UKAM Industrial Superhard Tools Division of LEL Diamond Tools International, Inc.
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DIAMOND DRILLING IN THE NEW MATERIAL AGE

Selecting the right diamond drill for your application will save you time, money, and improve the overall outcome of your project.

by BRIAN FARBEROV, **VP President** UKAM Industrial Superhard Tools, Valencia, Calif.

Today's growing variety and ever changing materials, Manufacturers, R & D facilities, hobbyists and everyone else involved in diamond drilling encounter wide variety of applications and challenges. **The ever increasing variety of advanced, new generation, ultra hard, composite, micro, and exotic materials transform the way we look at diamond drilling. And set many age old diamond drills and drilling methods obsolete. New materials require different technology and methods.** And although, today's market place offers the Production Engineer, R & D Scientist, Hobby Enthusiast, and Home Owner hundreds of choices of diamond drills, accessories, and equipment. It offers little advice on how the user can implement these tools to accomplish their specific objectives.

Many users still spend days and even weeks, trying different drills, and experimenting with different types of drilling equipment. An expensive and time consuming trial and error process, witch can be avoided with proper understanding of your material and objectives you need to accomplish. **Proper preparation, attention to detail, and following basic drilling technique can make the difference in the success of your drilling operation**. The following are some factors and criteria to consider when selecting the right diamond drill for your application.

MATERIAL TO BE DRILLED

Materials you are planning to drill will have a large impact in the types of diamond drills, equipment, and accessories you will be able to use. If you are drilling ultra hard materials such as sapphire, alumina, other types of advanced ceramics, high metallic content materials, precious and natural stone. It is generally recommended that you use a sintered (metal bonded) diamond drill. However, if you are drilling softer and less expensive materials such as glass, composites, soft stone and tile, an electroplated (nickel bonded) diamond drill may be a better and more cost effective solution. As a rule of thumb harder materials require softer bond, to drill faster and freer. While softer and abrasive materials require a harder bond, to last longer.

If the material you are planning to drill is precious, valuable, or expensive. The diamond drill cost will play a minor role in your drilling operation. It is suggested that you obtain a **thin wall diamond core drill** to minimize material loss and deformation. It's always a good idea to have some type of an estimate of target cost and quality per hole.

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Material Thickness

Material thickness will also play a critical role in your diamond drilling operation. Usually thicker materials require larger amount of coolant and water pressure. Drilling Depth of most applications require drilling depth of not more than 1". Applications requiring you to drill over 1" should be tread in a different way. We recommend running coolants from multiple directions. Through drill center, from side of drill, as well as drilling submerged in coolant. This will insure maximum amount of coolant and lubrication reaching your drilling zone. Apply more pressure and reduce speed the deeper you penetrate into your material. Lift drill up, after every inch drilling into your material, letting the drill cool and coolant reach deeper into your hole. Carefully examine the diamond tip condition, making sure its round, and not overheated.

Your maximum drilling depth will also be limited by spindle travel. The distance your drilling equipment can move in an upward and downward motion before touching the surface of your material. Make sure to take this into consideration when ordering diamond drills.

EQUIPMENT TO BE USED

The equipment you will be using and its physical condition, will dictate the speeds (RPM's) and coolants you can use along with your drills. Hence, somewhat limiting your diamond drill selection. **No matter what diamond drill you use or how well its made, it will not provide the performance you are looking for, if you don't use the right drilling equipment for your application.** Diamond drills are usually used on a drill press, angle grinders, hand held drills, milling machines and cnc equipment. A drill press, milling machine, or CNC machine is used in most production applications. R & D facilities also tend to utilize the same equipment. Hobby Enthusiasts, Contractors, and Home Owners most often use hand held drills, followed by drill presses, drilling rigs, and angle grinders.

Drill Press

For most drilling applications we recommend a you use diamond drills on a drill press. The drill press provides uniform drilling consistency, tighter tolerances, and better overall performance. Although it may cost more than an angle grinder, hand held grinder, or hand held drill. It will pay off in the long run. Although there are hundreds of different types of drill presses on the market. For the most part, drill presses can be classified as four different types:

Bench Drill Press is the most frequently used drill presses. Designed for smaller jobs and usually bolted or clamped to table or bench top or stand. This is the smallest and least expensive type of drill press. Perfect for the hobbyist and beginner. Floor Drill Press are larger drill presses. Usually has a base that stands directly on the floor of your shop. This drill press can be extended and adjusted for optimum use and movement. An operator may use this drill press in either sitting or standing position.

This type of drill press can be found used in most manufacturing and R & D facilities. Industrial / Production Drill Press on the other hand is a more heavier duty drill press, similar to a milling machine. Usually come with adjusted RPM (variable speed), larger drilling table (area) for holding larger parts (material), more powerful motor, capability to use chuck or collet, move drilling head up and down, move table horizontally and vertically. This type of equipment is used in more high production scenarios.

A few high production and manufacturing facilities have Specialty / Custom Drill Presses built specifically for their material / application. For example, when machining very

brittle or fragile materials the drill press will be made from special type of metal to minimize dust and corrosion.

Many come with X, Y, Z axis and have ultra precise chucks, collets, water pumps and devices. With these types of drill press you are usually able to regulate drilling depth either electronically or by computer, maintain consistent speed and feed rate. More advanced drill presses today may have feed back mechanism that provides information on all of these variables.

When buying a Diamond Drill to fit your current Drill Press or buying a Drill Press to fit a Diamond Drill, we recommend you carefully examine both drill and drilling equipment specifications to make sure they are compatible. Some variables you should consider:

Drill presses run on electric motors rated in horsepower. **Make sure the motor for the drill press you choose is powerful enough for the material you are planning to drill and the diamond drill you are planning to use**. Most Bench Drill Presses have motors rated between .3 hp and .5 hp. Floor Drill Presses on the other hand have motors that run between .75 hp and 1.5 hp. We recommend you choose the highest power motor you can afford. Doing so will place less strain on your job and will allow you to be more flexible, if you decide to use another drill or drill a different type of material in the future.

Depending on the material you are planning to drill, you will need to adjust the speed (RPM) at witch you diamond drills run. A drill press will usually allow you to run your diamond drills between 500 RPM (Revoltutions Per Minute) to 3,500 RPM. Some Drill Presses only provide specific speed settings, such as 500, 1,000, 1,500, 2,00, 2,500, and 3,000 RPM. This may be acceptable to you, again depending on the diameter of the diamond drill and material you are planning to use it on. **Before buying a drill press, make sure it will run at the Recommended RPM set for your diamond drills.**

Another important factor to consider when buying a drill press, is its throat depth. Drill Press design usually limits the distance between the center of the spindle (where the diamond drill is placed) and front edge of the vertical post that is used to support the drill head. This is called the throat depth. When drilling a hole in the center of a round work piece such as a tabletop, the radius of your work piece will need to be less than the throat depth itself.

Drill Press Variables:

Spindle Travel - The spindle of a drill press moves up and down only a certain distance. The distance the spindle can move is called spindle travel. This determines the maximum depth of the holes you will be able to drill. The drilling depth of your diamond drill will need to reflect and consider the spindle travel of your drill press.

Table Adjustments - Most Drill Presses have a tilting worktable. Some have the capability to tilt 45 degrees left and 45 degrees right. Others can tilt a full 90 degrees in each direction. Before buying a drill press, make sure the model you are considering, can work with the angles you need to make for your application. It is also recommended that the table swing in the horizontal pane as well. An excellent type of drill press is the on that can spin completely around the post.

Head Adjustments - A number of Drill Presses supplement a tilting table with a tilting drill head. Tilting heads typically move 45 degrees left and right, and ease the mind-bending work of compound angles. We recommend you are comfortable with both the adjustment mechanism and the angle gauge before using or buying this type of drill press.

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Drill Press Accessories - There are a number of accessories on the market that will make your drilling experience faster, easier, and provide better performance as well as lower cost per hole. A few important ones include:

Water Swivel Adapters - used to supply water through the center of your drills. Increase drill life 40% to 75%, improve quality of hole, and surface finish.

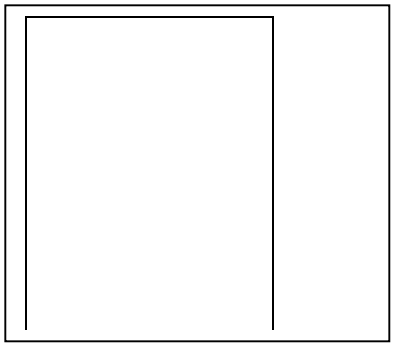
Shank Adapters - thread into your diamond drill collet, and allow the diamond drill to be placed in the drill press chuck.

Vises and Clamps - Designed for your drill press worktable. Hold you material firmly in place while drilling

Angle Grinders / Hand Held Grinders

Angle / Hand Held Grinder offer your diamond drilling operation the advantage of low cost, and increasing versatility.
With this one piece equipment you can drill, cut, grind, and polish. An angle grinder is excellent choice for small jobs, outside jobs, drilling hard to reach places, or when drilling a very large piece of material. An excellent alternate, where use of a conventional drill press is not feasible. Angle grinders can run up to 10,000 rpm. Water swivel adapters specially designed to fit all popular angle / hand held grinders can extend the capability of your angle grinder by supply coolant through center of your diamond drills or many other diamond tools. Giving your angle grinder and diamond drills to accomplish improved efficiency, drilling speed, and surface quality finish.

Hand Held Drills



Nothing beats the versatility and ease of use of a Hand Held Drill. Hand held drills are lightweight and portable, and can be taken with you anywhere you go.
Perfect for use on horizontal surfaces, and outside jobs. There are over a dozen of different types of hand held drills available on the market. Hand held drills are designed for use in many different applications. Some are made to use with low RPM's and there are some that can run over 35,000 RPM. A hand held drill is an excellent tool for the contractor, hobby enthusiast, and home owner.

Hand Held Drills are available in a wide selection of both corded electric and battery-powered cordless models. The drill type you choose will effect your drilling capability in terms of material and diameter of the hole. The first step in selecting the right hand held drill for your application is determining the size of holes you need to drill and in what materials will you are planning to drill.

Make sure you select the hand held drill that actually has the capacity to do the work you need. Doing so will make your jobs faster and easier. As well as avoid problems such as ruining the diamond drill or material, caused by drilling with the wrong hand held drill or hand held rill without enough capacity.

The following are some of the features you should consider when choosing the right hand held drill for your application:

Capacity

A hand held drill's capacity indicates the largest hole size you can drill. Most hand held drills are ranked according to the maximum diamond drill shank the chuck can hold. Most popular drill shank sizes are 3/8" and 1/2". For smaller Foredom™ and Dremel™ machines, shanks size is usually 1/8" or 1/16".

Power

Make sure your hand held drill has enough power to use the diamond drill at the recommend RPM. Hand held drills are ranked according to maximum horsepower the motor can give. If your hand held drill does not have enough power, your chuck capacity will be irrelevant.

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And you will not be able to drill the size of hole and material you need. Before buying a hand held drill, we recommend you compare the horsepower of the drill. By the same token, if you will be working only with small, or soft material, and need to drill only a few holes an inexpensive drill will probably be sufficient for your application. However, if you are planning to drill a large amount of

holes, drill hard materials, or make deep holes and need to use your drill often, a more heavy duty and higher powered drill will be required.

When drilling, ***never force your hand held drills***, doing causes a more wear and tear on your drill, than associated with normal usage. Hence, decreasing your machines life and deteriorating future performance.

CNC / Milling Machines

The best drilling results, precision tolerances, surface finish, and consistency will be obtained on a CNC / Milling Machine. An ideal choice for **high production drilling operations**

This equipment is fully automatic and controlled by a computer. And costs more than other types of drilling equipment.

Number of Holes to be Drilled

Your diamond drill requirements will greatly vary with your frequency of use and the number of holes you need to drill. High production diamond drilling requirements greatly differ from R & D, contractor, hobby, and home owner requirements.

Diamond Drills in production setting are used every day or several times a day, drilling several thousand holes until the drill is warn out and replaced. Metal Bond (Sintered) diamond drills are usually recommended for this type of heavy duty use. However, if you have a very fine or specific finish requirement and do not polish material after drilling. HYBRID Bond diamond drill may be the best solution for your application.

If you are planning to use Diamond Drill occasionally for a specific job and than stored for later use, or make less than a 100 holes, we recommend you use an **electroplated** (nickel bond) diamond drills are recommended. However, if you are planning to use the drill a number of times through the year. **Sintered (metal bonded) diamond drill** is a better overall solution and investment.

Technical Requirements/Specifications

Chipping/Finish Requirements – if you have an application where surface finish and chipping is a critical factor, a sintered **(metal bond) diamond drill** with a very fine diamond grit may be the best solution. **HYBRID Bond diamond drill** is another alternative.

Tolerances – if you are using diamond drills to drill holes in a product that requires on specific tolerances, you will need a **custom diamond drill** specifically designed for your application. Its important to have some kind of an idea on what accuracy and tolerance you need to obtain. Diamond Drills, accessories, and drilling equipment should be selected to achieve these requirements. Each material has different density, hardness, composition. For this reason a diamond drill and technique that may work on one material, may not work on another material. To obtain optimum drilling results, each diamond drill should be ideally made to factor in the unique differences and properties of each material.

Material Cost – if the material you are drilling drill precious, valuable, or expensive. The diamond drill cost will play a minor role in your drilling operation. It is suggested that you obtain a **thin wall diamond core drill** to minimize material loss and deformation. Thin wall diamond core drills are capable of being used at much higher rpm's than thicker wall drills. And will minimize material loose, and provide closer tolerances. Thin wall core drills are not recommended for use on angle grinders. It's always a good idea to have some type of an estimate of target cost and quality per hole.

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Coolant to be used

Your capability to use **coolant** while drill, will seriously effect your diamond drill selection. Most diamond core drills **must be used with coolant**. When drilling with diamond drills, the ***proper*** ***use of coolant*** is important for two reasons.

Minimize Drill & Material Overheating

Frictional heat produced at the working face of diamond tip must be disposed immediately. Otherwise the diamond become rapidly damaged by oxidation and graphitization. Excessive heat generated while drilling will also damage the metal matrix holding the diamonds in place.

Insure Drilling Consistency

Debris generated while drilling should be removed as soon as they are produced. When this drilling debris is not removed rapidly, diamond wear increases through abrasion caused by the presence of excessive coarse stone fragments.

Water is the most common coolant used for most drilling application. It is always a good idea to pump an adequate supply of water through the center of the drill. So that an uninterrupted flow is maintained flushing across the working surface of the drill diamond section. In this way diamonds and the metal matrix are both kept sufficiently cool. And rock debris is removed as soon as it is produced. This is the ***most optimum condition*** for your drill.

Reduce Friction between material and drill

Water also penetrates the micro-cracks witch are generated upon impact of material and diamond drill. Under ideal conditions, the material will absorb water, hence becoming completely saturated with water. In this state the material is weaker and more easily drillable. The coolant surface tension also plays an important part in the drilling operation. Usually the lower the surface tension, the easier it is for the coolant to enter the micro cracks. Coolant with a lower surface tension also wets the diamonds more easily. Most users find that by lowering the surface tension of their coolant, resulted in better cooling (wetting) of their diamond, and more effective overall cooling.

Lower surface tension also improves material debris lubrication, promoting efficient removal.

Shorter drill life, material and drill deformation will result when using drills dry. Electroplated (nickel bonded) diamond core drills may be used dry (without water) depending on the application (material being drilled). UKAM Industrial Superhard Tools does have the capability to manufactured diamond drills to be used without coolant. However, ***using diamond drills dry is not recommended*** on most applications. When chance prevails, use all diamond drills with coolant.

Diamond Drill Variables

The Bond Hardness of your diamond drill will determine the type of materials you will be able to drill with your diamond drill. Harder materials such as advanced ceramics and ultra hard stone generally require a softer bond. However, a diamond drill made for this application will not last a long time on softer and more brittle materials such as silicon and flagstone, witch require a harder bond. Another important factor to consider when selecting the right diamond drill for your application is Grit Size. Generally selected depending on the speed you wish to operate the drill and surface finish of your material. Courser (larger) size diamonds will drill faster than finer (smaller) diamonds. However, the trade off is smoother surface finish. Different materials and equipment require the use of diamond drills with various wall thickness. Many production facilities are equipment with precision CNC and milling machines, use thin wall

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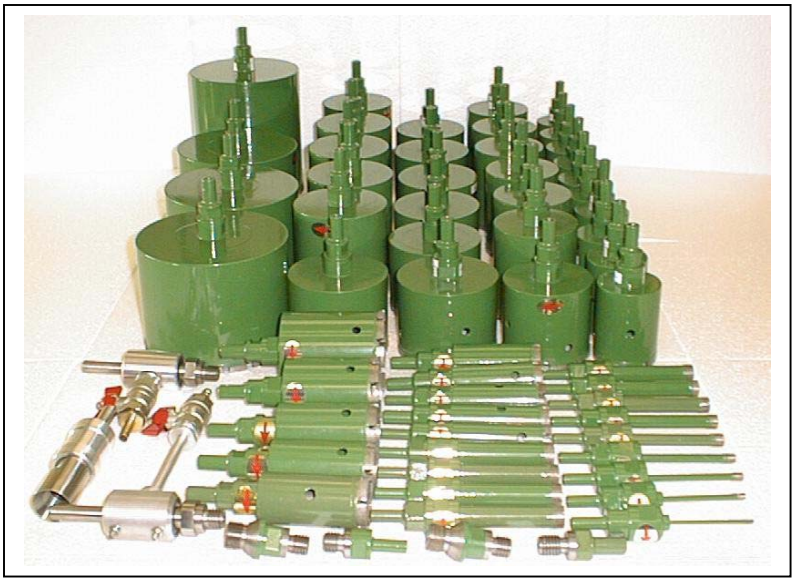
Diamond core drills. Thin wall diamond core drills provide less loss of material, minimum material deformation, less heat generation, faster drilling, speed, less chipping, better finish quality. Usually the thinner the wall thickness of your diamond drill, faster the speed (RPM) your drill may run, less chipping and heat your drill generates, and smoother and higher quality of the finish. Thin wall diamond core drills. One major drawback is shorter diamond drill life.

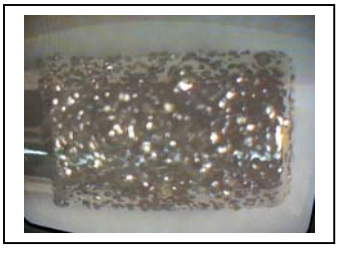
Diamond Bond Types

High production applications that require hundreds of holes, involve use of Sintered (Metal Bond) Diamond Drills. As a general rule of thumb, Metal Bond (sintered) diamond drills last longer than other diamond drills available. Although Drilling life will varies with manufacturer, and hardness of material being drilled. With most conventional sintered (metal bonded) diamond drills, you should be able to obtain 450 to 1200 holes. Metal bonded diamond core drills have diamonds sintered and multiple layers of diamonds impregnated inside the metal matrix. They wear evenly, and are known for their consistency. **Sintered (metal bonded) diamond core drills** are the latest technology available in diamond drills. And represent the best value and performance per hole.



Electroplated Diamond Core Drills are perfect for smaller jobs, softer materials and beginning diamond drill users. Electroplated diamond drill is just about the only type of diamond drill that may be used dry (without coolant) in a few applications, excellent for drilling very abrasive materials and have a high diamond concentration and give a freer, faster drilling action with minimum heat generation. Diamonds stay on the surface of the drill allowing for fast material removal. Electroplated Diamond Drills last less than metal bond, drills and are the least expensive diamond drills available. And are more forgiving than, metal bonded drills, in most cases capable of withstanding to greater amount of operator error.

Metal Bond Drills	**vs.**	**Electroplated Drills**
- Multiple layers of diamond		- Single layer of diamond
- Stands under aggressive conditions		- Cannot be dressed
- Super smooth finish		- Least Expensive
- Longest lasting drill		- Shortest Drill Life
- Very Universal		- Cannot be used on some materials
- Most cost effective		



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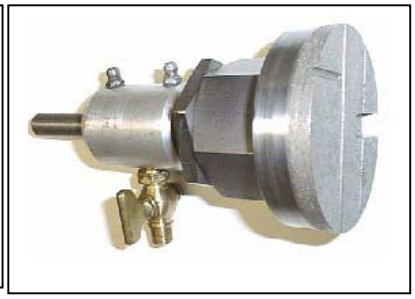
Varying with application and material, an average electroplated diamond core drill will last you 80 to 120 holes.

Electroplated drills cost less, and at first glance may seem like the most cost effective alternative. However depending on you application, they will cost you more in the long run. Varying with material and application, metal bonded diamond core drills will last significantly more than 20 electroplated diamond drills put together. You can't get more life out of any other drill. Instead of constantly putting diamond core drills on and off the drill press, you will save time and money by using one drill. This means cost per hole, metal bond diamond core drills are the best choice.

Electroplated drills have only one layer of diamond coated on metal body. Diamonds sit only on the surface. When this diamond portion is peeled off, the diamond drill will slow down, drill on the side (not drill straight) or stop working (drilling) altogether. Metal bonded diamond core drills have diamonds sintered and multiple layers of diamonds impregnated inside the metal matrix. Unlike electroplated drills, metal bond diamond core drills wear evenly, and are known for their consistency. You will get consistent

Diamond Bottoming Tool / Drill



Designed for drilling without core formation, Diamond Bottoming Drills/Tools are used for making **Blind Holes** in all types of material ranging in hardness. A bottoming tool does not have a core, and essentially works as both a diamond drill and grinding disc. The bottoming tools works by grinding the bottom and inside of the hole to a flat surface. This tool is just about the only way you can drill larger than 3/8" OD (outside diameter) blind holes. **Careful attention to detail will make the whole difference in quality of your diamond drilling operation.**

The goal of every diamond drill user should be to obtain the most precision holes without affecting or damaging structure of material. Many of today's materials are composed of several layers. Stress to material created by excessive heat or improper drilling technique, may affect structure of material. When one layer is damaged, it may affect other layers of material, spread through the material in a domino effect. This is an important liability issue that may come to hunt you even after a couple of years. **Maintaining material structure, integrity, and durability is the key to success for any diamond drilling operation**.

For more information about Selecting the Right Diamond Drills, Equipment, Accessories, and Process for your Applications. Contact UKAM Industrial Superhard Tools, 25345 Avenue Stanford, Unit 211, Valencia, CA 91355; (661) 257-2288; fax (661) 257-3833; e-mail lel@ukam.com; or visit www.ukam.com.

This article in different formats, was published in various industry trade magazines.