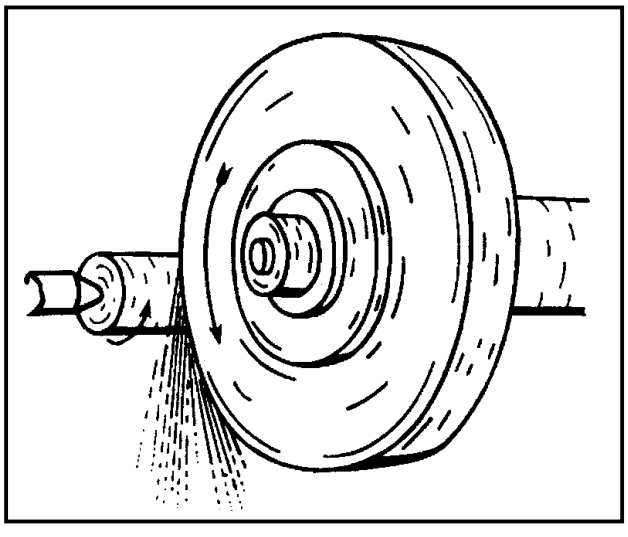
GRINDING PROCESS

"Grinding" in simple terms can be defined as a process of abrasion. The material is removed by using sharp abrasive grains on the face or on the sides of bonded grinding wheels. The grains actually cut chips out of the work. The two major types of grinding are Off-hand grinding and Precision grinding.



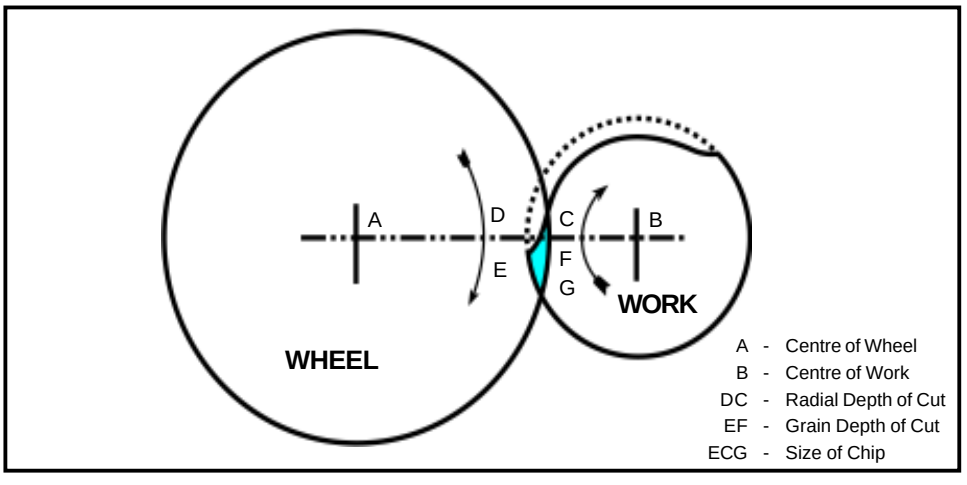
A Grinding wheel actually cuts away chips from the piece being ground

Off-hand grinding or Non-precision grinding is where the grinding wheel is applied manually to the work or where the work is applied off-hand to the grinding wheel. Off-hand grinding includes Snagging of castings/forging, Tool sharpening, Weld grinding, Cutting off, Bench grinding or Pedestal grinding applications.

Precision grinding is machine grinding where the traverse and or feed rates can be set and process parameters are measured and controlled. As the name indicates, here the need is more on surface finish, geometry, size control etc. Precision grinding operations include Cylindrical grinding, Centreless grinding, Internal grinding, Surface grinding, Tool and Cutter grinding, Thread grinding, Crankshaft and Camshaft grinding.

A Grinding Wheel is basically a precision tool composed of abrasive grains held together by a bonding material or 'bond'. The abrasive grains provide the wheel with its cutting points, which in turn help in cutting the material to the required dimensional accuracy or help impart a fine surface finish.

The arrangement of the abrasive grain and the bond in the grinding wheel gives a definite characteristic known as **'structure'** or **'pores'.** These pores are designed based on application needs and provide for chip clearance.



The abrasive grain cuts into the work until it becomes dull. Then it breaks down (fractures) and exposes new cutting crystals with sharp edges to the work.

Types of Abrasives :

Aluminium oxide and Silicon carbide are the two major abrasives used in the manufacture of grinding wheels. These synthetic or manufactured abrasives allow accurate control over the form and physical characteristics of the abrasive grain. It is therefore used in the manufacture of grinding wheels with very specific requirements of performance allied to application needs.

Aluminium Oxide

This grain is derived by refining bauxite ores in an electric furnace. The bauxite is first heated to drive off moisture and then mixed with coke and iron borings to form the furnace charge. After the mixture has been fused and cooled, the resulting rock-like mass is crushed and screened into various sizes.

The colour and the toughness of the abrasive is determined by the amount of impurities (iron oxide, titanium oxide and silica). Toughness is also strongly affected by additives.

Aluminium oxide, the most popular abrasive by a wide margin, is usually recommended for grinding most steels, annealed, malleable and ductile iron, and non-ferrous cast alloys.

White Aluminium Oxide is a highly refined form of aluminium oxide containing over 99% pure alumina. The high purity of this abrasive not only bestows its characteristic white colour, but also lends it with its unique property of high friability. The hardness of this abrasive is however similar to that of Brown Aloxide (1700 – 2000 kg/mm^2 knoop)

This white abrasive has exceptionally fast and cool cutting grinding characteristics, especially suitable for grinding hardened or high speed steel in varied precision grinding operations.

Zirconia :

Specialised alumina or Zirconia Aluminium Oxide is a fused mixture of zirconium oxide and aluminium oxide which is used for high production snagging, while sintered alumina, which is extremely tough, is ideal for billet conditioning and very high stock removal snagging operations.

Pink Aluminium Oxide :

Aluminium oxide and chromium oxide alloy is used to combine the cool, low stress grinding action of high purity aluminium with low abrasive wear. The result is a pink grinding abrasive which is slightly tougher and less friable than white abrasive, while still retaining its free cutting properties. This is particularly well suited for grinding abrasive resistant, heat sensitive tool steels.

Ceramic Aluminium Oxide :

Ceramic aluminium oxide abrasive is an extremely tough and durable abrasive produced in an unique sol or seeded gel process. The resulting grain is chemically quite pure and of uniform quality and is comprised of a complex polycrystalline microstructure. This is blended in varied percentages, with more friable conventional aluminium oxide, to make sol-gel wheels.

The wheel made out of this abrasive stays sharper because the grains actually discard microscopic crystals during use, which creates new, vital grinding surfaces. Free cutting and with a much longer and more productive life, these wheels are best suited for a variety of applications including centreless, centre-type, micro-centric, surface, internal, tool and cutter grinding applications.

Silicon Carbide

Silicon carbide (SiC) is produced by fusing a mixture of pure white quartz (sand) and fine petroleum coke in an electric furnace. This process is one of synthesising or combining the sand and coke, in contrast to refining bauxite into aluminium oxide. Again the resulting crystalline mass is crushed and graded by particle size.

Silicon carbide abrasives are not only harder than aluminium oxide abrasives but also more brittle. These characteristics make silicon carbide abrasives ideal for grinding low tensile materials like grey iron and unannealed malleable iron, non-ferrous metals like copper, brass, aluminium and magnesium and non-metallic materials such as glass, gem stones, plastic and rubber.

Diamond

Diamond is the hardest known substance. Until recently, use of diamond abrasive was generally limited to hard and dense materials like cemented carbides, marble, granite, glass and ceramics. However, recent developments in manufactured diamonds leading to controlled crystal configurations and surface coatings have expanded its use in some specialized cases, for grinding of other metals also.

Cubic Boron Nitride

This newest manufactured abrasive has a hardness second only to diamond and is 2.5 times as hard as aluminium oxide. It can withstand a temperature of 2500° F, unlike diamond which begins to burn around 1300° F. In its metal-coated form, cubic boron nitride has proved generally superior to both manufactured diamond and aluminium oxide in grinding super hard, high speed steel, tool steel and die steel.

AC

A blend of Aluminium oxide and Silicon carbide, this is used for specialized precision and non-precision applications.

TYPES OF BONDS

Types of Bonds used in grinding wheels :

The various bonds used in grinding wheels or bonded abrasives are Vitrified, Resinoid, Rubber, Silicate, Shellac, Magnesite and Metal bonds. Besides holding the grains together, these bonds also help in defining the type and character of the grinding wheel.

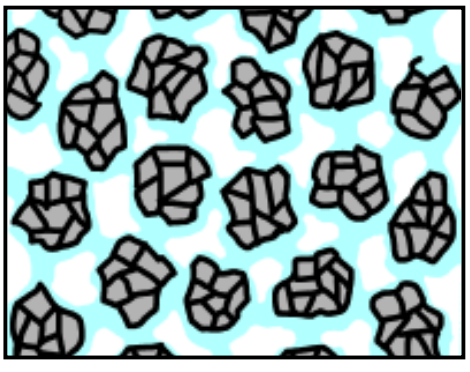


Illustration showing bond "Posts" holding abrasive grain particles (Cyan portion represents bond "posts")

Vitrified (V) or ceramic bonds :

These are made from clays, feldspar and other fusible materials in a carefully monitored process. Wheels which use this bond have a porous structure and are fired in kilns with temperatures exceeding 1000° C. Vitrified wheels are unaffected by water, acids, oils or normal temperature variation. The porosity and strength of these wheels make them ideal for high stock removal operations. Added to this, vitrified bonded wheels have a high modulus of elasticity and this rigidity makes them suitable for precision grinding applications.

Resinoid or Organic (B) bonds :

Resinoid or Organic bonds are made from phenolic type plastics or resins and cured in ovens under carefully controlled conditions of temperature ranging between 150° to 200° C. Resinoid wheels are tougher and less rigid than vitrified wheels and are ideally suited for high operating speeds and also for heavy duty operations, often with the aid of fabric or steel ring reinforcement. Their lower modulus of elasticity helps in achieving finer finishes. Unlike vitrified wheels, resinoid bonded wheels are affected by alkalis, humidity or extremes of climatic conditions and tend to deteriorate over a period of time.

Rubber (R) bonds :

These are made of both natural and synthetic rubber in a varied range of formulations. Used mainly in centreless and control wheels, these are ideally suited for grinding operations that require a high degree of precision and fine surface finish. In wet grinding operations, thin cut-off wheels used to produce burr and burn free cuts are also made of rubber.

Silicate (S) bond :

Releases abrasive grains rather readily and thus gives the wheels a comparatively mild and cool cutting action ideal for operations that require minimum heat and for sharpening edged tools.

Shellac (E) bonds :

Denoted by the letter **"E"** these are made of both natural and synthetic shellac. Wheels made from these bonds have exceptionally cool cutting properties and are particularly suited for grinding very soft materials such as copper. Shellac bonded wheels are highly recommended for very special grinding applications that require high surface finish such as razor blade and roll grinding.

Magnesite (O) Bond :

Magnesium Oxychloride denoted by the letter **"O"** is once again used in a very limited range of wheels. It is cool cutting even without a coolant and is greatly favoured in disc grinders. Being a cold setting bond this is also used for grinding heavy stocks like spring grinding, file grinding etc.

Metal Bonds :

Compared to vitrified and organic bonds, the use of metal bonds is very limited. The major use of metal bonds is with diamond abrasive for grinding under harsh conditions. The metal bonded diamond wheel removes material slowly and frequently with high heat generation, but in many applications such as certain glass grinding, abrasive wheel shaping and concrete or stone sawing, the long life outweighs these disadvantages.

Metal bonds are also used with aluminium oxide or diamond abrasive to provide conductive wheels for electrolytic grinding.

SAL-ABRASIVE TYPES, PROPERTIES AND USAGE

Abrasive	Abrasive denotion SAL	Properties	Major Applications
Brown Aluminium Oxide	**"A"**	Very tough abrasive	The most widely used SAL abrasive. Used for heavy duty work such as snagging steel casting and for stock removal in cylindrical grinding, on all but the hardest and most heat-sensitive steels like low alloy steel, cast steel and rough grinding applications.
White Aluminium Oxide	**"AA"**	More friable than Brown Aluminium Oxide. This is also a cool cutting grain.	AA is used for light grinding of all kinds of hard, heat–sensitive steels. It is excellent for tool room grinding, sharpening of high speed steel, cast alloy tools like Hardened Steel, H.S.S., Tool Steels S.S. (400 series) and chrome plated material. It is also recommended for cylindrical, surface and internal grinding applications of tools, dies and gauges.
Mixture of brown and white aluminium oxide	**"DA"** or **"MA"**	DA is a blend of brown regular A and white AA and therefore, has intermediate grinding action.	Used in applications where high stock removal rate with less thermal damage and better form holding is required. Eg. : Cylindrical plain and angular head grinding, camlobe grinding, Inner ring track grinding, bore grinding.
Pink Aluminium Oxide	**"PA"**	PA (Pink)- Chromic oxide alloyed with Brown Regular alumina gives a pink abrasive, which is very sharp and less friable than white aluminium oxide.	Very cool cutting, retains better form and sharp cutting edge for a long time. Used for bore grinding, cylindrical and some specialised precision applications, good on tool steel, H.S.S. applications where protecting components from thermal damage is of critical importance.

SAL-ABRASIVE TYPES, PROPERTIES AND USAGE

Abrasive	Abrasive denotion SAL	Properties	Major Applications
Pink aluminium oxide	**"PAA"**	PAA (Pink)- Chromic oxide alloyed with white aluminium gives a lovely pink abrasive. Free cutting properties, slightly tougher and less friable than white aloxide.	Excellent for dry grinding in tool sharpening and tool room grinding applications. Very cool cutting and sharp on 5% to 10% cobalt steels, Alloyed HSS and on difficult-to-grind materials. A popular abrasive and cost effective for tool room applications.
Black silicon carbide	**"C"**	Very hard and friable than Aluminium oxide	It is used for general grinding, heavy duty snagging, cylindrical, centreless and internal grinding. With special bonding process, it is also used for grinding cemented carbide, for bench grinding and centreless grinding applications. Also used for non-ferrous material, cast iron, stainless steel and rough grinding applications.
Green silicon carbide	**"GC"**	Hard and friable	Used for grinding cemented carbide tools, hard and high chilled cast iron, rolls etc.
Combination of black and green SiC	**"CGC"**	Combined properties of C and GC.	Used mainly in the mining field and also in double disc grinding application for grinding piston rings.
Blend of Aluminium oxide & Silicon carbide	**"AC"**	Combined properties of A and C.	Used mainly in specialized precision and non precision applications.
Zirconia with Brown Aluminium Oxide	**"ZA"**	Free cutting, very tough and long life abrasive.	Ideal for heavy stock removal operation. Used for de-scaling in stainless steel applications.

ELEMENTS OF ABRASIVES

Grain or Grit Size :

The size of the abrasive grain is expressed by the size of the screen opening through which the grains are sifted or sorted. For instance, a grain or grit which goes through a screen 8 mesh or openings per linear inch is called 8 grain or grit size, while a 24 grit size is roughly twenty fourth of an inch across. The higher the grit size, the finer its type.

Structure :

This is basically the spacing of the abrasive grains in a wheel or the volume content of the abrasive in the wheel. This is defined by the 'voids' or spaces between the abrasive grain and the bonding material and is called wheel 'porosity'. A 'close' structure wheel is one where the volume of closely packed grains are more. These are given structured numbers of 1 and 2. Conversely, 'open' structure wheels are those with wider grain spacing.

Wheel Grade :

This is generally a measure of 'hardness' or bonding strength of the wheel. For a wheel, of a particular bond type, the amount of bond used in the wheel mainly determines its hardness. When the amount of bond is increased, the size of the bond posts connecting each abrasive grain to its neighbours is also increased. The larger bond post is naturally stronger, thereby increasing the wheel's hardness.

Strong "Posts"

Medium Strength "Posts"

Weak "Posts"

Grade is therefore not a measure of the hardness of the abrasive material but of the durability of the wheel. A hard abrasive can be bonded into a 'soft', free cutting wheel by using less bond, while an increase in the amount of bond can make the wheel act harder. Wheel gradings range from 'D' for the softest, to 'Z' for the hardest.

How to Specify a Wheel ?

To specify a grinding wheel requirement, it is important to follow the following steps :

Standard Wheels :

1. Specify the wheel size by quoting in mm the overall dimension of

   Diameter x Thickness x Bore

   The diameter and thickness can be specified in nominal dimension whereas the bore diameter should be indicated to the closest two decimal places.

   E.g 180 x 13 x 31.75mm

2. Indicate the type and shape of the wheel face
3. Specify wheel grading.

Customised Wheels :

1. Specify the dimensions in the order of

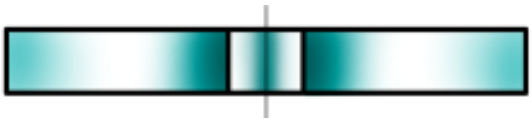
   Diameter x Thickness x bore

2. Mention the type of wheel required.
3. Indicate the recess size and depth for types 5 & 7 wheels (ROS & RBS)
4. Indicate the shape of the wheel face, if it is applicable
5. If the dimension has special tolerance of diameter, thickness or bore, this needs to be indicated.
6. Specify wheel grading.
7. A detailed drawing of the wheel to be provided.

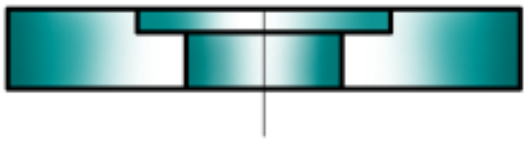
Grinding wheels can be manufactured in a wide range of standard shapes or customized to different application requirements. For easy selection, refer list of Standard Grinding Wheel Shapes as well as **SAL Wheel Marking System.**

STANDARD GRINDING WHEEL SHAPES

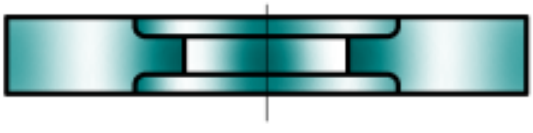
Straight Wheel Types



Type No. 1 – Straight



Type No. 5 – Recessed One Side



Type No. 7 – Recessed Both Sides

Straight Wheels

Wheel Type Nos.1, 5 & 7 are standard for internal grinding, cylindrical grinding, tool grinding, offhand grinding and snagging. The recesses in Type Nos. 5 and 7 give clearance for the mounting flanges.

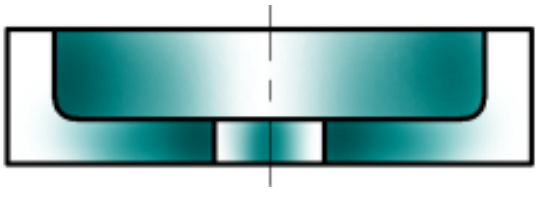
Type No. 2 – Cylinder

Cylinder Wheels

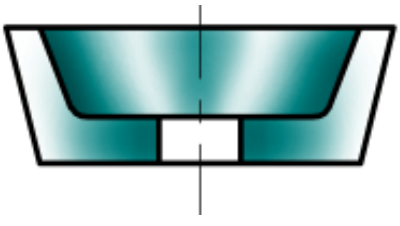
Wheel Types No. 2 is used for surface grinding on both horizontal and vertical spindle machines with the grinding performed on the face of the wheel.

Straight Cup Wheels

Wheel Type No. 6 is a straight cup wheel and is used primarily for surface grinding on horizontal or vertical spindle machines. It is also useful for off hand grinding when a flat surface on the work being ground is desired. Available in either plain or bevel face.



Type No. 6 – Straight Cup



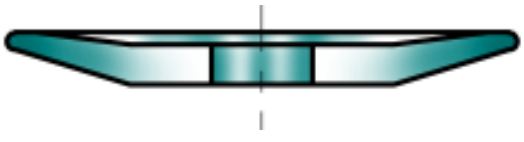
Type No. 11 – Flaring Cup

Flaring Cup Wheels

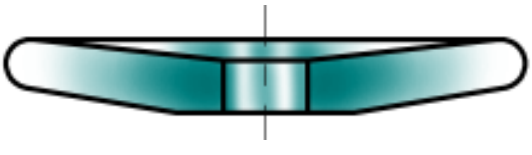
Wheel Type No.11 is a flaring cup wheel used for grinding in the tool room and in resinoid bonds for snagging. It is supplied with either a plain or bevelled face.

Dish Wheels

Wheel Type No.12 is a dish wheel for grinding in the tool room. Its thinness permits the insertion of the grinding edge of the wheel into narrow places.



Type No. 12 – Dish

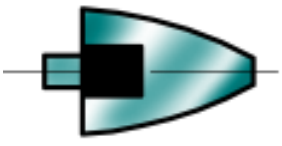


Type No. 13 – Saucer

Saucer Wheels

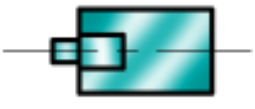
Wheel type No.13 is a saucer wheel or saw gummer. Its name is derived from its use for re-sharpening saws. (saw gumming).

D	Diameter (overall)	K	Diameter of inside flat
E	Thickness at hole or back thickness	M	Large Diameter of bevel
F	Depth of recess (see type 5 & 7)	P	Diameter of recess
G	Depth of recess (see type 7)	R	Radius of corner
H	Hole	T	Thickness (Overall)
J	Diameter of outside flat	U	Width of edge
		W	Wall thickness of grinding face



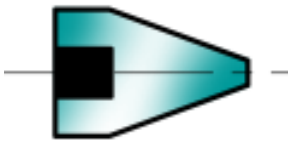
Type 16. – Cone. curved sid

Type 17. – Cone. streight side square tip.

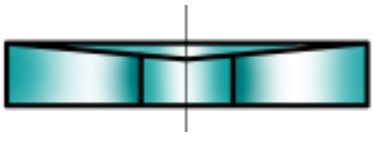


Type 18 – Plug.

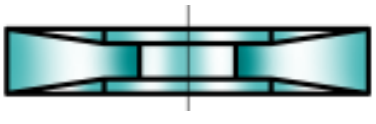
Type 18R – Plug



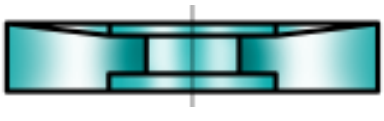
Type 19. – Plug



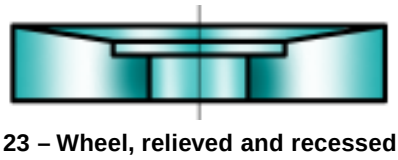
Type 20R –
Wheel, relieved one side.



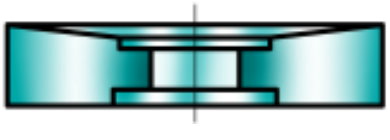
Type 21 –
Wheel, relieved two sides



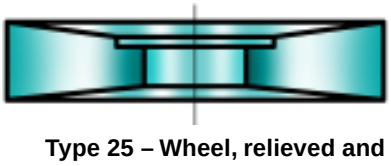
Type 22 –Wheel, relieved one side. recessed other side.



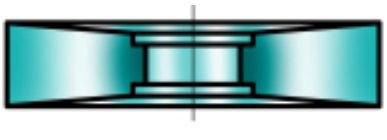
Type 23 – Wheel, relieved and recessed same side.



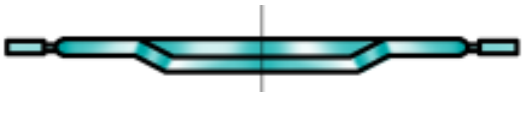
Type 24 – Wheel, relieved and recessed one side - recessed other side.



Type 25 – Wheel, relieved and recessed side. relieved other side.

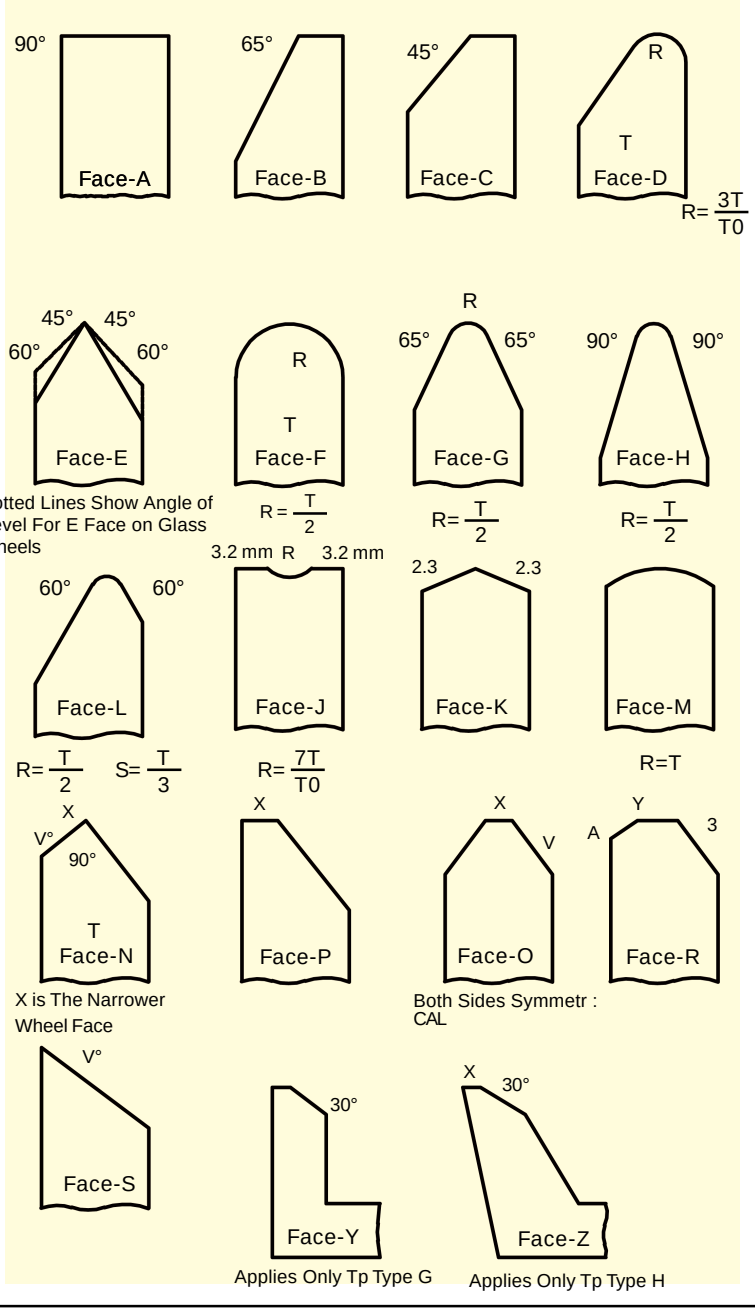


Type 26 – Wheel, relieved and recessed both sides.



Type 27 – Wheel, depressed canter

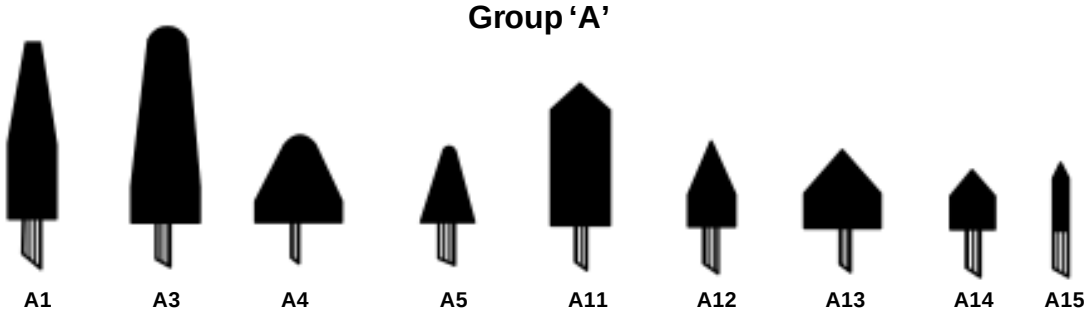
Standard
Shapes of Grinding Wheel Faces



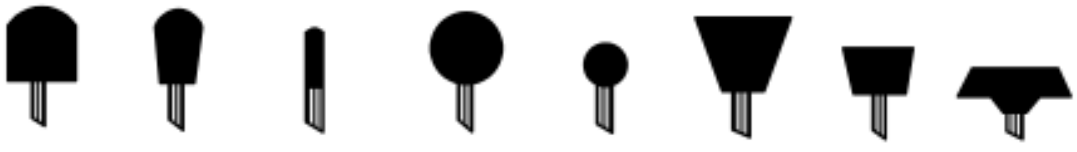
KEY TO LETTER DIMENSIONS

- A - Radial width of flat at peripheri
- B - Depth of blind hole bushing
- D - Diameter (overall)
- E - Thickness at hole
- F - Depth of recess one side
- G - Depth of recess other side
- H - Hole diameter
- J - Diameter of outside flat
- K - Diameter of inside flat
- N - Depth or relief one side
- O - Depth of relief other side
- P - diameter of recess
- R - Radius
- S - Length of cylindrical section
- T - Thickness (overall)
- U - Width of edge
- V - Face angle
- W - Wall (rim) thickness at grinding face

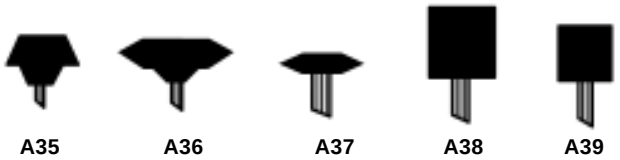
Group 'A'



A1 A3 A4 A5 A11 A12 A13 A14 A15

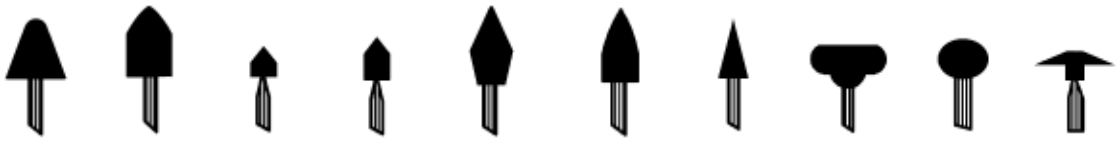


A21 A23 A24 A25 A26 A31 A32 A34

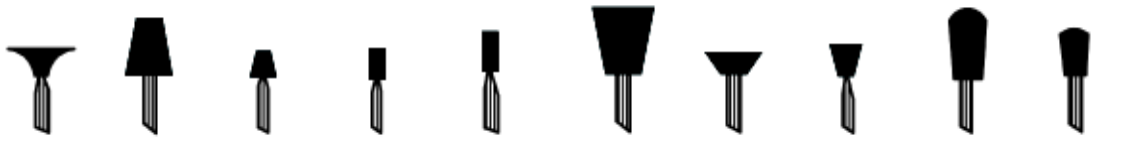


A35 A36 A37 A38 A39

Group 'B'



B41 B42 B43 B44 B51 B52 B53 B61 B62 B71



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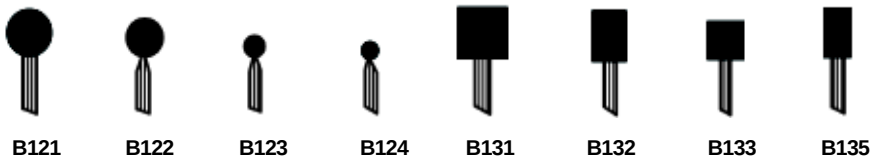

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'READING' A SAL GRINDING WHEEL

Bond used with Aluminium Oxide

1.	Fettling & Snagging	V9, BS
2.	Pin & Needle Grinding	V9
3.	Precision Grinding	V15, V18N, VP7, BS (F Type)
4.	Off-hand Tool Grinding	V9, V16, BS
5.	Super Finishing	V15, V18N
6.	Pink Tool & Cutter Grinding	V15, V18N, V5
7.	Centreless Precision Grinding	V15, V18N
8.	Crankshaft Precision Grinding	V15, V18N, VSC
9.	Precision & Thread Grinding	V15, V5
10.	For Porous Wheels & Segments	V18 old, V15, VSC, BS
11.	Gear Grinding	VP7, V15, V18N

Bond used with Silicon Carbide

1.	GC grain used for Tungsten Carbide	V4
2.	Precision & Off-hand Grinding	V4, V13, V1, BS
3.	Fettling & Snagging	V1, V13, BS
4.	Super Finishing	V4
5.	For Porous Wheel	V4, BS
6.	For Rice Polishing Stone	V13

STERLING ABRASIVES LTD.

'READING' A SAL GRINDING WHEEL
WHEEL MARKING SYMBOLS

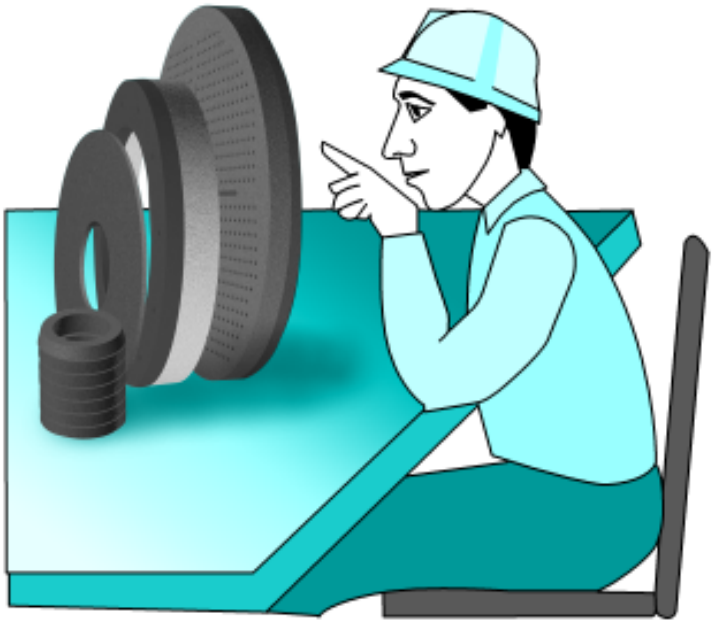
A	46	3	L	5	V15
I	II	III	IV	V	VI

Grain Type		Grain Size						Grain Combi-nation	Grade Range	Wheel Structure	Bond Type
Aluminium Oxide	Silicon Carbide	A/ DA	AA	C	GC/ CGC	ZA	PA/ PAA				
A	C	8	20	12	20	8	20	1	Soft	Dense	V=Vitrified
AA	GC	10	24	14	24	10	24	3	G	"3"	
DA	CGC	12	30	16	30	12	30	5	H		
PA		14	36	20	36	14	36	7	I		
PAA		16	46	24	46	16	46		J		
ZA		20	54	30	54	20	54		J^+		BS
		24	60	36	60	24	60		K		Resinoid
		30	70	46	70		70		L	Normal	
		36	80	54	80		80		M	"5"	
		46	90	60	90		90		N		
		54	100	70	100		100		O		EF
		60	120	80	120		120		P		Shellac
		70	150	90	150		150		Q		
		80	180	100	180		180		R		
		90	220	120	220		220		S		
		100		150	320				T		
		120		180	500				U	Open	
		150		220	600				Hard	"18"	
		180		320							
		220		400							
				600							
				800							

Note : This gives a general range of SAL wheel specification.

WHEEL SELECTION :

SAL has one of the widest range of grinding wheels. Available in standard sizes or customized to specific grinding applications, these premier quality wheels are manufactured to suit the diverse grinding needs of all user industries. Since there are as many types of wheels as there are grinding applications, correct wheel selection assumes very critical importance.



Factors affecting the Selection of a Grinding Wheel

Wheel selection is dependant on the kind of material to be ground and the type of grinding operation. The eight important factors that need to be considered in the selection of a grinding wheel are :

1. Material to be ground and its hardness
2. Stock removal and surface finish
3. The grinding process - whether wet or dry
4. Peripheral speed of the wheel
5. The area of grinding contact - large or small
6. The severity of grinding operation
7. Condition of grinding machine
8. Type of grinding machine

1. Material to be ground and its hardness :

The type of material to be ground determines the selection of abrasives, its grit size and grade. Aluminium oxide abrasives are ideal for grinding hard or high tensile materials such as alloy steel, high speed steel, annealed malleable iron and other ferrous metals.

Silicon Carbide abrasives are excellent for grinding or cutting low tensile strength materials such as cast iron, bronze, aluminium, copper and other non metallic materials.

While choosing the grit size, the hardness of the material is a major determining factor. While finer grit size wheels are required for hard and brittle materials, coarser grit wheels are ideal for soft and ductile materials.

Material hardness also dictates the choice of wheel grades. For optimum performance, harder grade wheels are recommended for soft and easily penetrated materials while softer grades are ideal for hard materials.

2. Stock removal and surface finish :

The amount of stock removal and the degree of surface finish required also depends on the abrasive size and the type of bond. When an operation demands high stock removal rates, as in fettling, coarse grit wheels are used. Whereas, fine grit wheels are ideally suited to achieve extremely close surface tolerances and fine geometrical finish.

Resinoid, rubber or shellac bonded wheels are usually recommended for operations that require fine finishes.

The following table illustrates the grit size vs form radius for grinding wheels that are commonly in use

Grit Size vs Form Radius

Work Radius (mm)	Grit Size	Abrasive Particle Dia. (microns)
1	36	500
0.75	46	350
0.50	60	250
0.40	80	177
0.20	120	100
0.13	180	70
0.10	220	60

3. Grinding Process – Wet or Dry

The grade of the wheel depends on whether the operation is wet or dry. During dry grinding with vitrified wheels, in order to minimize the heat generated, soft grade wheels should be used. These should be at least one or two grades softer than the ones chosen for wet grinding operations.

In wet grinding applications, where coolants reduce the heat, harder grade wheels should be used.

4. Peripheral Speed of the Wheel

The speed at which the grinding edge of the wheel passes the work surface is called the 'Peripheral Speed' of the wheel. This is a very important factor in grinding wheel selection.

Standard vitrified wheels are usually for speeds of not more than 33mps. However, on the other hand, special bonded vitrified wheels can take speeds up to 60mps. This is usually indicated on the blotter or on the face of the wheel. Organically bonded wheels (resinoid, rubber or shellac) are used for most applications where the required speed rate is above 33mps to 48mps. Higher speeds for reinforced products can go up to 100mps. Reducing the wheel speed reduces the wheel hardness.

The following table illustrates the effect of speed on grinding action :

Speed	Effect on Grinding Action when Speed is	
	Increased	Decreased
Wheel Speed	Harder	Softer
Work Speed	Softer	Harder
Traverse Speed	Softer	Harder
Infeed Rate	Softer	Harder

5. Area of Grinding Contact – Large or Small

The area of grinding contact influences the selection of wheel grade and grit size. As far as wheel grade is concerned, it is normal practice to use soft grade wheels where the area of grinding contact is large and harder grade wheels where the area of grinding contact is small.

In surface grinding, for instance, where the area of grinding is large, coarser grit, open structure wheels are recommended. Conversely, fine grit, closer structure wheels are ideal for use in narrower and close precision areas of contact, as in cylindrical grinding operations.

6. Severity of Grinding Operation :

Severity of a grinding operation can be due to various factors such as, the pressure of shock loads, heavy in-feeds, high work speeds and traverse rates and intermittent grinding contact. Hence, for wheel selection, the severity of a grinding operation dictates the choice of abrasive type, grade and even type of bond.

The greater the severity of the grinding operation, the harder the grade of wheel required and tougher the abrasive that should be used. For example, for severe grinding operations, like snagging, a tough abrasive like A or ZA is required. Medium and soft grade wheels are ideally suited for precision grinding jobs.

7. Condition of Grinding Machine :

Many grinding faults can be traced to bad machine conditions. These can vary from loose bearings, uneven or improperly spliced belts, belt slippage, worn gears, wrong alignment of machine, inadequate foundation or general machine vibration. In fact, it is very important that all grinding machines must be installed or fixed on flat and strong foundations.

8. The Type of Grinding Machine :

A very important factor in a grinding wheel selection, is the type of the grinding machine. The type of wheel and grinding operation defines the type of machine to be used. Only wheels, for which the machine is intended should be used. For instance, a non-reinforced cutting off wheel should never be mounted on a portable grinding machine or on any machine where the work is fed into the wheel.

8. a. The Power of the Machine (Kw):

The power of the machine is of paramount importance. This greatly influences the stock removal rate. If the motor power is insufficient, then the speed of the grinding wheel will be correspondingly reduced, as also the cutting power. This can result in increased temperatures and excessive pressure between the wheel and the work piece. If the power of the machine is high then a wheel of a harder grade should be used for efficient operations.

8. b. Machine Speed

The user should take care to check that the maximum rpm stated on the wheel is compatible with that stated on the machine. Under no circumstances should the user exceed the permissible speed limits. Machines with adjustable rotational speeds must be fitted with a locking system to prevent wheels from exceeding the maximum permissible speed.

General guide to Type of Machine relative to Feed Type & Nature of Operation

Machine Type	Feed Type	Nature of Operation
Fixed Machines	Mechanical Feed	Cylindrical Grinding between centres, Centreless Grinding, Internal Grinding, Surface grinding - using the wheel periphery or wheel face, Tool and cutter grinding.
Fixed Machines	Automatic Feed	High pressure grinding
Fixed machines (fixed mountings) or Swing frame or Wheelbarrow type machines	Manual Feed	Bench or pedestal grinding, Swing frame grinding of bulky workpieces
Hand held portable grinding machines (straight & angle grinders)	Manual Feed	Deburring or grinding of irregular surfaces & welds
Cutting-off fixed machines	Mechanical Feed	Cutting-off with resinoid wheels
Cutting-off on swing frame or slide mounted machines	Manual Feed	Cutting off runners, risers
Cutting-off on hand held machines	Manual Feed	Cutting-off with reinforced wheels

Wheel Spindle:

The design of the wheel spindle should suit the requirements of the grinding wheel with which it is to be used (dimensions, weight, speed etc.) and the loads to which it will be subjected.

To ensure ideal wheel and spindle fit, grinding wheel bores should have positive tolerances on them and grinding wheel spindles negative tolerances.

The spindle should be of sufficient length and threaded sufficiently to ensure that when the wheel and flanges are mounted there will be a bearing for atleast a full nut on the spindle. The spindle thread should extend inside the flange, but not into the hole in the wheel.

Spindles should be properly lubricated to prevent them from becoming overheated during grinding.

Mounting Flanges :

The mounting flange is used to clamp the wheel to the machine and to transfer the driving forces from the machine spindle to the grinding wheel.

The design and type of the wheel flange varies according to the machine and type of grinding wheel. The flange should not be less than one-third of the diameter of the wheel used. The grinding machine manufacturer should clearly state the type of material to be used and the thickness of the flange.

The various types of flanges are :

1. Straight recessed flange
2. Straight adaptor flange
3. Hubbed flange
4. Tapered flange
5. Straight flange

Flanges should be of a matched pair and of equal diameter. They should have equal bearing surfaces and be properly recessed or undercut.

The area between the grinding wheel and the clamping flanges should be flat and free from all foreign matter.

The flange should be fixed to the machine spindle by keying, bolting or by any other similar method.

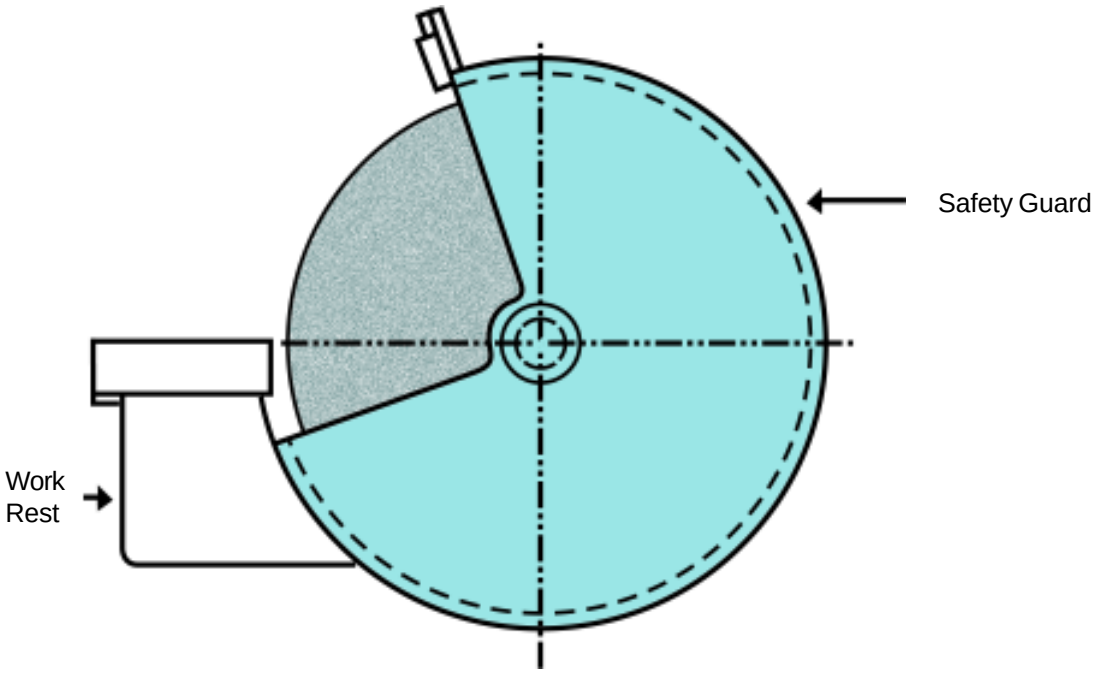
The screws or nuts used for clamping the flanges should be tightened uniformly in diametrical sequence and just sufficiently to hold the wheel firmly.

Safety Guards :

All grinding machines should be fitted with safety guards and guard bands, designed specifically for the type of wheel and grinding application. These safety guards should conform to standard specifications and cover the entire wheel, except the area of grinding. Certain operations however, require even the working area to be guarded. Mainly, safety guards should be able to effectively contain wheel fragments and protect the operator, in the event of a wheel breakage. These guards should also be adjustable to allow for wheel wear.

Work Rests :

Work rests should be fitted with fixed grinding heads to help in the easy guidance of hand held work pieces. They should be strong and rigid and be adjustable to allow for wheel wear. Work rests should be placed on the horizontal centreline of the wheel at a distance of not more than 3 mm from the wheel.



Wheel Balancing System :

All **SAL** wheels are balanced within normal limits. However, for certain precision grinding operations where closer limits of wheel balance are required, the machines should be equipped with wheel balancing systems. In such cases the machine manufacturer's instructions should be followed.

Similarly, when a wheel has been worn down or used for a long time without being trued, re-balancing it becomes necessary. Generally, the larger the wheel and higher its speed, greater is the need for balancing it. Using an out-of-balance wheel can result in damage both to the wheel and the spindle.

Blotters :

Blotters are very important in the operation of a grinding wheel. These are made of a flexible and compressible material, like cardboard or plastic of around 0.2 to 1.0 mm thickness and are placed between the flange and the grinding wheel.

Blotters of identical sizes are usually pasted on both sides of the wheel face or supplied loose with the wheel. In the case of loose blotters, the user should take care to see that there is no mix-up and that same size blotters are fixed on either side of the wheel.

The size of the blotters should always be larger than that of the mounting flange. Blotters must also be placed without any wrinkling on them.

The purpose of using blotters are :

- To act as a cushion between the metal mounting plates and the granular surface of the grinding wheel
- To eliminate any distortion, between the wheel and the flange within the locating area.
- To minimise the risk of slippage between the wheel and the flanges.
- To distribute equally, the axial clamping force, when the nuts are tightened, over the entire flange locating area.
- To prevent any uneven wear of the mounting flanges.

Wheel types for which blotters are not required :

- Small wheels up to 20mm diameter.
- Type 27 depressed centre wheels
- Type 29, semi-flexible wheels
- Types 41 and 42, reinforced cutting off wheels, up to 230mm diameter
- Type 43 steel centred saws
- Type 4 taper sided wheels
- Type 6 and I I straight and flared cup wheels, with centre nuts
- Type 35 and 36 cemented or nut inserted disc wheels
- Type 2 and 37 cemented cylinder and nut inserted cylinder wheels
- Type 31, segments
- Type 52 mounted wheels and points
- Types 16 to 19 plugs and cones with central thread insets
- Type 54 honing stones
- Type 90 hand stones
- Thin cutting and slitting wheels, up to 0.5mm thickness.
- Dove-tailed recessed wheels

Dressers :

Dressers are used for Truing and Dressing a grinding wheel. Truing a wheel is done to obtain the required geometry or form on the grinding face of the wheel.

Dressing a wheel changes the shape and cutting action of the grinding face. It restores the form and surface of a grinding wheel and also increases grinding efficiencies.

Guidelines for dressing :

- The dresser should be held as rigidly and as close as possible to the point of dressing. For machines equipped with work piece supports, the dresser should be made to rest against the support. This is to ensure vibration free operation.
- The diamond point of the dresser should be presented at an angle between 3^{o} to 10^{o} relative to the centre line of the wheel.
- To maintain the sharpness of the diamond point, the dresser should be rotated in the machine tool holder at an angle of 15^{o} to 45^{o}. Rotating the dresser before starting the machine for the day enhances the life of the tool as well provides consistent performance.
- Dressing should be carried out at normal speeds with copious amount of Metal working fluids.
- The dresser should not be quenched, if by accident it becomes overheated. It should be allowed to cool naturally.
- Never use a worn out diamond tool as it may jam into the grinding wheel and fracture or disintegrate.
- For best results, each machine should have its own dresser.

Grinding or Metal Working Fluids

One of the most critical factors in achieving a good finish and excellent finished product is the Metal Working Fluid (MWF) or the Grinding Fluid or the Coolant. Grinding fluids are used to reduce and dissipate the heat generated during a grinding operation.

Functions of a coolant

The main functions of the coolant are cooling and lubrication. Other functions of the coolant are as follows :

I. Dissipate the heat generated during grinding thus keeping the work and wheel cool.
2, Aids the grinding wheel to reproduce size more accurately through elimination of work distortion due to heat.
3. As a lubricant, it reduces the amount of friction between the cutting tool and the chip.
4. Decreases the effect of ductility of metal being ground and thus influences the form of chip.
5. Protects the diamond dressing tool while dressing.
6. Reduces loading to improve finish.
7. Good coolant has anti-rust characteristics to prevent rusting of machine or work being ground.
8. Aids in chip transportation and dust elimination.

Types of Coolants

Coolants can be classified as follows :

1. Neat Cutting Oils
2. Water based Cutting Fluids.

Water based fluids can be further classified as Synthetic, Emulsion and Semi - Synthetic.

Synthetic

Synthetic metal working fluids are fluids which are free from mineral oil. The constituents are finely distributed in water and form a transparent solution. The mineral oil free chemical solutions contain corrosion inhibitors and wetting agents. They have exceptional cooling and lubricating properties especially in very high speed cutting applications and hence are ideally suited for high speed CNC machines.

Emulsion

The most common form of water miscible metal working fluid is the emulsion. An emulsion is a dispense system which arises through mixing together of two liquids which are not soluble in each other. Emulsions basically contains higher proportion of mineral oil viz., 30 to 70% along with corrosion inhibitors and wetting agents. Product concentrates are diluted with water to form milky, opaque emulsions.

Some fluids in the above category contain synthetic lubricants and/or EP additives to extend their application range and enable the fluid to perform more difficult operations.

Semi Synthetic

Semi Synthetic are so called because they form in the main, clear emulsion combined with synthetic or natural emulsifiers. They contain 10 to 30% mineral oil, corrosion inhibitors and wetting agents. Product concentrates are dissolved in water to form stable, translucent mixes.

Selection of Coolants

Coolant type selection is based on the following factors :

- Application type & Severity of operation viz., stock removal
- Nature of machine operation (cutting method)
- Water quality (Soft, Hard, Chloride, Sulphate, Bi-carbonate %)
- Material to be machined
- Surface finish
- Filtering system in the machine tool
- High performance to cost ratio.

Coolant Usage

Metal working fluids should be used in the right proportion, since the strength of resin, shellac and rubber bonded grinding wheels can be reduced by Metal working fluids.

The concentration and alkalinity of Metal working fluids used should be regularly checked and the pH value should be maintained between 8.9 to 9.3.

Never immerse a stationary wheel in Metal working fluids for a long time. This will produce an out-of-balance condition in the wheel.

Always shut off the supply of Metal working fluids before the end of any wet grinding operation and allow the wheel to rotate until the Metal working fluids is completely drained.

For a detailed list of troubleshooting tips on coolant usage check section on **Problem Solving**.

STANDARD RECOMMENDATIONS

Work - Material - Operation	Abrasive	Grit Size	Grade	Struc-ture	Bond
Agate :					
Offhand	C	60	P	5	V 13
Aluminium :					
Cylindrical	C	46	J	8	V 4
Centreless	C	46	L	5	V 4
Surfacing (Cups & Cylinders)	C	24	K	8	V 4
Internal	C	36	K	8	V 4
Portable Grinders	C	24	O	6	B S
Cutting off	C	36	P	6	B S
Asbestos :					
Cutting off	C	24	T	8	B S
Axles :					
Centreless	A	60	M	5	V 18 N
Cylindrical	A	60	M	5	V 18 N
Ball Bearings :					
Grinding O.D. – Centreless	A	60	M	5	V 18 N
Grinding outer races (plunge cut)	A	120	M	6	V 9
Grinding inter races (plunge cut)	DA	180	L	8	V 5
Internal bore grinding	DA	80	M	8	V 5
	AA	80	M	8	V 5
	MCA	80	M	8	V 5
Billets (Alloy, H.S.S. Stainless) :					
Swing Frame 7000-9500 s.f.p.m.	A	14-3	T-R-Q	3	B S
Billets (Portable Grinder) :					
Portable Grinder 7000-9500 s.f.p.m.	A	16-3	S	3	B S
Bolts (Screw) :					
Cylindrical	A	60	N	5	V 18 N
Centreless	A	80	N	5	V 18 N
Brake Lining :					
Surfacing Discs	C	24	J	8	B S
Cutting off (Dry)	C	24	Q	6	B S
Brass & Bronze (Soft) :					
Centreless	C	46	M	6	V 4

Work - Material - Operation	Abrasive	Grit Size	Grade	Struc-ture	Bond
Cylindrical	C	46	L	6	V 4
Internal	C	36	K	8	V 4
Brooches :					
Sharpening	AA	46	I	5	V 18 N
Bushings (Hardened Steel) :					
Centreless	A	60	M	5	V 18 N
Cylindrical	A	60	M	5	V 18 N
Internal	A	60	L	8	V 18 N
Cams (Auto) (Hardened Steel) :					
Roughing	A	46	N	5	V 18 N
Finishing	A	80	P	6	B S
Camshaft Bearing (Auto) :					
Cylindrical	A	46	N	5	V 18 N
Cast Iron :					
Centreless	C	46	L	5	V 4
Cylindrical	C	36	L	8	V 4
Internal	C	46	J	5	V 4
	A	60	L	8	V 18 N
Surfacing (Cups & Cylinders)	C	24	H	8	V 4
	AA	36	I	8	V 18 N
Surfacing (Segments)	AA	36	I	8	V 18
Surfacing (Straight Wheels)	C	36	K	8	V 4
Snagging (Floorstands) 5000-6500 s.f.p.m.	C	20	S	5	V 1
Snagging (Floorstands) 7000-9500 s.f.p.m.	C	20	Q	4	B S
Snagging (Swing Frame) 5000-6500 s.f.p.m.	C	20	R	5	V 1
Snagging (Swing Frame) 7000-9500 s.f.p.m.	C	16	R	5	B S
Snagging (Portable Grinder) 5000-6500 s.f.p.m.	C	24	R	5	V 1
Snagging (Portable Grinder) 7000-9500 s.f.p.m.	C	20	R	5	B S
Cemented Carbides :					
SINGLE-POINT TOOLS OFF HAND CUP OR PLATE MOUNTED WHEELS :					
Roughing (Wet and Dry)	GC	60	J	8	V 4

Work - Material - Operation	Abrasive	Grit Size	Grade	Struc-ture	Bond
Semi-finishing	GC	120	I	8	V 4
STRAIGHT WHEELS					
Roughing (Wet and Dry)	GC	60	K	5	V 4
Semi-finishing (Wet and Dry)	GC	120	J	5	V 4
SINGLE-POINT TOOLS,					
MACHINE GRINDING STRAIGHT WHEELS :					
Roughing and Finishing (Wet)	GC	80	K	5	V 4
MILLING CUTTERS, reemers :					
Roughing	GC	60	I	8	V 4
SURFACE GRINDING STRAIGHT WHEELS :					
Roughing (Wet)	GC	60	I	8	V 4
Finishing (Wet)	GC	120	H	8	V 4
CYLINDRICAL GRINDING :					
Roughing (Wet)	GC	60	K	5	V 4
Finishing (Wet)	GC	120	J	7	V 4
Chilled Iron :					
Snagging (Floorstands) 5000-6500 s.f.p.m.	C	20	S	5	V 1
Snagging (Floorstands) 7000-9500 s.f.p.m.	C	20	R	4	B S
Surfacing Cups & Cylinders)	C	24	H	8	V 4
Surfacing (Straight Wheels)	C	36	I	8	V 4
Chromium Plating (Cylindrical) :					
Ordinary Finish	AA	80	L	8	V 18 N
Fine Finish	C	280	J	10	B S
Crankshafts :					
Auto	A	54	M	5	V 18 N
Diesel	A	54	N	5	V 18 N
AUTOMOTIVE (PINS AND BEARINGS) :					
Roughing – Heavy side removal	A	35	K	5	V 18 N
Light side removal	A	54	N	5	V 18 N
Finishing	A	60	M	5	V 18 N
Roughing and Finishing	A	54	N	5	V 18 N
Snagging - 5000-6500 s.f.p.m.	A	20	P	5	V 9

Work - Material - Operation	Abrasive	Grit Size	Grade	Struc-ture	Bond
Snagging - 7000-9500 s.f.p.m.	A	16	P	4	B S
Automotive (Regrinding)	A	54	N	5	V 18 N
Cutlery :					
OFFHAND :					
Surfacing sides	AA	120	I	8	V 18 N
Sharpening (Production)	AA	120	M	8	V 18 N
Snagging	A	60	Q	5	V 9
Cutters :					
Sharpening (Machine)	AA	60	K	5	V 18 N
Sharpening (Offhand)	A	60	M	5	V 18 N
Cylinders, Cast Iron Auto (Internal)					
Regrinding (Wheels)	C	36	I	8	V 4
HONING (NEW CYLINDERS) STICKS :					
Ordinary Finish	C	120	P	8	V 4
Very Fine Finish	C	280	M	8	V 4
Cylinders (Aircraft) (Internal) :					
MOLYBDENUM STEEL :					
Roughing	AA	46	J	8	V 18 N
Finishing	AA	60	I	8	V 18 N
Regrinding	AA	46	J	8	V 18 N
NITRIDED STEEL :					
Before	AA	46	J	8	V 18 N
After	C	60	I	8	V 4
Regrinding	C	60	I	8	V 4
Dies (Forgings) :					
OFFHAND – PORTABLE GRINDING :					
Mounted Points & Wheel (Coarse)		COARSE			
Mounted Points & Wheel (Medium)		MEDIUM			
Mounted Points & Wheel (Fine)		FINE			
St. Wheels-Roughing 5000-6500 s.f.p.m.	A	46	F	5	V 9
St. Wheels-Roughing 7000-9500 s.f.p.m.	A	36	R	5	B S
Dies (Drawing)					
SURFACING-HARDENED :					
Straight Wheels (Dry)	AA	60	G	8	V 18 N

Work - Material - Operation	Abrasive	Grit Size	Grade	Struc-ture	Bond
Straight Wheels (Fast Travere, Wet)	AA	60	I	8	V 18 N
Cup Wheels (Wet)	AA	46	H	8	V 18 N
Discs	AA	46	H	8	V 18 N
Segments	AA	46	H	8	V 18 N
SURFACING-ANNEALED :					
Straight Wheels (Dry)	AA	46	J	8	V 18 N
Cup Wheels (Wet)	AA	30	H	8	V 18 N
Segments	AA	24	H	8	V 18 N
Drill (Manufacturing) :					
Cutting off Soft (Wet)	A	46	R	6	B S
Cutting off Soft (Dry)	A	24	T	8	B S
Cutting off Hard (Wet)	A	60	Q	6	B S
Cutting off Hard (Dry)	A	46	P	6	B S
Cylindrical	A	60	M	5	V 18 N
Centreless (Soft)	A	60	M	5	V 18 N
Centreless (Hard)	A	80	L	5	V 18 N
Precision Sharpening	AA	46	L	5	V 18 N
Pointing	AA	60	M	5	V 18 N
Grinding Relief	AA	60	M	5	V 18 N
Hertline Grinding Machine	A	120	V	8	B S
Drills (Resharpening) :					
Machine	AA	100	J	8	V 18 N
Offhand	AA	80	L	8	V 18 N
Ebonite :					
Cutting off (Dry)	C	24	P	6	B S
Fibreglass Insulating Board :					
Cutting off	C	24	P	6	B S
Fibre :					
Surfacing	C	24	J	8	B S
Cutting off	C	36	P	6	B S
Forgings :					
Centreless	A	60	M	5	V 18 N
Cylindrical	DA	46	M	5	V 18 N

Work - Material - Operation	Abrasive	Grit Size	Grade	Struc-ture	Bond
Snagging - 7000-9500 s.f.p.m.	A	20	R	4	B S
Snagging - 5000-6500 s.f.p.m.	A	24	R	4	V 9
Surfacing - Discs	A	24	K	8	B S
Gauges (Plug) :					
Cylindrical	AA	80	L	8	V 18 N
Cylindrical (High Finish)	C	280	J	10	B S
Gears (Cast Iron) :					
Cleaning between teeth (offhand)	C	24	T	4	B S
Gears (Hardend Steel) :					
Teeth-Form Precision Grinding	AA	60	K	5	V 18 N
	AA	80	J	8	V 18 N
Teeth-Generative Precision Grinding	AA	54	K	5	V 18 N
	AA	60	L	5	V 18 N
Internal	AA	60	K	8	V 18 N
Surfacing (Cups and Cylinders)	AA	36	I	8	V 18 N
Surfacing (Segments)	A	36	I	8	V 18 N
Surfacing (Discs remove burrs)	AA	36	I	8	V 18 N
Surfacing (Straight Wheels)	AA	46	I	8	V 18 N
Granite :					
Coping-solid type	C	36	M	8	B S
Surfacing (Planer Wheels)	C	16	O	4	B S
Surfacing (Portable)	C	16	O	4	B S
Knives (Machine) :					
Cutting off (Dry)	A	46	R	6	B S
Cutting off (Wet)	AA	60	M	8	B S
Chipper and Barker, Sharpening	AA	36	I	8	V 18 N
Hog Sharpening	AA	36	I	8	V 18 N
Leather Fleshing, Sharpening (Bricks)	A	36	Q	5	V 9
Leather Shaving, Sharpening-Cylindrical	A	60	P	5	V 9
Leather Splitting, Sharpening	A	36	K	8	B S
Molding, Offhand, Sharpening	A	46	M	5	V 18 N
Machine Sharpening	AA	60	I	8	V 18 N
Paper, Sharpening	AA	60	I	8	V 18 N

Work - Material - Operation	Abrasive	Grit Size	Grade	Struc-ture	Bond
Section Bavelling	A	46	M	5	V 18 N
Surfacing Backs	AA	46	H	8	V 18 N
Sugar Best, Routing	AA	80	N	8	V 18 N
Veneer Sharpening	AA	60	I	8	V 18 N
Veneer Surfacing	AA	46	J	8	V 18 N
Magnesium :					
Snagging - 5000-6500 s.f.p.m.	C	20	P	5	V 9
7000-9500 s.f.p.m.	A	20	O	4	B S
Malleable Casting (Annealed) :					
Floor Stands 5000-6500 s.f.p.m.	A	16/20	R	5	V 9
Floor Stands 7000-9500 s.f.p.m.	A	20	R	4	B S
Swing Frames 5000-6500 s.f.p.m.	A	16/20	R	5	V 9
Swing Frames 7000-9500 s.f.p.m.	A	20	R	4	B S
Portable Grinders 5000-6500 s.f.p.m.	A	24	R	5	V 9
Portable Grinders 7000-9500 s.f.p.m.	A	20	R	4	B S
Malleable Castings (Unannealed) :					
Floor Stands 5000-6500 s.f.p.m.	C	20	R	5	V 1
Floor Stands 7000-9500 s.f.p.m.	C	20	R	4	B S
Surfacing - Discs	A	24	K	8	B S
Molybdenum :					
Cylindrical	AA	60	K	5	V 18 N
Surfacing	AA	46	H	8	V 18 N
Monel Metal :					
Cutting off (Dry)	A	36	Q	6	B S
Cutting off (Wet)	A	46	P	6	B S
Floor Stands 5000-6500 s.f.p.m.	A	24	R	5	V 9
Floor Stands 7000-9500 s.f.p.m.	A	20	R	4	B S
Cylindrical	C	60	K	7	V 4
Needles :					
Pointing	A	80	R	7	V 9
Nickel Rods And Bars :					
Cutting off (Dry)	A	46	R	6	B S
Cutting off (Wet)	A	46	P	6	B S

Work - Material - Operation	Abrasive	Grit Size	Grade	Struc-ture	Bond
Pipe (Cast Iron) :					
Cleaning-inside 5000-6500 s.f.p.m.	C	20	T	5	V 1
Cleaning-inside 7000-9500 s.f.p.m.	A	16/20	T	4	B S
Pipe (Soft Steel) :					
Cutting off (Wet)	A	80	P	6	B S
Cutting off (Dry) minimum burr	A	60	Q	6	B S
Pistons (Aluminium) :					
Cylindrical	C	46	J	8	V 4
Centreless	C	46	K	7	V 4
Regrinding	AA	46	J	8	V 18 N
Pistons (Cast Iron) :					
Cylindrical	C	46	J	6	V 4
	C	36	K	8	V 4
Centreless	C	46	L	6	V 4
Regrinding	AA	46	J	8	V 18 N
Pistons (Pins) :					
CENTRELESS MACHINE :					
Roughing	A	60	M	5	V 18 N
Semi-Finishing	A	80	L	5	V 18 N
Finishing	C	240	N	10	B S
Surfacing Ends (Discs)	A	60	I	8	B S
Lapping (Norton)	C	240	M	10	B S
Piston Rings (Cast Iron) :					
Surfacing Rough (Cylinders)	AA	36	I	8	V 18 N
SURFACING (DISCS) :					
Roughing	C	24	J	5	B S
Semi-Finishing	C	46	I	8	B S
Finishing	C	80	H	8	B S
Surfacing (Straight Wheels)	AA	80	J	8	B S
Lapping (Norton)	C	230	K	8	V 4
Internal (Snagging)	C	30	T	5	V 1
Piston Rods (Locomotive) :					
Cylindrical	A	46	M	5	V 18 N

Work - Material - Operation	Abrasive	Grit Size	Grade	Struc-ture	Bond
Plastics :					
Cutting off (Dry)	C	60	K	8	B S
Cutting off (Wet)	C	60	M	8	B S
Porcelain :					
Cutting off (Dry) Fired	C	120	M	8	B S
Cutting off (Low Speed) (Dry) Prefired	C	36	M	8	B S
Cylindrical	C	60	K	7	V 4
Removing imperfection (Bricks)	AA	80	L	8	V 18 N
Centreless	C	36	K	8	V 4
Rails :					
Surfacing Welds 5000-6500 s.f.p.m.	A	24	R	5	V 9
Surfacing Welds 7000-9500 s.f.p.m.	A	16	Q	4	B S
Cup Wheels	A	16	P	4	B S
Straight Wheels	A	16	Q	4	B S
Removing Corrugation	A	24	M	5	V 9
	A	16	N	5	V 9
Slotting after Welding	A	36	S	6	B S
	A	24	R	6	B S
Razor Blades (Safety) :					
CARBON STEEL - Roughing	A	220	I	8	E F
Semi-Finishing	A	400	M	8	E F
STAINLESS – Roughing	C	240	M	10	E F
Finishing	C	400	M	5	E F
Reamers :					
Backing off	AA	80	H	12	V 18 N
	AA	60	K	5	V 18 N
Cylindrical	DA	80	M	5	V 18 N
Roller Bearing Cups :					
Centreless O.D.	A	60	M	5	V 18 N
Internal	AA	60	M	5	V 18 N
Surfacing (Cylinders)	AA	80	G	9	V 18 N
Rollers For Bearings :					
Centreless - Roughing	A	80	N	5	V 18 N

Work - Material - Operation	Abrasive	Grit Size	Grade	Struc-ture	Bond
Surfacing Ends (Discs)	A	80	L	8	B S
Rolls, Aluminium Foil :					
FOR DARK REFLECTIVE FINISH :					
Roughing	A	80	K	5	V 18 N
Finishing	C	220	I	10	B S
Rolls (Brass Or Copper) :					
Cylindrical – Roughing	C	46	L	8	B S
Finishing	C	120	I	8	B S
Rolls (Granite) :					
New Rolls	C	36	I	8	B S
Regrinding	C	60	K	8	B S
Rolls (Cast Iron) :					
Cylindrical (Roughing)	C	36	L	6	B S
Cylindrical (Finishing)	C	80	J	6	B S
Rolls, Hot Mill (Chilled And Alloy) :					
Regrinding	C	36	K	8	B S
	C	36	M	8	B S
NEW ROLLS :					
Roughing	CA	24	K	8	B S
Finishing	C	36	K	8	B S
Rolls, Cold Mill (Hardened Steel) :					
REGRIND :					
First Stands	AA	36	I	8	B S
Other Stands	AA	80	H	8	B S
Rolls Paper Mill (Two–Wheel Grinders) :					
REGRINDING :					
Cast Iron, Granite, Rubber-covered					
Press Rolls	C	46	J	8	B S
Steel	PA	46	L	8	B S
For Coarser Finish Papers	C	46	J	8	B S
All-purpose Wheel for all rolls	C	46	H	8	B S
Rolls, Rubber :					
Soft Rubber (Dry Grind)	C	24	G	12	V 4

Work - Material - Operation	Abrasive	Grit Size	Grade	Struc-ture	Bond
Hard Rubber	C	36	J	8	B S
Rolls (High-Speed Tool Steel) :					
Roughing	A	120	I	8	V 18 N
Semi-Finishing	C	280	H	10	B S
Rolls, Scoring Bricks :					
Cold Mill Rolls	C	80	L	6	B S
Hot Mill Rolls	C	120	K	8	V 4
Rotors Laminated (Cylindrical) :					
Roughing	AA	120	I	8	V 18 N
Finishing	AA	240	H	10	B S
Rubber (Soft) :					
Cylindrical (Dry)	C	24	G	8	B S
Rubber (Hard) :					
Cutting off	C	36	K	8	B S
Cylindrical	C	30	K	8	B S
Rubber Hose :					
Cutting off (Dry)	C	24	R	6	B S
Cutting off (Dry) (Steel Mech)	A	36	S	6	B S
Sand Cores :					
Cutting off (Dry)	C	24	R	6	B S
Saws (Band And Circular) :					
Grinding	AA	46	M	5	V 18 N
Saws (Metal Cutting) :	A	60	O	5	V 9
	A	80	P	6	B S
Shear Blades (Power Metal Shears) :					
Sharpening (Segments)	AA	36	G	12	V 18
Sharpening (Cylinders)	AA	36	H	12	V 18 N
Springs Coil :					
Squaring Ends (Discs)	A	36	M	8	B S
Small Gauge Wire	DA	46	M	8	V 9
Medium Gauge Wire	DA	36	N	8	V 9
Large Gauge Wire	DA	24	P	8	V 9

Work - Material - Operation	Abrasive	Grit Size	Grade	Struc-ture	Bond
Springs (Leaf) :					
Grinding Eyes	A	24	M	8	B S
Chamfering	A	24	P	8	V 9
Steatite (Ceramic) :					
Centreless	C	60	K	7	V 4
Surfacing	C	46	J	7	V 4
Steel Castings (Law Carbon) :					
Swing Frames – 5000-6500 s.f.p.m.	A	20	R	5	V 9
Swing Frames – 7000-9500 s.f.p.m.	A	16	R	4	B S
Floor Stands – 5000-6500 s.f.p.m.	A	20	R	5	V 9
Floor Stands – 7000-9500 s.f.p.m.	A	16	Q	4	B S
Portable Grinders – 7300-9500 s.f.p.m.	A	20	R	4	B S
Steel Castings (Manganese) :					
Swing Frames – 5000-6500 s.f.p.m.	A	20	Q	5	V 9
Swing Frames – 7000-9500 s.f.p.m.	A	16	R	4	B S
Floor Stands – 5000-6500 s.f.p.m.	A	20	Q	5	V 9
Floor Stands – 7000-9500 s.f.p.m.	A	20	P	4	B S
Portable Grinders – 7000-9500 s.f.p.m.	A	20	R	4	B S
Surfacing-Planer type-5000-6500 s.f.p.m.	A	16/20	Q	5	V 9
Surfacing-Planer type-7000-9500 s.f.p.m.	A	16/20	Q	4	B S
Surfacing-Lathes & Boring Mills 5000-6500 s.f.p.m.	A	16	Q	5	V 9
Surfacing-Lathes & Boring Mills 7000-9500 s.f.p.m.	A	16	Q	4	B S
Internal-Rough Grinding-5000-6500 s.f.p.m.	A	16	Q	5	V 9
Internal-Rough Grinding-7000-9500 s.f.p.m.	A	24	R	4	B S
Steel (Hard) :					
Centreless (Com. Finish)	A	60	M	5	V 18 N
Centreless (Feed Wheel)	A	120	S	8	B S
Cylindrical (Smaller Wheel)	A	60	M	5	V 18 N
Cylindrical (Larger Wheels)	DA	60	L	5	V 18 N
Internal	PA	60	M	8	V 18 N
	PA	60	K	8	V 18 N
Surfacing (Straight Wheels)	AA	46	I	8	V 18 N
	AA	60	H	12	V 18 N

Work - Material - Operation	Abrasive	Grit Size	Grade	Struc-ture	Bond
Surfacing (Cups & Cylinders)	PA	46	H	8	V 18 N
Surfacing (Segments)	AA	46	I	8	V 18 N
Surfacing (Discs-Rough)	A	24	L	8	B S
Surfacing (Discs-Finish)	A	46	K	8	B S
Cutting off (Wet) 9000-12000 s.f.p.m.	A	60	O	6	B S
Cutting off (Dry) 9000-12000 s.f.p.m.	A	46	P	6	B S
Billet Grinding 5000-6500 s.f.p.m.	A	20	R	5	V 9
Billet Grinding 7000-9500 s.f.p.m.	A	14	T	3	B S
Steel (Stainless) :					
Centreless	A	46	L	5	V 18 N
Centreless (Com. Finish)	C	60	N	6	V 4
Centreless (Feed Wheel)	A	120	S	8	B S
Cylindrical	AA	46	L	5	V 18 N
Internal	AA	46	J	8	V 18 N
Surfacing (Straight Wheels)	AA	46	K	8	V 18 N
Surfacing (Cups and Cylinders)	AA	36	H	8	V 18 N
Steel Stainless - (Contd.) :					
Surfacing (Segments)	AA	36	H	8	V 18
Cutting off (Dry) 12000-16000 s.f.p.m.	A	36	R	6	B S
Steel (High Speed) :					
Centreless (Com. Finish)	A	60	M	5	V 18 N
Centreless (Fine Finish)	A	120	Q	6	B S
Centreless(Feed Wheel)	A	120	S	6	B S
Cylindrical (Smaller Wheels)	DA	60	M	5	V 18 N
Cylindrical (Larger Wheels)	DA	60	L	5	V 18 N
Internal	DA	60	L	8	V 18 N
	DA	60	M	8	V 18 N
Surfacing (Straight Wheels)	AA	46	H	8	V 18 N
Surfacing (Cups & Cylinders)	AA	60	G	8	V 18 N
Surfacing (Segments)	AA	46	H	8	V 18
Cutting off (Soft-Dry) 12000-16000 s.f.p.m.	A	36	T	8	B S
Cutting off (Soft-Wet) 9000-12000 s.f.p.m.	A	46	P	6	B S
Cutting off (Hard-Dry) 9000-12000 s.f.p.m.	A	46	P	6	B S

Work - Material - Operation	Abrasive	Grit Size	Grade	Struc-ture	Bond
Cutting off (Hard-Wet) 9000-12000 s.f.p.m.	A	60	O	6	B S
Cutting off (Wet) 9000-12000 s.f.p.m.	A	46	P	6	B S
Cutting off (Tubing-Dry) 12000-16000 s.f.p.m.	A	80	R	6	B S
Cutting off (Tubing-Wet) 9000-12000 s.f.p.m.	A	80	R	6	B S
BILLETS AND SLABS :					
Portable Grinders - 7000-9500 s.f.p.m.	A	16/20	R	4	B S
	A	20	T	4	B S
Steel (Stainless-Hardened) :					
Centreless (Com. Finish)	A	60	M	5	V 18 N
Centreless (Fine Finish)	A	120	Q	6	B S
Centreless(Feed Wheel)	A	120	S	8	B S
Cylindrical (Smaller Wheels)	DA	60	M	5	V 18 N
Cylindrical (Larger Wheels)	DA	60	L	5	V 18 N
Internal	PA	60	L	8	V 18 N
Surfacing (Straight Wheels)	AA	36	H	8	V 18 N
Surfacing (Cups & Cylinders)	AA	36	H	8	V 18 N
Surfacing (Segments)	AA	36	I	8	V 18 N
Cutting off (Dry)	A	46	R	6	B S
Cutting off (Wet) 9000-12000 s.f.p.m.	A	60	O	6	B S
HEMMING AND KLOTZ MACHINES :					
Cutlery-Small (Roughing)	AA	60	G	8	V 18 N
Strove Parts (Cast Iron) :					
SNAGGING	C	20	S	5	V I
SURFACING TAPS AUTOMATIC MACHINE :					
Roughing	C	36	Q	5	V I
Finishing	C	60	Q	6	V I
Surfacing (Discs)	C	24	J	8	B S
Taps :					
Fluting (Small Taps)	A	60	R	5	B S
(Large Taps)	AA	46	M	5	V 18 N
Grinding Relief	AA	80	M	8	V 18 N
Squaring Ends	A	60	O	5	V 18 N

Work - Material - Operation	Abrasive	Grit Size	Grade	Struc-ture	Bond
Tools (Lathe And Planer) :					
CARBON AND HIGH SPEED STEEL :					
OFFHAND GRINDING :					
BENCH AND PEDESTAL GRINDERS :					
Coarse	A	36	Q	5	V 9
Fine	A	60	P	5	V 9
WET TOOL GRINDERS :					
12" TO 24" diameter wheels	A	36	Q	5	V 9
Over 24" diameter wheels	A	24	R	5	V 9
MACHINE GRINDING : STRAIGHT WHEELS					
16" diameter wheels	A	36	M	5	V 18 N
24" diameter wheels	A	24	N	5	V 18 N
Cup or Cylinder Wheels	AA	24	L	5	V 18 N
Tubing Steel :					
Centreless	A	60	M	5	V 18 N
CUTTING OFF (DRY) 12000-16000 S.F.P.M.					
Steel (Finish Unimportan)	A	36	T	8	B S
Steel	A	36	T	8	B S
Stainless Steel	A	80	T	8	B S
Chrome-Molybdenum	A	60	S	6	B S
CUTTING OFF (WET) 9000-12000 S.F.P.M.					
Steel	A	80	T	8	B S
Stainless Steel	A	80	T	8	B S
Chrome-Molybdenum	A	80	T	8	B S
Tungsten :					
Centreless	C	60	K	7	V 4
Surfacing - 2000 s.f.p.m.	AA	46	J	8	V 4
6000 s.f.p.m.	C	46	I	8	B S
Valves (Automotive) :					
Refacing	C	80	N	6	V 4
	A	80	K	8	V 18 N
STEMS :					
Cylindrical	DA	60	M	5	V 18 N
Centreless	A	60	N	5	V 18 N
Cutting off (Dry)	A	36	S	6	B S

Work - Material - Operation	Abrasive	Grit Size	Grade	Struc-ture	Bond
Surfacing Ends (Discs)	AA	36	K	5	V 18 N
Valves Seat Inserts-Regrinding :					
Roughing : Cast Iron	C	60	M	6	V 4
Alloy Steel	AA	80	N	8	V 18 N
Stellite	AA	80	L	8	V 18 N
FINISHING :					
All Seats	C	120	K	8	V 4
Valve Tappets					
Centreless	A	60	O	5	V 18 N
Cylindrical	DA	60	M	5	V 18 N
Walboard (Hard)					
Cutting off (Dry)	C	36	T	8	B S
Welds :					
CARBON ALLOY STEELS :					
Portable Grinders 5000-6500 s.f.p.m.	A	24	R	5	V 9
Portable Grinders 7000-9500 s.f.p.m.	A	20	R	4	B S
STAINLESS STEEL :					
Portable Grinders 7000-9500 s.f.p.m.	A	20	R	4	B S
Wrenches :					
Floor Stands 5000-6500 s.f.p.m.	A	24	R	5	V 9
SURFACING-SIDES AND HEADS (DISCS) :					
Roughing	A	24	K	8	B S
Finishing	A	120	K	8	B S
Wrought Iron :					
Floor Stands 5000-6000 s.f.p.m.	A	24	R	5	V 9