

# MILLSTAR® High Speed Machining

## Ball Nose RPM Reference Guide

Material Hardness	Less Than 40 HRc		40-50 HRc		Over 50 HRc	
Diameter	Rough	Finish	Rough	Finish	Rough	Finish
0.020	30,000 - 60,000	30,000 - 60,000	30,000 - 60,000	30,000 - 60,000	30,000 - 60,000	30,000 - 60,000
0.031	30,000 - 60,000	30,000 - 60,000	30,000 - 60,000	30,000 - 60,000	30,000 - 60,000	30,000 - 60,000
0.062	30,000 - 60,000	30,000 - 60,000	30,000 - 60,000	30,000 - 60,000	20,000 - 49,290	30,000 - 60,000
0.090	20,000 - 46,000	30,000 - 60,000	30,000 - 42,444	30,000 - 60,000	20,000 - 33,956	30,000 - 60,000
0.093	20,000 - 45,000	30,000 - 60,000	20,000 - 41,075	30,000 - 60,000	20,000 - 32,860	30,000 - 60,000
0.125	20,000 - 33,616	30,000 - 60,000	18,000 - 30,560	30,000 - 60,000	18,336 - 24,448	25,000 - 45,840
0.187	18,385 - 22,471	30,000 - 51,070	16,342 - 20,428	22,471 - 44,941	12,257 - 16,342	20,428 - 30,642
0.250	13,752 - 16,808	30,000 - 38,200	12,224 - 15,280	16,808 - 33,616	9,168 - 12,224	15,280 - 22,920
0.312	11,019 - 13,468	24,487 - 30,609	9,795 - 12,244	13,468 - 26,936	7,346 - 9,795	12,244 - 18,365
0.375	9,168 - 11,205	20,373 - 25,467	8,149 - 10,187	11,205 - 22,411	6,112 - 8,149	10,187 - 15,280
0.437	7,867 - 9,616	17,483 - 21,854	6,993 - 8,741	9,616 - 19,231	5,245 - 6,993	8,741 - 13,112
0.500	6,876 - 8,404	15,280 - 19,100	6,112 - 7,640	8,404 - 16,808	4,584 - 6,112	7,640 - 11,460
0.625	5,501 - 6,723	12,224 - 15,280	4,890 - 6,112	6,723 - 13,446	3,667 - 4,890	6,112 - 9,168
0.750	4,584 - 5,603	10,187 - 12,733	4,075 - 5,093	5,603 - 11,205	3,056 - 4,075	5,093 - 7,640
1.000	3,438 - 4,202	7,640 - 9,550	3,056 - 3,820	4,202 - 8,404	2,292 - 3,056	3,820 - 5,730
1.250	2,750 - 3,362	6,112 - 7,640	2,445 - 3,056	3,362 - 6,723	1,834 - 2,445	3,056 - 4,584

## Ball Nose Chip Load per Tooth Reference Guide

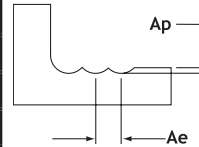
Material Hardness	Less Than 40 HRc		40-50 HRc		Over 50 HRc	
Diameter	Rough	Finish	Rough	Finish	Rough	Finish
0.020	.0003 - .0006	.0003 - .0007	.0004 - .0007	.0003 - .0006	.0001 - .0005	.0001 - .0004
0.031	.0007 - .0011	.0007 - .0010	.0006 - .0009	.0007 - .0008	.0005 - .0008	.0004 - .0007
0.062	.0013 - .0016	.0015 - .0017	.0011 - .0017	.0012 - .0016	.0009 - .0013	.0008 - .0013
0.090	.0014 - .0019	.0014 - .0022	.0013 - .0019	.0017 - .0023	.0009 - .0017	.0012 - .0019
0.093	.0021 - .0026	.0015 - .0027	.0017 - .0025	.0016 - .0027	.0012 - .0015	.0014 - .0025
0.125	.0026 - .0031	.0019 - .0029	.0022 - .0029	.0019 - .0029	.0016 - .0025	.0017 - .0028
0.187	.0036 - .0043	.0034 - .0045	.0035 - .0043	.0032 - .0041	.0031 - .0039	.0023 - .0035
0.250	.0051 - .0061	.0042 - .0055	.0052 - .0059	.0043 - .0054	.0042 - .0051	.0039 - .0049
0.312	.0064 - .0071	.0054 - .0069	.0054 - .0068	.0056 - .0064	.0053 - .0065	.0046 - .0054
0.375	.0071 - .0081	.0064 - .0081	.0064 - .0079	.0057 - .0068	.0062 - .0075	.0050 - .0067
0.437	.0081 - .0088	.0069 - .0087	.0068 - .0087	.0063 - .0079	.0068 - .0081	.0056 - .0075
0.500	.0088 - .0101	.0082 - .0098	.0083 - .0097	.0072 - .0093	.0079 - .0092	.0068 - .0089
0.625	.0111 - .0162	.0105 - .0155	.0105 - .0145	.0095 - .0132	.0085 - .0125	.0075 - .0105
0.750	.0132 - .0205	.0135 - .0205	.0117 - .0184	.0105 - .0172	.0095 - .0155	.0085 - .0135
1.000	.0145 - .0225	.0145 - .0205	.0123 - .0195	.0122 - .0174	.0105 - .0155	.0095 - .0115
1.250	.0155 - .0255	.0155 - .0245	.0133 - .0226	.0125 - .0210	.0155 - .0205	.0105 - .0155

## Ball Nose Axial and Radial Step Guide

	Less Than 40 HRc	40-50 HRc	50-60 HRc	Over 60 HRc
Ap	10% of Tool Dia. Max	7% of Tool Dia. Max	5% of Tool Dia. Max	4% of Tool Dia. Max
Ae	40% of Tool Dia. Max	35% of Tool Dia. Max	30% of Tool Dia. Max	25% of Tool Dia. Max

## L to D Compensation

Overhang Length	Cutting Speed	Ap	Feed
Length/Dia < 4	100%	100%	100%
Length/Dia < 5	60 - 80%	60 - 80%	70 - 90%
Length/Dia < 6	40 - 60%	40 - 60%	60 - 80%



$$SFM = \frac{\text{Effective Dia.} \times \text{RPM}}{3.82}$$

$$\text{RPM} = \frac{3.82 \times \text{SFM}}{\text{Effective Dia.}}$$

$$\text{IPM} = \text{RPM} \times \# \text{ Flutes} \times \text{Chip Load}$$

$$\text{Chip Load} = \frac{\text{IPM}}{\text{RPM} \times \# \text{ Flutes}}$$

$$ED = \frac{2 \times (R^2 - (R - A_d)^2)}{\dots}$$

## Ball Nose Tool Selection Table

Material Hardness	30-40 HRc		40-50 HRc		50-70 HRc						
	Rough	Finish	Rough	Finish	Rough	Finish					
0.020	BI or BM Series										
0.031											
0.062											
0.090											
0.125											
0.187											
0.250							VRBS	VRBS			
0.312							VRBS	VRBS			
0.375							MB	RB-N	MB or MBT	RB-N	MBT
0.437											
0.500											
0.625											
0.750											
1.000											
1.250											



## Machining Tips

- Cutting Tool run out should be less than 0.0003"
- Use Helical Engagement at all times
- Use of coolant: For all stainless steel (SS) use through the spindle or flood coolant. For gray cast iron use air or coolant. We recommend a liquid coolant concentration of 9-10%, not the usual 3-4%. This will lubricate and not just cool the cutting edge for longer tool life and better finish. For all other die/mold materials, use air-mist/minimum quantity lubrication (MQL) or high pressure air blow. Vegetable based oil mist works best in MQL/mist use.

