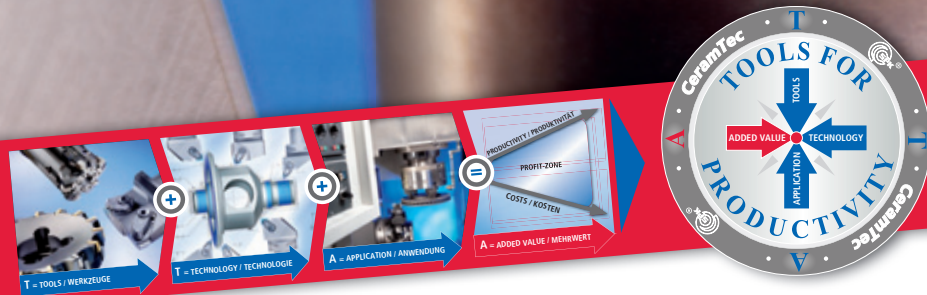


TOOLS

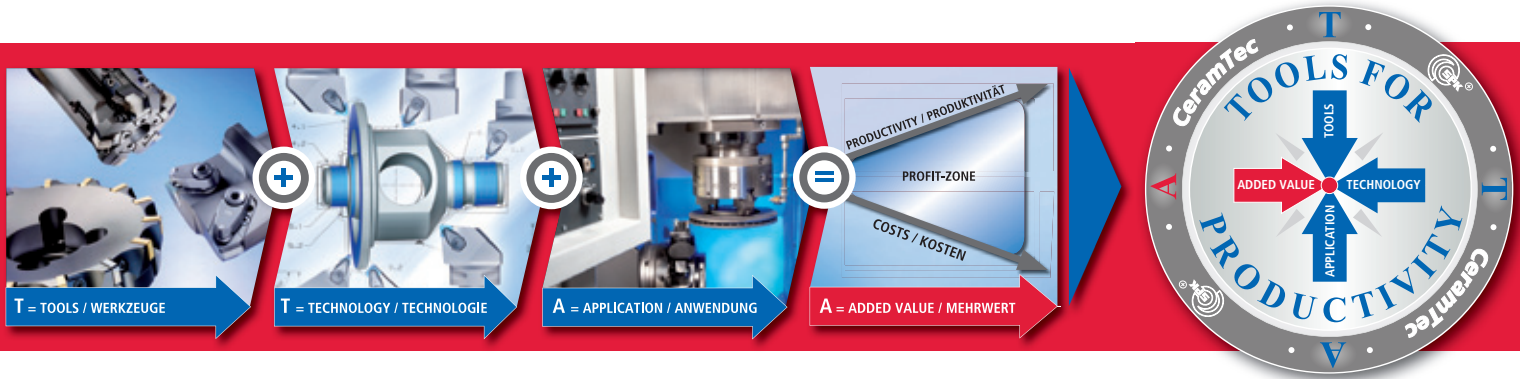
TECHNOLOGY

APPLICATION



SPK HD-LINE

CUTTING MATERIALS, TOOL SYSTEMS AND
TECHNOLOGIES FOR HARD TURNING IN GEAR,
DRIVE AND BEARING INDUSTRY



TOOLS FOR PRODUCTIVITY

Achieving the optimal machining of a workpiece is no longer solely dependent on the cutting process. Increasing technological and economical challenges require highly efficient machining processes. To this end, we have developed the programme **"SPK⁺ - The Productivity Experts"** with the formula: **tool + technology + application = increased productivity with lower costs**. It has already been shown that the formula means a boost in productivity for our customers in many specific applications. In the future, we will draw attention to this by placing a "productivity compass" on our products as a visible sign and seal

of quality. The compass stands for our Tools for Productivity. Wherever you find our productivity compass, it will show you that the maximum contribution to productivity is the focus in machining. Whether on our inserts, tool carriers or even on processing machines, whenever the machining process has been optimised by our engineering on location. We work together with our customers from the beginning and provide them with highly specialised experts in the world's most important markets. In this way, we can guarantee that using our **Tools for Productivity – tool + technology + application** – will guide you

directly to your goal of perfected machining and maximum productivity. Our high performance cutting materials, precision tooling systems and our extensive range of services are perfectly tailored to meet the demands resulting from higher productivity. Our productivity compass is the productivity seal you can trust. More information can be found at **www.tools-for-productivity.com**



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SPK hard turning solutions

Increasingly, components made from hardened steel such as those used in the gear, drive or bearing industries are being machined using hard turning with modern cutting materials and tools. Accordingly, the high standards being set in surface quality dimensional and shape accuracy must be achieved with process reliability. Components in mass or batch production must be manufactured with the highest possible efficiency. In this context, hard turning is the production process that facilitates a drastic reduction in processing times, which leads to a significant decrease in machining costs and a measurable increase in productivity. Further general conditions of production, corresponding to end user benefits, include high-precision at a reasonable price at the desired quality.

A hard turning process that is technically optimised for maximum efficiency is therefore essential:

The goal is to incorporate not only the appropriate high-performance tool systems, but also high-end machining technology, know-how and fine-tuned tool logistics into the hard turning procedure.

With its extensive product and service portfolio, SPK Cutting Tools – known as “SPK+ The Productivity Experts” – is rising to this challenge. The hard turning process is tailored to customer requirements – from the cutting edges and technology used up to machine application and tool logistics.

i SPK hard turning solutions for:

- ⊕ Significantly reduced machining times
- ⊕ Increased process reliability
- ⊕ High process flexibility
- ⊕ Excellent surface qualities
- ⊕ Continuous and interrupted cuts
- ⊕ Chip breakers for hard/ soft transitions
- ⊕ High dimensional and shape accuracy



SPK-HD-LINE NEXT GENERATION MATERIALS FOR HIGH-SPEED HARD TURNING AND GREATER MACHINING FREEDOM THANKS TO:

- Up to 200% more tool life
- Cutting speed up to 240 m/min
- With a feed rate up to 0.5 mm
- new treatment strategies with solid inserts allow short production times



The brand new cutting material the HD-LINE has been especially developed for high-performance hard turning operations. All HD-LINE grades have an exceptionally high edge stability and minimal crater wear. For the entire application spectrum – from continuous to lightly and heavily interrupted cuts – the high-performance specialists are well prepared with the

range of new grades, which means that users can design the optimal hard turning process for their respective application using the cutting materials of the HD-LINE. Both multi-tipped and Solid indexable inserts are therefore available for hard turning operations with the SPK HD-LINE.

SPK HD-LINE grades		
Grades	Solid	Multi-tipped
WXM 155	●	
WXM 255	●	●
WXM 355	●	●
WXM 455		●

WXM 155 The cycle time pro

This new type of cutting material is setting new standards when it comes to efficiency. High thermal stability and red hardness make it extremely wear resistant. Materials with a hardness of up to 62 HRC can be

easily machined with speeds up to $v_c = 180$ m/min in continuous cut. The Solid versions support the flexible design of the hard turning processes. Adjusting the process design in this way

can reduce machining times by 50% in excess of when compared to multi-tipped PCBN.

WXM 255 The dimensional accuracy expert

The extraordinary wear resistance of this cutting material is setting new standards for shape and dimensional accuracy. Thanks to its thermally highly-stable binder and low chemical affinity to

chrome, this grade is particularly suitable for machining hardened bearing steels. Extremely high tool lives can be achieved reliably in continuous cut. The outstanding crater wear resistance reduces the risk of

cutting edge breakage and increases the process reliability.

WXM 355 The all-rounder

Regardless of the operation, WXM355 is the right choice. The balance of toughness and wear resistance make this grade ideal for case-hardened steel; the tool life

window is also extended by up to 50%. The Solid version allows for reliable preturning as well as drawn cuts.

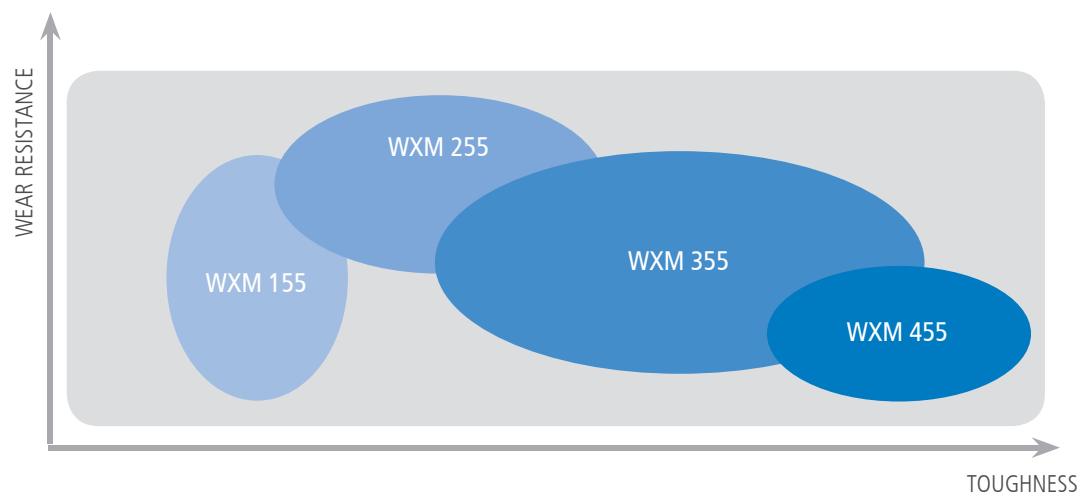
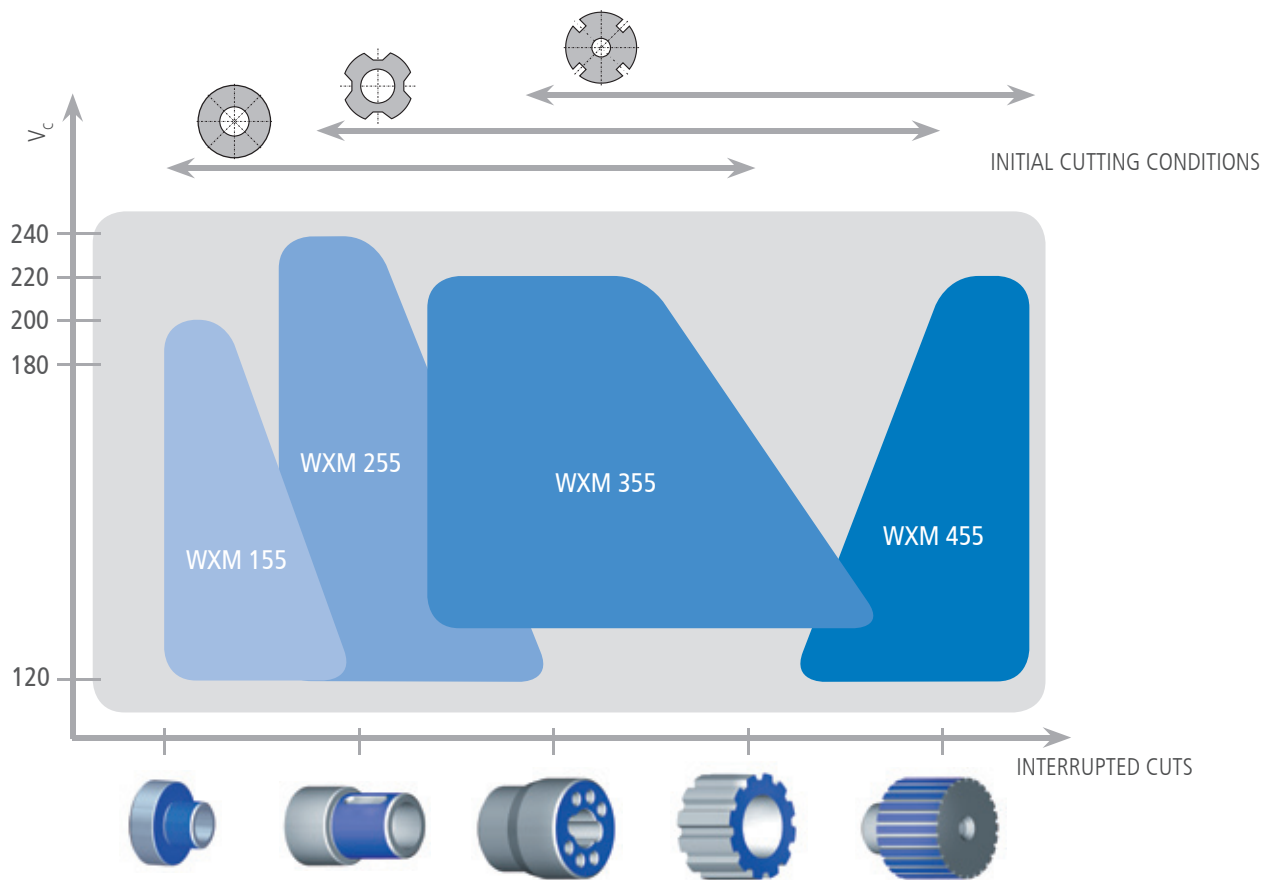
WXM 455 Specialist for interrupted cuts

The WXM 455 is the top choice for machining of heavily interrupted cuts. For these applications, the cutting material's

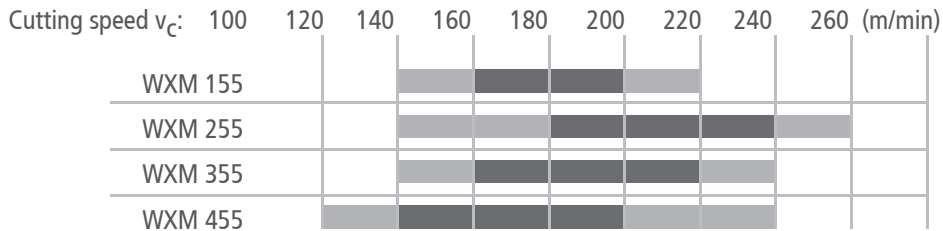
toughness and resistance to abrasion is important. This grade offers a high degree of toughness and, thanks to its optimised

wear resistance, it can be implemented for machining with cutting speeds up to $v_c = 220$ m/min with heavily interrupted cuts.

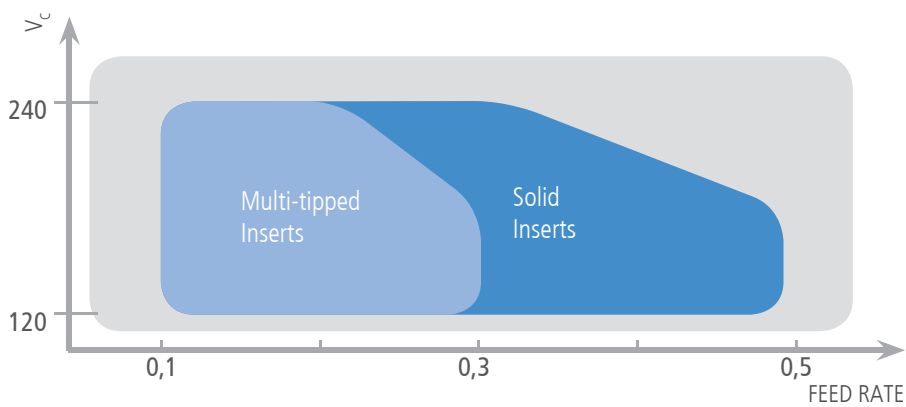
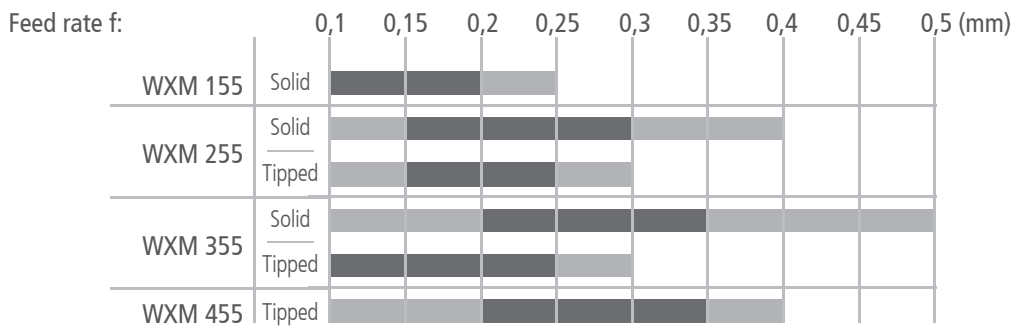
SPK HD-Line scope of application



CUTTING SPEED RANGES



FEED RATE RANGES

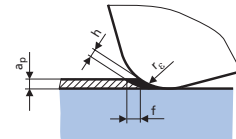


Recommended values for turning hardened steels

Hardness (HRC)	Cutting speed v_c (m/min)		Recommended value for chip thickness h (mm)
	Recommended	Range	
48	300	150 - 400	≤ 0.18
52	250	130 - 300	≤ 0.16
56	200	100 - 260	≤ 0.14
60	180	80 - 240	≤ 0.12
64	150	80 - 180	≤ 0.10

Factor M for corner radii

a_p (mm)	Corner radius r_ϵ			
	0.4	0.8	1.2	1.6
0.1	1.5	2.1	2.5	2.8
0.2	1.15	1.6	1.8	2.0
0.3	1.0	1.3	1.5	1.7
0.4	1.0	1.2	1.3	1.5
0.5		1.1	1.2	1.4



DETERMINING THE FEED RATE VALUES

When working with a small depth of cut for hard turning, the chips will have a "C" shape with a specific thickness h . In order to obtain the optimum chip formation, the

feed rate should be determined according to the given formula, depending on the variable chip thickness h .

$$f = h \cdot M$$

Example: recommended feed rate

Hardness 60 HRC

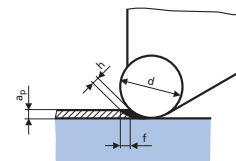
$h \leq 0.12$

with $r_\epsilon = 1.6$ mm where $a_p = 0.5$ mm

Feed rate $f = 0.12 \times 1.4$ mm = 0.17 mm

Factor M for round inserts

a_p (mm)	Diameter d (mm) = IC		
	6,35	9,52	12,70
0,3	2,3	2,9	3,3
0,5	1,8	2,2	2,6
1,0		1,6	1,9
1,5		1,4	1,6
2,0			1,4



CUT DEPTHS a_p :

Conventional hard turning: $a_p = 0.1 - 0.5$ mm

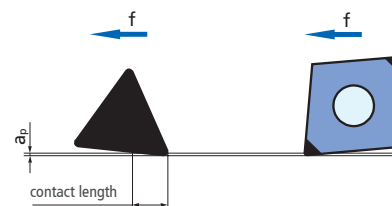
Hard/soft transition: a_p max: = 4.0 mm

DRAWN CUTS:

- with Solid inserts, approx. $\frac{2}{3}$ of the insert length is usable
- select a small actual approach angle
- take advantage of good surface qualities by setting high feed rates

drawn cut

conventional



DESIGNATION SYSTEM FOR INSERTS

Designation of multi-tipped HD-Line inserts with ZZ geometry

Number of cutting edges
(4 corners multi-tipped)

Length of PCBN insert > 2 mm

CNGA 120408 T - LL 95Z025

Chamfer

Approach angle

Width of the ZZ chamfer

Designation of Solid HD-LINE inserts with IKS-PROMini clamping system

Solid version

SNGX 090408 S - S - MDO

chamfered and rounded

System S3 IKS-PRO clamping notch

Designation of Solid HD-LINE inserts with System S3 for inscribed circle 12,70 mm

Solid version

SNGX 090408 S - S - LDO

chamfered and rounded

System S3 IKS-PRO clamping notch

Types of HD-Line inserts according to ISO 1832

Symbol	Illustration	Description	SPK PCBN grades
B		one-side, multi-tipped PCBN inserts, 2 corners	WXM 255, WXM 355, WXM 455
C		one-side, multi-tipped PCBN inserts, 3 corners	WXM 255, WXM 355, WXM 455
D		one-side, multi-tipped PCBN inserts, 4 corners	WXM 255, WXM 355, WXM 455
L		two-side, multi-tipped PCBN inserts, 4 corners	WXM 255, WXM 355, WXM 455
M		two-side, multi-tipped PCBN inserts, 6 corners	WXM 255, WXM 355, WXM 455
N		two-side, multi-tipped PCBN inserts, 8 corners	WXM 255, WXM 355, WXM 455
S		PCBN Solid	WXM 155, WXM 255, WXM 355

IKS-PRO Mini and System S3 for hard turning

Our goal is to provide the ideal tool for every hard turning application. In order to meet the extremely high

demands on positional and shape tolerances as well as surface quality, we have developed clamping systems which, in

combination with our cutting materials, can reliably meet these strict tolerance requirements.

IKS-PRO Mini for IC = 9.52 mm



The newly developed IKS-PRO Mini clamping system is based on the IKS-PRO.

The proven notch geometry used in IKS-PRO has been further developed in order to meet the requirements of hard turning with solid inserts with an inscribed circle of 9.52 mm. The form-fit and force-fit connection ensures the retraction of the insert into the insert seat and guarantees an extremely stable and secure clamp for hard turning. The cutting forces applied on the insert and the clamping system during hard fine machining are thereby optimally distributed across the entire insert seating. This makes the IKS-PRO Mini the ideal clamping system for achieving narrow tolerances using both

continuous and lightly to heavily interrupted cuts; with absolute process reliability. Moreover, thanks to its practical, simple and fast operation, IKS-PRO Mini allows users to meet the highest quality requirements quickly, safely and easily on a daily basis.

S3 SYSTEM for IC = 12.7 mm



The S3 tool holder and clamping system offers extreme process reliability along with

minimal tool maintenance costs for hard turning with solid PCBN inserts with an inscribed circle of 12.70 mm. Hard turning procedures with long operation times and high cutting data require precision tool solutions that offer the high level of process reliability while keeping tool maintenance costs to a minimum. The design and the materials selected for the S3 system have been developed with precisely these requirements in mind. The S3 system's unique characteristics are a result of its innovative ODC Force clamp-

ping technology, optimised design and the use of a modern combination of materials. The optional high-temperature-resistant material version of the insert seating prevents the insert from expanding or becoming embedded in the insert seating. This means that the workpieces can be clamped extremely securely and reliably while ensuring maximum dimensional accuracy with a long tool life.

Advantages of System S3

- ODC Force clamping technology for optimal clamping force distribution



- Clamping in front of the centre of the insert
- With 

- S3 with heat protector equipment thanks to a ceramic him made of high performance ceramic



- The insert seating does not expand thanks to high-temperature-resistant tool holder material (optional)

CUSTOMISED SOLUTIONS

The differing size and complexity of hardened components often demand sophisticated machining solutions that use special tools. Our engineering team assists customers with the knowledge of using as many standard tools as possible and as many special tools as required. Tool solutions are conceived for achieving

optimum machining results and the highest level of efficiency.

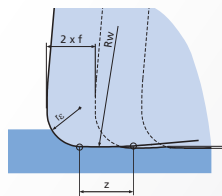
Solid and multi-tipped versions are available for implementing customised inserts. As a manufacturing company, we produce special insert geometries and tools in our production facility in Germany. This gives our customers the advantage that we

can supply even the most complex geometries within a short period of time. If adjustments need to be made on existing tools, these can also be performed quickly and flexibly.

WIPER TECHNOLOGY

i Advantages of wiper technology

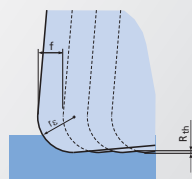
ZZ GEOMETRY



Equal feed rate
= doubled surface quality

Doubled feed rate
= machining times cut down by half

STANDARD GEOMETRY



Increase in production quality

Increase in productivity

Every oak was an acorn – this is probably the best way to describe the enormous increase in performance which can be achieved in finish-turning when using the ZZ geometry. The use of cutting inserts with a ZZ geometry allows for significantly higher surface qualities to be achieved in comparison with inserts featuring standard geometries. Alternatively, the main machining times can be reduced considerably without any consequences to high surface qualities. Therefore, the ZZ geometries represent one of the most efficient ways of increasing productivity in machining, especially in finishing operations.

TYPES OF CUTTING EDGES

A range of different tried and tested chamfer geometries are available for the various hard turning operations. The chamfer selection will not only influence the tool life, but also the surface quality

and dimensional accuracy of the workpiece. Optimising the chamfer may also cause a supplementary increase in productivity.

i Chamfer geometries

T-chamfer:

for continuous cuts

❖ 44 for smooth cuts

S-Fase: with rounding

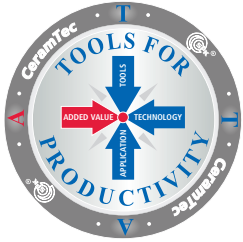
❖ 46 for lightly interrupted cuts

❖ 47 for heavily interrupted cuts

Additional chamfer geometries are available in different designs.



Machining Example



MACHINING TIME REDUCED BY 46 % TOOL LIFE INCREASED BY 280 % TURNING OF AN AXLE SHAFT USING WXM355

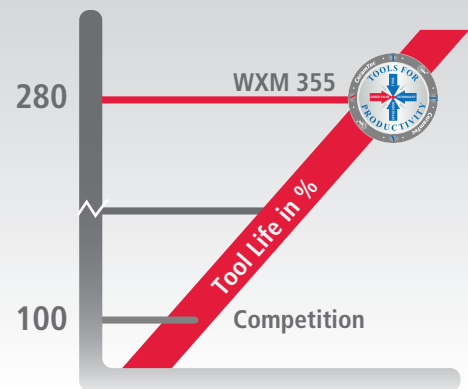
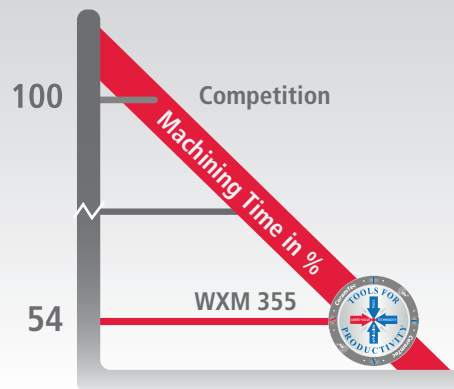
REQUIREMENTS:

- REDUCTION OF MACHINING TIME
- INCREASING TOOL LIFE

CONDITIONS:

- CONTINUOUS CUT
- 62 HRC
- HARDENED STEEL

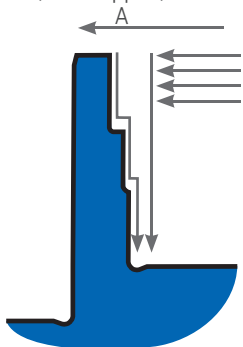
WXM 355



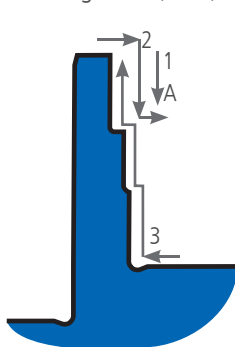
SPK-ENGINEERING FOR INCREASING EFFICIENCY

- HARMONIZING OF WORKPIECE- AND CUTTING MATERIALS
- USE OF SOLID-CBN INSERTS
- DEFINITION OF MACHINING STRATEGY
- DEFINITION OF CUTTING DATA

Starting situation
(multi-tipped)



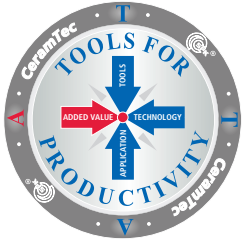
Optimisation of SPK
Cutting Tools (Solid)



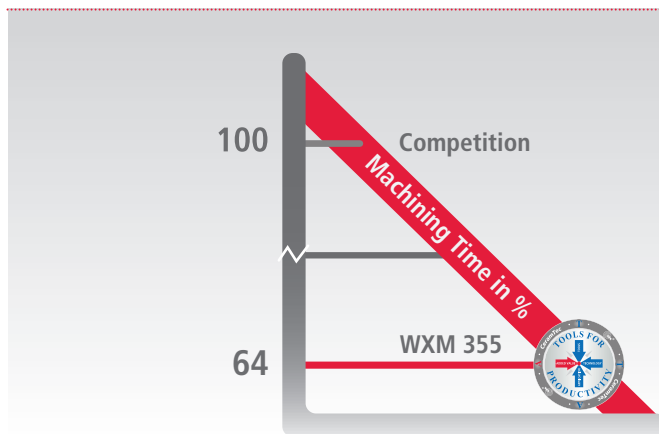
Turning of an axle shaft using WXM 355

	Competition	SPK
Grade	PCBN	WXM 355
Insert	CNGA 120408 T-BL	TNGX 110408 S-S MDO
Cutting speed v_c :	130 m/min	130 m/min
Feed rate f :	0,13 mm	0,13 mm
Depth of cut a_p :	bis 0,2 mm	bis 1,0 mm
Machining Time:	100 %	54 %
Tool Life:	120 pcs.	340 pcs.
Number of cuts:	7	3

The machining time can be reduced by 46% through the use of Solid inserts, which allow for the optimisation of cut allocation from 7 to 3 cuts.



MACHINING TIME REDUCED 36 % TURNING OF A GEAR WHEEL USING WXM355



REQUIREMENTS:

- REDUCING MACHINING TIME
- SURFACE QUALITY

CONDITIONS:

- 62 HRC
- HARD-SOFT TRANSITION

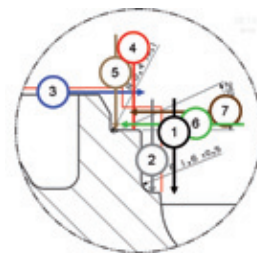
WXM 355

SPK-ENGINEERING FOR INCREASING EFFICIENCY

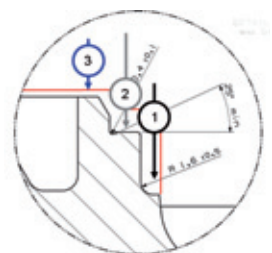
- DEFINITION OF MACHINING STRATEGY
- DEFINITION OF CUTTING DATA

Turning of a gear wheel using WXM 355

	Competition	SPK
Grade	PCBN	WXM 355
Insert	CNGA 120412 T-BL	TNGX 110412 S-S MDO
Cutting speed v_c :	150 - 200 m/min	150 - 200 m/min
Feed rate f :	0,1 - 0,2 mm	0,1 - 0,2 mm
Depth of cut a_p :	bis 1,0 mm	bis 4,0 mm
Machining Time:	100 %	64 %
Number of cuts:	7	3



before



after

Machining Example



INCREASED TOOL LIFE

TURNING OF A WAYDISC

INTERNAL MACHINING INCREASED UP TO 150%

EXTERNAL MACHINING INCREASED UP TO 300%

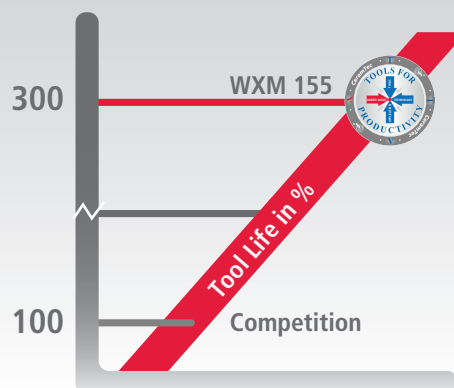
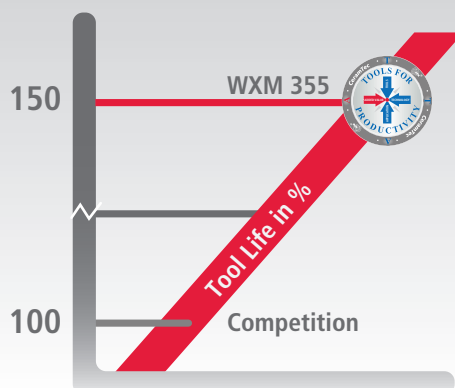
REQUIREMENTS:

- INCREASE TOOL LIFE
- QUANTITY
- NO BURR FORMATION

CONDITIONS:

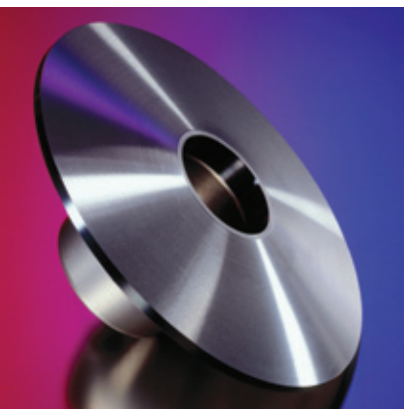
- 60-62 HRC
- DRY CUTTING
- CASE HARDENED STEEL

WXM 355



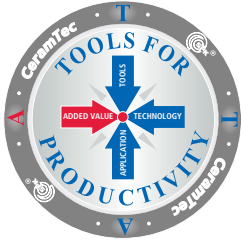
SPK-ENGINEERING FOR INCREASING EFFICIENCY

- HARMONIZING OF WORKPIECE- AND CUTTING MATERIALS
- DEFINITION OF MACHINING STRATEGY
- DEFINITION OF CUTTING DATA

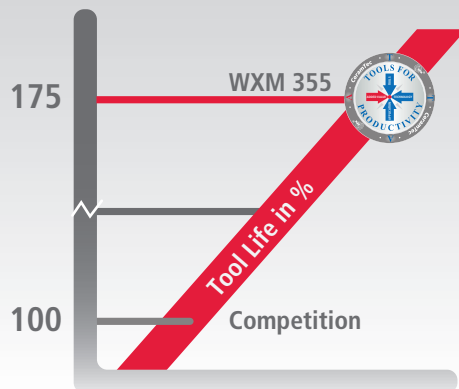


Machining: Turning of a waydisc with WXM 355 / WXM 155

	Internal Machining		External Machining	
	Competition	SPK	Competition	SPK
Grade:	PCBN	WXM 355	PCBN	WXM 155
Insert:	DCGW 11T308	DCGW 11T308 S-BL	RNGN 060300	SNGX 090412 S-S MDO
Cutting speed v_c :	170 m/min	170 m/min	180 m/min	180 m/min
Feed rate f :	0,07 - 0,09 mm	0,07 - 0,09 mm	0,18 mm	0,18 mm
Depth of cut a_p :	0,2 mm	0,2 mm	0,2 mm	0,2 mm
Tool Life:	200 pcs.	300 pcs.	60 pcs.	175 pcs.



TOOL LIFE QUANTITY INCREASED BY 175 % TURNING OF A GEAR WITH WXM 355



REQUIREMENTS:

- INCREASE TOOL LIFE QUANTITY
- BURR FORMATION
- SURFACE QUALITY

CONDITIONS:

- CONTINUOUS CUT
- DRY CUTTING
- 16MnCr5
- 58 - 62 HRC

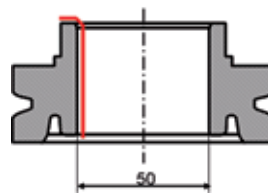
WXM 355

SPK-ENGINEERING FOR INCREASING EFFICIENCY

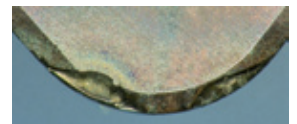
- HARMONIZING OF WORKPIECE- AND CUTTING MATERIALS
- DEFINITION OF CUTTING DATA

Machining: Turning of a gear with WXM 355

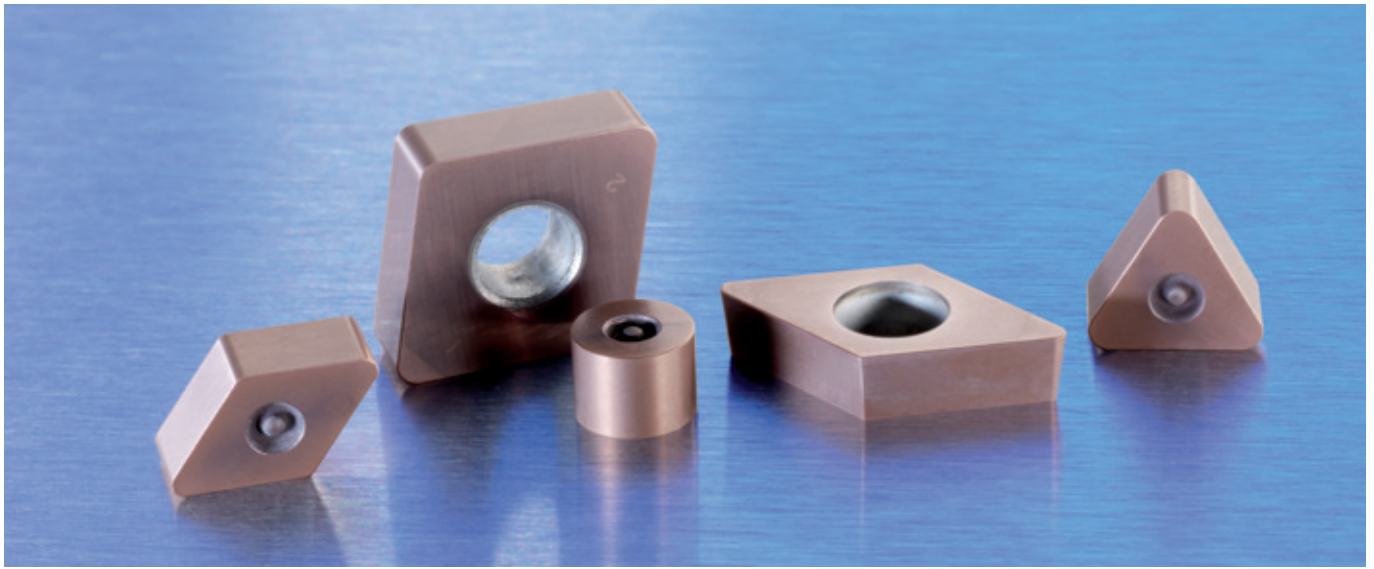
	Competition	SPK
Grade:	PCBN	WXM 355
Insert:	CNMA 120408 T-D	CNGA 120408 S-LL
Cutting speed v_c :	180 m/min	180 m/min
Feed rate f :	0,1 mm	0,1 mm
Depth of cut a_p :	0,15 mm	0,15 mm
Tool Life:	120 pcs.	210 pcs.



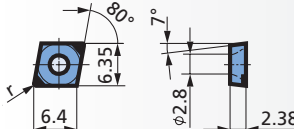
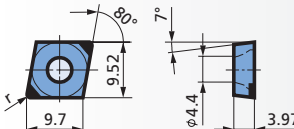
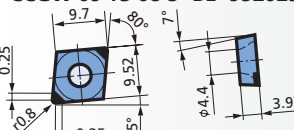
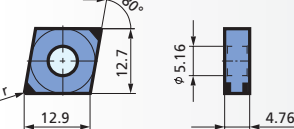
Competition



WXM 355



INSERTS IN MULTI-TIPPED AND SOLID VERSIONS

INSERT	ISO	GRADE	SPK-REF. NO.
CCGW 06 02 ... - BL 	CCGW 06 02 02 T - BL	WXM 255	12.57.405.44.3
	CCGW 06 02 04 T - BL	WXM 255	12.57.406.44.3
	CCGW 06 02 04 S - BL	WXM 455	12.57.406.46.5
CCGW 09 T3 ... - BL 	CCGW 09 T3 04 S - BL	WXM 355	12.57.401.46.4
	CCGW 09 T3 08 T - BL	WXM 255	12.57.402.44.3
	CCGW 09 T3 08 S - BL	WXM 355	12.57.402.46.4
CCGW 09 T3 08 S - BL -95Z025 	CCGW 09 T3 08 S - BL 95Z025	WXM 255	12.57.407.46.3
	CCGW 09 T3 08 S - BL 95Z025	WXM 455	12.57.407.46.5
CNGA 12 04 ... - LL 	CNGA 12 04 04 T - LL	WXM 255	12.56.421.44.3
	CNGA 12 04 04 S - LL	WXM 355	12.56.421.46.4
	CNGA 12 04 04 S - LL	WXM 455	12.56.421.46.5
	CNGA 12 04 08 T - LL	WXM 255	12.56.422.44.3
	CNGA 12 04 08 S - LL	WXM 355	12.56.422.46.4
	CNGA 12 04 08 S - LL	WXM 355	12.56.422.47.4
	CNGA 12 04 08 S - LL	WXM 455	12.56.422.46.5
	CNGA 12 04 12 T - LL	WXM 255	12.56.423.44.3
	CNGA 12 04 12 S - LL	WXM 355	12.56.423.46.4
	CNGA 12 04 12 S - LL	WXM 355	12.56.423.47.4
	CNGA 12 04 12 S - LL	WXM 455	12.56.423.46.5

i Chamfer geometries

T-chamfer:
for continuous cuts

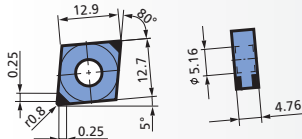
❖ 44 for smooth cuts

S-chamfer: with rounding
⊙ 46 for lightly
interrupted cuts

❖ 47 for heavily interrupted cuts



Multi-tipped

INSERT	ISO	GRADE	SPK-REF. NO.
CNGA 12 04 08 - LL - 95Z025 	CNGA 12 04 08 T - LL 95Z025	WXM 255	12.56.429.44.3
	CNGA 12 04 08 S - LL 95Z025	WXM 455	12.56.429.46.5

Chamfer geometries

T-chamfer:

for continuous cuts

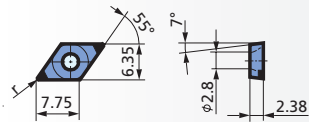
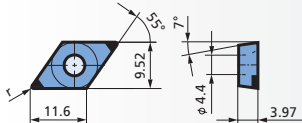
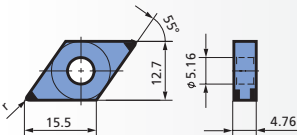
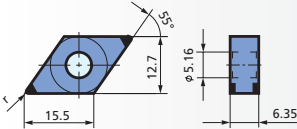
❖ 44 for smooth cuts

S-chamfer: with rounding

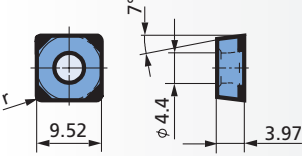
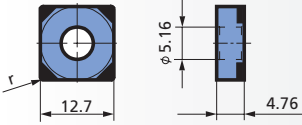
⚙ 46 for lightly interrupted cuts

⚙ 47 for heavily interrupted cuts



INSERT	ISO	GRADE	SPK-REF. NO.
DCGW 07 02 .. - BL 	DCGW 07 02 04 T - BL	WXM 255	12.57.410.44.3
	DCGW 07 02 04 S - BL	WXM 455	12.57.410.46.5
	DCGW 07 02 08 T - BL	WXM 255	12.57.411.44.3
	DCGW 07 02 08 S - BL	WXM 455	12.57.411.46.5
DCGW 11 T3 .. - BL 	DCGW 11 T3 04 T - BL	WXM 255	12.57.408.44.3
	DCGW 11 T3 04 S - BL	WXM 355	12.57.408.46.4
	DCGW 11 T3 04 S - BL	WXM 455	12.57.408.46.5
	DCGW 11 T3 08 T - BL	WXM 255	12.57.409.44.3
	DCGW 11 T3 08 S - BL	WXM 355	✱12.57.409.46.4
	DCGW 11 T3 08 S - BL	WXM 355	✧12.57.409.47.4
	DCGW 11 T3 08 S - BL	WXM 455	12.57.409.46.5
DNGA 15 04 .. - LL 	DNGA 15 04 04 T - LL	WXM 255	12.56.430.44.3
	DNGA 15 04 04 S - LL	WXM 455	12.56.430.46.5
	DNGA 15 04 08 T - LL	WXM 255	12.56.431.44.3
	DNGA 15 04 08 S - LL	WXM 355	12.56.431.46.4
	DNGA 15 04 08 S - LL	WXM 455	12.56.431.46.5
	DNGA 15 04 12 S - LL	WXM 355	12.56.432.46.4
DNGA 15 06 .. - LL 	DNGA 15 06 04 T - LL	WXM 255	12.56.424.44.3
	DNGA 15 06 04 S - LL	WXM 455	12.56.424.46.5
	DNGA 15 06 08 T - LL	WXM 255	12.56.425.44.3
	DNGA 15 06 08 S - LL	WXM 355	12.56.425.46.4
	DNGA 15 06 08 S - LL	WXM 455	12.56.425.46.5
	DNGA 15 06 12 T - LL	WXM 255	12.56.426.44.3
	DNGA 15 06 12 S - LL	WXM 355	✱12.56.426.46.4
	DNGA 15 06 12 S - LL	WXM 355	✧12.56.426.47.4
	DNGA 15 06 12 S - LL	WXM 455	12.56.426.46.5

Multi-tipped

INSERT	ISO	GRADE	SPK-REF. NO.
SCGW 09 T3 .. - DL 	SCGW 09 T3 04 T - DL	WXM 255	12.17.419.44.3
	SCGW 09 T3 04 S - DL	WXM 355	12.17.419.46.4
	SCGW 09 T3 04 S - DL	WXM 455	12.17.419.46.5
	SCGW 09 T3 08 T - DL	WXM 255	12.17.420.44.3
	SCGW 09 T3 08 S - DL	WXM 355	12.17.420.46.4
	SCGW 09 T3 08 S - DL	WXM 455	12.17.420.46.5
SNGA 12 04 .. - NL 	SNGA 12 04 04 T - NL	WXM 255	12.16.404.44.3
	SNGA 12 04 04 S - NL	WXM 455	12.16.404.46.5
	SNGA 12 04 08 T - NL	WXM 255	12.16.405.44.3
	SNGA 12 04 08 S - NL	WXM 355	✱ 12.16.405.46.4
	SNGA 12 04 08 S - NL	WXM 355	✧ 12.16.405.47.4
	SNGA 12 04 08 S - NL	WXM 455	12.16.405.46.5
	SNGA 12 04 12 T - NL	WXM 255	12.16.406.44.3
	SNGA 12 04 12 S - NL	WXM 355	12.16.406.46.4
	SNGA 12 04 12 S - NL	WXM 455	12.16.406.46.5

Chamfer geometries

T-chamfer:

for continuous cuts

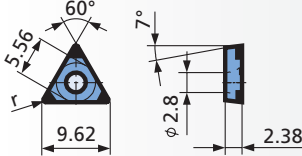
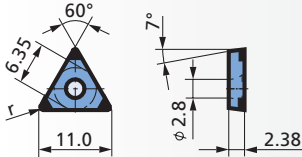
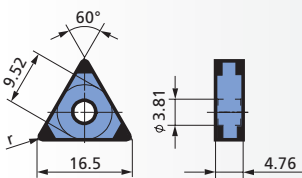
❖ 44 for smooth cuts

S-chamfer: with rounding

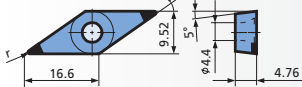
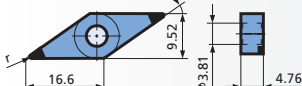
✱ 46 for lightly interrupted cuts

✧ 47 for heavily interrupted cuts



INSERT	ISO	GRADE	SPK-REF. NO.
TCGW 09 02 04 .. - CL 	TCGW 09 02 04 T - CL	WXM 255	12.37.405.44.3
	TCGW 09 02 04 S - CL	WXM 455	12.37.405.46.5
TCGW 11 02 .. - CL 	TCGW 11 02 04 T - CL	WXM 255	12.37.403.44.3
	TCGW 11 02 04 S - CL	WXM 355	12.37.403.46.4
	TCGW 11 02 04 S - CL	WXM 455	12.37.403.46.5
	TCGW 11 02 08 T - CL	WXM 255	12.37.404.44.3
	TCGW 11 02 08 S - CL	WXM 355	12.37.404.46.4
	TCGW 11 02 08 S - CL	WXM 455	12.37.404.46.5
TNGA 16 04 .. - ML 	TNGA 16 04 04 T - ML	WXM 255	12.36.405.44.3
	TNGA 16 04 04 S - ML	WXM 455	12.36.405.46.5
	TNGA 16 04 08 T - ML	WXM 255	12.36.406.44.3
	TNGA 16 04 08 S - ML	WXM 355	⊙12.36.406.46.4
	TNGA 16 04 08 S - ML	WXM 355	◇12.36.406.47.4
	TNGA 16 04 08 S - ML	WXM 455	12.36.406.46.5
	TNGA 16 04 12 T - ML	WXM 255	12.36.407.44.3
	TNGA 16 04 12 S - ML	WXM 355	⊙12.36.407.46.4
	TNGA 16 04 12 S - ML	WXM 355	◇12.36.407.47.4
	TNGA 16 04 12 S - ML	WXM 455	12.36.407.46.5

Multi-tipped

INSERT	ISO	GRADE	SPK-REF. NO.
VBGW 16 04 .. - BL 	VBGW 16 04 02 S - BL	WXM 355	12.57.423.46.4
	VBGW 16 04 04 T - BL	WXM 255	12.57.412.44.3
	VBGW 16 04 04 S - BL	WXM 355	12.57.412.46.4
	VBGW 16 04 04 S - BL	WXM 455	12.57.412.46.5
	VBGW 16 04 08 T - BL	WXM 255	12.57.413.44.3
	VBGW 16 04 08 S - BL	WXM 355	12.57.413.46.4
	VBGW 16 04 08 S - BL	WXM 455	12.57.413.46.5
	VBGW 16 04 12 T - BL	WXM 255	12.57.414.44.3
	VBGW 16 04 12 S - BL	WXM 355	12.57.414.46.4
	VBGW 16 04 12 S - BL	WXM 455	12.57.414.46.5
VNGA 16 04 .. - LL 	VNGA 16 04 04 T - LL	WXM 255	12.56.427.44.3
	VNGA 16 04 04 S - LL	WXM 455	12.56.427.46.5
	VNGA 16 04 08 T - LL	WXM 255	12.56.428.44.3
	VNGA 16 04 08 S - LL	WXM 455	12.56.428.46.5

Chamfer geometries

T-chamfer:

for continuous cuts

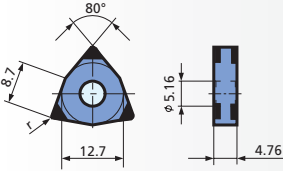
❖ 44 for smooth cuts

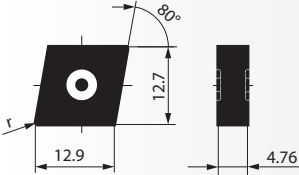
S-chamfer: with rounding

⊙ 46 for lightly interrupted cuts

⊙ 47 for heavily interrupted cuts



INSERT	ISO	GRADE	SPK-REF. NO.
WNGA 08 04 .. - ML 	WNGA 08 04 08 S - ML	WXM 355	✱12.66.406.46.4
	WNGA 08 04 08 S - ML	WXM 355	✧12.66.406.47.4
	WNGA 08 04 12 S - ML	WXM 355	✱12.66.407.46.4
	WNGA 08 04 12 S - ML	WXM 355	✧12.66.407.47.4

INSERT	ISO	GRADE	SPK-REF. NO.
CNGX 12 04 .. -S LDO 	CNGX 12 04 04 T-S LDO	WXM 255	❖12.52.086.44.3
	CNGX 12 04 04 S-S LDO	WXM 255	⊙12.52.086.46.3
	CNGX 12 04 04 S-S LDO	WXM 355	⊙12.52.086.46.4
	CNGX 12 04 04 S-S LDO	WXM 355	◇12.52.086.47.4
	CNGX 12 04 08 T-S LDO	WXM 255	❖12.52.087.44.3
	CNGX 12 04 08 S-S LDO	WXM 255	⊙12.52.087.46.3
	CNGX 12 04 08 S-S LDO	WXM 355	⊙12.52.087.46.4
	CNGX 12 04 08 S-S LDO	WXM 355	◇12.52.087.47.4
	CNGX 12 04 12 T-S LDO	WXM 255	❖12.52.088.44.3
	CNGX 12 04 12 S-S LDO	WXM 255	⊙12.52.088.46.3
	CNGX 12 04 12 S-S LDO	WXM 355	⊙12.52.088.46.4
	CNGX 12 04 12 S-S LDO	WXM 355	◇12.52.088.47.4

Chamfer geometries

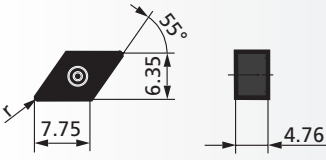
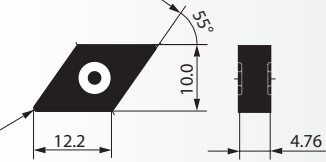
T-chamfer:
for continuous cuts

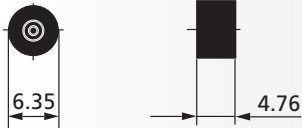
❖ 44 for smooth cuts

S-chamfer: with rounding
⊙ 46 for lightly
interrupted cuts

◇ 47 for heavily interrupted cuts



INSERT	ISO	GRADE	SPK-REF. NO.
DNGX 07 04 ... -S . MDO 	DNGX 07 04 04 S-S MDO	WXM 155	⊗12.52.062.46.2
	DNGX 07 04 04 S-S MDO	WXM 155	⊕12.52.062.47.2
	DNGX 07 04 04 S-S MDO	WXM 355	⊗12.52.062.46.4
	DNGX 07 04 08 S-S MDO	WXM 155	⊗12.52.063.46.2
	DNGX 07 04 08 S-S MDO	WXM 155	⊕12.52.063.47.2
	DNGX 07 04 08 S-S MDO	WXM 355	⊗12.52.063.46.4
	DNGX 07 04 08 S-S MDO	WXM 355	⊕12.52.063.47.4
	DNGX 07 04 12 S-S MDO	WXM 155	⊗12.52.064.46.2
	DNGX 07 04 12 S-S MDO	WXM 155	⊕12.52.064.47.2
	DNGX 07 04 12 S-S MDO	WXM 355	⊗12.52.064.46.4
	DNGX 07 04 12 S-S MDO	WXM 355	⊕12.52.064.47.4
DNGX 12 04 ... -S LDO 	DNGX 12 04 04 T-S LDO	WXM 255	⬠12.52.089.44.3
	DNGX 12 04 04 S-S LDO	WXM 255	⊗12.52.089.46.3
	DNGX 12 04 04 S-S LDO	WXM 355	⊗12.52.089.46.4
	DNGX 12 04 04 S-S LDO	WXM 355	⊕12.52.089.47.4
	DNGX 12 04 08 T- S LDO	WXM 255	⬠12.52.090.44.3
	DNGX 12 04 08 S-S LDO	WXM 255	⊗12.52.090.46.3
	DNGX 12 04 08 S-S LDO	WXM 355	⊗12.52.090.46.4
	DNGX 12 04 08 S-S LDO	WXM 355	⊕12.52.090.47.4
	DNGX 12 04 12 T-S LDO	WXM 255	⬠12.52.091.44.3
	DNGX 12 04 12 S-S LDO	WXM 255	⊗12.52.091.46.3
	DNGX 12 04 12 S-S LDO	WXM 355	⊗12.52.091.46.4
	DNGX 12 04 12 S-S LDO	WXM 355	⊕12.52.091.47.4

INSERT	ISO	GRADE	SPK-REF. NO.
RNGX 06 04 00 .. -S MDO 	RNGX 06 04 00 S-S MDO	WXM 155	♻12.42.035.46.2
	RNGX 06 04 00 S-S MDO	WXM 155	♻12.42.035.47.2
	RNGX 06 04 00 T-S MDO	WXM 255	12.42.035.44.3
	RNGX 06 04 00 S-S MDO	WXM 355	♻12.42.035.46.4
	RNGX 06 04 00 S-S MDO	WXM 355	♻12.42.035.47.4
	RNGX 06 04 00 S-F* MDO	WXM 455	12.42.230.47.5
* Flächig belegt			
RNGX 09 04 00 .. -S MDO 	RNGX 09 04 00 S-S MDO	WXM 155	♻12.42.036.46.2
	RNGX 09 04 00 S-S MDO	WXM 155	♻12.42.036.47.2
	RNGX 09 04 00 T-S MDO	WXM 255	12.42.036.44.3
	RNGX 09 04 00 S-S MDO	WXM 355	♻12.42.036.46.4
	RNGX 09 04 00 S-S MDO	WXM 355	♻12.42.036.47.4
RNGX 12 04 00 .. -S LDO 	RNGX 12 04 00 T-S LDO	WXM 255	♻12.42.038.44.3
	RNGX 12 04 00 S-S LDO	WXM 255	♻12.42.038.46.3
	RNGX 12 04 00 S-S LDO	WXM 355	♻12.42.038.46.4
	RNGX 12 04 00 S-S LDO	WXM 355	♻12.42.038.47.4

Chamfer geometries

T-chamfer:

for continuous cuts

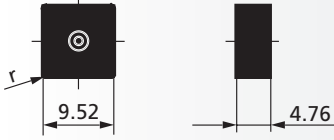
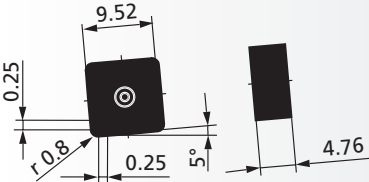
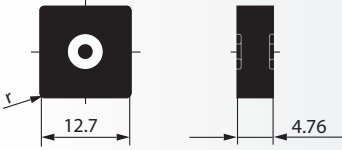
♻44 for smooth cuts

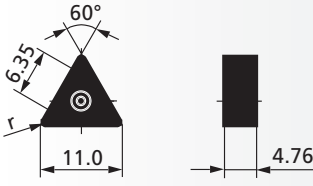
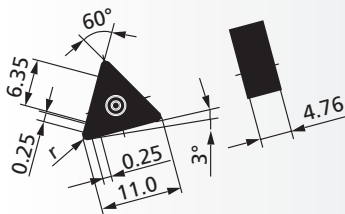
S-chamfer: with rounding

♻46 for lightly interrupted cuts

♻47 for heavily interrupted cuts



INSERT	ISO	GRADE	SPK-REF. NO.
SNGX 09 04 .. -S MDO 	SNGX 09 04 08 S-S MDO	WXM 155	⊗12.12.080.46.2
	SNGX 09 04 08 S-S MDO	WXM 155	⊕12.12.080.47.2
	SNGX 09 04 08 T-S MDO	WXM 255	⊕12.12.080.44.3
	SNGX 09 04 08 S-S MDO	WXM 255	⊗12.12.080.46.3
	SNGX 09 04 08 S-S MDO	WXM 355	⊗12.12.080.46.4
	SNGX 09 04 08 S-S MDO	WXM 355	⊕12.12.080.47.4
	SNGX 09 04 12 S-S MDO	WXM 155	⊗12.12.081.46.2
	SNGX 09 04 12 S-S MDO	WXM 155	⊕12.12.081.47.2
	SNGX 09 04 12 T-S MDO	WXM 255	12.12.081.44.3
	SNGX 09 04 12 S-S MDO	WXM 355	⊗12.12.081.46.4
	SNGX 09 04 12 S-S MDO	WXM 355	⊕12.12.081.47.4
	SNGX 09 04 16 S-S MDO	WXM 155	⊗12.12.082.46.2
	SNGX 09 04 16 S-S MDO	WXM 155	⊕12.12.082.47.2
	SNGX 09 04 16 T-S MDO	WXM 255	12.12.082.44.3
	SNGX 09 04 16 S-S MDO	WXM 355	⊗12.12.082.46.4
	SNGX 09 04 16 S-S MDO	WXM 355	⊕12.12.082.47.4
SNGX 09 04 08 .. -S MDO 85Z025 	SNGX 09 04 08 S-S MDO 85Z025	WXM 155	⊗12.12.083.46.2
	SNGX 09 04 08 S-S MDO 85Z025	WXM 155	⊕12.12.083.47.2
	SNGX 09 04 08 T-S MDO 85Z025	WXM 255	12.12.083.44.3
	SNGX 09 04 08 S-S MDO 85Z025	WXM 355	⊗12.12.083.46.4
SNGX 12 04 .. -S LDO 	SNGX 12 04 08 T-S LDO	WXM 255	⊕12.12.090.44.3
	SNGX 12 04 08 S-S LDO	WXM 255	⊗12.12.090.46.3
	SNGX 12 04 08 S-S LDO	WXM 355	⊗12.12.090.46.4
	SNGX 12 04 08 S-S LDO	WXM 355	⊕12.12.090.47.4
	SNGX 12 04 12 T-S LDO	WXM 255	⊕12.12.091.44.3
	SNGX 12 04 12 S-S LDO	WXM 255	⊗12.12.091.46.3
	SNGX 12 04 12 S-S LDO	WXM 355	⊗12.12.091.46.4
	SNGX 12 04 12 S-S LDO	WXM 355	⊕12.12.091.47.4

INSERT	ISO	GRADE	SPK-REF. NO.
TNGX 11 04 ...-S MDO 	TNGX 11 04 04 S-S MDO	WXM 155	⊗12.32.035.46.2
	TNGX 11 04 04 S-S MDO	WXM 155	⋄12.32.035.47.2
	TNGX 11 04 04 T-S MDO	WXM 255	12.32.035.44.3
	TNGX 11 04 04 S-S MDO	WXM 355	12.32.035.46.4
	TNGX 11 04 08 S-S MDO	WXM 155	⊗12.32.036.46.2
	TNGX 11 04 08 S-S MDO	WXM 155	⋄12.32.036.47.2
	TNGX 11 04 08 T-S MDO	WXM 255	12.32.036.44.3
	TNGX 11 04 08 S-S MDO	WXM 355	⊗12.32.036.46.4
	TNGX 11 04 08 S-S MDO	WXM 355	⋄12.32.036.47.4
	TNGX 11 04 12 S-S MDO	WXM 155	⊗12.32.037.46.2
	TNGX 11 04 12 S-S MDO	WXM 155	⋄12.32.037.47.2
	TNGX 11 04 12 T-S MDO	WXM 255	12.32.037.44.3
	TNGX 11 04 12 S-S MDO	WXM 355	⊗12.32.037.46.4
	TNGX 11 04 12 S-S MDO	WXM 355	⋄12.32.037.47.4
	TNGX 11 04 16 S-S MDO	WXM 155	12.32.039.46.2
	TNGX 11 04 16 T-S MDO	WXM 255	⋄12.32.039.44.3
	TNGX 11 04 16 S-S MDO	WXM 255	⋄12.32.039.47.3
	TNGX 11 04 16 S-S MDO	WXM 355	⊗12.32.039.46.4
	TNGX 11 04 16 S-S MDO	WXM 355	⋄12.32.039.47.4
TNGX 11 04 08 ...-S MDO 93Z025 	TNGX 11 04 08 S-S MDO 93Z025	WXM 155	12.32.041.46.2
	TNGX 11 04 08 T-S MDO 93Z025	WXM 255	12.32.041.44.3
	TNGX 11 04 08 S-S MDO 93Z025	WXM 355	12.32.041.46.4

i Chamfer geometries

T-chamfer:

for continuous cuts

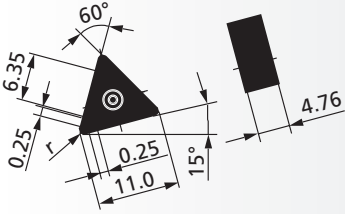
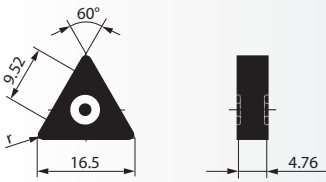
⋄ 44 for smooth cuts

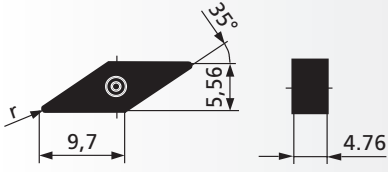
S-chamfer: with rounding

⊗ 46 for lightly interrupted cuts

⋄ 47 for heavily interrupted cuts



INSERT	ISO	GRADE	SPK-REF. NO.
TNGX 11 04 08 -S MDO 105Z025 	TNGX 11 04 08 S-S MDO 105Z025	WXM 155	⊙12.32.038.46.2
	TNGX 11 04 08 S-S MDO 105Z025	WXM 155	◇12.32.038.47.2
	TNGX 11 04 08 T-S MDO 105Z025	WXM 255	12.32.038.44.3
	TNGX 11 04 08 S-S MDO 105Z025	WXM 355	12.32.038.46.4
TNGX 16 04 .. -S LDO 	TNGX 16 04 04 T-S LDO	WXM 255	❖12.32.046.44.3
	TNGX 16 04 04 S-S LDO	WXM 255	⊙12.32.046.46.3
	TNGX 16 04 04 S-S LDO	WXM 355	⊙12.32.046.46.4
	TNGX 16 04 04 S-S LDO	WXM 355	◇12.32.046.47.4
	TNGX 16 04 08 T-S LDO	WXM 255	❖12.32.047.44.3
	TNGX 16 04 08 S-S LDO	WXM 255	⊙12.32.047.46.3
	TNGX 16 04 08 S-S LDO	WXM 355	⊙12.32.047.46.4
	TNGX 16 04 08 S-S LDO	WXM 355	◇12.32.047.47.4
	TNGX 16 04 12 T-S LDO	WXM 255	❖12.32.048.44.3
	TNGX 16 04 12 S-S LDO	WXM 255	⊙12.32.048.46.3
	TNGX 16 04 12 S-S LDO	WXM 355	⊙12.32.048.46.4
	TNGX 16 04 12 S-S LDO	WXM 355	◇12.32.048.47.4

INSERT	ISO	GRADE	SPK-REF. NO.
VNGX 09 04 .. S-S MDO 	VNGX 09 04 04 S-S-MDO	WXM 155	⊙12.52.065.46.2
	VNGX 09 04 04 S-S-MDO	WXM 155	⋄12.52.065.47.2
	VNGX 09 04 04 S-S-MDO	WXM 355	⊙12.52.065.46.4
	VNGX 09 04 08 S-S-MDO	WXM 155	⊙12.52.066.46.2
	VNGX 09 04 08 S-S-MDO	WXM 155	⋄12.52.066.47.2
	VNGX 09 04 08 S-S-MDO	WXM 355	⊙12.52.066.46.4
	VNGX 09 04 12 S-S MDO	WXM 155	⊙12.52.067.46.2
	VNGX 09 04 12 S-S MDO	WXM 155	⋄12.52.067.47.2
	VNGX 09 04 12 S-S MDO	WXM 355	⊙12.52.067.46.4

Chamfer geometries

T-chamfer:

for continuous cuts

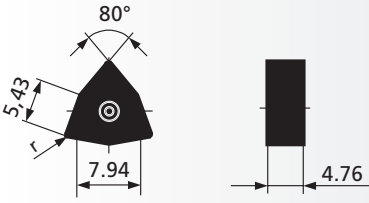
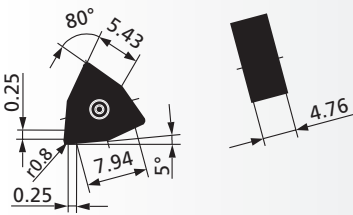
❖ 44 for smooth cuts

S-chamfer: with rounding

⊙ 46 for lightly interrupted cuts

⋄ 47 for heavily interrupted cuts



INSERT	ISO	GRADE	SPK-REF. NO.
WNGX 05 04 ... -S MDO 	WNGX 05 04 08 S-S MDO	WXM 155	⊗12.62.007.46.2
	WNGX 05 04 08 S-S MDO	WXM 155	⊕12.62.007.47.2
	WNGX 05 04 08 T-S MDO	WXM 255	12.62.007.44.3
	WNGX 05 04 08 S-S MDO	WXM 355	⊗12.62.007.46.4
	WNGX 05 04 08 S-S MDO	WXM 355	⊕12.62.007.47.4
	WNGX 05 04 12 S-S MDO	WXM 155	⊗12.62.010.46.2
	WNGX 05 04 12 S-S MDO	WXM 155	⊕12.62.010.47.2
	WNGX 05 04 12 T-S MDO	WXM 255	12.62.008.44.3
	WNGX 05 04 12 S-S MDO	WXM 355	⊗12.62.008.46.4
	WNGX 05 04 12 S-S MDO	WXM 355	⊕12.62.008.47.4
WNGX 05 04 08 ... -S MDO 95Z025 	WNGX 05 04 08 S-S MDO 95Z025	WXM 155	⊗12.62.009.46.2
	WNGX 05 04 08 S-S MDO 95Z025	WXM 155	⊕12.62.009.47.2
	WNGX 05 04 08 T-S MDO 95Z025	WXM 255	12.62.009.44.3
	WNGX 05 04 08 S-S MDO 95Z025	WXM 355	12.62.009.46.4

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