HardCut

Hard turning with PCBN indexable inserts

CERATIZIT is a high-technology engineering group specialized in cutting tools and hard material solutions.

Tooling a Sustainable Future

www.ceratizit.com

CERATIZIT GROUP

Welcome!

Get in touch

Customer Service Team

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On-site technical support

Your Local Technical Sales Engineer

Your customer number

Tooling a Sustainable Future

CERATIZIT: a specialist in sustainable cutting tools and hard material solutions.

Are you looking for a reliable partner for your tooling and machining-process needs?
Then look no further! CERATIZIT is not just a tool supplier. Our experts are also on hand to advise you with extensive industry knowledge and decades of experience.

What's more, anyone who wants to pay particular attention to their CO2 balance, will find in us a sustainability-conscious partner with a concrete strategy and target set out in our vision of becoming the #1 sustainable company in our industry.

For more than 100 years, CERATIZIT has been a pioneer in the field of ambitious hard material solutions for machining and protection against wear. This allows us to guarantee our customers the highest levels of quality and access to the latest developments in the carbide sector – all-round cutting tools expertise from a single source.

30 production sites

80 countries in which we are active

1 000 patents and utility models

Dear customers,

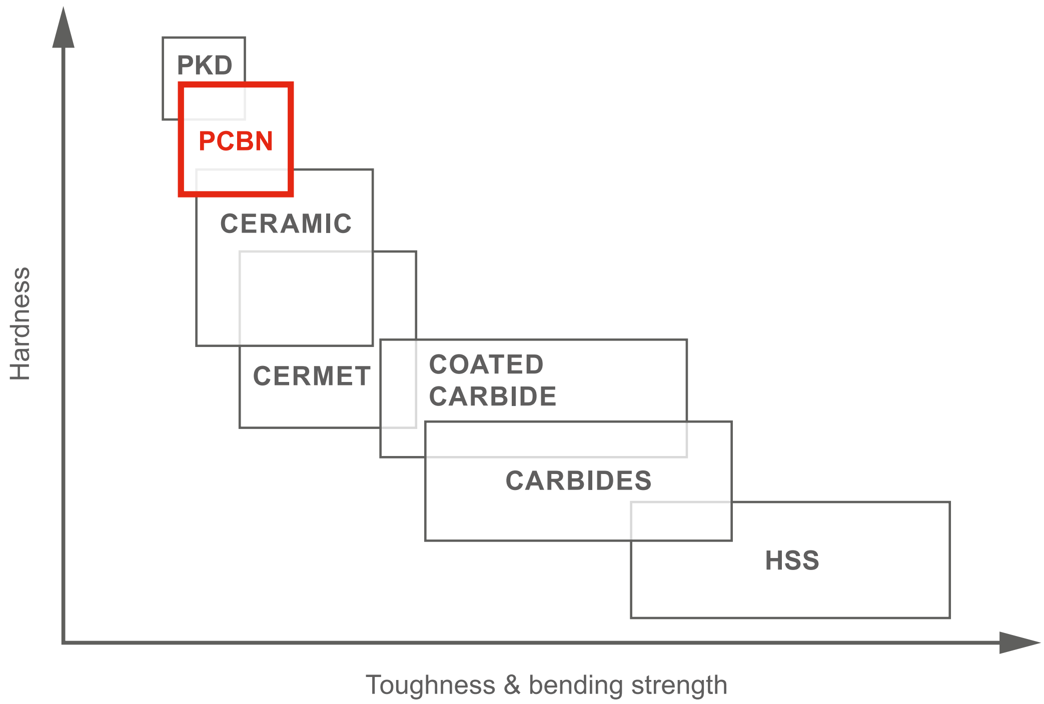
Extremely hard cutting materials allow you to machine hardened cast iron materials (hardness >55 HRC) with geometrically defined cutting edges. At the top end of the cutting material hardness scale are polycrystalline diamonds and cubic boron nitride, which is usually the first choice for hard machining. As your partner for premium-class machining solutions, who guarantees maximum tool life and optimal process security, we offer a wide range of PCBN cutting materials. Take a look at our portfolio of PCBN indexable inserts. Use our selection to find out more about hard machining and about the PCBN indexable inserts which are used in this area. Benefit from our application recommendations and use our tips to see for yourself what our PCBN cutting materials can do, and optimize your process.

Should you have any questions, our specialists in hard machining will be happy to help.

Your CERATIZIT team

Cutting material – hardness comparison

PCBN is one of the hardest materials in the world. In addition to many other exceptional properties, it is this hardness which makes the material ideal for machining hard, abrasive components. PCBN has a greater chemical and thermal stability than diamond, which reacts with iron and has a maximum temperature limit of approx. 700°C (1300°F). PCBN is resistant up to temperatures exceeding 1000°C (1800°F) and is therefore ideal for the high machining temperatures when hard turning.



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CERATIZIT \ Performance

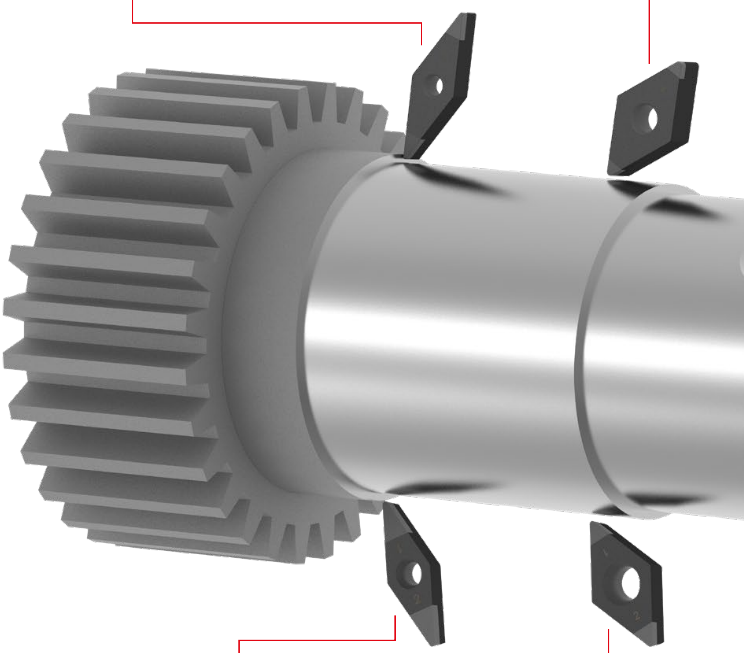
Premium quality tools for high performance.

The premium quality tools from the **CERATIZIT Performance** product line have been designed for specific applications and are distinguished by their outstanding performance. If you make high demands on the performance of your production and want to achieve the very best results, we recommend the Premium tools in this product line.

Toolfinder – indexable inserts

DNGA
24+25
F M R
RE 0.4 / 0.8 / 1.2

VNGA
30+31
F M R
RE 0.4 / 0.8



VCGW
43–45
F M R
RE 0.2 / 0.4 / 0.8

DCGW
37–39
F M R
RE 0.2 / 0.4 / 0.8

PCBN grade key CERATIZIT

wear-resistant v_c+ ○ ⟷ v_c– tough

1000 — 3000

C T B H x x x x C (Example)

- CERATIZIT
- B = CBN
- H = Hard
- S = Super alloys, Cast iron, Sintered materials
- xxxx = Substrate
- C = Coated
- U = uncoated

Symbol explanation

CTBH2000C *PCBN grade*

F	M	R
Fine Machining	Medium Machining	Rough Machining

Smooth cut – Interrupted cut – Interrupted cut

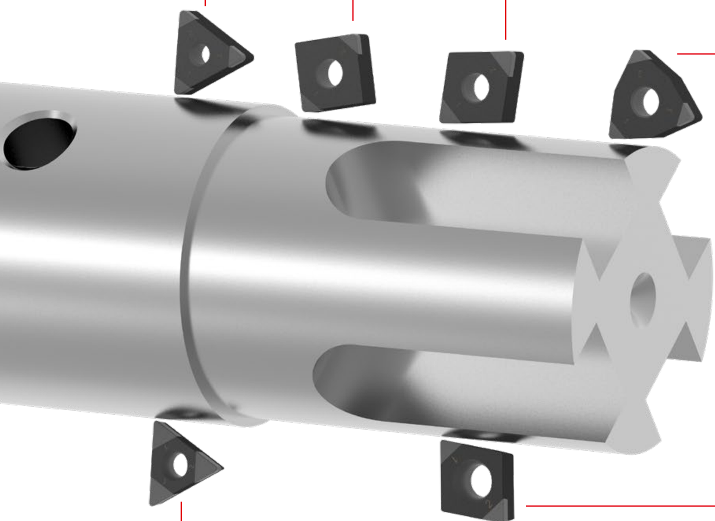
A detailed grades overview can be found on → **Page 20**

TNGA 28+29
F M R
RE 0.4 / 0.8 / 1.2

SNGA 26+27
F M R
RE 0.8 / 1.2

CNGA 22+23
F M R
RE 0.4 / 0.8 / 1.2

WNGA 32+33
F M R
RE 0.8 / 1.2

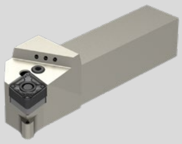
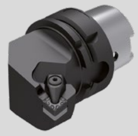
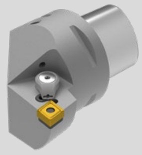


CCGW 34–36
F M R
RE 0.2 / 0.4 / 0.8

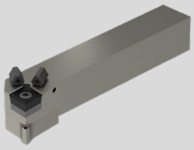
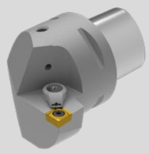
TCGW 40–42
F M R
RE 0.4 / 0.8

Toolfinder – holders

Tool holders and boring bars for negative inserts
can be found in the **2023 International Metric Catalog – Chapter 9, Indexable insert turning tools** on the following pages:

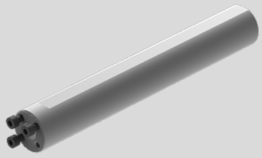
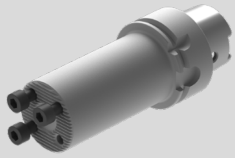
Geometry	 Tool holder	 Boring bars	 HSK-T	 PSC
CN..	→ 09 | 15–18	→ 09 | 21+22	→ 09 | 19	→ 09 | 20
DN..	→ 09 | 28–31	→ 09 | 38+39	→ 09 | 31+33	→ 09 | 34–37
SN..	→ 09 | 43–48	→ 09 | 49	→ 09 | 48	
TN..	→ 09 | 53+55	→ 09 | 56		
VN..	→ 09 | 59		→ 09 | 60	→ 09 | 60+61
WN..	→ 09 | 65+66	→ 09 | 68+69	→ 09 | 66	→ 09 | 66

Tool holders and boring bars for positive inserts
can be found in the **2023 International Metric Catalog – Chapter 9, Indexable insert turning tools** on the following pages:

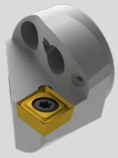
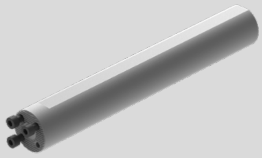
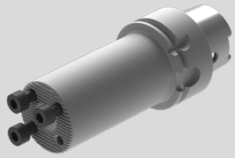
Geometry	 Tool holder	 Boring bars	 HSK-T	 PSC
CC..	→ 09 | 79–85	→ 09 | 88–92	→ 09 | 86	→ 09 | 87
DC..	→ 09 | 102–108	→ 09 | 112–116	→ 09 | 109	→ 09 | 110+111
TC..	→ 09 | 141–144	→ 09 | 145		
VC..	→ 09 | 152–160	→ 09 | 164–166	→ 09 | 160	→ 09 | 155+156

Toolfinder – holders

Exchangeable cutting heads and base holders for negative inserts
can be found in the **2023 International Metric Catalog – Chapter 9, Indexable insert turning tools** on the following pages:

Geometry	 Exchangeable cutting heads	 cylindrical	 HSK-T	 PSC
CN..	→ 09 | 176		→ 09 | 172	→ 09 | 169
DN..	→ 09 | 176+177	→ 09 | 175	Vibration damped → 09 | 173	Vibration damped → 09 | 170
WN..	→ 09 | 177		Actively vibration-damped → 09 | 174	Actively vibration-damped → 09 | 171

Exchangeable cutting heads and base holders for positive inserts
can be found in the **2023 International Metric Catalog – Chapter 9, Indexable insert turning tools** on the following pages:

Geometry	 Exchangeable cutting heads	 cylindrical	 HSK-T	 PSC
CC..	→ 09 | 178	→ 09 | 175	→ 09 | 172 Vibration damped → 09 | 173 Actively vibration-damped → 09 | 174	→ 09 | 169 Vibration damped → 09 | 170 Actively vibration-damped → 09 | 171
DC..	→ 09 | 178+179			

Introduction to hard turning

Hard materials

The materials machined have a hardness of up to 67 HRC. Case-hardened steels are subject to soft pre-machining (unhardened) using carbide indexable inserts. After hardening (minimum hardness of steel 55 HRC) areas showing hardening distortions and also the running surfaces must be reworked.

When finish machining with PCBN, very high surface quality (up to R_a 0.2) and close tolerances can be achieved. In many cases, grinding is not necessary.

Turning instead of grinding

Advantage/benefit

- ▲ Change to a grinding machine is not necessary
- ▲ Faster cycle time
- ▲ Several machining operations can be carried out with one tool: longitudinal and face turning, external and internal machining in one set-up
- ▲ Roughing and finishing in one process
- ▲ Coolant substitution

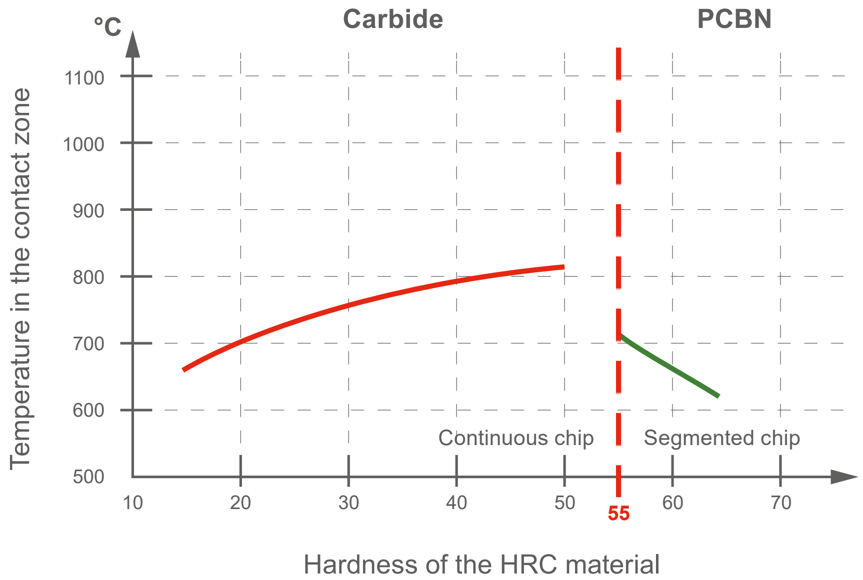
Principle of hard turning

Chip formation when machining steel

The softening of the chip thanks to high cutting speeds is the basis of hard machining. Shear chips can be created on hardened steel as a result of the cutting energy introduced (high temperatures). Carbide indexable inserts have a higher flexural strength than PCBN and are therefore more suitable for soft machining. From a hardness of 50 HRC, the temperatures generated during the machining process are so high that the wear of the carbide indexable insert is uneconomically high. The reason for this is the insufficiently elevated-temperature hardness of the carbide.
In contrast, PCBN has a higher hardness than carbide and can still be used cost-effectively at high temperatures.

Example:

Material:	100Cr6 (1.1645)
Feed:	f = .004" in/rev
Cutting speed:	v_c = 400 ft/min

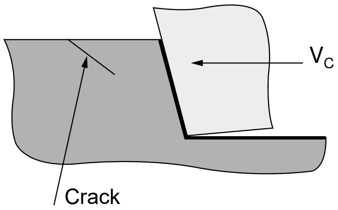


Hard machining with PCBN from 55 HRC

- up to 50 HRC use of carbide
- From 55 HRC use of PCBN

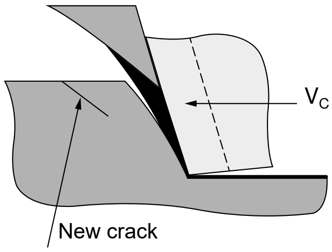
Segmented chip with chip thickness h_m>0.0008"

Due to the reduced width of cut of h_m>0.0008", the material (chip) is cut out upwards, the individual chip segments remain stuck to one another, thus forming the typical saw tip structure.



Material: 100Cr6 (60-62 HRC)
Chip thickness: h_m = 0.002"

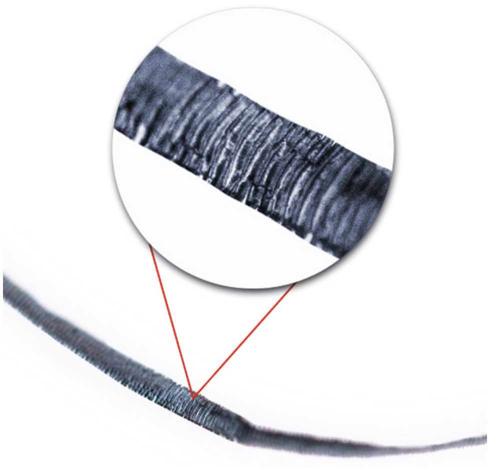
Crack on the surface of the steel

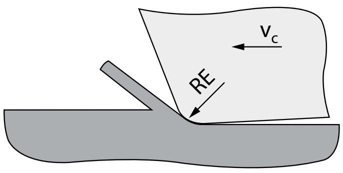


Chip segment is cut out, a new crack is created
Chip segments fuse into one segmented chip

Continuous chip with small chip thickness h_m<0.0008"

As a result of the reduced width of cut h_m<0.0008", a continuous chip is created since the typical cracks are not created at this width of cut. The chip is evacuated across the tool cutting edge, so that there is no breakage and a continuous chip forms.





Material: 100Cr6 (60-62 HRC)
Chip thickness: h_m = 0.002"

Application

▲ The basis for hard machining is the softening of the chip as a result of the high cutting speeds
→ Ideally, the chip is red hot.
This can be recognize by the medium-grey tempering colour on the cooled-down back of the chip.

Under optimal processing conditions the resulting shear chip is brittle and can easily be crumbled between the fingers.

CERATIZIT – the carbide concept for success

Carbide has become indispensable in numerous industries and production processes. Complex products and modern materials place increasingly high demand on tools, materials and precision processing.

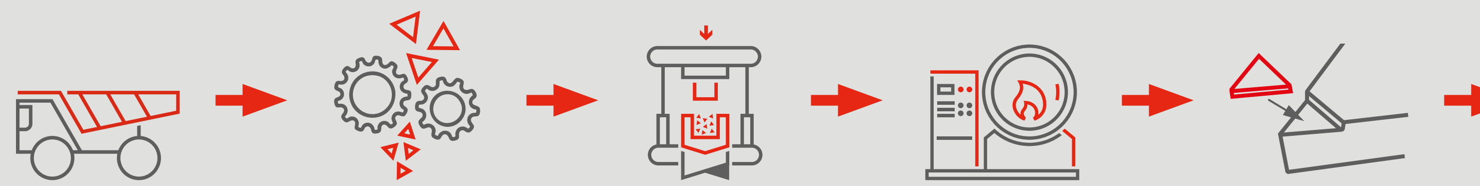
Carbides are composite materials consisting of a hard material and a very tough binder metal. They are extremely hard, and are characterized by high wear resistance and high hot hardness.

Carbide is used in various fields that require tools or components to be particularly wear-resistant, such as in the machining of hard materials. CERATIZIT composite carbides improve the quality of tools and components, give them a longer service life, reduce costs and ensure process reliability.

Carbides from CERATIZIT are made of super-strong tungsten carbide and a relatively soft binder metal such as cobalt. The two materials are fused in powder form. CERATIZIT offers more than 100 different carbide grades with different compositions. We have the perfect solution for every application and industry.

CERATIZIT masters the whole production process chain from powder production, molding and sintering to finishing and surface treatment. We grind, polish or erode the blank and coat it with innovative wear-resistant coatings. This gives our product the properties required for industrial applications.

To make a finished carbide blank from a powder mix, you first need to press it into a mold. The resulting green compact can then be machined. Once it has been sintered at a temperature of between 1,300 and 1,500 degrees Celsius and a pressure of up to 100 bar, it is turned into a homogeneous and dense cutting material.



Material extraction

- Global extraction of cobalt and tungsten with selected business partners to secure a responsible procurement of raw materials

Preparing and mixing the powder

- Powder and grade manufacturing

Forming/pressing

- Forming using a variety of technologies (extrusion moulding, direct pressing, isostatic pressing, manual forming)

Sintering

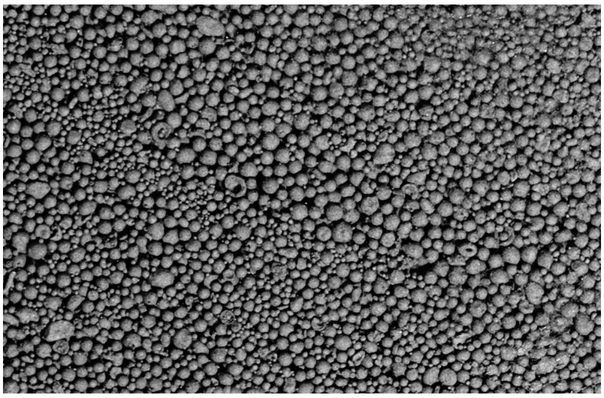
- Several decades of experience in the precise calculation of sinter shrinking, guaranteeing a high-quality end product

Brazing

- Joining of uncoated and indexable insert. Vacuum brazing and the special solder composition produce a robust connection

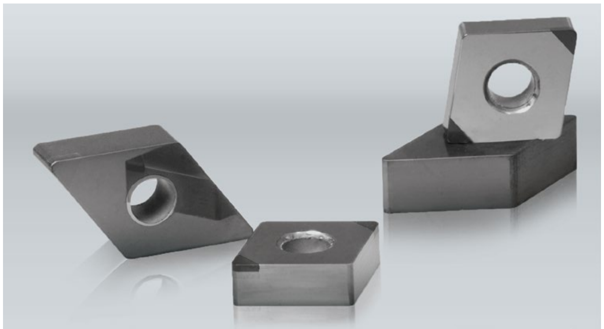
Carbide – composite material with valuable properties

The amount of metal binder used and the grain size of the tungsten carbide both have an impact on the performance characteristics of the carbide. The specific composition determines the hardness, flexural strength and fracture toughness of the cutting material. The tungsten carbide grains have an average size of 0.5 to 20 micrometres (µm). The softer binder metal, cobalt, fills the space in between.



On the one hand, when extremely high toughness is required, the cobalt content can amount to as much as 30%. On the other, the cobalt content is reduced and the grain size decreased to the ultrafine range (e.g. 0.000012"), in order to guarantee maximum wear resistance.

CERATIZIT offers a customized solution for every one of your applications, particularly for the machining sector and wear parts.



Grinding

- Peripheral grinding and chamfering; the indexable insert is ready for use

Coating

- Coating using the PVD process, metals such as titanium and aluminium are heated under vacuum, vaporous and using electric voltage, they stick to the surface of the indexable insert.

Quality assurance

- All products are subject to strict quality control tests by experienced specialists

Delivery/dispatch

- Automated high-tech shuttle warehouse, ensuring that your goods are ready for dispatch in next to no time.

Recycling

- We organise the entire process for you and also provide free collection containers.

PCBN – production of round blanks

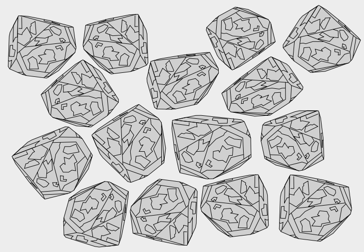
Pyrolysis

of boron-halogen compounds
in a catalytic reaction

Boron nitride with a hexagonal lattice structure

PCBN – synthesis

Pressure: 5 – 9 GPa
Temperature: 1600 – 2100°C



Boron nitride grains (grit) with cubic body and centred lattice

High hot hardness

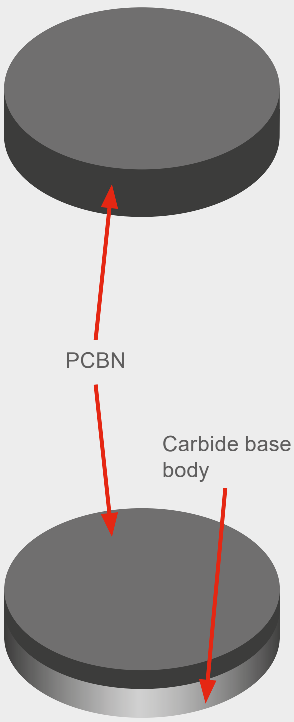
Hardness at 800°C comparable with the hardness of carbide at room temperature

PCBN – production of indexable inserts

Round blank

Ø 40 - 100 mm

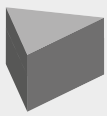
Solid PCBN

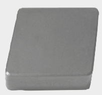


with base body

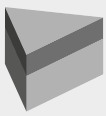
Separating the tips

Laser or wire erosion process



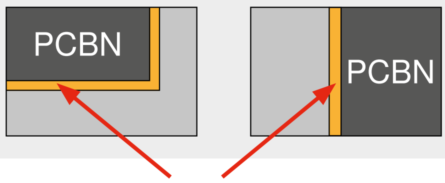


CNGN 1204...



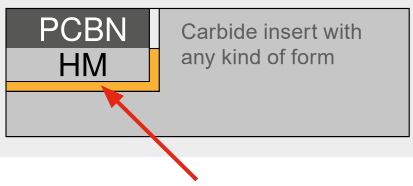
Brazing

Brazing
under vacuum



Brazing temperature: approx. 900°C

Brazing
under atmospheric pressure



Brazing temperature: approx. 750°C

Hot pressing

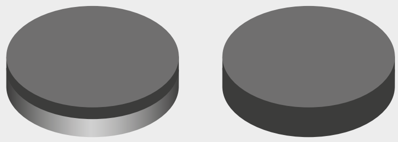
of the PCBN grains

Binder
- ▲ Ceramic (TiC, TiN, TiCN, Al_2O_3)
- ▲ Metallic (WC-Co-Ni)

Pressure: ca. 5 GPa
Temperature: >1000°C

Base body
flat cylindrical carbide substrate

PCBN round blanks



Properties of PCBN

- ▲ Second hardest cutting material after diamond (4,700 N/mm²)
- ▲ High wear resistance (abrasion)
- ▲ High oxidation resistance up to 1,250°C
  → therefore suitable for the machining of iron alloys
- ▲ High compressive strength but low tensile strength
- ▲ Good thermal conductivity

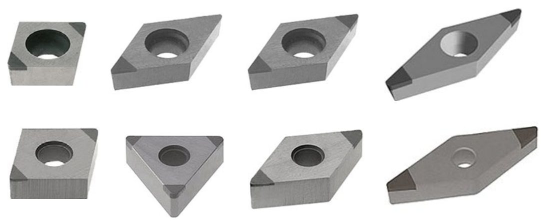
Grinding, chamfering, honing

(coating when necessary)

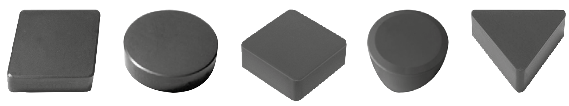
End product

Ready-to-use indexable insert

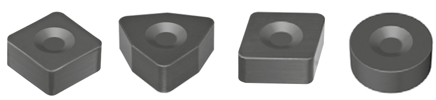
PCBN-tipped inserts



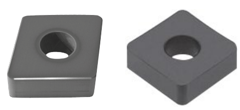
Solid PCBN inserts



Solid PCBN inserts with C-Clamp clamping dimple



Solid PCBN inserts with hole



Requirements of the machine, clamping, workpiece

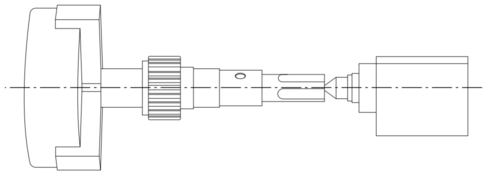
Stable machine

- Robust machine design, ideally specifically a machine for hard turning
- Extensive stress can lead to unstable processes on unstable machines

Backlash-free guides

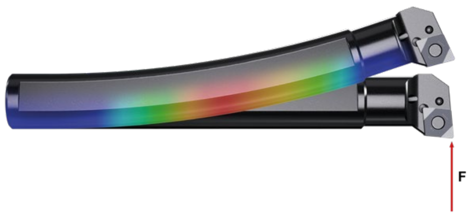
- Spindle run-out <0.000027"
- Repeatability of the axes <0.000031"
- Hydrostatic bearings
- Good maintenance condition of the machine
- Can cause the indexable insert to break uncontrollably, hindering the dimensional accuracy of the workpiece

Steady rest and tailstock



- Absolutely necessary for long or thin-walled workpieces
- If the required surface quality cannot be achieved

Tool interface

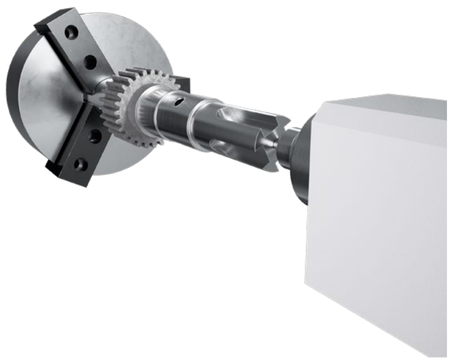


- Stable tool interface, avoid unnecessary overhangs
- Select the greatest possible tool interface
- Clamp the tool as short as possible

Natural vibrations of the machine

- Stable machine foundation
- To counteract vibrations from other machines
- It is best for the machine to be on an encapsulated foundation

Clamping and workpiece



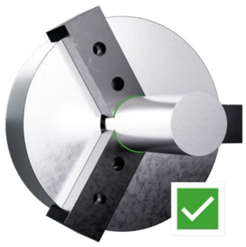
Clamping

One-sided clamped workpieces

- Clamp workpiece as short as possible, observe length and diameter ratio approx. 2:1
- Can lead to vibrations in the process

Long thin-walled workpieces

- Support workpieces with steady rest or tailstock
- To counteract vibrations in the process



Soft molded jaws or collet

- Positive clamping of the workpiece/in particular for thin-walled workpieces
- Stable manufacturing process

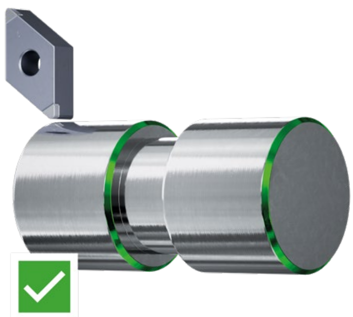
Workpiece pre-machining/soft machining

Burr formation

- Uncontrolled tool breakage when hard machining

Define tight dimension tolerances for pre-machining

- Better defined tool life when hard machining



Chamfers and radii

- Ensure a smooth entry and exit of the tool

Sharp edges

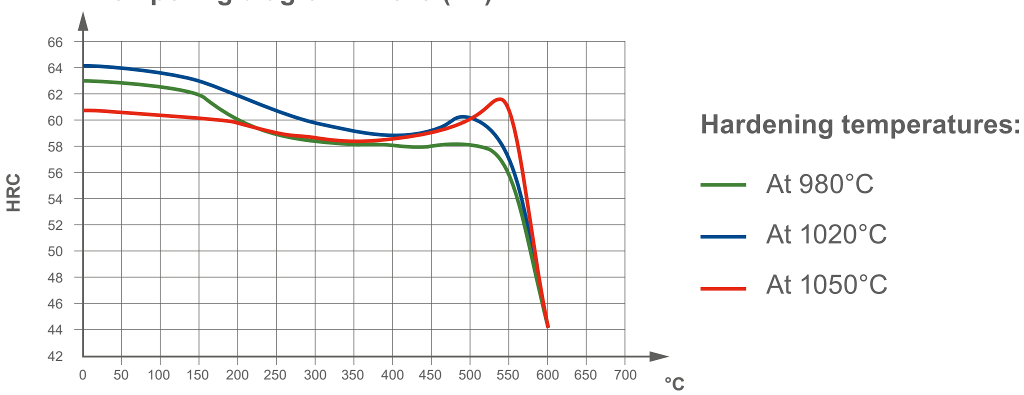
- Leads to edge breakages on cutting edge and workpiece

Material effect on hard machining

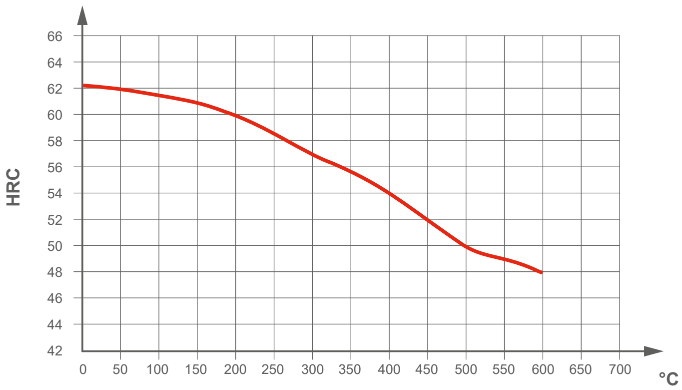
Hard machining with PCBN

When machining hardened steel, this is usually called hard machining. This machining mechanism involves self-induced hot machining. Here, a defined high temperature of approx. 550 to 750°C is needed in the shear zone. This required temperature is obtained by converting the existing energy into heat. This energy is available in the form of cutting speed v_c, feed f, depth of cut a_p and the chamfer geometries F-M-R of the PCBN cutting edges. Cooling is usually not necessary. Below are three tempering diagrams.
You can see the drop in hardness as the temperature increases.
There are, however, significant differences here. For self-induced hot machining with our PCBN grades, the ideal hardness is in the shear zone at 40 to 45 HRC. This means that different machining temperatures between 550 to 750°C are required.

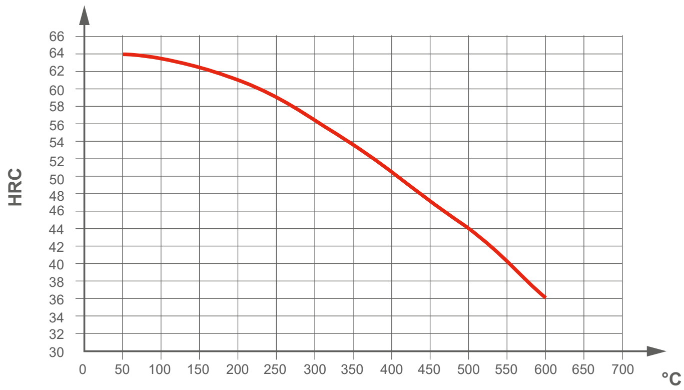
Tempering diagram 1.2379 (D2)



Tempering diagram 1.7131 (16MnCr5)



Tempering diagram 1.3505 (100Cr6)



At approx. 600°C, steel 1.2379 still has a hardness of approx. 58 HRC, steel 1.7131 of approx. 48 HRC and steel 1.3505 only achieves approx. 36 HRC, whereby the original hardness is approx. 62 HRC.

Cutting edge preparation

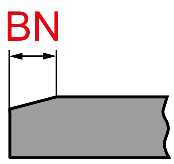
The stability of a cutting edge increases as the chamfer angle and chamfer width increase,
but at the same time the cutting force increases and subsequently also the temperature in the process.
A larger chamfer distributes the cutting force across a larger area of the cutting edge.
This increases the stability of the cutting edge, thereby facilitating higher feeds. If process stability and a constant tool life are the highest priority, then we recommend choosing a large chamfer.
If the highest priority is to achieve a very good surface quality and optimum dimensional accuracy, then it is advisable to use a small chamfer for the manufacturing process. Vibrations, cutting forces and temperature are hereby reduced.
Hard turning in most cases is the finishing of the workpiece, the optimum cutting edge preparation is a deciding factor in order to reliably produce high-quality components with a long service life.

In the case of indexable inserts with no chip breaker, the correct chamfer design is vital, as well as the type of cutting edge. For this reason, the designation system has been extended with the following key to the various chamfer designs. The design and angle can be seen in the overview below.

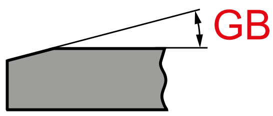
Preparation key at CERATIZIT

Designation in line with ISO **Type of cutting edge**	**CERATIZIT** **chamfer design**	**Definition**
SN (chamfered and rounded)	014D	0.0055“ x 20° / 0,14mm x 20°
EN (rounded)	rounded	

Chamfer design **SN**



Chamfer width



Chamfer angle

Type of cutting edge **EN**

CODE FOR CHAMFER ANGLE GB

A	B	C	D	E	F	G
5°	10°	15°	20°	25°	30°	35°

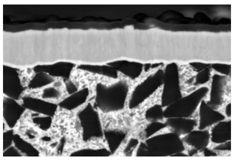
Examples	Chamfer width [mm]	Chamfer angle GB
CNGA 120408SN-009C	0,09	15°
DCGW 11T304SN-014D	0,14	20°

Grade description

PCBN grade

Features

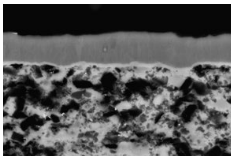
CTBH1000C



ISO | **H10**

Specifications:
Composition: Cubic boron nitride (PCBN) 70% | binder phase ceramic | Grain size: 3 µm | Layer system: PVD TiN/TiAlN
Recommended use:
High-performance grade for hard turning in a smooth and slightly interrupted cut. Ideal for extremely worn and hardened steel grades.

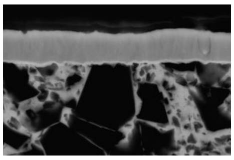
CTBH2000C



ISO | **H20**

Specifications:
Composition: Cubic boron nitride (PCBN) 40% | binder phase ceramic | Grain size: 1 µm | Layer system: PVD TiN/TiAlN
Recommended use:
Excellent surface qualities. First choice for hard-soft machining and surface layer. Perfect for very small-scale production and use in a wide variety of applications.

CTBH3000C

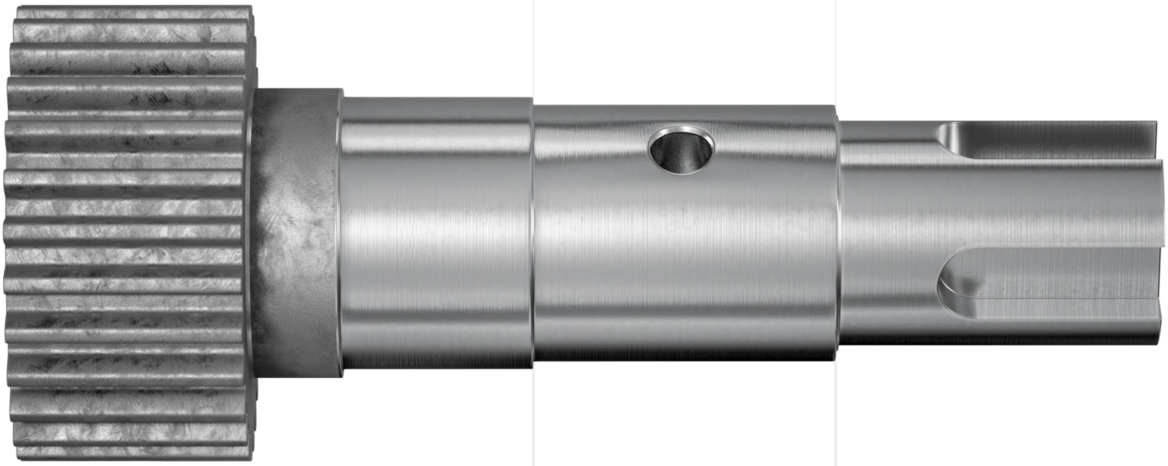


ISO | **H30**

Specifications:
Composition: Cubic boron nitride (PCBN) 65% | binder phase ceramic | Grain size: 2-3 µm | Layer system: PVD TiN/TiAlN
Recommended use:
Particularly suitable for strong to slightly interrupted cuts. Can also be used in unfavourable machining conditions such as vibrations.

Selecting the correct PCBN indexable insert

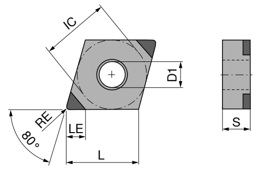
Interrupted cut / Machining	Smooth cut	Continuous to slightly interrupted cut	Strong to slightly interrupted cut
Fine machining	CTBH1000C **F** EN rounded	CTBH2000C **F** EN rounded	CTBH3000C **F** 0.0055“ x 20° 0,14mm x 20°
Medium machining	CTBH1000C **M** 0.0035“ x 15° 0,09mm x 15°	CTBH2000C **M** 0.0035“ x 15° 0,09mm x 15°	CTBH3000C **M** 0.0070“ x 25° 0,18mm x 25°
Rough machining	CTBH1000C **R** 0.0055“ x 20° 0,14mm x 20°	CTBH2000C **R** 0.0055“ x 20° 0,14mm x 20°	CTBH3000C **R** 0.0078“ x 35° 0,20mm x 35°



Interrupted cut	●○○	●●○	●●●
Cutting speed	●●●	●○○	●●○
Requirements on toughness	●○○	●●○	●●●

CNGA

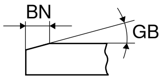
Designation	L inch	S inch	D1 inch	IC inch
CNGA 431E..	0.508	0.187	0.202	0.500
CNGA 431S..	0.508	0.187	0.202	0.500
CNGA 432E..	0.508	0.187	0.202	0.500
CNGA 432S..	0.508	0.187	0.202	0.500
CNGA 433E..	0.508	0.187	0.202	0.500
CNGA 433S..	0.508	0.187	0.202	0.500

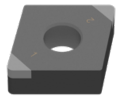
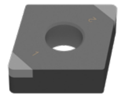
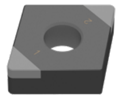


CNGA B

CNGA

▲ TCE(NOI) = Design and number of equipped cutting edge corners



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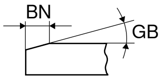
						CTBH1000C	CTBH2000C	CTBH3000C
						F	F	F
						PCBN CNGA	PCBN CNGA	PCBN CNGA
						71 003 ...	71 003 ...	71 003 ...
ANSI	RE inch	BN inch	GB	**TCE (NOI)**	LE inch			
431EN	0.016			**B (2)**	0.130	**70002**	**80002**	
431SN	0.016	0.006	20°	**B (2)**	0.130			**90002**
432EN	0.031			**B (2)**	0.130	**70302**	**80302**	
432SN	0.031	0.006	20°	**B (2)**	0.130			**90302**
433EN	0.047			**B (2)**	0.122	**70602**	**80602**	
433SN	0.047	0.006	20°	**B (2)**	0.122			**90602**
P								
M								
K								
N								
S								
H						●	●	●
O								

CNGA

▲ TCE(NOI) = Design and number of equipped cutting edge corners



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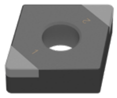
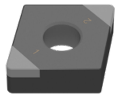
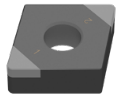
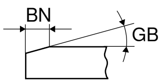
	CTBH1000C	CTBH2000C	CTBH3000C
			
	M	M	M
	PCBN	PCBN	PCBN
	CNGA	CNGA	CNGA
	71 003 ...	71 003 ...	71 003 ...

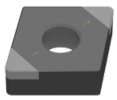
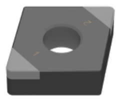
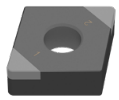
ANSI	RE inch	BN inch	GB	TCE (NOI)	LE inch	CTBH1000C	CTBH2000C	CTBH3000C
431SN	0.016	0.004	15°	B (2)	0.130	70102	80102	
431SN	0.016	0.007	25°	B (2)	0.130			90102
432SN	0.031	0.004	15°	B (2)	0.130	70402	80402	
432SN	0.031	0.007	25°	B (2)	0.130			90402
433SN	0.047	0.004	15°	B (2)	0.122	70702	80702	
433SN	0.047	0.007	25°	B (2)	0.122			90702

	CTBH1000C	CTBH2000C	CTBH3000C
P			
M			
K			
N			
S			
H	●	●	●
O			

CNGA

▲ TCE(NOI) = Design and number of equipped cutting edge corners



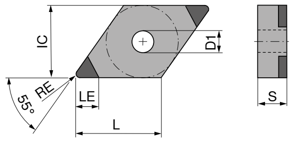
	NEW	NEW	NEW
	CTBH1000C	CTBH2000C	CTBH3000C
			
	R	R	R
	PCBN	PCBN	PCBN
	CNGA	CNGA	CNGA
	71 003 ...	71 003 ...	71 003 ...

ANSI	RE inch	BN inch	GB	TCE (NOI)	LE inch	CTBH1000C	CTBH2000C	CTBH3000C
431SN	0.016	0.006	20°	B (2)	0.130	70202	80202	
431SN	0.016	0.008	35°	B (2)	0.130			90202
432SN	0.031	0.006	20°	B (2)	0.130	70502	80502	
432SN	0.031	0.008	35°	B (2)	0.130			90502
433SN	0.047	0.006	20°	B (2)	0.122	70802	80802	
433SN	0.047	0.008	35°	B (2)	0.122			90802

	CTBH1000C	CTBH2000C	CTBH3000C
P			
M			
K			
N			
S			
H	●	●	●
O			

DNGA

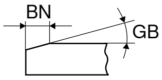
Designation	L inch	S inch	D1 inch	IC inch
DNGA 441E..	0.610	0.250	0.203	0.500
DNGA 441S..	0.610	0.250	0.203	0.500
DNGA 442E..	0.610	0.250	0.203	0.500
DNGA 442S..	0.610	0.250	0.203	0.500
DNGA 443E..	0.610	0.250	0.203	0.500
DNGA 443S..	0.610	0.250	0.203	0.500

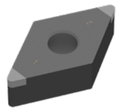


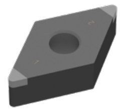
DNGA B

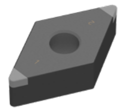
DNGA

▲ TCE(NOI) = Design and number of equipped cutting edge corners







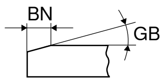


ANSI	RE inch	BN inch	GB	TCE (NOI)	LE inch	NEW CTBH1000C F PCBN DNGA 71 017 ...	NEW CTBH2000C F PCBN DNGA 71 017 ...	NEW CTBH3000C F PCBN DNGA 71 017 ...
441EN	0.016			B (2)	0.142	70002	80002	
441SN	0.016	0.006	20°	B (2)	0.142			90002
442EN	0.031			B (2)	0.130	70302	80302	
442SN	0.031	0.006	20°	B (2)	0.130			90302
443EN	0.047			B (2)	0.118	70602	80602	
443SN	0.047	0.006	20°	B (2)	0.118			90602

	CTBH1000C	CTBH2000C	CTBH3000C
P			
M			
K			
N			
S			
H	●	●	●
O			

DNGA

▲ TCE(NOI) = Design and number of equipped cutting edge corners



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						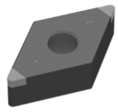	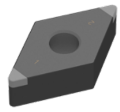	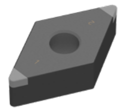
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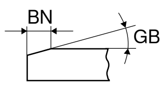
						PCBN	PCBN	PCBN
						DNGA	DNGA	DNGA
						71 017 ...	71 017 ...	71 017 ...
ANSI	RE inch	BN inch	GB	**TCE (NOI)**	LE inch			
441SN	0.016	0.004	15°	**B (2)**	0.142	**70102**	**80102**	
441SN	0.016	0.007	25°	**B (2)**	0.142			**90102**
442SN	0.031	0.004	15°	**B (2)**	0.130	**70402**	**80402**	
442SN	0.031	0.007	25°	**B (2)**	0.130			**90402**
443SN	0.047	0.004	15°	**B (2)**	0.118	**70702**	**80702**	
443SN	0.047	0.007	25°	**B (2)**	0.118			**90702**

	CTBH1000C	CTBH2000C	CTBH3000C
P			
M			
K			
N			
S			
H	●	●	●
O			

DNGA

▲ TCE(NOI) = Design and number of equipped cutting edge corners



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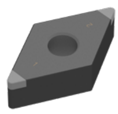
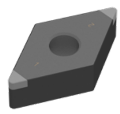
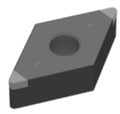
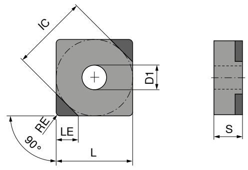
						CTBH1000C	CTBH2000C	CTBH3000C
								
						R	R	R
						PCBN	PCBN	PCBN
						DNGA	DNGA	DNGA
						71 017 ...	71 017 ...	71 017 ...
ANSI	RE inch	BN inch	GB	**TCE (NOI)**	LE inch			
441SN	0.016	0.006	20°	**B (2)**	0.142	**70202**	**80202**	
441SN	0.016	0.008	35°	**B (2)**	0.142			**90202**
442SN	0.031	0.006	20°	**B (2)**	0.130	**70502**	**80502**	
442SN	0.031	0.008	35°	**B (2)**	0.130			**90502**
443SN	0.047	0.006	20°	**B (2)**	0.118	**70802**	**80802**	
443SN	0.047	0.008	35°	**B (2)**	0.118			**90802**

	CTBH1000C	CTBH2000C	CTBH3000C
P			
M			
K			
N			
S			
H	●	●	●
O			

SNGA

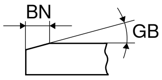
Designation	L inch	S inch	D1 inch	IC inch
SNGA 432E..	0.500	0.187	0.203	0.500
SNGA 432S..	0.500	0.187	0.203	0.500
SNGA 433E..	0.500	0.187	0.203	0.500
SNGA 433S..	0.500	0.187	0.203	0.500

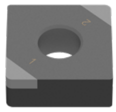
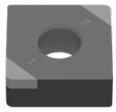
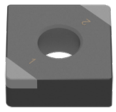


SNGA B

SNGA

▲ TCE(NOI) = Design and number of equipped cutting edge corners



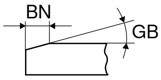




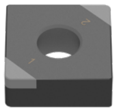
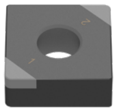
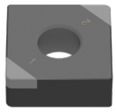
ANSI	RE inch	BN inch	GB	TCE (NOI)	LE inch	NEW CTBH1000C F **PCBN** SNGA 71 039 ...	NEW CTBH2000C F **PCBN** SNGA 71 039 ...	NEW CTBH3000C F **PCBN** SNGA 71 039 ...
432EN	0.031			**B (2)**	0.150	**70002**	**80002**	
432SN	0.031	0.006	20°	**B (2)**	0.150			**90002**
433EN	0.047			**B (2)**	0.150	**70302**	**80302**	
433SN	0.047	0.006	20°	**B (2)**	0.150			**90302**

	CTBH1000C	CTBH2000C	CTBH3000C
P			
M			
K			
N			
S			
H	●	●	●
O			

SNGA

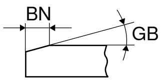
▲ TCE(NOI) = Design and number of equipped cutting edge corners

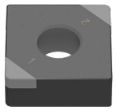
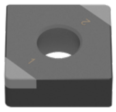
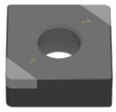


						NEW	NEW	NEW
						CTBH1000C	CTBH2000C	CTBH3000C
								
						M	M	M
						PCBN SNGA	PCBN SNGA	PCBN SNGA
						71 039 ...	71 039 ...	71 039 ...
ANSI	RE inch	BN inch	GB	**TCE (NOI)**	LE inch			
432SN	0.031	0.004	15°	**B (2)**	0.150	**70102**	**80102**	
432SN	0.031	0.007	25°	**B (2)**	0.150			**90102**
433SN	0.047	0.004	15°	**B (2)**	0.150	**70402**	**80402**	
433SN	0.047	0.007	25°	**B (2)**	0.150			**90402**
P								
M								
K								
N								
S								
H						●	●	●
O								

SNGA

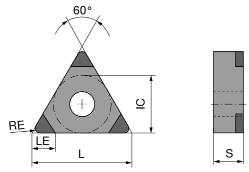
▲ TCE(NOI) = Design and number of equipped cutting edge corners



						NEW	NEW	NEW
						CTBH1000C	CTBH2000C	CTBH3000C
								
						R	R	R
						PCBN SNGA	PCBN SNGA	PCBN SNGA
						71 039 ...	71 039 ...	71 039 ...
ANSI	RE inch	BN inch	GB	**TCE (NOI)**	LE inch			
432SN	0.031	0.006	20°	**B (2)**	0.150	**70202**	**80202**	
432SN	0.031	0.008	35°	**B (2)**	0.150			**90202**
433SN	0.047	0.006	20°	**B (2)**	0.150	**70502**	**80502**	
433SN	0.047	0.008	35°	**B (2)**	0.150			**90502**
P								
M								
K								
N								
S								
H						●	●	●
O								

TNGA

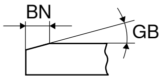
Designation	L inch	S inch	D1 inch	IC inch
TNGA 331E..	0.650	0.187	0.150	0.375
TNGA 331S..	0.650	0.187	0.150	0.375
TNGA 332E..	0.650	0.187	0.150	0.375
TNGA 332S..	0.650	0.187	0.150	0.375
TNGA 333E..	0.650	0.187	0.150	0.375
TNGA 333S..	0.650	0.187	0.150	0.375



TNGA C

TNGA

▲ TCE(NOI) = Design and number of equipped cutting edge corners





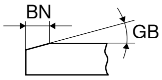
	NEW	NEW	NEW
	CTBH1000C	CTBH2000C	CTBH3000C
	F	**F**	**F**
	PCBN TNGA	**PCBN** TNGA	**PCBN** TNGA
	71 040 ...	**71 040 ...**	**71 040 ...**

ANSI	RE inch	BN inch	GB	TCE (NOI)	LE inch	CTBH1000C	CTBH2000C	CTBH3000C
331EN	0.016			**C (3)**	0.142	**70002**	**80002**	
331SN	0.016	0.006	20°	**C (3)**	0.142			**90002**
332EN	0.031			**C (3)**	0.130	**70302**	**80302**	
332SN	0.031	0.006	20°	**C (3)**	0.130			**90302**
333EN	0.047			**C (3)**	0.118	**70602**	**80602**	
333SN	0.047	0.006	20°	**C (3)**	0.118			**90602**

	CTBH1000C	CTBH2000C	CTBH3000C
P			
M			
K			
N			
S			
H	●	●	●
O			

TNGA

▲ TCE(NOI) = Design and number of equipped cutting edge corners



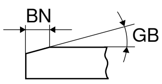


ANSI	RE inch	BN inch	GB	TCE (NOI)	LE inch	NEW CTBH1000C M PCBN TNGA 71 040 ...	NEW CTBH2000C M PCBN TNGA 71 040 ...	NEW CTBH3000C M PCBN TNGA 71 040 ...
331SN	0.016	0.004	15°	C (3)	0.142	70102	80102	
331SN	0.016	0.007	25°	C (3)	0.142			90102
332SN	0.031	0.004	15°	C (3)	0.130	70402	80402	
332SN	0.031	0.007	25°	C (3)	0.130			90402
333SN	0.047	0.004	15°	C (3)	0.118	70702	80702	
333SN	0.047	0.007	25°	C (3)	0.118			90702

	CTBH1000C	CTBH2000C	CTBH3000C
P			
M			
K			
N			
S			
H	●	●	●
O			

TNGA

▲ TCE(NOI) = Design and number of equipped cutting edge corners



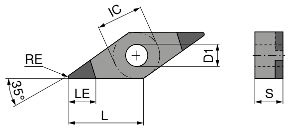


ANSI	RE inch	BN inch	GB	TCE (NOI)	LE inch	NEW CTBH1000C R PCBN TNGA 71 040 ...	NEW CTBH2000C R PCBN TNGA 71 040 ...	NEW CTBH3000C R PCBN TNGA 71 040 ...
331SN	0.016	0.006	20°	C (3)	0.142	70202	80202	
331SN	0.016	0.008	35°	C (3)	0.142			90202
332SN	0.031	0.006	20°	C (3)	0.130	70502	80502	
332SN	0.031	0.008	35°	C (3)	0.130			90502
333SN	0.047	0.006	20°	C (3)	0.118	70802	80802	
333SN	0.047	0.008	35°	C (3)	0.118			90802

	CTBH1000C	CTBH2000C	CTBH3000C
P			
M			
K			
N			
S			
H	●	●	●
O			

VNGA

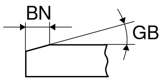
Designation	L inch	S inch	D1 inch	IC inch
VNGA 331E..	0.654	0.187	0.150	0.375
VNGA 331S..	0.654	0.187	0.150	0.375
VNGA 332E..	0.654	0.187	0.150	0.375
VNGA 332S..	0.654	0.187	0.150	0.375

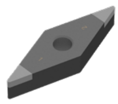
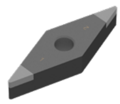
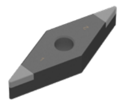


VNGA B

VNGA

▲ TCE(NOI) = Design and number of equipped cutting edge corners



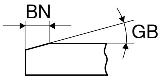
	NEW	NEW	NEW
	CTBH1000C	CTBH2000C	CTBH3000C
			
	F	**F**	**F**
	PCBN	**PCBN**	**PCBN**
	VNGA	VNGA	VNGA
	71 042 ...	**71 042 ...**	**71 042 ...**

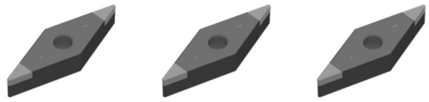
ANSI	RE inch	BN inch	GB	TCE (NOI)	LE inch	CTBH1000C	CTBH2000C	CTBH3000C
331EN	0.016			**B (2)**	0.201	**70002**	**80002**	
331SN	0.016	0.006	20°	**B (2)**	0.201			**90002**
332EN	0.031			**B (2)**	0.165	**70302**	**80302**	
332SN	0.031	0.006	20°	**B (2)**	0.165			**90302**

	CTBH1000C	CTBH2000C	CTBH3000C
P			
M			
K			
N			
S			
H	●	●	●
O			

VNGA

▲ TCE(NOI) = Design and number of equipped cutting edge corners



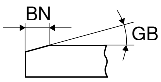


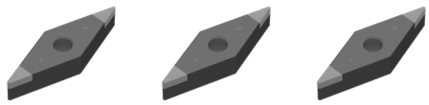
ANSI	RE inch	BN inch	GB	TCE (NOI)	LE inch	NEW CTBH1000C M PCBN VNGA 71 042 ...	NEW CTBH2000C M PCBN VNGA 71 042 ...	NEW CTBH3000C M PCBN VNGA 71 042 ...
331SN	0.016	0.004	15°	**B (2)**	0.201	**70102**	**80102**	
331SN	0.016	0.007	25°	**B (2)**	0.201			**90102**
332SN	0.031	0.004	15°	**B (2)**	0.165	**70402**	**80402**	
332SN	0.031	0.007	25°	**B (2)**	0.165			**90402**

	CTBH1000C	CTBH2000C	CTBH3000C
P			
M			
K			
N			
S			
H	●	●	●
O			

VNGA

▲ TCE(NOI) = Design and number of equipped cutting edge corners



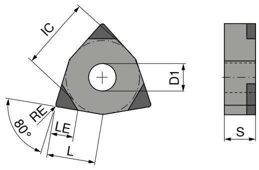


ANSI	RE inch	BN inch	GB	TCE (NOI)	LE inch	NEW CTBH1000C R PCBN VNGA 71 042 ...	NEW CTBH2000C R PCBN VNGA 71 042 ...	NEW CTBH3000C R PCBN VNGA 71 042 ...
331SN	0.016	0.006	20°	**B (2)**	0.201	**70202**	**80202**	
331SN	0.016	0.008	35°	**B (2)**	0.201			**90202**
332SN	0.031	0.006	20°	**B (2)**	0.165	**70502**	**80502**	
332SN	0.031	0.008	35°	**B (2)**	0.165			**90502**

	CTBH1000C	CTBH2000C	CTBH3000C
P			
M			
K			
N			
S			
H	●	●	●
O			

WNGA

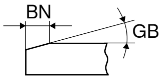
Designation	L inch	S inch	D1 inch	IC inch
WNGA 432E..	0.335	0.187	0.202	0.500
WNGA 432S..	0.335	0.187	0.202	0.500
WNGA 433E..	0.335	0.187	0.202	0.500
WNGA 433S..	0.335	0.187	0.202	0.500

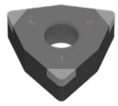
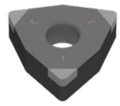
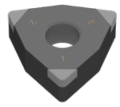


WNGA C

WNGA

▲ TCE(NOI) = Design and number of equipped cutting edge corners

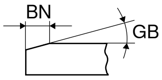


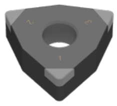
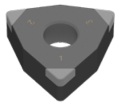
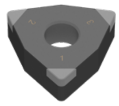




ANSI	RE inch	BN inch	GB	TCE (NOI)	LE inch	NEW CTBH1000C F PCBN WNGA 71 044 ...	NEW CTBH2000C F PCBN WNGA 71 044 ...	NEW CTBH3000C F PCBN WNGA 71 044 ...
432EN	0.031			**C (3)**	0.130	**70002**	**80002**	
432SN	0.031	0.006	20°	**C (3)**	0.130			**90002**
433EN	0.047			**C (3)**	0.122	**70302**	**80302**	
433SN	0.047	0.006	20°	**C (3)**	0.122			**90302**
P								
M								
K								
N								
S								
H						●	●	●
O								

WNGA

▲ TCE(NOI) = Design and number of equipped cutting edge corners

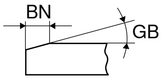


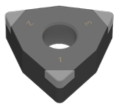
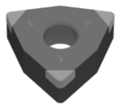
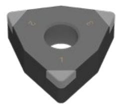
								
						NEW	NEW	NEW
						CTBH1000C	CTBH2000C	CTBH3000C
						M	M	M
						PCBN	PCBN	PCBN
						WNGA	WNGA	WNGA
						71 044 ...	71 044 ...	71 044 ...
ANSI	RE inch	BN inch	GB	**TCE (NOI)**	LE inch			
432SN	0.031	0.004	15°	**C (3)**	0.130	**70102**	**80102**	
432SN	0.031	0.007	25°	**C (3)**	0.130			**90102**
433SN	0.047	0.004	15°	**C (3)**	0.122	**70402**	**80402**	
433SN	0.047	0.007	25°	**C (3)**	0.122			**90402**

	CTBH1000C	CTBH2000C	CTBH3000C
P			
M			
K			
N			
S			
H	●	●	●
O			

WNGA

▲ TCE(NOI) = Design and number of equipped cutting edge corners

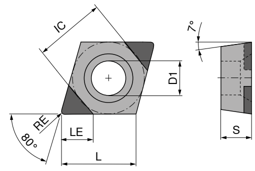


								
						NEW	NEW	NEW
						CTBH1000C	CTBH2000C	CTBH3000C
						R	R	R
						PCBN	PCBN	PCBN
						WNGA	WNGA	WNGA
						71 044 ...	71 044 ...	71 044 ...
ANSI	RE inch	BN inch	GB	**TCE (NOI)**	LE inch			
432SN	0.031	0.006	20°	**C (3)**	0.130	**70202**	**80202**	
432SN	0.031	0.008	35°	**C (3)**	0.130			**90202**
433SN	0.047	0.006	20°	**C (3)**	0.122	**70502**	**80502**	
433SN	0.047	0.008	35°	**C (3)**	0.122			**90502**

	CTBH1000C	CTBH2000C	CTBH3000C
P			
M			
K			
N			
S			
H	●	●	●
O			

CCGW

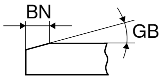
Designation	L inch	S inch	D1 inch	IC inch
CCGW 21.5..	0.254	0.094	0.110	0.250
CCGW 32.5..	0.382	0.156	0.173	0.375

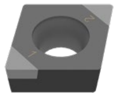
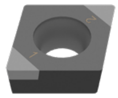
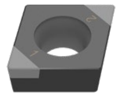


CCGW B

CCGW

▲ TCE(NOI) = Design and number of equipped cutting edge corners



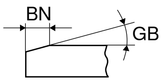
	NEW	NEW	NEW
	CTBH1000C	CTBH2000C	CTBH3000C
			
	F	F	F
	PCBN CCGW	**PCBN** CCGW	**PCBN** CCGW
	71 000 ...	**71 000 ...**	**71 000 ...**

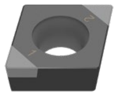
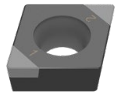
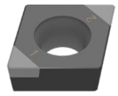
ANSI	RE inch	BN inch	GB	TCE (NOI)	LE inch	CTBH1000C	CTBH2000C	CTBH3000C
21.5.5EN	0.008			**B (2)**	0.114	**70002**	**80002**	
21.5.5SN	0.008	0.006	20°	**B (2)**	0.114			**90002**
21.51EN	0.016			**B (2)**	0.114	**70302**	**80302**	
21.51SN	0.016	0.006	20°	**B (2)**	0.114			**90302**
32.5.5EN	0.008			**B (2)**	0.130	**70602**	**80602**	
32.5.5SN	0.008	0.006	20°	**B (2)**	0.130			**90602**
32.51EN	0.016			**B (2)**	0.130	**70902**	**80902**	
32.51SN	0.016	0.006	20°	**B (2)**	0.130			**90902**
32.52EN	0.031			**B (2)**	0.130	**71202**	**81202**	
32.52SN	0.031	0.006	20°	**B (2)**	0.130			**91202**

	CTBH1000C	CTBH2000C	CTBH3000C
P			
M			
K			
N			
S			
H	●	●	●
O			

CCGW

▲ TCE(NOI) = Design and number of equipped cutting edge corners



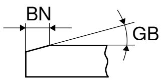
	NEW	NEW	NEW
	CTBH1000C	CTBH2000C	CTBH3000C
			
	M	M	M
	PCBN	PCBN	PCBN
	CCGW	CCGW	CCGW
	71 000 ...	71 000 ...	71 000 ...

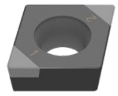
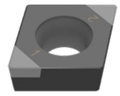
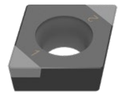
ANSI	RE inch	BN inch	GB	TCE (NOI)	LE inch	71 000 ... CTBH1000C	71 000 ... CTBH2000C	71 000 ... CTBH3000C
21.5.5SN	0.008	0.004	15°	**B (2)**	0.114	**70102**	**80102**	
21.5.5SN	0.008	0.007	25°	**B (2)**	0.114			**90102**
21.51SN	0.016	0.004	15°	**B (2)**	0.114	**70402**	**80402**	
21.51SN	0.016	0.007	25°	**B (2)**	0.114			**90402**
32.5.5SN	0.008	0.004	15°	**B (2)**	0.130	**70702**	**80702**	
32.5.5SN	0.008	0.007	25°	**B (2)**	0.130			**90702**
32.51SN	0.016	0.004	15°	**B (2)**	0.130	**71002**	**81002**	
32.51SN	0.016	0.007	25°	**B (2)**	0.130			**91002**
32.52SN	0.031	0.004	15°	**B (2)**	0.130	**71302**	**81302**	
32.52SN	0.031	0.007	25°	**B (2)**	0.130			**91302**

	CTBH1000C	CTBH2000C	CTBH3000C
P			
M			
K			
N			
S			
H	●	●	●
O			

CCGW

▲ TCE(NOI) = Design and number of equipped cutting edge corners



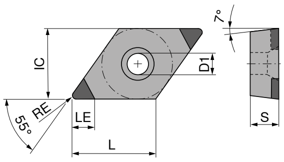
	NEW	NEW	NEW
	CTBH1000C	CTBH2000C	CTBH3000C
			
	R	R	R
	PCBN	**PCBN**	**PCBN**
	CCGW	CCGW	CCGW
	71 000 ...	71 000 ...	71 000 ...

ANSI	RE inch	BN inch	GB	TCE (NOI)	LE inch	CTBH1000C	CTBH2000C	CTBH3000C
21.5.5SN	0.008	0.006	20°	**B (2)**	0.114	**70202**	**80202**	
21.5.5SN	0.008	0.008	35°	**B (2)**	0.114			**90202**
21.51SN	0.016	0.006	20°	**B (2)**	0.114	**70502**	**80502**	
21.51SN	0.016	0.008	35°	**B (2)**	0.114			**90502**
32.5.5SN	0.008	0.006	20°	**B (2)**	0.130	**70802**	**80802**	
32.5.5SN	0.008	0.008	35°	**B (2)**	0.130			**90802**
32.51SN	0.016	0.006	20°	**B (2)**	0.130	**71102**	**81102**	
32.51SN	0.016	0.008	35°	**B (2)**	0.130			**91102**
32.52SN	0.031	0.006	20°	**B (2)**	0.130	**71402**	**81402**	
32.52SN	0.031	0.008	35°	**B (2)**	0.130			**91402**

	CTBH1000C	CTBH2000C	CTBH3000C
P			
M			
K			
N			
S			
H	●	●	●
O			

DCGW

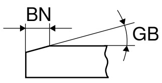
Designation	L inch	S inch	D1 inch	IC inch
DCGW 21.5..	0.305	0.094	0.094	0.250
DCGW 31.5..	0.457	0.156	0.173	0.375

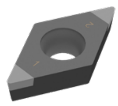
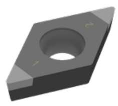
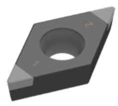


DCGW B

DCGW

▲ TCE(NOI) = Design and number of equipped cutting edge corners

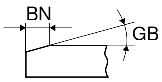


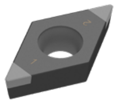
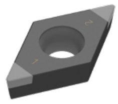
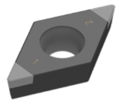
						NEW CTBH1000C	NEW CTBH2000C	NEW CTBH3000C
								
						F **PCBN** DCGW	**F** **PCBN** DCGW	**F** **PCBN** DCGW
						71 007 ...	**71 007 ...**	**71 007 ...**
ANSI	RE inch	BN inch	GB	**TCE (NOI)**	LE inch			
21.5.5EN	0.008			**B (2)**	0.146	**70002**	**80002**	
21.5.5SN	0.008	0.006	20°	**B (2)**	0.146			**90002**
21.51EN	0.016			**B (2)**	0.142	**70302**	**80302**	
21.51SN	0.016	0.006	20°	**B (2)**	0.142			**90302**
21.52EN	0.031			**B (2)**	0.130	**71202**	**81202**	
21.52SN	0.031	0.006	20°	**B (2)**	0.130			**91202**
31.5.5EN	0.008			**B (2)**	0.146	**70602**	**80602**	
31.5.5SN	0.008	0.006	20°	**B (2)**	0.146			**90602**
31.51EN	0.016			**B (2)**	0.142	**70902**	**80902**	
31.51SN	0.016	0.006	20°	**B (2)**	0.142			**90902**
31.52EN	0.031			**B (2)**	0.130	**71302**	**81302**	
31.52SN	0.031	0.006	20°	**B (2)**	0.130			**91302**

	CTBH1000C	CTBH2000C	CTBH3000C
P			
M			
K			
N			
S			
H	●	●	●
O			

DCGW

▲ TCE(NOI) = Design and number of equipped cutting edge corners

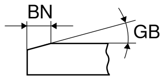


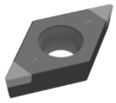
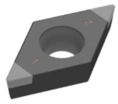
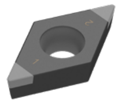
						NEW	NEW	NEW
						CTBH1000C	CTBH2000C	CTBH3000C
								
						M	M	M
						PCBN	PCBN	PCBN
						DCGW	DCGW	DCGW
						71 007 ...	71 007 ...	71 007 ...
ANSI	RE inch	BN inch	GB	**TCE (NOI)**	LE inch			
21.5.5SN	0.008	0.004	15°	**B (2)**	0.146	**70102**	**80102**	
21.5.5SN	0.008	0.007	25°	**B (2)**	0.146			**90102**
21.51SN	0.016	0.004	15°	**B (2)**	0.142	**70402**	**80402**	
21.51SN	0.016	0.007	25°	**B (2)**	0.142			**90402**
21.52SN	0.031	0.004	15°	**B (2)**	0.130	**71402**	**81402**	
21.52SN	0.031	0.007	25°	**B (2)**	0.130			**91402**
31.5.5SN	0.008	0.004	15°	**B (2)**	0.146	**70702**	**80702**	
31.5.5SN	0.008	0.007	25°	**B (2)**	0.146			**90702**
31.51SN	0.016	0.004	15°	**B (2)**	0.142	**71002**	**81002**	
31.51SN	0.016	0.007	25°	**B (2)**	0.142			**91002**
31.52SN	0.031	0.004	15°	**B (2)**	0.130	**71502**	**81502**	
31.52SN	0.031	0.007	25°	**B (2)**	0.130			**91502**

	CTBH1000C	CTBH2000C	CTBH3000C
P			
M			
K			
N			
S			
H	●	●	●
O			

DCGW

▲ TCE(NOI) = Design and number of equipped cutting edge corners



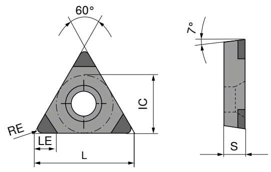
	NEW	NEW	NEW
	CTBH1000C	CTBH2000C	CTBH3000C
			
	R	R	R
	PCBN	PCBN	PCBN
	DCGW	DCGW	DCGW
	71 007 ...	71 007 ...	71 007 ...

ANSI	RE inch	BN inch	GB	TCE (NOI)	LE inch	CTBH1000C	CTBH2000C	CTBH3000C
21.5.5SN	0.008	0.006	20°	**B (2)**	0.146	**70202**	**80202**	
21.5.5SN	0.008	0.008	35°	**B (2)**	0.146			**90202**
21.51SN	0.016	0.006	20°	**B (2)**	0.142	**70502**	**80502**	
21.51SN	0.016	0.008	35°	**B (2)**	0.142			**90502**
21.52SN	0.031	0.006	20°	**B (2)**	0.130	**71602**	**81602**	
21.52SN	0.031	0.008	35°	**B (2)**	0.130			**91602**
31.5.5SN	0.008	0.006	20°	**B (2)**	0.146	**70802**	**80802**	
31.5.5SN	0.008	0.008	35°	**B (2)**	0.146			**90802**
31.51SN	0.016	0.006	20°	**B (2)**	0.142	**71102**	**81102**	
31.51SN	0.016	0.008	35°	**B (2)**	0.142			**91102**
31.52SN	0.031	0.006	20°	**B (2)**	0.130	**71702**	**81702**	
31.52SN	0.031	0.008	35°	**B (2)**	0.130			**91702**

	CTBH1000C	CTBH2000C	CTBH3000C
P			
M			
K			
N			
S			
H	●	●	●
O			

TCGW

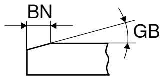
Designation	L inch	S inch	D1 inch	IC inch
TCGW 21.5..	0.433	0.094	0.110	0.250
TCGW 32.5..	0.650	0.156	0.173	0.375

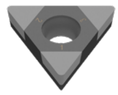
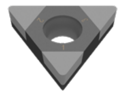
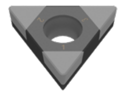


TCGW C

TCGW

▲ TCE(NOI) = Design and number of equipped cutting edge corners

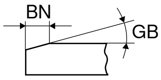


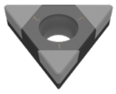
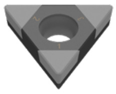
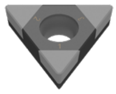




ANSI	RE inch	BN inch	GB	TCE (NOI)	LE inch	NEW CTBH1000C F PCBN TCGW 71 034 ...	NEW CTBH2000C F PCBN TCGW 71 034 ...	NEW CTBH3000C F PCBN TCGW 71 034 ...
21.51EN	0.016			**C (3)**	0.142	**70002**	**80002**	
21.51SN	0.016	0.006	20°	**C (3)**	0.142			**90002**
21.52EN	0.031			**C (3)**	0.130	**70302**	**80302**	
21.52SN	0.031	0.006	20°	**C (3)**	0.130			**90302**
32.51EN	0.016			**C (3)**	0.142	**70602**	**80602**	
32.51SN	0.016	0.006	20°	**C (3)**	0.142			**90602**
32.52EN	0.031			**C (3)**	0.130	**70902**	**80902**	
32.52SN	0.031	0.006	20°	**C (3)**	0.130			**90902**
P								
M								
K								
N								
S								
H						●	●	●
O								

TCGW

▲ TCE(NOI) = Design and number of equipped cutting edge corners



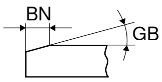
	NEW	NEW	NEW
	CTBH1000C	CTBH2000C	CTBH3000C
			
	M	M	M
	PCBN	**PCBN**	**PCBN**
	TCGW	TCGW	TCGW
	71 034 ...	71 034 ...	71 034 ...

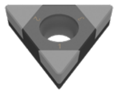
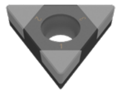
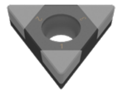
ANSI	RE inch	BN inch	GB	TCE (NOI)	LE inch	CTBH1000C	CTBH2000C	CTBH3000C
21.51SN	0.016	0.004	15°	**C (3)**	0.142	**70102**	**80102**	
21.51SN	0.016	0.007	25°	**C (3)**	0.142			**90102**
21.52SN	0.031	0.004	15°	**C (3)**	0.130	**70402**	**80402**	
21.52SN	0.031	0.007	25°	**C (3)**	0.130			**90402**
32.51SN	0.016	0.004	15°	**C (3)**	0.142	**70702**	**80702**	
32.51SN	0.016	0.007	25°	**C (3)**	0.142			**90702**
32.52SN	0.031	0.004	15°	**C (3)**	0.130	**71002**	**81002**	
32.52SN	0.031	0.007	25°	**C (3)**	0.130			**91002**

	CTBH1000C	CTBH2000C	CTBH3000C
P			
M			
K			
N			
S			
H	●	●	●
O			

TCGW

▲ TCE(NOI) = Design and number of equipped cutting edge corners



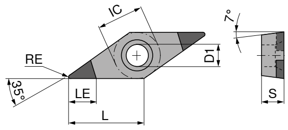




ANSI	RE inch	BN inch	GB	TCE (NOI)	LE inch	NEW CTBH1000C R PCBN TCGW 71 034 ...	NEW CTBH2000C R PCBN TCGW 71 034 ...	NEW CTBH3000C R PCBN TCGW 71 034 ...
21.51SN	0.016	0.006	20°	**C (3)**	0.142	**70202**	**80202**	
21.51SN	0.016	0.008	35°	**C (3)**	0.142			**90202**
21.52SN	0.031	0.006	20°	**C (3)**	0.130	**70502**	**80502**	
21.52SN	0.031	0.008	35°	**C (3)**	0.130			**90502**
32.51SN	0.016	0.006	20°	**C (3)**	0.142	**70802**	**80802**	
32.51SN	0.016	0.008	35°	**C (3)**	0.142			**90802**
32.52SN	0.031	0.006	20°	**C (3)**	0.130	**71102**	**81102**	
32.52SN	0.031	0.008	35°	**C (3)**	0.130			**91102**

	CTBH1000C	CTBH2000C	CTBH3000C
P			
M			
K			
N			
S			
H	●	●	●
O			

VCGW

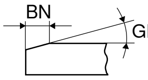
Designation	L inch	S inch	D1 inch	IC inch
VCGW 220...	0.437	0.125	0.114	0.250
VCGW 221E..	0.437	0.125	0.114	0.250
VCGW 221S..	0.437	0.125	0.114	0.250
VCGW 330...	0.654	0.187	0.173	0.375
VCGW 331E..	0.654	0.187	0.173	0.375
VCGW 331S..	0.654	0.187	0.173	0.375
VCGW 332E..	0.654	0.187	0.173	0.375
VCGW 332S..	0.654	0.187	0.173	0.375

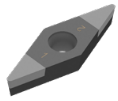
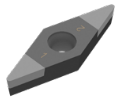
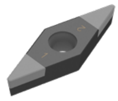


VCGW B

VCGW

▲ TCE(NOI) = Design and number of equipped cutting edge corners

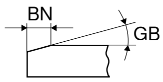


						NEW	NEW	NEW
						CTBH1000C	CTBH2000C	CTBH3000C
								
						F	**F**	**F**
						PCBN VCGW	**PCBN** VCGW	**PCBN** VCGW
						71 041 ...	**71 041 ...**	**71 041 ...**
ANSI	RE inch	BN inch	GB	**TCE (NOI)**	LE inch			
220.5EN	0.008			**B (2)**	0.217	**70002**	**80002**	
220.5SN	0.008	0.006	20°	**B (2)**	0.217			**90002**
221EN	0.016			**B (2)**	0.201	**70302**	**80302**	
221SN	0.016	0.006	20°	**B (2)**	0.201			**90302**
330.5EN	0.008			**B (2)**	0.217	**70602**	**80602**	
330.5SN	0.008	0.006	20°	**B (2)**	0.217			**90602**
331EN	0.016			**B (2)**	0.201	**70902**	**80902**	
331SN	0.016	0.006	20°	**B (2)**	0.201			**90902**
332EN	0.031			**B (2)**	0.165	**71202**	**81202**	
332SN	0.031	0.006	20°	**B (2)**	0.165			**91202**

P			
M			
K			
N			
S			
H	●	●	●
O			

VCGW

▲ TCE(NOI) = Design and number of equipped cutting edge corners

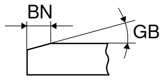


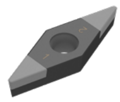
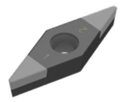
ANSI	RE inch	BN inch	GB	TCE (NOI)	LE inch	NEW CTBH1000C M PCBN VCGW 71 041 ...	NEW CTBH2000C M PCBN VCGW 71 041 ...	NEW CTBH3000C M PCBN VCGW 71 041 ...
220.5SN	0.008	0.004	15°	**B (2)**	0.217	**70102**	**80102**	
220.5SN	0.008	0.007	25°	**B (2)**	0.217			**90102**
221SN	0.016	0.004	15°	**B (2)**	0.201	**70402**	**80402**	
221SN	0.016	0.007	25°	**B (2)**	0.201			**90402**
330.5SN	0.008	0.004	15°	**B (2)**	0.217	**70702**	**80702**	
330.5SN	0.008	0.007	25°	**B (2)**	0.217			**90702**
331SN	0.016	0.004	15°	**B (2)**	0.201	**71002**	**81002**	
331SN	0.016	0.007	25°	**B (2)**	0.201			**91002**
332SN	0.031	0.004	15°	**B (2)**	0.165	**71302**	**81302**	
332SN	0.031	0.007	25°	**B (2)**	0.165			**91302**

	CTBH1000C	CTBH2000C	CTBH3000C
P			
M			
K			
N			
S			
H	●	●	●
O			

VCGW

▲ TCE(NOI) = Design and number of equipped cutting edge corners



						NEW	NEW	NEW
						CTBH1000C	CTBH2000C	CTBH3000C
								
						R	R	R
						PCBN	PCBN	PCBN
						VCGW	VCGW	VCGW
						71 041 ...	71 041 ...	71 041 ...
ANSI	RE inch	BN inch	GB	**TCE (NOI)**	LE inch			
220.5SN	0.008	0.006	20°	**B (2)**	0.217	**70202**	**80202**	
220.5SN	0.008	0.008	35°	**B (2)**	0.217			**90202**
221SN	0.016	0.006	20°	**B (2)**	0.201	**70502**	**80502**	
221SN	0.016	0.008	35°	**B (2)**	0.201			**90502**
330.5SN	0.008	0.006	20°	**B (2)**	0.217	**70802**	**80802**	
330.5SN	0.008	0.008	35°	**B (2)**	0.217			**90802**
331SN	0.016	0.006	20°	**B (2)**	0.201	**71102**	**81102**	
331SN	0.016	0.008	35°	**B (2)**	0.201			**91102**
332SN	0.031	0.006	20°	**B (2)**	0.165	**71402**	**81402**	
332SN	0.031	0.008	35°	**B (2)**	0.165			**91402**

	CTBH1000C	CTBH2000C	CTBH3000C
P			
M			
K			
N			
S			
H	●	●	●
O			

Cutting data standard values for negative PCBN inserts

Index	Cutting edges code negative insert*				Main Application	Extended application	CTBH 1000C		
							EN-F		
			Ra (theo.)				1,6–6,4		
	Material	Strength		Cutting condition			v_c	f	a_p
H.1.1	Hardened steel	46–55 HRC	x	Smooth	●		660	0.002–0.006	0.002–0.02
			x	Interrupted		○			
			x	Extremely interrupted					
H.1.2		56–60 HRC	x	Smooth	●		725	0.002–0.006	0.002–0.02
			x	Interrupted		○			
			x	Extremely interrupted					
H.1.3		61–65 HRC	x	Smooth	●		725	0.002–0.006	0.002–0.02
			x	Interrupted		○			
			x	Extremely interrupted					
H.1.4		66–70 HRC	x	Smooth	●		800	0.002–0.006	0.002–0.02
			x	Interrupted		○			
			x	Extremely interrupted					
H.2.1	Chilled iron	400 HB	x	Smooth					
			x	Interrupted					
			x	Extremely interrupted					
H.3.1	Hardened cast iron	55 HRC	x	Smooth					
			x	Interrupted					
			x	Extremely interrupted					

Index	Cutting edges code negative insert*				Main Application	Extended application	CTBH 2000C		
							EN-F		
			Ra (theo.)				1,6–6,4		
	Material	Strength		Cutting condition			v_c	f	a_p
H.1.1	Hardened steel	46–55 HRC	x	Smooth	●		525	0.002–0.006	0.004–0.02
			x	Interrupted	●		525	0.002–0.006	0.004–0.02
			x	Extremely interrupted		○			
H.1.2		56–60 HRC	x	Smooth	●		600	0.002–0.006	0.004–0.02
			x	Interrupted	●		600	0.002–0.006	0.004–0.02
			x	Extremely interrupted		○			
H.1.3		61–65 HRC	x	Smooth	●		600	0.002–0.006	0.004–0.02
			x	Interrupted	●		600	0.002–0.006	0.004–0.02
			x	Extremely interrupted		○			
H.1.4		66–70 HRC	x	Smooth	●		660	0.002–0.006	0.004–0.02
			x	Interrupted	●		660	0.002–0.006	0.004–0.02
			x	Extremely interrupted		○			
H.2.1	Chilled iron	400 HB	x	Smooth					
			x	Interrupted					
			x	Extremely interrupted					
H.3.1	Hardened cast iron	55 HRC	x	Smooth					
			x	Interrupted					
			x	Extremely interrupted					

Index	Cutting edges code negative insert*				Main Application	Extended application	CTBH 3000C		
							SN-014D-F		
			Ra (theo.)				1,0–3,2		
	Material	Strength		Cutting condition			v_c	f	a_p
H.1.1	Hardened steel	46–55 HRC	x	Smooth		○	600	0.002–0.006	0.004–0.02
			x	Interrupted	●		600	0.002–0.006	0.004–0.02
			x	Extremely interrupted	●		600	0.002–0.006	0.004–0.02
H.1.2		56–60 HRC	x	Smooth		○	660	0.002–0.006	0.004–0.02
			x	Interrupted	●		660	0.002–0.006	0.004–0.02
			x	Extremely interrupted	●		660	0.002–0.006	0.004–0.02
H.1.3		61–65 HRC	x	Smooth		○	660	0.002–0.006	0.004–0.02
			x	Interrupted	●		660	0.002–0.006	0.004–0.02
			x	Extremely interrupted	●		660	0.002–0.006	0.004–0.02
H.1.4		66–70 HRC	x	Smooth		○	725	0.002–0.006	0.004–0.02
			x	Interrupted	●		725	0.002–0.006	0.004–0.02
			x	Extremely interrupted	●		725	0.002–0.006	0.004–0.02
H.2.1	Chilled iron	400 HB	x	Smooth		○	660	0.003–0.006	0.004–0.016
			x	Interrupted		○	600	0.002–0.005	0.004–0.016
			x	Extremely interrupted		○	525	0.002–0.005	0.004–0.016
H.3.1	Hardened cast iron	55 HRC	x	Smooth		○	660	0.003-0.006	0.004-0.016
			x	Interrupted		○	600	0.002–0.005	0.004–0.016
			x	Extremely interrupted		○	525	0.002–0.005	0.004–0.016

With our PCBN indexable inserts, we recommend dry machining – information about this can be found on page 50

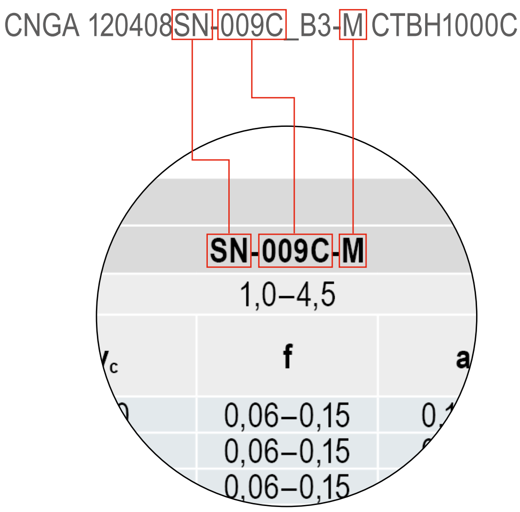
* Note chamfer width: The wider the chamfer, the more stable the cutting edge.

The cutting data is strongly influenced by external conditions, such as the stability of the tool and workpiece clamping, material and type of machine. The specified values represent guideline cutting data that can be adjusted by approx. **±20%** according to the usage conditions.

CTBH 1000C					
SN-009C-M			SN-014D-R		
1,0–3,2			0,5–1,6		
v_c	f	a_p	v_c	f	a_p
660	0.002–0.006	0.004–0.02	600	0.002–0.01	0.005–0.02
660	0.002–0.006	0.004–0.02	600	0.002–0.01	0.005–0.02
725	0.002–0.006	0.004–0.02	660	0.002–0.01	0.005–0.02
725	0.002–0.006	0.004–0.02	660	0.002–0.01	0.005–0.02
725	0.002–0.006	0.004–0.02	660	0.002–0.01	0.005–0.02
725	0.002–0.02	0.004–0.02	660	0.002–0.01	0.005–0.02
800	0.002–0.006	0.004–0.02	725	0.002–0.01	0.005–0.02
800	0.002–0.006	0.004–0.02	725	0.002–0.01	0.005–0.02

CTBH 2000C					
SN-009C-M			SN-014D-R		
1,0–4,5			0,8–3,0		
v_c	f	a_p	v_c	f	a_p
525	0.002–0.006	0.004–0.02	460	0.002–0.01	0.005–0.02
525	0.002–0.006	0.004–0.02	460	0.002–0.01	0.005–0.02
525	0.002–0.006	0.004–0.02	460	0.002–0.01	0.005–0.02
600	0.002–0.006	0.004–0.02	525	0.002–0.01	0.005–0.02
600	0.002–0.006	0.004–0.02	525	0.002–0.01	0.005–0.02
600	0.002–0.006	0.004–0.02	525	0.002–0.01	0.005–0.02
600	0.002–0.006	0.004–0.02	525	0.002–0.01	0.005–0.02
600	0.002–0.006	0.004–0.02	525	0.002–0.01	0.005–0.02
600	0.002–0.006	0.004–0.02	525	0.002–0.01	0.005–0.02
660	0.002–0.006	0.004–0.02	600	0.002–0.01	0.005–0.02
660	0.002–0.006	0.004–0.02	600	0.002–0.01	0.005–0.02
660	0.002–0.006	0.004–0.02	600	0.002–0.01	0.005–0.02

CTBH 3000C					
SN-018E-M			SN-020G-R		
1,6–3,2			0,8–3,0		
v_c	f	a_p	v_c	f	a_p
500	0.002–0.01	0.004–0.02	500	0.003-0.016	0.006-0.02
500	0.002–0.01	0.004–0.02	500	0.003-0.016	0.006-0.02
500	0.002–0.01	0.004–0.02	500	0.003-0.016	0.006-0.02
560	0.002–0.01	0.004–0.02	560	0.003-0.016	0.006-0.02
560	0.002–0.01	0.004–0.02	560	0.003-0.016	0.006-0.02
560	0.002–0.01	0.004–0.02	560	0.003-0.016	0.006-0.02
560	0.002–0.01	0.004–0.02	560	0.003-0.016	0.006-0.02
560	0.002–0.01	0.004–0.02	560	0.003-0.016	0.006-0.02
560	0.002–0.01	0.004–0.02	560	0.003-0.016	0.006-0.02
625	0.002–0.01	0.004–0.02	625	0.003-0.016	0.006-0.02
625	0.002–0.01	0.004–0.02	625	0.003-0.016	0.006-0.02
625	0.002–0.01	0.004–0.02	625	0.003-0.016	0.006-0.02
600	0.003-0.008	0.004–0.02	600	0.003-0.008	0.006-0.02
525	0.003-0.006	0.004–0.02	525	0.003-0.006	0.006-0.02
460	0.003-0.006	0.004–0.02	460	0.003-0.006	0.006-0.02
600	0.003-0.008	0.004–0.02	600	0.003-0.008	0.006-0.02
525	0.003-0.006	0.004–0.02	525	0.003-0.006	0.006-0.02
460	0.003-0.006	0.004–0.02	460	0.003-0.006	0.006-0.02



Cutting data standard values for positive PCBN inserts

Index	Material	Strength	Cutting edges code positive insert*	Cutting condition	Main Application	Extended application	CTBH 1000C		
							EN-F		
			Ra (theo.)				1,6–6,4		
	Material	Strength		Cutting condition			v_c	f	a_p
H.1.1	Hardened steel	46–55 HRC	x	Smooth	●		750	0.002–0.006	0.004–0.02
			x	Interrupted		○			
			x	Extremely interrupted					
H.1.2		56–60 HRC	x	Smooth	●		825	0.002–0.006	0.004–0.02
			x	Interrupted		○			
			x	Extremely interrupted					
H.1.3		61–65 HRC	x	Smooth	●		825	0.002–0.006	0.004–0.02
			x	Interrupted		○			
			x	Extremely interrupted					
H.1.4		66–70 HRC	x	Smooth	●		890	0.002–0.006	0.004–0.02
			x	Interrupted		○			
			x	Extremely interrupted					
H.2.1	Chilled iron	400 HB	x	Smooth					
			x	Interrupted					
			x	Extremely interrupted					
H.3.1	Hardened cast iron	55 HRC	x	Smooth					
			x	Interrupted					
			x	Extremely interrupted					

Index	Material	Strength	Cutting edges code positive insert*	Cutting condition	Main Application	Extended application	CTBH 2000C		
							EN-F		
			Ra (theo.)				1,6–6,4		
	Material	Strength		Cutting condition			v_c	f	a_p
H.1.1	Hardened steel	46–55 HRC	x	Smooth	●		600	0.002–0.006	0.004–0.02
			x	Interrupted	●		594	0.002–0.006	0.004–0.02
			x	Extremely interrupted		○			
H.1.2		56–60 HRC	x	Smooth	●		700	0.002–0.006	0.004–0.02
			x	Interrupted	●		693	0.002–0.006	0.004–0.02
			x	Extremely interrupted		○			
H.1.3		61–65 HRC	x	Smooth	●		700	0.002–0.006	0.004–0.02
			x	Interrupted	●		700	0.002–0.006	0.004–0.02
			x	Extremely interrupted		○			
H.1.4		66–70 HRC	x	Smooth	●		750	0.002–0.006	0.004–0.02
			x	Interrupted	●		750	0.002–0.006	0.004–0.02
			x	Extremely interrupted		○			
H.2.1	Chilled iron	400 HB	x	Smooth					
			x	Interrupted					
			x	Extremely interrupted					
H.3.1	Hardened cast iron	55 HRC	x	Smooth					
			x	Interrupted					
			x	Extremely interrupted					

Index	Material	Strength	Cutting edges code positive insert*	Cutting condition	Main Application	Extended application	CTBH 3000C		
							SN-014D-F		
			Ra (theo.)				1,0–3,2		
	Material	Strength		Cutting condition			v_c	f	a_p
H.1.1	Hardened steel	46–55 HRC	x	Smooth		○	700	0.002–0.006	0.004–0.02
			x	Interrupted	●		600	0.002–0.006	0.004–0.02
			x	Extremely interrupted	●		600	0.002–0.006	0.004–0.02
H.1.2		56–60 HRC	x	Smooth		○	750	0.002–0.006	0.004–0.02
			x	Interrupted	●		660	0.002–0.006	0.004–0.02
			x	Extremely interrupted	●		660	0.002–0.006	0.004–0.02
H.1.3		61–65 HRC	x	Smooth		○	660	0.002–0.006	0.004–0.02
			x	Interrupted	●		660	0.002–0.006	0.004–0.02
			x	Extremely interrupted	●		660	0.002–0.006	0.004–0.02
H.1.4		66–70 HRC	x	Smooth		○	825	0.002–0.006	0.004–0.02
			x	Interrupted	●		725	0.002–0.006	0.004–0.02
			x	Extremely interrupted	●		725	0.002–0.006	0.004–0.02
H.2.1	Chilled iron	400 HB	x	Smooth		○	759	0.003-0.006	0.004–0.02
			x	Interrupted		○	700	0.002–0.005	0.004–0.02
			x	Extremely interrupted		○	600	0.002–0.005	0.004–0.02
H.3.1	Hardened cast iron	55 HRC	x	Smooth		○	750	0.003-0.006	0.004–0.02
			x	Interrupted		○	700	0.002–0.005	0.004–0.02
			x	Extremely interrupted		○	600	0.002–0.005	0.004–0.02

With our PCBN indexable inserts, we recommend dry machining – information about this can be found on page 50

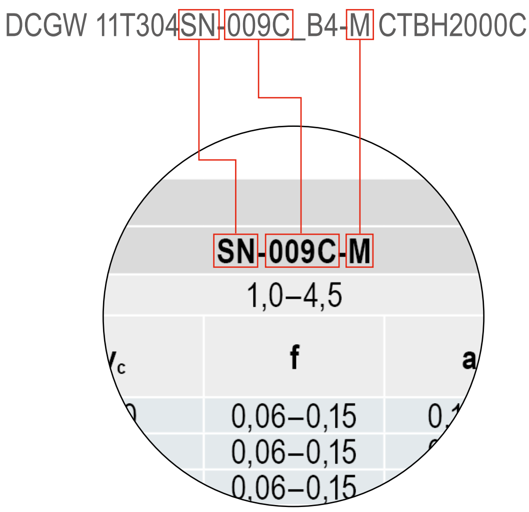
* Note chamfer width: The wider the chamfer, the more stable the cutting edge.

The cutting data is strongly influenced by external conditions, such as the stability of the tool and workpiece clamping, material and type of machine.
The specified values represent guideline cutting data that can be adjusted by approx. **±20%** according to the usage conditions.

CTBH 1000C					
SN-009C-M			SN-014D-R		
1,0–3,2			0,5–1,6		
v_c	f	a_p	v_c	f	a_p
760	0.002–0.006	0.004–0.02	700	0.002–0.01	0.005–0.02
760	0.002–0.006	0.004–0.02	700	0.002–0.01	0.005–0.02
825	0.002–0.006	0.004–0.02	760	0.002–0.01	0.005–0.02
825	0.002–0.006	0.004–0.02	760	0.002–0.01	0.005–0.02
825	0.002–0.006	0.004–0.02	760	0.002–0.01	0.005–0.02
825	0.002–0.006	0.004–0.02	760	0.002–0.01	0.005–0.02
890	0.002–0.006	0.004–0.02	825	0.002–0.01	0.005–0.02
890	0.002–0.006	0.004–0.02	825	0.002–0.01	0.005–0.02

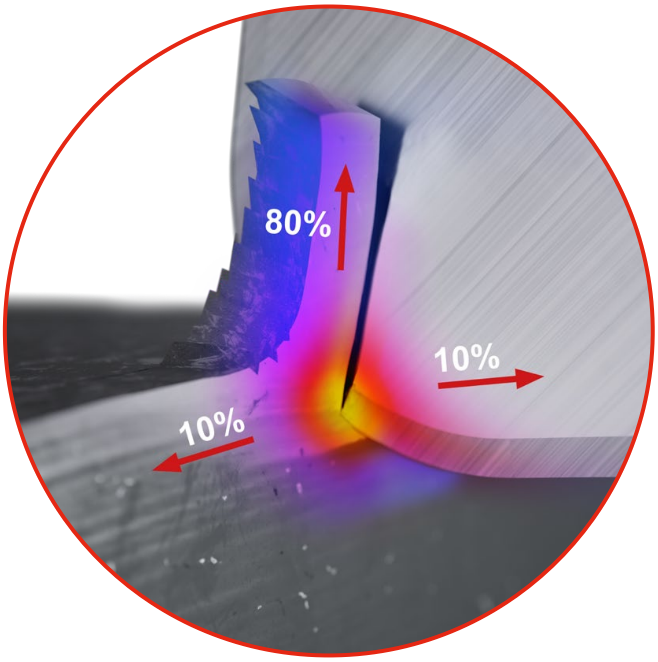
CTBH 2000C					
SN-009C-M			SN-014D-R		
1,0–4,5			0,8–3,0		
v_c	f	a_p	v_c	f	a_p
600	0.002–0.006	0.004–0.02	525	0.002–0.01	0.005–0.02
600	0.002–0.006	0.004–0.02	525	0.002–0.01	0.005–0.02
600	0.002–0.006	0.004–0.02	525	0.002–0.01	0.005–0.02
600	0.002–0.006	0.004–0.02	600	0.002–0.01	0.005–0.02
600	0.002–0.006	0.004–0.02	600	0.002–0.01	0.005–0.02
600	0.002–0.006	0.004–0.02	600	0.002–0.01	0.005–0.02
600	0.002–0.006	0.004–0.02	600	0.002–0.01	0.005–0.02
600	0.002–0.006	0.004–0.02	600	0.002–0.01	0.005–0.02
600	0.002–0.006	0.004–0.02	600	0.002–0.01	0.005–0.02
660	0.002–0.006	0.004–0.02	700	0.002–0.01	0.005–0.02
660	0.002–0.006	0.004–0.02	700	0.002–0.01	0.005–0.02
660	0.002–0.006	0.004–0.02	700	0.002–0.01	0.005–0.02

CTBH 3000C					
SN-018E-M			SN-020G-R		
1,6–3,2			0,8–3,0		
v_c	f	a_p	v_c	f	a_p
560	0.002–0.01	0.004–0.02	560	0.003–0.016	0.006–0.02
560	0.002–0.01	0.004–0.02	560	0.003–0.016	0.006–0.02
560	0.002–0.01	0.004–0.02	560	0.003–0.016	0.006–0.02
640	0.002–0.01	0.004–0.02	645	0.003–0.016	0.006–0.02
640	0.002–0.01	0.004–0.02	645	0.003–0.016	0.006–0.02
640	0.002–0.01	0.004–0.02	645	0.003–0.016	0.006–0.02
640	0.002–0.01	0.004–0.02	645	0.003–0.016	0.006–0.02
640	0.002–0.01	0.004–0.02	645	0.003–0.016	0.006–0.02
640	0.002–0.01	0.004–0.02	645	0.003–0.016	0.006–0.02
725	0.002–0.01	0.004–0.02	725	0.003–0.016	0.006–0.02
725	0.002–0.01	0.004–0.02	725	0.003–0.016	0.006–0.02
725	0.002–0.01	0.004–0.02	725	0.003–0.016	0.006–0.02
700	0.003–0.008	0.004–0.02	700	0.003–0.008	0.006–0.02
600	0.003–0.006	0.004–0.02	600	0.003–0.006	0.006–0.02
525	0.003–0.006	0.004–0.02	525	0.003–0.006	0.006–0.02
700	0.003–0.008	0.004–0.02	700	0.003–0.008	0.006–0.02
600	0.003–0.006	0.004–0.02	600	0.003–0.006	0.006–0.02
525	0.003–0.006	0.004–0.02	525	0.003–0.006	0.006–0.02



Wet or dry machining

The heat produced during hard turning is distributed as 80% to the chip, 10% to the component and 10% to the indexable insert. This underlines the importance of the correct chip removal from the cutting zone. There is therefore generally no need to use cooling lubricant. Machining without cooling lubricant supply is the ideal situation. PCBN indexable inserts withstand high temperatures, thus reducing the costs and problems associated with cooling lubricant. For some applications, cooling lubricant is however necessary to keep the temperature of the component constant. During the whole turning application, a continuous supply of cooling lubricant should be ensured. A temperature shock on the cutting edge must be avoided.



Advantages of hard turning over grinding

In the past, grinding was a common method used to finish components made of hardened steel. Today, hard turning is considered an efficient and cost-effective alternative. Hard turning can increase productivity massively and offers significant environmental benefits.

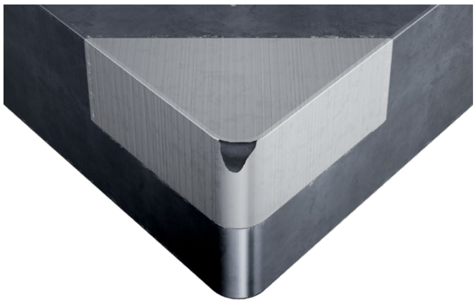
- High surface quality is possible (up to R_a 0.2 µm)
- Lower machine investment costs
- Shorter production time per workpiece
- Process flexibility (internal and external machining on one machine is possible)
- Complex geometries are easier to produce
- Shorter setup times
- Low tool costs (no formed grinding wheels)
- No cooling lubricant required
- Chips are more cost-efficient and easier to recycle
- No grinding sludge

Cutting data effect on wear

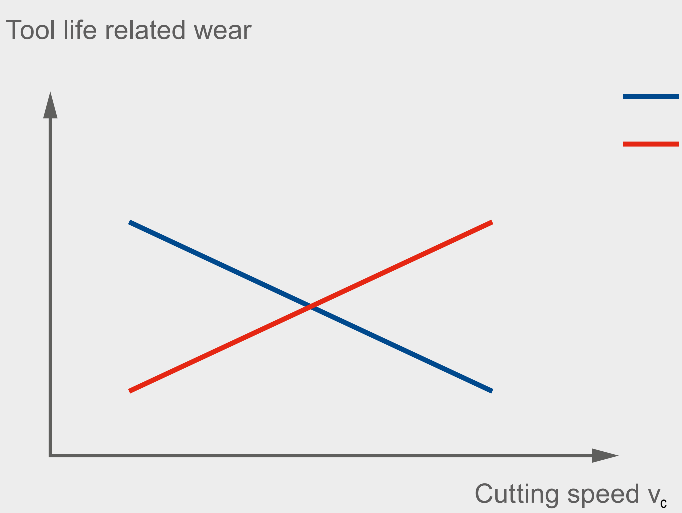
Cutting data and wear

Sufficient heat in the cutting zone leads to reduced cutting forces. If the cutting speed is too low, it generates too little energy and therefore less heat, which can subsequently cause a cutting edge breakage.
Crater wear affects the stability of the indexable insert, but only has a secondary effect on the surface quality of the workpiece. In contrast, flank wear affects the tolerance and geometrical accuracy.

Crater wear
Crater wear is the most dominant type of wear when machining case-hardened steel. It is caused by the chemical wear resulting from extremely high temperatures and forces, which are generated at the cutting edge contact point. Crater wear weakens the cutting edge.



Flank wear
With abrasive steels such as bearing steel or tool steel, there is mainly flank wear. This has a negative effect on the surface and dimensional accuracy.

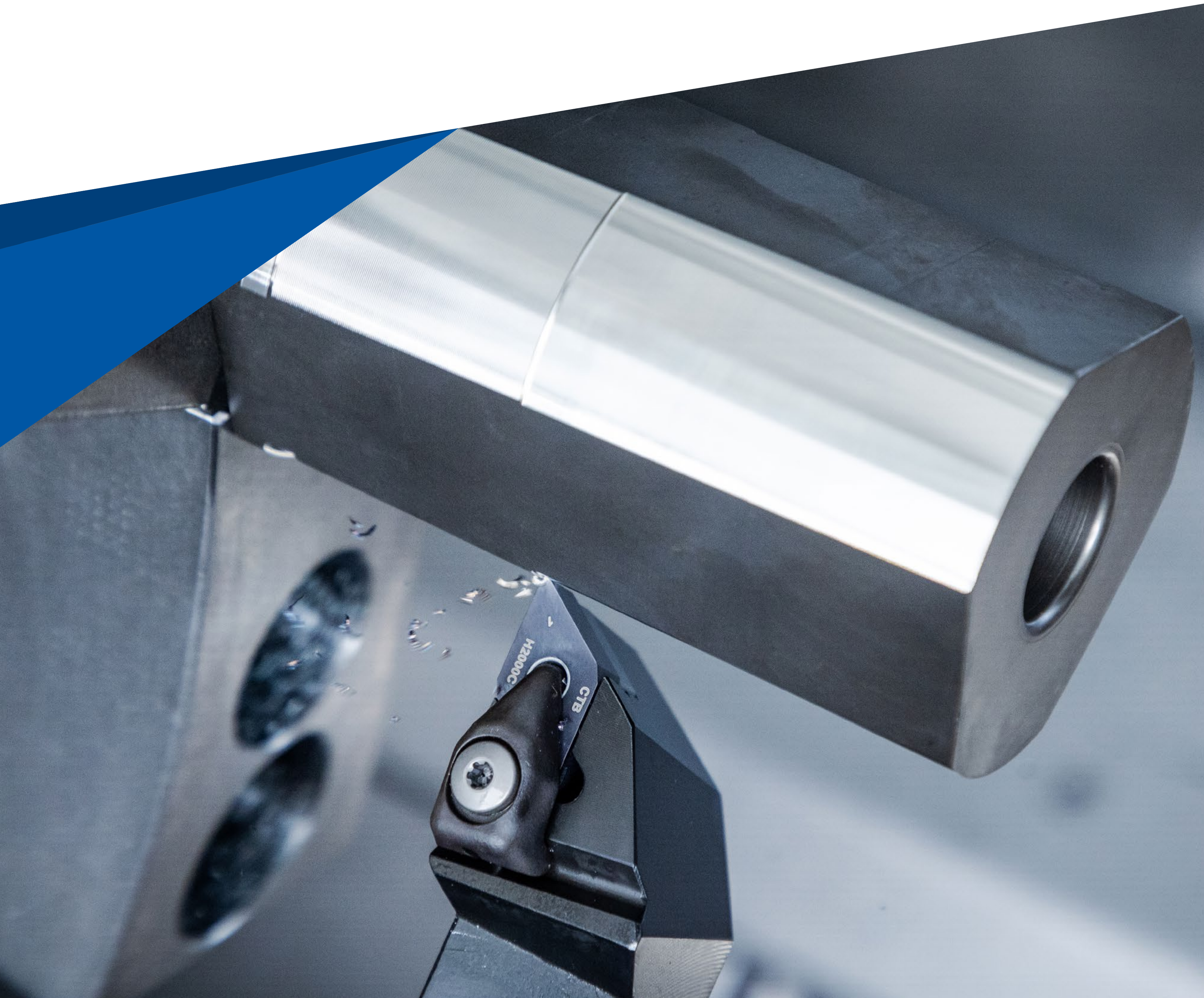


The matter of wear is extremely complex, but there are nevertheless ways to control it and ensure a stable and reliable production process. More information on this can be found on the next pages.

Benefits of the coating

The PVD layer system improves the oxidation resistance and protects against adhesion. The compressive stresses introduced by the coating process stabilize the system cutting material – cutting edge – coating. This leads to a better connection to the base material and a significantly greater process security.
By increasing the tool life and increasing the feeds, the machining times and the costs per workpiece are reduced significantly. The use of existing resources is hereby reduced and the competitiveness is increased considerably.

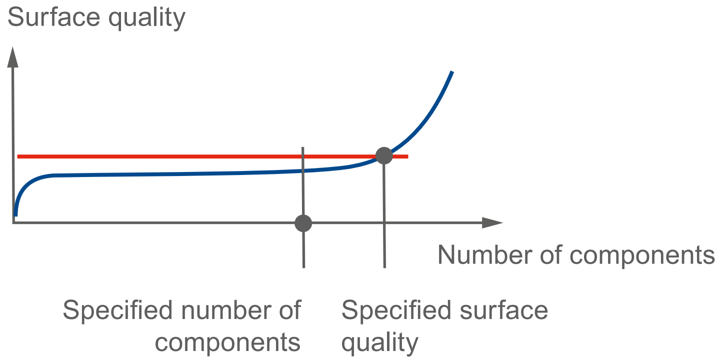
- ▲ The PVD coating protects the PCBN against the chemical interaction with oxygen during machining. Oxidation and diffusion wear are significantly reduced.
- ▲ At machining temperature, harder and more resistant to reactions than binder phase (TiN, TiCN)
- ▲ Offers additional wear protection especially for PCBN grades with a low CBN content.



Criteria for an indexable insert change

A key criterion for the indexable insert change during hard turning is the surface quality. The definition of the surface quality of the design on the drawing provides a measurable parameter. When the specified value is reached, this leads to an indexable insert change.

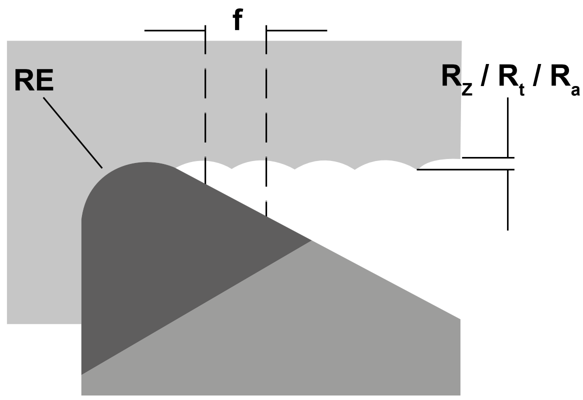
The specified number of workpieces should be below 10-20% of the average tool life of an optimized production process. The exact number of workpieces must be defined for every process.



Calculating the surface quality

The theoretical surface profile (R_z / R_t / R_a) can be calculated based on the radius and feed. The desired surface quality can hereby be calculated in advance as long as all relevant environmental conditions are OK. For example, poorer values are obtained with unstable machines, unstable workpieces, poor clamping, defective and incorrect tool systems.

When hard turning with PCBN, the calculated theoretical profile height is essentially undercut. A special machining mechanism (self-induced hot machining) with a high cutting pressure is created. Through this, the theoretical profile is smoothed and the surface quality is improved.



$$R_{th} = \frac{f^2}{8 \cdot r_\varepsilon} \qquad r_\varepsilon = \frac{f^2}{8 \cdot R_{th}}$$

$$f = \sqrt{8 \cdot r_\varepsilon \cdot R_{th}}$$

$R_{th} \approx R_Z$

r_ε = RE

Feed rate guide values for surface finish quality

Roughness range R_Z in µm	R_{th}	Corresponds to R_a	Roughness index	ISO 1302	Corner radius RE in mm and feed f in mm/rev						
					RE = 0.004"	RE = 0.008"	RE = 0.016"	RE = 0.032"	RE = 0.048"	RE = 0.064"	RE = 0.096"
63–100	R_{th}63	12.5–25	N11	25	0.009*	0.013*	0.018*	0.025	0.032	0.036	0.044
40–63	R_{th}40	6.3–12.5	N10	12.5	0.072*	0.010*	0.014	0.020	0.025	0.029	0.035
31.5–40	R_{th}31.5	4.9–6.3	N9	6.3	0.006*	0.008*	0.012	0.018	0.022	0.025	0.032
25–31.5	R_{th}25	4.0–4.9			0.005*	0.008*	0.012	0.016	0.020	0.023	0.028
16–25	R_{th}16	2.5–4.0	N8	3.2	0.004*	0.006	0.009	0.012	0.016	0.018	0.022
10–16	R_{th}10	1.6–2.5			0.003	0.005	0.008	0.010	0.012	0.015	0.018
6.3–10	R_{th}6.3	1.0–1.6	N7	1.6	0.002	0.004	0.005	0.008	0.010	0.012	0.014
4–6.3	R_{th}4	0.8–1.0	N6	0.8	0.002	0.003	0.004	0.006	0.008	0.009	0.012
2.5–4	R_{th}2.5	0.4–0.8	N5	0.4	0.001	0.002	0.004	0.005	0.006	0.007	0.008
1.6–2.5	R_{th}1.6	0.2–0.4	N4	0.2	0.001	0.002	0.003	0.004	0.005	0.006	0.007
1–1.6	R_{th}1	0.1–0.2	N3	0.1	0.001	0.002	0.003	0.003	0.004	0.005	0.006

*Please ensure that the feed rate values used do not exceed the corner radius (RE).

The feed rate values shown are recommended values and are based on purely theoretical calculations using the above-mentioned formula. These may however deviate in practice.

Single-cut or dual-cut machining

Whether single-cut or dual-cut machining should be selected, depends on the following factors:

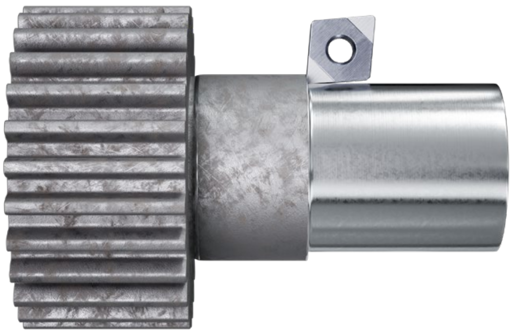
- ▲ Machine capacity
- ▲ Dimensional accuracy
- ▲ Geometrical accuracy
- ▲ Surface quality

Often it is a case of balancing between accuracy and productivity.

Single-cut machining

By using a high-quality machine tool and stable clamping, a single cut machining process can produce acceptable surface qualities and stable dimensions in many applications.

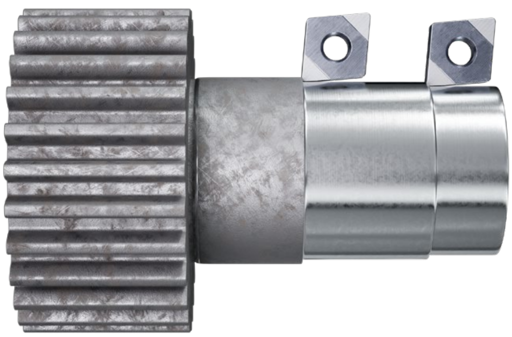
Single-cut machining



Dual-cut machining

In the case of unstable clamping, component batch fluctuations or where strict demands are placed on surface and dimension tolerances, dual-cut machining is advisable.
In this case it is advisable to work with two different widths of cut a_p.

Dual-cut machining



2
CTB 1
H3000C

ISO designation system for inserts

Indexable inserts, CBN, ceramic – metric

C	N	G	A	12	04	08	S	N	-	020D	_	B	3	-	F
1	2	3	4	5	6	7	8	9		10		11	12		13

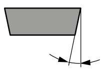
Indexable inserts, CBN, ceramic – inch

C	N	G	A	4	3	2	S	N	-	020D	_	B	3	-	F
1	2	3	4	5	6	7	8	9		10		11	12		13

1 Insert shape

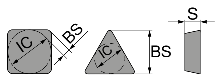
V	35°	Included angle
D	55°	
E	75°	
C	80°	
M	86°	
K	55°	Included angle
B	82°	
A	85°	
L	90°	Other shapes
P	108°	
H	120°	
O	135°	
R	-	
S	90°	
T	60°	
W	80°	

2 Clearance angle



	α		α
A	3°	F	25°
B	5°	G	30°
C	7°	N	0°
D	15°	P	11°
E	20°		
O	Clearance angles not included within the standard for which particular information is necessary.		

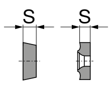
3 Tolerances



	IC±		BS		S	
	mm	inch	mm	inch	mm	inch
A	0,025	.0010	0,005	.0002	0,025	.001
F	0,013	.0005	0,005	.0002	0,025	.001
C	0,025	.0010	0,013	.0005	0,025	.001
H	0,013	.0005	0,013	.0005	0,025	.001
E	0,025	.0010	0,025	.0010	0,025	.001
G	0,025	.0010	0,025	.0010	0,13	.005
J	0,05-0,15*	.002-.006*	0,005	.0002	0,025	.001
K	0,05-0,15*	.002-.006*	0,013	.0005	0,025	.001
L	0,05-0,15*	.002-.006*	0,025	.0010	0,025	.001
M	0,05-0,15*	.002-.006*	0,05-0,20*	.003-.008*	0,13	.005
N	0,05-0,15*	.002-.006*	0,05-0,20*	.003-.008*	0,025	.001
U	0,08-0,25*	.003-.010*	0,13-0,38*	.005-.015*	0,13	.005

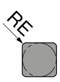
* Depends on insert size

6 Insert thickness



		Code	
mm	inch	mm	inch
1,59	1/16	01	1
2,38	3/32	02	1.5
3,18	1/8	03	2
3,97	5/32	T3	2.5
4,76	3/16	04	3
5,56	7/32	05	3.5
6,35	1/4	06	4
7,94	5/16	07	5
9,52	3/8	09	6

7 Corner radius



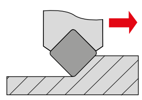
		Code		RN **00** RC **MO**
mm	inch	mm	inch	
≤ 0,05	.0015	00	X0	
0,1	.004	01	0	
0,2	.008	02	.5	
0,4	1/64	04	1	
0,8	1/32	08	2	
1,2	3/64	12	3	
1,6	1/16	16	4	
2,0	5/64	20	5	
2,4	3/32	24	6	
2,8	7/64	28	7	
3,2	1/8	32	8	

8 Cutting edge

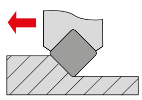
- **F** Sharp
- **E** rounded
- **T** chamfered
- **S** Chamfered and honed
- **K** Double-chamfered
- **P** Double-chamfered and honed
- **R** Round chamfer

9 Direction of cut

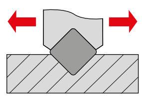
R



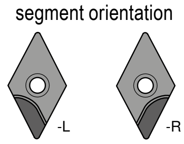
L

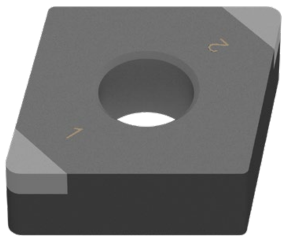


N



CBN and PCD segment orientation





4 Characteristics

N	
R	
F	
A	
M, P	
G, P	
W	
T	
Q	
U	
B	
H	
C	
J	
X	Special version

inch
Change at inscribed circle
IK < 1/4"

IK > 1/4"	IK < 1/4"
N / R / F	E
A / M / G	D
X	X

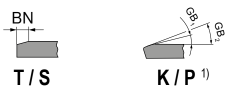
5 Cutting length

Type	ISO	ANSI	L mm	L inch	IC mm	IC inch
C	06	2	6,4	.250	6,35	.250
	09	3	9,7	.382	9,525	.375
	12	4	12,9	.508	12,70	.500
	16	5	16,1	.634	15,875	.625
	19	6	19,3	.760	19,05	.750
	25	8	25,8	1.016	25,4	1.000
	32	12	35,24	1.269	31,75	1.250
S	06	2	6,35	.250	6,35	.250
	09	3	9,525	.375	9,525	.375
	12	4	12,7	.500	12,7	.500
	15	5	15,875	.625	15,875	.625
	19	6	19,05	.750	19,05	.750
	25	8	25,4	1.000	25,4	1.000
	31	10	31,75	1.250	31,75	1.250
D	07	2	7,7	.303	6,35	.250
	11	3	11,6	.457	9,525	.375
	15	4	15,5	.610	12,70	.500
V	11	2	11,1	.437	6,35	.250
	16	3	16,6	.653	9,525	.375
	22	4	22,10	.870	12,70	.500

Type	ISO	ANSI	L mm	L inch	IC mm	IC inch
T	06	1.2	6,9	.272	3,97	.156
	09	1.8	9,6	.378	5,56	.219
	11	2	11,0	.433	6,35	.250
	16	3	16,5	.650	9,525	.375
	22	4	22,	.079	12,70	.039
	27	5	27,5	1.083	15,875	.625
	33	6	33,0	1.299	19,05	.750
W	06	3	6,5	.256	9,525	.375
	08	4	8,7	.331	12,70	.039
	10	5	10,9	.429	15,875	.625
R	06	2	6,35	.250	6,35	.250
	08	-	8,0	.315	8,0	.315
	09	3	9,52	.375	9,52	.375
	10	-	10,0	.394	10,0	.394
	12*	-	12,0	.472	12,0	.472
	12	4	12,7	.488	12,70	.488
	15	5	15,875	.625	15,875	.625
	16	-	16,0	.630	16,0	.630
	19	6	19,05	.750	19,05	.750
	25	8	25,0	.984	25,0	.984
	25*	-	25,4	1.000	25,4	1.000
	31	10	31,75	1.250	31,75	1.250
	32	-	32,0	1.260	32,0	1.260

* inch version

10 Chamfer type



	mm	inch		
015	0,15	.006	A	05°
020	0,20	.008	B	10°
025	0,25	.010	C	15°
050	0,50	.020	D	20°
075	0,75	.030	E	25°
100	1,00	.040	F	30°
			G	35°

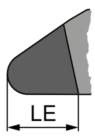
1) Two letters are assigned for double-chamfered cutting edges
e.g. BE =
chamfer angle 1 (y_1) = 10°
chamfer angle 2 (y_2) = 25°

11 Number of cutting edges TCE(NOI)

Single sided		Complete insert thickness	
A		T	
B		U	
C		V	
D		W	
G		X	
H		Y	

Double sided		Entire clamping flat	
K		S	
L		F	
M		E	
N			
P			
Q			

12 Segment length



Approx. specification in mm

13 Grade description

F = Smooth cut

M = Interrupted cut

R = Strongly interrupted cut

A detailed chip breaker overview can be found in the **2023 International Metric Catalog – Chapter 9** on
→ **Pages 201–207**

ISO designation system for tool holders

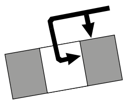
	P	C	L	N	R	20	20	K	12	-	T
	1	2	3	4	5	6	7	8	9		10
UT50 -	P	C	L	N	R				-12		
0	1	2	3	4	5	6	7	8	9		10
HSK-T63 -	D	C	L	N	R				-12		
0	1	2	3	4	5	6	7	8	9		10

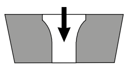
0 System/size

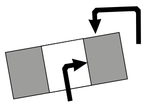
UT = UTS
according to ISO 26622
UT40 = UTS 40 mm
UT50 = UTS 50 mm
UT63 = UTS 63 mm

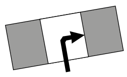
HSK-T
according to ISO 12164
HSK-T63 = 63 mm
HSK-T100 = 100 mm

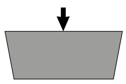
1 Tool holder

D

Retained from above and via bore

S

Retained via centre screw

M

Retained from above and via bore

P

Retained via the bore

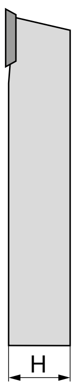
C

Retained from above

X
Special version

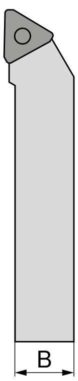
2 Insert shape

V	35°	Included angle
D	55°	
E	75°	
C	80°	
M	86°	
K	55°	Included angle
B	82°	
A	85°	
L	90°	Other shapes
P	108°	
H	120°	
O	135°	
R	-	
S	90°	
T	60°	
W	80°	

6 Shank height

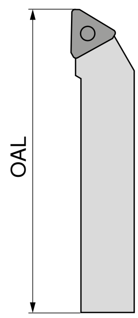


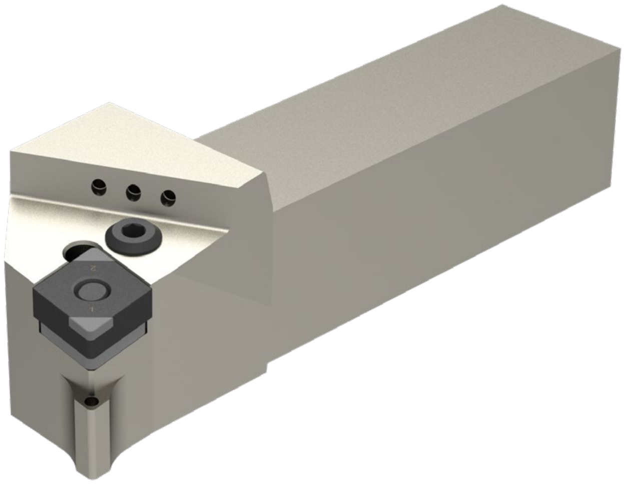
7 Shank width



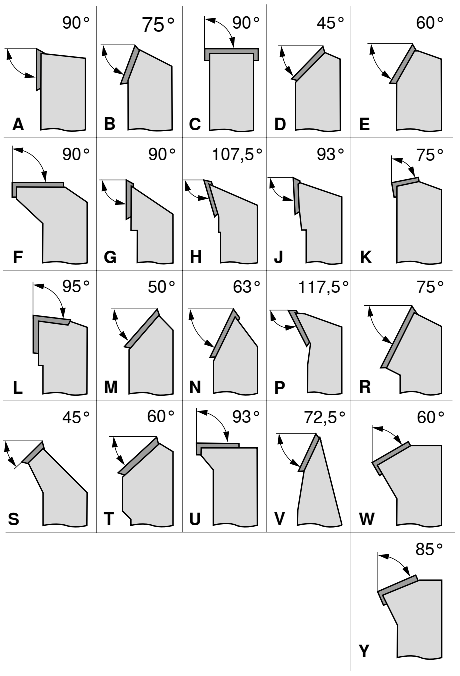
8 Tool length

OAL			OAL		
mm	inch		mm	inch	
32	4.000	**A**	160	4.500	**N**
40	4.500	**B**	170	5.500	**P**
50	5.000	**C**	180	–	**Q**
60	6.000	**D**	200	6.000	**R**
70	7.000	**E**	250	7.000	**S**
80	8.000	**F**	300	8.000	**T**
90	5.500	**G**	350	5.500	**U**
100	5.625	**H**	400	3.500	**V**
110	5.300	**J**	450	3.500	**W**
125	14.000	**K**	500	3.750	**Y**
140	6.800	**L**	Special version		**X**
150	4.400	**M**			

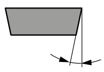




3 Style

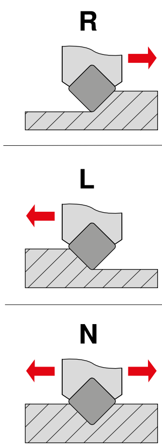


4 Clearance angle

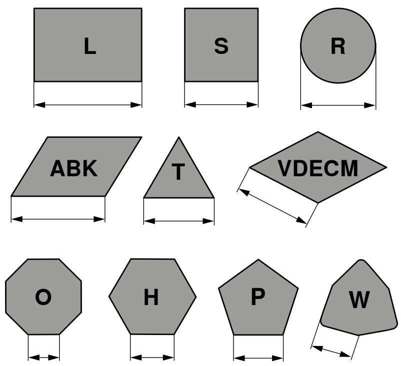


	α		α
A	3°	F	25°
B	5°	G	30°
C	7°	N	0°
D	15°	P	11°
E	20°		
O	Clearance angles not included within the standard for which particular information is necessary.		

5 Direction of cut



9 Cutting length



10 Manufacturer specification

T = Toggle
Special length (mm)
Insert thickness (deviating from standard)
Special version (X..)
Machine manufacturer (specific)
DC = DirectCooling

ISO designation system for boring bars

	A	25	R	P	C	L	N	R	12	
	1	2	3	4	5	6	7	8	9	10

UT40 -		25	G -	P	C	L	N	R -	12	
0	1	2	3	4	5	6	7	8	9	10

HSK-T63 -		50	Q -	D	C	L	N	R -	12	
0	1	2	3	4	5	6	7	8	9	10

0

System/size

UT = UTS
according to ISO 26622
UT40 = UTS 40 mm
UT50 = UTS 50 mm
UT63 = UTS 63 mm

HSK-T
according to ISO 12164
HSK-T63 = 63 mm
HSK-T100 = 100 mm

1

Shank type

S	Steel shank	**E**	As C with coolant hole
A	Steel shank with coolant hole	**F**	As C with antivibration system
B	Steel shank with antivibration system	**G**	As C with coolant hole and antivibration system
D	Steel shank with coolant hole and antivibration system	**H**	Heavy metal
C	Carbide shank with steel head	**J**	Heavy metal with coolant hole

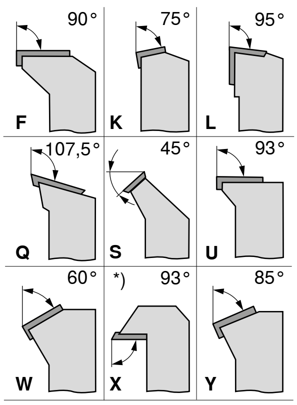
5

Insert shape

V	35°	Included angle	
D	55°		
E	75°		
C	80°		
M	86°		
K	55°	Included angle	
B	82°		
A	85°		
L	90°		Other shapes
P	108°		
H	120°		
O	135°		
R	-		
S	90°		
T	60°		
W	80°		

6

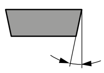
Style



*) CERATIZIT factory standard

7

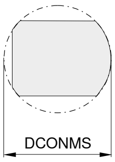
Clearance angle



	α		α
A	3°	**F**	25°
B	5°	**G**	30°
C	7°	**N**	0°
D	15°	**P**	11°
E	20°		
O	Clearance angles not included within the standard for which particular information is necessary.		

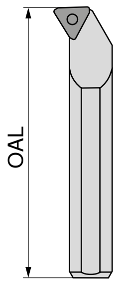
2 Shank type & size

DCONMS mm	DCONMS inch
08	A two-digit figure indicating the boring bar diameter in 1/16 of an inch.
10	
12	
16	
20	
25	
32	
40	
50	
60	



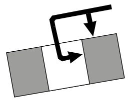
3 Tool length

OAL mm	OAL inch	
80	3	F
100	3,5	H
110	4	J
125	4,5	K
140	5	L
150	5,5	M
160	6	N
170	6,5	P
180	6,75	Q
200	7	R
250	8	S
300	10	T
350	12	U
400	14	V
450	16	W
500	18	Y
	20	
Special version		X



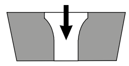
4 Clamping method

D



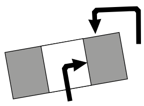
Retained from above and via bore

S



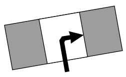
Retained via centre screw

M



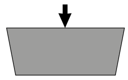
Retained from above and via bore

P



Retained via the bore

C



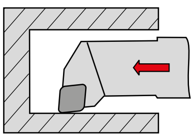
Retained from above

X

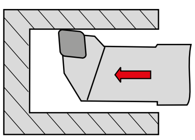
Special version

8 Direction of cut

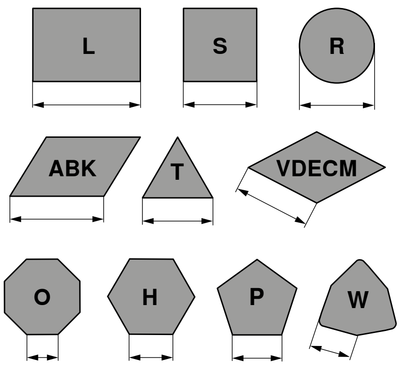
R



L



9 Cutting length



10 Manufacturer specification

T = Toggle
Special length (mm)
Insert thickness (deviating from standard)
Special version (X..)
Machine manufacturer (specific)

Types of wear

PCBN indexable inserts can be easily damaged if used incorrectly, or can even break. Frequent application errors include selecting the incorrect cutting material grade, incorrect cutting parameters (feed and cutting speed), and incorrect cutting edge preparation. In addition, unstable tools with a large overhang length and poor workpiece clamping can cause vibrations during hard turning.

Wear on clearance face

Cause

Abrasion on the flank: normal wear after a certain period of operation.

Remedy

- ▲ Reduction of cutting speed
- ▲ Increase feed (reduction of reaming length)
- ▲ Use more wear-resistant grade
- ▲ Reduce chamfer angle
- ▲ Use air cooling
- ▲ Use positive clearance angle

Edge breakages

Cause

Increased mechanical stress on the cutting edge results in chipping.

Remedy

- ▲ Use grade with higher PCBN content
- ▲ Reduction of cutting speed
- ▲ Increase chamfer angle and width
- ▲ Check centre height
- ▲ Reduce the feed
- ▲ Use larger corner radius
- ▲ Reduce vibrations
- ▲ Improve stability (tool, workpiece)

Cratering

Cause

The outgoing hot chip is causing cratering of the cutting insert on the clamping flat.

Remedy

- ▲ Use crater-resistant grades
- ▲ Reduction of cutting speed
- ▲ Increase the feed, thus reducing the reaming length
- ▲ Reduce chamfer angle

Notch wear

Cause

Necking at the maximum depth of cut.

Remedy

- ▲ Use grade with higher PCBN content
- ▲ Increase the cutting speed
- ▲ Reduce the feed
- ▲ Vary cutting depth
- ▲ Reduce chip thickness
- ▲ Increase corner radius (this reduces the setting angle)

Insert breakage

Cause

If a cutting insert is overloaded, insert breakage may occur.

Remedy

- ▲ Use a tougher cutting material
- ▲ Reduction of cutting speed
- ▲ Increase chamfer angle and width
- ▲ Reduce the feed
- ▲ Use larger corner radius
- ▲ Reduce vibrations
- ▲ Improve stability (tool, workpiece)
- ▲ Use more stable geometry
- ▲ Reduce cutting depth
- ▲ Check interference contours

Troubleshooting guide for turning

Problem

Type of wear							Workpiece problems			
Wear on clearance face	Cratering	Notch wear	Cracks at right angles to the cutting edge	Edge chipping	Insert breakage	Chipping on the surface	Surface quality	Vibration	Burr formation	**Remedy measures**
	▼		▼			↓	▲	↓		Cutting speed v_c
▲	▲	▼	▼	↓		▲	▼	~	↑	Feed f
▲			▼	↓					↑	Depth of cut a_p
	▼		↓	▲	▲	▼	↓		▼	Chamfer angle 35°, heavily interrupted cut Chamfer angle 25°, continuous, slightly interrupted cut Chamfer angle 15°, continuous, slightly interrupted cut
		▲		▲	▲		▲	▼	↓	Corner radius (↑ larger, ↓ smaller)
↓	↓		↓	↓	▲	↓	↓	↓	↓	Rounding
	▼	▲	▲	▲	▲					PCBN content (BH ↑ Wear resistance, BL ↓ toughness)
				~	~	~	~	~		Tool clamping
				~	~	~	~	~		Work piece clamping
				~	~	↓	↓	▼		Overhang
~				~	~	~	~	~		Tip height
○		○	○	○	○				●	Cooling lubricant

▲ raise, increase, large influence
↑ raise, increase, small influence
▼ avoid, reduce, large influence
↓ avoid, reduce, small influence
~ check, optimize
● use
○ do not use

Measures in the case of turning problems with PCBN

Troubleshooting

Problem	Possible causes	Remedy
Poor tool lives	▲ Cutting speed not within the specifications ▲ Chip softening not carried out	▲ Increase the cutting speed ▲ Ideally, chip is red hot
Bad surface quality	▲ Feed too high ▲ Corner radius too small	▲ Reduce feed ▲ Increase corner radius
Chatter marks	▲ Tool overhang too long	▲ Reduce projection length ▲ Use more stable holder
Vibration	▲ Cutting pressure too high ▲ Chip thickness too large ▲ Centre height incorrect ▲ Unstable tool or workpiece clamping ▲ Indexable insert radius too large, high recoil force	▲ Reduce cutting pressure ▲ Reduce chip thickness ▲ Check/adjust centre height ▲ Use smaller radius
Burrs on workpiece	▲ With soft materials (sintered steel) ▲ Cutting pressure too high ▲ Corner radius too large ▲ Chamfer angle too large	▲ Use smaller radius ▲ Adjust chip thickness ▲ Increase cutting depth ▲ Increase cutting speed ▲ Reduce chamfer angle ▲ Use sharp cutting edge
Notch wear	▲ Constant cutting depth leaving witness	▲ For dual-cut strategy, use different cutting depths ▲ Increase chamfer angle
Edge breakage on the workpiece	▲ Sharp edge at the exit	▲ Change machining direction ▲ Reduce feed at entry and exit ▲ Program soft machining with chamfers and radii

General formulas

Cutting speed [ft/min]

$$V_c = \frac{d \cdot \pi \cdot n}{12}$$

Speed [rpm]

$$n = \frac{V_c \cdot 12}{\pi \cdot d}$$

Feed [in/rev]

$$f = \frac{V_f}{n}$$

Clamping cross-section [in²]

$$A = a_p \cdot f$$

Feed rate [inch/min]

$$V_f = f \cdot n \quad \text{[inch/min]}$$

Chip volume [in³/min]

$$Q = V_c \cdot a_p \cdot f \quad \text{[in}^3\text{/min]}$$

Cutting length [m]

$$SCL = \frac{d \cdot 3{,}14 \cdot l_m}{12 \cdot f_n}$$

Chip thickness

$$h = f \cdot \sin\varkappa$$

Period of operation [min]

$$T_c = \frac{l_m}{f \cdot n}$$

KEY

V_c = Cutting speed [ft/min]
d = Turning diameter [mm]
n = Speed [rpm]
π = 3.141592
f = Feed [in/rev]
V_f = Feed rate [inch/min]
A = Clamping cross-section [in²]
a_p = Depth of cut [mm]
z = Number of flutes
Q = Chip volume [in³/min]
a_e = Radial depth of cut [mm]

SCL = Cutting length [m]
l_m = Turning length [mm]
T_c = Period of operation [min]
h = Chip thickness
sinϰ = Approach angle

Hardness comparison table

Tensile strength N/mm	Vickers HV	Brinell HB	Rockwell HRC	Shore C
575	180	171		
595	185	176		
610	190	181		
625	195	185		
640	200	190	12	
660	205	195	13	
675	210	199	14	
690	215	204	15	
705	220	209	15	28
720	225	214	16	
740	230	219	17	29
755	235	223	18	
770	240	228	20.3	30
785	245	233	21.3	
800	250	238	22.2	31
820	255	242	23.1	32
835	260	247	24	33
850	265	252	24.8	
865	270	257	25.6	
880	275	261	26.4	34
900	280	268	27.1	
915	285	271	27.8	35
930	290	276	28.5	
950	295	280	29.2	36
965	300	285	29.8	37
995	310	295	31	38
1030	320	304	32.2	39
1060	330	314	33.3	40
1095	340	323	34.3	41
1125	350	333	35.5	42
1155	360	342	36.6	43
1190	370	352	37.7	44
1220	380	361	38.8	45
1255	390	371	39.8	46
1290	400	380	40.8	47
1320	410	390	41.8	48
1350	420	399	42.7	
1385	430	409	43.6	49
1420	440	418	44.5	
1455	450	428	45.3	51
1485	460	437	46.1	52
1520	470	447	46.9	53
1555	480	465	47.7	54
1595	490	466	48.4	
1630	500	475	49.1	57
1665	510	485	49.8	58
1700	520	494	50.5	59
1740	530	504	51.1	60
1775	540	513	51.7	61
1810	550	523	52.3	62

Tensile strength N/mm	Vickers HV	Brinell HB	Rockwell HRC	Shore C
1845	560	532	53	63
1880	570	542	53.6	64
1920	580	551	54.1	65
1955	590	561	54.7	66
1995	600	570	55.2	67
2030	610	580	55.7	68
2070	620	589	56.3	69
2105	630	599	56.8	70
2145	640	608	57.3	71
2180	650	618	57.8	72
2210	660	628	58.3	73
2240	665	633	58.8	74
2280	670	638	59.3	
2310	675	643	59.8	75
2350	680	648	60.3	76
2380	685	653	61.1	77
2410	690	658	61.3	78
2450	695	663	61.7	79
2480	710	668	62.2	80
2520	720	678	62.6	81
2550	730	683	63.1	82
2590	740	693	63.5	
2630	750	703	63.9	83
2660	760	708	64.3	84
2700	770	718	64.7	85
2730	780	723	65.1	
2770	790	733	65.5	86
2800	800	738	65.9	
2840	810	748	66.3	87
2870	820	753	66.7	88
2910	830	763	67	
2940	840	768	67.4	89
2980	850		67.7	
3010	860		68.1	90
3050	870		68.4	
3080	880		68.7	91
3120	890		69	
3150	900		69.3	92
3190	910		69.6	
3220	920		69.9	
3260	930		70.1	

Conversion values are approximate, based on DIN EN ISO18265 (02-2004)

Extended Material Examples for the Cutting Data Tables

	Material sub-group	Index	Composition / Structure / Heat treatment		Tensile strength lbf/in²* / HB / HRC
P	Unalloyed steel	P.1.1	< 0.15 % C	Annealed	60900 lbf/in² / 125 HB
		P.1.2	< 0.45 % C	Annealed	92800 lbf/in² / 190 HB
		P.1.3		Tempered	121800 lbf/in² / 250 HB
		P.1.4	< 0.75 % C	Annealed	132000 lbf/in² / 270 HB
		P.1.5		Tempered	146500 lbf/in² / 300 HB
	Low-alloy steel	P.2.1		Annealed	88500 lbf/in² / 180 HB
		P.2.2		Tempered	134900 lbf/in² / 275 HB
		P.2.3		Tempered	146500 lbf/in² / 300 HB
		P.2.4		Tempered	174000 lbf/in² / 375 HB
	High-alloy steel and high-alloy tool steel	P.3.1		Annealed	98600 lbf/in² / 200 HB
		P.3.2		Hardened and tempered	159500 lbf/in² / 300 HB
		P.3.3		Hardened and tempered	188500 lbf/in² / 400 HB
	Stainless steel	P.4.1	Ferritic / martensitic	Annealed	98600 lbf/in² / 200 HB
		P.4.2	Martensitic	Tempered	117500 lbf/in² / 250 HB
M	Stainless steel	M.1.1	Austenitic / austenitic-ferritic	Quenched	88500 lbf/in² / 200 HB
		M.2.1	Austenitic	Tempered	300 HB
		M.3.1	Austenitic / ferritic (Duplex)		113100 lbf/in² / 230 HB
K	Grey cast iron	K.1.1	Pearlitic / ferritic		88500 lbf/in² / 180 HB
		K.1.2	Pearlitic (martensitic)		127600 lbf/in² / 260 HB
	Spherulitic graphite cast iron	K.2.1	Ferritic		78300 lbf/in² / 160 HB
		K.2.2	Pearlitic		122600 lbf/in² / 250 HB
	Malleable iron	K.3.1	Ferritic		63800 lbf/in² / 130 HB
		K.3.2	Pearlitic		113100 lbf/in² / 230 HB
N	Aluminium wrought alloy	N.1.1	Non-hardenable		60 HB
		N.1.2	Hardenable		49300 lbf/in² / 100 HB
	Cast aluminium alloy	N.2.1	≤ 12 % Si, non-hardenable		36300 lbf/in² / 75 HB
		N.2.2	≤ 12 % Si, hardenable		43500 lbf/in² / 90 HB
		N.2.3	> 12 % Si, non-hardenable		63800 lbf/in² / 130 HB
	Copper and copper alloys (bronze/brass)	N.3.1	Free-machining alloys, PB > 1 %		54400 lbf/in² / 110 HB
		N.3.2	CuZn, CuSnZn		43500 lbf/in² / 90 HB
		N.3.3	CuSn, lead-free copper and electrolytic copper		49300 lbf/in² / 100 HB
	Magnesium alloys	N.4.1	Magnesium and magnesium alloys		70 HB
S	Heat-resistant alloys	S.1.1	Fe - basis	Annealed	98600 lbf/in² / 200 HB
		S.1.2			137800 lbf/in² / 280 HB
		S.2.1	Ni or Co basis	Annealed	121800 lbf/in² / 250 HB
		S.2.2			171100 lbf/in² / 350 HB
		S.2.3		Cast	156600 lbf/in² / 320 HB
	Titanium alloys	S.3.1	Pure titanium		5800 lbf/in²
		S.3.2	Alpha + beta alloys		152300 lbf/in²
		S.3.3	Beta alloys		203100 lbf/in² / 410 HB
H	Hardened steel	H.1.1		Hardened and tempered	46-55 HRC
		H.1.2		Hardened and tempered	56-60 HRC
		H.1.3		Hardened and tempered	61-65 HRC
		H.1.4		Hardened and tempered	66-70 HRC
	Chilled iron	H.2.1		Cast	400 HB
	Hardened cast iron	H.3.1		Hardened and tempered	55 HRC
O	Non-metal materials	O.1.1	Plastics, duroplastic		≤ 21800 lbf/in²
		O.1.2	Plastics, thermoplastic		≤ 14500 lbf/in²
		O.2.1	Aramid fibre-reinforced		≤ 145000 lbf/in²
		O.2.2	Glass/carbon-fibre reinforced		≤ 145000 lbf/in²
		O.3.1	Graphite		

* Tensile Strength at Rupture (Rm)

The pages that follow give further information on our material examples for our usual indexes with additional international standards.

Overview of standards:

DIN

Deutsche **I**ndustrie **N**orm (German Standard)

AFNOR

Association **F**rancaise de **N**ormalisation (French Standard)

UNI

Unificazione **I**taliana (Italian Standard)

ČSN

Czechoslovakian Standard

BS

British **S**tandards

SIS

Standardiseringen **i** **S**verige (Swedish Standard)

UNE

Spanish Standard

JIS

Japanese **I**ndustrial **S**tandard

GOST / ГОСТ

Soviet Standard

UNS

Unified **N**umbering **S**ystem

USA

Under **USA** several American standards are summarized

Extract H materials:

	Index	Material number	DIN	AFNOR	UNI	ČSN	BS	SIS	UNE	JIS	ГОСТ	UNS	USA
H	H.1.1	1.2311	40 CrMnMo 7			19 520							
		1.2312	40 CrMnMoS 8 6	40 CMD 8 + S									
		1.2316	X 36 CrMo 17	Z 38 CD 17	X 38 CrMo 16 1 KU								
		1.2365	X 32 CrMoV 3 3	32 DCV 28	30 CrMoV 12 27 KU	19 541	BH 10			SKD 7	3Ch3M3F	T 20810	H 10
		1.2567	X 30 WCrV 5 3	Z 32 WCV 5	X 30 WCrV 5 3 KU	19 720				SKD 4			
		1.2581	X 30 WCrV 9 3	Z 30 WCV 9	X 30 WCrV 9 3 KU	19 721	BH 21			SKD 5	3Ch2W8F	T 20821	H 21
		1.2738	40 CrMnNiMo 8						F-5303				
		1.2885	X 32 CrMoCoV 3 3 3	30 DCKV 28									
		1.4028	X 30 Cr 13	Z 30 C 13	X 30 Cr 13	17 023	420 S 45	2304		SUS 420 J 2	30Ch13		
		1.4031	X 38 Cr 13	Z 40 C 14	X 40 Cr 14	17 024		2304	F-3404	SUS 420 J 2	40Ch13		
		1.4034	X 46 Cr 13	Z 40 C 14	X 40 Cr 14	17 029	420 S 45		F-3405		40Ch13		
		1.4112	X 90 CrMoV 18									S 44003	
		1.5122	37 MnSi 4			13 240							
		1.6358	X 2 NiCoMoTi 18 9 5										
		1.6582	34 CrNiMo 6	35 NCD 6	35 NiCrMo 6 (KW)	16 342	817 M 40	2541	F-128 / F-1270	SNCM 447	38Ch2N2MA		4340
		1.7003	38 Cr 2	38 C 2	38 Cr 2								
		1.7006	46 Cr 2	42 C 2	45 Cr 2								5045
		1.7030	28 Cr 4				530 A 30				30Ch		5130
		1.7176	55 Cr 3	55 C 3	55 Cr 3		527 A 60	2253	F-1431	SUP 9 (A)	50ChGA	G 51550	5155
		1.0961	60 SiCr 7	60 SC 7	60 SiCr 8					SUP 7			9262
		1.1248	Ck 75	XC 75	C 75	12 081	060 A 78	1774; 1778			75	G 10780	1078; 1080
		1.1273	90 Mn 4										
	H.1.2	1.2083	X 42 Cr 13	Z 40 C 14	X 41 Cr 13 KU	19 435			F-5263	SUS 420 J 2			
		1.2323	GS-48 CrMoV 6 7										
		1.2343	X 38 CrMoV 5 1	Z 38 CDV 5	X 37 CrMoV 5 1 KU	19 552	BH 11		F-5317	SKD 6	4Ch5MFS	T 28811	H 11
		1.2367	X 38 CrMoV 5 3										
		1.2510	100 MnCrW 4	90 MWCV 5	95 MnWCr 5 KU	19 314	BO 1	2140	F-5220	SKS 3		T 31501	O 1
		1.2542	45 WCrV 7		45 WCrV 8 KU	19 732	BS 1	2710				T 41901	S 1
		1.2550	60 WCrV 7	55 WC 20	55 WCrV 8 KU	19 735							
		1.2606	G-X 37 CrMoW 5 1										
		1.2711	54 NiCrMoV 6	55 NCDV 6		19 662							
		1.2713	55 NiCrMoV 6	55 NCDV 7		19 662			F-520.S	SKT 4	5ChNM	T 61206	L 6
		1.2764	X 19 NiCrMo 4										
		1.2767	X 45 NiCrMo 4	Y 35 NCD 16	42 NiCrMo 15 7	19 655							
		1.4109	X 65 CrMo 14										
		1.4112	X 90 CrMoV 18									S 44003	
		1.1157	40 Mn 4	35 M 5			150 M 36				40G	G 10390	1039
		1.1231	Ck 67	XC 68	C 70	12 071	060 A 67	1770			70	G 10700	1070
		1.1274	Ck 101	XC 100			060 A 96	1870		SUP 4		G 10950	1095
	H.1.3	1.2080	X 210 Cr 12	Z 200 C 12	X 210 Cr 13 KU	19 436	BD 3			SKD 1	Ch12	T 30403	D 3
		1.2101	62 SiMnCr 4										
		1.2162	21 MnCr 5	20 NC 5		19 487				SCR 420 H			
		1.2201	G-X 165 CrV 12										
		1.2210	115 CrV 3	100 C 3	107 CrV 3 KU	19 421						T 61202	L 2
		1.2341	X 6 CrMo 4										
		1.2379	X 155 CrVMo 12 1	Z 160 CDV 12	X 155 CrVMo 12 1 KU	19 573	BD 2		F-5211	SKD 11		T 30402	D 2
		1.2419	105 WCr 6	105 WC 13	107 WCr 5 KU					SKS 31	ChWG		
		1.2601	X 165 CrMoV 12		X 165 CrMoW 12 KU	19 572		2310					

	Index	Material number	DIN	AFNOR	UNI	ČSN	BS	SIS	UNE	JIS	ГОСТ	UNS	USA
H	H.1.3	1.2721	50 NiCr 13										
		1.2735	15 NiCr 14	10 NC 12		16 240				SNC 22		T 51606	
		1.2833	100 V 1	Y1 105 V	102 V 2 KU	19 356	BW 2			SKS 43		T 72302	W 210
		1.2842	90 MnCrV 8	90 MV 8	90 MnVCr 8 KU	19 314	BO 2					T 31502	O 2
		1.3505	100 Cr 6	100 C 6	100 Cr 6	14 100	534 A 99	2258	F-131 / F-1310	SUJ 2	SchCh 15	G 52986	52100
		1.4112	X 90 CrMoV 18									S 44003	
		1.4125	X 105 CrMo 17	Z 100 CD 17	X 105 CrMo 17					SUS 440 C		S 44004	440 C
		1.8161	58 CrV 4			15 261							
		1.1520	C 70 W1										
	H.1.4	1.2363	X 100 CrMoV 5 1	Z 100 CDV 5	X 100 CrMoV 5 1 KU	19 571	BA 2	2260	F-5227	SKD 12		T 30102	A 2
		1.2436	X 210 CrW 12	Z 200 CW 12	X 215 CrW 12 1 KU	19 437		2312	F-5213	SKD 2			
		1.2880	G-X 165 CrCoMo 12										
		1.3202	S 12-1-4-5			19 858						T 12015	T15
		1.3207	S 10-4-3-10	Z 130 WKCDV 10-10-04	HS 10-4-3-10	19 861	BT 42		F-5553	SKH 57			
		1.3243	S 6-5-2-5	Z 85 WDKCV 06-05-05	HS 6-5-2-5	19 852		2723	F-5613	SKH 55	R6M5K5		
		1.3246	S 7-4-2-5	Z 110 WKCDV 07-05-04	HS 7-4-2-5	19 851						T 11341	M 41
		1.3247	S 2-10-1-8	Z 110 DKCWV 09-08-04	HS 2-9-1-8		BM 42			SKH 51		T 11342	M 42
		1.3249	S 2-9-2-8				BM 34					T 11333	M 33; M 34
		1.3257	S 18-1-2-15										
		1.3333	S 3-3-2		HS 3-3-2	19 820							
		1.3343	S 6-5-2	Z 85 WDCV 06-05-04-0	HS 6-5-2	19 830	BM 2	2722	F-5603	SKH 9; SKH 51	R6AM5	T 11302	M 2
		1.3344	S 6-5-3	Z 120 WDCV 06-05-04	HS 6-5-3		BM 4			SKH 52; SKH 53		T 11323	M 3 Cl. 2
		1.3346	S 2-9-1	Z 85 DCWV 08-04-02-0	HS 1-8-1		BM 1				H41	T 11301	H 41; M 1
		1.3348	S 2-9-2	Z 100 DCWV 09-04-02	HS 2-9-2			2782				T 11307	M 7
		1.3355	S 18-0-1	Z 80 WCV 18-04-01	HS 18-0-1	19 824	BT 1			SKH 2	R18	T 12001	T 1
		1.1654	C 110 W										
	H.3.1	0.9620	G-X 260 NiCr 4 2				Grade 2 A	0512-00					A 532 I B NiCr-LC
		0.9625	G-X 330 NiCr 4 2				Grade 2 B	0513-00					A 532 I A NiCr-HC
		0.9630	G-X 300 CrNiSi 9 5 2				Grade 2 C; D; E	0457-00					A 532 I D Ni-HiCr
		0.9635	G-X 330 CrMo 15 3				Grade 3 A; B						A 532 II C 15% CrMo-
		0.9640	G-X 300 CrMoNi 15 2				Grade 3 A; B						
		0.9645	G-X 260 CrMoNi 20 2				Grade 3 C						A 532 II D 20% CrMo-
		0.9650	G-X 260 Cr 27				Grade 3 D	0466-00					A 532 III A 25% Cr
		0.9655	G-X 300 CrMo 27 1				Grade 3 E						A 532 III A 25% Cr

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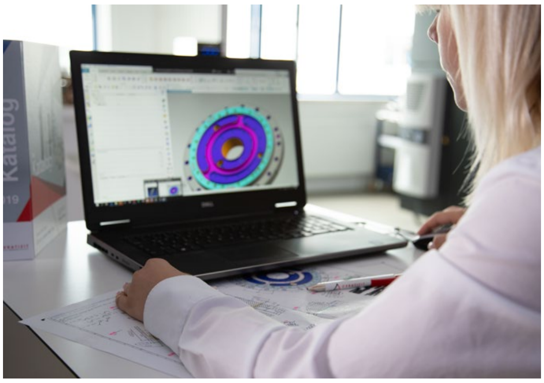

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