

**Effecticus.
Excellenticus.
Environmenticus.**

Epsilon² – Next Level Rotary Drill Bit



Three clever cones

It's all about flow. Getting your rig to work as fast and smoothly as possible – without unplanned stops.

Miners want to drill uninterruptedly, nothing else. That's how you become profitable. It's also how your operation becomes as gentle as possible on people and the environment.

At Epiroc, we know what has bothered miners for long. Bits getting stuck deep down below ground. Inserts wearing out prematurely. Bearings corroding due to moisture.

We decided to do something about it. We went back to the drawing board and asked our engineers to fix these problems.

They came up with a set of truly clever features. Brand new functions that we had some of our customers test in real and demanding conditions.

Like Torrent AWS and Tornado. They'll blow you away.



Did you know that...

The new Epsilon² comes with three patented features that make other tricone air bearing bits seem obsolete: Tornado vectored precision air bearing, Torrent AWS (air-water separator) and Nozzle optimization system (NOPS).



Excellenticus

Premium quality

For us at Epiroc, being your first choice is what counts. We know the importance of premium bit quality to minimize total drilling cost (TDC). The better the bit, the higher your profit – simple as that! We spend considerable resources on R&D, including extensive computational fluid dynamics (CFD) analyses. Not for show, but to boost drilling performance. Like with Epsilon², where our customers' tests show up to 61 percent longer distance drilled before bit discard compared to a standard tricone air bearing bit. Quality pays off and it will show on your bottom line.

Effecticus

Boosting profitability

Bearing failure is a common problem with air bearing bits. Either the bearing inside each cone becomes too hot due to friction, or it corrodes due to intrusion of damp from water injection for dust suppression. Not anymore. We developed new and patented features that cool bearings more efficiently, using almost completely dry air – thus solving both problems. As a result, we managed to increase bearing air flow by 60 percent and reduce cone erosion by 59 percent – doubling bearing life. Add more effective cleaning of the rock face, and you are looking at significantly faster penetration rates and longer life of the cutting structure.

Environmenticus

Reducing climate impact

At Epiroc, we are attentive to the demands of a changing world, and we are determined to grow our business safely and sustainably. Continuously reducing climate impact – our own as well as our customers' – is a key focus area for us. This quest characterizes every part of our business – from pushing the frontline of fossil-free electric drilling rigs to developing smart air bearing bits such as Epsilon². Because a bit that offers uninterrupted operation and extended service life means fewer products manufactured, less outtake of raw materials and reduced transportation.

What first meets the eye is impressive...

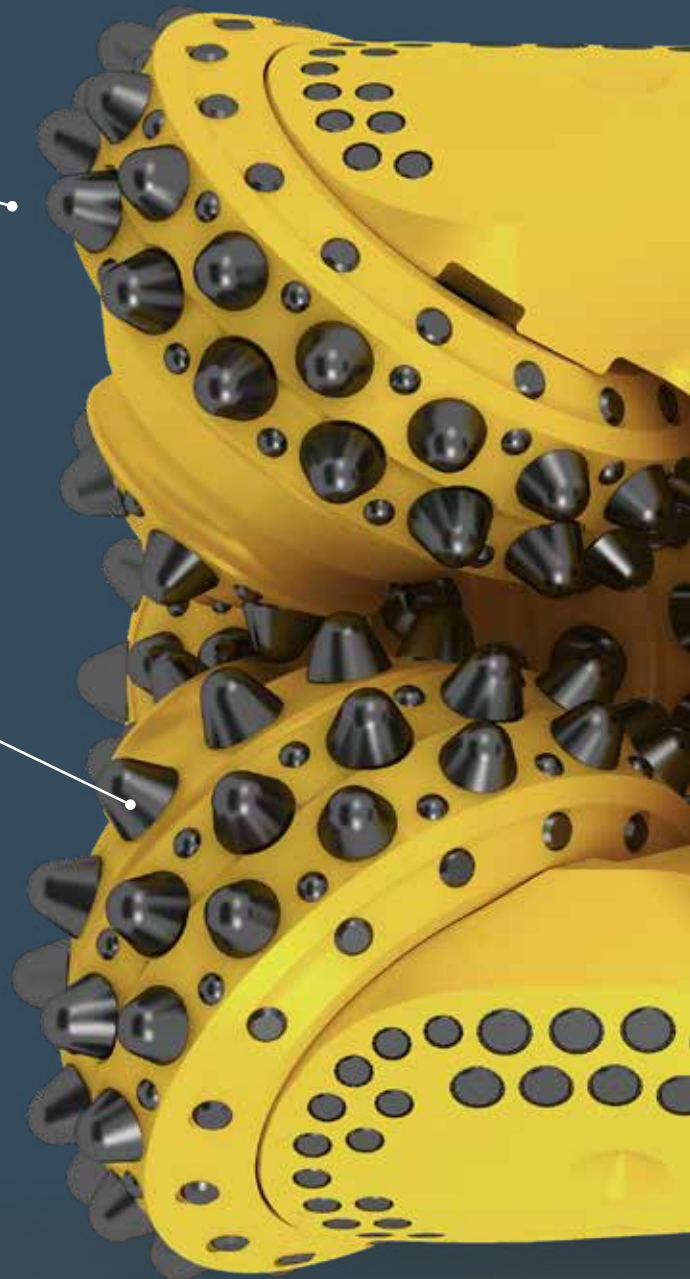
A quick glance at the exterior of Epsilon² is enough to spot several high-quality features. We re-designed our previous Epsilon bit with the most durable materials available in the market. We also added online capabilities, making Epsilon² the first air bearing bit prepared for tomorrow's connected mining operations.

Different insert configurations

Epsilon² comes in many varieties, ranging in diameter from 6-3/4 to 16 inches (171 to 406 mm), and with different insert configurations (cutting structures) for soft, medium, hard and very hard rock types.

Stronger. Tougher. Harder. Enduro.

Enduro carbide inserts last longer. They are more wear resistant, therefore keeping their original shape and sharpness longer. They are also tougher, so they won't break as easily, even under severe drilling conditions of broken rock or at high rotational speeds.



Strongest steel ever

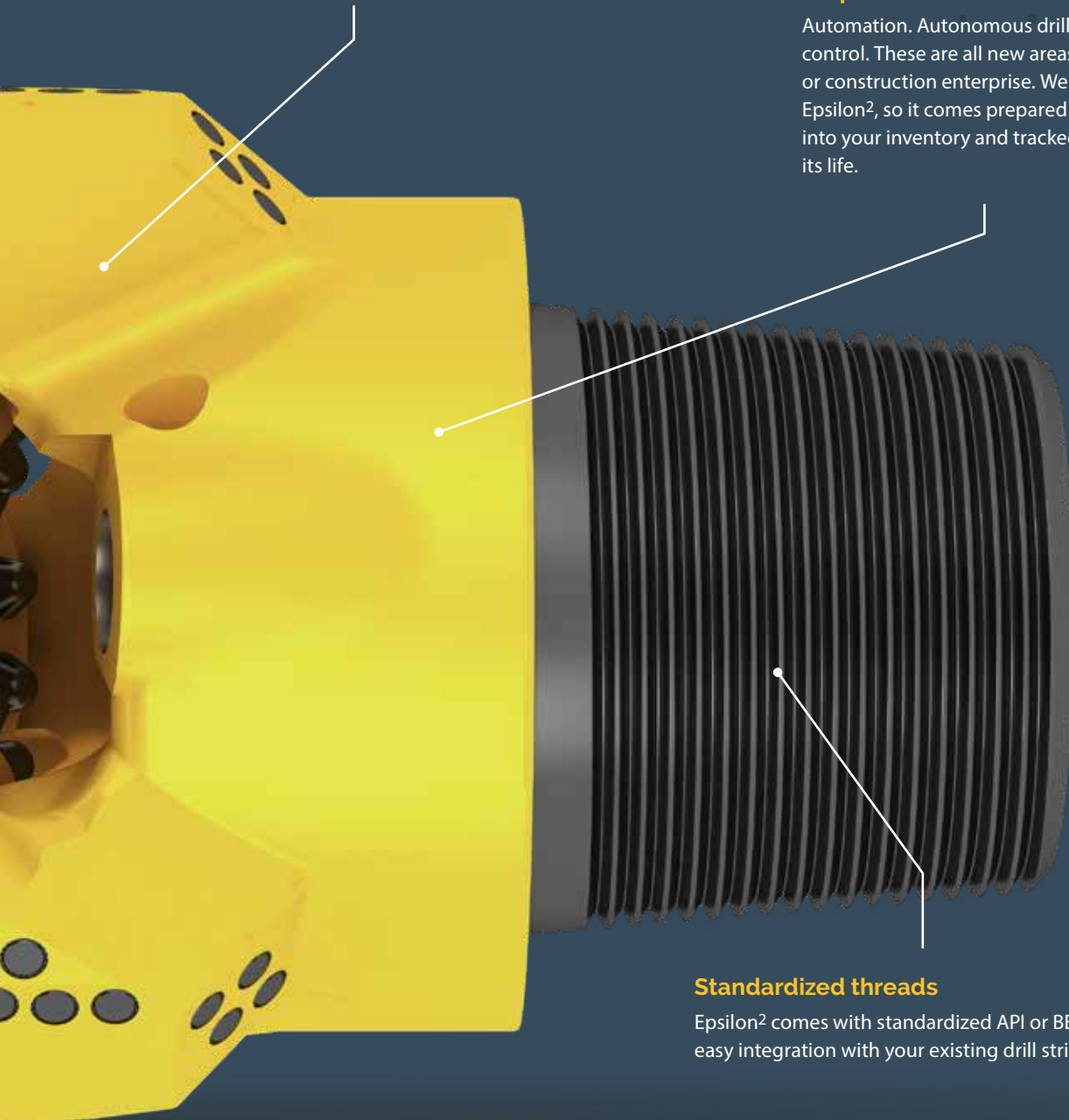
We put our metallurgists to work with a simple request – invent the most durable steel we’ve ever used in a drill bit (and our history dates back to 1873...). They got back to us with a new alloy of outstanding wear resistance and fatigue strength. Lug and cone material improvements mean a stronger, longer lasting structure.

Prepared for connectivity

Automation. Autonomous drilling. Inventory control. These are all new areas of any mining or construction enterprise. We online-enabled Epsilon², so it comes prepared to be scanned into your inventory and tracked throughout its life.

Standardized threads

Epsilon² comes with standardized API or BECO threads for easy integration with your existing drill string equipment.



...and more treasures are hidden inside

Opening up Epsilon² exposes some very special features, set to revolutionize air bearing bit technology. Patented Torrent AWS (air-water separator) and Tornado combine to eliminate a common cause of drilling stoppage – bearing failure – while NOPS helps to extend bit life and distance drilled before bit discard.

Keeping bearings cool – Tornado

Tornado, or the Vectored precision Tornado bearing airflow design, directs air to the load side of the bearings, thus improving cooling performance and increasing bearing life.

Keeping bearings cool and clean is a constant problem with tricone bits. We used computational fluid dynamics (CFD) modeling to effectively distribute the compressed air delivered to the bearings. This way, we were able to improve the cooling effect of the air on the frictional heat generated by continuously rolling elements supporting tons of load.

Previous designs almost immediately exhausted the air from the bearing through the exhaust ports, before it had the chance to cool the load side of the bearing (which is by far the hottest). Excessive heat would then deteriorate the bearing's surfaces, reducing its life. With Tornado, we devised a different path for the air through the bearing by optimizing the location of the exhaust ports and exhaust pathways inside the bearing.



Reducing bearing corrosion – Torrent AWS

Torrent AWS efficiently prevents moisture from water injected for dust suppression from entering the bearings.

The dust generated by blasthole drilling in rock often contains high levels of silica, a direct contributor to silicosis. Torrent AWS allows for water to be injected to suppress the dust and control fugitive dust in the environment, while reducing the exposure of water to the bearings.

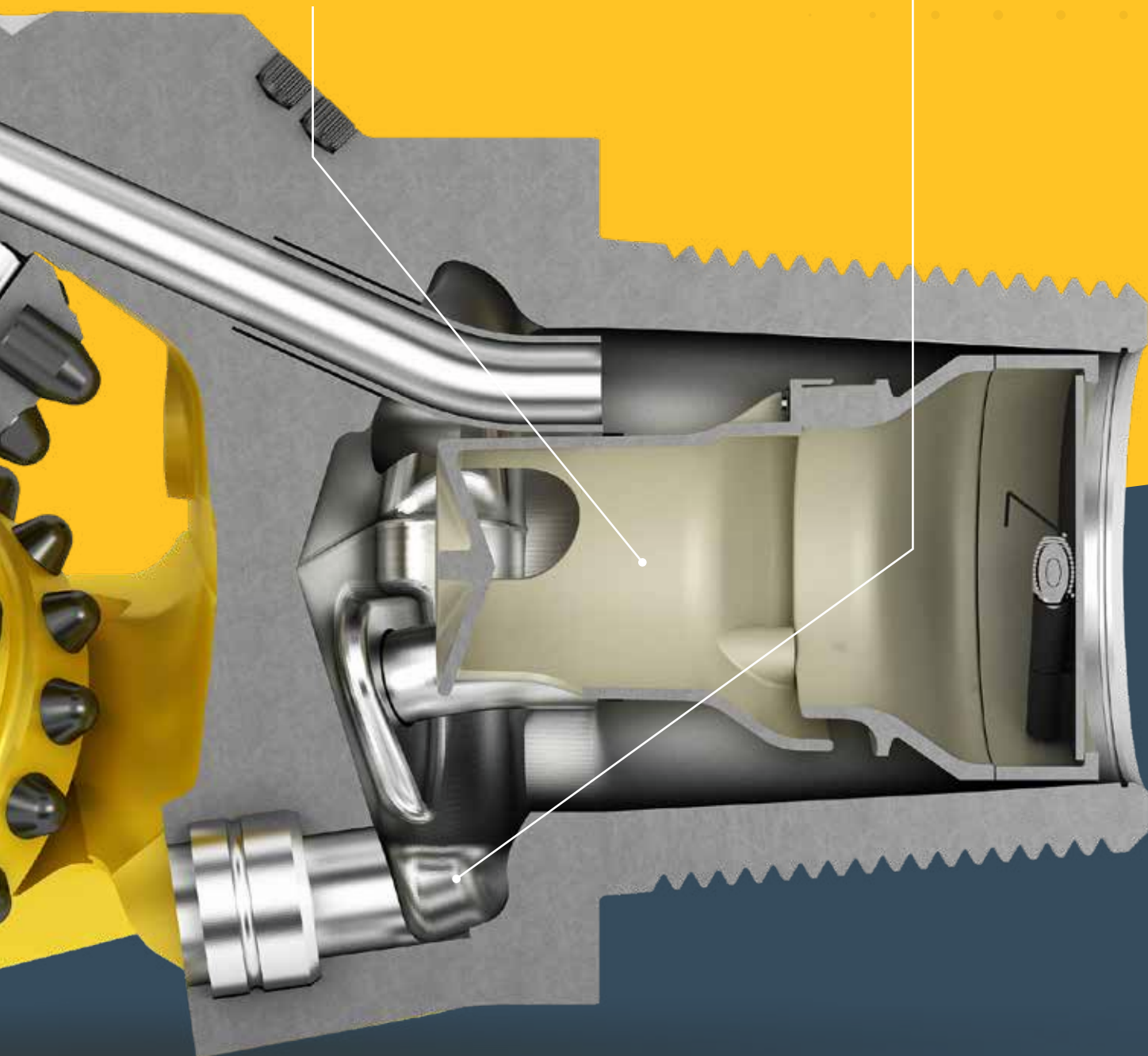
Torrent AWS channels dry air through the bearings, while allowing the remaining saturated air mixture to flow through the nozzles. The air-water mixture going to the bearings has to pass through two vertical 180 degree turns, which water struggles to do, separating 95 percent or more of the water – increasing bearing life by up to 100 percent.

Fastest cuttings evacuation – NOPS

Nozzle optimization (NOPS) helps to evacuate cuttings 50 percent faster, reducing cone erosion by up to 60 percent.

NOPS, a patent licensed from Baker Hughes, optimizes the direction of the nozzles used for water injection. This helps to remove cuttings and clean the rock face more efficiently, thereby increasing the rate of penetration (ROP) and extending the life of the bit's cutting structure.

NOPS cleans the bottom of the hole by targeting critical areas and making a smoother evacuation of the cuttings, while cleaning the cutting structure. This reduces tooling wear, extends bit life and reduces cost.



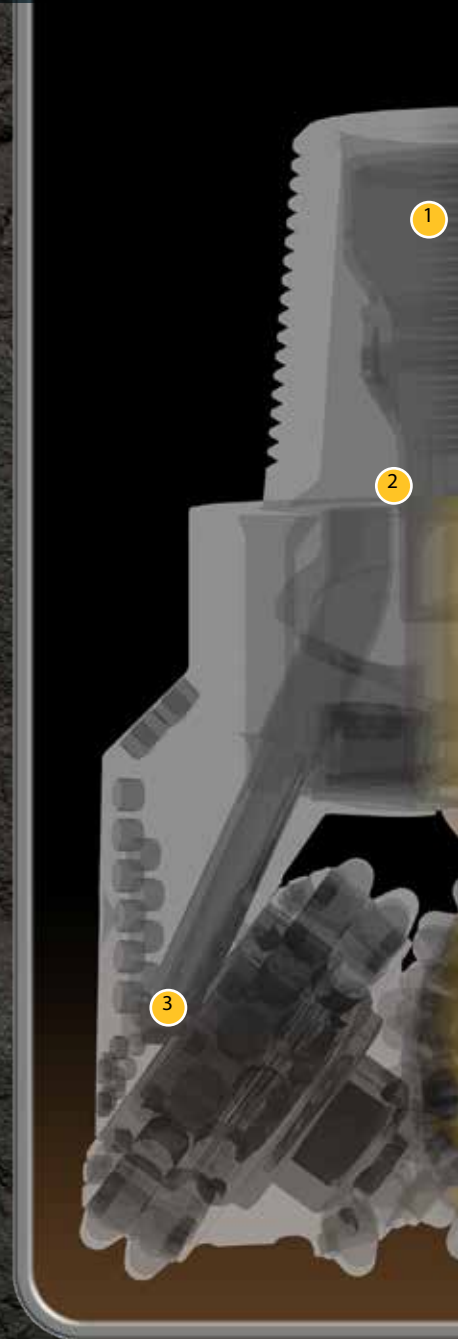
A closer look at our pate

Here you can have a closer look at the design of Tornado, Torrent AWS and NOPS.



Tornado

- 1 Dry and clean air is injected into the bearing of each cone.
- 2 Optimized location of exhaust ports and pathways channels more air over the hot load side.
- 3 The bearing is kept cooler, reducing wear of the surfaces – extending bit life.



Torrent AWS

- 1 Flanges on the airtube prevent moisture from the bearing cooling.
- 2 The air-water mixture turns, which water carries moisture from the air.
- 3 The moisture content enters the bearing.

nted features



...es separate most of the water
...oling air.
...e has to make two 180 degree
...annot make – separating more
...r.
...at is less than 5 percent as the air

NOPS

- 1 The direction of the nozzles is optimized using CFD analysis.
- 2 Three jets of saturated air mixture efficiently remove cuttings and clean the rock face.
- 3 The average time for cuttings to clear the bit sub is reduced by 50 percent.

Unbeatable drill string

Every part of the drill string must perform optimally. That's why we pay equal attention to shock absorbers, pipes and drill bits. For you, it means that you can get a complete, unbeatable special alloy drill string from a single supplier: Epiroc.

Each component is important

When developing a rotary drilling system, most of the attention is given to the drill rig – the capital equipment that requires significant investment and hence a planned payback.

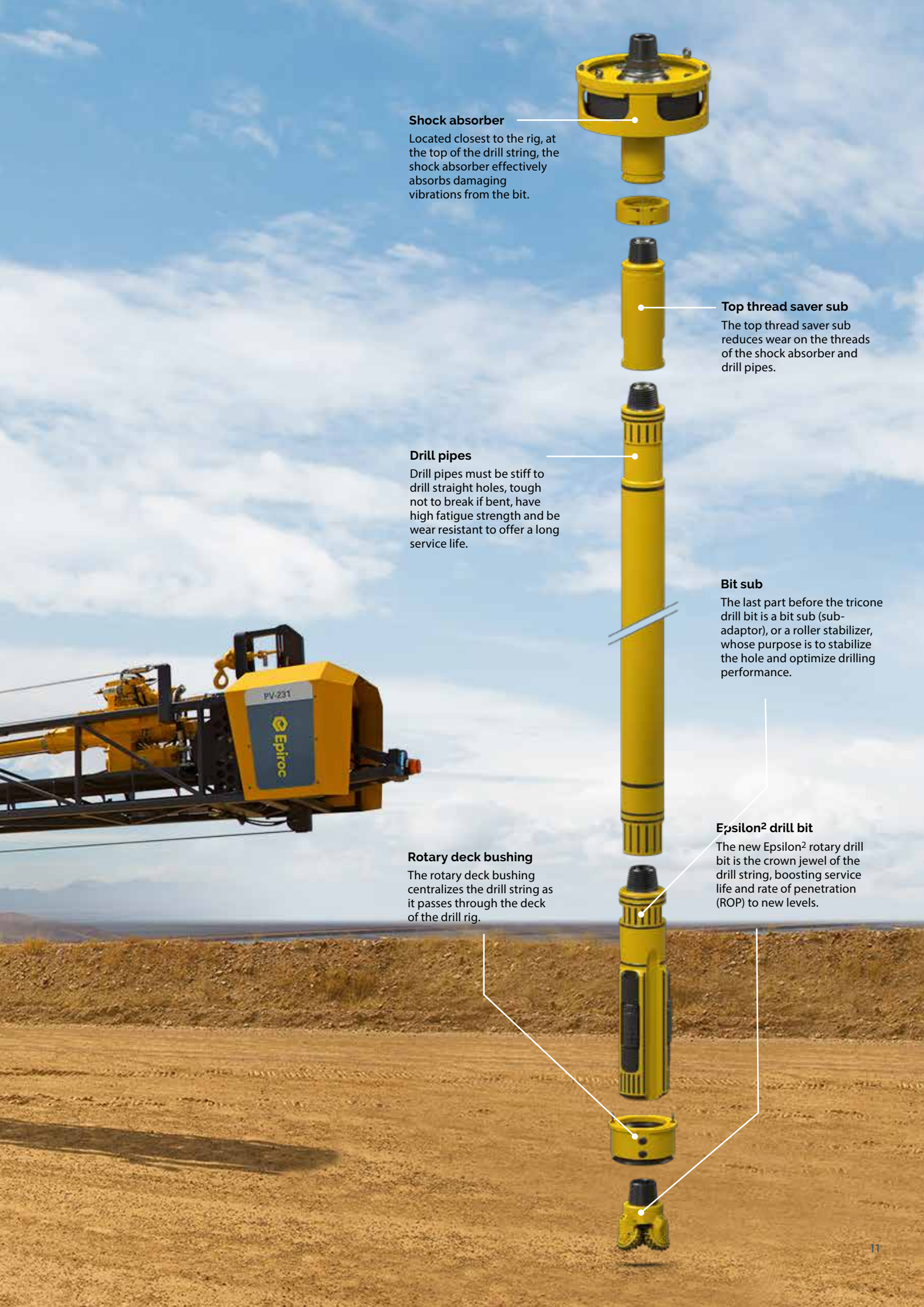
The second priority in the system tends to be choice of rotary tricone drill bit. However, to utilize the full power and capacity of the rig and the bit, and at the same time increase service life and productivity, serious consideration must be given to each component in the drill string.

The drill string's primary purpose

The primary purpose of the drill string is to transmit the rotational torque and weight from the rotary head power source to the rock breaking drill bit.

As in every rock drilling method, the power must be transmitted as efficiently as possible, and return as few vibrations as possible, as these cause unnecessary wear on the drill rig and reduce penetration rates.





Shock absorber

Located closest to the rig, at the top of the drill string, the shock absorber effectively absorbs damaging vibrations from the bit.

Top thread saver sub

The top thread saver sub reduces wear on the threads of the shock absorber and drill pipes.

Drill pipes

Drill pipes must be stiff to drill straight holes, tough not to break if bent, have high fatigue strength and be wear resistant to offer a long service life.

Bit sub

The last part before the tricone drill bit is a bit sub (sub-adaptor), or a roller stabilizer, whose purpose is to stabilize the hole and optimize drilling performance.

Epsilon² drill bit

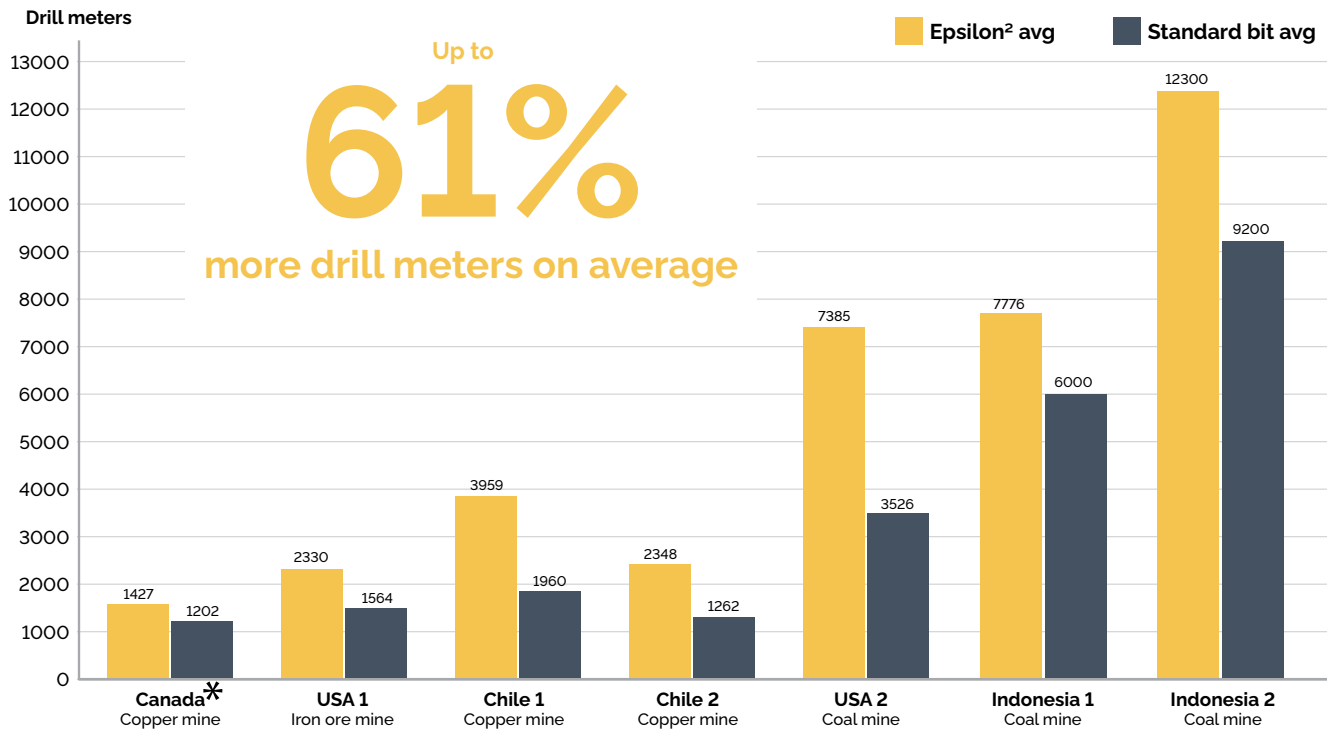
The new Epsilon² rotary drill bit is the crown jewel of the drill string, boosting service life and rate of penetration (ROP) to new levels.

Rotary deck bushing

The rotary deck bushing centralizes the drill string as it passes through the deck of the drill rig.

Proven performance

Epsilon² has been put to the test in numerous drill tests. Before launch, we tested hundreds of bits across the globe in collaboration with selected customers. The tests were made independently and offer strong evidence of the new bit's superior performance. See for yourself!



Test results show that Epsilon² provides up to **61 percent** more drill meters on average before discard than a standard bit. The chart shows the location of the sites used for testing.

* Average of six measurements, the highest of which was a 42 percent improvement as shown in the test case on page 13.



Two test cases

So how did we test Epsilon²? Here we present two of our test cases, including rig model, bit dimension and performance data.

Canada

Site characteristics

A conventional open pit, truck and shovel operation. The mine has a 40 kiloton per day plant that utilizes a conventional crushing, grinding and flotation circuit to produce copper concentrates, with silver and gold credits.

Method

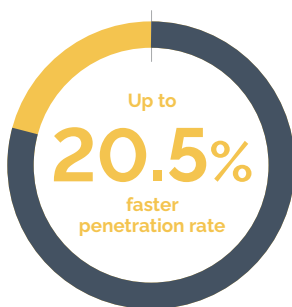
Various designs were tested with variations in the Epsilon² feature, including nozzle position, air-water separation and Enduro premium carbide inserts. Six test sets were made to measure distance drilled and penetration rate improvements compared to a standard bit.

Equipment

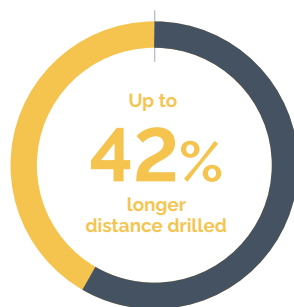
- Drill rig: Epiroc Pit Viper 351
- Speed: 65-75 rpm
- Airflow: 3,040 CFM (5,164 m³/h)
- Pressure: 72 psig (5 bar)
- Drill bit: Epsilon² tricone bit, 10-5/8 inches (270 mm)

Results

Rate of penetration: up to 20.5 percent faster
Distance drilled: up to 42 percent longer



The rate of penetration was up to 20.5 percent faster with Epsilon² than with a standard tricone bit.



The distance drilled was up to 42 percent longer with Epsilon² than with a standard tricone bit.

USA

Site characteristics

Testing was made in different Appalachian coal mines, allowing us to get feedback from several customers. The geological and operational conditions in the mountainous region are highly varied. Despite these differences – and other large variations such as a mix of old and newer rigs and different bench patterns – customers request to use only one robust, universal bit.

Method

Numerous Epsilon² tests were made, using mainly mid-range DML and DM-45 drill rigs. As one of the most commonly used dimensions in the region, the 6-3/4 inch Epsilon² bit was selected for testing and comparison with a standard air bearing bit.

Equipment

- Drill rig: Epiroc DML and DM-45
- Drill bit: Epsilon² tricone bit, 6-3/4 inches (171 mm)

Results

Distance drilled:

Standard bit: up to 11,569 feet (3,526 meters)
Epsilon²: up to 24,230 feet (7,385 meters)



The average distance drilled was up to 109 percent longer with Epsilon² than with a standard tricone air bearing bit design.



Easy selection

We made it as easy as possible for you to select the right Epsilon² bit for each drilling operation. The bits are divided into only four categories based on the strength of the rock where they will be used. The Epsilon² diameter range is from 6-3/4 inches (171 mm) to 16 inches (406 mm), and the IADC code range is from 412 to 722.



Rock strength 0–8,000 UCS / SOFT

Bit diameter	IADC code		
	41E2	43E2	44E2
6-3/4" (171 mm)			
7-7/8" (200 mm)			
9" (229 mm)	5697000042		
9-7/8" (251 mm)		5697000046	
10-5/8" (270 mm)			5697000010
12-1/4" (311 mm)			
13-3/4" (349 mm)			
16" (406 mm)			



Rock strength 6,000–28,000 UCS / MEDIUM

Bit diameter	IADC code		
	52E2	53E2	54E2
6-3/4" (171 mm)		5697000054	
7-7/8" (200 mm)	5697000038	5697000039	
9" (229 mm)		5697000043	
9-7/8" (251 mm)			5697000047
10-5/8" (270 mm)	5697000028		5697000013
12-1/4" (311 mm)		5697000029	5697000030b 5697000031
13-3/4" (349 mm)			
16" (406 mm)			



Rock strength 24,000–46,000 UCS / HARD

Bit diameter	IADC code		
	62E2	63E2	64E2
6-3/4" (171 mm)		5697000037	
7-7/8" (200 mm)	5697000040		5697000041
9" (229 mm)	5697000044		5697000045
9-7/8" (251 mm)	5697000048		5697000049
10-5/8" (270 mm)	5697000025	5697000026	5697000027
12-1/4" (311 mm)	5697000032		5697000034b 5697000033
13-3/4" (349 mm)	5697000036b		
16" (406 mm)			



Rock strength 38,000+ UCS / VERY HARD

Bit diameter	IADC code		
	71E2	72E2	
6-3/4" (171 mm)			
7-7/8" (200 mm)			
9" (229 mm)			
9-7/8" (251 mm)			
10-5/8" (270 mm)			
12-1/4" (311 mm)		5697000035b	
13-3/4" (349 mm)			
16" (406 mm)	5697000053b		

Nozzles diameter

Based on bit diameter and compressor rating.

Target bit PSI: 45 Assume: 3,000 feet elevation, 70°F (21°C) intake air temp, 120°F (49°C) delivered air temp

Bit diameter	Air compressor rating, iCFM							
	1000	1250	1400	1600	1900	2600	3000	3800
6-3/4" (171 mm)	5/16	3/8	7/16	1/2	5/8	-	-	-
7-7/8" (200 mm)	5/16	3/8	7/16	1/2	5/8	-	-	-
8-1/2" (216 mm)	1/4	5/16	3/8	7/16	9/16	13/16	-	-
9" (229 mm)	1/4	5/16	3/8	7/16	9/16	5/8	3/4	15/16
9-7/8" (251 mm)	3/16	5/16	5/16	7/16	1/2	9/16	11/16	15/16
10-5/8" (270 mm)	3/16	1/4	5/16	3/8	1/2	9/16	11/16	7/8
12-1/4" (311 mm)	1/8	1/4	5/16	3/8	7/16	1/2	5/8	7/8
13-3/4" (349 mm)	1/8	3/16	1/4	5/16	7/16	1/2	5/8	13/16
15" (381 mm)	1/8	3/16	1/4	5/16	7/16	1/2	5/8	13/16
16" (406 mm)	1/16	3/16	3/16	5/16	3/8	7/16	9/16	13/16

Target bit PSI: 60

	1000	1250	1400	1600	1900	2600	3000	3800
6-3/4" (171 mm)	2/8	5/16	3/8	7/16	1/2	11/16	13/16	1-1/16
7-7/8" (200 mm)	3/16	5/16	5/16	3/8	1/2	11/16	13/16	1
8-1/2" (216 mm)	3/16	1/4	5/16	5/16	7/16	5/8	3/4	15/16
9" (229 mm)	3/16	1/4	5/16	5/16	7/16	5/8	3/4	15/16
9-7/8" (251 mm)	-	3/16	1/4	5/16	3/8	9/16	11/16	15/16
10-5/8" (270 mm)	-	3/16	3/16	1/4	5/16	9/16	11/16	7/8
12-1/4" (311 mm)	-	-	3/16	1/4	5/16	1/2	5/8	7/8
13-3/4" (349 mm)	-	-	3/16	3/16	5/16	1/2	5/8	13/16
15" (381 mm)	-	-	-	3/16	5/16	1/2	5/8	13/16
16" (406 mm)	-	-	-	3/16	1/4	7/16	9/16	13/16

Target bit PSI: 45 Assume: 10,000 feet elevation, 60°F (16°C) intake air temp, 120°F (49°C) delivered air temp

Bit diameter	Air compressor rating, iCFM							
	1000	1250	1400	1600	1900	2600	3000	3800
6-3/4" (171 mm)	1/4	5/16	3/8	3/8	1/2	-	-	-
7-7/8" (200 mm)	3/16	1/4	5/16	3/8	7/16	-	-	-
8-1/2" (216 mm)	3/16	1/4	1/4	5/16	7/16	5/8	-	-
9" (229 mm)	3/16	1/4	1/4	5/16	7/16	10/16	3/4	15/16
9-7/8" (251 mm)	1/8	3/16	1/4	5/16	3/8	9/16	11/16	7/8
10-5/8" (270 mm)	1/16	1/8	3/16	1/4	5/16	1/2	5/8	7/8
12-1/4" (311 mm)	1/16	1/8	3/16	1/4	5/16	1/2	5/8	7/8
13-3/4" (349 mm)	1/16	1/8	1/8	3/16	5/16	1/2	5/8	13/16
15" (381 mm)	0	1/16	1/8	3/16	1/4	7/16	9/16	13/16
16" (406 mm)	0	1/16	1/8	3/16	1/4	7/16	9/16	3/4

Target bit PSI: 60

	1000	1250	1400	1600	1900	2600	3000	3800
6-3/4" (171 mm)	3/16	1/4	1/4	5/16	3/8	9/16	5/8	13/16
7-7/8" (200 mm)	-	3/16	1/4	5/16	3/8	1/2	5/8	6/8
8-1/2" (216 mm)	-	3/16	3/16	1/4	5/16	7/16	9/16	6/8
9" (229 mm)	-	3/16	3/16	1/4	5/16	7/16	9/16	6/8
9-7/8" (251 mm)	-	-	-	3/16	1/4	7/16	1/2	11/16
10-5/8" (270 mm)	-	-	-	3/16	1/4	3/8	1/2	5/8
12-1/4" (311 mm)	-	-	-	-	3/16	3/8	7/16	5/8
13-3/4" (349 mm)	-	-	-	-	3/16	5/16	7/16	5/8
15" (381 mm)	-	-	-	-	3/16	5/16	7/16	9/16
16" (406 mm)	-	-	-	-	-	5/16	3/8	9/16



United in performance. Inspired by innovation.

Performance unites us, innovation inspires us, and commitment drives us to keep moving forward. Count on Epiroc to deliver the solutions you need to succeed today and the technology to lead tomorrow.

epiroc.com



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