Volgaburmash

SAMARA | RUSSIA

DRILLING TOOLS FOR THE MINING INDUSTRY

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Volgaburmash

OUR MISSION

WE CREATE AND PROMPTLY DELIVER QUALITY PRODUCTS WITH AN EXCELLENT COST-BENEFIT RATIO FOR OUR CUSTOMERS.

OUR VISION

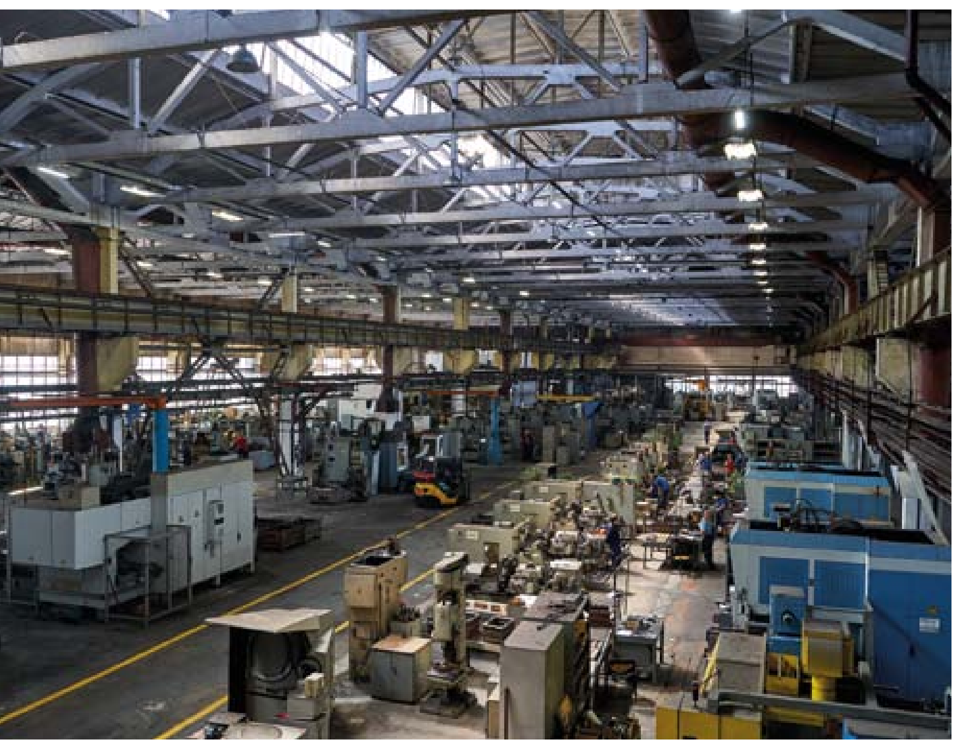
WE AIM TO PROVIDE OUR PARTNERS **ALL OVER THE WORLD** WITH SUPERIOR **INNOVATIONS** — RELIABLE PRODUCTS AND ENGINEERING COMPETENCE, MEETING SPECIFIC REQUIREMENTS FOR **GREAT RESULTS**.

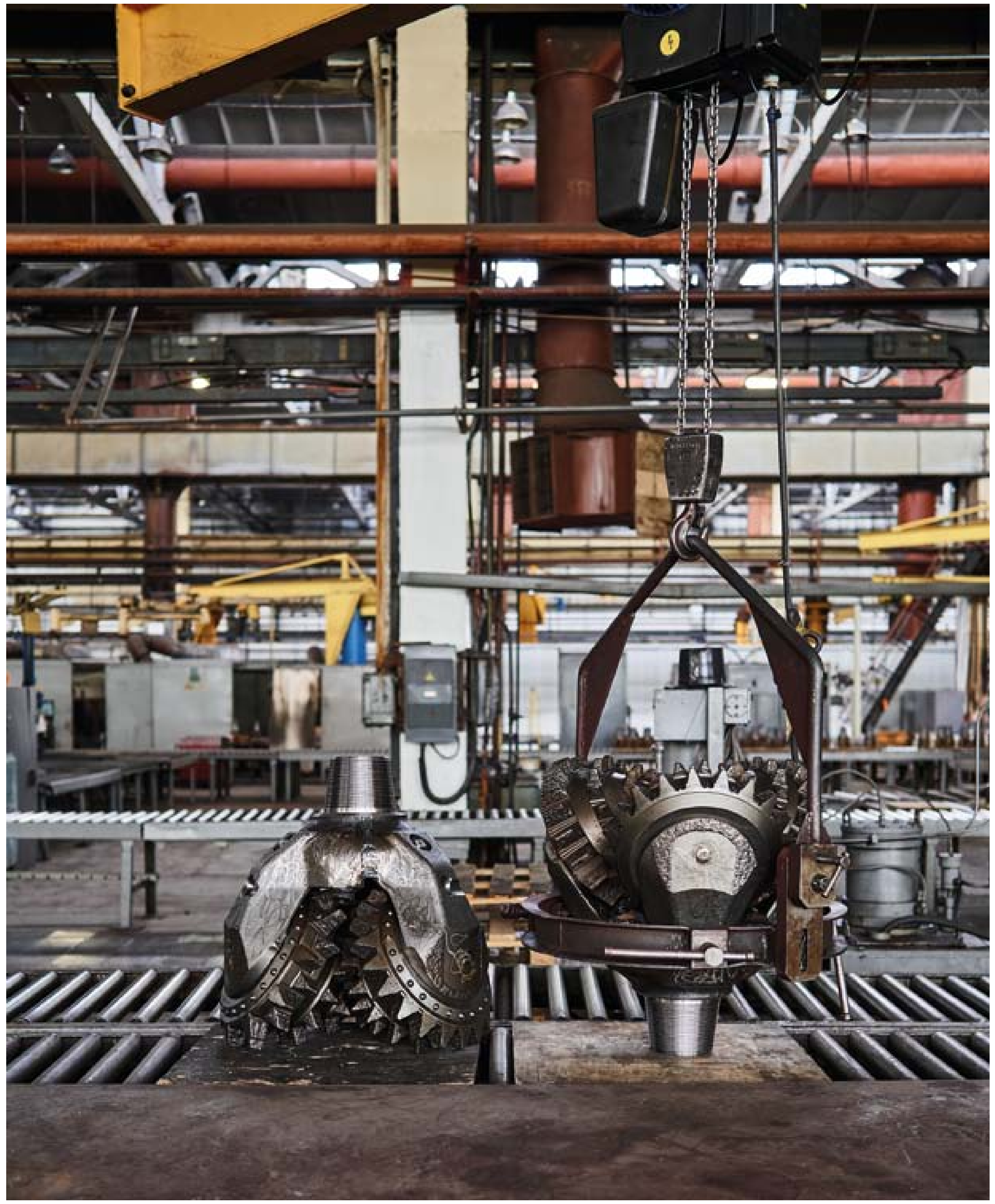
We successfully transform our expertise, manufacturing capacities and skills into your achievements:

- our drill bits are used in 75+ countries and across continents;
- VBM is ranked among the TOP-10 of world producers of drilling tools in terms of production quality and turnover;
- the plant produces drill bits for the oil and gas, mining, water well and construction industries;
- we offer customized bit design and manufacturing;
- our highly qualified personnel and the most up to date production digitization techniques enable continuously improving drill bit development and ensure production quality compliance with the highest world standards.

CONTENT

ABOUT THE COMPANY





Volgaburmash JSC (VBM) is the largest manufacturer in Russia of high-quality rock cutting tools for the oil and gas, mining, water well and construction industries.

VOLGABURMASH PRODUCES:

- over 100 roller cone bit designs from 6 1/2" up to 16" (165.1 - 406.4 mm) in diameter for the mining industry and drilling wells in different geological conditions;
- over 600 roller cone bit designs from 3 3/4" to 26" (95.3 - 660.4 mm) in diameter with milled tooth and tungsten carbide inserts (TCI) for the oil and gas industry;
- over 350 PDC bit designs from 3" to 17 1/2" (76 - 444.5 mm) in diameter with matrix or steel bodies;
- DTH bits, core bits and other rock cutting tools.

ABOUT THE COMPANY



VBM was established in the industrial, but picturesque Volga region, where all seasons are full of colors and natural beauty.

We actively encourage visits to our factory to inspect the industry leading manufacturing practices and of course to take advantage of the local Samara countryside.

WELCOME TO SAMARA AND VOLGABURMASH JSC!







OUR HISTORY

1948
Establishment of Kuybyshev machine-building plant.

1978
Contract signing between Dresser corporation (USA) and Stankoimport enterprise for construction of a low-speed drill bits plant with 100,000 drill bits per year capacity.

1994
Transformation of Kuybyshevburmash PO into Volgaburmash JSC.

1997
Certification of VBM Quality Management System in accordance with ISO 9001.

Certification of VBM drill bits by API, the American Petroleum Institute.

2002-2009
Machinery equipment upgrade: 3- and 5-axial modern foreign lathes, lasercutting and milling, grinding and drilling machines, lathe machining centers, as well as hydraulic presses etc.

2004
Membership in IADC, the International Association of Drilling Contractors (USA).

2006
Certification of VBM Quality Management System in accordance with API Spec. Q1 by API.

2007
Certification of Environment Management System for compliance with ISO 14001.

Certification of Health and Safety Management System for compliance with OHSAS 18001.

2016
Implementation of Teamcenter PLM system within work process automation for engineering data and production processes management during the product life cycle.

2017-2018
Implementation of '1C:ERP Enterprise management 2.0' accounting system: up to 100% of orders are now executed within a set timeframe.

2019
New Quality Passport format ensures a high degree of protection against forgery and simplifies product authenticity verification.

2014-2023
Implementation of digital technologies and innovations ensure integrity of drill bit settings built-in with 3D designing and timely adaptation of any product range.

SIGNIFICANT MILESTONES

1948
The first production output — 1,000 drill bits.

1967
1,000,000 drill bits produced.

2003
Implementation of industrial production of drill bits with steel body and hardfaced with synthetic diamond cutters (PDC).

2006
The roller cone bit 215,9 (8 1/2) MTR437 was used to drill a unique horizontal well at Ashalchinskoe field owned by Tatneft and it helped establish heavy viscous oil production.

2008
The roller cone bit 215,9 (8 1/2) MTR427 utilised at LUKOIL field set a record in performance — 2,933 meters were drilled.

2010
Industrial production of large diameter section roller cone drill bits (26˝) established.

QUALITY

Volgaburmash JSC has a long history of Quality Management System (QMS) certification for compliance with ISO 9001 and API Spec. Q1.

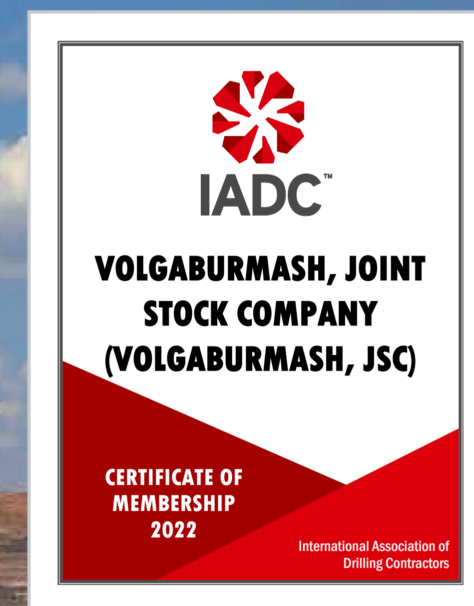
In May 2023 VBM successfully passed the QMS certification audit in accordance with:

- GOST R ISO 9001-2015 (ISO 9001:2015)
- INTI S.QS.1-2020 (it's a QMS standard developed by the Russian Institute of Oil and Gas Technological Initiatives as an alternative to API Q1 9th Edition).

VBM products comply with the requirements of the Technical regulations of the Customs Union, as well as the state standards GOST 20692 and GOST 26474. In addition to that, all of the API Spec. 7-1 requirements are built into our design, development and manufacturing processes.

According to the Quality Policy, our organization's priority is to 'Meet customer's requirements and expectations'. Key aspects of the Policy implementation are:

- maintaining an advanced communication system as well as establishing long-term and mutually beneficial cooperation with our business-partners;
- improving the design solutions;
- monitoring the quality of manufacturing processes;
- ensuring a high level of competence of employees;
- continuous improvement of the quality management system effectiveness;
- compliance with legal requirements, the requirements of national and international standards and specifications, customer requirements, as well as the internal requirements of the organization.



QUALITY

VBM drill tools are certified in compliance with the Technical Regulations of the Customs Union, and meet the State Standards GOST 20692 and GOST 26474.

VBM's certified Quality Management System regulates all aspects of VBM operations, from signing supply contracts to delivery of goods to the Customer. Special attention is paid to Customer's satisfaction evaluation and continuous improvement. Quality control is deeply embedded into processes throughout entire manufacturing cycle to guarantee uncompromised output quality.

All raw materials and components used for drill tools production are subject to thorough incoming inspection control in the Central Plant Laboratory. Conformance to all the requirements is mandatory for release into production.

Prior to assembling, a multistage inspection is performed against a set of design and engineering specifications. Finished goods are admitted to the warehouse upon successful completion of special control performed by highly qualified inspectors.

Measuring and control instruments are checked and calibrated initially and periodically to ensure the uniformity and required accuracy of measurements.

Due to the integrated approach to quality, VBM drilling equipment fully complies with international and local standards as well as customer's requirements and expectations.

ЕВРАЗИЙСКИЙ ЭКОНОМИЧЕСКИЙ СОЮЗ

ЕАС

СЕРТИФИКАТ СООТВЕТСТВИЯ

ЕВРАЗИЙСКИЙ ЭКОНОМИЧЕСКИЙ СОЮЗ

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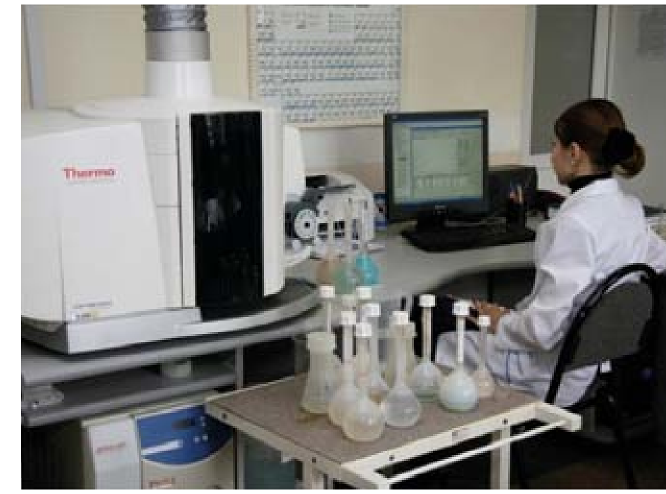
QUALITY CONTROL METHODS

Quality control covers all stages of the product life cycle.

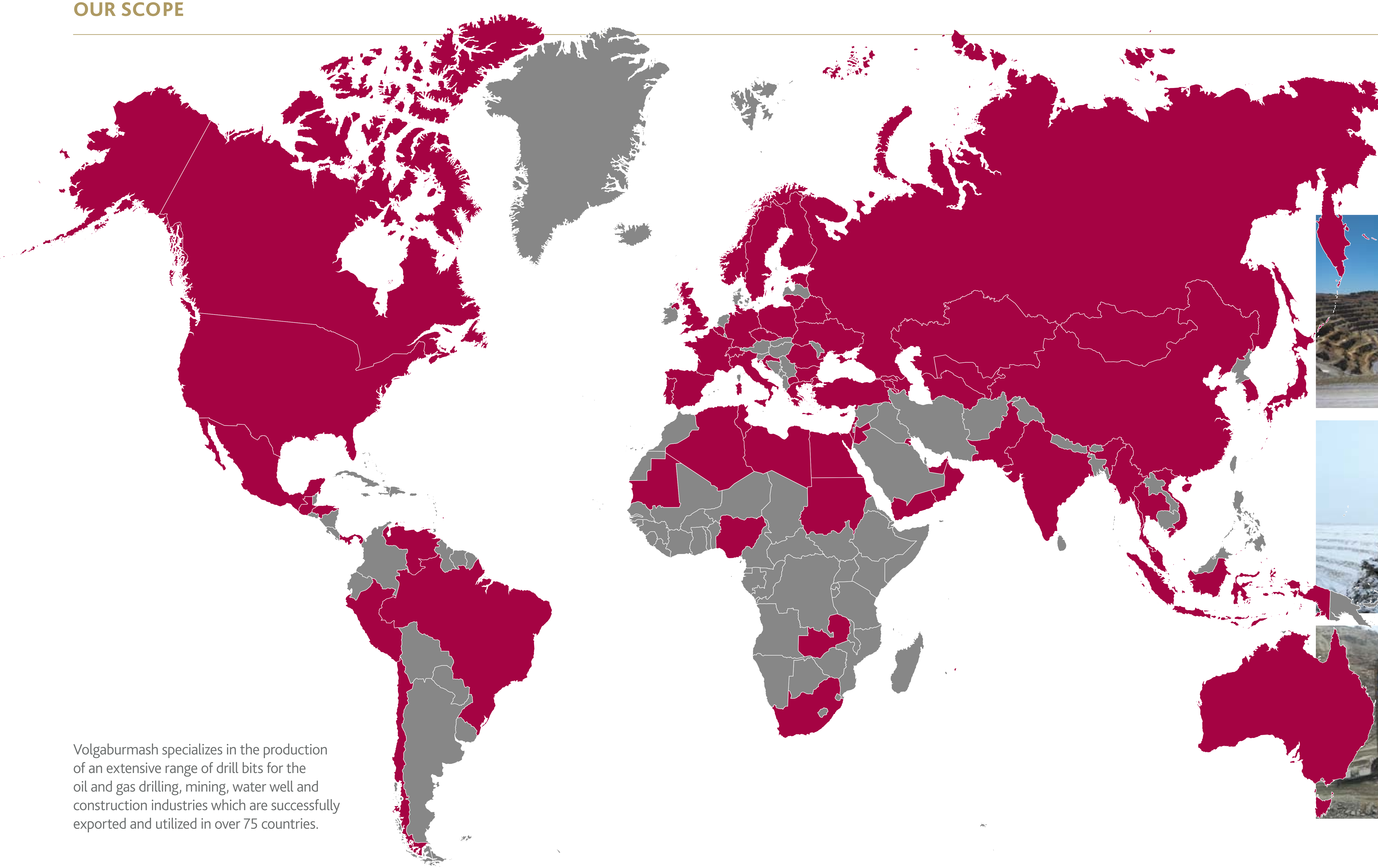
One of the quality control methods is chemical content analysis of the main raw materials and components. Spectro-chemical analysis allows to determine the quantitative content of elements in the sample with high accuracy and exclude the use of materials with deviations while VBM tools production.

One of the tests applied to tungsten carbide inserts and hardfacing materials used for protection of bit legs and milled teeth is the measure of hardness and microhardness. Hardness gradient of bit bearings and cones is also measured.

Bit bearing durability is one of the key factors that affects drill bit performance. Chemical and heat treatment are both applied to enhance bit bearing performance followed by 50-1500-power microscope-assisted metallurgical survey. Silver-plated parts of the bearing are checked with an image analyzer IA-32, which defines a grain size (10-200 µm) and coating thickness (20-30 µm) with visualization eliminating the risk of personal assessment. Such studies ensure that only high quality components are used for manufacturing.



OUR SCOPE

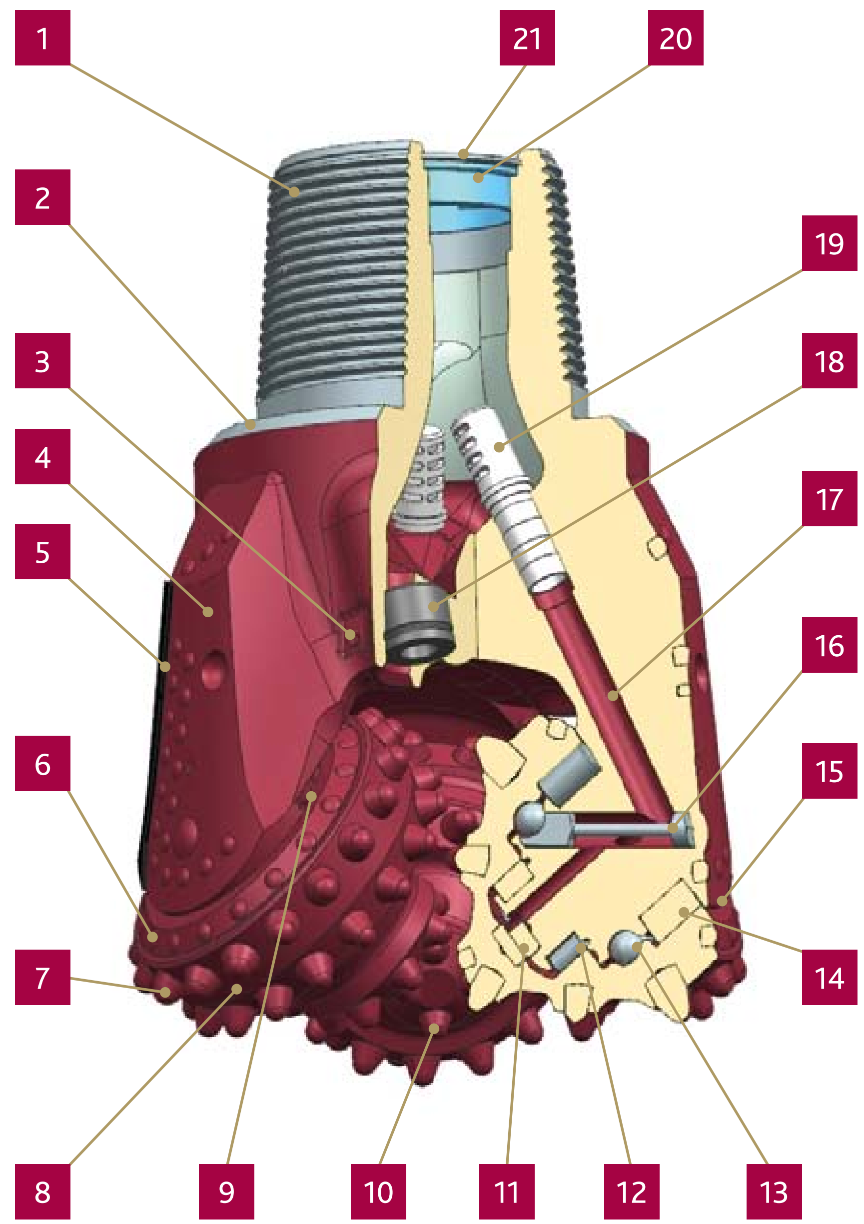


Volgaburmash specializes in the production of an extensive range of drill bits for the oil and gas drilling, mining, water well and construction industries which are successfully exported and utilized in over 75 countries.

DRILLING TOOLS FOR THE MINING INDUSTRY

- Roller cone bits
- Pilot bits
- DTH bits
- Reamer cutters
- FDC bits

Tricone roller bits are used for rotary blast hole drilling with air flush.



1. Pin connection
2. Pin shoulder
3. Nozzle nail lock
4. Lug
5. Shirttail insert
6. Gage insert
7. Gage row insert
8. Cutter cone
9. Air exit slot
10. Nose inserts
11. Thrust plain bearing
12. Inner roller bearing
13. Ball bearing
14. Outer roller bearing
15. Shirttail hardfacing
16. Ball retaining plug
17. Air passage to bearing
18. Nozzle
19. Air tube
20. Back flow valve
21. Retaining ring

IADC CLASSIFICATION SYSTEM FOR ROLLER CONE BITS

The IADC classification system is used to choose the best roller cone bit for the appropriate geological conditions. It's based on the 4-character code describing both a bit design and a formation/rock type which can be drilled through by a suitable bit.

Groups	1st IADC character	2nd IADC character	GOST 20692	
Milled teeth bits	1	1	M	Soft formations
		2		
		3	MC	Soft formations with medium interlayers
		4		
	2	1	C	Medium formations
		2		
		3	CT	Medium formations with hard interlayers
		4		
	3	1	T	Hard formations
		2		
		3		
		4		
Tungsten carbide insert bits	4	1	M3	Soft abrasive formations
		2		
		3		
		4		
	5	1		
		2		
		3	MC3	Soft abrasive formations with medium interlayers
		4	C3	Medium abrasive formations
	6	1	T3	Hard abrasive formations
		2		
		3	TK3	Hard abrasive formations with extra-hard interlayers
		4		
	7	1	K	Very hard formations
		2		
		3		
		4		
	8	1	OK	Extra-hard formations
		2		
		3		

3rd IADC character	Bearing		
1	Open bearing	AIRJ	Roller bearing without TCI on the cones gage (does not apply in mining industry)
2			Open roller bearing with air flush
3			Roller bearing with TCI on the cones gage (does not apply in mining industry)
4	Sealed bearing	AIRP	Journal bearing without TCI on the cones gage (does not apply in mining industry)
5			Roller bearing with TCI on the cones gage
6		AIRX	Journal bearing without TCI on the cones gage (does not apply in mining industry)
7			Journal bearing with TCI on the cones gage

Drill bit applicationin different formations

- **1st IADC numeric character** refers to **cutting structure series.**

  Series 1-3 refer to milled teeth bits. **Series 4-8** refer to tungsten carbide insert bits. Within steel teeth and insert bit groups formations become harder and more abrasive as the series numbers increase.

- **2nd IADC numeric character** refers to the **bit's cutting structure type.**

  Each series is divided into types depending on formation hardness: **1** refers to bits designed for the softest formation within the series; **4** — for the hardest one.

- **3rd IADC numeric character** means **bearing design** and availability of tungsten carbide inserts on the cone.

- **4th IADC alphabetic character** refers to **available features.**

  16 alphabetic characters are used to indicate special cutting structures, bearings, nozzle configurations and bit body protection. Some bit designs may have more than one of optional features, then the most critical feature is indicated.

4th IADC alphabetic character Available features	
A	air flush
B	sealed bearing, special seal design for higher RPM
C	central nozzle
D	special cutting structure minimizing borehole deviation
E	extended nozzles
G	enhanced shirttail protection with hardfacing or TCI
H	bits for horizontal or directional drilling
J	jet bits for drilling tangent sections
L	leg pads with TCI
M	motor application
S	standard steel teeth bits
T	two-cone bits
W	improved cutting structure
X	mostly chisel inserts
Y	conical inserts
Z	other shape inserts

PRODUCT LINES OF TRICONE ROLLER BITS

AIRJET

Wide design range	Side or combined jet (optionally, four jets)	Leaf-type back flow valve	Open roller bearing made of high quality materials	Options availability: cone hardfacing, improved carbide etc.

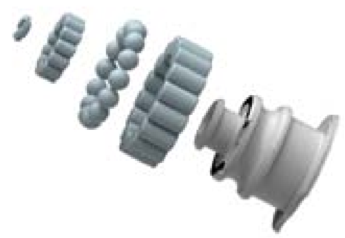
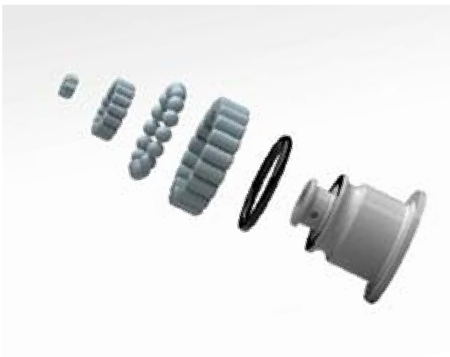
AIRPRO

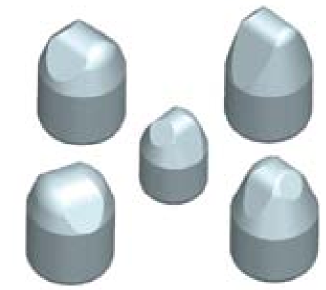
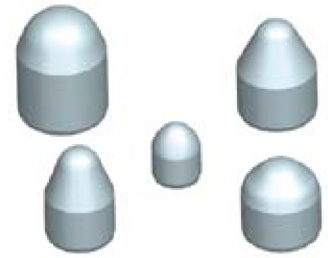
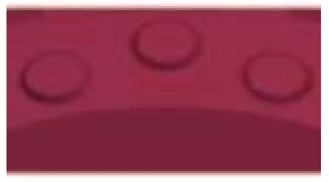
Premium materials application	Leaf-type back flow valve	Enhanced performance in holes where water is present	Options available: cone hardfacing, improved carbide etc.
Side or combined jet (optionally, four jets)	Sealed roller bearing		

AIRXTREME

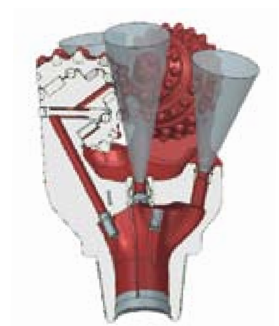
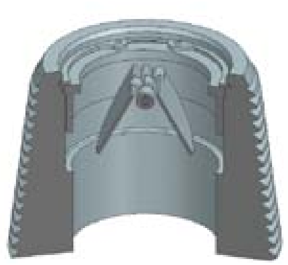
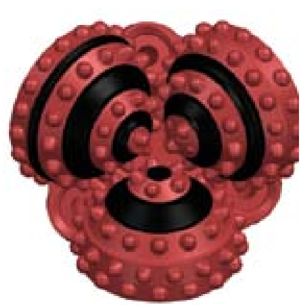
Leaf-type back flow valve	Side jet or combined jet (optionally, four jets)	Options availability: cone hardfacing, improved carbide etc.	Application of high quality wear-resistant components and materials
Superior bearing performance for severe drilling conditions and heavy-duty rigs	Sealed journal bearing made of high quality wear-resistant materials		

FEATURES

Features	Abbreviation	Appearance	Description
ROLLER BEARING	RB		Open roller bearing with rollers in large and small roller race. Absence of seal allows placing of maximum size of rollers, increasing the bearing capacity.
JOURNAL BEARING	JB		Sealed journal bearing with O-ring, floating bushing and thrust washer made of wear-resistant material and silver plated.
ROLLER BEARING SEALED	RBS		Sealed roller bearing with O-ring, rollers in large and small roller race. It provides high performance in a wide range of applications.
PREMIUM JOURNAL BEARING	PJB		Sealed journal bearing with O-ring, two floating bushings and thrust washer made of wear-resistant material and silver plated.

Features	Abbreviation	Appearance	Description
CHISEL INSERTS (IADC GUIDELINES)	X		Chisel-shaped TCI are applied for cutting and chipping action and assure high ROP in applicable strata.
CONICAL INSERTS (IADC GUIDELINES)	Y		Conical and sphero-conical shaped TCI are applied for cutting and chipping action, have higher wear-resistance when used in medium-hard, hard and extra hard brittle formations.
GAGE ROW	GR		TCI on the cone gage is applied to maintain hole diameter and protect cone shell against erosion wear.
DOUBLE GAGE ROW	DGR		Double row of TCI on the cone gage are designed to increase contact area between the borehole and a bit, to improve borehole quality and protect cone shell against erosion wear.
ADDITIONAL GAGE ROW	AGR		Additional heel row of TCI is designed to protect cone shell against erosion wear, increase contact area between the borehole and a bit and improve borehole quality.

FEATURES

Features	Abbreviation	Appearance	Description
GAGE HARDFACING	GH		Hardfacing between heel row and gage TCI on the cone is designed to protect cone shell against erosion wear and to prevent loss of heel row inserts in highly abrasive formations.
SIDE JET	SJ		Side flush is applied.
FOUR JETS	FJ		Three side jets with an additional central jet improve bottomhole cleaning, prevent cuttings re-grinding and bit balling.
BACK FLOW VALVE	BFV		Leaf-type back flow valve is made to protect air ports and bearings as well as drill pipe bore against cuttings during operational or emergency shutdowns.
CONE HARDFACING	CHF		Hardfacing between TCI rows is designed to protect cone shell against erosion wear and to prevent inserts loss in highly abrasive formations.

BIT STAMPING

This information is marked at the pin/box face of every VBM drill bit:

- company trade mark (vbm)
- bit notation key
- serial number
- thread type
- inspection stamp

NOTATION KEY

215,9	(8 1/2)	AIRJ	632
Bit size, mm	Bit size, inch	Product line	IADC code

- AirJet (AIRJ)
- AirPro (AIRP)
- AirXtreme (AIRX)

PRODUCT RANGE

Bit identification	Bit size		IADC code	Product line	Features*	Recommended drilling mode		Connecting thread	Gross weight, kg Shipping dimensions, mm
	mm	inch				Rotation speed, rpm	Weight on bit, kN	API	
1	2	3	4	5	6	7	8	9	11
165,1 (6 1/2) AIRX627	165,1	6 1/2	627Y	AirXtreme	JB; Y; GR; SJ; BFV	100-50	73-158	Pin 3 1/2 Reg	19,8 220x220x334
165,1 (6 1/2) AIRX637	165,1	6 1/2	637Y	AirXtreme	JB; Y; GR; SJ; BFV	100-50	73-158	Pin 3 1/2 Reg	19,8 220x220x334
171,4 (6 3/4) AIRJ432	171,4	6 3/4	432Y	AirJet	RB; Y; GR; SJ; CHF; BFV	50-130	45-150	Pin 3 1/2 Reg	21,3 220x220x334
171,4 (6 3/4) AIRJ512	171,4	6 3/4	512Y	AirJet	RB; Y; GR; SJ; BFV	50-130	45-150	Pin 3 1/2 Reg	21,3 220x220x334
171,4 (6 3/4) AIRJ522	171,4	6 3/4	522Y	AirJet	RB; Y; AGR; SJ; CHF; BFV	50-130	45-150	Pin 3 1/2 Reg	21,3 220x220x334
171,4 (6 3/4) AIRJ532	171,4	6 3/4	532Y	AirJet	RB; Y; GR; SJ; BFV	50-130	45-150	Pin 3 1/2 Reg	20,3 220x220x334
171,4 (6 3/4) AIRJ542	171,4	6 3/4	542Y	AirJet	RB; Y; AGR; SJ; CHF; BFV	50-130	45-150	Pin 3 1/2 Reg	22,3 220x220x334
171,4 (6 3/4) AIRJ612	171,4	6 3/4	612X	AirJet	RB; X; GR; SJ; BFV	50-120	75-165	Pin 3 1/2 Reg	21,3 220x220x334
171,4 (6 3/4) AIRJ622	171,4	6 3/4	622Y	AirJet	RB; Y; GR; SJ; BFV	50-120	75-165	Pin 3 1/2 Reg	21,3 220x220x334
171,4 (6 3/4) AIRJ632	171,4	6 3/4	632Y	AirJet	RB; Y; GR; SJ; BFV	50-120	75-165	Pin 3 1/2 Reg	21,3 220x220x334
171,4 (6 3/4) AIRJ642	171,4	6 3/4	642Y	AirJet	RB; Y; DGR; SJ; BFV	50-120	75-165	Pin 3 1/2 Reg	21,3 220x220x334
171,4 (6 3/4) AIRJ722	171,4	6 3/4	722Y	AirJet	RB; Y; DGR; SJ; BFV	50-90	75-195	Pin 3 1/2 Reg	21,3 220x220x334
200,0 (7 7/8) AIRJ412	200,0	7 7/8	412Y	AirJet	RB; Y; GR; SJ; CH; CHF; BFV	60-140	35-130	Pin 4 1/2 Reg	31,7 220x220x334
200,0 (7 7/8) AIRJ512	200,0	7 7/8	512Y	AirJet	RB; Y; GR; SJ; CHF; BFV	50-130	60-180	Pin 4 1/2 Reg	31,7 220x220x334
200,0 (7 7/8) AIRJ522	200,0	7 7/8	522Y	AirJet	RB; Y; GR; SJ; BFV	50-130	60-180	Pin 4 1/2 Reg	31,7 220x220x334
200,0 (7 7/8) AIRJ532	200,0	7 7/8	532Y	AirJet	RB; Y; GR; SJ; BFV	50-130	60-180	Pin 4 1/2 Reg	31,7 220x220x334
200,0 (7 7/8) AIRJ542	200,0	7 7/8	542Y	AirJet	RB; Y; GR; SJ; CH; CHF; BFV	50-130	60-180	Pin 4 1/2 Reg	32,7 220x220x334
200,0 (7 7/8) AIRJ612	200,0	7 7/8	612Y	AirJet	RB; Y; GR; SJ; CH; CHF; BFV	50-120	95-200	Pin 4 1/2 Reg	33,7 220x220x334
200,0 (7 7/8) AIRJ622	200,0	7 7/8	622Y	AirJet	RB; Y; GR; SJ; CHF; BFV	50-120	95-200	Pin 4 1/2 Reg	34,7 220x220x334
200,0 (7 7/8) AIRJ632	200,0	7 7/8	632Y	AirJet	RB; Y; GR; SJ; BFV	50-120	95-200	Pin 4 1/2 Reg	35,7 220x220x334
200,0 (7 7/8) AIRJ642	200,0	7 7/8	642Y	AirJet	RB; Y; GR; SJ; CHF; BFV	50-120	95-200	Pin 4 1/2 Reg	32,7 220x220x334
200,0 (7 7/8) AIRJ722	200,0	7 7/8	722Y	AirJet	RB; Y; GR; SJ; BFV	50-90	95-230	Pin 4 1/2 Reg	32,7 220x220x334
200,0 (7 7/8) AIRJ742	200,0	7 7/8	742Y	AirJet	RB; Y; GR; SJ; BFV	50-90	95-230	Pin 4 1/2 Reg	32,7 220x220x334
200,0 (7 7/8) AIRP615	200,0	7 7/8	615Y	AirPro	RBS; Y; GR; SJ; BFV; CHF	50-120	95-200	Pin 4 1/2 Reg	33,3 255x255x389
200,0 (7 7/8) AIRX417	200,0	7 7/8	417X	AirXtreme	JB; X; GR; SJ; BFV	60-140	35-130	Pin 4 1/2 Reg	31,3 255x255x389
200,0 (7 7/8) AIRX417	200,0	7 7/8	417X	AirXtreme	JB; X; GR; CH; SJ; BFV	60-140	35-130	Pin 4 1/2 Reg	32,3 255x255x389
200,0 (7 7/8) AIRX437	200,0	7 7/8	437Y	AirXtreme	JB; Y; GR; SJ; BFV	60-140	35-130	Pin 4 1/2 Reg	32,3 255x255x389
215,9 (8 1/2) AIRJ422	215,9	8 1/2	422Y	AirJet	RB; Y; GR; SJ; BFV	60-140	35-145	Pin 4 1/2 Reg	38,7 255x255x389
215,9 (8 1/2) AIRJ542	215,9	8 1/2	542Y	AirJet	RB; Y; GR; SJ; BFV	50-130	70-200	Pin 4 1/2 Reg	38,7 255x255x389
215,9 (8 1/2) AIRJ612	215,9	8 1/2	612X	AirJet	RB; X; GR; SJ; BFV	50-120	100-210	Pin 4 1/2 Reg	37,7 255x255x389
215,9 (8 1/2) AIRJ622	215,9	8 1/2	622Y	AirJet	RB; Y; GR; SJ; CH; CHF; BFV	50-120	100-210	Pin 4 1/2 Reg	38,7 255x255x389
215,9 (8 1/2) AIRJ632	215,9	8 1/2	632Y	AirJet	RB; Y; GR; SJ; BFV	50-120	100-210	Pin 4 1/2 Reg	38,7 255x255x389
215,9 (8 1/2) AIRJ642	215,9	8 1/2	642Y	AirJet	RB; Y; GR; SJ; BFV	50-120	100-210	Pin 4 1/2 Reg	37,7 255x255x389
215,9 (8 1/2) AIRJ732	215,9	8 1/2	732Y	AirJet	RB; Y; GR; SJ; BFV	50-90	100-250	Pin 4 1/2 Reg	38,7 255x255x389
215,9 (8 1/2) AIRP635	215,9	8 1/2	635Y	AirPro	RBS; Y; DGR; SJ; BFV; CHF	50-120	100-210	Pin 4 1/2 Reg	39,3 255x255x389
228,6 (9) AIRJ412	228,6	9	412Y	AirJet	RB; Y; GR; SJ; BFV	60-140	40-150	Pin 4 1/2 Reg	39,7 255x255x389
228,6 (9) AIRJ522	228,6	9	522Y	AirJet	RB; Y; DGR; SJ; BFV	50-130	80-210	Pin 4 1/2 Reg	40,7 255x255x389
228,6 (9) AIRJ542	228,6	9	542Y	AirJet	RB; Y; GR; SJ; CHF; BFV	50-130	80-210	Pin 4 1/2 Reg	40,7 255x255x389
228,6 (9) AIRJ612	228,6	9	612Y	AirJet	RB; Y; DGR; SJ; BFV	50-120	110-230	Pin 4 1/2 Reg	40,7 255x255x389
228,6 (9) AIRJ622	228,6	9	622Y	AirJet	RB; Y; GR; SJ; CHF; BFV	50-120	110-230	Pin 4 1/2 Reg	40,7 255x255x389
228,6 (9) AIRJ632	228,6	9	632Y	AirJet	RB; Y; GR; SJ; BFV	50-120	110-230	Pin 4 1/2 Reg	41,3 255x255x389
228,6 (9) AIRJ722	228,6	9	722Y	AirJet	RB; Y; DGR; SJ; BFV	50-90	110-270	Pin 4 1/2 Reg	41,3 255x255x389
228,6 (9) AIRP115	228,6	9	115	AirPro	RBS; GR; AGR; SJ; BFV	120-50	40-156	Pin 4 1/2 Reg	38,3 255x255x389

PRODUCT RANGE

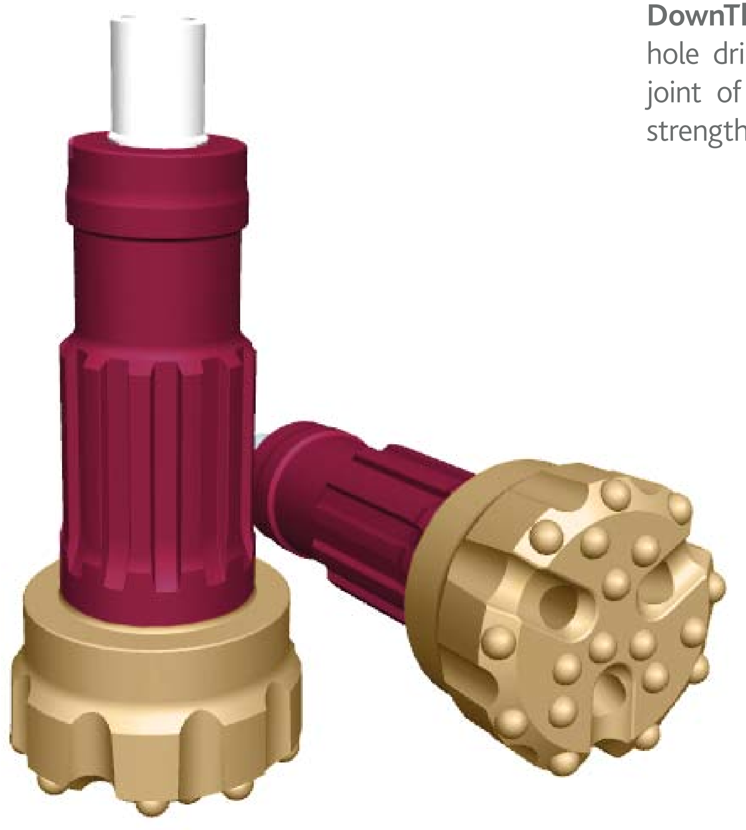
1	2	3	4	5	6	7	8	9	11
228,6 (9) AIRP415	228,6	9	415Y	AirPro	RBS; Y; GR; AGR; SJ; BFV	60-140	40-150	Pin 4 1/2 Reg	41,3 255x255x389
228,6 (9) AIRP415	228,6	9	415Y	AirPro	RBS; Y; GR; AGR; GH; SJ; BFV	60-140	40-150	Pin 4 1/2 Reg	40,3 255x255x389
228,6 (9) AIRP435	228,6	9	435Y	AirPro	RBS; Y; GR; SJ; BFV	60-140	40-150	Pin 4 1/2 Reg	41,3 255x255x389
228,6 (9) AIRP615	228,6	9	615Y	AirPro	RBS; Y; GR; GH; SJ; BFV	50-120	110-230	Pin 4 1/2 Reg	43,3 255x255x389
228,6 (9) AIRP635	228,6	9	635Y	AirPro	RBS; Y; GR; SJ; BFV	50-120	110-230	Pin 4 1/2 Reg	43,3 255x255x389
244,5 (9 5/8) AIRJ612	244,5	9 5/8	612Y	AirJet	RB; Y; GR; SJ; BFV	50-120	130-250	Pin 4 1/2 FH	48,9 295x295x439
244,5 (9 5/8) AIRJ632	244,5	9 5/8	632Y	AirJet	RB; Y; GR; SJ; BFV	50-120	130-250	Pin 4 1/2 FH	50,9 295x295x439
244,5 (9 5/8) AIRJ722	244,5	9 5/8	722Y	AirJet	RB; Y; GR; SJ; BFV	50-90	130-290	Pin 4 1/2 FH	50,9 295x295x439
244,5 (9 5/8) AIRJ742	244,5	9 5/8	742Y	AirJet	RB; Y; GR; SJ; BFV	50-90	130-290	Pin 4 1/2 FH	51,9 295x295x439
244,5 (9 5/8) AIRP625	244,5	9 5/8	625Y	AirPro	RBS; Y; GR; SJ; BFV	50-120	130-250	Pin 4 1/2 FH	48,9 295x295x439
244,5 (9 5/8) AIRP725	244,5	9 5/8	725Y	AirPro	RBS; Y; GR; SJ; BFV	50-90	130-290	Pin 4 1/2 FH	50,9 295x295x439
250,8 (9 7/8) AIRJ422	250,8	9 7/8	422Y	AirJet	RB; Y; GR; SJ; BFV	60-140	40-180	Pin 6 5/8 Reg	61,9 295x295x439
250,8 (9 7/8) AIRJ512	250,8	9 7/8	512Y	AirJet	RB; Y; GR; SJ; BFV	50-130	90-240	Pin 6 5/8 Reg	61,9 295x295x439
250,8 (9 7/8) AIRJ522	250,8	9 7/8	522Y	AirJet	RB; Y; GR; SJ; CHF; BFV	50-130	90-240	Pin 6 5/8 Reg	63,9 295x295x439
250,8 (9 7/8) AIRJ542	250,8	9 7/8	542Y	AirJet	RB; Y; GR; SJ; CHF; BFV	50-130	90-240	Pin 6 5/8 Reg	62,9 295x295x439
250,8 (9 7/8) AIRJ622	250,8	9 7/8	622Y	AirJet	RB; Y; GR; SJ; BFV	50-120	130-260	Pin 6 5/8 Reg	62,9 295x295x439
250,8 (9 7/8) AIRJ622K	250,8	9 7/8	622Y	AirJet	RB; Y; GR; SJ; BFV	50-120	130-260	Pin 6" BECO	63,9 295x295x439
250,8 (9 7/8) AIRJ632	250,8	9 7/8	632Y	AirJet	RB; Y; GR; SJ; BFV	50-120	130-260	Pin 6 5/8 Reg	63,9 295x295x439
250,8 (9 7/8) AIRJ722	250,8	9 7/8	722Y	AirJet	RB; Y; GR; SJ; BFV	50-90	130-300	Pin 6 5/8 Reg	65,9 295x295x439
250,8 (9 7/8) AIRJ742	250,8	9 7/8	742Y	AirJet	RB; Y; GR; SJ; BFV	50-90	130-300	Pin 6 5/8 Reg	64,9 295x295x439
250,8 (9 7/8) AIRP415	250,8	9 7/8	415Y	AirPro	RBS; Y; GR; AGR; GH; SJ; BFV	60-140	40-180	Pin 6 5/8 Reg	62,9 295x295x439
250,8 (9 7/8) AIRP435	250,8	9 7/8	435Y	AirPro	RBS; Y; GR; SJ; BFV	60-140	40-180	Pin 6 5/8 Reg	63,9 295x295x439
250,8 (9 7/8) AIRP625	250,8	9 7/8	625Y	AirPro	RBS; Y; GR; SJ; BFV	50-120	130-260	Pin 6 5/8 Reg	64,9 295x295x439
250,8 (9 7/8) AIRX637K	250,8	9 7/8	637Y	AirXtreme	PJB; Y; GR; SJ; BFV	50-120	130-260	Pin 4 1/2 FH	54,9 295x295x439
250,8 (9 7/8) AIRX637	250,8	9 7/8	637Y	AirXtreme	PJB; Y; GR; SJ; BFV	50-120	130-260	Pin 6 5/8 Reg	64,9 295x295x439
258,0 (10 5/32) AIRJ722	258,0	10 5/32	722Y	AirJet	RB; Y; GR; SJ; BFV	50-90	130-300	Pin 6 5/8 Reg	64,9 295x295x439
258,0 (10 5/32) AIRP725	258,0	10 5/32	725Y	AirPro	RBS; Y; GR; SJ; BFV	50-90	130-300	Pin 6 5/8 Reg	63,9 295x295x439
269,9 (10 5/8) AIRJ422	269,9	10 5/8	422Y	AirJet	RB; Y; GR; SJ; BFV	60-140	50-190	Pin 6 5/8 Reg	70,9 295x295x439
269,9 (10 5/8) AIRJ522	269,9	10 5/8	522Y	AirJet	RB; Y; DGR; SJ; BFV	50-130	100-260	Pin 6 5/8 Reg	70,9 295x295x439
269,9 (10 5/8) AIRJ522K	269,9	10 5/8	522Y	AirJet	RB; Y; DGR; SJ; BFV	50-130	100-260	Pin 6" BECO	70,9 295x295x439
269,9 (10 5/8) AIRJ532	269,9	10 5/8	532Y	AirJet	RB; Y; DGR; SJ; CHF; BFV	50-130	100-260	Pin 6 5/8 Reg	70,9 295x295x439
269,9 (10 5/8) AIRJ612	269,9	10 5/8	612Y	AirJet	RB; Y; DGR; SJ; BFV	50-120	140-280	Pin 6 5/8 Reg	70,9 295x295x439
269,9 (10 5/8) AIRJ612K	269,9	10 5/8	612Y	AirJet	RB; Y; DGR; SJ; BFV	50-120	140-280	Pin 6" BECO	70,9 295x295x439
269,9 (10 5/8) AIRJ622	269,9	10 5/8	622Y	AirJet	RB; Y; GR; SJ; BFV	50-120	140-280	Pin 6 5/8 Reg	66,9 295x295x439
269,9 (10 5/8) AIRJ712	269,9	10 5/8	712Y	AirJet	RB; Y; DGR; SJ; BFV	50-90	140-330	Pin 6 5/8 Reg	71,9 295x295x439
269,9 (10 5/8) AIRJ722	269,9	10 5/8	722Y	AirJet	RB; Y; GR; SJ; BFV	50-90	140-330	Pin 6 5/8 Reg	71,9 295x295x439
269,9 (10 5/8) AIRJ742	269,9	10 5/8	742Y	AirJet	RB; Y; GR; SJ; BFV	50-90	140-330	Pin 6 5/8 Reg	71,9 295x295x439
269,9 (10 5/8) AIRP725	269,9	10 5/8	725Y	AirPro	RBS; Y; GR; SJ; BFV	50-90	140-330	Pin 6 5/8 Reg	73,9 295x295x439
269,9 (10 5/8) AIRX617	269,9	10 5/8	617Y	AirXtreme	PJB; Y; DGR; AGR; SJ; BFV; CHF	50-120	140-280	Pin 6 5/8 Reg	75,9 295x295x439
269,9 (10 5/8) AIRX637	269,9	10 5/8	637Y	AirXtreme	PJB; Y; GR; SJ; BFV	50-120	140-280	Pin 6 5/8 Reg	75,9 295x295x439
279,4 (11) AIRJ522	279,4	11	522Y	AirJet	RB; Y; GR; SJ; BFV	50-130	100-270	Pin 6 5/8 Reg	73,9 340x340x524
279,4 (11) AIRJ622	279,4	11	622Y	AirJet	RB; Y; GR; SJ; BFV	50-120	150-290	Pin 6 5/8 Reg	74,9 340x340x524
279,4 (11) AIRJ732	279,4	11	732Y	AirJet	RB; Y; GR; SJ; BFV	50-90	150-340	Pin 6 5/8 Reg	76,9 340x340x524
311,1 (12 1/4) AIRJ522	311,1	12 1/4	522Y	AirJet	RB; Y; GR; SJ; BFV	50-130	110-290	Pin 6 5/8 Reg	98,9 340x340x524
311,1 (12 1/4) AIRJ522K	311,1	12 1/4	522Y	AirJet	RB; Y; GR; SJ; BFV	50-130	110-290	Pin 6" BECO	98,9 340x340x524
311,1 (12 1/4) AIRJ622	311,1	12 1/4	622Y	AirJet	RB; Y; GR; SJ; BFV	50-120	170-330	Pin 6 5/8 Reg	98,9 340x340x524

PRODUCT RANGE

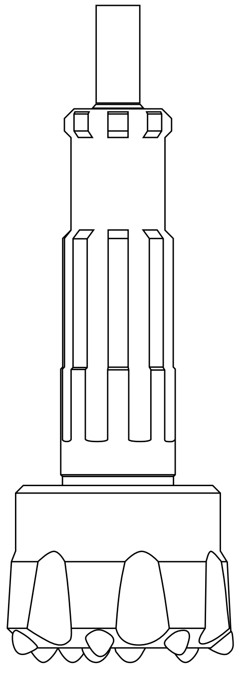
1	2	3	4	5	6	7	8	9	11
311,1 (12 1/4) AIRJ622K	311,1	12 1/4	622Y	AirJet	RB; Y; GR; SJ; BFV	50-120	170-330	Pin 6" BECO	98,9 340x340x524
311,1 (12 1/4) AIRJ632	311,1	12 1/4	632Y	AirJet	RB; Y; GR; SJ; BFV	50-120	170-330	Pin 6 5/8 Reg	98,9 340x340x524
311,1 (12 1/4) AIRJ632K	311,1	12 1/4	632Y	AirJet	RB; Y; GR; SJ; BFV	50-120	170-330	Pin 6" BECO	98,9 340x340x524
311,1 (12 1/4) AIRJ722	311,1	12 1/4	722Y	AirJet	RB; Y; GR; SJ; BFV	50-90	170-380	Pin 6 5/8 Reg	99,9 340x340x524
311,1 (12 1/4) AIRJ742	311,1	12 1/4	742Y	AirJet	RB; Y; GR; SJ; BFV	50-90	170-380	Pin 6 5/8 Reg	99,9 340x340x524
311,1 (12 1/4) AIRJ742K	311,1	12 1/4	742Y	AirJet	RB; Y; GR; SJ; BFV	50-90	170-380	Pin 6" BECO	99,9 340x340x524
311,1 (12 1/4) AIRP635	311,1	12 1/4	635Y	AirPro	RBS; Y; GR; SJ; BFV	50-120	170-330	Pin 6 5/8 Reg	98,9 340x340x524
311,1 (12 1/4) AIRP715	311,1	12 1/4	715Y	AirPro	RBS; Y; GR; SJ; BFV	50-90	170-380	Pin 6 5/8 Reg	98,9
311,1 (12 1/4) AIRX637	311,1	12 1/4	637Y	AirXtreme	JB; Y; GR; SJ; BFV	50-120	170-330	Pin 6 5/8 Reg	105,9 340x340x524
349,2 (13 3/4) AIRJ532	349,2	13 3/4	532Y	AirJet	RB; Y; GR; SJ; BFV	50-130	140-350	Pin 6 5/8 Reg	130,9 430x430x676
349,2 (13 3/4) AIRJ542	349,2	13 3/4	542Y	AirJet	RB; Y; GR; SJ; BFV	50-130	140-350	Pin 6 5/8 Reg	131,9 430x430x676
349,2 (13 3/4) AIRJ622	349,2	13 3/4	622Y	AirJet	RB; Y; GR; SJ; BFV	50-120	200-380	Pin 6 5/8 Reg	134,9 430x430x676
393,7 (15 1/2) AIRJ632	393,7	15 1/2	632Y	AirJet	RB; Y; DGR; FJ; BFV	50-120	230-430	Pin 7 5/8 Reg	190,9 430x430x676
393,7 (15 1/2) AIRJ632K	393,7	15 1/2	632Y	AirJet	RB; Y; DGR; FJ; BFV	50-120	230-430	Pin 6 5/8 FH	190,9 430x430x676
406,4 (16) AIRJ632	406,4	16	632Y	AirJet	RB; Y; DGR; FJ; BFV	50-110	240-450	Pin 7 5/8 Reg	197,9 430x430x676

**Volgaburmash JSC permanently refines bit construction design.*
Information on the current bit features can be provided by your dealer/VBM representative.

DTH BITS



DownTheHole (DTH) bits are utilized while blast hole drilling with downhole hammers. A splined joint of the shank improves reliability and joint strength and provides quick and easy tool change.



Plastic valve

Splined joint

Cutter body with inserts

NOTATION KEY

203	(8)	DTH	QL6	F	2	S
Bit size, mm	Bit size, inch	Product line	Shank type	Face configuration (F, C, CV)	Number of flushing ports	Insert configuration (S, B)

FACE CONFIGURATION

F — flat

C — concave

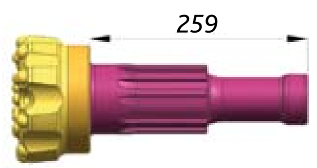
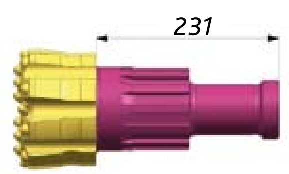
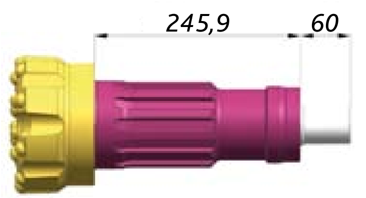
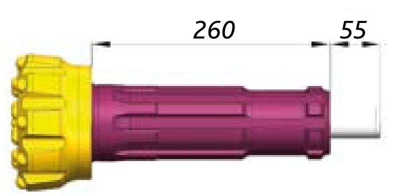
CV — convex

INSERT CONFIGURATION

S - spherical

B - ballistic

SHANK TYPE

Shank type	Appearance	Number of splines	Compatible shanks
RC5		8	RC50
M5		12	M50
M6		12	M60
QL5		12	QL50 TD50 Cop 54GE
QL6		12	QL60 TD60/65/70 Cop 64G
DHD350		8	DHD350
QL8		16	QL80 TD80/85

PRODUCT RANGE

Bit identification	Bit size		Shank		Flushing ports, pcs	Cutting structure		Height, mm	Weight, kg
	mm	inch	Type	Height, mm		Outer row, pcs x mm	Inner row, pcs x mm		
140 (5,5) DTH-RC5C2S	140	5 1/2	RC50	292	2	8x16	4x16, 4x14,5	382	19,4
152 (6) DTH-M5F3S			M50	259		9x18	9x16	352	15,5
152 (6) DTH-QL5C3S	152	6	QL50	240	3	9x18	9x16, 2x14,5	342	17,9
152 (6) DTH-M6C3B			M60	231		9x18	9x16, 2x14,5	328	18
152 (6) DTH-DHD350F2S	152	6	DHD350	260	2	10x16	10x16	403	17,3
165 (6,5) DTH-QL6C3S					3	9x18	11x16	346	23,4
165 (6,5) DTH-QL6F2S	165	6 1/2			2	10x16	10x16	347	23,6
165 (6,5) DTH-QL6F3S					3	9x18	9x18	346	24,4
171 (6,75) DTH-QL6C3S			QL60	246	3	9x18	11x16	346	24,6
171 (6,75) DTH-QL6F2S	171	6 3/4			2	10x18	10x16		24,3
171 (6,75) DTH-QL6F3S					3	9x18	9x16	347	24,3
203 (8) DTH-QL6F2S	203	8			2	10x18	17x16		30,9
222 (8,75) DTH-QL8F2S	222	8 3/4	QL80	332		12x19	12x18	461	49

PILOT BITS

Pilot bits are utilized for pilot hole drilling during raise boring operations.

NOTATION KEY

349,2	(13 3/4)	GRDX	837
Bit size, mm	Bit size, inch	Product line MTR for bit range ≤ 311.1 mm (12 1/4″) GRDX for bit range > 311.1 mm (12 1/4″)	IADC code

PRODUCT RANGE

<table>
<tr><th rowspan="2">Bit identification</th><th colspan="2">Bit size</th><th rowspan="2">IADC code</th><th rowspan="2">Product line</th><th>Connecting thread</th><th rowspan="2">Gross weight, kg
Shipping dimensions, mm</th></tr>
<tr><th>mm</th><th>inch</th><th>API</th></tr>
<tr><td>228,6 (9) MTR837</td><td>228.6</td><td>9</td><td rowspan="7">837Y</td><td rowspan="4">Motor</td><td>Pin 4 1/2 Reg</td><td>41.7
255 x 255 x 389</td></tr>
<tr><td>250,8 (9 7/8) MTR837</td><td>250.8</td><td>9 7/8</td><td rowspan="4">Pin 6 5/8 Reg</td><td>62.2
295 x 295 x 439</td></tr>
<tr><td>279,4 (11) MTR837</td><td>279.4</td><td>11</td><td>79.1
340 x 340 x 524</td></tr>
<tr><td>311,1 (12 1/4) MTR837</td><td>311.1</td><td>12 1/4</td><td>101.1
340 x 340 x 524</td></tr>
<tr><td>349,2 (13 3/4) GRDX837</td><td>349.2</td><td>13 3/4</td><td rowspan="3">GrandXtreme</td><td>139.6
430 x 430 x 676</td></tr>
<tr><td>381,0 (15) GRDX837</td><td>381.0</td><td>15</td><td rowspan="2">Pin 7 5/8 Reg</td><td>175.6
430 x 430 x 676</td></tr>
<tr><td>444,5 (17 1/2) GRDX837</td><td>444.5</td><td>17 1/2</td><td>232.3
475 x 475 x 702</td></tr>
</table>

FDC BITS

FastDrillConstruction (FDC) bits are applied for construction and mining industries and can be successfully used for exploration drilling, methane drainage borehole drilling and injection drilling.

FDC bit comprises a steel body and polycrystalline diamond cutters (PDC), they are used for drilling both vertical and directional full-hole wells. Application of wear-resistant PDC cutters multiplies bit life and performance. Flushing through ports directed towards the well bottom efficiently cleans the hole and cools the bit.

NOTATION KEY

96	(3 25/32)	FDC	3	13	S	K
Bit size, mm	Bit size, inch	Product line	Number of gauge cutters or flushing ports	Cutter size, mm	Formation class	Additional suffix (used for 'box' thread)

PRODUCT RANGE

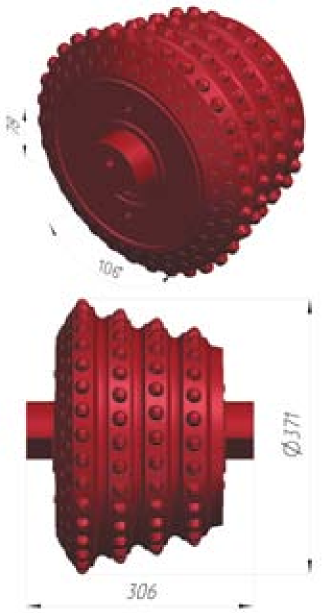
Bit identification	Bit size		Connecting thread	Gross weight, kg Shipping dimensions, mm
	mm	inch	API / DCDMA	
76,0 (3) FDC313S	76	3	-	3.3 120 x 120 x 159
93,0 (3 21/32) FDC313S	93	3 21/32	-	4.1 120 x 120 x 159
93,0 (3 21/32) FDC313SK			-	4.1 120 x 120 x 159
96,0 (3 25/32) FDC313S	96	3 25/32	Pin 2 3/8 Reg	4.1 120 x 120 x 159
96,0 (3 25/32) FDC313S			Pin NW	4.1 120 x 120 x 159
98,0 (3 27/32) FDC313S	98	3 27/32	Pin 2 3/8 Reg	4.3 120 x 120 x 159

REAMER CUTTERS

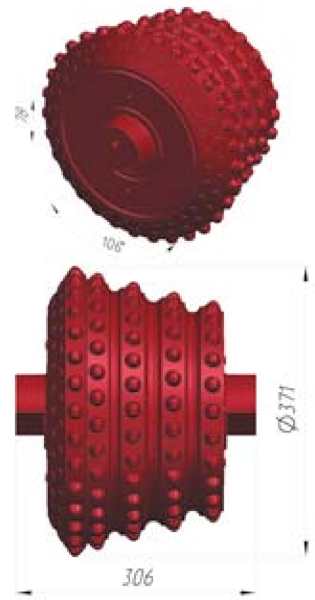
Reamer cutters are developed for the mining, construction and oil & gas industries. The cutting structure of cutters depends on the rock's category and can be equipped with both spherical or conical tungsten carbide inserts or steel teeth.

Connecting and overall dimensions of cutters are shown in the images below.

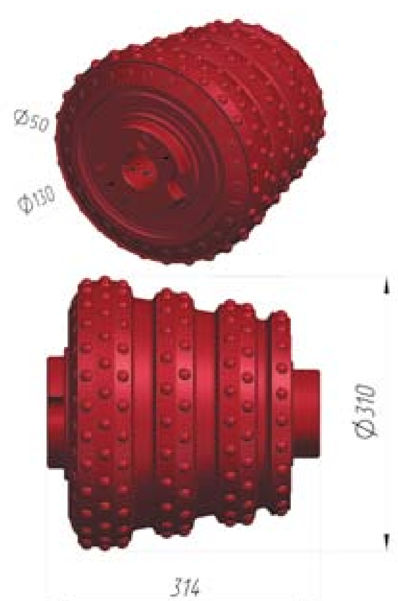
RCC4



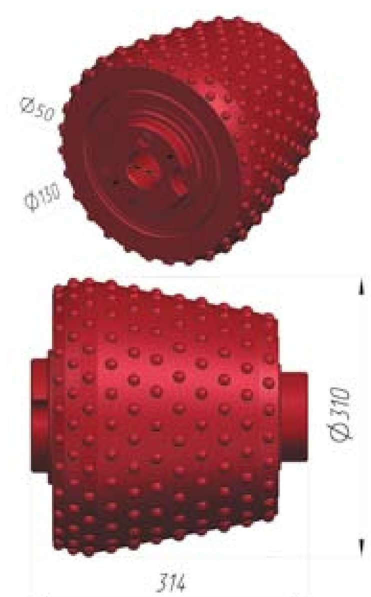
RCC5



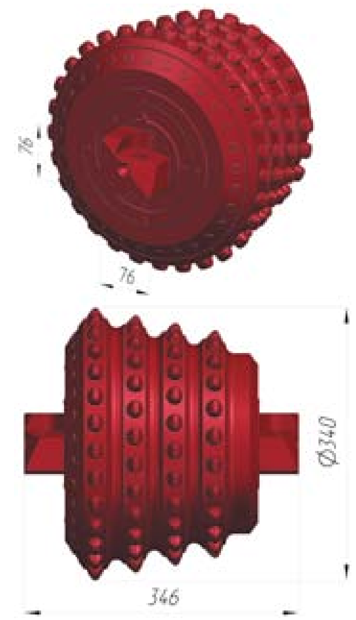
SH12



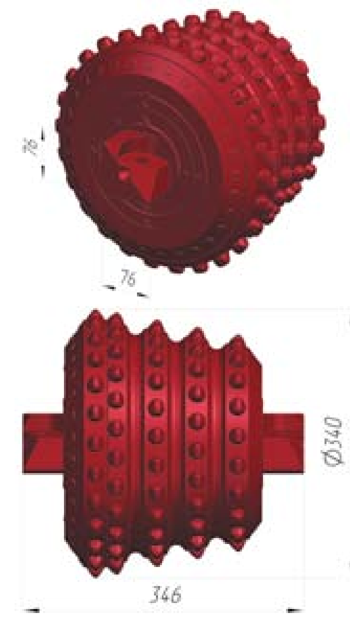
SH16



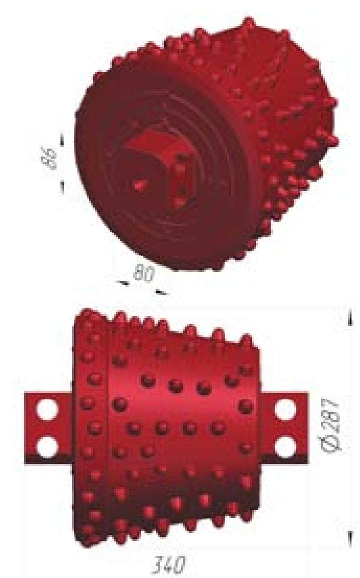
CMR41



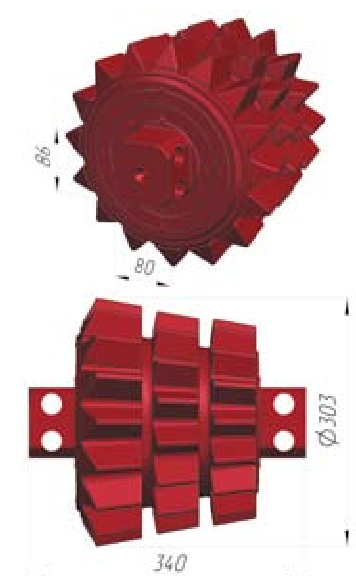
CMR52



TK3224



M224



ROCK DESTRUCTION

Efficient rock drilling requires an optimum combination of many factors, including dynamic load or an impact energy applied to the bit cutting structure. Experiments proved that the depth of cut depends on the load applied to the insert.

Figure 1 shows this regularity in a form of a polygonal line with 4 main areas of rock destruction (a, b, c, d) under it.

Figure 2 illustrates the rock destruction patterns in the process of insert penetration.

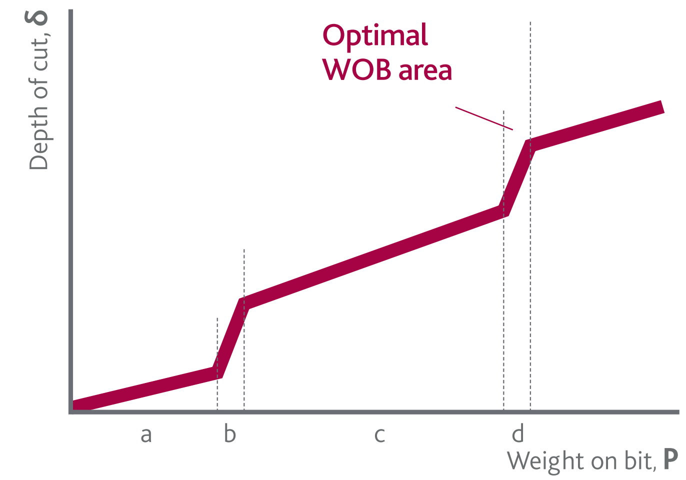
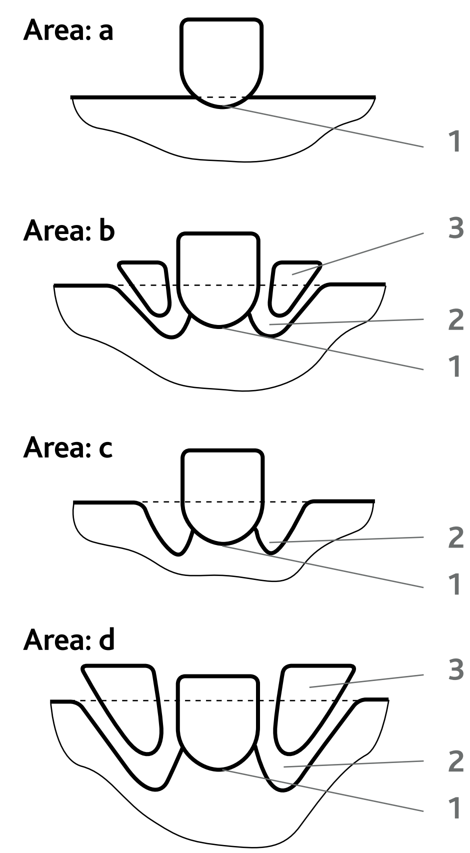


Figure 1



When only a minor impact energy is applied there is only minor fragmentation made by the insert on the rock surface (residual deformation). This results in the rock cracking around the insert contour.

With further increase in impact energy the rock starts chipping away from the insert contour. This is the first stage of rock destruction. The force resulting in chipping around the insert contour is called the load of the first stage of rock destruction.

The further increase in the impact energy up to the load of the second phase of rock destruction results only in an insignificant increase in the volume of destruction.

When maximum load is applied the volume of destruction increases proportionately. This type of failure is called the second stage of rock failure.

Figure 2

Figure 2 illustrates: 1 – insert-rock contact surface; 2 – rock destruction crater; 3 – cutting cross section.

Conditions for rock destruction failure (**Figure 1, b, d stages**) depend on the properties of the rock, weight on bit (WOB), revolutions per minute (RPM) and bottomhole cleaning conditions.

Optimization of drilling parameters is achieved through experimental selection of WOB and RPM.

Specifications shown for WOP and RPM of the bit type should not exceed the values presented in VBM Tricone Roller Bits Operation Manual. Experiments proved the relation between the bottomhole penetration δ per one rotation and WOB while drilling with a rock bit.

Figure 3 illustrates the relation as a curve. Three main areas of rock destruction are shown under it.

Figure 3

Area I

The rock is cut by abrasive wear, micro chipping, crushing and movement of some bottomhole irregularities which is much smaller in size than inserts. This area demonstrates insufficient WOB. ROP is not more than 3 m/h.

Area II

Fatigue failure, voluminous chipping after several impacts on the same bottomhole area. Very hard formations are mostly drilled in this area. ROP does not exceed 10 m/h.

Area III

This is a bulk failure area where specific power inputs per unit of rock volume are considerably lower than in the first two areas, but ROP is higher.

When RPM is modified, the quantity of insert impacts against the bottomhole per time unit changes. The penetration per one rotation (δ) can be expressed by rate of penetration (ROP):

$$ROP = n \cdot \delta$$

Figure 4 shows how bit penetration per one rotation (δ) and ROP depends on RPM.

With increased revolutions per minute in $n \le n_1$ section, the values of ROP and δ increase. With increased RPM in $n_1 \le n \le n_2$ section, δ decreases, but ROP keeps growing. With further increase in RPM in $n > n_3$ section, the values of δ and ROP decrease considerably.

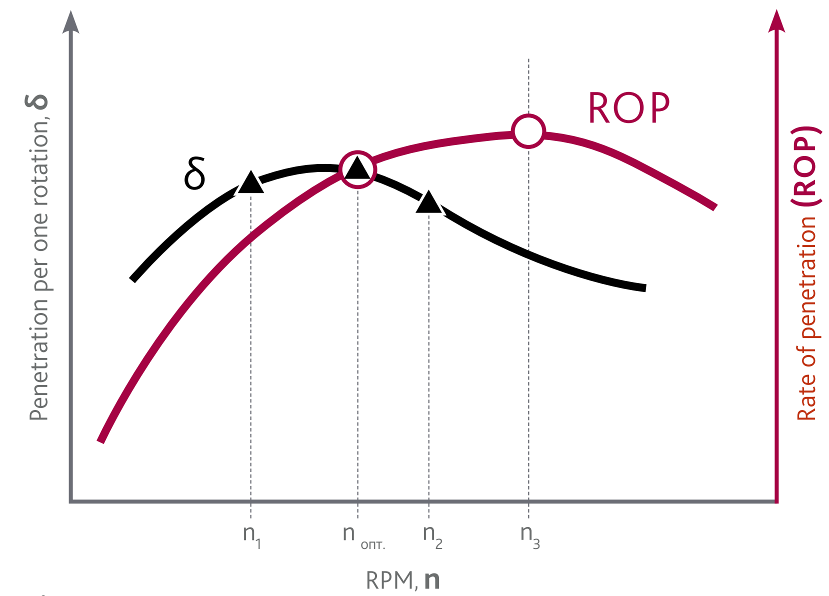


Figure 4

ROP decreases after the point n_3 due to:

- reduced insert-rock interaction time;
- decreased impact energy applied to an insert;
- increased dynamic resistance of the rock drilled due to its plastic properties with light penetration per one rotation;
- increased drilling rod vibrations;
- changed mode of the air flow at the bottomhole;
- increased power consumption for idle RPM.

Continuous air flushing while drilling ensures bottomhole cleaning, the bit cooling and efficient penetration into rock.

An optimum ratio of the value of a bit penetration per one rotation δ and ROP on **Figure 4** corresponds to bit RPM n_{opt}. A further increase of RPM will result in erosion of the bit cutting structure and bearing with little further increase of ROP.

DETERMINATION OF MAXIMUM RATE OF PENETRATION (ROP)

The maximum ROP is determined experimentally for each bit type and size in given mining and geological applications. Therefore an optimum ratio of WOB and RPM is theoretically achieved when the depth of cut is about 80% of insert protrusion. 20% remain for efficient cuttings removal. In practice the recommended drilling modes are determined by a particular bit type and size. The target is to determine the maximum ROP with the given WOB and RPM according to specifications presented in VBM Tricone Roller Bits Operation Manual. The maximum ROP value will correspond to the optimal WOB and RPM values.

Excessive WOB which makes depth of cut more than 80% results in the following:

- cuttings are not completely removed from rock cutting area;
- rock is milled repeatedly;
- ROP is decreasing;
- bit cutting structure and bearing wear intensively;
- load on the drilling rig rotary head is increasing.

AIR CIRCULATION MODE

An optimum air circulation in up-to-date drilling with mining bits covers the following tasks:

- Efficient cuttings removal from the bottom to the surface.
- Reduction of erosive wear of cutting structure and bearings by means of efficient bottom cleaning.
- Bearing cooling and cleaning of cuttings.

An efficient bottomhole cleaning is achieved by utilizing the required annular upward velocity.

The annular upward velocity produces a lifting force that ensures cuttings removal. It can be controlled by:

- selection of a compressor and its adjustment to the optimum air capacity;
- selection of a bit size and drilling rod outer diameter (OD);
- selection of replaceable nozzles with optimum flow area.

Actual compressor capacity varies with the throttle position, screw pair wear, altitude and manifold leakage.

Factors that affect annular velocity for cuttings removal:

- correlation between the bit size and the drill rod outer diameter;
- drilling rod size loss as a result of natural wear;
- density of drilled formations;
- sizes and shapes of cuttings;
- water in the hole.

They can be expressed by the following formula:

$$Q = 47 \cdot V \cdot (D_b^2 - D_r^2)$$

Q is required compressor capacity, m³/min,

V is required upward velocity, m/sec;

D_b is bit size, m;

D_r is rod size, m;

It should be noted that:

- annular velocity for drilling light weight formations should be at least 25 m/sec;
- annular velocity for drilling heavy weight formations should be not less than 35 m/sec;
- annular velocity for drilling heavy weight formations with high water content should be at least 50 m/sec.

Data presented within **Table 1** provide just an estimate of the compressor capacity. Only test drilling can give a definite answer.

Table 1. Required compressor capacity versus bit diameters, drill rod diameters and geological conditions

Bit size		Rod size		Required compressor capacity for air drilling, m³/min		
inch	mm	inch	mm	25 m/sec	35 m/sec	50 m/sec
1	2	3	4	5	6	7
3	76.0	60	2 1/3	3	4	5
3 2/3	93.0	60	2 1/3	6	9	12
		65	2 5/9	6	8	11
3 7/8	98.4	60	2 1/3	7	10	14
		65	2 5/9	6	9	13
		73	2 7/8	5	7	10
4 1/2	114.3	65	2 5/9	10	15	21
		73	2 7/8	9	13	18
		89	3 1/2	6	8	12
4 3/4	120.6	60	2 1/3	13	18	26
		65	2 5/9	12	17	24
		73	2 7/8	11	15	22
		89	3 1/2	8	11	6
		102	4	5	7	10
5 1/8	130.2	73	2 7/8	14	19	27
		89	3 1/2	11	15	21
		102	4	8	11	15
5 3/8	136.5	73	2 7/8	16	22	31
		89	3 1/2	13	18	25
		102	4	10	14	19
5 1/2	139.7	89	3 1/2	14	19	27
		102	4	11	15	21
		114	4 1/2	8	12	17
5 5/8	142.9	73	2 7/8	18	25	35
		89	3 1/2	15	21	29
		102	4	12	17	24
		114	4 1/2	9	13	19
5 7/8	149.2	102	4	14	19	28
		114	4 1/2	11	15	22
		127	5	7	10	14
6	152.4	102	4	15	21	30
		114	4 1/2	12	17	24
		127	5	8	12	17
1	2	3	4	5	6	7
6 1/4	158.7	89	3 1/2	20	28	41
		102	4	17	24	35
		114	4 1/2	14	20	29
		127	5	11	15	21
6 3/4	171.4	102	4	22	31	45
		114	4 1/2	19	27	38
		127	5	16	22	31
		140	5 1/2	12	16	23
7 3/8	187.3	114	4 1/2	26	36	52
		127	5	22	31	45
		140	5 1/2	18	26	37
		152	6	14	20	28
		159	6 1/4	12	16	23
7 7/8	200.0	140	5 1/2	24	34	48
		152	6	20	28	39
		159	6 1/4	17	24	35
		168	6 3/5	14	19	27
8 1/2	215.9	140	5 1/2	32	44	63
		152	6	27	38	55
		159	6 1/4	25	35	50
		168	6 3/5	21	30	43
9	228.6	168	6 3/5	28	39	56
		178	7	24	34	48
		180	7	23	33	47
		191	7 1/2	19	26	38
		197	7 3/4	16	22	32
9 1/5	233.0	168	6 3/5	31	43	61
		178	7	27	37	53
		180	7	26	36	51
		191	7 1/2	21	29	42
		197	7 3/4	18	25	36
9 7/8	250.8	178	7	33	46	49
		180	7	32	44	48
		191	7 1/2	27	38	41
		197	7 3/4	25	34	37
		203	8	22	30	33
		219	8 5/8	18	25	35

1	2	3	4	5	6	7
10 5/8	269.9	197	7 3/4	40	56	80
		203	8	37	52	74
		219	8 5/8	29	41	58
		229	9	24	34	48
11	279.4	203	8	43	61	86
		219	8 5/8	35	50	71
		229	9	30	42	60
11 3/5	295.3	203	8	54	76	108
		219	8 5/8	46	65	92
		229	9	41	57	82
		235	9 1/4	38	53	75
12 1/4	311.1	219	8 5/8	57	80	115
		229	9	52	73	105
		235	9 1/4	49	68	98
		254	10	38	53	76
		273	10 3/4	26	37	52
12 5/8	320.0	229	9	59	82	118
		235	9 1/4	55	78	111
		254	10	45	62	89
13 3/4	349.2	254	10	67	94	135
		273	10 3/4	56	78	111
		305	12	34	48	68
15 1/2	393.7	305	12	73	102	145
		311	12 1/4	68	96	137
		330	13	54	76	108

BIT NOZZLES SELECTION

Optimal combination of drilling equipment mounted on a drilling rig (considering a bit size, drilling rod diameter, actual compressor capacity for the given mining and geological applications) helps to achieve the required annular velocity and sufficient bottomhole cleaning and cuttings removal. The better are the borehole cleaning and cuttings removal, the less is the erosive wear of the cutting structure and the bearing at maximum ROP. However, it is very important to realize that air circulation system is to ensure not only the required annular upward velocity, but to provide conditions for the best bearing cooling and cleaning.

The challenge is being addressed by the right choice of bit nozzles size, because only nozzles selection makes it possible to gain an air pressure drop in a bit which is required for successful drilling. The list of available VBM bit nozzles is presented below (**Table 2**).

Table 2. Nozzle selection versus roller cone bits with air flush

Nozzle range for tricone roller bits AIRJ / AIRP / AIRX																							
Bit size		Outlet size, mm																					
mm	inch	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	22	24	25	26	28	30	32
171.4	6 3/4	*	*	*	*	*	*	*	*	*	*	*	*	*	*								
187.3 – 233.0	7 3/8 – 9 1/5		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*						
244.5 – 393.7	9 5/8 – 15 1/2			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*				
349.2	13 3/4								*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
393.7	15 1/2									*	*	*	*	*	*	*	*	*	*				
406.4	16									*	*	*	*	*	*	*	*	*	*				

Recommended air pressure in a bit is determined in each case experimentally by making measurements with a special pressure gauge. The long-term experience in blast hole drilling proves that air pressure in a bit has to be within the range of not less than 35 psi and in correspondence with physical and mechanical properties of formations and drilling applications. Moreover, it should be considered that pressure loss in the drilling rig airline (in direction to the bit) can reach 10-20 psi. Environment temperature, altitude and air temperature in a bit should be considered for actual compressor capacity and performance evaluation.

Failure to comply with recommended values of air pressure in a bit will inevitably result in premature bearing failure including bearing fatigue.

DRILL BIT SELECTION

Table 3. Drill bit selection according to rock physico-chemical features

Rocks hardness	Rocks/formations	Rock type according to GOST 20692-2003	Protodyakonov scale of hardness, f	Drillability grade	Uniaxial Compressive Strength (UCS), δ: kg/cm²	MPa	psi	VBM bit selection: Cutting structure type	Optimal bearing type	IADC code (w/t the last figure)
Very soft and soft	Bog soil. Silt wet. Loose loess. Running soil.	OM3, M	0.2	I	< 50	< 7	< 1,000	Milled teeth / Tungsten carbide inserts (TCI)	OPEN (product lines AIRS, AIRV, AIRJ)	11X - 14X
	Filled-up ground. Sand. Vegetable layer. Peat high-purity.		0.4	II						
	Ice. Dry and dense loess. Top soil with rubble and rock debris. Peat with gravel. Black soil.		0.6	III	40-120					
	Light and sandy ground. Moraine, coarse gravel. Very soft marl. Heavy loam. Soft coal.		0.9	IV						
Soft	Heavy, dry clay interbedded with sandstone and marl. Silty gravel and sand. Earthly gypsum. Weakly cemented coquina. Medium coal (Donetsk type).	MC, M3	1.2	V	80-300	7 - 14	1,000 - 2,000			
	Coaly argillite. Weakly cemented rubble and gravel. Porous gypsum. Shaly clay. Pinal schist. Medium coal (Kuznetsk type).		1.5							
	Anthracite. Coaly-clay argillite. Crystallized gypsum. Gravel and rubble soil. Porous limestone. Gravel compact. Soft dolomite. Chalk stone. Marl. Frozen soil. Silicite. Soft sandstone. Fissile shale. Rock salt. Tough coal. Serpentinite talcose and magnetized.		2.0	VI, VII		14 - 21	2,000 - 3,000			41X - 44X
Soft and medium	Hard antracite. Clay siltstone. Barite. Fine grained gypsum. Porous dolomite. Soft limestone. Compact frozen sand. Pozzolana. Iron ore.	C, MC3	3.0	VIII						21X - 24X
	Siltstone and argillite with siliceous and argillaceous cement. Anhydrite. Apatite ore. Compact bauxite. Soft dolomite. Brown, porous and weathered ironstone. Marly and soft limestone. Hard marl. Sandstone with argillaceous and gypseous cement. Weathered serpentinite. Conglomerate of sedimentary rock with argillaceous cement. Very hard clay shale, mica schist and sericitic schist, slate. Very hard coal.		4.0	IX	200-450	21 - 28; 28 - 41	3,000 - 4,000; 4,000 - 6,000			
Medium and hard	Siltstone with siliceous and sericitic cement. Apatite-nepheline ore. Stone and jasperoid bauxite. Soft gneiss. Weathered dunite. Run-of-mine limestone. Conglomerate of sedimentary rock with carbonate cement. Striate magnetite and weathered massive magnetite. Coarse grained and mineralized marble. Sandstone with argillaceous-sericitic porous carbonate cement. Serpentinite. Siderite. Argillaceous, silicificated, micaceous, hard, coaly and sandstone shale. Phosphorite with phosphoric acid and carbonate cement.	CT, C3	5.0; 6.0	X; XI	350 - 700	41 - 48; 48-62	6,000 -7,000			41X - 44X; 31X - 34X

Rocks hardness	Rocks/formations	Rock type	f	Drillability grade	kg/cm²	MPa	psi	Cutting structure type	Optimal bearing type	IADC code
Hard	Laminated siltstone with siliceous cement. Solid brown hematite. Dolomite. Compact and dolomitic limestone. Coarse grained granite, granodiorite, gabbro, dunite, pegmatite. Basaltic lava. Massive magnetite. Medium grained marble. Biotite paragneiss. Sandstone with mixed argillaceous-carbonaceous and siliceous-argillaceous cement. Conglomerate. Mica-quartz shale. Weathered porphyrite. Pyrrhotite and chalcopyrite ore. Kimberlite.	T, T3	7.0; 8.0	XII	550 - 950	62 - 76	7,000 - 11,000	Milled teeth / Tungsten carbide inserts (TCI)	OPEN / SEALED (product lines AIRS, AIRV, AIRJ / AIRP, AIRX)	51X - 54X; 31X - 34X
	Gneiss, granite-gneiss. Weathered diabase. Conglomerate with limestone gravel. Medium-hard martite and hematite-martite ore. Medium grained anisomerous porphyraveous granite, granodiorite, gabbro, peridotite, pyroxenite, syenite, pegmatite. Acid tuff. Magnesite.		9.0; 10.0	XIII; XIV	750 - 1350	76 -90; 90 - 117	11,000 - 13,000; 13,000 -17,000	Tungsten carbide inserts (TCI)		61X - 62X; 63X - 64X
	Amphibole. Fine and medium grained gabbro. Massive limestone. Conglomerated with igneous rock pebble with mixed cement. Porous acid and medium lava. Fine and medium grained granite, granodiorite, syenite. Gabbro. Oxidated ferruginous quartzite. Massive sandstone with siliceous cement. Alkaline dike rock. Silicificated magnesite.		11.0; 12.0; 13.0	XV		117 - 152	17,000 -22,000			
	Granite-porphyry. Fine grained sandstone. Siliceous limestone. Hard magnetite and hematite-magnetite ore. Fine grained granite (Onezhsky type). Ferruginous quartzite. Sandstone with siliceous cement. Medium size grained diorite. Compact garnet skarn.	TK3	14.0; 15.0; 16.0	XVI	1100 - 1700	152 - 186	22,000 - 27,000			71X - 72X
Very hard	Olivinic basalt and andesite. Medium and fine grained granite. Dacite and dacite porphyrite. Fine grained diorite and diorite porphyrite. Diabase. Massive diorite. Magnetite ferruginous quartzite, very compact. Quarz porphyry. Martite ore. Micro granite and micro diorite. Quartzitic sandstone. Silicificated shale. Very fine grained skarn. Quartz, biotite, pyroxene gneiss. Soft pegmatite.	K	17.0; 18.0; 19.0; 20.0	XVII; XVIII	1,500 - 2,100	186 - 221; 221 - 283; 283 -359	27,000 - 41,000; 41,000 - 53,000			71X - 74X
Extra hard	Jasperite. Fine grained gabbro-diorite. Solid diabase and basalt. Martite ferruginous quartzite. Fine grained solid quartzite. Solid quzrtzite. Emery chlorite ore. Metabasalt. Massive porphyrite. Chert and jasperoid shale. Coarse granite and medium-grained granite.	OK	> 20	XIX	1,850 - 2,700					
	Basalt, diabase and very dense porphyrite. Solid jasperite, quartzite and jasper. Corundum ore. Nephrite. Massive pyretic hornfels. Titanium magnetite ore. Jasper. Continuous micro quartzite. Andesite.			XX	> 2,500	> 359	> 53,000			81X - 84X

DRILL BIT SELECTION

Table 4. IADC drill bit selection

Constructive groups	1st IADC character	Categories of formations		2nd IADC character	3rd IADC character		
					2	5	7
					Bearing		
					Open	Sealed	
					Product line		
					AIRJ	AIRP	AIRX
Milled teeth bit	1	M	Soft formations	1			
				2			
		MC	Soft formations with medium interlayers	3			
				4			
	2	C	Medium formations	1			
				2			
		CT	Medium formations with hard interlayers	3			
				4			
	3	T	Hard formations	1			
				2	393,7 (15 1/2)		
				3			
				4			
Tungsten carbide inserts bit	4	M3	Soft abrasive formations	1	200,0 (7 7/8) 228,6 (9)	228,6 (9) 250,8 (9 7/8) 269,9 (10 5/8)	200,0 (7 7/8)
				2	215,9 (8 1/2) 250,8 (9 7/8) 269,9 (10 5/8)		
				3		228,6 (9) 250,8 (9 7/8)	200,0 (7 7/8)
				4			
	5			1			
				2			
		MC3	Medium formations with hard interlayers	3			
		C3	Medium abrasive formations	4			
Tungsten carbide inserts bit	6	T3	Hard abrasive formations	1	171,4 (6 3/4) 215,9 (8 1/2) 228,6 (9) 269,9 (10 5/8)	228,6 (9)	269,9 (10 5/8)
				2	171,4 (6 3/4) 200,0 (7 7/8) 250,8 (9 7/8) 269,9 (10 5/8) 279,4 (11) 311,1 (12 1/4) 349,2 (13 3/4)	250,8 (9 7/8)	

Constructive groups	1st IADC character	Categories of formations		2nd IADC character	3rd IADC character		
					2	5	7
					Bearing		
					Open	Sealed	
					Product line		
					AIRJ	AIRP	AIRX
Tungsten carbide inserts bit	6	TK3	Hard abrasive formations with extra-hard interlayers	3	171,4 (6 3/4) 200,0 (7 7/8) 215,9 (8 1/2) 228,6 (9) 244,5 (9 5/8) 250,8 (9 7/8) 311,1 (12 1/4) 393,7 (15 1/2) 406,4 (16)	215,9 (8 1/2) 228,6 (9) 311,1 (12 1/4)	250,8 (9 7/8) 269,9 (10 5/8) 311,1 (12 1/4)
				4	171,4 (6 3/4) 200,0 (7 7/8) 215,9 (8 1/2) 228,6 (9)		
	7	K	Very hard formations	1	269,9 (10 5/8)	311,1 (12 1/4)	
				2	171,4 (6 3/4) 200,0 (7 7/8) 228,6 (9) 244,5 (9 5/8) 250,8 (9 7/8) 258,0 (10 5/32) 269,9 (10 5/8) 311,1 (12 1/4)	258,0 (10 5/32) 269,9 (10 5/8)	250,8 (9 7/8)
				3	215,9 (8 1/2) 279,4 (11)		
				4	200,0 (7 7/8) 244,5 (9 5/8) 250,8 (9 7/8) 269,9 (10 5/8) 311,1 (12 1/4)		
	8	OK	Extra-hard formations	1			
				2			
				3			
				4			

BIT PREPARATION FOR OPERATIONS

1. Before running a new bit, analyze and assess efficiency of the old one: wear, RPM, drilling modes, penetration rate etc.
2. Inspect the bit condition and its configuration: back flow valve mounting security and performance, nozzles availability and their sizes, thread condition. Ensure that the thread of connecting drill rod (stabilizer, sub etc) is non-defective, not damaged and complies with bit thread.
3. Inspect the drill rod condition. Do not use bent rods or ones with worn thread. It is not recommended to use drill rods of different producers.
4. Inspect the centering deck bushing condition. Gap between a drill rod and centering deck bushings should not exceed 5/8″ (16 mm).
5. Check compressor capacity, as well as air hoses and air piping for leakage. Air leakage in blower pressure pipe negatively affects cuttings velocity and bit bearing cooling.
6. Inspect hoisting jacks: avoid misalignment of drill rig and borehole axes while drilling.
7. Do not make unauthorized changes to the bit design by welding additional parts or removing back flow valve or nozzles.

BIT MAKE-UP OPERATIONS

1. Blow the drill string through before make-up operations.
2. Clean and lubricate pin and box thread of drill rod.
3. Use a bit breaker or a rig tong for make-up/break-out operations. Never apply a sledge hammer to a bit. Perform make-up operations without impact and distortions.

BIT RUNNING

1. It is not recommended to run a new bit in an old, non-penetrating borehole as it results in damage to shirttail and teeth/inserts on gage row causing cone interference.
2. Tripping and reaming operations without drill string rotation and with air off is not recommended.

3. Avoid bit contacting with borehole ledges and drill string bushing edge during bit running operations. Minimize bit running speed while approaching the borehole bottom. Avoid heavy contact with borehole bottom when resuming drilling.

A NEW BIT DRILLING

1. A new bit should be run for the first 15-20 minutes with RPM not exceeding 35-50 rpm and WOB not exceeding 10-15% of the recommended rate.
2. Increase bit load smoothly (according to manufacturers recommendations) up to maximum RPM to avoid excessive vibration.
3. It is not recommended to run a new bit when drilling boreholes in the first row of the drilling pad or while angle drilling.

DRILLING

1. Injected water volume should be minimal and sufficient only for dust suppression. While drilling the first 3-6 m of a borehole and while drilling in intensively fractured, broken rocks, water supply should be increased for borehole stabilization to avoid wall collapse.
2. Drilling modes should be chosen on the basis of optimal bit run results within the ranges presented in the **Table 5**:

Table 5. Recommended drilling modes

IADC code	Required weight on each millimeter of a bit size		Recommeded rotation speed, rpm
	MIN, kg	MAX, kg	
4XX	15.24	76.86	50 – 130
5XX	46.06	99.89	50 – 120
6XX	61.29	107.34	50 – 100
7XX	61.29	122.92	50 – 90
8XX	92.10	138.15	40 – 80

3 Drilling mode is defined as a condition that provides maximum bit life, maximum ROP and maximum drill efficiency in the relevant geological conditions.

4 Drilling should be performed only with the air compressor on, and air valve open.

5 Do not apply weight on bit (WOB) without rotation.

6 In case of drill string vibration while drilling it is recommended to reduce axial load on a bit (WOB), or reduce either axial load and RPM to the level until vibration stops.

7 Avoid drilling with plugged/obstructed air ports/nozzles.

8 It is always recommended to initiate drill string rotation prior to applying down force to the bit as it can cause bit, TCI, drill rod and joint failure.

9 New bits should not be used for redrills of blocked boreholes.

10 In case of prolonged drilling break (breakdown, repair jobs, power outage etc) raise the bit up a minimum of 3-4 m from bottom of borehole. It is not recommended to leave a drill bit in the hole as it can result in bit balling and cone interference. Before drilling restart the compressor, open air valve flush for 40-60 seconds to start cuttings lifting and blowing air pressurizing.

11 Drilling is not recommended in case of loose iron in the hole.

12 A drilling rig operator should inspect the bit at least 5 times per shift (bit cutting structure, ease of cones rotation, cone play, heat level of each cone, bit shirttail wear should be inspected).

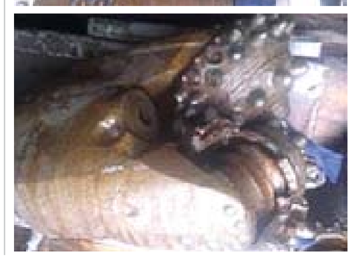
SIGNS OF BIT WEAR

- Cone bearing seizure
- Excessive play causing rotation seizure or cone interference
- Roller drop-out of any cone bearing
- Cutting structure wear up to 90%
- Bit failure (bit leg journal failure, welding seams cracking, cones cracking)
- Increase in torque while drilling

DULL GRADING

Challenging operating conditions cause wear of drill bit components including cutting structure, flush system, diameter loss etc. Bit performance analysis and dull grading help to diagnose causes of roller cone bit failure and can be used to enhance design of new rock-cutting tools.

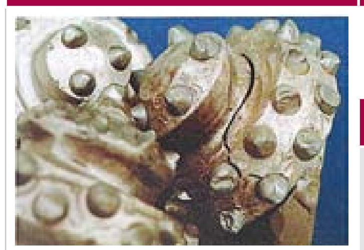
BC — BROKEN CONE

PART OF ONE OR SOME CONES ARE BROKEN IN THE AXIAL OR RADIAL DIRECTIONS, BUT MOST OF THEM ARE STILL IN PLACE ON THE BIT.

CAUSES	RECOMMENDATIONS
1. Junk/loose iron in the well. 2. Cone shell thinning due to erosive wear / cone metal fatigue. 3. Shock loads due to hitting ledges while running operations. 4. Dropped bit / drill string in the hole. 5. Cone external toothing results in overheat with further cracking in case of axial overloading on a bit.	1. Clean the borehole / avoid foreign objects dropping in the hole. 2. Cone shell seems to contact formation (cuttings bed). Use drilling modes corresponding to the current drilling conditions, or replace a bit with a more aggressive one. 3. Move slowly in case of ledges / follow drilling procedure. 4. Avoid drill string dropping in the hole / control wear of drill string thread connections. 5. Analyze drilling conditions and reduce WOB if necessary.

CC — CRACKED CONE




CRACKS APPEARS ON SHELL OF ONE OR SOME CONES (CONES ARE HELD AT THE BIT LEG JOURNAL).

CAUSES	RECOMMENDATIONS
1. Bit hitting ledges or bottom. 2. Drill string dropping due to twist-off. 3. Overload, additional cyclic loads due to bit over-time in the hole. 4. Loose iron in the well (including lost bit cutting elements).	1. Follow acceptable drilling procedure. 2. Timely replace worn drill string elements and monitor thread wear. 3. Adjust optimal load for bit type or reduce bit time in the hole, or select another bit. 4. Avoid foreign objects dropping in the hole. Inspect a bit at least 5 times per shift.

LC — LOST CONE


A CONE IS LOST FROM A BIT LEG JOURNAL.

CAUSES	RECOMMENDATIONS
1. Bit overrun caused by issues with a bearing (drilling with a bit with a damaged bearing results in uncontrolled cone movement across bearing and finally loss). 2. Bit bouncing on hole bottom.	1. Closely monitor the change in torque according to the readings of the instruments (usually 2-3 times exceeding the torque indicates problems with the bearings). 2. Follow acceptable drilling procedure. Avoid drill string dropping in the borehole.

WT — WORN TEETH


A TOOTH IS EVENLY WORN. MAIN WEAR FEATURES ARE HIGH ABRASION DUE TO CONTACT WITH ROCKS, SMALL FRACTURES AND CRACKING.

CAUSES	RECOMMENDATIONS
1. While hard formations drilling such a wear is considered normal if required results are achieved. 2. Abrasiveness of rocks exceeds cutting elements wear hardness. 3. Low WOB together with high rotation speed while drilling hard formations and insufficient uphole veloicty (multiple drilling of cuttings).	1. Replace bit. 2. Select a bit design with more abrasion-resistant cutting structure. 3. Use test approach to find an optimal WOB and rotation speed to achieve the best ROP. If WOB can't be physically increased or it's not recommended, apply a hard formation bit.

BT — BROKEN TEETH


A CONE TOOTH IS BROKEN (LOWER SECTION REMAINS IN PLACE).

CAUSES	RECOMMENDATIONS
1. A bit run on junk left in the hole. 2. Bit hitting ledges/bottom. 3. Excessive RPM results in broken teeth on gage row. 4. Too hard formation, fractured, decayed rocks, alternation of strata with extra hard formations/ incorrect selection of a bit type for the current conditions. 5. Cone interference.	1. Avoid foreign objects dropping in the hole. 2. Follow drilling procedure. 3. Reduce RPM. 4. Replace a bit with a more suitable one for the current drilling conditions. 5. Reduce WOB after confirming bit bearing is operable and has no play.

CT — CHIPPED TEETH


A TOOTH IS CHIPPED BY AT LEAST 1/2 OF ITS LENGTH (FOR WHATEVER REASON).

CAUSES	RECOMMENDATIONS
1. Excessive axial / impact load on a bit. 2. Excessive RPM for the current drilling conditions. 3. Fractured decayed formations while drilling or collaring. 4. Incorrect running-in of a new bit. 5. Incorrect selection of TCI / bit type / formation hardness exceeds the expected one. 6. Cone interference. 7. Alternation of layers with well-defined boundaries.	1. Use shock sub in case of layers alteration / reduce axial load on bit up to recommended rates. 2. Follow drilling procedure. 3. Adjust RPM smoothly to prevent vibration and drill string bouncing in the borehole. 4. Perform part-load running-in of a new bit. 5. Select a bit with coated hard-alloy teeth / select a correct bit type. 6. Reduce axial load if there is no bearing float. In case of over 8 mm play, replace a bit. 7. Select an optimal WOB and RPM for the current drilling conditions.

LT — LOST TEETH


TCI REMOVAL FROM THE CONE SHELL.

CAUSES	RECOMMENDATIONS
1. Cone shell erosion. 2. Loose iron in the hole. 3. Excessive WOB (especially in intensively fractured formations with heavy vibration while drilling). 4. A crack in the cone that loosens the grip of the inserts.	1. Analyze and compare geological/mining conditions and drilling modes. If there are no deviations, select a bit with more aggressive cutting structure. 2. Ensure proper borehole cleanout with air flush 3. Reduce WOB / follow drilling procedure. 4. Replace bit.

SS — SELF-SHARPENING WEAR


SUCH A FEATURE IS REFERRED ONLY TO BITS WITH MILLED TEETH, WHEN A TOOTH KEEPS SHORT SHARP CUTTERS FOR WEAR.

CAUSES	RECOMMENDATIONS
1. Such a wear is an indicator of the optimal bit selection for the current drilling conditions.	1. No need to correct.

RG — ROUNDED GAGE

CONE GAGE TEETH WEAR IS ROUNDED TOWARDS THE BIT CENTER RESULTING IN DRILLING SPEED DROP, TORQUE JUMP AND BOREHOLE NARROWING.

CAUSES	RECOMMENDATIONS
1. Excessive RPM. 2. Tight borehole reaming. 3. Rocks abrasiveness exceeds insert wear-resistance.	1. Adjust RPM. 2. If possible avoid borehole reaming. If necessary use partial load drilling modes. 3. Select a bit with hard-wearing inserts, rugged structure and with more cone gage teeth.

HC — HEAT CHECKING

OVERHEATING OF INSERT MATERIAL. TINY SHEARS AND A NETWORK OF FINE CRACKS ON THE SURFACE OF A CARBIDE INSERT («SNAKE SKIN»), CAUSED BY CYCLIC HEATING WITH THE FURTHER COOLING.

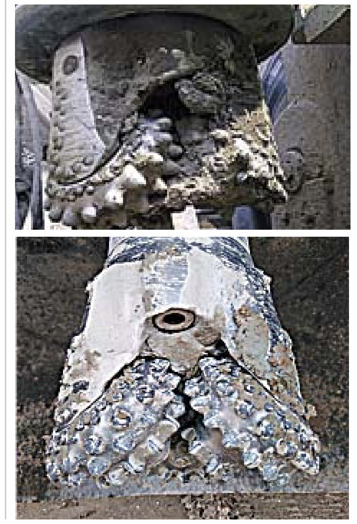
CAUSES	RECOMMENDATIONS
1. Repeated rapid heating and TCI damage while drilling and water cooling injected with air to the hole together with groundwater. 2. Insert alloy properties do not correspond to categories of drilling formations. 3. Tight hole reaming with high RPM. 4. A typical cause while carbonate drilling.	1. Select bits with teeth made of alloys less resistant to heat damage (with less cobalt content or large-scale carbide splinters), and reduce RPM and water supply. 2. Replace bit. 3. For tight hole reaming use an old stand-by bit and apply part-load drilling modes according to working conditions. 4. Use diamond impact-resistant inserts with increased temperature stability.

OC — OFF CENTER WEAR

MISALIGNMENT IN BIT ROTATION IN THE HOLE (BIT ROTATES AROUND ITS GEOMETRIC CENTER WHICH DOES NOT MATCH BOREHOLE CENTER). REAMING SIZE EXCEEDS NOMINAL WELLBORE SIZE.

CAUSES	RECOMMENDATIONS
1. Bent drill rods. 2. Different manufacturers' rods are used in one drill string. 3. Often observed while straight-hole and angle boreholes drilling by rigs with a worn deck bushing.	1. Replace drill rod. 2. Include only drill rods of the same manufacture. 3. Timely replace deck bushing.

BU — BALLED UP



PLUGGED GAPS BETWEEN CONES AND BIT BODY RESULT IN DRAMATIC DECLINE IN RATE OF PENETRATION.

CAUSES	RECOMMENDATIONS
1. Insufficient cleaning of the hole bottom (insufficient air pressure). 2. Drilling procedure violations. 3. Viscous, sticky andplastic type strata. 4. Incorrect selection of a bit type for the current drilling conditions. 5. Bit jamming into cuttings in the hole with the air off.	1-2. Test compressor output and provide recommended air supply speed and WOB (increase air delivery speed with correct nozzle selection) and inspect and clean the bit after every borehole. 3. Use central nozzles for better cleaning of the cones. 4. Select a more aggressive bit (e.g. with milled teeth). 5. ALWAYS have compressor on and air valve open when running drill tools in or out of borehole.

CD — CONE DRAGGED

ONE OR SOME CONES STOP ROTATING. PLAIN WEAR PATTERNS ARE SEEN ON SHELL AND CUTTING STRUCTURE OF NON-ROTATING CONES.

CAUSES	RECOMMENDATIONS
1. Bearing damage of one or more cones. 2. Junk lodging between the cones (or bit balling including plugged air ports). 3. Pinched bit causes cone interference and drag. 4. Drilling with air off or faulty compressor / air supply stops or is insufficient due to air hose rupture or severe leakage in air system.	1. Replace bit / select a bit with durable bearing (if bit life is within acceptable parameters then it's considered asa normal bit wear). 2. Inspect a bit periodically, especially while sticky and plastic rock drilling. Clean bit, in particular during long drilling breaks. 3. Do not jam bit in the hole without rotation. 4. Provide sufficient air pressure in a bit.

TR — TRACKING

TOOTH WEAR IS MAINLY ONE-SIDED RESULTING IN THE PREVIOUS CONE'S TEETH PENETRATION OR PREVIOUS BIT REVOLUTION (LIKE A WHEEL). CONE SHELL CONTACTS THE BOREHOLE BOTTOM.

CAUSES	RECOMMENDATIONS
1. Often caused while unconsolidated rock formation drilling and accompanied with dramatic decline in ROP. 2. WOB exceeds the requirement for drilling in the specific geological conditions.	1-2. Select a more aggressive bit and drilling modes required for the specific conditions.

CI — CONE INTERFERENCE


INTERFERENCE OF ONE CONE WITH THE OTHERS.

CAUSES

1. Pinched bit (possibly while applying a large bit for smaller-sized borehole drilling, or re-entry operations, or drilling ahead up to the target depth with a new bit).
2. Bearing failure results in cone rotation out of revolution axis.
3. Eccentric drilling with bent rod / worn drill string thread or bushing.

RECOMMENDATIONS

1. Do not use a new bit for drilled borehole cleanout, use only old stand-by bits (if there are no worn bits suitable for well completion and cleanout, drill a new borehole adjacent to the old one).
2. Select a bit with premium bearing / in some cases when acceptable results are achieved it's considered a normal bit wear.
3. Inspect drill string alignment as well as drill string thread connections and bushing.

PN — PLUGGED NOZZLE


NOZZLES PLUGGED.

CAUSES

1. Junk/foreign objects in airline (drill rods and air hoses components, etc).
2. Bit jamming into cuttings in the hole with the air off / nozzle is obstructed with cuttings.
3. Often observed while adding drill rods in wet boreholes when debris enters a drill string due to lack of back flow valve.

RECOMMENDATIONS

1. Avoid foreign objects in airline.
2. Ensure that air on and flushing starts before drilling.
3. Use bits with back flow valves especially where surface water is encountered.

BL — BREAKING LEG


ONE OF SOME BIT LEGS ARE MISSING.

CAUSES

1. Dropped drill string.
2. Bit hitting a ledge or bottom of borehole.
3. Excessive erosive leg wear.

RECOMMENDATIONS

1. Timely replace of worn thread connections.
2. Follow correct drilling procedure.
3. Replace bit.

JD — JUNK DAMAGE


BIT BODY OR ITS CUTTING STRUCTURE ARE DAMAGED BY JUNK (NOT ROCKS).

CAUSES

1. Loose iron dropped into borehole from the surface or from drilling equipment.
2. Drill string junk on the bottom (rods, reamers, stabilizers, subs elements and parts left in the hole).
3. Bit fragments in the hole (TCI, rollers etc).
4. Borehole crossed old casing or drill rods, or air shafts left or lost while previous exploration or subsurface mining operations.

RECOMMENDATIONS

1. Avoid foreign objects dropping in the hole.
2. Replace elements of a drill string before experiencing excessive wear.
3. Inspect a bit at least 5 times per shift, timely replace it if necessary.
4. No recommendations.

LN — LOST NOZZLE


LOSS OF NOZZLES.

CAUSES

1. Nozzle dissembling by a rig operator or maintenance/mechanical personnel.
2. Incorrect nozzle installation/mounting in bit bore.
3. Installation of inappropriate nozzle types (other manufacturers' nozzles) for the current bit type.
4. Nozzles or fitting mechanically damaged.

RECOMMENDATIONS

1. Investigate the reasons of nozzle dissembling (if good cause is high pressure in air supply system, then select large-sized nozzles).
2. Follow rules for nozzle installation/mounting.
3. Use original Volgaburmash nozzles only.
4. Be careful working with all nozzle types including extended ones and follow rules for nozzle installation/mounting.

CB — CLEARANCE BEARING


CLEARANCE BEARING (OPEN BEARING BITS).

CAUSES

1. Bearing wear due to overheating (insufficient compressor capacity, improper nozzle selection).
2. Bearing wear due to excessive drill string vibration.

RECOMMENDATIONS

1. Supply correct air volume to bit to cool its bearing.
2. Check alignment of drill strings. Timely replace worn deck bushings.

SD — SHIRTTAIL DAMAGE

DAMAGE OF SHIRTTAIL (RESULTING IN BEARING WEAR).

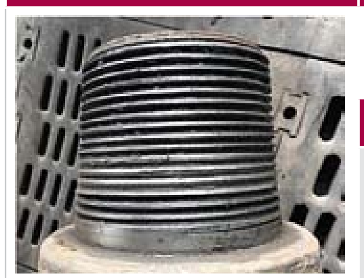
CAUSES	RECOMMENDATIONS
1. Axial load is such that shirttail covers its part (in soft formations). 2. Junk damage in the hole. 3. Tight hole reaming. 4. Directional drilling in abrasive rock formations.	1. Reduce axial load or select a bit with lower inclination between bit leg journal axis and bit axis. 2. Avoid foreign objects dropping in the borehole. If a bit part is left in the hole (an insert, a nozzle etc), then stop drilling and drill a new borehole. 3. Avoid tight hole reaming. If necessary, use part-load drilling modes or an old used bit. 4. Select a bit with hardfaced shirttail.

PL — PLUGGED BIT

BIT BLOCKED BY UNCIRCULATED CUTTINGS OR OTHER DEBRIS, ACCOMPANIED BY PRESSURE BUILDUP IN THE AIRLINE.

CAUSES	RECOMMENDATIONS
1. Low pressure air supply. 2. Attempting to drill with air valve closed. 3. Lack of back flow valve. 4. Junk/foreign objects entering a bit from airline. 5. A bit left in the hole for a long time (e.g. during shift change or repair operations).	1. Adjust required air supply to bit. 2. Follow correct drilling procedure. Ensure compressor is fully operational and air valve open prior to commencing drilling operations. 3. Always use a back flow valve where there is surface water or water injection is being used. 4. Avoid junk/foreign objects in the airline. While replacing drill string be sure that no foreign objects are inside the equipment. 5. Always raise a bit from the hole bottom (at least 3 m upward) during extended down time.

XT — CROSS THREADED



CROSS-THREADING OF A BIT ON A DRILLING STRING.

CAUSES	RECOMMENDATIONS
1. Misalignment of drill string (sub) to a new bit. 2. Bit sub thread damaged.	1. Avoid misalignment while threading. 2. Check for thread integrity before mounting bit to sub.

SF — SEAL FAILURE

SEAL OF ONE OR ALL CONES ARE WORN OR MISSING RESULTED IN BEARING FAILURE (SEALED BEARING BITS).

CAUSES	RECOMMENDATIONS
1. Operational life of such bearing type is limited if used in inappropriate strata. 2. Excessive WOB. 3. Vibration while drilling. 4. Damage is caused if bits are stored under extreme low temperatures.	1. Select a bit with another bearing type. 2. Follow drilling procedure and roller-cone bits operational manual. 3. Avoid heavy vibration while drilling. 4. Sealed bearing bits should not be stored under extreme low temperatures.

LPB — LOST BALL PLUG

THE BALL PLUG IS MISSING FROM A LUG.

CAUSES	RECOMMENDATIONS
1. Permanently caving and collapsing holes drilling. 2. Off center wear. 3. Back-reaming operations.	1. Use water supply system for 'pasting'technique. Use a bit with a extra shirt tail protection. 2. Do not drill with a bent drill rod or worn deck bushing. 3. Use a special back reamer.

Ab — ABRASION

NON-EROSIVE WEAR OF THE BIT BODY OR ITS PARTS RESULTING FROM CUTTING OR SCRAPING BY COLLAPSED DRILLING FORMATIONS.

CAUSES	RECOMMENDATIONS
1. Drilling out of collapsing holes. 2. Application of the stabilizer between a drilling rod and a bit together with low flushed air supply pressure.	1. Use 'pasting' technique / a roller stabilizer / a bit with back reamer feature. 2. Provide enough flushing air for adequate circulation / use a roller stabilizer allowing cuttings egress from the borehole.

CR	CORED

ABNORMAL WEAR OF THE CONE'S CENTRE ACCOMPANIED WITH CONE INSERTS AND NOSES LOST.

CAUSES	RECOMMENDATIONS
1. Low air supply causes cuttings concentration in the bottomhole center. 2. With excessive axial load on a bit with central jet while abrasive formation drilling due to sand blasting. 3. Prolonged cone interference (CI). 4. Drilling foreign objects in the hole. 5. Formation abrasiveness exceeds wear properties of cutting elements of the cone noses.	1. Monitor compressor operation, drill rod size and nozzle selection. 2. Replace bit with central jet with a bit with a side jet/reduce WOB. 3. Follow recommendations presented in the chapter 'Cone interference CI'. 4. Avoid debris dropping in the hole. 5. To drill hard formations, select a bit with cone axis side misalignment, as well as equipped with more teeth, hard-alloyed and hard-structured.

ER	EROSION

CONE SHELL WEAR DUE TO EFFECT OF FLUSHED AIR AND INJECTED WATER COMBINED WITH ABRASIVE CUTTINGS.
OFTEN RESULTS IN INSERT LOSS FROM THE CONE SHELL.

CAUSES	RECOMMENDATIONS
1. Abrasive formation contacts cone shell (an insert full-length penetration into the rock) due to excessive WOB, and debris damages cone shell due to insufficient air flushing (drilling cuttings). 2. Excessive air pressure caused by incorrect nozzle size selection. 3. Heavy (caused by ground water or excessive water injection), sticky, abrasive formations.	1. Reduce WOB / check air compressor output (make air leak check in the airline) and provide optimal WOB for the current drilling conditions. Select a bit with more aggressive cutting structure and additional abrasive wearprotection for the specific mining environment. 2. Select nozzles size according to the geological conditions (if dust suppression by water is used at a site, reduce water supply and inspect nozzle cleanout) / reduce air supply pressure to recommended rates. 3. Regularly inspect efficiency of cuttings lifting / select an abrasion-resistant bit / proceed with operations (without any changes) in case of high RPM.

STORAGE AND TRANSPORTATION

- Bits should be properly stored in a dry area. Direct contact with moisture should be avoided. Relative humidity and temperature should be monitored in indoor storage areas.
- Storage of sealed bearing bits at low temperatures is not recommended; sudden changes in temperature should be avoided as seal life may be affected.
- Bit storage and transportation should be made in original manufacturer boxes oriented vertically (a bit should be stored with pin face upward). Handling and stowage while transporting should ensure bit box stability.
- Bits should be stored on the drill rigs in the manufacturer's package, if without the original packaging bit should be stored with pin up to protect thread from mechanical damage, moisture and atmospheric precipitations.

APPLICATION FORM

To select an optimal Volgaburmash drill bit

DRILLING MODE:		
		air flush
		mud flush

1. GENERAL INFORMATION:

1.1	Enterprise/company	
1.2	Open-pit/section	
1.3	Field address	
1.3	Annual drilling output, m	

2. REQUIRED TOOL:

		Type 1	Type 2	Type 3
2.1	Required bit size, mm			
2.2	Required bit/shank thread			
2.3	Planned average life, m			
2.4	Planned performance per shift, m/shift			
2.5	Additional requirements / Other			

3. GEOLOGICAL ENVIRONMENT FOR DRILLING

3.1	Type of minable mineral	
3.2	Rock description	
3.3	Protodyakonov scale of hardness, f	
3.4	Drillability grade (1 to 10)	
3.5	Abrasivity (1 to 8)	
3.6	Water content (1 to 3)	
3.7	Jointing (1 to 5)	

4. DRILLING EQUIPMENT

		Model 1	Model 2	Model 3
4.1	Models of the applied drilling rigs			
4.2	Quantity, pcs			
4.3	Compressor/pump capacity, m^3/min			
4.4	Drilling rod size, mm			

5. OTHER PRODUCERS' BIT MODELS APPLIED AT THE OPEN-PIT

		Type 1	Type 2	Type 3
5.1	Bit producer			
5.2	Bit size, mm			
5.3	Model			
5.4	IADC reference code			
5.5	Average meterage, m			

Name

Position

E-mail

BIT RUN REPORT CARD

OPENPIT

BIT MODEL

SERIAL NUMBER

DRILLING RIG /NUMBER

NOZZLE SIZE

ROD SIZE

WEAR

DATE OF ISSUE AT A SITE

ISSUED BY

RECEIVED BY

DRILLED ROCKS DESCRIPTION:

Date	Change	Horizon	Unit	Drilled wells numbers	Fortress factor, f	Well water cut, %	Drilling modes: WOB	Drilling modes: RPM	Drilling modes: Air pressure	Total meterage, m	Rig floorman

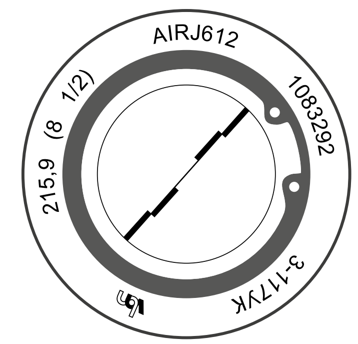
COMMENTS/NOTES

Superintendant ____________________ Shift foreman ____________________

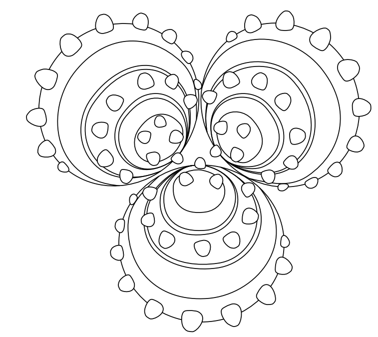
FEEDBACK APPLICATION FORM

FEEDBACK				
Description				
BIT DATA				
Bit model				
Serial number				
Installation date				
Removal date				
Meterage, m				
Wear description				
GENERAL INFORMATION				
Company				
Open pit				
DRILLING MINING CONDITIONS				
Rock description				
Protodyakonov scale of hardness, f				
Drillability grade (1-10)				
Water content (1-3)				
Jointing (1-5)				
Horizon number				
Block number / Excavator face				
MINING EQUIPMENT				
Drilling rig producer				
Rig model				
Rig number				
Drilling rod size, mm				
DRILLING MODES				
WOB	*Workload*		*MAX*	
RPM	*Workload*		*MAX*	
Gage pressure in the cabin	*W/O water*		*With water*	

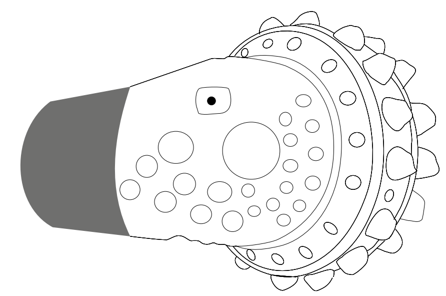
PHOTOS OF THE WORN-OUT DRILL BIT



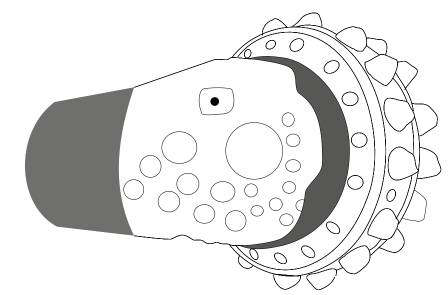
View of the pin face



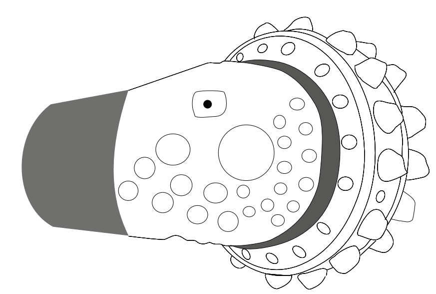
View of all three bit cutters



Lateral-side view of the bit leg (1)



Lateral-side view of the bit leg (2)



Lateral-side view of the bit leg (3)

Additional photo
of the element worth of attention

DRILLING COST

Bit design efficiency depends upon comparative test results in mining and geological conditions, and efficient bit design is considered as one that ensures the minimum value of operational expenses for 1 meter borehole drilling that is determined by the formula:

$$C = \frac{C_{bit}}{H} + \frac{C_{rig}}{ROP_{av}}$$

C — 1 meter well drilling cost, RUR;

C_{bit} — drill bit cost, RUR;

H — average meterage per bit, m;

C_{rig} — cost of 1 hour drilling performed by a drilling rig, without a bit cost, RUR;

ROP_{av} — average rate of penetration, m/h

RECOMMENDED TORQUE FOR THREAD CONNECTIONS

Recommended torque for thread connections				
Bit size		Thread	Recommended torque	
mm	inch	API	Ft-lbs	kN•m
76.0	3	-	900 – 1,800	1.2 – 2.5
93.0	3 21/32	-	1,500 – 1,800	2.1 – 2.4
96.0 – 98.0	3 25/32 - 3 55/64	-	3,000 – 3,500	4.0 – 4.8
130.2 – 136.5	5 1/8 – 5 3/8	2 7/8 Reg	4,500 – 5,500	6.0 – 7.5
142.9 – 190.5	5 5/8 – 7 1/2	3 1/2 Reg	7,000 – 9,000	9.5 – 12.0
200.0 – 233.0	7 7/8 – 9 3/16	4 1/2 Reg	12,000 – 16,000	16.0 – 22.0
244.5 – 258.0	9 5/8 - 10 5/32	4 1/2 FH	16,600 – 21,000	22.5 – 28.0
250.8 – 349.2	9 7/8 - 13 3/4	6 5/8 Reg	28,000 – 32,000	38.0 – 43.0
393.7	15 1/2	7 5/8 Reg	34,000 – 40,000	46.0 – 54.0

Volgaburmash

Trust
VBM experts!

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