Technical Information

R1~R40

SI Unit Conversion Table / Cutting Symbol

SI Derived Units Conversion Chart

(Bold lined units are the ones by SI Derived Unit.)

(Extracted from JIS Handbook "Steel")

● Force

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

● Stress

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

Pa or **N/m^2**	**MPa** or **N/mm^2**	kgf/mm^2	kgf/cm^2	kgf/m^2
1	1×10^{-6}	$1.019\ 72\times10^{-7}$	$1.019\ 72\times10^{-5}$	$1.019\ 72\times10^{-1}$
1×10^{6}	1	$1.019\ 72\times10^{-1}$	$1.019\ 72\times10$	$1.019\ 72\times10^{5}$
$9.806\ 65\times10^{6}$	9.806 65	1	1×10^{2}	1×10^{6}
$9.806\ 65\times10^{4}$	$9.806\ 65\times10^{-2}$	1×10^{-2}	1	1×10^{4}
9.806 65	$9.806\ 65\times10^{-6}$	1×10^{-6}	1×10^{-4}	1

● Pressure

1Pa=1N/m^2

Pa	**kPa**	**Mpa**	bar	kgf/cm^2
1	1×10^{-3}	1×10^{-6}	1×10^{-5}	$1.019\ 72\times10^{-5}$
1×10^{3}	1	1×10^{-3}	1×10^{-2}	$1.019\ 72\times10^{-2}$
1×10^{6}	1×10^{3}	1	1×10	$1.019\ 72\times10$
1×10^{5}	1×10^{2}	1×10^{-1}	1	1.019 72
$9.806\ 65\times10^{4}$	$9.806\ 65\times10$	$9.806\ 65\times10^{-2}$	$9.806\ 65\times10^{-1}$	1

Symbols of cutting conditions

● Cutting conditions below are indicated by the new symbols listed in 2nd column.

1) Turning

Cutting Condition	New symbol	(Previous symbol)	Unit
Cutting speed	Vc	V	m/min
Feed rate	f	f	mm/rev
Depth of cut	ap	d	mm
Edge width	W	W	mm
Workpiece diameter	Dm	D	mm
Power required at spindle	Pc	Pkw	kW
Specific cutting resistance	kc	Ks	MPa
Theoretical surface roughness	h	Rz	μm
Corner radius	rε	R	mm
Revolution	n	N	min^{-1}

Note: 'rε' is read as 'r epsilon'

2) Milling

Cutting Condition	New symbol	(Previous symbol)	Unit
Cutting speed	Vc	V	m/min
Feed speed	Vf	F	mm/min
Feed per tooth	fz	f	mm/t
Feed rate	f	f	mm/rev
Number of inserts	Z	Z	teeth
Depth of cut	ap	d	mm
Width of cut	ae	w	mm
Pick feed	Pf	Pf	mm
Power required at spindle	Pc	Pkw	kW
Specific cutting resistance	kc	Ks	MPa
Metal Removal Rate	Q	Q	cm^3/min
Revolution	n	N	min^{-1}

3) Drilling

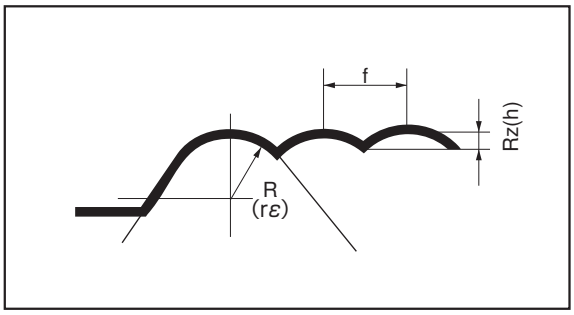
Cutting Condition	New symbol	(Previous symbol)	Unit
Cutting speed	Vc	V	m/min
Feed speed	Vf	F	mm/min
Feed rate	f	f	mm/rev
Drill diameter	Dc	D (Ds)	mm
Power required at spindle	Pc	Pkw	kW
Specific cutting resistance	kc	Ks	MPa
Depth of hole	H	d	mm
Revolution	n	N	min^{-1}

Theoretical (Geometrical) Surface Roughness

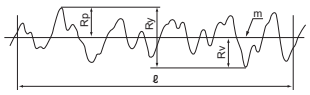
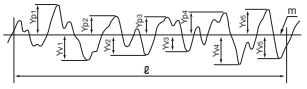
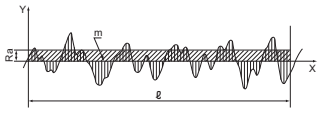
Theoretical Surface Roughness at Turning indicates the minimum roughness value from the cutting conditions and it is shown by the formula as follows:

$$Rz(h)=\frac{f^2}{8R(r\varepsilon)}\times 10^3$$

Rz(h)：Theoretical Surface Roughness〔μm〕
f ：Feed Rate〔mm/rev〕
R(rε)：Corner Radius of Insert〔mm〕



How to Obtain Surface Roughness Values

Type	Symbol	How to Obtain	Explanation
Max. Height Roughness	Rz	Ry is obtained from the distance in micron meter between the highest peak and the lowest valley in the range of sampled reference length (ℓ) to the direction of mean line of the roughness curve. Rz=Rp+Rv	
Ten Points Mean Roughness	RzJIS	Rz is obtained from the total in micron meter of the mean value of the each distance between the mean line and 5 peaks (Yp) from the highest one, and the mean value of the each distance between the mean line and the 5 valleys (Yv) from the lowest one, of the roughness curve in the range of sampled reference length "ℓ". $RzJIS=\frac{(Yp1+Yp2+Yp3+Yp4+Yp5)+(Yv1+Yv2+Yv3+Yv4+Yv5)}{5}$	 *Yp1, Yp2, Yp3, Yp4, Yp5:* Distance from the mean line to highest 5 peaks in the range of sampled reference length "ℓ" *Yv1, Yv2, Yv3, Yv4, Yv5:* Distance from the mean line to the lowest 5 valleys in the range of sampled reference length "ℓ"
Arithmetical Mean Roughness	Ra	Ra is obtained from the following formula in micron meter when the roughness curve is expressed by y=f(x), taking X-axis to the mean line direction and Y-axis to the vertical magnification of the roughness curve in the range of sampled reference length "ℓ". $Ra=\frac{1}{\ell}\int_0^{\ell}\{f(x)\}\,dx$	

Relationship with Triangle Symbol

Arithmetical Mean Roughness Ra(μm)	Max. Height Roughness Rz(μm)	Ten PointsMean Roughness RzJIS(μm)	Note: (Relationship with Triangle)
0.025 0.05 0.1 0.2	0.1 0.2 0.4 0.8	0.1 0.2 0.4 0.8	▽▽▽▽
0.4 0.8 1.6	1.6 3.2 6.3	1.6 3.2 6.3	▽▽▽
3.2 6.3	12.5 25	12.5 25	▽▽
12.5 25	50 100	50 100	▽

Note: Finishing symbol (Triangle▽and wave~) was abolished from JIS standard from 1994 Revision.

・How to Indicate

Example
①When Ra is 1.6μm→1.6μmRa
②When Rz is 6.3μm→6.3μmRz
③When RzJIS is 6.3μm→6.3μmRzJIS

Indication in JIS Standard

Example of Ra Indication		Example of Ry, (Rz) Indication	
①When indicating the upper limit only (when upper limit is 6.3μmRa)	6.3	①When indicating upper limit onlyIndicate surface roughness following the parameter symbol.	Rz6.3
②When indicating both lower and upper limit (when upper limit is 6.3μmRa, lower limit is 1.6μmRa)	6.3 1.6	②When indicating both lower and upper limit Indicate surface roughness as (upper limit ~ lower limit) following the parameter symbol.	Rz6.3~1.6

Note: The indications of Ra and Rz are different.

Surface Roughness Symbol Caution

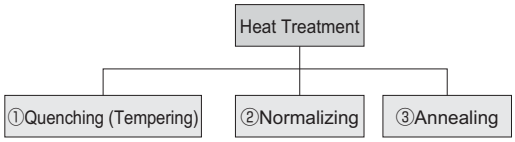
The above information is based on JIS B 0601-2001.
However, some symbols were revised as shown in the right table in accordance with ISO Standard from JIS B 0601-2001 version.
Ten Points Mean Roughness (Rz) was eliminated from 2001 version but it still remains as RzJIS reference, since it was popular in Japan.

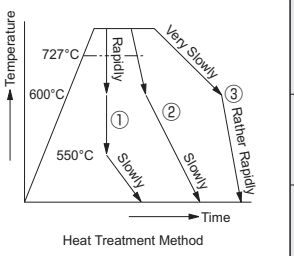
Type	Symbol of JIS B 0601-1994		Symbol of JIS B 0601-2001
Max. Height Roughness	Ry	→	Rz
Ten Points Mean Roughness	Rz	→	(RzJIS)
Arithmetical Mean Roughness	Ra	→	Ra

Heat Treatment and Hardness Expression

Heat Treatment

One of the ways to determine the hardness of steel is the heat treatment and it is classified to 3 types.



	・Quenching (Tempering)	After heating to over 727°C, cool rapidly down to 550°C in water or oil.	Quenching makes steel hard because it cools down red-hot steel very rapidly in water or oil, but it may promote internal stress. In order to remove such internal stress, tempering is used. (After cooled down once, reheat it to 200°C~600°C)
	・Normalizing	After heating to over 727°C, cool down rapidly to 600°C and then to normal temperature.	It miniaturizes the crystals. (Steel is also composed of small cells.) It is used to improve the mechanical character or machinability.
	・Annealing	After heating to over 727°C, cool down very slowly to 600°C, then to normal temperature.	It miniaturizes the crystals like the process of normalizing, but the crystal size is bigger than that of normalizing. It targets machinability improvement and distortion correction.

Heat Treatment Method

Hardness Value

Hardness	Reference Standard	Example	Explanation of Example
Brinell Hardness	JIS Z 2243：1992	250HB	Hardness Value : 250, Hardness Symbol : HB
		200~250HB	When the hardness has the range
Vickers Hardness	JIS Z 2244：1998	640HV	Hardness Value : 640, Hardness Symbol : HV
Rockwell Hardness	JIS Z 2245：1992	60HRC	Hardness Value : 60, Hardness Symbol : HRC
Shore Hardness	JIS Z 2246：1992	50HS	Hardness Value : 50, Hardness Symbol : HS

Vickers Hardness Conversion Chart

Vickers Hardness (HV)	Brinell Hardness 10mm Dia. Ball Load: 3000kgf (HB)		Rockwell Hardness[2]			Shore Hardness (HS)	Tensile Strength Mpa[1]
	Standard Ball	Tungsten Carbide Ball	A Scale Load: 60kgf Diamond Point (HRA)	B Scale Load: 100kgf 1.6mm Dia. Ball (HRB)	C Scale Load: 150kgf Diamond Point (HRC)		
940	–	–	85.6	–	68.0	97	
920	–	–	85.3	–	67.5	96	
900	–	–	85.0	–	67.0	95	
880	–	(767)	84.7	–	66.4	93	
860	–	(757)	84.4	–	65.9	92	
840	–	(745)	84.1	–	65.3	91	
820	–	(733)	83.8	–	64.7	90	
800	–	(722)	83.4	–	64.0	88	
780	–	(710)	83.0	–	63.3	87	
760	–	(698)	82.6	–	62.5	86	
740	–	(684)	82.2	–	61.8	84	
720	–	(670)	81.8	–	61.0	83	
700	–	(656)	81.3	–	60.1	81	
690	–	(647)	81.1	–	59.7	–	
680	–	(638)	80.8	–	59.2	80	
670	–	630	80.6	–	58.8	–	
660	–	620	80.3	–	58.3	79	
650	–	611	80.0	–	57.8	–	
640	–	601	79.8	–	57.3	77	
630	–	591	79.5	–	56.8	–	
620	–	582	79.2	–	56.3	75	
610	–	573	78.9	–	55.7	–	
600	–	564	78.6	–	55.2	74	
590	–	554	78.4	–	54.7	–	2055
580	–	545	78.0	–	54.1	72	2020
570	–	535	77.8	–	53.6	–	1985
560	–	525	77.4	–	53.0	71	1950
550	505	517	77.0	–	52.3	–	1905
540	496	507	76.7	–	51.7	69	1860
530	488	497	76.4	–	51.1	–	1825
520	480	488	76.1	–	50.5	67	1795
510	473	479	75.7	–	49.8	–	1750
500	465	471	75.3	–	49.1	66	1705
490	456	460	74.9	–	48.4	–	1660
480	448	452	74.5	–	47.7	64	1620
470	441	442	74.1	–	46.9	–	1570
460	433	433	73.6	–	46.1	62	1530
450	425	425	73.3	–	45.3	–	1495
440	415	415	72.8	–	44.5	59	1460
430	405	405	72.3	–	43.6	–	1410
420	397	397	71.8	–	42.7	57	1370
410	388	388	71.4	–	41.8	–	1330
400	379	379	70.8	–	40.8	55	1290
390	369	369	70.3	–	39.8	–	1240
380	360	360	69.8	(110.0)	38.8	52	1205
370	350	350	69.2	–	37.7	–	1170
360	341	341	68.7	(109.0)	36.6	50	1130
350	331	331	68.1	–	35.5	–	1095
340	322	322	67.6	(108.0)	34.4	47	1070
330	313	313	67.0	–	33.3	–	1035

Vickers Hardness (HV)	Brinell Hardness 10mm Dia. Ball Load: 3000kgf (HB)		Rockwell Hardness[2]			Shore Hardness (HS)	Tensile Strength Mpa[1]
	Standard Ball	Tungsten Carbide Ball	A Scale Load: 60kgf Diamond Point (HRA)	B Scale Load: 100kgf 1.6mm Dia. Ball (HRB)	C Scale Load: 150kgf Diamond Point (HRC)		
320	303	303	66.4	(107.0)	32.2	45	1005
310	294	294	65.8	–	31.0	–	980
300	284	284	65.2	(105.5)	29.8	42	950
295	280	280	64.8	–	29.2	–	935
290	275	275	64.5	(104.5)	28.5	41	915
285	270	270	64.2	–	27.8	–	905
280	265	265	63.8	(103.5)	27.1	40	890
275	261	261	63.5	–	26.4	–	875
270	256	256	63.1	(102.0)	25.6	38	855
265	252	252	62.7	–	24.8	–	840
260	247	247	62.4	(101.0)	24.0	37	825
255	243	243	62.0	–	23.1	–	805
250	238	238	61.6	99.5	22.2	36	795
245	233	233	61.2	–	21.3	–	780
240	228	228	60.7	98.1	20.3	34	765
230	219	219	–	96.7	(18.0)	33	730
220	209	209	–	95.0	(15.7)	32	695
210	200	200	–	93.4	(13.4)	30	670
200	190	190	–	91.5	(11.0)	29	635
190	181	181	–	89.5	(8.5)	28	605
180	171	171	–	87.1	(6.0)	26	580
170	162	162	–	85.0	(3.0)	25	545
160	152	152	–	81.7	(0.0)	24	515
150	143	143	–	78.7	–	22	490
140	133	133	–	75.0	–	21	455
130	124	124	–	71.2	–	20	425
120	114	114	–	66.7	–	–	390
110	105	105	–	62.3	–	–	–
100	95	95	–	56.2	–	–	–
95	90	90	–	52.0	–	–	–
90	86	86	–	48.0	–	–	–
85	81	81	–	41.0	–	–	–

・Extracted from JIS Handbook “Iron & Steel” (SAE J 417)
Note (1) 1MPa = 1N/mm²
(2) Value in ( ) is not in practical use, but reference only

Material List (JIS)

Metal

Classification		Name of JIS Standard	Symbol
Structural Steel		Rolled Steel for Welded Structure	SM
		Re-Rolled Steel	SRB
		Rolled Steel for General Structure	SS
		Light Guage Steel for General Structure	SSC
		Hot-Rolled Steel Plate, Sheet and Strip for Automobile Structural Use	SAPH
Steel Sheet		Cold-Rolled Steel Plate, Sheet and Strip	SPC
		Hot-Rolled Soft Steel Plate, Sheet and Strip	SPH
Steel Pipe		Carbon Steel Pipe for Ordinary Piping	SGP
		Carbon Steel Pipe for Boiler / Heat Exchanger	STB
		Seamless Steel Pipe for High Pressure Gas Cylinder	STH
		Carbon Steel Pipe for General Structural Use	STK
		Carbon Steel Pipe for Machine Structural Use	STKM
		Alloy Steel Pipe for Structural Use	STKS
		Stainless Steel Pipe for Machine Structural Use	SUS-TK
		Steel Square Pipe for General Structural Use	STKR
		Alloy Steel Pipe for Ordinary Piping	STPA
		Carbon Steel Pipe for Pressure Service	STPG
		Carbon Steel Pipe for High-Temperature Service	STPT
		Carbon Steel Pipe for High-Pressure Service	STS
		Stainless Steel Pipe for Ordinary Piping	SUS-TP
Steel for Machine Structural Use		Carbon Steel for Machine Structural Use	SxxC, SxxCK
		Aluminium Chromium Molybdenum Steel	SACM
		Chromium Molybdenum Steel	SCM
		Chromium Steel	SCr
		Nickel Chromium Steel	SNC
		Nickel Chromium Molybdenum Steel	SNCM
		Manganese Steel and Manganese Chromium Steel for Machine Structural Use	SMn, SMnC
Special Steel	Tool Steel	Carbon Tool Steel	SK
		Hollow Drill Steel	SKC
		Alloy Tool Steel	SKS, SKD, SKT
		High Speed Tool Steel	SKH
	Special Steel	Free Cutting Carbon Steel	SUM
		High Carbon Chromium Bearing Steel	SUJ
		Spring Steel	SUP
	Stainless Steel	Stainless Steel Bar	SUS-B
		Hot-Rolled Stainless Steel Plate, Sheet and Strip	SUS-HP, SUS-HS
		Cold-Rolled Stainless Steel Plate, Sheet and Strip	SUS-CP, SUS-CS
	Heat Resisting Steel	Heat-Resisting Steel Bar	SUH-B, SUH-CB
		Heat-Resisting Steel Plate and Sheet	SUH-HP, SUH-CP
	Super Alloy	Corrosion-Resisting and Heat-Resisting Superalloy Bar	NCF-B
		Corrosion-Resisting and Heat-Resisting Superalloy Plate and Sheet	NCF-P
Forged Steel		Carbon Steel Forging	SF
		Chromium Molybdenum Steel Forging	SFCM
		Nickel Chromium Molybdenum Steel Forging	SFNCM
Cast Iron		Gray Cast Iron	FC
		Spheroidal Graphite Cast Iron	FCD
		Blackheart Malleable Cast Iron	FCMB
		Whiteheart Malleable Cast Iron	FCMW
		Pearlitic Malleable Cast Iron	FCMP
Cast Steel		Carbon Cast Steel	SC
		High Tensile Strength Carbon Cast Steel & Low Alloy Cast Steel	SCC
		Stainless Cast Steel	SCS
		Heat-Resisting Cast Steel	SCH
		High Manganese Cast Steel	SCMnH
		Cast Steel for High Temperature and High Pressure Service	SCPH

Non-ferrous Metal

Classification	Name of JIS Standard	Symbol
Copper	Copper and Copper Alloy Sheet / Strip	CxxxxP CxxxxPP CxxxxR
	Copper and Copper Alloy Rod and Bar	CxxxxBD CxxxxBDS CxxxxBE
Aluminum Alloy and Aluminum Alloy Expanded Material	Aluminum and Al. Alloy Sheet / Strip	AxxxxP AxxxxPC
	Aluminum and Al. Alloy Rod, Bar, and Wire	AxxxxBE AxxxxBES AxxxxBD AxxxxBDS AxxxxW AxxxxWS
	Aluminum and Al. Alloy Extruded Shape	AxxxxS
	Aluminum and Al. Alloy Forging	AxxxxFD AxxxxFH
Magnesium Alloy Expanded Material	Magnesium Alloy Sheet and Plate	MP
	Magnesium Alloy Rod and Bar	MB
Nickel Alloy	Nickel Copper Alloy Sheet and Plate	NCuP
	Nickel Copper Alloy Rod and Bar	NCuB
Titanium Expanded Material	Titanium Rod and Bar	TB
Casting	Brass Casting	CAC20x
	High Strength Brass Casting	CAC30x
	Bronze Casting	CAC40x
	Phosphoric Bronze Casting	CAC50x
	Aluminum Bronze Casting	CAC70x
	Aluminum Alloy Casting	AC
	Magnesium Alloy Casting	MC
	Zinc Alloy Die Casting	ZDCx
	Aluminum Alloy Die Casting	ADC
	Magnesium Alloy Die Casting	MD
	White Metal	WJ

Material Cross Reference Table

● Steel

Classification	Germany	UK	France	Russia	USA	Japan	China
	DIN	BS	NF	ГОСТ	AISI / SAE	JIS	GB
Carbon Steel for Machine Structural Use	C10E C10R	040A10 045A10 045M10	XC10		1010	S10C	08 10
		040A12	XC12		1012	S12C	
	C15E C15R	055M15			1015	S15C	15
			XC18		1017	S17C	
	C22 C22E C22R	070M20 C22 C22E C22R	C22 C22E C22R		1020	S20C	20
					1023	S22C	
	C25 C25E C25R	C25 C25E C22R	C25 C25E C25R		1025	S25C	25
				25Г	1029	S28C	
	C30 C30E C30R	080A30 080M30 C30 C30E C30R	C30 C30E C30R	30Г	1030	S30C	30
				30Г		S33C	
	C35 C35E C35R	C35 C35E C35R	C35 C35E C35R	35Г	1035	S35C	35
				35Г	1038	S38C	
	C40 C40E C40R	080M40 C40 C40E C40R	C40 C40E C40R	40Г	1039 1040	S40C	40
		080A42		40Г	1042 1043	S43C	
	C45 C45E C45R	C45 C45E C45R	C45 C45E C45R	45Г	1045 1046	S45C	45
		080A47		45Г		S48C	
	C50 C50E C50R	080M50 C50 C50E C50R	C50 C50E C50R	50Г	1049	S50C	50
				50Г	1050 1053	S53C	
	C55 C55E C55R	070M55 C55 C55E C55R	C55 C55E C55R		1055	S55C	55
	C60 C60E C60R	C60 C60E C60R	C60 C60E C60R	60Г	1059 1060	S58C	60
	C10E	045A10 045M10	XC10			S09CK	
	C15E		XC12			S15CK	15F
			XC18			S20CK	

Material Cross Reference Table

● Steel

Classification	Germany	UK	France	Russia	USA	Japan	China
	DIN	BS	NF	ГОСТ	AISI / SAE	JIS	GB
Nickel Chromium Steel				40XH		SNC236	
						SNC415	
				30XH3A		SNC631	
	15NiCr13	655M13				SNC815	
						SNC836	
Nickel Chromium Molybdenum Steel	20NiCrMo2 20NiCrMoS2	805A20 805M20 805A22 805M22	20NCD 2		8615 8617 8620 8622	SNCM220	
					8637 8640	SNCM240	
						SNCM415	
				20XH2M (20XHM)	4320	SNCM420	
						SNCM431	
					4340	SNCM439	
						SNCM447	
						SNCM616	
						SNCM625	
						SNCM630	
						SNCM815	
Chromium Steel	17Cr3 17CrS3			15X 15XA		SCr415	15Cr 15CrA
				20X	5120	SCr420	20Cr
	34Cr4 34CrS4	34Cr4 34CrS4	34Cr4 34CrS4	30X	5130 5132	SCr430	30Cr
	37Cr4 37CrS4	37Cr4 37CrS4	37Cr4 37CrS4	35X	5132	SCr435	35Cr
	41Cr4 41CrS4	530M40 41Cr4 41CrS4	41Cr4 41CrS4	40X	5140	SCr440	40Cr
				45X		SCr445	45Cr 50Cr
Chromium Molybdenum Steel	15CrMo4					SCM415	15CrMo
	18CrMo4 18CrMoS4			20XM		SCM418	20CrMo
	20CrMo4	708M20		20XM		SCM420	
						SCM421	
				30XM 30XMA	4131	SCM430	30CrMo 30CrMoA
						SCM432	
	34CrMo4 34CrMoS4	34CrMo4 34CrMoS4	34CrMo4 34CrMoS4	35XM	4137	SCM435	35CrMo
	42CrMo4 42CrMoS4	708M40 709M40 42CrMo4 42CrMoS4	42CrMo4 42CrMoS4		4140 4142	SCM440	42CrMo
					4145 4147	SCM445	
						SCM822	

● Steel

Classification	Germany	UK	France	Russia	USA	Japan	China
	DIN	BS	NF	ГОСТ	AISI / SAE	JIS	GB
Manganese Chromium Steel Manganese Steel		150M19			1522	SMn420	20Mn2
		150M36		30Г2 35Г2	1534	SMn433	30Mn2 35Mn2
		150M36		35Г2 40Г2	1541	SMn438	40Mn2
				40Г2 45Г2	1541	SMn443	45Mn2
						SMnC420	
						SMnC443	
Structural Steel with Specified Hardenability Band (H-Shape Steel)					1522H	SMn420H	
						SMn433H	
					1541H	SMn438H	
					1541H	SMn443H	
						SMnC420H	
						SMnC443H	
	17Cr3 17CrS3			15Х		SCr415H	
				20Х	5120H	SCr420H	
	34Cr4 34CrS3	34Cr4 34CrS4	34Cr4 34CrS4	30Х	5130H 5132H	SCr430H	
	37Cr4 34CrS4	37Cr4 37CrS4	37Cr4 37CrS4	35Х	5135H	SCr435H	
	41Cr4 41CrS4	41Cr4 41CrS4	41Cr4 41CrS4	40Х	5140H	SCr440H	
						SCN415H	
	18CrMo4 18CrMoS4					SCM418H	
		708H20				SCM420H	
	34CrMo4 34CrMoS4	34CrMo4 34CrMoS4	34CrMo4 34CrMoS4		4135H 4137H	SCM435H	
	42CrMo4 42CrMoS4	42CrMo4 42CrMoS4	42CrMo4 42CrMoS4		4140H 4142H	SCM440H	
					4145H 4147H	SCM445H	
						SCM822H	
						SNC415H	
						SNC631H	
	15NiCr13	655H13				SNC815H	
		805H17 805H20 805H22	20NCD 2		8617H 8620H 8622H	SNCM220H	
					4320H	SNCM420H	

Material Cross Reference Table

● Steel

Classification	Germany	UK	France	Russia	USA		Japan	China
	DIN	BS	NF	ГОСТ	UNS	AISI	JIS	GB
Stainless Steel			Z12CMN17-07Az		S20100	201	SUS 201	1Cr17Mn6Ni5N
		284S16		12Х17Г9АН4	S20200	202	SUS 202	1Cr18Mn8Ni5N
	X12CrNi17 7	301S21	Z11CN17-08	07Х16Н6	S30100	301	SUS 301	1Cr18Mn10Ni5Mo3N 1Cr17Ni7
	X2CrNiN18-7						SUS 301L	
	X12CrNi17 7						SUS 301J1	
		302S25	Z12CN18-09	12Х18Н9	S30200	302	SUS 302	1Cr18Ni9
					S30215	302B	SUS 302B	
	X10CrNiS18 9	303S21	Z8CNF18-09		S30300	303	SUS 303	Y1Cr18Ni9
		303S41		12Х18Н10Е	S30323	303Se	SUS 303Se	Y1Cr18Ni9Se
	X5CrNi18 10	304S31	Z7CN18-09	08Х18Н10	S30400	304	SUS 304	0Cr18Ni9
	X2CrNi19 11	304S11	Z3CN19-11	03Х18Н11	S30403	304L	SUS 304L	00Cr18Ni10
			Z6CN19-09Az		S30451	304N	SUS 304N1	0Cr18Ni9N
					S30452		SUS 304N2	0Cr19Ni10NbN
	X2CrNiN18 10		Z3CN18-10Az		S30453	304LN	SUS 304LN	00Cr18Ni10N
							SUS 304J1	
							SUS 304J2	
					S30431	S30431	SUS 304J3	
	X5CrNi18 12	305S19	Z8CN18-12	06Х18Н11	S30500	305	SUS 305	1Cr18Ni12
							SUS 305J1	
			Z10CN24-13		S30908	309S	SUS 309S	0Cr23Ni13
		310S31	Z8CN25-20	10Х23Н18	S31008	310S	SUS 310S	0Cr25Ni20
	X5CrNiMo17 12 2	316S31	Z7CND17-12-02		S31600	316	SUS 316	0Cr17Ni12Mo2
	X5CrNiMo17 13 3		Z6CND18-12-03					
	X2CrNiMo17 13 2	316S11	Z3CND17-12-02		S31603	316L	SUS 316L	00Cr17Ni14Mo2
	X2CrNiMo17 14 3		Z3CND17-13-03	03Х17Н14М3				
					S31651	316N	SUS 316N	0Cr17Ni12Mo2N
	X2CrNiMoN17 12 2		Z3CND17-11Az		S31653	316LN	SUS 316LN	00Cr17Ni13Mo2N
	X2CrNiMoN17 13 3		Z3CND17-12Az					
	X6CrNiMoTi17 12 2		Z6CNDT17-12	08Х17Н13М2Т	S31635		SUS 316Ti	
							SUS 316J1	0Cr18Ni12Mo2Cu2
							SUS 316J1L	00Cr18Ni14Mo2Cu2
		317S16			S31700	317	SUS 317	0Cr19Ni13Mo3
	X2CrNiMo18 16 4	317S12	Z3CND19-15-04		S31703	317L	SUS 317L	00Cr19Ni13Mo3
			Z3CND19-14Az		S31753		SUS 317LN	
							SUS 317J1	0Cr18Ni16Mo5
							SUS 317J2	
							SUS 317J3L	
					N08367		SUS 836L	
		904S14	Z2NCDU25-20		N08904	N08904	SUS 890L	
	X6CrNiTi18 10	321S31	Z6CNT18-10	08Х18Н10Т	S32100	321	SUS 321	1Cr18Ni9Ti 0Cr18Ni10Ti
	X6CrNiNb18 10	347S31	Z6CNNb18-10	08Х18Н12Б	S34700	347	SUS 347	0Cr18Ni11Nb
			Z6CN18-16		S38400	384	SUS 384	
		394S17	Z2CNU18-10		S30430	304Cu	SUS XM7	0Cr18Ni9Cu3
			Z15CNS20-12		S38100		SUS XM15J1	0Cr18Ni13Si4
					S32900	329	SUS 329J1	0Cr26Ni5Mo2
			Z3CNDU22-05Az	08Х21Н6М2Т	S39240	S31803	SUS 329J3L	
			Z3CNDU25-07Az		S39275	S31260	SUS 329J4L	

● Steel

Classification	Germany	UK	France	Russia	USA		Japan	China
	DIN	BS	NF	ГОСТ	UNS	AISI	JIS	GB
Stainless Steel	X6CrAl13	405S17	Z8CA12		S40500	405	SUS 405	0Cr13Al 0Cr13
			Z3C14				SUS 410L	00Cr12
					S42900	429	SUS 429	
	X6Cr17	430S17	Z8C17	12Х17	S43000	430	SUS 430	1Cr17
	X7CrMoS18		Z8CF17		S43020	430F	SUS 430F	Y1Cr17
	X6CrTi17		Z4CT17		S43035		SUS 430LX	
	X6CrNb17							
			Z4CNb17				SUS 430J1L	
	X6CrMo17 1	434S17	Z8CD17-01		S43400	434	SUS 434	1Cr17Mo
					S43600	436	SUS 436L	
							SUS 436J1L	
			Z3CDT18-02		S44400	444	SUS 444	
					S44700		SUS 447J1	00Cr30Mo2
			Z1CD26-01		S44627		SUS XM27	00Cr27Mo
					S40300	403	SUS 403	1Cr12
	X10Cr13	410S21	Z13C13		S41000	410	SUS 410	1Cr13
	X6Cr13	403S17	Z8C12	08Х13	S41008	410S	SUS 410S	
							SUS 410F2	
					S41025		SUS 410J1	1Cr13Mo 1Cr12Mo
		416S21	Z11CF13		S41600	416	SUS 416	Y1Cr13
	X20Cr13	420S29	Z20C13	20Х13	S42000	420	SUS 420J1	2Cr13
	X30Cr13	420S37	Z33C13	30Х13	S42000	420	SUS 420J2	3Cr13
			Z30CF13		S42020	420F	SUS 420F	Y3Cr13
							SUS 420F2	
							SUS 429J1	
	X20CrNi17 2	431S29	Z15CN16-02	20Х17Н2	S43100	431	SUS 431	1Cr17Ni2
			Z70C15		S44002	440A	SUS 440A	7Cr17
					S44003	440B	SUS 440B	8Cr17
			Z100CD17	95Х18	S44004	440C	SUS 440C	9Cr18 11Cr17 9Cr18Mo
					S44020	S44020	SUS 440F	Y11Cr17
			Z6CNU17-04		S17400	S17400	SUS 630	0Cr17Ni4CuNb
	X7CrNiAl17 7		Z9CNA17-07	09Х17Н7 Ю	S17700	S17700	SUS 631	0Cr17Ni7Al
							SUS 632J1	

● Representative Classification of Stainless Steel

- Stainless Steel (Austenitic related)

JIS	
SUS201	SUS309S
SUS202	SUS310S
SUS301	SUS316
SUS302	SUS316L
SUS302B	SUS316N
SUS303	SUS317
SUS303Se	SUS317L
SUS304	SUS321
SUS304L	SUS347
SUS304N1	SUS384
SUS304N2	SUSXM7
SUS305	SUSXM15J1
SUS308	

- Stainless Steel (Ferritic related)

JIS
SUS405
SUS429
SUS430
SUS430F
SUS434
SUSXM27

- Stainless Steel: (Precipitation Hardening related)

JIS
SUS630
SUS631

- Stainless Steel (Martensitic related)

JIS
SUS403
SUS410
SUS410S
SUS416
SUS420J1
SUS420F
SUS431
SUS440A
SUS440B
SUS440C
SUS440F

Material Cross Reference Table

● Steel

Classification	Germany	UK	France	Russia	USA		Japan	China
	DIN	BS	NF	ГОСТ	UNS	AISI	JIS	GB
Heat Resisting Steel		331S42	Z35CNWS14-14	45Х14Н14В2М			SUH 31	
		349S52	Z52CMN21-09Az				SUH 35	
	X53CrMnNi21 9	349S54	Z55CMN21-09Az	55Х20 Г 9АН4	S63008		SUH 36	5Cr21Mn9Ni4N
		381S34			S63017		SUH 37	2Cr21Ni12N
							SUH 38	
		309S24	Z15CN24-13		S30900	309	SUH 309	2Cr23Ni13
	CrNi2520	310S24	Z15CN25-20	20Х25Н20С2	S31000	310	SUH 310	2Cr25Ni20
			Z12NCS35-16		N08330	N08330	SUH 330	1Cr16Ni35
			Z6NCTV25-20		S66286		SUH 660	0Cr15Ni25Ti2MoAlVB
					R30155		SUH 661	
	CrAl1205						SUH 21	
	X6CrTi12	409S19	Z6CT12		S40900	409	SUH 409	
			Z3CT12				SUH 409L	
			Z12C25	15Х28	S44600	446	SUH 446	2Cr25N
	X45CrSi9 3	401S45	Z45CS9		S65007		SUH 1	4Cr9Si2
			Z40CSD10	40Х10С2М			SUH 3	4Cr10Si2Mo
		443S65	Z80CSN20-02				SUH 4	8Cr20Si2Ni
				40Х 9С2			SUH 11	
				20Х12ВНМБФР			SUH 600	2Cr12MoVNbN
					S42200		SUH 616	2Cr12NiMoWV

● Representative Classification of Heat Resisting Steell

• Heat Resisting Steel (Austenitic related)

JIS
SUH31
SUH35
SUH36
SUH37
SUH38
SUH309
SUH310
SUH330
SUH660
SUH661

• Heat Resisting Steel (Ferritic related)

JIS
SUH21
SUH409
SUH446

• Heat Resisting Steel (Martensitic related)

JIS
SUH1
SUH3
SUH4
SUH11
SUH600
SUH616

● Steel

Classification	Germany	UK	France	Russia	USA	Japan	China
	DIN	BS	NF	ГОСТ	AISI / ASTM	JIS	GB
Carbon Tool Steel			C140E3U	Y13		SK140 (SK1)	T13
			C120E3U	Y12	W1-11$^{1}/_{2}$	SK120 (SK2)	T12
	C105W1		C105E2U	Y11	W1-10	SK105 (SK3)	T11
			C90E2U	Y10	W1-9	SK95 (SK4)	T10
	C80W1		C90E2U C80E2U	Y8Г Y9	W1-8	SK85 (SK5)	T8Mn T9
	C80W1		C80E2U C70E2U	Y8		SK75 (SK6)	T8
	C70W2		C70E2U	Y7		SK65 (SK7)	T7
High Speed Tool Steel		BT1	HS18-0-1	P18	T1	SKH2	W18Cr4V
	S18-1-2-5	BT4	HS18-1-1-5	P18K5Ф2	T4	SKH3	W18Cr4VCo5
		BT5	HS18-0-2-9	P18K5Ф	T5	SKH4	W18Cr4V2Co8
	S12-1-4-5	BT15	HS12-1-5-5		T15	SKH10	W12Cr4V5Co5
	S6-5-2	BM2	HS6-5-2	P6M5	M2	SKH51	W6Mo5Cr4V2
				P6M5Ф3	M3-1	SKH52	CW6Mo5Cr4V2 W6Mo5Cr4V3
	S6-5-3		HS6-5-3	P6M5Ф3	M3-2	SKH53	CW6Mo5Cr4V3
		BM4	HS6-5-4		M4	SKH54	
	S6-5-2-5	BM35	HS6-5-2-5HC	P6M5K5	M35 M41	SKH55	W6Mo5Cr4V2Co5 W7Mo5Cr4V2Co5
					M36	SKH56	
	S10-4-3-10	BT42	HS10-4-3-10			SKH57	
			HS2-9-2		M7	SKH58	W2Mo9Cr4V2
	S2-10-1-8	BM42	HS2-9-1-8		M42	SKH59	W2Mo9Cr4VCo8
Alloy Tool Steel				XB4	F2	SKS11	
	105WCr6		105WCr5	XBГ		SKS2	
						SKS21	W
						SKS5	
					L6	SKS51	
						SKS7	
			C140E3UCr4	13X		SKS8	Cr06
				6XB2C 5XB2CФ	S1	SKS4	5CrW2Si 6CrW2Si
				4XB2C	S1	SKS41	4CrW2Si
		BW2	100V2		W2-9$^{1}/_{2}$	SKS43	
					W2-8	SKS44	
				9XBГ		SKS3	9CrWMn
	105WCr6		105WCr5	XBГ		SKS31	CrWMn
						SKS93	
						SKS94	
						SKS95	8MnSi
	X210Cr12	BD3	X200Cr12	X12	D3	SKD1	Cr12
				X12MФ	D2	SKD10	Cr12Mo1V1
		BD2	X160CrMoV12		D2	SKD11	Cr12MoV
		BA2	X100CrMoV5		A2	SKD12	Cr5Mo1V
			X32WCrV3			SKD4	
		BH21	X30WCrV9		H21	SKD5	3Cr2W8V
	X38CrMoV51	BH11	X38CrMoV5	4X5MФC	H11	SKD6	4Cr5MoSiV
	X40CrMoV51	BH13	X40CrMoV5	4X5MФ1C	H13	SKD61	4Cr5MoSiV1
		BH12	X35CrWMoV5	3X3M3Ф	H12	SKD62	
	X32CrMoV33	BH10	32CrMoV12-18		H10	SKD7	4Cr3Mo3SiV
		BH19			H19	SKD8	
			55CrNiMoV4			SKT3	
	55NiCrMoV6	BH224 / 5	55NiCrMoV7	5XHM		SKT4	5CrNiMo

Material Cross Reference Table

● Steel

Classification	Germany	UK	France	Russia	USA	Japan	China
	DIN	BS	NF	ГОСТ	AISI / ASTM	JIS	GB
Spring Steel				75 80 85	1075 1078	SUP3	
			60Si7	60С2		SUP6	
			60Si7	60С2Г	9260	SUP7	
	55Cr3		55Cr3		5155	SUP9	
			60Cr3		5160	SUP9A	
	50CrV4	735A51, 735H51	51CrV4	ХФА50ХГФА	6150	SUP10	
				50ХГР	51B60	SUP11A	
	54SiCr6	685A57, 685H57	54SiCr6		9254	SUP12	
		705A60, 705H60	60CrMo4		4161	SUP13	
Free Cutting Carbon Steel					1110	SUM11	
					1108	SUM12	Y12
					1212	SUM21	
	9SMn28	(230M07)	S250		1213	SUM22	Y15
	9SMnPb28		S250Pb		12L13	SUM22L	Y12Pb
					1215	SUM23	
						SUM23L	
	9SMnPb28		S250Pb		12L14	SUM24L	Y15Pb
	9SMn36		S300			SUM25	
	15S10				1117	SUM31	
						SUM31L	
		210M15, 210A15	(13MF4)			SUM32	Y20
			(35MF6)		1137	SUM41	Y30 Y35
			(45MF6.1)		1141	SUM42	Y40Mn
		(226M44)	(45MF6.3)		1144	SUM43	
Carbon Chromium Bearing Steel					51100	SUJ1	
	100Cr6		100Cr6	ШХ15	52100	SUJ2	Cr2
					ASTM A 485 Grade 1	SUJ3	
						SUJ4	
						SUJ5	

● Cast Iron

Classification	Germany	UK	France	Russia	USA	Japan	China
	DIN	BS	NF	ГОСТ	AISI / SAE	JIS	GB
Gray Cast Iron		100		СУ10	NO.20	FC100	HT100
	GG15	150	FGL150	СУ15	NO.30	FC150	HT150
	GG20	200	FGL200	СУ20	NO.35	FC200	HT200
	GG25	250	FGL250	СУ25	NO.45	FC250	HT250
	GG30	300	FGL300	СУ30	NO.50	FC300	HT300
	GG35	350	FGL350	СУ35	NO.60	FC350	HT350
	GG40		FGL400	СУ40			
Nodular Cast Iron	GGG40	400 / 17	FGS370-17	ВУ40	60-40-18	FCD400	QT400-18
		420 / 12	FGS400-12	ВУ45	65-45-12	FCD450	QT450-10
	GGG50	500 / 7	FGS500-7	ВУ50	70-50-05	FCD500	QT500-7
	GGG60	600 / 7	FGS600-2	ВУ60	80-60-03	FCD600	QT600-3
	GGG70	700 / 2	FGS700-2	ВУ70	100-70-03	FCD700	QT700-2
	GGG80	800 / 2	FGS800-2	ВУ80	120-90-02	FCD800	QT800-2
		900 / 2		ВУ100			QT900-2

● Non-ferrous Metal

Classification	Germany	UK	France	Russia	USA	Japan	China
	DIN	BS	NF	ГОСТ	ASTM	JIS	GB
Aluminum Alloy	A199.99R			А99	1199		1A99
	A199.98R			А97			1A97
				А95			1A95
	A199.90	1080(1A)	1080A	А8		A1080	1A80
	A199.50	1050(1B)	1050A	А5	1050	A1050	1A50
	AlMg2.5	NS4	5052	Амг	5052	A5052	5A02
		NS5		АМг3			5A03
	AlMg5	NB6		АМг5В	5056	A5056	5A05
		NG61	5957		5456	A5556	5A30
	AlCu2.5Mg0.5		2117	Д18	2036	A2117	2A01
	AlCuMg1	HF15	2017S	Д1		A2017	2A11
	AlCuMg2		2024	Д16АВТВ	2124	A2024	2A12
					2319		2B16
				АК4		A2N01	2A80
				АК2	2218	A2018	2A90
	AlCuSiMn		2014	АК8	2014	A2014	2A14
	AlZnMgCu1.5		7075	В95Р	7175	A7075	7A09
Aluminum Alloy Casting	G-AlSi7Mg	LM25			356.2	AC4C	ZAlSi7Mn
	G-Al12	LM6	A-S12-Y4	АЛ2	413.2	AC3A	ZAlSi12
				АЛ5	355.2		ZAlSi5Cu1Mg
	G-Al12(Cu)				413.0	AC8A	ZAlSi2Cu2Mg1
				АЛ19			ZAlCu5Mn
					201.0		ZAlCu5MnCdVA
	G-AlMg10	LM10	AG11	АЛ8	520.2		ZAlMg10
	G-AlMg5Si			АЛ13			ZAlMg5Si

Insert Cross Reference Table

CVD Coated Carbide (Turning)

・This table is Kyocera´s own estimation based on publications and is not authorized by companies mentioned in it.

Classification		Kyocera	Hitachi	Iscar	Kennametal WIDIA	Mitsubishi	NTK	Sandvik	Seco	Sumitomo	Tungaloy
Class	Symbol										
P (Steel)	P01	CA5505	HC5000 HG3305	IC9015 IC9150	KC910	UE6005		GC4005 GC4205	TP1000 TX100	AC700G	T9005
	P10	CA5505 CA5515	GM10 GM20 GM8015 HG8010	IC9015 IC9150 IC9250	KC9010 KC9110	UC6010 UE6005 UE6010 UE6020	CP2 CP5	GC4015 GC3115 GC4215	TP1000 TP100 TX150	AC700G AC2000 AC820P	T9005 T9015
	P20	CA5515 CA5525 CR9025	GM20 GM8020 HG8025	IC9015 IC9025 IC9250 IC9350	KC8050 KC9025 KC9125	UC6010 UE6110 UE6020 F7030	CP2 CP5 CP7	GC4020 GC4025 GC4215 GC4225	TP200 CP250	AC2000 AC3000 AC820P	T9015 T9025
	P30	CA5525 CA5535 CR9025	GM25 GM8035 HG8025 HG8035	IC635 IC9025 IC9350	KC5025 KC9040 KC9140	UE6035 UH6400 F7030		GC4030 GC4225 GC4230 GC4235	TP200 CP300	AC3000 AC630M AC830P	T9025 T9035 T3130
	P40	CA5535	GX30	IC635	KC9045 KC9240	UE6035 UH6400		GC4235 GC4240	TP40 TP300	AC630M AC830P	T9035
M (Stainless Steel)	M10	CA6515	GM10	IC9250 IC9350	KC5010 KC9010 KC9110 KC9215	US7020	CP2 CP5	GC2015	TP100	AC610M	T9015
	M20	CA6525	GM8020 HG8025	IC9025 IC9250 IC9350	KC8050 KC9025 KC9125 KC9225	UC7020 F7030	CP2 CP5	GC2025 GC2030	TP200	AC610M AC630M	T6020 T9025
	M30		GM25 GM8035 HG8035	IC4050	KC9040 KC9240	US735 F7030		GC2040 GC2135	TP300	AC630M	T6030 T3130
	M40		GX30 GF30		KC9045 KC9245				TP40		
K (Cast Iron)	K01	CA4010 CA4505 CA5505	HC5000 GM3005 HG3305	IC428 IC9007 IC9150	KC5410 KC9315 KC910	UC5005 UC5015		GC3205 GC3210	TX100	AC300G	T5105 T5010
	K10	CA4010 CA4115 CA4505 CA4515 CA5505	GM10 GM8015 HG8010 HG3315	IC418 IC428 IC9015 IC9150	KC5010 KC7310 KC9010	UC5015 UC5115 UE6010	CP2 CP5	GC3205 GC3210 GC3215	TX150	AC700G AC410K	T5105 T5115 T5010 T1015
	K20	CA4115 CA4120 CA4515	GM8020 HG8025	IC418 IC9015 IC9150	KC8050 KC9025 KC9120 KC9325	UE6010	CP5	GC3020 GC3215 K20W	TX150 TP200	AC700G AC820P	T5115 T5125 T5020
	K30							GC3040	TP200		T5125

PVD Coated Carbide (Turning)

・This table is Kyocera´s own estimation based on publications and is not authorized by companies mentioned in it.

Classification		Kyocera	Hitachi	Iscar	Kennametal WIDIA	Mitsubishi	NTK	Sandvik	Seco	Sumitomo	Tungaloy
Class	Symbol										
P (Steel)	P01	PR915 PR1005								ACZ150	
	P10	PR915 PR930 PR1005 PR1025 PR1115	CY15 CY150 IP2000	IC507 IC907	KC5010 KC5510 KU10T	VP10MF		GC1025	CP200	ACZ150 ACZ310	AH710
	P20	PR930 PR1025 PR1115	CY150 IP2000	IC507 IC570 IC907 IC908	KC5025 KC5525 KC7215 KC7315 KU25T	VP15TF VP20MF UP20M	QM1 VM1 TA1 TAS	GC1020 GC1025 GC4125	CP250	ACZ310 ACZ330 AC520U	AH710 AH730
	P30		CY250 CY9020 HC844 IP3000	IC328 IC928 IC3028	KC7015 KC7020 KC7235 KU25T	VP15TF VP20MF UP20M	ZM3 QM3 TAS		CP500	ACZ330 ACZ350 AC530U	GH330 AH120 AH740
	P40		CY250 HC844	IC328 IC3028	KC7030 KC7040 KC7140		ZM3 QM3 TAS	GC1120 GC2145	CP500	ACZ350	AH140
M (Stainless Steel)	M10	PR915 PR1025	IP50S	IC507 IC907	KC5010 KC5510 KC6005 KC6015	VP10MF		GC1005 GC1025	CP200	EH510Z ACZ150 AC510U	AH710
	M20	PR915 PR930 PR1025 PR1125	IP100S	IC308 IC507 IC907 IC908 IC3028	KC5025 KC5525 KC7020 KC7025	VP15TF VP20MF UP20M	QM1 VM1 TA1 TAS	GC2030 GC4125	CP200 CP500	EH520Z ACZ150 ACZ310 AC520U	AH730 GH330 GH730 SH730
	M30	PR1125	GF30 CY250 CY9020	IC908 IC1008 IC1028 IC3028	KC7030 KC7225	VP15TF VP20MF UP20M	ZM3 QM3 TAS	GC1020 GC1120 GC2035	CP500	ACZ330 ACZ350 AC530U	AH120
	M40			IC928			ZM3 QM3 TAS	GC2145		ACZ350	AH140
K (Cast Iron)	K01									EH10Z	AH110
	K10	PR905	CY100H CY10H	IC507 IC908	KC5010 KC7210	VP05RT		GC1010	CP200	EH10Z EH510Z AC510U	GH110 AH110
	K20	PR905	GF30 CY9020	IC507 IC908	KC7015 KC7215 KC7315	VP10RT VP15TF	QM1 TA1	GC1020 GC1120	CP200 CP250	EH20Z ACZ310	AH120
	K30			IC508 IC3028	KC7225	VP15TF	QM3 TA3	GC4125	CP500	ACZ310	

Insert Cross Reference Table

Cermet (Turning)

・This table is Kyocera´s own estimation based on publications and is not authorized by companies mentioned in it.

Classification		Kyocera	Hitachi	Iscar	Kennametal WIDIA	Mitsubishi	NTK	Sandvik	Seco	Sumitomo	Tungaloy
Class	Symbol										
P (Steel)	P01	TN30 **PV30** TN6010 **PV7010**	CH350	IC20N **IC520N**	KT125 HTX	NX1010	T3N T15			T110A	NS520 **GT520** **GT720**
	P10	TN60 TN6010 TN6020 **PV7010** **PV7020**	CH350 **CZ25**	IC20N **IC520N** **IC530N** IC75T	KT315 KT175 HT2	NX2525 **AP25N**	T15 **C7Z**	CT5015 CT525	CM	**T2000Z** T1200A	NS520 **AT530** **GT720** **GT730**
	P20	TN90 TN6020 **PV7020**	CH550 CH7030 **CZ1025**	IC20N **IC520N** **IC530N** IC75T IC30N	PS5	NX2525 NX3035 **AP25N** **UP35N**	C7X **C7Z**	CT530 **GC1525**		T1200A **T2000Z** **T3000Z**	NS530 NS730 **AT530** **GT530** **GT730**
	P30			IC75T IC30N		NX4545 **VP45N**	N40 C7X			T250A **T3000Z**	NS530 NS540 NS730 NS740
M (Stainless Steel)	M10	TN60 TN6020 **PV7020**	CH350		KT315 KT125	NX2525 **AP25N**	T15 C7X **C7Z**	CT5015 CT525	CM	T110A	NS520 **AT530** **GT530** **GT730**
	M20	TN90 TN6020 **PV7020**	CH550 CH7030 **CZ1025**		KT175 HT2 PS5	NX2525 NX3035 **AP25N**	C7X **C7Z**	CT530 **GC1525**		T1200A **T2000Z**	NS530 NS730
	M30					NX4545				T250A **T3000Z**	NS540 NS730
K (Cast Iron)	K01	TN30 **PV30** **PV7005**				NX1010	T3N T15			T110A	NS520 **AT520** **GT520** **GT720**
	K10	TN60 TN6010 **PV7005** **PV7010**	CH350		KT315 HTX	NX2525 **AP25N**	T15 C7X **C7Z**	CT5015		T1200A **T2000Z**	NS530 NS730 **GT530** **GT730**
	K20					NX2525 **AP25N**					

・**Boldface** grade shows PVD Coated Cermet.

Carbide

Classification		Kyocera	Hitachi	Iscar	Kennametal WIDIA	Mitsubishi	NTK	Sandvik	Seco	Sumitomo	Tungaloy
Class	Symbol										
P (Steel)	P10		WS10	IC70	K2885	STi10T		S1P		ST10P	TX10S
	P20		EX35	IC70 IC50M	K125M	STi20		SMA	S10M	ST20E	TX20 TX25
	P30	PW30	EX35 EX40	IC50M IC54	KMF			SM30	S25M	A30N A30 ST30E	TX30 UX30
	P40		EX45	IC54	PVA			S6	S60M	ST40E	TX40
K (Cast Iron)	K01		WH02 WH05	IC04	K68 K313	HTi05T		H1P		H2 H1	TH03
	K10	KW10 GW15	WH10	IC20	KMI K8735	HTi10		H1P H10 HM		EH10 EH510	G1F TH10 H10T
	K20	GW25	WH20	IC20 IC10	KMF	HTi20T	KM1	H13A	883 890 HX	G10E EH20 EH520	G2F G2 KS20
	K30			IC10 IC28			KM3			G3	G3
V (Wear and Shock Resistant Tool)	V40		WH50			GTi30				G5	D40
	V50	VW50	WH60			GTi35 GTi40 GTi30S				G6	D50
	V60		WB60			GTi40S GTi50S				G7 G8	D60

Coated (Milling)

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Classification		Kyocera	Hitachi	Iscar	Kennametal WIDIA	Mitsubishi	NTK	Sandvik	Seco	Sumitomo	Tungaloy
Class	Symbol										
P (Steel)	P10	PR730 PR830 PR1025	JX1020		KC715M			GC1025		ACP100	
	P20	PR730 PR830 PR1025	CY150 TB6020 JX1015	IC250 IC520M IC950	KC522M KC525M	F7030 UP20M		GC1030 GC4220 GC4020 GC4030	T250M T25M T20M	ACP200	
	P30	PR660	CY250 CY9020 HC844 TB6045 JX1045	IC328 IC635 IC908 IC928	KC994M KC725M KC792M KC530M	F7030 VP15TF VP30RT		GC4040 GC4230	T250M T25M F25M F30M	AC230 ACP300	T325 GH330 AH120 AH330 AH740
	P40		CY250 HC844 TB6060 JX1060	IC635 IC928 IC4050	KC735M			GC4040 GC4240	T60M T25M	AC230 ACZ330 ACZ350	AH120
M (Stainless Steel)	M10	PR730 PR1025	CY9020 JX1020		KC522M			GC1025 GC1030		EH10Z	
	M20	PR660 PR730 PR1025	CY150 TB6020 JX1015	IC908 IC928	KC730M KC525M	F7030 UP20M VP30RT		GC2030	T250M T25M F20M F25M F30M	ACP200 EH20Z	GH330 AH330
	M30	PR660	CY250 TB6045 JX1045	IC328	KC994M KC725M	F7030 VP15TF		GC2040	T250M T25M F40M	ACP300 ACZ350	AH120
	M40									ACZ350	AH140
K (Cast Iron)	K01		TB6005	IC4100							AH110
	K10	PR905	CY10H CY100H CY9020	IC4010 IC910 DT7150	KC915M	F5010 VP10RT		GC3220	T150M F15M	AC211	T1015 T1020 AH110
	K20	PR905	CY150 TB6020 JX1015	IC328 KC4050	KC920M KC925 KC992M	F5020		GC1020 GC3020	T150M T250M T25M	EH20Z ACZ310 ACK300	AH120
	K30			IC328	KC930			GC3040 GC4040	T250M T25M		

Cermet (Milling)

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Classification		Kyocera	Hitachi	Iscar	Kennametal WIDIA	Mitsubishi	NTK	Sandvik	Seco	Sumitomo	Tungaloy
Class	Symbol										
P (Steel)	P10	TN60			KT530M KT195M	NX2525			C15M		NS530 NS730
	P20	TN60 TN100M	CH550 CH570 CH7030	IC30N	HT7 KT530M KT605M	NX2525	C7X C7Z	CT530	C15M	T250A	NS530 NS730
	P30			IC30N		NX4545					NS540
M (Stainless Steel)	M10	TN60				NX2525			C15M		
	M20	TN60 TN100M	CH550 CH570 CH7030		KT7 KT530M KT605M	NX2525		CT530	C15M	T250A	NS530 N308
	M30					NX4545			C15M		NS530
K (Cast Iron)	K01										
	K10			IC30N		NX2525					
	K20					NX2525					

Insert Cross Reference Table

Ceramic

・This table is Kyocera´s own estimation based on publications and is not authorized by companies mentioned in it.

Classification		Kyocera	Iscar	Kennamtal WIDIA	Mitsubishi	NTK	Sandvik	Seco	Sumitomo	Tungaloy
Class	Symbol									
K (Cast Iron)	K01	KA30 A65 KT66 **PT600M**		KW80 KY1615 AC5		HC1 HC2 HC5 HC6 HW2	CC620 CC650		NB90S NB90M WX120	LX11 LX21
	K10	A65 KT66 **A66N** **PT600M**		KB90 KB90X KY3000		WA1 SX1 **SP2** **SX9**	CC690 CC6090 **GC1690**		WX120 **NS260C**	WG300
	K20	KS6000		KY1310 KY3400 KY3500		SX1 SX8 **SP2**	CC690 CC6090 **GC1690**		**NS260C** NS260	FX105 CX710
S (Difficult-to-Cut Material)	S01									
	S10	CF1		KY4300 KY1525 KY1540		WA1 SX9	CC670 CC6080		WX120	WG300
	S20									
H (Hardened Material)	H01	A65 KT66 **A66N** **PT600M**				HC4 HC7 **ZC4**	CC650 CC670		**NB100C**	LX11
	H10	A65 KT66 **A66N** **PT600M**		KY4300		**ZC4** WA1				

・**Boldface** grade shows PVD Coated Ceramic.

CBN

Classification		Kyocera	Hitachi	Iscar	Kennametal WIDIA	Mitsubishi	NTK	Sandvik	Seco	Sumitomo	Tungaloy
Class	Symbol										
K (Cast Iron)	K01	**KBN60M**		IB85	KD120 PB100	MB710	B20 B22	CB50 CB7050	CBN050C	BN500	BX930 BX950 BX90S
	K10	**KBN60M** **KBN900**	BH200		**KB9610**	MB710 MB730	B22		CBN20 CBN300	BN600 BN700	BX950 BXC90
	K20	**KBN900**	BH250		**KB9640**	MB730 MBS140			CBN350	BNS800	
H (Hardened Material)	H01	KBN510 **KBN10C** **KBN05M** **KBN10M**			KD050 KD081	**MBC010** MB810	B20 B24	CB20 CB7020	CBN10 CBN100 CBN100P	BNX10 **BNC80** **BNC160**	BXA30 BX310 BXC30
	H10	KBN525 **KBN25C** **KBN25M**	BH200	IB50	KD050 KD120 KB1615 **KB9610**	**MBC020** MB820 MB825 MB8025	B24	CB50 CB7050	CBN150 CBN200 CBN300P	BNX20 BN250 BN300 **BNC200**	BXA40 BX330 BX360 **BXC50**
	H20	**KBN30M** **KBN35M** **KBN900**	BH250	IB55	KB1340 KB5625 **KB9640**	**MBC020** MB835 MB8025	B26		CBN350	BNX25 BN350 **BNC300**	BX380 **BXC50**
Iron Sintered Metal	-	KBN65B **KBN65M** **KBN70M**								BN700 BN7500	

・**Boldface** grade shows PVD Coated CBN.

PCD

Classification		Kyocera	Hitachi	Iscar	Kennametal WIDIA	Mitsubishi	NTK	Sandvik	Seco	Sumitomo	Tungaloy
Class	Symbol										
N (Non-ferrous Material)	N01	KPD001			PD100 KD1405	MD205	PD1		PD10	DA90 DA1000 DA2200	DX180 DX160
	N10	KPD001 KPD010 KPD230		ID5	KD100 KD1415	MD220		CD10	PD20	DA150 DA1000 DA2200	DX140
	N20	KPD001 KPD010 KPD230				MD230			PD30	DA200 DA1000 DA2200	DX120

Molded Chipbreaker Cross Reference Table

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Negative Inserts

Cutting Range		Kyocera		Hitachi	Iscar	Kennametal WIDIA	Mitsubishi	NTK	Sandvik	Seco	Sumitomo	Tungaloy
		General Chip-breaker	Chipbreaker for Sticky Material / Soft Steel									
Carbon Steel / Alloy Steel	Finishing (With Wiper Edge)	WP				FW	SW		WF	MF2	LUW	AFW
	Finishing - Medium (With Wiper Edge)	WQ			WG	MW	MW		WM	M3	GUW	ASW
	Finishing	DP GP VF	XP XP-T	BE BH FE	SF	FF UF	F FH FS FY PK	WM ZF1	QF PF	FF1	SU FP SP FA FL LU	TF 01 AS TSF
	Finishing - Medium	HQ CQ CJ	XQ	AB B CE CT	NF	FN	SH C SA MV SY	WV WR	QM	MF2	EX GU SK SJ SX UU UJ	TS NS NM CB 11 17 27 ZF
	Medium - Roughing	GS CS HS PS	XS	AE DE AH	TF	MN	MA MH	Z5 ZW1	SM PM	M3 MF3	UA UG	DM TM ZM
	Medium-Roughing High Feed Rate	PT GT HT		AR AY	NR	P	GH	GS	MR	M5 MR5	MU UX	TH 32Y 32 37
	Roughing	Standard PH		RE	GN	PR MG RN	MT Standard	G	Standard 23	MR7	MC MU MX UZ	31 33 F-K
	Roughing One Side / High Feed Rate	PX		H HX HE TE UE	NM	RH RM	HV HX HZ HXD		QR PR HR	R4 R5 R6 R7 RP	HG HP MP	TU 57 65
Stainless Steel	Finishing	GU MQ		BH MP		FP	FS SH FJ	ZF1	MF		SU	SS
	Medium - Roughing	MS MU TK		DE SE PV	TF PP	MP	MS MA MJ ES MH GH GJ	ZP WS	MM MR	MF1 MF3 A3 A5	EX MU UP	SM SA S
Cast Iron	Medium	C Standard		AH VA VY			Standard		KF KM		GZ UX UJ	Standard 33 CF
	Roughing	GC ZS				UN	GH		KR		UZ	CM CH
Non ferrous Metals	Medium - Roughing	AH			PP	GP MS			AL	95	AG	P

Positive Inserts

Cutting Range		Kyocera		Hitachi	Iscar	Kennametal WIDIA	Mitsubishi	NTK	Sandvik	Seco	Sumitomo	Tungaloy
		General Chip-breaker	Chipbreaker for Sticky Material / Soft Steel									
Carbon Steel / Alloy Steel	Minute ap	CF										01
	Finishing	DP GP VF	XP		PF SM	11 GF UF	FV SQ SV SMG	AZ3 AZ7	PF UF	FF1	FC FK FP LU	PF 23
	Finishing - Medium ①	HQ	XQ	JE	14	LF	MQ MV	AF1	PM UM	F1	SF SU	PS 24
	Finishing - Medium ②	GK		JQ			No Indication	QD	PF PM			
	Medium	Standard		J	Standard	GM MR	Standard	AM3	PR UR KM	F2	MU SC	PM
Stainless Steel	Finishing	MQ			WF	FW MW	FV		MF		LU	PF SS
Non ferrous Metals	Finishing - Medium	AH			AF AS	HP	AZ		AL		AG AW	AL

Positive Inserts (Automatic Lathe)

Cutting Range		Kyocera	Hitachi	Iscar	Kennametal WIDIA	Mitsubishi	NTK	Sandvik	Seco	Sumitomo	Tungaloy
Carbon Steel / Alloy Steel	Minute ap	CF									01
	Finishing	CK GF	JQ MP	PF SM	11 UF	FV SV SMG	AZ7 ZR	PF	FF1	FC	PF
	Finishing - Medium	GQ	JE	14	LF	AM MV	AM3	PM	F1	SU	PS
	Medium	GK	J	Standard	MF	Standard	QD	PR	F2	SC	PM
Stainless Steel	Finishing	MQ		WF	FW MW	FV		MF		LU	PF
Non ferrous Metals	Finishing - Medium	AH		AF AS	HP	AZ		AL		AG AW	AL

Milling Insert Description Cross Reference Table

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Kyocera	Class	Appli-cation	Hitachi	Iscar	Mitsubishi	Sandvik	Sumitomo	Tungaloy
SDMR1203AUER-H SDKR1203AUEN-S	M K	Steel	SDKR42TN	SDKR1203AUTR-HS SDKR1203AUN-76	SDNR1203AEEN-JS		SDMR1203AEEN SDMR1203AETN	SDMR1203AETN-MJ SDKR1203AESR-MJ SDKR1203AETN-MJ SDKR1203AEPN-MS SDKR42ZSR-MJ SDKR42ZPN-MS
SDCN1203AUTN	C		SDC42TN-C9					SDCN1203AETN-12 SDCN42ZTN (SDEN1203AETNCR) (SDEN42ZTNCR)
SDKN1203AUTN	K		SDK42TN-C9	SDKN1203AETN	SDKN1203AEN SDKN1203AETN (SDNN1203AETN1)		SDKN42MT (SDNN1203AETN)	SDKN1203AETN-12 SDKN42ZTN
SDKN1203AUFN	K	Cast Iron	SDK42FN-C9				SDKN42M (SDNN1203AEEN)	SDKN1203AEFN-12 SDKN42ZFN
		Non-ferrous Metal					SDKN42M	(SDCN1203AEFN-D) (SDCN42ZFN-DIA)
SDCN1504AUTN	C	Steel	SDC53TN-C9					SDCN1504AETN SDCN53ZTN
SDKN1504AUTN	K		SDK53TN-C9	SDKN1504AETN	SDKN1504AEN SDKN1504AETN		SDKN53MT	SDKN1504AETN SDKN53ZTN
SEMR1203AFER-H SEKR1203AFEN-S	M K	Steel	SEKR42TN	SEKR1203AFTR-HS SEKR1203AFR-HS SEKR1203AFN-76 SEKR1203AFN-42	(SEER1203AFEN-JS)	SEKR1203AZ-WM (SEER1203AZ-WL)	SEMR1203AFEN (SEER1203AFEN)	SEMR1203AFTN-MJ SEKR1203AFSR-MJ SEKR1203AFTN-MJ SEKR1203AFPN-MS
SEMR1204AFER-H	M			(SEKR1204AFTR-HS) (SEKN1204AFTN)		SEKR1204AZ-WM (SEER1204AZ-WL)	SEMR1204AFEN (SEER1204AFEN)	
SEEN1203AFTN	E		SEE42TN-C9		SEEN1203AFTN1		SEEN42MT	SEEN1203AFTNCR-14
SEKN1203AFTN	K		SEK42TN-C9		SEKN1203AFTN1 (SENN1203AFTN1)	SEKN1203AZ (SEMN1203AZ)	SEKN42MT (SENN1203AFTN)	SEKN1203AFTN SEKN1203AFTN-16 SEKN42AFTN SEKN42AFTN16
SEKN1203AFFN	K	Cast Iron	SEK42FN-C9		(SEEN1203AFFN1)	SEKN1203AZ (SEMN1203AZ)	SEKN42M (SENN1203AFEN)	SEKN1203AFFN SEKN42AFFN
SEEN1203AFFN	E	Non-ferrous Metal			(SECN1203AFFR1)			
SEKN1203EFTR	K	Steel	SEK42TR-G3		SEKN1203EFTR1	(SECN1203EER)		SEKN1203EFTR SECN1203EFTR SEEN1203EFTR SECN42EFTRCR SEEN42EFTRCR
SPEN1203EESR	E	Cast Iron	(SPK42FR-A3E)		SPEN42EFSR1 SPEN1203EESR1 (SPEN1203EEER1) (SPNN1203EEER1)			
SPMR1203EDER-H SPKR1203EDER-S	M K	Steel		SPKR1203EDR-76 SPKR1203EDTR-HS	SPER1203EDER-JS	SPKN1203EDR-WH		SPKR1203EDSR-MJ SPKR42SSR-MJ
SPCN1203EDTR	C					SPAN1203EDR	SPCH42TR-R	SPCN1203EDTR SPCN42STR
SPKN1203EDTR	K		SPK42TR-A3	SPKN1203EDTR SPKN1203EDTR-42	SPKN1203EDR	SPKN1203EDR	(SPCH42TR) (SPCH42TR-R)	SPKN1203EDTR SPKN42STR (SPEN1203EDTR) (SPEN42STR)
SPKN1203EDFR	K	Cast Iron	SPK42FR-A3	SPKN1203EDFR		SPKN1203EDR	(SPCH42R)	SPKN1203EDFR SPKN42SFR
SPKN1504EDTR	K	Steel	SPK53TR-A3	SPKN1504EDTR	SPKN1504EDR	SPKN1504EDR	(SPCH53TR-R)	SPKN1504EDTR SPKN53STR (SPCN1504EDTR) (SPCN53STR)
SPKN1504EDFR	K	Cast Iron	SPK53FR-A3	SPKN1504EDFR			(SPCH53R-R) (SPCH53TR-R)	SPKN1504EDFR (SPKN53SFR)

Note1. Tolerance is different for description in ( ).

2. Since edge shape of Milling insert is slightly different by each maker, please adjust edges (Z axis direction) during operation.

Milling Insert Description Cross Reference Table

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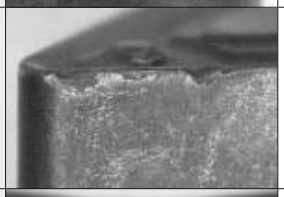
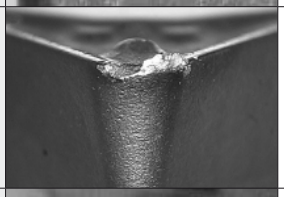
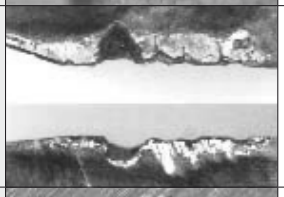
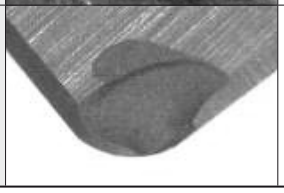
Kyocera	Class	Appli-cation	Hitachi	Iscar	Mitsubishi	Sandvik	Sumitomo	Tungaloy
SPCN1203XPTR	C	Steel	SPC42TR-A5					SPCN1203ZPTR SPCN42ZTR
SPKN1203XPTR	K		SPK42TR-A5					SPKN1203ZPTR SPKN42ZTR (SPEN1203ZPTR) (SPEN42ZTR)
SPKN1203XPFR	K	Cast Iron	SPK42FR-A5					SPKN1203ZPFR SPKN42ZFR
SPKN1504XETR	K	Steel			SPK53C2SR			
TPMR1603PDER-H	M	Steel		(TPKR1603PPTR-HS)	TPER1603PPER-JS	TPKN1603PPR-WH		
TPKN1603PDTR	K		TPK32TR-E0 TPK32TR-G0	TPKN1603PPTR	TPKN1603PPR	TPKN1603PPR	TPKN32TR	
TPKN1603PDFR	K	Cast Iron		TPKN1603PPFR		TPKN1603PPR	TPKN32R	
TPMR2204PDER-H **TPKR2204PDER-S**	M K	Steel		TPKR2204PDTR-HS TPKR2204PDR-76	TPER2204PDER-JS	TPKN2204PDR-WH		TPMR2204PDSR-MJ TPKR2204PDSR-MJ TPKR43ZSR-MJ
TPKN2204PDTR	K		TPK43TR-E0 TPK43TR-G0	TPKN2204PDTR TPKN2204PDTR-42	TPKN2204PDR	TPKN2204PDR	(TPCH43TR)	TPKN2204PPTR TPKN43ZTR (TPCN2204PPTR) (TPCN43ZTR)
TPKN2204PDFR	K	Cast Iron	TPK43FR-E0	TPKN2204PDFR		TPKN2204PDR	(TPCH43R)	TPKN2204PPFR TPKN43ZFR (TPCN2204PPFR) (TPCN43ZFR) (TPEN2204PPTR-16) (TPEN43ZTR)
TEMR1603PTER-H	M	Steel			TEER1603PEER-JS			TEKR1603PEPR-MS
TEKN1603PTTR	K		TEK32TR-G0 (TEE32TR-G0)		(TEEN1603PETR1)		TEKN32TR	(TECN1603PETR) (TEEN1603PETR) (TECN32ZTR) (TEEN32ZTR)
TEKN1603PTFR	K	Cast Iron	TEK32FR-G0 (TEE32FR-G0)		(TEEN1603PEFR1)		TEKN32R	(TEEN1603PEFR) (TEEN32ZFR)
TEEN1603PTFR	E	Non-ferrous Metal			(TECN1603PEFR1)		TEEN32R	(TECN1603PEFR-D) (TECN32ZFR-DIA)
TEMR2204PTER-H **TEKR2204PTER-S**	M K	Steel			TEER2204PEER-JS			TEKR2204PEPR-MS
TEEN2204PTTR	E		TEK43TR-G0E		TEEN2204PETR1		TEEN43TR	TEEN2204PETR (TECN2204PETR) TEEN43ZTR (TECN43ZTR)
TEKN2204PTTR	K		TEK43TR-G0E		TEKN2204PETR1		TEKN43TR	(TEEN2204PETR) (TECN2204PETR) TEEN43ZTR (TECN43ZTR)
TEKN2204PTFR	K	Cast Iron	TEK43FR-G0E		(TEEN2204PEFR1)		TEKN43R	(TEEN2204PEFR) (TEEN43ZFR)
		Non-ferrous Metal			(TECN2204PEFR1)		(TEEN43R)	(TECN2204PEFR-D) (TECN43ZFR-DIA)
SNCN1204XNTN	C	Steel	SNC43TN-D5		SNC43B2S		(CSN43MT)	SNCN1204ZNTN (SNCN43ZTN)
SNKN1204XNTN	K		SNK43TN-D5		SNK43B2S		(CSN43MT)	SNKN1204ZNTN (SNKN43ZTN)
SNCN1204ENTN	C	Steel			(SNKN1204EN)	(SNKN1204ENN)		
SNMF1204XNTN	M	Steel	(SNKF43TN-D5)		(SNKF43B2S)		(CSNB43MT)	(SNKF1204ZNTN) (SNKF43ZFN)

Note1. Tolerance is different for description in ( ).

2. Since edge shape of Milling insert is slightly different by each maker, please adjust edges (Z axis direction) during operation.

Cutting Edges Figuration and Countermeasures

Typical Cutting Edge Figuration		Observation	Causes	Countermeasures
Nose Wear		• Deterioration of surface roughness and dimensional accuracy	• Too high Vc • End of tool life	• Reduce Vc • Change to higher wear resistant grade
Notching		• Burr formation • Cutting force increase	• Too high f and Vc	• Sharper cutting performance • Reduce Vc • Change to higher heat resistant grade
Crater Wear		• Chip control deterioration • Surface finish deterioration (peeled surface)	• Too high Vc	• Reduce Vc • Change to high speed type like Cermet or Al_2O_3 coated insert
Plastic Deformation		• Workpiece dimension's change • Crack at nose	• Too high cutting load • Inappropriate tool grade	• Change to harder grade • Reduce f and *ap*
Crack from Wear		• Surface finish's sudden deterioration • Workpiece dimension	• Too high Vc	• Reduce the pre-set tool life • Change to higher wear resistant grade
Chipping		• Cutting force increase • Surface roughness deterioration	• Too high f • Chattering • Lack of insert toughness	• Reduce f and *ap* • Change to more rigid toolholder • Change to tougher grade
Crack from Welding or Built-up Edge		• Surface finish deterioration • Cutting force increase	• Too low Vc	• Increase Vc • Improve sharp cutting performance (rake angle, chamfer)
Mechanical Fracture		• Sudden cracking • Unstable tool life	• Too high f and *ap* • Chattering	• Change to tougher grade • Enlarge chamfer • Enlarge Corner-R(rε) • Change to more rigid toolholder
Fracture from Thermal Crack		• Cracking by heat cycle • Possible in interrupted cutting and milling	• Too high Vc and f	• Reduce f • Reduce Vc • Change to dry cutting
Flaking		• Possible in high-hardness material cutting • Possible in machining with chattering	• Lack of insert toughness • Lack of toolholder's rigidity	• Change to harder grade (TiC-base ceramic to CBN.) • Change to more rigid toolholder • Change edge preparation

Turning

Trouble	Trouble Item	Measures: Change to Harder Grade	Change to Tougher Grade	Change to More Thermal Shock Resistant Grade	Change to More Welding Resistant Grade	Vc (Higher (Larger) ↑ Lower (Smaller)↓)	f (Higher (Larger) ↑ Lower (Smaller)↓)	ap (Higher (Larger) ↑ Lower (Smaller)↓)	Tool Path Review	Coolant: Wet	Coolant: Dry	Chipbreaker Review	Rake Angle (Larger ↑ Smaller ↓)	Corner-R (rε) (Larger ↑ Smaller ↓)	Approach Angle (Larger ↑ Smaller ↓)	Edge Strength / Honing (Larger ↑ Smaller ↓)	Change to Higher Tolerance (M→G)	Toolholder Rigidity	Workpiece / Tool Installation	Overhang Length	Power, Rigidity
Unstable Dimension	Unstable Workpiece Dimension	Unsuitable Insert Tolerance															●				
		Tool and Workpiece Evacuation										●	●↑	●↓	●↓			●	●	●	●
	Frequent Offset during Cutting	Flank Wear Increase	●											●↑							
		Unsuitable Cutting Conditions					●↓	●↑														
		Built-up Edge				●	●↑															
Surface Roughness	Poor Surface Roughness	Poor Cutting by Tool Wear	●			●	●↓				●		●	●↑	●↑		●↓	●				
		Chipping		●				●↓	●↓				●		●↑		●↑			●	●	●
		Welding, Built-up Edge				●	●↑				●		●	●↑			●↓	●				
		Unsuitable Cutting Conditions					●↑	●↓	●↓		●											
		Unsuitable Tool Geometry											●		●↑		●↓	●				
		Vibration, Chattering		●			●↓	*1 ●↓	●↓				●	●↑	●↓	●↓	●↓		●	●	●	●
Heat	Deterioration of Accuracy or Tool Life by Cutting Heat	Unsuitable Cutting Conditions					●↓	●↓	●↓		●											
		Unsuitable Tool Geometry	●										●	●↑			●↓					
Bur, Chipping	Burr	Unsuitable Cutting Conditions					●↓	●↑		●	●											
		Unsuitable Tool Geometry	●										●	●↑	●↓	●↓	●↓					
	Workpiece Chip Off	Unsuitable Cutting Conditions						●↓	●↓	●												
		Unsuitable Tool Geometry	●										●	●↑	●↑	●↑	●↓		●	●	●	●
	Scuffing	Unsuitable Cutting Conditions					●↑	*2 ●↓			●											
		Unsuitable Tool Geometry	●			●							●	●↑			●↓					
Edge Damage	Wear Increase at Relief Face, Rake Face	Flank Wear	●				●↓				●		●	●↑	●↑		●↓					
		Rake Face Wear	●				●↓	●↓	●↓		●		●	●↑		●↑						
	Notching	Notching				●	●↓				●											
	Chipping	Vibration, Chattering		●				●↓	●↓				●			●↑	●↑		●	●	●	●
	Crack	Unsuitable Tool Geometry		●	●			●↓	●↓				●		●↑	●↑	●↑		●	●	●	●
	Thermal Crack	Work Hardness, Unsuitable Cutting Conditions			●		●↓	●↓	●↓			●	●	●↑			●↓					
	Edge Nose Deformation	Edge Nose Deformation at Interrupted Cutting	●				●↓	●↓	●↓				●	●↓	●↑	●↑	●↑					
	Built-up Edge	Work Hardness, Unsuitable Cutting Conditions				●	●↑	●↑			●		●	●↑			●↓	●				
Chip Control	Long, Tangling Chips	Unsuitable Cutting Conditions					*3 ●↓	●↑	●↑	●		●										
		Unsuitable Tool Geometry											●		●↓	●↓						
	Chips scattering	Unsuitable Cutting Conditions						●↓	●↓			●										
		Unsuitable Tool Geometry											●		●↑	●↑						

*1) To prevent chattering, the higher f may be suitable.
*2) To prevent scuffing, the higher f may be suitable.
*3) When using X-chipbreaker insert for soft steel and low carbon steel, the higher Vc cuts chips short.

Milling

Trouble	Trouble Item	Check Item / Measures	Tool Grade: Change to Harder Grade	Tool Grade: Change to Tougher Grade	Tool Grade: Change to More Thermal Shock Resistant Grade	Tool Grade: Change to More Welding Resistant Grade	Cutting Conditions: Vc (Higher (Larger) ↑ Lower (Smaller) ↓)	Cutting Conditions: fz (Higher (Larger) ↑ Lower (Smaller) ↓)	Cutting Conditions: ap (Higher (Larger) ↑ Lower (Smaller) ↓)	Cutting Conditions: Cutter Dia. Cutting Width Review	Cutting Conditions: Tool Path Review	Cutting Conditions: Coolant: Usage of Mist	Cutting Conditions: Coolant: Dry	Tool Geometry: Insert with Chipbreaker	Tool Geometry: Relief Angle (Larger ↑ Smaller ↓)	Tool Geometry: Corner Angle (Larger ↑ Smaller ↓)	Tool Geometry: Edge Strength / Honing (Larger ↑ Smaller ↓)	Tool Geometry: Insert Number (More ↑ Less ↓)	Tool Geometry: Insert Pocket (Larger ↑ Smaller ↓)	Tool Geometry: Wiper Edge (Relief Angle) Review	Tool Geometry: Insert Runout Check	Tool Geometry: Cutter Rigidity	Setting: Workpiece / Tool Installation	Setting: Overhang Length	Machine: Power, Rigidity
Edge Damage	Flank Wear Increase	Unsuitable Cutting Conditions					● ↓					●													
		Unsuitable Tool Geometry	●												● ↑		● ↓			●					
	Rake Face Wear Increase	Unsuitable Cutting Conditions					● ↓	● ↓	● ↓			●													
		Unsuitable Tool Geometry	●												● ↑	● ↑	● ↓								
	Chipping, Cracking	Unsuitable Cutting Conditions						● ↓	● ↓	●	●														
		Unsuitable Tool Geometry		●											● ↓	● ↑	● ↑			●	●	●	●	●	●
	Edge Breakage by Thermal Shock	Unsuitable Cutting Conditions					● ↓	● ↓	● ↓				●												
		Unsuitable Tool Geometry			●										● ↑		● ↓								
	Built-up Edge	Unsuitable Cutting Conditions					● ↑	● ↑				●													
		Unsuitable Tool Geometry				●									● ↑		● ↓								
Machining Accuracy	Poor Surface Finish	Unsuitable Cutting Conditions					● ↑	● ↓	● ↓			●													
		Unsuitable Tool Geometry	●			●											● ↓	● ↓		●	●		●	●	●
	Burr	Unsuitable Cutting Conditions					● ↓	● ↓	● ↓	●	●														
		Unsuitable Tool Geometry													● ↑	● ↓	● ↓			●					
	Workpiece Chip Off	Unsuitable Cutting Conditions						● ↓	● ↓		●														
		Unsuitable Tool Geometry													● ↑	● ↑	● ↓	● ↑		●					
	Poor Planeness / Parallelness	Tool and Workpiece Evacuation						● ↓	● ↓			*5 ●		●	● ↑	● ↓	● ↓	● ↓		●	●	●	●	●	●
Others	Heavy Chattering, Vibration	Unsuitable Cutting Conditions, Installation					● ↓	*1 ● ↓	*2 ● ↓	●	*4 ●			●	● ↑	● ↓	● ↓	● ↓				●	●	●	●
	Damaging Chips	Unsuitable Cutting Conditions					● ↑	*3 ● ↓		●		*6 ●	●												
		Unsuitable Tool Geometry												●	● ↑			● ↓	●						

*1) To prevent chattering, the higher fz may be suitable.
*2) To prevent chattering, the larger *ap* may be suitable.
*3) Higher fz may be suitable.
*4) Down-cut method is recommended for Helical Endmilling.
*5) If the surface is warped by cutting heat.
*6) Compressed air is recommended.

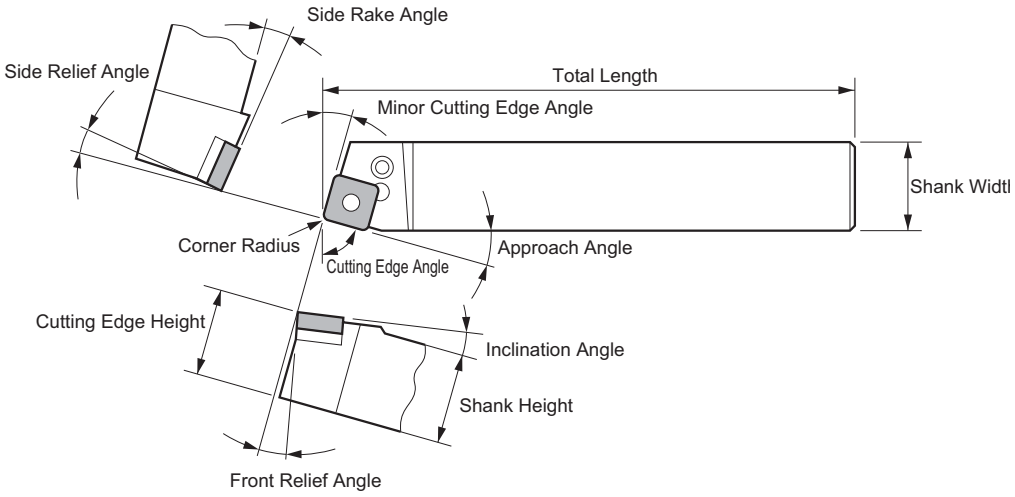
Drilling

Trouble	Trouble Item	Grade Selection: Changfe to Harder Grade	Grade Selection: Change to Tougher Grade	Cutting Conditions: Vc (Higher (Larger)↑ Lower (Smaller)↓)	Cutting Conditions: f (Higher (Larger)↑ Lower (Smaller)↓)	Cutting Conditions: Coolant Discharge Condition	Tool Geometry: Chipbreaker Review	Tool Geometry: Inner Edge's Center Height Check (Core Dia. Check) (Larger ↑ Smaller ↓)	Tool Geometry: Tool Rigidity Improvement (Short Type)	Setting: Workpiece / Tool Installation	Setting: Insert Installation	Setting: Offset Check	Setting: Adjustable Sleeve Usage	Machine: Power, Rigidity
Edge Damage	Unusual Wear	Unsuitable Cutting Speed (too high)	●		●↓									
		Unsuitable Cutting Speed (too low)		●	●↑									
		Unsuitable Coolant Discharge					●							
		Poor Rigidity of Machine / Workpiece								●				●
		Small Hole Dia.										*1 ●	●	
		Unsuitable Tool Grade	●											
	Inner Edge Cracking	No core, Too Small Core						●↑						
		Poor Rigidity of Machine / Workpiece							●	●				●
		Unstable Drilling Start				●↓								
		High Hardness Workpiece	●		●↓	●↓								
		Clogged Chips			●↑			●↓						
		Unstable Insert Installation									●			
	Outer Edge Cracking	Poor Rigidity of Machine / Workpiece								●				●
		Unstable Drilling Start				●↓								
		High Hardness Workpiece	●		●↓	●↓								
		Poor Chip Control		●	●↑									
		Unstable Insert Installation									●			
Toolholder, Others	Scratches on Tool Body	Poor Rigidity of Machine / Workpiece								●				●
		Inaccurate Tool Installment										*1 ●	●	
		Clogged Chips			●↑	●↓								
		Unstable Drilling Start				●↓								
	Poor Hole Dia. Accuracy / Surface Finish	Poor Rigidity of Machine / Workpiece								●				●
		Poor Rigidity of Toolholder							●		●			
		Inaccurate Tool Installment										*1 ●	●	
		Clogged Chips			●↑	●↓		●↓						
		Large Core Dia.						●↓						
		Unstable Drilling Start				●↓								
		Unsuitable Coolant Discharge					●							
	Large Chattering / Vibration	Unsuitable Cutting Conditions, Installation			●↑	●↓				●				●
	Long Chips	Unsuitable Cutting Conditions			●↑									
		Unsuitable Chipbreaker					●							
	Machine Failure	Lack of Machine Power			●↓	●↓		●						●

*1) For lathe operation

Terms and Angles of Toolholder

Terms and Angles of Turning Toolholder



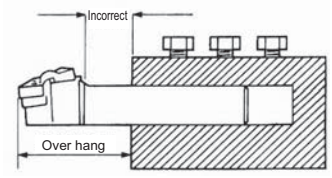
Function of Tool Angle

Tool Angle	Name	Function	Effect
Rake Angle	Side Rake Angle	• Affects cutting force, cutting heat, chip evacuation and tool life.	• If it is positive (+) angle, sharper cutting performance is obtained. (less cutting resistance, less edge strength) • Positive (+) angle is recommended for easy to machine workpieces or thin workpieces. • Smaller rake angle or negative (-) angle is recommended when a stronger edge is required like scale cutting or interrupted cutting.
	Inclination Angle		
Relief Angle	Front Relief Angle Side Relief Angle	• Prevents the tool's contact to the workpiece surface, except the cutting edge.	• When it is small, the cutting edge becomes strong, but the wear at relief faces may shorten the tool life.
Cuting Edge Angle	Cutting Edge Angle	• Affects chip control and the direction of cutting force.	• When it is large, chip thickness becomes thick and chip control improves.
	Approach Angle	• Affects chip control and the direction of cutting force.	• When it is large, chip thickness becomes thin and chip control worsens, but cutting force is dispersed and edge strength improves. • When it is small, chip control ability improves.
	Minor Cutting Edge Angle	• Prevents friction between cutting edge and work surface.	• When it is large, edge strength deteriorates.

Toolholder Rigidity

1. Flexure of Toolholder

$$\delta = \frac{4\times F\times L^3}{E\times b\times h^3} = \frac{4\times k\times d\times f\times L^3}{E\times b\times h^3}$$



Symbol	Name	Measure
δ (Delta)	Deflection	mm
b	Shank Width	mm
h	Shank Height	mm
E	Young ratio	N/mm²
d	ap	mm
f	Feed rate	mm/rev
k	Specific Cutting Resistance	N/mm²
L	Over hang	mm
F	Cutting force	N

(F=k x d x f)

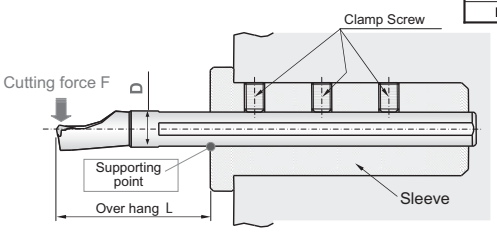
The flexure of toolholder will decrease by increasing of shank height by third root and will decrease of reducing over hang by third root. Minimizing toolholder shank over hang as much as possible is important as well as shank's sectional square measure.

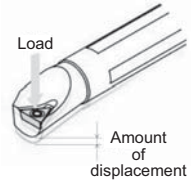
2. Flexure of Boring Bar

$$\delta = \frac{64\times F\times L^3}{3\times E\times \pi\times D^4} = \frac{64\times k\times d\times f\times L^3}{3\times E\times \pi\times D^4}$$

Symbol	Name	Measure
δ (Delta)	Deflection	mm
D	Shank Dia.	mm
E	Young ratio	N/mm²
d	ap	mm
f	Feed rate	mm/rev
k	Specific Cutting Resistance	N/mm²
L	Over hang	mm
F	Cutting force	N

(F=k x d x f)

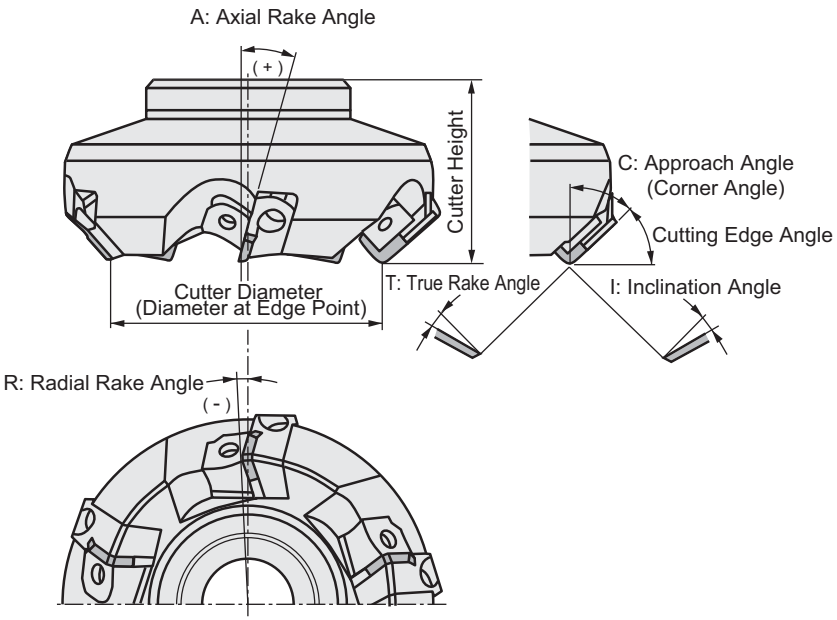


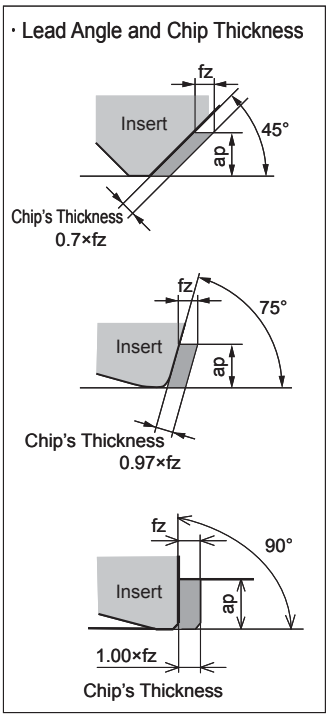


R

Technical Information

Terms and Angles of Milling Cutter





Function of Tool Angle

Symbol	Name	Function	Effect
A	Axial Rake Angle: A.R.	Controls chip flow direction and cutting force	When it is positive --- Good cutting performance and less chip welding
R	Radial Rake Angle: R.R.	Controls chip flow direction and cutting force	When it is negative--- Good chip evacuation
C	Approach Angle	Controls chip thickness and chip flow direction	When it is large --- Thinner chip thickness Less cutting load
T	True Rake Angle	Actual rake angle	When it is positive --- Good cutting performance and less chip welding, but lower edge strength When it is negative--- Higher edge strength but easier to weld
I	Inclination Angle	Controls chip flow direction	When it is positive --- Good chip evacuation Less cutting resistance Lower edge strength at corner part

$\tan T = \tan R \times \cos C + \tan A \times \sin C$

$\tan I = \tan A \times \cos C - \tan R \times \sin C$

Turning

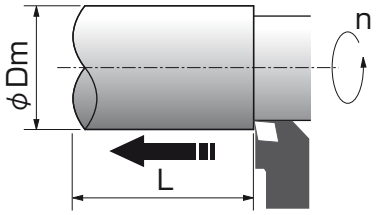
Cutting Speed

$$Vc = \frac{\pi \times Dm \times n}{1000}$$

Vc : Cutting Speed [m/min]

Dm : Workpiece Diameter [mm]

n : Spindle Revolution [min^{-1}]



Power Requirement

$$Pc = \frac{Ks \times Vc \times ap \times f}{6120 \times \eta}$$

$$P_{HP} = \frac{Ks \times Vc \times ap \times f}{4500 \times \eta}$$

Pc : Power Requirement [kW]

P_{HP} : Power Requirement (Horse Power) [HP]

Vc : Cutting Speed [m/min]

ap : Depth Of Cut [mm]

f : Feed Rate [mm/rev]

K_S : Specific Cutting Resistance [kgf/mm^2]

η : Mechanical Efficiency (0.7 ~ 0.8)

Ks Figure	
Low Carbon Steel	190
Medium Carbon Steel	210
High Carbon Steel	240
Low Alloy Steel	190
High Alloy Steel	245
Cast Iron	93
Malleable Cast Iron	120
Bronze, Brass	70

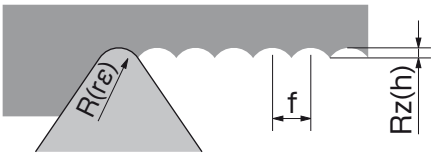
Surface Roughness

$$Rz = h = \frac{f^2}{8 \times R(r\varepsilon)} \times 1000$$

Rz=h : Theoretical Surface Roughness [μm]

f : Feed Rate [mm/rev]

R(rε) : Corner Radius of Insert [mm]



Chip Removal Volume

$$Q = Vc \times ap \times f$$

Q : Chip Removal Volume [cm^3/min]

Vc : Cutting Speed [m/min]

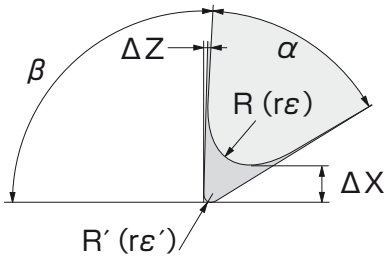
ap : Depth Of Cut [mm]

f : Feed Rate [mm/rev]

Edge position Compensation

$$\Delta X = (R - R') \times \left\{ \frac{\cos\left(\frac{\alpha}{2} + (\beta - 90°)\right)}{\sin\frac{\alpha}{2}} - 1 \right\}$$

$$\Delta Z = (R - R') \times \left\{ \frac{\sin\left(\frac{\alpha}{2} + (\beta - 90°)\right)}{\sin\frac{\alpha}{2}} - 1 \right\}$$



⊿X: X-axis Direction Edge Position Compensation [mm]

⊿Z: Z-axis Direction Edge Position Compensation [mm]

R : Corner-R before Change [mm]

R′: Corner-R after Change [mm]

α : Insert Corner Angle [°]

β : Toolholder's Cutting Edge Angle [°]

Toolholder Type	Insert Corner Angle α	Cutting Edge Angle β	⊿X	⊿Z
PCLN	80°	95°	0.100× (R-R')	0.100× (R-R')
PTGN	60°	91°	0.714× (R-R')	0.030× (R-R')
PDJN	55°	93°	0.866× (R-R')	0.099× (R-R')
PDHN	55°	107.5°	0.531× (R-R')	0.531× (R-R')
PVLN	35°	95°	2.072× (R-R')	0.273× (R-R')
PVPN	35°	117.5°	1.351× (R-R')	1.351× (R-R')
PSBN	90°	75°	0.225× (R-R')	-0.293× (R-R')

Example: Compensation when changing corner-R from 0.8 to 0.4, using PCLN type toolholder,

⊿X=0.100×(0.8-0.4)=0.04(mm)

⊿Z=0.100×(0.8-0.4)=0.04(mm)

Turning (Cutting Time)

Cutting Time (External Turning Case 1: 1 Pass machining)

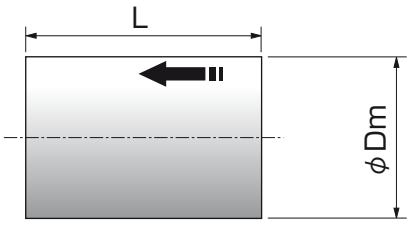
• At Constant Revoluation

$$T=\frac{60\times L}{f\times n}$$

• At Constant Cutting Speed

$$T=\frac{60\times\pi\times L\times Dm}{1000\times f\times Vc}$$

T : Cutting Time [second]
L : Cutting Length [mm]
f : Feed Rate [mm/rev]
n : Spindle Revolution [min^{-1}]
Dm : Workpiece Diameter [mm]
Vc : Cutting Speed [m/min]



Cutting Time (External Turning Case 2: Multi-Pass machining)

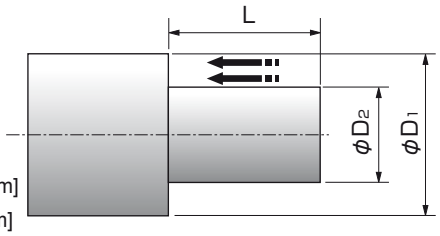
• At Constant Revoluation

$$T=\frac{60\times L}{f\times n}\times N$$

• At Constant Cutting Speed

$$T=\frac{60\times\pi\times L\times(D_1+D_2)}{2\times1000\times f\times Vc}\times N$$

T : Cutting Time [second]
L : Cutting Length per Pass [mm]
ap : Depth Of Cut per Pass [mm]
f : Feed Rate [mm/rev]
n : Spindle Revolution [min^{-1}]
D_1 : Max. Diameter of Workpiece [mm]
D_2 : Min. Diameter of Workpiece [mm]
Vc : Cutting Speed [m/min]
N : Number of Passes = (D_1 - D_2)/ap/2 (if it is indivisible, obtain integer by rounding up one place of decimals.)



Cutting Time (Facing)

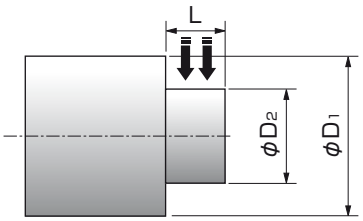
• At Constant Revoluation

$$T=\frac{60\times(D_1-D_2)}{2\times f\times n}\times N$$

• At Constant Cutting Speed

$$T_1=\frac{60\times\pi\times(D_1+D_2)\times(D_1-D_2)}{4000\times f\times Vc}\times N$$

T : Cutting Time [second]
T_1 : Machining Time before reaching Max. Spindle Revolution [second]
L : Cutting Length [mm]
ap : Depth Of Cut per Pass [mm]
f : Feed Rate [mm/rev]
n : Spindle Revolution [min^{-1}]
D_1 : Max. Diameter of Workpiece [mm]
D_2 : Min. Diameter of Workpiece [mm]
Vc : Cutting Speed [m/min]
N : Number of Passes = L/ap (if it is indivisible, obtain integer by rounding up one place of decimals.)



Cutting Time (Grooving)

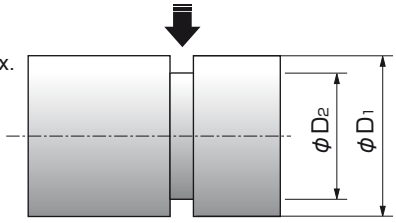
• At Constant Revoluation

$$T=\frac{60\times(D_1-D_2)}{2\times f\times n}$$

• At Constant Cutting Speed

$$T_1=\frac{60\times\pi\times(D_1+D_2)\times(D_1-D_2)}{4000\times f\times Vc}$$

T : Cutting Time [second]
T_1 : Machining Time before reaching Max. Spindle Revolution [second]
L : Cutting Length [mm]
f : Feed Rate [mm/rev]
n : Spindle Revolution [min^{-1}]
D_1 : Max. Diameter of Workpiece [mm]
D_2 : Min. Diameter of Workpiece [mm]
Vc : Cutting Speed [m/min]



Cutting Time (Cut-Off)

• At Constant Revoluation

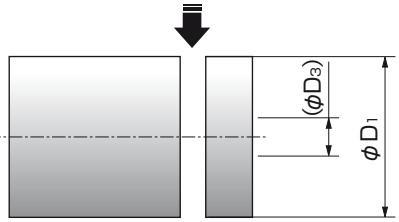
$$T=\frac{60\times D_1}{2\times f\times n}$$

• At Constant Cutting Speed

$$T_1=\frac{60\times\pi\times(D_1+D_3)\times(D_1-D_3)}{4000\times f\times Vc}$$

$$T_3=T_1+\frac{60\times D_3}{2\times f\times n_{max}}$$

T : Cutting Time [second]
T_1 : Machining Time before reaching Max. Spindle Revolution [second]
T_3 : Machining Time when reaching Max. Spindle Revolution [second]
f : Feed Rate [mm/rev]
n : Spindle Revolution [min^{-1}]
n_{max} : Max. Spindle Revolution [min^{-1}]
D_1 : Max. Diameter of Workpiece [mm]
D_3 : Diameter when reaching Max. Spindle Revolution [mm]
Vc : Cutting Speed [m/min]



Basic Formulas

Milling

Cutting Speed

$$Vc = \frac{\pi \times Ds \times n}{1000}$$

Vc : Cutting Speed [m/min]

Ds : Cutter Diameter [mm]

n : Spindle Revolution [min^{-1}]

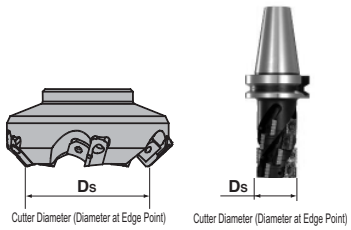


Table Feed & Feed per Tooth

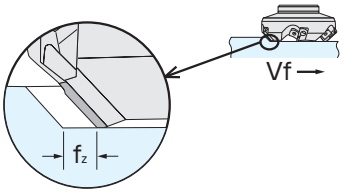
$$f_z = \frac{Vf}{Z \times n}$$

f_z : Feed per Tooth [mm/t]

Vf : Table Feed [mm/min]

Z : Number of Inserts

n : Spindle Revolution [min^{-1}]



Power Requirement

$$Pc = \frac{Ks \times Q}{6120 \times \eta} = \frac{Ks \times ae \times Vf \times ap}{6120000 \times \eta}$$

$$= \frac{Ks \times ae \times fz \times Z \times n \times ap}{6120000 \times \eta}$$

$$P_{HP} = \frac{6120}{4500} \times Pc$$

Pc : Power Requirement [kW]

P_{HP} : Power Requirement (Horse Power) [HP]

ae: Width of Cut [mm]

Vf : Table Feed [mm/min]

f_z : Feed per Tooth [mm/t]

Z : Number of Inserts

n : Spindle Revolution [min^{-1}]

ap: Depth Of Cut [mm]

Ks: Specific Cutting Resistance [kgf/mm^2]

η : Mechanical Efficiency (0.7 ~ 0.8)

Ks Figure	
Low Carbon Steel	190
Medium Carbon Steel	210
High Carbon Steel	240
Low Alloy Steel	190
High Alloy Steel	245
Cast Iron	93
Malleable Cast Iron	120
Bronze, Brass	70

Chip Removal Volume

$$Q = \frac{ae \times Vf \times ap}{1000} = \frac{ae \times fz \times Z \times n \times ap}{1000}$$

Q : Chip Removal Volume [cm^3/min]

ae: Width of Cut [mm]

Vf: Table Feed [mm/min]

f_z : Feed per Tooth [mm/t]

Z : Number of Inserts

n : Spindle Revolution [min^{-1}]

ap: Depth Of Cut [mm]

Cutting Time

$$T = \frac{60 \times L'}{Vf} = \frac{60 \times L'}{fz \times Z \times n}$$

T : Cutting Time [second]

L´ : Total Table Transfer Length [mm]

(=L + DS + 2α)

L : Work Length [mm]

Ds: Cutter Diameter [mm]

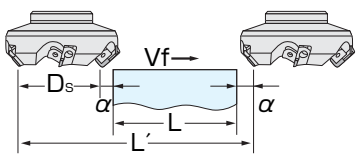
α : Idling Distance [mm]

Vf : Table Feed [mm/min]

f_z : Feed per Tooth [mm/t]

Z : Number of Inserts

n : Spindle Revolution [min^{-1}]



True Rake Angle

$$\tan T = \tan R \times \cos C + \tan A \times \sin C$$

Inclination Angle

$$\tan I = \tan A \times \cos C - \tan R \times \sin C$$

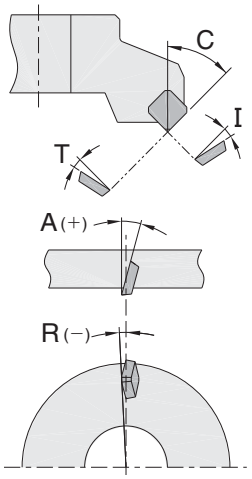
A : Axial Rake Angle A.R. [°] (-90° < A < 90°)

R : Radial Rake Angle R.R. [°] (-90° < R < 90°)

C : Approch Angle [°] (0° < C < 90°)

T : True Rake Angle [°] (-90° < T < 90°)

I : Inclination Angle [°] (-90° < I < 90°)



Ball-Nose Endmill Cutting & Revolution

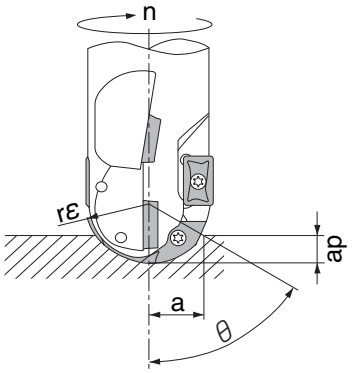
$$n = \frac{1000 \times V_a}{2 \times \pi \times \sqrt{a(2r\varepsilon - ap)}}$$

n : Revolution [min-1]

rε : Radius of Ball-Nose Endmill (Ball Part's redius [mm])

ap : Depth Of Cut [mm]

V_a : Cutting Speed at Point "a" [m/min]



Drilling

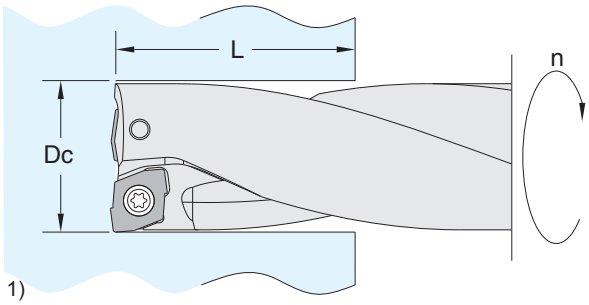
Cutting Speed

$$Vc = \frac{\pi \times Dc \times n}{1000}$$

Vc : Cutting Speed [m/min]

Dc : Drill Diameter [mm]

n : Spindle Revolution [min^{-1}]



Feed Rate (Milling)

$$Vf = fz \times Z \times n$$

Vf : Table Feed [mm/min]

fz : Feed per Tooth [mm/t]

Z : Number of Insert (Number of Insert = 1)

n : Spindle Revolution [min^{-1}]

Cutting Time

$$T = \frac{60 \times L}{f \times n} = \frac{60 \times \pi \times Dc \times L}{1000 \times Vc \times f}$$

T : Cutting Time [second]

L : Drilling Depth [mm]

f : Feed Rate [mm/rev]

n : Spindle Revolution [min^{-1}]

Dc : Drill Diameter [mm]

Vc : Cutting Speed [m/min]

Power Requirement (Reference Value)

$$Pc = \frac{Dc}{20} \times \frac{Vc}{100} \times \left(1 + \left(\frac{2.5 \times f}{0.1}\right)\right)$$

Pc : Power Requirement [kw]

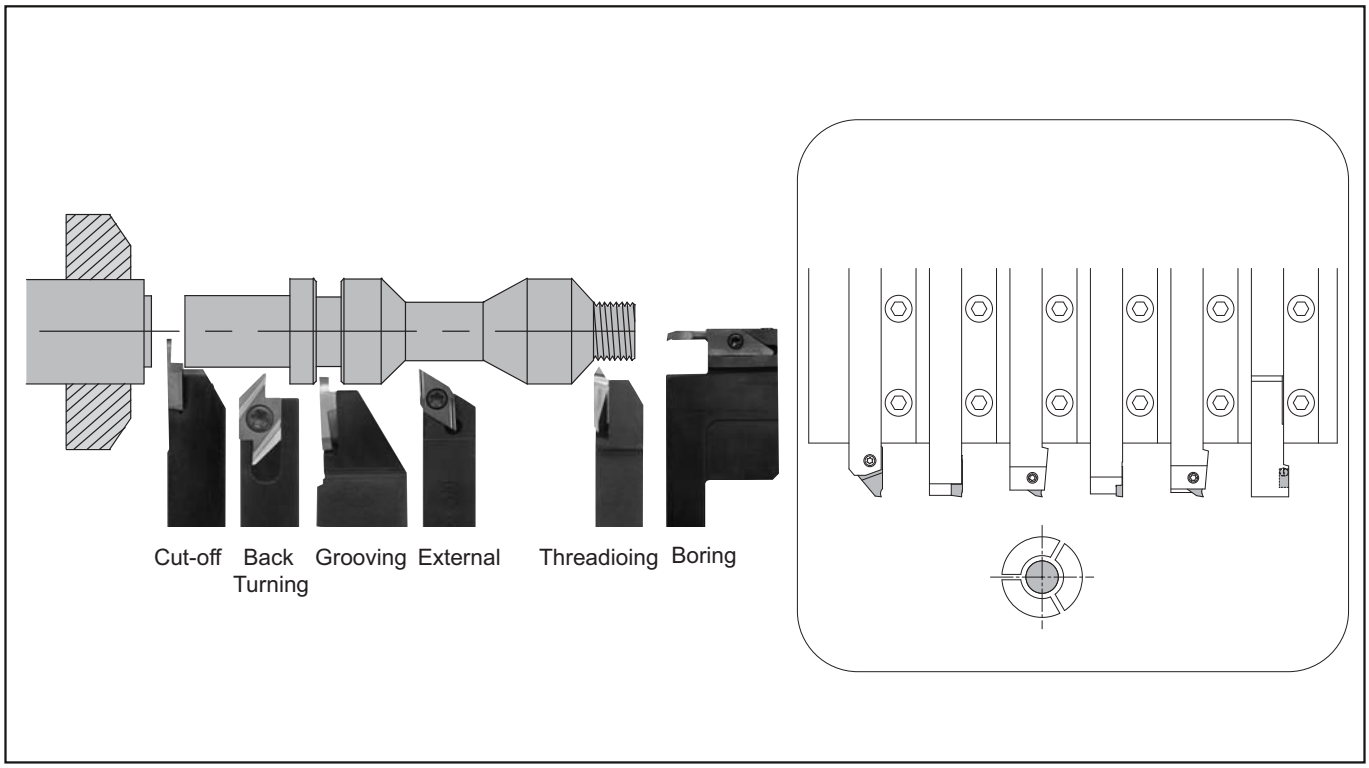
Dc : Drill Diameter [mm]

Vc : Cutting Speed [m/min]

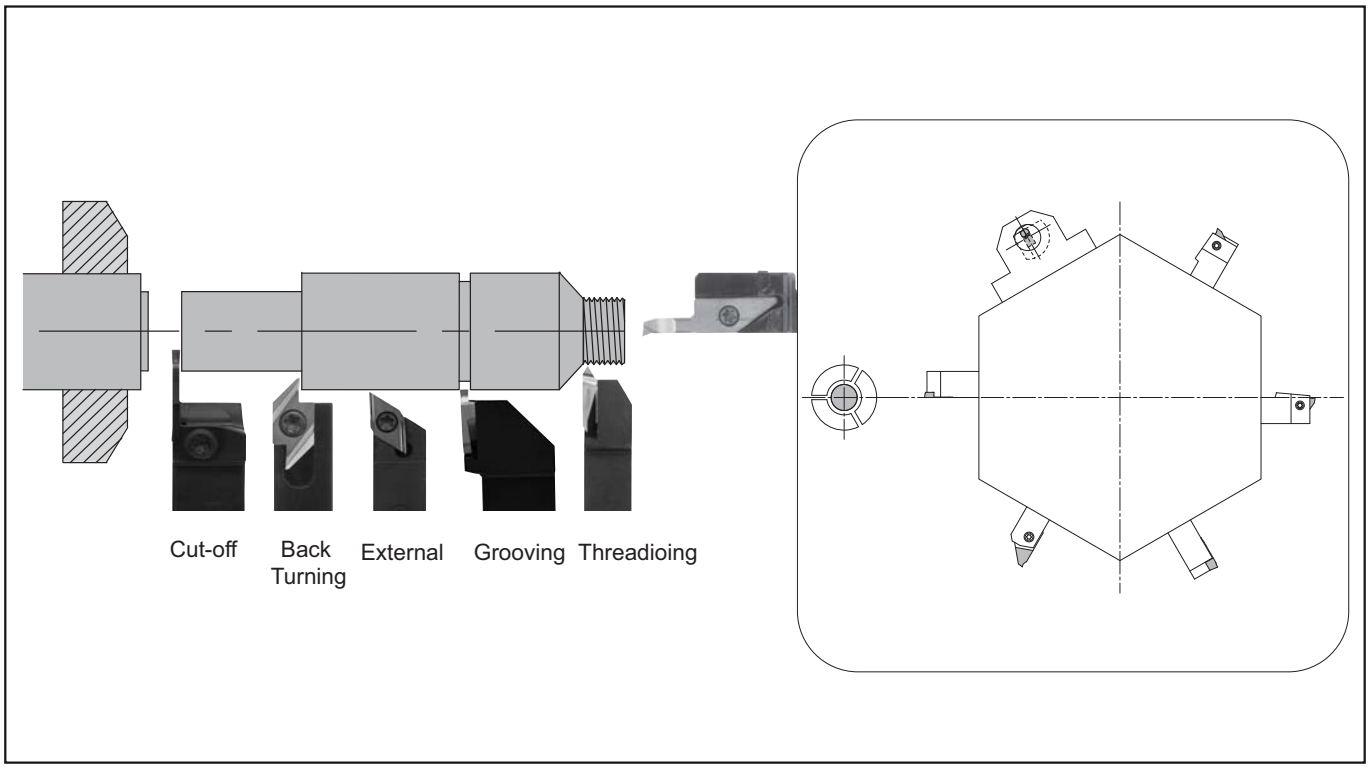
f : Feed Rate [mm/rev]

Tooling Examples of Small Tools

Tooling Example ① CNC Automatic Lathe (Gang Type)

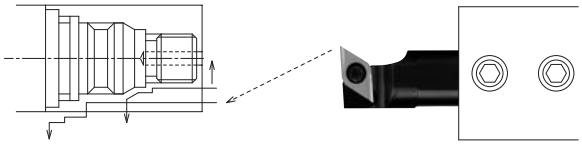


Tooling Example ② CNC Automatic Lathe (Turret Type)

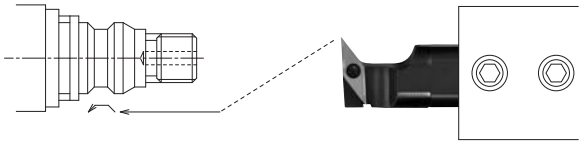


Tooling Example ③ CNC Automatic Lathe (Opposed Gang Type)

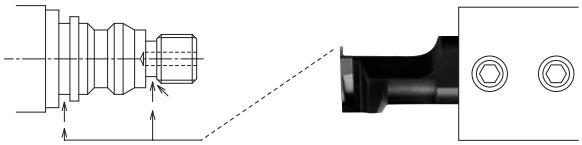
External / Facing



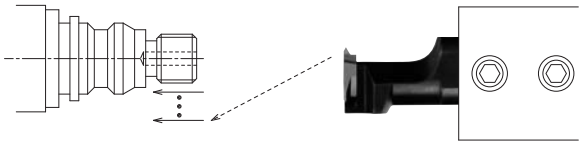
External / Copying



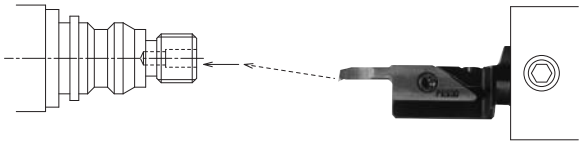
Grooving

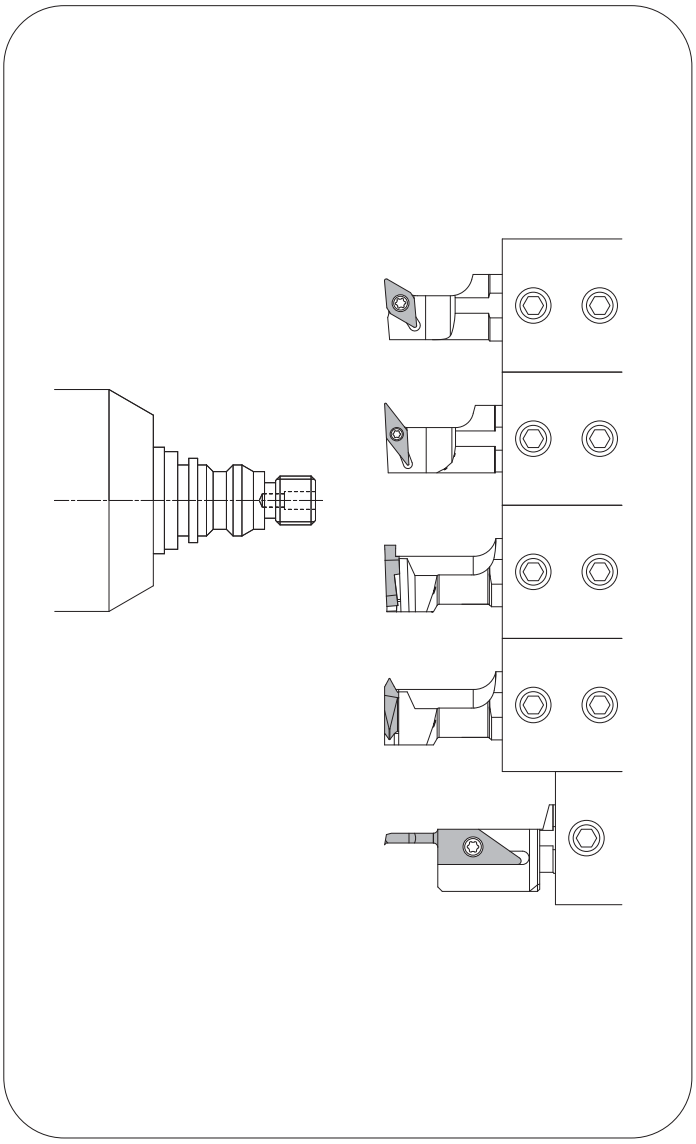


Threading



Boring





Citizen Machinery

Model	Toolholder Dimensions (Gang-Type)	Number of tools	Toolholder Dimensions (Turret-Type)	Number of tools	Sleeve Dia.	Number of tools	Max. Cutting Dia.	Remarks
A12	10×10×100	5			ø19.05 / ø20		ø12	
A16	10×10×100	5			ø19.05 / ø20		ø16	
A20	12(13)×12(13)×120*1	7			ø25.4		ø20	
B12	10×10×100	5			ø19.05 / ø20		ø12	
B20	12(13)×12(13)×120	6			ø19.05 / ø20		ø20	
BL12	10×10×60~120	5			ø20(ø19.05)		ø12	
BL20	12(13)×12(13)×120	4~7			ø20(ø19.05)		ø20	
BL25	12(13)×12(13)×120	4~7			ø20(ø19.05)		ø25	
C12	10×10×120	6			ø19.05		ø12	
C16	10×10×120	6			ø19.05		ø16	
C32	16×16×130	5			ø25.4		ø32	
E16	10×10×60	20			ø19.05		ø16	
E20	16×16×90	20			ø25.4		ø20	
E25	16×16×90	20			ø25.4		ø25	
E32			16(19)×16(13)×90	20	ø25.4		ø32	
F10			10×10×60	10	ø19.05		ø10	
F12			10×10×60	10	ø19.05		ø12	
F16			10×10×60	10	ø19.05		ø16	
F20			16(19)×16(13)×90	10	ø25.4		ø20	
F25			16(19)×16(13)×90	10	ø25.4		ø25	
FL25			16×16×90	12	ø16		ø25	
FL42			16×16×90	12	ø16		ø42	
G32			16(19)×16(19)×90	10	-		ø32	
K12	12×12×100	6			ø19.05 / ø20		ø12	
K16	12×12×100	6			ø19.05 / ø20		ø16	
L10	8×8×100~130	5			ø15.875		ø10	
L16	12(10)×12(10)×130	5			ø19.05		ø16	
L20	12×12×130	5			ø19.05		ø20	
L25	16×16×130	5			ø25.4		ø25	
L32	16×16×130	5			ø25.4		ø32	
M212, M312	10×10×120	5	10×10×60	10	ø19.05		ø12	
M216, M316	10×10×120	5	10×10×60	10	ø19.05		ø16	
M220, M320	16×16×130	5	16×16×90	10	ø25.4		ø20	
M232, M332	16×16×130	5	16×16×90	10	ø25.4		ø32	
M20	13(12)×13(12)×130	5	10×10×60	10	ø19.05		ø20	
MSL12	10×10×120				-		ø12	
R04	8×8×120	5			ø15.875		ø4	
R07	8×8×120	5			ø15.875		ø7	
RL01	10(8)×10(8)×90				ø16(ø20)		ø10	
RL02	16×16×90				ø20		ø20	
RL21	10(12)×10(12)×90				ø19.05		ø35	

・This table is approved by machine manufacturers.
・Manufacturers are in no particular order.

Star Micronics

Model	Toolholder Dimensions (Gang-Type)	Number of tools	Toolholder Dimensions (Turret-Type)	Number of tools	Sleeve Dia.	Number of tools	Max. Cutting Dia.	Remarks
ECAS-12	10×10×95~150	6	-	-	ø22		ø13	
ECAS-20	12×12×80~150	6	-	-	ø22		ø20	
	16×16×80~144		-	-				
ECAS-32T	16×16×80~120	4	16×16×60~78	St.10	ø22 / ø32		ø32	
			16×16×80~88	St.10				
JNC-10			8×8×80~120	5	ø22		ø10	
JNC-16			10×10×80~120	5	ø22		ø16	
JNC-25 / 32			10×10×78~120	1×St.10	ø22			
KJR-16B / 25B								
KNC-16 / 20								
KNC-25Ⅱ / 32Ⅱ								
RNC-10 / 16								
RNC-16 / 16BⅡ								
SA-16R								
SB-16 TYPE-A / C / D	12×12×95~130	5	-	-	ø22 / (ø22)	4		
	12(10)×12(10)×95~130	6	-	-	ø22 / ø22	4/4		
SC20	12×12×95~130	5	-	-	ø22	4		
	12(10)×12(10)×95~130	6	-	-		4/4		
SE-12 / 12B·16 / 16B								
SH-7								
SH-12 / 16								
SI-12 / 12C								
SR-10J	8×8×67~110	6			ø16	4		
SR-16 / 20								
SR-20RⅡ	12×12×100~135	6			ø22			
SR-20RⅢ / 20J	12×12×95~135	6	2 (For opposed SP side, deep hole machining)	4/4			ø20, ø30 (ø24)	
SR-25J / 32J	16×16×95~155	6						
SR-32								
SV-12 / 20	12×12×95~135	5	12×12×70~78	St.8	ø22 / ø32			
	16×16×95~135	4	16×16×65~70					
SV-32	16×16×95~135	4	16×16×60~70 / 80~88	St.8	ø22 / ø32			
SV-32J / 32JⅡ	16×16×95~135	4	16×16×65~70	St.8	ø22 / ø32			
SW-7								
VNC-12								
VNC-20								
VNC-32								

・This table is approved by machine manufacturers.
・Manufacturers are in no particular order.

Tsugami

Model	Toolholder Dimensions (Gang-Type)	Number of tools	Toolholder Dimensions (Turret-Type)	Number of tools	Sleeve Dia.	Number of tools	Max. Cutting Dia.	Remarks
B007-Ⅱ	7×7×85 (8)×(8)×(85) (10)×(10)×(85)	8			ø25		ø7	
B012-Ⅲ / Ⅴ	12×12×85	9			ø20		ø12	
B018-Ⅲ	12×12×85	9			ø20		ø18	
B020-Ⅴ	12×12×85	9			ø20		ø20	
BA20	12×12×85	6			ø25		ø20	
BA26	12(16)×12(16)×85	6			ø25		ø26	
BC18	12×12×85	10			ø25 / ø10		ø18	
BC25	12×12×85	10			ø10 / ø25		ø25	
BE12	12×12×85	9			ø20		ø12	
BE18	12×12×85	9			ø20		ø18	
BH20	12×12×85	4	12×12×90 16×16×90	St.12	ø25 / ø32		ø20	
BH38	16×16×100	7	20×20×125	St.12	ø25 / ø32		ø38.1	
BM07	8×8×85	9			ø20		ø7	
BM16	12×12×85	9			ø20		ø16	
BM16E	12×12×85	9			ø20		ø16	
BN12	12×12×85	7			ø20		ø12	
BN20	12(16)×12(16)×85	7			ø20		ø20	
BS12-Ⅲ	12×12×85	7 or 10			ø14 / ø25		ø12	
BS12-Ⅴ	12×12×85	8 or 12			ø20 / ø25		ø12	
BS18-Ⅲ	12×12×85	7 or 10			ø14 / ø25		ø18	
BS20-Ⅲ	16×16×100	7 or 10			ø16 / ø25		ø20	
BS20-Ⅴ	12×12×85	8 or 12			ø20 / ø25		ø20	
BS26-Ⅲ	16×16×100	7 or 10			ø16 / ø25		ø26	
BS32-Ⅲ	16×16×100	6			ø16 / ø25		ø32	
BU12	12×12×85	4	12×12×80	St.8	ø20		ø51	
BU20	12×12×85	4	12×12×80	St.8	ø20		ø20	
BU26	16×16×100	7	20×20×90	St.8	ø20 / ø32		ø26	
BU38	16×16×100	7	20×20×90	St.8	ø20 / ø32		ø38	
BW07	12×12×85	7			ø20		ø7	
BW12	12×12×85	7			ø20		ø12	
BW20	12(16)×12(16)×85	7			ø20		ø20	
C004-Ⅱ / Ⅲ	12×12×60~100	6~8			-		ø100	
C15	10×10×60~100	10~14			-		ø75	
C150	12×12×60~100	4~6			-		ø75	
C220	12×12×60~100	6~8			-		ø100	
C300	16×16×100~130	6~10			-		ø150	
M34J	-	-	20×20×125	St.12	ø20 / ø32		ø34	
M42J	-	-	20×20×125	St.12	ø25 / ø32		ø42	
M42SD	-	-	20×20×125	St.12	ø25 / ø32		ø42	
M50	-	-	20×20×100	St.12	ø32		ø51	
M50J	-	-	20×20×100	St.12	ø20 / ø32		ø51	
MB35	-	-	20×20×90	2×St.8	ø20 / ø32		ø35	
MB38	-	-	20×20×90	2×St.8	ø20 / ø32		ø38	
MB50	-	-	20×20×90	2×St.8	ø20 / ø32		ø50	
MU26	-	-	20×20×90	2×St.8	ø20 / ø32		ø26	
MU38	-	-	20×20×90	2×St.8	ø20 / ø32		ø38	
NU50	-	-	20×20×100	St.12	ø20 / ø32		ø51	
TMA8-Ⅱ	20×20×100~125	1			ø25 / ø32		ø65	
TMU1	20×20×100~125	1	20×20×125	St.16	ø25 / ø32		ø38	

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Nomura VTC

Model	Toolholder Dimensions (Gang-Type)	Number of tools	Toolholder Dimensions (Turret-Type)	Number of tools	Sleeve Dia.	Number of tools	Max. Cutting Dia.	Remarks
NN-10C	10×10×130	6			ø17		ø10	
NN-10CS	10×10×130	5			ø17		ø10	
NN-10SB5	10×10×130	5			ø23		ø10	
NN-10SⅡ	10×10×130	5			ø23		ø10	
NN-10T	10×10×130	7			ø23		ø10	
NN-16SB5	10×10×130	5			ø23		ø16	
NN-16HⅢ	12×12×130	6			ø23		ø16	
NN-16UB5	12×12×130	5			ø23		ø16	
NN-16UⅢ	12×12×130	5			ø23		ø16	
NN-16J	12×12×130	6			ø23		ø16	
NN-20HⅢ	12×12×130	6			ø23		ø20	
NN-20UB5	12×12×130	5			ø23		ø20	
NN-20UB7	12×12×130	6			ø23		ø20	
NN-20UⅢ	12×12×130	5			ø23		ø20	
NN-20YB	12×12×130	8			ø23		ø20	
NN-25YB / 32YB	16×16×130	8			ø23 / ø32		ø25	
NS-P1053A	9.5×9.5×130	5			-		ø10	
NN-20J	12×12×130	6			ø23		ø20	
NN-16SB6	12×12×130	5			ø22		ø16	

Miyano

Model	Toolholder Dimensions (Gang-Type)	Number of tools	Toolholder Dimensions (Turret-Type)	Number of tools	Sleeve Dia.	Number of tools	Max. Cutting Dia.	Remarks
ABX-51TH3			20×20×125	St.36	ø25	72	ø51	
ABX-64TH3			20×20×125	St.36	ø25	72	ø64	
ABX-51SY			20×20×125	St.24	ø25	48	ø51	
ABX-64SY			20×20×125	St.24	ø25	48	ø64	
BNC-34C$_5$			20×20×125	St.8	ø25	16	ø34	
BNC-42C$_5$			20×20×125	St.8	ø25	16	ø42	
BND-34C$_5$			20×20×125	St.12	ø25	24	ø34	
BND-34S$_5$			20×20×125	St.12	ø25	24	ø34	
BND-42C$_5$			20×20×125	St.12	ø25	24	ø42	
BND-42S$_5$			20×20×125	St.12	ø25	24	ø42	
BND-51S$_2$			20×20×125	St.12	ø25	24	ø51	
BND-51SY2			20×20×125	St.12	ø25	24	ø51	
BNE-34S5			20×20×125	St.24	ø25	48	ø34	
BNE-34SY5			20×20×125	St.24	ø25	48	ø34	
BNE-51S5			20×20×125	St.24	ø25	48	ø51	
BNE-51SY5			20×20×125	St.24	ø25	48	ø51	
BNJ-34S			20×20×125	St.18	ø25	30	ø34	
BNJ-34SY			20×20×125	St.18	ø25	30	ø34	
BNJ-42S			20×20×125	St.18	ø25	30	ø42	
BNJ-42SY			20×20×125	St.18	ø25	30	ø42	
BNJ-51SY2			20×20×125	St.18	ø25	30	ø51	
BX-20S	16×16×120	9			ø20	8	ø20	
BX-26S	16×16×120	9			ø20	8	ø26	
B6-16	12×12×80	6	12×12×80(Cross Slide)	St.6	ø38		ø16	Multi-Spindle Automatic Lathe
G6-26		6	13×13×120(Cross Slide)	St.6	ø41.275		ø26	
F6-26		6	13×13×120(Cross Slide)	St.6	ø41.275		ø26	
MZ-32		6	13×13×120(Cross Slide)	St.6	ø41.275		ø32	
E6-C62		6	13×13×120(Cross Slide)	St.6	ø41.275		ø62	

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Automatic Lathe List by Manufacturer

Eguro

Model	Toolholder Dimensions (Gang-Type)	Number of tools	Toolholder Dimensions (Turret-Type)	Number of tools	Sleeve Dia.	Number of tools	Max. Cutting Dia.	Remarks
SANAX-6	12×12	5 (Max.)		5	ø16		ø15	
SANAX-8	16×16	5 (Max.)		5	ø25 / ø30		ø20	
	12×12	7 (Max.)		5	ø25 / ø30		ø20	
SANAX-10	16×16	5 (Max.)		5	ø25 / ø30		ø25.5	
EBN-10EX	12×12	6 (Max.)			ø20		ø25.5	
NUCBOY-8EX	12×12	6 (Max.)			ø20		ø20	
NUCLET-10EX	16×16	10 (Max.)			ø20		ø25.5	
NUCPAL-10EX	16×16	10 (Max.)			ø20		ø25.5	

Amada Wasino

Model	Toolholder Dimensions (Gang-Type)	Number of tools	Toolholder Dimensions (Turret-Type)	Number of tools	Sleeve Dia.	Number of tools	Max. Cutting Dia.	Remarks
G05	16×16				ø20		ø50×40	
G06	16×16				ø20		ø60×60	
G07	16×16				ø20		ø100×100	
G07M	16×16				ø20		ø100×100	
G07F	20×20				ø20		ø120×120	
GG5	16×16				ø20		ø50×40	
GS04	16×16				ø20		ø30×20	
J1			20×20	8	ø25		ø120×120	
J3			25×25	8	ø32		ø170	
J5			25×25	8	ø32		ø240	
JJ1			20×20	8	ø25		ø50×50	
JJ3			25×25	8	ø32		ø100×100	
JJ3M			25×25	12	ø32		ø100×100	
Ai8			20×20	8	ø25		ø50×50	
A12				12	ø25		ø50×80	
A18S				18	ø25		ø50×80	
AD12				9	ø25		ø50×80	
AD18S				15	ø25		ø50×80	
AA1			20×20	8	ø25		ø50×50	

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