3M Science. Applied to Life.™

3M Precision Grinding & Finishing

3M™ Diamond & CBN Tools

english

Your partner with a century of grinding experience

As a part of the 3M Abrasive Systems Division, 3M Precision Grinding & Finishing is your committed and competent supplier for abrasives, tools, service and support.

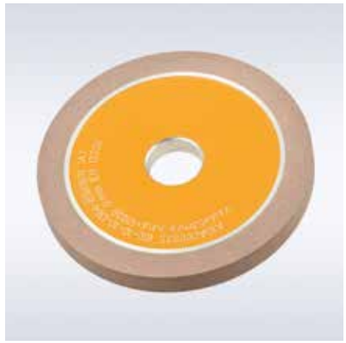
3M™ Diamond and CBN Tools

The originals

The innovative use of diamond tools for grinding hard materials and CBN tools for machining steel has triggered rapid development in cutting and grinding manufacturing technology that still continues today. As an innovator and pioneer, we support our business partners from industry and manufacturing with individual system solutions so they can meet the constantly increasing international requirements for efficiency and product quality.

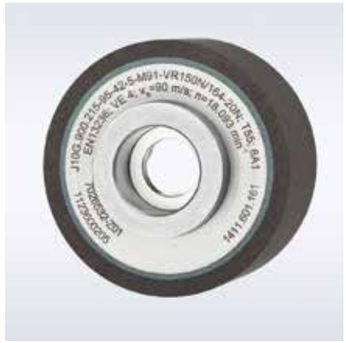
That is why we offer for rational machining of hard-to-machine materials (like HSS, high-temperature alloys, tungsten carbide, ceramic, PCD, PCBN, cermets), high quality diamond (DIA) and CBN grinding tools in all bonding systems for every type of application.
Our DIA grinding tools with synthetic resin and metal sinter bonds set new standards for the machining of tungsten carbides. Our DIA grinding tools with vitrified bonding also set new standards for the economical machining of very hard modern materials.

The mass production of precision components cannot be imagined without our CBN grinding tools using vitrified bond in the end. Our CBN grinding tools with electroplated bond technology reach new highs in terms of their grinding process performance in high speed grinding.

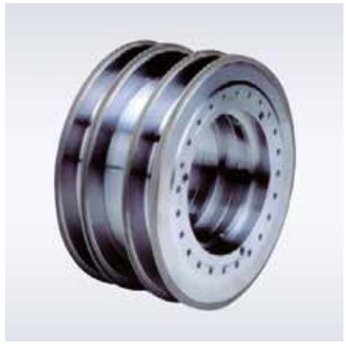


3M DIA grinding wheels with synthetic resin bonds enable precise shapes and dimensions when grinding small, complex workpieces
- Long tool life, corrections need to be made less frequently
- Low level of cutting edge chipping
- High material removal rate
- Excellent grip
- High surface finish quality
- Excellent, proven product performance
- Cost optimal solutions

3M DIA grinding wheels with vitrified bonds (VIT-DIA) – for grinding PCD / PCBN
- High removal rates
- Outstanding cutting edge quality
- Easy conditioning
- Short grinding times
- Perfect solution for super hard grinding substrates, also ceramics/cermets
- Suitable also for profiling purposes for 3D shapes/contures



3M CBN grinding wheels with vitrified bonds (VIT-CBN) – for production grinding of steel and high temperature alloys
- Outstanding grinding and profiling properties
- Easy conditioning
- Short grinding times
- High material removal rate
- Good shape retention



3M CBN grinding wheels with electroplated bonds – for production grinding of all steel and cast materials with high material removal rates
- Highest process reliability
- Shorter grinding times
- High material removal capability
- No conditioning necessary

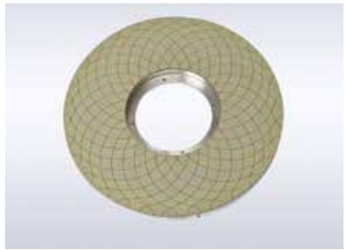
3M™ Bonds

Grinding tools with diamond or CBN abrasive grit generally consist of an abrasive coating of grit and bonding material which are applied to a core or wheel body.

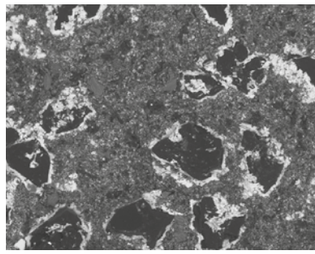
For optimal grinding performances, the abrasive grit and bond must be matched so that the abrasive grit are held in the bonding material as long as the grit still has or can form cutting edges. If the worn abrasive grit remains for too long in the bonding agent, the grinding tool loses its efficiency. On the other hand, if the bond wears down before the abrasive grit, then the abrasive grit is not used adequately and the life expectancy of the grinding tool becomes uneconomically short.

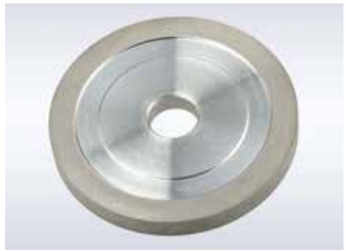
Matching the correct bond construction for individual applications allows the highest possible efficiency through the effective use of the grain materials.

That is why it is so important to use a combination of abrasive grit and bond that matches the individual grinding and operating conditions.

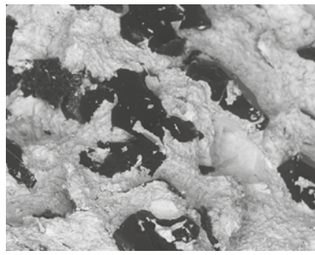


3M Synthetic resin bond
- For grinding tungsten carbide and steel materials
- High material removal volumes at low grinding forces
- For wet and dry grinding
- High flexibility by mixing in suitable additives
- For fine grinding operations

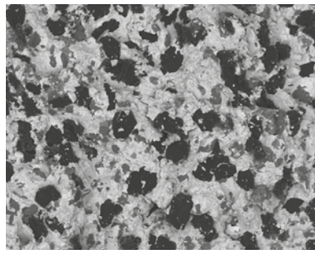


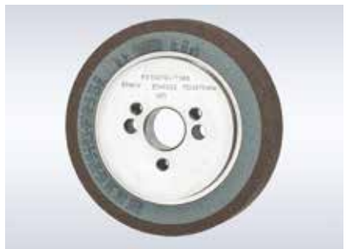


3M Metal sinter bond
- Highest wear resistance and profile retention
- High effective forces and therefore lower material removal volume in comparison to synthetic resin bonds

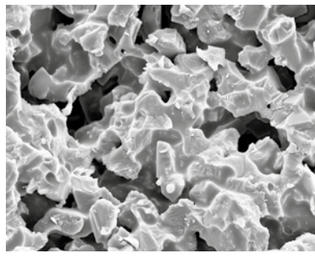


3M Hybrid bond
- Optimal cost/grinding performance compromise, mainly for hard metals
- Fast grinding infeed
- Lower wheel wear
- Perfect dressing behaviour

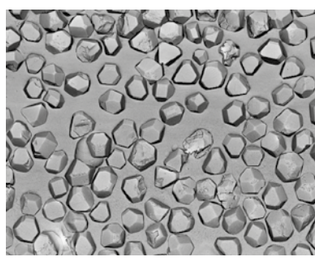




3M Vitrified bond
- Used to manufacture abrasive coatings with defined porosities for an extremely wide range of applications
- Especially good dressing and profiling capability, optimally suited for the conditioning of diamond dressing rollers in particular
- Lower wheel wear, low grinding forces for high quality workpiece surfaces



3M Electroplated bond
- Electrolytic depositing through a layer of grain on a metallic body
- Very high grip for the highest possible grinding performance
- For pre-grinding complex profiles with high material removal volumes
- For finishing grinding with high precision, for example in the gear-cutting industry



Diamond and CBN grains

Grinding and dressing grits made of diamond (DIA) or cubic boron nitride (CBN) are used in modern grinding technology. While diamond is available in natural or synthetic form, CBN is a purely synthetic product. What they have in common is the cubic crystalline structure and the associated physical characteristics of DIA and CBN grains (Table 1).
While diamond is essentially harder than CBN (diagram 1), CBN exhibits much higher thermal stability due to its lower tendency to oxidize and greater chemical stability (Diagram 2). Depending on your individual work requirements, our experts will recommend the optimal combination of grain size and grain quality as essential factors affecting the grinding performance.
General correlations between the tool quality, grinding response, and grain quality can only be formulated in actual use. The most important factor for determining suitability for grinding is the formation of the cutting edge on the DIA and CBN grains.

The following generally applies:
An angular type of grain improves the cutting capability of the grinding wheel but lowers the attainable surface finish quality.
A block-like type of grain improves the life expectancy of the grinding wheel and the surface finish quality achieved but reduces the cutting capability.
The commonly encountered coating of the grains with copper or nickel improves the anchoring in the bonding material, the heat dissipation, and the chemical and mechanical characteristics. Coated grain qualities are generally used in tools with synthetic resin bonding.

		DIA	CBN
Density	g/cm³	3,52	3,48
Hardness (Knoop)	kN/mm²	80	47
Hardness (Mohs)	–	10	9 –10
Thermal stability in air	°C	bis 700	bis 1. 400
Chemical formula		C	BN

Table 1

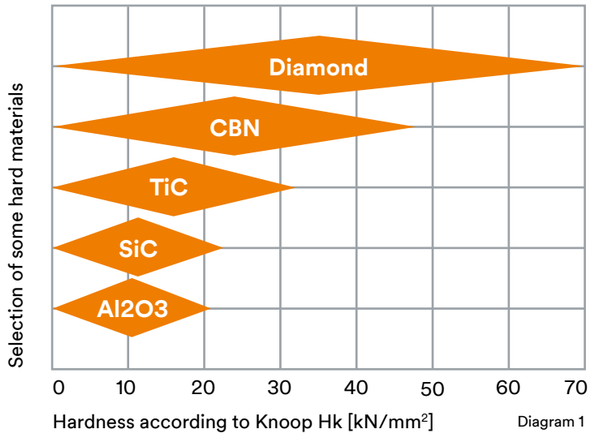


Diagram 1

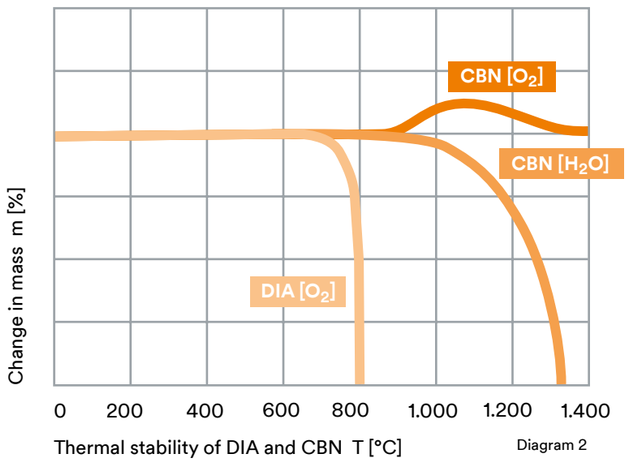


Diagram 2

Grain sizes

As large as possible, as small as necessary

The grain size of the grinding material has a decisive influence on the process flow and final result when grinding.
For example, reducing the grain size increases the number of active cutters, and the roughness of the surface created is improved independently from the workpiece speed. The grain size therefore has a decisive influence on the ease of grinding and the life expectancy of the grinding tool. Although there are some exceptions, it can be stated in general that the ease of grinding as well as the life expectancy are increased as the grain size increases. For this reason, the coarsest possible grain size should always be selected.

The classification and designation of grain sizes is based on the ISO standard 6106-1979, the FEPA standard, and DIN 848 and use two designation systems:

- The metric designation, which is based on the mesh size of the screens (EU)
- The number of screen openings per inch of the corresponding screens (mesh, USA)

Screen grain sizes

Europe (metric) Designation for DIA: D... for CBN: B... (or M... for VIT-CBN) (1)	(2)	Screen mesh size in µm	USA (mesh) Designation for DIA: D... for CBN: B... (or M... for VIT-CBN) (1)	(2)
	1182	1180 – 1000	16 / 18	16/20
1001		1000 – 850	18 / 20	
851	852	850 – 710	20 / 25	20/30
711		710 – 600	25 / 30	
601	602	600 – 500	30 / 35	30/40
501		500 – 425	35 / 40	
426	427	425 – 355	40 / 45	40/50
356		355 – 300	45 / 50	
301	–	300 – 250	50 / 60	–
251	252	250 – 212	60 / 70	60/80
213		212 – 180	70 / 80	
181	–	180 – 150	80 / 100	–
151	–	150 – 125	100 / 120	–
126	–	125 – 106	120 / 140	–
107	–	106 – 90	140 / 170	–
91	–	90 – 75	170 / 200	–
76	–	75 – 63	200 / 230	–
64	–	63 – 53	230 / 270	–
54	–	53 – 45	270 / 325	–
46	–	45 – 38	325 / 400	–

Table 2: Overview of the common DIA grinding grits in the narrow (1) and wide (2) range of values

Micro-grain sizes

Designation for DIA: MD... for CBN: MB...		3M Designation Ø size in µm	FEPA Standard Ø size in µm	USA Designation (mesh)
MD/MB	40	30 –40	27 – 53	500 / 600
MD/MB	40A	30 –60		
MD/MB	40B	36 –54		
MD/MB	25	20 –30	16 – 34	600 / 800
MD/MB	25A	15 – 25		
MD/MB	25B	15 – 30		
MD/MB	25C	20 – 40		
MD/MB	16	10 – 20	10 – 22	800 / 1200
MD/MB	16A	8 – 16		
MD/MB	10	6 – 12	6 – 14	1200 / 1800
MD/MB	6,3	4 – 8	4 – 9	1400 / 3000
MD	4,0	3 – 6	2,5 –5,5	3000 / 8000
MD	2,5	2 – 4	1,5 – 4	8000 / 12000
MD	1,6	1 – 3	1,0 –2,5	12000 / 13000
MD	1,0	0 – 2	0,5 –1,5	13000 / 14000

Table 3: For especially fine grains (micro-grain sizes), the grains are classified according to the FEPA Standard or the 3M designation (Table 3).

3M™ Concentrations

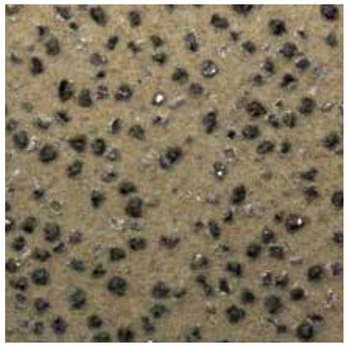
The concentration refers to the percentage by weight of the grinding grit per unit of volume of the abrasive coating. Although internationally valid standards for the concentration are lacking, the following definition has become the standard in Germany according to DIN 69800 Part 2 (DIA and CBN grains):
Concentration C100 = 4.4 ct/cm³ abrasive coating (1 carat [ct] = 0.2 g). Taking the density of the abrasive grit into account, this results in a volume percentage of grain of 25% for diamond abrasive coatings, for example.
In terms of standardization, DIA and CBN grinding grits of the concentrations stated in Table 4 are primarily used. Some manufacturers specify the concentration by volume.

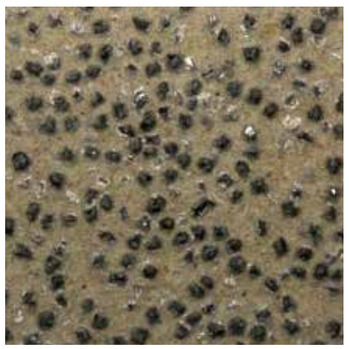
This means, for example, that the designation V24 or V240 is used to specify the concentration instead of C100. It is generally true that the higher the concentration is, the lower the roughness of the ground workpieces will be, which means improved surface finish quality and less cutting edge chipping. The grinding energy required becomes larger, the realizable material removal rates become lower and the cutting capability of the grinding wheel decreases. At the same time, though, the tool service life increases due to the lower load placed on the individual grains.

3M Concentrations								
25	38	50	75	100	125	150	175	200
Carats / cm³								
1,1	1,65	2,2	3,3	4,4	5,5	6,6	7,7	8,8
Volume-based concentrations in percent								
V6	V9	V12	V18	V24	V30	V36	V42	V48
Volume-based concentrations in parts per thousand								
V60	V90	V120	V180	V240	V300	V360	V420	V480

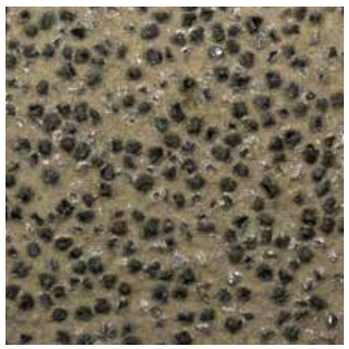
Table 4

Concentration 50





Concentration 75



Concentration 100

Standard & Custom bonds

Depending on the task at hand, there are various standard bonds with corresponding characteristics available. In addition, there is also a large number of special custom bonds available (not listed here).

3M Synthetic resin bonds
- Cool grinding at high feed rates and with high material removal volumes
- Good grip and free-cutting
- Low grinding forces
- Dry and wet applications possible
- Easy to process

3M Metal sinter bonds
- High mechanical strength
- Thermally resistant
- High wear resistance
- Higher grinding forces
- Primarily wet grinding
- Hard to dress

3M Vitrified bonds
- Cool grinding at high feed rates and with high material removal volumes
- Good grip and free-cutting
- Good dressing and profiling capability
- Low grinding forces
- Primarily wet grinding

3M Electroplated bonds
- Generally one-layer coating
- Suitable for complicated and complex shapes
- Very high grip
- Primarily wet grinding
- No conditioning necessary

3M Synthetic resin bonds

Diamond	Standard bonds	CBN
BXH	Especially soft-grinding	RXF
BJ ; BXJ BJ...D ; BXN BJ...W	Soft grinding	RXJ
BN BN...D ; BXR BN...W ; BXR...W	Good grip, stable	RN...D RN...W ; RXN RN...S ; RXR
BR BR...D BR...W ; BXS BR...S ; BXR...S	Wear-resistant	RR...D RR...W RR...S ; RXS
BY BY...W ; BXY BXY...S	Extremely wear-resistant	RX...S

3M Metal sinter bonds

Diamond	Standard bonds	CBN
MHJ...J	Extremely soft-grinding	SF...N
MJ... ; MHJ...N	Soft grinding	SJ...N
MHL...J MHL...N MHL...R	Soft-grinding stability	SML...N
MN...J ; MHN...J MN...N ; MHN...N MN...R ; MHN...R	Good grip, stable	SN...N ; SMN...N SMN...R
MHR...J MR...N ; MHR...N MR...R ; MHR...R	Wear-resistant	SR...N ; SMR...R
MX...J MX...N ; MHS...R MX...R	Extremely wear-resistant	SX...N ; SNX...N SMX...R
MC...N ; MHC...N	Crush dressable	SC...N ; SMC...N

3M Vitrified bonds

Diamond	Standard bonds	CBN
KJ...J KJ...N	Soft grinding	VJ...J ; VJ...N VY...F ; VY...G ; VY...H
KN...J KN...N	Good grip, stable	VN...J ; VN...N VY...I ; VY...K
KR...J KR...N	Wear-resistant	VR...J ; VR...N VY...L ; VY...M
KX...J KX...N	Extremely wear-resistant	VX...J ; VX...N VY...N ; VY...P

3M Electroplated bonds

Diamond	Standard bonds	CBN
GN 333 / GXN200		PN 2000 / PXN200

3M™ Body and shape designations

Quality standards

The body determines the static and dynamic strength of the wheel and has a great influence on the vibration response of the grinding tool. We select and design the body based on the shape of the wheel, the manufacturing process, the grinding task, and the international safety regulations.

Shape	3M	FEPA	Shape	3M	FEPA	Shape	3M	FEPA
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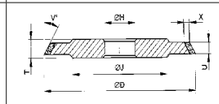
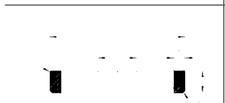
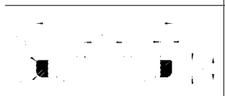
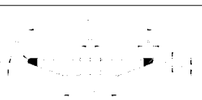
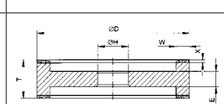
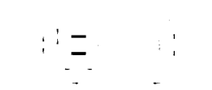
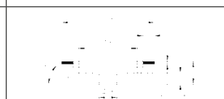
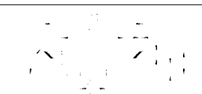
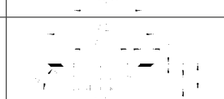
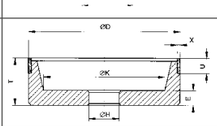
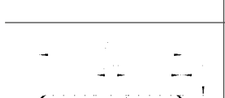
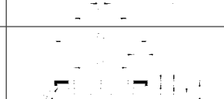
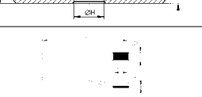
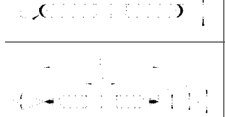
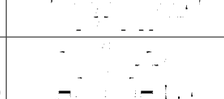
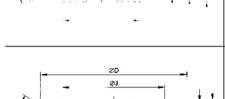
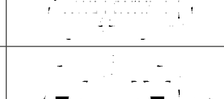
	*10B	14A1		*15A	14V1		*38A	13A2
	*10D	1L1		*18A	1A1R		*39A	4ET9
	*10D	14L1		*27A	14U1		*39C	4F9
	*11B	1A8		*28A	9A3		*39D	4BT9
	*12A	1A1W		*30A	6A2		*40A	11V9
	*12D	6A2W		*31A	12A2 45°		*41A	12V9
	*13A	1F1		*31B	12V2 45°		*43A	6A9
	*13B	1FF1		*31C	12C9 45°		*51A *51B *51C *51D	- - - -
	*14A	14E6Q		*34A	11A2	Additional shapes are available on request.		
	*14B	14EE1		*36A	12A2 20°			

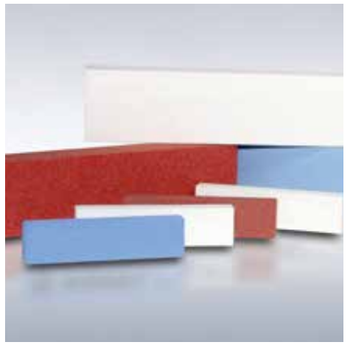
Conditioning

The shape of the profile, the sharpening process, and the cleaning of the abrasive coating are the primarily factors in the efficiency of the grinding process.

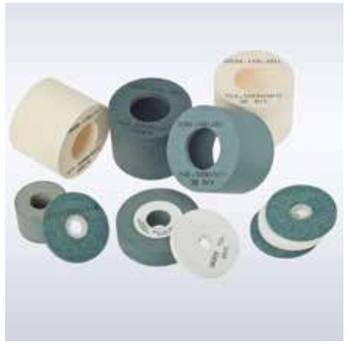
To optimally exploit the performance of the grinding tool, it is essential to create a macro- and micro-geometric design of the abrasive coating with adequate grain protrusion, enough chip space, and a targeted influence on the grain with a defined product quality.

The selection of a suitable conditioning process is primarily determined by the structure of the abrasive coating. Synthetic resin and metal sinter bonded grinding tools are generally conditioned with conventional SiC or corundum dressing tools. Diamond dressing tools are generally used to condition grinding tools with vitrified bonding. Grinding tools with electroplated bonds are not conditioned in general.

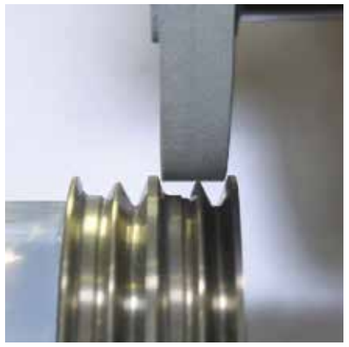
Roughening
After the dressing operation or in the case of a dull diamond or CBN grinding wheel, the abrasive grit and bond form a level surface. Since only abrasive grit protruding from the bond can actually perform machining work, the diamond and CBN grinding wheels need to be sharpened. 3M roughing stones are available for the various bonding systems.



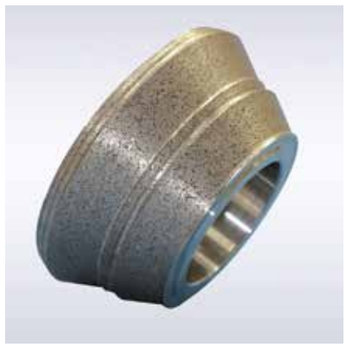
Dressing and sharpening
To dress diamond and CBN grinding wheels when on and when off the grinding machine, we offer dressing systems with cup or peripheral grinding wheels made of SiC or corundum. The ROTODRESS sharpening system with cup-shaped, rotary sharpening rollers that can be fed in cyclically, intermittently, or continuously is becoming more and more important in this context. With it, it is possible to use very fine grain sizes when grinding at higher feed rates.

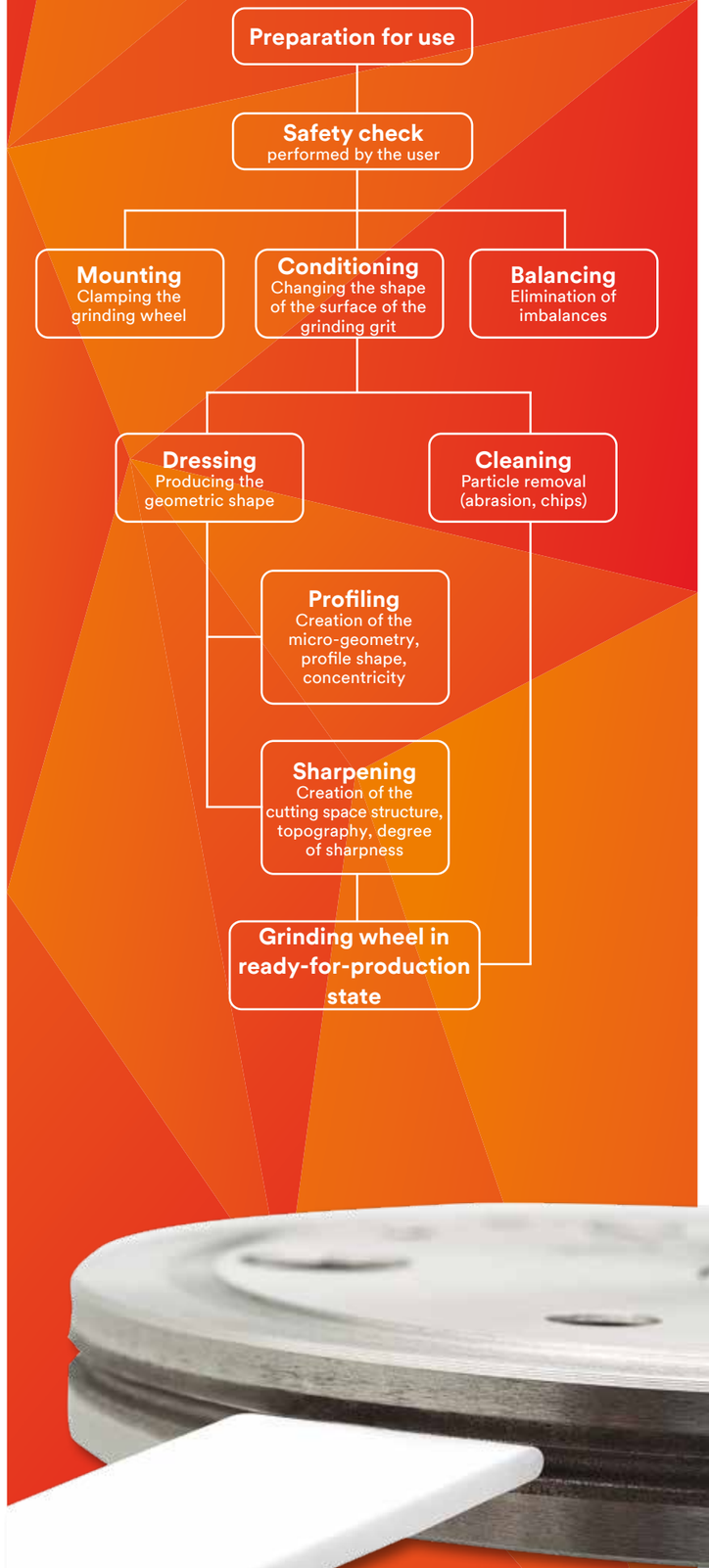


Crush dressing
To manufacture profile and cutting tools made of tungsten carbide and steel, a profiling method is used to precisely cut fine profiles. In crush dressing, a hardened steel or tungsten carbide roller bearing the workpiece profile on its rim is pressed against the grinding wheel. While the wheel and roller rotate, the profile is formed in the abrasive coating of the grinding wheel with vitrified bonding. We offer the complete system consisting of the machine, grinding wheel, and crush roll dresser.



Diamond dressing rollers
Diamond dressing rollers are a permanent fixture in modern grinding technology. They allow grinding wheels to be shaped extremely quickly. They guarantee the highest possible efficiency for simple or highly complex workpieces in high precision medium-scale and mass production. Whether its rotary diamond profile and shaping rollers or non-rotary diamond dressing tools, we offer you the optimal type of tool for every dressing task.





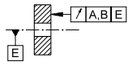
Tolerances

Functionality is top priority

When specifying the tolerances, perfect functionality is the only critical factor. With this in mind, the tolerances should be as large as possible to ensure the dressing and grinding tools are not unnecessarily expensive. The dimensional tolerances (Table 8) apply to the 3M tool shapes and to the length, radius, and angular dimensions defined in the FEPA standard for diamond and CBN grinding tools as well as to tools ordered in non-metric units.

The positional tolerances for axial run-out and concentricity (Table 7) are divided into two classes (A and B). The narrower class A applies to the main grinding surface (axial run-out for cup grinding wheels, concentricity for peripheral grinding wheels). For all grinding tools with a grain coarser than D151 a higher tolerance of about 50% applies. The additional class B applies to secondary grinding surfaces (concentricity for cup grinding wheels, axial run-out for peripheral grinding wheels).

The specifications in the drawing provided apply to precision profile grinding wheels. An additional charge for tolerance restrictions requested by customers generally applies.



[mm]	Class	Diameter D [mm]	[mm]	Class
0,02	A	≤ 250	0,02	A
0,05	B		0,05	B
0,02	A	> 250	0,02	A
0,07	B		0,07	B

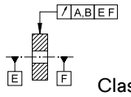


Table 7: Positional tolerances for axial run-out and concentricity

Outer diameter D	
Nominal diameter D [mm]	Dimensions [mm]
≤ 6	+ 0,3 - 0
> 6 to ≤ 30	+ 0,8 - 0
> 30 to ≤ 120	+ 1,3 - 0
> 120 to ≤ 400	+ 2,0 - 0
> 400	+ 4,0 - 0

Other length dimensions (E, J, K, L1, L2)	
Nominal diameter [mm]	Dimensions [mm]
≤ 6	± 0,1
> 6 to ≤ 30	± 0,2
> 30 to ≤ 120	± 0,3
> 120 to ≤ 400	± 0,4
> 400	± 0,6

Coating dimensions (T, U, X, W)	
Nominal diameter [mm]	Dimensions [mm]
≤ 3	+ 0,1 - 0
> 3 to ≤ 6	+ 0,1 - 0
> 6 to ≤ 30	+ 0,2 - 0
> 30	+ 0,2 - 0

Angular dimensions (S, V)	
Nominal dimensions of the shorter side of the angle [mm]	Dimensions [´]
≤ 10	± 60 ´
> 10 to ≤ 50	± 30 ´
> 50 to ≤ 120	± 20 ´
> 120 to ≤ 400	± 10 ´
> 400	± 5 ´

Radius R	
Nominal dimensions R [mm]	Dimensions [mm]
≤ 3	± 0,1
> 3 to ≤ 6	± 0,1
> 6 to ≤ 30	± 0,1
> 30	± 0,2

Table 8: Dimensional tolerances

Application instructions

We know how to do it

The laws and regulations for the use of grinding tools apply to manufacturers and users. In Germany, this means BGR500 (section 2.25) and EN 13236. Since the regulations can vary from country to country, please ask our sales representative.

The most important tests for proper use are:

- Visual inspection for external damage
- Sound check for wheels with ceramic bodies
- Check if the tools are properly mounted and clamped
- Test of the concentricity and axial run-out
- Elimination of imbalances
- Test run

In general, diamond and CBN grinding wheels must be conditioned before they are used for the first time. Grinding tools with electroplated bonding must trued to a running accuracy of < 0.005 mm since these tools cannot be dressed. To make things as simple as possible, tools that have already been prepared should be left on the flange for their entire service life.

Cooling lubricant

A simple solution

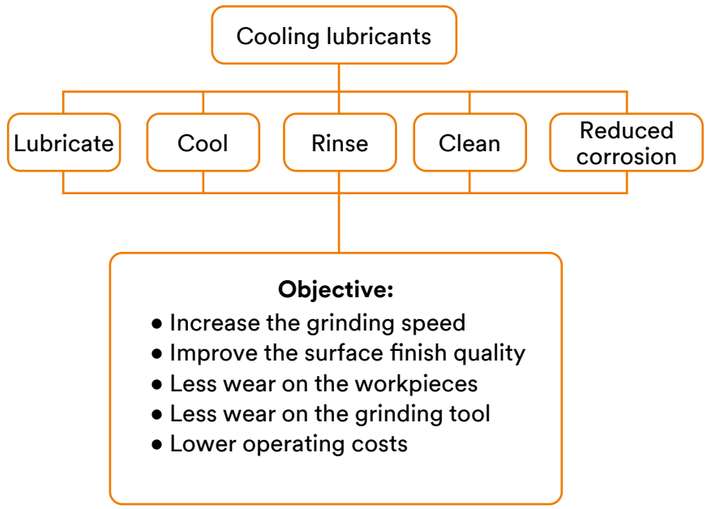
Cooling lubricants are classified as water-soluble and non-water-soluble cooling lubricants (e.g. oils) (VDI Directive 3396). The water-soluble cooling lubricants are classified further as cooling lubricant emulsions and cooling lubricant solutions.

Characteristics of cooling lubricant emulsions and solutions:

- Very good heat dissipation
- Very good cooling
- High cutting capability due to higher grinding friction
- Lower grinding pressure
- Risk of lacquer and corrosion damage
- Risk of fast aging due to bacteria and fungi, which is why special care and cleanliness is necessary
- No deflagration or explosion of the cooling lubricant vapor

Characteristics of cooling lubricant oils:

- Lower grinding friction
- Higher material removal rates
- Short grinding times
- Lower power requirement on the machine
- Better workpiece quality
- Better surface finish quality
- Optimal corrosion protection for the machine
- Lower grinding wheel wear
- Longer dressing cycles
- Complicated tooling of machine



Terms and explanations

At a glance

We have collected a large number of the most important terms used in grinding and conditioning technology. The list is by no means complete.

To improve understanding, we have specified the units in the usual form encountered in applications, which do not necessarily correspond to the units in the international SI system.

Additional explanations and definitions of terms can be found in the German book "Manufacturing Processes 2: Grinding, Honing, Lapping" written by F. Klocke and published by the Springer-Verlag, Berlin.

Symbols in formulas and abbreviations

Grinding wheel volume loss	[mm³]	V_s
Volume loss through wear	[mm³]	V_{sw}
Volume loss through dressing	[mm³]	V_{sd}
Material removal volume	[mm³]	V_w
Material removal volume ratio	[mm³/mm]	V'_w
Width of the active wheel profile	[mm]	b_D
Wearing ratio	-	G
Dressing cycle	[h, min, s]	T_s
Grinding wheel service life	[h, min, s]	$T_{s\,ges}$
Dressing tool life	[h, min, s]	T_d
Grinding time or cutting time	[h, min, s]	t_c
Dressing time	[h, min, s]	t_d
Cutting speed	[m/s]	v_c
Workpiece speed	[mm/s]	v_w
Workpiece diameter	[mm]	d_w
Workpiece rotational speed	[1/min]	n_w
Grinding wheel diameter	[mm]	d_s
Grinding wheel rotational speed	[1/min]	n_s
Regulating wheel rotational speed	[1/min]	n_{Re}
Circumferential speed of the dressing roller	[m/s]	v_R
Dressing roller diameter	[mm]	d_R
Dressing roller rotational speed	[1/min]	n_R
Dressing speed ratio	-	q_d
Tangential feed rate	[mm/s]	v_{ft}
Radial feed rate	[mm/s]	v_{fr}
Axial feed rate	[mm/s]	v_{fa}
Radial feed	[mm]	f_r
Axial feed	[mm]	f_a
Influence of infeed	[mm]	a_e
Dressing infeed	[mm]	a_{ed}
Total infeed	[mm]	a
Material removal rate ratio	[mm³/mm*s]	Q'_w
Height of surface roughness on the workpiece	[µm]	R_{tw}
Average roughness	[µm]	R_a
Average height of surface roughness	[µm]	R_z

Table 9

3M™ System Approach

Tools for grinding hard materials

Diamond:
- Grinding wheels and grinding quills
- Cut-off grinding wheels
- Annular saw holes
- Manual lapping, filing, segments
- Pastes, sprays, and suspensions

Tools for grinding steel

CBN:
- Grinding wheels and grinding quills
- High-speed grinding wheels (for example for grinding camshafts and crankshafts)
- Cut-off grinding wheels
- Precision profile grinding wheels (for example for the gear-cutting industry)

Diamond:
- Honing sticks and segments
- Dressing rollers and dressing blocks
- Dressing wheels and dressing gears
- Single and multi-grain dressers

Dressing machines

Tools for grinding glass

Diamond:
- Grinding wheels
- Cut-off grinding wheels
- Hollow drills and drill/countersink systems
- Milling tools of all kinds
- Pellets, pads, and segments

Wendt GmbH
3M Abrasives Systems Division
Fritz-Wendt-Str. 1
40670 Meerbusch
Germany
Tel.: +49 2159 671-0

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