

# **HARD** **TURNING**

*Making hard turning less hard than it seems!*



***FEED the SPEED!***

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**CUBIC  
BORON  
NITRIDE**

**the second hardest material known to mankind**

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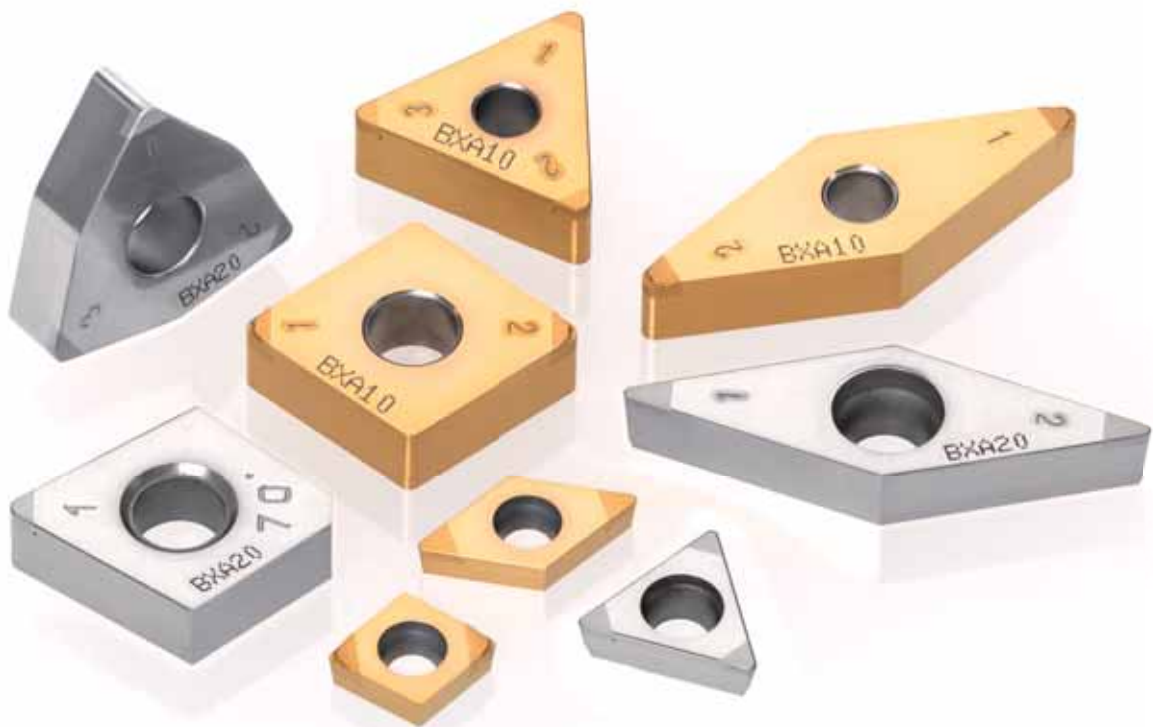


# WHAT IS **HARD** **TURNING?**

Tungaloy has always been a pathfinder in hard turning applications, *making hard turning less hard than it seems...*

**HARD TURNING** commonly refers to turning operations of a part or bar stock harder than 50HRC on a lathe or turning center. In profiling hardened steel parts, grinding had long been the first-choice process for manufacturers to obtain the dimensions required on the workpiece. This was true until polycrystalline cubic boron nitride (**PcBN**) was introduced in late 1970s, which eventually impelled a shift from time- and energy-consuming grinding operations to hard turning operations.

Hard turning started to rapidly develop in the beginning of the 1990s as the availability of **PcBN** and ceramics increased, along with further advancement in physical vapor deposition (PVD) coating technologies and the capability of designing and building turning machines that are rigid, stable, and accurate enough to successfully finish hard turning. These advancements have made finish hard turning a viable alternative to grinding, as an accurate finishing operation.



## **Tool materials** for hard turning

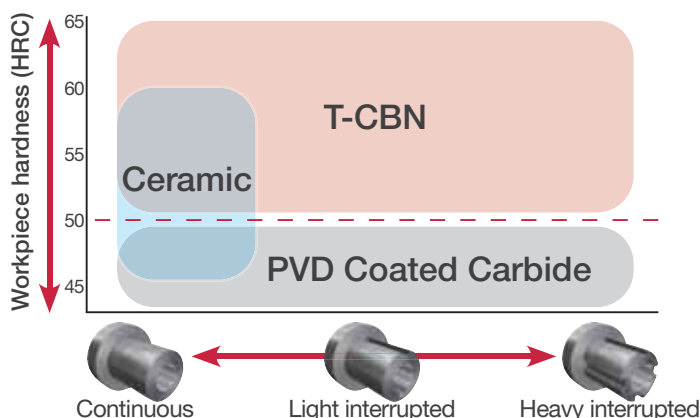
Natural and synthetic diamonds are used for precision turning of non-ferrous metals. The hardest of all materials, however, cannot be used to machine steel because of its strong affinity for iron at high temperature.

**PcBN** solves this problem because of its hardness, which is approximately the same as diamond, and its thermal stability and inertness to iron at elevated temperatures. These unique properties make **PcBN** a perfect cutting tool material for machining hard, abrasive ferrous workpiece materials at higher cutting speeds.

**Ceramic** also have excellent wear resistance at high cutting parameters. Ceramic inserts are economically priced when compared with other insert grades and can be applied to high speed, continuous turning of hardened parts. Their low thermal shock resistance and fracture toughness, however, require blunt cutting edge geometry, which creates a stronger cutting force and lessens the surface finish potential. Tungaloy's **LX11** is the ceramic grade most suitable for turning hardened steel.

Hard turning on low power machines poses challenges in terms of reliability and cost effectiveness. The **PVD-coated carbide grade** makes a great alternative in such machine setups. Tungaloy's **AH8000 series** is not only efficient in turning heat-resistant superalloys but also proven to have superior performance in hard turning where high cutting parameters are not attainable. Its superior fracture toughness makes the grades excellent alternatives, over PcBN and ceramic grades, for efficient turning of hardened steel and tempered steel at low speed settings.

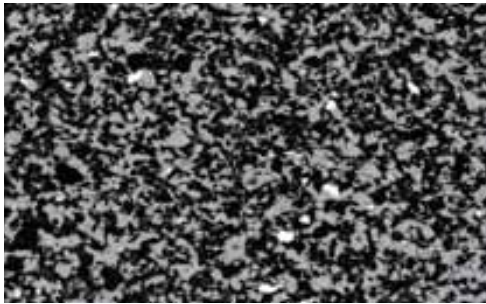
## **Grade recommendations** for different applications



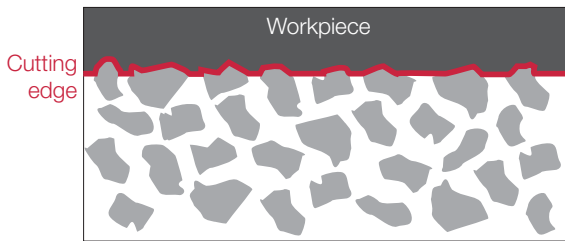
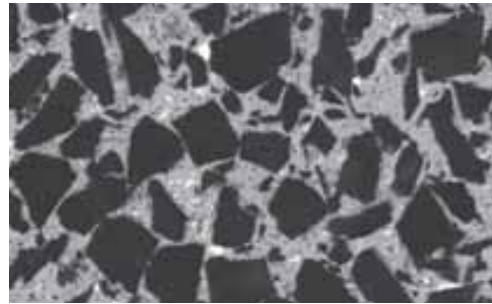
# TUNGALOY'S **CBN**

**CBN grain sizes** and their effects on surface roughness

Fine grain (Grain size:  $\leq 1 \mu\text{m}$ )



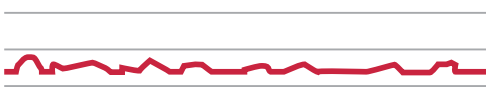
Coarse grain (Grain size: 3 - 6  $\mu\text{m}$ )



**Fine-grain CBN grades**

Sharp and uniform cutting edge

**Better surface finish quality**



Roughness ( $R_z < 1.6 \mu\text{m}$ )



**Coarse-grain CBN grade**

Strong bond between grains

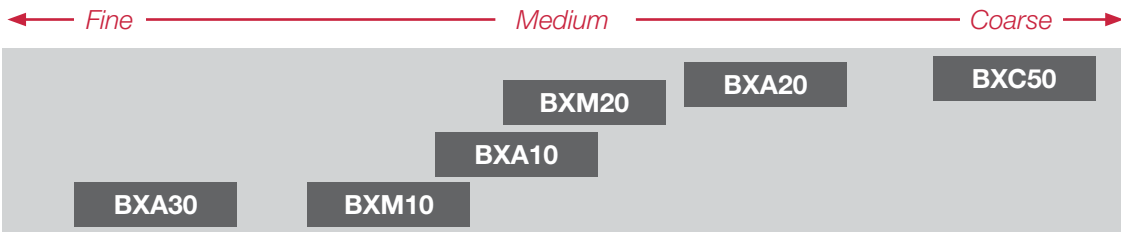
**Higher speeds and feeds can be applied**



Roughness ( $R_z < 6.3 \mu\text{m}$ )

CBN inserts are generally used in a finishing process. A CBN insert grade with coarse abrasive grains will output a rough surface and may not be able to achieve the surface quality required. To achieve superior surface quality of  $R_z = 3.2$  or better, always use a fine grain CBN insert.

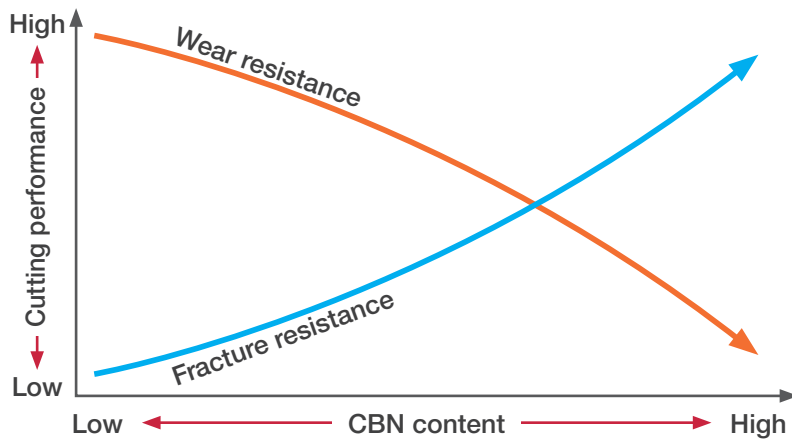
**Grain Size - Coated Grades**



**Grain Size - Uncoated Grades**

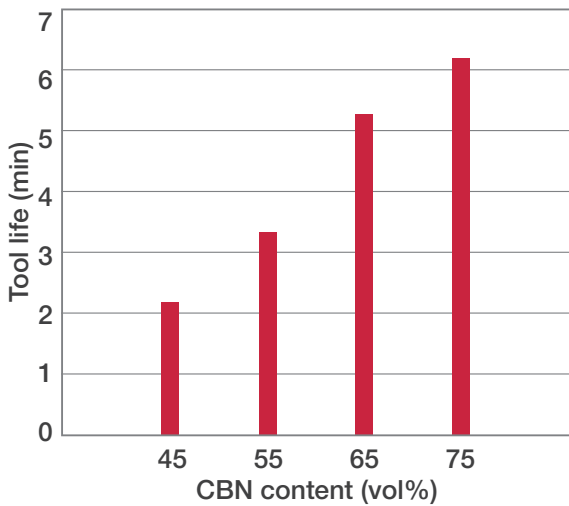


**Wear and fracture resistance** in terms of CBN content



The lower the CBN content is, the more wear resistant the grade will be, and the higher the CBN content is, the more fracture resistant the grade will be when turning hardened steel.

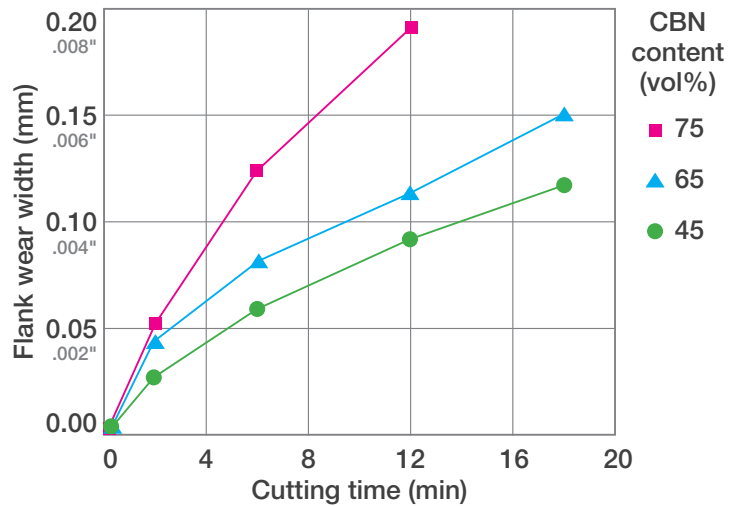
**Interrupted Cutting**



**Cutting conditions**  
 Cutting speed:  $V_c = 180$  m/min (590 sfm)  
 Depth of cut:  $a_p = 0.1$  mm (.004")  
 Feed:  $f = 0.1$  mm/rev (.004")  
 Coolant: Dry  
 Workpiece material: SCM435 (60HRC)

**High CBN content**  
 ↓  
**High fracture resistance**

**Continuous Cutting**



**Cutting conditions**  
 Cutting speed:  $V_c = 180$  m/min (590 sfm)  
 Depth of cut:  $a_p = 0.2$  mm (.008")  
 Feed:  $f = 0.1$  mm/rev (.004")  
 Coolant: Wet  
 Workpiece material: SCM415 (60HRC)

**Low CBN content**  
 ↓  
**High wear resistance**

## Typical parts

Ring Gear



Idler Gear

Transmission Shaft



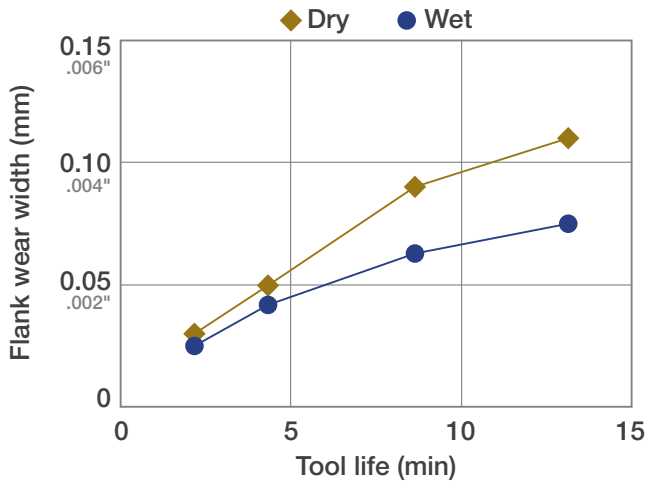
CVJ



Tool Holders

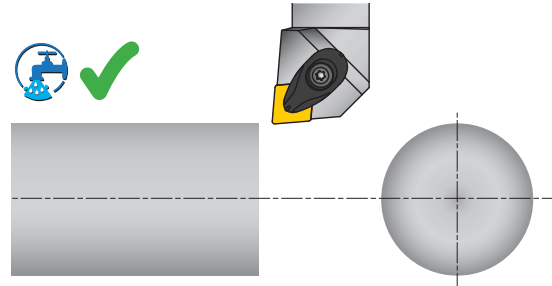


**Coolant effect - Continuous cutting**



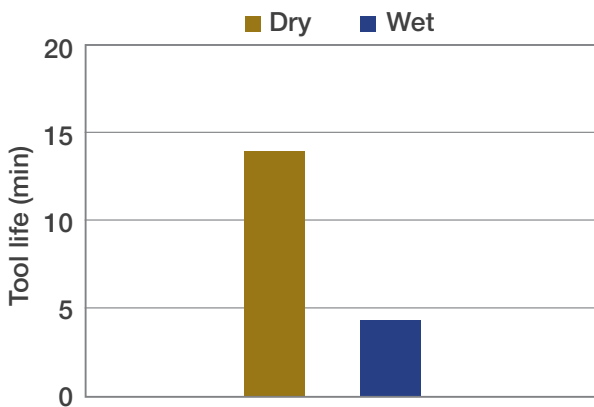
**Cutting conditions**

Cutting speed:  $V_c = 180$  m/min (590 sfm)  
 Depth of cut:  $a_p = 0.2$  mm (.008")  
 Feed:  $f = 0.1$  mm/rev (.004")  
 Workpiece material: SCM415 (60HRC)



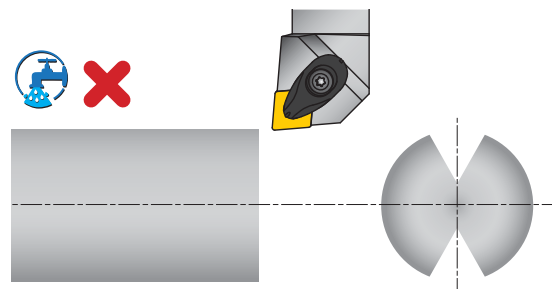
**Wet cutting** improves tool life for continuous cutting operations.

**Coolant effect - Interrupted cutting**



**Cutting conditions**

Cutting speed:  $V_c = 150$  m/min (492 sfm)  
 Depth of cut:  $a_p = 0.2$  mm (.008")  
 Feed:  $f = 0.2$  mm/rev (.008")  
 Workpiece material: SCM415 (60HRC)

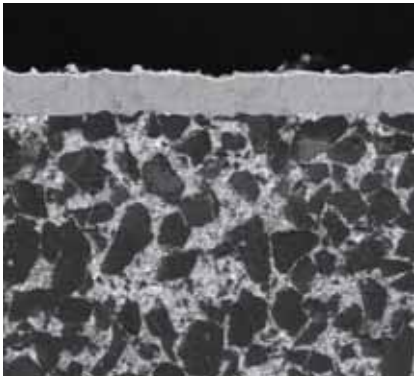


**Dry cutting** improves tool life for interrupted cutting operations.

**Use of coolant**

	Dry	Wet
Continuous cutting	✗	✓
Interrupted cutting	✓	✗

# BENEFITS OF **COATED CBN**



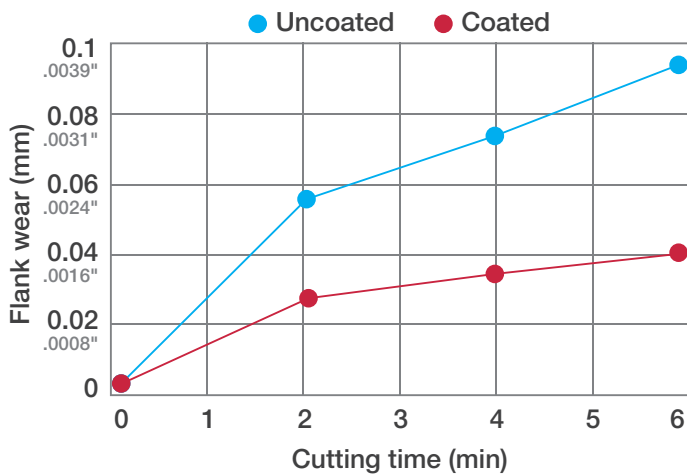
**Anti-oxidation wear**

PVD coating protects **CBN** from interacting with oxygen.

**Enhanced wear resistance**

**CBN** has high thermal conductivity and plastic deformation resistance, preventing the coating from delaminating under extreme temperatures generated during hard turning process.

**Coated Grades: BXA10, BXA20, BXA30, BXM10, BXM20, and BXC50**



**Cutting conditions**

Cutting speed:  $V_c = 180$  m/min (590 sfm)  
 Depth of cut:  $a_p = 0.2$  mm (.008")  
 Feed:  $f = 0.1$  mm/rev (.004")  
 Coolant: Dry  
 Workpiece material: SCM415 (60HRC)

Insert wear after 6 minutes

Uncoated



Coated



# CBN GRADES

Tungaloy's hard-turning CBN grades and their properties

Grade	CBN grain size			CBN content			Binder type		Recommended cutting speed (Vc)	Application range
	Fine	Medium	Coarse	Low	Medium	High	Ceramic	Metal		
<b>BXA10</b> TiCN/TiAlN-based multilayer		●			●		●		100 - 230 m/min 328 - 754 sfm	
<b>BXA20</b> TiAlN-based multilayer		●				●	●		60 - 180 m/min 197 - 590 sfm	
<b>BXA30</b> TiAlN monolayer	●				●		●		70 - 250 m/min 206 - 762 sfm	
<b>BXM10</b> TiCN-based multilayer		●			●		●		150 - 350 m/min 492 - 1148 sfm	
<b>BXM20</b> TiCN-based multilayer		●				●	●		70 - 220 m/min 230 - 394 sfm	
<b>BXC50</b> TiCNO monolayer			●			●	●		70 - 120 m/min 230 - 394 sfm	
<b>BX310</b> -		●		●			●		100 - 300 m/min 328 - 984 sfm	
<b>BX330</b> -	●			●			●		50 - 200 m/min 164 - 656 sfm	
<b>BX360</b> -		●			●		●		50 - 200 m/min 164 - 656 sfm	
<b>BX380</b> -			●			●	●		70 - 120 m/min 230 - 394 sfm	

# EDGE PREPARATIONS

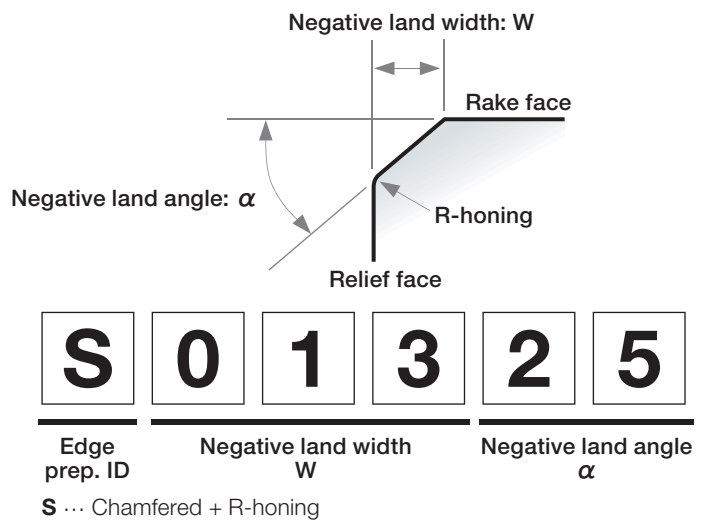
## Edge preparation - Designation

Negative land angle → Large

W (mm)	Negative land angle $\alpha$		
	15°	25°	35°
0.05 .002"	LF	-	LC
0.13 .005"	L	Standard	-
0.18 .007"	-	-	H

Wide ↓ Negative land width

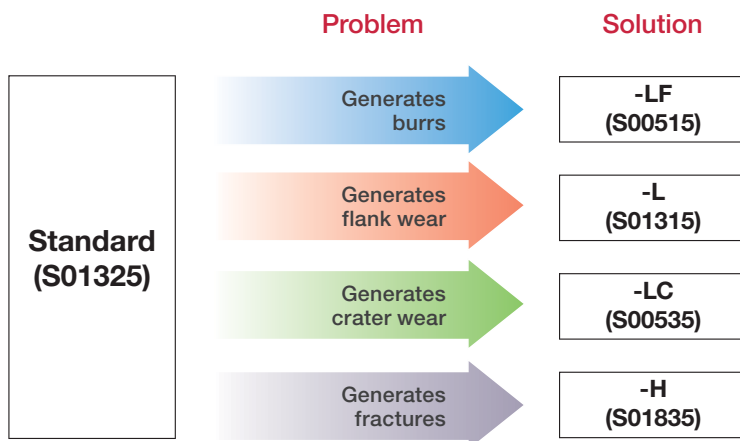
BXA10 and BXA20 inserts



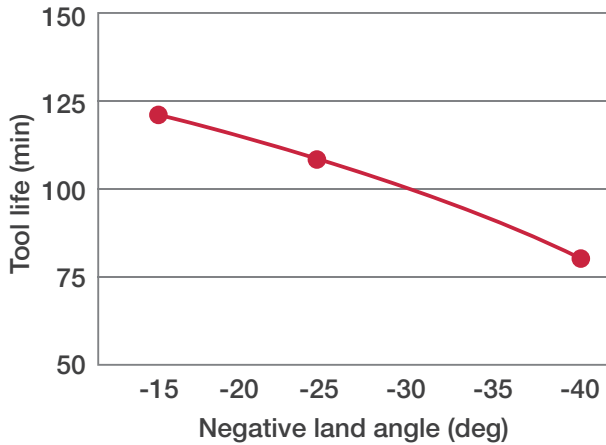
Five standard edge preparations are available for BXA10 and BXA20 inserts for hard turning.

## Edge preparation - Selection guide

Based on the performance of the insert with standard edge preparation, the following solutions are recommended.



**Edge preparation - Continuous cutting**



**Cutting conditions**

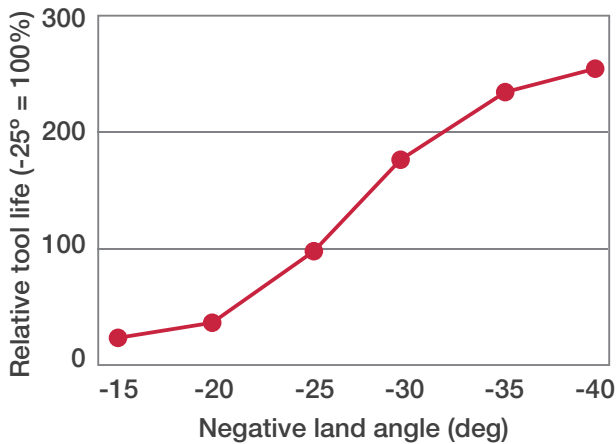
Cutting speed:  $V_c = 100$  m/min (328 sfm)  
 Depth of cut:  $a_p = 0.25$  mm (.010")  
 Feed:  $f = 0.1$  mm/rev (.004")  
 Coolant: Dry  
 Continuous cutting  
 Workpiece material: SCM415 (60HRC)  
 Criteria:  $VB_{max} = 0.15$  mm

**Edge preparations**

Width: 0.13 mm  
 Angles: -15, -25, and -40°  
 Honed to: R0.01~0.02 mm (R.0004" ~ .0008")

The smaller the negative land angle is, the more wear resistant the cutting edge will be in continuous cuts.

**Edge preparation - Interrupted cutting**



**Cutting conditions**

Cutting speed:  $V_c = 100$  m/min (328 sfm)  
 Depth of cut:  $a_p = 0.25$  mm (.010")  
 Feed:  $f = 0.15$  mm/rev (.006")  
 Coolant: Dry  
 Workpiece material: SCM415 (60HRC)  
 Criteria: Fracture

**Edge preparations**

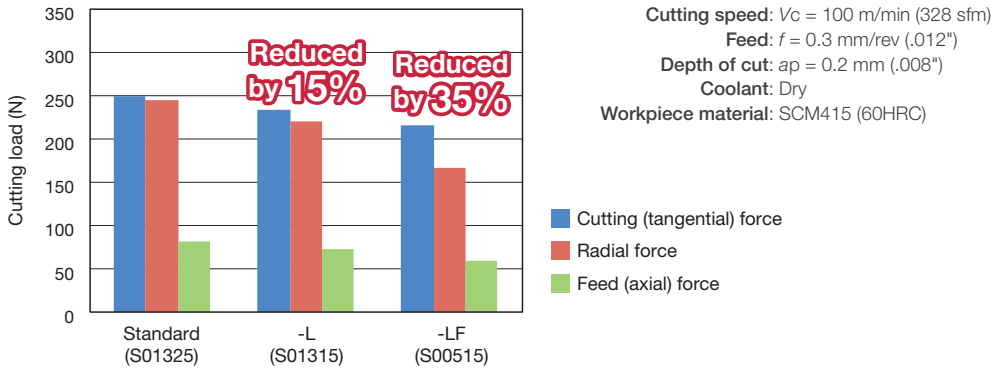
Width: 0.13 mm  
 Angles: -15, -20, -25, -30, -35, and -40°  
 Honed to: R0.01~0.02 mm (R.0004" ~ .0008")

The larger the negative land angle is, the more fracture resistant the cutting edge will be in interrupted cuts.



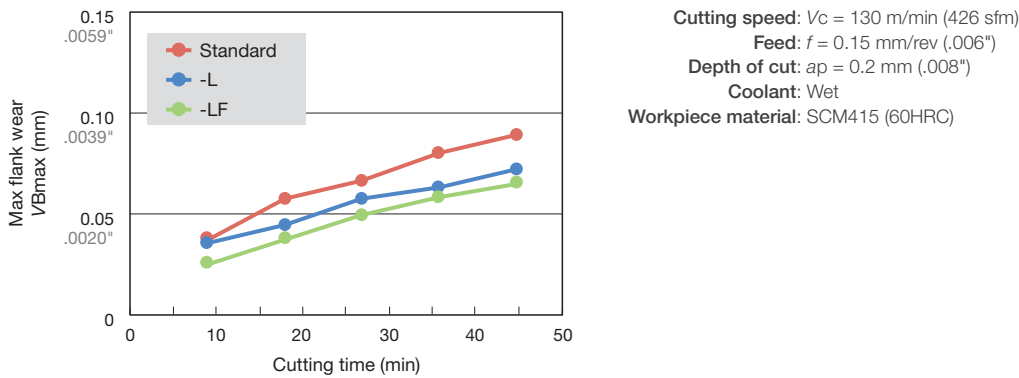
## Edge preparation - Cutting loads

The -L and -LF edge preparations provide reduced cutting loads over the insert with standard edge preparation.



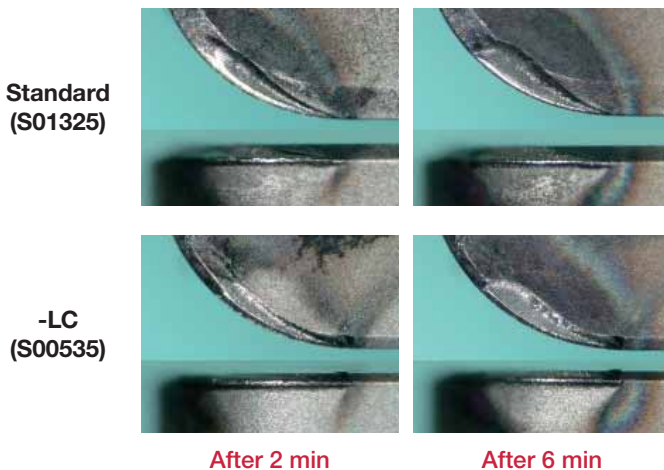
## Edge preparation - Flank wear

The -L and -LF edge preparations provide reduced flank wear over the insert with standard edge preparation.



## Edge preparation - Crater wear

The -LC edge preparation provides reduced crater wear over the insert with standard edge preparation. As a result, insert fracture induced by crater wear is reduced.



Cutting speed:  $V_c = 200$  m/min (656 sfm)  
 Feed:  $f = 0.1$  mm/rev (.004")  
 Depth of cut:  $a_p = 0.2$  mm (.008")  
 Coolant: Dry  
 Workpiece material: SCM415 (60HRC)



# CHIPBREAKERS



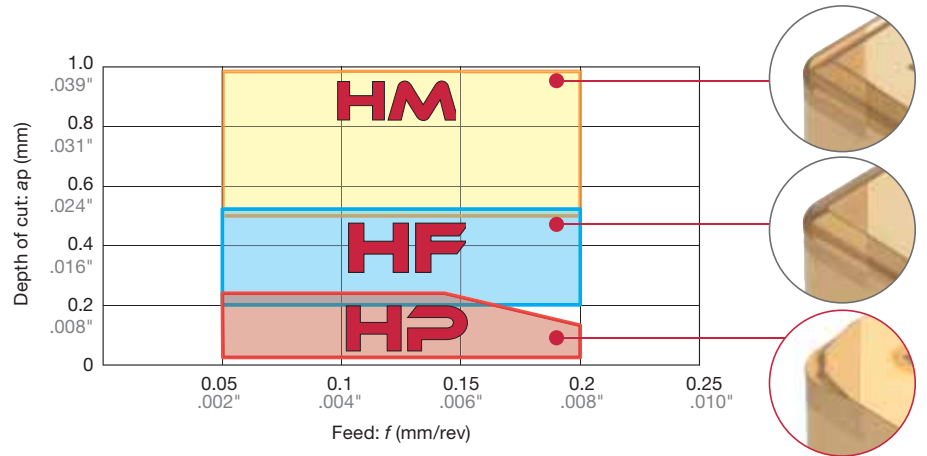
## Negative Inserts

Three standard types of chipbreakers are available for negative inserts:

**HP:** For standard finishing

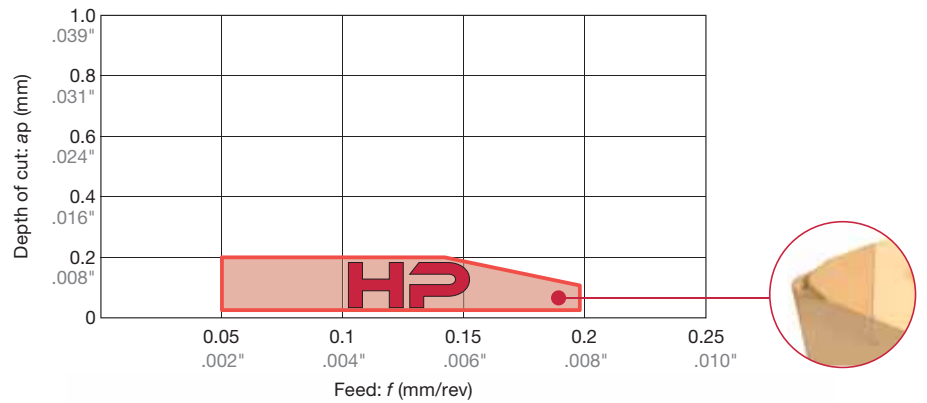
**HF:** For removable carburized layer (at light DOC) of case-hardened steel

**HM:** For removable carburized layer (at great DOC) of case-hardened steel



## Positive Inserts

**HP:** For standard finishing





**HP - HardBreakers for finishing hardened steel**

**Innovative 3D chipbreaker for efficient chip control**

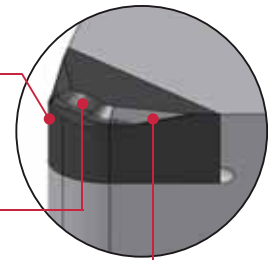
- By separating the chipbreaker from the cutting edge, the cutting force imposed on the cutting edge during machining is significantly reduced, thus providing long tool life.
- The cutting edge preparation is designed to ensure easy cutting at low cutting forces, while maintaining close tolerances with no deviations.
- The HP style chipbreaker, combined with built-in wipers, yields excellent surface quality and good chip control.



**Optimized edge preparation for low cutting force**

**HP chipbreaker**

**Wiper**



**Consistent and durable chip breaking**

**HARDBREAKER HP** **Vs.** **Competitor**

**40 min**

**80 min**

Insert: 2QP-CNGM120408-HP  
 Workpiece material: SCM420 (58 HRC)  
 Cutting speed:  $V_c = 180$  m/min (590 sfm)  
 Feed:  $f = 0.15$  mm/rev (.006")  
 Depth of cut:  $a_p = 0.15$  mm (.006")  
 Holder: ACLNR2525M12-A  
 Coolant: Wet  
 Machining: External continuous cutting

**Chatter-free machining**

**HARDBREAKER HP**

**Competitor (without breaker)**



Due to low cutting force, chatter stability is greatly improved.



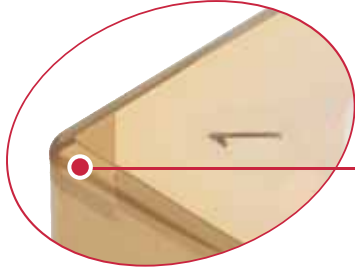
For more information

# HARD TURNING SERIES

## HF & HM - HardBreakers for removing carburized layer

Two types of chipbreakers provide excellent chip control in a wide application range

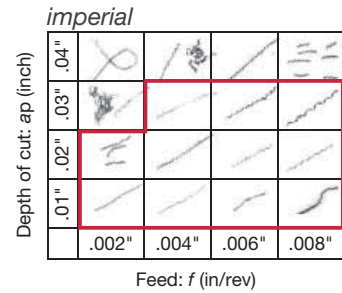
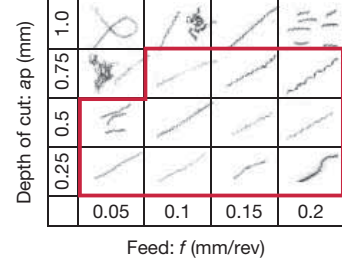
### HARDBREAKER HF



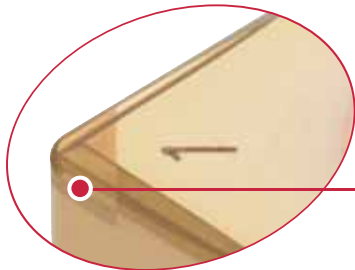
Single-sided CBN insert provides high stability in heavy machining

- Excellent chip control in small depth of cut due to the high functional nose
- Delivers exceptional surface finishes

#### HF chipbreaker



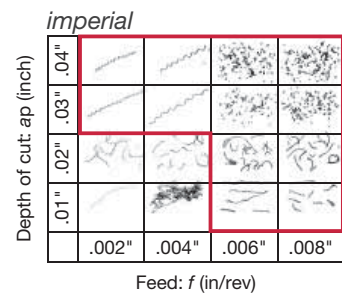
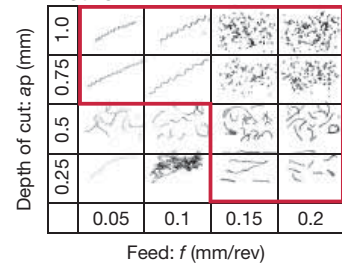
### HARDBREAKER HM



Single-sided CBN insert provides high stability in heavy machining

- Provides ideal chip control in large depth of cut with the well-designed chipbreaker
- Suitable for medium cutting or roughing

#### HM chipbreaker





# **TAILORED** TO YOUR NEEDS

*Tungaloy is the market leader* of CBN Blanks

## *Made by Tungaloy*

Carefully-selected micron-sized cubic boron nitride powders are sintered with a ceramic or metallic binder under high-temperature, high-pressure (HTHP) environment of over 5 GPa (over 725,189 psi) at 1400 °C -1500 °C (2552 °F - 2730 °F) in Tungaloy's latest sintering equipment. The **CBN** blanks will then undergo strict quality screening before being fabricated into **CBN** inserts.

Tungaloy welcomes customers to collaborate with its Advanced Materials Team to develop customized **CBN** grades perfectly tailored to the customer's specific hard turning needs. Tungaloy offers a high level of performance in the most challenging hard turning applications but can also bring these unique products to the customers in a short time span.



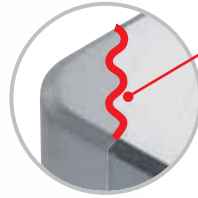
## Wavy Joint

New brazing technology for increased machining efficiency - "WavyJoint"



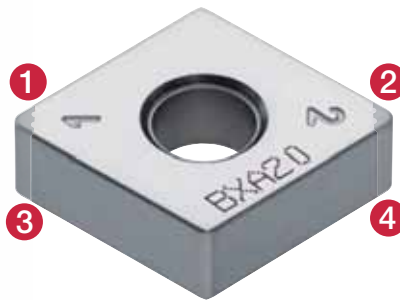
For high depth of cut in hard turning up to 0.8 mm

Great performance for continuous to heavy interrupted cutting at low and medium speeds



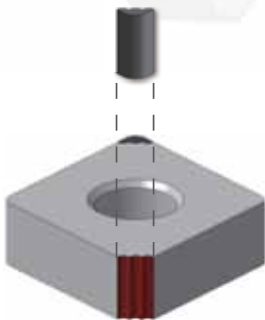
### Strong joint

The "wavy" contact surface enhances the brazing strength.



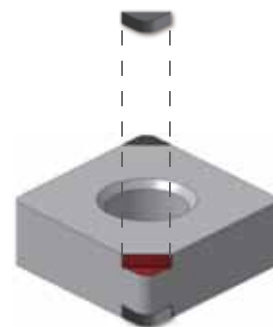
Double sided inserts

### WavyJoint



Vs.

### Standard



**CBN Tip Size: 200%** larger for improved wear resistance of the cutting edge

**Brazing Area: 160%** larger for enhanced brazing strength



For more information

# CERAMIC SERIES

*Medium speed, continuous turning* of hardened steel

## Ceramic



Ceramic cutting tools make a great alternative for efficient and economical hard turning generally due to its excellent wear resistance at high cutting speeds.

However, ceramics suffer lack of fracture toughness and thermal shock resistance, and, as the result, any type of shocks or impact during machining must be avoided to prevent chipping or fracture.

**LX11** is Tungaloy's oxide-based ceramic grade composed of aluminum oxide ( $Al_2O_3$ ), or alumina, in a titanium nitride (TiN) coating. It is suited for hard turning in continuous to light-interrupted cuts, where surface finish requirements are moderate.

**LX21** is another alumina-based ceramic grade of Tungaloy with higher bend strength than **LX11** to enhance the grade's fracture resistance. Designed with fracture toughness, **LX21** is best suited for interrupted cuts or large removal applications, such as hard turning of steel rolls.

## Ceramic Grades

Grade	Grain size			Main component $Al_2O_3$ -TiC	Recommended cutting speed (Vc)	Application range
	Fine	Medium	Coarse			
<b>LX11</b> TiN monolayer		●		●	60 - 180 m/min 197 - 590 sfm	 Continuous    Light Interrupted    Heavy Interrupted
<b>LX21</b>		●		●	60 - 150 m/min 197 - 490 sfm	 Continuous    Light Interrupted    Heavy Interrupted





# PVD COATED CARBIDE SERIES

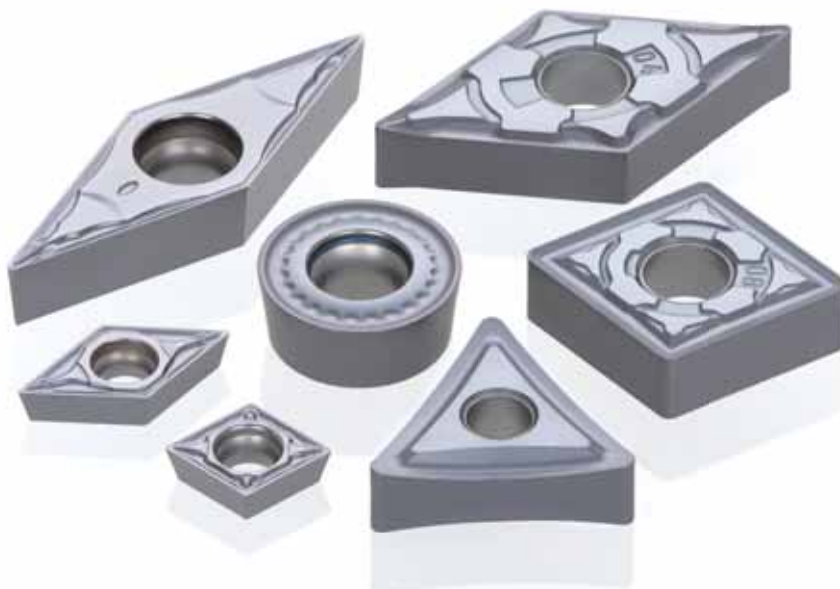
**Cost-effective solution** for turning hardened steel

## The AH8000 series

Tungaloy's **AH8000** series features a nano multi-layered PVD coating with high Al content. This provides the grades with multiple characteristics, including high hardness, good cutting edge integrity, and strong adhesion to the tough carbide substrate, all of which are vital for efficient turning of hardened steel. The **AH8000** series is particularly suited for hard turning applications using moderate cutting speeds of up to 50 m/min and large depths of cut of 0.5 mm or greater.

## The AH8000 Series

Grade	Grain size			Main component	Recommended cutting speed (Vc)	Application range
	Fine	Medium	Coarse	WC-Co		
<b>AH8005</b> AlTiN multilayer	●			●	~ 50 m/min ~ 164 sfm	 Continuous    Light Interrupted    Heavy Interrupted
<b>AH8015</b> AlTiN multilayer	●			●	~ 50 m/min ~ 164 sfm	 Continuous    Light Interrupted    Heavy Interrupted



For more information





# SELECTION GUIDE

Tungaloy's recommended solutions *for hard turning*

## Get started!

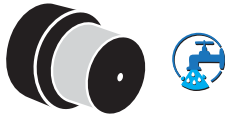
Is the workpiece hardened to 50 HRC or higher?

NO

PVD Grade  
**AH8000** Series

YES

Cutting Condition



Continuous



Light Interrupted



Heavy Interrupted

First Recommendations

**BXA10**

Edge preparation -  
*Standard*

**BXA20**

Edge preparation -  
*Standard*

**BXA20**

*Wavy Joint*  
Edge preparation - *H*

More Solutions

For reduce burr

**BXA10**

Edge preparation - *LF*

For improved crater wear

**BXA10**

Edge preparation - *LC*

For improved fracture resistance

**BXA20**

Edge preparation - *H*

For low cutting speed

**BX360**

Edge preparation - *Standard*

For low cutting speed

**BX380**

Edge preparation - *Standard*

Other Solutions

For better surface finish

**BXA30**

Edge preparation - *Standard*

For improved chip control

**BXA10**

with *Hardbreaker HP*

For an economical solution

**LX11**

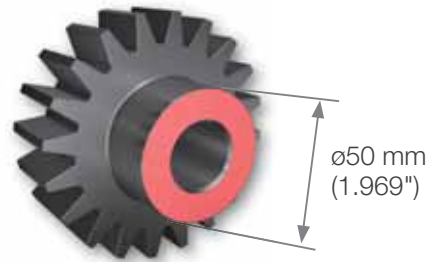
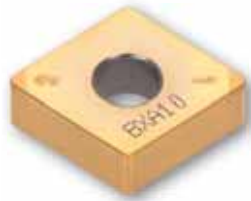
# FIELD TEST REPORTS

**Industry:** Automotive / Gear  
**Material:** 18CrMo4 / SCM420 (62HRC)  
**Toolholder:** ACLNL2525M12-A  
**Insert:** 2QP-CNGA120408  
**Grade:** BXA10

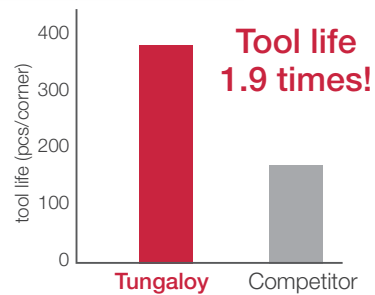
**Cutting conditions:**

**Vc** = 100 m/min (328 sfm)  
**f** = 0.05 mm/rev (.002 ipr)  
**ap** = 0.15 mm (.006")  
**Coolant** = Wet

**Application:** Face turning  
**Machine:** NC lathe



**H**

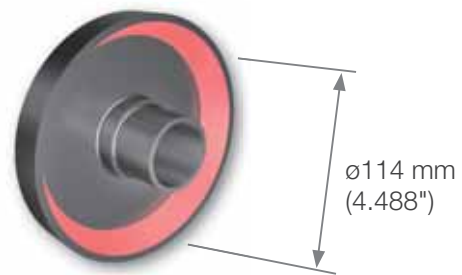
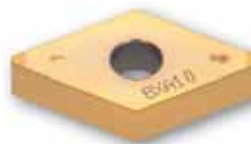


**Industry:** Automotive / CVT  
**Material:** 18CrMo4 / SCM420 (HV720 - 850)  
**Toolholder:** A32S-PDUNL15-D400  
**Insert:** 2QP-DNGA150408  
**Grade:** BXA10

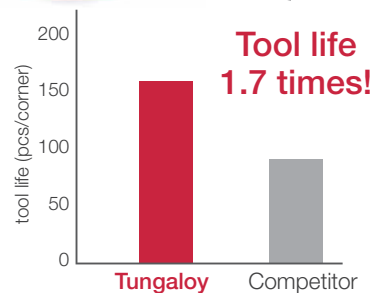
**Cutting conditions:**

**Vc** = 130 m/min (426 sfm)  
**f** = 0.1 mm/rev (.004 ipr)  
**ap** = 0.15 mm (.006")  
**Coolant** = Wet

**Application:** Internal turning  
**Machine:** NC lathe



**H**

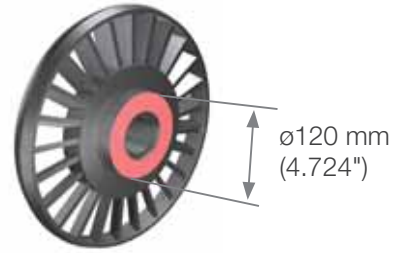


**Industry:** Automotive / Stator  
**Material:** 18CrMo4 / SCM420 (62HRC)  
**Toolholder:** SDJCR2020K11  
**Insert:** 2QP-DCGW11T308  
**Grade:** BXA10

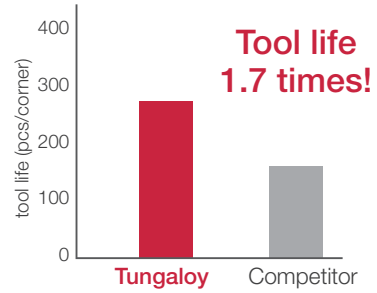
**Cutting conditions:**

$V_c = 168 \text{ m/min (551 sfm)}$   
 $f = 0.08 \text{ mm/rev (.003 ipr)}$   
 $ap = 0.2 \text{ mm (.008") x2 passes}$   
**Coolant = Wet**

**Application:** Face turning  
**Machine:** NC lathe



**H**

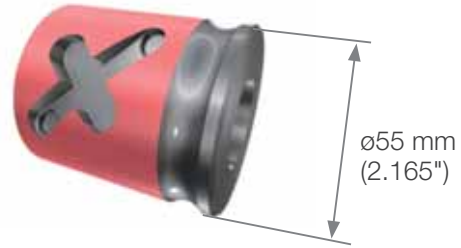


**Industry:** General Engineering / Nut  
**Material:** 20CrMo4 / SCM420 (58HRC)  
**Toolholder:** ATGNR2525M16-A  
**Insert:** 3QP-TNGA160408  
**Grade:** BXA20

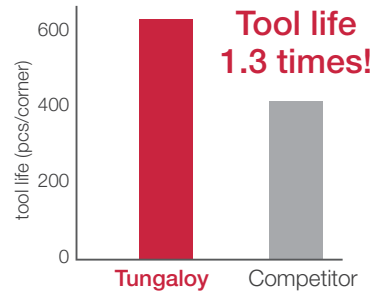
**Cutting conditions:**

$V_c = 200 \text{ m/min (656 sfm)}$   
 $f = 0.08 \text{ mm/rev (.003 ipr)}$   
 $ap = 0.15 \text{ mm (.006")}$   
**Coolant = Wet**

**Application:** External turning  
**Machine:** NC lathe



**H**



**Industry:** Automotive / Input shaft  
**Material:** 20Cr4 / SCr420 (63HRC)  
**Toolholder:** E12G-SCLCR06-D160  
**Insert:** 2QP-CCGW060204  
**Grade:** BXA20

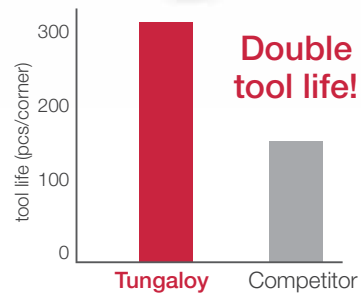
**Cutting conditions:**

$V_c = 120 \text{ m/min (394 sfm)}$   
 $f = 0.1 \text{ mm/rev (.004 ipr)}$   
 $ap = 0.1 \text{ mm (.004")}$   
**Coolant = Wet**

**Application:** Internal turning  
**Machine:** NC lathe



**H**



# HARD TURNING SERIES - FIELD TEST REPORTS

**Industry:** Automotive / Input shaft  
**Material:** SNCM420 (58HRC)  
**Toolholder:** E20S-STUPR1103-D220  
**Insert:** 3QP-TPGW110308  
**Grade:** BXA20

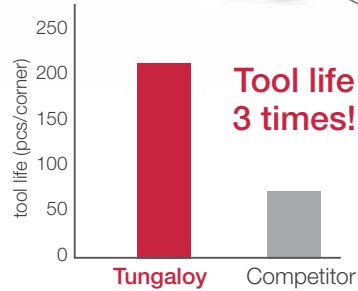
**Cutting conditions:**

$V_c = 170$  m/min (558 sfm)  
 $f = 0.08$  mm/rev (.003 ipr)  
 $ap = 0.10$  mm (.004")  
 Coolant = Wet

**Application:** Internal turning  
**Machine:** NC lathe



**H**



**Industry:** Automotive / Gear wheel  
**Material:** SCM420 (58HRC)  
**Toolholder:** ACLNL2525M12-A  
**Insert:** 4QS-CNGA120412-H  
**Grade:** BXA20

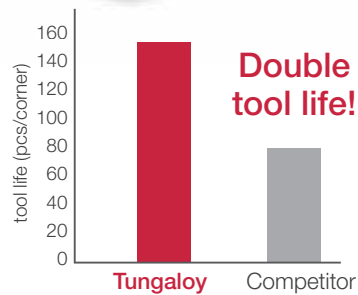
**Cutting conditions:**

$V_c = 100$  m/min (328 sfm)  
 $f = 0.15$  mm/rev (.006 ipr)  
 $ap = 1.0$  mm (.039")  
 Coolant = Wet

**Application:** External turning & facing  
**Machine:** NC lathe



**H**

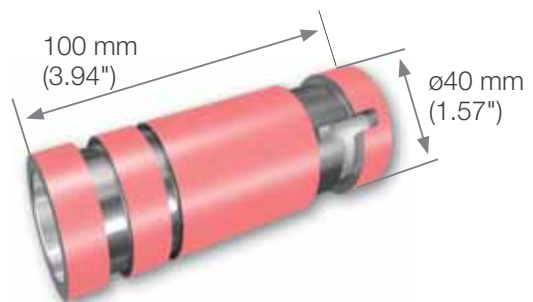


**Industry:** Heavy Industries / Movable arm shaft  
**Material:** S45C (50HRC)  
**Toolholder:** ACLNR2020K12-A  
**Insert:** 4QS-CNGA120408-H  
**Grade:** BXA20

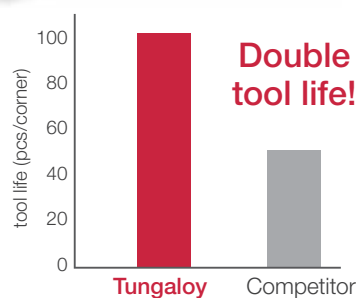
**Cutting conditions:**

$V_c = 180$  m/min (591 sfm)  
 $f = 0.10$  mm/rev (.04 ipr)  
 $ap = 0.5$  mm (.020")  
 Coolant = Dry

**Application:** External turning  
**Machine:** NC lathe



**H**

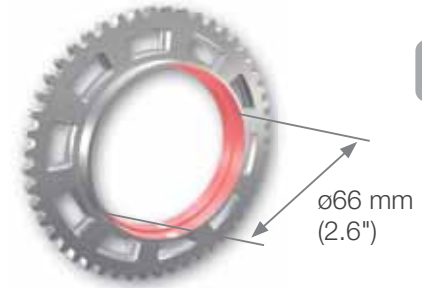


Industry: **Automotive** / Gear part  
 Material: 20Cr4 / SCr420 (60HRC)  
 Toolholder: D25T-DCLNR1204-32  
 Insert: 2QP-GNGA120408  
 Grade: BXA20

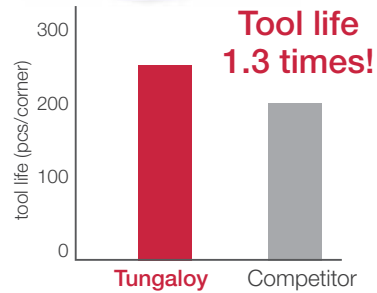
**Cutting conditions:**

$V_c = 120$  m/min (394 sfm)  
 $f = 0.10$  mm/rev (.004 ipr)  
 $ap = 0.10$  mm (.004")  
 Coolant = Wet

Application: Internal turning  
 Machine: NC lathe



**H**

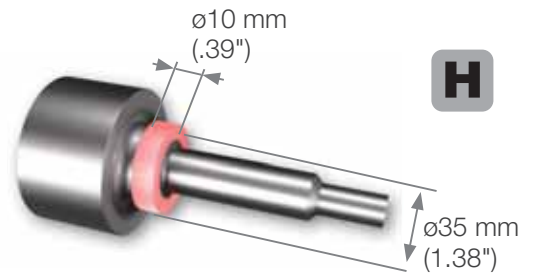
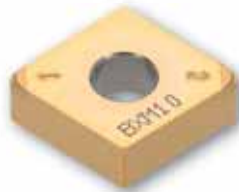


Industry: **Automotive** / CVJ part  
 Material: SCr420 (60HRC)  
 Toolholder: ACLNR2525M12-A  
 Insert: 2QP-CNGM120408-HP  
 Grade: BXM10

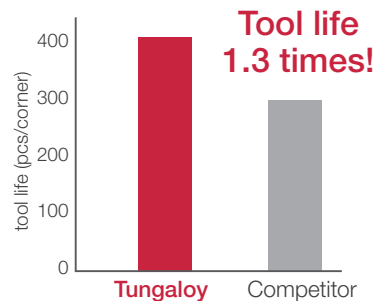
**Cutting conditions:**

$V_c = 250$  m/min (820 sfm)  
 $f = 0.20$  mm/rev (.08 ipr)  
 $ap = 0.20$  mm (.08")  
 Coolant = Wet

Application: External turning & facing  
 Machine: NC lathe



**H**



Industry: **Automotive** / Shaft  
 Material: SCM420 (59HRC)  
 Toolholder: SDJCR2525M11  
 Insert: 2QP-DCGT11T304-HP  
 Grade: BXM10

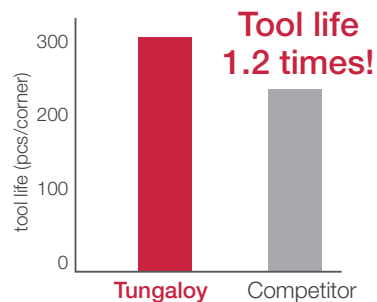
**Cutting conditions:**

$V_c = 120$  m/min (394 sfm)  
 $f = 0.05$  mm/rev (.002 ipr)  
 $ap = 0.20$  mm (.08")  
 Coolant = Wet

Application: External turning  
 Machine: NC lathe



**H**



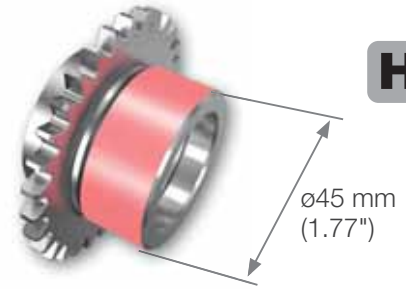
# HARD TURNING SERIES - FIELD TEST REPORTS

Industry: **Automotive** / Sprocket  
 Material: SCM415 (55HRC)  
 Toolholder: ACLNL2020K12-A  
 Insert: 2QP-CNGM120404WL-HP  
 Grade: BXA20

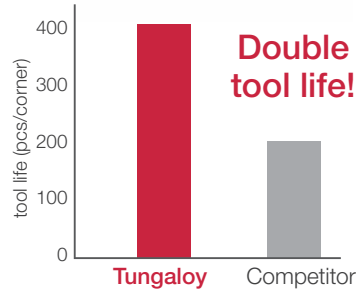
**Cutting conditions:**

$V_c = 120$  m/min (394 sfm)  
 $f = 0.05$  mm/rev (.002 ipr)  
 $ap = 0.10$  mm (.04")  
 Coolant = Wet

Application: External turning  
 Machine: NC lathe



**H**

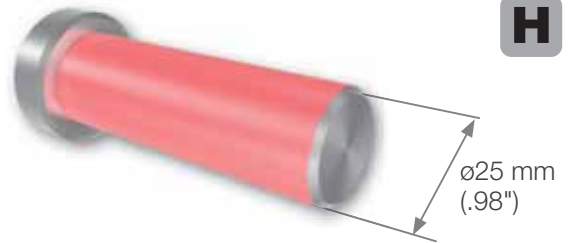


Industry: **Die&Mold** / Guide pin  
 Material: D2 tool steel (60 HRC)  
 Toolholder: ADJNR2525M15  
 Insert: DNGA432  
 Grade: LX11

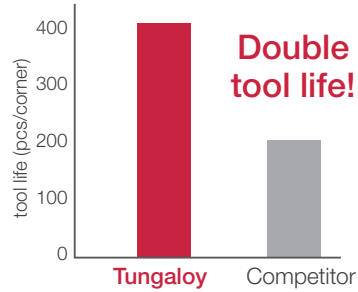
**Cutting conditions:**

$V_c = 120$  m/min (394 sfm)  
 $f = 0.2$  mm/rev (.008 ipr)  
 $ap = 1.0$  mm (.04")  
 Coolant = Wet

Application: External turning  
 Machine: NC lathe



**H**

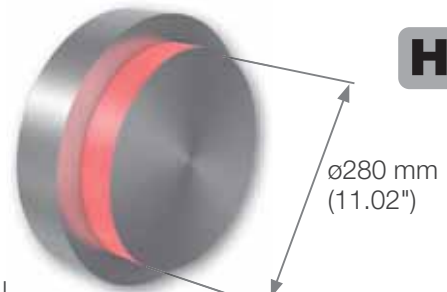


Industry: **Automotive** / Guide starter gear  
 Material: 16MnCr5 (58 HRC)  
 Toolholder: ACLNL2525M12-A  
 Insert: CNGA120408  
 Grade: LX11

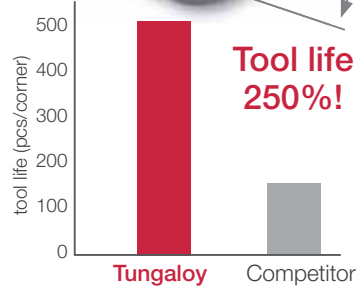
**Cutting conditions:**

$V_c = 90$  m/min (295 sfm)  
 $f = 0.08$  mm/rev (.003 ipr)  
 $ap = 0.05$  mm (.002")  
 Coolant = Wet

Application: External turning  
 Machine: NC lathe



**H**

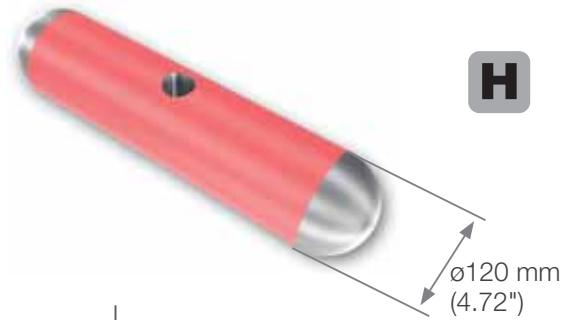
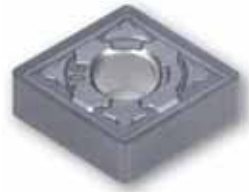


**Industry:** General Engineering / Toggle pin  
**Material:** Tool steel (49 HRC)  
**Toolholder:** PCLNR3232P19E  
**Insert:** CNMG190616-HRM  
**Grade:** AH8005

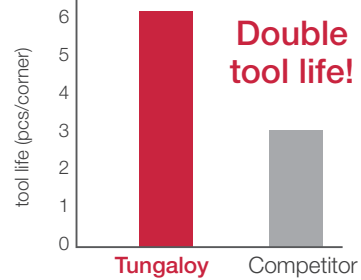
**Cutting conditions:**

$V_c = 66 \text{ m/min (216 sfm)}$   
 $f = 0.6 \text{ mm/rev (.023 ipr)}$   
 $ap = 1.25 \text{ mm (.010")}$   
**Coolant = Dry**

**Application:** External turning  
**Machine:** NC lathe



**H**



**Industry:** Die & Mold / Pin for die set  
**Material:** SKH51 (63 HRC)  
**Toolholder:** PTGMR2525M16  
**Insert:** TNMG160408-HRF  
**Grade:** AH8005

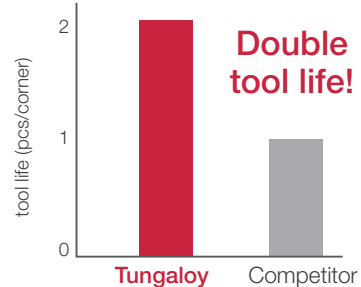
**Cutting conditions:**

$V_c = 30 \text{ m/min (98.4 sfm)}$   
 $f = 0.1 \text{ mm/rev (.004 ipr)}$   
 $ap = 1.0 \text{ mm (.040")}$   
**Coolant = Wet**

**Application:** External turning  
**Machine:** NC lathe



**H**



**Industry:** Heavy Industries / Roll  
**Material:** SKD11 (60 HRC)  
**Toolholder:** PRGCL2525M12  
**Insert:** RCMT1204M0-RS  
**Grade:** AH8005

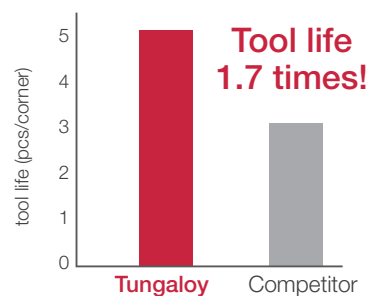
**Cutting conditions:**

$V_c = 80 \text{ m/min (262 sfm)}$   
 $f = 0.2 \text{ mm/rev (.008 ipr)}$   
 $ap = 2.0 \text{ mm (.08")}$   
**Coolant = Wet**

**Application:** External turning  
**Machine:** NC lathe



**H**

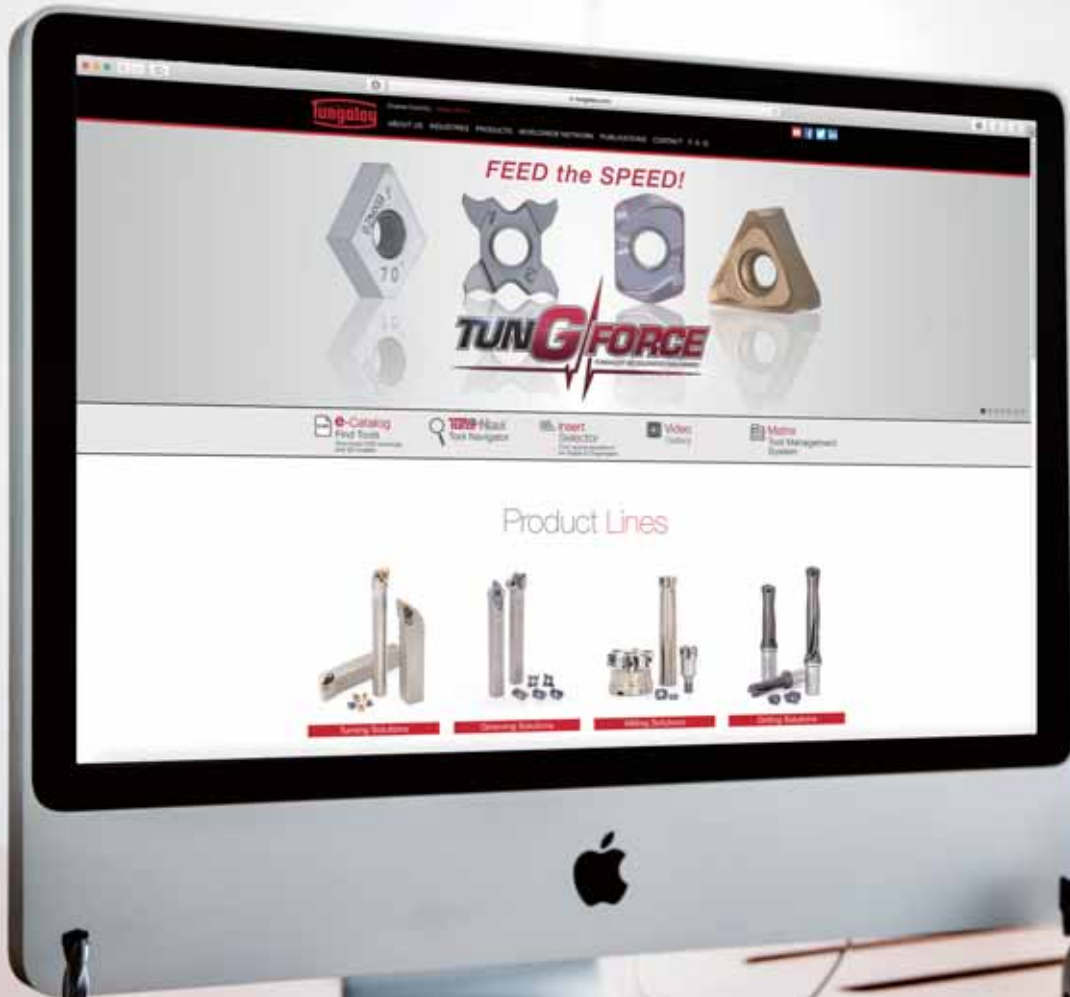


MEMO

A large grid of graph paper, consisting of 20 columns and 30 rows of small squares, intended for taking notes or calculations.



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