SAE40	SAE10	SAE20	SAE30	SAE40
CHE60~80	SAE20	SAE30	SAE40	SAE50				

Lubrication methods (mentioned in the power transmission efficiency tables are based on the followings.)

Lubrication	Method	Service Interval and Oiling Quantity	Notes
A	Hand Oiling 	Apply oil by hand using a hand oiler or a brush, normally at least once everyday.	While slowly turning the chain, apply oil evenly 3~4 times onto the entire length of the chain. Be careful not to allow hands or clothing to be caught between the chain and the sprocket. When the mechanism is run for the first time after oiling, be careful about excess oil splashing over.
	Drop Lubrication 	Oil the chain in such a way that approximately 5~20 drops of oil are applied onto the chain per minute.	It is recommended that a simple casing be installed over the chain to prevent oil from splashing over.
B	Oil Bath Lubrication 	Dip the bottom of the chain approximately 10 mm below the oiled surface.	Use a leak-free oil container. Before installing the oil container, wash it carefully to remove dust, dirt and other foreign particles. Maintain the correct oil level. Do not overfill the container.
	Rotating Plate Lubrication 	The chain is oiled by a rotating plate. Dip the plate approximately 20mm below the oil surface. The wind velocity of the plate should be 200 m/min or faster.	
C	Forced Circulation Lubrication by Pump 	It is necessary to adjust the oil quantity appropriately to prevent overheating.	Use a leak-free oil container. Before installing the oil container, wash it carefully to remove dust, dirt and other foreign particles.

Chain
Double Speed Chain / Table Top Conveyor Chain Selection

Selection Procedure for Double Speed Chains

[Step 1] Confirm Usage Condition

Confirm that the following conditions are met.
Temp.: -10°C ~ +80°c
Chain Velocity: 5~15m/min
Conveyor Length: 15m or less
Environment: No abrasive dusts, corrosive gasses, or high humidity

[Step 2] Determine Chain

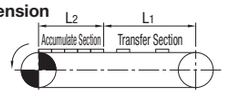
Based on the result from calculation of conveyed object mass per square meter, select a chain that satisfies the requirements for the allowable load mass.

$WA(kg/m)=(W_1+W_2)/PL$
WA: Conveyed Object Mass per Square Meter (Kgf)
W_1: Workpiece Mass (kgf)
W_2: Pallet Mass (kgf)
P_L: Pallet Travel Length (m)

Table 1 Allowable Load Mass

Chain	Allowable Load Mass (kgf/m)
WCHE3	30
WCHE4	55
WCHE5	75

[Step 3] Confirm Allowable Tension



$T=G/1000\times\{(Hw+Cw)L_1\cdot fc+Aw\cdot L_2\cdot fa+(Aw+Cw)L_2\cdot fr+1.1Cw(L_1+L_2)\cdot fc\}$

T: Max. Tension Applied on Chain (kN)
L_1: Transfer Section Length (m)
L_2: Accumulation Section Length (m)
Hw: Conveyed Object Mass on Transfer Section, including that of pallets (kg/m)
Aw: Conveyed Object Mass on Accumulation Section, including that of pallets (kg/m)
Cw: Chain Weight (kg/m)
fa: Friction Coefficient between conveyed object and Chain During Accumulation
fc: Friction Coefficient between Chain and Rail
fr: Friction Coefficient between Chain and Rail During Accumulation
G: Gravitational Acceleration=9.80665 (m/s^2)

Table 2 Friction Coefficient of Double Speed Chains

	Friction Coefficient
fa	0.10
fc	0.08
fr	0.20

Multiply the max. tension applied to a chain (T) by the velocity factor (K_1) and the conveyed object load factor (K_2).
For Free Flow Conveyors , which are generally designed to have two chains installed, calculate the tension for each of the two chains.
Allowable Chain Tension ≥ $(T\times K_1\times K_2)/2$
If the calculated result exceeds the allowable tension of selected chain, re-select a chain one size larger or re-calculate with conveyor length divided into shorter sections.

Table 3 Velocity Factor Table

Chain Velocity m/min.	Factor K_1
1~4 or less	1.0
Over 4, 8 or less	1.1
Over 8, 10 or less	1.2
Over 10, 14 or less	1.5
Over 14, 18 or less	1.6

Table 4 Conveyed Object Load Factor

Average Conveyed Object Weight Wa (kg/m)	Factor K_2
30 or less	1.00
31~40	1.10
41~50	1.15
51~70	1.20
71~90	1.25
91~120	1.35

Table 5 Max. Allowable Tension for Double Speed Chains

Chain Velocity m/min.	Allowable Tension (kN)
WCHE3	0.55
WCHE4	0.88
WCHE5	1.37

Selection Procedure for Table Top Conveyor Chains

[Step 1] Calculate Effective Tension (Fe)

$Fe=g\cdot(m\cdot Lc\cdot\mu R+(m+M)\cdot(Lc\text{-}A)\cdot\mu R+MA\cdot A\cdot(\mu c+\mu R)+m\cdot A\cdot\mu R)$

Fe: Effective Tension (N)
Lc: Conveyor Length (m)
A: Accumulation Length (m)
* A=0 when there is no Accumulation.
M: Mass of Conveyed Object
MA: Mass of Conveyed Object for Accumulation Section
m: Chain Mass (kg/m)
μc: Dynamic Friction Coefficient between Chain and Conveyed Object
μR: Dynamic Friction Coefficient between Chain and Rail
g: Gravitational Acceleration=9.80665 (m/sec^2)

Table 1 Friction Coefficient

Lubrication Method	Material of Conveyed Object				
	Steel	Aluminum	Glass	Paper	Plastic
Dry	0.25	0.2	0.15	0.3	0.2
Soap Water	0.15	0.12	0.1	–	0.15

Lubrication Method	Gide Rail Material			
	Steel	Stainless steel	UHMW Polyethylene	Nylon
Dry	0.2	0.2	0.15	0.2
Soap Water	0.12	0.12	0.1	0.14

*The Friction Coefficients above are estimated values with safety ratio added, so those values serve as element for tension calculation.

[Step 2] Calculate Post-adjusted Tension based on conditions

Fs=Fe · Cs

Fs: Post-adjusted Tension (N)
Cs: Load Correction Factor
For frequent starts and stops =1.2
For wear intensive applications =1.2
For multiple row use =1.25
For other than above =1.0

[Step 3] Calculate Chain Allowable Tension

Fadm=FN · Va · Ta
Fadm: Allowable Tension (N)
FN: Max. Allowable Tension (N)
Va: Velocity Factor
Ta: Temperature Factor

Table 2 Maximum Allowable Tension

Type	Nominal	Max. Allowable Tension (N)
TPCH	826	1650
	1143	

Table 3 Velocity Factor

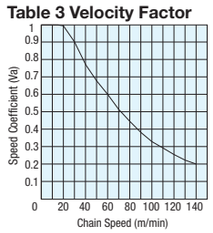
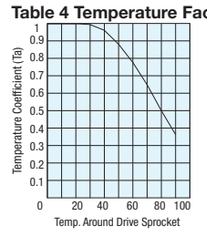


Table 4 Temperature Factor



[Step 4] Compare Allowable Tension and Post-adjusted Tension

If Fs≤Fadm, the selection is applicable.

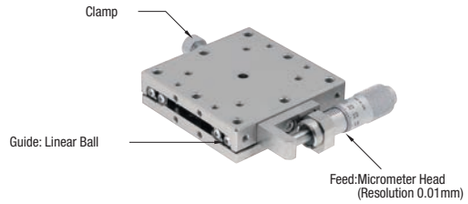
[Step 5] Calculating Required Power

$P=Fs\cdot V/(60\cdot\eta)$
P: Required Power (W)
V: Chain Velocity (m/min)
η: Transmission Efficiency

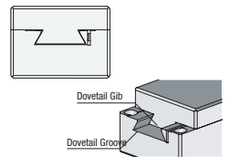
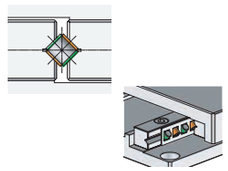
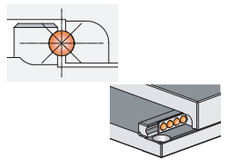
Positioning Stages
Overview

What is a Stage?

Stages are mechanical unit products composed of Guides, Feed mechanisms, and Clamps. Since they can easily adjust object positions for inspections, machining, and assembly fixtures. A single unit would be used as an X-Axis, and two units can be combined as an XY-Axis stage. Use a Z-Axis for height adjustments.



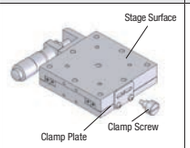
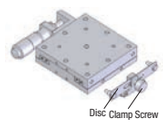
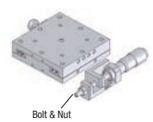
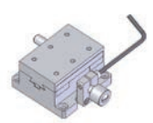
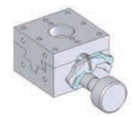
Linear Guidance Structures

	Dovetail Slide	Cross Roller	Linear Ball
			
Structure	Sliding male/female trapezoid grooves facilitate the guiding.	Caged cylindrical rollers are alternately crossed, and placed between two grooved rails. The rolling motion of the rollers facilitates the guiding.	Steel balls are aligned in gothic arch grooves machined on the body of stage. The rolling motion of the rollers facilitates the guiding.
Straightness	[Standard] 50μm [High Precision] 30μm	[Standard] 30μm [High Precision] 3μm	[High Precision, Motorized] 1μm

About Feed Mechanisms

	Rack & Pinion	Feed Screw	Feed Screw	Micrometer Head	Coarse/Fine Micrometer Head	Digital Micrometer Head
						
Guide Mechanism	Dovetail Slide		Cross Roller / Linear Ball Slide			
Travel per Rotation	17~20mm	0.5~10mm	0.5~1mm	0.5mm	0.025~0.5mm	0.5mm
Features	• Suitable for rapid feeding. • Not suitable for accurate positioning.	• Suitable for fine feeding and slightly fast feeding. • Screw lead selectable	• Suitable for fine feeding. • More economical compared to Micrometer Head • Not scaled and incapable of numerical adjustments.	• Suitable for precise positioning by 0.01mm.	• Enables finer adjustment compared to standard Micrometer Head. • 0.5μm Graduation	• With digital display, output • 1μm Graduation

About Clamp Mechanism

	Standard Clamp	Disc Clamp	Opposed Clamp	Slit Clamp	Lever Clamp
					
Features	Clamp plate is pressed against the side of the stage by a clamp screw. It is the most economical and standard holding method.	The stage is immobilized by clamping a disc applying no load on the stage surface. The advantage is that position displacement can be prevented.	The carriage is braced by a bolt from the other side of the micrometer head. The bolt is secured with a nut for vibration resistance and strong holding capacity.	The feed knob shaft is clamped directly. Compared to the conventional model, larger retaining force can be obtained. Drift can be prevented by using it in combination with conventional standard clamp.	The final tightening action of the clamp screw is managed with a lever for easy operation.

Notes on Clamps

The standard clamps for the stages work on frictional forces generated when screws are tightened by turning the knobs and levers. Applied loads exceeding the friction of the clamp mechanical forces can displace the stages. Please devise proper countermeasures to prevent the stage surfaces from being displaced in actual applications.
MISUMI offers the following clamp reinforcement measures.
・Selecting the Reinforced Clamp Type Stages (Slit Type Clamp)
・Changing the clamp type when available as "Alterations" (Opposed Clamp, Disc Clamp)

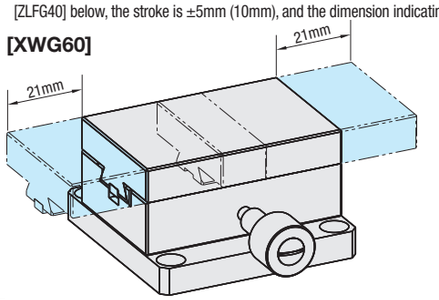
Positioning Stages
Technical Information

High Precision Stages and Standard Accuracy Stages (Common)

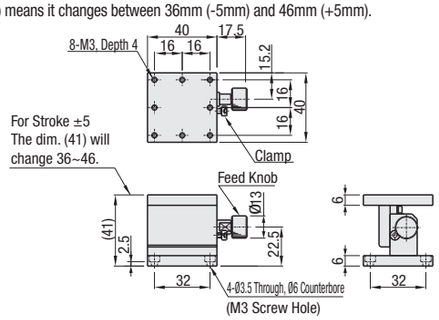
■About Stroke (move distance) descriptions.

The dimensions shown in the drawings are for tables at 0mm positions. The dimensions shown in ( ) mean that they would change as the stroke changes. Below diagram [XWG60] as an example, the stroke is ±21mm (42mm) where the table moves 21mm to the right and 21mm to the left, as the position in the diagram as the center. In the case of the drawing [ZLFG40] below, the stroke is ±5mm (10mm), and the dimension indicating the stage height (41) means it changes between 36mm (-5mm) and 46mm (+5mm).

[XWG60]



[ZLFG40]



■About Resolutions

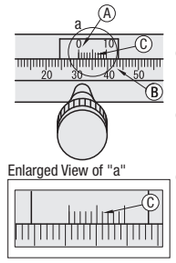
There are 3 ways of position reading options: Scale Plates, Vernier Scale and Micrometer Heads.These position indicating options can be used as references for applications requiring positional repeatability.

<How to Read Vernier Scale>

① The scale Ⓑ value is read at the 0 position of the sub-scale Ⓐ in 1mm resolution.
(30mm in the right figure)

② While looking at Ⓐ scale, read the graduation Ⓒ aligning the Ⓑ scale as 0.1mm resolution.
(0.6mm in the right figure)

③ A sum of ① and ② is the value.
(30.6mm in the right figure)

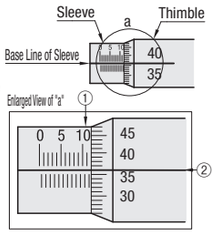


<How to Read 0.01mm Micrometer Head>

① Read where the position of end face of the thimble is located on the scale of sleeve by 0.5mm resolution.
(11.5mm in the right figure)

② Read a value of the thimble on the position where the base line of sleeve coincides with the scale line of the thimble.
(0.36mm in the right figure)

③ The total value of ① and ② is the current position of the stage.
(11.86mm in the right figure)



Although the micrometer head stroke will be expressed ±3.25mm and ±6.5mm, the scale starts as 0 (zero) at the left farthest end.
For the case of ±6.5mm stroke, the relationship of the scale and the stroke would be as shown below.
- When the scale reads 0 (zero): Stroke [-6.5mm]
- When the scale reads 6.5mm: Stroke [0 (zero)]
- When the scale reads 13mm: Stroke [+6.5mm]

■About Load Capacity

Load Capacity

It is a force that the stage can withstand with the CG of the load is the stage center. The unit is in (N). If the stage is operated at beyond this load capacity, it may no longer operate smoothly. For the load capacities in horizontal orientation, see [Horizontal] values, and see [Vertical] values for the vertically oriented stages. Please be advised that vertically oriented or inverted stages may not always meet the catalog accuracy values.

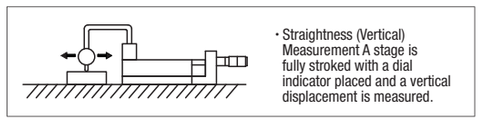
Allowable Moment Load

It indicates loads the stage can withstand when the CG of the load is located away from the stage center. The unit is in (N • m). When CG of the workpiece is located away from the center of the stage (=Overhung), the allowable moment load values will need to be taken in consideration along with the Load Capacity. Products high in this value is defined as [High Rigidity].

■About Accuracy Standards

Definition of Straightness

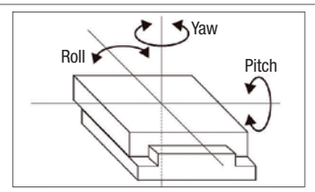
Straightness is a value represented by a maximum difference between an ideal straight line of travel and the actual travel of a top plate over the entire stroke range of the stage. It is the max. deviation in horizontal or vertical direction in relation to the ideal straight axis.



- Straightness (Vertical)
  Measurement A stage is fully stroked with a dial indicator placed and a vertical displacement is measured.

Definition of Pitching / Yawing / Rolling

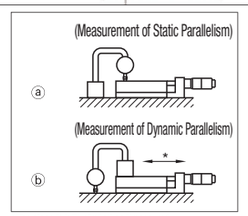
These indicate the amounts of top plate inclinations during linear motion.
To direction of traveling
Leaning forward and back : Pitching
Rotation in a horizontal plane : Yawing
Leaning right and left : Rolling



Allowable Moment Capacity (see Overview page) and Moment Rigidity (carriage attitude in angles against these forces) are used to represent the stage's rigidness.

Definition of Parallelism

A value indicating the parallelism of the top surface against the bottom surface. The illustrations on the right show how ⓐ Static Parallelism and ⓑ Dynamic Parallelism are measured.



* The stage is fully stroked and measured.

Caution

Travel accuracy values shown are for single axis configuration.

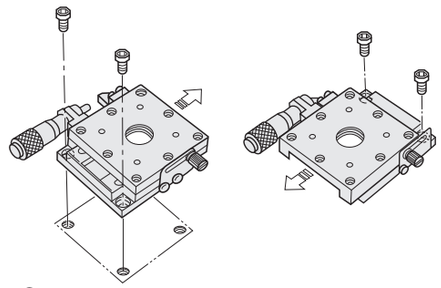
■Stage Operating Environment

Operating Environment :10 ~ 50°C, 20 ~ 70%RH (No Condensation)
Recommended Operating Environment: 22±5°C, 20 ~ 70%RH (No Condensation)

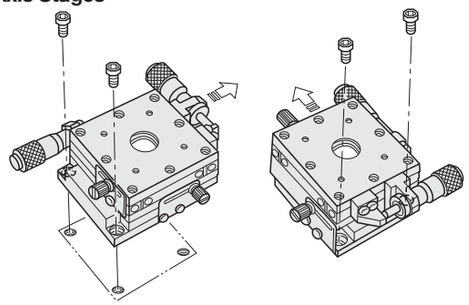
■Stage Installation Method

To mount a stage on the base surface, move the top plate to access mounting holes as shown below.

X-Axis Stages

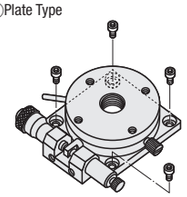


XY-Axis Stages

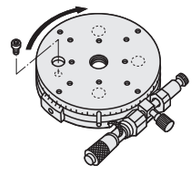


Rotary Stages

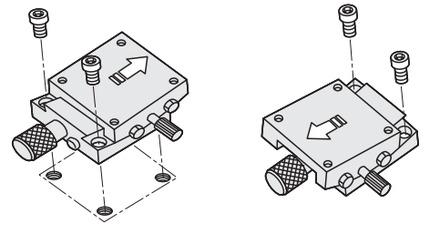
①Plate Type



②No Plate Type
(REG,RPG85,RPG110)



Goniometer Stages

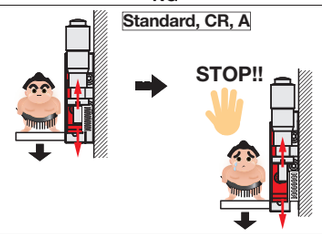
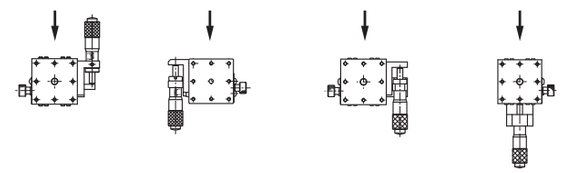


Notes on Mounting Surface Accuracies

Intended product performances may not be achieved if the stage mounting surface or the carried object's mounting surface do not have sufficient flatness.
(General Flatness Guideline: 10μm or better)

■Vertical Use of X-Axis Stages

When mounting a stage in vertical orientation, note the directions of the feed mechanisms and springs.

NG	OK
	
A load exceeding the spring pull force will cause the carriage to drop.	CZ: The carriage does not drop since the micrometer head tip pushes the bracket on the bottom plate. Standard, CR, A: The stage does not move down when the micrometer head is mounted pointing up.

However, do not apply a load exceeding the specified vertical load capacity.

Standard Stages

■Holding Force

Holding Force (Reference) is the (reference) value to hold the stage top surface rest when clamped.

■Measured Holding Force

<Test Conditions>Clamp screws are tightened with the tightening torque below and pressed with the test instrument (F in the diagram). The max. holding force is the load measured where the stage top surface starts to move.
- Tightening Torque (Standard)
  ⓐ XDTS (Standard, Dovetail Slide, Rack & Pinion) Size 50 and 60: 0.1N·m; Size 90: 0.15N·m
  ⓑ XDTSC (Standard, Dovetail Slide, Low Profile, Rack & Pinion) Size 50 and 60: 0.1N·m; Size 90: 0.15N·m
  ⓒ XCRS (Standard, Cross Roller): 0.15N·m

<Max. Holding Force (Ref.)>

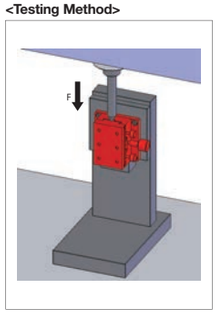
Type		Max. Holding Force (Ref.)
ⓐ XDTS	50	30N
	60	60N
	90	70N
ⓑ XDTSC	50	10N
	60	20N
	90	40N
ⓒ XCRS	40	60N
	60	60N
	80	70N

<Max. Holding Force (Ref.) depending on Tightening Torque>

Type	Tightening Torque (Standard at 100%)		
	50%	100%	150%
XDTS60	50N	60N	90N
XCRS60	40N	60N	100N

Max. Holding Force (Ref.) will vary depending on the tightening torque variations. Ensure adequate safety margins for design.

<Testing Method>



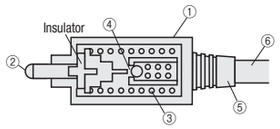
Positioning Switch
Contact Type Overview

Switch Type		Signal Point Repeatability *1	Contact Point Accuracy Life *2	Operating Temp. Range
Compact		0.003mm	3,000,000 times	*3 0~80°C
High Precision		0.0005mm		
Standard		0.005mm	10,000,000 times	
With Stopper		0.01mm (except Flat Type)	10,000,000 times	
Plunger				
Heat Resistant		At Ambient Temperature 0.01mm	500,000 times	0~200°C

*1 Operating Speed 50 ~ 200mm/min.
*2 When used at rated voltage and rated current without failure of switch caused by vibration.
*3 The encapsulated structure of the IP67 Type may cause delay in returning under low temperatures (5°C or less).

■Feafures
Contacting switch that can detect position highly accurately without being affected by materials, shapes, magnetism, luminosity of the detected objects.

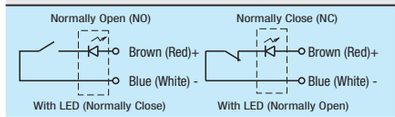
■Basic Stracture
Designed to open/close with high repeatability in sync. with the contact point.
①Switch Enclosure
②Contact Part
③Spring
④Switch Contact
⑤Cord Protector
⑥Cable



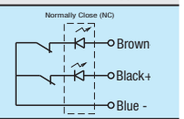
■Schematics

All Types

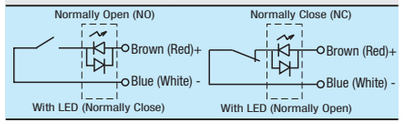
Common to all LED types



Common to all types



High Precision



■Mechanical Specifications

Vibration	10 ~ 55Hz, Full Wave Amplitude 1.5mm in Respective X, Y, Z Direction
Impact	300m/s² in Respective X, Y, Z Direction
Allowable Operating Speed	10mm~5m/min.
Cable Tensile Strength	30N or less
Cable Min. Bending Radius	R7mm

■Electrical Specifications

Contact Rating	DC5 ~ 24V 20mA (MAX) Resistive Load (10mA with LED)
Dielectric Strength	100MΩ or more DC250V Megohm-meter
Withstand Voltage	AC500V 50/60Hz, 1 min. between each Terminal and Case

Use within the contact ratings. Using at over contact ratings may cause failures.

■Others
These switches are designed for low voltage and low current, and are not applicable to Export Trade Control Ordinance, CE Marking and China Compulsory Certification.

■Hazards and Warnings
1. Accident may occur with circuit damages due to abnormal generation of heat, smoke and fire in the following conditions.
   a. When switch ratings, cycle life, environment conditions and others exceed the operating range
   b. When electric wire and connectors are used over the allowable operating current capacity
   c. When cables are exposed near to the heat generating objects
2. Safety measures such as redundant circuits are necessary to avoid a serious accidents resulting in injury or death or further damage caused by the failures in operation.
3. When signal output failure may cause the damage of equipment or machine, install an emergency stop.

■Design Precautions
• Protection Structure
・Note that sealing ability may be affected by operational conditions or environment, such as cutting oil, chemicals, or existence of dust. Select machine types referring to the IP codes.
・Do not use the switches with exposed rubber boots under the environment where metal chips may fall on products, as rubber boots will be damaged.

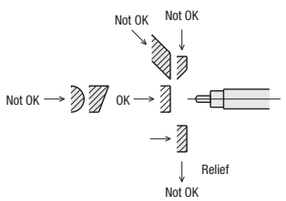
• Contact Angle
・Contacting angle of the switch to objects should be within ±3° (±1° for Deceleration Signal Type).
(Excluding: Wide Contact Angle Type, Ball Contact Type, Ball Plunger Type). (Fig. 1)

• Stroke
・Detected subjects should not collide with the switch housing (except switches with stoppers).
Install a stopper if the risk of collision exists. (Fig. 2)
(Please confirm the impact resistance of switches with stopper, referring to each catalog page.)

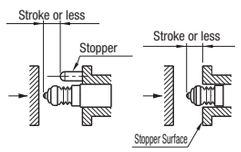
• Contact Speed
・Do not use at low speed contact (10mm/min. or less). That will cause prolonged operational instability and resultant deterioration of the switch contacts.

• Effects of Micro-Vibration
・Do not use the switch in an environment where chattering arises from micro-vibrations.

(Fig. 1)



(Fig. 2)

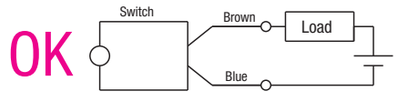


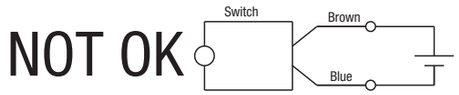
Do not use this product as a detection device for human body protection.
(For human body protection, use products compliant with the local laws and regulations such as OSHA, ANSI and IEC.)

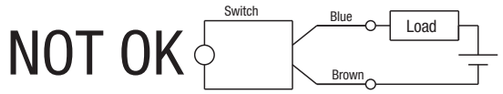
■Installation Precautions
• Cable Damages
・Excessive force on cable inlet and sensor body may cause wire breakage.
Do not pull or twist the loose wires with 15N or more. Also do not pull or twist the cab tire cords with 30N or more.
・Bending radius is to be R7 or more.
・When clamping the cable to stop from moving around, ensure to avoid excessive force on cable inlet and sensor body.
When clamping cables in a bundle, take special care not to apply excessive force on switches.

•Clamping of Knurled Head
・Clamping with tools, such as long nose pliers, may cause damages.
Tighten firmly with fingers.

■Precautions on Electrical Wiring
• Connecting to Power
・Direct connection to the power will damage the switch and the internal element.
・Install correctly noting the polarity.

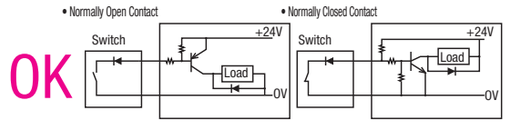




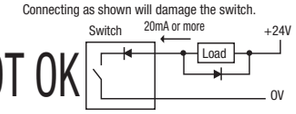


• Connection with Inductive Load
・Direct connection to an inductive load will damage the switch.
・If the switch is to be connected to an inductive load, include a drive circuit for the load.

Good Example

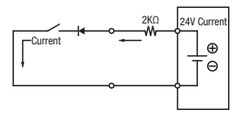


Bad Example
Connecting as shown will damage the switch.



• Grounding
・When grounded the machine's DC power 0V, ensure to connect the switch on the GND side. (If the switch is connected on (+) side, the switch may be damaged at the moment the (–) side of switch touches the body.)

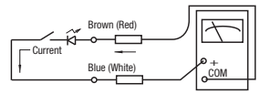
• About Wiring of Switch with LED
・To prevent damage to the LED due to unexpected over current, insert a current limiting resistor.
・For load within the switch rating or installation onto a PLC, current limiting resistors are not necessary as long as the current is about 7mA.



・The type with LED has polarity. The brown cable is positive (+), while the blue one is negative (-). Install correctly.

• Wiring
1. Use within the contact ratings.
2. Do not pull or twist the cable and conductor wire with excessive force. Bending radius is to be R7 or more.
3. When the machine is grounded, connect the switch to the grounded side.
4. Noises and surges may induce the over rated current and damage the switch contact. Switch wiring should be located away from power sources or noise sources.
5. When the cord is extended, use cabtyre cable with sectional areas of 0.3mm² or more.
6. When the switch drives the relay etc., use the coil current of around 10mA.

■Confirmation of Switch Action
• Correct Circuit Check Method Using Analog Multimeter



LED lights when the contact is closed.

Analog Multimeter: Confirm in Ohms Range x10

⚠Measurement of Contact Resistance Using Digital Multimeter.

Switches with LEDs cannot be measured correctly in ohms range.

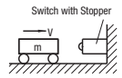
Only when there is a voltage output terminal, LED ON state can be confirmed.

■Calculation of Impact Energy
Please confirm the impact resistance of switches with stoppers, referring to each catalog page.

$E=1/2mv^2$
E: Energy J
m: Mass kg
v: Velocity m/s

$E=mgh$
E: Energy J
g: Gravitational Acceleration 9.8m/s²
h: Drop Height m

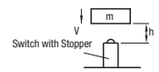
Pure Horizontal Impact



Calculation Example

m	v	1/2mv²[J]
4	0.3	0.18
5	0.4	0.4
20	0.2	0.4

Vertical Free Fall



m	h	$v=\sqrt{2gh}$	mgh[J]
0.4	0.05	1	0.2
0.4	0.1	1.4	0.4

Springs
Overview

■Tension Springs

Load P[N] = Initial Tension Pi[N] + (Spring Constant k[N/mm] x Deflection F[mm])

- MISUMI Tension Springs (except for Specified Types) are standardized to maintain the maximum load constantly to the same diameter. Produced based on the maximum load value, the initial tension and spring constant are reference values.
- Use the springs within the range of the allowable deflection F max.(mm). Using at higher than the allowable deflection values may cause deformation or failure after a few uses. Also, do not extend tension springs more than its allowable deflection during the installation.

For Tension Springs durability can not be shown because stress concentration may occur depending on the hook installation. It is recommended to use the springs within 70 % of allowable deflection F max.(mm).

- It is recommended to use the tension springs (AW□, BW□, AWFM, WFSP, LWS, LWSH) under ambient temperature (at 40°C or less). Load value attenuates when tension springs are used in temperature higher than 40°C, although it depends on other conditions.

■Round Coil Springs / Irregular Shaped Coil Springs

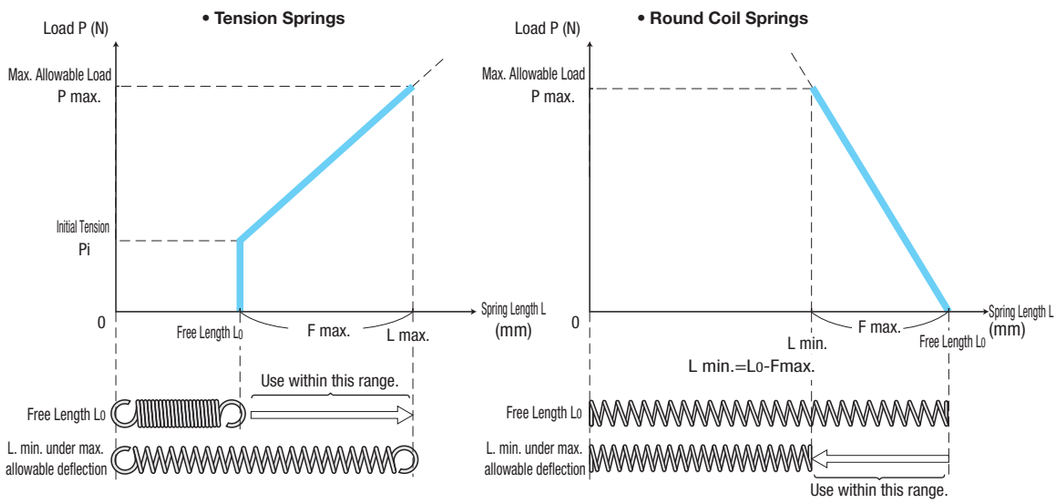
Load P[N] = (Spring Constant k[N/mm] x Deflection F[mm])

- MISUMI Round Coil Springs are standardized to maintain the spring constant constantly to the same diameter. The tolerance of spring constant is ±10%.
  Irregular shaped coil springs are standardized to maintain the maximum load constantly to the same diameter. The load tolerances vary depending on the spring type, please refer to the respective page.
- Use the springs within the range of the allowable deflection F max.(mm). Using at higher than the allowable deflection values may cause deformation or failure.
- The values of solid length are for reference only. Using it compressed to the solid length may cause deformation or break after a few uses.
- Round Coil Springs are manufactured based on the following diametric tolerance priorities given. I.D. Selectable Type: Inner diameter tolerance prioritized / O.D. Selectable Type: Outer diameter tolerance prioritized.
  For inner/outer diameter tolerances of irregular shaped coil springs, refer to the respective pages.

It is recommended to use the round coil springs and irregular shaped coil springs under ambient temperature (40°C or less). Load value attenuates when tension springs are used in temperature higher than 40°C, although it depends on other conditions. (Heat resistant springs are listed on "Standard Components for Plastic Mold".)

- Irregular Shaped Coil Springs are listed on "Standard Components for Press Dies" and "Standard Components for Plastic Mold". (Large Dia. Sizes are also available.)

■Relationship between Spring Length L and Load P



Springs
How to Use Coil Springs and Precautions

■How to Use Coil Springs and Precautions

MISUMI is engaged in a constant effort to design coil springs (excluding Round Wire Springs) with optimum cross-sectional shape and maximum durability. When using the springs, pay due attention to the following precautions and undesirable usage that should be avoided for the sake of safety.

① Always Use A Spring Guide
When used without a spring guide, the coil spring may buckle or bend midway. This can cause it to break since the internal surface of the bending is subjected to concentrated high stress. Be sure to use a spring guide, such as a shaft and an outer diameter guide, with the coil spring.
*In most cases, the best results are obtained by inserting a shaft all the way through the coil spring, from top to bottom, as an inner diameter guide.

② Clearance between the Spring Inner Diameter and Shaft
When clearance between the spring and the shaft is insufficient, the coil spring's internal surface may come into contact with the shaft and be subject to abrasion at that point. This can lead to the spring eventually breaking at the point of wear. Excessive clearance with shaft, on the other hand, can lead to buckling of the coil spring. It is recommended that the shaft diameter be set approximately 1.0 mm smaller than the inner diameter of the coil spring.
When the coil spring has a long free length (i.e., free length/OD is 4 or larger), set up a step on the shaft as shown in Fig.-1 to prevent the coil spring's internal surface from touching the shaft when it bends.

③ Clearance between The Spring OD and Counterbore Hole
The coil spring expands in the outward direction when it deflects. Insufficient clearance between the spring and the counterbore hole restrains expansion, and the resulting concentration of stress can cause the coil spring to break. It is recommended that the counterbore diameter be set approximately 1.5mm larger than the outer diameter of the coil spring. The counterbore configuration shown in Fig.-1 is ideal for a coil spring with a long free length.

④ Avoid A Short Shaft Length and Shallow Counterbore Hole Depth
If the guide is too short, the coil spring may touch the guides tip when it is buckled. The resulting friction can cause the coil spring to break. It is recommended that the guide length be set longer than half of the initial height. Also be sure to chamfer the shaft to around C3 level.

⑤ Do Not Use in Excess of The Maximum Deflection (300,000 times limit) or Near Its Solid Length
When the coil spring is used in excess of the 300,000 times limit, its Cross-section starts receiving stress that is higher than the theoretical value. This can cause the coil spring to break. Furthermore, when the coil spring is used at around its solid length, its active coils gradually adhere to each other, increasing the spring constant value and causing the load curve to rise, as shown in Fig.-2. Do not use the coil spring in excess of the 300,000 times limit.

⑥ Set up An Initial Deflection
When there is a gap for the coil spring to move vertically, it receives an impact force that causes it to bend midway or to buckle.
Setting up an initial deflection stabilizes the top and bottom ends of the spring.

⑦ Avoid Entrapment of Debris or Foreign Matter
Debris or foreign object that becomes caught between the coils cause that part of the coil spring to stop functioning as active coils, forcing the other coils to deflect, as shown in Fig.-3. This sharply reduces the number of active coils, increasing the stress on the spring, and eventually causing it to break. Be careful not to allow debris or foreign object to clog the coils.

⑧ Keep Mounting Faces Parallel
Improper parallelism at the mounting surface can cause the spring to bend midway, subjecting the bend to high stress. This can cause the spring to break at the point. The same applies to the dies in which the coil spring is used, if the parallel alignment between the dies is poor, as shown in Fig.-4, the coil spring can bend midway or exceed the 300,000 times limit prematurely. Keep the coil spring mounting faces as perfectly parallel as possible to prevent this from occurring.

⑨ Do Not Use Coil Springs in Series
If you use two coil springs in series, they will tend to bend, as shown in Fig.-5. This can cause them to move out of the shaft, counterbore holes. If this happens, this coil spring will eventually break for the same reasons as described in ① above. Moreover, due to spring load differences, the weaker spring is overcome by, and deflects more than, the stronger spring, as shown in Fig.-6. This will make the weaker spring more prone to damage, or cause it to break.

⑩ Do Not Use Two Coil Springs in Parallel
Use of two coil springs in parallel, as shown in Fig.-7, may result in the inner coils being sandwiched between the outer coils, or vice versa, when they contract. This can cause the coil springs to break for the same reason as noted in ④.

⑪ Do Not Use the Coil Spring Horizontally
When the coil spring is used horizontally, the internal surface of the spring will come into contact with the shaft, causing abrasion at those spots. The spring will eventually break at these weakened spots.

MISUMI Endurance Test Conditions

(1)Spring Guide Formula
Shaft Penetration
Shapt Dia.: -1.0mm less than d dimension

(2)Initial Deflection
1.0mm

(3)Amplitude
Deflection with 300,000 time limit value

(4)Velocity
180spm

*The maximum number of allowable operating times may vary depending on the service conditions.

Fig-1

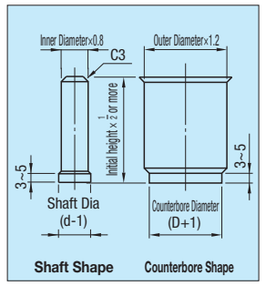


Fig-2

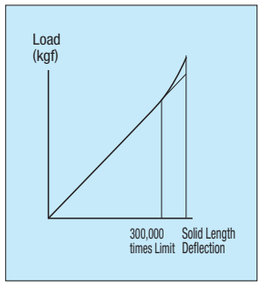


Fig-3

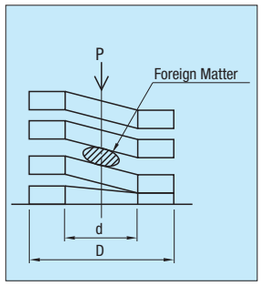


Fig-4

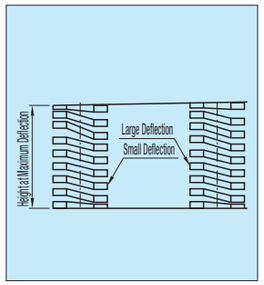


Fig-5

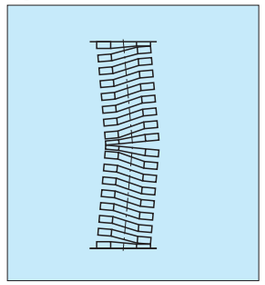


Fig-6

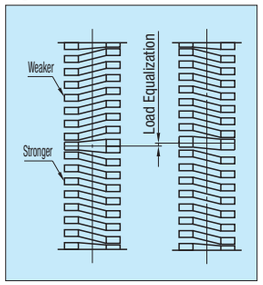
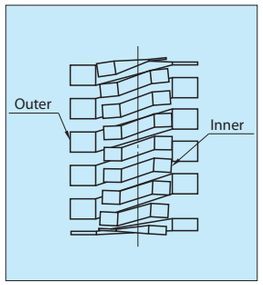


Fig-7



1. Calculation

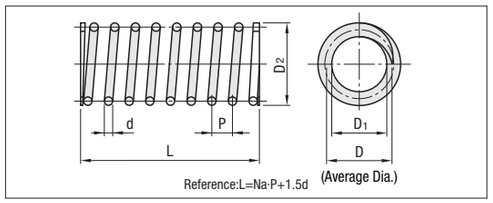
1.1 Symbols Used in Spring Design Formulas

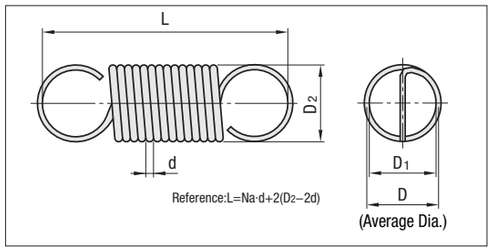
Symbols used in spring design formulae are shown in Table 1.

Table 1 Meaning of Symbols

Symbol	Meaning of Symbols	Unit
d	Diameter of Material	mm
D_1	Inner Diameter of a Coil	mm
D_2	Outer Diameter of a Coil	mm
D	Coil Mean Diameter= $\frac{D_1+D_2}{2}$	mm
N_t	Total Number of Winding	–
N_a	Number of Active Winding	–
L	Free Length(Length)	mm
H_s	Solid Length	mm
p	Pitch	mm
P_i	Initial Tension	N{kgf}
c	Spring Index $c=\frac{D}{d}$	–
G	Shear Modulus of Elasticity	N/mm²{kgf/mm²}
P	Load on Spring	N{kgf}
δ	Spring Deflection	mm
k	Spring Constant	N/mm{kgf/mm}
τ_0	Torsional Stress	N/mm²{kgf/mm²}
τ	Corrected Torsional Stress	N/mm²{kgf/mm²}
τ_i	Initial Stress	N/mm²{kgf/mm²}
χ	Stress Correction Factor	–
f	Frequency	Hz
U	Spring-Retained Energy	N·mm{kgf·mm}
ω	Per Unit Volume Material Weight	kg/mm³
W	Mass of Moving Parts	kg
g	Gravitational Acceleration (1)	mm/s²

Note (1) In spring calculations, a gravitational acceleration of 9806.65mm/s², is used.





1.2 Basic Formulas Used in Designing of Springs

1.2.1 Compression Springs, and Tension Springs without Initial Tension

$$\delta=\frac{8N_aD^3P}{Gd^4} \quad (1) \qquad \tau=\chi\tau_0 \quad (5)$$

$$k=\frac{P}{\delta}=\frac{Gd^4}{8N_aD^3} \quad (2) \qquad d=\sqrt[3]{\frac{8DP}{\pi\tau_0}}=\sqrt[3]{\frac{8\chi DP}{\pi\tau}} \quad (6)$$

$$\tau_0=\frac{8DP}{\pi d^3} \quad (3) \qquad N_a=\frac{Gd^4\delta}{8D^3P}=\frac{Gd^4}{8D^3k} \quad (7)$$

$$\tau_0=\frac{Gd\delta}{\pi N_aD^2} \quad (4) \qquad U=\frac{P\delta}{2}=\frac{k\delta^2}{2} \quad (8)$$

1.2.2 Tension Springs with Initial Tension (Where P>Pi)

$$\delta=\frac{8N_aD^3(P-P_i)}{Gd^4} \quad (1') \qquad \tau=\chi\tau_0 \quad (5')$$

$$k=\frac{P-P_i}{\delta}=\frac{Gd^4}{8N_aD^3} \quad (2') \qquad d=\sqrt[3]{\frac{8DP}{\pi\tau_0}}=\sqrt[3]{\frac{8\chi DP}{\pi\tau}} \quad (6')$$

$$\tau_0=\frac{8DP}{\pi d^3} \quad (3') \qquad N_a=\frac{Gd^4}{8D^3k}=\frac{Gd^4\delta}{8D^3(P-P_i)} \quad (7')$$

$$\tau_0=\frac{Gd\delta}{\pi N_aD^2}+\tau_i \quad (4') \qquad U=\frac{(P+P_i)\delta}{2} \quad (8')$$

1.3 Points to Note when Designing Springs

1.3.1 Shear Modulus of Elasticity

Shear modulus of elasticity (G) listed in Table 2 is recommended for the designing of springs.

Table 2 Shear Modulus of Elasticity (G)

Material		G Value N/mm² (kgf/mm²)	Symbol
Spring Steel		78×10³{8×10³}	SUP6, 7, 9, 9A, 10, 11A, 12, 13
Hard Steel Wire		78×10³{8×10³}	SW-B, SW-C
Piano Wire		78×10³{8×10³}	SWP
Oil Tempered Steel Wire		78×10³{8×10³}	SWO, SWO-V, SWOC-V, SWOSC-V, SWOSM, SWOSC-B
Stainless Steel Wire	SUS 302	69×10³{7×10³}	SUS 302
	SUS 304		SUS 304
	SUS 304N1		SUS 304N1
	SUS 316		SUS 316
	SUS 631 J1	74×10³{7.5×10³}	SUS 631 J1

1.3.2 Number of Active Winding

The number of active winding can be determined as follows.

(1) Compression Springs

$N_a=N_t-(X_1+X_2)$

Where X_1 and X_2 are the number of turns at each end of the coil.

(a) When only the end of the coil is in contact with the next free coil
[Corresponding to (a) ~ (c) in Fig.2]
$X_1=X_2=1$
Therefore, $N_a=N_t-2$

(b) When the end of the coil is not in contact with the next coil, and the spring end has $\frac{3}{4}$ of a turn.
[Corresponding to (a) ~ (e) in Fig.2]
$X_1=X_2=0.75$
Therefore, $N_a=N_t-1.5$

(2) Tension Springs The number of active winding can be determined as follows. But hooks are ignored.

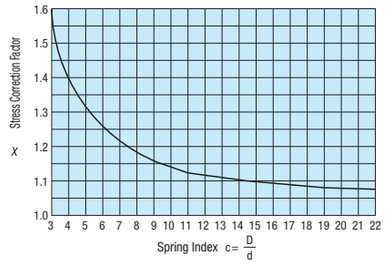
$N_a=N_t$

1.3.3 Stress Correction Factor

The stress correction factor relative to the spring index (C) can be determined by using the following formula or based on Fig.1.

$$\chi=\frac{4c-1}{4c-4}+\frac{0.615}{c} \quad (9)$$

Fig-1.Stress Correction Factor : χ



1.3.4 Solid Length

The solid length of a spring can normally be obtained by using the following simplified formula. Generally, the purchaser of a compression spring does not specify the solid length of the spring.

$$H_s=(N_t-1)d+(t_1+t_2) \quad (10)$$

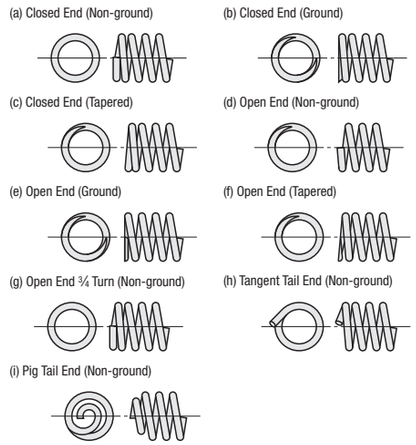
where, (t_1+t_2) is the sum of the thicknesses of the coil ends.

As for those compression springs, both ends of which are shaped as shown in (b), (c), (e) or (f) of Figure 2 and for which the solid length needs to be specified, the following formula can be used to obtain the maximum solid length. However, the actual maximum solid length can be greater than the value thus calculated depending on the shape of the spring in question.

$$H_s=N_t\times d_{max} \quad (11)$$

where d_{max} : Material diameter measured when the maximum tolerance is applied for d.

Fig-2. Coil End Shape



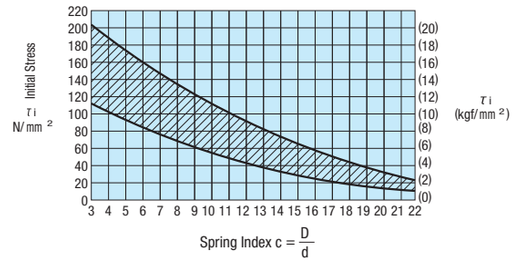
1.3.5 Initial Tension of Tension Springs

Cold-formed solid-coiled tension springs are subjected to initial tension (Pi). The initial tension can be obtained using the following formula.

$$P_i=\frac{\pi d^3}{8D}\tau_i \quad (12)$$

On solid-coiled piano wire, hard steel wire, and other steel wires that are not low-temperature annealed, the initial stress occurs within the hatched range shown in Fig.3. However, if materials other than steel wire are used, or the wire in question is low-temperature annealed, the initial stress taken from within the hatched range in Fig.3 should be corrected as follows.

Fig-3 Initial Stress : τ_i (Spring formed from steel coil, not low-temperature annealed)



(1) When using stainless steel wire, decrease the initial stress value for steel wire by 15%.
(2) If the spring is low-temperature annealed after being formed, decrease the value by 20~35% for springs made of piano wire, hard steel wire, or other stainless steel wires, and by 15~25% for springs made of stainless steel wire.

Reference In place of Fig.3, the following empirical formula can be used to establish the initial stress for springs before low-temperature annealing.

$$\tau_i=\frac{G}{100c}$$

The following examples are for applications of this formula to obtain the initial tension.

(1) Piano Wire / Hard Steel Wire [G=78×10³N/mm²{8×10³kgf/mm²}]

Initial Stress $\tau_i=\frac{G}{100c}\times0.75$ (0.75 by 25, reduction by low-temperature annealing).

Initial Tension $P_i=\frac{\pi d^3}{8D}\tau_i=\frac{Gd^4}{255D^2}\times0.75=\frac{229d^4}{D^2}\left\{\frac{24d^4}{D^2}\right\}$

(2) When using stainless steel wire [G=69×10³N/mm²{7×10³kgf/mm²}]

Initial Stress $\tau_i=\frac{G}{100c}\times0.8$(0.8 by 20, reduction by low-temperature annealing).

Initial Tension $P_i=\frac{\pi d^3}{8D}\tau_i=\frac{Gd^4}{255D^2}\times0.8=\frac{216d^4}{D^2}\left\{\frac{22d^4}{D^2}\right\}$

1.3.6 Surging

In order to prevent surging, the spring should be selected in such a way that its natural frequency does not resonate with any of the natural frequencies that may act upon the spring.
The initial tension can be obtained using the following formula.

$$f=a\sqrt{\frac{kg}{W}}=a\frac{70d}{\pi N_aD^2}\sqrt{\frac{G}{\omega}} \quad (13)$$

where, $a=\frac{i}{2}$:when both spring ends are either free or fixed

$a=\frac{2i-1}{4}$:When one spring end is fixed while the other end is free i=1,2,3

G=78×10³N/mm²{8×10³kgf/mm²},
w=76.93×10⁻⁶ N/mm³{7.85×10⁻⁶kgf/mm³}

If both spring ends are either free or fixed, the natural primary frequency of a spring can be obtained as follows.

$$f_1=3.56\times10^5\frac{d}{N_aD^2} \quad (13')$$

1.3.7 Other Points to Note

In spring design calculations, the following points should also be taken into account.

(1) Spring Index Excessive local stress can result from too small spring index. Machinability should be considered if the spring index is too great or small. The spring index should be selected from the range of 4~15 when hot forming, and from the range of 4~22 when cold forming.

(2) Slenderness Ratio In order to ensure the correct number of active winding, the slenderness ratio for a compression spring (Ratio of free height to coil mean diameter) should be 0.8 or greater. Furthermore, buckling considered, it is generally recommended that the slenderness ratio be selected from the range of 0.8 ~ 4 to prevent buckling.

(3) Number of Active Winding The number of active winding should be 3 or more in order to stabilize spring characteristics.

(4) Pitch Generally, when the pitch exceeds 0.5D, the spring deflection (load) increases to the extent that the coil diameter changes. This requires correction of the deflection and torsional stress values obtained by the basic formula. Therefore, the pitch should be 0.5D or smaller. The pitch can generally be estimated using the following simplified formula.

$$p=\frac{L-H_s}{N_a}+d \quad (14)$$

Shock Absorbers
Water & Coolant Resistant Type

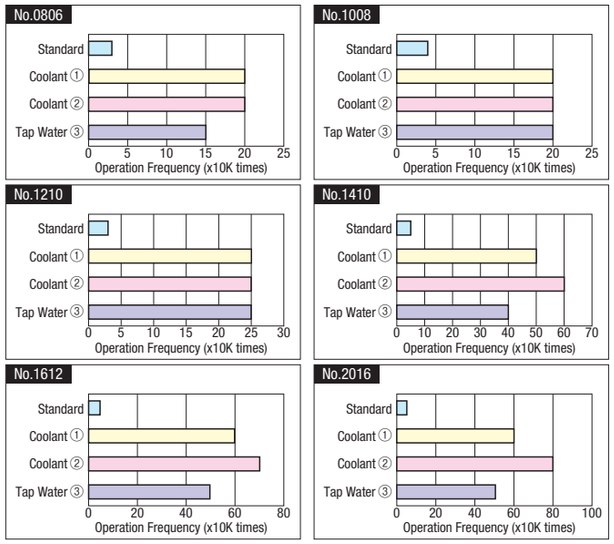
■ Features of Water & Coolant Resistant Type

- Having a structure of protection seals for fluid intrusions makes usable in wet conditions, suitable for machine tools and related applications.
- Replacement is possible with Standard Type since mounting O.D. screw size is the same.
- Suitable for water-soluble cutting oil A1 [JIS K2241-2000], but also available for water-insoluble cutting oil or under wet conditions. (In case of using water instead of water-soluble cutting oil, the durability may be inferior.)

■ Durability Test Data (Ref.)

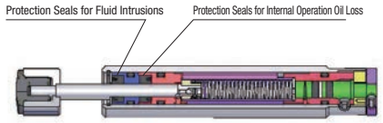
Test Condition

- Coolant①:JIS A1 Emulsion Water-Soluble Cutting Oil (Yushiro Chemical Industry Co., Ltd. Yushiroken FGE330 Dilution 20 times)
- Coolant②:JIS N1 Water-Insoluble Cutting Oil (Yushiro Chemical Industry Co., Ltd. Yushiro Oil CG8)
- ③: Tap Water
- Load: Ø40 Air Cylinder (Cylinder Propulsion only)
- Collision Cycle: 30/min.
- Dripping: 4cc/min.

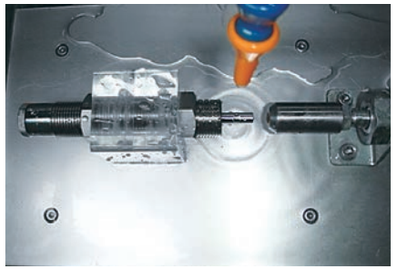


- Durability results may vary depending on each test condition. Testing fluid or volume may affect the results. Prior tests are recommended to obtain appropriate results.
- When used in environments where the piston rods are kept from fluid contacts, the internal oil may be lost by premature leakage.

■ Inner Structure

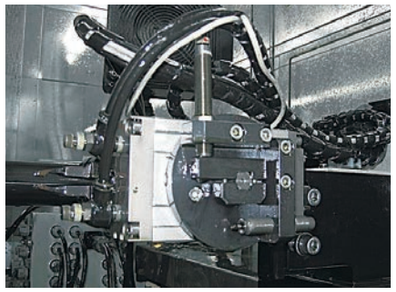


■ Test Scene



■ App. Example

Rotating Table Stopper [Dedicated Machining Equipment]



Gas Springs
Overview

Gas Springs

- High pressure gas (Nitrogen gas: non-combustible) is sealed in a cylinder, and the gas reaction force is used as spring. Because this small gas spring receive small spring constant from large initial load in spite of its size, it can be used for wide range of applications including machines, furniture, cars, office automation equipments, etc.

Features

- In spite of its size and weight, large spring (reaction) force can be obtained.
- Spring (reaction) force is almost constant throughout its stroke.
- Can be designed as required for wide applications.

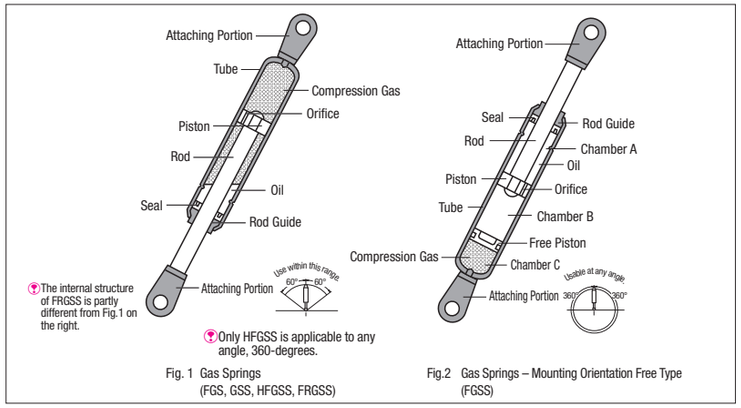


Fig. 1 Gas Springs (FGS, GSS, HFGSS, FRGSS)

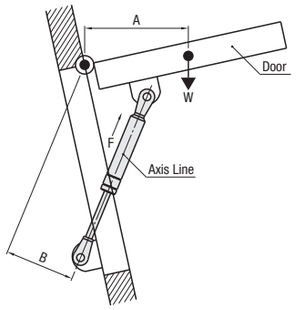
Fig.2 Gas Springs – Mounting Orientation Free Type (FGSS)

About Initial Selection

1. Calculate the necessary reaction force (F) through the following formula, then find out possible model types.

$$F=\frac{W \times A}{B}$$

F : Necessary Reaction Force (at Max. Length)
W : Weight of Doors, etc.
A : Horizontal Distance between Fulcrum (Door Hinge, etc.) and the Center of Gravity
B : Vertical Distance between Fulcrum (Door Hinge, etc.) and the Axis of Gas Spring



2. Select Fx1.1 or more for the gas spring reaction force. Gas reaction forces may vary within about ±10%.
3. If required reaction force (Fx1.1) is larger than the reaction force at the max. length of gas spring -( ) mm, use 2 or more springs.
4. Reaction forces are designed at 20°C. Reaction forces increase or decrease as the temperature changes.

Gas reaction force at the max. length -10 (5) mm and the max. length -(s) mm are listed in this catalog. Gas reaction force generally changes proportionately. If the gas reaction force on a certain stroke is required, connect the 2 points with a straight line as shown in Fig. 3 and read the value on the stroke to conjecture.

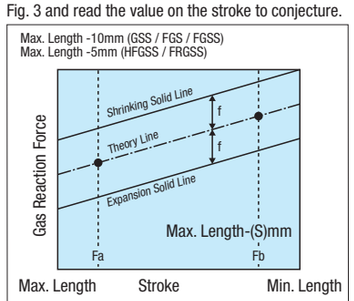


Fig.3 Gas Spring Reaction Force

f= Internal Sliding Resistance (Theoretical Value x0.1)

About Final Selection

- Load may vary depending on door angles or gas spring mounting positions. Calculate the reaction force moment based on the subject design drawing.

Precautions for Use (for FGS, GSS, FGSS, HFGSS and FRGSS)

- Pay attention to temperature of gas springs during use. Do not store for prolonged duration. It will cause premature seal deterioration and reaction force decline. (Product Temperature Range: GSS, FGSS: -20°C ~ 60°C / HFGSS: -20°C ~ 80°C / FRGSS: -30°C ~ 80°C Some products have different temperature range. Confirm on each product page.)
- Gas reaction forces are slightly different among individual products and may change depending on the temperature.
- Reaction force may decrease depending on the operating condition and times of use. Please replace it when it cannot reach the necessary reaction force.
- Do not store or use in the environments where the rod may rust, or in chemical atmosphere. Furthermore, do not paint the gas spring.
- Do not damage the cylinders and rods. If rods are wrapped with tape or plastic strings, adhesives or fibers remained on the surface will come inside, resulting in gas/oil leakage. Be sure to see if there is no rust, scratches, adhesives and foreign objects on the rod before use.
- Do not apply forces like bending load and torsion. Receiving load only with gas springs results in unbalanced load, which causes early deterioration and gas/oil leakage. For rotating motion, be sure to secure smooth sliding on the hinge. For linear motion, install a guide, etc. to prevent unbalanced load.
- Do not extend gas springs beyond its max. length. Even in the max. stroke (during compression), it must remain about 10mm away from the stroke end. Do not extend and compress at high speeds (with 1m/s or more).
- Use FGS and GSS with the cylinder side up and the rod side down, so that internal oil protects the rubber seal. For FGS, GSS and FRGSS, do not tilt more than 60 degrees. When it is necessary to temporarily store, do not tilt more than 60 degrees.
- Although there is no restriction in the use angle for the FGSS and HFGSS, rod downward is recommended.

Features of Mounting Orientation Free Gas Springs (FGSS)

- **Mounting Orientation Free Gas Springs**

1. Nitrogen gas (non-combustible) is sealed in the gas chamber C with a free moving piston intervening, and gas reaction force is used as a spring.
2. Gas chamber C has a constant reaction force in extending direction since it pressurizes oil chamber AB. Therefore the size of reaction force depends on the inner pressure of gas chamber C.
3. When rod moves from the predetermined position, oil in chamber AB moves through orifice hole of the piston.
4. The rod volume change in the cylinder is adjusted by the change of gas chamber C.

Urethane, Rubbers and Sponges
Features of High Performance Urethane and Rubber

Urethane Properties

The characteristic values of tensile strength and elongation are tested based on the JIS standard K6251.

Item	Unit	Urethane															
		Standard					Vulkollan®		Abrasion Resistant		Ceramic Urethane				Heat Resistant	Low Rebound	Extra Low Hardness
Hardness	Shore A	95	90	70	50	30	92	68	90	70	95	90	70	50	90	70	15
Specific Gravity	-	1.13	1.13	1.20	1.20	1.20	1.26		1.20		1.13	1.13	1.20	1.15	1.13	1.03	1.02
Tensile Strength	MPa	44	27	56	47	27	46.5	60	44.6	31.3	42	26	53	45	44.6	11.8	0.6
Elongation	%	380	470	720	520	600	690	650	530	650	360	440	680	490	530	250	445
Heat resistance	°C	70					80 (120 deg. for Short Time)		70		70	70			120	70	80
Low Temp. Resistance	°C	-40	-20				-20		-20		-40	-20			-20	-20	-40

Urethane (Ether Type, Ester Type) Property Comparison

Properties		Ether Type (Shore A95, 90)	Ester Type (Shore A70, 50, 30)
Tensile Strength			OK
Elongation			OK
Tear Strength			OK
Impact Resilience		OK	
Abrasion Resistance	Slip Wear		OK
	Shock Wear	OK	
Hydrolysis Resistance		OK	
Oil Resistance			OK
Strength			OK
Durability			OK
Acid Resistance, Alkali Resistance		OK	

Discoloration of Urethane

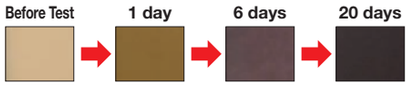
Urethane may experience discoloration and yellowing with age.
Urethane turns yellow by aging, but physical property or characteristics remain unchanged.
Discoloration is distinct especially with antistatic urethane and Vulkollan®. See the explanation below.

• Aging Discoloration of Antistatic Urethane

* Time to turn yellow and level of yellowing vary depending on operating environment, etc.

• Discoloration of Vulkollan®

Vulkollan® has poorer color stability against ultraviolet rays than general urethanes due to its unique composition.
Pictures below show the process of change in colors of a sample exposed to outdoor sunlight.



* No change in physical property or characteristics due to discoloration.

Features of Various Urethanes

Material	Features
Standard Urethane Ether / Ester Polyurethane	Excels in strength in repeat use and shock-absorbing properties. Can be used for applications such as Mechanical Stoppers. Ester Type is Hydrolytic. Do not use in humid and wet areas.
Antistatic Urethane	Excels in antistatic effect. Can be used where mechanical strength and anti-static measures are required.
Heat Resistant Urethane	CThis urethane has up to 120°C heat resistance. (70 deg. for the standard urethane) Suitable for use in applications where high material strength in high-temperature range is required.
Super Abrasion Resistant Urethane (Vulkollan®)	Vulkollan® is a super abrasion resistant urethane which is far superior to conventional urethanes in abrasion resistance and load bearing. Excels in tearing strength. 6 times higher in abrasion resistance and 1.5 times in material strength than the standard urethane.
Abrasion Resistant Urethane	Unique composition realized abrasion resistance 2.5 times higher than standard urethane at low cost. Helps to reduce the exchange frequency. Color is dark brown.
Ceramic Urethane	These MISUMI original urethane sheets are unique mixture of ceramic particles. Vulkollan® and Wear Resistant Urethane have resistant property against "surface", and the Ceramic Urethane has resistance against "line". Compared to the Standard Urethane and various rubbers, the Ceramic Urethane is relatively smooth in its machined surfaces though it is lower in hardness. Note that cutting due to contact may cause dust.

• Characteristic Values of Antistatic Urethane

Specific Volume Resistivity	$2.1 \times 10^8 \Omega \cdot cm$
Surface Resistivity	$4.0 \times 10^8 \Omega$

(Test Conditions: Temperature 30°C Humidity 60%)
All other properties are equal to those of urethane of the same hardness.

• Taber Abrasion Test Results

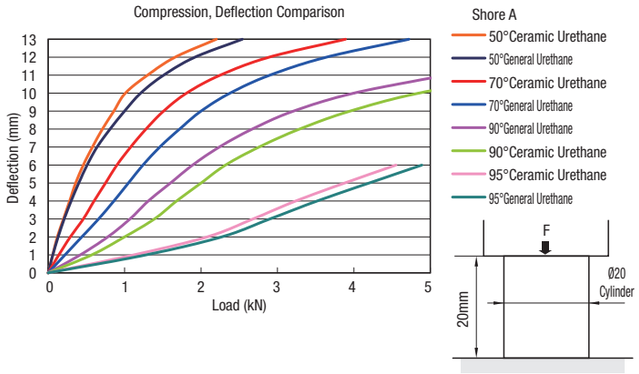
Test \ Material	Standard Urethane	Super Abrasion esistant Vulkollan®	Abrasion Resistant Urethane	Ceramic Urethane
Abrasion Test (Taber Method) Abrasion Volume (mm^3)	197.3	33.9	73.8	101

Testing Method
JIS K 7204: 1999 "Plastics - Determination of Resistance to Wear by Abrasive Wheels"
Abrasive Wheel: H, 22 Load: 9.8N
Number of Strokes: 1,000 Test Parameter: 1
The values are not guaranteed but measured ones.

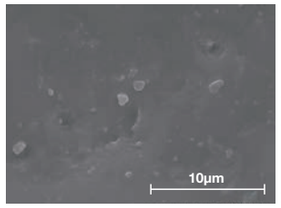
Features of Ceramic Urethane

• Deflection Comparison of Standard Urethane and Ceramic Urethane

Deflection between the ceramic urethane and the standard urethane differs when the same load is applied. Careful consideration should be given for replacement.



• Enlarged View of Ceramic Urethane

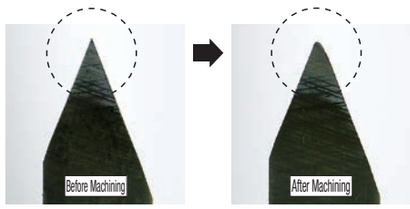


Please be advised that white section seen on the photo is ceramic powder particles occurring during the manufacturing process. These micro-particles are very fine not to create any surface roughness even when they fall off.

(Close-up: x5,000)

• Change after Ceramic Urethane is Machined

Change after ceramic urethane round bar is machined (Lathe: 600rev/min.) for 2 minutes.



Rubber Properties

The characteristic values of tensile strength and elongation are tested based on the JIS standard K6251.

Item	Unit	Nitrile Rubber (NBR)		Chloroprene Rubber (CR)	Ethylene Rubber (EPDM)	Butyl Rubber (IIR)	Fluororubber (FPM)		Silicon Rubber (SI)			Low Elasticity Rubber (Hanenaito®)		Natural Rubber (NR)
									Standard		High Strength			
Hardness	Shore A	70	50	65	65	65	80	60	70	50	50	57	32	45
Specific Gravity	-	1.6	1.3	1.6	1.2	1.5	1.8	1.9	1.2		1.2	1.3	1.2	0.9
Tensile Strength	MPa	12.7	4.4	13.3	12.8	7.5	12.5	10.8	7.4	8.8	7.8	8.3	10.3	16.1
Elongation	%	370	400	460	490	380	330	270	300	330	400	810	840	730
Maximum Operating Temperature	°C	90	99	100	120	120	230	230	200		200	60	60	70
Temperature of Continuous Use	°C	80	80	80	80	80	210	210	150		150	30	30	70
Low Temp. Resistance	°C	-10	-10	-35	-40	-30	-10	-10	-70		-50	10	10	0

Features of Low Rebound Urethane and Low Elasticity Rubber (Hanenaito®)

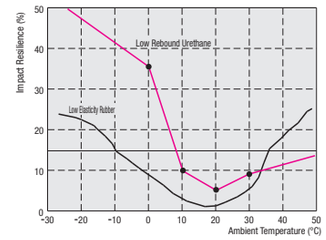
・Low Rebound Urethane
It has the same properties as urethane, and excels in shock absorption. With more resistance to permanent compression than standard urethane, it is hard to deform. Not suitable for absorption of large impact energy because its tensile strength and elongation resistance are weaker than that of urethane of the same hardness.
・Low Elasticity Rubber (Hanenaito®) Hanenaito® is a registered trademark of Naigai Rubber Industry Co., Ltd.
It is used as cushioning material for pallet damper, conveyor machine, precision instrument etc, because of its good elongation and shock absorption. Also it is used as vibration absorption materials of various precision instruments because of its excellent vibration absorption.

Reference: Compression Set of Low Rebound Urethane

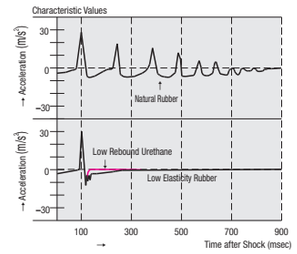
Low Rebound Urethane	1%
Urethane (Shore A70)	25%

* The above data is measured at room temperature 23°C.
* 70°Cx24H 25% Compression

Impact Resilience Variation by Temperature of Low Elasticity Rubber and Low Rebound Urethane

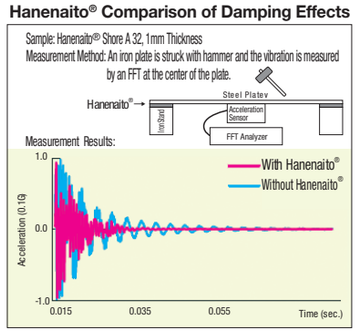


Shock Absorption Comparison of Low Elasticity Rubber and Low Rebound Urethane



Listed values are for reference, not guaranteed.

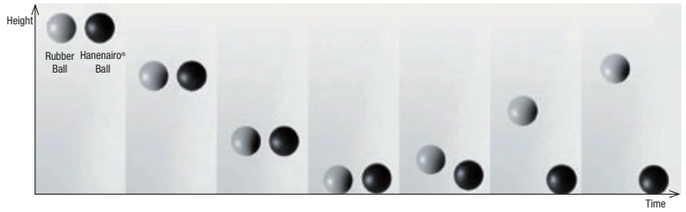
Hanenaito® Comparison of Damping Effects



• Correlation of Hardness and Rebound Force of Shock Absorbing Materials

		Hardness	
		Extra Low (F Hardness)	High (A Hardness)
Rebound	Low	Shock Absorbing Gel	Low Rebound Urethane Low Elasticity Rubber
	Large		General Purpose Urethane General Purpose Rubber

Drop Comparison of Rubber Ball and Hanenaito® Ball



Elasticity of Shock Absorbing Gel P.410, 435

• Shock Absorbing Gel

• Urethane, Shore A50

A major characteristic is the three-dimensional slow recovery, the function to recover after compression slowly and in multiple directions.
Pressed as thin as shown in the photo and recovers to the original shape gradually after being released from pressure.
* The double-layer structure of the gel part reduces stickiness.

• Properties of Shock Absorbing Gel

Item	Unit	Shock Absorbing Gel
Specific Gravity	-	1.0
Hardness	Asker F	75
Tensile Strength	MPa	0.81
Elongation	%	885
Heat resistance	°C	100
Low Temp. Resistance	°C	-10

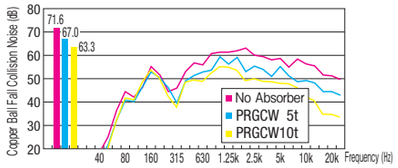
*Above figures are the measured values for the shock absorbing gel as a material, and there are slight differences between the values for the bumping products made with this material featured.

Features of Shock Absorbing Foam

Excellent sound damping and vibration absorbing characteristics.
Flexible material can be pasted on curved surfaces with ease.
Lightweight material can be applied on large panel areas.
Best suited for human body protection. Can be pasted in multi-layers where more protection is needed.

Steel Ball Collision Noise Level Test

PRGCW Comparison Data of PRGCW Copper Ball Collision Noise



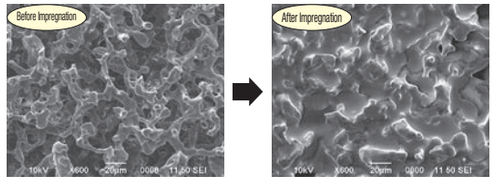
Item	No Absorber	PRGCW5	PRGCW10
Collision Noise (dB)	71.6	67	63.3
Sound Pressure	-	40% Reduced Sound Pressure	60% Reduced Sound Pressure

*A steel ball (Ø20, 36g) is dropped on a wooden base from a 55cm height, and the sound pressure level is measured with a microphone at a distance of 50m, positioned 50cm above the ground.

Features of Special Urethane Foam SOFRAS®

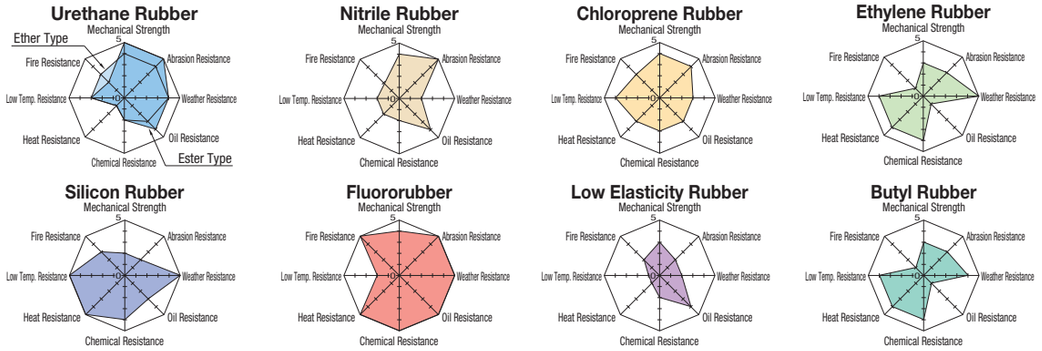
This special urethane foam excels in water retention and abrasion resistance allowing it to be used in industrial purposes such as application and moisture absorption. SOFRAS® excels in abrasion resistance and requires less concerns about dust shedding, whereas the use of sponges and felts may result in shedding of dust and felt fiber.

• Enlarged Photo of Grease-impregnated Special Urethane



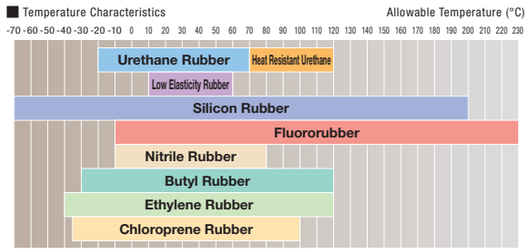
Urethane, Rubbers and Sponges
Rubber Properties

Rubber Properties



Material	Features
Urethane Rubber	Superior in mechanical strength and abrasion resistance to other rubbers. Especially excels in strength in repeat use and shock-absorbing properties. Can be used for applications such as Mechanical Stopper. Excellent in oil resistance but poor in chemical resistance. Ester Type is Hydrolytic. Do not use in humid and wet areas.
Nitrile Rubber (NBR)	Acrylic Nitrile Butadiene Rubber Economical general-purpose rubber excellent in oil resistance. Used for various applications such as O-rings and gaskets.
Chloroprene Rubber (CR)	Chloroprene Rubber Well-balanced synthetic rubber excellent in weather, heat, oil and chemical resistance. Non-staining chloroprene rubber which minimizes contamination from contacting materials is also available.
Ethylene Rubber (EPDM)	Excels in weather, low temperature and chemical resistance. Can be used for general-purpose applications such as gaskets and doorstops.
Silicon Rubber (SI)	Excels in heat resistance and electric property (insulation). Physiologically safe and can be used for medical, food-related and electronic devices which require heat resistance.
Fluororubber (FPM)	Expensive, but widely used with its excellent heat, oil, solvent and chemical resistance. Fluororubber is generally known as Teflon and Viton®. Has the highest resistance to ozone, heat, oil and chemicals in rubbers.
Low Elasticity Rubber (Hanenaito®)	Excels in shock and vibration resistance and absorbs energy without rebound. Physical property and durability are equal to general rubbers. Widely used as components for quiet and low-vibration products.
Butyl Rubber (IIR)	Isobutylene Isoprene Rubber Excellent in heat, cold and weather resistance, and good in water and chemical resistance.

Comparison of Allowable Temperature



Comparison of Chemical Resistance

	Urethane	Nitrile	Chloroprene	Ethylene	Butyl	Fluorine	Silicon	Low Elasticity
Gasoline Light Oil	++	++	+	--	--	++	0-+	0
Water	0	++	++	++	++	++	+	0
Strong Acid	--	+	+	+	++	++	0	0
Strong Alkali	--	+	++	++	++	--	++	+
Ether	--	-- -0	-- -0	+	0-+	-- -0	-- -0	0
Keton	--	--	-- -+	++	++	--	+	--

++= Very good, += Good, 0= Acceptable, --= Not Acceptable

Indication of Hardness

Three hardness categories are used for MISUMI's Urethane, Rubbers and Sponges.

①**Shore A**
Used to describe the hardness of Urethane and Rubbers.
"Shore A 70" means hardness measured by using type-A Durometer in accordance with New JIS Standard K6253.

②**ASKER C**
Used to describe the hardness of Sponges.
"Asker C 25" means hardness measured by using a spring type hardness tester Asker C in accordance with SRIS 0101 (Standard by the Society of Rubber Industry, Japan).
For those two above, larger value indicates harder material.

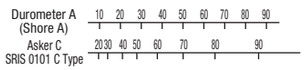
③**Penetration**
Used to describe the hardness of gel materials.
JIS K 2207 Standardized testing method. It indicates hardness by the penetrated length that a pin of specified weight penetrates in a sample perpendicularly.
The value is one penetration for 1/10mm length. (Larger value indicates softer material.)

Hardness Images

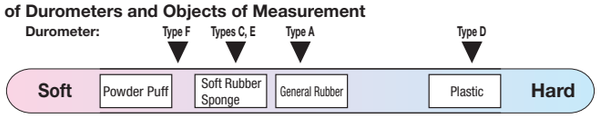
Shore A95	Golf Ball
Shore A90	Baseball
Shore A70	Softball
Shore A50	Plastic Eraser
Shore A30	Bicycle Tube
Shore A15	Firm Gelatin

Hard ↕ Soft

•Margin of Error: ±5



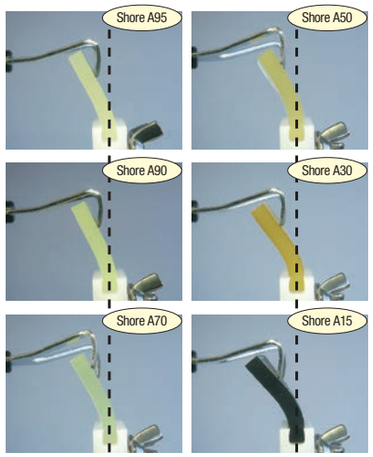
•**Types of Durometers and Objects of Measurement**



There are various types of durometer instrument as shown above to measure the hardness of a material, depending on the property of the measured material. For urethane and rubber, Type A (Asker Durometer Type A) compliant with JIS K 6253 is most commonly used. Hardness of materials softer than urethane and rubber is measured by Asker Type C or Type E. Shock absorbing gel is soft and super flexible material whose hardness is measured by Asker Type F.

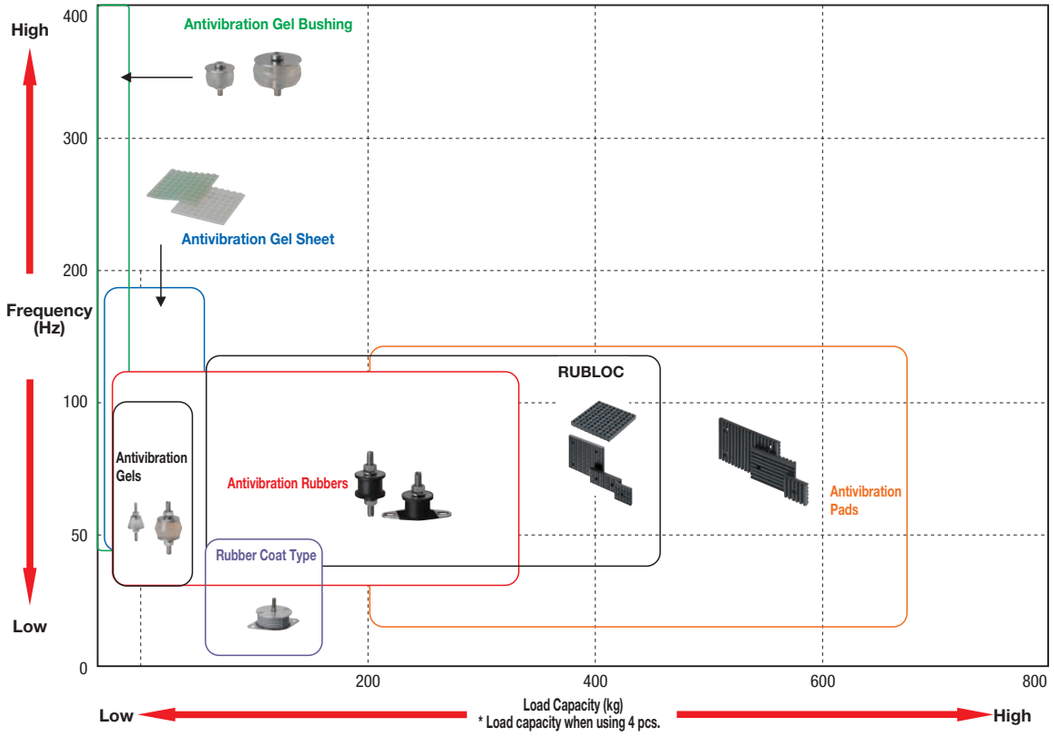
Ref.: Bending Test by Hardness

Test Conditions: Standard Urethane, Thickness 5mm, Width 30mm, Length 40mm
When pulled by push-pull gauge with the load 5N:



Antivibration Materials
Vibration Transmissibility Data

Vibration Damping Proofing Antivibration Materials Selection Chart



Antivibration Materials

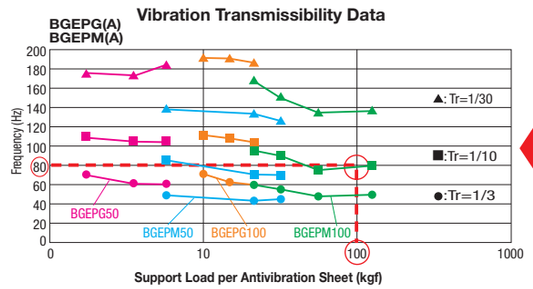
Selection Methods for Antivibration Gel Sheet, Antivibration Pads and Antivibration Gel, Antivibration Rubber
Select the antivibration material by referring to the table above, and then determine the nominal by referring vibration transmissibility data of each product.

Vibration Transmissibility Data

Antivibration effects of antivibration material (Tr= Vibration Transmissibility) depend on load and characteristic frequency of supported object (natural frequency).
Graphs on each page have been generated by calculating the expected antivibration effects from the support load per antivibration material and the frequency of the supported object.
Select the optimal antivibration materials according to the following instruction.

1. Find out the support load = _____(kgf) for each antivibration material.
   Evaluate the frequency= _____(Hz) of the subject of antivibration.
   (Frequency = Number of Vibration per Second
   When motor speed is 4800rpm, 4800(rpm)/60(s)=80(Hz))
2. By plotting the value 1 on the graph, useable antivibration material type and vibration transmissibility (Tr) can be found.

Ex. Support Load for Each Antivibration Material = 100(kgf)
Frequency of Antivibration Object = 80(Hz)
When BGEPM100 is selected, the vibration transmissibility will approximately be 1/10.



More antivibration effects can be expected from smaller Tr (vibration transmissibility) values.

Tr=1/30 means to suppress the vibration to 1/30
Tr=1/3 means to suppress the vibration to 1/3

Aluminum Extrusion Tolerance Data

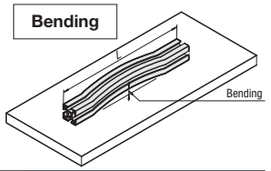
Aluminum Extrusion JIS Standards

• Bend Tolerance (Special Grade)

Unit: mm

Diameter of Circumscribed Circle mm	Minimum Thickness mm	Per Arbitrary Section of 300mm Length	per Full Length (L) mm
38 or less	2.4 or less	1.3 or less	1.3 x $\frac{L}{300}$ or Less
	Over 2.4	0.3 or less	0.3 x $\frac{L}{300}$ or Less
Over 38 to 300 or less	-	0.3 or less	0.3 x $\frac{L}{300}$ or Less
Over 300	-	0.5 or less	0.5 x $\frac{L}{300}$ or Less

Bending



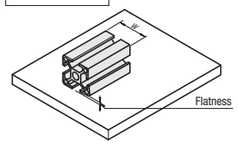
Note
- Given values are for extrusions placed on flat surfaces with minimized bends by own weight.
- When the overall length is not an integral multiple of 300mm, determine the tolerance by rounding up the remainder length to 300mm.

• Flatness Tolerance

Unit: mm

Shape Type / Minimum Thickness of Measurement Point / Width	General Shape	Hollow Shape	
	-	4.7mm or Less	Over 4.7mm
25mm or Less	0.10 or less	0.15 or less	0.10 or less
Over 25mm	0.004xW or Less	0.006xW or Less	0.004xW or Less
Per Arbitrary Section of 25mm Width	0.10 or less	0.15 or less	0.10 or less

Flatness



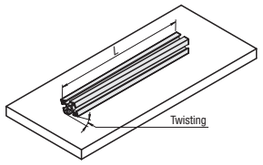
Note: Not Applicable to the plane including open section.

• Twist Tolerance

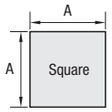
Unit: degree

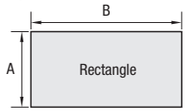
Diameter of Circumscribed Circle mm	Length	
	Per Arbitrary Section of 300mm Length	per Full Length (L) mm
38 or less	1 or less	1 x $\frac{L}{300}$ or Less; However, Max. Value is 7
Over 38 to 76 or less	1/2 or less	$\frac{1}{2}$ x $\frac{L}{300}$ or Less; However, Max. Value 5
Over 76	1/4 or less	$\frac{1}{4}$ x $\frac{L}{300}$ or Less; However, Max. Value 3

Twisting



Reference: Tolerance of Outer Dimension (JIS)





Unit: mm

Outer Dimension Tolerance (JIS)	A Dimension
HFS5-2020	±0.41
HFS5-4040	±0.54
HFS6-3030	
HFS6-6060	±0.86
HFS8-4040	±0.54
HFS8-8080	±0.86
HFS8-4545	±0.60
HFS8-9090	±0.86

Outer Dimension Tolerance (JIS)	A Dimension	B Dimension
HFS5-2040	±0.41	±0.54
HFS6-3060	±0.54	±0.86
HFS8-4080		
HFS8-4590	±0.60	

*MISUMI Aluminum Extrusions are within JIS dimension tolerance above.

Mechanical Properties of Aluminum Extrusions

	JIS Standard (Reference)	JIS Standard (Reference)	Actual Measurement	JIS Standard (Reference)
Series	HFS Series	GFS Series		NFS Series
Material (JIS Symbol)	EN A6N01SS-T5	EN A6061SS-T6 Equivalent		EN A6063S-T5
Tensile Strength (N/mm²)	245 or more	265 or more	278	155 or more
Proof Stress (N/mm²)	205 or more	245 or more	247	110 or more
Longitudinal Elastic Modulus (N/mm²)	69972	69972		69972
Brinell Hardness (HB)	88	88		88
Surface Treatment	Anodize 9μm or more	Anodize 9μm or more		Anodize 9μm or more

Aluminum Extrusion Load Capacity Calculations

Deflection Calculations

The following pages assist in optimum extrusion type selections by providing a quick Load vs. Deflection Chart (below) and calculation formulas (right-hand page). In general, load calculations are typically based on beam's both ends supported for structural safety.

Selection Example

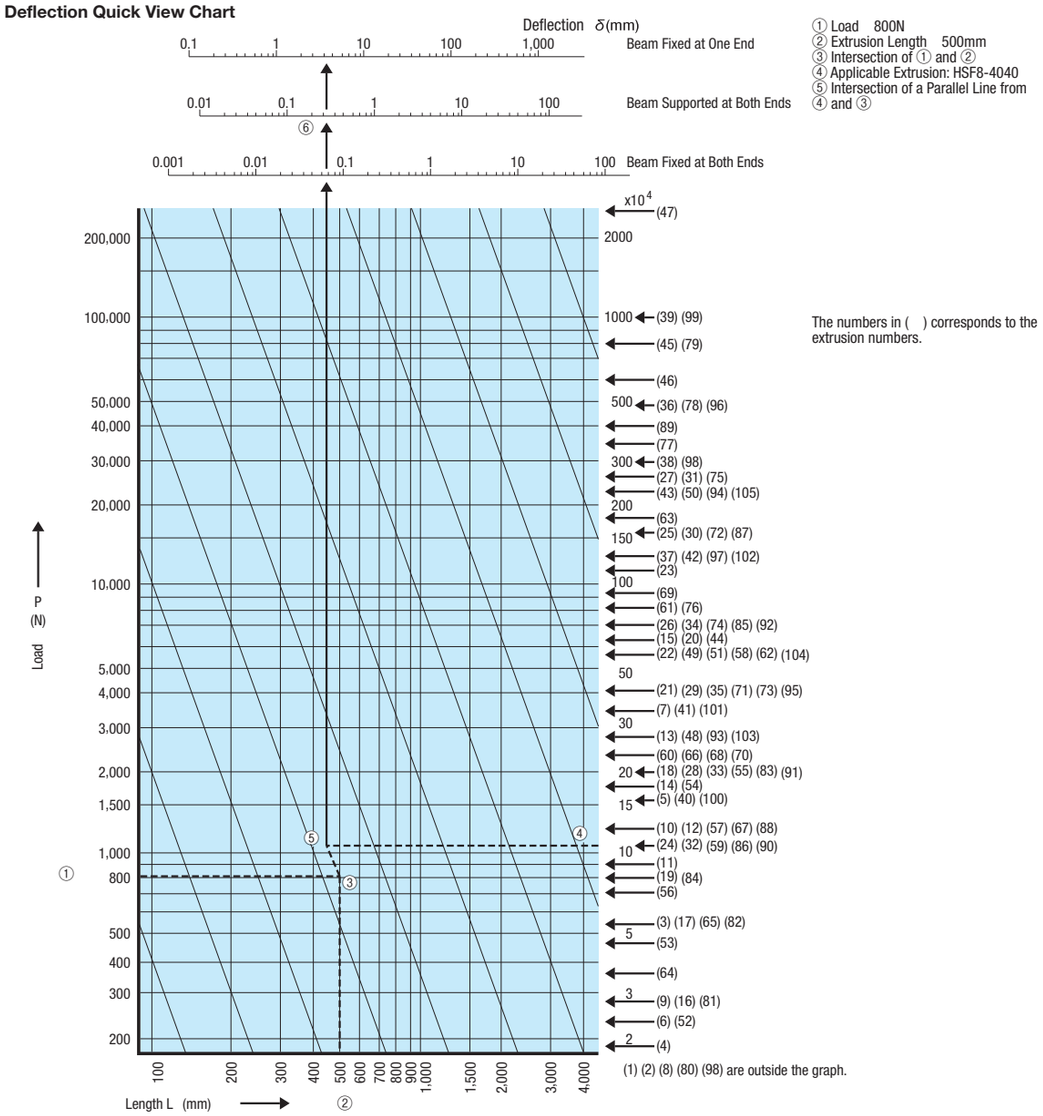
Values used for this example
Load 800N
Extrusion HFS8-4040
Length 500 mm

Step
(1) Find a point ① on the Y (Load) axis for the applied load P (Unit: N)*1.
(2) Find a point (②) on the X (Length) axis for the extrusion length.
(3) Draw a horizontal line from ① and a vertical line from ②, and name the intersection of the two as ③.
(4) Find a point ④ on the right hand Y axis for the Cross Sectional Moment of Inertia of the extrusion used.
(5) Draw a horizontal line from ④, and draw a parallel line to the graph's diagonal lines from ③.
(6) Name the intersection of the lines from (5) as ⑤.
(7) Draw a line UP from ⑤ and locate an intersection ⑥ corresponding to the extrusion support method used.
Result: According to the example values used and the calculation based on the values, the deflection amount would be 0.3mm when the extrusion is supported at both ends.

*1. Conversion: 1kgf=9.80665N (Ex.) 81.6kgf=800N

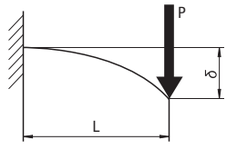
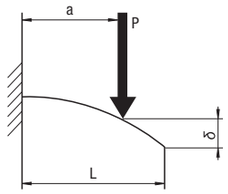
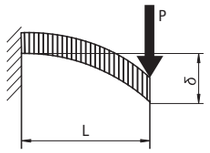
• MISUMI defines the Load Capacity (Max Allowable Load) to be a deflection 1/1000 of the extrusion length.

• Deflection Quick View Chart

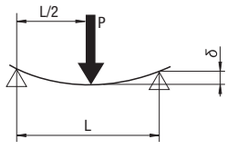
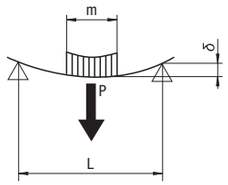
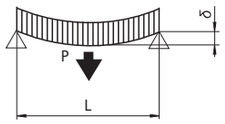
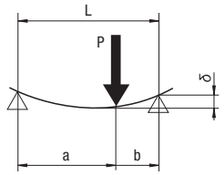


Aluminum Extrusion
Load Capacity Calculations

• **Deflection Calculations**

	1	2	3
Cantilever			
Deflection δ	$\delta = \frac{P \cdot L^3}{3E \cdot I}$	$\delta = \frac{P \cdot a^3}{3E \cdot I}$	$\delta = \frac{P \cdot L^3}{8E \cdot I}$

means that the load is equally distributed.

	4	5	6	7
Both Ends Supported				
Deflection δ	$\delta = \frac{P \cdot L^3}{48E \cdot I}$	$\delta = \frac{P \cdot L^3}{(48+\frac{29m}{l}) \cdot E \cdot I}$	$\delta = \frac{5P \cdot L^3}{384E \cdot I}$	$\delta = \frac{P \cdot a^2 \cdot b^2}{3E \cdot I \cdot L}$

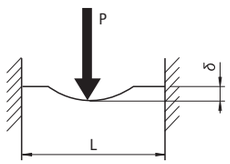
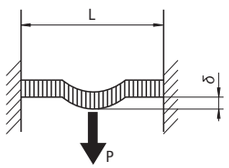
Example of No.4 as "Beam Supported on Both Ends"

P	(N)	Load
L	(mm)	Extrusion Length
E	(N/mm^2)	Young's Modulus $69{,}972 N/mm^2$
I	(mm^4)	Cross Sectional Moment of Inertia
δ	(mm)	Deflection

When the selection is calculated as "Beam Supported on Both Ends"

$$\delta = \frac{800 \times 500^3}{48 \times 69{,}972 \times 10.4 \times 10^4}$$

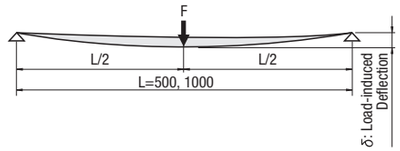
≈ 0.29 (mm)

	8	9
Both Ends Fixed		
Deflection v	$\delta = \frac{P \cdot L^3}{192E \cdot I}$	$\delta = \frac{P \cdot L^3}{384E \cdot I}$

Aluminum Extrusion
Load Capacity Guideline

Load Capacity Calculations

1. Calculation Conditions: Calculations are based on centralized loads on both ends supported extrusions.
2. The load capacities (allowable loads) are defined as: Load that generates a deflection amount 1/1000 of the extrusion length.
   These loads are the allowed maximum. Use within the given capacities.



Part Number			Height x Width (mm)	Section Modulus x 10^3 (mm^3)	Cross Sectional Moment of Inertia x 10^4 (mm^4)	For 500mm Extrusion Length Allowable Load		For 1000mm Extrusion Length Allowable Load	
Type	Extrusion					(N)	(kgf)	(N)	(kgf)
HFS5 NFS5	2020	(1)	20x 20	0.74	0.74	99	10	24	2
	2040	(2)	20x 40	1.35	1.35	182	18	45	4
		(3)	40x 20	2.55	5.11	687	70	171	17
	2060	(4)	20x 60	1.97	1.97	264	26	66	6
		(5)	60x 20	5.32	15.96	2144	218	536	54
	2080	(6)	20x 80	2.58	2.58	347	35	86	8
		(7)	80x 20	9.02	36.11	4851	494	1212	123
	2525	(8)	25x 25	1.36	1.71	229	23	57	5
	2550	(9)	25x 50	2.37	2.96	398	40	99	10
		(10)	50x 25	5.09	12.74	1711	174	427	43
	4040	(11)	40x 40	4.45	8.9	1196	122	299	30
	4060	(12)	40x 60	6.3	12.62	1695	172	423	43
		(13)	60x 40	9	27	3627	369	906	92
	4080	(14)	40x 80	9.18	18.38	2469	251	617	62
		(15)	80x 40	15.87	63.49	8529	869	2132	217
HFS6 NFS6	3030	(16)	30x 30	1.89	2.83	381	38	95	9
	3060	(17)	30x 60	3.55	5.33	716	73	179	18
		(18)	60x 30	6.84	20.53	2758	281	689	70
	3090	(19)	30x 90	5.62	8.43	1133	115	283	28
		(20)	90x 30	14.71	66.19	8892	906	2223	226
	6060	(21)	60x 60	13.78	41.35	5555	566	1388	141
	6090	(22)	60x 90	17.53	52.59	7065	720	1766	180
		(23)	90x 60	24.77	111.5	14979	1527	3744	381
	30120	(24)	30x 120	7.52	11.29	1516	154	379	38
		(25)	120x 30	25.55	153.3	20595	2100	5148	525
	60120	(26)	60x 120	23.06	69.18	9294	947	2323	236
		(27)	120x 60	41.18	247.1	33196	3385	8299	846
	5050	(28)	50x 50	8.66	21.66	2909	296	727	74
	50100	(29)	50x 100	16.98	42.44	5701	581	1425	145
		(30)	100x 50	30.63	153.2	20581	2098	5145	524
	100100	(31)	100x 100	53.08	265.4	35655	3635	8913	908
HFS8 NFS8	4040	(32)	40x 40	5.24	10.48	1407	143	351	35
	4080	(33)	40x 80	9.95	19.91	2674	272	668	68
		(34)	80x 40	18.07	72.26	9707	989	2426	247
	40160	(35)	40x 160	19.36	38.72	5201	530	1300	132
		(36)	160x 40	61.89	496.3	66676	6799	16669	1699
	8080	(37)	80x 80	32.45	129.8	17438	1778	4359	444
	80160	(38)	80x 160	73.95	295.8	39739	4052	9934	1013
		(39)	160x 80	125.2	1002	134614	13726	33653	3431
	4545	(40)	45x 45	6.77	15.25	2048	208	512	52
	4590	(41)	45x 90	14.44	32.5	4366	445	1091	111
		(42)	90x 45	27.9	125.5	16860	1719	4215	429
	9090	(43)	90x 90	46.78	210.5	28279	2883	7069	720
	45180	(44)	45x 180	27.14	61.05	8201	836	2050	209
		(45)	180x 45	89.87	808.8	108659	11080	27164	2770
	90180	(46)	90x 180	133.3	600	80607	8219	20151	2054
		(47)	180x 90	237.9	2141	287635	29330	71908	7332
	5050	(48)	50x 50	10.91	27.28	3665	374	916	93
	50100	(49)	50x 100	20.66	51.67	6942	707	1735	177
		(50)	100x 50	42.23	211.1	28383	2894	7093	723
	6060	(51)	60x 60	17.3	51.91	6973	711	1743	177
HFSL6 NFSL6	3030	(52)	30x 30	1.78	2.68	360	36	90	9
	3060	(53)	30x 60	3.24	4.87	654	66	163	16
		(54)	60x 30	5.95	17.88	2402	244	600	61
	5050	(55)	50x 50	7.51	18.79	2524	257	631	64
HFSL8 NFSL8	4040	(56)	40x 40	3.77	7.54	1013	103	253	25
	4080	(57)	40x 80	6.71	13.43	1804	183	451	45
		(58)	80x 80	13.25	52.98	7117	725	1779	181
	4545	(59)	45x 45	5.21	11.73	1575	160	393	40
	4590	(60)	45x 90	10.15	22.85	3069	313	767	78
		(61)	90x 45	19.26	86.68	11645	1187	2911	296
HFSG6	6060	(62)	60x 60	18.09	54.28	7292	743	1823	185
HFSH8	8080	(63)	80x 80	45.83	183.3	24625	2511	6156	627

Aluminum Extrusion
Load Capacity Guideline

Part Number			Height x Width (mm)	Section Modulus x 10^3 (mm^3)	Cross Sectional Moment of Inertia x 10^4 (mm^4)	For 500mm Extrusion Length		For 1000mm Extrusion Length	
						Allowable Load		Allowable Load	
Type	Extrusion					(N)	(kgf)	(N)	(kgf)
GFS6	3030	(64)	30x 30	2.32	3.47	466	48	117	12
	3060	(65)	30x 60	3.96	5.9	792	81	199	20
		(66)	60x 30	7.95	23.78	3194	326	798	81
GFS8	4040	(67)	40x 40	6.83	13.76	1848	188	462	47
	4080	(68)	40x 80	12.56	25.21	3384	345	846	86
		(69)	80x 40	22.47	90.87	12208	1245	3052	311
	4545	(70)	45x 45	10.42	23.64	3172	323	793	81
	4590	(71)	45x 90	18.87	42.99	5772	589	1443	147
		(72)	90x 45	35.67	163.4	21792	2222	5448	556
	5050	(73)	50x 50	15.23	38.16	5124	523	1281	131
	50100	(74)	50x 100	27.23	68.08	9147	932	2286	223
		(75)	100x 50	54.62	273.1	36706	3742	9173	935
	6060	(76)	60x 60	26.58	79.86	10728	1094	2682	273
	9090	(77)	90x 90	71.17	320.2	43016	4386	10754	1097
	100100	(78)	100x 100	93.48	465.8	62576	6381	15644	1595
	100200	(79)	100x 200	174.8	874.3	117507	11982	29365	2994
		(80)	200x 100	317.7	3179	427334	43576	106791	10890
EFS6 NEFS6	3030	(81)	30x 30	1.89	2.85	382	39	95	9
	3060	(82)	30x 60	3.66	5.48	736	75	184	19
		(83)	60x 30	6.86	20.46	2758	281	689	70
	3090	(84)	30x 90	5.86	8.8	1181	120	295	30
		(85)	90x 30	15.19	69	9185	2296	936	234
	30120	(86)	30x 120	7.65	11.48	1583	161	395	40
		(87)	120x 30	26.29	157.62	20628	2103	5157	525
	30300	(88)	30x 300	9.57	13.50	2079	272	519	53
		(89)	300x 30	35.4	375.5	51487	5259	12896	1317
EFS8 NEFS8	4040	(90)	40x 40	5.24	10.49	1409	144	352	35
	4080	(91)	40x 80	9.96	19.93	2677	273	669	68
		(92)	80x 40	18.13	72.55	9745	994	2436	248
	40120	(93)	40x 120	14.5	29	3940	401	985	100
		(94)	120x 40	37.03	223.51	29958	3054	7489	763
	40160	(95)	40x 160	19.47	38.8	5203	530	1300	132
		(96)	160x 40	63.17	506	67114	6843	16778	1710
	8080	(97)	80x 80	32.55	130	17494	1783	4373	445
	80160	(98)	80x 160	75.85	304.4	40708	4151	10177	1037
		(99)	160x 80	125.86	1007	134584	13723	33646	3430
	4545	(100)	45x 45	6.85	15.42	2071	211	517	53
	4590	(101)	45x 90	14.52	32.67	4389	448	1097	112
		(102)	90x 45	27.84	125.3	16860	1719	4215	430
	5050	(103)	50x 50	10.79	26.98	3665	374	916	93
	50100	(104)	50x 100	21.2	53	7120	726	1780	182
		(105)	100x 50	42.24	211.2	28385	2894	7094	723

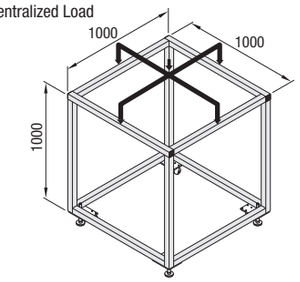
Load Capacity Guideline for Extrusion Frame Units

Condition: Calculated as: Loads causing 1mm deflection at the center of each extrusion of a 1000mm x 1000mm square frame.

Part Number		Height x Width (mm)	Allowable Load			
			Centralized Load		Evenly Distributed Load	
Type	Extrusion		(N)	(kgf)	(N)	(kgf)
HFS5 NFS5	2020	20x 20	99	10	199	20
	2040	20x 40	182	18	364	37
		40x 20	687	70	1375	140
	2060	20x 60	264	26	529	53
		60x 20	2144	218	4288	437
	2080	20x 80	347	35	694	70
		80x 20	4851	494	9702	989
	2525	25x 25	229	23	459	46
	2550	25x 50	398	40	797	81
		50x 25	1711	174	3423	349
	4040	40x 40	1196	121	2393	244
	4060	40x 60	1695	172	3390	345
		60x 40	3627	369	7254	739
	4080	40x 80	2469	251	4938	503
		80x 40	8529	869	17059	1739
HFS6 NFS6	3030	30x 30	380	38	762	77
	3060	30x 60	716	73	1433	146
		60x 30	2758	281	5516	562
	3090	30x 90	1133	115	2266	231
		90x 30	8892	906	17784	1813
	6060	60x 60	5555	566	11110	1132
	6090	60x 90	7065	720	14130	1440
		90x 60	14979	1527	29959	3054
	30120	30x 120	1516	154	3033	309
		120x 30	20594	2100	41190	4200
	60120	60x 120	9293	947	18588	1895
		120x 60	33196	3385	66393	6770
	5050	50x 50	2909	296	5819	593
	50100	50x 100	5701	581	11403	1162
		100x 50	20581	2098	41163	4197
	100100	100x 100	35654	3635	71310	7271
HFS8 NFS8	4040	40x 40	1407	143	2815	287
	4080	40x 80	2674	272	5349	545
		80x 40	9707	989	19415	1979
	40160	40x 160	5201	530	10403	1060
		160x 40	66674	6798	133352	13598
	8080	80x 80	17437	1778	34876	3556
	80160	80x 160	39738	4052	79479	8104
		160x 80	134611	13726	269229	27453
	4545	45x 45	2048	208	4097	417
	4590	45x 90	4366	445	8732	890
		90x 45	16859	1719	33720	3438
	9090	90x 90	28279	2883	56559	5767
	45180	45x 180	8201	836	16403	1672
		180x 45	108656	11079	217318	22160
	90180	90x 180	80605	8219	161215	16439
		180x 90	287627	29329	575270	58661
	5050	50x 50	3665	374	7330	747
	50100	50x 100	6942	707	13883	1415
		100x 50	28383	2894	56721	5783
	6060	60x 60	6973	711	13947	1422
HFSL6 NFSL6	3030	30x 30	360	36	720	73
	3060	30x 60	654	66	1309	133
		60x 30	2402	244	4804	489
	5050	50x 50	2524	257	5048	514
HFSL8 NFSL8	4040	40x 40	1013	103	2027	206
	4080	40x 80	1804	183	3608	367
		80x 40	7124	726	14235	1451
	4545	45x 45	1575	160	3151	321
	4590	45x 90	3071	313	6139	626
		90x 45	11648	1187	23290	2374
HFSG6	6060	60x 60	7292	743	14584	1487
HFSH8	8080	80x 80	24622	2510	49251	5022

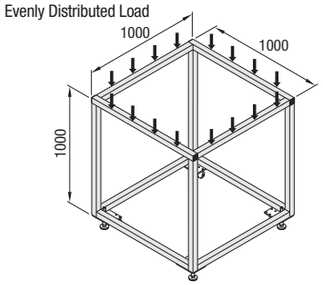
Centralized Load: Concentrated load is applied at the center.

Centralized Load



Evenly Distributed Load: When the load is evenly distributed over the extrusion.

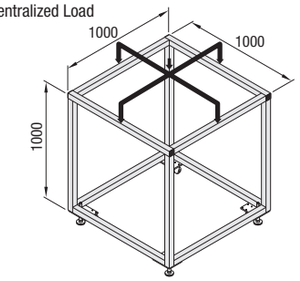
Evenly Distributed Load



Part Number		Height x Width (mm)	Allowable Load			
			Centralized Load		Evenly Distributed Load	
Type	Extrusion		(N)	(kgf)	(N)	(kgf)
GFS6	3030	30x 30	466	48	932	95
	3060	30x 60	792	81	1585	162
		60x 30	3194	326	6389	651
GFS8	4040	40x 40	1848	188	3696	377
	4080	40x 80	3384	345	6768	690
		80x 40	12208	1245	24416	2490
	4545	45x 45	3172	323	6344	647
	4590	45x 90	5772	589	11544	1177
		90x 45	21792	2222	43584	4444
	5050	50x 50	5124	523	10248	1045
	50100	50x 100	9147	932	18292	1865
		100x 50	36706	3742	73380	7482
	6060	60x 60	10728	1094	21456	2188
	9090	90x 90	43016	4386	86032	8773
	100100	100x 100	62576	6381	125152	12762
	100200	100x 200	117507	11982	234918	23955
		200x 100	427334	43576	854170	87101
EFS6 NEFS6	3030	30x 30	382	39	765	78
	3060	30x 60	736	75	1472	150
		60x 30	2758	281	5516	562
	3090	30x 90	1181	120	2362	240
		90x 30	9185	2296	18371	1873
	30120	30x 120	1583	161	3166	322
		120x 30	20628	2103	41257	4207
	30300	30x 300	2079	272	4158	548
		300x 30	51487	5259	102974	10318
EFS8 NEFS8	4040	40x 40	1409	144	2818	287
	4080	40x 80	2677	273	5355	546
		80x 40	9745	994	19493	1988
	40120	40x 120	3940	401	7881	803
		120x 40	29958	3054	59916	6109
	40160	40x 160	5203	530	10407	1061
		160x 40	67114	6843	134228	13687
	8080	80x 80	17494	1783	34988	3567
	80160	80x 160	40708	4151	81417	8302
		160x 80	134584	13723	269168	27447
	4545	45x 45	2071	211	4143	422
	4590	45x 90	4389	448	8778	895
		90x 45	16860	1719	33720	3438
	5050	50x 50	3665	374	7330	747
	50100	50x 100	7120	726	14240	1452
		100x 50	28385	2894	56748	5787

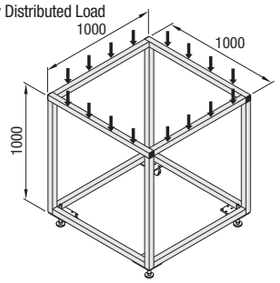
Centralized Load: Concentrated load is applied at the center.

Centralized Load



Evenly Distributed Load: When the load is evenly distributed over the extrusion.

Evenly Distributed Load



Aluminum Extrusion Q&A

Aluminum Extrusion Q&A

Q. What is a guideline to select the appropriate size of aluminum extrusions?

A. MISUMI Aluminum Extrusions are comprised of the following product series.
Slot Width 6: 5 Series (20, 40mm square) for small coverings, small part racks, etc.
Slot Width 8: 6 Series (30, 50, 60mm square) for medium coverings, conveyor frames, etc.
Slot Width 10: 8 Series (40, 80mm square), 8-45 Series (45, 90, 50, 100, 60mm square) for larger clean booths, equipment bases and structural material, etc.
Find the weight that will apply on the extrusion frame, and select the extrusions from the tables on **P.418**.

Q. What is a guideline to select some blackets?

A. Applicable brackets and load capacity guidelines for each extrusion type are separately listed on bracket product pages.
・If brackets interfere with panels and others, use Blind Brackets, Simple Joints, Tapping Joints, Screw Joints, Single Joints, Center Joints, Post Assy. Insertion Double joints and Pre Assy. Insertion Double Joints.

Q. What is the aluminum material used?

A. A6N01SS-T5 (JIS Symbol) is used for HFS, HFSL and EFS Series. A6063S-T5 (JIS Symbol) is used for NFS Series.
The High Rigidity Type is made with A6061SS-T6 Equivalent with more strength.
For detailed data for this material, see Alum. Extrusion Material Data on **P.415**.

Q. What is cutting tolerance?

A. Within ±0.5mm of customer specified length.

Q. What are the surface treatment methods used for?

A. The extrusion surfaces are anodized (9μm or more). Cut surfaces are not anodized.
* Glossy clear coated aluminum extrusions are pre-anodized (9μm or more), then clear-coated (7μm).

Q. How are the extrusions cut?

A. The extrusions are cut with carbide tipped saws for soft steel material. Use the Extrusion End Caps to cover the open cut ends after assembly.

Q. What is the cut's perpendicularity?

A. Since the extrusions do not have any datum, perpendicularity of cuts is not defined.

Q. Can JIS standard hex nuts and square nuts be used with the extrusions?

A. No, they cannot be used. Our dedicated nuts are designed with larger seating areas to prevent aluminum from buckling under load.
* Flat Extrusions can be used with standard nuts.

Q. The nuts fall within extrusion slots when the extrusions are vertically positioned.

A. Mount "Pre-Assembly Insertion Stopper" on Pre-Assembly Nut Insert them into the slot.
Post-Assembly Insertion Nut and Stopper Sets are also available.
When many nuts are required, Pre-Assembly Insertion Spring Nuts and Post Assembly Insertion Spring Nuts are more convenient to use.

Q. What are the proper tightening torques for the nuts and hex socket cap screws?

A. See the tightening torque (N・m) references on each nut page.
Post-Assembly Insertion Easy Brackets Pre-Assembly Insertion Nuts Post-Assembly Insertion Nuts Long Nuts Flanged Nuts
* Conditions vary depending on bracket and washer uses. Use as approximated references.

Q. I want to mount resin panels on aluminum extrusion...

A. There are following methods to mount resin panels. Select an applicable method specific to your application.
(1) Mounting panels on brackets within the extrusions.
This method results in aesthetically good appearance, and makes for easy install/remove of the panels. Recommended for Safety Covers, etc.
(2) Fitting in the extrusion slots.
Requires no panel drilling or screws, and recommended for applications where designed appearance is of high priority.
(Some notching of the panels may be required depending on the type of brackets in use.)
(3) Mounting panels on the outside of the extrusions.
Pre-insert nuts with stoppers in the extrusion slots, and use Panel Mounting Screws to mount the panels.
Specify M5 tap for the nuts to be used (Ex. HNTT6-5)

Q. How can I mount doors on my extrusion frame?

A. There are following methods to mount resin panels. Select an applicable method specific to your application.
Resin Plate Doors: See Hinges, Handles, etc.
Extrusion Frame Doors: Use Cover Plates and HFS5-2020/HFS6-3030 extrusions to construct the doors.
* Extrusions for Doors HFTF Series can be used in place for the HFS Series for even easier door creation.

Q. I want to mount adjusters and casters.

A. Adjusters and Casters useable for each extrusion size are offered.

Q. Any precautions on the assembly?

A. ・Provide a flat and ample space for the assembly work.
・For orthogonality checks and face leveling during the assembly, use plates (assembly fixture on) for your convenience.
・We recommend that you purchase some Post Assy. Ins. Nuts prior to the assembly work as spares.
・Be sure to check for the screw torques after the assembly is complete.

Q. Is Express-T for extrusions free of charge?

A Yes, and we intend on keeping it free. If same day shipping is desired, simply specify as Express-T. There is no additional charge for the service. (Aluminum Extrusions for Brackets, Aluminum Extrusions, Fence Extrusions are not subject to free Express-T service.)

Q. What is Fixed Length Extrusion (Effective Length 4000mm)?

A It indicates the extrusion with 4000mm or more effective length. The actual length with extra lengths on ends is more than 4000mm (several tens of mm). Fixed Length Extrusions need to be cut by users thus the exact length cannot be specified.

Casters
Overview

In Caster Selection

In the Selection Table below

Step 1: Select Load
Calculate the maximum value of applicable load, and then select a caster with proper allowable load.
Note that the allowable load per unit is generally calculated based on the following formula in consideration of offset load and some shock.

$$\text{Allowable load per unit} = \frac{\text{The maximum load value}}{\text{Four units x 0.8 (when four casters are used)}}$$

Step 2: Select Specifications
Select specifications according to the application.

Step 3: Select Similar Products
Selection must be made based on RoHS compliance or travel distance.

On the product page

Step 4: Select Wheel Material
Select wheel material according to applications and road surface condition. See <Features of Wheels by Material> for details.

Step 5: Select Wheel Diameter
Select wheel diameter taking distance from floor to mounting surface into consideration.
The larger the wheel diameter is, the smoother the traveling is. Good for traveling on rough surfaces and overcoming steps.

<Selection Chart>

	Allowable Load		Light Load	Light/Medium Load / Medium Load	Medium Load / Heavy Load	Super Heavy Load	Features
	RoHS		Compliant	Compliant	Compliant	Compliant	
	Running Test Standards (Distance)		JIS (10km)	JIS (10km)	JIS (10km)	JIS (10km)	
	-		Similar Products	Similar Products	Similar Products	Similar Products	
Specification	Standards	Direct Mount Plate					Commonly-used casters directly mounted with plates on carriages and machines.
			80~700N	80~5000N	1569~6000N	4000~9000N	
		Screw-In			-	-	Can be screwed-in the female threads on a pipe or frame for which direct mount is not possible, or when the mounting surface on the mating material is limited.
			500~600N	300~1600N			
		With Leveling Mounts	-				Suitable for firmly securing the equipment for regular use, where relocation is infrequent. The casters can be secured by lowering the integrated leveling mounts.
				600~2500N	1500~3600N	588~4902N	
	Dual Wheel Casters	Press Formed	-	-		-	Dual wheel type is excellent in swiveling and capable of making small turns, compared with single wheel type.
					4000~6000N		
		Design			-	-	Press formed product is excellent in load capacity. Designed product has desirable appearance and is offered at a relatively-low price.
			392~1176N	1000~1200N	-	-	
	Vibration Damping Casters			-	-	-	Good vibration absorption and less particle generation during moving. Best use for clean environments.
			300N				
	Casting		-	-			The type with high durability in harsh environments compared to the press-formed caster products.
					700~8300N	1400~15000N	

For products not listed in Selection Chart, see the catalog listings.

<Features of Wheels by Material> (++= Very Good, += Good, 0= Acceptable, --= Not Acceptable)

Item	Rubber	Urethane Rubber	TPE	Nylon (White)	MC Nylon	Polypropylene	Phenol	Special Reinforced Plastic	Electrically Conductive Rubber	Electrically Conductive MC Nylon	Casting
Abrasion Resistance	++	++	+	+	++	0	+	0	++	++	++
Oil Resistance	0	+	0	++	++	++	++	+	0	++	++
Water Resistance	++	+	++	++	++	++	+	+	++	++	+
Cost	++	+	+	++	0	++	0	+	+	0	+
Noise	++	+	+	--	0	--	0	0	++	0	--
Allowable Load	0	++	0	0	++	0	++	++	0	++	++
Moving Resistance	0	+	+	+	++	+	++	+	0	++	+
Rubber Hardness Shore A	70±5	90±5	90±5						75±5		
Operating Temperature	-5~60°C	-20~80°C	-10~100°C	-10~120°C	-20~120°C	0~100°C	-40~180°C	-20~80°C	-5~60°C	-20~120°C	-40~200°C
Features	Most common wheel material. Economical, but not oil resistant, and the black rubber wheels may stain floor surfaces.	Compared with rubber, higher hardness with good starting property. Good oil resistance and non-soiling to floor surfaces.	Has characteristics intermediate between rubber and resin. Running noise is low.	Smooth traveling with high hardness and no deflection. Disadvantages are floor scratching and noise while running.	Good oil resistance like nylon, and mechanical strength is high.	Smooth traveling with high hardness and no deflection like nylon. Relatively low in cost.	Excellent in oil, heat and load resistance. Low starting resistance.	Excellent in mechanical strength and suitable for heavy loads. Relatively low in cost.	SBR rubber compounded with a larger amount of carbon black content, which works as earthing.	Anti-static grease is impregnated. Ideal for environments where dust adhesion is undesired.	Often used under high temperature because of its high resistance against heat and shock. Disadvantage is that handling is troublesome because it is subject to rust and weight itself is heavy.

Cautions on Caster Use

1. Allowable Load
Do not use at loads beyond the allowed loads.
The allowable loads shown in the tables of the catalog indicate the load limits that can be transported by human power on a flat surface.

2. Operating Speed
Operating speed should be walking speed or slower in intermittent usage. Avoid powered pulling (except for some casters) and continuous operation that may cause heat generation.

Wheel Diameter	Operating Speed
75mm or Less	2km/h or Less
100mm or Less	4km/h or Less

3. Stoppers
Note that the performance may degrade without user attention due to wear and damages from long-term operation.
Braking power generally depends on wheel materials.
To ensure safe use, use wheel stops, floor stoppers, etc.

4. Operating Environment
It is normally assumed that the casters are used in a room at ambient temperature (except for some casters)
Avoid unusual environment that might be affected by high temperature, low temperature, high humidity, acidic, alkaline, salt, solvent, oil, seawater and chemical products, etc.

5. How to Mount
①Install the mounting plane horizontally.
②Install a swivel caster with its turning axle vertical.
③Install the fixed casters mutually parallel.
④Mount firmly with proper bolts and nuts.
⑤To install screw-in casters, tighten the hex of the screws at a proper torque. Excessive torque may strain and damage the shafts.
(Reference: Proper Torque for Thread Dia. 12mm is 20 ~ 50N・m)

Sanitary Pipes
Overview

Common Specifications

Material	Standards	
EN 1.4301 Equiv.	(No. 8A~15A)	JIS G3459
EN 1.4404 Equiv.	(No. 1S~3S)	JIS G3447

Common Specifications (Weld bead portion inside excluded)

	Surface Finish
Inner Surface	#320~400 (Ra≤1.0μm)
Outer Surface	#320~400 (Ra≤2.5μm)

Table of Applicable Standards

Shape	Standards
Sanitary Pipes (1S ~ 3S)	JIS G3447
Sanitary Small Diameter Pipes (EN 1.4404 Equiv. 8A ~ 15A)	JIS G3459
Clamp	IDF/ISO
Thread	IDF
Flange	JIS B2220

For detailed dimensions, refer to stipulated standards.

Table of Sanitary Pipes: Depending on Dimension Standard

JIS G3447(1994)			JIS G3459			3A (USA Sanitary Standards)			ISO		DIN (DIN1 1850) (DIN)		
Size	O.D. (D)	Thickness (t)	Size	O.D. (D)	Thickness (t)	Size	O.D. (D)	Thickness (t)	O.D. (D)	Thickness (t)	Size	O.D. (D)	Thickness (t)
-	-	-	8A	13.8	1.65	-	-	-	12	1	DN10	12	1
-	-	-	10A	17.3	1.65	-	-	-	17.2	1	15	18	1
-	-	-	15A	21.7	2.1	-	-	-	21.3	1	20	22	1
1S	25.4	1.2	20A	27.2	2.1	1	25.4	1.25 1.65	25	1.2	25	28	1.5
1.25S	31.8	1.2	25A	34	2.8	1 1/4	-	-	33.7	1.2	32	34	1.5
1.5S	38.1	1.2	32A	42.7	2.8	1 1/2	38.1	1.25 1.65	38	1.2	-	-	-
-	-	-	-	-	-	-	-	-	40	1.2	40	40	1.5
2S	50.8	1.5	40A	48.6	2.8	2	50.8	1.65	51	1.2	50	52	1.5
2.5S	63.5	2	50A	60.5	2.8	2 1/2	63.5	1.65	63.5	1.6	-	-	-
-	-	-	-	-	-	-	-	-	70	1.6	65	70	2
3S	76.3	2	65A	76.3	3	3	76.2	1.65	76.1	1.6	-	-	-

Information about Sanitary Pipes

Size	O.D. (D)	Thickness (t)	Area of I.D. mm^2	Cross-sectional Area of Pipes mm^2	Weight of Pipes kg/m	Capacity of Liquid in Pipes ℓ/m	Flow Rate at Velocity of 1m/sec m^3/h
8A	13.8	1.65	87	63	0.499	0.11	0.396
10A	17.3	1.65	154	81.1	0.463	0.154	0.554
15A	21.7	2.1	241	129	1.03	0.241	0.868
1S	25.4	1.2	415	91.2	0.723	0.415	1.49
1.25S	31.8	1.2	679	115	0.915	0.679	2.44
1.5S	38.1	1.2	1001	139	1.1	1	3.6
2S	50.8	1.5	1795	232	1.84	1.8	6.46
2.5S	63.5	2	2781	386	3.06	2.78	10
3S	76.3	2	4106	467	3.7	4.11	14.8

Weight of Pipe and Liquid (kg/m) = Weight of Pipe + Amount of Liquid in Pipe

Weight of pipe and liquid indicates a weight per length (m) when pipes is filled with water (calculated as specific gravity 1.0). For liquid with different specific gravity, multiply capacity of pipes by specific gravity, and add weight of pipes to it.

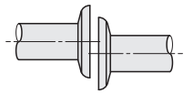
Use flow rate of 1m/sec for calculating flow rate and velocity in pipes and diameter of pipes.
Ex.) For flow velocity when using 2S pipe at $10m^3/h$: V (Velocity of Flowing Fluid) $=10(m^3/h)/6.46[(m^3/h)/(1m/sec)]=1.55m/sec$

Recommended Tightening Torque and Incompatible Mounting Method

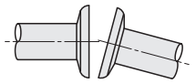
Tightening torque for 1S ~ 3S should be 3N・m, and for 8A ~ 15A should be 3N・m or more. Further tightening or loading of pipes may deform the gaskets and cause liquid slug, leakages and damages.
When fluid leaks during use, retighten pipes with torque above. If this fails to stop leakage, replace gaskets.

<Incompatible Mounting Methods>

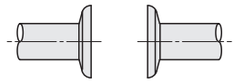
1) Pipes are not aligned.



2) Pipes are not horizontally aligned.



3) There is too much clearance between pipe fittings.



Cylinders
Overview

■Compact Cylinders - Overview

MISUMI compact air cylinders are designed to be compact to save space.
The general-purpose thin-type cylinders have been standardized.
Standard-stroke compact air cylinders can be shipped immediately, while those of selectable shape (with specified stroke) can be dispatched on the fifth day after receiving an order.
Each of the MISUMI standard thin-type cylinders is equipped with a magnet rubber cushion.

■Features of Compact Air Cylinder

For the I.D. of the cylinder tube, eight types are offered.
For selectable shapes (with specified stroke), the stroke can be specified in 1mm increments, and the rod tip type can be selected.
The cylinder body can be fixed directly through four through holes.
In addition, connecting parts can be selected from two shapes: Foot and U-Shaped Clevis
Sensors can be installed at eight locations (Ø12: 3 locations; Ø16: 6 locations).

■Selection of Cylinders

①Define the requirements for the load.

1) Load (N) · · · · · · · · · · · · · · · · · Refer to "Load Calculation".
2) Operating Pressure (Mpa)
3) Stroke (mm)
4) Operating Time (s)

②Calculate the cylinder output. (for Double Acting Type)

1) Determine the cylinder output. (for Outstroke)
F1 $=\eta$xA1xP
F1 = Outstroke Thrust (N)
A1 = Outstroke Pressure Area (mm²) · · · · · Refer to "Cylinder Pressure Area Table".
η = Load Factor Meeting the Purpose (%) · · · · · Refer to "Load Factor Coefficient Table".
P =Operating Pressure (Mpa)
2) Determine the cylinder output. (for Instroke)
F2 $=\eta$xA2xP
F2 =Thrust of Instroke (N)
A2 = Instroke Pressure Area (mm²) · · · · · Refer to "Cylinder Pressure Area Table".
η = Load Factor Meeting the Purpose (%) · · · · · Refer to "Load Factor Coefficient Table".
P =Operating Pressure (Mpa)

③Determine I.D. of the tube.

・Determine the I.D. of the tube based on the cylinder output (N) and load (N).
Select a cylinder for required load to be within the ▭ range in the table.
· · · · · Refer to "Tube I.D. Selection Table" and "Theoretical Output Table".
For example, if the operating pressure is 0.5MPa and the 105N cylinder is required, the cylinder diameter is selectable from following 3 sizes: Ø20 (load factor: approx. 70%), Ø25 (load factor: approx. 45%), and Ø32 (load factor: approx. 25%).

$$\text{Load Factor} = \frac{\text{Load}}{\text{Theoretical Output}}$$

Theoretical Output (N) = Pressure Area (mm²) x Operating Pressure (MPa)

④Determine the theoretical reference speed.

・Determine the theoretical reference speed based on the stroke (mm) and operating time (s).
· · · · · Refer to "Theoretical Reference Speed Selection Table".

⑤Verify the cylinder cushion mechanism.

・Check allowable kinetic energy (J) when the load is to be stopped near the end of the cylinder stroke.
E=m/2xV² · · · · · Refer to the "Allowable Kinetic Energy Table."
E=Kinetic Energy (J) m=Mass (kg) V=Velocity (m/s)
CAUTION: If load beyond the allowable kinematic energy (J) is applied to the cylinder,
1) Review the I.D. of the cylinder tube.
2) Install an external stopper.
The measures above are required.

⑥Verify the lateral load to be applied to the cylinder.

・If the lateral load is applied to the tip of the cylinder piston rod, check the allowable lateral load (N).
Verify the load based on the following three conditions. · · · · · Refer to the "Allowable Tip Lateral Load Table".
1) I.D. of Cylinder Tube
2) Cylinder Stroke (mm)
3) Lateral Load Applied to the Tip of the Rod (N)
CAUTION : If load beyond the allowable lateral load (N) is applied to the tip of the cylinder piston rod,
1) Review the I.D. of the cylinder tube.
2) Install a guiding mechanism on the piston rod to contain the applied load under the allowable lateral load.
The measures above are required.

■Theoretical Output

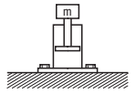
Unit : N

Tube I.D. mm	Operating Direction	Operating Pressure (Mpa) 0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Ø12	Push	11	23	34	45	57	68	79	90	102	113
	Pull	8	17	25	34	42	51	59	68	76	85
Ø16	Push	20	40	60	80	101	121	141	161	181	201
	Pull	15	30	45	60	75	90	106	121	136	151
Ø20	Push	31	63	94	126	157	188	220	251	283	314
	Pull	24	47	71	94	118	141	165	188	212	236
Ø25	Push	49	98	147	196	245	295	344	393	442	491
	Pull	38	76	113	151	189	227	264	302	340	378
Ø32	Push	80	161	241	322	402	483	563	643	724	804
	Pull	60	121	181	241	302	362	422	483	543	603
Ø40	Push	126	251	377	503	628	754	880	1005	1131	1257
	Pull	106	211	317	422	528	633	739	844	950	1056
Ø50	Push	196	393	589	785	982	1178	1374	1571	1767	1963
	Pull	165	330	495	660	825	990	1155	1319	1484	1649
Ø63	Push	312	623	935	1247	1559	1870	2182	2494	2806	3117
	Pull	280	561	841	1121	1402	1682	1962	2242	2523	2803

Load Calculation Calculate the load from the applied mass on the cylinder and its direction.

For vertical direction

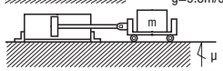
F= mxg



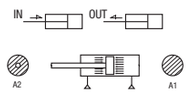
However,
F=Load (N)
m = Mass of Object (kg)
μ = Friction Coefficient (Standard μ=0.3)
g=9.8m/sec²

For lateral direction

F= mxgxμ



Cylinder Pressure Area Table



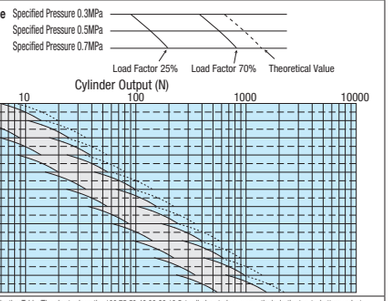
Cylinder Pressure Area

Tube I.D. (mm)	Rod Dia. (mm)	A2 Pressure Area (mm²) IN (Pull)	A1 Pressure Area (mm²) OUT (Push)
12	6	85	113
16	8	151	201
20	10	236	314
25	12	378	491
32	16	603	804
40	16	1056	1257
50	20	1649	1963
63	20	2803	3117

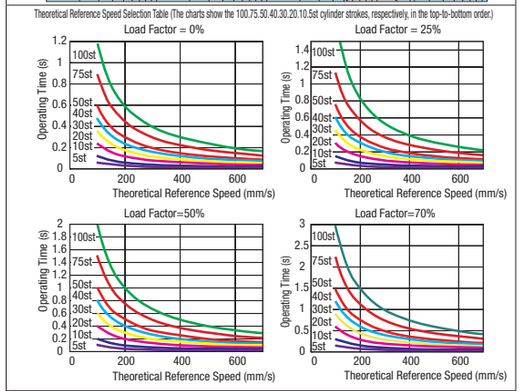
Load Factor Coefficient Table

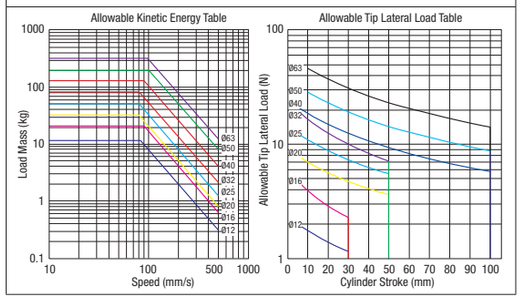
Load Factor Constant	Purpose of Work	Load Factor η
	Static Work (Clamping, Vise, Low Speed Tightening, etc.)	0.7 or Less
Dynamic Work	Lateral Direction of the Load Placed on the Guide	1 or Less
	Vertical to Horizontal Operation of Load	0.5 or Less

Tube I.D. Selection Table



Theoretical Reference Speed Selection Table (The charts show the 100.75.50.40.30.20.10.5st cylinder strokes, respectively, in the top-to-bottom order.)





Above two tables (Allowable Kinetic Energy Table and Allowable Tip Lateral Load Table) are for Compact Type Cylinders.
For Small Cylinders; for Air Cylinders (Pen-Style Type).

■Air Consumption and Required Air Amounts

• Air Consumption (per Reciprocating Motion of Double Acting Cylinder)

①Volume of the air consumed by the reciprocating motion of the air cylinder, in the cylinder or between the cylinder and the changeover valve. It is required to select an air compressor or to calculate the running costs.
(Formulas)

$$Q_{cc}=(A1+A2)xLx\frac{P+0.1013}{0.1013}x10^{-6}$$
$$Q_{cp}=2axℓx\frac{P}{0.1013}x10^{-6}$$
$$Q_c=Q_{cc}+Q_{cp}$$

Q_{cc}= Air Consumption of Air Cylinder [ℓ (ANR)]
Q_{cp}= Air Consumption of Tube or Pipe [r ((ANR)]
A1 = Extruding End Pressure Area [mm²] · · · · · Refer to "Cylinder Pressure Area Table".
A2 = Retreating End Pressure Area [mm²] · · · · · Refer to "Cylinder Pressure Area Table".
L =Cylinder Stroke [mm]
P =Operating Pressure [MPa]
ℓ = Pipe Length [mm]
a = Inner Cross-sectional Area of Pipe [mm²]
Q_c = Air Consumption Required for One Reciprocating Motion of Air Cylinder [ℓ (ANR)]

②Select a compressor that has enough capacity for the total amount of air consumed downstream by the air actuator.
Air is consumed due to leakages in the pips, or in the drain valve or pilot valve. In addition, air volume decreases with the temperature decrease.
(Formulas)

Q_c' = Qcxnx Number of Cylinders Used x Margin Ratio
Q_c' = Compressor Discharged Flow Rate [ℓ/min(ANR)]
n = Cylinder Reciprocating Motions per Minute
Margin Ratio=1.5 ~ (To be set by the user)

• Required Air Volume (per Minute)

Amount of the air necessary for actuating the air cylinder at a predetermined speed. This is required for selecting a diameter of any pipe upstream of the changeover valve, or selecting the F, R and L equipment (filter, regulator and lubricator on)
(Formulas)

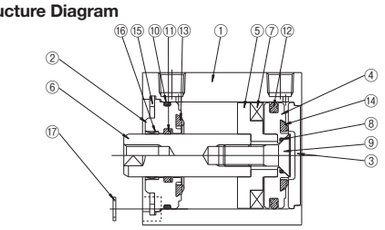
$$Q_{r1}=60xA1xVx\frac{P+0.1013}{0.1013}x10^{-6}$$
$$Q_{r2}=60xA2xVx\frac{P+0.1013}{0.1013}x10^{-6}$$

Q_{r1} = Extruding End Air Requirement [ℓ/min(ANR)]
Q_{r2} = Retreating End Air Requirement [ℓ/min(ANR)]
A1= Extruding End Pressure Area [mm²] · · · · · Refer to "Cylinder Pressure Area Table".
A2= Retreating End Pressure Area [mm²] - - - - - - Refer to "Cylinder Pressure Area Table".
V =Maximum Piston Speed [mm/s]
P =Operating Pressure [MPa]
* For Double Acting Cylinders, use one with larger Q_{r1} and Q_{r2}.
When there are multiple air cylinders downstream in selecting the plumbing or equipment, apply the maximum amount among all cylinders in simultaneous operation.

■Compact Cylinder Basic Specifications

Tube I.D. (mm)	12~25	32~40	50	63
Operating Type	Double Acting			
Applicable Fluid	Air			
Min. Operating Pressure (MPa)	0.1			
Max. Operating Pressure (MPa)	1.0			
Pressure Resistance (MPa)	1.5			
Operating Temp. Range (°C)	5~60			
Piston Speed (mm/s)	50~500			
Cushion Mechanism	NBR			
Stroke Tolerance (mm)	0~+1.0		0~+2.0	
Lubrication	Lubrication Free			
Pipe Connection Bore Dia.	M5x0.8	Rc1/8	Rc1/4	

■Compact Cylinders Basic Structure Diagram



■Compact Cylinders Parts Details

Number	Part Name	Material Ø12~32	Material Ø40~63	S Surface Treatment
①	Main Body	EN AW-6063-T5 Equiv.	EN AW-6063-T5 Equiv.	Clear Anodize
②	Rod Cover	EN AW-4032 Equiv.	EN AW-6061-T6 Equiv.	Clear Anodize
③	Head Cover	EN AW-6061-T6 Equiv.	EN AW-6061-T6 Equiv.	Clear Anodize
④	Piston	EN AW-6061-T6 Equiv.	EN AW-6061-T6 Equiv.	Clear Anodize
⑤	Piston R	EN AW-6061-T6 Equiv.	EN AW-6061-T6 Equiv.	Clear Anodize
⑥	Piston Rod	EN 1.4301 Equiv.	EN 1.1191 Equiv.	Hard Chrome Plating
⑦	Magnet			
⑧	Piston Gasket	NBR	NBR	
⑨	Hex Socket Flat Head Cap Screw	EN 1.4301 Equiv.	EN 1.7220 Equiv.	
⑩	Body Gasket	NBR	NBR	
⑪	Rod Gasket	NBR	NBR	
⑫	Piston Gasket	NBR	NBR	
⑬	Rod Cushion	NBR	NBR	
⑭	Head Cushion	NBR	NBR	
⑮	Stop Ring	EN 1.4301 Equiv.	EN 1.1525 Equiv.	Nickel Plating (Ø40 ~ 63)
⑯	Rod Bushing		Oil Free Bushing	
⑰	Washer	EN 1.0330 Equiv.	EN 1.0330 Equiv.	Nickel Plating

Gaskets of MSCCN and MSCCA are NB (Nitrile Rubber).

■Sensors for Cylinders Specifications

Part Number		MD13	ME33	MD14	ME34
Cable Exit Direction	Rear	Rear	Top	Rear	Top
Contact Type	Contact	No Contact			
Power Supply Voltage Range		5DC~28V			
Load Voltage Range	24VDC, 110VAC	28VDC or Less		DC10~28V	
Load Current Range	24VDC:5~40mA	0.1~40mA		5~20mA	
	110VAC:5~20mA				
Internal Voltage Drop	3V or Less	0.5V or Less		5V or Less	
Leakage Current	0 μ A	50 μA or Less		1mA or Less (24VDC, 25°C)	
Consumption Current	10mA or Less				
Response Time	1ms or Less				
Reset Time	1ms or Less				
Insulation Resistance	100mΩ or more with 500 VDC (between Case and Code)				
Withstand Voltage	1 min. with 1500VAC (between Case and Code)				
Impact Resistance	294m/s²				
Vibration Resistance	Lateral Amplitude 1.5mm, 10 ~ 55Hz (1 sweep/min, 2 hours in each of X, Y, Z Directions)				
Ambient Temperature	0 ~ +60°C (Non-Freezing)				
Connection Method	PVC 0.2mm² 2 Conductors O.D. Ø2.6mm	PVC 0.15mm² 3 Conductors O.D. Ø2.6mm		PVC 0.2mm² 2 Conductors O.D. Ø2.6mm	
Lead Wire Length	1m, 3m				
Protection Structure	IP67 (IEC Standard), JIS0920 (Water Resistant Type)				
Protection Circuit	No	Yes			
Indicator Light	LED (Lights when ON)				
Applicable Load	Small Relay – PLC				
Electrical Circuit	Brown [+] Blue [-]	Brown [+] Black [OUT] Blue [-]		Brown [+] Blue [-]	

Caution Note

[IMPORTANT] PRECAUTIONS
DANGER: A clearly dangerous state. Unless avoided, death or serious injuries might be caused.
CAUTION: A potentially dangerous state depending on usage. Unless avoided, death or injuries might be caused.
NOTE: A potentially dangerous state depending on usage. Unless avoided, low-grade to moderate injuries might be caused, or property might be damaged.

(Cylinders) ▲ CAUTION
①Check the air cylinder specifications and use the cylinder within the allowed specification range.
If the cylinder is used under pressure or temperature exceeding the specifications, or any fluid other than compressed air is used, there is a danger of personal injury or damage to the machine by broken or malfunctioning cylinders. Be sure to use the cylinder within the allowed specification range.
②Please note that there may be potential damages to the machine or human body, e.g, hands and/or legs being caught in the moving mechanisms.
If there are potential hazards to human body, install a protective cover as a safety measure.
③Provide safety measures against possible injuries and equipment damages by air cylinder malfunctions due to power and air supply troubles.
④The air cylinder and the coupling with other equipment must be fixed securely to avoid loosening.

(Cylinders) ▲ NOTE
①Use a filter and a dryer in order to supply clean and dry compressed air to the air cylinder.
Impurities in the compressed air may cause malfunctions.
②Use a speed controller to operate the air cylinder at a predetermined speed.
③A lateral load beyond the allowable range must not be applied to the piston rod.
Otherwise, the air cylinder may operate improperly, or the gaskets may be damaged.
④The air cylinder can be operated without lubrication.
For lubricating the cylinder, supply Category-1 turbine oil (ISO VG32). Once lubricated, continue to use the same lubricant. If lubrication is stopped, the initial lubricant may be lost, thus causing the cylinder to malfunction.

(Sensors for Cylinders) ▲ DANGER
①Never use the cylinder in an atmosphere containing explosion gas.
Otherwise, the sensor may cause an explosion because it does not have an explosion-proof structure.

(Sensors for Cylinders) ▲ CAUTION
①After reviewing the specifications of sensors for cylinders, use them within the specifications. If the sensor is used with a load current, voltage, temperature, impact, or any other condition outside the range of the specifications, the sensor may break the sensor may break or operate improperly.
②Do not use the sensor under conditions such as: a magnetized area; an atmosphere containing an explosive gas; water or oil may be splashed to the cylinder; the temperature may change in an extremely wide range; an impact may occur; a dusty area. Otherwise, the sensor may operate improperly or break.
③Perform wiring correctly according to the color-coded labels of the sensor lead wires.
<Contacting Sensor>
・If the wiring is reversed, the lamp will not light, although the sensor operates. (24 VDC only)
<Two-wire Non-contact Sensor>
・If the wiring is reversed, the lamp will continually stay ON.
<Three-wire Non-contact Sensor>
・If the power and output lines are wired incorrectly, the sensor will break.
④To connect a load that generates a surge voltage (e.g. relay), use a switch that contains a contact protection circuit, or use a protection circuit.
⑤If power is turned on without connecting a load such as relay, PLC (programmable controller) or a similar load to the two-wire sensor, the sensor will fail. Be sure to connect a load before turning the power on.
⑥Do not bundle sensor wires with power lines or high voltage circuits.
Otherwise, noise may be generated, resulting in malfunction of the sensor.
⑦If the wire contains insulation faults, an over-current may flow through the sensor, causing the sensor to fail.
Confirm that there is no insulation fault.
⑧If the sensor wire is too long, turning power on may generate a in-rush current, resulting in breakage of the contacts. If the wire length exceeds 5m, be sure to connect a contact protection circuit.
⑨Do not drop or bump the sensor, as the internal mechanism of the sensor may break.
⑩Fix the sensor in accordance with the tightening torque specifications. (0.1 ~ 0.2Nm)

Heat Insulating Plates Characteristics

■Characteristics of Insulation Plate

MISUMI heat insulating plates provide excellent heat insulation. These plates are laminated heat resistance sheets which are made of the glass fiber (that is forming frames) and the highly heat resistant combined material. They are asbestos-free new materials. Eight grades of heat insulating plates are available to meet various applications.

- Standard Grade: It serves as the heat resistant structural material for heating presses and die spacers.
- Heat Resistant Grade : It can be used as heat resisting structural material in much higher temperature and is more cost-effective than the standard grade.
- High Strength Grade: It has excellent compression and bending strength properties and is suitable to use as heat insulating material for the outside of heating furnaces.
- High Temperature Resistant Grade: It maintains compression strength property under high temperature and is suitable for a use of heat resisting and insulating material for the outside of electric furnaces.
- High Temperature Insulating Grade: As both of low heat conductivity and high strength were realized, it provides excellent heat insulation effect with smaller thickness of plate.
- High Temperature Super Insulating Grade: Low temperature conductivity, lightweight and strength in high temperature provide excellent insulation.
- Very High Temperature Resistant Grade: Excellent heat resistance up to 1000°C. Usable for heating furnaces with high temperature.
- Free Cutting Grade : It has excellent mechanical strength and dimension stability. It can be used as cement board for electric insulation.

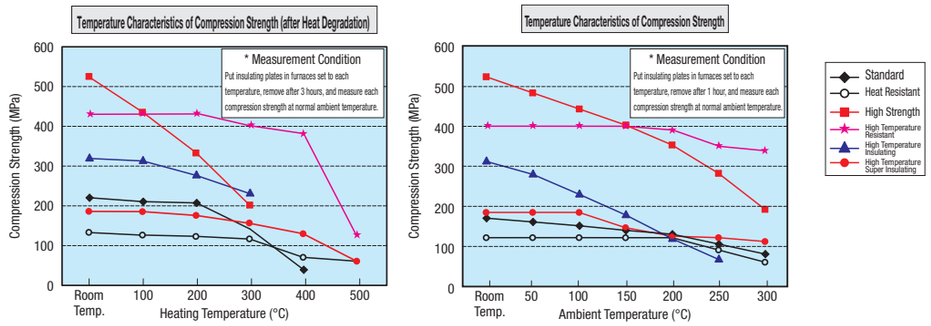
■Characteristics of Thermal Plate

MISUMI's Insulation Plates are light-weighted and provide excellent heat insulation effect.
The Heat Insulation Plates make it possible to improve operational environment such as heat reservation of equipment and prevention of burns at a low cost.

Item			Unit	Part Number: Insulation Plates, Insulation Sheets: Standard	Heat Resistant	High Strength	High Temp. Resistant	High Temperature Insulating	High Temperature Super Insulating	Very High Temp. Resistant	Free-cutting	Thermal Plates
				HIPA KJLHP ENJHP	HIPHA KJLHH ENJHH	HIPYA HIPYKH ENJHY	HIPLA HIPLKH KJLHL ENJHL	HIPIA ENJHA	HIPAL	HRMB	HIPMA	HIPCA
Component	Main Base Material		-	Glass Fiber	Glass Fiber	Glass Fiber	Glass Fiber	Glass Fiber	Glass Fiber	Calcium Silicate	Glass Fiber (Small Amount)	Glass Felt
	Main Material		-	Silicic Acid Base	Borate Type	Super Heat Resistant Epoxy Resin	Calcium Silicate Base Binder	ISO Type Unsaturated Polyester	Calcium Silicate Base Binder		Cement	Calcium Silicate Base Binder
Electrical Characteristic	Dielectric Breakdown in Crosswise		kV/mm	6	3	27	10	10	10	-	2.9	-
	Volume Resistivity	4h/150°C	Ω · cm	$2.0x10^{14}$	$1.0x10^{12}$	$2.0x10^{15}$	$5.7x10^{16}$	$6.0x10^{16}$	$1.3x10^{15}$	-	$1.0x10^{10}$ (Note 4)	$2.4x10^{10}$
		100h / 25°C / 90%RH	Ω · cm	$3.0x10^{9}$	$1.0x10^{7}$	$1.0x10^{14}$	$8.2x10^{15}$	-	$7.2x10^{14}$	-	$1.0x10^{9}$	-
	Surface Resistance		Ω	-	-	$2.0x10^{15}$	$3.0x10^{16}$	$4.3x10^{16}$	$3.4x10^{15}$	-	$1.0x10^{11}$ (Note 5)	$8.0x10^{13}$
	Insulation Resistance	Ordinary Condition	Ω	-	-	10^{13}~10^{14}	$1.0x10^{14}$	$3.0x10^{15}$	$1.0x10^{13}$	-	-	$3.0x10^{13}$
		After Boiling	Ω	-	-	10^{11}~10^{13}	$2.0x10^{9}$	$1.3x10^{9}$	$2.0x10^{8}$	-	-	-
Mechanical Characteristic	Bending Strength		MPa {kgf/mm²}	100~150 {10~15}	45~55 {4.6~5.6}	390~540 {40~55}	145 {14.8}	142 {14.5}	94 {9.6}	8.8 {0.90}	19.6~29.5 (Note 5) {2.0~3.0}	8.8 {0.9}
	Compression Strength	Perpendicular to Lamination	MPa {kgf/mm²}	150~200 {15~20}	120~150 {12~15}	500~588 {51~60}	439 {44.7}	313 {31.9}	182 {18.5}	4.4 {0.45}	108 {11}	1.2 (Note 3) {0.12}
		Parallel to Lamination	MPa {kgf/mm²}	-	-	270~390 {27~40}	98 {10}	235 {24}	59 {6.0}	-	-	1.8 (Note 3) {0.18}
	Izod Impact Strength		J/cm	-	-	4.6 or More	2.9	5.6	5.1	-	-	0.12
	Cleavage Strength		kN	2.6~3.4	1.8~2.4	7.8~10.8	3.1	4.2	2.6	-	-	-
Thermal Characteristic	Recommended Operating Temperature (Note 1)		°C	Room Temp. ~ 220	Room Temp. ~ 500	Room Temp. ~ 180	-80~400	Room Temp. ~ 180	Room Temp. ~ 400	Room Temp. ~ 1000	Room Temp. ~ 300	Room Temp. ~ 350
	Reference - Destructive Temp. (Note 2)		°C	-	-	-	-	230	500	-	-	450
	Expansion Coefficient		$°C^{-1}$	$6.6x10^{-6}$	$9.0x10^{-6}$	$1.6x10^{-4}$	$2.6x10^{-5}$	$1.4x10^{-4}$	$7.3x10^{-5}$	-	-	$9.2x10^{-5}$
	Thermal Conductivity		W/m・K {cal/cm・sec・°C}	0.71 $\{1.7x10^{-3}\}$	1.21 $\{2.9x10^{-3}\}$	0.59 $\{1.4x10^{-3}\}$	0.24 $\{0.58x10^{-3}\}$	0.13 $\{0.36x10^{-3}\}$	0.08 $\{0.19x10^{-3}\}$	0.20 $\{0.50x10^{-3}\}$	0.44 $\{1.22x10^{-3}\}$	0.07 $\{0.19x10^{-3}\}$
Others	Arc Resistance		sec	180	240	180	345	75	250	-	240~370	250
	Water Absorption Ratio		%	2~5	4~6	0.03	0.05~0.06	0.06	0.09	-	15	6.3
	Specific Gravity		-	2.0~2.2	2.0~2.2	1.8~2.0	2.0	1.41	1.2	0.84	1.75	0.5

Testing method conforms to JIS K6911. The values are representative values and not a guarantee.
(Note 1) "Recommended Operating Temperature" is the temperature in which some long-term use does not reduce the quality rapidly. (Refer to next page "Insulation Plates Characteristics Graphs".)
(Note 2) "Destructive Temperature" is a temperature where carbonization, collapse, and meltdown will begin.
(Note 3) "Compression Strength" of Thermal Plate (HIPCA) is the value for 5% deformation.
(Note 4) Condition for "Volume Resistivity" of Free-cutting Grade (HIPMA) is 24h/150°C.
(Note 5) Values of "Surface Resistance" and "Bending Strength" of Free-cutting Grade (HIPMA) are those after drying.

■Insulating Plate Characteristic Graph (The following graph is an example of actual measurement. The data are reference values because of variations depending on measurement conditions.)



■Notes on Usage of Insulating Plate and Thermal Plate

①Be sure to use a washer with a bolt. The insulating plate may break when the bolt is tightened too hard. Especially, thermal plate (HIPCA) must be handled with care because of its softness. (Fig. A)

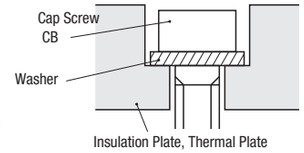
②Do not use in places where there may be splashes of water, chemicals. Insulation plates that have absorbed moisture are the most likely to be cracked or sharply degraded in performance due to rise in temperature. Especially, Free Cutting Grade (HIPMA) is more likely to absorb moisture and water and thus, must be dried sufficiently before use.

③They are laminated products, so do not apply load in the direction of the layer (cleavage direction).

④When using the heat resisting grade (HIPHA) and thermal plates (HIPCA) at 300°C higher, Initial smoke and slight odor may occur (i.e. the thermal plates (HIPCA) may have slight odor) but is not seriously harmful. In such a case, take the same measures as for usual smoke agent, such as ventilating air and keeping face away from the above devices.

⑤High Insulating Plates have a hollow to provide excellent heat insulation. They may have lines on the surface, but the lines do not affect the property and heat insulating effect.

(Fig. A)



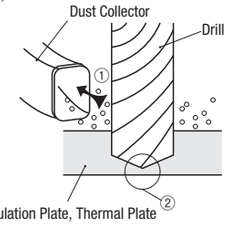
■Notes on Machining of Insulating Plate and Thermal Plate

①When machining, vacuum dust into a dust collector so that it will not scatter. (Figure B-①)
Be sure to firmly fix a Insulating Plate on the bench because it is soft.
The dust does not contain the designated chemicals such as asbestos, but safety measures for usual works in dust, such as masks and goggles, are required.
It may affect the skin such as itching, because it contains glass fiber. Wear gloves when handling the plates. In addition, when dusts adhere to the sliding parts of machine tools, there may be degradation in accuracy due to abrasion.

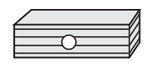
②Drilling of the insulating plate may cause cracks. Be careful with hole pitches, hole diameters, machining conditions, etc. (Figure B-②)

③They are laminated products, and not suitable for tapping and three-dimensional machining. Especially, machining such as drilling or cutting in the direction of lamination may cause cracks and should be avoided.
(Fig. C)

(Fig. B)



(Fig. C)



Avoid machining in the direction as shown in the above figure.

• Machinable Ceramic Process Conditions

	Circular Cut	Milling	Drilling
Tool	Carbide (K-10)	Carbide (K-10)	Carbide (K-10)
Cutting Speed V (m/min.)	Large ~ Small Blades 45~200	Large ~ Small Blades 100~300	Large ~ Small Blades 120~350
Rotational Speed (r.p.m.)	Large ~ Small Blades 50~1000	Large ~ Small Blades 300~1000	Ø2 Through 1000 ~ 1500 Ø5 Through 500 ~ 1000
Cutting Depth (mm)	0.3~0.5	0.5~2.0	-
Feed (mm/Rotation)	0.1~0.2	0.1~0.2	0.1~0.5

The above values are references only.
Because insulating plates and thermal plates are very fragile in periods when drilling is interrupted, be sure to use underlay plate.

For Plastic Plates.
Available in "Material Shop 24" as well.

■MISUMI's Insulating Plates / Thermal Plates are available in the catalog or "Material Shop 24".

[Material Shop 24 Insulating Plates / Thermal Plates Website Content]
- Selectable from 10 types of Insulating Plates / Thermal Plates
- MISUMI part numbers, lead times and prices are automatically generated after selecting the specifications, and the order can be placed directly from the web site.

■Selection Steps

1	Selecting Specifications	Maximum Operating Temperature, Size, Quantity, Hole Machining
2	Auto Product Extraction	List up MISUMI Part Numbers, Days to Ship and Prices
3	Selecting How to Order	Ordering through WOS
		Print FAX Ordering Sheet
		Download CSV data

* Please register with "MISUMI EC Service ID Registration" and "WOS ID Registration" to use WOS.

Metal Plates
Property Table

Property Comparison of Metal Plate Materials

* Data below are not guaranteed values but standard values.

Type	Material Code	Heat Treatment (°C)	Representative Values of Mechanical Properties: Tensile Strength (N/mm²)	Proof Stress (N/mm²)	Elongation	Hardness	Representative Values of Physical Properties: Specific Gravity (at 20°C) (g/cm³)	Conductivity (20°C) IACS	Thermal Conductivity (at 20°C) (CGS)	Linear Expansion Coefficient (20 ~ 100°C) (x10-6/°C)
Structural Steel	EN 1.0038 Equiv.	-	400~510	215 or More	21% or More	-	7.87	-	-	11.7
Carbon Steel	EN 1.1206 Equiv.	Normalized 810 ~ 860 Air-cooled	610 or More	365 or More	18% or More	179~235HB	7.87	-	-	11.7
		Annealed Approx. 800 Furnace-cooled	-	-	-	143~187HB				
		Hardened 810 ~ 860 Water-cooled	740 or More	540 or More	15% or More	212~277HB				
		Tempered 550 ~ 650 Quenched								
	EN 1.1203 (normalized) Equiv.	Normalized (At the Time of Delivery)	700 or More	370 or More	25% or More	210HB	7.87	-	-	11.7
		Hardened 850 Oil-cooled	810 or More	540 or More	25% or More	250HB				
		Tempered 600 Air-cooled								
Special Steel	JIS-SKS93	Hardened 820 Oil-cooled	-	-	-	63HRC or More	7.87	-	-	11.7
		Tempered 180 Air-cooled								
	EN 1.2510 Equiv.	Hardened 800 ~ 850 Oil-cooled	-	-	-	58~63HRC	7.85	-	0.083	12.2
		Tempered 150 ~ 200 Air-cooled								
	EN 1.2379 Equiv.	Hardened 1000 ~ 1050 Air-cooled	-	-	-	58~63HRC	7.8	-	0.07	12
		Tempered 150 ~ 200 Air-cooled								
	DC 53 ® (Daido)	Hardened 1020 ~ 1040 Air-cooled	-	-	-	56~63HRC	7.87	-	0.057	12.2
		Tempered 180 ~ 200 Air-cooled								
	EN 1.7220 Equiv.	Normalized 850 ~ 1050 Air-cooled	980 or More	835 or More	12% or More	285~352HB	7.85	-	-	-
		Annealed 830 ~ 880 Furnace-cooled								
		Hardened 830 ~ 880 Oil-cooled								
	EN 1.3343 Equiv.	Annealed 800 ~ 880 Slow-cooled	-	-	-	255HB or Less	8.16	-	-	11.9
		Hardened 1220 ~ 1240 Oil (Hot Bath)				63HRC or More				
		Tempered 550 ~ 570 Air-cooled								
Stainless Steel	EN 1.4305 Equiv.	Solution Treatment Heat Treatment 1010 ~ 1150 Quenched	520 or More	205 or More	40% or More	187HB or Less	7.93	-	0.039	17.3
	EN 1.4301 Equiv.	Solution Treatment Heat Treatment 1010 ~ 1150 Quenched	520 or More	205 or More	40% or More	187HB or Less	7.93	-	0.039	17.3
	EN 1.4401 Equiv.	Solution Treatment Heat Treatment 1010 ~ 1150 Quenched	520 or More	205 or More	40% or More	187HB or Less	7.98	-	0.039	15.9
	EN 1.4404 Equiv.	Solution Treatment Heat Treatment 1010 ~ 1150 Quenched	481 or More	177 or More	40% or More	187HB or Less	7.98	-	0.039	15.9
	EN 1.4016 Equiv.	Annealed 780 ~ 850 Air-cooled	450 or More	205 or More	22% or More	183HB or More	7.7	-	0.063	10.4
	EN 1.4125 Equiv.	Hardened 1010 ~ 1070 Oil-cooled	-	-	-	58HRC or More	7.7	-	0.058	10.2
		Tempered 100 ~ 180 Air-cooled								
Pre-Hardened Steel	G-Star® (Daido)	-	1060	855	16%	33~37HRC	7.78	-	0.06	10.3
	PX5® (Daido)	-	990	880	20%	30~33HRC	7.85	-	0.101	12.7
	NAK55® (Daido)	-	1255	981	15%	37~43HRC	7.8	-	0.093	12.5
Aluminum Alloy	EN AW-5052-H112 Equiv.	-	225	125	18%	65HB	2.68	35%	0.33	23.8
	EN AW-5052-H112 Equiv. (Precision Rolled Type)	-	215	120	21%	58HB	2.68	35%	0.33	23.8
	A6061P-T651	-	309	274	12%	95HB	2.7	43%	0.52	23.6
	EN AW-2017-T351 Equiv.	-	390	250	13%	105HB	2.79	34%	0.32	23.6
	ANP79-T651	-	560	500	12%	165HB	2.77	32%	0.31	22.1
	EN AW-7075-T651 Equiv.	-	550	490	12%	160HB	2.8	33%	0.31	23.6
Rolled Copper	Tough Pitch Copper EN CW004A Equiv.	-	215~275	49~343	25% or More	87HB or Less	8.89	97% or More	0.93	16.8
	Oxygen Free Copper EN CW008A Equiv.	-	245~315	49~343	15% or More	112HB or Less	8.89	97% or More	0.93	16.8
	Chromium Copper Z3234	-	380 or More	-	15% or More	125HB	8.89	70% or More	0.8	-
	Brass Board EN CW505L Equiv.	-	355~440	-	25% or More	-	8.43	-	-	-
Pure Titanium Class 2	EN 3.7035 Equiv.	Annealed	340~510	215 or More	23% or More	-	4.51	3~4%	0.04	8.4

CGS: Cal/°C, cm, sec

Property Comparison of Aluminum Alloy

Type	Material Code	Part Number	Corrosion Resistance	Weldability (Argon)	Machinability	Solderability	Anodize Finish
Al-Mg Alloy	EN AW-5052-H112 Equiv.	ALN□ PN□□□	Good	Good	Average	Average	Good
	EN AW-5052-H112 Equiv. (Precision Rolled Type)	ALA□ PH□□□	Good	Good	Average	Average	Good
Al-Mg-Si Alloy	A6061P-T6	A6061□□□	Average	Good	Average	Good	Good
	A6061P-T651						
Al-Cu Alloy (Duralmin)	EN AW-2017-T351 Equiv.	ALD□ ALJ PD□□□	Inferior	Not for Practical Use	Good	Inferior	Inferior
Al-Zn-Mg Alloy (Ultra super Duralmin)	ANP79-T651	P79□□□	Inferior	Inferior	Very Good	Inferior	Inferior
	EN AW-7075-T651 Equiv.	ALP□ PP□□□	Inferior	Not for Practical Use	Good	Inferior	Inferior

High Precision Plates, ALA□ / ANP79 Plates and P79□□□ are internal stress relieved during cold rolling process. Since residual stress is little, machining distortion will smaller compared to general EN AW-5052 Equiv. / EN AW-7075 Equiv materials.

Characteristics Comparison of Metal Plate Materials

Structural Steel		EN 1.0038 Equiv.	The most general steel grade. Widely used as it has strength and high machinability and is low price.
		EN 1.0038 Equiv. Annealed Material	SS400 is annealed to relieve its internal stress. It is effective for prevention of warp by machining.
Carbon Steel		EN 1.1206 Equiv.	Carbon steel with adequate level of toughness and durability
		EN 1.1203 (normalized) Equiv.	Normalized S55C, which relieves its internal stress. Added free-cutting elements enhance its machinability. It has higher mechanical strength than S50.
Chrome Molybdenum Steel		EN 1.7220 Equiv.	A chrome steel with a small amount of molybdenum. Increased temper softening resistance and higher toughness.
Special Steel		JIS-SKS93	Carbon steel for oil hardening which excels in toughness and abrasion resistance.
		EN 1.2510 Equiv.	It has good machinability as spheroidizing annealing is applied. Has higher hardenability and less heat-treating distortion than SKS93.
		EN 1.2379 Equiv.	Can be air or vacuum hardened due to its high hardenability. Very little heat treat distortion and has high abrasion resistance.
		DC 53 ® (Daido)	Tougher than SKD11. Good machinability and grindability. Hardness equal to SKD11 is obtained by low-temperature tempering, and hardness equal to 62HRC is obtained by high-temperature tempering.
		EN 1.3343 Equiv.	Excels in toughness and abrasion resistance. Very little heat-treatment distortion.
Stainless Steel	Austenite	EN 1.4305 Equiv.	Has better machinability than SUS304. However, corrosion resistance is somewhat inferior. No magnetic permeability.
		EN 1.4301 Equiv.	The most general stainless steel. Excels in corrosion resistance and is widely used. No magnetic permeability.
		EN 1.4305 Equiv. Annealed Material	SUS303 is treated with stress-relief heat-treatment to relieve internal stress. It is effective for prevention of warp by machining. Has somewhat inferior corrosion resistance compared to SUS303. No magnetic permeability.
		EN 1.4301 Equiv. Annealed Material	SUS304 is treated with stress-relief heat-treatment to relieve internal stress. It is effective for prevention of warp by machining. Has somewhat inferior corrosion resistance compared to SUS304. No magnetic permeability.
		EN 1.4401 Equiv.	SUS304 to which Molybdenum is added. Superior in corrosion resistance and acid resistance to SUS304. No magnetic permeability.
		EN 1.4404 Equiv.	SUS316 ultra-low carbon stainless steel categorized within austenitic stainless steel. Suitable for the operations requiring corrosion resistance or good weldability.
	Ferrite	EN 1.4016 Equiv.	A stainless steel with excellent corrosion resistance. It is effective for prevention of warp by machining. Its tempering hardenability is low. Magnetically permeable.
	Martensite	EN 1.4125 Equiv.	Has high strength and hardness because of the heat treatment applied. Has high abrasion resistance and is hardest in stainless steel. Magnetically permeable.
Pre-Hardened Steel	Martensite Free-Cutting Stainless Steel	G-Star® (Daido)	Has corrosion resistance and excels in machinability. Has high hardness because of the heat treatment applied. (1030°C Hardening Hardness 48HRC)
	SCM	PX5® (Daido)	Excels in machinability and has toughness. Good weldability.
	Precipitation Hardening	NAK55® (Daido)	Excels extremely in machinability. Smooth machined surfaces facilitate grinding machining afterward.
Aluminum Alloy	A5000	EN AW-5052 Equiv.	The most general aluminum alloy. Excels in corrosion resistance and weldability.
	A2000 (Duralmin)	EN AW-2017 Equiv.	Though it inferiors in corrosion resistance and weldability, it has high strength and forging is possible.
	A6000	EN AW-6061 Equiv.	Heat-treatable alloy, excelling in strength and corrosion resistance.
	A7000 (Ultra super Duralmin)	ANP79 (AlZnMgCu-Alloy)	Compared with Iron 15C, it is harder and its machinability is at least 10 times higher. Compared with 7075 material, it has about the same hardness, higher uniformity and lower internal stress.
		EN AW-7075 Equiv.	Has the highest strength in aluminum alloy. Extremely strong and be widely used for aircrafts or mechanical parts.
Rolled Copper	Tough Pitch Copper	EN CW004A Equiv.	The most widely used copper, and excellent in electrical and thermal conductivity.
	Oxygen Free Copper	EN CW008A Equiv.	Highest purity copper commercially available. The oxygen free nature prevents hydrogen embrittlement.
	Chromium Copper	Z3234	Excellent in mechanical strength and abrasion resistance at high temperature.
	Brass Board	EN CW505L Equiv.	Excellent in strength and ductile.
Pure Titanium Class 2		EN 3.7035 Equiv.	Most common titanium material categorized into Pure Titanium Class 2, and well-balanced in machinability and strength. Light weight (Specific gravity 4.51) and excellent corrosion resistance.