

ULTRATOOL Patented SmoothFlute Series 323 Monolith™ Series End Mills

Monolith end mills by Ultra-Tool represent a culmination of decades of experience and craftsmanship in solid carbide grinding. Extended reach applications are notoriously difficult, but each respective Monolith Series combines the best of SmoothGrind, SmoothConcricity, SmoothEdge and SmoothCoat to maximize success. The 323ML holds size and concentricity to a maximum of .0003 deviation, even at a 12" reach! All Monoliths feature SmoothEdge with standard AT hardcoating.



Series 323ML MONOLITH™

Solid Carbide Extended Reach End Mill  
for Steels & Exotics • Four Flute • AT Coated  
• Tight Tolerance • Minimal TIR • Neck  
• Corner Radius • Variable Helix

This product is manufactured under  
U.S. Patent No. 7,284,935



SmoothFlute  
ULTRATOOL PERFORMANCE  
S E R I O U S

Diam	LOC	LBS	OAL	Neck	Shank	.015 rad EDP#	.030 rad EDP#	.060 rad EDP#	.090 rad EDP#	.125 rad EDP#	.190 rad EDP#	.250 rad EDP#	Ball EDP#	AT Coated
3/8	1/2	2-1/8	4"	.355	3/8	27000AT	23021AT	27001AT	27002AT				27003AT	\$63.20
3/8	1/2	4-1/8	6"	.355	3/8	27004AT	23022AT	27005AT	27006AT				27007AT	\$85.80
1/2	5/8	2-1/4	4"	.475	1/2	27008AT	23033AT	27009AT	27010AT	27011AT			27012AT	\$93.60
1/2	5/8	4-1/8	6"	.475	1/2	27013AT	23034AT	27014AT	27015AT	27016AT			27017AT	\$127.90
1/2	5/8	5-1/2	8"	.475	1/2	27018AT	23035AT	27019AT	27020AT	27021AT			27022AT	\$167.20
5/8	3/4	2-3/8	4"	.593	5/8		23041AT	27023AT	27024AT	27025AT			27026AT	\$136.40
5/8	3/4	4-1/8	6"	.593	5/8		23042AT	27027AT	27028AT	27029AT			27030AT	\$185.80
5/8	3/4	5-1/2	8"	.593	5/8		23043AT	27031AT	27032AT	27033AT			27034AT	\$245.10
3/4	1"	3-1/4	5"	.712	3/4		27627AT	27631AT	27635AT	27639AT	27643AT	27647AT	27651AT	\$230.70
3/4	1"	4-1/8	6"	.712	3/4		23049AT	27035AT	27036AT	27037AT	27038AT	27039AT	27040AT	\$255.20
3/4	1"	5"	7"	.712	3/4		27628AT	27632AT	27636AT	27640AT	27644AT	27648AT	27652AT	\$284.40
3/4	1"	5-1/2	8"	.712	3/4		23050AT	27041AT	27042AT	27043AT	27044AT	27045AT	27046AT	\$333.70
3/4	1"	8"	12"	.712	3/4		23051AT	27047AT	27048AT	27049AT	27050AT	27051AT	27052AT	\$458.00
1"	1-1/4	3"	5"	.950	1"		27629AT	27633AT	27637AT	27641AT	27645AT	27649AT	27653AT	\$377.10
1"	1-1/4	4-1/8	6"	.950	1"		23065AT	27053AT	27054AT	27055AT	27056AT	27057AT	27058AT	\$392.60
1"	1-1/4	5"	7"	.950	1"		27630AT	27634AT	27638AT	27642AT	27646AT	27650AT	27654AT	\$436.60
1"	1-1/4	5-1/2	8"	.950	1"		23066AT	27059AT	27060AT	27061AT	27062AT	27063AT	27064AT	\$513.70
1"	1-1/4	8"	12"	.950	1"		23067AT	27065AT	27066AT	27067AT	27068AT	27069AT	27070AT	\$719.70
1-1/4	1-1/2	4-1/8	6"	1.20	1-1/4		23068AT		27071AT	27072AT	27073AT	27074AT	27075AT	\$526.70
1-1/4	1-1/2	5-1/2	8"	1.20	1-1/4		23069AT		27076AT	27077AT	27078AT	27079AT	27080AT	\$673.90
1-1/4	1-1/2	8"	12"	1.20	1-1/4		23070AT		27081AT	27082AT	27083AT	27084AT	27085AT	\$955.30
1-1/2	2"	-	6"	-	1-1/4		23071AT						27086AT	\$634.60
1-1/2	2"	-	8"	-	1-1/4		23072AT						27087AT	\$817.90
1-1/2	2"	-	12"	-	1-1/4		23073AT						27088AT	\$1151.60

**new!** Standard Radius sizes throughout the range!

ULTRATOOL PERFORMANCE  
S E R I O U S

MONOLITH™



Premium Series EM Specs:  
Cutting Diam +.000/-0.02  
Shank Diam -.0000/-0.0025  
Radius ±.0005

**About the Monolith configuration:** Ultra-Tool® has taken the very best of all our technologies and consolidated them within our Monolith end mills. Ultra-Grain, patented and/or unique designs, SmoothGrind, SmoothConcricity, SmoothEdge, SmoothFlute and SmoothCoat are all incorporated into a behemoth which showcases the attributes necessary for successful machining in challenging applications. Special blank prep procedures and toolholding guarantee incredible concentricity characteristics. The Monolith is now available within the 323, 365, 355, 395, 330AL, and 333AL Series (designated with the "ML" suffix). These are superb products; you'll find nothing else like them in the industry!

Please use heat-shrink holding for best results.

ULTRA-Grain® + SmoothGrind® + SmoothConcricity® + SmoothEdge® + SmoothCoat®

SmoothFlute

Our patented SmoothFlute is included on the 323, 323ML, 365, 365ML, and 395ML

Application Data for High Performance Series 323, 355, 377, & 365 Series ULTRATOOL End Mills

The milling data presented below is for the 323, 355, 377, and 365 Series of Ultra end mills. When using SmoothCoat & SmoothEdge surface treatments, Surface Feet or Meters Per Minute can be increased from the stated levels by at least 25%.

Do not use a radial DOC exceeding more than 25% of diameter for Series 355 only.



Peripheral Milling data based on axial depth ≤ 100% of tool diameter & radial depth of ≤ 25% of tool diameter.



Slot Milling data based on axial depth of cut = 50% of tool diameter.

End Mill Specifications:

Diameter: +.000 / -.002  
Shank Diameter: +.0000 / -.0003  
LOC: +.060 / -.000  
OAL: ± .060  
Helix: ± 2°

Milling;  
Fractional

Material	SFPM	SFPM	1/8"	3/16"	1/4"	5/16"	3/8"	7/16"	1/2"	5/8"	3/4"	1"
<b>Steel</b>	<b>Peripheral</b>	<b>Slotting</b>	<b>Feed Per Tooth (FPT)</b>									
1018 / 1020	300 to 600	200 to 400	.0007	.0012	.0015	.0018	.0020	.0025	.0030	.0035	.0040	.0045
4140 / 4340 / P20	250 to 500	200 to 350	.00065	.0010	.0012	.0015	.0018	.0022	.0025	.0030	.0035	.0040
<b>Stainless Steel</b>												
303 / 304 / 316	250 to 400	200 to 350	.0006	.0008	.0010	.0012	.0018	.0022	.0025	.0030	.0035	.0038
410 / 420 / 440C	200 to 300	150 to 250	.0006	.0008	.0010	.0012	.0018	.0022	.0025	.0030	.0035	.0038
15-5/17-4 ≤ 32HRc	200 to 350	150 to 300	.0006	.0008	.0010	.0012	.0018	.0022	.0025	.0030	.0035	.0038
15-5/17-4 ≥ 32HRc	150 to 250	150 to 250	.0004	.0006	.0008	.0010	.0015	.0020	.0020	.0025	.0030	.0035
<b>Tool Steel</b>												
A2/D2/H13 ≤ 32HRc	200 to 300	150 to 250	.0005	.0008	.0010	.0012	.0018	.0022	.0025	.0030	.0035	.0035
A2/D2/H13 ≥ 32HRc	150 to 250	100 to 200	.0004	.0006	.0008	.0010	.0015	.0020	.0020	.0025	.0030	.0035
<b>Titanium</b>												
6Al-4V	150 to 300	125 to 225	.0005	.0008	.0010	.0010	.0012	.0020	.0025	.0025	.0030	.0040
<b>High Temp Alloys</b>												
Inconel 625	100 to 150	75 to 125	.0005	.0007	.0010	.0012	.0012	.0018	.0020	.0020	.0025	.0030
Inconel 718	70 to 150	50 to 100	.0005	.0007	.0008	.0009	.0012	.0018	.0020	.0020	.0030	.0040
<b>Cast Iron</b>												
Gray Iron ≤ 32HRc	150 to 400	150 to 300	.0005	.0007	.0010	.0012	.0015	.0018	.0020	.0030	.0040	.0045

Application Data for Series 323, 355, 377, and 365 High Performance End Mills (continued); Peel Milling



Recommendations are based upon a radial cut depth of 10% of the end mill's diameter and axial cut depth of 50-85% of the tool's LOC.

Peel milling can be performed wet or dry (with AT coating); please consult [technical@toolalliance.com](mailto:technical@toolalliance.com) for specific application data.



See it run now!

Series 323, 355, 377, and 365 Peel Milling

Surface Feet Per Minute (SFPM) and Feed Per Tooth (FPT) recommendations by tool diameter and material:

Scan the Quick Code and watch the Series 365 milling various materials on the Tool Alliance YouTube channel.

Material	SFPM	1/8"	3/16"	1/4"	5/16"	3/8"	7/16"	1/2"	5/8"	3/4"	1"
<b>Steel</b>	<b>Peripheral</b>	<b>Feed Per Tooth (FPT)</b>									
1018 / 1020	400 to 600	.001-.003	.001-.004	.0015-.005	.002-.008	.002-.008	.003-.010	.003-.010	.003-.010	.004-.012	.004-.012
4140 / 4340 / P20	350 to 500	.001-.002	.001-.003	.001-.004	.0015-.006	.0015-.006	.002-.007	.002-.007	.002-.007	.0025-.008	.0025-.008
<b>Stainless Steel</b>											
303 / 304 / 316	300 to 500	.001-.002	.001-.003	.0015-.004	.002-.006	.002-.006	.003-.008	.003-.008	.003-.008	.003-.010	.003-.010
410 / 420 / 440C	250 to 400	.001-.002	.001-.003	.0015-.004	.002-.006	.002-.006	.003-.008	.003-.008	.003-.008	.003-.010	.003-.010
15-5/17-4 ≤ 32HRc	300 to 500	.001-.002	.001-.003	.0015-.004	.002-.006	.002-.006	.003-.008	.003-.008	.003-.008	.003-.010	.003-.010
15-5/17-4 ≥ 32HRc	200 to 300	.0005-.002	.0005-.002	.001-.003	.0015-.005	.0015-.005	.002-.006	.002-.006	.002-.006	.003-.008	.003-.008
<b>Tool Steel</b>											
A2/D2/H13 ≤ 32HRc	250 to 350	.001-.002	.001-.003	.0015-.004	.002-.006	.002-.006	.003-.008	.003-.008	.003-.008	.003-.010	.003-.010
A2/D2/H13 ≥ 32HRc	200 to 300	.001-.002	.001-.003	.0015-.004	.002-.006	.002-.006	.003-.008	.003-.008	.003-.008	.003-.010	.003-.010
<b>Titanium</b>											
6Al-4V	250 to 300	.001-.002	.001-.003	.0015-.004	.002-.006	.002-.006	.003-.008	.003-.008	.003-.008	.003-.010	.003-.010
<b>High Temp Alloys</b>											
Inconel 625	125 to 200	.0005-.002	.0005-.002	.001-.003	.0015-.005	.0015-.005	.002-.006	.002-.006	.002-.006	.003-.008	.003-.008
Inconel 718	100 to 150	.0005-.002	.0005-.002	.001-.003	.0015-.005	.0015-.005	.002-.006	.002-.006	.002-.006	.003-.008	.003-.008
<b>Cast Iron</b>											
Gray Iron ≤ 32HRc	250 to 500	.001-.002	.001-.003	.001-.004	.0015-.006	.0015-.006	.002-.007	.002-.007	.002-.007	.0025-.008	.0025-.008

1

ULTRA-Grain®

# Components of Guaranteed Quality

**COMPONENT #1: Carbide Substrate** From being the first Company to introduce MicroGrain carbide to the mass-market round tool industry through the present day, Tool Alliance® has consistently innovated new powder and grade combinations for demanding applications. We recognize that our material is the very first Significant Characteristic. By creating partnerships with a limited number of tungsten powder and cemented-carbide material suppliers, we are able to guarantee that our customers receive precision-tolerance tools ground from only the purest, finest grades available worldwide. The following photographs of Ultra-Carb® 1 and Ultra-Grain® 1 respectively demonstrate the complexity of the compound we commonly refer to as Cemented Carbide. Taken at magnification of 10,000 X through an SEM (Scanning Electron Microscope), the visible grains are tungsten while the cobalt binder appears as dark shadows. The largest tungsten grains appearing in the Ultra-Carb photo are less than one micron in size. Note that these grades are two samples representing more than a dozen different substrates we use throughout our product lines, each having a particular application niche. Compared to other industry participants, you will find that Tool Alliance offers the best month-to-month and year-to-year consistency in carbide grain structure.



**Ultra-Carb® 1**  
Cobalt Percentage: 6%  
Grain Size (µm): ≤ 0.8  
Hardness: 93.5 HRA  
Fracture Toughness (K1c): 6.6  
TRS (GPa): 3.8  
Density (gm/cc): 14.90



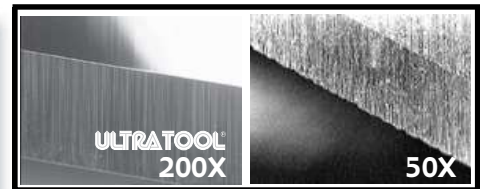
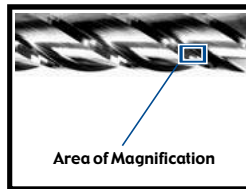
**Ultra-Grain® 1**  
Cobalt Percentage: 10%  
Grain Size (µm): ≤ 0.7  
Hardness: 92.7 HRA  
Fracture Toughness (K1c): 7.9  
TRS (GPa): 4.1  
Density (gm/cc): 14.30



2

## SmoothGrind®

**COMPONENT #2: The Grinding Process** After selecting the best material available, Tool Alliance has perfected the manufacturing technology to optimize 100% of its physical properties. We call this process SmoothGrind®. Years in development, SmoothGrind is the result of a proprietary combination of material, abrasive, coolant, machine-tool, software, and grinding method technologies that produce cutting tools with superior qualitative characteristics. Sharper and longer lasting cutting edges, enhanced work piece finishes, and much improved lubricity are just some of the benefits brought to you by the latest solid carbide rotary tooling advances from Tool Alliance. The two photos above display an Ultra-Tool end mill primary relief featuring SmoothGrind (left) versus a major competitor's product (right). To fully demonstrate the difference, the Ultra end mill is shown at double the magnification. Note the straight line of our end mill's primary relief in comparison to the jagged edge of the competing product. Keep in mind the competitive end mill is a very good product that has a large following, yet the difference is substantial.



SmoothGrind® Competitor's

3

## SmoothContricity®



**COMPONENT #3: The Tooling Process** All the best physical ingredients are wasted unless they are all pulled together in a comprehensive system that maximizes their respective attributes. Tool Alliance calls this process SmoothContricity®. Our customer base represents the leading edge of machine tool utilization, and SmoothContricity ensures that optimum results can be obtained in a variety of ways; minimized run-out (TIR), industry-leading tolerances on diameter & radius, and 100% Shrink Fit Ready (SFR) shanks. Combined, these attributes allow our consumers to reach full machining potential and position the cutting tool as a systematic contributor to process consistency and repeatability.



Shrink Fit Ready

4

## SmoothEdge®

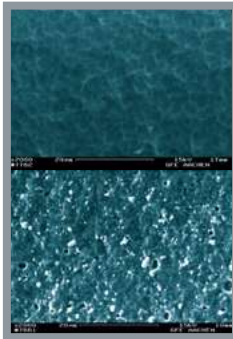


.0001 SmoothEdge atop cylindrical margin atop primary relief.



**COMPONENT #4: The Edge Preparation Process**

Our cutting edges are literally too sharp for certain materials. For our carbide inserts and now increasingly for our solid carbide round tools, proper edge preparation can yield huge productivity improvements to "out of the box" tool application. Using a treatment we call SmoothEdge® and performed on machine tools developed in our own R&D lab, we've taken the mystery out of tool "break-in" and provided a consistency that can be counted on time and again. The processes range from a microblasting treatment using extremely fine aluminum oxide powder to a diamond-lapping compound to brushes. All are application-specific to sound and run smooth from the first cut and protect your tooling investment from unnecessary potential for chipping during your initial tooling paths. Big productivity gains can be achieved in certain applications as well due to improved chip formation and evacuation. Learn more about SmoothEdge on Page #55.



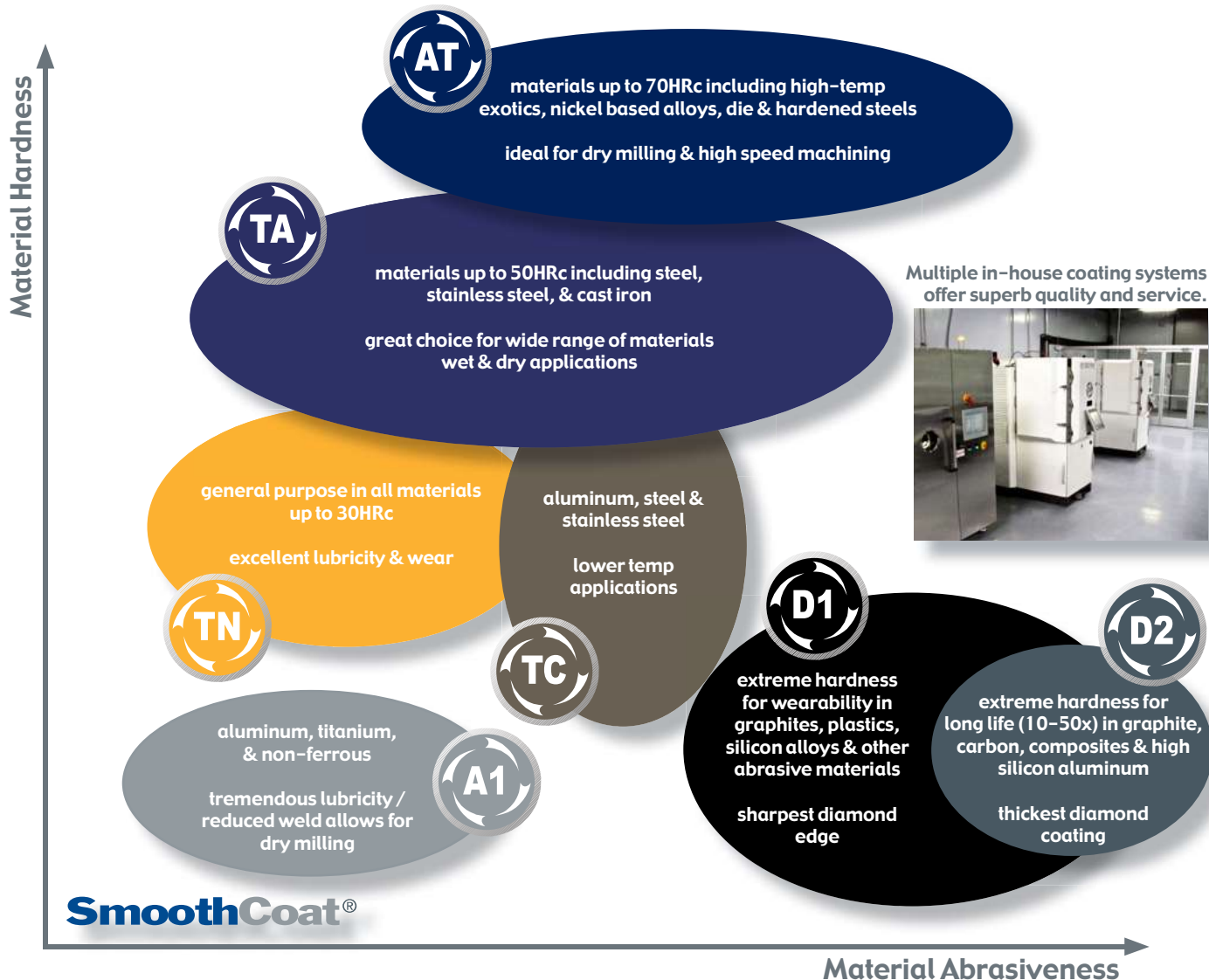
Our coating @ 2,000X (top).  
Everybody else's (bottom).

# SmoothCoat® 5

**COMPONENT #5: The Coating Process** The challenge of finding a coating method to leverage 100% of the inherent assets of our carbide grade and grinding technologies was difficult. What we finally discovered was such a perfect fit and so logical for our product lines that we invested heavily into the process we now call SmoothCoat®. Much more than simply the standard arc-deposited PVD coating, SmoothCoat involves sputter multi-layering and a multi-step prep & post operation called Micro-Blasting. The advantages of this procedure include relieving of tensile stresses underneath the cutting edge, increased stability of the coating surface, and perhaps most importantly, elevating SmoothGrind even another notch by leveling and activating the cemented carbide substrate. The result is a smooth, shiny, tough, and durable surface that can withstand tomorrow's machining requirements and outlast competitive coatings. Additionally, we've made it a standard feature on thousands of our standard catalog items. Our coating services are performed within our own factories for quality & extremely quick turnaround times.

## Coating Availability

Order by adding the suffix TA, TN, AT, TC, A1, D1, or D2 to the EDP #.



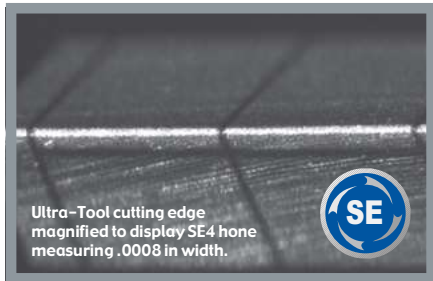
SmoothCoat®

ULTRATOOL® Technical Data

# SmoothEdge®

## The Edge Preparation Process

Our cutting edges are literally too sharp for certain materials. For our carbide inserts and now increasingly for our solid carbide round tools, proper edge preparation can yield huge productivity improvements to “out of the box” tool application. Using a process we call **SmoothEdge®** and performed on machine tools developed in our own R&D lab, we’ve taken the mystery out of tool “break-in” and provided a consistency that can be counted on time and again. All five types of **SmoothEdge** will yield different benefits dependent upon application. **SmoothEdge** will make your tools sound and run smooth from the first cut and protect your tooling investment from unnecessary potential for chipping during initial tool paths.



Combine SmoothEdge with our other value added features to design the ultimate cutting solution.

## SmoothGrind®

- Lubricity
- Sharpness
- Polished Cutting Edges
- Hardness & Adhesion
- Masked Shanks
- Coating Uniformity
- Minimized TIR
- Shrink Fit Ready (SFR)
- Tight Tolerances

SmoothCoat®

## SmoothContricity®

Primary SmoothCoat recommendations:



A1 for SE2



TA for SE4



AT for SE5

Our newest technology can achieve incredible productivity increases in specific applications. Many of our new Series include SmoothEdge as a standard feature, while on others it can be added as a same day post treatment for a small charge. Ask your Inside Sales representative about SmoothEdge today!



### SmoothEdge 1

A microblasting treatment using extremely fine aluminum oxide powder to smooth the carbide surface while generating a very light edge preparation. This feature comes standard with any SmoothCoat® coating.

Uses: Highly recommended for most milling and drilling applications.



### SmoothEdge 2

A lapping treatment to create extreme lubricity & smoothness with minimal edge prep on uncoated tools.

Uses: Highly recommended for milling and drilling of aluminum and other non-ferrous applications using UnCoated, A1, or TC coated tools.



### SmoothEdge 3

Combines microblasting and lapping for a light hone with extreme lubricity.

Uses: Highly recommended for a wide range of general purpose machining applications using coated tools.



### SmoothEdge 4

Adds a proprietary hone to the blasting and lapping cycles for a medium edge prep with excellent lubricity.

Uses: Highly recommended for milling and drilling applications involving general steels, stainless, and cast iron.



### SmoothEdge 5

Doubles the honing and lapping cycle for maximum edge strength; a robust edge preparation combined with excellent lubricity characteristics.

Uses: Highly recommended for milling and drilling applications involving stainless, high-temp alloys, and exotics.

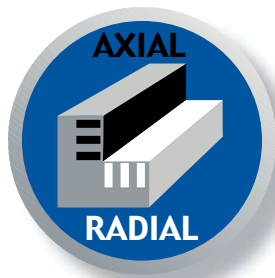
## ULTRATOOL Technical Data

With so many variables present in the machining process, it is essential to optimize every possible factor to achieve world-class efficiency. Your choice of a genuine Ultra-Tool® Solid Carbide product is an excellent first step in the process. Ultra-Tool® Solid Carbide products are high-performance tools that will perform best in a machining environment characterized by rigid fixturing and minimal spindle runout. Attention to proper speed and feed will eliminate vibration, chatter, and overheating as well as extending tool life. Generally speaking, the peripheral speed of solid carbide tools will vary with the hardness of the material being cut. The harder the material, the slower the speed. High speed and insufficient feed will cause work surface glazing and poor tool life. Chipping of cutting edges is an indication of chatter which can be caused by too high of speed, too light of cut, or improper support of the tool or workpiece. Handling is also very important; sharpened cutting edges should never be allowed to come into contact with any hard object (or another tool) in a non-machining environment as they will chip easily. Keep your Ultra-Tool® products in their original protective packaging until ready for use.

The guidelines on the following pages are generalities designed to demonstrate the operating window within which you may experience the best results. The charts and information provided should prove valuable in longer tool life with greatly reduced operational costs. This information is for uncoated product: SmoothCoat products will have significantly higher speed and feed rates. For more information contact an Ultra-Tool® Factory Engineer, Sales Manager or consult our websites at [ultra-tool.com](http://ultra-tool.com) and [toolalliance.com](http://toolalliance.com). eMails can be sent to [technical@toolalliance.com](mailto:technical@toolalliance.com).

Ultra-Tool International, Inc. is constantly striving to improve its processes, specifications, and tolerances. As such, products are subject to change without prior notice.

**WARNING:** Grinding or other use of this tool may produce hazardous dust and fumes which may endanger health. Grinding or modification should be done by professionals only. To avoid adverse health effects, read the material safety data sheet for this product. Utilize adequate ventilation and appropriate protection. Cutting tools may shatter when broken; eye protection in vicinity of use is strongly advised. MSDS available at [www.ultra-tool.com](http://www.ultra-tool.com).



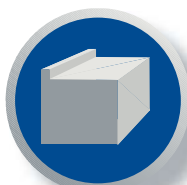
## Commonly Used Formulas:

Surface Feet Minute (SFM)=RPM x Diam. x .262  
 Revolutions Per Minute (RPM)=3.82 x (SFM / Diam.)  
 Feed Rate (IPM)=IPT x #teeth x RPM  
 Drilling (IPM)=IPR x RPM  
 Feed Per Tooth (IPT)=IPM / (#teeth x RPM)  
 Convert Inches to millimeters: Multiply by 25.4  
 Convert millimeters to Inches: Multiply by .03937

**Tech Help** Call, eMail us at [technical@toolalliance.com](mailto:technical@toolalliance.com), or copy / fax us this page for detailed assistance beyond what printed materials can provide. Please have the following information available to assure we can promptly process a response.

Checklist:

- Tool Description
- Application Description
- Work Piece Material
- Hardness (HRc)
- Current Speed (RPM or SFPM)
- Current Feed (CPT or IPM or FPR)
- Axial DOC
- Radial DOC
- Hole Depth (drilling)
- Machine Tool



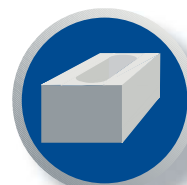
Face Milling



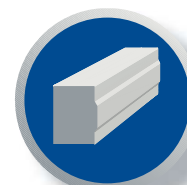
End Milling



Slot Milling



Pocket Milling



Peripheral Milling



Application Tips for ULTRATOOL® Solid Carbide Products

Trouble Shooting for Ultra-Tool® Carbide End Mills

Problem	Cause	Solution
<b>Chipping</b>	<ul style="list-style-type: none"> <li>Feed rate too high</li> <li>Up milling (conventional)</li> <li>Cutting edge too sharp</li> <li>Chattering</li> <li>Loose tool</li> <li>Workpiece rigidity</li> <li>Tool rigidity</li> <li>Low cutting speed</li> <li>Loose toolholder</li> </ul>	<ul style="list-style-type: none"> <li>Reduce feed rate</li> <li>Change to down milling (climb)</li> <li>Hone cutting edge or allow break-in</li> <li>Reduce RPM</li> <li>Remove, clean, and retighten</li> <li>Tighten workpiece holding method</li> <li>Shorten LOC, place shank further up holder</li> <li>Increase RPM</li> <li>Remove from spindle, clean and replace</li> </ul>
<b>Wear</b>	<ul style="list-style-type: none"> <li>High cutting speed</li> <li>Low feed rate</li> <li>Up milling (conventional)</li> <li>Hard material</li> <li>Poor chip evacuation</li> <li>Improper cutter helix</li> <li>Poor coolant</li> </ul>	<ul style="list-style-type: none"> <li>Reduce RPM</li> <li>Increase feed rate</li> <li>Change to down milling (climb)</li> <li>Use coated tool</li> <li>Reposition coolant lines, use air blasting</li> <li>Change to recommended helix angle</li> <li>Replace coolant or correct mixture</li> </ul>
<b>Breakage</b>	<ul style="list-style-type: none"> <li>Feed rate too high</li> <li>Depth of cut too large</li> <li>Poor tool rigidity</li> <li>Tool wear</li> <li>Poor chip evacuation</li> </ul>	<ul style="list-style-type: none"> <li>Reduce feed rate</li> <li>Reduce depth of cut</li> <li>Shorten LOC, place shank further up holder</li> <li>Replace/regrind sooner</li> <li>Reposition coolant lines, use air blasting</li> </ul>
<b>Chattering</b>	<ul style="list-style-type: none"> <li>Speed and feed too high</li> <li>Poor toolholder rigidity</li> <li>Poor spindle rigidity</li> <li>Workpiece rigidity</li> <li>Relief angle too high</li> <li>Depth of cut too large</li> <li>Poor tool rigidity</li> </ul>	<ul style="list-style-type: none"> <li>Reduce feed rate</li> <li>Replace with shorter/more rigid holder</li> <li>Use larger spindle or different machine tool</li> <li>Tighten workpiece holding method</li> <li>Regrind with smaller relief angle</li> <li>Reduce depth of cut</li> <li>Shorten LOC, place shank further up holder</li> </ul>
<b>Short Life</b>	<ul style="list-style-type: none"> <li>Cutter/workpiece friction</li> <li>Hard material</li> <li>Poor material condition</li> <li>Improper cutter angle</li> <li>Poor coolant</li> </ul>	<ul style="list-style-type: none"> <li>Use coated tool</li> <li>Use coated tool, clean material surface</li> <li>Regrind with proper primary relief angle</li> <li>Replace coolant or correct mixture</li> </ul>
<b>Chip Packing</b>	<ul style="list-style-type: none"> <li>Feed rate too high</li> <li>Low cutting speed</li> <li>Insufficient chip room</li> <li>Insufficient coolant</li> </ul>	<ul style="list-style-type: none"> <li>Reduce feed rate or increase speed</li> <li>Increase RPM or reduce feed rate</li> <li>Use tool with less flutes, increase helix</li> <li>Increase volume of coolant</li> </ul>
<b>Poor Surface Finish</b>	<ul style="list-style-type: none"> <li>Feed rate too high</li> <li>Low cutting speed</li> <li>Tool wear</li> <li>Edge build up</li> <li>Depth of cut too large</li> <li>Chip welding</li> </ul>	<ul style="list-style-type: none"> <li>Reduce feed rate</li> <li>Increase RPM</li> <li>Replace or regrind tool</li> <li>Increase RPM, switch to higher helix tool</li> <li>Reduce depth of cut</li> <li>Increase volume of coolant</li> </ul>
<b>Burring or Workpiece Chipping</b>	<ul style="list-style-type: none"> <li>Tool wear</li> <li>Improper helix angle</li> <li>Feed rate too high</li> <li>Depth of cut too large</li> </ul>	<ul style="list-style-type: none"> <li>Replace or regrind tool</li> <li>Change to recommended helix angle</li> <li>Reduce feed rate</li> <li>Reduce depth of cut</li> </ul>
<b>Workpiece Inaccuracy</b>	<ul style="list-style-type: none"> <li>Loose/worn toolholder</li> <li>Poor toolholder rigidity</li> <li>Poor spindle rigidity</li> <li>Insufficient number of flutes</li> <li>Tool deflection</li> </ul>	<ul style="list-style-type: none"> <li>Repair or replace</li> <li>Replace with shorter/more rigid toolholder</li> <li>Use larger spindle or different machine tool</li> <li>Use tool with higher flute quantity</li> <li>Shorten LOC, place shank further up holder</li> </ul>

Trouble Shooting for Ultra-Tool® Carbide Drills

Problem	Cause	Solution (see key below)
<b>Heavy Wear at Outer Edge</b>	<ul style="list-style-type: none"> <li>Insufficient coolant</li> <li>Incorrect speed &amp; feed</li> </ul>	<ul style="list-style-type: none"> <li>5, 6</li> <li>1, 2, 8</li> </ul>
<b>Chipping at Outer Cutting Edge</b>	<ul style="list-style-type: none"> <li>Loose tool, tool movement</li> <li>Workpiece movement</li> <li>Poor coolant conditions</li> <li>Incorrect speed &amp; feed</li> </ul>	<ul style="list-style-type: none"> <li>8, 10, 11, 12, 14, 16, 17, 21</li> <li>8, 12, 13, 21</li> <li>5, 6</li> <li>1, 2, 3, 4</li> </ul>
<b>Drill Point Chipping</b>	<ul style="list-style-type: none"> <li>Loose tool, tool movement</li> <li>Incorrect speed &amp; feed</li> <li>Drill centering</li> </ul>	<ul style="list-style-type: none"> <li>10, 11, 12, 14</li> <li>1, 2, 3, 4</li> <li>8, 10, 11, 12, 21</li> </ul>
<b>Margin Wear</b>	<ul style="list-style-type: none"> <li>Drill margin rubbing wall</li> <li>Poor chip evacuation</li> <li>Poor coolant conditions</li> <li>Workpiece movement</li> </ul>	<ul style="list-style-type: none"> <li>20 (check drill for backtaper)</li> <li>5, 6, 8, 20</li> <li>5, 6</li> <li>8, 13, 21</li> </ul>
<b>Tool Breakage</b>	<ul style="list-style-type: none"> <li>Loose tool, tool movement</li> <li>Workpiece movement</li> <li>Wrong drill type</li> <li>Poor coolant conditions</li> <li>Incorrect speed &amp; feed</li> </ul>	<ul style="list-style-type: none"> <li>8, 10, 11, 12, 14, 16, 17, 21</li> <li>8, 12, 13, 21</li> <li>9, 15, 16, 18, 19, 20</li> <li>5, 6</li> <li>1, 2, 3, 4</li> </ul>
<b>Poor Tool Life</b>	<ul style="list-style-type: none"> <li>Incorrect speed &amp; feed</li> <li>Poor coolant conditions</li> <li>Wrong drill point</li> </ul>	<ul style="list-style-type: none"> <li>1, 2, 3, 4</li> <li>5, 6</li> <li>8, 21</li> </ul>
<b>Drill Walk</b>	<ul style="list-style-type: none"> <li>Incorrect speed &amp; feed</li> <li>Tool wear</li> <li>Wrong drill point</li> <li>Material condition</li> </ul>	<ul style="list-style-type: none"> <li>1, 2</li> <li>7, 8, 21</li> <li>8, 10, 11, 21</li> <li>11, 12, 15, 16, 17</li> </ul>
<b>Chip Welding</b>	<ul style="list-style-type: none"> <li>Poor coolant conditions</li> <li>Wrong drill type</li> </ul>	<ul style="list-style-type: none"> <li>5, 6</li> <li>19, 20</li> </ul>
<b>Hole Size Inaccuracy</b>	<ul style="list-style-type: none"> <li>Incorrect speed &amp; feed</li> <li>Poor coolant conditions</li> <li>Loose tool</li> <li>Wrong drill type</li> </ul>	<ul style="list-style-type: none"> <li>1, 2, 3, 4</li> <li>5, 6</li> <li>14</li> <li>9, 18</li> </ul>
<b>Non-Cylindrical Hole</b>	<ul style="list-style-type: none"> <li>Loose tool, tool movement</li> <li>Workpiece movement</li> <li>Incorrect speed &amp; feed</li> <li>Wrong drill type</li> </ul>	<ul style="list-style-type: none"> <li>8, 10, 11, 12, 14, 16, 17</li> <li>13</li> <li>1, 2</li> <li>18, 21</li> </ul>
<b>Heavy Burr</b>	<ul style="list-style-type: none"> <li>Incorrect speed &amp; feed</li> <li>Incorrect drill point</li> </ul>	<ul style="list-style-type: none"> <li>1, 2</li> <li>8, 21</li> </ul>
<b>Blue Chips</b>	<ul style="list-style-type: none"> <li>Poor coolant conditions</li> <li>Tool wear</li> </ul>	<ul style="list-style-type: none"> <li>5, 6</li> <li>7, 8</li> </ul>
<b>Long Chips</b>	<ul style="list-style-type: none"> <li>Poor point grind</li> <li>Incorrect speed &amp; feed</li> </ul>	<ul style="list-style-type: none"> <li>8</li> <li>1, 2</li> </ul>
<b>Solutions Key for Drills</b>	<ul style="list-style-type: none"> <li>1) Reduce RPM</li> <li>2) Increase feed</li> <li>3) Increase RPM</li> <li>4) Reduce feed</li> <li>5) Increase coolant</li> <li>6) Increase mixture</li> <li>7) Add negative hone</li> <li>8) Repoint drill</li> <li>9) Correct drill type/size</li> <li>10) Use self-centering drill</li> <li>11) Spot/center drill</li> <li>12) Clean surface</li> <li>13) Improve rigidity/clamp</li> <li>14) Tighten holder</li> <li>15) Use straight flute</li> <li>16) Use stub length</li> <li>17) Place further up holder</li> <li>18) Use three-flute</li> <li>19) Use slower helix</li> <li>20) Use parabolic design</li> <li>21) Change point style</li> </ul>	

Trouble Shooting for Ultra-Tool® Carbide Reamers

Problem	Cause	Solution
<b>Chatter</b>	<ul style="list-style-type: none"> <li>High cutting speed</li> <li>Feed rate too low</li> <li>Workpiece movement</li> <li>Toolholder rigidity</li> <li>Tool rigidity</li> </ul>	<ul style="list-style-type: none"> <li>Lower RPM or increase feed rate</li> <li>Increase feed rate</li> <li>Tighten workpiece rigidity</li> <li>Tighten toolholder or reduce float</li> <li>Use shorter tool, place further up holder</li> </ul>
<b>Tool Wear / Chipping</b>	<ul style="list-style-type: none"> <li>Incorrect feed rate</li> <li>Incorrect speed</li> <li>Poor hole condition</li> <li>Abrasive material</li> <li>Poor chip evacuation</li> <li>Poor coolant</li> <li>Insufficient coolant</li> <li>Workpiece alignment</li> <li>Excessive stock removal</li> </ul>	<ul style="list-style-type: none"> <li>Increase feed rate (typically)</li> <li>Reduce speed (typically)</li> <li>Work-hardened hole; change drilling type</li> <li>Use proper coolant, coated reamer</li> <li>Use/increase coolant, use helical reamer</li> <li>Replace coolant or correct mixture</li> <li>Increase coolant volume</li> <li>Use bushing, floating holder, lead chamfer</li> <li>Use larger diameter starter drill</li> </ul>
<b>Tool Breakage</b>	<ul style="list-style-type: none"> <li>Incorrect feed rate</li> <li>Incorrect speed</li> <li>Tool wear</li> <li>Bottoming of hole</li> <li>Coolant conditions</li> <li>Insufficient stock removal</li> <li>Poor set up</li> <li>Excessive stock removal</li> </ul>	<ul style="list-style-type: none"> <li>Increase feed rate (typically)</li> <li>Reduce speed (typically)</li> <li>Sharpen or replace reamer</li> <li>Adjust stop depth, check preset</li> <li>Increase, replace, or correct coolant</li> <li>Use smaller diameter starter drill</li> <li>Use bushing, floating toolholder</li> <li>Use larger diameter starter drill</li> </ul>

Problem	Cause	Solution
<b>Poor Finish</b>	<ul style="list-style-type: none"> <li>Feed rate too low</li> <li>Insufficient stock removal</li> <li>Poor hole condition</li> <li>Poor coolant</li> <li>Insufficient coolant</li> </ul>	<ul style="list-style-type: none"> <li>Increase feed rate</li> <li>Use smaller diameter starter drill</li> <li>Work-hardened hole; change drilling type</li> <li>Replace/correct coolant mixture</li> <li>Increase coolant volume</li> </ul>
<b>Hole Tolerance</b>	<ul style="list-style-type: none"> <li>Workpiece alignment</li> <li>Incorrect tool size</li> <li>Material shrinkage</li> <li>Tool wear</li> <li>Toolholder runout</li> </ul>	<ul style="list-style-type: none"> <li>Use bushing, floating toolholder</li> <li>Check diameter of tool</li> <li>Adjust diameter for shrinkage; more coolant</li> <li>Sharpen or replace tool</li> <li>Adjust or replace toolholder</li> </ul>