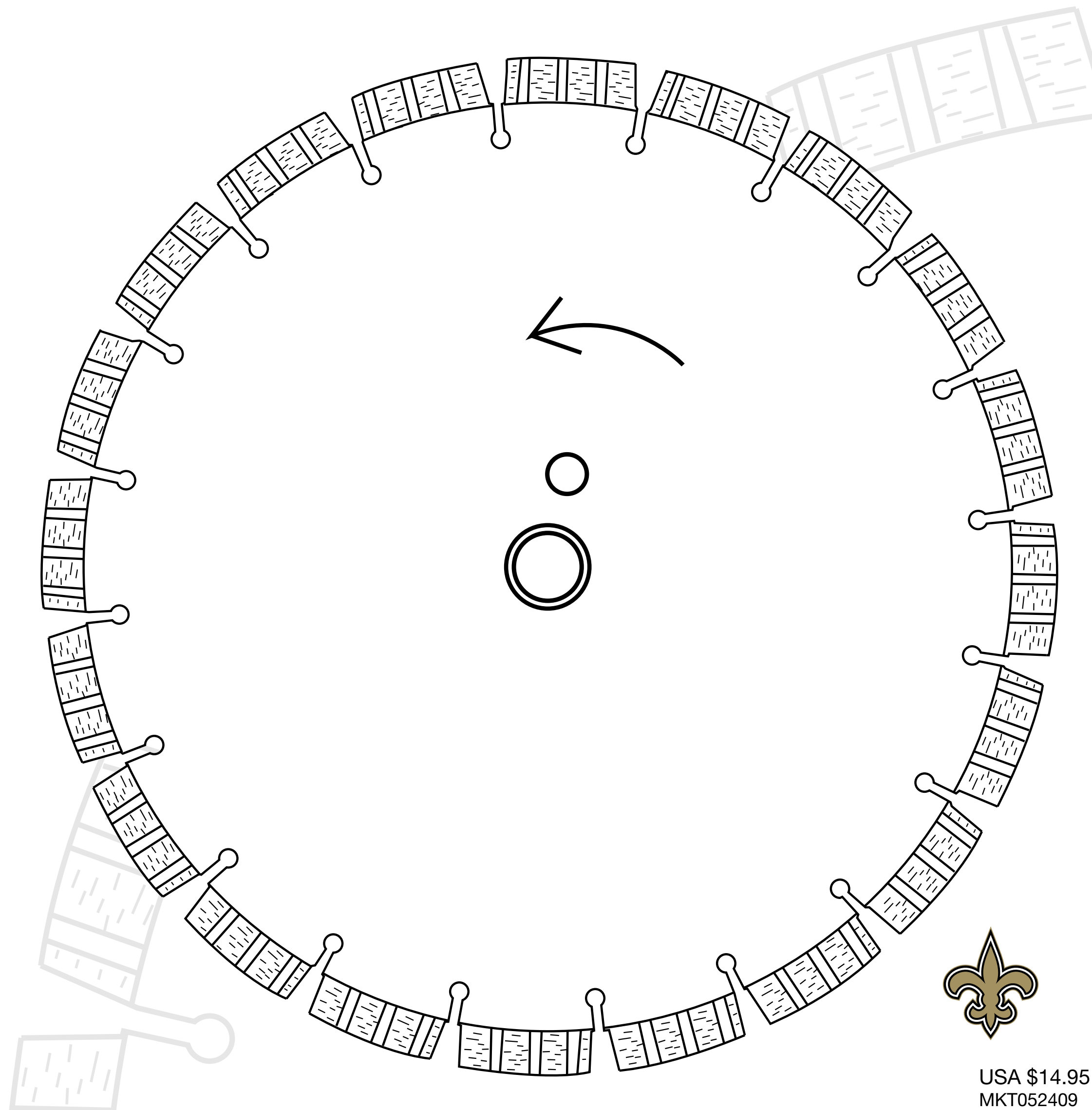
Trouble Shooting
Diamond Blade Cutting



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Trouble Shooting Diamond Blade Cutting

What Makes Diamond Blades Work

The Basics

Learning Objectives

This session will start with an introduction to concrete and its properties and finish with an in-depth introduction to diamonds and diamond tools. From this introduction, you will learn how segments are made and attached to blades and bits. It will conclude with general discussions about the basic attributes of blades and how to trouble shoot blade performance.

Upon completion of this section, the attendee will:

1. Understand concrete basics including aggregate hardness and reinforcing theory and how it relates to blade selection.
2. Have a thorough understanding of how man-made diamond is produced and how it is used in diamond cutting tools.
3. Understand the manufacture and use of diamond tools, including the basic attributes of blades.
4. Have demonstrated methods and means to trouble shoot blade performance.

Introduction

This session provides the attendee with the technical information and techniques to evaluate diamond blade performance, determine the cause and effect of equipment, operator, and site conditions on blade performance, and determine what type of diamond blade to use for the job site conditions.

Concrete Basics

In this part we will discuss the properties of concrete that affect the ability of a blade or bit to cut concrete.

Factors Involving Concrete

When cutting concrete, several factors influence your choice of diamond blades. These include:

- Compressive strength
- Hardness of the aggregate
- Size of the aggregate

- Type of sand
- Steel reinforcing (rebar)
- Green or cured concrete

The guidelines in this section of the workbook are for general reference only. Your best source for information on the characteristics of the concrete you have to cut is from the original contractor. Contact your local Department of Transportation or city hall for help in locating this information.

Compressive Strength

Concrete slabs may vary greatly in compressive strength, measured in pounds per square inch (PSI). Compressive strength in concrete is a measurement of the load carrying capability of concrete:

Concrete Hardness	PSI
Critically Hard	8,000 or more
Hard	6-8,000
Medium	4-6,000
Soft	3,000 or less

Most concrete roads are 4-6,000 PSI, while typical patios or sidewalks are about 3,000 PSI.

Hardness of the Aggregate

There are many different types of rock used as aggregate. Hardness often varies even within the same classification of rock. For example, granite varies in hardness and friability (a measure of how easily a material crumbles) over a wide range of medium soft to hard.

The MOHs scale is frequently used to measure aggregate hardness. Values of hardness are assigned from one to 10. A substance with a higher MOHs number scratches a substance with a lower number - higher MOHs scale numbers indicate harder materials. The following table shows where some common minerals fall on the MOHs scale.

MOHs Scale

1 - Talc	4 - Flourite	7 - Quartz	10 - Diamond
2 - Gypsum	5 - Apatite	8 - Topaz	
3 - Calcite	6 - Feldspar	9 - Corundum	

Most aggregates fall into the 2 to 9 range on the MOHs scale. Some commonly used aggregates measure this way on the MOHs scale:

MOHs Range	Description	Aggregates
8-9	Critically Hard	Flint, Chert, Trap Rock, Basalt
6-7	Hard	Some River Rock, Some Granites, Basalt, Quartz, Trap Rock
4-5	Medium Hard	Some Granites, Some River Rock
3-4	Medium	Dense Limestone, Sandstone, Dolomite, Marble
2-3	Medium Soft	Soft Limestone

Aggregate hardness is one important factor when cutting concrete. Because hard aggregate dulls diamond more quickly, segment bonds generally need to be softer when cutting hard aggregate. This allows the segment to wear normally and bring new, sharp diamond grit to the surface. Softer aggregate will not dull diamond grit as quickly, so harder segment bonds are needed to hold the diamonds in place long enough to use their full potential.

Size of the Aggregate

The size of aggregate affects diamond blade performance. Large aggregates tend to make a blade cut slower. Smaller aggregates tend to make a blade cut faster. The most common standard sizes of aggregate are:

- Pea Gravel- variable in size, usually 3/8" or less in diameter
- 3/4 inch - sieved size of 3/4" or less
- 1-1/2 inch - sieved size of 1-1/2" or less

Type of Sand

Sand is part of the aggregate mix and determines the abrasiveness of concrete. Small aggregate is usually sand. Sand can either be sharp (abrasive) or round (non-abrasive). To determine the sharpness of sand, you need to know where the sand is from. Crushed sand and bank sand are usually sharp; river sand is usually round.

Green concrete is more abrasive than cured concrete. This is because when concrete is not fully cured there has not been enough lime to allow the cement to gain strength to hold all the sand in place; sand is scraped or tom free from the surface being cut by the cutting action of the blade. As this free sand works past the spinning blade, it abrades the segment and core, thus accelerating wear. More loose sand means more abrasiveness.

Amount of Steel Reinforcing (Rebar)

Heavy steel reinforcing tends to make a blade cut slower. Less reinforcing tends to make a blade cut faster.

Light to heavy rebar is a very subjective term. Examples include:

Light	Wire mesh, single mat
Medium	#4 rebars every 12” on center each way (OCEW), single mat Wire mesh, multi-mats
Heavy	#4 rebars every 12” on center each way (OCEW), double mat

“Heavy” rebar can also result from different grades of steel. Typical rebar is grade 40 steel. Grade 60 steel would make the example of #4 (medium) rebar above into a heavy rebar. Rebar gauges (diameter of the bar) are measured in eighths of an inch - #4 rebar is 1/2” diameter (4 x 1/8”), #5 is 5/8” (5 x 1/8”).

Green or Cured Concrete

The drying or curing time of concrete greatly affects how the material will interact with a diamond blade. Green concrete is freshly poured concrete that has set up but not yet fully cured. It is softer and more abrasive than cured concrete. You need a harder-bonded blade with undercut protectors to cut green concrete. You need a softer-bonded blade to cut the same concrete in a cured state.

As it applies to diamond blade sawing, concrete defined as “green” is less than 24 hours from pour or younger, the actual time can vary widely. Weather, temperature, moisture in the aggregate, time of year, and the amount of water in the mix all influence curing time. Also, much of the concrete poured today has additives, which can either shorten or extend curing time. Consult your mix design to find the relative curing time for your job. As soon as wet concrete sets up and does not spall or ravel, green cutting should begin. Spalling or raveling is a condition where the edges of a saw cut are ragged and very rough because of aggregate pullout. This condition is a result of the concrete surface not having enough cure time to achieve enough strength to hang on to the surface aggregate. The best method to determine when concrete is ready to be “green sawn”, is when surface aggregate and sand particles are not torn free by scratching the surface with a knife or other hard metal object. Currently a more promising and exact technique is emerging utilizing a maturity meter to determine when a concrete slab is ready for green cutting.

Diamonds: The Key to Your Cutting Success

Size

Diamond crystals can be grown in a wide range of sizes. The size of the diamond crystals used in a cutting tool determines the amount of diamond exposed above the tool’s cutting surface. The exposure, or height, of diamond protrusion influences the depth of cut of each crystal, and subsequently, the material removal rate for the cutting tool. Larger crystals and greater diamond protrusion will result in a potentially faster material removal rate.

In general, larger crystals are used for cutting softer materials and smaller crystals are used for harder materials.

The mesh size of the diamond also determines the number of crystals per carat. As the mesh increases, the pieces per carat increase. Mesh size is a measure of the size of a diamond; larger diamonds have smaller mesh numbers. This is similar to grit size in sand paper. The larger the grit numbers the smaller the size of the abrasive particle.

Selection of tile mesh size is critical for tool performance since the number of crystals on the surface of a cutting tool affects the tool's life and power requirements. For instance, changing to a finer mesh size to increase the number of crystals on the cutting edge of a low concentration tool generally increases tool life and power requirements.

In addition to the crystal size, the concentration of diamond used in the cutting segment also determines the number of crystals on the cutting surface. Mesh size and concentration must be balanced for the best performance. Concentration is a measure of the number of diamond particles in a cubic inch of segment and is measured in one of two ways: 100 con = 72 carats/cubic inch or 125 can = 75 carats/cubic inch. The two methods of measurement for diamond concentration were established years ago in Europe and the United States. No single measurement standard has ever been agreed upon by the industry.

Shape

Diamond crystal shapes can vary from the well -structured crystals to partially-grown, irregular shapes to fragments. When crystals grow together in clusters they are called polycrystalline agglomerates.

Fig. 1

Fig. 2

Fig. 3

A definite relationship exists between the shape and performance of the diamond crystal. A high proportion of irregularly shaped, angular crystals are desirable for less severe applications (see Fig. 1). As the shape of the crystals becomes blockier, the diamond product becomes more suited for applications of greater severity (see Fig. 2).

Experience has shown the optimum diamond product for applications with severe crystal loads is one that contains predominantly block-shaped crystals. This shape offers the greatest resistance to fracturing with a maximum number of points or edges and a minimum surface contact. The result is lower machine power requirements and longer tool life. The ideal diamond shape for sawing and drilling applications is a shape called "cubo-octahedron" (see Fig. 3).

Inclusions

Inclusions are foreign material trapped in the diamond crystal during its growth. They can vary by type and amount, by location, and distribution throughout the crystal. Inclusions can be either metallic or nonmetallic. They affect the performance of a diamond product by influencing how the crystals break down.

The cutting process is dynamic. The crystal loading fluctuates significantly from high energy impact to a varying continuous load even within a single cut. Severity of the cutting application determines the amount and type of loading on the crystal. The inclusions within the crystal are an important factor in determining how the crystal withstands the loading.

Impact Strength

The impact strength of a diamond product is a measure of the ability of the population of crystals to withstand impact loads. The impact strength is influenced by crystal shape, size, inclusions, and the distribution of these crystal properties within the population.

Factors that must be considered in selecting a diamond product include the tool's design, properties of the bond and of the work piece material, available machine power, removal rates, and the economics of the system. Selecting the right grade of diamond will lead to the best performance at minimum cost.

Generally, the tougher the material being cut, the greater the impact strength required from the diamond product Studies also indicate that there is a minimum impact strength needed for a given application. Using a diamond product with impact characteristics above the minimum required for the application may not significantly improve tool performance. As the severity of the application increases, the minimum impact strength requirement for the diamond product increases. A measure of the impact strength of diamond is known as the Toughness Index (TI).

Impact loading is not the only loading considered for selection of a grade of diamond. Diamond crystals are also subjected to very high temperatures during the cutting process. The measure of a diamond crystal to withstand thermal cycling is known as the Thermal Toughness Index (TTI). This index is determined by measuring the toughness of a sample of diamond crystals, subjecting them to a high temperature, then allowing them to return to ambient temperature and measure the change in toughness.

Bond Characteristics

Diamond does not act alone, but in combination with its bond system. This system plays several important roles in the performance of the tool:

- Disperses and supports the diamond
- Provides controlled wear while allowing crystal protrusion
- Prevents crystal pull-out
- Acts as a heat sink
- Distributes impact and load as the diamond attacks the work piece

Optimum performance of a diamond tool is achieved through the proper choice of diamond grade, bond system, and machine parameters. Low temperature bonds (less than 900°C, 1652°F) preserve diamond crystal properties best. Such bonds are usually made from cobalt, nickel iron, bronze or a combination of these metals.

The bond system must be designed to wear away at the same rate as the diamond crystals fracture or become dull. As the bond wears, new sharp diamond crystals are exposed and begin to cut. A bond that is not properly designed for the cutting application is said to be too soft or too bard.

Diamond Tools and Technology

General theory

Diamond tools don't really "cut" like a knife ... they grind. Envision trying to saw through a 2 x 4 using your hand wrapped in sandpaper, this is how diamond blades cut.

During the manufacturing "break-in" (grinding) process, individual diamond crystals are exposed on the outside edge and sides of the diamond segments or rim. These exposed surface diamonds do the grinding work. The metal matrix, or bond, locks each diamond in place. Trailing behind each exposed diamond is a "bond tail" (also called "comet tail"), which helps support the diamond. Nothing known to man sticks to diamond (i.e. acts as an adhesive) therefore, in the sawing application, the metal bond surrounds the diamond and locks it into place by a mechanical lock or hold.

The primary function of the metal bond is to lock the diamond in place and support it under load. It is important to note that due to the shape of diamond crystals, one-half of all the diamond put into a segment is thrown away. A simplified diamond crystal shape is shown in Fig 4. As you can see, once the surrounding metal wears to the point that is equal to or below the "equator" of the diamond crystal, the crystal will pop out. This is like trying to hold the end of a flat- blade screwdriver after dipping it into oil. The harder you grip the screwdriver the more it wants to slip out from between your fingers. To better utilize the diamond crystals in a segment the metal bond is designed to develop bond tails. This extra metal holds the diamond crystal in the metal bond longer and is the reason that bond tail development in a cutting segment is so important for blade performance.

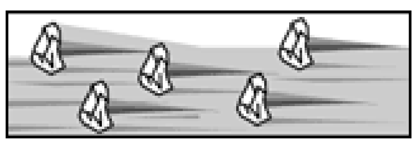


Fig. 4

While the blade rotates on the arbor shaft of the saw, the operator or saw pushes the blade into the material. The blade begins to cut through the material, while the material begins wearing away the blade.

Exposed, surface diamonds score the material, grinding it into a fine powder. Embedded diamonds remain beneath the bond surface.

Exposed diamonds crack or fracture as they cut, breaking down into even smaller pieces. Hard, dense materials cause the diamonds to fracture even faster. The material also begins to wear away the metal matrix through abrasion. Highly abrasive materials will cause the matrix to wear faster.

This grinding and wearing process continues until the blade is worn out. A blade is worn out when there is no longer any usable diamond segment and the steel core is exposed. Sometimes, a small, unusable part of the segments or rim may remain. **It is important to understand that the diamond blade and the material must work together (or interact) for the blade to cut effectively.**

In order for a diamond blade to work properly, the diamond type, quality, and grit size must be suited for the saw and the material. The metal matrix or bond must also be “matched” to the material.

Tools for cutting hard, dense (less abrasive) materials (such as tile, hard brick, stone or hard-cured concrete) require a softer metal matrix. The softer metal matrix wears faster, replacing worn-out diamonds fast enough for the blade to keep cutting.

Tools for cutting soft, abrasive materials (such as block, green concrete or asphalt) must have a hard metal matrix to resist abrasion and ‘hold’ the diamonds longer.

Factors That Affect Cutting Performance

The life of a blade or bit and the speed at which it will cut depends on the following application conditions. For a manufacturer or distributor to supply the proper blade, they must be told what the material, project timing, and equipment conditions are for your job. If any of these conditions change, you should know how the change will affect blade performance.

Type of aggregate

The type of aggregate has a pronounced effect. Hard aggregates shorten blade life and slow the cutting rate. Cutting concrete with a hard aggregate, such as quartz, will cost much more than cutting concrete with a soft aggregate, such as limestone. Cutting concrete made with hard aggregates also requires more power.

Blades used to cut hard aggregates should have segments with tough diamonds and soft metal bonds otherwise the diamond particles will wear down even with the bond, and the blade will become glazed and unable to cut. Likewise, segments for cutting soft aggregates should have hard metal bonds, so that the diamond particles are not lost before their cutting life is used up. Aggregate hardness can be measured using the MOHs Scratch Test, the Los Angeles Abrasion-Loss Test, or the Shore Hardness Test.

Size of aggregate is also important. Concrete made with two-inch flint aggregate will be extremely difficult to cut, but concrete with; one--half-inch flint aggregate will cut much more easily. This is because there is more aggregate surface per unit volume of concrete in contact with the cutting segments when a larger size aggregate is used.

Reinforcing steel

Diamond blade I bond systems are designed to cut concrete which has an abrasive component present at all times. When diamond blades cut steel there is very limited abrasive material present resulting in slower cutting rates. The ratio of the volume of steel per unit volume of concrete has an impact on blade performance. The higher the ratio is the slower the cutting rate will be. Blade life will generally decrease as well.

Tip: When steel is encountered, reduce blade speed if possible, increase cutting pressure, and decrease water flow.

Operating speed

To keep blades from distorting at high speeds, they are manufactured in the form of a dish that will straighten when the blade is rotated at optimum speed. The dishing is small, about five ten-thousandths of an inch per inch of diameter. If the design speed is not achieved, the blade will tend to wander as cutting commences. This dishing is called tensioning. When a blade is said to be out of tension the amount of dish is not correct and the blade wobbles from side to side while out of the cut and wanders in the cut. An out of tension blade cannot be made to cut a straight line. It will cut a very regular sinusoidal line.

Manufacturers usually list the recommended operating speed directly on the blade. Recommended operating speeds for diamond blades are based on the blade size and the type of material to be cut. For optimum blade life and cutting speed, the actual operating speed will most likely have to be adjusted for the type of aggregate and the amount of steel encountered.

When in doubt about the correct operating speed for a particular material, choose a lower speed rather than higher speed. Then, if the blade cuts well, try increasing the speed to improve blade life. To cut softer and more abrasive materials use a faster operating speed, faster forward speed, and more water.

In general, higher operating speeds tend to lengthen blade life and slow cutting.

WARNING: Never operate a blade above the maximum or "Do Not Exceed" RPM stamped on the blade. Failure to comply with this speed will result in injury or death.

Depth of cut

The depth of cut should be adjusted such that a forward speed of 8 to 10 FPM (feet per minute) can be maintained. This speed has been determined over many years of cutting to be the most economical cutting speed based on labor costs, blade costs, machine costs and operation costs.

Coolant

Water or some other coolant must be used to cool most diamond blades. If not enough water is used, the swarf (fine particles) will not be removed from the cut quickly. This is a common cause of ***undercutting:*** the abrasive particles from the cut wear away that part of the steel core where the diamond segments are attached. Without sufficient water, the core will also overheat, causing cracks and premature loss of segments. To minimize blade wear, an adequate volume of water is essential. The water flow for saw blades should be between ½ and 3 gallons per minute. Sawing water systems can deliver a maximum flow of 5 gallons per minute.

Horsepower

If a blade is used with a machine that does not have sufficient horsepower for the diamond / bond system, the blade will not perform well. Diamond particles will polish forming flat spots and the blade will become glazed. Typically flat saws range in power from 8 to 75 horsepower. In selecting a blade, manufacturers or distributors should be told what the horsepower of the saw is. Using a blade designed for low horsepower saws on a high horsepower saw will result in fast cutting rate and short blade life. Using a blade designed for high horsepower saws on a low horsepower saw will result in slow cutting rates, long blade life.

To summarize all of these factors that impact blade performance the following chart is presented. This chart at first glance can be confusing; however, it does demonstrate the impact of changing any of the aforementioned variables on blade performance.

Variables Which Affect Diamond Blade Performance

VARIABLES	CONDITION	CUTTING SPEED	BLADE LIFE
BOND HARDNESS	HARDER	SLOWER	LONGER
	SOFTER	FASTER	SHORTER
DIAMOND QUALITY	LOWER	SLOWER	SHORTER
	HIGHER	FASTER	LONGER
DIAMOND AMOUNT	LOWER	FASTER	SHORTER
	HIGHER	SLOWER	LONGER
SEG WIDTH	THINNER	FASTER	SHORTER
	THICKER	SLOWER	LONGER
HORSEPOWER	LOWER	SLOWER	LONGER
BLADE RPM	LOWER	FASTER	SHORTER
	HIGHER	SLOWER	LONGER
WATER VOLUME	LOWER	FASTER	SHORTER
	HIGHER	SLOWER	LONGER
CUTTING DEPTH	SHALLOW	FASTER	LONGER
	DEEP	SLOWER	SHORTER
MATERIAL HARDNESS	HARDER	SLOWER	LONGER
	SOFTER	FASTER	SHORTER
ABRASIVENESS	MORE	FASTER	SHORTER
	LESS	SLOWER	LONGER
AGGREGATE SIZE	LARGER	SLOWER	SHORTER
	SMALLER	FASTER	LONGER
STEEL	LESS	FASTER	LONGER
	MORE	SLOWER	SHORTER

TABLE 2.1

Basics of Blades:

A diamond blade is a circular steel disc with a diamond bearing edge. The edge of the blade may be a smooth or textured continuous rim or a segmented rim with smaller, individual diamond sections.

The blade core is a precision-made steel disc, which may have a continuous rim or a slotted rim. The slots (also called "gullets") provide faster cooling by allowing water or air to flow between the segments. The slots also allow the blade to flex under cutting pressure.

Most blade cores are tensioned at the factory, so the blade will run straight at cutting speeds. Proper tension also allows the blade to remain flexible enough to bend slightly under cutting pressure and "snap" back into position.

Diamond segments or rims are made up of a mixture of diamonds and metal powders. Diamond used in blades is almost exclusively manufactured diamond in various grit sizes and quality grades. In the manufacturing process, the metal powder and diamond grit mixture is pressed and sintered to form a solid metal alloy (called metal bond or matrix) in which the diamond grit is suspended.

The segment or rim is slightly wider than the blade core. This side clearance allows the cutting edge to penetrate through the material without the blade core coming into contact with the material being cut.

To attach the diamond rim or segments securely to the steel core, several different processes are used.

- **Brazing:** Silver solder is placed between the segment or rim and the core. At high temperatures, the solder melts and bonds the two parts together.
- **Laser Welding:** The diamond segment and steel blade core are welded (fused) together by a laser beam.
- **Mechanical Bond:** A notched, serrated, or textured blade core may be used to "lock" the diamond rim or segments onto the edge of the blade. Mechanical bonds usually also include brazing or other metallurgical bonding processes to hold the rim or segments in place.

Diamond Blade Performance

Blade performance is a combination of both cutting speed and blade life. Selecting the right blade (for the saw, the material, and the job) is the most important factor in getting maximum performance. Many other variables also affect blade performance. Changing anyone variable will have an effect on cutting speed and blade life. Here are some examples:

RECOMMENDED OPERATING SPEED (RPM)

DIAMETER	SAFE SPEED (RPM)	MAX. SPEED (RPM)
8"	4,536	7,640
9"	4,032	6,790
10"	3,629	6,115

RECOMMENDED OPERATING SPEED (RPM)

DIAMETER	SAFE SPEED (RPM)	MAX. SPEED (RPM)
12”	3,024	5,095
12”	High Speed	6,300
14”	2,592	4,365
14”	High Speed	6,300
16”	2,268	3,820
18”	2,016	3,395
20”	1,8 14	3,055
22”	1,649	2,780
24”	1,512	2,550
26”	1,396	2,350
28”	1,296	2,185
30”	1,210	2,040
32”	1,134	1,910
36”	1,008	1,700
42”	864	1,455
48”	756	1,275

The chart above is based on 10,000 SFPM (surface feet per minute), which is the general optimum performance range for diamond blades, plus or minus 10%.

Blade shaft speeds (RPM’s at no load) for most tools will be higher than the recommended operating speeds shown above. Under normal sawing conditions, the actual blade shaft speed of the tool will slow down under load and should fall within the optimum speed range.

Maximum safe speed in revolutions per minute (RPM) is the maximum speed at which each blade can be used. Before using any blade, make sure the blade shaft (arbor) speed of the tool is within the “maximum safe” limit for that blade.

Blade Cutting Depths

The following numbers represent the maximum cutting depth for each diameter blade shown. The collar size on your saw determines how deep the blade will cut. Blade collars must be one-sixth the diameter of the blade to meet ANSI B7.1 code.

Saw Blade Cutting Depth	
Diameter	Depth
12”	3 ⅝”
14”	4 ⅝”
16”	5 ⅝”
18”	6 ⅝”
20”	7 ⅝”
24”	9 ⅝”
26”	10 ⅝”
30”	11 ¾”
36”	14 ¾”
42”	17 ¾”
48”	19 ¾”
52”	20 ¾”

Note: Diamond blade cutting depths listed above are approximate. Actual cutting depth will vary with the exact blade diameter or saw type (or brand) or the exact diameter of the blade flanges. Cutting depth will also be reduced if saw components (motor housing, blade guard, etc)extend below the blade flanges.

Trouble Shooting Blades

Core Cracks

One of the most common blade failures is core crack failure. Core Cracks are a result of the stress put on the core at the root of the notch or gullet from the segments being pushed into the material at the point of initial contact and being pulled out of the cut at the end of contact with the material. This is analogous to bending a piece of wire back and forth until it breaks. **Core cracking can not be stopped or eliminated.** Blade manufactures design the blade core system to not begin core cracking until well after the expected life of the blade under normal operating conditions. If during cutting operations the blade is subjected to pounding, twisting, overheating, or other abnormal stresses, core cracks will develop prior to the blade being worn out. The presence of a visible core crack renders the blade unusable. The danger in using a core cracked blade is that for every visible crack there are several cracks that are not visible. Continuing to use a core cracked blade will result in catastrophic failure of the core causing large sections of the core to fly off at energy levels equal to a 22 caliber bullet. **A core cracked must not be used.** Fig. 5 shows a core cracked blade that has two major cracks and several small cracks that under visual inspection may not be visible.

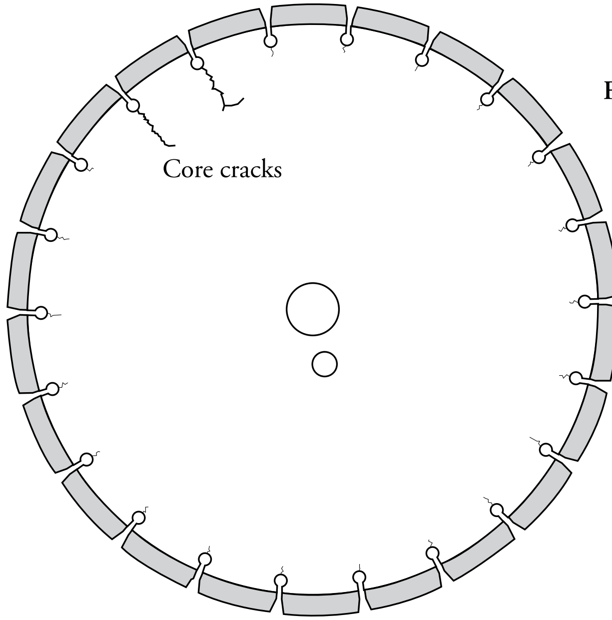


Fig. 5

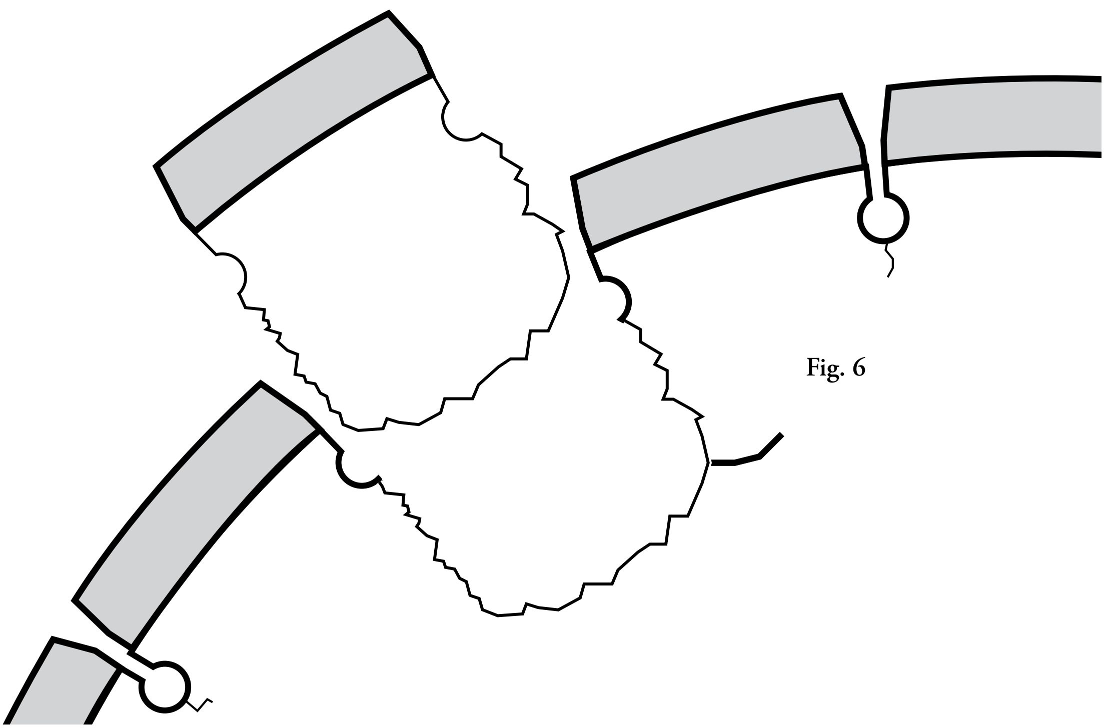


Fig. 6

Fig. 6 shows the progression of the two major cracks toward each other and the subsequent loss of the segment and attached core fragment.

This failure occurs almost instantaneously because the cracks progress slowly until the material separating the cracks can no longer withstand the stresses imparted to it and then failure occurs at the speed of sound in steel which is 19,553.81 ft/sec.

One of the leading causes of core cracks is that the blade specification is too hard for the material being cut. The saw operator has a tendency to push the blade very hard in order to "make" it cut. Eventually something has to give, and many times it is the steel core which cracks. The solution is to check the blade specification and make sure it is the correct one for the material the user is cutting. If the blade has become dull, sharpen it by cutting some soft abrasive material such as asphalt, block or mortar before sawing again.

A misaligned saw or excessive side pressure put on the blade while cutting can cause core cracks. A misaligned saw or excessive side pressure can be detected by uneven signs of wear on one side of the blade core. To prevent this problem, make sure that your saw is properly aligned and cuts in a straight line. If, for whatever reason, the blade begins to saw "off-line", it is easier on the blade (and generally faster), to take the blade up out of the cut and restart the cut on-line. Continually trying to make alignment correction while the blade is in the cut will cause core cracks.

A worn blade shaft or blade shaft bearing can set up a "pounding" effect. Be sure that your saw is properly maintained and that worn blade shafts or blade shaft bearings are replaced immediately.

Segment Loss

Except for rare instances such as bad weld or undercutting, the reasons that diamond blade segments are lost are impact damage or extreme stress. Let's look at some of the common causes for segment loss.

Material slipping and jamming itself against the blade is a common cause for segment loss, particularly in masonry or tile sawing applications. Many times the break itself will appear very jagged, and damage to the core itself will be obvious. To prevent this type of damage, the saw operator must make sure that the material is "seated" securely on the saw, and that he holds the material firmly through the entire cutting stroke.

A worn blade shaft or blade shaft bearing is another common cause of segment loss. In addition to loose or broken segments, these blades will sometimes show signs of eccentric or uneven segment wear caused by the "pounding" effect of the blade in the cut.

A worn blade shaft can be the result of blades spinning on the shaft which wears a groove in the shaft at the point where blades are normally mounted. With a grooved shaft, the blade drops into the groove when it is mounted on the saw. This means the blade is mounted "off center" and will be jumping up and down in the cut.

This same type of "pounding" effect can be caused by worn blade shaft bearings which allow the blade shaft to move up and down inside the bearing housing.

Both the blade shaft and the blade shaft bearing should be checked regularly. At the first sign of wear or damage, those parts should be replaced.

Inadequate water supply or air coolant is a frequent cause of blade damage. If diamond blades are not properly cooled, they can generate a tremendous amount of heat from friction in the cut. It is critical that saw operators constantly monitor water flow on wet cutting diamond blades, and the entire water system should be checked regularly, including the water pump, water tubes and water jets in the blade guard.

For dry cutting diamond blades, the operator's sawing technique is critical in making sure that there is plenty of cooling air flow around the blade. Dry cutting diamond blades should not be used for one-pass, deep cutting or subjected to continuous cutting pressure. It is important to remember that dry cutting blades are cooled with air, and must be given periodic rest periods (i.e. Removal of cutting pressure) to allow air to remove the heat generated in the cut.

The effects of inadequate water or air coolant on a diamond blade are obvious. Blades will typically have black and blue discolorations around the edge of the blade. An overheated blade can also show other signs of damage such as segment loss, tension loss and core cracks.

Preventing overheating problems on wet cutting diamond blades is really very simple. The operator must make sure that he has adequate water flow on both sides of the blade at all times. Many times it only takes a few seconds without water for blades to be damaged.

For dry cutting blades, saw operators should make intermittent shallow cuts. If full depth cutting is required, the operator should make several shallow passes (step cut). Dry cutting diamond blades should be used only for intermittent sawing. This means that the blade should be allowed to run free by taking cutting pressure off the blade every few seconds and allowing it to run back up to full speed. The operator must allow air to flow around the blade core to keep it cool.

A mismounted diamond blade or loose blade flanges can cause segment loss. The nut or bolt which holds the flanges and blade shaft together on the shaft must be "wrench tight". If the blade shaft bolt or nut is not tightened securely, the blade may "flutter" on the shaft at high speed. Diamond blades which have lost segments due to loose flanges will sometimes have damaged or distorted arbor holes or drive pin holes.

If foreign material such as dirt or sand is between the blade core and flanges, or if he blade is mismounted on the shaft, the blade still may "flutter" on the shaft - even though the blade shaft nut or bolt feels "tight". Often there is evidence of debris on the blade or flanges, or marks around the arbor hole as evidence of mismounting .

Excessive Wear

Sooner or later everyone involved in using diamond blades hears about this one... "The blade wore out too fast". Before you get too far, make sure that you do indeed have a problem. Every user seems to have a different opinion about what is acceptable diamond blade life. Just make sure that you understand what is considered good blade life, and what is considered bad blade life.

Assuming there is a problem, the most common cause is simply using the wrong blade specification. If you buy a "bard cured concrete" blade specification, and then uses it to cut asphalt, the blade will wear out very fast. Check the application and then check and make sure have the right blade for the job.

Insufficient water supply or cooling air can cause excessive diamond blade wear. Make sure that there is plenty of water for cooling wet cutting diamond blades, and make sure proper sawing techniques are used with dry cutting diamond blades. Saw operators need to get into the habit of making sure that there is proper coolant on the diamond blade.

Another cause for excessive diamond blade wear is insufficient power or speed to the blade. Whenever a blade is turning well below the recommended speed range, the blade will tend to wear fast. This condition can be caused by loose drive belts, a lack of power from the engine. or low voltage/amperage going into the electric motor.

To correct this condition make sure that you have adequate voltage and amperage going into your electric motor. Also check belt tension regularly. Voltage and amperage should be checked at the motor. For gas or diesel engines, make sure that they are properly tuned and that they are running at full speed when sawing. The blade user should make sure to match the diameter of the blade to the blade shaft speed of the saw. 'While it is acceptable to use a slightly smaller blade on a given capacity saw, (such as using a 12" (300mm) diameter blade on a 14" (350mm) capacity saw), a substantially smaller blade used on a larger capacity saw will cause the smaller diameter blade to be turning at a very low speed, decreasing blade life.

Undercutting

Undercutting is a common condition found in almost every blade application involving the sawing of abrasive materials. Undercutting is caused by abrasive slurry wearing away the steel core, just beneath the diamond segment. The steel core can wear to a "knife edge" which will cause the diamond segments to separate from the core. This condition is found mostly on diamond blades used for asphalt or green concrete pavement sawing. Undercutting can be greatly accelerated when the diamond blade cuts completely through the pavement and into the loose sub-base.

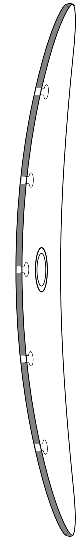
While the undercutting problem on a diamond blade is easy to diagnose, preventing undercutting on diamond blades is impossible. A certain amount of undercutting is normal and acceptable on green concrete or asphalt sawing. Further, by adding some type of undercut protection, such as recessed segment blade cores or undercut retardant inserts, the undercutting wear can be slowed down to the point that the user can get full use out of his diamond segments before the steel core wears completely through.

Another means of slowing down undercutting action is to be sure to use plenty of water on the diamond blade. This will help keep abrasive slurry washed out of the cut. When sawing, the user should take care not to cut completely through the pavement into the sub-base. One way for the operator to keep the blade out of the sand and dirt is to watch the color of slurry which flows up out of the cut behind the blade. When this slurry starts becoming very muddy and sandy, he should raise the cutting height of the blade until the water starts to run more clearly. The operator can then proceed with the cut, checking the slurry coming out of the cut frequently

Other Blade Problems

The problems we have discussed cover the most common blade problems encountered. The following are a list of other blade problems that you will encounter and are presented in a cause and remedy format:

Loss of Tension



Blade is used on a misaligned saw.
Check for proper saw alignment.

Blade is excessively hard for the material being cut, creating stress on he steel center.
Make certain that the blade is correct for the material being cut. (Consult manufacturer's recommendation chart or see your dealer)

Material slippage causing the blade to twist and become kinked or bent.
Maintain a tight grip on the material while sawing.

Utilizing blade flanges that are under size or not the same diameter, creating uneven pressure on the center.
Make certain that the blade flanges are of proper size and identical diameter.

Blade is used at improper RPM, overspeeding.
Make certain the blade shaft is turning at the proper RPM by using a Tachometer. This is especially important 'with concrete saws.

Blade is improperly mounted on the arbor shoulder and becomes bent when the flanges are tightened.
Hold the blade securely on arbor shoulder until the outside flange and nut are firmly tightened.

Blade core is overheating from lack of side clearance due to uneven or too rapid segment wear.
Specify a blade with a greater side clearance or a specification more suited to the material being cut.

Blade core is overheating from lack or adequate coolant.
Check water supply system for even water flow on both sides of the blade. For dry cutting, make more shallow, intermittent cuts allowing time for air to cool the blade

Undercutting

Undercutting is a condition in which the steel core wears faster than the diamond segment, especially in the areas where the segment and core are joined. The condition is caused by highly abrasive material grinding against the blade during the sawing operation. Usually materials containing sand are responsible for causing this condition. (See section on Segment Loss.)
The flow of slurry (abrasive cuttings) must be distributed over a wider area, away from the critical segment area. On most occasions this can be accomplished by using undercut protectors specially positioned around the steel core to change the pattern of abrasion. Although successful in most cases, undercut protectors do not provide 100% protection. Use high water flow to thin the slurry and flush away sand articles.

With a floor saw, sawing all the way through the material, allowing the blade to pickup sub-base material.
Set the cutting depth slightly less than or equal to the total thickness of the slab.

Cracked Core

Blade is too hard for the material being cut.
Use the correct blade with a softer bond.

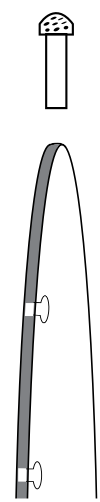
Excessive culling pressure, or jamming or twisting the blade in the cut can cause the blade core to bend or flex. When subjected to extreme stress and metal fatigue, the blade's steel core will eventually crack.
The saw operator should use steady, even infeed pressure, and be careful not to twist or jam the blade in the cut.

Overheating through inadequate water supply or improper use of dry cutting blades.
Use adequate water to cool wet cutting diamond blades (for example, 2 to 5 gallons per minute (7-18 liters per minute) for concrete saws). Allow adequate airflow around dry cutting diamond blades to prevent overheating.

RPM is too high.
Check the operating RPM of the blade shaft. Change equipment or blades if necessary.

Blade is out of tension.
Replace the blade or have the blade retensioned by manufacturer.

Excessive Wear



Using the wrong blade on highly abrasive material. (Example: hard concrete blade used on asphalt).
Recommend the proper blade specification for abrasive material.

Lack of sufficient water to the blade. Often detected by examining the segment and noting overexposed or highly exposed diamonds.
Clean up the water system. Make certain the water pump is functioning properly.

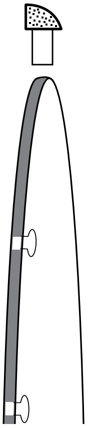
Wearing out of round accelerates wear. Usually caused by bad bearings, worn shaft or using a blade too hard for the materials being cut.
Check the bearings and arbor. If worn, replace with new parts before installing another blade; select the proper blade for the application.

Insufficient power caused by loose V-belts, inadequate voltage/amperage, or improper RPMs.
Tighten belts (taut). Replace worn belts. Check voltage/amperage. Use proper size extension cord.

Blade is not perpendicular to material being cut.
Check blade shaft and flanges to ensure proper alignment of the blade and equipment.

Blade shaft RPM is too low.
Check the operating RPM of the blade shaft. J f necessary, change equipment or modify the blade shaft speed.

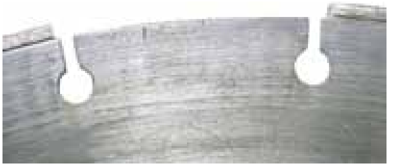
Uneven Segment Wear



Segments worn on one side reducing side clearance. Usually caused by misalignment of the saw or a lack of sufficient water on both sides of the blade.
Check the saw alignment. Clean the water system, making certain that water is properly applied to both sides of the blade. Check to see if the pump is supplying sufficient water. (See Excessive Wear section)

Blade is worn out of round due to bad bearings, worn arbor, missing bushing, arbor hole larger than arbor, cleanliness of or damage to flange surfaces or excessively dull condition. (See section on Excessive Wear).
Replace the bearings or worn arbor as required. Inspect the flanges for damage and foreign materials; replace if necessary. Do not remove drive pins when supplied with blade flanges.

Segment Loss



Blade is too hard for the material it is cutting, causing excessive dullness, which causes the segment to pound off or fatigue.
Use a softer blade specification.

Worn blade flanges fail to provide proper support, causing the blade to deflect.
Replace both blade flanges.

Out of round blade rotation results in pounding, caused by a worn arbor or bad bearings in the shaft.
Replace worn arbor and/or bearings.

Overheating. Usually an easily detected bluish color on the steel center, generally confined to the area where the segment was lost.
Check the water system for blocked water passages. Test the pump to see if it is functioning. For dry cutting it may be necessary to make shallower cuts and allow the blade to run free every few minutes to let the air cool it.

Segment is subjected to sudden, sharp jolting while moving the machine or when contacting the material being cut.
A void jarring the blade when transporting the machine. Contact the material with slow, even movements.

Undercutting (see page 21).
See page 21.

Repair note: It is possible to replace two or three missing diamond segments, providing the steel center is not cracked or undercut badly. If many segments are missing, or if there is less than 50% blade life remaining, repairing the diamond blade may not be economical. Be certain to eliminate mechanical or operational problems before installing replacement blades.

Blade Won't Cut

Blade is too hard for the materials being cut. (Examples: block or general purpose blade being used for extended period on hard brick. Asphalt blade being used to cut hard concrete.)
Consult the dealer or manufacturer for the proper blade to cut materials on the job.

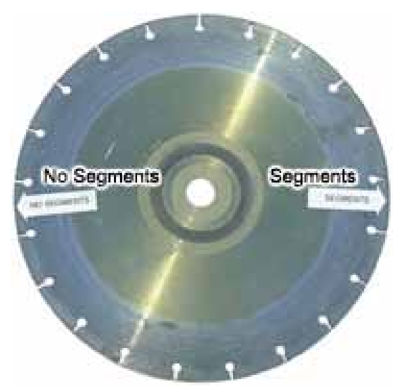
Insufficient power to permit the blade to cut properly. (Loose V -belts, low voltage, motor lacks horse-power).
Check belts, voltage/amperage and horsepower.

Blade segments still appear to have plenty of life, but the blade will not cut.
Some blades have a non-diamond bearing section in a backing at the base of the diamond segment for better adherence to the steel core. A blade used to this stage has worn out in the normal manner and should be replaced.

Blades become glazed due to excessive RPM.
Match blade specification and diameter to the machine RPM and cutting conditions.

Blade becomes glazed due to inadequate pressure against the material being cut.
Ensure proper pressure to keep the blade sharpened, while avoiding an excess of pressure.

Eccentricity (Blade out of Round)



The bond is too hard for the material being cut. The hard bond retains the diamonds, which begin to round off, causing the blade to become dull. Instead of cutting, the blade begins to pound, causing the blade to wear out of round.
Change to a softer bond, which will wear away more readily, allowing the dull diamonds to be released and sharp, new cutting edges to become exposed.

The saw's blade shaft may have a groove scored in it, caused by a blade spinning between the flanges. A new blade, installed on the arbor shaft, will seat into the groove, and immediately run eccentrically when the saw starts.
Replace the worn shaft.

If the blade shaft bearings are worn, the shaft and mandrel will run eccentrically, causing the blade to wear out of round. Can happen with concrete saws when proper lubrication of the bearings is neglected.
Install new blade shaft bearings. In some cases it might also be necessary to replace the blade shaft if it is worn or out of alignment.

Arbor Hole Out Of Round

Saw arbor badly worn due to blade being improperly mounted.
Be certain the blade is properly mounted on the arbor before tightening the flange.

Blade flanges have been improperly tightened, permitting the blade to rotate on the shaft.
Always wrench tighten the arbor nut. Never hand tighten. Always use hexagonal nuts. Never use wing nuts.

Blade flanges, drive pin or the arbor shaft are worn and not providing proper blade support.
Check the blade flanges, arbor shaft and drive pin for wear, foreign matter and proper tightness. Both flanges should be no less diameter than recommended by the manufacturer. Replace worn parts.

Note: If the out of round condition of the blade is not too serious, return the blade to the factory for possible repair.

Cracked Segments

Blade is too hard for the material being cut.
Use a blade with a softer bond.

Blade is being flexed in the cut by misaligned saw, or operator making dramatic saw course corrections.
Align saw. If cut has slightly wandered off line, gradually steer the saw back on line. If the cut is way off line, remove the blade from the cut. Align the saw blade with the cut line, plunge the blade to proper cut depth and resume sawing.

Blade is overheated.
Apply proper cooling.

Overheated Blade

Adequate coolant was not provided.
Check the water supply for an adequate volume and for obstructions through water system. Use dry blades only for shallow cutting of 1 to 2 inches deep (2-5 cm) or step cutting. Allow the blade to run free every 10 to IS seconds to increase cooling airflow.

Using improper specification for the material being cut.
Consult the manufacturer’s specification chart for the proper blade.

Glazed Blade

Glazed Blade: Surface of segment and diamond are smooth

Reasons:
- Diamonds are too friable
- Bond is too hard
- Blade speed is too high

Results:
- Blade initially cuts, slows and then stops cutting
- If cutting conditions are not modified, overheating, segment loss, segment breakage, core cracking or tension loss will occur

Crushed Diamonds

Crushed Diamonds: Majority of diamonds show heavy fracture

Reasons:
- Diamonds are too friable.
- Diamonds are too large.
- Excessive pounding or vibration.

Results:
- Blade cuts fast.
- Blade life is short due to premature loss of diamonds if bond cannot hold the crushed diamonds.

Heavy Premature Diamond Loss

Heavy Premature Diamond Loss: Surface of segment has a high percentage of missing diamonds.

Reasons:
- Diamonds are not impact resistant, too low in quality.
- Bond is overpowered by cutting conditions and high quality diamonds were used.

Results:
- Blade cuts very fast.
- Blade wear is high.
- Short blade life.

Polished Segment

Polished Segment: Diamonds are smooth or have flat tops and protrude from the bond surface.

Reasons:
- Diamonds have too high impact resistance.
- Diamond size is too large
- Diamond concentration is too high
- Insufficient workload on diamonds

Results:
- Blade initially cuts, slows and then stops cutting.
- If cutting conditions are not modified, overheating, segment loss, segment breakage, core cracking or tension loss will occur.

Over-exposed Diamonds

Over-exposed Diamonds: Diamonds protrude from bond with minimal support from bond.

Reasons:
- Abrasive resistance of bond is incorrect for the material being cut
- Diamond concentration and bond type are unsuitable for the application

Results:
- Blade cuts fast
- Blade life is short due to premature loss of diamonds

Do's and Don'ts

Wet Cutting Do's

- Do follow manufacturer's recommended blade specifications for material to be cut.
- Do inspect the diamond blade for damage that may have occurred during shipment or damage due to previous use.
- Do check mounting flanges for equal diameter, excess wear and flatness. Mounting flanges must have adequate relief around arbor hole.
- Do be sure that the diamond saw blade is mounted on a correct diameter blade shaft between proper blade flanges and is securely hand-tightened with a wrench.
- Do check the saw for proper operating conditions:
    - All fluids are at proper levels.
    - Blade shaft bearings should be free of end and radial play.
    - V ·belts should be properly tensioned and pulleys checked for excessive wear.
    - Lead-off adjustment is set correctly, to allow the blade to travel straight.
    - Do operate with blade guard in place and properly secured.
- Do be sure there is a continuous water flow to each side of the blade. Gravity feed does not supply sufficient water flow. **The water pumps on concrete saws are "booster" pumps only and are not adequate as a primary pressure source.** An adequate water supply is required for wet cutting blades to maintain blade life and cutting efficiency.
- DO FOLLOW THE MANUFACTURER'S RECOMMENDED PULLEY SIZES AND OPERATING SPEEDS. FOR SPECIFIC BLADE DIAMETERS, REFER TO MANUFACTURER'S OPERATING MANUAL.
- Do operate saw with proper safety attire, i.e., safety glasses, safety helmet, safety shoes, hearing protection.
- Do examine blade periodically for cracks in the steel center or segments and for excessive wear under the segments.

Wet Cutting Don'ts:

- Don't use a diamond saw blade without checking manufacturer's recommendations for the material to be cut. Improper selection can cause excessive blade wear and possible damage to the diamond saw blade and/or machine and create an unsafe operating condition.
- Don't use a new diamond saw blade, or remount a used blade, which has a core that is not flat or is cracked. This indicates segment damage or loss or a damaged arbor hole.
- Don't use mounting flanges that are not clean and flat.
- Don't force blade onto machine blade shaft or mount blade on undersized blade shaft. Either condition can result in unsafe operating conditions and excessive blade wear.
- Don't mount blade on machine that does not meet the minimum requirements set forth in the manufacturer's machine operating manual.
- Misalignment of the blade results in loss of blade side clearance and proper blade tension.
- Loose or worn blade shaft bearings cause short diamond blade life and may cause segment loss.
- Use of worn pulleys or improper feed belt tension causes loss of proper operating speed and reduced blade efficiency.
- Restricted coolant flow causes excessive heat, poor blade performance, and possible segment loss.
- Don't cut dry with blades recommended for wet cutting.
- Don't use blotters with diamond saw blades.
- Don't operate machine with a damaged or open blade guard.
- Don't exceed maximum safe operating speed.
- Don't operate machine without blade guard in place and properly secured.
- Don't operate machine before reading operating instructions provided by machine manufacturer.
- Don't operate machine with blade diameter larger than the machine's capacity.
- Don't allow bystanders in the work area.
- Don't stand in direct line with diamond or abrasive blades during start up or operation.
- Don't increase saw travel to a rate that will reduce the blade's operating speed.

Dry Cutting Do's:

- Do follow manufacturer's recommendation regarding specifications for material to be cut and suitability for dry cutting applications.
- Do inspect the diamond saw blade for damage that may have occurred during shipment or damage due to previous use.
- Do inspect the diamond blade periodically during use for core flatness, fatigue cracks. segment damage, undercutting and arbor hole wear.
- Do check the mounting flanges to be sure that they are of equal and correct diameter, that they do not show excessive wear and that they are Oat.
- Do be sure that the diamond blade is mounted on a correct diameter blade shaft between proper blade flanges and is securely hand tightened with the wrench provided or an adjustable wrench no longer than 8".
- Do check for proper saw machine condition. Spindle bearing should be free of end and radial play. Consult the operating manual from the saw manufacturer for proper machine maintenance conditions.
- Do follow the manufacturer's recommendation for operating speeds for specific blade diameters.
- Do maintain a firm grip on hand held saws during cutting operation.
- Do wear proper safety equipment. Always wear safety glasses, safety footwear, snug fitting clothing, hearing and head protection and respiratory equipment where required.

Dry Cutting Don'ts:

- Don't cut dry except with a blade specifically designated for dry cutting by the manufacturer.
- Don't force blade onto machine blade shaft, alter the size of the mounting hole, or tighten mounting nut excessively. Use of bushing to reduce the arbor hole size is not recommended for diamond blades used on high-speed saws.
- Don't exceed the maximum operating speed established for the diamond blade.
- Don't operate a saw without proper safety guards in place. NEVER OPERATE ANY SAW, WET OR DRY, WITHOUT A BLADE GUARD!
- Don't stand in direct line with diamond or abrasive blades during start up or operation.
- Don't cut or grind with the sides of a diamond blade.
- Don't force the blade into the material; allow the blade to cut at its own speed. Forcing the blade may cause overheating and blade damage.
- Don't make long continuous cuts with dry diamond blades. Allow the blade to cool by turning in air every few minutes. The harder the material being cut, the more often the blade should be allowed to cool.
- Don't use the blade to cut material other than that recommended by the manufacturer for that specific blade type.
- Don't use the blade on a type of saw other than that specified by the manufacturer.
- Don't allow the blade to deflect in the cut.
- Don't attempt to cut a curve or a radius.

Trouble Shooting Diamond Blade Cutting

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