










# SURFACE TREATMENTS AND COATINGS

All of our tools are available in a variety of application specific surface treatments and coatings. Please see individual tool listings for stocked treatments and coatings. Other treatments and coatings are available upon request. These surface treatments and coatings are designed to enhance performance as well as the life of the tool. The chart below is a handy reference outlining the surface treatment and coating composition as well as the suggested application. If the material you are preparing to machine is not listed, please give us a call and we can help.

Photo Illustration	Code No.	Composition	Characteristics	Applications
	02	Nitride (N)	A thin hardened case, penetrating the surface of the tool to a depth of .0005 to .0020. Improves wear resistance and reduces galling.	Most abrasive materials, both ferrous and non-ferrous. Not recommended where chipping may be a problem.
	03	Oxide (Ox)	A layer of ferrous oxide on the surface of the tool adding lubricant retaining properties and improving toughness.	Low Carbon, Stainless and Free Machining Steels. Not recommended for non-ferrous materials where it may cause galling.
	23	Nitride and Oxide (NOx)	A combination of two treatments which produces the favorable characteristics of both.	Iron, Cast Iron, Stainless Steel and High Tensile Steels. Not recommended for non-ferrous materials where it may cause galling.
	53	Hard Lube Coating - Standard (TiAlN+WC/C Std)	Multi-layer coating, consisting of a hard layer and a lubrication layer.	For improved chip flow and possible dry machining. Improved edge wear resistance and increased lubricity.
	84	Titanium Aluminum Nitride (TiAlN)	A very hard coating on the surface of the tool which has very good wear resistance, reduces friction and prevents galling.	Titanium, Titanium Alloys, Nickel-Base Alloys, Stainless Steel and Cast Iron. Effective at higher speeds. Not recommended for Wrought Aluminum, Copper or Brass.
	85	Aluminum Titanium Nitride (AlTiN)	An extremely hard coating very similar to TiAlN with outstanding wear resistance. AlTiN has a higher aluminum content which makes it harder and smoother than TiAlN.	Very effective in the same materials as TiAlN. Excellent for small depths of cut and excels in high speed and dry machining applications.
	86	Zirconium Nitride (ZrN)	A thin hard coating that improves lubricity and increases oxidation resistance. Specifically designed for machining abrasive and gummy materials.	Suitable for machining Aluminum Alloys, High Silica Aluminum, Cast Iron, High Temperature Alloys, Stainless Steel and Glass Filled Plastics. Not recommended for machining Carbon Steels.
	88	Titanium Nitride (TiN)	A general purpose coating which has excellent wear resistance, reduces friction and prevents galling.	Most Ferrous, Non-Ferrous and Non-Metallic materials. Although it's unlikely, galling may occur in Titanium and Titanium Alloys.
	89	Titanium Carbonitride (TiCN)	An extremely hard coating on the surface of the tool which has outstanding wear resistance, reduces friction and prevents galling.	Most Ferrous, Non-Ferrous and Non-Metallic materials. Very effective at higher speeds. Although it's unlikely, galling may occur in Titanium and Titanium Alloys.

For technical support and questions about your machining requirements, please call us at 1-800-522-8665.

# SPEEDS AND FEEDS CHART EXPLANATION PAGE

The Speeds and Feeds Chart below provides an instruction on how to use the charts found on the following four pages after Type and Diameter of tool is determined.

- 1) RPM and IPM are dependent upon material being machined.
- 2) Locate material that will be machined (Precipitation Stainless Steel in example below)
- 3) Determine starting SFM (80 in example below)
- 4) Determine RPM based upon material and SFM. Multiply SFM by 3.82 divided by Tool Diameter = Starting RPMs
- 5) Determine IPM based upon RPM and application (SLOTTING, HP, or LP in example below). Multiply RPM by Feed Per Tooth by # of Flutes (4 in example below) = Starting IPM
- 6) Based upon material and SFM selected, the application below would have a starting RPM of 611 with a starting feedrate of 6.11 IPM.

As always, should you have any questions or you are unsure of starting parameters for your application, call us toll free at 800-522-8665 and ask to speak to our Technical Support Department.

## SPEED (SFM) AND FEED (FEED PER TOOTH (FPT))

$$RPM = SFM \times 3.82 / \text{TOOL DIAMETER}$$

$$RPM = 80 \times 3.82 / .500$$

$$RPM = 611$$

$$IPM = RPM \times FPT \times \# \text{ Of Flutes}$$

$$IPM = 611 \times .0025 \times 4$$

$$IPM = 6.11$$

## SOLID CARBIDE SPEEDS AND FEEDS CHART FOR FERROUS MATERIALS

MATERIALS	Carbon Steels	Alloy Steel	Stainless Steels 300 Series	Stainless Steels 400 Series	Precipitation Stainless Steels	Gray Cast Iron	Ductile Cast Iron	High Temp Alloys	Titanium Pure	Titanium Cast / Wrought
DESCRIPTION	10XX, 11XX, 13XX, 15XX	40XX, 41XX, 42XX, 43XX, 44XX, 46XX, 86XX, Series	304, 304L, 316, 316L, 312	420, 420F, 416, 440C	15-5PH, 16-6PH, 17-4PH, AM-xx Series	Gray	Ductile	Inconel 625/718, A286, Haynes	Pure	Cast / Wrought 6AL4V, ASTM 1,2,3, Alpha - Beta
SFM < 32	200 - 450	150 - 300	150 - 350	200 - 450	80 - 250	250 - 450	120 - 350	70 - 120	140 - 220	140 - 200
SFM > 32	100 - 250	80 - 200	80 - 200	100 - 250	90 - 125	130 - 300	80 - 140	40 - 90	90 - 160	90 - 160
1/2" S	0.0025	0.0020	0.0023	0.0023	0.0020	0.0020	0.0020	0.0015	0.0023	0.0020
HP	0.0030	0.0025	0.0030	0.0030	0.0025	0.0025	0.0025	0.0020	0.0030	0.0025
LP	0.0035	0.0030	0.0033	0.0033	0.0030	0.0030	0.0030	0.0025	0.0033	0.0030

S = SLOTTING  
Axial Depth up to .5 x Diameter

HP = HEAVY PERIPHERAL  
Axial Depth up to Effective  
1 x Diameter  
Radial width .5 x Diameter

LP = LIGHT PERIPHERAL  
Axial Depth up to 1.5 x Diameter  
Radial width .15 x Diameter

For technical support and questions about your machining requirements, please call us at 1-800-522-8665.

# SOLID CARBIDE SPEEDS AND FEEDS CHART FOR NON-FERROUS MATERIALS

Speed in Surface Feet per Minute (SFM)      Feed in Feed Per Tooth (FPT)

MATERIALS	Aluminum Alloys	Aluminum Cast	Aluminum >10% Silicon	Copper	Brass	Magnesium
DESCRIPTION	6061, 7075	Sand & Permanent Mold	High Silicon Based	Cast, Wrought	Yellow, Red, Leaded Brass	Cast, Wrought
SFM	800 - Max	250 - 600	600 - 1000	700 - 1000	500 - 900	500 - 900
Tool Dia.						
1/8"	S	0.0012	0.0012	0.0012	0.0012	0.0012
	HP	0.0014	0.0014	0.0014	0.0014	0.0014
	LP	0.0017	0.0017	0.0017	0.0017	0.0017
1/4"	S	0.0024	0.0024	0.0024	0.0024	0.0024
	HP	0.0029	0.0029	0.0029	0.0029	0.0029
	LP	0.0033	0.0033	0.0033	0.0033	0.0033
5/16"	S	0.0030	0.0030	0.0030	0.0030	0.0030
	HP	0.0036	0.0036	0.0036	0.0036	0.0036
	LP	0.0042	0.0042	0.0042	0.0042	0.0042
3/8"	S	0.0036	0.0036	0.0036	0.0036	0.0036
	HP	0.0043	0.0043	0.0043	0.0043	0.0043
	LP	0.0050	0.0050	0.0050	0.0050	0.0050
1/2"	S	0.0050	0.0050	0.0050	0.0050	0.0050
	HP	0.0060	0.0060	0.0060	0.0060	0.0060
	LP	0.0070	0.0070	0.0070	0.0070	0.0070
5/8"	S	0.0063	0.0063	0.0063	0.0063	0.0063
	HP	0.0075	0.0075	0.0075	0.0075	0.0075
	LP	0.0088	0.0088	0.0088	0.0088	0.0088
3/4"	S	0.0075	0.0075	0.0075	0.0075	0.0075
	HP	0.0090	0.0090	0.0090	0.0090	0.0090
	LP	0.0105	0.0105	0.0105	0.0105	0.0105
1"	S	0.0100	0.0100	0.0100	0.0100	0.0100
	HP	0.0120	0.0120	0.0120	0.0120	0.0120
	LP	0.0140	0.0140	0.0140	0.0140	0.0140

S = SLOTTING  
Axial Depth up to .5 x Diameter

HP = HEAVY PERIPHERAL  
Axial Depth up to 1 x Diameter  
Radial width .5 x Diameter

LP = LIGHT PERIPHERAL  
Axial Depth up to 1.5 x Diameter  
Radial width .15 x Diameter

**CALCULATIONS FOR SPEED**  
RPM = (3.82 x SFM) / DIA.  
SFM = (RPM x DIA.) / 3.82

**CALCULATIONS FOR FEED**  
IPM = # of FLUTES x FPT x RPM  
FPT = IPM / (RPM x # of FLUTES)

Notes: Horsepower will be the limiting factor with larger diameter end mills.  
Using coated end mills will improve tool life.  
See page 96 for an example of how to use the Speeds and Feeds Chart.

# SOLID CARBIDE SPEEDS AND FEEDS CHART FOR FERROUS MATERIALS

Speed in Surface Feet per Minute (SFM)      Feed in Feed Per Tooth (FPT)

MATERIALS	Carbon Steels	Alloy Steel	Stainless Steels 300 Series	Stainless Steels 400 Series	Precipitation Stainless Steels	Gray Cast Iron	Ductile Cast Iron	High Temp Alloys	Titanium Pure	Titanium Cast / Wrought
DESCRIPTION	10XX, 11XX, 13XX, 15XX	40XX, 41XX, 42XX, 43XX, 44XX, 46XX, 86XX, Series	304, 304L, 312, 316, 316L,	416, 420, 420F, 430F, 440C	15-5PH, 16-6PH, 17-4PH, AM-xx Series	Gray	Ductile	Inconel 625/718, A286, Haynes	Pure	Cast / Wrought 6AL4V, ASTM 1,2,3, Alpha - Beta
SFM < 32 Rc	200 - 450	150 - 300	150 - 350	200- 450	80 - 250	250 - 450	120 - 350	70 - 120	140 - 220	140 - 200
SFM > 32 Rc	100 - 250	80 - 200	80 - 200	100 - 250	90 - 125	130 - 300	80 - 140	40 - 90	90 - 160	90 - 160
<b>Tool Dia.</b>										
1/8"	S	0.0006	0.0005	0.0005	0.0005	0.0005	0.0005	0.0004	0.0005	0.0005
	HP	0.0007	0.0006	0.0007	0.0007	0.0006	0.0006	0.0005	0.0007	0.0006
	LP	0.0008	0.0007	0.0008	0.0008	0.0007	0.0007	0.0006	0.0008	0.0007
1/4"	S	0.0012	0.0010	0.0011	0.0011	0.0010	0.0010	0.0007	0.0011	0.0010
	HP	0.0014	0.0012	0.0014	0.0014	0.0012	0.0012	0.0010	0.0014	0.0012
	LP	0.0017	0.0014	0.0016	0.0016	0.0014	0.0014	0.0012	0.0016	0.0014
5/16"	S	0.0015	0.0012	0.0014	0.0014	0.0012	0.0012	0.0009	0.0014	0.0012
	HP	0.0018	0.0015	0.0018	0.0018	0.0015	0.0015	0.0012	0.0018	0.0015
	LP	0.0021	0.0018	0.0020	0.0020	0.0018	0.0018	0.0015	0.0020	0.0018
3/8"	S	0.0018	0.0014	0.0016	0.0016	0.0014	0.0014	0.0011	0.0016	0.0014
	HP	0.0021	0.0018	0.0021	0.0021	0.0018	0.0018	0.0014	0.0021	0.0018
	LP	0.0025	0.0021	0.0024	0.0024	0.0021	0.0021	0.0018	0.0024	0.0021
1/2"	S	0.0025	0.0020	0.0023	0.0023	0.0020	0.0020	0.0015	0.0023	0.0020
	HP	0.0030	0.0025	0.0030	0.0030	0.0025	0.0025	0.0020	0.0030	0.0025
	LP	0.0035	0.0030	0.0033	0.0033	0.0030	0.0030	0.0025	0.0033	0.0030
5/8"	S	0.0031	0.0025	0.0029	0.0029	0.0025	0.0025	0.0019	0.0029	0.0025
	HP	0.0038	0.0031	0.0038	0.0038	0.0031	0.0031	0.0025	0.0038	0.0031
	LP	0.0044	0.0038	0.0041	0.0041	0.0038	0.0038	0.0031	0.0041	0.0038
3/4"	S	0.0038	0.0030	0.0035	0.0035	0.0030	0.0030	0.0023	0.0035	0.0030
	HP	0.0045	0.0038	0.0045	0.0045	0.0038	0.0038	0.0030	0.0045	0.0038
	LP	0.0053	0.0045	0.0050	0.0050	0.0045	0.0045	0.0038	0.0050	0.0045
1"	S	0.0050	0.0040	0.0046	0.0046	0.0040	0.0040	0.0030	0.0046	0.0040
	HP	0.0060	0.0050	0.0060	0.0060	0.0050	0.0050	0.0040	0.0060	0.0050
	LP	0.0070	0.0060	0.0066	0.0066	0.0060	0.0060	0.0050	0.0066	0.0060

S = SLOTTING  
Axial Depth up to .5 x Diameter

HP = HEAVY PERIPHERAL  
Axial Depth up to 1 x Diameter  
Radial width .5 x Diameter

LP = LIGHT PERIPHERAL  
Axial Depth up to 1.5 x Diameter  
Radial width .15 x Diameter

**CALCULATIONS FOR SPEED**  
RPM = (3.82 x SFM) / DIA.  
SFM = (RPM x DIA.) / 3.82

**CALCULATIONS FOR FEED**  
IPM = # of FLUTES x FPT x RPM  
FPT = IPM / (RPM x # of FLUTES)

Notes: When using coated end mills increase SFM by 20% - 35%.  
See page 96 for an example of how to use the Speeds and Feeds Chart.

# HSS, COBALT AND POWDERED METAL SPEEDS AND FEEDS CHART FOR NON-FERROUS MATERIALS

Speed in Surface Feet per Minute (SFM)

Feed in Feed Per Tooth (FPT)

MATERIALS	Aluminum Alloys	Aluminum Cast	Aluminum >10% Silicon	Copper	Brass
DESCRIPTION	6061, 7075	Sand & Permanent Mold	High Silicon Based	Cast, Wrought	Yellow, Red, Leaded Brass
HSS SFM	450 - 650	150 - 300	200 - 400	250 - 450	250 - 450
Cobalt SFM	600 - 800	200 - 400	250 - 500	300 - 600	300 - 600
PM SFM	700 - Plus	300 - 600	400 - 700	450 - 800	450 - 900
<b>Tool Dia.</b>					
1/4"	S	0.0024	0.0022	0.0020	0.0020
	HP	0.0027	0.0027	0.0023	0.0023
	LP	0.0037	0.0037	0.0032	0.0032
3/8"	S	0.0038	0.0035	0.0032	0.0032
	HP	0.0041	0.0041	0.0034	0.0034
	LP	0.0054	0.0054	0.0047	0.0047
1/2"	S	0.0060	0.0055	0.0050	0.0050
	HP	0.0060	0.0060	0.0050	0.0050
	LP	0.0080	0.0080	0.0070	0.0070
3/4"	S	0.0068	0.0062	0.0057	0.0057
	HP	0.0077	0.0077	0.0064	0.0064
	LP	0.0103	0.0103	0.0090	0.0090
1"	S	0.0108	0.0099	0.0090	0.0090
	HP	0.0114	0.0114	0.0095	0.0095
	LP	0.0152	0.0152	0.0133	0.0133
1-1/4"	S	0.0115	0.0106	0.0096	0.0096
	HP	0.0122	0.0122	0.0102	0.0102
	LP	0.0162	0.0162	0.0142	0.0142
1-1/2"	S	0.0194	0.0178	0.0162	0.0162
	HP	0.0217	0.0217	0.0181	0.0181
	LP	0.0289	0.0289	0.0253	0.0253
2"	S	0.0220	0.0202	0.0184	0.0184
	HP	0.0278	0.0278	0.0231	0.0231
	LP	0.0370	0.0370	0.0324	0.0324

S = SLOTTING  
Axial Depth up to 1 x Diameter  
High Coolant Pressure

HP = HEAVY PERIPHERAL  
Axial Depth up to 1.5 x Diameter  
Radial width .5 x Diameter

LP = LIGHT PERIPHERAL  
Axial Depth up to 2 x Diameter  
Radial width .2 x Diameter

**CALCULATIONS FOR SPEED**  
RPM = (3.82 x SFM) / DIA.  
SFM = (RPM x DIA.) / 3.82

**CALCULATIONS FOR FEED**  
IPM = # of FLUTES x FPT x RPM  
FPT = IPM / (RPM x # of FLUTES)

Notes: Horsepower will be the limiting factor with larger diameter end mills.  
Using coated end mills will improve tool life.  
See page 96 for an example of how to use the Speeds and Feeds Chart.

# HSS, COBALT AND POWDERED METAL SPEEDS AND FEEDS CHART FOR FERROUS MATERIALS

Speed in Surface Feet per Minute (SFM)      Feed in Feed Per Tooth (FPT)

MATERIALS	Carbon Steels	Alloy Steel	Stainless Steels 300 Series	Stainless Steels 400 Series	Precipitation Stainless Steels	Gray Cast Iron	Ductile Cast Iron	High Temp Alloys	Titanium Pure	Titanium Cast / Wrought
DESCRIPTION	10XX, 11XX, 13XX, 15XX	40XX, 41XX, 42XX, 43XX, 44XX, 46XX, 86XX, Series	304, 304L, 312, 316, 316L	416, 420, 420F, 430F, 440C	15-5PH, 16-6PH, 17-4PH, AM-xx Series	Gray	Ductile	Inconel 625/718, A286, Haynes	Pure	Cast / Wrought 6AL4V, ASTM 1,2,3, Alpha - Beta
HSS SFM	50 - 110	30 - 80	30 - 80	50 - 100	30 - 65	55 - 150	35 - 75	5 - 30	40 - 90	35 - 80
Cobalt SFM	60 - 120	30 - 100	30 - 90	50 - 110	30 - 70	60 - 160	40 - 80	5 - 35	55 - 100	40 - 90
PM SFM	70 - 140	40 - 110	40 - 100	60 - 120	40 - 80	70 - 180	50 - 90	5 - 40	70 - 120	50 - 100
Tool Dia.										
1/4"	S	0.0013	0.0010	0.0010	0.0010	0.0010	0.0010	0.0008	0.0013	0.0010
	HP	0.0015	0.0010	0.0013	0.0013	0.0010	0.0013	0.0008	0.0015	0.0012
	LP	0.0019	0.0018	0.0018	0.0018	0.0018	0.0023	0.0020	0.0018	0.0018
3/8"	S	0.0019	0.0015	0.0015	0.0015	0.0015	0.0015	0.0011	0.0019	0.0015
	HP	0.0023	0.0015	0.0019	0.0019	0.0015	0.0015	0.0019	0.0011	0.0023
	LP	0.0028	0.0026	0.0026	0.0026	0.0026	0.0034	0.0030	0.0026	0.0028
1/2"	S	0.0025	0.0020	0.0020	0.0020	0.0020	0.0020	0.0015	0.0025	0.0020
	HP	0.0030	0.0020	0.0025	0.0025	0.0020	0.0020	0.0025	0.0015	0.0030
	LP	0.0037	0.0035	0.0035	0.0035	0.0035	0.0045	0.0040	0.0035	0.0037
3/4"	S	0.0038	0.0026	0.0032	0.0032	0.0026	0.0026	0.0032	0.0019	0.0038
	HP	0.0043	0.0029	0.0036	0.0036	0.0029	0.0029	0.0036	0.0021	0.0043
	LP	0.0053	0.0050	0.0050	0.0050	0.0050	0.0064	0.0057	0.0050	0.0053
1"	S	0.0054	0.0036	0.0045	0.0045	0.0036	0.0036	0.0045	0.0027	0.0054
	HP	0.0060	0.0040	0.0050	0.0050	0.0040	0.0040	0.0050	0.0030	0.0060
	LP	0.0074	0.0070	0.0070	0.0070	0.0070	0.0090	0.0080	0.0070	0.0074
1-1/4"	S	0.0069	0.0046	0.0058	0.0058	0.0046	0.0046	0.0058	0.0035	0.0069
	HP	0.0075	0.0050	0.0063	0.0063	0.0050	0.0050	0.0063	0.0038	0.0075
	LP	0.0093	0.0088	0.0088	0.0088	0.0088	0.0113	0.0100	0.0088	0.0093
1-1/2"	S	0.0081	0.0054	0.0068	0.0068	0.0054	0.0054	0.0068	0.0041	0.0081
	HP	0.0090	0.0060	0.0075	0.0075	0.0060	0.0060	0.0075	0.0045	0.0090
	LP	0.0111	0.0105	0.0105	0.0105	0.0105	0.0135	0.0120	0.0105	0.0111
2"	S	0.0108	0.0072	0.0090	0.0090	0.0072	0.0072	0.0090	0.0054	0.0108
	HP	0.0120	0.0080	0.0100	0.0100	0.0080	0.0080	0.0100	0.0060	0.0120
	LP	0.0148	0.0140	0.0140	0.0140	0.0140	0.0180	0.0160	0.0140	0.0148

S = SLOTTING  
Axial Depth up to 1 x Diameter

HP = HEAVY PERIPHERAL  
Axial Depth up to 2 x Diameter  
Radial width >.3 x Diameter

LP = LIGHT PERIPHERAL  
Axial Depth up to 3 x Diameter  
Radial width >.05 x Diameter

CALCULATIONS FOR SPEED  
RPM = (3.82 x SFM) / DIA.  
SFM = (RPM x DIA.) / 3.82

CALCULATIONS FOR FEED  
IPM = # of FLUTES x FPT x RPM  
FPT = IPM / (RPM x # of FLUTES)

Notes: When using coated end mills increase SFM by 20% - 35%.  
See page 96 for an example of how to use the Speeds and Feeds Chart.