REISHAUER

Gear Grinding Technology

REISHAUER THREADED WHEELS

MACHINES | PERIPHERAL SYSTEMS | **TOOLING** | TECHNOLOGY | SERVICES

Threaded Grinding Wheels

Circle of Competence

The Reishauer Circle of Competence

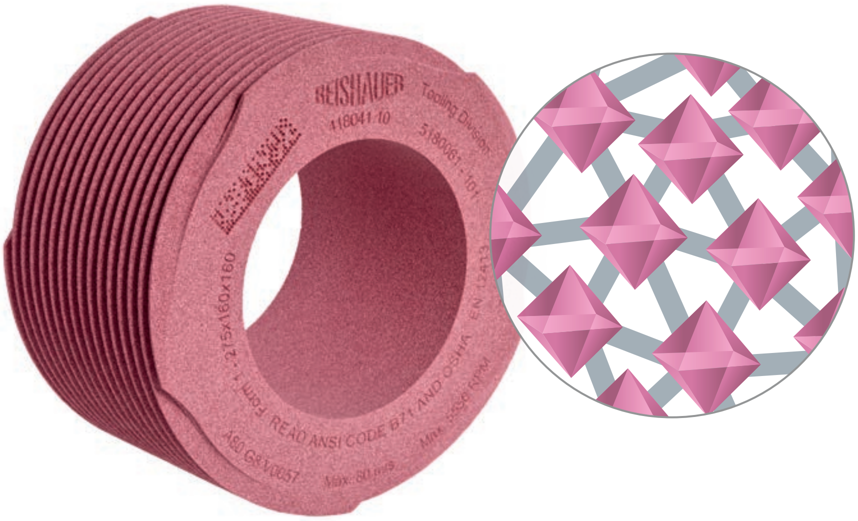
The gear grinding machine, both in qualitative and quantitative performance levels for the large volume production of high-accuracy gears, is at the core of the continuous generating grinding technology invented by Reishauer. To ensure a steady and high production output of our machines at constant quality, and at lower costs per piece, we have continuously extended our technical competency and support structure in the areas of automation, tooling, application engineering and service. Hence, today we are a single source supplier, and thus we guarantee our customers a long service life of the machine system and lower life cycle costs.

Threaded wheels for gear grinding

The Reishauer performance portfolio, the Circle of Competence, embraces all aspects of the grinding of gears as Reishauer does not limit itself to the making of sophisticated gear grinding machines. For this reason, the performance portfolio includes the design and the manufacture of workholding devices, threaded grinding wheels and diamond dressing tools, too.

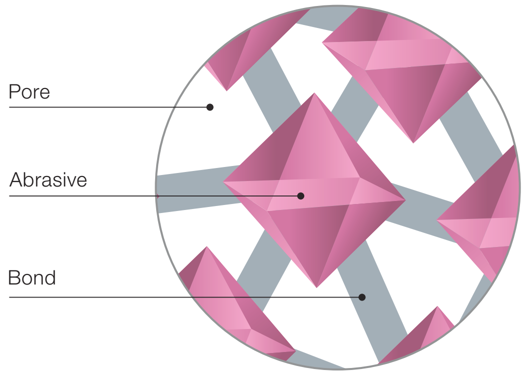
Why threaded grinding wheels from Reishauer?

To master the gear grinding process, threaded grinding wheels play a fundamental role and these wheels may justifiably be seen as the core part of the generating grinding process. For this reason, Reishauer has arguably built the most modern grinding wheel factory to offer a complete tooling system and to be independent of third parties. Our focus is to supply the best possible tools for the continuous generating process to offer our customers stable processes. The modern manufacturing methods we use have become the industry benchmark in terms of reproducibility, homogeneity and the low hardness differential across the full wheel width.



Grinding wheel structure

A grinding wheel consists of three elements, all of which fulfill a specific purpose. The elements are the grit (abrasive grains) the bond and the pores. In short, the grit´s task is to perform the cutting of hardened steel at an acceptable material removal rate, to be free-cutting, to give a surface finish within a given range, and to make sure that there will be no grinding burn during the process.

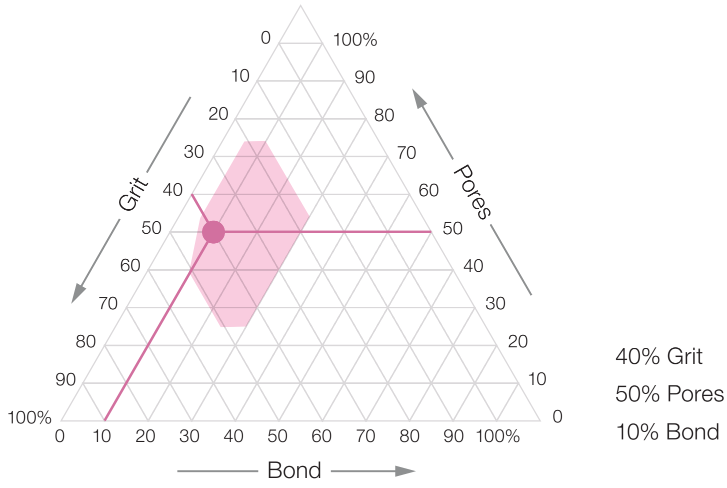


Elements of a grinding wheel

The bond holds the grit in place in such a way that individual grits will not break out under heavy cutting loads in the roughing passes. Even though the bond does not aid the cutting process, and is often seen as a necessary evil, it is of the utmost importance as it determines the cutting action indirectly by holding the grit in place. Mastering the bond quality is what sets Reishauer apart as, contrary to many other wheel makers, Reishauer develops and manufactures its own bonds in-house. Furthermore, and very importantly, the bond must ensure the safety of the grinding process at high speeds, which in the case of Reishauer machines, may reach up to 100 m/s (~20,000 sfpm).

The third element, the pores, gives the grinding wheel an open structure to ensure that the coolant gets into the contact area during grinding and that the chips generated during the process do not weld to the grinding wheel and will be transported away from the grinding zone. Furthermore, if the percentage of pore volume is insufficient, thermal damage to the workpiece might ensue.

Phase diagram of typical wheel structures



In an ideal world, one would aim for a threaded grinding wheel with as low a percentage of bond as possible, with as many pores as possible and with a balanced portion of abrasive grit within the wheel's matrix. Realistically, looking at the available options, vitrified grinding wheels have a specific "window of feasibility" as illustrated above, a so-called phase diagram. The white section within the diagram's triangle represents the possible combinations of percentages of Grit – Pores – Bond. The diagram shows a combination of 40% grit, 50% pores and 10% bond, which would be typical for a threaded gear grinding wheel.

Grinding Wheel Specification

A typical Reishauer threaded wheel specification reads as shown below:

Grinding wheel specification

A	80	G	8	V	0057
Abrasives	Grit Size	Hardness	Structure	Bond	Types of Bond
13A	60 coarse	G = soft	3 standard	V = vitrified	0057
19A	80 medium	H = medium	4		0058
14YA	100 fine	I = hard	5		0076
1YA	120		7		0093
	150		8 porous		0167
	180		9		0168
			10		

Average grit size

60	0.21–0.30 mm
80	0.15–0.21 mm
100	0.11–0.15 mm
120	0.09–0.13 mm
150	0.06–0.11 mm
180	0.05–0.09 mm

Wheel structure

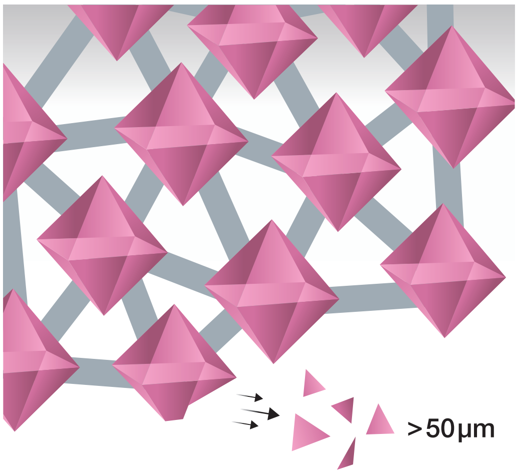
Types of Grit

As shown on page 5, a grinding wheel specification starts with the abrasive under the header "A," which stands for aluminum oxide (Al_2O_3). With very few exceptions, threaded wheels for generating grinding have some form of aluminum oxide as their abrasive. The many wheels specifications encountered in the marketplace are all sub-variants or blends of different types of aluminum oxide. At present, Reishauer uses four different types of abrasive specifications, all of which are blends of different aluminum oxides.

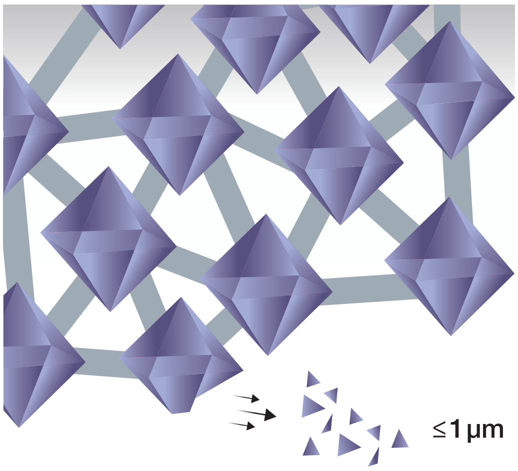
Reishauer's different abrasive grit mixtures represent technical solutions to customer requirements in regards to economics, performance, surface finishes, dressing tools, and the hardness and the retained austenite of the steel to be ground.

The **13A** specification consists of a blend of macrocrystalline red and white aluminum oxides (particle size at self-sharpening > 50 µm). This is Reishauer's answer to standard applications; a trusted workhorse that performs economically in most situations.

Macrocrystalline grit 13A



Microcrystalline grit 14YA



Self-sharpening mechanism
of different grits

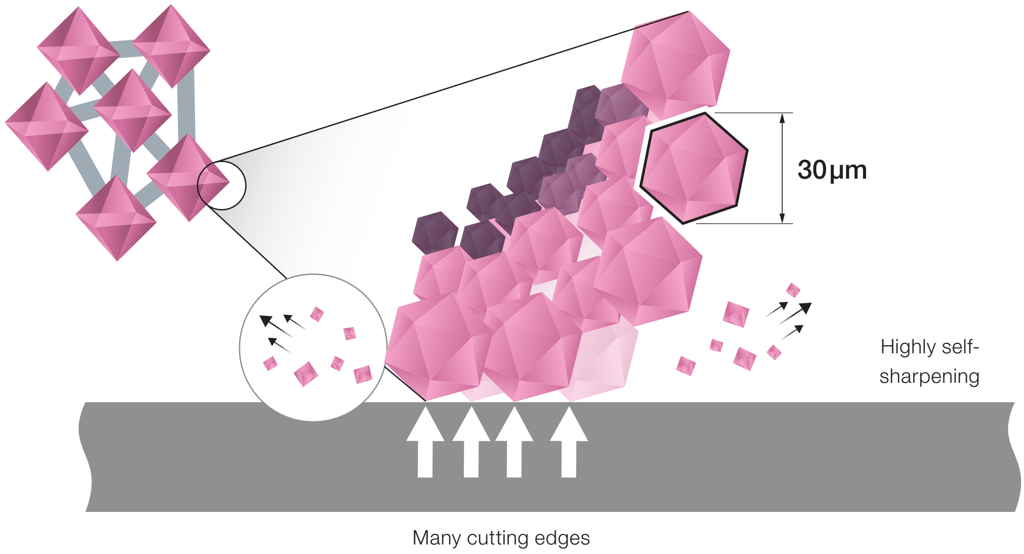
The **19A** specification consists of fine-crystalline agglomerated Al_2O_3 grits that are blended with white aluminum oxide (particle size at self-sharpening ≤30 µm). This is a specification when high material removal rates are on top of the list of customer requirements. Each individual grit consists of an agglomerate of sharp particles that self-sharpen easily under high-performance material removal rates, maintain a steady self-sharpening process, and thus ensure a cool grinding process.

The **14YA** and the **1YA** are ceramic specifications that consist of microcrystalline ceramic Al_2O_3 with a particle size of ≤1 µm. These ceramic abrasive grits are also blended with white aluminum oxide. These are Reishauer's high-performance grinding wheels that deliver the highest material removal rates of all the specifications presented in this brochure. These ceramic specifications are best suited when there is limited machine tool availability, if there is retained austenite in the workpiece material, or if there is a lot of material to be removed due to excessive grinding stock.

In general, one distinguishes between different forms of self-sharpening of the individual type of grit as shown in the illustration above. As soon as the grinding pressure increases above a certain level, the abrasive grits will fracture to some extent at their worn points in order to produce new and sharp cutting points. This fracturing is called selfsharpening. In the case of the 13A macro-crystalline grit, this fracturing will be in macro particles greater than 50 microns (µm). For the microcrystalline grits (14AY and 1AY), the fracturing is in smaller particles, typically with a particle size of ≤1 µm.

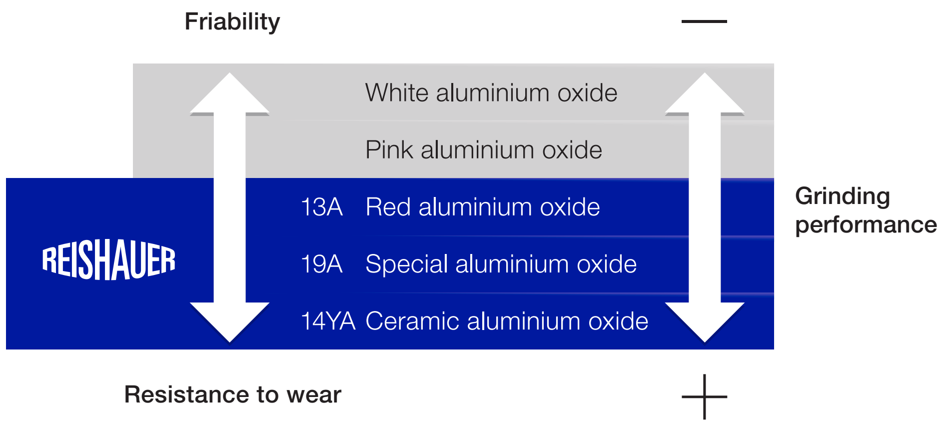
Average crystal size

19A agglomerated fine-crystalline grit



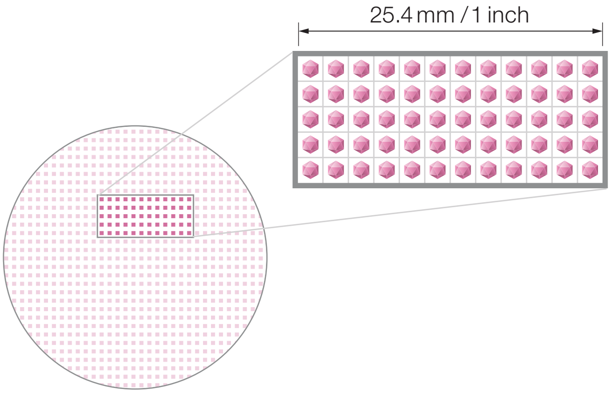
The pink **19A** fine-crystalline grit, as shown in above, is a grain with particle sizes of around 30 microns (µm). It features more cutting edges than the standard grits of the 13A and fewer cutting edges than the ceramic abrasives 14YA und 1YA. For this reason, the 19A´s potential material removal rate falls between the rates of the standard 13A and the ceramic grits 14YA and 1Y. As soon as the fine-crystalline 19A grit develops any wear flats, the affected fine-crystalline particles break off, exposing new and new sharp cutting edges.

Choice of abrasives



The choice of threaded grinding wheel specification depends on specific customer requirements. Microcrystalline ceramic abrasives are more expensive to procure than standard abrasives. Furthermore, microcrystalline abrasives require specials bonds and processing methods. On the other hand, ceramic abrasives deliver higher material removal rates and better form retention.

"Mesh" refers to the number of sieve openings per linear inch. Here: 12 openings per inch, thus a grit size "12".



Grit size

The grit size distribution is governed by the DIN ISO standard 8486-2 with which Reishauer fully complies. The grit size designation has its origin in the USA and is given in mesh. In other words, the grit size refers to the openings in a sieve per linear inch as illustrated above. A grit size 80 refers to a mesh size of 80 grits per linear inch. This translates into an average grit size of 0.15 to 0.21 mm for the 80 grit, the most commonly used abrasive. This can be calculated as follows:

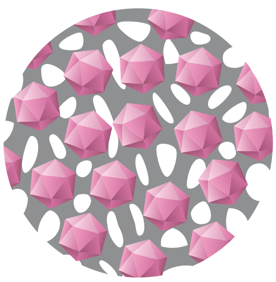
- 1 inch (25.4 mm) minus wire diameter (30 % of 25.4 mm) divided by the nominal grit value (here 80)
- (25.4 mm x 0.7)/80 = 0.22 mm, whereas the mean value is given as approximately 0.185 mm

The finer the chosen grit size, the better the surface finish and the better the form holding will be. However, at the same time, too fine a grit increases the risk of grinding burn and reduces the material removal rate potential.

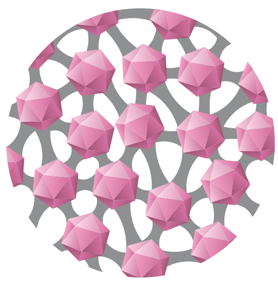
Grinding wheel hardness and structure

The letters of the alphabet denote the wheel's hardness. The closer to the letter to "A," the softer the threaded wheel will be, whereas "Z" denotes the hardest possible structure. Reishauer wheels range between "G to I" as these hardnesses have proven themselves as the best balance between self-sharpening and form holding for continuous generating gear grinding. The softer the wheel's structure, the cooler the grinding wheel will act. However, form holding will decrease with increased softness. The inverse holds true, too: The harder the wheel structure, the better the form holding will be. However, this also increases the risk of burning. This shows how important it is to observe the aforementioned criteria carefully and to design the appropriate structure. In general, the wheel's hardness is controlled by the amount of bond added to the mix and by the pressure applied to the mixture in the mold during pressing.

All grinding wheels feature some natural porosity, as the pressing process cannot push the grits together such that there are no gaps between them. As mentioned before, porosity aids in getting the coolant into the grinding zone and helps to remove the chips from that zone. More importantly, porosity reduces the contact area between the wheel and the workpiece. In this manner, there is more pressure on an individual grit, and this increased pressure on the individual grit makes for better selfsharpening and, therefore, for a cooler cutting process. Porosity is introduced artificially into a grinding wheel by means of adding pore inducing agents into the wheel mixture prior to pressing the wheels in a mold and subsequently firing them in a kiln. The pore inducing agents will decompose completely, leaving a void. Grinding wheels are categorized into closed (natural) and open (pore induced) structures as illustrated below.



Closed structure

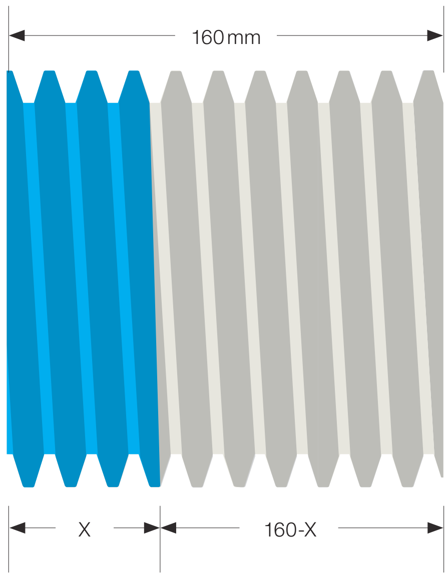


Open structure

Combined grinding and polishing wheel

Threaded polishing grinding wheels

Reishauer grinding machines allow the grinding and subsequent polishing in the same clamping operation. Therefore, these threaded wheels are divided into two areas: a grinding zone and a polishing zone. The grinding zone consists of either vitrified standard aluminum oxide or vitrified ceramic aluminum oxide. The polishing zone, in turn, consists of resin bonded fine grits. The gear parts are ground to final size, mostly using one roughing and one finishing stroke, and subsequently moved into the polishing zone by a shift jump, where the parts are polished in one or several strokes.



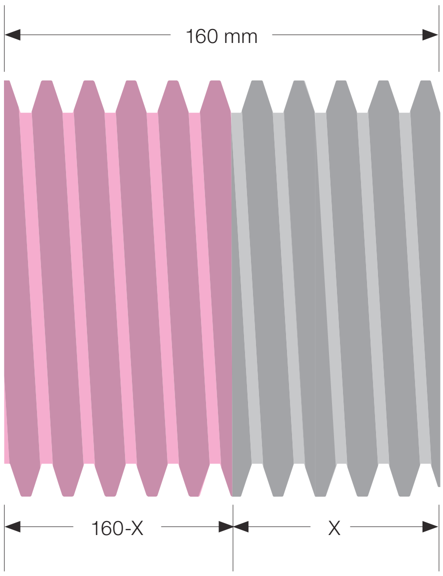
Combined grinding and polishing wheel (zone division)

Reishauer bonds the two zones together and preprofiles them in accordance to customer specifications. For this purpose, blanks are kept on stock. The width of the individual zones are based on the given gear data, whereas the combined widths are mostly kept at 160 mm. In general, the width of the polishing zone is 35, 45 or 60 mm.

Combined rough and
fine grinding wheel

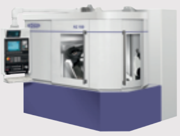
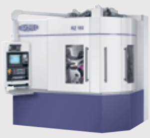
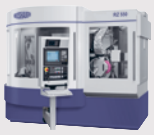
Fine grinding wheels

Special applications may demand threaded wheels that consist of two vitrified bonded zones. The first zone is for rough grinding with a coarser grit and the second zone for finish grinding with a fine grit. The total width is mostly kept at 160 mm whereas the width of the fine finishing zone depends on the specific gear data.



Combined rough and
fine grinding wheel

Recommended threaded wheel specifications

Machine	Dimension	Grit	Specification	Color	Module
RZ 150 	275 × 125 × 160	13A	A80 G8 V 0057	Red	>1.3
		13A	A80 H8 V 0058	Red	>1.3
		13A	A100 G8 V 0108	Red	0.9 to 1.5
		19A	A80 H8 V 0167	Pink	>1.3
		19A	A120 G8 V 0176	Pink	0.7 to 0.9
		14YA	A80 G8 V 0166	Light blue	>1.3
		14YA	A80 H8 V 0233	Light blue	>1.3
RZ 60 **RZ 160** **RZ 260** 	275 × 160 × 160 275 × 125 × 160	13A	A80 G8 V 0057	Red	>1.3
		13A	A80 H8 V 0058	Red	>1.3
		13A	A100 G8 V 0108	Red	0.9 to 1.5
		19A	A80 G8 V 0167	Pink	>1.3
		19A	A120 G8 V 0176	Pink	0.7 to 0.9
		14YA	A80 G8 V 0166	Light blue	>1.3
		14YA	A80 H8 V 0233	Light blue	>1.3
RZ 410 **RZ 550** 	300 × 125 × 160 300 × 145 × 160 300 × 160 × 160	13A	A80 G8 V 0057	Red	>1.3
		13A	A80 H8 V 0058	Red	>1.3
		19A	A80 G8 V 0167	Pink	>1.3
		14YA	A80 G8 V 0166	Light blue	>1.3
		14YA	A80 H8 V 0233	Light blue	>1.3

Reishauer reserves the right to change technical specifications.

Grinding wheel safety

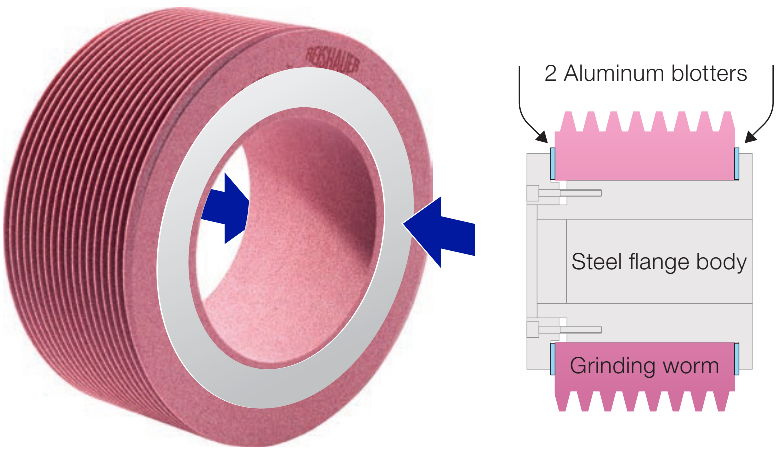
Reishauer strictly adheres to all country specific safety rules and regulations and supplies the grinding wheels tested and marked in accordance with theses rules and regulations. This encompasses safety standards according to FEPA, the European standard EN 12413 for bonded abrasives and the US standard pertaining to bonded abrasives, ANSI B7.1, “Safety Code for the Use, Care, and Protection of Abrasive Wheels.”

To ensure safe practices in the workshop or the factory floor, it is mandatory that the relevant publications are read and the rules therein implemented. The machine tool builder, the wheel maker and the user all have individual obligations to fulfill. Most importantly, the user may never exceed the permissible wheel speed as marked by the wheel maker! Reishauer threaded wheels have their maximum operating speed laser marked. Hence, unlike printed markings, the laser marking will not be deleted during usage.

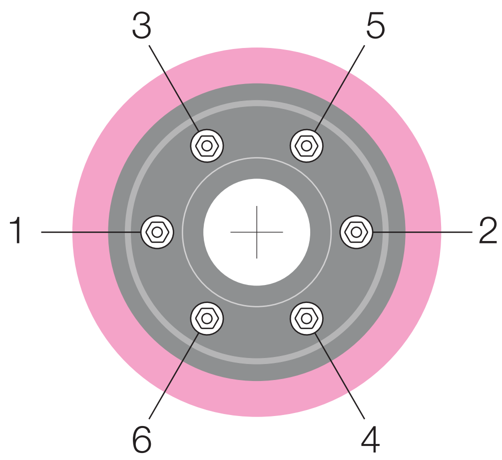
Safety: ring test

Ring test for vitrified bonded grinding wheels

Before any grinding wheel is mounted on its flange, it must be subjected to a ring test as shown above. By this simple method, the user can find out if a wheel is cracked or not. When tapping the wheel lightly with a non-metallic hammer, or a copper hammer, a clear bell-like sound should occur. If the tapped grinding wheel emits a dull sound, the wheel is most likely cracked and should be immediately discarded. Such a wheel must not be used under any circumstances.

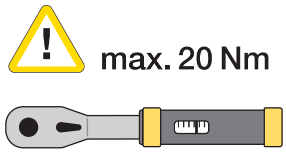


While mounting a grinding wheel on its flange, aluminum blotters must be placed on either side of the wheel as illustrated above. These blotters will equalize any unevenness that may be present on the wheel's faces. Hence, the blotters will prevent that the flange cuts into the wheel face and weakens it. The blotters are an important safety feature that must be adhered to.



Safety:
use of torque wrench

Use diametrically opposed tightening sequence as indicated. Set torque wrench to 20 Nm or 15 foot-pound.

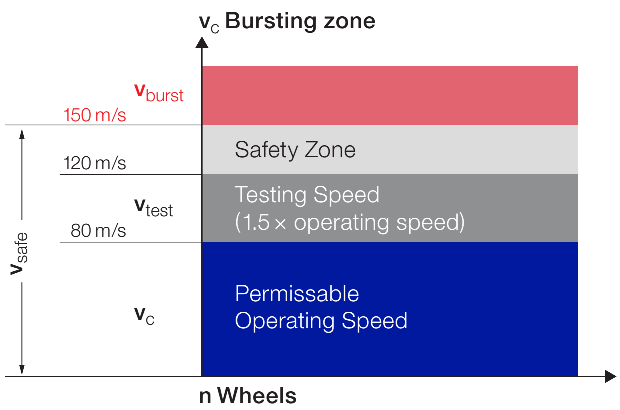


Once the grinding wheel has been mounted on the metal flange, the flange bolts must be tightened with a torque wrench which has been set to a torque of 20 Newtonmeters (Nm) or 15 foot-pound (ft-lb). A diametrically opposed tightening sequence should be used as illustrated above.

As mentioned before, the operating speed marked on the grinding wheel should never be exceeded. Ignoring this instruction may lead to the wheel bursting, and may cause serious bodily harm and/or damage to the machine tool. The illustration on the right shows the laser-marked maximum operating speed of a specific threaded grinding wheel. Reishauer ensures that the manufacturing process, from pressing the wheel to its position in the kiln, is completely monitored and documented.

Never, ever exceed the max. surface speed as indicated on the grinding wheel! Here: 80 m/s or 15,750 sfpm

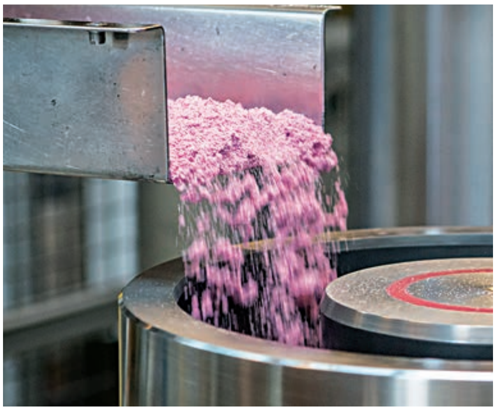
For the European and the US market, each Reishauer grinding wheel is speed tested at a factor of 1.5 x the permissible operating speed. In the case of a wheel approved for 80 m/s, this translates into a speed test at 120 m/s. (For Japan, the safety factor applied is two times operating speed). Each wheel features a laser marked and electronically readable code. Thus, each wheel is traceable across is complete manufacturing chain; from pressing to its position in the kiln and speed testing, each step is monitored and documented. Furthermore, Reishauer wheels are systematically and frequently subjected to a bursting test. This ensures that all batches are made and stay within a narrow range of manufacturing tolerance. This is illustrated in on the right. Additionally, all wheels are checked for their constant homogeneity in terms of density and modulus of elasticity.

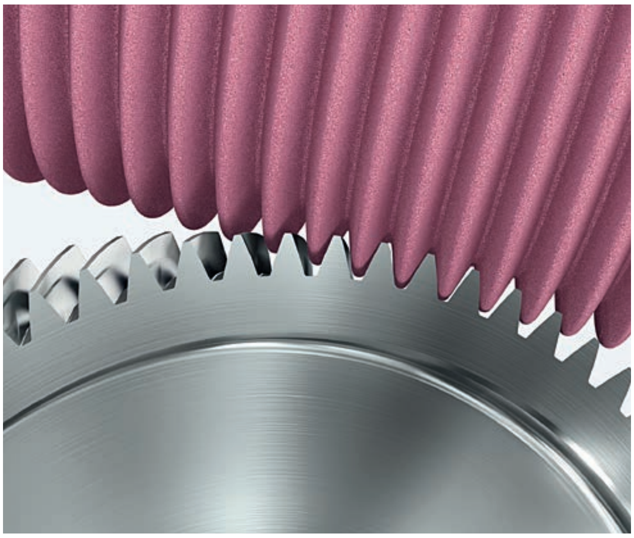


Safety: wheel operating and testing speed

Threaded grinding wheel production in our Swiss plant

From loose grit to finished threaded grinding wheels





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