Diamond tools

Drillers' guide

Epiroc

Content

Epiroc's goal is simple – to help drillers' improve their performance.

How? By developing and distributing the best diamond tools, equipment and accessories to small and large businesses specializing in core drilling for the mineral exploration, geotechnical and environmental industries.

These solutions are designed to improve performance, lower costs and make life easier for the drilling community.

That is our mission and how we live it is our strength. We provide exceptional service, demonstrated daily by our worldwide representatives. Our distribution network ensures Epiroc products can be delivered globally, right on schedule. We are highly committed to quality and innovation.

Our mission is based on our fundamental values and principles, which guide our policies and actions, which in turn guide our employees and the relationships that we develop with our clients.

Diamond drilling is hard work. Make it easier with high-quality diamond tools.

Epiroc works with its customers to provide high-quality drilling solutions.

Working as your partner, we deliver diamond tools that meet your specific needs while providing excellent customer service and technical support.

Choose the right diamond tool

Choosing the right drill tool is a decision that will have the greatest impact on your success and drilling productivity, so make sure you pick high-quality diamond tools.

The team at Epiroc is always looking to develop new products and to improve the performance of existing ones so that drillers achieve success easily.

See also our **Mineral exploration: Choosing the right core bit** on our website.

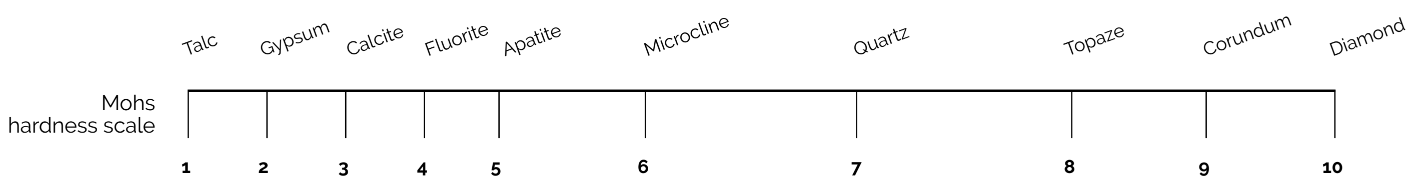
Core bit selection

Define rock hardness

The simplest and most reliable way to determine rock hardness is to perform a scratch test using an etcher kit and compare results with Mohs scale.

If you do not have such tools, it may still be possible to determine the hardness using a pocket knife or a metal saw, although results may not be as precise.

You should use the many tools at your disposal to help you decide the right type of diamond tools to choose, starting with the matrix selection chart.



If you are using a pocket knife, the average hardness of this tool is approximately 6.0 to 6.5 and if you are using a metal saw, it should be around 6.5 to 7.0 on Mohs scale. For more details on how to perform a scratch test, or to order an Epiroc etcher kit, contact your sales representative.

Example

Mike measured an average hardness of 6.5 after performing three scratch tests on samples of his latest project. As the ground is coarse grained and slightly abrasive, his representative suggests he should choose a HERO 7 bit.

After a couple hundred meters, Mike realizes that the penetration rate is too slow. His representative then suggests he should use a higher number matrix and sends him a couple of HERO 9 core bits.

A core bit with a higher number has a softer matrix which means that during drilling, the diamonds will be exposed more readily and this will improve the penetration rate.

A week later, the new bits have already given results; penetration rate has improved and Mike has reached the productivity level he was hoping for.

Choose an appropriate bit range

According to the results obtained through the scratch test, select the appropriate bit range with Epiroc's Matrix Selection Chart (see Page 8). You should be able to identify at least one matrix that fits your specific needs.

Note that more than one matrix may fit the bit range you are looking for. If the ground is made of a wide range of minerals and if several hardness results have been measured, choose the T-Xtreme series. If the ground is relatively homogeneous, choose the HERO series.

Evaluate results and make adjustments

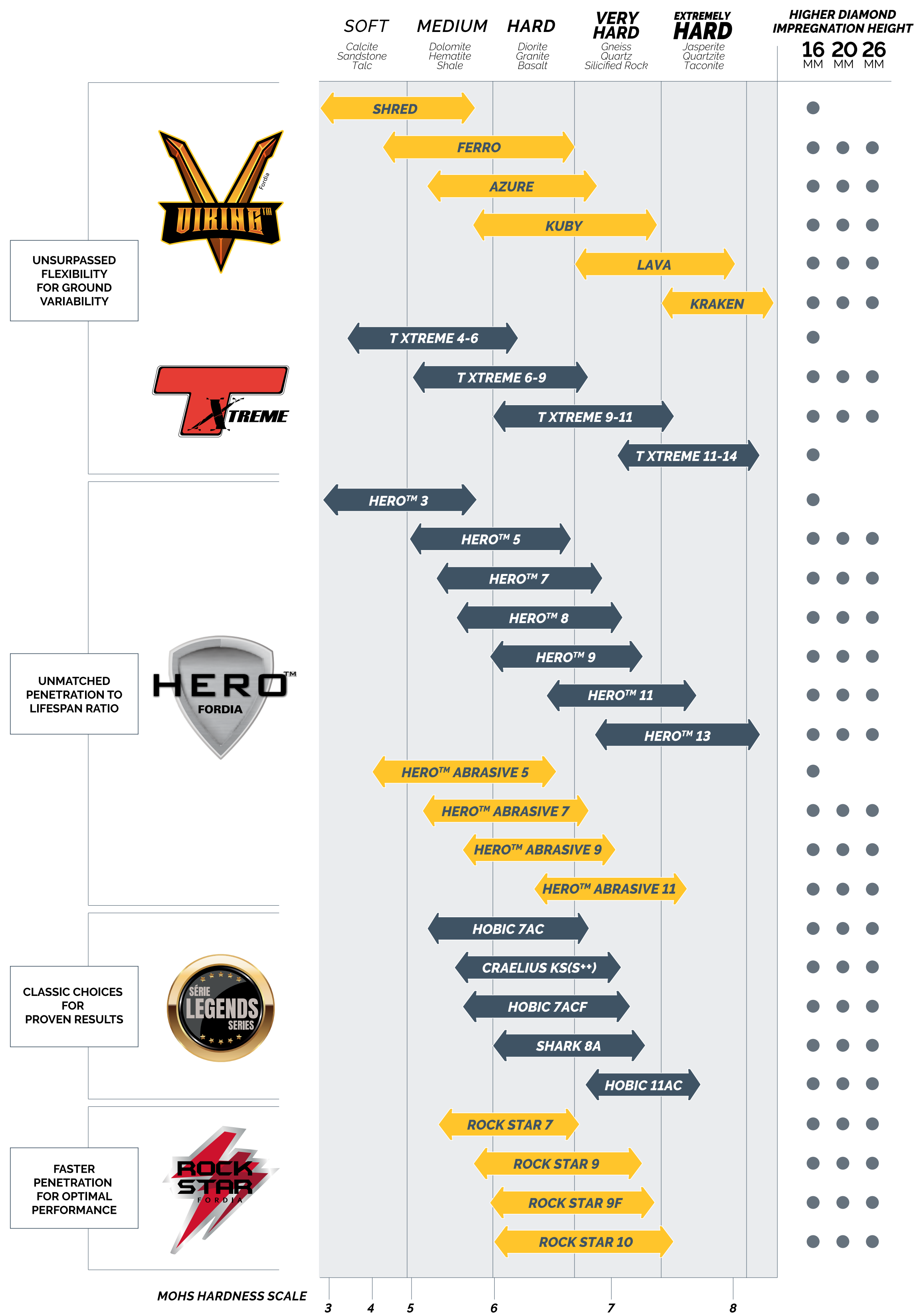
As every ground is unique, these rules of thumb may not always be enough to find the perfect bit on your first attempt. Abrasiveness, fractures or competence in rock formations are some other major considerations when it comes to choosing a bit.

Reviewing bit performance is important — it may provide critical information to help you find the right bit and to improve productivity.

For example, if the penetration rate is too slow, using a higher matrix could help solve the problem. However, if bit life is too short, try a lower number matrix. For personalized advice, please contact your sales representative.

NOTE: If you are drilling in deep hole applications, try a Vulcan bit - their higher diamond impregnation offers greater lifespan and reduces rod pulls.

Matrix selection chart



Drilling parameters

Understand the different drilling parameters so that the performance of your tools will be optimized.

Revolutions per minute (RPM)

Many factors can affect the choice of the speed or rotation.

These factors are:

- Penetration speed
- Diameter of the bit
- Depth of the hole
- Vibration

The RPM must be measured using a tachometer. If the RPM is too high, this will cause polishing of the bit. On the contrary, if the RPM is too slow, this will cause premature wear of the bit.

Water flow

The water flow should be as high as possible but must be related to the bit size and type of rock to be drilled. For example 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 diminish the risk of polishing the diamonds.

Chart gives the water flow suggested for different standard sizes of core bits

Types	Water flow - Gal Imp/min (L/min)				
	AWL	BWL	NWL	HWL	PWL
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)

Bit pressure

While drilling, the force applied by the drill and the weight of the rods must be as low as possible. It is important to keep sufficient speed of penetration in order to prevent the polishing of diamonds.

The consequences of pressure that is too high are variable. These include:

1. Premature wear of the mechanical components of the drill, the rods and the core barrel
2. Premature wear of the bit
3. A greater probability of deviation of the hole

Sharpening techniques

While drilling in hard to extremely hard rock, the bit matrices can polish, or become dull. Sharpening of the matrix is needed to expose new diamonds. This is a delicate operation because it can wear down too much of the matrix.

Here are different sharpening techniques:

- Reduce water flow
- Increase drilling pressure
- Increase drilling pressure and reduce water flow
- Reduce water flow and RPM

Matrix troubleshooting

Evaluate the wear profile of the bit crown and change drilling parameters, if necessary.

Even wear to the carbides with the diamonds evenly worn.

Caused by:
- The bit was well-suited to the rock formation and conditions.
- Drill settings a flushing provided optimum drilling.
- The diamond and matrix wear are balanced to provide optimum performance.

Solutions:
- Continue to use the same drill settings unless the conditions change.
- Continue to drill with this bit type unless the rock formation and conditions change.

Ideal wear

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)

Diamonds overly exposed

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)

O.D. gauge loss

Wear of outside diameter and outside ringing.

Caused by:

- Vibration
- Rotation speed too high
- Water flow too low
- Cave in, the hole was reamed
- Continuous drilling in a convex wear pattern

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)

I.D. gauge loss

Wear of inside diameter and inside ringing.

Caused by:

- Drilling pressure too high
- Very broken ground
- Core left in the hole
- Water flow too low
- Matrix too soft
- Continuous drilling in a concave wear pattern

Solutions:

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

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 the core barrel
- Add drilling fluids (fractured ground)
- Don't try to push through a core block

Inside 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 from the rods
- Hole "reamed"

Solutions:

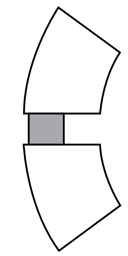
- Increase the water flow
- Check for leaks
- Check the diameter of shell

Outside wear pattern

Core bit configuration and dimensions

Choose from a wide range of waterway configurations that provide you with the best drilling performance, no matter what type of work needs to be done. All of our configurations are available with different waterway widths and come in all matrix heights. Make sure to refer to the **Fundamental guide to core bit configurations** for more in-depth information and advice.

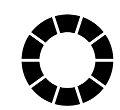
Deep lateral discharge



- Features a deeper waterway design to increase the space for water and mud to flow to the bit
- Has waterways that limit water and pressure on the core sample
- Is ideal for soft broken ground
- Is the preferred choice when sampling in overburden

Other waterways configurations available

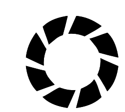
Standard



Provides great fluid circulation from the inside to the outside diameters

Is available with wider and/or larger waterways

Cyclone

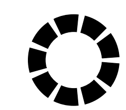


Is designed with specifically angled waterways

Provides excellent ejection of drilling fluids

Works best in broken ground and clay

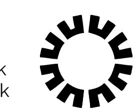
Pie shaped



Has pie-shaped openings to ensure greater ejection of rock cuttings that may block waterways

Is recommended for higher rotation speeds

Turbo pie shaped (TPS)



Is a freer cutting bit

Provides the same optimal flushing performance

In some cases, can reach higher penetration rates when compared with the non-turbo

Is available with wider and/or larger waterway configurations

Other configurations are available. Please contact your representative for more information.

Casing shoes

Size	Outside diameter		Inside diameter		Hole volume	
	Mm	Inches	Mm	Inches	US Gal /100ft	Liters /100m
EW	47.63	1.875	37.97	1.495	14.3	178.1
AW	59.56	2.345	48.26	1.900	22.4	278.6
BW	75.31	2.965	60.38	2.377	35.9	445.5
NW	91.82	3.615	76.20	3.000	53.3	662.2
HW	117.48	4.625	99.70	3.925	87.3	1,083.9
PW	143.51	5.650	123.27	4.853	130.2	1,617.5
HWT	117.48	4.625	101.09	3.980	87.3	1,083.9

Diamond core bits

Size	Core diameter		Hole diameter			Hole volume		
	Decimal	Fractional	Mm	Decimal	Fractional	Mm	US Gal /100ft	Liters /100m
AWL	1.062	1 1/16	27.0	1.890	1 57/64	48.0	14.60	181.0
BWL	1.432	1 7/16	36.5	2.360	2 23/64	60.0	22.70	282.2
NWL	1.875	1 7/8	47.6	2.980	2 63/64	75.7	36.30	451.0
HWL	2.500	2 1/2	63.5	3.782	3 25/32	96.0	58.30	724.4
PWL	3.345	3 11/32	85.0	4.827	4 53/64	122.5	95.10	1,180.4
BWL3	1.320	1 5/16	33.5	2.360	2 23/64	60.0	22.70	282.2
NWL3	1.775	1 25/32	45.0	2.980	2 63/64	75.7	36.30	451.0
HWL3	2.406	2 13/32	61.1	3.782	3 25/32	96.0	58.30	724.4
PWL3	3.270	3 9/32	83.0	4.827	4 53/64	122.6	95.10	1,180.4
ATW	1.185	1 3/16	30.1	1.890	1 57/64	48.0	14.60	181.0
BTW	1.656	1 21/32	42.0	2.360	2 23/64	60.0	22.70	282.2
NTW	2.205	2 13/64	56.0	2.980	2 63/64	75.7	36.30	451.0
HTW	2.792	2 51/64	70.9	3.762	3 49/64	95.6	57.58	717.8
NWL2	1.990	1 63/64	50.5	2.980	2 63/64	75.7	36.30	451.0
AWLTK	1.200	1 13/64	30.5	1.890	2 57/64	48.0	14.60	181.0
BWLTK	1.602	1 19/32	40.7	2.360	2 23/64	60.0	22.70	282.2

Reaming shells

Size	Millimeters		Inches	
	Minimum	Maximum	Minimum	Maximum
AWL	47.88	48.13	1.885	1.895
BWL	59.82	60.07	2.355	2.365
NWL	75.57	75.82	2.975	2.985
HWL	95.89	96.27	3.775	3.790
PWL	122.43	122.81	4.820	4.835
ATW	47.88	48.13	1.885	1.895
BTW	59.82	60.07	2.355	2.365
NTW	75.57	75.82	2.975	2.985
AWLTK	47.88	48.13	1.885	1.895
BWLTK	59.82	60.07	2.355	2.365

Operating parameters

Size	Normal recommended bit load range	Normal recommended RPM	Normal recommended fluid circulation rates	Estimated penetration rates	
				150 rev/in drilled 60 rev/cm drilled	250 rev/in drilled 100 rev/cm drilled
AWL	2,000 to 4,000 lb 8.9 to 18 kN	800 to 2,000 RPM	1.5 to 3.5 US Gal/min 5.7 to 13 Liter/min	5.3 to 13.2 in/min 13 to 34 cm/min	3.2 to 7.9 in/min 8.1 to 20 cm/min
AWL THIN KERF	2,000 to 3,500 lb 7.9 to 16 kN				
BWL	3,000 to 5,500 lb 13 to 24 kN	650 to 1,600 RPM	2 to 5.5 US Gal/min 7.6 to 21 Liter/min	4.2 to 10.6 in/min 11 to 27 cm/min	2.5 to 6.4 in/min 6.4 to 16 cm/min
BWL THIN KERF	2,500 to 5,000 lb 11 to 21 kN				
NWL	4,500 to 8,500 lb 20 to 38 kN	500 to 1,250 RPM	3.5 to 9 US Gal/min 13 to 34 Liter/min	3.4 to 8.4 in/min 8.6 to 21 cm/min	2.0 to 5.0 in/min 5.1 to 13 cm/min
NWL THIN KERF	4,000 to 8,000 lb 19 to 35 kN				
HWL	6,500 to 13,000 lb 29 to 58 kN	400 to 1,000 RPM	5 to 14 US Gal/min 19 to 53 Liter/min	2.6 to 6.6 in/min 6.6 to 17 cm/min	1.6 to 4.0 in/min 4.1 to 10 cm/min
PWL	10,000 to 19,000 lb 44 to 84 kN	300 to 800 RPM	7.5 to 20 US Gal/min 28 to 76 Liter/min	2.1 to 5.2 in/min 5.3 to 13 cm/min	1.2 to 3.1 in/min 3.0 to 7.9 cm/min

Case study Vulcan 26 MM

Savings of a 26 mm vs 12 mm

The benefits of the 26 mm crown height have been proven. At a drill site in Val-d'Or, Canada, the Vulcan 26 mm increased the team's productivity up to 200 percent compared to a standard 12 mm diamond tool.

Because the lifespan of the Vulcan 26 mm is dramatically longer, drilling operations are more efficient – the team increased the number of metres drilled per shift and reduced rod tripping resulting in less downtime. It all adds up to improved profitability.

Chart no.1

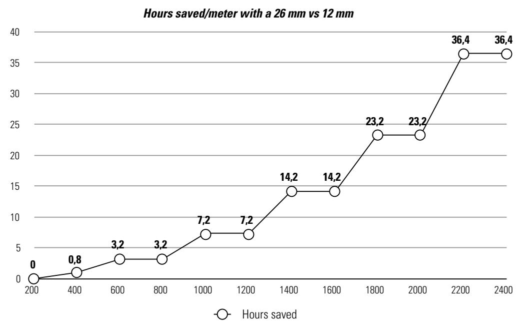
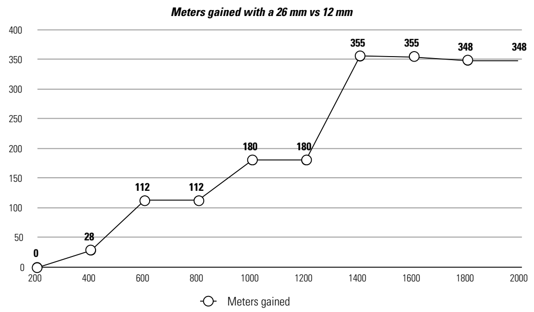


Chart no.2



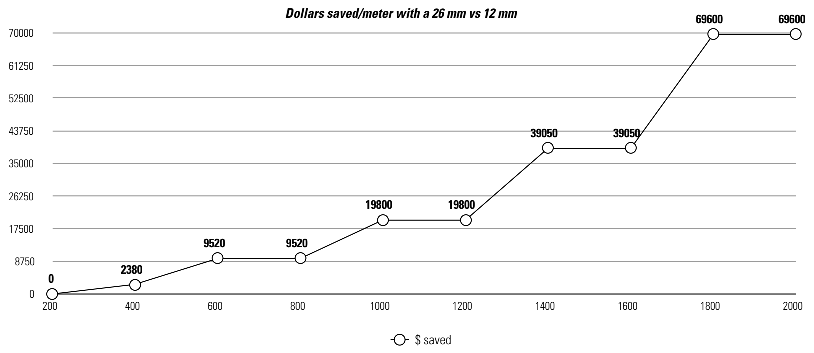
1. The secret of the Vulcan 26 mm's longevity is its **water management system**. It is constructed with destroyable pins under the bridge that allow exceptional fluid circulation all the way to the crown to ensure cooling and consistent wearing, thus maximizing every mm of the bit.

2. The innovative **patented bridge design** is also a significant factor for productivity improvements with the Vulcan 26 mm. It is made of the same material as the matrix, which ensures consistent wearing and maximizes lifespan.

Benefits

- Eliminate half of rod pulls
- Increase the number of meters drilled per shift
- Save more time and money per meter drilled
- Save up to $69,600 when 2,000 m is reached

Chart no.3



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