Tungsten Carbide End Mills
UNIMAX Series

Published April 2025

2 Flute Long Neck Ball End Mills

HGLB
HMG COAT

Most effective for hard materials over 60HRC

Add

HWLB
HMW COAT

For hard materials from 40HRC to over 60HRC

new

HWLB-S

Short shank series of HWLB

CWLB
UTW COAT

Best for soft materials up to 40HRC

UNION TOOL CO.

New Coating Series

New coating that exceeds the conventional tools

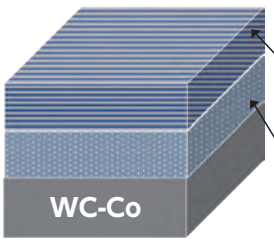
HMG COAT

Suitable for hard materials especially over 65HRC

Developed a hard coating with higher wear resistance than HARDMAX.
Offers longer tool life than conventional tools.

HMW COAT

Upgraded version of HARDMAX coating with improved wear resistance

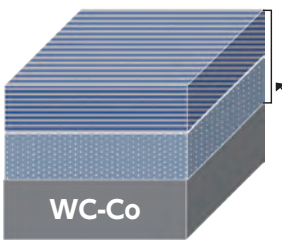


Ultra-high hardness layer
Increased numbers of layers by nano-laminated structure.
Longer tool life due to wear resistance and the suppression of crack propagation.

Shock absorption layer
New nanocomposite structure improves hardness and toughness.

UTW COAT

New coating with the best performance achievable in work materials up to 40HRC



High hardness and high toughness
New nanocomposite structure offers ultra multilayer structure
High toughness and wear resistance provide excellent performance in work materials up to 40HRC

How to find the best series for your material applications

(★ Highly Recommended ● Recommended ○ Suggested)

Model Number		Features	Ball tip design	Copper	Carbon Steels	Prehardened Steels	Hardened Steels				
							~50 HRC	~55 HRC	~60 HRC	~65 HRC	~70 HRC
HGLB		Best suited for Hard Materials	Super Negative 			○	●	●	●	★	★
HWLB		For Hard Materials	Negative 	○	○	●	★	★	★	●	●
CWLB		Multi-purpose Excellent surface quality	Neutral 	●	★	★	●				

HGLB

HMGCOAT 2 Flute Long Neck Ball End Mills for Hard Materials

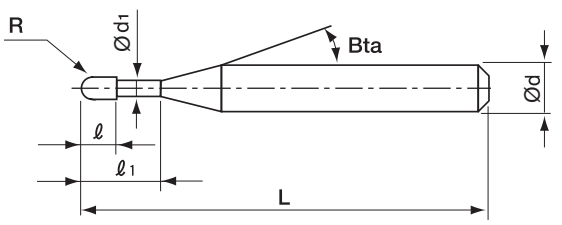
R0.05～R3

Super MG | HMG COAT | Back Taper Geometry

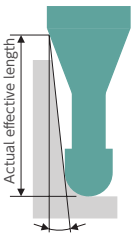
Back taper geometry does not apply to R0.4 or below, ℓ1 / D ≦ 10

Material Applications (★ Highly Recommended ● Recommended ○ Suggested)

Work Material															
CARBON STEELS S45C S55C	ALLOY STEELS SK / SCM SUS	PREHARDENED STEELS NAK HPM	HARDENED STEELS ～50 HRC	～55 HRC	～60 HRC	～65 HRC	～70 HRC	CAST IRON	ALUMINUM ALLOYS	GRAPHITE	COPPER	PLASTICS	GLASS FILLED PLASTICS	TITANIUM ALLOYS	HEAT RESISTANT ALLOYS	CEMENTED CARBIDE	HARD BRITTLE (NON-METALLIC) MATERIALS
		○	●	●	●	★	★										



The shank taper angle shown is not an exact value.



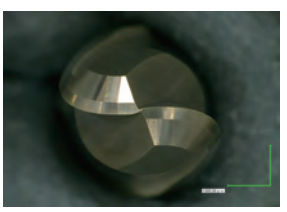
Inclined angle

Tool Design

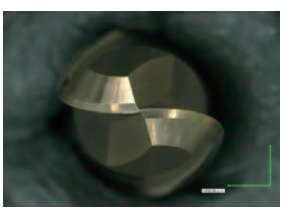
New geometry with higher resistance to chipping

Optimized rake angle and relief angle for milling hard materials of 60HRC or more

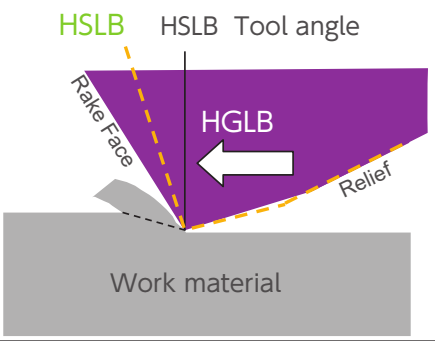
HGLB



HSLB



Tool Angle: HGLB > HSLB



High Precision

HGLB

Unit (mm)

Radius of Ball Nose	Diameter Tolerance	Ball Radius Accuracy	Shank Diameter Tolerance	Helix Angle
R0.05 ～ 0.075	0/-0.008	± 0.002	0/-0.004 (h4)	30°
R0.1 ～ R1.25		± 0.003		
R1.5 ～ R2	0/-0.01			
R2.5 ～ R3		± 0.005		

Spur gear die　Milling example
HGB/HGLB　R0.5 / R1 / R1.5

HAP72(68HRC)

4 Flute / 6 Flute Radius End Mills for Hard Materials

HMERS

Coolant: Air Blow (Through Spindle)

Work size: Ø50.4 x Depth 11 mm

Ball End Mills for Hard Materials

HGB

Long Neck Ball End Mills for Hard Materials

HGLB

Process	Tool	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p (mm)	a_e (mm)	Allowance (mm)	Cycle Time (h:m)	Milling Method
Roughing	HGB R1.5	8,280	1,140	0.12	0.55	0.02	1:40	Roughing
Semi-Finishing	HGLB R1 × EL6	12,250	1,800	0.06	0.3	0.02	0:11	Rest machining
Semi-Finishing			1,800	0.06	0.05	0.005	0:50	Semi-Finishing
Finishing			900	0.00015 Cusp Height	—	0	0:09	45° surface / Finishing
Finishing	HMERS Ø 3 × CR0.1	8,600	465 1,500	2	1	0	0:02	Above the gear teeth / Finishing
Finishing			465 1,500	0.0002 Cusp Height	1	0	0:01	Bottom surface of cylindrical part / Finishing
Finishing	HGLB R0.5 × EL6	20,000	800	0.00015 Cusp Height	—	0	0:55	Gear wall / Finishing
Finishing			800	0.005	0.02	0	1:37	Gear bottom/ Finishing

Total　5:25

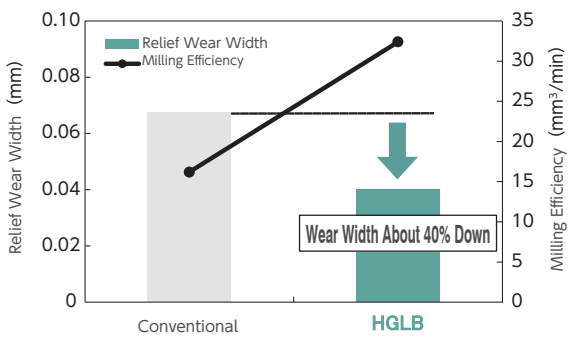
Wear comparison　Milling example
HGLB　R1×EL6

HAP72(68HRC)

Tools after milling

Conventional

HGLB



HGLB mills twice as efficient as the conventional tool.

Tool	Conventional	HGLB 2020-060
Spindle Speed	9,200 min^{-1}	12,250 min^{-1}
Feed Rate	900 mm/min	1,800 mm/min
a_p Axial Depth	0.06 mm	
a_e Radial Depth	0.3 mm	
Coolant	Air Blow (Through-Spindle)	
Milling Shape	Square Pocket (20 x 15 x Depth 2 mm) × 2 Pockets	
Cycle Time	76 min	50 min

Milling Efficiency (mm^3/min) = Feed Rate × a_p × a_e

Finishing process comparison of HWLB and HGLB
HWLB / HGLB　R0.5 × EL10

STAVAX (52HRC)

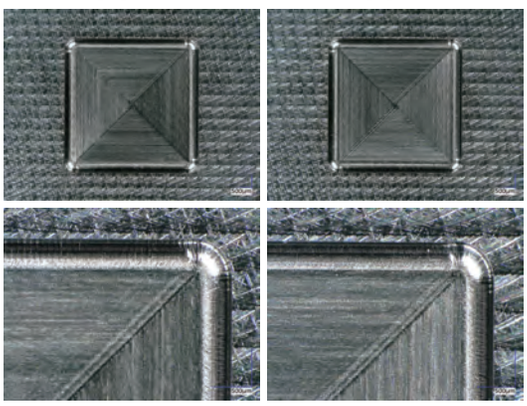
· Pocket Size
6 × 6 × D0.2 mm

· Coolant : Oil Mist

Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Cycle Time (min)
22,000	600	0.01	0.01	180

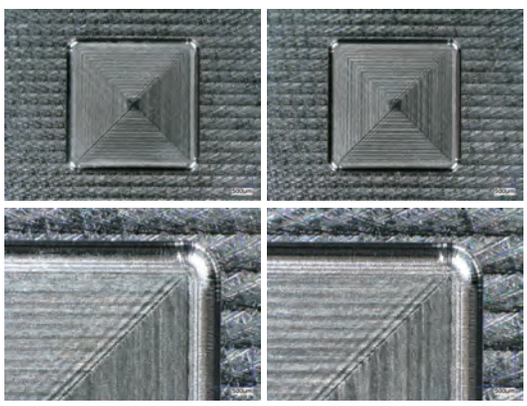
HWLB

1 pocket 90min　　2 pockets 180min



HGLB

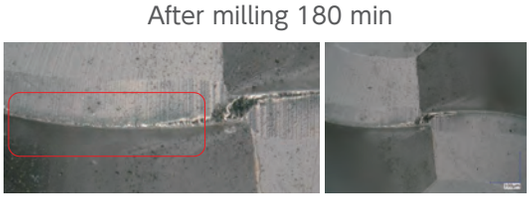
1 pocket 90min　　2 pockets 180min



Surface finish on STAVAX with the HWLB is smoother than that of the HGLB.

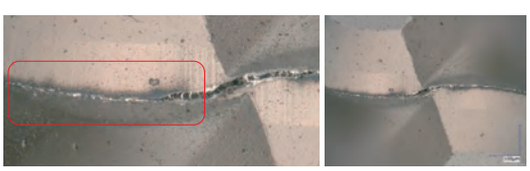
HWLB

After milling 180 min



HGLB

After milling 180 min



Wearing at the tip is similar, however, the HWLB has less wear on the radius part.

The HWLB is recommended for STAVAX milling as opposed to the HGLB.

(★ Highly Recommended ● Recommended ○ Suggested)

Model Number			Features	Ball tip design	Copper	Carbon Steels	Prehardened Steels	Hardened Steels ~50 HRC	~55 HRC	~60 HRC	~65 HRC	~70 HRC	Page
HMG COAT	HGLB		Best suited for Hard Materials	Super Negative			○	●	●	●	★	★	3
HMW COAT	HWLB		For Hard Materials	Negative	○	○	●	★	★	★	●	●	14
UTW COAT	CWLB		Multi-purpose Excellent surface quality	Neutral	●	★	★	●					31

Total 155 models

Unit (mm)

Model Number	Radius of Ball Nose R	Effective Length ℓ_1	Length of Cut ℓ	Neck Diameter $\varnothing d_1$	Shank Taper Angle Bta	Overall Length L	Shank Diameter $\varnothing d$	Series	Effective Length by Inclined Angles				
									30′	1°	1°30′	2°	3°
HGLB 2001-002	**R0.05**	0.2	0.08	0.095	16°	45	4	HGLB	0.22	0.24	0.26	0.28	0.31
HGLB 2001-003		0.3				45	4	HGLB	0.33	0.36	0.38	0.40	0.44
HGLB 2001-005		0.5				45	4	HGLB	0.55	0.58	0.61	0.64	0.68
HGLB 20015-003	**R0.075**	0.3	0.12	0.14	16°	45	4	HGLB	0.35	0.37	0.39	0.41	0.44
HGLB 20015-005		0.5				45	4	HGLB	0.56	0.59	0.62	0.64	0.69
HGLB 20015-0075		0.75				45	4	HGLB	0.83	0.86	0.90	0.93	1.00
HGLB 20015-010		1				45	4	HGLB	1.09	1.13	1.17	1.21	1.30
HGLB 2002-003	**R0.1**	0.3	0.16	0.19	16°	45	4	HGLB	0.42	0.44	0.46	0.48	0.52
HGLB 2002-005		0.5				45	4	HGLB	0.63	0.66	0.68	0.71	0.76
HGLB 2002-0075		0.75				45	4	HGLB	0.89	0.93	0.96	0.99	1.07
HGLB 2002-010		1				45	4	HGLB	1.15	1.20	1.24	1.28	1.37
HGLB 2002-015		1.5				45	4	HGLB	1.66	1.72	1.78	1.84	1.97
HGLB 2002-020		2				45	4	HGLB	2.18	2.25	2.33	2.41	2.58
HGLB 2003-005	**R0.15**	0.5	0.24	0.29	16°	45	4	HGLB	0.63	0.65	0.68	0.70	0.75
HGLB 2003-0075		0.75				45	4	HGLB	0.89	0.92	0.96	0.99	1.05
HGLB 2003-010		1				45	4	HGLB	1.15	1.19	1.23	1.27	1.36
HGLB 2003-015		1.5				45	4	HGLB	1.66	1.72	1.77	1.83	1.96
HGLB 2003-020		2				45	4	HGLB	2.18	2.25	2.32	2.40	2.57
HGLB 2003-025		2.5				45	4	HGLB	2.70	2.78	2.87	2.97	3.18
HGLB 2003-030		3				45	4	HGLB	3.21	3.32	3.42	3.54	3.80
HGLB 2004-005	**R0.2**	0.5	0.32	0.39	16°	45	4	HGLB	0.63	0.65	0.67	0.70	0.74
HGLB 2004-0075		0.75				45	4	HGLB	0.89	0.92	0.95	0.98	1.04
HGLB 2004-010		1				45	4	HGLB	1.15	1.19	1.23	1.26	1.35
HGLB 2004-010-6		1				50	6	HGLB	1.15	1.19	1.23	1.26	1.35
HGLB 2004-0125		1.25				45	4	HGLB	1.40	1.45	1.49	1.54	1.64
HGLB 2004-015		1.5				45	4	HGLB	1.66	1.71	1.77	1.82	1.95
HGLB 2004-015-6		1.5				50	6	HGLB	1.66	1.71	1.77	1.82	1.95
HGLB 2004-020		2				45	4	HGLB	2.18	2.25	2.32	2.39	2.56
HGLB 2004-020-6		2				50	6	HGLB	2.18	2.25	2.32	2.39	2.56
HGLB 2004-025		2.5				45	4	HGLB	2.70	2.78	2.87	2.96	3.17
HGLB 2004-025-6		2.5				50	6	HGLB	2.70	2.78	2.87	2.96	3.17
HGLB 2004-030		3				45	4	HGLB	3.21	3.31	3.42	3.53	3.79
HGLB 2004-030-6		3				50	6	HGLB	3.21	3.31	3.42	3.53	3.79
HGLB 2004-035		3.5				45	4	HGLB	3.73	3.84	3.97	4.10	4.40
HGLB 2004-040		4				45	4	HGLB	4.24	4.38	4.52	4.67	5.01
HGLB 2005-010	**R0.25**	1	0.4	0.49	16°	45	4	HGLB	1.15	1.19	1.22	1.26	1.34
HGLB 2005-015		1.5				45	4	HGLB	1.65	1.71	1.76	1.82	1.94
HGLB 2005-020		2				45	4	HGLB	2.18	2.24	2.31	2.39	2.55
HGLB 2005-025		2.5				45	4	HGLB	2.69	2.78	2.86	2.96	3.16
HGLB 2005-030		3				45	4	HGLB	3.21	3.31	3.41	3.53	3.77
HGLB 2005-035		3.5				45	4	HGLB	3.73	3.84	3.96	4.09	4.39
HGLB 2005-040		4				45	4	HGLB	4.24	4.37	4.51	4.66	5.00
HGLB 2005-045		4.5				45	4	HGLB	4.76	4.91	5.06	5.23	5.61
HGLB 2005-050		5				45	4	HGLB	5.27	5.44	5.61	5.80	6.22
HGLB 2005-060		6				45	4	HGLB	6.30	6.50	6.71	6.94	7.45

Model Number	Radius of Ball Nose R	Effective Length ℓ_1	Length of Cut ℓ	Neck Diameter $\varnothing d_1$	Shank Taper Angle Bta	Overall Length L	Shank Diameter $\varnothing d$	Series	Effective Length by Inclined Angles				
									30′	1°	1°30′	2°	3°
HGLB 2006-010		1				45	4	HGLB	1.14	1.18	1.22	1.25	1.33
HGLB 2006-015		1.5				45	4	HGLB	1.65	1.71	1.76	1.81	1.93
HGLB 2006-015-6		1.5				50	6	HGLB	1.65	1.71	1.76	1.81	1.93
HGLB 2006-020		2				45	4	HGLB	2.17	2.24	2.31	2.38	2.54
HGLB 2006-020-6		2				50	6	HGLB	2.17	2.24	2.31	2.38	2.54
HGLB 2006-025		2.5				45	4	HGLB	2.69	2.77	2.86	2.95	3.15
HGLB 2006-025-6		2.5				50	6	HGLB	2.69	2.77	2.86	2.95	3.15
HGLB 2006-030		3				45	4	HGLB	3.21	3.31	3.41	3.52	3.76
HGLB 2006-030-6	**R0.3**	3	0.48	0.59	16°	50	6	HGLB	3.21	3.31	3.41	3.52	3.76
HGLB 2006-035		3.5				45	4	HGLB	3.72	3.84	3.96	4.09	4.38
HGLB 2006-040		4				45	4	HGLB	4.24	4.37	4.51	4.66	4.99
HGLB 2006-045		4.5				45	4	HGLB	4.76	4.90	5.06	5.23	5.60
HGLB 2006-050		5				45	4	HGLB	5.27	5.44	5.61	5.80	6.21
HGLB 2006-055		5.5				45	4	HGLB	5.79	5.97	6.16	6.37	6.82
HGLB 2006-060		6				45	4	HGLB	6.30	6.50	6.71	6.93	7.43
HGLB 2006-080		8				45	4	HGLB	8.37	8.63	8.91	9.21	9.88
HGLB 2006-100		10				45	4	HGLB	10.43	10.76	11.11	11.49	12.33
HGLB 2008-020		2				45	4	HGLB	2.17	2.23	2.30	2.37	2.52
HGLB 2008-025		2.5				45	4	HGLB	2.69	2.77	2.85	2.94	3.13
HGLB 2008-030		3				45	4	HGLB	3.21	3.30	3.40	3.50	3.74
HGLB 2008-040		4				45	4	HGLB	4.24	4.36	4.50	4.64	4.97
HGLB 2008-050	**R0.4**	5	0.64	0.79	16°	45	4	HGLB	5.27	5.43	5.60	5.78	6.19
HGLB 2008-060		6				45	4	HGLB	6.30	6.49	6.70	6.92	7.41
HGLB 2008-070		7				45	4	HGLB	7.33	7.56	7.80	8.06	8.64
HGLB 2008-080		8				45	4	HGLB	8.36	8.62	8.90	9.20	9.86
HGLB 2010-020		2				45	4	HGLB	2.18	2.24	2.30	2.36	2.51
HGLB 2010-020-6		2				50	6	HGLB	2.18	2.24	2.30	2.36	2.51
HGLB 2010-025		2.5				45	4	HGLB	2.70	2.77	2.85	2.93	3.12
HGLB 2010-030		3				45	4	HGLB	3.21	3.30	3.40	3.50	3.73
HGLB 2010-030-6		3				50	6	HGLB	3.21	3.30	3.40	3.50	3.73
HGLB 2010-040		4				45	4	HGLB	4.24	4.37	4.50	4.64	4.96
HGLB 2010-040-6		4				50	6	HGLB	4.24	4.37	4.50	4.64	4.96
HGLB 2010-050		5				45	4	HGLB	5.28	5.43	5.60	5.78	6.18
HGLB 2010-050-6		5				50	6	HGLB	5.28	5.43	5.60	5.78	6.18
HGLB 2010-060		6				45	4	HGLB	6.31	6.50	6.70	6.92	7.40
HGLB 2010-060-6	**R0.5**	6	0.8	0.98	16°	50	6	HGLB	6.31	6.50	6.70	6.92	7.40
HGLB 2010-070		7				45	4	HGLB	7.34	7.56	7.80	8.06	8.63
HGLB 2010-070-6		7				50	6	HGLB	7.34	7.56	7.80	8.06	8.63
HGLB 2010-080		8				45	4	HGLB	8.37	8.63	8.90	9.20	9.85
HGLB 2010-080-6		8				50	6	HGLB	8.37	8.63	8.90	9.20	9.85
HGLB 2010-100		10				45	4	HGLB	10.43	10.76	11.10	11.47	12.30
HGLB 2010-100-6		10				50	6	HGLB	10.43	10.76	11.10	11.47	12.30
HGLB 2010-120		12				45	4	HGLB	12.50	12.89	13.30	13.75	14.75
HGLB 2010-140		14				45	4	HGLB	14.56	15.02	15.51	16.03	17.19
HGLB 2010-160		16				50	4	HGLB	16.62	17.15	17.71	18.31	19.64

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									30′	1°	1°30′	2°	3°
HGLB 2015-030	**R0.75**	3	1.2	1.47	16°	45	4	HGLB	3.10	3.18	3.26	3.35	3.55
HGLB 2015-030-6		3				50	6	HGLB	3.10	3.18	3.26	3.35	3.55
HGLB 2015-040		4				45	4	HGLB	4.13	4.24	4.36	4.49	4.77
HGLB 2015-060		6				45	4	HGLB	6.19	6.37	6.56	6.76	7.22
HGLB 2015-060-6		6				50	6	HGLB	6.19	6.37	6.56	6.76	7.22
HGLB 2015-080		8				45	4	HGLB	8.25	8.50	8.76	9.04	9.67
HGLB 2015-080-6		8				50	6	HGLB	8.25	8.50	8.76	9.04	9.67
HGLB 2015-100		10				45	4	HGLB	10.32	10.63	10.96	11.32	12.11
HGLB 2015-100-6		10				50	6	HGLB	10.32	10.63	10.96	11.32	12.11
HGLB 2015-120		12				45	4	HGLB	12.38	12.76	13.16	13.60	14.56
HGLB 2015-120-6		12				50	6	HGLB	12.38	12.76	13.16	13.60	14.56
HGLB 2015-140		14				45	4	HGLB	14.44	14.89	15.36	15.87	17.01
HGLB 2015-160		16				50	4	HGLB	16.50	17.02	17.57	18.15	19.46
HGLB 2015-200		20				60	4	HGLB	20.63	21.28	21.97	22.71	24.35
HGLB 2020-030	**R1**	3	1.6	1.98	16°	45	4	HGLB	3.07	3.14	3.21	3.29	3.47
HGLB 2020-030-6		3				50	6	HGLB	3.07	3.14	3.21	3.29	3.47
HGLB 2020-040		4				45	4	HGLB	4.10	4.20	4.31	4.43	4.70
HGLB 2020-040-6		4				50	6	HGLB	4.10	4.20	4.31	4.43	4.70
HGLB 2020-060		6				45	4	HGLB	6.16	6.33	6.51	6.71	7.14
HGLB 2020-060-6		6				50	6	HGLB	6.16	6.33	6.51	6.71	7.14
HGLB 2020-080		8				45	4	HGLB	8.23	8.46	8.72	8.99	9.59
HGLB 2020-080-6		8				50	6	HGLB	8.23	8.46	8.72	8.99	9.59
HGLB 2020-100		10				45	4	HGLB	10.29	10.59	10.92	11.26	12.04
HGLB 2020-100-6		10				50	6	HGLB	10.29	10.59	10.92	11.26	12.04
HGLB 2020-120		12				45	4	HGLB	12.35	12.72	13.12	13.54	14.48
HGLB 2020-120-6		12				50	6	HGLB	12.35	12.72	13.12	13.54	14.48
HGLB 2020-140		14				45	4	HGLB	14.41	14.85	15.32	15.82	16.93
HGLB 2020-160		16				45	4	HGLB	16.48	16.98	17.52	18.10	19.38
HGLB 2020-200		20				60	4	HGLB	20.60	21.24	21.92	22.65	No Interference
HGLB 2020-250		25				60	4	HGLB	25.76	26.56	27.42	28.34	No Interference
HGLB 2020-300		30				70	4	HGLB	30.92	31.89	32.93	No Interference	No Interference
HGLB 2030-060	**R1.5**	6	2.4	2.95	16°	60	6	HGLB	6.20	6.35	6.52	6.69	7.09
HGLB 2030-080		8				60	6	HGLB	8.26	8.48	8.72	8.97	9.54
HGLB 2030-100		10				60	6	HGLB	10.32	10.61	10.92	11.25	11.99
HGLB 2030-120		12				60	6	HGLB	12.38	12.74	13.12	13.53	14.43
HGLB 2030-140		14				60	6	HGLB	14.45	14.87	15.32	15.80	16.88
HGLB 2030-160		16				60	6	HGLB	16.51	17.00	17.52	18.08	19.33
HGLB 2030-180		18				60	6	HGLB	18.57	19.13	19.72	20.36	21.78
HGLB 2030-200		20				70	6	HGLB	20.64	21.26	21.92	22.64	24.22
HGLB 2030-220		22				70	6	HGLB	22.70	23.39	24.12	24.91	26.67
HGLB 2030-250		25				70	6	HGLB	25.79	26.58	27.43	28.33	30.34
HGLB 2030-270		27				70	6	HGLB	27.86	28.71	29.63	30.61	No Interference
HGLB 2030-300		30				70	6	HGLB	30.95	31.91	32.93	34.02	No Interference

Model Number	Radius of Ball Nose R	Effective Length ℓ1	Length of Cut ℓ	Neck Diameter Ød1	Shank Taper Angle Bta	Overall Length L	Shank Diameter Ød	Series	Effective Length by Inclined Angles				
									30′	1°	1°30′	2°	3°
HGLB 2040-080		8				70	6	HGLB	8.24	8.45	8.67	8.90	9.43
HGLB 2040-100		10				70	6	HGLB	10.31	10.58	10.87	11.18	11.88
HGLB 2040-120		12				70	6	HGLB	12.37	12.71	13.07	13.46	14.32
HGLB 2040-140		14				70	6	HGLB	14.43	14.84	15.27	15.74	16.77
HGLB 2040-160		16				70	6	HGLB	16.49	16.97	17.47	18.01	19.22
HGLB 2040-180		18				70	6	HGLB	18.56	19.10	19.67	20.29	No Interference
HGLB 2040-200	**R2**	20	3.2	3.95	16°	70	6	HGLB	20.62	21.23	21.87	22.57	No Interference
HGLB 2040-220		22				70	6	HGLB	22.68	23.36	24.08	24.85	No Interference
HGLB 2040-250		25				70	6	HGLB	25.78	26.55	27.38	28.26	No Interference
HGLB 2040-270		27				70	6	HGLB	27.84	28.68	29.58	30.54	No Interference
HGLB 2040-300		30				70	6	HGLB	30.93	31.87	32.88	No Interference	No Interference
HGLB 2040-350		35				80	6	HGLB	36.09	37.20	38.38	No Interference	No Interference
HGLB 2040-400		40				90	6	HGLB	41.25	42.52	No Interference	No Interference	No Interference
HGLB 2060-100		10				80	6	HGLB	No Interference	No Interference	No Interference	No Interference	No Interference
HGLB 2060-150		15				80	6	HGLB	No Interference	No Interference	No Interference	No Interference	No Interference
HGLB 2060-180		18				80	6	HGLB	No Interference	No Interference	No Interference	No Interference	No Interference
HGLB 2060-200		20				80	6	HGLB	No Interference	No Interference	No Interference	No Interference	No Interference
HGLB 2060-250	**R3**	25	4.8	5.95	—	80	6	HGLB	No Interference	No Interference	No Interference	No Interference	No Interference
HGLB 2060-300		30				80	6	HGLB	No Interference	No Interference	No Interference	No Interference	No Interference
HGLB 2060-350		35				80	6	HGLB	No Interference	No Interference	No Interference	No Interference	No Interference
HGLB 2060-400		40				90	6	HGLB	No Interference	No Interference	No Interference	No Interference	No Interference
HGLB 2060-500		50				120	6	HGLB	No Interference	No Interference	No Interference	No Interference	No Interference

HGLB Milling Conditions

WORK MATERIAL			PREHARDENED STEELS/ HARDENED STEELS NAK / STAVAX (~55HRC)				HARDENED STEELS SKD11 (55~62HRC)				HARDENED STEELS HAP10 (62~66HRC)				HARDENED STEELS HAP72 (66~70HRC)			
Model Number	Radius of Ball Nose (mm)	Effective Length (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)
2001-002	R0.05	0.2	48,000	200	0.005	0.01	48,000	200	0.005	0.01	48,000	150	0.003	0.006	40,000	120	0.002	0.004
2001-003		0.3	48,000	200	0.005	0.01	48,000	200	0.005	0.01	48,000	150	0.003	0.006	40,000	120	0.002	0.004
2001-005		0.5	48,000	200	0.005	0.01	48,000	200	0.005	0.01	48,000	150	0.003	0.006	40,000	120	0.002	0.004
20015-003	R0.075	0.3	48,000	230	0.007	0.014	48,000	230	0.007	0.014	48,000	170	0.005	0.01	40,000	135	0.003	0.006
20015-005		0.5	48,000	230	0.007	0.014	48,000	230	0.007	0.014	48,000	170	0.005	0.01	40,000	135	0.003	0.006
20015-0075		0.75	48,000	230	0.007	0.014	48,000	230	0.007	0.014	48,000	170	0.005	0.01	40,000	135	0.003	0.006
20015-010		1	38,400	160	0.005	0.01	38,400	160	0.005	0.01	38,400	120	0.003	0.007	32,000	90	0.002	0.004
2002-003	R0.1	0.3	44,000	250	0.01	0.03	42,000	250	0.01	0.03	40,000	200	0.008	0.024	36,000	150	0.006	0.018
2002-005		0.5	44,000	250	0.01	0.03	42,000	250	0.01	0.03	40,000	200	0.008	0.024	36,000	150	0.006	0.018
2002-0075		0.75	44,000	250	0.01	0.03	42,000	250	0.01	0.03	40,000	200	0.008	0.024	36,000	150	0.006	0.018
2002-010		1	44,000	250	0.01	0.03	42,000	250	0.01	0.03	40,000	200	0.008	0.024	36,000	150	0.006	0.018
2002-015		1.5	35,200	175	0.008	0.023	33,600	175	0.008	0.023	32,000	140	0.006	0.018	28,800	100	0.004	0.012
2002-020		2	35,200	120	0.003	0.008	33,600	100	0.003	0.008	32,000	90	0.003	0.008	28,800	70	0.002	0.006
2003-005	R0.15	0.5	44,000	400	0.01	0.03	42,000	350	0.01	0.03	40,000	300	0.01	0.03	36,000	250	0.008	0.024
2003-0075		0.75	44,000	400	0.01	0.03	42,000	350	0.01	0.03	40,000	300	0.01	0.03	36,000	250	0.008	0.024
2003-010		1	44,000	400	0.01	0.03	42,000	350	0.01	0.03	40,000	300	0.01	0.03	36,000	250	0.008	0.024
2003-015		1.5	44,000	400	0.01	0.03	42,000	350	0.01	0.03	40,000	300	0.01	0.03	36,000	250	0.008	0.024
2003-020		2	35,200	280	0.008	0.023	33,600	245	0.008	0.023	32,000	210	0.008	0.023	28,800	175	0.006	0.018
2003-025		2.5	35,200	185	0.006	0.017	33,600	165	0.006	0.017	32,000	150	0.006	0.017	28,800	115	0.005	0.014
2003-030		3	35,200	140	0.004	0.01	33,600	125	0.004	0.01	32,000	110	0.004	0.01	28,800	85	0.003	0.009
2004-005	R0.2	0.5	44,000	600	0.015	0.045	42,000	550	0.015	0.045	40,000	500	0.013	0.036	36,000	350	0.01	0.027
2004-0075		0.75	44,000	600	0.015	0.045	42,000	550	0.015	0.045	40,000	500	0.013	0.036	36,000	350	0.01	0.027
2004-010		1	44,000	600	0.015	0.045	42,000	550	0.015	0.045	40,000	500	0.013	0.036	36,000	350	0.01	0.027
2004-0125		1.25	44,000	600	0.015	0.045	42,000	550	0.015	0.045	40,000	500	0.013	0.036	36,000	350	0.01	0.027
2004-015		1.5	44,000	600	0.015	0.045	42,000	550	0.015	0.045	40,000	500	0.013	0.036	36,000	350	0.01	0.027
2004-020		2	44,000	600	0.015	0.045	42,000	550	0.015	0.045	40,000	500	0.013	0.036	36,000	350	0.01	0.027
2004-025		2.5	35,200	420	0.011	0.034	33,600	385	0.011	0.034	32,000	350	0.01	0.027	28,800	250	0.008	0.02
2004-030		3	35,200	330	0.008	0.024	33,600	310	0.008	0.024	32,000	280	0.008	0.022	28,000	200	0.006	0.016
2004-035		3.5	35,200	300	0.007	0.022	31,900	280	0.007	0.022	30,400	250	0.007	0.02	26,600	175	0.005	0.014
2004-040		4	35,200	270	0.006	0.019	30,240	250	0.006	0.019	28,800	220	0.006	0.018	25,200	150	0.004	0.012
2005-010	R0.25	1	44,000	900	0.02	0.065	40,000	800	0.015	0.05	36,000	600	0.015	0.05	30,000	400	0.015	0.03
2005-015		1.5	44,000	900	0.02	0.065	40,000	800	0.015	0.05	36,000	600	0.015	0.05	30,000	400	0.015	0.03
2005-020		2	44,000	900	0.02	0.065	40,000	800	0.015	0.05	36,000	600	0.015	0.05	30,000	400	0.015	0.03
2005-025		2.5	44,000	900	0.02	0.065	40,000	800	0.015	0.05	36,000	600	0.015	0.05	30,000	400	0.015	0.03
2005-030		3	32,700	450	0.01	0.04	31,500	400	0.01	0.03	30,000	300	0.008	0.03	24,000	200	0.007	0.015
2005-035		3.5	32,700	450	0.01	0.04	31,500	400	0.01	0.03	30,000	300	0.008	0.03	24,000	200	0.007	0.015
2005-040		4	32,700	450	0.01	0.04	31,500	400	0.01	0.03	30,000	300	0.008	0.03	24,000	200	0.007	0.015
2005-045		4.5	29,430	405	0.008	0.03	28,350	360	0.008	0.025	27,000	270	0.006	0.025	21,600	180	0.005	0.013
2005-050		5	26,160	360	0.005	0.02	25,200	320	0.005	0.02	24,000	240	0.004	0.02	19,200	160	0.003	0.01
2005-060		6	26,160	360	0.005	0.02	25,200	320	0.005	0.02	24,000	240	0.004	0.02	19,200	160	0.003	0.01

HGLB Milling Conditions

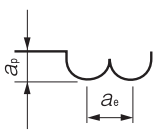
WORK MATERIAL			PREHARDENED STEELS/ HARDENED STEELS NAK / STAVAX (~55HRC)				HARDENED STEELS SKD11 (55~62HRC)				HARDENED STEELS HAP10 (62~66HRC)				HARDENED STEELS HAP72 (66~70HRC)			
Model Number	Radius of Ball Nose (mm)	Effective Length (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)
2006-010	R0.3	1	40,000	1,400	0.045	0.15	36,000	1,500	0.03	0.13	32,000	1,000	0.02	0.1	25,000	600	0.02	0.1
2006-015		1.5	40,000	1,400	0.03	0.13	36,000	1,300	0.03	0.13	32,000	1,000	0.02	0.1	25,000	600	0.02	0.1
2006-020		2	40,000	1,400	0.03	0.13	36,000	1,300	0.03	0.13	32,000	1,000	0.02	0.1	25,000	600	0.02	0.1
2006-025		2.5	40,000	1,200	0.025	0.1	36,000	1,100	0.025	0.1	32,000	900	0.02	0.1	25,000	500	0.02	0.1
2006-030		3	40,000	1,200	0.025	0.1	36,000	1,100	0.025	0.1	32,000	900	0.02	0.1	25,000	500	0.02	0.1
2006-035		3.5	40,000	1,100	0.023	0.09	34,000	950	0.023	0.09	32,000	800	0.018	0.09	25,000	450	0.015	0.09
2006-040		4	40,000	1,000	0.02	0.08	32,000	800	0.02	0.08	32,000	700	0.015	0.07	25,000	400	0.01	0.075
2006-045		4.5	32,000	600	0.01	0.07	28,000	600	0.01	0.05	25,600	500	0.01	0.05	20,000	300	0.005	0.05
2006-050		5	32,000	600	0.01	0.07	28,000	600	0.01	0.05	25,600	500	0.01	0.05	20,000	300	0.005	0.05
2006-055		5.5	32,000	600	0.01	0.07	28,000	600	0.01	0.05	25,600	500	0.01	0.05	20,000	300	0.005	0.05
2006-060		6	32,000	600	0.01	0.07	28,000	600	0.01	0.05	25,600	500	0.01	0.05	20,000	300	0.005	0.05
2006-080		8	25,600	480	0.008	0.02	22,400	480	0.008	0.02	20,480	350	0.007	0.02	16,000	210	0.004	0.01
2006-100		10	20,480	390	0.006	0.02	17,920	390	0.006	0.02	16,400	250	0.005	0.02	12,800	150	0.003	0.01
2008-020	R0.4	2	35,000	1,600	0.06	0.21	30,000	1,600	0.04	0.17	26,000	1,350	0.04	0.15	20,000	700	0.02	0.12
2008-025		2.5	35,000	1,600	0.06	0.21	30,000	1,600	0.04	0.17	26,000	1,350	0.04	0.15	20,000	700	0.02	0.12
2008-030		3	35,000	1,600	0.06	0.21	30,000	1,600	0.04	0.17	26,000	1,350	0.04	0.15	20,000	700	0.02	0.12
2008-040		4	35,000	1,600	0.06	0.21	30,000	1,600	0.04	0.17	26,000	1,350	0.04	0.15	20,000	700	0.02	0.12
2008-050		5	31,500	1,300	0.04	0.17	27,500	1,300	0.03	0.15	23,400	1,000	0.03	0.11	18,000	530	0.015	0.09
2008-060		6	28,000	1,000	0.02	0.12	25,000	1,000	0.02	0.12	20,800	675	0.02	0.075	16,000	350	0.01	0.06
2008-070		7	25,200	900	0.02	0.11	22,500	900	0.02	0.11	18,700	600	0.018	0.068	14,400	330	0.009	0.05
2008-080		8	22,400	800	0.02	0.1	20,000	800	0.02	0.1	16,640	540	0.016	0.06	12,800	300	0.008	0.048
2010-020	R0.5	2	30,000	1,750	0.2	0.4	24,000	2,000	0.1	0.3	21,000	1,750	0.05	0.2	16,000	875	0.05	0.2
2010-025		2.5	30,000	1,750	0.2	0.4	24,000	2,000	0.1	0.3	21,000	1,750	0.05	0.2	16,000	875	0.05	0.2
2010-030		3	30,000	1,750	0.1	0.3	24,000	2,000	0.1	0.2	21,000	1,750	0.03	0.17	16,000	875	0.03	0.17
2010-040		4	30,000	1,750	0.1	0.3	24,000	2,000	0.1	0.2	21,000	1,750	0.03	0.17	16,000	875	0.03	0.17
2010-050		5	30,000	1,750	0.1	0.3	24,000	2,000	0.1	0.2	21,000	1,750	0.03	0.17	16,000	875	0.03	0.17
2010-060		6	30,000	1,150	0.06	0.23	21,500	1,250	0.03	0.17	19,700	1,050	0.025	0.15	14,500	525	0.025	0.15
2010-070		7	27,000	980	0.04	0.19	20,000	920	0.02	0.15	19,000	770	0.02	0.14	14,200	380	0.02	0.14
2010-080		8	24,000	800	0.025	0.155	18,500	580	0.015	0.12	18,400	480	0.015	0.12	13,800	240	0.015	0.12
2010-100		10	22,000	600	0.018	0.13	14,800	430	0.01	0.09	14,700	360	0.01	0.09	14,700	360	0.01	0.09
2010-120		12	14,150	320	0.015	0.12	13,400	380	0.008	0.08	13,300	290	0.008	0.08	13,300	290	0.008	0.08
2010-140		14	13,500	280	0.012	0.1	12,000	350	0.007	0.08	12,000	220	0.007	0.08	12,000	220	0.007	0.08
2010-160		16	12,150	250	0.011	0.09	10,800	320	0.006	0.07	10,800	200	0.006	0.07	10,800	200	0.006	0.07

HGLB Milling Conditions

WORK MATERIAL			PREHARDENED STEELS/ HARDENED STEELS NAK / STAVAX (~55HRC)				HARDENED STEELS SKD11 (55~62HRC)				HARDENED STEELS HAP10 (62~66HRC)				HARDENED STEELS HAP72 (66~70HRC)			
Model Number	Radius of Ball Nose (mm)	Effective Length (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)
2015-030	R0.75	3	30,000	2,450	0.25	0.55	17,000	2,000	0.12	0.4	15,000	1,750	0.06	0.29	11,250	875	0.06	0.29
2015-040		4	30,000	2,450	0.25	0.55	17,000	2,000	0.12	0.4	15,000	1,750	0.06	0.29	11,250	875	0.06	0.29
2015-060		6	30,000	2,450	0.15	0.45	17,000	2,000	0.07	0.31	15,000	1,750	0.04	0.24	11,250	875	0.04	0.24
2015-080		8	23,500	1,300	0.1	0.37	15,000	1,250	0.045	0.25	14,000	1,050	0.03	0.21	10,500	525	0.03	0.21
2015-100		10	23,500	1,300	0.1	0.37	15,000	1,250	0.045	0.25	14,000	1,050	0.03	0.21	10,500	525	0.03	0.21
2015-120		12	13,100	480	0.03	0.21	13,000	580	0.02	0.17	13,000	480	0.02	0.17	9,750	240	0.02	0.17
2015-140		14	11,200	400	0.025	0.19	10,900	490	0.015	0.145	10,900	390	0.015	0.145	8,200	190	0.015	0.145
2015-160		16	10,000	360	0.023	0.17	9,800	440	0.014	0.13	9,800	350	0.014	0.13	7,380	170	0.014	0.13
2015-200		20	8,900	320	0.02	0.15	8,700	390	0.012	0.12	8,700	310	0.012	0.12	6,560	150	0.012	0.12
2020-030	R1	3	28,000	2,900	0.3	0.7	14,000	2,100	0.15	0.5	14,700	2,100	0.15	0.35	12,250	1,800	0.08	0.35
2020-040		4	28,000	2,900	0.3	0.7	14,000	2,100	0.15	0.5	14,700	2,100	0.15	0.35	12,250	1,800	0.08	0.35
2020-060		6	28,000	2,900	0.2	0.6	14,000	2,100	0.1	0.4	14,700	2,100	0.15	0.3	12,250	1,800	0.06	0.3
2020-080		8	28,000	2,900	0.2	0.6	14,000	2,100	0.1	0.4	14,700	2,100	0.15	0.3	12,250	1,800	0.06	0.3
2020-100		10	28,000	2,900	0.2	0.6	14,000	2,100	0.1	0.4	14,700	2,100	0.15	0.3	12,250	1,800	0.06	0.3
2020-120		12	19,500	1,350	0.12	0.45	12,400	1,350	0.06	0.34	13,800	1,320	0.09	0.27	11,500	1,100	0.045	0.27
2020-140		14	19,500	1,350	0.12	0.45	12,400	1,350	0.06	0.34	13,800	1,320	0.09	0.27	11,500	1,100	0.045	0.27
2020-160		16	10,800	500	0.05	0.3	10,800	600	0.03	0.24	12,840	588	0.06	0.24	10,700	490	0.03	0.24
2020-200		20	10,800	500	0.035	0.25	10,800	450	0.02	0.19	10,270	440	0.04	0.19	8,560	370	0.02	0.19
2020-250		25	9,720	450	0.032	0.23	9,720	410	0.018	0.17	9,250	400	0.036	0.17	7,700	330	0.018	0.17
2020-300		30	8,650	400	0.028	0.2	8,650	360	0.016	0.15	8,200	350	0.032	0.15	6,850	300	0.016	0.15
2030-060	R1.5	6	21,000	3,000	0.4	1	13,250	2,500	0.24	0.55	11,040	2,280	0.24	0.55	9,200	1,900	0.12	0.55
2030-080		8	21,000	3,000	0.4	1	13,250	2,500	0.24	0.55	11,040	2,280	0.24	0.55	9,200	1,900	0.12	0.55
2030-100		10	21,000	3,000	0.3	0.9	12,200	2,300	0.2	0.5	11,040	2,280	0.2	0.5	9,200	1,900	0.1	0.5
2030-120		12	21,000	3,000	0.3	0.9	12,200	2,300	0.2	0.5	11,040	2,280	0.2	0.5	9,200	1,900	0.1	0.5
2030-140		14	21,000	3,000	0.3	0.9	12,200	2,300	0.2	0.5	11,040	2,280	0.2	0.5	9,200	1,900	0.1	0.5
2030-160		16	21,000	3,000	0.3	0.9	12,200	2,300	0.2	0.5	11,040	2,280	0.2	0.5	9,200	1,900	0.1	0.5
2030-180		18	17,750	2,300	0.24	0.8	11,750	1,850	0.18	0.48	10,680	1,830	0.18	0.48	8,900	1,525	0.088	0.48
2030-200		20	14,500	1,600	0.18	0.7	11,350	1,400	0.15	0.45	10,320	1,380	0.15	0.45	8,600	1,150	0.075	0.45
2030-220		22	13,000	1,440	0.16	0.63	11,000	1,020	0.13	0.42	9,960	1,000	0.13	0.42	8,300	830	0.063	0.42
2030-250		25	11,600	1,280	0.14	0.56	10,500	620	0.1	0.38	9,600	610	0.1	0.38	8,000	510	0.05	0.38
2030-270		27	10,500	1,150	0.13	0.51	9,000	540	0.08	0.34	8,200	530	0.08	0.34	6,850	440	0.04	0.34
2030-300		30	9,280	1,020	0.11	0.45	7,500	450	0.06	0.29	6,840	440	0.06	0.29	5,700	370	0.03	0.29

HGLB Milling Conditions

WORK MATERIAL			PREHARDENED STEELS/ HARDENED STEELS NAK / STAVAX (~55HRC)				HARDENED STEELS SKD11 (55~62HRC)				HARDENED STEELS HAP10 (62~66HRC)				HARDENED STEELS HAP72 (66~70HRC)			
Model Number	Radius of Ball Nose (mm)	Effective Length (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)
2040-080		8	18,000	3,200	0.5	1.3	11,380	2,880	0.36	0.95	9,480	2,400	0.3	0.75	7,900	2,000	0.15	0.75
2040-100		10	18,000	3,200	0.5	1.3	11,380	2,880	0.36	0.95	9,480	2,400	0.3	0.75	7,900	2,000	0.15	0.75
2040-120		12	18,000	3,200	0.4	1.2	11,380	2,880	0.31	0.85	9,480	2,400	0.26	0.7	7,900	2,000	0.13	0.7
2040-140		14	18,000	3,200	0.4	1.2	11,380	2,880	0.31	0.85	9,480	2,400	0.26	0.7	7,900	2,000	0.13	0.7
2040-160		16	18,000	3,200	0.4	1.2	11,380	2,880	0.31	0.85	9,480	2,400	0.26	0.7	7,900	2,000	0.13	0.7
2040-180		18	18,000	3,200	0.4	1.2	11,380	2,880	0.31	0.85	9,480	2,400	0.26	0.7	7,900	2,000	0.13	0.7
2040-200	R2	20	18,000	3,200	0.4	1.2	10,730	1,800	0.21	0.7	8,940	1,500	0.18	0.55	7,450	1,250	0.09	0.55
2040-220		22	15,250	2,250	0.33	1.1	10,730	1,800	0.21	0.7	8,940	1,500	0.18	0.55	7,450	1,250	0.09	0.55
2040-250		25	12,500	1,250	0.25	0.95	10,730	1,800	0.21	0.7	8,940	1,500	0.18	0.55	7,450	1,250	0.09	0.55
2040-270		27	11,500	1,150	0.23	0.9	10,400	1,250	0.18	0.58	8,670	1,050	0.15	0.5	7,250	890	0.075	0.5
2040-300		30	10,630	1,000	0.2	0.76	10,080	780	0.15	0.45	8,400	650	0.12	0.45	7,000	540	0.06	0.45
2040-350		35	9,030	800	0.16	0.61	8,640	730	0.13	0.43	7,200	610	0.11	0.43	6,000	510	0.055	0.43
2040-400		40	8,300	700	0.14	0.54	8,000	700	0.12	0.42	6,650	590	0.11	0.42	5,500	500	0.05	0.42
2060-100		10	14,400	3,200	0.5	1.5	9,140	2,880	0.38	1.05	7,620	2,400	0.32	0.88	6,350	2,000	0.16	0.88
2060-150		15	14,400	3,200	0.5	1.5	9,140	2,880	0.38	1.05	7,620	2,400	0.32	0.88	6,350	2,000	0.16	0.88
2060-180		18	14,400	3,200	0.5	1.5	9,140	2,880	0.38	1.05	7,620	2,400	0.32	0.88	6,350	2,000	0.16	0.88
2060-200		20	14,400	3,200	0.5	1.5	9,000	2,300	0.32	0.95	7,620	2,400	0.32	0.88	6,350	2,000	0.16	0.88
2060-250	R3	25	14,400	3,200	0.5	1.5	8,100	2,000	0.3	0.95	7,500	1,920	0.27	0.805	6,250	1,600	0.135	0.805
2060-300		30	14,400	3,200	0.5	1.5	7,700	1,800	0.26	0.88	7,440	1,500	0.22	0.73	6,200	1,250	0.11	0.73
2060-350		35	9,200	2,050	0.32	1	6,200	1,450	0.21	0.71	6,000	1,200	0.18	0.59	5,000	1,000	0.09	0.59
2060-400		40	7,000	1,050	0.2	0.8	5,600	1,000	0.19	0.64	4,800	950	0.14	0.47	4,000	810	0.07	0.47
2060-500		50	5,600	850	0.16	0.6	4,500	810	0.15	0.52	3,900	780	0.12	0.38	3,200	650	0.06	0.38



Note:
- Decrease the feed rate more than 50% from the milling parameters when slot milling.
- Decrease both spindle speed and feed rate proportionally when the milling parameters exceed the machine's maximum spindle speed, or when chattering and red-hot occur.
- Every coolant offers stable milling.

HWLB/HWLB-S

Additional 143 models

HMWCOAT 2 Flute Long Neck Ball End Mills / Short Shank Long Neck Ball End Mills

R0.05～R3

Super MG | HMW COAT | Back Taper Geometry

Back taper geometry does not apply below R0.25.
Back taper geometry does not apply on R0.25 ≦ R ≦ R0.45 and ℓ1/D ≦ 10.

Material Applications (★ Highly Recommended ● Recommended ○ Suggested)

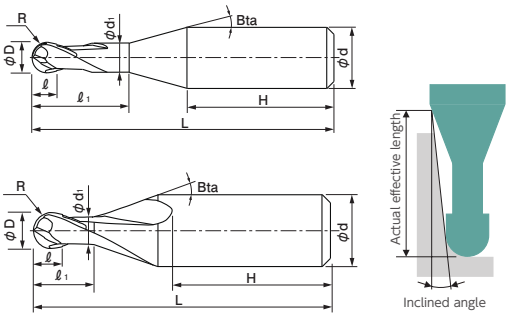
Work Material															
CARBON STEELS S45C S55C	ALLOY STEELS SK / SCM SUS	PREHARDENED STEELS NAK HPM	HARDENED STEELS ～50 HRC	～55 HRC	～60 HRC	～65 HRC	～70 HRC	CAST IRON	ALUMINUM ALLOYS	GRAPHITE	COPPER	PLASTICS	GLASS FILLED PLASTICS	TITANIUM ALLOYS	HEAT RESISTANT ALLOYS	CEMENTED CARBIDE	HARD BRITTLE (NON-METALLIC) MATERIALS
○	○	●	★	★	★	●	●	○			○			○	○		

- **Upgrade**

Wear resistance and tool accuracy have been improved with HWLB and CWLB series.

CSELB				HSLB			HGLB
Copper	Raw Materials	～30 HRC	～40 HRC	～50 HRC	～55 HRC	～60 HRC	～65 HRC	～70 HRC

CWLB				HWLB			HGLB
Copper	Raw Materials	～30 HRC	～40 HRC	～50 HRC	～55 HRC	～60 HRC	～65 HRC	～70 HRC



The shank taper angle shown is not an exact value.

Tool Design

With the same tool shape as our long-selling HSLB, the transition from HSLB is made easy.

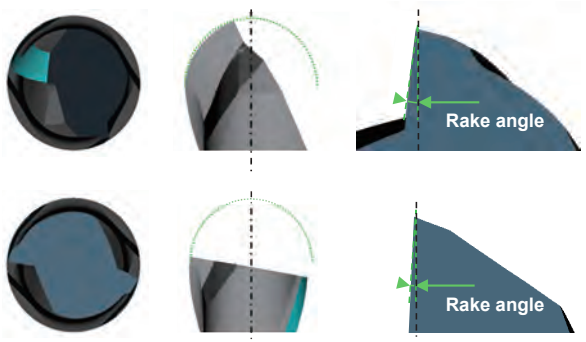
Variable rake angle design

Tip point

Negative rake angle design prevents fracture and chipping.

Peripheral cutting edge

Slightly negative rake angle design reduces cutting resistance and prevents chattering.



High Precision

Even higher accuracy than before!

Conventional HSLB

Radius of Ball Nose	Ball Radius Accuracy	Diameter Tolerance	Shank Diameter Tolerance
R0.05 ～ R0.075	± 0.002	0/-0.01	0/-0.005
R0.1 ～ R3	± 0.005	0/-0.015	

HWLB

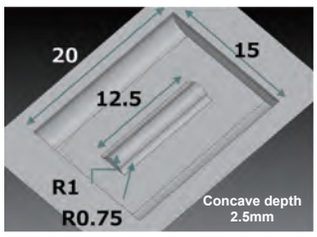
Unit (mm)

Radius of Ball Nose	Ball Radius Accuracy	Diameter Tolerance	Shank Diameter Tolerance	Helix Angle
R0.05 ～ R0.075	± 0.002	0/-0.006	0/-0.004 (h4)	0°
R0.1 ～ R1.25	± 0.003			30°
R1.5 ～ R3		0/-0.009		

Improved wear resistance (50 HRC)

Relief wear width comparison **R0.5 × EL2.5**

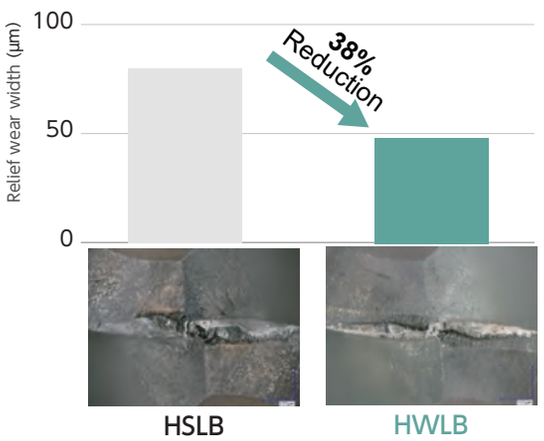
STAVAX (52 HRC) / SKD61 (50 HRC)



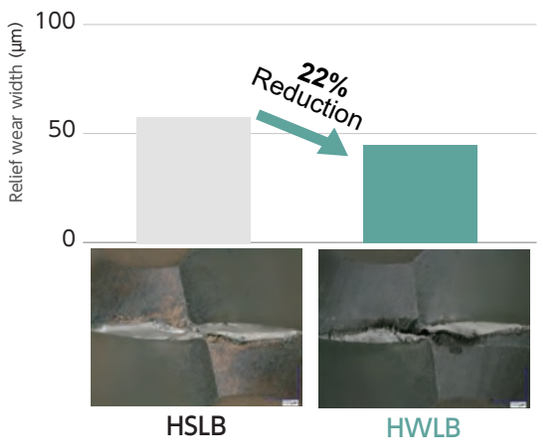
Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Allowance (mm)	Cycle Time 1pc (m:s)
30,000	1,750	0.1	0.3	0.03	22:50

Coolant : Air Blow

STAVAX (52 HRC) 120 min

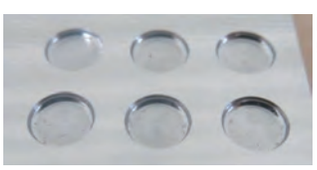


SKD61 (50 HRC) 60 min



Comparison with competitor's tool for hard materials **R0.5 × EL12**

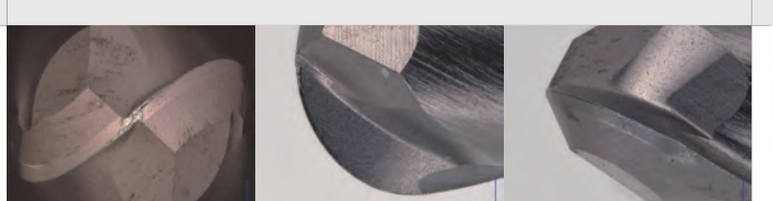
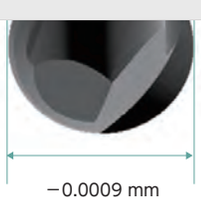
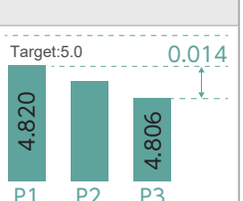
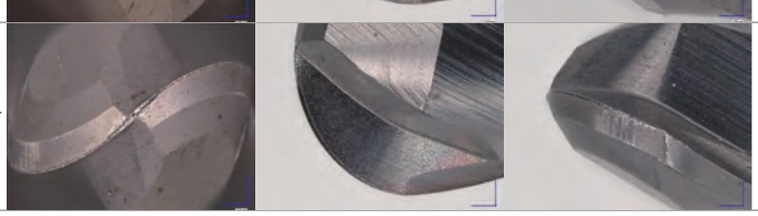
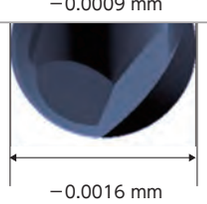
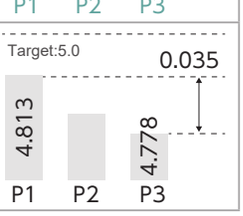
STAVAX (52 HRC)



Pocket Size
Ø 5 × Depth 0.7 mm

Coolant : Air Blow

Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Cycle Time 1 Pocket
14,150	320	0.015	0.12	20 min

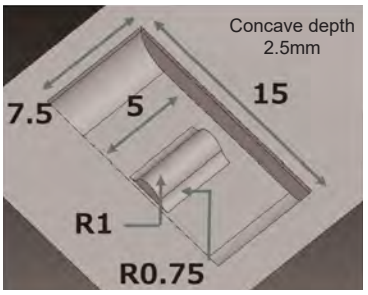
	Tool after milling 20 min x 3 pockets	Diameter reduction amount 20 min x 3 pockets	(mm) Work piece dimensional change Actual measurements of circle pocket 20 min x 3 pockets
HWLB		 −0.0009 mm	
Competitor		 −0.0016 mm	

HWLB achieves less wearing at the peripheral cutting edge which results in smaller dimensional changes on the work piece and excellent milling accuracy.

Improved wear resistance (60 HRC)

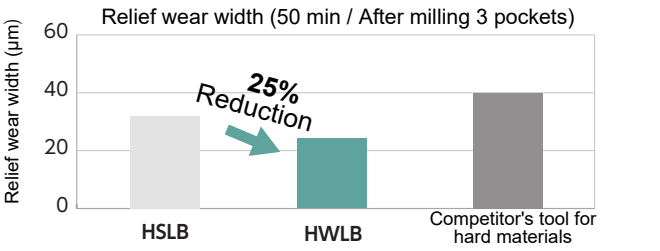
Roughing Wear comparison
HWLB, HSLB and competitor's tool for hard materials **R0.5 × EL2.5**

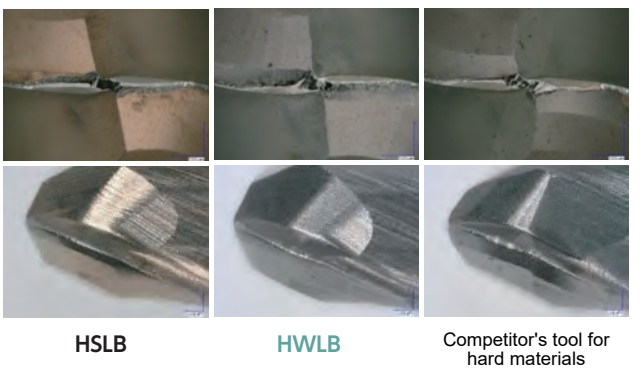
SKD11（60 HRC）



Coolant: Air Blow

Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Allowance (mm)	Cycle Time 1 pc (m:s)
24,000	2,000	0.05	0.2	0.03	16:11

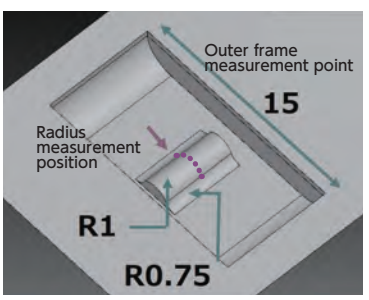




Less tool damage when roughing large areas as compared to the conventional HSLB and the competitor's tool.

Finishing: Milling dimensional error comparison between HWLB, HSLB and competitor's tool for hard materials **R0.5 × EL2.5**

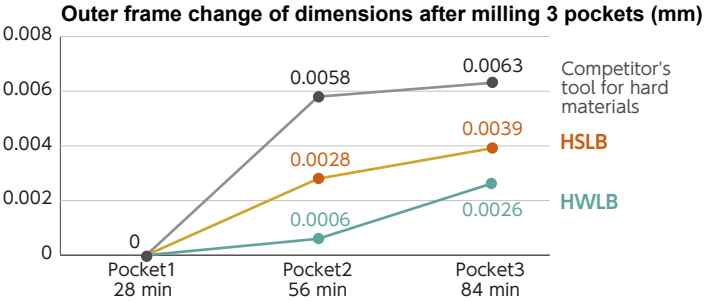
SKD11 (60 HRC)



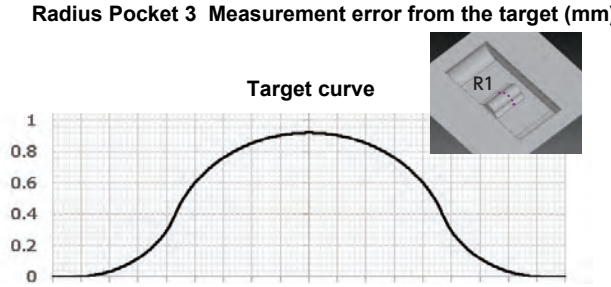
Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Cycle Time 1 pc
24,000	1,000	0.01	0.01	28 min

Coolant: Air Blow

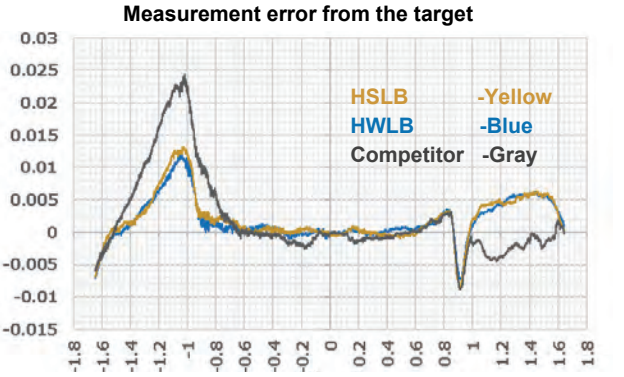
Outer frame change of dimensions after milling 3 pockets (mm)



Radius Pocket 3 Measurement error from the target (mm)



Measurement error from the target



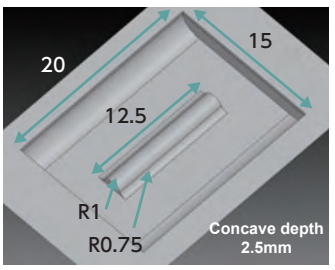
Offers higher milling accuracy as compared to our conventional tools and the competitor's tools, even with hard materials of 60 HRC.

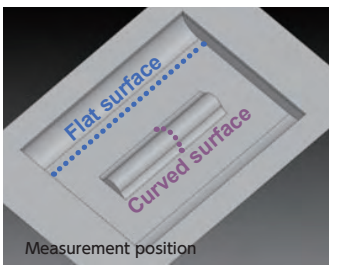
Finishing roughness and dimensional error

**Milled surface quality remains very good.
The finishing roughness is almost the same as conventional tools.**

Finishing after milling 6 pockets (360min) Surface roughness comparison
HWLB and HSLB R0.5 × EL2.5

STAVAX (52 HRC)

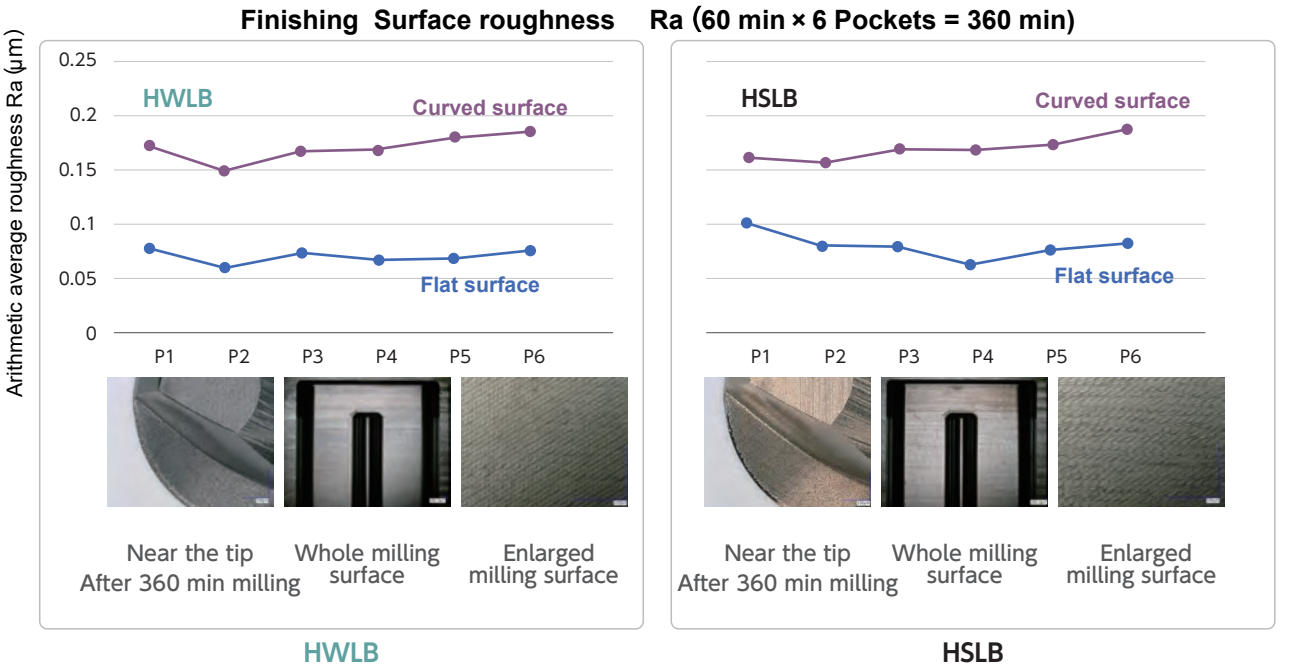




Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Allowance (mm)	Cycle Time 1pc
30,000	1,000	0.01	0.01	0	60 min

Coolant: Oil Mist

Finishing Surface roughness Ra (60 min × 6 Pockets = 360 min)

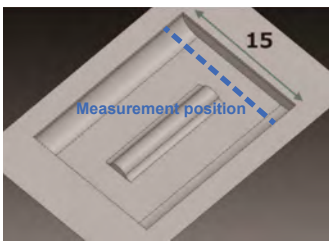


HWLB HSLB

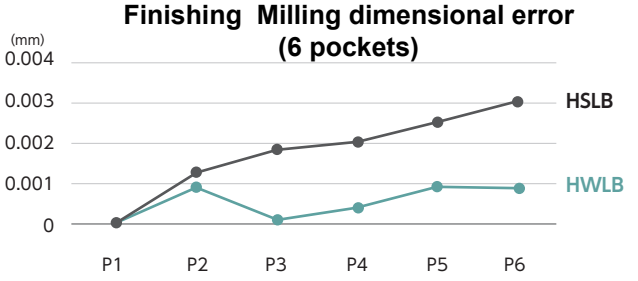
**Both HSLB and HWLB maintain excellent surface roughness on flat/curved surfaces until the 6th pocket.
Minimal wear near the tip of the tool allows for continuous milling.**

Finishing after milling 6 pockets (360 min) Milling dimensional error comparison
HWLB and HSLB R0.5 × EL2.5

STAVAX (52 HRC)



Finishing Milling dimensional error (6 pockets)



**Surface roughness between HSLB and HWLB show minor differences.
Meanwhile HWLB makes smaller milling dimensional error due to the improved wear resistance.**

Total 344 models

Unit (mm)

	Model Number	Short Shank	Radius of Ball Nose R	Effective Length ℓ1	Length of Cut ℓ	Neck Diameter Ød1	Shank Taper Angle Bta	Overall Length L	Shank Diameter Ød	Shank Length H	Series	Effective Length by Inclined Angles				
												30′	1°	1°30′	2°	3°
※	HWLB 2001-002S	○	R0.05	0.2	0.08	0.095	11°	35	4	23.6	HWLB	0.22	0.24	0.26	0.28	0.32
	HWLB 2001-002			0.2				45	4	33.6	HWLB	0.22	0.24	0.26	0.28	0.32
※	HWLB 2001-003S	○		0.3				35	4	23.5	HWLB	0.33	0.36	0.38	0.40	0.45
	HWLB 2001-003			0.3				45	4	33.5	HWLB	0.33	0.36	0.38	0.40	0.45
※	HWLB 2001-004S	○		0.4				35	4	23.4	HWLB	0.44	0.47	0.50	0.52	0.59
※	HWLB 2001-005S	○		0.5				35	4	23.3	HWLB	0.55	0.58	0.61	0.65	0.73
	HWLB 2001-005			0.5				45	4	33.3	HWLB	0.55	0.58	0.61	0.65	0.73
※	HWLB 20015-003S	○	R0.075	0.3	0.12	0.135	11°	35	4	23.6	HWLB	0.37	0.39	0.41	0.43	0.48
	HWLB 20015-003			0.3				45	4	33.6	HWLB	0.37	0.39	0.41	0.43	0.48
※	HWLB 20015-005S	○		0.5				35	4	23.4	HWLB	0.58	0.61	0.64	0.67	0.75
	HWLB 20015-005			0.5				45	4	33.4	HWLB	0.58	0.61	0.64	0.67	0.75
※	HWLB 20015-010S	○		1				35	4	22.9	HWLB	1.10	1.16	1.21	1.28	1.44
	HWLB 20015-010			1				45	4	32.9	HWLB	1.10	1.16	1.21	1.28	1.44
※	HWLB 2002-003S	○	R0.1	0.3	0.16	0.19	16°	35	4	27.4	HWLB	0.42	0.44	0.46	0.48	0.52
	HWLB 2002-003			0.3				45	4	37.4	HWLB	0.42	0.44	0.46	0.48	0.52
※	HWLB 2002-005S	○		0.5				35	4	27.2	HWLB	0.63	0.66	0.68	0.71	0.76
	HWLB 2002-005			0.5				45	4	37.2	HWLB	0.63	0.66	0.68	0.71	0.76
※	HWLB 2002-005-6			0.5				50	6	38.4	HWLB	0.63	0.66	0.68	0.71	0.76
※	HWLB 2002-0075S	○		0.75				35	4	26.9	HWLB	0.89	0.93	0.96	0.99	1.07
	HWLB 2002-0075			0.75				45	4	36.9	HWLB	0.89	0.93	0.96	0.99	1.07
※	HWLB 2002-010S	○		1				35	4	26.7	HWLB	1.15	1.20	1.24	1.28	1.37
	HWLB 2002-010			1				45	4	36.7	HWLB	1.15	1.20	1.24	1.28	1.37
※	HWLB 2002-010-6			1				50	6	37.9	HWLB	1.15	1.20	1.24	1.28	1.37
※	HWLB 2002-0125			1.25				45	4	36.4	HWLB	1.40	1.45	1.50	1.55	1.67
※	HWLB 2002-015S	○		1.5				35	4	26.2	HWLB	1.66	1.72	1.78	1.84	1.97
	HWLB 2002-015			1.5				45	4	36.2	HWLB	1.66	1.72	1.78	1.84	1.97
※	HWLB 2002-0175S	○		1.75				35	4	25.9	HWLB	1.92	1.99	2.05	2.12	2.28
※	HWLB 2002-020S	○		2				35	4	25.7	HWLB	2.18	2.25	2.33	2.41	2.58
	HWLB 2002-020			2				45	4	35.7	HWLB	2.18	2.25	2.33	2.41	2.58
	HWLB 2002-025			2.5				45	4	35.2	HWLB	2.70	2.79	2.88	2.98	3.20
	HWLB 2002-030			3				45	4	34.7	HWLB	3.22	3.32	3.43	3.55	3.81
※	HWLB 2003-005S	○	R0.15	0.5	0.24	0.29	16°	35	4	27.3	HWLB	0.63	0.65	0.68	0.70	0.75
	HWLB 2003-005			0.5				45	4	37.3	HWLB	0.63	0.65	0.68	0.70	0.75
※	HWLB 2003-0075S	○		0.75				35	4	27.1	HWLB	0.89	0.92	0.96	0.99	1.05
	HWLB 2003-0075			0.75				45	4	37.1	HWLB	0.89	0.92	0.96	0.99	1.05
※	HWLB 2003-010S	○		1				35	4	26.8	HWLB	1.15	1.19	1.23	1.27	1.36
	HWLB 2003-010			1				45	4	36.8	HWLB	1.15	1.19	1.23	1.27	1.36
※	HWLB 2003-010-6			1				50	6	38.1	HWLB	1.15	1.19	1.23	1.27	1.36
※	HWLB 2003-0125			1.25				45	4	36.6	HWLB	1.40	1.45	1.50	1.55	1.66
※	HWLB 2003-015S	○		1.5				35	4	26.3	HWLB	1.66	1.72	1.77	1.83	1.96
	HWLB 2003-015			1.5				45	4	36.3	HWLB	1.66	1.72	1.77	1.83	1.96
※	HWLB 2003-015-6			1.5				50	6	37.6	HWLB	1.66	1.72	1.77	1.83	1.96
※	HWLB 2003-020S	○		2				35	4	25.8	HWLB	2.18	2.25	2.32	2.40	2.57
	HWLB 2003-020			2				45	4	35.8	HWLB	2.18	2.25	2.32	2.40	2.57

※ Additional model

	Model Number	Short Shank	Radius of Ball Nose R	Effective Length ℓ_1	Length of Cut ℓ	Neck Diameter $\varnothing d_1$	Shank Taper Angle Bta	Overall Length L	Shank Diameter $\varnothing d$	Shank Length H	Series	Effective Length by Inclined Angles				
												30′	1°	1°30′	2°	3°
※	HWLB 2003-025S	○	R0.15	2.5	0.24	0.29	16°	35	4	25.3	HWLB	2.70	2.78	2.87	2.97	3.18
	HWLB 2003-025			2.5				45	4	35.3	HWLB	2.70	2.78	2.87	2.97	3.18
※	HWLB 2003-030S	○		3				35	4	24.8	HWLB	3.21	3.32	3.42	3.54	3.80
	HWLB 2003-030			3				45	4	34.8	HWLB	3.21	3.32	3.42	3.54	3.80
※	HWLB 2003-035			3.5				45	4	34.3	HWLB	3.73	3.85	3.97	4.11	4.41
	HWLB 2003-040			4				45	4	33.8	HWLB	4.25	4.38	4.52	4.68	5.02
※	HWLB 2003-045			4.5				45	4	33.3	HWLB	4.76	4.91	5.07	5.25	5.63
※	HWLB 2003-050			5				45	4	32.8	HWLB	5.28	5.44	5.62	5.82	6.24
※	HWLB 2004-005S	○	R0.2	0.5	0.32	0.39	16°	35	4	27.5	HWLB	0.63	0.65	0.68	0.70	0.74
	HWLB 2004-005			0.5				45	4	37.5	HWLB	0.63	0.65	0.68	0.70	0.74
	HWLB 2004-0075			0.75				45	4	37.3	HWLB	0.89	0.92	0.95	0.98	1.05
※	HWLB 2004-010S	○		1				35	4	27.0	HWLB	1.15	1.19	1.23	1.27	1.35
	HWLB 2004-010			1				45	4	37.0	HWLB	1.15	1.19	1.23	1.27	1.35
	HWLB 2004-010-6			1				50	6	38.3	HWLB	1.15	1.19	1.23	1.27	1.35
※	HWLB 2004-015S	○		1.5				35	4	26.5	HWLB	1.66	1.72	1.77	1.83	1.95
	HWLB 2004-015			1.5				45	4	36.5	HWLB	1.66	1.72	1.77	1.83	1.95
	HWLB 2004-015-6			1.5				50	6	37.8	HWLB	1.66	1.72	1.77	1.83	1.95
※	HWLB 2004-020S	○		2				35	4	26.0	HWLB	2.18	2.25	2.32	2.40	2.56
	HWLB 2004-020			2				45	4	36.0	HWLB	2.18	2.25	2.32	2.40	2.56
	HWLB 2004-020-6			2				50	6	37.3	HWLB	2.18	2.25	2.32	2.40	2.56
※	HWLB 2004-025S	○		2.5				35	4	25.5	HWLB	2.70	2.78	2.87	2.96	3.18
	HWLB 2004-025			2.5				45	4	35.5	HWLB	2.70	2.78	2.87	2.96	3.18
※	HWLB 2004-030S	○		3				35	4	25.0	HWLB	3.21	3.31	3.42	3.53	3.79
	HWLB 2004-030			3				45	4	35.0	HWLB	3.21	3.31	3.42	3.53	3.79
	HWLB 2004-030-6			3				50	6	36.3	HWLB	3.21	3.31	3.42	3.53	3.79
※	HWLB 2004-035S	○		3.5				35	4	24.5	HWLB	3.73	3.85	3.97	4.10	4.40
	HWLB 2004-035			3.5				45	4	34.5	HWLB	3.73	3.85	3.97	4.10	4.40
※	HWLB 2004-040S	○		4				35	4	24.0	HWLB	4.25	4.38	4.52	4.67	5.01
	HWLB 2004-040			4				45	4	34.0	HWLB	4.25	4.38	4.52	4.67	5.01
※	HWLB 2004-045			4.5				45	4	33.5	HWLB	4.76	4.91	5.07	5.24	5.62
	HWLB 2004-050			5				45	4	33.0	HWLB	5.28	5.44	5.62	5.81	6.24
	HWLB 2004-060			6				45	4	32.0	HWLB	6.31	6.51	6.72	6.95	7.46
※	HWLB 2005-0075S	○	R0.25	0.75	0.4	0.49	16°	35	4	27.5	HWLB	0.89	0.92	0.95	0.98	1.03
※	HWLB 2005-010S	○		1				35	4	27.2	HWLB	1.15	1.19	1.22	1.26	1.34
	HWLB 2005-010			1				45	4	37.2	HWLB	1.15	1.19	1.22	1.26	1.34
※	HWLB 2005-015S	○		1.5				35	4	26.7	HWLB	1.66	1.71	1.76	1.82	1.94
	HWLB 2005-015			1.5				45	4	36.7	HWLB	1.66	1.71	1.76	1.82	1.94
	HWLB 2005-015-6			1.5				50	6	38.0	HWLB	1.66	1.71	1.76	1.82	1.94
※	HWLB 2005-020S	○		2				35	4	26.2	HWLB	2.18	2.25	2.31	2.39	2.55
	HWLB 2005-020			2				45	4	36.2	HWLB	2.18	2.25	2.31	2.39	2.55
	HWLB 2005-020-6			2				50	6	37.5	HWLB	2.18	2.25	2.31	2.39	2.55
※	HWLB 2005-025S	○		2.5				35	4	25.7	HWLB	2.70	2.78	2.86	2.96	3.17
	HWLB 2005-025			2.5				45	4	35.7	HWLB	2.70	2.78	2.86	2.96	3.17
※	HWLB 2005-030S	○		3				35	4	25.2	HWLB	3.21	3.31	3.42	3.53	3.78
	HWLB 2005-030			3				45	4	35.2	HWLB	3.21	3.31	3.42	3.53	3.78
	HWLB 2005-030-6			3				50	6	36.5	HWLB	3.21	3.31	3.42	3.53	3.78

※ Additional model

	Model Number	Short Shank	Radius of Ball Nose R	Effective Length ℓ_1	Length of Cut ℓ	Neck Diameter $\varnothing d_1$	Shank Taper Angle Bta	Overall Length L	Shank Diameter $\varnothing d$	Shank Length H	Series	Effective Length by Inclined Angles				
												30′	1°	1°30′	2°	3°
	HWLB 2005-035		R0.25	3.5	0.4	0.49	16°	45	4	34.7	HWLB	3.73	3.84	3.97	4.10	4.39
※	HWLB 2005-040S	O		4				35	4	24.2	HWLB	4.24	4.38	4.52	4.67	5.00
	HWLB 2005-040			4				45	4	34.2	HWLB	4.24	4.38	4.52	4.67	5.00
	HWLB 2005-040-6			4				50	6	35.5	HWLB	4.24	4.38	4.52	4.67	5.00
※	HWLB 2005-045			4.5				45	4	33.7	HWLB	4.76	4.91	5.07	5.24	5.61
※	HWLB 2005-050S	O		5				35	4	23.2	HWLB	5.28	5.44	5.62	5.80	6.22
	HWLB 2005-050			5				45	4	33.2	HWLB	5.28	5.44	5.62	5.80	6.22
	HWLB 2005-060			6				45	4	32.2	HWLB	6.31	6.50	6.72	6.94	7.45
※	HWLB 2005-070			7				45	4	31.2	HWLB	7.34	7.57	7.82	8.08	8.67
	HWLB 2005-080			8				45	4	30.2	HWLB	8.37	8.63	8.92	9.22	9.90
	HWLB 2005-100			10				50	4	33.2	HWLB	10.43	10.76	11.12	11.50	12.34
※	HWLB 2006-010S	O	R0.3	1	0.48	0.59	16°	35	4	27.4	HWLB	1.15	1.18	1.22	1.25	1.33
	HWLB 2006-010			1				45	4	37.4	HWLB	1.15	1.18	1.22	1.25	1.33
※	HWLB 2006-0125			1.25				45	4	37.2	HWLB	1.39	1.44	1.48	1.53	1.62
※	HWLB 2006-015S	O		1.5				35	4	26.9	HWLB	1.66	1.71	1.76	1.81	1.93
	HWLB 2006-015			1.5				45	4	36.9	HWLB	1.66	1.71	1.76	1.81	1.93
	HWLB 2006-015-6			1.5				50	6	38.2	HWLB	1.66	1.71	1.76	1.81	1.93
※	HWLB 2006-020S	O		2				35	4	26.4	HWLB	2.18	2.24	2.31	2.38	2.54
	HWLB 2006-020			2				45	4	36.4	HWLB	2.18	2.24	2.31	2.38	2.54
	HWLB 2006-020-6			2				50	6	37.7	HWLB	2.18	2.24	2.31	2.38	2.54
※	HWLB 2006-025S	O		2.5				35	4	25.9	HWLB	2.69	2.77	2.86	2.95	3.15
	HWLB 2006-025			2.5				45	4	35.9	HWLB	2.69	2.77	2.86	2.95	3.15
※	HWLB 2006-030S	O		3				35	4	25.4	HWLB	3.21	3.31	3.41	3.52	3.77
	HWLB 2006-030			3				45	4	35.4	HWLB	3.21	3.31	3.41	3.52	3.77
	HWLB 2006-030-6			3				50	6	36.7	HWLB	3.21	3.31	3.41	3.52	3.77
※	HWLB 2006-035S	O		3.5				35	4	24.9	HWLB	3.73	3.84	3.96	4.09	4.38
	HWLB 2006-035			3.5				45	4	34.9	HWLB	3.73	3.84	3.96	4.09	4.38
※	HWLB 2006-040S	O		4				35	4	24.4	HWLB	4.24	4.37	4.51	4.66	4.99
	HWLB 2006-040			4				45	4	34.4	HWLB	4.24	4.37	4.51	4.66	4.99
	HWLB 2006-040-6			4				50	6	35.7	HWLB	4.24	4.37	4.51	4.66	4.99
※	HWLB 2006-045			4.5				45	4	33.9	HWLB	4.76	4.90	5.06	5.23	5.60
※	HWLB 2006-050S	O		5				35	4	23.4	HWLB	5.27	5.44	5.61	5.80	6.21
	HWLB 2006-050			5				45	4	33.4	HWLB	5.27	5.44	5.61	5.80	6.21
※	HWLB 2006-050-6			5				50	6	34.7	HWLB	5.27	5.44	5.61	5.80	6.21
※	HWLB 2006-060S	O		6				35	4	22.4	HWLB	6.30	6.50	6.71	6.94	7.44
	HWLB 2006-060			6				45	4	32.4	HWLB	6.30	6.50	6.71	6.94	7.44
	HWLB 2006-060-6			6				50	6	33.7	HWLB	6.30	6.50	6.71	6.94	7.44
※	HWLB 2006-070			7				45	4	31.4	HWLB	7.34	7.57	7.81	8.08	8.66
	HWLB 2006-080			8				45	4	30.4	HWLB	8.37	8.63	8.91	9.21	9.88
※	HWLB 2006-090			9				45	4	29.4	HWLB	9.40	9.70	10.01	10.35	11.11
	HWLB 2006-100			10				50	4	33.4	HWLB	10.43	10.76	11.11	11.49	12.33
※	HWLB 2006-100-6			10				50	6	29.7	HWLB	10.43	10.76	11.11	11.49	12.33
※	HWLB 2006-120			12				50	4	31.4	HWLB	12.49	12.89	13.31	13.77	14.78
※	HWLB 2007-020		R0.35	2	0.56	0.69	16°	45	4	36.6	HWLB	2.17	2.24	2.30	2.37	2.53
※	HWLB 2007-040			4				45	4	34.6	HWLB	4.24	4.37	4.51	4.65	4.98
※	HWLB 2007-060			6				45	4	32.6	HWLB	6.30	6.50	6.71	6.93	7.43

※ Additional model

	Model Number	Short Shank	Radius of Ball Nose R	Effective Length ℓ_1	Length of Cut ℓ	Neck Diameter $\varnothing d_1$	Shank Taper Angle Bta	Overall Length L	Shank Diameter $\varnothing d$	Shank Length H	Series	Effective Length by Inclined Angles				
												30′	1°	1°30′	2°	3°
※	**HWLB 2008-015**			1.5				45	4	37.3	HWLB	1.65	1.70	1.75	1.80	1.91
※	**HWLB 2008-020S**	○		2				35	4	26.8	HWLB	2.17	2.24	2.30	2.37	2.52
	HWLB 2008-020			2				45	4	36.8	HWLB	2.17	2.24	2.30	2.37	2.52
	HWLB 2008-020-6			2				50	6	38.0	HWLB	2.17	2.24	2.30	2.37	2.52
※	**HWLB 2008-025**			2.5				45	4	36.3	HWLB	2.69	2.77	2.85	2.94	3.13
※	**HWLB 2008-030S**	○		3				35	4	25.8	HWLB	3.21	3.30	3.40	3.51	3.74
	HWLB 2008-030			3				45	4	35.8	HWLB	3.21	3.30	3.40	3.51	3.74
	HWLB 2008-030-6			3				50	6	37.0	HWLB	3.21	3.30	3.40	3.51	3.74
※	**HWLB 2008-040S**	○		4				35	4	24.8	HWLB	4.24	4.37	4.50	4.65	4.97
	HWLB 2008-040		**R0.4**	4	0.64	0.79	16°	45	4	34.8	HWLB	4.24	4.37	4.50	4.65	4.97
	HWLB 2008-040-6			4				50	6	36.0	HWLB	4.24	4.37	4.50	4.65	4.97
	HWLB 2008-050			5				45	4	33.8	HWLB	5.27	5.43	5.60	5.78	6.19
※	**HWLB 2008-060S**	○		6				35	4	22.8	HWLB	6.30	6.50	6.70	6.92	7.42
	HWLB 2008-060			6				45	4	32.8	HWLB	6.30	6.50	6.70	6.92	7.42
※	**HWLB 2008-070**			7				45	4	31.8	HWLB	7.33	7.56	7.80	8.06	8.64
	HWLB 2008-080			8				45	4	30.8	HWLB	8.36	8.62	8.90	9.20	9.86
	HWLB 2008-100			10				50	4	33.8	HWLB	10.43	10.75	11.10	11.48	12.31
	HWLB 2008-120			12				50	4	31.8	HWLB	12.49	12.88	13.30	13.75	14.76
※	**HWLB 2008-160**			16				50	4	27.8	HWLB	16.62	17.14	17.71	18.31	19.65
※	**HWLB 2009-040**			4				45	4	35.0	HWLB	4.24	4.36	4.50	4.64	4.96
※	**HWLB 2009-080**		**R0.45**	8	0.72	0.89	16°	45	4	31.0	HWLB	8.36	8.62	8.90	9.19	9.85
※	**HWLB 2009-120**			12				50	4	32.0	HWLB	12.49	12.88	13.30	13.75	14.75
※	**HWLB 2010-015S**	○		1.5				35	4	27.6	HWLB	1.66	1.71	1.75	1.80	1.90
※	**HWLB 2010-015**			1.5				45	4	37.6	HWLB	1.66	1.71	1.75	1.80	1.90
※	**HWLB 2010-020S**	○		2				35	4	27.1	HWLB	2.18	2.24	2.30	2.36	2.51
	HWLB 2010-020			2				45	4	37.1	HWLB	2.18	2.24	2.30	2.36	2.51
※	**HWLB 2010-025S**	○		2.5				35	4	26.6	HWLB	2.70	2.77	2.85	2.93	3.12
	HWLB 2010-025			2.5				45	4	36.6	HWLB	2.70	2.77	2.85	2.93	3.12
※	**HWLB 2010-030S**	○		3				35	4	26.1	HWLB	3.21	3.30	3.40	3.50	3.73
	HWLB 2010-030			3				45	4	36.1	HWLB	3.21	3.30	3.40	3.50	3.73
	HWLB 2010-030-6			3				50	6	37.4	HWLB	3.21	3.30	3.40	3.50	3.73
※	**HWLB 2010-040S**	○		4				35	4	25.1	HWLB	4.24	4.37	4.50	4.64	4.96
	HWLB 2010-040			4				45	4	35.1	HWLB	4.24	4.37	4.50	4.64	4.96
	HWLB 2010-040-6		**R0.5**	4	0.8	0.98	16°	50	6	36.4	HWLB	4.24	4.37	4.50	4.64	4.96
	HWLB 2010-050			5				45	4	34.1	HWLB	5.28	5.43	5.60	5.78	6.18
	HWLB 2010-050-6			5				50	6	35.4	HWLB	5.28	5.43	5.60	5.78	6.18
※	**HWLB 2010-060S**	○		6				35	4	23.1	HWLB	6.31	6.50	6.70	6.92	7.40
	HWLB 2010-060			6				45	4	33.1	HWLB	6.31	6.50	6.70	6.92	7.40
	HWLB 2010-060-6			6				50	6	34.4	HWLB	6.31	6.50	6.70	6.92	7.40
	HWLB 2010-070			7				45	4	32.1	HWLB	7.34	7.56	7.80	8.06	8.63
※	**HWLB 2010-070-6**			7				50	6	33.4	HWLB	7.34	7.56	7.80	8.06	8.63
※	**HWLB 2010-080S**	○		8				40	4	26.1	HWLB	8.37	8.63	8.90	9.20	9.85
	HWLB 2010-080			8				45	4	31.1	HWLB	8.37	8.63	8.90	9.20	9.85
	HWLB 2010-080-6			8				50	6	32.4	HWLB	8.37	8.63	8.90	9.20	9.85

※ Additional model

	Model Number	Short Shank	Radius of Ball Nose R	Effective Length ℓ1	Length of Cut ℓ	Neck Diameter Ød1	Shank Taper Angle Bta	Overall Length L	Shank Diameter Ød	Shank Length H	Series	Effective Length by Inclined Angles 30′	1°	1°30′	2°	3°
	HWLB 2010-090			9				45	4	30.1	HWLB	9.40	9.69	10.00	10.34	11.08
※	**HWLB 2010-100S**	○		10				40	4	24.1	HWLB	10.43	10.76	11.10	11.47	12.30
	HWLB 2010-100			10				45	4	29.1	HWLB	10.43	10.76	11.10	11.47	12.30
	HWLB 2010-100-6			10				50	6	30.4	HWLB	10.43	10.76	11.10	11.47	12.30
	HWLB 2010-120			12				45	4	27.1	HWLB	12.50	12.89	13.30	13.75	14.75
	HWLB 2010-140		**R0.5**	14	0.8	0.98	16°	50	4	30.1	HWLB	14.56	15.02	15.51	16.03	17.19
	HWLB 2010-140-6			14				60	6	36.4	HWLB	14.56	15.02	15.51	16.03	17.19
	HWLB 2010-160			16				50	4	28.1	HWLB	16.62	17.15	17.71	18.31	19.64
	HWLB 2010-180			18				55	4	31.1	HWLB	18.68	19.28	19.91	20.58	22.09
	HWLB 2010-200			20				55	4	29.1	HWLB	20.75	21.41	22.11	22.86	24.54
※	**HWLB 2010-220-6**			22				70	6	38.4	HWLB	22.81	23.54	24.31	25.14	26.98
※	**HWLB 2012-020**			2				45	4	37.6	HWLB	2.03	2.08	2.13	2.19	2.32
	HWLB 2012-030			3				45	4	36.6	HWLB	3.07	3.15	3.24	3.33	3.54
	HWLB 2012-040			4				45	4	35.6	HWLB	4.10	4.21	4.34	4.47	4.76
	HWLB 2012-060			6				45	4	33.6	HWLB	6.16	6.34	6.54	6.75	7.21
	HWLB 2012-080		**R0.6**	8	0.96	1.19	16°	45	4	31.6	HWLB	8.22	8.47	8.74	9.02	9.66
	HWLB 2012-100			10				45	4	29.6	HWLB	10.29	10.60	10.94	11.30	12.10
	HWLB 2012-120			12				45	4	27.6	HWLB	12.35	12.73	13.14	13.58	14.55
※	**HWLB 2012-140**			14				50	4	30.6	HWLB	14.41	14.86	15.34	15.85	17.00
	HWLB 2012-160			16				50	4	28.6	HWLB	16.47	16.99	17.54	18.13	19.45
※	**HWLB 2014-060**			6				45	4	34.0	HWLB	6.19	6.37	6.57	6.77	7.23
※	**HWLB 2014-080**		**R0.7**	8	1.12	1.37	16°	45	4	32.0	HWLB	8.26	8.50	8.77	9.05	9.68
※	**HWLB 2014-120**			12				45	4	28.0	HWLB	12.38	12.76	13.17	13.60	14.57
※	**HWLB 2015-030S**	○		3				35	4	27.2	HWLB	3.10	3.18	3.26	3.35	3.55
	HWLB 2015-030			3				45	4	37.2	HWLB	3.10	3.18	3.26	3.35	3.55
※	**HWLB 2015-040S**	○		4				35	4	26.2	HWLB	4.13	4.24	4.36	4.49	4.77
	HWLB 2015-040			4				45	4	36.2	HWLB	4.13	4.24	4.36	4.49	4.77
※	**HWLB 2015-060S**	○		6				35	4	24.2	HWLB	6.19	6.37	6.56	6.76	7.22
	HWLB 2015-060			6				45	4	34.2	HWLB	6.19	6.37	6.56	6.76	7.22
	HWLB 2015-060-6			6				50	6	35.4	HWLB	6.19	6.37	6.56	6.76	7.22
※	**HWLB 2015-080S**	○		8				40	4	27.2	HWLB	8.25	8.50	8.76	9.04	9.67
	HWLB 2015-080			8				45	4	32.2	HWLB	8.25	8.50	8.76	9.04	9.67
	HWLB 2015-080-6			8				50	6	33.4	HWLB	8.25	8.50	8.76	9.04	9.67
※	**HWLB 2015-100S**	○	**R0.75**	10	1.2	1.47	16°	40	4	25.2	HWLB	10.32	10.63	10.96	11.32	12.11
	HWLB 2015-100			10				45	4	30.2	HWLB	10.32	10.63	10.96	11.32	12.11
	HWLB 2015-100-6			10				50	6	31.4	HWLB	10.32	10.63	10.96	11.32	12.11
	HWLB 2015-120			12				45	4	28.2	HWLB	12.38	12.76	13.16	13.60	14.56
	HWLB 2015-140			14				50	4	31.2	HWLB	14.44	14.89	15.36	15.87	17.01
	HWLB 2015-160			16				50	4	29.2	HWLB	16.50	17.02	17.57	18.15	19.46
※	**HWLB 2015-160-6**			16				60	6	35.4	HWLB	16.50	17.02	17.57	18.15	19.46
	HWLB 2015-180			18				55	4	32.2	HWLB	18.57	19.15	19.77	20.43	21.90
	HWLB 2015-200			20				55	4	30.2	HWLB	20.63	21.28	21.97	22.71	24.35
※	**HWLB 2015-220**			22				55	4	28.2	HWLB	22.69	23.41	24.17	24.98	No Interference
	HWLB 2015-250			25				65	4	35.2	HWLB	25.79	26.60	27.47	28.40	No Interference
※	**HWLB 2015-300**			30				70	4	35.2	HWLB	30.94	31.93	32.97	34.09	No Interference

※ Additional model

	Model Number	Short Shank	Radius of Ball Nose R	Effective Length ℓ_1	Length of Cut ℓ	Neck Diameter $\varnothing d_1$	Shank Taper Angle Bta	Overall Length L	Shank Diameter $\varnothing d$	Shank Length H	Series	Effective Length by Inclined Angles				
												30′	1°	1°30′	2°	3°
	HWLB 2016-040		R0.8	4	1.28	1.58	16°	45	4	36.3	HWLB	4.11	4.22	4.34	4.46	4.74
	HWLB 2016-080			8				45	4	32.3	HWLB	8.23	8.48	8.74	9.02	9.64
	HWLB 2016-120			12				45	4	28.3	HWLB	12.36	12.74	13.14	13.57	14.53
	HWLB 2016-160			16				50	4	29.3	HWLB	16.49	17.00	17.54	18.12	19.42
	HWLB 2016-200			20				55	4	30.3	HWLB	20.61	21.26	21.94	22.68	No Interference
※	HWLB 2018-040		R0.9	4	1.44	1.78	16°	45	4	36.7	HWLB	4.11	4.21	4.33	4.45	4.72
	HWLB 2018-060			6				45	4	34.7	HWLB	6.17	6.34	6.53	6.72	7.17
※	HWLB 2018-080			8				45	4	32.7	HWLB	8.23	8.47	8.73	9.00	9.61
	HWLB 2018-100			10				45	4	30.7	HWLB	10.29	10.60	10.93	11.28	12.06
※	HWLB 2018-120			12				45	4	28.7	HWLB	12.36	12.73	13.13	13.56	14.51
	HWLB 2018-160			16				50	4	29.7	HWLB	16.48	16.99	17.53	18.11	19.40
	HWLB 2018-200			20				55	4	30.7	HWLB	20.61	21.25	21.93	22.67	No Interference
	HWLB 2018-300			30				70	4	35.7	HWLB	30.92	31.90	32.94	No Interference	No Interference
※	HWLB 2020-030S	○	R1	3	1.6	1.98	16°	35	4	28.1	HWLB	3.07	3.14	3.21	3.29	3.47
	HWLB 2020-030			3				45	4	38.1	HWLB	3.07	3.14	3.21	3.29	3.47
※	HWLB 2020-040S	○		4				35	4	27.1	HWLB	4.10	4.21	4.32	4.43	4.70
	HWLB 2020-040			4				45	4	37.1	HWLB	4.10	4.21	4.32	4.43	4.70
	HWLB 2020-040-6			4				50	6	38.4	HWLB	4.10	4.21	4.32	4.43	4.70
※	HWLB 2020-060S	○		6				35	4	25.1	HWLB	6.17	6.33	6.52	6.71	7.14
	HWLB 2020-060			6				45	4	35.1	HWLB	6.17	6.33	6.52	6.71	7.14
	HWLB 2020-060-6			6				50	6	36.4	HWLB	6.17	6.33	6.52	6.71	7.14
※	HWLB 2020-080S	○		8				40	4	28.1	HWLB	8.23	8.46	8.72	8.99	9.59
	HWLB 2020-080			8				45	4	33.1	HWLB	8.23	8.46	8.72	8.99	9.59
	HWLB 2020-080-6			8				50	6	34.4	HWLB	8.23	8.46	8.72	8.99	9.59
※	HWLB 2020-100S	○		10				40	4	26.1	HWLB	10.29	10.59	10.92	11.27	12.04
	HWLB 2020-100			10				45	4	31.1	HWLB	10.29	10.59	10.92	11.27	12.04
	HWLB 2020-100-6			10				50	6	32.4	HWLB	10.29	10.59	10.92	11.27	12.04
※	HWLB 2020-120S	○		12				40	4	24.1	HWLB	12.35	12.72	13.12	13.54	14.49
	HWLB 2020-120			12				45	4	29.1	HWLB	12.35	12.72	13.12	13.54	14.49
	HWLB 2020-120-6			12				50	6	30.4	HWLB	12.35	12.72	13.12	13.54	14.49
※	HWLB 2020-140S	○		14				45	4	27.1	HWLB	14.42	14.85	15.32	15.82	16.93
	HWLB 2020-140			14				50	4	32.1	HWLB	14.42	14.85	15.32	15.82	16.93
※	HWLB 2020-160S	○		16				45	4	25.1	HWLB	16.48	16.98	17.52	18.10	19.38
	HWLB 2020-160			16				50	4	30.1	HWLB	16.48	16.98	17.52	18.10	19.38
	HWLB 2020-160-6			16				60	6	36.4	HWLB	16.48	16.98	17.52	18.10	19.38
※	HWLB 2020-180S	○		18				45	4	23.1	HWLB	18.54	19.11	19.72	20.37	No Interference
	HWLB 2020-180			18				55	4	33.1	HWLB	18.54	19.11	19.72	20.37	No Interference
※	HWLB 2020-200S	○		20				50	4	26.1	HWLB	20.60	21.24	21.92	22.65	No Interference
	HWLB 2020-200			20				55	4	31.1	HWLB	20.60	21.24	21.92	22.65	No Interference
	HWLB 2020-200-6			20				70	6	42.4	HWLB	20.60	21.24	21.92	22.65	24.28
	HWLB 2020-220			22				60	4	34.1	HWLB	22.67	23.37	24.12	24.93	No Interference
	HWLB 2020-250			25				65	4	36.1	HWLB	25.76	26.57	27.43	28.35	No Interference
※	HWLB 2020-250-6			25				80	6	47.4	HWLB	25.76	26.57	27.43	28.35	30.39
	HWLB 2020-300			30				70	4	36.1	HWLB	30.92	31.89	32.93	No Interference	No Interference
※	HWLB 2020-300-6			30				80	6	42.4	HWLB	30.92	31.89	32.93	34.04	36.51

※ Additional model

	Model Number	Short Shank	Radius of Ball Nose R	Effective Length ℓ1	Length of Cut ℓ	Neck Diameter Ød1	Shank Taper Angle Bta	Overall Length L	Shank Diameter Ød	Shank Length H	Series	Effective Length by Inclined Angles 30′	1°	1°30′	2°	3°
	HWLB 2020-350		R1	35	1.6	1.98	16°	80	4	41.1	HWLB	36.08	37.21	38.43	No Interference	No Interference
	HWLB 2020-400			40				80	4	36.1	HWLB	41.23	42.54	No Interference	No Interference	No Interference
	HWLB 2025-060		R1.25	6	2	2.45	16°	45	4	36.0	HWLB	6.21	6.37	6.55	6.74	7.15
	HWLB 2025-100			10				45	4	32.0	HWLB	10.34	10.63	10.95	11.29	12.05
	HWLB 2025-150			15				50	4	32.0	HWLB	15.49	15.96	16.45	16.98	No Interference
	HWLB 2025-200			20				55	4	32.0	HWLB	20.65	21.28	21.96	22.68	No Interference
	HWLB 2025-250			25				65	4	37.0	HWLB	25.81	26.61	27.46	No Interference	No Interference
※	HWLB 2025-300			30				70	4	37.0	HWLB	30.96	31.93	No Interference	No Interference	No Interference
	HWLB 2030-060-3		R1.5	6	2.4	2.95	—	60	3	51.5	HWLB	No Interference	No Interference	No Interference	No Interference	No Interference
※	HWLB 2030-060-4S	○		6			16°	35	4	26.9	HWLB	6.19	6.35	6.51	6.69	7.09
	HWLB 2030-060-4			6				60	4	51.9	HWLB	6.19	6.35	6.51	6.69	7.09
	HWLB 2030-060			6				60	6	48.2	HWLB	6.19	6.35	6.51	6.69	7.09
※	HWLB 2030-080-4S	○		8				40	4	29.9	HWLB	8.26	8.48	8.72	8.97	9.54
	HWLB 2030-080			8				60	6	46.2	HWLB	8.26	8.48	8.72	8.97	9.54
※	HWLB 2030-100-4S	○		10				40	4	27.9	HWLB	10.32	10.61	10.92	11.25	No Interference
	HWLB 2030-100			10				60	6	44.2	HWLB	10.32	10.61	10.92	11.25	11.98
※	HWLB 2030-120-4S	○		12				40	4	25.9	HWLB	12.38	12.74	13.12	13.52	No Interference
	HWLB 2030-120			12				60	6	42.2	HWLB	12.38	12.74	13.12	13.52	14.43
	HWLB 2030-140			14				60	6	40.2	HWLB	14.45	14.87	15.32	15.80	16.88
※	HWLB 2030-160-4S	○		16				45	4	26.9	HWLB	16.51	17.00	17.52	No Interference	No Interference
	HWLB 2030-160			16				60	6	38.2	HWLB	16.51	17.00	17.52	18.08	19.33
	HWLB 2030-180			18				60	6	36.2	HWLB	18.57	19.13	19.72	20.36	21.77
※	HWLB 2030-200-4S	○		20				50	4	27.9	HWLB	20.63	21.26	No Interference	No Interference	No Interference
	HWLB 2030-200			20				70	6	44.2	HWLB	20.63	21.26	21.92	22.63	24.22
※	HWLB 2030-220			22				70	6	42.2	HWLB	22.70	23.39	24.12	24.91	26.67
	HWLB 2030-250			25				70	6	39.2	HWLB	25.79	26.58	27.42	28.33	30.34
	HWLB 2030-300			30				70	6	34.2	HWLB	30.95	31.91	32.93	34.02	No Interference
	HWLB 2030-350			35				80	6	39.2	HWLB	36.10	37.23	38.43	39.71	No Interference
	HWLB 2030-400			40				80	6	34.2	HWLB	41.26	42.55	43.93	No Interference	No Interference
※	HWLB 2035-100		R1.75	10	2.8	3.45	16°	60	6	45.1	HWLB	10.31	10.59	10.88	11.21	11.92
※	HWLB 2035-200			20				65	6	40.1	HWLB	20.62	21.23	21.89	22.59	24.16
※	HWLB 2035-300			30				70	6	35.1	HWLB	30.93	31.88	32.89	33.98	No Interference
※	HWLB 2040-080-4S	○	R2	8	3.2	3.95	—	35	4	24.8	HWLB	No Interference	No Interference	No Interference	No Interference	No Interference
	HWLB 2040-080-4			8				70	4	59.8	HWLB	No Interference	No Interference	No Interference	No Interference	No Interference
	HWLB 2040-080			8			16°	70	6	58.0	HWLB	8.24	8.45	8.67	8.90	9.43
※	HWLB 2040-100-4S	○		10			—	40	4	30.0	HWLB	No Interference	No Interference	No Interference	No Interference	No Interference
	HWLB 2040-100			10			16°	70	6	56.0	HWLB	10.30	10.58	10.87	11.18	11.88
※	HWLB 2040-120-4S	○		12			—	40	4	28.0	HWLB	No Interference	No Interference	No Interference	No Interference	No Interference
	HWLB 2040-120			12			16°	70	6	54.0	HWLB	12.37	12.71	13.07	13.46	14.32
	HWLB 2040-140			14				70	6	52.0	HWLB	14.43	14.84	15.27	15.73	16.77
※	HWLB 2040-160-4S	○		16			—	45	4	29.0	HWLB	No Interference	No Interference	No Interference	No Interference	No Interference
	HWLB 2040-160			16			16°	70	6	50.0	HWLB	16.49	16.97	17.47	18.01	19.22
	HWLB 2040-180			18				70	6	48.0	HWLB	18.56	19.10	19.67	20.29	No Interference
※	HWLB 2040-200-4S	○		20			—	50	4	30.0	HWLB	No Interference	No Interference	No Interference	No Interference	No Interference
	HWLB 2040-200			20			16°	70	6	46.0	HWLB	20.62	21.22	21.87	22.57	No Interference

※ Additional model

	Model Number	Short Shank	Radius of Ball Nose R	Effective Length ℓ_1	Length of Cut ℓ	Neck Diameter $\varnothing d_1$	Shank Taper Angle Bta	Overall Length L	Shank Diameter $\varnothing d$	Shank Length H	Series	Effective Length by Inclined Angles				
												30′	1°	1°30′	2°	3°
※	**HWLB 2040-220**			22			16°	70	6	44.0	HWLB	22.68	23.35	24.07	24.84	No Interference
※	**HWLB 2040-250-4S**	○		25			—	55	4	30.0	HWLB	No Interference	No Interference	No Interference	No Interference	No Interference
	HWLB 2040-250			25			16°	70	6	41.0	HWLB	25.78	26.55	27.37	28.26	No Interference
※	**HWLB 2040-300-4S**	○		30			—	60	4	30.0	HWLB	No Interference	No Interference	No Interference	No Interference	No Interference
	HWLB 2040-300		**R2**	30				70	6	36.0	HWLB	30.93	31.87	32.88	No Interference	No Interference
	HWLB 2040-350			35	3.2	3.95	16°	80	6	41.0	HWLB	36.09	37.20	38.38	No Interference	No Interference
	HWLB 2040-400			40				90	6	46.0	HWLB	41.25	42.52	No Interference	No Interference	No Interference
	HWLB 2040-450			45				90	6	41.0	HWLB	46.40	47.85	No Interference	No Interference	No Interference
※	**HWLB 2040-500**			50				100	6	46.0	HWLB	51.56	53.17	No Interference	No Interference	No Interference
※	**HWLB 2040-600**			60				120	6	56.0	HWLB	61.87	No Interference	No Interference	No Interference	No Interference
	HWLB 2050-100			10				70	6	57.9	HWLB	10.29	10.55	10.82	11.11	11.77
	HWLB 2050-150			15				70	6	52.9	HWLB	15.45	15.87	16.32	16.81	No Interference
	HWLB 2050-200		**R2.5**	20	4	4.95	16°	70	6	47.9	HWLB	20.60	21.19	21.82	No Interference	No Interference
	HWLB 2050-250			25				70	6	42.9	HWLB	25.76	26.52	No Interference	No Interference	No Interference
	HWLB 2050-300			30				80	6	47.9	HWLB	30.92	31.84	No Interference	No Interference	No Interference
※	**HWLB 2050-400**			40				90	6	47.9	HWLB	41.23	No Interference	No Interference	No Interference	No Interference
	HWLB 2060-100			10				80	6	65.6	HWLB	No Interference	No Interference	No Interference	No Interference	No Interference
※	**HWLB 2060-150S**	○		15				45	6	30.0	HWLB	No Interference	No Interference	No Interference	No Interference	No Interference
	HWLB 2060-150			15				80	6	65.0	HWLB	No Interference	No Interference	No Interference	No Interference	No Interference
※	**HWLB 2060-200S**	○		20				50	6	30.0	HWLB	No Interference	No Interference	No Interference	No Interference	No Interference
	HWLB 2060-200			20				80	6	60.0	HWLB	No Interference	No Interference	No Interference	No Interference	No Interference
	HWLB 2060-250			25				80	6	55.0	HWLB	No Interference	No Interference	No Interference	No Interference	No Interference
※	**HWLB 2060-300S**	○	**R3**	30	4.8	5.95	—	60	6	30.0	HWLB	No Interference	No Interference	No Interference	No Interference	No Interference
	HWLB 2060-300			30				80	6	50.0	HWLB	No Interference	No Interference	No Interference	No Interference	No Interference
	HWLB 2060-350			35				80	6	45.0	HWLB	No Interference	No Interference	No Interference	No Interference	No Interference
	HWLB 2060-400			40				90	6	50.0	HWLB	No Interference	No Interference	No Interference	No Interference	No Interference
	HWLB 2060-450			45				100	6	55.0	HWLB	No Interference	No Interference	No Interference	No Interference	No Interference
	HWLB 2060-500			50				120	6	70.0	HWLB	No Interference	No Interference	No Interference	No Interference	No Interference
	HWLB 2060-600			60				120	6	60.0	HWLB	No Interference	No Interference	No Interference	No Interference	No Interference

※ Additional model

HWLB/HWLB-S Milling Conditions

WORK MATERIAL			PREHARDENED STEELS/ HARDENED STEELS NAK / STAVAX (~55HRC)				HARDENED STEELS SKD11 (55~62HRC)				HARDENED STEELS HAP10 (62~66HRC)				HARDENED STEELS HAP72 (66~70HRC)			
Model Number	Radius of Ball Nose (mm)	Effective Length (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)
2001	**R0.05**	0.2	48,000	55	0.002	0.002	48,000	45	0.002	0.002	48,000	45	0.002	0.002	36,000	22	0.002	0.002
		0.3	48,000	55	0.002	0.002	48,000	45	0.002	0.002	48,000	45	0.002	0.002	36,000	22	0.002	0.002
		0.4	48,000	50	0.002	0.002	48,000	40	0.002	0.002	48,000	40	0.002	0.002	36,000	20	0.002	0.002
		0.5	48,000	35	0.002	0.002	48,000	35	0.002	0.002	48,000	35	0.002	0.002	36,000	17	0.002	0.002
20015	**R0.075**	0.3	48,000	90	0.004	0.004	48,000	70	0.004	0.004	48,000	70	0.004	0.004	36,000	35	0.004	0.004
		0.5	48,000	60	0.004	0.004	48,000	50	0.004	0.004	48,000	50	0.004	0.004	36,000	25	0.004	0.004
		1	48,000	60	0.001	0.002	48,000	20	0.001	0.002	48,000	20	0.001	0.002	36,000	10	0.001	0.002
2002	**R0.1**	0.3	60,000	200	0.003	0.005	60,000	200	0.002	0.003	60,000	130	0.002	0.003	45,000	65	0.002	0.003
		0.5	60,000	200	0.003	0.005	60,000	200	0.002	0.003	60,000	130	0.002	0.003	45,000	65	0.002	0.003
		0.75	60,000	200	0.003	0.005	60,000	200	0.002	0.003	60,000	130	0.002	0.003	45,000	65	0.002	0.003
		1	60,000	200	0.003	0.005	60,000	200	0.002	0.003	60,000	130	0.002	0.003	45,000	65	0.002	0.003
		1.25	60,000	160	0.002	0.004	54,000	140	0.001	0.002	54,000	95	0.001	0.002	40,500	45	0.001	0.002
		1.5	60,000	130	0.002	0.003	48,000	80	0.001	0.002	48,000	65	0.001	0.002	36,000	30	0.001	0.002
		1.75	60,000	110	0.001	0.002	48,000	60	0.001	0.001	48,000	50	0.001	0.001	36,000	25	0.001	0.001
		2	60,000	90	0.001	0.002	48,000	50	0.001	0.001	48,000	40	0.001	0.001	36,000	20	0.001	0.001
		2.5	46,850	60	0.001	0.001	40,450	30	0.001	0.001	40,450	20	0.001	0.001	30,350	10	0.001	0.001
		3	33,750	30	0.001	0.001	33,600	20	0.001	0.001	33,600	15	0.001	0.001	25,200	7	0.001	0.001
2003	**R0.15**	0.5	60,000	350	0.006	0.008	45,000	310	0.004	0.007	43,500	180	0.003	0.005	32,500	90	0.003	0.005
		0.75	60,000	350	0.006	0.008	45,000	310	0.004	0.007	43,500	180	0.003	0.005	32,500	90	0.003	0.005
		1	60,000	350	0.006	0.008	45,000	310	0.004	0.007	43,500	180	0.003	0.005	32,500	90	0.003	0.005
		1.25	60,000	350	0.006	0.008	45,000	310	0.004	0.007	43,500	180	0.003	0.005	32,500	90	0.003	0.005
		1.5	60,000	350	0.006	0.008	45,000	310	0.004	0.007	43,500	180	0.003	0.005	32,500	90	0.003	0.005
		2	60,000	210	0.004	0.007	45,000	190	0.003	0.005	43,500	110	0.002	0.004	32,500	55	0.002	0.004
		2.5	51,250	175	0.003	0.005	38,500	135	0.002	0.004	37,750	85	0.001	0.003	28,300	40	0.001	0.003
		3	42,500	140	0.002	0.004	32,000	80	0.002	0.004	32,000	65	0.001	0.002	24,000	30	0.001	0.002
		3.5	33,200	90	0.002	0.003	27,300	60	0.002	0.003	27,200	40	0.001	0.002	20,400	20	0.001	0.002
		4	23,900	45	0.001	0.001	22,550	30	0.001	0.001	22,300	20	0.001	0.001	16,720	10	0.001	0.001
		4.5	22,500	40	0.001	0.001	21,300	30	0.001	0.001	20,900	20	0.001	0.001	15,700	10	0.001	0.001
		5	21,000	30	0.001	0.001	20,000	20	0.001	0.001	19,500	10	0.001	0.001	14,600	5	0.001	0.001
2004	**R0.2**	0.5	50,000	500	0.01	0.02	37,500	420	0.007	0.012	35,000	240	0.005	0.008	26,250	120	0.005	0.008
		0.75	50,000	500	0.01	0.02	37,500	420	0.007	0.012	35,000	240	0.005	0.008	26,250	120	0.005	0.008
		1	50,000	500	0.01	0.02	37,500	420	0.007	0.012	35,000	240	0.005	0.008	26,250	120	0.005	0.008
		1.5	50,000	500	0.01	0.02	37,500	420	0.007	0.012	35,000	240	0.005	0.008	26,250	120	0.005	0.008
		2	50,000	500	0.01	0.02	37,500	420	0.007	0.012	35,000	240	0.005	0.008	26,250	120	0.005	0.008
		2.5	45,000	360	0.007	0.012	34,500	300	0.005	0.008	32,500	190	0.004	0.007	24,300	95	0.004	0.007
		3	40,000	250	0.005	0.008	31,900	210	0.004	0.008	30,500	160	0.003	0.005	22,800	80	0.003	0.005
		3.5	36,000	210	0.004	0.007	28,700	180	0.003	0.006	27,400	140	0.002	0.004	20,550	70	0.002	0.004
		4	32,000	180	0.003	0.005	25,500	150	0.002	0.004	24,300	120	0.002	0.004	18,200	60	0.002	0.004
		4.5	28,500	150	0.002	0.004	23,500	125	0.002	0.003	22,400	100	0.001	0.003	16,800	50	0.001	0.003
		5	25,000	120	0.002	0.003	21,500	100	0.001	0.002	20,500	80	0.001	0.002	15,350	40	0.001	0.002
		6	18,000	60	0.001	0.002	18,000	60	0.001	0.002	17,000	45	0.001	0.002	12,750	20	0.001	0.002

HWLB/HWLB-S Milling Conditions

WORK MATERIAL			PREHARDENED STEELS/ HARDENED STEELS NAK / STAVAX (~55HRC)				HARDENED STEELS SKD11 (55~62HRC)				HARDENED STEELS HAP10 (62~66HRC)				HARDENED STEELS HAP72 (66~70HRC)			
Model Number	Radius of Ball Nose (mm)	Effective Length (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)
2005	**R0.25**	0.75	44,000	650	0.015	0.04	33,000	530	0.01	0.02	30,000	300	0.007	0.01	22,500	150	0.007	0.01
		1	44,000	650	0.015	0.04	33,000	530	0.01	0.02	30,000	300	0.007	0.01	22,500	150	0.007	0.01
		1.5	44,000	650	0.015	0.04	33,000	530	0.01	0.02	30,000	300	0.007	0.01	22,500	150	0.007	0.01
		2	44,000	650	0.015	0.04	33,000	530	0.01	0.02	30,000	300	0.007	0.01	22,500	150	0.007	0.01
		2.5	44,000	650	0.015	0.04	33,000	530	0.01	0.02	30,000	300	0.007	0.01	22,500	150	0.007	0.01
		3	40,000	500	0.01	0.02	31,000	400	0.007	0.01	28,550	230	0.005	0.008	21,400	115	0.005	0.008
		3.5	36,350	340	0.007	0.017	29,000	270	0.005	0.008	27,100	160	0.003	0.006	20,300	80	0.003	0.006
		4	32,700	180	0.005	0.015	27,150	150	0.003	0.008	25,650	100	0.002	0.005	19,900	50	0.002	0.005
		4.5	29,900	150	0.004	0.01	25,700	130	0.002	0.007	24,500	85	0.002	0.004	18,350	43	0.002	0.004
		5	27,000	135	0.003	0.008	24,200	110	0.002	0.005	23,500	75	0.002	0.004	17,600	35	0.002	0.004
		6	21,350	90	0.002	0.005	21,300	75	0.001	0.003	21,300	50	0.001	0.002	16,000	25	0.001	0.002
		7	18,600	75	0.001	0.004	18,600	55	0.001	0.002	18,600	35	0.001	0.002	13,950	17	0.001	0.002
		8	15,900	60	0.001	0.003	15,900	40	0.001	0.002	15,900	25	0.001	0.002	11,950	12	0.001	0.002
		10	14,900	50	0.001	0.002	13,600	20	0.001	0.001	13,600	15	0.001	0.001	10,200	7	0.001	0.001
2006	**R0.3**	1	40,000	1,400	0.045	0.15	30,000	1,500	0.03	0.13	26,500	1,000	0.015	0.09	20,000	500	0.015	0.09
		1.25	40,000	1,250	0.035	0.14	30,000	1,350	0.025	0.11	26,500	900	0.01	0.08	20,000	450	0.01	0.08
		1.5	40,000	1,100	0.03	0.13	30,000	1,200	0.02	0.1	26,500	800	0.01	0.075	20,000	400	0.01	0.075
		2	40,000	1,100	0.03	0.13	30,000	1,200	0.02	0.1	26,500	800	0.01	0.075	20,000	400	0.01	0.075
		2.5	40,000	800	0.02	0.1	30,000	800	0.015	0.09	26,500	520	0.008	0.065	20,000	260	0.008	0.065
		3	40,000	800	0.02	0.1	30,000	800	0.015	0.09	26,500	520	0.008	0.065	20,000	260	0.008	0.065
		3.5	40,000	500	0.015	0.09	30,000	500	0.01	0.075	26,500	340	0.006	0.05	20,000	170	0.006	0.05
		4	40,000	500	0.015	0.09	30,000	500	0.01	0.075	26,500	340	0.006	0.05	20,000	170	0.006	0.05
		4.5	32,000	400	0.01	0.075	25,000	390	0.007	0.05	23,000	260	0.005	0.04	18,000	130	0.005	0.04
		5	32,000	400	0.01	0.075	25,000	390	0.007	0.05	23,000	260	0.005	0.04	18,000	130	0.005	0.04
		6	24,000	300	0.007	0.06	21,000	320	0.005	0.04	19,500	210	0.004	0.03	15,000	105	0.004	0.03
		7	20,000	250	0.006	0.05	18,500	280	0.004	0.03	17,500	180	0.003	0.02	13,100	90	0.003	0.02
		8	16,000	200	0.005	0.05	16,000	240	0.003	0.02	16,000	160	0.003	0.02	12,000	80	0.003	0.02
		9	15,450	185	0.004	0.035	15,450	200	0.002	0.017	15,450	135	0.002	0.017	11,580	65	0.002	0.017
		10	14,900	175	0.003	0.02	14,900	175	0.002	0.015	14,900	115	0.002	0.015	11,100	55	0.002	0.015
		12	13,800	150	0.002	0.015	13,800	110	0.001	0.01	13,800	70	0.001	0.01	10,350	35	0.001	0.01
2007	**R0.35**	2	37,000	1,350	0.045	0.17	28,500	1,400	0.03	0.135	25,000	900	0.015	0.1	18,750	450	0.015	0.1
		4	31,250	920	0.035	0.15	25,750	975	0.025	0.12	23,750	650	0.012	0.09	17,800	325	0.012	0.09
		6	25,500	500	0.025	0.13	23,000	550	0.02	0.11	22,500	400	0.01	0.08	16,850	200	0.01	0.08
2008	**R0.4**	1.5	35,000	1,700	0.065	0.22	27,000	1,700	0.045	0.18	23,500	1,050	0.022	0.13	17,500	520	0.022	0.13
		2	35,000	1,600	0.06	0.21	27,000	1,600	0.04	0.17	23,500	1,000	0.02	0.12	17,500	500	0.02	0.12
		2.5	35,000	1,500	0.055	0.2	27,000	1,500	0.035	0.16	23,500	950	0.018	0.11	17,500	480	0.018	0.11
		3	35,000	1,400	0.05	0.19	27,000	1,400	0.03	0.15	23,500	900	0.015	0.1	17,500	450	0.015	0.1
		4	35,000	1,200	0.04	0.17	27,000	1,200	0.025	0.135	23,500	600	0.012	0.095	17,500	300	0.012	0.095
		5	31,500	900	0.03	0.15	25,000	900	0.02	0.12	22,000	500	0.01	0.085	16,500	250	0.01	0.085
		6	28,000	600	0.02	0.12	23,000	600	0.012	0.095	20,500	400	0.006	0.065	15,500	200	0.006	0.065
		7	23,750	460	0.016	0.105	20,500	480	0.009	0.08	18,750	340	0.005	0.062	14,000	170	0.005	0.062
		8	19,500	330	0.012	0.095	18,000	375	0.007	0.07	17,000	285	0.005	0.06	12,750	140	0.005	0.06
		10	15,000	260	0.01	0.085	14,700	340	0.005	0.06	14,650	225	0.004	0.05	11,000	110	0.004	0.05
		12	14,000	220	0.005	0.06	13,700	290	0.003	0.04	13,650	140	0.002	0.03	10,250	70	0.002	0.03
		16	13,300	185	0.003	0.02	11,100	150	0.001	0.013	11,100	90	0.001	0.013	8,300	45	0.001	0.013

HWLB/HWLB-S Milling Conditions

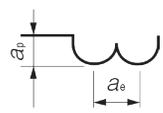
WORK MATERIAL			PREHARDENED STEELS/ HARDENED STEELS NAK / STAVAX (~55HRC)				HARDENED STEELS SKD11 (55~62HRC)				HARDENED STEELS HAP10 (62~66HRC)				HARDENED STEELS HAP72 (66~70HRC)			
Model Number	Radius of Ball Nose (mm)	Effective Length (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)
2009	**R0.45**	4	32,500	1,650	0.08	0.25	25,500	1,800	0.04	0.18	22,000	1,300	0.02	0.13	16,500	650	0.02	0.13
		8	25,500	700	0.015	0.11	18,500	500	0.01	0.09	18,500	420	0.01	0.09	13,850	210	0.01	0.09
		12	15,000	280	0.01	0.09	13,300	300	0.006	0.07	13,300	220	0.006	0.07	10,000	110	0.006	0.07
2010	**R0.5**	1.5	30,000	1,750	0.2	0.4	24,000	2,000	0.1	0.3	21,000	1,750	0.05	0.2	16,000	880	0.05	0.2
		2	30,000	1,750	0.2	0.4	24,000	2,000	0.1	0.3	21,000	1,750	0.05	0.2	16,000	875	0.05	0.2
		2.5	30,000	1,750	0.2	0.4	24,000	2,000	0.1	0.3	21,000	1,750	0.05	0.2	16,000	875	0.05	0.2
		3	30,000	1,750	0.1	0.3	24,000	2,000	0.05	0.2	21,000	1,750	0.03	0.17	16,000	875	0.03	0.17
		4	30,000	1,750	0.1	0.3	24,000	2,000	0.05	0.2	21,000	1,750	0.03	0.17	16,000	875	0.03	0.17
		5	30,000	1,750	0.1	0.3	24,000	2,000	0.05	0.2	21,000	1,750	0.03	0.17	16,000	875	0.03	0.17
		6	30,000	1,150	0.06	0.23	21,500	1,250	0.03	0.17	19,700	1,050	0.025	0.15	14,500	525	0.025	0.15
		7	24,250	800	0.04	0.19	20,000	900	0.02	0.14	19,000	750	0.02	0.14	14,250	375	0.02	0.14
		8	24,000	800	0.025	0.155	18,500	580	0.015	0.12	18,400	480	0.015	0.12	13,800	240	0.015	0.12
		9	23,000	700	0.021	0.14	16,650	500	0.012	0.1	16,550	420	0.012	0.1	12,400	210	0.012	0.1
		10	22,000	600	0.018	0.13	14,800	430	0.01	0.09	14,700	360	0.01	0.09	11,100	180	0.01	0.09
		12	14,150	320	0.015	0.12	13,400	380	0.008	0.08	13,300	290	0.008	0.08	9,950	145	0.008	0.08
		14	13,500	280	0.012	0.1	12,000	350	0.007	0.08	12,000	220	0.007	0.08	9,000	110	0.007	0.08
		16	12,750	240	0.008	0.08	10,500	250	0.005	0.045	10,500	160	0.005	0.045	7,850	80	0.005	0.045
		18	12,350	220	0.006	0.065	9,750	200	0.004	0.035	9,750	130	0.004	0.035	7,300	65	0.004	0.035
		20	12,000	200	0.005	0.03	9,000	150	0.003	0.02	9,000	100	0.003	0.02	6,750	50	0.003	0.02
		22	12,000	150	0.003	0.02	9,000	110	0.002	0.012	9,000	75	0.002	0.012	6,750	35	0.002	0.012
2012	**R0.6**	2	30,000	2,000	0.12	0.36	20,000	2,000	0.06	0.24	17,500	1,750	0.036	0.2	13,100	880	0.036	0.2
		3	30,000	2,000	0.12	0.36	20,000	2,000	0.06	0.24	17,500	1,750	0.036	0.2	13,100	875	0.036	0.2
		4	30,000	2,000	0.12	0.36	20,000	2,000	0.06	0.24	17,500	1,750	0.036	0.2	13,100	875	0.036	0.2
		6	30,000	2,000	0.12	0.36	20,000	2,000	0.06	0.24	17,500	1,750	0.036	0.2	13,100	875	0.036	0.2
		8	20,200	800	0.05	0.23	16,600	900	0.025	0.17	15,850	750	0.025	0.17	11,900	375	0.025	0.17
		10	15,500	480	0.03	0.18	15,500	580	0.015	0.13	15,350	480	0.015	0.13	11,500	240	0.015	0.13
		12	12,400	360	0.02	0.15	12,400	430	0.01	0.095	12,250	360	0.01	0.095	9,200	180	0.01	0.095
		14	11,850	320	0.018	0.14	11,200	380	0.008	0.085	11,100	290	0.008	0.085	8,300	145	0.008	0.085
		16	11,300	280	0.014	0.12	10,000	360	0.007	0.08	10,000	230	0.007	0.08	7,500	115	0.007	0.08
2014	**R0.7**	6	25,200	2,000	0.13	0.42	17,150	2,000	0.065	0.27	15,000	1,750	0.036	0.23	11,250	875	0.036	0.23
		8	25,200	1,300	0.08	0.32	15,350	1,250	0.04	0.23	14,050	1,050	0.03	0.2	10,550	525	0.03	0.2
		12	13,500	450	0.035	0.21	12,500	460	0.025	0.18	12,000	300	0.02	0.16	9,000	150	0.02	0.16
2015	**R0.75**	3	30,000	2,450	0.25	0.55	17,000	2,000	0.12	0.4	15,000	1,750	0.06	0.29	11,250	875	0.06	0.29
		4	30,000	2,450	0.25	0.55	17,000	2,000	0.12	0.4	15,000	1,750	0.06	0.29	11,250	875	0.06	0.29
		6	30,000	2,450	0.15	0.45	17,000	2,000	0.07	0.31	15,000	1,750	0.04	0.24	11,250	875	0.04	0.24
		8	23,500	1,300	0.1	0.37	15,000	1,250	0.045	0.25	14,000	1,050	0.03	0.21	10,500	525	0.03	0.21
		10	23,500	560	0.035	0.23	15,000	680	0.025	0.2	14,000	580	0.025	0.2	10,500	290	0.025	0.2
		12	13,100	480	0.03	0.21	13,000	580	0.02	0.17	13,000	480	0.02	0.17	9,750	240	0.02	0.17
		14	11,200	400	0.025	0.19	10,900	485	0.015	0.145	10,900	385	0.015	0.145	8,200	190	0.015	0.145
		16	9,350	320	0.02	0.17	8,850	390	0.012	0.13	8,800	290	0.012	0.13	6,600	145	0.012	0.13
		18	9,150	300	0.019	0.165	8,400	370	0.011	0.125	8,400	255	0.011	0.125	6,300	125	0.011	0.125
		20	9,000	280	0.018	0.16	8,000	350	0.01	0.12	8,000	220	0.01	0.12	6,000	110	0.01	0.12
		22	8,580	245	0.014	0.13	7,150	320	0.008	0.12	7,150	165	0.008	0.12	5,350	80	0.008	0.12
		25	8,100	210	0.01	0.11	6,250	220	0.006	0.09	6,250	120	0.005	0.08	4,700	60	0.005	0.08
		30	7,600	175	0.006	0.04	5,370	135	0.004	0.03	5,370	75	0.003	0.03	4,000	35	0.003	0.03

HWLB/HWLB-S Milling Conditions

WORK MATERIAL			PREHARDENED STEELS/ HARDENED STEELS NAK / STAVAX (~55HRC)				HARDENED STEELS SKD11 (55~62HRC)				HARDENED STEELS HAP10 (62~66HRC)				HARDENED STEELS HAP72 (66~70HRC)			
Model Number	Radius of Ball Nose (mm)	Effective Length (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)
2016	**R0.8**	4	30,000	2,500	0.25	0.58	17,500	2,100	0.12	0.4	15,300	1,800	0.06	0.3	11,500	900	0.06	0.3
		8	30,000	2,500	0.16	0.48	17,500	2,100	0.08	0.32	15,300	1,800	0.05	0.275	11,500	900	0.05	0.275
		12	13,500	500	0.04	0.245	13,500	600	0.024	0.19	13,400	490	0.024	0.19	10,050	245	0.024	0.19
		16	10,800	375	0.03	0.21	10,800	450	0.016	0.15	10,700	370	0.016	0.15	8,000	185	0.016	0.15
		20	10,300	330	0.025	0.19	9,750	400	0.013	0.13	9,650	230	0.013	0.13	8,000	115	0.013	0.13
2018	**R0.9**	4	30,000	2,700	0.28	0.65	15,000	2,000	0.14	0.48	13,000	1,750	0.07	0.34	9,750	875	0.07	0.34
		6	30,000	2,700	0.18	0.54	15,000	2,000	0.07	0.34	13,000	1,750	0.04	0.26	9,750	875	0.04	0.26
		8	30,000	2,700	0.18	0.54	15,000	2,000	0.07	0.34	13,000	1,750	0.04	0.26	9,750	875	0.04	0.26
		10	25,750	2,000	0.14	0.48	14,400	1,650	0.06	0.32	12,900	1,425	0.035	0.24	9,700	713	0.035	0.24
		12	21,500	1,350	0.1	0.41	13,800	1,350	0.05	0.29	12,800	1,100	0.03	0.23	9,600	550	0.03	0.23
		16	15,550	390	0.032	0.23	11,700	490	0.016	0.18	11,150	400	0.01	0.14	8,400	200	0.01	0.14
		20	9,300	350	0.027	0.21	9,050	420	0.014	0.15	9,000	330	0.009	0.12	6,750	165	0.009	0.12
		30	8,000	240	0.015	0.15	7,000	250	0.009	0.07	7,000	160	0.006	0.06	5,250	80	0.006	0.06
2020	**R1**	3	28,000	2,900	0.3	0.7	14,000	2,100	0.15	0.5	12,250	1,800	0.08	0.35	9,200	900	0.08	0.35
		4	28,000	2,900	0.3	0.7	14,000	2,100	0.15	0.5	12,250	1,800	0.08	0.35	9,200	900	0.08	0.35
		6	28,000	2,900	0.2	0.6	14,000	2,100	0.1	0.4	12,250	1,800	0.06	0.3	9,200	900	0.06	0.3
		8	28,000	2,900	0.2	0.6	14,000	2,100	0.1	0.4	12,250	1,800	0.06	0.3	9,200	900	0.06	0.3
		10	28,000	2,900	0.2	0.6	14,000	2,100	0.1	0.4	12,250	1,800	0.06	0.3	9,200	900	0.06	0.3
		12	19,500	1,350	0.12	0.45	12,400	1,350	0.06	0.34	11,500	1,100	0.045	0.27	8,650	550	0.045	0.27
		14	19,500	1,350	0.12	0.45	12,400	1,350	0.06	0.34	11,500	1,100	0.045	0.27	8,650	550	0.045	0.27
		16	10,800	500	0.05	0.3	10,800	600	0.03	0.24	10,700	490	0.03	0.24	8,000	245	0.03	0.24
		18	9,700	435	0.04	0.28	9,700	520	0.025	0.22	9,650	430	0.025	0.22	7,250	215	0.025	0.22
		20	8,650	375	0.035	0.25	8,650	450	0.02	0.19	8,560	370	0.02	0.19	6,400	185	0.02	0.19
		22	8,450	350	0.032	0.245	8,200	440	0.018	0.18	8,200	330	0.018	0.18	6,150	165	0.018	0.18
		25	8,250	320	0.03	0.24	7,800	440	0.016	0.16	7,800	290	0.016	0.16	5,850	145	0.016	0.16
		30	7,850	280	0.024	0.2	7,000	350	0.014	0.16	7,000	220	0.014	0.16	5,250	110	0.014	0.16
		35	7,450	240	0.016	0.16	6,150	250	0.01	0.09	6,150	160	0.01	0.09	4,600	80	0.01	0.09
		40	7,000	200	0.01	0.06	5,250	150	0.006	0.04	5,250	100	0.006	0.04	3,950	50	0.006	0.04
2025	**R1.25**	6	25,000	3,000	0.35	0.85	12,400	2,200	0.17	0.6	11,000	1,850	0.1	0.45	8,250	920	0.1	0.45
		10	25,000	3,000	0.24	0.76	12,400	2,200	0.13	0.51	11,000	1,850	0.08	0.38	8,250	920	0.08	0.38
		15	17,300	1,400	0.145	0.57	11,000	1,400	0.08	0.44	10,300	1,140	0.06	0.35	7,700	570	0.06	0.35
		20	9,600	520	0.06	0.38	9,600	630	0.04	0.31	9,600	510	0.04	0.31	7,200	255	0.04	0.31
		25	6,900	375	0.042	0.32	6,900	450	0.024	0.235	6,840	370	0.024	0.235	5,150	185	0.024	0.235
		30	6,500	320	0.025	0.24	6,200	400	0.02	0.22	6,200	280	0.02	0.22	4,650	140	0.02	0.22
2030	**R1.5**	6	21,000	3,000	0.4	1	10,500	2,200	0.2	0.7	9,200	1,900	0.12	0.55	6,900	950	0.12	0.55
		8	21,000	3,000	0.4	1	10,500	2,200	0.2	0.7	9,200	1,900	0.12	0.55	6,900	950	0.12	0.55
		10	21,000	3,000	0.3	0.9	10,500	2,200	0.15	0.65	9,200	1,900	0.1	0.5	6,900	950	0.1	0.5
		12	21,000	3,000	0.3	0.9	10,500	2,200	0.15	0.65	9,200	1,900	0.1	0.5	6,900	950	0.1	0.5
		14	21,000	3,000	0.3	0.9	10,500	2,200	0.15	0.65	9,200	1,900	0.1	0.5	6,900	950	0.1	0.5
		16	21,000	3,000	0.3	0.9	10,500	2,200	0.15	0.65	9,200	1,900	0.1	0.5	6,900	950	0.1	0.5
		18	17,750	2,180	0.24	0.8	9,800	1,800	0.13	0.57	8,900	1,500	0.08	0.47	6,650	760	0.08	0.47
		20	14,500	1,360	0.18	0.7	9,250	1,400	0.1	0.5	8,600	1,150	0.075	0.45	6,450	575	0.075	0.45
		22	11,250	940	0.12	0.57	8,625	1,000	0.07	0.44	8,300	830	0.06	0.41	6,200	410	0.06	0.41
		25	8,000	520	0.07	0.45	8,000	630	0.05	0.38	8,000	510	0.05	0.38	6,000	255	0.05	0.38
		30	5,750	375	0.05	0.38	5,750	450	0.03	0.29	5,700	370	0.03	0.29	4,275	185	0.03	0.29
		35	5,550	335	0.045	0.36	5,350	440	0.025	0.27	5,350	310	0.025	0.27	4,000	155	0.025	0.27
		40	5,350	300	0.04	0.34	4,900	390	0.02	0.24	4,850	250	0.02	0.24	3,650	125	0.02	0.24

HWLB/HWLB-S Milling Conditions

WORK MATERIAL			PREHARDENED STEELS/ HARDENED STEELS NAK / STAVAX (~55HRC)				HARDENED STEELS SKD11 (55~62HRC)				HARDENED STEELS HAP10 (62~66HRC)				HARDENED STEELS HAP72 (66~70HRC)			
Model Number	Radius of Ball Nose (mm)	Effective Length (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)
2035	**R1.75**	10	19,000	3,000	0.35	1.05	10,000	2,200	0.17	0.75	8,400	1,900	0.11	0.61	6,300	950	0.11	0.61
		20	19,000	3,000	0.35	1.05	10,000	2,200	0.17	0.75	8,400	1,900	0.11	0.61	6,300	950	0.11	0.61
		30	6,900	520	0.08	0.52	6,900	630	0.06	0.45	6,900	510	0.06	0.45	5,200	255	0.06	0.45
2040	**R2**	8	18,000	3,200	0.5	1.3	9,000	2,300	0.25	0.95	7,900	2,000	0.15	0.75	5,900	1,000	0.15	0.75
		10	18,000	3,200	0.5	1.3	9,000	2,300	0.25	0.95	7,900	2,000	0.15	0.75	5,900	1,000	0.15	0.75
		12	18,000	3,200	0.4	1.2	9,000	2,300	0.2	0.85	7,900	2,000	0.13	0.7	5,900	1,000	0.13	0.7
		14	18,000	3,200	0.4	1.2	9,000	2,300	0.2	0.85	7,900	2,000	0.13	0.7	5,900	1,000	0.13	0.7
		16	18,000	3,200	0.4	1.2	9,000	2,300	0.2	0.85	7,900	2,000	0.13	0.7	5,900	1,000	0.13	0.7
		18	18,000	3,200	0.4	1.2	9,000	2,300	0.2	0.85	7,900	2,000	0.13	0.7	5,900	1,000	0.13	0.7
		20	18,000	3,200	0.4	1.2	9,000	2,300	0.2	0.85	7,900	2,000	0.13	0.7	5,900	1,000	0.13	0.7
		22	15,000	2,350	0.32	1.05	8,500	1,850	0.16	0.75	7,650	1,600	0.11	0.6	5,750	810	0.11	0.6
		25	12,500	1,500	0.25	0.95	8,000	1,450	0.13	0.7	7,450	1,250	0.09	0.55	5,600	625	0.09	0.55
		30	7,000	550	0.1	0.6	7,000	660	0.06	0.45	7,000	540	0.06	0.45	5,250	270	0.06	0.45
		35	6,000	520	0.09	0.59	6,000	630	0.055	0.43	6,000	510	0.055	0.43	4,500	255	0.055	0.43
		40	4,300	375	0.065	0.5	4,300	450	0.04	0.39	4,300	370	0.04	0.39	3,200	185	0.04	0.39
		45	4,150	330	0.058	0.47	4,000	440	0.033	0.36	4,000	300	0.033	0.36	3,000	150	0.033	0.36
		50	4,000	300	0.053	0.44	3,750	400	0.03	0.33	3,750	260	0.03	0.33	2,800	130	0.03	0.33
		60	3,900	280	0.048	0.4	3,500	350	0.028	0.3	3,500	220	0.028	0.3	2,600	110	0.028	0.3
2050	**R2.5**	10	14,400	3,200	0.5	1.5	7,200	2,300	0.25	1.05	6,350	2,000	0.16	0.88	4,750	1,000	0.16	0.88
		15	14,400	3,200	0.5	1.5	7,200	2,300	0.25	1.05	6,350	2,000	0.16	0.88	4,750	1,000	0.16	0.88
		20	14,400	3,200	0.5	1.5	7,200	2,300	0.25	1.05	6,350	2,000	0.16	0.88	4,750	1,000	0.16	0.88
		25	12,200	2,350	0.405	1.35	6,800	1,850	0.205	0.95	6,250	1,600	0.135	0.805	4,650	800	0.135	0.805
		30	10,000	1,500	0.31	1.2	6,400	1,450	0.16	0.88	6,200	1,250	0.11	0.73	4,650	625	0.11	0.73
		40	6,000	570	0.125	0.78	6,000	690	0.08	0.625	6,000	570	0.08	0.625	4,500	285	0.08	0.625
2060	**R3**	10	13,000	3,500	0.6	1.8	6,500	2,500	0.3	1.3	5,700	2,200	0.2	1	4,300	1,100	0.2	1
		15	13,000	3,500	0.6	1.8	6,500	2,500	0.3	1.3	5,700	2,200	0.2	1	4,300	1,100	0.2	1
		20	13,000	3,500	0.6	1.8	6,500	2,500	0.3	1.3	5,700	2,200	0.2	1	4,300	1,100	0.2	1
		25	13,000	3,500	0.6	1.8	6,500	2,500	0.3	1.3	5,700	2,200	0.2	1	4,300	1,100	0.2	1
		30	13,000	3,500	0.6	1.8	6,500	2,500	0.3	1.3	5,700	2,200	0.2	1	4,300	1,100	0.2	1
		35	11,000	2,750	0.48	1.6	6,100	2,050	0.25	1.05	5,500	1,800	0.175	0.8	4,150	900	0.175	0.8
		40	9,000	2,050	0.375	1.35	5,750	1,600	0.2	0.8	5,350	1,400	0.15	0.65	4,000	700	0.15	0.65
		45	7,000	1,300	0.26	1.1	5,350	1,150	0.15	0.55	5,150	1,000	0.125	0.45	3,850	500	0.125	0.45
		50	5,000	600	0.15	0.9	5,000	720	0.1	0.3	5,000	600	0.1	0.3	3,750	300	0.1	0.3
		60	3,600	430	0.105	0.75	3,600	510	0.08	0.22	3,550	435	0.08	0.22	2,650	215	0.08	0.22



Note:
- Decrease the feed rate more than 50% from the milling parameters when slot milling.
- Decrease both spindle speed and feed rate proportionally when the milling parameters exceed the machine's maximum spindle speed, or when chattering and red-hot occur.
- Every coolant offers stable milling.

CWLB

UTWCOAT 2 Flutes　Long Neck Ball End Mills

R0.05～R3

Super MG　UTW COAT　Back Taper Geometry

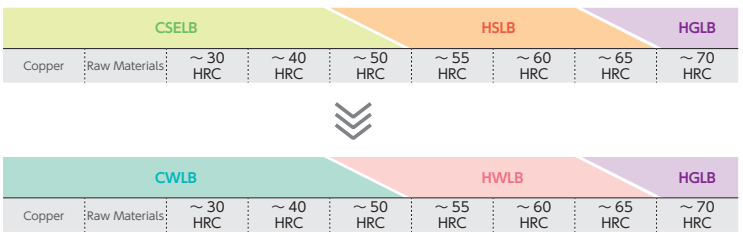
Back taper geometry does not apply to R0.05-R0.15.

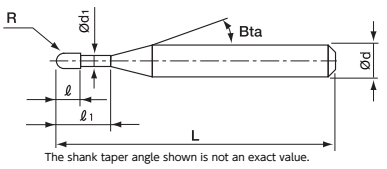
Material Applications (★ Highly Recommended ● Recommended ○ Suggested)

Work Material																
CARBON STEELS S45C S55C	ALLOY STEELS SK / SCM SUS	PREHARDENED STEELS NAK HPM	HARDENED STEELS ～50 HRC	～55 HRC	～60 HRC	～65 HRC	～70 HRC	CAST IRON	ALUMINUM ALLOYS	GRAPHITE	COPPER	PLASTICS	GLASS FILLED PLASTICS	TITANIUM ALLOYS	HEAT RESISTANT ALLOYS	CEMENTED CARBIDE	HARD BRITTLE (NON-METALLIC) MATERIALS
★	★	★	●					○	●		●			○	○		

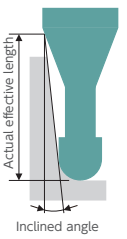
- **Upgrade**

Wear resistance and tool accuracy have been improved with CWLB and HWLB series.





The shank taper angle shown is not an exact value.



Longer tool life and improved mirror surface finish

Longer tool life and improved mirror surface finish on SCM Prehardened Steels compared to conventional tools.

Longer tool life

UTWCOAT
New Coating

Improved mirror surface finish

Tool tip has a micro flatland design reducing milling surface roughness.

※Micro flatland design at the tip does not apply to below R0.1.

High Precision

Even higher accuracy than before !

Conventional CSELB

Radius of Ball Nose	Ball Radius Accuracy	Diameter Tolerance	Shank Diameter Tolerance
R0.05 ～ R0.075	± 0.002	0/-0.01	0/-0.005
R0.1 ～ R1.25	± 0.005	0/-0.015	
R1.5 ～ R2			
R2.5 ～ R3			

CWLB

Unit (mm)

Radius of Ball Nose	Ball Radius Accuracy	Diameter Tolerance	Shank Diameter Tolerance	Helix Angle
R0.05 ～ R0.075	± 0.002	0/-0.006	0/-0.004 (h4)	0°
R0.1 ～ R1.25	± 0.003			30°
R1.5 ～ R2	± 0.004	0/-0.009		
R2.5 ～ R3	± 0.005			

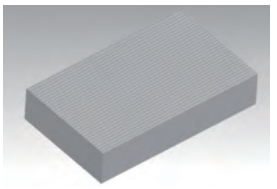
PXA30 (30 HRC) Finishing

Longer tool life and improved mirror surface finish.

Flat surface milling - Tool wear and milling surface comparison
R0.5 × EL6

PXA30 (30 HRC)

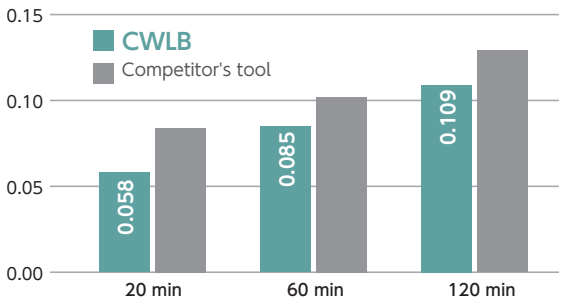
Spindle Speed	20,000 min^{-1}
Feed Rate	500 mm/min
a_p Axial Depth	0.03 mm
a_e Radial Depth	0.03 mm
Cycle Time	120 min

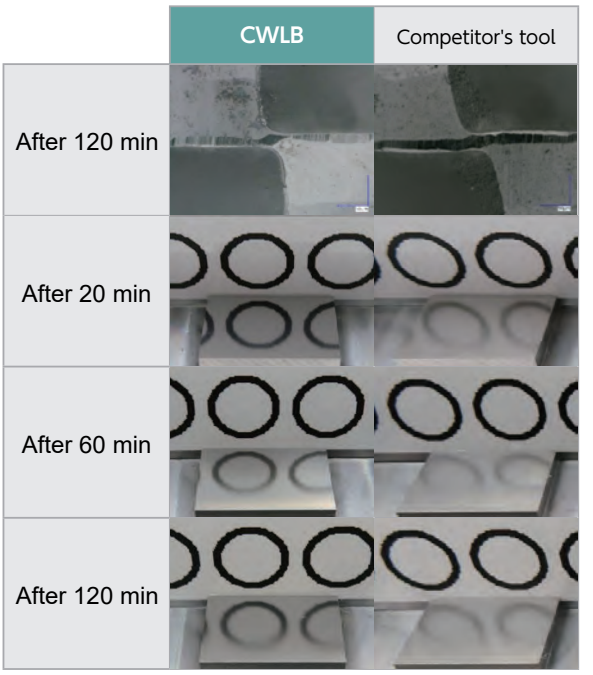


Work Size
15 × 10 × 0.06 mm

Coolant:
Water Soluble

Milling time and transition of Ra (Unit μm)

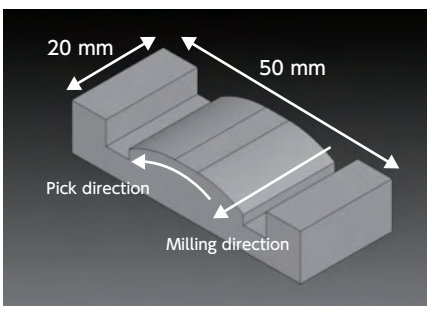




Normal wear on both CWLB and the competitor's tools, and still functional after 120 minutes of milling. Meanwhile CWLB offers better milling surface.

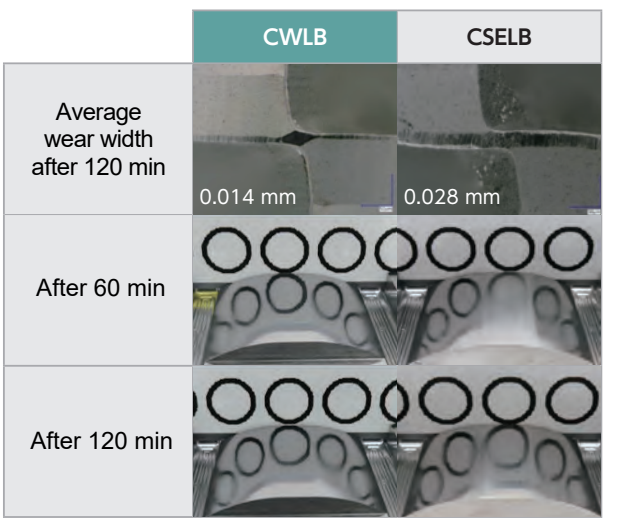
Curved surface milling - Tool wear and milling surface comparison
R0.5 × EL6

PXA30 (30 HRC)



Coolant:
Water Soluble

Spindle Speed	20,000 min^{-1}
Feed Rate	500 mm/min
a_p Axial Depth	0.03 mm
a_e Radial Depth	0.03 mm
Cycle Time	120 min



CWLB offers better milling surface on both flat and curved surfaces.

NAK80 (40 HRC) Finishing

Longer tool life and improved mirror surface finish

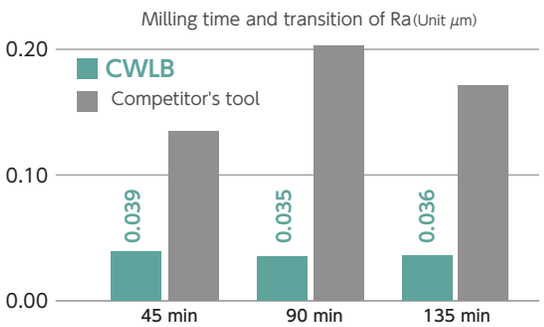
Finishing - Tool wear and milling surface comparison
R0.5 × EL6

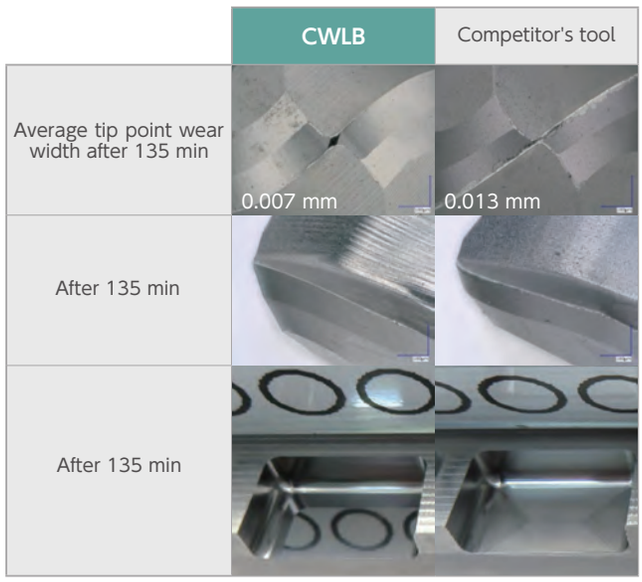
NAK80 (40 HRC)

Spindle Speed	20,000 min^{-1}
Feed Rate	500 mm/min
a_p Axial Depth	0.02 mm
a_e Radial Depth	0.02 mm
Cycle Time	135 min

Work Size
18 × 12 × 5 mm

Coolant
Water Soluble





※ Pocket wall removed for better visibility

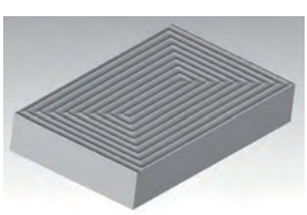
CWLB offers better milling surface and wear resistance even on NAK80

Carbon Steels S50C Roughing

Longer tool life

Roughing - Tool damage comparison
R1.5 × EL12

Carbon Steels S50C



Work Size
200 × 105 × 1.12 mm

Coolant
Water Soluble
(Through Spindle)

Spindle Speed	22,000 min^{-1}
Feed Rate	2,300 mm/min
a_p Axial Depth	0.28 mm
a_e Radial Depth	0.7 mm
Cycle Time	60 min

CWLB offers excellent wear resistance even on Carbon Steel Roughing

Carbon Steels S50C Finishing

Longer tool life

Finishing - Tool wear and surface roughness comparison
R0.5 × EL6

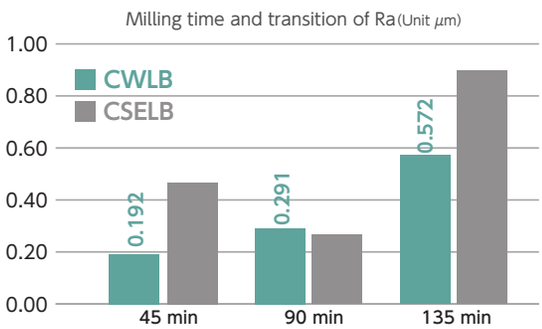
Carbon Steels S50C

Spindle Speed	20,000 min^{-1}
Feed Rate	500 mm/min
a_p Axial Depth	0.02 mm
a_e Radial Depth	0.02 mm
Cycle Time	135 min

Work Size
18 × 12 × 5 mm

Coolant
Water Soluble

	CWLB	CSELB
Average tip point wear width after 135 min	0.025 mm	0.036 mm
After 135 min		



CWLB offers excellent wear resistance on Carbon Steels finishing

Copper C1100 Finishing

Longer tool life and improved mirror surface finish

Finishing - Tool wear and milling surface comparison
R0.5 × EL6

Copper C1100

Spindle Speed	20,000 min^{-1}
Feed Rate	500 mm/min
a_p Axial Depth	0.02 mm
a_e Radial Depth	0.02 mm
Cycle Time	135 min

Work Size
18 × 12 × 5 mm

Coolant
Oil Mist

	CWLB	Competitor's tool
Average tip point wear width after 135 min	0.009 mm	0.019 mm
After 90 min		
After 135 min		

※ Pocket wall removed for better visibility

CWLB offers excellent wear resistance and milling surface

Total 190 models

Unit (mm)

Model Number	Radius of Ball Nose R	Effective Length ℓ1	Length of Cut ℓ	Neck Diameter Ød1	Shank Taper Angle Bta	Overall Length L	Shank Diameter Ød	Series	Effective Length by Inclined Angles				
									30′	1°	1°30′	2°	3°
CWLB 2001-002		0.2				45	4	CWLB	0.23	0.25	0.27	0.28	0.32
CWLB 2001-003	**R0.05**	0.3	0.08	0.095	11°	45	4	CWLB	0.34	0.36	0.38	0.40	0.46
CWLB 2001-005		0.5				45	4	CWLB	0.55	0.58	0.61	0.65	0.73
CWLB 20015-003		0.3				45	4	CWLB	0.37	0.39	0.41	0.43	0.48
CWLB 20015-005	**R0.075**	0.5	0.12	0.135	11°	45	4	CWLB	0.58	0.61	0.64	0.67	0.76
CWLB 20015-010		1				45	4	CWLB	1.10	1.16	1.22	1.28	1.44
CWLB 2002-003		0.3				45	4	CWLB	0.43	0.45	0.47	0.49	0.55
CWLB 2002-005		0.5				45	4	CWLB	0.63	0.66	0.69	0.73	0.81
CWLB 2002-0075		0.75				45	4	CWLB	0.89	0.94	0.98	1.03	1.16
CWLB 2002-010	**R0.1**	1	0.16	0.19	11°	45	4	CWLB	1.16	1.21	1.27	1.34	1.50
CWLB 2002-015		1.5				45	4	CWLB	1.67	1.75	1.83	1.93	2.17
CWLB 2002-020		2				45	4	CWLB	2.19	2.30	2.41	2.54	2.85
CWLB 2002-030		3				45	4	CWLB	3.24	3.39	3.57	3.76	4.22
CWLB 2003-005		0.5				45	4	CWLB	0.63	0.66	0.69	0.72	0.80
CWLB 2003-0075		0.75				45	4	CWLB	0.89	0.93	0.97	1.02	1.14
CWLB 2003-010		1				45	4	CWLB	1.15	1.21	1.26	1.33	1.48
CWLB 2003-015		1.5				45	4	CWLB	1.66	1.74	1.83	1.92	2.15
CWLB 2003-020	**R0.15**	2	0.24	0.29	11°	45	4	CWLB	2.19	2.29	2.40	2.53	2.83
CWLB 2003-025		2.5				45	4	CWLB	2.71	2.84	2.98	3.14	3.52
CWLB 2003-030		3				45	4	CWLB	3.23	3.39	3.56	3.75	4.20
CWLB 2003-040		4				45	4	CWLB	4.28	4.49	4.72	4.97	5.57
CWLB 2003-050		5				45	4	CWLB	5.33	5.59	5.87	6.19	6.94
CWLB 2004-005		0.5				45	4	CWLB	0.63	0.66	0.68	0.71	0.78
CWLB 2004-0075		0.75				45	4	CWLB	0.89	0.93	0.97	1.01	1.12
CWLB 2004-010		1				45	4	CWLB	1.15	1.20	1.26	1.32	1.46
CWLB 2004-010-6		1				50	6	CWLB	1.15	1.20	1.26	1.32	1.46
CWLB 2004-015		1.5				45	4	CWLB	1.66	1.74	1.82	1.91	2.13
CWLB 2004-020		2				45	4	CWLB	2.18	2.29	2.40	2.52	2.81
CWLB 2004-020-6	**R0.2**	2	0.32	0.39	11°	50	6	CWLB	2.18	2.29	2.40	2.52	2.81
CWLB 2004-025		2.5				45	4	CWLB	2.71	2.83	2.97	3.13	3.50
CWLB 2004-030		3				45	4	CWLB	3.23	3.38	3.55	3.74	4.18
CWLB 2004-030-6		3				50	6	CWLB	3.23	3.38	3.55	3.74	4.18
CWLB 2004-035		3.5				45	4	CWLB	3.76	3.93	4.13	4.35	4.87
CWLB 2004-040		4				45	4	CWLB	4.28	4.48	4.71	4.96	5.55
CWLB 2004-050		5				45	4	CWLB	5.33	5.58	5.86	6.18	6.92
CWLB 2004-060		6				45	4	CWLB	6.37	6.68	7.02	7.40	8.29

Model Number	Radius of Ball Nose R	Effective Length ℓ_1	Length of Cut ℓ	Neck Diameter $\varnothing d_1$	Shank Taper Angle Bta	Overall Length L	Shank Diameter $\varnothing d$	Series	Effective Length by Inclined Angles				
									30′	1°	1°30′	2°	3°
CWLB 2005-010		1				45	4	CWLB	1.15	1.20	1.25	1.31	1.45
CWLB 2005-015		1.5				45	4	CWLB	1.66	1.73	1.81	1.90	2.11
CWLB 2005-020		2				45	4	CWLB	2.18	2.28	2.39	2.51	2.80
CWLB 2005-020-6		2				50	6	CWLB	2.18	2.28	2.39	2.51	2.80
CWLB 2005-025		2.5				45	4	CWLB	2.71	2.83	2.97	3.12	3.48
CWLB 2005-030		3				45	4	CWLB	3.23	3.38	3.54	3.73	4.17
CWLB 2005-030-6	**R0.25**	3	0.4	0.49	11°	50	6	CWLB	3.23	3.38	3.54	3.73	4.17
CWLB 2005-040		4				45	4	CWLB	4.28	4.48	4.70	4.95	5.54
CWLB 2005-040-6		4				50	6	CWLB	4.28	4.48	4.70	4.95	5.54
CWLB 2005-050		5				45	4	CWLB	5.32	5.58	5.86	6.17	6.90
CWLB 2005-060		6				45	4	CWLB	6.37	6.68	7.01	7.39	8.27
CWLB 2005-080		8				45	4	CWLB	8.46	8.87	9.32	9.82	11.01
CWLB 2005-100		10				50	4	CWLB	10.56	11.07	11.63	12.26	13.75
CWLB 2006-010		1				45	4	CWLB	1.15	1.19	1.24	1.30	1.43
CWLB 2006-015		1.5				45	4	CWLB	1.66	1.73	1.80	1.89	2.09
CWLB 2006-020		2				45	4	CWLB	2.18	2.28	2.38	2.50	2.78
CWLB 2006-020-6		2				50	6	CWLB	2.18	2.28	2.38	2.50	2.78
CWLB 2006-025		2.5				45	4	CWLB	2.70	2.82	2.96	3.11	3.46
CWLB 2006-030		3				45	4	CWLB	3.23	3.37	3.54	3.72	4.15
CWLB 2006-030-6		3				50	6	CWLB	3.23	3.37	3.54	3.72	4.15
CWLB 2006-035	**R0.3**	3.5	0.48	0.59	11°	45	4	CWLB	3.75	3.92	4.12	4.33	4.83
CWLB 2006-040		4				45	4	CWLB	4.27	4.47	4.69	4.94	5.52
CWLB 2006-040-6		4				50	6	CWLB	4.27	4.47	4.69	4.94	5.52
CWLB 2006-050		5				45	4	CWLB	5.32	5.57	5.85	6.16	6.89
CWLB 2006-060		6				45	4	CWLB	6.37	6.67	7.00	7.38	8.26
CWLB 2006-060-6		6				50	6	CWLB	6.37	6.67	7.00	7.38	8.26
CWLB 2006-080		8				45	4	CWLB	8.46	8.87	9.32	9.81	10.99
CWLB 2006-100		10				50	4	CWLB	10.56	11.06	11.63	12.25	13.73
CWLB 2008-020		2				45	4	CWLB	2.18	2.27	2.37	2.48	2.74
CWLB 2008-020-6		2				50	6	CWLB	2.18	2.27	2.37	2.48	2.74
CWLB 2008-030		3				45	4	CWLB	3.22	3.36	3.52	3.70	4.11
CWLB 2008-030-6		3				50	6	CWLB	3.22	3.36	3.52	3.70	4.11
CWLB 2008-040		4				45	4	CWLB	4.27	4.46	4.68	4.92	5.48
CWLB 2008-040-6	**R0.4**	4	0.64	0.79	11°	50	6	CWLB	4.27	4.46	4.68	4.92	5.48
CWLB 2008-050		5				45	4	CWLB	5.32	5.56	5.83	6.13	6.85
CWLB 2008-060		6				45	4	CWLB	6.36	6.66	6.99	7.35	8.22
CWLB 2008-080		8				45	4	CWLB	8.46	8.86	9.30	9.79	10.96
CWLB 2008-100		10				50	4	CWLB	10.55	11.06	11.61	12.23	13.70
CWLB 2008-120		12				50	4	CWLB	12.65	13.25	13.92	14.67	16.43

Model Number	Radius of Ball Nose R	Effective Length ℓ_1	Length of Cut ℓ	Neck Diameter $\varnothing d_1$	Shank Taper Angle Bta	Overall Length L	Shank Diameter $\varnothing d$	Series	Effective Length by Inclined Angles				
									30′	1°	1°30′	2°	3°
CWLB 2010-020		2				45	4	CWLB	2.18	2.27	2.37	2.47	2.72
CWLB 2010-025		2.5				45	4	CWLB	2.71	2.82	2.94	3.08	3.41
CWLB 2010-030		3				45	4	CWLB	3.23	3.37	3.52	3.69	4.09
CWLB 2010-030-6		3				50	6	CWLB	3.23	3.37	3.52	3.69	4.09
CWLB 2010-040		4				45	4	CWLB	4.28	4.47	4.68	4.91	5.46
CWLB 2010-040-6		4				50	6	CWLB	4.28	4.47	4.68	4.91	5.46
CWLB 2010-050		5				45	4	CWLB	5.32	5.57	5.83	6.13	6.83
CWLB 2010-060		6				45	4	CWLB	6.37	6.66	6.99	7.35	8.20
CWLB 2010-060-6		6				50	6	CWLB	6.37	6.66	6.99	7.35	8.20
CWLB 2010-070		7				45	4	CWLB	7.42	7.76	8.14	8.57	9.57
CWLB 2010-080	**R0.5**	8	0.8	0.98	11°	45	4	CWLB	8.47	8.86	9.30	9.79	10.94
CWLB 2010-080-6		8				50	6	CWLB	8.47	8.86	9.30	9.79	10.94
CWLB 2010-090		9				45	4	CWLB	9.51	9.96	10.46	11.00	12.31
CWLB 2010-100		10				45	4	CWLB	10.56	11.06	11.61	12.22	13.68
CWLB 2010-100-6		10				50	6	CWLB	10.56	11.06	11.61	12.22	13.68
CWLB 2010-120		12				45	4	CWLB	12.65	13.26	13.92	14.66	16.42
CWLB 2010-120-6		12				50	6	CWLB	12.65	13.26	13.92	14.66	16.42
CWLB 2010-140		14				50	4	CWLB	14.75	15.45	16.23	17.10	19.15
CWLB 2010-160		16				50	4	CWLB	16.84	17.65	18.55	19.54	21.89
CWLB 2010-180		18				55	4	CWLB	18.94	19.85	20.86	21.98	24.63
CWLB 2010-200		20				55	4	CWLB	21.03	22.05	23.17	24.41	27.37
CWLB 2012-030		3				45	4	CWLB	3.13	3.25	3.39	3.55	3.93
CWLB 2012-040		4				45	4	CWLB	4.17	4.35	4.55	4.77	5.30
CWLB 2012-060		6				45	4	CWLB	6.27	6.55	6.86	7.21	8.03
CWLB 2012-080	**R0.6**	8	0.96	1.19	11°	45	4	CWLB	8.36	8.75	9.17	9.65	10.77
CWLB 2012-100		10				45	4	CWLB	10.45	10.94	11.48	12.09	13.51
CWLB 2012-120		12				45	4	CWLB	12.55	13.14	13.80	14.52	16.25
CWLB 2012-160		16				50	4	CWLB	16.74	17.54	18.42	19.40	21.73
CWLB 2015-030		3				45	4	CWLB	3.17	3.30	3.43	3.58	3.94
CWLB 2015-040		4				45	4	CWLB	4.22	4.39	4.59	4.80	5.31
CWLB 2015-060		6				45	4	CWLB	6.31	6.59	6.90	7.24	8.05
CWLB 2015-060-6		6				50	6	CWLB	6.31	6.59	6.90	7.24	8.05
CWLB 2015-080		8				45	4	CWLB	8.41	8.79	9.21	9.68	10.79
CWLB 2015-080-6		8				50	6	CWLB	8.41	8.79	9.21	9.68	10.79
CWLB 2015-100		10				45	4	CWLB	10.50	10.99	11.52	12.12	13.53
CWLB 2015-100-6	**R0.75**	10	1.2	1.47	11°	50	6	CWLB	10.50	10.99	11.52	12.12	13.53
CWLB 2015-120		12				45	4	CWLB	12.60	13.18	13.83	14.55	16.26
CWLB 2015-140		14				50	4	CWLB	14.69	15.38	16.14	16.99	19.00
CWLB 2015-160		16				50	4	CWLB	16.78	17.58	18.46	19.43	21.74
CWLB 2015-180		18				55	4	CWLB	18.88	19.78	20.77	21.87	24.48
CWLB 2015-200		20				55	4	CWLB	20.97	21.97	23.08	24.31	No Interference
CWLB 2015-250		25				65	4	CWLB	26.21	27.47	28.86	30.40	No Interference

Model Number	Radius of Ball Nose R	Effective Length ℓ_1	Length of Cut ℓ	Neck Diameter $\varnothing d_1$	Shank Taper Angle Bta	Overall Length L	Shank Diameter $\varnothing d$	Series	Effective Length by Inclined Angles				
									30′	1°	1°30′	2°	3°
CWLB 2016-040		4				45	4	CWLB	4.19	4.36	4.55	4.76	5.26
CWLB 2016-080		8				45	4	CWLB	8.38	8.76	9.17	9.64	10.74
CWLB 2016-120	**R0.8**	12	1.28	1.58	11°	45	4	CWLB	12.57	13.15	13.80	14.51	16.21
CWLB 2016-160		16				50	4	CWLB	16.75	17.54	18.42	19.39	21.69
CWLB 2016-200		20				55	4	CWLB	20.94	21.94	23.04	24.26	No Interference
CWLB 2018-060		6				45	4	CWLB	6.28	6.55	6.85	7.18	7.96
CWLB 2018-080	**R0.9**	8	1.44	1.78	11°	45	4	CWLB	8.37	8.75	9.16	9.61	10.70
CWLB 2018-120		12				45	4	CWLB	12.56	13.14	13.78	14.49	16.18
CWLB 2020-030		3				45	4	CWLB	3.13	3.24	3.36	3.49	3.81
CWLB 2020-040		4				45	4	CWLB	4.18	4.34	4.52	4.71	5.18
CWLB 2020-040-6		4				50	6	CWLB	4.18	4.34	4.52	4.71	5.18
CWLB 2020-060		6				45	4	CWLB	6.27	6.54	6.83	7.15	7.92
CWLB 2020-060-6		6				50	6	CWLB	6.27	6.54	6.83	7.15	7.92
CWLB 2020-080		8				45	4	CWLB	8.37	8.73	9.14	9.59	10.66
CWLB 2020-080-6		8				50	6	CWLB	8.37	8.73	9.14	9.59	10.66
CWLB 2020-100		10				45	4	CWLB	10.46	10.93	11.45	12.03	13.40
CWLB 2020-100-6		10				50	6	CWLB	10.46	10.93	11.45	12.03	13.40
CWLB 2020-120		12				45	4	CWLB	12.55	13.13	13.76	14.47	16.14
CWLB 2020-120-6	**R1**	12	1.6	1.98	11°	50	6	CWLB	12.55	13.13	13.76	14.47	16.14
CWLB 2020-140		14				50	4	CWLB	14.65	15.32	16.07	16.90	18.87
CWLB 2020-160		16				50	4	CWLB	16.74	17.52	18.38	19.34	No Interference
CWLB 2020-160-6		16				60	6	CWLB	16.74	17.52	18.38	19.34	21.61
CWLB 2020-180		18				55	4	CWLB	18.84	19.72	20.70	21.78	No Interference
CWLB 2020-200		20				55	4	CWLB	20.93	21.92	23.01	24.22	No Interference
CWLB 2020-200-6		20				70	6	CWLB	20.93	21.92	23.01	24.22	27.09
CWLB 2020-250		25				65	4	CWLB	26.17	27.41	28.79	No Interference	No Interference
CWLB 2020-300		30				70	4	CWLB	31.40	32.90	34.56	No Interference	No Interference
CWLB 2020-350		35				80	4	CWLB	36.64	38.40	No Interference	No Interference	No Interference
CWLB 2020-400		40				80	4	CWLB	41.87	43.89	No Interference	No Interference	No Interference
CWLB 2025-060		6				45	4	CWLB	6.34	6.60	6.88	7.19	7.94
CWLB 2025-100	**R1.25**	10	2	2.45	11°	45	4	CWLB	10.53	10.99	11.50	12.07	13.41
CWLB 2025-150		15				50	4	CWLB	15.76	16.48	17.28	18.16	No Interference
CWLB 2025-200		20				55	4	CWLB	21.00	21.98	23.06	No Interference	No Interference
CWLB 2030-060-3		6			-	60	3	CWLB	No Interference	No Interference	No Interference	No Interference	No Interference
CWLB 2030-060-4		6				60	4	CWLB	6.32	6.56	6.83	7.13	7.84
CWLB 2030-060		6				60	6	CWLB	6.32	6.56	6.83	7.13	7.84
CWLB 2030-080		8				60	6	CWLB	8.42	8.76	9.14	9.57	10.58
CWLB 2030-100		10				60	6	CWLB	10.51	10.96	11.45	12.00	13.31
CWLB 2030-120		12				60	6	CWLB	12.60	13.16	13.77	14.44	16.05
CWLB 2030-140	**R1.5**	14	2.4	2.95	11°	60	6	CWLB	14.70	15.35	16.08	16.88	18.79
CWLB 2030-160		16				60	6	CWLB	16.79	17.55	18.39	19.32	21.53
CWLB 2030-200		20				70	6	CWLB	20.98	21.94	23.01	24.19	27.01
CWLB 2030-250		25				70	6	CWLB	26.21	27.44	28.79	30.29	No Interference
CWLB 2030-300		30				70	6	CWLB	31.45	32.93	34.57	36.38	No Interference
CWLB 2030-350		35				80	6	CWLB	36.68	38.42	40.35	42.48	No Interference
CWLB 2030-400		40				80	6	CWLB	41.92	43.92	46.12	No Interference	No Interference

Model Number	Radius of Ball Nose R	Effective Length ℓ_1	Length of Cut ℓ	Neck Diameter $\varnothing d_1$	Shank Taper Angle Bta	Overall Length L	Shank Diameter $\varnothing d$	Series	Effective Length by Inclined Angles				
									30′	1°	1°30′	2°	3°
CWLB 2040-080-4		8			-	70	4	CWLB	No Interference	No Interference	No Interference	No Interference	No Interference
CWLB 2040-080		8				70	6	CWLB	8.39	8.71	9.06	9.46	10.39
CWLB 2040-100		10				70	6	CWLB	10.48	10.91	11.37	11.89	13.13
CWLB 2040-120		12				70	6	CWLB	12.58	13.10	13.69	14.33	15.87
CWLB 2040-140		14				70	6	CWLB	14.67	15.30	16.00	16.77	18.61
CWLB 2040-160	**R2**	16	3.2	3.95	11°	70	6	CWLB	16.77	17.50	18.31	19.21	No Interference
CWLB 2040-200		20				70	6	CWLB	20.95	21.89	22.93	24.08	No Interference
CWLB 2040-250		25				70	6	CWLB	26.19	27.39	28.71	30.18	No Interference
CWLB 2040-300		30				70	6	CWLB	31.42	32.88	34.49	No Interference	No Interference
CWLB 2040-350		35				80	6	CWLB	36.66	38.37	40.27	No Interference	No Interference
CWLB 2040-400		40				90	6	CWLB	41.89	43.87	No Interference	No Interference	No Interference
CWLB 2040-450		45				90	6	CWLB	47.13	49.36	No Interference	No Interference	No Interference
CWLB 2050-100		10				70	6	CWLB	10.46	10.86	11.30	11.79	No Interference
CWLB 2050-150		15				70	6	CWLB	15.69	16.35	17.08	No Interference	No Interference
CWLB 2050-200	**R2.5**	20	4	4.95	11°	70	6	CWLB	20.93	21.84	No Interference	No Interference	No Interference
CWLB 2050-250		25				70	6	CWLB	26.17	27.34	No Interference	No Interference	No Interference
CWLB 2050-300		30				80	6	CWLB	31.40	No Interference	No Interference	No Interference	No Interference
CWLB 2060-100		10				80	6	CWLB	No Interference	No Interference	No Interference	No Interference	No Interference
CWLB 2060-150		15				80	6	CWLB	No Interference	No Interference	No Interference	No Interference	No Interference
CWLB 2060-200		20				80	6	CWLB	No Interference	No Interference	No Interference	No Interference	No Interference
CWLB 2060-250		25				80	6	CWLB	No Interference	No Interference	No Interference	No Interference	No Interference
CWLB 2060-300	**R3**	30	4.8	5.95	-	80	6	CWLB	No Interference	No Interference	No Interference	No Interference	No Interference
CWLB 2060-350		35				80	6	CWLB	No Interference	No Interference	No Interference	No Interference	No Interference
CWLB 2060-400		40				90	6	CWLB	No Interference	No Interference	No Interference	No Interference	No Interference
CWLB 2060-450		45				100	6	CWLB	No Interference	No Interference	No Interference	No Interference	No Interference
CWLB 2060-500		50				120	6	CWLB	No Interference	No Interference	No Interference	No Interference	No Interference
CWLB 2060-600		60				120	6	CWLB	No Interference	No Interference	No Interference	No Interference	No Interference

CWLB Milling Conditions

WORK MATERIAL			COPPER / ALUMINUM ALLOYS				CARBON STEELS / ALLOY STEELS S45C / S50C / SK / SCM (~325HB)				PREHARDENED STEELS NAK80 / STAVAX / HPM38 (30~45HRC)				HARDENED STEELS STAVAX / HPM38 / SKD61 (45~55HRC)			
Model Number	Radius of Ball Nose (mm)	Effective Length (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)
2001-002	**R0.05**	0.2	54,000	85	0.004	0.004	54,000	85	0.004	0.004	48,000	55	0.002	0.002	48,000	55	0.002	0.002
2001-003		0.3	54,000	85	0.004	0.004	54,000	85	0.004	0.004	48,000	55	0.002	0.002	48,000	55	0.002	0.002
2001-005		0.5	54,000	75	0.004	0.004	54,000	75	0.004	0.004	48,000	35	0.002	0.002	48,000	35	0.002	0.002
20015-003	**R0.075**	0.3	54,000	160	0.007	0.009	54,000	160	0.007	0.009	48,000	90	0.004	0.004	48,000	90	0.004	0.004
20015-005		0.5	54,000	140	0.007	0.009	54,000	140	0.007	0.009	48,000	60	0.004	0.004	48,000	60	0.004	0.004
20015-010		1	54,000	100	0.003	0.005	54,000	100	0.003	0.005	48,000	60	0.001	0.002	48,000	60	0.001	0.002
2002-003	**R0.1**	0.3	60,000	350	0.008	0.024	60,000	350	0.008	0.016	60,000	300	0.008	0.024	60,000	300	0.006	0.018
2002-005		0.5	60,000	350	0.008	0.024	60,000	350	0.008	0.016	60,000	300	0.008	0.024	60,000	300	0.006	0.018
2002-0075		0.75	60,000	300	0.007	0.021	60,000	320	0.007	0.015	60,000	300	0.007	0.021	60,000	270	0.005	0.015
2002-010		1	60,000	250	0.006	0.018	60,000	250	0.005	0.015	60,000	250	0.006	0.018	60,000	220	0.005	0.015
2002-015		1.5	48,000	200	0.005	0.015	48,000	180	0.004	0.012	60,000	200	0.005	0.015	48,000	170	0.004	0.012
2002-020		2	48,000	150	0.003	0.009	48,000	150	0.003	0.009	60,000	150	0.003	0.009	48,000	120	0.003	0.007
2002-030		3	33,000	50	0.002	0.003	33,000	50	0.002	0.003	33,000	50	0.002	0.003	33,000	50	0.002	0.002
2003-005	**R0.15**	0.5	43,000	500	0.012	0.036	43,000	500	0.012	0.024	54,000	450	0.012	0.036	43,000	450	0.008	0.024
2003-0075		0.75	43,000	500	0.012	0.036	43,000	500	0.012	0.024	54,000	450	0.012	0.036	43,000	450	0.008	0.024
2003-010		1	43,000	450	0.01	0.03	43,000	450	0.008	0.024	54,000	400	0.01	0.03	43,000	400	0.007	0.021
2003-015		1.5	43,000	400	0.008	0.024	43,000	400	0.007	0.021	54,000	400	0.008	0.024	43,000	400	0.006	0.018
2003-020		2	40,000	300	0.006	0.018	40,000	300	0.006	0.018	50,000	300	0.007	0.021	40,000	300	0.005	0.015
2003-025		2.5	40,000	250	0.005	0.015	40,000	250	0.005	0.015	46,000	250	0.005	0.015	40,000	250	0.004	0.012
2003-030		3	38,000	200	0.004	0.012	38,000	200	0.004	0.012	42,000	200	0.004	0.012	38,000	200	0.004	0.008
2003-040		4	35,000	100	0.003	0.009	35,000	100	0.003	0.009	35,000	100	0.003	0.009	32,000	100	0.003	0.005
2003-050		5	26,000	60	0.003	0.004	26,000	60	0.003	0.004	26,000	60	0.003	0.004	26,000	60	0.003	0.003
2004-005	**R0.2**	0.5	35,000	1,200	0.03	0.09	35,000	1,200	0.02	0.04	50,000	650	0.025	0.075	35,000	650	0.015	0.045
2004-0075		0.75	35,000	1,200	0.03	0.09	35,000	1,200	0.02	0.04	50,000	650	0.025	0.075	35,000	650	0.015	0.045
2004-010		1	35,000	1,200	0.03	0.09	35,000	1,200	0.02	0.04	50,000	650	0.025	0.075	35,000	650	0.015	0.045
2004-015		1.5	35,000	900	0.02	0.06	35,000	900	0.016	0.033	50,000	550	0.02	0.06	35,000	500	0.012	0.036
2004-020		2	35,000	600	0.015	0.045	35,000	600	0.011	0.033	50,000	500	0.015	0.045	35,000	400	0.01	0.03
2004-025		2.5	35,000	450	0.012	0.036	35,000	450	0.01	0.03	46,000	450	0.012	0.036	35,000	360	0.01	0.025
2004-030		3	35,000	400	0.01	0.03	35,000	400	0.008	0.024	42,000	400	0.01	0.03	35,000	330	0.007	0.021
2004-035		3.5	35,000	350	0.007	0.02	35,000	350	0.006	0.018	38,000	350	0.007	0.021	35,000	300	0.007	0.018
2004-040		4	35,000	300	0.005	0.015	35,000	300	0.005	0.015	35,000	300	0.005	0.015	35,000	250	0.005	0.015
2004-050		5	30,000	160	0.003	0.01	30,000	160	0.003	0.01	30,000	160	0.003	0.01	30,000	150	0.003	0.008
2004-060		6	23,000	90	0.003	0.005	23,000	90	0.003	0.005	23,000	90	0.003	0.005	23,000	80	0.003	0.004
2005-010	**R0.25**	1	34,000	1,300	0.035	0.105	34,000	1,300	0.03	0.06	45,000	900	0.03	0.09	32,000	900	0.02	0.06
2005-015		1.5	34,000	1,000	0.03	0.09	34,000	1,000	0.025	0.05	45,000	800	0.025	0.075	32,000	800	0.018	0.054
2005-020		2	34,000	800	0.025	0.075	34,000	800	0.023	0.046	45,000	700	0.022	0.066	32,000	700	0.016	0.048
2005-025		2.5	34,000	700	0.02	0.06	34,000	700	0.015	0.045	45,000	600	0.018	0.054	32,000	600	0.015	0.045
2005-030		3	32,000	550	0.016	0.048	32,000	550	0.012	0.036	41,000	550	0.014	0.042	31,000	500	0.012	0.036
2005-040		4	31,000	450	0.012	0.036	31,000	450	0.01	0.03	35,000	450	0.01	0.03	30,000	390	0.01	0.03
2005-050		5	29,000	340	0.007	0.021	29,000	340	0.007	0.021	29,000	340	0.006	0.018	29,000	300	0.006	0.018
2005-060		6	24,000	220	0.006	0.018	24,000	220	0.006	0.018	24,000	220	0.005	0.015	24,000	200	0.005	0.015
2005-080		8	19,000	130	0.004	0.012	19,000	130	0.004	0.012	19,000	130	0.003	0.009	19,000	110	0.003	0.009
2005-100		10	17,000	100	0.003	0.009	17,000	100	0.003	0.009	17,000	100	0.002	0.006	17,000	80	0.002	0.006

CWLB Milling Conditions

WORK MATERIAL			COPPER / ALUMINUM ALLOYS				CARBON STEELS / ALLOY STEELS S45C / S50C / SK / SCM (~325HB)				PREHARDENED STEELS NAK80 / STAVAX / HPM38 (30~45HRC)				HARDENED STEELS STAVAX / HPM38 / SKD61 (45~55HRC)			
Model Number	Radius of Ball Nose (mm)	Effective Length (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)
2006-010		1	33,000	1,500	0.05	0.15	33,000	1,500	0.04	0.08	40,000	1,300	0.045	0.09	30,000	1,300	0.04	0.06
2006-015		1.5	33,000	1,500	0.05	0.15	33,000	1,500	0.04	0.08	40,000	1,300	0.045	0.09	30,000	1,300	0.04	0.06
2006-020		2	33,000	1,400	0.045	0.135	33,000	1,400	0.036	0.072	40,000	1,200	0.045	0.09	30,000	1,200	0.036	0.054
2006-025		2.5	33,000	1,100	0.04	0.12	33,000	1,200	0.033	0.066	40,000	1,000	0.04	0.08	30,000	1,100	0.033	0.053
2006-030		3	33,000	900	0.035	0.105	33,000	900	0.025	0.066	40,000	800	0.03	0.075	30,000	900	0.026	0.052
2006-035	**R0.3**	3.5	32,000	900	0.03	0.09	32,000	800	0.022	0.066	38,000	650	0.025	0.075	28,000	720	0.02	0.06
2006-040		4	31,000	700	0.027	0.081	31,000	700	0.02	0.06	35,000	560	0.022	0.066	28,000	600	0.018	0.054
2006-050		5	29,000	440	0.018	0.054	29,000	440	0.015	0.045	29,000	440	0.015	0.045	26,000	440	0.012	0.036
2006-060		6	24,000	380	0.012	0.036	24,000	380	0.012	0.036	24,000	380	0.01	0.03	24,000	380	0.008	0.024
2006-080		8	18,000	240	0.008	0.024	18,000	240	0.008	0.024	18,000	240	0.006	0.018	18,000	240	0.005	0.015
2006-100		10	15,000	160	0.006	0.018	15,000	160	0.006	0.018	15,000	160	0.004	0.012	15,000	160	0.003	0.01
2008-020		2	30,000	2,200	0.1	0.3	30,000	1,800	0.06	0.12	35,000	1,800	0.07	0.14	25,000	1,700	0.07	0.1
2008-030		3	30,000	1,700	0.08	0.24	30,000	1,600	0.05	0.1	35,000	1,600	0.06	0.12	25,000	1,500	0.06	0.09
2008-040		4	30,000	1,400	0.07	0.21	30,000	1,300	0.04	0.1	35,000	1,300	0.05	0.12	25,000	1,200	0.045	0.09
2008-050		5	30,000	1,100	0.06	0.18	30,000	1,100	0.035	0.1	30,000	1,100	0.04	0.12	25,000	1,000	0.04	0.08
2008-060	**R0.4**	6	27,000	900	0.04	0.12	27,000	900	0.025	0.075	27,000	800	0.03	0.09	23,000	800	0.023	0.069
2008-080		8	19,000	450	0.02	0.06	19,000	450	0.02	0.06	19,000	450	0.015	0.045	19,000	450	0.01	0.03
2008-100		10	15,000	350	0.012	0.036	15,000	350	0.012	0.036	15,000	300	0.01	0.03	15,000	300	0.007	0.021
2008-120		12	14,000	300	0.01	0.03	14,000	300	0.01	0.03	14,000	240	0.006	0.018	14,000	240	0.006	0.018
2010-020		2	30,000	2,000	0.12	0.36	30,000	1,600	0.08	0.16	30,000	1,600	0.09	0.18	22,000	1,600	0.09	0.13
2010-025		2.5	30,000	2,000	0.12	0.36	30,000	1,600	0.08	0.16	30,000	1,600	0.09	0.18	22,000	1,600	0.09	0.13
2010-030		3	30,000	1,800	0.11	0.33	24,000	1,600	0.07	0.14	30,000	1,500	0.08	0.16	21,500	1,400	0.08	0.12
2010-040		4	30,000	1,700	0.09	0.27	24,000	1,500	0.065	0.13	30,000	1,300	0.075	0.15	21,500	1,300	0.075	0.1
2010-050		5	30,000	1,600	0.08	0.24	24,000	1,400	0.06	0.12	30,000	1,200	0.07	0.14	21,500	1,200	0.06	0.09
2010-060		6	30,000	1,400	0.06	0.18	18,000	1,200	0.04	0.12	30,000	1,100	0.06	0.12	21,500	1,100	0.05	0.1
2010-070		7	27,000	1,200	0.05	0.15	17,000	1,000	0.03	0.09	24,000	800	0.04	0.12	20,000	900	0.03	0.09
2010-080	**R0.5**	8	24,000	1,000	0.04	0.12	16,500	900	0.027	0.081	18,500	620	0.035	0.1	18,500	580	0.025	0.1
2010-090		9	22,000	720	0.035	0.11	15,500	700	0.02	0.08	16,500	550	0.025	0.1	16,500	500	0.02	0.08
2010-100		10	20,000	650	0.03	0.09	15,000	500	0.018	0.072	14,800	490	0.02	0.08	14,800	430	0.015	0.06
2010-120		12	18,000	600	0.02	0.08	15,000	500	0.016	0.064	13,400	380	0.01	0.05	13,400	380	0.008	0.04
2010-140		14	16,000	530	0.015	0.06	14,000	460	0.015	0.06	12,000	350	0.008	0.04	12,000	350	0.006	0.03
2010-160		16	14,000	460	0.014	0.056	14,000	460	0.014	0.056	10,500	250	0.005	0.025	10,500	250	0.005	0.025
2010-180		18	13,500	440	0.012	0.06	13,500	440	0.012	0.06	9,500	200	0.004	0.02	9,500	200	0.004	0.02
2010-200		20	13,000	430	0.008	0.04	13,000	430	0.008	0.04	9,000	150	0.003	0.015	9,000	150	0.003	0.015
2012-030		3	30,000	2,000	0.13	0.39	30,000	1,600	0.09	0.18	30,000	1,600	0.1	0.2	18,000	1,600	0.1	0.15
2012-040		4	30,000	1,800	0.12	0.36	20,000	1,500	0.08	0.16	30,000	1,400	0.09	0.18	18,000	1,400	0.09	0.13
2012-060		6	30,000	1,600	0.09	0.27	20,000	1,200	0.07	0.14	30,000	1,100	0.08	0.16	18,000	1,100	0.08	0.12
2012-080	**R0.6**	8	25,000	1,200	0.06	0.18	15,000	900	0.05	0.12	20,000	800	0.06	0.15	16,500	750	0.05	0.11
2012-100		10	20,000	900	0.05	0.15	13,500	650	0.035	0.11	16,000	640	0.045	0.12	15,500	550	0.03	0.09
2012-120		12	16,500	600	0.035	0.12	12,500	480	0.025	0.1	12,000	440	0.03	0.12	12,500	430	0.018	0.072
2012-160		16	13,000	470	0.018	0.072	11,500	440	0.018	0.072	10,000	350	0.01	0.05	10,000	350	0.01	0.05

CWLB Milling Conditions

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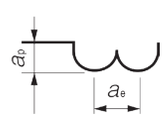
Model Number	Radius of Ball Nose (mm)	Effective Length (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)
2015-030		3	30,000	2,000	0.15	0.45	30,000	1,600	0.12	0.24	30,000	1,700	0.12	0.24	18,000	1,500	0.12	0.18
2015-040		4	30,000	1,800	0.14	0.42	30,000	1,500	0.11	0.22	30,000	1,600	0.11	0.22	18,000	1,400	0.11	0.17
2015-060		6	30,000	1,800	0.12	0.36	23,000	1,300	0.1	0.2	30,000	1,400	0.1	0.2	15,000	1,200	0.1	0.16
2015-080		8	30,000	1,600	0.11	0.33	18,000	1,100	0.08	0.16	30,000	1,200	0.08	0.2	14,000	1,000	0.08	0.16
2015-100		10	23,000	1,200	0.09	0.27	15,000	850	0.06	0.15	23,500	900	0.06	0.18	14,000	700	0.05	0.15
2015-120	**R0.75**	12	16,000	900	0.07	0.21	13,000	600	0.05	0.15	13,000	650	0.05	0.15	13,000	550	0.03	0.12
2015-140		14	14,500	700	0.05	0.19	10,500	550	0.04	0.12	10,500	500	0.04	0.12	10,500	470	0.025	0.1
2015-160		16	13,000	650	0.04	0.16	10,000	550	0.03	0.12	8,850	400	0.03	0.12	8,850	390	0.02	0.08
2015-180		18	12,000	580	0.03	0.15	10,000	510	0.025	0.1	8,500	350	0.018	0.09	8,500	360	0.014	0.07
2015-200		20	10,500	530	0.02	0.1	9,200	470	0.02	0.1	8,000	320	0.12	0.06	8,000	320	0.012	0.06
2015-250		25	9,000	440	0.014	0.07	8,750	440	0.014	0.07	7,250	250	0.008	0.04	7,250	250	0.006	0.03
2016-040		4	30,000	2,000	0.16	0.48	30,000	1,600	0.12	0.24	30,000	1,800	0.12	0.36	18,000	1,400	0.1	0.2
2016-080		8	30,000	1,700	0.15	0.45	15,000	1,100	0.1	0.2	30,000	1,500	0.12	0.24	13,500	1,000	0.08	0.24
2016-120	**R0.8**	12	23,000	1,200	0.1	0.3	11,000	700	0.06	0.18	18,000	1,000	0.06	0.18	12,500	650	0.04	0.16
2016-160		16	15,000	800	0.05	0.2	10,000	530	0.034	0.13	10,000	530	0.035	0.14	9,000	420	0.02	0.1
2016-200		20	11,000	580	0.034	0.17	9,400	490	0.025	0.12	8,500	400	0.018	0.09	7,800	380	0.014	0.07
2018-060		6	30,000	1,800	0.18	0.52	24,000	1,500	0.15	0.29	30,000	1,700	0.16	0.4	14,000	1,200	0.13	0.27
2018-080	**R0.9**	8	30,000	1,800	0.17	0.5	18,000	1,200	0.13	0.26	30,000	1,700	0.16	0.32	12,000	1,000	0.11	0.26
2018-120		12	24,000	1,450	0.12	0.36	13,000	1,000	0.08	0.2	18,000	1,100	0.09	0.23	12,000	750	0.07	0.21
2020-030		3	30,000	2,000	0.2	0.6	30,000	2,000	0.21	0.42	30,000	2,000	0.2	0.6	16,000	1,300	0.17	0.5
2020-040		4	30,000	2,000	0.2	0.6	30,000	2,000	0.21	0.42	30,000	2,000	0.2	0.6	16,000	1,300	0.17	0.5
2020-060		6	30,000	2,000	0.2	0.6	30,000	2,000	0.21	0.42	30,000	2,000	0.2	0.6	14,000	1,100	0.15	0.4
2020-080		8	30,000	2,000	0.2	0.6	30,000	2,000	0.18	0.36	30,000	2,000	0.16	0.56	12,000	950	0.12	0.4
2020-100		10	30,000	2,000	0.2	0.6	30,000	2,000	0.17	0.36	30,000	2,000	0.13	0.45	10,800	850	0.1	0.4
2020-120		12	30,000	2,000	0.18	0.54	30,000	2,000	0.12	0.36	30,000	2,000	0.1	0.35	10,800	850	0.08	0.32
2020-140		14	22,000	1,450	0.15	0.5	22,000	1,450	0.11	0.33	20,000	1,300	0.08	0.24	10,800	850	0.06	0.24
2020-160	**R1**	16	15,000	1,000	0.1	0.4	15,000	1,000	0.07	0.28	10,800	700	0.06	0.18	10,800	600	0.03	0.15
2020-180		18	13,500	900	0.08	0.32	13,500	900	0.06	0.24	9,700	600	0.05	0.15	9,700	520	0.025	0.12
2020-200		20	12,000	800	0.07	0.28	12,000	800	0.05	0.2	8,650	500	0.04	0.16	8,650	450	0.02	0.1
2020-250		25	9,000	600	0.04	0.2	9,000	600	0.035	0.17	7,800	440	0.025	0.1	7,800	440	0.016	0.08
2020-300		30	7,000	470	0.035	0.17	7,000	470	0.03	0.15	7,000	350	0.02	0.08	7,000	350	0.01	0.05
2020-350		35	6,500	430	0.03	0.15	6,500	430	0.025	0.12	6,150	250	0.015	0.06	6,150	250	0.008	0.04
2020-400		40	6,500	430	0.02	0.1	6,500	430	0.02	0.1	5,250	150	0.01	0.05	5,250	150	0.006	0.03
2025-060		6	27,000	2,300	0.28	0.75	27,000	2,300	0.25	0.5	27,000	2,300	0.25	0.75	13,000	1,100	0.21	0.63
2025-100	**R1.25**	10	25,000	2,100	0.26	0.67	25,000	2,100	0.23	0.46	24,000	2,200	0.2	0.65	11,000	930	0.14	0.44
2025-150		15	22,000	1,950	0.23	0.59	22,000	1,950	0.15	0.45	20,000	1,600	0.13	0.42	9,000	720	0.08	0.32
2025-200		20	11,000	1,150	0.14	0.38	11,000	1,150	0.1	0.3	8,000	600	0.06	0.24	7,600	470	0.04	0.12

CWLB Milling Conditions

WORK MATERIAL			COPPER / ALUMINUM ALLOYS				CARBON STEELS / ALLOY STEELS S45C / S50C / SK / SCM (~325HB)				PREHARDENED STEELS NAK80 / STAVAX / HPM38 (30~45HRC)				HARDENED STEELS STAVAX / HPM38 / SKD61 (45~55HRC)			
Model Number	Radius of Ball Nose (mm)	Effective Length (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)
2030-060		6	24,000	2,500	0.32	0.9	24,000	2,500	0.32	0.9	24,000	2,500	0.3	0.9	14,000	1,400	0.25	0.76
2030-080		8	24,000	2,500	0.32	0.9	24,000	2,500	0.32	0.9	24,000	2,500	0.3	0.9	14,000	1,400	0.25	0.76
2030-100		10	22,000	2,300	0.28	0.8	22,000	2,300	0.28	0.8	24,000	2,500	0.25	0.75	13,000	1,200	0.25	0.76
2030-120		12	22,000	2,300	0.28	0.7	22,000	2,300	0.28	0.7	20,000	2,100	0.2	0.65	10,700	1,000	0.18	0.54
2030-140		14	20,000	2,100	0.24	0.6	20,000	2,100	0.24	0.6	18,000	1,850	0.18	0.5	9,400	800	0.16	0.48
2030-160	**R1.5**	16	20,000	2,100	0.24	0.6	20,000	2,100	0.24	0.6	16,000	1,650	0.16	0.5	9,000	700	0.14	0.42
2030-200		20	14,000	1,800	0.2	0.45	14,000	1,800	0.2	0.45	11,000	1,000	0.12	0.36	7,000	600	0.1	0.3
2030-250		25	8,000	1,250	0.16	0.32	8,000	1,250	0.16	0.32	6,400	510	0.08	0.24	5,600	390	0.06	0.18
2030-300		30	6,000	1,000	0.1	0.3	6,000	1,000	0.1	0.3	4,600	450	0.05	0.2	3,900	370	0.04	0.12
2030-350		35	5,500	800	0.07	0.28	5,500	800	0.07	0.28	3,300	320	0.04	0.16	2,900	270	0.03	0.1
2030-400		40	4,500	700	0.05	0.25	4,500	700	0.05	0.25	2,700	240	0.03	0.12	2,300	210	0.02	0.08
2040-080		8	24,000	2,900	0.4	1.2	24,000	2,900	0.4	1.2	18,000	2,400	0.4	1.2	11,000	2,000	0.34	1
2040-100		10	24,000	2,900	0.4	1.2	24,000	2,900	0.4	1.2	18,000	2,400	0.4	1.2	11,000	2,000	0.34	1
2040-120		12	24,000	2,900	0.4	1.2	24,000	2,900	0.4	1.2	18,000	2,400	0.4	1.2	9,700	1,500	0.28	0.85
2040-140		14	21,000	2,630	0.35	1.1	21,000	2,630	0.35	1.1	15,000	2,150	0.3	1.1	9,700	1,200	0.28	0.8
2040-160		16	18,000	2,250	0.3	1	18,000	2,250	0.3	1	15,000	2,150	0.3	0.9	8,000	1,000	0.2	0.6
2040-200	**R2**	20	15,000	1,900	0.3	0.9	15,000	1,900	0.3	0.9	12,000	1,750	0.2	0.7	7,000	750	0.15	0.45
2040-250		25	12,000	1,550	0.25	0.7	12,000	1,550	0.25	0.7	9,000	1,300	0.15	0.5	6,000	560	0.12	0.36
2040-300		30	7,000	1,400	0.2	0.5	7,000	1,400	0.2	0.5	7,000	850	0.1	0.3	5,000	460	0.08	0.2
2040-350		35	6,000	1,200	0.2	0.4	6,000	1,200	0.2	0.4	4,800	450	0.1	0.25	4,000	370	0.07	0.17
2040-400		40	4,000	1,000	0.11	0.33	4,000	1,000	0.11	0.33	3,450	400	0.06	0.24	2,900	270	0.06	0.15
2040-450		45	3,800	760	0.08	0.32	3,800	760	0.08	0.32	2,700	300	0.05	0.2	2,300	240	0.04	0.12
2050-100		10	18,000	3,000	0.5	1.5	18,000	3,000	0.5	1.5	13,750	2,400	0.45	1.4	8,800	1,800	0.42	1.2
2050-150		15	18,000	3,000	0.5	1.5	18,000	3,000	0.5	1.5	13,750	2,400	0.45	1.4	7,800	1,300	0.34	1
2050-200	**R2.5**	20	14,000	2,600	0.37	1.2	15,600	2,600	0.37	1.2	12,000	1,800	0.36	1.1	6,300	830	0.27	0.75
2050-250		25	12,000	2,000	0.33	1.1	12,000	2,000	0.33	1.1	9,600	1,350	0.25	1	5,700	750	0.25	0.67
2050-300		30	9,600	1,800	0.31	0.9	9,600	1,800	0.31	0.9	8,400	1,100	0.23	0.8	5,000	650	0.2	0.5
2060-100		10	16,000	3,100	0.6	1.8	16,000	3,100	0.6	1.8	11,000	2,310	0.55	1.7	7,500	1,800	0.5	1.5
2060-150		15	16,000	3,100	0.6	1.8	16,000	3,100	0.6	1.8	11,000	2,310	0.55	1.7	7,500	1,800	0.5	1.5
2060-200		20	16,000	3,100	0.6	1.8	16,000	3,100	0.6	1.8	11,000	2,310	0.55	1.7	6,500	1,300	0.4	1.4
2060-250		25	13,000	2,600	0.45	1.5	13,000	2,600	0.45	1.5	10,000	1,800	0.4	1.3	5,300	840	0.32	0.9
2060-300		30	10,000	2,100	0.4	1.3	10,000	2,100	0.4	1.3	8,000	1,350	0.3	1.1	4,700	750	0.3	0.8
2060-350	**R3**	35	8,000	1,800	0.38	1.1	8,000	1,800	0.38	1.1	7,000	1,100	0.26	0.9	4,200	670	0.25	0.6
2060-400		40	7,000	1,800	0.36	0.9	7,000	1,800	0.36	0.9	6,000	900	0.23	0.75	3,700	550	0.2	0.4
2060-450		45	5,800	1,700	0.33	0.75	5,800	1,700	0.33	0.75	4,600	670	0.19	0.6	3,200	470	0.15	0.3
2060-500		50	4,000	1,500	0.3	0.6	4,000	1,500	0.3	0.6	3,200	450	0.15	0.4	2,800	400	0.1	0.2
2060-600		60	2,700	1,000	0.21	0.42	2,700	1,000	0.21	0.42	2,300	320	0.1	0.3	1,950	270	0.08	0.16



Note:
- Decrease the feed rate more than 50% from the milling parameters when slot milling.
- Decrease both spindle speed and feed rate proportionally when the milling parameters exceed the machine's maximum spindle speed,or when chattering and red-hot occur.
- Recommend oil coolant for Stainless Steels and Heat Resistant Alloys.
- Recommend wet coolant for Copper.

Advisory for Safe Use of End Mills

Correct application and operation is strongly advised to avoid clogging, abrasion, etc, that could cause serious accidents or injuries.
Ignition or sparks generated during milling could lead to fire or extreme damage to the work piece.
End Mills are made with very sharp cutting edges and must be handled with extra care.

- Never touch the cutting edge with your bare hands, as this could cause serious injury. Special caution is required when opening the package.
- Dropping the tool could cause breakage or flying debris, leading to serious injury.
- During milling, unexpected impact or shock on the tool could cause breakage or flying debris. Ensure to use protective items such as safety glasses and a face guard.
- For best results, fine parameter adjustment may be required, depending on the materials; milling shape and strategy; machine rigidity and spindle capability.
- Use a machine that has high rigidity and generates a low level of vibration. Recommend setting the runout control value at 5μm or below for the small diameter tools ϕ1 or below.
- Do not use flammable cutting oils.

Advisory for Regrinding End Mills

- Never regrind the tool without wearing safety glasses and a face guard.

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Price & Specifications are subject to change without notice.

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