Galip Oilfield Drilling Series Screw Drilling Tools

HANDBOOK

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I. Preface:

This manual primarily introduces the working principles, structure, mechanical properties, and correct usage and maintenance of screw drilling tools. This is to facilitate users to better select tools according to drilling and well-repair needs, allowing the tools to exhibit their mechanical and technical performance, and enhance the efficiency of drilling and well-repair tasks.

II. Working Principle of Screw Drilling Tools:

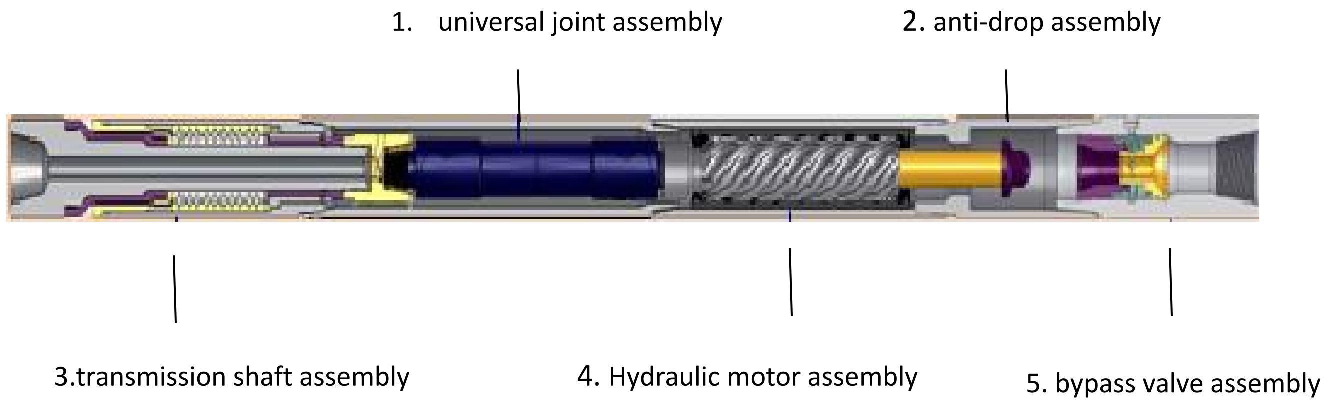
Screw drilling tools utilize hydraulic power from drilling fluids, converting hydraulic energy into mechanical energy—a kind of volumetric downhole power drilling tool. When the mud pumped out by the mud pump passes through the bypass valve, the flow pressure causes the bypass valve to close. Subsequently, the mud flows into the motor. A certain pressure difference forms at the inlet and outlet of the motor, which drives the rotor to revolve and rotate around the stator's axis. The rotational speed and torque are then transmitted to the drill bit via the universal shaft and the transmission shaft, achieving drilling and well-repair operations.

III. Composition of Screw Drilling Tools:

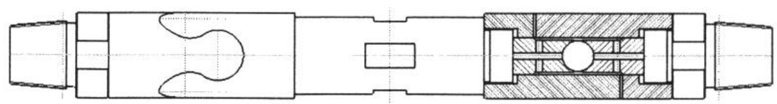
Screw drilling tools mainly consist of four major components: the bypass valve, hydraulic motor, universal shaft, and transmission shaft. There are also auxiliary facilities like anti-drop devices installed on the upper part of the motor and the lower part of the transmission shaft.

IV. Screw Drilling Tools:

Screw drilling tools are downhole tools powered by drilling mud. They consist of five major parts: the transmission shaft assembly, motor assembly, universal shaft assembly, anti-drop assembly, and bypass valve assembly. The mud output from the mud pump flows through the bypass valve into the motor. A certain pressure difference forms at the inlet and outlet of the motor, driving the motor's rotor to rotate. The torque and rotational speed are then transmitted to the drill bit via the universal shaft and transmission shaft. The performance of the screw drilling tool mainly relies on the complete motor assembly.



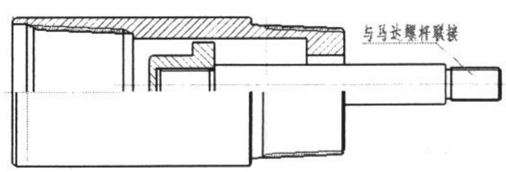
1. The universal joint (or U-joint) is a component that allows connected shafts to rotate and pivot, thereby transmitting power even when they are not in a straight line relative to each other. It's commonly used in various machinery, including vehicles, to accommodate angles between parts.



   It is composed of parts like the petal sleeve, middle connector, and steel balls. It connects to the rotor at the top and the transmission shaft at the bottom. Its role is to transfer the mechanical performance of the motor's planetary motion to the transmission shaft, serving as a specialized connector.

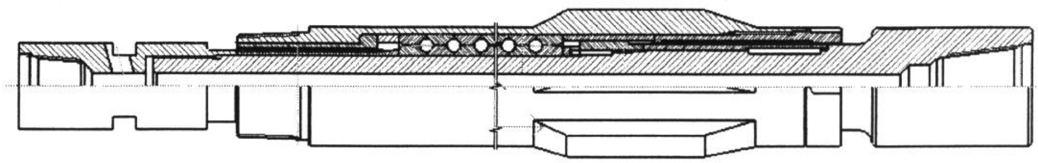
   After using the drilling tool, it should be immediately disassembled to inspect the wear condition of the universal joint. If the wear exceeds the maintenance standards, related parts should be replaced. Otherwise, excessive use of the universal joint could lead to its breakage, rendering the drilling tool non-functional.

2. This component or feature is designed to prevent the equipment or part from accidentally dropping or falling, especially in applications where dropping could lead to equipment damage or safety hazards.



   To avoid the loss of components in the well due to unexpected factors, such as the breakage or decoupling of the drilling tool casing, a short drop prevention section is added below the bypass valve at the upper end of the drilling tool screw. The short section casing is not easily damaged on the upper part of the screw motor, and in the middle of the short section, there's a large circular nut and a hanger connected to the screw. Under normal operation, the drop prevention device is inactive (with some stirring losses). However, if the casing below the short drop prevention section breaks, decouples, and the screw and hanger move downward, then the large nut in the middle of the short section falls onto the reduced diameter of the short section casing. This action effectively hangs onto components like the screw and blocks the mud channel, causing an increase in the mud pump pressure. This alerts the surface crew to the issue in a timely manner, allowing them to take measures and prevent further losses.

3. The transmission shaft is a component designed to transmit the motor's rotary motion to the drill bit. It also withstands axial and radial loads produced by the drilling pressure. There are two types of transmission shaft assemblies for drilling tools:



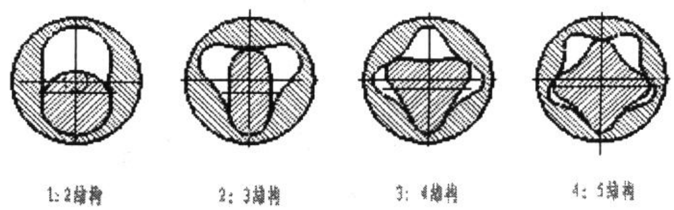
3.1 With a pressure drop of 3.5Mpa in the drill bit water hole, the transmission shaft assembly is oriented at both ends using needle roller bearings, with a thrust ball bearing in the middle to bear the pressure.

3.2 With a pressure drop of 7.0Mpa in the drill bit water hole, the transmission shaft assembly is oriented at both ends using hard alloy radial bearings. In the middle, a series of bearings are used to bear the pressure. This structure enhances the wear resistance and bearing capacity of the transmission shaft assembly, prolonging its service life.

4. Hydraulic Motor assembly refers to the complete set or group of components that make up the motor, allowing it to function as intended.

   It is composed of a single-screw rotor and a stator. The rotor is a machined screw with an X-head and has a surface coated with a corrosion-resistant and wear-resistant layer. The stator's outer shell is made of alloy steel, with an X+1 headed internal spiral rubber lining firmly cast inside. The shape and size of the rotor and stator should ensure meshing relationships. These meshing points form the motor's sealed cavity along the axial lead. As the rotor spirally rotates within the stator, when the drilling fluid with a certain energy passes through, the cavity moves downward axially. The upper inlet is continuously generated, and the lower outlet gradually disappears, completing its energy conversion. This propels the rotor to make an eccentric revolution and self-rotation along the stator's spiral inner wall, fulfilling the motor's function. This is the basic working principle of the screw motor. The spiral line of the motor rotor can be single-headed or multi-headed (the stator spiral line has one more head than the rotor).

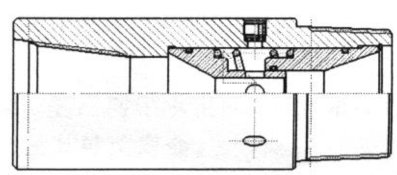
The fewer the heads of the rotor, the higher the rotation speed, and the smaller the torque. The more the heads, the lower the rotation speed, and the larger the torque.



The screw motor is an essential component of the drilling tool. Through many practical experiences and theoretical analyses, under current conditions, if you want the motor to work effectively and efficiently, the pressure drop that each motor stage can withstand should not exceed 0.8 Mpa (one lead of the motor is one stage). The maximum pressure drop is 1.3 times the rated working pressure. If the pressure drop value exceeds this value, the motor will leak, speed up, wear severely, or even overheat and seize, causing motor damage. Users should be particularly aware; the mud flow used on-site should be within the recommended range, otherwise, it will increase the wear of the stator, affecting the motor's efficiency and lifespan.

The performance parameters of the screw motor are the main performance parameters of the screw drilling tool. The theoretical output torque of the motor is directly proportional to the motor's pressure drop, and the output rotation number is directly proportional to the input mud flow rate. As the load increases, the rotation speed of the drilling tool decreases. Therefore, as long as you control the readings of the pressure gauge on the ground and the flow of the pump, you can control the torque and rotation speed of the downhole drilling tool.

5. The bypass valve is a component that allows fluid (or another medium) to flow around another section of a system, typically for the purpose of regulating pressure or diverting flow. The "assembly" indicates that it's a complete set or group of parts related to the bypass valve that work together as a unit.



It consists of parts such as the valve body, valve sleeve, valve core, spring, O-ring seal, and retaining ring. Its function during drilling is to connect the drill column with the annular space, preventing drilling mud from contaminating the well platform. When the mud flow rate and pressure reach the preset standard values, the valve core moves downward, closing the bypass valve hole. At this point, the mud flow goes through the motor, converting pressure energy into mechanical energy. When the mud flow rate and pressure are too low or the pump stops, and the liquid pressure generated is less than the spring's force, the spring pushes the valve core upwards. The bypass valve hole is then in the open position, connecting the drill column with the annular space.

Main Performance Parameters of the Screw Drilling Tool

Specification		5LZ95x7.0-4	7LZ102x7.0-5	5LZ120x7.0-4	7LZ127x7.0-5	5LZ165x7.0-5	7LZ172x7.0-5	7LZ203x7.0-5	5LZ216x7.0-5	5LZ244x7.0-5
OD		3 ¾”	4”	4 ¾”	2”	6 ½”	6 ¾”	8”	8 ½”	9 5/8”
Bit Size	mm	118 ~ 152	118 ~ 152	149 ~ 200	149 ~ 200	213 ~ 270	213 ~ 311	251 ~ 346	251 ~ 346	311 ~ 444.5
	in	$4^{5}/_{8}$ ~ 6	$4^{5}/_{8}$ ~ 6	$5^{7}/_{8}$ ~ $7^{7}/_{8}$	$5^{7}/_{8}$ ~ $7^{7}/_{8}$	$8^{3}/_{8}$ ~ $10^{5}/_{8}$	$8^{3}/_{8}$ ~ $12^{1}/_{4}$	$9^{7}/_{8}$ ~ $13^{5}/_{8}$	$9^{7}/_{8}$ ~ $13^{5}/_{8}$	$12^{1}/_{4}$ ~ $17^{1}/_{2}$
Lobe		5:6	7:8	5:6	7:8	5:6	7:8	7:8	5:6	5:6
Stages		4	5	4	5	5	5	5	5	5
Differential Pressure	Mpa	4.8	5	5.4	6.0	6.6	6.0	7.0	6.0	6.0
	Psi	696	725	783	870	957	870	1015	870	870
Connection	Front end	$3^{1}/_{2}$REG.Box	$3^{1}/_{2}$REG.Box	$3^{1}/_{2}$REG.Box	$3^{1}/_{2}$REG.Box	$4^{1}/_{2}$ ~ $6^{5}/_{8}$REG	$4^{1}/_{2}$ ~ $6^{5}/_{8}$REG	$6^{5}/_{8}$REG.Box	$6^{5}/_{8}$REG.Box	$6^{5}/_{8}$REG.Box
	rear-end	NC31.Pin	NC31.Pin	NC38.Pin	NC38.Pin	NC50.Pin	Nc50 / $5^{1}/_{2}$ FH	$6^{5}/_{8}$ FH / REG	$6^{5}/_{8}$ FH / REG	$6^{5}/_{8}$ FH / REG
Flow Rate	LPM	300 ~ 720	350 ~ 750	600 ~ 1080	600 ~ 1140	1080 ~ 1680	1200 ~ 2160	1800 ~ 3900	1920 ~ 3000	2400 ~ 3600
	GPM	80 ~ 190	93 ~ 198	159 ~ 285	159 ~ 301	285 ~ 444	320 ~ 576	480 ~ 1040	512 ~ 800	640 ~ 960
Bit Speed	r/min	110 ~ 260	92 ~ 210	126 ~ 227	100 ~ 189	106 ~ 165	85 ~ 160	85 ~ 160	105 ~ 163	95 ~ 140
Torque	N.m	1428	2620	3100	4380	9360	10400	13920	14190	19600
	Ft-lbs	1054	1934	2288	3232	6908	7675	10272	10472	14465
Max.Torque	N.m	2142	4080	4650	6445	13210	15600	20880	21260	29400
	Ft-lbs	1579	3011	3430	4756	9749	11505	15450	15690	21697
Weight on Bit	KN	25	25	40	50	100	100	170	180	180
	Lb	5500	5500	8800	11000	22000	22000	37400	39600	39600
Output power	Kw	18 ~ 64.8	28.8 ~ 67	30.2 ~ 53.8	49.2 ~ 97.2	108 ~ 168	122 ~ 182	121 ~ 212	154 ~ 240	160 ~ 240
	HP	24.1 ~ 86.8	38.6 ~ 89.7	40.4 ~ 72	65.9 ~ 130.2	145 ~ 225	164 ~ 244	162 ~ 284	206 ~ 322	214 ~ 322
Length	1.75°/mm	3700	4300	5600	6300	7800	8200	8300	8500	9188
Weight	Kg	182	216	524	615	987	1040	1565	1666	2289

6. Usage Instructions:

6.1 **Equipment Familiarity:**

Field well repair technicians, drilling technicians, and drillers must understand the structural principles and usage parameters of drilling tools. They should use the tools in accordance with the user manual.

6.2 **Drilling Fluid Requirements**:

- The motor of the screw drilling tool is volumetric. The factors determining its performance are the input flow of the motor and the pressure drop at both ends, not the type of drilling fluid.

- The physicochemical properties of the drilling fluid generally don't impact the performance of the drilling tool, with a few exceptions that can decrease the tool's lifespan.

- Hard particles in the drilling fluid must be limited, as they can accelerate the wear of bearings and stator motors, reducing the tool's service life. Thus, the sand content in the mud must be controlled to below 0.5%.

- Mud viscosity and specific gravity have a minimal impact on the drilling tool but directly affect the entire system's pressure. If the pressure at the recommended discharge is greater than the rated pump pressure, reduce the mud discharge or decrease the pressure drop through the drill and drill bit. Each type of drilling tool has its input flow range, and it operates most efficiently within this range. The optimal input flow is generally the midpoint of this range.

6.3 **Mud Pressure Requirements**:

- When the drilling tool is suspended, if the discharge remains unchanged, the mud pressure drop through the tool also remains unchanged. As the drill bit contacts the bottom, the mud circulating pressure and pump pressure increase. Drillers can control the operation using the following formula:

Drilling Pump Pressure = Circulating Pump Pressure + Drill Tool Load Pressure Drop

- The circulating pump pressure (when the drill doesn't contact the bottom) is also called off-bottom pump pressure. When the drilling tool increases torque, the pump pressure rises, and this reading is referred to as drilling pump pressure. Off-bottom pump pressure isn't constant; it varies with well depth and mud properties. However, in actual operations, there's no need to continuously measure the exact circulating pump pressure. Instead, the off-bottom pump pressure taken after each contact serves as an approximation, sufficiently meeting formula accuracy requirements.

- During operation, when drilling pump pressure reaches the maximum recommended pressure, the drilling tool produces optimal torque. If drilling pressure continues to increase and exceeds the maximum design pressure, the motor might stall. In this case, immediately reduce the drilling pressure to prevent internal damage to the tool.

6.4 **Torque**:

- The torque of the screw drilling tool is directly proportional to the pressure drop caused by the mud flowing through the motor. The rotation speed is directly proportional to the input discharge. When the discharge is fixed, the torque increases, but the speed remains roughly constant. The speed drop from no-load to full-load usually doesn't exceed about 10%.

7. Method of Use:

When selecting drilling tools and their combination schemes, a drilling operation plan should be formulated, considering the wellbore trajectory, type and specifications of drill bits, geological structure, and hydraulic calculations in detail. Screw drilling tools are coated with anaerobic adhesive on the threads between parts at the factory, and are tightened to the specified torque, so there is no need to retighten before use.

7.1 Ground inspection before the tool is sent down the well:

7.1.1 Except for the lifting short section connected to the bypass valve, all other parts of the tool casing are coated with anaerobic adhesive.

7.1.2 Use the bit installer to install the drill bit. Only the chain wrench is allowed to rotate the drive shaft of the drilling tool, and it can only be rotated counterclockwise to prevent internal threads from loosening.

7.2 Lowering the tool into the well:

7.2.1 When lowering the tool into the well, control the speed strictly to prevent the motor from reversing too quickly, disconnecting the internal thread, and to prevent the tool from being damaged when passing through sand bridges and casing shoes. During operations, remember that the rotation direction of the bit connector relative to the casing is counterclockwise. Violations, such as rotating the turntable in the opposite direction or tightening parts above the motor, may cause the internal parts to loosen or disconnect.

7.2.3 When entering deep well sections or high-temperature sections, or passing through sand layers, regularly circulate the drilling fluid to cool the drilling tool, protect the stator rubber, and prevent sand blockage.

7.2.4 When the tool approaches the bottom of the well, slow down and circulate before continuing to drill. Start with a small discharge and increase the discharge after the mud returns to the wellhead.

7.2.5 It is not allowed to stun the drill or let the drilling tool sit at the bottom of the well.

7.3 Starting the tool:

7.3.1 If at the bottom of the well, lift 0.3-0.6m and start the drilling mud pump. Note the pressure gauge reading and compare it with the calculated pressure value.

7.3.2 Clean the bottom of the well, which should be "clean" enough, as debris affects the rotation speed.

7.4 Drilling progress:

7.4.1 Before drilling, clean the bottom of the well thoroughly and measure the circulation pump pressure.

7.4.2 Begin drilling slowly, and once normal drilling is achieved, use the following formula for control: Drilling pump pressure = Circulation pump pressure + Tool load pressure drop.

7.5 Retrieving and inspecting the tool from the wellbore:

7.5.1 When pulling out, the bypass valve is open, allowing drilling fluid in the drill column to drain into the annulus.

7.5.2 Pay attention to the speed when pulling out to prevent the tool from getting stuck.

7.5.3 After the tool is lifted to the bypass valve position, disassemble all parts on top of the bypass valve and clean it.

7.5.4 Measure the bearing clearance of the drilling tool. If the bearing clearance exceeds the maximum allowable value, repair the drilling tool and replace the bearing.

7.5.5 After removing the drilling tool, clean the drill bit through the drive shaft hole. If the tool is not in use for an extended period, it is recommended to inject a small amount of mineral oil for rust prevention (do not add diesel fuel).

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8. Drill Tool Failure Analysis:

Changes in the drilling fluid circulation pressure reflected on the rod pressure gauge can help onsite personnel identify situations and problems at the bottom of the well. Experience proves that the correct judgment can save a lot of time and cost for pulling and lowering drills. Based on various factors during the use of drilling tools, the following table is summarized for user reference

Anomalies	Possible Causes	Judgment and processing methods
Pressure gauge suddenly rises	Motor stalls	Drill tool lifting 0.5m Check the circulating pressure, gradually increase the drilling pressure, and the pressure gauge gradually increases, all of which are normal, indicating that the motor has stalled.
	The motor and transmission shaft are stuck, and the water hole of the drill bit is blocked.	After the drilling tool is lifted from the bottom of the well, if the pressure gauge reading is still high, the drilling tool should be lifted out to check or the drill bit should be replaced.
Gauge pressure slowly increases (not the normal pressure drop that increases with well depth or well temperature)	The water hole of the drill bit is blocked	Lift the drilling tool from the bottom of the well and check the pressure again. If the pressure is still higher than the normal circulation pressure, you can try to change the circulation flow or move the drill pipe up and down. If it does not work, you can only lift the drilling tool for inspection and maintenance.
	Drill bit wear	You can continue drilling and observe carefully, but if there is still no progress, you can only take it out and replace it.
	stratigraphic changes	Lift the drilling tool slightly, and if the pressure is the same as the circulating pressure, you can continue working.
Pressure gauge pressure slowly decreases	Cycle pressure loss changes	Check mud (well fluid) flow rate
	Drill pipe damaged	After lifting the drilling tool slightly, the pressure gauge reading was lower than the circulating pressure. After appropriately increasing the pump pressure, it still had no effect, so the wellbore was removed for inspection.
No footage	Motor failure	The pressure gauge reading increases, the drilling tool is lifted off the bottom of the well, the circulating pressure is checked, and the drilling pressure is gradually increased from a small drilling pressure.
	Bypass valve is "open"	If the pressure gauge reading is low, if the drilling tool is slightly lifted and the mud pump is started and stopped twice but still fails, the bypass valve needs to be checked or replaced.
	Universal joint damaged	It is often accompanied by pressure fluctuations. If you lift the drilling tool slightly, the pressure fluctuation range will be smaller. Pull out the drilling tool and check and replace it.
	Drill bit wear	Replace with new drill bit.

9. Drill Tool Maintenance:

The service life of drilling tools is determined not only by careful design and precision manufacturing but also by proper use and strengthened maintenance. After each well is used, serious maintenance should be performed. If the bearing clearance exceeds the maximum tolerance, it should be returned to the repair station for disassembly and inspection.

9.1 Disassembly:

- After use, if technicians determine the drill tool is faulty and unfit for use, it should be immediately disassembled and inspected at the repair station.

- Familiarize with the drill structure and disassemble in order.

- Disassembly involves the shell and the internal transmission connection. Because of the anaerobic adhesive applied, avoid excessive torque during disassembly. Heat to 250-300°C before rapidly disassembling.

- Prepare the necessary tools and record details: drill number, user, progress, running time, well depth, well temperature, axial clearance, reason for repair, etc.

9.2 Bypass Valve Maintenance:

- Clean and inspect each part. Replace parts showing grooves, nicks, plating peeling, etc. Replace all "O" rings.

- If the mesh holes show erosion, replace the bypass valve.

- Springs should be replaced every 100 hours of use.

- Apply grease to the component surfaces during assembly. Move the valve core several times to ensure no jamming.

9.3 Motor Component Maintenance:

- Remove the rotor, clean the stator cavity, and thread surface.

- Check the stator rubber for debonding or peeling. If found, replace the stator.

- Inspect the rotor surface for issues and replace if necessary.

- After cleaning and checking, apply grease to the rotor and conduct a leak test and torque test.

9.4 Transmission Shaft Maintenance:

- If the bearing clearance exceeds the specified value, replace the complete multi-row thrust centripetal ball bearing set.

- Do not mix old and new steel balls.

- Check radial bearings. If issues are found, replace the radial bearing.

- Inspect the transmission shaft and replace if necessary.

9.5 Tool Assembly:

After inspecting the bypass valve, motor, universal joint, and transmission shaft, assemble them. Clean the threads, apply anaerobic adhesive, ensure the transmission shaft gap is maintained, and then tighten to the specified torque.

10. Ordering Information:

To achieve satisfactory results with the drilling tools, you must consider not only the quality but also the intended use, environment, medium conditions, and tool combination. If you are unsure about the drill model, please contact our company.

For accurate and timely product provision, confirm the following when ordering:

10.1 Need for accessories (like lifting short sections, etc.).

10.2 Provide as much information as possible for tracking: drill user, well location, purpose, expected usage time, well structure, mud conditions, etc.