



elementsixTM

DE BEERS GROUP

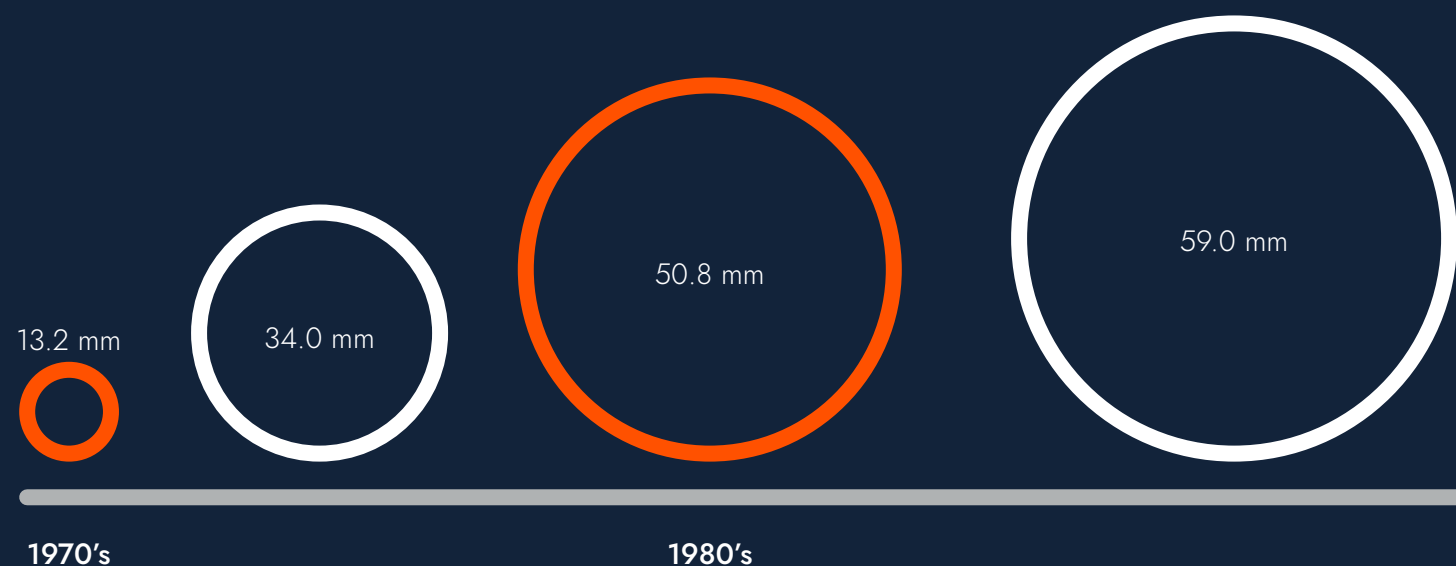
**Precision machining
with polycrystalline
diamond (PCD)**

Giving toolmakers a
competitive edge

Competitive advantage through innovation

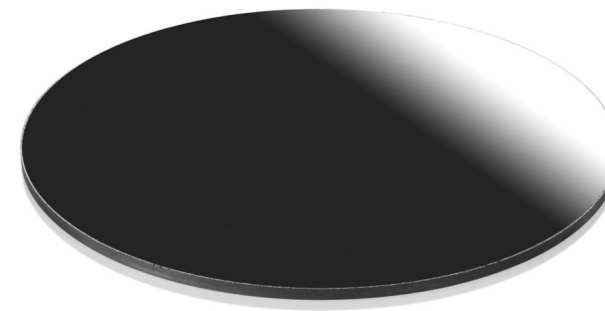
50 years of PCD expertise

Element Six (E6) polycrystalline diamond (PCD) solutions are the result of over half a century of relentless innovation. While quality and consistency are always at the core of what we do, our products have evolved over time to meet your changing needs.



Our tailored product ranges

E6's PCD materials are produced and qualified to the highest standards. Our range of products is differentiated based on dimensions, tolerances and surface finish. This provides our customers with a wider and improved choice of products to suit the broad range of applications and industries our PCD materials are used in today.



E6 PCD disc

E6 Superior

range is built on E6's capability to control PCD layer and overall height into very tight dimensional tolerances while, at the same time, delivering a flawless polish quality. The combination of these advantages is achieved on the largest disc available in the market.

E6's Superior PCD materials are used for high-end applications such as hole-making tools for the automotive industry or milling tools for producing smartphones, where high-quality surface finish is critical.

E6 Advanced

is E6's market-leading range of PCD products. E6 Advanced provides customers with two different disc diameters. The larger disc is ideal for large batch production, where the bigger certified area offers a significant advantage in cutting efficiency. The smaller disc is more suitable where the customer only needs to cut small volumes, to meet specific order batch sizes.

These materials are also used in high-precision applications and is more suitable for milling and turning tools.

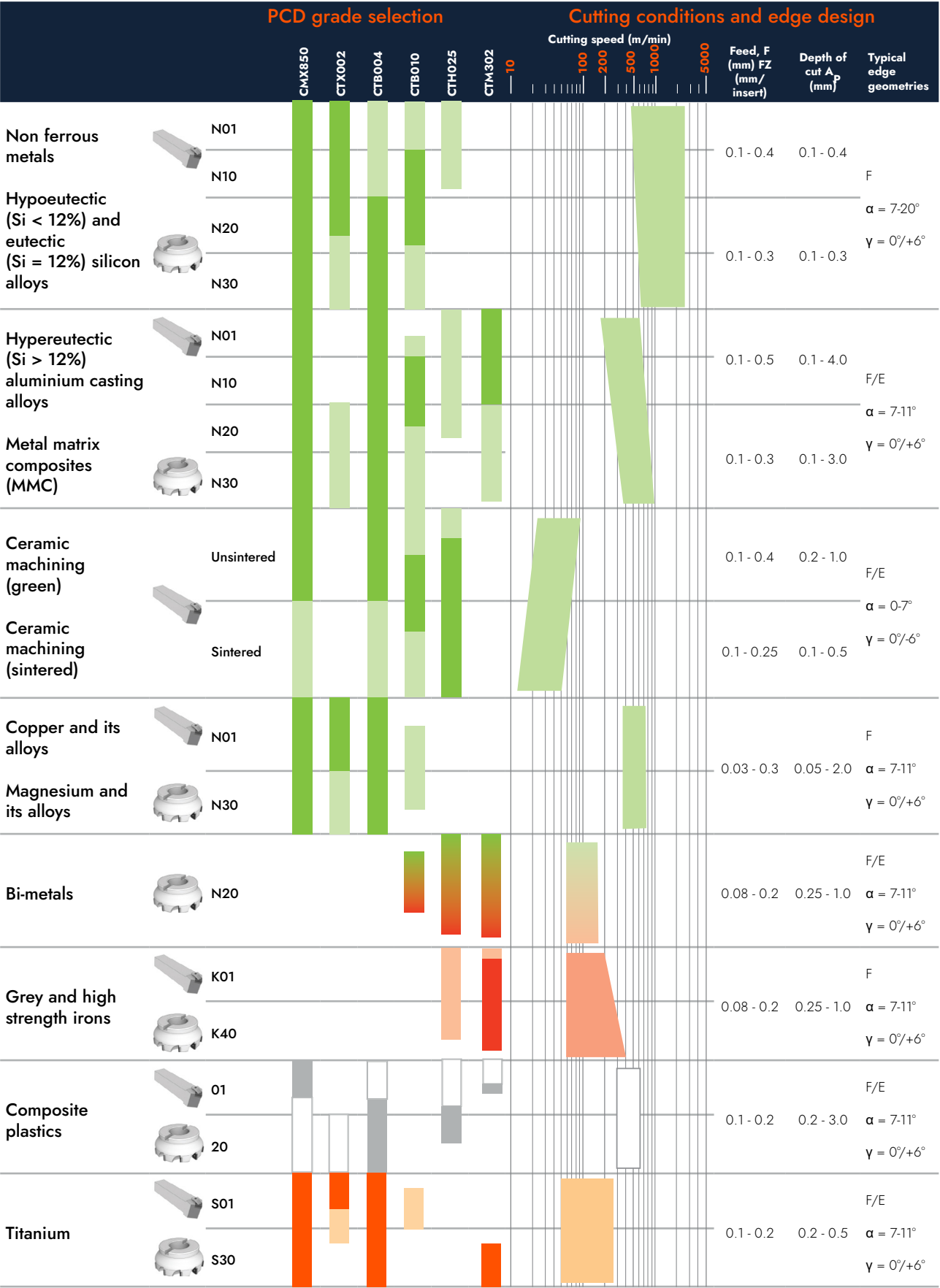
E6 Assured

is an ideal range for applications where dimensional tolerances may not be so critical. E6 Assured offers customers a competitively priced solution to enable higher volume applications.

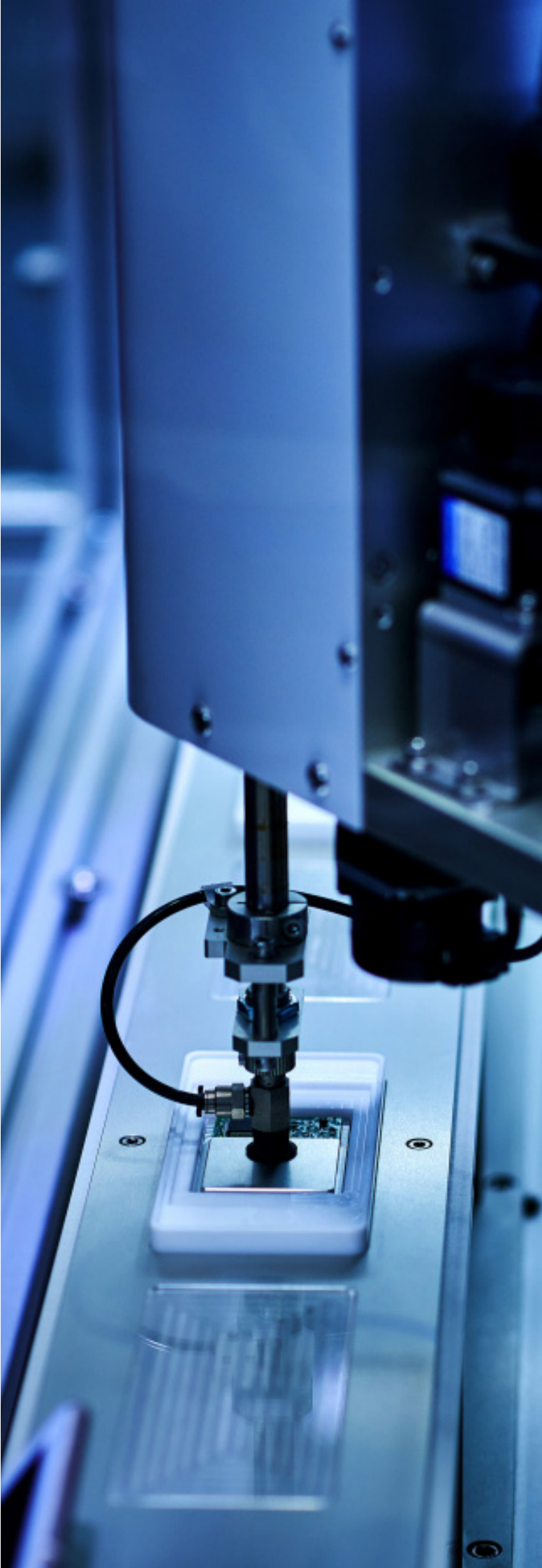
These materials are also used in applications such as saw blades and routers in the woodworking industry.

Innovation is in our DNA

PCD application guide

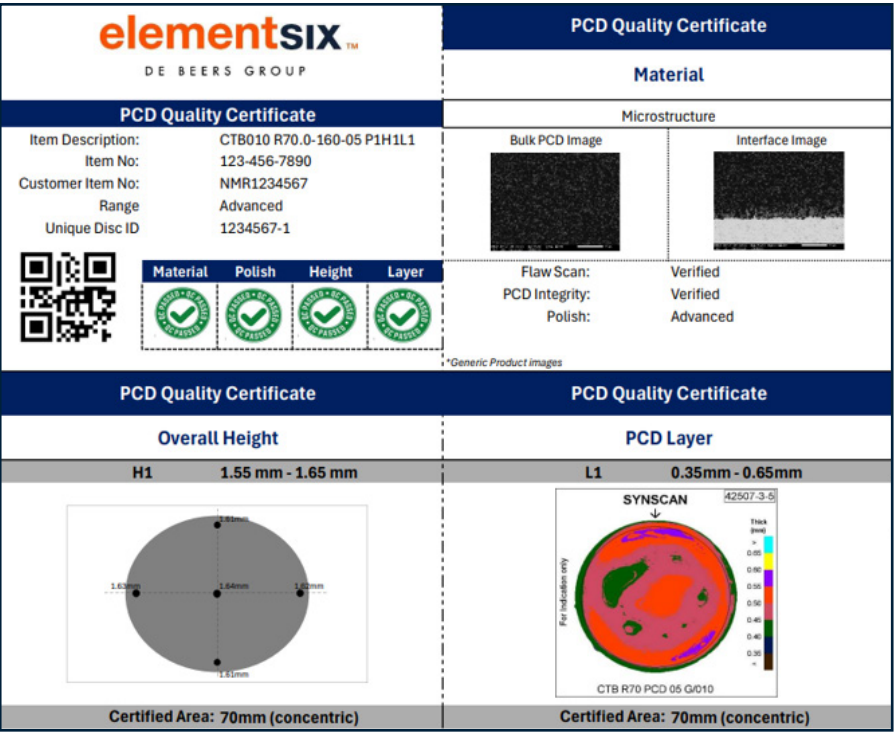


Work material characteristics and, to a lesser extent, cutting parameters, determine the demands placed on the cutting tool and, hence, the optimum balance of tool material properties. Knowledge of the application, including workpiece composition, facilitates selection of the optimum grade and correct tool geometry. Often, work material composition and machining parameters (v_c , f , a_p) are closely correlated. It is possible, therefore, only to provide a typical range of values for each parameter.



PCD product range

Grade	Standard PCD layer (mm)	Overall height (mm)							
		0.8	1.0	1.2	1.4	1.6	2.0	3.18	8.0
CMX850	0.3	✓	✓	✓		✓			
	0.5		✓			✓	✓		
	1.0							✓	
CTX002	0.5		✓			✓		✓	
CTB004	0.5					✓			
CTB010	0.3	✓	✓	✓	✓	✓		✓	
	0.5		✓	✓		✓	✓	✓	
	0.7					✓		✓	✓
	1.0							✓	
CTH025	0.5					✓	✓	✓	
CTM302	0.5					✓	✓		
	0.7							✓	
	1.5							✓	✓



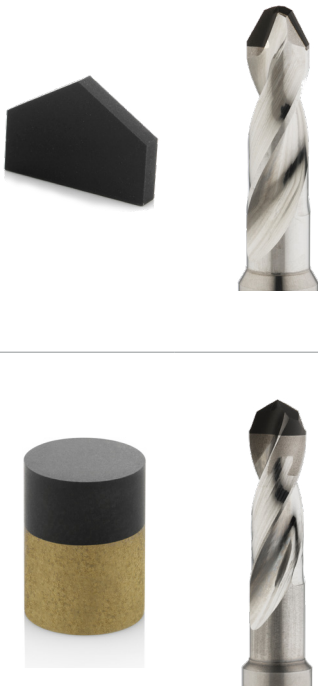
- Quality certificate**
E6 supplies a detailed quality certificate alongside each PCD product. The certificate provides:
- Traceability - quality steps and records
 - Material quality validation
 - Unique disc ID
 - Microstructure
 - Ultrasonic fault analysis
 - Attribute validation
 - Polish quality
 - Layer height
 - Overall height

Example of E6 quality certificate

Aero-Dianamics™ PCD round tool blanks

Grades and characteristics

Grade	Applications	Grain sizes	Characteristics
A2DS chevron	Drilling	Coarse	• Tool life extended by 10 times compared to tungsten carbide drills • Half round disc formats available • Electrical discharge machining (EDM) segments available and cut to order
A3DP planar	Drilling	Fine	• Virtually infinite flexibility in drill point geometry • Tool life extended by 10 times compared to tungsten carbide drills • Large rake angles available for lower tool forces



"We have seen a huge shift in global culture over the last years and an increasing focus on sustainability. High performance tools, optimal cutting data and particularly dry machining reduce the environmental impact and can help our customers with achieving their sustainability targets and upcoming regulatory requirements. At E6, it is our aim to work closely together with our customers to create new solutions for a greener future."

WAYNE LEAHY
E6 HEAD OF SALES, MACHINING

Sustainability at E6

Through the De Beers Group, E6 is a member of the UN Global Compact (UNGC). The UNGC drives business awareness and action towards the UN Sustainable Development Goals (SDGs), focussing on 10 principles around human rights, labour, environment and anti-corruption. E6 works within the De Beers Group Building Forever commitment and Science Based Target Initiative (STBi), which is also based on the UNGC principles.

We incorporate and take responsibility for these principles through the E6 Code of Conduct, Our Values, Responsibilities and Policies.

Our sites in Ireland and Germany are ISO 50001 certified.

At E6, we have active communities working towards sustainability from a variety of angles, such as environmental impact, inclusion, diversity and community outreach, both internally and externally.

Our sustainability principles



ENERGY & EMISSIONS

We strive for maximum energy efficiency.

We are committed to renewable energies and use them as much as possible.

Energy efficiency must be an essential factor in the development of processes and products as well as in the purchase of machines and changes to the infrastructure.

We strive to improve our carbon footprint and continuously avoid wasting energy.

**RENEWABLE ENERGIES
ENERGY EFFICIENCY
ISO 50001**



USE OF RESOURCES

We are committed to recyclable resources and use them as much as possible.

Our goal is sustainable water management.

We will avoid waste as much as possible.

Avoiding waste must be a key factor in the development of processes and products, as well as in the purchase of machines and changes to the infrastructure.

We conscientiously dispose of unavoidable hazardous waste.

**REDUCE
REUSE
RECYCLE**



INDIVIDUAL BEHAVIOUR & CULTURE

We educate our employees, customers and suppliers about important issues regarding sustainability and motivate them to act themselves.

We strive to improve sustainability across the whole supply chain, by working together with external parties to shape the future.

We are leading the way in terms of climate protection, environmental protection and sustainability.

**ENLIGHTENMENT
COLLABORATION
TRANSPARENCY**

Grade: CMX850

Key material characteristics

- 0.85 μm diamond grain size
- $\geq 15\%$ cobalt ratio (wt %)
- High chip resistance

Ideal for milling and rough cutting of aluminium alloys where extreme chip resistance is required, can also be used for machining titanium and composites. Sub- micron grain size. CMX850's ultra-fine grain structure is suitable for applications where mirror finishes are required due to its extreme edge sharpness/retention.

Typical microstructure



BEC 20 kV X500 Magnification 50 μ m

Grade Grain size	Behaviour in application		Processing characteristics	
	Chip resistance	Abrasion resistance	Electro-discharge machinability	Grindability
CMX850 0.85 µm				
CTX002 2 µm				
CTB004 4 µm				
CTB010 10 µm				
CTH025 25 µm				
CTM302 2 - 30 µm				

Size and format available

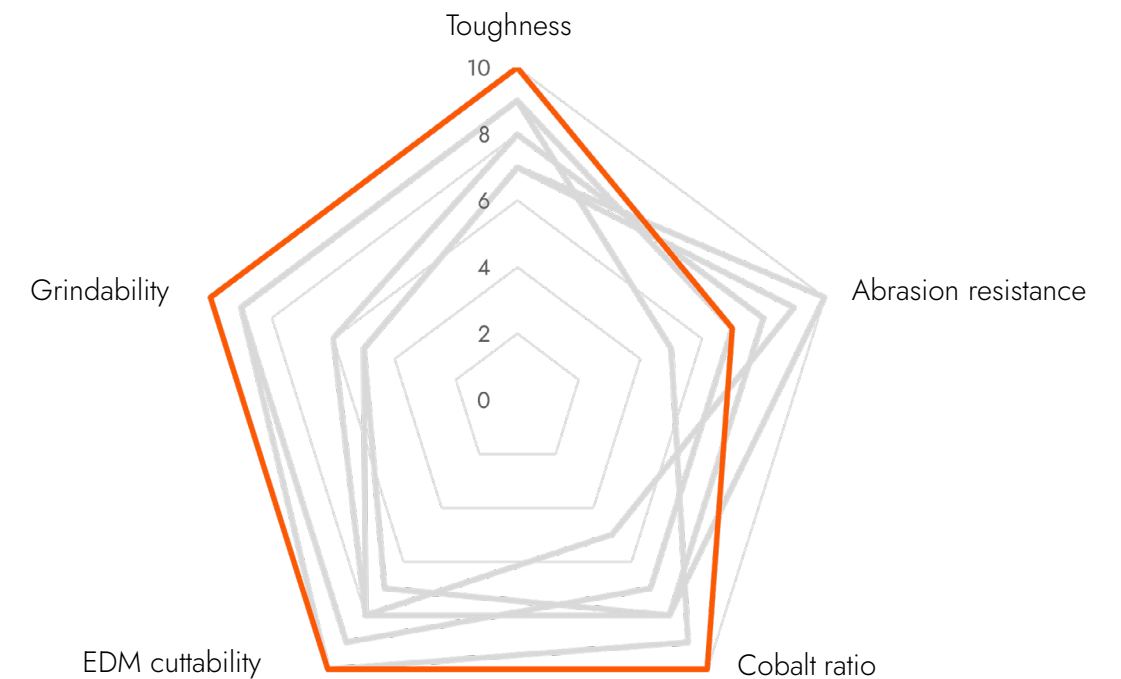
Maximum disc diameter: 76 mm

Maximum PCD certified area: 70 mm

Overall height

PCD layer thickness	0.8	1.0	1.2	1.4	1.6	2.0	3.18	8.0
0.3	✓	✓	✓		✓			
0.5		✓			✓	✓		
1.0							✓	

Material characteristics



Physical and metallurgical properties

Property	Measurement	Applicable standard
Mean coefficient of thermal expansion ($10^{-6}/^{\circ}\text{C}$) for temperature range 150 $^{\circ}\text{C}$ to 500 $^{\circ}\text{C}$	4.2	ASTM E228-06
Transverse rupture strenght characteristic strenght (MPa)	2387	ASTM C1239
Weibull modulus	6	
Fracture toughness mean ($\text{MPa}\cdot\text{m}^{1/2}$)	11.3 - 15.5	Shetty et al. (1995)
Elastic modulus (GPa)	827	ASTM E494
Poisson's ratio	0.08	
Density (g/cm^3)	4.37	Archimedes principle
Thermal conductivity ($\text{W}/\text{m}/\text{K}$) at 500 $^{\circ}\text{C}$	253.5	Calculated from thermal diffusivity, specific heat capacity and density
Knoop hardness (Indentation)(GPa)	50	ASTM C1326-03

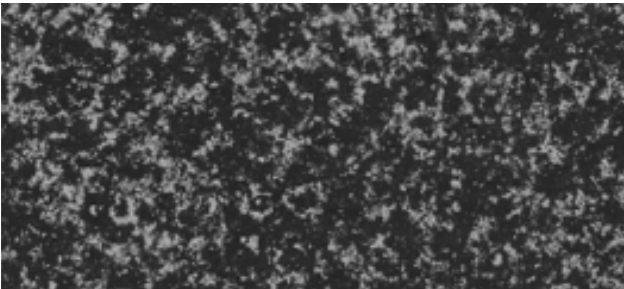
Grade: CTX002

Key material characteristics

- 2 µm diamond grain size
- 13 % cobalt ratio (wt %)
- High chip resistance

Ideal for profile routers and thread cutting tools, can also be used in wear part applications. 2 µm average grain size with increased cobalt for ease of processing. CTX002 is ideal for complex tools where intensive processing is required.

Typical microstructure

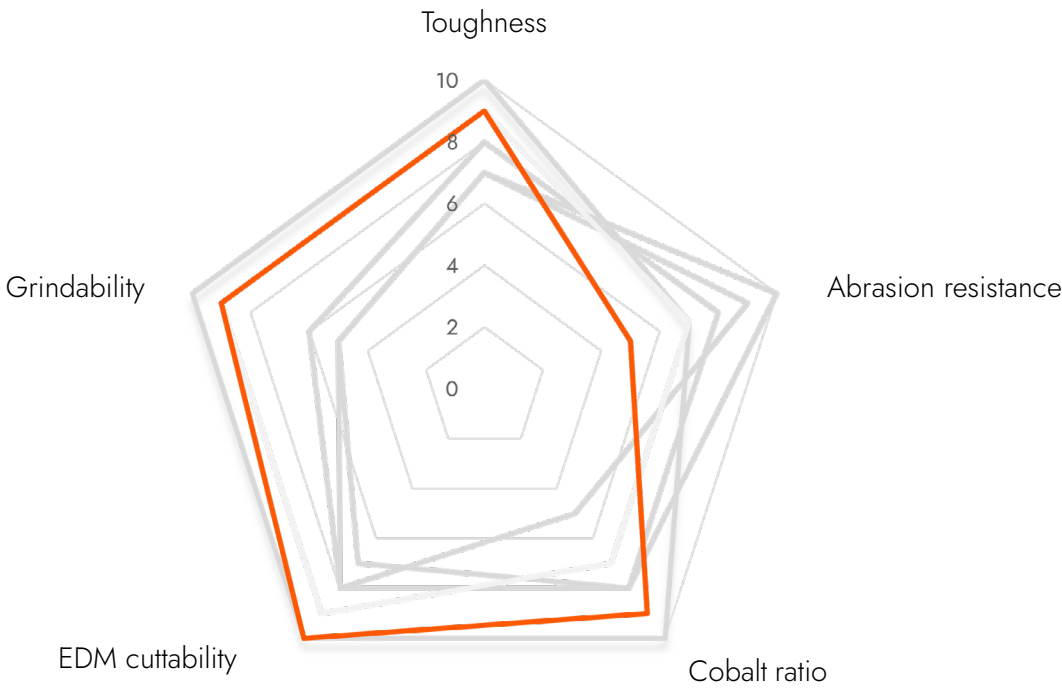


BEC 20 kV X500 Magnification 50 µm

	Behaviour in application		Processing characteristics	
Grade Grain size	Chip resistance	Abrasion resistance	Electro-discharge machinability	Grindability
CMX850 0.85 μm				
CTX002 2 μm				
CTB004 4 μm				
CTB010 10 μm				
CTH025 25 μm				
CTM302 2 - 30 μm				

Size and format available								
Maximum disc diameter: 76 mm				Maximum PCD certified area: 70 mm				
Overall height								
PCD layer thickness	0.8	1.0	1.2	1.4	1.6	2.0	3.18	8.0
0.5		✓			✓		✓	

Material characteristics



Physical and metallurgical properties		
Property	Measurement	Applicable standard
Transverse rupture strenght characteristic strength (MPa)	2175	ASTM C1239
Weibull modulus	7.1	
Fracture toughness mean (MPa.m ^{1/2})	9.12	Shetty et al. (1995)
Elastic modulus (GPa)	950	ASTM E494
Poisson's ratio	0.1	
Density (g/cm ³)	4.36	Archimedes principle
Thermal conductivity (W/m/K) at 500 °C	304.3	Calculated from thermal diffusivity, specific heat capacity and density
Knoop hardness (Indentation)(GPa)	45	ASTM C1326-03

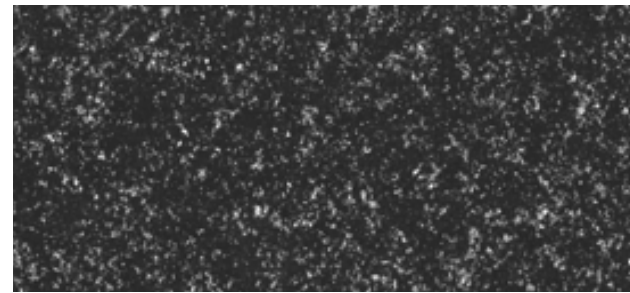
Grade: CTB004

Key material characteristics

- 4 μm diamond grain size
- 10 % cobalt ratio (wt %)
- High wear resistance

Ideal for cutting aluminium alloys where high surface finish is required, alongside higher wear resistance. 4 μm average grain size. CTB004's finer grain structure offers optimum balance between tool performance and resistance to abrasion and chipping.

Typical microstructure



BEC 20 kV X500 Magnification 50 μ m

Grade Grain size	Behaviour in application		Processing characteristics	
	Chip resistance	Abrasion resistance	Electro-discharge machinability	Grindability
CMX850 0.85 µm				
CTX002 2 µm				
CTB004 4 µm				
CTB010 10 µm				
CTH025 25 µm				
CTM302 2 - 30 µm				

Size and format available

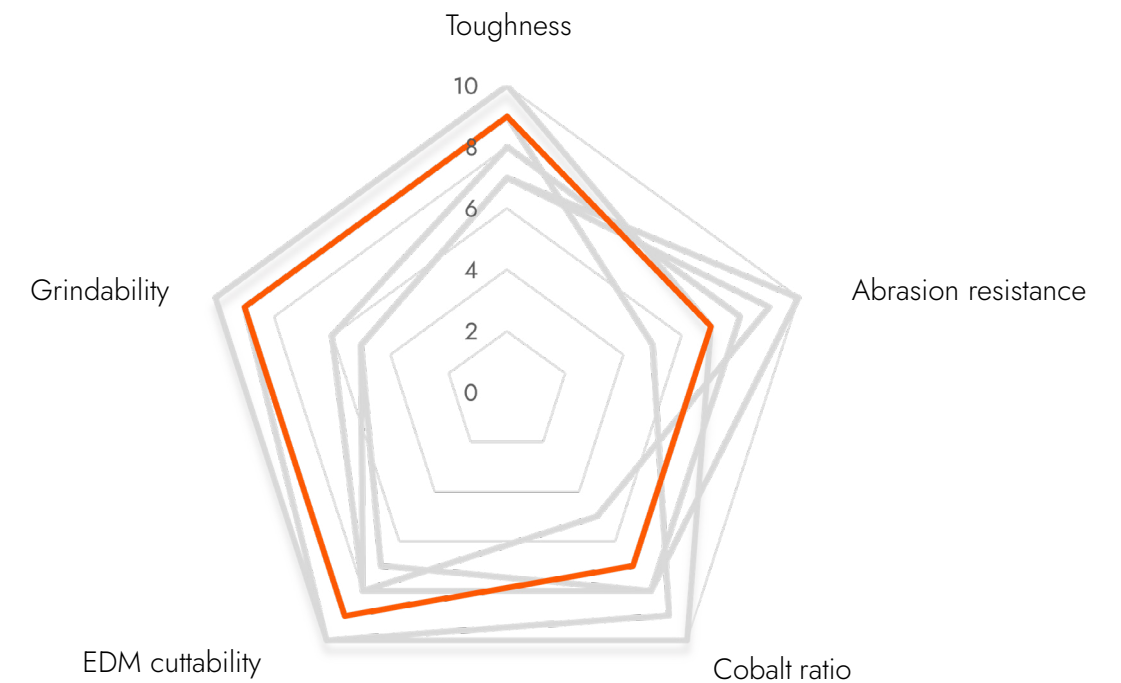
Maximum disc diameter: 76 mm

Maximum PCD certified area: 70 mm

Overall height

PCD layer thickness	0.8	1.0	1.2	1.4	1.6	2.0	3.18	8.0
0.5					✓			

Material characteristics



Physical and metallurgical properties

Property	Measurement	Applicable standard
Transverse rupture strenght characteristic strength (MPa)	1921	ASTM C1239
Weibull modulus	6.35	
Fracture toughness mean (MPa.m ^{1/4})	9.15	Shetty et al. (1995)
Elastic modulus (GPa)	950	ASTM E494
Poisson's ratio	0.1	
Density (g/cm ³)	4.19	Archimedes principle
Thermal conductivity (W/m/K) at 500 °C	248.1	Calculated from thermal diffusivity, specific heat capacity and density
Knoop hardness (Indentation)(GPa)	47	ASTM C1326-03

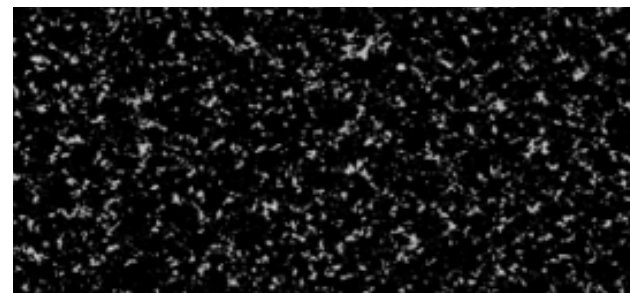
Grade: CTB010

Key material characteristics

- 10 μm diamond grain size
- 10 - 13 % cobalt ratio (wt %)
- Balanced performance

The ideal grade for roughing and finishing performed with a single tool. Highly recommended for low to medium content aluminium alloys. 10 µm grain size. CTB010 is E6's workhorse PCD grade, ideal for applications where a good balance of toughness and wear resistance is required.

Typical microstructure



BEC 20 kV X500 Magnification 50 μ m

Grade Grain size	Behaviour in application		Processing characteristics	
	Chip resistance	Abrasion resistance	Electro-discharge machinability	Grindability
CMX850 0.85 µm				
CTX002 2 µm				
CTB004 4 µm				
CTB010 10 µm				
CTH025 25 µm				
CTM302 2 - 30 µm				

Size and format available

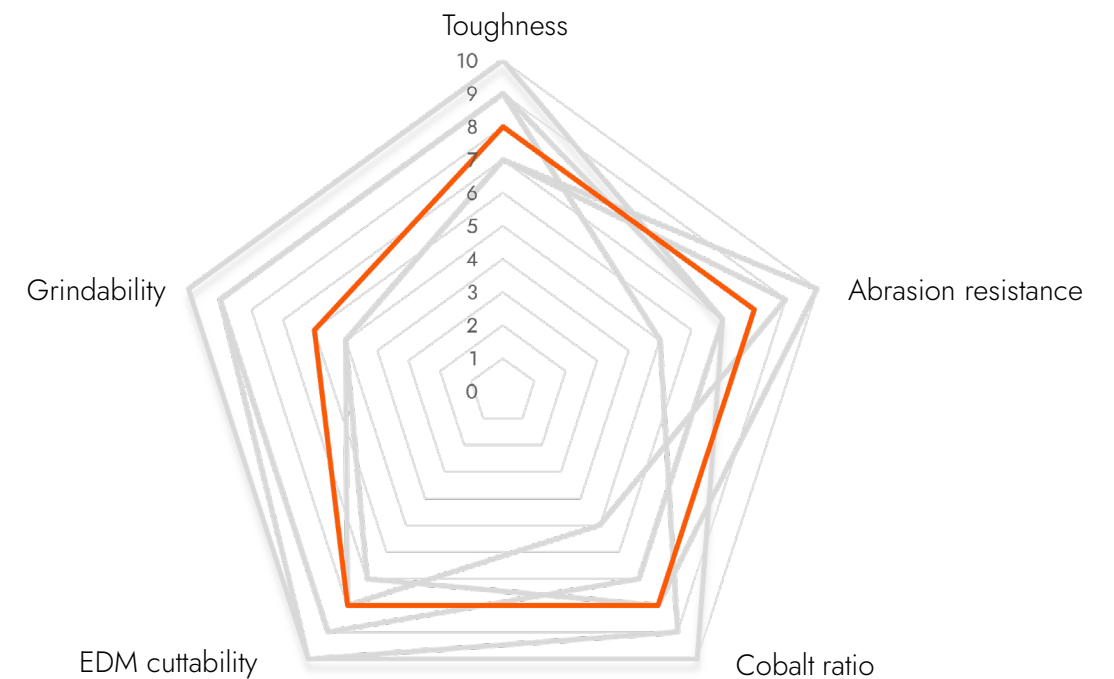
Maximum disc diameter: 76 mm

Maximum PCD certified area: 70 mm

Overall height

PCD layer thickness	0.8	1.0	1.2	1.4	1.6	2.0	3.18	8.0
0.3	✓	✓	✓	✓	✓		✓	
0.5		✓	✓		✓	✓	✓	
0.7					✓		✓	✓
1.0							✓	

Material characteristics



Physical and metallurgical properties

Property	Measurement	Applicable standard
Mean coefficient of thermal expansion (10 ⁻⁶ /°C) for temperature range 150 °C to 500 °C	4.0	ASTM E228-06
Transverse rupture strenght characteristic strength (MPa)	1890	ASTM C1239
Weibull modulus	8.2	
Fracture toughness mean (MPa.m ^½)	8.19 - 9.73	Shetty et al. (1995)
Elastic modulus (GPa)	1000	ASTM E494
Poisson's ratio	0.1	
Density (g/cm ³)	4.09	Archimedes principle
Thermal conductivity (W/m/K) at 500 °C	365.6	Calculated from thermal diffusivity, specific heat capacity and density
Knoop hardness (Indentation)(GPa)	50	ASTM C1326-03

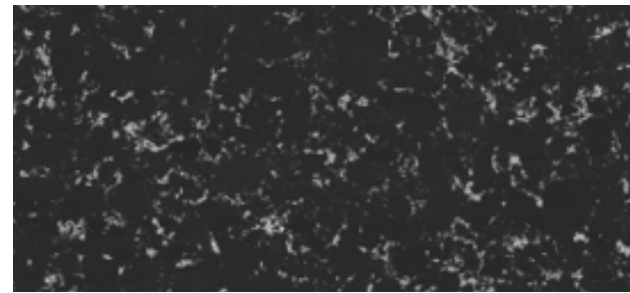
Grade: CTH025

Key material characteristics

- 25 μm diamond grain size
- 8 % cobalt ratio (wt %)
- High wear resistance

Suitable for machining of high silicon aluminium alloys, metal matrix composites (MMC), tungsten carbide and ceramics. Average grain size of 25 μm . CTH025 offers optimum wear resistance for abrasive machining conditions.

Typical microstructure



BEC 20 kV X500 Magnification 50 μ m

Grade Grain size	Behaviour in application		Processing characteristics	
	Chip resistance	Abrasion resistance	Electro-discharge machinability	Grindability
CMX850 0.85 µm				
CTX002 2 µm				
CTB004 4 µm				
CTB010 10 µm				
CTH025 25 µm				
CTM302 2 - 30 µm				

Size and format available

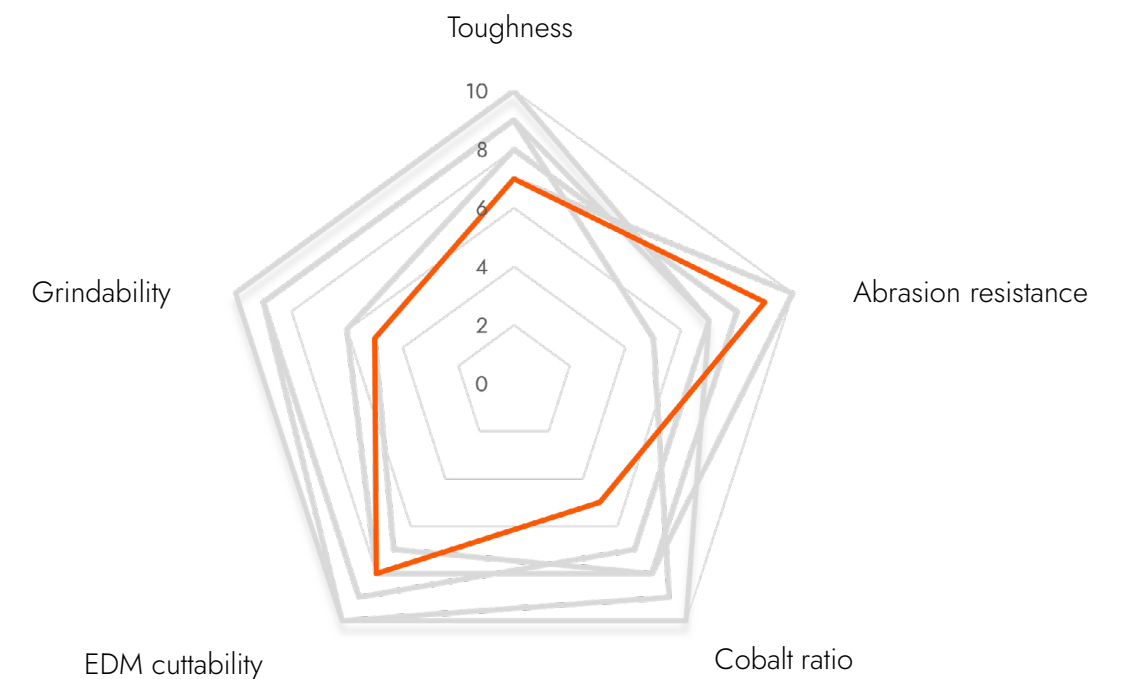
Maximum disc diameter: 76 mm

Maximum PCD certified area: 70 mm

Overall height

PCD layer thickness	0.8	1.0	1.2	1.4	1.6	2.0	3.18	8.0
0.5					✓	✓	✓	

Material characteristics



Physical and metallurgical properties

Property	Measurement	Applicable standard
Transverse rupture strenght characteristic strength (MPa)	1154	ASTM C1239
Weibull modulus	8.34	
Fracture toughness mean (MPa.m ^{1/2})	9.3	Shetty et al. (1995)
Elastic modulus (GPa)	1100	ASTM E494
Poisson's ratio	0.1	
Density (g/cm ³)	3.79	Archimedes principle
Thermal conductivity (W/m/K) at 500 °C	336.16	Calculated from thermal diffusivity, specific heat capacity and density
Knoop hardness (Indentation)(GPa)	62	ASTM C1326-03

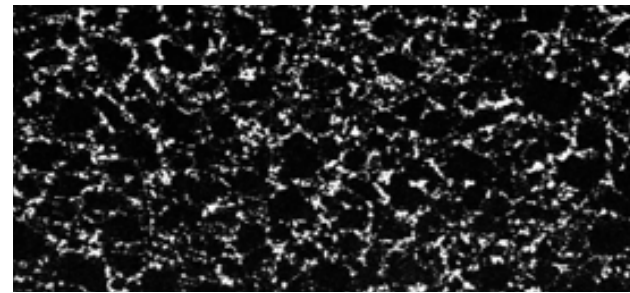
Grade: CTM302

Key material characteristics

- Bi-modal 30 & 2 μm diamond grain size
- 10 - 13 % cobalt ratio (wt %)
- Highest wear resistance

Application areas include MMC, high silicon aluminium alloys, high strength cast irons and bi metal applications. excellent abrasion resistance and good thermal stability. A multi-modal PCD with grain size ranging from 2 μm . to 30 μm , giving CTM302 excellent wear resistance, edge strength and quality, as well as outstanding abrasion resistance and good thermal stability.

Typical microstructure



BEC 20 kV X500 Magnification 50 μ m

Grade Grain size	Behaviour in application		Processing characteristics	
	Chip resistance	Abrasion resistance	Electro-discharge machinability	Grindability
CMX850 0.85 µm				
CTX002 2 µm				
CTB004 4 µm				
CTB010 10 µm				
CTH025 25 µm				
CTM302 2 - 30 µm				

Size and format available

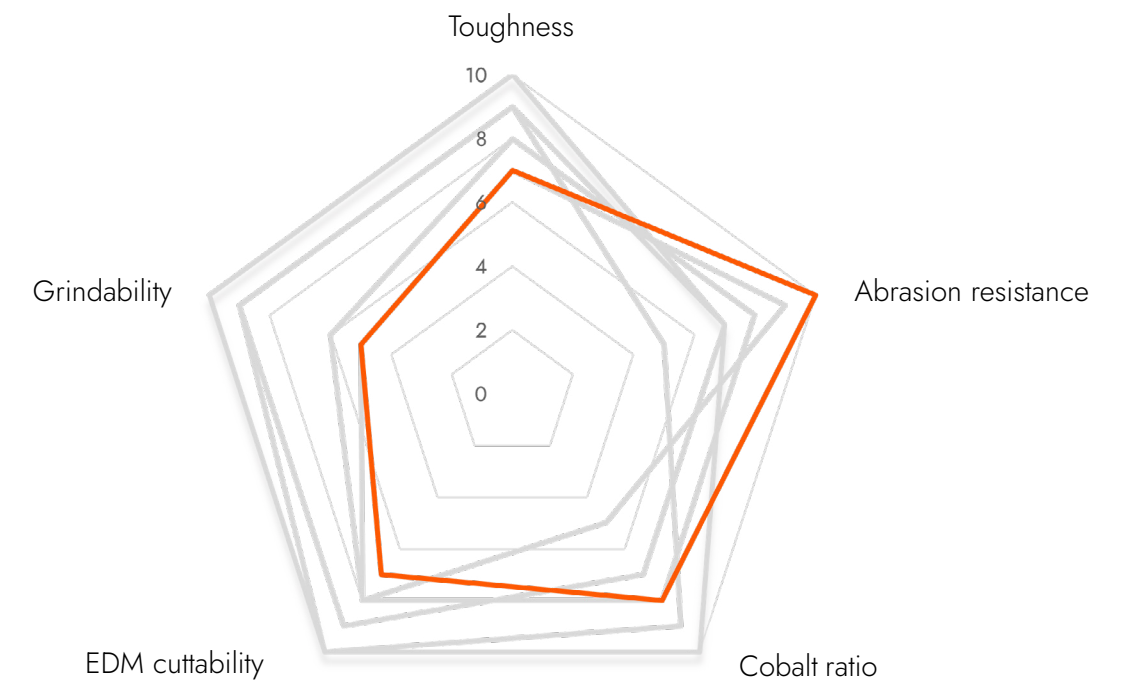
Maximum disc diameter: 76 mm

Maximum PCD certified area: 70 mm

Overall height

PCD layer thickness	0.8	1.0	1.2	1.4	1.6	2.0	3.18	8.0
0.5					✓	✓		
0.7							✓	
1.5							✓	✓

Material characteristics



Physical and metallurgical properties

Property	Measurement	Applicable standard
Mean coefficient of thermal expansion ($10^{-6}/^{\circ}\text{C}$) for temperature range 150 $^{\circ}\text{C}$ to 500 $^{\circ}\text{C}$	3.5	ASTM E228-06
Transverse rupture strenght characteristic strenght (MPa)	1521	ASTM C1239
Weibull modulus	6.4	
Fracture toughness mean ($\text{MPa}\cdot\text{m}^{1/2}$)	8.56 - 10.12	Shetty et al. (1995)
Elastic modulus (GPa)	883	ASTM E494
Poisson's ratio	0.109	
Density (g/cm^3)	3.91	Archimedes principle
Thermal conductivity ($\text{W}/\text{m}/\text{K}$) at 500 $^{\circ}\text{C}$	402.5	Calculated from thermal diffusivity, specific heat capacity and density
Knoop hardness (Indentation)(GPa)	50	ASTM C1326-03



Element Six is a global leader in the development and production of synthetic diamond and tungsten carbide solutions. For over 70 years, our innovation expertise has enabled a wide range of industries, from aerospace and mining, to semiconductors and sensing. Part of the De Beers Group, our primary manufacturing sites are located in the US, UK, Ireland, Germany and South Africa.

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