

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 |
| 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 |
| 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 |

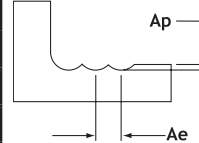
MILLSTAR® High Speed Machining *cont'd*

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% |



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

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

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

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

$$ED = 2 \times (R^2 - (R - Ad)^2)$$

Ball Nose Tool Selection Table

| Material Hardness | 30-40 HRc | | 40-50 HRc | | 50-70 HRc | | | | | | |
|-------------------|-----------------|--------|-----------|--------|-----------|--------|------|------|-----------|------|-----|
| | Rough | Finish | Rough | Finish | Rough | Finish | | | | | |
| 0.020 | Bl 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.