V Series

ϕ3 mm Shank End Mills

Vol.3

Opening the future of small diameter milling with ϕ3mm shank tools.

Eco-friendly and significant cost savings on tools

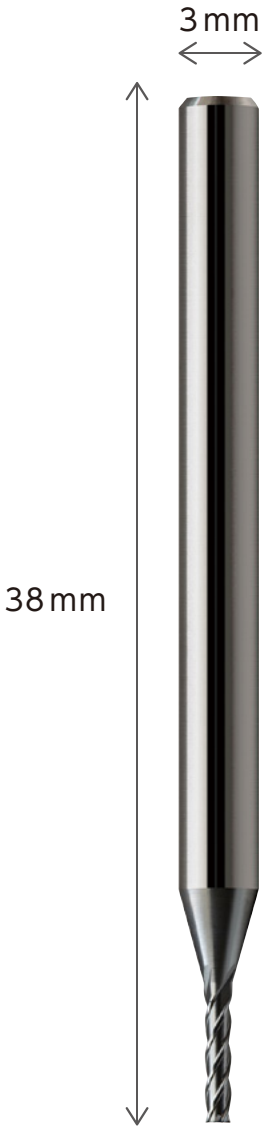
UNION TOOL CO.

Recommended for improved milling quality and cost reduction!

ϕ3 mm Shank V series

ϕ3 mm Shank (h4 tolerance) × Overall length 38* mm

Fixed size of ϕ3 Shank x Overall Length 38 mm
ϕ3 shank is used to save valuable carbide material. h4 tolerance is compatible for both shrink fit and collet holders. More series to follow in the future.
(*The overall length of VCBN series is 35 mm.)



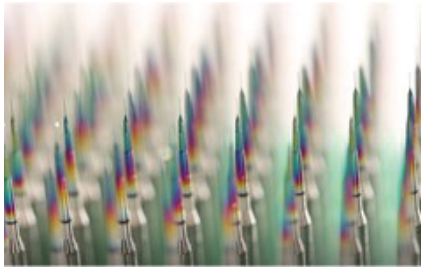
Cost effective

PCB drills mass production technology is applied to end mills
To attain affordable prices, we applied our existing and proven automatic mass production technology for blank rods, flute grinding, coating and inspection to these new end mills.

High Quality

Small diameter V series are high-precision as a result of using the latest in-house technologies.
We developed new grinding machines specialized for small diameter end mills for high-precision milling that will innovate manufacturing technology for high-precision, high-efficiency milling.


Our in-house developed production facility for PCB tools


Over 5million coated PCB tools manufactured every month


Carefully crafted in Mitsuke of Niigata prefecture

PCB: Printed Circuit Board

More eco-friendly compared to ϕ4 shank

Outside Diameter ϕ4
× Overall Length 45mm

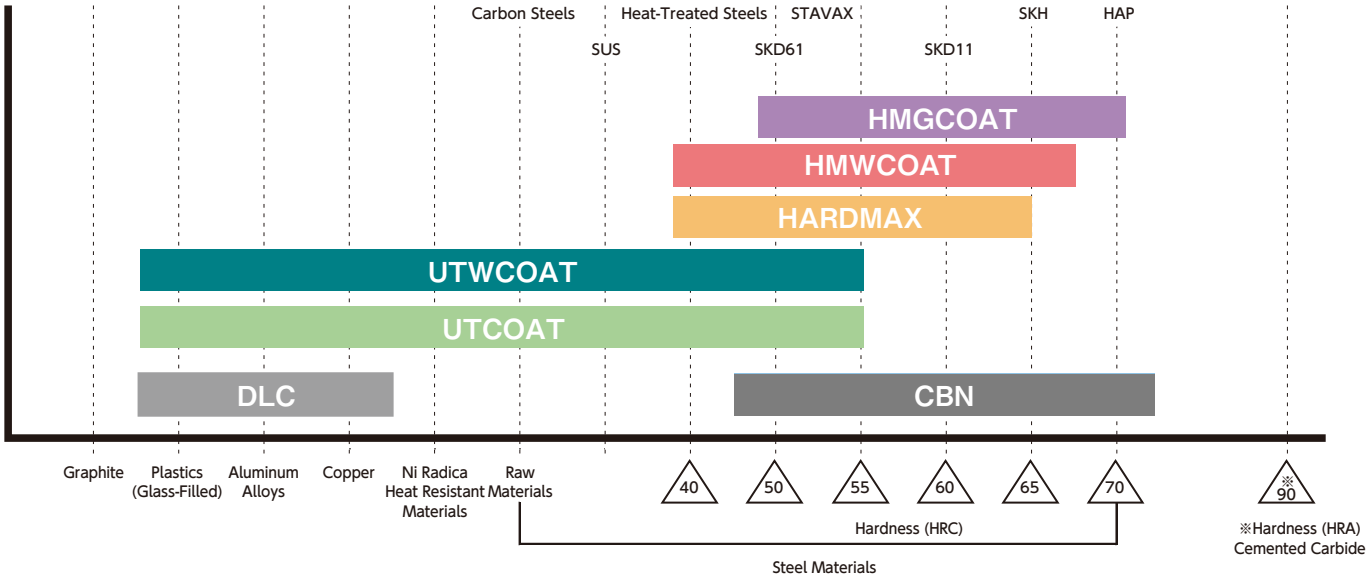
About 6.3g

Outside Diameter ϕ3
× Overall Length 38mm

About 3.0g

About 52% reduction in cemented carbide usage

Find the best coating for your material applications



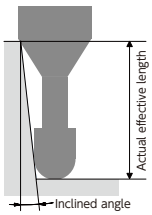
	For Copper, Aluminum DLC	For Raw Materials ~ 55HRC UT COAT / UTW COAT	For Hard Materials (40~65 HRC) HARD MAX / HMW COAT	For Hard Materials (50~70 HRC) HMG COAT	CBN
Square		VCES2000 VCES4000			
Long Neck Square	VDLC-AZS VDLCLS		VHLS		
Long Neck Radius			VHLRS		VCBN-LRF
Ball			VHWB	VHGB	
Long Neck Ball	VDLCLB	VCWLB VCSELB	VHSLB	VHGLB	VCBN-LBSF VCBN-LBF

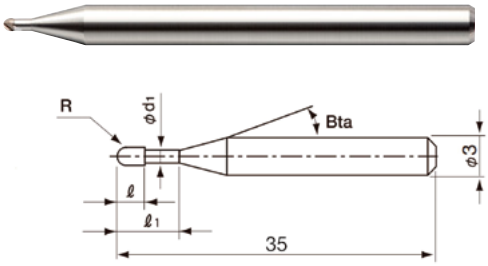
VCBN-LBSF CBN 2 Flutes Short Shank Long Neck Ball End Mills

V Series CBN Long Neck Ball

NEW Launched May 2024

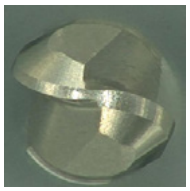
CBN | Shank Dia 0/-0.003 | 20° | R ±0.002 | Back Taper Geometry

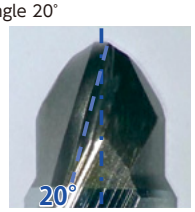




The shank taper angle shown is not an exact value.

Helix angle 20°





Label Sample

#001 R0.5 R+0.001/0.000

Ball radius accuracy measurements are printed on the label to support high precision milling.

For better surface finish

Material Applications (★ Highly Recommended ● Recommended ○ Suggested)

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

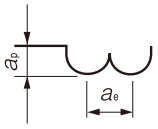
Total 20 models

Unit (mm)

Model Number	Radius of Ball Nose R	Effective Length ℓ1	Length of Cut ℓ	Neck Diameter φd1	Shank Taper Angle Bta	Effective Length by Inclined Angles 30′	1°	1°30′	2°	3°
VCBN-LBSF 2001-002	R0.05	0.2	0.07	0.09	15°	0.22	0.23	0.24	0.25	0.27
VCBN-LBSF 2001-003	R0.05	0.3	0.07	0.09	15°	0.33	0.34	0.35	0.37	0.40
VCBN-LBSF 20015-003	R0.075	0.3	0.1	0.14	15°	0.33	0.34	0.36	0.37	0.40
VCBN-LBSF 20015-0045	R0.075	0.45	0.1	0.14	15°	0.49	0.50	0.52	0.54	0.58
VCBN-LBSF 2002-003	R0.1	0.3	0.13	0.19	15°	0.34	0.35	0.36	0.37	0.40
VCBN-LBSF 2002-006	R0.1	0.6	0.13	0.19	15°	0.65	0.67	0.69	0.71	0.77
VCBN-LBSF 2003-005	R0.15	0.5	0.22	0.28	15°	0.57	0.59	0.60	0.62	0.67
VCBN-LBSF 2003-0075	R0.15	0.75	0.22	0.28	15°	0.83	0.85	0.88	0.91	0.98
VCBN-LBSF 2004-005	R0.2	0.5	0.32	0.38	15°	0.51	0.53	0.54	0.56	0.59
VCBN-LBSF 2004-010	R0.2	1	0.32	0.38	15°	1.03	1.06	1.10	1.13	1.21
VCBN-LBSF 2005-010	R0.25	1	0.4	0.48	15°	1.03	1.06	1.09	1.12	1.20
VCBN-LBSF 2005-015	R0.25	1.5	0.4	0.48	15°	1.54	1.59	1.64	1.70	1.82
VCBN-LBSF 2006-010	R0.3	1	0.48	0.58	15°	1.02	1.05	1.08	1.11	1.18
VCBN-LBSF 2006-015	R0.3	1.5	0.48	0.58	15°	1.54	1.59	1.64	1.69	1.81
VCBN-LBSF 2006-020	R0.3	2	0.48	0.58	15°	2.06	2.12	2.19	2.26	2.43
VCBN-LBSF 2008-020	R0.4	2	0.6	0.78	15°	2.05	2.11	2.18	2.25	2.40
VCBN-LBSF 2010-015	R0.5	1.5	0.7	0.96	15°	1.56	1.60	1.64	1.68	1.79
VCBN-LBSF 2010-020	R0.5	2	0.7	0.96	15°	2.07	2.13	2.19	2.26	2.41
VCBN-LBSF 2010-025	R0.5	2.5	0.7	0.96	15°	2.59	2.67	2.75	2.83	3.03
VCBN-LBSF 2010-030	R0.5	3	0.7	0.96	15°	3.11	3.20	3.30	3.41	3.65

VCBN-LBSF Milling Conditions

WORK MATERIAL			HEAT-TREATED STEELS / HARDENED STEELS STAVAX / ELMAX / HAP10 / HAP72 (~68HRC)			
Model Number	Radius of Ball Nose (mm)	Effective Length (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p (mm)	a_e (mm)
2001-002	**R0.05**	0.2	30,000	80	0.003 or below	0.006 or below
2001-003	**R0.05**	0.3	30,000	70	0.003 or below	0.006 or below
20015-003	**R0.075**	0.3	30,000	180	0.004 or below	0.008 or below
20015-0045	**R0.075**	0.45	30,000	150	0.004 or below	0.008 or below
2002-003	**R0.1**	0.3	30,000	240	0.005 or below	0.01 or below
2002-006	**R0.1**	0.6	30,000	200	0.005 or below	0.01 or below
2003-005	**R0.15**	0.5	30,000	300	0.005 or below	0.01 or below
2003-0075	**R0.15**	0.75	30,000	250	0.005 or below	0.01 or below
2004-005	**R0.2**	0.5	30,000	360	0.005 or below	0.01 or below
2004-010	**R0.2**	1	30,000	300	0.005 or below	0.01 or below
2005-010	**R0.25**	1	30,000	420	0.005 or below	0.01 or below
2005-015	**R0.25**	1.5	30,000	350	0.005 or below	0.01 or below
2006-010	**R0.3**	1	30,000	500	0.01 or below	0.015 or below
2006-015	**R0.3**	1.5	30,000	500	0.01 or below	0.015 or below
2006-020	**R0.3**	2	30,000	350	0.01 or below	0.015 or below
2008-020	**R0.4**	2	30,000	620	0.01 or below	0.015 or below
2010-015	**R0.5**	1.5	30,000	750	0.01 or below	0.02 or below
2010-020	**R0.5**	2	30,000	750	0.01 or below	0.02 or below
2010-025	**R0.5**	2.5	30,000	750	0.01 or below	0.02 or below
2010-030	**R0.5**	3	30,000	500	0.01 or below	0.02 or below



Note:
・Decrease both spindle speed and feed rate proportionally when the milling parameters exceed the machine's maximum spindle speed.
・Recommend oil mist to avoid tool damage.

Comparison of ϕ3 shank (VCBN-LBSF) and ϕ4 shank (CBN-LBSF)

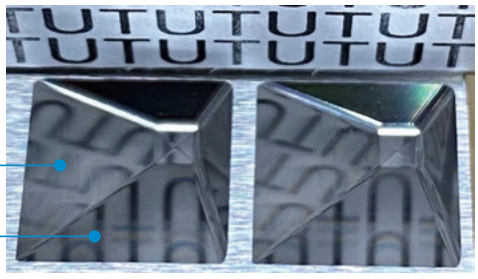
Roughness comparison on finished surface R0.3 × EL1.5

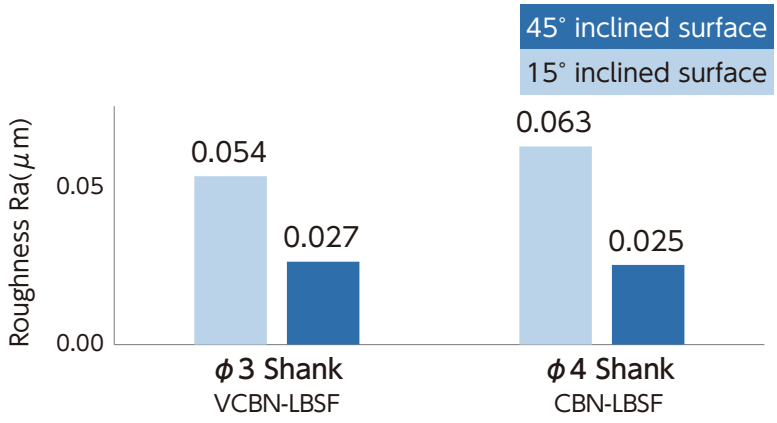
Work material : ELMAX (61 HRC)
Pocket Size : 9 × 9 × 1.5 mm

<Roughing condition>
・Tool : HSB R0.5 × L1
・Coolant : Air blow
・n : 30,000 min^{-1}
・Vf : 1,000 mm/min
・a_p : 0.1 mm
・a_e : 0.3 mm
・Allowance : 0.01 mm
・Cycle time : 3 min

<Semi-finishing>
・Tool : HSB R0.5 × L1
・Coolant : Air blow
・n : 30,000 min^{-1}
・Vf : 1,000 mm/min
・a_p : 0.02 mm
・a_e : 0.05 mm
・Allowance : 0.005 mm
・Cycle time : 11 min

<Finishing condition>
・Tool : CBN R0.3 × EL1.5
・Coolant : Oil mist
・n : 30,000 min^{-1}
・Vf : 550 mm/min
・a_p : 0.015 mm
・a_e : 0.035 mm
・Allowance : 0 mm
・Cycle time : 20 min



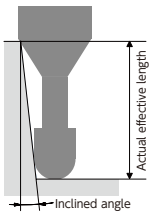


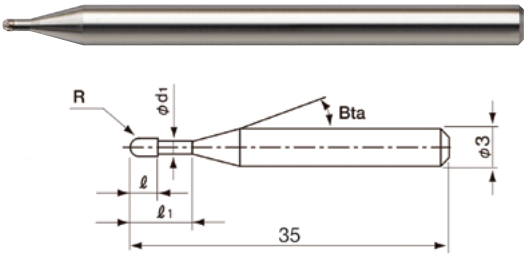
VCBN-LBF CBN 2 Flutes Short Shank Long Neck Ball End Mills

V Series CBN Long Neck Ball

CBN | Shank Dia 0/-0.003 | 0°

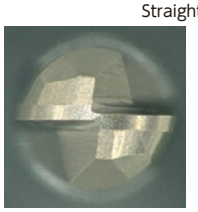
R ±0.002 (R0.03) | R ±0.003 (R0.05~R0.5) | Back Taper Geometry

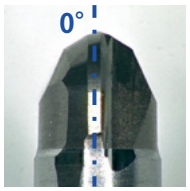




The shank taper angle shown is not an exact value.

Straight Flute





Label Sample

#001 φD0.600 R+0.003/0.000

Diameter and ball radius accuracy measurements are printed on the label to support high precision milling.

For longer tool life

Material Applications (★ Highly Recommended ● Recommended ○ Suggested)

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

Total 23 models

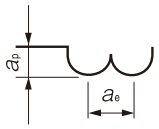
Unit (mm)

Model Number	Radius of Ball Nose R	Effective Length ℓ1	Length of Cut ℓ	Neck Diameter φd1	Shank Taper Angle Bta	Effective Length by Inclined Angles 30′	1°	1°30′	2°	3°
VCBN-LBF20006-0015	R0.03	0.15	0.05	0.055	15°	0.16	0.17	0.18	0.19	0.20
VCBN-LBF 20006-0025	R0.03	0.25	0.05	0.055	15°	0.26	0.28	0.29	0.30	0.33
VCBN-LBF 2001-003	R0.05	0.3	0.08	0.09	15°	0.32	0.34	0.35	0.36	0.40
VCBN-LBF 2001-005	R0.05	0.5	0.08	0.09	15°	0.53	0.55	0.57	0.59	0.64
VCBN-LBF 20015-0045	R0.075	0.45	0.15	0.14	15°	0.49	0.50	0.52	0.54	0.58
VCBN-LBF 20015-0075	R0.075	0.75	0.15	0.14	15°	0.79	0.82	0.85	0.88	0.95
VCBN-LBF 2002-0045	R0.1	0.45	0.16	0.19	15°	0.49	0.51	0.52	0.54	0.58
VCBN-LBF 2002-0075	R0.1	0.75	0.16	0.19	15°	0.79	0.82	0.85	0.88	0.95
VCBN-LBF 2003-005	R0.15	0.5	0.24	0.28	15°	0.57	0.59	0.60	0.62	0.67
VCBN-LBF 2003-009	R0.15	0.9	0.24	0.28	15°	0.97	1.00	1.04	1.07	1.15
VCBN-LBF 2004-005	R0.2	0.5	0.32	0.38	15°	0.51	0.52	0.54	0.55	0.58
VCBN-LBF 2004-010	R0.2	1	0.32	0.38	15°	1.03	1.06	1.09	1.13	1.21
VCBN-LBF 2004-012	R0.2	1.2	0.32	0.38	15°	1.22	1.26	1.30	1.35	1.44
VCBN-LBF 2005-012	R0.25	1.2	0.4	0.48	15°	1.22	1.26	1.30	1.34	1.43
VCBN-LBF 2005-015	R0.25	1.5	0.4	0.48	15°	1.53	1.58	1.63	1.68	1.80
VCBN-LBF 2006-010	R0.3	1	0.48	0.58	15°	1.02	1.05	1.08	1.11	1.18
VCBN-LBF 2006-015	R0.3	1.5	0.48	0.58	15°	1.53	1.57	1.62	1.68	1.79
VCBN-LBF 2006-020	R0.3	2	0.48	0.58	15°	2.05	2.11	2.18	2.25	2.41
VCBN-LBF 2008-020	R0.4	2	0.6	0.78	15°	2.04	2.10	2.17	2.24	2.39
VCBN-LBF 2010-015	R0.5	1.5	0.7	0.98	15°	1.53	1.57	1.61	1.66	1.76
VCBN-LBF 2010-020	R0.5	2	0.7	0.98	15°	2.05	2.11	2.17	2.23	2.38
VCBN-LBF 2010-025	R0.5	2.5	0.7	0.98	15°	2.57	2.64	2.72	2.81	3.00
VCBN-LBF 2010-030	R0.5	3	0.7	0.98	15°	3.09	3.18	3.28	3.38	3.62

VCBN-LBF Milling Conditions

WORK MATERIAL			HEAT-TREATED STEELS / HARDENED STEELS STAVAX (~52HRC)				HARDENED STEELS SKD11 (~62HRC)				HARDENED STEELS HAP10 / HAP72 (~68HRC)			
Model Number	Radius of Ball Nose (mm)	Effective Length (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p (mm)	a_e (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p (mm)	a_e (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p (mm)	a_e (mm)
20006-0015	**R0.03**	0.15	60,000	90	0.001	0.002	60,000	70	0.001	0.002	60,000	50	0.001	0.002
20006-0025	**R0.03**	0.25	60,000	70	0.001	0.002	60,000	60	0.001	0.002	60,000	50	0.001	0.002
2001-003	**R0.05**	0.3	30,000	200	0.005	0.005	30,000	150	0.003	0.005	30,000	100	0.002	0.005
2001-005	**R0.05**	0.5	30,000	150	0.003	0.005	30,000	120	0.003	0.005	30,000	90	0.002	0.005
20015-0045	**R0.075**	0.45	30,000	350	0.005	0.005	30,000	270	0.004	0.005	30,000	200	0.003	0.005
20015-0075	**R0.075**	0.75	30,000	220	0.004	0.005	30,000	160	0.004	0.005	30,000	100	0.003	0.005
2002-0045	**R0.1**	0.45	30,000	580	0.005	0.005	30,000	480	0.005	0.005	30,000	370	0.005	0.005
2002-0075	**R0.1**	0.75	30,000	420	0.005	0.005	30,000	330	0.005	0.005	30,000	230	0.005	0.005
2003-005	**R0.15**	0.5	30,000	1,000	0.005	0.005	30,000	950	0.005	0.005	30,000	620	0.005	0.005
2003-009	**R0.15**	0.9	30,000	760	0.005	0.005	30,000	600	0.005	0.005	30,000	430	0.005	0.005
2004-005	**R0.2**	0.5	30,000	1,580	0.005	0.01	30,000	1,330	0.005	0.01	30,000	860	0.005	0.005
2004-010	**R0.2**	1	30,000	1,200	0.005	0.01	30,000	950	0.005	0.01	30,000	730	0.005	0.005
2004-012	**R0.2**	1.2	30,000	1,050	0.005	0.01	30,000	800	0.005	0.01	30,000	620	0.005	0.005
2005-012	**R0.25**	1.2	30,000	1,480	0.01	0.01	30,000	1,180	0.01	0.01	30,000	860	0.005	0.01
2005-015	**R0.25**	1.5	30,000	1,300	0.01	0.01	30,000	1,000	0.01	0.01	30,000	760	0.005	0.01
2006-010	**R0.3**	1	30,000	2,400	0.02	0.03	30,000	1,900	0.02	0.03	30,000	1,080	0.01	0.02
2006-015	**R0.3**	1.5	30,000	2,000	0.02	0.03	30,000	1,500	0.02	0.03	30,000	1,000	0.01	0.02
2006-020	**R0.3**	2	28,700	1,700	0.02	0.02	28,700	1,300	0.02	0.02	28,700	920	0.01	0.01
2008-020	**R0.4**	2	30,000	2,500	0.02	0.03	30,000	2,100	0.02	0.03	30,000	1,700	0.01	0.02
2010-015	**R0.5**	1.5	30,000	3,700	0.04	0.05	30,000	3,400	0.03	0.04	30,000	2,300	0.025	0.03
2010-020	**R0.5**	2	30,000	3,500	0.04	0.04	30,000	3,200	0.03	0.04	30,000	2,200	0.02	0.03
2010-025	**R0.5**	2.5	30,000	3,300	0.04	0.04	30,000	3,000	0.03	0.04	30,000	2,100	0.02	0.03
2010-030	**R0.5**	3	29,000	3,100	0.03	0.04	29,000	2,770	0.03	0.03	29,000	2,000	0.02	0.02

Note:
・Decrease both spindle speed and feed rate proportionally when the milling parameters exceed the machine's maximum spindle speed.
・Recommend oil mist to avoid tool damage.



Comparison of ϕ3 shank (VCBN-LBF) and ϕ4 shank (CBN-LBF)

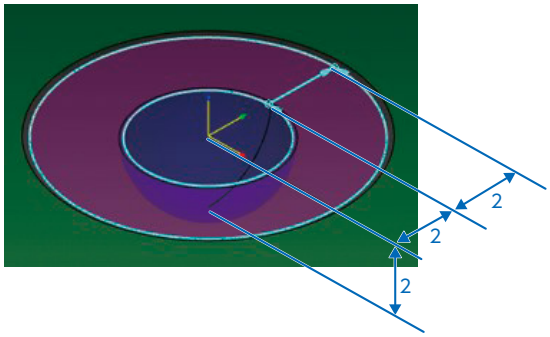
Hemispherical + Flat milling example R0.1 x Effective Length 0.45

<Milling condition>

・Work material : HAP72(67 HRC)
・Coolant : Oil mist
・Milling shape : Hemisphere (R2) + Flat (Width 2)
・Cycle time : About 3 h 40 min / 6 pcs

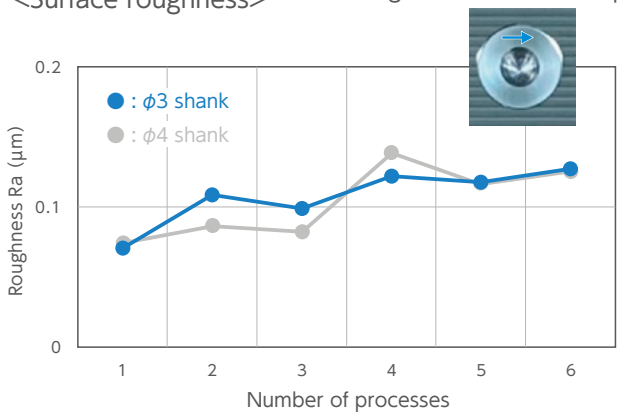
n : 30,000 min^{-1}
Vf : 370 mm/min
a_p : 0.005 mm
a_e : 0.005 mm
Allowance : 0.005 mm

<Milling shape>

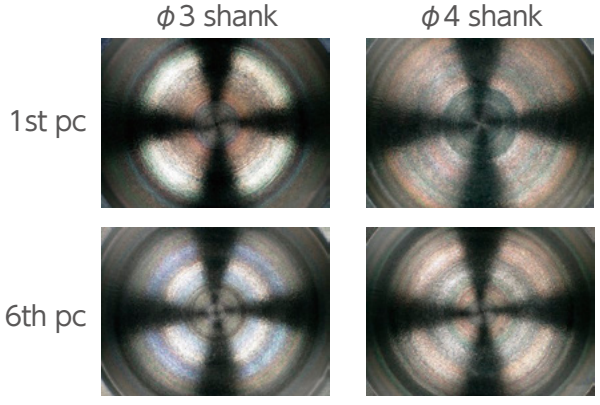


<Surface roughness>

Roughness measurement position



<Hemispherical surface condition>



VCBN-LRF CBN 2 Flutes Short Shank Long Neck Radius End Mills

V Series CBN Long Neck Radius

CBN

Shank Dia 0/-0.003

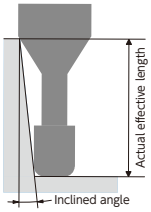
0°

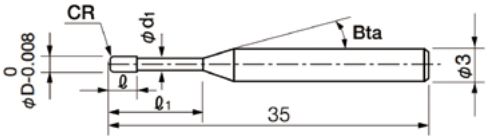
R

R ±0.002 CR≦0.03

R ±0.003 CR≧0.05

Back Taper Geometry





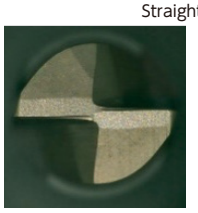
The shank taper angle shown is not an exact value.

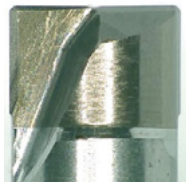
Label Sample

#001 ϕD0.997 R+0.001/0.000

Diameter and Corner R accuracy measurements are printed on the label to support high precision milling.

Straight Flute





For longer tool life

Material Applications (★ Highly Recommended ● Recommended ○ Suggested)

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

Total 20 models

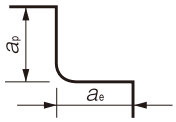
Unit (mm)

Model Number	Outside Diameter ϕD	Corner Radius CR	Effective Length ℓ1	Length of Cut ℓ	Neck Diameter ϕd1	Shank Taper Angle Bta	Effective Length by Inclined Angles 30′	1°	1°30′	2°	3°
VCBN-LRF 2001-002002	0.1	R0.02	0.2	0.04	0.09	15°	0.22	0.23	0.24	0.25	0.27
VCBN-LRF 2001-003002	0.1	R0.03	0.2	0.04	0.09	15°	0.21	0.23	0.24	0.25	0.27
VCBN-LRF 2002-002005	0.2	R0.02	0.5	0.08	0.19	15°	0.53	0.55	0.57	0.59	0.65
VCBN-LRF 2002-005005	0.2	R0.05	0.5	0.08	0.19	15°	0.53	0.55	0.57	0.59	0.64
VCBN-LRF 2003-002005	0.3	R0.02	0.5	0.13	0.28	15°	0.56	0.58	0.61	0.63	0.68
VCBN-LRF 2003-005005	0.3	R0.05	0.5	0.13	0.28	15°	0.56	0.58	0.60	0.62	0.68
VCBN-LRF 2003-010005	0.3	R0.1	0.5	0.13	0.28	15°	0.56	0.58	0.60	0.62	0.66
VCBN-LRF 2004-002005	0.4	R0.02	0.5	0.24	0.38	15°	0.51	0.53	0.55	0.57	0.62
VCBN-LRF 2004-005005	0.4	R0.05	0.5	0.24	0.38	15°	0.51	0.52	0.54	0.56	0.61
VCBN-LRF 2004-010005	0.4	R0.1	0.5	0.24	0.38	15°	0.50	0.52	0.54	0.56	0.60
VCBN-LRF 2005-002010	0.5	R0.02	1	0.3	0.48	15°	1.02	1.06	1.10	1.14	1.24
VCBN-LRF 2005-005010	0.5	R0.05	1	0.3	0.48	15°	1.02	1.06	1.10	1.14	1.23
VCBN-LRF 2005-010010	0.5	R0.1	1	0.3	0.48	15°	1.02	1.06	1.09	1.13	1.22
VCBN-LRF 2006-005010	0.6	R0.05	1	0.3	0.58	15°	1.02	1.06	1.10	1.14	1.23
VCBN-LRF 2006-010010	0.6	R0.1	1	0.3	0.58	15°	1.02	1.06	1.09	1.13	1.22
VCBN-LRF 2008-005010	0.8	R0.05	1	0.56	0.78	15°	1.02	1.06	1.10	1.14	1.23
VCBN-LRF 2008-010010	0.8	R0.1	1	0.56	0.78	15°	1.02	1.06	1.09	1.13	1.22
VCBN-LRF 2010-002020	1	R0.02	2	0.7	0.98	15°	2.06	2.13	2.21	2.30	2.48
VCBN-LRF 2010-005020	1	R0.05	2	0.7	0.98	15°	2.06	2.13	2.21	2.29	2.48
VCBN-LRF 2010-010020	1	R0.1	2	0.7	0.98	15°	2.06	2.13	2.20	2.28	2.47

VCBN-LRF Milling Conditions

WORK MATERIAL				HEAT-TREATED STEELS / HARDENED STEELS STAVAX (~52HRC)				HARDENED STEELS SKD11 (~62HRC)				HARDENED STEELS HAP10 / HAP72 (~68HRC)			
Model Number	Outside Diameter (mm)	Corner Radius (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)
2001-002002	**0.1**	R0.02	0.2	30,000	90	0.002	0.01	30,000	60	0.002	0.01	30,000	30	0.002	0.005
2001-003002	**0.1**	R0.03	0.2	30,000	90	0.002	0.01	30,000	60	0.002	0.01	30,000	30	0.002	0.005
2002-002005	**0.2**	R0.02	0.5	30,000	140	0.003	0.02	30,000	120	0.003	0.02	30,000	80	0.003	0.01
2002-005005	**0.2**	R0.05	0.5	30,000	140	0.003	0.02	30,000	120	0.003	0.02	30,000	80	0.003	0.01
2003-002005	**0.3**	R0.02	0.5	30,000	185	0.003	0.045	30,000	160	0.003	0.045	30,000	120	0.003	0.02
2003-005005	**0.3**	R0.05	0.5	30,000	240	0.005	0.045	30,000	225	0.005	0.045	30,000	210	0.004	0.02
2003-010005	**0.3**	R0.1	0.5	30,000	370	0.005	0.045	30,000	340	0.005	0.045	30,000	310	0.004	0.02
2004-002005	**0.4**	R0.02	0.5	30,000	230	0.005	0.065	30,000	200	0.005	0.065	30,000	160	0.004	0.02
2004-005005	**0.4**	R0.05	0.5	30,000	340	0.01	0.065	30,000	300	0.01	0.065	30,000	220	0.005	0.02
2004-010005	**0.4**	R0.1	0.5	30,000	520	0.01	0.065	30,000	450	0.01	0.065	30,000	320	0.005	0.02
2005-002010	**0.5**	R0.02	1	30,000	280	0.005	0.09	30,000	240	0.005	0.09	30,000	200	0.005	0.03
2005-005010	**0.5**	R0.05	1	30,000	440	0.01	0.09	30,000	380	0.01	0.09	30,000	280	0.01	0.03
2005-010010	**0.5**	R0.1	1	30,000	700	0.02	0.09	30,000	600	0.02	0.09	30,000	410	0.01	0.03
2006-005010	**0.6**	R0.05	1	30,000	500	0.01	0.11	30,000	430	0.01	0.11	30,000	340	0.01	0.035
2006-010010	**0.6**	R0.1	1	30,000	800	0.02	0.11	30,000	675	0.02	0.11	30,000	492	0.01	0.035
2008-005010	**0.8**	R0.05	1	30,000	600	0.01	0.16	30,000	510	0.01	0.16	30,000	450	0.01	0.04
2008-010010	**0.8**	R0.1	1	30,000	920	0.02	0.16	30,000	790	0.02	0.16	30,000	560	0.01	0.04
2010-002020	**1**	R0.02	2	30,000	500	0.005	0.2	30,000	430	0.005	0.2	30,000	400	0.005	0.05
2010-005020	**1**	R0.05	2	30,000	700	0.01	0.2	30,000	600	0.01	0.2	30,000	500	0.01	0.05
2010-010020	**1**	R0.1	2	30,000	1,000	0.02	0.2	30,000	850	0.02	0.2	30,000	600	0.01	0.05

Note:
・Decrease both spindle speed and feed rate proportionally when the milling parameters exceed the machine's maximum spindle speed.
・Recommend oil mist to avoid tool damage.



Comparison of VCBN-LRF (ϕ3 shank) and CBN-LRF (ϕ4 shank)

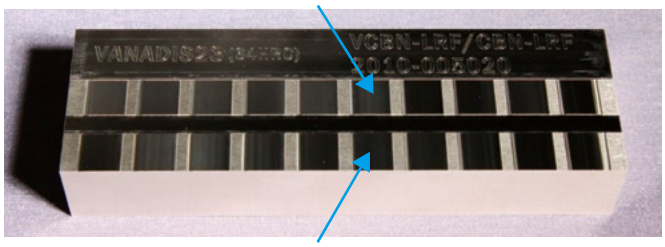
Air vent milling example ϕ1 × CR0.05 × EL2

<Milling condition>

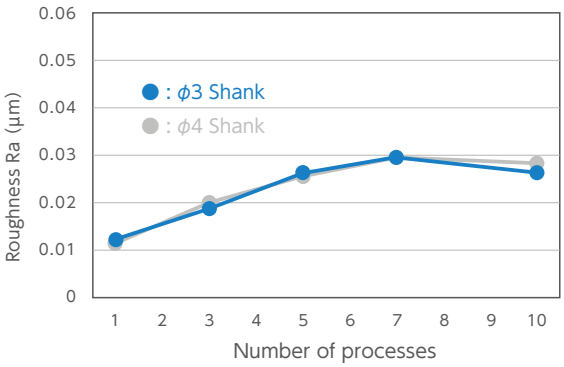
Work material : VANADIS23(64 HRC)
Coolant : Oil Mist
Milling shape : Flat surface 10 mm × 10 mm
Cycle time : About 70 min / 10 surfaces

n : 30,000 min^{-1}
Vf : 500 mm/min
a_p : 0.005 mm
a_e : 0.05 mm
Allowance : 0.005 mm

<Finished work>

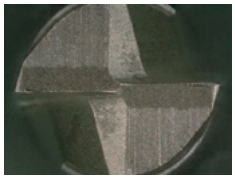


<Surface roughness>

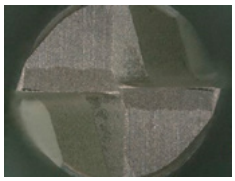


<Tool condition after milling>

ϕ3 Shank



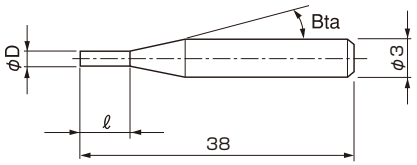
ϕ4 Shank



VCES2000 UTCOAT 2 Flutes Short Shank Square End Mills

V Series UTCOAT Square

Super MG | UT COAT | 30° | Shank Dia 0/-0.003 | Flatland



The shank taper angle shown is not an exact value.

Multi-purpose Standard type

Material Applications (★ Highly Recommended ● Recommended ○ Suggested)

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

Total 35 models

Unit (mm)

Model Number	Outside Diameter φD	Length of Cut ℓ	Shank Taper Angle Bta
VCES 2001-0015	0.1	0.15	16°
VCES 2001-0020	0.1	0.2	16°
VCES 2002-0040	0.2	0.4	16°
VCES 2002-0050	0.2	0.5	16°
VCES 2002-0060	0.2	0.6	16°
VCES 2003-0045	0.3	0.45	16°
VCES 2003-0060	0.3	0.6	16°
VCES 2003-0075	0.3	0.75	16°
VCES 2003-0090	0.3	0.9	16°
VCES 2004-0060	0.4	0.6	16°
VCES 2004-0080	0.4	0.8	16°
VCES 2004-0100	0.4	1	16°
VCES 2004-0120	0.4	1.2	16°
VCES 2005-0100	0.5	1	16°
VCES 2005-0125	0.5	1.25	16°
VCES 2005-0150	0.5	1.5	16°
VCES 2005-0200	0.5	2	16°
VCES 2006-0150	0.6	1.5	16°
VCES 2006-0180	0.6	1.8	16°
VCES 2006-0240	0.6	2.4	16°
VCES 2008-0120	0.8	1.2	16°
VCES 2008-0200	0.8	2	16°
VCES 2008-0240	0.8	2.4	16°
VCES 2008-0320	0.8	3.2	16°
VCES 2010-0200	1	2	16°
VCES 2010-0250	1	2.5	16°
VCES 2010-0300	1	3	16°
VCES 2010-0400	1	4	16°
VCES 2015-0300	1.5	3	16°
VCES 2015-0400	1.5	4	16°
VCES 2020-0400	2	4	16°
VCES 2020-0600	2	6	16°
VCES 2025-0750	2.5	7.5	16°
VCES 2030-0450	3	4.5	—
VCES 2030-0900	3	9	—

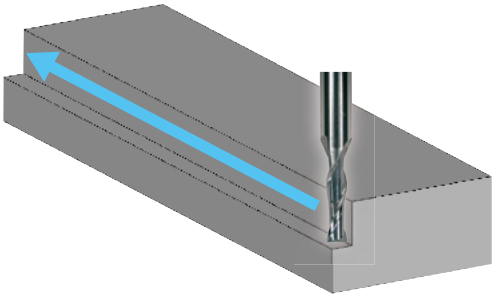
The comparison example of VCES(ϕ3 shank) & C-CES(ϕ4 shank)　ϕ2 × L6

VCES2000 Side milling example

<Milling condition>
Work material : S50C
Coolant : Water soluble
Milling method : Side milling L 70 × H 5 mm
Cycle time : 30 min (Roughing + Finishing)

n : 11,000 min^{-1}
V_f : Roughing 130 mm/min
Finishing 65 mm/min
a_p : 5.0 mm
a_e : Roughing 0.1 mm
Finishing 0.01 mm

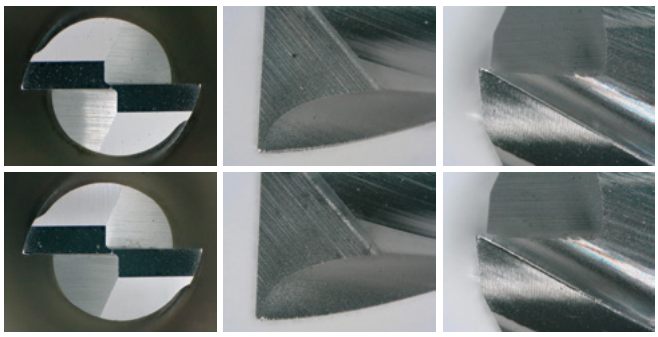
<Side milling image>



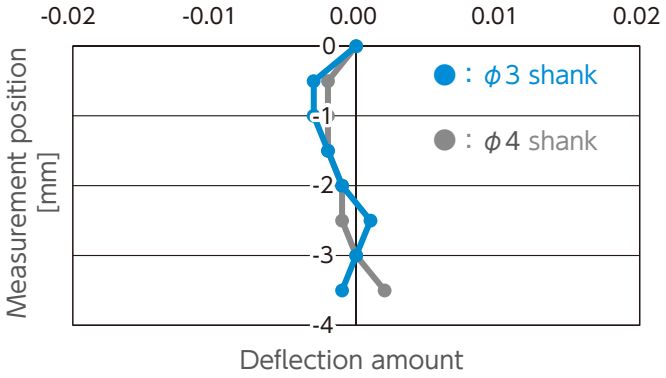
Tool damage after the roughing process

ϕ3 shank
VCES

ϕ4 shank
C-CES

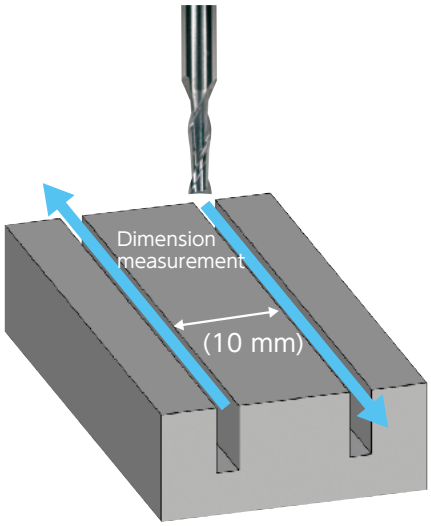


Wall deflection after the finishing process



VCES2000 Slotting example

<Slotting, Dimensional measurement image>



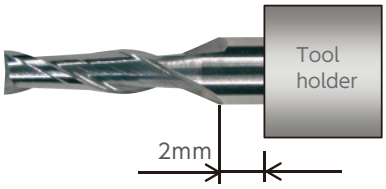
※ Dimensional measurement point:
Center of the slots, at a depth of 3 mm

<Milling condition>
Work material : S50C
Coolant : Water soluble
Milling shape : Slotting
L 45 × D 6 mm
Cycle time : 20 min

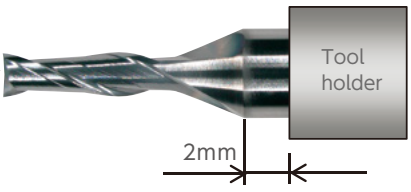
n : 11,000 min^{-1}
V_f : 130 mm/min
a_p : 0.25 mm

<Tool overhang image>

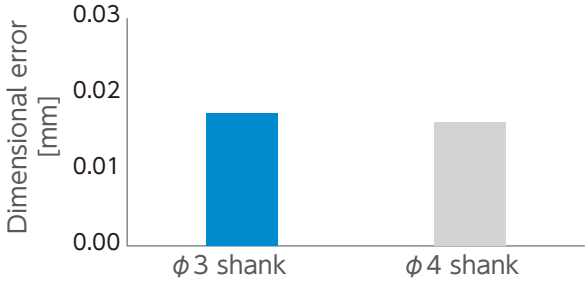
ϕ3 shank
VCES



ϕ4 shank
C-CES



Dimensional error of the slots



Equivalent results were obtained despite the shank diameter gap.

Milling Condition for VCES2000

Slotting

WORK MATERIAL			CARBON STEELS S45C / S50C (~225HB)			ALLOY STEELS SK / SCM / SUS (225~325HB)			PREHARDENED STEELS / HARDENED STEELS NAK / SKD (30~45HRC)			HARDENED STEELS SKD / SKT (45~55HRC)		
Model Number	Outside Diameter (mm)	Length of Cut (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)
2001	**0.1**	0.15	30,000	30	0.01	30,000	30	0.01	30,000	15	0.01	30,000	10	0.002
2001	**0.1**	0.2	30,000	30	0.01	30,000	30	0.01	30,000	15	0.01	30,000	10	0.002
2002	**0.2**	0.4	30,000	85	0.02	30,000	85	0.02	30,000	30	0.02	30,000	25	0.004
2002	**0.2**	0.5	30,000	85	0.014	30,000	85	0.014	30,000	30	0.014	30,000	25	0.004
2002	**0.2**	0.6	30,000	85	0.01	30,000	85	0.01	30,000	30	0.01	30,000	25	0.002
2003	**0.3**	0.45	30,000	110	0.03	30,000	110	0.03	30,000	55	0.03	22,000	25	0.006
2003	**0.3**	0.6	30,000	110	0.03	30,000	110	0.03	30,000	55	0.03	22,000	25	0.006
2003	**0.3**	0.75	30,000	110	0.021	30,000	110	0.021	30,000	55	0.021	22,000	25	0.006
2003	**0.3**	0.9	30,000	110	0.015	30,000	110	0.015	30,000	55	0.015	22,000	25	0.003
2004	**0.4**	0.6	30,000	120	0.04	30,000	120	0.04	27,000	60	0.04	17,000	25	0.008
2004	**0.4**	0.8	30,000	120	0.04	30,000	120	0.04	27,000	60	0.04	17,000	25	0.008
2004	**0.4**	1	30,000	120	0.028	30,000	120	0.028	27,000	60	0.028	17,000	25	0.008
2004	**0.4**	1.2	30,000	120	0.02	30,000	120	0.02	27,000	60	0.02	17,000	25	0.004
2005	**0.5**	1	30,000	120	0.05	29,000	120	0.05	21,500	60	0.05	13,000	25	0.01
2005	**0.5**	1.25	30,000	120	0.035	29,000	120	0.035	21,500	60	0.035	13,000	25	0.01
2005	**0.5**	1.5	30,000	120	0.025	29,000	120	0.025	21,500	60	0.025	13,000	25	0.005
2005	**0.5**	2	30,000	120	0.01	29,000	120	0.01	21,500	60	0.01	13,000	25	0.005
2006	**0.6**	1.5	30,000	120	0.042	24,000	120	0.042	18,000	60	0.042	11,000	25	0.012
2006	**0.6**	1.8	30,000	120	0.03	24,000	120	0.03	18,000	60	0.03	11,000	25	0.006
2006	**0.6**	2.4	30,000	120	0.012	24,000	120	0.012	18,000	60	0.012	11,000	25	0.006
2008	**0.8**	1.2	24,000	120	0.08	19,000	120	0.08	13,800	60	0.08	8,800	30	0.016
2008	**0.8**	2	24,000	120	0.056	19,000	120	0.056	13,800	60	0.056	8,800	30	0.016
2008	**0.8**	2.4	24,000	120	0.04	19,000	120	0.04	13,800	60	0.04	8,800	30	0.008
2008	**0.8**	3.2	24,000	120	0.016	19,000	120	0.016	13,800	60	0.016	8,800	30	0.008
2010	**1**	2	20,000	125	0.25	15,000	120	0.25	11,000	65	0.25	7,100	30	0.05
2010	**1**	2.5	20,000	125	0.2	15,000	120	0.2	11,000	65	0.2	7,100	30	0.03
2010	**1**	3	20,000	125	0.125	15,000	120	0.125	11,000	65	0.125	7,100	30	0.02
2010	**1**	4	20,000	125	0.075	15,000	120	0.075	11,000	65	0.075	7,100	30	0.01
2015	**1.5**	3	13,500	130	0.375	10,000	120	0.375	8,000	70	0.375	5,100	35	0.075
2015	**1.5**	4	13,500	130	0.1875	10,000	120	0.1875	8,000	70	0.1875	5,100	35	0.03
2020	**2**	4	11,000	130	0.5	8,500	120	0.5	6,400	70	0.5	4,000	40	0.1
2020	**2**	6	11,000	130	0.25	8,500	120	0.25	6,400	70	0.25	4,000	40	0.04
2025	**2.5**	7.5	8,800	195	0.3125	7,000	135	0.3125	5,000	70	0.3125	3,200	40	0.05
2030	**3**	4.5	7,400	195	1.5	6,400	145	1.5	4,500	80	1.5	2,800	45	0.15
2030	**3**	9	7,400	195	0.9	6,400	145	0.9	4,500	80	0.9	2,800	45	0.06

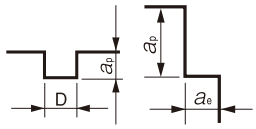
Milling Condition for VCES2000

Side Milling

WORK MATERIAL			CARBON STEELS S45C / S50C (~225HB)				ALLOY STEELS SK / SCM / SUS (225~325HB)				PREHARDENED STEELS / HARDENED STEELS NAK / SKD (30~45HRC)				HARDENED STEELS SKD / SKT (45~55HRC)			
Model Number	Outside Diameter (mm)	Length of Cut (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	**0.1**	0.15	30,000	30	0.15	0.01	30,000	30	0.15	0.01	30,000	15	0.15	0.01	30,000	10	0.1	0.005
2001	**0.1**	0.2	30,000	30	0.15	0.01	30,000	30	0.15	0.01	30,000	15	0.15	0.01	30,000	10	0.1	0.005
2002	**0.2**	0.4	30,000	85	0.3	0.02	30,000	85	0.3	0.02	30,000	30	0.3	0.02	30,000	25	0.2	0.01
2002	**0.2**	0.5	30,000	85	0.4	0.014	30,000	85	0.4	0.014	30,000	30	0.4	0.014	30,000	25	0.3	0.006
2002	**0.2**	0.6	30,000	85	0.5	0.01	30,000	85	0.5	0.01	30,000	30	0.5	0.01	30,000	25	0.4	0.004
2003	**0.3**	0.45	30,000	110	0.45	0.03	30,000	110	0.45	0.03	30,000	55	0.45	0.03	22,000	25	0.3	0.015
2003	**0.3**	0.6	30,000	110	0.45	0.03	30,000	110	0.45	0.03	30,000	55	0.45	0.03	22,000	25	0.3	0.015
2003	**0.3**	0.75	30,000	110	0.6	0.021	30,000	110	0.6	0.021	30,000	55	0.6	0.021	22,000	25	0.45	0.009
2003	**0.3**	0.9	30,000	110	0.75	0.015	30,000	110	0.75	0.015	30,000	55	0.75	0.015	22,000	25	0.6	0.006
2004	**0.4**	0.6	30,000	120	0.6	0.04	30,000	120	0.6	0.04	27,000	60	0.6	0.04	17,000	25	0.4	0.02
2004	**0.4**	0.8	30,000	120	0.6	0.04	30,000	120	0.6	0.04	27,000	60	0.6	0.04	17,000	25	0.4	0.02
2004	**0.4**	1	30,000	120	0.8	0.028	30,000	120	0.8	0.028	27,000	60	0.8	0.028	17,000	25	0.6	0.012
2004	**0.4**	1.2	30,000	120	1	0.02	30,000	120	1	0.02	27,000	60	1	0.02	17,000	25	0.8	0.008
2005	**0.5**	1	30,000	120	0.75	0.05	29,000	120	0.75	0.05	21,500	60	0.75	0.05	13,000	25	0.5	0.025
2005	**0.5**	1.25	30,000	120	1	0.035	29,000	120	1	0.035	21,500	60	1	0.035	13,000	25	0.75	0.015
2005	**0.5**	1.5	30,000	120	1.25	0.025	29,000	120	1.25	0.025	21,500	60	1.25	0.025	13,000	25	1	0.01
2005	**0.5**	2	30,000	120	1.75	0.01	29,000	120	1.75	0.01	21,500	60	1.75	0.01	13,000	25	1.5	0.005
2006	**0.6**	1.5	30,000	120	1.2	0.042	24,000	120	1.2	0.042	18,000	60	1.2	0.042	11,000	25	0.9	0.018
2006	**0.6**	1.8	30,000	120	1.5	0.03	24,000	120	1.5	0.03	18,000	60	1.5	0.03	11,000	25	1.2	0.012
2006	**0.6**	2.4	30,000	120	2.1	0.012	24,000	120	2.1	0.012	18,000	60	2.1	0.012	11,000	25	1.8	0.006
2008	**0.8**	1.2	24,000	120	1.2	0.08	19,000	120	1.2	0.08	13,800	60	1.2	0.08	8,800	30	0.8	0.04
2008	**0.8**	2	24,000	120	1.6	0.056	19,000	120	1.6	0.056	13,800	60	1.6	0.056	8,800	30	1.2	0.024
2008	**0.8**	2.4	24,000	120	2	0.04	19,000	120	2	0.04	13,800	60	2	0.04	8,800	30	1.6	0.016
2008	**0.8**	3.2	24,000	120	2.8	0.016	19,000	120	2.8	0.016	13,800	60	2.8	0.016	8,800	30	2.4	0.008
2010	**1**	2	20,000	125	1.5	0.1	15,000	120	1.5	0.1	11,000	65	1.5	0.1	7,100	30	1	0.05
2010	**1**	2.5	20,000	125	2	0.07	15,000	120	2	0.07	11,000	65	2	0.07	7,100	30	1.5	0.03
2010	**1**	3	20,000	125	2.5	0.05	15,000	120	2.5	0.05	11,000	65	2.5	0.05	7,100	30	2	0.02
2010	**1**	4	20,000	125	3.5	0.02	15,000	120	3.5	0.02	11,000	65	3.5	0.02	7,100	30	3	0.01
2015	**1.5**	3	13,500	130	2.25	0.15	10,000	120	2.25	0.15	8,000	70	2.25	0.15	5,100	35	1.5	0.075
2015	**1.5**	4	13,500	130	3.75	0.075	10,000	120	3.75	0.075	8,000	70	3.75	0.075	5,100	35	3	0.03
2020	**2**	4	11,000	130	3	0.2	8,500	120	3	0.2	6,400	70	3	0.2	4,000	40	2	0.1
2020	**2**	6	11,000	130	5	0.1	8,500	120	5	0.1	6,400	70	5	0.1	4,000	40	4	0.04
2025	**2.5**	7.5	8,800	195	6.25	0.125	7,000	135	6.25	0.125	5,000	70	6.25	0.125	3,200	40	5	0.05
2030	**3**	4.5	7,400	195	4.5	0.3	6,400	145	4.5	0.3	4,500	80	4.5	0.3	2,800	45	3	0.15
2030	**3**	9	7,400	195	7.5	0.15	6,400	145	7.5	0.15	4,500	80	7.5	0.15	2,800	45	6	0.06

Note:
- Recommend water soluble or oil coolant.
- Recommend oil coolant for Titanium Alloys and Heat Resistant Alloys.

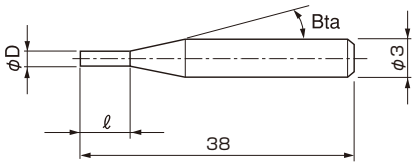
Slotting Side Milling



VCES4000 UTCOAT 4 Flutes Short Shank Square End Mills

V Series UTCOAT Square

Super MG | UT COAT | 30° | Shank Dia 0/-0.003 | Flatland



The shank taper angle shown is not an exact value.

Multi-purpose Standard type

Material Applications (★ Highly Recommended ● Recommended ○ Suggested)

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

Total 10 models

Unit (mm)

Model Number	Outside Diameter φD	Length of Cut ℓ	Shank Taper Angle Bta
VCES 4010-0250	1	2.5	16°
VCES 4010-0400	1	4	16°
VCES 4015-0600	1.5	6	16°
VCES 4020-0500	2	5	16°
VCES 4020-0600	2	6	16°
VCES 4020-0800	2	8	16°
VCES 4025-0625	2.5	6.25	16°
VCES 4025-1000	2.5	10	16°
VCES 4030-0800	3	8	—
VCES 4030-1200	3	12	—

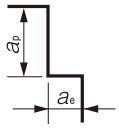
Milling Condition for VCES4000

Side Milling

WORK MATERIAL			CARBON STEELS S45C / S50C (~225HB)				ALLOY STEELS SK / SCM / SUS (225~325HB)				PREHARDENED STEELS / HARDENED STEELS NAK / SKD (30~45HRC)				HARDENED STEELS SKD / SKT (45~55HRC)			
Model Number	Outside Diameter (mm)	Length of Cut (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)
4010	**1**	2.5	20,000	240	2	0.07	15,000	215	2	0.07	11,000	85	2	0.07	7,100	40	1.5	0.03
4010	**1**	4	20,000	240	3.5	0.02	15,000	215	3.5	0.02	11,000	85	3.5	0.02	7,100	40	3	0.01
4015	**1.5**	6	13,500	245	5.25	0.03	10,000	215	5.25	0.03	8,000	90	5.25	0.03	5,100	50	4.5	0.015
4020	**2**	5	11,000	245	4	0.14	8,500	215	4	0.14	6,400	90	4	0.14	4,000	55	3	0.06
4020	**2**	6	11,000	245	5	0.1	8,500	215	5	0.1	6,400	90	5	0.1	4,000	55	4	0.04
4020	**2**	8	11,000	245	7	0.04	8,500	215	7	0.04	6,400	90	7	0.04	4,000	55	6	0.02
4025	**2.5**	6.25	8,800	370	5	0.175	7,000	245	5	0.175	5,000	90	5	0.175	3,200	55	3.75	0.075
4025	**2.5**	10	8,800	370	8.75	0.05	7,000	245	8.75	0.05	5,000	90	8.75	0.05	3,200	55	7.5	0.025
4030	**3**	8	7,400	370	7.5	0.15	6,400	260	7.5	0.15	4,500	105	7.5	0.15	2,800	65	6	0.06
4030	**3**	12	7,400	370	10.5	0.06	6,400	260	10.5	0.06	4,500	105	10.5	0.06	2,800	65	9	0.03

Note:
・Recommend water soluble or oil coolant.
・Recommend oil coolant for Titanium Alloys and Heat Resistant Alloys.

Side Milling

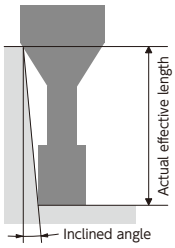


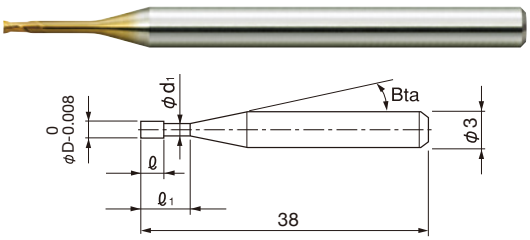
VHLS

V Series HARDMAX Long Neck Square

HARDMAX
2 Flutes Short Shank Long Neck Square End Mills

Super MG | HARD MAX | 30° | Shank Dia 0/-0.003 | Flatland





The shank taper angle shown is not an exact value.

For hard materials
Negative tip design

Material Applications (★ Highly Recommended ● Recommended ○ Suggested)

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

Total 30 models

Unit (mm)

Model Number	Outside Diameter φD	Effective Length ℓ1	Length of Cut ℓ	Neck Diameter φd1	Shank Taper Angle Bta	Effective Length by Inclined Angles 30°	1°	1°30′	2°	3°
VHLS 2001-003	0.1	0.3	0.1	0.093	11°	0.35	0.37	0.39	0.42	0.48
VHLS 2002-005	0.2	0.5	0.3	0.18	16°	0.68	0.72	0.76	0.80	0.87
VHLS 2002-010	0.2	1	0.3	0.18	16°	1.21	1.27	1.32	1.37	1.48
VHLS 2003-010	0.3	1	0.4	0.28	16°	1.25	1.32	1.39	1.45	1.56
VHLS 2003-015	0.3	1.5	0.4	0.28	16°	1.77	1.86	1.94	2.02	2.17
VHLS 2003-020	0.3	2	0.4	0.28	16°	2.30	2.41	2.50	2.59	2.78
VHLS 2004-015	0.4	1.5	0.6	0.38	16°	1.85	1.97	2.07	2.17	2.34
VHLS 2004-020	0.4	2	0.6	0.38	16°	2.38	2.52	2.64	2.75	2.96
VHLS 2004-030	0.4	3	0.6	0.38	16°	3.44	3.61	3.75	3.88	4.18
VHLS 2004-040	0.4	4	0.6	0.38	16°	4.49	4.69	4.85	5.02	5.40
VHLS 2005-015	0.5	1.5	0.7	0.49	16°	1.92	2.06	2.19	2.30	2.51
VHLS 2005-020	0.5	2	0.7	0.49	16°	2.46	2.62	2.76	2.89	3.13
VHLS 2005-025	0.5	2.5	0.7	0.49	16°	2.99	3.18	3.33	3.47	3.74
VHLS 2005-030	0.5	3	0.7	0.49	16°	3.52	3.73	3.89	4.04	4.35
VHLS 2005-040	0.5	4	0.7	0.49	16°	4.58	4.82	5.01	5.18	5.57
VHLS 2005-060	0.5	6	0.7	0.49	16°	6.69	6.97	7.21	7.46	8.02
VHLS 2006-020	0.6	2	0.9	0.59	16°	2.52	2.71	2.88	3.03	3.30
VHLS 2006-030	0.6	3	0.9	0.59	16°	3.60	3.83	4.02	4.20	4.52
VHLS 2006-040	0.6	4	0.9	0.59	16°	4.67	4.93	5.15	5.34	5.75
VHLS 2006-060	0.6	6	0.9	0.59	16°	6.78	7.10	7.36	7.62	8.19

HARDMAX 2 Flutes Short Shank Long Neck Square End Mills

Model Number	Outside Diameter ϕD	Effective Length ℓ_1	Length of Cut ℓ	Neck Diameter ϕd_1	Shank Taper Angle Bta	Effective Length by Inclined Angles				
						30′	1°	1°30′	2°	3°
VHLS 2008-030	**0.8**	**3**	1.2	0.79	16°	3.60	3.83	4.02	4.20	4.52
VHLS 2008-040	**0.8**	**4**	1.2	0.79	16°	4.67	4.93	5.15	5.34	5.75
VHLS 2008-060	**0.8**	**6**	1.2	0.79	16°	6.78	7.10	7.36	7.62	8.19
VHLS 2010-030	**1**	**3**	1.5	0.96	16°	3.71	3.92	4.10	4.26	4.59
VHLS 2010-040	**1**	**4**	1.5	0.96	16°	4.77	5.01	5.22	5.40	5.81
VHLS 2010-050	**1**	**5**	1.5	0.96	16°	5.82	6.09	6.32	6.54	7.03
VHLS 2010-060	**1**	**6**	1.5	0.96	16°	6.87	7.17	7.42	7.68	8.26
VHLS 2015-040	**1.5**	**4**	2.3	1.46	16°	4.17	4.31	4.46	4.61	4.96
VHLS 2015-060	**1.5**	**6**	2.3	1.46	16°	6.24	6.44	6.66	6.89	7.41
VHLS 2020-060	**2**	**6**	3	1.93	16°	6.29	6.49	6.71	6.95	7.47

VHLS Milling Conditions

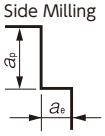
WORK MATERIAL			COPPER OFC / TPC				CARBON STEELS S45C / S50C (~225HB)				ALLOY STEELS SK / SCM / SUS (225~325HB)			
Model Number	Outside Diameter (mm)	Effective Length (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	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)
2001-003	**0.1**	0.3	50,000	170	0.018	0.035	50,000	170	0.005	0.035	50,000	160	0.005	0.035
2002-005	**0.2**	0.5	50,000	340	0.027	0.13	50,000	340	0.009	0.13	50,000	310	0.008	0.13
2002-010	**0.2**	1	50,000	290	0.018	0.035	50,000	290	0.007	0.035	50,000	260	0.006	0.035
2003-010	**0.3**	1	50,000	560	0.045	0.101	50,000	560	0.015	0.101	50,000	500	0.013	0.101
2003-015	**0.3**	1.5	50,000	460	0.041	0.05	50,000	460	0.013	0.05	50,000	410	0.011	0.05
2003-020	**0.3**	2	41,500	350	0.032	0.023	41,500	350	0.01	0.023	41,500	320	0.009	0.023
2004-015	**0.4**	1.5	50,000	660	0.054	0.095	50,000	660	0.016	0.095	50,000	640	0.015	0.095
2004-020	**0.4**	2	50,000	610	0.045	0.052	50,000	610	0.014	0.052	50,000	580	0.013	0.052
2004-030	**0.4**	3	44,500	510	0.027	0.018	44,500	510	0.009	0.018	43,600	450	0.008	0.018
2004-040	**0.4**	4	41,000	440	0.018	0.008	41,000	440	0.006	0.008	38,000	360	0.005	0.008
2005-015	**0.5**	1.5	50,000	1,020	0.09	0.139	50,000	1,020	0.029	0.139	50,000	870	0.027	0.139
2005-020	**0.5**	2	50,000	900	0.081	0.098	50,000	900	0.025	0.098	50,000	760	0.023	0.098
2005-025	**0.5**	2.5	50,000	780	0.072	0.057	50,000	780	0.021	0.057	47,000	650	0.019	0.057
2005-030	**0.5**	3	44,200	660	0.05	0.037	44,200	660	0.016	0.037	39,900	530	0.015	0.037
2005-040	**0.5**	4	40,600	580	0.041	0.016	40,600	580	0.013	0.016	36,100	460	0.012	0.016
2005-060	**0.5**	6	33,400	420	0.023	0.005	33,400	420	0.007	0.005	28,500	320	0.006	0.005
2006-020	**0.6**	2	50,000	1,240	0.117	0.18	50,000	1,240	0.038	0.18	50,000	930	0.034	0.18
2006-030	**0.6**	3	50,000	990	0.09	0.075	50,000	990	0.03	0.075	44,000	740	0.026	0.075
2006-040	**0.6**	4	41,300	740	0.063	0.03	41,300	740	0.021	0.03	34,700	550	0.018	0.03
2006-060	**0.6**	6	32,100	520	0.036	0.01	32,100	520	0.012	0.01	27,000	390	0.01	0.01
2008-030	**0.8**	3	41,200	1,050	0.171	0.15	41,200	1,050	0.053	0.15	34,500	790	0.049	0.15
2008-040	**0.8**	4	37,100	930	0.14	0.08	37,100	930	0.044	0.08	31,100	700	0.04	0.08
2008-060	**0.8**	6	28,800	680	0.077	0.024	28,800	680	0.025	0.024	24,200	510	0.022	0.024
2010-030	**1**	3	37,900	1,340	0.257	0.263	37,900	1,340	0.067	0.263	31,500	990	0.072	0.263
2010-040	**1**	4	34,100	1,170	0.212	0.195	34,100	1,170	0.067	0.195	28,400	870	0.06	0.195
2010-050	**1**	5	30,300	1,000	0.167	0.127	30,300	1,000	0.053	0.127	25,300	750	0.048	0.127
2010-060	**1**	6	26,500	850	0.122	0.058	26,500	850	0.039	0.058	22,100	630	0.035	0.058
2015-040	**1.5**	4	26,600	1,340	0.378	0.462	26,600	1,340	0.12	0.462	22,100	1,000	0.109	0.462
2015-060	**1.5**	6	22,800	1,120	0.297	0.293	22,800	1,120	0.094	0.293	19,000	840	0.085	0.293
2020-060	**2**	6	20,300	1,350	0.338	0.926	20,300	1,350	0.107	0.926	17,400	1,030	0.097	0.926

VHLS Milling Conditions

WORK MATERIAL			PREHARDENED STEELS / HARDENED STEELS NAK / SKD (30~45HR)				HARDENED STEELS SKD / SKT (45~55HRC)				HARDENED STEELS SKD / SKH (55~60HRC)			
Model Number	Outside Diameter (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)
2001-003	**0.1**	0.3	50,000	140	0.004	0.035	50,000	90	0.002	0.035	30,000	10	0.002	0.08
2002-005	**0.2**	0.5	50,000	270	0.006	0.13	44,800	180	0.004	0.13	15,000	10	0.002	0.13
2002-010	**0.2**	1	50,000	230	0.004	0.035	40,800	160	0.002	0.035	15,000	10	0.002	0.035
2003-010	**0.3**	1	50,000	440	0.01	0.101	50,000	330	0.007	0.101	14,600	14	0.004	0.101
2003-015	**0.3**	1.5	50,000	360	0.009	0.05	42,700	260	0.006	0.05	14,600	13	0.004	0.05
2003-020	**0.3**	2	41,500	280	0.007	0.023	33,200	190	0.005	0.023	14,600	12	0.003	0.023
2004-015	**0.4**	1.5	48,100	470	0.012	0.095	38,500	320	0.008	0.095	14,300	17	0.004	0.095
2004-020	**0.4**	2	44,600	430	0.01	0.052	35,700	290	0.007	0.052	14,300	17	0.004	0.052
2004-030	**0.4**	3	37,500	340	0.006	0.018	30,000	230	0.005	0.018	14,300	16	0.003	0.018
2004-040	**0.4**	4	33,100	280	0.004	0.008	26,500	190	0.003	0.008	14,300	15	0.002	0.008
2005-015	**0.5**	1.5	46,500	610	0.02	0.139	37,300	410	0.015	0.139	14,000	20	0.008	0.139
2005-020	**0.5**	2	40,600	510	0.018	0.098	32,500	350	0.013	0.098	14,000	20	0.007	0.098
2005-025	**0.5**	2.5	34,700	410	0.016	0.057	27,700	290	0.011	0.057	14,000	20	0.006	0.057
2005-030	**0.5**	3	32,200	370	0.011	0.037	25,700	260	0.009	0.037	14,000	19	0.005	0.037
2005-040	**0.5**	4	29,700	330	0.009	0.016	23,700	230	0.007	0.016	14,000	18	0.004	0.016
2005-060	**0.5**	6	24,700	250	0.005	0.005	19,700	170	0.003	0.005	14,000	16	0.002	0.005
2006-020	**0.6**	2	39,100	600	0.026	0.18	31,300	410	0.019	0.18	12,000	23	0.01	0.18
2006-030	**0.6**	3	33,500	500	0.02	0.075	26,800	340	0.015	0.075	12,000	22	0.008	0.075
2006-040	**0.6**	4	27,900	390	0.014	0.03	22,300	270	0.01	0.03	12,000	21	0.005	0.03
2006-060	**0.6**	6	23,000	290	0.008	0.01	18,400	200	0.006	0.01	12,000	19	0.003	0.01
2008-030	**0.8**	3	26,200	530	0.038	0.15	21,000	370	0.027	0.15	8,000	21	0.016	0.15
2008-040	**0.8**	4	24,100	480	0.031	0.08	19,300	330	0.022	0.08	8,000	20	0.013	0.08
2008-060	**0.8**	6	19,800	370	0.017	0.024	15,800	250	0.012	0.024	8,000	18	0.007	0.024
2010-030	**1**	3	23,400	650	0.057	0.263	18,700	440	0.039	0.263	6,500	15	0.016	0.263
2010-040	**1**	4	21,500	580	0.047	0.195	17,200	400	0.033	0.195	6,500	15	0.015	0.195
2010-050	**1**	5	19,600	510	0.037	0.127	15,700	360	0.027	0.127	6,500	15	0.014	0.127
2010-060	**1**	6	17,600	440	0.027	0.058	14,100	310	0.02	0.058	6,500	14	0.012	0.058
2015-040	**1.5**	4	16,300	640	0.084	0.462	13,000	440	0.06	0.462	9,600	95	0.036	0.462
2015-060	**1.5**	6	14,400	550	0.066	0.293	11,500	380	0.047	0.293	9,600	60	0.028	0.293
2020-060	**2**	6	12,500	650	0.075	0.926	10,000	450	0.054	0.926	9,600	211	0.032	0.926

Note:
- Recommend using a non-contact measuring device to avoid damaging the precision tip point.
- Decrease both spindle speed and feed rate proportionally when the milling parameters exceed the machine's maximum spindle speed.
- Every coolant offers stable milling.
- Recommend oil coolant for Stainless Steels and Heat Resistant Alloys.
- Recommend wet coolant for Copper.

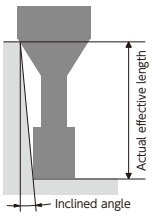
Side Milling

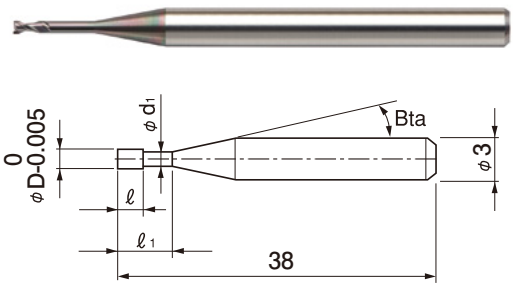


VDLCLS DLCCOAT
2 Flutes Short Shank Long Neck Square End Mills

V Series DLCCOAT Long Neck Square

Super MG | DLC | 35° | Shank Dia 0/-0.003 | Flatland





The shank taper angle shown is not an exact value.

Label Sample

#001 φD0.998

Diameter measurements are printed on the label to support High Precision milling.

DLC coating
For copper electrode milling

Material Applications (★ Highly Recommended ● Recommended ○ Suggested)

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

Total 20 models

Unit (mm)

Model Number	Outside Diameter φD	Effective Length ℓ1	Length of Cut ℓ	Neck Diameter φd1	Shank Taper Angle Bta	Effective Length by Inclined Angles 30′	1°	1°30′	2°	3°
VDLCLS 2002-005	**0.2**	0.5	0.3	0.18	11°	0.64	0.67	0.71	0.75	0.85
VDLCLS 2002-010	**0.2**	1	0.3	0.18	11°	1.16	1.22	1.29	1.36	1.54
VDLCLS 2003-010	**0.3**	1	0.45	0.28	11°	1.16	1.22	1.29	1.36	1.54
VDLCLS 2003-015	**0.3**	1.5	0.45	0.28	11°	1.67	1.76	1.85	1.96	2.20
VDLCLS 2004-010	**0.4**	1	0.6	0.38	11°	1.16	1.22	1.29	1.36	1.54
VDLCLS 2004-020	**0.4**	2	0.6	0.38	11°	2.20	2.31	2.43	2.57	2.89
VDLCLS 2004-030	**0.4**	3	0.6	0.38	11°	3.24	3.41	3.59	3.79	4.26
VDLCLS 2005-020	**0.5**	2	0.75	0.48	11°	2.20	2.31	2.43	2.57	2.89
VDLCLS 2005-030	**0.5**	3	0.75	0.48	11°	3.24	3.41	3.59	3.79	4.26
VDLCLS 2005-040	**0.5**	4	0.75	0.48	11°	4.29	4.50	4.74	5.00	5.63
VDLCLS 2006-020	**0.6**	2	0.9	0.58	11°	2.20	2.31	2.43	2.57	2.89
VDLCLS 2006-030	**0.6**	3	0.9	0.58	11°	3.24	3.41	3.59	3.79	4.26
VDLCLS 2006-040	**0.6**	4	0.9	0.58	11°	4.29	4.50	4.74	5.00	5.63
VDLCLS 2008-040	**0.8**	4	1.2	0.79	11°	4.27	4.48	4.72	4.98	5.60
VDLCLS 2008-060	**0.8**	6	1.2	0.79	11°	6.37	6.68	7.03	7.42	8.34
VDLCLS 2010-040	**1**	4	1.5	0.98	11°	4.31	4.52	4.76	5.02	5.65
VDLCLS 2010-060	**1**	6	1.5	0.98	11°	6.40	6.72	7.07	7.46	8.39
VDLCLS 2010-080	**1**	8	1.5	0.98	11°	8.49	8.92	9.38	9.90	11.13
VDLCLS 2015-060	**1.5**	6	2.25	1.46	11°	6.35	6.67	7.02	7.41	8.33
VDLCLS 2020-080	**2**	8	3	1.97	11°	8.42	8.84	9.30	9.81	No Interference

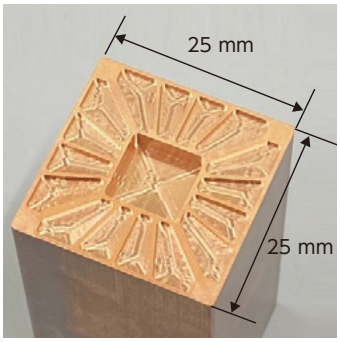
Microchip shape milling example (C1100) ϕ1

Comparison of VDLCLS (2 flutes) and a 2 flute end mill for steels

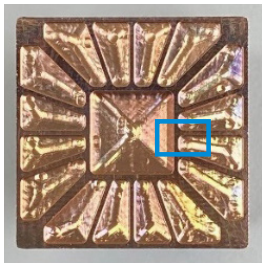
< Milling condition >
Coolant : Oil mist
Milling shape : 25 × 25 × depth 2.5 mm

Process	n (min^{-1})	Vf (mm/min)	a_p (mm)	a_e (mm)	Allowance (mm)	Cycle time
Roughing	24,000	1,200	0.5	0.05	0.02	14 min 8 sec
Finishing	24,000	1,200	0.02	0.02	0	29 min 22 sec
					Total	43 min 30 sec

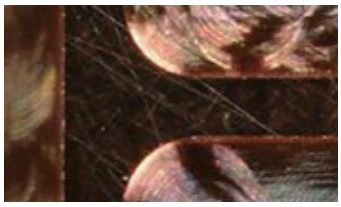
< Work >



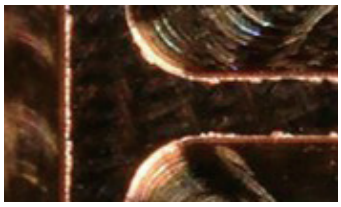
< Work surface burr >
Comparison position for surface burr



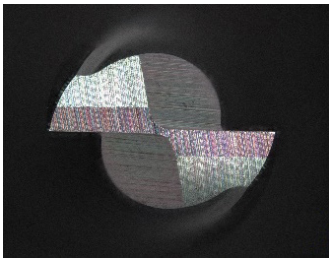
VDLCLS (2 flutes)
ϕ1 × EL4



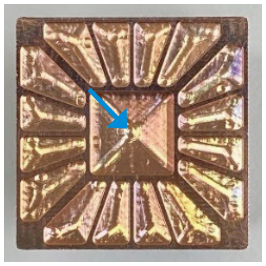
End mill for steels (2 flutes)
ϕ1 × L2.5

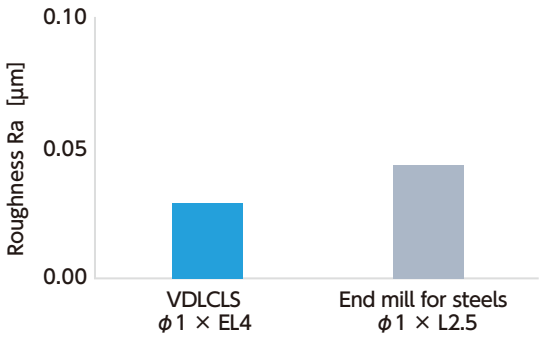


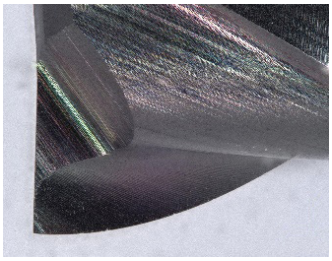
< Tool after milling >



< Surface roughness >
Measurement position for roughness







DLC Coating and the dedicated tool geometry for copper offers the suppression of burrs and allows for a very smooth surface.

Microchip shape milling example (A5052) ϕ1

Comparison of VDLC-AZS (3 flutes) and a 2 flute end mill for steels

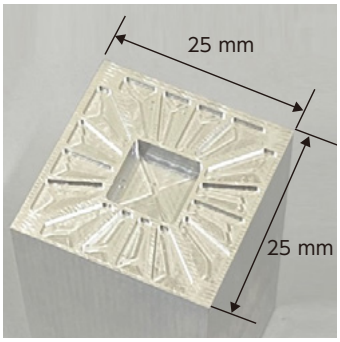
< Milling condition >

Coolant : Oil mist

Milling shape : 25 × 25 × depth 2.5 mm

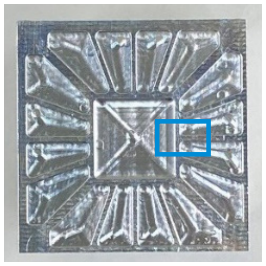
Process	n (min^{-1})	Vf (mm/min)	a_p (mm)	a_e (mm)	Allowance (mm)	Cycle time
Roughing	30,000	1,100	0.5	0.3	0.02	4 min 33 sec
Finishing	30,000	1,100	0.02	0.03	0	24 min 35 sec
					Total	29 min 8 sec

< Work >



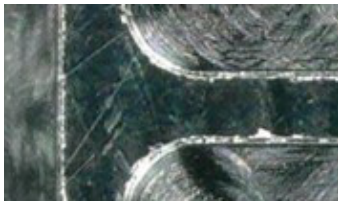
< Work surface burr >

Comparison position for surface burr



VDLC-AZS (3 flutes) ϕ1 × EL3

End mill for steels (2 flutes) ϕ1 × L2.5



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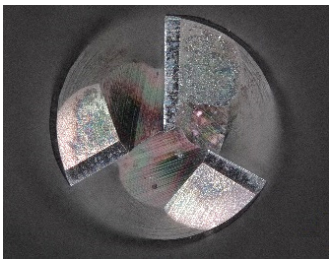
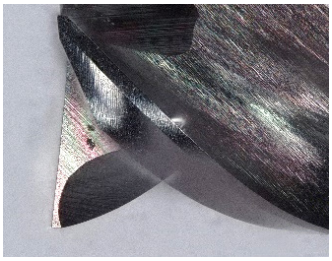
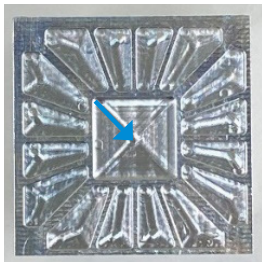
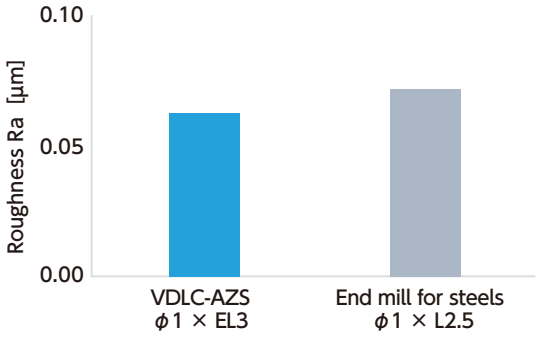




< Surface roughness >

Measurement position for roughness

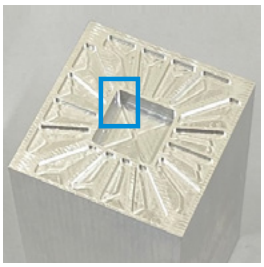




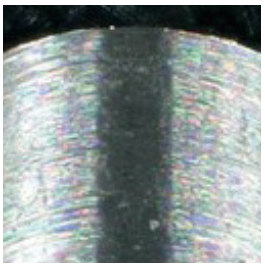
DLC Coating and the dedicated tool geometry for aluminum alloy offers the suppression of burrs and allows for a very smooth surface.

< Surface at the corner >

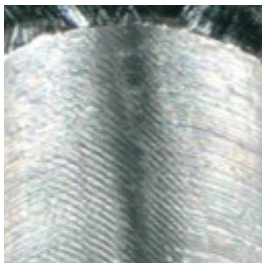
Comparison position for corner surface



VDLC-AZS (3 flutes) ϕ1 × EL3



End mill for steels (2 flutes) ϕ1 × L2.5



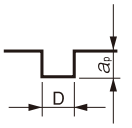
Small relief face are effective in suppressing chattering at the corners.

Milling Condition for VDLCLS

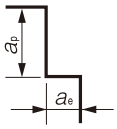
WORK MATERIAL			COPPER / ALUMINUM ALLOYS							TUNGSTEN COPPER						
			Side Milling				Slotting			Side Milling				Slotting		
Model Number	Outside Diameter (mm)	Effective Length (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p Axial Depth (mm)	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)
2002-005	**0.2**	0.5	40,000	400	0.2	0.01	40,000	200	0.02	36,000	360	0.1	0.01	36,000	180	0.02
2002-010	**0.2**	1	40,000	300	0.2	0.01	40,000	150	0.02	36,000	270	0.1	0.01	36,000	135	0.02
2003-010	**0.3**	1	40,000	600	0.3	0.015	40,000	300	0.03	36,000	540	0.15	0.015	36,000	270	0.03
2003-015	**0.3**	1.5	40,000	590	0.3	0.015	40,000	295	0.03	36,000	530	0.15	0.015	36,000	265	0.03
2004-010	**0.4**	1	40,000	800	0.4	0.02	40,000	400	0.04	36,000	720	0.2	0.02	36,000	360	0.04
2004-020	**0.4**	2	40,000	600	0.4	0.02	40,000	300	0.04	36,000	540	0.2	0.02	36,000	270	0.04
2004-030	**0.4**	3	32,000	400	0.4	0.016	32,000	200	0.04	28,800	360	0.2	0.016	28,800	180	0.04
2005-020	**0.5**	2	40,000	1,000	0.5	0.025	40,000	500	0.05	36,000	900	0.25	0.025	36,000	450	0.05
2005-030	**0.5**	3	32,000	750	0.5	0.02	32,000	375	0.05	28,800	680	0.25	0.02	28,800	340	0.05
2005-060	**0.5**	6	25,600	380	0.5	0.015	25,600	190	0.05	23,000	340	0.25	0.015	23,000	170	0.05
2006-020	**0.6**	2	38,000	1,140	0.6	0.03	38,000	570	0.06	34,200	1,030	0.3	0.03	34,200	515	0.06
2006-030	**0.6**	3	38,000	1,000	0.6	0.03	38,000	500	0.06	34,200	900	0.3	0.03	34,200	450	0.06
2006-040	**0.6**	4	30,400	700	0.6	0.024	30,400	350	0.06	27,500	630	0.3	0.024	27,500	315	0.06
2008-040	**0.8**	4	30,000	1,000	0.8	0.04	30,000	500	0.08	27,000	900	0.4	0.04	27,000	450	0.08
2008-060	**0.8**	6	24,000	790	0.8	0.032	24,000	395	0.08	21,600	710	0.4	0.032	21,600	355	0.08
2010-040	**1**	4	24,000	1,200	1	0.05	24,000	600	0.1	21,600	1,080	0.5	0.05	21,600	540	0.1
2010-060	**1**	6	19,200	900	1	0.04	19,200	450	0.1	17,300	810	0.5	0.04	17,300	405	0.1
2010-080	**1**	8	19,200	680	1	0.04	19,200	340	0.1	17,300	610	0.5	0.04	17,300	305	0.1
2015-060	**1.5**	6	20,000	1,500	1.5	0.075	20,000	750	0.15	18,000	1,350	0.75	0.075	18,000	675	0.15
2020-080	**2**	8	18,000	1,800	2	0.1	18,000	900	0.2	16,200	1,620	1	0.1	16,200	810	0.2

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 occurs.
- Recommend wet coolant for Copper and Tungsten-Copper.

Slotting



Side Milling

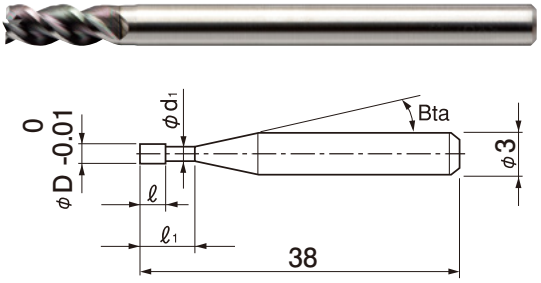


D : Outside Diameter (mm)

VDLC-AZS DLCCOAT 3 Flutes Short Shank Long Neck Square End Mills

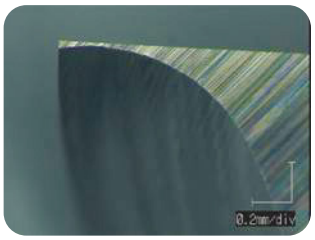
V Series DLCCOAT Long Neck Square

Super MG | DLC | 45° | Shank Dia 0/-0.003 | Flatland



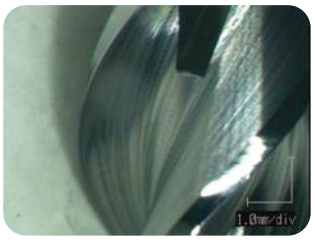
The shank taper angle shown is not an exact value.

■ Micro Flatland Design



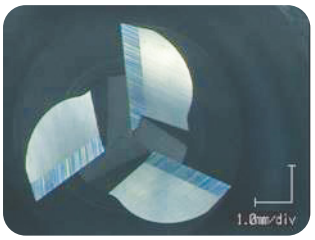
Excellent sharpness + Chipping protection design

■ Smooth Flute Design



Outstanding chip evacuation by seamless flute.

■ 3 Flute Design



Highly efficient 3 flutes. Significant productivity improvement.

DLC coating For aluminum milling

Material Applications (★ Highly Recommended ● Recommended ○ Suggested)

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

Total 7 models

Unit (mm)

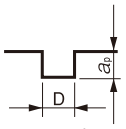
Model Number	Outside Diameter φD	Effective Length ℓ1	Length of Cut ℓ	Neck Diameter φd1	Shank Taper Angle Bta
VDLC-AZS 3010-030	**1**	3	2	0.97	16°
VDLC-AZS 3010-050	**1**	5	2	0.97	16°
VDLC-AZS 3015-045	**1.5**	4.5	3	1.45	16°
VDLC-AZS 3020-060	**2**	6	4	1.95	16°
VDLC-AZS 3020-100	**2**	10	4	1.95	16°
VDLC-AZS 3025-075	**2.5**	7.5	5	2.42	16°
VDLC-AZS 3030-090	**3**	9	6	2.92	—

Milling Condition for VDLC-AZS

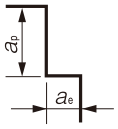
WORK MATERIAL			A5052							
Model Number	Outside Diameter (mm)	Effective Length (mm)	Spindle Speed (min^{-1})	Vertical		Slotting		Side Milling		
				Feed Rate (mm/min)	a_p Axial Depth (mm)	Feed Rate (mm/min)	a_p Axial Depth (mm)	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)
3010-030	**1**	3	30,000	150	0.75	900	0.75	1,100	0.75	0.3
3010-050	**1**	5	22,500	100	0.75	600	0.75	800	0.75	0.3
3015-045	**1.5**	4.5	30,000	180	1.125	1,350	1.125	1,630	1.125	0.45
3020-060	**2**	6	30,000	225	1.5	1,800	1.5	2,150	1.5	0.6
3020-100	**2**	10	22,500	150	1.5	1,300	1.5	1,500	1.5	0.6
3025-075	**2.5**	7.5	25,000	225	1.875	1,900	1.875	2,300	1.875	0.75
3030-090	**3**	9	21,600	225	2.25	2,000	2.25	2,400	2.25	0.9
Milling Amount (mm)				a_p=0.75D		a_p=0.75D		a_p=0.75D a_e=0.3D		

WORK MATERIAL			A7075							
Model Number	Outside Diameter (mm)	Effective Length (mm)	Spindle Speed (min^{-1})	Vertical		Slotting		Side Milling		
				Feed Rate (mm/min)	a_p Axial Depth (mm)	Feed Rate (mm/min)	a_p Axial Depth (mm)	Feed Rate (mm/min)	a_p Axial Depth (mm)	a_e Radial Depth (mm)
3010-030	**1**	3	30,000	150	0.75	540	0.75	860	0.75	0.3
3010-050	**1**	5	22,500	100	0.75	400	0.75	600	0.75	0.3
3015-045	**1.5**	4.5	30,000	180	1.125	820	1.125	1,230	1.125	0.45
3020-060	**2**	6	30,000	225	1.5	1,100	1.5	1,600	1.5	0.6
3020-100	**2**	10	22,500	150	1.5	800	1.5	1,100	1.5	0.6
3025-075	**2.5**	7.5	23,400	220	1.875	1,070	1.875	1,550	1.875	0.75
3030-090	**3**	9	20,200	225	2.25	1,100	2.25	1,600	2.25	0.9
Milling Amount (mm)				a_p=0.75D		a_p=0.75D		a_p=0.75D a_e=0.3D		

Slotting



Side Milling



D : Outside Diameter (mm)

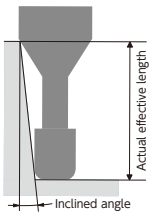
Note:
- Recommend using a non-contact measuring device to avoid damaging the sharp bottom corner.
- Decrease both spindle speed and feed rate proportionally in case of chattering.
- These milling parameters are calculated based on the shortest overhang length. Longer overhangs may require an adjustment to the milling parameters.
- Reduce the milling amount and feed rate in accordance with required milling precision.
- Spindle rigidity should be considered when setting milling parameters, especially for Z-Axis drilling.
- When slotting, using Z-Axis drilling, the milling parameters should promote good chip evacuation.
- Reduce the milling amount when chips clog on the tool during Z-Axis drilling.
- Set axial depth (ap) to 1/3 (ap=0.25D) in the area closest to a vertical wall with more than 2D work depth.
- These are milling parameters under the work material is firmly fixed. Decrease spindle speed and feed rate according to the condition.
- Recommend wet coolant.

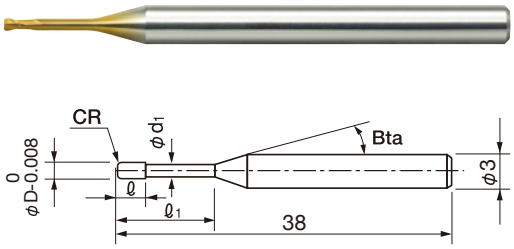
VHLRS

V Series HARDMAX Long Neck Radius

HARDMAX
2 Flutes Short Shank Long Neck Radius End Mills

Super MG | HARD MAX | 30° | R | R ±0.005 | Shank Dia 0/-0.003





The shank taper angle shown is not an exact value.

For hard materials
Negative tip design

Material Applications (★ Highly Recommended ● Recommended ○ Suggested)

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

Total 24 models

Unit (mm)

Model Number	Outside Diameter φD	Corner Radius CR	Effective Length ℓ1	Length of Cut ℓ	Neck Diameter φd1	Shank Taper Angle Bta	Effective Length by Inclined Angles 30′	1°	1°30′	2°	3°
VHLRS 2002-005-010	**0.2**	R0.05	1	0.2	0.18	16°	1.21	1.26	1.32	1.37	1.47
VHLRS 2003-005-010	**0.3**	R0.05	1	0.3	0.28	16°	1.25	1.32	1.38	1.44	1.55
VHLRS 2004-005-020	**0.4**	R0.05	2	0.4	0.38	16°	2.38	2.52	2.63	2.74	2.94
VHLRS 2004-01-020	**0.4**	R0.1	2	0.4	0.38	16°	2.38	2.51	2.63	2.73	2.93
VHLRS 2005-005-020	**0.5**	R0.05	2	0.5	0.49	16°	2.45	2.62	2.76	2.88	3.12
VHLRS 2005-01-020	**0.5**	R0.1	2	0.5	0.49	16°	2.45	2.61	2.75	2.88	3.11
VHLRS 2006-005-020	**0.6**	R0.05	2	0.6	0.59	16°	2.52	2.71	2.87	3.02	3.29
VHLRS 2006-005-030	**0.6**	R0.05	3	0.6	0.59	16°	3.59	3.82	4.02	4.19	4.51
VHLRS 2006-005-040	**0.6**	R0.05	4	0.6	0.59	16°	4.66	4.93	5.14	5.34	5.74
VHLRS 2006-01-020	**0.6**	R0.1	2	0.6	0.59	16°	2.51	2.70	2.86	3.01	3.28
VHLRS 2006-01-030	**0.6**	R0.1	3	0.6	0.59	16°	3.59	3.82	4.01	4.18	4.50
VHLRS 2006-01-040	**0.6**	R0.1	4	0.6	0.59	16°	4.66	4.92	5.14	5.33	5.72
VHLRS 2008-005-040	**0.8**	R0.05	4	0.8	0.79	16°	4.66	4.93	5.14	5.34	5.74
VHLRS 2008-01-040	**0.8**	R0.1	4	0.8	0.79	16°	4.66	4.92	5.14	5.33	5.72
VHLRS 2008-02-040	**0.8**	R0.2	4	0.8	0.79	16°	4.65	4.91	5.13	5.32	5.70
VHLRS 2010-01-020	**1**	R0.1	2	1	0.96	16°	2.64	2.80	2.95	3.09	3.34
VHLRS 2010-01-040	**1**	R0.1	4	1	0.96	16°	4.76	5.00	5.20	5.39	5.79
VHLRS 2010-01-060	**1**	R0.1	6	1	0.96	16°	6.87	7.16	7.41	7.67	8.24
VHLRS 2010-02-020	**1**	R0.2	2	1	0.96	16°	2.63	2.79	2.94	3.07	3.32
VHLRS 2010-02-040	**1**	R0.2	4	1	0.96	16°	4.76	4.99	5.19	5.38	5.77
VHLRS 2010-02-060	**1**	R0.2	6	1	0.96	16°	6.86	7.15	7.40	7.65	8.21
VHLRS 2015-02-060	**1.5**	R0.2	6	1.5	1.46	16°	6.23	6.43	6.64	6.86	7.36
VHLRS 2020-01-060	**2**	R0.1	6	2	1.93	16°	6.28	6.49	6.70	6.93	7.45
VHLRS 2020-02-060	**2**	R0.2	6	2	1.93	16°	6.28	6.48	6.69	6.92	7.43

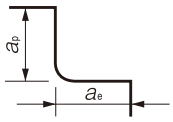
VHLRS Milling Conditions

WORK MATERIAL			COPPER OFC / TPC				CARBON STEELS S45C / S50C (~225HB)				ALLOY STEELS SK / SCM / SUS (225~325HB)			
Model Number	Outside Diameter (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)
2002-005-010	**0.2**	1	55,000	200	0.027	0.02	55,000	200	0.009	0.02	55,000	200	0.009	0.02
2003-005-010	**0.3**	1	60,000	500	0.03	0.02	60,000	500	0.011	0.02	60,000	500	0.011	0.02
2004-005-020	**0.4**	2	40,400	540	0.042	0.054	40,400	450	0.017	0.045	40,400	450	0.017	0.045
2004-01-020	**0.4**	2	40,400	540	0.042	0.054	40,400	450	0.017	0.045	40,400	450	0.017	0.045
2005-005-020	**0.5**	2	39,900	1,000	0.075	0.108	39,900	830	0.044	0.117	39,900	830	0.044	0.117
2005-01-020	**0.5**	2	39,900	1,000	0.075	0.108	39,900	830	0.044	0.117	39,900	830	0.044	0.117
2006-005-020	**0.6**	2	28,600	610	0.114	0.162	28,600	510	0.015	0.219	28,600	510	0.015	0.219
2006-005-030	**0.6**	3	23,800	480	0.09	0.135	23,800	400	0.012	0.108	23,800	400	0.012	0.108
2006-005-040	**0.6**	4	20,400	400	0.063	0.108	20,400	330	0.008	0.104	20,400	330	0.008	0.104
2006-01-020	**0.6**	2	28,600	610	0.114	0.162	28,600	510	0.015	0.219	28,600	510	0.015	0.219
2006-01-030	**0.6**	3	23,800	480	0.09	0.135	23,800	400	0.012	0.108	23,800	400	0.012	0.108
2006-01-040	**0.6**	4	20,400	400	0.063	0.108	20,400	330	0.008	0.104	20,400	330	0.008	0.104
2008-005-040	**0.8**	4	17,500	540	0.132	0.198	17,500	450	0.021	0.117	17,500	450	0.021	0.117
2008-01-040	**0.8**	4	17,500	540	0.132	0.198	17,500	450	0.021	0.117	17,500	450	0.021	0.117
2008-02-040	**0.8**	4	17,500	540	0.132	0.198	17,500	450	0.021	0.117	17,500	450	0.021	0.117
2010-01-020	**1**	2	17,600	1,100	0.21	0.45	17,600	920	0.053	0.27	17,600	920	0.053	0.27
2010-01-040	**1**	4	13,800	980	0.201	0.405	13,800	820	0.045	0.27	13,800	820	0.045	0.27
2010-01-060	**1**	6	11,300	790	0.117	0.387	11,300	650	0.032	0.216	11,300	650	0.032	0.216
2010-02-020	**1**	2	17,600	1,100	0.21	0.45	17,600	920	0.053	0.27	17,600	920	0.053	0.27
2010-02-040	**1**	4	13,800	980	0.201	0.405	13,800	820	0.045	0.27	13,800	820	0.045	0.27
2010-02-060	**1**	6	11,300	790	0.117	0.387	11,300	650	0.032	0.216	11,300	650	0.032	0.216
2015-02-060	**1.5**	6	10,600	1,240	0.282	0.63	10,600	1,030	0.062	0.405	10,600	1,030	0.062	0.405
2020-01-060	**2**	6	12,800	1,220	0.321	0.855	12,800	1,020	0.065	0.81	12,800	1,020	0.065	0.81
2020-02-060	**2**	6	12,800	1,220	0.321	0.855	12,800	1,020	0.065	0.81	12,800	1,020	0.065	0.81

VHLRS Milling Conditions

WORK MATERIAL			PREHARDENED STEELS / HARDENED STEELS NAK / SKD (30~45HRC)				HARDENED STEELS SKD / SKT (45~55HRC)				HARDENED STEELS SKD / SKH (55~65HRC)			
Model Number	Outside Diameter (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)
2002-005-010	**0.2**	1	55,000	200	0.006	0.02	35,000	150	0.004	0.02	15,000	25	0.002	0.015
2003-005-010	**0.3**	1	60,000	500	0.007	0.02	35,000	350	0.005	0.02	22,000	35	0.004	0.015
2004-005-020	**0.4**	2	40,400	450	0.011	0.045	32,300	330	0.009	0.045	19,200	35	0.004	0.045
2004-01-020	**0.4**	2	40,400	450	0.011	0.045	32,300	330	0.009	0.045	19,200	35	0.004	0.045
2005-005-020	**0.5**	2	39,900	830	0.029	0.117	32,500	630	0.026	0.117	20,100	68	0.011	0.117
2005-01-020	**0.5**	2	39,900	830	0.029	0.117	32,500	630	0.026	0.117	20,100	68	0.011	0.117
2006-005-020	**0.6**	2	28,600	510	0.01	0.219	23,700	390	0.01	0.219	15,200	43	0.004	0.219
2006-005-030	**0.6**	3	23,800	400	0.008	0.108	19,700	300	0.007	0.108	12,600	33	0.003	0.108
2006-005-040	**0.6**	4	20,400	330	0.005	0.104	16,800	250	0.005	0.104	10,800	28	0.002	0.104
2006-01-020	**0.6**	2	28,600	510	0.01	0.219	23,700	390	0.01	0.219	15,200	43	0.004	0.219
2006-01-030	**0.6**	3	23,800	400	0.008	0.108	19,700	300	0.007	0.108	12,600	33	0.003	0.108
2006-01-040	**0.6**	4	20,400	330	0.005	0.104	16,800	250	0.005	0.104	10,800	28	0.002	0.104
2008-005-040	**0.8**	4	17,500	450	0.014	0.117	15,000	360	0.015	0.117	10,200	41	0.007	0.117
2008-01-040	**0.8**	4	17,500	450	0.014	0.117	15,000	360	0.015	0.117	10,200	41	0.007	0.117
2008-02-040	**0.8**	4	17,500	450	0.014	0.117	15,000	360	0.015	0.117	10,200	41	0.007	0.117
2010-01-020	**1**	2	17,600	920	0.035	0.27	15,300	750	0.04	0.27	10,900	89	0.02	0.27
2010-01-040	**1**	4	13,800	820	0.03	0.27	12,000	670	0.035	0.27	8,500	80	0.017	0.27
2010-01-060	**1**	6	11,300	650	0.021	0.216	9,800	540	0.024	0.216	7,000	64	0.012	0.216
2010-02-020	**1**	2	17,600	920	0.035	0.27	15,300	750	0.04	0.27	10,900	89	0.02	0.27
2010-02-040	**1**	4	13,800	820	0.03	0.27	12,000	670	0.035	0.27	8,500	80	0.017	0.27
2010-02-060	**1**	6	11,300	650	0.021	0.216	9,800	540	0.024	0.216	7,000	64	0.012	0.216
2015-02-060	**1.5**	6	10,600	1,030	0.041	0.405	9,700	900	0.055	0.405	7,400	117	0.03	0.405
2020-01-060	**2**	6	12,800	1,020	0.043	0.81	12,000	930	0.06	0.81	9,700	133	0.036	0.81
2020-02-060	**2**	6	12,800	1,020	0.043	0.81	12,000	930	0.06	0.81	9,700	133	0.036	0.81

Note:
- Decrease both spindle speed and feed rate proportionally when the milling parameters exceed the machine's maximum spindle speed.
- Every coolant offers stable milling.
- Recommend oil coolant for Stainless Steels and Heat Resistant Alloys.
- Recommend wet coolant for Copper.

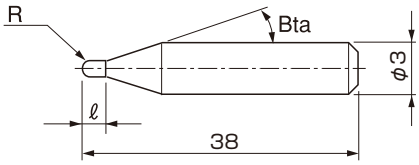


MEMO

VHGB HMGCOAT 2 Flutes Short Shank Ball End Mills for Hard Materials

V Series HMGCOAT Ball

Super MG | HMG COAT | Shank Dia 0/-0.003



The shank taper angle shown is not an exact value.

Unit (mm)

Radius of Ball Nose R	Radius Accuracy	Diameter Tolerance	Helix Angle
R0.05 ~ R0.075	± 0.002	0/-0.008	30°
R0.1 ~ R1	± 0.003		
R1.5		0/-0.01	

For hard materials (~70HRC) Super Negative tip design

Material Applications (★ Highly Recommended ● Recommended ○ Suggested)

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

Total 16 models

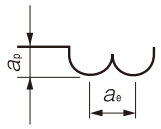
Unit (mm)

Model Number	Radius of Ball Nose R	Length of Cut ℓ	Shank Taper Angle Bta
VHGB 2001-0010	R0.05	0.1	16°
VHGB 20015-0015	R0.075	0.15	16°
VHGB 2002-0030	R0.1	0.3	16°
VHGB 2003-0030	R0.15	0.3	16°
VHGB 2003-0045	R0.15	0.45	16°
VHGB 2004-0040	R0.2	0.4	16°
VHGB 2004-0060	R0.2	0.6	16°
VHGB 2005-0050	R0.25	0.5	16°
VHGB 2005-0075	R0.25	0.75	16°
VHGB 2006-0060	R0.3	0.6	16°
VHGB 2006-0090	R0.3	0.9	16°
VHGB 2008-0120	R0.4	1.2	16°
VHGB 2010-0150	R0.5	1.5	16°
VHGB 2015-0225	R0.75	2.25	16°
VHGB 2020-0300	R1	3	16°
VHGB 2030-0450	R1.5	4.5	—

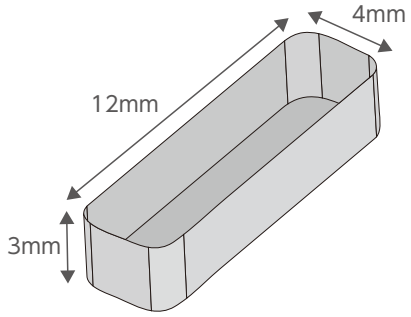
VHGB Milling Conditions

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)	Length of Cut (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p (mm)	a_e (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p (mm)	a_e (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p (mm)	a_e (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p (mm)	a_e (mm)
2001-0010	R0.05	0.1	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
20015-0015	R0.075	0.15	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
2002-0030	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
2003-0030	R0.15	0.3	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
2003-0045	R0.15	0.45	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
2004-0040	R0.2	0.4	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
2004-0060	R0.2	0.6	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
2005-0050	R0.25	0.5	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
2005-0075	R0.25	0.75	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
2006-0060	R0.3	0.6	40,000	1,400	0.045	0.15	36,000	1,200	0.025	0.13	32,000	1,000	0.02	0.1	25,000	600	0.02	0.1
2006-0090	R0.3	0.9	40,000	1,400	0.045	0.15	36,000	1,200	0.025	0.13	32,000	1,000	0.02	0.1	25,000	600	0.02	0.1
2008-0120	R0.4	1.2	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
2010-0150	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	875	0.05	0.2
2015-0225	R0.75	2.25	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
2020-0300	R1	3	28,000	2,900	0.3	0.7	14,000	2,100	0.15	0.5	14,700	2,160	0.1	0.35	11,040	1,080	0.08	0.35
2030-0450	R1.5	4.5	21,000	3,000	0.4	1	10,500	2,200	0.2	0.7	11,040	2,280	0.15	0.55	8,280	1,140	0.12	0.55

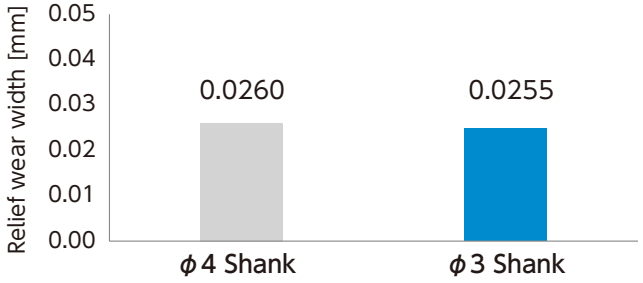
Note:
- Decrease the feed rate more than 50% from the milling parameters when slot milling.
- Decrease both spindle speed and feed rate proportionally when the milling parameters exceed the machine's maximum spindle speed, or when chattering and red-hot occur.
- Every coolant offers stable milling.



Comparison of ϕ3 shank (VHGB) and ϕ4 shank (HGB) R1 × L3

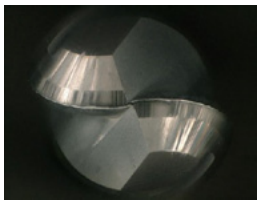


Relief wear width comparison (30 min)

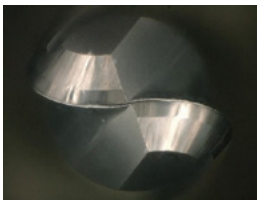


<Milling condition>

- Work material : HAP72(67 HRC)
- Coolant : Air Blow
- n : 11,000 min^{-1}
- Vf : 1,080 mm/min
- a_p : 0.08 mm
- a_e : 0.35 mm
- Cycle time 30 min



HGB

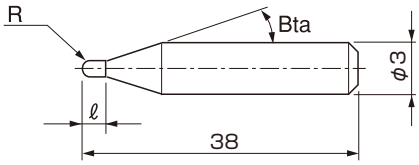


VHGB

VHWB HMWCOAT
2 Flutes Short Shank Ball End Mills

V Series HMWCOAT Ball

Super MG | HMW COAT | Shank Dia 0/-0.003



The shank taper angle shown is not an exact value.

Unit (mm)

Radius of Ball Nose R	Radius Accuracy	Diameter Tolerance	Helix Angle
R0.05 ~ R0.075	± 0.002	0/-0.006	0°
R0.1 ~ R1	± 0.003		30°
R1.5		0/-0.009	

For hard materials
Negative tip design

Material Applications (★ Highly Recommended ● Recommended ○ Suggested)

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

Total 20 models

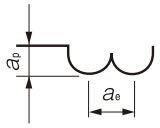
Unit (mm)

Model Number	Radius of Ball Nose R	Length of Cut ℓ	Shank Taper Angle Bta
VHWB 2001-0010	R0.05	0.1	11°
VHWB 20015-0015	R0.075	0.15	11°
VHWB 2002-0030	R0.1	0.3	16°
VHWB 2003-0030	R0.15	0.3	16°
VHWB 2003-0045	R0.15	0.45	16°
VHWB 2004-0040	R0.2	0.4	16°
VHWB 2004-0060	R0.2	0.6	16°
VHWB 2005-0050	R0.25	0.5	16°
VHWB 2005-0075	R0.25	0.75	16°
VHWB 2006-0060	R0.3	0.6	16°
VHWB 2006-0090	R0.3	0.9	16°
VHWB 2008-0080	R0.4	0.8	16°
VHWB 2008-0120	R0.4	1.2	16°
VHWB 2010-0100	R0.5	1	16°
VHWB 2010-0150	R0.5	1.5	16°
VHWB 2010-0250	R0.5	2.5	16°
VHWB 2015-0150	R0.75	1.5	16°
VHWB 2015-0225	R0.75	2.25	16°
VHWB 2020-0300	R1	3	16°
VHWB 2030-0450	R1.5	4.5	—

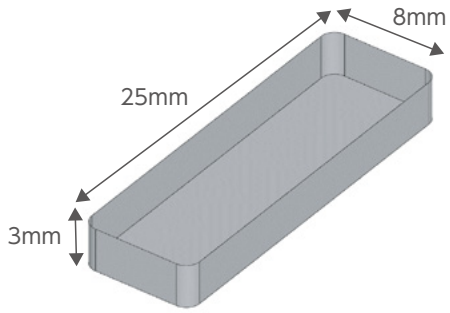
VHWB Milling Conditions

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)	Length of Cut (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p (mm)	a_e (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p (mm)	a_e (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p (mm)	a_e (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p (mm)	a_e (mm)
2001-0010	R0.05	0.1	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
20015-0015	R0.075	0.15	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
2002-0030	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
2003-0030	R0.15	0.3	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
2003-0045	R0.15	0.45	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
2004-0040	R0.2	0.4	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
2004-0060	R0.2	0.6	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
2005-0050	R0.25	0.5	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
2005-0075	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
2006-0060	R0.3	0.6	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
2006-0090	R0.3	0.9	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
2008-0080	R0.4	0.8	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
2008-0120	R0.4	1.2	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
2010-0100	R0.5	1	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
2010-0150	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	875	0.05	0.2
2010-0250	R0.5	2.5	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
2015-0150	R0.75	1.5	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
2015-0225	R0.75	2.25	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
2020-0300	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
2030-0450	R1.5	4.5	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

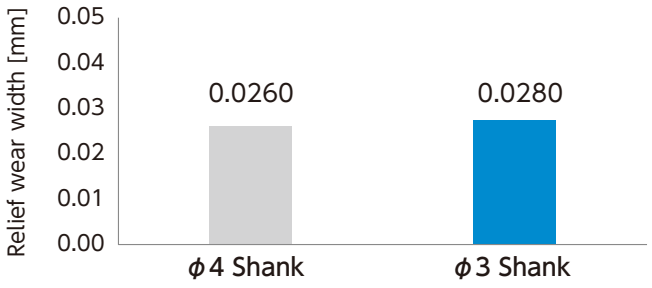
Note:
- Decrease the feed rate more than 50% from the milling parameters when slot milling.
- Decrease both spindle speed and feed rate proportionally when the milling parameters exceed the machine's maximum spindle speed, or when chattering and red-hot occur.
- Every coolant offers stable milling.



Comparison of ϕ3 shank (VHWB) and ϕ4 shank (HMWCOAT) R1 × L3

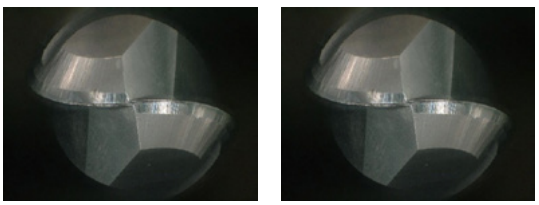


Relief wear width comparison (30 min)



<Milling condition>

- Work material : SKD11 (59 HRC)
- Coolant : Air Blow
- n : 14,000 min^{-1}
- Vf : 2,100 mm/min
- a_p : 0.15 mm
- a_e : 0.5 mm
- Cycle time 30 min



HMWCOAT VHWB

VHGLB HMGCOAT 2 Flutes Short Shank Long Neck Ball End Mills

V Series HMGCOAT Long Neck Ball

Super MG

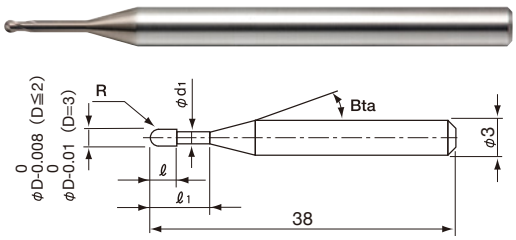
HMG COAT

Shank Dia 0/-0.003

30°

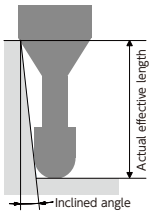
Back Taper Geometry

Except for R0.05~R0.4



The shank taper angle shown is not an exact value.

For hard materials (~70HRC)
Super Negative tip design



Unit (mm)

Radius of Ball Nose	Diameter Tolerance	Ball Radius Accuracy
R0.05 ~ R0.075	0/-0.008	± 0.002
R0.1 ~ R1		± 0.003
R1.5	0/-0.01	

Material Applications (★ Highly Recommended ● Recommended ○ Suggested)

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

Total 31 models

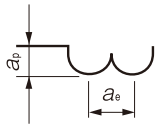
Unit (mm)

Model Number	Radius of Ball Nose R	Effective Length ℓ1	Length of Cut ℓ	Neck Diameter φd1	Shank Taper Angle Bta	Effective Length by Inclined Angles 30′	1°	1°30′	2°	3°
VHGLB 2001-003	R0.05	0.3	0.08	0.093	16°	0.34	0.36	0.38	0.40	0.44
VHGLB 20015-003	R0.075	0.3	0.12	0.14	16°	0.36	0.38	0.40	0.41	0.45
VHGLB 2002-005	R0.1	0.5	0.16	0.18	16°	0.63	0.66	0.68	0.71	0.76
VHGLB 2002-010	R0.1	1	0.16	0.18	16°	1.15	1.20	1.24	1.28	1.37
VHGLB 2003-010	R0.15	1	0.24	0.28	16°	1.15	1.19	1.23	1.27	1.36
VHGLB 2003-015	R0.15	1.5	0.24	0.28	16°	1.67	1.73	1.78	1.84	1.97
VHGLB 2004-010	R0.2	1	0.32	0.38	16°	1.15	1.19	1.23	1.27	1.35
VHGLB 2004-020	R0.2	2	0.32	0.38	16°	2.19	2.25	2.33	2.40	2.57
VHGLB 2004-030	R0.2	3	0.32	0.38	16°	3.22	3.32	3.43	3.54	3.79
VHGLB 2005-015	R0.25	1.5	0.4	0.48	16°	1.67	1.72	1.77	1.83	1.95
VHGLB 2005-020	R0.25	2	0.4	0.48	16°	2.19	2.25	2.32	2.40	2.56
VHGLB 2005-025	R0.25	2.5	0.4	0.48	16°	2.71	2.79	2.87	2.97	3.18
VHGLB 2006-010	R0.3	1	0.48	0.58	16°	1.15	1.19	1.22	1.26	1.33
VHGLB 2006-015	R0.3	1.5	0.48	0.58	16°	1.67	1.72	1.77	1.82	1.94
VHGLB 2006-020	R0.3	2	0.48	0.58	16°	2.19	2.25	2.32	2.39	2.55
VHGLB 2006-030	R0.3	3	0.48	0.58	16°	3.22	3.32	3.42	3.53	3.78
VHGLB 2006-040	R0.3	4	0.48	0.58	16°	4.25	4.38	4.52	4.67	5.00
VHGLB 2008-020	R0.4	2	0.64	0.78	16°	2.18	2.25	2.31	2.38	2.53
VHGLB 2008-040	R0.4	4	0.64	0.78	16°	4.25	4.37	4.51	4.66	4.98
VHGLB 2010-020	R0.5	2	0.8	0.97	16°	2.20	2.26	2.32	2.38	2.53
VHGLB 2010-025	R0.5	2.5	0.8	0.97	16°	2.72	2.79	2.87	2.95	3.14
VHGLB 2010-030	R0.5	3	0.8	0.97	16°	3.23	3.32	3.42	3.52	3.75
VHGLB 2010-040	R0.5	4	0.8	0.97	16°	4.26	4.39	4.52	4.66	4.98
VHGLB 2010-060	R0.5	6	0.8	0.97	16°	6.33	6.52	6.72	6.94	7.43
VHGLB 2015-030	R0.75	3	1.2	1.46	16°	3.11	3.19	3.28	3.37	3.57
VHGLB 2015-040	R0.75	4	1.2	1.46	16°	4.15	4.26	4.38	4.51	4.79
VHGLB 2015-060	R0.75	6	1.2	1.46	16°	6.21	6.39	6.58	6.78	7.24
VHGLB 2020-030	R1	3	1.6	1.96	16°	3.11	3.18	3.25	3.33	3.52
VHGLB 2020-040	R1	4	1.6	1.96	16°	4.14	4.24	4.35	4.47	4.74
VHGLB 2020-060	R1	6	1.6	1.96	16°	6.20	6.37	6.55	6.75	7.19
VHGLB 2030-060	R1.5	6	2.4	2.93	–	No Interference	No Interference	No Interference	No Interference	No Interference

VHGLB 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	Outside Diameter (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)
2001-003	R0.05	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
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
2002-005	R0.1	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
2002-010	R0.1	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
2003-010	R0.15	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	R0.15	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
2004-010	R0.2	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
2004-020	R0.2	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
2004-030	R0.2	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
2005-015	R0.25	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	R0.25	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	R0.25	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
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	R0.3	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	R0.3	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
2006-030	R0.3	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
2006-040	R0.3	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
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
2008-040	R0.4	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
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	R0.5	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	R0.5	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	R0.5	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
2010-060	R0.5	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
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	R0.75	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	R0.75	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
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	R1	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	R1	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
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

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 the tool is chattering and heats up to a red color.
- Every coolant offers stable milling.



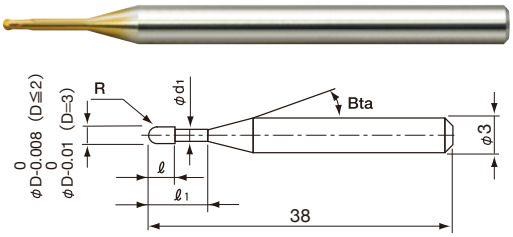
VHSLB HARDMAX 2 Flutes Short Shank Long Neck Ball End Mills

V Series HARDMAX Long Neck Ball

Super MG | HARD MAX | Shank Dia 0/-0.003

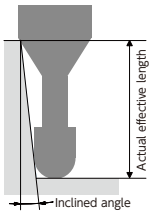
Back Taper Geometry

Except for R0.05～R0.4



The shank taper angle shown is not an exact value.

For hard materials
Negative tip design



Unit (mm)

Radius of Ball Nose	Diameter Tolerance	Ball Radius Accuracy	Helix Angle
R0.05	0/-0.008	± 0.002	0°
R0.1 ～ R0.75		± 0.003	
R1		± 0.004	30°
R1.5	0/-0.01	± 0.005	

Material Applications (★ Highly Recommended ● Recommended ○ Suggested)

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

Total 53 models

Unit (mm)

Model Number	Radius of Ball Nose R	Effective Length ℓ1	Length of Cut ℓ	Neck Diameter φd1	Shank Taper Angle Bta	Effective Length by Inclined Angles 30′	1°	1°30′	2°	3°
VHSLB 2001-003	R0.05	0.3	0.08	0.093	11°	0.34	0.37	0.39	0.41	0.46
VHSLB 2002-003	R0.1	0.3	0.16	0.18	16°	0.43	0.45	0.46	0.48	0.52
VHSLB 2002-005	R0.1	0.5	0.16	0.18	16°	0.64	0.66	0.69	0.71	0.76
VHSLB 2002-0075	R0.1	0.75	0.16	0.18	16°	0.90	0.93	0.97	1.00	1.07
VHSLB 2002-010	R0.1	1	0.16	0.18	16°	1.16	1.20	1.24	1.28	1.38
VHSLB 2003-005	R0.15	0.5	0.24	0.28	16°	0.63	0.66	0.68	0.71	0.75
VHSLB 2003-0075	R0.15	0.75	0.24	0.28	16°	0.90	0.93	0.96	0.99	1.06
VHSLB 2003-010	R0.15	1	0.24	0.28	16°	1.16	1.20	1.24	1.28	1.37
VHSLB 2003-015	R0.15	1.5	0.24	0.28	16°	1.67	1.73	1.78	1.84	1.97
VHSLB 2003-020	R0.15	2	0.24	0.28	16°	2.19	2.26	2.33	2.41	2.59
VHSLB 2003-030	R0.15	3	0.24	0.28	16°	3.22	3.33	3.43	3.55	3.81
VHSLB 2004-005	R0.2	0.5	0.32	0.38	16°	0.63	0.65	0.68	0.70	0.74
VHSLB 2004-010	R0.2	1	0.32	0.38	16°	1.15	1.19	1.23	1.27	1.35
VHSLB 2004-015	R0.2	1.5	0.32	0.38	16°	1.67	1.73	1.78	1.84	1.96
VHSLB 2004-020	R0.2	2	0.32	0.38	16°	2.19	2.26	2.33	2.41	2.57
VHSLB 2004-030	R0.2	3	0.32	0.38	16°	3.22	3.32	3.43	3.54	3.80
VHSLB 2004-040	R0.2	4	0.32	0.38	16°	4.25	4.39	4.53	4.68	5.02
VHSLB 2005-010	R0.25	1	0.4	0.48	16°	1.15	1.19	1.23	1.26	1.34
VHSLB 2005-015	R0.25	1.5	0.4	0.48	16°	1.67	1.72	1.77	1.83	1.95
VHSLB 2005-020	R0.25	2	0.4	0.48	16°	2.19	2.25	2.32	2.40	2.56
VHSLB 2005-025	R0.25	2.5	0.4	0.48	16°	2.71	2.79	2.87	2.97	3.18
VHSLB 2005-030	R0.25	3	0.4	0.48	16°	3.22	3.32	3.42	3.54	3.79
VHSLB 2005-040	R0.25	4	0.4	0.48	16°	4.25	4.38	4.53	4.68	5.01

HARDMAX 2 Flutes Short Shank Long Neck Ball End Mills

Model Number	Radius of Ball Nose R	Effective Length ℓ_1	Length of Cut ℓ	Neck Diameter ϕd_1	Shank Taper Angle Bta	Effective Length by Inclined Angles				
						30′	1°	1°30′	2°	3°
VHSLB 2006-010	R0.3	1	0.48	0.58	16°	1.15	1.19	1.22	1.26	1.33
VHSLB 2006-015	R0.3	1.5	0.48	0.58	16°	1.67	1.72	1.77	1.82	1.94
VHSLB 2006-020	R0.3	2	0.48	0.58	16°	2.19	2.25	2.32	2.39	2.55
VHSLB 2006-025	R0.3	2.5	0.48	0.58	16°	2.70	2.78	2.87	2.96	3.16
VHSLB 2006-030	R0.3	3	0.48	0.58	16°	3.22	3.32	3.42	3.53	3.78
VHSLB 2006-040	R0.3	4	0.48	0.58	16°	4.25	4.38	4.52	4.67	5.00
VHSLB 2006-050	R0.3	5	0.48	0.58	16°	5.28	5.45	5.62	5.81	6.22
VHSLB 2006-060	R0.3	6	0.48	0.58	16°	6.31	6.51	6.72	6.95	7.45
VHSLB 2008-020	R0.4	2	0.64	0.78	16°	2.18	2.25	2.31	2.38	2.53
VHSLB 2008-030	R0.4	3	0.64	0.78	16°	3.22	3.31	3.41	3.52	3.75
VHSLB 2008-040	R0.4	4	0.64	0.78	16°	4.25	4.37	4.51	4.66	4.98
VHSLB 2008-050	R0.4	5	0.64	0.78	16°	5.28	5.44	5.61	5.79	6.20
VHSLB 2008-060	R0.4	6	0.64	0.78	16°	6.31	6.50	6.71	6.93	7.43
VHSLB 2010-020	R0.5	2	0.8	0.97	16°	2.20	2.26	2.32	2.39	2.54
VHSLB 2010-025	R0.5	2.5	0.8	0.97	16°	2.72	2.79	2.87	2.96	3.15
VHSLB 2010-030	R0.5	3	0.8	0.97	16°	3.24	3.33	3.42	3.53	3.76
VHSLB 2010-040	R0.5	4	0.8	0.97	16°	4.27	4.39	4.52	4.67	4.98
VHSLB 2010-050	R0.5	5	0.8	0.97	16°	5.30	5.46	5.62	5.80	6.21
VHSLB 2010-060	R0.5	6	0.8	0.97	16°	6.33	6.52	6.72	6.94	7.43
VHSLB 2010-080	R0.5	8	0.8	0.97	16°	8.39	8.65	8.93	9.22	9.88
VHSLB 2015-030	R0.75	3	1.2	1.46	16°	3.12	3.20	3.28	3.37	3.58
VHSLB 2015-040	R0.75	4	1.2	1.46	16°	4.15	4.26	4.38	4.51	4.80
VHSLB 2015-060	R0.75	6	1.2	1.46	16°	6.21	6.39	6.58	6.79	7.25
VHSLB 2015-080	R0.75	8	1.2	1.46	16°	8.28	8.52	8.78	9.07	9.69
VHSLB 2020-030	R1	3	1.6	1.96	16°	3.11	3.18	3.26	3.34	3.52
VHSLB 2020-040	R1	4	1.6	1.96	16°	4.14	4.24	4.36	4.48	4.74
VHSLB 2020-060	R1	6	1.6	1.96	16°	6.20	6.37	6.56	6.75	7.19
VHSLB 2020-080	R1	8	1.6	1.96	16°	8.27	8.50	8.76	9.03	9.64
VHSLB 2030-060	R1.5	6	2.4	2.93	—	No Interference	No Interference	No Interference	No Interference	No Interference
VHSLB 2030-080	R1.5	8	2.4	2.93	—	No Interference	No Interference	No Interference	No Interference	No Interference

VHSLB Milling Conditions

WORK MATERIAL			COPPER OFC / TPC				CARBON STEELS S45C / S50C (~225HB)				ALLOY STEELS SK / SCM / SUS (225~325HB)				PREHARDENED STEELS / HARDENED STEELS NAK / STAVAX (~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)
2001-003	**R0.05**	0.3	54,000	85	0.004	0.004	54,000	85	0.004	0.004	54,000	85	0.004	0.004	48,000	55	0.002	0.002
2002-003	**R0.1**	0.3	54,000	430	0.01	0.01	60,000	350	0.008	0.016	60,000	350	0.008	0.016	60,000	200	0.003	0.005
2002-005	**R0.1**	0.5	54,000	430	0.01	0.01	60,000	350	0.008	0.016	60,000	350	0.008	0.016	60,000	200	0.003	0.005
2002-0075	**R0.1**	0.75	54,000	380	0.008	0.008	60,000	320	0.007	0.015	60,000	320	0.007	0.015	60,000	200	0.003	0.005
2002-010	**R0.1**	1	54,000	380	0.008	0.008	60,000	250	0.005	0.015	60,000	250	0.005	0.015	60,000	200	0.003	0.005
2003-005	**R0.15**	0.5	54,000	720	0.015	0.015	43,000	500	0.012	0.024	43,000	500	0.012	0.024	60,000	350	0.006	0.008
2003-0075	**R0.15**	0.75	54,000	720	0.015	0.015	43,000	500	0.012	0.024	43,000	500	0.012	0.024	60,000	350	0.006	0.008
2003-010	**R0.15**	1	54,000	640	0.014	0.015	43,000	450	0.008	0.024	43,000	450	0.008	0.024	60,000	350	0.006	0.008
2003-015	**R0.15**	1.5	54,000	640	0.014	0.015	43,000	400	0.007	0.021	43,000	400	0.007	0.021	60,000	350	0.006	0.008
2003-020	**R0.15**	2	49,000	530	0.011	0.011	40,000	300	0.006	0.018	40,000	300	0.006	0.018	60,000	210	0.004	0.007
2003-030	**R0.15**	3	43,000	460	0.009	0.01	38,000	200	0.004	0.012	38,000	200	0.004	0.012	42,500	140	0.002	0.004
2004-005	**R0.2**	0.5	54,000	870	0.023	0.036	35,000	1,200	0.02	0.04	35,000	1,200	0.02	0.04	50,000	500	0.01	0.02
2004-010	**R0.2**	1	54,000	870	0.023	0.036	35,000	1,200	0.02	0.04	35,000	1,200	0.02	0.04	50,000	500	0.01	0.02
2004-015	**R0.2**	1.5	54,000	790	0.022	0.036	35,000	900	0.016	0.033	35,000	900	0.016	0.033	50,000	500	0.01	0.02
2004-020	**R0.2**	2	54,000	790	0.022	0.036	35,000	600	0.011	0.033	35,000	600	0.011	0.033	50,000	500	0.01	0.02
2004-030	**R0.2**	3	50,000	660	0.017	0.018	35,000	400	0.008	0.024	35,000	400	0.008	0.024	40,000	250	0.005	0.008
2004-040	**R0.2**	4	50,000	640	0.012	0.018	35,000	300	0.005	0.015	35,000	300	0.005	0.015	32,000	180	0.003	0.005
2005-010	**R0.25**	1	57,000	1,380	0.029	0.054	34,000	1,300	0.03	0.06	34,000	1,300	0.03	0.06	44,000	650	0.015	0.04
2005-015	**R0.25**	1.5	57,000	1,380	0.029	0.054	34,000	1,000	0.025	0.05	34,000	1,000	0.025	0.05	44,000	650	0.015	0.04
2005-020	**R0.25**	2	57,000	1,250	0.028	0.054	34,000	800	0.023	0.046	34,000	800	0.023	0.046	44,000	650	0.015	0.04
2005-025	**R0.25**	2.5	57,000	1,250	0.028	0.054	34,000	700	0.015	0.045	34,000	700	0.015	0.045	44,000	650	0.015	0.04
2005-030	**R0.25**	3	55,000	1,010	0.021	0.036	32,000	550	0.012	0.036	32,000	550	0.012	0.036	40,000	500	0.01	0.02
2005-040	**R0.25**	4	55,000	1,010	0.021	0.036	31,000	450	0.01	0.03	31,000	450	0.01	0.03	32,700	180	0.005	0.015
2006-010	**R0.3**	1	57,000	1,670	0.035	0.144	33,000	1,500	0.04	0.08	33,000	1,500	0.04	0.08	40,000	1,400	0.045	0.15
2006-015	**R0.3**	1.5	57,000	1,670	0.035	0.144	33,000	1,500	0.04	0.08	33,000	1,500	0.04	0.08	40,000	1,100	0.03	0.13
2006-020	**R0.3**	2	57,000	1,540	0.034	0.144	33,000	1,400	0.036	0.072	33,000	1,400	0.036	0.072	40,000	1,100	0.03	0.13
2006-025	**R0.3**	2.5	57,000	1,540	0.034	0.144	33,000	1,200	0.033	0.066	33,000	1,200	0.033	0.066	40,000	800	0.02	0.1
2006-030	**R0.3**	3	57,000	1,540	0.034	0.144	33,000	900	0.025	0.066	33,000	900	0.025	0.066	40,000	800	0.02	0.1
2006-040	**R0.3**	4	54,000	1,130	0.026	0.108	31,000	700	0.02	0.06	31,000	700	0.02	0.06	40,000	500	0.015	0.09
2006-050	**R0.3**	5	46,000	960	0.019	0.072	29,000	440	0.015	0.045	29,000	440	0.015	0.045	32,000	400	0.01	0.075
2006-060	**R0.3**	6	46,000	960	0.019	0.072	24,000	380	0.012	0.036	24,000	380	0.012	0.036	24,000	300	0.007	0.06
2008-020	**R0.4**	2	55,000	2,060	0.063	0.18	30,000	1,800	0.06	0.12	30,000	1,800	0.06	0.12	35,000	1,600	0.06	0.21
2008-030	**R0.4**	3	55,000	1,860	0.063	0.18	30,000	1,600	0.05	0.1	30,000	1,600	0.05	0.1	35,000	1,400	0.05	0.19
2008-040	**R0.4**	4	55,000	1,860	0.063	0.18	30,000	1,300	0.04	0.1	30,000	1,300	0.04	0.1	35,000	1,200	0.04	0.17
2008-050	**R0.4**	5	47,000	1,410	0.038	0.108	30,000	1,100	0.035	0.1	30,000	1,100	0.035	0.1	31,500	900	0.03	0.15
2008-060	**R0.4**	6	47,000	1,410	0.038	0.108	27,000	900	0.025	0.075	27,000	900	0.025	0.075	28,000	600	0.02	0.12

VHSLB Milling Conditions

WORK MATERIAL			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)
2001-003	**R0.05**	0.3	48,000	45	0.002	0.002	48,000	45	0.002	0.002	36,000	22	0.002	0.002
2002-003	**R0.1**	0.3	60,000	200	0.002	0.003	60,000	130	0.002	0.003	45,000	65	0.002	0.003
2002-005	**R0.1**	0.5	60,000	200	0.002	0.003	60,000	130	0.002	0.003	45,000	65	0.002	0.003
2002-0075	**R0.1**	0.75	60,000	200	0.002	0.003	60,000	130	0.002	0.003	45,000	65	0.002	0.003
2002-010	**R0.1**	1	60,000	200	0.002	0.003	60,000	130	0.002	0.003	45,000	65	0.002	0.003
2003-005	**R0.15**	0.5	45,000	310	0.004	0.007	43,500	180	0.003	0.005	32,500	90	0.003	0.005
2003-0075	**R0.15**	0.75	45,000	310	0.004	0.007	43,500	180	0.003	0.005	32,500	90	0.003	0.005
2003-010	**R0.15**	1	45,000	310	0.004	0.007	43,500	180	0.003	0.005	32,500	90	0.003	0.005
2003-015	**R0.15**	1.5	45,000	310	0.004	0.007	43,500	180	0.003	0.005	32,500	90	0.003	0.005
2003-020	**R0.15**	2	45,000	190	0.003	0.005	43,500	110	0.002	0.004	32,500	55	0.002	0.004
2003-030	**R0.15**	3	32,000	80	0.002	0.004	32,000	65	0.001	0.002	24,000	30	0.001	0.002
2004-005	**R0.2**	0.5	37,500	420	0.007	0.012	35,000	240	0.005	0.008	26,250	120	0.005	0.008
2004-010	**R0.2**	1	37,500	420	0.007	0.012	35,000	240	0.005	0.008	26,250	120	0.005	0.008
2004-015	**R0.2**	1.5	37,500	420	0.007	0.012	35,000	240	0.005	0.008	26,250	120	0.005	0.008
2004-020	**R0.2**	2	37,500	420	0.007	0.012	35,000	240	0.005	0.008	26,250	120	0.005	0.008
2004-030	**R0.2**	3	31,900	210	0.004	0.008	30,500	160	0.003	0.005	22,800	80	0.003	0.005
2004-040	**R0.2**	4	25,500	150	0.002	0.004	24,300	120	0.002	0.004	18,200	60	0.002	0.004
2005-010	**R0.25**	1	33,000	530	0.01	0.02	30,000	300	0.007	0.01	22,500	150	0.007	0.01
2005-015	**R0.25**	1.5	33,000	530	0.01	0.02	30,000	300	0.007	0.01	22,500	150	0.007	0.01
2005-020	**R0.25**	2	33,000	530	0.01	0.02	30,000	300	0.007	0.01	22,500	150	0.007	0.01
2005-025	**R0.25**	2.5	33,000	530	0.01	0.02	30,000	300	0.007	0.01	22,500	150	0.007	0.01
2005-030	**R0.25**	3	31,000	400	0.007	0.01	28,550	230	0.005	0.008	21,400	115	0.005	0.008
2005-040	**R0.25**	4	27,150	150	0.003	0.008	25,650	100	0.002	0.005	19,900	50	0.002	0.005
2006-010	**R0.3**	1	30,000	1,500	0.03	0.13	26,500	1,000	0.015	0.09	20,000	500	0.015	0.09
2006-015	**R0.3**	1.5	30,000	1,200	0.02	0.1	26,500	800	0.01	0.075	20,000	400	0.01	0.075
2006-020	**R0.3**	2	30,000	1,200	0.02	0.1	26,500	800	0.01	0.075	20,000	400	0.01	0.075
2006-025	**R0.3**	2.5	30,000	800	0.015	0.09	26,500	520	0.008	0.065	20,000	260	0.008	0.065
2006-030	**R0.3**	3	30,000	800	0.015	0.09	26,500	520	0.008	0.065	20,000	260	0.008	0.065
2006-040	**R0.3**	4	30,000	500	0.01	0.075	26,500	340	0.006	0.05	20,000	170	0.006	0.05
2006-050	**R0.3**	5	25,000	390	0.007	0.05	23,000	260	0.005	0.04	18,000	130	0.005	0.04
2006-060	**R0.3**	6	21,000	320	0.005	0.04	19,500	210	0.004	0.03	15,000	105	0.004	0.03
2008-020	**R0.4**	2	27,000	1,600	0.04	0.17	23,500	1,000	0.02	0.12	17,500	500	0.02	0.12
2008-030	**R0.4**	3	27,000	1,400	0.03	0.15	23,500	900	0.015	0.1	17,500	450	0.015	0.1
2008-040	**R0.4**	4	27,000	1,200	0.025	0.135	23,500	600	0.012	0.095	17,500	300	0.012	0.095
2008-050	**R0.4**	5	25,000	900	0.02	0.12	22,000	500	0.01	0.085	16,500	250	0.01	0.085
2008-060	**R0.4**	6	23,000	600	0.012	0.095	20,500	400	0.006	0.065	15,500	200	0.006	0.065

VHSLB Milling Conditions

WORK MATERIAL			COPPER OFC / TPC				CARBON STEELS S45C / S50C (~225HB)				ALLOY STEELS SK / SCM / SUS (225~325HB)				PREHARDENED STEELS / HARDENED STEELS NAK / STAVAX (~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)
2010-020	**R0.5**	2	46,000	2,000	0.072	0.36	30,000	1,600	0.08	0.16	30,000	1,600	0.08	0.16	30,000	1,750	0.2	0.4
2010-025	**R0.5**	2.5	46,000	2,000	0.072	0.36	30,000	1,600	0.08	0.16	30,000	1,600	0.08	0.16	30,000	1,750	0.2	0.4
2010-030	**R0.5**	3	46,000	2,000	0.072	0.36	24,000	1,600	0.07	0.14	24,000	1,600	0.07	0.14	30,000	1,750	0.1	0.3
2010-040	**R0.5**	4	46,000	2,000	0.071	0.36	24,000	1,500	0.065	0.13	24,000	1,500	0.065	0.13	30,000	1,750	0.1	0.3
2010-050	**R0.5**	5	46,000	2,000	0.071	0.36	24,000	1,400	0.06	0.12	24,000	1,400	0.06	0.12	30,000	1,750	0.1	0.3
2010-060	**R0.5**	6	39,000	1,500	0.071	0.18	18,000	1,200	0.04	0.12	18,000	1,200	0.04	0.12	30,000	1,150	0.06	0.23
2010-080	**R0.5**	8	39,000	1,500	0.043	0.18	16,500	900	0.027	0.081	16,500	900	0.027	0.081	24,000	800	0.025	0.155
2015-030	**R0.75**	3	30,000	2,200	0.171	0.324	30,000	1,600	0.12	0.24	30,000	1,600	0.12	0.24	30,000	2,450	0.25	0.55
2015-040	**R0.75**	4	30,000	2,200	0.171	0.324	30,000	1,500	0.11	0.22	30,000	1,500	0.11	0.22	30,000	2,450	0.25	0.55
2015-060	**R0.75**	6	30,000	1,980	0.147	0.324	23,000	1,300	0.1	0.2	23,000	1,300	0.1	0.2	30,000	2,450	0.15	0.45
2015-080	**R0.75**	8	26,000	1,500	0.106	0.27	18,000	1,100	0.08	0.16	18,000	1,100	0.08	0.16	23,500	1,300	0.1	0.37
2020-030	**R1**	3	22,000	2,140	0.232	0.54	30,000	2,000	0.21	0.42	30,000	2,000	0.21	0.42	28,000	2,900	0.3	0.7
2020-040	**R1**	4	22,000	2,140	0.232	0.54	30,000	2,000	0.21	0.42	30,000	2,000	0.21	0.42	28,000	2,900	0.3	0.7
2020-060	**R1**	6	22,000	2,140	0.232	0.54	30,000	2,000	0.21	0.42	30,000	2,000	0.21	0.42	28,000	2,900	0.2	0.6
2020-080	**R1**	8	22,000	1,920	0.185	0.36	30,000	2,000	0.18	0.36	30,000	2,000	0.18	0.36	28,000	2,900	0.2	0.6
2030-060	**R1.5**	6	15,000	2,890	0.278	0.54	24,000	2,500	0.32	0.9	24,000	2,500	0.32	0.9	21,000	3,000	0.4	1
2030-080	**R1.5**	8	15,000	2,890	0.278	0.54	24,000	2,500	0.32	0.9	24,000	2,500	0.32	0.9	21,000	3,000	0.4	1

Long Neck Ball End Mills R0.5 × Effective Length 6

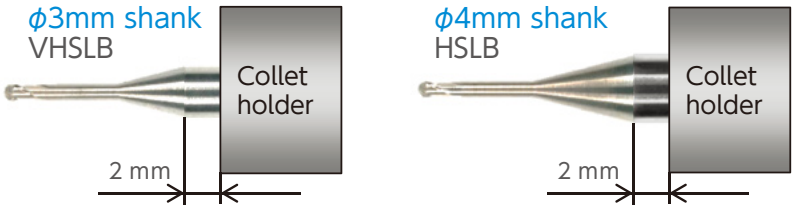
Comparison example of ϕ3 mm and ϕ4 mm shank diameters

Comparison of tool wearing and dimensional accuracy

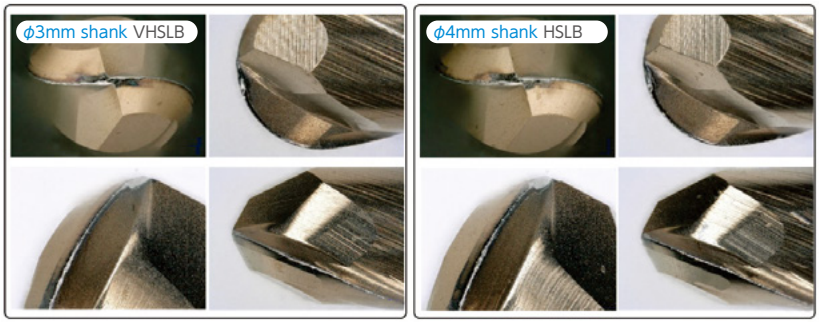
<Milling condition>

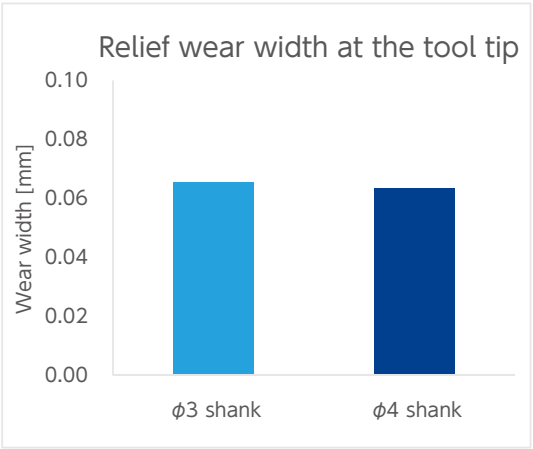
Work material : SKD11(60 HRC)
Coolant : Air blow
Tool holder : Collet holder
Milling shape : Pocket (□8 mm × 8 mm × depth 3 mm)
Cycle time : about 35 min

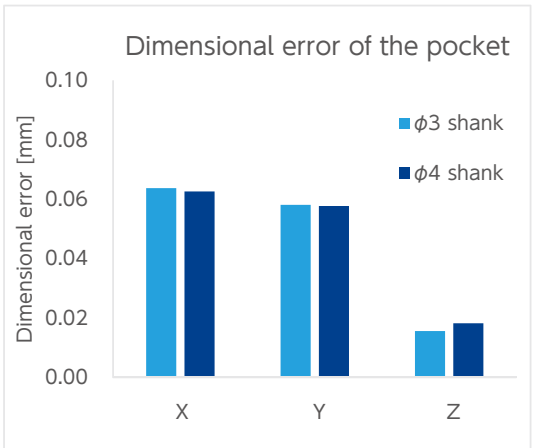
n : 21,500 min^{-1}
V_f : 1,250 mm/min
a_p : 0.03 mm
a_e : 0.17 mm



<Tool damage>





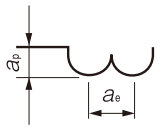


If the overhang is shortened, the performance equivalent to that of a ϕ4mm shank can be obtained.

VHSLB Milling Conditions

WORK MATERIAL			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)
2010-020	**R0.5**	2	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	**R0.5**	2.5	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	**R0.5**	3	24,000	2,000	0.05	0.2	21,000	1,750	0.03	0.17	16,000	875	0.03	0.17
2010-040	**R0.5**	4	24,000	2,000	0.05	0.2	21,000	1,750	0.03	0.17	16,000	875	0.03	0.17
2010-050	**R0.5**	5	24,000	2,000	0.05	0.2	21,000	1,750	0.03	0.17	16,000	875	0.03	0.17
2010-060	**R0.5**	6	21,500	1,250	0.03	0.17	19,700	1,050	0.025	0.15	14,500	525	0.025	0.15
2010-080	**R0.5**	8	18,500	580	0.015	0.12	18,400	480	0.015	0.12	13,800	240	0.015	0.12
2015-030	**R0.75**	3	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	**R0.75**	4	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	**R0.75**	6	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	**R0.75**	8	15,000	1,250	0.045	0.25	14,000	1,050	0.03	0.21	10,500	525	0.03	0.21
2020-030	**R1**	3	14,000	2,100	0.15	0.5	12,250	1,800	0.08	0.35	9,200	900	0.08	0.35
2020-040	**R1**	4	14,000	2,100	0.15	0.5	12,250	1,800	0.08	0.35	9,200	900	0.08	0.35
2020-060	**R1**	6	14,000	2,100	0.1	0.4	12,250	1,800	0.06	0.3	9,200	900	0.06	0.3
2020-080	**R1**	8	14,000	2,100	0.1	0.4	12,250	1,800	0.06	0.3	9,200	900	0.06	0.3
2030-060	**R1.5**	6	10,500	2,200	0.2	0.7	9,200	1,900	0.12	0.55	6,900	950	0.12	0.55
2030-080	**R1.5**	8	10,500	2,200	0.2	0.7	9,200	1,900	0.12	0.55	6,900	950	0.12	0.55

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 the tool is chattering and heats up to a red color.
- Every coolant offers stable milling.
- Recommend wet coolant for Copper.



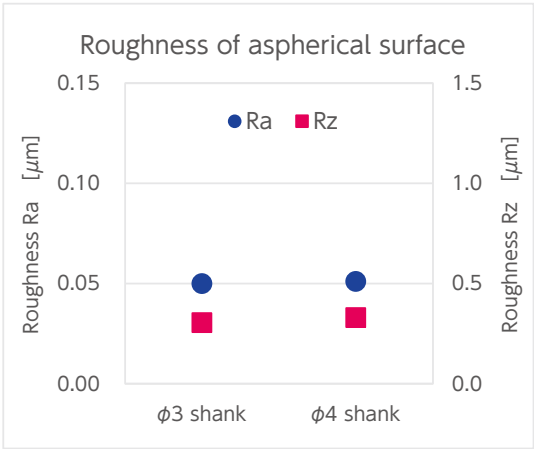
Comparison of roughness and reflection of the aspherical surface (Finishing process)

The upper surface of the square prism was processed aspherically, and the surface roughness and reflection were compared.
We obtained the same results as the ϕ4mm shank in terms of surface roughness and reflection.

<Milling condition>

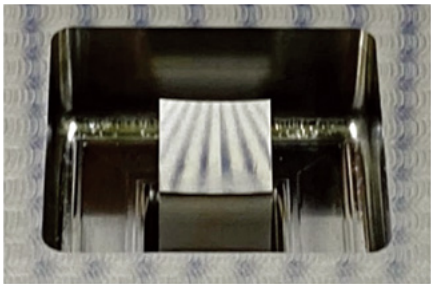
Work material : HAP10(64HRC)
Coolant : Air blow
Tool holder : Hydraulic chuck
(Overhang : 2 mm of the shank part)
Milling shape : Aspherical surface (□5 mm × 5 mm) R25
Cycle time : about 26 min

n : 29,600 min^{-1}
V_f : 500 mm/min
a_p : 0.015 mm
a_e : 0.006 mm

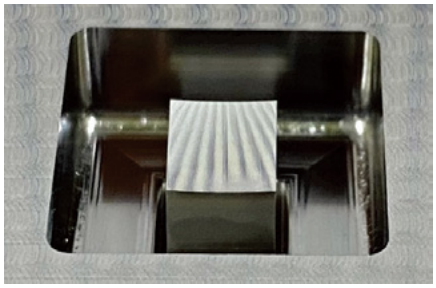


<Aspherical surface photos>

ϕ3mm shank VHSLB



ϕ4mm shank HSLB



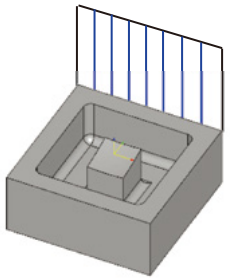


Image of the time of shooting

* These photos were taken as shown in the image on the right so that the blue line printed on the paper would reflected.

VCWLB UTWCOAT
2 Flutes Short Shank Long Neck Ball End Mills

V Series UTWCOAT Long Neck Ball

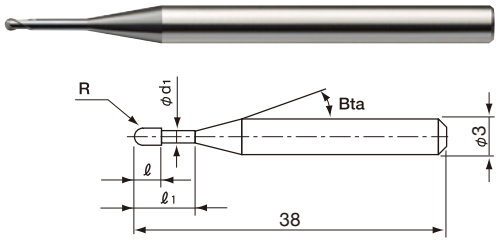
Super MG

UTW COAT

Shank Dia 0/-0.003

Back Taper Geometry

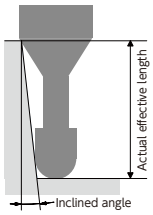
Except for R0.05-R0.15



The shank taper angle shown is not an exact value.

Unit (mm)

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



Best performance at materials up to 40HRC
Improved mirror surface finish

Material Applications (★ Highly Recommended ● Recommended ○ Suggested)

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

Total 30 models

Unit (mm)

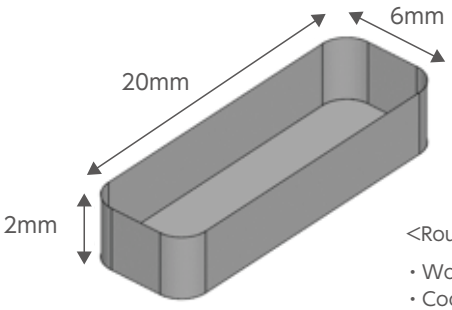
Model Number	Radius of Ball Nose R	Effective Length ℓ1	Length of Cut ℓ	Neck Diameter φd1	Shank Taper Angle Bta	Effective Length by Inclined Angles 30′	1°	1°30′	2°	3°
VCWLB 2001-003	R0.05	0.3	0.08	0.094	11°	0.34	0.37	0.39	0.41	0.46
VCWLB 20015-003	R0.075	0.3	0.12	0.14	11°	0.38	0.39	0.41	0.44	0.49
VCWLB 2002-005	R0.1	0.5	0.16	0.18	11°	0.64	0.67	0.70	0.74	0.82
VCWLB 2002-010	R0.1	1	0.16	0.18	11°	1.16	1.22	1.28	1.35	1.51
VCWLB 2003-010	R0.15	1	0.24	0.28	11°	1.16	1.21	1.27	1.34	1.49
VCWLB 2003-020	R0.15	2	0.24	0.28	11°	2.20	2.31	2.42	2.55	2.85
VCWLB 2003-030	R0.15	3	0.24	0.28	11°	3.25	3.41	3.58	3.77	4.22
VCWLB 2004-010	R0.2	1	0.32	0.38	11°	1.16	1.21	1.26	1.33	1.47
VCWLB 2004-020	R0.2	2	0.32	0.38	11°	2.20	2.30	2.41	2.54	2.84
VCWLB 2004-030	R0.2	3	0.32	0.38	11°	3.25	3.40	3.57	3.76	4.21
VCWLB 2004-040	R0.2	4	0.32	0.38	11°	4.29	4.50	4.73	4.98	5.57
VCWLB 2005-020	R0.25	2	0.4	0.48	11°	2.20	2.30	2.41	2.53	2.82
VCWLB 2005-030	R0.25	3	0.4	0.48	11°	3.25	3.40	3.56	3.75	4.19
VCWLB 2005-040	R0.25	4	0.4	0.48	11°	4.29	4.49	4.72	4.97	5.56
VCWLB 2006-020	R0.3	2	0.48	0.58	11°	2.20	2.29	2.40	2.52	2.80
VCWLB 2006-030	R0.3	3	0.48	0.58	11°	3.24	3.39	3.56	3.74	4.17
VCWLB 2006-040	R0.3	4	0.48	0.58	11°	4.29	4.49	4.71	4.96	5.54
VCWLB 2006-060	R0.3	6	0.48	0.58	11°	6.38	6.69	7.02	7.39	8.28
VCWLB 2008-020	R0.4	2	0.64	0.78	11°	2.19	2.28	2.38	2.50	2.76
VCWLB 2008-040	R0.4	4	0.64	0.78	11°	4.29	4.48	4.70	4.93	5.50
VCWLB 2008-060	R0.4	6	0.64	0.78	11°	6.38	6.68	7.01	7.37	8.24

UTWCOAT　2 Flutes　Short Shank Long Neck Ball End Mills

Model Number	Radius of Ball Nose R	Effective Length ℓ1	Length of Cut ℓ	Neck Diameter φd1	Shank Taper Angle Bta	Effective Length by Inclined Angles				
						30′	1°	1°30′	2°	3°
VCWLB 2010-030	R0.5	3	0.8	0.97	11°	3.26	3.40	3.56	3.73	4.14
VCWLB 2010-040	R0.5	4	0.8	0.97	11°	4.31	4.50	4.71	4.95	5.51
VCWLB 2010-050	R0.5	5	0.8	0.97	11°	5.36	5.60	5.87	6.17	6.87
VCWLB 2010-060	R0.5	6	0.8	0.97	11°	6.40	6.70	7.02	7.39	8.24
VCWLB 2015-040	R0.75	4	1.2	1.45	11°	4.25	4.43	4.62	4.84	5.35
VCWLB 2015-060	R0.75	6	1.2	1.45	11°	6.35	6.63	6.93	7.28	8.09
VCWLB 2020-040	R1	4	1.6	1.96	11°	4.24	4.40	4.58	4.78	5.26
VCWLB 2020-060	R1	6	1.6	1.96	11°	6.33	6.60	6.89	7.22	8.00
VCWLB 2030-060	R1.5	6	2.4	2.93	—	No Interference	No Interference	No Interference	No Interference	No Interference

Comparison of φ3 shank (VCWLB) and φ4 shank (CWLB)　R0.5 × EL6

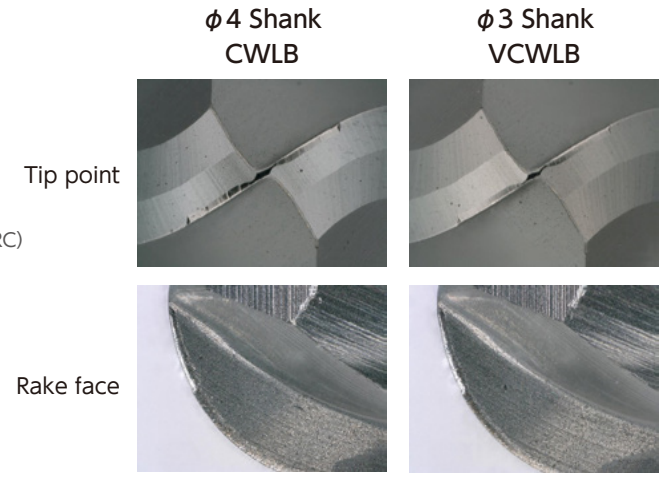
Roughing　Tool wear comparison



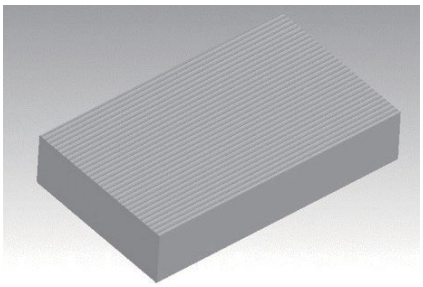
<Roughing condition>

- Work material : PXA30 (30 HRC)
- Coolant : Water soluble
- n : 30,000 min^{-1}
- Vf : 1,100 mm/min
- a_p : 0.06 mm
- a_e : 0.12 mm
- Cycle time 60 min

Tools after 60min milling



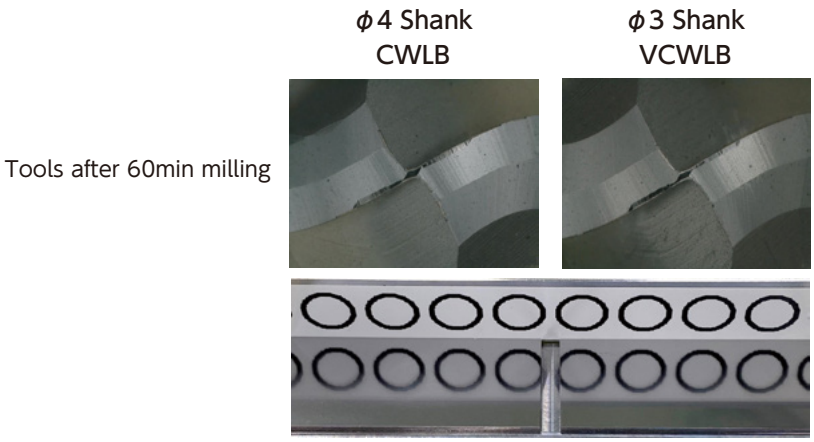
Finishing　Tool wear / Milling surface comparison

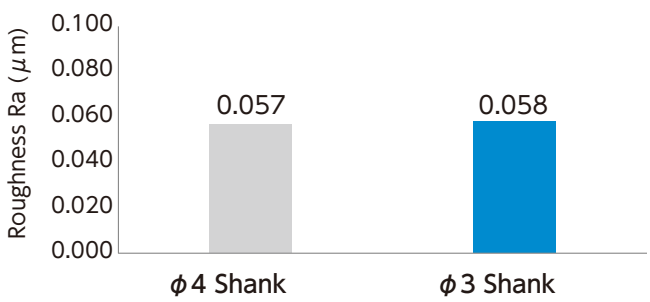


Work Size
40 × 20 × 0.06mm

<Finishing condition>

- Work material : PXA30 (30 HRC)
- Coolant : Water soluble
- n : 30,000 min^{-1}
- Vf : 900 mm/min
- a_p : 0.03 mm
- a_e : 0.03 mm
- Cycle time 60 min



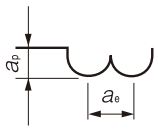


VCWLB Milling Conditions

WORK MATERIAL			COPPER / ALUMINUM ALLOYS				CARBON STEELS / ALLOY STEELS S45C / S50C / SK / SCM (~325HB)				PREHARDENED STEELS NAK80 / STAVAX / HPM38 (30~45HRC)			
Model Number	Radius of Ball Nose (mm)	Effective Length (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p (mm)	a_e (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p (mm)	a_e (mm)	Spindle Speed (min^{-1})	Feed Rate (mm/min)	a_p (mm)	a_e (mm)
2001-003	**R0.05**	0.3	54,000	85	0.004	0.004	54,000	85	0.004	0.004	48,000	55	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
2002-005	**R0.1**	0.5	60,000	350	0.008	0.024	60,000	350	0.008	0.016	60,000	300	0.008	0.024
2002-010	**R0.1**	1	60,000	250	0.006	0.018	60,000	250	0.005	0.015	60,000	250	0.006	0.018
2003-010	**R0.15**	1	43,000	450	0.01	0.03	43,000	450	0.008	0.024	54,000	400	0.01	0.03
2003-020	**R0.15**	2	40,000	300	0.006	0.018	40,000	300	0.006	0.018	50,000	300	0.007	0.021
2003-030	**R0.15**	3	38,000	200	0.004	0.012	38,000	200	0.004	0.012	42,000	200	0.004	0.012
2004-010	**R0.2**	1	35,000	1,200	0.03	0.09	35,000	1,200	0.02	0.04	50,000	650	0.025	0.075
2004-020	**R0.2**	2	35,000	600	0.015	0.045	35,000	600	0.011	0.033	50,000	500	0.015	0.045
2004-030	**R0.2**	3	35,000	400	0.01	0.03	35,000	400	0.008	0.024	42,000	400	0.01	0.03
2004-040	**R0.2**	4	35,000	300	0.005	0.015	35,000	300	0.005	0.015	35,000	300	0.005	0.015
2005-020	**R0.25**	2	34,000	800	0.025	0.075	34,000	800	0.023	0.046	45,000	700	0.022	0.066
2005-030	**R0.25**	3	32,000	550	0.016	0.048	32,000	550	0.012	0.036	41,000	550	0.014	0.042
2005-040	**R0.25**	4	31,000	450	0.012	0.036	31,000	450	0.01	0.03	35,000	450	0.01	0.03
2006-020	**R0.3**	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
2006-030	**R0.3**	3	33,000	900	0.035	0.105	33,000	900	0.025	0.066	40,000	800	0.03	0.075
2006-040	**R0.3**	4	31,000	700	0.027	0.081	31,000	700	0.02	0.06	35,000	560	0.022	0.066
2006-060	**R0.3**	6	24,000	380	0.012	0.036	24,000	380	0.012	0.036	24,000	380	0.01	0.03
2008-020	**R0.4**	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
2008-040	**R0.4**	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
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
2010-030	**R0.5**	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
2010-040	**R0.5**	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
2010-050	**R0.5**	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
2010-060	**R0.5**	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
2015-040	**R0.75**	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
2015-060	**R0.75**	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
2020-040	**R1**	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
2020-060	**R1**	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
2030-060	**R1.5**	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

VCWLB Milling Conditions

WORK MATERIAL			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 (mm)	a_e (mm)
2001-003	**R0.05**	0.3	48,000	55	0.002	0.002
20015-003	**R0.075**	0.3	48,000	90	0.004	0.004
2002-005	**R0.1**	0.5	60,000	300	0.006	0.018
2002-010	**R0.1**	1	60,000	220	0.005	0.015
2003-010	**R0.15**	1	43,000	400	0.007	0.021
2003-020	**R0.15**	2	40,000	300	0.005	0.015
2003-030	**R0.15**	3	38,000	200	0.004	0.008
2004-010	**R0.2**	1	35,000	650	0.015	0.045
2004-020	**R0.2**	2	35,000	400	0.01	0.03
2004-030	**R0.2**	3	35,000	330	0.007	0.021
2004-040	**R0.2**	4	35,000	250	0.005	0.015
2005-020	**R0.25**	2	32,000	700	0.016	0.048
2005-030	**R0.25**	3	31,000	500	0.012	0.036
2005-040	**R0.25**	4	30,000	390	0.01	0.03
2006-020	**R0.3**	2	30,000	1,200	0.036	0.054
2006-030	**R0.3**	3	30,000	900	0.026	0.052
2006-040	**R0.3**	4	28,000	600	0.018	0.054
2006-060	**R0.3**	6	24,000	380	0.008	0.024
2008-020	**R0.4**	2	25,000	1,700	0.07	0.1
2008-040	**R0.4**	4	25,000	1,200	0.045	0.09
2008-060	**R0.4**	6	23,000	800	0.023	0.069
2010-030	**R0.5**	3	21,500	1,400	0.08	0.12
2010-040	**R0.5**	4	21,500	1,300	0.075	0.1
2010-050	**R0.5**	5	21,500	1,200	0.06	0.09
2010-060	**R0.5**	6	21,500	1,100	0.05	0.1
2015-040	**R0.75**	4	18,000	1,400	0.11	0.17
2015-060	**R0.75**	6	15,000	1,200	0.1	0.16
2020-040	**R1**	4	16,000	1,300	0.17	0.5
2020-060	**R1**	6	14,000	1,100	0.15	0.4
2030-060	**R1.5**	6	14,000	1,400	0.25	0.76



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.

VCSELB UTCOAT 2 Flutes Short Shank Long Neck Ball End Mills

V Series UTCOAT Long Neck Ball

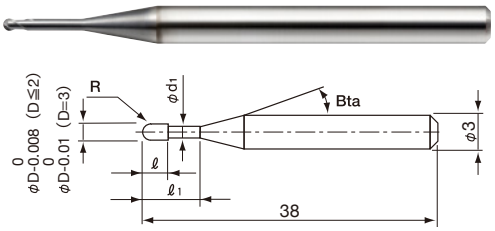
Super MG

UT COAT

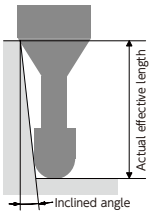
Shank Dia 0/-0.003

Back Taper Geometry

Except for R0.05 ~ R0.15



The shank taper angle shown is not an exact value.



From raw materials to 55HRC
Standard type

Unit (mm)

Radius of Ball Nose	Diameter Tolerance	Ball Radius Accuracy	Helix Angle
R0.05 ~ R0.075	0/-0.008	± 0.002	0°
R0.1 ~ R0.75		± 0.003	30°
R1		± 0.004	
R1.5	0/-0.01	± 0.005	

Material Applications (★ Highly Recommended ● Recommended ○ Suggested)

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

Total 30 models

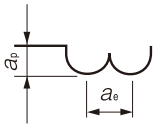
Unit (mm)

Model Number	Radius of Ball Nose R	Effective Length ℓ1	Length of Cut ℓ	Neck Diameter φd1	Shank Taper Angle Bta	Effective Length by Inclined Angles 30′	1°	1°30′	2°	3°
VCSELB 2001-003	R0.05	0.3	0.08	0.094	11°	0.34	0.36	0.38	0.41	0.46
VCSELB 20015-003	R0.075	0.3	0.12	0.14	11°	0.37	0.39	0.41	0.43	0.48
VCSELB 2002-005	R0.1	0.5	0.16	0.18	11°	0.64	0.67	0.70	0.73	0.82
VCSELB 2002-010	R0.1	1	0.16	0.18	11°	1.16	1.21	1.28	1.34	1.50
VCSELB 2003-010	R0.15	1	0.24	0.28	11°	1.16	1.21	1.27	1.33	1.49
VCSELB 2003-020	R0.15	2	0.24	0.28	11°	2.20	2.30	2.42	2.55	2.85
VCSELB 2003-030	R0.15	3	0.24	0.28	11°	3.25	3.40	3.58	3.77	4.22
VCSELB 2004-010	R0.2	1	0.32	0.38	11°	1.16	1.21	1.26	1.32	1.47
VCSELB 2004-020	R0.2	2	0.32	0.38	11°	2.20	2.30	2.41	2.54	2.83
VCSELB 2004-030	R0.2	3	0.32	0.38	11°	3.24	3.40	3.57	3.76	4.20
VCSELB 2004-040	R0.2	4	0.32	0.38	11°	4.29	4.50	4.72	4.97	5.57
VCSELB 2005-020	R0.25	2	0.4	0.48	11°	2.19	2.29	2.40	2.52	2.81
VCSELB 2005-030	R0.25	3	0.4	0.48	11°	3.24	3.39	3.56	3.74	4.18
VCSELB 2005-040	R0.25	4	0.4	0.48	11°	4.29	4.49	4.71	4.96	5.55
VCSELB 2006-020	R0.3	2	0.48	0.58	11°	2.19	2.29	2.39	2.51	2.79
VCSELB 2006-030	R0.3	3	0.48	0.58	11°	3.24	3.39	3.55	3.73	4.16
VCSELB 2006-040	R0.3	4	0.48	0.58	11°	4.28	4.48	4.70	4.95	5.53
VCSELB 2006-060	R0.3	6	0.48	0.58	11°	6.38	6.68	7.02	7.39	8.27
VCSELB 2008-020	R0.4	2	0.64	0.78	11°	2.19	2.28	2.38	2.49	2.76
VCSELB 2008-040	R0.4	4	0.64	0.78	11°	4.28	4.47	4.69	4.93	5.50
VCSELB 2008-060	R0.4	6	0.64	0.78	11°	6.37	6.67	7.00	7.37	8.23
VCSELB 2010-030	R0.5	3	0.8	0.97	11°	3.26	3.40	3.55	3.73	4.13
VCSELB 2010-040	R0.5	4	0.8	0.97	11°	4.31	4.50	4.71	4.94	5.50
VCSELB 2010-050	R0.5	5	0.8	0.97	11°	5.35	5.60	5.87	6.16	6.87
VCSELB 2010-060	R0.5	6	0.8	0.97	11°	6.40	6.70	7.02	7.38	8.24
VCSELB 2015-040	R0.75	4	1.2	1.46	11°	4.25	4.42	4.62	4.84	5.35
VCSELB 2015-060	R0.75	6	1.2	1.46	11°	6.34	6.62	6.93	7.27	8.09
VCSELB 2020-040	R1	4	1.6	1.96	11°	4.24	4.40	4.58	4.78	5.26
VCSELB 2020-060	R1	6	1.6	1.96	11°	6.33	6.60	6.89	7.22	8.00
VCSELB 2030-060	R1.5	6	2.4	2.93	—	No Interference	No Interference	No Interference	No Interference	No Interference

VCSELB 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)
2001-003	**R0.05**	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
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
2002-005	**R0.1**	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
2002-010	**R0.1**	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
2003-010	**R0.15**	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
2003-020	**R0.15**	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
2003-030	**R0.15**	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
2004-010	**R0.2**	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
2004-020	**R0.2**	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
2004-030	**R0.2**	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
2004-040	**R0.2**	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
2005-020	**R0.25**	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
2005-030	**R0.25**	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	**R0.25**	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
2006-020	**R0.3**	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
2006-030	**R0.3**	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
2006-040	**R0.3**	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
2006-060	**R0.3**	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
2008-020	**R0.4**	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
2008-040	**R0.4**	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
2008-060	**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
2010-030	**R0.5**	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	**R0.5**	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	**R0.5**	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	**R0.5**	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
2015-040	**R0.75**	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	**R0.75**	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
2020-040	**R1**	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	**R1**	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
2030-060	**R1.5**	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

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 the tool is chattering and heats up to a red color.
- Recommend oil coolant for Stainless Steels and Heat Resistant Alloys.
- Recommend wet coolant for Copper.



VDLCLB DLCCOAT 2 Flutes Short Shank Long Neck Ball End Mills

V Series DLCCOAT Long Neck Ball

Super MG

DLC

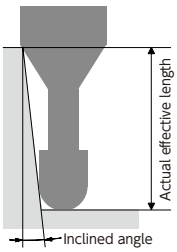
30°

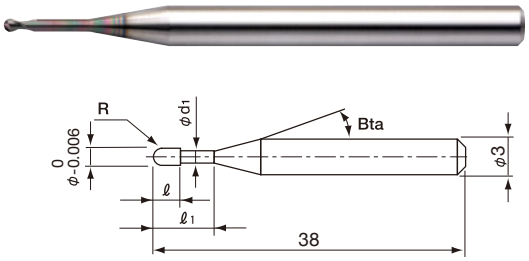
R ±0.002
R0.05～R0.2

R ±0.003
R0.25～R1

Shank Dia 0/-0.003

Back Taper Geometry
Except for R0.05～R0.15





The shank taper angle shown is not an exact value.

Label Sample

#001 φD0.997 R+0.001/−0.001

Diameter and Ball R accuracy measurements are printed on the label to support High Precision milling.

DLC coating For copper electrode milling

Material Applications (★ Highly Recommended ● Recommended ○ Suggested)

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

Total 32 models

Unit (mm)

Model Number	Radius of Ball Nose R	Effective Length ℓ1	Length of Cut ℓ	Neck Diameter φd1	Shank Taper Angle Bta	Effective Length by Inclined Angles 30°	1°	1°30′	2°	3°
VDLCLB 2001-003	R0.05	0.3	0.08	0.092	11°	0.35	0.37	0.39	0.41	0.46
VDLCLB 2001-005	R0.05	0.5	0.08	0.092	11°	0.56	0.59	0.62	0.66	0.74
VDLCLB 2002-005	R0.1	0.5	0.16	0.18	11°	0.64	0.67	0.70	0.74	0.83
VDLCLB 2002-010	R0.1	1	0.16	0.18	11°	1.17	1.22	1.28	1.35	1.51
VDLCLB 2002-015	R0.1	1.5	0.16	0.18	11°	1.68	1.77	1.86	1.95	2.19
VDLCLB 2003-010	R0.15	1	0.24	0.28	11°	1.16	1.22	1.27	1.34	1.49
VDLCLB 2003-020	R0.15	2	0.24	0.28	11°	2.21	2.31	2.43	2.55	2.86
VDLCLB 2004-010	R0.2	1	0.32	0.38	11°	1.16	1.21	1.27	1.33	1.48
VDLCLB 2004-020	R0.2	2	0.32	0.38	11°	2.20	2.31	2.42	2.54	2.84
VDLCLB 2004-030	R0.2	3	0.32	0.38	11°	3.25	3.40	3.57	3.76	4.21
VDLCLB 2004-040	R0.2	4	0.32	0.38	11°	4.30	4.50	4.73	4.98	5.58
VDLCLB 2005-020	R0.25	2	0.4	0.48	11°	2.20	2.30	2.41	2.53	2.82
VDLCLB 2005-030	R0.25	3	0.4	0.48	11°	3.25	3.40	3.57	3.75	4.19
VDLCLB 2005-040	R0.25	4	0.4	0.48	11°	4.29	4.50	4.72	4.97	5.56
VDLCLB 2006-020	R0.3	2	0.48	0.58	11°	2.20	2.30	2.40	2.52	2.80
VDLCLB 2006-030	R0.3	3	0.48	0.58	11°	3.25	3.39	3.56	3.74	4.17
VDLCLB 2006-040	R0.3	4	0.48	0.58	11°	4.29	4.49	4.71	4.96	5.54
VDLCLB 2006-050	R0.3	5	0.48	0.58	11°	5.34	5.59	5.87	6.18	6.91
VDLCLB 2006-060	R0.3	6	0.48	0.58	11°	6.39	6.69	7.03	7.40	8.28
VDLCLB 2008-030	R0.4	3	0.64	0.78	11°	3.24	3.38	3.54	3.72	4.14
VDLCLB 2008-040	R0.4	4	0.64	0.78	11°	4.29	4.48	4.70	4.94	5.51
VDLCLB 2008-060	R0.4	6	0.64	0.78	11°	6.38	6.68	7.01	7.38	8.24
VDLCLB 2010-020	R0.5	2	0.8	0.97	11°	2.22	2.31	2.41	2.52	2.77
VDLCLB 2010-030	R0.5	3	0.8	0.97	11°	3.27	3.41	3.56	3.73	4.14
VDLCLB 2010-040	R0.5	4	0.8	0.97	11°	4.32	4.51	4.72	4.95	5.51
VDLCLB 2010-060	R0.5	6	0.8	0.97	11°	6.41	6.70	7.03	7.39	8.25
VDLCLB 2010-080	R0.5	8	0.8	0.97	11°	8.50	8.90	9.34	9.83	10.99
VDLCLB 2015-040	R0.75	4	1.2	1.45	11°	4.26	4.43	4.63	4.85	5.36
VDLCLB 2015-060	R0.75	6	1.2	1.45	11°	6.35	6.63	6.94	7.28	8.10
VDLCLB 2020-040	R1	4	1.6	1.95	11°	4.25	4.41	4.59	4.79	5.27
VDLCLB 2020-060	R1	6	1.6	1.95	11°	6.34	6.61	6.90	7.23	8.01
VDLCLB 2020-080	R1	8	1.6	1.95	11°	8.43	8.80	9.21	9.67	No Interference

Milling Example of Copper Electrode Model (Tough Pitch Copper)
R1 × Effective length 8mm
Comparison of ϕ3 shank (VDLCLB) and ϕ4 shank (DLCLB)

Comparison of tool wearing

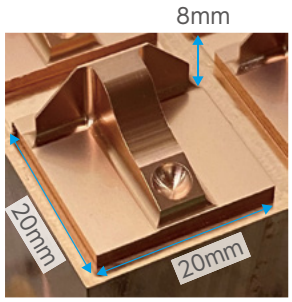
<Milling condition>

Work material : Tough Pitch Copper
Coolant : Oil mist
Milling shape : □20 mm × 20 mm × height 8 mm

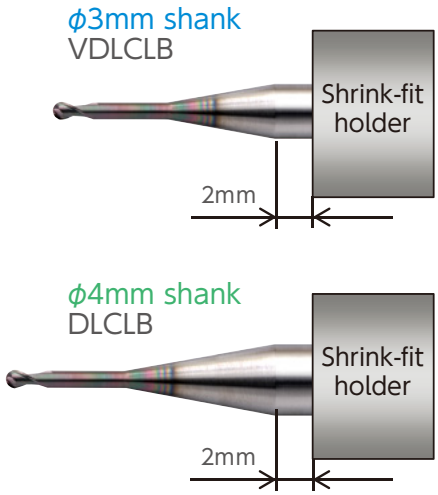
<Tool>*1

VDLCLB 2020-080 (ϕ3 shank)
DLCLB 2020-080 (ϕ4 shank)
*1 1 for roughing to semi-finishing, 1 for finishing
total 2 ea.
*2 Both models are set so that the overhang of shank is 2 mm.

VDLCLB
Milling Video

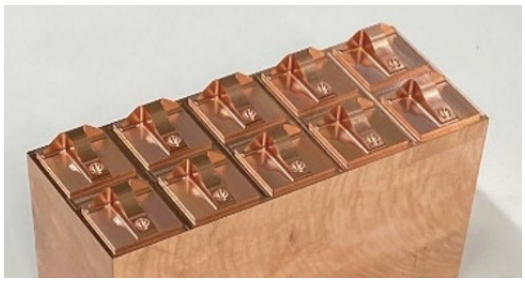


Milling shape

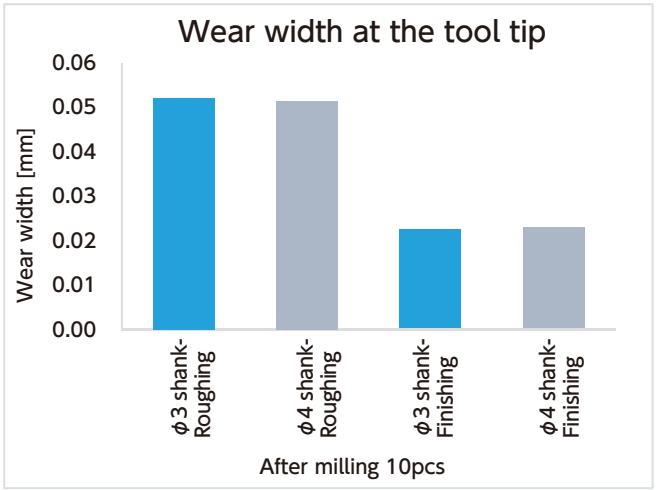


No.	Milling Process	Spindle speed (min^{-1})	Feed rate (mm/min)	a_p (mm)	a_e (mm)	Allowance (mm)	Cycle time/ 1 pc
1	Roughing	18,700	1,800	0.4	0.8	0.08	14 min 6 sec
2	Semi-finishing	18,700	1,800	0.05	0.05	0.03	1 h 17 min 24 sec
3	Finishing	18,700/ 30,000 (Bottom)	900	0.03	0.03	0	1 h 17 min 0 sec
						Total	2 h 48 min 30 sec

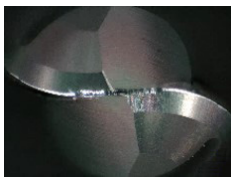
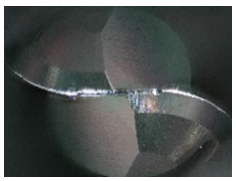
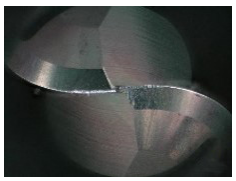
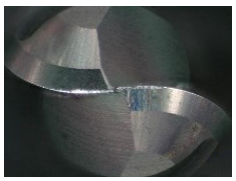
VDLCLB(ϕ3 shank)
Finished work



DLCLB(ϕ4 shank)
Finished work



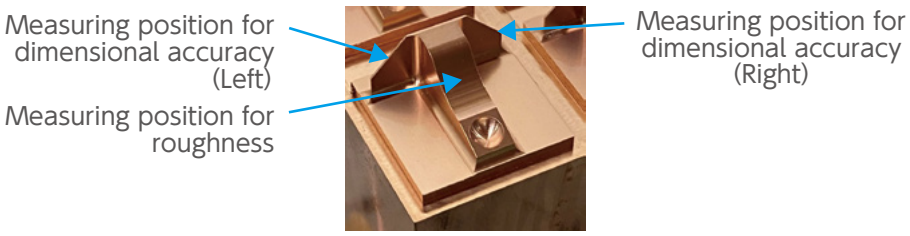
【Tool after milling 10pcs】

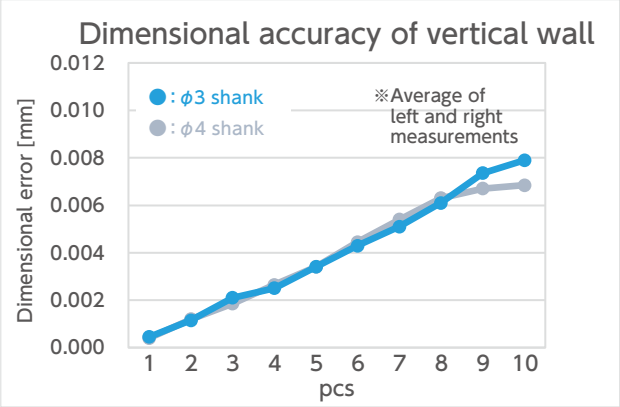
	VDLCLB (ϕ3 shank)	DLCLB (ϕ4 shank)
Roughing to Semi-finishing Cycle time: 15 h 15 min		
Finishing Cycle time: 12 h 50 min		

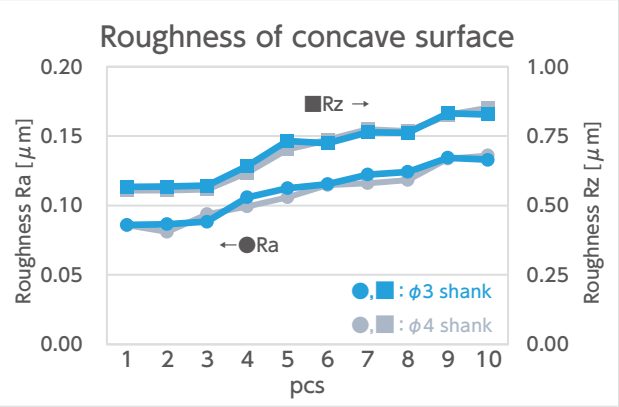
No difference of tool wearing with regard to the shank diameter gap.

Comparison of dimensional accuracy and roughness

Measuring for dimensional accuracy of vertical wall and roughness of concave surface.





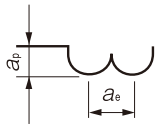


Both the dimensional accuracy and roughness gave very similar results, with no difference with regard to the shank diameter gap.

VDLCLB Milling Conditions

WORK MATERIAL			COPPER / ALUMINUM ALLOY				TUNGSTEN COPPER			
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)
2001-003	**R0.05**	0.3	43,600	220	0.01	0.01	32,700	160	0.008	0.008
2001-005	**R0.05**	0.5	43,600	160	0.007	0.007	32,700	110	0.005	0.005
2002-005	**R0.1**	0.5	43,600	550	0.025	0.05	32,700	380	0.02	0.04
2002-010	**R0.1**	1	43,600	440	0.02	0.04	32,700	270	0.015	0.03
2002-015	**R0.1**	1.5	32,900	250	0.015	0.03	24,700	120	0.008	0.02
2003-010	**R0.15**	1	43,600	760	0.03	0.07	32,700	550	0.03	0.07
2003-020	**R0.15**	2	39,200	390	0.02	0.03	29,400	200	0.01	0.02
2004-010	**R0.2**	1	43,600	1,090	0.05	0.1	32,700	760	0.04	0.08
2004-020	**R0.2**	2	43,600	650	0.035	0.06	32,700	380	0.02	0.05
2004-030	**R0.2**	3	35,000	470	0.02	0.04	29,200	230	0.01	0.03
2004-040	**R0.2**	4	27,300	270	0.008	0.015	19,600	110	0.005	0.01
2005-020	**R0.25**	2	43,600	870	0.08	0.15	32,700	550	0.08	0.15
2005-030	**R0.25**	3	38,200	650	0.06	0.1	29,500	390	0.06	0.08
2005-040	**R0.25**	4	32,700	440	0.04	0.08	24,000	220	0.025	0.05
2006-020	**R0.3**	2	43,600	1,750	0.12	0.2	32,700	1,310	0.12	0.2
2006-030	**R0.3**	3	43,600	1,090	0.1	0.14	32,700	760	0.08	0.1
2006-040	**R0.3**	4	32,700	760	0.07	0.1	27,300	440	0.04	0.06
2006-050	**R0.3**	5	29,500	650	0.05	0.08	24,000	330	0.02	0.04
2006-060	**R0.3**	6	27,300	550	0.04	0.06	21,800	220	0.01	0.03
2008-030	**R0.4**	3	43,600	2,180	0.15	0.3	32,700	1,530	0.15	0.3
2008-040	**R0.4**	4	38,200	1,750	0.12	0.2	29,500	1,090	0.1	0.16
2008-060	**R0.4**	6	32,700	1,090	0.08	0.15	21,800	550	0.05	0.1
2010-020	**R0.5**	2	39,100	2,740	0.25	0.4	30,000	2,050	0.25	0.4
2010-030	**R0.5**	3	39,100	2,740	0.25	0.4	30,000	1,960	0.25	0.4
2010-040	**R0.5**	4	39,100	2,350	0.2	0.4	29,500	1,560	0.2	0.4
2010-060	**R0.5**	6	34,500	1,840	0.14	0.3	26,200	1,150	0.1	0.25
2010-080	**R0.5**	8	27,300	1,090	0.12	0.2	19,600	550	0.06	0.1
2015-040	**R0.75**	4	25,500	2,270	0.3	0.6	21,300	1,700	0.3	0.6
2015-060	**R0.75**	6	25,500	2,040	0.3	0.6	21,300	1,530	0.3	0.6
2020-040	**R1**	4	18,700	2,490	0.45	0.8	14,000	1,500	0.45	0.8
2020-060	**R1**	6	18,700	2,080	0.45	0.8	14,000	1,250	0.45	0.8
2020-080	**R1**	8	18,700	1,800	0.4	0.8	13,500	1,200	0.4	0.8

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 occurs.
- Recommend wet coolant for Copper, Aluminum alloy and Tungsten-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 5 μm or below for the small diameter tools ϕ1 or below.
- Do not use flammable cutting oils.

Advisory for regrinding UNIMAX Tungsten Carbide 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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