

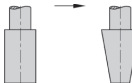

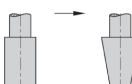

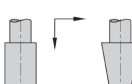

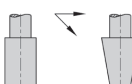

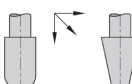
<b>1.</b> <b>F – Solid carbide mill</b>	<b>2.</b> <b>2</b>	<b>3.</b> <b>Mill type</b> <b>A</b> Solid material with continuous cutting edge <b>B</b> Solid material with discontinuous cutting edge <b>D</b> With soldered, continuous cutting edge <b>E</b> With soldered, discontinuous cutting edge	<b>4.</b> <b>H</b>	<b>5.</b> <b>Milling cutter diameter</b> Values in 1/100 mm <b>0600</b>	<b>6.</b> <b>Shank form</b> <b>B</b>	<b>7.</b> <b>Standard/size</b> <b>DN</b> DIN 6528 <b>DK</b> DIN 6527 short <b>DL</b> DIN 6527 long <b>WS</b> Factory standard Small Total length ≤ 60 mm <b>WM</b> Factory standard Medium Total length > 60 ≤ 75 mm <b>WL</b> Factory standard Large Total length > 75 ≤ 100 mm <b>WX</b> Factory standard Extra Large Total length > 100 mm	<b>8.</b> <b>30</b>	<b>9.</b> <b>Specification</b> <b>L</b> Cutting edge length <b>R</b> Corner radius <b>C</b> Internal cooling and cutting edge length Values in 1/10 mm <b>L200</b>
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**2.**  
**Number of teeth**

**4.**  
**Milling cutter type**

**6.**  
**Shank form**

**8.**  
**Helix Angle**

<p><b>F</b> T-slot mill</p> 	<p><b>A</b> Smooth straight shank</p> 
<p><b>G</b> Helical end mill, straight and tapered</p> 	<p><b>B</b> Straight shank with lateral clamping surface (ISO 3338-1) (Weldon)</p> 
<p><b>H</b> Slotting mill, straight and tapered</p> 	<p><b>E</b> Straight shank with inclined clamping surface (Whistle Notch)</p> 
<p><b>J</b> Slot mill, straight and tapered</p> 	
<p><b>K</b> Die sinking mill with round face</p> 	
<p><b>L</b> Die sinking mill with round face</p> 	

**Special applications**

- D** – Dry machining
- A** – Aluminium machining
- R** – Non-regrinding end mill
- U** – Undersize mill
- V** – Hard machining (Vickers)
- S** – Stainless steel
- T** – Radiused mill
- W** – Radiused mill and ball nose

Group	Material	Description	
P2	Medium and high carbon steels > 0.3% C	AISI:	1008, 1010, 1020, 1026, 1035, 1040, 1045, 1080, 1525, 1541, 1551, 1561, 1572
P3	Alloy steels and tool steels <330HB, <35HRC	AISI:	1300, 2000, 3000, 4000, 5000, 6000, 7000, and 8000 series steels.
		Tool Steels:	SAE classes M and T hot and cold work SAE classes: A, D, H, O, and S; Wrought high carbon/low alloy W1, W2, L2, P1, P6, and P20
P4	Alloy steels and tool steels 340-450HB, 36-48HRC	AISI:	1300, 2000, 3000, 4000, 5000, 6000, 7000, and 8000 series steels.
		Tool Steels:	SAE classes M and T hot and cold work SAE classes: A, D, H, O, and S; Wrought high carbon/low alloy W1, W2, L2, P1, P6, and P20
P5	Ferritic, martensitic and PH stainless steels <330HB, <35HRC	AISI:	410, 416, 416F, 416 Se, 420F, 15-5 PH, 17-4 PH, 13-8 PH
P6	Ferritic, martensitic and PH stainless steels >330HB, >35HRC	AISI:	410, 416, 416F, 416 Se, 420F, 15-5 PH, 17-4 PH, 13-8 PH
M1	Austenitic stainless steel	AISI:	200, 201, 202, 209, 219, 301, 302, 303, 304, 304L, 305
M2	Austenitic stainless steel	AISI:	310, 314, 316, 316L, 317, 321, 347, 384, ASTM: XM-1, XM-5 XM-7, XM-21, CF-8M
M3	Austenitic stainless steel: Duplex (ferritic and austenitic mixture)	AISI:	323, 329, F55, 2205, S329000
K1	Grey cast iron (GG)	ASTM A48:	Class 20, 25, 30, 35, 40, 45, 50, 55, 60, SAE J431: grade G1800, G3000, G3500
		SAE J431:	grade G1800, G3000, G3500
K2	Ductile, CGI, and malleable cast iron <80KSI	SAE J431:	60-40-18, 65-45-12
		SAE J434:	D4018, D4512, D5506
		ASTM A47:	grade 32510, 35018
		SAE J58:	grade M3210, M4504, M5503
		ASTM A842:	grade 250, 300, 350, 400, 450
N1	Aluminum alloys <12.2% Si	Low silicon aluminum, 6061-T6, 7075-T6	
N2	Aluminum alloys >12.2% Si	High silicon aluminum, 6061-T6, 7075-T6	
S1	Iron-based heat-resistant alloys	Wrought:	A-286, Discaloy, Incoloy 801, N-155, 16-25-6, 19-9 DL
		Cast:	ASTM A297, A351, A608, A567
S2	Cobalt-based heat-resistant alloys	Wrought:	AiResist 213, Haynes 25 (L605), Haynes 188, J-1570, Stellite
		Cast:	AiResist 13, Haynes 21, MAR-M302, MAR-M509, NASA Co-W-Re, WI-52
S3	Nickel-based heat-resistant alloys	Astroloy, Hastelloy C/C-276/X, Inconel 6061/617-625/700/706/718	
		IN102, Incoloy 901, Mar-M200, Nimonic, Rene 41, Udimet, Waspaloy, Monel	
S4	Alpha-Beta titanium alloys	Pure: Ti98.9, Ti99.9 Alloyed Ti-5Al-2.5Sn, Ti-6Al-4V, Ti-6Al-2Sn-4Zr-2Mo, Ti-3Al-8V-6Cr-4Mo-4Zr, Ti-10V-2Fe-3Al, Ti-13V-11Cr-3Al	
H1	Hardened steels <48HRC	Tool steels: H10, H11, H13, D2, D3, Alloy steels AISI: 1335, 4140, 4150, 4320, 4340, Die steels P20, P21	
H2	Hardened steels 48-55HRC	Tool steels: H10, H11, H13, Alloy steels AISI: 1335, 4140, 4150, 4320, 4340, Die steels P20, P21	
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H4	Hardened steels >60HRC	Tool steels: H10, H11, H13, Alloy steels AISI: 1335, 4140, 4150, 4320, 4340, Die steels P20, P21	

See page 516 for complete material listing.

SOLID CARBIDE

INSERTS

FACE MILLS

90° MILLS

SLOTTING

DIE AND MOLD

CERAMIC MILLS


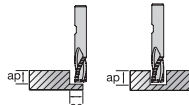

CLASSIC MILLS

THREAD MILLS

TECHNICAL DATA


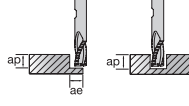

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SFRHEC

 <p>Coarse Pitch</p>			<p>Reduce speed by 20% for slotting applications</p>		<p>Recommended fz- Feed Per Tooth (Inch/th) for side cutting operations. For slotting operations, reduce fz by 20%.</p> <p>D1- Diameter (Inch)</p>					
	<p>Application</p>									
	<p>Material</p>	<p>Side Milling ap</p>			<p>ae</p>	<p>Slotting ap</p>	<p>SFM</p>	<p>1/4"</p>	<p>3/8"</p>	<p>1/2"</p>
<p>N1</p>	<p>1.5XD</p>	<p>0.5XD</p>	<p>1XD</p>	<p>600~1800</p>	<p>.0015</p>	<p>.0025</p>	<p>.0030</p>	<p>.0040</p>	<p>.0045</p>	<p>.0060</p>

These guidelines may require variations to achieve optimum results.

HPRSS

 <p>Chipbreaker Pitch</p>			<p>Reduce speed by 20% for slotting applications</p>		<p>Recommended fz- Feed Per Tooth (Inch/th) for side cutting operations. For slotting operations, reduce fz by 20%.</p> <p>D1- Diameter (Inch)</p>					
	<p>Application</p>									
	<p>Group</p>	<p>Side Milling ap</p>			<p>ae</p>	<p>Slotting ap</p>	<p>SFM</p>	<p>1/4"</p>	<p>3/8"</p>	<p>1/2"</p>
<p>P2</p>	<p>1XD</p>	<p>0.5XD</p>	<p>1XD</p>	<p>400~500</p>	<p>.0013</p>	<p>.0020</p>	<p>.0030</p>	<p>.0035</p>	<p>.0040</p>	<p>.0045</p>
<p>M1</p>	<p>1XD</p>	<p>0.5XD</p>	<p>1XD</p>	<p>350~450</p>	<p>.0012</p>	<p>.0016</p>	<p>.0024</p>	<p>.0030</p>	<p>.0035</p>	<p>.0040</p>
<p>M2</p>	<p>1XD</p>	<p>0.5XD</p>	<p>1XD</p>	<p>250~325</p>	<p>.0008</p>	<p>.0016</p>	<p>.0024</p>	<p>.0030</p>	<p>.0035</p>	<p>.0040</p>
<p>S3</p>	<p>1XD</p>	<p>0.5XD</p>	<p>1XD</p>	<p>65~95</p>	<p>.0006</p>	<p>.0008</p>	<p>.0012</p>	<p>.0015</p>	<p>.0020</p>	<p>.0024</p>

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		ASTM A47:	grade 32510, 35018
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		ASTM A842:	grade 250, 300, 350, 400, 450
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S4	Alpha-Beta titanium alloys	Pure: Ti98.9, Ti99.9 Alloyed Ti-5Al-2.5Sn, Ti-6Al-4V, Ti-6Al-2SN-4Zr-2Mo, Ti-3Al-8V-6Cr-4Mo-4Zr, Ti-10V-2Fe-3Al, Ti-13V-11Cr-3Al	
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 INSERTS  
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 90° MILLS  
 SLOTTING  
 DIE AND MOLD  
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 CLASSIC MILLS  
 THREAD MILLS  
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See page 516 for complete material listing.

If the radial width of cut ( $a_e$ ) is less than  $.5 \times D1$ , the actual chipload at the cutting edge is less than the programmed chipload.

To obtain the correct chipload at the cutting edge, follow the simple 4-step process.

**Step 1:** Determine the following values from your application:

$D1$  = end mill cutting diameter

$a_e$  = radial width of cut

$f_z$  = desired chipload per tooth at the cutting edge

**Step 2:** Determine the radial width engagement ratio:

radial width engagement ratio =  $a_e/D1$

**Step 3:** Determine the chipload factor from the table below using the radial width engagement ratio from Step 2:

**Step 4:** Calculate what the programmed chipload should be to get the desired chipload at the cutting edge:

$f_z \text{ programmed} = f_z \times \text{chipload factor}$

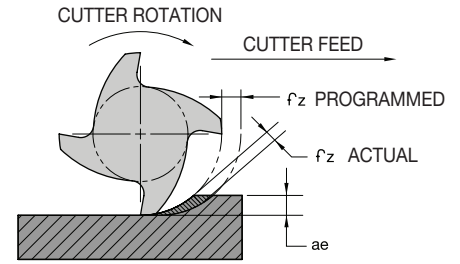
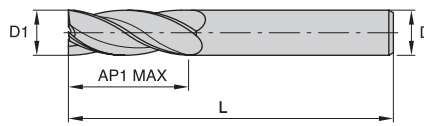
**Example: What is the programmed chipload to achieve a desired chipload of .002"/tooth using a 1/2"-diameter end mill with a radial width of cut of .05"?**

**Step 1:**  $D1 = .500"$   $a_e = .05"$   $f_z = .002"$

**Step 2:** Radial width engagement ratio =  $a_e/D1 = .05"/.500" = .1$

**Step 3:** Chipload factor for a .1 radial width engagement ratio = **1.73**

**Step 4:** The programmed chipload =  $f_z \times \text{chipload factor} = .002" \times 1.73 = .0034"$



Radial Width Engagement Ratio = $a_e/D1$	Chip Load Factor
0.3	1.1
0.25	1.15
0.2	1.25
0.15	1.41
0.1	1.73
0.07	2.0
0.05	2.33
0.03	2.93
0.02	3.6
0.01	5.0

**Ball Nose**

**Effective Cutting Diameter Calculation**

When the axial depth of cut is less than half of the cutting diameter ( $a_p < .5D1$ ), the end mill diameter used to determine speed and feed rate is smaller than the cutting diameter ( $D1$ ). This smaller end mill diameter is known as the effective cutting diameter ( $D_{eff}$ ). This effective cutting diameter can be calculated using a simple 4-step process.

**Step 1:** Determine the following values from your application:

$D1$  = end mill cutting diameter

$a_p$  = axial depth of cut

**Step 2:** Determine the depth of cut ratio:

depth of cut ratio =  $a_p/D1$

**Step 3:** Determine the diameter factor from the table below using the depth of cut ratio from Step 2:

**Step 4:** Calculate the effective cutting diameter ( $D_{eff}$ ):

$D_{eff} = D1$  multiplied by the diameter factor

**Example: What is the effective cutting diameter**

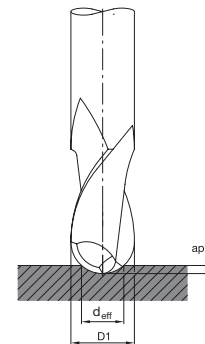
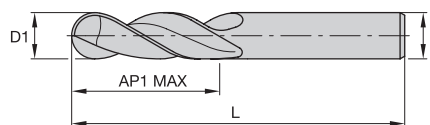
**for a 1/2"-diameter ball nose end mill running at a .05" axial depth of cut?**

**Step 1:**  $D = 1/2"$   $a_p = .05"$

**Step 2:** Depth-of-cut ratio =  $.05/.5 = .1$

**Step 3:** Diameter factor = **.6**

**Step 4:** Effective cutting diameter =  $.5 \times .6 = .3"$



Depth of cut ratio = $a_p/D1$	Diameter factor
0.40	0.98
0.30	0.917
0.25	0.87
0.20	0.8
0.15	0.71
0.10	0.6
0.08	0.54
0.05	0.44
0.04	0.39
0.03	0.34
0.02	0.28
0.01	0.19

SOLID CARBIDE

INSERTS

FACE MILLS

90° MILLS

SLOTTING

DIE AND MOLD

CERAMIC MILLS

CLASSIC MILLS

THREAD MILLS

TECHNICAL DATA

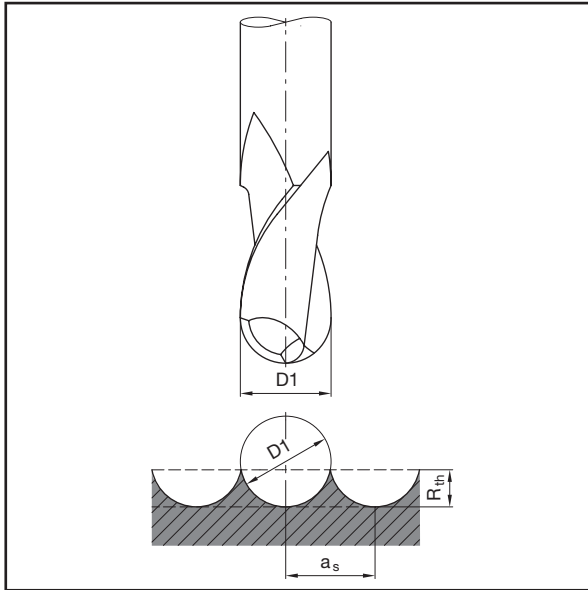
INDEX

### Number of Cutting Edges

	Main Application	Comment
	Plunging (drilling)	Very suitable for full slot milling, greater dimensional accuracy in feather key slot milling (F2AU ... DK30, F3AU ... DK30)
	Full slot (Feather key slot)	Better for full slot milling and helical end milling; combined → machining more efficient
	Face milling Roughing/finishing Helical end milling	Smaller chip chambers With two cutting edges in the center Plunging possible, but small plunge depth <sub>max.</sub> (0,1 x d) → Steps
	Contouring Helical end milling Finishing	High form and positioning tolerance, surface quality, feed rates (efficiency)
	(small $a_e$ with increasing number of teeth)	Higher $a_e$ → Poor chip evacuation → Chip chambers become clogged

### Helix angle

0°	<ul style="list-style-type: none"> <li>• Small <math>a_p</math> and <math>a_e</math></li> <li>• Trimming</li> <li>• Contouring</li> </ul>	E.g. de-burr elbow, trimming of cast iron parts
20° 30° 45°	<ul style="list-style-type: none"> <li>• Full cut</li> </ul>	E.g. the 45° twist enables approximately 30% - 40% higher feed rates than the 30° twist
60°	<ul style="list-style-type: none"> <li>• Progressive cut</li> </ul>	<ul style="list-style-type: none"> <li>• Progressive cut</li> <li>• High surface quality</li> <li>• High axial forces</li> <li>• Low radial forces</li> <li>• (low drift)</li> <li>• Not suitable for plunging</li> </ul>
<p><b>General principle:</b> The greater the helix, the lower the radial forces, and the greater the axial forces.</p>		

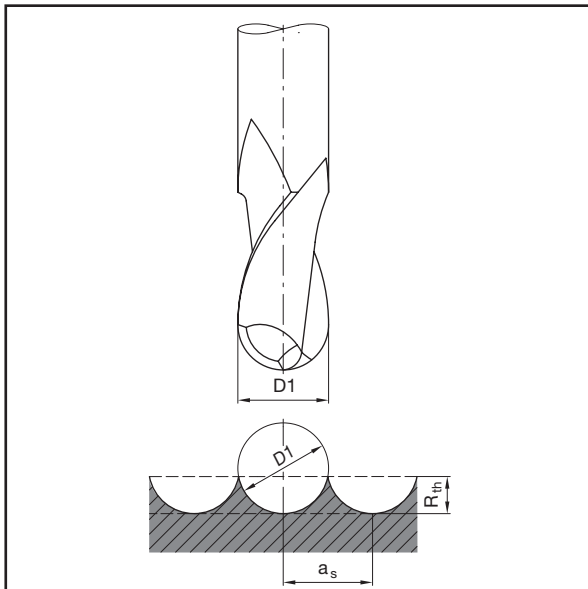

**Calculating the row distance  $a_e$** 

$d_1$  = Cutting edge diameter [mm]

$R_{th}$  = Theoretical row depth [mm]

$a_e$  = Row distance

$$R_{th} = \frac{d_1}{2} - \frac{\sqrt{d_1^2 - a_e^2}}{4}$$

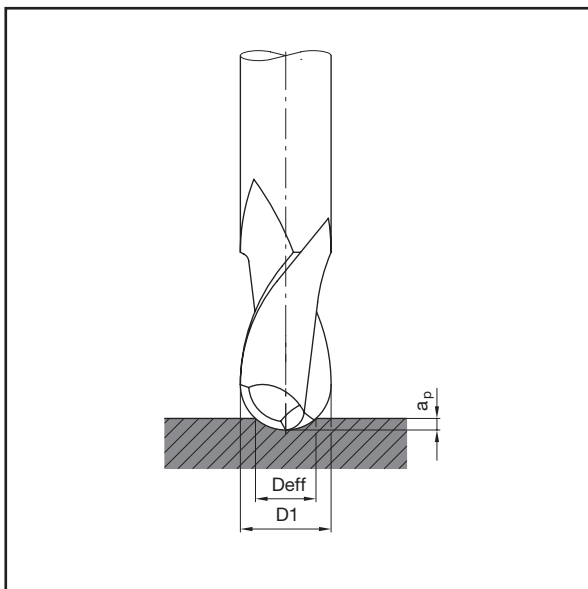

**Calculating the theoretical row depth  $R_{th}$** 

$d_1$  = Cutting edge diameter [mm]

$R_{th}$  = Theoretical row depth [mm]

$a_e$  = Row distance

$$a_s = 2\sqrt{R_{th}(d_1 - R_{th})}$$


**Calculating the effective diameter  $d_{eff}$** 

$d_1$  = Cutting edge diameter [mm]

$d_{eff}$  = Effective diameter [mm]

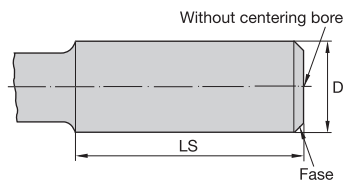
$a_p$  = Axial adjustment depth

$$d_{eff} = 2\sqrt{a_p(d_1 - a_p)}$$

	Cutting problems in solid carbide milling	Suggested remedy
SOLID CARBIDE	<b>Splintering of the cutting edge (thermal load)</b>	<ul style="list-style-type: none"> <li>- Decrease feed per tooth</li> <li>- Increase cutting speed</li> </ul>
INSERTS		
FACE MILLS	<b>Crumbling of the cutting edge (mechanical load)</b>	<ul style="list-style-type: none"> <li>- Check rigidity of machine, workpiece, and workpiece clamping</li> <li>- Reduce feed per tooth</li> <li>- Shorten protrude length</li> <li>- Climb milling</li> <li>- Check tool clamping</li> <li>- Check spindle movement</li> </ul>
90° MILLS	<b>Mill breakage</b>	<ul style="list-style-type: none"> <li>- Ensure free cutting process</li> <li>- Increase cutting speed</li> <li>- Reduce feed rate and cutting depth</li> <li>- Check tool clamping</li> <li>- Shorten protrude length</li> <li>- Reduce cutting depth</li> <li>- Improve chip evacuation</li> </ul>
SLOTTING	<b>Heavy crater wear</b>	<ul style="list-style-type: none"> <li>- Reduce cutting speed</li> <li>- Use more wear-resistant carbide grade</li> </ul>
DIE AND MOLD	<b>Heavy flank wear</b>	<ul style="list-style-type: none"> <li>- Increase feed per tooth</li> <li>- Reduce cutting speed</li> <li>- Use coated version</li> <li>- Use more wear-resistant carbide grade</li> </ul>
CERAMIC MILLS	<b>Edge build-up</b>	<ul style="list-style-type: none"> <li>- Increase cutting speed and /or feed rate</li> <li>- Improve cooling</li> </ul>
CLASSIC MILLS	<b>Vibrations (chatter)</b>	<ul style="list-style-type: none"> <li>- Check clamping and machine stability</li> <li>- Select a different cutting geometry</li> <li>- Check alignment of milling cutter and workpiece</li> <li>- Climb milling</li> </ul>
THREAD MILLS	<b>Inadequate surface on the workpiece</b>	<ul style="list-style-type: none"> <li>- Reduce feed per tooth</li> <li>- Check clamping and machine stability</li> <li>- Increase cutting speed</li> <li>- Select a different cutting geometry, with larger twist angle</li> <li>- Use milling cutter with more of teeth</li> </ul>
TECHNICAL DATA	<b>Splintering on the workpiece</b>	<ul style="list-style-type: none"> <li>- Reduce feed per tooth</li> <li>- Use milling cutter with more teeth</li> </ul>
INDEX	<b>Chip buildup</b>	<ul style="list-style-type: none"> <li>- Use tool with larger chip chambers (less teeth)</li> <li>- Modify cutting geometry</li> <li>- Modify cutting values</li> <li>- Reduce cutting depth</li> <li>- Use milling cutter with less teeth</li> </ul>

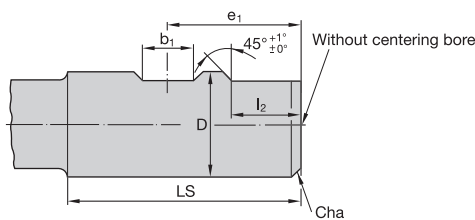
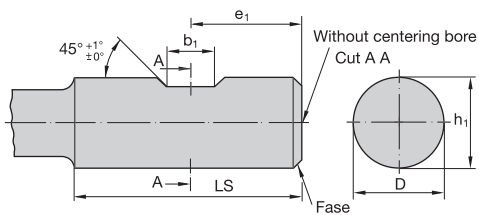
### Straight shanks to DIN 6535, Form HA

without lateral clamping flat  
for use in expansion chucks



### Straight shanks to DIN 6535, Form HB

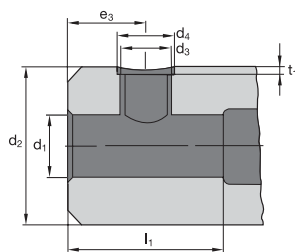
with lateral clamping flat:  
One clamping flat for  $d_1 = 6$  to 20 mm



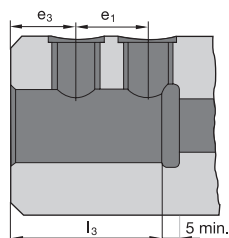
### Chuck for straight shanks (Form B and Form HB)

with lateral clamping flats

For  $d_1 = 6$  to 20 mm



For  $d_1 = 25$  to 32 mm



### Fitting dimensions

End mill body with straight shank  
to DIN 6535/form HA and HB

D	without pulling face LS	with lateral clamping flat $b_1$	$h_1$ $h_{11}$	LS	$l_2$	$e_1$
6	36	4,2	5,1	36	-	18,0
8	36	5,5	6,9	36	-	18,0
10	40	7,0	8,5	40	-	20,0
12	45	8,0	10,4	45	-	22,5
14	45	8,0	12,7	45	-	22,5
16	48	10,0	14,2	48	-	24,0
18	48	10,0	16,2	48	-	24,0
20	50	11,0	18,2	50	-	25,0
25	56	12,0	23,0	56	17	32,0
32	60	14,0	30,0	60	19	35,0

### Fitting dimensions

Chucks for straight shanks  
to DIN 1835 Part 2 /Form B  
(Extended by  $d_1 = 14$  and  $= 18$  mm)

$d_1$ H5	D	$d_3$	$d_4$	$e_3$	$e_4$	$t_1$	$l_3$
6	25	M 6	8	18,0	-	1,0	35
8	28	M 8	10	18,0	-	1,3	35
10	35	M10	12	20,0	-	1,5	39
12	42	M12	14	22,5	-	1,6	44
14	44	M12	14	22,5	-	1,6	44
16	48	M14	16	24,0	-	1,7	47
18	50	M14	16	24,0	-	1,7	47
20	52	M16	18	25,0	-	2,1	49
25	65	M18x2	20	24,0	25	2,1	54
32	72	M20x2	22	24,0	28	2,2	58

### Recommended torques

for solid carbide tool shanks

clamping screw	torque
M 6	5 Nm
M 8	10 Nm
M10	16 Nm
M12	28 Nm
M14	42 Nm
M16	50 Nm
M18	60 Nm
M20	60 Nm

SOLID CARBIDE

INSERTS

FACE MILLS

90° MILLS

SLOTTING

DIE AND MOLD

CERAMIC MILLS

CLASSIC MILLS

THREAD MILLS

TECHNICAL DATA

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■ Tolerances, shanks

tolerances	nominal size in mm													
	over -	up to 3	over 3	up to 6	over 6	up to 10	over 10	up to 18	over 18	up to 30	over 30	up to 50	over 50	up to 80
	in µm													
e8	-14	-20	-25	-32	-40	-50	-60							
	-28	-38	-47	-59	-73	-89	-106							
h6	0	0	0	0	0	0	0							
	-6	-8	-9	-11	-13	-16	-19							
h7	0	0	0	0	0	0	0							
	-10	-12	-15	-18	-21	-25	-30							
h8	0	0	0	0	0	0	0							
	-14	-18	-22	-27	-33	-39	-46							
h9	0	0	0	0	0	0	0							
	-25	-30	-36	-43	-52	-62	-74							
h10	0	0	0	0	0	0	0							
	-40	-48	-58	-70	-84	-100	-120							
h11	0	0	0	0	0	0	0							
	-60	-75	-90	-110	-130	-160	-190							
k8	+14	+18	+22	+27	+33	+39	+46							
	0	0	0	0	0	0	0							
k9	+25	+30	+36	+43	+52	+62	+74							
	0	0	0	0	0	0	0							
k10	+40	+48	+58	+70	+84	+100	+120							
	0	0	0	0	0	0	0							
m7	+12	+16	+21	+25	+29	+34	+41							
	+2	+4	+6	+7	+8	+9	+11							

■ Tolerances, holes

tolerances	nominal size in mm													
	over -	up to 3	over 3	up to 6	over 6	up to 10	over 10	up to 18	over 18	up to 30	over 30	up to 50	over 50	up to 80
	in µm													
P9	-6	-12	-15	-18	-22	-26	-32							
	-31	-40	-51	-61	-74	-88	-106							
H6	+6	+8	+9	+11	+13	+16	+19							
	0	0	0	0	0	0	0							
H7	+10	+12	+15	+18	+21	+25	+30							
	0	0	0	0	0	0	0							
H8	+14	+18	+22	+27	+33	+39	+46							
	0	0	0	0	0	0	0							
H9	+25	+30	+36	+43	+52	+62	+74							
	0	0	0	0	0	0	0							
H10	+40	+48	+58	+70	+84	+100	+120							
	0	0	0	0	0	0	0							
H11	+60	+75	+90	+110	+130	+160	+190							
	0	0	0	0	0	0	0							
H12	+0,1	+0,12	+0,15	+0,18	+0,21	+0,25	+0,3							
	0	0	0	0	0	0	0							
H13	+0,14	+0,18	+0,22	+0,27	+0,33	+0,39	+0,46							
	0	0	0	0	0	0	0							