

GÜHRING

GÜHRING HIGH-PERFORMANCE TOOLS FOR
MACHINING FIBRE COMPOSITE MATERIALS













































- without fraying of fibres and delamination
- for optimal component surface finish quality



Machining modern composite materials

GÜHRING - YOUR WORLDWIDE PARTNER

Pictograms

| | | | | | | | |
|----------------------|--|---|---|--|--|--|---|
| Tool material | VHM Solid carbide | PKD Polycrystalline diamond | | | | | |
| Surface finish |  bright |  TICN |  Cristall | | | | |
| Ø-tolerance |  e10 |  h6 |  h7 |  h8 |  m7 | | |
| Shank form |  HA to DIN 6535 |  Cyl | | | | | |
| Standard |  DIN 6539 |  WN to Guhring std. | | | | | |
| Type |  H |  N |  W |  FK |  CR 100 |  FR 100 | |
| Cutting direction |  R right-hand | | | | | | |
| Applications |  slotting |  roughing |  ramping |  Helix |  drilling |  finishing |  copying |
| Lenght |  long (DIN) |  medium length | | | | | |
| No. of cutting edges |  2 |  3 |  4 |  4-8 | | | |
| | no. of cutting lips | | | | | | |
| Web thinning |  | | | | | | |
| Helix angle |  0° |  2-4° |  4° |  10° |  30° | | |
| | size of helix angle / no. of different helix angles | | | | | | |
| Rake angle |  10° |  15° |  25° | | | | |
| | rake angle of circumferential cutting edges | | | | | | |
| Infeed |  for lateral infeed |  for lateral infeed and oblique plunging |  for lateral infeed, oblique plunging and drilling | | | | |

MACHINING MODERN COMPOSITE MATERIALS

Modern fibre reinforced plastics (FRP's) are making an entry into a broad range of industrial applications for reasons of efficiency, weight reduction, strength and dynamics. With their specific properties they extend the group of conventional metal lightweight construction materials such as aluminium- and titanium-alloys. FRP's or multi-material combinations, ie. a mixture of FRP and metallic materials, are therefore no longer exclusively retained for the aerospace industry, motorsport and other high-end applications. It is especially worth highlighting the great growth in the general automotive and commercial vehicle technology.

FRP's are applied where high specific strength and low weight as well as high dynamic or energy efficient processes can be found. For the machining of CFRP, GFRP and stacks (FRP-metal-layer composite) without component damage, cutting edge quality and wear resistance of the tool material are of absolute importance. Guhring provides special solid carbide, coated carbide and PCD tooling solutions for these demanding materials. They are specially adapted to the respective material structure and ensure optimum chip evacuation as well as uniform hole diameters across all materials.

CHALLENGES

- components without fraying of fibres
- delamination-free component surface finish
- no component damage through "peel-up or "push-out"
- prevention of split fibres on component
- minimising burr development
- prevention of thermal damage

TOOLS

FOR THE MACHINING OF MODERN COMPOSITE MATERIALS



SOLID CARBIDE DRILLS

from \varnothing 2.50 mm to \varnothing 10.00 mm
see pages 7–8

Solid carbide



END MILLS Z=4

from \varnothing 8.00 mm to \varnothing 12.70 mm
see page 22

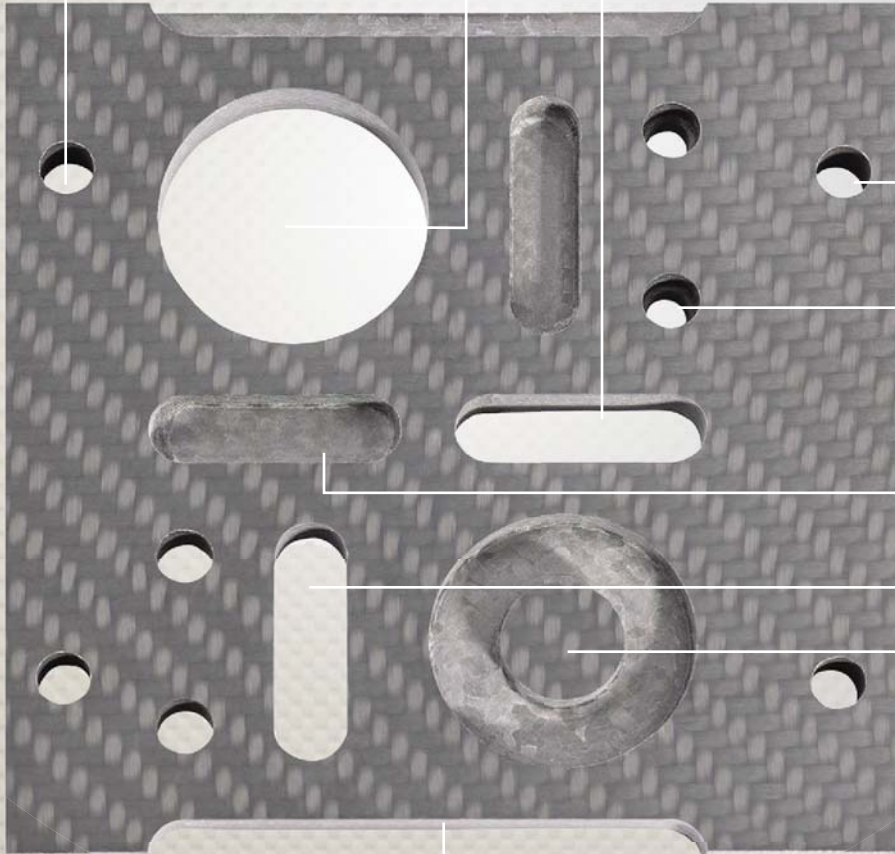
PCD




END MILLS Z=1


from \varnothing 2.00 mm to \varnothing 16.00 mm
see page 9


Solid carbide






PCD DRILLS
from Ø 2.70 mm to Ø 12.70 mm
see pages 16–17

PCD 




TAPS
from M3 mm to M16 mm
see page 15

Solid carbide



KEVLAR END MILLS FR 100
from Ø 4.00 mm to Ø 12.70 mm
see pages 13–14

Solid carbide



KEVLAR END MILLS CR 100
from Ø 4.00 mm to Ø 16.00 mm
see pages 10–12

Solid carbide



SLOT DRILLS Z=2
from Ø 4.00 mm to Ø 20.00 mm
see pages 18–19

PCD 



SLOT DRILLS Z=3
from Ø 14.00 mm to Ø 20.00 mm
see pages 20–21

PCD 



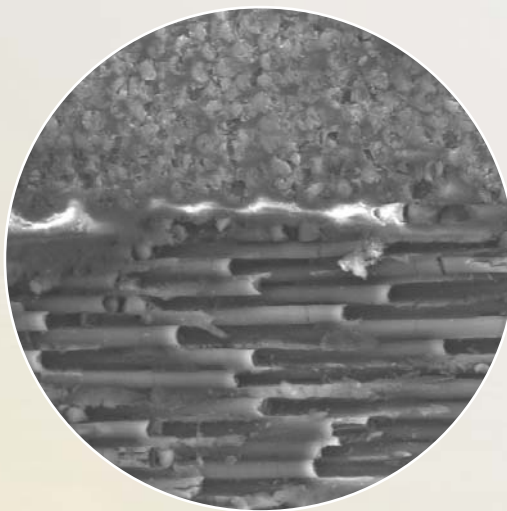
PCD COMPRESSION MILLING CUTTERS
from Ø 12.70 mm to Ø 16.00 mm
see page 23

PCD 

RESULT OF A DRILLING OPERATION WITH SPECIALISED GUHRING TOOLING SOLUTIONS



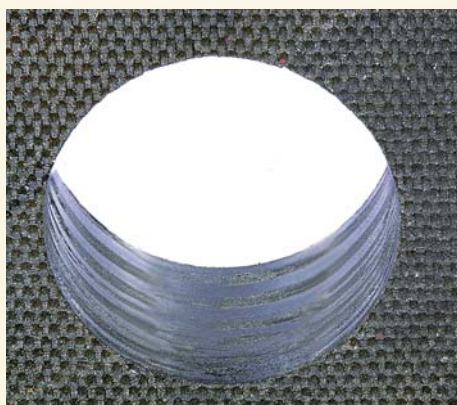
Machining with a Guhring tool retains the structure and direction of the fibres in the component, as the REM examination shows. The fibres are neither pressed into the matrix or ripped out of the composite.



CFRP cut surface with 500-fold magnification

Optimal machining results in CFRP

no peel-up – no push-out



hole exit in CFRP
with woven cover layer
hole D=6.35 mm



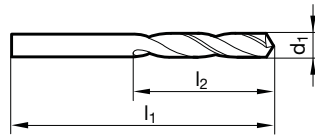
hole exit in
unidirectional CFRP
hole D=6.35 mm



Stub drills



| | |
|-------------------|----------------------|
| Tool material | solid carbide |
| Surface finish | ○ |
| Cutting direction | Ⓜ |



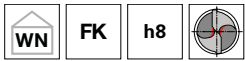
Article no. 730

| d1 | d1 | l1 | l2 | Availability |
|-------|------|-------|-------|--------------|
| mm | inch | mm | mm | |
| 2.50 | | 43.00 | 14.00 | ● |
| 3.00 | | 46.00 | 16.00 | ● |
| 3.20 | | 49.00 | 18.00 | ● |
| 3.26 | | 49.00 | 18.00 | ● |
| 3.30 | | 49.00 | 18.00 | ● |
| 3.50 | | 52.00 | 20.00 | ● |
| 3.57 | 9/64 | 52.00 | 20.00 | ● |
| 3.60 | | 52.00 | 20.00 | ● |
| 4.00 | | 55.00 | 22.00 | ● |
| 4.10 | | 55.00 | 22.00 | ● |
| 4.50 | | 58.00 | 24.00 | ● |
| 4.76 | 3/16 | 62.00 | 26.00 | ● |
| 4.80 | | 62.00 | 26.00 | ● |
| 5.00 | | 62.00 | 26.00 | ● |
| 5.50 | | 66.00 | 28.00 | ● |
| 6.00 | | 66.00 | 28.00 | ● |
| 6.35 | | 70.00 | 31.00 | ● |
| 6.40 | | 70.00 | 31.00 | ● |
| 6.50 | | 70.00 | 31.00 | ● |
| 7.00 | | 74.00 | 34.00 | ● |
| 7.50 | | 74.00 | 34.00 | ● |
| 8.00 | | 79.00 | 37.00 | ● |
| 8.50 | | 79.00 | 37.00 | ● |
| 9.00 | | 84.00 | 40.00 | ● |
| 9.50 | | 84.00 | 40.00 | ● |
| 10.00 | | 89.00 | 43.00 | ● |

| Material | Process | Cutting speed | Feed rate |
|---------------------|---------|---------------|------------------------|
| CFRP GFRP aramid | | 40-130 m/min | 0.03 - 0.15 f (mm/rev) |



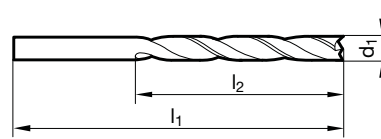
Kevlar drills



Tool material **solid carbide**

Surface finish

Cutting direction



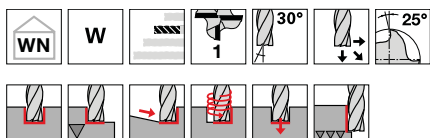
Article no. 1149

| d1 | d1 | l1 | l2 | Availability |
|-------|------|-------|-------|--------------|
| mm | inch | mm | mm | |
| 2.50 | | 43.00 | 14.00 | ● |
| 3.20 | | 49.00 | 18.00 | ● |
| 3.57 | 9/64 | 52.00 | 20.00 | ● |
| 4.00 | | 55.00 | 22.00 | ● |
| 4.76 | 3/16 | 62.00 | 26.00 | ● |
| 5.00 | | 62.00 | 26.00 | ● |
| 6.00 | | 66.00 | 28.00 | ● |
| 8.00 | | 79.00 | 37.00 | ● |
| 10.00 | | 89.00 | 43.00 | ● |

| Material | Process | Cutting speed | Feed rate |
|---------------------|---------|---------------|-------------------------|
| CFRP GFRP aramid | | 40-130 m/min | 0.03 - 0.15 f (mm/rev.) |



End mills Z=1

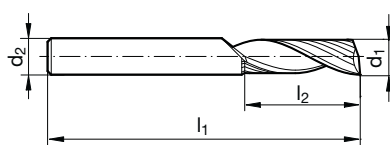


Tool material **solid carbide**

Surface finish **D**

Cutting direction **R**

polished flutes, centre cutting

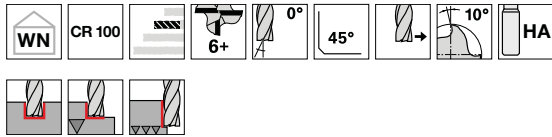


Article no. **6793**

| d1 h10 mm | d2 h6 mm | l1 mm | l2 mm | Z | Availability |
|--------------|-------------|----------|----------|---|--------------|
| 2.00 | 2.00 | 38 | 10.0 | 1 | ● |
| 3.00 | 3.00 | 39 | 12.0 | 1 | ● |
| 4.00 | 4.00 | 40 | 15.0 | 1 | ● |
| 5.00 | 5.00 | 50 | 16.0 | 1 | ● |
| 6.00 | 6.00 | 57 | 20.0 | 1 | ● |
| 8.00 | 8.00 | 63 | 22.0 | 1 | ● |
| 10.00 | 10.00 | 73 | 25.0 | 1 | ● |
| 12.00 | 12.00 | 83 | 30.0 | 1 | ● |
| 16.00 | 16.00 | 92 | 35.0 | 1 | ● |

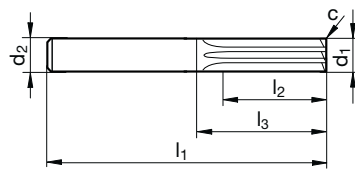
| Material | Process | Cutting speed | Feed rate |
|----------------|---------|---------------|------------------------|
| CFK GFK aramid | | 100-250 m/min | 0,03 - 0,12 fz (mm/z) |
| CFK GFK aramid | | 80-150 m/min | 0,03 - 0,2 f (mm/rev.) |

Kevlar CR 100 end mills



Solid carbide ultra-fine grain, diamond-coated, without face cutting, for slotting and trimming

| | |
|-------------------|----------------------|
| Tool material | solid carbide |
| Surface finish | ⓓ |
| Cutting direction | Ⓜ |



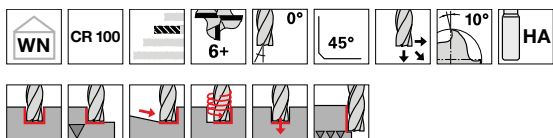
Article no. 6717

| d1 e10 | d2 h6 | l1 | l2 | l3 | c | Z | Availability |
|--------|-------|--------|-------|-------|----------|----|--------------|
| mm | mm | mm | mm | mm | mm x 45° | | |
| 4.00 | 6.00 | 57.00 | 10.00 | 19.40 | 0.10 | 6 | ● |
| 6.00 | 6.00 | 65.00 | 15.00 | 29.00 | 0.15 | 8 | ● |
| 8.00 | 8.00 | 75.00 | 20.00 | 39.00 | 0.15 | 10 | ● |
| 10.00 | 10.00 | 80.00 | 25.00 | 40.00 | 0.15 | 12 | ● |
| 12.00 | 12.00 | 93.00 | 32.00 | 48.00 | 0.15 | 14 | ● |
| 16.00 | 16.00 | 108.00 | 34.00 | 60.00 | 0.15 | 14 | ● |
| | | | | | | | |
| | | | | | | | |

| Material | Process | Cutting speed | Feed rate |
|---------------------|---------|---------------|-----------------------|
| CFRP GFRP aramid | | 250-500 m/min | 0.03 - 0.12 fz (mm/z) |

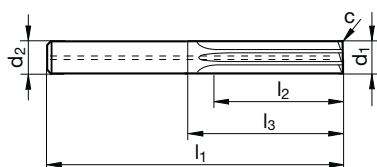


CR 100 Kevlar end mills



| | |
|-------------------|----------------------|
| Tool material | solid carbide |
| Surface finish | ⓓ |
| Cutting direction | Ⓜ |

Solid carbide ultra-fine grain, diamond-coated, with centre cutting, for slotting and trimming as well as oblique plunging

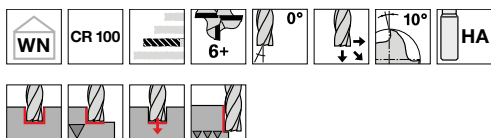


Article no. 6719

| d1 e10 | d2 h6 | l1 | l2 | l3 | c | Z | Availability |
|--------|-------|--------|-------|-------|----------|----|--------------|
| mm | mm | mm | mm | mm | mm x 45° | | |
| 4.00 | 6.00 | 57.00 | 10.00 | 19.40 | 0.32 | 6 | ● |
| 6.00 | 6.00 | 65.00 | 15.00 | 29.00 | 0.48 | 8 | ● |
| 8.00 | 8.00 | 75.00 | 20.00 | 39.00 | 0.64 | 10 | ● |
| 10.00 | 10.00 | 80.00 | 25.00 | 40.00 | 0.80 | 12 | ● |
| 12.00 | 12.00 | 93.00 | 32.00 | 48.00 | 0.96 | 14 | ● |
| 16.00 | 16.00 | 108.00 | 34.00 | 60.00 | 1.28 | 14 | ● |

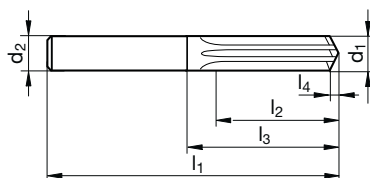
| Material | Process | Cutting speed | Feed rate |
|---------------------|---------|---------------|------------------------|
| CFRP GFRP aramid | | 250-500 m/min | 0.03 - 0.12 fz (mm/z) |
| CFRP GFRP aramid | | 100-250 m/min | 0.05 - 0.2 f (mm/rev.) |

CR 100 Kevlar end mills



Solid carbide ultra-fine grain, diamond-coated, with drill point, especially for plunging and subsequent milling

| | |
|-------------------|----------------------|
| Tool material | solid carbide |
| Surface finish | ⓓ |
| Cutting direction | Ⓜ |



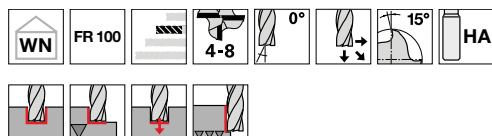
Article no. 6720

| d1 (e10) | d2 (h6) | l1 | l2 | l3 | l4 | Z | Availability |
|----------|---------|--------|-------|-------|-----|----|--------------|
| mm | mm | mm | mm | mm | mm | | |
| 4,00 | 6,00 | 57.00 | 10.00 | 27.00 | 1.3 | 6 | ● |
| 6,00 | 6,00 | 65.00 | 15.00 | 29.00 | 1.9 | 8 | ● |
| 8,00 | 8,00 | 75.00 | 20.00 | 39.00 | 2.5 | 10 | ● |
| 10,00 | 10,00 | 80.00 | 25.00 | 40.00 | 3.1 | 12 | ● |
| 12,00 | 12,00 | 93.00 | 32.00 | 48.00 | 3.7 | 14 | ● |
| 16,00 | 16,00 | 108.00 | 34.00 | 60.00 | 4.9 | 14 | ● |

| Material | Process | Cutting speed | Feed rate |
|---------------------|---------|---------------|-------------------------|
| CFRP GFRP aramid | | 250-500 m/min | 0.03 - 0.12 fz (mm/z) |
| CFRP GFRP aramid | | 100-250 m/min | 0.05 - 0.20 f (mm/rev.) |



FR 100 Kevlar end mills

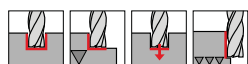
Tool material **solid carbide**

Surface finish

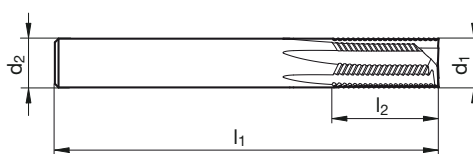
D

O

Cutting direction

R₁R₁

Solid carbide ultra-fine grain, diamond-coated, with drill centre cutting, for slotting and trimming as well as oblique plunging



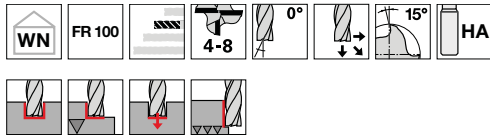
6769

6805

| d1 (e10) | d1 (e10) | d2 (h6) | l1 | l1 | l2 | l2 | Z | Availability | |
|----------|----------|---------|-------|------|-------|-------|---|--------------|---|
| mm | inch | mm | mm | inch | mm | inch | | | |
| 4.000 | | 6.000 | 66.00 | | 15.00 | | 4 | ● | ● |
| 4.762 | 3/16 | 4.762 | 63.50 | 2.5 | 15.00 | 37/64 | 4 | ● | ● |
| 6.000 | | 6.000 | 70.00 | | 20.00 | | 4 | ● | ● |
| 6.350 | 1/4 | 6.350 | 63.50 | 2.5 | 15.00 | 37/64 | 4 | ● | ● |
| 8.000 | | 8.000 | 75.00 | | 25.00 | | 6 | ● | ● |
| 9.525 | 3/8 | 9.525 | 76.20 | 2.5 | 18.00 | 45/64 | 6 | ● | ● |
| 12.700 | 1/2 | 12.700 | 88.90 | 3.5 | 25.40 | 1 | 8 | ● | ● |

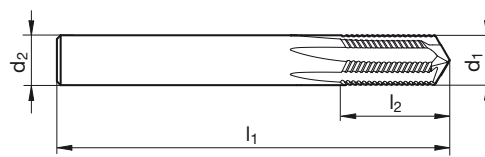
| Material | Process | Cutting speed | Feed rate |
|---------------------|---------|---------------|-------------------------|
| CFRP GFRP aramid | | 150-450 m/min | 0.03 - 0.12 fz (mm/z) |
| CFRP GFRP aramid | | 125-150 m/min | 0.05 - 0.20 f (mm/rev.) |

FR 100 Kevlar end mills



Solid carbide ultra-fine grain, diamond-coated, with drill point, specially for plunging and subsequent milling

| | | |
|-------------------|--|--|
| Tool material | solid carbide | |
| Surface finish | <input checked="" type="radio"/> D | <input type="radio"/> |
| Cutting direction | <input checked="" type="checkbox"/> R ₁ | <input checked="" type="checkbox"/> R ₂ |



Article no. 6770 6806

| d1 (e10) | d1 (e10) | d2 (h6) | l1 | l1 | l2 | l2 | Z | Availability | |
|----------|----------|---------|-------|------|-------|-------|---|--------------|---|
| mm | inch | mm | mm | inch | mm | inch | | | |
| 4.000 | | 6.000 | 66.00 | | 15.00 | | 4 | ● | ● |
| 4.762 | 3/16 | 4.762 | 63.50 | 2.5 | 15.00 | 37/64 | 4 | ● | ● |
| 6.000 | | 6.000 | 70.00 | | 20.00 | | 4 | ● | ● |
| 6.350 | 1/4 | 6.350 | 63.50 | 2.5 | 15.00 | 37/64 | 4 | ● | ● |
| 8.000 | | 8.000 | 75.00 | | 25.00 | | 6 | ● | ● |
| 9.525 | 3/8 | 9.525 | 76.20 | 2.5 | 18.00 | 45/64 | 6 | ● | ● |
| 12.700 | 1/2 | 12.700 | 88.90 | 3.5 | 25.40 | 1 | 8 | ● | ● |

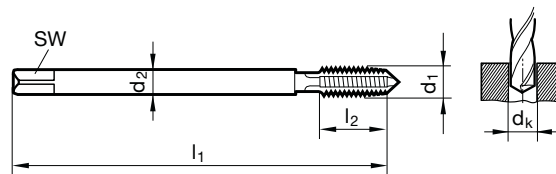
| Material | Process | Cutting speed | Feed rate |
|---------------------|---------|---------------|-------------------------|
| CFRP GFRP aramid | | 150-450 m/min | 0.03 - 0.12 fz (mm/z) |
| CFRP GFRP aramid | | 125-150 m/min | 0.05 - 0.18 f (mm/rev.) |



Machine taps for ISO metric threads

Tool material **solid carbide**Surface finish **C**

Tolerance on Ø ISO2/6H

Article no. **2944**

| d1 | P | d2 | SW | dk | l1 | l2 | Availability |
|-----|-------|-------|--------|-------|--------|-------|--------------|
| | mm | mm | mm | mm | mm | mm | |
| M3 | 0,500 | 3,50 | 2,700 | 2,60 | 56,00 | 12,00 | ● |
| M4 | 0,700 | 4,50 | 3,400 | 3,40 | 63,00 | 14,00 | ● |
| M5 | 0,800 | 6,00 | 4,900 | 4,30 | 70,00 | 17,00 | ● |
| M6 | 1,000 | 6,00 | 4,900 | 5,10 | 80,00 | 20,00 | ● |
| M8 | 1,250 | 8,00 | 6,200 | 6,90 | 90,00 | 20,00 | ● |
| M10 | 1,500 | 10,00 | 8,000 | 8,60 | 100,00 | 24,00 | ● |
| M12 | 1,750 | 12,00 | 9,000 | 10,40 | 110,00 | 28,00 | ● |
| M16 | 2,000 | 16,00 | 12,000 | 14,10 | 110,00 | 40,00 | ● |

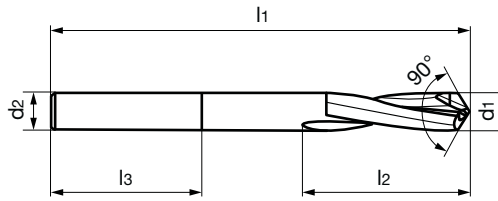
| Material | Process | Cutting speed |
|----------|----------------------------|---------------|
| CFK GFK | blind hole through hole | 15 - 25 m/min |



90° PCD drills



Tool material **PCD**
Cutting direction



| d1 | d1 | d2 h6 | l1 | l2 | l3 | Material number |
|--------|------|-------|--------|-------|-------|-----------------|
| mm | inch | mm | mm | mm | mm | |
| 2.700 | | 4.00 | 60.00 | 18.00 | 28.00 | 303 209 684 |
| 3.000 | | 4.00 | 60.00 | 18.00 | 28.00 | 303 209 685 |
| 3.250 | | 4.00 | 60.00 | 18.00 | 28.00 | 303 420 038 |
| 3.572 | 9/64 | 4.00 | 60.00 | 18.00 | 28.00 | 303 209 686 |
| 4.000 | | 5.00 | 60.00 | 20.00 | 28.00 | 303 209 802 |
| 4.170 | | 5.00 | 75.00 | 25.00 | 28.00 | 303 420 039 |
| 4.762 | 3/16 | 5.00 | 75.00 | 25.00 | 28.00 | 303 209 803 |
| 4.830 | | 5.00 | 75.00 | 25.00 | 28.00 | 303 420 040 |
| 5.000 | | 6.00 | 75.00 | 25.00 | 36.00 | 303 209 804 |
| 6.000 | | 8.00 | 75.00 | 30.00 | 36.00 | 303 209 805 |
| 6.350 | 1/4 | 8.00 | 75.00 | 35.00 | 36.00 | 303 209 806 |
| 7.937 | 5/16 | 10.00 | 75.00 | 40.00 | 40.00 | 303 209 807 |
| 8.000 | | 10.00 | 75.00 | 40.00 | 40.00 | 303 209 808 |
| 9.525 | 3/8 | 10.00 | 100.00 | 50.00 | 40.00 | 303 209 809 |
| 10.000 | | 12.00 | 125.00 | 50.00 | 45.00 | 303 209 810 |
| 12.000 | | 14.00 | 125.00 | 60.00 | 45.00 | 303 209 811 |
| 12.700 | 1/2 | 14.00 | 150.00 | 65.00 | 45.00 | 303 209 812 |

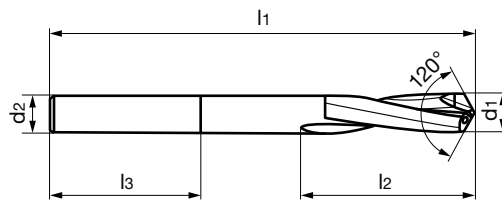
| Material | Process | Cutting speed | Feed rate |
|---------------------|---------|---------------|------------------------|
| CFRP GFRP aramid | | 75-200 m/min | 0.05 - 0.2 f (mm/rev.) |



120° PCD drills



Tool material **PCD**
Cutting direction

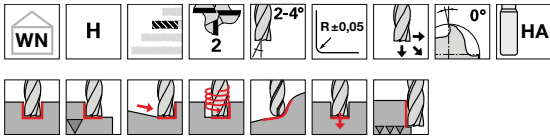


| d1 | d1 | d2 h6 | l1 | l2 | l3 | Material number |
|--------|------|-------|--------|-------|-------|-----------------|
| mm | inch | mm | mm | mm | mm | |
| 2.700 | | 4.00 | 60.00 | 18.00 | 28.00 | 303 209 813 |
| 3.000 | | 4.00 | 60.00 | 18.00 | 28.00 | 303 209 814 |
| 3.250 | | 4.00 | 60.00 | 18.00 | 28.00 | 303 420 041 |
| 3.572 | 9/64 | 4.00 | 60.00 | 18.00 | 28.00 | 303 209 815 |
| 4.000 | | 5.00 | 60.00 | 20.00 | 28.00 | 303 209 816 |
| 4.170 | | 5.00 | 75.00 | 25.00 | 28.00 | 303 420 047 |
| 4.762 | 3/16 | 5.00 | 75.00 | 25.00 | 28.00 | 303 209 817 |
| 4.830 | | 5.00 | 75.00 | 25.00 | 28.00 | 303 420 048 |
| 5.000 | | 6.00 | 75.00 | 25.00 | 36.00 | 303 209 818 |
| 6.000 | | 8.00 | 75.00 | 30.00 | 36.00 | 303 209 819 |
| 6.350 | 1/4 | 8.00 | 75.00 | 35.00 | 36.00 | 303 209 820 |
| 7.937 | 5/16 | 10.00 | 75.00 | 40.00 | 40.00 | 303 209 821 |
| 8.000 | | 10.00 | 75.00 | 40.00 | 40.00 | 303 209 822 |
| 9.525 | 3/8 | 10.00 | 100.00 | 50.00 | 40.00 | 303 209 823 |
| 10.000 | | 12.00 | 125.00 | 50.00 | 45.00 | 303 209 824 |
| 12.000 | | 14.00 | 125.00 | 60.00 | 45.00 | 303 209 825 |
| 12.700 | 1/2 | 14.00 | 150.00 | 65.00 | 45.00 | 303 209 826 |

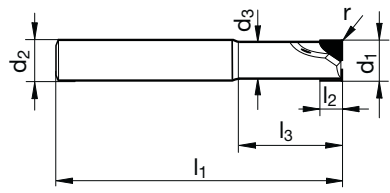
| Material | Process | Cutting speed | Feed rate |
|---------------------|---------|---------------|-------------------------|
| CFRP GFRP aramid | | 100-250 m/min | 0.05 - 0.20 f (mm/rev.) |



PCD slot drills Z=2



| | |
|-------------------|------------|
| Tool material | PCD |
| Surface finish | ○ |
| Cutting direction | Ⓜ |



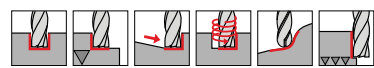
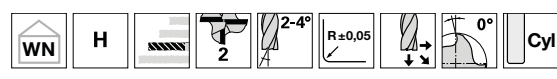
Article no. 5492

| d1 | d1 | d2 h6 | d3 | l1 | l2 | l3 | r | Z | Availability |
|--------|--------|-------|-------|-----|------|------|-----|---|--------------|
| mm | | mm | mm | mm | mm | mm | mm | | |
| 4.000 | ± 0.02 | 6.00 | 3.70 | 51 | 6.0 | 14.0 | 0.1 | 2 | ● |
| 5.000 | ± 0.02 | 6.00 | 4.70 | 51 | 8.0 | 14.5 | 0.1 | 2 | ● |
| 6.000 | ± 0.02 | 6.00 | 5.70 | 57 | 8.0 | 20.0 | 0.1 | 2 | ● |
| 8.000 | ± 0.02 | 8.00 | 7.40 | 63 | 8.0 | 26.0 | 0.1 | 2 | ● |
| 8.001 | ± 0.02 | 8.00 | 7.40 | 63 | 12.0 | 26.0 | 0.1 | 2 | ● |
| 10.000 | ± 0.02 | 10.00 | 9.40 | 72 | 8.0 | 30.0 | 0.1 | 2 | ● |
| 10.001 | ± 0.02 | 10.00 | 9.40 | 72 | 16.0 | 30.0 | 0.1 | 2 | ● |
| 12.000 | ± 0.02 | 12.00 | 11.20 | 83 | 8.0 | 36.0 | 0.1 | 2 | ● |
| 12.001 | ± 0.02 | 12.00 | 11.20 | 83 | 16.0 | 36.0 | 0.1 | 2 | ● |
| 14.000 | ± 0.02 | 14.00 | 13.00 | 83 | 8.0 | 36.0 | 0.1 | 2 | ● |
| 14.001 | ± 0.02 | 14.00 | 13.00 | 83 | 16.0 | 36.0 | 0.1 | 2 | ● |
| 16.000 | ± 0.02 | 16.00 | 15.00 | 100 | 12.0 | 50.0 | 0.1 | 2 | ● |
| 16.001 | ± 0.02 | 16.00 | 15.00 | 100 | 20.0 | 50.0 | 0.1 | 2 | ● |
| 18.000 | ± 0.02 | 18.00 | 17.00 | 100 | 12.0 | 50.0 | 0.1 | 2 | ● |
| 18.001 | ± 0.02 | 18.00 | 17.00 | 100 | 20.0 | 50.0 | 0.1 | 2 | ● |
| 20.000 | ± 0.02 | 20.00 | 19.00 | 100 | 12.0 | 48.0 | 0.1 | 2 | ● |
| 20.001 | ± 0.02 | 20.00 | 19.00 | 100 | 20.0 | 48.0 | 0.1 | 2 | ● |

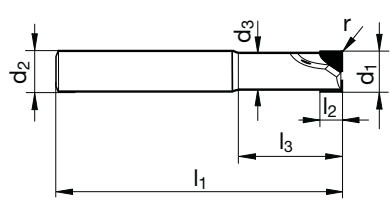
| Material | Process | Cutting speed | Feed rate |
|---------------------|---------|---------------|-------------------------|
| CFRP GFRP aramid | | 150-450 m/min | 0.03 - 0.12 fz (mm/z) |
| CFRP GFRP aramid | | 125-150 m/min | 0.05 - 0.18 f (mm/rev.) |



PCD slot drills Z=2



| | |
|-------------------|------------|
| Tool material | PCD |
| Surface finish | ○ |
| Cutting direction | Ⓜ |



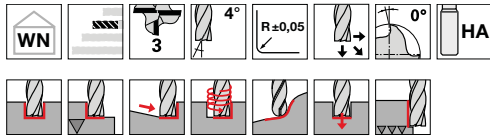
Article no. 5493

| d1 | d1 | d2 h6 | d3 | l1 | l2 | l3 | r | Z | Availability |
|-------|--------|-------|-------|-----|------|------|-----|---|--------------|
| mm | | mm | mm | mm | mm | mm | mm | | |
| 4.00 | ± 0.02 | 6.00 | 3.70 | 70 | 6.0 | 14.0 | 0.1 | 2 | ● |
| 5.00 | ± 0.02 | 6.00 | 4.70 | 70 | 8.0 | 14.5 | 0.1 | 2 | ● |
| 6.00 | ± 0.02 | 6.00 | 5.70 | 75 | 8.0 | 20.0 | 0.1 | 2 | ● |
| 8.00 | ± 0.02 | 8.00 | 7.40 | 100 | 8.0 | 26.0 | 0.1 | 2 | ● |
| 8.00 | ± 0.02 | 8.00 | 7.40 | 100 | 12.0 | 26.0 | 0.1 | 2 | ● |
| 10.00 | ± 0.02 | 10.00 | 9.40 | 100 | 8.0 | 30.0 | 0.1 | 2 | ● |
| 10.00 | ± 0.02 | 10.00 | 9.40 | 100 | 16.0 | 30.0 | 0.1 | 2 | ● |
| 12.00 | ± 0.02 | 12.00 | 11.20 | 100 | 8.0 | 36.0 | 0.1 | 2 | ● |
| 12.00 | ± 0.02 | 12.00 | 11.20 | 100 | 16.0 | 36.0 | 0.1 | 2 | ● |
| 14.00 | ± 0.02 | 14.00 | 13.00 | 100 | 8.0 | 36.0 | 0.1 | 2 | ● |
| 14.00 | ± 0.02 | 14.00 | 13.00 | 100 | 16.0 | 36.0 | 0.1 | 2 | ● |
| 16.00 | ± 0.02 | 16.00 | 15.00 | 150 | 12.0 | 50.0 | 0.1 | 2 | ● |
| 16.00 | ± 0.02 | 16.00 | 15.00 | 150 | 20.0 | 50.0 | 0.1 | 2 | ● |
| 18.00 | ± 0.02 | 18.00 | 17.00 | 125 | 12.0 | 50.0 | 0.1 | 2 | ● |
| 18.00 | ± 0.02 | 18.00 | 17.00 | 125 | 20.0 | 50.0 | 0.1 | 2 | ● |
| 18.00 | ± 0.02 | 18.00 | 17.00 | 150 | 12.0 | 50.0 | 0.1 | 2 | ● |
| 18.00 | ± 0.02 | 18.00 | 17.00 | 150 | 20.0 | 50.0 | 0.1 | 2 | ● |
| 20.00 | ± 0.02 | 20.00 | 19.00 | 150 | 12.0 | 48.0 | 0.1 | 2 | ● |
| 20.00 | ± 0.02 | 20.00 | 19.00 | 150 | 20.0 | 48.0 | 0.1 | 2 | ● |

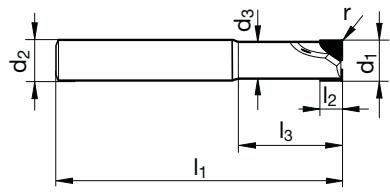
| Material | Process | Cutting speed | Feed rate |
|----------------|---------|---------------|-------------------------|
| CFK GFK aramid | | 150-450 m/min | 0.03 - 0.12 fz (mm/z) |
| CFK GFK aramid | | 125-150 m/min | 0.05 - 0.18 f (mm/rev.) |



PCD slot drills Z=3



| | |
|-------------------|------------|
| Tool material | PCD |
| Surface finish | ○ |
| Cutting direction | Ⓜ |



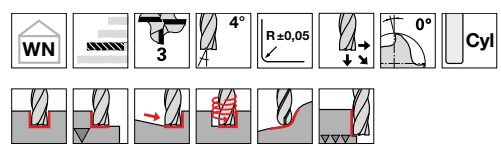
Article no. 5495

| d1 | d1 | d2 h6 | d3 | l1 | l2 | l3 | r | Z | Availability |
|-------|--------|-------|-------|-----|------|------|-----|---|--------------|
| mm | | mm | mm | mm | mm | mm | mm | | |
| 14.00 | ± 0.02 | 14.00 | 13.00 | 83 | 8.0 | 38.0 | 0.1 | 3 | ● |
| 14.00 | ± 0.02 | 14.00 | 13.00 | 83 | 16.0 | 38.0 | 0.1 | 3 | ● |
| 16.00 | ± 0.02 | 16.00 | 15.00 | 100 | 12.0 | 52.0 | 0.1 | 3 | ● |
| 16.00 | ± 0.02 | 16.00 | 15.00 | 100 | 20.0 | 52.0 | 0.1 | 3 | ● |
| 18.00 | ± 0.02 | 18.00 | 17.00 | 100 | 12.0 | 52.0 | 0.1 | 3 | ● |
| 18.00 | ± 0.02 | 18.00 | 17.00 | 100 | 20.0 | 52.0 | 0.1 | 3 | ● |
| 20.00 | ± 0.02 | 20.00 | 19.00 | 100 | 12.0 | 50.0 | 0.1 | 3 | ● |
| 20.00 | ± 0.02 | 20.00 | 19.00 | 100 | 20.0 | 50.0 | 0.1 | 3 | ● |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

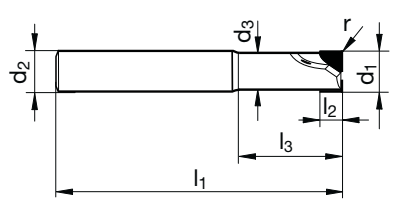
| Material | Process | Cutting speed | Feed rate |
|----------------|---------|---------------|-------------------------|
| CFK GFK aramid | | 150-450 m/min | 0.03 - 0.12 fz (mm/z) |
| CFK GFK aramid | | 125-150 m/min | 0.05 - 0.18 f (mm/rev.) |



PCD Slot drills Z=3



| | |
|-------------------|------------|
| Tool material | PCD |
| Surface finish | ○ |
| Cutting direction | Ⓜ |



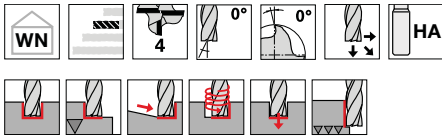
Article no. 5496

| d1 | d1 | d2 h6 | d3 | l1 | l2 | l3 | r | Z | Availability |
|-------|--------|-------|-------|-----|------|------|-----|---|--------------|
| mm | | mm | mm | mm | mm | mm | mm | | |
| 14.00 | ± 0.02 | 14.00 | 13.00 | 100 | 8.0 | 38.0 | 0.1 | 3 | ● |
| 14.00 | ± 0.02 | 14.00 | 13.00 | 100 | 16.0 | 38.0 | 0.1 | 3 | ● |
| 16.00 | ± 0.02 | 16.00 | 15.00 | 150 | 12.0 | 52.0 | 0.1 | 3 | ● |
| 16.00 | ± 0.02 | 16.00 | 15.00 | 150 | 20.0 | 52.0 | 0.1 | 3 | ● |
| 18.00 | ± 0.02 | 18.00 | 17.00 | 150 | 12.0 | 52.0 | 0.1 | 3 | ● |
| 18.00 | ± 0.02 | 18.00 | 17.00 | 150 | 20.0 | 52.0 | 0.1 | 3 | ● |
| 20.00 | ± 0.02 | 20.00 | 19.00 | 150 | 12.0 | 50.0 | 0.1 | 3 | ● |
| 20.00 | ± 0.02 | 20.00 | 19.00 | 150 | 20.0 | 50.0 | 0.1 | 3 | ● |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

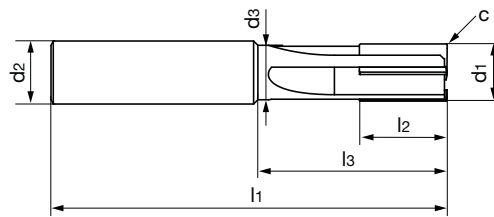
| Material | Process | Cutting speed | Feed rate |
|----------------|---------|---------------|-------------------------|
| CFK GFK aramid | | 150-450 m/min | 0.03 - 0.12 fz (mm/z) |
| CFK GFK aramid | | 125-150 m/min | 0.05 - 0.18 f (mm/rev.) |



PCD End mills



| | |
|-------------------|------------|
| Tool material | PCD |
| Surface finish | ○ |
| Cutting direction | Ⓜ |

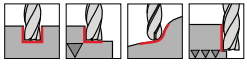
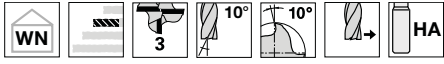


| d1 | d1 | d2 h6 | d3 | l1 | l2 | l3 | c | Z | Material number |
|--------|------|-------|-------|-------|-------|-------|----------|-----|-----------------|
| mm | inch | mm | mm | mm | mm | mm | mm x 45° | | |
| 8.000 | | 8.00 | 7.40 | 75.00 | 19.50 | 38.50 | 0.20 | 4 | 303 206 512 |
| 9.525 | 3/8 | 10.00 | 8.92 | 80.00 | 19.50 | 39.26 | 0.20 | 4 | 303 206 513 |
| 10.000 | | 10.00 | 9.40 | 80.00 | 19.50 | 39.50 | 0.20 | 4 | 303 206 514 |
| 12.000 | | 12.00 | 11.40 | 88.00 | 19.50 | 42.50 | 0.20 | 4 | 303 206 515 |
| 12.700 | 1/2 | 14.00 | 12.10 | 88.00 | 19.50 | 41.85 | 0.20 | 4 | 303 211 229 |
| 12.700 | 1/2 | 14.00 | 11.10 | 88.00 | 19.50 | 41.35 | 0.20 | 2+1 | 303 211 230 |

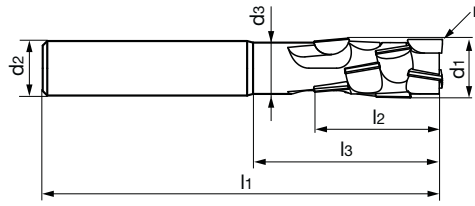
| Material | Process | Cutting speed | Feed rate |
|----------------|---------|---------------|-------------------------|
| CFK GFK aramid | | 150-500 m/min | 0.03 - 0.12 fz (mm/z) |
| CFK GFK aramid | | 125-200 m/min | 0.05 - 0.20 f (mm/rev.) |



PCD Compression milling cuttersz=3



Tool material **PCD**
 Cutting direction



| d1 | d1 | d2 h6 | d3 | l1 | l2 | l3 | r | Material number |
|--------|------|-------|-------|-------|-------|-------|------|-----------------|
| mm | inch | mm | mm | mm | mm | mm | mm | |
| 12,700 | 1/2 | 12,00 | 11,30 | 88,00 | 28,00 | 41,49 | 0,10 | 303 211 231 |
| 14,000 | | 14,00 | 12,60 | 88,00 | 28,00 | 40,19 | 0,10 | 303 211 257 |
| 16,000 | | 16,00 | 14,60 | 91,00 | 28,00 | 40,19 | 0,10 | 303 211 258 |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

| Material | Process | Cutting speed | Feed rate |
|---------------------|---------|---------------|-----------------------|
| CFRP GFRP aramid | | 150-500 m/min | 0.03 - 0.12 fz (mm/z) |



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