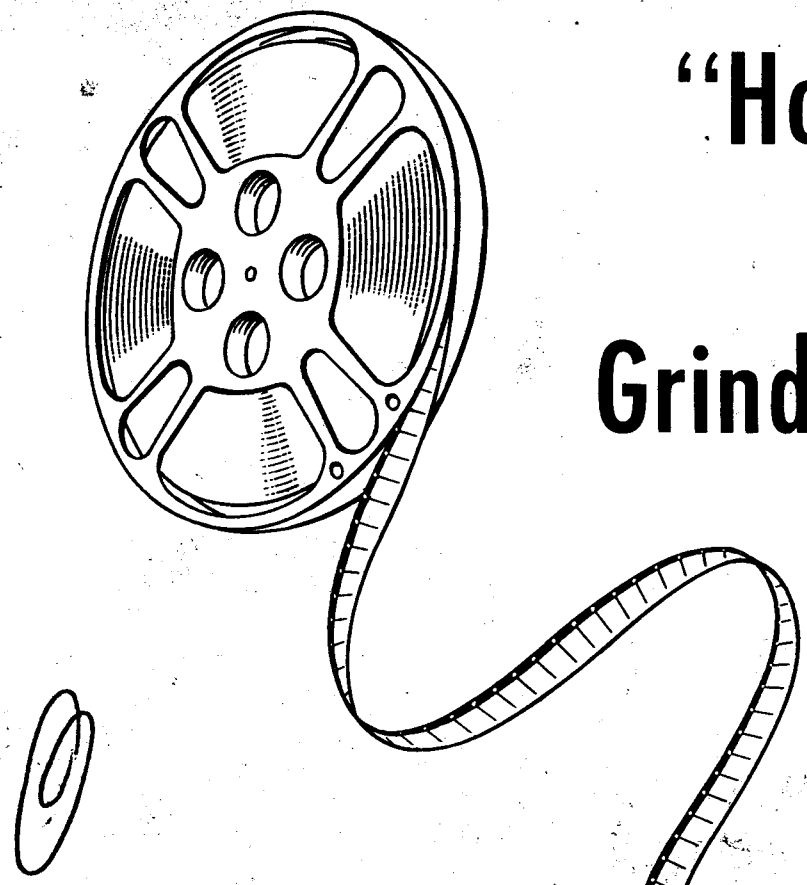
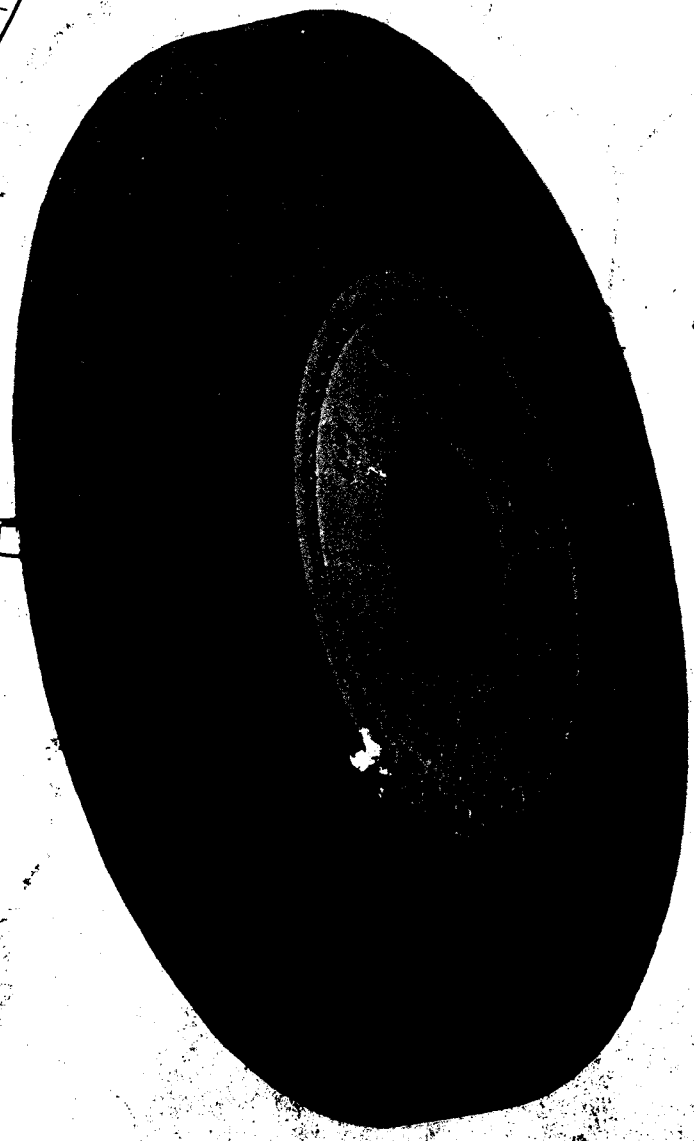
"How to Select the Right Grinding Wheel"...





. . . an explanation of grinding wheel markings . . . selecting the right wheel for a job . . . two problems of wheel selection worked out step by step.

A thirty minute "Lessons in Grinding" film by NORTON COMPANY Worcester 6, Massachusetts

Introduction

To many people, the marking or specifications printed on a grinding wheel blotter or stenciled on the wheel itself is somewhat of a mystery; and perhaps even more puzzling is the way the combination of numbers and letters comprising the wheel marking is arrived at.

The film you saw is intended to clear up any such mystery. It explains not only what a NORTON wheel marking means, but also the step-by-step procedure in selecting each of the several components of the wheel specifications - the abrasive, grit size, grade (hardness), structure number and bond - for a specific grinding operation. You have seen that this is not a hit-or-miss proposition, but an orderly, logical procedure in order that the wheel may be closely suited to the material to be ground, stock removal, finish and other conditions.

In this outline, we are presenting the highlights of the film story to help you retain the salient facts pertaining to grinding wheel markings, and the basic rules to be followed in selecting a wheel for a specific grinding operation. The outline itself is condensed in chart form on the last two pages. After having viewed the film and reviewed these paragraphs, we hope you will have a better understanding of grinding wheel markings and the problem of wheel selection.

Until you have had an opportunity, however, to implement this knowledge with some experience in selecting wheels, it is advisable, when you have a grinding problem, to consult your grinding wheel representative and draw upon his experience. He will gladly assist you.

You will also find the various Norton booklets containing tables of wheel recommendations helpful in selecting an average or starting specification for any common grinding operation.

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PART I

What the Grinding Wheel Marking Means

The marking describes the complete composition and grinding characteristics of the wheel, namely,

- Type of abrasive
- Grit size
- Grade (wheel hardness)
- Structure (grain spacing)
- Type of bond and Norton modification of that bond

These units combine to form a complete wheel marking, for example, 32A46-H8VG. Breaking this typical marking down into its six component parts,

32A . . . designates NORTON'S 32 ALUNDUM brand of aluminum oxide abrasive. The abrasive designation could also be one of the following:

38A for 38 ALUNDUM	brand	of	aluminum	oxide	abrasive
44A for 44 ALUNDUM	"	"	"	"	"
A for ALUNDUM*	"	"	"	"	"
57A for 57 ALUNDUM	"	"	"	"	"
19A for 19 ALUNDUM	"	"	"	"	"
37C for 37 CRYSTOLON	"	"	silicon	carbide	"
39C for 39 CRYSTOLON	"	"	"	"	"
D for diamond abrasive					

*Commonly referred to as "Regular" ALUNDUM

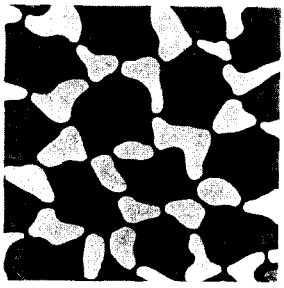
46 . . . is the size of the abrasive used in the wheel. It represents the number of openings per linear inch in the final screen used to size the grain.

The standard grit sizes, ranging from 8 in very coarse wheels to 500 in extremely fine wheels and laps, are as follows:

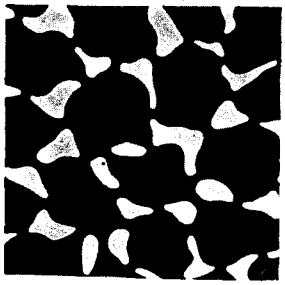
Coarse			to		Fine
8	16	36	70	120	240
10	20	46	80	150	280
12	24	54	90	180	320
14	30	60	100	220	400
					500

The most commonly used grit sizes are in the range of 24 to 80.

H . . . identifies the grade or hardness of the wheel - a measure of the relative strength of the bonding by which the abrasive grains are held in place. As shown in the following cross-sectional views of a vitrified wheel, the heavier the bond coating and the thicker the bond posts, the stronger (harder) the wheel.



Abrasive grains with light bond coating and weak bond posts as in a relatively soft grade wheel



Abrasive grains of same size but with heavier bond coating and thicker, stronger bond posts as in a harder grade wheel

Grade letters run in the order of the alphabet. E, for example, is very soft while Z is very hard:

Soft										to									Hard
C,	D,	E,	F,	G,	H,	I,	J,	K,	L,	M,	N,	O,	P,	Q,	R,	S,	T,	U,	V,	W,	X,	Y,	Z

Of course, all grinding wheels are hard and the terms "soft" and "hard" grade denote simply relative hardness. The proper grade for a wheel varies with the severity of the grinding operation; a wheel that is on the hard side for a precision grinding operation very likely would be on the soft side for a severe, rough grinding job.

For the majority of precision grinding jobs, the grades fall between F and N, while for rough grinding the grades commonly used range from M to Z.

8 . . . A number identifies the structure or spacing of the abrasive grains within the wheel. When the grains are close together relative to their size, the wheel has a dense structure as indicated by a low structure number such as 4 or 5. No. 8 indicates a relatively open structure or wide grain spacing.

Extra open structure or porous type wheels have a high structure number such as 10 or 12 and, in addition, are usually identified by the letter "P" at the end of the wheel marking.

The structure number is omitted entirely from some types of wheels such as 44 ALUNDUM abrasive and 11 type resinoid bond.

No. 8 structure has been shown by test to be the best for our typical ALUNDUM wheel of 46 grit size, grade H, vitrified bond and hence is called the standard structure for this wheel.

V . . . designates a vitrified or ceramic type of bond consisting chiefly of carefully blended clays and feldspars. Other wheel bonds and their designations are:

Rubber bond ..... R

Resinoid bond ..... B

Silicate bond ..... S

Shellac bond ..... E

G . . . tells you that this particular wheel is made with the NORTON "G" modification of vitrified bond used in many ALUNDUM abrasive wheels. Some of the other NORTON bond modifications and their symbols are "K" vitrified bond used in CRYSTOLON abrasive wheels "11" resinoid bond, "FR" reinforced resinoid bond, and "50" rubber bond.

Thus, the marking 32A46-H8VG that we have just analyzed tells you that the

- abrasive is aluminum oxide, of the NORTON

  32 ALUNDUM brand 32A

- grit size is 46 ..... 32A46

- grade (hardness) is H 32A46-H

- structure number is 8 ..... 32A46-H8

- bond is vitrified of the NORTON

  G type 32A46-H8VG

Other typical NORTON wheel markings are:

A60-N5VG	A100-MS	A46-Q8R50
39C60-I8VK	44A16-QB11	37C46-J7E4

Notes

PART II

Selecting the Right Wheel for a Job

Keep in mind that a grinding wheel is a form of cutting tool, and that except in the case of wheels for general purpose grinding, the abrasive, grit size, grade and bond type should be selected to fit the particular job on which the wheel is to be used, just as a cutter, drill or tap is selected for its specific job.

The Six Factors to Consider

There are six factors which affect the choice of the grinding wheel specifications (abrasive, grit size, grade and bond). These are:

1. Material to be ground and its hardness.
2. Amount of stock to be removed, and the ~~finish~~ finish required.
3. Whether the grinding is done wet or dry.
4. Wheel speed.
5. Area of grinding contact.
6. Severity of the grinding operation.

1. Let's first consider the material to be ground and its hardness. These affect the choice of (a) abrasive, (b) grit size, and (c) grade or hardness of the wheel.

   - In general, ALUNDUM (aluminum oxide) abrasives are best for steels, while CRYSTOLON (silicon carbide) abrasives are better suited to grinding cast iron, nonferrous metals (including cemented carbides) and nonmetallic materials.

   - A relatively fine grit size works best on hard and brittle materials. A coarser grit capable of taking heavier cuts can be used advantageously on soft and ductile materials that are readily penetrated. The following drawings illustrate this:

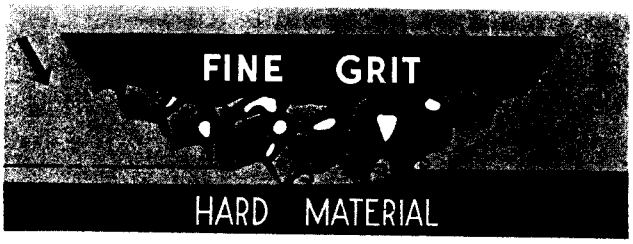


Fig. 1

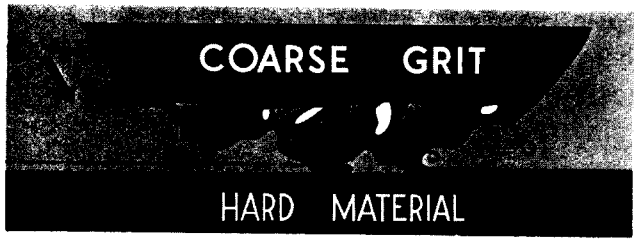


Fig. 2

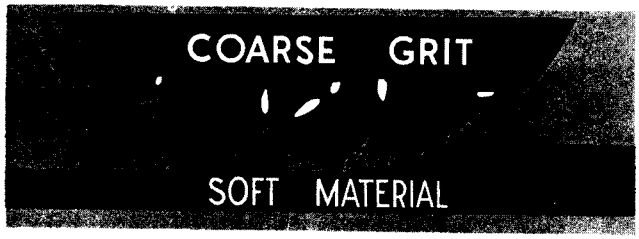


Fig. 3

To explain, on hard materials the increased number of cutting points on the face of a moderately fine grit wheel (Fig. 1) will remove stock faster than the fewer cutting points presented by a coarser wheel (Fig. 2). The larger abrasive grains in a coarser grit wheel cannot penetrate as deeply into the hard material without burning it. On soft, ductile materials, however, the larger grains penetrate easily, and provide the necessary chip clearance to minimize wheel loading (Fig. 3).

The hardness of the material to be ground also affects choice of wheel grade or hardness. A harder grade can be used on soft, easily penetrated materials than on hard materials which naturally tend to dull the wheel faster. The softer grades release the dull grains more readily to present new, sharp grains to the work.

2. The second factor to be considered in selecting a wheel is the amount of stock to be removed, and the finish required. These affect the choice of (a) grit size and (b) bond as follows:

- As a rule, a relatively coarse grit size is selected for rapid stock removal without regard for finish as in rough grinding; a fine grit should be used where a high finish is desired.

- Vitrified bonded wheels are generally used where a commercial finish is satisfactory. The organic bonds, resinoid, rubber and shellac, produce the highest finish.

3. Is the operation wet or dry? This affects the choice of grade.

   - Softer grade wheels must be used in dry grinding to minimize the heat generated. Wheels about one grade harder can be used in wet grinding as the coolant reduces the grinding heat.

4. The speed at which the grinding wheel is to be operated often dictates the type of bond.

   - Vitrified bonded wheels should not be used at speeds over 6,500 s.f.p.m. With few exceptions, when the speed exceeds this figure, resinoid, rubber or shellac bonded wheels should be used. Remember, the safe operating speed shown on the tag, wheel or blotter must never be exceeded.

5. The area of grinding contact between the wheel and the work affects the choice of (a) grit size and (b) grade.

   - A coarse grit is required when the contact area is relatively large, as in surface grinding with cup wheels, cylinders or segments, to provide adequate chip clearance between the abrasive grains. As area of contact becomes smaller and the unit pressure tending to break down the wheel face becomes greater, finer grit wheels should be used.

   - As to the grade or hardness, on large areas of contact a soft grade will provide normal breakdown of the wheel, insuring continuous, free-cutting action. A harder grade, on the other hand, is needed to stand up under the increasingly higher unit pressure as the area of contact becomes smaller.

6. The severity of the grinding operation affects the choice of (a) abrasive and (b) grade.

- A tough abrasive like 44 ALUNDUM or "regular" ALUNDUM should be used for rough, heavy-duty grinding of steel as in snagging, for cylindrical and centerless grinding where production is a factor, or where a special wheel face must be maintained as in thread grinding or saw gumming.

- The milder abrasives like 32 ALUNDUM and 38 ALUNDUM are best for lighter precision grinding operations on steels and semisteels, while the intermediate 57 ALUNDUM and 19 ALUNDUM abrasives are used for precision and semi-precision grinding of both mild and hard steels.

- The severity of the grinding operation also influences the choice of grade. Hard grades provide durable wheels for rough grinding such as snagging, while medium and softer grade wheels can be used for precision type operations which are less severe on the wheel.

PART III

Applying the Factors

We will now see how each of the six factors just discussed influenced the selection of the wheel marked 32A46-H8VG that was used for surface grinding a block of heat-treated die steel.

Abrasive

First, the reason for choosing 32 ALUNDUM as the type of abrasive. According to our rules, the factors which affect the choice of abrasive are: the material to be ground and its hardness, and the severity of the grinding operation.

The material to be ground was steel, which pointed to an aluminum oxide abrasive. The 32 ALUNDUM brand of aluminum oxide abrasive was a logical choice on this light surface grinding operation because of its fast and cool cutting action when grinding a heat-treated tool steel. So, 32 ALUNDUM or 32A takes the first position in our wheel marking.

32A

Grit Size

Weighing the factors which influenced our selection of 46 grit size, the material to be ground was fairly hard, suggesting a medium grit size. The amount of stock to be removed was moderate, and a commercial finish was called for, so again a medium grit size appeared correct.

Another factor affecting grit size is the area of grinding contact. In surface grinding, this is relatively large, so we wanted a medium - coarse grit size to provide adequate chip clearance. All of these factors point to a medium grit size - about a 46.

32A46

Grade (Hardness)

Next, the grade letter H. The first factor affecting the choice of grade is the material to be ground and its hardness. The material was a hard steel, so a moderately soft grade wheel was called for.

Since we were grinding dry, we went one grade softer than should have been used for wet grinding.

The area of grinding contact was fairly large, which also suggested a moderately soft grade wheel.

The operation was not severe -- stock removal was moderate - so a relatively soft, free cutting wheel could be used. Taking all these factors into consideration, we arrive at a moderately soft grade -- H.

32A46-H

Structure Number

In a 32 ALUNDUM wheel of 46 grit size and a grade H, the grain spacing found to give best performance, and therefore called the standard structure for this wheel, was No. 8.

32A46-H8

Bond Type

Considering the factors that influenced the choice of bond, the amount of stock to be removed was moderate, and a commercial finish was satisfactory, both conditions indicating a vitrified bond.

Wheel speed was well under 6,500 s.f.p.m., so a vitrified bonded wheel could be used. Consequently, in the bond position of our wheel marking we add V for vitrified.

32A46-H8V

We chose the NORTON "G" modification of vitrified bond to insure cool cutting and a maximum number of pieces per dressing. This completes our wheel marking:

32A46-H8VG

This wheel gave very satisfactory performance on surface grinding the block of die steel that you saw in the film.

Review

Thus you have seen that selecting the right grinding wheel for a given job is not a hit-or-miss proposition; a few simple rules make it a very logical procedure. Repeating these rules,

1. The choice of abrasive depends upon the type of material to be ground and its hardness, and upon the severity of the grinding operation.

2. The grit size is determined by the hardness of the material to be ground, the amount of stock to be removed and finish required, and the area of grinding contact.

3. In choosing the grade or hardness, we consider the hardness of the material to be ground, whether the grinding will be done wet or dry, the area of grinding contact, and the severity of the grinding operation.

4. The structure number does not have to be selected in the same way as the other wheel components. It is generally the standard, proved best by experience for each grit size and grade. It is omitted from the marking of some wheels.

5. The choice of bond depends chiefly upon the finish required and the maximum wheel speed. Thin cut-off wheels must be either resinoid, rubber or shellac bonded.

Many of the Norton "Know-How" booklets, all available without charge, contain tables of grinding wheel recommendations for materials commonly ground and based on average conditions. of stock removal, finish, etc. You will find these tables useful in selecting, quickly, a starting specification. The recommendations are subject to change, of course, with any change in the six factors which affects the choice of grinding wheel specifications.

COMPONENT OF NORTON WHEEL MARKING	FACTORS AFFECTING ITS CHOICE
1. ABRASIVE ALUNDUM = A 19 ALUNDUM = 19A 32 ALUNDUM = 32A 44 ALUNDUM = 44A 57 ALUNDUM = 57A 37 CRYSTOLON = 37C 39 CRYSTOLON = 39C	✓Material to be ground and its hardness ..... ALUNDUM (aluminum oxide) type abrasive for steels. CRYSTOLON (silicon carbide) type abrasive for cast iron, nonferrous metals including cemented carbides, and nonmetallic materials ✓Severity of grinding operation ..... Tough abrasive like 44 ALUNDUM or "regular" ALUNDUM for rough, offhand grinding, and for strictly production cylindrical and centerless grinding, thread grinding, saw gumming and cutting off. Milder (friable) type abrasive like 32 ALUNDUM or 38 ALUNDUM for light, precision grinding of steel and steel alloys. Intermediate type abrasive like 57 ALUNDUM or 19 ALUNDUM for precision and semiprecision grinding of both mild and hard steels.
2. GRIT SIZE — Coarse to Fine — 8 \ 16 \ 36 \ 70 \ 120 \ 240 10 \ 20 \ 46 \ 80 \ 150 \ 280 12 \ 24 \ 54 \ 90 \ 180 \ 320 14 \ 30 \ 60 \ 100 \ 220 \ 400 500	✓Material to be ground and its hardness ..... Coarse grit size for soft, ductile (easily penetrated) materials. Finer grit size for hard and brittle materials. ✓Amount of stock to be removed and finish required ..... Coarse grit size for rapid stock removal as in rough grinding. Finer grit size for high finish. ✓Area of contact between wheel and work ..... Coarse grit size for large area of contact as in surface grinding with cup wheels, cylinders and segments. Finer grit size as area of contact becomes smaller.

(Continued on next page)

COMPONENTS OF NORTON WHEEL MARKING	FACTORS AFFECTING ITS CHOICE
3. GRADE (hardness) — Soft to Hard — C G K O S W D H L P T X E I M Q U Y F J N R V Z	✓ Hardness of material to be ground ..... { Soft grades for hard materials Harder grades for soft, easily penetrated materials ✓ Is operation wet or dry? ..... { Wet grinding permits using slightly harder grade than required for dry grinding. ✓ Area of contact between wheel and work ..... { The smaller the area of contact, the harder the wheel should be. ✓ Severity of grinding operation ..... { The more severe the operation, the harder the wheel should be.
4. STRUCTURE (grain spacing) Structure Number* Dense to Open Structure 0 3 6 9 12 1 4 7 10 2 5 8 11 *Sometimes omitted from marking.	The number designating the wheel's structure is not selected in the same way as the other wheel components. There is a "standard" structure for each grit size and grade, found best by experience. The structure number is omitted from the marking of certain types of wheels such as 44 ALUNDUM abrasive, and "11" type resinoid bond.
5. BOND Vitrified = V Rubber = R Resinoid = B Silicate = S Shellac = E NORTON modification of the basic bond is designated by a letter or numeral or both following the basic bond symbol, such as VG, VBE, VK, B11, R50, E4,	✓ Finish required ..... { Vitrified, as a rule, for a commercial finish. Resinoid, rubber or shellac, for highest finish. ✓ Wheel speed ..... { Vitrified, as a rule, for speeds up to 6,500 sfpm. The few exceptions include thread grinding, automotive crankshaft and camshaft grinding. Resinoid, rubber or shellac for speeds over 6,500 sfpm.