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DIAMOND DRILLER'S GUIDE TO EXTENDING CORE BIT LIFE

INTRODUCTION

Getting the longest life possible for your core matrix is an important consideration if you want to run a productive and profitable drilling operation. Changing a drill bit takes time especially the farther down the hole it is, and the time spent replacing a bit is not productive. It is time when you are not recovering core and core recovery is the goal of diamond drilling.

It is difficult to provide an average for the number of meters drilled by a core bit. It will depend on each hole, the type of ground, and many other variables. However, as an example, we can say we have a hole where a bit averages approximately 125 meters. If you are drilling holes that are shallower, you may be able to achieve your objectives with only one core bit, especially if you use the current methods and products that have been developed to extend bit life.

However, if you have to drill a hole that is 1000 meters deep, you can expect to change the bit often – even up to eight times. If you are able to extend the life of a bit by only 15%, you can expect one less drill bit replacement. The further into the hole you've drilled, the more time saved this represents. When you are at a depth of about 800-1000 meters, it can take up to four hours to replace a bit. That translates to four hours where you will not be collecting core. The key is ensuring that you drill with the best matched matrix and that you use the optimal configuration for the ground type to maximize the time you are coring.

The goal of this guide is to help you get that extra percentage of bit life so your productivity is as high as possible.

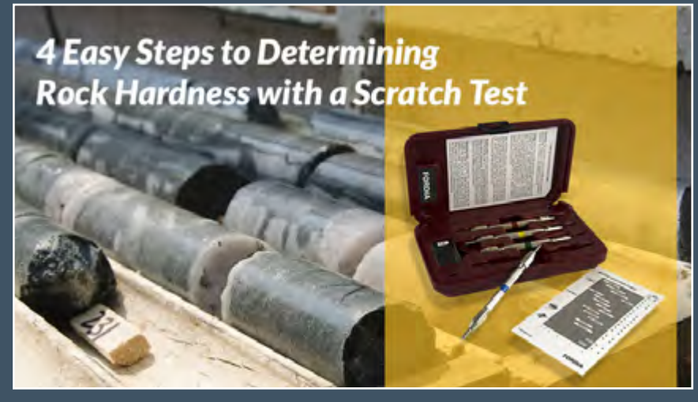
1 CHOOSE THE RIGHT CORE BIT

HARDNESS

Choosing the right matrix is one of the most important decisions. Make sure you choose a bit that is suitable for the hardness of rock in which you will be drilling. The hardness of the ground is measured according to Mohs hardness scale, a chart of relative hardness of various minerals.

The scale consists of numbers one through ten; 1 being the softest and 10 being the hardest. Only a diamond will measure a 10 on the scale. Drilling matrices are developed to perform ideally within a certain range of the scale so you need to pick a bit suitable to the hardness of the ground to be drilled. There are tools that help you identify the hardness of the ground such as an Etcher kit or scratch test.

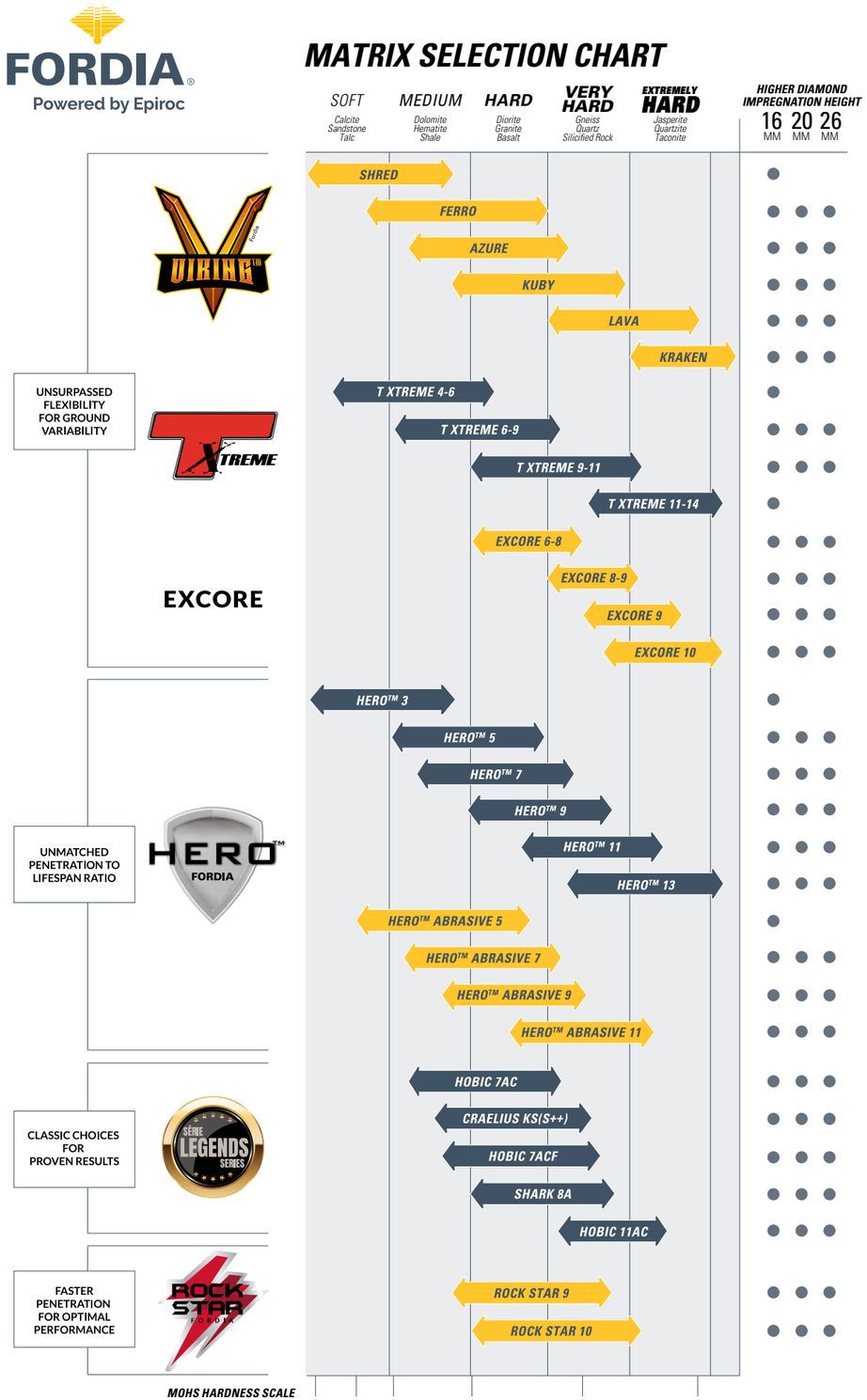
You can watch this video to illustrate how to perform a scratch test.



CUSTOMIZED MATRIX

In addition to a core bit that is suited to a particular hardness, you should also consider a crown matrix that is customized for the type of ground, e.g. abrasive ground. For example, the HERO Abrasive line, has been developed specifically for abrasive ground conditions. These bits have a special matrix consisting of metallic materials and diamonds that when combined, are very resistant to abrasive conditions but are also relatively easy to sharpen in the hardest conditions. As innovations lead to more customization, always look for the best pairing of ground conditions and matrix.

There are other variables that should be taken into account when choosing the appropriate core bit. These include ground variability and competency, the drill rig used and the driller himself. You can get even more information about how to choose the right core bit in this guide.



2 CHOOSE THE RIGHT CONFIGURATION

In addition to the type of matrix, you should consider core bit configurations that specifically address the conditions you will be encountering. Two important considerations are waterways and height of segments.

WATERWAYS

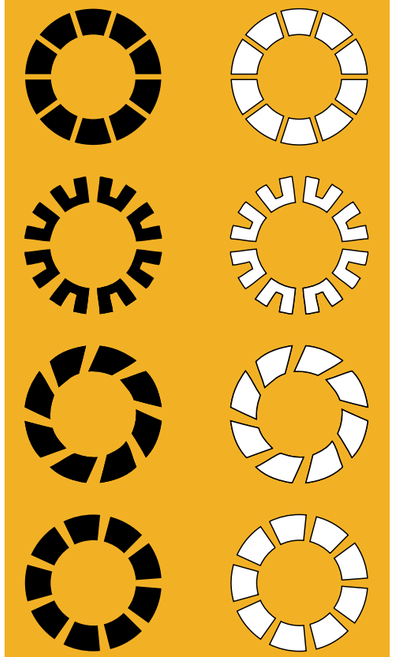
Waterways are an important feature of crown configurations. The waterways allow cooling fluids through and you want to make sure that these drilling fluids have enough velocity to flush the rock cuttings from the bottom of the hole and carry them up to the top of the borehole.

The number, shape and width of waterways will have an effect on the number of diamonds being exposed on the bit face and how the feed pressure will be distributed on each diamond exposed. For example a crown profile may have a similar number of diamonds in the matrix itself, but because there is less surface area in contact with the rock, it would cut more freely.

Shape of waterways

There are many types of waterway shapes to choose from, depending on the manufacturer of the core bit. These include the standard option (straight waterways), which has been around for years, along with other options such as pie shaped (or extended channel flushing), turbo pie-shaped (or V), Jet and cyclone.

Other variables include regular or deep, lateral or face discharge and in some cases, blocked.



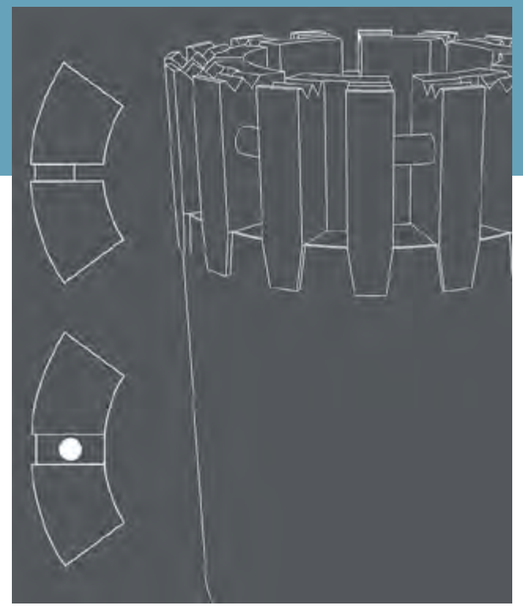
Width of waterways

The width of the waterways on the configuration you choose depends upon the type of ground in which you will be drilling.

When drilling in softer, unconsolidated ground you should consider wider waterways. In soft friable formations, wider water ways produce less pressure on the core and the tip of the bit, while allowing better evacuation of cuttings. This can be further aided by choosing a deep lateral discharge or face discharge to keep flow away from the incoming core as much as possible.

When drilling in harder, competent ground, you should consider smaller, narrower waterways which can work well.

When drilling hard consolidated formations, smaller passages will allow the same flow to come through at a higher pressure. This will provide greater cooling at the tip of the bit, where the diamonds are working hard at cutting the rock, but can be damaging to softer formations.



Number of waterways

To obtain more cutting ability from the bit with less weight on the bit (WOB), you should consider adding more waterways to your configuration

HIGHER CROWNS

One of the most important considerations when choosing the right core bit is the height of the crown, especially if you plan to be doing deep hole drilling. For example, the Vulcan or Jet are two configuration options that allow you to extend your core bit life. They refer to the height of the crown and they are available in 16 mm, 20 mm or 26 mm heights.

Learn more about choosing the right core bit configuration in this guide.

3 CARE AND HANDLING OF YOUR BITS

Once you have chosen the type of core bit and the configuration options, you also need to make sure you handle them properly so that they get to drill the ground they were chosen for and provide optimal performance. Too often, improper handling of a core bit can shorten its life.

ABOVE GROUND

Unfortunately, core bits can get damaged before they're even used, often above ground when drillers are adding or changing a new core bit. Be careful with other tools that can damage a bit.

Pipe wrenches

Whenever possible, try to use a proper, full grip outer tube wrench when installing the core bit. If one is not available, a regular pipe wrench can be used. Pay attention to where you grip the core bit with a pipe wrench. Too close to the top and you can damage the matrix which is made of special metal alloys. Gripping it too close to the bottom can be dangerous as the bit is thinner near the threads.

Jaws

Be careful with the jaws on the drill rig chuck and the jaws on the rod holder. If you are impatient or rush to change the core bit, you can catch the side of the core bit on the jaws of either one. A simple knock or bump can damage the teeth of the crown and ruin the bit.

The core bit can also get crushed by the jaws of the rod holder or chuck as well. Make sure you don't use the chuck to force the core barrel.

Rod holder

Make sure the rod holder is locked open when you are trying to pass the core barrel through it to the casing. Otherwise, lateral pressure on the core bit can distort its shape from round to oval or damage the diamond segments. Once distorted, the core bit will cut a smaller core sample. If the core sample is too small the core lifter spring will not grip the core and it will stay in the hole.

Do it by hand

You should never use the hydraulic force of the chuck to force the core barrel through the rod holder and down into the casing. Ideally, you should do this by hand. Have the core barrel suspended by the hoisting cable so you can guide it manually to the rod holder and through to the casing. If you align the core barrel correctly, the core bit will not catch on any edges and you will not damage the crown.

ON THE WAY DOWN

Other pitfalls can occur on the way down, including:

Accidently releasing your core bit.

Pay special attention when descending through the casing shoe to avoid dropping the core bit. The jaws on the chuck and the rod handler should work in tandem as the bit lowers. Rushing through this operation can lead to a slip-up where neither is holding the rod and the string is dropped. It is always good practice to lower the rod string with the inner tube latched in place, this will restrict water flow and slow the descent in the event of a dropped rod string.

Catching the edges of your core bit

When descending through the bore hole it can be easy to catch the edges of your bit on wedges, directional cuts, or difficult ground formations. Catching the edge of a core bit can easily damage the crown. The best way to avoid this is to keep a detailed log book that lists the conditions found in the hole, the types of ground formations encountered and any equipment that had been used. Refer to the logbook before you descend so you know what to look for and how to avoid problem spots.

If you expect to encounter difficult ground conditions, you should keep in mind that you may have to re-drill.

Graphite plugs

A graphite plug is a good tool that many experienced diamond drillers will consider using to protect the core bit. You should always remember that they are not indestructible, so dropping a core bit too quickly with the assumption that the graphite plug will protect it from damage, is a mistake.

AT THE BOTTOM

Problems can arise at the bottom of the bore hole, where it is often hard to know what is going on.

Rushing the job

Rushing can often lead to problems that will take even more time to fix. When lowering your drill rods, take your time so you don't slam into the bottom of the hole. The crown of your bit can be easily damaged. Lowering your rods too fast is risky and can also cause your equipment to jam.

Hitting the bottom of the hole

To avoid having your equipment slam into the bottom of your borehole, you should know exactly where the bottom is. Keep your log book up to date with detailed and precise information. Check the log book and make sure you always stop a few feet before the bottom of your bore hole.

Not Re-drilling

It is possible to lose diameter at the bottom of the bore hole. This is why stopping before you hit the bottom is so important. The outer gauge of the bit and the reaming shell can wear out as you drill, often at the same time. Keep in mind that the gauge of the reaming shell is larger than the bit's gauge but you need to be careful to verify the gauge of the reaming shell as you drill. If both have reached the end of their life, they will not be able to maintain the desired gauge of the bore hole. Forcing a new core bit into a funnel-shaped bottom can cause the fragile ends of the matrix crown to pop off.

Watch this video to learn more about handling your core bit.

4 DRILLING PARAMETERS

Drilling parameters play a large role in helping drillers achieve a good ROP (rate of penetration), and long bit life. Drilling parameters are basic recommendations that help guide a driller avoid burning bits or damaging other drilling equipment. Drillers should always remember that there is a relationship between the drilling parameters and all others factors in drilling, such as the diameter of the equipment you're using, rock hardness or ground variability. Understanding how to adjust drilling parameters can help you improve performance in difficult drilling situations.

WATER FLOW

One of the parameters that has a direct impact on bit life is the water flow. Proper flow and pressure at the bit face will make sure rock cuttings are flushed and the bit is cooled.

The water flow is often given in terms of Gallons per Minute/Liters per Minute (GPM/LPM) The suggested water flow should be considered as a minimum and the setting of your pump should be well above this.

Drilling fluids should be pumped across the core bit at a rate that flushes away the rock cuttings as they are cut by the diamonds. Improper flushing results in a negative impact on ROP and bit life because the rock cuttings can adhere to the cutting face of the bit, leading to a convex wear pattern on the face or an overheating of the cutting face. The velocity of the drilling fluids must be high enough to keep the rock cuttings suspended and away from the cutting action of the diamonds.

The water flow is related to the bit size and type of rock to be drilled. In soft or fractured rock, the water flow must be high. However, in a very hard and competent rock, where the speed of penetration is low, the water flow must be reduced to enable the cutting of the rock and to reduce the risk of polishing the diamonds. In the case of hard rock, you may want to take advantage of the abrasive properties of the cuttings to expose the sharp edges of the diamonds so the cuttings should not be removed too quickly from the cutting face.

Consult this chart to see the recommended water flow for different standard sizes of core bits, and to learn more about drilling parameters, read this guide

TYPES	WATER FLOW GAL IMP/MIN (L/MIN)				
	AO	BO	NO	HO	PO
Very hard to extremely hard and competent	3-4 (14-18)	5-6 (23-27)	6-8 (27-36)	8-9 (36-41)	10-11 (45-50)
Hard to very hard and competent	4-5 (18-23)	6-8 (23-36)	8-9 (36-50)	10-12 (45-54)	12-13 (55-60)
Other	6-8 (27-36)	7-10 (32-45)	12-14 (56-64)	14-16 (64-73)	15-17 (68-77)

Weight on Bit WOB

Weight on Bit (WOB) is also known as feed pressure. A lot of WOB can help increase the rate of penetration (ROP) increasing productivity. However, caution needs to be exercised as it can shortened bit life. Always start with the lower end of the to the manufacturer's recommended WOB.
Consult our guide for more information.

5 SHARPENING CORE BITS

Sharpening a core bit is also known as stripping. Core bits need to be sharpened when they stop cutting. Sharpening a bit takes experience and knowledge and there is no one easy method that will work for all situations.

Diamond impregnated core bits are made to be self-sharpening, meaning that they are designed to stay sharp throughout the drilling process. In ideal conditions, as the matrix wears away, new sharp diamonds are exposed at a steady rate, and dull or worn diamonds are released.

However, if the drilling parameters are not properly set or if a specific core bit is not suited to the type of ground conditions being drilled, the diamonds on the face of the bit can become worn without the matrix abrading away. The core bit becomes polished and it will stop cutting.

Once this happens, the core bit will need to be sharpened or stripped. The procedure involves removing a thin layer of the matrix in order to expose new diamonds so that the bit can start cutting again. It is not necessary to remove the core bit from the bore hole as this can be done while drilling continues, by changing or adjusting some of the drilling parameters.

It is important to note that this technique will consume your matrix, the amount of which will depend on the driller's experience, ability and reflexes.

1. Momentarily increase the weight on bit (WOB) by 15 to 20 percent,

2. At the same time, reduce the water flow to near the minimum recommended by the core bit manufacturer.

3. When you see a slight increase in the WOB and a spike in the rotation torque, these are indications of stripping and wearing away of the matrix to expose new sharp diamonds. The bit should begin to cut.

4. Immediately restore the water flow to the original volume and lower the WOB.

5. Try adjusting your parameters to different drill settings than the ones you used previously, to avoid having the problem repeat itself.

6. Sharpening a core bit requires some experience so if you are uncertain you should call a technical support representative to help guide you. Performing this technique improperly could result in using up a lot of your matrix.

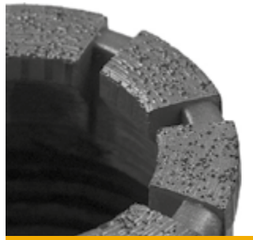
6 TROUBLESHOOTING MATRIX WEAR

- There are many variables that can cause a really good core bit to underperform. It can be a change in ground conditions, drilling parameter or simply lack of experience. One of the best ways to determine what is off is to examine the wear profile of your bit crown and change drilling parameters if necessary.

- Examining the different wear patterns on a bit crown can provide a lot of information. By looking at the wear profile, you can get clues as to why your core bit may be underperforming.

- Remember that the ideal wear on a core bit is attained when the wear on the diamonds and matrix is balanced and even, and the full depth of impregnation is evenly consumed. This allows you to get as much footage as possible on the bit, before you have to retire it.

- Consult the chart to see different wear patterns and suggestions on how to correct the problems.



IDEAL WEAR

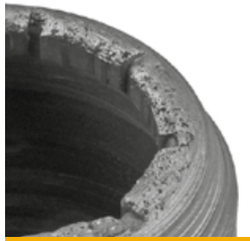
Even wear to the carbides with the diamonds evenly worn.

DIAMONDS OVERLY EXPOSED

Matrix wears before diamonds have worn out. Diamonds pop out prematurely, reducing bit life.

Caused by:
- Drilling pressure too high for the speed of rotation
- Water flow is too low
- Matrix used is too soft

Solutions:
- Increase speed of rotation and reduce the drilling pressure
- Increase the water flow
- Change the bit for a lower series (harder matrix)



BURNT

Matrix has completely melted, waterways are closed.

Caused by:
- Water ran out
- Poor water circulation

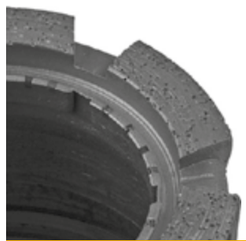
Solutions:
- Increase water flow
- Check if the pump is working well
- Check the rods for leaks in the joints
- Confirm whether the inner tube is too long and adjust, if necessary

CORE BIT POLISHED OR GLAZED

Bit doesn't cut and diamonds appear polished.

Caused by:
- Drilling pressure too low for the speed of rotation
- Water flow too high
- Matrix used is too hard

Solutions:
- Sharpen the bit
- Reduce the rotation speed and increase drilling pressure
- Reduce water flow
- Select a bit from a higher series (softer matrix)



I.D. GAUGE LOSS

Wear of inside diameter and inside ringing. Concave wear pattern.

Caused by:
- Drilling pressure too high
- Very broken ground
- Core left in the hole
- Water flow too low
- Matrix too soft

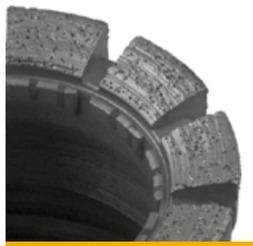
Solutions:
- Increase rotation speed
- Reduce drilling pressure
- Change for a lower series core bit (harder matrix)
- Increase water flow
- Check and adjust the length of inner tube

O.D. GAUGE LOSS

Wear of outside diameter and outside ringing. Convex wear pattern.

Caused by:
- Vibration
- Rotation speed too high
- Water flow too low
- Cave in, the hole was reamed

Solutions:
- Increase water flow
- Reduce rotation speed
- Check the diameter of reaming shell
- Add drilling fluids (to reduce vibration)
- Try new configurations (deep lateral discharge or deep water way)

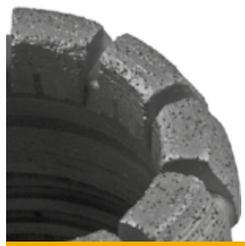


INSIDE WEAR PATTERN

Inside of the bit has worn down before the outside, in a concave pattern.

Caused by:
- Drilling pressure too high for the rotation speed
- Core left in the hole had to be drilled
- Very broken ground
- Core blocked in the inner tube

Solutions:
- Decrease drilling pressure
- Increase rotation speed
- Check and adjust the length of inner tube
- Add drilling fluids (fractured ground)
- Don't try to push through a core block



OUTSIDE WEAR PATTERN

Outside of the bit has worn down before the inside, in a convex pattern.

Caused by:
- Water flow too low
- Loss of water by the rods
- Hole "reamed"

Solutions:
- Increase the water flow
- Check for leaks
- Check the diameter of shell

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7 USE DRILLING FLUID ADDITIVES

Reduction of torque leads to longer life of your drilling equipment. Torqueless is an environmentally safe product that can be used alone or in combination with other additives to lubricate and cool the core bit. It is often used with DD-2000.

The DD-2000 also raises the viscosity of the drilling fluids so that cuttings can be more easily flushed out. One added benefit is that DD 2000 is non-abrasive and when mixed with Torqueless, it results in longer bit life.

CONCLUSION

By learning how to choose the right matrix and the best water way configuration, you can easily extend the life of your bit. By handling your core bits properly as you use them and by monitoring their wear patterns, you can make sure you get the most value from them. And finally, implementing a good mud program will not only help extend the life of your core bits, but will help reduce wear and tear on all your drilling equipment.

Our technical support team is always available to help and has a lot of experience to share. Don't hesitate to contact them for provide guidance and tips. At Fordia powered by Epiroc, our goal is help make drillers' lives easier and help improve drilling performance.

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