BOART LONGYEAR™

DIAMOND PRODUCTS FIELD MANUAL

Guide to the Selection and Field Use of Diamond Tools

2024

SAFETY

Safety is at the forefront of all we do at Boart Longyear. Diamond products may seem like a small, insignificant safety hazard but we think the same safety minded behavior should be observed from the smallest tasks to the largest ones.

We recommend handling diamond products with proper work site gloves, securing them when not in use to avoid falling or loose rolling objects, and using proper equipment to add or remove all diamond products from the drill string.

By observing all safety practices, you can make sure that all those involved in your project can make it home safe.

Make it safe. Make it personal. Make it home.

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HISTORY

EARLY SUCCESS IN THE COPPER BELT

In the 1930s, Boart International led the research and development program which enabled practical and reliable manufacturing of diamond coring bits. The first Boart bits off the line were used exploring for copper in Zambia and gold in South Africa. The early success of these bits paved the way for widespread adoption of the technology within the industry.

FIRST GENERATION LONGYEAR BITS

In 1938, the Longyear contract drilling department started using castset diamond bits. Almost immediately after Longyear had the bits in the field, the sales department started receiving inquiries from around the world regarding the availability of the diamond bit.

As our surface-set diamond bit technology developed, Longyear brand bits were put to use around the world.

REVOLUTIONARY ENGINEERING

In 1974, Boart International became the sole owner of Longyear. With the newfound technical talent and capital investment from Boart International, Longyear became the leading manufacturer of diamond bits. It was during this transition when engineers in North Bay, Ontario secured a reliable source of high-performance synthetic diamonds, triggering the development of a completely revolutionary bit design – the impregnated-diamond bit. With decades of powder metallurgy experience behind them, Longyear engineers set out to develop a new crown which consisted of synthetic diamonds evenly distributed throughout a composite matrix. This new design could drill further and faster than surface-set bits. By 1980, 75% of our Canadian-produced bits were of the new impregnated type and Longyear was manufacturing diamond bits in more than eight countries.

ALPHA

Alpha series impregnated bits contain coated diamond technology. This coating protects the diamond from oxidation and surface degradation during the manufacturing process.

STAGE™ WATERWAYS

The innovative Stage™ waterway design pushes the envelope by allowing the tallest crown height in the industry, with 75mm crowns beings successfully used in the field. The Stage waterway design lets you spend more time drilling and less time tripping rods.

NEXT GENERATION LONGYEAR BITS

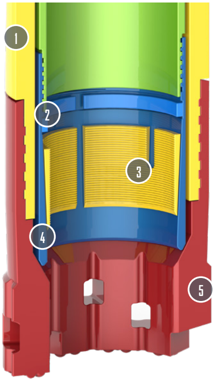
The proprietary coating used in Longyear bits forms a chemical bond between the diamond and the matrix. The improved retention reduces premature‘pull-out’ of the diamond, increases the number of cutting edges exposed to the rock, and increases the protrusion of diamond beyond the matrix. The result is a bit capable of faster penetration rates and longer life.

CONTINUED INNOVATION

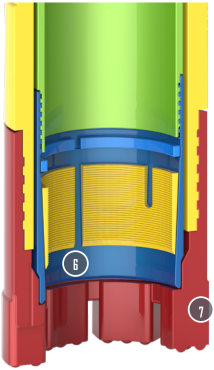
Today, there are many marketers of diamond bits and very few of those companies invest in bit development. Boart Longyear is dedicated to the development of diamond bit technology. You can see it in our recent designs — such as the patented Stage™ waterway and Longyear series — and you can trust us to deliver continued innovation.

SYSTEM OVERVIEW

Q™ & Q™ TK SYSTEM



Q™-P SYSTEM



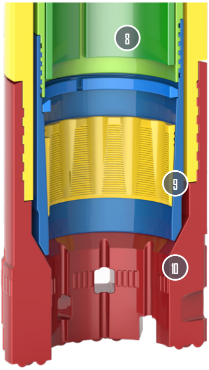
1. Q REAMING SHELL
2. Q STOP RING
3. Q CORE LIFTER
4. Q CORE LIFTER CASE
5. Q CORE DRILLING BIT
6. Q-P CORE LIFTER CASE
7. Q-P CORE DRILLING BIT
8. SPLIT TUBE
9. Q3 CORE LIFTER CASE
10. Q3 CORE DRILLING BIT
11. QTT CORE LIFTER CASE
12. QTT CORE DRILLING BIT

Q™ & Q™ TK SYSTEM
Genuine Q™ double tube wireline systems are ideal for use in most drilling conditions and are available for application in standard DCDMA hole sizes (A, B, N, H, P).

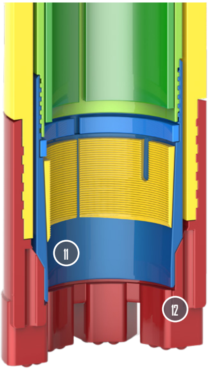
QTK systems are optimized to allow for a larger core sample while retaining the same hole size. QTK systems can penetrate faster due to their smaller kerfs but are not as robust as standard kerf systems QTK systems are offered in the A, B, and N* sizes.

*NQTK also known as NQ2

Q™ 3 SYSTEM



Q™ TT SYSTEM



Q™-P SYSTEM
The Q-P system is a double tube configuration like Q and QTK double tube systems but includes a specialized core lifter case and bit. These components redirect the water flow away from the core by creating a seal on the ID, improving core recovery. Available in N and H sizes.

Q™ 3 SYSTEM
Q™ 3 wireline systems consist of the same components as the Q and QTK but utilize a third tube called an inner-tube liner or split tube. The liner is placed inside the inner-tube. Q3 systems enable integral core recovery when drilling coal, clay bearing, or highly fractured formations.

The liner, or split tube, retains the core sample in its received state for easier loading into sample trays or for storage and subsequent presentation to the geologist. The Q3 system is only available in N, H and P sizes and is primarily used in surface applications.

Q™ TT SYSTEM
The Q-TT system is a triple tube configuration like Q3 but includes a specialized core lifter case and bit. These components redirect the water flow away from the core by creating a seal on the ID, improving core recovery. Available in N, H, and P sizes.

Q is a trademark of Boart Longyear.

CORE RECOVERY

Recovering core can be a simple process in ground that is competent or well cemented. However, not all ground conditions are ideal. Formations can be broken, fractured, unconsolidated, or swelling which can lead to lost core or stuck tooling.

There are several other factors that can lead to loss of core:

- Worn or broken tooling such as worn-out core lifters, bent tubes, blocked waterways
- Drill rig equipment not maintained
- Poor drilling fluid/mud chosen for formations

An estimate of recovered core can help to measure the success of core recovery, need for new equipment, or a change in type of coring system and/or drilling fluid.

Loss of core can lead to many issues for the mine site, from poor estimation of actual depth of mineralization to inaccurate estimations of grade of the ore body.

Core recovery is calculated using a simple equation. Take a measurement of the core that is recovered, divide it by the run length, and multiply by 100.

$$\textbf{Rock Quality Designation (RQD)} = \left(\frac{\text{(total length of recovered core)}}{\text{(total core run length)}}\right) \times 100$$

Recovered Core = 2.5m

Core run length = 3m

CR = 2.5m/3m X 100 = 83.3%

$$RQD = \frac{0,17 + 0,74}{1} *100\% = 91\%$$

$$RQD = \frac{0,50 + 0,30 + 0,20}{1} *100\% = 100\%$$

$$RQD = \frac{0,20 + 0,48 + 0,26}{1} *100\% = 94\%$$

Each project will be affected by different geology and drilling parameters but it is recommended if continuous core recovery is less than 80% a change to a QTT or Q-P system to aid in core recovery.

Check core lifters, core lifter cases, and inner tubes after each run for defects that could cause core loss. Rigs should be anchored to reduce unneeded vibrations and movement and regular maintenance performed on the critical systems, refer to owner's manual for maintenance schedules. Fluid and mud should be chosen according to ground conditions and modified based on ground conditions and core recovery.

Another recommendation to increase core recovery is to change diamond bits as ground conditions change. For example the bit used to open the hole and drill through surface soil and unconsolidated sediments may not be the correct bit once bedrock is located.

Recommendations on drilling parameters will be set forth in this manual and venturing away from these recommendations may cause low core recovery.

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DIAMOND CORING DRILL BIT GAUGES

Compared to most core drilling systems, Q™ systems provide maximum performance, balancing drilling fluid and cuttings management with reliable inner and outer tubes.

The Boart Longyear nomenclature and hole sizes are based on the globally accepted Diamond Core Drilling Manufacturers Association (DCDMA) “W" series. Also note that the DCDMA specifications were adopted into ISO3551 (1992) and British Standard BS4019 (1993) Rotary Drilling Equipment.

INSTALLATION

All recommended torque values are for use with full grip outer tube wrenches. Pipe wrenches/Stilsons can crush, ovalize, or leave deep gripper marks that lead to fatigue failures. Steel-brush thread cleaning and generous application of anti-galling thread compound prior to make up is also recommended to prevent galling.

Bit, Shell, Coupling and O/Tube Joint Torque Values:

AQ/BQ/BQTK:
Minimum full-grip wrench torque =
100 ft-lbs or 67 lbf using an 18" full-grip wrench

NQ/NQTK:
Minimum full-grip wrench torque =
125 ft-lbs or 83 lbf using an 18" full-grip wrench

HQ:
Minimum full-grip wrench torque =
150 ft-lbs or 100 lbf using an 18" full-grip wrench

PQ:
Minimum full-grip wrench torque =
200 ft-lbs or 133 lbf using an 18" full-grip wrench

Size	Core Diameter		Standard OD		Reaming
	in	mm	in	mm	in
Q™ WIRELINE					
BQ	1.433	36.4	2.345	59.6	2.360
NQ, NQ-P	1.875	47.6	2.965	75.3	2.980
HQ, HQ-P	2.500	63.5	3.763	95.6	3.782
PQ	3.345	85.0	4.805	122.0	4.827
Q™ THIN KERF					
AQTK	1.202	30.5	1.875	47.6	1.890
BQTK	1.601	40.7	2.345	59.6	2.360
NQTK*	1.995	50.7	2.965	75.3	2.980
Q™ TRIPLE TUBE					
NQ3, NQTT	1.775	45.1	2.965	75.3	2.980
HQ3, HQTT	2.406	61.1	3.763	95.6	3.782
PQ3, PQTT	3.270	83.1	4.805	122.0	4.827

Shell OD	Oversized OD		Hole Volume	
mm	in	mm	(gal/100 ft)	(L/100 m)
59.9	N/A	NA	22.7	282
75.7	3.032	77.0	36.3	451
96.1	3.830, 3.895	97.3, 98.9	58.3	724
122.6	4.950	125.7	95.1	1180
48.0	N/A	N/A	14.6	181
59.9	N/A	N/A	22.7	282
75.7	3.032	77.0	36.3	451
75.7	3.032	77.0	36.3	451
96.1	3.830, 3.895	97.3, 98.9	58.3	724
122.6	4.950	125.7	95.1	1180

GEOLOGY

There are several geologic properties to look at when selecting bits. The primary property to consider is the hardness of the material being drilled. Hardness is easily defined through the Mohs Hardness Scale (fig. 1). It was developed in 1812 my Friedrich Mohs and is used to characterize mineral resistance to being scratched or abraded by another mineral.

Talc is considered one of the softest minerals while diamond is the hardest. A mineral that has a higher Mohs value will scratch a mineral with a lower Mohs value.

There are several other properties to be considered when selecting the correct bit for your project:

Grain Size: Larger grain sizes can increase the abrasiveness experienced by the bit and a more durable bit should be utilized. Smaller grains can be cleared more readily so a more free cutting bit should be utilized.

Figure 1

MOHS HARDNESS OF MINERALS	
Mohs 1	Talc
Mohs 2	Gypsum
Mohs 3	Calcite
Mohs 4	Fluorite
Mohs 5	Apatite
Mohs 6	Orthoclase
Mohs 7	Quartz
Mohs 8	Topaz
Mohs 9	Corundum
Mohs 10	Diamond

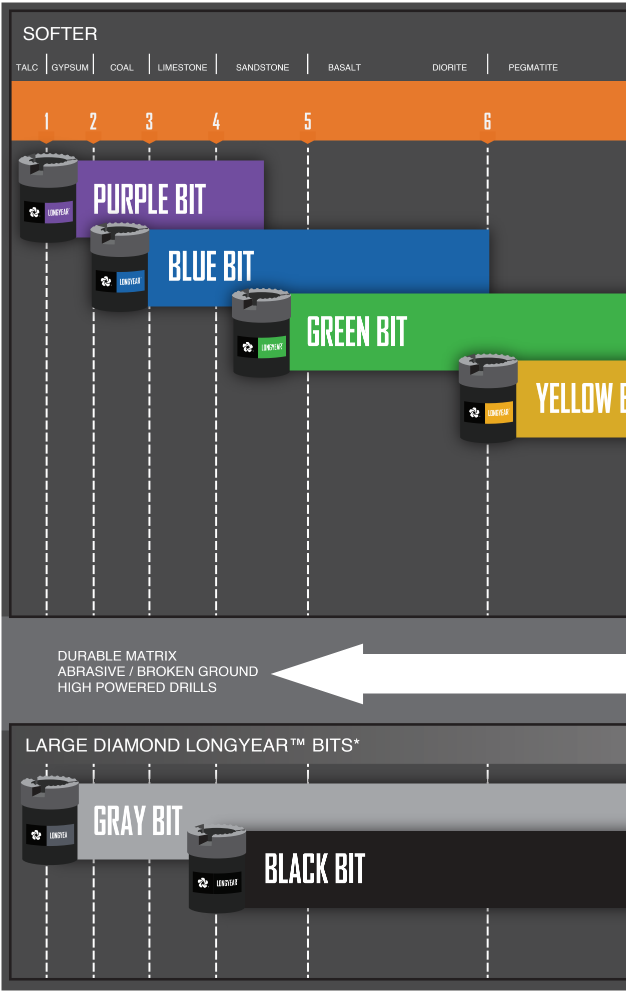
Abrasiveness: This property is usually driven by the amount of quartz present in the rock. More quartz leads to a high abrasiveness and a more durable bit should be selected. Less quartz content will decrease the abrasiveness and a free cutting bit should be selected.

Broken: This type of rock is fragmented, like gravel, and causes bits to wear quickly. A more durable bit should be selected for these ground conditions.

Swelling: This property refers to the ability of the formation to absorb water and swell, like clays, leading to tooling becoming stuck. A bit with a water control option should be selected for these formations.

Unconsolidated: This property refers to material that is unconsolidated, like topsoil, and can lead to poor core recovery due to washout. A triple tube option with water control should be selected to assist in core recovery.

HARDNESS SCALE



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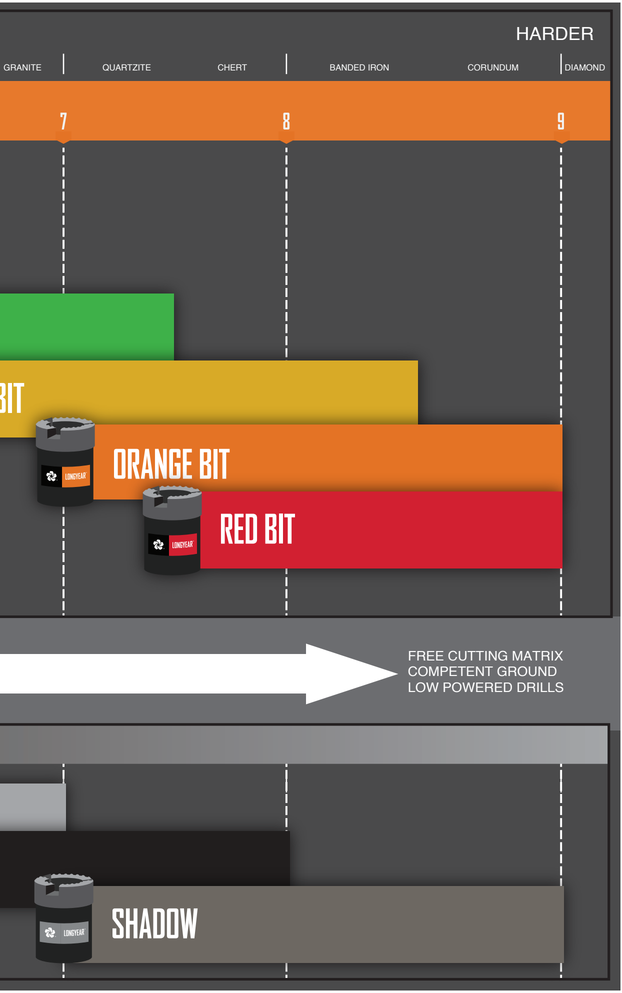
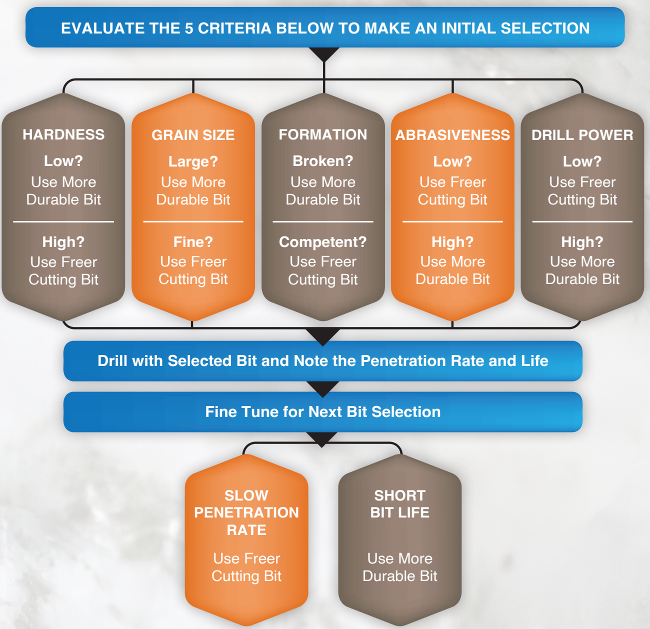

HARDER
GRANITE
QUARTZITE
CHERT
BANDED IRON
CORUNDUM
DIAMOND
7
8
9
BIT
ORANGE BIT
RED BIT
FREE CUTTING MATRIX
COMPETENT GROUND
LOW POWERED DRILLS
SHADOW

PRODUCT SELECTION

Selecting the right bit for the job is not as difficult as it may seem. Just assess the speed and power capability of your drill for the size and depths of the holes to be drilled and gain as much knowledge as you can about the expected rock types and down-hole conditions; then follow the guidelines below.

Boart Longyear recognizes that drilling conditions are often encountered where formations change repeatedly within a very short interval of drilling. Under such circumstances, the most durable bit which will cut the hardest of the expected formations is recommended, and some discretion should be exercised to restrict penetration rates in any abrasive rocks encountered to protect the bit from excessive wear rates. However, if hole deviation becomes a problem, a freer cutting bit, combined with reduced penetration rates, may contribute to bringing it under control.

In certain instances, particularly in broken ground conditions, a mud program should be developed to maintain hole stability.


EVALUATE THE 5 CRITERIA BELOW TO MAKE AN INITIAL SELECTION
HARDNESS
Low?
Use More Durable Bit
High?
Use Freer Cutting Bit
GRAIN SIZE
Large?
Use More Durable Bit
Fine?
Use Freer Cutting Bit
FORMATION
Broken?
Use More Durable Bit
Competent?
Use Freer Cutting Bit
ABRASIVENESS
Low?
Use Freer Cutting Bit
High?
Use More Durable Bit
DRILL POWER
Low?
Use Freer Cutting Bit
High?
Use More Durable Bit
Drill with Selected Bit and Note the Penetration Rate and Life
Fine Tune for Next Bit Selection
SLOW PENETRATION RATE
Use Freer Cutting Bit
SHORT BIT LIFE
Use More Durable Bit

BIT NAMING CONVENTION

Finding the right bit for the job is easy. The naming convention directly corresponds to the description of the bit in the list of part numbers.

NQ	LYB GREEN	-R	C16	FD	TW 6@150<450	PINS
1	2	3	4	5	6	7

1. SIZE
Describes diameter size

2. SERIES
Series is the formula

3. GAUGE
Gauge is outer diameter gauge

4. CROWN HEIGHT
Crown height is denoted by C16, C25, etc.

5. OPTIONS
Water control options like face discharge (FD)

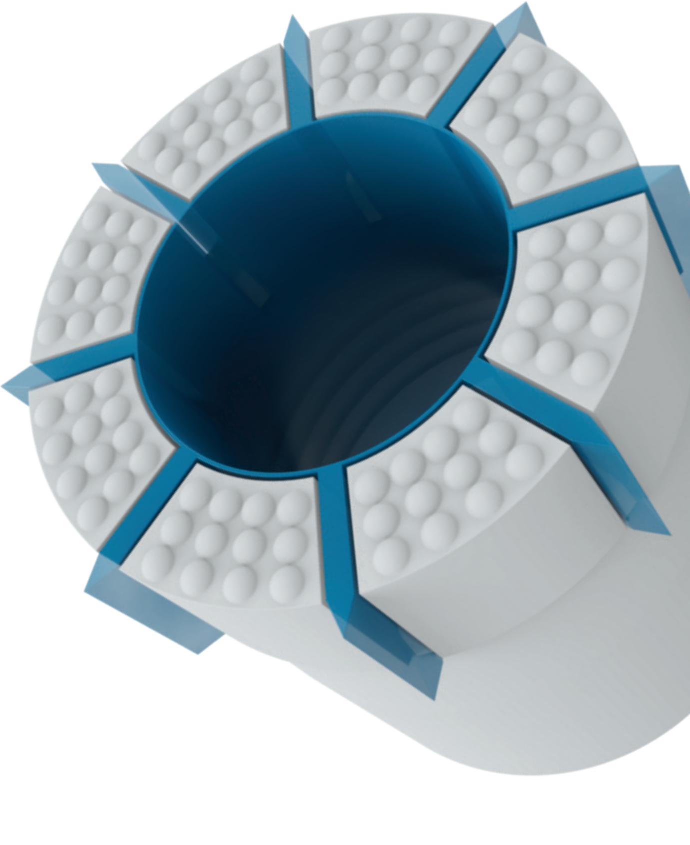
6. WATERWAYS
Waterways describes the geometry

7. SPECIAL
Special refers to any additions like pins or steps

WATERWAYS

STANDARD (STD)

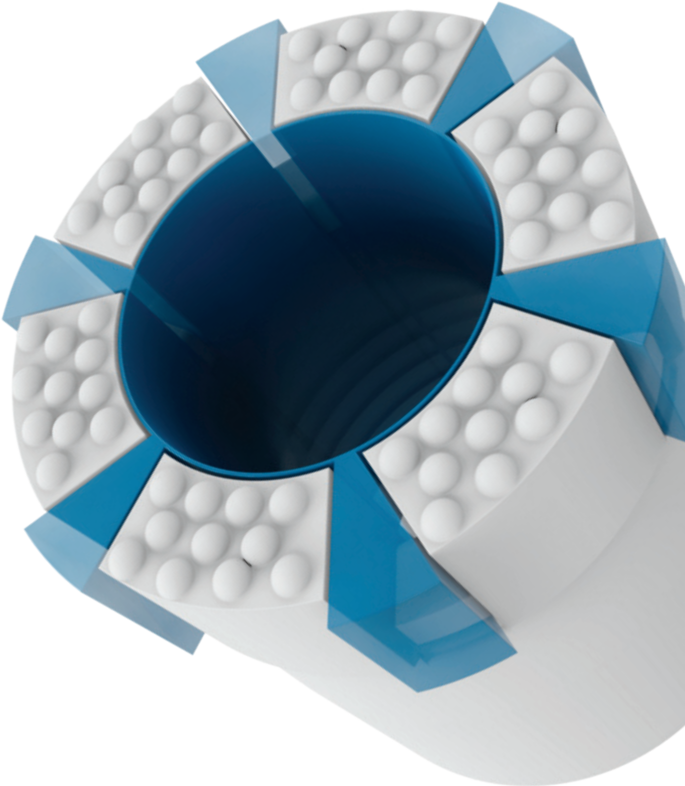
Recommended for general purpose use in competent, fine-grained formations.



WATERWAYS

TAPERED (TW)

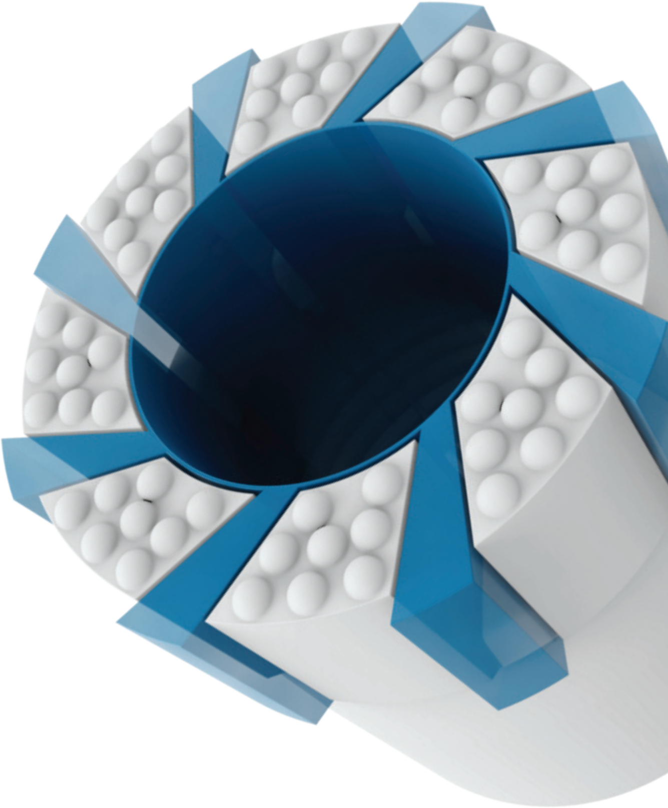
Recommended for general purpose in areas that can encounter broken ground. Pushes cuttings to the OD and reduces pressure across bit face.



WATERWAYS

TAPERED SWIRL (TSW)

Recommended for fast penetration in competent ground with the ability to push cuttings from broken ground easily to OD.



WATERWAYS

EXPRESS (EX)

Recommended for fast cutting in competent formations.
Offers faster penetration and lower weight.

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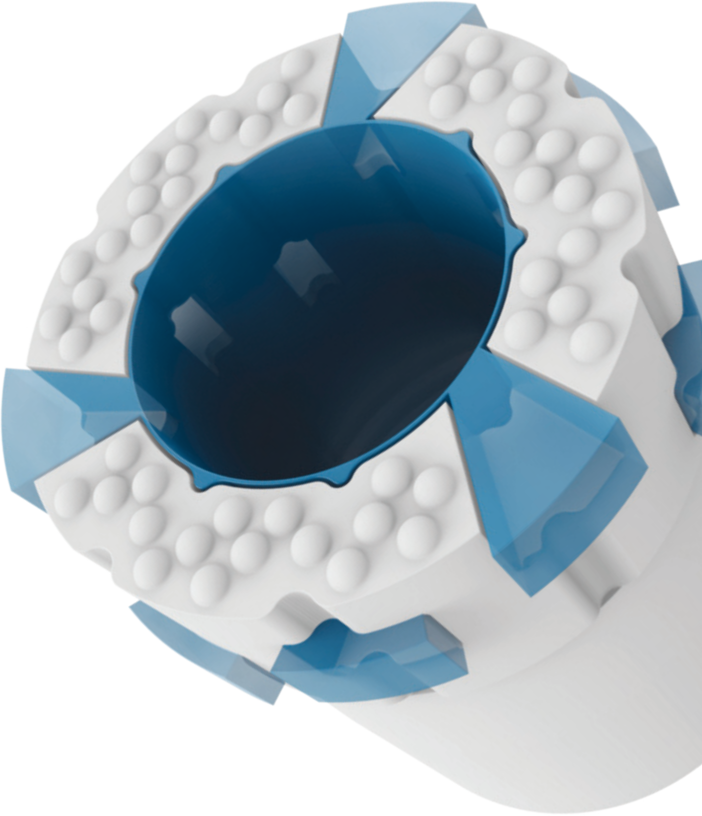
WATERWAYS

STAGE and GT (STG, GT)

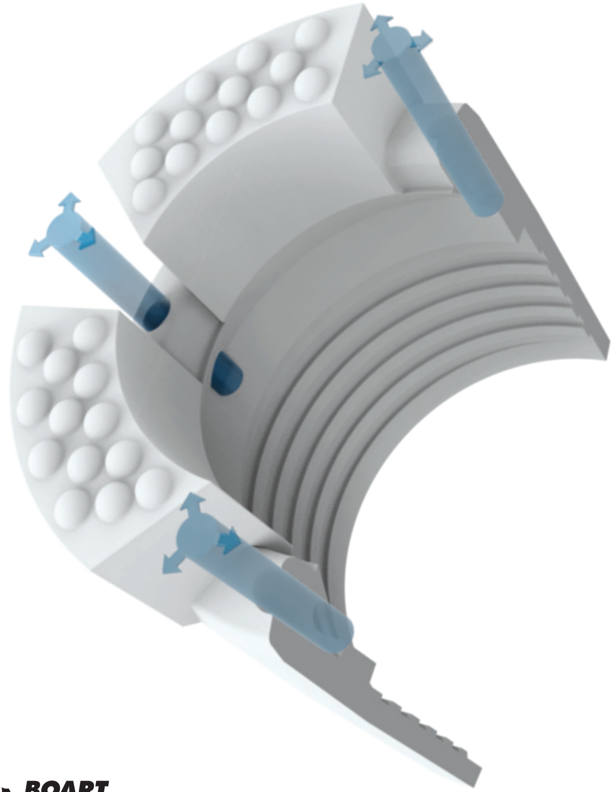
Recommended for the maximum life. Wide waterways offering better flushing than other waterway configurations.



WATERWAYS

FACE DISCHARGE (FD)

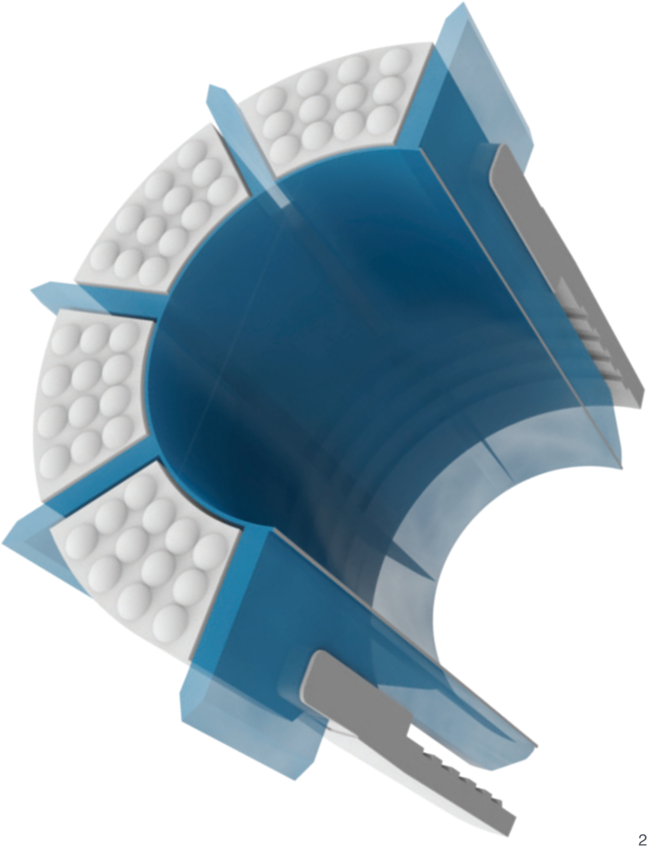
Recommended for broken and soft formations. Reduces water pressure on core and redirects fluid to the bit face.



WATERWAYS

DEEP ID (DD)

Recommended for lost circulation by preventing lifter case from pulling into the bit and shutting off water.



IMPREGNATED BIT DRILLING GUIDELINES

* Scaled matching OD surface velocity, chip volume, and contact pressure
** Rotation speeds are Max, Typical, and Broken Ground

	Fluid Volume Range		Rotation Speed**	Penetration Rate				Indicative Bit Weight Range			
				in/min		cm/min		lb		kN	
	GPM	LPM	RPM	100 rpi	200 rpi	40 r/cm	80 r/cm	Low	High	Low	High
AQTK	3-5	11-19	2000	20.0	10.0	50.0	25.0	1200	3200	5	14
			1500	15.0	7.5	37.5	18.8				
			750	7.5	3.8	18.8	9.4				
BQ/ BQTK	6-8	22-30	1500	15.0	7.5	37.5	18.8	2000	5500	9	24
			1200	12.0	6.0	30.0	15.0				
			600	6.0	3.0	15.0	7.5				
NQ/ NQ3	10-13	38-49	1200	12.0	6.0	30.0	15.0	3000	8000	13	36
			1000	10.0	5.0	25.0	12.5				
			500	5.0	2.5	12.5	6.3				
HQ/ HQ3	14-20	53-75	900	9.0	4.5	22.5	11.3	5000	12000	22	53
			750	7.5	3.8	18.8	9.4				
			400	4.0	2.0	10.0	5.0				
PQ/ PQ3	20-28	75-105	700	7.0	3.5	17.5	8.8	7000	18000	31	80
			600	6.0	3.0	15.0	7.5				
			300	3.0	1.5	7.5	3.8				

DRILLING GUIDELINES

This section of the field book is intended to provide our customers with some guidelines that may help to make Longyear bits work better.

A condensed, convenient reference for the selection of suitable drilling guidelines for impregnated bits is provided in the chart on **the previous page.**

ROTATIONAL SPEEDS

Rotational speed is typically set at a fixed value based on the size of the tools being used. If the rig has sufficient torque, the speed can be increased to get higher penetration rates.

The rpi index (bit revolutions per inch of penetration) or r/cm (bit revolutions per cm of penetration) is a tool in achieving maximum bit life, lowest bit cost and good productivity.

To calculate the rpi (r/cm) index, divide the rotational speed (rpm) of the bit by the rate of penetration:

800 rpm divided by 4 in/min = 200 rpi, or

800 rpm divided by 10 cm/min = 80 r/cm

IDEAL MINIMUM RPI OR R/CM:

200 rpi or 80 r/cm for surface projects

100 rpi or 40 r/cm for underground projects

DRILLING GUIDELINES

Providing you work within this guideline and the bit selected matches the formation, drilling should

progress smoothly and the bit will wear at a constant rate over its entire life.

If rpi (r/cm) is below the recommended minimum of 100 (40) for underground or 200 (80) for surface, excessive wear may occur. If it does, you should either increase rpm or decrease penetration rate by reducing bit weight. If ground conditions or drill limitations prevent you from making these adjustments, change to a more durable bit.

If rpi (r/cm) index becomes too high, the bit may polish. If it does, you should reduce rpm or increase penetration rate by increasing bit weight. If rpm or weight cannot be altered, change to a more free cutting bit.

Polishing or glazing are two terms for the same condition, where no diamond points protrude from the matrix. Penetration will stop and it will become necessary to strip the bit face and re-expose diamonds.

BIT WEIGHT

The bit weights shown on the gauge/guidance chart indicate the range of weights considered normal for a given size of core barrel. If weight on bit is too low, both the penetration rate and torque drop, due to polishing, which results in shorter life and lower productivity. If weight on bit is too high, characterized by very little or no increase in penetration rate for additional weight, the bit will constantly sharpen and wear rapidly.

DETERMINING BIT WEIGHT FROM HYDRAULIC PRESSURE

The weight of the rods and the down force developed by the hydraulic cylinders provide the force exerted on the diamond bit. Unfortunately, drill rig controls do not typically display weight on bit but instead display feed cylinder pressure. The weight on bit or force can easily be found by the following off bottom method:

- Suspend the rods with the hydraulic system in the lowering position.
- With the drilling motor running at a drill rotation, note the reading on the cylinder feed pressure gauge. This is approximately equal to the hydraulic pump pressure plus the weight of the rods in terms of hydraulic pressure. This is called the off bottom pressure.
- Rotate the rods and feed them down by opening the restrictor valve. As the bit touches bottom, part of the weight of the rods is supported on the bit. This action is indicated by a decrease in the gauge reading. The difference in the gauge readings is the pressure applied to the bit.
- The pressure applied to the bit multiplied by the area of the hydraulic cylinders gives the force or weight on bit.
- The bit torque can be measured in a similar fashion by comparing the off bottom hydraulic pressure of the rotation unit to the hydraulic pressure while drilling:

Area of both cylinders (4in diameter)	= 25.1in^2 or 162cm^2
Drop Pressure	= 100psi or 7kg/cm^2
25.1in^2 X 100psi	= 2510 lbs
162cm^2 X 7 kg/cm^2	= 1136 kg

The following tables are for a LF90D and LM underground rig with a 1300FF in an uphole configuration. These are guidelines and for values for your particular rig, please refer to your Ops and Service manual for more information. For the LF160 and LM with DCi WOB is calculated automatically.

BIT WEIGHT	FORCE ON BIT		WOB	LF90D			
OFF PRESSURE	LBF	kN	kg	BQ	NQ	HQ	PQ
100	1257	5.59	570				
150	1885	8.38	855				
200	2513	11.18	1140				
250	3142	13.97	1425				
300	3770	16.77	1710				
350	4398	19.56	1995				
400	5027	22.35	2280				
450	5655	25.15	2565				
500	6283	27.94	2850				
550	6912	30.73	3135				
600	7540	33.53	3420				
650	8168	36.32	3705				
700	8796	39.11	3990				
750	9425	41.91	4275				
800	10053	44.70	4560				
850	10681	47.49	4845				
900	11310	50.29	5130				
950	11938	53.08	5415				
1000	12566	55.87	5700				
1050	13195	58.67	5985				
1100	13823	61.46	6270				
1150	14451	64.25	6555				
1200	15080	67.05	6840				

BIT WEIGHT	FORCE ON BIT		1300FF UPHOLE			
HOLDBACK PRESSURE (MPA)	LBF	kN	BQ	NQ	HQ	PQ
1	515	2.28				
2	1025	2.28				
3	1539	2.28				
4	2050	2.28				
5	2565	2.28				
6	3080	2.28				
7	3590	2.28				
8	4100	2.28				
9	4615	2.28				
10	5130	2.28				
11	5645	2.28				
12	6155	2.28				
13	6670	2.28				
14	7180	2.28				
15	7695	2.28				
16	8210	2.28				
17	8721	2.28				
18	9234	2.28				
19	9750	2.28				
20	10260	2.28				

TORQUE

Torque generated by the bit is a function of sharpness of the bit and weight on bit, and results from the diamonds cutting the formation. As such, torque should be viewed as beneficial and an indication of drilling effectiveness. Minimum torque occurs just after bit sharpening has completed and as bit weight is reduced. Maximum bit torque occurs during bit sharpening due to the bit matrix coming into contact with the rock. A simultaneous decrease of torque and penetration rate indicates that the bit is polishing and needs to be sharpened. Torque increases due to sharpening should only be a concern in lost circulation or when sharpening requires water restriction. Bits with large diamonds can drop or stall RPM when sharpening. If RPM drops during sharpening then a lower gear or speed should be used to increase available torque. If WOB is reduced when stalling, the bit will polish.

PENETRATION RATE

The cutting rate varies as a result of weight on bit, sharpness, bit formula, and ground conditions. Typical penetration rates vary anywhere from 2 ipm to 12 ipm depending on bit formula and formation. As formations become harder, the penetration rate should be reduced to achieve good bit life. In extremely broken ground, drill at half RPM and weight on bit sufficient to reach 1 to 2 ipm (3 to 5 cpm).

FLUID FLOW

The flow of drilling fluid in the drill hole serves many purposes including the essential cooling of the diamonds, and removal of cuttings. High penetration rates require additional flow to keep cuttings off the bit face. There is no maximum water flow rate, though at high-flow rates, the bit can be lifted off the rock face, causing it to polish. Free-cutting bits obtain maximum life and penetration using plenty of water. If pumping at the highest flow rates, there is a frequent need to sharpen the bit pump output should be reduced. This will create a minor buildup of cuttings and sharpen the bit.

Water pressure is not an indication of water flow in positive displacement pumps. To calculate water flow, measure pump rpm with a tachometer. Pump output is proportional to output at max speed, as follows:

FMC LO918 Nameplate

Max Speed: 625 rpm

Output Flow: 20.2 GPM

Measured rpm of 240 rpm

$$\left(\frac{625\text{ rpm}}{240\text{ rpm}}\right) \text{X } 20.2\text{ GPM} = 7.5\text{ GPM}$$

SHARPENING

Simultaneous decrease of torque and penetration rate indicates that the bit is polishing and needs to be sharpened. Torque increases due to sharpening should only be a concern in lost circulation or when sharpening requires water restriction.

If a more durable bit has been selected for the rock type or if an impregnated bit has been allowed to slow down and polish, it is necessary to "open" or "strip" the matrix surface to expose new diamonds. This can usually be accomplished by reducing the spindle rpm by about 1/3 - 1/2 (select a lower gear if you have a transmission) and maintaining a constant penetration rate. Bit pressure will build up for approximately 1/2 - 1 in (1 - 2 cm) of drilling and then the bit pressure will drop quickly, signaling that stripping has occurred and the bit is cutting freely again. Immediately reduce bit pressure and increase spindle rpms to return to the target rpi (r/cm). If it becomes necessary to frequently repeat this process, it is recommended that you change to a more free cutting bit.

DRILL TIPS

Geology:

- In broken ground, rock is removed by grinding instead of cutting, run at half RPM and apply sufficient weight on bit to reach 1 to 2 ipm (3 to 5 cpm).
- Fluctuation in torque, particularly during sharpening is caused by unstable rock fragmentation and/or insufficient rock penetration. Weight on bit needs to be maintained to establish secondary fracturing and stable cutting.

Weight on Bit (WOB):

- WOB is too low if the bit polishes and torque drops. Results in low life and penetration rate.
- WOB is too high if added weight does not increase penetration rate. Results in constant sharpening and rapid wear.

Fluid Flow:

- High penetration rates require additional flow.
- The maximum flow rate will be reached when the bit is lifted off the rock face, causing it to polish.
- Free-cutting bits obtain maximum life and penetration using plenty of water.

Torque:

- If the head stalls under normal operation, reduce the speed to produce more torque and maintain steady rotation.
- Maximum bit torque occurs during bit sharpening. Only be concerned with torque rise when restricting water or in lost circulation.

DRILL TIPS

Penetration:

- The penetration rate to prevent polishing may be higher in large diamond bits.
- If reducing rotation by 1/3 and maintaining penetration does not sharpen the bit (up-holes, underpowered rigs, or too low a series bit), reduce RPM by 1/2 and reduce water flow. Wait until torque and penetration rate rises. Return speed and water flow to normal operation.

Sharpening:

- Sandblasting bit with a hard abrasive will restore exposure.
- Large diamond bits have a greater rise in torque on initial sharpening. WOB needs to be held until penetration rate increases. Reduce WOB to maintain desired RPI once sharp.
- If frequent sharpening is required, a higher series bit formula should be selected.

Sharpening DO-NOTs:

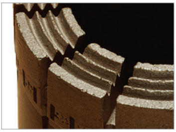
- Under no circumstances should any acid be used for sharpening a Longyear™ bit.
- Shutting off the water flow while drilling and waiting for the bit to "bite", is not recommended due to the likelihood of burning in the bit.
- It is not recommended to drop nuts or bolts down hole to sharpen bits as these can melt and block waterways.

WEAR PATTERNS, PROBLEMS, AND REMEDIES

Much can be learned from examining impregnated bits when they are pulled from the hole. The illustrations and observations in this section can help identify and remedy many common field problems.

Normal retirement or discarding of an impregnated bit should take place only after it has been totally consumed. Most Longyear™ impregnated bits have full-depth waterways to allow the bit to be fully consumed. The first indicator that a bit is nearing normal retirement is a rise or kick in pump pressure due to the diminishing depth of waterways. In Stage™ bits, this rise is observed at the transition of each stage.

NORMAL WEAR PATTERNS



NEW CONDITION

IDEAL WEAR PATTERN

The face wear pattern of an impregnated bit should be relatively flat with slightly chamfered sides. Bit feels sharp, comet tails have formed to support diamonds. Diamonds release from matrix as they are worn. Gauge stays within tolerance.

NORMAL RETIREMENT

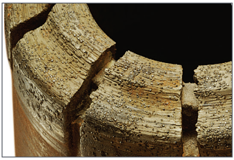
Full depth of impregnation evenly consumed. Gauge stays within tolerance.

IRREGULAR WEAR PATTERNS

CONCAVE FACE WEAR
(ROUNDED TO INNER DIAMETER)

Cause: Often caused by excessive penetration rate for the RPM used. This can also be caused by core grinding, overdrilling.

Solution: Reduce penetration rate or increase RPM Gauge stays within tolerance.



CONVEX FACE WEAR (ROUNDED TO OUTER DIAMETER)

Cause: Insufficient water flow

Solution: Check pump and rod string for leaks; increase pump output.

GAUGE LOSS ID

Cause: (A) Overfeeding (B) Broken formations (C) Drilling over lost core (D) Insufficient drilling fluid

Solution: (A) Reduce penetration rate (B) Cement or change to a more durable bit (C) Check core barrel/core lifter/core lifter case (D) Check inner tube length adjustment; check pump and rod string for leaks – increase pump output

The causes and solutions described in this section are not exclusive lists, but represent common causes and generally effective solutions based on the experience of Boart Longyear and its customers.

WEAR PATTERNS, PROBLEMS, AND REMEDIES

GAUGE LOSS OUTER DIAMETER

Cause: (A) Lack of circulation (B) Bit being reamed down under-size hole (C) Vibration

Solution: (A) Increase coolant flow rate (B) Check reamer shell gauge and replace if under-sized (C) Alter RPM

EXCESSIVE DIAMOND EXPOSURE

Matrix abrades away before diamonds have worn sufficiently, resulting in high diamond exposure and low bit life.

Cause: Caused by overfeeding / over drilling

Solution: Increase RPM, change to a more durable bit, or reduce bit weight.

FACE GLAZED (DIAMOND POLISHED AND METAL BOUND)

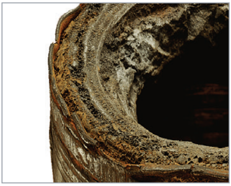
Cause: Bit does not feel sharp; diamonds flush with matrix; no significant “comet tails” behind each diamond.

Solution: Sand blast face or use other recommended methods to re-expose diamond. If the face glazes repeatedly, change to a more free cutting bit.– increase pump output

CRACKED WATERWAYS
(DIAMONDS POLISHED)

Cause: (A) Excessive bit load; dropped rods; free fall of (wireline) inner tube in dry hole; (B) bit crushed by rod holder, foot clamp or pipe wrench; (C) Pushed down an undersized hole (i.e., reaming shell worn out)

Solution: Review proper operating procedures.



BURNT

Cause: (A) Lack of fluid. (B) Too high of weight on bit being used

Solution: Check pump and rod string for leaks, check inner tube adjustment, maintain coolant flow rates.

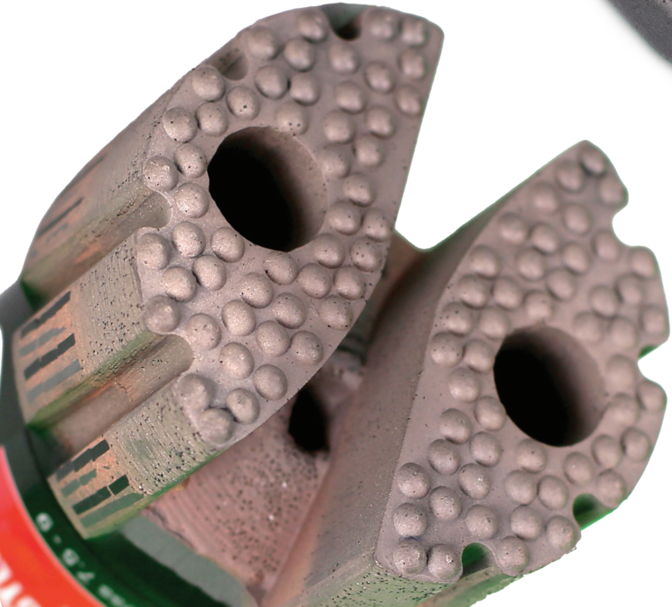
DIRECTIONAL DRILLING BITS

DOWN HOLE MOTOR (DHM)

DHM bits are threaded on to downhole motors and used in directional drilling applications They have reinforced center ports and have an impregnated full-face crown. These bits can also be used as impregnated plug bits.

WEDGE CORING BITS

Wedging bits are diamond products designed to follow wedges set in the bore hole with the intention of altering the hole direction. These special profiles are required to avoid drilling straight through the wedge.



DHM	Fluid Volume Range		Rotation Speed	Pen Rate		Pen Rate		Indicative Bit Weight Range			
				in/min		cm/min		lb		kN	
	GPM	LPM	RPM	100 rpi	200 rpi	40 r/cm	80 r/cm	Low	High	Low	High
N Size	15-21	56-79	1200	12.0	6.0	30.0	15.0	5000	12000	22	53
			1000	10.0	5.0	25.0	12.5				
			500	5.0	2.5	12.5	6.3				
H Size	25-33	94-124	900	9.0	4.5	22.5	11.3	8000	22000	36	98
			750	7.5	3.8	18.8	9.4				
			400	4.0	2.0	10.0	5.0				

* Scaled matching OD surface velocity, chip volume, and contact pressure

REAMING SHELLS

Although Boart Longyear diamond reaming shells do last longer than bits it is recommended to alternate two or more reaming shells in each hole drilled to maintain proper hole size and to retire reamers which wear under gauge. Failure to observe this customary practice will results in either a poorly stabilized bit or undersized hole that will have to be reamed. It is recommended that a ring gauge is used to check wear of the reaming shell.

Our reaming shells come standard with single pad (6”) design but are available in a dual pad (10”) and adapter coupling designs for added stability in hole.

RSUMX

Patented technology enables the use of large synthetic diamonds enhancing wear life and eliminating the need for specialty shells. Outer diameter grinding pre-exposes the diamond and reduces variation in size improving stability and helping to produce the longest lasting reaming shell on the market.

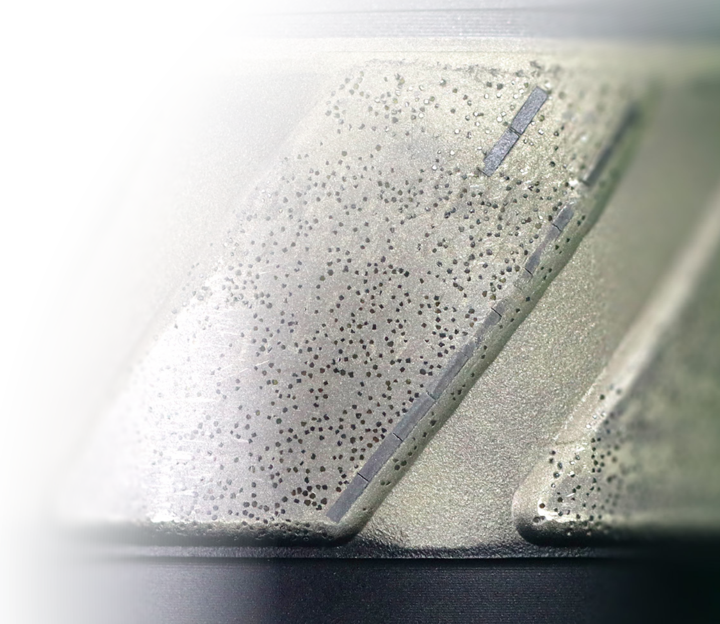
Available in standard single pad (6”), dual pad (10”), adapter coupling, and heavy-duty versions.

TOUGH

Along with exposed diamonds, each pad includes tungsten carbide and thermally stable diamonds on the leading cutting edge making this reamer ready to drill out of the box.

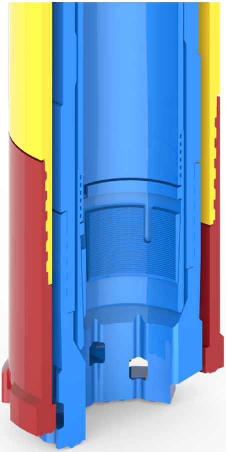
Available in standard single pad (6”), dual pad (10”), and adapter coupling versions.

A reaming shell gauge should be used each time a shell is out of the hole to check if it meets minimum requirements to avoid issues of stuck rods or undue wear on the OD of the bit. If a reaming shell passes through the minimum size reaming shell gauge it should be retired from service.



CASING SHOES AND CASING BITS

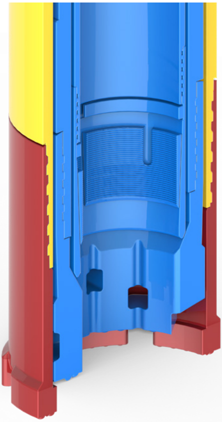
CASING SHOES



Casing and rod shoes are threaded to the end of the outer drill string for penetration through overburden. It assists in seating the outer drill string into the bedrock, providing a tight seal for the drilling fluids to return to the surface. A casing shoe can be used to ream the casing downward when advancing a casing string in an existing hole with the rod string still in place.

The casing shoe ID is flush with casing which allows free passage of the core barrel through the shoe.

CASING BITS



These are less commonly used and differ from casing shoes in that the ID of the casing bit is smaller. It does not permit the passage of the core barrel due to the overlap of dimensions.

Casing bits are used when deep or difficult overburden is encountered or to ream over rod strings when stuck in the hole.

APPLICATIONS

Boart Longyear casing shoes are designed for all exploration and geotechnical casing applications. The ability to drill faster with high penetration rates and outperform existing shoe technology in a wide range of ground formations make them ideal for anyone seeking a cost-effective alternative to their current shoe selection.

CORE LIFTER CASES

Boart Longyear lifter cases are made of a high quality alloy steel that is specially heat treated to increase strength, toughness, and wear life. Available in Q, QTK, Q-P, Q3, and QTT versions. The specialized Q-P/QTT core lifter case works with Q-P/QTT bits to route fluid flow to the cutting face and away from the core.

Q Lifter Case

Q3 Lifter Case

QP Lifter Case

QTT Lifter Case

AQTK

PART #	DESCRIPTION
5001021	AQTK CORE LIFTER CASE

BQ

PART #	DESCRIPTION
24830	BQ CORE LIFTER CASE
53199	BQTK CORE LIFTER CASE

NQ

PART #	DESCRIPTION
5008320	NQ-P CORE LIFTER CASE
24892	NQ CORE LIFTER CASE
29209	NQTK* CORE LIFTER CASE
26529	NQ3 CORE LIFTER CASE
65600	NQTT CORE LIFTER CASE

*NQTK also known as NQ2

HQ

PART #	DESCRIPTION
5007937	HQ-P CORE LIFTER CASE
25237	HQ CORE LIFTER CASE
26514	HQ3 CORE LIFTER CASE
65607	HQTT CORE LIFTER CASE

PQ

PART #	DESCRIPTION
52172	PQ CORE LIFTER CASE
26160	PQ3/PQTT CORE LIFTER CASE

GAUGES & SCRATCH TEST KIT

SCRATCH TEST KITS

Used to determine the Mohs hardness for a given material. This data can help in selecting the correct bit. The kit comes with 4 scratchers with 8 replaceable tips covering Mohs values 2 to 9.

1. Clean surface of rock to be tested.
2. Hold core sample and firmly press point of scratcher into the rock.
3. Brush away any fragments or powder produced.
4. Make sure a distinct groove was made, not a mark that can be wiped away.
5. If no scratch was made, move up to next scratcher.
6. Once a scratch is made, conduct a second test to confirm results.

PART #	DESCRIPTION
4065217	Scratch Test Kit

STEEL RING GAUGES

Used for verifying the size of new bits and shells. All gauges are stamped with measurement size for reference.

PART #	DESCRIPTION
4065882	BQ/LTK60 BIT -R & SHELL
4065874	NQ BIT -R & SHELL
4066272	NQ BIT OS & SHELL
4065869	HQ BIT -R & SHELL
4066537	HQ 3.830 OS BIT & SHELL
4066542	HQ 3.895 OS BIT & SHELL
4065919	PQ BIT -R & SHELL R
4066547	PQ OS BIT & SHELL

EXPLORATION KIT

Used by drilling personnel to improve performance during exploration by measuring parameters and examining tooling wear.

PART #	DESCRIPTION
5010602	KIT, EXPLORATION INSPECTION
	OGIO BACKPACK
	CONTACTLESS TACHOMETER
	STOPWATCH
	MEASURING TAPE
	DIGITAL CALIPER
	10X EYE LOUPE
	SCRATCH TEST KIT
	BIT/SHELL GUAGES
	ROD WEAR GUAGES - Q, RQ, XQ

NOTES

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NOTES

CONVERSIONS*

square inch (in^2)	x 645.160	= square millimeter (mm^2)	x 0.00155	= square inch (in^2)
square inch (in^2)	x 6.452	= square centimeter (cm^2)	x 0.155	= square inch (in^2)
square feet (ft^2)	x 0.093	= square meter (m^2)	x 10.764	= square feet (ft^2)
pound-force (lbf)	x 4.448	= Newton (N)	x 0.225	= pound-force (lbf)
kilogram-force (kgf)	x 9.807	= Newton (N)	x 0.102	= kilogram force (kgf)
inch (in)	x 25.4	= millimeter (mm)	x 0.039	= inch (in)
foot (ft)	x 0.305	= meter (m)	x 3.281	= foot (ft)
mile (mi)	x 1.609	= kilometer (km)	x 0.621	= mile (mi)
pound (lb)	x 0.454	= kilogram (kg)	x 2.205	= pound (lb)
ounce (oz)	x 28.350	= gram (g)	x 0.0353	= ounce (oz)
pound-force foot (lbf ft)	x 1.356	= Newton meter (Nm)	x 0.735	= pound-force foot (lbf ft)
pound-force inch (lbf in)	x 0.113	= Newton meter (Nm)	x 8.851	= pound-force inch (lbf in)
horsepower (hp)	x 0.746	= kilowatt (kW)	x 1.341	= horsepower (hp)
kilowatt hour (kWh)	x 3,600,000	= joule (j)	x 0.00000278	= kilowatt hour (kWh)
pound per square inch (psi)	x 6.895	= kilo pascal (kPa)	x 0.145	= pound per square inch (psi)
pound per square inch (psi)	x 0.00689	= mega pascal (MPa)	x 145.03	= pound per square inch (psi)
inch of water (in H_20) @ 60°F	x 248.830	= Newton per square meter (N/m^2)	x 0.00402	= inch of water (in H_20) @ 60°F
degree Fahrenheit (°F) -32	x 0.556	= degree Celsius (°C)	x 1.8+ 32	= degrees Fahrenheit (°F)
feet per second (ft/sec)	x 0.305	= meter per second (m/sec)	x 3.281	= feet per second (fi/sec)
miles per hour (mph)	x 1.609	= kilometer per hour (km/h)	x 0.621	= miles per hour (mph)
U.S. gallon (U.S. gal.)	x 3.785	= litre (l or L)	x 0.264	= U.S. gallon (U.S. gal.)
Imperial gallon (imp. gal.)	x 4.544	= litre (l or L)	x 0.2196	= Imperial gallon (imp. gal.)
cubic inch (in^3)	x 16.387	= cubic centimeter (cm^3)	x 0.061	= cubic inch (in^3)
cubic inch (in^3)	x 0.0164	= litre (l or L)	x 61.02	= cubic inch (in^3)
cubic feet (ft^3)	x 0.0283	= cubic meter (m^3)	x 35.315	= cubic feet (ft^3)
U.S. gallon per minute (gpm)	x 3.785	= litre per minute (L/min)	x 0.264	= U.S. gallon per minute (gpm)
cubic feet per minute (cfm)	x 0.0283	= cubic meter per minute m^3/min)	x 35.315	= cubic feet per minute (cfm)

OTHER UNITS

1 bar = 0.1 MPa = 14.5 psi
1 kg/cm^2 = 0.981 bar = 0.0981 MPa
1 kg m = 9.81 Nm = 7.233 lbf ft
1 lb/U.S. gal. = 0.12 kg/L

* Factors have been rounded off for field use.

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