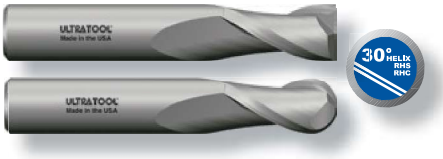
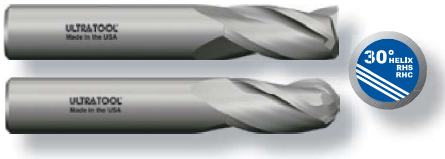
phone 714.898.9224 / 800.854.2431 / fax 714.891.7816
5451 McFadden Avenue • Huntington Beach, CA 92649
ultra-tool.com

Single End Standard Length End Mills by ULTRATOOL®

Series 330S Square End
330B Ball End • Two Flute



Series 362S Square End
362B Ball End • Three Flute



Series 320S Square End
320B Ball End • Four Flute

The **Ultra-Tool®** Series 330, 362, and 320 represents the industry's best value in a general purpose design. These end mills are more than capable of handling 75% of milling applications due to robust geometry, quality craftsmanship, and best-in-class carbide substrate. Most importantly, the Series 330, 362, and 320 all benefit from the Tool Alliance® duo of proprietary & value-added features: SmoothGrind® & SmoothContricity®, with SmoothCoat® and SmoothEdge® available individually for an extra charge. Additionally, special radii and clearance necks can quickly be added to any size.

Detailed Speeds and Feeds instructions can be located on Page #59.

Standard features:
SmoothGrind® SmoothContricity®
Available options:
SmoothCoat® SmoothEdge®

ULTRA-Grain®

SFR Ultra-Tool End Mill Specs:
Cutting Diam +.000/-.002
Shank Diam +.0000/-.0003

Diam	LOC	OAL	Shank	330S EDP#	330B EDP#	362S EDP#	362B EDP#	320S EDP#	320B EDP#	Square Price	Coated Square	Ball Price	Coated Ball
1/64	3/64	1-1/2	1/8	33001	33101	36201	36301	32001	32101	$10.90	$12.70	$13.90	$15.60
1/32	3/32	1-1/2	1/8	33002	33102	36202	36302	32002	32102	$8.20	$9.90	$10.40	$12.20
3/64	3/16	1-1/2	1/8	33003	33103	36203	36303	32003	32103	$8.20	$9.90	$10.40	$12.20
1/16	3/16	1-1/2	1/8	33004	33104	36204	36304	32004	32104	$7.50	$9.30	$9.80	$11.60
5/64	1/4	1-1/2	1/8	33005	33105	36205	36305	32005	32105	$7.50	$9.30	$9.80	$11.60
3/32	3/8	1-1/2	1/8	33006	33106	36206	36306	32006	32106	$7.40	$9.10	$9.60	$11.30
7/64	1/2	1-1/2	1/8	33007	33107	36207	36307	32007	32107	$7.40	$9.10	$9.60	$11.30
1/8	1/2	1-1/2	1/8	33008	33108	36208	36308	32008	32108	$6.70	$8.40	$8.70	$10.40
9/64	1/2	2"	3/16	33009	33109	36209	36309	32009	32109	$10.20	$12.30	$12.80	$14.90
5/32	9/16	2"	3/16	33010	33110	36210	36310	32010	32110	$10.20	$12.30	$12.80	$14.90
11/64	9/16	2"	3/16	33011	33111	36211	36311	32011	32111	$10.20	$12.30	$12.80	$14.90
3/16	5/8	2"	3/16	33012	33112	36212	36312	32012	32112	$9.50	$11.50	$12.10	$14.20
13/64	5/8	2-1/2	1/4	33013	33113	36213	36313	32013	32113	$12.80	$16.80	$16.00	$20.10
7/32	5/8	2-1/2	1/4	33014	33114	36214	36314	32014	32114	$12.80	$16.80	$16.00	$20.10
15/64	3/4	2-1/2	1/4	33015	33115	36215	36315	32015	32115	$12.80	$16.80	$16.00	$20.10
1/4	3/4	2-1/2	1/4	33016	33116	36216	36316	32016	32116	$11.30	$15.30	$14.50	$18.60
17/64	3/4	2-1/2	5/16	33017	33117	36217	36317	32017	32117	$17.80	$22.80	$22.20	$27.20
9/32	3/4	2-1/2	5/16	33018	33118	36218	36318	32018	32118	$17.80	$22.80	$22.20	$27.20
19/64	13/16	2-1/2	5/16	33019	33119	36219	36319	32019	32119	$17.80	$22.80	$22.20	$27.20
5/16	13/16	2-1/2	5/16	33020	33120	36220	36320	32020	32120	$17.40	$22.30	$22.20	$27.10
21/64	13/16	2-1/2	3/8	33021	33121	36221	36321	32021	32121	$24.00	$29.30	$29.80	$35.10
11/32	13/16	2-1/2	3/8	33022	33122	36222	36322	32022	32122	$24.00	$29.30	$29.80	$35.10
23/64	1"	2-1/2	3/8	33023	33123	36223	36323	32023	32123	$24.00	$29.30	$29.80	$35.10
3/8	1"	2-1/2	3/8	33024	33124	36224	36324	32024	32124	$20.70	$26.00	$26.40	$31.70
25/64	1"	2-3/4	7/16	33025	33125	36225	36325	32025	32125	$31.80	$38.70	$39.90	$46.70
13/32	1"	2-3/4	7/16	33026	33126	36226	36326	32026	32126	$31.80	$38.70	$39.90	$46.70
27/64	1"	2-3/4	7/16	33027	33127	36227	36327	32027	32127	$31.80	$38.70	$39.90	$46.70
7/16	1"	2-3/4	7/16	33028	33128	36228	36328	32028	32128	$29.30	$36.30	$37.40	$44.30
29/64	1"	3"	1/2	33029	33129	36229	36329	32029	32129	$36.80	$43.80	$45.80	$52.90
15/32	1"	3"	1/2	33030	33130	36230	36330	32030	32130	$36.80	$43.80	$45.80	$52.90
31/64	1"	3"	1/2	33031	33131	36231	36331	32031	32131	$36.80	$43.80	$45.80	$52.90
1/2	1"	3"	1/2	33032	33132	36232	36332	32032	32132	$34.10	$41.10	$43.10	$50.20
9/16	1-1/4	3-1/2	9/16	33034	33134	36234	36334	32034	32134	$58.80	$68.80	$73.90	$83.90
5/8	1-1/2	3-1/2	5/8	33036	33136	36236	36336	32036	32136	$65.00	$75.90	$81.20	$92.20
11/16	1-1/2	4"	3/4	33038	33138	36238	36338	32038	32138	$97.90	$110.80	$122.60	$135.50
3/4	1-1/2	4"	3/4	33040	33140	36240	36340	32040	32140	$90.70	$103.60	$113.40	$126.30
7/8	1-1/2	4"	7/8	33044	33144	36244	36344	32044	32144	$143.30	$158.10	$178.30	$193.10
1"	1-1/2	4"	1"	33048	33148	36248	36348	32048	32148	$149.40	$168.00	$186.60	$205.00
1-1/4	2"	4-1/2	1-1/4	33080	33180	36280	36380	32080	32180	$345.50	$376.40	$414.60	$445.50

Application Data for Standard ULTRATOOL® End Mills

The milling data presented below is for all "standard" Series of Ultra end mills (data is presented separately on each respective product page for our application-specific high performance designs). Note: When using SmoothCoat & SmoothEdge surface treatments, Surface Feet or Meters Per Minute can be increased from the stated levels by at least 25%.

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"
Steel	**Peripheral**	**Slotting**					**Feed Per Tooth (FPT)**					
1018 / 1020	150 to 350	150 to 300	.0005	.0010	.0015	.0018	.0020	.0025	.0030	.0035	.0040	.0045
4140 / 4340 / P20	150 to 300	125 to 225	.0005	.0007	.0010	.0012	.0015	.0018	.0020	.0025	.0030	.0040
Stainless Steel												
303 / 304 / 316	150 to 300	125 to 250	.0005	.0007	.0010	.0012	.0015	.0018	.0020	.0030	.0040	.0040
410 / 420 / 440C	150 to 300	125 to 250	.0005	.0007	.0010	.0012	.0015	.0018	.0020	.0025	.0035	.0038
15-5/17-4 ≤ 32HRc	125 to 250	100 to 225	.0005	.0007	.0010	.0012	.0015	.0018	.0020	.0025	.0030	.0038
15-5/17-4 ≥ 32HRc	100 to 150	100 to 150	.0003	.0005	.0010	.0012	.0015	.0015	.0015	.0020	.0030	.0038
13-8 / 316L	125 to 300	125 to 250	.0005	.0007	.0010	.0012	.0015	.0018	.0020	.0030	.0040	.0040
Tool Steel												
A2/D2/H13 ≤ 32HRc	125 to 250	100 to 200	.0005	.0007	.0010	.0012	.0015	.0018	.0020	.0025	.0030	.0035
A2/D2/H13 ≥ 32HRc	100 to 150	100 to 125	.0003	.0005	.0010	.0012	.0015	.0015	.0015	.0020	.0030	.0035
Titanium												
6Al-4V	120 to 250	100 to 175	.0005	.0007	.0010	.0012	.0012	.0018	.0020	.0020	.0030	.0040
High Temp Alloys												
Inconel 625	50 to 150	50 to 125	.0005	.0007	.0010	.0012	.0012	.0018	.0020	.0020	.0025	.0030
Inconel 718	50 to 150	50 to 125	.0003	.0005	.0010	.0012	.0012	.0015	.0015	.0020	.0025	.0025
Cast Iron												
Gray Iron ≤ 32HRc	150 to 350	125 to 300	.0005	.0007	.0010	.0012	.0015	.0018	.0020	.0030	.0040	.0045
Ductile Iron	150 to 300	125 to 250	.0005	.0007	.0010	.0012	.0015	.0018	.0020	.0025	.0035	.0045
Non-Ferrous												
6061 T6 Aluminum	up to 2000	up to 1500	.0010	.0020	.0020	.0025	.0030	.0035	.0040	.0050	.0060	.0070
Copper,Brass,Bronze	up to 1200	up to 1000	.0010	.0010	.0020	.0022	.0025	.0028	.0030	.0040	.0040	.0050
Plastic	up to 2000	up to 1500	.0010	.0020	.0030	.0035	.0040	.0050	.0060	.0080	.0100	.0120

Metric End Mill Specifications:
Diameter (mm): +.000 / -.051mm
Shank Diameter(mm): +.000 / -.007mm
LOC: +1.52 / -0.00mm
OAL: ±1.52mm

Metric

Material	SMPM	SMPM	2 mm	3 mm	4 mm	6 mm	8 mm	10 mm	12 mm	16 mm	20 mm	25 mm
Steel	**Peripheral**	**Slotting**					**Feed Per Tooth (FPT)**					
1018 / 1020	45 to 110	45 to 90	0.010	0.012	0.025	0.038	0.045	0.050	0.080	0.090	0.100	0.120
4140 / 4340 / P20	45 to 90	40 to 70	0.010	0.012	0.018	0.025	0.030	0.038	0.050	0.065	0.080	0.100
Stainless Steel												
303 / 304 / 316	45 to 90	40 to 75	0.010	0.012	0.018	0.025	0.030	0.038	0.050	0.080	0.100	0.100
410 / 420 / 440C	45 to 90	40 to 75	0.010	0.012	0.018	0.025	0.030	0.038	0.050	0.065	0.080	0.100
15-5/17-4 ≤ 32HRc	38 to 75	30 to 70	0.010	0.012	0.018	0.025	0.030	0.038	0.050	0.065	0.080	0.100
15-5/17-4 ≥ 32HRc	30 to 45	30 to 45	0.005	0.007	0.012	0.025	0.030	0.038	0.038	0.050	0.080	0.100
13-8 / 316L	38 to 90	40 to 75	0.010	0.012	0.018	0.025	0.030	0.038	0.050	0.080	0.100	0.100
Tool Steel												
A2/D2/H13 ≤ 32HRc	38 to 75	30 to 60	0.010	0.012	0.018	0.025	0.030	0.038	0.050	0.065	0.080	0.090
A2/D2/H13 ≥ 32HRc	30 to 45	30 to 40	0.005	0.007	0.012	0.025	0.030	0.038	0.038	0.050	0.080	0.090
Titanium												
6Al-4V	35 to 75	30 to 53	0.010	0.012	0.018	0.025	0.030	0.038	0.050	0.065	0.080	0.100
High Temp Alloys												
Inconel 625	15 to 45	15 to 38	0.010	0.012	0.018	0.025	0.030	0.038	0.050	0.050	0.065	0.070
Inconel 718	15 to 45	15 to 38	0.005	0.007	0.012	0.025	0.030	0.038	0.038	0.050	0.065	0.065
Cast Iron												
Gray Iron ≤ 32HRc	45 to 110	40 to 90	0.010	0.012	0.018	0.025	0.030	0.038	0.050	0.080	0.100	0.120
Ductile Iron	45 to 90	40 to 75	0.010	0.012	0.018	0.025	0.030	0.038	0.050	0.065	0.090	0.120
Non-Ferrous												
6061 T6 Aluminum	up to 600	up to 450	0.020	0.025	0.050	0.050	0.064	0.080	0.100	0.130	0.150	0.180
Copper,Brass,Bronze	up to 365	up to 300	0.020	0.025	0.025	0.050	0.056	0.065	0.080	0.100	0.100	0.130
Plastic	up to 600	up to 450	0.020	0.025	0.050	0.080	0.089	0.100	0.150	0.200	0.250	0.300

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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 (K_{1c}): 6.6
TRS (GPa): 3.8
Density (gm/cc): 14.90

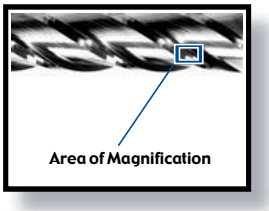
ULTRA-Carb®

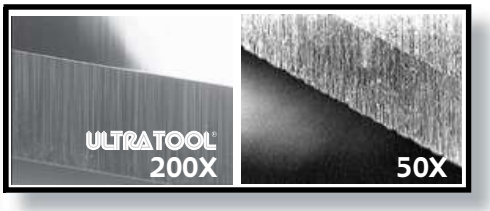
Ultra-Grain® 1
Cobalt Percentage: 10%
Grain Size (µm): ≤ 0.7
Hardness: 92.7 HRa
Fracture Toughness (K_{1c}): 7.9
TRS (GPa): 4.1
Density (gm/cc): 14.30

ULTRA-Grain®

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.

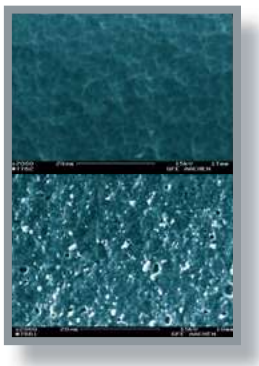
SFR
Shrink Fit Ready

4 SmoothEdge®

.0001 SmoothEdge atop cylindrical margin atop primary relief.

SE

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

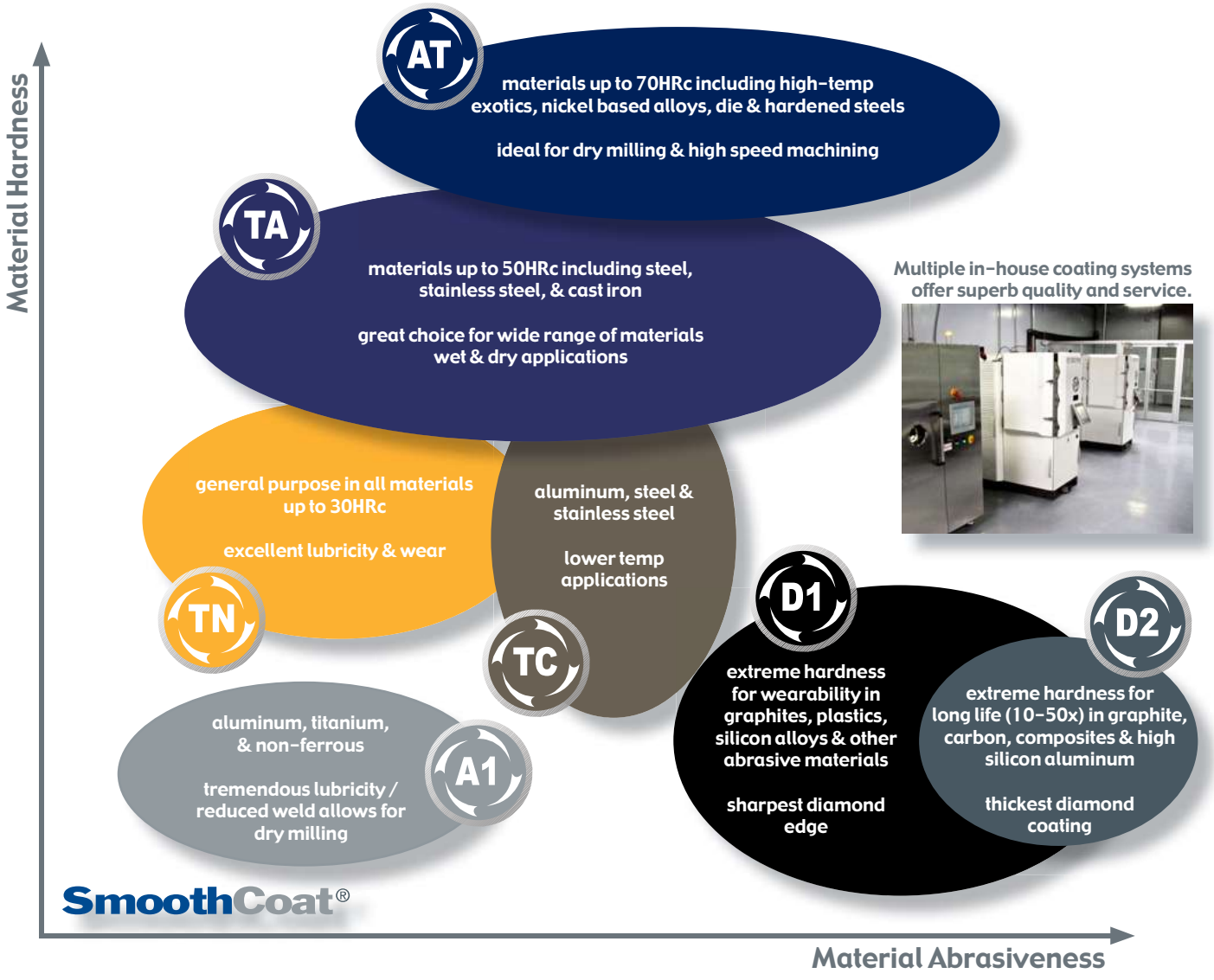
COMPONENT #5: The Coating Process The challenge of finding a coating method to leverage 100% of the inherent assets of our carbide grade and grinding technologies was difficult. What we finally discovered was such a perfect fit and so logical for our product lines that we invested heavily into the process 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 #.

UC	TA	TN	AT	TC	A1	D1	D2
UnCoated	TiAlN	TiN	AlTiN HSN^2	TiCN	TiB2	PVD Diamond	CVD Diamond

Standard Coatings available at "Coated" List Price

Premium Coatings available



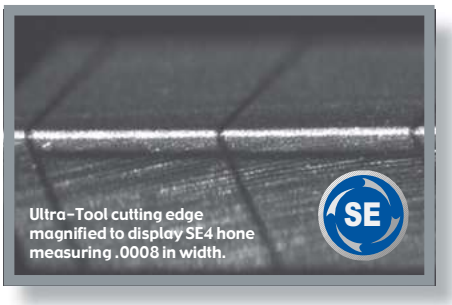
Multiple in-house coating systems offer superb quality and service.

SmoothEdge®

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!

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.



Ultra-Tool cutting edge magnified to display SE4 hone measuring .0008 in width.

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

Primary SmoothCoat recommendations:

A1 for SE2 TA for SE4 AT for SE5

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.

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ultra-tool.com

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** and **toolalliance.com**. eMails can be sent to **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.

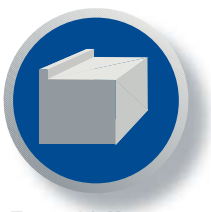
WARNING: Grinding or other use of this tool may produce hazardous dust and fumes which may endanger health. Grinding or modification should be done by professionals only. To avoid adverse health effects, read the material safety data sheet for this product. Utilize adequate ventilation and appropriate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

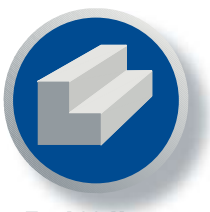
Commonly Used Formulas:

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

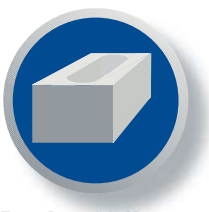
Tech Help Call, eMail us at **technical@toolalliance.com**, or copy / fax us this page for detailed assistance beyond what printed materials can provide. Please have the following information available to assure we can promptly process a response.

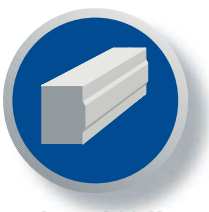
Checklist:
- Tool Description
- Application Description
- Work Piece Material
- Hardness (HRc)
- Current Speed (RPM or SFPM)
- Current Feed (CPT or IPM or FPR)
- Axial DOC
- Radial DOC
- Hole Depth (drilling)
- Machine Tool


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
Chipping	• Feed rate too high • Up milling (conventional) • Cutting edge too sharp • Chattering • Loose tool • Workpiece rigidity • Tool rigidity • Low cutting speed • Loose toolholder	• Reduce feed rate • Change to down milling (climb) • Hone cutting edge or allow break-in • Reduce RPM • Remove, clean, and retighten • Tighten workpiece holding method • Shorten LOC, place shank further up holder • Increase RPM • Remove from spindle, clean and replace
Wear	• High cutting speed • Low feed rate • Up milling (conventional) • Hard material • Poor chip evacuation • Improper cutter helix • Poor coolant	• Reduce RPM • Increase feed rate • Change to down milling (climb) • Use coated tool • Reposition coolant lines, use air blasting • Change to recommended helix angle • Replace coolant or correct mixture
Breakage	• Feed rate too high • Depth of cut too large • Poor tool rigidity • Tool wear • Poor chip evacuation	• Reduce feed rate • Reduce depth of cut • Shorten LOC, place shank further up holder • Replace/regrind sooner • Reposition coolant lines, use air blasting
Chattering	• Speed and feed too high • Poor toolholder rigidity • Poor spindle rigidity • Workpiece rigidity • Relief angle too high • Depth of cut too large • Poor tool rigidity	• Reduce feed rate • Replace with shorter/more rigid holder • Use larger spindle or different machine tool • Tighten workpiece holding method • Regrind with smaller relief angle • Reduce depth of cut • Shorten LOC, place shank further up holder
Short Life	• Cutter/workpiece friction • Hard material • Poor material condition • Improper cutter angle • Poor coolant	• Use coated tool • Use coated tool • Use coated tool, clean material surface • Regrind with proper primary relief angle • Replace coolant or correct mixture
Chip Packing	• Feed rate too high • Low cutting speed • Insufficient chip room • Insufficient coolant	• Reduce feed rate or increase speed • Increase RPM or reduce feed rate • Use tool with less flutes, increase helix • Increase volume of coolant
Poor Surface Finish	• Feed rate too high • Low cutting speed • Tool wear • Edge build up • Depth of cut too large • Chip welding	• Reduce feed rate • Increase RPM • Replace or regrind tool • Increase RPM, switch to higher helix tool • Reduce depth of cut • Increase volume of coolant
Burring or Workpiece Chipping	• Tool wear • Improper helix angle • Feed rate too high • Depth of cut too large	• Replace or regrind tool • Change to recommended helix angle • Reduce feed rate • Reduce depth of cut
Workpiece Inaccuracy	• Loose/worn toolholder • Poor toolholder rigidity • Poor spindle rigidity • Insufficient number of flutes • Tool deflection	• Repair or replace • Replace with shorter/more rigid toolholder • Use larger spindle or different machine tool • Use tool with higher flute quantity • Shorten LOC, place shank further up holder

Trouble Shooting for Ultra-Tool® Carbide Drills

Problem	Cause	Solution (see key below)
Heavy Wear at Outer Edge	• Insufficient coolant • Incorrect speed & feed	• 5, 6 • 1, 2, 8
Chipping at Outer Cutting Edge	• Loose tool, tool movement • Workpiece movement • Poor coolant conditions • Incorrect speed & feed	• 8, 10, 11, 12, 14, 16, 17, 21 • 8, 12, 13, 21 • 5, 6 • 1, 2, 3, 4
Drill Point Chipping	• Loose tool, tool movement • Incorrect speed & feed • Drill centering	• 10, 11, 12, 14 • 1, 2, 3, 4 • 8, 10, 11, 12, 21
Margin Wear	• Drill margin rubbing wall • Poor chip evacuation • Poor coolant conditions • Workpiece movement	• 20 (check drill for backtaper) • 5, 6, 8, 20 • 5, 6 • 8, 13, 21
Tool Breakage	• Loose tool, tool movement • Workpiece movement • Wrong drill type • Poor coolant conditions • Incorrect speed & feed	• 8, 10, 11, 12, 14, 16, 17, 21 • 8, 12, 13, 21 • 9, 15, 16, 18, 19, 20 • 5, 6 • 1, 2, 3, 4
Poor Tool Life	• Incorrect speed & feed • Poor coolant conditions • Wrong drill point	• 1, 2, 3, 4 • 5, 6 • 8, 21
Drill Walk	• Incorrect speed & feed • Tool wear • Wrong drill point • Material condition	• 1, 2 • 7, 8, 21 • 8, 10, 11, 21 • 11, 12, 15, 16, 17
Chip Welding	• Poor coolant conditions • Wrong drill type	• 5, 6 • 19, 20
Hole Size Inaccuracy	• Incorrect speed & feed • Poor coolant conditions • Loose tool • Wrong drill type	• 1, 2, 3, 4 • 5, 6 • 14 • 9, 18
Non-Cylindrical Hole	• Loose tool, tool movement • Workpiece movement • Incorrect speed & feed • Wrong drill type	• 8, 10, 11, 12, 14, 16, 17 • 13 • 1, 2 • 18, 21
Heavy Burr	• Incorrect speed & feed • Incorrect drill point	• 1, 2 • 8, 21
Blue Chips	• Poor coolant conditions • Tool wear	• 5, 6 • 7, 8
Long Chips	• Poor point grind • Incorrect speed & feed	• 8 • 1, 2

Solutions Key for Drills

1) Reduce RPM	8) Repoint drill	15) Use straight flute
2) Increase feed	9) Correct drill type/size	16) Use stub length
3) Increase RPM	10) Use self-centering drill	17) Place further up holder
4) Reduce feed	11) Spot/center drill	18) Use three-flute
5) Increase coolant	12) Clean surface	19) Use slower helix
6) Increase mixture	13) Improve rigidity/clamp	20) Use parabolic design
7) Add negative hone	14) Tighten holder	21) Change point style

Trouble Shooting for Ultra-Tool® Carbide Reamers

Problem	Cause	Solution
Chatter	• High cutting speed • Feed rate too low • Workpiece movement • Toolholder rigidity • Tool rigidity	• Lower RPM or increase feed rate • Increase feed rate • Tighten workpiece rigidity • Tighten toolholder or reduce float • Use shorter tool, place further up holder
Tool Wear / Chipping	• Incorrect feed rate • Incorrect speed • Poor hole condition • Abrasive material • Poor chip evacuation • Poor coolant • Insufficient coolant • Workpiece alignment • Excessive stock removal	• Increase feed rate (typically) • Reduce speed (typically) • Work-hardened hole; change drilling type • Use proper coolant, coated reamer • Use/increase coolant, use helical reamer • Replace coolant or correct mixture • Increase coolant volume • Use bushing, floating holder, lead chamfer • Use larger diameter starter drill
Tool Breakage	• Incorrect feed rate • Incorrect speed • Tool wear • Bottoming of hole • Coolant conditions • Insufficient stock removal • Poor set up • Excessive stock removal	• Increase feed rate (typically) • Reduce speed (typically) • Sharpen or replace reamer • Adjust stop depth, check preset • Increase, replace, or correct coolant • Use smaller diameter starter drill • Use bushing, floating toolholder • Use larger diameter starter drill

Problem	Cause	Solution
Poor Finish	• Feed rate too low • Insufficient stock removal • Poor hole condition • Poor coolant • Insufficient coolant	• Increase feed rate • Use smaller diameter starter drill • Work-hardened hole; change drilling type • Replace/correct coolant mixture • Increase coolant volume
Hole Tolerance	• Workpiece alignment • Incorrect tool size • Material shrinkage • Tool wear • Toolholder runout	• Use bushing, floating toolholder • Check diameter of tool • Adjust diameter for shrinkage; more coolant • Sharpen or replace tool • Adjust or replace toolholder