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**HSS & HSCO End Mills –
Speeds & Feeds**

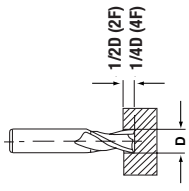
SOWA 
HIGH PERFORMANCE CUTTING TOOLS

HSS & HSCO End Mills – Speeds & Feeds

2-Flute HSCO End Mills

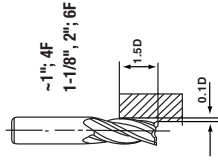


Materials	1. Mild Steels (Up to 70 x 10 ³ lb/in ²)		2. Brass 3. Bronze		1. Medium Tensile Steels (70 x 10 ³ - 115 x 10 ³ lb/in ²)		2. Mild Steel Forgings 3. Cast Iron 4. Hard Brass and Bronze 5. Copper		1. High Tensile Steels (142 x 10 ³ - 200 x 10 ³ lb/in ²)		2. Tool Steels 3. Medium Strength Stainless Steels 4. Medium Strength Titanium Alloys		1. Heat Resistant High Alloys 2. High Strength Stainless Steels 3. High Strength Titanium Alloys		1. Aluminum 2. Alloyed Aluminum 3. Plastic 4. Woods	
	Hardness	Up to Bhn 145 Up to OHRc	Bhn 145-237 0-22 HRC	Bhn 237-286 22-30 HRC	Bhn 286-390 30-42 HRC	Bhn 390-451 42-48 HRC	rpm	Feed (in/min)	rpm	Feed (in/min)	rpm	Feed (in/min)	rpm	Feed (in/min)	rpm	Feed (in/min)
Cutting Speeds	80~150 SFM	80~110 SFM	50~65 SFM	30~50 SFM	16~32 SFM	80~395 SFM										
Dia. of Mills																
1/8	4000	3000	1800	1250	800	10000	0.079	800	0.34	10000	9.00					
5/32	3150	2360	1400	1000	630	8000	0.090	630	0.34	8000	10.24					
3/16	2500	1900	1120	800	500	6300	1.01	500	0.45	6300	10.80					
1/4	2000	1500	900	630	400	5000	1.13	400	0.56	5000	11.93					
5/16	1600	1180	710	500	315	4000	1.24	315	0.56	4000	13.73					
3/8	1400	1060	630	450	280	3550	1.35	280	0.56	3550	13.50					
7/16	1120	850	500	355	224	2800	1.35	224	0.56	2800	13.39					
1/2	1000	750	450	315	200	2500	1.35	200	0.68	2500	13.50					
9/16	900	670	400	280	180	2240	1.46	180	0.68	2240	12.71					
5/8	800	600	355	250	160	2000	1.46	160	0.68	2000	12.04					
11/16	710	530	315	224	140	1800	1.46	140	0.68	1800	12.15					
3/4	710	530	315	224	140	1800	1.46	140	0.68	1800	12.15					
13/16	630	475	280	200	125	1600	1.46	125	0.68	1600	11.48					
7/8	560	425	250	180	112	1400	1.35	112	0.68	1400	10.69					
15/16	500	375	224	160	100	1250	1.13	100	0.68	1250	10.13					
1	500	375	224	160	100	1250	1.13	100	0.68	1250	10.13					
1-1/8	450	335	200	140	90	1120	1.01	90	0.68	1120	9.56					
1-1/4	400	300	180	125	80	1000	0.90	80	0.56	1000	8.55					
1-3/8	355	265	160	112	71	900	0.79	71	0.56	900	8.10					
1-1/2	315	236	140	100	63	800	0.68	63	0.45	800	7.20					
1-3/4	280	212	125	90	56	710	0.68	56	0.45	710	6.41					
2	250	190	112	80	50	630	0.56	50	0.34	630	5.63					



NOTES:
 1) The cutting conditions in this table are given for reference, which should be varied depending on the machine, tooling, depth of cut, cutting fluid and other conditions
 2) Use a holder of strong gripping force and machine of high stiffness
 3) In case of deeper operation, slow down feed by 20~50%
 4) The feed, in long types, should be reduced by around 50%

Multi-Flute HSCO End Mills



NOTES:

- 1) The cutting conditions in this table are given for reference, which should be varied depending on the machine, tooling, depth of cut, cutting fluid and other conditions
- 2) Use a holder of strong gripping force and machine of high stiffness
- 3) For 2-fl end mill slow down to 1/2 of feed speed
- 4) For finish cut put rpm, up to 1.5 to 1.3 times faster
- 5) The feed, in long types should be reduced by around 50%

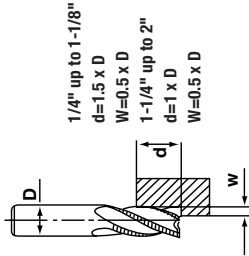
Materials	1. Medium Tensile Steels (70 x 10 ³ - 115 x 10 ³ lb/in ²)				1. High Tensile Steels (142 x 10 ³ - 200 x 10 ³ lb/in ²)				1. Heat Resistant High Alloys															
	1. Mild Steels (Up to 70 x 10 ³ lb/in ²) 2. Brass 3. Bronze				2. Mild Steel Forgings 3. Cast Iron 4. Hard Brass and Bronze 5. Copper				2. Tool Steels 3. Medium Strength Stainless Steels 4. Medium Strength Titanium Alloys				2. High Strength Stainless Steels 3. High Strength Titanium Alloys											
Hardness	Up to Bhn 145 Up to OHRc				Bhn 145-237 0-22 HRC				Bhn 237-286 22-30 HRC				Bhn 286-390 30-42 HRC				Bhn 390-451 42-48 HRC							
	130~135 SFM				105~125 SFM				65~80 SFM				30~50 SFM				16~32 SFM				325~590 SFM			
Cutting Speeds	rpm		Feed (in/min)		rpm		Feed (in/min)		rpm		Feed (in/min)		rpm		Feed (in/min)		rpm		Feed (in/min)		rpm		Feed (in/min)	
	1/8	4500	9.11	6.41	3.26	2240	1800	1000	3.60	1250	1000	800	1.46	800	630	500	10000	16000	28.80	31.95	34.20	38.03	43.09	42.75
5/32	3550	10.24	7.20	4.05	1800	1400	800	3.60	1000	800	630	1.69	630	500	10000	12500	31.95	34.20	38.03	43.09	42.75	42.98	43.20	40.28
3/16	2800	11.14	8.10	4.50	1400	1120	630	4.05	800	630	500	1.91	500	400	8000	10000	34.20	38.03	43.09	42.75	42.98	43.20	38.03	37.80
1/4	2240	12.94	9.11	4.50	1120	900	560	4.50	630	500	400	2.14	400	280	4500	8000	38.03	43.09	42.75	42.98	43.20	38.03	37.80	36.00
5/16	1800	14.51	10.13	5.18	900	800	630	5.18	500	400	315	2.36	315	224	2800	4500	43.09	42.75	42.98	43.20	38.03	37.80	36.00	34.31
3/8	1600	15.30	10.58	5.51	800	630	560	5.51	450	355	280	2.59	280	200	2500	3550	42.75	42.98	43.20	38.03	37.80	36.00	34.31	32.40
7/16	1250	15.06	10.80	5.63	630	500	400	5.63	315	250	224	2.70	224	180	2000	3150	42.98	43.20	38.03	37.80	36.00	34.31	32.40	32.40
1/2	1120	15.06	10.24	5.29	560	450	355	5.29	280	224	180	2.70	180	140	1800	2800	43.20	38.03	37.80	36.00	34.31	32.40	32.40	42.54
9/16	1000	14.40	9.56	5.60	500	400	355	5.60	250	200	160	2.81	160	125	1600	2500	40.28	38.03	37.80	36.00	34.31	32.40	32.40	42.54
5/8	900	13.73	8.55	5.06	450	355	315	5.06	224	180	140	2.81	140	112	1400	2240	38.03	37.80	36.00	34.31	32.40	32.40	42.54	37.73
11/16	800	13.73	8.55	5.06	400	315	280	5.06	200	160	125	2.81	125	100	1200	2000	37.80	36.00	34.31	32.40	32.40	42.54	37.73	34.78
3/4	800	13.73	8.55	5.06	400	315	280	5.06	200	160	125	2.81	125	100	1200	2000	37.80	36.00	34.31	32.40	42.54	37.73	34.78	31.05
13/16	710	12.83	7.54	4.50	355	280	224	4.50	180	140	112	2.93	112	90	1000	1800	36.00	34.31	32.40	42.54	37.73	34.78	31.05	30.26
7/8	630	12.04	6.75	4.05	315	250	200	4.05	160	125	100	2.59	100	80	800	1400	34.31	32.40	42.54	37.73	34.78	31.05	30.26	27.00
15/16	560	11.25	6.08	4.05	280	224	180	4.05	140	112	90	2.25	90	71	700	1250	32.40	42.54	37.73	34.78	31.05	30.26	27.00	27.00
1	560	11.25	6.08	4.05	280	224	180	4.05	140	112	90	2.25	90	71	700	1250	32.40	42.54	37.73	34.78	31.05	30.26	27.00	27.00
1-1/8	500	13.97	7.45	4.97	250	200	160	4.97	140	112	90	2.79	90	71	700	1250	32.40	42.54	37.73	34.78	31.05	30.26	27.00	27.00
1-1/4	450	13.35	6.68	4.50	224	180	140	4.50	125	100	80	2.48	80	63	600	1120	32.40	42.54	37.73	34.78	31.05	30.26	27.00	27.00
1-3/8	400	11.95	5.90	4.04	200	160	125	4.04	112	90	71	2.17	71	56	500	1000	32.40	42.54	37.73	34.78	31.05	30.26	27.00	27.00
1-1/2	355	11.18	5.28	3.57	180	140	112	3.57	100	80	63	2.02	63	56	500	1000	32.40	42.54	37.73	34.78	31.05	30.26	27.00	27.00
1-3/4	315	10.69	5.06	3.49	160	125	100	3.49	90	71	56	1.91	56	50	500	1000	32.40	42.54	37.73	34.78	31.05	30.26	27.00	27.00
2	280	9.56	4.50	3.04	140	112	90	3.04	80	63	50	1.69	50	40	400	800	32.40	42.54	37.73	34.78	31.05	30.26	27.00	27.00

HSCO Roughers & Cutting Diameter, Shank Tolerances



Roughing HSCO

Materials	1. Mild Steels (Up to 115 x 10 ³ lb/in ²)		1. High Tensile Sheers (115 x 10 ³ - 145 x 10 ³ lb/in ²)		1. High Tensile Sheets (145 x 10 ³ - 200 x 10 ³ lb/in ²)		1. Heat Resistant High Alloys		1. Aluminum	
	Hardness	Up to Bhn 237 Up to 22HRC	Bhn 237-286 22-30 HRC	Bhn 286-390 30-42 HRC	Bhn 390-451 42-48 HRC	195-330 SFM	26-40 SFM	26-40 SFM	26-40 SFM	26-40 SFM
Cutting Speeds	80-100 SFM	60-75 SFM	40-55 SFM	26-40 SFM	195-330 SFM	rpm	rpm	rpm	rpm	rpm
Feed (in/min)	Feed (in/min)	Feed (in/min)	Feed (in/min)	Feed (in/min)	Feed (in/min)	Feed (in/min)	Feed (in/min)	Feed (in/min)	Feed (in/min)	Feed (in/min)
rpm	rpm	rpm	rpm	rpm	rpm	rpm	rpm	rpm	rpm	rpm
1/4	1320	1000	750	500	400	10.01	0.63	0.63	0.63	10.01
5/16	1060	800	600	500	400	11.14	0.75	0.75	0.75	11.14
3/8	950	710	530	375	250	11.70	0.75	0.75	0.75	11.70
1/2	670	500	375	300	200	14.18	0.90	0.90	0.90	14.18
5/8	600	400	300	265	180	15.86	1.01	1.01	1.01	15.86
3/4	475	355	265	212	140	16.88	1.35	1.35	1.35	16.88
7/8	375	280	212	190	125	15.98	1.46	1.46	1.46	15.98
1	335	250	190	170	112	15.19	1.46	1.46	1.46	15.19
1-1/8	300	224	170	150	100	17.89	1.69	1.69	1.69	17.89
1-1/4	256	200	150	118	80	15.86	1.46	1.46	1.46	15.86
1-1/2	212	160	118	106	71	14.8	1.35	1.35	1.35	14.8
1-3/4	190	140	106	95	63	13.28	1.24	1.24	1.24	13.28
2	170	125	95	95	63		1.24	1.24	1.24	



NOTES:

- 1) The cutting conditions in this table are given for references, which should be varied depending on the machine, tooling, depth of cut, cutting fluid and other conditions
- 2) Use a holder of strong gripping force and machine of high stiffness
- 3) For TiN-Coated End Mills, put cutting speed, feed up to 1.5-1.8 times faster
- 4) The feed, in long types, should be reduced by around 50%

End Mill Cutting Diameter & Shank Tolerances								
Type	No. of Flute	Series	Shank Type	Size	Cutting Edge Tolerance	Shank Dia. Tolerance		
Slot Drill & Ball Nose	2-Flute	Short	Plain / Flatted	< 12mm & 1/2"	-0.025mm	+0.000mm -0.025mm		
		Long		> 12mm & 1/2"	h9			
	End Mill & Ball Nose	4-Flute		Short	< 32mm		-0.025mm	
Long				< 12mm & 1/2"	k9			
							> 12mm & 1/2"	
Slot Drill & Ball Nose	2-Flute	Short		Threaded	< 12mm & 1/2"		-0.025mm	+0.000mm -0.025mm
		Long	> 12mm & 1/2"		h9			
	Unimill	3-Flute	Short			< 1.1/2"		
Long			< 12mm & 1/2"					
						> 12mm & 1/2"		
End Mill & Ball Nose	4-Flute	Short			< 1.1/2"	+0.025mm		
		Long		< 12mm & 1/2"	k9			
						> 12mm & 1/2"		
End Mill & Ball Nose	4-Flute	Short		Plain / Flatted	All	js10		+0.000mm -0.010mm
		Long						
		Short						
		Long						

4-Flute Ball Nose

- Increase Feeds 40% to 50% for 4-Flute Ball Nose

Speeds and feeds are critical to tool life, machining time and surface finish. What we have provided is a general starting point for machining certain materials under standard machining conditions. Please keep in mind that the workpiece material, how the workpiece is held, the coolant used, the tool holder and the machine horsepower has a tremendous impact on cutting tool effectiveness and tool life. You may find greater results at much more aggressive speeds and feeds in some set ups than others for the same material. These charts are intended to give the machinist a starting point and it is up to the machinist to understand the variables that can impact material removal efficiency.

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