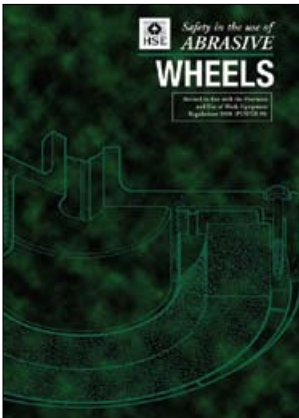


Safety in the use of abrasive wheels

Revised in line with the Provision and Use of Work
Equipment Regulations 1998 (PUWER 98)



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This revision supplied new guidance following the repeal of the Abrasive Wheels Regulations. Its usefulness is widespread – in the construction and foundry industries and in engineering generally. This revision encompasses relevant PUWER issues, and any conflicts which exist with draft European standards.

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The Health and Safety Executive would like to acknowledge the help of Geoff Wheway, the British Abrasives Federation, and Tassia – Training and Safety Specialists in Abrasives in the preparation of this revised guidance.

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Preface

This guidance was last revised in 1992. This latest revision is part of a major review of guidance by the Health and Safety Executive and follows the introduction of the Supply of Machinery (Safety) Regulations 1992¹ as amended and the Provision and Use of Work Equipment Regulations 1998 (PUWER 98).²

The publication of European Standard BS EN 12413 *Safety requirements for bonded abrasive products*³ and other standards supporting the health and safety requirements of the Supply of Machinery (Safety) Regulations¹ means that much design-related information has been omitted. However, where the design information is still in draft form, this has been retained.

The primary objective of PUWER 98 is to ensure that work equipment, including abrasive wheels, does not give rise to risks to health and safety, regardless of the work equipment's age, condition or origin. PUWER 98 applies to all workplaces and work situations subject to the Health and Safety at Work etc Act 1974 (HSW Act).⁴

PUWER 98, which covers the selection and use of work equipment in general, revoked the remaining provisions of the Abrasive Wheels Regulations 1970 (these dealt with the training, competence and appointment of people to mount abrasive wheels). This guidance expands on how the general requirements of PUWER 98 relate to abrasive wheels.

Introduction

1 The purpose of this guidance is to give advice on precautions for the prevention of accidents in the use of abrasive wheels, in particular injury resulting from either wheel breakage or contact with a running wheel. For the duties of those people using abrasive wheels to be fully understood, the guidance should be read in conjunction with the PUWER Approved Code of Practice (ACOP).²

2 The risk of breakage is inherent in every abrasive wheel. If the number of breakages is to be kept low, the initial care exercised in the design, manufacture and testing by abrasive wheel and machine makers must be coupled with the adoption of safety measures by the users. Accident statistics indicate that nearly half of all accidents involving abrasive wheels are due to an unsafe system of work or operator error.

3 In relation to abrasive wheels, PUWER 98 requires, among other things, that all machinery is suitable for its intended use and is properly maintained, and that employees, including those using, mounting and managing the operation of abrasive wheels, are fully informed and properly trained in their safe use.

4 This guidance deals primarily with wheels which are formed by abrasive particles being bonded together, ie bonded abrasives.

5 It does not deal with other risks to safety and health which may arise from the use of abrasive wheels, for example:

- (a) dust; and
- (b) noise and vibration.

Regulations covering these hazards as well as other regulations which the user of an abrasive wheel must comply with are listed under Further reading.

Training

6 There is no substitute for thorough practical training in all aspects of the mounting and use of abrasive wheels. Any training programme should cover at least the following:

- (a) hazards and risks arising from the use of abrasive wheels and the precautions to be observed;
- (b) methods of marking abrasive wheels with their type, size and maximum operating speed;
- (c) how to store handle and transport abrasive wheels;
- (d) how to inspect and test abrasive wheels for damage;
- (e) the functions of all the components used with abrasive wheels such as flanges, blotters, bushes, nuts etc;
- (f) how to assemble abrasive wheels correctly to make sure they are properly balanced and fit to use;
- (g) the proper method of dressing an abrasive wheel (removing dulled abrasive or other material from the cutting surface and/or removing material to correct any uneven wear of the wheel);
- (h) the correct adjustment of the work rest on pedestal or bench grinding machines;
- (i) the use of suitable personal protective equipment, for example eye protection (see also paragraph 158).

It is recommended that a record of training in the safe mounting of abrasive wheels is kept, showing the trainee's name and date of training.

7 Training courses are offered by many organisations which usually provide a certificate of attendance, not competence. Further information can be obtained from the British Abrasives Federation.

Abrasive wheel characteristics

8 An abrasive wheel is usually defined as a wheel consisting of abrasive particles bonded together with various substances. There are two main types of bonding agent: inorganic and organic.

9 Inorganic bonds are mainly vitrified, ie the wheel is generally fired in a furnace to give the bond a hard, strong but brittle structure. These wheels are used for precision grinding applications as they hold their shape, but require dressing.

10 Organic bonds are not fired but are cured at low temperature; the bond agents are resinoid (B), rubber (R) and shellac (E). Such wheels are tough, shock-resistant and self-dressing, and are most suited to non-precision applications, for example fettling and cutting off.

11 The following words in bold are the variable elements in abrasive wheel manufacture. Full details are given in Clause 5.5 of BS ISO 525: 1999.⁵

- (a) **Abrasive** means the type of abrasive used in wheel construction;
- (b) **Grain/grit size** means the particle size of abrasive grains. The range is expressed by number (very coarse 4 to very fine 1200);
- (c) **Grade** represents the tenacity with which the bonding material holds the abrasive grain in a wheel. Wheels are graded as 'soft' or 'hard' according to their degree of tenacity. The grade scale is expressed in letters from A (extremely soft) to Z (extremely hard);
- (d) **Structure** means the level of porosity in the wheel. The higher the number, the greater the level of porosity;
- (e) **Bond type** means the bonding material used in the wheel construction.

Abrasive wheel marking system

Marking

12 This should conform to Annex A of BS EN 12413³ (see Figure 1).

Maximum permissible speed

13 The maximum permissible speed in revolutions per minute (rpm) and metres per second (m/s) specified by manufacturers should be marked on every abrasive wheel larger than 80 mm in diameter, or on the blotter or identification label which is sometimes attached to it. Since it is not practicable to mark smaller wheels, the maximum permissible speed in rpm of wheels 80 mm in diameter or less should be stated in a notice posted in a position where it can easily be read. For speeds of 50 m/s and above, colour-coded stripes will appear on the wheel.

Restrictions of use

14 Annex A of BS EN 12413³ and BS ISO 525⁵ specify how wheels should be marked to indicate specific restrictions for use. These are:

(a) RE1: Not permitted for hand-held and manually guided grinding;

(b) RE2: Not permitted for hand-held cutting-off machines (see Figure 1);

(c) RE3: Not suitable for wet grinding;



(d) RE4: Only permitted for totally enclosed working area;

(e) RE6: Not permitted for face grinding.

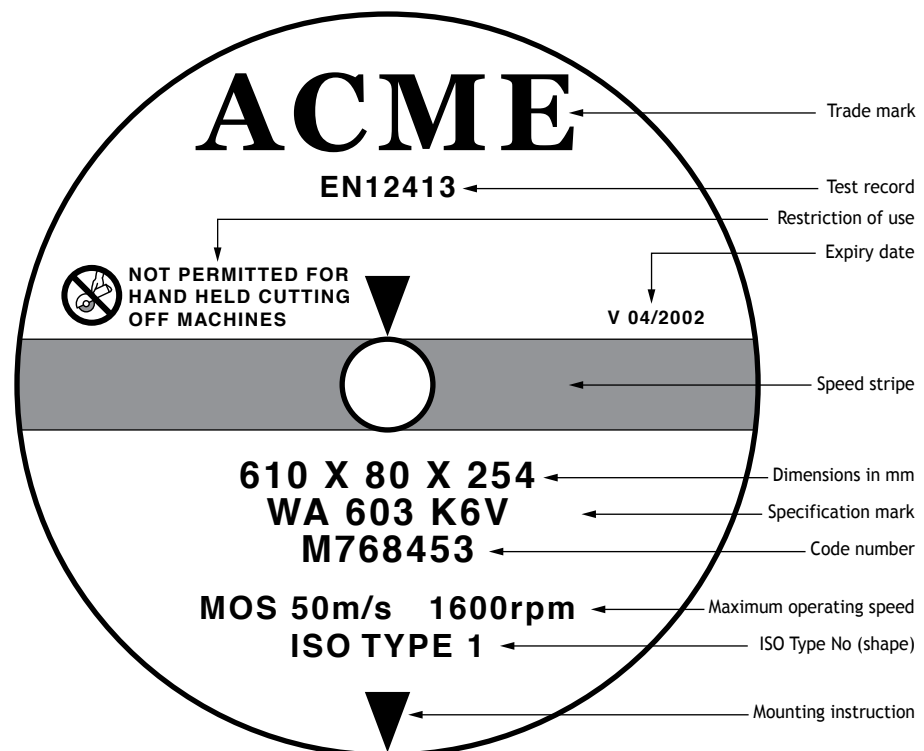


Figure 1 British Standard system for specifying abrasive wheels from BS EN 12413: 1999³ and BS ISO 525: 1999⁵

Shelf life

15 All organic bonded wheels for hand-held applications will bear a use-by date of three years from the date of manufacture.

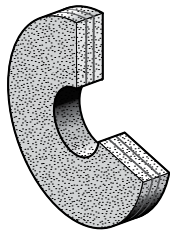
Traceable number

16 A code number should be marked on the wheel to indicate the source and manufacturing details of the wheel.

Safety

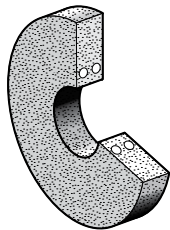
Wheel breakage

17 Abrasive wheel manufacturers take all reasonable precautions, including speed tests, to supply sound wheels, and various methods are used in their construction to reduce the risk of breakage. These include:



(a)

(a) **Fibre reinforcement:** This is normally a resin-coated, woven, glass-fibre mat used in organic wheels (resinoid and rubber bonded) for heavy-duty grinding and cutting operations. It allows the wheel to withstand high stresses and helps to contain fragments if the wheel breaks in use;



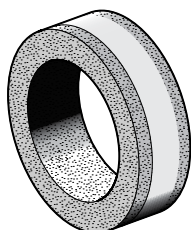
(b)

(b) **Steel rings:** These are moulded into the wheel close to the bore and are designed to retain wheel fragments if breakage occurs when the wheel is near to throwaway size. They can also be used to prevent excessive wear on the wheel;



(c)

(c) **Safety inserts:** These are threaded nuts incorporating locking teeth and form part of a plate which strengthens the base of a cup wheel used for portable grinding. They serve merely as an additional safety device and may **not** replace the guard;



(d)

(d) **Tapewinding:** Adhesive tape, glass-fibre or metallic wire may be used to strengthen thin-walled cup and cylinder wheels. In the event of breakage, they help to hold the fragments together;

(e) **Fine grit centre or similar:** A fine grit centre is placed around the bore to increase the strength of a vitrified grinding wheel. The centre is moulded together with the wheel. The bore area may also be impregnated by epoxy resin to increase the strength of the wheel. These two types of reinforcement are used for wheels operating at 63 m/s to 125 m/s.

In spite of these precautions breakage may occur in service due to a defect caused by subsequent misuse or handling. Bad storage, incorrect selection of a wheel, improper mounting, excessive out-of-balance conditions, excessive speed, grinding machine defects, and malpractices in the grinding operations are all factors that can result in breakage. Two or more of these factors may operate together, and it is essential that every breakage of a wheel should be followed by careful investigation, to establish the cause of the breakage and take suitable action to prevent a recurrence.

Examination, handling and storage of abrasive wheels

Examination

18 Wheels should be carefully unpacked, cleaned with a brush and examined for possible damage in transit. In unpacking, the careless use of a tool may cause damage to the wheel. The soundness of wheels can be further checked by tapping them with a light, non-metallic implement. This is known as the 'ring' test. Wheels must be dry and free from sawdust for the ring test otherwise the sound will be deadened. It should also be noted that organic bonded wheels do not emit the same clear metallic ring as inorganic bonded wheels. Heavy wheels should be supported on a clean hard floor for the ring test while light wheels should be suspended from their hole on a finger or small pin. If the wheel sounds dead, for example due to cracking, it should not be used.

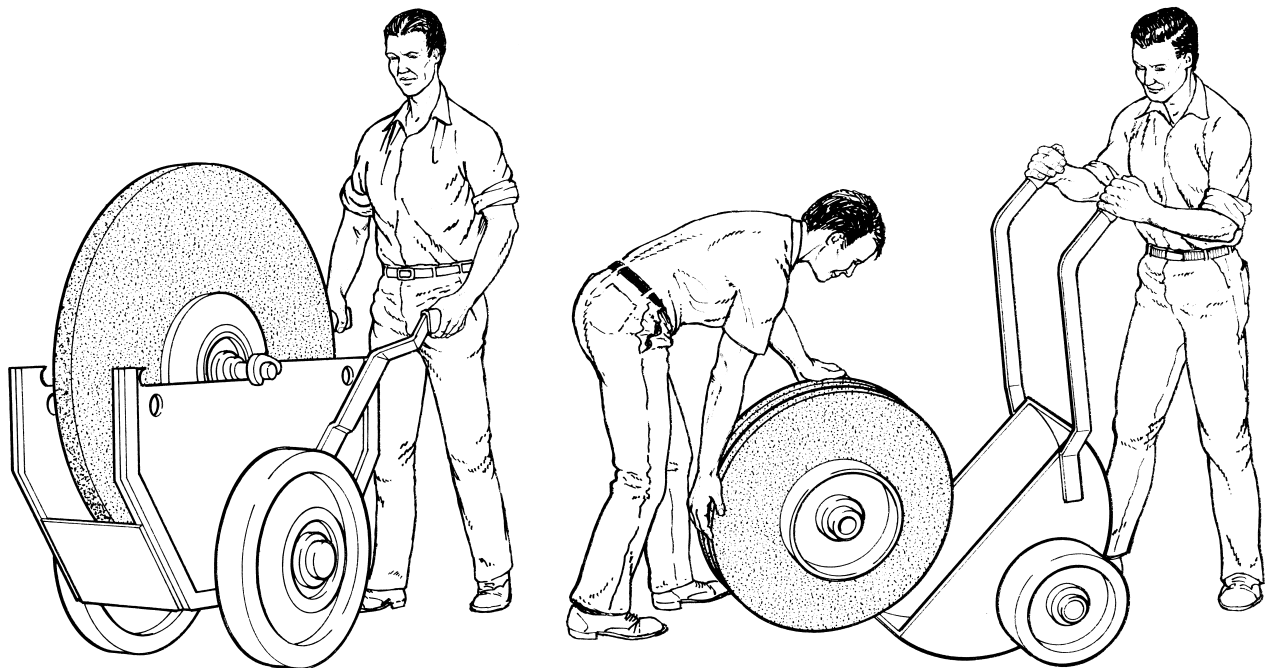
Comparison with other wheels of the same lot and specification will allow rejection of any wheel with a suspiciously different ring before use. In case of doubt, the manufacturer should be notified. The ring test is not practicable with the following types of wheels because of their shape or size, so extra care and vigilance is required during the visual examination:

- (a) small wheels (100 mm diameter and smaller);
- (b) plugs and cones;
- (c) mounted wheels;
- (d) segments;
- (e) plate-mounted wheels;
- (f) inserted nut disc and cylinder wheels.

Handling

19 All abrasive wheels are relatively fragile. It should not be assumed that organic bonded wheels (resin, shellac, rubber) will stand rough handling. The following rules should be observed to avoid chipping, cracking and breakage:

- (a) handle wheels carefully to prevent dropping or bumping. Do not roll abrasive wheels. Where this is unavoidable because of the large size of the wheel, a soft, resilient floor surface is essential.
- (b) use trucks or suitable conveyors which will provide proper support for transporting wheels which cannot be carried by hand (Figures 2 and 3). Stack and support wheels carefully on trucks so that they will not topple over and be damaged. Do not pile heavy castings or tools on top of abrasive wheels.



Figures 2 and 3 When handling large wheels use a truck or other suitable conveyance. They should not be rolled along the floor unless a suitable mat or other protection is available

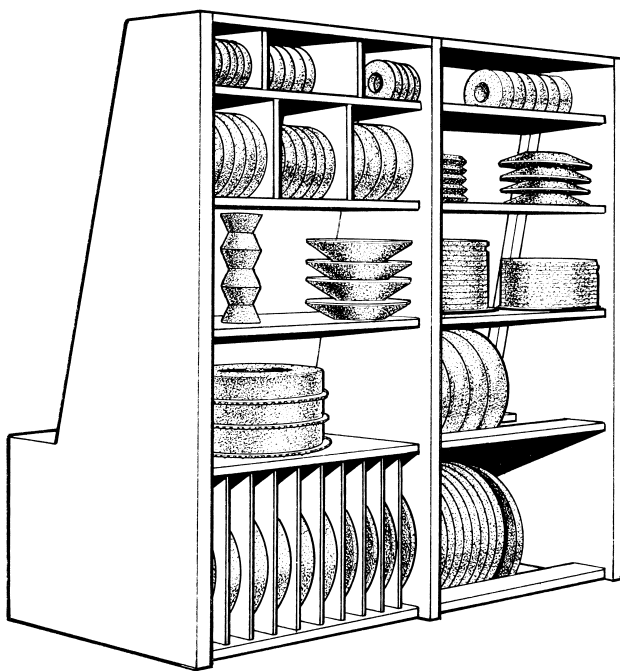


Figure 4a Typical wheel storage

Storage

20 Suitable racks, bins or compartmented drawers should be provided to accommodate the various types of wheels used. The following suggestions covering the design of facilities may be helpful. Most plain and tapered wheels are best supported on their edges or on a central support.

21 Where the wheels are placed on their edges, the support should take the form of a cradle to prevent rolling, with a sufficient number of partitions to prevent wheels from falling over. To prevent warping, thin, organic bonded wheels such as those used for cutting-off should be laid flat on a horizontal surface of steel or similar rigid material away from excessive heat and moisture. Blotters or other packing should not be placed between stacked thin wheels. However, if the wheels are supplied with blotters attached, suitable separators should be used to preserve flatness. Cylinder wheels and large, straight cup wheels may be stacked on the flat side with corrugated cardboard or other cushioning material between them, or they may be stored in racks similar to those used for large, straight wheels. To prevent chipping of edges, taper cup wheels are best stored as shown in the illustration of a typical storage rack (Figures 4a and 4b).

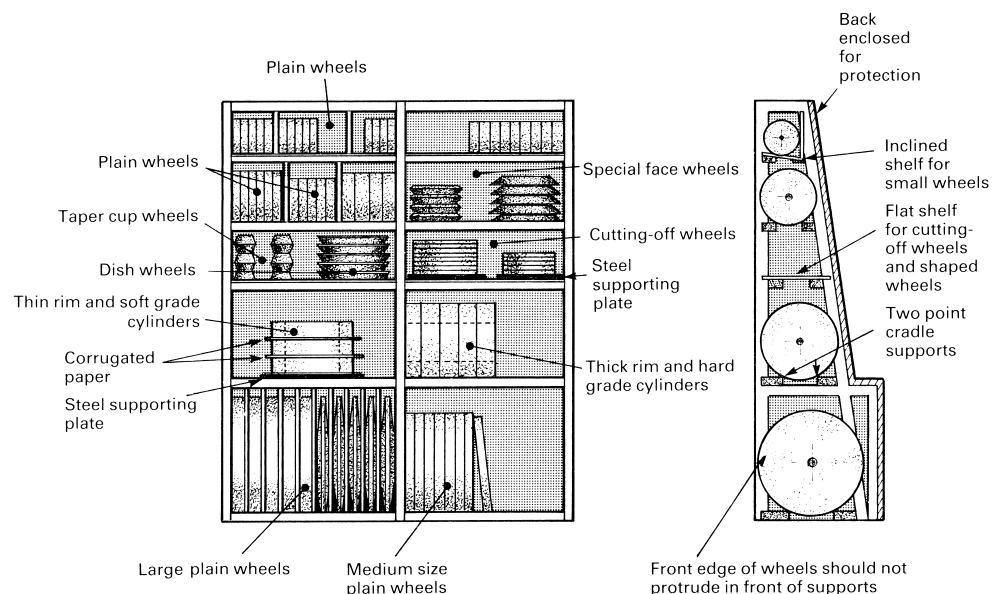


Figure 4b A storage rack suitable for all types of wheels

22 To minimise deterioration, wheels must be stored in a room which is dry and not subject to extreme temperatures. It is recommended that wheels should be marked with the date they are received from the supplier. Older wheels should be issued before newer wheels and if there is any doubt, or if wheels have been in stock for more than three years, the manufacturer should be consulted about their suitability for use.

23 Selecting the correct wheel for the job is essential for safety. A grinding wheel may be dangerous if used for an application for which it is not intended. It is therefore essential that the fullest details of the type of grinding operation should be given to the manufacturer to enable the correct wheel to be supplied.

24 As a rough guide, soft wheels are preferred on hard material and hard wheels on soft material. With wheels of unsuitable structure for the job, 'loading' may result, ie the abrasive wheel face becomes clogged with particles of the material being ground. A wheel may also be either too hard or too fine, resulting in 'glazing'. The operator is then tempted to use excessive pressure for the work on the wheel, a contributory cause of wheel breakage. Each type of wheel has its uses and is best suited to certain classes of work. **The best policy in selecting grinding machinery is to consult machines and abrasive wheels manufacturers and not to experiment without competent advice.** When ordering a new wheel, the most important factors are: wheel dimensions, shapes and recesses (Figure 5), the speed of the machine or spindle on which the wheel is to be mounted, the type of grinding machine, the material to be ground or cut, the rate of stock removal, the accuracy and finish required, and the area of contact of the wheel and workpiece.

25 Grinding wheel manufacturers establish the maximum operating speeds of different types of wheels after taking into account the requirements of the application and the stresses set up under operating conditions. Table 1 (see page 43) gives the general maximum operating speeds in m/s for various classes of wheels and grinding processes. Higher speeds, in excess of those listed, for specially designed and totally enclosed machines may be used, subject to:

- (a) the machine being designed for the speed and fitted with a guard specially designed for this purpose; and
- (b) the wheel being approved by the wheel manufacturer as suitable for the speed and the particular mode of operation, and marked with the appropriate maximum operating speed and the code indicating specific restrictions for use.

26 Once the correct selection has been made, re-ordering the correct wheel can be ensured by recording the information shown on the wheel, blotter or identification label and always quoting it in full on the order to the manufacturer or stockist. Where a variety of wheels are kept in store, it is very important that the correct wheel is issued for the machine on which it is intended to be used.

Speed

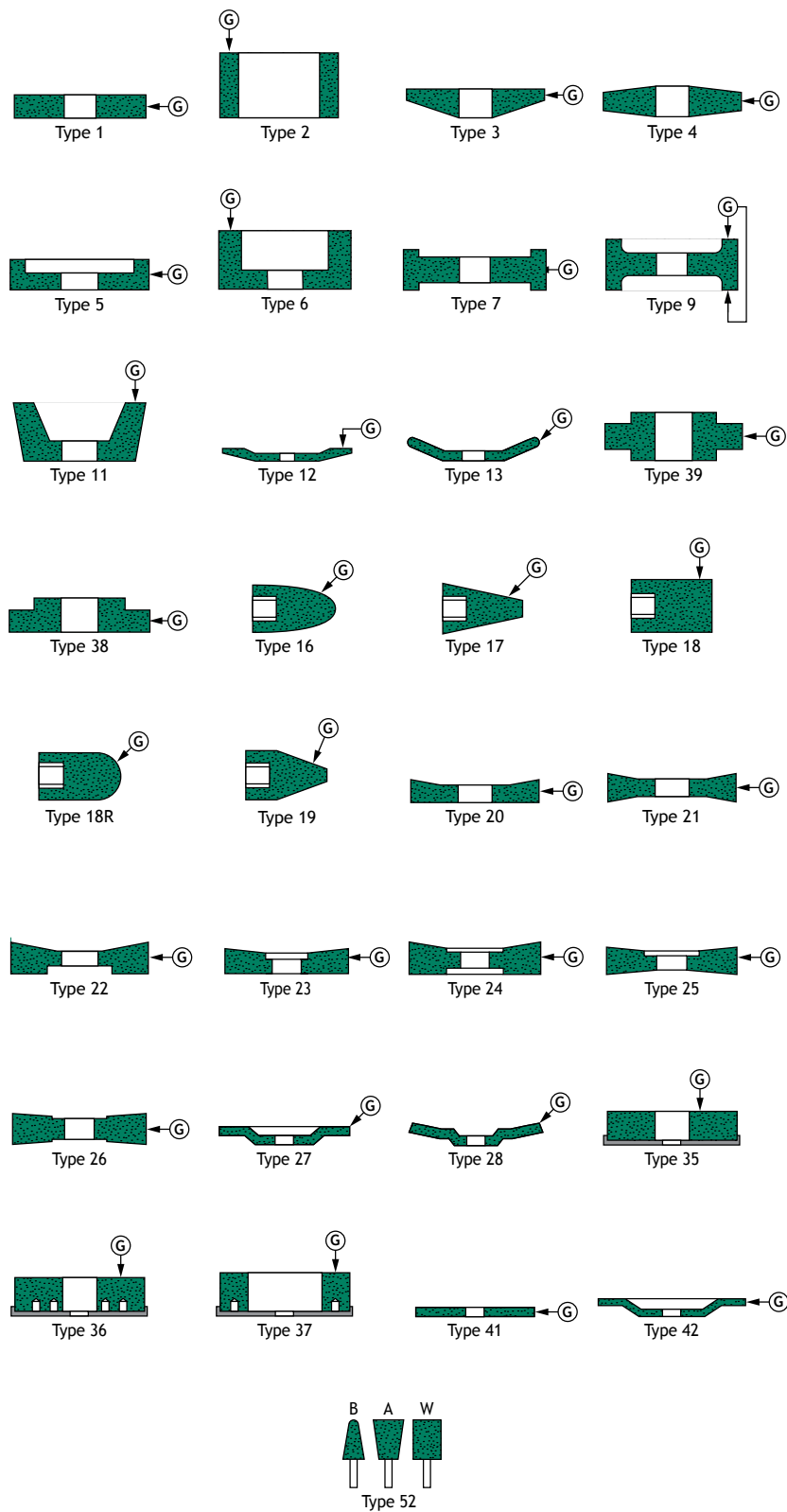
27 Remember that centrifugal force (the ultimate cause of wheel bursts) increases not directly with speed, but as the square of the speed. The speed at which the abrasive wheel revolves is, therefore, extremely important. **It cannot be too strongly emphasised that doubling the speed increases fourfold the stress in the wheel and hence the risk of the wheel bursting.**

Peripheral and rotational speed

28 The maximum operating speed is marked on every wheel in two ways:

- (a) the peripheral surface speed which is given in m/s;
- (b) the rotational speed which is given in rpm.

As the wheel wears down in use, the effective peripheral surface speed will reduce if the rotational speed remains constant and may result in a reduced grinding efficiency. To counteract this, the spindle speed can be increased, providing the maximum peripheral surface speed of the wheel is not exceeded. Always ensure that the spindle speed is reduced to its original value before fitting new wheels.



ⓐ denotes grinding face

Figure 5 Abrasive wheels – types (from Table 12 of BS EN 12413: 1999³)

29 **Never operate new abrasive wheels at speeds (in rpm) in excess of that marked on the wheel. Overspeeding is one of the main causes of wheel breakage.** To illustrate the point, a fragment from a burst wheel operating at 35 m/s is travelling at 80 mph (126 km/hr) and for 125 m/s at 280 mph (450 km/hr).

30 Table 2 (see page 45) gives the conversion of rpm to a peripheral speed in m/s for a wide range of wheel diameters.

The grinding machine

31 Abrasive wheels should not be mounted on makeshift apparatus. They should be mounted on the type of machine for which they are intended. These appear to be obvious precautions, but accidents still occur because wheels are mounted on home-made or improvised apparatus quite unsuitable for the work. Likewise, accidents are caused by heavy wheels being fitted to spindles designed to take only the lightest of wheels. As a result, vibration is excessive and breakages occur. On no account should an abrasive wheel be screwed on to the tapered spindle of a buffing machine. This dangerous method of mounting is likely to result in the breaking of the wheel owing to the wedging action of the tapered spindle.

32 Pedestal grinders should be heavily built and mounted on good foundations. Bench grinders should be securely anchored to a stout bench.

Spindles

33 The spindle should be long enough and threaded to a sufficient length to ensure that when the wheel and flanges are mounted, there will be enough thread for full engagement of the nut on the spindle. The thread should extend inside the flange but not into the hole in the wheel. When the wheel is secured by means of a single central spindle nut, the thread should be such that the direction of tightening the nut is opposite to the direction of rotation of the wheel to ensure that the nut will not come loose as the wheel rotates.

Machine bearings

34 Machine bearings should be maintained in good condition, free from play and adequately lubricated. Loose bearings or any other factor causing an out-of-balance condition will produce vibration and may cause the wheel to knock against the work excessively with the eventual risk of wheel breakage. In addition, heat generated by machine bearings in poor condition can be transmitted to the spindle causing thermal expansion which may result in cracking of the abrasive wheel.

Speed control

35 In no circumstances should the maximum permissible operating speed specified by the wheel manufacturers be exceeded.

36 The maximum speed of the spindle should be marked on every grinding machine so that it is easy to compare the speed marked on the wheel with the speed of the machine spindle. Where the spindle can be operated at more than one specific speed, each speed must be shown, and if the speed is infinitely variable within a specified range, the notice must show the maximum and minimum speeds.

37 The peripheral speed of a wheel on a fixed-speed spindle will decrease as the wheel wears and some loss of efficiency will ensue. In cutting-off work, a speed lower than that recommended may lead to unnecessary breakages. To eliminate the loss of efficiency, some machines are fitted with stepped pulleys so that as the wheel wears, the spindle speed can be increased and an efficient peripheral speed maintained. On these machines, however, an interlocking device should be provided to prevent the spindle speed from being stepped up before the wheel diameter has been sufficiently reduced, otherwise a dangerous peripheral speed may be reached leading to the bursting of the wheel. Some machine manufacturers incorporate this device on new machines. On other machines it is possible to vary the speed infinitely over a specified range, and here it is usual to control the spindle speed by means of the wheel guard which is connected to a split cone pulley. The correct speed is selected by adjusting the whole of the guard, or a hinged visor at the top of the guard (Figure 28, page 26), as close as possible to the periphery of the wheel. When the guard is moved forward or the visor opened to accommodate a large wheel, the speed is reduced.

38 A constant peripheral speed is maintained automatically on some machines by means of a sensing device which detects small changes in the diameter of the wheel as it wears down, and increases the speed accordingly. These devices should be designed so that in the event of an electrical fault, the machine is automatically switched off or made to run at its lowest speed. Air motors in pneumatic grinders can usually attain a very high speed under free-running conditions, and to prevent the wheel from over-speeding, a governor is built into the machine. An exception to this is the class of small grinding machines on which mounted wheels and points are used. The speed of these high-speed machines is controlled by restricting the rate at which air is introduced to or exhausted from the machine to the atmosphere, a method which is also used to a limited extent on larger portable pneumatic machines.

39 Experience has shown that governor failure is a common cause of wheel breakage, so that attention to the governor is most important. Defects in governors can be caused by inadequate lubrication or excessive wear due to grit, scale or moisture in the air supply. Clean air is therefore essential and an effective filter combined with a pressure regulator and lubricator should be connected in the supply line. Failures have also occurred due to the presence of foreign bodies such as stray washers, nuts etc inadvertently left in the governor chamber after maintenance. Governors should be designed to prevent incorrect assembly which has been the cause of a number of accidents. Regular maintenance of governors to manufacturers' instructions is essential and they should be repaired or adjusted only by a competent person. Governors should never be disconnected when a grinder is in use.

Operators should be instructed to report any instability in speed immediately, as this might be the first symptom of a governor defect. Pneumatic grinding machines should be marked with the maximum working air pressure at the machine inlet. As a precaution against this pressure being exceeded, a pressure regulator set to the correct pressure should be connected in the air supply line to the machine. This is especially important with pneumatic machines which do not incorporate a mechanical governor but depend on the control of the air inlet or exhaust to control the speed, when the spindle speed should be checked with a tachometer.

40 Where work-rests are provided on pedestal and bench machines they should be made of steel with renewable top plates, preferably of hardened steel. The rests should be of substantial construction, securely clamped to the machine, and be readily adjustable to follow wheel wear. The rests should be kept adjusted as close as possible to the periphery of the wheel to prevent the workpiece getting between the wheel and the rest, causing jamming, break-up of the wheel and possible injury to the operator. Adjustments to work rests should be made only when the grinding wheel is stationary and the machine isolation switch is in the 'off' position. Work rests should be examined periodically and maintained in good condition.

41 Some machines have a work rest at the side of the wheel which encourages the dangerous practice of side grinding. The use of work rests in this manner can cause the wheel to burst or break after being weakened by grooves worn in the side or, as previously mentioned, when the workpiece becomes jammed between the wheel and work-rest which cannot be correctly adjusted in relation to the side of the wheel.

Insufficient power

42 Inadequate power at the grinding wheel may be caused by a belt slipping or a driving motor of insufficient power. This will cause the wheel to slow down when grinding starts. The operator may apply greater pressure on the workpiece against the wheel and increase the stresses in the wheel. Flat spots will tend to develop and cause 'bumping' and breakage of the wheel.

Stopping devices

43 Means for starting and stopping grinding machines should be clearly visible and marked, placed in a safe position and within easy reach of the operator. On portable machines the control should be located so that there is no risk of accidental starting when the grinder is placed on a flat surface.

Magnetic tables and chucks

44 Magnetic tables and chucks are commonly used on grinding machines. Permanent magnets have great advantages as they do not depend on an electricity supply. The ability of these devices to hold work depends on the material, surface conditions and the area of contact of the work. These factors, together with the use of stops and suitable fixtures, should all be considered. It is also good practice to provide a substantial guard around the machine table as a protection against the workpiece being ejected.

Mounting of abrasive wheels

45 The danger of an abrasive wheel bursting is considerably increased if it is not properly mounted; many accidents could be prevented if the people mounting the wheels were instructed (see paragraph 6) in the hazards arising from incorrect mounting and in the correct method of assembly. Paragraphs 46–90 explain the purpose of the various components used with abrasive wheels and the precautions which should be taken in the mounting of each type of wheel.

Flanges

NB: The information contained in this section may be subject to revision following publication of proposed CEN standards on grinding machines.

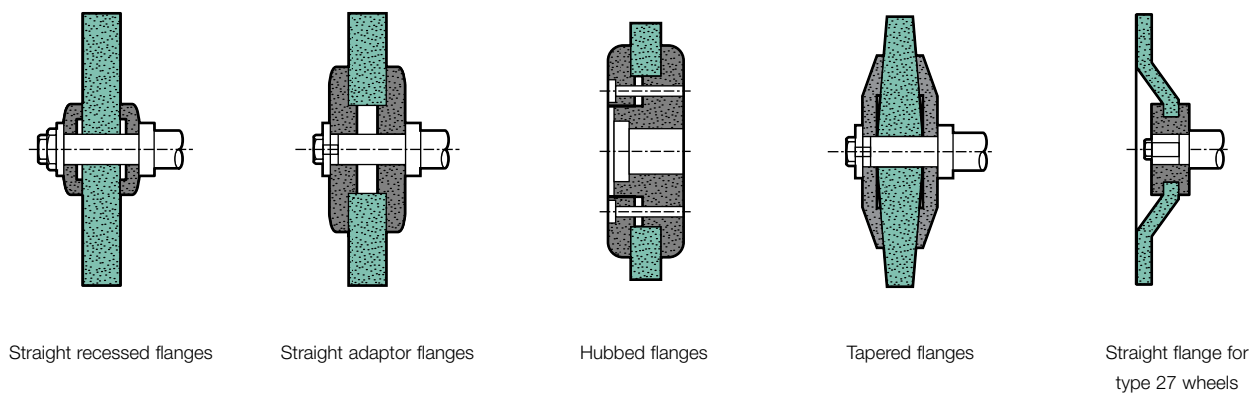


Figure 6 Basic types of mounting

46 The major stresses produced in an abrasive wheel under operating conditions tend to become greatest near the hole. It is therefore important that stresses due to mounting and driving are as far from the hole as practicable. This is done by recessing the side of the flange next to the wheel. In the case of straight adaptor and hubbed flanges there is an undercut in place of a recess (see paragraph 50). With certain exceptions, every abrasive wheel should be mounted between flanges which are at least one third of the diameter of the wheel.

47 The exceptions are:

- (a) mounted wheels and points;
- (b) wheels with threaded inserts;
- (c) abrasive discs (inserted nut discs and cylinders);
- (d) plate-mounted wheels;
- (e) cylinder and cup wheels and segments mounted in chucks;
- (f) wheels of 20 mm diameter or less.

48 Reinforced resin bonded depressed-centre grinding and depressed-centre and flat cutting-off wheels up to 230 mm diameter may be mounted between smaller flanges on portable machines. Reinforced resin-bonded flat cutting-off wheels on fixed and portable petrol-engined cutting-off machines may be mounted between flanges of at least one quarter of the wheel diameter or more.

Material for flanges

49 Flanges should be made from good-quality mild steel such as that specified in BS 970: Part 1: 1996⁶ or another material with sufficient strength and rigidity to resist undue deflection when the flanges are tightened on the wheel. In view of its low tensile strength and the risks of cracks developing in service, grey cast iron cannot be regarded as safe for the flanges of abrasive wheels. For small abrasive wheels (for example straight wheels on small bench grinders) flanges of non-ferrous alloys have been used successfully.

Recess and undercut

50 Flanges should be recessed on the side next to the wheel. An exception is the single flat flanges used with threaded-hole wheels. Flanges for wheels with large holes, adaptor and hubbed flanges are illustrated in Figure 6. These are not recessed, but the corners of the wheel seatings should be undercut so that there will be no bearing on the side of the wheels within 6 mm of the hole.

Finish of bearing surfaces

51 The surfaces of the flanges which bear on the wheel should be machined true and there should be no exposed rough edges or surfaces. If the bearing surfaces become damaged, they should be re-trued, and the recess re-cut, care being taken to maintain the original diameter and depth of recess without unduly impairing the stiffness of the flanges. When re-truing the flanges would result in an unacceptable loss of stiffness they should be replaced by new flanges. Before any attempt is made to re-true cambered flanges, the advice of the machine manufacturer should be sought.

Driving flange

52 The inner (driving) flange should be keyed, screwed, shrunk or otherwise secured to the spindle to prevent rotation, and the bearing surface should run true with the spindle. For bench-mounted machines driven by a motor of less than 560 W and fitted with pressed steel flanges, the inner (driving) flange may be secured by friction only.

Uniformity of diameter

53 As a general rule both the flanges used to secure a wheel to the spindle should be the same diameter and have the same recess diameter to create equal bearing surfaces on the wheel, but the shape of some wheels may not allow this rule to be followed, for example certain internal and cup wheels (see Figure 18, page 25).

Dimensions

54 Dimensions of flanges for different types of abrasive wheels are given in British Standards, for example BS EN 13218.⁷

Blotters

55 Blotters of compressible material (usually cardboard not less than 0.2 mm thick and not more than 1.0 mm) as supplied by the wheel or machine manufacturer, should be used between the wheels and their flanges, except for the wheels mentioned in paragraph 56. The main purpose of blotters is to distribute the clamping force of the flanges evenly on the wheel, but they also prevent slipping at lower clamping forces and reduce wear on flanges. Blotters should be an easy fit on the spindle or on the wheel locating spigot, if there is one, and should be slightly larger than the flanges. Care should be taken to see that each blotter is free from wrinkles. If the wheel has been used previously, any pieces of old blotter or loose grains of abrasive should be carefully removed, otherwise high spots will occur leading to severe local stresses when the wheel is clamped tight. A blotter can serve as a label; however, a label cannot act as a blotter.

56 Blotters should not be used with the following types of wheels:

- (a) mounted wheels and points;
- (b) abrasive discs (inserted nut discs and cylinders);
- (c) plate-mounted wheels;
- (d) cylinder wheels mounted in chucks;
- (e) rubber-bonded cutting-off wheels 0.5 mm or less in thickness;
- (f) taper-sided wheels;
- (g) wheels with threaded inserts.

Wheel bushes

57 Bushes are inserts made of plastics or metal and used to reduce the hole size in an abrasive wheel so that it can be mounted correctly on a small diameter spindle. Bushes are hand-pressed into the hole of the wheel and are not recommended for use with wheels fitted to portable grinding machines. They should be slightly less than the width of the wheel and blotters. As the power required to drive a grinding wheel is transmitted to it through the flanges, care should be taken to ensure that the bearing area of the flange is in contact with the wheel and not the bush.

58 Before using wheel bushes, the depth of the recess in the securing flanges should be measured to see if it is possible for the bush to slide out of the wheel and become loose in the recess of the flange. This is most likely to occur when two narrow bushes are used one at each end of the hole as an alternative to one bush extending the full width of the wheel. If the depth of the recess will allow this to happen, the bushes should not be used and a wheel with a hole to suit the machine spindle should be used.

Securing the wheel

59 The abrasive wheel should fit freely but not loosely on the spindle. If it grips the spindle or flange location diameter, heat generated during the grinding operation could cause the spindle to expand and possibly crack the wheel.

60 Where the wheel is clamped by means of a single central nut, the nut should be tightened only enough to ensure that the flanges drive the wheel and prevent slip.

61 Where a tightening torque is recommended by the machine manufacturer a torque wrench should be used. Otherwise tightening should be done only by hand pressure on a spanner.

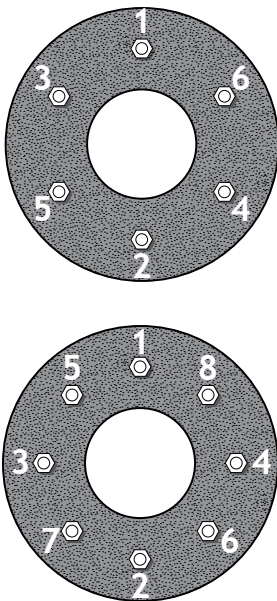


Figure 7 Sequence for tightening screws

62 Excessive clamping pressure applied by using an extension to a spanner for example, or by hammering, may damage the wheel. Screws on multiple screw-type flanges should first be tightened by hand, having ensured that the flange is properly located and seated firmly on the blotter, then fully tightened using the recommended tool. Tightening should proceed from the first screw to the one diametrically opposite and then in criss-cross sequence until sufficient pressure is applied uniformly to prevent the abrasive wheel slipping between the flanges (Figure 7). Care should be taken to avoid excessive tightening which may cause springing of the flanges and result in wheel breakage. This is particularly important with wheels 150 mm or more in thickness, when flange screws are tightened under hot operating conditions and the machine is then allowed to cool after use. Spindle contraction along its axis on cooling may distort the flanges so that they exert pressure on the corners of the hole in the wheel and produce a fracture.

63 Threads of screws and tapped holes should be in good condition and kept clean, otherwise equal torque applied on all screws will not provide a uniform clamping force. If clean screws are not easily tightened they should be replaced or the holes in which they fit should be re-tapped.

64 If the flange screws are too long, they may touch bottom in tapped holes, resulting in a loosely clamped wheel.

Multiple wheel mounting for fixed machines

65 Such assemblies may be complex and advice should be sought from the manufacturer as to the mounting requirements, for example use of blotters. NB: Where different wheel diameters are used on multiple assemblies the maximum operating speed of the largest diameter wheel should not be exceeded.

Checking the speed

66 Before the wheel is mounted, a check should be made to ensure that the maximum permissible speed marked on the wheel, blotter or identification label is not exceeded by the speed of the spindle marked on the machine. The speed of spindles should be checked at suitable intervals by means of a tachometer, and several readings should be taken to obtain an average speed in rpm.

67 It may be necessary to remove the guard in order to measure the spindle speed by means of a tachometer or other instrument. The guard must then be replaced before operation starts. Electronic tachometers do not require any contact with the rotating parts and can therefore be used with the guard in place.

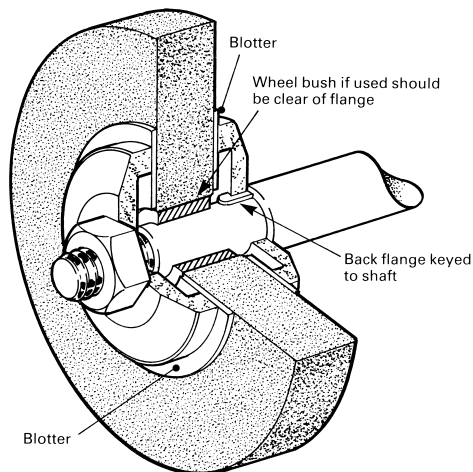


Figure 8 A straight-sided wheel with a small hole, correctly mounted

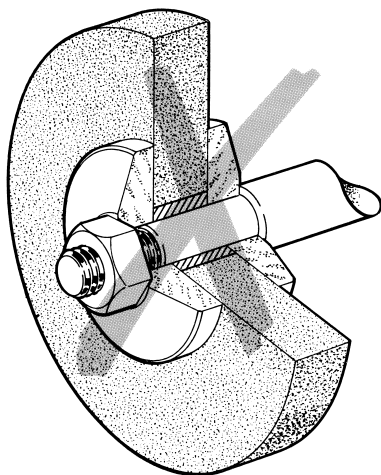


Figure 9 An incorrectly mounted wheel. The flanges are not recessed and washers (blotters) are not fitted

Starting new wheels

68 Before the wheel is run, the guard should be properly adjusted and secured. If the machine is fitted with a work rest, it should be adjusted as close as possible to the wheel and the wheel should then be rotated by hand to ensure that it is clear all the way round. New or re-fitted wheels should be run free at full operational speed for a short period before they are used, and during the trial run everyone should stand clear. With portable machines the operator should ensure the machine is operated with the guards properly positioned.

Plain wheels with small holes

69 Figure 8 shows a wheel correctly mounted. The wheel is gripped between two flanges of equal diameter, the inner (driving) flange being keyed on the spindle and the outer one tightened by a nut on the threaded spindle end. Excessive tightening of this nut is unnecessary and, by setting up an undue crushing stress in the wheel, might cause breakage. Each flange has an equal recess and the blotters are slightly larger than the diameter of the flanges.

70 Figure 9 shows a wheel incorrectly mounted. Here the flanges are not recessed and blotters are not used. The result may be that when the nut is tightened, proper gripping is not obtained even with normal pressure and localised stresses are set up near the hole. Other unsatisfactory and dangerous conditions which are sometimes found include: flanges unmatched in outside diameter and diameter of recess; one flange omitted and the nut tightened directly against the wheel; use of an ordinary washer as a substitute for a properly recessed flange. Such conditions increase the liability of a wheel to fracture because they result in undue concentration of stress near the hole.

71 Wheels for internal grinding are mounted as shown in Figure 10.

Plain wheels with large holes

72 One of the types of flanges used for wheels with large holes is the adapter flange shown in Figure 11. The flanges are tightened by means of a central nut. The other type of flange is the hub flange (Figure 12). The flanges are tightened by a series of clamping screws and the wheel holder or collet is machined to fit the tapered end of the spindle. If the machine manufacturer has provided a keyway, a close side-fitting key should be used. Hub flanges frequently have grooves machined into them to accommodate adjustable balance weights and it is usual to keep wheels of different grits and grades mounted on the collet to facilitate wheel changing and reduce changeover time. When not in use, these collets should be supported in suitable cradles. The wheel flange seatings should be undercut (Figures 11 and 12) to prevent pressure being exerted on the corners of the wheel.

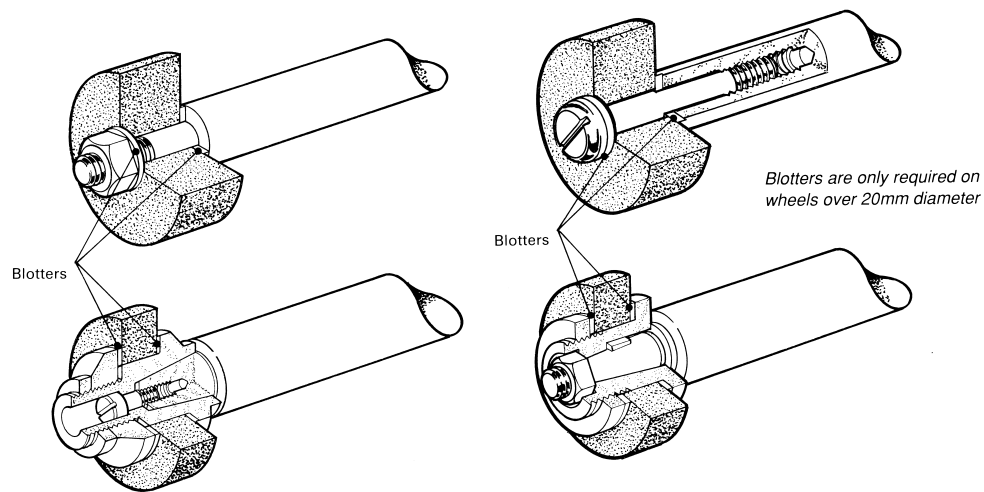


Figure 10 Methods of mounting small wheels for internal grinding

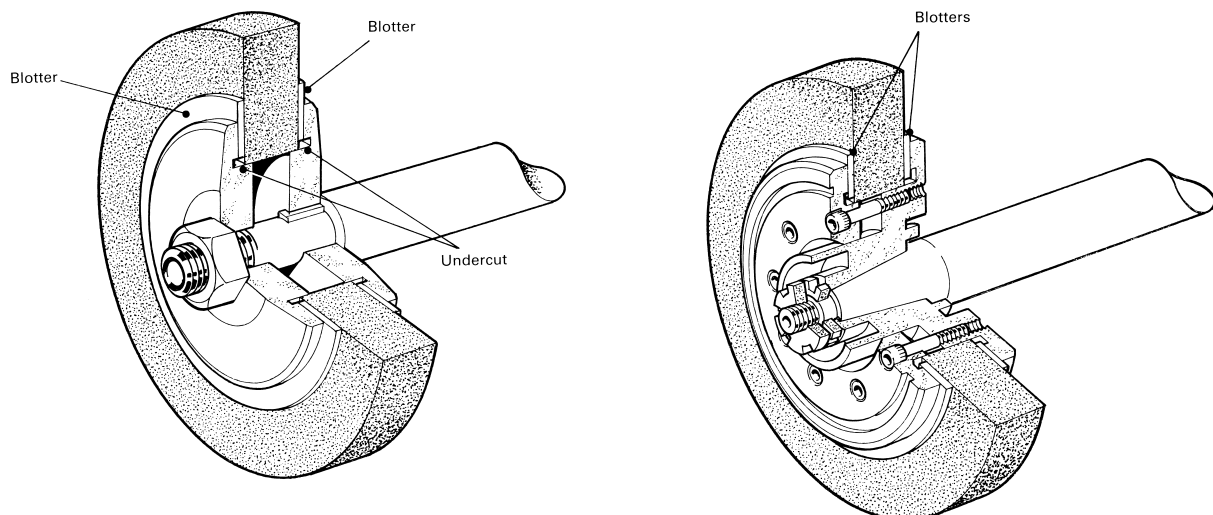


Figure 11 A straight-sided wheel with a large hole mounted between adaptor flanges and secured by a central nut. The corners of the wheel seatings should be undercut as shown

Figure 12 A method of mounting a precision wheel for external grinding

Tapered wheels

73 For portable grinding machines using abrasive wheels of 200 mm diameter or less there are certain grinding operations where the use of a normally guarded abrasive wheel is difficult, such as grinding inside a hole. One solution to this difficulty is to use a Type 4 taper-sided wheel (see Figure 13). These wheels have each side tapered by 6% and are clamped by flanges with matching tapers. These flanges are intended to grip large fragments of a broken wheel when a major fracture occurs. However, they cannot contain fragments which break off that part of the wheel not covered by the tapered flange. These wheels should never be used with ordinary, straight, flanges. Blotters are not required.

The recommended flange size is at least half the wheel diameter.

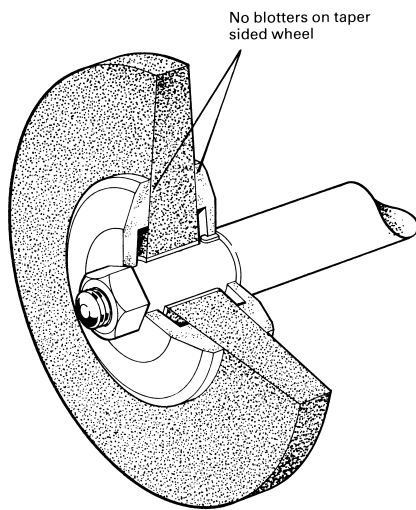


Figure 13 Protection flanges used with a tapered wheel. To be effective, the degree of taper of the flanges must correspond with that of the wheel

74 Tapered wheels should only be used inside a bore where the workpiece can act as a guard in the event of a wheel fracture. Where possible, they should be used with guards. They should not be used without guards for general fettling operations. Another, safer possibility is to use a cone or plug wheel, for example Types 16, 17, 18, 18R, 19 in Figure 5, page 13.

Recessed wheels

75 Recessed wheels are used to give a wider grinding face than that obtained by using straight-sided wheels. They may be recessed on one or both sides and should be mounted in the same way as straight-sided wheels. The diameter of the flanges should be at least one-third of the diameter of the wheel and the diameter of the recess should be large enough to accommodate the flange without allowing it to bear on the corner radius in the recess. The total depth of recess on each side of the wheel should not exceed half the wheel thickness.

Discs and cylinder wheels

Inserted nut mounting

76 In this method of mounting abrasive discs and cylinder wheels, threaded nuts are anchored in the back of the wheels by cementing, casting or moulding (Figure 14). The wheels are secured to a faceplate, with a diameter not less than that of the wheel, and thick enough to provide proper support. The screw holes in the faceplate and the tapped holes in the inserted nuts in the wheel should be accurately matched, and the screw holes should be large enough to prevent binding.

77 Bolts, which should be of high tensile steel, need to be long enough to engage the threads properly in their inserted nuts, yet not so long that there will be any possibility of the screw ends touching the bottom of the hole. They should have square ends so that there will be a full thread to the end of the screw. The faceplate should be maintained true and flat to provide even support over the area of contact between plate and wheel, and before mounting, both the plate and the wheel clamping face should be cleaned. The screws should be tightened uniformly in a diametrical sequence, as described in paragraph 62.

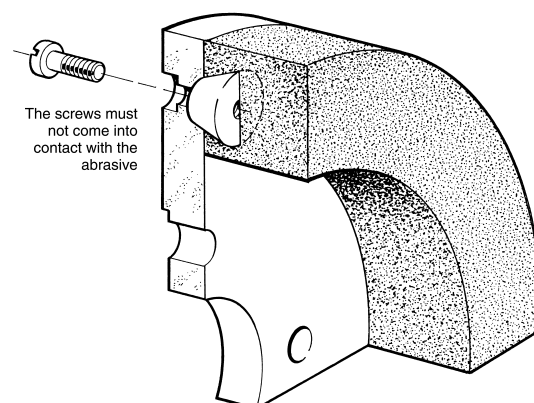


Figure 14 A cylinder wheel secured to a backplate by means of nuts anchored in the back of the wheel

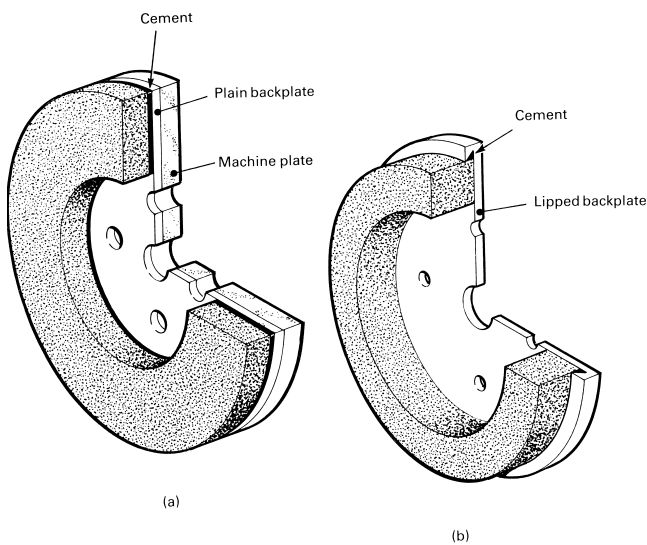


Figure 15 A bonded abrasive disc cemented to (a) a plain backplate and (b) a lipped backplate

Cementing to a backplate

78 Some wheels have a steel plate permanently cemented to the back, and this is fastened to the machine plate by screws. Figure 15a illustrates a plate-mounted wheel of this type. Other wheels are cemented to a lipped backplate (Figure 15b). Various cements may be used for this purpose, and the manufacturer's instructions should be strictly followed. Epoxy resin adhesives can be used for this purpose, but with this type of adhesive it may be necessary to discard the backplate or return it to the wheel manufacturer when the abrasive wheel is no longer usable.

Chuck mounting

79 Cylinder wheels may be mounted in protection or safety chucks (Figure 16). The wheel rests against a circular plate and is kept tightly in position by sector wedges which are secured by bolts. When the face of the wheel has worn down, the wedges are slackened, the plate is advanced along the screwed boss of the wheel housing by use of a special tool and the wedges are re-tightened. The chuck should be kept adjusted to give minimum projection of the wheel beyond the chuck.

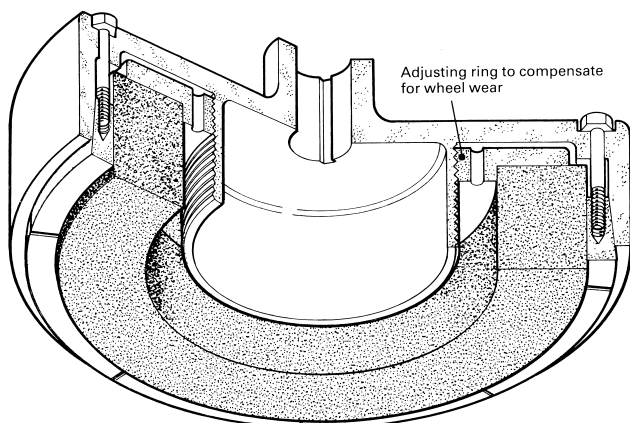


Figure 16 A cylinder wheel mounted in a protection chuck

Segments

80 Abrasive wheels consisting of separate segments are generally used for heavy stock removal. They stand up to heavy grinding and may allow the use of harder grades of abrasive than with solid wheels. They are used particularly on vertical grinding machines. The segments are held by special chucks with provision for the adjustment of segments to compensate for wear. Care should be taken to ensure that the segments, when mounted, do not protrude from the chuck for a distance exceeding 1.5 times the thickness of the segment. Figure 17 shows a typical arrangement of the segments and chuck. One segment is shown removed to illustrate the method of adjusting the segments to take up wear.

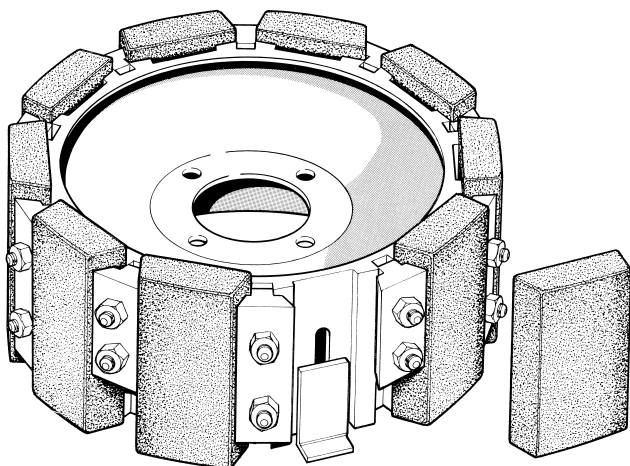


Figure 17 A typical mounting for abrasive segments

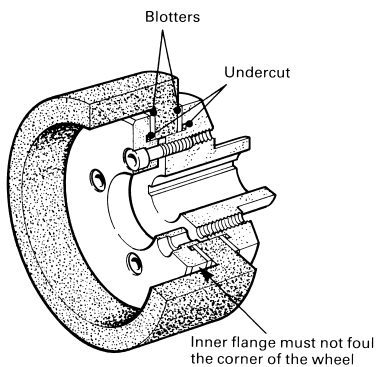


Figure 18 A cup wheel mounting for a fixed machine

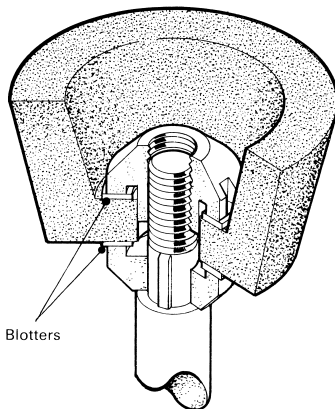


Figure 19 An adaptor flange for an unthreaded-hole cup wheel. To provide proper support, the adaptor flange and back flange should be equal in outside diameter and diameter of recess

Cup wheels

Fixed machines

81 Figure 18 shows how a cup wheel should be mounted on a fixed machine. The same principles apply as for the mounting of plain wheels, but the diameter of the flange and blotter inside the cup must be slightly smaller than the diameter of the wheel recess to prevent any risk of radial pressure on the wheel. When used for work heavier than light tool and cutter grinding, the back flange can, with advantage, be larger than that inside the cup, **but the diameter of the recess in both flanges must still be equal.**

Portable machines (unthreaded-hole cup wheels)

82 Wheels of this type used on portable machines are mounted by means of an adaptor flange as in Figure 19. To provide proper support for the wheel the back flange and adaptor should be equally recessed, as with plain wheels, and blotters should be used. Care should be taken that the clamping flange does not foul the radius in the corner of the wheel.

Portable machines (threaded-hole cup wheels)

83 Threaded-hole cup wheels are screwed on to the end of the machine spindle against a flange. The flange should be flat and not recessed (Figure 20) as a recessed flange (Figure 21) would tend to strain the threaded bush. A blotter must not be used. Breakages of this type of wheel may generally be attributed to such faults as a spindle having insufficient thread, or the use of a recessed flange which tends to pull the bush out of the wheel.

Cone and plug wheels

84 Cone and plug wheels are manufactured with blind threaded holes. When mounting, it is important that the hole is free from foreign matter and that the threaded spindle is shorter than the hole so that it will be long enough to give sufficient thread engagement to hold the cone but not to press on the bottom of the hole. The flange should not be recessed as this would tend to pull out the bush, and a blotter is not required.

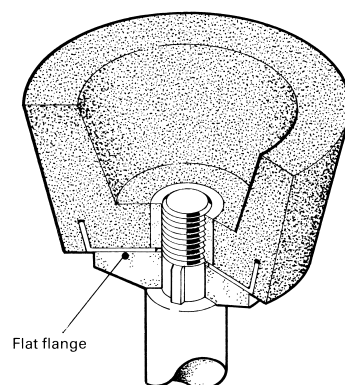


Figure 20 A correctly mounted threaded-hole cup wheel

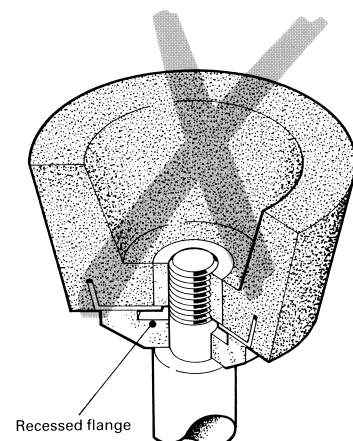


Figure 21 An incorrectly mounted threaded-hole cup wheel. The recessed flange does not provide proper support

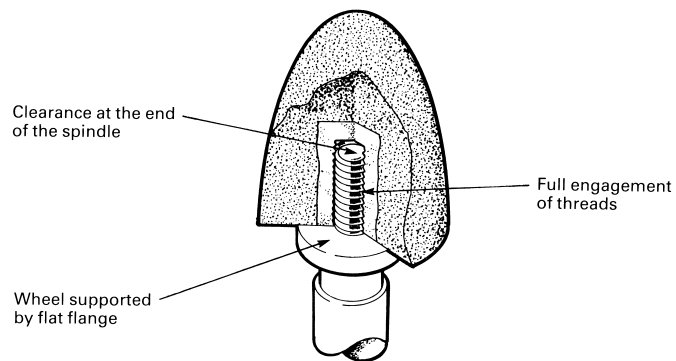


Figure 22 A correctly mounted threaded-hole cup wheel

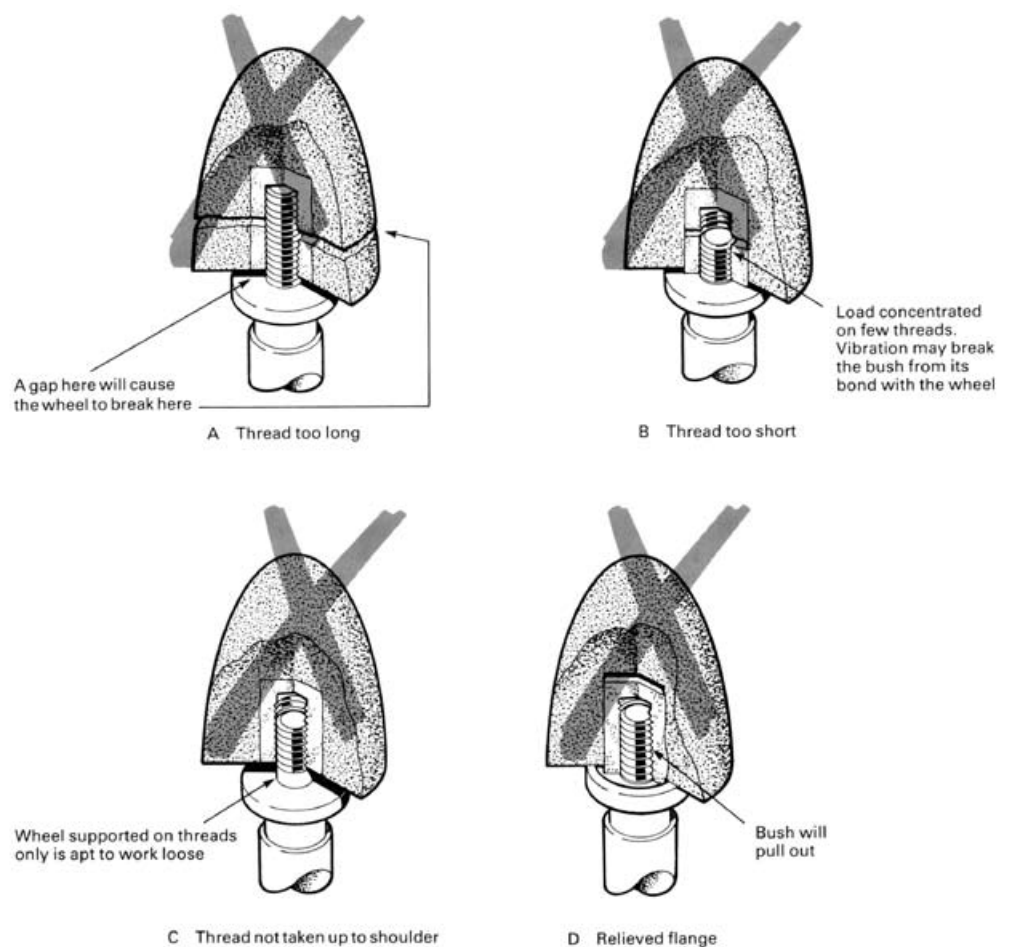


Figure 23 Common faults in the mounting of cone wheels

Figure 22 shows a properly mounted cone wheel while Figure 23 shows examples of common mounting faults. In (a) the spindle is too long and will cause the cone to crack and break up; in (b) the spindle is too short, concentrating the load on a few threads. Vibration may break the bush from its bond with the wheel allowing it to pull out; in (c) the threaded length of the spindle is inadequate and the cone may work loose; in (d) a recessed flange has been used which may well result in the bush being pulled out.

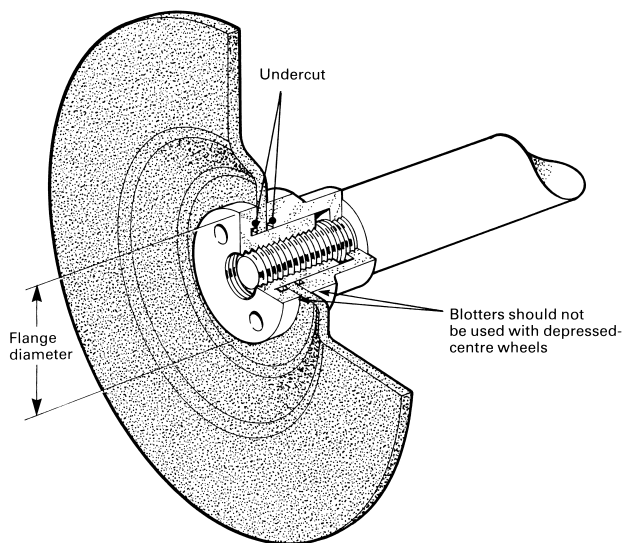


Figure 24a Mounting for a depressed-centre wheel

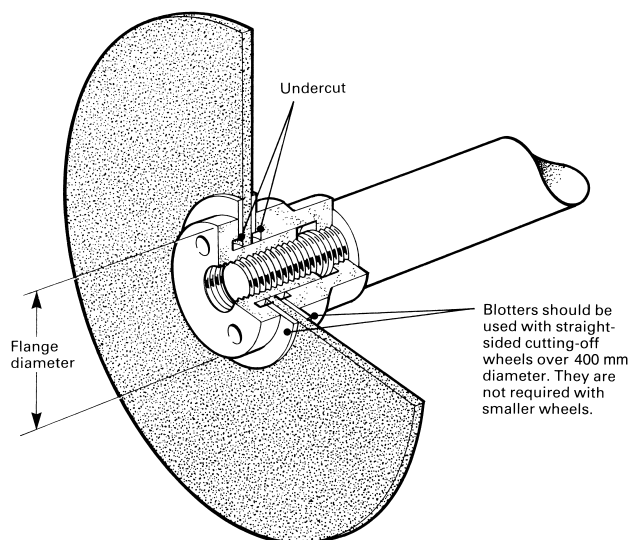


Figure 24b Mounting for a cutting-off wheel

Depressed-centre wheels

85 Depressed-centre wheels are reinforced wheels used mainly on portable machines. Type 27 wheels are for grinding, for example dressing the face of a workpiece. Type 42 wheels are for cutting-off operations such as the removal of runners and risers on castings and cutting reinforcing rods on building and civil engineering projects. They may be mounted between small flanges which grip on the hub, as in Figure 24a.

Flat cutting-off wheels

86 Flat cutting-off wheels are thin, straight-sided wheels with a central hole, used at high peripheral speed and may be either reinforced or unreinforced. Unreinforced cutting-off wheels are particularly susceptible to shock and should only be mounted on machines designed specially for their use, never on makeshift or improvised machines, such as woodworking circular-saw benches. An unreinforced cutting-off wheel should never be used on a portable grinding machine, mobile machine or on any machine where the work is fed into the wheel by hand; in such cases the wheel must be of the reinforced type (see the advice on the use of cutting-off wheels on portable machines in paragraph 87). For cutting metal, unreinforced cutting-off wheels used on fixed machines should be mounted between flanges which are as large as practicable and at least one third of the diameter of the wheel. For cutting non-metallic materials, reinforced cutting-off wheels used on fixed machines should be mounted between flanges which are at least one quarter of the diameter of the wheel.

Portable machines

87 Reinforced cutting-off wheels used on portable machines should be mounted as in Figure 24b. The flanges should be of equal diameter with equal diameter recesses; the use of unequal flanges is liable to cause distortion and breakage of a cutting-off wheel. Blotters need not be used between the wheel and the flanges for wheels of 400 mm diameter or less. However, if slippage occurs blotters should be used.

Mounted wheels and points

88 Mounted wheels and points, with a maximum diameter of 80 mm, are used extensively in operations such as die finishing where the nature of the work prevents the use of conventional wheels. There is a wide variety of standard shapes of mounted wheels and points. The abrasive point is secured on the end of a spindle, normally 38 mm long.

89 The factors to be considered in the safe use of mounted wheels and points are more complex than for ordinary wheels. Because of the smaller diameter of the abrasive surface, a high speed of rotation is necessary for efficient working. Small air or electrically driven portable grinders are available with speeds exceeding 100 000 rpm. Operation above the recommended speed is liable to cause fracture of the spindle or result in the spindle bending through a right angle and the point flying off, and it is possible that the collet may also fracture.

90 Severe injuries to eyes and face have occurred as a result of overspeed accidents. The correct operating speed depends on three factors: the shape and dimensions of the point; the diameter of the spindle; and the overhang of the point from the collet (see Tables 3, 4 and 5). (The overhang is the part of the spindle which is exposed between the collet and the part of the abrasive material nearest to the collet.) Further information is also available in Annex C of BS EN 12413: 1999 *Safety requirements for bonded abrasive products*³ to ensure that the overhang does not exceed that appropriate to the speed, size of point, and diameter of spindle. For longer spindle lengths and overhangs the wheel manufacturer should be consulted. Some collets are made to close and grip at each end by means of opposing tapers. This type of collet is also capable of tolerating a greater variation in spindle diameter than other collets which only grip at one end.

Summary of mounting procedures

91 Wheel mounting should be carried out only by an appropriately trained person. A wheel should be mounted only on the machine for which it was intended. Before mounting, all wheels should be closely inspected to ensure that they have not been damaged in storage or transit.

92 The speed marked on the machine should not exceed the speed marked on the wheel, blotter or identification label.

93 The bush, if any, should not project beyond the sides of the wheel and blotters. The wheel should fit freely but not loosely on the spindle.

94 Flanges should not be smaller than their specified minimum diameter, and their bearing surfaces should be true and free from burrs.

95 With the exception of the single flange used with threaded-hole wheels, all flanges should be properly recessed or undercut.

96 Flanges should be of equal diameter and have equal bearing surfaces (but see paragraph 53). Protection flanges should have the same degree of taper as the wheel. Blotters, slightly larger than the flanges, should be used with all abrasive wheels except those listed in paragraph 56. Wrinkles in blotters should be avoided.

97 Wheels, blotters and flanges should be free from foreign matter. Clamping nuts should be tightened only sufficiently to hold the wheel firmly. When the flanges are clamped by a series of screws they should be tightened uniformly in a criss-cross sequence. Screws for inserted nut mounting of discs, cylinders and cones should be long enough to engage a sufficient length of thread, but not so long that they contact the abrasive.

98 When mounting the wheels and points, the overhang appropriate to the speed, diameter of the mandrel and size of the wheel should not be exceeded, and there should be sufficient length of mandrel in the collet or chuck.

Guards

Purpose of guards

99 In spite of the care exercised by abrasive wheel manufacturers in the design, manufacture and testing of wheels, the risk of a burst is inherent in every abrasive wheel and a guard of adequate strength must be provided to prevent injury from flying fragments.

100 A guard has two main functions: firstly to contain the wheel parts in the event of a burst; and secondly to prevent, as far as possible, the operator from coming into contact with the wheel. A guard also has the secondary functions of protecting the wheels against inadvertent damage and preventing an oversize wheel from being fitted.

101 Internal grinding wheels are, while operating, guarded by the workpiece itself. On fixed internal grinding machines, however, arrangements can be made so that a guard may be placed in position automatically when the wheel in motion is withdrawn from the work (Figures 25 and 26a–c).

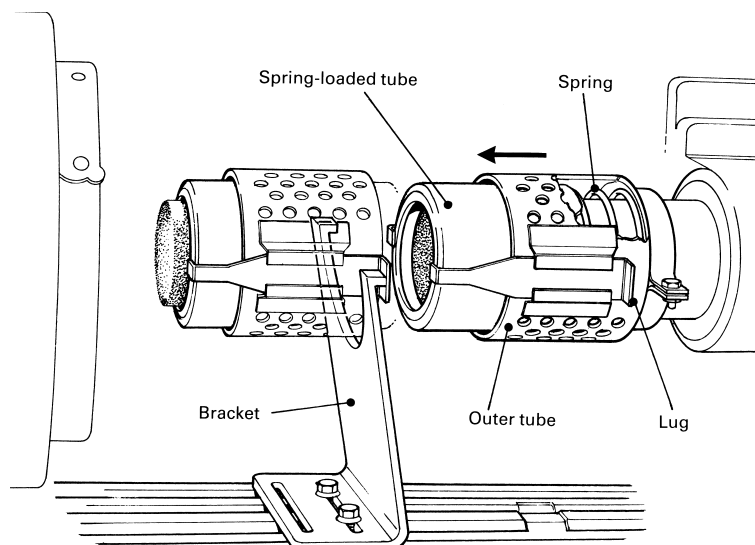


Figure 25 A spring-loaded telescopic guard for use on an internal grinding machine. As the workpiece advances towards the wheel the bracket strikes the lugs and retracts the guard to expose the wheel. When the work is withdrawn, the guard is returned by the spring to its original position covering the wheel

102 The internal grinding machine in Figure 26a is enclosed to control the emission of noise, vapour and splash. The sliding door is interlocked to ensure that access to the workpiece is prevented until it has stopped rotating. The abrasive wheel is guarded by a pneumatically operated telescopic guard which retracts and extends like the mechanical guard shown in Figure 25. The valves controlling the movement of the air cylinder are operated by a cam attached to the traversing table. Figure 26b shows the guard retracted to expose the wheel while Figure 26c shows the guard fully extended to cover the wheel.

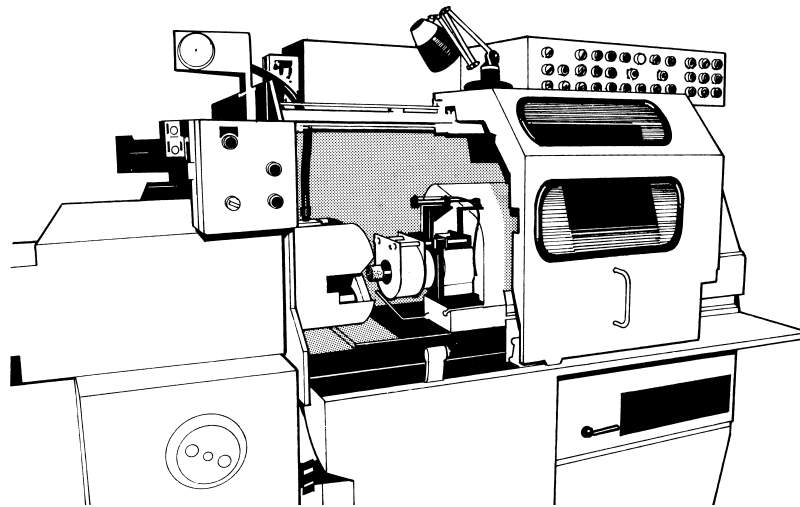
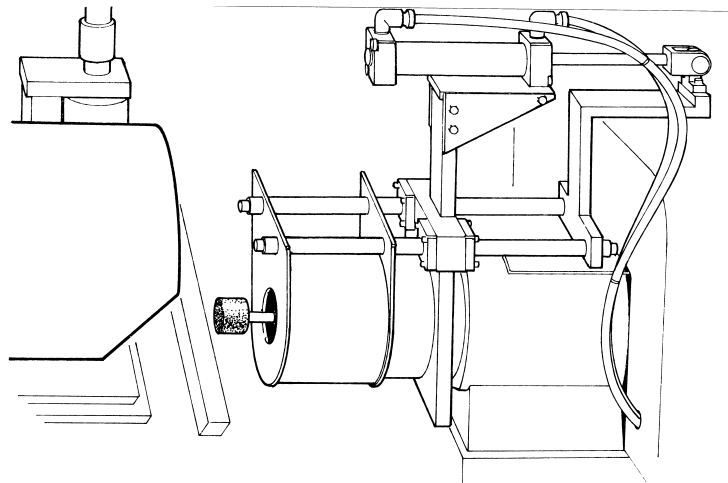


Figure 26a An internal grinding machine with an enclosure to control the emission of noise, splash and vapour. The sliding door, shown in the open position, is interlocked to prevent access to the rotating work spindle. The abrasive wheel is separately guarded by a telescopic guard (see Figures 26b and 26c)



Figures 26b Pneumatically operated telescopic guard in the retracted position to expose the wheel

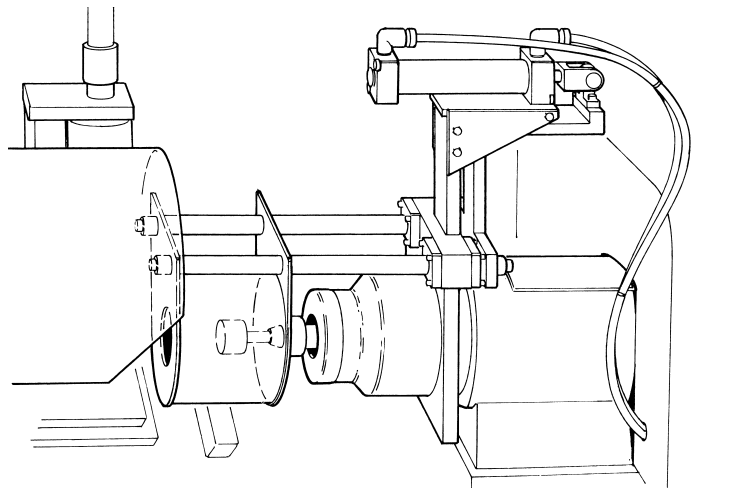


Figure 26c The guard in the extended position to cover the wheel

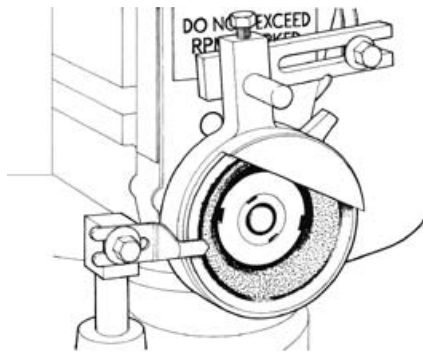


Figure 27 A cup wheel enclosed by an energy absorbent foam-lined steel guard

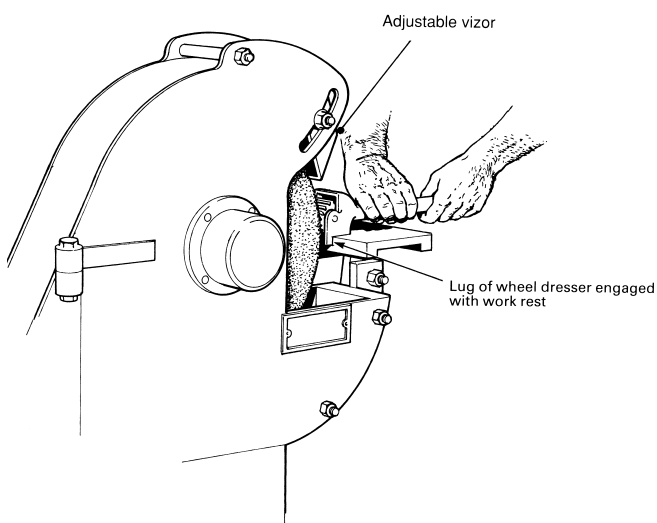


Figure 28 A wheel guard with an adjustable vizor for a pedestal grinder. This illustration shows the correct method of using a revolving cutter wheel dresser with the lugs of the dresser firmly engaged with the work rest

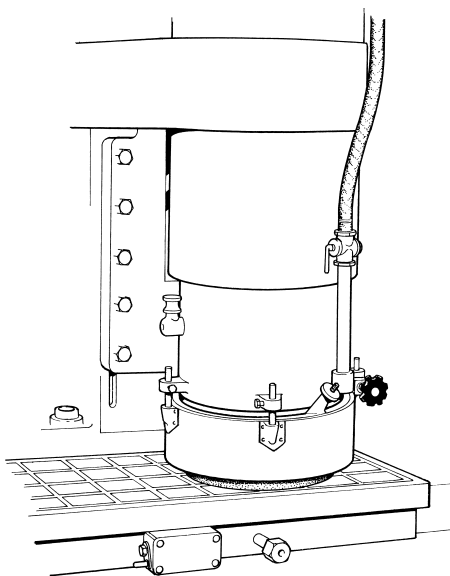


Figure 29 A band-type guard for cylinder and segmental wheels on a fixed machine

103 Another example of guard design can be seen in Figure 27 where an energy absorbent foam lining is contained inside a light sheet-metal housing. This combination can, in some circumstances, be as effective as a heavier all-metal guard. Guards of this kind should only be used after extensive tests involving the bursting of an abrasive wheel have been conducted in safe conditions.

Material and thickness

104 The relevant European Standard (published in the UK as a BS EN standard) for any particular machine should be consulted for details of guard design and material. Examples include BS EN 13218⁷ for stationary machines and BS EN 1454⁸ for internal combustion portable cutting-off machines.

105 The aim is to enclose the wheel to the greatest possible extent, and to keep the opening as small as possible, consistent with the nature of the work. To compensate for the increased exposure caused by wheel wear, either an adjustable vizor is provided (Figure 28) or the guard is constructed so that it can be adjusted manually as the wheel wears down. The guard has side members to limit the exposed area of the wheel and to contain flying fragments. It is usually necessary to construct the outer side member with a hollow boss which will enclose the projecting spindle and nut. When a guard is constructed from several component parts, the fastening should be strong enough to prevent disintegration of the guard in the event of a burst and the dangerous projection of the various parts into the surrounding working area.

106 The entire assembly should be securely anchored to the machine frame. Accidents have occurred when guards, though robust, have been attached to the frame by bolts of inadequate strength, with the result that a burst wheel has projected the entire guard bodily from the machine.

107 Cylinder wheels, cup wheels and segmental wheels can be guarded by a band-type guard (Figure 29). The inside diameter of the guard should not exceed the diameter of the wheel by more than 25 mm, and the guard should be adjustable vertically to restrict the exposure of the wheel below the guard to a minimum. Surface grinding by vertical spindle machines is generally performed wet and the splash screen surrounding the table should not be confused with safeguards to protect the operators in the event of a wheel burst. In addition to the risk of wheel breakage, accidents have occurred from flying components in surface grinding.

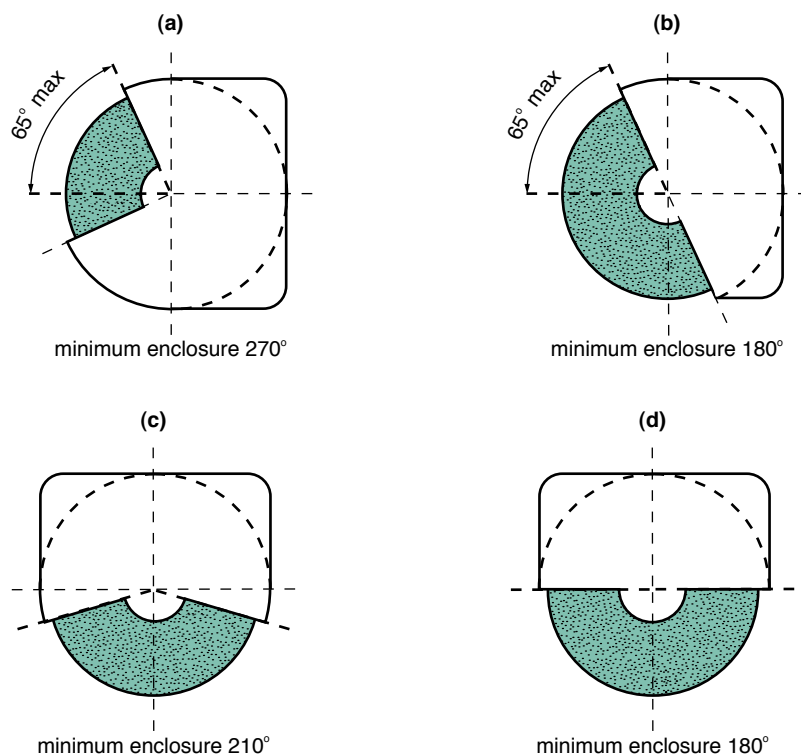


Figure 30 Wheel enclosure angles for various fixed machines (the dotted line indicates an alternative guard profile)

(a) Bench and pedestal grinder

(b) Cylindrical grinder

(c) Stationary cutting-off and peripheral surface grinder

(d) Swing frame and high-pressure grinder

To protect against this hazard it is advisable to provide substantial steel plates high enough around the table to contain any flying components. In some industries, such as the stone industry, where large wheels may be used with a long horizontal traverse between the wheel and the work, some additional enclosure, other than ordinary wheel guards, is desirable around the machine to restrict the exposure of the wheel below the guard to a minimum.

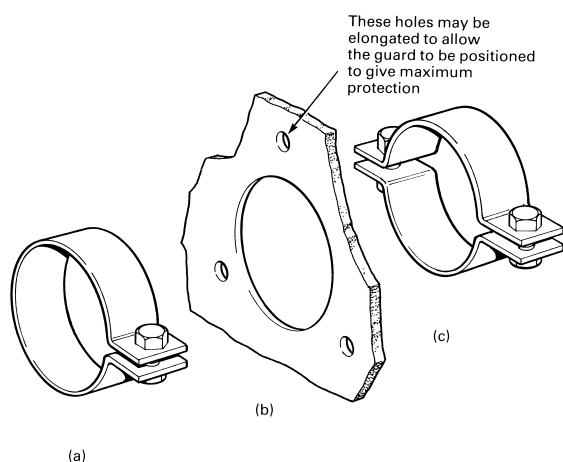


Figure 31 Alternative methods of attaching guards to portable grinding machines. The fastening elements should be designed so that they remain attached or retained by the clamp or grinder

Wheel enclosure angles for fixed machines

108 Abrasive wheels should be enclosed to the greatest extent practicable and this will depend on the nature of the work. For particular grinding operations there are recommended openings in the guard which allow almost all grinding operations to be carried out. The size and positions of these openings are shown in Figure 30. **Machines supplied after the publication of BS EN 13218 Machine tools – Safety – Stationary grinding machines⁷ should comply with the guarding requirements contained in that standard.**

Wheel guards for portable machines

109 Guards for portable machines should be so designed that in the event of a wheel bursting or breaking, the guard remains attached to the machine (see Figure 31). The design and construction of the clamp should allow the guard to be positioned directly between the wheel and the operator. The clearance between the inside of the guard and the periphery of an unused wheel should not be greater than 6 mm.

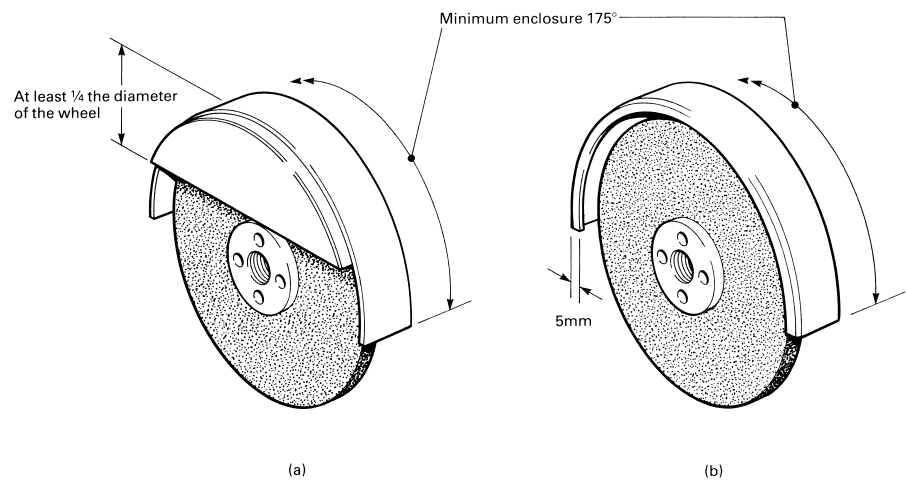


Figure 32 Alternative types of guards for reinforced depressed-centre cutting-off wheels and reinforced straight-sided wheels other than cutting-off wheels over 130 mm used on portable machines

Wheel enclosure angles for portable machines

Reinforced depressed-centre, cutting-off wheels and reinforced straight-sided wheels other than cutting-off wheels (Figures 32a and 32b)

110 A guard for these wheels should have a minimum enclosure of 175° and the side towards the machine should be covered by the guard. When the machine is in use the guard should always be positioned between the operator and the wheel. If the wheel is larger than 130 mm diameter the guard should have a front lip of at least 5 mm or a curtain segment with a minimum height of one quarter of the diameter of the wheel.

Non-reinforced straight-sided wheels (Figure 33)

111 At least 175° of the abrasive wheel periphery, and both sides, should be covered by the guard. The front curtain should be designed to facilitate easy replacement of the wheel.

Cup wheels (Figure 34)

112 These should be provided with an adjustable guard which covers the periphery and back of the wheel. The guard should be adjustable to compensate for wear of the wheel and to restrict the wheel exposure to a minimum.

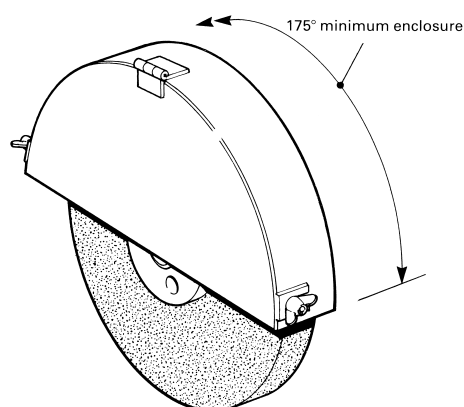


Figure 33 A wheel guard for use with a non-reinforced straight-sided wheel on a portable machine

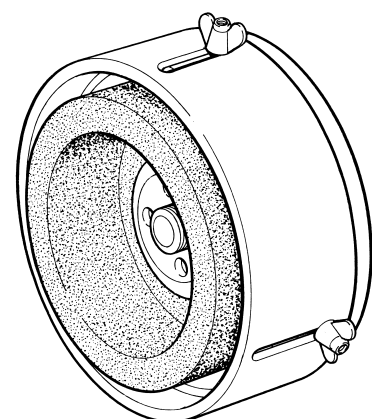


Figure 34 An adjustable band-type guard for straight and taper cup wheels mounted on a portable machine

Portable and hand-held grinding machines


113 The largest number of abrasive wheels used are those found on hand-held machines. These machines are often used by people who have a wide range of skills, from the domestic user to the skilled tradesman, with the predominant user being semi-skilled. Only organic-bonded wheels should be used. Those intended for cutting-off operations should additionally have some form of reinforcement, usually fibre glass. The only exception is for the use of vitrified mounted wheels and points (see Figure 5, page 13, for wheel shapes).

114 The general safety precautions for abrasive wheels apply equally to all wheels used on all classes of portable machine. It is important that all machine guards are secured in place and are adjusted so that the guard is between the user and the rotating wheels. Serious, often fatal, accidents have happened when a guard is removed to allow an oversize wheel to be mounted on a machine. The unguarded wheel will then be running at a speed in excess of the wheel manufacturer's recommended maximum with the consequent risk of a wheel burst.

Electric grinding machines

115 These are the most common machines on which abrasive wheels are mounted. Electrical safety must be considered as well as the safe use of the wheel.

All portable electric machines should comply with BS EN 51044 *Safety of hand-held electric motor operated tools, Part 2 Section 3 Grinders, disc type sanders and polishers* when published.⁹ Machines in service marked BS 2769 (*Hand-held electric motor-operated tools. Specifications for grinders, polishers and disc-type sanders. Implements CENELECDH400.2C*)¹⁰ can still be used. Additionally machines when supplied after 1/1/97 should carry the CE marking. The preferred voltage for these machines on construction sites is 110 volts. However, if a 240-volt supply has to be used then the supply to a portable machine should be protected by an RCD (residual current device).

116 These tools are classified according to the way in which protection against electric shock is provided. For Class I tools, accessible metalwork has to be effectively earthed so as to provide protection for the operator if the metalwork is made 'live' because of an internal fault. For Class II tools, marked with the symbol , protection is provided by the use of all insulated or double insulated construction, and accessible metalwork should not be earthed.

Cables and connectors

117 Hand-held tools are often required to withstand constant handling and rough usage, and the conditions of use should be taken into account when selecting flexible cables for the tools. Cables manufactured to British Standard 6500: 2000 *Electrical cables*,¹¹ with an abrasion-resistant sheath would be satisfactory for normal use, but where the cable is vulnerable to damage, additional precautions such as heavy-duty sheathing or protective braiding will be necessary.

118 In the case of single-phase tools, two-core cable is suitable for Class II tools, but for Class I tools, a three-core cable is essential. The cable should be connected to the supply by a properly constructed connector, such as a plug and socket. For Class I tools the connector should incorporate an effective means of maintaining earth continuity, for example an earth pin or a scraping earth (ie a sliding

connection between the earthed metalwork on the plug and the earthed metalwork on the socket).

119 In order to ensure correct matching between the electrical supply and the portable tool, it is essential that plugs, sockets and couplers for different electrical supply systems are not interchangeable. Connectors conforming to the following British Standards are recommended for industrial applications:

- (a) BS EN 60309-2:1999 *Plugs, socket outlets and couplers for industrial purposes*,¹²
- (b) BS 196:1961 *Specification for protected-type non-reversible plugs, socket-outlets, cable-couplers and appliance-couplers with earthing contacts for single-phase a.c. circuits up to 250 volts*.¹³

Inspection and maintenance

120 Routine checks, regular inspection and preventive maintenance are essential if accidents are to be avoided. An efficient maintenance system will also reduce days lost due to tools being out of commission.

121 The user of a hand-held tool should carry out a visual check on the tool before using it so that obvious defects can be identified, for example damage to the cable sheath, loose plug connections etc. Any tool in an unserviceable or unsafe condition **must** be withdrawn from use until defects have been rectified by a person competent to carry out this class of work.

122 Routine visual checks are in addition to and are not a substitute for planned maintenance of hand-held tools.

123 All tools should be accompanied by specific instructions from the manufacturer. If there are no instructions, the following system of planned maintenance is recommended. All hand-held apparatus, including extension leads, should be identified by a serial number which should be recorded in a register. The register should indicate how often each item should be recalled for inspection. The recommended frequency of checks, inspection and testing for portable electric grinders is:

- (a) For 110-volt machines the user is to carry out:
 - (i) a weekly safety check;
 - (ii) a formal visual inspection (eg a detailed inspection by a person competent to do so);
 - (iii) a combined inspection and test every three months (eg a detailed inspection and tests by a person competent to do so).
- (b) For 240-volt machines the user is to carry out:
 - (i) a daily safety check;
 - (ii) a formal visual inspection every week (eg a detailed inspection by a person competent to do so);
 - (iii) combined inspection and tests before first-time use and then every month (eg a detailed inspection and tests by a person competent to do so).

Extension leads should be treated as for 240-volt tools.

124 For all the apparatus there should be a careful inspection for signs of damage or deterioration including, for example, plug pins, terminals and cable anchoring devices, the cable sheath (particularly near the terminations), and the casing of the portable tool, together with its controls, brush gear and commutators. Any defects should be rectified. For further guidance and information see *Maintaining portable and transportable electrical equipment*.¹⁴

Pneumatic grinding machines

125 Although there should be no electrical risk with these machines it is vital that the compressed air supply is clean and water-free. Particular attention must be paid to the maintenance of two devices:

- (a) the maximum speed governor. Ingress of dust into the governor is often a cause of failure;
- (b) any form of pressure reduction valve that will prevent over-pressurization.

The relevant standard for this class of machine is BS 4390: 1969 *Specification for portable pneumatic grinding machines*¹⁵ to be replaced by BS EN 792 *Hand-held non electric power tools – Safety Requirements Part 7 Grinders*^{16a} and Part 9 *Die Grinders*.^{16b} New machines should carry the CE marking.

Internal combustion grinding machines

126 These machines, usually powered with a petrol engine, are mainly used for cutting operations using reinforced resin-bonded abrasive wheels or diamond and CBN wheels. One particular safety hazard with this type of machine is overspeeding. This may be due to a number of causes such as petrol/air ratio (mixture setting), together with ignition timing. **However, under no circumstances should the speed marked on the wheel be exceeded.** The speed-governing device should be given close attention, the ingress of dust being a common cause of failure. BS EN 1454 *Portable, hand-held, internal combustion cutting-off machines – Safety*⁸ is the relevant standard. New machines should carry the CE marking.

Multiple wheel mounting for portable machines

127 Portable machines are often used to chase or cut grooves in masonry, concrete or plaster. No attempt should be made to mount more than one wheel with a spacer between them or with the wheels in contact with each other. Nor should wheels be stuck together with an adhesive to increase their width, unless designed specifically for that purpose, as there is a risk of pieces of aggregate or debris being forced between the wheels causing one or both to burst, and a trapped piece of material can become a missile if it is flung out of the guard opening.

Blotters

128 The use of blotters on cutting-off wheels less than 400 mm diameter is not required.

Bushes

129 The use of bushes to reduce the bore size of an abrasive cutting-off wheel is not recommended on portable hand-held machines.

Operation of abrasive wheels

Truing and dressing

130 The operator's fingers may become trapped between the work-rest and the wheel, or the workpiece being trapped in a similar way. Although such accidents are more frequently caused by poor adjustment of the work rest, their possibility is minimised by frequent truing to keep the wheel concentric on its spindle. A wheel 'out-of-round' will cause excessive vibration and periodic knocking of the work against the wheel. This will invariably result in damage to the abrasive wheel surface, such as 'loading' or 'glazing', which impair the cutting action and may induce the operator to compensate by additional pressure of the workpiece on the abrasive wheel. Dressing the wheel is therefore essential for efficient production, and frequent light dressings are generally preferable to occasional severe dressings. The following important precautions should be taken:

- (a) hand dressers should be properly supported so that leverage may be applied without undue effort;
- (b) with a dresser of the revolving cutter type, the lugs provided as an anchor should always be used (Figure 28, page 31);
- (c) haphazard methods of dressing, such as the use of a chipping hammer, or even striking the work against the wheel, should be forbidden;
- (d) care should be taken to prevent the possibility of dressing tools becoming jammed between the abrasive wheel and work rest or any fixed part of the machine;
- (e) it is important that the work rest is in good condition before wheel dressing and it is helpful to fit a spare rest with a straight edge especially for this purpose.

131 There are many types of abrasive wheel dressers, and various methods by which these operations may be carried out. If necessary, wheel and machine manufacturers should be consulted on the technical aspects of the subject.

Wheel balance

132 Abrasive wheels are balanced by the manufacturers within normal limits but after they have been taken into use, wheels used for off-hand grinding can become out of balance if they are not frequently trued. If the out-of-balance force is allowed to become excessive, it may result in damage to the wheel and spindle. For precision grinding, closer limits of balance may be required and this is obtained by various methods such as the use of heavy paint or by an arrangement of sliding weights which are incorporated in the flanges or collet. Adjustment of the sliding weights is normally done with the wheel assembly removed from the machine, on a balancing arbor and stand. An accelerometer probe is placed in contact with a fixed part of the machine near the wheel and a measure of the out-of-balance force is then shown on a meter. With some instruments it is necessary to move the

balance weights by trial and error until the meter shows that the out-of-balance force is eliminated, but more sophisticated instruments show the angular position of the out-of-balance force.

133 As the wheel wears, it may be necessary to re-balance it. Generally, the larger the wheel and the higher the speed, the greater the importance of correct wheel balancing.

134 Some large wheels are supplied as 'oriented wheels'. An oriented wheel is marked with an arrow to facilitate its assembly on the grinding machine in a specific position (see Figure 35).

Side grinding

135 Grinding on the side of a straight-sided wheel used for off-hand grinding is dangerous, particularly when it is appreciably worn or when sudden pressure is applied. However, for certain precision grinding operations it may be necessary to allow the side of the wheel to lightly touch a face adjoining the surface being ground, for example the thrust face on a stepped shaft, and in this case the side of the wheel may be lightly dressed with a diamond to create a shallow relief. Excessive dressing could however create a dangerously weak section which may cause the wheel to break under side loading or due to centrifugal force.

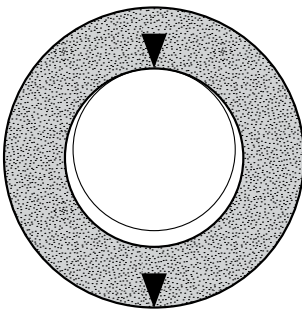


Figure 35 An oriented wheel with the marking indicating the correct mounting position

Grinding fluids

136 Abrasive wheels may be used wet or dry according to type, unless there is a restriction marked on the wheel. The choice of a suitable grinding fluid depends on the requirements of the work and the type of wheel. This is important from the safety aspect because with some wheels prolonged contact with fluids containing alkalis, acids or other organic or inorganic solvents may ultimately affect the strength of the wheel. The pH of the fluid should not exceed 8 to 9. Vitrified wheels are not normally affected by grinding fluids. Other wheels may be affected to a greater or lesser extent by some of the fluids normally used in grinding operations. For example, shellac-bonded wheels, in contact with alkaline solutions with a soda content exceeding 3% may suffer damage. Magnesite wheels may be damaged by any fluid. Particular care should therefore be taken to follow the fluid manufacturer's instructions.

137 A wheel should not be allowed to stand partly immersed in grinding fluid. The soaked portion will throw the wheel out of balance when the machine is started. At the completion of a wet grinding operation the fluid should be drained off and the wheel run free until it is dry.

Grinding of magnesium alloys

138 These alloys usually contain a large proportion of magnesium. The dust produced by grinding and similar operations will burn freely and, when mixed with air, is capable of forming an explosive mixture. Severe accidents including fatalities have occurred when dust from the clothing of workpeople has been ignited. Explosions resulting in fatalities have also occurred in dust extraction and settling systems.

139 A spark from a grinding machine may act as a source of ignition. Measures which are intended to cope with these dangers include: precautions against causing sparks, the prohibition of smoking, open lights, fire and other causes of

ignition; the provision of appliances for the interception, removal and drenching of dust by exhaust appliances and scrubbers; and the provision of protective clothing. Dust extraction and settling systems should be kept clean and free from deposits of dried sludge, which should be safely removed from the scrubber and the workroom.

Additional protection

140 Fixed shields are particularly useful on machines used for short periods by different workers. Screens should be of toughened or reinforced glass, or other suitable transparent material allowing clear vision as shown in Figure 36. They may embody a light source and this is useful from a production as well as a safety aspect. It may also be desirable that eye protection be provided and used for wet grinding work. The removal of a foreign body from an eye requires skill and should always be done by a medically trained person. Inexpert attention may do more harm and could even cause permanent damage.

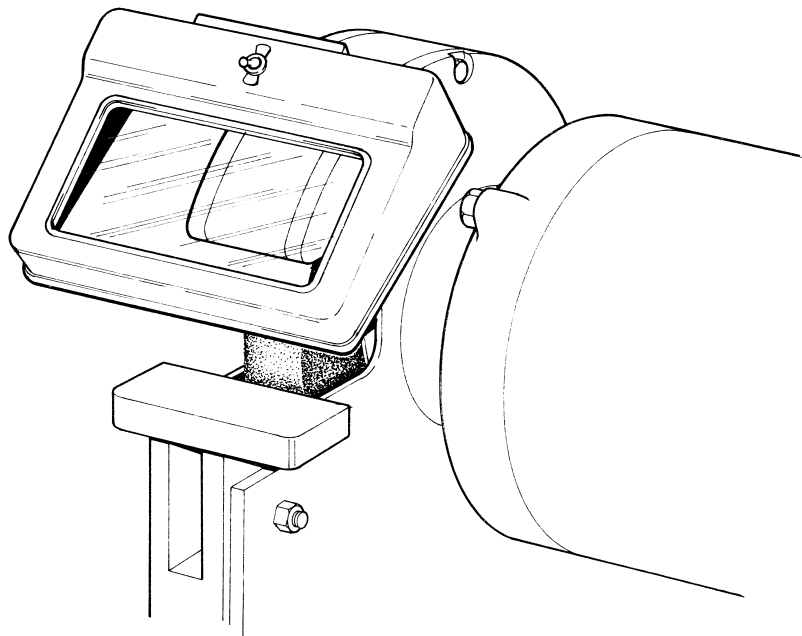


Figure 36 Screens of toughened glass are useful at machines used for short periods by different workers

Summary of operating precautions

141 Given an abrasive wheel of sound manufacture, mounted on a well-designed machine, safe operation depends largely on proper maintenance and on the treatment to which the wheel is subjected when in use. The following are among the main operating precautions to consider, some of which are discussed in greater detail elsewhere in this booklet.

142 **Training of operators.** Operators should be properly trained in the safe use of grinding machines (see paragraph 6).

143 **Floors.** The floor immediately surrounding fixed grinding machines should be maintained in good condition, and free from obstruction. Splash guards should be used when appropriate to prevent the floor from becoming slippery.

144 **Mounting.** Mounting of abrasive wheels should only be done by appropriately trained people (see paragraph 6).

145 **Speed.** The maximum operating speed marked on the wheel should under no circumstances be exceeded (see paragraphs 28–30).

146 **Guarding.** The wheel guard should always be secured in position and properly adjusted before the wheel is run (see paragraphs 99–112).

147 **Work rests.** Work rests should be kept adjusted as close as possible to the wheel. Lack of compensation for wheel wear is the main reason for the work rest to be out of adjustment. Work rests should therefore be inspected and adjusted at frequent intervals.

148 **Side grinding.** Grinding on the sides of straight-sided wheels used for off-hand grinding is dangerous, particularly when they are appreciably worn or when sudden pressure is applied (see paragraph 135).

149 **Truing and dressing.** Wheels used for off-hand grinding should be trued frequently to eliminate out-of-balance conditions and to enable the work rest to be adjusted close to the wheel surface.

150 **Lubrication.** Spindles should not be allowed to become overheated due to lack of lubrication (see also paragraph 34).

151 **Starting new wheels.** New wheels should be run free at normal operating speed for about a minute. Operators and others should stand clear during the trial run.

152 **Stopping wheels.** Wheels should not be brought to rest by applying pressure to the periphery or face.

153 **Wet grinding.** Prolonged immersion of a stationary wheel in coolant can throw the wheel out of balance when the machine is started. Before a wheel is stopped the coolant should be turned off, and the wheel run free until it is dry.

154 **Centreless grinding.** Components in the tray should be carefully inspected before grinding, as an oversize piece may damage the wheel or may be projected back.

155 **Cutting-off and depressed-centre wheels.** The correct wheel for the job, recommended by the wheel manufacturer, should be used. Before mounting, cutting-off wheels should be inspected for possible warping or other defects. A warped wheel should not be used as it may cause excessive vibration, side pressure, or heating and possible wheel breakage. Cutting-off wheels should be mounted only on machines designed for their use. Only the reinforced type should be used on hand-held portable machines. Power should be adequate, otherwise stresses may build up and the wheel may stall and break. Pressure should be applied evenly. Care should be taken to avoid twisting or exerting pressure on the side of the wheel. The workpiece should be rigidly supported and firmly clamped. Lack of rigidity either in the wheel or in the workpiece can lead to wheel breakage.

156 **Cylinder wheels.** Wire- or tape-bound cylinder wheels should be worn down to the first tape or group of wires before any are removed. Care should be taken not to damage the wheel when removing the wires or tape.

157 **Mounted wheels and points.** The overhang should not exceed that appropriate to the speed, size of point and diameter of the mandrel.

158 **Eye protection.** Eye protectors should be worn in all dry grinding operations or, alternatively, transparent screens should be fitted to fixed machines to intercept sparks and particles.

Personal protective equipment

159 To comply with the Personal Protective Equipment Regulations 1992¹⁷ and other regulations, for example the Control of Substances Hazardous to Health Regulations¹⁸ and the Control of Noise at Work Regulations 2005,¹⁹ appropriate protection must be worn. People who use abrasive wheels on any type of machine are exposed to a number of risks:

- (a) Injury to the eyes from flying abrasive and metallic particles,
- (b) Inhalation of dust from dry grinding operations (for example petrol-engined cutting-off machines);
- (c) Physical injury due to flying wheel fragments or ejected workpieces;
- (d) Noise and vibration;
- (e) On construction sites there will be a need for head protection as well as for feet and hands in addition to the other precautions mentioned.

160 Eye protection should conform to the relevant BS EN standard such as BS EN 166 *Personal eye protection. Specifications*;²⁰ BS EN 167 *Personal eye protection. Optical test methods*;²¹ and BS EN 168 *Personal eye protection. Non-optical test methods*.²²

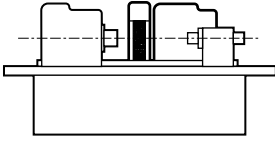
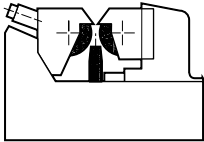
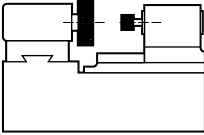
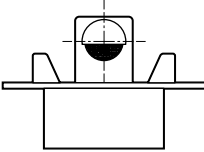
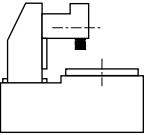
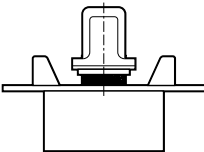
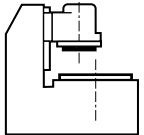
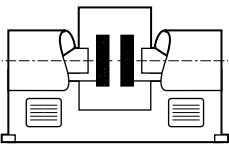
161 Dust protection (face masks) etc should comply with BS EN 149 *Respiratory protective devices*.²³

162 **Loose clothing** Loose clothing such as ties or coat sleeves are easily drawn in between the wheel and the workpiece and should not be worn. Rags and waste should not be used near a revolving wheel as they may also become entangled.

163 **Supervision** Frequent checks should be made by management to ensure that the safety precautions in paragraphs 142–162 are being observed.

Table 1 General maximum permissible peripheral speeds of abrasive wheels in metres per second

The maximum speeds listed in this table are not necessarily the recommended speeds of operation for optimum grinding efficiency

| | Machine classification and grinding operation | Type of wheel See Figure 5 | Maximum speed m/s | Special conditions |
|---|--|-------------------------------|---|--|
|  | External cylindrical | 1, 5, 7 20-26 | 45 | |
| | Tool room (universal) | 1, 5, 7 | 45 | |
| | Crankshaft | 1, 5, 7 | 45 | |
| | Camshaft | 1, 5, 7 | 45 | |
| | Thread | 1 | 60 | |
| | Thread | 5, 7 | 45 | |
|  | Centreless | 1, 5, 7 | 35 | |
| | Control wheels | 1, 5, 7 | 16 | |
|  | Internal | 1, 5 | 45 | |
| | | 52 | See Annex C of BS EN 12413: 1999 ³ | |
|  | Surface horizontal spindle reciprocating table | 1, 5, 7 | 45 | |
| | | | | |
|  | horizontal spindle rotary table | 1, 5, 7 | 35 | |
| | | | | |
|  | vertical spindle reciprocating table | 2, 37 | 32 | inorganic bonds organic bonds organic bonds vitrified bonds |
| | | 6 | 50 | |
| | | 35, 36, 37 | 50 | |
| | | | 32 | |
|  | vertical spindle rotary table | 2, 37 | 32 | inorganic bonds organic bonds organic bonds vitrified bonds |
| | | 6 | 50 | |
| | | 35, 36, 37 | 50 | |
| | | | 32 | |
|  | duplex | 2, 37 | 32 | inorganic bonds organic bonds organic bonds vitrified bonds |
| | | 6 | 50 | |
| | | 35, 36 | 50 | |
| | | | 32 | |

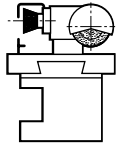
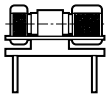
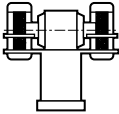
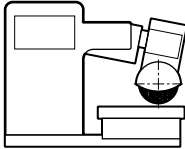
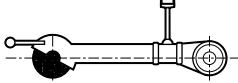
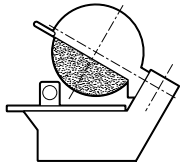
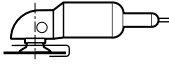

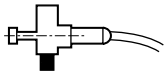
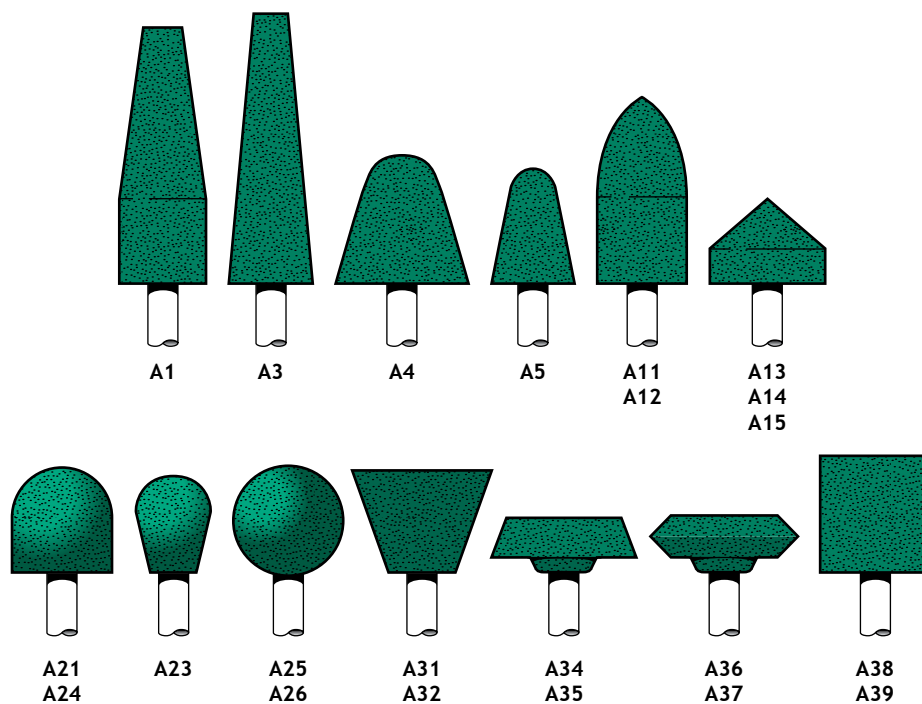
| | <i>Machine classification and grinding operation</i> | <i>Type of wheel See Figure 5</i> | <i>Maximum speed m/s</i> | <i>Special conditions</i> |
|---|--|---------------------------------------|------------------------------|---|
|  | Tool cutter | 1, 5, 7 | 45 | |
| | Grinding and sharpening | 6, 11, 12, 13 | 32 | |
|  | Off-hand grinding and fettling | | | |
| | bench and floorstand | 1, 5, 7 | 35 | vitriified bond |
| | pedestal | 1 | 50 | organic bonds |
|  | face grinding | 6, 35, 36 | 32 | |
| | | | | |
|  | Billet and slab mechanical control | 1 | 80 | special high-density organic bond |
| | swing frame manual control | 1 | 50 | organic bond |
|  | | | | |
| | | | | |
|  | Cutting-off | 41 | 80 | unreinforced organic bond |
| | | 41 | 100 | reinforced organic bond |
|  | Portable, right angle grinding | 6, 11 27 | 50 80 | organic bonds only reinforced organic bonds only |
| | cutting-off | 41, 42 | 80 | reinforced organic bonds only |
| | | | | |
|  | Portable vertical spindle grinder | 6, 11 | 50 | organic bonds only |
|  | Portable straight grinder | 1, 4 16, 17, 18, 18R, 19, 52 | 50 50 | organic bonds only |

Table 2 Speed conversion table for speed of rotation (rpm) vs peripheral operating speed (m/s) of various wheel diameters

| Wheel diameter in millimeters | Maximum operating speed in m/s | | | | | | | | | | | | | |
|----------------------------------|--------------------------------|--------|--------|--------|--------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| | 10 | 12 | 16 | 20 | 25 | 32 | 35 | 40 | 45 | 50 | 63 | 80 | 100 | 125 |
| 6 | 31 900 | 38 200 | 51 000 | 64 000 | 80 000 | 102 000 | 112 000 | 128 000 | 143 500 | 160 000 | 201 000 | - | - | - |
| 8 | 24 000 | 29 000 | 38 200 | 48 000 | 60 000 | 76 500 | 84 000 | 95 500 | 107 500 | 120 000 | 150 500 | 191 000 | - | - |
| 10 | 19 100 | 23 000 | 30 600 | 38 200 | 48 000 | 61 200 | 67 000 | 76 500 | 86 000 | 95 500 | 120 500 | 153 000 | 191 000 | - |
| 13 | 14 700 | 17 700 | 23 550 | 29 500 | 35 600 | 47 100 | 51 500 | 58 800 | 66 200 | 73 500 | 92 600 | 118 000 | 147 000 | 184 000 |
| 16 | 11 950 | 14 350 | 19 100 | 23 900 | 29 850 | 38 200 | 41 800 | 47 800 | 53 750 | 59 700 | 75 200 | 95 500 | 120 000 | 150 000 |
| 20 | 9 550 | 11 500 | 15 300 | 19 100 | 23 900 | 30 600 | 33 500 | 38 200 | 43 000 | 47 800 | 60 200 | 76 500 | 95 500 | 120 000 |
| 25 | 7 650 | 9 200 | 12 300 | 15 300 | 19 100 | 24 500 | 26 800 | 30 600 | 34 500 | 38 200 | 48 200 | 61 200 | 76 500 | 95 500 |
| 32 | 6 000 | 7 200 | 9 550 | 11 950 | 14 950 | 19 100 | 20 900 | 23 900 | 27 000 | 30 000 | 37 600 | 48 000 | 60 000 | 75 000 |
| 40 | 4 800 | 5 750 | 7 650 | 9 550 | 11 950 | 15 300 | 16 750 | 19 100 | 21 500 | 23 900 | 30 100 | 38 200 | 47 200 | 59 700 |
| 50 | 3 850 | 4 600 | 6 150 | 7 650 | 9 550 | 12 250 | 13 400 | 15 300 | 17 200 | 19 100 | 24 100 | 30 600 | 38 200 | 47 750 |
| 63 | 3 050 | 3 650 | 4 850 | 6 100 | 7 600 | 9 750 | 10 650 | 12 150 | 13 650 | 15 200 | 19 100 | 24 300 | 30 250 | 37 900 |
| 80 | 2 400 | 2 900 | 3 850 | 4 800 | 6 000 | 7 650 | 8 400 | 9 550 | 10 750 | 12 000 | 15 100 | 19 100 | 23 900 | 29 850 |
| 100 | 1 950 | 2 300 | 3 100 | 3 850 | 4 800 | 6 150 | 6 700 | 7 650 | 8 600 | 9 550 | 12 100 | 15 300 | 19 100 | 23 900 |
| 115 | 1 700 | 2 000 | 2 700 | 3 350 | 4 200 | 5 350 | 5 850 | 6 650 | 7 500 | 8 350 | 10 500 | 13 300 | 16 650 | 20 800 |
| 125 | 1 550 | 1 850 | 2 450 | 3 100 | 3 850 | 4 900 | 5 350 | 6 150 | 6 900 | 7 650 | 9 650 | 12 250 | 15 300 | 19 100 |
| 150 | 1 300 | 1 550 | 2 050 | 2 550 | 3 200 | 4 100 | 4 500 | 5 100 | 5 750 | 6 400 | 8 050 | 10 200 | 12 700 | 16 000 |
| 180 | 1 100 | 1 300 | 1 700 | 2 150 | 2 700 | 3 400 | 3 750 | 4 250 | 4 780 | 5 350 | 6 700 | 8 500 | 10 650 | 13 300 |
| 200 | 955 | 1 150 | 1 550 | 1 950 | 2 400 | 3 100 | 3 350 | 3 850 | 4 300 | 4 800 | 6 050 | 7 650 | 9 550 | 11 950 |
| 230 | 830 | 1 000 | 1 350 | 1 700 | 2 100 | 2 700 | 2 950 | 3 350 | 3 750 | 4 200 | 5 250 | 6 650 | 8 350 | 10 400 |
| 250 | 765 | 920 | 1 250 | 1 550 | 1 950 | 2 450 | 2 700 | 3 100 | 3 450 | 3 850 | 4 850 | 6 150 | 7 650 | 9 550 |
| 300 | 640 | 765 | 1 050 | 1 300 | 1 600 | 2 050 | 2 250 | 2 550 | 2 870 | 3 200 | 4 050 | 5 100 | 6 400 | 8 000 |
| 350/356 | 550 | 655 | 875 | 1 100 | 1 400 | 1 750 | 1 950 | 2 200 | 2 460 | 2 750 | 3 450 | 4 400 | 5 500 | 6 850 |
| 400/406 | 480 | 575 | 765 | 960 | 1 200 | 1 550 | 1 700 | 1 950 | 2 150 | 2 400 | 3 050 | 3 850 | 4 800 | 6 000 |
| 450/457 | 425 | 510 | 680 | 850 | 1 100 | 1 400 | 1 500 | 1 700 | 1 910 | 2 150 | 2 700 | 3 400 | 4 250 | 5 350 |
| 500/508 | 385 | 460 | 615 | 765 | 960 | 1 250 | 1 350 | 1 550 | 1 720 | 1 950 | 2 450 | 3 100 | 3 850 | 4 800 |
| 600/610 | 320 | 385 | 510 | 640 | 800 | 1 050 | 1 150 | 1 300 | 1 450 | 1 600 | 2 050 | 2 550 | 3 200 | 4 000 |
| 660 | 290 | 350 | 465 | 580 | 725 | 930 | 1 050 | 1 200 | 1 300 | 1 450 | 1 850 | 2 350 | 2 900 | 3 650 |
| 750/762 | 255 | 310 | 410 | 510 | 640 | 820 | 895 | 1 050 | 1 150 | 1 300 | 1 650 | 2 050 | 2 550 | 3 200 |
| 800/813 | 240 | 290 | 385 | 480 | 600 | 765 | 840 | 960 | 1 075 | 1 200 | 1 550 | 1 950 | 2 400 | 3 000 |
| 900/914 | 215 | 255 | 340 | 425 | 535 | 680 | 750 | 850 | 955 | 1 100 | 1 350 | 1 700 | 2 150 | 2 700 |
| 1 000/1 016 | 195 | 230 | 310 | 385 | 480 | 615 | 670 | 765 | 860 | 960 | 1 250 | 1 550 | 1 950 | 2 400 |
| 1 050/1 067 | 185 | 220 | 295 | 365 | 455 | 585 | 640 | 730 | 820 | 910 | 1 150 | 1 500 | 1 850 | 2 300 |
| 1 120 | 175 | 210 | 280 | 350 | 435 | 560 | 610 | 695 | 785 | 870 | 1 100 | 1 400 | 1 750 | 2 200 |
| 1 220 | 160 | 195 | 255 | 320 | 400 | 510 | 560 | 640 | 720 | 800 | 1 050 | 1 300 | 1 600 | 2 000 |
| 1 500 | 130 | 155 | 205 | 255 | 320 | 410 | 450 | 510 | 575 | 640 | 805 | 1 050 | 1 300 | 1 600 |

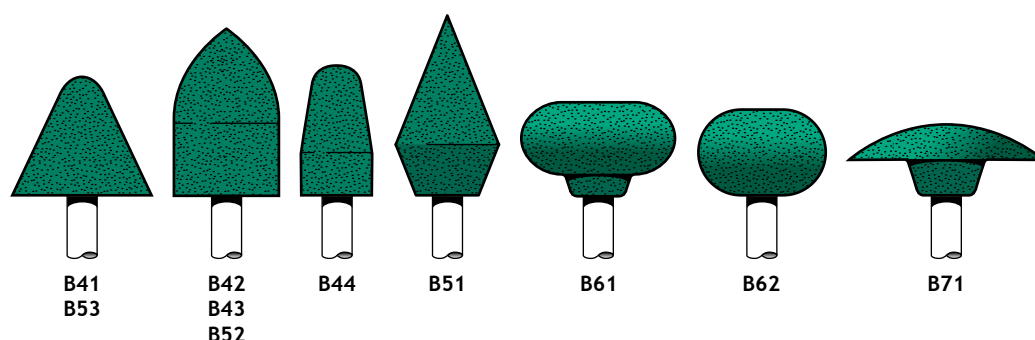
from BS EN 12413: 1999

Table 3 Maximum permissible speed in revolutions per minute of mounted wheels and points in relation to the overhang – Group A (shaped wheels)

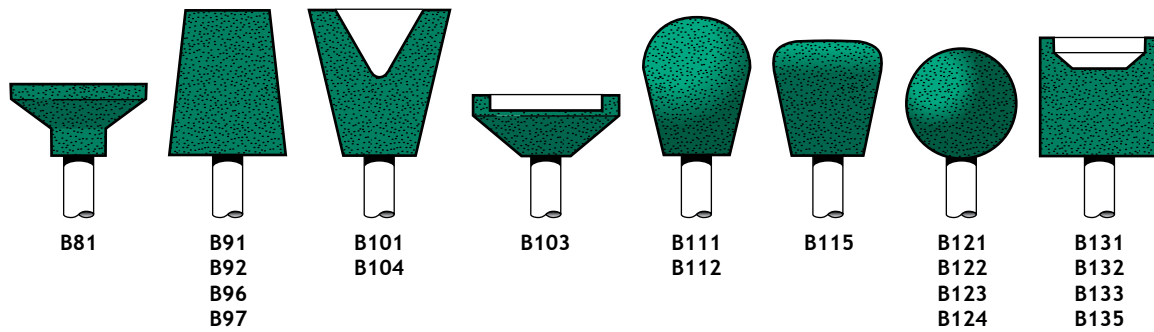


| Shape number | Wheel diameter mm | Wheel thickness mm | 6.0 or 6.3 mm diameter mandrels | |
|--------------|-------------------|--------------------|--------------------------------------|----------------|
| | | | 13 mm overhang and threaded mandrels | Overhang 25 mm |
| A1 | 20 | 65 | 19 800 | 16 500 |
| A3 | 22 | 70 | 16 100 | 13 080 |
| A4 | 30 | 30 | 29 840 | 24 750 |
| A5 | 20 | 28 | 45 000 | 33 750 |
| A11 | 21 | 45 | 19 860 | 15 100 |
| A12 | 18 | 30 | 48 000 | 35 250 |
| A13 | 25 | 25 | 33 950 | 32 250 |
| A14 | 18 | 22 | 53 050 | 40 500 |
| A15 | 6 | 25 | 72 750 | 47 620 |
| A21 | 25 | 25 | 34 500 | 26 250 |
| A23 | 20 | 25 | 39 370 | 30 370 |
| A24 | 6 | 20 | 76 500 | 49 500 |
| A25 | 25 | - | 35 620 | 27 370 |
| A26 | 16 | - | 59 680 | 46 500 |
| A31 | 35 | 26 | 27 260 | 26 250 |
| A32 | 25 | 20 | 38 200 | 38 200 |
| A34 | 38 | 10 | 25 130 | 25 130 |
| A35 | 25 | 10 | 38 200 | 38 200 |
| A36 | 40 | 10 | 23 520 | 23 520 |
| A37 | 30 | 6 | 29 840 | 29 840 |
| A38 | 25 | 25 | 34 500 | 26 250 |
| A39 | 20 | 20 | 47 250 | 35 250 |

Table 4 Maximum permissible speed in revolutions per minute of mounted wheels and points in relation to the overhang – Group B (shaped wheels)

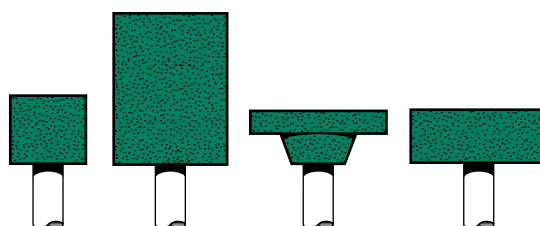


| Shape number | Wheel diameter mm | Wheel thickness mm | 3 or 3.15 mm diameter mandrels | | 6 or 6.3 mm diameter mandrels | |
|--------------|-------------------|--------------------|--------------------------------------|----------------|--------------------------------------|----------------|
| | | | 13 mm overhang and threaded mandrels | Overhang 25 mm | 13 mm overhang and threaded mandrels | Overhang 25 mm |
| B41 | 16 | 16 | 33 750 | 23 250 | 59 680 | 46 500 |
| B42 | 13 | 20 | 33 750 | 23 250 | 59 680 | 46 500 |
| B43 | 6 | 8 | 61 370 | 51 000 | - | - |
| B44 | 5, 6 | 10 | 68 400 | 42 370 | - | - |
| B51 | 11 | 20 | 45 370 | 28 500 | 81 000 | 54 370 |
| B52 | 10 | 20 | 45 370 | 28 500 | 81 000 | 54 370 |
| B53 | 8 | 16 | 60 000 | 38 020 | - | - |
| B61 | 20 | 8 | 38 250 | 24 370 | 47 750 | 47 750 |
| B62 | 13 | 10 | 41 020 | 26 400 | 71 250 | 47 620 |
| B71 | 16 | 3 | 59 680 | 48 000 | 59 680 | 59 680 |
| B81 | 20 | 5 | 47 750 | 41 250 | - | - |
| B91 | 13 | 16 | 34 500 | 22 500 | 61 500 | 42 000 |
| B92 | 6 | 6 | 81 370 | 51 000 | - | - |
| B96 | 3 | 6 | 105 000 | 64 500 | - | - |
| B97 | 3 | 10 | 105 000 | 64 500 | - | - |



| Shape number | Wheel diameter mm | Wheel thickness mm | 3 or 3.15 mm diameter mandrels | | 6 or 6.3 mm diameter mandrels | |
|--------------|-------------------|--------------------|--------------------------------------|----------------|--------------------------------------|----------------|
| | | | 13 mm overhang and threaded mandrels | Overhang 25 mm | 13 mm overhang and threaded mandrels | Overhang 25 mm |
| B101 | 16 | 18 | 33 750 | 23 250 | 59 680 | 46 500 |
| B103 | 16 | 5 | 59 680 | 41 250 | - | - |
| B104 | 8 | 10 | 68 400 | 42 370 | - | - |
| B111 | 11 | 18 | 33 750 | 23 250 | 66 000 | 46 500 |
| B112 | 10 | 13 | 45 370 | 28 500 | 81 000 | 54 370 |
| B115 | 2, 5 | 3 | 105 000 | 64 500 | - | - |
| B121 | 13 | - | 45 370 | 28 500 | 73 460 | 54 370 |
| B122 | 10 | - | 61 650 | 37 720 | - | - |
| B123 | 5 | - | 104 250 | 61 820 | - | - |
| B124 | 3 | - | 105 000 | 64 500 | - | - |
| B131 | 13 | 13 | 34 500 | 22 500 | 61 500 | 42 000 |
| B132 | 10 | 13 | 45 370 | 28 500 | 81 000 | 5 430 |
| B133 | 10 | 10 | 54 000 | 33 000 | - | - |
| B135 | 6 | 13 | 60 000 | 38 020 | - | - |

Table 5 Maximum permissible speed in revolutions per minute of mounted wheels and points in relation to the overhang – Group W (plain wheels)



| Shape number | Wheel diameter mm | Wheel thickness mm | 3 or 3.15 mm diameter mandrels | | 6 or 6.3 mm diameter mandrels | |
|--------------|-------------------|--------------------|--------------------------------------|----------------|--------------------------------------|----------------|
| | | | 13 mm overhang and threaded mandrels | Overhang 25 mm | 13 mm overhang and threaded mandrels | Overhang 25 mm |
| W144 | 3 | 6 | 105 000 | 64 500 | - | - |
| W145 | 3 | 10 | 105 000 | 64 500 | - | - |
| W146 | 3 | 13 | 105 000 | 64 500 | - | - |
| W149 | 4 | 6 | 105 000 | 64 500 | - | - |
| W152 | 5 | 6 | 105 000 | 64 500 | - | - |
| W153 | 5 | 10 | 80 850 | 52 500 | - | - |
| W160 | 6 | 6 | 81 370 | 51 000 | - | - |
| W162 | 6 | 10 | 68 400 | 42 370 | - | - |
| W163 | 6 | 13 | 60 000 | 38 020 | - | - |
| W164 | 6 | 20 | 45 900 | 30 000 | - | - |
| W174 | 13 | 3 | 69 000 | 41 250 | - | - |
| W175 | 10 | 10 | 54 000 | 33 000 | - | - |
| W176 | 10 | 13 | 45 370 | 28 500 | 81 00 | 54 380 |
| W177 | 10 | 20 | 33 750 | 23 250 | 66 000 | 46 500 |
| W178 | 10 | 25 | 26 250 | 18 750 | 55 200 | 40 500 |
| W182 | 13 | 3 | 73 460 | 43 650 | 73 460 | 62 400 |
| W183 | 13 | 6 | 51 750 | 31 870 | 73 460 | 54 750 |
| W184 | 13 | 10 | 41 020 | 26 400 | 71 250 | 47 620 |
| W185 | 13 | 13 | 34 500 | 22 500 | 61 500 | 42 000 |
| W187 | 13 | 25 | 20 620 | 13 870 | - | - |
| W188 | 13 | 40 | - | - | 30 370 | 24 000 |
| W194 | 16 | 13 | 29 400 | 19 120 | 55 400 | 39 750 |
| W196 | 16 | 25 | 17 620 | 11 620 | 32 250 | 27 000 |
| W197 | 16 | 50 | - | - | 21 000 | 16 500 |
| W200 | 20 | 3 | 47 750 | 33 520 | - | - |
| W201 | 20 | 6 | 38 250 | 24 370 | 47 750 | 47 750 |
| W202 | 20 | 10 | 30 000 | 19 500 | 47 750 | 44 100 |
| W203 | 20 | 10 | 25 500 | 15 900 | 47 750 | 36 370 |

| Shape number | Wheel diameter mm | Wheel thickness mm | 3 or 3.15 mm diameter mandrels | | 6 or 6.3 mm diameter mandrels | |
|-----------------|-------------------------|--------------------------|--|-------------------|--|-------------------|
| | | | 13 mm overhang and threaded mandrels | Overhang 25 mm | 13 mm overhang and threaded mandrels | Overhang 25 mm |
| W204 | 20 | 20 | 18 900 | 12 000 | 42 750 | 30 750 |
| W205 | 20 | 25 | - | - | 34 500 | 25 870 |
| W207 | 20 | 40 | - | - | 24 000 | 18 520 |
| W208 | 20 | 50 | - | - | 18 750 | 15 370 |
| W215 | 25 | 3 | 38 200 | 24 900 | 38 200 | 38 200 |
| W216 | 25 | 6 | 30 520 | 18 600 | 38 200 | 38 200 |
| W217 | 25 | 10 | - | - | 38 200 | 38 200 |
| W218 | 25 | 13 | - | - | 38 200 | 32 770 |
| W220 | 25 | 25 | - | - | 25 500 | 19 120 |
| W221 | 25 | 40 | - | - | 19 120 | 14 620 |
| W222 | 25 | 50 | - | - | 15 900 | 12 370 |
| W225 | 30 | 6 | - | - | 29 840 | 29 840 |
| W226 | 30 | 10 | - | - | 29 840 | 29 840 |
| W228 | 30 | 20 | - | - | 29 840 | 22 500 |
| W230 | 30 | 30 | - | - | 20 400 | 18 750 |
| W232 | 30 | 50 | - | - | 14 250 | 10 650 |
| W235 | 40 | 6 | - | - | 25 130 | 25 130 |
| W236 | 40 | 13 | - | - | 25 130 | 25 130 |
| W237 | 40 | 25 | - | - | 22 500 | 17 620 |
| W238 | 40 | 40 | - | - | 15 600 | 12 000 |
| W242 | 50 | 25 | - | - | 19 100 | 15 950 |

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