element six™

DE BEERS GROUP

Precision machining: giving toolmakers a competitive edge

PCD, PCBN, CVD diamond and single crystal diamond solutions

Competitiveadvantage through innovation

At Element Six (E6), we work in collaboration with our customers to develop cutting-edge solutions and materials. We have a proven commitment and capacity to deliver innovative polycrystalline diamond (PCD), polycrystalline cubic boron nitride (PCBN), tungsten carbide (WC), chemical vapour deposition (CVD) and single crystal diamond solutions that enable next generation performance in metalworking applications.

Our state-of-the-art Global Innovation Centre (GIC) located near Oxford, UK, gives us unique access to first-class research and development facilities that enable us to develop and enhance our innovative supermaterials solutions. We strive to continually find new ways to transform the extreme properties of our synthetic diamond and tungsten carbide solutions, to deliver next generation performance.

PCBN standard product range available

Other sizes and formats available on request

PCBN WC-backed disc product range

Grade	Outside disc diameter (mm)	PCBN usable area (mm)	PCBN layer (mm)	Overall thickness (+/- 0.05 mm)			
				1.6	2.38	3.18	4.76
DCN450 **DCC500** **DCX650** **DBW85** **DBS900**	75	70	0.8 (0.7 - 1.0)	✓	✓	✓	✓

PCBN solid low-content product range

Grade	Conductive/ non-conductive	Overall thickness (+/- 0.05 mm)							Outside disc diameter (mm)	PCBN
		1.0	1.6	2.38	3.18	4.76	6.35	7.94		
DSN450* **DSC500** **DIA550** **DHA650** **DFA750**	Conductive	✓	✓	✓	✓	✓	✓	✓	95 90	
AMT75			✓	✓	✓	✓				

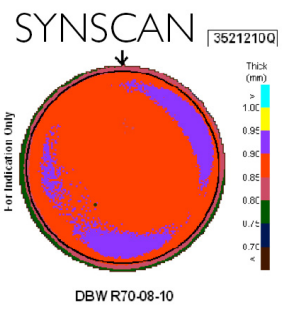
*DSN450 not avalible at 1.0 overall thickness

PCBN solid high-content product range

Grade	Conductive/ non-conductive	Overall thickness (+/- 0.05 mm)			Outside disc diameter (mm)	PCBN usable area (mm)
		3.18	4.76	6.35		
AMB90	Non-conductive	✓	✓	✓	99	97
AMK90		✓	✓			
ZAA		✓	✓			

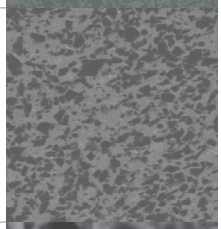
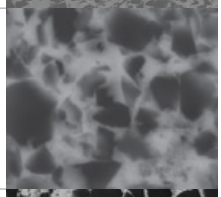
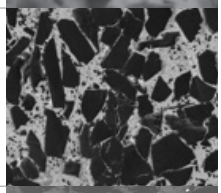
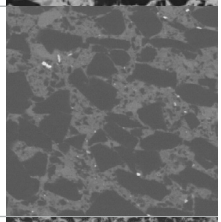
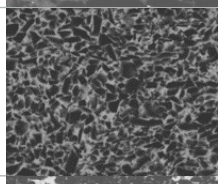
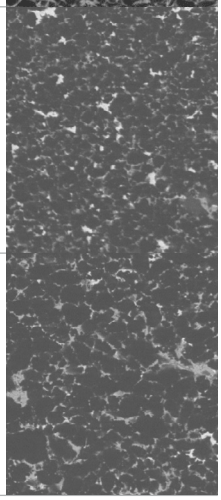
PCBN synscan
Element Six supplies a unique ultrasonic scan depicting the PCBN layer profile.

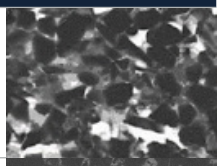
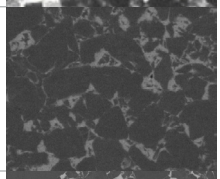
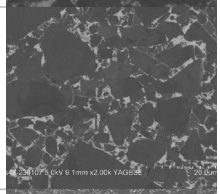
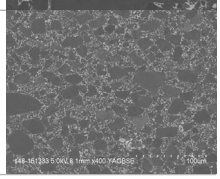
The PCBN scan indicates a 'North Point', which matches a 'North Point' laser marked on the disc, allowing users to optimise the cutting areas.



Our unique scalable segmentation service
Our fast, high quality and cost-effective segmentation service is support ed by the largest laser cutting and electrical discharge machinery (EDM) capacity of all abrasive manufacturers. We provide both standard and complex bespoke geometries.

PCBN grades and characteristics

Grade	Applications	Characteristics	Microstructure
DCN450 (WC-backed) **DSN450 (solid)**	For moderately interrupted hard turning and finish hard milling as well as high speed continuous turning. Its resistance to crater wear is among the highest in the market. With one of the finest structures of all commercial grades, DCN450 provides for sub-µm surface roughness	• Approximately 45% CBN • Sub-µm CBN grain size • TiCN binder	
DCC500 (WC-backed) **DSC500 (solid)**	For continuously and lightly interrupted cutting of the majority of automotive steels. Excellent abrasion resistance makes it the ideal choice for cold work tool steels and certain valve seat alloys. Also recommended for finishing abrasive high strength cast irons	• Approximately 50% CBN • 1.5 µm average grain size • Principally TiC binder	
DIA550	For light to moderately interrupted hard turning and finish hard milling in both dry and wet conditions. Suitable for both conventional and high machining speeds	• 55% vol cBN • 2 µm avg. grain size • TiC/TiN binder	
DHA650	For moderately to heavily interrupted hard turning and finish hard milling in both dry and wet conditions. Suitable for both conventional and elevated machining speeds	• Approximately 65% CBN • <4 µm avg. grain size • Binder phase includes TiC/TiN	
DCX650	For moderately to heavily interrupted turning of all common hardened steels. Provides an excellent balance of toughness, and crater and flank wear resistance. Also used for plunge machining of valve seat rings	• Approximately 65% CBN • Average 3 µm proprietary multi-modal grain size • TiN binder	
DFA750	For heavily interrupted machining of hardened steels, where a balance of chemical wear and toughness is required. Ideal for ball path milling of cv joints	• 75% vol cBN • 4 µm avg. grain size • TiN binder	
DBW85	For applications such as grey iron fine boring and valve seat machining, due to excellent strength and abrasion resistance. Ideal for heavily interrupted cutting of all hard and abrasive work piece materials, including powder metallurgy components. Proven performance also in hard fine milling applications	• Approximately 85% CBN • 2 µm average grain size • AlWCoB binder for extreme chip resistance	
DBS900	Ideal for applications where longer tool life is required. Excels in interrupted machining of grey and hard cast irons, hardened steel milling and in the machining of the majority of valve seat ring alloys. Excellent first choice grade for the majority of ferrous powder metals	• Approximately 90% CBN • 2 µm average grain size • Novel binder system to provide the ultimate abrasion and chip resistance	

Grade	Applications	Characteristics	Microstructure
AMT75	Excels in highly abrasive high chrome cast irons, where a balance of chemical and abrasive mechanical wear is crucial. Suitable for both milling and turning	• 75% vol cBN • <4.5 µm avg. grain size • TiN binder	
AMB90	For turning and milling of grey and hard cast irons and heavy turning of hardened steels; including components such as brake discs, pump bodies and impellers and large rolls	• Approximately 90% CBN • Binder phase includes aluminium nitrides and borides	
AMK90	For similar application areas as AMB90, but providing higher wear resistance. Exhibits particularly high performance in abrasive work materials such as high chrome cast irons. Usable edges on both faces of insert	• Approximately 90% CBN • Binder phase includes aluminium nitrides and borides	
ZAA	A value-orientated grade for turning of grey cast iron, including components such as brake discs and pump bodies	• Approximately 90% CBN • Binder phase includes aluminium nitrides and borides	

PCBN application guide

Selecting products and grades for your applications

- Due to the very large number of unique applications, it is possible only to make general recommendations
- Significant improvements in tool performance should be possible through further optimisation
- ISO513's colour-coded classification of cutting tool applications has been used here to indicate the intended application area for cutting tool materials
- Deeper colour bars indicate preferred grades
- Lighter colour bars indicate other grades which may be preferable in specific circumstances

		Grade recommendations												Cutting	
		DCN450/DSN450	DCC500/DSC500	DIA550	DHA650	DCX650	DFA750	AMT75	DBW85	DBS900	AMB90	AMK90	ZAA	Cutting speed, V_c (m/min) [8, 16]	
														Min	Max
Hardened steels	**H01**													130	210
	H10													100	170
	H20													100	160
	H30 Hard milling													100	190
Cast irons [1, 2]	**Grey iron - K01**													600	2500
	Grey iron - K10 [12]														
	Grey iron - K20 [12]														
	Grey iron - K30														
	AD [9] **- K01**													150	500
	ADI - K10														
	ADI - K20 - K30													200	400
	Nodular iron and CGI [10, 11]													150	350
	White and chrome irons - K10													50	80
	White and chrome irons - K20-K30													50	100
	Ferrous powder metals < 300 HV													-	350
	(Excl. VSR [13] **) < 750 HV**													-	250
Valve seat rings	**< 350 HV: Plunging**													50	150
	< 350 HV: Turning													50	180
	< 350 HV: Plunging													50	150
	< 350 HV: Turning													50	180
Super-alloys	**NI-base: S10** [14, 15]													150	400
	NI-base: S20 - S30													100	150
	CO-base: S10													50	200
	CO-base: S20 - S30													50	100

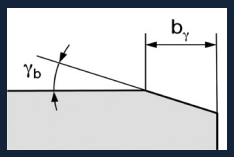
conditions				Edge geometry guide			
Feed, f (mm) (3, 4, 7)		Depth of cut, a_p (mm) (4, 5, 7)		Champfer angle, γ_b	Champfer width, b_γ (mm)	Edge radius, r_β (µm)	Nose radius, r_ε (mm) (6)
Min	Max	Min	Max	Recommended ranges			
-	0.5	-	0.5	15 - 25	0.1-0.2	5-10	0.4-1.6
-	0.5	-	0.3	20 - 35	0.1-0.2	5-10	0.4-1.6
-	0.5	-	0.3	25 - 35	0.1-0.2	10-30	0.4-3.2
-	0.5	-	0.3	25 - 35	0.1-0.2	10-30	0.4-3.2
0.1	1	0.1	2	15 - 25	0.2 - 1.0	- 20	- 3.2
0.2	2	0.5	5				
0.15	0.5	0.15	0.5	15 -	0.1 -	10 -	0.8 -
0.2	0.4	0.2	0.4	25	0.3	20	1.6
0.1	1	0.2	2	As for ADI			
0.1	0.5	0.2	2	20 -	0.2 -	20 -	1.6 -
0.2	2	1	6	15	1	30	> 9.0
0.1	0.5	-	1.0	0. - 20	-0.2	-15	-1.6
0.1	0.3	-	1.0	15 - 35	-0.2	-30	-1.6
0.02	0.05	NA	NA	10 -	0.1 -	0 -	NA
0.05	0.2	0.1	0.5	30	0.2	20	- 1.6
0.02	0.05	NA	NA	15 -	0.1 -	10 -	NA
0.05	0.2	0.1	0.5	25	0.2	30	- 1.6
-	0.3	-	0.5	0 - 20	0 - 0.3	20 - 40	1.6 - 3.2
			1.0				
			0.5	0 - 20	0 - 0.3		
			1.0				

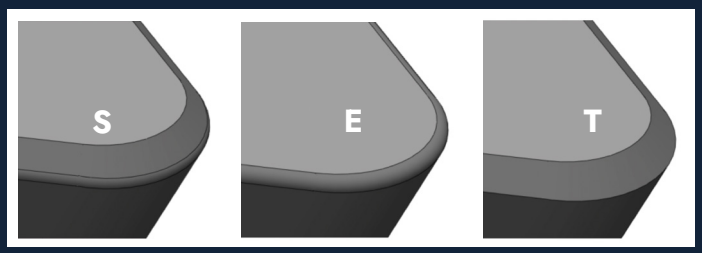
ISO1832 prescribes several edge conditions, three of which are most commonly applied to PCBN indexable inserts.

Indexable inserts made in accordance with ISO16462 are obliged to indicate the edge condition, expressed as a letter symbol (e.g. S, T, E). Five digits indicate the T-land dimensions. Hone dimensions are not indicated in ISO designations.

Example: CNGA120408 S 015 30

- Edge shape (S, E, T, etc.)
- Chamfer width, bγ, in 1/100th mm
- Chamfer angle, γb in degrees





Chamfer & hone
Stronger than T-land - First choice for HPT. Feed must be greater than hone size

Honed edge
Hone size is more difficult to control than chamfers, but popular for HRSAs

Chamfer / T-land
The larger the T-land width and angle, the higher the forces

1. For cast iron and roll machining, solid grades AMB90 and AMK90 are more economical, while DBW85 and DBS900 provide for a superior finish and greater edge strength; e.g. for positive inserts or a heavily interrupted cut
2. Performance for grey irons can vary depending on casting quality and degree of ageing
3. The feed is selected with nose radius according to surface roughness requirements
4. The depth of cut is typically determined by stock removal allowance (oversize) prior to hardening of the component
5. While there is no strict minimum feed or depth of cut, excessively low values (e.g., < 0.02 mm) may result in adverse machining vibrations
6. While a larger nose radius provides a stronger edge, excessively large values may result in adverse machining vibrations
7. For braze-tipped tools, the segment area (in mm^2) should be > 100*f*ap so as to securely bear the cutting load
8. Indicated cutting speeds for hard steels are primarily for case hardened steels. For higher alloy steels, it may be necessary to reduce the cutting speed to achieve the required tool life
9. ADI: Austempered Ductile Iron
10. CGI: Compacted Graphite Iron (also known as vermicular iron)
11. Compacted graphite cast irons are also successfully machined with PCD - we recommend CTM302. The cutting speed for PCD should be 200 +/- 50 m/min
12. Milling of grey cast irons is typically done within the upper portion of the speed range indicated
13. VSR: Valve Seat Rings
14. Super-alloys - also known as heat resistant superalloys (HRSA) - consist of a very large range of compositions and properties, resulting in very different machining characteristics
15. For HRSAs it is preferable to use round inserts. It is also advisable to assess the use of un-chamfered, but honed, cutting edge geometries
16. PureCut™ grades are designed to operate at higher speeds than E6's other grades. Please contact E6 technical support for further details

Reduce downtime and improve productivity by converting to integral inserts

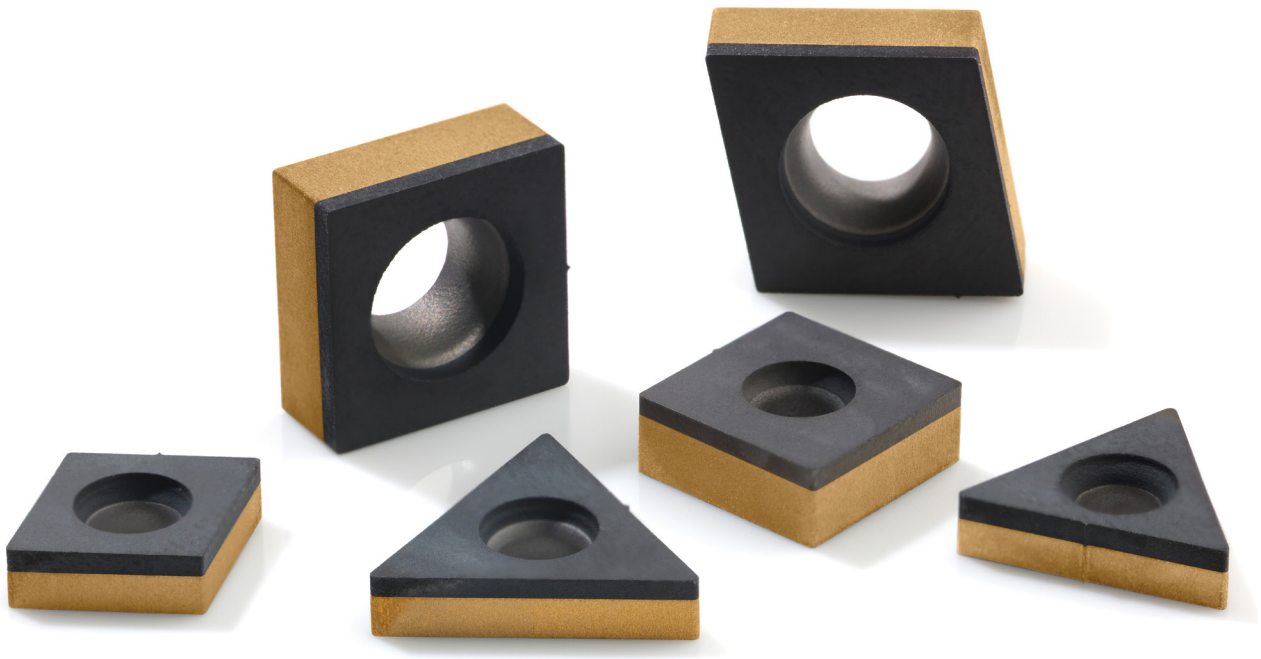
With increasing pressure from competitors and end users, tool manufacturers are always looking for ways to simplify the manufacturing process, raise productivity and reduce costs. By switching from brazed inserts to centre-lock full-face inserts, these aspirations can become a reality.

High performance components
Centre-lock full-face PCBN inserts provide for easily manufactured multi-cornered tools with a number of benefits:

- A more robust cutting component than a conventional brazed tool
- Greater reliability in interrupted cutting applications
- Elimination of the braze joint allowing higher temperature coatings to be applied
- Reduced insert failure risks and improved production continuity
- Longer cutting edges that enable productivity improvements in application; either through the use of larger depths of cut or plunge-type machining operations
- High and low CBN content configurations

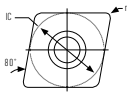
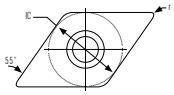
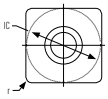
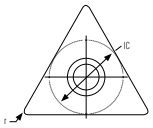
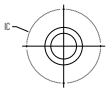
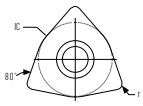
The benefits of using centre-lock full-face inserts

- Eliminate pocketing and brazing procedures
- Improved precision by eliminating brazing inaccuracies
- Reduce the amount of handling
- Cut the overall production cost per usable corner
- Apply higher temperature coatings
- Shorten the production pipeline by eliminating the need for:
  - carbide preparation
  - segment cleaning
  - brazing
  - after-brazing cleaning



Standard PCBN range available

Other sizes and formats available on request.

Insert shape	Insert style	Clearance	Tolerance class(1)	Hole style	Finished IC(2)	Insert thickness	Corner radius
	C	N	M	W 	06 - 6.35	02 - 2.38	02
	80				09 - 9.52	T3 - 3.97	02
	D	N	M	W 	07 - 6.35	02 - 2.38	02
	55				11 - 9.52	T3 - 3.97	02
	S	N	M	W 	06 - 6.35	02 - 2.38	02
	90				09 - 9.52	T3 - 3.97	02
	T	N	M	W 	09 - 5.56	02 - 2.38	02
	60				11 - 6.35	02 - 2.38	02
	R	N	M	W 	06 - 6.35	03 - 3.18	02
	360				07 - 7.94	03 - 3.18	02
	W	N	M	W 	06 - 9.52	03 - 3.18	02
	80						

IC - Inscribed Circle

1. Tolerance on overall thickness +/-0.05 and IC tolerance +/- 0.10 mm
2. Grinding allowances apply, IC diameters shown will be produced with a 0.3 mm grinding
3. All measurements are mm

PCBN grade availability

Centre-lock full-face PCBN inserts are available in all WC-backed PCBN grades.

End user benefits

Machine operators and engineering managers value the benefits of integral inserts over brazed inserts; the ability to switch from corner to corner means that maintaining production continuity is simply a matter of adjusting the insert. The longer cutting edges of an integral insert also enable plunge machining which can achieve valuable gains in productivity and reductions in both downtime and costs.

Element Six is a global leader in the design, development and production of synthetic diamond and tungsten carbide supermaterials. Part of the De Beers Group, we employ over 1,900 people. Our primary manufacturing sites are located in the UK, Ireland, Germany, South Africa, and the US.

Since 1959, our focus has been on developing the diamond synthesis process to enable innovative synthetic diamond and tungsten carbide solutions. As well as being the planet's hardest material, diamond's extreme and diverse properties give it high tensile strength, chemical inertness, broad optical transmission and very high thermal conductivity.

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