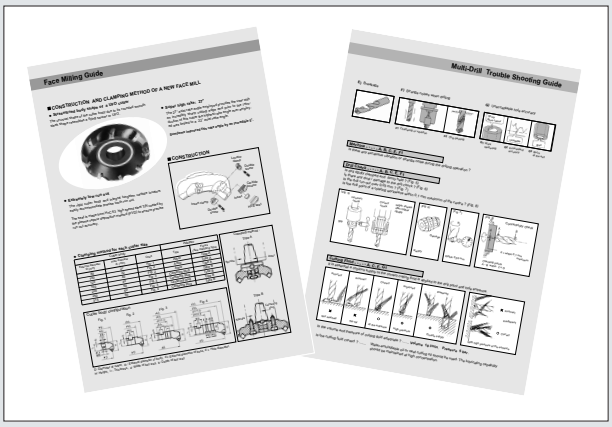
Problem and Remedies / References

N

N9 ~ N16



Trouble Shooting

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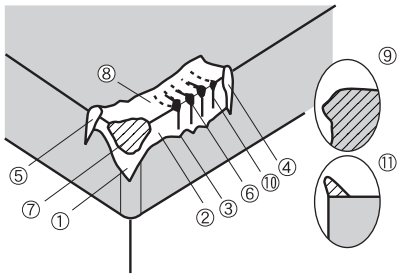
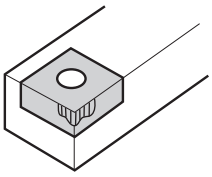
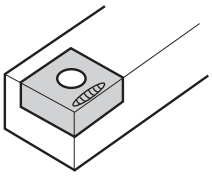
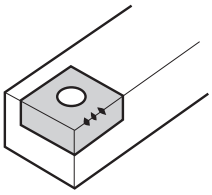
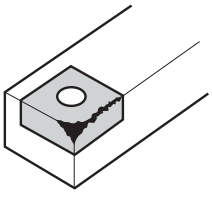
Problem and Remedies

■ Form of Tool Failures



No.	Failure	Cause	
1~5	Flank Wear	Physical	Due to the scratching effect of hard grains contained within the work material.
6	Chipping		Fine breakages caused by high pressure cutting, chatter and vibration, etc.
7	Partial Fracture		Due to mechanical impact when an excessive force is applied to the cutting edge.
8	Crater Wear	Chemical	Due to a combination of galling and welding between the chips and the top rake.
9	Plastic Deformation		The cutting edge is deformed due to its softening at high temperature.
10	Thermal Crack		Thermal fatigue from the heating and cooling cycle during interrupted cutting
11	Built-up Edge		The deposition and adhesion of the hardened work material on the cutting edge.

■ Trouble Shooting Guide for Turning

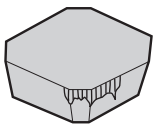
	Failure		Basic Remedies	Remedies Examples
Cutting Edge Failure	Excessive Flank Wear 	Tool Material	- Select a more wear resistant grade.	- Recommended insert grades Steel: Finishing: T2000Z (Coated Cermet); Roughing: AC700G (Coated Carbide) Cast Iron: Finishing: BN700 (SumiBoron); Roughing: AC410K (Coated Carbide)
		Cutting Conditions	- Reduce cutting speeds.	
		Tool Design	- Select a large rake angle.	
	Excessive Crater Wear 	Tool Material	- Select a creater wear resistant grade.	- Recommended insert grades Steel: Finishing: T3000Z (Coated Cermet); Roughing: AC700G (Coated Carbide) Cast Iron: Finishing: BN700 (SumiBoron); Roughing: AC410K (Coated Carbide)
		Cutting Conditions	- Decrease cutting speeds. Reduce depth-of cut and feed rate.	
		Tool Design	- Select a large rake angle. - Select an appropriate chipbreaker.	
	Cutting Edge Chipping 	Tool Material	- Select a tougher grade. P10 ⇨ P20 ⇨ P30 K01 ⇨ K10 ⇨ K20 - If built-up-edge is the cause, select a less susceptible grade (Cermet).	- Recommended insert grades Steel: Finishing: T3000Z (Coated Cermet); Roughing: AC830P (Coated Carbide) Cast Iron: Finishing: AC410K (Coated Carbide); Roughing: AC700G (Coated Carbide)
		Cutting Conditions	- If increase cutting speeds. (If the cause is build-up edge)	
		Tool Design	- Select a smaller rake angle.	
	Cutting Edge Fracture 	Tool Material	- Select a tougher grade. P10 ⇨ P20 ⇨ P30 K01 ⇨ K10 ⇨ K20	- Recommended insert grades Steel: Roughing: AC830P (Coated Carbide) Cast Iron: Roughing: AC820P (Coated Carbide) - Insert: to use MX type chipbreaker.
		Cutting Conditions	- Reduce depth-of-cut and feed rate. - Select a strong cutting edged chipbreaker. - Use a holder with a larger approach angle.	
		Tool Design	- Use a large shank tool holder.	
	Built-Up Edge	Tool Material	- Select an adhesion resistant.	- Recommended insert grade: T2000Z (Coated Cermet).
		Cutting Conditions	- Increase cutting speeds and feed rates. - Select a higher heat resistant grade.	
	Plastic Deformation	Tool Material	- Select a higher heat resistant grade.	- Recommended insert grade: AC700G (Coated Carbide).
		Cutting Conditions	- Increase cutting speeds and feed rates. - Select a higher heat resistant grade.	

Problem and Remedies

■ Trouble Shooting Guide for Milling

Cutting Edge Failure

Excessive Flank Wear

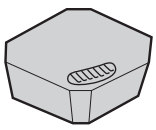


Basic Remedies	
Tool Material	- Select a move wear resistant grade. Carbide (P30 ⇨ P20 / K20 ⇨ K10) ⇨ { Coated / Cermet
Cutting Conditions	- Reduce cutting speeds. - Increase feedrate.

- Recommended insert grades

	Steel	Cast Iron	Non-Ferrous Alloy
Finishing	T250A (Cermet)	ACK200 (Coated Carbide) BN700 (SumiBoron)	DA2200 (SumiDia)
Roughing	ACP100 (Coated Carbide)	ACK200 (Coated Carbide)	DL1000 (Coated Carbide)

Excessive Crater Wear

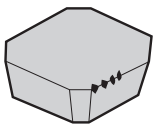


Basic Remedies	
Tool Material	- Select crater wear resistant grade.
Cutting Conditions	- Reduce cutting speeds. - Reduce depth-of-cut and feedrate.

- Recommended insert grades

	Steel	Cast Iron	Non-Ferrous Alloy
Finishing	T250A (Cermet)	ACK200 (Coated Carbide)	DA2200 (SumiDia)
Roughing	ACP100 (Coated Carbide)	ACK200 (Coated Carbide)	DL1000 (Coated Carbide)

Cutting Edge Chipping



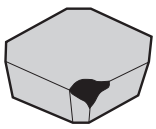
Basic Remedies	
Tool Material	- Select tougher grade. Carbide P10 ⇨ P20 ⇨ P30 K01 ⇨ K10 ⇨ K20
Cutting Conditions	- Reduce feed rates.
Tool Design	- Select a negative-positive cutter configuration with a large approach angle. - Reinforce the cutting edge (Honing).

- Recommended insert grades

	Steel	Cast Iron
Finishing	ACP200 (Coated carbide)	ACK200 (Coated carbide) EH20 (Uncoated carbide)
Roughing	ACP300 (Coated carbide)	ACK300 (Coated carbide)

- Recommended cutter: WaveMill WGC type
- Cutting conditions: refer to recommended conditions listed in the general catalogue

Partial Fracture of Cutting Edges



Basic Remedies	
Tool Material	- If it is due to excessive low speeds or very low feed rates, select an adhesion resistant grade. - If it is due to thermal cracking, select a thermal impact resistant grade.
Cutting Conditions	- Select appropopriate conditions with regards to the particular application.
Tool Design	- Select a negative-positive (or negative) cutter configuration with a large approach angle. - Reinforce the cutting (Honing) - Increase insert size- (Thickness in particular).

- Recommended insert grades

	Steel	Cast Iron
Roughing	ACP300 (Coated Carbide)	ACK300 (Coated Carbide)

- Recommended cutter: WaveMill WGC type
- Insert thickness: 3,18 → 4,76mm
- Insert type: Standard → Strong edge type
- Cutting conditions: Refer to recommended conditions listed in the general catalogue

Others

Unsatisfactory Surface Finish

Basic Remedies	
Tool Material	- Select an adhesion resistant grade. Carbide ⇨ Cermet
Cutting Conditions	- Increase cutting speeds.
Tool Design	- Improve axial run-out of cutting edges. (Use a cutter with less run-out) (Attach correct inserts) - Use wiper inserts. - Use special purpose cutters designed for finishing..

- Recommended insert grades

		Steel	Cast Iron	Non-Ferrous Alloy
Roughing	Cutter Insert	WGC* type T1200A (Cermet)	WGC(F)* type T250A (Cermet)	RF type* H1 (Carbide) DL1000 (Coated Carbide)
Finishing	Cutter Insert	WGC* type T1200A (Cermet)	FMU type BN700 (SumiBoron)	RF type DA2200 (SumiDia)

* marked cutters can be fitted with wiper inserts.

Chattering

Basic Remedies	
Cutting Conditions Tool Design Others	- Reduce number of teeth. - Select a high rake cutter with sharp cutting edges - Use an irregular pitched cutter. - Improve workpiece and cutter clamp rigidity.

- Recommended cutters:

For steel: WaveMill WGC type
For cast iron: Face Mill WGC(F) type
For Non-ferrous alloy: RF type high speed cutter for aluminium

Unsatisfactory Chip Control

Basic Remedies	
Tool Design	- Select cutter with good chip removal features. - Reduce number of teeth. - Enlarge chip pocket.

- Recommended cutter: WaveMill WGC type

Edge Chipping on Workpiece

Basic Remedies	
Tool Design Cutting Conditions	- Select a large approach angle. - Reduce feed rate.

- Recommended cutter: WaveMill WGC type

Burr on Workpiece

Basic Remedies	
Tool Design Cutting Conditions	- Select a cutter with sharp cutting edges. - Increase feed rates.

- Recommended cutter: WaveMill WGC type

Problem and Remedies

■ Trouble Shooting Guide for Endmilling

Failure		Basic Remedies		Remedies Examples
Cutting Edge Failure	Excessive Wear on Periphery and Cutting Edge Corner	Tool Material	- Select a more wear resistant grade.	- Uncoated type ⇨ Coated type, eg. GS MILL.
		Cutting Conditions	- Reduce cutting speeds. Increase feed rates. - Check the cutting fluid use.	- Cutting fluid: Water soluble ⇨ Oil based
	Chipping on Cutting Edge	Cutting Conditions	- Reduce feed rates. - Use Down-cut milling. - Reduce depth-of-cut.	- Refer to recommended cutting conditions listed in the general catalogue.
		Machine and Others	- Remove backlash on machine. - Ensure strong workpiece clamping. - Improve tool clamp rigidity. - Reduce tool overhang.	- Check for damage on the collet and run-out precision
	Tool Breakage During Machining	Cutting Conditions	- Increase cutting speeds. - Reduce feed rates. - Reduce depth-of-cut. - Reduce tool overhang.	- Use an arbor speed inducer if spindle speed is too slow
		Tool Design	- Shorten the length of cut.	- Check for damage on the collet and run-out precision
Unsatisfactory Surface Finish	Unsatisfactory Surface Finish: - Surface Roughness - Surface Waviness - Squareness	Tool Material	- Select a grade with high Young's Modulus. - Select an adhesion resistant grade.	
		Cutting Conditions	- Reduce feed rates. - Reduce the depth-of-cut. - Use Down-cut milling.	- Use high helix type endmills, eg. HSM type
		Tool Design	- Select a large helix angle. - Increase the number of flutes. - Shorten the length of cut.	- 4 teeth ⇨ 2 teeth eg. SSM2000/ZX type change to SSM4000/ZX type or GLM40000SF type
		Others	- Prevent build-up on the cutting edge.	-For Aluminium endmilling, select ASM-DL type or
	Chattering	Cutting Conditions	- Reduce cutting speeds. - Use Down-cut milling. - Use cutting fluid.	
		Tool Design	- Improve workpiece and tool clamp rigidity.	- Check clearances between the spindle chuck and collet. - Check clearances between the collet and endmill.
Others	Packing of Chip	Tool Material	- Reduce feed rates. - Reduce depth-of-cut.	
		Cutting Conditions	- Reduce the number of flutes. - Improve chip evacuation capabilities.	- 4 teeth ⇨ 2 teeth - Use good chip evacuation type endmills, eg. UP MILL or GS MILL
		Tool Design	- Increase the amount of cutting fluid.	

Problem and Remedies

■ Trouble Shooting Guidefor Drilling

Failure		Basic Remedies		Remedies Examples
Drill Failures	Excessive Wear of the Cutting Edge	Cutting Conditions Cutting Fluid	- Use higher cutting speed range. - Increase feed rates. - Increase pressure if useing internal coolant. - Use cutting fluid with more lubricity.	- Vc=80~100m/min - Refer to recommended cutting conditions listed in the general catalogue. - Below 1,5MPa.
	Chisel point Chipping	Tool Design Cutting Conditions Others	- Increase size of chisel width. - Increase amount of honing on cutting edge. - Reduce feed rate at entry phase. - Improve workpiece clamping rigidity.	 - f=0,05~0,1mm/rev .
	Chipping on Peripheral Cutting Edge	Tool Design Cutting Conditions Cutting Fluid Others	- Increase amount of edge honing. - Reduce margin width. - Reduce cutting speeds. - Increase feed rates. - Use cutting fluid with more lubricity. - Improve workpiece clamp rigidity.	 - Reffer to recommended cutting conditions listed in the general catalogue.
	Margin Wear	Tool Design Cutting Conditions Cutting Fluid Others	- Increase amount of back taper. - Reduce margin width. - Reduce cutting speeds. - Increase feed rates. - Use cutting fluid with more lubricity. - Improve workpiece clamp rigidity.	 - Refer to recommended cutting conditions listed in the general catalogue.
	Drill Breakage	Tool Design Cutting Conditions Cutting Fluid Others	- Increase amount of back taper. - Reduce margin width. - Reduce cutting speeds. - Increase feed rates. - Use cutting fluid with more lubricity. - Improve workpiece clamp rigidity.	 - Refer to recommended cutting conditions listed in the general catalogue.
Unsatisfactory Surface Finish	Oversized Holes	Tool Design Cutting Conditions Cutting Fluid Others	- Improve overall dril rigidity. (large web, small flute). - Reduce drill point angle. - Reduce feed rate at entry phase. - Reduce cutting speeds. - Improve workpiece clamp rigidity. - Improve drill clamp precision. - Improve drill clamp rigidity.	 - 130°~120° - f=0,05~0,1mm/min. - Refer to recommended cutting conditions listed in the general catalogue. - Drill run-out below 0,02mm
	Poor Surface Finish	Tool Design Cutting Conditions Cutting Fluid	- Increase amount of back taper. - Increase cutting speeds. - Use cutting fluid with more lubricity.	 - Refer to recommended cutting conditions listed in the general catalogue.
	Holes are Not Straight	Tool Design Cutting Conditions Others	- Reduce amount of edge honing. - Reduce feedrates. - Improve workpiece clamp rigidity. - Improve drill clamp precision. - Improve drill clamp ridigity.	 - Refer to recommended cutting conditions listed in the general catalogue. - Drill run-out below 0,02mm
Others	Packing of Chips	Cutting Conditions Cutting Fluid	- Increase cutting speeds. - Increase feed rates. - Reduce pressure if using internal coolant.	- Refer to recommended cutting conditions listed in the general catalogue. - Below 1,5MPa.
	Long Stringy Chips	Tool Design Cutting Conditions Cutting Fluid	- Reduce amount of edge honing. - Increase feed rates. - Reduce pressure if using internal coolant.	 - Refer to recommended cutting conditions listed in the general catalogue. - Below 1,5MPa.

Reference

■ Steel and Non-Ferrous Metal Symbols Chart

● Carbon Steels

JIS	AISI	DIN
S10C	1010	C10
S15C	1015	C15
S20C	1020	C22
S25C	1025	C25
S30C	1030	C30
S35C	1035	C35
S40C	1040	C40
S45C	1045	C45
S50C	1049	C50
S55C	1055	C55

● Ni-Cr-Mo Steels

SNCM220	8620	21NiCrMo2
SNCM240	8640	—
SNCM415	—	—
SNCM420	4320	—
SNCM439	4340	40NiCrMo6
SNCM447	—	34NiCrMo6

● Cr Steels

SCr415	—	15CrMo5
SCr420	—	20Cr4
SCr430	5130	34Cr4
SCr435	5135	37Cr4
SCr440	5140	42Cr4
SCr445	5147	—

● Cr-Mo Steels

SCM415	—	15CrMo5
SCM420	—	20CrMo5
SCM430	4130	25CrMo4
SCM435	4135	34CrMo4
SCM440	4140	42CrMo4
SCM445	4145	—

● Mn Steels and Mn-Cr Steels for Structural Use

SMn420	1522	—
SMn433	1536	—
SMn438	1541	—
SMn443	1541	—
SMnC420	—	—
SMnC443	—	—

● Cr-Mo Steels

SK1	W1-13	—
SK2	W1-11 1/2	—
SK3	W1-10	C105W1
SK4	W1-9	—
SK5	W1-8	C80W1
SK6	W1-7	C80W1
SK7	—	C70W2

● High Speed Steels

JIS	AISI	DIN
SKH2	T1	—
SKH3	T4	—
SKH10	T15	—
SKH51	M2	S6-5-2
SKH52	M3–1	—
SKH53	M3–2	S6-5-3
SKH54	M4	—
SKH56	M36	—

● Alloy Tool Steels

SKS11	F2	—
SKS51	L6	—
SKS43	W2-9 1/2	—
SKD1	D3	X210Cr12
SKD11	D2	X155CrVMo12-1
SKD61	—	X40CrVMo5-1

● Grey Cast Iron

FC100	20	GG-10
FC150	25	GG-15
FC200	30	GG-20
FC250	35	GG-25
FC300	40	GG-30
FC350	50	GG-35

● Nodular Cast Iron

FCD400	—	GGG-40
FCD450	60/40/ 8	GGG-40.3
FCD500	65/45/12	GGG-50
FCD600	80/55/06	GGG-60
FCD700	100/70/03	GGG-70

● Ferritic Stainless Steels

SUS405	AISI 405	DINX6CrAl13
SUS429	AISI 429	
SUS430	AISI 430	DINX6Cr17
SUS430F	AISI 430F	DINX12CrMoS17
SUS434	AISI 434	

● Martensitic Stainless Steels

SUS403	AISI 403	
SUS410	AISI 410	DINX10Cr13
SUS416	AISI 416	
SUS420JI	AISI 420	DINX20Cr13
SUS420F	AISI 420F	
SUS431	AISI 431	DINX20CrNi172
SUS440A	AISI 440A	
SUS440B	AISI 440B	
SUS440C	AISI 440C	

● Austenitic Stainless Steels

JIS	AISI	DIN
SUS201	AISI 201	
SUS202	AISI 202	
SUS301	AISI 301	
SUS302	AISI 302	
SUS302B	AISI 302B	
SUS303	AISI 303	DINX10CrNiS189
SUS303Se	AISI 303Se	
SUS304	AISI 304	DINX5CrNi1810
SUS304L	AISI 304L	DINX2CrNi1911
SUS304NI	AISI 304N	
SUS305	AISI 305	DINX5CrNi1812
SUS308	AISI 308	
SUS309S	AISI 309S	
SUS310S	AISI 310S	
SUS316	AISI 316	DINX5CrNiMo17122
SUS316L	AISI 316L	DINX2CrNiMo17132
SUS316N	AISI 316N	
SUS317	AISI 317	DINX2CrNiMo18164
SUS317L	AISI 317L	
SUS321	AISI 321	
SUS347	AISI 347	DINX6CrNiNb1810
SUS384	AISI 384	

● Heat Resisting Steels

SUH31		
SUH35		
SUH36		
SUH37		
SUH38		
SUH309	AISI 309	
SUH310	AISI 310	DINCrNi2520
SUH330	AISI 330	

● Ferritic Heat Resisting Steels

SUH21		DINCrAl1205
SUH409	AISI 409	DINX6CrTi12
SUH446	AISI 446	

● Martensitic Heat Resisting Steels

SUH1		
SUH3		
SUH4		
SUH11		
SUH600		

Reference

■ Hardness Scale Comparision Chart

Brinell Hardness (HB) 3.000kgf	Rockwell Hardness "A" Scale 60kgf (Brale)	"B" Scale 100kgf (1/10" Ball)	"C" Scale 150kgf (Brale)	"D" Scale 100kgf (Brale)	Vickers Hardness 50kgf	Shore Hardness	Traverse Rupture Strength (kg/mm²)
—	85,6	—	68,0	76,9	940	97	—
—	85,3	—	67,5	76,5	920	96	—
—	85,0	—	67,0	76,1	900	95	—
767	84,7	—	66,4	75,7	880	93	—
757	84,.4	—	65,9	75,3	860	92	—
745	84,1	—	65,3	74,8	840	91	—
733	83,8	—	64,7	74,3	820	90	—
722	83,4	—	64,0	73,8	800	88	—
712	—	—	—	—	—	—	—
710	83,0	—	63,3	73,3	780	87	—
698	82,6	—	62,5	72,6	760	86	—
684	82,2	—	61,8	72,1	740	—	—
682	82,2	—	61,7	72,0	737	84	—
670	81,8	—	61,0	71,5	720	83	—
656	81,3	—	60,1	70,8	700	—	—
653	81,2	—	60,0	70,7	697	81	—
647	81,1	—	59,7	70,5	690	—	—
638	80,8	—	59,2	70,1	680	80	—
630	80,6	—	58,8	69,8	670	—	—
627	80,5	—	58,7	69,7	667	79	—
601	79,8	—	57,3	68,7	640	77	—
578	79,1	—	56,0	67,7	615	75	—
555	78,4	—	54,7	66,7	591	73	210
534	77,8	—	53,5	65,8	569	71	202
514	76,9	—	52,1	64,7	547	70	193
495	76,3	—	51,0	63,8	528	68	186
477	75,6	—	49,6	62,7	508	66	177
461	74,9	—	48,5	61,7	491	65	170
444	74,2	—	47,1	60,8	472	63	162
429	73,4	—	45,7	59,7	455	61	154
415	72,8	—	44,5	58,8	440	59	149
401	72,0	—	43,1	57,8	425	58	142
388	71,4	—	41,8	56,8	410	56	136
375	70,6	—	40,4	55,7	396	54	129
363	70,0	—	39,1	54,6	383	52	124
352	69,3	(110,0)	37,9	53,8	372	51	120
341	68,7	(109,0)	36,6	52,8	360	50	115
331	68,1	(108,5)	35,5	51,9	350	48	112

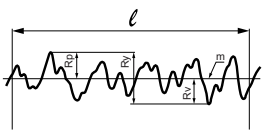
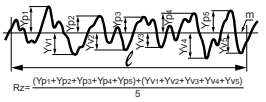
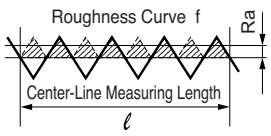
Brinell Hardness (HB) 3.000kgf	Rockwell Hardness "A" Scale 60kgf (Brale)	"B" Scale 100kgf (1/10" Ball)	"C" Scale 150kgf (Brale)	"D" Scale 100kgf (Brale)	Vickers Hardness 50kgf	Shore Hardness	Traverse Rupture Strength (kg/mm²)
321	67,5	(108,0)	34,3	50,1	339	47	108
311	66,9	(107,5)	33,1	50,0	328	46	105
302	66,3	(107,0)	32,1	49,3	319	45	103
293	65,7	(106,0)	30,9	48,3	309	43	99
285	65,3	(105,5)	29,9	47,6	301	—	97
277	64,6	(104,5)	28,8	46,7	292	41	94
269	64,1	(104,0)	27,6	45,9	284	40	91
262	63,6	(103,0)	26,6	45,0	276	39	89
255	63,0	(102,0)	25,4	44,2	269	38	86
248	62,5	(101,0)	24,2	43,2	261	37	84
241	61,8	100,0	22,8	42,0	253	36	82
235	61,4	99,0	21,7	41,4	247	35	80
229	60,8	98,2	20,5	40,5	241	34	78
223	—	97,3	(18,8)	—	234	—	—
217	—	96,4	(17,5)	—	228	33	74
212	—	95,5	(16,0)	—	222	—	72
207	—	94,6	(15,2)	—	218	32	70
201	—	93,8	(13,8)	—	212	31	69
197	—	92,8	(12,7)	—	207	30	67
192	—	91,9	(11,5)	—	202	29	65
187	—	90,7	(10,0)	—	196	—	63
183	—	90,0	(9,0)	—	192	28	63
179	—	89,0	(8,0)	—	188	27	61
174	—	87,8	(6,4)	—	182	—	60
170	—	86,8	(5,4)	—	178	26	58
167	—	86,0	(4,4)	—	175	—	57
163	—	85,0	(3,3)	—	171	25	56
156	—	82,9	(0,9)	—	163	—	53
149	—	80,8	—	—	156	23	51
143	—	78,7	—	—	150	22	50
137	—	76,4	—	—	143	21	47
131	—	74,0	—	—	137	—	46
126	—	72,0	—	—	132	20	44
121	—	69,8	—	—	127	19	42
116	—	67,6	—	—	122	18	41
111	—	65,7	—	—	117	15	39

1) Figures within the ( ) are not commonly used
2) Rockwell A, C and D scales utilises a diamond brale

Reference

■ Finished Surface Roughness

● Types of Surface Roughness Measurements

Types	Symbol	Method of Determination	Descriptive Figure
Maximum Height	※1) Rz	This is the value (expressed in μm) measured from the deepest valley to the highest peak of the reference line, ℓ, extracted from the profile. (Disregard unusually high peaks and deep valleys as they are considered as flaws.)	
Ten-point Mean Roughness	※2) Rz_{JIS}	From the profile, extract a portion to be the reference line, ℓ. Select the 5 highest peak and 5 deepest valleys. Measure the distance between the two lines and express it in μm. (1 μm = 0,001mm)	
Calculated Roughness	Ra	This method is to obtain a center line between the peaks and valleys within the reference line, ℓ. Fold along the center line to superimpose the valleys against the peaks. (Shaded portions with dashed outline on the right figure). Take the total shaded area and divided it by ℓ in μm.	

Designated values of the above types of surface roughness, standard reference length values and the triangular symbol classifications are shown on the table on the right.

※1) Rz : According to new **JIS B 0601**:2001 (Old symbol: Ry)
※2) Rz_{JIS} : According to new **JIS B 0601**:2001 (Old symbol: Rz)

Designated values for ※1) Rz	Designated values for ※2) Rz_{JIS}	Designated values for Ra	Standard reference length values ℓ (mm)	Triangular Symbols
(0,05S) 0,1S 0,2S 0,4S	(0,05Z) 0,1Z 0,2Z 0,4Z	(0,013a) 0,025a 0,05a 0,10a	—	▽▽▽▽
0,8S	0,8Z	0,20a	0,25	
1,6S 3,2S 6,3S	1,6Z 3,2Z 6,3Z	0,40a 0,80a 1.,6a	0,8	▽▽▽
12,5S (18S) 25S	12,5Z (18Z) 25Z	3,2a 6,3a	2,5	▽▽
(35S) 50S (70S) 100S	(35Z) 50Z (70Z) 100Z	12,5a 25a	—	▽
(140S) 200S (280S) 400S (560S)	(140Z) 200Z (280Z) 400Z (560Z)	(50a) (100a)	—	—

Remarks: The designated values in the brackets do not apply unless otherwise stated.