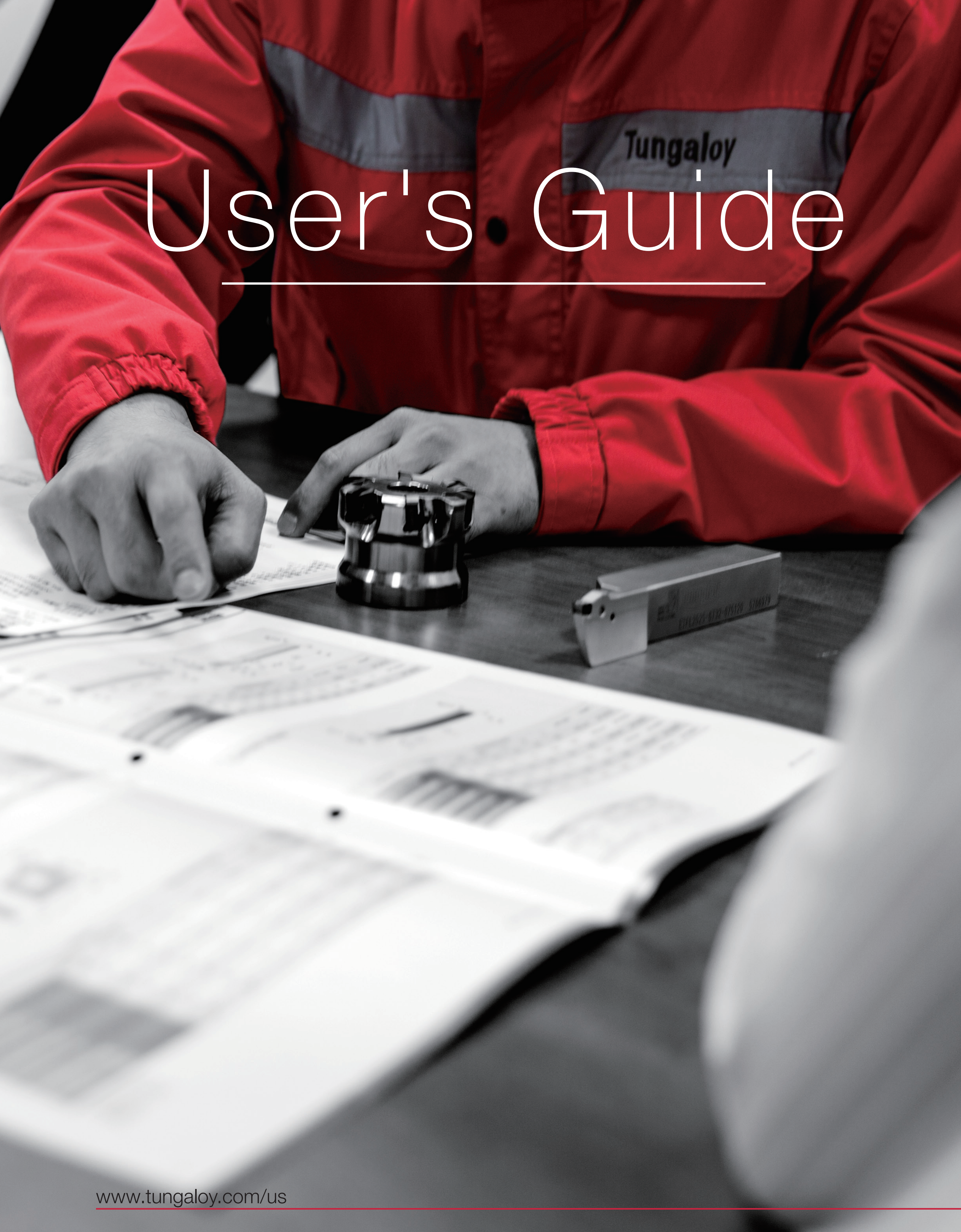

User's Guide

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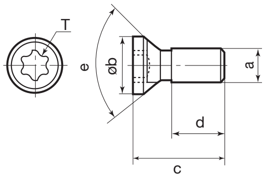
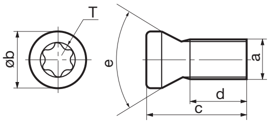
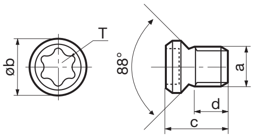
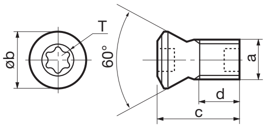
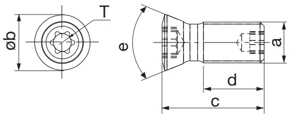
USER´S GUIDE

User's Guide - Parts for Tools

Screws

Shape	Designation	Dimension (in)						Torque (lbs·ft)
		a	øb	c	d	e	T / f	
 (Steel)	**CSTA-NO2**	#2-56UNC	0.157	0.236	0.157	82°	T8	0.96
	CSTA-NO2S			0.197	0.118			
	CSTA-NO2L			0.315	0.236			
	CSTA-NO3	#3-48UNC	0.169	0.276	0.157		T9	1.70
	CSTA-NO5	#5-40UNC	0.197	0.315	0.197			
	CSTA-1.6	M1.6x0.35	0.098	0.122	0.035	80°	T6	0.44
	CSTA-4	M4x0.7	0.276	0.394	0.303	82°	T15	2.58
	CSTA-5	M5x0.8	0.283	0.591	0.433			
	CSTA-5S			0.472	0.315			
	CSTA-5SS			0.374	0.217			
	CSTA-5ST25			0.472	0.315		T25	3.69
	CSPA-5IP15		0.280	0.591	0.433		15IP	2.58
	CSPA-5SIP15			0.472	0.315			
	CSPA-5IP20			0.591	0.433		20IP	3.69
	CSPA-5SIP20			0.472	0.315			
  CSP-2L033 type shown  CSTB-4SD type shown  CSTC-4L type shown (Steel)	**CSP-2L033**	M2x0.4	0.102	0.130	0.075	88°	6IP	0.52
	CSTB-2		0.106	0.130	0.055	60°	T6	0.52
	CSTB-2L			0.205	0.130			
	CSTB-2L040			0.157	0.083			
	CSTB-2.2	M2.2x0.45	0.138	0.240	0.138		T7	0.74
	CSTB-2.2L038			0.150	0.087			
	CSTB-2.2S			0.181	0.079			
	CSTB-2.2R		0.122	0.240	0.146			
	CSTB-2.5	M2.5x0.45	0.138	0.236	0.134		T8	0.96
	CSTB-2.5L080			0.315	0.213			
	CSTB-2.5B			0.217	0.102			
	CSTB-2.5S			0.189	0.087			
	CSTB-3	M3x0.5	0.161	0.315	0.177		T9	1.70
	CSTB-3L042			0.165	0.028			
	CSTB-3L050			0.197	0.079			
	CSTB-3L081		0.165	0.319	0.185		T8	0.96
	CSTB-3S		0.161	0.236	0.098		T9	1.70
	CSTB-3.5ST	M3.5x0.6	0.209	0.492	0.157		T15	2.58
	CSTB-3.5H		0.205	0.256	0.122			
	CSTB-3.5		0.217	0.331	0.169			
	CSTB-3.5T		0.256	0.394	0.217		T20	3.69
	CSTB-3.5TS			0.335	0.157			
	CSTB-3.5D		0.185	0.331	0.193		T9	1.70
	CSTB-3.5L110		0.217	0.433	0.295		T15	2.58
	CSTB-3.5L115		0.189	0.453	0.276		T10	1.84
	CSTB-3.5L115-S		0.189	0.453	0.256			2.58
	CSTB-3.5L		0.209	0.492	0.331		T15	2.58
	CSTB-4	M4x0.7	0.217	0.449	0.291			
	CSTB-4L060			0.236	0.079			
	CSTB-4L085			0.334	0.137			
	CSTB-4L090		0.224	0.354	0.217			
	CSTB-4L115-S		0.217	0.453	0.256			4.06
	CSTB-4S		0.217	0.315	0.157			2.58
	CSTB-4ST	M4x0.5	0.252	0.579				
	CSTB-4SD	M4x0.7	0.217	0.315			T8	0.96
	CSTB-4M			0.374	0.217		T15	2.58
	CSTB-4F	M4x0.5	0.276	0.579	0.343			
	CSTB-4TS	M4x0.7	0.256	0.354	0.177		T20	3.69
	CSTB-5	M5x0.8	0.276	0.472	0.295			
	CSTB-5S			0.374	0.197			
	CSTB-5L105			0.413	0.240			
	CSTB-5L120			0.472	0.256			
	CSTB-5L159		0.283	0.626	0.441			
	CSTB-5L163-S		0.272	0.642	0.445			4.43

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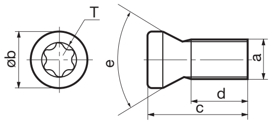
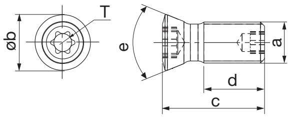
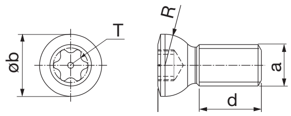
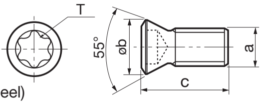
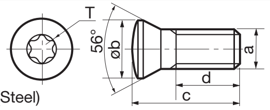
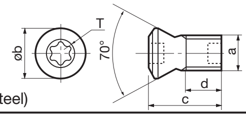
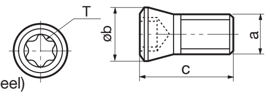
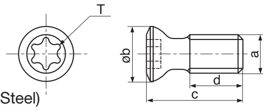
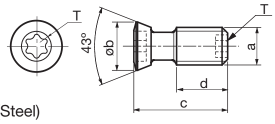
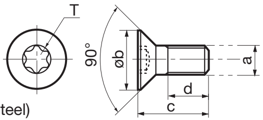
Screws

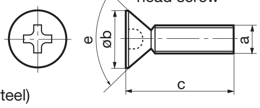
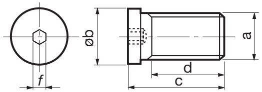
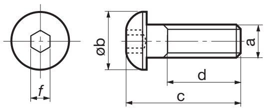
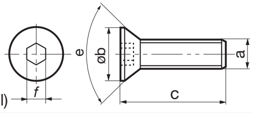
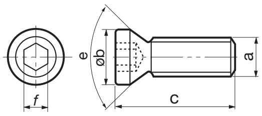
Shape	Designation	Dimension (in)						Torque (lbs·ft)
		a	øb	c	d	e / R	T / f	
	CSTC-4L055DR	M4x0.5	0.213	0.217	0.079	44°	T8/T10	0.96/1.84
	CSTC-4L055DL	M4x0.5	0.213	0.217	0.079		T8/T10	0.96/1.84
	CSTC-4L100DR	M4x0.7	0.213	0.394	0.234		T8/T10	0.96/1.84
	CSTC-4L100DL	M4x0.7	0.213	0.394	0.234		T8/T10	0.96/1.84
	CSPB-2L043	M2x0.4	0.106	0.169	0.098	60°	6IP	0.52
	CSPB-2H		0.102	0.134	0.063			
	CSPB-2.2	M2.2x0.45	0.118	0.236	0.154		7IP	0.74
	CSPB-2.2SH			0.157	0.079			0.81
	CSPB-2.5	M2.5x0.45	0.138	0.236	0.138		8IP	0.96
	CSPB-2.5S			0.165	0.067			
	CSPB-2.5SH		0.130	0.205	0.130		7IP	0.81
	CSPB-3.5	M3.5x0.6	0.205	0.354	0.220		15IP	2.58
	CSPB-3.5S	M3.5x0.6	0.205	0.256	0.122	60°	15IP	2.58
	CSPB-4	M4x0.7	0.217	0.457	0.291			
	CSPB-4S			0.323	0.157			
	CSPB-5	M5x0.8	0.276	0.472	0.295		20IP	3.69
	**VX040024A**	M4	0.215	0.354	0.236		T15	3.32
	VX040028A	M4	0.205	0.382	0.185	44°	T15	3.32
	SR14-500/L5.1	M4	0.217	0.201	0.091	60°	T15	2.58
	SR14-500-L7.0	M4	0.217	0.276	0.165		T15	2.58
	SR14-562	M3.5	0.189	0.344	0.219		T10	2.58
	SR14-562/S	M3.5	0.189	0.256	0.130		T10	2.58
	SR14-591	M5x0.8	0.260	0.531	0.299		T20	3.69
	SR34-508	M2.2x0.45	0.124	0.181	0.105		T7	0.66
	SR34-514	M2.5x0.45	0.130	0.205	0.126		T7	0.66
	**SR76-943**	M6	0.378	0.787	0.394	90°	T20	3.69
	SR76-961	M5	0.260	0.531	0.289	61°	T15	2.58
	SR76-963	M5	0.339	0.787	0.378	91°	T15	2.58
	SR-10503833-S	M2.5X0.45	0.128	0.150	0.069	60°	T7	-
SCREW TORX M4 L=9.5MM type shown	**SR 114-018-L3.40**	M2.5	0.142	0.132	0.079	56°	T6	0.52
	SM40-143-H0	M4X0.7	0.220	0.563	0.331	61°	T15	2.58
	TS25F080A	M2.25X0.35	0.146	0.272	0.083	60°	T8	0.96
	TS25064I	M2.5X0.45	0.138	0.252	0.150	50°	T8	0.96
	TS30F100A	M3X0.35	0.181	0.327	0.087	60°	T10	1.84
	TS30085I/HG	M3X0.5	0.169	0.335	0.220		T9	1.70
	TS30C72I	M3X0.5	0.165	0.283	0.177		T9	1.70
	TS40085I/HG	M4	0.224	0.335	0.177		T15	2.58
	TS35085I/HG	M3X0.6	0.209	0.335	0.169		T15	2.58
	**TS40093I/HG**	M4	0.224	0.366	0.169		T15	2.58
	TS40B100I	M4	0.236	0.394	0.236	R = 3.0	T15	2.58
	TS40F120A	M4X0.5	0.236	0.417	0.118	60°	T15	2.58
	TS45120I	M4.5	0.272	0.472	0.295	R = 3.5	T20	3.69
TS40B100I, TS45120I shown	**TS50115I**	M5	0.276	0.447	0.252	60°	T20	3.69
	TS50230D3	M5X0.8	0.276	0.906	0.531		T20	-
	TS50250D35	M5X0.8	0.295	0.984	0.571		T25	-
	TS50F160A	M5X0.5	0.276	0.547	0.138		T20	3.69
	TS60265D4	M6X1.0	0.315	1.043	0.610		T25	-
	TS60285D42	M6X1.0	0.335	1.122	0.657		T25	-
	TS60320D5	M6X1.0	0.374	1.220	0.709		T25	-
	TS60F200A	M6X0.75	0.323	0.657	0.177		T20	5.16
	TS70F250A	M7X0.75	0.394	0.827	0.220		T25	5.16
(Steel)	**TS80340D6**	M8X1.25	0.394	1.339	0.787		T25	-
	TS80F300A	M8X1.0	0.472	0.984	0.287		T30	7.38

User's Guide - Parts for Tools

Screws

Shape	Designation	Dimension (in)						Torque (lbs·ft)
		a	øb	c	d	e	T / f	
 (Steel)	**CSPD-1.8S**	M1.8x0.35	0.094	0.130	0.055	55°	6IP	0.52
	CSTD-3T	M3x0.5	0.169	0.276	0.177		T10	1.84
	CSPD-3				0.165		10IP	1.84
 (Steel)	**CSTB-4.5L110P**	M4.5X0.75	0.260	0.461	0.276	56°	T15	2.58
 (Steel)	**SRM5X0.8IP20X+ACROLYTE**	M5X0.8	0.362	0.591	0.386	70°	20IP	5.53
 (Steel)	**CSTC-2**	M2x0.4	0.122	0.201	-	-	T6	0.52
 (Steel)	**CSTR-4L100**	M4x0.7	0.224	0.394	0.217	-	T15	2.58
 (Steel)	**SR16-212-01397**	M5x0.8	0.252	0.492	0.268	43°	T20/T10	1.84
	SR16-212-01397L							
 (Steel) Cross recessed head screw	**CST-3.5**	M3.5X0.6	0.236	0.189	-	90°	T9	1.70
	CST-3.5S			0.138	-			
	CST-5	M5x0.8	0.394	0.709	0.512		T25	3.69
	CST-5S			0.472	0.276			
	CSTF-2L055-S	M2x0.4	0.106	0.217	0.150		T6	0.52

Screws

Shape	Designation	Dimension (in)						Torque (lbs·ft)
		a	øb	c	d	T / f	e	
Cross recessed head screw  (Steel)	**SM2.5×0.45×8**	M2.5x0.45	0.197	0.315	-	-	90°	-
	SM2.5×0.5×8	M2.5x0.5	0.197	0.315	-	-	90°	-
	SM3×0.5×6	M3x0.5	0.236	0.236	-	-	90°	-
	SM3×0.5×8			0.315	-	-	90°	-
	SM3×0.5×10			0.394	-	-	90°	-
 (Steel)	**MSP-5**	M5x0.8	0.240	0.311	0.193	0.079		1.11
	MSP-6.3	M6.3x1	0.303	0.500	0.390	0.098		2.21
 (Steel)	**BHM3-8**	M3x0.5	0.217	0.394	0.315	0.079		1.11
	BHM4-8	M4x0.7	0.276	0.417		0.098		1.62
	BHM4-10			0.496	0.394			
	BHM5-14	M5x0.8	0.354	0.693	0.551	0.118		2.21
	BHM6-20-A	M6x1.0	0.413	0.945	0.787	0.157		3.69
	BHM8-25U	M8	0.551	1.154	0.984	0.197		6.27
	BHM8-30U			1.350	1.181			
 (Steel)	**CSHM-3-8**	M3	0.236	0.315	-	0.079	90°	1.11
 (Steel)	**CSHB-4-A**	M4	0.217	0.433	-	T15	60°	1.48
	CSHB-6	M6	0.335	0.748		0.157	60°	3.69
	CSHB-6-A	M6	0.335	0.748				3.69

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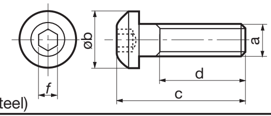
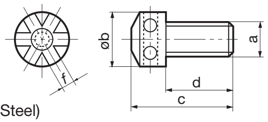
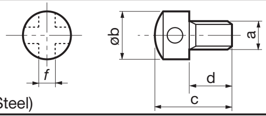
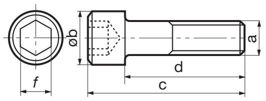
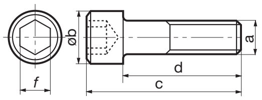
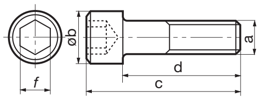
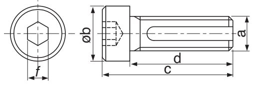
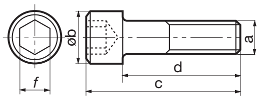
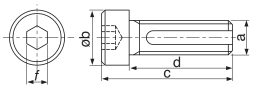
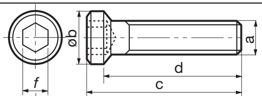
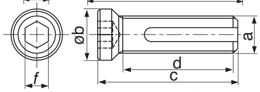
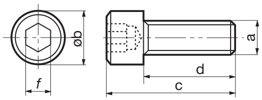
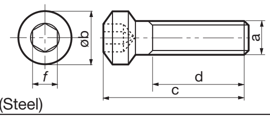
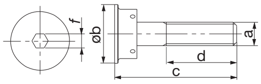
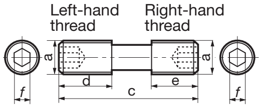
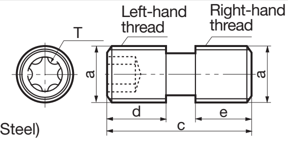
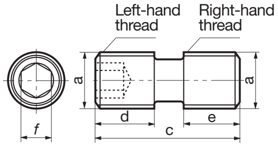
Screws

Shape	Designation	Dimension (in)						Torque (lbs·ft)
		a	øb	c	d	T / f		
 (Steel)	**RT-1**	M6	0.394	0.886	0.551	0.157		3.69
	RT-2	M8	0.512	1.220	0.787	0.197		6.27
 (Steel)	**ASM6**	M6	0.394	0.709	0.472	0.118		-
	AJM5F	M5x0.5	0.354	0.512	0.315	0.079		-
	AJM5	M5x0.8	0.354	0.512	0.315	0.079		-
 (Steel)	**ASM34S**	M3	0.189	0.315	0.197	0.079		-
	ASM34L			0.433	0.315			-
	ASM54	M5x0.8	0.354	0.551	0.354	0.118		-
 (Steel)	**CHHM3.5-10**	M3.5x0.6	0.236	0.531	0.394	0.118		2.21
	CHHM4-10	M4x0.7	0.276	0.551				
	CHHM5-14	M5x0.8	0.335	0.748	0.551	0.157		3.69
	CHHM5-18			0.906	0.709			
	CHHM6-15	M6	0.394	0.827	0.591	0.197		6.27
	CHHM6-20			-	0.787			
	CHHM6-25			1.220	0.984			
 Hex. socket head screw (JISB1176) (Steel)	**CM3X0.5X6**	M3x0.5	0.217	0.354	0.236	0.098		1.62
	CM3X0.5X10			0.512	0.394			
	CM4X0.7X10	M4x0.7	0.276	0.551		0.118		2.21
	CM4X0.7X12			0.630	0.472			
	CM4X0.7X14			0.709	0.551			
	CM4X0.7X15			0.748	0.591			
	CM4X0.7X20			0.945	0.787			
	CM4X0.7X20-M0-A		0.236	0.945	0.787			
	CM5X0.8X8	M5x0.8	0.335	0.512	0.315	0.157		3.69
	CM5X0.8X10-A			0.591	0.394			
	CM5X0.8X12			0.669	0.472			
	CM5X0.8X12-A			0.669	0.472			
	CM5X0.8X14			0.709	0.551			
	CM5X0.8X16			0.827	0.630			
	CM5X0.8X16-A			0.827	0.630			
	CM5X0.8X18			0.906	0.709			
	CM5X0.8X20-A			0.984	0.787			
	CM5X0.8X25-A			1.181	0.984			
	CM5X15	M5		0.787	0.591			
 Hex. socket head screw (JISB1176)	**CM6X1X16-A**	M6x1.0	0.394	0.866	0.630	0.197		6.27
	CM6X1X20-A			1.024	0.787			
	CM6X1X25-A			1.220	0.984			
	CM6X1.0X40-A			1.811	1.575			
	CM6X10	M6		0.630	0.394			
	CM6X15			0.827	0.591			
	CM6X16			0.866	0.630			
	CM6X20			1.024	0.787			
	CM6X25			1.220	0.984			
	CM6X30-S	M6x1.0	0.394	1.406	1.102			
	CM8X1.25X20-A	M8x1.25	0.512	1.102	0.787	0.236		18.44
	CM8X1.25X25-A			1.299	0.984			
	CM8X30H			1.417	1.181	0.197		
 **CM***H**	**CM10X30**	M10x1.5	0.630	1.181	0.787	0.315		29.50
	CM10X30H		0.630	1.496	1.181	0.236		29.50
	CM12X30H	M12x1.75	0.709	1.575		0.315		51.63
	CM16X40H	M16x2	0.945	2.126	1.575	0.394		73.75
	CM16x75	M16	0.945	2.953	2.008	0.551		73.75
	CM16x120	M16	0.945	4.724	3.780	0.551		73.75
	CM16x140	M16	0.945	5.512	4.567	0.551		73.75

User's Guide - Parts for Tools

Screws

Shape	Designation	Dimension (in)							Torque (lbs·ft)
		a	øb	c	d	e	T / f		
 Hex. socket head screw (JISB1176)  CM***H (Steel)	**CM20x80**	M20	1.181	3.150	1.969		0.669		110.63
	CM20x120	M20	1.181	4.724	3.543		0.669		110.63
	CM20x150	M20	1.181	5.906	4.724		0.669		110.63
	CAP-CM12x1.75x50	M12	0.709	1.969	1.496		0.394		51.63
	CAP-CM16X2.0X55	M16	0.945	2.165	1.535		0.551		29.50
	CAP-CM20X2.5X50	M20	1.181	1.969	1.181		0.669		73.75
	C0.375X1.125H	3/8-24UNF	0.562	1.500	1.125		0.219		25.81
	C0.500X1.375H	1/2-20UNF	0.750	1.875	1.375		0.313		51.63
	SD06-A3	M10x1.5	0.630	2.756	2.362		0.315		29.50
	SRM6X16DIN912-12.9	M6x1	0.394	0.866	0.555		0.197		
	VC00TEDI12040F	M12	1.024	2.008	1.575		0.315		44.25
	VC00TEDI20040F	M20	1.929	1.969	1.358		0.472		110.63
	VC00TANG16040F	M16	1.811	1.831	1.299		0.394		44.25
	SD08-98	M12x1.75	0.709	3.031	2.559		0.394		51.63
	LHM12x1.75x30-C	M12	0.709	1.453	1.181		0.315		51.63
	VC004762I10035F	M10	0.630	1.772	1.358		0.315		44.25
	FCS3	M3x0.5	0.217	0.630	0.472		0.098		
	FCS6	M6x1	0.394	1.024	0.787		0.197		
  (Steel) FSHM*-*H	**FSHM8-30**	M8x1.25	0.433	1.181	1.063		0.197		18.44
	FSHM8-30H								18.44
	FSHM10-40	M10	0.551	1.575	1.437		0.236		29.50
	FSHM10-40H								29.50
 (Steel)	**SHCM4-10**	M4x0.7	0.236	0.551	0.394		0.118		2.21
	SHCM4-12			0.630	0.472				
	SHCM4-16			0.787	0.630				
 (Steel)	**CTS-M6**	M6x1	0.394	0.984	0.646		0.157		3.69
 (Steel)	**RSFTS-050M**	M10	0.984	2.047	1.673	0.827	0.236		
 (Steel)	**MCS520-2.5**	M5×0.8		0.787	0.276	0.236	0.098		2.21
	MCS620-3	M6×1				0.276	0.118		4.43
	MCS625-3			0.984	0.394	0.315			
	MCS825-4	M8×1			0.492	0.256	0.157		5.90
	MCS828-4			1.122	0.472	0.413			
	NDS-8A			1.181	0.453	0.453			
	NDS-8S	M8×1.25		0.787	0.315	0.315			
	RSRGR5M40	M4		0.354	0.144	0.164	T8		
	SR PS 118-0273	M10		1.575	0.650	0.591	0.197		29.50
	SR 5/16-32UNEF_3/8-24UNF	5/16-32UNEF-2A		1.260	0.394	0.453	0.156		
 (Steel)	**DS-5T**	M5×0.8		0.472	0.197	0.197	T10		2.58
	DS-6T	M6		0.591	0.236	0.236	T15		2.58
	DS-6P	M6×1		0.827	0.276	0.276	15IP		4.43
	FDS-8ST	M8×1		0.787	0.315	0.315	T27		7.38
	FDS-8ST-18			0.709		0.236			
 (Steel)	**DS-6**	M6×1		0.591	0.236	0.236	0.118		4.43
	DS-8	M8×1.25		0.630	0.276	0.276	0.157		5.90
	DS-8S			0.512	0.217	0.217			
	DS-10	M10×1.5		1.024	0.394	0.472	0.197		5.90
	FDS-6Z	M6×0.75		0.807		0.217	0.118		4.43
	FDS-8	M8×1		1.024		0.394	0.157		5.90
	FDS-8S			0.787	0.315	0.315			
	FDS-8SS			0.728		0.256			

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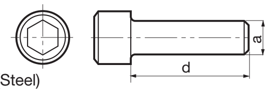
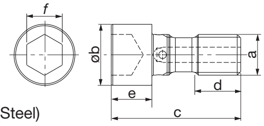
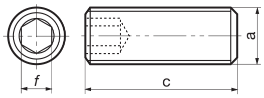
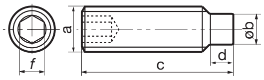
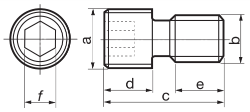
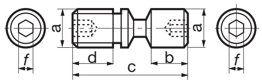
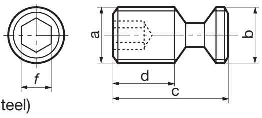
Screws

Shape	Designation	Dimension (in)						Torque (lbs·ft)
		a	øb	c	d	e	T / *f*	
 (Steel)	**SS100**	1/4-20UNC			0.750			
	S-412	10-32UNF			0.750			
 (Steel)	**SHM8x1.25x35-C**	M8	0.512	1.693	0.906	0.315	0.236	18.44
	SHM10x1.5x30-C	M10	0.630	1.575	0.669	0.394	0.315	29.50
	SHM16x2x35-C	M16	0.945	2.008	0.709	0.630	0.551	73.75
	SHM20x2.5x40-C	M20	1.181	2.283	0.787	0.709	0.669	110.63
 Hex. socket screw (Flat end)(JISB1177) (Steel)	**SSHM2.5-3**	M2.5		0.118			0.059	0.74
	SSHM3-3	M3		0.118				
	SSHM3-4			0.157				
	SSHM3-6			0.236				
	SSHM4-4	M4		0.157			0.079	1.11
	SSHM4-5			0.197				
	SSHM4-6			0.236				
	SSHM4-8			0.315				
	SSHM4-10			0.394				
	SSHM4-14			0.551				
	SSHM5-6	M5		0.236			0.098	1.48
	SSHM5-10			0.394				
	SSHM5-16			0.630				
	SSHM6-12	M6		0.472			0.118	2.21
	SSHM6-16			0.630				
	SSHM6-18			0.709				
	SSHM6-20			0.787				
	SSHM8-8	M8		0.315			0.157	3.69
	SSHM8-10			0.394				
	SSHM8-12			0.472				
	SSHM8-14			0.551				
	SSHM8-16			0.630				
	SSHM8-18			0.709				
 Hex. socket screw (Cylindrical end) (JISB1177) (Steel)	**M5×7**	M5	0.138	0.276	0.049		0.098	1.48
	M5×8			0.315				
	M5×10			0.394				
	M6×30	M6	0.157	1.181	0.059	-	0.118	2.21
 (Steel)	**JDS-3525**	M3.5x0.35	M2.5 x0.45	0.295	0.118	0.098	0.079	0.74
	JDS-5040	M5x0.5	M4 x0.7	0.394	0.157	0.157	0.098	0.74

Screws

Shape	Designation	Dimension (in)						Torque (lbs·ft)
		a	b	c	d	e	T / *f*	
 LCS2 has a hex. socket in threaded end only. (Steel)	**LCS2**	M5	0.197	0.551	0.256		0.079	1.11
	LCS3	M6	0.236	0.669			0.098	1.48
	LCS3B			0.591				
	LCS4	M8	0.315	0.827			0.118	2.21
	LCS4K				0.378			
	LCS4CA			0.689	0.256			
	LCS5			0.984	0.335			
	LCS5CA			0.807				
	LCS6	M10	0.386	1.071	0.390		0.157	3.69
	LCS8	M12	0.465	1.417	0.504		0.197	5.90
	LCS8C	M10	0.386	1.189	0.524		0.157	3.69
 (Steel)	**LCS22**	M5	M5	0.394	0.185		0.079	1.11
	LCS22A	M6	M6	0.421				
	LCS23A	M5	M5	0.516	0.201		0.098	1.48
	LCS33	M5	M5	0.472	0.244		0.079	1.11
	LCS43	M6	M6	0.531	0.287		0.098	1.48

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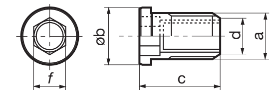
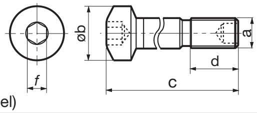
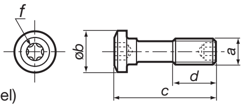
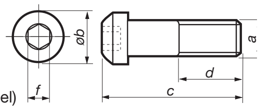
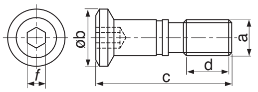
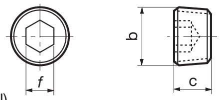
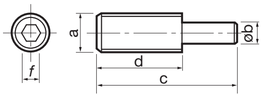
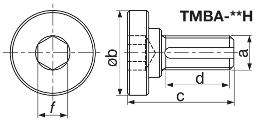
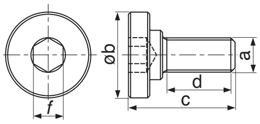
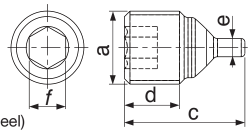
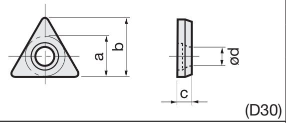
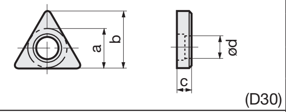
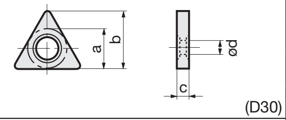
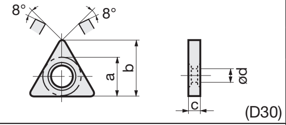
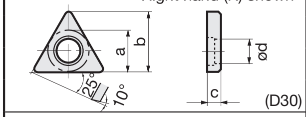
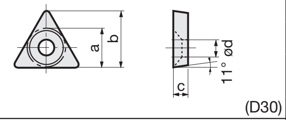
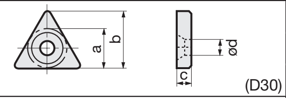
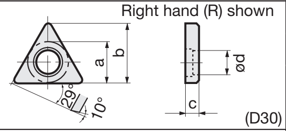
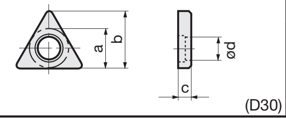
Shape	Designation	Dimension (in)						Torque (lbs·ft)
		a	b	c			T / f	
 (Steel)	**DTS5-3.5**	M5	0.248	0.341	M3.5		0.138	2.95
	DTS5-3.5SS			0.268				
	DTS5-3.5S			0.276				
	DTS6-4	M6	0.303	0.402	M4		0.157	3.69
	DTS6-4.5		0.295	0.394	M4.5		0.177	3.69
 (Steel)	**DLCS33**	M5	0.354	1.240	0.394		0.118	2.21
	DLCS43	M6	0.472	1.339	0.374		0.157	3.69
	DLCS54	M8x1	0.551	1.614	0.433			5.16
	DLCS64	M10x1	0.630	1.969	0.591		0.197	5.90
 (Steel)	**ACS-5W**	M5	0.315	0.787	0.335		T15	2.95
	ACS-6W	M6	0.394	1.024	0.476		T20	4.72
 (Steel)	**ACS3**	M5x0.8	0.295	1.010	12-15 (mm)		0.118	2.95
	ACS4	M6x1	0.354	1.090	14-17 (mm)		0.157	5.16
 (Steel)	**WCS3**	M6	0.374	0.886	0.315		0.118	2.21
 (Steel)	**PT1/4GN**		0.519	0.394	-		0.236	7.01
	1/8-28		0.383	0.276	-		0.197	5.90
 (Steel)	**LS-8**	M8	0.236	1.299	0.787		0.157	3.69
  (Steel)	**TMBA-M10**	M10x1.5	1.063	1.181	0.827		0.315	29.50
	TMBA-M12	M12x1.75	1.299	1.417	1.024		0.394	51.63
	TMBA-M12H	M12x1.75		1.358			0.315	
	TMBA-M16	M16x2	1.575	1.969	1.575		0.551	73.75
	TMBA-M16H	M16x2						
	TMBA-M20	M20x2.5	1.969	2.205	1.654		0.669	110.63
	TMBA-M20H	M20x2.5						
	TMBA-M24	M24x3	2.559	2.717	2.165		0.748	110.63
	TMBA-M24H	M24x3						
	TMBA-0.500H	1/2-20UNF	1.299	1.335	1.000		0.313	51.63
	TMBA-0.625S.375H	5/8-11UNF	1.484	2.256	1.750		0.313	75
	TMBA-0.750H	3/4-16UNF	1.969	2.294	1.861		0.500	110.63
	TMBA-0.750S.375H	3/4-16UNF	1.875	1.700	1.310		0.375	75.00
 (Steel)	**SR-10400611**	M4X0.5		0.260	0.118	0.039	0.079	

User's Guide - Parts for Tools

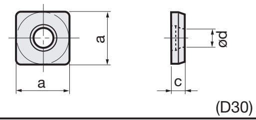
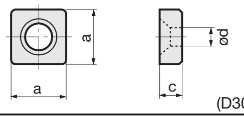
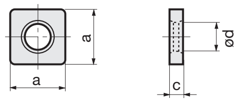
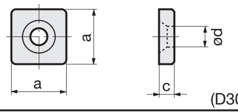
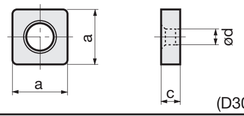
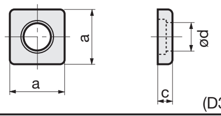
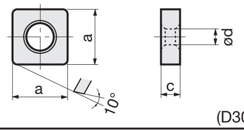
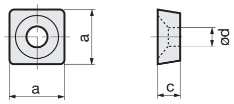
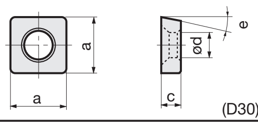
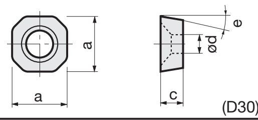
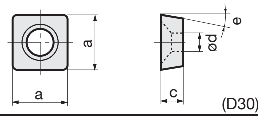
Shims

Shape	Designation	Dimension (in)				
		a	b	c	ød	
	**AST322**	0.366	0.520	0.126	0.173	
	AST422	0.492	0.709			
	**MST-322**	0.358	0.508	0.128	0.228	
	MST-432	0.492	0.705	0.189	0.287	
	MST-533	0.614	0.874		0.382	
	MST-644	0.740	1.047	0.252	0.445	
	**LST317**	0.366	0.520	0.106	0.197	
	LST42	0.492	0.709	0.126	0.264	
	LST53	0.618	0.878	0.189	0.303	
	LST42K	0.429	0.614	0.126	0.264	
	**LST317CA**	0.366	0.520	0.106	0.197	
	LST42CA	0.492	0.709	0.126	0.264	
Right hand (R) shown 	**ELST42**	0.453	0.650	0.126	0.256	
	ELST317	0.335	0.472	0.106	0.193	
	ELST317BR					
	ELST317BL					
	**PAT-32**	0.323	0.461	0.126	0.138	
	***PAT-53**	0.528	0.780	0.189	0.197	
	**NAT-32**	0.374	0.528	0.126	0.138	
	NAT-42E	0.488	0.701		0.122	
Right hand (R) shown 	**LST317BR**	0.366	0.520	0.106	0.197	
	LST317BL					
	**SST32**	0.335	0.469	0.126	0.213	

Note: * marked shims are made of steel.

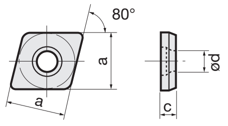
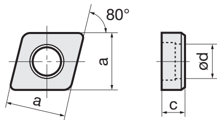
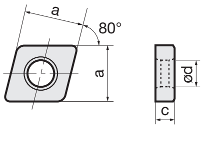
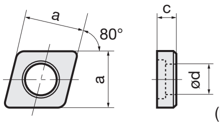
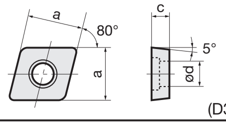
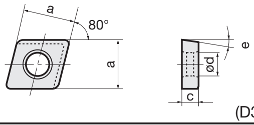
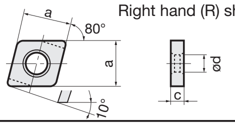
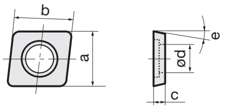
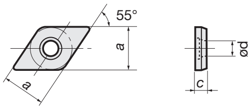
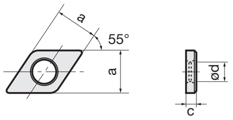
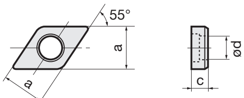
User's Guide - Parts for Tools

Shims

Shape	Designation	Dimension (in)				
		a	b	c	ød	e
 (D30)	**ASS422**	0.492		0.126	0.173	
	CS44-A			0.185		
 (D30)	**ASS533**	0.618		0.189	0.217	
	ASS634	0.744				
 (D30)	**ELSS32**	0.335		0.126	0.193	
	LSS33	0.366		0.169	0.197	
	ELSS42	0.461		0.126	0.256	
	LSS42	0.492			0.264	
	ELSS53	0.579		0.189	0.315	
	LSS53	0.618			0.303	
	ELSS63	0.705			0.382	
	LSS63	0.744				
	ELSS84	0.953		0.252	0.508	
	LSS84	0.992			0.516	
 (D30)	**NAS-42**	0.500		0.126	0.138	
	NAS-04	1.240		0.252	0.358	
 (D30)	**MSS-432**	0.492		0.189	0.287	
	MSS-442			0.252		
 (D30)	**SSS32**	0.335		0.126	0.213	
Right hand (R) shown  (D30)	**LSS42BR**	0.492		0.126	0.264	
	LSS42BL					
 (D30)	**PAS-32**	0.323		0.126	0.118	
	PAS-42	0.449			0.138	
	***PAS-63**	0.669		0.189	0.197	
 (D30)	**LSS42CA**	0.492		0.126	0.264	8°
	LSS53CA	0.618		0.189	0.303	10°
 (D30)	**FSSA1102**	0.457		0.079	0.217	13°
 (D30)	**FSSP1102**	0.433		0.079	0.217	17°

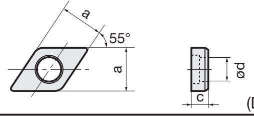
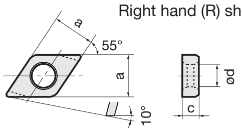
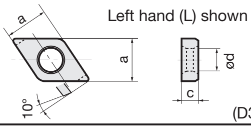
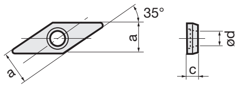
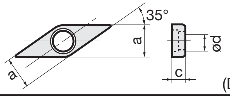
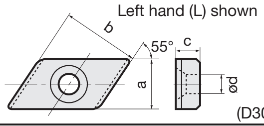
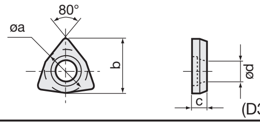
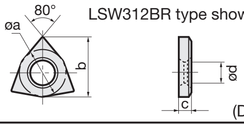
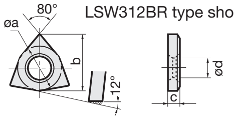
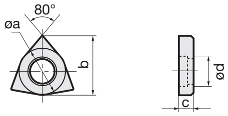
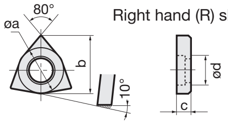
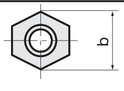
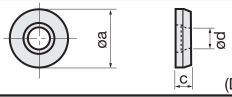
Note: * marked shims are made of steel.

User's Guide - Parts for Tools

Shape	Designation	Dimension (in)				
		a	b	c	ød	e
 (D30)	**ASC322**	0.366		0.126	0.173	
	ASC422	0.492				
	ASC533	0.618		0.189	0.217	
	ASC634	0.744				
	CC44-A	0.492		0.185		
 (D30)	**MSC-432**	0.492		0.189	0.287	
	MSC-442			0.252		
	MSC-533	0.614		0.189	0.382	
	MSC-543			0.252		
	MSC-634	0.740			0.445	
 (D30)	**ELSC32**	0.335		0.126	0.244	
	LSC42	0.492			0.256	
	ELSC42	0.461				
	LSC53	0.618		0.189	0.303	
	ELSC53	0.579			0.319	
	ELSC63	0.705			0.382	
	LSC63	0.744				
	LSC317	0.366		0.106	0.197	
 (D30)	**SSC32**	0.335		0.126	0.213	
	SSC4T3	0.449		0.157	0.260	
 (D30)	**SSC4T3-P**	0.449		0.157	0.260	5°
	SSC54-P	0.528				5°
 (D30)	**LSC42CA**	0.492		0.126	0.264	8°
	LSC53CA	0.618		0.189	0.303	10°
Right hand (R) shown  (D30)	**LSC42BR**	0.492		0.126	0.264	
	LSC42BL					
 (D30)	**ZSA1102**	0.413	0.433	0.079	0.216	11°
	ZSA1502	0.614	0.488		0.236	11°
 (D30)	**ASD322**	0.366		0.126	0.173	
	ASD423	0.492		0.126	0.173	
	ASD432	0.492		0.189	0.173	
	CD44-A	0.492		0.185		
 (D30)	**ELSD32**	0.335		0.126	0.193	
	ELSD42	0.461			0.256	
	LSD42	0.492			0.264	
	LSD42A					
	LSD43			0.189		
	LSD43A					
 (D30)	**MSD-322**	0.366		0.126	0.228	
	MSD-432	0.492		0.189	0.287	
	MSD-442			0.252		

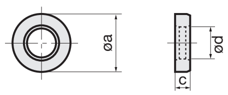
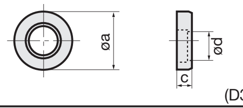
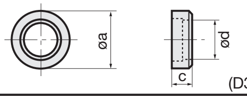
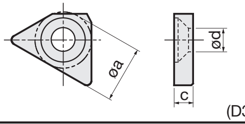
User's Guide - Parts for Tools

Shims

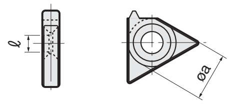
Shape	Designation	Dimension (in)				
		a	b	c	ød	
 (D30)	**SSD32**	0.335		0.126	0.213	
Right hand (R) shown  (D30)	**ELSD317BR**	0.335		0.106	0.193	
	ELSD317BL					
	LSD42BR	0.492		0.126	0.264	
	LSD42BL					
Left hand (L) shown  (D30)	**LSZ42BR**	0.492		0.126	0.264	
	LSZ42BL					
 (D30)	**ASV222**	0.274		0.125	0.130	
	ASV322	0.366		0.126	0.173	
	CV34-A	0.366		0.185		
	LSV212	0.281		0.087	0.195	
 (D30)	**MSV-322**	0.365		0.126	0.228	
	SSV32	0.331			0.213	
	SSV42	0.433			0.248	
Left hand (L) shown  (D30)	**CSK54R**	0.370	0.583	0.189	0.138	
	CSK54L					
 (D30)	**ASW322**	0.367	0.453	0.126	0.173	
	ASW422	0.492	0.598			
LSW312BR type shown  (D30)	**LSW312**	0.367	0.453	0.106	0.197	
	LSW42	0.492	0.610	0.126	0.264	
LSW312BR type shown  (D30)	**LSW312BR**	0.367	0.453	0.106	0.197	
	LSW312BL					
 (D30)	**MSW-432**	0.504	0.622	0.189	0.287	
	MSW-533	0.630	0.776		0.382	
	MSW-633	0.756	0.933		0.445	
Right hand (R) shown  (D30)	**MSW-432BR**	0.504	0.622	0.189	0.287	
	MSW-432BL					
 (D30)	**CH44-A**		0.492	0.185		
 (D30)	**ASR420**	0.492		0.126	0.173	

User's Guide - Parts for Tools

Shims

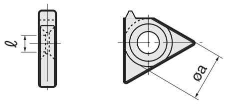
Shape	Designation	Dimension (in)				
		øa	b	c	ød	
 (D30)	**LSR32**	0.350		0.126	0.197	
	LSR32C	0.331				
	LSR42	0.476			0.264	
	LSR42C	0.390			0.197	
	LSR53C	0.551		0.189	0.264	
	LSR63C	0.677			0.323	
	LSR84C	0.862		0.252	0.382	
 (D30)	**MSR-43**	0.492		0.189	0.287	
	MSR-44			0.252		
 (D30)	**SSR32**	0.343		0.125	0.205	
Right hand (R) shown  (D30)	**G16EL/IR**	0.374		0.126	0.157	
	G16ER/IL			0.126		
	G16EL/IR-DT			0.156	0.213	
	G16ER/IL-DT			0.156		

Shims

Shape	Designation	Dimension (in)		
		øa	ℓ	Lead angle
 (D30)	**AE16-4DT**	0.374	0.213	4°
	AE16-3DT		0.213	3°
	AE16-2DT		0.213	2°
	A16-1DT		0.213	1°
	AE16-0DT		0.213	0°
	AE16-99DT		0.213	-1°
	AE16-98DT		0.213	-2°
	AE16-4		0.157	4°
	AE16-3		0.157	3°
	AE16-2		0.157	2°
	A16-1		0.169	1°
	AE16-0		0.157	0°
	AE16-99		0.157	-1°
	AE16-98		0.157	-2°
	AN16-4DT	0.374	0.213	4°
	AN16-3DT		0.213	3°
	AN16-2DT		0.213	2°
	AN16-0DT		0.213	0°
	AN16-99DT		0.213	-1°
	AN16-98DT		0.213	-2°
	AN16-4		0.157	4°
	AN16-3		0.157	3°
	AN16-2		0.157	2°
	AN16-0		0.157	0°
	AN16-99		0.157	-1°
	AN16-98		0.157	-2°

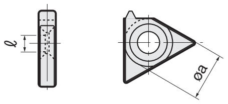
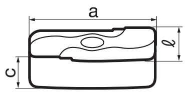
User’s Guide - Parts for Tools

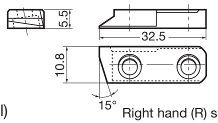
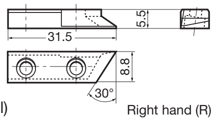
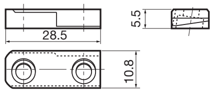
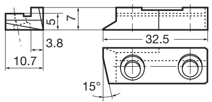
Shims

Shape	Designation	Dimension (in)		
		øa	ℓ	Lead angle
	GXE16-98	0.374	0.157	-2°
	GXE16-98DT		0.213	-2°
	GXE16-99		0.157	-1°
	GXE16-99DT		0.213	-1°
	GXE16-0		0.157	0°
	GXE16-0DT		0.213	0°
	GXE16-1		0.169	1°
	GX16-1DT		0.213	1°
	GXE16-2		0.157	2°
	GXE16-2DT		0.213	2°
	GXE16-3		0.157	3°
	GXE16-3DT		0.213	3°
	GXE16-4		0.157	4°
	GXE16-4DT		0.213	4°
	GXE22-98DT	0.500	0.260	-2°
	GXE22-99DT			-1°
	GXE22-0DT			0°
	GX22-1DT			1°
	GXE22-2DT			2°
	GXE22-3DT			3°
	GXE22-4DT			4°
	GXN16-98	0.374	0.157	-2°
	GXN16-98DT		0.213	-2°
	GXN16-99		0.157	-1°
	GXN16-99DT		0.213	-1°
	GXN16-0		0.157	0°
	GXN16-0DT		0.213	0°
	GXN16-1		0.169	1°
	GXN16-2		0.157	2°
	GXN16-2DT		0.213	2°
	GXN16-3		0.157	3°
	GXN16-3DT		0.213	3°
	GXN16-4		0.157	4°
	GXN16-4DT		0.213	4°
	GXN22-98DT	0.500	0.260	-2°
	GXN22-99DT			-1°
	GXN22-0DT			0°
	GXN22-2DT			2°
	GXN22-3DT			3°
	GXN22-4DT			4°

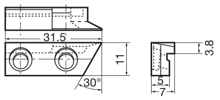
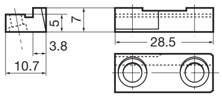
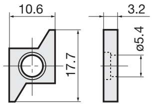
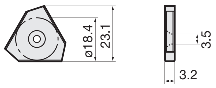
User's Guide - Parts for Tools

Shims

Shape	Designation	Dimension (in)				
		a	øa	ℓ	c	Lead angle
 (D30)	NXE22-98		0.500	0.157		-2°
	NXE22-99					-1°
	NXE22-0					0°
	NXE22-1			0.177		1°
	NXE22-2			0.157		2°
	NXE22-3					3°
	NXE22-4					4°
	NXE27-98		0.626	0.157		-2°
	NXE27-99					-1°
	NXE27-0					0°
	NXE27-1			0.177		1°
	NXE27-2			0.157		2°
	NXE27-3					3°
	NXE27-4					4°
	NXN22-98		0.500	0.157		-2°
	NXN22-99					-1°
	NXN22-0					0°
	NXN22-1			0.177		1°
	NXN22-2			0.157		2°
	NXN22-3					3°
	NXN22-4					4°
	NXN27-98		0.626	0.157		-2°
	NXN27-99					-1°
	NXN27-0					0°
	NXN27-1			0.177		1°
	NXN27-2			0.157		2°
	NXN27-3					3°
	NXN27-4					4°
 (D30)	TSL12R	0.472		0.185	0.177	4.5°
	TSL12L	0.472		0.185	0.177	4.5°
	TSL16R	0.626		0.252	0.197	5°
	TSL16L	0.626		0.252	0.197	5°
	TSL24R	0.937		0.370	0.280	7°
	TSL24L	0.937		0.370	0.280	7°
	TSL12RI	0.421		0.185	0.177	4.5°
	TSL12LI	0.421		0.185	0.177	4.5°
	TSL16RI	0.740		0.252	0.197	5°
	TSL16LI	0.740		0.252	0.197	5°

Shape	Designation
 (Steel) Right hand (R) shown	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

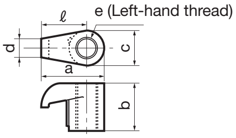
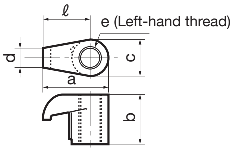
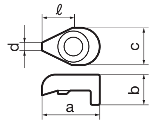
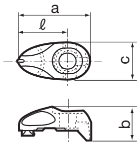
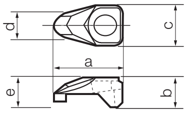
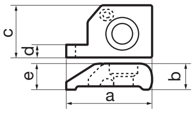
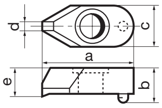
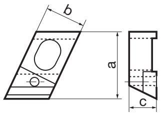
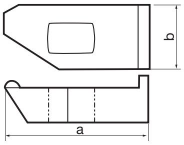
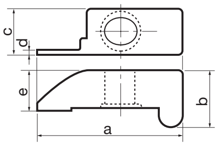
(Unit: mm)

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

(Unit: mm)

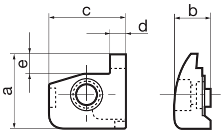
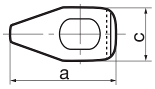
User's Guide - Parts for Tools

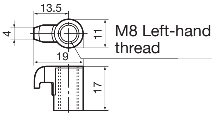
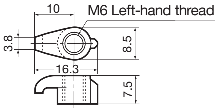
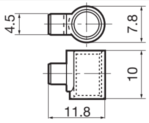
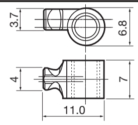
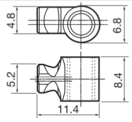
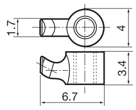
Clamps

Shape	Designation	Dimension (in)					
		a	b	c	d	e	ℓ
 (Steel)	**MCL-5M**	0.579	0.433	0.307	0.157	M5	0.425
	MCL-6	0.732	0.453	0.374		M6	0.543
	MCL-8S	0.752	0.531	0.429	0.197	M8	0.535
	MCL-8M	0.886					0.669
	MCL-8L	1.004	0.571		0.157		0.787
 (Steel)	**MCPM-6**	0.579	0.441	0.311	0.157	M5	0.425
	MCPM-9	0.752	0.661	0.429	0.197	M8×1	0.535
	MCPM-12	0.886					0.669
	MCPM-20	0.732	0.374	0.374	0.157	M6	0.543
	MCPM-21		0.480				
	MCPM-22	0.846	0.520				0.657
	MCPM-30	1.004	0.661	0.429	0.197	M8×1	0.787
 (Steel)	**DCPM-33**	0.630	0.366	0.413	0.094		0.335
	DCPM-43	0.835	0.453	0.531	0.118		0.520
	DCPM-54	1.016	0.600	0.551	0.138		
	DCPM-64	1.118	0.610	0.630	0.157		
 (Steel)	**ACP3S**	0.898	0.374	0.394			0.591
	ACP3S-E	0.854	0.374	0.394			0.547
	ACP3L-3	1.038	0.472	0.512			0.723
	ACP4S	1.012	0.472	0.512			0.697
	ACP5S	1.185	0.508	0.591	-	-	0.815
	ACP6S	1.315	0.504	0.650	-	-	0.945
 (Steel)	**ACP3**	0.705	0.394	0.394	0.256	0.248	
	ACP4	1.020	0.547	0.472	0.276	0.425	
 (Steel) Right hand (R) shown	**CTC-3R**	1.142	0.346	0.630	0.087	0.315	
	CTC-3L						
	CTC-4R			0.669	0.126		
	CTC-4L						
	CTC-5R			0.709	0.165		
	CTC-5L						
 (Steel)	**CP81A**	1.102	0.413	0.472	0.138	0.315	
	CP81B						
 (Steel) TC-3 type shown, TC-4 : Left-hand thread	**TC-3**	0.748	0.492	0.327			
	TC-4	0.850		0.315			
 (Steel)	**TF-72**	0.866	0.445				
	TF-73	0.866	0.445				
	TF-184	0.866	0.445				
	TF-185	0.866	0.445				
 (Steel)	**CCR2**	1.366	0.587	0.421	0.047	0.413	
	CCL2						
	CCR3				0.087		
	CCL3						
	CCR4				0.110		
	CCL4						
	CCR5				0.126		
	CCL5						
	CCR6				0.154		
	CCL6						
	CCR8				0.193		
	CCL8						

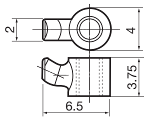
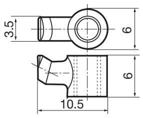
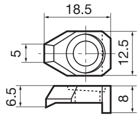
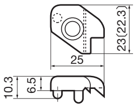
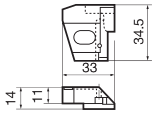
User's Guide - Parts for Tools

Clamps

Shape	Designation	Dimension (in)					
		a	b	c	d	e	
 Right hand (R) shown (Steel)	CFG-3SR	0.866	0.433	0.909	0.079	0.236	
	CFG-3SL						
	CFG-4SR				0.118		
	CFG-4SL						
	CFG-4DR	1.260				0.630	
	CFG-4DL						
	CFG-5SR	0.866			0.157	0.236	
	CFG-5SL						
	CFG-5DR	1.260				0.630	
	CFG-5DL						
	CFG-6SR	0.906			0.197	0.276	
	CFG-6SL						
	CFG-6DR	1.299				0.669	
	CFG-6DL						
	CFG-8SR	1.102		1.067	0.276	0.315	
	CFG-8SL						
	CFG-8DR	1.496				0.709	
	CFG-8DL						
 (Steel)	CCP4-A	1.146		0.551			

Shape	Designation
 (Steel)	NF-84A
 (Steel)	CP536
 (Steel)	CP91
 (Steel)	CP900
 (Steel)	CP910
 (Steel)	JCP-1

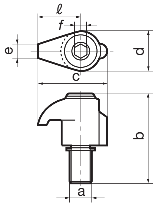
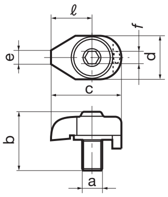
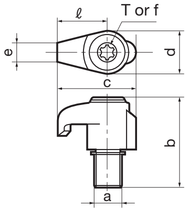
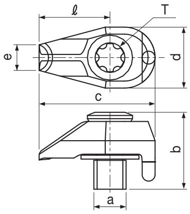
(Unit: mm)

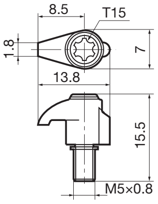
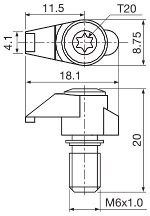
Shape	Designation
 (Steel)	JCP-2
 (Steel)	JCP-3 JCP-3N
 (Steel)	CQ-1
Right hand (R) shown (Steel) 	CPK5R CPK5L
Right hand (R) shown (Steel) 	C11R-5 C11L-5

(Unit: mm)

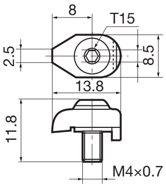
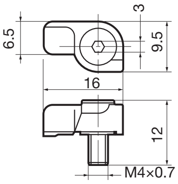
User's Guide - Parts for Tools

Clamp Sets

Shape	Designation	Dimension (in)						
		a	b	c	d	e	ℓ	T / f
 (Steel)	**CSG-5S**	M5×0.8	0.531	0.543	0.276	0.071	0.335	0.098
	CSG-5		0.610					
	CSG-6S	M6×1		0.642	0.335	0.098	0.394	0.118
	CSG-6		0.709					
	CSG-6L		0.846					
	CSG-8S	M8×1	0.827	0.807	0.433	0.138	0.492	0.157
	CSG-8		0.925					
 (Steel)	**CSW-00**	M4×0.7	0.453	0.472	0.315	0.079	0.295	0.098
	CSW-1	M5×0.8	0.650	0.650	0.374	0.157	0.394	0.118
	CSW-0	M4×0.7	0.453	0.543	0.335	0.098	0.315	0.098
	CSW-2	M6×1	0.787	0.807	0.433	0.236	0.512	0.157
	CSW-40	M4×0.7	0.472	0.520	0.315	0.079	0.295	0.098
	CSW-50	M5×0.8	0.591	0.665	0.394		0.374	0.118
 (Steel)	**CSP16**	M5×0.8	0.610	0.567	0.272	0.126	0.358	T15
	CSP22	M6×1	0.787	0.713	0.350	0.165	0.453	T20
	CSP27	M8×1.25	0.925	0.961	0.469	0.154	0.614	0.157
 (Steel)	**CSY-15**	M4×0.7	0.457	0.453	0.276	0.118	0.236	15IP
	CSY-20	M5×0.8	0.472	0.709	0.374	0.157	0.433	20IP

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

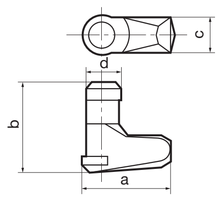
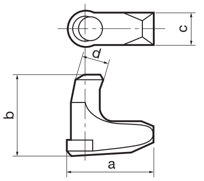
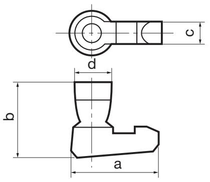
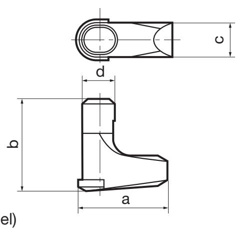
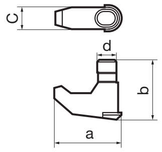
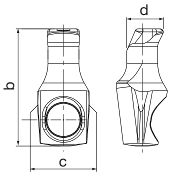
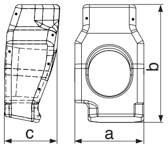
(Unit: mm)

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

(Unit: mm)

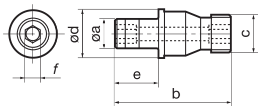
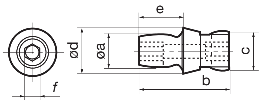
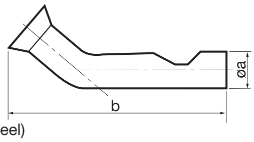
User's Guide - Parts for Tools

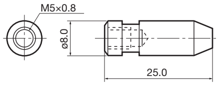
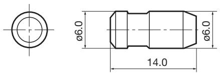
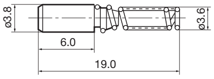
Levers

Shape	Designation	Dimension (in)				
		a	b	c	d	
 (Steel)	**LCL3**	0.394	0.472	0.146	0.142	
	LCL4	0.575	0.551	0.185	0.185	
	LCL5	0.673	0.669	0.236	0.236	
	LCL6	0.807	0.827	0.295	0.295	
	LCL8	1.000	1.000	0.339	0.339	
 (Steel)	**LCL3C**	0.425	0.465	0.134	0.118	
	LCL4C	0.512	0.528	0.146	0.134	
	LCL5C	0.732	0.697	0.185	0.177	
	LCL6C	0.807	0.748	0.236	0.224	
	LCL8C	0.953	0.925	0.295	0.244	
 (Steel)	**LCL22N**	0.295	0.256	0.102	0.081	
	LCL32N	0.394	0.307	0.126	0.126	
	LCL33NL	0.453	0.374	0.122	0.142	
	LCL33N	0.394	0.370	0.126	0.126	
	LCL43N	0.528	0.394	0.185	0.185	
 (Steel)	**LCL23**	0.307	0.335	0.102	0.083	
	LCL33	0.398	0.476	0.142	0.146	
	LCL33L	0.472	0.453	0.122	0.142	
	LCL43S	0.531	0.520	0.185	0.185	
	LCL43M					
	LCL44	0.634	0.575	0.185	0.185	
	LCL54	0.650	0.677	0.240	0.236	
 (Steel)	**DLCL43**	0.612	0.551	0.197	0.185	
	DLCL54	0.752	0.752	0.240	0.236	
	DLCL64	0.846	0.827	0.295	0.295	
 (Steel)	**SLLV-1**		0.305	0.134	0.096	
	SLLV-2		0.305	0.134	0.108	
 (Steel)	**FCL4**	0.197	0.306	0.150		
	FCL8	0.394	0.563	0.212		

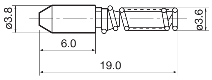
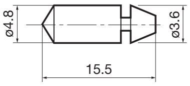
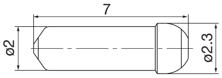
User's Guide - Parts for Tools

Pins

Shape	Designation	Dimension (in)					
		øa	b	øc	ød	e	*f*
 (Steel)	**MLP32L**	0.154	0.346	M5×0.8	0.220	0.138	0.079
	MLP33	0.146					
	MLP34L	0.146	0.516		0.244	0.197	
	MLP46	0.197	0.677	M6.3×1	0.307	0.217	0.098
	MLP46L		0.732			0.272	
	MLP58	0.244	0.862	M8×1	0.406		0.118
	MLP68	0.307		M10×1	0.469		0.157
	MLP68L		0.949			0.358	
 (Steel)	**MLP44**	0.197	0.520	M6.3×1	0.280	0.217	0.098
	MLP33L	0.146	0.409	M5×0.8	0.220	0.201	0.079
 (Steel)	**SW99**	0.315	1.870				

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

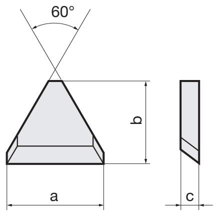
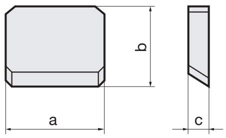
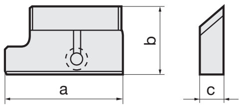
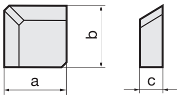
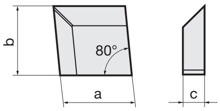
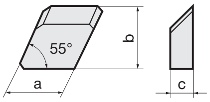
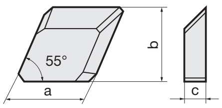
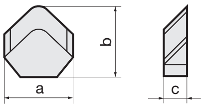
(Unit: mm)

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

(Unit: mm)

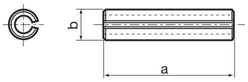
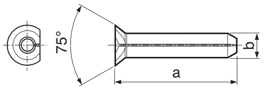
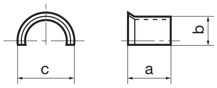
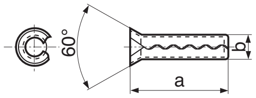
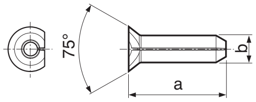
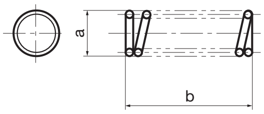
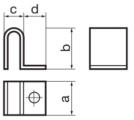
User's Guide - Parts for Tools

Chipbreaker Pieces

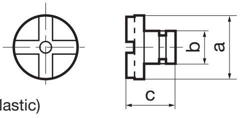
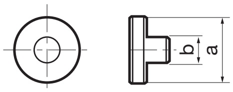
Shape	Designation	Dimension (in)				
		a	b	c		
 (TX30)	**CBT-2S**	0.346	0.299	0.079		
	CBT-2M	0.291	0.260			
	CBT-3S	0.524	0.476	0.098		
	CBT-3M	0.484	0.437			
	CBT-3L	0.445	0.398			
	CBT-4S	0.740	0.665			
	CBT-4M	0.701	0.626			
	CBT-4L	0.661	0.567			
	NCT-2S	0.559	0.465			
	NCT-2M	0.512	0.425			
	NCT-2L	0.469	0.386			
 (TX30)	**CBS-3S**	0.374	0.327	0.079		
	CBS-3M		0.287			
	CBS-4S	0.500	0.457	0.098		
	CBS-4SN					
	CBS-4M		0.417			
	CBS-4L		0.358			
	NCS-3S		0.441			
	NCS-3M		0.402			
	NCS-3L		0.343			
 Right hand (R) shown (TX30)	**B11 R-5**	0.945	0.512	0.197		
	B11 L-5					
 (TX30)	**CBS-4SN**	0.453	0.453	0.098		
	CBS-4MN	0.413	0.413			
	CBS-4LN	0.354	0.354			
	NCS-3SN	0.441	0.441			
	NCS-3MN	0.402	0.402			
	NCS-3LN	0.343	0.343			
 (TX30)	**CBC-4SN**	0.453	0.453	0.098		
	CBC-4MN	0.413	0.413			
	CBC-4LN	0.374	0.374			
 Right hand (R) shown (TX30)	**CBD-4SR**	0.500	0.453	0.098		
	CBD-4MR		0.413			
	CBD-4ML					
	CBD-4LR		0.374			
 (TX30)	**CBD-4SN**	0.453	0.453	0.098		
	CBD-4MN	0.413	0.413			
 (TX30)	**CBR-4SN**	0.500	0.469	0.098		
	CBR-4MN		0.429			

User's Guide - Parts for Tools

Springs (Springs for Shims)

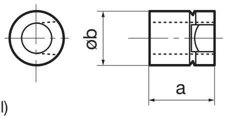
Shape	Designation	Dimension (in)					
		a	b	c	d		
 (Steel)	**SP-2.5**	0.472	0.106				
 (Steel)	**SP-16-L14**	0.535	0.112				
 (Steel)	**LSP3**	0.217	0.118	0.232			
	LSP3L	0.276					
	LSP4		0.157	0.299			
	LSP4S	0.236					
	LSP5	0.335	0.177	0.346			
	LSP6	0.433	0.232	0.429			
	LSP6C	0.335	0.189	0.366			
	LSP8	0.472	0.394	0.606			
 (Steel)	**PSP-2.5**	0.394	0.106				
	PSP-4.0	0.630	0.165				
	PSP301	0.299	0.118				
 (Steel)	**PSP-16**	0.384	0.112				
 (Steel)	**BP-0**	0.142	0.512				
	BP-5-A						
	BP-7	0.276	0.433				
	BP-8.8	0.346	0.394				
	BP-9	0.327					
	BP-10	0.358					
	SP913	0.354	0.512				
 (Steel)	**BSP-1**	0.307	0.295	0.189	0.236		

Coolant Supply Attachment

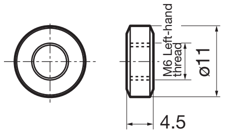
Shape	Designation	Dimension (in)					
		a	b	c	Thread		
 (Plastic)	**EA-20**	0.787	0.394	0.591			
	EA-25	0.984					
	EA-32	1.260	0.630				
 (Plastic)	**CA-16**	0.630	0.315		M6		
	CA-20	0.787	0.335		M6		
	CA-25	0.984	0.453		R1/8		
	CA-32	1.260	0.453		R1/8		
	CA-40	1.575	0.453		R1/8		

User's Guide - Parts for Tools

Pistons

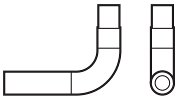
Shape	Designation	Dimension (in)				
		a	øb			
 (Steel)	**DPIS33**	0.496	0.354			
	DPIS43	0.465	0.394			
	DPIS44	0.528	0.394			
	DPIS54	0.630	0.512			
	DPIS64		0.591			

Nuts

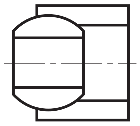
Shape	Designation
	**SRW11**

(Unit: mm)

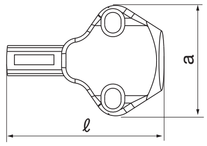
Coolant Pipe & Nozzle

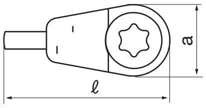
Shape	Designation
	**PNZ5**

Coolant Nozzle

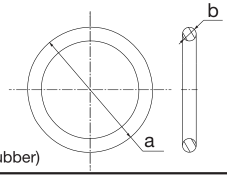
Shape	Designation
	**CNZ125**
	SATZ-M8X1-M3
	SATZ-M10X1-M5
	EZ104
	EZ83

Coolant unit

Shape	Designation	Dimension (in)	
		a	ℓ
	**CU-CW-CHP**	0.819	1.169
	CU-D-CHP	0.819	1.165
	CU-V-CHP	0.819	1.181

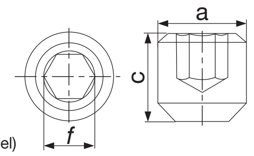
Shape	Designation	Dimension (in)	
		a	ℓ
	**S-CU-CHP**	0.276	0.638

O-ring for TungTurn-Jet

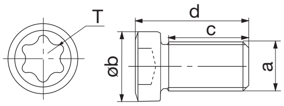
Shape	Designation	Dimension (in)				
		a	øb			
 (Rubber)	**OR6.4X0.9N**	0.323	0.035			
	OR14X2.5NN	0.748	0.098			

User's Guide - Parts for Tools

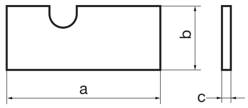
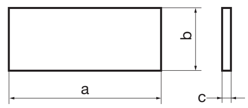
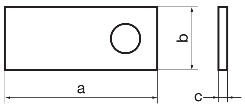
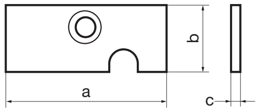
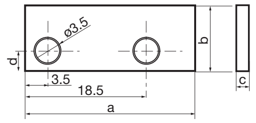
Coolant screw for TungTurn-Jet

Shape	Designation	Dimension (in)				
		a	c			T / f
 (Steel)	**SRM4X4 TL360**	M4	0.157			0.079

Mounting screw for TungTurn-Jet

Shape	Designation	Dimension (in)				
		a	øb	c	d	T / f
 (Steel)	**SRM3**	M3X0.5	0.165	0.276	0.193	T8

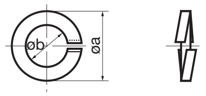
Sizing Plates

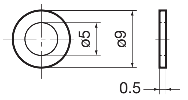
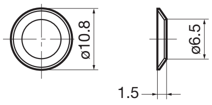
Shape	Designation	Dimension (in)					
		a	b	c	d		
 (Steel)	**S0816A**	2.165	0.610	0.031			
	S1016A			0.039			
	S0816B	1.969		0.031			
	S1016B			0.039			
	S0816C	1.772		0.031			
	S1016C			0.039			
	S0820A	2.402	0.768	0.031			
	S1020A			0.039			
	S0820B	2.146		0.031			
	S1020B			0.039			
	SM-00	0.709	0.315	0.039			
 (Steel)	**SW04**	1.004	0.228	0.010 0.020 0.039			
	SW05	1.457	0.327	0.010 0.020 0.039 0.079			
	SW06	1.417	0.425				
	SW08	1.398	0.484				
 (Steel)	**S0810**	1.575	0.433	0.031			
	S1010			0.039			
 Attached with fix screw and wrench. (Steel)	**PSTR08**	0.945	0.433	0.059			
	PSTL08						
	PSTR10	1.654	0.650	0.079			
	PSTL10						
	PSTR12	1.850	0.748	0.079			
	PSTL12						
 (Steel) (Unit: mm)	**AP0801**	1.024	0.374	0.020	0.118		
	AP0802			0.039			
	AP0803			0.059			
	AP0804			0.079			
	AP0805			0.098			
	AP1101	1.181	0.453	0.020	0.197		
	AP1102			0.039			
	AP1103			0.059			
	AP1104			0.079			
	AP1105			0.098			
	AP1106			0.118			

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

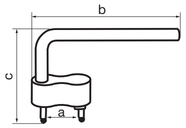
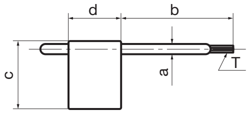
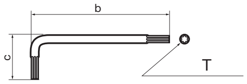
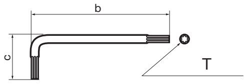
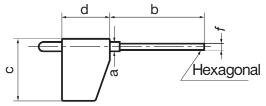
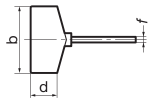
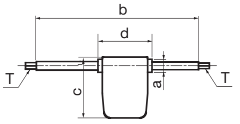
Washers

Shape	Designation	Dimension (in)					
		øa	øb				
	VA4	0.299	0.161				
	VA5	0.362	0.201				
	VA6	0.413	0.240				

Shape	Designation
	CPW5
	CDW6

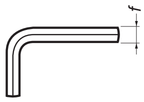
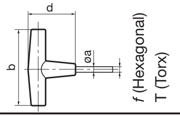
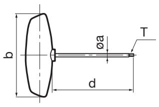
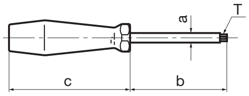
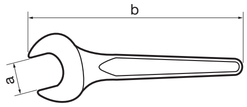
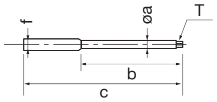
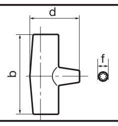
(Unit: mm)

Wrenches and Drivers

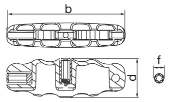
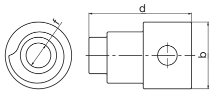
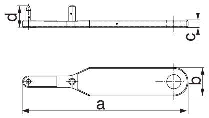
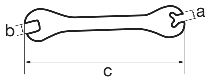
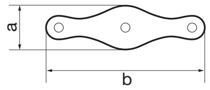
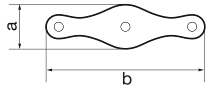
Shape	Designation	Dimension (in)					
		a	b	c	d	*f*	T
	CRW23	0.382	3.091	2.165			
	CRW33	0.366					
	T-6F	0.079	1.378	0.571	0.591		T6
	T-7F			0.748	0.748		T7
	T-8F	0.098	1.575				T8
	T-9F	0.118		0.925	0.787		T9
	T-15F	0.138	1.772	1.102	0.827		T15
	T-20F	0.157					T20
	IP-6F	0.079	1.378	0.583	0.587		6IP
	SET T-15/5	0.138	1.772	1.102	0.827		T15
	T-20TORX	0.154	1.929	1.181	0.866		T20
	T-6L		1.890	0.630			T6
	T-8L						T8
	T-9L						T9
	T-15L		2.323	0.866			T15
	T-25TORX		2.598	0.917			T25
	KEYV-T20		2.362	0.866			T20
	KEYV-T25		2.559	0.906			T25
	KEYV-T30L		7.480	1.457			T30
	KEYV-T40L		8.189	1.693			T40
	KEYV-T50L		9.134	1.890			T50
	P-2F	0.157	1.732	0.787	0.492	0.079	
	P-2.5F	0.197	1.772	0.984	0.787	0.098	
	HW2.0/5RED	0.118	1.496	0.591	0.591	0.079	
	P-2.5T		1.654		0.591	0.098	
	T-1008/5	0.256	3.346	1.102	0.984		T10/T8
	T-2010/5						T10/T20

User’s Guide - Parts for Tools

Wrenches, Drivers and Lubricant

Shape	Designation	Dimension (in)					
		a	b	c	d	*f*	T
	**1/4HEX**					0.250	
	5/32HEX					0.156	
	1/8HEX					0.125	
	3/32HEX					0.094	
	P-1.5					0.059	
	P-2					0.079	
	P-2.5					0.098	
	P-3					0.118	
	P-3.5					0.138	
	P-4					0.157	
	P-4.5					0.177	
	P-5					0.197	
	P-6					0.236	
	**TP-3A**		2.756		1.791	0.118	
	TP-4		3.346		2.087	0.157	
	TP-5					0.197	
	T-27T	0.197	3.346		1.654		T27
	**T-15T**	0.157	3.937		3.937		T15
	T-20T						T20
	IP-20T						20IP
 Handle shape somewhat varies depending on the type number from the above figure.	**T-6D**	0.098	1.772	2.756			T6
	T-7D	0.079					T7
	T-8D	0.102	2.402	2.657			T8
	T-9D	0.118	2.559	3.150			T9
	T-10D	0.130	2.756	3.543			T10
	T-15D	0.144	2.795	3.937			T15
	T-20D	0.181	3.543				T20
	T-25D	0.173	3.425	3.386			T25
	IP-6DB		1.772	2.756			6IP
	IP-7D	0.098	1.772	2.953			7IP
	IP-8D	0.118	2.165	3.150			8IP
	IP-10D	0.130	2.795	3.504			10IP
	IP-15D	0.157	3.150	3.937			15IP
	IP-20D	0.157	3.543	3.937			20IP
	**KS-21**	0.827	7.677				
	KS-24	0.945	8.465				
	KS-27	1.063	9.252				
	KS-32	1.260	10.827				
	KS-36	1.417	12.008				
	**M-1000**						
	**BT15S**	0.154	1.969	3.543		0.236	T15
	BT15M	0.154	1.969	4.646		0.236	T15
	BT20S	0.181	1.969	3.543		0.236	T20
	BT20M	0.181	1.969	4.646		0.236	T20
	BLD IP15/S7	0.154	1.969	3.543		0.236	15IP
	BLD IP15/M7	0.154	1.969	4.646		0.236	15IP
	BLD IP20/S7	0.181	1.969	3.543		0.236	20IP
	BLD IP20/M7	0.181	1.969	4.646		0.236	20IP
	BLD T10/S7	0.154	2.244	2.953		0.236	T10
	BLD T10/S7-A	0.154	2.244	2.953		0.236	T10
	**H-TB**		3.937		1.457	0.236	
	H-TBS		2.953		1.457	0.236	

Wrenches and Drivers

Shape	Designation	Dimension (in)					
		a	b	c	d	*f*	
	**H-TB2W**		3.740		1.236	0.236	
	**AJC08**		0.433		0.669	0.161	
	**ECW-456EF**	3.425	0.591	0.157	0.453		
	ECW-456I	3.169	0.866	0.157	0.413		
	**KEYV-S05**	0.157	0.217	3.937			
	KEYV-S06	0.213	0.315	4.921			
	KEYV-S08	0.260	0.394	5.906			
	KEYV-S10	0.303	0.512	6.890			
	KEYV-S12	0.370	0.630	9.843			
	KEYV-W20						
	**KEYV-177**	1.142	4.331				
	KEYV-217	1.142	4.331				
	**KGDT-100**	1.260	4.272				
	KGDT-110	1.260	4.272				
	KGDT-120	1.260	4.272				
	KGDT-130	1.260	4.272				
	KGDT-140	1.260	4.272				
	KGDT-150	1.260	4.272				

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

Insert locking wedges

Designation	Applicable Tool
FDS-8SST	EDPD09063R EDPD09063RB
FDS-8ST-18	EDP09080R EDPD09080RB DPD09100R~DPD09160R DPD09100RB~DPD09160RB
FW-242R	DPD24063R
FW-243R	DPD24080R, DPD24100R
FW-245R	DPD24125R, DPD24160R
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
WF875N	TPYD06 EPYD06
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
RSFTC1008	TPYP12...
RSFTC1009	EPYP12M032C25.0R05
RSFTC1011	EPYP12M025C25.0R03

Fine adjusting screws

Designation	Applicable Tool
AJM5	DPD09 EDPD09
ASM34L	DPD24

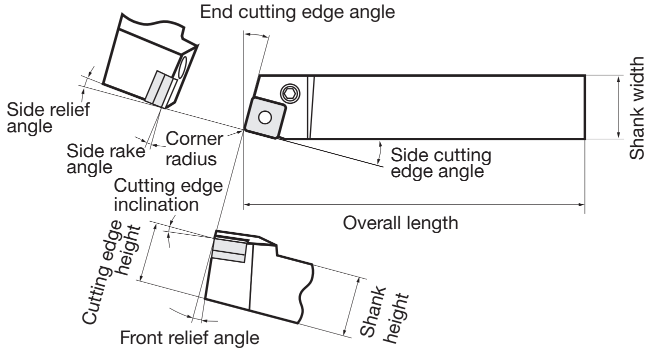
Cover

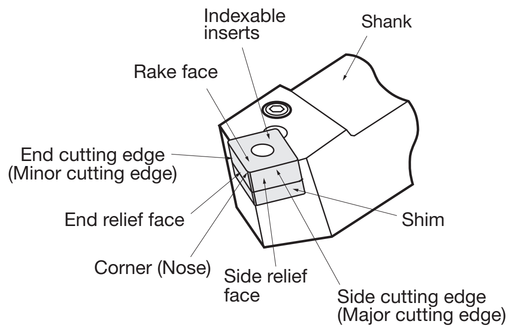
Designation	Applicable Tool
RSFTS6063M	TPYP12M063B22.0R10
RSFTS6080	TPYP12*080B**R12
RSFTS6100	TPYP12*100B**R16
RSFTS6125	TPYP12*125B**R20

User's Guide - Technical Reference

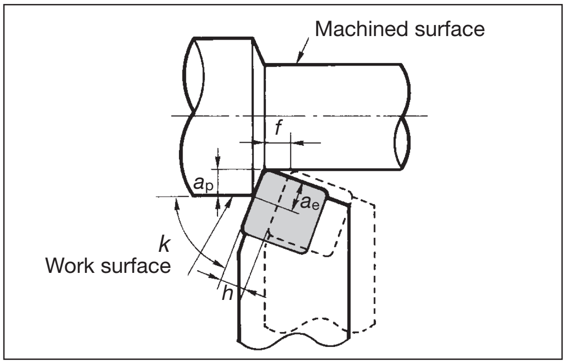
Turning Tools

Name of tool parts



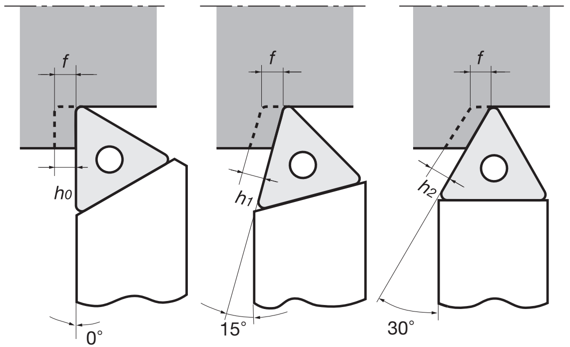


Relating angles between tool and workpiece



a_p … Depth of cut (Distance between work surface and machined surface)
a_e … Length of cutting edge engaging in cutting.
k … 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



In the cutting of same feed, as the side cutting edge angle increases, the chip thickness decreases.

$h_0 > h_1 > h_2$

●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 Increasing	Flank wear	Crater wear	Edge strength	Cutting force	Surface finish	Chattering	Cutting edge temperature	Chip shape and flow
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	–

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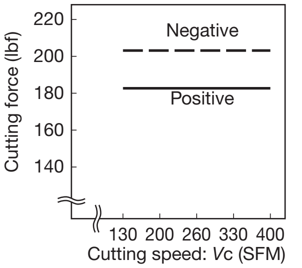
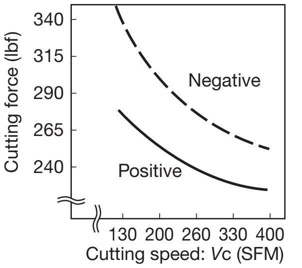
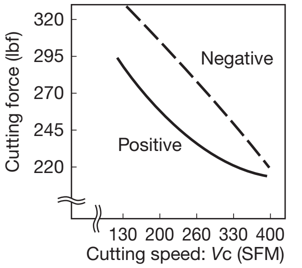
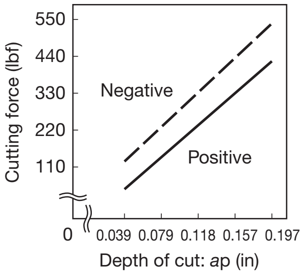
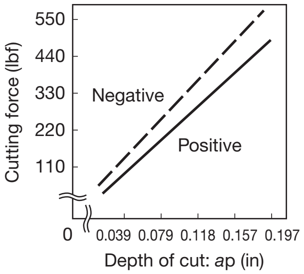
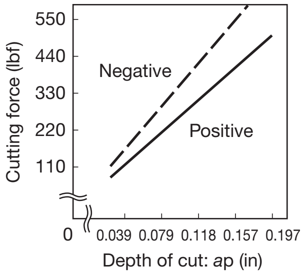
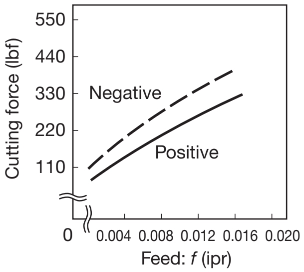
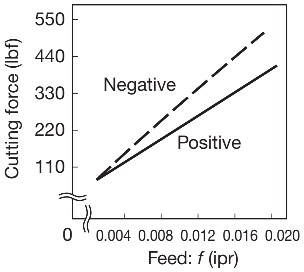
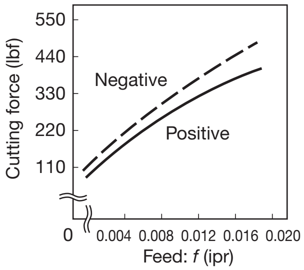
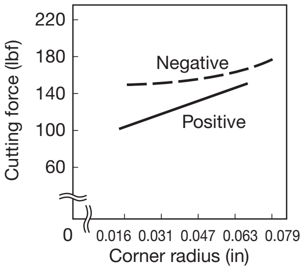
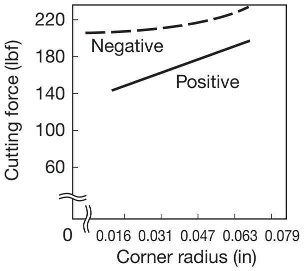
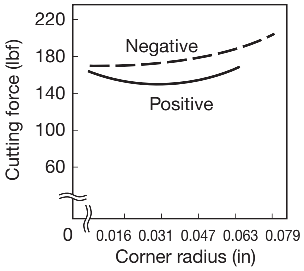
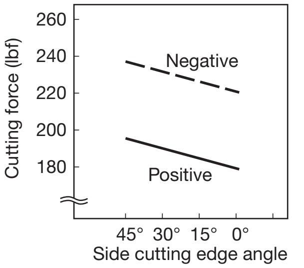
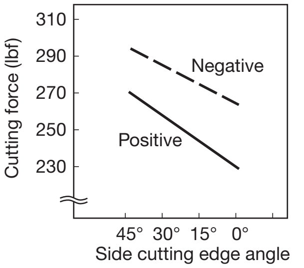
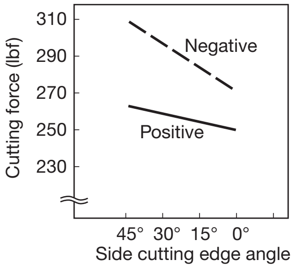
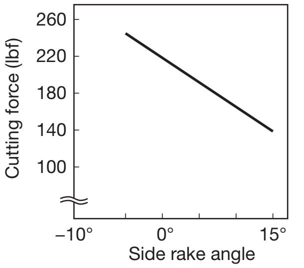
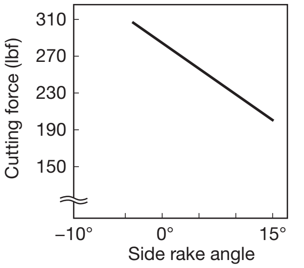
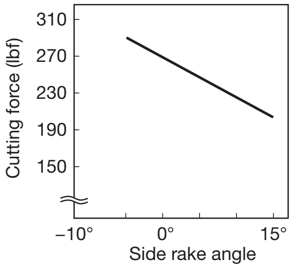
Turning Tools

Relations between cutting force and cutting conditions or cutting phenomena

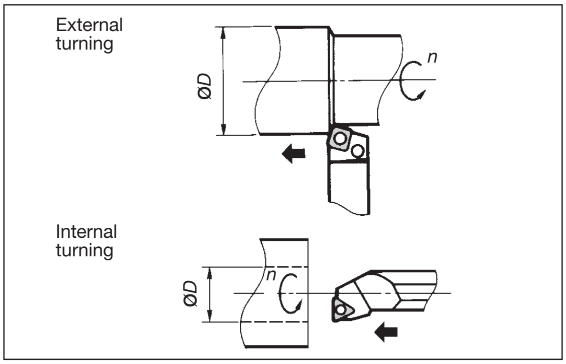
Condition	Grey cast iron (HB130)	Stainless steel (HB145)	Carbon steel (HB230)
Cutting speed and cutting force f = 0.008 ipr a_p = 0.079" Side cutting edge angle 0° Corner radius RE = 0.016"			
Depth of cut and cutting force V_c = 330 SFM f = 0.008 ipr Side cutting edge angle 0° Corner radius RE = 0.016"			
Feed and cutting force V_c = 330 SFM a_p = 0.079" Side cutting edge angle 0° Corner radius RE = 0.016"			
Corner radius and cutting force V_c = 330 SFM f = 0.008 ipr a_p = 0.047" Side cutting edge angle 0°			
Side cutting edge angle and cutting force V_c = 330 SFM f = 0.008 ipr a_p = 0.079" Corner radius RE = 0.016"			
Side rake angle and cutting force V_c = 330 SFM f = 0.008 ipr a_p = 0.079" Side cutting edge angle 0° Corner radius RE 0.008"			

User's Guide - Technical Reference

Turning Tools

Calculation formulas for turning

●Cutting speed



When calculating cutting speed from number of revolutions:

$$Vc = \frac{\varnothing D \times n}{3.82}$$

Vc : Cutting speed (sfm)
n : Number of revolution (rpm)
øD : Diameter of workpiece (in)
π : 3.14

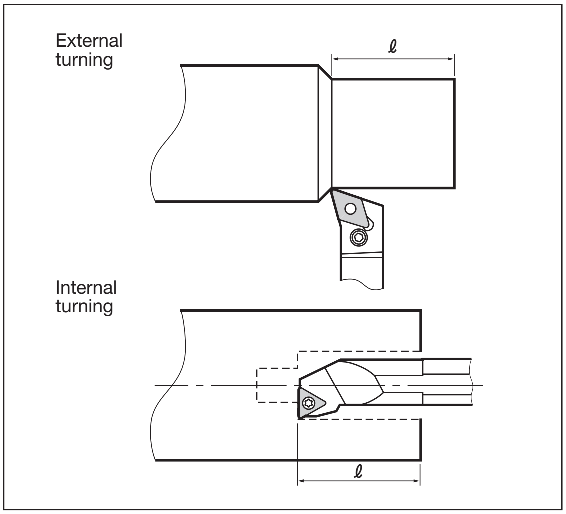
When calculating required number of revolutions from cutting speed:

$$n = \frac{Vc \times 3.82}{\varnothing D}$$

Example : Calculating the cutting speed when turning a ø6"- diameter workpiece at 250 rpm

$$V_c = \frac{6 \times 250}{3.82} = 392 \text{ sfm}$$

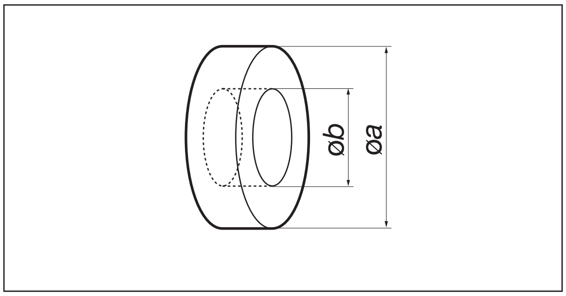
●Cutting time on external and internal turning



$$\underset{(\text{min})}{T} = \frac{\ell}{f \times n}$$

T : Cutting time (min)
ℓ : Cutting length (in)
f : Feed (ipr)
n : RPM

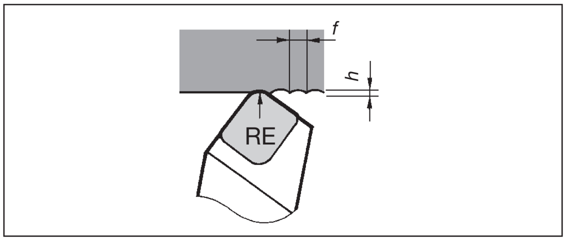
●Cutting time on face turning



$$\underset{(\text{min})}{T} = \frac{\pi \times (a^2 - b^2)}{48 \times v_c \times f}$$

V_c : Cutting speed (sfm)
f : Feed (ipr)
T : Cutting Time (min)

●Theoretical surface roughness



$$\underset{(\mu m)}{h} = \frac{f^2}{8 \times r} \times 1000$$

h : Surface roughness (μm)
f : Feed (ipr)
r : Nose radius (in) 〔RE〕

〔 〕 The notation in the brackets is the one used in the catalog (ISO compliant)

●Calculation of power consumption (kW)

$$\underset{(\text{HP})}{P_c} = \frac{F \times v_c}{33000}$$

P_c : Power requirement (kW)
F : Cutting force (N)
V_c : Cutting speed (sfm)

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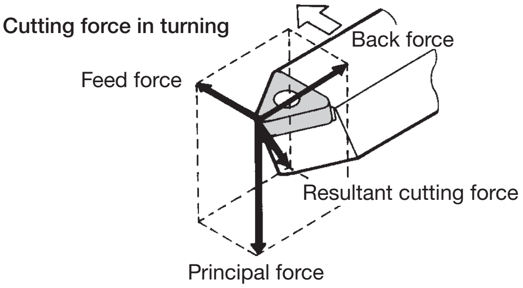
Turning Tools

Cutting forces

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



$$F = k_c \times a_p \times f \times 1000$$
(lb-force)

F : Cutting force (lb-force)
k_c : Specific cutting force KPI (Kilo pound force)
a_p : Depth of cut (in)
f : Feed (ipr)

Example :
Calculating the cutting force when cutting a high carbon steel (1055) at f = 0.007 ipr and ap = 0.118".
$F = 499 \times 0.118 \times 0.0078 \times 1000$
$= 460$ lb-force

●Calculating power requirement

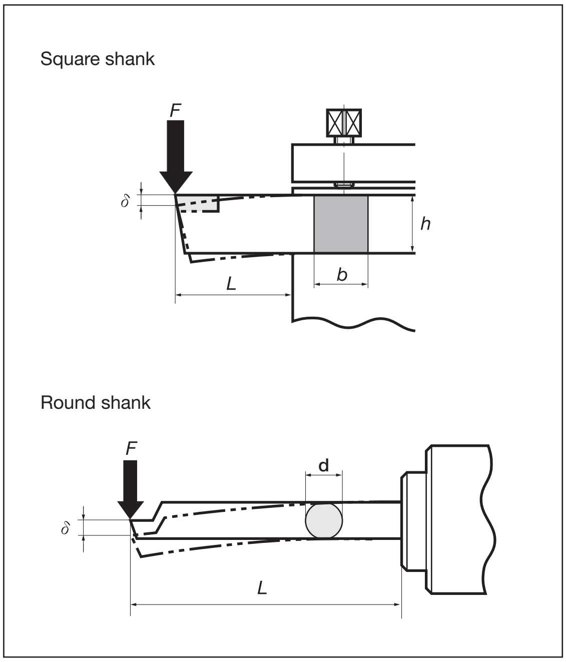
$$P_c = \frac{k_c \times a_p \times v_c \times f}{33}$$
(kW)

P_c : Net power requirement (H)
k_c : Specific cutting force (KPI) [Refer to the Table below]
v_c : Cutting speed (sfm)
a_p : Depth of cutting (in)
f : Feed (ipr)

Value of specific cutting force (k_c)

Workpiece material (JIS)	Tensile strength lb/in² (PSI)	Hardness (HB)	Value of specific cutting force on feed k_c (KPI)				
			0.0016 (ipr)	0.004 (ipr)	0.008 (ipr)	0.016 (ipr)	0.039 (ipr)
SS400, S15C	56,565	100	497	412	355	302	247
S35C, S40C	85,572	170	612	506	426	363	302
S50C, SCr430	113,855	230	711	583	497	426	348
SCM440, SNCM439	142,137	300	782	640	548	470	384
SDK	225,992 (56HRC)	56HRC	1,217	996	853	725	598
FC200	(160HB)	160	370	284	236	194	149
FCD600	(200HB)	200	483	370	306	254	194
Aluminum alloy	(89HB)	89	196	164	138	117	97
Aluminum			152	126	107	93	75
Magnesium alloy			57	57	57	57	57
Brass			157	157	157	157	157

●Bending stress and tool deflection



Bending stress

(1) Square shank

$$S = \frac{6 \times F \times L \times 145}{b \times h^2}$$
(PSI)

(2) Round shank

$$S = \frac{32 \times F \times L \times 145}{\pi \times d^3}$$
(PSI)

S : Bending stress in shank (PSI)
F : Cutting force (lb)
L : Overhang length of tool (in)
b : Shank width (in) : 〔B〕
h : Shank height (in) : 〔H〕
d : Shank diameter (in) : 〔DCONMS〕
E : Modulus of elasticity of shank material (lb/in²)

〔 〕 The notation in the brackets is the one used in the catalog (ISO compliant)

Tool deflection (in)

(1) Square shank

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

(2) Round shank

$$\delta = \frac{64 \times F \times L^3}{3 \times \pi \times E \times d^4}$$
(in)

(Ref.) Values of E

Material	MPa (SPI)	{kgf/mm²}
Steel	30,457,980	30,457,980
Cemented Carbide	81,221,280 ~ 89,923,560	81,221,280 ~ 89,923,560

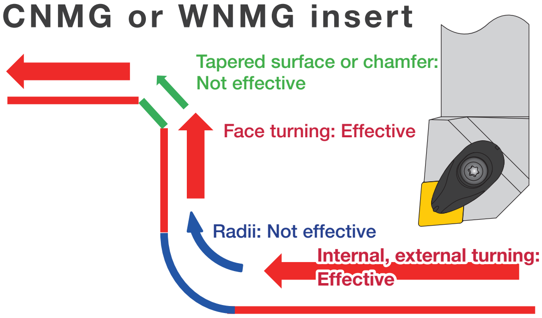
Turning Tools

Machining program compensation for wiper -SW / -FW insert

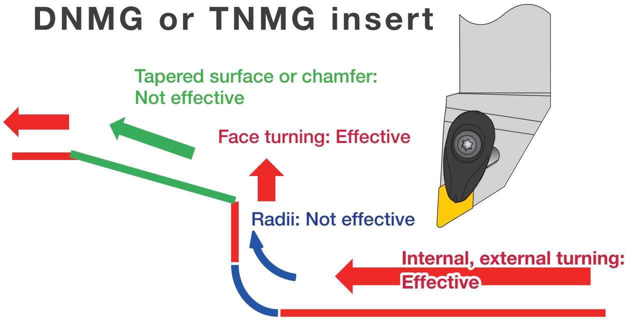
The nose radius on a wiper insert has a different configuration from that on standard ISO insert's. Machining program adjustments are, therefore, required to generate a correct offset for the wiper insert to machine the correct workpiece dimension. No compensation is needed, however, for the positive, CCMT-SW wiper insert.

Wiper effectiveness (surface finish quality improvement) by applications

CNMG or WNMG insert

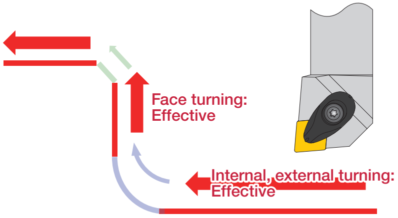
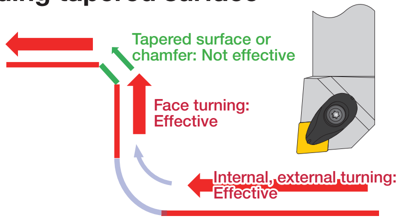
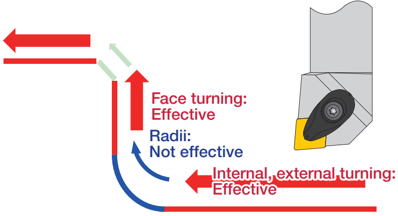
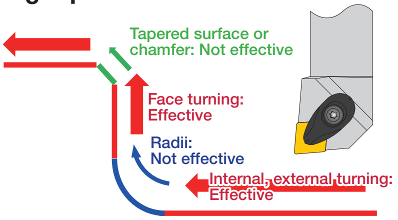


DNMG or TNMG insert



Program compensations by insert shapes and applications

Match your insert shape and application to find the proper compensation method.

Insert shape / Application	CNMG/WNMG -SW/FW	DNMG/TNMG -SW/FW	CCMT-SW
	Type **L**	Type **J, G, F**	Type **L**
Internal, External and Face turning  	Proceed to Compensation ① (See Page L035)	Proceed to Compensation ④ (See Page L036)	No compensation needed
Including tapered surface  	Proceed to Compensation ①, ② (See Page L035)	Proceed to Compensation ④, ⑤ (See Page L036 - L037)	↑
Including corner radius  	Proceed to Compensation ①, ③ (See Page L035)	Proceed to Compensation ④ (See Page L036) Proceed to Compensation ⑥ (See Page L037)	↑
Including tapered surface and corner radius  	Proceed to Compensation ①, ②, ③ (See Page L035)	Proceed to Compensation ④, ⑤, ⑥ (See Page L036 - L037)	↑

Turning Tools

Compensations for CNMG/WNMG -SW / -FW

Compensations ① Tool offsets (Compensations for X- and Z-axis)

Match the insert approach angle and the insert style to find the value and compensate the machining program for the insert radius.
*This compensation procedure will not be necessary if the insert is compensated with the built-in tool presetter after insert replacement.

CNMG/WNMG-SW/-FW(Type L)

Nose Radius	X-axis direction	Z-axis direction
R0.016	0.001	0.001
R0.031	0.002	0.002
R0.047	0.002	0.002

(Unit: in)

Compensations ② Program compensations for tapered surface (proceed after ①)

To machine tapered surfaces, compensate the nose radius position in the x-axis position to obtain the correct workpiece dimension.

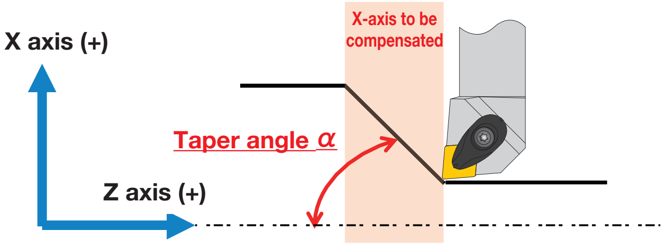
Compensations for x-axis when using CNMG or WNMG-SW/-FW (Tool approach angle: L) insert

Match the insert nose radius and the angle of the surface taper to find the value in Table 1 below to compensate the x-axis position.

For CNMG/WNMG-SW/-FW (Type L)

Compensation values for x-axis (in)

Nose radius (in)	Taper angle α (θ)																	
	0	0.197	0.394	0.591	0.787	0.984	1.181	1.378	1.575	1.772	1.969	2.165	2.362	2.559	2.756	2.953	3.150	3.346	3.543
R0.016	0	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0
R0.031	0	0.001	0.002	0.002	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.006	0.006	0.007	0.007	0.007	0.005	0.005	0
R0.047	0	0.001	0.002	0.002	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.006	0.006	0.007	0.007	0.007	0.006	0.006	0



Compensations ③ Program compensation for corner radii (proceed after ①)

To achieve the correct corner radius dimension on the workpiece, compensate the tool position, using the values listed below for respective insert styles.

CNMG/WNMG-SW/-FW(Type L)

Nose Radius	Deviation on the corner radius	Compensate radius by
R0.016	0.002	+0.005
R0.031	0.003	+0.007
R0.047	0.003	+0.007

(Unit: in)

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Compensations for CNMG/WNMG -SW / -FW

Compensations ④ Tool offsets (Compensations for X- and Z-axis)

Match the insert approach angle and the insert style to find the value and compensate the machining program for the insert radius.
*This compensation procedure will not be necessary if the insert is compensated with the built-in tool presetter after insert replacement.

DNMG-SW/-FW (Type J)

Nose Radius	X-axis direction	Z-axis direction
R0.016	0.009	0.001
R0.031	0.009	0.002
R0.047	0.005	0.001

(Unit: in)

TNMG-SW/-FW (Type J)

Nose Radius	X-axis direction	Z-axis direction
R0.016	0.009	0.002
R0.031	0.008	0.002
R0.047	0.006	0.002

(Unit: in)

TNMG-SW/-FW (Type G)

Nose Radius	X-axis direction	Z-axis direction
R0.016	0.009	0.001
R0.031	0.008	0.001
R0.047	0.006	0.001

(Unit: in)

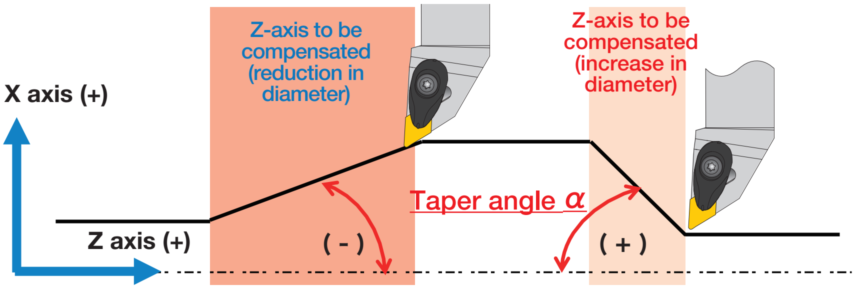
TNMG-SW/-FW (Type F)

Nose Radius	X-axis direction	Z-axis direction
R0.016	0.001	0.009
R0.031	0.001	0.008
R0.047	0.001	0.006

(Unit: in)

Compensations ⑤ Program compensations for tapered surface (proceed after ④)

To machine tapered surfaces with DNMG or TNMG-SW/-FW insert, compensate both the x-axis and z-axis positions. Since these inserts are commonly used for profiling, to machine a tapered surface with a gradual reduction in diameter, the z-axis position has to be compensated in the negative direction.



Compensations for x- and z-axis when using DNMG or TNMG-SW/-FW

Match the insert nose radius and the angle of the surface taper to find the value in below to compensate the x-axis and/or z-axis positions.

For DNMG-SW/-FW (Type J)

X-axis compensation values for plus-tapered surface (increase in diameter)

(Unit: in)

Nose radius (in)	Taper angle α (θ)																		
	0	0.197	0.394	0.591	0.787	0.984	1.181	1.378	1.575	1.772	1.969	2.165	2.362	2.559	2.756	2.953	3.150	3.346	3.543
R0.016	0	-0.0004	-0.0004	-0.0004	-0.0004	-0.0008	-0.0012	-0.0016	-0.0024	-0.0031	-0.0039	-0.0055	-0.0075	-0.0079	-0.0079	-0.0075	-0.0075	-0.0075	0
R0.031	0	0.0004	0.0008	0.0008	0.0012	0.0012	0.0008	0.0004	0.0000	-0.0008	-0.0020	-0.0035	-0.0059	-0.0067	-0.0059	-0.0051	-0.0047	-0.0043	0
R0.047	0	0.0008	0.0016	0.0020	0.0024	0.0028	0.0028	0.0024	0.0016	0.0008	-0.0008	-0.0035	-0.0067	-0.0075	-0.0063	-0.0055	-0.0051	-0.0059	0

Z-axis compensation values for minus-tapered surface (reduction in diameter)

Nose radius (in)	Taper angle α (θ)				
	-0.984	-0.787	-0.591	-0.394	-0.197
R0.016	0.013	0.013	0.013	0.013	0.013
R0.031	0.012	0.013	0.013	0.013	0.013
R0.047	0.013	0.014	0.015	0.016	0.016

(Unit: in)

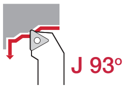
* Match the taper angle and insert nose radius to find the value in Table 2 and compensate the NC program by either adding or deducting the value.

Example:
Tapering a surface of +45° (increase in diameter) with a R0.031" insert.
Current NC program: X3.937"
Compensation value: -0.001"
Parameter after compensation: X3.936"

Compensations for DNMG / TNMG -SW / -FW

Compensations ⑤ Program compensations for tapered surface (proceed after ④)

For **TNMG-SW/-FW** (Type J)



X-axis compensation values for plus-tapered surface (increase in diameter)

Nose radius (mm)	Taper angle α (θ)																		
	0	0.197	0.394	0.591	0.787	0.984	1.181	1.378	1.575	1.772	1.969	2.165	2.362	2.559	2.756	2.953	3.150	3.346	3.543
R0.016	0	0	0	-0.0004	-0.0004	-0.0008	-0.0012	-0.0016	-0.0020	-0.0028	-0.0039	-0.0055	-0.0071	-0.0098	-0.0110	-0.0110	-0.0106	-0.0106	0
R0.031	0	0.0004	0.0008	0.0012	0.0016	0.0016	0.0016	0.0012	0.0008	0	-0.0008	-0.0024	-0.0043	-0.0075	-0.0087	-0.0079	-0.0075	-0.0083	0
R0.047	0	0.0008	0.0020	0.0028	0.0031	0.0035	0.0039	0.0035	0.0031	0.0024	0.0012	-0.0008	-0.0039	-0.0087	-0.0102	-0.0098	-0.0098	-0.0122	0

(Unit: in)

Z-axis compensation value for minus-tapered surface (reduction in diameter)

Nose radius (mm)	Taper angle α(θ)				
	-0.984	-0.787	-0.591	-0.394	-0.197
R0.016	0.0165	0.0165	0.0165	0.0161	0.0157
R0.031	0.0138	0.0126	0.0130	0.0134	0.0130
R0.047	0.0165	0.0142	0.0150	0.0154	0.0146

(Unit: in)

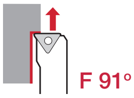
For **TNMG-SW/-FW** (Type G)

X-axis compensation values for plus-tapered surface (increase in diameter)

Nose radius (mm)	Taper angle α (θ)																		
	0	0.197	0.394	0.591	0.787	0.984	1.181	1.378	1.575	1.772	1.969	2.165	2.362	2.559	2.756	2.953	3.150	3.346	3.543
R0.016	0	0	-0.0004	-0.0004	-0.0008	-0.0012	-0.0016	-0.0020	-0.0028	-0.0035	-0.0047	-0.0063	-0.0087	-0.0110	-0.0114	-0.0114	-0.0114	-0.0126	0
R0.031	0	0.0004	0.0008	0.0008	0.0012	0.0008	0.0008	0.0004	-0.0004	-0.0012	-0.0024	-0.0039	-0.0067	-0.0098	-0.0098	-0.0098	-0.0110	-0.0157	0
R0.047	0	0.0012	0.0024	0.0031	0.0035	0.0039	0.0043	0.0039	0.0035	0.0028	0.0016	-0.0004	-0.0035	-0.0071	-0.0071	-0.0071	-0.0079	-0.0134	0

(Unit: in)

For **TNMG-SW/-FW** (Type F)



X-axis compensation values for plus-tapered surface (increase in diameter)

Nose radius (mm)	Taper angle α (θ)																		
	0	0.197	0.394	0.591	0.787	0.984	1.181	1.378	1.575	1.772	1.969	2.165	2.362	2.559	2.756	2.953	3.150	3.346	3.543
R0.016	0	-0.0012	-0.0020	-0.0031	-0.0039	-0.0051	-0.0051	-0.0043	-0.0039	-0.0035	-0.0031	-0.0028	-0.0024	-0.0020	-0.0020	-0.0016	-0.0012	-0.0008	0
R0.031	0	-0.0016	-0.0020	-0.0028	-0.0035	-0.0047	-0.0039	-0.0028	-0.0020	-0.0012	-0.0004	0.0004	0.0012	0.0020	0.0028	0.0035	0.0043	0.0051	0
R0.047	0	-0.0012	-0.0016	-0.0020	-0.0028	-0.0035	-0.0020	-0.0004	0.0012	0.0028	0.0043	0.0059	0.0071	0.0087	0.0098	0.0110	0.0126	0.0138	0

Compensations ⑥ Program compensation for corner radii (proceed after ④)

To achieve the correct corner radius dimension on the workpiece, compensate the tool position, using the values listed below for respective insert styles.

DNMG-SW/-FW (Type J)

Nose Radius	Deviation on the corner radius	Compensate radius by
R0.016	0	0
R0.031	0.0008	+0.0079
R0.047	0.0039	+0.0134

(Unit: in)

TNMG-SW/-FW(Type J)

Nose Radius	Deviation on the corner radius	Compensate radius by
R0.016	0	0
R0.031	0.0012	+0.0051
R0.047	0.0043	+0.0142

(Unit: in)

TNMG-SW/-FW(Type G, Type F)

Nose Radius	Deviation on the corner radius	Compensate radius by
R0.016	0	0
R0.031	0.0008	+0.0059
R0.047	0.0035	+0.0150

(Unit: in)

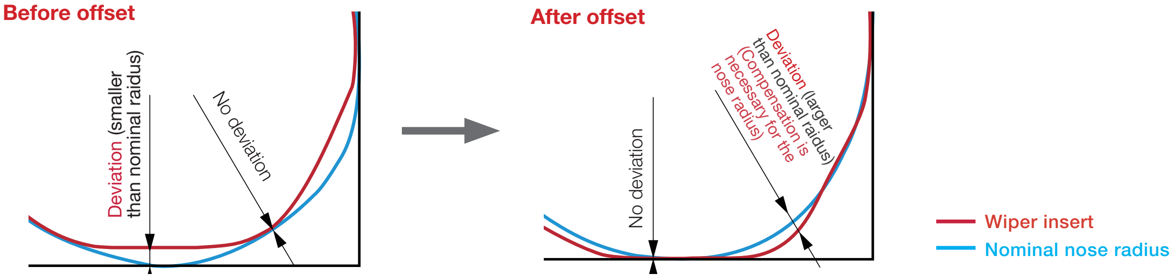
Additional information on offsetting -SW / -FW wiper inserts

Compensations ① , ④ Tool offsets (Compensations for X- and Z-axis)

Why need to offset ?

Ex. When using DNMG 433

The wiper insert does not provide the exact corner radius. A deviation from the standard nose radius shape as shown below will always occur when going into a corner. An additional program adjustment is, therefore, required to achieve the correct corner radius or tapered surface dimension on the workpiece.



Wiper nose radius' contour is slightly smaller than the nominal radius.
→ The nose radius profile deviates from the required corner radius, thus the actual corner profile will be incorrect.

Wiper nose radius' contour is partially larger than the nominal radius.
→ No compensations necessary for ID, OD, or face turning.
Meanwhile, due to these deviations, compensations to the NC program are necessary when turning corners and tapered surfaces for the correct workpiece dimensions.

Compensations ③ , ⑥ Program compensation for corner radii (proceed after ① , ④)

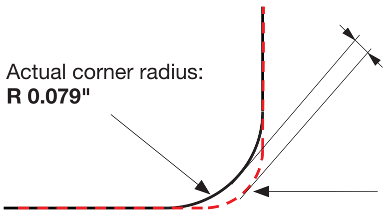
Compensation for corner radius

Ex. When using DNMG 433

Example: to machine a corner radius = R0.079", using insert nose radius = R0.047".

For standard ISO insert: DNMG 433 **
Input R0.031" for G2 or G3 (circular interpolation) to compensate the nose radius deviation.

Wiper insert
For wiper insert: DNMG150412-SW/-FW
Input **R0.055"**(= R0.031" + 0.013" from the list) for the nose radius, instead of R0.031", to compensate the nose radius deviation.



Actual corner radius:
R 0.079"

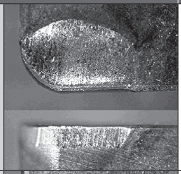
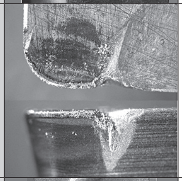
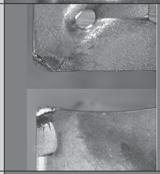
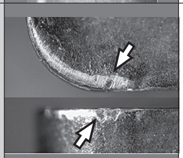
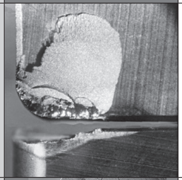
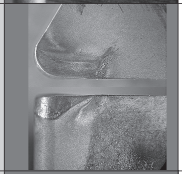
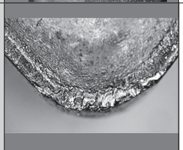
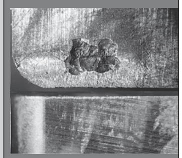
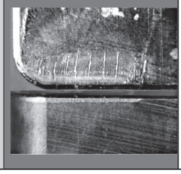
The deviation generated when using the ISO insert parameters for the wiper insert.
0.004"

Theoretical corner radius shape when R0.047"(=nominal nose radius) is programmed for the wiper insert
The actual corner radius becomes smaller than the required radius due to the insert radius deviation.
Corner radius = R0.065"
(R0.079" - 0.013")

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 rigidity of 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 rigidity of 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				
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 • Select a freer-cutting chipbreaker type • 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 • 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	

Chipbreakers

Chip controllability

Necessity of chip control

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

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

①Why is chip control needed?

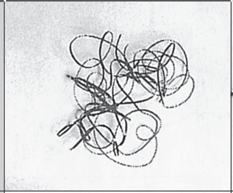
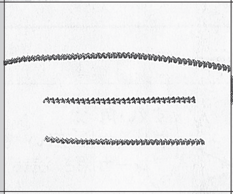
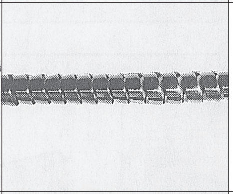
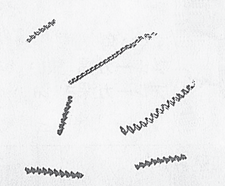
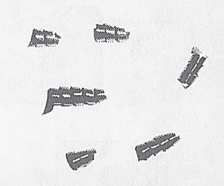
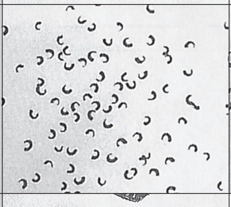
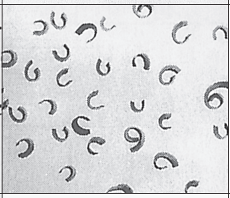
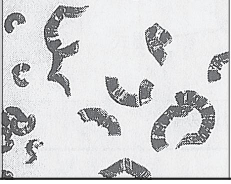
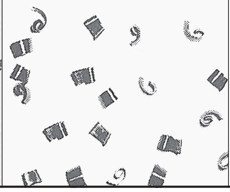
What is chip?

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

②Effect 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"**

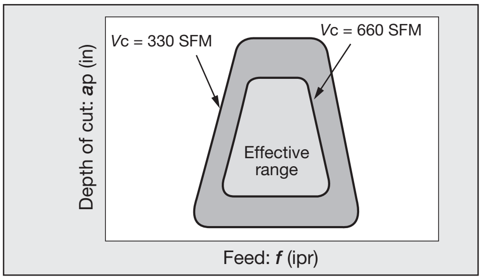
Classification	Chip shape		Description of chip shape	Acceptability	Effect
	Depth of cut: small	Depth of cut: large			
Shape A			Chips irregularly entangled	Not acceptable	• Wrapping around the tool or workpiece or accumulation around the cutting point, hindering cutting • Possible damage to the machined surface
Shape B			Long continuous spiral chips $\ell > 2$"	Acceptable	• Bulky during transport in the automatic line • May be preferred when one operator handles one machine
Shape C			Short spiral chips $\ell < 2$"		• 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.

Chipbreakers

Factors affecting chip control

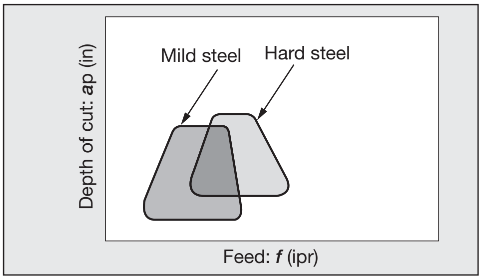
(1) Cutting conditions
1 Feed
2 Depth of cut
3 Cutting speed

- 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.



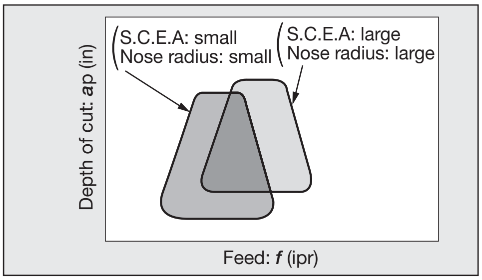
(2) Workpiece material
1 Alloy element
2 Hardness
3 Heat treatment condition

- 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.



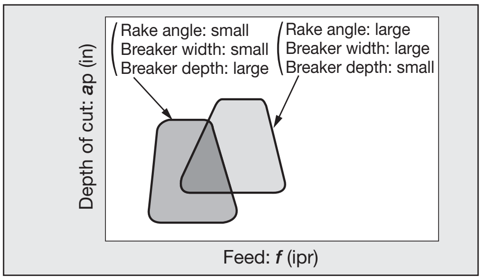
(3) Tool geometry
1 Side cutting edge angle
2 Nose radius

- 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.



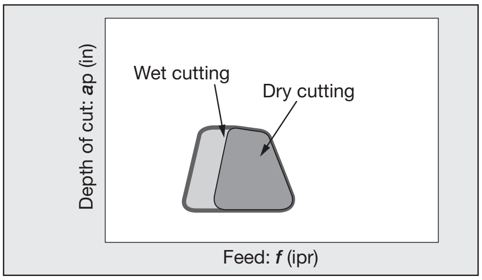
(4) Shape of chipbreaker
1 Rake angle
2 Chipbreaker width
3 Chipbreaker depth

- 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.



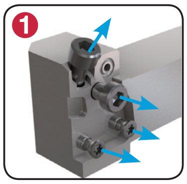
(6) Machine
1 Rigidity
2 Power limit

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

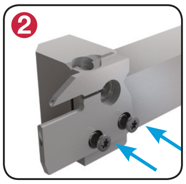
Grooving and Parting Tools

How to install and remove the blade and insert

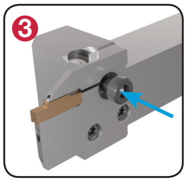
●Assembly



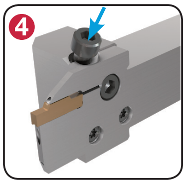
① Remove all 4 screws and ensure the O rings are all in place.



② Place the blade and tighten 2 bottom clamping screws.



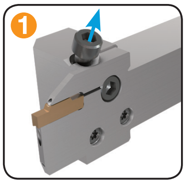
③ Place the insert in the pocket and tighten the fixing screw in the center.



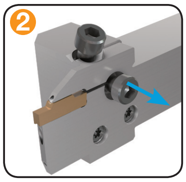
④ Place the long screw in the angular direction and tighten to clamp the insert.

Please follow the installation order as shown above. When the screws are tightened in the ④→③ order, the insert clamping may be insufficient and unstable.

●Disassembly

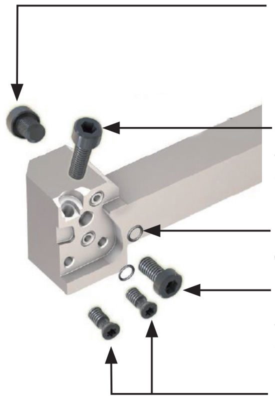


① First loosen the long screw in the angular direction.



② Loosen the Fixing screw in the center and remove the insert.

Loosing the long screw alone may not release the insert.



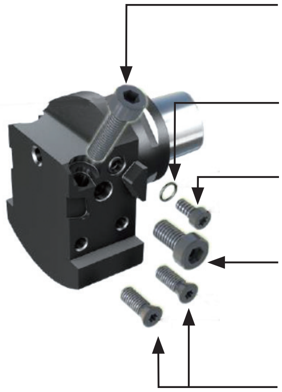
Plug Screw
PLUG G1/8ISO1179
(Wrench: HW5.0)

Long diagonal screw
SR M6X20-XT
(Wrench: HW5.0)

O-ring
OR5X1N

Center screw
SR M6X12DIN6912
(Wrench: HW5.0)

Short bottom screws
SR M5-04451
(Wrench: T-20/5)



Long diagonal screw
SRM6X20-XT
(Wrench: HW5.0)

O-ring
OR5X1N

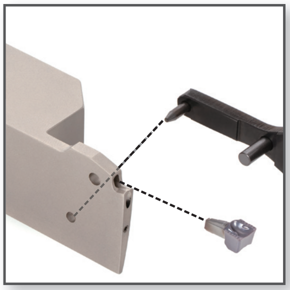
Plug screw for oil hole
SRM4X8ISO14580
(Wrench: HW5.0)

Center screw
SRM6X12DIN6912
(Wrench: HW5.0)

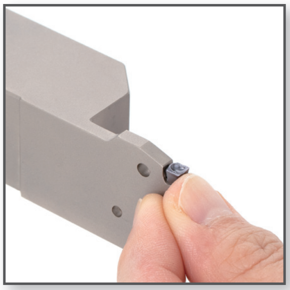
Short bottom screws
SRM5-04451
(Wrench: T-20/5)

※ All parts listed here are included in the tool holder.

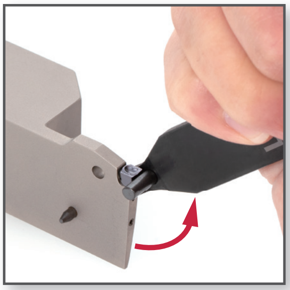
PROCEDURE TO CLAMP AND UNCLAMP INSERT



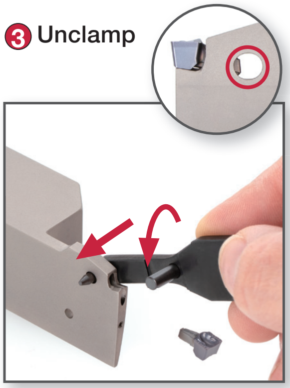
① Put the insert in the pocket



② Turn the wrench and push the insert into the pocket to clamp



③ Unclamp

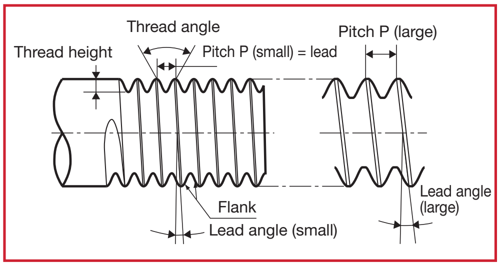


User's Guide - Technical Reference

Fundamentals of screw threads

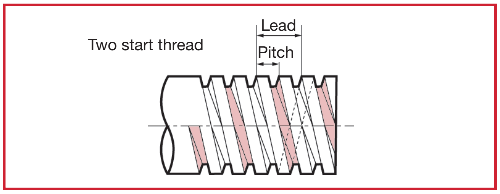
●Relationship between lead, lead angle and pitch

1. Lead is the axial distance a screw advances in one rotation. In single start screw, the lead is equal to the pitch.
2. The inclination angle of a threaded groove is called lead angle. In screws of the same diameter, the lead angle increases as the pitch increases.
3. The side face of a completed thread groove is called flank. The distance between the crest and the root is called thread height.



●Single and multi start thread

1. The single start thread has a single groove. Two start thread or three start thread has two grooves or three grooves respectively.
2. The pitch of multi start thread is the distance of adjoining groove.
3. When viewing the section of the multi start thread, the pitch is same as that of the single start thread. The lead of the two or three start thread is twice or three times the pitch. The multi start thread is mainly used for trapezoidal threads.



●Tolerance class of threads

Tolerance classes of screw threads are expressed as follows:

Metric coarse external thread: 6h, 6g Metric coarse internal thread: 5H, 6H

These classes are ranked with tolerances of thread diameter, pitch, thread angle, etc. For fastening applications, 6H- and 6g-class (former JIS second class) threads, manufactured by cutting or rolling, are generally used. 5H- and 4h-class threads (former JIS first class) are generally finished by grinding.

For example, M8-6g means metric coarse external thread of 6g tolerance class.

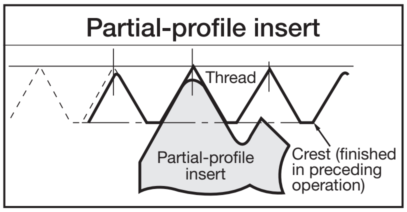
TAC threading insert

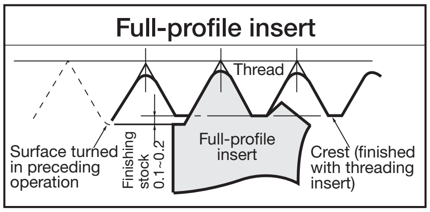
●Difference between full-profile and partial-profile insert

Full-profile insert

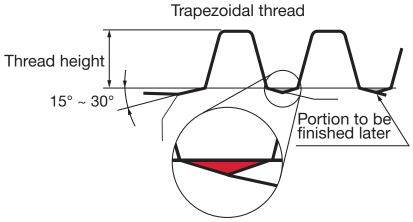
In the full-profile insert, the major diameter of the thread is finished by the profiled finishing edge as shown in Figure below. Therefore, about 0.1 mm of finishing stock must be left on the outer surface of the workpiece before threading. In trapezoidal threads, since slants of 15° to 30° are left on the crest of the thread as shown in Figure below, these portions must be finished by another tool later.

Full-profile insert could produce no burr and good thread by the profiled finishing edge.


Partial-profile insert


Full-profile insert

● When machining trapezoidal threads:



Partial-profile insert

Partial-profile inserts can not be used for finishing of the crest, but can be applied to a wide range of pitches.

For example

Designation	Pitch (mm)	TPI	Insert radius RE (mm)
16ERA60	0.5 ~ 1.5	48 ~ 16	0.06
16ERG60	1.75 ~ 3	14 ~ 8	0.22

Corner radii of inserts are fitted to the thread of the smallest pitch.

●Difference between external and internal use inserts

In full-profile inserts for metric and unified threads, the corner radius and thread height differ from those for the external and internal use insert respectively. Therefore, the right hand insert for external use and the left hand insert for internal use are not the same tool.

Since the rake angles of toolholders are -10° for external toolholders and -15° for internal toolholders, the external / internal toolholders can not be used for machining internal / external thread.

In Whitworth thread, though the external thread and internal thread have the same thread form, the external and internal toolholders are incompatible because of the different rake angle.

For example

Designation	Applicable inserts	Insert radius R RE (mm)	Thread hight (mm)	Rake angle of holders
16ER20ISO	External	0.25	1.52	-10°
16IL20ISO	Internal	0.14	1.3	-15°

Shim replacement method of ST-type tools

Compensation for the lead angle and tool relief angle

When the pitch is large or the screw diameter is small, the lead angle becomes large and the effective relief angle on the advance flank side β_2 becomes small. In particular, this will cause shorter life of the insert in the case of trapezoidal screw with small flank angle. It is ideal without any interference for the thread cutting insert to have an equal relief angle on both right and left. Replace the shim so that the rake face of insert faces the thread groove direction (that is, $\beta = \beta_3$).

Calculating the lead angle

The lead angle is calculated as follows:

$$\beta = \tan^{-1}(\ell/\pi d) = \tan^{-1}(nP/\pi d)$$

β : Lead angle
ℓ : Lead
n : No. of threads
P : Pitch
d : Pitch diameter

Calculating the relief angle

The relief angle β_1 is calculated as follows:

$$\beta_1 = \tan^{-1}(\tan\theta \cdot \tan\alpha)$$

The α of a standard toolholder is 10° for external threading and 15° for internal threading.

Included angle 2θ	θ	β_1	
		External threading tool	Internal threading tool
60°	30°	5.8°	8.8°
55°	27.5°	5.2°	7.9°
30°	15°	2.7°	4.1°
29°	14.5°	2.6°	4°

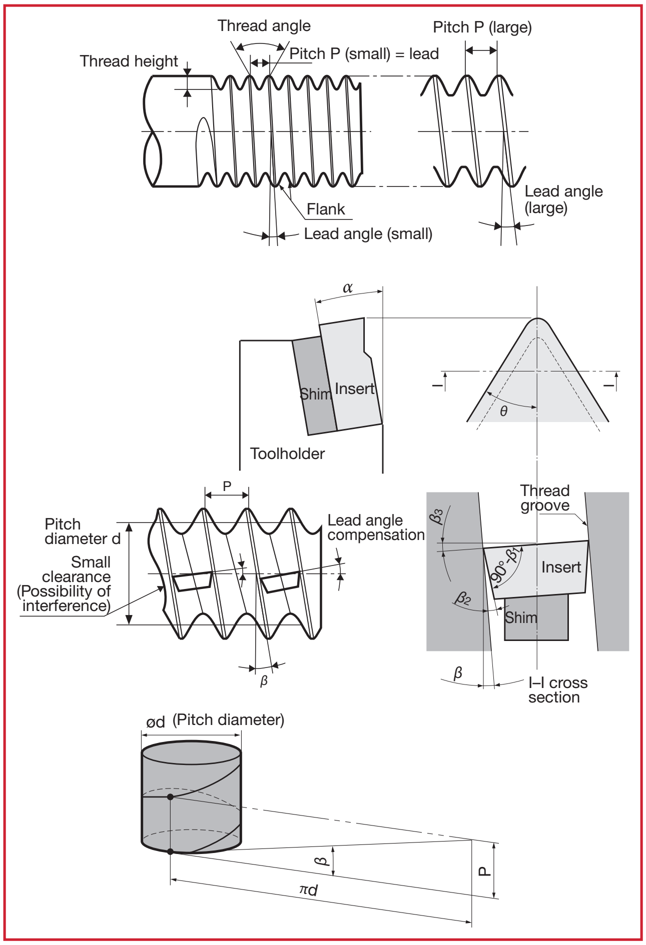
Accordingly, the effective relief angle is calculated as follows:

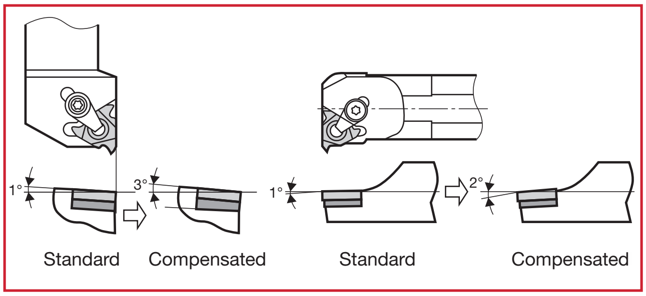
$$\beta_2 = \beta_1 + \beta_3 - \beta$$

β : Lead angle
β_2 : Effective relief angle
β_3 : Lead angle compensation value

In other words, $\beta_1 = \beta_2$ when the thread lead angle is equal to the compensation value. Namely, the relief angle of the tool itself is equal to the effective relief angle. If the wrong compensation value is used, $\beta_1 > \beta_2$. The effective relief angle becomes smaller and cause the interference between the flank side of insert and the thread groove. Therefore, carry out compensation of the lead angle so that the following range is obtained:

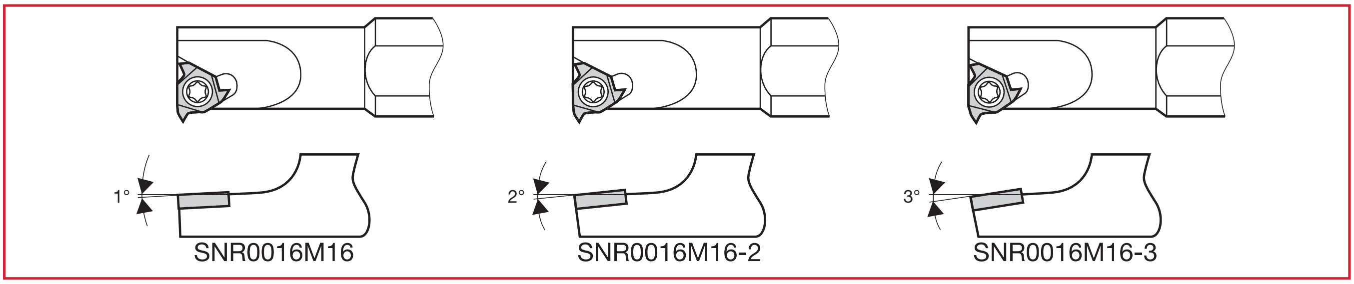
±1° when the thread angle is 60° and 55°
±30° when the thread angle is 30° and 29°





Compensation of lead angle for shim less internal toolholders

When using internal threading toolholders without shim, the above-mentioned method can not be applied for lead angle compensation. Therefore, special toolholders for large lead angles are available as shown below. The final figure of the designation (-2 or -3) indicates 2° or 3° lead angle to be used respectively. The toolholders without these figures are for 1° lead angle.



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Shim replacement method of ST-type tools

Type of shim and the compensation value of lead angle

The designation of the shim and compensated lead angles are shown in the table.

Compensated lead angles	-2°	-1°	0°	1°	2°	3°	4°
Shim	□□□**-98**	□□□**-99**	□□□**-0**	□□□**-1**	□□□**-2**	□□□**-3**	□□□**-4**

Note: The last numeral of the shim designation is the compensated lead angle.

■ Toolholders and applicable shims

Screw-on / clamp-on dual toolholders

Toolholder designation	Shim	
	R	L
CER/L□□□□□16DT	AE16-□DT	AN16-□DT
CER/L□□□□□22DT	GXE22-□DT	GXN22-□DT
TCNR/L□□□□□16DT	AN16-□DT	AE16-□DT
TCNR/L□□□□□22DT	GXN22-□DT	GXE22-□DT

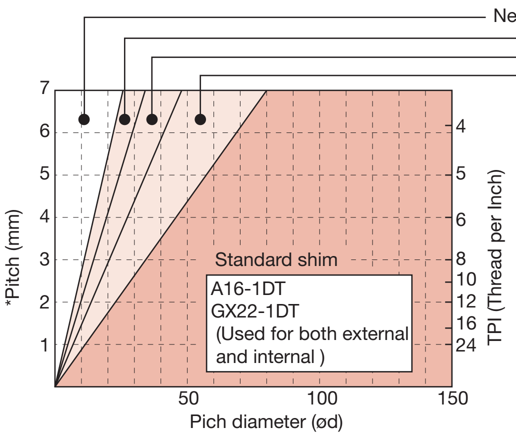
Note: Standard shim is AE16-1DT or GX22-1DT. Other types are optional.

Clamp-on type toolholders

Toolholder designation	Shim	
	R	L
CER/L□□□□□16-T	AE16-□	AN16-□
CER/L□□□□□22-T	NXE22-□	NXN22-□
CER/L□□□□□27-T	NXE27-□	NXN27-□
CNR/L□□□□□16	AN16-□	AE16-□
CNR/L□□□□□22	NXN22-□	NXE22-□
CNR/L□□□□□27	NXN27-□	NXE27-□
B-CER/L□□□16	AE16-□	AN16-□

Note: Standard shim is □□□□□-1. Other types are optional.

Shim selection guide for screw-on / clamp-on dual ST-type tools

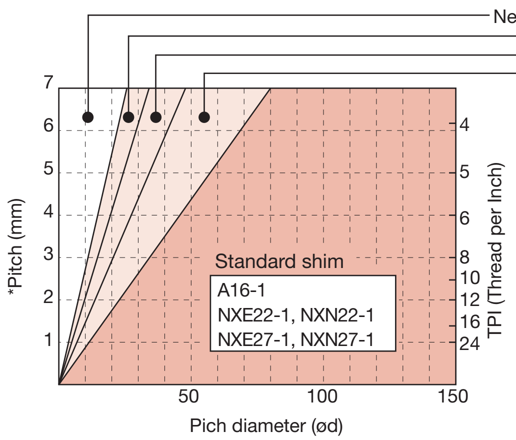


* For the multi start thread lead (multiplied by the pitch and No. of threads)

● List of exchangeable shims

	Designation	D30	Designation	D30	Designation	D30	Designation	D30
β3 = 4°	**AE16-4DT**	●	**AN16-4DT**	●	**GXE22-4DT**	●	**GXN22-4DT**	●
β3 = 3°	**AE16-3DT**	●	**AN16-3DT**	●	**GXE22-3DT**	●	**GXN22-3DT**	●
β3 = 2°	**AE16-2DT**	●	**AN16-2DT**	●	**GXE22-2DT**	●	**GXN22-2DT**	●
β3 = 1° Standard shim	**A16-1DT**	●	**A16-1DT**	●	**GX22-1DT**	●	**GX22-1DT**	●
β3 = 0°	**AE16-0DT**	●	**AN16-0DT**	●	**GXE22-0DT**	●	**GXN22-0DT**	●
β3 = -1°	**AE16-99DT**	●	**AN16-99DT**	●	**GXE22-99DT**	●	**GXN22-99DT**	●
β3 = -2°	**AE16-98DT**	●	**AN16-98DT**	●	**GXE22-98DT**	●	**GXN22-98DT**	●
Applicable toolholders	CER--16DT TCNL--16DT		CEL--16DT TCNR--16DT		CER--22DT TCNL--22DT		CEL--22DT TCNR--22DT	

Shim selection guide for clamp-on type ST-tools



* For the multi start thread lead (multiplied by the pitch and No. of threads)

● List of exchangeable shims

	Designation	D30	Designation	D30	Designation	D30	Designation	D30	Designation	D30	Designation	D30
β3 = 4°	**AE16-4**	●	**AN16-4**	●	**NXE22-4**	●	**NXN22-4**	●	**NXE27-4**		**NXN27-4**	
β3 = 3°	**AE16-3**	●	**AN16-3**	●	**NXE22-3**	●	**NXN22-3**	●	**NXE27-3**		**NXN27-3**	
β3 = 2°	**AE16-2**	●	**AN16-2**	●	**NXE22-2**	●	**NXN22-2**	●	**NXE27-2**		**NXN27-2**	
β3 = 1° Standard shim	**A16-1**	●	**A16-1**	●	**NXE22-1**	●	**NXN22-1**	●	**NXE27-1**	●	**NXN27-1**	●
β3 = 0°	**AE16-0**	●	**AN16-0**	●	**NXE22-0**	●	**NXN22-0**	●	**NXE27-0**		**NXN27-0**	
β3 = -1°	**AE16-99**	●	**AN16-99**	●	**NXE22-99**	●	**NXN22-99**	●	**NXE27-99**		**NXN27-99**	
β3 = -2°	**AE16-98**	●	**AN16-98**	●	**NXE22-98**	●	**NXN22-98**	●	**NXE27-98**		**NXN27-98**	
Applicable toolholders	CER--16T CNL--16 B-CER--16		CEL--16T CNR--16 B-CEL--16		CER--22T CNL--22		CEL--22T CNR--22		CER--27T CNL--27		CEL--27T CNR--27	

● : Line up

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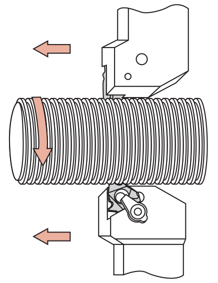
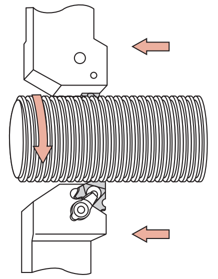
Threading Methods and Combinations

External threading

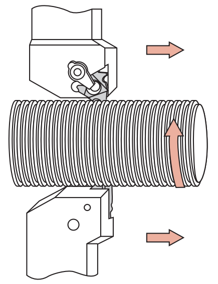
Right hand thread



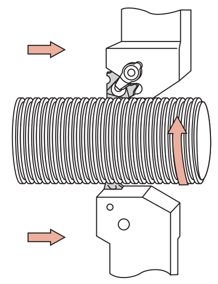
Work rotation	Regular
Feed direction	Push
Hand of toolholder	Right
Hand of insert	Right
Standard shim	①



Work rotation	Regular
Feed direction	Pull
Hand of toolholder	Left
Hand of insert	Left
Standard shim	④

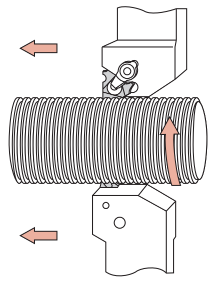


Work rotation	Reverse
Feed direction	Push
Hand of toolholder	Right
Hand of insert	Right
Standard shim	①

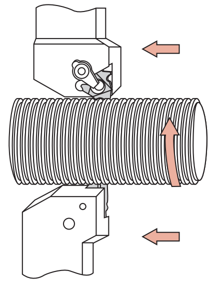


Work rotation	Reverse
Feed direction	Pull
Hand of toolholder	Left
Hand of insert	Left
Standard shim	④

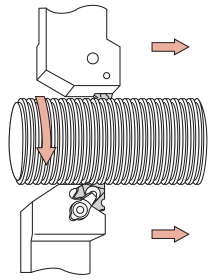
Left hand thread



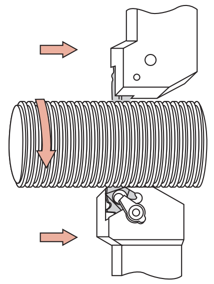
Work rotation	Reverse
Feed direction	Push
Hand of toolholder	Left
Hand of insert	Left
Standard shim	②



Work rotation	Reverse
Feed direction	Pull
Hand of toolholder	Right
Hand of insert	Right
Standard shim	③



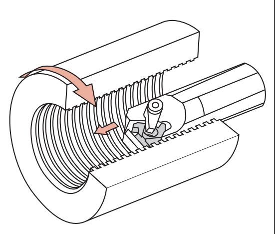
Work rotation	Regular
Feed direction	Push
Hand of toolholder	Left
Hand of insert	Left
Standard shim	②



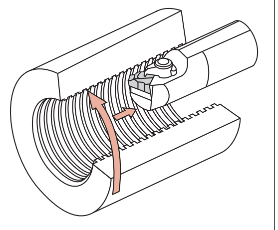
Work rotation	Regular
Feed direction	Pull
Hand of toolholder	Right
Hand of insert	Right
Standard shim	③

Internal threading

Right hand thread

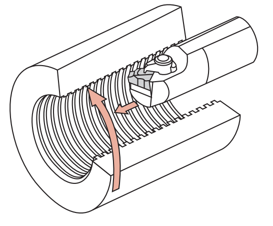


Work rotation	Regular
Feed direction	Push
Hand of toolholder	Right
Hand of insert	Right
Standard shim	②

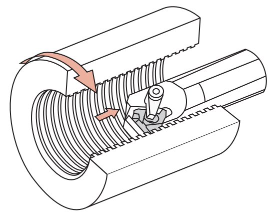


Work rotation	Reverse
Feed direction	Pull
Hand of toolholder	Left
Hand of insert	Left
Standard shim	③

Left hand thread



Work rotation	Reverse
Feed direction	Push
Hand of toolholder	Left
Hand of insert	Left
Standard shim	①



Work rotation	Regular
Feed direction	Pull
Hand of toolholder	Right
Hand of insert	Right
Standard shim	④

Standard shim

No.	New	No.	New
①	A16-1DT	②	A16-1DT
	A16-1		A16-1
	GX22-1DT		GX22-1DT
	NXE22-1		NXN22-1
	NXE27-1		NXN27-1
③	AE16-99DT	④	AN16-99DT
	AE16-99		AN16-99
	GXE22-99DT		GXN22-99DT
	NXE22-99		NXN22-99
	NXE27-99		NXN27-99

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Infeed per Pass and Number of Passes

ISO metric full-profile inserts (for external)

Pitch		0.5	0.75	1	1.25	1.5	1.75	2	2.5	3	3.5	4	4.5	5	5.5	6
Height of thread		0.32	0.47	0.63	0.79	0.95	1.11	1.27	1.58	1.9	2.21	2.53	2.85	3.16	3.48	3.8
Total depth of cut		0.42	0.57	0.73	0.89	1.05	1.21	1.37	1.68	2	2.31	2.63	2.95	3.26	3.58	3.9
Number of passes	1	0.15	0.18	0.25	0.25	0.3	0.3	0.3	0.3	0.35	0.35	0.4	0.4	0.45	0.5	0.5
	2	0.12	0.12	0.2	0.2	0.25	0.25	0.25	0.25	0.3	0.3	0.35	0.35	0.35	0.35	0.4
	3	0.1	0.12	0.13	0.15	0.2	0.2	0.2	0.25	0.25	0.3	0.3	0.3	0.3	0.3	0.3
	4	0.05	0.1	0.1	0.14	0.15	0.16	0.2	0.23	0.2	0.25	0.25	0.25	0.25	0.25	0.25
	5		0.05	0.05	0.1	0.1	0.15	0.15	0.2	0.2	0.21	0.2	0.2	0.25	0.23	0.25
	6				0.05	0.05	0.1	0.12	0.15	0.15	0.2	0.2	0.2	0.2	0.2	0.2
	7						0.05	0.1	0.15	0.15	0.15	0.15	0.2	0.2	0.2	0.2
	8							0.05	0.1	0.15	0.15	0.15	0.15	0.18	0.15	0.15
	9								0.05	0.1	0.15	0.15	0.15	0.15	0.15	0.15
	10									0.1	0.1	0.13	0.15	0.15	0.15	0.15
	11									0.05	0.1	0.1	0.15	0.13	0.15	0.15
	12										0.05	0.1	0.1	0.1	0.15	0.15
	13											0.1	0.1	0.1	0.15	0.15
	14											0.05	0.1	0.1	0.1	0.15
	15												0.1	0.1	0.1	0.1
	16												0.05	0.1	0.1	0.1
	17													0.1	0.1	0.1
	18													0.05	0.1	0.1
	19														0.1	0.1
	20														0.05	0.1
	21															0.1
	22															0.05
	23															
	24															

(Unit: mm)

ISO metric full-profile inserts (for internal)

Pitch		0.5	0.75	1	1.25	1.5	1.75	2	2.5	3	3.5	4	4.5	5	5.5	6
Height of thread		0.29	0.43	0.58	0.72	0.87	1.01	1.16	1.45	1.74	2.03	2.32	2.61	2.9	3.19	3.48
Total depth of cut		0.39	0.53	0.68	0.82	0.97	1.11	1.26	1.55	1.84	2.13	2.42	2.71	3	3.29	3.58
Number of passes	1	0.08	0.1	0.14	0.15	0.2	0.2	0.2	0.25	0.25	0.3	0.3	0.35	0.35	0.4	0.4
	2	0.07	0.09	0.13	0.13	0.16	0.18	0.18	0.22	0.22	0.25	0.25	0.25	0.25	0.25	0.25
	3	0.07	0.08	0.11	0.12	0.14	0.16	0.17	0.2	0.2	0.22	0.22	0.22	0.22	0.22	0.22
	4	0.06	0.08	0.1	0.11	0.12	0.14	0.16	0.18	0.18	0.2	0.2	0.2	0.2	0.2	0.2
	5	0.06	0.07	0.08	0.1	0.12	0.12	0.14	0.16	0.16	0.18	0.18	0.18	0.2	0.2	0.19
	6	0.05	0.06	0.07	0.09	0.1	0.1	0.12	0.15	0.15	0.16	0.18	0.18	0.18	0.18	0.18
	7		0.05	0.05	0.07	0.08	0.09	0.1	0.1	0.14	0.14	0.16	0.16	0.16	0.16	0.17
	8				0.05	0.05	0.07	0.08	0.1	0.13	0.13	0.14	0.14	0.14	0.14	0.16
	9						0.05	0.06	0.08	0.12	0.12	0.14	0.14	0.14	0.14	0.15
	10							0.05	0.06	0.1	0.11	0.12	0.12	0.13	0.13	0.14
	11								0.05	0.08	0.1	0.12	0.12	0.13	0.13	0.14
	12									0.06	0.1	0.1	0.12	0.12	0.13	0.13
	13									0.05	0.07	0.1	0.11	0.12	0.12	0.13
	14										0.05	0.09	0.1	0.12	0.12	0.13
	15											0.07	0.1	0.11	0.12	0.12
	16											0.05	0.09	0.1	0.12	0.12
	17												0.08	0.1	0.1	0.12
	18												0.05	0.1	0.1	0.1
	19													0.08	0.1	0.1
	20													0.05	0.1	0.1
	21														0.08	0.1
	22														0.05	0.1
	23															0.08
	24															0.05

(Unit: mm)

Unified full-profile inserts

		For external							For internal						
TPI		24	20	18	16	14	12	8	24	20	18	16	14	12	8
Height of thread		0.67	0.8	0.89	1.01	1.15	1.34	2.01	0.61	0.74	0.82	0.92	1.05	1.23	1.84
Total depth of cut		0.77	0.9	0.99	1.11	1.25	1.44	2.11	0.71	0.84	0.92	1.02	1.15	1.33	1.94
Number of passes	1	0.25	0.25	0.28	0.3	0.3	0.3	0.35	0.2	0.2	0.2	0.2	0.25	0.25	0.3
	2	0.22	0.2	0.23	0.25	0.25	0.25	0.3	0.16	0.16	0.18	0.18	0.2	0.2	0.25
	3	0.15	0.16	0.18	0.18	0.23	0.21	0.25	0.12	0.13	0.15	0.16	0.18	0.18	0.22
	4	0.1	0.14	0.15	0.15	0.18	0.18	0.22	0.1	0.12	0.14	0.14	0.16	0.16	0.2
	5	0.05	0.1	0.1	0.1	0.14	0.15	0.2	0.08	0.1	0.1	0.11	0.13	0.13	0.18
	6		0.05	0.05	0.08	0.1	0.12	0.2	0.05	0.08	0.1	0.1	0.1	0.1	0.16
	7				0.05	0.05	0.1	0.16		0.05	0.05	0.08	0.08	0.1	0.14
	8						0.08	0.16				0.05	0.05	0.08	0.12
	9						0.05	0.12						0.08	0.12
	10							0.1						0.05	0.1
	11							0.05							0.1
	12														0.05
	13														
	14														

(Unit: mm)

Whitworth full-profile inserts

		For external									For internal								
TPI		20	19	18	16	14	12	11	10	8	20	19	18	16	14	12	11	10	8
Height of thread		0.83	0.88	0.92	1.04	1.19	1.39	1.51	1.66	2.08	0.83	0.88	0.92	1.04	1.19	1.39	1.51	1.66	2.08
Total depth of cut		0.93	0.98	1.02	1.14	1.29	1.49	1.61	1.76	2.18	0.93	0.98	1.02	1.14	1.29	1.49	1.61	1.76	2.18
Number of passes	1	0.25	0.28	0.3	0.3	0.3	0.3	0.3	0.35	0.35	0.2	0.2	0.22	0.22	0.25	0.25	0.25	0.3	0.35
	2	0.2	0.22	0.24	0.25	0.25	0.25	0.25	0.3	0.3	0.18	0.18	0.18	0.18	0.21	0.21	0.21	0.25	0.3
	3	0.18	0.18	0.18	0.18	0.23	0.2	0.2	0.23	0.25	0.16	0.16	0.17	0.17	0.2	0.2	0.2	0.22	0.25
	4	0.15	0.15	0.15	0.14	0.2	0.18	0.18	0.2	0.23	0.14	0.16	0.16	0.16	0.18	0.18	0.18	0.2	0.22
	5	0.1	0.1	0.1	0.12	0.16	0.15	0.15	0.15	0.22	0.12	0.13	0.14	0.14	0.16	0.16	0.16	0.16	0.2
	6	0.05	0.05	0.05	0.1	0.1	0.14	0.14	0.14	0.2	0.08	0.1	0.1	0.12	0.14	0.14	0.14	0.14	0.18
	7				0.05	0.05	0.12	0.12	0.12	0.18	0.05	0.05	0.05	0.1	0.1	0.1	0.12	0.12	0.16
	8						0.1	0.12	0.12	0.16				0.05	0.05	0.1	0.1	0.12	0.14
	9						0.05	0.1	0.1	0.14						0.1	0.1	0.1	0.12
	10							0.05	0.05	0.1						0.05	0.1	0.1	0.11
	11									0.05							0.05	0.05	0.1
	12																		0.05
	13																		
	14																		
	15																		

(Unit: mm)

User’s Guide - Technical Reference

Infeed per Pass and Number of Passes

30° Trapezoidal (TR) inserts

		For external					For internal				
Pitch		2	3	4	5	6	2	3	4	5	6
Height of thread		1.25	1.75	2.25	2.75	3.5	1.25	1.75	2.25	2.75	3.5
Total depth of cut		1.35	1.85	2.35	2.85	3.6	1.35	1.85	2.35	2.85	3.6
Number of passes	1	0.25	0.25	0.3	0.3	0.3	0.2	0.22	0.25	0.25	0.25
	2	0.2	0.22	0.25	0.25	0.25	0.18	0.2	0.22	0.22	0.22
	3	0.2	0.2	0.22	0.2	0.23	0.18	0.18	0.2	0.2	0.21
	4	0.18	0.18	0.2	0.2	0.2	0.16	0.16	0.2	0.18	0.2
	5	0.15	0.17	0.18	0.18	0.18	0.15	0.16	0.17	0.18	0.18
	6	0.12	0.16	0.16	0.16	0.18	0.13	0.16	0.16	0.16	0.18
	7	0.1	0.14	0.15	0.16	0.16	0.1	0.14	0.16	0.16	0.16
	8	0.1	0.14	0.14	0.15	0.16	0.1	0.14	0.14	0.15	0.16
	9	0.05	0.12	0.14	0.14	0.16	0.1	0.12	0.14	0.14	0.16
	10		0.12	0.12	0.14	0.16	0.05	0.12	0.12	0.14	0.16
	11		0.1	0.12	0.14	0.16		0.1	0.12	0.14	0.16
	12		0.05	0.12	0.12	0.15		0.1	0.12	0.12	0.15
	13			0.1	0.12	0.15		0.05	0.1	0.12	0.15
	14			0.1	0.12	0.15			0.1	0.12	0.15
	15			0.05	0.12	0.14			0.1	0.12	0.14
	16				0.1	0.14			0.05	0.1	0.14
	17				0.1	0.12				0.1	0.12
	18				0.1	0.12				0.1	0.12
	19				0.05	0.12				0.1	0.12
	20					0.12				0.05	0.12
	21					0.1					0.1
	22					0.1					0.1
	23					0.05					0.1
	24										0.05
	25										
	26										

(Unit: mm)

29° Trapezoidal (TR) inserts

		For external			For internal		
TPI		8	6	5	8	6	5
Height of thread		1.88	2.41	2.92	1.88	2.41	2.92
Total depth of cut		1.98	2.51	3.02	1.98	2.51	3.02
Number of passes	1	0.25	0.25	0.25	0.22	0.22	0.22
	2	0.22	0.22	0.22	0.2	0.2	0.2
	3	0.2	0.2	0.2	0.18	0.18	0.18
	4	0.18	0.18	0.18	0.16	0.18	0.18
	5	0.16	0.17	0.18	0.16	0.16	0.16
	6	0.16	0.16	0.16	0.16	0.15	0.16
	7	0.16	0.16	0.16	0.15	0.15	0.15
	8	0.14	0.14	0.14	0.14	0.14	0.14
	9	0.14	0.14	0.14	0.14	0.14	0.14
	10	0.12	0.14	0.14	0.12	0.14	0.14
	11	0.1	0.14	0.14	0.1	0.14	0.14
	12	0.1	0.12	0.14	0.1	0.12	0.14
	13	0.05	0.12	0.12	0.1	0.12	0.12
	14		0.12	0.12	0.05	0.12	0.12
	15		0.1	0.12		0.1	0.12
	16		0.1	0.12		0.1	0.12
	17		0.05	0.12		0.1	0.12
	18			0.12		0.05	0.12
	19			0.1			0.1
	20			0.1			0.1
	21			0.05			0.1
	22						0.05
	23						
	24						
	25						
	26						

(Unit: mm)

PT full-profile inserts

		For external				For internal		
TPI		28	19	14	11	19	14	11
Height of thread		0.6	0.86	1.16	1.48	0.86	1.16	1.48
Total depth of cut		0.7	0.96	1.26	1.58	0.96	1.26	1.58
Number of passes	1	0.25	0.28	0.3	0.3	0.22	0.25	0.25
	2	0.2	0.2	0.25	0.25	0.2	0.22	0.22
	3	0.1	0.18	0.2	0.22	0.18	0.18	0.18
	4	0.1	0.15	0.15	0.18	0.16	0.14	0.18
	5	0.05	0.1	0.11	0.15	0.1	0.12	0.15
	6		0.05	0.1	0.12	0.05	0.1	0.13
	7			0.1	0.11	0.05	0.1	0.12
	8			0.05	0.1		0.1	0.1
	9				0.1		0.05	0.1
	10				0.05			0.1
	11							0.05
	12							
	13							
	14							
	15							
	16							
	17							
	18							
	19							
	20							
	21							
	22							
	23							
	24							
	25							
	26							

(Unit: mm)

NPT full-profile inserts

		For external				For internal		
TPI		18	14	11.5	8	14	11.5	8
Height of thread		1.14	1.47	1.79	2.58	1.47	1.79	2.58
Total depth of cut		1.24	1.57	1.89	2.68	1.57	1.89	2.68
Number of passes	1	0.2	0.25	0.25	0.3	0.22	0.22	0.25
	2	0.18	0.22	0.22	0.25	0.2	0.2	0.2
	3	0.17	0.2	0.2	0.2	0.18	0.18	0.2
	4	0.16	0.18	0.18	0.2	0.18	0.18	0.2
	5	0.14	0.17	0.18	0.2	0.16	0.16	0.2
	6	0.12	0.16	0.17	0.2	0.14	0.16	0.2
	7	0.12	0.12	0.16	0.18	0.12	0.16	0.18
	8	0.1	0.12	0.14	0.18	0.12	0.14	0.18
	9	0.05	0.1	0.12	0.16	0.1	0.12	0.16
	10		0.05	0.12	0.16	0.1	0.12	0.16
	11			0.1	0.14	0.05	0.1	0.14
	12			0.05	0.14		0.1	0.14
	13				0.12		0.05	0.12
	14				0.1			0.1
	15				0.1			0.1
	16				0.05			0.1
	17							0.05
	18							
	19							
	20							
	21							
	22							
	23							
	24							
	25							
	26							

(Unit: mm)

Standard Cutting Conditions and Infeed Methods

Threading guidelines

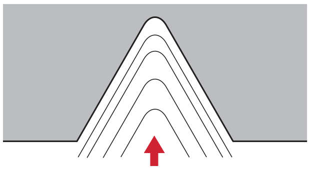
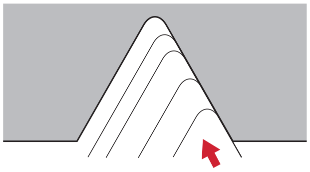
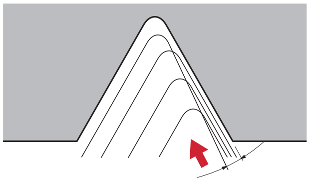
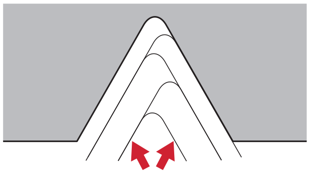
Determine the infeed per pass and number of threads whilst referring to the table and description below.

Pitch (mm)	0.5	0.75	1	1.25	1.5	1.75	2	2.5	3	3.5	4	4.5	5 ~
TPI	48	32	24	20	16	14	12	10	8	7	6	5.5	5 ~
No. of passes	4 ~ 6	4 ~ 7	4 ~ 8	5 ~ 9	6 ~ 10	7 ~ 12	7 ~ 12	8 ~ 14	10 ~ 16	11 ~ 18	11 ~ 18	11 ~ 19	12 ~ 24

Note:

- When using the full-profile insert, set the total infeed amount by taking the finish stock of 0.1mm into account.
- Set the first infeed to 150 ~ 200% of nose R and do not allow it to exceed 0.5 mm.
- The infeed amount during the final pass must be a minimum of 0.05 mm. No zero cuts should be made. (Extra small infeed or zero cutting of work hardened surfaces will reduce tool life.)
- The partial-profile insert or inside diameter insert has small nose R. Reduce the infeed per pass and increase the no. of passes.
- Regarding standard infeed per passes and no. of passes, please refer to our catalogue.

Infeed methods for threading tools

Infeed method	Features
 Straight infeed (radial infeed)	• Most simple and usual method • Suitable for relatively small pitch threads of easily machinable material. • Chip contact length on right and left is longer, causing chattering, with increased load on the nose end. • When the half included angle is not symmetrical to the right and left, infeeding in the direction of 1/2 of the included angle will ensure equal machining with right and left cutting edges.
 Single edge infeed (flank infeed)	• Suitable for large pitch threads or easy to tear materials. Effectively prevents chattering. • Chips are discharged in one direction only. Satisfactory chip control. • Edge on the right (with zero infeed) tends to be worn heavily.
 Modified single-edge infeed (flank infeed)	• Edge on the right performs some cutting, therefore wear of this edge can thus be suppressed. • Suitable for large pitch threads or easy to tear materials. Effectively prevents chattering. • Chips are discharged in one direction only. Satisfactory chip control.
 Alternating flank infeed	• Suitable for large pitch threads or easy to tear material. Effectively prevents chattering. • Chips are discharged alternately in right and left directions, resulting possibly in entanglement. • Right and left edges are used alternately, ensuring uniform wear and extending tool life.

Selection of internal threading toolholders

Relation between internal toolholders and machinable threads

In the tables starting from next page, the relationships between toolholders, inserts, threads to be machined, and shims to be replaced are shown. In these tables, the criteria are set as follows.

- **The minimum machining diameter.**
- **The L/D ratio of the toolholder.**
- **The lead angle of the thread.**
- **Cutting conditions.**

Especially when machining near the minimum machining diameter, the compensation for the lead angle should be done carefully.

Moreover, in threading, because chips generally can not be broken into small pieces, the shank size should be selected in consideration of adequate clearance (C_1).

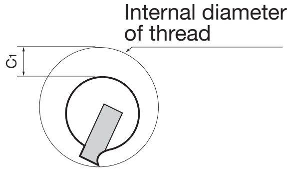
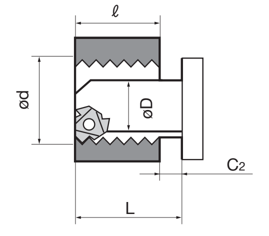
Symbols

○ Recommended

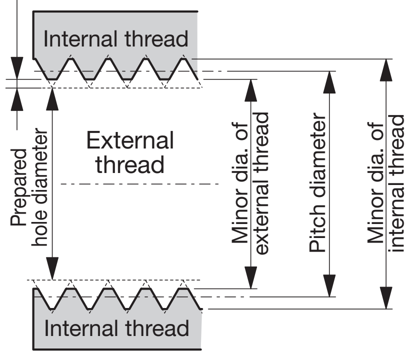
• Usable

$\boxed{2}$ Needs replacing of the shim. "2" indicates "Change to the shim for 2° lead angle".

▨ Unusable

<table>
<tr><td rowspan="2">Clearance C_1</td><td>
</td><td colspan="2">$C_1 \geq 3$ mm
(1 mm for 6IR insert holders)</td></tr>
<tr></tr>
<tr><td rowspan="2">Overhang ratio L/D</td><td rowspan="2">
</td><td>Steel shank</td><td>L/D ≤ 2→○</td></tr>
<tr><td>Carbide shank</td><td>L/D ≤ 3→○</td></tr>
</table>

Stock to be removed with full-profile insert.



How to use the tables

①Firstly, find the nominal thread diameter. Example: M35 X 1.5

②The table indicates that the lead angle is 0°48′.

③The Cat. No. of the insert to be used corresponds with IR15ISO.

④By following the row to the right, • and ○ marks are found. The ○ mark indicates the optimum toolholder type. The toolholders of • mark are usable, but less rigid because the shank diameter against the threading diameter is smaller than those of ○ marked toolholder. In this example, CNR0025R16 and TCNR0020R16DT are the optimum toolholders. The insert Cat.No. is 16IR15ISO.

⑤In the case of M33 X 3 thread, the lead angle is 1°46′. By following the row to the right. $\boxed{2}$ mark is found. This indicates that the shim should be replaced to 2° type. For calculation of the lead angle, refer to page L045.

Metric fine screw thread (ISO)

(For full size of this table, see page L053.)

				Shank material	Steel shank																	Carbide shank										"Tsuppari-Ichiban"					
				Insert size	6IR				11IR				16IR					22IR				6IR				11IR				16IR		16IR				22IR	
Nominal size	Pitch	Effective diameter	Lead angle	Holder Cat. No. Insert Cat. No.	SNR0006H06-2	SNR0006H06-3	SNR0008H06-2	SNR0008H06-3	SNR0010K11	SNR0010K11-2	SNR0013L11	SNR0013L11-2	SNR0016M16	SNR0016M16-2	CNR0020P16	CNR0025R16	CNR0032S16	SNR0020Q22	SNR0020Q22-2	CNR0025R22	CNR0032S22	SNR0006K06SC-2	SNR0006K06SC-3	SNR0008K06SC-2	SNR0008K06SC-3	SNR0010M11SC	SNR0010M11SC-2	SNR0012P11SC	SNR0012P11SC-2	SNR0016R16SC	SNR0016R16SC-2	TSNR0016Q16	TCNR0020R16DT	TCNR0025S16DT	(TCNR0032T16DT)	TSNR0020R22	TCNR0025S22DT
M33×1.5	1.5	32.03	0°51′	IR15ISO					•		•		•		○											•		•		•		•	○				
M33×2	2	31.7	1°09′	IR20ISO	•		•		•		•		•		•	○						•		•		•		•		•		•	○				
M33×3	3	31.05	1°46′	IR30ISO											$\boxed{2}$																	•	$\boxed{2}$				
M35×1.5	1.5	34.03	0°48′	IR15ISO					•		•		•		•	○										•		•		•		•	○				
M36×1.5	1.5	35.03	0°47′	IR15ISO					•		•		•		•	○										•		•		•		•	○				
M36×2	2	34.7	1°03′	IR20ISO											•	○						•		•		•		•		•		•	○				
M36×3	3	34.05	1°3																													•	$\boxed{2}$				
M38×1.5	1.5	37																								•		•		•		•	•	○			
																										•		•		•		•	•				

User's Guide - Technical Reference

Selection of ST-type Toolholders

Selection of Internal Toolholders—Relationship between thread sizes, toolholders, and inserts—Part 1

Metric coarse screw thread (ISO)

Nominal size	Pitch	Pitch diameter	Lead angle	Shank material	Steel shank																	Carbide shank								"Tsuppari-Ichiban"	
				Insert size	6IR				11IR				16IR		22IR					27IR		6IR				11IR		16IR		22IR	
				Holder Cat. No. Insert Cat. No.	SNR0006H06-2	SNR0006H06-3	SNR0008H06-2	SNR0008H06-3	SNR0010K11-2	SNR0010K11-3	SNR0013L11-2	SNR0013L11-3	SNR0016M16-2	SNR0016M16-3	SNR0020Q22-2	SNR0020Q22-3	CNR0025R22	CNR0032S22	(CNR0040T22)	CNR0040T27	(CNR0050U27)	SNR0006K06SC-2	SNR0006K06SC-3	SNR0008K06SC-2	SNR0008K06SC-3	SNR0010M11SC-2	SNR0010M11SC-3	SNR0016R16SC-2	(SNR0016R16SC-3)	TCNR0025S22DT	(TCNR0032T22DT)
M10	1.5	9.03	3°02´	IR15ISO																											
M11	1.5	10.03	2°44´	IR15ISO		○																	○								
M12	1.75	10.86	2°56´	IR175ISO		○																	○								
M14	2	12.7	2°52´	IR20ISO		•		○															•		○						
M16	2	14.7	2°29´	IR20ISO	•		○															•		○							
M18	2.5	16.38	2°47´	IR25ISO																											
M20	2.5	18.38	2°29´	IR25ISO																											
M22	2.5	20.38	2°14´	IR25ISO																											
M24	3	22.05	2°29´	IR30ISO																											
M27	3	25.05	2°11´	IR30ISO									○															○			
M30	3.5	27.73	2°18´	IR35ISO																											
M33	3.5	30.73	2°05´	IR35ISO											○																
M36	4	33.4	2°11´	IR40ISO											○																
M39	4	36.4	2°00´	IR40ISO											•		$\boxed{2}$													$\boxed{2}$	
M42	4.5	39.08	2°06´	IR45ISO											•		$\boxed{2}$													$\boxed{2}$	
M45	4.5	42.08	1°57´	IR45ISO											•		$\boxed{2}$													$\boxed{2}$	
M48	5	44.75	2°02´	IR50ISO											•		$\boxed{2}$	$\boxed{2}$												$\boxed{2}$	$\boxed{2}$
M52	5	48.75	1°52´	IR50ISO											•		$\boxed{2}$	$\boxed{2}$												$\boxed{2}$	$\boxed{2}$
M56	5.5	52.43	1°55´	IR55ISO																											
M60	5.5	56.43	1°47´	IR55ISO																$\boxed{2}$											
M64	6	60.1	1°49´	IR60ISO																$\boxed{2}$											
M68	6	64.1	1°42´	IR60ISO																$\boxed{2}$	$\boxed{2}$										

$\boxed{2}$: Change the shim to NXN22-2

$\boxed{2}$: Change the shim to NXN27-2

$\boxed{2}$: Change the shim to GXN22-2DT

Metric fine screw thread (ISO)

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Nominal size	Pitch	Pitch diameter	Lead angle	Shank material	Steel shank										Carbide shank									
				Insert size	6IR				11IR						6IR				11IR					
				Holder Cat. No. Insert Cat. No.	SNR0006H06-2	SNR0006H06-3	SNR0008H06-2	SNR0008H06-3	SNR0010K11	SNR0010K11-2	SNR0010K11-3	SNR0013L11	SNR0013L11-2	SNR0013L11-3	SNR0006K06SC-2	SNR0006K06SC-3	SNR0008K06SC-2	SNR0008K06SC-3	SNR0010M11SC	SNR0010M11SC-2	SNR0010M11SC-3	SNR0012P11SC	SNR0012P11SC-2	SNR0012P11SC-3
M9×0.75	0.75	8.51	1°36´	IR075ISO																				
M9×1	1	8.32	2°11´	IR10ISO																				
M10×0.75	0.75	9.51	1°26´	IR075ISO																				
M10×1	1	9.35	1°57´	IR10ISO	○										○									
M10×1.25	1.25	9.19	2°29´	IR125ISO																				
M11×0.75	0.75	10.51	1°18´	IR075ISO																				
M11×1	1	10.35	1°46´	IR10ISO	○										○									
M12×1	1	11.35	1°36´	IR10ISO	•		○								•		○							
M12×1.25	1.25	11.19	2°02´	IR125ISO	○										○									
M12×1.5	1.5	11.03	2°29´	IR15ISO	○										○									
M14×1	1	13.35	1°22´	IR10ISO																				
M14×1.25	1.25	13.19	1°44´	IR125ISO	•		○								•		○							
M14×1.5	1.5	13.03	2°06´	IR15ISO	•		○								•		○							
M15×1	1	14.35	1°16´	IR10ISO																				
M15×1.5	1.5	14.03	1°57´	IR15ISO	•		○								•		○							
M16×1	1	15.35	1°11´	IR10ISO					○															
M16×1.5	1.5	15.03	1°49´	IR15ISO	•		○								•		○							
M17×1	1	16.35	1°07´	IR10ISO					○										○					
M17×1.5	1.5	16.03	1°42´	IR15ISO	•		•			○					•		○							
M18×1	1	17.35	1°03´	IR10ISO					○										○					
M18×1.5	1.5	17.03	1°36´	IR15ISO	•		•			○					•		•			○				
M18×2	2	16.7	2°11´	IR20ISO	•		•			○					•		•			○				
M20×1	1	19.35	0°57´	IR10ISO					•			○							•			○		
M20×1.5	1.5	19.03	1°26´	IR15ISO					•			○							•			○		
M20×2	2	18.7	1°57´	IR20ISO	•		•			○					•		•			•			○	

Note : The above tables show correspondence of internal toolholders at the time of setting clearance between thread and toolholder to 3 mm (1 mm in case of SN type) and the finishing stock to 0.1 mm.

Metric fine screw thread (ISO)

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Nominal size	Pitch	Pitch diameter	Lead angle	Shank material	Steel shank													Carbide shank														"Tsuppari-Ichiban"	
				Insert size	6IR				11IR					16IR				6IR				11IR						16IR				16IR	
				Holder Cat. No. Insert Cat. No.	SNR0006H06-2	SNR0006H06-3	SNR0008H06-2	SNR0008H06-3	SNR0010K11	SNR0010K11-2	SNR0013L11	SNR0013L11-2	SNR0013L11-3	SNR0016M16	SNR0016M16-2	SNR0016M16-3	CNR0020P16	SNR0006K06SC-2	SNR0006K06SC-3	SNR0008K06SC-2	SNR0008K06SC-3	SNR0010M11SC	SNR0010M11SC-2	SNR0010M11SC-3	SNR0012P11SC	SNR0012P11SC-2	SNR0012P11SC-3	SNR0016R16SC	SNR0016R16SC-2	(SNR0016R16SC-3)	TSNR0016Q16	TCNR0020R16DT	TCNR0025S16DT
M22×1	1	21.35	0°51′	IR10ISO					•		○											•			○								
M22×1.5	1.5	21.03	1°18′	IR15ISO	•		•		•		○							•		•		•			○								
M22×2	2	20.7	1°46′	IR20ISO	•		•			•		○						•		•			•			○							
M24×1	1	23.35	0°47′	IR10ISO							○			•								•			○						•		
M24×1.5	1.5	23.03	1°11′	IR15ISO	•		•				○			•				•		•		•			○						•		
M24×2	2	22.07	1°39′	IR20ISO	•		•			•		○						•		•			•			○							
M25×1	1	24.35	0°45′	IR10ISO					•		○			•											○			•			•		
M25×1.5	1.5	24.03	1°08′	IR15ISO	•		•		•		○			•				•		•					○			•			•		
M25×2	2	23.7	1°32′	IR20ISO	•		•			•		○			•			•		•			•			○							
M26×1.5	1.5	25.03	1°06′	IR15ISO	•		•		•		•			○				•		•		•			•			•			○		
M27×1	1	26.35	0°42′	IR10ISO					•		•			○								•			•			•			○		
M27×1.5	1.5	26.03	1°03′	IR15ISO	•		•		•		•			○				•		•		•			•			•			○		
M27×2	2	25.7	1°25′	IR20ISO	•		•		•		•			○				•		•		•			•			•			○		
M28×1	1	27.35	0°40′	IR10ISO					•		•			○								•			•			•			○		
M28×1.5	1.5	27.03	1°01′	IR15ISO	•		•		•		•			○				•		•		•			•			•			○		
M28×2	2	26.7	1°22′	IR20ISO	•		•		•		•			○				•		•		•			•			•			○		
M30×1	1	29.35	0°37′	IR10ISO					•		•			○								•			•			•			○		
M30×1.5	1.5	29.03	0°57′	IR15ISO					•		•			○								•			•			•			○		
M30×2	2	28.7	1°16′	IR20ISO	•		•		•		•			○				•		•		•			•			•			○		
M30×3	3	28.05	1°57′	IR30ISO											○														○				
M32×1.5	1.5	31.03	0°53′	IR15ISO					•		•			○			○					•			•			•			•	○	
M32×2	2	30.07	1°11′	IR20ISO	•		•		•		•			○			○	•		•		•			•			•			•	○	

Metric fine screw thread (ISO)

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Nominal size	Pitch	Pitch diameter	Lead angle	Shank material	Steel shank																	Carbide shank										"Tsuppari-Ichiban"					
				Insert size	6IR				11IR				16IR					22IR				6IR				11IR				16IR		16IR				22IR	
				Holder Cat. No. Insert Cat. No.	SNR0006H06-2	SNR0006H06-3	SNR0008H06-2	SNR0008H06-3	SNR0010K11	SNR0010K11-2	SNR0013L11	SNR0013L11-2	SNR0016M16	SNR0016M16-2	CNR0020P16	CNR0025R16	CNR0032S16	SNR0020Q22	SNR0020Q22-2	CNR0025R22	CNR0032S22	SNR0006K06SC-2	SNR0006K06SC-3	SNR0008K06SC-2	SNR0008K06SC-3	SNR0010M11SC	SNR0010M11SC-2	SNR0012P11SC	SNR0012P11SC-2	SNR0016R16SC	SNR0016R16SC-2	TSNR0016Q16	TCNR0020R16DT	TCNR0025S16DT	(TCNR0032T16DT)	TSNR0020R22	TCNR0025S22DT
M33×1.5	1.5	32.03	0°51′	IR15ISO					•		•		•		○											•		•		•		•	○				
M33×2	2	31.7	1°09′	IR20ISO	•		•		•		•		•		•	○						•		•		•		•		•		•	○				
M33×3	3	31.05	1°46′	IR30ISO											$\boxed{2}$																	•	$\boxed{2}$				
M35×1.5	1.5	34.03	0°48′	IR15ISO					•		•		•		•	○										•		•		•		•	○				
M36×1.5	1.5	35.03	0°47′	IR15ISO					•		•		•		•	○										•		•		•		•	○				
M36×2	2	34.7	1°03′	IR20ISO	•		•		•		•		•		•	○						•		•		•		•		•		•	○				
M36×3	3	34.05	1°36′	IR30ISO											$\boxed{2}$																	•	$\boxed{2}$				
M38×1.5	1.5	37.03	0°44′	IR15ISO					•		•		•		•	○										•		•		•		•	•	○			
M39×1.5	1.5	38.03	0°43′	IR15ISO					•		•		•		•	○										•		•		•		•	•	○			
M39×2	2	38.7	0°58′	IR20ISO					•		•		•		•	○										•		•		•		•	•	○			
M39×3	3	37.05	1°29′	IR30ISO									•		•	○														•		•	•	○			
M40×1.5	1.5	39.03	0°42′	IR15ISO					•		•		•		•	○										•		•		•		•	•	○			
M40×2	2	37.8	0°57′	IR20ISO					•		•		•		•	○										•		•		•		•	•	○			
M40×3	3	38.05	1°26′	IR30ISO									•		•	○														•		•	•	○			
M42×1.5	1.5	41.03	0°40′	IR15ISO					•		•		•		•	○										•		•		•		•	•	○			
M42×2	2	40.7	0°54′	IR20ISO					•		•		•		•	○										•		•		•		•	•	○			
M42×3	3	40.05	1°22′	IR30ISO									•		•	○														•		•	•	○			
M42×4	4	39.4	1°51′	IR40ISO																$\boxed{2}$																•	$\boxed{2}$
M45×1.5	1.5	44.03	0°37′	IR15ISO					•		•		•		•	•	○									•		•		•		•	•	○	○		
M45×2	2	43.7	0°50′	IR20ISO					•		•		•		•	•	○									•		•		•		•	•	○	○		
M45×3	3	43.05	1°16′	IR30ISO									•		•	•	○					•		•		•		•		•		•	•	○	○		
M45×4	4	42.4	1°43′	IR40ISO																$\boxed{2}$																•	$\boxed{2}$
M48×1.5	1.5	47.03	0°35′	IR15ISO					•		•		•		•	•	○									•		•		•		•	•	○	○		
M48×2	2	46.7	0°47′	IR20ISO					•		•		•		•	•	○									•		•		•		•	•	○	○		
M48×3	3	46.05	1°11′	IR30ISO									•		•	•	○													•		•	•	○	○		
M48×4	4	45.4	1°36′	IR40ISO																	$\boxed{2}$															•	$\boxed{2}$

$\boxed{2}$: Change the shim to AN16-2

$\boxed{2}$: Change the shim to NXN22-2

$\boxed{2}$: Change the shim to AN16-2DT

$\boxed{2}$: Change the shim to GXN22-2DT

Note : The above tables show correspondence of internal toolholders at the time of setting clearance between thread and toolholder to 3 mm (1 mm in case of SN type) and the finishing stock to 0.1 mm.

User's Guide - Technical Reference

Selection of ST-type Toolholders

Metric fine screw thread (ISO)

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Nominal size	Pitch	Pitch diameter	Lead angle	Shank material	Steel shank																				Carbide shank										“Tsuppari-Ichiban”						
				Insert size	6IR				11IR				16IR							22IR					6IR				11IR				16IR		16IR				22IR		
				Holder Cat. No. / Insert Cat. No.	SNR0006H06-2	SNR0006H06-3	SNR0008H06-2	SNR0008H06-3	SNR0010K11	SNR0010K11-2	SNR0013L11	SNR0013L11-2	SNR0016M16	SNR0016M16-2	CNR0020P16	CNR0025R16	CNR0032S16	(CNR0040T16)	(CNR0050U16)	SNR0020Q22	SNR0020Q22-2	CNR0025R22	CNR0032S22	(CNR0040T22)	SNR0006K06SC-2	SNR0006K06SC-3	SNR0008K06SC-2	SNR0008K06SC-3	SNR0010M11SC	SNR0010M11SC-2	SNR0012P11SC	SNR0012P11SC-2	SNR0016R16SC	SNR0016R16SC-2	TSNR0016Q16	TCNR0020R16DT	TCNR0025S16DT	(TCNR0032T16DT)	TSNR0020R22	TCNR0025S22DT	(TCNR0032T22DT)
M50×1.5	1.5	49.03	0°33′	IR15ISO					•		•		•		•	•	○	•											•		•		•		•	•	○	○			
M50×2	2	48.7	0°45′	IR20ISO					•		•		•		•	•	○												•		•		•		•	•	○	○			
M50×3	3	48.05	1°08′	IR30ISO									•		•	•	○																•		•	•	○	○			
M52×1.5	1.5	51.03	0°32′	IR15ISO					•		•		•		•	•	•	○											•		•		•		•	•	○	○			
M52×2	2	50.7	0°43′	IR20ISO					•		•		•		•	•	•	○											•		•		•		•	•	○	○			
M52×3	3	50.05	1°06′	IR30ISO									•		•	•	○	•															•		•	•	○	○			
M52×4	4	49.4	1°29′	IR40ISO																•	•	•	•																•	•	○
M55×1.5	1.5	54.03	0°30′	IR15ISO					•		•		•		•	•	○	•											•		•		•		•	•	○	○			
M55×2	2	53.7	0°41′	IR20ISO					•		•		•		•	•	•	○											•		•		•		•	•	○	○			
M55×3	3	53.05	1°02′	IR30ISO									•		•	•	•	○															•		•	•	○	○			
M55×4	4	52.4	1°24′	IR40ISO																•	•	•	•	○															•	•	○
M56×1.5	1.5	55.03	0°30′	IR15ISO					•		•		•		•	•	•	○											•		•		•		•	•	○	○			
M56×2	2	54.7	0°40′	IR20ISO					•		•		•		•	•	•	○											•		•		•		•	•	○	○			
M56×3	3	54.05	1°01′	IR30ISO									•		•	•	•	○															•		•	•	○	○			
M56×4	4	53.4	1°22′	IR40ISO																•	•	•	•	○															•	•	○
M58×1.5	1.5	57.03	0°29′	IR15ISO					•		•		•		•	•	•	○											•		•		•		•	•	○	○			
M58×2	2	56.7	0°39′	IR20ISO					•		•		•		•	•	•	○											•		•		•		•	•	○	○			
M58×3	3	56.05	0°59′	IR30ISO									•		•	•	•	○															•		•	•	○	○			
M58×4	4	55.4	1°19′	IR40ISO																•	•	•	•	○															•	•	○
M60×1.5	1.5	59.03	0°28′	IR15ISO					•		•		•		•	•	•	○											•		•		•		•	•	○	○			
M60×2	2	58.7	0°37′	IR20ISO					•		•		•		•	•	•	○											•		•		•		•	•	○	○			
M60×3	3	58.05	0°57′	IR30ISO									•		•	•	•	○															•		•	•	○	○			
M60×4	4	57.4	1°16′	IR40ISO																•	•	•	•	○															•	•	○

Unified coarse screw thread (UNC)

Nominal size	TPI	Pitch diameter	Lead angle	Shank material	Steel shank																		Carbide shank									“Tsuppari-Ichiban”	
				Insert size	11IR						16IR			22IR						27IR			11IR						16IR			22IR	
				Holder Cat. No. / Insert Cat. No.	SNR0010K11	SNR0010K11-2	SNR0010K11-3	SNR0013L11	SNR0013L11-2	SNR0013L11-3	SNR0016M16	SNR0016M16-2	SNR0016M16-3	SNR0020Q22	SNR0020Q22-2	SNR0020Q22-3	CNR0025R22	CNR0032S22	(CNR0040T22)	CNR0040T27	(CNR0050U27)	(CNR0063V27)	SNR0010M11SC	SNR0010M11SC-2	SNR0010M11SC-3	SNR0012P11SC	SNR0012P11SC-2	SNR0012P11SC-3	SNR0016R16SC	SNR0016R16SC-2	(SNR0016R16SC-3)	TCNR0025S22DT	(TCNR0032T22DT)
7/16-14UNC	14	9.93	3°20′	(IR14UN)																													
1/2-13UNC	13	11.43	3°07′	(IR13UN)																													
9/16-12UNC	12	12.91	2°59′	IR12UN																													
5/8-11UNC	11	14.38	2°56′	(IR11UN)																													
3/4-10UNC	10	17.4	2°40′	(IR10UN)																													
7/8-9UNC	9	20.39	2°31′	IR9UN																													
1-8UNC	8	23.34	2°29′	IR8UN								○																					
1 1/8-7UNC	7	26.22	2°31′	(IR7UN)																													
1 1/4-7UNC	7	29.39	2°15′	(IR7UN)											○																		
1 3/8-6UNC	6	32.17	2°24′	(IR6UN)											○																		
1 1/2-6UNC	6	35.35	2°11′	(IR6UN)											○		$\boxed{2}$															$\boxed{2}$	
1 3/4-5UNC	5	41.15	2°15′	(IR5UN)											○		$\boxed{2}$															$\boxed{2}$	
2-4 1/2UNC	4.5	47.14	2°11′	(IR45UN)																													
2 1/4-4 1/2UNC	4.5	53.49	1°55′	(IR45UN)																$\boxed{2}$													
2 1/2-4UNC	4	59.38	1°57′	(IR4UN)																$\boxed{2}$													
2 3/4-4UNC	4	65.73	1°46′	(IR4UN)																$\boxed{2}$	$\boxed{2}$												
3-4UNC	4	72.08	1°36′	(IR4UN)																$\boxed{2}$	$\boxed{2}$												
3 1/4-4UNC	4	78.43	1°29′	(IR4UN)																•	•	○											
3 1/2-4UNC	4	84.78	1°22′	(IR4UN)																•	•	○											
3 3/4-4UNC	4	91.13	1°16′	(IR4UN)																•	•	○											
4-4UNC	4	97.48	1°11′	(IR4UN)																•	•	○											

$\boxed{2}$: Change the shim to NXN22-2

$\boxed{2}$: Change the shim to NXN27-2

$\boxed{2}$: Change the shim to GXN22-2DT

Note : The above tables show correspondence of internal toolholders at the time of setting clearance between thread and toolholder to 3 mm (1 mm in case of SN type) and the finishing stock to 0.1 mm.

Unified fine screw thread (UNF)

Nominal size	TPI	Pitch diameter	Lead angle	Shank material	Steel shank										Carbide shank										"Tsuppari-Ichiban"		
				Insert size	6IR				11IR		16IR				6IR				11IR				16IR		16IR		
				Holder Cat. No. / Insert Cat. No.	SNR0006H06-2	SNR0006H06-3	SNR0008H06-2	SNR0008H06-3	SNR0010K11-2	SNR0013L11-2	SNR0016M16	SNR0016M16-2	CNR0020P16	CNR0025R16	SNR0006K06SC-2	SNR0006K06SC-3	SNR0008K06SC-2	SNR0008K06SC-3	SNR0010M11SC	SNR0010M11SC-2	SNR0012P11SC	SNR0012P11SC-2	SNR0016R16SC	SNR0016R16SC-2	TSNR0016Q16	TCNR0020R16DT	TCNR0025S16DT
3/8-24UNF	24	8.84	2°11´	(IR24UN)																							
				IRA60																							
7/16-20UNF	20	10.29	2°15´	(IR20UN)																							
				IRA60	○										○												
1/2-20UNF	20	11.87	1°57´	(IR20UN)																							
				IRA60	•		○								•		○										
9/16-18UNF	18	13.37	1°55´	(IR18UN)																							
				IRA60	•		○								•		○										
5/8-18UNF	18	14.96	1°43´	(IR18UN)																							
				IRA60	•		○								•		○										
3/4-16UNF	16	18.02	1°36´	IR16UN					○											○							
7/8-14UNF	14	21.05	1°34´	IR14UN					•	○										•		○					
1-12UNF	12	24.03	1°36´	IR12UN								○												○			
1 1/8-12UNF	12	27.2	1°25´	IR12UN							○												○		○		
1 1/4-12UNF	12	30.38	1°16´	IR12UN							•		○										○		•	○	
1 3/8-12UNF	12	33.55	1°09´	IR12UN							•		•	○									○		•	•	○
1 1/2-12UNF	12	36.73	1°03´	IR12UN							•		•	○									○		•	•	○

Unified extra fine screw thread (UNEF)

Nominal size	TPI	Pitch diameter	Lead angle	Shank material	Steel shank											Carbide shank								"Tsuppari-Ichiban"		
				Insert size	6IR		11IR				16IR					6IR		11IR				16IR		16IR		
				Holder Cat. No. / Insert Cat. No.	SNR0006H06-2	SNR0008H06-2	SNR0010K11	SNR0010K11-2	SNR0013L11	SNR0013L11-2	SNR0016M16	SNR0016M16-2	CNR0020P16	CNR0025R16	CNR0032S16	SNR0006H06SC-2	SNR0008H06SC-2	SNR0010K11	SNR0010K11-2	SNR0012L11	SNR0012L11-2	SNR0016M16	SNR0016M16-2	TSNR0016Q16	TCNR0020R16DT	TCNR0025S16DT
3/8	32	9.01	1°61´	IR32UN																						
7/16	28	10.52	1°57´	IR28UN	○											○										
1/2	28	12.11	1°37´	IR28UN																						
9/16	24	13.6	1°42´	IR24UN																						
5/8	24	15.19	1°27´	IR24UN																						
11/16	24	16.77	1°15´	IR24UN			○											○								
3/4	20	18.22	1°27´	IR20UN			○											○								
13/16	20	19.81	1°17´	IR20UN			•		○									•		○						
7/8	20	21.4	1°08´	IR20UN			•		○									•		○						
15/16	20	22.99	1°01´	IR20UN			•		•		○							•		○				○		
1	20	24.57	0°94´	IR20UN			•		•		○							•		•		○		○		
1 1/16	18	26.07	0°99´	IR18UN			•		•		○							•		•		○		○		
1 1/8	18	27.66	0°93´	IR18UN			•		•		○							•		•		○		○		
1 3/16	18	29.25	0°88´	IR18UN			•		•		•		○					•		•		○		•	○	
1 1/4	18	30.83	0°84´	IR18UN			•		•		•		○					•		•		○		•	○	
1 5/16	18	32.42	0°79´	IR18UN			•		•		•		○					•		•		○		•	○	
1 3/8	18	34.01	0°76´	IR18UN			•		•		•		•	○				•		•		○		•	•	○
1 7/16	18	35.6	0°72´	IR18UN			•		•		•		•	○				•		•		○		•	•	○
1 1/2	18	37.18	0°69´	IR18UN			•		•		•		•	○				•		•		○		•	•	○
1 9/16	18	38.77	0°66´	IR18UN			•		•		•		•	○				•		•		○		•	•	○
1 5/8	18	40.36	0°64´	IR18UN			•		•		•		•	•	○			•		•		○		•	•	○
1 11/16	18	41.95	0°61´	IR18UN			•		•		•		•	•	○			•		•		○		•	•	○

Note : The above tables show correspondence of internal toolholders at the time of setting clearance between thread and toolholder to 3 mm (1 mm in case of SN type) and the finishing stock to 0.1 mm.

User's Guide - Technical Reference

Selection of ST-type Toolholders

Whitworth British Standard (BSW) (for pipe)

Nominal size	TPI	Pitch diameter	Lead angle	Shank material	Steel shank											Carbide shank		"Tsuppari-Ichiban"				
				Insert size	16IR						22IR					16IR		16IR			22IR	
				Holder Cat. No. / Insert Cat. No.	SNR0016M16	SNR0016M16-2	SNR0016M16-3	CNR0020P16	CNR0025R16	CNR0032S16	SNR0020Q22	SNR0020Q22-2	SNR0020Q22-3	CNR0025R22	CNR0032S22	SNR0016M16	SNR0016M16-2	TSNR0016Q16	TCNR0020R16DT	TCNR0025S16DT	TSNR0020R22	TCNR0025S22DT
7/16	14	9.95	3°32′	IR14W																		
1/2	12	11.34	3°40′	IR12W																		
9/16	12	12.93	2°98′	IR12W																		
5/8	11	14.4	2°92′	IR11W																		
11/16	11	15.98	2°63′	IR11W																		
3/4	10	17.42	2°66′	IR10W																		
7/8	9	20.42	2°52′	IR9W																		
1	8	23.37	2°48′	IR8W																		
1 1/8	7	26.25	2°52′	IR7W																		
1 1/4	7	29.43	2°25′	IR7W								○										
1 1/2	6	35.39	2°18′	IR6W								○										
1 3/4	5	41.2	2°25′	IR5W								•		$\boxed{2}$								$\boxed{2}$

$\boxed{2}$: Change the shim to NXN22-2

$\boxed{2}$: Change the shim to GXN22-2DT

Whitworth British Standard Fine (BSF) (for pipe)

Nominal size	TPI	Pitch diameter	Lead angle	Shank material	Steel shank														Carbide shank				"Tsuppari-Ichiban"				
				Insert size	6IR		11IR		16IR					22IR					6IR		16IR		16IR			22IR	
				Holder Cat. No. / Insert Cat. No.	SNR0006H06-2	SNR0008H06-2	SNR0010K11	SNR0010K11-2	SNR0016M16	SNR0016M16-2	SNR0016M16-3	CNR0020P16	CNR0025R16	SNR0020Q22	SNR0020Q22-2	SNR0020Q22-3	CNR0025R22	CNR0032S22	SNR0006H06SC-2	SNR0008H06SC-2	SNR0016M16	SNR0016M16-2	TSNR0016Q16	TCNR0020R16DT	TCNR0025S16DT	TSNR0020R22	TCNR0025S22DT
7/16	18	10.21	2°52′	IR18W																							
1/2	16	11.68	2°48′	IR16W	○														○								
9/16	16	13.27	2°18′	IR16W	•	○													•	○							
5/8	14	14.71	2°25′	IR14W																							
11/16	14	16.3	2°03′	IR14W				○																			
3/4	12	17.69	2°18′	IR12W																							
7/8	11	20.75	2°03′	IR11W																							
1	10	23.77	1°95′	IR10W						○																	
1 1/8	9	26.77	1°92′	IR9W						○												○					
1 1/4	9	29.94	1°72′	IR9W						•		$\boxed{2}$										○		$\boxed{2}$			
1 3/8	8	32.89	1°76′	IR8W						•		$\boxed{2}$										○		$\boxed{2}$			
1 1/2	8	36.07	1°61′	IR8W						•		•	$\boxed{2}$									○		•	$\boxed{2}$		
1 5/8	8	39.24	1°48′	IR8W					•			•	○								○		•	•	○		
1 3/4	7	42.13	1°57′	IR7W											○		$\boxed{2}$										$\boxed{2}$
2	7	48.48	1°37′	IR7W										•			•	○								•	○
2 1/4	6	54.44	1°42′	IR6W										•			•	○								•	○
2 1/2	6	60.79	1°27′	IR6W										•			•	○								•	○
2 3/4	6	67.14	1°15′	IR6W										•			•	○								•	○
3	5	72.95	1°27′	IR5W										•			•	○								•	○
3 1/4	5	79.3	1°17′	IR5W										•			•	○								•	○

$\boxed{2}$: Change the shim to AN16-2

$\boxed{2}$: Change the shim to AN16-2DT

$\boxed{2}$: Change the shim to NXN22-2

$\boxed{2}$: Change the shim to GXN22-2DT

Note : The above tables show correspondence of internal toolholders at the time of setting clearance between thread and toolholder to 3 mm (1 mm in case of SN type) and the finishing stock to 0.1 mm.

30° trapezoidal thread (TR) (for machine parts)

1/2

Nominal size	Pitch	Pitch diameter	Lead angle	Shank material	Steel shank															Carbide shank			"Tsuppari-Ichiban"						
				Insert size	16IR								22IR					27IR		16IR			16IR				22IR		
				Holder Cat. No. Insert Cat. No.	SNR0016M16	SNR0016M16-2	SNR0016M16-3	CNR0020P16	CNR0025R16	CNR0032S16	CNR0040T16	CNR0050U16	SNR0020Q22	SNR0020Q22-2	SNR0020Q22-3	CNR0025R22	CNR0032S22	CNR0040T27	(CNR0050U27)	SNR0016R16SC	SNR0016R16SC-2	(SNR0016R16SC-3)	TSNR0016Q16	TCNR0020R16DT	TCNR0025S16DT	(TCNR0032T16DT)	TSNR0020R22	TCNR0025S22DT	(TCNR0032T22DT)
TR22×3	3	20.5	2°40′	IR30TR																									
TR24×5	5	21.5	4°14′	IR50TR																									
TR24×3	3	22.5	2°26′	IR30TR																									
TR26×5	5	23.5	3°52′	IR50TR																									
TR26×3	3	24.5	2°14′	IR30TR		○																							
TR28×5	5	25.5	3°34′	IR50TR																									
TR28×3	3	26.5	2°04′	IR30TR		•															○								
TR30×6	6	27	4°03′	IR60TR																									
TR30×3	3	28.5	1°55′	IR30TR		•															○								
TR32×6	6	29	3°46′	IR60TR																									
TR32×3	3	30.5	1°48′	IR30TR		•		$\boxed{2}$													•			$\boxed{2}$					
TR34×6	6	31	3°32′	IR60TR																									
TR34×3	3	32.5	1°41′	IR30TR		•		$\boxed{2}$													•			$\boxed{2}$					
TR36×6	6	33	3°19′	IR60TR																									
TR36×3	3	34.5	1°35′	IR30TR		•		2	$\boxed{2}$												•			$\boxed{2}$	$\boxed{2}$				
TR38×3	3	36.5	1°30′	IR30TR		•		2	$\boxed{2}$												•			$\boxed{2}$	$\boxed{2}$				
TR40×3	3	38.5	1°25′	IR30TR	•			•	○											○				•	○				
TR42×3	3	40.5	1°21′	IR30TR	•			•	○											○				•	○				
TR44×3	3	42.5	1°17′	IR30TR	•			•	•	○										○				•	•	○			
TR46×3	3	44.5	1°14′	IR30TR	•			•	•	○										○				•	•	○			
TR48×3	3	46.5	1°11′	IR30TR	•			•	•	○										○				•	•	○			
TR50×3	3	48.5	1°08′	IR30TR	•			•	•	○										○				•	•	○			
TR52×3	3	50.5	1°05′	IR30TR	•			•	•	•	○									○				•	•	○			
TR55×3	3	53.5	1°01′	IR30TR	•			•	•	•	○									○				•	•	○			
TR60×3	3	58.5	0°56′	IR30TR	•			•	•	•	○									○				•	•	○			

$\boxed{2}$: Change the shim to AN16-2

$\boxed{2}$: Change the shim to AN16-2DT

30° trapezoidal thread (TR) (for machine parts)

2/2

Nominal size	Pitch	Pitch diameter	Lead angle	Shank material	Steel shank																	Carbide shank			"Tsuppari-Ichiban"						
				Insert size	16IR						22IR								27IR			16IR			16IR				22IR		
				Holder Cat. No. Insert Cat. No.	SNR0016M16	SNR0016M16-2	SNR0016M16-3	CNR0020P16	CNR0025R16	CNR0032S16	SNR0020Q22	SNR0020Q22-2	SNR0020Q22-3	CNR0025R22	CNR0032S22	(CNR0040T22)	(CNR0050U22)	(CNR0063V22)	CNR0040T27	(CNR0050U27)	(CNR0063V27)	SNR0016R16SC	SNR0016R16SC-2	(SNR0016R16SC-3)	TSNR0016Q16	TCNR0020R16DT	TCNR0025S16DT	(TCNR0032T16DT)	TSNR0020R22	TCNR0025S22DT	(TCNR0032T22DT)
TR65×4	4	63	1°09′	IR40TR							•			•	•	•	○												•	•	○
TR70×4	4	68	1°04′	IR40TR							•			•	•	•	○												•	•	○
TR75×4	4	73	1°00′	IR40TR							•			•	•	•	○												•	•	○
TR80×4	4	78	0°56′	IR40TR							•			•	•	•	•	○											•	•	○
TR85×4	4	83	0°53′	IR40TR							•			•	•	•	•	○											•	•	○
TR90×4	4	88	0°50′	IR40TR							•			•	•	•	•	○											•	•	○
TR95×4	4	93	0°47′	IR40TR							•			•	•	•	•	○											•	•	○
TR100×4	4	98	0°45′	IR40TR							•			•	•	•	•	○											•	•	○
TR105×4	4	103	0°42′	IR40TR							•			•	•	•	•	○											•	•	○
TR110×4	4	108	0°41′	IR40TR							•			•	•	•	•	○											•	•	○
TR115×6	6	112	0°59′	IR60TR															•	•	○										
TR120×6	6	117	0°56′	IR60TR															•	•	○										
TR125×6	6	122	0°54′	IR60TR															•	•	○										
TR130×6	6	127	0°52′	IR60TR															•	•	○										
TR135×6	6	132	0°50′	IR60TR															•	•	○										
TR140×6	6	137	0°48′	IR60TR															•	•	○										
TR145×6	6	142	0°46′	IR60TR															•	•	○										
TR150×6	6	147	0°45′	IR60TR															•	•	○										
TR155×6	6	152	0°43′	IR60TR															•	•	○										
TR160×6	6	157	0°42′	IR60TR															•	•	○										
TR165×6	6	162	0°41′	IR60TR															•	•	○										
TR170×6	6	167	0°39′	IR60TR															•	•	○										

Note : The above tables show correspondence of internal toolholders at the time of setting clearance between thread and toolholder to 3 mm (1 mm in case of SN type) and the finishing stock to 0.1 mm.

User's Guide - Technical Reference

Selection of ST-type Toolholders

Parallel pipe thread (G) (for pipe) This table is also applied to PF, Rp, and PS type threads.

Nominal size	TPI	Pitch	Pitch diameter	Lead angle	Shank material	Steel shank													Carbide shank										"Tsuppari-Ichiban"			
					Insert size	6IR		11IR				16IR							6IR				11IR				16IR		16IR			
					Holder Cat. No. / Insert Cat. No.	SNR0006H06-2	SNR0008H06-2	SNR0010K11	SNR0010K11-2	SNR0013L11	SNR0013L11-2	SNR0016M16	SNR0016M16-2	CNR0020P16	CNR0025R16	CNR0032S16	(CNR0040T16)	(CNR0050U16)	SNR0006K06SC-2	SNR0006K06SC-3	SNR0008K06SC-2	SNR0008K06SC-3	SNR0010M11SC	SNR0010M11SC-2	SNR0012P11SC	SNR0012P11SC-2	SNR0016R16SC	SNR0016R16SC-2	TSNR0016Q16	TCNR0020R16DT	TCNR0025S16DT	(TCNR0032T16DT)
G1/4	19	1.34	12.30	1°59′	IR19W	•	○												•		○											
G3/8	19	1.34	15.81	1°33′	IR19W	•	•		○										•		○											
G1/2	14	1.81	19.79	1°40′	IR14W				•		○													•		○						
G5/8	14	1.81	21.75	1°31′	IR14W				•		○													•		○						
G3/4	14	1.81	25.28	1°18′	IR14W			•		•		○											•		•		○		○			
G7/8	14	1.81	29.04	1°08′	IR14W			•		•		•		○									•		•		○		•	○		
G1	11	2.31	31.77	1°20′	IR11W							•		○													○		•	○		
G1-1/8	11	2.31	36.42	1°09′	IR11W							•		•	○												○		•	•	○	
G1-1/4	11	2.31	40.43	1°02′	IR11W							•		•	○												○		•	•	○	
G1-1/2	11	2.31	46.32	0°55′	IR11W							•		•	•	○											○		•	•	•	○
G1-3/4	11	2.31	52.27	0°48′	IR11W							•		•	•	•	○										○		•	•	•	○
G2	11	2.31	58.14	0°43′	IR11W							•		•	•	•	○										○		•	•	•	○
G2-1/4	11	2.31	64.23	0°39′	IR11W							•		•	•	•	•	○									○		•	•	•	○
G2-1/2	11	2.31	73.71	0°34′	IR11W							•		•	•	•	•	○									○		•	•	•	○
G2-3/4	11	2.31	80.06	0°32′	IR11W							•		•	•	•	•	○									○		•	•	•	○
G3	11	2.31	86.41	0°29′	IR11W									0	0	0	0	$\boxed{0}$												0	0	$\boxed{0}$
G3-1/2	11	2.31	98.85	0°26′	IR11W									0	0	0	0	$\boxed{0}$												0	0	$\boxed{0}$
G4	11	2.31	111.55	0°23′	IR11W									0	0	0	0	$\boxed{0}$												0	0	$\boxed{0}$
G4-1/2	11	2.31	124.25	0°20′	IR11W									0	0	0	0	$\boxed{0}$												0	0	$\boxed{0}$
G5	11	2.31	136.95	0°18′	IR11W									0	0	0	0	$\boxed{0}$												0	0	$\boxed{0}$
G6	11	2.31	162.35	0°16′	IR11W									0	0	0	0	$\boxed{0}$												0	0	$\boxed{0}$

$\boxed{0}$: Change the shim to AN16-0

$\boxed{0}$: Change the shim to AN16-0DT

Taper pipe thread (PT) (for pipe) This table is also applied to Rc type pipe thread.

Nominal size	TPI	Pitch	Pitch diameter	Lead angle	Shank material	Steel shank															Carbide shank										"Tsuppari-Ichiban"			
					Insert size	6IR				11IR				16IR							6IR				11IR				16IR		16IR			
					Holder Cat. No. / Insert Cat. No.	SNR0006H06-2	SNR0006H06-3	SNR0008H06-2	SNR0008H06-3	SNR0010K11	SNR0010K11-2	SNR0013L11	SNR0013L11-2	SNR0016M16	SNR0016M16-2	CNR0020P16	CNR0025R16	CNR0032S16	(CNR0040T16)	(CNR0050U16)	SNR0006K06SC-2	SNR0006K06SC-3	SNR0008K06SC-2	SNR0008K06SC-3	SNR0010M11SC	SNR0010M11SC-2	SNR0012P11SC	SNR0012P11SC-2	SNR0016R16SC	SNR0016R16SC-2	TSNR0016Q16	TCNR0020R16DT	TCNR0025S16DT	(TCNR0032T16DT)
PT1/4	19	1.34	12.30	1°59′	IR19PT	○															○													
PT3/8	19	1.34	15.81	1°33′	IR19PT	•		○													•		○											
PT1/2	14	1.81	19.79	1°40′	IR14PT						○															•		○						
PT3/4	14	1.81	25.28	1°19′	IR14PT									○											•		•		○		○			
PT1	11	2.31	31.77	1°20′	IR11PT									•		○													○		•	○		
PT1 1/4	11	2.31	40.43	1°02′	IR11PT									•		•	○												○		•	•	○	
PT1 1/2	11	2.31	46.32	0°55′	IR11PT									•		•	•	○											○		•	•	•	○
PT2	11	2.31	58.14	0°43′	IR11PT									•		•	•	•	○										○		•	•	•	○
PT2 1/2	11	2.31	73.71	0°34′	IR11PT									•		•	•	•	•	○									○		•	•	•	○
PT3	11	2.31	86.41	0°29′	IR11PT											0	0	0	0	$\boxed{0}$												0	0	$\boxed{0}$
PT3 1/2	11	2.31	98.85	0°26′	IR11PT											0	0	0	0	$\boxed{0}$												0	0	$\boxed{0}$
PT4	11	2.31	111.55	0°23′	IR11PT											0	0	0	0	$\boxed{0}$												0	0	$\boxed{0}$
PT5	11	2.31	136.95	0°18′	IR11PT											0	0	0	0	$\boxed{0}$												0	0	$\boxed{0}$
PT6	11	2.31	162.35	0°16′	IR11PT											0	0	0	0	$\boxed{0}$												0	0	$\boxed{0}$
PT7	11	2.31	187.75	0°13′	IR11PT											0	0	0	0	$\boxed{0}$												0	0	$\boxed{0}$
PT8	11	2.31	213.15	0°12′	IR11PT											0	0	0	0	$\boxed{0}$												0	0	$\boxed{0}$
PT9	11	2.31	238.55	0°11′	IR11PT											0	0	0	0	$\boxed{0}$												0	0	$\boxed{0}$
PT10	11	2.31	263.95	0°10′	IR11PT											0	0	0	0	$\boxed{0}$												0	0	$\boxed{0}$
PT12	11	2.31	314.75	0°08′	IR11PT											0	0	0	0	$\boxed{0}$												0	0	$\boxed{0}$

$\boxed{0}$: Change the shim to AN16-0

$\boxed{0}$: Change the shim to AN16-0DT

Note : The above tables show correspondence of internal toolholders at the time of setting clearance between thread and toolholder to 3 mm (1 mm in case of SN type) and the finishing stock to 0.1 mm.

National taper pipe thread (NPT) (for pipe)

Nominal size	TPI	Pitch	Lead angle	Shank material	Steel shank												Carbide shank							“Tsuppari-Ichiban”			
				Insert size	6IR				16IR								6IR				16IR			16IR			
				Holder Cat. No. / Insert Cat. No.	SNR0006H06-2	SNR0006H06-3	SNR0008H06-2	SNR0008H06-3	SNR0016M16	SNR0016M16-2	SNR0016M16-3	CNR0020P16	CNR0025R16	CNR0032S16	(CNR0040T16)	(CNR0050U16)	SNR0006K06SC-2	SNR0006K06SC-3	SNR0008K06SC-2	SNR0008K06SC-3	SNR0016R16SC	SNR0016R16SC-2	(SNR0016R16SC-3)	TSNR0016Q16	TCNR0020R16DT	TCNR0025S16DT	(TCNR0032T16DT)
3/8NPT	18	1.41	1°37´	**IR18NPT**	•		○										•		○								
1/2NPT	14	1.81	1°40´	**IR14NPT**																							
3/4NPT	14	1.81	1°19´	**IR14NPT**					○												○			○			
1NPT	11.5	2.21	1°17´	**IR115NPT**					○			○									○			•	○		
1 1/4NPT	11.5	2.21	1°00´	**IR115NPT**					○			•	•	○							○			•	•	•	○
1 1/2NPT	11.5	2.21	0°52´	**IR115NPT**					○			•	•	○							○			•	•	•	○
2NPT	11.5	2.21	0°41´	**IR115NPT**					○			•	•	•	•	○					○			•	•	•	○
2 1/2NPT	8	3.175	0°50´	**IR8NPT**					○			•	•	•	•	○					○			•	•	•	○
3NPT	8	3.175	0°40´	**IR8NPT**					○			•	•	•	•	○					○			•	•	•	○
3 1/2NPT	8	3.175	0°35´	**IR8NPT**					○			•	•	•	•	○					○			•	•	•	○
4NPT	8	3.175	0°31´	**IR8NPT**					○			•	•	•	•	○					○			•	•	•	○
5NPT	8	3.175	0°25´	**IR8NPT**								0	0	0	0	$\boxed{0}$									0	0	$\boxed{0}$
6NPT	8	3.175	0°21´	**IR8NPT**								0	0	0	0	$\boxed{0}$									0	0	$\boxed{0}$
8NPT	8	3.175	0°16´	**IR8NPT**								0	0	0	0	$\boxed{0}$									0	0	$\boxed{0}$
10NPT	8	3.175	0°13´	**IR8NPT**								0	0	0	0	$\boxed{0}$									0	0	$\boxed{0}$
12NPT	8	3.175	0°11´	**IR8NPT**								0	0	0	0	$\boxed{0}$									0	0	$\boxed{0}$
14NPT	8	3.175	0°10´	**IR8NPT**								0	0	0	0	$\boxed{0}$									0	0	$\boxed{0}$
16NPT	8	3.175	0°09´	**IR8NPT**								0	0	0	0	$\boxed{0}$									0	0	$\boxed{0}$
18NPT	8	3.175	0°08´	**IR8NPT**								0	0	0	0	$\boxed{0}$									0	0	$\boxed{0}$
20NPT	8	3.175	0°07´	**IR8NPT**								0	0	0	0	$\boxed{0}$									0	0	$\boxed{0}$
24NPT	8	3.175	0°06´	**IR8NPT**								0	0	0	0	$\boxed{0}$									0	0	$\boxed{0}$

$\boxed{0}$: Change the shim to AN16-0 ←

$\boxed{0}$: Change the shim to AN16-0DT ←

29° trapezoidal thread (ACME) (for machine parts, pipe)

Nominal size	TPI	Pitch	Pitch diameter	Lead angle	Shank material	Steel shank													Carbide shank			“Tsuppari-Ichiban”			
					Insert size	16IR						22IR					27IR		16IR			16IR		22IR	
					Holder Cat. No. / Insert Cat. No.	SNR0016M16	SNR0016M16-2	SNR0016M16-3	CNR0020P16	CNR0025R16	CNR0032S16	SNR0020Q22	SNR0020Q22-2	SNR0020Q22-3	CNR0025R22	CNR0032S22	CNR0040T27	(CNR0050U27)	SNR0016R16SC	SNR0016R16SC-2	SNR0016R16SC-3	TSNR0016Q16	TCNR0020R16DT	TCNR0025S22DT	(TCNR0032T22DT)
3/8	12	2.12	8.465	4°33´	IR12ACME																				
7/16	12	2.12	10.053	3°50´	IR12ACME																				
1/2	10	2.54	11.43	4°03´	IR10ACME																				
5/8	8	3.18	14.274	4°03´	IR8ACME																				
3/4	6	4.23	16.934	4°33´	IR6ACME																				
7/8	6	4.23	20.109	3°50´	IR6ACME																				
1	5	5.08	22.86	4°03´	IR5ACME																				
1-1/8	5	5.08	26.035	3°33´	IR5ACME																				
1-1/4	5	5.08	29.21	3°10´	IR5ACME																				
1-3/8	4	6.35	31.75	3°39´	IR4ACME																				
1-1/2	4	6.35	34.925	3°19´	IR4ACME																				
1-3/4	4	6.35	41.275	2°48´	IR4ACME																				
2	4	6.35	47.625	2°26´	IR4ACME																				

Because this thread standard is characterized with large pitch and small diameter, (that is a large lead angle) the standard inserts and toolholders can not be used for machining this thread type. The application is limited to outside of the standard.

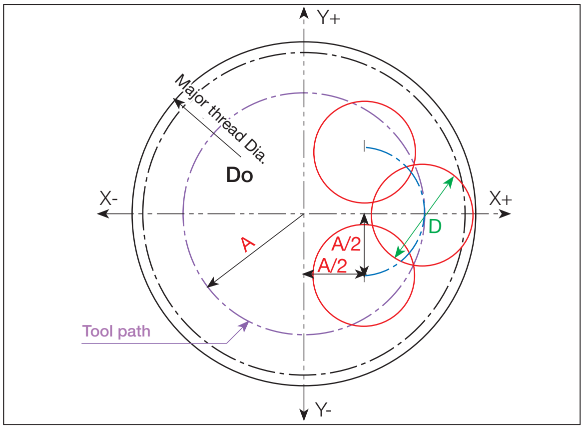
Note : The above tables show correspondence of internal toolholders at the time of setting clearance between thread and toolholder to 3 mm (1 mm in case of SN type) and the finishing stock to 0.1 mm.

Thread Milling CNC Program for Internal Thread

Right-hand thread (climb milling) from bottom up. Program is based on tool center.
This method of programming needs no tool radius compensation value, other than an offset for wear.

$$A = \frac{Do - D}{2}$$

A = Radius of tool path
Do = Major thread diameter
D = Cutting diameter



General Program

```
G90   G00 G54 G43 H1X0 Y0 Z10 S (n : Number of revolutions)
G00   Z-(to thread depth)
G01   G91 G41 D1 X (A/2) Y-(A/2) Z0  F (Center of tool)
G03   X(A/2) Y(A/2) R (A/2) Z(1/8 pitch)  F (Cutting edge)
G03   X0 Y0 I -(A) J0 Z (pitch)
G03   X-(A/2) Y(A/2) R (A/2) Z(1/8 pitch)
G01   G40 X -(A/2) Y-(A/2) Z0
G90   X0 Y0 Z0
```

$$F\ (\text{Center of tool}) = n \times f \times z$$

$$F\ (\text{Cutting edge}) = \frac{Do - D}{Do} \times n \times f \times z$$

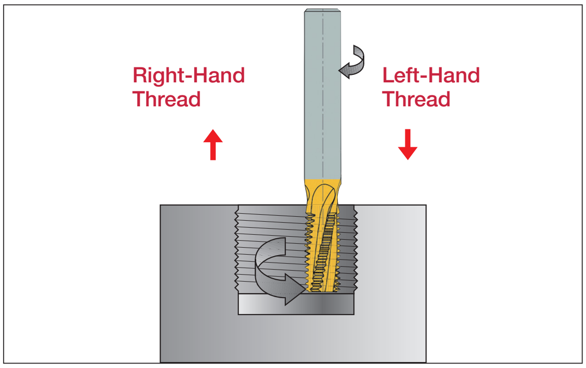
n : Number of revolutions
f : rev / tooth
z : Number of edge

Internal Thread

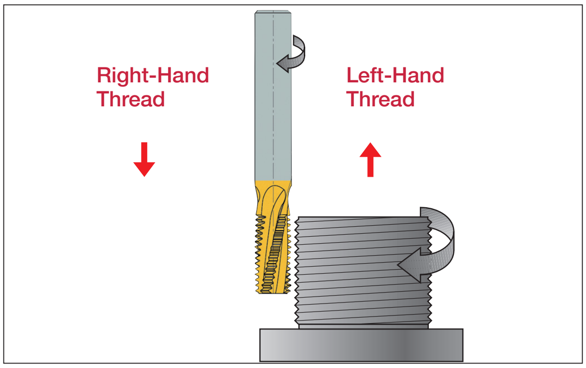
Example: M20x2.0 **IN-RH** (Thread depth 20 mm)
Tool : **MTEC1010C27 2.0ISO**
(Cutting dia. 10 mm)
A=(**Do**-**D**)/2=(20-10)/2=5
A/2=2.5
(Tool compensation of radius=0)

```
G90     G0 G54 G43 G17 H1X0 Y0 Z10 S4000
G0      Z-20
G01     G91 G41 D1X 2.5 Y-2.5 Z0 F840
G03     X2.5 Y2.5 R2.5 Z0.25 F420
G03     X0 Y0 I-5.0 J0 Z2.0
G03     X-2.5 Y2.5 R2.5 Z0.25
G01     G40 X-2.5 Y-2.5 Z0
G90     G0 X0 Y0 Z0
M30
%
```

Internal Thread



External Thread



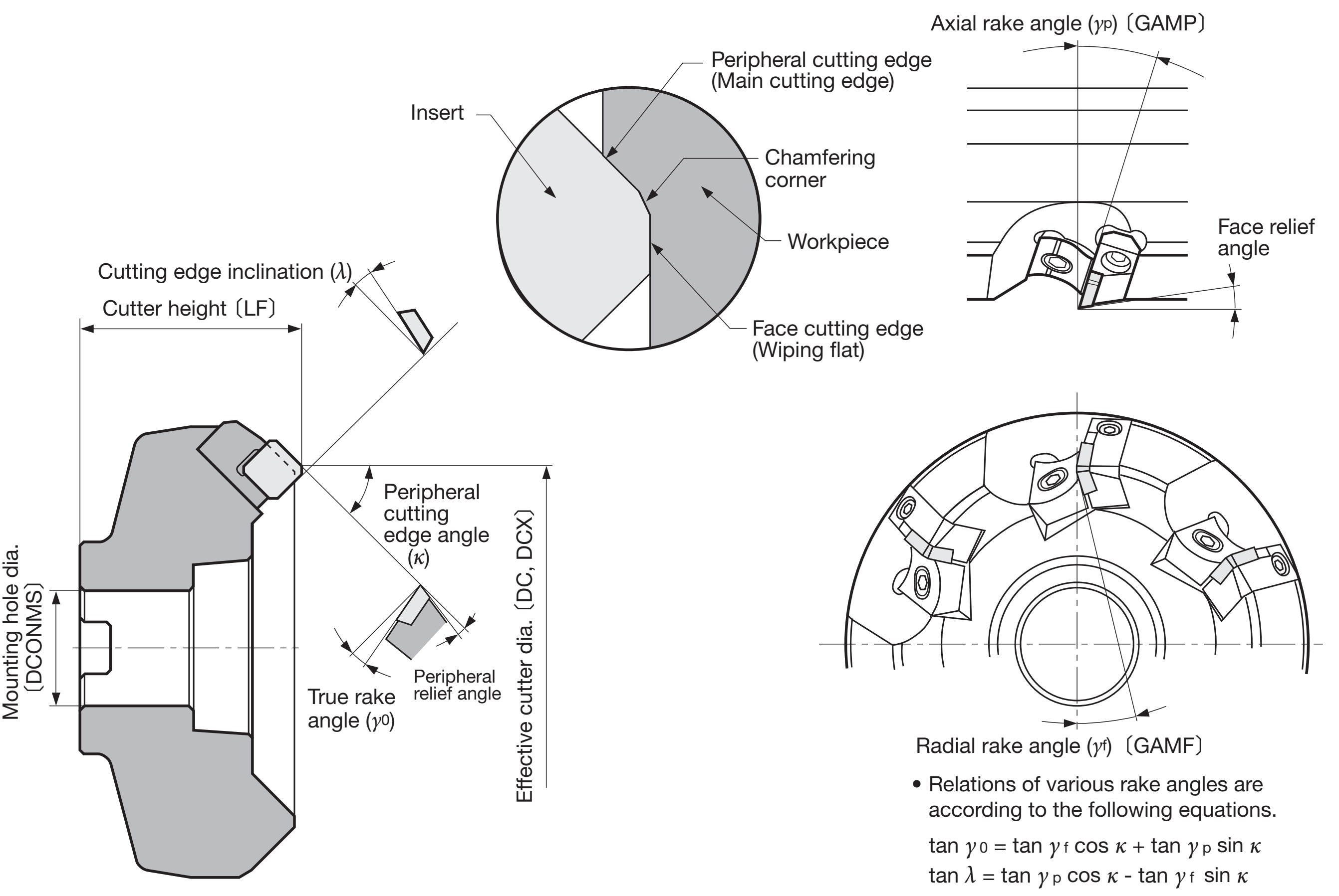
A thread milling operation is applicable for thread cutting in non-symmetrical parts utilizing the advantage of helical interpolation programs on modern machining centers.

For more details, please check ThreadMilling advisor.

User's Guide - Technical Reference

Milling tools

Nomenclature for face milling cutter



- Relations of various rake angles are according to the following equations.

$$\tan \gamma_0 = \tan \gamma_f \cos \kappa + \tan \gamma_p \sin \kappa$$

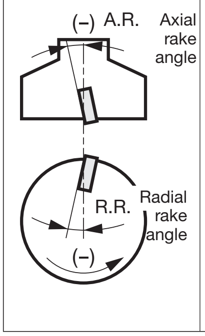
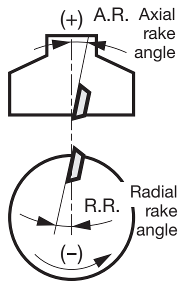
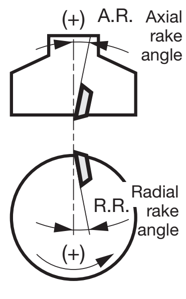
$$\tan \lambda = \tan \gamma_p \cos \kappa - \tan \gamma_f \sin \kappa$$

〔 〕The notation in the brackets is the one used in the catalog (ISO compliant)

Cutter geometry and applications

Condition		Rake angle combination and applicability		
		Negative-Negative	Negative-Positive	Positive-Positive
Shapes of cutting edge	γp〔GAMP〕	-	+	+
	γf〔GAMF〕	-	-	+
	γo	-	+	+
Workpiece material	Carbon steels, alloy steels (< 300HB)	△	◎	◎
	Stainless steels (< 300HB)	×	◎	○
	Die steels (< 300HB)	△	◎	○
	Cast irons Ductile cast irons	◎	○	○
	Aluminum 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		DoPent	TungMill DoTripleMill	TFE12 DPD09

〔 〕The notation in the brackets is the one used in the catalog (ISO compliant)

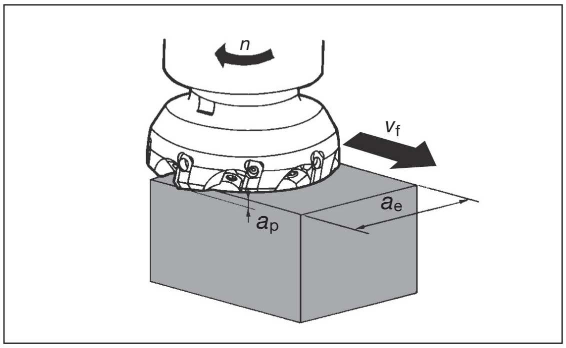
Rake angle combination		
Negative type (Negative-Negative)	Negative-Positive type	Positive type (Positive-Positive)
		

User's Guide - Technical Reference

Milling tools

Calculation formulas for milling

●Cutting speed



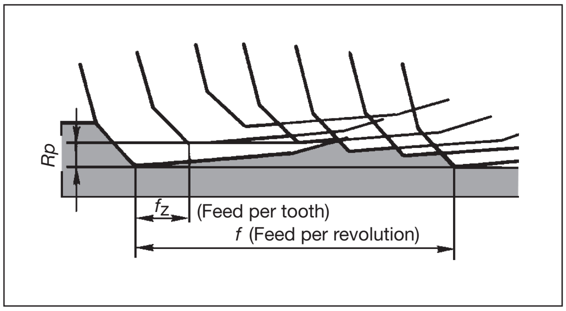
●Cutting speed (Calculated from number of revolutions)

$$SFM = \frac{RPM \ X \ D}{3.82}$$

SFM : Cutting speed (m/min)
D : Effective diameter (mm) 〔DC, DCX〕
RPM : Number of revolutions (min-1)

●Number of revolution (Calculated from cutting speed)

$$RPM = \frac{SFM \ X \ 3.82}{D}$$



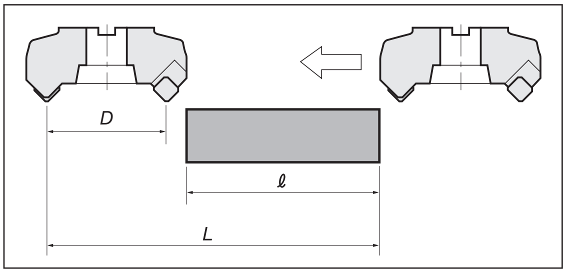
●Feed speed and feed per tooth

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

v_f : Feed speed (in/min)
f_z : Feed per tooth (ipt)
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

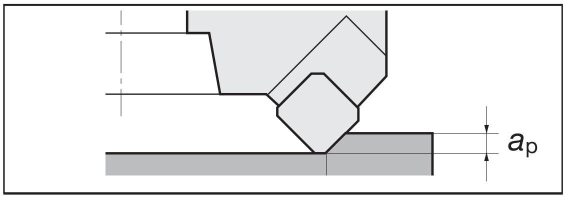


$$T_{(min)} = \frac{L}{v_f}$$

T : Cutting time (min)
L : Total table feed length.
(ℓ : Workpieces length (in) + ØDc: Effective cutter diameter (in) 〔DC, DCX〕)
V_f : Feed speed (in/min)

〔 〕 The notation in the brackets is the one used in the catalog (ISO compliant)

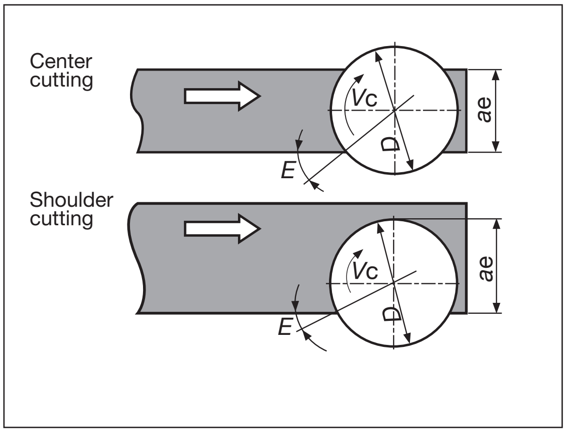
Depth of cut and width of cut



●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 catalog.

a_p : Depth of cut (in)



●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.

D : Cutter diameter (in) 〔DC, DCX〕
E : Engage angle
a_e : Width of cut (in)

〔 〕 The notation in the brackets is the one used in the catalog (ISO compliant)

Center cutting

Workpiece material	Appropriate E	Cutter dia. and a_e
Steel	~ 42°	$a_e \fallingdotseq \frac{2}{3} D$
Cast iron	~ 53°	$a_e \fallingdotseq \frac{4}{5} D$

Shoulder cutting

Workpiece material	Appropriate E	Cutter dia. and a_e
Steel	~ 30°	$a_e \fallingdotseq \frac{3}{5} D$
Cast iron	~ 40°	$a_e \fallingdotseq \frac{3}{4} D$

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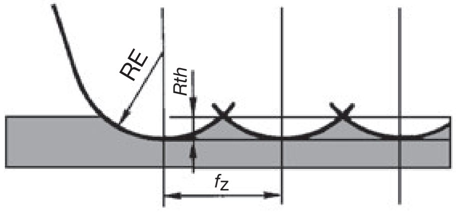
Milling tools

Roughness of finished surface

(1) Theoretical surface roughness
Theoretical roughness as shown below, is the same as for single point turning

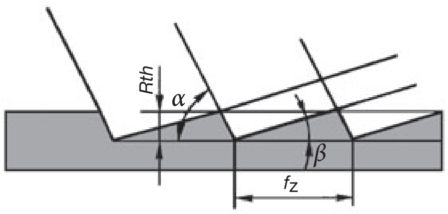
●With corner radius RE

$$Rth=\frac{fz^2}{8RE}\times1000\times1000$$

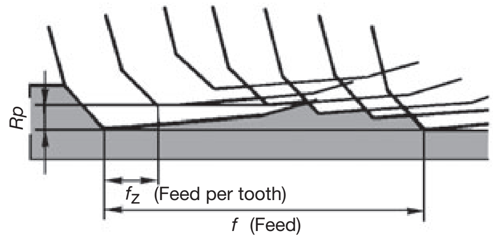


●Without corner radius RE

$$Rth=fz\left(\frac{\tan\alpha\ \cdot\tan\beta}{\tan\alpha\ +\tan\beta}\right)\times1000\times40$$

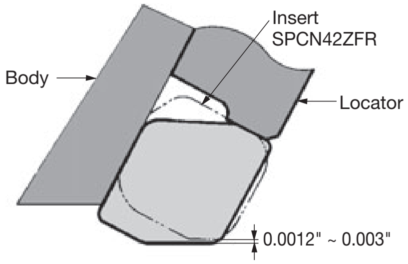


Rth : Theoretical roughness (μm)
f_z : Feed per tooth (ipt)
RE : Corner radius (in)
α : Corner angle
β : Face cutting edge angle



(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 (*Rp*) 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* (ipr) superimposing on the feed per tooth *fz* (ipt).

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 ($a_p < 0.039"$).
- Use of super finish mill for finishing such as NMS cutters and SFP4000 etc.

User's Guide - Technical Reference

Milling tools

Calculating power requirement

$$\underset{\text{(HP)}}{P_c} = \frac{k_c \times a_p \times a_e \times v_f}{330}$$

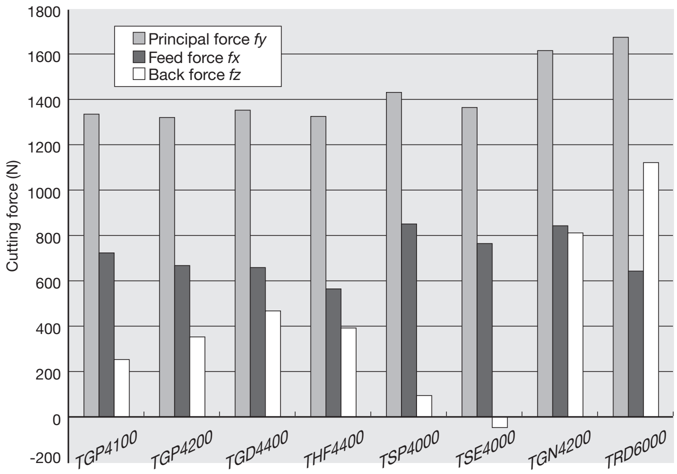
P_c : Net power requirement (HP)
k_c : Specific cutting force (KPI)
[Refer to the Table below]
a_p : Depth of cut (in)
a_e : Width of cut (in)
v_f : Feed speed (in/min)

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.

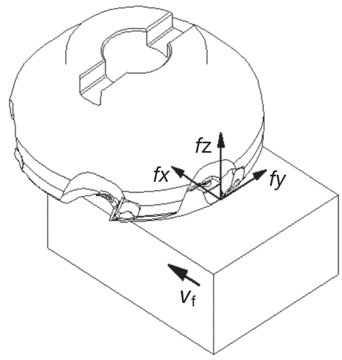
●Values of specific cutting force (k_c)

Workpiece material (JIS)	Tensile strength	Value of specific cutting force on feed per tooth k_c (N/mm^2)				
	MPa	0.004 (ipt)	0.006 (ipt)	0.008 (ipt)	0.012 (ipt)	0.016 (ipt)
SS400	75,420	312	290	276	254	239
S55C	111,679	286	270	261	255	235
SCM435	105,878	355	341	319	287	248
SKT4	(HB352)	294	292	263	244	231
SC450	75,420	393	367	350	325	307
FC250	(HB200)	241	210	191	167	149
Al (Si)	29,008	96	84	76	67	59
Brass	72,519	158	139	127	110	99

●Values of cutting force (k_c)



Workpiece material : 1049 (210HB), Diameter of mill : ø6.29"
Cutting speed : V_c = 490 sfm, Feed per tooth: f_z = 0.008 ipr
Depth of cut: a_p = 0.118", Cutting by a single edge, dry



●Conversion from cutting speed to number of revolutions

(unit : min^{-1})

Cutter diameter DC, DCX (in)	Cutting speed : V_c (sfm)												
	33	98	164	328	410	492	656	984	1640	2625	3281	6562	13123
0.394	318	955	1,592	3,184	3,980	4,777	6,369	9,554	15,923	25,477	31,847	63,694	127,388
0.472	265	796	1,326	2,653	3,317	3,980	5,307	7,961	13,269	21,231	26,539	53,078	106,157
0.630	199	597	995	1,990	2,488	2,985	3,980	5,971	9,952	15,923	19,904	39,808	79,617
0.787	159	477	796	1,592	1,990	2,388	3,184	4,777	7,961	12,738	15,923	31,847	63,694
0.984	127	382	636	1,273	1,592	1,910	2,547	3,821	6,369	10,191	12,738	25,477	50,955
1.181	106	318	530	1,061	1,326	1,592	2,123	3,184	5,307	8,492	10,615	21,231	42,462
1.260	99	298	497	995	1,244	1,492	1,990	2,985	4,976	7,961	9,952	19,904	39,808
1.378	90	272	454	909	1,137	1,364	1,819	2,729	4,549	7,279	9,099	18,198	36,396
1.575	79	238	398	796	995	1,194	1,592	2,388	3,980	6,369	7,961	15,923	31,847
1.969	63	191	318	636	796	955	1,273	1,910	3,184	5,095	6,369	12,738	25,477
2.480	50	151	252	505	631	758	1,011	1,516	2,527	4,044	5,055	10,110	20,220
3.150	39	119	199	398	497	597	796	1,194	1,990	3,184	3,980	7,961	15,923
3.937	31	95	159	318	398	477	636	955	1,592	2,547	3,184	6,369	12,738
4.921	25	76	127	254	318	382	509	764	1,273	2,038	2,547	5,095	10,191
6.299	19	59	99	199	248	298	398	597	995	1,592	1,990	3,980	7,961
7.874	15	47	79	159	199	238	318	477	796	1,273	1,592	3,184	6,369
9.843	12	38	63	127	159	191	254	382	636	1,019	1,273	2,547	5,095
12.402	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.

Milling tools

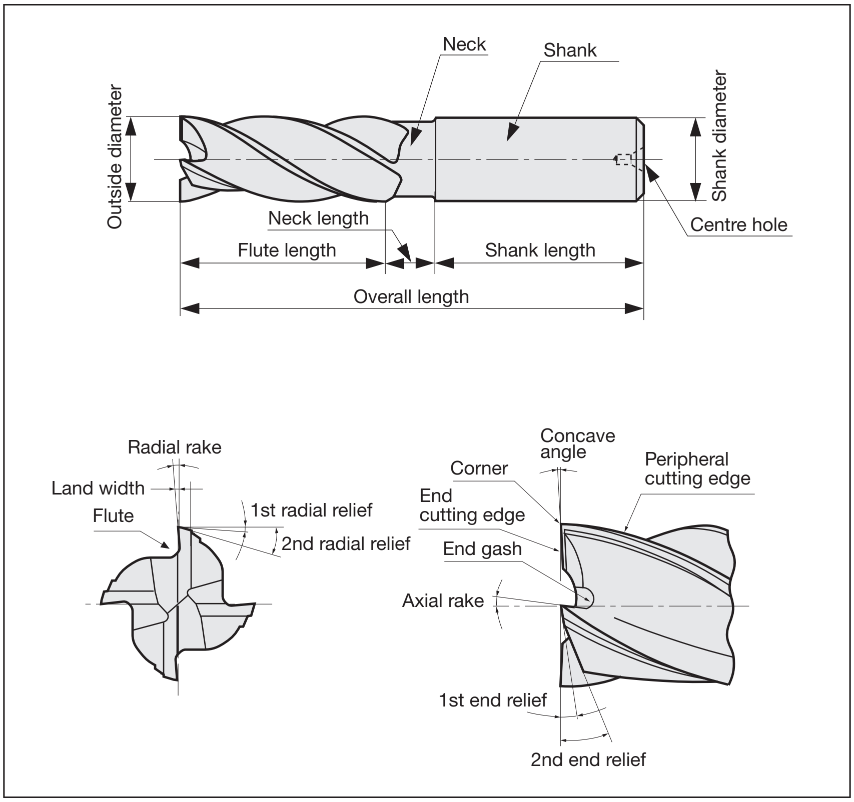
Trouble shooting in face milling

Trouble	Possible causes	Countermeasures
Rapid wear of cutting edge	• Improper insert grade selection (Insufficient wear resistance)	• Use a grade with high wear resistance P30 → P20
	• 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)	• Use a grade with high fracture resistance P10 → P20
	• 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 aluminum, copper, mild steel	• Use cutter with large rake angle
	• Cutting stainless steel	• 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

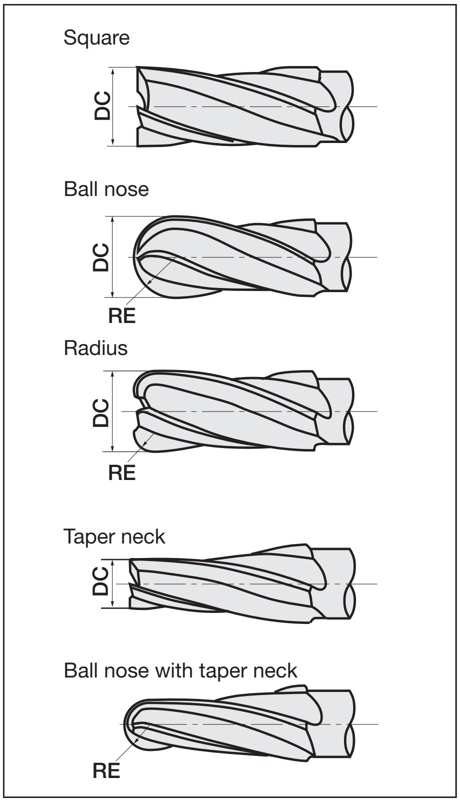
User's Guide - Technical Reference

Solid Carbide Endmills

Part details

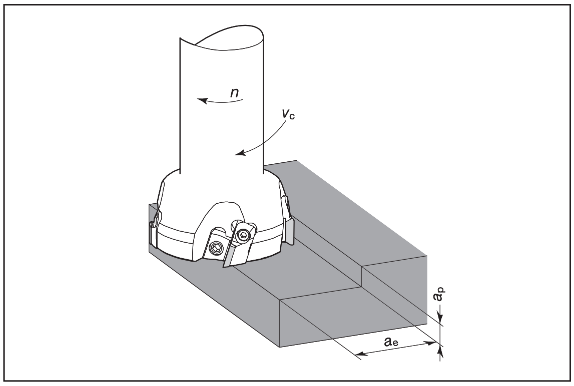


Types



Cutting condition of Endmills

● Cutting speed



● Cutting speed (Calculated from number of revolutions)

$$SFM = \frac{RPM \text{ X } D}{3.82}$$

SFM：Cutting speed
D ：Effective diameter (in)〔DC〕
RPM：Number of revolutions (min-1)

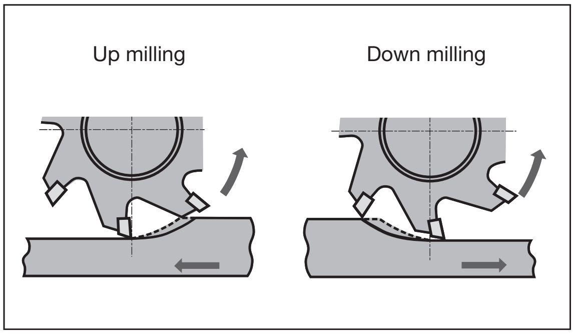
● Number of revolution (Calculated from cutting speed)

$$RPM = \frac{SFM \text{ X } 3.82}{D}$$

● Feed speed and feed per tooth

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

v_f : Feed speed (in/min)
f_z : Feed per tooth (ipt)
z : No. of teeth of the endmills
n : Number of revolutions (min^{-1})
〔 〕The notation in the brackets is the one used in the catalog (ISO compliant)



● Cutting

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

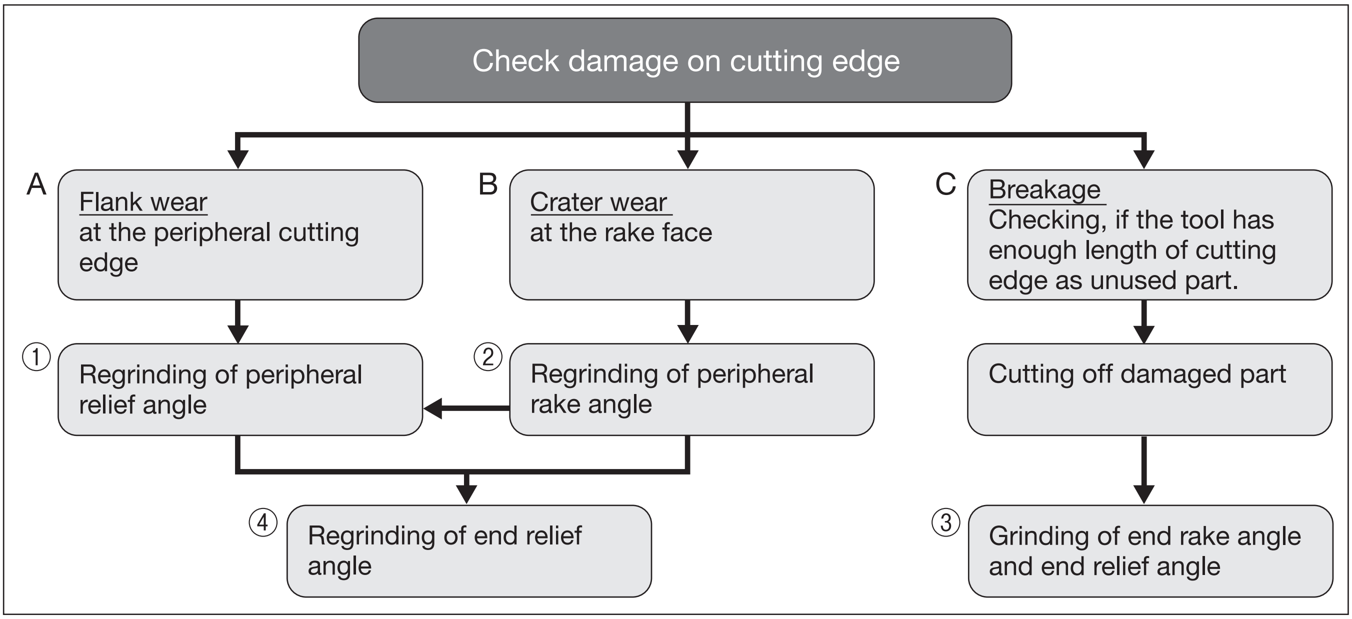
● Up milling and down milling

Down milling generally produces better tool life and surface roughness.

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

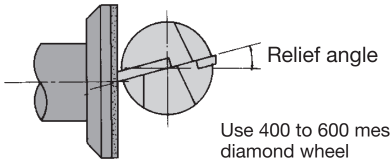
Solid Carbide Endmills

Regrinding procedures of solid carbide endmill



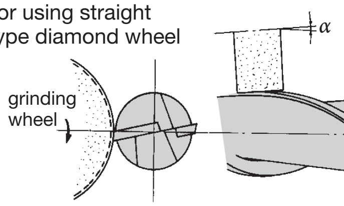
1 Regrinding of end relief angle

1. For using cup type diamond wheel



Use 400 to 600 mesh diamond wheel

2. For using straight type diamond wheel



Setting angle of grinding wheel

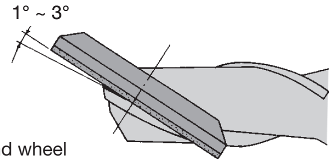
Formular of setting angle α

$\tan \alpha = \tan \beta \times \tan \theta$

β : peripheral relief angle

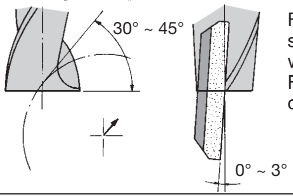
θ : spiral angle

2 Regrinding of peripheral rake angle



Cup type diamond wheel

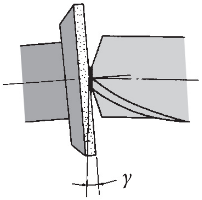
3 Regrinding of end rake angle (End gash)



For 2 flutes endmill: straight type diamond wheel

For ≥ 3 flutes endmill: cup type diamond wheel

4 Regrinding of end relief angle



Cup type diamond wheel

γ : 1st end relief angle: 5° ~ 7°

2nd end relief angle: 15° ~ 20°

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 aluminum 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 0.0004".

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.

Solid Carbide Endmills

Trouble shooting in Endmilling

Trouble	Possible causes	Countermeasures
Breakage	● 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 → 3 flutes, or 2 flutes. ● 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.

(Continued on next page)

Solid Carbide Endmills

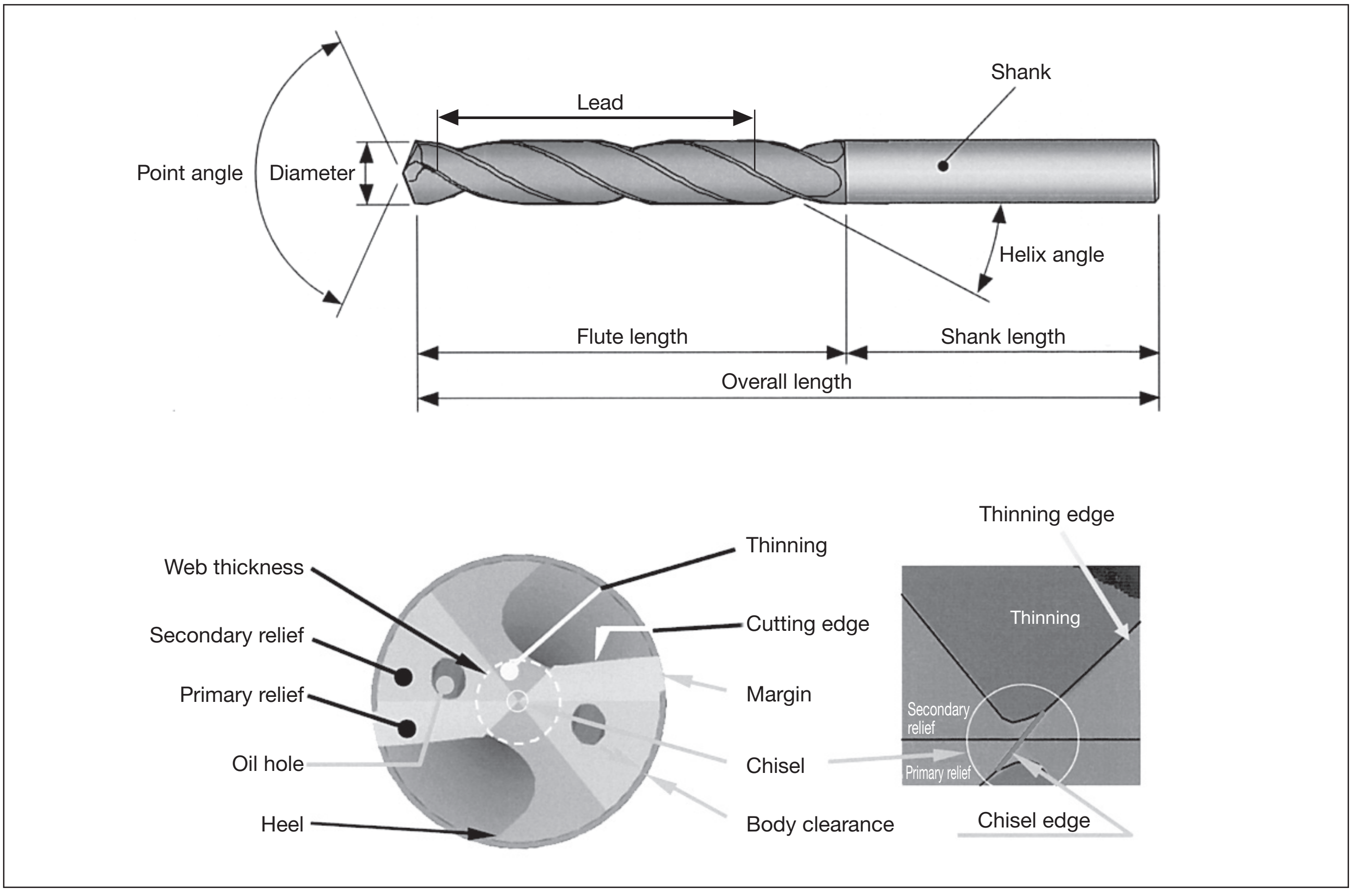
Trouble	Possible causes	Countermeasures
Poor surface finish	Bright, but Wavy surface	● Reduce feed per tooth. ● Increase flutes; E.g. 2 flutes → 3flutes, or 4flutes.
	Small chips are welded on surface.	● Increase cutting speed. ● Use coolant or air blast, or increase coolant. ● Make slight honing on 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 0.003 ipt. ● 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.

A Grade
B Insert
C Ext. Toolholder
D Int. Toolholder
E Threading
F Grooving
G Miniature Tool
H Milling Cutter
I Endmill
J Drilling Tool
K Tooling System
L User's Guide
M Index

User’s Guide - Technical Reference

Drilling Tools

Nomenclature for solid carbide drills



Cutting forces and power requirement

●Twist drill

Power requirement

$$P_C = KD^2 n \left(0.647 + 17.29f \right) \times 10^{-6}$$

(kW)

1kw = 1.34 HP

Thrust force

$$T_C = 570 K D f^{0.85}$$

(N)

Torque

$$M_C = \frac{KD^2 \left(0.630 + 16.84f \right)}{100}$$

(N·m)

P_C : Power requirement (kW)
T_C : Thrust force (N)
M_C : Torque (N·m)
D : Drill diameter (mm)〔DC〕
f : Feed (mm/rev)
n : No. of revolutions (min^{-1})
K : Material constant···· Refer to the Table at right

〔 〕The notation in the brackets is the one used in the catalog (ISO compliant)

●Material constant compensating for power requirement and thrust force

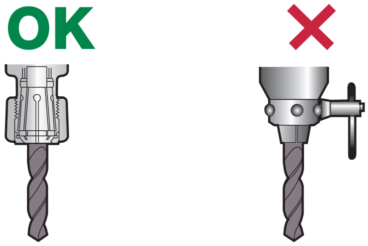
Workpiece material	Tensile strength		Brinell hardness (HB)	Material constant (K)
	MPa(N/mm^2)	{Kgf/mm^2}		
Cast iron	210	21	177	1.00
Cast iron	280	28	198	1.39
Cast iron	350	35	224	1.88
Aluminum	250	25	100	1.01
Low carbon steel (JIS S20C)	550	55	160	2.22
Free cutting steel (JIS SUM32)	620	62	183	1.42
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

Guidelines for correct usage of carbide drills

● Holders for solid carbide drills:

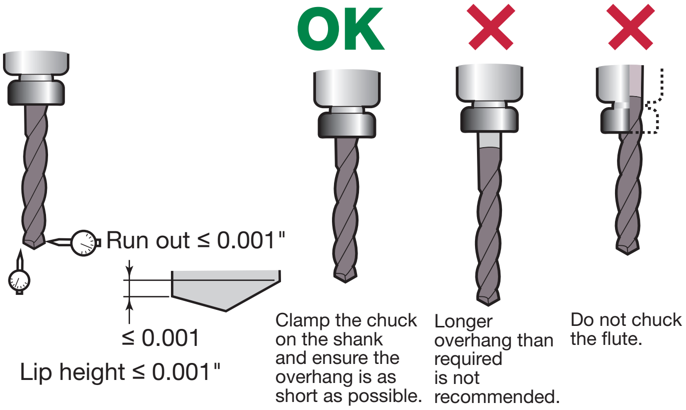
A collet chuck holder is recommended for use with carbide drills. When using a milling chuck holder, a collet chuck with a straight shank or straight collet should be used.



Collet chuck   Drill chuck

● Chucking drills:

- Radial run out and lip height should be less than 0.001". If run out or lip height is larger (close to 0.002"), machining is possible. However, less accurate holes or short tool life may be a result.
- Overhang length should be as short as possible.



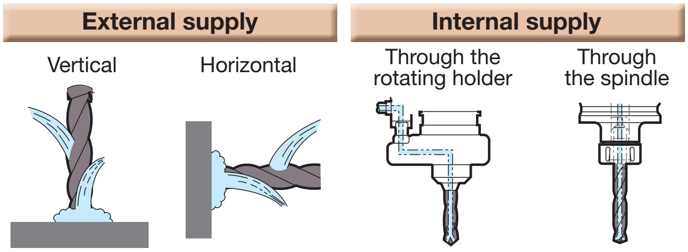
Clamp the chuck on the shank and ensure the overhang is as short as possible.

Longer overhang than required is not recommended.

Do not chuck the flute.

● Coolant Supply:

When using a drill without a coolant hole, such as the DSW-DE type, coolant should always be directed to the entrance of the hole. Maintaining this supplying is very important for stable drilling performance.

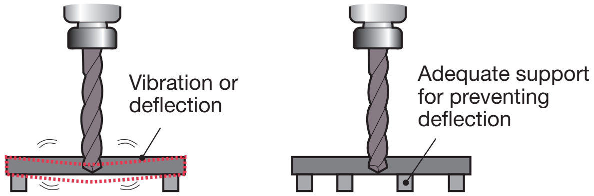


External coolant should be supplied at high pressure and directed at the hole entry point.

Coolant pressure: 0.5 - 2.0 MPa (Air pressure for MQL: 0.3 - 0.5 MPa)

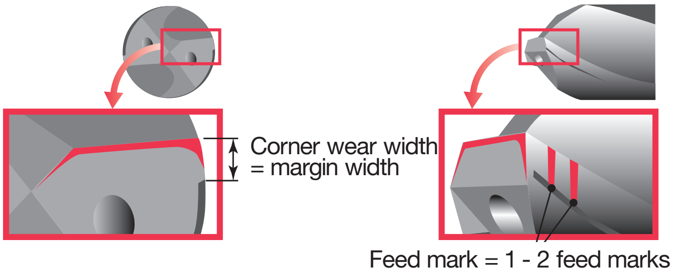
● Clamping workpieces:

As solid carbide drills have a higher thrust force, machining with low rigidity or inadequate support can cause fractures or breakages through vibration. It is important the workpiece is rigidly clamped and has adequate support.



● The criteria of tool life:

- Corner wear width: equal to margin width
- Feed mark: 1 - 2 feed marks on the margin
- Spindle load increase: 30% higher than starting level
- Irregular situation: worse chip control, hole diameter change, worse surface finish, larger burrs, bigger sound.



User's Guide - Technical Reference

Drilling Tools

Regrinding method [Applied to DSW]

Please refer to the following instructions prior to regrinding DSW type drills.

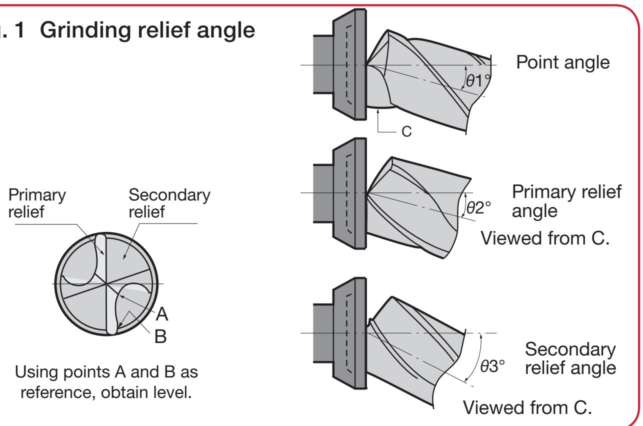
Before regrinding
Check the cutting edge for damage and wear. If any large fracture is found, remove with a silicon carbide wheel.

(1) Grinding the flank

- Use a 280 to 400 grit diamond cup type wheel of 3.937" - 7.874" in diameter.

1) Grind the relief surface so that primary relief angle (*θ*) of 2° can be formed as shown in Fig.1. After grinding the other side likewise, do sparkout grinding so that the difference of the lip height will be kept within 0.02 mm.
2) In the cases of DSW types: After grinding the primary relief angle (*θ*) 2°, without rotating the drill, grind the secondary relief surface so that the relief angle (*θ*) of 3° can be formed. In the same way as 2), take care to bring the ridge line formed between the primary and secondary relief surfaces to the drill center. (Values (*θ*) of 1° ~ 3° are shown in Table 1)

Fig. 1 Grinding relief angle



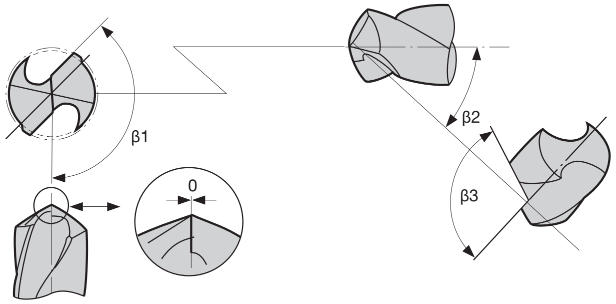
(2) Thinning

- Use a 280 ~ 400 grit diamond straight-type wheel of 3.937" - 7.874" in diameter.
- Conduct thinning in the same manner as cross thinning (X-type).
- Values of *β*1 to *β*3 written in the figures are given in the Table 2.

Table 1	*θ*1 (Point angle)	*θ*2 (Primary relief angle)	*θ*3 (Secondary relief angle)
DSW	–20°	–6° ~ –12°	–23° ~ –27°

Table 2	*β*1	*β*2	*β*3
DSW	147° ~ 153°	30° ~ 42°	95° ~ 110°

Fig. 2



(3) Honing

- The honing angle *θ* and width H should be varied depending on the drill type, diameter, and work material. Recommended honing specifications are given in the Table below.
- Honing procedures (refer to Fig.3)
  (1) Round the R portion shown in Fig.3 in large.
  (2) Then, roughly hone the cutting edge lines by using an electro-deposited diamond file of around 170 grit.
  (3) Carry out finish honing by using a diamond hand stick of 400 to 600 grit.
- The honing width should be changed depending on the drill diameter. For smaller side of diameters, the width should be in smaller side of values given in the Table.

• Angle honing

	~ ø0.236"	ø0.236" ~ ø0.394"	ø0.394" ~ ø0.630"
θ	- 20°	- 20°	- 20°
H	0.001" ~ 0.002"	0.002" ~ 0.003"	0.003" ~ 0.004"

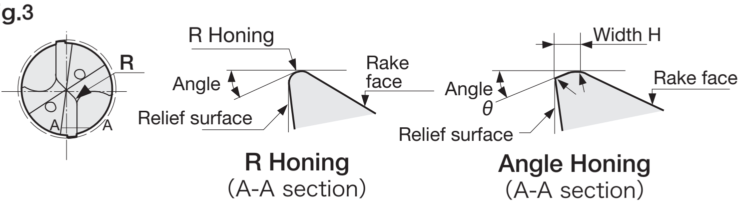
• R Honing

Dimensions (in)	R Honing R (in)
DC ≤ ø0.236"	0.0008" ~ 0.0016"
ø0.236" < DC ≤ ø0.630"	0.0012" ~ 0.0020"

After regrinding, check the following before use.

- The difference of the lip height is kept within 0.0008".
- Any damaged portion on the cutting edges is not left.
- Cutting edges are properly honed.
- Any grinding burr is not left.

Fig.3



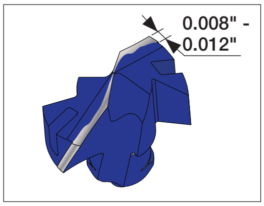
Notes:
- For more details on regrinding, consult the nearest Tungaloy sales office.

DRILLMEISTER

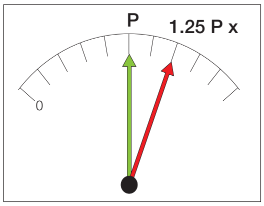
Technical guidelines

●When to change drill heads (Criteria for the end of tool life)

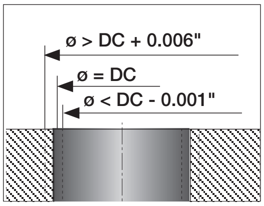
The criteria to identify the time for tool change are as follows:



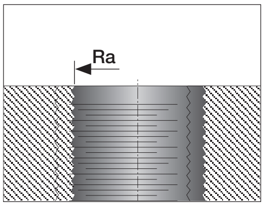
Width of corner wear reaches 0.008" - 0.012".



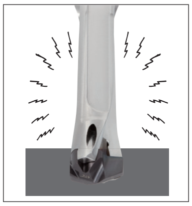
Spindle load exceeds 125% of the normal value.



Hole diameter is 0.006" larger or 0.001" smaller than the drill diameter.



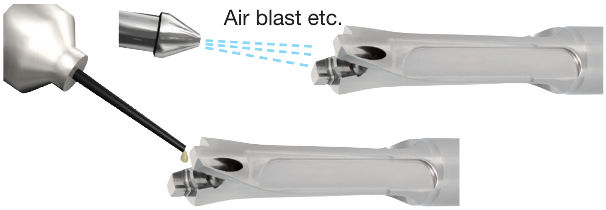
Surface roughness deteriorates.



Vibration or unusual noise occurs.

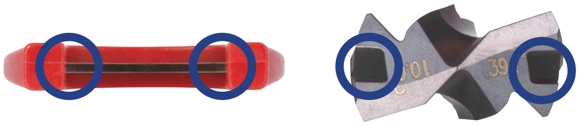
●How to clamp the drill head

① **Clean and lubricate the pocket.**

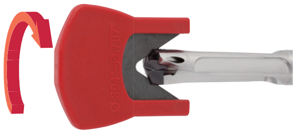


② **Set the drill head into the pocket.**

③ **Set the clamping key on the drill head**

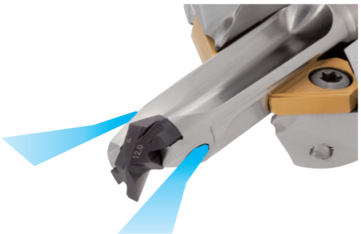


④ **Clamp**

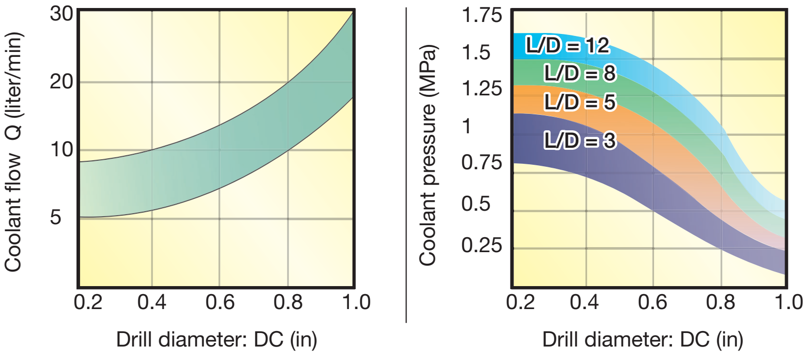


●Coolant supply

Internal coolant supply is recommended.



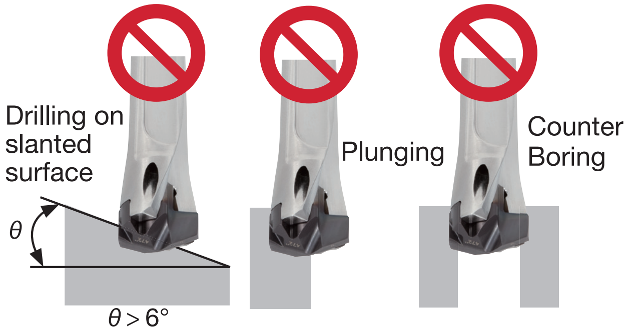
■ **The required coolant flow and pressure**



User's Guide - Technical Reference

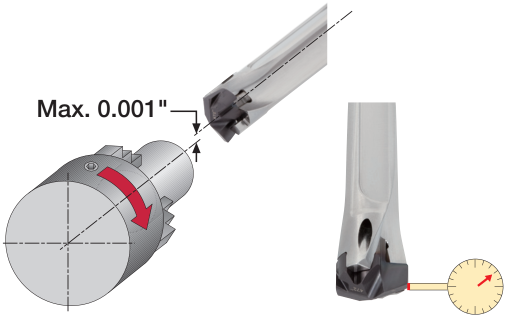
Drilling Tools

● Applications that are not recommended



● Run-out

Run-out should be less than 0.001".



Ideal : ≤ 0.001"
Acceptable : ≤ 0.002"
Not acceptable : > 0.002"

Instruction of clamping head

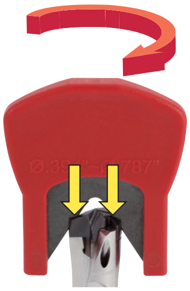


Fig. #1

Fig. #2

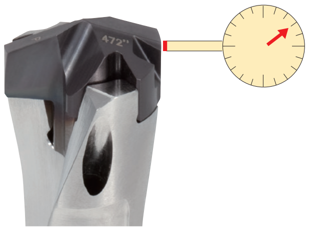


Fig. #3

Procedure

① Clean the clamping areas on the drill body and the head with an air blast, lubricate them, and put the drill head in the pocket.
② Set the clamping key in the groove on the drill head. Push the head toward the pocket with equal torque on the right and the left sides, and turn the clamping key to clamp the head completely. (Fig. #1)
③ Be sure that there is no gap between the bottom of the head and the drill body. A shim in the thickness of around 0.004" is useful to check the gap. (Fig. #2)
④ If there is a gap thicker than 0.004", unclamp the head and return to procedure No. ①
⑤ Check the run-out at the margin of the drill head. Run-out must be less than 0.002". (Fig. #3) (Recommended value: less than 0.001")
If the run-out exceeds 0.002", unclamp the head and return to procedure No. ① .

Note #1: If the clamping torque is not equally applied on the right and the left sides of the drill head, there may be a gap between the head and the body, which increases the run-out of the head.

Note #2: Low accuracy in holding the drill body may affect the run-out. If the run-out is large, check the accuracy in holding the drill body.

KEY FOR MEASURING HEAD RELEASE TORQUE

The release torque in unclamping a head is measured with a torque driver to determine the body's tool life. Please refer to the below for the standard release torque value which indicates the end of tool life (The value less than the standard should be judged as the end of tool life).

Dedicated key designation :
KHS-TID10-19.99

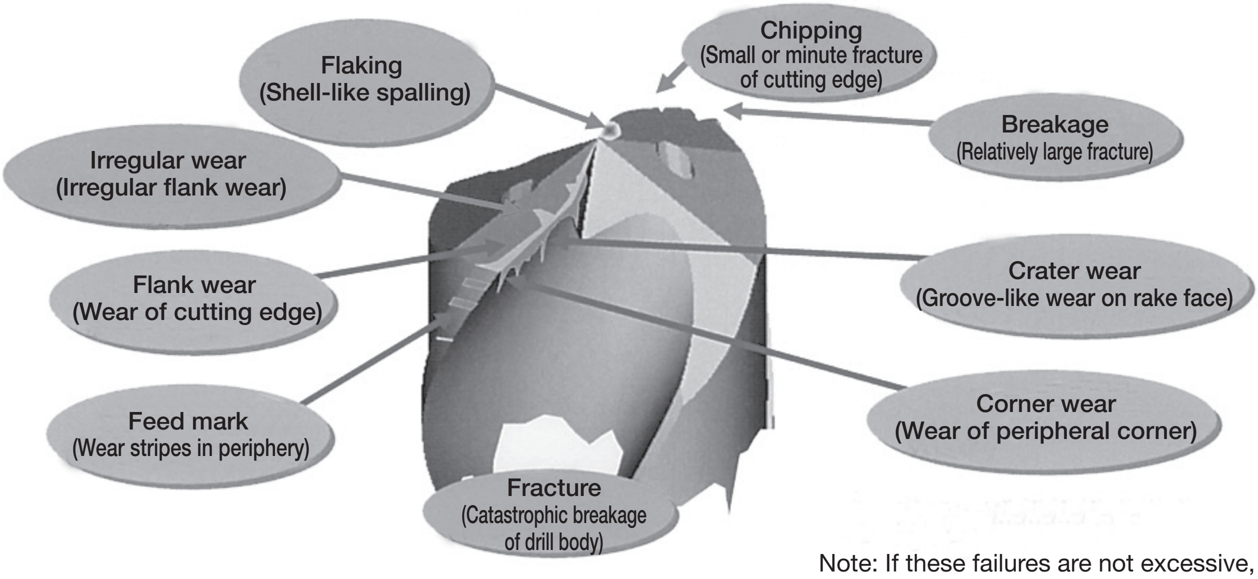
*Can be connected with a commercially available torque driver.

Head designation	Release torque value to indicate tool replacement		
	(N·m)	(lbs·ft)	(cN·M)
DMP100-109	0.2	0.15	20
DMP110-119	0.2	0.15	20
DMP120-129	0.25	0.18	25
DMP130-139	0.25	0.18	25
DMP140-149	0.3	0.22	30
DMP150-159	0.3	0.22	30
DMP160-169	0.35	0.26	35
DMP170-179	0.35	0.26	35
DMP180-189	0.4	0.3	40
DMP190-199	0.4	0.3	40

(Unit: mm)

Drilling Tools

Cutting edge failure of solid carbide drills



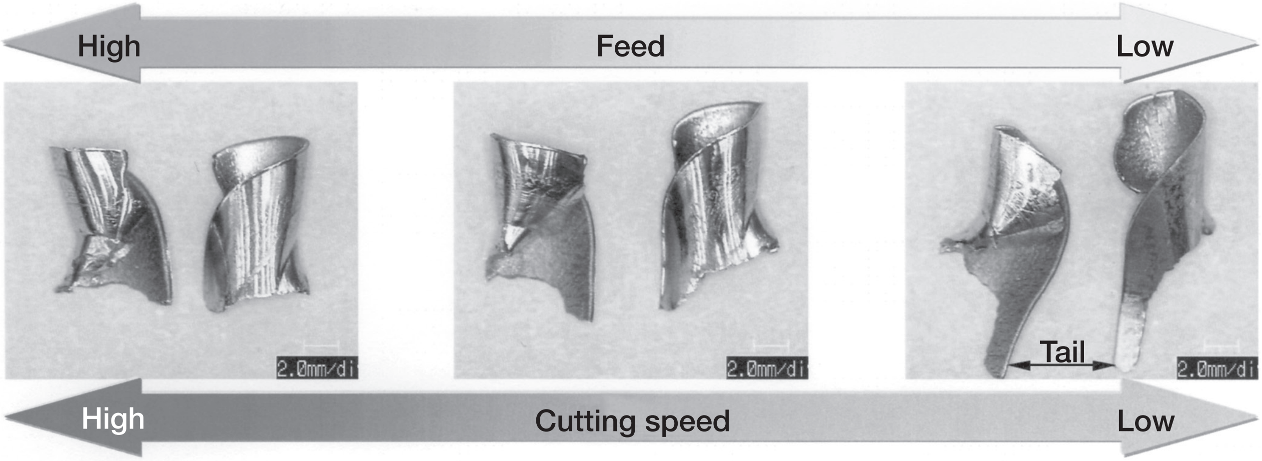
Note: If these failures are not excessive, the tool is in a normal condition.

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.



User’s Guide - Technical Reference

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)
		Intermittent cutting when entering	•Avoid interruption at entry and exit. •Lower the feed by about 50% during entering into and leaving from the workpiece.
Chipping and fracture	Chisel section (center of drill cutting edge)	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%.
		Inappropriate honing	•Check if honing has been made to the center of cutting edge.
	Peripheral 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. (0.0012" or less)
		Insufficient machinery and workpiece rigidity	•Change the clamp method to the one with rigidity. •Lower the feed during entering and leaving from the workpiece.
		Inappropriate honing	•Check if honing has been made to the cutting edge periphery.
	Margin	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. (0.0012" 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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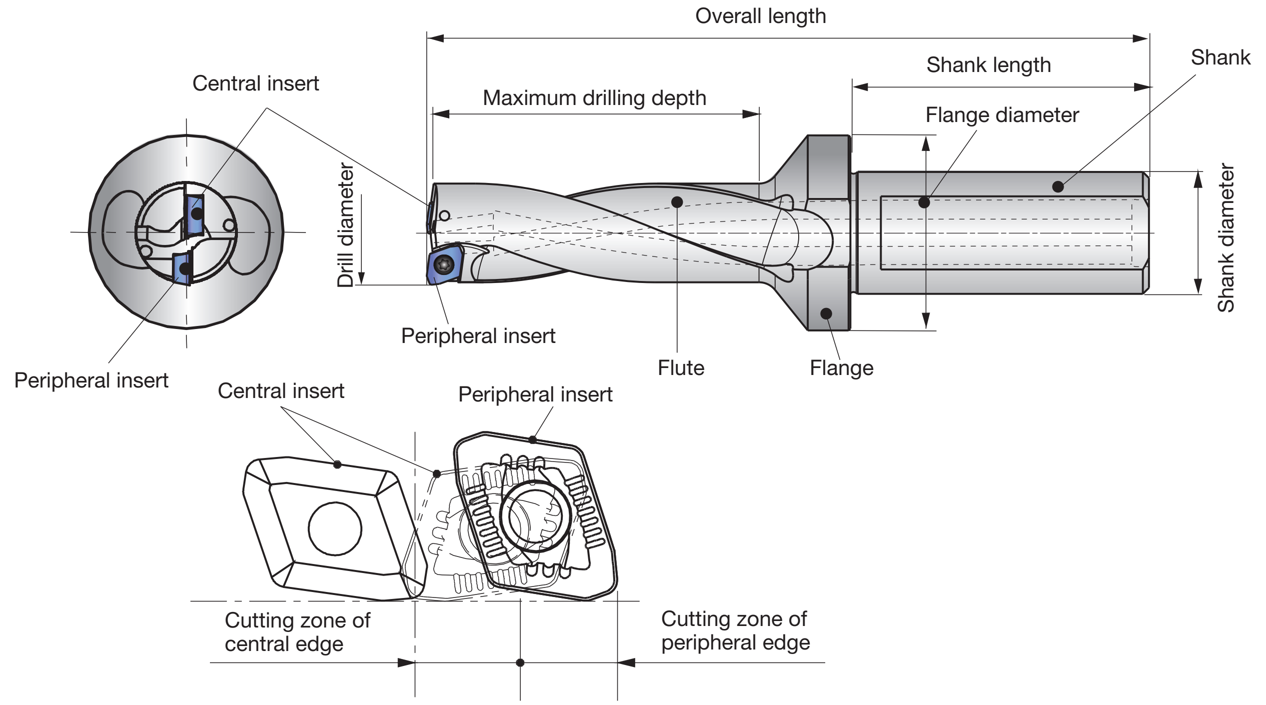
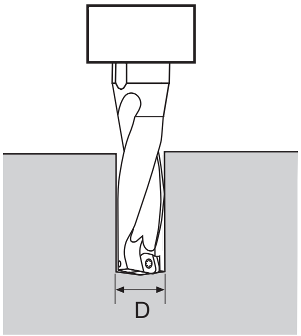
Drilling Tools

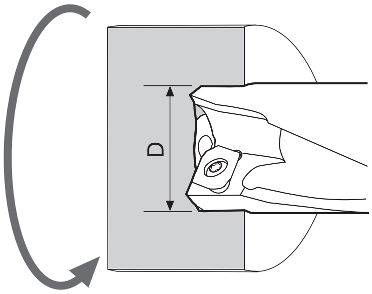
Nomenclature for Indexable drill



Calculation formulas for Indexable drill

●Cutting speed





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

$$SFM = \frac{RPM\ X\ D}{3.82}$$

SFM: Cutting speed
D : Drill diameter (in)〔DC〕
RPM: Number of revolution (min-1)

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

$$RPM = \frac{SFM\ X\ 3.82}{D}$$

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

$$v_c = \frac{\pi \times D \times n}{1000}$$

v_c : Cutting speed (sfm)
D : Drilling diameter (in)〔DC〕
n : Number of revolution (min^{-1})
$\pi \approx 3.14$

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

$$\underset{(\mathrm{min}^{-1})}{n} = \frac{1000 \times v_c}{\pi \times D}$$

●Calculation of feed speed

$$\underset{(\mathrm{in/min})}{v_f} = f \times n$$

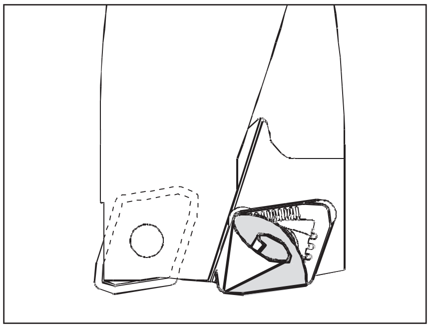
v_f : Feed speed (in/min)
f : Feed (ipr)
n : Number of revolution (min^{-1})

〔 〕The notation in the brackets is the one used in the catalog (ISO compliant)

Drilling Tools

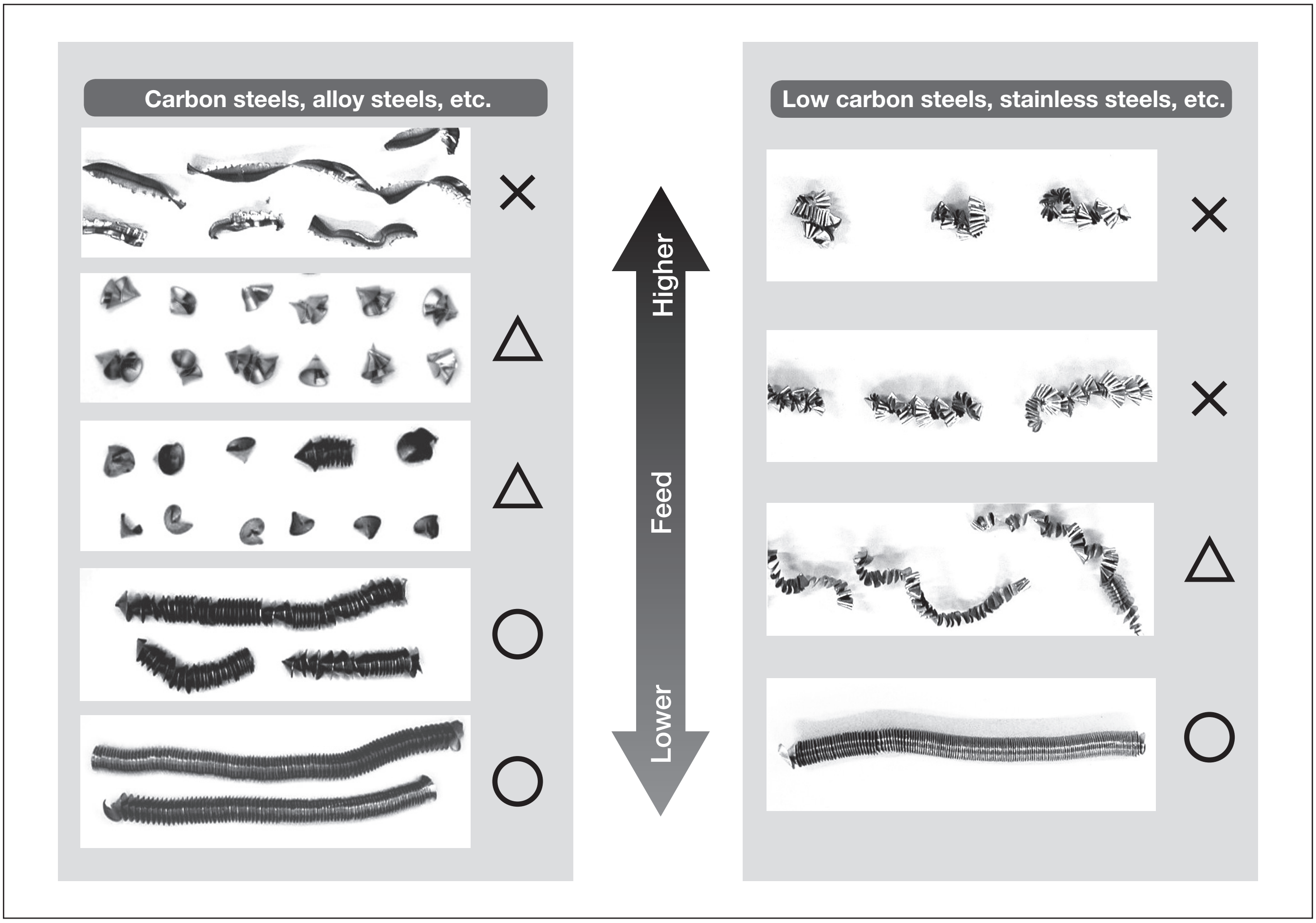
Chip shapes

Chip shape produced with central insert



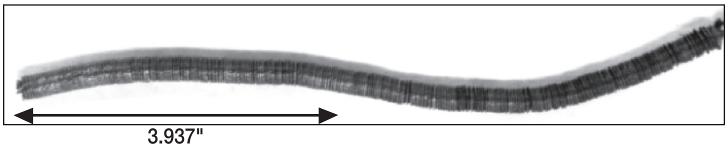
- A conical coil shape whose apex point coincides with the rotating center of the drill is the basic shape. The chips are broken into small sections with increases in feed. However, excessively high feed causes the chip to increase in thickness and develops vibration which disturbs stable machining.
- 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)

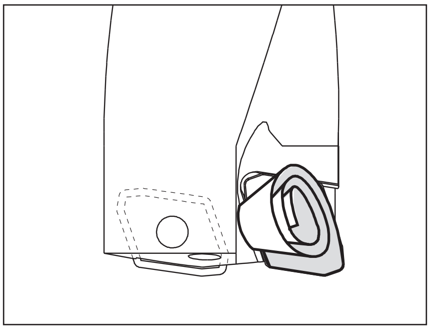
(ø1.024", 1045, V_c = 330 sfm, f = 0.004 ipr)



Drilling Tools

● Chip shape produced with peripheral insert

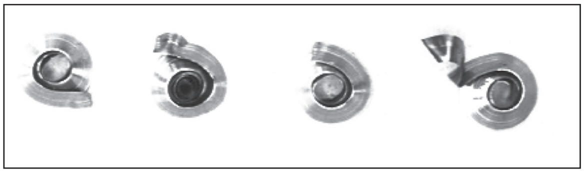
- Chip problems such as entangling are mainly caused by chips produced with the peripheral insert. These problems are dependent on the types of Workpiece material and the cutting conditions.
- As shown below, when the feed is extremely low, the chips jump over the chipbreaker groove and the continuously 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.



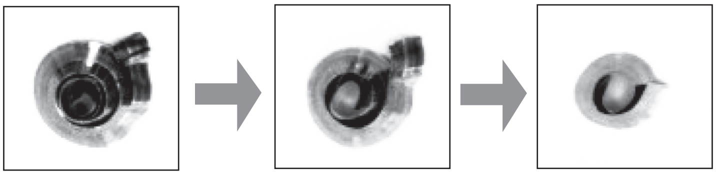
Medium to high carbon steels, alloy steels, etc.

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



f = 0.003 ipr

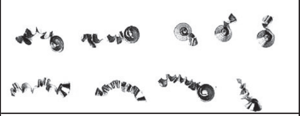
f = 0.004 ipr

f = 0.005 ipr

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) (ø0.866", V_c = 330 sfm, f = 0.004 ipr)	**Mild steel (JIS SS400)** (ø0.866", V_c = 530 sfm, f = 0.003 ipr)
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%.

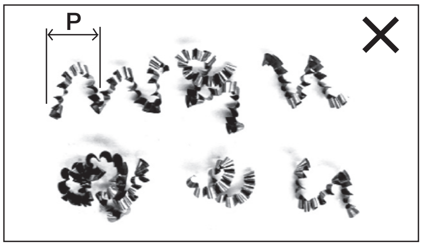
Apple-peel-like chips (Without curling)

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.



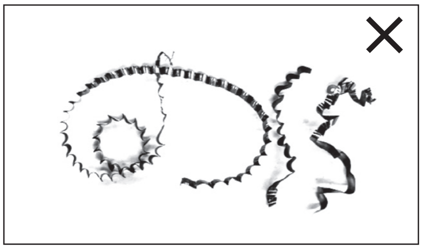
Continuously curled "C" shape chips with short lead (P).

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%.

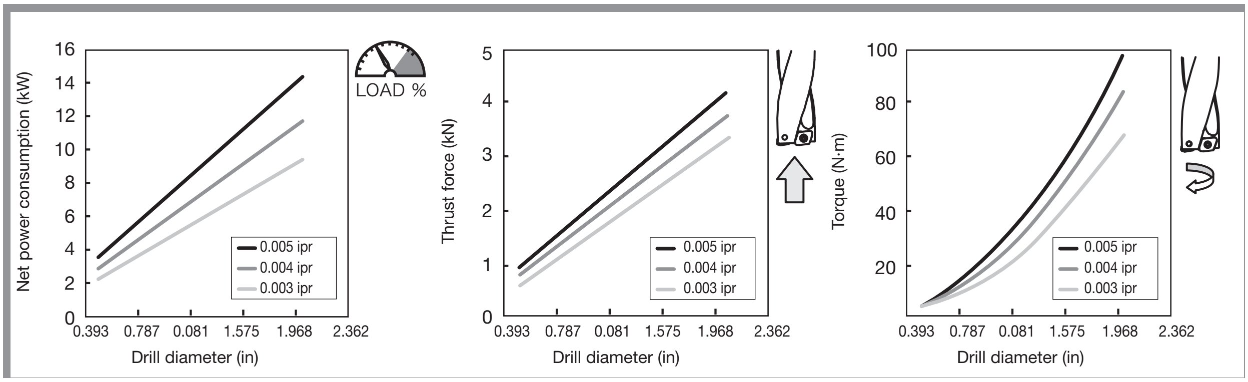


Continuously coiled long chips

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 = 330 sfm
Workpiece material: Alloy steel 4140),
240HB
Cutting fluid: Used

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	The rotation center of drill	Misalignment for workpiece rotation	● Set the misalignment to 0 ~ 0.008".
			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 0.002 ipr 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	Peripheral corner area	Using inserts in excess of tool-life	● Exchange the corner or the insert before the nose wear reaches 0.012".
			No flatness of machined surface	● Flatten the entry surface in pre-machining. ● Set the feed for lower than 0.002 ipr at rough surface area.
			The existence of interrupted area	● Set the feed for lower than 0.002 ipr in interrupted area.
			Using a chipped corner	● Confirm the corner when exchanging inserts.
	Common	The unused corner area and cutting edge	High hardness of workpiece	● 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).
			Chip packing	● Lower the feed by 20% within standard conditions.
			Machinery impact	● Change to continuous feed in case of pick feeding.
		Contact boundary	Using inserts in excess of tool-life	● Exchange the corner or the insert before the nose wear reaches 0.012".
			Vibration in drilling	● Change to the machine with higher rigidity. ● Change to the clamp method with rigidity. ● Change the drill setting method.
		Flaking	High hardness of workpiece	● Set the feed for lower than 0.002 ipr.
			Thermal impact	● Change to internal cutting fluid supply from external one. ● Lower the feed by 20% within standard conditions.
		Common	Unsuitable for selection of grade	● Change the grade to toughness.
			Looseness of screws	● Tighten the screw.

User's Guide - Technical Reference

Drilling Tools

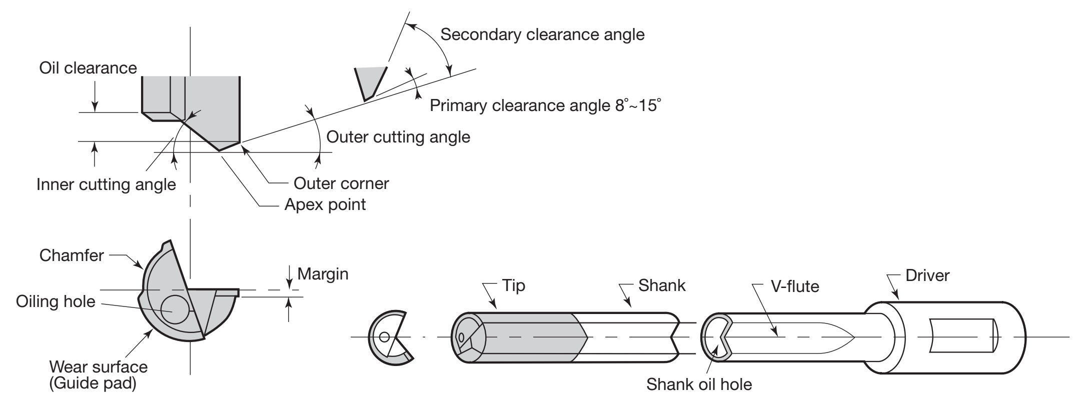
Troubleshooting for indexable drills

Problem		Cause	Countermeasure
Scratch marks on the tool	The tool periphery	Misalignment of workpiece rotation	● Set the misalignment to 0 ~ 0.008".
		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 0.002 ipr 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 ~ 0.008".
		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 0.002 ipr 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	Trigger	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 (*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.
		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 (*Vc*).

User’s Guide - Technical Reference

Drilling Tools

Troubleshooting in gun drilling

Problem		Cause	Trigger	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 +0.00012" and +0.00031").
			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, cyndricity, and oversize	Machine	The clearance between the guide bush and the drill is not appropriate.	Replace the guide bush (The clearance should be between +0.00012" and +0.00031").
			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 +0.00012" and +0.00031").
		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.

Drilling Tools

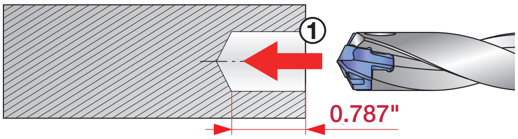
Troubleshooting in gun drilling

Problem		Cause	Trigger	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 mm and +0.008 mm).
			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.

Drilling Tools

Drilling procedure on machining centers and lathes

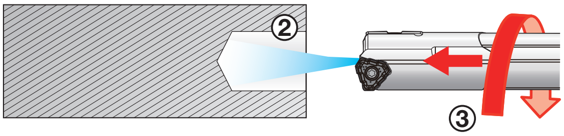
Proceed as instructed below in order to maximize the tool performance.



① Drill a pilot hole

Hole diameter tolerance: +0.0004" - +0.004"
Hole depth: H = 0.787"

Please use DrillMeister or DrillForce-Meister for a pilot hole
Use a drill with 3xD or smaller

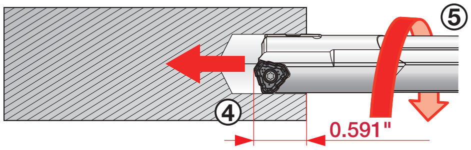


② Start coolant

③ Slowly insert DeepTri-Drill into the pilot hole

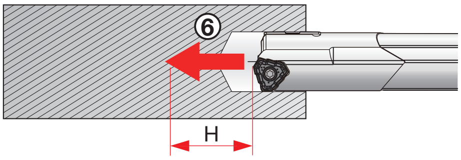
No. of revolution: *n* = 1.969 - 3.937 rpm
Feed speed: *Vf* = 4 - 12 ipm

Caution: Do not rotate the drill at a full machining speed before engaging the pilot hole.



④ Stop the drill at 0.591" depth

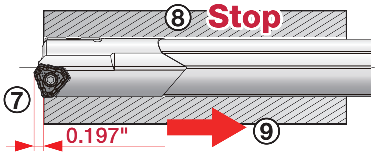
⑤ Start rotating at full machining speed



⑥ Start feeding

At the entry (H = 0.591" - 0.984"):
→ Feed: *f* = 80% of programmed feed

Hole depth:
H ≥ 0.984" → Feed: *f* = 100%



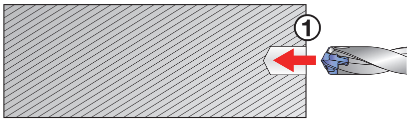
⑦ For a through hole

Continue drilling until the drill head passes through the workpiece by 0.197"

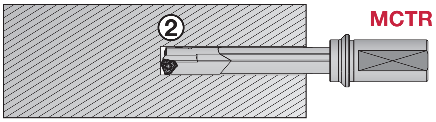
⑧ Stop the rotation and coolant
⑨ Return the drill

How to use a TRLG type DeepTri-Drill on a horizontal machining center or boring machine

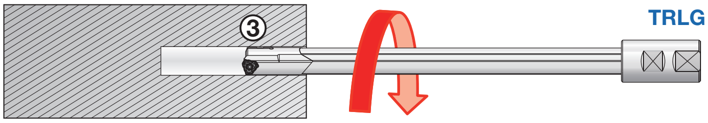
When using the TRLG drill on a conventional machining center or horizontal boring machine where there are no drilling-bush supports available, a pilot hole needs to be further deepened with a MCTR drill to better support the long gundrill. A long gundrill such as the TRLG type drill tends to “whip” when the pilot hole is too short to support the gundrill.



① Drill a pilot hole

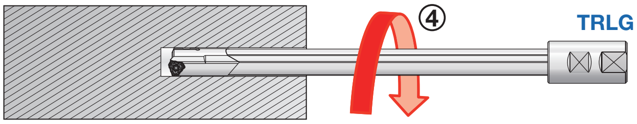


② Expand the pilot hole deeper using a MCTR drill

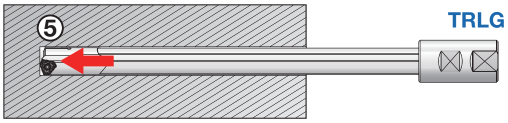


③ Drill with a TRLG drill at a reduced rotation and feed. Use the following parameters:

No. of revolution: *n* = 50 - 100 rpm
Feed speed: *Vf* = 4 - 12 ipm



④ When DeepTri-Drill reaches all the way to the end of the pilot hole, increase drill rotation to full machining speed.



⑤ Start feeding to complete the drilling

(Caution)
Always use Step ② to prevent the gundrill from whipping, which may lead to drill breakage and a possible superfluous injury.

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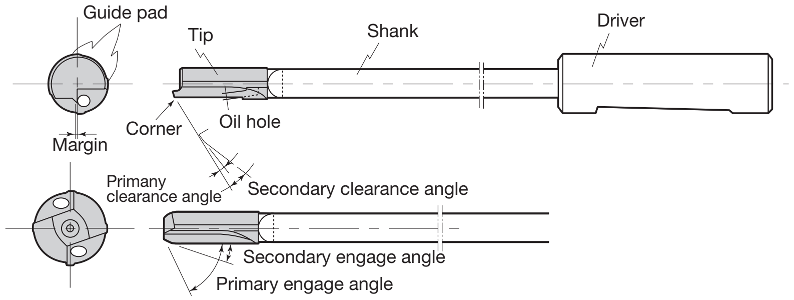
Drilling Tools

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 Too large and inconsistent over-sized	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	● Reduce chamfer angle ● Reduce back taper ● Improve run out accuracy
		Faulty regrinding	● Cutting edge run out is large ● Residual damage of preceding process	● Improve run out accuracy ● Remove residual damage completely
		Improper cutting fluid	● Excessive fluid pressure ● Improper selection of cutting fluid	● Reduce fluid pressure ● Increase activity and lubricity of the fluid
		Faulty machine accuracy		● Correct spindle run out and bushing clearance and alignment
		Faulty clamping of workpiece	● Clamping position wrong ● Clamping force inadequate	● Improper clamping position ● Increase clamping force
	Defective out-of-roundness	Faulty machine accuracy	● Excessive bushing clearance ● Faulty spindle run out and alignment	● Correct bushing clearance ● Correct spindle run out and alignment
		Improper tool specifications	● Outer run out of reamer large ● Insufficient reamer rigidity	● Correct peripheral run out ● Increase 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	● Decrease cutting speed ● Increase lubricating capacity
		Faulty regrinding (residual damage)		● Increase regrinding stock amount

User's Guide - Technical Reference

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 ø8.0 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.

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				
			U.S.A.	Great Britain	Germany	France	Russia
	JIS	ISO	AISI SAE	BS BS/EN	DIN DIN/EN	NF NF/EN	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				
				U.S.A.	Great Britain	Germany	France	Russia
		JIS	ISO	AISI SAE	BS BS/EN	DIN DIN/EN	NF NF/EN	ГОСТ
Alloy steel	Nickel chromium steel	SNC236	–	–	–	–	–	40XH
		SNC415(H)	–	–	–	–	–	–
		SNC631(H)	–	–	–	–	–	30XH3A
		SNC815(H)	15NiCr13	–	15NiCr13	15NiCr13	15NiCr13	–
		SNC836	–	–	–	–	–	–
	Nickel chromium molybdenum steel	SNCM220	20NiCrMo2 20NiCrMoS2	8615 8617(H) 8620(H) 8622(H)	20NiCrMo2-2 20NiCrMoS2-2	20NiCrMo2-2 20NiCrMoS2-2	20NiCrMo2-2 20NiCrMoS2-2	–
		SNCM240	41CrNiMo2 41CrNiMoS2	8637 8640	–	–	–	–
		SNCM415	–	–	–	–	–	–
		SNCM420(H)	–	4320(H)	–	–	–	20XH2M(20XHM)
		SNCM431	–	–	–	–	–	–
		SNCM439	–	4340	–	–	–	–
		SNCM447	–	–	–	–	–	–
		SNCM616	–	–	–	–	–	–
		SNCM625	–	–	–	–	–	–
		SNCM630	–	–	–	–	–	–
		SNCM815	–	–	–	–	–	–

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

Symbols of Metals

● Alloy steel

Type		Japan	International	Other countries				
				U.S.A.	Great Britain	Germany	France	Russia
		JIS	ISO	AISI SAE	BS BS/EN	DIN DIN/EN	NF NF/EN	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	34Cr4 34CrS4	30X
		SCr435(H)	34Cr4 34CrS4 37Cr4 37CrS4	5132	37Cr4 37CrS4	37Cr4 37CrS4	37Cr4 37CrS4	35X
		SCr440(H)	37Cr4 37CrS4 41Cr4 41CrS4	5140(H)	530M40 41Cr4 41CrS4	41Cr4 41CrS4	41Cr4 41CrS4	40X
		SCr445(H)	–	–	–	–	–	45X
	Chromium molybdenum steel	SCM415(H)	–	–	–	–	–	–
		SCM418(H)	18CrMo4 18CrMoS4	–	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	34CrMo4 34CrMoS4	35XM
		SCM440(H)	42CrMo4 42CrMoS4	4140(H) 4142(H)	42CrMo4 42CrMoS4	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)	–	–	–	–	–	–
		SMnC443(H)	–	–	–	–	–	–
	Aluminum chromium molybdenum steel	SACM645	41CrAlMo74	–	–	–	–	–

● Stainless steel

Type		Japan	International	Other countries					
				U.S.A.		Great Britain	Germany	France	Russia
		JIS	ISO	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			12X17Г9AH4
		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					
				U.S.A.		Great Britain	Germany	France	Russia
		JIS	ISO	UNS	AISI SAE	BS BS/EN	DIN DIN/EN	NF NF/EN	ГОСТ
Stainless steel	Austenitic	SUS305J1							
		SUS309S		S30908	309S			Z10CN24-13	
		SUS310S	X6CrNi25-21	S31008	310S	310S31		Z8CN25-20	10Х23Н18
		SUS315J1							
		SUS315J2							
		SUS316	X5CrNiMo17-12-2 X3CrNiMo17-12-3	S31600	316	316S31	X5CrNiMo17-12-2 X5CrNiMo17-13-3	Z7CND17-12-02 Z6CND18-12-03	
		SUS316F							
		SUS316L	X2CrNiMo17-12-2 X2CrNiMo17-12-3 X2CrNiMo18-14-3	S31603	316L	316S11	X2CrNiMo17-13-2 X2CrNiMo17-14-3	Z3CND17-12-02 Z3CND17-12-03	03Х17Н14М3
		SUS316N		S31651	316N				
		SUS316LN	X2CrNiMoN17-11-2 X2CrNiMoN17-12-3	S31653	316LN		X2CrNiMoN17-12-2 X2CrNiMoN17-13-3	Z3CND17-11Az Z3CND17-12Az	
		SUS316Ti	X6CrNiMoTi17-12-2	S31635			X6CrNiMoTi17-12-2	Z6CNDT17-12	08Х17Н13М2Т
		SUS316J1							
		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		Z2NCDU25-20	
		SUS321	X6CrNiTi18-10	S32100	321	321S31	X6CrNiTi18-10	Z6CNT18-10	08Х18Н10Т
		SUS347	X6CrNiNb18-10	S34700	347	347S31	X6CrNiNb18-10	Z6CNNb18-10	08Х18Н12Б
		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	08Х21Н6М2Т
		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	12Х17
		SUS430F	X7CrS17	S43020	430F		X7CrS18	Z8CF17	
		SUS430LX	X3CrTi17 X3CrNb17	S43035			X6CrTi17	Z4CT17	
		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	08Х13
		SUS410F2							
		SUS410J1		S41025					
		SUS416	X12CrS13	S41600	416	416S21		Z11CF13	
		SUS420J1	X20Cr13	S42000	420	420S29	X20Cr13	Z20C13	20Х13
		SUS420J2	X30Cr13	S42000	420	420S37	X30Cr13	Z33C13	30Х13
		SUS420F	X29CrS13	S42020	420F			Z30CF13	
		SUS420F2							
		SUS429J1							
		SUS431	X19CrNi16-2	S43100	431	431S29	X20CrNi17-2	Z15CN16-02	20Х17Н2
		SUS440A	X70CrMo15	S44002	440A			Z70C15	
		SUS440B		S44003	440B				
		SUS440C	X105CrMo17	S44004	440C			Z100CD17	95Х18
		SUS440F		S44020	S44020				
	Precipitation hardening type	SUS630	X5CrNiCuNb16-4	S17400	S17400			Z6CNU17-04	
		SUS631	X7CrNiAl17-7	S17700	S17700		X7CrNiAl17-7	Z9CNA17-07	09Х17Н7Ю
		SUS631J1							

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					
				U.S.A.		Great Britain	Germany	France	Russia
		JIS	ISO	UNS	AISI SAE	BS BS/EN	DIN DIN/EN	NF NF/EN	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	
		SUH660		S66286				Z6NCTV25-20	
		SUH661		R30155					
	Ferritic	SUH21					CrAl1205		
		SUH409	X6CrTi12	S40900	409	409S19	X6CrTi12	Z6CT12	
		SUH409L	X2CrTi12					Z3CT12	
		SUH446		S44600	446			Z12C25	15X28
	Martensitic	SUH1		S65007		401S45	X45CrSi9-3	Z45CS9	
		SUH3						Z40CSD10	40X10C2M
		SUH4				443S65		Z80CSN20-02	
		SUH11							40X9C2
		SUH600							20X12BHMБФP
		SUH616		S42200					

● Tool steel

Type	Japan	International	U.S.A.
	JIS	ISO	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	–	–
High speed steel	SKH2	HS18-0-1	T1
	SKH3	–	T4
	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	–	–

Type	Japan	International	U.S.A.
	JIS	ISO	AISI ASTM
Alloy tool steel	SKS5	–	–
	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	International	U.S.A.
	JIS	ISO	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	–	–

Type	Japan	International	U.S.A.
	JIS	ISO	AISI ASTM
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				
				U.S.A.	Great Britain	Germany	France	Russia
		JIS	ISO	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-	BЧ
	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			
				U.S.A.		Great Britain	Germany
		JIS	ISO	ASTM SAE		BS BS/EN	DIN DIN/EN
Copper alloy, Nickel alloy	**Copper alloy casting**	CAC101	–	–	–	–	
		CAC102	–	–	–	Cu-C(CC040AgrodeC)	
		CAC103	–	–	–	Cu-C(CC040AgrodeA,B)	
	Brass casting	CAC201	–	–	–	CuZn15As-C(CC760S)	
		CAC202	–	C85400	–	CuZn33Pb2-C(CC750S)	
		CAC203	–	C85700	–	CuZn39Pb1-C(CC754S)	
	High strength brass casting	CAC301	–	C86500	–	CuZn35Mn2Al1Fe-C(CC765S)	
		CAC302	–	C86400	–	CuZn34Mn3Al2Fe1-C(CC764S)	
		CAC303	–	C86200	–	CuZn25Al5Mn4Fe3-C(CC762S)	
		CAC304	–	C86300	–	CuZn25Al5Mn4Fe3-C(CC762S)	
	Bronze casting	CAC401	–	C84400	–	CuSn3Zn8Pb5-C(CC490K)	
		CAC402	–	C90300	–	–	
		CAC403	–	C90500	–	–	
		CAC406	–	C83600	–	CuSn5Zn5Pb5-C(CC490K)	
		CAC407	–	C92200	–	–	
	Phosphor bronze casting	CAC502A	–	C90700 C90800	–	CuSn10-C(CC480K) CuSn12-C(CC483K)	
		CAC502B	–		–		
		CAC503A	–		–		
		CAC503B	–		–		
	Aluminum bronze casting	CAC701	–	C95200	–	CuAl10Fe2-C(CC331G)	
		CAC702	–	C95400	–	CuAl10Ni3Fe2-C(CC332G)	
			–	C95410	–		
		CAC703	–	C95800	–	CuAl10Fe5Ni5-C(CC333G)	
		CAC704	–	C95700	–	–	
	Silicon bronze castings	CAC801	–	–	–	–	
		CAC802	–	C87500	–	–	
		CAC803	–	C87400	–	CuZn16Si4-C(CC761S)	

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

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Symbols of Metals

● Non-ferrous alloy

Type		Japan	International	Other countries			
				U.S.A.	Great Britain	Germany	France
		JIS	ISO	ASTM SAE	BS BS/EN	DIN DIN/EN	NF NF/EN
Aluminum alloy	Aluminum 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	–	–	–		
	Aluminum 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			
				U.S.A.	Great Britain	Germany	France
		JIS	ISO	ASTM AA	BS BS/EN	DIN DIN/EN	NF NF/EN
Aluminum alloy	Aluminum 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	EN 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	Rockwell *3				HS	Approx. tensile strength (MPa) *2
Brinell, 10mm ball, Load 3000kg		Vickers	HRA	HRB	HRC	HRD	Shore	
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	–
–	–	920	85.3	–	67.5	76.5	96	–
–	–	900	85.0	–	67.0	76.1	95	–
–	(767)	880	84.7	–	66.4	75.7	93	–
–	(757)	860	84.4	–	65.9	75.3	92	–
–	(745)	840	84.1	–	65.3	74.8	91	–
–	(733)	820	83.8	–	64.7	74.3	90	–
–	(722)	800	83.4	–	64.0	73.8	88	–
–	(712)	–	–	–	–	–	–	–
–	(710)	780	83.0	–	63.3	73.3	87	–
–	(698)	760	82.6	–	62.5	72.6	86	–
–	(684)	740	82.2	–	61.8	72.1	–	–
–	(682)	737	82.2	–	61.7	72.0	84	–
–	(670)	720	81.8	–	61.0	71.5	83	–
–	(656)	700	81.3	–	60.1	70.8	–	–
–	(653)	697	81.2	–	60.0	70.7	81	–
–	(647)	690	81.1	–	59.7	70.5	–	–
–	(638)	680	80.8	–	59.2	70.1	80	–
–	630	670	80.6	–	58.8	69.8	–	–
–	627	667	80.5	–	58.7	69.7	79	–
–	–	677	80.7	–	59.1	70.0	–	–
–	601	640	79.8	–	57.3	68.7	77	–
–	–	640	79.8	–	57.3	68.7	–	–
–	578	615	79.1	–	56.0	67.7	75	–
–	–	607	78.8	–	55.6	67.4	–	–
–	555	591	78.4	–	54.7	66.7	73	2055
–	–	579	78.0	–	54.0	66.1	–	2015
–	534	569	77.8	–	53.5	65.8	71	1985
–	–	553	77.1	–	52.5	65.0	–	1915
–	514	547	76.9	–	52.1	64.7	70	1890
(495)	–	539	76.7	–	51.6	64.3	–	1855
–	–	530	76.4	–	51.1	63.9	–	1825
–	495	528	76.3	–	51.0	63.8	68	1820
(477)	–	516	75.9	–	50.3	63.2	–	1780
–	–	508	75.6	–	49.6	62.7	–	1740
–	477	508	75.6	–	49.6	62.7	66	1740
(461)	–	495	75.1	–	48.8	61.9	–	1680
–	–	491	74.9	–	48.5	61.7	–	1670
–	461	491	74.9	–	48.5	61.7	65	1670
444	–	474	74.3	–	47.2	61.0	–	1595
–	–	472	74.2	–	47.1	60.8	–	1585
–	444	472	74.2	–	47.1	60.8	63	1585
429	429	455	73.4	–	45.7	59.7	61	1510
415	415	440	72.8	–	44.5	58.8	59	1460
401	401	425	72.0	–	43.1	57.8	58	1390
388	388	410	71.4	–	41.8	56.8	56	1330
375	375	396	70.6	–	40.4	55.7	54	1270
363	363	383	70.0	–	39.1	54.6	52	1220
352	352	372	69.3	(110.0)	37.9	53.8	51	1180
341	341	360	68.7	(109.0)	36.6	52.8	50	1130
331	331	350	68.1	(108.5)	35.5	51.9	48	1095
321	321	339	67.5	(108.0)	34.3	51.0	47	1060
311	311	328	66.9	(107.5)	33.1	50.0	46	1025
302	302	319	66.3	(107.0)	32.1	49.3	45	1005
293	293	309	65.7	(106.0)	30.9	48.3	43	970
285	285	301	65.3	(105.5)	29.9	47.6	–	950
277	277	292	64.6	(104.5)	28.8	46.7	41	925
269	269	284	64.1	(104.0)	27.6	45.9	40	895
262	262	276	63.6	(103.0)	26.6	45.0	39	875
255	255	269	63.0	(102.0)	25.4	44.2	38	850
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
235	235	247	61.4	99.0	21.7	41.4	35	785
229	229	241	60.8	98.2	20.5	40.5	34	765
223	223	234	–	97.3	(18.8)	–	–	–
217	217	228	–	96.4	(17.5)	–	33	725
212	212	222	–	95.5	(16.0)	–	–	705
207	207	218	–	94.6	(15.2)	–	32	690
201	201	212	–	93.8	(13.8)	–	31	675
197	197	207	–	92.8	(12.7)	–	30	655
192	192	202	–	91.9	(11.5)	–	29	640
187	187	196	–	90.7	(10.0)	–	–	620
183	183	192	–	90.0	(9.0)	–	28	615
179	179	188	–	89.0	(8.0)	–	27	600
174	174	182	–	87.8	(6.4)	–	–	585
170	170	178	–	86.8	(5.4)	–	26	570
167	167	175	–	86.0	(4.4)	–	–	560
163	163	171	–	85.0	(3.3)	–	25	545
156	156	163	–	82.9	(0.9)	–	–	525
149	149	156	–	80.8	–	–	23	505
143	143	150	–	78.7	–	–	22	490
137	137	143	–	76.4	–	–	21	460
131	131	137	–	74.0	–	–	–	450
126	126	132	–	72.0	–	–	20	435
121	121	127	–	69.8	–	–	19	415
116	116	122	–	67.6	–	–	18	400
111	111	117	–	65.7	–	–	15	385

Note :

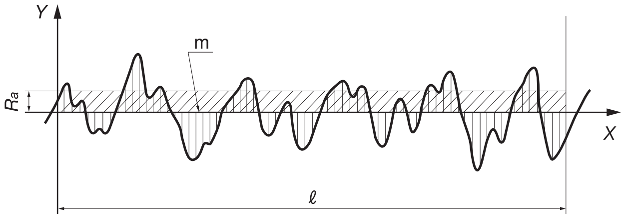
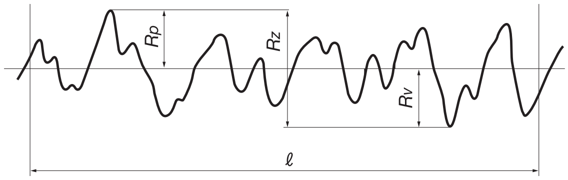
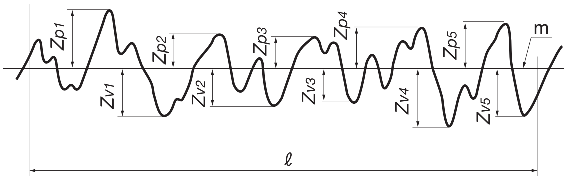
*1: This table is based on AMS Metals Handbook, the 8th Edition, Volume 1, and includes some information added to “Approx. tensile strength (MPa),” such as the values calculated in metric; and Brinell hardness that exceeds recommended values.

*2: 1 MPa = 1 N/mm^2

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

Surface Roughness

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

Type	Symbol	How to determine	Example (Fig.)
Arithmetic mean roughness	*Ra*	*Ra* 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): $Ra=\frac{1}{\ell}\int_0^1\|f(x)\|\mathrm{d}x$ where, ℓ : reference length	
Maximum height	*Rz*	*Rz* 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). $Rz=Rp+Rv$	
Ten point mean roughness	*RzJIS*	*RzJIS* 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 (*Zp*) and the depths of five deepest profile valleys (*Zv*) measured in the vertical magnification direction from the mean line of this sampled portion and this sum is expressed in micrometer (µm) $Rz_{JIS}=\frac{\|Zp1+Zp2+Zp3+Zp4+Zp5\|+\|Zv1+Zv2+Zv3+Zv4+Zv5\|}{5}$	 where, $Zp1, Zp2, Zp3, Zp4, Zp5$: altitudes of the heights of five highest profile peaks of the sampled portion corresponding to the reference length ℓ where, $Zv1, Zv2, Zv3, Zv4, Zv5$: altitudes of the depths of five deepest profile valleys of the sampled portion corresponding to the reference length ℓ