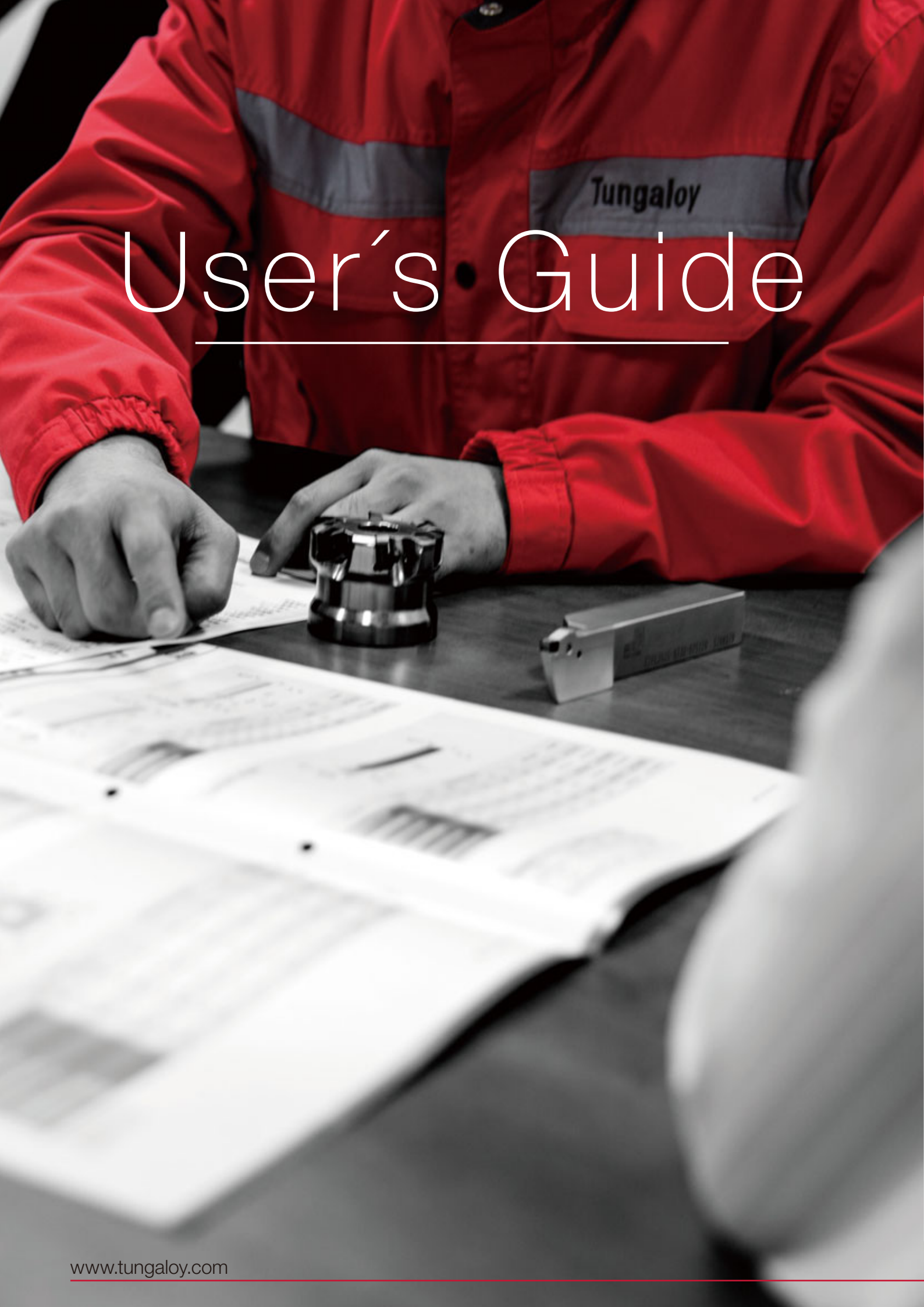


A person wearing a red work jacket with the brand name 'Tungaloy' on the chest is working at a table. They are looking at technical drawings and holding a small, complex mechanical part. A metal block is also on the table. The scene is in black and white, with the jacket being the only color.

User's Guide

USER'S GUIDE



Parts for Tools

G002

Technical Reference

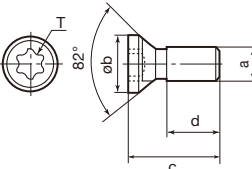
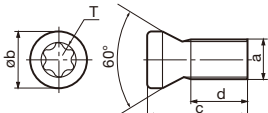
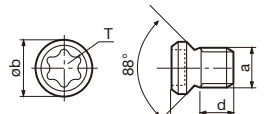
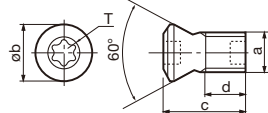
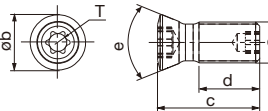
G029

Alphanumeric Index

G084

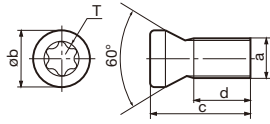
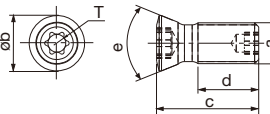
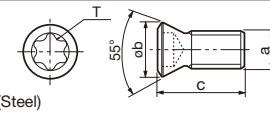
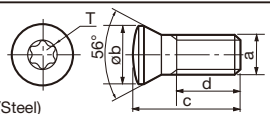
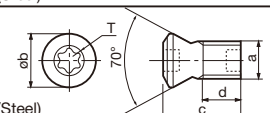
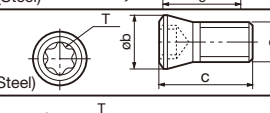
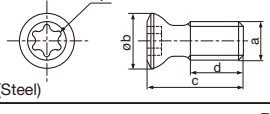
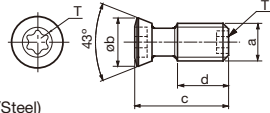
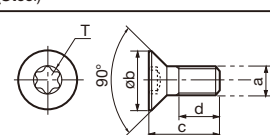
User's Guide- Parts for Tools

Screws

Shape	Designation	Dimension (mm)					T / f	Torque (N·m)
		a	øb	c	d	e		
 (Steel)	CSTA-NO2	#2-56UNC	4	6	4	82	T8	1.3
	CSTA-NO2S			5	3			
	CSTA-NO2L			8	6			
	CSTA-NO3	#3-48UNC	4.3	7	4		T9	2.3
	CSTA-NO5	#5-40UNC	5	8	5			
	CSTA-1.6	M1.6x0.35	2.5	3.1	0.9			
	CSTA-4	M4x0.7	7	10	7.7		T15	3.5
	CSTA-5	M5x0.8	7.2	15	11			
	CSTA-5S			12	8			
	CSTA-5SS			9.5	5.5			
	CSTA-5ST25		12	8	T25		5	
	CSPA-5IP15		7.1	15	11		15IP	3.5
	CSPA-5SIP15			12	8		20IP	5
	CSPA-5IP20			15	11			
	CSPA-5SIP20		12	8				
  CSP-2L033 type shown  CSTB-4SD type shown  CSTC-4L type shown (Steel)	CSP-2L033	M2x0.4	2.6	3.3	1.9	60	6IP	0.7
	CSTB-2		2.7	3.3	1.4		T6	0.7
	CSTB-2L			5.2	3.3			
	CSTB-2L040	M2.2x0.45	3.5	4	2.1		T7	1
	CSTB-2.2			6.1	3.5			
	CSTB-2.2L038			3.8	2.2			
	CSTB-2.2S	M2.5x0.45	3.1	4.6	2		T8	1.3
	CSTB-2.2R			6.1	3.7			
	CSTB-2.5			8	5.4			
	CSTB-2.5L080	M3x0.5	4.1	5.5	2.6		T9	2.3
	CSTB-2.5B			4.8	2.2			
	CSTB-2.5S			8	4.5			
	CSTB-3	M3.5x0.6	4.2	4.2	0.7		T8	1.3
	CSTB-3L042			5	2			
	CSTB-3L050			8.1	4.7			
	CSTB-3L081	M4x0.7	5.5	4.1	2.5		T9	2.3
	CSTB-3S			5.5	12.5	4		
	CSTB-3.5ST			5.2	6.5	3.1	T15	3.5
	CSTB-3.5H	5.5	8.4	4.3				
	CSTB-3.5	M3.5x0.6	6.5	10	5.5	T20	5	
	CSTB-3.5T			8.5	4			
	CSTB-3.5TS			4.7	8.4	4.9	T9	2.3
	CSTB-3.5D	5.5	11	7.5				
	CSTB-3.5L110	M4x0.7	5.5	4.8	11.5	7	T15	3.5
	CSTB-3.5L115			4.8	11.5	6.5		
	CSTB-3.5L115-S			12.5	8.4	T10	2.5	
	CSTB-3.5L	11.4	7.4	3.5				
	CSTB-4	M4x0.7	5.5		6	2	T15	3.5
	CSTB-4L060			8.48	3.48			
	CSTB-4L085			5.7	9	5.5	5.5	3.5
	CSTB-4L090	5.5	11.5	6.5				
	CSTB-4L115-S	5.5	8	4	T8	1.3		
	CSTB-4S	6.4	14.7					
	CSTB-4ST	M4x0.5	5.5	8	5.5	3.5		
	CSTB-4SD	M4x0.7	9.5	5.5				
	CSTB-4M	M4x0.5	7	14.7	8.7	T15	3.5	
	CSTB-4F	M4x0.7	6.5	9	4.5			
	CSTB-4TS	M5x0.8	7	12	7.5	T20	5	
	CSTB-5			9.5	5			
	CSTB-5S			10.5	6.1			
	CSTB-5L105	M4x0.5	7.2	12	6.5	44	T8/T10	1.3/2.5
	CSTB-5L120			15.9	11.2			
	CSTB-5L159			6.9	16.3	11.3		
	CSTB-5L163-S	M4x0.5	5.42	5.5	2	60	6IP	0.7
	CSTC-4L055DR	M4x0.5	5.42	5.5	2			
	CSTC-4L055DL	M4x0.7	5.42	10	5.95	44	T8/T10	1.3/2.5
	CSTC-4L100DR	M4x0.7	5.42	10	5.95			
	CSTC-4L100DL	M2x0.4	2.7	4.3	2.5	60	6IP	0.7
	CSPB-2L043	M2x0.4	2.6	3.4	1.6			
	CSPB-2H							

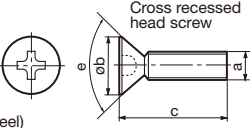
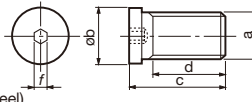
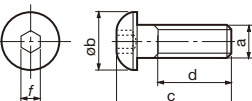
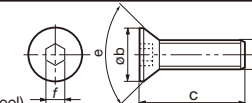
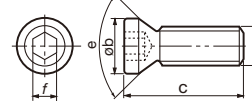
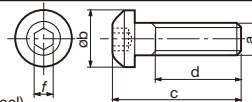
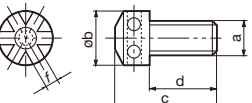
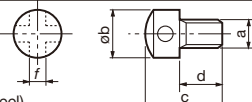
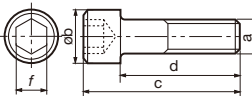
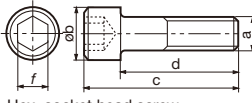
User's Guide- Parts for Tools

Screws

Shape	Designation	Dimension (mm)						Torque (N·m)
		a	øb	c	d	e	T / f	
  SCREW TORX M4 L=9.5MM type shown	CSPB-2.2	M2.2x0.45	3	6	3.9	60	7IP	1
	CSPB-2.2SH			4	2			1.1
	CSPB-2.5	M2.5x0.45	3.5	6	3.5		8IP	1.3
	CSPB-2.5S			4.2	1.7			
	CSPB-2.5SH	M3.5x0.6	5.2	5.2	3.3		7IP	1.1
	CSPB-3.5			9	5.6		15IP	3.5
	CSPB-3.5S	M4x0.7	5.5	6.5	3.1			
	CSPB-4			11.6	7.4			
	CSPB-4S	M5x0.8	7	8.2	4		20IP	5
	CSPB-5			12	7.5			
	VX040024A	M4	5.45	9	6	60	T15	4.5
	VX040028A	M4	5.2	9.7	4.7	44	T15	4.5
	SR14-500/L5.1	M4	5.5	5.1	2.3	60	T15	3.5
	SR14-500-L7.0	M4	5.5	7	4.2		T15	3.5
	SR14-562	M3.5	4.8	8.75	5.55		T10	3.5
	SR14-562/S	M3.5	4.8	6.5	3.3		T10	3.5
	SR14-591	M5x0.8	6.6	13.5	7.6		T20	5
	SR34-508	M2.2x0.45	3.15	4.6	2.67		T7	0.9
	SR34-514	M2.5x0.45	3.3	5.2	3.2		T7	0.9
	SR76-943	M6	9.6	20	10	90	T20	5
	SR76-961	M5	6.6	13.5	7.35	61	T15	3.5
	SR76-963	M5	8.6	20	9.6	91	T15	3.5
	SR114-018-L3.40	M2.5	3.6	3.35	2	56	T6	0.7
	SM40-143-H0	M4X0.7	5.6	14.3	8.4	61	T15	3.5
	TS25F080A	M2.25X0.35	3.7	6.9	2.1	60	T8	1.3
	TS30F100A	M3X0.35	4.6	8.3	2.2		T10	2.5
	TS40085I/HG	M4	5.7	8.5	4.5		T15	3.5
	TS40093I/HG	M4	5.7	9.3	4.3		T15	3.5
	TS40B100I	M4	6	10	6	R3.0	T15	3.5
	TS40F120A	M4X0.5	6	10.6	3	60	T15	3.5
	TS45120I	M4.5	6.9	12	7.5	R3.5	T20	5
	TS50115I	M5	7	11.35	6.4	60	T20	5
	TS50F160A	M5X0.5	7	13.9	3.5		T20	5
	TS60F200A	M6X0.75	8.2	16.7	4.5		T20	7
	TS70F250A	M7X0.75	10	21	5.6		T25	7
	TS80F300A	M8X1.0	12	25	7.3		T30	10
	CSPD-1.8S	M1.8x0.35	2.4	3.3	1.4	55	6IP	0.7
 (Steel)	CSTD-3T	M3x0.5	4.3	4.5			T10	2.5
	CSPD-3			4.2			10IP	2.5
 (Steel)	CSTB-4.5L110P	M4.5X0.75	6.6	11.7	7	56	T15	3.5
 (Steel)	SRM5X0.8IP20X+ACROLYTE	M5X0.8	9.2	15	9.8	70	20IP	7.5
 (Steel)	CSTC-2	M2x0.4	3.1	5.1	-		T6	0.7
 (Steel)	CSTR-4L100	M4x0.7	5.7	10	5.5	-	T15	3.5
 (Steel)	SR16-212-01397	M5x0.8	6.4	12.5	6.8	43	T20/T10	2.5
	SR16-212-01397L							
 (Steel)	CST-3.5	M3.5X0.6	6	4.8	-	90	T9	2.3
	CST-3.5S			3.5	-			
	CST-5	M5x0.8	10	18	13		T25	5
	CST-5S			12	7			
	CSTF-2L055-S	M2x0.4	2.7	5.5	3.8		T6	0.7

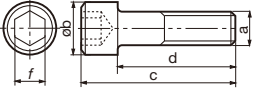
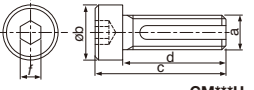
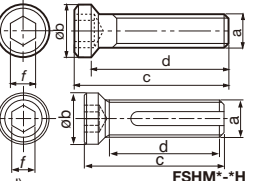
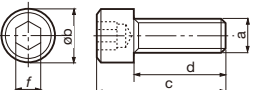
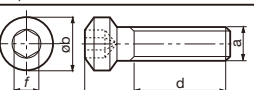
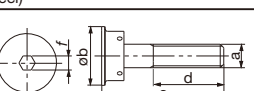
User's Guide- Parts for Tools

Screws

Shape	Designation	Dimension (mm)						Torque (N·m)
		a	øb	c	d	T / f	e	
 (Steel)	SM2.5×0.45×8	M2.5x0.45	5	8	-	-	90°	-
	SM2.5×0.5×8	M2.5x0.5	5	8	-	-	90°	-
	SM3×0.5×6	M3x0.5	6	6	-	-	90°	-
	SM3×0.5×8			8	-	-	90°	-
	SM3×0.5×10			10	-	-	90°	-
 (Steel)	MSP-5	M5x0.8	6.1	7.9	4.9	2		1.5
	MSP-6.3	M6.3x1	7.7	12.7	9.9	2.5		3
 (Steel)	BHM3-8	M3x0.5	5.5	10	8	2		1.5
	BHM4-8	M4x0.7	7	10.6		2.5		2.2
	BHM4-10			12.6	10			
	BHM5-14	M5x0.8	9	17.6	14	3		3
	BHM6-20-A	M6x1.0	10.5	24	20	4		5
	BHM8-25U	M8	14	29.3	25	5		8.5
	BHM8-30U			34.3	30			
 (Steel)	CSHM-3-8	M3	6	8	-	2	90°	1.5
 (Steel)	CSHB-4-A	M4	5.5	11		T15	60°	2
	CSHB-6	M6	8.5	19	-	4	60°	5
	CSHB-6-A	M6	8.5	19				5
 (Steel)	RT-1	M6	10	22.5	14	4		5
	RT-2	M8	13	31	20	5		8.5
 (Steel)	ASM6	M6	10	18	12	3		-
	AJM5F	M5x0.5	9	13	8	2		-
	AJM5	M5x0.8	9	13	8	2		-
 (Steel)	ASM34S	M3	4.8	8	5	2		-
	ASM34L			11	8			-
	ASM54	M5x0.8	9	14	9	3		-
 (Steel)	CHHM3.5-10	M3.5x0.6	6	13.5	10	3		3
	CHHM4-10	M4x0.7	7	14				
	CHHM5-14	M5x0.8	8.5	19	14	4		5
	CHHM5-18			23	18			
	CHHM6-15	M6	10	21	15	5		8.5
	CHHM6-20			—	20			
	CHHM6-25			31	25			
 (Steel)	CM3X0.5X6	M3x0.5	5.5	9	6	2.5		2.2
	CM3X0.5X10			13	10			
	CM4X0.7X10			14				
	CM4X0.7X12	M4x0.7	7	16	12	3		3
	CM4X0.7X14			18	14			
	CM4X0.7X15			19	15			
	CM4X0.7X20			24	20			
	CM4X0.7X20-M0-A			24	20			
	CM5X0.8X8	M5x0.8	8.5	13	8	4		5
	CM5X0.8X10-A			15	10			
	CM5X0.8X12			17	12			
	CM5X0.8X12-A			17	12			
	CM5X0.8X14			18	14			
	CM5X0.8X16			21	16			
	CM5X0.8X16-A			21	16			
	CM5X0.8X18			23	18			
	CM5X0.8X20-A			25	20			
	CM5X0.8X25-A			30	25			
	CM5X15	M5		20	15			

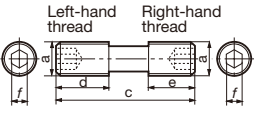
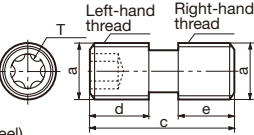
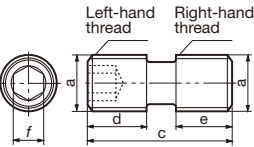
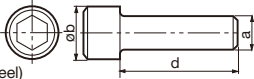
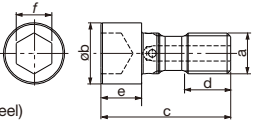
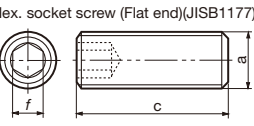
User's Guide- Parts for Tools

Screws

Shape	Designation	Dimension (mm)							Torque (N·m)
		a	øb	c	d	e	f	g	
 Hex. socket head screw (JISB1176)  CM***H	CM6X1X16-A	M6x1.0	10	22	16		5		8.5
	CM6X1X20-A			26	20				
	CM6X1X25-A			31	25				
	CM6X1.0X40-A			46	40				
	CM6X10	M6	10	16	10		5		8.5
	CM6X15			21	15				
	CM6X16			22	16				
	CM6X20			26	20				
	CM6X25			31	25				
	CM6X30-S	M6x1.0	10	35.7	28		6		25
	CM8X1.25X20-A	M8x1.25	13	28	20				
	CM8X1.25X25-A			33	25				
	CM8X30H	M10x1.5	16	36	30		5		40
	CM10X30			30	20		8		
	CM10X30H	M12x1.75	18	38	30		6		40
	CM12X30H	M16x2	24	40	30		8		70
	CM16X40H	M16	24	54	40		10		100
	CM16x75	M16	24	75	51		14		100
	CM16x120	M16	24	120	96		14		100
	CM16x140	M16	24	140	116		14		100
	CM20x80	M20	30	80	50		17		150
	CM20x120	M20	30	120	90		17		150
	CM20x150	M20	30	150	120		17		150
	CAP-CM12x1.75x50	M12	18	50	38		10		70
	CAP-CM16X2.0X55	M16	24	55	39		14		40
	CAP-CM20X2.5X50	M20	30	50	30		17		100
	C0.375X1.125H	3/8-24UNF	14.27	38.11	28.58		5.55		35
	C0.500X1.375H	1/2-20UNF	19.05	47.63	34.93		7.94		70
	SD06-A3	M10x1.5	16	70	60		8		40
	SRM6X16DIN912-12.9	M6x1	10	22	14.1		5		
	VC00TEDI12040F	M12	26	51	40		8		60
	VC00TEDI20040F	M20	49	50	34.5		12		150
	VC00TANG16040F	M16	46	46.5	33		10		60
	SD08-98	M12x1.75	18	77	65		10		70
	LHM12x1.75x30-C	M12	18	36.9	30		8		70
	VC004762110035F	M10	16	45	34.5		8		60
 FSHM*-H	FCS3	M3x0.5	5.5	16	12		2.5		
	FCS6	M6x1	10	26	20		5		
	FSHM8-30	M8x1.25	11	30	27		5		25
	FSHM8-30H								25
 SHCM	FSHM10-40	M10	14	40	36.5		6		40
	FSHM10-40H								40
	SHCM4-10	M4x0.7	6	14	10		3		3
	SHCM4-12			16	12				
 CTS	SHCM4-16			20	16				
	CTS-M6	M6x1	10	25	16.4		4		5
 RSFTS	RSFTS-050M	M10	25	52	42.5		6		

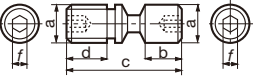
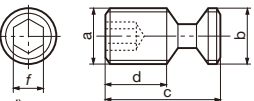
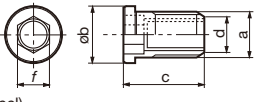
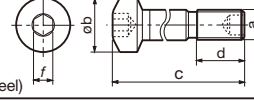
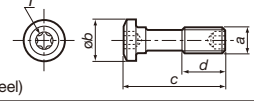
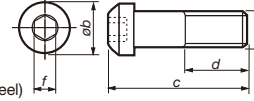
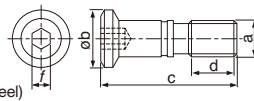
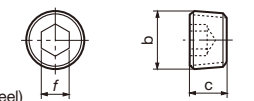
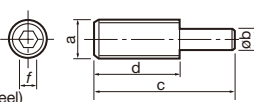
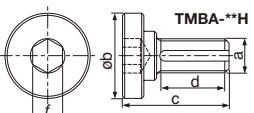
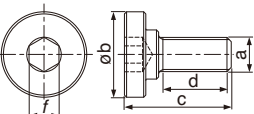
User's Guide- Parts for Tools

Screws

Shape	Designation	Dimension (mm)						Torque (N·m)
		a	øb	c	d	e	T / f	
 (Steel)	MCS520-2.5	M5×0.8		20	7	6	2.5	3
	MCS620-3	M6×1			10	7	3	6
	MCS625-3			25	12.5	8		
	MCS825-4	M8×1			12	6.5	4	8
	MCS828-4			28.5	10.5			
	NDS-8A			30	11.5	11.5		
	NDS-8S	M8×1.25		20	8	8		
	RSRGR5M40	M4		9	3.67	4.17	T8	
 (Steel)	SR PS 118-0273	M10		40	16.5	15	5	40
	DS-6T	M6		15	6	6		3.5
	DS-6P	M6×1		21	7	7	15IP	6
	FDS-8ST	M8×1		20	8	8	T27	10
 (Steel)	FDS-8ST-18			18		6		
	DS-6	M6×1		15	6	6	3	6
	DS-8	M8×1.25		16	7	7	4	8
	DS-8S			13	5.5	5.5		
	DS-10	M10×1.5		26		12	5	8
	FDS-6Z	M6×0.75		20.5	10	5.5	3	6
	FDS-8			26		10		
	FDS-8S	M8×1		20	8	8	4	8
 (Steel)	FDS-8SS			18.5		6.5		
	SS100	1/4-20UNC			19.05			
 (Steel)	S-412	10-32UNF			19.05			
	SHM8x1.25x35-C	M8	13	43	23	8	6	25
	SHM10x1.5x30-C	M10	16	40	17	10	8	40
	SHM16x2x35-C	M16	24	51	18	16	14	100
 (Steel)	SHM20x2.5x40-C	M20	30	58	20	18	17	150
	SSH2.5-3	M2.5		3				
	SSH3-3			3			1.5	1
	SSH3-4	M3		4				
	SSH3-6			6				
	SSH4-4			4			2	1.5
	SSH4-5			5				
	SSH4-6	M4		6				
	SSH4-8			8				
	SSH4-10			10				
	SSH4-14			14				
	SSH5-6			6			2.5	2
	SSH5-10	M5		10				
	SSH5-16			16				
	SSH6-12			12			3	3
	SSH6-16	M6		16				
	SSH6-18			18				
	SSH6-20			20				
	SSH8-8			8			4	5
	SSH8-10	M8		10				
	SSH8-12			12				
	SSH8-14			14				
	SSH8-16			16				
	SSH8-18			18				
 (Steel)	Hex. socket screw (Flat end)(JISB1177)							
	M5×7			7		-		
	M5×8	M5	3.5	8	1.25	-	2.5	2
	M5×10			10		-		
 (Steel)	M6×30	M6	4	30	1.5	-	3	3
	JDS-3525	M3.5x0.35	M2.5 x0.45	7.5	3	2.5	2	1
	JDS-5040	M5x0.5	M4 x0.7	10	4	4	2.5	1

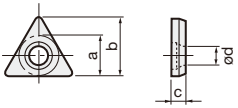
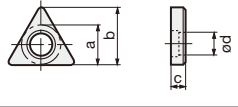
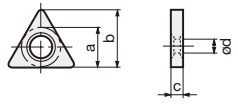
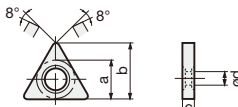
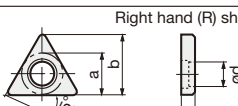
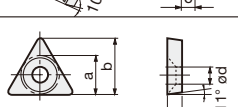
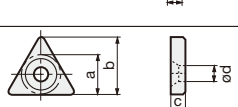
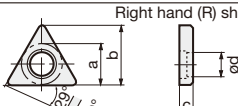
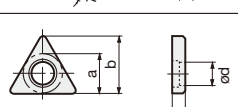
User's Guide- Parts for Tools

Screws

Shape	Designation	Dimension (mm)						Torque (N·m)
		a	b	c	d	e	T / f	
 LCS2 has a hex. socket in threaded end only.	LCS2	M5	5	14			2	1.5
	LCS3	M6	6	17	6.5		2.5	2
	LCS3B			15				
	LCS4	M8	8	21	9.6		3	3
	LCS4K							
	LCS4CA			17.5	6.5			
	LCS5			25	8.5			
	LCS5CA			20.5				
	LCS6	M10	9.8	27.2	9.9		4	5
	LCS8	M12	11.8	36	12.8		5	8
(Steel)	LCS8C	M10	9.8	30.2	13.3		4	5
	LCS22	M5	M5	10	4.7		2	1.5
	LCS22A	M6	M6	10.7				
	LCS23A	M5	M5	13.1	5.1		2.5	2
	LCS33	M5	M5	12	6.2		2	1.5
	LCS43	M6	M6	13.5	7.3		2.5	2
	DTS5-3.5	M5	6.3	8.65	M3.5		3.5	4
	DTS5-3.5SS			6.8				
	DTS5-3.5S			7				
	DTS6-4	M6	7.7	10.2	M4		4	5
	DTS6-4.5		7.5	10	M4.5		4.5	5
	DLCS33	M5	9	31.5	10		3	3
	DLCS43	M6	12	34	9.5		4	5
	DLCS54	M8x1	14	41	11			7
	DLCS64	M10x1	16	50	15		5	8
	ACS-5W	M5	8	20	8.5		T15	4
	ACS-6W	M6	10	26	12.1		T20	6.4
	ACS3	M5x0.8	7.5	25.6	12-15		3	4
	ACS4	M6x1	9	27.7	14-17		4	7
	WCS3	M6	9.5	22.5	8		3	3
	PT1/4GN		13.175	10	-		6	9.5
	1/8-28		9.728	7	-		5	8
	LS-8	M8	6	33	20		4	5
	CCS4-A							
	BH5-10-A							
	BH4-10-A							
	BH-40050-A							
	TMBA-M10	M10x1.5	27	30	21		8	40
	TMBA-M12	M12x1.75	33	36	26		10	70
	TMBA-M12H	M12x1.75		34.5			8	
	TMBA-M16	M16x2	40	50	40		14	100
	TMBA-M16H	M16x2						
	TMBA-M20	M20x2.5	50	56	42		17	150
	TMBA-M20H	M20x2.5						
	TMBA-M24	M24x3	65	69	55		19	150
	TMBA-M24H	M24x3						
	TMBA-0.500H	1/2-20UNF	33	33.9	25.4		7.94	70
	TMBA-0.750H	3/4-16UNF	50	58.28	47.28		12.7	150
	SR-10400611	M4X0.5		6.6	3	1	2	
(Steel)								

User's Guide- Parts for Tools

Shims

Shape	Designation	Dimension (mm)				
		a	b	c	ød	
 (D30)	AST322	9.3	13.2	3.2	4.4	
	AST422	12.5	18	3.2	4.4	
 (D30)	MST-322	9.1	12.9	3.24	5.8	
	MST-432	12.5	17.9	4.8	7.3	
	MST-533	15.6	22.2		9.7	
	MST-644	18.8	26.6	6.4	11.3	
 (D30)	LST317	9.3	13.2	2.7	5	
	LST42	12.5	18	3.2	6.7	
	LST53	15.7	22.3	4.8	7.7	
	LST42K	10.9	15.6	3.2	6.7	
 (D30)	LST317CA	9.3	13.2	2.7	5	
	LST42CA	12.5	18	3.2	6.7	
 (D30)	ELST42	11.5	16.5	3.2	6.5	
	ELST317	8.5	12	2.7	4.9	
	ELST317BR					
	ELST317BL					
 (D30)	PAT-32	8.2	11.7	3.2	3.5	
	PAT-53*	13.4	19.8	4.8	5	
 (D30)	NAT-32	9.5	13.4	3.2	3.5	
	NAT-42E	12.4	17.8	3.2	3.1	
 (D30)	LST317BR	9.3	13.2	2.7	5	
	LST317BL					
 (D30)	SST32	8.5	11.9	3.2	5.4	

Note: * marked shims are made of steel.

User's Guide- Parts for Tools

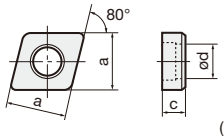
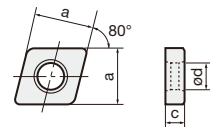
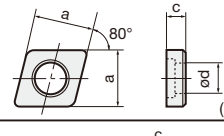
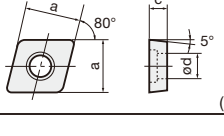
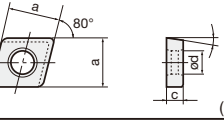
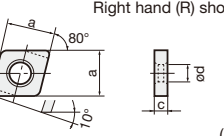
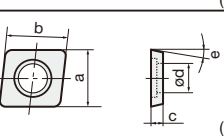
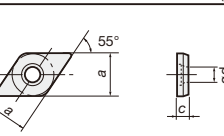
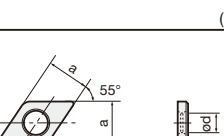
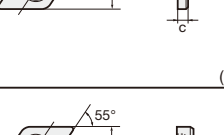
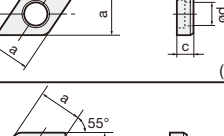
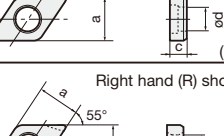
Shims

Shape	Designation	Dimension (mm)				
		a	b	c	ød	e
 (D30)	ASS422	12.5		3.2	4.4	
	CS44-A	12.5		4.7		
 (D30)	ASS533	15.7		4.8	5.5	
	ASS634	18.9				
 (D30)	ELSS32	8.5		3.2	4.9	
	LSS33	9.3		4.3	5	
	ELSS42	11.7		3.2	6.5	
	LSS42	12.5		3.2	6.7	
	ELSS53	14.7		4.8	8	
	LSS53	15.7			7.7	
	ELSS63	17.9			9.7	
	LSS63	18.9				
	ELSS84	24.2		6.4	12.9	
	LSS84	25.2		6.4	13.1	
 (D30)	NAS-42	12.7		3.2	3.5	
	NAS-04	31.5		6.4	9.1	
 (D30)	MSS-432	12.5		4.8	7.3	
	MSS-442			6.4		
 (D30)	SSS32	8.5		3.2	5.4	
 (D30)	LSS42BR	12.5		3.2	6.7	
	LSS42BL					
 (D30)	PAS-32	8.2		3.2	3	
	PAS-42	11.4			3.5	
	PAS-63*	17		4.8	5	
 (D30)	LSS42CA	12.5		3.2	6.7	8°
	LSS53CA	15.7		4.8	7.7	10°
 (D30)	FSSA1102	11.6		2	5.5	13°
 (D30)	FSSP1102	11		2	5.5	17°
 (D30)	ASC322	9.3		3.2	4.4	
	ASC422	12.5		3.2	4.4	
	ASC533	15.7		4.8	5.5	
	ASC634	18.9				
	CC44-A	12.5		4.7		

Note: * marked shims are made of steel.

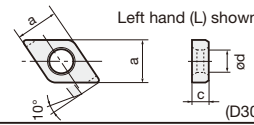
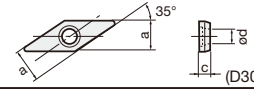
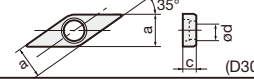
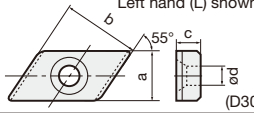
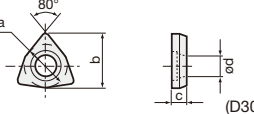
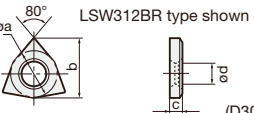
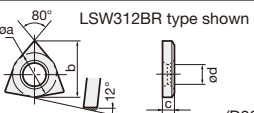
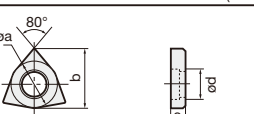
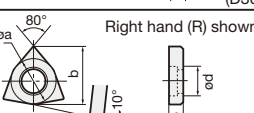
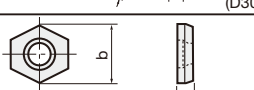
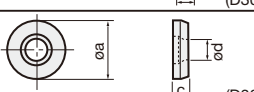
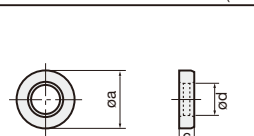
User's Guide- Parts for Tools

Shims

Shape	Designation	Dimension (mm)				
		a	b	c	ød	e
 (D30)	MSC-432	12.5		4.8	7.3	
	MSC-442			6.4		
	MSC-533	15.6		4.8	9.7	
	MSC-543			6.4		
	MSC-634	18.8			11.3	
 (D30)	ELSC32	8.5		3.2	6.2	
	LSC42	12.5			6.5	
	ELSC42	11.7		4.8		
	LSC53	15.7		7.7		
	ELSC53	14.7		8.1		
	ELSC63	17.9				
	LSC63	18.9		9.7		
	LSC317	9.3		2.7	5	
 (D30)	SSC32	8.5		3.2	5.4	
	SSC4T3	11.4		4	6.6	
 (D30)	SSC4T3-P	11.4		4	6.6	5°
	SSC54-P	13.4				5°
 (D30)	LSC42CA	12.5		3.2	6.7	8°
	LSC53CA	15.7		4.8	7.7	10°
 (D30)	LSC42BR	12.5		3.2	6.7	
	LSC42BL					
 (D30)	ZSA1102	10.5	11	2	5.475	11°
	ZSA1502	15.6	12.4		6	11°
 (D30)	ASD322	9.3		3.2	4.4	
	ASD423	12.5		3.2	4.4	
	ASD432	12.5		4.8	4.4	
	CD44-A	12.5		4.7		
 (D30)	ELSD32	8.5		3.2	4.9	
	ELSD42	11.7			6.5	
	LSD42	12.5		4.8	6.7	
	LSD42A					
	LSD43					
	LSD43A					
 (D30)	MSD-322	9.3		3.2	5.8	
	MSD-432	12.5		4.8	7.3	
	MSD-442			6.4		
 (D30)	SSD32	8.5		3.2	5.4	
 (D30)	ELSD317BR	8.5		2.7	4.9	
	ELSD317BL					
	LSD42BR	12.5		3.2	6.7	
	LSD42BL					

User's Guide- Parts for Tools

Shims

Shape	Designation	Dimension (mm)				
		øa	b	c	ød	
	LSZ42BR	12.5		3.2	6.7	
	LSZ42BL					
	ASV322	9.3		3.2	4.4	
	CV34-A	9.3		4.7		
	MSV-322	9.26		3.2	5.8	
	SSV32	8.4			5.4	
	SSV42	11			6.3	
	CSK54R	9.4	14.8	4.8	3.5	
	CSK54L					
	ASW322	9.33	11.5	3.2	4.4	
	ASW422	12.5	15.2			
	LSW312	9.33	11.5	2.7	5	
	LSW42	12.5	15.5	3.2	6.7	
	LSW312BR	9.33	11.5	2.7	5	
	LSW312BL					
	MSW-432	12.8	15.8	4.8	7.3	
	MSW-533	16	19.7		9.7	
	MSW-633	19.2	23.7		11.3	
	MSW-432BR	12.8	15.8	4.8	7.3	
	MSW-432BL					
	CH44-A		12.5	4.7		
	ASR420	12.5		3.2	4.4	
	LSR32	8.9		3.2	5	
	LSR32C	8.4			6.7	
	LSR42	12.1			5	
	LSR42C	9.9		4.8	6.7	
	LSR53C	14			8.2	
	LSR63C	17.2			9.7	
	MSR-43	12.5		4.8	7.3	
	MSR-44			6.4		
	SSR32	8.7		3.18	5.2	
	G16EL/IR	9.5	-	3.2	4	
	G16ER/IL			3.2	5.4	
	G16EL/IR-DT			3.97		
	G16ER/IL-DT			3.97		

User's Guide- Parts for Tools

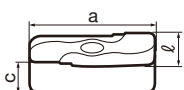
Shims

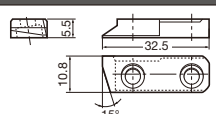
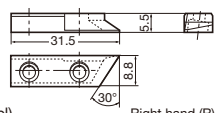
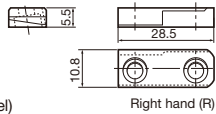
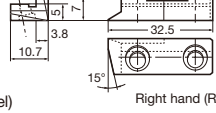
Shape	Designation	Dimension (mm)		
		ϕa	ℓ	Lead angle
	AE16-4DT	9.5	5.4	4°
	AE16-3DT		5.4	3°
	AE16-2DT		5.4	2°
	A16-1DT		5.4	1°
	AE16-0DT		5.4	0°
	AE16-99DT		5.4	-1°
	AE16-98DT		5.4	-2°
	AE16-4		4	4°
	AE16-3		4	3°
	AE16-2		4	2°
	A16-1		4.3	1°
	AE16-0		4	0°
	AE16-99		4	-1°
	AE16-98		4	-2°
	AN16-4DT	9.5	5.4	4°
	AN16-3DT		5.4	3°
	AN16-2DT		5.4	2°
	AN16-0DT		5.4	0°
	AN16-99DT		5.4	-1°
	AN16-98DT		5.4	-2°
	AN16-4		4	4°
	AN16-3		4	3°
	AN16-2		4	2°
	AN16-0		4	0°
	AN16-99		4	-1°
	AN16-98		4	-2°
	GXE16-98	9.5	4	-2°
	GXE16-98DT		5.4	-2°
	GXE16-99		4	-1°
	GXE16-99DT		5.4	-1°
	GXE16-0		4	0°
	GXE16-0DT		5.4	0°
	GXE16-1		4.3	1°
	GX16-1DT		5.4	1°
	GXE16-2		4	2°
	GXE16-2DT		5.4	2°
	GXE16-3		4	3°
	GXE16-3DT		5.4	3°
	GXE16-4		4	4°
	GXE16-4DT		5.4	4°
	GXE22-98DT	12.7	6.6	-2°
	GXE22-99DT			-1°
	GXE22-0DT			0°
	GX22-1DT			1°
	GXE22-2DT			2°
	GXE22-3DT			3°
	GXE22-4DT			4°
	GXN16-98	9.5	4	-2°
	GXN16-98DT		5.4	-2°
	GXN16-99		4	-1°
	GXN16-99DT		5.4	-1°
	GXN16-0		4	0°
	GXN16-0DT		5.4	0°
	GXN16-1		4.3	1°
	GXN16-2		4	2°
	GXN16-2DT		5.4	2°
	GXN16-3		4	3°
	GXN16-3DT		5.4	3°
	GXN16-4		4	4°
	GXN16-4DT		5.4	4°
	GXN22-98DT	12.7	6.6	-2°
	GXN22-99DT			-1°
	GXN22-0DT			0°
	GXN22-2DT			2°
	GXN22-3DT			3°
	GXN22-4DT			4°

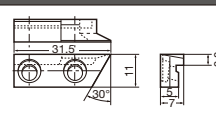
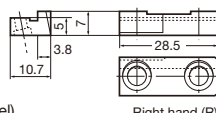
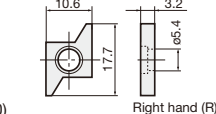
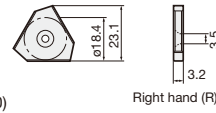
(D30)

User's Guide- Parts for Tools

Shims

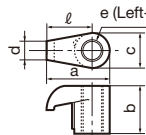
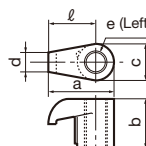
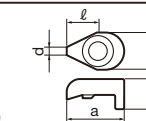
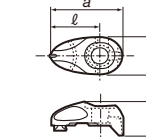
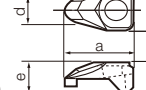
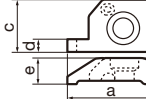
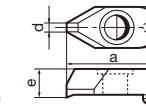
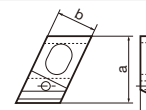
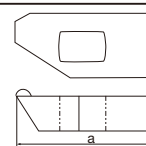
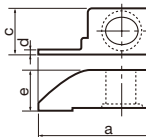
Shape	Designation	Dimension (mm)				
		a	øa	ℓ	c	Lead angle
	NXE22-98		12.7	4		-2°
	NXE22-99					-1°
	NXE22-0					0°
	NXE22-1					1°
	NXE22-2			4		2°
	NXE22-3					3°
	NXE22-4					4°
	NXE27-98		15.9	4		-2°
	NXE27-99					-1°
	NXE27-0					0°
	NXE27-1					1°
	NXE27-2			4		2°
	NXE27-3					3°
	NXE27-4					4°
	NXN22-98		12.7	4		-2°
	NXN22-99					-1°
	NXN22-0					0°
	NXN22-1					1°
	NXN22-2			4		2°
	NXN22-3					3°
	NXN22-4					4°
	NXN27-98		15.9	4		-2°
	NXN27-99					-1°
	NXN27-0					0°
	NXN27-1					1°
	NXN27-2			4		2°
	NXN27-3					3°
	NXN27-4					4°
	(D30) NXN27-4					4°
	TSL12R	12		4.7	4.5	4.5°
	TSL12L	12		4.7	4.5	4.5°
	TSL16R	15.9		6.4	5	5°
	TSL16L	15.9		6.4	5	5°
	TSL24R	23.8		9.4	7.1	7°
	TSL24L	23.8		9.4	7.1	7°
	TSL12RI	10.7		4.7	4.5	4.5°
	TSL12LI	10.7		4.7	4.5	4.5°
	TSL16RI	18.8		6.4	5	5°
	(D30) TSL16LI	18.8		6.4	5	5°

Shape	Designation
	SL-1R
	SL-1L
(Steel) Right hand (R) shown	
	SL-2R
	SL-2L
(Steel) Right hand (R) shown	
	SL-3R
	SL-3L
(Steel) Right hand (R) shown	
	SL-6R
	SL-6L
(Steel) Right hand (R) shown	

Shape	Designation
	SL-7R
	SL-7L
(Steel) Right hand (R) shown	
	SL-8R
	SL-8L
(Steel) Right hand (R) shown	
	SGSR151
	SGSL151
(D30) Right hand (R) shown	
	STN62R
	STN62L
(D30) Right hand (R) shown	

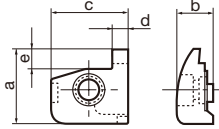
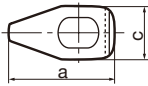
User's Guide- Parts for Tools

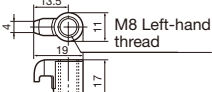
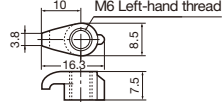
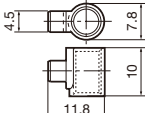
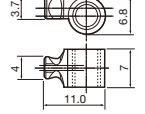
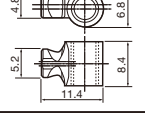
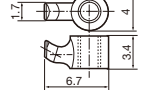
Clamps

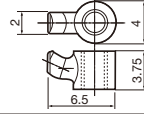
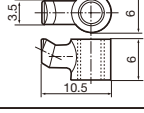
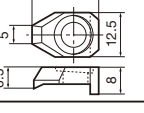
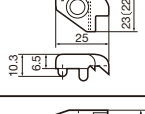
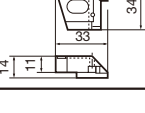
Shape	Designation	Dimension (mm)					
		a	b	c	d	e	ℓ
 (Steel)	MCL-5M	14.7	11	7.8	4	M5	10.8
	MCL-6	18.6	11.5	9.5		M6	13.8
	MCL-8S	19.1	13.5	10.9	5	M8	13.6
	MCL-8M	22.5					17
	MCL-8L	25.5	14.5	4		20	
 (Steel)	MCPM-6	14.7	11.2	7.9	4	M5	10.8
	MCPM-9	19.1	16.8	10.9	5	M8×1	13.6
	MCPM-12	22.5					
	MCPM-20	18.6	9.5	9.5	4	M6	13.8
	MCPM-21		12.2				
	MCPM-22	21.5	13.2			16.7	
	MCPM-30	25.5	16.8	10.9	5	M8×1	20
 (Steel)	DCPM-33	16	9.3	10.5	2.4		8.5
	DCPM-43	21.2	11.5	13.5	3		13.2
	DCPM-54	25.8	15.25	14	3.5		
	DCPM-64	28.4	15.5	16	4		
 (Steel)	ACP3S	22.8	9.5	10			15
	ACP3S-E	21.7	9.5	10			13.9
	ACP4S	25.7	12	13			17.7
	ACP5S	30.1	12.9	15	-	-	20.7
	ACP6S	33.4	12.8	16.5	-	-	24
 (Steel)	ACP3	17.9	10	10	6.5	6.3	
	ACP4	25.9	13.9	12	7	10.8	
 (Steel)	CTC-3R	29	8.8	16	2.2	8	
	CTC-3L						
	CTC-4R			17	3.2		
	CTC-4L						
	CTC-5R			18	4.2		
	CTC-5L						
 (Steel)	CP81A	28	10.5	12	3.5	8	
	CP81B						
 (Steel)	TC-3	19	12.5	8.3	-	-	-
	TC-4	21.6		8			
 (Steel)	TF-72	22	11.3				
	TF-73	22	11.3				
	TF-184	22	11.3				
	TF-185	22	11.3				
 (Steel)	CCR2	34.7	14.9	10.7	1.2	10.5	
	CCL2						
	CCR3				2.2		
	CCL3						
	CCR4				2.8		
	CCL4						
	CCR5				3.2		
	CCL5						
	CCR6				3.9		
	CCL6						
	CCR8				4.9		
	CCL8						

User's Guide- Parts for Tools

Clamps

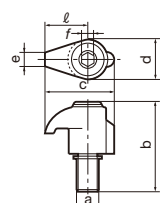
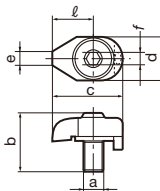
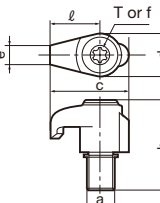
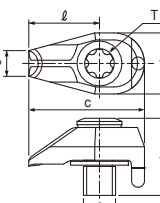
Shape	Designation	Dimension (mm)								
		a	b	c	d	e				
 Right hand (R) shown	CFG-3SR	22	11	23.1	2	6				
	CFG-3SL				3					
	CFG-4SR									
	CFG-4SL	32			4	16				
	CFG-4DR									
	CFG-4DL									
	CFG-5SR	22			5	6				
	CFG-5SL	32				16				
	CFG-5DR									
	CFG-5DL									
	CFG-6SR	23		27.1	7	7				
	CFG-6SL	33				17				
	CFG-6DR									
	CFG-6DL									
	CFG-8SR	28			18	8				
	CFG-8SL	38				18				
	CFG-8DR									
	CFG-8DL									
(Steel)										
	CCP4-A	29.1		14						
(Steel)										

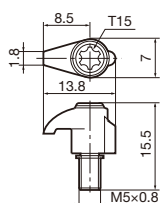
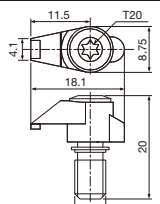
Shape	Designation
 M8 Left-hand thread	NF-84A
(Steel)	
 M6 Left-hand thread	CP536
(Steel)	
	CP91
(Steel)	
	CP900
(Steel)	
	CP910
(Steel)	
	JCP-1
(Steel)	

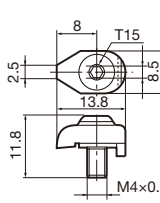
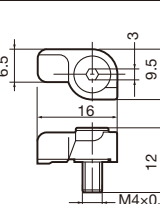
Shape	Designation
	JCP-2
(Steel)	
	JCP-3
(Steel)	JCP-3N
	CQ-1
(Steel)	
 Right hand (R) shown	CPK5R
(Steel)	CPK5L
 Right hand (R) shown	C11R-5
(Steel)	C11L-5

User's Guide- Parts for Tools

Clamp Sets

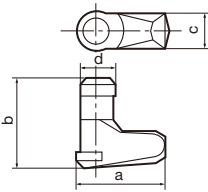
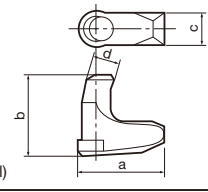
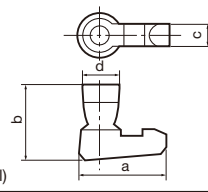
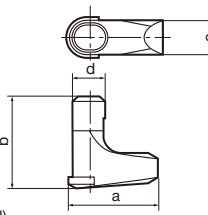
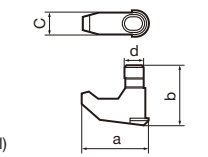
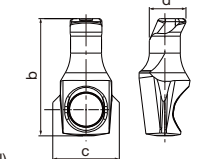
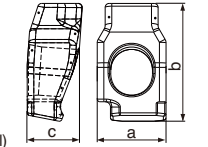
Shape	Designation	Dimension (mm)						
		a	b	c	d	e	ℓ	T / f
 (Steel)	CSG-5S	M5×0.8	13.5	13.8	7	1.8	8.5	2.5
	CSG-5		15.5					
	CSG-6S	M6×1	18	16.3	8.5	2.5	10	3
	CSG-6		21.5					
	CSG-6L	M8×1	21	20.5	11	3.5	12.5	4
	CSG-8S		23.5					
	CSG-8							
 (Steel)	CSW-00	M4×0.7	11.5	12	8	2	7.5	2.5
	CSW-1	M5×0.8	16.5	16.5	9.5	4	10	3
	CSW-0	M4×0.7	11.5	13.8	8.5	2.5	8	2.5
	CSW-2	M6×1	20	20.5	11	6	13	4
	CSW-40	M4×0.7	12	13.2	8	2	7.5	2.5
	CSW-50	M5×0.8	15	16.9	10		9.5	3
 (Steel)	CSP16	M5×0.8	15.5	14.4	6.9	3.2	9.1	T15
	CSP22	M6×1	20	18.1	8.9	4.2	11.5	T20
	CSP27	M8×1.25	23.5	24.4	11.9	3.9	15.6	4
 (Steel)	CSY-15	M4×0.7	11.6	11.5	7	3	6	15IP
	CSY-20	M5×0.8	12	18	9.5	4	11	20IP

Shape	Designation
 (Steel)	CSG-5T
 (Steel)	CSX20

Shape	Designation
 (Steel)	CSW-0T
 (Steel)	CSL-4

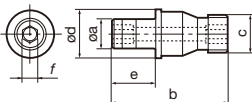
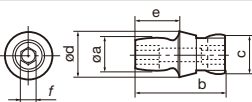
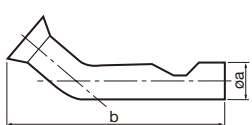
User's Guide- Parts for Tools

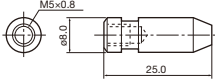
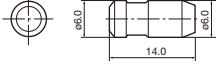
Levers

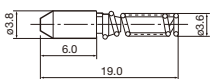
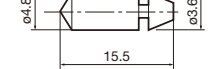
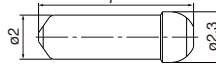
Shape	Designation	Dimensions (mm)				
		a	b	c	d	
 (Steel)	LCL3	10	12	3.7	3.6	
	LCL4	14.6	14	4.7	4.7	
	LCL5	17.1	17	6	6	
	LCL6	20.5	21	7.5	7.5	
	LCL8	25.4	25.4	8.6	8.6	
 (Steel)	LCL3C	10.8	11.8	3.4	3	
	LCL4C	13	13.4	3.7	3.4	
	LCL5C	18.6	17.7	4.7	4.5	
	LCL6C	20.5	19	6	5.7	
	LCL8C	24.2	23.5	7.5	6.2	
 (Steel)	LCL22N	7.5	6.5	2.6	2.06	
	LCL32N	10	7.8	3.2	3.2	
	LCL33NL	11.5	9.5	3.1	3.6	
	LCL33N	10	9.4	3.2	3.2	
	LCL43N	13.4	10	4.7	4.7	
 (Steel)	LCL23	7.8	8.5	2.6	2.1	
	LCL33	10.1	12.1	3.6	3.7	
	LCL33L	12	11.5	3.1	3.6	
	LCL43S	13.5	13.2	4.7	4.7	
	LCL43M					
	LCL44	16.1	14.6	4.7	4.7	
	LCL54	16.5	17.2	6.1	6	
 (Steel)	DLCL43	15.55	14	5	4.7	
	DLCL54	19.1	19.1	6.1	6	
	DLCL64	21.5	21	7.5	7.5	
 (Steel)	SLLV-1		7.75	3.4	2.43	
	SLLV-2		7.75	3.4	2.75	
 (Steel)	FCL4	5	7.78	3.81		
	FCL8	10	14.3	5.39		

User's Guide- Parts for Tools

Pins

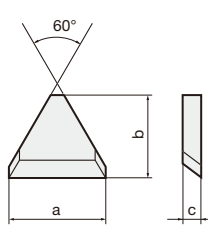
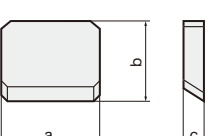
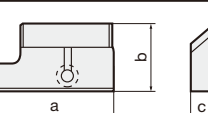
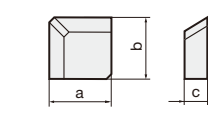
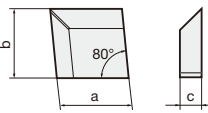
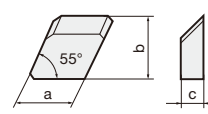
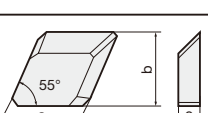
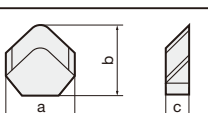
Shape	Designation	Dimension (mm)					
		øa	b	øc	ød	e	f
 (Steel)	MLP32L	3.9	8.8	M5×0.8	5.6	3.5	2
	MLP33	3.7			6.2	5	
	MLP34L	3.7	13.1	5.5		2.5	
	MLP46	5	17.2	M6.3×1	7.8		6.9
	MLP46L		18.6			3	
	MLP58	6.2	21.9	M8×1	10.3	4	
	MLP68	7.8		M10×1	11.9		9.1
	MLP68L		24.1				
 (Steel)	MLP44	5	13.2	M6.3×1	7.1	5.5	2.5
	MLP33L	3.7	10.4	M5×0.8	5.6	5.1	2
 (Steel)	SW99	8	47.5				

Shape	Designation
 (Steel)	SP-8
 (Steel)	SP-6
 (Steel)	BP-3

Shape	Designation
 (Steel)	BP-360
 (Steel)	BP-490
 (Steel)	SL-PI-2

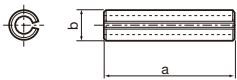
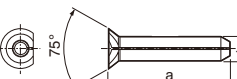
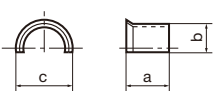
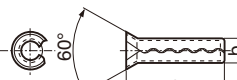
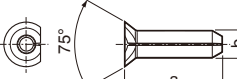
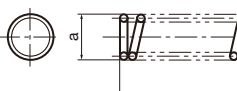
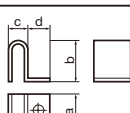
User's Guide- Parts for Tools

Chipbreaker Pieces

Shape	Designation	Dimension (mm)			
		a	b	c	
 (TX30)	CBT-2S	8.8	7.6	2	
	CBT-2M	7.4	6.6		
	CBT-3S	13.3	12.1	2.5	
	CBT-3M	12.3	11.1		
	CBT-3L	11.3	10.1		
	CBT-4S	18.8	16.9		
	CBT-4M	17.8	15.9		
	CBT-4L	16.8	14.4		
	NCT-2S	14.2	11.8		
	NCT-2M	13	10.8		
	NCT-2L	11.9	9.8		
 (TX30)	CBS-3S	9.5	8.3	2	
	CBS-3M		7.3		
	CBS-4S	12.7	11.6	2.5	
	CBS-4SN				
	CBS-4M		10.6		
	CBS-4L		9.1		
	NCS-3S		11.2		
	NCS-3M		10.2		
	NCS-3L		8.7		
 Right hand (R) shown (TX30)	B11 R-5	24	13	5	
	B11 L-5				
 (TX30)	CBS-4SN	11.5	11.5	2.5	
	CBS-4MN	10.5	10.5		
	CBS-4LN	9	9		
	NCS-3SN	11.2	11.2		
	NCS-3MN	10.2	10.2		
	NCS-3LN	8.7	8.7		
 (TX30)	CBC-4SN	11.5	11.5	2.5	
	CBC-4MN	10.5	10.5		
	CBC-4LN	9.5	9.5		
 Right hand (R) shown (TX30)	CBD-4SR	12.7	11.5	2.5	
	CBD-4MR		10.5		
	CBD-4ML		9.5		
	CBD-4LR				
 (TX30)	CBD-4SN	11.5	11.5	2.5	
	CBD-4MN	10.5	10.5		
 (TX30)	CBR-4SN	12.7	11.9	2.5	
	CBR-4MN		10.9		

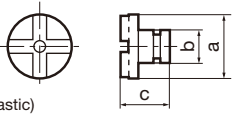
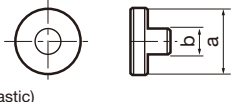
User's Guide- Parts for Tools

Springs (Springs for Shims)

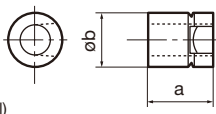
Shape	Designation	Dimension (mm)					
		a	b	c	d		
 (Steel)	SP-2.5	12	2.7				
 (Steel)	SP-16-L14	13.6	2.85				
 (Steel)	LSP3	5.5	3	5.9			
	LSP3L	7					
	LSP4	6	4	7.6			
	LSP4S						
	LSP5	8.5	4.5	8.8			
	LSP6	11	5.9	10.9			
	LSP6C	8.5	4.8	9.3			
	LSP8	12	10	15.4			
 (Steel)	PSP-2.5	10	2.7				
	PSP-4.0	16	4.2				
	PSP301	7.6	3				
 (Steel)	PSP-16	9.75	2.85				
 (Steel)	BP-0	3.6	13				
	BP-5-A						
	BP-7	7	11				
	BP-8.8	8.8	10				
	BP-9	8.3					
	BP-10	9.1					
	SP913	9	13				
 (Steel)	BSP-1	7.8	7.5	4.8	6		

User's Guide- Parts for Tools

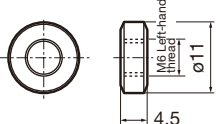
Coolant Supply Attachment

Shape	Designation	Dimension (mm)					
		a	b	c	Thread		
 (Plastic)	EA-20	20	10	15			
	EA-25	25					
	EA-32	32	16				
 (Plastic)	CA-16	16	8		M6		
	CA-20	20	8.5		M6		
	CA-25	25	11.5		R1/8		
	CA-32	32	11.5		R1/8		
	CA-40	40	11.5		R1/8		

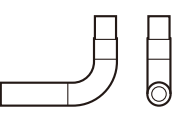
Pistons

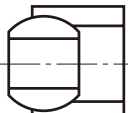
Shape	Designation	Dimension (mm)					
		a	øb				
 (Steel)	DPIS33	12.6	9				
	DPIS43	11.8	10				
	DPIS44	13.4	10				
	DPIS54	16	13				
	DPIS64		15				

Nuts

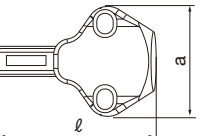
Shape	Designation
	SRW11

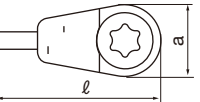
Coolant Pipe & Nozzle

Shape	Designation
	PNZ5

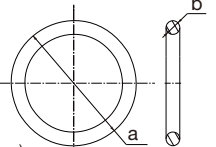
Shape	Designation
	CNZ125

Coolant unit

Shape	Designation	Dimension (mm)	
		a	ℓ
	CU-CW-CHP	20.8	29.7
	CU-D-CHP	20.8	29.6
	CU-V-CHP	20.8	30

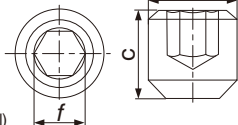
Shape	Designation	Dimension (mm)	
		a	ℓ
	S-CU-CHP	7	16.2

O-ring for TungTurn-Jet

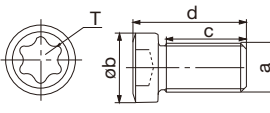
Shape	Designation	Dimension (mm)					
		a	øb				
 (Rubber)	OR6.4X0.9N	8.2	0.9				
	OR14X2.5NN	19	2.5				

User's Guide- Parts for Tools

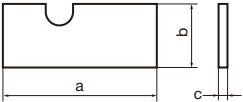
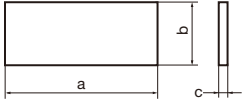
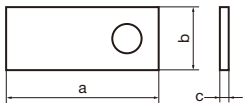
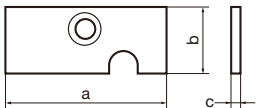
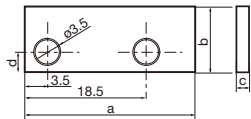
Coolant screw for TungTurn-Jet

Shape	Designation	Dimension (mm)				
		a	c			T / f
 (Steel)	SRM4X4 TL360	M4	4			2

Mounting screw for TungTurn-Jet

Shape	Designation	Dimension (mm)				
		a	øb	c	d	T / f
 (Steel)	SRM3	M3X0.5	4.2	7	4.9	T8

Sizing Plates

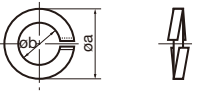
Shape	Designation	Dimension (mm)					
		a	b	c	d		
 (Steel)	S0816A	55	15.5	0.8			
	S1016A			1			
	S0816B	50		0.8			
	S1016B			1			
	S0816C	45		0.8			
	S1016C			1			
	S0820A	19.5	0.8				
	S1020A		1				
	S0820B		0.8				
	S1020B		1				
	SM-00	18	8	1			
 (Steel)	SW04	25.5	5.8	0.25 0.5 1			
	SW05	37	8.3	0.25 0.5 1 2			
	SW06	36	10.8				
	SW08	35.5	12.3				
	 (Steel)	S0810	40	11	0.8		
S1010		1					
 Attached with fix screw and wrench. (Steel)	PSTR08	24	11	1.5			
	PSTL08						
	PSTR10	42	16.5	2			
	PSTL10						
	PSTR12	47	19	2			
	PSTL12						
 (Steel)	AP0801	26	9.5	0.5	3		
	AP0802			1			
	AP0803			1.5			
	AP0804			2			
	AP0805			2.5			
	AP1101	30	11.5	0.5	5		
	AP1102			1			
	AP1103			1.5			
	AP1104			2			
	AP1105			2.5			
	AP1106			3			

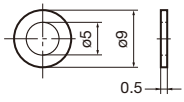
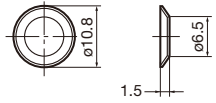
SW04 is composed of three plates and SW05 to SW08 are composed of four plates.

Note on fixing screws: PSTR/L08 is attached with CSSM2-4 and other types are attached with CSHM3-8.

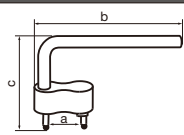
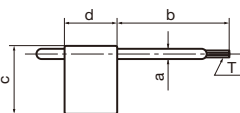
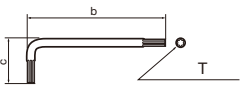
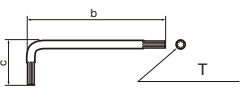
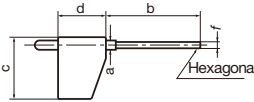
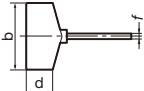
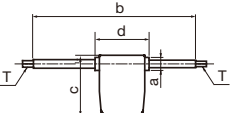
User's Guide- Parts for Tools

Washers

Shape	Designation	Dimension (mm)					
		øa	øb				
	VA4	7.6	4.1				
	VA5	9.2	5.1				
	VA6	10.5	6.1				

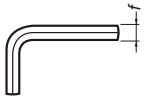
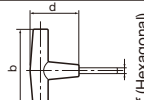
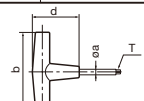
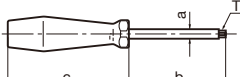
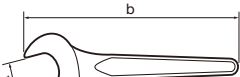
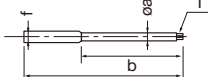
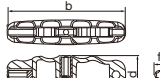
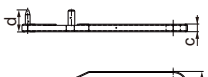
Shape	Designation
	CPW5
	CDW6

Wrenches and Drivers

Shape	Designation	Dimension (mm)					
		a	b	c	d	f	T
	CRW23	9.7	78.5	55.0			
	CRW33	9.3	78.5	55.0			
	T-6F	2	35	14.5	15		T6
	T-7F	2	35	19	19		T7
	T-8F	2.5	40	19	19		T8
	T-9F	3	40	23.5	20		T9
	T-15F	3.5	45	28	21		T15
	T-20F	4	45	28	21		T20
	IP-6F	2	35	14.8	14.9		6IP
	SET T-15/5	3.5	45	28	21		T15
	T-20TORX	3.9	49	30	22		T20
	T-6L		48	16			T6
	T-8L		48	16			T8
	T-9L		48	16			T9
	T-15L		59	22			T15
	T-25TORX		66	23.3			T25
	KEYV-T20		60	22			T20
	KEYV-T25		65	23			T25
	KEYV-T30L		190	37			T30
	KEYV-T40L		208	43			T40
	KEYV-T50L		232	48			T50
	P-2F	4	44	20	12.5	2	
	P-2.5F	5	45	25	20	2.5	
	HW2.0/5RED	3	38	15	15	2	
	P-2.5T		42		15	2.5	
	T-1008/5	6.5	85	28	25	-	T10/T8
	T-2010/5	6.5	85	28	25	-	T10/T20

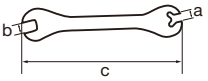
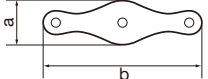
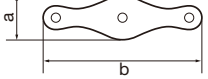
User's Guide- Parts for Tools

Wrenches, Drivers and Lubricant

Shape	Designation	Dimension (mm)					
		a	b	c	d	f	T
	1/4HEX					6.35	
	5/32HEX					3.97	
	1/8HEX					3.18	
	3/32HEX					2.38	
	P-2					2	
	P-2.5					2.5	
	P-3					3	
	P-3.5					3.5	
	P-4					4	
	P-4.5					4.5	
	P-5					5	
	P-6					6	
	TP-3A		70		45.5	3	
	TP-4		85		53	4	
	TP-5					5	
	T-15T						T15
	T-20T	5	65		45		T20
	T-27T		85		42		T27
	IP-20T	4	100		32		20IP
 Handle shape somewhat varies depending on the type number from the above figure.	T-6D	2.5					T6
	T-7D	2	45	70			T7
	T-8D	2.6	61	67.5			T8
	T-9D	3	65	80			T9
	T-10D	3.3	70	90			T10
	T-15D	3.65	71				T15
	T-20D	4.6	90	100			T20
	T-25D	4.4	87	86			T25
	IP-6DB		45	70			6IP
	IP-7D	2.5	45	75			7IP
	IP-8D	3	55	80			8IP
	IP-10D	3.3	71	89			10IP
	IP-15D	4	80	100			15IP
	IP-20D	4	90	100			20IP
	KS-21	21	195				
	KS-24	24	215				
	KS-27	27	235				
	KS-32	32	275				
	KS-36	36	305				
	M-1000						
	BT15S	3.9	50	90		6	T15
	BT15M	3.9	50	118		6	T15
	BT20S	4.6	50	90		6	T20
	BT20M	4.6	50	118		6	T20
	BLD IP15/S7	3.9	50	90		6	15IP
	BLD IP15/M7	3.9	50	118		6	15IP
	BLD IP20/S7	4.6	50	90		6	20IP
	BLD IP20/M7	4.6	50	118		6	20IP
	H-TB		100		37	6	
	H-TBS		75		37	6	
	H-TB2W		95		31.4	6	
	ECW-456EF	87	15	4	11.5		
	ECW-456I	80.5	22	4	10.5		

User's Guide- Parts for Tools

Wrenches and Drivers

Shape	Designation	Dimension (mm)					
		a	b	c	d	f	T
	KEYV-S05	4	5.5	100			
	KEYV-S06	5.4	8	125			
	KEYV-S08	6.6	10	150			
	KEYV-S10	7.7	13	175			
	KEYV-S12	9.4	16	250			
	KEYV-W20						
	KEYV-177	29	110				
	KEYV-217	29	110				
	KGDT-100	32	108.5				
	KGDT-110	32	108.5				
	KGDT-120	32	108.5				
	KGDT-130	32	108.5				
	KGDT-140	32	108.5				
	KGDT-150	32	108.5				

User's Guide- Parts for Tools

Locators

Designation	Applicable Tool
LD150R	TXD15125R ~ TXD15315R
LD440R/L	TMD44 TGD4400R/L-A TFD44
LD442R/L	EGD4400R
LD540R/L	TMD54
LE302R	ESE3050R (RS**) ~ 3063R (RS**)
LE303R/L	TSE3003R/LIA ~ 3006R/LIA
LE402AR	ESE4050RA ESE4063RA
LE403R/L	TSE4003R/LIA TSE4004R/LIA ESE4003RIA-S32
LE405R/L	TSE4005R/LIA ~ 4012R/LIA
LE413R/L	THE40
LE444R/L	TME4403R/LI ~ 4405R/LI TME4403R/LB ~ 4405R/LB EME4405R ~ 4404RI
LE446R/L	TME4406R/LI ~ 4412R/LI TME4406R/LB ~ 4412R/LB
LE540R/L	TME54
LF440R/L	THF44
LF540R/L	THF54
LF602R	ERF6050R ~ ERF6063R
LF602R/L	TRF6003R/LI ~ TRF6006R/LI TRF6008R/LI ~ TRF6012R/LI
LMS56R/L	MS08R/L ~ MS12R/L
LN423R/L	TGN42
LN645R/L	TPN64
LP403R/L	TSP4003R/LIA ~ TSP4004R/LIA TFP4004R/LIA
LP405R/L	TSP4005R/LIA ~ TSP4012R/LIA TFP4005R/LIA ~ TFP4012R/LIA
LP413R/L	TGP41 TGP42
LP514R/L	TGP51
LPP16R	TPP16
LR602R/L	ERD6050RA ~ ERD6063RA
LR603R/L	TRD6003R/L TRD6004R/L ~ TRD6008R/L
LV525R/L	VSN 1
LV530R/L	VSN 2
LV556R/L	VSN60
LW400R	EFP4063R
LW400R/L	TFD44 TFP4000 SFP4000
LW402R	EFP4050R

User's Guide- Parts for Tools

Insert locking wedges

Designation	Applicable Tool
FDS-8SST	EDPD09063R EDPD09063RB
FDS-8ST-18	EDP09080R EDPD09080RB DPD09100R~DPD09160R DPD09100RB~DPD09160RB
FW-242R/L	ø63
FW-243R/L	ø80~100
FW-245R/L	ø125 ~
FW304R/L-D	DAD15 DPD15 EDPD15 QPP15
LE302R	ESE3050R (RS**) ~ 3063R (RS**)
WF150R	TXD15125R ~ TXD15315R
WF310R/L	TGP4100BA TGP4103R/LIA
WF330N	TSE4003R/LIA TSE4004R/LIA ESE4003RIA-S32 TSP4003R/LIA ~ TSP4004R/LIA TFP4004R/LIA
WF330R/L	TSE3003R/LIA ~ 3006R/LIA
WF444R/L	TME4403R/LI ~ 4405R/LI TME4403R/LB ~ 4405R/LB EME4405R ~ 4404RI TME4406R/LI ~ 4412R/LI TME4406R/LB ~ 4412R/LB
WF500R	TSE4005R/LIA ~ 4012R/LIA TSP4005R/LIA ~ TSP4012R/LIA TFP4005R/LIA ~ TFP4012R/LIA
WF500R/L	TMD54 TGP51 THF54
WF50R/L	TME54
WF602R	ERF6050R ~ ERF6063R
WF603R/L	TRF6003R/LI ~ TRF600R/LI
WF608R/L	TRF6008R/LI ~ TRF6012R/LI
WN645R/L	TPN64
WP193TR/L	EGD4400R
WP440R/L	TMD44 TGD4400R/L-A TFD44 TGP4100IA ~ TGP4112R/LIA TGP42 THF44 THE40
WR602R/LW	ERD6050RA ~ ERD6063RA
WR603R/L	TRD6003R/L TRD6004R/L ~ TRD6008R/L
WT402R	ESE4050RA ESE4063RA
WT402R/L	EME4450RB ~ 4404RB

User's Guide- Parts for Tools

Locator adjusting wedges

Designation	Applicable Tool
FW-305	TFD44 TFP40 SFP4000 EFP4063
FW325R/L-D	DAD15 QPP15 DPD15 EDPD15

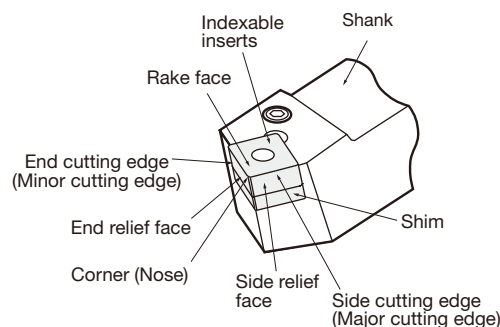
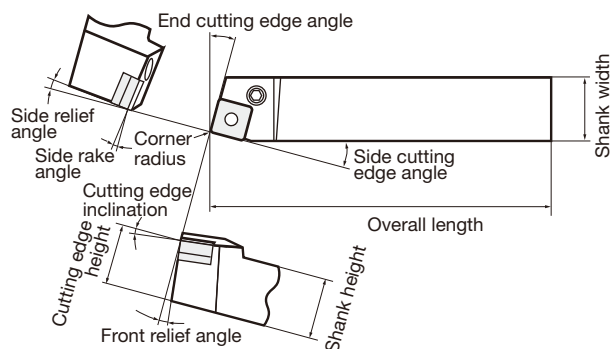
Fine adjusting screws

Designation	Applicable Tool
AJM5	DPD09 EDPD09
ASM34L	DPD24

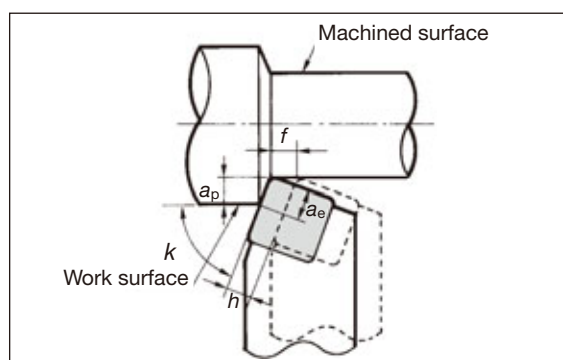
User's Guide- Technical Reference

Turning Tools

Name of tools parts



Relating angles between tool and workpiece



a_p ... Depth of cut (Distance between work surface and machined surface)

a_e ... Length of cutting edge engaging in cutting.

κ ... Cutting edge angle (Angle to be made by cutting edge and work surface)

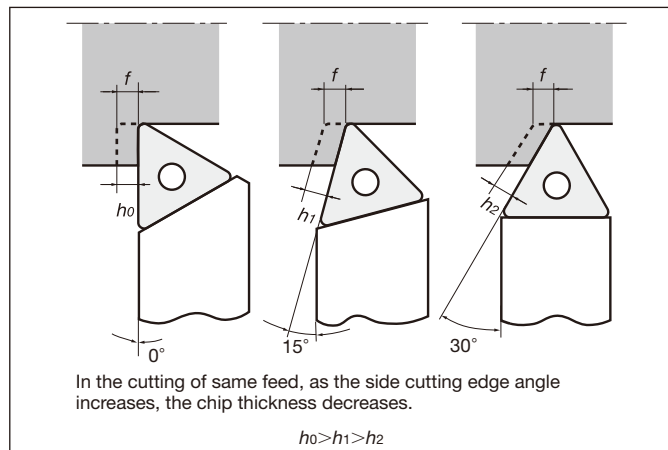
f ... Feed per revolution

h ... Thickness to be cut per revolution

Machined surface ... Workpiece surface after having machined.

Work surface ... Workpiece surface to be cut.

●Effect of side cutting edge angle



●Honing

TAC indexable inserts of steel cutting grades are honed. Honing specifications are shown in the following table.

Edge condition	Shape
Sharp edge	
Round honing	
Chamfered honing	

●Effects of tool geometry on cutting phenomena

Phenomena	Flank wear	Crater wear	Edge strength	Cutting force	Surface finish	Chattering	Cutting edge temperature	Chip shape and flow
Increasing								
Cutting edge inclination	–	Decrease	Lower	Radial force decrease	–	Less tendency	Lower	Effect on flow direction
Side rake angle	–	Decrease	Lower	Decrease	–	–	Lower	Effect on shape
Relief angle	Decrease	–	Lower	Decrease	–	Likely to occur	Lower	–
End cutting edge angle	Decrease	–	Lower	Radial force decrease	Roughen	Less tendency	Lower	–
Side cutting edge angle	Decrease	Decrease	Increase	Radial force decrease	–	Likely to occur	Increase	Decrease thickness
Nose radius	Decrease to some level		Increase	Increase	Improve	Likely to occur	Increase	Effect on flow direction
Honing width	Increase	–	Increase	Increase	–	Likely to occur	Increase	–

User's Guide- Technical Reference

Turning Tools

Relations between cutting force and cutting conditions or cutting phenomena

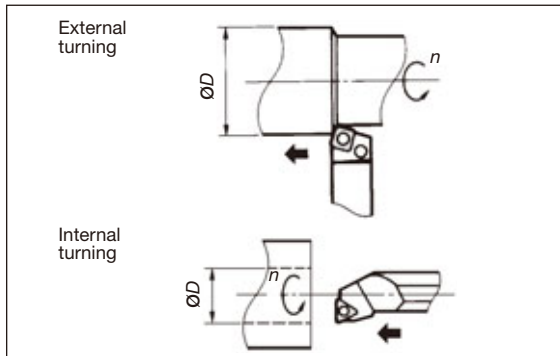
Condition	Grey cast iron (HB130)	Stainless steel (HB145)	Carbon steel (HB230)
Cutting speed and cutting force $f = 0.2 \text{ mm/rev}$ $a_p = 2 \text{ mm}$ Side cutting edge angle 0° Corner radius $r_\epsilon 0.4$			
Depth of cut and cutting force $V_c = 100 \text{ m/min}$ $f = 0.2 \text{ mm/rev}$ Side cutting edge angle 0° Corner radius $r_\epsilon 0.4$			
Feed and cutting force $V_c = 100 \text{ m/min}$ $a_p = 2 \text{ mm}$ Side cutting edge angle 0° Corner radius $r_\epsilon 0.4$			
Corner radius and cutting force $V_c = 100 \text{ m/min}$ $f = 0.2 \text{ mm/rev}$ $a_p = 1.2 \text{ mm}$ Side cutting edge angle 0°			
Side cutting edge angle and cutting force $V_c = 100 \text{ m/min}$ $f = 0.2 \text{ mm/rev}$ $a_p = 2 \text{ mm}$ Corner radius $r_\epsilon 0.4$			
Side rake angle and cutting force $V_c = 100 \text{ m/min}$ $f = 0.2 \text{ mm/rev}$ $a_p = 2 \text{ mm}$ Side cutting edge angle 0° Corner radius $r_\epsilon 0.2$			

* 9.8N = 1kgf

Turning Tools

Calculation formulas for turning

●Cutting speed



When calculating cutting speed from number of revolutions:

$$V_c = \frac{\pi \times \phi D \times n}{1000}$$

V_c : Cutting speed (m/min)
 n : Number of revolution (min^{-1})
 ϕD : Diameter of workpiece (mm)
 $\pi \approx 3.14$

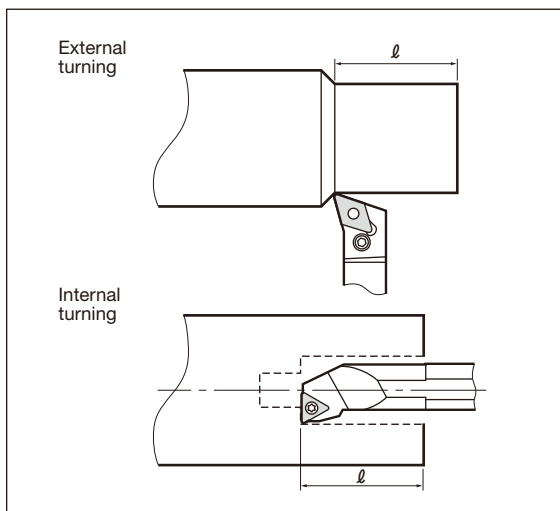
When calculating required number of revolutions from cutting speed:

$$n = \frac{V_c \times 1000}{\pi \times \phi D}$$

Example : Calculating the cutting speed when turning a $\phi 150$ mm-diameter workpiece at 250 min^{-1}

$$V_c = \frac{3.14 \times 150 \times 250}{1000} = 117 \text{ m/min}$$

●Cutting time on external and internal turning

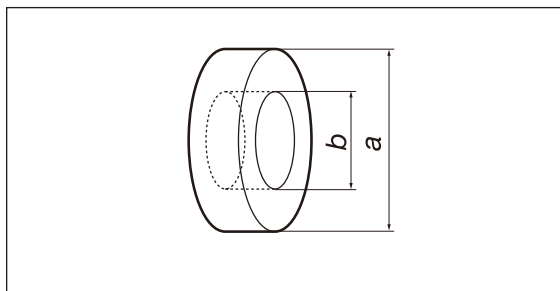


$$T = \frac{\ell}{f \times n}$$

(min)

T : Cutting time (min)
 ℓ : Cutting length (mm)
 f : Feed (mm/rev)
 n : Number of revolution (min^{-1})

●Cutting time on face turning

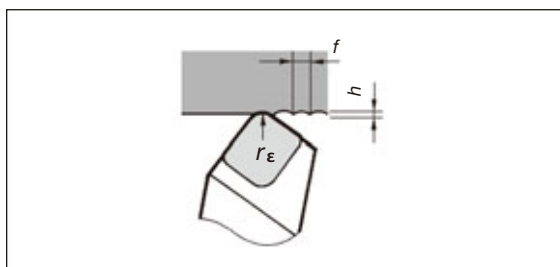


$$T = \frac{\pi \times (a^2 - b^2)}{4000 \times v_c \times f}$$

(min)

V_c : Cutting speed (m/min)
 f : Feed (mm/rev)
 T : Cutting Time (min)

●Theoretical surface roughness



$$h = \frac{f^2}{8 r_\epsilon} \times 1000$$

(μm)

h : Surface roughness (μm)
 f : Feed (mm/rev)
 r_ϵ : Nose radius (mm)

●Calculation of power consumption (kW)

$$P_c = \frac{F \times v_c}{60000}$$

(kW)

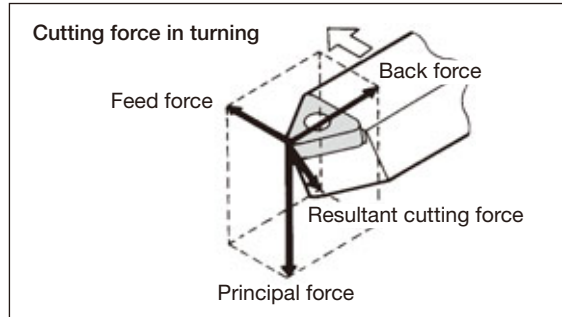
P_c : Power requirement (kW)
 F : Cutting force (N)
 V_c : Cutting speed (m/min)

User's Guide- Technical Reference

Turning Tools

●Cutting forces

- (1) Finding from the diagram based on experimental data.
- (2) In case determining by simplified equation:



$$F = k_c \times a_p \times f$$

(N)

F : Cutting force (N)
 k_c : Specific cutting force (N/mm²)
 [Refer to the Table below]
 a_p : Depth of cut (mm)
 f : Feed (mm/rev)

Example :
 Calculating the cutting force when
 cutting a high carbon steel (ISO C55)
 at $f = 0.2$ mm/rev and $a_p = 3$ mm.
 $F = 3430 \times 3 \times 0.2 = 2058$ N

●Calculating power requirement

$$P_c = \frac{k_c \times a_p \times v_c \times f}{60 \times 1000}$$

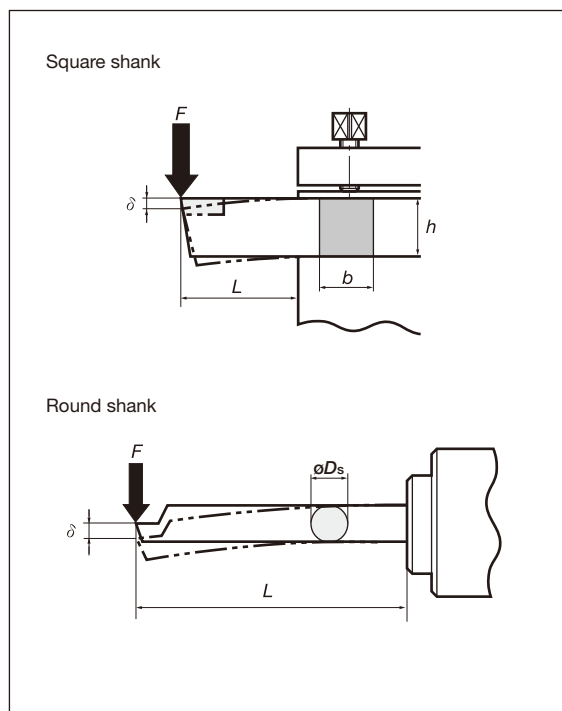
(kW)

P_c : Net power requirement (kW)
 k_c : Specific cutting force (N/mm²)
 [Refer to the Table below]
 v_c : Cutting speed (m/min)
 a_p : Depth of cutting (mm)
 f : Feed (mm/rev)

Value of specific cutting force (k_c)

Workpiece material (JIS)	Tensile strength (MPa)	Hardness (HB)	Value of specific cutting force on feed k_c (N/mm ²)				
			0.04 (mm/rev)	0.1 (mm/rev)	0.2 (mm/rev)	0.4 (mm/rev)	1.0 (mm/rev)
SS400, S15C	390	100	3430	2840	2450	2080	1700
S35C, S40C	590	170	4220	3490	2940	2500	2080
S50C, SCr430	785	230	4900	4020	3430	2940	2400
SCM440, SNCM439	980	300	5390	4410	3780	3240	2650
SDK	1765 (56HRC)	56HRC	8390	6870	5880	5000	4120
FC200	(160HB)	160	2550	1960	1630	1340	1030
FCD600	(200HB)	200	3330	2550	2110	1750	1340
Aluminium alloy	(89HB)	89	1350	1130	950	810	670
Aluminium			1050	870	740	640	520
Magnesium alloy			390	390	390	390	390
Brass			1080	1080	1080	1080	1080

●Bending stress and tool deflection



Bending stress

(1) Square shank

$$S = \frac{6 \times F \times L}{b \times h^2}$$

(MPa)

S : Bending stress in shank (MPa)
 F : Cutting force (N)
 L : Overhang length of tool (mm)
 b : Shank width (mm)
 h : Shank height (mm)
 ϕD_s : Shank diameter (mm)
 E : Modulus of elasticity of shank material (MPa)

(2) Round shank

$$S = \frac{32 \times F \times L}{\pi \times \phi D_s^3}$$

(MPa)

Tool deflection (mm)

(1) Square shank

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

(mm)

(2) Round shank

$$\delta = \frac{64 \times F \times L^3}{3 \times \pi \times E \times \phi D_s^4}$$

(mm)

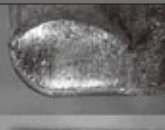
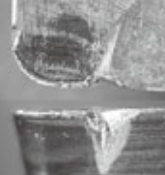
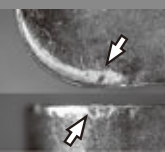
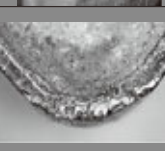
(Ref.) Values of E

Material	MPa (N/mm ²)	{kgf/mm ² }
Steel	210,000	21,000
Cemented Carbide	560,000~620,000	56,000~62,000

User's Guide- Technical Reference

Turning Tools

Troubleshooting in turning

Typical tool failure		Countermeasure		
		Tool grade	Cutting conditions	Tool geometry
Flank wear		Change to more wear resistant grades P, M, K30 → 20 → 10	- Reduce cutting speed - Change to appropriate feed - Change to wet cutting	- Decrease honing width - Increase relief angle - Increase end cutting edge angle - Increase corner radius - Select free-cutting chipbreaker - Increase rake angle
Crater wear		Change to more wear resistant grades P, M, K30 → 20 → 10	- Reduce cutting speed - Reduce feed - Reduce depth of cut - Change to wet cutting	- Increase rake angle - Select an appropriate chipbreaker - Increase side cutting edge angle - Increase corner radius
Notch wear		Change to more wear resistant grades P, M, K30 → 20 → 10	- Reduce cutting speed - Reduce feed	- Increase rake angle - Increase side cutting edge angle
Fracture		- Change to tougher grades - Change to thermal-shock resistant grades P, M, K10 → 20 → 30	- Reduce feed - Reduce depth of cut - Improve holding rigidity of work and tool - Reduce overhang length of toolholder - Improve looseness in machine	- Reduce rake angle - Select a chipbreaker with high edge strength - Increase honing width - Increase side cutting edge angle - Select larger shank size - Increase corner radius
Chipping		Change to tougher grades P, M, K10 → 20 → 30	- Reduce cutting speed - Reduce feed - Reduce depth of cut - Improve holding rigidity of work and tool - Reduce overhang length of toolholder - Improve looseness in machine	- Reduce rake angle - Select a chipbreaker with high edge strength - Increase honing width - Increase side cutting edge angle - Select larger shank size
Flaking		Change to tougher grades P, M, K10 → 20 → 30	- Reduce cutting speed - Reduce feed	- Reduce rake angle - Increase corner radius - Increase honing width
Plastic deformation		Change to more wear resistant grade P, M, K30 → 20 → 10	- Reduce cutting speed - Change to appropriate feed - Reduce depth of cut - Supply cutting fluid in adequate volume	- Increase relief angle - Increase rake angle - Reduce corner radius - Reduce side cutting edge angle - Select a free-cutting chipbreaker
Chip welding		Use a grade which has a low tendency to adhere to Workpiece material Cemented carbide → Coated carbide or cermet	- Increase cutting speed - Increase feed - Change to water-insoluble cutting fluid - Change to wet cutting	- Increase rake angle - Select a free-cutting chipbreaker - Decrease honing width
Built-up edge		Use a grade which has a low tendency to adhere to Workpiece material Cemented carbide → Coated carbide or cermet	- Increase cutting speed - Increase feed - Change to water-insoluble cutting fluid - Change to wet cutting	- Increase rake angle - Select a free-cutting chipbreaker - Decrease honing width
Thermal cracking		- Change to tougher grades - Change to thermal-shock resistant grades P, M, K10 → 20 → 30	- Reduce cutting speed - Reduce feed - Change to dry cutting - Supply cutting fluid in adequate volume - Reduce depth of cut - Change to water-insoluble cutting fluid	- Increase rake angle - Select a free-cutting chipbreaker - Decrease honing width

User's Guide- Technical Reference

Turning Tools

Problem	Cause	Countermeasure	
		Tool	Cutting conditions and others
Deteriorated surface roughness	• Increased tool wear	• Select a more wear resistant grade • Use an insert with a larger rake angle • Use an insert with a larger nose radius • Use a more lightly honed insert • Use an insert of closer tolerance (from M class to G class)	• Select a proper feed • Decrease the cutting speed • Select a freer-cutting chipbreaker type • Use a cutting fluid
	• Edge chipping	• Use a tougher grade • Select a chipbreaker with strong cutting edges • Use a largely honed insert • Increase the side cutting edge angle • Use a larger shank size	• Decrease the depth of cut • Decrease the feed • Use a more rigid machine • Improve the holding rigidity of the tool and workpiece • Shorten the overhang of the toolholder • Improve the machine looseness
	• Chip welding • Built-up-edge	• Select a grade with less affinity with the Workpiece material • Use an insert with a larger rake angle • Select a freer-cutting chipbreaker type • Use a more lightly honed insert • Use an insert of closer tolerance (from M class to G class)	• Increase the cutting speed • Increase the feed • Use a water-insoluble cutting fluid • Use a cutting fluid
	• Vibration and chatter	• Use a tougher grade • Use an insert with a larger rake angle • Select a freer-cutting chipbreaker type • Use an insert with a smaller nose radius • Decrease the side cutting edge angle • Use a more lightly honed insert • Use a larger shank size	• Use a proper cutting speed • Decrease the feed • Decrease the depth of cut • Improve the holding rigidity of the tool and workpiece • Shorten the overhang of the toolholder • Improve the machine looseness
Deteriorated dimensional accuracy	• Improper insert accuracy	• Use an insert of closer tolerance (from M class to G class)	
	• Incomplete engagement of tool and workpiece	• Use an insert with a larger rake angle • Select a freer-cutting chipbreaker type • Use an insert with a smaller nose radius • Use a more lightly honed insert	• Improve the holding rigidity of the tool and workpiece • Shorten the overhang of the toolholder • Improve the machine looseness
Burr occurrence	• Unsuitable cutting speed		• Decrease the cutting speed • Increase the feed • Use a cutting fluid
	• Worn tool or improper cutting edge geometry	• Use a harder grade • Use an insert with a larger rake angle • Select a freer-cutting chipbreaker type • Increase the relief angle • Use an insert with a smaller nose radius • Decrease the side cutting edge angle • Use a more lightly honed insert	
Edge breakout	• Improper cutting speed		• Decrease the feed • Decrease the depth of cut
	• Worn tool or improper cutting edge geometry	• Use a harder grade • Use an insert with a larger rake angle • Select a freer-cutting chipbreaker type • Increase the side cutting edge angle • Use an insert with a larger nose radius • Use a more lightly honed insert • Use a larger shank size	• Improve the holding rigidity of the tool and workpiece • Shorten the overhang of the toolholder • Improve the machine looseness
Fuzzy surface finish	• Improper cutting conditions		• Increase the cutting speed • Select a proper feed • Use a water-insoluble cutting fluid • Use a cutting fluid
	• Worn tool or improper cutting edge geometry	• Use a harder grade. • Select a grade with less affinity with the Workpiece material • Use an insert with a larger rake angle • Select a freer-cutting chipbreaker type • Use a more lightly honed insert	

User's Guide- Technical Reference

Chipbreakers

Chip controllability

Necessity of chip control

- ① Why is chip control needed?
- ② Effect of improper chip control

① Why is chip control needed?

What is chip?

For making a product from a workpiece, removed objects produced by a tool which is set to cut to a specified depth with the relative motion of the tool and the workpiece.

Problems when chips are not properly controlled

Necessity of chip control (Problems and effects)

Problems	Effects
1. Scattering of chips and coolant. 2. Wrapping around the workpiece and the tool. 3. Accumulation on the tool, jig, and machining facilities.	1. Disturbs unmanned and automated machining. 2. Disturbs high-speed and high-efficiency machining. 3. Degrades finished surface. 4. Threatens operator's safety. 5. Reduced operation rate.

Additional problems when chips are not properly controlled

② Effect of improper chip control

Effects on quality

- Defective work.
- Defective surface finish
- Chip entangling

Effects on operation

- Increased number of man-hours for handling.
- Increased tool costs.
- Troublesome chip handling.
- Machine stoppage and reduced operation rate.

Effect on safety and health.

- Stain and damage on machine caused from improper carrying-out of chips.
- Dangerous effects on the human body. (Injury and burns on hand, etc.)

Effective measures

"Chipbreaker"

Classification	Chip shape		Description of chip shape	Acceptability	Effect
	Depth of cut: small	Depth of cut: large			
Shape A			Chips irregularly entangled	Not acceptable	• Wrapping around the tool or workpiece or accumulation around the cutting point, hindering cutting • Possible damage to the machined surface
Shape B			Long continuous spiral chips $\ell > 50 \text{ mm}$	Acceptable	• Bulky during transport in the automatic line • May be preferred when one operator handles one machine
Shape C			Short spiral chips $\ell < 50 \text{ mm}$		• Smooth chip flow • Difficult to scatter • Favorable shape
Shape D			"C" or "9" shaped chips (Around one coiling)		• Favorable shape if not scattering • Not bulky and easy to transport
Shape E			Excessively broken chips. Thin pieces or connected in a form of wave as shown in the figure left	Not acceptable	• Readily scattering. If scattering is the only trouble, it may be acceptable because the chip cover, etc. may be used. • Tend to cause chatter, causing harm on the finished surface roughness or tool life.

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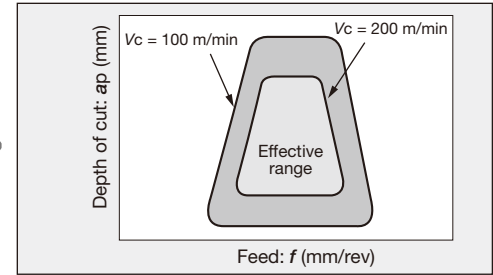
Chipbreakers

Factors affecting chip control

(1) Cutting conditions

- 1 Feed
- 2 Depth of cut
- 3 Cutting speed

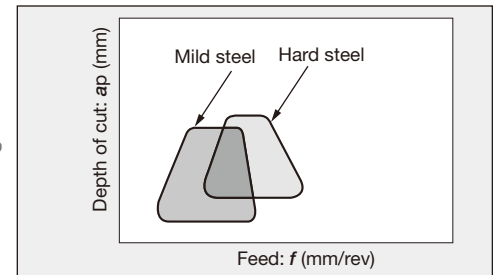
- Of these, feed has the greatest effect followed by depth of cut and cutting speed in order listed.
- Feed is proportionate to the thickness of chips.
- Depth of cut is proportionate to the width of chips.
- There are optimum values (effective range) in feed and depth of cut.
- Cutting speed is in inverse proportion to chip thickness. Effective range becomes narrow at high speed.



(2) Workpiece material

- 1 Alloy element
- 2 Hardness
- 3 Heat treatment condition

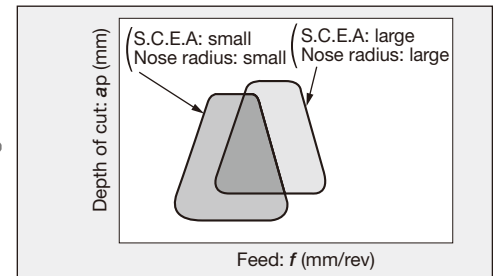
- These are related to thickness of chips and ease of curling.
- Mild steel chips are thicker than those of hard steel.
- Hard steel chips are liable to curl more than those of mild steel.
- Chips that do not curl are thin. As an exception, in case of mild steel even if thick, may not curl.



(3) Tool geometry

- 1 Side cutting edge angle
- 2 Nose radius

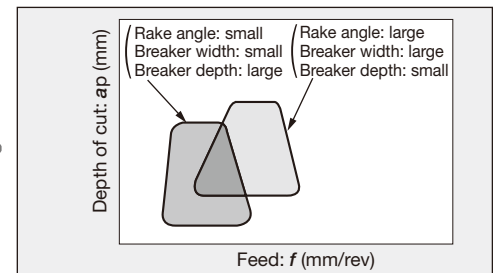
- Side cutting edge angle is relative to chip thickness and width
- Side cutting edge angle is preferably small.
- Nose radius is relative to thickness and width and the direction of flowing out.
- In finishing, small nose radius, whilst for rough cutting, large nose radius is better.



(4) Shape of chipbreaker

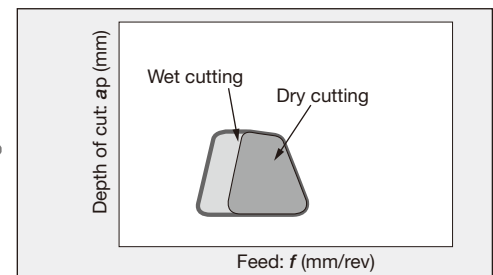
- 1 Rake angle
- 2 Chipbreaker width
- 3 Chipbreaker depth

- Rake angle is in inverse proportion to chip thickness.
- Depending on the Workpiece material, there is an optimum value.
- Chipbreaker width is selected proportionately to feed.
- Narrow at low feed and wide at high feed.
- Chipbreaker depth is to be selected so as to be inversely proportionate to feed.
- Deep at low feed and shallow at high feed.



(5) Coolant

- Effective range is wider with wet cutting.
- Especially at low feed range is liable to curl.



(6) Machine

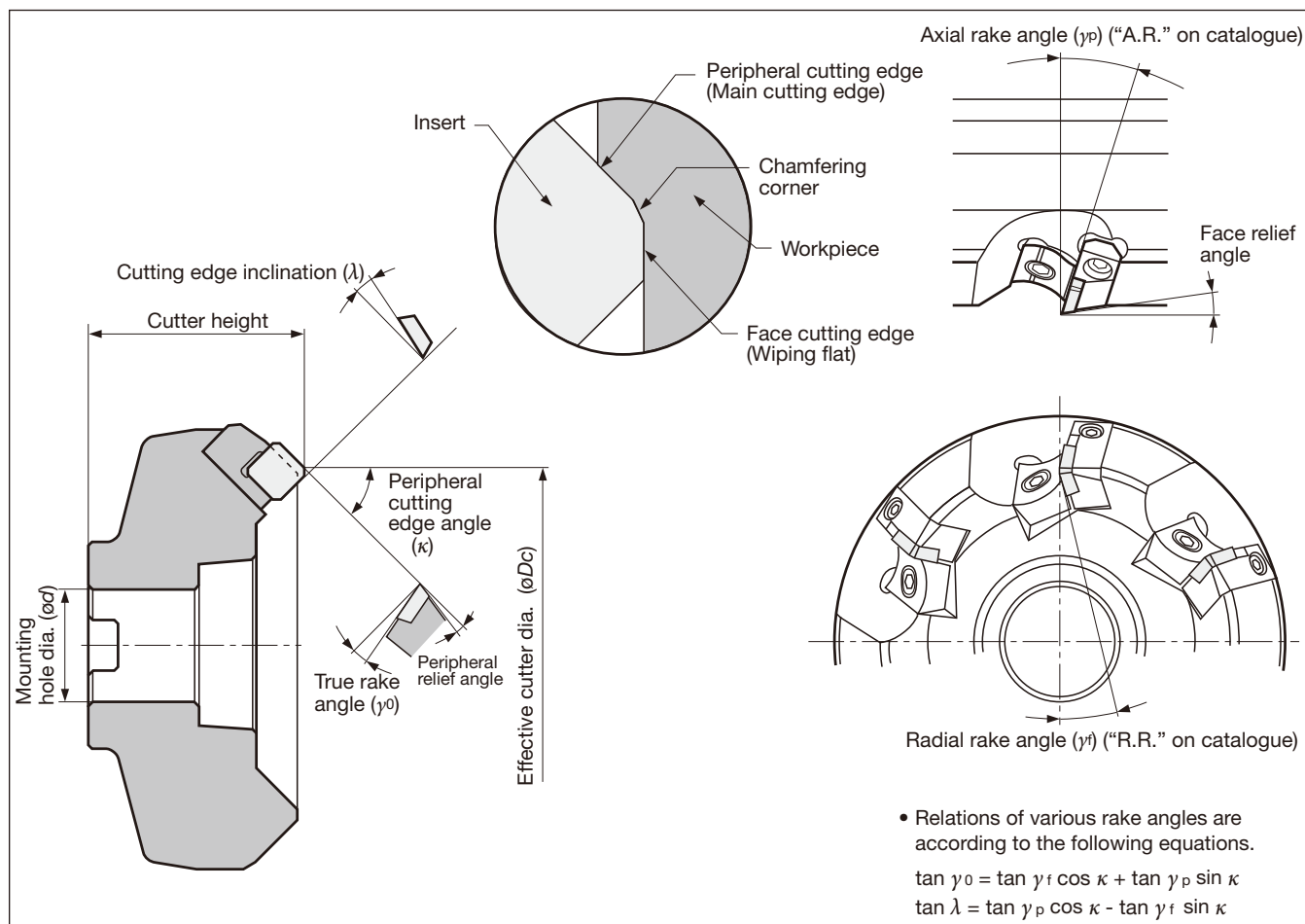
- 1 Rigidity
- 2 Power limit

- The machine has enough power and mechanical strength.
- Select the machine consistent with the size of Workpiece material to be used.

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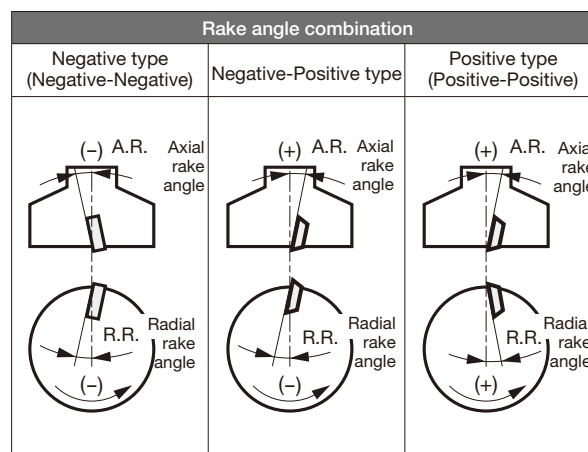
Milling tools

Nomenclature for face milling cutter



Cutter geometry and applications

Condition		Rake angle combination and applicability		
		Negative-Negative	Negative-Positive	Positive-Positive
Shapes of cutting edge	γ_p (A.R.)	-	+	+
	γ_r (R.R.)	-	-	+
	γ_0	-	+	+
Workpiece material	Carbon steels, alloy steels (< 300HB)	△	◎	◎
	Stainless steels (< 300HB)	×	◎	○
	Die steels (< 300HB)	△	◎	○
	Cast irons Ductile cast irons	◎	○	○
	Aluminium alloys	×	○	◎
	Copper and its alloys	×	○	◎
	Titanium and its alloys	×	○	○
	Hardened steels (40 ~ 55HRC)	○	○	×
Features		- Higher cutting edge strength - Many usable corners of inserts	- Excellent chip removal - Higher cutting edge strength and Freer cutting action	Most excellent cutting action
Typical examples of mills		TGN4200 DoPent	TAW13 TME4400 TMD4400	THF4000 THE4000

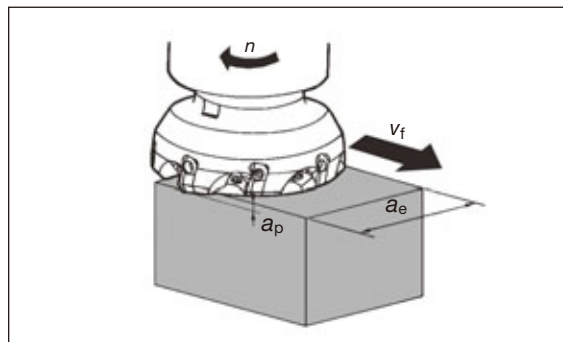


User's Guide- Technical Reference

Milling tools

Calculation formulas for milling

●Cutting speed



●Cutting speed (Calculated from number of revolutions)

$$v_c = \frac{\pi \times \phi D_c \times n}{1000}$$

(m/min)

v_c : Cutting speed (m/min)

ϕD_c : Effective diameter (mm)

n : Number of revolutions (min^{-1})

$\pi \approx 3.14$

●Number of revolution (Calculated from cutting speed)

$$n = \frac{1000 \times v_c}{\pi \times \phi D_c}$$

(min^{-1})

●Feed speed and feed per tooth

$$v_f = f_z \times z \times n$$

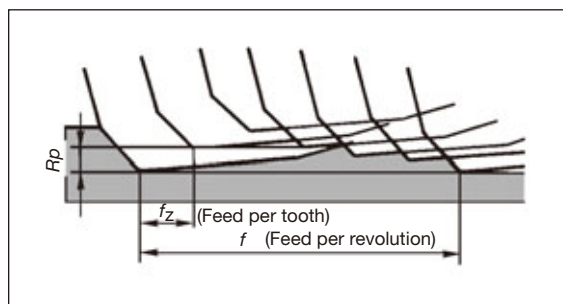
(mm/min)

v_f : Feed speed (mm/min)

f_z : Feed per tooth (mm/t)

z : No. of teeth of the cutter

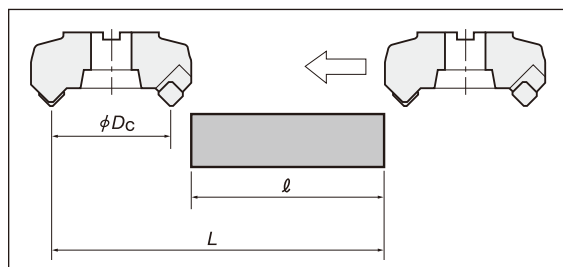
n : Number of revolutions (min^{-1})



Feed speed is relative speed of cutter and Workpiece material and in the normal milling machine, it is the table speed.

In milling, the feed per tooth is very important. The recommended cutting condition is expressed by v_c and f_z and using the above equation calculate n and v_f and input in the machine.

●Cutting time on face milling



$$T = \frac{L}{v_f}$$

(min)

T : Cutting time (min)

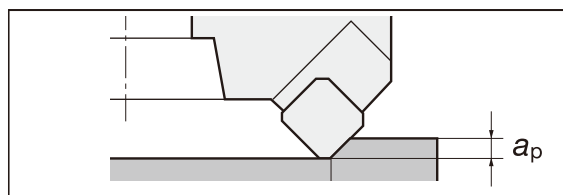
L : Total table feed length.

(l : Workpieces length (mm) + ϕD_c :

Effective cutter diameter (mm))

v_f : Feed speed (mm/min)

Depth of cut and width of cut



●Depth of cut

Determine by required allowance for machining and capacity of the machine. In case of mill, there are cutting limits according to shape and size of the insert. Please see spec in the catalogue.

a_p : Depth of cut (mm)

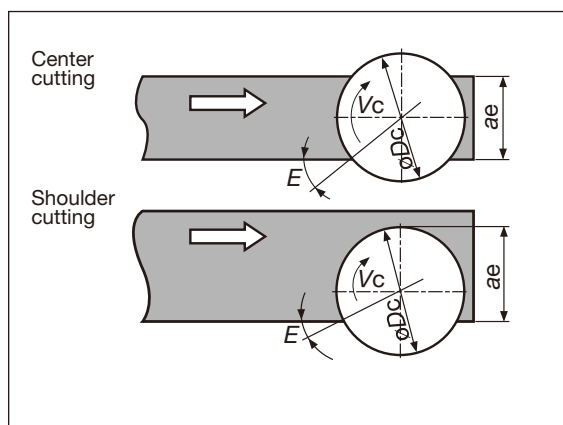
●Width of cut and engagement angle

There is an appropriate engage angle depending on the cutter diameter, cutting position, Workpiece material, etc., and ordinarily the values in the table below are used as a guide.

ϕD_c : Cutter diameter (mm)

E : Engage angle

a_e : Width of cut (mm)



Center cutting

Workpiece material	Appropriate E	Cutter dia. and a_e
Steel	$\sim 42^\circ$	$a_e \approx \frac{2}{3} \phi D_c$
Cast iron	$\sim 53^\circ$	$a_e \approx \frac{4}{5} \phi D_c$

Shoulder cutting

Workpiece material	Appropriate E	Cutter dia. and a_e
Steel	$\sim 30^\circ$	$a_e \approx \frac{3}{5} \phi D_c$
Cast iron	$\sim 40^\circ$	$a_e \approx \frac{3}{4} \phi D_c$

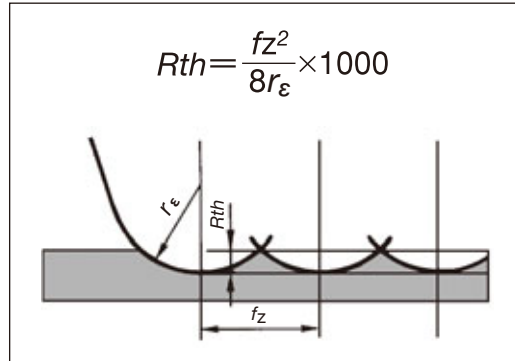
Milling tools

Roughness of finished surface

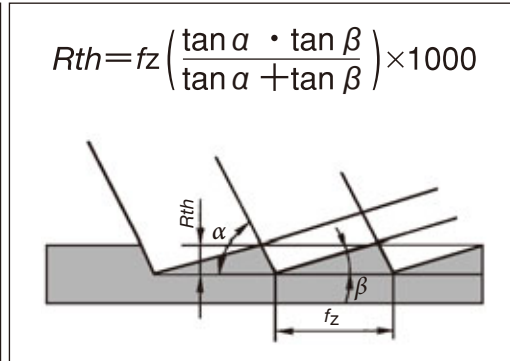
(1) Theoretical surface roughness

Theoretical roughness as shown below, is the same as for single point turning

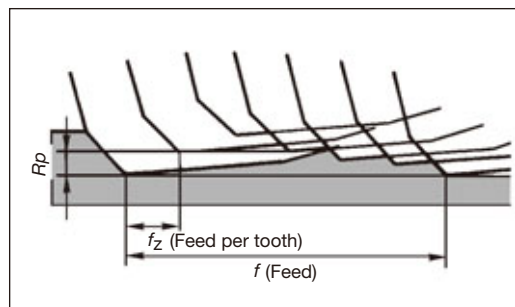
●With corner radius r_ϵ



●Without corner radius r_ϵ



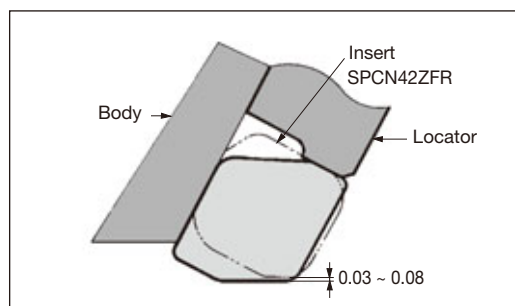
R_{th} : Theoretical roughness (μm)
 f_z : Feed per tooth (mm/t)
 r_ϵ : Corner radius (mm)
 α : Corner angle
 β : Face cutting edge angle



(2) Actual surface roughness

A facemill cutter in practice is composed of multiple point cutting edges and is prone to create uneven peaks, or an axial runout error (R_p) on cutting edges. One or two cutting edges being non-coplanar to the rest invariably create the dominant mark on a face-milled surface, producing periodic patterns corresponding to the feed per revolution f (mm/rev) superimposing on the feed per tooth f_z (mm/t).

Improving surface roughness



Face run out must be minimized and a low feed and high speed should be used. Also, in order to attain good finished surface at high efficiency, there are the following methods:

(1) In case of ordinary mill

Use wiper insert as shown in the figure at left.

(2) Use of super finish mill for finishing.

- Use of combination mills with finishing insert such as TFD4400-A and TFP4000IA ($a_p < 1.0$ mm).
- Use of super finish mill for finishing such as NMS cutters and SFP4000 etc.

User's Guide- Technical Reference

Milling Tools

Calculating power requirement

$$P_c = \frac{k_c \times a_p \times a_e \times v_f}{60 \times 1000 \times 1000} \quad (\text{kW})$$

Because practical power requirements depend on the type of mill (proportional to the true rake angle) and the motor efficiency of the machine used, the result calculated from the above formula should be considered as a rough guide.

P_c : Net power requirement (kW)

k_c : Specific cutting force (N/mm²)

[Refer to the Table below]

a_p : Depth of cut (mm)

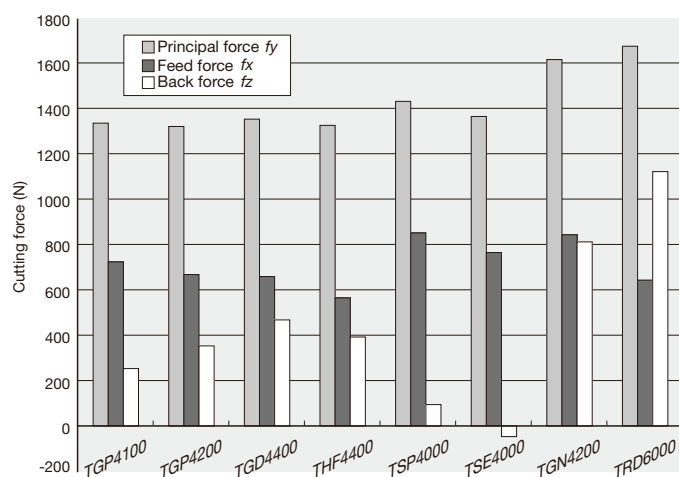
a_e : Width of cut (mm)

v_f : Feed speed (mm/min)

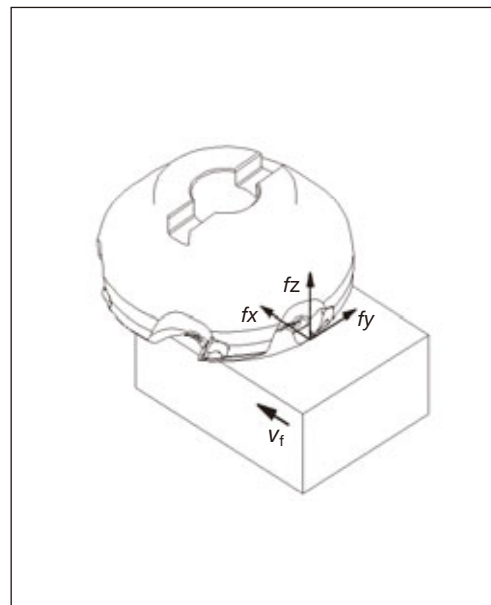
●Values of specific cutting force (k_c)

Workpiece material (JIS)	Tensile strength	Value of specific cutting force on feed per tooth k_c (N/mm ²)				
	MPa	0.1 (mm/t)	0.15 (mm/t)	0.2 (mm/t)	0.3 (mm/t)	0.4 (mm/t)
SS400	520	2150	2000	1900	1750	1650
S55C	770	1970	1860	1800	1760	1620
SCM435	730	2450	2350	2200	1980	1710
SKT4	(HB352)	2030	2010	1810	1680	1590
SC450	520	2710	2530	2410	2240	2120
FC250	(HB200)	1660	1450	1320	1150	1030
Al (Si)	200	660	580	522	460	410
Brass	500	1090	960	877	760	680

●Values of cutting force (k_c)



Workpiece material : S50C (210HB), Diameter of mill : $\phi 160$ mm
Cutting speed : $V_c = 150$ m/min, Feed per tooth: $f_z = 0.20$ mm/t
Depth of cut: $a_p = 3$ mm, Cutting by a single edge, dry



●Conversion from cutting speed to number of revolutions

(unit : min⁻¹)

Cutter diameter ϕD_c (mm)	Cutting speed (v_c) m/min												
	10	30	50	100	125	150	200	300	500	800	1,000	2,000	4,000
10	318	955	1,592	3,184	3,980	4,777	6,369	9,554	15,923	25,477	31,847	63,694	127,388
12	265	796	1,326	2,653	3,317	3,980	5,307	7,961	13,269	21,231	26,539	53,078	106,157
16	199	597	995	1,990	2,488	2,985	3,980	5,971	9,952	15,923	19,904	39,808	79,617
20	159	477	796	1,592	1,990	2,388	3,184	4,777	7,961	12,738	15,923	31,847	63,694
25	127	382	636	1,273	1,592	1,910	2,547	3,821	6,369	10,191	12,738	25,477	50,955
30	106	318	530	1,061	1,326	1,592	2,123	3,184	5,307	8,492	10,615	21,231	42,462
32	99	298	497	995	1,244	1,492	1,990	2,985	4,976	7,961	9,952	19,904	39,808
35	90	272	454	909	1,137	1,364	1,819	2,729	4,549	7,279	9,099	18,198	36,396
40	79	238	398	796	995	1,194	1,592	2,388	3,980	6,369	7,961	15,923	31,847
50	63	191	318	636	796	955	1,273	1,910	3,184	5,095	6,369	12,738	25,477
63	50	151	252	505	631	758	1,011	1,516	2,527	4,044	5,055	10,110	20,220
80	39	119	199	398	497	597	796	1,194	1,990	3,184	3,980	7,961	15,923
100	31	95	159	318	398	477	636	955	1,592	2,547	3,184	6,369	12,738
125	25	76	127	254	318	382	509	764	1,273	2,038	2,547	5,095	10,191
160	19	59	99	199	248	298	398	597	995	1,592	1,990	3,980	7,961
200	15	47	79	159	199	238	318	477	796	1,273	1,592	3,184	6,369
250	12	38	63	127	159	191	254	382	636	1,019	1,273	2,547	5,095
315	10	30	50	101	126	151	202	303	505	808	1,011	2,022	4,044

Note: In this table, the effects of centrifugal force on the rotating balance of the tool and the toolholder, flying risk of cutter parts, and limited value of toolholder destruction are not considered. Therefore, when using the tool at high speeds, be sure to observe the specified condition range.

User's Guide- Technical Reference

Milling Tools

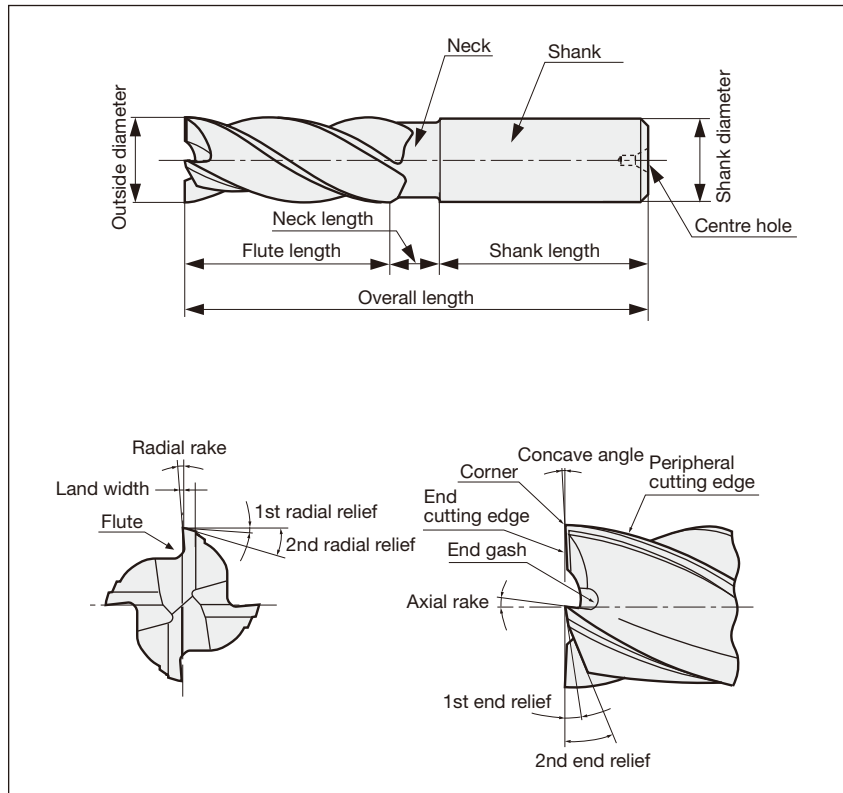
Trouble shooting in face milling

Trouble	Possible causes	Countermeasures
Rapid wear of cutting edge	• Improper insert grade selection (Insufficient wear resistance)	• P30 (Cemented carbide) → Cermet, coated grade (For steels) • K10 (Cemented carbide) → Coated grade (For cast irons)
	• Excessive cutting speed	• Select cutting speed suited for Workpiece material and insert grade
	• Inadequate feed	• Use standard cutting condition in catalog as guide
Rapid chipping of cutting edge	• Improper Insert grade selection (Insufficient toughness)	• Cermet → P30 (For steels), K10 → K20 (For cast irons)
	• Cutting hard material and unfavorable surface condition	• Decrease cutting speed • Use cutter with strong cutting edge
	• Excessive feed	• Proper selection of feed conditions, using recommended cutting conditions in catalog as guide
	• Excessive pressure applied on cutting edge	• Proper selection of engaging angle
	• Machining superalloys	• Use a negative-positive type cutter with large corner angle
Fracturing	• Cracking due to thermal shock	• Select insert grade of stronger thermal shock resistance • Decrease cutting speed
	• Continuous use of excessively worn insert	• Shorten replacement standard time of insert
	• Cutting hard material	• Use cutter with stronger cutting edge • Use cutter of larger corner angle
	• Obstruction to chip flow • Recutting of chips after chip welding	• Use cutter with better chip expulsion • Select insert grades difficult for chips to adhere Cemented carbides → cermets, coated grades • Use air blow
	• Excessively slow cutting, too fine feed	• Select cutting speed and feed optimized for insert grade and Workpiece material
Excessive chip welding or build-up on cutting edge	• Cutting soft material such as aluminium, copper, mild steel	• Use cutter with large rake angle
	• Cutting stainless steel	• P30 → coated grades (AH130, AH3135)
	• Use of cutter with negative rake or too small rake angle	• Use cutter with large rake angle
Rough finish	• Effect of built-up edge	• Increase cutting speed • Appropriate cutting depth (finish allowance) • Change insert grade For steels : P → coated → cermet For cast irons : K → coated
	• Effect of face cutting edge run out	• Proper installing of inserts • Use insert of high dimensional accuracy • Cleaning of insert pocket
	• Continuous use of excessively worn insert	• Shorten replacement standard time of insert
	• Remarkable feed marks	• Feed per revolution to be set within flatland width • Use wiper insert type cutter such as T/EAW13 • Use cutter exclusively for finishing
Chattering	• Unstable clamping of workpiece	• Check clamping method of workpiece
	• Cutting of welded construction of thin steel plate	• Use cutter of large rake angle and small corner angle
	• Excessive cutting condition	• Re-examine allowable chip removal rate according to motor HP
	• Face milling of narrow width workpiece	• Use cutter of small cutter diameter and with many teeth
	• Too many simultaneous cutting teeth engagement	• Reduce No. of teeth or use irregular pitch cutter

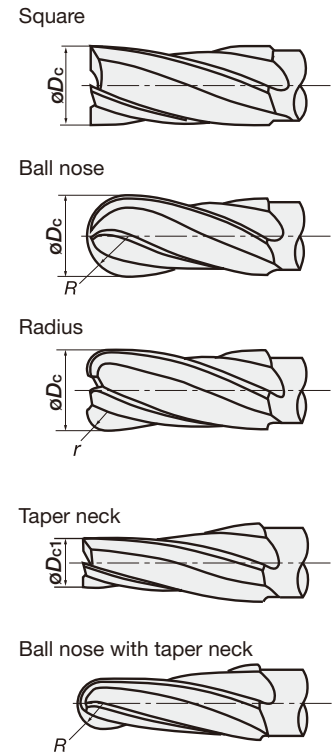
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Solid Carbide Endmills

Part details

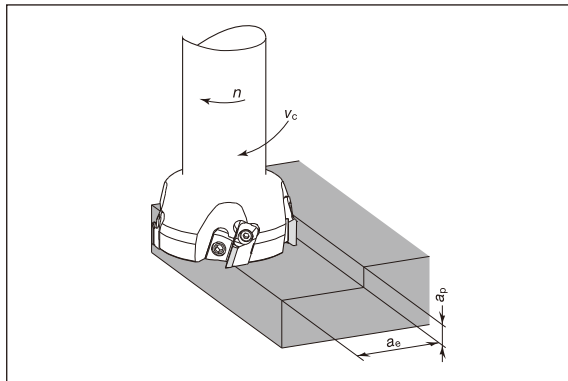


Types



Cutting condition of Endmills

● Cutting speed



● Cutting speed (Calculated from number of revolutions)

$$v_c = \frac{\pi \times \phi D_c \times n}{1000}$$

(m/min)

v_c : Cutting speed (m/min)

ϕD_c : Effective diameter (mm)

n : Number of revolutions (min^{-1})

$\pi \approx 3.14$

● Number of revolution (Calculated from cutting speed)

$$n = \frac{1000 \times v_c}{\pi \times \phi D_c}$$

(min^{-1})

● Feed speed and feed per tooth

$$v_f = f_z \times z \times n$$

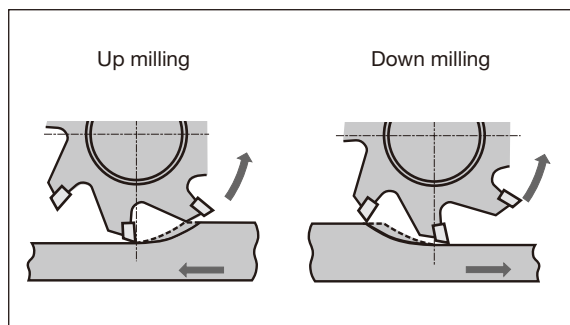
(mm/min)

v_f : Feed speed (mm/min)

f_z : Feed per tooth (mm/t)

z : No. of teeth of the endmills

n : Number of revolutions (min^{-1})



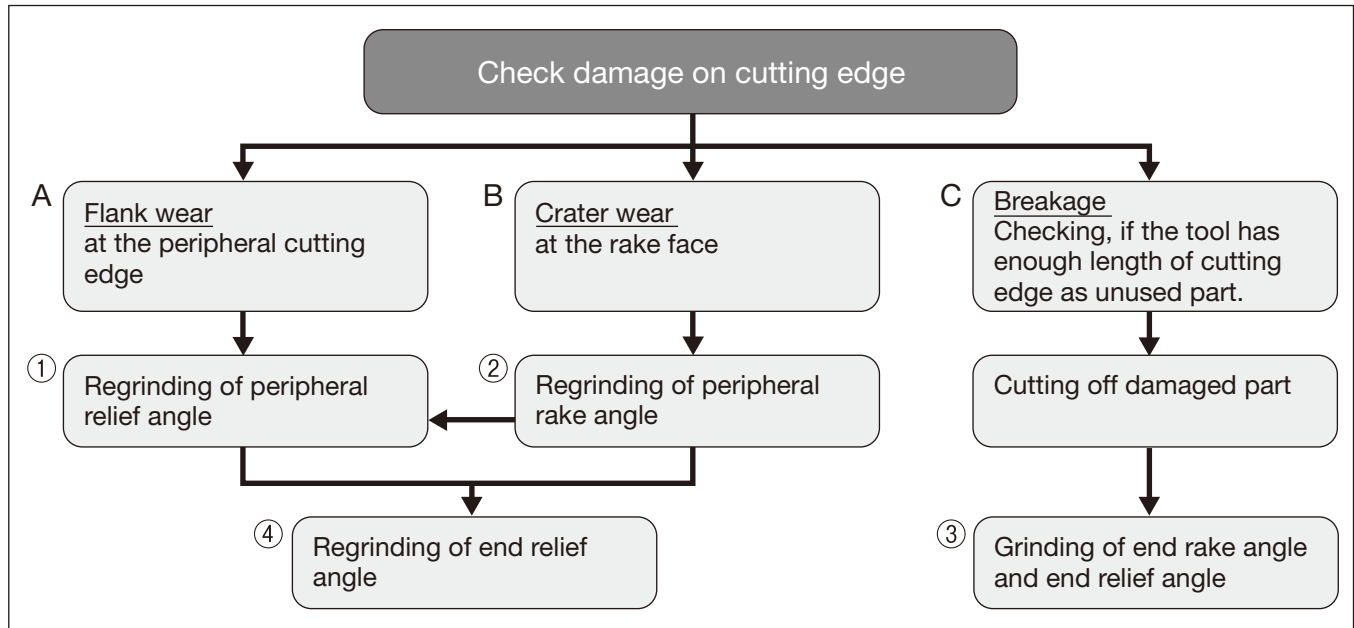
● Cutting

The necessary capacity of the machine is limited by the length of cut edge of the endmill.

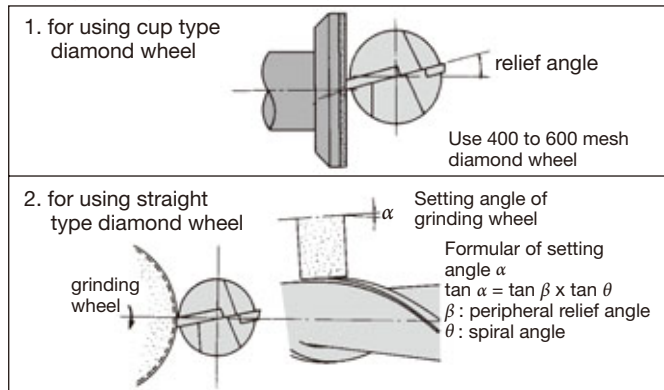
● Up milling and down milling

Down milling generally produces better tool life and surface roughness.

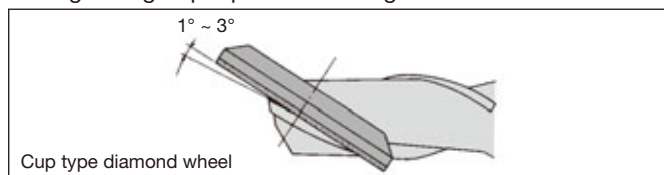
In case of cast iron sand inclusion or welding surface, up milling is recommended.



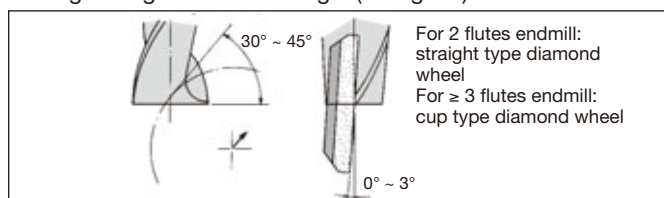
① Regrinding of end relief angle



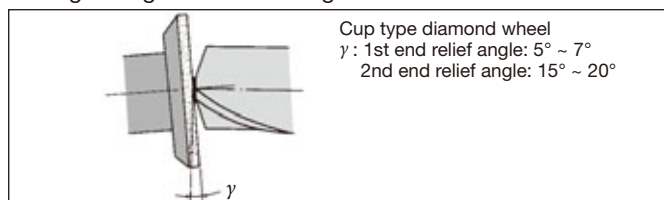
② Regrinding of peripheral rake angle



③ Regrinding of end rake angle (End gash)



④ Regrinding of end relief angle



Notice of regrinding

- (1) If, after checking the damage of the cutting edge, the damage is as case "A" or "B" of the flow chart, the tool must be reground.
Too much damage of the cutting edge requires too much stock removal and thus reduces tool life.
- (2) Please use diamond grinding wheel.
- (3) Peripheral relief angle must be ground between 18° and 10°.
Relief angle of small diameter cutters for aluminium machining must be a large degree.
- (4) First check if "C" in flow chart can be adapted for the case of coated endmill or not.
If procedure "C" can be adapted for regrinding, tool life after the grinding would be more improved than new one. The reason is remaining coated layer of cutting edge and shorter tool length will keep much higher rigidity of the tool than before regrinding.
- (5) Please check run out of peripheral cutting edge, face cutting edge, with Vee block after regrinding.
The value of the run out must be controlled within 0.01 mm.

Notice for regrinding of ball nose endmill

- Regrinding of relief angle only is available. The dimension of nose radius will be smaller after grinding.
- Honing of cutting edge is necessary after regrinding.

User's Guide- Technical Reference

Solid Carbide Endmills

Trouble shooting in Endmilling

Trouble	Possible causes	Countermeasures
Breakage (In case of solid carbide endmill and brazed endmill with small diameter)	● At the start of machining ● At the end of machining	● Reduce feed. ● Reduce tool overhang length. ● Exchange to short cutting edge tool.
	When usual machining	● Reduce feed. ● Managing tool life → Exchange in shorter time. ● Replace chuck or collet to new one. ● Reduce tool overhang length. ● Make optimum honing on the edge. ● Reduce flutes. E.g. 4 flutes → 3flutes, or 2flutes. ● Use enough coolant. Change direction of supplying coolant.
	When change the direction of feed	● Use the circular interpolation in NC machine. Stop feed shortly before changing. ● Lower feed around changing part. ● Replace chuck or collet to new one.
Fracture on cutting edge	Chipping on corner edge	● Chamfer the corner with hand-stick grinder. ● Down cutting ⇒ Upward milling.
	Chipping on boundary part	● Change cutting direction, Down cutting → Upward milling. ● Reduce cutting speed.
	Chipping on central part or all edges.	● Make slight honing on the edge. Or make honing bigger. ● Change spindle revolution number. ● Increase cutting speed. ● If chattering, increase feed. ● Use coolant or air blast. ● Replace chuck or collet to new one. ● Decrease cutting speed.
	Fracture on cutting edge	● Decrease feed. ● Reduce flutes. E.g. 4 flutes → 3flutes, or 2flutes. ● Make slight honing on the edge. Or make honing bigger. ● Replace chuck or collet to new one. [For Solid carbide endmill] ● Decrease cutting speed. ● Use enough coolant. Change direction of supplying coolant.
Large wear in short time		● Decrease cutting speed. ● Change cutting direction, Upward milling → down cutting. ● Increase feed. ● Use coolant or air blast. ● In reground tool, grind flank face with FINER wheel.

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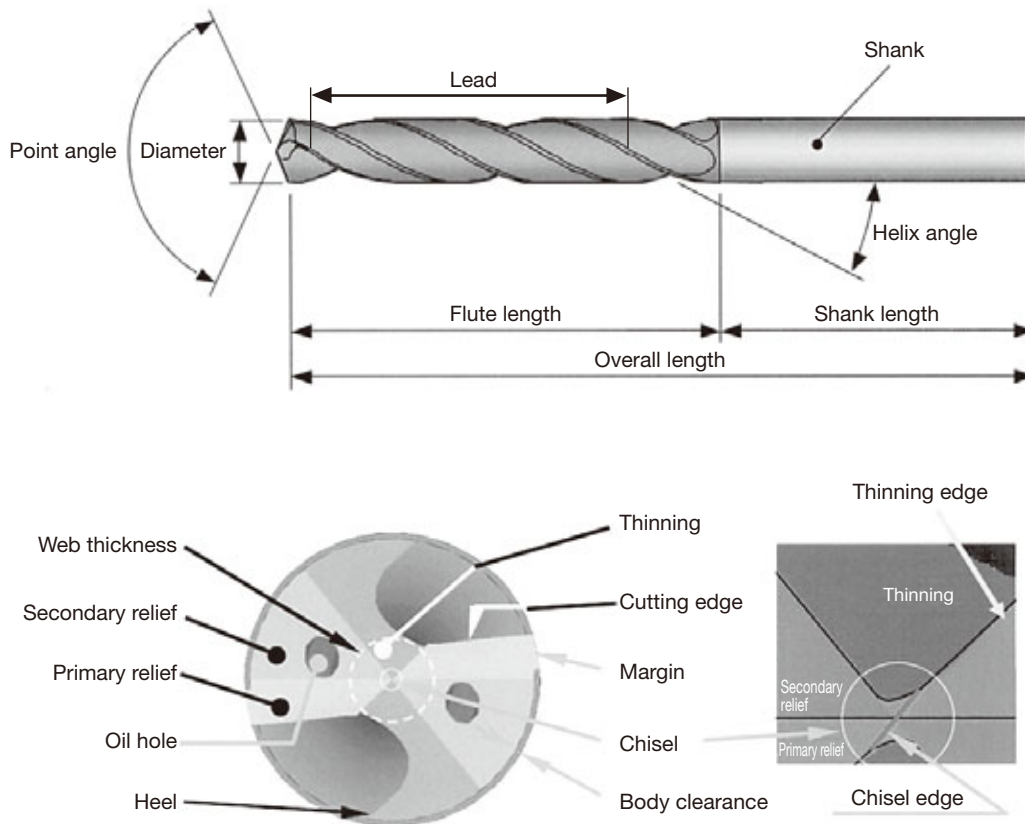
Solid Carbide Endmills

Trouble	Possible causes	Countermeasures
Poor surface finish	Bright, but Wavy surface	● Reduce feed per tooth. ● Increase flutes; E.g. 2 flutes → 3flutes, or 4flutes.
	Small chips are welded on surface.	● Increase cutting speed. ● Use coolant or air blast, or increase coolant. ● Make slight honing on the edge. ● Upward milling → Down cutting. ● Increase feed per tooth. Increase Depth of Cut.
	Scratches on the surface	● Make slight honing on the edge. ● Use non-water soluble coolant. ● Down cutting → Upward milling.
	Poor surface by over cutting	● Reduce depth of cut. ● Increase cutting speed. ● Reduce feed per tooth.
Poor accuracy	Finish size becomes a minus tendency.	● Upward milling → Down cutting. ● Reduce depth of cut. ● Replace chuck or collet to new one. ● Reduce overhang length. ● Increase cutting speed.
	Poor straightness	● Reduce depth of cut. ● Replace chuck or collet to new one. ● Reduce overhang length. ● Increase cutting speed. ● Increase flutes; E.g. 2 flutes → 4flutes. ● Reduce feed per tooth. ● Check the edge. Change tool, when needed.
Chattering		● Increase feed per tooth. ● Reduce feed per tooth, when current feed is more than 0.07 mm/t. ● Change cutting speed. ● Replace chuck or collet to new one. ● Reduce overhang length. ● Use 2 flutes tool in roughing. Use 4 flutes tool in finishing. ● Down cutting → Upward milling.

User's Guide- Technical Reference

Drilling Tools

Nomenclature for solid carbide drills



Cutting forces and power requirement

● Twist drill

Power requirement

$$P_c = K \phi D_c^2 n \quad (0.647 + 17.29f) \times 10^{-6} \text{ (kW)}$$

Thrust force

$$T_c = 570 K \phi D_c f^{0.85} \text{ (N)}$$

Torque

$$M_c = \frac{K \phi D_c^2 (0.630 + 16.84f)}{100} \text{ (N·m)}$$

P_c : Power requirement (kW)

T_c : Thrust force (N)

M_c : Torque (N·m)

ϕD_c : Drill diameter (mm)

f : Feed (mm/rev)

n : No. of revolutions (min^{-1})

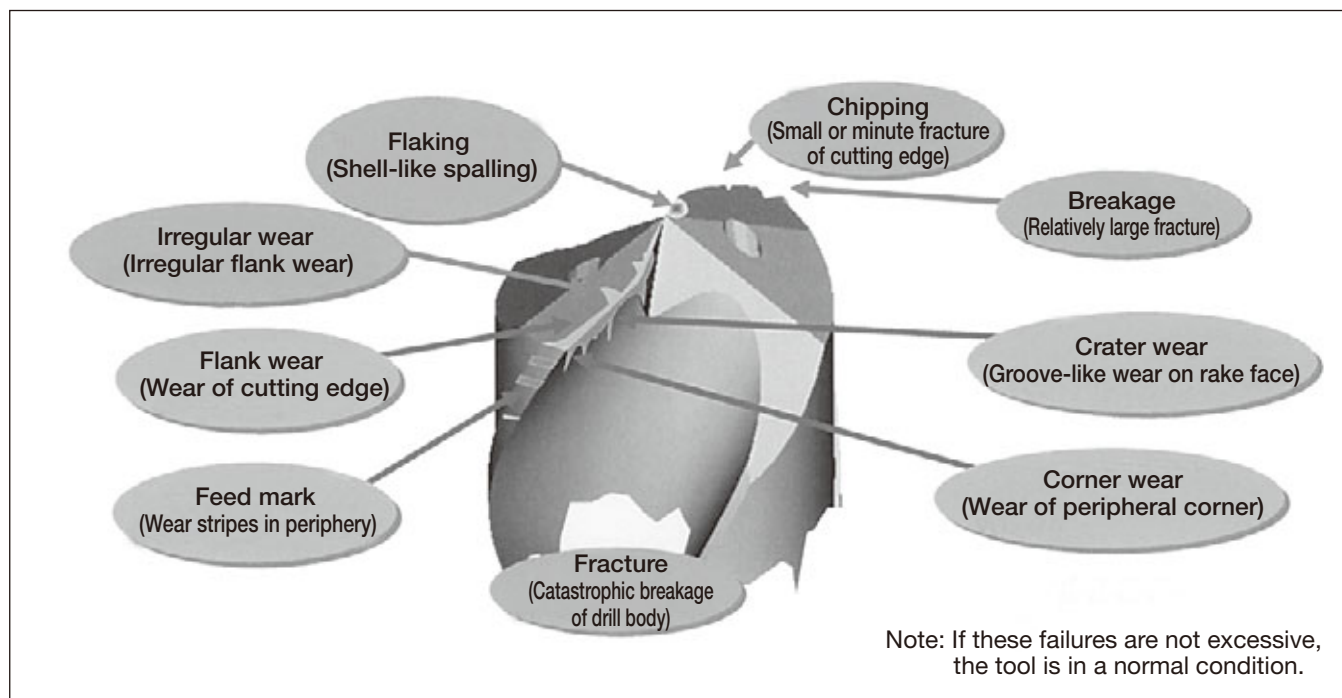
K : Material constant... Refer to the Table at right

● Material constant compensating for power requirement and thrust force

Workpiece material	Tensile strength		Brinell hardness (HB)	Material constant (K)
	MPa (N/mm ²)	Kgf/mm ²		
Cast iron	210	21	177	1.00
Cast iron	280	28	198	1.39
Cast iron	350	35	224	1.88
Aluminium	250	25	100	1.01
Low carbon steel (JIS S20C)	550	55	160	2.22
Free cutting steel (JIS SUM32)	620	62	183	1.42
Manganese steel (JIS SMn438)	630	63	197	1.45
Nickel chromium steel (JIS SNC236)	690	69	174	2.02
4115 steel Cr0.5, Mo0.11, Mn0.8	630	63	167	1.62
Chromium molybdenum steel (JIS SCM430)	770	77	229	2.10
Chromium molybdenum steel (JIS SCM440)	940	94	269	2.41
Nickel chromium molybdenum steel (JIS SNCM420)	750	75	212	2.12
Nickel chromium molybdenum steel (JIS SNCM625)	1,400	140	390	3.44
Chromium vanadium steel				
Cr0.6, Mn0.6, V0.12	580	58	174	2.08
Cr0.8, Mn0.8, V0.1	800	80	255	2.22

Drilling Tools

Cutting edge failure of solid carbide drills

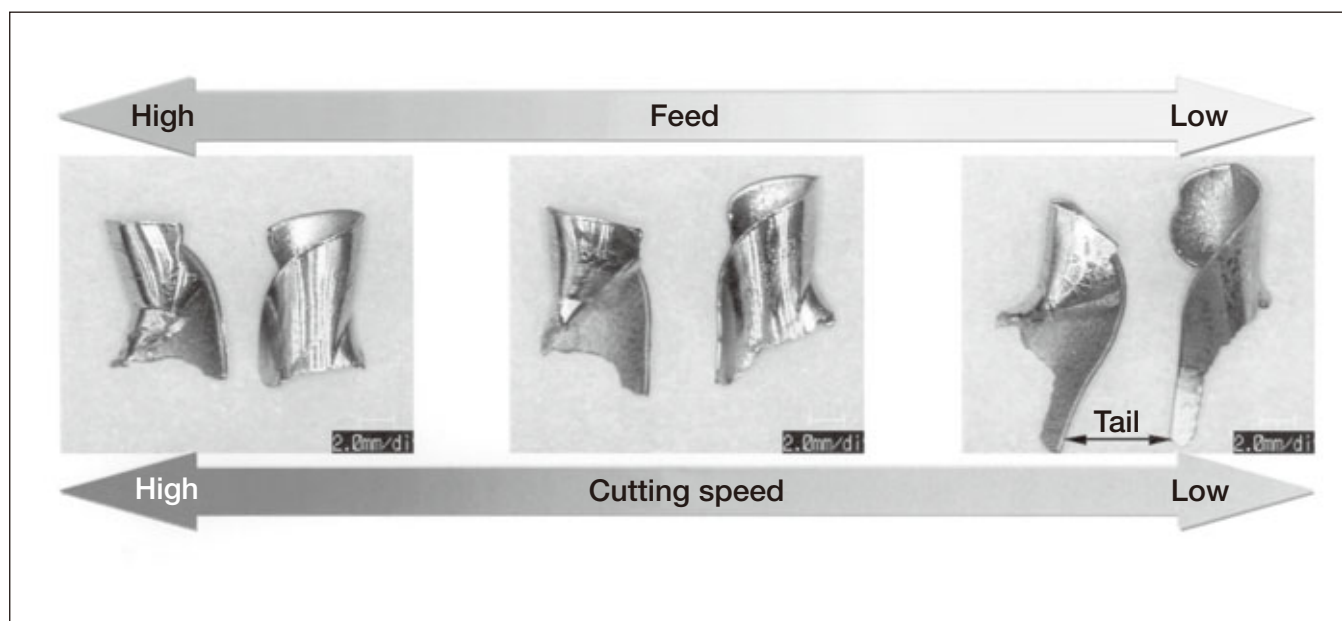


Change of chip shapes in drilling

● Change of chip shapes relating to cutting conditions

Photographs below show the change of chip shapes relating to change of the feed and the cutting speed. These chip shapes are all well controlled in a proper condition range.

When the speed and feed are low, the chip shows whitish color and the tail of the chip tends to lengthen gradually. In contrast, as the speed or the feed increases, the chip tends to increase in brightness and becomes a compact shape with a short tail. These changes in the shape depend on the cutting temperature. As the temperature increases, chips tend to be broken.



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Drilling Tools

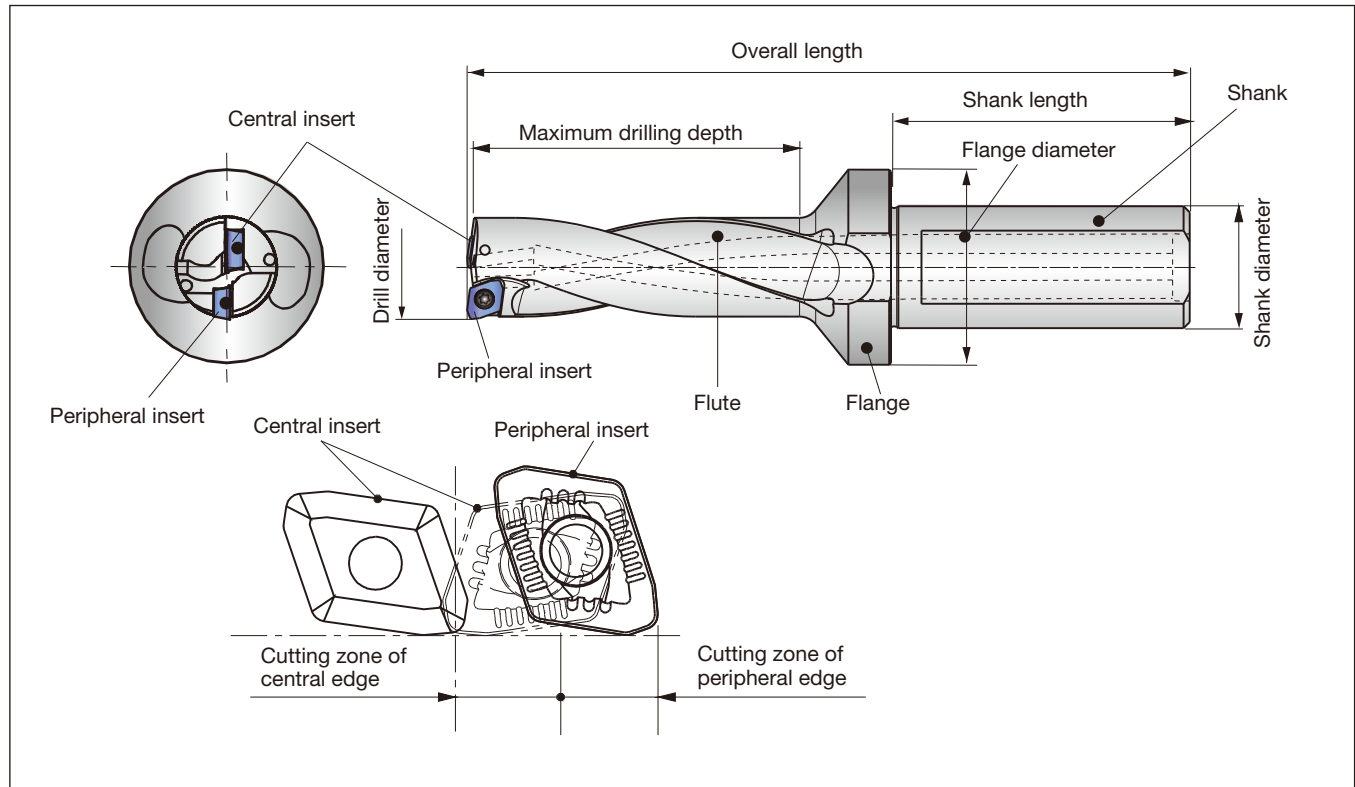
Troubleshooting for solid carbide drills

Problem		Cause	Countermeasure
Abnormal wear	Relief surface	Inappropriate cutting speed	•Increase the cutting speed by 10 % within standard conditions if abnormal wear is around center. •Lower the cutting speed by 10 % within standard conditions if abnormal wear is on the periphery.
		Inappropriate cutting fluid	•Check the filter. •Use the cutting fluid superior in lubricity. (Increase the dilution rate)
	Margin	Inappropriate cutting speed	•Lower the cutting speed by 10 %.
		Regrinding timing, insufficient reground amount	•Shorten the regrinding timing.
		Insufficient rigidity of the machine and workpiece	•Change the clamp method to the one with rigidity.
		Insufficient drill rigidity	•Use smallest possible overhang.
		Inappropriate cutting fluid	•Check the filter. •Use the cutting fluid superior in lubricity. (increase the dilution rate)
Chipping and fracture	Chisel section (center of drill cutting edge)	Intermittent cutting when entering	•Avoid interruption at entry and exit. •Lower the feed by about 50 % during entering into and leaving from the workpiece.
		Insufficient rigidity of the drill	•Reduce the drill overhang as much as possible. •Increase the feed at entry when the low speed feed is selected in standard cutting condition range. •Use a bushing or a center drill.
		Insufficient rigidity of the machine and workpiece	•Change the clamp method to the one with rigidity.
		Inappropriate entry into the workpiece	•Avoid interruption at entry into the workpiece. •Lower the feed by 10 % at entry.
		High workpiece hardness	•Lower the feed by 10 %.
	Peripheral cutting edge	Inappropriate honing	•Check if honing has been made to the center of cutting edge.
		Insufficient drill rigidity	•Lower the cutting speed by 10 %. •Increase the feed at entry when the low speed feed is selected in standard cutting condition range.
		Inappropriate drill mounting accuracy	•Check the run out accuracy after drill installation. (0.03 mm or less)
		Insufficient machinery and workpiece rigidity	•Change the clamp method to the one with rigidity. •Lower the feed during entering into and leaving from the workpiece.
	Margin	Inappropriate honing	•Check if honing has been made to the cutting edge periphery.
		Insufficient machine and workpiece rigidity	•Change the clamp method to the one with rigidity.
		Insufficient drill rigidity	•Use smallest possible overhang. •Use a bushing or center drill.
		Regrinding timing and insufficient amount of reground stock	•Shorten the regrinding timing.
		Intermittent cutting when entering or exiting the cut	•Avoid interruption at entry and exit. •Lower the feed by about 50 % during entering into and leaving from the workpiece.
Breakage		Tendency to cause chipping or develop abnormal wear	•Check the failure mode condition before breakage and find out the wear and chip countermeasures.
		Chip packing in the drill flutes	•Review the cutting conditions. •For internal coolant supply, raise the supply pressure of cutting fluid. •Use peck feed for deep holes.
		Insufficient machine output	•Review the cutting conditions. •Use the machine with high power.
Insufficient hole accuracy		Insufficient rigidity of the machinery and workpiece	•Change to the clamp method with rigidity
		Inappropriate drill installation accuracy	•Check the run out accuracy of drill mounting. (0.03 mm or less)
		Chip packing in the flutes.	•Review the cutting conditions. •Raise the cutting oil supply pressure. •Use peck-feed for deep holes.
		Inappropriate edge sharpening accuracy	•Check the edge shape accuracy.
Prolonged chips		Inappropriate cutting conditions	•Increase the feed by 10 % within standard conditions.
		Inappropriate honing	•Provide the appropriate honing.
		Cutting edge with chipping or breakage	•Lower the cutting speed by 10 %.

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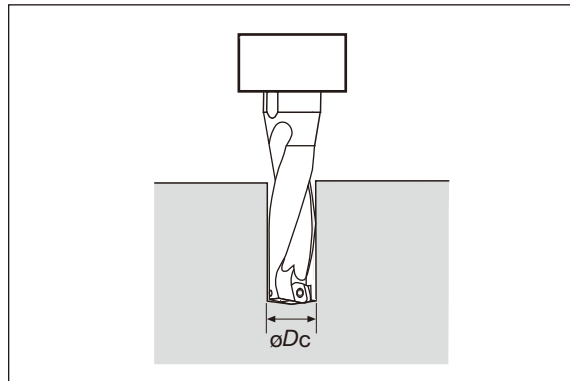
Drilling Tools

Nomenclature for Indexable drill



Calculation formulas for Indexable drill

●Cutting speed



●When calculating cutting speed from number of revolutions: (Drilling formulas)

$$v_c = \frac{\pi \times \phi D_c \times n}{1000} \quad \left(\frac{\text{m}}{\text{min}} \right)$$

v_c : Cutting speed (m/min)
 ϕD_c : Drilling diameter (mm)
 n : Number of revolution (min^{-1})
 $\pi \approx 3.14$

●When calculating required number of revolutions from cutting speed: (Drilling formulas)

$$n = \frac{1000 \times v_c}{\pi \times \phi D_c} \quad (\text{min}^{-1})$$

●When calculating cutting speed from number of revolutions: (Where the workpiece rotates.)

$$v_c = \frac{\pi \times \phi D_c \times n}{1000} \quad \left(\frac{\text{m}}{\text{min}} \right)$$

v_c : Cutting speed (m/min)
 ϕD_c : Drilling diameter (mm)
 n : Number of revolution (min^{-1})
 $\pi \approx 3.14$

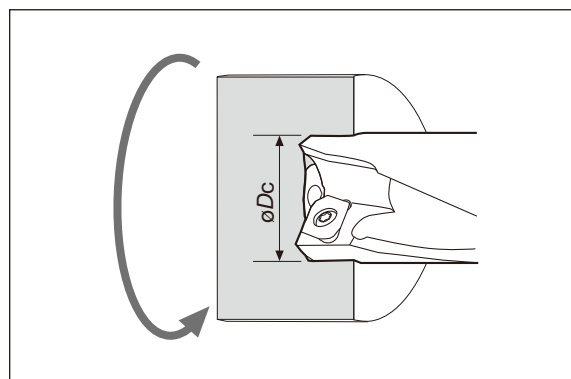
●When calculating required number of revolutions from cutting speed: (Where the workpiece rotates.)

$$n = \frac{1000 \times v_c}{\pi \times \phi D_c} \quad (\text{min}^{-1})$$

●Calculation of feed speed

$$v_f = f \times n \quad \left(\frac{\text{mm}}{\text{min}} \right)$$

v_f : Feed speed (mm/min)
 f : Feed (mm/rev)
 n : Number of revolution (min^{-1})



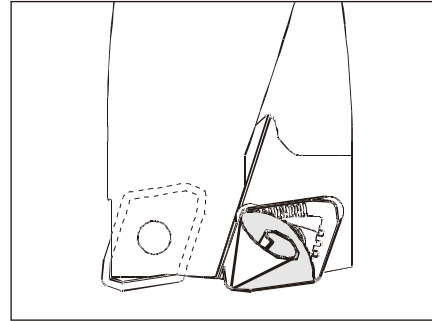
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Drilling Tools

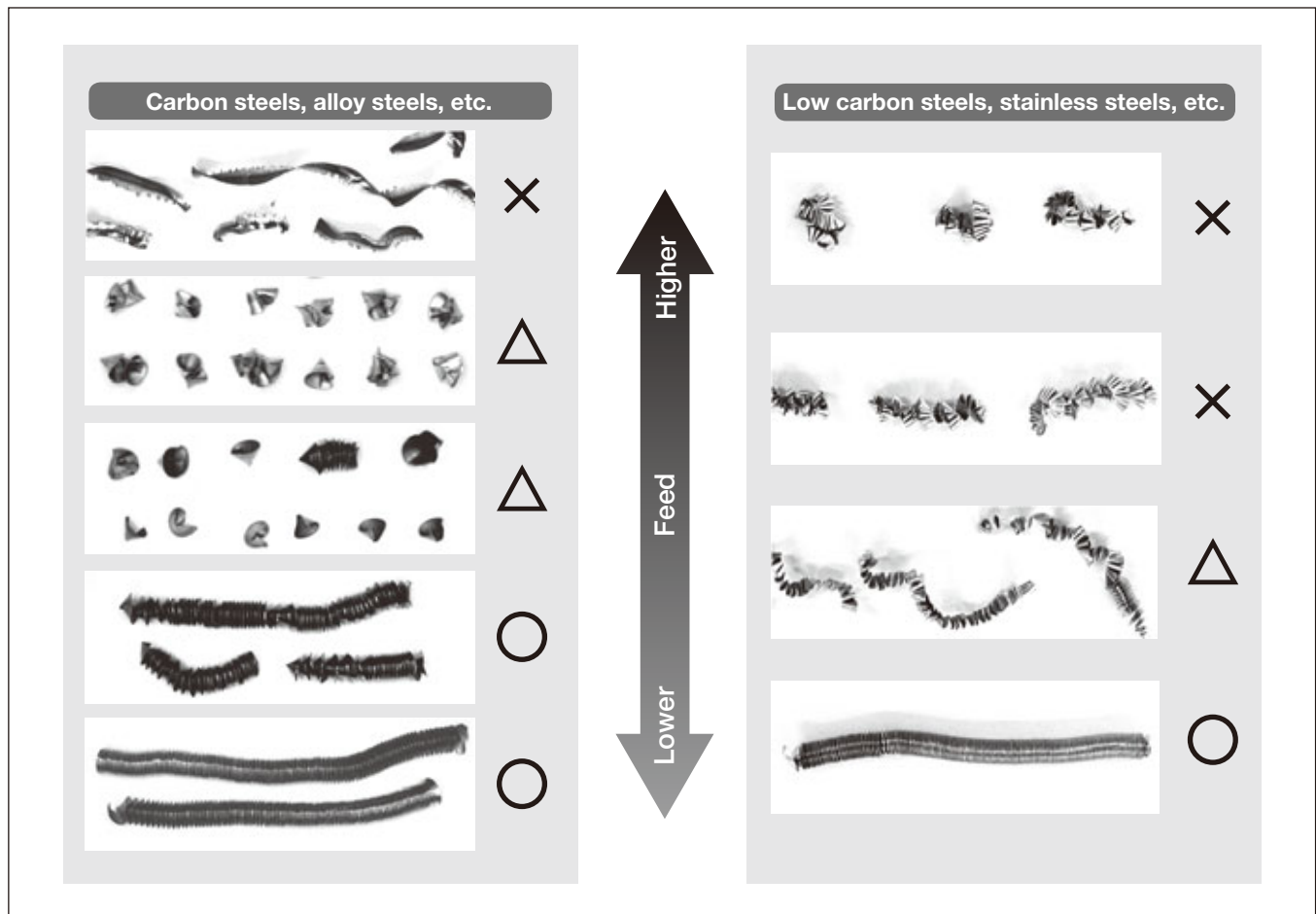
Chip shapes

● Chip shape produced with central insert

- A conical coil shape whose apex point coincides with the rotating center of the drill is the basic shape. The chips are broken into small sections with increases in feed. However, excessively high feed causes the chip to increase in thickness and develops vibration which disturbs stable machining.
- In TDX drills, ○ marked chips shown below are the most preferable shapes. This type of chip is broken into adequate lengths by centrifugal forces when used in tool-rotating condition. On the other hand, when used in work-rotating condition such as on a lathe, a continuously long chip is often produced without entangling.

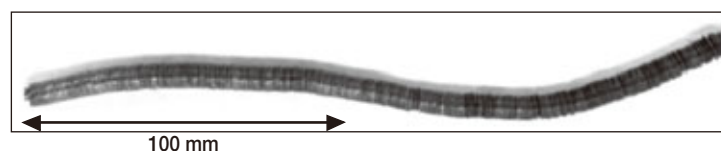


● Relation between chip shapes and feeds (In the case of central insert)



● Example of chip shape in work-rotating applications (In the case of central insert)

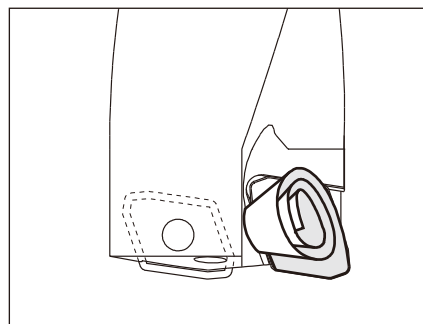
($\phi 26$, JIS S45C, $V_c = 100$ m/min, $f = 0.1$ mm/rev)



Drilling Tools

● Chip shape produced with peripheral insert

- Chip problems such as entangling are mainly caused by chips produced with the peripheral insert. These problems are dependent on the types of Workpiece material and the cutting conditions.
- As shown below, when the feed is extremely low, the chips jump over the chipbreaker groove and the continuously long chips may wrap around the drill body.
- When the feed is too high, the chips increase in thickness and can not be curled.
- Therefore, it is important to select proper cutting conditions to suit the machining so that well controlled chips will be formed.



Medium to high carbon steels, alloy steels, etc.

As shown below, several turns of coil are an ideal shape.

As the feed increases, the curl radius and the number of turns tend to decrease.

● Typical chip shapes of general steels



● Variation of chip shapes relating to feeds



Stainless steels, low-carbon steels, low-alloy steels, etc.

- When machining long-chip materials such as stainless steels and mild steels, the wrong selection of cutting conditions results in chip entangling and tool breakage at worst. Therefore, cutting conditions should be carefully selected.
- “C” shaped, continuous coils of several to ten turns having adequately divided lengths are the ideal shape.

● Ideal chip shapes

	Stainless steel (JIS SUS 304) ($\phi 22$, $V_c = 100$ m/min, $f = 0.1$ mm/rev)	Mild steel (JIS SS400) ($\phi 22$, $V_c = 160$ m/min, $f = 0.08$ mm/rev)
DS chipbreaker		
DJ chipbreaker		

For machining stainless steels or low carbon steels, DS chipbreaker is recommended.

When using a TDX drill in tool-rotating condition, DS chipbreaker produces compact chips and allows more stable machining than DJ chipbreaker. When using it in work-rotating condition, DS chipbreaker provides outstanding affect on chip control.

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Drilling Tools

● Chip shapes which tend to entangle and remedies against them

① Apple-peel-like chips

These chips are often produced in machining mild steels or low-carbon steels at low-speeds and low-feeds.

Remedies

Increase the cutting speed in stages by 20% within the range of standard cutting conditions. If there is no effect, increase the feed by about 10 % as the cutting speed is raised by 20%.



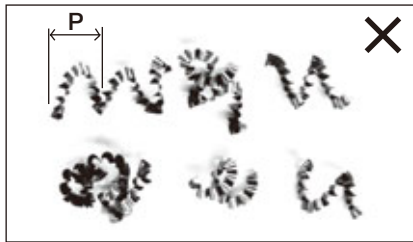
Apple-peel-like chips (Without curling)

② Short-lead chips

These chips are often produced in machining stainless steels at low-feeds and tend to entangle to the tool in spite of short length.

Remedies

Increase the feed by about 10 %. If there is no effect, increase the cutting speed in stages by 10% within the range of standard cutting conditions.



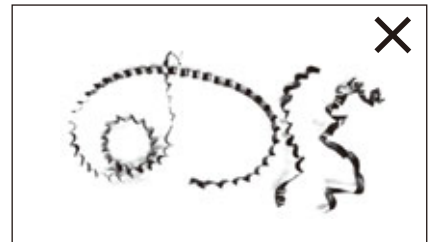
Continuously curled "C" shape chips with short lead (P).

③ Very long chips

Often produced in machining mild steels or low-carbon steels under improper cutting conditions.

Remedies

Increase the cutting speed in stages by 20% within the range of standard cutting conditions. If there is no effect, decrease the feed by about 10 % as the cutting speed is raised by 20%.

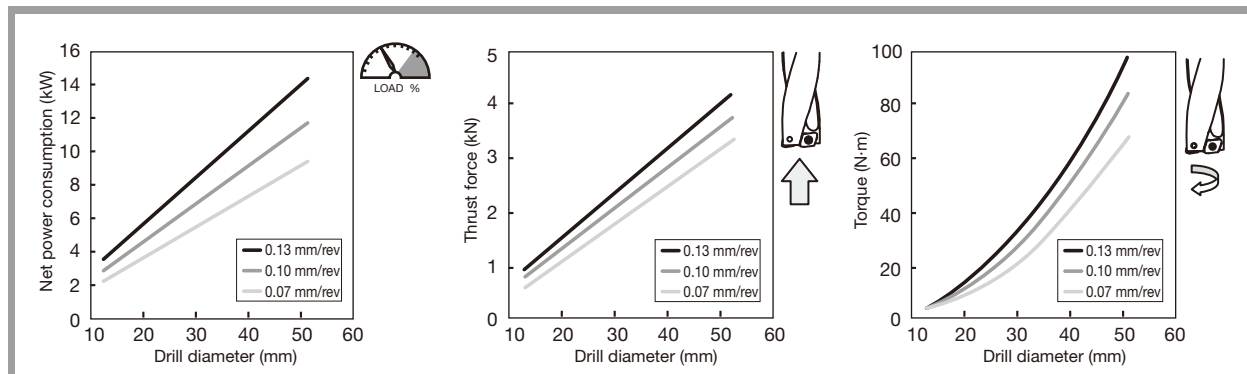


Continuously coiled long chips

Cutting forces

The charts below show a guideline for cutting forces. Use TDX drills on a machine with ample power and sufficient rigidity.

● Guidelines for cutting forces



Cutting speed: $V_c = 100$ m/min
Workpiece material: Alloy steel (JIS SCM440), 240HB
Cutting fluid: Used

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Drilling Tools

Troubleshooting for indexable drills

Problem			Cause	Countermeasure
Abnormal wear	Central cutting edge	Relief surface	Inappropriate cutting conditions	● Increase the cutting speed by 10 % within standard conditions. ● Lower the feed by 10 %.
	Peripheral cutting edge	Relief surface	Inappropriate cutting conditions	● Increase the cutting speed by 10 % within standard conditions. ● When the feed is extremely low or high, set up it within standard conditions.
	Common	Relief surface	Varieties and supply of cutting fluid	● Confirm that the cutting fluid flow is higher than 7 liter/min. ● The concentration of cutting fluid must be higher than 5 %. ● Use the cutting fluid superior in lubricity. ● Change to internal cutting fluid supply from external one.
			Vibration in drilling	● Change to the machine with higher torque. ● Change to the clamp method with rigidity. ● Change the drill setting method.
			Unsuitable for selection of grade	● Change the grade to high wear resistant.
			Looseness of screws	● Tighten the screw.
		Crater	Cutting heat is too high	● Change to internal cutting fluid supply from external one. ● Increase the supply rate of the cutting fluid. (Higher than 10 liter/min.) ● Lower the feed by 20 % within standard conditions. ● Lower the cutting speed by 20 % within standard conditions.
			Excessive chip welding	● Lower the feed by 20 % within standard conditions. ● Lower the cutting speed by 20 % within standard conditions.
		Chipbreaker	Chip packing	● Increase the cutting speed by 20% and lower the feed by 20% within standard conditions. ● Raise the fluid pressure (for higher than 1.5 MPa).
	Chipping and fracture	Central cutting edge	Misalignment for workpiece rotation	● Set the misalignment to 0 ~ 0.2 mm.
			Large offset	● Check the manual and use the tool in the allowable offset range.
			No flatness of machined surface	● Flatten the entry surface in pre-machining. ● Set the feed for lower than 0.05 mm/rev in rough surface area.
			High feed	● Lower the feed by 20 ~ 50 % within standard conditions.
			Using a chipping corner	● Confirm the corner when exchanging inserts.
		Peripheral cutting edge	Using inserts in excess of tool-life	● Exchange the corner or the insert before the nose wear reaches 0.3 mm.
			No flatness of machined surface	● Flatten the entry surface in pre-machining. ● Set the feed for lower than 0.05 mm/rev at rough surface area.
			The existence of interrupted area	● Set the feed for lower than 0.05 mm/rev in interrupted area.
			Using a chipped corner	● Confirm the corner when exchanging inserts.
		Common	The unused corner area and cutting edge	● Increase the cutting speed by 20 % and lower the feed by 20 % within standard conditions. ● Raise the fluid pressure (for higher than 1.5 MPa).
				● Lower the feed by 20 % within standard conditions.
				● Change to continuous feed in case of pick feeding.
			Contact boundary	● Exchange the corner or the insert before the nose wear reaches 0.3 mm.
				● Change to the machine with higher rigidity. ● Change to the clamp method with rigidity. ● Change the drill setting method.
			Flaking	● Set the feed for lower than 0.05 mm/rev.
				● Change to internal cutting fluid supply from external one. ● Lower the feed by 20 % within standard conditions.
			Common	● Change the grade to toughness.
				● Tighten the screw.

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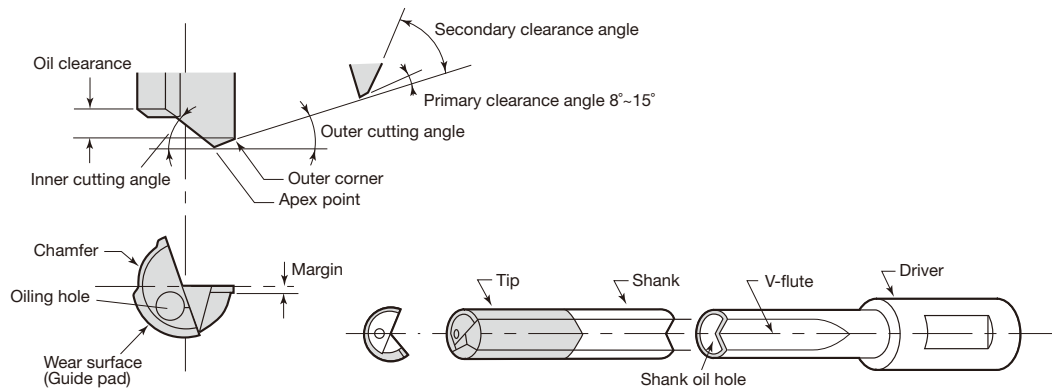
Drilling Tools

	Problem	Cause	Countermeasure
Scratch marks on the tool	The tool periphery	Misalignment of workpiece rotation	● Set the misalignment to 0 ~ 0.2 mm.
		Offset machining in excess of allowable range	● Use the tool in the allowable offset range.
		Offset direction reduced diameter of workpiece	● Set offset direction extended diameter of workpiece
		No flatness of the entry surface	● Flatten the entry surface in pre-machining. ● Set the feed for lower than 0.05 mm/rev in rough surface area.
		Chipping of peripheral cutting edge	● Exchange the insert.
		Bend of workpiece	● Change to the clamp method with rigidity.
		Chip packing	● Increase the cutting speed by 20 % and lower the feed by 20 % within standard conditions. ● Raise the fluid pressure (for higher than 1.5 MPa).
Inappropriate hole accuracy	Hole diameter	Misalignment for workpiece rotation	● Set the misalignment to 0 ~ 0.2 mm.
		Inappropriate offset contents	● Adjust offset contents.
		No flatness of the entry surface	● Flatten the entry surface in pre-machining. ● Set the feed for lower than 0.05 mm/rev at rough surface area.
		Bend of workpiece	● Change to the clamp method with rigidity.
	Roughness	Varieties and supply of cutting fluid	● The concentration of cutting fluid must be higher than 5 %. ● Use the cutting fluid superior in lubricity. ● Change to internal cutting fluid supply from external one.
		Inappropriate cutting conditions	● Increase the cutting speed by 20 % within standard conditions. ● Lower the feed by 20 % within standard conditions.
	Common	Failures of inserts	● Exchange the insert.
		Chip packing	● Increase the cutting speed by 20 % and lower the feed by 20 % within standard conditions. ● Raise the fluid pressure (for higher than 1.5 MPa).
		Looseness of screws	● Tighten the screw.
Chip control	Prolonged and twisted of chips	Inappropriate cutting conditions	● Work within standard conditions. ● Increase the cutting speed by 10 % within standard conditions. ● Increase the feed by 10 % within standard conditions.
		Failures of inserts	● Exchange inserts.
		Machining by external fluid supply	● Change to internal cutting fluid supply from external one. ● Work by step feed. ● Use dwell function for 0.1 sec approximately.
		Chips around the central cutting edge	● There is a tendency to shorten the chips when shifting to higher speed and feed.
	Chip packing	Fluid supply	● Change to internal cutting fluid supply from external one. ● Raise the fluid pressure (for higher than 1.5 MPa).
		Inappropriate cutting conditions	● Increase the cutting speed by 20 % and lower the feed by 20 % within standard conditions. ● Raise the fluid pressure (for higher than 1.5 MPa).
	Common	Large failure of drill holders	● Exchange the drill holder.
		Looseness of screws	● Tighten the screw.
Others	Chatter	Inappropriate cutting conditions	● Lower the cutting speed by 20 % within standard conditions. ● Increase the feed by 10 % within standard conditions.
		Large wear of inserts	● Exchange the insert.
		Vibration in drilling	● Change to the machine with higher torque rigidity. ● Change to the clamp method with rigidity. ● Change the drill setting method.
		Looseness of screws	● Tighten the screw.
	Machine stop	Insufficient machine power and torque	● Use the range of number of revolutions suited machine spec. Lower the feed by 20 ~ 50%.
		Burned inserts	● Exchange inserts before the failure becomes larger. ● Check the oil-hole plug screw is tightly screwed in place. ● Check that the fluid flows powerfully from the drill. ● Lower the cutting speed and the feed by 20 % within standard conditions.
	Large burr	Failures of inserts	● Exchange the insert.
		Inappropriate cutting conditions	● Lower the feed by 20 ~ 50% just before leaving from the workpiece.

User's Guide- Technical Reference

Drilling Tools

Nomenclature for gun drill



Troubleshooting in gun drilling

Problem		Cause		Countermeasure
Breaking of drill	At entry into workpiece	Machine	Clamping the workpiece is unstable.	Clamp the workpiece firmly.
			The guide bush is apart from the workpiece surface at the entry.	Contact the guide bush closely with the workpiece.
			The machine's rapid feed is used.	Use cutting feed.
			Whipping effect occurs.	Place a whip guide at the appropriate position.
			The shape of the guide bush is not suitable.	Use the guide bush in the shape suitable for the workpiece.
		Drill	The drill is not set properly.	Set the drill with an appropriate torque, hydraulic pressure, etc.
			Regrinding is in poor quality.	Make sure no damage is left on the drill and that the cutting edge geometry is not changed.
		Cutting condition	The feed (f) is too high.	Use low feed.
		Workpiece	The workpiece surface is slanted.	Use low feed.
	During drilling	Machine	Clamping the workpiece is unstable.	Clamp the workpiece firmly.
			The shape of the guide bush is not suitable.	Modify the shape of the guide bush. See "Chip packing" for the details.
			The feed speed (V_f) varies.	Use mechanical feed.
			The number of revolutions varies (decreases).	Increase the machine power or adjust the cutting conditions.
		Drill	Abnormal damage occurs.	See "Short tool life" for the details.
		Cutting condition	The feed (f) is not suitable.	Use an appropriate feed.
		Workpiece	Interrupted or cross drilling is required.	Change the tool to a standard gundrill.
		Others	Chip packing occurs.	See "Chip packing" for the details.
	At exit from workpiece	Drill	The tip is too long.	Make the tip length short.
			The selection of the guide pads is not suitable.	Use 2 guide pads instead of 3.
			The clearance of the coolant hole is too large.	Reduce the clearance of the coolant hole.
		Cutting condition	The feed (f) is too high.	Use low feed.
		Workpiece	The workpiece surface is slanted.	Use low feed.
	During retracting	Machine	Clamping the workpiece is unstable.	Clamp the workpiece firmly.
		Cutting condition	Burnishing torque (cutting power) is increased due to reduced hole diameter.	Reduce cutting speed (V_c).

User's Guide- Technical Reference

Drilling Tools

Troubleshooting in gun drilling

Problem		Cause		Countermeasure
Hole accuracy	Rough surface finish	Machine	Clamping the workpiece is unstable.	Clamp the workpiece firmly.
			The type of coolant is not appropriate.	Use water-insoluble coolant.
			Foreign material is in the coolant.	Thoroughly filtrate the coolant (Use a filter with the filtration accuracy in 10μm or less).
			The run-out of the spindle is too large.	Minimize the run-out of the spindle.
			The clearance between the guide bush and the drill is not appropriate.	Replace the guide bush (The clearance should be between +0.003 and +0.008).
			The feed speed (Vf) varies.	Use mechanical feed.
			The number of revolutions varies (decreases).	Increase the machine power or adjust the cutting conditions.
		Drill	Abnormal damage occurs.	See "Short tool life" for the details.
			Regrinding is in poor quality.	Make sure no damage is left on the drill and that the cutting edge geometry is not changed.
		Cutting condition	The feed (f) is too high.	Reduce the feed.
		Others	Chip packing occurs.	See "Chip packing" for the details.
	Unacceptable circularity, cylindricity, and oversize	Machine	The clearance between the guide bush and the drill is not appropriate.	Replace the guide bush (The clearance should be between +0.003 and +0.008).
			The guide bush is apart from the workpiece surface at the entry.	Contact the guide bush closely with the workpiece.
			The type of coolant is not appropriate.	Use water-insoluble coolant.
			The concentricity of the guide bush and the spindle is too large.	Decrease the concentricity of the guide bush and the spindle.
		Drill	Abnormal damage occurs.	See "Short tool life" for the details.
			Regrinding is in poor quality.	Make sure no damage is left on the drill and that the cutting edge geometry is not changed.
		Cutting condition	The feed (f) is not suitable.	Use an appropriate feed.
		Workpiece	Interrupted or cross drilling is required.	Change the tool to a standard gundrill.
		Others	Chip packing occurs.	See "Chip packing" for the details.
	Bending of hole	Machine	Clamping the workpiece is unstable.	Clamp the workpiece firmly.
			The guide bush is apart from the workpiece surface at the entry.	Contact the guide bush closely with the workpiece.
			The concentricity of the guide bush and the spindle is too large.	Decrease the concentricity of the guide bush and the spindle.
			The clearance between the guide bush and the drill is not appropriate.	Replace the guide bush (The clearance should be between +0.003 and +0.008).
		Drill	The selection of the guide pads is not suitable.	Use 2 guide pads instead of 3.
			Regrinding is in poor quality.	Make sure no damage is left on the drill and that the cutting edge geometry is not changed.
		Cutting condition	The feed (f) is too high.	Reduce the feed.
		Workpiece	The workpiece has blow holes or unevenness.	Use the workpiece without defect.
			The workpiece surface is slanted at the entry.	Use low feed.
			Interrupted or cross drilling is required.	Change the tool to a standard gundrill.

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Drilling Tools

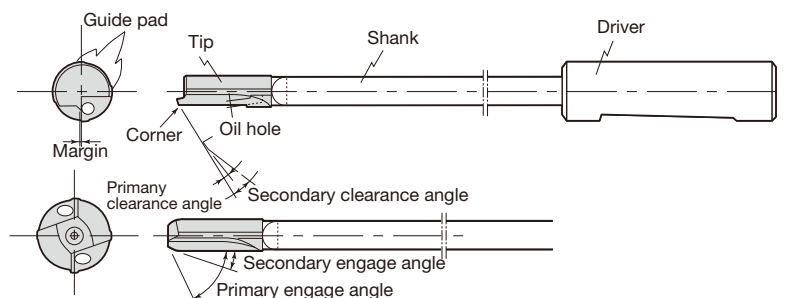
Troubleshooting in gun drilling

Problem		Cause		Countermeasure
Short tool life	Abnormal wear	Machine	The type of coolant is not appropriate.	Use water-insoluble coolant.
			Foreign material is in the coolant.	Thoroughly filtrate the coolant (Use a filter with the filtration accuracy in 10μm or less).
			The clearance between the guide bush and the drill is not appropriate.	Replace the guide bush (The clearance should be between +0.003 and +0.008).
			Whipping effect occurs.	Place a whip guide at the appropriate position.
			The concentricity of the guide bush and the spindle is too large.	Decrease the concentricity of the guide bush and the spindle.
			The coolant temperature is too high.	Increase the capacity of the tank.
		Drill	The selection of the guide pads is not suitable.	Use 2 guide pads instead of 3.
			Regrinding is in poor quality.	Make sure no damage is left on the drill and that the cutting edge geometry is not changed.
			The drill's overall length is excessive.	Reduce the drill's overall length.
			Excessive wear occurs and the chip shape changes.	Regrind the gundrill (ease the tool life criteria).
		Cutting condition	The cutting speed (Vc) is too high.	Reduce the cutting speed.
			The feed (f) is too high.	Reduce the feed.
			The coolant pressure is not high enough.	Increase the coolant pressure.
		Workpiece	The material quality varies.	Reduce the cutting speed (Vc).
Chip control	Chip packing	Machine	The shape of the guide bush is not suitable.	Modify the tip of the guide bush to match the shape of the workpiece surface at the entry.
			The number of revolutions varies (decreases).	Increase the machine power or adjust the cutting conditions.
			The chip box is too small for smooth chip evacuation.	Enlarge the chip box.
		Cutting condition	The feed (f) is not suitable.	Use an appropriate feed.
			The coolant pressure is not high enough.	Increase the coolant pressure.
		Workpiece	Interrupted or cross drilling is required.	Change the tool to a standard gundrill.
			The operation is for stacked plates.	Change the cutting edge shape so that the cores become small.
			The material quality varies.	Increase the feed.
	Chip entanglement	Drill	The cutting edge is fractured or chipped.	See "Breakage" for the details.
			Wear on the outer corner is excessive.	Regrind the gundrill (ease the tool life criteria).
		Cutting condition	The feed (f) is too low.	Increase the feed.
		Workpiece	Drilling a center hole is required.	Make the center hole as small as the drill diameter and increase the coolant pressure.

User's Guide- Technical Reference

Drilling Tools

Nomenclature for gun reamer



Troubleshooting in gun reaming

Trouble		Possible cause	Countermeasure
Breaking of reamer	Increased burnishing torque due to excessively small stock allowance	● Chamfer angle small	● Enlarge chamfer angle and increase stock allowance
		● Excessive wear in peripheral cutting edge.	● Reduce cutting speed to prevent peripheral wear of edge ● Increase lubricity of cutting fluid
	Sticking	● Faulty filtering of cutting fluid ● Incorrect selection of cutting fluid ● Insufficient cutting fluid pressure	● Improve filtering accuracy ● Change to fluid with higher lubricity ● Increase fluid pressure
	Mechanical trouble		● Repair electrical system ● Improve clamping method of workpiece
Faulty machining accuracy	Unacceptable surface roughness	Excessive feed rate per tooth	● Reduce fluid pressure ● Increase number of teeth
		Improper tool specifications	● Excessive chamfer angle ● Excessive back taper ● Peripheral run out excessive
		Faulty regrinding	● Cutting edge run out is large ● Residual damage of preceding process
		Improper cutting fluid	● Excessive fluid pressure ● Improper selection of cutting fluid
		Faulty machine accuracy	● Correct spindle run out and bushing clearance and alignment
		Faulty clamping of workpiece	● Clamping position wrong ● Clamping force inadequate
	Too large and inconsistent over size	Faulty machine accuracy	● Excessive bushing clearance ● Faulty spindle run out and alignment
		Improper tool specifications	● Outer run out of reamer large ● Insufficient reamer rigidity
		Faulty clamping position of workpiece	● Change clamping position
		Unevenness in wall thickness of workpiece	● Reduce reamer guide width (margin width)
	Insufficient oversize allowance	Chamfer angle small	● Increase chamfer angle
		Excessive wear in peripheral cutting edge	● Too high cutting speed ● Faulty lubricity of cutting fluid
		Faulty regrinding (residual damage)	● Increase regrinding stock amount

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International Tolerance (IT Grade)

International Tolerance (IT Grade)

IT grades shows a tolerance allowable for difference of the diameters of a hole and a shaft. As the number added after IT increases, the tolerance becomes rough. Depending on the basic size, the tolerance value in each grade varies.

In the catalog, IT grades are shown as a guide of dimensional dispersion in the diameters of holes machined with the drill. For information, H8 tolerance for a $\varnothing 8.0$ hole is 0 to + 0.022 mm, the width of the value is the same as that of IT 8.

In the Table shown below, tolerance areas attainable with typical drilling tools are distinguished by using different colors. Solid drills are generally used for machining holes of IT 9 to 12. For machining a hole of better than IT 8, finishing process such as reaming is required. For a hole better than IT 5, high-precision finishing is required. Above description is based on machining of general steel. In practice, the IT grade attained with the tool varies widely depending on the hardness and the composition of the work material.

● IT (International Tolerance) Grades

Basic size (mm)		International tolerance grade																	
>	≤	IT1	IT2	IT3	IT4	IT5	IT6	IT7	IT8	IT9	IT10	IT11	IT12	IT13	IT14	IT15	IT16	IT17	IT18
								(μm)						(mm)					
-	3	0.8	1.2	2	3	4	6	10	14	25	40	60	0.1	0.14	0.25	0.4	0.6	1	1.4
3	6	1	1.5	2.5	4	5	8	12	18	30	48	75	0.12	0.18	0.3	0.48	0.75	1.2	1.8
6	10	1	1.5	2.5	4	6	9	15	22	36	58	90	0.15	0.22	0.36	0.58	0.9	1.5	2.2
10	18	1.2	2	3	5	8	11	18	27	43	70	110	0.18	0.27	0.43	0.7	1.1	1.8	2.7
18	30	1.5	2.5	4	6	9	13	21	33	52	84	130	0.21	0.33	0.52	0.84	1.3	2.1	3.3
30	50	1.5	2.5	4	7	11	16	25	39	62	100	160	0.25	0.39	0.62	1	1.6	2.5	3.9
50	80	2	3	5	8	13	19	30	46	74	120	190	0.3	0.46	0.74	1.2	1.9	3	4.6
80	120	2.5	4	6	10	15	22	35	54	87	140	220	0.35	0.54	0.87	1.4	2.2	3.5	5.4
120	180	3.5	5	8	12	18	25	40	63	100	160	250	0.4	0.63	1	1.6	2.5	4	6.3
180	250	4.5	7	10	14	20	29	46	72	115	185	290	0.46	0.72	1.15	1.85	2.9	4.6	7.2
250	315	6	8	12	16	23	32	52	81	130	210	320	0.52	0.81	1.3	2.1	3.2	5.2	8.1
315	400	7	9	13	18	25	36	57	89	140	230	360	0.57	0.89	1.4	2.3	3.6	5.7	8.9
400	500	8	10	15	20	27	40	63	97	155	250	400	0.63	0.97	1.55	2.5	4	6.3	9.7
500	630	9	11	16	22	32	44	70	110	175	280	440	0.7	1.1	1.75	2.8	4.4	7	11
630	800	10	13	18	25	36	50	80	125	200	320	500	0.8	1.25	2	3.2	5	8	12.5
800	1000	11	15	21	28	40	56	90	140	230	360	560	0.9	1.4	2.3	3.6	5.6	9	14
1000	1250	13	18	24	33	47	66	105	165	260	420	660	1.05	1.65	2.6	4.2	6.6	10.5	16.5
1250	1600	15	21	29	39	55	73	125	195	310	500	780	1.25	1.95	3.1	5	7.8	12.5	19.5
1600	2000	18	25	35	46	65	92	150	230	370	600	920	1.5	2.3	3.7	6	9.2	15	23
2000	2500	22	30	41	55	78	110	175	280	440	700	1100	1.75	2.8	4.4	7	11	17.5	28
2500	3150	26	36	50	68	96	135	210	330	540	860	1350	2.1	3.3	5.4	8.6	13.5	21	33

Tolerance area
requiring finishing
process such as
with a reamer.

Tolerance area
attainable with a
solid drill.

Tolerance area
attainable with an
indexable drill.

User's Guide- Technical Reference

Deviations of Shafts to be Used in Commonly Used Fits

Deviations of Shafts to be Used in Commonly Used Fits (JIS B0401 extrac)

Basic size step (mm)		Tolerance zone class of shaft (μm)															
>	≤	e9	f6	f7	f8	g5	g6	h5	h6	h7	h8	h9	js5	js6	js7	k5	k6
—	3	-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
3	6	-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
6	10	-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	+7 +1	+10 +1
10	14	-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
14	18																
18	24	-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	+11 +2	+15 +2
24	30																
30	40	-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	+13 +2	+18 +2
40	50																
50	65	-60 -134	-30 -49	-30 -60	-30 -76	-10 -23	-10 -29	0 -13	0 -19	0 -30	0 -46	0 -74	±6.5	±9.5	±15	+15 +2	+21 +2
65	80																
80	100	-72 -159	-36 -58	-36 -71	-36 -90	-12 -27	-12 -34	0 -15	0 -22	0 -35	0 -54	0 -87	±7.5	±11	±17	+18 +3	+25 +3
100	120																

In every step given in the table, the value on the upper side shows the upper deviation and the value on the lower side, the lower deviation.

Deviations of Holes to be Used in Commonly Used Fits. (JIS B0401 extrac)

Basic size step (mm)		Tolerance zone class of hole (μm)																
>	≤	E7	E8	E9	F6	F7	F8	G6	G7	H6	H7	H8	H9	H10	JS6	JS7	K6	K7
—	3	+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
3	6	+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
6	10	+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	+2 -7	+5 -10
10	14	+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
14	18																	
18	24	+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	+2 -11	+6 -15
24	30																	
30	40	+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	+3 -13	+7 -18
40	50																	
50	65	+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
65	80																	
80	100	+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	+4 -18	+10 -25
100	120																	

In every step given in the table, the value on the upper side shows the upper deviation and the value on the lower side, the lower deviation.

User's Guide- Technical Reference

Symbols of Metals

● Carbon steel and alloy steel for structural use

Type	Japan	International	Other countries				
	JIS	ISO	U.S.A. AISI SAE	Great Britain BS BS/EN	Germany DIN DIN/EN	France NF NF/EN	Russia ГОСТ
Carbon steel	S10C	C10	1010	C10 C10E C10R	C10E C10R	C10E C10R	–
	S15C	C15E4 C15M2	1015	C15 C15E C15R	C15E C15R	C15E C15R	–
	S20C	–	1020	C22, C22E C22R	C22 C22E C22R	C22 C22E C22R	–
	S25C	C25 C25E4 C25M2	1025	C25 C25E C25R	C25 C25E C25R	C25 C25E C25R	–
	S30C	C30 C30E4 C30M2	1030	C30 C30E C30R	C30 C30E C30R	C30 C30E C30R	30Г
	S35C	C35 C35E4 C35M2	1035	C35 C35E C35R	C35 C35E C35R	C35 C35E C35R	35Г
	S40C	C40 C40E4 C40M2	1039 1040	C40 C40E C40R	C40 C40E C40R	C40 C40E C40R	40Г
	S43C	–	1042 1043	080A42	–	–	40Г
	S45C	C45 C45E4 C45M2	1045 1046	C45 C45E C45R	C45 C45E C45R	C45 C45E C45R	45Г
	S48C	–	–	–	–	–	45Г
	S50C	C50 C50E4 C50M2	1049	C50 C50E C50R	C50 C50E C50R	C50 C50E C50R	50Г
	S53C	–	1050 1053	–	–	–	50Г
	S55C	C55 C55E4 C55M2	1055	C55 C55E C55R	C55 C55E C55R	C55 C55E C55R	–
	S58C	C60 C60E4 C60M2	1059 1060	C60 C60E C60R	C60 C60E C60R	C60 C60E C60R	60Г

Type	Japan	International	Other countries				
	JIS	ISO	U.S.A. AISI SAE	Great Britain BS BS/EN	Germany DIN DIN/EN	France NF NF/EN	Russia ГОСТ
Alloy steel	Nickel chromium steel	SNC236	–	–	–	–	40XH
		SNC415(H)	–	–	–	–	–
		SNC631(H)	–	–	–	–	30XH3A
		SNC815(H)	–	–	–	–	–
	Nickel chromium molybdenum steel	SNC836	–	–	–	–	–
		SNCM220	20NiCrMo2 20NiCrMoS2	8615 8617(H) 8620(H) 8622(H)	20NiCrMo2-2 20NiCrMoS2-2	20NiCrMo2-2 20NiCrMoS2-2	–
		SNCM240	41CrNiMo2 41CrNiMoS2	8637 8640	–	–	–
		SNCM415	–	–	–	–	–
		SNCM420(H)	–	–	–	–	20XH2M(20XHM)
		SNCM431	–	–	–	–	–
		SNCM439	–	–	–	–	–
		SNCM447	–	–	–	–	–
		SNCM616	–	–	–	–	–
		SNCM625	–	–	–	–	–
		SNCM630	–	–	–	–	–
		SNCM815	–	–	–	–	–

Note: The above chart is based on published data and not authorized by each manufacturer.

User's Guide- Technical Reference

Symbols of Metals

● Alloy steel

Type	Japan	International	Other countries				
	JIS	ISO	U.S.A. AISI SAE	Great Britain BS BS/EN	Germany DIN DIN/EN	France NF NF/EN	Russia ГОСТ
Alloy steel	Chromium steel	SCr415(H)	—	17Cr3 17CrS3	17Cr3 17CrS3	17Cr3 17CrS3	15X 15XA
		SCr420(H)	20Cr4(H) 20CrS4	5120(H)	—	—	20X
		SCr430(H)	34Cr4 34CrS4	5130(H) 5132(H)	34Cr4 34CrS4	34Cr4 34CrS4	30X
		SCr435(H)	34Cr4 34CrS4 37Cr4 37CrS4	5132	37Cr4 37CrS4	37Cr4 37CrS4	35X
		SCr440(H)	37Cr4 37CrS4 41Cr4 41CrS4	5140(H)	530M40 41Cr4 41CrS4	41Cr4 41CrS4	40X
		SCr445(H)	—	—	—	—	45X
	Chromium molybdenum steel	SCM415(H)	—	—	—	—	—
		SCM418(H)	18CrMo4 18CrMoS4	—	18CrMo4 18CrMoS4	18CrMo4 18CrMoS4	20XM
		SCM420(H)	—	—	708M20(708H20)	—	20XM
		SCM430	—	4130	—	—	30XM 30XMA
		SCM432	—	—	—	—	—
		SCM435(H)	34CrMo4 34CrMoS4	4137(H)	34CrMo4 34CrMoS4	34CrMo4 34CrMoS4	35XM
		SCM440(H)	42CrMo4 42CrMoS4	4140(H) 4142(H)	42CrMo4 42CrMoS4	42CrMo4 42CrMoS4	—
		SCM445(H)	—	4145(H) 4147(H)	—	—	—
	Manganese steel and manganese chromium steel	SMn420(H)	22Mn6(H)	1522(H)	—	—	—
		SMn433(H)	—	1534	—	—	30Г2 35Г2
		SMn438(H)	36Mn6(H)	1541(H)	—	—	35Г2 40Г2
		SMn443(H)	42Mn6(H)	1541(H)	—	—	40Г2 45Г2
		SMnC420(H)	—	—	—	—	—
	Aluminium chromium molybdenum steel	SMnC443(H)	—	—	—	—	—
		SACM645	41CrAlMo74	—	—	—	—

● Stainless steel

Type		Japan	International	Other countries					
		JIS	ISO	U.S.A.		Great Britain	Germany	France	Russia
				UNS	AISI SAE	BS BS/EN	DIN DIN/EN	NF NF/EN	ГОСТ
Stainless steel	Austenitic	SUS201	X12CrMnNiN17-7-5	S20100	201			Z12CMN17-07Az	
		SUS202	X12CrMnNiN18-9-5	S20200	202	284S16			12X17T9AH4
		SUS301	X10CrNi18-8	S30100	301	301S21	X12CrNi17-7	Z11CN17-08	07X16H6
		SUS301L	X2CrNiN18-7				X2CrNiN18-7		
		SUS301J1					X12CrNi17-7		
		SUS302		S30200	302	302S25		Z12CN18-09	12X18H9
		SUS302B	X12CrNiSi18-9-3	S30215	302B				
		SUS303	X10CrNiS18-9	S30300	303	303S21	X10CrNiS18-9	Z8CNF18-09	
		SUS303Se		S30323	303Se	303S41			12X18H10E
		SUS303Cu							
		SUS304	X5CrNi18-9	S30400	304	304S31	X5CrNi18-10	Z7CN18-09	08X18H10
		SUS304L	X2CrNi18-9	S30403	304L	304S11	X2CrNi19-11	Z3CN19-11	03X18H11
		SUS304N1	X5CrNiN18-8	S30451	304N			Z6CN19-09Az	
		SUS304N2		S30452					
		SUS304LN	X2CrNiN18-9	S30453	304LN		X2CrNiN18-10	Z3CN18-10Az	
		SUS304J1							
		SUS304J2							
		SUS304J3		S30431	S30431				
		SUS305	X6CrNi18-12	S30500	305	305S19	X5CrNi18-12	Z8CN18-12	06X18H11

Note: The above chart is based on published data and not authorized by each manufacturer.

User's Guide- Technical Reference

Symbols of Metals

● Stainless steel

Type	Japan	International	Other countries					
	JIS	ISO	U.S.A.		Great Britain	Germany	France	Russia
			UNS	AISI SAE	BS BS/EN	DIN DIN/EN	NF NF/EN	ГОСТ
Stainless steel	Austenitic	SUS305J1						
		SUS309S						
		SUS310S	X6CrNi25-21	S30908	309S		Z10CN24-13	
		SUS315J1		S31008	310S	310S31	Z8CN25-20	10X23H18
		SUS315J2						
		SUS316	X5CrNiMo17-12-2	S31600	316	316S31	X5CrNiMo17-12-2	Z7CND17-12-02
			X3CrNiMo17-12-3				X5CrNiMo17-13-3	Z6CND18-12-03
		SUS316F						
		SUS316L	X2CrNiMo17-12-2	S31603	316L	316S11	X2CrNiMo17-13-2	Z3CND17-12-02
			X2CrNiMo17-12-3				X2CrNiMo17-14-3	Z3CND17-12-03
			X2CrNiMo18-14-3					03X17H14M3
		SUS316N		S31651	316N			
		SUS316LN	X2CrNiMoN17-11-2	S31653	316LN		X2CrNiMoN17-12-2	Z3CND17-11Az
			X2CrNiMoN17-12-3				X2CrNiMoN17-13-3	Z3CND17-12Az
		SUS316Ti	X6CrNiMoTi17-12-2	S31635			X6CrNiMoTi17-12-2	Z6CNDT17-12
		SUS316J1						08X17H13M2T
		SUS316J1L						
		SUS317		S31700	317	317S16		
		SUS317L	X2CrNiMo19-14-4	S31703	317L	317S12	X2CrNiMo18-16-4	Z3CND19-15-04
		SUS317LN	X2CrNiMoN18-12-4	S31753				Z3CND19-14Az
		SUS317J1						
		SUS317J2						
		SUS317J3L						
		SUS836L		N08367				
		SUS890L	X1CrNiMoCu25-20-5	N08904	N08904	904S14		Z2NCU25-20
		SUS321	X6CrNiTi18-10	S32100	321	321S31	X6CrNiTi18-10	Z6CNT18-10
		SUS347	X6CrNiNb18-10	S34700	347	347S31	X6CrNiNb18-10	Z6CNNb18-10
		SUS384	X3NiCr18-16	S38400	384			Z6CN18-16
		SUSXM7	X3CrNiCu18-9-4	S30430	304Cu	394S17		Z2CNU18-10
		SUSXM15J1		S38100				Z15CNS20-12
	Austenitic Ferritic	SUS329J1		S32900	329			
		SUS329J3L	X2CrNiMoN22-5-3	S31803	31803			Z3CNDU22-05Az
		SUS329J4L	X2CrNiMoCuN25-6-3	S32250	32250			Z3CNDU25-07Az
	Ferritic	SUS405	X6CrAl13	S40500	405	405S17	X6CrAl13	Z8CA12
		SUS410L						Z3C14
		SUS429		S42900	429			
		SUS430	X6Cr17	S43000	430	430S17	X6Cr17	Z8C17
		SUS430F	X7CrS17	S43020	430F		X7CrS18	Z8CF17
		SUS430LX	X3CrTi17	S43035			X6CrTi17	Z4CT17
			X3CrNb17					
		SUS430J1L	X2CrTi17				X6CrNb17	Z4CNb17
		SUS434	X6CrMo17-1	S43400	434	434S17	X6CrMo17-1	Z8CD17-01
		SUS436L	X1CrMoTi16-1	S43600	436			
		SUS436J1L						
		SUS444	X2CrMoTi18-2	S44400	444			Z3CDT18-02
		SUS445J1						
		SUS445J2						
		SUS447J1		S44700				
		SUSXM27		S44627				Z1CD26-01
	Martensitic	SUS403		S40300	403			
		SUS410	X12Cr13	S41000	410	410S21	X10Cr13	Z13C13
		SUS410S	X6Cr13	S41008	410S	403S17	X6Cr13	Z8C12
		SUS410F2						08X13
		SUS410J1		S41025				
		SUS416	X12CrS13	S41600	416	416S21		Z11CF13
		SUS420J1	X20Cr13	S42000	420	420S29	X20Cr13	Z20C13
		SUS420J2	X30Cr13	S42000	420	420S37	X30Cr13	Z33C13
		SUS420F	X29CrS13	S42020	420F			Z30CF13
		SUS420F2						
		SUS429J1						
		SUS431	X19CrNi16-2	S43100	431	431S29	X20CrNi17-2	Z15CN16-02
		SUS440A	X70CrMo15	S44002	440A			Z70C15
		SUS440B		S44003	440B			
		SUS440C	X105CrMo17	S44004	440C			Z100CD17
		SUS440F		S44020				95X18
	Precipitation hardening type	SUS630	X5CrNiCuNb16-4	S17400	S17400			Z6CNU17-04
		SUS631	X7CrNiAl17-7	S17700	S17700		X7CrNiAl17-7	Z9CNA17-07
		SUS631J1						09X17H7IO

Note: The above chart is based on published data and not authorized by each manufacturer.

User's Guide- Technical Reference

Symbols of Metals

● Heat resistant steel

Type	Japan	International	Other countries					
	JIS	ISO	U.S.A. UNS	AISI SAE	Great Britain BS BS/EN	Germany DIN DIN/EN	France NF NF/EN	Russia ГОСТ
Heat resistant steel	Austenitic	SUH31			331S42		Z35CNWS14-14	45X14H14B2M
		SUH35	S63008		349S52		Z52CMN21-09Az	
		SUH36			349S54	X53CrMnNi21-9	Z55CMN21-09Az	55X20Г9 AH4
		SUH37	S63017		381S34			
		SUH38						
		SUH309	S30900	309	309S24		Z15CN24-13	
		SUH310	S31000	310	310S24	CrNi2520	Z15CN25-20	20X25H20C2
		SUH330	N08330	N08330			Z12NCS35-16	
	Ferritic	SUH660	S66286				Z6NCTV25-20	
		SUH661	R30155					
		SUH21				CrAl1205		
		SUH409	X6CrTi12	S40900	409	409S19	X6CrTi12	Z6CT12
	Martensitic	SUH409L	X2CrTi12					Z3CT12
		SUH446	S44600	446			Z12C25	15X28
		SUH1	S65007		401S45	X45CrSi9-3	Z45CS9	
		SUH3					Z40CSD10	40X10C2M
		SUH4			443S65		Z80CSN20-02	
		SUH11						40X9C2
		SUH600						20X12BHMБФP
		SUH616	S42200					

● Tool steel

Type	Japan JIS	International ISO	U.S.A. AISI ASTM
Carbon tool steel	SK140	—	—
	SK120	C120U	W1-11 1/2
	SK105	C105U	W1-10
	SK95	—	W1-9
	SK90	C90U	—
	SK85	—	W1-8
	SK80	C80U	—
	SK75	—	—
	SK70	C70U	—
	SK65	—	—
	SK60	—	—
	SKH2	HS18-0-1	T1
	SKH3	—	T4
High speed steel	SKH4	—	T5
	SKH10	—	T15
	SKH40	HS6-5-3-8	—
	SKH50	HS1-8-1	—
	SKH51	HS6-5-2	M2
	SKH52	HS6-6-2	M3-1
	SKH53	HS6-5-3	M3-2
	SKH54	HS6-5-4	M4
	SKH55	HS6-5-2-5	—
	SKH56	—	M36
	SKH57	HS10-4-3-10	—
	SKH58	HS2-9-2	M7
	SKH59	HS2-9-1-8	M42
Alloy tool steel	SKS11	—	F2
	SKS2	—	—
	SKS21	—	—
	SKS5	—	—
Alloy tool steel	SKS51	—	L6
	SKS7	—	—
	SKS81	—	—
	SKS8	—	—
	SKS4	—	—
	SKS41	—	—
	SKS43	105V	W2-9 1/2
	SKS44	—	W2-8 1/2
	SKS3	—	—
	SKS31	—	—
	SKS93	—	—
	SKS94	—	—
	SKS95	—	—
	SKD1	X210Cr12	D3
	SKD2	X210CrW12	—
	SKD10	X153CrMoV12	—
	SKD11	—	D2
	SKD12	X100CrMoV5	A2
	SKD4	—	—
	SKD5	X30WCrV9-3	H21
	SKD6	—	H11
	SKD61	X40CrMoV5-1	H13
	SKD62	X35CrWMoV5	H12
	SKD7	32CrMoV12-28	H10
	SKD8	38CrCoWV18-17-17	H19
	SKT3	—	—
	SKT4	55NiCrMoV7	—
	SKT6	45NiCrMo16	—

● Special use steel

Type	Japan JIS	International ISO	U.S.A. AISI ASTM
Free cutting carbon steels	SUM11	—	1110
	SUM12	—	1109
	SUM21	9S20	1212
	SUM22	11SMn28	1213
	SUM22L	11SMnPb28	—
	SUM23	—	1215
	SUM23L	—	—
	SUM24L	11SMnPb28	12L14
	SUM25	12SMn35	—
	SUM31	—	1117
	SUM31L	—	—
Free cutting carbon steels	SUM32	—	—
	SUM41	—	1137
	SUM42	—	1141
	SUM43	44SMn28	1144
High carbon chromium	SUJ1	—	—
	SUJ2	B1	52100
	SUJ3	B2	ASTM A 485 Grade 1
	SUJ4	—	—
	SUJ5	—	—

Note: The above chart is based on published data and not authorized by each manufacturer.

User's Guide- Technical Reference

Symbols of Metals

● Casting or forging steel

Type		Japan	International	Other countries				
		JIS	ISO	U.S.A.	Great Britain	Germany	France	Russia
				AISI ASTM	BS BS/EN	DIN DIN/EN	NF NF/EN	ГОСТ
Casting steel	Carbon steel casting	SC	200-400, 230-450, 270-480	U-	A1, A2	GS-	GE230, GE280, GE320	—
	Steel casting for welded structure	SCW	200-400W, 230-450W, 270-480W, 340-550W	WCA, WCB, WCC	A4	—	GE230, GE280	—
	Heat resisting steel casting	SCH	GX40CrSi24, GX40CrNiSi22-10, GX40NiCrSi38-19	Grade HC, HD, HF	309C30, 310C45, 330C12	—	GX40NiCrNb45-35, GX50NiCrCoW35-25-15-5	—
	Steel casting for high temperature and high pressure service	SCPH	—	Grade WC1, WC6, WC9	A1, A2, B1, B2, B3, B4, B5, B7	G20Mo5, G17CrMo5-5, G17CrMo5-10	G17CrMo9-10, GX15CrMo5, GP240GH, GP280GH	—
	Steel casting for low temperature and high pressure service	SCPL	—	Grade LCB, LC1, LC2, LC3	AL1, BL2	—	FB-M, FC1-M, FC2-M, FC3-M	—
Casting iron	Grey iron casting	FC	100,150,200,250, 300,350	No.20,25,30,35, 40,45,50	EN-GJL-	EN-GJL-	EN-GJL-	—
	Spheroidal graphite iron casting	FCD	700-2, 600-3, 500-7, 450-10, 400-15, 400-18, 350-22	60-40-18, 65-45-12, 8-55-06, 100-70-03, 120-90-02	EN-GJS-	EN-GJS-	EN-GJS-	ВЧ
	Austempered spheroidal graphite iron casting	FCAD	—	—	EN-GJS-	EN-GJS-	EN-GJS-	—
	Austenitic iron casting	FCA-FCDA-	L-, S-	Type 1, 2, Type D-2, D-3A Class 1, 2	F1, F2, S2W, S5S	GGL-, GGG-	L-, S-	—
Forging steel	Carbon steel forging for general use	SF	—	Class A, B, C, D, E, F	C22, C25, C30, C35, C40, C45, C50, C55, C60	P285, P355	P245, P280, P305	—
	Chromium molybdenum steel forgings for general use	SFCM	—	Class E, F, G, I Grade 3A, 4 Class G, J, K, L, M	—	—	—	—
	Nickel Chromium molybdenum steel forgings for general use	SFNCM	—	Class G, H, I, J Class 3A, 4, 5, 6 Class K, L, M	—	—	—	—

● Non-ferrous alloy

Type	Japan	International	Other countries		
	JIS	ISO	U.S.A. ASTM SAE	Great Britain BS BS/EN	Germany DIN DIN/EN
Copper alloy, Nickel alloy	Copper alloy casting	CAC101	-	-	-
		CAC102	-	-	-
		CAC103	-	-	-
	Brass casting	CAC201	-	-	-
		CAC202	-	-	-
		CAC203	-	-	-
	High strength brass casting	CAC301	-	-	-
		CAC302	-	-	-
		CAC303	-	-	-
		CAC304	-	-	-
	Bronze casting	CAC401	-	-	-
		CAC402	-	-	-
		CAC403	-	-	-
		CAC406	-	-	-
	Phosphor bronze casting	CAC502A	-	-	-
		CAC502B	-	-	-
		CAC503A	-	-	-
		CAC503B	-	-	-
	Aluminium bronze casting	CAC701	-	-	-
		CAC702	-	-	-
		CAC703	-	-	-
		CAC704	-	-	-
	Silicon bronze castings	CAC801	-	-	-
		CAC802	-	-	-
		CAC803	-	-	-

Note: The above chart is based on published data and not authorized by each manufacturer.

User's Guide- Technical Reference

Symbols of Metals

● Non-ferrous alloy

Type		Japan	International	Other countries			
		JIS	ISO	U.S.A.	Great Britain	Germany	France
				ASTM SAE	BS BS/EN	DIN DIN/EN	NF NF/EN
Aluminium alloy	Aluminium alloy ingots for casting	AC1B	Al-Cu4MgTi	204.0	EN AC-2100		
		AC2A	—	—	—		
		AC2B	—	319.0	—		
		AC3A	—	—	EN AC-44100		
		AC4A	—	—	—		
		AC4B	Al-Si8Cu3	333.0	EN AC-46200		
		AC4C	Al-Si7Mg(Fe)	356.0	EN AC-42000		
		AC4CH	Al-Si7Mg0.3	A356.0	EN AC-42100		
		AC4D	—	355.0	EN AC-45300		
		AC5A	Al-Cu4Ni2Mg2	242.0	—		
		AC7A	—	514.0	—		
		AC8A	Al-Si12CuNiMg	—	EN AC-48000		
		AC8B	—	—	—		
		AC8C	—	332.0	—		
		AC9A	—	—	—		
	AC9B	—	—	—			
	Aluminium alloy die casting	ADC1	—	A413.0	—		
		ADC3	—	A360.0	—		
		ADC5	—	518.0	—		
		ADC6	—	—	—		
		ADC10	—	—	—		
		ADC10Z	—	A380.0	—		
		ADC12	—	—	—		
		ADC12Z	—	383.0	—		
		ADC14	—	B390.0	—		
Magnesium alloy	Magnesium alloy casting	MC5	—	AM100A	—		
		MC6	—	ZK51A	—		
		MC7	—	ZK61A	—		
		MC8	MgRE3Zn2Zr	EZ33A	EN MC65120		
		MC9	MgAg3RE2Zr	QE22A	EN MC65210		
		MC10	MgZn4RE1Zr	ZE41A	EN MC35110		
	Magnesium alloy die casting	MD1A	—	AZ91A	G-A9Z1Y4		
		MDC1B	—	AZ91B	—		
		MDC1D	MgAl9Zn1(A)	AZ91D	EN MC21120		
		MDC2B	MgAl6Mn	AM60B	EN MC21320		
Type		Japan	International	Other countries			
		JIS	ISO	U.S.A. ASTM AA	Great Britain BS BS/EN	Germany DIN DIN/EN	France NF NF/EN
Aluminium alloy	Aluminium alloy extruded shapes	A5052S	—	5052	EN AW-5052		
		A5454S	—	5454	EN AW-5454		
		A5083S	AlMg4.5Mn0.7	5083	EN AW-5083		
		A5086S	—	5086	EN AW-5086		
		A6061S	AlMg1SiCu	6061	EN AW-6061		
		A6063S	AlMg0.7Si	6063	EN AW-6063		
		A7003S	—	—	EN AW-7003		
		A7N01S	—	—	—		
		A7075S	AlZn5.5MgCu	7075	FN AW-7075		

Note: The above chart is based on published data and not authorized by each manufacturer.

User's Guide- Technical Reference

Approximate Conversion Table of Hardness

● Approximate conversion value for Brinell hardness. *1

(The source: JIS HB Ferrous Materials and Metallurgy I -2005)

HB		HV Vickers	Rockwell *3				HS Shore	Approx. tensile strength (MPa) *2	HB		HV Vickers	Rockwell *3				HS Shore	Approx. tensile strength (MPa) *2
Brinell, 10mm ball, Load 3000kg			HRA	HRB	HRC	HRD			Brinell, 10mm ball, Load 3000kg			HRA	HRB	HRC	HRD		
Standard ball	Tungsten carbide ball		A Scale, Load 60kg, Brale Diamond	B Scale, Load 100kg, Diameter 1/16 in. Steel ball	C Scale, Load 150kg, brale diamond	D Scale, Load 100kg, Brale Diamond			Standard ball	Tungsten carbide ball		A Scale, Load 60kg, Brale Diamond	B Scale, Load 100kg, Diameter 1/16 in. Steel ball	C Scale, Load 150kg, brale diamond	D Scale, Load 100kg, Brale Diamond		
-	-	940	85.6	-	68.0	76.9	97	-	429	429	455	73.4	-	45.7	59.7	61	1510
-	-	920	85.3	-	67.5	76.5	96	-	415	415	440	72.8	-	44.5	58.8	59	1460
-	-	900	85.0	-	67.0	76.1	95	-	401	401	425	72.0	-	43.1	57.8	58	1390
-	(767)	880	84.7	-	66.4	75.7	93	-	388	388	410	71.4	-	41.8	56.8	56	1330
-	(757)	860	84.4	-	65.9	75.3	92	-	375	375	396	70.6	-	40.4	55.7	54	1270
-	(745)	840	84.1	-	65.3	74.8	91	-	363	363	383	70.0	-	39.1	54.6	52	1220
-	(733)	820	83.8	-	64.7	74.3	90	-	352	352	372	69.3	(110.0)	37.9	53.8	51	1180
-	(722)	800	83.4	-	64.0	73.8	88	-	341	341	360	68.7	(109.0)	36.6	52.8	50	1130
-	(712)	-	-	-	-	-	-	-	331	331	350	68.1	(108.5)	35.5	51.9	48	1095
-	(710)	780	83.0	-	63.3	73.3	87	-	321	321	339	67.5	(108.0)	34.3	51.0	47	1060
-	(698)	760	82.6	-	62.5	72.6	86	-	-	-	-	-	-	-	-	-	-
-	(684)	740	82.2	-	61.8	72.1	-	-	311	311	328	66.9	(107.5)	33.1	50.0	46	1025
-	(682)	737	82.2	-	61.7	72.0	84	-	302	302	319	66.3	(107.0)	32.1	49.3	45	1005
-	(670)	720	81.8	-	61.0	71.5	83	-	293	293	309	65.7	(106.0)	30.9	48.3	43	970
-	(656)	700	81.3	-	60.1	70.8	-	-	285	285	301	65.3	(105.5)	29.9	47.6	-	950
-	(653)	697	81.2	-	60.0	70.7	81	-	277	277	292	64.6	(104.5)	28.8	46.7	41	925
-	(647)	690	81.1	-	59.7	70.5	-	-	269	269	284	64.1	(104.0)	27.6	45.9	40	895
-	(638)	680	80.8	-	59.2	70.1	80	-	262	262	276	63.6	(103.0)	26.6	45.0	39	875
-	630	670	80.6	-	58.8	69.8	-	-	255	255	269	63.0	(102.0)	25.4	44.2	38	850
-	627	667	80.5	-	58.7	69.7	79	-	248	248	261	62.5	(101.0)	24.2	43.2	37	825
-	-	-	-	-	-	-	-	-	241	241	253	61.8	100.0	22.8	42.0	36	800
-	-	677	80.7	-	59.1	70.0	-	-	235	235	247	61.4	99.0	21.7	41.4	35	785
-	601	640	79.8	-	57.3	68.7	77	-	229	229	241	60.8	98.2	20.5	40.5	34	765
-	-	-	-	-	-	-	-	-	223	223	234	-	97.3	(18.8)	-	-	-
-	-	640	79.8	-	57.3	68.7	-	-	217	217	228	-	96.4	(17.5)	-	33	725
-	578	615	79.1	-	56.0	67.7	75	-	212	212	222	-	95.5	(16.0)	-	-	705
-	-	607	78.8	-	55.6	67.4	-	-	207	207	218	-	94.6	(15.2)	-	32	690
-	555	591	78.4	-	54.7	66.7	73	2055	201	201	212	-	93.8	(13.8)	-	31	675
-	-	-	-	-	-	-	-	2015	197	197	207	-	92.8	(12.7)	-	30	655
-	534	569	77.8	-	53.5	65.8	71	1985	192	192	202	-	91.9	(11.5)	-	29	640
-	-	-	-	-	-	-	-	-	187	187	196	-	90.7	(10.0)	-	-	620
-	-	553	77.1	-	52.5	65.0	-	1915	183	183	192	-	90.0	(9.0)	-	28	615
-	514	547	76.9	-	52.1	64.7	70	1890	179	179	188	-	89.0	(8.0)	-	27	600
-	-	-	-	-	-	-	-	-	174	174	182	-	87.8	(6.4)	-	-	585
(495)	-	539	76.7	-	51.6	64.3	-	1855	170	170	178	-	86.8	(5.4)	-	26	570
-	-	530	76.4	-	51.1	63.9	-	1825	167	167	175	-	86.0	(4.4)	-	-	560
-	495	528	76.3	-	51.0	63.8	68	1820	-	-	-	-	-	-	-	-	-
(477)	-	516	75.9	-	50.3	63.2	-	1780	163	163	171	-	85.0	(3.3)	-	25	545
-	-	508	75.6	-	49.6	62.7	-	1740	156	156	163	-	82.9	(0.9)	-	-	525
-	477	508	75.6	-	49.6	62.7	66	1740	149	149	156	-	80.8	-	-	23	505
(461)	-	495	75.1	-	48.8	61.9	-	1680	143	143	150	-	78.7	-	-	22	490
-	-	491	74.9	-	48.5	61.7	-	1670	137	137	143	-	76.4	-	-	21	460
-	461	491	74.9	-	48.5	61.7	65	1670	131	131	137	-	74.0	-	-	-	450
444	-	474	74.3	-	47.2	61.0	-	1595	126	126	132	-	72.0	-	-	20	435
-	-	472	74.2	-	47.1	60.8	-	1585	121	121	127	-	69.8	-	-	19	415
-	444	472	74.2	-	47.1	60.8	63	1585	116	116	122	-	67.6	-	-	18	400
-	-	-	-	-	-	-	-	-	111	111	117	-	65.7	-	-	15	385

Note :

*1: This table is based on AMS Metals Handbook, the 8th Edition, Volume 1, and includes some information added to "Approx. tensile strength (MPa)," such as the values calculated in metric; and Brinell hardness that exceeds recommended values.

*2: 1 MPa = 1 N/mm²

*3: Figures in () are not commonly used. It's just reference.

User's Guide- Technical Reference

Surface Roughness

(According to JIS B 0601, 2001 and its explanation.)

Type	Symbol	How to determine	Example (Fig.)
Arithmetic mean roughness	R_a	R_a means the value obtained by the following formula and expressed in micrometer (μm) when sampling only the reference length from the roughness curve in the direction of mean line, taking X-axis in the direction of mean line and Y-axis in the direction of longitudinal magnification of this sampled part and the roughness curve is expressed by $y=f(x)$: $R_a = \frac{1}{\ell} \int_0^\ell f(x) dx$ where, ℓ : reference length	
Maximum height	R_z	R_z shall be that only the reference length is sampled from the roughness curve in the direction of mean line, the distance between the top of profile peak line and the bottom of profile valley line on this sampled portion is measured in the longitudinal magnification direction of roughness curve and the obtained value is expressed in micrometer (μm). $R_z = R_p + R_v$	
Ten point mean roughness	R_{zJIS}	R_{zJIS} shall be that only the reference length is sampled from the roughness curve in the direction of its mean line, the sum of the average value of absolute values of the heights of five highest profile peaks (Z_p) and the depths of five deepest profile valleys (Z_v) measured in the vertical magnification direction from the mean line of this sampled portion and this sum is expressed in micrometer (μm) $R_{zJIS} = \frac{ Z_{p1} + Z_{p2} + Z_{p3} + Z_{p4} + Z_{p5} + Z_{v1} + Z_{v2} + Z_{v3} + Z_{v4} + Z_{v5} }{5}$	where, $Z_{p1}, Z_{p2}, Z_{p3}, Z_{p4}, Z_{p5}$: altitudes of the heights of five highest profile peaks of the sampled portion corresponding to the reference length ℓ where, $Z_{v1}, Z_{v2}, Z_{v3}, Z_{v4}, Z_{v5}$: altitudes of the depths of five deepest profile valleys of the sampled portion corresponding to the reference length ℓ

User's Guide- Technical Reference

Grade Comparison Chart

●CVD Coated Grades for Turning

ISO		Tungaloy	Mitsubishi Carbide	Sumitomo Electric	Sandvik	Kyocera	Mitsubishi Hitachi Tool	Dijet	NTK	Seco Tools	Kennametal	Iscar	TaeguTec	Widia	Walter	Ceratizit
Classification	Symbol															
P	P01	T9105	UE6105	AC810P	GC4205 GC4305	CA5505 CA510	HG8010	JC110V		TP0500 TP0501	KC9105 KCP05	IC8150 IC9150 IC9015	TT8115	TN10P TN20K	WPP01 WPP05 WPP05S	
	P10	T9105 T9115	UE6105 UE6110	AC810P AC820P	GC4205 GC4215 GC4305 GC4315	CA5515 CA515	HG8010 GM8020	JC110V JC215V	CP7 CP5	TP0500 TP1500 TP0501 TP1501	KC9110 KC9105 KCP10	IC8150 IC9150 IC8080 IC9080 IC9015	TT8115	TN10P TN20K WP15CT	WPP05 WPP10 WAK20 WPP05S WPP10S	CTC3110 CTCK120
	P20	T9115 T9125	UE6110 UE6020 MC6025	AC820P AC830P AC8025P	GC4215 GC4315 GC4225 GC4325	CA5515 CA515 CA5525 CA525	HG8025 GM8020 GM25	JC110V JC215V	CP7 CP5	TP1500 TP2500 TP1501 TP2501	KC9215 KC9225 KC9325 KCP25	IC8150 IC9150 IC9015 IC8250 IC9250	TT8125 TT5100	TN10P TN15M WP25CT	WPP20 WPP20S	CTCP115 CTCP125 CTC1425
	P30	T9125 T9135 T6130	MC6025 UE6035	AC8025P AC830P	GC4225 GC4235 GC4325	CA5525 CA5535 CA530	HG8025 GM8035 GM25	JC215V JC325V		TP2500 TP3500 TP2501	KC9140 KC9240 KCP30	IC8080 IC656 IC9350	TT8125 TT5100 TT8135	TN30P TN30M WP35CT	WPP30 WAK30 WPP30S	CTCP125 CTC1425 CTC1135 CTC1435 CTC2135
	P40	T9135 T6130	UE6035 UH6400	AC830P AC630M	GC4235	CA5535 CA530	GM8035 GX30	JC325V		TP3500	KC9140 KC9240 KCP40	IC9350 IC635	TT8135 TT7100	TN30P TN30M	WPP30 WAK30 WPP30S	CTC1135 CTC1435 CTC2135
M	M10	T9115	MC7015	AC610M	GC2015	CA6515		JC110V			KCM15	IC9250 IC520M	TT9215	TN15M WM15CT		CTCP115
	M20	T6120 T9125	MC7015 US7020 MC7025	AC6030M	GC2015 GC2025	CA6525	HG8025 GM25	JC110V		TM2000	KCM15 KCM25	IC9025 IC9350 IC4050	TT9215 TT9225	TN15M WM25CT		CTC1425 CTCP125 CTC1135
	M30	T6130	MC7025 US735	AC6030M AC630M	GC2025 GC235		GM8035 GM25 GX30	JC215V		TM2000 TM4000	KCM25 KCM35	IC9350 IC4050 IC635	TT9225 TT9235	TN30M WM35CT		CTC1435 CTC2135
	M40		US735		GC235		GX30			TM4000	KCM35 KCP40	IC635	TT9235			
K	K01	T5105	MC5005 UC5105	AC405K	GC3205	CA4505	HX3505	JC050W JC105V	CP1	TK1001 TK1000	KCK05	IC8080		WK05CT	WAK10 WPP01	
	K10	T515 T5105 T5115	MC5015 UC5115	AC415K	GC3210	CA4515	HX3515 GM10 HG8010	JC105V JC110V	CP1	TK1001 TK1000	KCK05 KCK15	IC9150 IC5100 IC4100	TT7005	WK05CT	WAK10 WPP10 WKK10S	CTC3110 CTC1425
	K20	T515 T5115 T5125	MC5015 UC5115	AC420K	GC3215	CA4515	HX3515 GM8020	JC110V JC215V	CP1	TK2000 TK2001	KCK15 KCK20	IC9150 IC5100 IC4100 IC9080	TT7310	WK20CT	WAK20 WPP20 WKK20S	CTC1435 CTCK120 CTCP115
	K30	T5125 T9115					HG8025	JC215V			KCP25	IC520M IC4050			WAK30 WKP30S	CTCP125

Note: The above table is selected from a publication. We have not obtained approval from each company.

User's Guide- Technical Reference

Grade Comparison Chart

●PVD Coated Grade for Turning

ISO		Tungaloy	Mitsubishi Carbide	Sumitomo Electric	Sandvik	Kyocera	Mitsubishi Hitachi Tool	Dijet	NTK	Seco Tools	Kennametal	Iscar	TaeguTec	Widia	Walter	Ceratizit
Classification	Symbol															
P	P01					PR1005									WXN10	
	P10	AH710	VP10RT		GC1525	PR930 PR1005 PR1115 PR1215 PR1425	IP2000	JC5003 JC5030	VM1 DT4 DM4	TS2000 CP200	KC5010 KC5510 KCU10	IC507 IC807 IC907		WS10PT	WSM10 WSM21	
	P20	AH120 AH725 AH730 SH725 SH730 J740	VP10RT VP15TF VP20MF VP20RT UP20M	AC520U	GC1525 GC1125	PR930 PR1025 PR1115 PR1215 PR1425 PR1225	IP2000 IP3000	JC5030 JC5040	VM1 DT4 DM4	TS2500 CP200	KC5025 KC5525 KCU25	IC507 IC807 IC907	TT9030	WS10PT WS25PT	WSM20 WSM21	
	P30	AH120 AH725 SH725 AH730 SH730 GH730 GH330 J740	VP15TF VP20MF VP20RT UP20M	AC530U	GC1125	PR1025 PR1225	IP3000	JC5040	DT4 DM4 QM3	CP500	KC5025 KC5525 KCU25	IC328 IC928 IC3028	TT9030 TT8020	WS25PT	WSM30	CTP1235 CTP1625 CTP2235
	P40	AH120 AH725 AH645		AC530U						CP500		IC328 IC3028	TT8020			CTP1235 CTP2235
M	M01											IC520			WXM10	
	M10	AH630	VP10RT		GC1105 GC1115 GC1525	PR1025 PR1215	IP100S IP050S	JC5003 JC8015	TM4 ZM3	TS2000 TS2500 CP200	KC5010 KC5510 KCU10	IC520 IC507 IC807 IC907		WS10PT	WSM10 WSM10S	
	M20	AH630 AH120 AH725 SH725 SH730 AH8015	VP10RT VP15TF VP20MF VP20RT UP20M	AC520U	GC1115 GC1125 GC1525	PR930 PR1025 PR1125 PR1215 PR1425 PR1225	IP100S IP050S	JC5015 JC5030 JC8015	TM4 ZM3 DT4 DM4	TS2500 CP200 CP500	KC5025 KC5525 KCU25	IC520 IC507 IC807 IC907 IC308 IC3028	TT9030 TT8010	WS10PT WS25PT	WSM20 WSM21 WSM20S	CTP1235 CTP2120
	M30	AH645 AH120 AH725 SH725 SH730 J740	VP15TF VP20MF VP20RT UP20M MP7035	AC530U AC6040M	GC1125 GC2035	PR1125	IP100S	JC5015 JC5030 JC5040	TM4 ZM3 DT4 DM4	CP500	KC5025 KC5525 KCU25	IC3028 IC308 IC908 IC928	TT8020	WS25PT	WSM30 WSM30S	CTP1235 CTP2120 CTP2235 CTP1625
	M40	AH645	MP7035	AC530U AC6040M	GC2035							IC228 IC328				
K	K01	AH110										IC910				
	K10	GH110 AH110	VP10RT	AC510U		PR905 PR1215		JC5003 JC5015		TS2000 CP200	KC5010 KC5510 KCU10	IC910 IC308 IC508	TT9030	WS10PT		CTP6215
	K20	AH120	VP10RT VP20RT VP15TF			PR905 PR1215		JC5015		TS2500 CP200 CP250	KC5025 KC5525 KCU25	IC910 IC308 IC508 IC928 IC1008	TT9030	WS10PT WS25PT		CTP6215
	K30	AH120 GH130	VP20RT VP15TF							CP500		IC928 IC1008	TT9030	WS25PT		CTP1625
S	S01	AH8005	VP05RT MP9005					JC8003							WSM10	
	S10	AH8005 AH8015	VP10RT MP9015	AC510U AC520U	GC1105	PR1305 PR1310		JC8015 JC5015	DT4 DM4	TS2000 TS2500 CP200 CP500	KC5010 KC5510 KCU10	IC507 IC807 IC808 IC907 IC908	TT8010	WS10PT	WSM10 WSM10S	CTP2235
	S20	AH8015	VP15TF MP9015 VP20RT	AC520U	GC1115 GC1125	PR1310		JC8015 JC5015	DT4 DM4	TS2000 TS2500 CP200 CP500	KC5025 KC5525 KCU25	IC507 IC807 IC808 IC907 IC908	TT8020	WS10PT WS25PT	WSM20 WSM21 WSM20S	CTP2235
	S30	AH630 AH7025	VP15TF VP20RT	AC520U	GC1125	PR1325						IC830 IC928		WS25PT	WSM30 WSM30S	

Note: The above table is selected from a publication. We have not obtained approval from each company.

User's Guide- Technical Reference

Grade Comparison Chart

●Cermet for Turning

ISO		Tungaloy	Mitsubishi Carbide	Sumitomo Electric	Sandvik	Kyocera	Mitsubishi Hitachi Tool	Dijet	NTK	Seco Tools	Kennametal	Iscar	TaeguTec	Widia	Walter	Ceratizit
Classification	Symbol															
P	P01	NS520	AP25N VP25N	T110A T1000A		TN30 PV30 TN6010 PV7010		LN10	Q15 C7Z		KT1120		PV3010 CT3000			
	P10	GT9530 NS9530 J9530	AP25N VP25N NX2525	T1500Z T2000Z T1200A T1500A	CT5015	TN60 TN6010 PV7010 TN610 PV710	CZ25	CX50 PX75	C7Z Z15	TP1020 C15M	KT315	IC30N IC530N	PV3010 CT3000	TTI15	WCE10	TCC410 TCM10 TCM407
	P20	GT9530 NS9530 J9530	AP25N VP25N VP45N NX2525 NX3025	T1200A T2000Z T1500Z T2000Z	CT5015 GC1525	TN90 TN6020 PV7020 PV7025 TN620 PV720	CZ25 CH550	CX75 PX75 PX90	C7Z T15	TP1020 TP1030 C15M	KT5020	IC30N IC530N	PV3010 CT3000	TTI15	WCE10	TCC410 TCM10
	P30	NS9530	VP45N NX4545	T3000Z	GC1525			PX90	N40 C7X							
M	M10	NS520	AP25N VP25N NX2525	T1000A T2000Z	CT5015	TN60 TN6020 PV7020 PV7025		LN10 CX50	C7Z C7X	TP1020 TP1030	KT315 KT5020		PV3010 CT3000	TTI15		TCC410 TCM10 TCM407
	M20	GT9530 NS9530 J9530	NX2525 AP25N VP25N	T1500A T2000Z	GC1525	TN90 TN6020 PV7020 PV7025	CZ25 CH550	CX75	C7Z C7X	C15M	KT5020	IC30N IC530N	PV3010 CT3000			
	M30	NS9530	NX4545	T3000Z												
K	K01	NS520	AP25N VP25N	T1000A		TN30 PV30 PV7005		LN10					PV3010 CT3000			TCC410
	K10	GT9530 NS9530 J9530	AP25N VP25N NX2525	T1500A T2000Z	CT5015	TN60 TN6010 PV7005 PV7010	CZ25 CH550	LN10 CX75			KT315 KT5020	IC30N IC530N	CT3000	TTI15		TCC410 TCM10 TCM407
	K20	NS9530	AP25N VP25N NX2525	T3000Z				CX75			KT5020					TCM407

Note: The above table is selected from a publication. We have not obtained approval from each company.

User's Guide- Technical Reference

Grade Comparison Chart

●Cemented Carbide for Turning

ISO Classifi- cation	Symbol	Tungaloy	Mitsubishi Carbide	Sumitomo Electric	Sandvik	Kyocera	Mitsubishi Hitachi Tool	Dijet	NTK	Seco Tools	Kennametal	Iscar	Ingersoll	TaeguTec	Widia	Walter	Ceratizit
P	P01																
	P10	TH10		ST10P			WS10	SRT			P10	IC70		P10	TN15U		
	P20	KS20	UTi20T	ST20E	SMA H10F		EX35	SRT SR20	KM1	S10M	K125M TTM	IC70	P40	P20	TN15U		
	P30	KS15F UX30	UTi20T	A30 A30N	SM30 H10F	PW30	EX40	DX30 SR30	KM3	S25M	GK K600 TTR	IC28 IC54	P40	P30			S40T
	P40	TX40		ST40E			EX45	SR30		S60M	G13	IC28 IC54		P40			S40T
M	M01																
	M10	TH10		U10E EH510	H10A		WA10B	UMN	KM1	890	K313	IC20		M10	TN15U WU10HT		
	M20	KS20	UTi20T	U2 EH520	H13A		EX35	DX25 UMS		HX 883	K68 KMF K125M TTM	IC20	IN30M	M20	TN15U WU10HT		CTW7120 H210T
	M30	UX30	UTi20T	A30 A30N	H10F SM30		EX45	UMS			GK K600 TTR	IC28	IN30M				
	M40	TU40						UM40			G13	IC28	IN30M	M40			S40T
K	K01	KS05F	HTi05T	H2 H1			WH01 WH05	KG03			K605			UF1	TN15U WU10HT		
	K10	TH10	HTi10	H1 EH10 EH510	H10	KW10	WH10	KG10 KT9 CR1	KM1	890	K313 K110M THM THM-U	IC20 IC09T	IN05S	K10	TN15U WU10HT		H210T H216T H10T
	K20	KS15F KS20	UTi20T	G10E EH20 EH520	H13A H10F	KW10 GW15	WH20	KT9 CR1 KG20 FB15		890 HX 883	K715 KMF K600	IC20 IC09T	IN05S IN10K IN15K IN30M	K20	TN15U WU10HT		CTW7120 H210T H216T H10T
	K30		UTi20T	G10E	H13A H10F	GW25		KG30		883	THR	IC28	IN10K IN15K IN30M	K30			
	K40										G13		IN30M				
N	N01	KS05F		H1	H10	KW10					K605	IC20					
	N10	TH10	HTi10	H1	H10 H10F	GW15	WH10	KT9 CR1	KM1	890 HX KX H15	K313 K110M THM THM-U	IC20 IC28	IN05S IN10K	K10	TN15U WU10HT	WK1 WK10	H210T H216T H10T
	N20	KS15F			H10F H13A		WH20	KT9 CR1	KM1	890 HX KX 883	K715 KMF K600	IC20 IC28	IN10K IN15K	K20	TN15U WU10HT	WK1 WK10	CTW7120 H210T H216T H10T
	N30									883 H25	G13 THR		IN15K IN30M			WK40 WMG40	
	S01		RT9005									IC20					
S	S10	KS05F TH10	RT9005 RT9010	EH510	H10 H10A	KW10	WH10	KG10	KM1	890 883	K10 K313 THM	IC20	IN05S IN10K	K10	TN15U WU10HT	WK1	H210T H216T H10T
	S20	KS15F KS20	RT9010 TF15	EH520	H10F H13A	GW25	WH20	KG20	KM1	890 883 H25	K715 KMF	IC20 IC28	IN10K IN15K	K20	TN15U WU10HT	WK1 WMG40	CTW7120 H210T H216T H10T
	S30		TF15							883	G13 K600 THR		IN15K IN30M			WMG40	
	H01							KG03				IC20					
H	H10	TH10			H13A			FZ05				IC20	IN10K	K10			
	H20							FZ15		890 HX 883			IN15K				

Note: The above table is selected from a publication. We have not obtained approval from each company.

User's Guide- Technical Reference

Grade Comparison Chart

●PCBN and PCD for Turning

ISO		Tungaloy	Mitsubishi Carbide	Sumitomo Electric	Sandvik	Kyocera	Dijet	NTK	Seco Tools	Kennametal	Iscar	Ingersoll	TaeguTec	Widia	Walter	Ceratizit
Classification	Symbol															
K	K01	BX930 BX910 BX870	MB710 MB730 MB5015	BN500 BNC500	CB7525 CB7050 CB50	KBN60M		B52		KB9610 KD120 KB1630	IB10K		KB90	WBH10C	WCB80	TA100 CTL3215
	K10	BX470 BX480 BX950	MB710 MB730	BN7000 BN7500 BN500 BNC500	CB7050 CB7925 CB50	KBN60M	JBN795	B23 B30 B52	CBN200 CBN300 CBN400C CBN010	KB9640 KD120 KB1630	IB05S IB10S		KB90A	WBK40U	WCB80 WCB50	TA120 TA201 CTL3215
	K20	BXC90 BX90S	MB730 MBS140	BNS800	CB7050	KBN900		B23 B30 B52	CBN300 CBN500 CBN600 CBN010	KB1340 KB1345	IB90 IB25KD			WBK45U	WCB80	CTL3215
	K30	BXC90 BX90S	MBS140	BNS800		KBN900		B16	CBN500 CBN600	KB1340 KB1345						
S	S01	M714B	MB730	BN350			JBN795	JP2	CBN170				KB90			
	S10	BX470 BX480 BX950	MB4020	BN7500	CB7050	KBN65B KBN65M		B23 B30	CBN200	KB1630	IB05S IB10S		KB90A	WBK45U	WCB80	TA201
H	H01	BXM10 BX310	BC8110 BC0010 MB810	BNC100 BNC160 BNC2010 BNX10 BN1000	CB20	KBN510 KBN10C KBN05M KBN10M		B52 B5K	CBN10 CBN100 CBN160C CBN050C	KB1610 KB5610	IB05H IB10HC		KB50	WBH10C	WCB30	
	H10	BXM10 BX330 BX530	BC8110 MBC025 MB8025	BNC160 BNC200 BNC2020 BN250 BN1000	CB7015 CB7025 CB20 CB50	KBN525 KBN05M KBN10M KBN25M	JBN245	B36 B52 B6K	CBN150 CBN200 CBN300 CBN060K CBN050C CBN160C CBN300P CBN400C	KB9610 KB1610 KB5610	IB50 IB55 IB10H IB10HC IB20H IB25HA		KB50 TB650	WBH10C WBH10P WBH10U	WCB30 WCB50	CTL3215 TA100
	H20	BXM20 BXA20 BX360	MBC020 BC8120 MB8025 MB825	BNC200 BNC2020 BN250 BNX20 BNX25 BN2000	CB7025 CB20 CB7035	KBN525 KBN05M KBN10M KBN25M	JBN300 JBN330	B22 B36 B40 B6K	CBN150 CBN200 CBN300 CBN060K CBN160C CBN300P CBN400C	KB5625 KB1625	IB20H IB20HC IB25HA IB25HC		TB650	WBH25P	WCB50 WCB80	CTL3215 TA120
	H30	BXC50 BX380	MB835	BNC300 BN350 BNX25	CB7525	KBN35M KBN900	JBN300 JBN330	B22 B40	CBN500	KB1630 KB9640	IB25HC			WBH40C		TA201
	N01	DX160 DX180	MD205	DA90	CD10	KPD001	JDA30 JDA735			KD1400 KD1405 KD100	ID5				WCD10	CTD4125
N	N10	DX140	MD205 MD220	DA150	CD10	KPD001 KPD010 KPD230	JDA715	PD1	PCD05 PCD10	KD100 KD1400 KD1425	ID5	IN90D	KP500	WDN25U	WCD10	CTD4125 CTD4110
	N20	DX120	MD220 MD230	DA2200 DA1000	CD10	KPD001 KPD010 KPD230	JDA715	PD1	PCD05 PCD20	KD1425		IN90D	KP300	WDN25U	WCD10	CTD4205
	N30	DX110	MD230	DA2200 DA1000			JDA10		OVD20 PCD30 PCD30M				KP100			

Note: The above table is selected from a publication. We have not obtained approval from each company.

User's Guide- Technical Reference

Grade Comparison Chart

●Ceramics for Turning

ISO		Tungaloy	Mitsubishi Carbide	Sumitomo Electric	Sandvik	Kyocera	Mitsubishi Hitachi Tool	Dijet	NTK	Seco Tools	Kennametal	Iscar	Ingersoll	TaeguTec	Widia	Walter	Ceratizit
Classification	Symbol																
K	K01	LX11 LX21		NB90S NB90M	CC6190 CC650	KA30 A65 KT66 PT600M			HC1 HW2 SE1 HC2		KY1310 KY1615			AW20 AB30 AS10	CW2015		CTN3105 CTS3105
	K10	CX710 FX105			CC6190 CC650	A65 KT66 A66N PT600M			HC1 HW2 SE1 WA1 WA5		KY1310 KY1320 KY1615 KY3400		IN70N	AB30 AS10	CW2015 CW5025	WSN10	CTN3105 CTM3110 CTI3105 CTN3110 CTS3105
	K20	FX105 CX710			CC6190	KS6000			SP9 SX1 SX8 SX9		KY1320 KY3400 KY3500 KY4300		IN70N	AS10	CW5025	WSN10	CTM3110 CTN3110
H	H01	LX11		NB100C	CC6050 CC650	A65 KT66 A66N PT600M			ZC4 ZC7		KY4300			AW20	CW2015		CTS3105

Note: The above table is selected from a publication. We have not obtained approval from each company.

User's Guide- Technical Reference

Grade Comparison Chart

●CVD Coated Grade for Milling

ISO		Tungaloy	Mitsubishi Carbide	Sumitomo Electric	Sandvik	Kyocera	Mitsubishi Hitachi Tool	Dijet	NTK	Seco Tools	Kennametal	Iscar	Ingersoll	TaeguTec	Widia	Walter	Ceratizit
Classification	Symbol																
P	P01											IC9015 IC5400 IC8080 IC9080			TN2510		
	P10		FH7020	ACP100	GC4220 GC4230			JC730U		MP1500	KCPM20	IC9015 IC5400 IC8080 IC9080 IC4100 IC5100			TN2510 TN7525	WKP25	GM226+
	P20	T3225	FH7020 F7030	ACP100	GC4220 GC4230		GX2140 GX2160	JC730U		MP1500 MP2500 T25M	KCPM20 KCPK30 KCPM30 KC927M	IC8080 IC9080 IC4100 IC5100 IC9250 IC520M	IN6530	TT7800	TN7525 TN7535	WKP25 WKP35 WKP35S	GM226+
	P30	T3130 T3225	F7030	ACP100	GC4230 GC4240 GC2040		GX2140 GX2160			MP1500 MP2500 T350M T25M	KCPK30 KCPM30 KC927M	IC9250 IC520M IC4050 IC635	IN6530	TT7800	TN7525 TN7535	WKP25 WKP35 WKP35S	GM226+ GM246 GM43+
	P40				GC4230 GC4240 GC2040		GX2160			MM4500 T350M	KCPK30 KCPM30	IC4050 IC635	IN6530	TT7800	TN7535	WKP35 WKP35S	GM246 GM43+
M	M10			ACM200	GC2015			JC730U			KCPM20	IC9250 IC520M IC9350			TN7525		
	M20	T3225	F7030	ACM200	GC4230	CA6535		JC730U		MP2500 T350M T25M	KCPM20 KCPM30 KC927M	IC9250 IC520M IC9350 IC4050 IC635	IN6530	TT7800	TN7525 TN7535		CTC5235 GM226+
	M30	T3225 T3130	F7030	ACM200	GC2040 GC4230 GC4240 S40T	CA6535	GX2160	JC730U		MP2500 T350M T25M	KCPM30 KC927M	IC9350 IC4050 IC635	IN6530	TT7800	TN7525 TN7535		CTC5235 CTC5240 GM226+ GM246 GM43+
	M40				GC2040 GC4240 S40T	CA6535	GX2160			MM4500 T350M		IC635	IN6530		TN7535		CTC5235 CTC5240 GM246 GM43+
K	K01		MC5020	ACK200		CA420M		JC605W			KC907M	IC8080 IC4100 IC5100 IC9150			TN2510 TN5505	WKP15	CTC3215
	K10	T1215 T1115	MC5020	ACK200	GC3220	CA420M	GX2120	JC605W JC608X JC610		MK1500	KC907M KC914M KC917M KC924M KCK15	IC8080 IC4100 IC5100 IC9150 IC9080 IC520M		TT6800	TN2510 TN5505 TN5515 TN5520	WKP15 WKP25	CTC3215 SR216 SR226+
	K20	T1215	MC5020	ACK200	GC3220 GC3330 GC3040 GC4220 GC4230	CA420M	GX2120 GX2140	JC605W JC608X JC610		MK1500 MP1500	KC917M KC924M KCK15 KCPM20 KCPK30 KC927M	IC5100 IC9150 IC9080 IC520M IC4050	IN6515 IN6530	TT6800	TN5515 TN5520	WKP15 WKP25 WKP35 WKP35S	SR216 SR226+
	K30		MC5020		GC3330 GC3040 GC4220 GC4230 GC4240		GX2140	JC610		MK1500 MP1500	KCPM20 KCPK30 KC927M	IC520M IC4050	IN6515 IN6530			WKP25 WKP35 WKP35S	

Note: The above table is selected from a publication. We have not obtained approval from each company.

User's Guide- Technical Reference

Grade Comparison Chart

●PVD Coated Grade for Milling

ISO	Classification	Symbol	Tungaloy	Mitsubishi Carbide	Sumitomo Electric	Sandvik	Kyocera	Mitsubishi Hitachi Tool	Dijet	NTK	Seco Tools	Kennametal	Iscar	Ingersoll	TaeguTec	Widia	Walter	Ceratizit
P	P01	AH710 AH110				GC1010		ATH80D JP4105	JC8003			KC505M KC510M KC515M	IC903		TT2510 TT5505	TN2505 TN6505		
	P10	AH120 AH725 AH8015	MP6120 VP15TF	ACP200	GC1010 GC1025	PR830 PR1225 PR1230 PR1525	ATH80D PN08M ATH10E PN15M JP4105 JP4115 JP4120	JC8003 JC8015 JC5015 JC5118	DM4			KC505M KC510M KC515M KC610M KC715M	IC903 IC907 IC950 IC908 IC910 IC380 IC900	IN2505	TT2510 TT5505 TT5515 TT7080	TN2505 TN2525 TN6425 TN6505	WHH15 WXM15	
	P20	AH120 AH725 AH3135 AH9030	MP6120 VP15TF MP6130 UP20M VP20RT	ACP200 ACP300	GC1025 GC1030 GC2030	PR830 PR1225 PR1230 PR1525	JP4120 JS4045 CY250	JC8015 JC5015 JC5118 JC5040			MP3000 F25M	KC522M KC525M KC527M KC530M KC610M KC620M KC635M KC715M KC720M KC730M	IC907 IC950 IC908 IC910 IC380 IC900 IC830 IC928 IC1008	IN2040 IN2505 IN4005 IN4030	TT2510 TT5505 TT5525 TT7080 TT9030 TT9080	TN2525 TN6425 TN6430 TN6525	WHH15 WXM15	CTP1235 CTP1625
	P30	AH120 AH725 AH3135 AH130 AH6030	MP6120 VP15TF MP6130 UP20M VP20RT VP30RT	ACP200 ACP300	GC1025 GC1030 GC2030	PR830 PR1225 PR1230 PR1525	JS4045 CY250 JM4160	JC5118 JC5040 JC8050 JC7560			MP3000 F25M F30M F40M	KC525M KC527M KC530M KC537M KC610M KC620M KC720M KC725M KC730M KC735M	IC907 IC950 IC908 IC910 IC380 IC900 IC830 IC928 IC1008	IN2040 IN2505 IN2530 IN4005 IN4030	TT5525 TT7080 TT8020 TT8080 TT9030 TT9080	TN6430 TN6525 TN6540	WSP45 WSP46	CTP1235 CTP1625 CTP2235
	P40	AH140	VP30RT	ACP300	GC1030 GC2030		JM4160	JC5118 JC5040 JC8050 JC7560			MP3000 F40M T60M	KC537M KC720M KC725M KC735M	IC830 IC928 IC1008	IN2040 IN2530 IN4005 IN4030	TT8020	TN6540	WSP45 WSP46	CTP1235 CTP2235
	M01			ACM100 ACK300	GC1010		PCS08M		DM4				IC907 IC903					
M	M10	AH725	VP15TF	ACM100 ACK300 ACP300	GC1010 GC1025 GC1030 GC2030	PR830 PR1225 PR1525 PR1535	PCS08M CY150		DM4			KC515M KC610M KC635M KC720M	IC907 IC903	IN2505	TT5525 TT9030 TT9080	TN6425 TN6525	WXM15	
	M20	AH725 AH3135 AH130 AH6030	VP15TF MP7030 MP7030 UP20M VP20RT	ACM300 ACP300	GC1025 GC1030 GC1040 GC2030	PR830 PR1225 PR1525 PR1535	CY150 CY250	JC8015 JC5015 JC5118	DM4		MP3000 MS2050 F25M F30M F40M	KC522M KC525M KC530M KC537M KC610M KC635M KC720M KC730M	IC380 IC900 IC908 IC928 IC1008	IN2005 IN2505 IN2530 IN4005	TT8020 TT8080	TN6425 TN6525	WXM15 WSM35 WSM36	CTP1235 CTP1625
	M30	AH3135 AH130	VP15TF MP7130 MP7030 UP20M VP20RT MP7140 VP30RT	ACM300	GC1040 GC2030	PR830 PR1225 PR1525 PR1535	CY250 JM4160	JC8015 JC5015 JC5118 JC8050 JC7560			MP3000 MS2050 F30M F40M	KC522M KC525M KC530M KC537M KC725M KC730M KC735M	IC380 IC900 IC908 IC928 IC1008 IC328 IC330	IN2005 IN2505 IN2530 IN4005 IN4030	TT8020 TT8080	TN6540	WSM35 WSM36 WSP45 WSP46	CTP1235 CTP2235
	M40	AH140	MP7140 VP30RT	ACM300	GC1040	PR1225 PR1525 PR1535	JM4160	JC5015 JC5118 JC8050 JC7560			MS2050 F40M	KC725M	IC1008 IC328 IC330	IN2005 IN2530 IN4005 IN4030	TT8020	TN6540	WSM35 WSM36 WSP45 WSP46	CTP2235
	K01	AH110	MP8010		GC1010	PR1510	ATH80D JP4105	JC8003					IC380 IC900		TT6080	TN2505 TN6405 TN6505		AMZ
	K10	AH110 AH120	MP8010 VP15TF		GC1010 GC1020	PR1210 PR1510	ATH80D JP4105 JP4120 CY150	JC8015			MK2050	KC514M KC515M KC520M KC620M	IC380 IC900 IC810 IC910	IN2015 IN2505 IN4015	TT6080	TN2505 TN6405 TN6505 TN6510	WHH15 WXM15 WKK25	AMZ CTP3220 CTP6215
K	K20	AH120 AH9030	MP8010 VP15TF VP20RT	ACK300	GC1020	PR1210 PR1510	JP4120 CY150 CY250	JC8015 JC5015			MK2050	KC514M KC520M KC522M KC524M KC527M KC610M KC620M KC635M	IC810 IC910 IC950 IC350 IC830 IC928	IN2015 IN2505 IN4015 IN4030		TN2525 TN6510 TN6520 TN6525	WHH15 WXM15 WKK25	CTP3220 CTP1625
	K30	AH120	VP15TF VP20RT	ACK300		PR1510	CY250	JC8015 JC5015			MK2050	KC522M KC524M KC527M KC537M KC610M KC620M KC635M	IC830 IC928 IC1008 IC908	IN2015 IN2505 IN4015 IN4030		TN6430 TN6525 TN6540	WKK25	

User's Guide- Technical Reference

●PVD Coated Grade for Milling

ISO		Tungaloy	Mitsubishi Carbide	Sumitomo Electric	Sandvik	Kyocera	Mitsubishi Hitachi Tool	Dijet	NTK	Seco Tools	Kennametal	Iscar	Ingersoll	TaeguTec	Widia	Walter	Ceratizit
Classification	Symbol																
N	N01										KC410M KC510M KC5410			TT6080	TN6501		AMZ
	N10	DS1100		DL1000	GC1025 GC1030		SD5010 HD7010				KC410M KC510M KC5410 KC620M			TT6080 TT8020	TN6501 TN6502	WXN15	AMZ
	N20	DS1200	LC15TF	DL1000	GC1025 GC1030		SD5010 HD7010			F15M	KC422M KC620M			TT8020		WXN15	
S	S01	AH110 AH710		ACM100 ACK300	GC1010	PR905 PR1210 PR1535		JC8003 JC8015			KC510M	IC808 IC907 IC908			TN6405		AMZ
	S10	AH120 AH725	MP9120 VP15TF MP9130 MP9030	ACM100 ACK300	S30T GC1010 GC1030 GC2030	PR905 PR1210 PR1535	PTH13S JS1025	JC8003 JC8015 JC5015 JC5118		MS2050	KC510M KC610M	IC808 IC907 IC908 IC903	IN2505 IN2530	TT9030 TT9080 TT8080	TN6405 TN6425		AMZ CTP1625
	S20	AH725 AH130 AH6030	MP9120 VP15TF MP9130 MP9030	ACM300	S30T GC1030 GC1040 GC2030 GC2040	PR905 PR1210 PR1535	PTH13S JS1025	JC8015 JC5015 JC5118 JC8050 JC7560		MS2050 F40M	KC522M KC525M KC610M	IC300 IC900 IC830 IC928	IN2505 IN2530	TT8080 TT8020	TN6425	WSM35 WSM36	CTP1235 CTP1625
	S30	AH130	MP9130 MP9030	ACM300	S30T GC1040 GC2040	PR1535		JC5118 JC8050 JC7560		MS2050 F40M	KC522M KC525M KC725M	IC830 IC928	IN2530	TT8020	TN6540	WSM35 WSM36 WSP45 WSP46	CTP1235 CTP2235
H	H01	AH110	MP8010		GC1010			DH102 JC6102 JC8003 JC8008			KC510M	IC903		TT2510 TT5505	TN2505		
	H10	AH110 AH120 AH8015	MP8010 VP15TF		GC1010 GC1025 GC1030		PTH08M JP4105	JC6102 JC8003 JC8008 JC8015 JC5118		MH1000 F15M	KC505M KC510M KC635M	IC903 IC808 IC907 IC908		TT5515 TT6080	TN2505 TN2525	WHH15	CTP6215
	H20	AH120 AH725 AH9030	VP15TF		GC1025 GC1030		JP4105	JC8015 JC5118		F15M	KC635M	IC808 IC907 IC908 IC380 IC900		TT5515 TT6080	TN2525	WHH15	CTP6215
	H30									MP3000 F30M		IC380 IC900 IC1008					

Note: The above table is selected from a publication. We have not obtained approval from each company.

User's Guide- Technical Reference

Grade Comparison Chart

●Cermet for Milling

ISO		Tungaloy	Mitsubishi Carbide	Sumitomo Electric	Sandvik	Kyocera	Mitsubishi Hitachi Tool	Dijet	NTK	Seco Tools	Kennametal	Iscar	Ingersoll	TaeguTec	Widia	Walter	Ceratizit
Classification	Symbol																
P	P01			T250A	CT530	TN60 TN100M	MZ1000						IN0560	CT3000			TCC410
	P10	NS740	NX2525	T250A	CT530	TN60 TN100M TC60M	MZ1000 MZ2000 CH550	NIT CX75 CX90		MP1020	KTPK20	IC30N	IN0560 IN60C	CT3000 CT7000	TTI25		TCC410 TCM10
	P20	NS740	NX2525 NX4545	T250A T4500A		TN60 TN100M TC60M	MZ2000 MZ3000 CH500 CH7030	NIT CX75 CX90 SC30		MP1020	KTPK20	IC30N	IN60C	CT3000 CT7000	TTI25		TCM10
	P30		NX4545	T4500A			MZ3000 CH7035		C7X			IC30N	IN0545	CT7000			
M	M10	NS740	NX2525	T250A	CT530	TN60 TN100M TC60M	MZ1000 CH550	NIT CX75			KTPK20	IC30N	IN0560	CT3000 CT7000	TTI25		TCC410
	M20	NS740	NX2525 NX4545	T250A T4500A		TN60 TN100M TC60M	MZ2000 MZ3000 CH500 CH7030	NIT CX75 SC30	C7X	MP1020	KTPK20	IC30N		CT7000	TTI25		TCC410 TCM10
	M30		NX4545	T4500A			MZ3000 CH7035	SC30									
K	K01						MZ1000 CH550	NIT									TCC410
	K10	NS740	NX2525				MZ2000 MZ3000 CH500 CH7030	NIT CX75			KTPK20			CT7000			TCC410 TCM10
	K20						MZ2000 MZ3000 CH500 CH7030	CX75			KTPK20						

Note: The above table is selected from a publication. We have not obtained approval from each company.

User's Guide- Technical Reference

Grade Comparison Chart

●Cemented Carbide for Milling

ISO		Tungaloy	Mitsubishi Carbide	Sumitomo Electric	Sandvik	Kyocera	Mitsubishi Hitachi Tool	Dijet	NTK	Seco Tools	Kennametal	Iscar	Ingersoll	TaeguTec	Widia	Walter	Ceratizit
Classification	Symbol																
P	P01																
	P10																S26T
	P20		UTi20T	A30N			EX35				K125M	IC50M		P30	TTM		S26T
	P30	UX30	UTi20T	A30N	SM30		EX40				K125M	IC50M IC28		P30	TTM TTR		S26T
	P40				SM30							IC28			TTR		
M	M01																
	M10											IC20 IC07 IC08					S26T
	M20		UTi20T		SM30							IC07 IC08			TTM		S26T
	M30		UTi20T	A30N	SM30							IC28			TTM TTR		S26T
	M40			A30N								IC28			TTR		
K	K01					KW10					K115M K313			K10	THM-F		
	K10	TH10	HTi10	G10E	H13A	KW10 GW25	WH10				K115M K313 K110M	IC20		K10	THM-F THM		CTW4615 H216T
	K20		HTi10 UTi20T	G10E	H13A	KW10 GW25				HX	KMF	IC20	IN10K		THM THR		CTW4615 H216T
	K30		UTi20T								KMF		IN10K		THR		
	K40												IN10K				
N	N01	KS05F	HTi10		H10	KW10					K115M				THM-U	WK10	
	N10	TH10	HTi10		H10 H13A H10F	KW10 GW25	WH10			H15	K115M K313 K110M	IC20 IC08		K10 UF10	THM-U THM-F THR-S	WK10	CTW4615 H216T
	N20	KS15F	HTi10 TF15	H1	H13A H10F	KW10 GW25				HX H15 H25	KMF K313 K110M	IC20 IC08 IC28		K10 UF10	THM-F THR-S THM	WMG40	CTW4615 H216T
	N30		TF15	H1						H25	KMF	IC28				WMG40	
S	S01					KW10					K313	IC20					
	S10			EH520	H13A	KW10 GW25		FZ15			K313 K110M	IC20 IC07 IC08			THM-F		
	S20	KS20		EH520	H10F H13A	KW10 GW25		FZ15		HX H25	KMF	IC20 IC07 IC08 IC28			THM		
	S30				H10F							IC07 IC08					
H	H01				H1P			FZ05									
	H10				H1P			FZ05 FZ15				IC20			THM-F		
	H20							FZ15									

Note: The above table is selected from a publication. We have not obtained approval from each company.

User's Guide- Technical Reference

Chipbreaker Comparison Chart

●Negative insert type

ISO Classification	Cutting Mode	Tungaloy	Mitsubishi Carbide	Sumitomo Electric	Kyocera	Sandvik	Mitsubishi Hitachi Tool	Kennametal	Dijet	Iscar	TaeguTec	Widia	Walter	Ceratizit
P	Precision finishing	01 TF	PK FH	FA	DP	QF	FE	FS , LF	PF	SF , PP , TF	FA			
	Finishing and light cutting	TS , TSF ZF 11 , NS AS TQ NM CB C	SA FY C SH MP	SU FL SE , SX	PQ , VF CJ PQ GP , PP HQ GS CQ	PF , QF LC MF R/L-K	BE , BH AB , CT CE	FF , FN	UA , FT UR , UT	F3P NF , SF	FG VF , EA FC MC ML , MP	4 AP	NF3 NS6	CF , TF
	Finishing and light cutting (With Wiper)	AFW , FW ASW , SW	SW	LUW SEW GUW	WP WQ	WL , WF WMX WM , WR		FW MW RW		WF WG	WS WT	FW MW	NF NM	TFQ TMQ
	Medium cutting	TM , AM DM , ZM All-round	MA MH , MP	GU GE , UX	HS , PT , GT CS , PS	PM , QM XM , XRM	AH AE , AY , B	P MN	PG , UB GN GNP	M3P , M3M PP , TF , GN	PC , MT MC , MG-	48	NMT , NM4	TMF , TMM M50
	Medium to heavy cutting	TH THS	RP , GH HZ , HL	MU , ME HG	PH All-round	HM , PR MR	RE	RN , RP MR	GG , UD	NR MR	RT	49	NM5 , NM6 NM9	TM TRM
	Heavy cutting	TU TRS TUS	HM , HX HV	HG , HP HU , HW HF	PX	PR , MR HR , QR	TE , UE HX , HE H	RM RH	UC	R3P NM	HT , HD RX , RH HY , HZ		NR6 NRF NRR	TRR , TR R28 , R58 R88
M	Finishing and light cutting	SF , SA SS	GM , MS SH , LM	EX , EG SU , EF	GU MQ	MF , XF LC , R/L-K	MP BH , AB	FP	SF	TF , VL	EA , SF , SU FG		NF4 NMS	CF , F30 , M34 F32 , TF
	Medium cutting	SM S	MM , MA ES	GU HM	TK MU	MM , QM XM , XRM	PV , SE DE	MP , P	SZ	M3M , PP	EM , ET		NM4	TMF , M42 M30 , M52
	Heavy cutting	TH , SH TU	GH , RM , HZ	EM , MU	MS	MR HM , PR	AH , AE	UP , RP	SG	MR , MH		SR	NR4 NRT , NRS	TM , M60 TRM , TMR , TRR R80
K	Finishing	CF	LK , MA	UZ	C	KF , XF	Y , AH	FN		GN	FG			CF
	Medium cutting	CM All-round	MK GK	GZ	ZS All-round	KM , QM XM , XRM	V , AE VA	RP , UN	PG		MT MG		NM5	M50
	Heavy cutting	CH Without chipbreaker	RK Without chipbreaker	Without chipbreaker	GC Without chipbreaker	KR Without chipbreaker	RE Without chipbreaker	Without chipbreaker	GG , UD Without chipbreaker		RT		Without chipbreaker	TMR , TR R28 R58 , R88
N	Cutting of non-ferrous metals	P		AX	AH , A3	MF QM	Without chipbreaker	MS , MP MG		PP	ML			F32
S	Finishing	HRF	FJ , LS	EF EX	MQ	SF 01		FS , LS MS			SF		NFT NF4	
	Medium cutting	HRM HMM SA	MS RS , GJ	EG MU	TK , MS , MU	MM , QM SMR		UP , P , NGP RP		PP	SU	SM	NMS	M34 , M52
													NM4 , NPS , NR4	

Note: Above charts are based on published data and not authorized by each manufacturer.

User's Guide- Technical Reference

Chipbreaker Comparison Chart

●Positive insert type

ISO Classification	Cutting Mode	Tungaloy	Mitsubishi Carbide	Sumitomo Electric	Kyocera	Sandvik	Mitsubishi Hitachi Tool	Kennametal	Dijet	Iscar	TaeguTec	Widia	Walter	Ceratizit
P	Precision finishing	01	FV, SMG	FC, FW	CF CK		No sign MP	UF		SF		2	PF2	F32
	Finishing and light cutting	PSF, PF, SS PS, PSS, TS	FP, FV, SV LP	FP, FZ, LU FK, SS, SC SU, SK, SF US	GQ, GK GP, HQ XP, XQ	R/L-K PF, XF UF, PM	JQ	11, GM LF	FT	PF SM, 14, 17 19, XL	FA FG	41	PF5 PF4 PS5	SF SMF
		TSW W08~20	SW, MW R/L, R/L-FD R/L-FS R/L-MV R/L-F, R/L-L	LUW, SDW W, SD FX, FY		WF, WK, WM				R/L RF, LF	GF		PF, PM	SMQ, 25Q
	Medium cutting	PM 23 24 All-round RS	MP MV No sign	SU, MU UJ SC (except for G-class inserts) RP	All-round VF, MF	PM, XM UM, PR, XR UR	JE	GM, MP, MR		DT, HQ	MT		PM5	SM
	High-feed, small depth of cut cutting	61	No sign			No mark	WE		GG	No sign 14	No sign	No sign		
M	Finishing	PSF, SS	FM, FV, SV	FC		R/L-K UF, MF	MP	GM, LF			FG	41		
	Finishing to Medium cutting	PSS PS	LM SV		MQ	MM, XM UM	JQ	MF					PF4	SF, SMF
	Medium cutting	PM	MM, MV	MU		MR, XR UR	JE						PM5	F23, F43 SM
K	Cutting of cast irons	CM Flat-top	MK Flat-top	Flat-top	Flat-top	KF, XF KM, XM UM, KR, XR	JQ, JE	Flat-top	Flat-top	19	MT Flat-top		PS5, PM5 Flat-top	SF 25P 27, 29
N	Cutting of non-ferrous metals	AL PP	AZ	AG AX, AY	AH, A3	AL		GT-HP		AS	FL	AL1, AL2, AL3	PF2 PM2	23P 25P 27, 29
		Ground	R/L-F R/L											
S	Finishing	PSF	FJ	FC	MQ	MF, UF, R/L-K								SF
	Finishing to Medium cutting	PSS PS		FX, FY		MM, XM								F23
	Medium cutting	All-round		SI		UM, MR, UR, XR					FG		PF2, PF4	SM, 25P, 29
P M N S	Turning on small lathes	01 W08, W15, W20 J10	R/L-SR R/L-SN R/L-SS FS, F	W, SD FX, FY	R/L-F, R/L-FSF ER/L-U FR/L-U R/L-U FR/L-U, R/L-USF MF, R/L-FSF	F, M	No sign		MF, MM ALU, MM1 ASF FT, ACB		GF, GW		PM5	
		JRP, JSP, JPP TS, JTS TSW SS, JSS	SW, MW	LUW, SDW										
		JS		LU, FP, FK, SU FB, LB FC, SI, SC	GK E-GK									
			SMG											

Note: Above charts are based on published data and not authorized by each manufacturer.

User's Guide- Technical Reference

Unified symbols for cutting conditions and tool dimensions

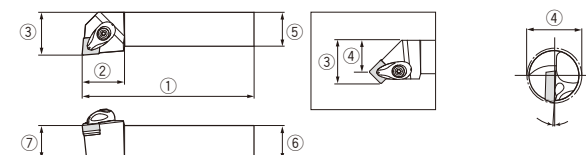
Standardized symbols for cutting conditions and tool specifications are used in order to avoid confusion caused by each manufacturer's using its own symbols.

(Quantity symbols of cutting conditions) Symbol / Unit

Turning	Cutting speed		Feed		Depth of cut		Cutting edge width		Min. bore diameter	
	V_c	m/min	f	mm/rev	ap	mm	W	mm	ϕD_m	mm
	Power consumption		Specific cutting force		Theoretical surface roughness		Corner radius		Number of revolutions	
	P_c	kW	k_c	MPa	h	μm	r_ϵ	mm	n	min ⁻¹
Milling	Cutting speed		Feed speed		Feed per tooth		Feed		Number of teeth	
	V_c	m/min	V_f	mm/min	f_z	mm/t	f	mm/rev	z	
	Axial depth of cut		Radial depth of cut		Pick feed		Power consumption		Specific cutting force	
	ap	mm	ae	mm	P_f	mm	P_c	kW	k_c	MPa
	Chip removal rate		Number of revolutions							
	Q	cm ³ /min	n	min ⁻¹						
Drilling	Cutting speed		Feed speed		Feed		Tool diameter		Power consumption	
	V_c	m/min	V_f	mm/min	f	mm/rev	ϕD_c	mm	P_c	kW
	Torque		Thrust force		Specific cutting force		Drilling depth		Number of revolutions	
	M_c	N·m	T_c	N	K_c	MPa	H	mm	n	min ⁻¹

Dimensional symbols of turning tools

● External turning tools



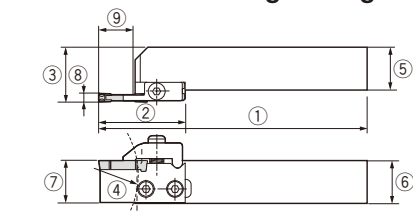
①	②	③	④	⑤	⑥	⑦
Overall length	Head length	Distance to cutting edge	Distance to cutting edge	Shank width	Shank height	Cutting edge height
L_1	L_2	f	f_1	b	h	h_1

● Internal turning tools



①	②	③	④	⑤	⑥
Overall length	Head length	Distance to cutting edge	Minimum bore diameter	Shank diameter	Shank height
L_1	L_2	f	ϕD_m	ϕD_s	h

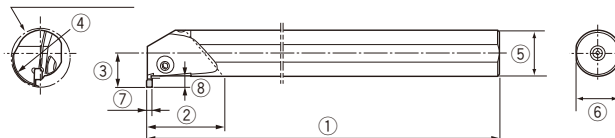
● External and face grooving tools



①	②	③	④	⑤
Overall length	Head length	Distance to cutting edge	Maximum grooving diameter	Shank width
L_1	L_2	f	ϕD_m	b
⑥	⑦	⑧	⑨	
Shank height	Cutting edge height	Cutting edge width	Maximum grooving depth	
h	h_1	w	ar	

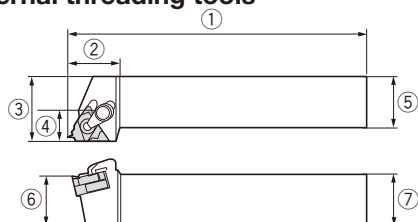
● Internal grooving tools

Min. bore diameter ϕD_m



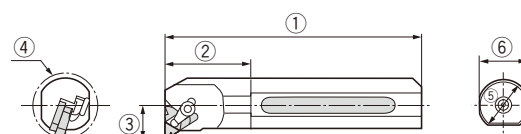
①	②	③	④
Overall length	Head length	Distance to cutting edge	Maximum grooving diameter
L_1	L_2	f	ϕD_m
⑤	⑥	⑦	⑧
Shank diameter	Shank height	Cutting edge width	Maximum grooving depth
ϕD_s	h	w	ar

● External threading tools



①	②	③	④	⑤	⑥	⑦
Overall length	Head length	Distance to cutting edge	Shoulder width	Shank width	Shank height	Cutting edge height
L_1	L_2	f	-	b	h	h_1

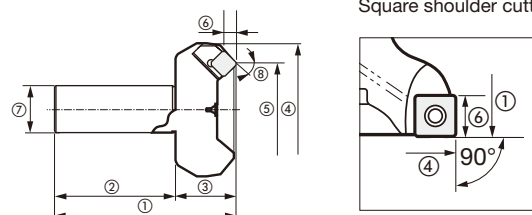
● Internal threading tools



①	②	③	④	⑤	⑥
Overall length	Head length	Distance to cutting edge	Maximum grooving diameter	Shank diameter	Shank height
L_1	L_2	f	ϕD_m	ϕD_s	h

● **Bore type milling tools** Square shoulder cutter

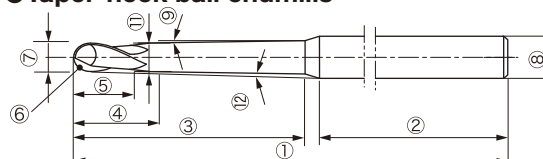
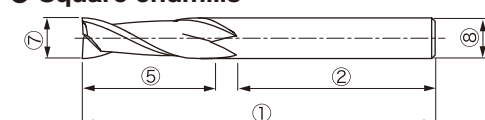
Square shoulder cutter



①	②	③	④
Overall length	Shank length	Cutter height	Cutter diameter
L	l_s	L_f	$\varnothing D_c$
⑤	⑥	⑦	⑧
Maximum outer diameter	Maximum depth of cut	Shank diameter	Corner angle
$\varnothing D_1$	ap	$\varnothing D_s$	κ

①	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪	⑫	⑬	⑭	⑮
Cutter height	Cutter diameter	Maximum outer diameter	Maximum depth of cut	Hole diameter	Keyway width	Keyway depth	Mounting hole depth	Mounting flat diameter	Corner angle	Mounting bolt counter bore dia.	Mounting bolt hole diameter	Mounting bolt hole depth
L_f	$\varnothing D_c$	$\varnothing D_1$	ap	d	a	b	l	$\varnothing D_b$	κ	$\varnothing d_1$	$\varnothing d_2$	l_1

- **Square endmills**

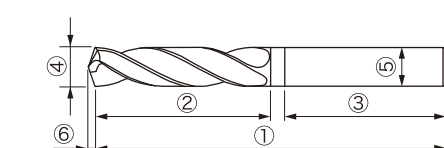


Technical drawing of a shaft with a keyway. The drawing shows a shaft with a keyway cut into it. The dimensions are labeled as follows: 1 is the length of the shaft, 2 is the length of the keyway, 3 is the width of the shaft, 4 is the width of the keyway, 5 is the depth of the keyway, 6 is the radius of the fillet at the end of the shaft, 7 is the radius of the fillet at the end of the keyway, 8 is the radius of the fillet at the end of the shaft, and 9 is the radius of the fillet at the end of the keyway.

①	②	③	④	⑤	⑥ Ball end	⑥ Radius end	⑦	⑧	⑨	⑩	⑪	⑫	⑬
Overall length	Shank length	Neck length	Length of parallel portion	Cutting edge length	Ball radius	Corner radius	Tool diameter	Shank diameter	Half angle of neck taper	Half angle of cutting edge taper	Neck diameter	Interference angle	Helix angle
L	ℓ_s	ℓ_2	ℓ_1	ℓ	R	r	$\varnothing D_c$	$\varnothing D_s$	θ_n	θ_c	$\varnothing D_1$	θ_k	λ

①	②	③	④	⑤
Cutter diameter	Bore diameter	Cutting edge width	Boss thickness	Boss diameter
$\varnothing D_c$	$\varnothing d$	ℓ	T	$\varnothing D_b$
⑥	⑦	⑧	⑨	⑩
Cutting edge angle	Corner radius	Keyway width	Keyway depth	Number of teeth
α	R	a	b	z

- Solid straight drills



①	②	③	④	⑤	⑥
Overall length	Flute length	Shank length	Drill diameter	Shank diameter	Point length
L	ℓ	ℓ_s	$\varnothing D_c$	$\varnothing D_s$	L_p

A technical drawing of a mechanical part, likely a propeller or a similar rotating component. The drawing includes several dimension lines labeled with numbers 1 through 8. Dimension 1 is the total length. Dimension 2 is the length of the main body. Dimension 3 is the length of the tail section. Dimension 4 is the diameter of the main body. Dimension 5 is the diameter of the tail section. Dimension 6 is the diameter of the base. Dimension 7 is the diameter of the tip. Dimension 8 is the length of the main body from the base to the tip.

①	②	③	④	⑤	⑥	⑦	⑧
Overall length	Flute length	Shank length	First step drill diameter	Shank diameter	Point length	Second step drill diameter	Step length
L	ℓ	ℓ_s	$\varnothing D_c$	$\varnothing D_s$	L_p	$\varnothing D_{c2}$	ℓ_1

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