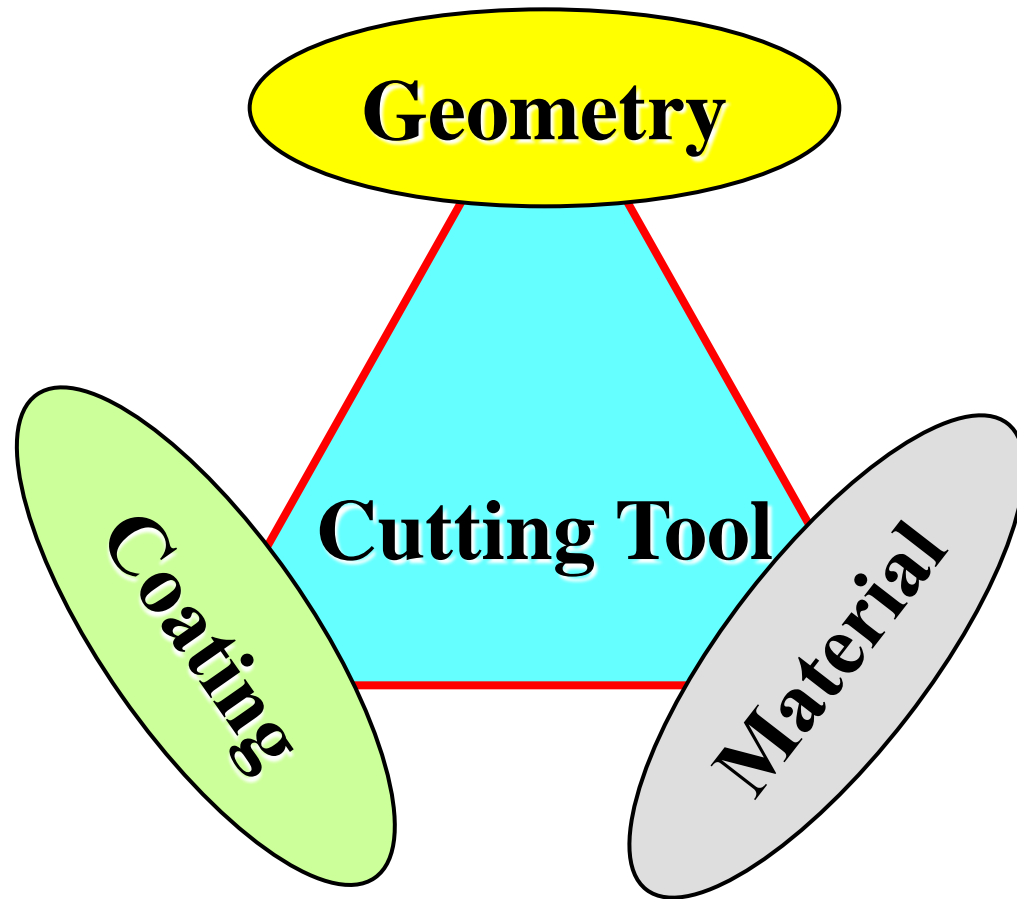


End Mill Training

Three Key Elements of a Cutting Tool



- 3 Elements Needed in a Good Cutting Tool
- Well Balanced For Best Performance

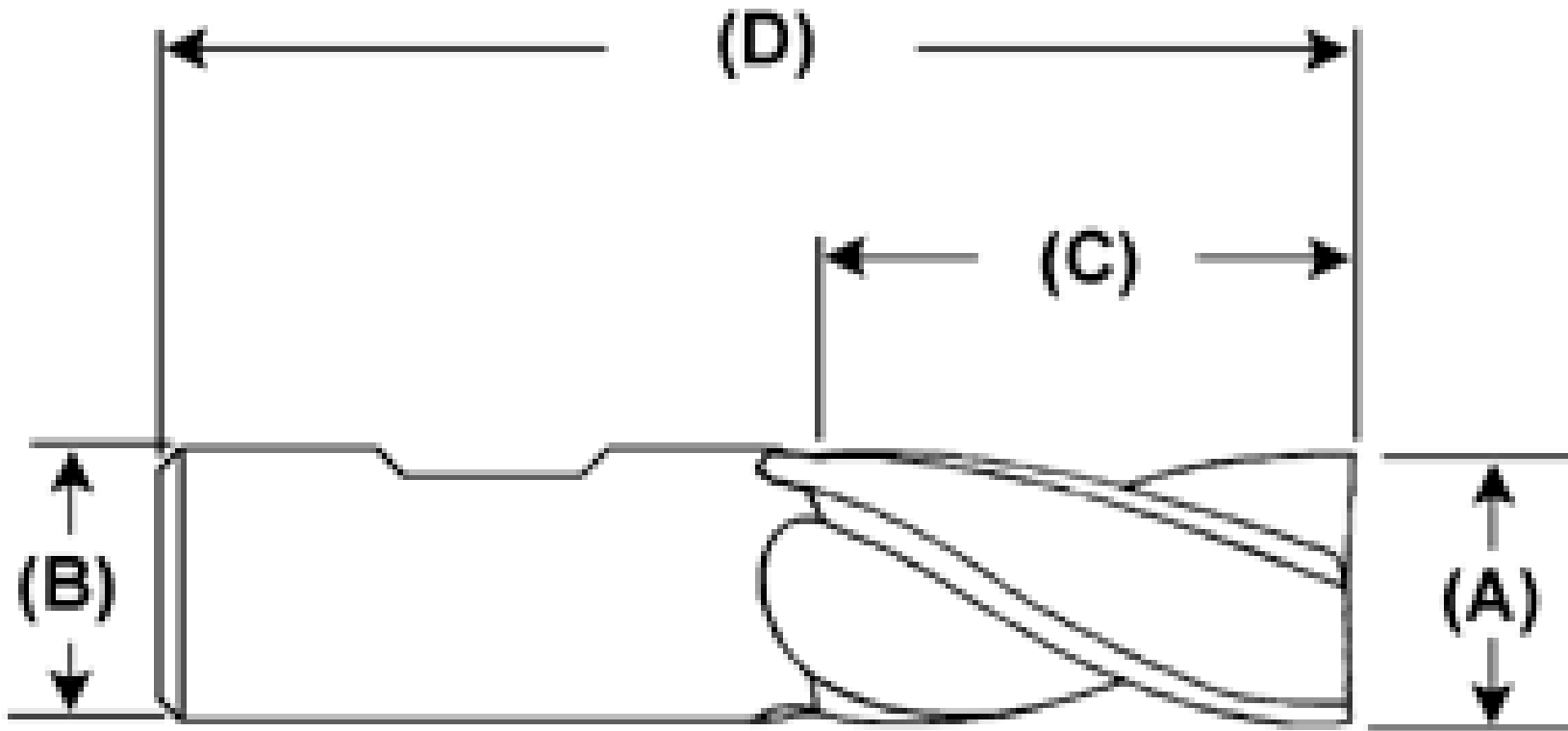
End Mill Terms

A - Mill Size or Cutting Diameter

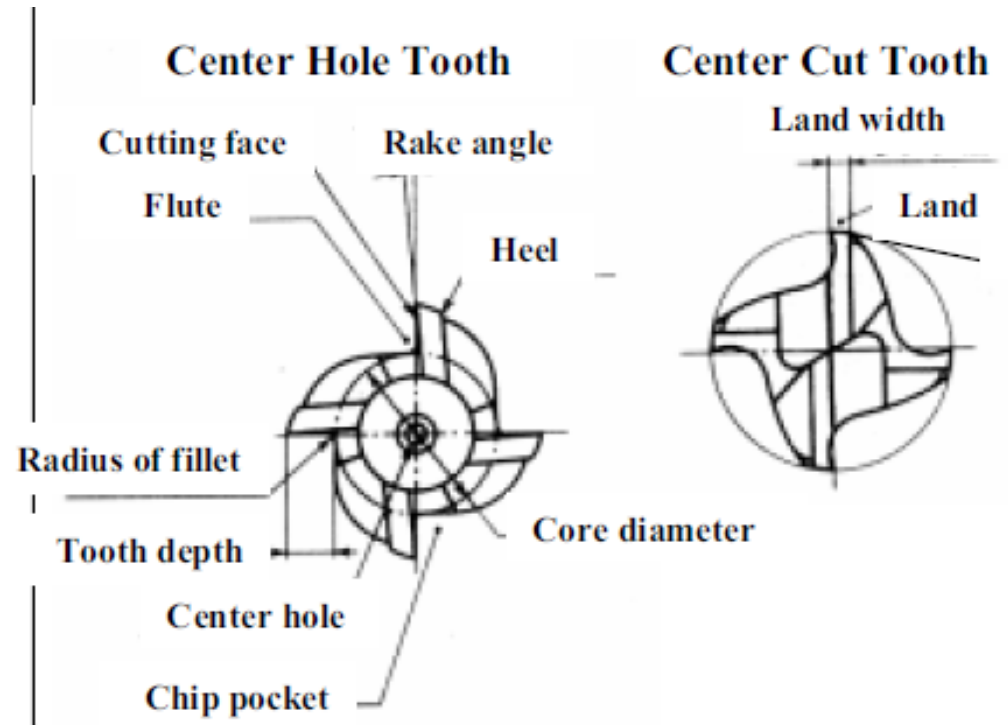
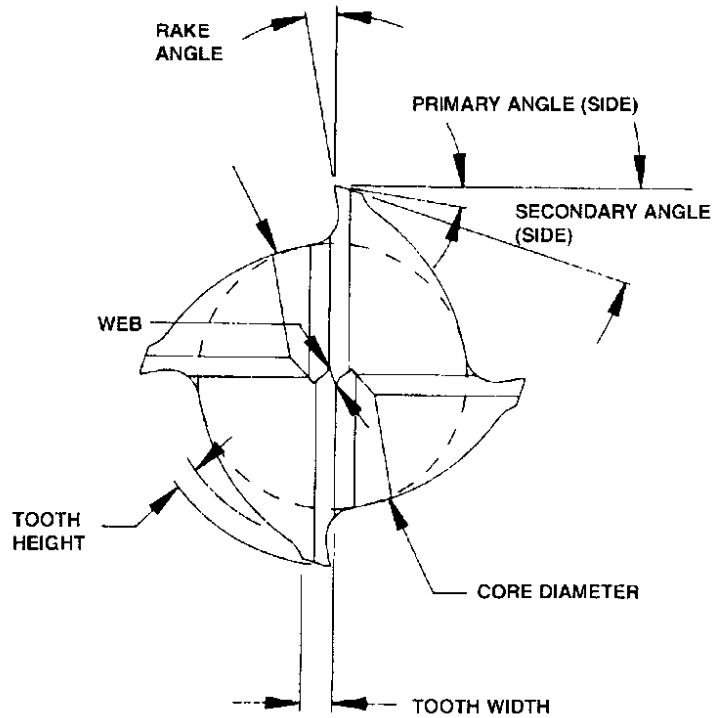
B - Shank Diameter

C - Length of Cut or Flute Length

D - Overall Length

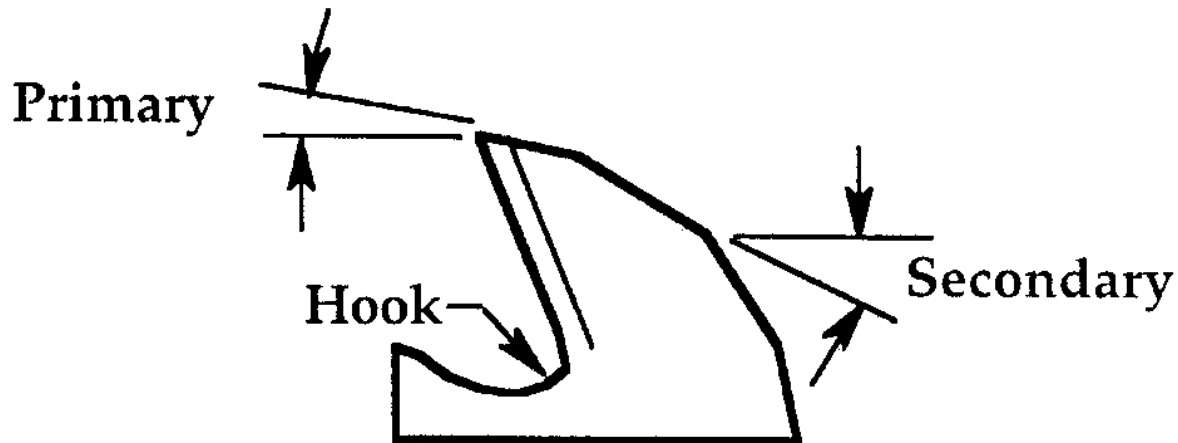


End Mill Terms Continued



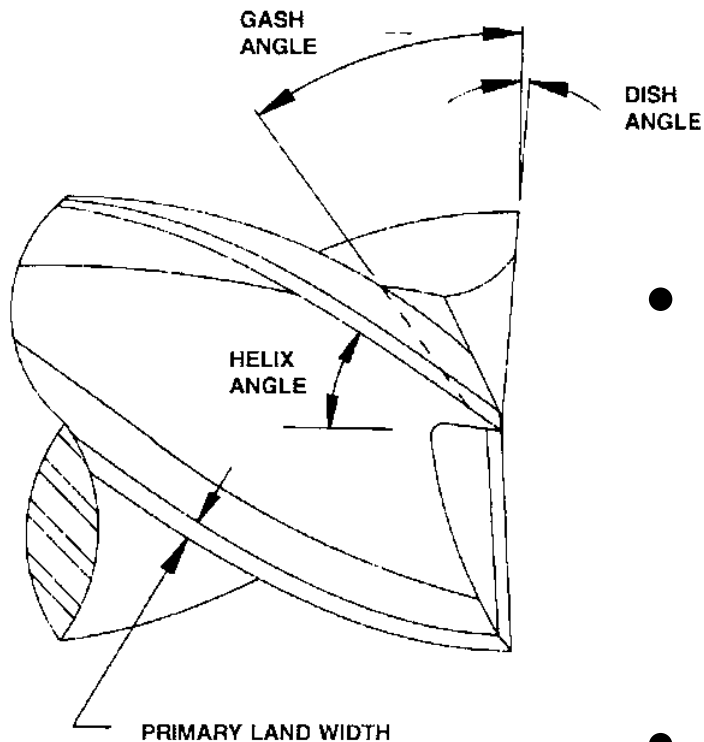
End Mill Side Clearance

- Primary (1st angle, 5° - 9°)
 - Relief Adjacent to Cutting Edge
- Secondary (2nd angle, 14° - 17°)
 - Relief Adjacent to Primary Angle
- Tertiary (3rd)
 - Additional Relief Provided Adjacent to the Secondary
 - High Performance End Mills



End Mill End Clearance

- Dish Angle
 - Angle Between End of Cutting Edge and Perpendicular to the Cutter Axis
 - Dish Ensures a flat Surface is Produced
- Gash (Notch)
 - Secondary Cuts to Provide Chip Space at Corners and Ends
 - Forming the End Cutting Edge when Feeding Axially
- Gash Angle
 - Relief Angle of the Gash Feature

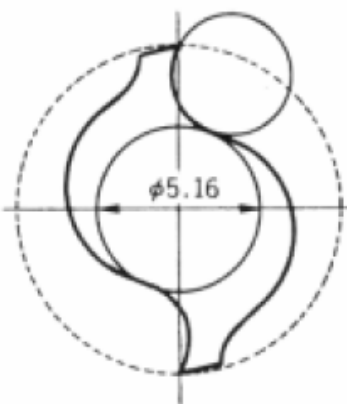
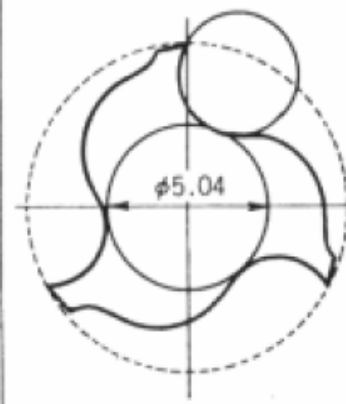
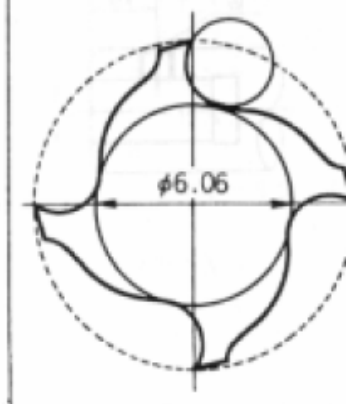


End Mill Flutes

- Evacuate Chips
 - Outward
 - Not Upward like a Drill
- Two or More Flutes
- Usually Spiral Helix Shape
- Low Helix 10-20°
 - Harder Material 35 HRC +
- Normal (GP) Helix 28-30°
- High Helix 40° +
 - Stringy Chips



Chip Pocket and # Teeth

	$\phi 10$ Two flutes	$\phi 10$ Three flutes	$\phi 10$ Four flutes
Core diameter and size of chip pocket			
Cross section of tooth	41 mm ²	44 mm ²	48 mm ²
Section rate	52%	56%	61%

Less No. of tooth=better chip ejection,less rigidity



More No. of tooth=worse chip ejection,high rigidity



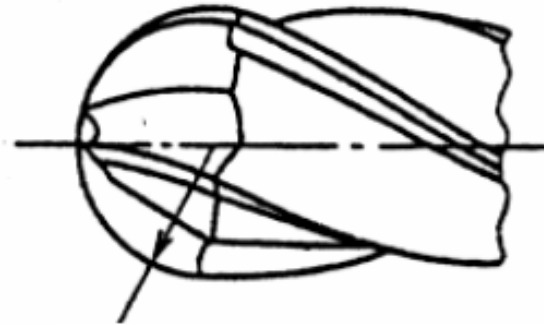
Four flutes end mill is not suitable for spot facing

End Cutting Edge Types

Square type



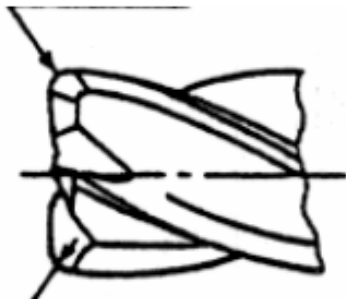
Ball nosed type



Radius of ball nose

Radius type

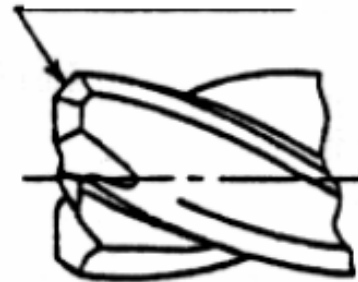
Rounded corner



Corner radius

Chamfer type

Chamfer

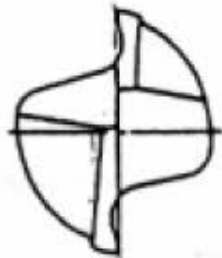


Cutting Edge Type

Center cut tooth



Two Flutes



Two Flutes(Long & Short Teeth)



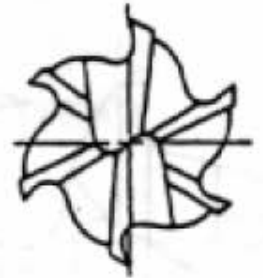
Three Flutes



Four Flutes

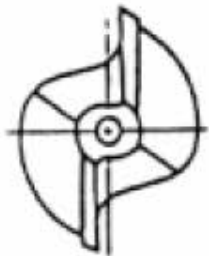


Four Flutes(Long & Short Teeth)



Six Flutes

Center hole tooth



Two Flutes



Three Flutes



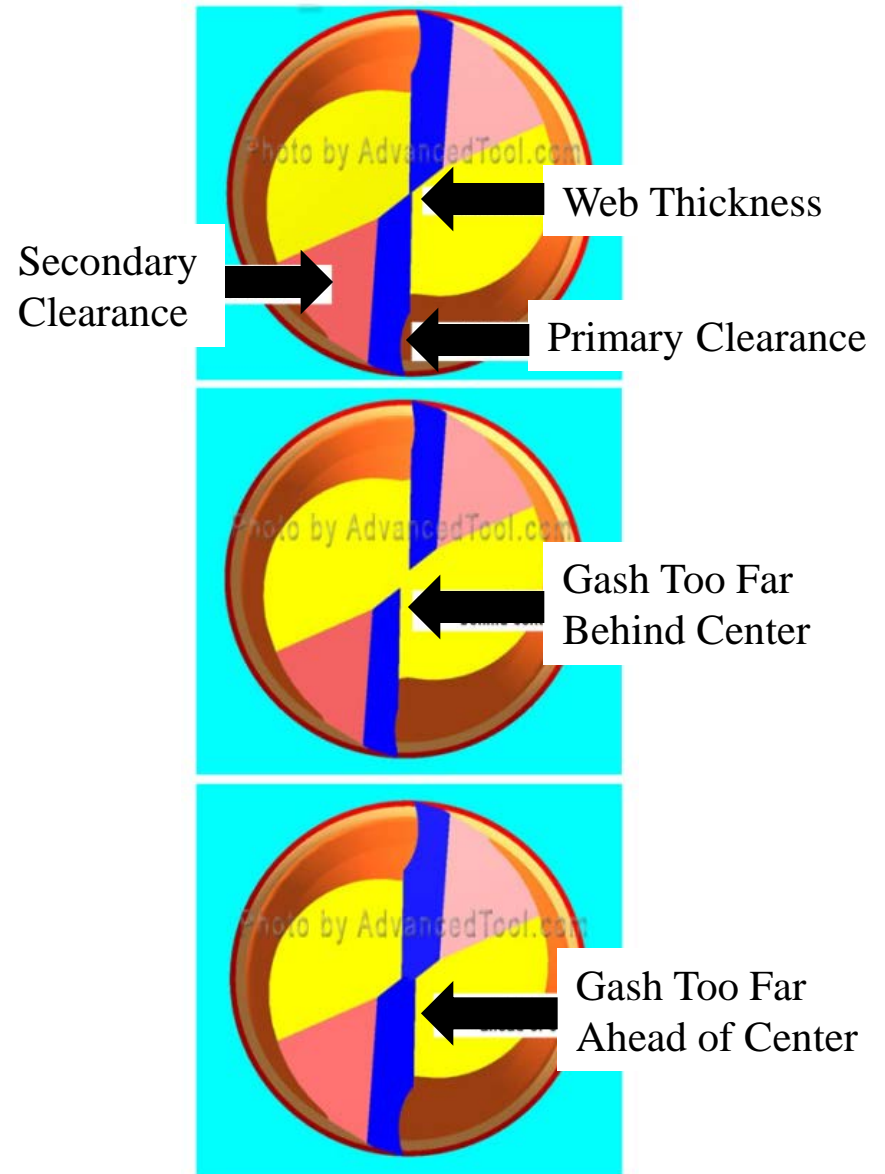
Four Flutes



Six Flutes

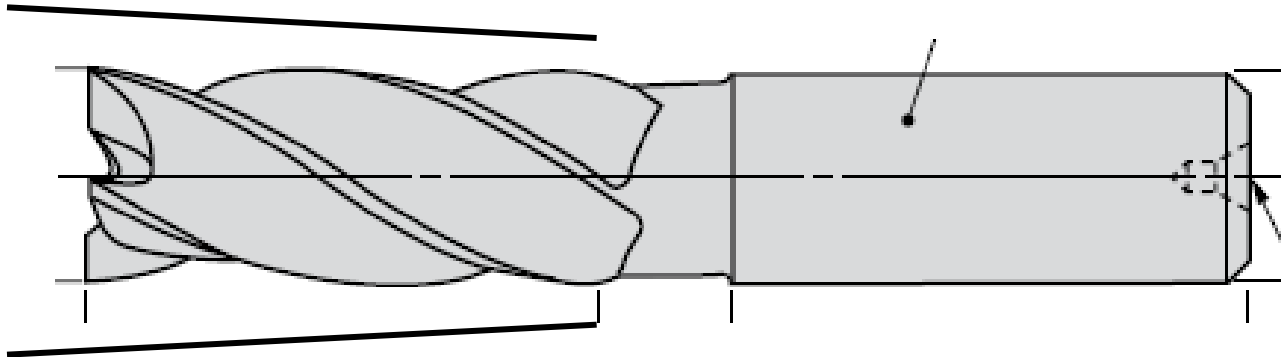
End Mill Web Thinning

- The Web is Non-Cutting
- Consume Power and Torque to Plow Through the Work
- Thinning Reduces These
- Thinned Using Gash



Back Taper

- \emptyset is Tapered Towards the Shank
- Aids in Plunging/Drilling
- Compensate for Deflection

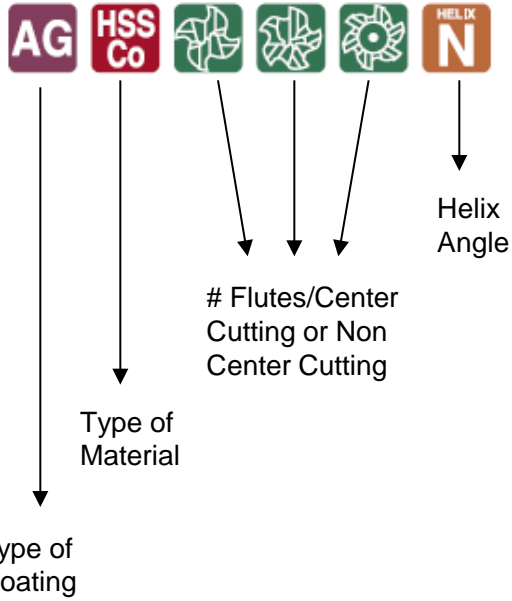


	Mark	Explanation	Mark	Explanation
Coating		G (TiN) Coating		Normal Helix Flutes ~ 30°
		UG (TiCN multi layer) Coating		High Helix Flutes 40° - 45°
		SG (TiCN multi layer) Coating		Low Helix Flutes 15° - 20°
		AG (TiAlN multi layer) Coating		Point Angle of Drills
		AQ (TiAlN multi layer) Coating		Drill Length is from Center Point
		X's (TiAlN multi layer) Coating		Drill Length is from Corner Point
		GS (TiAlN multi layer) Coating		Oil-hole Drills
		DLC Coating		Three Flutes Drills
		Diamond Coating		Shape of Lip Relief is Conical
	Tool Materials		High Speed Steels	
		Cobalt High Speed Steels		Shape of Lip Relief is Three Rake
		Fine Melting HSS		S-type Thinning
		High Grade Powder HSS		Notch Thinning
		Vanadium HSS		X-type Thinning
		Vanadium HSS		XH-type Thinning
		Cobalt/Vanadium HSS		2Rake Relief & X-type Thinning
		Tungsten Carbide		2Rake Relief & XR-type Thinning
				3 Flutes Drills & 3F-type Thinning

	Mark	Explanation	Mark	Explanation	
Tolerance of Drills Dia.		Tolerance of Drills Diameter is js6	Flutes of End Mills		4 Flutes Radius End mills (Center Cut)
		Tolerance of Drills Diameter is h7			2 Flutes Ball Nose End mills (Center Cut)
		Tolerance of Drills Diameter is h8			4 Flutes Ball Nose End mills (Center Cut)
Flutes of End Mills		Sharp corner Type End mills		6 Flutes Ball Nose End mills (Center Cut)	
		2 Flutes Square End mills (Center Cut)	Type of Taps		Cutting Taps
		3 Flutes Square End mills (Center Cut)			Forming Taps
		4 Flutes Square End mills (Center Cut)	Flutes of Taps		Straight Flutes Taps
		4 Flutes Square for X's-mill Hard (Center Cut)			Spiral Pointed Taps
		5 Flutes Square End mills (Center Cut)			Normal Helix Flutes Taps
		6 Flutes Square End mills (Center Cut)			High Helix Flutes Taps
		6 Flutes Square for X's-mill Hard & X's-mill Multi Flutes (Center Cut)			Low Helix Flutes Taps
	Chamfer of Taps		8 Flutes Square for X's-mill Hard & X's-mill Multi Flutes (Center Cut)		Chamfer Length is 2.5P to 3P
			4 Flutes Square End mills (with Center Hole)		Chamfer Length is 4P to 5P (for through hole)
			5 Flutes Square End mills (with Center Hole)		Chamfer Length is 1.5P (for blind hole)
			6 Flutes Square End mills (with Center Hole)		Chamfer Length is 2.5P
			Multiple Flutes (over 8) Square End mills (with Center Hole)		Chamfer Length is 3.5P
			2 Flutes Radius End mills (Center Cut)		Cutting Taps for Taper Pipe

Endmills / Visual Index

List 6488 AG-MILL ROUGHING LONG



H=High Helix (40°)
N= Normal Helix (30°)
L= Low Helix (15°)

Specs/Sizes
Speeds/Feeds



P160
P192

Specs /Sizes

Speeds & Feeds

NACHI CNC TOLERANCE (Cutting Diameter)

+.0010 0				0 -.0010	
List No.	Tool No.	List No.	Tool No.	List No.	Tool No.
6201	PF	6233	PGE	6230	MPG
6203	PFL	6367	PK	6290	MPR
6207	PFX	6367P	PKP	±.0040	
6210	HPF	6367X	PKX		
6211M	PFC	7221P	PHP	6303	PQ
6211X	PFCX	0 -0.0015		6303P	PQP
6213	PFLC			6303X	PQX
6231	PG	6261	PC	6304	MPQ
6231X	PGX	6295	PRR	6305	PQA
				6307	PQF

*Some items, present stock until depleted.

Nachi End mill Materials

- HSS = High Speed Steel

- General Purpose

- Symbol= 



EX's – L231, L261,
L211, L215, & L271

- HSSCo = Cobalt High Speed Steel


- HSS With Added Cobalt for Wear Resistance

- Symbol= 



EX's – L6231HD, L6450, L6485, L6406, L6484, L6486, L6488,
L6403, L6402, L6404, L6231X, L6211X, L6367X, L6303X, L6231,
L6233, L6230, L6213, L6210, L6211M, 6367, L6303, & L6307

Nachi Materials

- Carbide = Tungsten Carbide
- Compacted & Sintered 3 X Stiffer than Steel
- Symbol= 

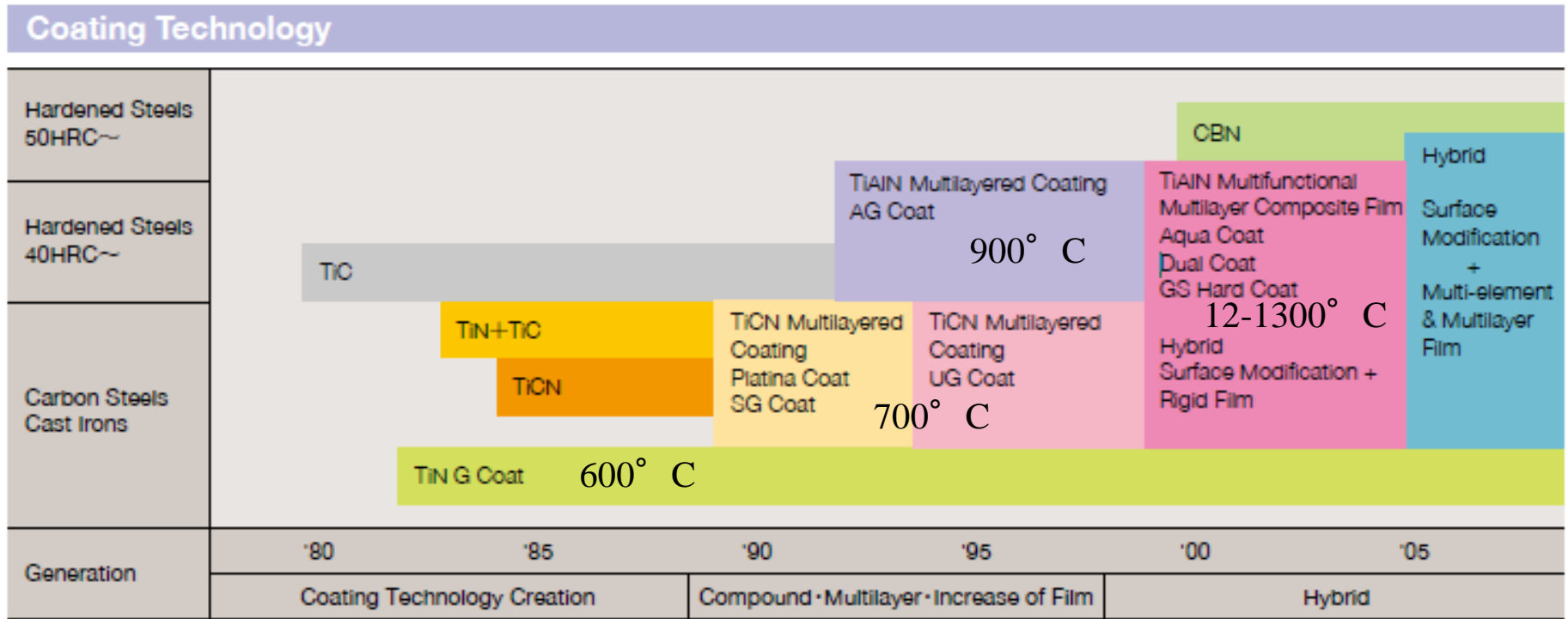


EX's – L9382, L9384, L9386, L9398,
 L9422, L9399, L9423, L9408, L9321, L9322,
 L9324, L9338, L9366, L9368, L9340, L9332, L9330,
 L9378, L9302, L9390, L9360, L9261X, L9265X, L9271X,
 L9275X, L9263X, L9267X, L9273X, L9277X, L9251X, & L9221X


Coatings Advantages

- Better Wear Resistance
- Better Toughness
- Better Heat Resistance
- Better Lubrication

Coatings Development and Approx. Temperature Max



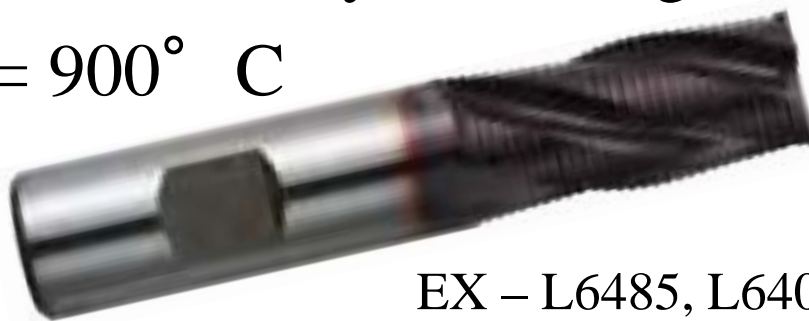
Nachi Coatings

- SG-Coating = TiN + TiCN (Multi Layer Coating)
- Service Temperature= 700° C
- Color= Gold Yellow
- Symbol= 



EX – L9261X, L9265X, L9271X, L9275X, L9263X, L9267X,
L9273X, L9277X, L9251X, L9221X, L6231X, L6211X, L6367X, & L6303X

- AG-Coating = TiALN (Multi Layer Coating)
- Service Temperature= 900° C
- Color= Violet-Gray
- Symbol= 




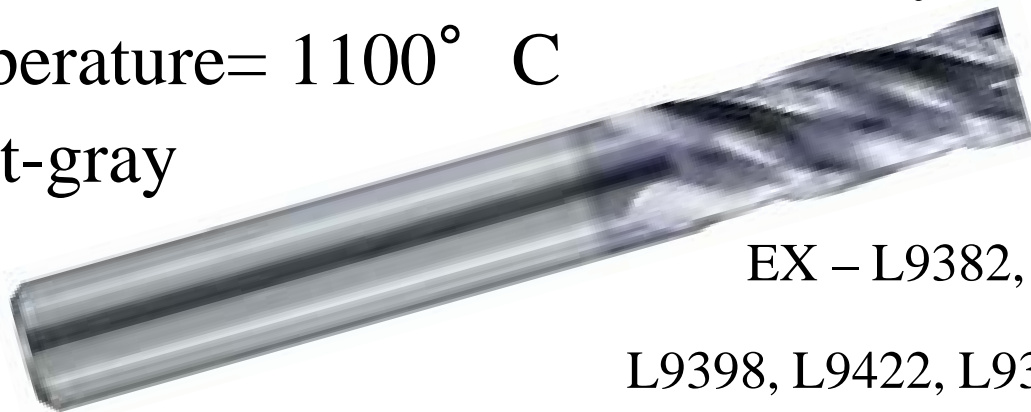
EX – L6485, L6406, L6484,
L6486, L6488, L6403, L6402, & L6404

Nachi Coatings


- X's-Coating = TiALN (Multi Layer Coating) for End Mills
- Service Temperature= 900° C
- Color= Violet-Gray
- Symbol=  EX – L9408, L9321, L9322, L9324, L9338, L9366, L9368, L9340, & L9332

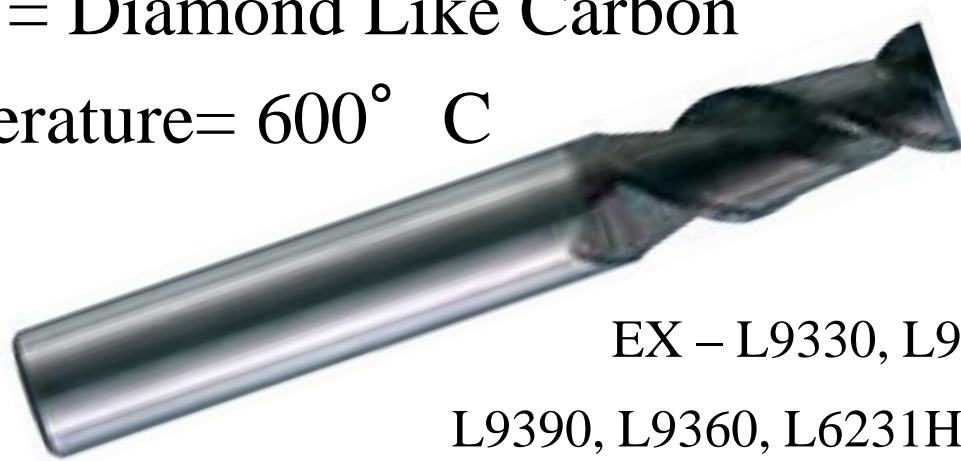


- GS-Coating = TiALN + Al-Ti-Cr (Multi Layer Coating)
- Service Temperature= 1100° C
- Color= Violet-gray
- Symbol=  EX – L9382, L9384, L9386, L9398, L9422, L9399, & L9423



Nachi Coatings

- DLC-Coating = Diamond Like Carbon
- Service Temperature= 600° C
- Color= Black
- Symbol= 



EX – L9330, L9378, L9302,
L9390, L9360, L6231HD, & L6450