



Your technology partner for cost-effective machining

MICRO DRILLING

MICRO DRILLING

Solid carbide micro drill programme

Precise drilling in the micro range requires tools with the highest accuracy. MAPAL offers a precisely coordinated micro portfolio for maximum process reliability. A perfectly coordinated process is crucial for reliable and cost-effective results – from pilot drilling to deep drilling. MAPAL offers a consistent tool concept made of solid carbide with internal cooling for this purpose. The pilot tools of the MICRO-Drill series, with four guide lands, offer optimal guidance properties and stability.

An optimized geometry and a special flute shape with core taper enable reliable chip evacuation.

The geometry of the Micro-Deep-Drill, specially tailored to small diameters, with a newly designed chip flute and special face grinding, is ideally suited for the highest feed rates and cutting speeds.

The result: a consistent, precise, and cost-effective drilling system for the most demanding applications in the micro range.



PILOTING

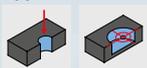


MICRO-Drill-Steel 5xD
Pilot drill specially designed for MICRO-Deep-Drill.

Length version:

5xD

Application:



>> See page 6



MICRO-Step-Drill-Steel
For general drilling conditions incl. 90° countersink.

Application:



>> See page 5

MICRO DRILLING

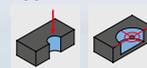


MICRO-Drill-Steel
Drill diameters from 0.80 mm with internal cooling.

Length version:

5xD 8xD 12xD

Application:



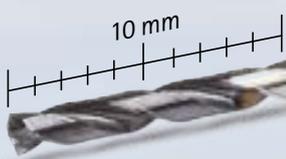
>> See page 6



MICRO DEEP DRILLING

MICRO-Deep-Steel

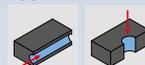
Deep drilling up to 30xD in one operation, without deflashing cycles.



Length version:

20xD **30xD**

Application:



[» See page 9](#)

MICRO-Drill-Steel

Drilling diameters from 0.80 mm with internal cooling

The MICRO drill steel has been specially developed for the efficient machining of small bores in steel. It offers optimal guidance properties and stability thanks to its four marging lands. The geometry and flute design with core tapering allow for ideal chip removal, even with tough steels. Highest performance and tool life are ensured by a new cutting material combination and adapted microgeometries.

1 Four marging lands

- For improved qualities and stability

2 Slot form with back taper

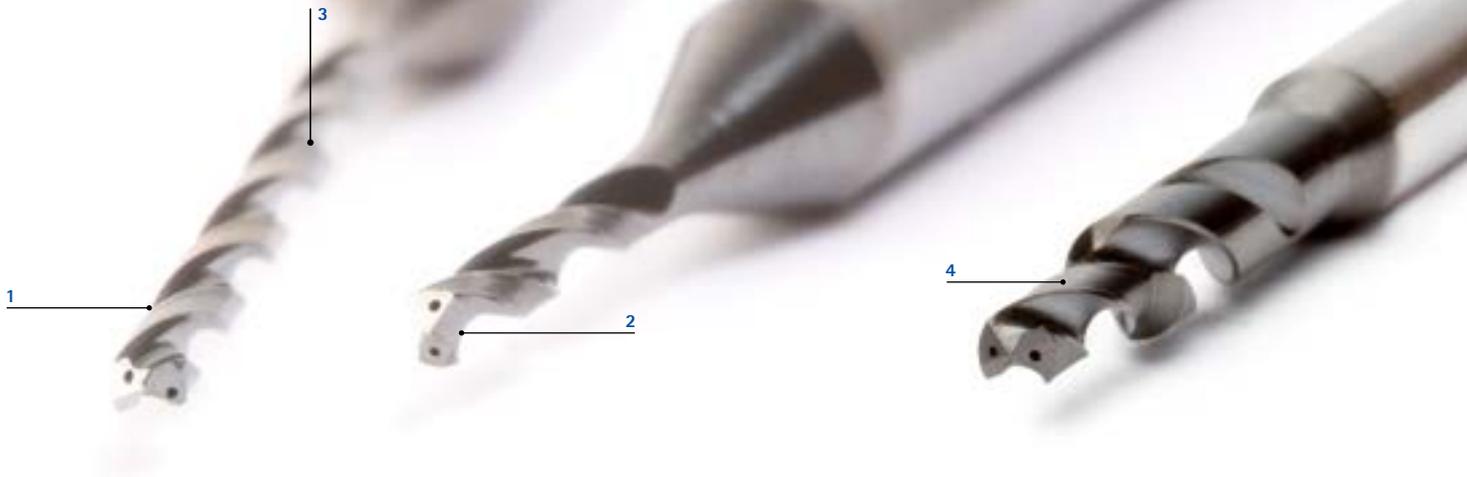
- Ideal transport of the chips even with tough steel materials

3 New cutting material combination

- Highest performance
- Improved tool life

4 MICRO-Step-Drill-Steel

- Variant with a sink level of 90°



Features

Dimensions:

- Number of cutting edges: 2
- Shank form: HA
- Internal coolant supply

Preferred series in stock:

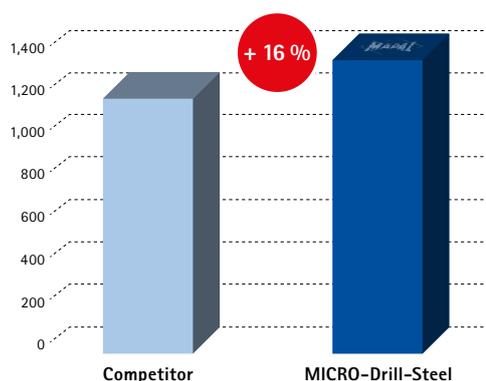
- ϕ -range: 0.80 to 2.0 mm

Configurable features:

- ϕ -range: 0.80 to 2.99 mm

Tool life comparison MICRO-Drill-Steel

Number of bores:



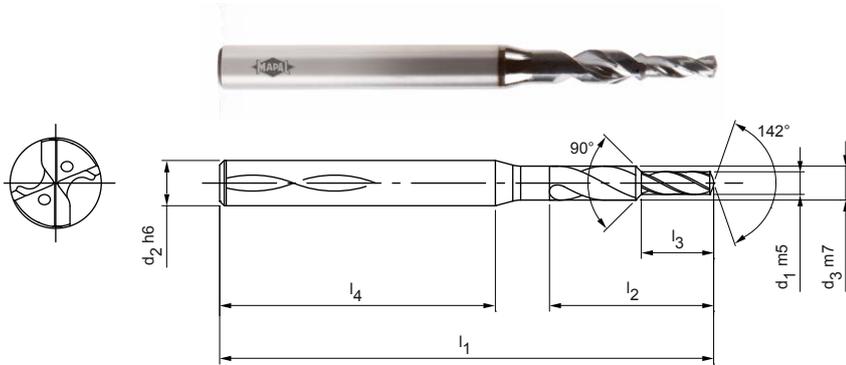
MICRO-Drill-Steel 5xD
 Material: ST52 (1.0570)
 Tool- ϕ : 1.00 mm
 v_c : 60 m/min
 f_u : 0.030 mm/rev.

MICRO-Step-Drill-Steel

Solid carbide step drill
SCD581, internal coolant supply

Design:
 Drill diameter: 1.00 – 3.00 mm
 Bore tolerance: IT9 (achievable)
 Cutting material: HP246
 Number of cutting edges: 2
 Number of guiding chamfers: 2
 Tip angle: 142°

Application:
 Pilot drill specially adapted to MICRO-Deep-Drill.
 Can be used to a maximum of < 3.00 mm diameter
 with countersink step for optimum insertion of
 the following deep drill.

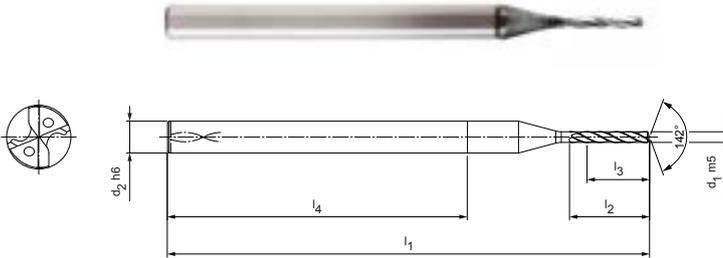


| Dimensions | | | | | | | Shank form HA | |
|-------------------|-------------------|-------------------|----------------|----------------|----------------|----------------|-----------------------------|-----------|
| d ₁ m5 | d ₂ h6 | d ₃ m7 | l ₁ | l ₂ | l ₃ | l ₄ | Specification | Order No. |
| 1,00 | 3,00 | 1,50 | 50 | 7,2 | 3,0 | 38 | SCD581-0100-2-2-142HA-HP246 | 31080870 |
| 1,10 | 3,00 | 1,65 | 50 | 7,9 | 3,3 | 37,5 | SCD581-0110-2-2-142HA-HP246 | 31080871 |
| 1,20 | 3,00 | 1,80 | 50 | 8,6 | 3,6 | 36,9 | SCD581-0120-2-2-142HA-HP246 | 31080872 |
| 1,30 | 3,00 | 1,95 | 50 | 9,4 | 3,9 | 36,3 | SCD581-0130-2-2-142HA-HP246 | 31080873 |
| 1,40 | 3,00 | 2,10 | 50 | 10,1 | 4,2 | 35,7 | SCD581-0140-2-2-142HA-HP246 | 31080874 |
| 1,50 | 3,00 | 2,25 | 50 | 10,8 | 4,5 | 35,1 | SCD581-0150-2-2-142HA-HP246 | 31080875 |
| 1,60 | 3,00 | 2,40 | 50 | 11,5 | 4,8 | 34,6 | SCD581-0160-2-2-142HA-HP246 | 31080876 |
| 1,70 | 3,00 | 2,55 | 50 | 12,2 | 5,1 | 34 | SCD581-0170-2-2-142HA-HP246 | 31080877 |
| 1,80 | 3,00 | 2,70 | 50 | 13,0 | 5,4 | 33,4 | SCD581-0180-2-2-142HA-HP246 | 31080878 |
| 1,90 | 4,00 | 2,85 | 55 | 13,7 | 5,7 | 35,9 | SCD581-0190-2-2-142HA-HP246 | 31080879 |
| 2,00 | 4,00 | 3,00 | 55 | 14,4 | 6,0 | 35,3 | SCD581-0200-2-2-142HA-HP246 | 31080880 |
| 2,10 | 4,00 | 3,15 | 55 | 15,1 | 6,3 | 34,8 | SCD581-0210-2-2-142HA-HP246 | 31080881 |
| 2,20 | 4,00 | 3,30 | 55 | 15,8 | 6,6 | 34,2 | SCD581-0220-2-2-142HA-HP246 | 31080882 |
| 2,30 | 4,00 | 3,45 | 55 | 16,6 | 6,9 | 33,6 | SCD581-0230-2-2-142HA-HP246 | 31080883 |
| 2,40 | 4,00 | 3,60 | 55 | 17,3 | 7,2 | 33 | SCD581-0240-2-2-142HA-HP246 | 31080884 |
| 2,50 | 4,00 | 3,75 | 55 | 18,0 | 7,5 | 32,4 | SCD581-0250-2-2-142HA-HP246 | 31080885 |
| 2,60 | 6,00 | 3,90 | 66 | 18,7 | 7,8 | 39,1 | SCD581-0260-2-2-142HA-HP246 | 31080886 |
| 2,70 | 6,00 | 4,05 | 66 | 19,4 | 8,1 | 38,5 | SCD581-0270-2-2-142HA-HP246 | 31080887 |
| 2,80 | 6,00 | 4,20 | 66 | 20,2 | 8,4 | 37,9 | SCD581-0280-2-2-142HA-HP246 | 31080888 |
| 2,90 | 6,00 | 4,35 | 66 | 20,9 | 8,7 | 37,4 | SCD581-0290-2-2-142HA-HP246 | 31080889 |
| 3,00 | 6,00 | 4,50 | 66 | 21,6 | 9,0 | 36,8 | SCD581-0300-2-2-142HA-HP246 | 31080890 |

Dimensions in mm.
 For recommended cutting values, see page 14/15.
 Special designs and other coatings on request.

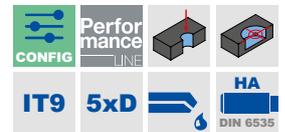
MICRO-Drill-Steel

Solid carbide twist drill
SCD371 (5xD), internal coolant supply



Design:
 Drill diameter: 0.80 – 2.99 mm
 Bore tolerance: IT9 (achievable)
 Cutting material: HP246
 Number of cutting edges: 2
 Number of guiding chamfers: 4
 Tip angle: 142°
 Helix angle: 30°

Application:
 Spotting drill specifically designed for the MICRO-Deep-Drill.
 Maximum use up to < diameter 3.00 mm.



Stocked preferred series in shank form HA

| Dimensions | | | | | | Shank form HA | |
|-------------------|-------------------|----------------|----------------|----------------|----------------|-------------------------------|-----------|
| d ₁ m5 | d ₂ h6 | l ₁ | l ₂ | l ₃ | l ₄ | Specification | Order no. |
| 0,80 | 3 | 45 | 6 | 4 | 28 | SCD371-0080-2-4-142HA05-HP246 | 31238823 |
| 1,00 | 3 | 45 | 7,5 | 5 | 28 | SCD371-0100-2-4-142HA05-HP246 | 31238825 |
| 1,10 | 3 | 45 | 8,3 | 5 | 28 | SCD371-0110-2-4-142HA05-HP246 | 31238826 |
| 1,20 | 3 | 45 | 9 | 6 | 28 | SCD371-0120-2-4-142HA05-HP246 | 31238827 |
| 1,50 | 3 | 45 | 11,3 | 7,5 | 28 | SCD371-0150-2-4-142HA05-HP246 | 31238890 |
| 1,60 | 3 | 50 | 12 | 8 | 28 | SCD371-0160-2-4-142HA05-HP246 | 31238891 |
| 1,70 | 3 | 50 | 12,8 | 8 | 28 | SCD371-0170-2-4-142HA05-HP246 | 31238892 |
| 1,80 | 3 | 50 | 13,5 | 8 | 28 | SCD371-0180-2-4-142HA05-HP246 | 31238893 |
| 1,90 | 3 | 50 | 14,3 | 9,5 | 28 | SCD371-0190-2-4-142HA05-HP246 | 31238894 |
| 2,00 | 3 | 50 | 15 | 10 | 28 | SCD371-0200-2-4-142HA05-HP246 | 31238895 |
| 2,10 | 3 | 50 | 28 | 9,5 | 28 | SCD371-0210-2-4-142HA05-HP246 | 31238896 |
| 2,20 | 3 | 52 | 16,5 | 11 | 28 | SCD371-0220-2-4-142HA05-HP246 | 31238897 |
| 2,40 | 3 | 52 | 18 | 12 | 28 | SCD371-0240-2-4-142HA05-HP246 | 31238899 |
| 2,50 | 3 | 52 | 18,8 | 12,5 | 28 | SCD371-0250-2-4-142HA05-HP246 | 31238900 |
| 2,60 | 3 | 55 | 19,5 | 13 | 28 | SCD371-0260-2-4-142HA05-HP246 | 31238901 |
| 2,70 | 3 | 55 | 20,3 | 13 | 28 | SCD371-0270-2-4-142HA05-HP246 | 31238902 |
| 2,80 | 3 | 55 | 21 | 14 | 28 | SCD371-0280-2-4-142HA05-HP246 | 31238903 |
| 2,90 | 3 | 55 | 21,8 | 13 | 28 | SCD371-0290-2-4-142HA05-HP246 | 31238904 |

Configurable features



Diameter:
Diameter in increments of 0.01 mm freely selectable



Specification:
SCD371-[diameter]-2-4-142HA05-HP246

Example:
SCD371-0221-2-4-142HA05-HP246

Tool diameter d₁ = 2.21 mm

Dimensions of configurable series

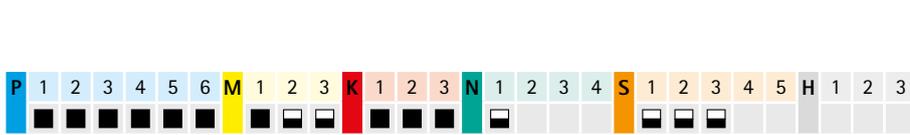
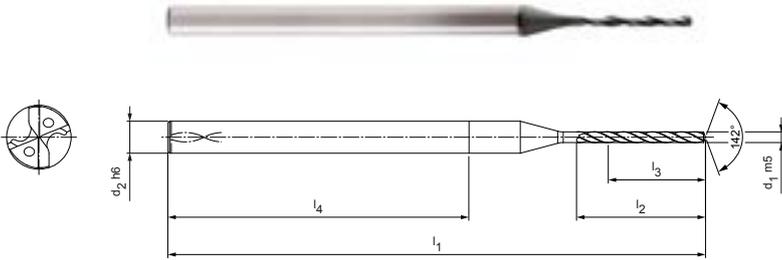
| d ₁ min. | d ₁ max. | d ₂ h6 | l ₁ | l ₂ | l ₃ | l ₄ |
|---------------------|---------------------|-------------------|----------------|---------------------------------------|------------------------------|----------------|
| 0,80 | 0,99 | 3 | 45 | l ₂ = l ₃ x 1.5 | d ₁ x Drill depth | 28 |
| 1,00 | 1,29 | 3 | 45 | | | 28 |
| 1,30 | 1,59 | 3 | 45 | | | 28 |
| 1,60 | 1,89 | 3 | 50 | | | 28 |
| 1,90 | 2,19 | 3 | 50 | | | 28 |
| 2,20 | 2,59 | 3 | 52 | | | 28 |
| 2,60 | 2,99 | 3 | 55 | | | 28 |

Dimensions in mm.
 For recommended cutting values, see page 16/17.
 Special designs and other coatings on request.

MICRO-Drill-Steel

Solid carbide twist drill
SCD371 (8xD), internal coolant supply

Design:
 Drill diameter: 1.00 – 2.99 mm
 Bore tolerance: IT9 (achievable)
 Cutting material: HP246
 Number of cutting edges: 2
 Number of guiding chamfers: 4
 Tip angle: 142°
 Helix angle: 30°



Stocked preferred series in shank form HA

| Dimensions | | | | | | Shank form HA | |
|-------------------|-------------------|----------------|----------------|----------------|----------------|-------------------------------|-----------|
| d ₁ m5 | d ₂ h6 | l ₁ | l ₂ | l ₃ | l ₄ | Specification | Order no. |
| 1,00 | 3 | 50 | 12 | 8 | 28 | SCD371-0100-2-4-142HA08-HP246 | 31238905 |
| 1,20 | 3 | 50 | 14,4 | 9,6 | 28 | SCD371-0120-2-4-142HA08-HP246 | 31238907 |
| 1,50 | 3 | 52 | 18 | 12 | 28 | SCD371-0150-2-4-142HA08-HP246 | 31238910 |
| 1,60 | 3 | 55 | 19,2 | 12,8 | 28 | SCD371-0160-2-4-142HA08-HP246 | 31238911 |
| 1,80 | 3 | 55 | 21,6 | 12,8 | 28 | SCD371-0180-2-4-142HA08-HP246 | 31238913 |
| 1,90 | 3 | 60 | 22,8 | 15,2 | 28 | SCD371-0190-2-4-142HA08-HP246 | 31238914 |
| 2,00 | 3 | 60 | 24 | 16 | 28 | SCD371-0200-2-4-142HA08-HP246 | 31238915 |
| 2,10 | 3 | 60 | 25,2 | 15,2 | 28 | SCD371-0210-2-4-142HA08-HP246 | 31238916 |
| 2,20 | 3 | 62 | 26,4 | 17,6 | 28 | SCD371-0220-2-4-142HA08-HP246 | 31238917 |
| 2,50 | 3 | 62 | 30 | 20 | 28 | SCD371-0250-2-4-142HA08-HP246 | 31238920 |
| 2,80 | 3 | 66 | 33,6 | 20,8 | 28 | SCD371-0280-2-4-142HA08-HP246 | 31238923 |
| 2,90 | 3 | 66 | 34,8 | 20,8 | 28,0 | SCD371-0290-2-4-142HA08-HP246 | 31238924 |

Configurable features



Diameter:
Diameter in increments of 0.01 mm freely selectable

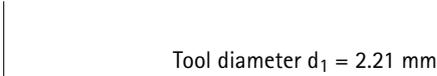
Specification:
SCD371-[diameter]-2-4-142HA08-HP246

Dimensions of configurable series

| d ₁ min. | d ₁ max. | d ₂ h6 | l ₁ | l ₂ | l ₃ | l ₄ |
|---------------------|---------------------|-------------------|----------------|---------------------------------------|---|----------------|
| 1,00 | 1,29 | 3 | 50 | l ₂ = l ₃ × 1.5 | l ₃ = d ₁ × Drill depth | 28 |
| 1,30 | 1,59 | 3 | 52 | | | 28 |
| 1,60 | 1,89 | 3 | 55 | | | 28 |
| 1,90 | 2,19 | 3 | 60 | | | 28 |
| 2,20 | 2,59 | 3 | 62 | | | 28 |
| 2,60 | 2,99 | 3 | 66 | | | 28 |

Example:

SCD371-0221-2-4-142HA08-HP246



Dimensions in mm.
 For recommended cutting values, see page 16/17.
 Special designs and other coatings on request.

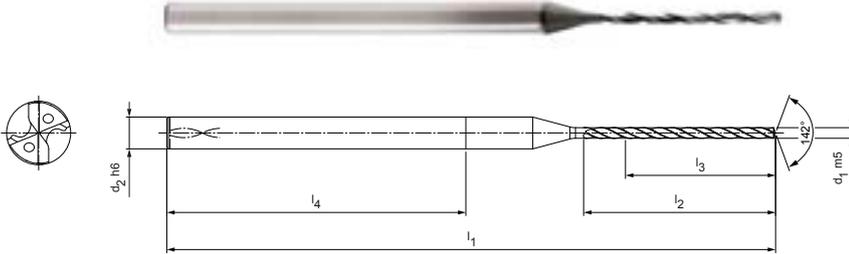
MICRO-Drill-Steel

Solid carbide twist drill

SCD371 (12xD), internal coolant supply

Design:

| | |
|-----------------------------|------------------|
| Drill diameter: | 1.00 – 2.99 mm |
| Bore tolerance: | IT9 (achievable) |
| Cutting material: | HP246 |
| Number of cutting edges: | 2 |
| Number of guiding chamfers: | 4 |
| Tip angle: | 142° |
| Helix angle: | 30° |



Stocked preferred series in shank form HA

| Dimensions | | | | | | Shank form HA | |
|-------------------|-------------------|----------------|----------------|----------------|----------------|-------------------------------|-----------|
| d ₁ m5 | d ₂ h6 | l ₁ | l ₂ | l ₃ | l ₄ | Specification | Order no. |
| 1,00 | 3 | 57 | 18 | 12 | 28 | SCD371-0100-2-4-142HA12-HP246 | 31238925 |
| 1,20 | 3 | 57 | 21,6 | 14,4 | 28 | SCD371-0120-2-4-142HA12-HP246 | 31238927 |
| 1,30 | 3 | 62 | 23,4 | 15,6 | 28 | SCD371-0130-2-4-142HA12-HP246 | 31238928 |
| 1,50 | 3 | 62 | 27 | 18 | 28 | SCD371-0150-2-4-142HA12-HP246 | 31238930 |
| 2,00 | 3 | 72 | 36 | 24 | 28 | SCD371-0200-2-4-142HA12-HP246 | 31238935 |
| 2,10 | 3 | 72 | 37,8 | 22,8 | 28 | SCD371-0210-2-4-142HA12-HP246 | 31238936 |
| 2,50 | 3 | 79 | 45 | 30 | 28 | SCD371-0250-2-4-142HA12-HP246 | 31238940 |
| 2,80 | 3 | 85 | 50,4 | 31,2 | 28 | SCD371-0280-2-4-142HA12-HP246 | 31238943 |
| 2,90 | 3 | 85 | 52,2 | 31,2 | 28 | SCD371-0290-2-4-142HA12-HP246 | 31238944 |

Configurable features



Diameter:
Diameter in increments of
0.01 mm freely selectable



Specification:

SCD371-[diameter]-2-4-142HA12-HP246

Example:

SCD371-0221-2-4-142HA12-HP246

Tool diameter d₁ = 2.21 mm

Dimensions of configurable series

| d ₁ min. | d ₁ max. | d ₂ h6 | l ₁ | l ₂ | l ₃ | l ₄ |
|---------------------|---------------------|-------------------|----------------|--|--|----------------|
| 1,00 | 1,29 | 3 | 57 | l ₂ = l ₃ x 1.5 | l ₃ = d ₁ x Drill depth | 28 |
| 1,30 | 1,59 | 3 | 62 | | | 28 |
| 1,60 | 1,89 | 3 | 66 | | | 28 |
| 1,90 | 2,19 | 3 | 72 | | | 28 |
| 2,20 | 2,59 | 3 | 79 | | | 28 |
| 2,60 | 2,99 | 3 | 85 | | | 28 |

Dimensions in mm.

For recommended cutting values, see page 16/17.

Special designs and other coatings on request.

MICRO-Deep-Drill

Deep drill also for smallest diameters

The geometry of the micro deep drill has been specifically tailored to the small diameter range. Thanks to the newly designed flute and special face geometry, the highest feed rates and cutting speeds can be achieved during deep drilling. With the innovative cooling channel design, the drills are also suitable for the use of minimum quantity lubrication. Despite lengths of up to 30xD, the gas-oil mixture reaches the cutting edges reliably. Instead of a full coating, the new tools are coated only at the head for greater efficiency.

1 Head coating

- Economic coating for longer tool life

2 Innovative cooling channel management

- Suitable for minimum quantity lubrication

3 Newly designed groove

- Highest feed rates and cutting speeds



Features

Dimensions:

- Number of cutting edges: 2
- Shank form: HA
- Internal coolant supply

Preferred series in stock:

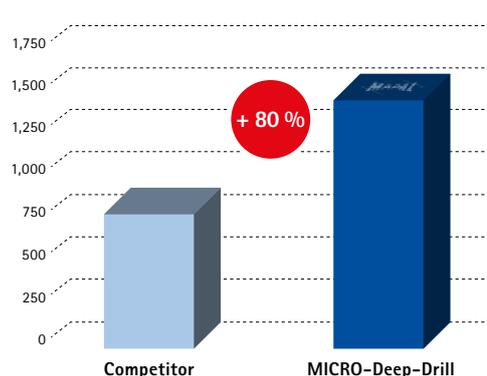
- ϕ -range: 1.00 to 2.90 mm

Configurable features:

- ϕ -range: 1.00 to 2.99 mm

Tool life comparison MICRO-Deep-Drill

Number of bores:

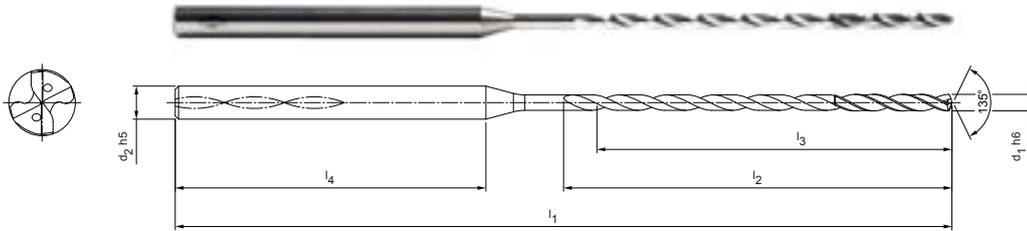


MICRO-Deep-Drill 30xD
 Material: 42CrMo4
 Nominal- ϕ : 2.50 mm
 v_c : 80 m/min
 f_u : 0.060 mm/rev.

MICRO-Deep-Drill

Solid carbide twist drill
SCD171 (20xD), internal coolant supply

Design:
 Drill diameter: 1.00 – 2.99 mm
 Bore tolerance: ≥ IT9
 Cutting material: HP246
 Number of cutting edges: 2
 Number of guiding chamfers: 4
 Tip angle: 135°
 Helix angle: 30°



| Dimensions | | | | | | | Shank form HA | |
|-------------------|-------------------|----------------|----------------|----------------|--------------|----------------|-------------------------------|-----------|
| d ₁ h6 | d ₂ h5 | l ₁ | l ₂ | l ₃ | L/d relation | l ₄ | Specification | Order No. |
| 1,00 | 3 | 62 | 27 | 25 | 25 | 28 | SCD171-0100-2-4-135HA20-HP246 | 30998795 |
| 1,10 | 3 | 62 | 27 | 25 | 23 | 28 | SCD171-0110-2-4-135HA20-HP246 | 30998796 |
| 1,20 | 3 | 62 | 27 | 25 | 21 | 28 | SCD171-0120-2-4-135HA20-HP246 | 30998798 |
| 1,30 | 3 | 70 | 35 | 33 | 25 | 28 | SCD171-0130-2-4-135HA20-HP246 | 30998799 |
| 1,40 | 3 | 70 | 35 | 32 | 23 | 28 | SCD171-0140-2-4-135HA20-HP246 | 30998800 |
| 1,50 | 3 | 70 | 35 | 32 | 21 | 28 | SCD171-0150-2-4-135HA20-HP246 | 30998801 |
| 1,60 | 3 | 75 | 41 | 38 | 24 | 28 | SCD171-0160-2-4-135HA20-HP246 | 30998802 |
| 1,70 | 3 | 75 | 41 | 38 | 22 | 28 | SCD171-0170-2-4-135HA20-HP246 | 30998803 |
| 1,80 | 3 | 75 | 41 | 38 | 21 | 28 | SCD171-0180-2-4-135HA20-HP246 | 30998804 |
| 1,90 | 3 | 80 | 46 | 43 | 23 | 28 | SCD171-0190-2-4-135HA20-HP246 | 30998805 |
| 2,00 | 3 | 80 | 46 | 43 | 22 | 28 | SCD171-0200-2-4-135HA20-HP246 | 30998806 |
| 2,10 | 3 | 80 | 46 | 42 | 20 | 28 | SCD171-0210-2-4-135HA20-HP246 | 30998807 |
| 2,20 | 3 | 90 | 55 | 51 | 23 | 28 | SCD171-0220-2-4-135HA20-HP246 | 30998808 |
| 2,30 | 3 | 90 | 55 | 51 | 22 | 28 | SCD171-0230-2-4-135HA20-HP246 | 30998809 |
| 2,40 | 3 | 90 | 55 | 51 | 21 | 28 | SCD171-0240-2-4-135HA20-HP246 | 30998810 |
| 2,50 | 3 | 90 | 55 | 51 | 20 | 28 | SCD171-0250-2-4-135HA20-HP246 | 30998811 |
| 2,60 | 3 | 100 | 66 | 62 | 24 | 28 | SCD171-0260-2-4-135HA20-HP246 | 30998812 |
| 2,70 | 3 | 100 | 66 | 61 | 23 | 28 | SCD171-0270-2-4-135HA20-HP246 | 30998813 |
| 2,80 | 3 | 100 | 66 | 61 | 22 | 28 | SCD171-0280-2-4-135HA20-HP246 | 30998814 |
| 2,90 | 3 | 100 | 66 | 61 | 21 | 28 | SCD171-0290-2-4-135HA20-HP246 | 30998815 |

Configurable features



Diameter:
Diameter in increments of 0.01 mm freely selectable



Specification:
SCD171-[diameter]-2-4-135HA20-HP246

Example:
SCD171-0221-2-4-135HA20-HP246

Tool diameter d₁ = 2.21 mm

Dimensions of configurable series

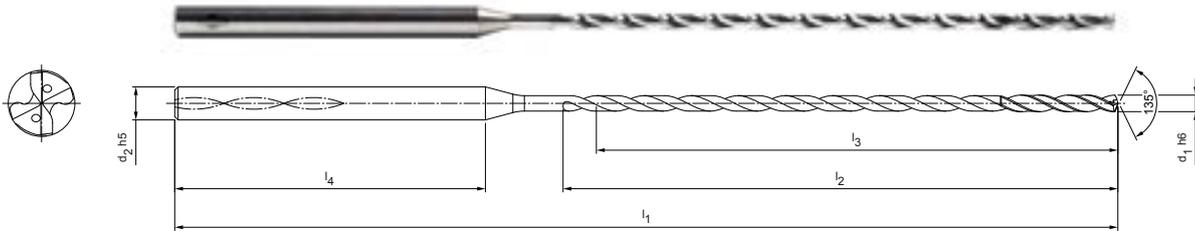
| d ₁ h6 | d ₂ h5 | l ₁ | l ₂ | l ₃ | l ₄ |
|-------------------|-------------------|----------------|----------------|----------------|----------------|
| 1,00 - 1,20 | 3 | 62 | 27 | 25 | 28 |
| 1,21 - 1,50 | 3 | 70 | 35 | 32 | 28 |
| 1,51 - 1,80 | 3 | 75 | 41 | 38 | 28 |
| 1,81 - 2,10 | 3 | 80 | 46 | 42 | 28 |
| 2,11 - 2,50 | 3 | 90 | 55 | 51 | 28 |
| 2,51 - 2,99 | 3 | 100 | 66 | 61 | 28 |

Dimensions in mm.
For recommended cutting values, see page 18/19.
Special designs and other coatings on request.

MICRO-Deep-Drill

Solid carbide twist drill
SCD171 (30xD), internal coolant supply

Design:
 Drill diameter: 1.00 – 2.99 mm
 Bore tolerance: \geq IT9
 Cutting material: HP246
 Number of cutting edges: 2
 Number of guiding chamfers: 4
 Tip angle: 135°
 Helix angle: 30°



| Dimensions | | | | | | | Shank form HA | |
|-------------------|-------------------|----------------|----------------|----------------|--------------|----------------|-------------------------------|-----------|
| d ₁ h6 | d ₂ h5 | l ₁ | l ₂ | l ₃ | L/d relation | l ₄ | Specification | Order No. |
| 1,00 | 3 | 75 | 38 | 36 | 36 | 28 | SCD171-0100-2-4-135HA30-HP246 | 30998816 |
| 1,10 | 3 | 75 | 38 | 36 | 33 | 28 | SCD171-0110-2-4-135HA30-HP246 | 30998817 |
| 1,20 | 3 | 75 | 38 | 36 | 30 | 28 | SCD171-0120-2-4-135HA30-HP246 | 30998818 |
| 1,30 | 3 | 85 | 50 | 48 | 37 | 28 | SCD171-0130-2-4-135HA30-HP246 | 30998819 |
| 1,40 | 3 | 85 | 50 | 47 | 34 | 28 | SCD171-0140-2-4-135HA30-HP246 | 30998820 |
| 1,50 | 3 | 85 | 50 | 47 | 31 | 28 | SCD171-0150-2-4-135HA30-HP246 | 30998821 |
| 1,60 | 3 | 95 | 59 | 56 | 35 | 28 | SCD171-0160-2-4-135HA30-HP246 | 30998822 |
| 1,70 | 3 | 95 | 59 | 56 | 33 | 28 | SCD171-0170-2-4-135HA30-HP246 | 30998823 |
| 1,80 | 3 | 95 | 59 | 56 | 31 | 28 | SCD171-0180-2-4-135HA30-HP246 | 30998824 |
| 1,90 | 3 | 100 | 66 | 63 | 33 | 28 | SCD171-0190-2-4-135HA30-HP246 | 30998825 |
| 2,00 | 3 | 100 | 66 | 63 | 32 | 28 | SCD171-0200-2-4-135HA30-HP246 | 30998826 |
| 2,10 | 3 | 100 | 66 | 62 | 30 | 28 | SCD171-0210-2-4-135HA30-HP246 | 30998827 |
| 2,20 | 3 | 115 | 80 | 76 | 35 | 28 | SCD171-0220-2-4-135HA30-HP246 | 30998828 |
| 2,30 | 3 | 115 | 80 | 76 | 33 | 28 | SCD171-0230-2-4-135HA30-HP246 | 30998829 |
| 2,40 | 3 | 115 | 80 | 76 | 32 | 28 | SCD171-0240-2-4-135HA30-HP246 | 30998830 |
| 2,50 | 3 | 115 | 80 | 76 | 30 | 28 | SCD171-0250-2-4-135HA30-HP246 | 30451572 |
| 2,60 | 3 | 130 | 96 | 92 | 35 | 28 | SCD171-0260-2-4-135HA30-HP246 | 30998832 |
| 2,70 | 3 | 130 | 96 | 91 | 34 | 28 | SCD171-0270-2-4-135HA30-HP246 | 30998833 |
| 2,80 | 3 | 130 | 96 | 91 | 33 | 28 | SCD171-0280-2-4-135HA30-HP246 | 30998834 |
| 2,90 | 3 | 130 | 96 | 91 | 31 | 28 | SCD171-0290-2-4-135HA30-HP246 | 30998835 |

Configurable features



Diameter:
Diameter in increments of 0.01 mm freely selectable



Specification:
SCD171-[diameter]-2-4-135HA30-HP246

Example:
SCD171-0221-2-4-135HA30-HP246

Tool diameter d₁ = 2.21 mm

Dimensions of configurable series

| d ₁ h6 | d ₂ h5 | l ₁ | l ₂ | l ₃ | l ₄ |
|-------------------|-------------------|----------------|----------------|----------------|----------------|
| 1,00 - 1,20 | 3 | 75 | 38 | 36 | 28 |
| 1,21 - 1,50 | 3 | 85 | 50 | 47 | 28 |
| 1,51 - 1,80 | 3 | 95 | 59 | 56 | 28 |
| 1,81 - 2,10 | 3 | 100 | 66 | 62 | 28 |
| 2,11 - 2,50 | 3 | 115 | 80 | 76 | 28 |
| 2,51 - 2,99 | 3 | 130 | 96 | 91 | 28 |

Dimensions in mm.
For recommended cutting values, see page 18/19.
Special designs and other coatings on request.

Deep drilling in two steps

1 Drilling of pilot hole

Recommendation:

Pilot drill 5xD

MICRO-Step-Drill-Steel

[SCD581]

For general drilling conditions incl. 90° countersink



Alternative:

MICRO-Drill-Steel

[SCD371]



Valid for MICRO-Deep-Drill [SCD171]

Nominal diameter: 1.00 - 2.99 mm

Info:

Pilot bore depth between 3xD - 5xD

2 Deep drilling up to 30xD

Entry into the pilot bore:

- Entering with max. 300 rpm and $v_f = 1,000$ mm/min
- Without coolant – down to 1 mm before reaching ground of pilot bore
- Start of coolant → cooling lubricant = 10–40 bar/MQL
- Spot drilling with predefined cutting data according to table

Info:

Another option for spot drilling with the MEGA-Deep-Drill-Steel:

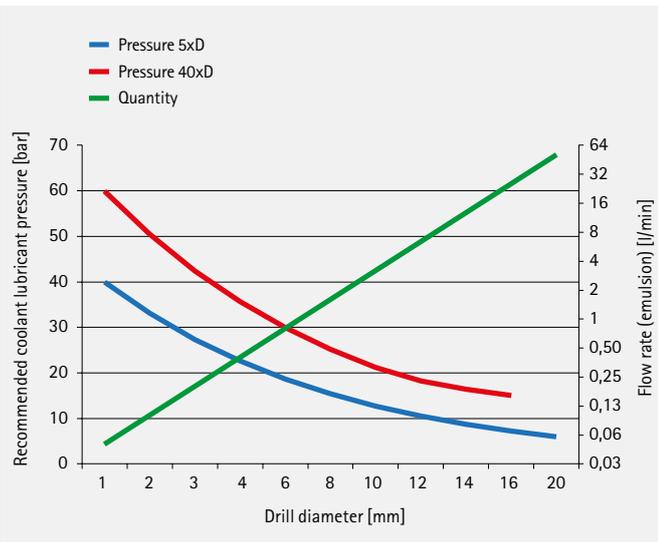
Spot drilling with feed rate 50%, linear acceleration to feed rate 100% up to drilling depth 4xD

- **Deep drilling up to 30xD in one step, without chip release cycles**

Pulling out:

- Pulling out with max. 300 rpm and double feed ($2x v_f$)
- Switch off coolant

Reference values for coolant pressure and quantity



System pressures for MQL for deep drills

MQL systems

Supply pressure

One-channel systems

up to 16 bar

Recommended supply pressure

5–6 bar

High pressure for Deep drilling < nominal \varnothing 12 mm

8–10 bar

High pressure for Deep drilling < nominal \varnothing 3 mm

14–16 bar

MICRO-Deep-Drill; SCD171 (nominal \varnothing range: 1.00 - 2.99 mm)

Two-channel systems

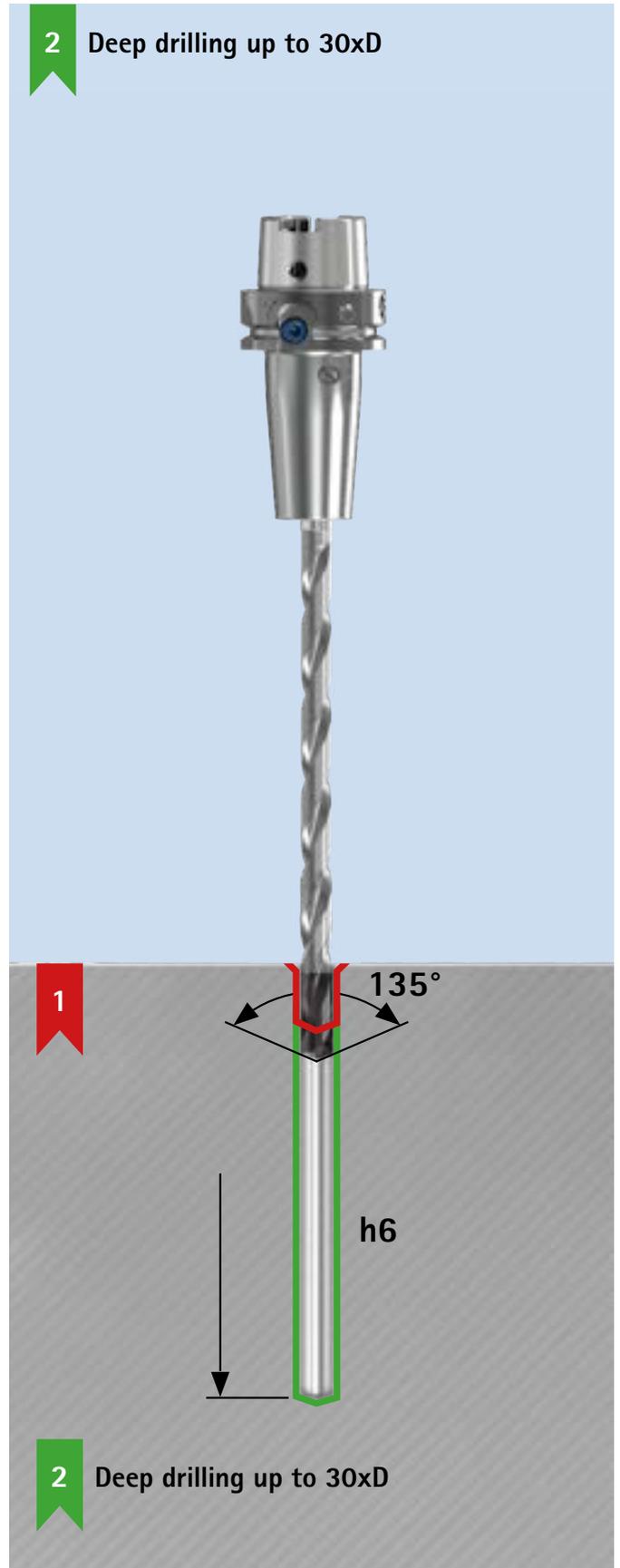
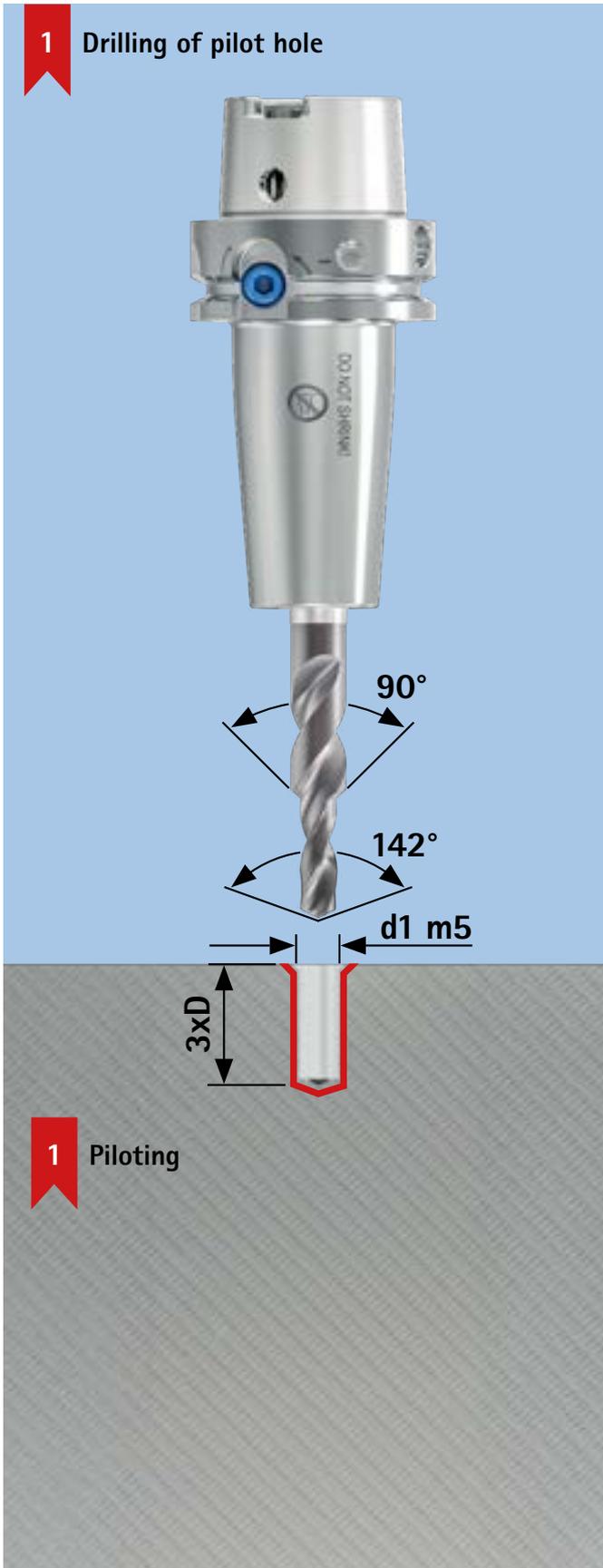
up to 10 bar

Recommended supply pressure

5–6 bar

High pressure for Deep drilling < nominal \varnothing 6 mm

8–10 bar



Recommended cutting values for solid carbide drills

Feed and cutting speed

MICRO-Step-Drill-Steel | SCD581

| MMG* | Workpiece material | Strength/hardness [N/mm ²] [HRC] |
|---|---|---|
| P | P1.1 Structural, free-cutting, case hardened and heat-treated steels, non-alloy | < 700 |
| | P1.2 Structural, free-cutting, case hardened and heat-treated steels, non-alloy | < 1,200 |
| | P2.1 Nitrided, case hardened and heat-treated steels, alloy | < 900 |
| | P2.2 Nitrided, case hardened and heat-treated steels, alloy | < 1,400 |
| | P3.1 Tool, bearing, spring and high-speed steels** | < 800 |
| | P3.2 Tool, bearing, spring and high-speed steels** | < 1,000 |
| | P3.3 Tool, bearing, spring and high-speed steels** | < 1,500 |
| | P4.1 Stainless steels, ferritic and martensitic | |
| | P5.1 Cast steel | |
| P6.1 Stainless cast steel, ferritic and martensitic | | |
| M | M1.1 Stainless steels, austenitic | < 700 |
| | M1.2 Stainless steels, ferritic/austenitic (duplex) | < 1,000 |
| | M2.1 Stainless/heat-resistant cast steel, austenitic | < 700 |
| | M3.1 Stainless cast steel, ferritic/austenitic (duplex) | < 1,000 |
| K | K1.1 Cast iron with lamellar graphite (grey cast iron), GJL | < 300 |
| | K2.1 Cast iron with spheroidal graphite, GJS | < 500 |
| | K2.2 Cast iron with spheroidal graphite, GJS | ≤ 800 |
| | K2.3 Cast iron with spheroidal graphite, GJS | > 800 |
| | K3.1 Cast iron with spheroidal graphite, GJV; malleable cast iron, GJM | < 500 |
| | K3.2 Cast iron with spheroidal graphite, GJV; malleable cast iron, GJM | > 500 |
| N | N1.1 Aluminium, non-alloy and alloy < 3 % Si | |
| | N1.2 Aluminium, alloy ≤ 7 % Si | |
| | N1.3 Aluminium, alloy > 7-12 % Si | |
| | N1.4 Aluminium, alloy > 12 % Si | |
| S | S1.1 Titanium, titanium alloys | < 400 |
| | S2.1 Titanium, titanium alloys | < 1,200 |
| | S2.2 Titanium, titanium alloys | > 1,200 |
| | S3.1 Nickel, unalloyed and alloyed | < 900 |
| | S3.2 Nickel, unalloyed and alloyed | > 900 |

** MAPAL machining groups

** If the alloy components Cr, Mo, Ni, V, W in total > 8 % then select the next higher MAPAL machining group.

The cutting values given are guide values.

The optimum data for the respective machining case should be determined in trials or during machining.

| | Cutting speed v_c [m/min] | | | | Feed f [mm] for drill diameter | | | | | |
|--|-----------------------------|------------------|------------|-----------|----------------------------------|-------|-------|-------|-------|-------|
| | Internal cooling | External cooling | MQL | Air | 1.00 | 1.25 | 1.55 | 1.93 | 2.41 | 3.00 |
| | 80 | 70 | 70 | | 0.04 | 0.05 | 0.05 | 0.06 | 0.07 | 0.08 |
| | 70 | 60 | 60 | | 0.05 | 0.06 | 0.06 | 0.07 | 0.08 | 0.1 |
| | 80 | 70 | 70 | | 0.05 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 |
| | 55 | 50 | 50 | | 0.05 | 0.05 | 0.06 | 0.06 | 0.07 | 0.08 |
| | 60 | 50 | 50 | | 0.04 | 0.05 | 0.05 | 0.06 | 0.07 | 0.08 |
| | 50 | 45 | 45 | | 0.04 | 0.04 | 0.05 | 0.05 | 0.06 | 0.07 |
| | 50 | 35 | 40 | | 0.04 | 0.04 | 0.04 | 0.05 | 0.05 | 0.06 |
| | 50 | 35 | 40 | | 0.03 | 0.03 | 0.04 | 0.04 | 0.05 | 0.06 |
| | 80 | 70 | 70 | | 0.05 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 |
| | 50 | 35 | 40 | | 0.03 | 0.03 | 0.04 | 0.04 | 0.05 | 0.06 |
| | 40 | 25 | 25 | | 0.03 | 0.03 | 0.04 | 0.04 | 0.05 | 0.06 |
| | 40 | 25 | 25 | | 0.02 | 0.03 | 0.03 | 0.04 | 0.04 | 0.05 |
| | 40 | 25 | 25 | | 0.03 | 0.03 | 0.04 | 0.04 | 0.05 | 0.06 |
| | 40 | 25 | 25 | | 0.02 | 0.03 | 0.03 | 0.04 | 0.04 | 0.05 |
| | 95 | 70 | 70 | 70 | 0.04 | 0.04 | 0.06 | 0.07 | 0.09 | 0.11 |
| | 130 | 80 | 95 | 95 | 0.05 | 0.05 | 0.06 | 0.08 | 0.09 | 0.11 |
| | 80 | 60 | 60 | | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.1 |
| | 50 | 30 | 40 | | 0.04 | 0.04 | 0.05 | 0.05 | 0.06 | 0.07 |
| | 70 | 65 | 65 | | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 | 0.11 |
| | 65 | 55 | 55 | | 0.05 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 |
| | 225 | 150 | 190 | | 0.04 | 0.05 | 0.05 | 0.06 | 0.07 | 0.08 |
| | 190 | 135 | 150 | | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.1 |
| | 165 | 115 | 135 | | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.1 |
| | 135 | 90 | 115 | | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.1 |
| | 32 | 20 | | | 0.028 | 0.032 | 0.036 | 0.041 | 0.048 | 0.055 |
| | 24 | 16 | | | 0.024 | 0.027 | 0.031 | 0.035 | 0.041 | 0.047 |
| | 20 | 12 | | | 0.02 | 0.023 | 0.026 | 0.029 | 0.034 | 0.04 |
| | 16 | 12 | | | 0.016 | 0.018 | 0.021 | 0.024 | 0.027 | 0.032 |
| | 12 | 8 | | | 0.02 | 0.023 | 0.026 | 0.029 | 0.034 | 0.04 |

Recommended cutting values for solid carbide drills

Feed and cutting speed

MICRO-Drill-Steel | SCD371

| MMG* | | Workpiece material | Strength/hardness [N/mm ²] [HRC] |
|------|---|---|---|
| P | P1 | P1.1 Structural, free-cutting, case hardened and heat-treated steels, non-alloy | < 700 |
| | | P1.2 Structural, free-cutting, case hardened and heat-treated steels, non-alloy | < 1,200 |
| | P2 | P2.1 Nitrided, case hardened and heat-treated steels, alloy | < 900 |
| | | P2.2 Nitrided, case hardened and heat-treated steels, alloy | < 1,400 |
| | P3 | P3.1 Tool, bearing, spring and high-speed steels** | < 800 |
| | | P3.2 Tool, bearing, spring and high-speed steels** | < 1,000 |
| | | P3.3 Tool, bearing, spring and high-speed steels** | < 1,500 |
| | P4 | P4.1 Stainless steels, ferritic and martensitic | |
| | P5 | P5.1 Cast steel | |
| P6 | P6.1 Stainless cast steel, ferritic and martensitic | | |
| M | M1 | M1.1 Stainless steels, austenitic | < 700 |
| | | M1.2 Stainless steels, ferritic/austenitic (duplex) | < 1,000 |
| | M2 | M2.1 Stainless/heat-resistant cast steel, austenitic | < 700 |
| | M3 | M3.1 Stainless cast steel, ferritic/austenitic (duplex) | < 1,000 |
| K | K1 | K1.1 Cast iron with lamellar graphite (grey cast iron), GJL | < 300 |
| | | K2.1 Cast iron with spheroidal graphite, GJS | < 500 |
| | K2 | K2.2 Cast iron with spheroidal graphite, GJS | ≤ 800 |
| | | K2.3 Cast iron with spheroidal graphite, GJS | > 800 |
| | K3 | K3.1 Cast iron with spheroidal graphite, GJV; malleable cast iron, GJM | < 500 |
| | | K3.2 Cast iron with spheroidal graphite, GJV; malleable cast iron, GJM | > 500 |
| N | N1 | N1.1 Aluminium, non-alloy and alloy < 3 % Si | |
| | | N1.2 Aluminium, alloy ≤ 7 % Si | |
| | | N1.3 Aluminium, alloy > 7-12 % Si | |
| | | N1.4 Aluminium, alloy > 12 % Si | |
| S | S1 | S1.1 Titanium, titanium alloys | < 400 |
| | | S2.1 Titanium, titanium alloys | < 1,200 |
| | S2 | S2.2 Titanium, titanium alloys | > 1,200 |
| | | S3.1 Nickel, unalloyed and alloyed | < 900 |
| | S3 | S3.2 Nickel, unalloyed and alloyed | > 900 |

** MAPAL machining groups

** If the alloy components Cr, Mo, Ni, V, W in total > 8 % then select the next higher MAPAL machining group.

The cutting values given are guide values.

The optimum data for the respective machining case should be determined in trials or during machining.

| | Cutting speed v_c [m/min] | | | | Feed f [mm] for drill diameter | | | | | |
|--|-----------------------------|------------------|-----|-----|----------------------------------|-------|-------|-------|-------|-------|
| | Internal cooling | External cooling | MQL | Air | 0.80 | 1.04 | 1.36 | 1.77 | 2.30 | 3.00 |
| | 80 | 70 | 70 | | 0.04 | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 |
| | 70 | 60 | 60 | | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.10 |
| | 80 | 70 | 70 | | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 |
| | 55 | 50 | 50 | | 0.04 | 0.05 | 0.05 | 0.06 | 0.07 | 0.08 |
| | 60 | 50 | 50 | | 0.04 | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 |
| | 50 | 45 | 45 | | 0.04 | 0.04 | 0.04 | 0.05 | 0.06 | 0.07 |
| | 50 | 35 | 40 | | 0.03 | 0.04 | 0.04 | 0.05 | 0.05 | 0.06 |
| | 50 | 35 | 40 | | 0.03 | 0.03 | 0.03 | 0.04 | 0.05 | 0.06 |
| | 80 | 70 | 70 | | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 |
| | 50 | 35 | 40 | | 0.03 | 0.03 | 0.03 | 0.04 | 0.05 | 0.06 |
| | 40 | 25 | 25 | | 0.03 | 0.03 | 0.03 | 0.04 | 0.05 | 0.06 |
| | 35 | 20 | 20 | | 0.02 | 0.02 | 0.03 | 0.03 | 0.04 | 0.05 |
| | 40 | 25 | 25 | | 0.03 | 0.03 | 0.03 | 0.04 | 0.05 | 0.06 |
| | 35 | 20 | 20 | | 0.02 | 0.02 | 0.03 | 0.03 | 0.04 | 0.05 |
| | 95 | 70 | 70 | 70 | 0.03 | 0.04 | 0.05 | 0.06 | 0.08 | 0.11 |
| | 130 | 80 | 95 | 95 | 0.04 | 0.05 | 0.06 | 0.07 | 0.09 | 0.11 |
| | 80 | 60 | 60 | | 0.04 | 0.05 | 0.05 | 0.07 | 0.08 | 0.10 |
| | 50 | 30 | 40 | | 0.04 | 0.04 | 0.04 | 0.05 | 0.06 | 0.07 |
| | 70 | 65 | 65 | | 0.04 | 0.05 | 0.06 | 0.07 | 0.09 | 0.11 |
| | 65 | 55 | 55 | | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 |
| | 210 | 140 | 175 | | 0.04 | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 |
| | 175 | 125 | 140 | | 0.04 | 0.05 | 0.05 | 0.07 | 0.08 | 0.10 |
| | 155 | 105 | 125 | | 0.04 | 0.05 | 0.05 | 0.07 | 0.08 | 0.10 |
| | 125 | 85 | 105 | | 0.04 | 0.05 | 0.05 | 0.07 | 0.08 | 0.10 |
| | 32 | 20 | | | 0.025 | 0.029 | 0.033 | 0.039 | 0.046 | 0.055 |
| | 24 | 16 | | | 0.022 | 0.025 | 0.028 | 0.033 | 0.040 | 0.047 |
| | 20 | 12 | | | 0.018 | 0.020 | 0.024 | 0.028 | 0.033 | 0.040 |
| | 16 | 12 | | | 0.014 | 0.016 | 0.019 | 0.022 | 0.026 | 0.032 |
| | 12 | 8 | | | 0.018 | 0.020 | 0.024 | 0.028 | 0.033 | 0.040 |

Recommended cutting values for solid carbide drills

Feed and cutting speed

MICRO-Deep-Drill | SCD171

| MMG* | | Workpiece material | Strength/hardness [N/mm ²] [HRC] |
|------|---|---|---|
| P | P1 | P1.1 Structural, free-cutting, case hardened and heat-treated steels, non-alloy | < 700 |
| | | P1.2 Structural, free-cutting, case hardened and heat-treated steels, non-alloy | < 1,200 |
| | P2 | P2.1 Nitrided, case hardened and heat-treated steels, alloy | < 900 |
| | | P2.2 Nitrided, case hardened and heat-treated steels, alloy | < 1,400 |
| | P3 | P3.1 Tool, bearing, spring and high-speed steels** | < 800 |
| | | P3.2 Tool, bearing, spring and high-speed steels** | < 1,000 |
| | | P3.3 Tool, bearing, spring and high-speed steels** | < 1,500 |
| | P4 | P4.1 Stainless steels, ferritic and martensitic | |
| | P5 | P5.1 Cast steel | |
| P6 | P6.1 Stainless cast steel, ferritic and martensitic | | |
| M | M1 | M1.1 Stainless steels, austenitic | < 700 |
| | | M1.2 Stainless steels, ferritic/austenitic (duplex) | < 1,000 |
| | M2 | M2.1 Stainless/heat-resistant cast steel, austenitic | < 700 |
| | M3 | M3.1 Stainless cast steel, ferritic/austenitic (duplex) | < 1,000 |
| K | K1 | K1.1 Cast iron with lamellar graphite (grey cast iron), GJL | < 300 |
| | | K2.1 Cast iron with spheroidal graphite, GJS | < 500 |
| | K2 | K2.2 Cast iron with spheroidal graphite, GJS | ≤ 800 |
| | | K2.3 Cast iron with spheroidal graphite, GJS | > 800 |
| | K3 | K3.1 Cast iron with spheroidal graphite, GJV; malleable cast iron, GJM | < 500 |
| | | K3.2 Cast iron with spheroidal graphite, GJV; malleable cast iron, GJM | > 500 |
| N | N1 | N1.1 Aluminium, non-alloy and alloy < 3 % Si | |
| | | N1.2 Aluminium, alloy ≤ 7 % Si | |
| | | N1.3 Aluminium, alloy > 7-12 % Si | |
| | | N1.4 Aluminium, alloy > 12 % Si | |
| S | S1 | S1.1 Titanium, titanium alloys | < 400 |
| | | S2.1 Titanium, titanium alloys | < 1,200 |
| | S2 | S2.2 Titanium, titanium alloys | > 1,200 |
| | | S3.1 Nickel, unalloyed and alloyed | < 900 |
| | S3 | S3.2 Nickel, unalloyed and alloyed | > 900 |

** MAPAL machining groups

** If the alloy components Cr, Mo, Ni, V, W in total > 8 % then select the next higher MAPAL machining group.

The cutting values given are guide values.

The optimum data for the respective machining case should be determined in trials or during machining.

| | Cutting speed v_c [m/min] | | | | Feed f [mm] for drill diameter | | | | | |
|--|-----------------------------|------------------|-----|-----|----------------------------------|-------|-------|-------|-------|-------|
| | Internal cooling | External cooling | MQL | Air | 1.00 | 1.24 | 1.53 | 1.89 | 2.34 | 2.90 |
| | 70 | 65 | 65 | | 0.04 | 0.05 | 0.06 | 0.06 | 0.07 | 0.09 |
| | 65 | 55 | 55 | | 0.04 | 0.05 | 0.06 | 0.06 | 0.07 | 0.09 |
| | 70 | 60 | 60 | | 0.04 | 0.05 | 0.05 | 0.06 | 0.07 | 0.08 |
| | 50 | 40 | 40 | | 0.04 | 0.04 | 0.05 | 0.05 | 0.06 | 0.07 |
| | 55 | 45 | 45 | | 0.04 | 0.04 | 0.05 | 0.05 | 0.06 | 0.07 |
| | 40 | 40 | 40 | | 0.03 | 0.04 | 0.04 | 0.05 | 0.05 | 0.06 |
| | 40 | 30 | 35 | | 0.03 | 0.04 | 0.04 | 0.04 | 0.05 | 0.05 |
| | 40 | 30 | 35 | | 0.02 | 0.03 | 0.03 | 0.04 | 0.04 | 0.05 |
| | 70 | 60 | 60 | | 0.04 | 0.05 | 0.05 | 0.06 | 0.07 | 0.08 |
| | 40 | 30 | 35 | | 0.02 | 0.03 | 0.03 | 0.04 | 0.04 | 0.05 |
| | 35 | 20 | 20 | | 0.02 | 0.03 | 0.03 | 0.04 | 0.04 | 0.05 |
| | 30 | 20 | 20 | | 0.02 | 0.02 | 0.03 | 0.03 | 0.04 | 0.04 |
| | 35 | 20 | 20 | | 0.02 | 0.03 | 0.03 | 0.04 | 0.04 | 0.05 |
| | 30 | 20 | 20 | | 0.02 | 0.02 | 0.03 | 0.03 | 0.04 | 0.04 |
| | 85 | 60 | 60 | 60 | 0.03 | 0.04 | 0.05 | 0.06 | 0.07 | 0.09 |
| | 110 | 70 | 85 | 85 | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 |
| | 70 | 55 | 55 | | 0.04 | 0.05 | 0.05 | 0.06 | 0.07 | 0.08 |
| | 40 | 30 | 35 | | 0.03 | 0.04 | 0.04 | 0.05 | 0.05 | 0.06 |
| | 65 | 55 | 55 | | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 |
| | 55 | 50 | 50 | | 0.04 | 0.05 | 0.05 | 0.06 | 0.07 | 0.08 |
| | 180 | 120 | 150 | | 0.04 | 0.04 | 0.05 | 0.05 | 0.06 | 0.07 |
| | 150 | 110 | 120 | | 0.04 | 0.05 | 0.05 | 0.06 | 0.07 | 0.08 |
| | 130 | 90 | 110 | | 0.04 | 0.05 | 0.05 | 0.06 | 0.07 | 0.08 |
| | 110 | 70 | 90 | | 0.04 | 0.05 | 0.05 | 0.06 | 0.07 | 0.08 |
| | 24 | 15 | | | 0.025 | 0.028 | 0.032 | 0.036 | 0.042 | 0.048 |
| | 18 | 12 | | | 0.021 | 0.024 | 0.027 | 0.031 | 0.036 | 0.041 |
| | 15 | 9 | | | 0.018 | 0.020 | 0.023 | 0.026 | 0.030 | 0.034 |
| | 12 | 9 | | | 0.014 | 0.016 | 0.018 | 0.021 | 0.024 | 0.027 |
| | 9 | 6 | | | 0.018 | 0.020 | 0.023 | 0.026 | 0.030 | 0.034 |



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