m = meter = 39.37 inches
mm = millimeter = .039 inches
mn = minute

		Units
Vc	Cutting Speed	**m/mn**
	Tool Diameter	**mm**
R	Tool Radius	**mm**
Ad	Feed Rate per minute	**mm**
N	Rotation per minute	**RPM**
Z	Number of teeth / flutes	
Ae	Maximum depth of cut	**mm**

BELIN PRECISION TOOLS

METRTIC FORMULAS

Recommended cutting & feed rates for specific materials

- Select [**Vc**] for specific material to rout/mill – **calculate** RPM and Feed Rates using Belin formula
- Plunge at 40-60% [hard materials 20-30%] of the calculated feed rate / avoid tool hitting table in plunge
- Best results are achieved with stable material /proper hold down / no vibration
- Machine rigidity / software / setup / minimal runout [side pressure] - gives best results and longer tool life
- Follow Max. Depth of Cut [**Ae**] - and - Lubrication/Coolant recommendations for best results

The quality, efficiency and performance of Belin tools depend on numerous interdependent factors

		Metric - Ad *(Feed rate per minute)* *Cutting Edge Diameters in mm*			Ae	Lubricant	Recommended		
Material	**Vc**	**Ø < 3mm**	**3mm <Ø < 8mm**	**Ø> 8mm**					
Aluminum Pure	200<Vc<400	0.01xDxZxN R	0.02xDxZxN D	0.025xDxZxN D	**Ae**	Petrol or RGV Swarf soft, sticky	176 22000 33000 99203	176	176
Aluminum Alloy	200<Vc<400	0.01xDxZxN R	0.02xDxZxN D	0.025xDxZxN D	**Ae**	Cutting oil emulsion Drier swarf			
Brass	150<Vc<300	0.01xDxZxN R	0.02xDxZxN D	0.025xDxZxN D	**Ae**	Cutting oil emulsion	176 22000 33000 99203	102 176 15000	102 176 16000
Bronze- Zinc	100<Vc<150	0.01xDxZxN R	0.02xDxZxN D	0.025xDxZxN D	**Ae**	Cutting oil emulsion			
Material	**Vc**	**Ø < 4mm**	**4mm <Ø < 8mm**	**Ø> 8mm**					
Plastics - Bakelite	50<Vc<100	0.03xDxZxN 1.5xR	0.04xDxZxN 1.5xD	0.045xDxZxN 1.5xD	**Ae**	Air	12000 13000 91361 94106 99058	13000 91361 94106	13000 91361 94106
Plastics - PVC	100< Vc <200	0.03xDxZxN 1.5xR	0.04xDxZxN 1.5xD	0.045xDxZxN 1.5xD	**Ae**	Air			
Plastics - Acetate Plexiglas - Nylon	300< Vc <500	0.03xDxZxN 1.5xR	0.04xDxZxN 1.5xD	0.045xDxZxN 1.5xD	**Ae**	Air Vaporized water			
Material	**Vc**	**Ø < 3mm**	**3mm <Ø < 8mm**	**Ø> 8mm**					
Wood	300< Vc <400	0.01xDxZxN 1.5xR	0.02xDxZxN 1.5xD	0.025xDxZxN 1.5xD	**Ae**	Air			
Material	**Vc**	**Ø < 3mm**	**3mm <Ø < 8mm**	**Ø> 8mm**					
Stainless Steel	90	0.0033xDxZxN R	0.0045xDxZxN R	0.0045xDxZxN R	**Ae**	Cutting oil emulsion	102 16000	102 15000	102 16000

Formulas: $N=\frac{1000 \times Vc}{\Pi \times D}$ $Vc=\frac{\Pi \times D \times N}{1000}$

For other tool profiles refer to bottom of catalog page for cutting information.

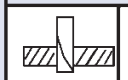
		Units
SFM	Cutting Speed	Feet / mn
D	Tool Diameter	Inches
R	Tool Radius	Inches
IPM	Inches per minute / Feed Rate	Inches / mn
RPM	Revolutions per minute	RPM
Z	Number– Flutes /Teeth	
Ae	Maximum depth of cut	Inches

BELIN PRECISION TOOLS

INCH FORMULAS

Recommended cutting & feed rates for specific materials

- Select [**SFM**] for specific material to rout/mill – **calculate** RPM and Feed Rates using Belin formula
- Plunge at 40-60% [hard materials 20-30%] of the calculated feed rate / avoid tool hitting table in plunge
- Best results are achieved with stable material /proper hold down / no vibration
- Machine rigidity / software / setup / minimal runout [side pressure] - gives best results and longer tool life
- Follow Max. Depth of Cut [**Ae**] - and - Lubrication/Coolant recommendations for best results
- The quality, efficiency and performance of Belin tools depend on numerous interdependent factors

		IPM *(Feed rate per minute)* *by* *Cutting Edge Diameters - inches*			**Ae-** Max depth of cut each pass 	**Lubricant/Coolant**	**Recommended**   		
Materials	**SFM**	**Up to 1/8"**	**3/16" to 3/8"**	**3/8" to 1"**					
Aluminum Pure	> 1000	.0004xDxZxRPM x25.4	.0008xDxZxRPM x25.4	.001xDxZxRPM x25.4		Petrol or RGV	176000	176000	176000
		R	D	D	Ae	Swarf soft, sticky	22000	00199	00203
Aluminum Alloy	> 1000	.0004xDxZxRPM x25.4	.0008xDxZxRPM x25.4	.001xDxZxRPM x25.4		Cutting oil emulsion	33000		
		R	D	D	Ae	Drier swarf	99203		
Brass	490< >1000	.0004xDxZxRPM x25.4	.0008xDxZxRPM x25.4	.001xDxZxRPM x25.4		Cutting oil emulsion	176000	102000	102000
		R	D	D	Ae		22000	176000	176000
Bronze- Zinc	330 < > 500	.0004xDxZxRPM x25.4	.0008xDxZxRPM x25.4	.001xDxZxRPM x25.4		Cutting oil emulsion	33000	15000	16000
		R	D	D	Ae		99203		
Materials	**SFM**	**Up to 1/8"**	**3/16" to 3/8"**	**3/8" to 1"**					
Plastics - Bakelite	160 < > 330	.0012xDxZxRPM x25.4	.0016xDxZxRPM x25.4	.0018xDxZxRPM x25.4		Air	12000	13000	13000
		1.5xR	1.5xD	1.5xD	Ae		13000	91361	91361
Plastics - PVC	330 < > 700	.0012xDxZxRPM x25.4	.0016xDxZxRPM x25.4	.0018xDxZxRPM x25.4		Air	91361	94106	94106
		1.5xR	1.5xD	1.5xD	Ae		94106	00196	00192
Plastics - Acetate Plexiglas - Nylon	980 < > 1600	.0012xDxZxRPM x25.4	.0016xDxZxRPM x25.4	.0018xDxZxRPM x25.4		Air Vaporised water	99058		
		1.5xR	1.5xD	1.5xD	Ae				
Materials	**SFM**	**Up to 1/8"**	**3/16" to 3/8"**	**3/8" to 1"**					
Wood	980 < > 1300	.0004xDxZxRPM x25.4	.0008xDxZxRPM x25.4	.001xDxZxRPM x25.4		Air		43000	
		1.5xR	1.5xD	1.5xD	Ae				
Materials	**SFM**	**Up to 1/8"**	**3/16" to 3/8"**	**3/8 to 1"**					
Stainless steel	300	.00013xDxZxRPMx25.4	.00018xDxZxRPM x25.4	.00018xDxZxRPMx25.4		Cutting oil emulsion	102000	102000	102000
		R	R	R	Ae		16000	15000	16000

Formulas: $RPM = \frac{SFM}{0.2618 \times D}$ $SFM = 0.262 \times D \times RPM$

For other tool profiles refer to bottom of catalog page for cutting information.

Follow the CNC machine manufacturer guidelines for setup — alignment — calibration and maintenance schedules. Regular attention to these guidelines will keep your CNC machine in top operating condition. Belin Precision Tools work best in well-maintained CNC machines giving excellent cutting performance and longer tool life.

CNC Rigidity – Setup – machine stability is when material hold down is achieved with no movement and minimal vibration. Also, consider that software programs need to be verified and the spindle(s) aligned and calibrated, creating the optimum working conditions to minimize runout side pressures giving the best cut/edge quality and longer tool life.

Collets – inspect often, especially if you change tools hourly — daily — weekly. Clean and inspect collets at every tool changeover. Replace collets at the first sign of wear. Worn or dirty collets will contribute to shorter tool life and tool breakage.

Plunging the material – harder the material to be routed/milled, the softer you should plunge. Reducing the plunge helps to avoid damaging the tool as it "hits" the material. Consider slower plunge when using small diameter tools, extra long cutting length tools and flatter tipped tools.
Examples:
Plastic/Wood – 40-60% of the calculated feed rate [IPM]
Aluminum/Non-Ferrous – 35-50% of the calculated feed rate [IPM]
Steel/Ferrous Metal – 20-30% of the calculated feed rate [IPM]

Depth of Cut – 'Ae' – important to follow the recommended ' Ae ' listed on the Belin Cutting Formula Chart. Smaller cutting edge diameters and harder material being routed/milled require the depth of cut 'Ae' be reduced. Exceeding the recommended 'Ae' can contribute to less than optimal edge quality, shorter tool life and tool breakage.
Examples:
1/8" CED - rout/mill aluminum – 'Ae' R- radius = 1/16" 'Ae' per pass/cut
1/4" CED - rout/mill steel/ferrous metal – 'Ae' R- radius = 1/8" 'Ae' per pass/cut
3/16" CED - rout/mill aluminum – 'Ae' D- diameter = 3/16" 'Ae' per pass/cut
1/8" CED - rout/mill plastic/wood – 'Ae'1.5 x R- radius = 3/16" 'Ae' per pass/cut
1/4" CED - rout/mill plastic/wood – 'Ae'1.5 x D- diameter- = 3/8" 'Ae' per pass/cut

Lubricant - Coolant – follow recommendation on the Belin Cutting Formula Chart for safe CNC production. Routing – Milling without recommended lubricant-coolant will contribute to shorter tool life, less than optimum edge quality and tool breakage.
Problems to consider when lubricant – coolant is not used:

- Contributes to weld back when routing – milling most plastic materials
- Excessive heat builds up of when routing – milling non-ferrous and ferrous metal creating an unsafe working environment and potential fire hazard.

RPM Formula/Cutting Edge Diameters *(1/16" Thru 1")*

SFM listed by material type on the Belin Cutting Formula Chart.
Calculate RPM by multiplying .262* x CED = .0000 (listed below) –
that result is then divided into SFM which = RPM
*[Pi (3.14) divided by 12 = .262 rounded]

$$RPM = \frac{SFM}{.262 \times CED}$$

1/16 - .063 x .262 = .0165		9/16 - .563 x .262 = .1475	
1/8 - .125 x .262 = .0328		5/8 - .625 x .262 = .1638	
3/16 - .188 x .262 = .0493		11/16 - .688 x .262 = .1803	
1/4 - .250 x .262 = .0655		3/4 - .750 x .262 = .1965	
5/16 - .313 x .262 = .0820		13/16 - .813 x .262 = .2130	
3/8 - .375 x .262 = .0983		7/8 - .875 x .262 = .2293	
7/16 - .438 x .262 = .1148		15/16 - .938 x .262 = .2458	
1/2 - .500 x .262 = .1310		1/1 - .1000 x .262 = .2620	

DECIMAL / METRIC CONVERTER

Inch		mm	Inch		mm
1/64	.015	0.396	33/64	.515	13.096
1/32	.031	0.793	17/32	.531	13.493
3/64	.046	1.190	35/64	.546	13.890
1/16	.062	1.587	9/16	.562	14.287
5/64	.078	1.984	37/64	.578	14.684
3/32	.093	2.381	19/32	.593	15.081
7/64	.109	2.778	39/64	.609	15.478
1/8	.125	3.175	5/8	.625	15.875
9/64	.140	3.571	41/64	.640	16.271
5/32	.156	3.968	21/32	.656	16.668
11/64	.171	4.365	43/64	.671	17.065
3/16	.187	4.762	11/16	.687	17.462
13/64	.203	5.159	45/64	.703	17.859
7/32	.218	5.556	23/32	.718	18.256
15/64	.234	5.953	47/64	.734	18.653
1/4	.250	6.350	3/4	.750	19.050
17/64	.265	6.746	49/64	.765	19.446
9/32	.281	7.143	25/32	.781	19.843
19/64	.296	7.540	51/64	.796	20.240
5/16	.312	7.937	13/16	.812	20.637
21/64	.328	8.334	53/64	.828	21.034
11/32	.343	8.731	27/32	.843	21.431
23/64	.359	9.123	55/64	.859	21.828
3/8	.375	9.525	7/8	.875	22.225
25/64	.390	9.921	57/64	.890	22.621
13/32	.406	10.318	29/32	.906	23.018
27/64	.421	10.715	59/64	.921	23.415
7/16	.437	11.112	15/16	.937	23.812
29/64	.453	11.509	61/64	.953	24.209
15/32	.468	11.906	31/32	.968	24.606
31/64	.484	12.303	63/64	.984	25.003
1/2	.500	12.700	1/1	1.000	25.400

Examples of RPM calculated for:

ALUMINUM - SFM 1000
Material to be routed - milled - Aluminum – SFM 1000
Formula .262 x CED [Cutting Edge Diameter] .262 x 1/4" [.250] = .0655
SFM – 1000 divided by .0655 = 15,267 RPM

PLASTIC/WOOD - SFM - select by material type – SFM range 160 to 1600
Material to be routed - milled - example Plexiglas - 1200 SFM
Material to be routed - milled - example PVC - 600 SFM
Material to be routed - milled - example Hardwood - 980 SFM
Formula .262 x CED [Cutting Edge Diameter] .262 x 3/16" [.188] = .0493
SFM – 1200 divided by .0493 = 24,340 RPM for Plexiglas
SFM – 600 divided by .0493 = 12,170 RPM for PVC
SFM – 980 divided by .0493 = 19,880 RPM for Hardwood

STEEL/FERROUS METAL - SFM 300
Material to be routed - milled - Stainless Steel – SFM 300
Formula .262 x CED [Cutting Edge Diameter] .262 x 3/16" [.188] = .0493
SFM – 300 divided by .0493 = 6085 RPM

Example 1:
Material to be routed - milled – Aluminum – SFM is 1000
Belin Tool # 33635 - 1/4" CED
.262 x .250 = .0655
SFM 1000 divided by .0655 = 15,267 RPM
Belin Cutting Formula for Aluminum - 1/4 " CED
.0008 x .250 x 1 x 15,267 x 25.4 = 77" - IPM Feed Rate
Ae – max depth of cut D – 1/4" each pass
Lubricant/Coolant – recommended for best results and longer tool life

Example 2:
Material to be routed - milled – Stainless Steel – SFM is 300
Belin Tool # 102476 - 3/16" CED
.262 x .188 = .0493
SFM 300 divided by .0493 = 6,085 RPM
Belin Cutting Formula for Stainless Steel - 3/16 " CED
.00018 x .188 x 3 x 6,085 x 25.4 = 15/16" - IPM Feed Rate
Ae – max depth of cut R – 3/32" each pass
Lubricant/Coolant – recommended for best results and longer tool life

Example 3:
Material to be routed - milled - Foam board - SFM 980 to 1600
Belin Tool # 13952A - 3/8" CED - Special XXL CEL 3 3/16"
SFM 1600 divided by .0983 = 16,275 RPM
Belin Cutting Formula - **** Reduce RPM & IPM by 30-50% ****
.0018 x .375 x 1 x 16,275 x 25.4 = 279" - IPM Feed Rate
** REDUCE RPM & IPM **
Reduced by 30% - RPM = 11,393 - IPM = 195 inches per minute
Reduced by 40% - RPM = 9,765 - IPM = 167 inches per minute
Reduced by 50% - RPM = 8,138 - IPM = 140 inches per minute
#13952A- 3/8" designed for Routing/Milling 2"- 3" Foam Board Material **ONLY**.
#13635B- 1/4" designed for Routing/Milling 1 1/2" - 2" Foam Board Material **ONLY**.
Belin strongly recommends reducing RPM and Feed Rate [IPM] by 30-50% to avoid tool breakage due to extra long cutting length [XXL CEL].
Ae - max depth of cut - 3"- #13952A FOAM ONLY - 2" - #13635B FOAM ONLY
Lubricant/Coolant recommended for best results and longer tool life

Example 4:
Material to be routed - milled – Plastic -Acetate – SFM is 980 to 1600
Belin Tool # 13476 – 3/16" CED
.262 x .188 = .0493
SFM 1400 divided by .0493 = 28,397 RPM
Belin Cutting Formula for Plastic – Acetate – SFM 1400
.0016 x .188 x 1 x 28,397 x 25.4 = 217" - IPM Feed Rate
Ae – max depth of cut 1.5 x D – 9/32" each pass
Lubricant/Coolant – recommended for best results and longer tool life

***When using different RPM than Cutting Formula ***

When the router spindle RPM is higher or lower, or you prefer a specific RPM, this will adjust feed rates [IPM]. Belin recommends not exceeding the cutting formula RPM and feed rate [IPM] calculation more than 20%. Best results are when feed rate [IPM] and RPM are in balance allowing the tool and CNC machine to work together giving the best results.

*Refer to Example 4:

- CNC - Spindle RPM = 34,076 RPM
- .0016 x .188 x 1 x 34,076 x 25.4 = 260" – IPM Feed Rate
- CNC - Spindle RPM = 18,000 RPM
- .0016 x .188 x 1 x 18,000 x 25.4 = 137 - 138" – IPM Feed Rate
- CNC - Spindle RPM = 15,500 RPM
- .0016 x .188 x 1 x 15,500 x 25.4 = 118" – IPM Feed Rate
- CNC - Spindle RPM = 12,000 RPM
- .0016 x .188 x 1 x 12,000 x 25.4 = 91 - 92" – IPM Feed Rate