GRINDING WHEELS

SELECTION

STORAGE

SAFETY

CARBORUNDUM UNIVERSAL LTD.
BONDED ABRASIVES DIVISION
P.B. NO. 2272, Tiruvottiyur, Chennai – 600 019
Ph. 2573 3322, 2573 3029, 2573 3513 Fax : 25733499

CONTENTS

CUMI

CUMI, a pioneer and leader in the manufacture of abrasives in India, is today globally reputed as a provider of total grinding solutions. Besides manufacturing one of the widest range of grinding wheels in the world, **CUMI** offers its customers, a complete package in grinding solutions. Called **GSE** or **Grinding System Engineering,** this includes world class coolants, natural diamond dressers, wheel balancing systems, the **Predict-A-Grind** software,designed to predict ideal grinding cycles and the revolutionary. **DATA PRIME,** to analyse grinding parameters and optimize grinding efficiencies. All this,of course,supported by **CUMI's** team of technical experts, offering customers their expertise in grinding, from problem mapping to problem resolution.

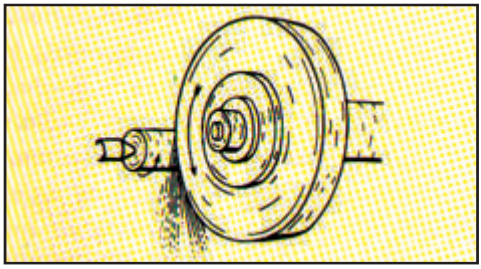
In its goal of being reckoned as a global leader in abrasives, **CUMI** has made a major transition from a manufacturer to a solution provider. Today, **CUMI** provides customers not just grinding wheels that are tailor made to the most exacting specifications,but ideal grinding cycles,that are technically proves,efficient and cost effective.

This handbook is offered to the customer a s a general guide on the selection of grinding wheels, the method for storing them and the safety measures to be followed in their usage. There is also a selection guide on **CUMI's** range of dressers and metal working fluids. A selection chart of **CUMI** wheels, vis-¨-vis the type of work and material used for grinding, is added for easy reference. Also included are conversion tables, together with a section on trouble shooting ti ps for some of the common problems encountered during grinding.

However,since grinding includes many operational variables,it is necessary to avail technical guidance for specific problems. For any further help on grinding wheel selection or application engineering support,kindly consult any of our local offices nearest to you,for technical guidance.

Grinding...

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 Offhand grinding and Precision grinding.



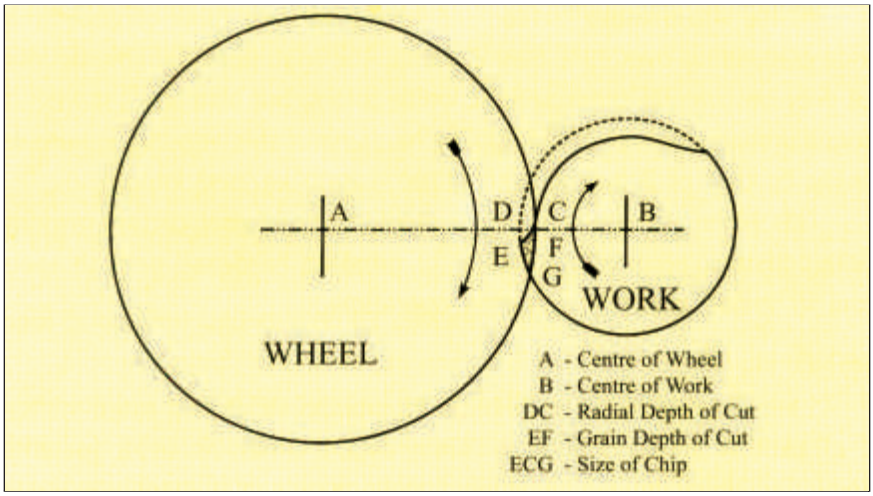
A Grinding wheel actually cuts away chips from the piece being ground

Offhand grinding or Non-precision grinding is where the grinding wheel is applied manually to the work or where the work is applied offhand to the grinding wheel. Offhand 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.

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 Aloxite (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 synthesizing 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 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 (Yellow 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^{0}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^{0} to 200^{0}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 (0) Bond :

Magnesium Oxychloride denoted by the letter ''0'' 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 are 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.

CUMI Abrasive types, properties and usage

Abrasives	Abrasive denotion (CUMI)	Properties	Major Applications
Brown Aluminium Oxide	''A''	Very tough abrasive	The most widely used CUMI 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.
Zirconia with Brown Aluminium Oxide	''AZA''	Free cutting, very tough and long life abrasive	Ideal for heavy stock removal operation. Used for descaling in stainless steel applications
Mixture of Brown and White Aluminium Oxide	''DA''	DA is a blend of 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 tract Grinding, Bore Grinding.
Pink Aluminium Oxide	''RA''	RA (Pink)-Chromic Oxide alloyed with brown Regular alumina gives a pink abrasive, 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 specialized precision applications. Good on Tool Steel, H.S.S. Applications, where protecting components from thermal damage is of critical importance.
Ceramic Aluminium Oxide	''MSB''	Prepared by a special seeded get process this abrasive has multi-fracturing property	Very cool cutting, with self sharpening cutting edges. Very durable, this abrasive is ideal for very high material removal. Used in centreless, micro-centric, surface, internal, cylindrical, tool & cutter and roll grinding applications.

CUMI Abrasive types, properties and usage

Abrasives	Abrasive denotion (CUMI)	Properties	Major Applications
Pink Aluminium Oxide	''RAA'	RAA (Pink)-Chromic Oxide alloyed with White aluminium gives a lovely pink abrasive. Free cutting properties, slightly tougher and less friable than white aloxite	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.
Semi-friable Aluminium Oxide	''SA'	As the name indicates friability and chemical composition is in between that of Brown and White Aluminium Oxide. The friability is controlled and retains the form even under tough grinding conditions	Applications where better form / size tolerance is very critical. Its principle use is in bore grinding, cylindrical and crankshaft grinding. The combination of friability and toughness resulting from this chemical composition gives wheels using SA abrasive the free cutting characteristics. This combined with good form holding and high degree of versatility makes it suitable for precision grinding applications.
Black Silicon Carbide	''C'	Very hard and more 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 Greed 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.

Elements of Abrasives

Grain or Grit Size :

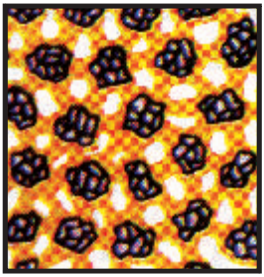
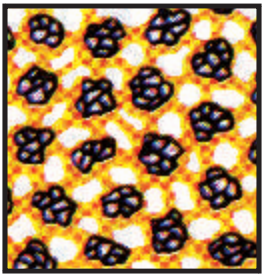
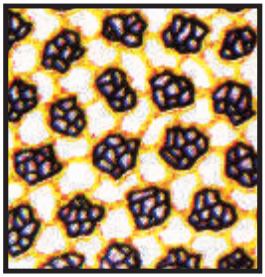
The size of the abrasive grain is expressed by the size of the screen opening through which the grains are shifted or sorted. For instance,a grain or grit which goes through a screen 8 mesh or openings per linear inch is called 8 grain or grit size,while a 24 grit size is roughly twenty fourth of an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

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 31.75 mm

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

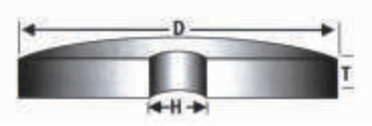
Customised Wheels :

1. Specify the dimensions in the order of Diameter X Thickness X Bore
2. Mention the type of the wheel required.
3. Indicate the recess size and depth for type 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 on pages 12 to 15 as well as **CUMI Wheel Marking System** on pages 16 & 17.

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

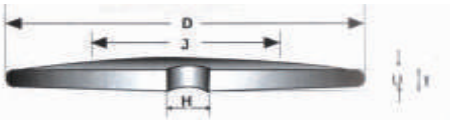
Wheel Type Nos. 1, 5 & 7 are standard for internal grinding, cylindrical grinding, tool grinding, offhand grinding and snagging. The recesses in Type Nos. 5 and 7 give clearance for the mounting flanges.

Type No. 1 cutting off wheel is used for cutting and slitting. These can be supplied as thin as 0.79 mm depending on the diameter and grit size of the wheel.

Tapered Wheels

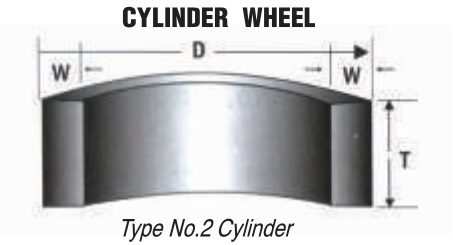
Wheel Type No. 4,is a modification on type No. 1 having a taper on both sides and is used principally in snagging operations. Tapered wheels with tapered mounting flanges are a safety device to prevent pieces of the wheel from flying out should the wheel break in operation.

TAPERED WHEEL



Cylinder Wheels

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



Type No.2 Cylinder

Type No.6 Straight Cup

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 offhand grinding when a flat surface on the work being ground is desired. Available in either plain or bevel face.

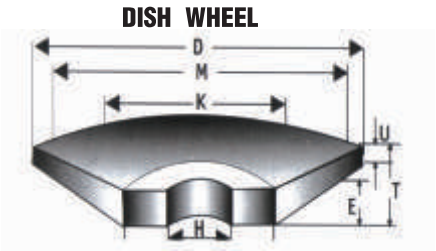
Flaring Cup Wheels

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 beveled face.

Type No.11 Flaring Cup

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

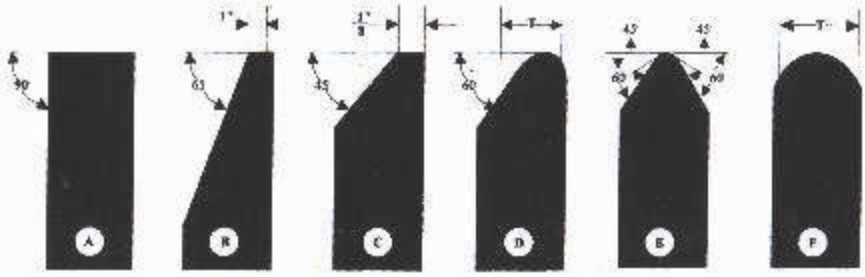
Saucer Wheels

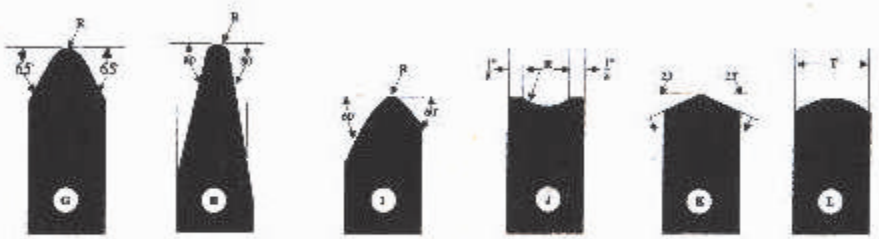
Wheel Type No. 13 is a saucer wheel or saw gummer. Its name is derived from its use for re-sharpening saws (saw gumming).

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

Standard Grinding Wheel Faces

For work requiring special contour wheels, straight wheel types can be furnished with any of the following standard wheel faces.





Nomenclature of CUMI Grinding Wheel

83A | **100** | **1** | **K** | **6** | **V308C** | **/60**

Grain

Abrasive material to grind the component. To be selected based on the material to be ground.

Aluminium Oxide - For Ferrous Materials		
Grain Type	**Marking**	**Properties & Application**
Brown Aluminium Oxide	A	Tough Grain - for High Tensile Strength Materials
White Aluminium Oxide	AA	Fast and Cool cutting Grain - for Hardened or High Speed Steels
Semifriable Aluminium Oxide	SA	Free Cutting Grain with good form holding - for complete range of Steels
Combination of A & AA	DA	To get the advantages of both A & AA Grains
Pink Aluminium Oxide	RA	Friable Grain - for Alloyed and Chromium Based Materials
Sintered Aluminium Oxide	MSB	Ceramic Grain - for High MRR & GR Requirements
Sharp Crystalline Abrasive	BDA	Sharp Ceramic Grain - For High MRR & GR Requirements
Zirconia Abrasive	ZA	Hard and Tough Grain - Primarily for very high MRR requirements
Silicon Carbide - For Non Ferrous Materials		
Black Silicon Carbide	C	For Roughing operations in coarse grit and Resinoid wheels
Green Silicon Carbide	GC	For Tungsten Carbide grinding and Finishing operations
Mixture of Black & Green Silicon Carbide	CGC	To get the advantages of both C & GC

Grain Combination

Combination of different grit sizes in predetermined percentages - For applications where high stock removal is required with fine finish

Grade Hardness

Measure of the bonding strength of the wheel i.e., % of bond in the wheel, is the hardness.

Hardness Range : C to Z
Softer ← → Harder

Grade Selection

Description	Soft Grade	Hard Grade
Material / Job Hardness	Hard Material	Soft Material
Area / Arc of Contact	High	Low
Severity of Operation	High	Low
Form Holding	Poor	Good
Wheel Speed	High	Low
Wheel Width	More	Less
Type of Coolant	Neat Oils	Water Soluble

Note : Hard Wheel indicates wheel with High Bond % and Vice Versa

Material Hardness

Wheel Grade	Soft	Medium	Hard
M			
L	■		
K		■	
J			■
I			
	50 Rc	50 - 57 Rc	58 - 63 Rc

Structure

Spacing of abrasive grains measured in terms of volume of abrasive particles

Structure Range 3 to 29
Open → ← Close

Description	Open Structure	Closed Structure
Material Removal Rate	High	Low
Grinding Ratio	Low	High
Area / Arc of Contact	High	Low
Severity of Operation	High	Low
Form Holding	Poor	Good
Wheel Speed	Low	High
Type of Operation	High Stock Removal, Creep Feed	Normal Stock Removal
Thermal conductivity of Work Material	Low	High

Wheel Speed : 33 to 100 M/Sec

Colour Coding on a grinding wheel

Wheel Speed	Colour Band
33 M/Sec	No Band
45 M/Sec	Blue Band
60 M/s Sec	Yellow Band
80 M/Sec	Red Band
100 M/Sec	Green Band

Grit Size

Measured by size of screen opening through which the grain passes
Grits Range - 12 to 1200 - Ex. 60 grit means there will be 60 openings per linear square inch of the screen

Coarser ← → Finer

Grit Size V/s Form Raidus Comparison

Work Radius (mm)	Grit Size	Abrasive Particle Dia (microns)
1	36	500
0.75	46	350
0.5	60	250
0.4	80	177
0.2	120	100
0.13	180	70
0.1	240	50
0.08	320	30
0.05	400	20

Grit Size Vs Surface Finish

CLA	Ra	60	80	120	180	240	320	400
24.0	0.6							
20.0	0.5	■	■					
16.0	0.4		■					
12.0	0.35		■	■				
10.0	0.25			■				
8.0	0.2			■	■			
6.3	0.16				■			
4.0	0.1				■	■		
3.2	0.08					■	OSC	
2.0	0.05							
1.2	0.03						OSC	OSC
0.8	0.02							OSC

Bond

Material which holds the Abrasive Grains together in a wheel

Vitrified Bond (V)	Resinoid Bond (B)	Rubber Bond (R)
Glassy Bond Made of ingredients available Naturally	Made of Phenolic Thermo Setting Resins	Made of Natural / Synthetic Rubber
Very Brittle	Very Resilient - Can withstand shock loads	Better Resiliency - Can withstand shock loads
Water, Chemical Resistance	Low Water, Chemical Resistance	Water, Chemical Resistance
Very good Form Retention	Poor Form Retention	Poor Form Retention
No Shelf Life	Has got Shelf life 1 -2 years	No Shelf Life
Severity of Operation - Medium	Severity of Operation - High	Severity of Operation - Low
For Wheel Speeds upto 100 M/Sec	For Wheel Speeds upto 80 M/Sec	For Wheel Speeds upto 40 M/Sec
Applicable for almost any kind of application	Gives cool cutting and is more suitable for application with high area of contact, High Material Removal Rate	For application where very fine surface finish is required with high feed rate

"Reading" a CUMI Grinding Wheel

VITRIFIED BONDS (V)	
Used with Aluminium Oxide	
V6	Fettling and Snagging
V7	Pin and Needle Grinding
V8, V10, V45, V60, V223, V2020, V500	Precision Grinding
V30	Off hand grinding
V204	Super Finishing
V206	Pink Tool & Cutter Grinding
V2016, V223, V2020, V500	Precision Grinding
V2018, V223, V2020, V500	Crankshaft/Precision Grinding
Vf8	Precision & Thread Grinding
VL, VCOOL	Surface Grinding - Cups, Cylinders, Segments
VMC	Creepfeed Grinding
VMPA	For Porous Wheels
VMTA, VFT, V457	Thread Grinding
V877, V736, VCA2	Gear Grinding

RESINOID BONDS (B)	
Used with Aluminium Oxide	
BR	Precision Grinding & Cutting-off
BM4, Bm6	Fettling, Snagging & Cutting-off
BFW	Reinforced cutting-off wheels
BM4, TD722, TDR186, BM50, TDR758, BA12	Snagging Wheels
TDR153E	Cutting Off
BRT, B14	Precision Grinding
TD924, TD1020	F type Disc Grinding
RBG BYZ	Razor Blade Grinding
Bs99	Hypodermic Needle Grinding
B266	Spring Grinding

VITRIFIED BONDS (V)	
Used with Silicon Carbide	
VG & VR	With GC grain used for Tungsten Carbide grinding
VG, VS2110, VK10	Precision, & Off hand grinding
VVR, VK3	Fettling and Snagging
V91	Super finishing
VMKRP	For Porous Wheels
VB	Ball Grinding

RESINOID BONDS (B)	
Used with Silicon Carbide	
BR & BFW	as above
TD924	F type Disc Grinding
BC4	Fettling, Snagging & Cutting off
B1551, TDR505	Fettling & Snagging
Td1235	Fettling & Snagging

RUBBER BOND- R	
Used with Aluminium Oxide	
R	Control Wheels
RT1, R188M	Centreless & Track

RESINOID BONDS (B)	
Used with Silicon Carbide	
RCS	Cutting off and slitting

RUBBER RESIN BOND- RB	
Used with Aluminium Oxide	
RB	Tap Flute, Drill Flute, Tap Chamfer & Lip Grinding

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 33 mps. However,on the other hand,special bonded vitrified wheels can take speeds up to 60 mps. 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 33 mps to 48 mps. Higher speeds for reinforced products can go up to 100 mps. 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
When 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 AZA 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 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.

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

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.

Technical Grinding Information

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 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 type 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

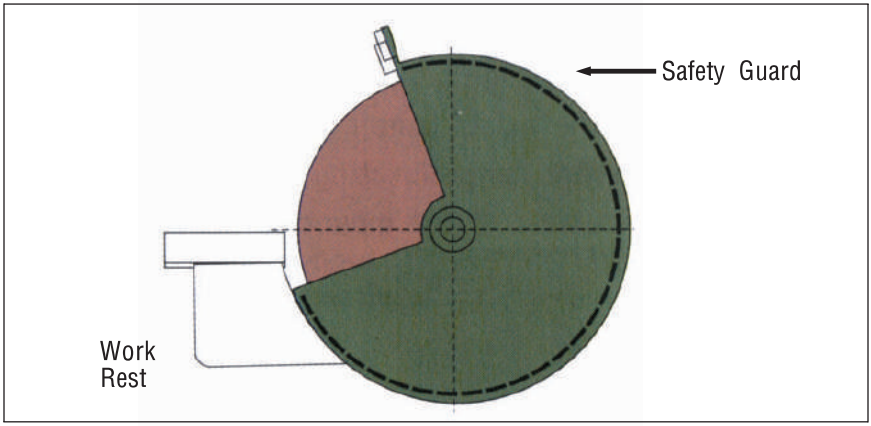
All grinding machines should be fitted with safety guards and guard bands, designed specifically for the type of wheel and grinding application. These safety guards should conform to standard specifications and cover the entire wheel, except the area of grinding. Certain operations however,require even 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 all 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. These 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 **CUMI** wheels are balanced within normal limits. However, for certain precision grinding operations where closer limits of wheel balance is 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, around 0.2 to 1.0 mm thickness and is 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 minimize the risk of sli ppage 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 upto 20 mm diameter.
- Type 27,depressed centre wheels.
- Type 29,semi-flexible wheels.
- Types 41 and 42,reinforced cutting off wheels,upto 230 mm diameter.
- Type 43,steel centred saws.
- Type 4,taper sided wheels.
- Type 6 and 11,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,upto 0.5 mm thickness.
- Dove-tailed recessed wheels.

Dressers

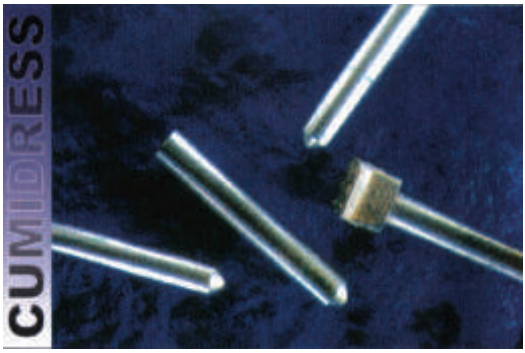
Dressers are used for Truing and Dressing a grinding wheel. Truing a wheel is done to obtain the required geometry or form on the grinding face of the wheel.

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.

The **CUMIDRESS** range of single and multi-point dressers from CUMI, are made from natural crystal diamonds, mounted by means of special bonds. Extremely sharp and highly durable, these dressers are specifically designed for different application needs.

Guidelines for dressing :

- The dresser should be held as rigidly and as close to the point of dressing as possible. For machines equipped with work piece supports, the dresser should be made to rest against the support. This is to ensure vibration free operation.



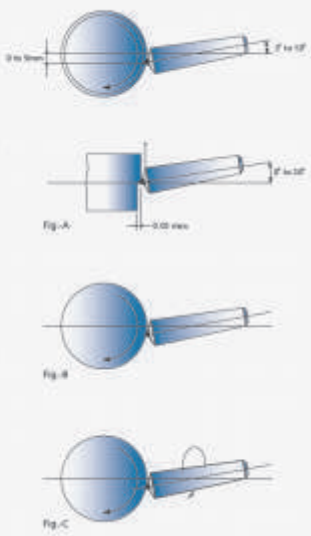
- The diamond point of the dresser should be presented at an angle between 3° to 10° relative to the centre line of the wheel.
- To maintain the sharpness of the diamond point, the dresser should be rotated in the machine tool holder at an angle of 15° to 45°. Rotating the dresser before starting the machine for the day enhances the life of the tool and 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.

CUMIDRESS Selection Chart

Recommended Application / Machine	Wheel Diameter	Recommended Dresser
Aloxide / Sic. Wheels for Internal, Tool & Cutter and Surface Grinding	Up to 100 mm and width up to 30 mm	Natural Point Dressers up to 0.35 carat or A Grade Dressers up to 1 carat
Aloxide / Sic. Wheels for Surface Grinding and Tool & Cutter Grinding	Up to 250mm and width up to 40mm	Natural Point Dressers of 0.5 and 1.0 carat or A Grade Dressers above 1.0 up to 2.0 carats
Aloxide / Sic. Wheels for Cylindrical and Centreless Grinding	Up to 400mm and width up to 75mm	Natural Point Dressers of 1 carat or A Grade Dressers 3.0 to 5.0 carats
Angle Grinding / Centreless Grinding Wheels	Above 300mm and width above 75mm	Blade Type Dressers as per machine feasibility or Multi-Point Dressers or Single Point A Grade Dressers above 4 carats

Directions for Use

- The diamond point of the dresser should be presented at an angle between 3° and 10° relative to the centerline of the wheel. It should have a trailing position as shown in Fig. A.
- In feeds: 0.01 to 0.03 mm stroke
  Feed rates: 0.03 to 0.20 mm resolution
  The larger the infeed and feed rates, the coarser the surface finish of the grinding wheel.
- When the dresser's diamond point becomes flat as in Fig. B, it should be rotated in the machine tool holder.
- To maintain diamond sharpness, the dresser should be rotated in the holder at 15° - 45° as shown in Fig. C. Rotating the dresser before starting the machine for the day would enhance the life of the tool as well as provide consistent performance.
- Dressing is to be carried out at normal speeds with copious amount of coolant.
- 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. CUMI has a wide range of world class Metal working fluids, blended to high quality specification and suited for different application needs.

Functions of a Coolant

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

1. 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 fluid can be further classified as Synthetic, Emulsion and Semi-Synthetic.

CUMI's coolants cover the entire range of Water based Cutting Fluids.

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.

CUMI's Synthetic type coolant is CIMTECH D14.

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.

CUMI's Emulsion range are CIMSTAR MB 602 C and CIMPERIAL 22 DB.

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.

CUMI's Semi synthetic range are CIMCOOL SI-R and CIMPERIAL C 60. Apart from the above three types, CUMI's range also includes Machine Cleaners, Corrosion Preventives and Speciality Products.

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 fluid is completely drained.

For a detailed list of troubleshooting tips on coolant usage check section on **Problem Solving.** Page Nos. : 51 to 55.

Product Selection Chart - Water Solubles

Range	Product	Severity of Operation	Water Hardness Range -	Grinding			Turning & Machining			Chemical Characteristics	
				Cast Iron	Steel	Aluminium & Alloys	Cast Iron	Steel	Aluminium & Alloys	Mineral Oil %	Boron
Synthetic	Cimtech 10	1	0-200	■■■	■■■■					0	N
	Cimtech 500 **	1	200-300		■■■■					0	N
	Cimtech 614	2	200-300	■■■	■■■■					0	P
	Cimtech 628	2	200-300	■■■	■■■■					0	P
	Cimtech 660	3	0-200	Carbide Grinding Only						0	P
	Cimtech 431	1	0-50	■	■■■	■■■■	■	■■■	■■■■	0	N
	Cimtech 85 971R	3	0-200	■■■■	■■■■	■	■■■	■■■	■	0	N
	Cimtech 650	2	0-200	Glass Shearing						0	
	Cumi Synth 6442	2	200-300	■■	■■					0	P
	Cumi Tech 550	2	200-300	■	■■■	■■■■	■	■■■	■■■■	0	N
	Cumi Tech 6462C	2	0-200	Carbide Grinding Only						0	N
Semi Synthetic	Cimstar 166	3	200 - 300	■■■■	■■■■	■	■■■	■■■	■	31%	P
	Cimstar 306	4	200 - 300	■■■■	■■■■	■	■■■	■■■	■	35%	P
	Cimstar 500	4	0-200	■■■■	■■■■	■	■■■	■■■	■	34%	P
	Cimstar VD6020	4	200 - 300	■■■■	■■■■	■	■■■	■■■	■	35%	P
	Cimstar SIR	3	0-200	■■■	■■■	■	■■■	■■■	■	14%	P
	Cumi Micro 9938	3	0-200	■■■	■■■	■	■■■	■■■	■	42%	P
	Cumi Micro 9942	3	0-200	■■■	■■■	■	■■■	■■■	■	34%	P
Emulsion	Cimperial 946010	3	200-300	■■■	■■■		■■■	■■■		16% + EP	P
	Cimperial 946060	4	200-300	■■■	■■■	■■■	■■■■	■■■■	■■■■	49%	P
	Cumi EMSOL 618105	3	0-100	■■	■■	■■■	■■	■■■	■■■	52%	P

CIMCOOL

Severity of Operation

1. Light
2. Light to Medium
3. Medium
4. Heavy
5. Extremely Heavy

■ Possible
■■ Adequate
■■■ Good
■■■■ Excellent

** - For Tape Honing Also
EP - Extreme Pressure Additive

Storage of Grinding Wheels

Grinding wheels must be handled with extreme care and tremendous importance should also be given to the method of storing them. A grinding wheel,if handled or stored badly,can cause serious problems when in operation.

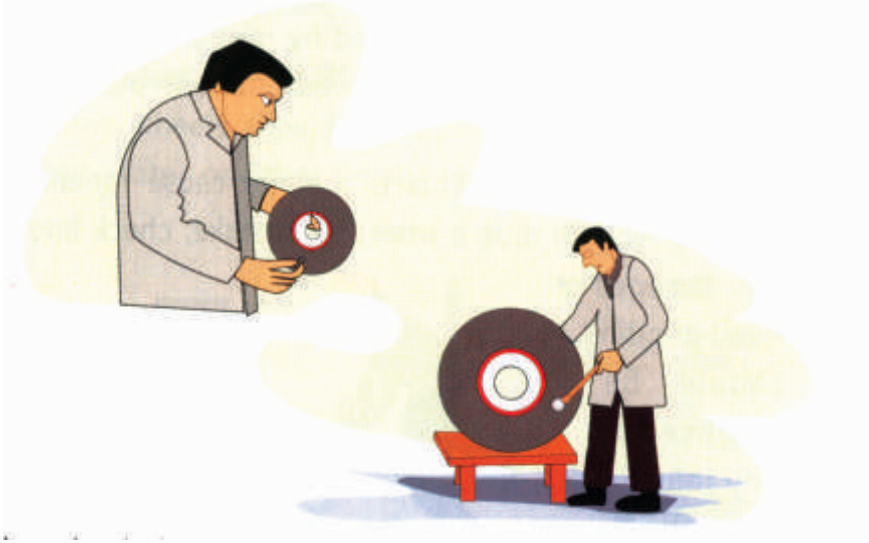
Given below are a few basic guidelines in handling and storing of grinding wheels :

On receipt of a wheel

When you receive a grinding wheel,first check to see if the wheel shows any sign of damage,such as chipping,cracking or discolouration. If the wheel has anyone of these problems,then it is definitely damaged. Just reject the wheel.

Ring Test

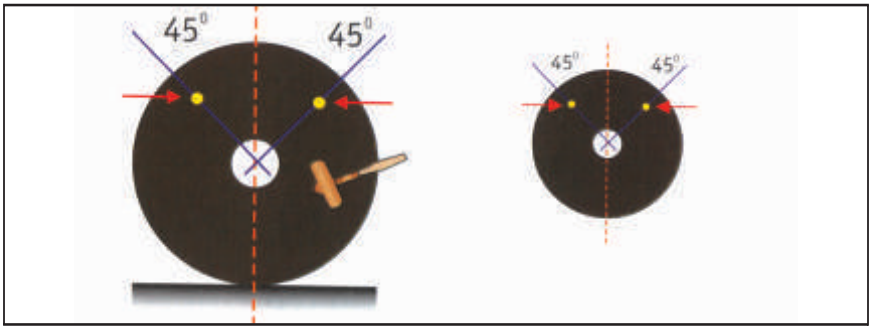
A ring test should always be conducted on receipt of a grinding wheel as well as before mounting it. This is mainly done to detect if there is any damage to the wheel. While conducting the ring test,small wheels should be held with the fore finger inside the bore while large wheels should be placed on a stand or support as shown in the figure.



The wheel should be tapped lightly with a non metallic implement like a screw driver handle in case of small wheels or a wooden mallet in the case of heavier wheels.

Ring Test :

While conducting the ring test, tap the wheel on either side at 45°of its vertical axis and at 1'' or 2'' from its periphery. Rotate the wheel again to 45°and repeat the test till the entire circumference of the wheel is covered. A good wheel will give a clear ring while a cracked or damaged wheel will produce a dull sound. The wheel giving a dull sound should not be used.



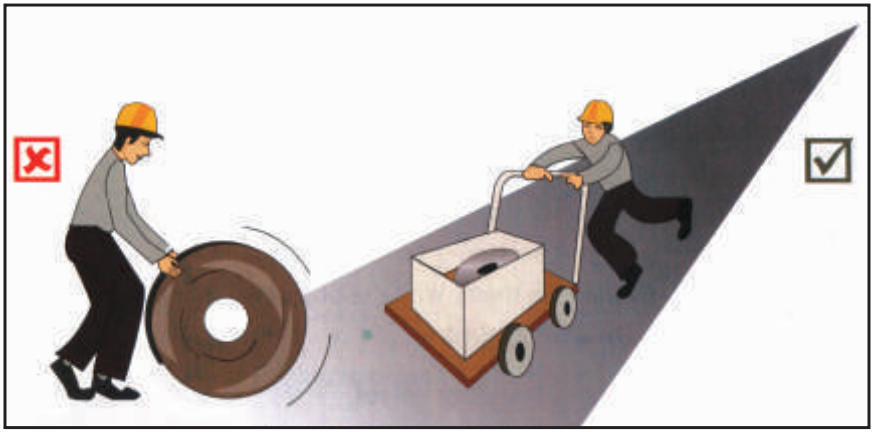
A ring test should be held in a place where the 'ring' can easily be heard. It should be conducted only by a person qualified or skilled enough to interpret the result.

Wheel handling

Grinding wheels can also be damaged by mishandling. This can be during transportation or when they are moved from one place to another within the workplace.

- Never drop a grinding wheel. This is a major cause for most wheel damages. In case,you do drop a wheel by mistake,check immediately to see if it is damaged or not. A cracked grinding wheel should be discarded since it can seriously injure the operator while in use.

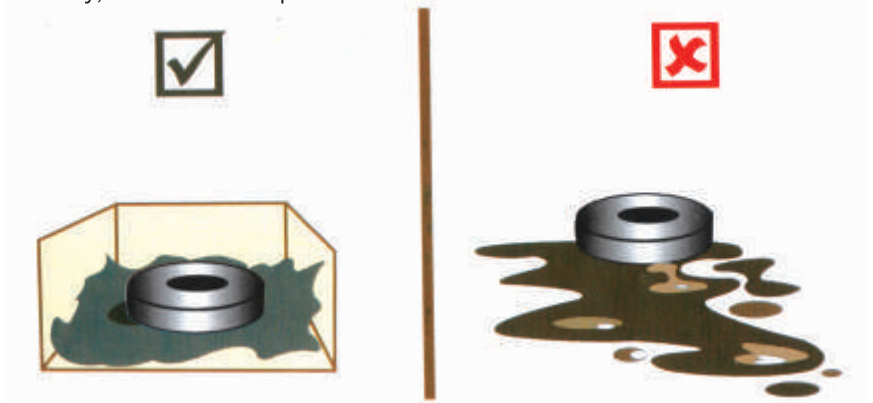
- Never pile other objects on top of stacked grinding wheels.
- Never roll a grinding wheel on the floor.
- Use trucks or suitable conveyors to move a grinding wheel from one place to another.



- Never bang a grinding wheel against any other object. This may chip or break the wheel. Also,any shock applied to a grinding wheel can cause a crack in the wheel which may not be visible to the naked eye. These kind of invisible cracks can result in a wheel breakage,due to centrifugal forces applied when the wheel is in motion.

Rules for Grinding Wheel Storage

Grinding wheels should be stored in a dry place and not exposed to humidity,water or other liquids.

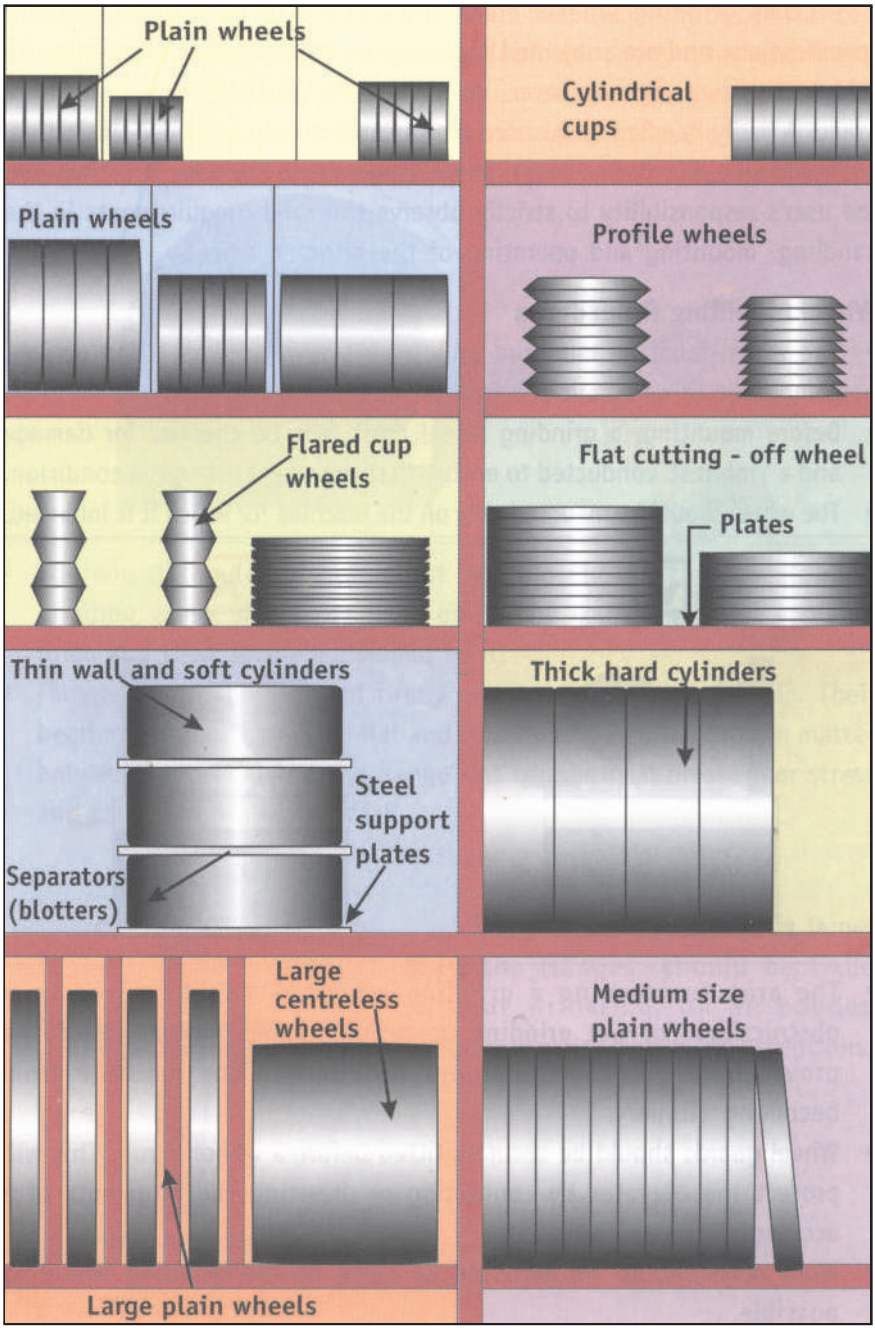


- Wheels should not be exposed to freezing temperature conditions.
- Subjecting wheels to any extreme fluctuations in temperature should also be avoided. For instance, avoid any sudden variance in temperature that can cause condensation on the wheels when moving them from storage to an area of high temperature conditions.
- The outer surface of certain rubber, resinoid, shellac or magnesite wheels may be affected by oxidation if the wheels are stored for a long period. These wheels should not be stored beyond two years. Careful monitoring of stock is also required to ensure that earlier stock wheels are used first. However,vitrified grinding wheels can be stored for any period of time.
- Grinding wheels should be stored in racks or bins in such a way so as to prevent any damage to them. While removing a wheel,the adjacent wheels should not be disturbed.

The method for storing a grinding wheel,varies according to the wheel type

- Flat cutting-off wheels should be placed without anything between them,on a flat surface of steel or a similar rigid material to prevent warpage.
- Thin wall, soft grade cylinder wheels (type 2), cup wheels (type 6), dish wheels (type 12) and saucer wheels (type 13) should be stored on flat sides with blotters or cushioning material between them.
- Thick rim,hard grade cylinder wheels,straight cup wheels and also medium sized plain wheels may be stored on their periphery.
- Soft grade straight cup wheels and taper cup wheels (type 11) are best stored base to base,one the opposite way to the other,to prevent chipping of the edges and cracking of the walls.
- Large,plain and centreless wheels (types 1,3 to 5,7,9,20 to 26,35 & 37) of considerable thickness have to be stood on their sides, in racks and chocked so that they do not move or roll.
- Small wheels,upto 80 mm,mounted wheels and points,inserted nut cones (type 16 to 19) may be stored in appropriate sized boxes,bins,or drawers.

Rack design suitable for storing a wide variety of grinding wheels

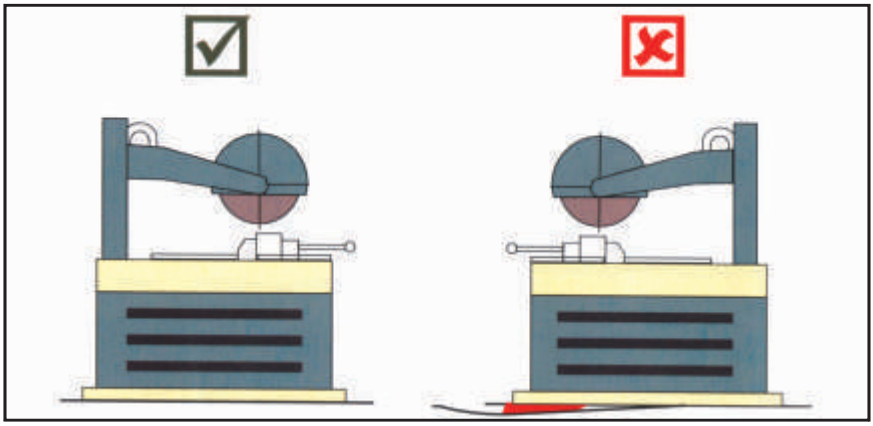


Safety measures in the usage of Grinding Wheels

CUMI grinding wheels are manufactured to very high standard specifications and are subjected to stringent quality tests before they are sold to the customer. However, much depends on their correct and safe usage. A badly handled or misused wheel can not only be under productive, but could also, in extreme cases, prove dangerous to the user. It is therefore the user's responsibility to strictly observe the safety requirements in the handling, mounting and operating of the grinding wheel.

Wheel Mounting Procedures

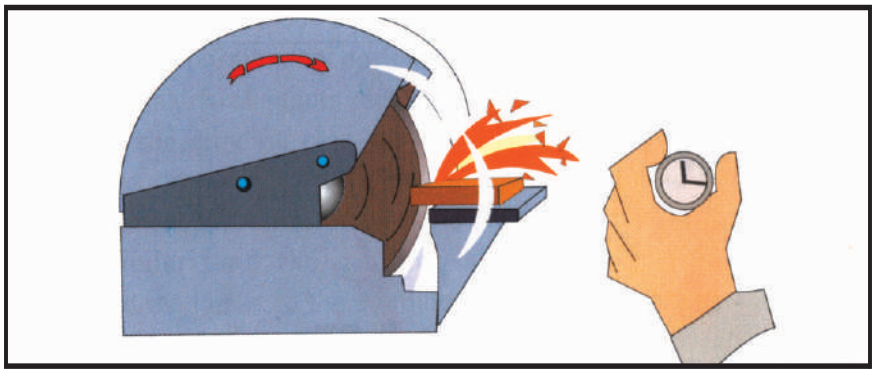
- The wheel must be mounted only by a trained and certified person, competent to carry out the job.
- Before mounting, a grinding wheel must first be checked for damage and a 'ring test' conducted to ensure that the wheel is in good condition.
- The wheel should be mounted only on the machine for which it is intended.



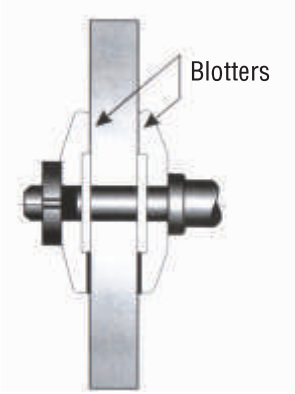
- The area surrounding a grinding machine should be free from obstruction. For wet grinding operations, splash guards should be provided to prevent the floors surrounding the machine from becoming slippery.
- Wheel guards should be securely fitted before a wheel is run. This will protect the operator by containing or diverting the fragments of a accidentally broken wheel.
- Work rests should be adjusted as close to the grinding wheel as possible.

Wheel Mounting Procedures

- The speed marked on the machine should not, under any circumstances, exceed the speed marked on the wheel, blotter or any other document. Operating wheels beyond the maximum permissible speeds or 'MOS' indicated,may cause them to break and lead to fatal accidents.



- The wheel should fit freely, but not loosely, on the spindle. The grinding wheel should be fixed on to the spindle without applying force and then securely clamped to it.
- Flanges should be clamped firmly and run true to the spindle. Their bearing surfaces should be flat and free from burrs. Any foreign matter between the wheel and the flange can trigger local pressure or stress and cause the wheel to break.

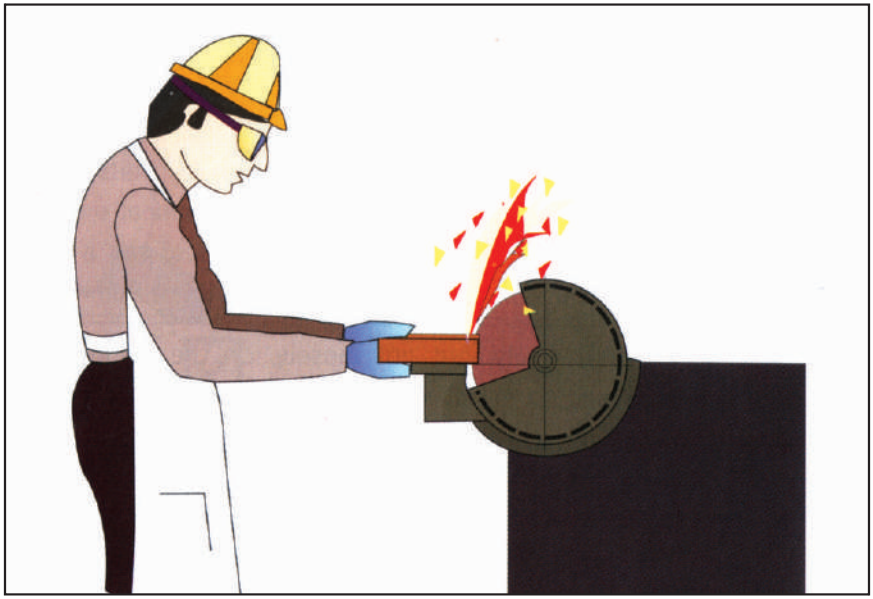


Blotters which are slightly larger than the flanges,should be fixed without wrinkling,on all bonded abrasive wheels, except for exceptions.

Wheel Mounting Procedures

The bush,if used,should not project beyond the wheel and the blotters.

After mounting,a wheel must be allowed to run freely,at its full operating speed,for atleast 1 minute. This test run is applicable both for new wheels as well as old wheels re-mounted for grinding.



Never grind material for which the wheel is not designed.

Do not grind on the side of the wheel unless the wheel is specifically designed for that purpose.

Since a grinding operation generates sparks and swarf,the operator should compulsorily wear safety goggles and face shields. Protective clothing like aprons,gloves and safety shoes should also be used to enable the operator to work safely and efficiently.

In certain types of grinding where the swarf or dust generation is very high,operators should be provided with dust masks.

Wheels should never be stopped by applying pressure or force to the periphery or face. Instead the wheel should be allowed to stop by itself.

'GSE' or Grinding System Engineering

Systems Approach to Grinding

Though grinding as an industrial process is known to have existed from a fairly long period,grinding as a technology is just beginning to mature. As such, in many user industries, achieving outputs is still based on trial and error methods of wheel selection and operating parameters. However it is possible to optimize grinding efficiencies based on a scientific analysis of inputs and outputs of both the grinding machine as well as the grinding process. And this is precisely what CUMI's GSE seeks to do. To take grinding from the realm of trial and error to that of an exact science. Precise,perfect and predictable.

To understand the grinding operations, it is important to understand the inputs to the grinding machine and inputs to the grinding process. The typical inputs to the grinding machines are feed rate, wheel and work speed, depth of dress and spark out time,work piece microstructure and stock. The true input to the grinding process is the normal force developed at the wheel-work interface, while the power,stock removal rate,surface finish are output variables from the process.

CUMI's Grinding System Engineering or GSE provides guidance on each of the above components and operational parameters.

Grinding Machine

In order to make full use of the developments in wheel technology and high speed grinding,the machine tool design should also adhere to very strict requirements. Machines should have a high degree of stiffness,in the range of 20 to 80 N/micron,should be vibration-free,and be able to accommodate very high wheel speeds. Machines should be equipped with automatic wheel changing systems and should have the ability, by measuring forces, vibration, temperature etc., to modify the process parameters. For example dressing frequency, removal rates,etc.,to optimize the grinding operation.

GSE includes a process monitoring mechanism,which is able to accurately asses machine condition and capability and also provide an arithmetic evaluation of the operational efficiencies that could be derived. It also guides the customer on how best to maximize existing efficiencies.

Grinding Wheels

CUMI has one of the widest range of both conventional as well as seeded gel abrasive wheels in the world. Customised to different design specification and application needs, these premium quality wheels are made from specially developed bond systems,guaranteeing superior performance,high form retention and very fine surface finish.

Grinding Fluids

Grinding fluids play a major role in many manufacturing processes and a choice of the correct one is vital if all process requirements are to be optimized. The three major types of metal cutting fluids are Neat Oils,Emulsifiable Oils and Water soluble synthetic fluids.

CUMI offers customers the CIMCOOL range of metal working fluids. Blended to high quality specifications and specially manufactured to suit diverse grinding applications, these metal working fluids have a proven record of increasing grinding efficiencies. The CIMCOOL range of metal working fluids are eco-friendly (free of Nitrites and other carcinogenic substances) and easily disposable. These metal working fluids, have long product life and provide superior rust and rancidity control besides offering a greater level of hard water stability. As part of GSE, CUMI has developed the system of fluid monitoring, guiding customers on effective use of grinding fluids to increase operational efficiencies.

Truing and Dressing

Since truing and dressing a wheel is very important to increase wheel life and its productivity,a good dressing tool is of very critical importance. Hitherto dressing tools were manufactured to standard carats and sizes with very little reference to the grinding applications. The CUMIDRESS range of single and multi-point dressers from CUMI, are made from natural crystal diamonds, mounted by means of special bonds. Extremely sharp and highly durable, CUMIDRESS dressers are specifically designed to suit different application needs. The natural diamond points of these dressers increase wheel life and maximize grinding efficiencies.

Wheel Balancing System

All CUMI wheels are balanced within normal limits. However,for certain precision grinding operations where closer limits of wheel balance is required,the machines should be equipped with wheel balancing systems. CUMI,in its goal of being a single window solution provider for all grinding problems,now offers customers the world's best automatic wheel balancer.

The SBS Dynamic Balance System from Schmitt,U.S.,has taken balancing to a new level of accuracy (.02 microns), speed (300 to 30,000 RPM) and convenience (balances wheels on the machine). The SB-4500 model balancer is elegantly simple with a computer control,sensor,spindle mounting adapter,and a balance head. It is designed as an inexpensive,permanent installation on grinding machines and eliminates the necessity to pre-balance grinding wheels.

This model balancer fits most machines,measures displacement or velocity and eliminates wheel vibration. It helps improve part quality, maximizes machine efficiency, and provides longer life for wheels, dressing diamonds and spindle bearings. Its multi-channel facility (as many as 4 balancers) minimizes cost of multi-machine balancing.

Process Monitoring and Process Prediction

A very important part of GSE is the highly futuristic DATA Prime and the Predict-A-Grind Software. This state-of-the-art equipment helps to analyse and predict ideal grinding cycles. It shows the customer the lacunae in his grinding process,the operational variables to be addressed and the optimum efficiencies that can be derived.

Designing Grinding Cycles

Technically proven at most user industries,GSE has re-defined grinding and made it a precise science. With this scientific mapping of the grinding process, the customer is able to reduce grinding cycles and improve operational efficiencies, which in turn reduce cost per component. Reduced man and machine time also entails a major cost saving for the customer.

With 'GSE' CUMI has made yet another major transition. From pioneer and leader in the manufacture of abrasives to a designer ideal grinding cycles.

Problem Solving

Causes & Correction of Common Grinding Errors

Chatter

Indication	Cause	Methods of Correction
Chatter	Wheels out of balance	Re-balance wheel on own mounting
		Re-balance wheel after truing Run wheel without coolant to remove excess water. After removing wheel from machine, store on side to prevent water from settling at lower edge of wheel
	Wheel out of round	True before and after balancing True side to face
	Wheel grading too hard	Select softer grade, more open bond or coarser grit. See "Wheel Grading"
	Work centres or work rests not true, or improperly lubricated	Check fit of centres and rests. Provide constant and even lubrication
	Dressing	Use Sharp diamond dresser rigidly held close to wheel

Spiral on Work

Indication	Cause	Methods of Correction
Spirals (traverse lines) same lead on work as rate of traverse	Mis-alignment	Check alignment of head and tail stocks, also wheel head to work
	Truing	Have truing tool set on work-wheel contact line, but pointed down 3. Round off edges of wheel face.

Wheel Grading Effect

Indication	Cause	Methods of Correction
Lack of cut; glazing; some loading; burning of work, chatter	Wheel too hard in effect	Increase work and traverse speeds and wheel pressure (infeed)
		Decrease spindle speed, wheel diameter and width of wheel face. Open up wheel by sharper dressing Use thinner coolant Avoid dwelling at end of traverse Avoid gummy coolants Use coarser grain size and softer grade.
Wheel marks, short wheel life, not holding cut; Tapered work	Wheel too soft in effect	Decrease work and traverse speeds and wheel pressure (infeed) Increase spindle speed, wheel diameter and width of wheel face. Dress with slow traverse and slight penetration Use heavier coolants Do not pass off work at end of traverse

Wheel Loading

Indication	Cause	Methods of Correction
Metal lodged on grains; or in wheel pores	Incorrect wheel	Use coarser grain size, or more open bond, to provide chip clearance. Use more coolant
	Faulty dressing	Use sharper dresser. Dress faster. Clean wheel after dressing
	Faulty coolant	Use more, cleaner and thinner coolant
	Faulty operation	Manipulate operation to soften effect of wheel. See "Wheel Grading Effect". Use more in-feed.

Wheel Glazing

Indication	Cause	Methods of Correction
Shiny appearance, smooth feel	Improper wheel	Use coarser grain size, softer grade. Manipulate operation to soften effect. See "Wheel Grading Effect"
	Improper dressing	Keep wheel sharp by using sharp dresser. Use faster dressing tool traverse. Allow more dressing tool penetration
	Faulty coolant	Use less oily coolant. Use more coolant.
	Gummy coolant	Use greater in-feed. See "Wheel Grading Effect"
	Faulty operations	Increase soda content if water is hard. Do not use soluble oils in hard water

Inaccuracies in Work

Indication	Cause	Methods of Correction
Work out-of-round, out-of-parallel, or tapered	Work centres or work rests not true, or improperly lubricated	Check fit of centres and rests. Provide constant and even lubrication. Provide adequate steady rests.
	Improper dressing	Make sure machine conditions are the same at dressing points as at point of grinding position
	Improper Operation	Do not permit wheel to pass off work at end of traverse, which causes taper at work ends. Decrease pressure, which springs work. Use harder wheel.
	Expansion of work	Reduce temperature of work by using more coolant and lighter cuts

'Checking' of Work

Indication	Cause	Methods of Correction
Work shows check marks	Improper wheel manipulation	Prevent wheel from acting too hard. Do not force wheel into work. See "Wheel Grading Effect". Use greater and even flow of coolant.

Burning of Work

Indication	Cause	Methods of Correction
Work shows discolouration	Improper wheel	Use softer wheel or manipulate to get softer effect. See "Wheel Grading Effect". Prevent glazing and loading. Use more coolant.
	Faulty operation	Bring wheel to work more gradually, use less in-feed. Prevent stoppage of work while in contact with wheel.

Scratching of Work

Indication	Cause	Methods of Correction
Narrow and deep regular marks	Wheel too Coarse	Use finer grain size
Wide irregular marks of varying depth	Wheel too soft	Use harder grading. See 'Wheel Grading Effect'
Widely spaced spots on work	Oil spots or glazed areas on wheel face.	Balance and true wheel. Avoid getting oil on wheel face
Fine spiral or thread on work	Faulty wheel dresser	Replace cracked on broken diamonds. Use slower dressing traverse. Set dressing tool at angles of 5^0 down and 30^0 side. Turn diamond every third dressing. Tighten holder or diamond. Dress with less penetration. Do not allow tool to dwell in contact with wheel. Do not start dressing cuts on face-locate tool on face, but start cuts from edge. Make final pass in dressing in opposite direction to grinding traverse. Traverse diamond evenly across wheel face. Round off wheel edges-just chamfering or dressing back is not enough.
	Faculty operation	Prevent penetration of advancing or following edge of wheel by being careful to dress wheel face parallel to work. Reduce wheel pressure. Provide addition steady-rests. Reduce traverse in relation to work rotation. Wheel making numerous passes, make slight change in traverse rate at each pass to break up pattern.

Scratching of Work

Indication	Cause	Methods of Correction
Wavy traverse line	Ragged wheel edges	Round off wheel edges.
Isolated deep marks	Improper wheel dressing	Use sharper dressing tools. Brush wheel after dressing using a stiff bristle brush.
	Coarse grains or foreign matter in wheel face	Dress out.
	Bond disintegrates; grain pulls out	Coolant too strong for some organic bonds; decrease soda content.
Irregular Marks	Loose dirt	Keep machine clean.
Irregular marks of varying length and width scratches usually fishtail	Dirty coolant	Clean tank frequently. Flush guards etc. after dressing and when changing to finer wheels.
Deep irregular marks	Loose wheel flanges	Tighten flanges, using blotters.
Grain marks	Wheel too coarse or too soft	Select finer grain size of harder grade wheel.
	Too much difference in grain size between roughing and finishing wheels	Use finer roughing wheel or finish out better with roughing wheel.
	Dressing too coarse	Less dresser penetration and slower dresser traverse.
	Improper cut from finishing wheel	Start with high work and traverse speeds, to cut away previous wheel marks; finish out with high work and slow traverse speeds; allowing wheel to spark out entirely.

Wheel Breakage

Indication	Cause	Methods of Correction
Radial break, three or more pieces	Excess wheel speeds	Reduce wheel speed to rated speed
	Improper mounting of wheel	Correct improper mounting such as lack of blotters, tight arbors, uneven flange pressure, dirt between flanges and wheel
	Over heating	Prevent overheating by using sufficient amount of coolant
	Excessive wheel pressure	Prevent excessive pressure on work
	Jamming of wheel	Do not allow wheel to become jammed on work
Radial break, two pieces	Excessive side strain	Prevent excessive strain on the side of the wheel
Irregular break	Wheel jamming	Do not allow wheel to become jammed on work
	Wheel damage	Prevent blows on wheel. Do not use wheels that have been damaged in handling. Examine wheel before using
General	Wheel arbor too tight	Check wheels for damage by ring test' or tapping. Do not use a wheel that is too tight on the arbor as wheel will break when started.
	Excessive wheel hammering	Prevent excessive hammering action of wheel

Coolants - Trouble Shooting Tips

Indication	Reason	Remedy
Excessive foam	High Concentration	• Check concentration and adjust to the recommended concentration
	Soft Water	• Use foam depressant after consultation with our Product Engg. Department
	Contamination	• Drain thoroughly and clean the reservoir. Then charge with a fresh coolant. • Add **ANTIFOAME** after consultation with our Product Engg. Department
	Turbulence due to wrong machine design	• Modify machine design to avoid sharp corners for coolant passage • Check to see if coolant drainline is free of all obstruction
Corrosion of the work piece or machine	Low Concentration	• Check concentration and adjust to the recommended concentration
	Hard Water	• Check concentration of rust inhibitor (A Kit)
	High Chloride or sulphate content in the water	• Analyse the water and change to another product that is more compatible with these conditions

Coolants - Trouble Shooting Tips

Indication	Reason	Remedy
Corrosion of the work piece or machine	High Bacteria Content	• Improve hygienic conditions, make a bacteria count and add biocide to bring the coolant to normal condition.
	Hot, humid conditions may accelerate corrosion problems	• Increase the concentration of mix. • Improve plant ventilation. • Apply CUMI's rust preventive.
Rancidity or Foul smell	Lack of ventilation	• Ensure coolant tank is kept open to air circulation atleast once in 2 to 3 days during long layoff or on holidays.
	Low Concentration	• Check concentration and adjust to the recommended concentration. Supplement it with additives. (Biocide)
	Contamination	• Drain thoroughly and clean the reservoir. Then charge with a fresh coolant. • Ensure metal swarf and tramp oil is removed periodically from the coolant.

Coolants - Trouble Shooting Tips

Indication	Reason	Remedy
Rancidity or Foul smell	High sulphate content	• Analyse the water and change to another product that is more compatible with these condition.
	High tramp oil content	• Ensure tramp oil is removed regularly and add biocides.
Unsatisfactory surface finish or Burn marks on the work piece	Wrong Concentration	• Check concentration and adjust to the recommended concentration.
	Insufficient flow of coolant	• Increase the volume and readjust the nozzle so that a maximum amount of fluid reaches the metal removal area.
	Wrong direction of coolant nozzle	• Adjust the nozzle so that coolant is directed to the right spot.
	Cutting fluid is full of chips or grinding swarf	• Check the dirt content (should not exceed 75 mg/litre) • Check if filtration system is working properly. • Drain thoroughly and clean the reservoir. Then charge with a fresh coolant.

Coolants - Trouble Shooting Tips

Indication	Reason	Remedy
Unsatisfactory surface finish or Burn marks on the work piece	Water may be too hard	• Analyse the water and change to another product that is more compatible with hard water. • Use treated water.
Skin Irritation	High Concentration	• Make a concentration analysis and adjust to the recommended concentration. Most frequently this is a human error or mechanical problem with the mixing devices.
	High Ph (>9.5)	• Could be due to alkaline cleaners and/or contamination. Only remedy is to flush out the contaminated coolant and use fresh coolant.
	Metal chips and grinding grit may cut the skin	• Repair defective filter media • Encourage use of water proof barrier creams or protective gloves.
	Operator's hand may be immersed	• Use material handling devices wherever

Coolants - Trouble Shooting Tips

Indication	Reason	Remedy
Eye, Nose or Throat Irritation	High concentration	• Make a concentration analysis and adjust to the recommended concentration. • Provide good ventilation/ exhaust system in the shop floor. • Most frequently this is a human error or mechanical problem with the mixing devices.
	Excessive splashing or misting of the cutting fluid	• Reposition the guards on the machine to contain the splash or mist. • Encourage use of safety glasses

Selection Chart of CUMI Wheels

Material and Type of Work	First Selection	Range of Grits and Grades	
		Grit	Grade
AGATE			
Surfacing (Roughing)	C601-VS 1/28	60-100	
Surfacing (Finishing)	C240-J5-VG	220-240	-K
Offhand	C80-N5-V8	60-100	M-O
ALUMINIUM ARMATURES & CORES	Please refer to us with full details of operation		
Cylindrical	A46J-L5-V10	46-60	K-L
Internal	DA60-L3-V10	60	K-L
AXES			
Surfacing	A30-R5-VE	24-30	R-S
Edging	A20 R5 VE	20 24	R S
AXLES			
Automobile (Cylindrical)	A46J-N5-V10		K-M
Automobile (Centreless)	A60-L5-V10C		
Carriage & Wagon (Cylindrical)	A46J-N5-V10		
BAKELITE			
Cutting-off	C30-N-BII	24-36	N-P
Cylindrical	C60-K5-VG	46-60	J-K
BEARINGS			
Centre less (Rings)	A60-K5-V1092		
Face (Rings)	AA60-K5-BRT		
Bore	SA80I-TDV144		
Track (Outer Rings)	SA120-L7VF8(S)		
Track (Inner Rings)	DA120-K7-V1092/60		
Super Finishing			
(Rough)	AA8001-G5-V204(S)		
(Finish)	C1000 G5 V01(S)		
	C1200-D5-V01(S)		
BILLETS (Alloy Steel)			
Portable	A163-R2-BM4		
Swing Frame	A143BSN-82"		
	A163-TD995		
Automatic Grinding	AZA 123-Y8-H780		
	AZA 163-Y8-BZ60		
BILLETS (SS)			
Swing Frame	A163TD-722		
BOLTS (Case Hardened Steel)			
Cylindrical	A46J-L5-V10		
Centreless	A60-05 V10C		
	A60-N5-V1092		
BRAKE DRUMS			
Internal (Cast Iron)	C36-I5-VG	36-46	H-I
Internal (Steel)	AA46 I5 V8	30 46	H I

Material and Type of Work	First Selection	Range of Grits and Grades	
		Grit	Grade
BRAKE LININGS			
Cutting-off	C24-Q-BC4	24-36	Q-R
Cylindrical	C60-K5-VG	46-80	J-L
Surfacing	C16-RS500		
BRAKE SHOES (Chilled Iron)			
Snagging	C20-R5-VVR	20-24	R-S
BRASS			
Fettling (Low Speed)	C30-Q5-VVR	24-30	Q-R
Fettling (High Speed)	C163-B 1550		
	C163-TD1235		
Cylindrical	C461-L5-VG	46-60	K-L
Centreless	C463-L5-VG	46-60	K-L
Internal	C46-I5-VG	36-46	I-J
Cutting-off	A30-S-BM4/RS	R-S	
Surfacing (Peripheral)	C36-I5-VG	36-46	I-J
BROACHES			
Backing off	RAA60-K6-V206		
(Type 11 and 12 Wheels)	AA60-K5-V8		
Face Grinding			
(Type 12 wheels)	A60-I5-V10		
BRONZE-Soft (See Brass)			
BRONZE-Hard			
Fettling (Low Speed)	C30-Q5-VVR	24-30	Q-R
Cylindrical	A463-K5-V10	46-60	K-L
Centreless	A60-N5-V10-C	60	L-N
Surfacing	AA24-J+5-V8	24-30	
(Cups and Cylinders)			
Surfacing (Peripheral)	A46/54-J5-V10		
Surfacing (Segments)	C24-I5-VG	24-36	I-J
Internal	A46-K5-V10	36-60	K-L
Cutting-off	A30-S-BM4/RS		R-S
	A30-T5-BFW		
BUSHINGS (Hardened Steel)			
Cylindrical	A463-K5-V10	46-60	K-L
Centreless	A60-L5-V10-C	60	K-L
Internal	DA60-L3-V10	60	K-L
BUSHINGS (Cast Iron)			
Cylindrical	C363-L5-VG	36-46	K-L
Centreless	C461-L5-VG	46-60	K-L
Internal	C36-I5-VG	36-46	I-J
CAMS (Rough Forgings)			
Roughing	A36-O5-V10		
Finishing	A543-J5-VI0		
Lobe Grinding (CNC m/c)	SA803-J5-V20 18/60		

Material and Type of Work	First Selection	Range of Grits and Grades	
		Grit	Grade
CAM ROLLERS (Hardened Steel)			
Cylindrical	A54-N5-V30		
Internal	DA60-L3-V10		
CAMSHAFT BEARINGS			
Cylindrical (Rough & Finish)	A463-L5-V10		
CARBON			
Centreless	C60-J7-VS2001		
	C36-I7-VS2001		
	C363-N5-VG		
Cylindrical	C461K5VG	3660	J-K
Cutting-off	C36-O-BR	36-60	N-P
CAST IRON			
Large Castings (Low Speed)	C24-S5-VVR	16-24	R-S
Large Castings (High Speed)	C163-TD1235		
Small Castings (Low Speed)	C24-S5-VVR	20-36	R-S
Small Castings (High Speed)	C163-TD 1235		
Portable Machines (Low Speed)	C24-S5-VVR	20-30	R-S
CAST IRON			
Cylindrical	C461-L5-VG	46-60	K-L
Centreless	C363-N5-VG	36-60	K-N
Internal	C46-J5-VG	36-46	I-J
Surfacing (Segments)	AA24-J5-VL	24-30	J-K
Surfacing (Peripheral)	C36-15-VG	36-46	I-J
Surfacing (Table Grinder)	C24-L5-VG	20-24	J-L
Surfacing (Cups & Cylinders)	C24-I5-VG	20-30	H-K
Cutting-off	A30-TD662		
	A30-TDRI53E(Hi-Life)		
	A30-T5-BFW		
CHASERS			
Thread Chasers :			
Type 1 Wheels	A46/54-J5-V10		
Type 6, 11 and 12 wheels	AA46/54-J5-V8		
Tap Chasers :			
Type 1 wheels	AA46/54-J5-V8		
Type 6, 11 and 12 wheels	RAA46/54-K6-V206		
	AA46/54-J5-V8		
Circular Thread Chasers :			
Type 1 wheels (under 5 dia)	A60-J5-V10		
Type 1 wheels (5 to 10 dia)	A60-K5-V10		
Type 6, 11 and 12 wheels	AA46/54-J5-V8 RAA46/54-K6-V206		

Material and Type of Work	First Selection	Range of Grits and Grades	
		Grit	Grade
CHILLED IRON			
Snagging	C24-S5-VVR	20-24	R-S
Cylindrical	C30-K5-VG	30-36	I-K
Surfacing (Cups & Cylinders)	C24-I5-VG	24-30	I-J
Surfacing (Peripheral)	C36-I5-VG	36-46	I-J
CHISELS (Wood Working)			
Sharpening	A60-N5-V30		
CHISELS (Engineers)	A36-Q5-V30	30-46	O-Q
CHROMIUM PLATING			
Cylindrical	AA80-L5-V8	60-80	K-L
CLUTCH PLATES (Cast Iron)			
Surfacing	C46-I5-VG	36-46	H-J
CLUTCH PLATES			
(Hardened Steel)			
Surfacing	AA46-H5-V8	36-46	H-J
COMMUTATORS			
Cylindrical (Roughing)	C60-N5-VG		
Cylindrical (Finishing)	C150-L5-VG		
Grooving (Steel Laminations)	AA46-54-J5-V8	46-54	J-K
Hand Application	COARSE		
	MEDIUM		
	FINE		
Brush Seater Stone	AA220-VS2109		
CONCRETE			
Surfacing (Bricks by hand)	C20-S-VVR	20-30	R-S
Surfacing (Bricks by machine-Rough)	C30-R-VVR	20-30	P-R
Surfacing (Bricks by machine-Finish)	C80-P-VG	80-120	P-R
CONNECTING RODS			
Internal	DA60-L3-V10	46-80	K-M
Surfacing (Cups & Cylinders)	AA30-J5-V8	24-30	I-K
Surfacing (Segments)	AA30-K5-VL	24-30	J-K
CONTROL WHEELS			
For Centreless Grinders	A80-R-R		
(all operations)			
COPPER			
Cylindrical	C461-L5-VG	36-60	J-L
Centerless	C363-L5-VG	36-46	J-L
Cutting-off	A30-R-BM4-RS		
COUPLERS AND DRAW BARS			
Snagging	A24-R5-V6	20-24	R-S
CRANKSHAFTS			
Motor-Roughing	A363-N5-V10	36-46	N-Q
Motor-Finishing	A463-N5-V10	46-60	N-P
Motor-Roughing and	A463-N5-V2018		
Finishing	A463-L5-V10	36-60	N-P
Motor-Re-grind	A463-L5-V2016	46-60	L-N
Snagging (Low Speed)	A24-Q5-V30	20-24	O-Q
Snagging (High Speed)	A145-R5-BM4		

Material and Type of Work	First Selection	Range of Grits and Grades	
		Grit	Grade
Aero	A463-L5-V10	46-60	K-M
Diesel	A463-L5-V10	36-60	K-M
Mechanite	C463-L5-VG		
Nitrided	A463-K5-V10		
SG-Iron/Nodular CI	DA603-K5-V2018		
CUTLERY (See Knives)			
CUTTERS			
Sharpening-Type1 wheels	A60-J5-V10		
Sharpening-Type 6	AA46/54-K5-V8	46-60	J-K
And 11 wheels	RAA46/54-K6-V206		
DIES			
Surfacing (Peripheral)	AA46/54-I5-V8	46-60	H-I
Surfacing (Segments)	AA36-H5-VL	30-36	H-I
DRILLS			
Point Grinding	AA100S12BHP		
	(Horizontal Spindle)		
	A803 R5 BRT		
	(Vertical Spindle)		
Sharpening (Offhand)	A60-N5-V30	46-60	N-O
Point Thinning	A60-N5-V30		
Fluting	DA120-R-RB		
	AA120-R19BHK		
Backing-off	A60-N5-V30	60-80	N-O
Cylindrical	A60-N5-V10	46-60	L-N
Centreless	A60-N5-V10-C	46-60	L-N
EBONITE			
Centreless	C363-N5-VG		
EDGE TOOLS			
Shovels (Edging)	A24-R5-V6	20-30	R-S
Picks	A24-R5-V6	20-30	R-S
FIBRE RODS			
Centreless (Roughing)	C461-L5-VG		
Centreless (Finishing)	GC80-J+5-VG		
FILES			
Hand Surfacing	A36-Q5-V30		
	A36-T5-V7		
Setting and Shaping	A24-R5-V6		
Stripping	A60-Q5-V30		
Edging	A30-R5-V6		
Centreless	A60-P5-V30		
FIRE BRICKS			
Surfacing	C30-I5-VG	24-30	I-K
Cutting-off	C243-S-BC4/RS	P-S	
FLAT IRONS			
Surfacing (Cups, Cylinders and Segments)	C30-I5 VG	24-30	I-J
Surfacing (Off-hand)	AA30-J5-VL	24-30	I-J
Snagging (Low Speed)	C24-N5-VG	24-30	M
	C30-S5-VVR	24-30	R-S

Material and Type of Work	First Selection	Range of Grits and Grades	
		Grit	Grade
FORGINGS			
Fettling Large (Low Speed	A24-R5-V6	16-24	Q-R
Fettling Large (High Speed)	A163-R2-BM4		
	A163-TD995 (High G.R)	20-36	Q-R
	A163-TDR186 (High G.R)		
Fettling-Small (High	A163-R2-BM4		
Speed)			
GAUGES			
Plug-Cylindrical	A60-K5-V10		
GEARS			
Cast Iron-Teeth Cleaning	C36-Q5-VG		
Steel-Teeth Cleaning	A36-Q5-V30		
Steel-Form Precision :			
Maag	AA60-L5-V8	46-60	J-L
Les Bradner	AA46/54-I5-V8	46-60	I-J
Pratt and Whitney	AA60-K5-V8	46-60	J-L
Orcutt	AA46/54-K5-V8	46-60	K-L
Reishauer	RA100-K7 VU869G		
Steel Internal	A60-L5-V10	46-60	K-M
Surfacing (Cups & Cylinders)	AA30-J5-VL	24-30	I-J
Surfacing (Peripheral)	AA46/54-H5-V8	46-60	H-I
GLASS			
Plate-Edging (Peripheral)	GC80-K5-VG	80	J-L
Plate-Table Tops			
Windscreens			
Mirrors, etc.			
Rough Bevelling-			
Vertical Spindle	GC80-J5-VG		
GUDGEON PINS			
Centreless	A60-L5-V10-C	46-60	K-L
HAMMER HEADS			
Fettling	A24-R5-V6	20-30	Q-R
HOBS			
Sharpening, Type 1 Wheels	A60-J5-V10		
(under 5 dia.)			
Sharpening, Type 1 wheels (5 to 10 dia.)	AA60-J5-V8		
Sharpening, Type 12 wheels	RAA60-K6-V206		
HOUSINGS (Auto Axle)			
Cylindrical	A463-L5-V10		
Snagging	A24-R5-V6	20-24	R-S
Surfacing (Segments)	AA24-J+5-VL	24	J-J+
Surfacing (Cylinders)	AA24-J5-VL	24	J-J+

Material and Type of Work	First Selection	Range of Grits and Grades	
		Grit	Grade
KNIVES (Band)			
Sharpening	AA60-K5-V8		
KNIVES (Leather Shaving)			
Sharpening (Low Speed machines)	A60-Q5-V30	60-100	O-Q
Sharpening (High Speed machines)	A60-L5-BR		
KNIVES (Leather Skiving)			
Sharpening	A80-Q5-V30		
KNIVES (Leather Splitting)			
Sharpening	A24-N5-V30		
KNIVES (Moulding)			
Offhand Sharpening	A60-N5-V30		
KNIVES (Tobacco)			
Sharpening-Cylinder	A36-I5-BR	36-46	I-J
Wheels			
KNIVES (Veneer)			
Sharpening	A36-J5-BR		
	A36-I5-V10		
LATHE CENTRES	A461-L5-V10		
LEATHER	C36-J5-VG		
LINKS, MOTION			
Loco Links-Machine Grinding	A463-L5-V10	46-60	L-N
LINKS (Chain-Malleable Iron & Steel)			
Snagging (Low Speed)	A30-S5-V6	24-30	S-T
LINKS (Chain-Unannealed Malleable Iron)			
Snagging	A24-T5-V6	24-30	S-T
LINKS (Chain-Manganese)			
Snagging	A24-S5-V6	24-30	S-T
MACHINE SHOP GRINDING			
General Offhand	A36-Q5-V30	36-46	
MALLEABLE IRON-Annealed			
Large Castings (Low Speed)	A24-R5-V6	16-24	Q-R
Large Castings (High Speed)	A143-R5-BM4		

Material and Type of Work	First Selection	Range of Grits and Grades	
		Grit	Grade
MALLEABLE IRON-Annealed			
Small Castings (Low Speed)	A24-S5-V6	20-30	R-S
Small Castings (High Speed)	A163-R2-BM4		
Portable Machines	A163-R2-BM4		
MALLEABLE IRON-Unannealed			
Large Castings (Low Speed)	C24-S5-V VR	16-20	R-S
Large Castings (High Speed)	C163-TD1235		
Small Castings (Low Speed)	C24-S5-V VR	20-30	R-S
Portable Machines	C163-TD1235		
MONEL METAL			
Fettling	C30-Q5-VG	24-30	P-Q
	A30-Q5-V30	24-30	P-Q
Cylindrical	A463-L5-V10	46-60	K-L
Surfacing	A463-I5-V10	46-60	I-J
Cutting-off	A30-R-BM4/RS		
NEEDLES			
Pointing-			
Gramophone	C46-R5-VG		
Sewing Machine	A60-Q5-V30	46-60	
Textile	A46-T5-V7		
NIMONIC			
Centreless	A463-L5-V10		
Cylindrical	AA46/54-J5-V8		
Fettling (High Speed)	A163-R2-BM4		
Internal	DA60-L3-V10		
Surfacing (Peripheral)	AA46/54-J5-V8		
NITRALLOY STEEL			
(After Nitriding)			
Cylindrical	AA46/54-J5-V8	36-60	I-K
Cylindrical (Fine Finish)	AA100-J5-VF8P		
Surfacing (Peripheral)	AA46/54-H5-V8	36-60	H-I
Surfacing (Cups & Cylinders)	AA24-H5-VL	24-36	H-I
Internal	AA46-I5-V8	36-60	H-J
PISTON			
Cast Iron			
Cylindrical	C363-L5-VG	36-46	J-L
Centreless	C461-J5-VG	46-60	J-L
PISTON RINGS			
(Cast Iron or Semi-Steel)			
Face	C46-TD 924		
PISTON RODS (Locomotive)			
Cylindrical	A463-L5-V10	46-60	K-L

Material and Type of Work	First Selection	Range of Grits and Grades	
		Grit	Grade
PLASTICS			
Cutting-off	C30-N-BR		
PLOUGHS-Steel			
Surfacing	A20-R5-V6	20-24	R-S
Editing & Jointing	A20-R5-V6	20-24	R-S
Fitting	A24-Q5-V30	24-30	
Re-Sharpening Points	A24-Q5-V30	24-30	
PLOUGHS-Chilled Iron			
Surfacing	C30-R5-VVR	20-30	R-S
Editing & Jointing	C20-R5-VVR	20-24	R-S
Fitting	C20-R5-VVR	20-24	R-S
POINTS & CROSSINGS			
(Manganese Steel)			
Hole Grinding	C24-L5-VG		
Offhand Grooving			
Portable machines	A24-R5-V6		
(Low Speed)			
Offhand Grooving			
Portable machines	A163-R2-BM4		
(High Speed)			
POINTS & CROSSINGS (Manganese Steel)			
Semi-Precision	A20-R5-V6		
(Grooving Planer Type Machines)			
Snagging- (Low Speed)	A20-S5-V6		
Snagging- (High Speed)	A163-R2-BM4		
Surfacing	A20-P5-V30		
PORCELAIN			
Cylindrical	C36-L5-VG	36-60	J-L
	C36-L5-VS2110 (High G.R)		
Removing Imperfections	C60-Q5-VG		
	AA80-N5-V8	80-100	N-P
Surfacing (Cylinder wheels)	C20-I5-VG		
PULLEYS (Cast Iron)			
Cylindrical	C363-J5-VG	36-46	J-K
RAILS			
Surfacing-Welds	A24-R5-V6	20-30	R-S
(Low Speed)			
Surfacing-Welds	A163-R2-BM4		
(High Speed)			
Cutting-Off	A30-TD1069EM		
RAZORS			
Blades (Roughing)	C240 PRBG	240-320	
(Semi Finishing)	C400 K5 BYZ	400-600	K-P
(Finishing)	A1000 K5 BYZ	800-1000	K-Q
	A800 Q5 BYZ		

Material and Type of Work	First Selection	Range of Grits and Grades	
		Grit	Grade
REAMERS			
Backing Off	AA46/54-J5-V8	40-60	J-M
Cylindrical	AA46/54-K5-V8	46-60	K-L
Fluting	AA60-K5-V8	46-60	K-L
Blade Surfacing	AA46/54-H5-V8	46-60	H-J
RIMS			
Automobile and Cycles			
Removing Welds	A24-R5-V6	20-36	R-S
	A46-Q5-BN	-	Q-S
ROLLER BEARING CUPS			
Centreless			
(Small Diameters)	A60-J5-V10-C	60	I-J+
(Medium Diameters)	A60-I5-V10-C	60	I-J
(Large Diameters)	A60-H5-V10-C	60	H-I
Internal	DA60-L3-V10	60	K-L
ROLLERS FOR BEARINGS			
Centreless	A80-LRTI		
ROLLS (Steel Mills)			
Hot Mill Work Rolls	GC36-TDR024		
Hot Mill Backup Rolls	A36-I5 BRT		
Cold Mill Work Rolls	A60-I5 V10 (Matt Finish)		
	DA60-I5 V10 (Matt Finish)		
	A80-J5 BRT		
Cold Mill Backup Rolls	A36-I5 BRT		
ROLLS			
(Re-grinding and job work)			
Work Roll (Steel)	A60-I5-V10		
	DA60-I5-V10		
Work Roll (Cast Iron)	C363-I5-VG		
ROLLS			
(Aluminium Foil Mill)			
Work Roll (Rough)	A80-J5-BRT		
(Semi Finish)	A150-J5-BRT		
(Semi Finish)	C320-J5-BRT		
(Finishing)	FC320-J5-BRT		
ROLLS			
(Aluminium Sheet)			
Work Roll	AA60-H5-V8		
	DA60-I5-V10		
Back-up Roll	A36-I5-BRT		
ROLLS (Paper Mills)			
Chiled Iron	C30-G14-VMKRP		
	C242-VS1887		

Material and Type of Work	First Selection	Range of Grits and Grades	
		Grit	Grade
ROLLS II			
Printing Machine Rolls	AA60-K8/VMPA		
Rubber Rolls	C36-L5 BRT		
SAWS			
Band (Fine Teeth)	A80-Q5-V30	60-100	O-Q
Band (Long Saws)	A60-Q5-V30	60-100	O-Q
(Wood)	A60-N5-V30	60-100	N-Q
Metal Cutting	A80-Q5-V30	60-80	O-Q
(Band Gumming)			
Metal Cutting	AA46/54-K5-V8	46-60	J-L
(Circular inserted Tooth)			
Circular Saw	AA46/S4-J5-V8		
Surface Grinding-Rotary	AA54-H5-V8		
Table (Wheels over 12 dia.)			
SCISSORS AND SHEARS			
Blades-Surfacing (Cylinders)	C46-Q5-VG		
Blades-Surfacing (Offhand)	A60-N5-V30		
Re-sharpening	A80-N5-V30		
Grinding Flash from Bows	A46-Q5-V30		
Pointing & Shaping	A60-Q5-V30		
Grinding Neck or Corner	A100-Q5-V30		
Striking Cutting Edges	A100-N5-V30		
SHOVELS			
Edging	A24-R5-V6	20-30	R-S
SLATE			
Grooving	C46-L5-VG		
Surfacing	C46-J5-VG		
SLIDE BARS			
Surfacing (Cups & Cylinders)	AA24-J+5-V8	24-30	
Surfacing (Peripheral)	A36-L5-V10	30-36	K-M
SPANNERS			
Trimming	A24-R5-V6	24-30	R-S
Jaws	A36-Q5-V30	30-36	O-Q
SPLINE SHAFTS			
Cylindrical	A60-N5-V10	46-60	M-N
Centreless	A60-L5-V10C	46-60	L-N
SURFACE SPLINES			
Orcutt Machine	AA60-L5-V8		
Churchill Machine	AA60-J5-V8		
SPRINGS-LEAF			
Grinding Eyes	A24-R5-V6	24-30	Q-R
SPRINGS-COIL			
Squaring Ends-Large	A24-TD1035B		
Squaring Ends-Small	A24-TD1035B		

Material and Type of Work	First Selection	Range of Grits and Grades	
		Grit	Grade
STEATITE TUBES			
Cutting-off	C60-O-BR		
STEEL-CASTINGS			
(Low Carbon)			
Snagging-Swing frame	A24-R5-V6	16-24	R-S
(Low Speed)			
Snagging-Swing frame	A163-R2-BM4		
(High Speed)			
Snagging-Floor stand	A24-R5-V6	16-24	R-S
(Low Speed)			
Snagging-Floor stand	A163-R2-BM4		
(Higli Speed)			
Snagging-Bench Stand	A24-R5-V6	20-30	R-S
(Low Speed)			
Fettling-Portable machines	A24-R5-V6	20-30	R-S
(Low Speed)			
Fettling-Portable machines	A163-R2-BM4		
(High Speed)			
STEEL MANGANESE	(See also Points and Crossings)		
Snagging-Swing frame	A20-S5-V6	16-24	Q-S
(Low Speed)			
Snagging-Swing frame	A163-R2-BM4		
(High Speed)			
Snagging-Floor stand	A20-S5-V6	16-24	Q-S
(Low speed)			
Snagging-Floor Stand	A163-R2-BM4		
(High Speed)			
Snagging-Portable machines	A24-R5-V6	20-24	Q-S
(Low Speed)			
Snagging-Portable machines	A163-R2-BM4		
(High Speed)			
Carbon Steel Billets	(See Billets)		
STEEL SOFT			
Cylindrical	A463-L5-V10	36-60	L-N
Centreless	A60-N5-V10-C	46-80	L-N
Surfacing (Peripheral)	A46/54-J5-V10	46-60	J-K
Cups & Cylinders	AA24-J+5-V8	20-36	
Surfacing (Segments)	AA24-J5-VL	24-30	J-K
Internal	DA60-N3-V10	60	L-N
Cutting-off	A30-TD662		

Material and Type of Work	First Selection	Range of Grits and Grades	
		Grit	Grade
STEEL (Hardened)			
Cylindrical	A463-K5-V10	46-60	K-L
Centreless	A60-L5-V0-C	46-80	J-L
Surfacing (Peripheral)	AA46/54-I5-V8	46-60	I-J
Surfacing (Peripheral-thin sections)	AA46/54-H5-V8	46-60	H-I
Surfacing (Cups & Cylinders)	AA30-J+5-V8	24-36	
Surfacing (Segments)	AA30-J5-VL	24-30	H-J
Internal	DA60-L3-V10	60	K-L
	RA60-L5-VF8		
Cutting-off	A30-Q-BM4/RS		
	A30-T5-BFW		
STEEL - High Speed			
Billets	(See Billets)		
Cylindrical	A463-J5-V10	46-60	J-K
Centreless	A60-K5-V10.C	46-60	J-L
(Peripheral)	AA46/54-H5-V8	46-60	H-I
(Cups & Cylinders)	AA30-J+5-VL	24-30	
Surfacing (Segments)	AA30-H5-VL	24-30	H-J
Internal	AA60-K3-V8		
	RA60-L5-VF8	46-80	I-K
Cutting-off	A30 T5 BFW		
	A30-Q-BM4/RS		
STEEL-Stainless			
Billets	(See Billets)		
Cylindrical	C363-N5-VG	36-60	L-N
	C363-N5-VS2110 (High G.R)		
Centreless	C363-L5-VG	36-60	K-N
	C463-L5-VS2110 (High G.R)		
Surfacing (Cups & Cylinders)	AA30-H5-V8	30-36	H-I
Surfacing (Peripheral)	C46-J5-VG	36-60	H-I
	AA46-J5-V8	36-60	I-J
Surfacing (Segments)	AA30-H5-VL	24-30	H-I
Cutting-off	A30-Q-BM4/RS		
	A30-T5-BFW		
Internal	C60-L5-VG	46-60	K-L
STELLITE			
Cylindrical	A463-L5-V10	46-60	J-L
Centreless	A60-L5-V10-C	46-60	K-M
Surfacing (Cups & Cylinders)	AA36-J5-VL	30-36	J-K
Surfacing (Peripheral)	AA46-J5-V8	46-60	J-K
Cutting-off	A30-S-BM4/RS		
Internal	AA60-K5-V8	46-60	J-K
Tools (Off-hand)	A46-P5-V30		
Tools and Cutters	AA46/54-J5-V8	46-80	I-J
Drills-Pointing (Machine)	A46-K5-V10		
Drills-Pointing (Hand)	A60-N5-V30		

Material and Type of Work	First Selection	Range of Grits and Grades	
		Grit	Grade
STOVE PARTS (Cast Iron)			
Snagging	C24-S5-VVR	20-24	R-S
Fitting and Mounting	C30-R5-VVR		
Surfacing Tops (Automatic Machine)			
Roughing	C30-Q5-VG		
Finishing	C60-Q5-VG		
TAPS			
Squaring Ends	A54-O5-V30		
Grinding Relief	A60-J5-V10		
Grinding Shanks (Cylindrical)	A463-L5-V10		
TILES			
Edging	C46-O5-VG	46-60	M-O
Cutting-off	C36-O-BR		
TOOLS			
Lathe and Planner-Off-hand			
Roughing-Light	MEDIUM		
Roughing-Heavy	COARSE		
Finishing	FINE		
Chisels	A46-P5-V30		
TUBES-Cutting-off :	Please refer to us with full details of operation		
TUNGSTEN CARBIDE			
Off-hand- (Roughing)	GC46-L5-VG		
	GC46-L5-VS2110		
	GC60-K5-VS2110		
	GC60-K5-VG		
Off-hand (Finishing	GC120-J5-VG		
	GC220-I5-VG		
Surface Grinding			
Roughing	GC60-I5-VG		
Finishing	GC120-J5-VG		
Cylindrical Grinding			
Roughing	GC60-J5-VG		
	GC60-J5-VS2110 (High G.R)		
Finishing	GC120-I5-VG		
	GC120-I5-VS2110 (High G.R)		
	GC120-J5-VG		
Form Grinding	GC120-J5-VS2110 (High G.R)		

Material and Type of Work	First Selection	Range of Grits and Grades	
		Grit	Grade
Tool and Cutter Grinding			
Roughing	GC46-K5-VG		
	GC60-J5-VG		
Finishing	GC120-J5-VG		
Tool and Cutter Grinding			
Cutter and Reamer Grinding			
Roughing (Cup Wheel)	GC60-J5-VG		
Finishing (Cup Wheel)	GC120-J5-VG		
Saw Sharpening			
Roughing (Cup Wheel)	GC60-J5-VG		
Finishing (Cup Wheel)	GC120-J5-VG		
VALVE (Automobile)			
Stem (Infeed)			
Centerless (Rough)	A463-M3-V1092	46-60	M-N
(Semi Finish)	A60-L5-V10C		
(Finish)	A100-I5-V10		
Seat grinding :	AA100-N5-VF8		
Cutting off	A30-TD-153E		
Centreless			
Bar Grinding	A463-M3-V1092		
Bar Cutting Off	A30-TDR153E		
VALVE TAPPETS			
Cylindrical	A463-L5-V10		
Centreless	A60-N5-V10C		
WELDS			
Low Speed (Peripheral)	A24-R5-V6	16-24	R-S
High Speed (Peripheral)	A163-R2-BM4		
High Speed (Portable)	A163-R2-BM4		

Reference Section Tables

Approximate Diameter of Abrasive Grains

FEPA grain size (mesh) in mm and inches

Average Grain Diameter

1 / 1000 inch = 25 microns
1 micron = 0.001 mm

FEPA Designation	Average Dia in mm	Average Dia in inch
8	2.40	0.096
10	2.00	0.080
12	1.70	0.068
14	1.40	0.056
16	1.20	0.048
20	1.00	0.040
24	0.71	0.028
30	0.59	0.024
36	0.50	0.020
40	0.42	0.017
46	0.35	0.014
54	0.30	0.012
60	0.25	0.010
70	0.21	0.008
80	0.18	0.007
90	0.15	0.006
100	0.13	0.005
120	0.10	0.004
150	0.08	0.003
180	0.07	0.0028
220	0.06	0.0024
240	0.05	0.0021
280	0.04	0.0017
320	0.03	0.0012
400	0.02	0.0008
500	0.014	0.0006
600	0.010	0.0004
850	0.007	0.0003
1200	0.004	0.0002

Surface Finish Comparison Table

R_a µm	R_t µm	R_z µm	RMS µinch	CLA µinch	PVA µinch
0.025	0.2	0.16	1.12	1	6
0.05	0.4	0.32	2.2	2	12
0.06	0.5	0.38	2.7	2.4	16
0.08	0.6	0.5	3.6	3.2	20
0.1	0.8	0.6	4.5	4	25
0.12	1	0.75	5.3	5	32
0.16	1.25	1	7.1	6.3	40
0.2	1.5	1.25	9	8	50
0.25	2	1.6	11.2	7.1	63
0.31	2.5	2	14	12.5	80
0.4	3.2	2.5	18	16	100
0.5	4	3.2	22.4	20	125
0.6	5	4	28	25	160
0.8	6.3	5	35.5	31.5	200
1.0	8	6.3	45	40	250
1.25	10	8	56	50	320
1.6	12.5	10	71	63	400

R_a = DIN Centre Line Average

R_t = Maximum Peak to Trough Height over the surface

RMA = Root Mean Square Avg. Height

CLA = Centre Line Average

PVA = Peak to Valley Avg. Height

R_z = Average of fine absolute Maximum peaks and troughs within the length of 1 m.

Hardness Conversion Chart

Rockwell Scale C	VPN	Brinell Hardness	Tons/ Sq.in	Kgf/ Sq.mm
68.0	940			
67.5	920			
67.0	900			
66.5	883			
66.0	865			
65.5	848			
65.0	832		150	237
64.5	817		147	232
64.0	800		145	229
63.5	787		142	224
63.0	772		140	221
62.5	759		138	218
62.0	746		137	116
61.5	733		135	213
61.0	720		133	210
60.0	697		129	204
59.0	674		126	199
58.0	653		123	194
57.0	633		120	189
56.0	613		117	185
55.0	595		114	180
54.0	577		122	177
53.0	560	510	109	172
52.0	544	500	107	169
51.0	528	487	104	164
50.0	513	475	102	161
49.0	498	464	100	158
48.0	484	450	98	155
47.0	471	442	96	151
46.0	458	432	94	148
45.0	446	421	92	145
44.0	434	410	90	142
43.0	423	401	88	139
42.0	412	390	86	136
41.0	402	381	85	134
40.0	392	371	83	131
39.0	382	362	81	128
38.0	372	353	80	126
37.0	363	344	78	123
36.0	354	336	76	120
35.0	345	327	74	117
34.0	336	319	72	113
33.0	327	311	70	110
32.0	318	301	38	107
31.0	310	294	67	106
30.0	302	286	65	102

Hardness Conversion Chart

Rockwell Scale C	VPN	Brinell Hardness	Tons/ Sq.in	Kgf/ Sq.mm
29.0	294	279	64	101
28.0	286	273	62	98
27.0	279	267	61	96
26.0	272	261	59	93
25.0	266	258	58	91
24.0	260	253	57	90
23.0	254	248	55	87
22.0	248	243	54	85
21.0	243	239	53	83
20.0	238	235	52	82
	228	226	50	79
	217	216	47	74
	207	206	45	71
	196	195	43	68
	184	187	41	64
	176	176	39	61
	165	165	37	58
	145	145	33	52
	131	131	30	47

Bore (H11) Tolerance Chart

Bore Diameter		H11 Tolerance		
Above (mm)	Upto and including (mm)	Maximum (mm)	Maximum (inches)	Minimum
3	6	+0.075	+0.0030	0
6	10	+0.090	+0.0035	0
10	18	+0.110	+0.0042	0
18	30	+0.130	+0.0050	0
30	50	+0.160	+0.0060	0
50	80	+0.190	+0.0075	0
80	120	+0.220	+0.0085	0
120	180	+0.250	+0.0100	0
180	250	+0.290	+0.0115	0
250	315	+0.320	+0.0125	0
315	400	+0.360	+0.0145	0
400	500	+0.400	+0.0160	0

SPEED TABLE

Wheel Dia.		Revolutions per minute										
		Peripheral Speed m/s. S.F.P.M.										
inch	mm	12	25	30	35	43	45	50	60	63	80	100
		2362	4922	5906	6890	8465	8859	9843	11812	12402	15749	19686
		Revolutions per minute										
1/8	3	76390	159160	190990	222820	273750	286480	318310	381970	401070	509300	436620
1/4	6	38200	79580	95490	11410	136870	143240	159160	190900	200540	254650	318310
5/16	8	28650	59680	71620	83560	102660	107430	119370	143240	150400	190990	238730
3/8	10	22920	47750	57300	66850	82120	85940	95490	114590	120320	152790	190990
1/2	13	17630	36730	44070	51420	63170	6610	73460	88150	92560	117530	146910
5/8	16	14320	29840	35810	41780	51330	53720	59680	71620	75200	95490	119370
3/4	20	11460	23870	28650	33420	41060	42970	47750	57300	60160	76390	95490
1	25	9170	19100	22920	26740	32850	34380	38200	45840	48130	61120	76390
1	32	7160	14920	17910	20890	25660	26860	29840	35180	37600	47750	59680
1	40	5730	11940	14320	16710	20530	21490	23870	28650	30080	38200	47750
2	50	4580	9550	11460	13370	16430	17190	19100	22920	24060	30560	38200
2	63	3640	7580	9100	10610	13040	13640	15160	18190	19100	24250	30320
3	80	2870	5970	7160	8360	10270	10740	11940	14320	15040	19100	23870
4	100	2290	4780	5730	6680	8210	8590	9550	11460	12030	15280	19100
5	125	1830	3820	4580	5350	6570	6880	7640	9170	9630	12220	15280
6	150	1530	3180	3820	4460	5480	5730	6370	7640	8020	10190	12730
7	180	1270	2650	3180	3710	4560	4780	5310	6370	6680	8490	10610
8	200	1150	2390	2870	3340	4110	4300	4780	5730	6020	7640	9550
9	230	1000	2080	2490	2910	3570	3740	4150	4980	5230	6640	8300

SPEED TABLE

Wheel Dia.		Revolutions per minute										
		Peripheral Speed m/s. S.F.P.M.										
inch	mm	12	25	30	35	43	45	50	60	63	80	100
		2362	4922	5906	6890	8465	8859	9843	11812	12402	15749	19686
		Revolutions per minute										
10	250	920	1910	2290	2670	3290	3440	3820	4580	4810	6110	7640
12	300	760	1590	1910	2230	2740	2870	3180	3820	4010	5090	6370
14	350	660	1360	1640	1910	2350	2460	2730	3270	3440	4370	5460
16	400	570	1190	1430	1670	2050	2150	2390	2870	3010	3820	4780
18	450	510	1060	1270	1490	1830	1910	2120	2550	2670	3400	4240
20	500	460	960	1150	1340	1640	1720	1910	2290	2410	3060	3820
22	550	420	870	1040	1220	1490	1560	1740	2080	2190	2780	3470
24	600	380	800	960	1110	1370	1430	1590	1910	2010	2550	3180
26	650	350	740	880	1030	1260	1320	1470	1760	1850	2350	2940
28	700	330	680	820	960	1170	1230	1360	1640	1720	2180	2730
30	750	310	640	760	890	1100	1150	1270	1530	1600	2040	2550
32	800	290	600	720	840	1030	1070	1190	1430	1500	1910	2390
34	850	270	560	670	790	970	1010	1120	1350	1420	1800	2250
36	900	260	530	640	740	910	60	1060	1270	1340	1700	2120
38	950	240	500	600	700	860	910	1010	1210	1270	1610	2010
40	1000	230	480	570	670	820	860	960	1150	1200	1530	1910
42	1050	220	460	550	640	780	820	910	1090	1150	1460	1820
44	1100	210	430	520	610	750	780	870	1040	1090	1390	1740

CARBORUNDUM UNIVERSAL LTD.

HEAD QUARTERS :

Post Box No. 2272, Tiruvottiyur, Chennai 600 019
Tel. : 044-25733322, 25733029, 25733513
Fax : 044-25733499
E-mail : DeepakDurairajPL@cumi.murugappa.com
GaneshH@cumi.murugappa.com

AREA OFFICES

AHMEDABAD :

No. 303, Mahalaya, Near Hotel President,
Off C.G. Road, Near Municipal Market,
Navrangpura, Ahmedabad - 380 009.
Tel. : 079-3008 2582
Fax : 079-3008 2583
E-mail : SaravananMS@cumi.murugappa.com

BANGALORE :

N-706, Manpal Centre, No.47, Dickenson Road,
Bangalore - 560 042.
Tel. : 080-3077 0600/0601
Fax : 080-2558 4785
E-mail : AlexA@cumi.murugappa.com

CHENNAI :

No. 81, Vetrivinayagar Kovil Street, Thiruvaleeswarar Nagar,
Thirumangalam, Anna Nagar, Chennai - 600 040.
Tel. : 044-3013 2488-94,
Fax : 044-3013 2493
E-mail : MuralikrishnanBJ@cumi.murugappa.com

DELHI :

Param Tower, Second Floor, 11/5-B, Pusa Road,
Opp.Telephone Exchange, New Delhi - 110 005.
Tel. : 011-3090 1910
E-mail : SinghalRajeev@cumi.murugappa.com

JAMSHEDPUR :

Flat No. C4/S Phase 9, Adarsh Nagar,
Sonari, Jamshedpur 831011.
Tel. : 0657-2225329, 2227107
Fax : 0657-2225877
E-mail : Sunilkumar@cumi.murugappa.com

KOCHI :

Post Box No.1, Kalamssery Developed Plot (PO),
Kalamassery - 683 109. Ernakulam District, Kerala
Tel. : 0484-302 3501-2
Fax : 0484-253 2019
E-mail : VancheeswaranS@cumi.murugappa.com

KOLKATA	:	Shrachi Tower, Unit 1-A, 1st Floor, 686, Anandapur Kasba (PO), Kolkata - 700 017. Tel. : 033-3023 8060-69 / 3023 9671-75 Fax : 033-3024 9673 E-mail : SrivastavaSunil@cumi.murugappa.com
LUDHIANA	:	P.No. 172, BXV Street, No.6, Guru Nanak Motor Market, G.T Road, Miller Ganj, Ludhiana - 141 003. Tel. : 0161-302 8415-424 Fax : 0161-302 8420 E-mail : ParasheRajesh@cumi.murugappa.com
MUMBAI	:	P.B. No. 962, United India Building, III Floor, Sir Pherozshah Mehta Road, Mumbai - 400 001. Tel. : 022-3192 0221-226 Fax : 022-2266 2289 E-mail : MalikVi pin@cumi.murugappa.com
PUNE	:	Plot No.106, Shruthi Enclave, Near Telco Road, Udhayam Nagar, Pimpri. Pune - 411 018. Tel. : 020-3917 0032-38 Fax : 020-3917 0030 E-mail : GnanamaniN@cumi.murugappa.com
SECUNDERABAD	:	Plot No.1-B-208, Door No.106&107, 1st Floor, Golden Hawk Building, Sindhi Colony, P.G Road, Secunderabad - 500 003. Tel. : 040-3000 5096/3235 Fax : 040-2789 0176 E-mail : ThandeswaranV@cumi.murugappa.com

RESIDENTIAL OFFICES

AURANGABAD	:	Mobile : 98232 93506 E-mail : Tri pathyCS@cumi. Murugappa.com
BARODA	:	Tel. : 0265-2253452 Fax : 0265-2253452 Mobile : 98254 11839 E-mail : MichaelAD@cumi. Murugappa.com
COIMBATORE	:	Mobile : 98422 25025 E-mail : SenthilkumarT@cumi. Murugappa.com
KANPUR	:	Mobile :94151 26754 E-mail : JhaAK@cumi. Murugappa.com
NAGPUR	:	Tel. : 0712 - 2223030