GENERAL INFORMATION

Haefeli Diamantwerkzeugfabrik AG · Tel: (+41) 44 377 80 50
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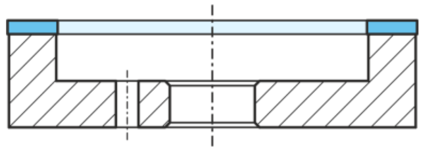
HAEFELI TYPE DESIGNATION

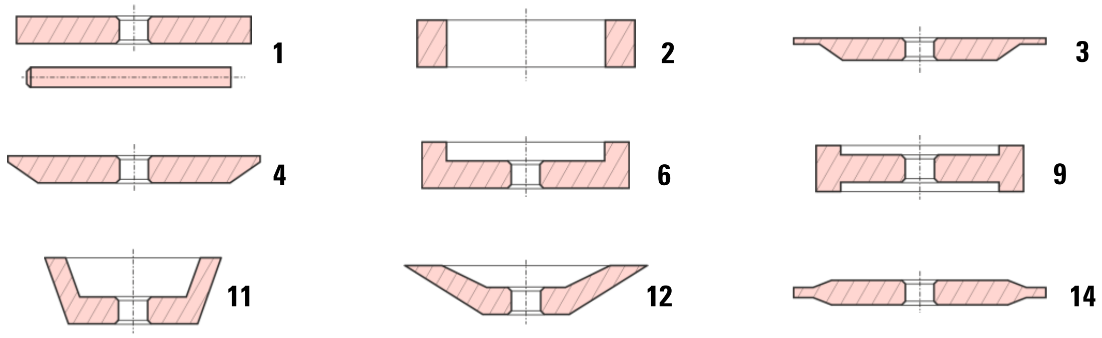
All our grinding tools have a type designation based on the FEPA norm (Federation of European Producers of Abrasives). The first number stands for the core shape, the first letter(s) or for the shape of the abrasive layer, the second number for the position of the abrasive layer while any letters at the end stand for special features. Here is an example:



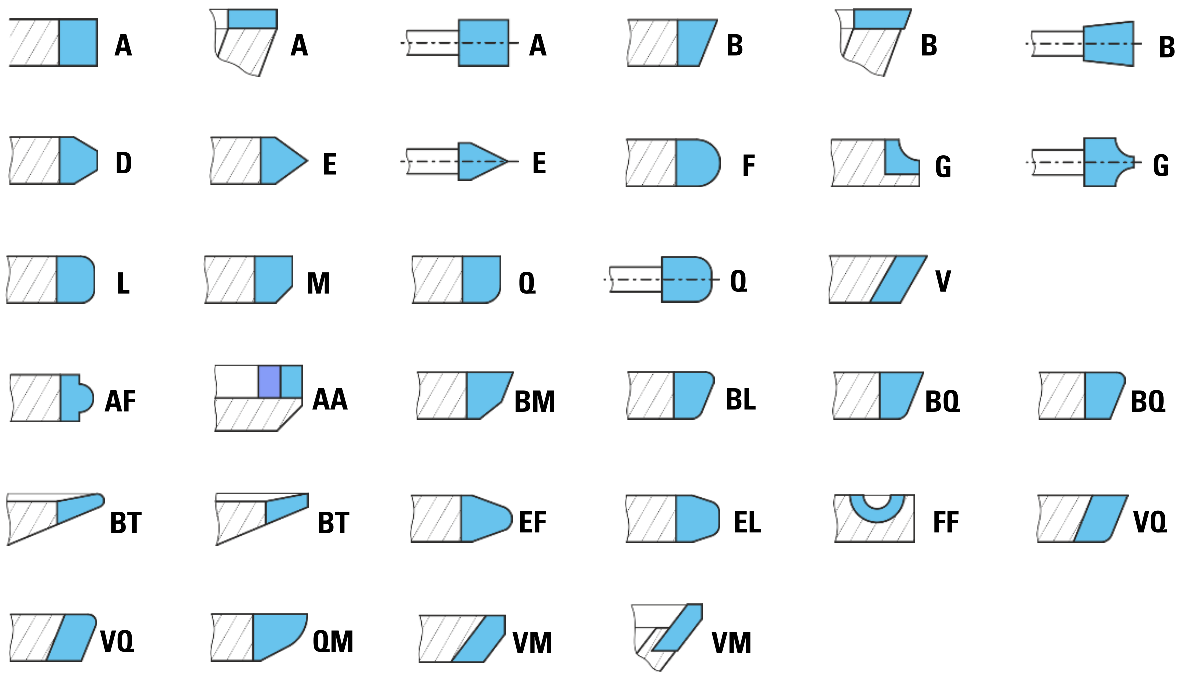
6A2H

Core shape:	**6**	= Cylindrical cup
Shape of abrasive layer:	**A**	= Rectangle
Position of abrasive layer:	**2**	= On one side
Special feature:	**H**	= Additional bore(s)

CORE SHAPE



SHAPE OF ABRASIVE LAYER



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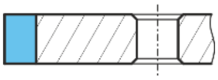
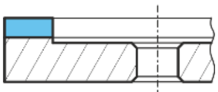
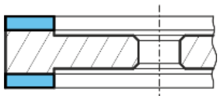
POSITION OF ABRASIVE LAYER



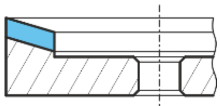
1 - Periphery



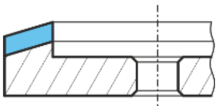
2 - One side



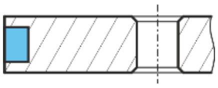
3 - Both sides



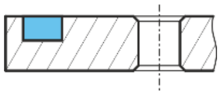
4 - Sloped inwards



5 - Sloped outwards

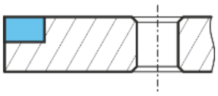


6 - Part of periphery

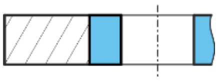


7 - Part of side

8 - Throughout

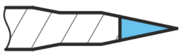


9 - Corner

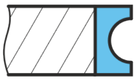


10 - Inside

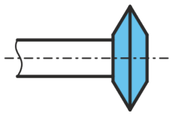
SPECIAL FEATURE



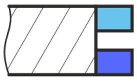
D - Thin/pointed



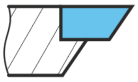
V/Y - Inverted profile



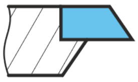
Z - Profile 90° turned



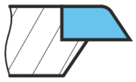
N - Gap between abrasive layers



B - Diameter of abrasive layer smaller on reinforced side

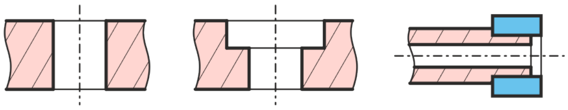


K - Diameter of abrasive layer larger on reinforced side

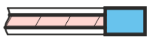


E - Radius closer to the centre, not at the tip as usual

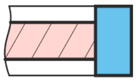
There is also X, that functions as a random differentiating marker



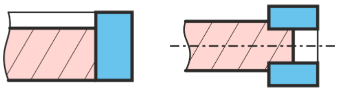
H - Additional bore(s), any shape including coolant holes



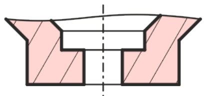
R - Relieved on both sides, thin



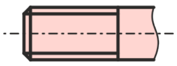
RR - Relieved on both sides, thick



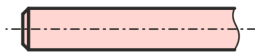
P - Relieved on one side; grinding pins: relieved on the front side



A - Cylindrical core at the bottom

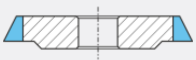


G - Thread



W - Shank

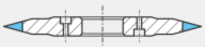
Examples



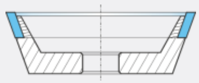
3B1K

1E1W

1E1WZ



14E1DH



11V9

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GRAVUR

Our **wheels** are engraved with the following:

The **ID number** that can be found on each of our grinding tools is not an article number but a lot number from our production. Our tools can be exactly identified and traced back to the year 1956 with that number. The ID number is always recorded in our order confirmations, invoices and delivery notes.

Grinding wheels with diamond are marked **green** while those with CBN are marked **red**. This colour code can also be found in this catalogue.

Depending on the wheel, additional information can be engraved such as the angle, radius or maximum cutting speed.

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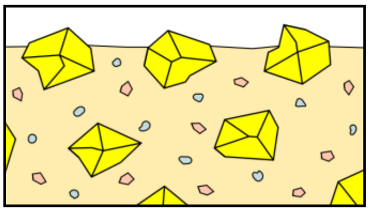
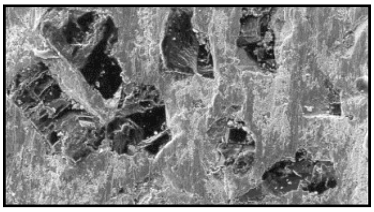
BONDS

In addition to the quality of the abrasive grains, the grit size and the concentration of the grains in the abrasive layer, the bond has decisive influence on the grinding performance. All sorts of different grinding tasks can be optimally tackled with various adapted bonds. For this, we have more than 400 self-developed bonds at our disposal.

Metal bonds

M (**M**etal)





- **highest tool life**
- **very wear resistant**
- **excellent profile and edge retention**
- **application-specific variants**

Sintered metal bonds are predominantly bronze alloys and distinguish themselves with their particular high hardness. The abrasive grains are tightly enclosed, which leads to the grinding wheel appearing “blunter”, but also to significantly longer tool life and higher shape retention. In contrast to resin ceramic bonds, metal bonds generate more grinding heat and shallower depths of cut have to be used if the protrusion of the abrasive grains from the bond is not maintained (see → 4-08). Metal bonds are ideal for profiles, small radiuses starting from 0.02 mm, thin wheel widths and smallest grinding pins starting from ø 0,18 mm as well as when grinding materials subject the bond to high levels of wear. Our metal bonds can be eroded very well and are very wear resistant. We possess a large selection of various metal bonds suited for different applications.

Materials		
Diamond:	especially carbide, technical ceramics (Al_2O_3, ZrO_2, Si_3N_4), sapphire, ruby, glass and cermet	
CBN:	high speed steel, alloyed tool steel, hardened steel, ...	
Cooling:	wet (oil, emulsion) and dry grinding	
Dressing:	with rotating SiC wheels (no stationary dressers or metal bonded dressing wheels!) or electrical discharge machining (EDM)	
Regenerating:	HACO-FLEX	
Cutting speed:	between 2 and 30 m/s, optimal mostly between 20 and 25 m/s (guide values)	
Grinding wheels: (in general)	Type/shape:	small 1A1W, distinct profile, e.g. 14E1D, 1E1W
	Diameter:	ø 0.18 - 300 mm
	Grit sizes:	D/BN 16 - D/BN 251
	Concentration:	C 30 - C 175

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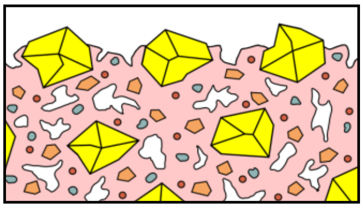
Metal hybrid bonds (SHARKLINE)

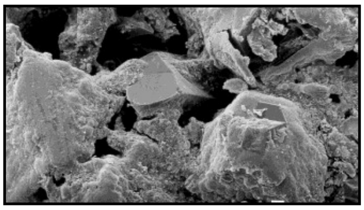
Specially for creep feed grinding with high feed rates and deep depths of cut on the newest CNC machines we have developed metal hybrid bonds with a lot of bite. They have a more porous bond structure and thus generate less grinding pressure and in consequence less heat.

Materials		
Diamond:	carbide, (ceramics)	
CBN:	HSS	
Cooling:	wet (oil)	
Dressing:	rotating SiC wheels (no stationary dressers or metal bonded dressing wheels!) or electrical discharge machining (EDM)	
Regenerating:	HACO-FLEX	
Cutting speed:	14 m/s (guide value)	
Grinding tools:	Type/shape:	esp. 1A1, 1V1, 11A2, 11B2, 12A2, 12B2
(in general)	Diameter:	ø 75 - 250 mm
	Grit sizes:	D 46 - 64, BN 64 - BN 126
	Concentration:	C 75 - C 100

Resin bonds

R (Resin)





- **universally applicable**
- **low grinding forces**
- **cheapest bond**
- **application-specific variants**

Resins containing the abrasive grains and fillers are used as the binding agent with which the grinding characteristics of the bond can be selectively regulated. Grinding wheels with resin bonds offer rapid and cool grinding, can be used for dry and wet grinding and generate only low grinding forces. The maximum thermic load of this bonding system lies between 200° and 350° C. Resin bonds can be used for polishing, creep feed grinding with high stock removal rates and anything in between. In short, it is the most universally applicable bond which also happens to be the cheapest.

Materials	
Diamond:	esp. carbide, but also cermet and ceramics
CBN:	high speed steel, alloyed tool steel, hardened steel, ...
Cooling:	wet (oil, emulsion) & dry grinding
Dressing:	rotating SiC wheels (no stationary dressers or metal bonded dressing wheels!)
Regenerating:	HACO-FLEX
Cutting speeds:	between 15 and 35 m/s, optimal mostly between 25 and 28 m/s (guide values)

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Resin ceramic bonds

Resin ceramic bonds work with the smallest grinding pressures, can be used in wet or dry grinding and with the finest as well as the most coarse grit sizes. Our resin ceramic bonds have a broad range of application. Nevertheless, we have a large number of application-specific resin ceramic bonds.

Grinding tools:	Type/shape:	basically all forms and shapes
(in general)	Diameter:	ø 3 - 400 mm
	Grit sizes:	D/BN 3 - D/BN 251
	Concentration:	C 30 - C 125

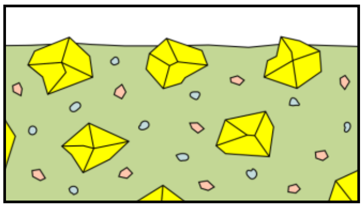
Resin hybrid bonds

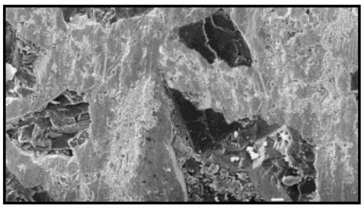
For deep grinding, particularly for tool grinding with high stock removal rates, we have developed resin hybrid bonds that distinguish themselves with their long tool life and high profile retention. Thanks to their excellent ability to divert heat away, high stock removal can be achieved. Grinding wheels with resin hybrid bonds are only used wet (oil) and on CNC machines. Materials to be machined are mainly carbide and cermet. These bonds can be spark eroded with the right body.

Grinding tools:	Type/shape	z.B. 1A1, 1V1, 11V9, 12A2, 14E1D
(in general)	Diameter:	ø 3 - 200 mm
	Grit sizes:	D 30 - D 151, BN 46 - BN 151
	Concentration:	C 75 - C 125

Bakelite bonds

B (Bakelite)





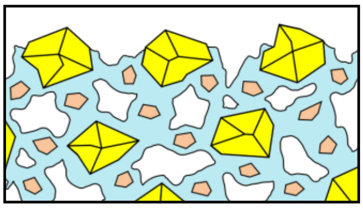
- **Polishing**

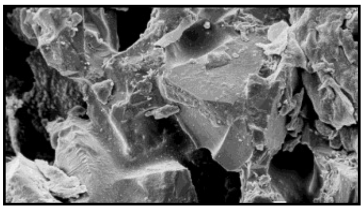
Bakelite (thermosetting plastic), to which fillers have been added along with the abrasive grains, is used as the binding agent. This bond can be used with fine abrasive grains due to their polishing effect. Grinding wheels with bakelite bond are only used in a few exceptional cases as the more versatile resin bond can handle the grinding tasks better most of the time.

Grinding tools:	Type/shape:	e.g. 1A1W, 6A2, 9A3
(in general)	Diameter:	ø 3 - 200 mm
	Grit sizes:	D/BN 3 - D/BN 26
	Concentration:	C 30 - C 125

Vitrified bonds

V (Vitrified)



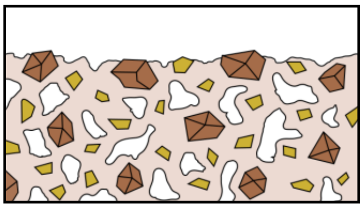


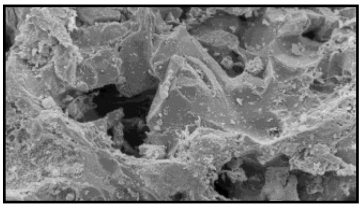
- **high stock removal rates**
- **high porosity**
- **low grinding pressures**
- **easy to dress**

A mixture of meltable glass powder, fillers and abrasive grains constitutes the vitrified bond. In contrast to the metal and resin bonds, the vitrified bond offers amongst others the advantage that a certain pore volume can be produced. Due to its porosity, the bond is suitable for materials producing long chips. Vitrified bonds are mainly used in conjunction with CBN. As the bond is made from glass, the grinding wheels cannot withstand major impacts or temperature shocks. Uninterrupted cooling is therefore always required. The vitrified bond provides cool grinding with low grinding forces and can be easily dressed on the machine with rotating dressers. Hence, it is particularly suited for the production on a large scale and the production of thin workpieces.

Materials		
CBN:	high alloyed tool steel and hardened steel, but also high speed steel (HSS)	
Cooling:	only wet (oil, emulsion)	
Dressing:	rotating metal bonded wheels	
Regenerating:	not necessary	
Cutting speeds:	between 20 and 45 m/sec, optimal mostly between 30 and 35 m/sec (guide values)	
Grinding tools:	Type/shape:	1A1W, 1A1, profiles
(in general)	Diameter:	ø 4 - 60 mm
	Grit sizes:	BN 46 - BN 251 (D 7 - D 30)
	Concentration:	C 100 - C 150

Ceramic bonds (conventional grinding wheels)





Ceramic bonds are used in conventional grinding wheels that contain neither diamond or CBN but silicon carbide (SiC) or corundum. We do not offer such wheels except as dressing wheels for dressing our diamond and CBN grinding wheels. The ceramic bond consists of meltable glass powder, filler and abrasive grains. It can be used to grind "soft" (<50 HRC) workpieces. As the bond uses higher grinding forces and is subjected to higher wear such wheels are not recommended for harder materials.

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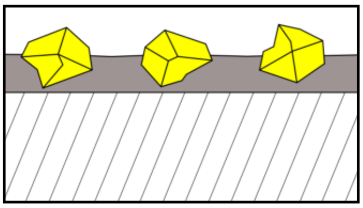
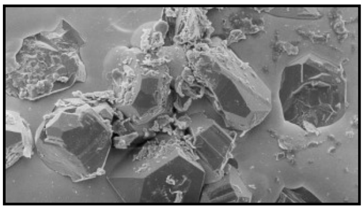
Electroplated bonds

E (Electro Plated)





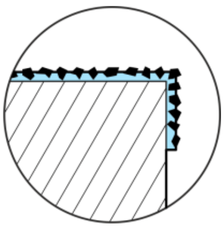
- **complex profile shapes possible**
- **single-layered bond**

This bond is electroplated onto a base body made from steel or carbide. As a result of this coating process, the bond has large chip spaces. The galvanic bond is particularly suited for coating profiled base bodies. Profile accuracy does depend on the grain size though. Due to the large grain protrusion, the electroplated wheel has good grip and leaves the workpiece with a very rough surface. With increased use, the grip is reduced as the abrasive tips are worn away. Depending on the size of the base body, it can be worth it to recoat the body when the thin abrasive layer has been used up.

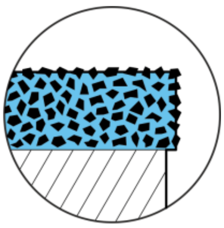
Materials		
Diamond:	in particular plastics, incl. glass fibre reinforced (GRP), carbide	
CBN:	alloyed tool steel, hardened steel, high speed steel	
Cooling:	wet (oil, emulsion) & dry grinding	
Dressing:	not possible	
Regenerating:	not possible	
Cutting speeds:	dry grinding 8 - 18m/s (diamond), 15 - 25m/s (CBN) wet grinding 15 - 25m/s (diamond), 25 - 40m/s (CBN)	
Grinding tools: (in general)	Type/shape: Diameter: Grit sizes:	profiles ø 0.5 - 400 mm D/BN 46 - D/BN 352

Advantages of sintered bonds

While the abrasive layer is massive in sintered bonds, it consists only of a thin layer in electroplated bonds. When the abrasive grains that were electroplated are blunting or breaking out, grinding is no longer possible. Not with sintered bonds where the whole thick abrasive layer is permeated with abrasive grains and where grinding is possible until the very last grain. Hence, sintered bonds have massively higher durability and are therefore very economical. In addition, sintered bonds have better edge retention than electroplated bonds and result in finer surfaces when using the same grit size. Furthermore, electroplated bonds are not suitable for small grit sizes.



electroplated



sintered

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ABRASIVES and MATERIALS

The abrasives contained in our grinding tools are diamond and CBN. Through choosing the suitable grain the grinding behaviour can be decisively influenced. We consider the different characteristics of the grain such as its size, outer and inner structure, cutting and splitting properties as well as any coating of grains.

Diamond

For our grinding tools we use natural as well as synthetic diamonds. Even though diamond is the hardest material known (≈ 70'000 - 80'000 N/mm² Knoop hardness), not everything can be ground with it as some materials can react with the carbon of the diamond.

Brittle, crystalline, not long swarf building materials are ground with diamond such as:

- carbide, all kinds of
- oxide and non-oxide ceramics, amongst others:
  - alumina (Al_2O_3)
  - zirconium oxide (ZrO_2)
  - silicon nitride (Si_3Ni_4)
  - silicon carbide (SSiC, SiSiC)
- cermet
- ferrite
- silicon
- silicon carbide and emery grinding wheels (dressing)
- titanium carbide (Ferro-TiC, Ferro-Titanit)
- graphite
- glass
- quartz
- technical gemstones (sapphire, ruby)
- other precious and semi-precious stones
- spraying alloys and hard facing alloys
- carbide-based powder coating
- glass fibre and carbon fibre plastics (FRP)
- PCD & CBN plates
- ...

CBN

CBN (**C**ubic **B**oron **N**itride) is the second hardest material (≈ 45'000 - 48'000 N/mm² Knoop hardness). CBN cannot be found in nature; it is exclusively manufactured artificially.

Hard (sometimes already from 45 HRC though), non-crystalline, long swarf building materials are ground with CBN such as:

- tool steel, incl.
  - high speed steel (HSS)
  - hot working steel
  - cold working steel
- case hardening steel
- heat treatable steel
- hardened steel alloy
- high alloy steel
- chrome steel
- stellite
- steel on cobalt and nickel basis
- powder metallurgical steel (PM steel)
- nickel-based super-alloy
- iron-based powder coating
- chilled casting
- ...

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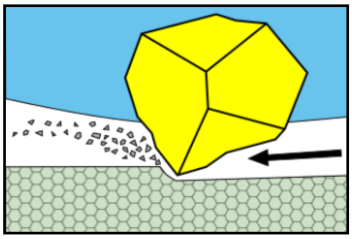
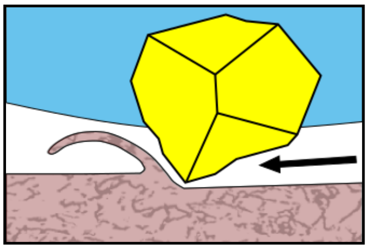
Grinding with diamond



When grinding said materials with diamond, small particles are knocked from the material (dust formation). As there is no need to shorten any chips with those materials, grinding can be done with lower cutting speeds but deeper depths of cut in comparison to grinding with CBN.

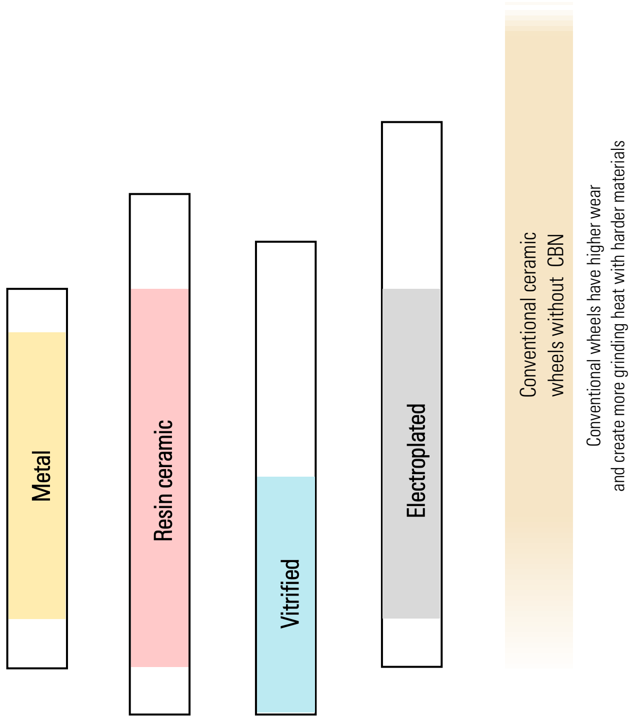
Grinding with CBN



When grinding said materials with CBN shorter or longer chips are formed. In order to keep the chips small and short so that the bond and the grain get damaged less, higher cutting speeds are used in comparison to grinding with diamond. To give the chips enough room, CBN grinding wheels with lower concentrations are normally used.

Grinding of steel with CBN: range of application of the bonds

Tensile strength N/mm2	Hardness HRC
≈ 500	-
[...]	[...]
≈ 1400	44
≈ 1480	46
≈ 1575	48
≈ 1675	50
≈ 1795	52
≈ 1910	54
≈ 2050	56
≈ 2200	58
	60
	62
	64
	66
	68



Metal bond:	52 - 66 HRC, esp. 54 - 64 HRC
Resin ceramic bond:	48 - 68 HRC, esp. 52 - 66 HRC
Vitrified bond:	50 - 68 HRC, esp. 60 - 68 HRC
Electroplated bond:	45 - 66 HRC, esp. 52 - 64 HRC

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GRAIN SIZES (D & BN)

FEPA grains Micrometre (µ) min. - max.	Diamond FEPA	Diamond Application	CBN FEPA	CBN Application	Mesh sizes US mesh
212 - 250	D 251	Rough grinding	BN 251	Very rough grinding	60 - 70
180 - 212	D 213		BN 213		70 - 80
150 - 180	D 181		BN 181		80 - 100
125 - 150	D 151		BN 151		100 - 120
106 - 125	D 126		BN 126		120 - 140
90 - 106	D 107	Pre-grinding	BN 107	Rough grinding	140 - 170
75 - 90	D 91		BN 91		170 - 200
63 - 75	D 76		BN 76		200 - 230
53 - 63	D 64	Finegrinding	BN 64	Pre-grinding	230 - 270
45 - 53	D 54		BN 54		270 - 325
38 - 45	D 46		BN 46		325 - 400

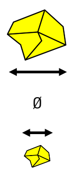
Mesh sizes are used with emery or silicon carbide wheels.

No uniform designation for micro grain sizes

Micro grains Micrometre (µ) min. - max.	Diamond HAEFELI	Diamond Application	CBN HAEFELI	CBN Application	Manufacturer Example A	Manufacturer Example B	Mesh sizes US mesh
30 - 40	D 41	Finishing	BN 41	Finegrinding		MD/MB 25	
32 - 38	D 39		BN 39				≈ 400 - 500
22 - 36	D 37		BN 37				
25 - 32	D 33		BN 33	Finishing	D/B 30		≈ 500 - 600
20 - 30	D 31		BN 31		D 25	MD 20	
15 - 25	D 26		BN 26		D 20	MD 18	≈ 550 - 1'000
12 - 22	D 23		BN 23			MD/MB 16	
10 - 20	D 21		BN 21		D/B 15		≈ 625 - 1'250
8 - 15	D 16		BN 16		D 10		
6 - 12	D 13		BN 13		D 7	MD 10	≈ 1000 - 2'200
6 - 10	D 11		BN 11				≈ 1'250 - 2'200
4 - 8	D 9		BN 9		D 6	MD 6.3	≈ 1'750 - 3'000
3 - 6	D 7					MD 4	
1 - 5	D 6						≈ 2'500 - 12'000
2 - 4	D 5				D 3	MD 2.5	
0.5 - 3	D 4						≈ 4'500 - 12'000
1 - 2	D 3				D 1	MD 1	
0 - 1	D 2						≈ >12'000

1 micrometre (µ) = 0.001 mm, i.e. 1/1000 mm.

With micro grains, many grinding wheel manufacturers base their grit size designation on the medium size of the grains used, even though the largest grains decisively determine the surface quality. We, however, carry the FEPA norm for the larger grains into the micro grains: largest grain in micrometre +1 = HAEFELI designation. The higher the number, the larger the grain. It is the opposite with mesh sizes, as the designation corresponds to the number of mesh in a sieve of one inch length, through which the grains can still be sieved through.



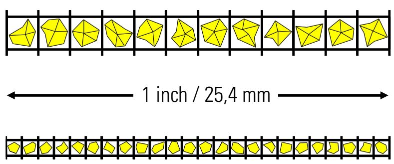
HAEFELI/FEPA:

180 µ + 1 = D/BN 181 corresponds to 100

largest grain + 1 meshes per inch

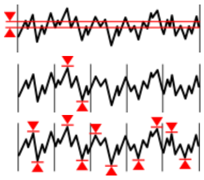
45 µ + 1 = D/BN 46 corresponds to 400

US mesh:

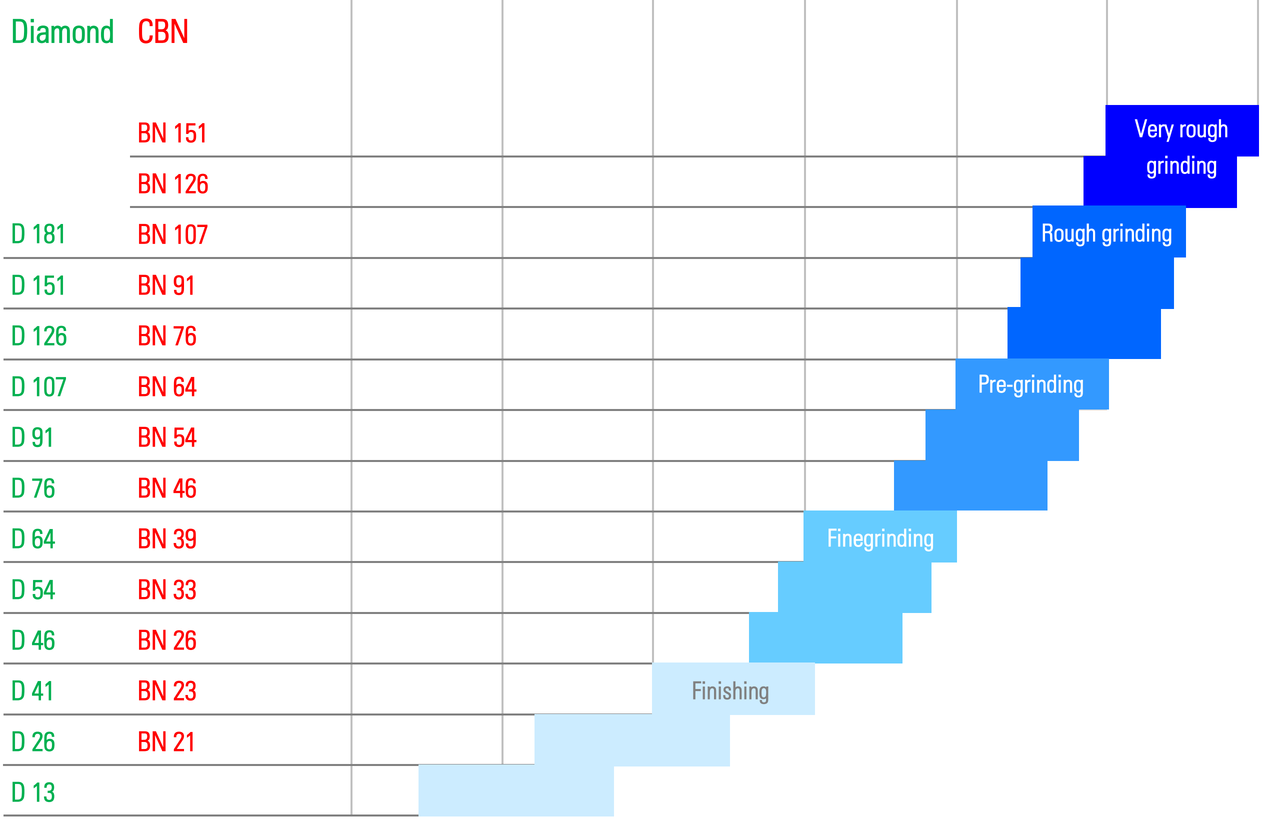


SURFACE QUALITY

Guide values for **cross-grinding** with HAEFELI cup wheels in resin ceramic bond.



micron (µ)						
Ra	**0.025**	**0.05**	**0.10**	**0.20**	**0.40**	**0.80**
Rmax	0.50	0.80	1.25	2.50	5.00	8.00
Rz	0.4	0.63	1.00	2.00	4.00	6.30
	N1	N2	N3	N4	N5	N6



Given the same grain size, finer surface qualities can be achieved with diamond than with CBN.

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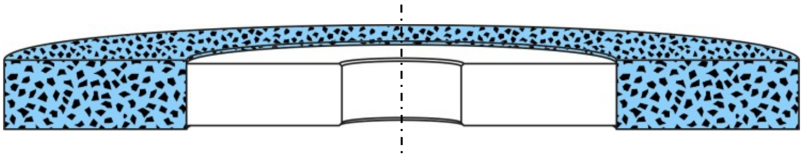
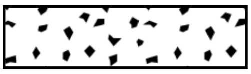
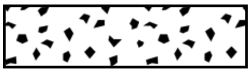
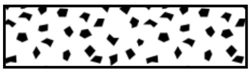
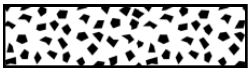
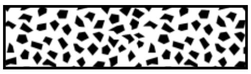
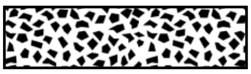
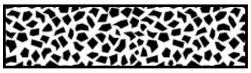
CONCENTRATION (C)



The concentration C indicates how much diamond or CBN is contained in the abrasive layer. The higher the number, the higher the content of diamond or CBN grains in the abrasive layer. Usually the concentration is between C 50 and C 150, i.e. the abrasive layer consists between 12.5% and 37.5% of diamond or CBN

	Diamond & CBN Volume %	Designation: FEPA Diamond & CBN C	Designation: CBN V
	0 V%	**C 0**	(≈ V0)
	7.5 V%	**C 30**	≈ V70
	12.5 V%	**C 50**	≈ V120
	15 V%	**C 60**	≈ V150
	18.75 V%	**C 75**	≈ V180
	25 V%	**C 100**	≈ V240
	31.25 V%	**C 125**	≈ V300
	37.5 V%	**C 150**	≈ V360
	50 V%	**C 200**	≈ V480
	100 V%	**C 400**	(≈ V1000)

The higher the concentration, the more abrasive grains are actively in use. This leads to longer tool life and better form retention, but also to larger grinding forces. Higher concentrations are used with small grinding contact surfaces (e.g. pointed profile wheels). Lower concentrations are used with large grinding contract surfaces (e.g. flat grinding wheels).

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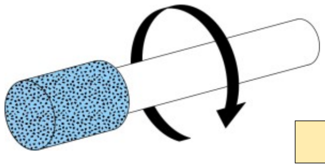
CUTTING SPEEDS (rpm)

The table below converts the cutting speed - also known as the peripheral speed (v_c) - of the grinding wheel or grinding pin from meter per second (m/s) to revolutions per minute (rpm). It also shows in which range our bonds are usually used and where the optimum normally lies. The cutting speeds are faster with CBN than with diamond, faster with coolant than without.



Vitrified (Dia/CBN: **30 - 35 m/s**)

Resin (Dia/CBN: **25m/s - 28m/s**)

Metal (Dia/CBN: **20 - 25 m/s**)

Vitrified (grinding tool ø 4 - 60 mm)

Resin ceramic (grinding tool ø 3 - 400 mm)

Metal (grinding tool ø 0.18—300 mm)

Diameter of grinding tool	2 m/s	5 m/s	10 m/s	15 m/s	20 m/s	25 m/s	30 m/s	35 m/s	40 m/s	45 m/s
ø 600.0 mm	64	159	318	477	637	796	955	1’114	1’273	1’432
ø 500.0 mm	76	191	382	573	764	955	1’146	1’337	1’528	1’719
ø 400.0 mm	95	239	477	716	955	1’194	1’413	1’671	1’910	2’148
ø 350.0 mm	109	273	546	818	1’091	1’364	1’637	1’910	2’182	2’455
ø 300.0 mm	127	318	637	955	1’273	1’591	1’910	2’228	2’546	2’864
ø 250.0 mm	153	382	764	1’146	1’528	1’910	2’292	2’673	3’055	3’437
ø 225.0 mm	170	424	849	1’273	1’697	2’122	2’546	2’971	3’395	3’819
ø 200.0 mm	191	477	955	1’432	1’910	2’387	2’864	3’342	3’819	4’297
ø 175.0 mm	218	546	1’091	1’637	2’182	2’728	3’274	3’819	4’365	4’910
ø 150.0 mm	255	637	1’273	1’910	2’546	3’183	3’819	4’456	5’092	5’729
ø 125.0 mm	306	764	1’528	2’292	3’055	3’819	4’583	5’347	6’111	6’875
ø 100.0 mm	382	955	1’910	2’864	3’819	4’774	5’729	6’684	7’638	8’593
ø 75.0 mm	509	1’273	2’546	3’819	5’092	6’365	7’638	8’912	10’185	11’458
ø 50.0 mm	764	1’910	3’819	5’729	7’638	9’548	11’458	13’367	15’277	17’187
ø 40.0 mm	955	2’387	4’774	7’161	9’548	11’935	14’322	16’709	19’096	21’483
ø 30.0 mm	1’273	3’183	6’365	9’548	12’731	15’913	19’096	22’279	25’461	28’644
ø 25.0 mm	1’528	3’819	7’638	11’418	15’277	19’096	22’915	26’735	30’544	34’373
ø 20.0 mm	1’910	4’774	9’548	14’322	19’096	23’870	28’644	33’418	38’192	42’966
ø 15.0 mm	2’546	6’365	12’731	19’096	25’461	31’827	38’192	44’558	50’923	57’288
ø 12.0 mm	3’183	7’957	15’913	23’870	31’827	39’784	47’740	55’697	63’654	71’610
ø 10.0 mm	3’819	9’548	19’096	28’644	38’192	47’740	57’288	66’836	76’384	85’933
ø 8.0 mm	4’774	11’935	23’870	35’805	47’740	59’675	71’610	83’546	95’481	107’416
ø 6.0 mm	6’365	15’913	31’827	47’740	63’654	79’567	95’481	111’394	127’307	143’221
ø 5.0 mm	7’638	19’096	38’192	57’288	76’384	95’481	114’577	133’673	152’769	171’865
ø 4.0 mm	9’548	23’870	47’740	71’610	95’481	119’351	143’221	167’091	190’961	214’831
ø 3.0 mm	12’731	31’827	63’654	95’481	127’307	159’134	190’961	222’788	254’615	286’442
ø 2.0 mm	19’096	47’740	95’481	143’221	190’961	238’701	286’442	334’182		
ø 1.8 mm	21’218	53’045	106’090	159’134	212’179	265’224	318’269			
ø 1.5 mm	25’461	63’654	127’307	190’961	254’615	318’269				
ø 1.2 mm	31’827	79’567	159’134	238’701	318’269					
ø 1.0 mm	38’192	95’481	190’961	286’442						
ø 0.8 mm	47’740	119’351	238’701							
ø 0.6 mm	63’654	159’134	318’269							
ø 0.5 mm	76’384	190’961								
ø 0.4 mm	95’481	238’701								
ø 0.3 mm	127’307	318’269								
ø 0.2 mm	190’961									

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GRINDING PARAMETERS

Depth of cut a_e

Giving general values for the depth of cut is difficult since it depends on so many factors (grinding type, abrasive grain, bond, material to be ground, grinding contact surface, cooling, stability of the machine, infeed, cutting speed, clamping and so forth). Nonetheless, we cautiously try to give some reference points for the depth of cut.

In general, cutting depths in the range of about **10 - 12% of the grain size** used per stroke or workpiece revolution is not a bad start (for the grit sizes and the designation used by us, please refer to page 1-10). With the exception of creep feed grinding, the depth of cut should **generally not exceed 1/3 of the grit size**.

When grinding internally, the depth of cut should normally be less than the aforementioned 8 - 12% of the grit size. Said range can be exceeded with electroplated bonds in general. The depth of cut can of course be higher when deep grinding with good cooling (creep feed grinding).

Speed ratio q_s

The speed ratio q_s indicates the ratio between the peripheral speed of the grinding wheel and the peripheral speed of the workpiece.

With cylindrical grinding, it is generally advised that the peripheral speed of the grinding wheel exceeds the peripheral speed of the workpiece by a factor of 60 to 120 (roughing: 60-80, finishing: 80-120). With creep feed grinding the speed ratio is massively higher (> 1’200).

$$Q_s = \frac{\text{peripheral speed of grinding wheel } v_c \text{ (m/s) x 1000 x 60}}{\text{peripheral speed of workpiece } v_w \text{ (mm/min)}}$$

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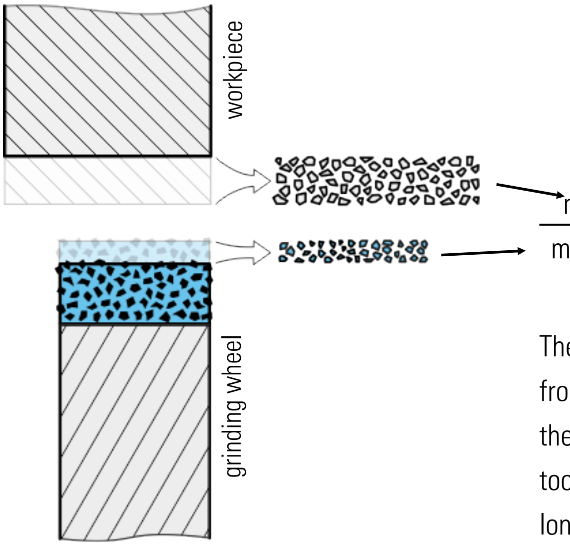
KEY FIGURES IN THE GRINDING PROCESS

G-ratio

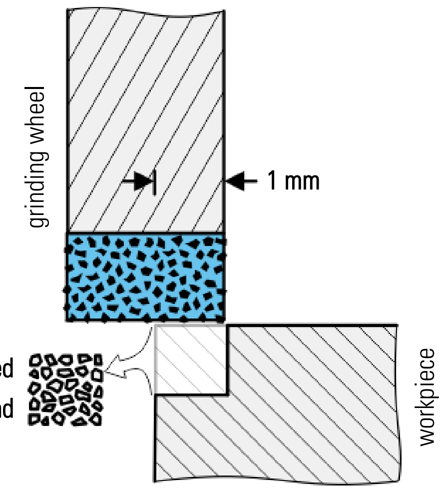


$$\frac{\text{mm}^3 \text{ (removed from the workpiece)}}{\text{mm}^3 \text{ (removed from the grinding tool)}} = \text{G-ratio}$$

The G-ratio indicates the ratio of the volume of material removed from the workpiece(s) and the volume that has been consumed on the grinding wheel through abrasion and dressing. Our grinding tools distinguish themselves with high G-ratios. Thus, they have long tool lives.

Specific material removal rate Q'_w

The specific material removal rate indicates how many cubic millimetres (mm³) a grinding tool can remove from the workpiece in one second per one millimetre wheel width.



Formulas that are valid for most grinding types:

Internal and external cylindrical grinding (without significant cross feed):

$$Q'_w = \frac{a_e \cdot n_w \cdot d_w \cdot \pi}{60}$$

a_e = depth of cut in mm per revolution of the workpiece
n_w = revolution of the workpiece per minute
d_w = internal or external diameter of the workpiece in mm

Flat/surface grinding:

$$Q'_w = \frac{a_e \cdot n_w}{60}$$

a_e = depth of cut in mm per stroke
n_w = workpiece (table) speed in mm per minute

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DRESSING

Dressing is for restoring the desired geometry of the abrasive layer and to correct any radial and axial runouts.

Generally, our grinding tools keep their shape and profile for very long if used correctly so that dressing is only rarely required. After each dressing, but also in between dressing intervals, we recommend to open the abrasive layer (metal or resin ceramic bond) with regenerators in order to obtain an ideal protrusion of the abrasive grains from the bond (HACO-FLEX → 4-02).

Our grinding tools should only be dressed with silicon carbide wheels, never with single point dressers or multiple diamond dressers. Vitrified bonds (V5000) ideally should be dressed with metal bonded diamond grinding wheels (→ 4-05). SiC dressing wheels that are suited for our grinding tools can be obtained from us (→ 4-04). We also offer our services for regrinding wheels.

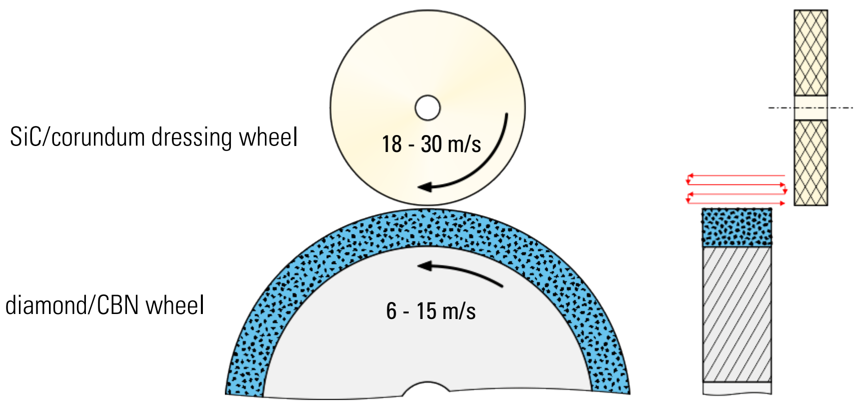
The values below are **approximate values**.

Dressing with powered grinding wheel

Dressing can be done on a dressing machine (wheel profiling machines) or within the cylindrical grinding machine itself, where the dressing wheel is mounted like a workpiece.

Peripheral wheel speeds:	**18 - 30 m/s**	SiC or corundum dressing wheel
	6 - 15 m/s	Diamond/CBN wheel (**concurrent rotation**)
	The peripheral wheel speed of the dressing wheel should be about **2x** - **3x** faster than that of the diamond or CBN wheel.	
Depth of cut per stroke:	**> 0.01 mm, but at least 1/3 of the grain size** (e.g. with D 64 at least 0.02 mm, with D 151 at least 0.05 mm). Depth of cut can be larger with wheels in metal and vitrified bonds than with wheels in resin ceramic bonds. After every stroke, the grinding wheels have to overtravel each other fully, i.e. they should not touch each other.	
Traverse feed:	200 - 400 mm/min	

In general, dressing can be done with or without coolant. Vitrified bonds, however, should preferably only be dressed wet since they do not sustain high temperatures.



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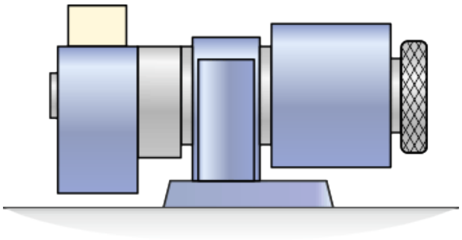
Dressing with brake controlled truing device

A method less used is the dressing with small devices with a centrifugal brake. For detailed instructions please refer to the information given by the manufacturer of such devices.



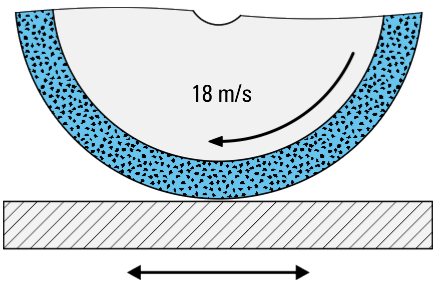
Brake controlled truing device

Dressing with soft steel

If the aforementioned methods are not available, wheels with resin ceramic or vitrified bonds can also be dressed by grinding soft steel. However, this takes longer. Normal construction steel can be used (St 37-2 / S235 JR).

Peripheral wheel speeds:	≈ 18 m/s	Diamond/CBN wheels
	≈ 0.3 m/s	Cylindrical grinding with steel cylinder
Traverse feed/table speed:	16 - 24 m/min	Flat grinding with steel plate
Depth of cut per stroke:	≈ 0.008 - 0.01 mm	with medium grit size

Dry or wet grinding. With vitrified bonds only wet.

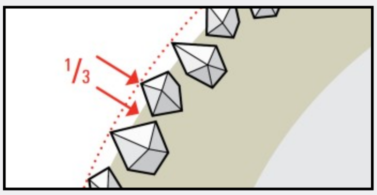


Diamond/CBN wheel

Steel plate

Regenerate for more bite

We recommend regenerating the abrasive layer in metal or resin bond after each dressing, but also between dressing intervals, so that the abrasive grains protrude by about 1/3 from the bond. The wheel then grinds with less heat and pressure → 4-02



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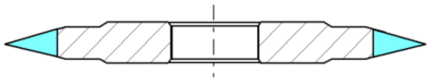
HAEFELI SWISS MADE

Dressing of 14E1D pointed profile wheels

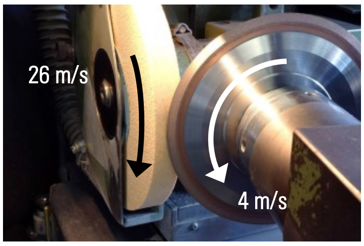


The pointed profile wheels of HAEFELI belong to the very best. To tap their full potential over their tool life, we recommend the following values. They apply to our standard grit sizes for this type of wheels:

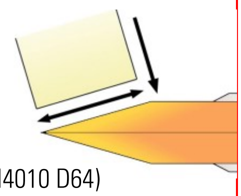
Resin hybrid bond **R159** **D126** & metal bond **M4010** **D64**

Dressing wheel:	Soft ceramic wheel of medium structure and porosity (aluminium oxide with grit 120)
Bond regenerator:	HACO-FLEX, „RGIH" disc or „RSCE" stick

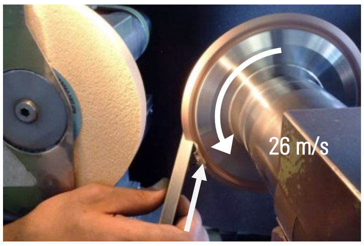
1. Dressing the flanks



Pointed profile wheel:	4 m/s	
Dressing wheel:	26 m/s (concurrent rotation)	
Oscillating swing.	Infeed at the rear:	
Roughing:	0.05 - 0.10 mm (R159 D126)	0.03 - 0.07 mm (M4010 D64)
Finishing:	0.02 - 0.05 mm (R159 D126)	0.01 - 0.03 mm (M4010 D64)

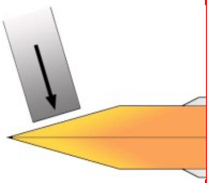


2. Regenerating the flanks

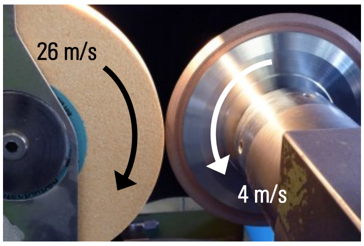


Pointed profile wheel: 26 m/s

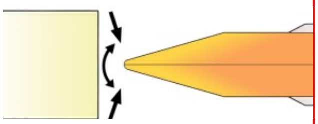
Press the HACO-FLEX regenerator (RGIH/RSCE) continuously by hand very lightly into the flanks from the side.



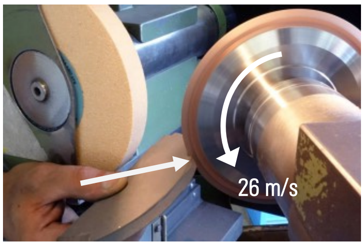
3. Dressing the radius



Pointed profile wheel:	4 m/s
Dressing wheel:	26 m/s (concurrent rotation)
Oscillating swing.	Infeed left and right:
Finishing:	0.01 - 0.02 mm (R159 D126 & M4010 D64)

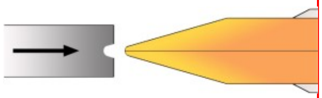


4. Regenerating the radius



Pointed profile wheel: 26 m/s

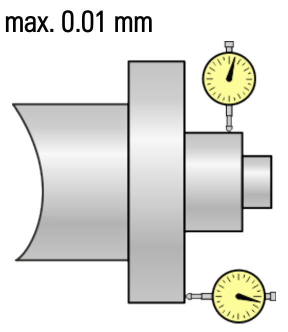
Press the HACO-FLEX regenerator (RGIH/RSCE) lightly by hand and only shortly, but continuously head-on.

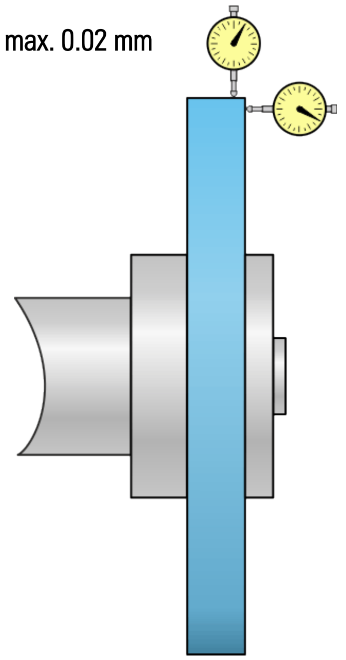


With grit sizes smaller than D/BN 64 the infeed has to be reduced accordingly and finer dressing wheels have to be used. With very small grit sizes (≤ D/BN 26) the dressing wheel should only turn half as fast, i.e. with about 13 m/s.

4 m/s ≈	ø 75 mm: 1'000 rpm	ø 100 mm: 760 rpm	ø 150 mm: 500 rpm	ø 175 mm: 440 rpm	ø 200 mm: 380 rpm	ø 250 mm: 300 rpm
26 m/s ≈	ø 75 mm: 6'600 rpm	ø 100 mm: 5'000 rpm	ø 150 mm: 3'300 rpm	ø 175 mm: 2'850 rpm	ø 200 mm: 2'500 rpm	ø 250 mm: 2'000 rpm

MOUNTING OF GRINDING WHEEL





- The flange must be ground and appropriate for the bore tolerance. Our bores are manufactured according to your diameter specifications with ISO H7 tolerance (ISO H6 available upon request).
- Control the flange without the wheel on the machine. The concentricity and axial run-out has to be less than 0.01 mm.
- The wheel now has to be positioned with loosely tightened flange screws. The concentricity and axial run-out should be less than 0.02 mm. The finer the grit size the more important it is to keep the run-outs as small as possible.
- Tighten the screws.
- In general, all HAEFELI wheels are balanced. Depending on the application the wheels still have to be balanced finely on the flange.
- If necessary, the grinding wheel has to grind for a while to correct the last radial run-outs.

  Option A: Grind a soft material for a couple of minutes (→1-19).

  Option B: Dress the wheel with SiC dressing wheels (→1-18). It is recommended to regenerate the abrasive layer afterwards (→ 4-02).
- The abrasive layer does not have to be opened unless it was dressed with a SiC wheel. Our wheels are delivered “sharp”, i.e. they were already regenerated with HACO-FLEX (→ 4-02).
- The wheel should not be taken from the flange until the end of its tool life if possible.

We wish successful grinding!

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