URALBURMASH

ROLLER CONE BIT OPERATION GUIDE

For Mining, Water Well & Construction Applications

1. GENERAL INFORMATION

1.1. This guide provides information on:
- operation;
- storage;
- transportation;
- monitoring of bit parameters during operation and drilling performance.

And it is mandatory for use by all consumers.

1.2. It's based on the requirements of GOST 20692-2003 and TU 3664-082-00217550-2009.

1.3. These guidelines were developed with the aim of improving the technology of rotary drilling with roller cone bits and increasing efficiency, and also contains recommendations for identifying correct bit size, design and applicable drilling mode.

2. ROLLER CONE BIT DESIGNS INFORMATION

2.1. Roller cone bits produced by Uralburmash for drilling in the mining, construction and water well industries comply with the requirements of GOST 20692-2003 "Roller cone bits. Technical conditions" and TU 3664-082-00217550-2009 "Roller cone bits. Technical conditions".

3. RECOMMENDATIONS FOR BIT SELECTION

3.1. A rational size of a bit for a certain category of rocks is considered a size that provides a minimum operating cost for drilling 1 meter of wells, determined by the formula:

$$C = \frac{C_д}{H}$$

- **Сд** is a cost (or wholesale price) of the bit, RUR
- **Н** is average meterage (life of the bit), m

3.2. To select rational bit sizes and appropriate drilling modes drilling shops\crews should:
- carry out a systematic accounting and analysis of the performance of bits;
- regularly assess, record and analyse the results of trials and implementation of bit prototypes of new designs;
- ensure the study, analysis and accounting of failure and the nature of wear of bits elements;
- systematically study and analyse the mechanical properties and drillability of rocks in order to select optimum design of bits;
- develop technical standards for bit performance to control them;
- promote the optimum application of roller cone bits by drilling crews.

3.3. Optimum drilling mode is ensured by the use of additional devices and correct values of the following parameters of drilling modes:
- weight on bit (WOB);
- rotation (RPM);
- flow of compressed air.

3.4. Additional devices are designed to increase the service life of the bit and include:
- back flow valves;
- bushings for oil slingers;
- additional washers;
- diffusive screws.

At present, all bits are equipped with back flow valves, which are designed to protect the roller cone bearings from slugging during stops in drilling, at the same time create a pressure drop across the central nozzle and act as an oil deflector sleeve, separating the oil from the blowing agent and directing it to the bearings.

Additional washers are designed to increase the pressure drop across the bit and are used in conjunction with check valves.

Diffusive screws are designed to swirl the air flow in order to increase the cross-sectional area of the jet leaving the central nozzle of the bit.

Washers and screws are manufactured by other companies.

4. BIT COMMISSIONING

4.1. Before attaching the bit to the bit sub, the drilling rig operator must check:
- marking of the serial number and standard size of the bit;
- smooth rotation of all cones and cleanliness of air blowing channels;
- axial and radial clearances of bearing assemblies;
- the condition of the carbide inserts (TCI) and the protective coating of the drilling bit legs;

4.2. If large defects (cracks, pits in welds, undercuts and large nicks in the thread, not drilled blow-out channels in the feet, etc.) are found, the bit should be returned to the drilling area to eliminate/repair them or, if necessary, return to the manufacturer.

4.3. Each bit must be equipped with a back flow valve.

4.4. Before bit attachment, the drill rod should be blown out.

4.5. The bit should be attached using a special tool or bit basket. In this case, do not use a sledgehammer and hold bit with your hands.

4.6. All threaded connections of the drill rod and the connecting thread of the bit should be coated with a sealing grease compound. Avoid the ingress of grease into the drill pipes.

4.7. To maintain the cleanliness of the bearing assembly, it is necessary to ensure that a sufficient amount of compressed air passes through them, this is achieved by selecting the correct bore diameter of the air nozzle for each bit. For normal bit operation, the pressure drop across the bit should be a minimum of 0.15 MPa (22 psi). The required pressure differential is achieved by selecting an additional washer installed in the central nozzle under the back flow valve. To determine the value of pressure drop across the bit according to the readings of the manometer, the pressure in the air line is recorded without the bit (Put the compressor into operation and note the readings of the manometer on the drilling string airline, the minimum compressed air pressure on the open rod should be at least 3.0-3.2 atm. If this value is less than the specified value, the compressor is not suitable and must be replaced or repaired) and with the bit attached. The difference between these readings is the desired value.

4.8. When attaching the bit and running the bit into the borehole, avoid impacts that can damage the bit.

4.9. Also avoid excessive impact of the drill string onto the bottom of the hole.

5. RULES OF BITS OPERATION

5.1. All tripping operations should be carried out with minimum rotation of the drill string and with the compressor running.

5.2. The new bit should be run in at the bottomhole for 10-15 min at a rotational speed of 30-40 rpm and a load of 10-15% of the average value adopted for a given bit size. Running-in is performed with the compressor turned on at the maximum possible air flow rate. Do not put a load on the bit and then turn on the rotator, avoiding damage to the bit or tool joints.

5.3. It is not recommended to use a new bit when drilling a hole in the first row.

5.4. After running-in the bit, WOB should gradually increase to the optimal value recommended at which the maximum mechanical rotation and feed can be used without causing excessive vibration.
5.5. The volume of water injected into the air flow should be minimal and sufficient only to suppress dust. The main reason for bit balling of bearing assemblies is the ingress of wet sludge.
5.6. In the process of drilling, it is necessary to prevent balling of the cone bearings, the main features of which are as follows:

- increasing air pressure;
- increasing rotation pressure;
- tight rotation during drilling start up;

When signs of balling of the cone bearings appear, it is required to:

- stop drilling immediately;
- thoroughly blow through the bit by lifting it above the bottomhole;
- apply a small amount of liquid lubricant to the bearing units, apply rotation and, at low load and speed, re-start the drilling process.

If it is not possible to eliminate the balling of the cones, the bit should be raised to the surface and the cones and bearings should be washed with diesel fuel or machine oil, freeing the rotation of the cones by hand.

5.7. Drilling modes should be selected on the basis of obtaining optimal performance of the bit, within the range of values recommended in Appendix № 2 and should not exceed those indicated in the bit passport. It is not recommended to rotate the bit faster than 115 rpm.
5.8. A drilling mode is considered to be rational, in which the highest indicator of bit resistance and productivity of drilling rigs is achieved for given specific mining and geological conditions.
5.9. It is not recommended to drill at modes exceeding the manufacturers recommendation. At the maximum rated WOB drilling is carried out at the minimum permissible speed of the drill string, and at maximum speed the pressure on the bottom hole is minimal. Manufacturers recommended WOB and rotation speed are guidelines only. It is not recommended to drill at maximum feed and rotation parameters for extended periods and especially in extra-hard formations (16 and higher drillability grade).
5.10. The bit should be carefully inspected after each hole drilled. The ease of cones rotation and backlash is checked. The degree of heating of each cutter is checked by hand. The high temperature of one of them indicates a possible blockage of the cone bearing. It is necessary to turn on the compressor and make sure that the blowing on to each cone is uniform.
5.11. In case of vibrations, it is necessary to reduce the rotational speed of the bit or WOB to a level at which the vibration stops.
5.12. While drilling in fractured rocks, the borehole should be reamed repeatedly by raising and lowering the drill string with rotation and continuous air flushing. Drilling in such formations should be done at reduced loads and lower rotation speeds.
5.13. Avoid drilling with bits with non-rotating cutters or channels clogged with cuttings in the legs.
5.14. After the end of drilling and before removal of the drill string, the borehole must be cleared of cuttings. To do this, the compressor of the drilling rig must continue to operate with a simultaneous slow rotation as the bit is raised from the bottom of the hole until the hole is completely clear of cuttings. It is recommended to raise the pressure in the line to 0.6-0.7 MP (6-7 kgf/sq.cm) and with quickly opening the valve, direct compressed air to the well bottom. By repeating this operation, it is possible to achieve effective cleaning of the well and bit bearings from cuttings.
5.15. When building up, the previous rod must be tong-installed. It is forbidden to leave the rod at the bottom.
5.16. It is not recommended to continue the drilling of a part completed borehole with a new bit, in order to avoid jamming of the drilling rod and damage to the gauge of the bit.
5.17. It is not recommended to drill if there is any metal junk in the hole

5.18. In case of a long break in drilling (change of shifts, power outages, repair work, etc.), the drill string must be lifted at least the length of one drill rod from the hole bottom.

5.19. In winter, after a long break in work, start drilling only after the discharge air has heated up to operating temperature.

5.20. It is not recommended to alter the mast position during drilling, because this may cause hole deviation or stuck drill string.

5.21. The use of a new bit is not recommended for cleaning and re-drilling blocked holes.

5.22. The bit may be considered used/failed as soon as one cone shows obvious evidence of failure. The suitability of the bit for its further work is determined by the drilling rig operator during the control inspection of the bit after hole drilling.

5.23. The bit can be considered used and removed from the drill string for the following reasons:

- jamming of the bearing of at least one roller cutter, which, as a rule, is accompanied by strong vibration, uneven rotation of the tool, with jerks, as well as a sharp decrease in the ROP;
- essential wear of the bearing elements of at least one cone, which creates a threat of catastrophic failure (e.g. loss of cones in the hole);
- exposure of more than half the diameter of the rollers due to wear of the bit leg shirttail;
- the rollers fall out of the support;
- interference of cones with each other;
- strong wear of the cone cutting structure accompanied by a sharp decrease in drilling speed, increased vibration;
- bit failure (bit leg journal failure, welding seams cracking, cones cracking etc.);
- a sharp increase in torque.

5.24. After removal of the bit from the drill string, the waste bits should be thoroughly washed and cleaned of cuttings, stored on site for dull grading by shift foremen, as well as complete technical appraisal in the case of a new bit model trial.

6. INSPECTION, WEAR MEASUREMENTS AND ACCOUNTING OF INDICATORS OF BITS PERFORMANCE

6.1. Monitoring the development and recording the performance of roller cone bits is the responsibility of all customers.

6.2. Each used bit must be carefully inspected by a foreman, shift foreman or the person responsible for their operation. Inspection data and bit wear measurement, encoded by a code (see Appendix № 1), together with the bit performance results are entered into the drill log and into the roller cone bit passport. The drill log data is recorded by the shift foreman or operational manager on a cumulative sheet located at the drill site.

6.3. The drill log and cumulative statement are the original source. The results of drill bit runs should be provided to the manufacturer's representatives upon their request.

6.4. Based on the accounting and analysis of the results of drill bit runs, usage is planned depending on the mining and geological conditions and scope of drilling to avoid issues with supply.

7. USE OF BIT INSPECTION AND WEAR MEASUREMENTS

7.1. Systematically updated information on the composition and properties of the strata and bit wear are necessary for the prompt correction of the type of bits used and the parameters of the drilling mode.

7.2. At the end of each year the technical services department of the mine operator, on request of the manufacturer, should send information about the bit performance for further analysis and recommendations.

7.3. If milled teeth bits fail due to wear of the roller cone bearings (levels П3 or П4 according to the code), and the wear of the milled teeth (including peripheral rims) is relatively low (В1 or В2) and the bit is not worn out in diameter, then in these conditions, it is impractical to use roller cone bits with carbide teeth or combined cutting.

7.4. If in bits with milled cuttings with relatively small values of wear of the teeth on the main rims of the cones (В1 or В2) and bearings (П1 or П2), the tops of the teeth of the peripheral rims calibrating the borehole have significant wear in height (up to the level of В4) and rounding from the outside, the back surfaces of the cutters, peaks and backs of the legs are worn out before the bearing is opened and the bit is worn out in diameter of more than 3-5 mm (depending on the bit size), it is recommended to use bits for harder rocks, for example , replace a C-type bit with a T-type bit, a T-bit – with a bit with carbide cutting structure (Т3 or ТК3).

7.5. The fatigue fracture of milled teeth indicates the advisability of using bits designed for drilling in harder formations in these conditions, and drilling should be carried out at lower rotational speeds.

7.6. If the wear of the milled teeth on the main rims of the cones is abrasive and its value reaches the levels В3 or В4, and on the peripheral rims there is a significant rounding of the tops of the teeth from the outside, and the wear of the supports does not exceed the level П2, then it is recommended to use roller cone bits hardfaced with tungsten carbide.

Significant shirttail and back wear also indicate an unsatisfactory cleaning of the bottomhole zone from cuttings. In this case, it is advisable to increase the air flow rate by using an additional compressor.

7.7. If the surface of the milled teeth is riveted, then it means that the bit has worked in harder formations than the formations for which it was intended.

7.8. The wear of the tops of the milled cutters with the formation of a "sugar loaf" at the bottom of the hole (it’s a cone-shaped elevation in the center of the bottomhole surface) indicates the need to replace this bit type with a bit with a carbide cutter. Such an is elevation should be drilled out with a light load and a reduced speed.

7.9. If a bit with carbide cutting structure breaks down due to a significant number of breaks (chips) of the teeth, then the rotational speed or weight on bit (WOB)should be reduced. Chipping of the teeth along the generatrix of the cutter indicates an excessive rotational speed, and across - an overestimated WOB.

7.10. If a TCI bit breaks down due to wear of the roller cutter bearing elements, check whether the air channels in the legs are not blocked and the serviceability of the back flow valve. If the valve is in good working order, it is advisable to use a bit designed for drilling in less hard formations than previously used, i.e. replace ОК type bit with К type, etc.

7.11. If a TCI bit is replaced due to wear of the tops of the legs, which led to the loss of the rolling elements, it is necessary to improve the hole cleaning or use a bit design with reinforced leg cutting edges.

7.12. Elimination of the loss of bit size with a carbide cutter due to abrasive wear of the roller cutter body and falling out of the cutters can be achieved by improving the bottom hole cleaning or by using a bit design with reinforced peripheral rims.

7.13. If an erosive wear of the tops of the cones with their subsequent breakage occurred at a bit with hard-alloy teeth and a central flush, then in this application it is necessary to use a diffusive screw or a bit with a side flush.

8. BIT STORAGE AND TRANSPORTATION

8.1. In a warehouse roller cone bits should be stored on special racks or wooden pallets under a canopy or in a closed room, and on drilling rigs in metal closed boxes with the shank up. Bit storage in open areas or on the ground is forbidden.

8.2. Bits should be stored and transported in their original packaging. With bulk delivery of bits, the connecting thread and the inner cavity of the shank should be closed with a protective cap.

8.3. Each bit stored in a warehouse or on a drilling rig must have a passport enclosed in the original packaging or in the inner cavity of the bit shank.

8.4. Storage and transportation of bits in a metal case without wooden pallets is forbidden.

8.5. Do not strike the bit with a hammer.

8.6. It is recommended the bits are stored in the engine room on the drill rig. This will help prevent cuttings from drilling and foreign objects entering the inner cavity of the bit, as well as possible impacts during handling operations on the side platform. Do not store bits on the drill floor.

9. PRECAUTIONS FOR HANDLING BITS

9.1. The roller cone bits handling operations should be carried out wearing protective gloves, and for over 215.9 mm bits - with the appropriate mechanical tools and equipment.

9.2. Inspection and measurements of used roller cone bits should be carried out on a level surface.

Appendix № 1

CODE FOR SHORT RECORDING OF ROLLER CONE BIT WEAR

1. Wear of cutting structure (at least one gauge):

- B1 - decrease in the height of the teeth (teeth) by 1/4
- B2 - the same for 1/2
- B3 - the same for 3/4
- B4 - the same for 4/4 (completely)

In case of chipping of milled teeth, chipping and loss of tungsten carbide inserts (TCI)s, index C is added. The total number of chipped teeth, chipped and dropped TCI (%) is written in parentheses, for example: C (20). In case of rounded gage, the index P is added. For example, C (20) P.

2. Bearing wear (at least one roller cutter cone):

- П1 - the wear is small, the cutter end "rolling" relative to the journal axis is not large (for example, for a 215.9 mm bit - up to 3 mm), the rolling elements are not exposed.
- П2 - medium wear: "rolling" of the cone end is significant (for example, for 215.9 mm bit – over 5 mm), significant wear of the rolling elements, they are exposed.
- П3 - high wear: the roller cone end “rolls” is significant (for example, for a 215.9 mm bit - over 8 mm), the rolling elements are exposed, and there is a danger of their falling out, the cones are jammed during rotation.
- П4 – bearing failure: destruction of rolling bodies, shirttails and the rear of the cones with the loss of rolling bodies, cracks and flats on the cones. In case of cones jamming, the index K is added, and the number of jammed cones is indicated in brackets, for example, K (2).

3. Bit size wear:
Reducing the bit size is indicated by the index D and is expressed in mm, for example, Д6

4. Bit failure:

- А в - loss of the tops of the cones at the bottom.
- А ш - loss of cones at the bottom.
- А с - loss of sections at the bottomhole.
- А ц - loss of a journal with a cutter at the bottom.

Examples of using the CODE for bit wear assessing:

1. Bit cutting structure is worn out by 10%, the bearings are of average wear, two cones are jammed, the bit size is preserved: В1 Р2 К (2) ДО.
2. Bit cutting structure is worn by 3/4, 50% of the teeth are chipped, the gauging edges of the peripheral rims of teeth are rounded, the bearings have a lot of wear: the cutter end “rolling” is 10 mm, the bit size has decreased by 7 mm: ВЭС (50) РП3 Д7.3. Bit cutting structure is completely worn out, the bearing is destroyed, some of the rolling bodies have fallen out, the first roller cutter is left at the bottom: В4 П4 Аш (1).
4. All cutters are left\lost in the well: Аш (3).

Examples of bit wear recording using a CODE in the drill log.

1. Ш 215,9 М3-ПГВ (215,9 AIRV522) № 1216, В2С (30) РП3Д4
2. Ш 215,9 К-ПГВ (215,9 AIRV722) № 8637, В1 П1 К (1) Ав (1) ДО
3. Ш 244,5 ОК-ПВ (244,5 AIRS832) № 9883, В1 П2 К2 Д3

Appendix № 2

Bit size, mm	Outside rod size, mm	Bit type		RPM
		М, С, СТ, Т (IADC code 11 – 34)	ТЗ, ТКЗ, К, ОК (IADC code 51 – 84)	
		Weight on bit (WOB), kN		
1	2	3	4	5
146	89-114	60 – 80	80 – 100	Up to 115
161	127	100 – 130	130 – 150	
190,5	152	130 – 150	140 – 160	
215,9	180	140 – 180	160 – 200	
244,5	203, 219	180 – 220	180 – 250	
250,8	219	180 – 220	180 – 250	
269,9	219	200 – 270	250 – 300	

*For more accurate drilling modes see the bit passport.

The Bit Operation Guide designed by UBM sales department is provided to workers engaged in drilling in the mining and construction industries.
This manual is a general guide for the operation of all sizes of roller cone bits