ALLIANCE DRILLING TOOLS

Motor Handbook

Motor Operations Manual
First Edition

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ADT RMK MOTORS

About Us
Alliance Drilling Tools was incorporated in 2009 in response to a perceived need for a full service down-hole tool company with a comprehensive inventory of tools and a conscientious and knowledgeable support staff.

Product Offering
Alliance Drilling Tools offers complete downhole tool services including the assembly / disassembly, cleaning, inspection, repair, and maintenance of downhole motors, drilling jars, shock subs, and related equipment such as subs, stabilizers, reamers, and non- magnetic equipment. Our staff of highly experienced personnel is ready to provide technical assistance with issues concerning all aspects of downhole tool performance.

Motor Highlights

- **Rotors:** Solid and bored rotors are precision machined, chrome plated, and polished to achieve a smooth and accurate finish. Carbide rotors are available for brine or high chloride applications.

- **Stators:** Stators are manufactured with a high durometer Nitrile Butadiene Hard Rubber (NBHR). The power section designs provide the optimal combination of Speed and Torque to be used for the majority of drilling applications. Nitrile Butadiene Rubber (NBHR) is also used because it has good oil resistance and can therefore be used for a majority of drilling applications. ADT RMK motors standard elastomer has an operating temperature range up to 250°F (120°C) and a maximum temperature range to 300°F (150°C).

- **Top / Safety Catch Systems:** Our safety catch systems in each motor will provide security against leaving motor components in the hole in the event of a connection failure or back-off. In addition to the catch rod, our top subs are also bored for float valves which are installed in each motor.

•**Coupling:** The ADT RMK motor includes a high strength torsion roller drive coupling for maximum performance. The coupling is precision machined for smooth articulation and minimal wear while providing optimum torque to the bit.

•**Adjustable Bend Housing (ABH):** The ADT RMK Motor offers an adjustable bend housing with a 0° to 3° degree bend angle adjustment. The ADT RMK ABH is engineered for simple adjustment and ease of use at the rig site.

•**Adjustable Bend Housing (ABH):** 0° - 3.00°

- 0.00° 2.23°
- 0.31° 2.42°
- 0.62° 2.60°
- 0.93° 2.74°
- 1.22° 2.85°
- 1.50° 2.93°
- 1.76° 2.98°
- 2.00° 3.00°

Fixed Bend Housing (FBH): 1.50° - 2.38°
- 1.50°
- 1.75°
- 1.83°
- 2.00°
- 2.12°
- 2.25°
- 2.38°

•**Bearing Assembly:** The ADT RMK bearing section is a mud lubricated bearing assembly. It is a robust and field proven design. ADT uses a special tungsten carbide tile matrix for the radial bearings for maximum protection against radial wear. Axial thrust is managed by a series of full contact mud lubricated hardended steel thrust bearings. Mud lubricated bearings offer the advantage of providing higher differential pressures across the drill bit without the concern of losing seal integrity that is possible with sealed bearing motors. The ADT RMK bearing assembly has a proven history of excellence in both performance and reliability.

DRILLING MOTOR APPLICATIONS

Conventional Applications:
Typically, a low-speed, high-torque motor is used in conjunction with single-shot-survey orientation instrumentation and an ABH or FBH. This type of motor is effective for kickoffs, course corrections, angle control, and sidetracking. It provides low operating costs and easy maintenance.

Vertical Drilling Applications:
ADT RMK motors can be used over extended vertical drilling intervals. By turning the bit faster than the drillstring, these motors effectively provide increased rate of penetration (ROP) and they provide angle control under the adverse conditions found in many vertical applications. Compared to rotary drilling technology, downhole motors offer intangible benefits that must be taken into consideration in the final cost / benefits analysis. These benefits include:

- Fewer round trips for BHA changes.
- Fewer hole problems, such as formation swelling, formation caving, doglegs, keyseats, and hole sloughing enabled by faster ROP and less open hole time.
- Minimized wear, tear, and fatigue of drillstring components, surface pipe, and casing enabled by reduced drillstring RPM.
- Reduction of drillstring torque.
- Faster and smoother casing setting.

Directional Applications:
ADT offers steerable systems in which stabilized, adjustable bend housing motors are used. The motor provides continuous bit rotation, while selective rotation of the drillstring controls well bore trajectory. Applications that are technically and economically feasible with these systems include:

- Wells that penetrate complex multiple targets.
- Horizontal wells that stay in narrow, dipping production zones.
- Vertical wells in formations with severe crooked hole tendency.

An ADT motor is an ideal choice for the demands imposed by directional drilling. Our steerable motor can be matched with various types of bits, such as PDC, roller cone, or natural diamond.

Special Applications:
A variety of motors are available for mining, geothermal drilling, coring, workover, milling, hole opening, and under-reaming, as well as for piling, casing, and template-drilling applications. Applications for ADT small motors (3-3/4” OD) include the following:

•Drilling through sand bridges and cement plugs.
•Cleaning out paraffin build-up.

DRILLING MOTOR OPERATION

Motor Selection

While the proposed drilling operation may be very complex and require detailed planning, a number of factors must also be considered when selecting the motor. The particular application for which the motor will be used is the first consideration.

Applications

•Vertical drilling
•Directional drilling
•Steerable-system drilling
•Horizontal directional drilling (HDD)
•Directional crossing
•Performance drilling
•Casing drilling
•Air drilling
•Coring
•Reaming / hole opening / under-reaming
•Prevention of casing wear

Other Factors for Motor Selection

•Bit type and size
•Speed
•Torque
•Weight-on-bit (WOB)
•Bit pressure drop
•Flow rate / annular velocity required to clean the hole
•Mud type (composition)
•Bottom hole circulating temperature
•Hole size
•Tubular specifications
•Stabilizer placement
•Well profile
•Site logistics

Making up the Motor
1.Using a bit breaker, make up the drill bit by placing tongs on the motor bit box.
Caution: If a bit crossover sub or thread adapter is used, the overall length of the sub should be only long enough to accept make-up tongs: (recommended maximum is 10 inches). Lengths greater than those recommended may reduce bearing life, affect directional characteristics of the motor, or result in drive shaft breakage and loss of the bit and sub in the hole.

2.After the bit is made up, one of the following steps may be taken to break initial static friction between the rotor and stator which helps increase stator life.
•Place make-up tongs on the lower end of the bent housing or lower adjustable housing. With the bit in the bit breaker, slowly rotate the rotary table one to two revolutions in the counter-clockwise direction, or
•Place make-up tongs on the lower end of the bent housing or lower adjustable housing. Lock the table and pull on the tongs to rotate the motor one to two revolutions in the clockwise direction.

Note: Do not place tongs on the bearing assembly. This may pinch the inner bearings and could prevent the motor from turning.

3. Lower the motor into the slips and secure with a drill collar clamp before removing or making up additional equipment.

Setting the ABH (if equipped)

The procedure for setting the 0° - 3° degree adjustable bend housing is presented in a separate section of the Manual. The procedure is simple; however, the following guidelines should be followed when setting the ABH:

- Tong on the upper and lower ABH housing only. Do not tong on the adjusting ring.

- Rotate the adjusting ring no more than ½ turn when setting the angle.

- Align the desired angle mark of the adjusting ring to the angle mark on the housing.

- Be sure that the adjusting ring alignment slots are fully engaged prior to applying torque to the connection.

- Do not use thread-locking compound on the threads of the ABH.

Surface Flow Test

Caution: A surface flow test is not recommended when using PDC/diamond bits in the casing.

1. Make up the kelly to the RMK motor and lower the motor below the rotary table.

2. Start the rig pumps, using only enough pump strokes to operate the motor. Use minimum flow rate for the first few revolutions, then increase slowly as needed.

3. Raise the tool far enough to visually check that the bit sub is rotating and the tool is operational.

4. Keep the test short to avoid damage to the bit, surface pipe, or blowout preventer (BOP) stack.

Tripping Recommendations

Tripping in the Hole

While the ADT drilling motor is a reliable tool, it is susceptible to damage if care is not taken when tripping the drillpipe. The following are recommendations for tripping in the hole:

- Trip in at a controlled rate to avoid damage from striking bridges, shelves, or casing shoes.

Ream:
Through any tight spots by starting the pumps and reaming slowly. Note that reaming operations use up motor life at a greater rate than drilling operations and increase connection fatique more than drilling operations.

- If tripping to extreme depths and / or temperatures, periodic stops for circulation (staging in the hole) are required. Every 20 to 40 minutes, it is recommended that the drillstring be circulated for 30 to 60 seconds with the lowest volume and pressure necessary to start the motor.
- If extended circulation is required while in the casing, reciprocate the drillstring to avoid localized casing wear.
- If there is a float valve in the string or if fluid characteristics prevent easy flow, periodic stops are recommended to fill the drillpipe.

Caution:
Reduce tripping speed when approaching the last 60 to 90 feet of hole to avoid hard contact with the bottom of the hole as there may be fill in the bottom of the hole or the pipe tally may be incorrect

Tripping Out of the Hole

The following are recommendations for tripping out of the hole.

- When tripping out, the rotary table should not be used to break out connections.
- Slow down when nearing casing shoe points.
- Control tripping speed to avoid swabbing the hole.
- Avoid excessive back-reaming.

Maintenance Procedures After Tripping:

The following post-run maintenance steps are required after tripping out of the hole:

1.Remove remaining fluid from the motor by placing the bit in a bit breaker.

2.Secure the motor body above the rotating bit sub with rig tongs.

3.Rotate the rotary table and bit counter-clockwise, forcing or "pumping" the fluid out the top of the motor.

4.After the bit has been removed, spray water directly through the bit box. This will wash out the ports above the drive shaft and help clean the bearing section.

5.If the tool is to be stored for an extended time before re-use, pour a small amount of mineral oil or equivalent into the motor. Do not use diesel fuel or synthetic oils.

6.Re-dope the bit box and top sub box. Install thread protectors.

Drilling Considerations:

The performance life of the motor is determined by the environment in which it operates. To ensure optimum performance, avoid:

•Abrasive solids in the circulating system.

•High temperatures.

•Exceeding the recommended pressure drop across the bit and motor.

•Pumping higher than recommended fluid volume.

Note: Exceeding recommended bit weight results in excessive pressure drop across the tool and increases bearing fatigue.

Starting the Motor

Before tagging the bottom of the hole, start the pumps and increase the flow rate slowly to the recommended operating range. A short period of circulation is recommended.

Drilling

The ADT motor is a hydraulically operated tool. Therefore, the primary rig-floor reference is the standpipe pressure gauge. The weight indicator may, for example, give inaccurate information about actual WOB because of "wall hanging" while sliding. In this case, the only true indication of whether the bit is on bottom drilling, is the pressure gauge. Refer to Figure 9 for examples of off-bottom, drill-off, and stall-out conditions discussed in the following subsections.

Pressure While Drilling

More WOB means a higher total system pressure at the surface. As the bit drills off, the total system pressure decreases. The standpipe pressure gauge, therefore, can be used as an indicator of bit weight and torque. Drill pipe friction will not distort the readings. When the pressure gauge reads the optimum on-bottom pressure and the driller subsequently stops adding weight to the bit, a drill-off occurs. The pressure will steadily fall until the driller puts more weight on the bit. Recommended motor differential pressures are included in this manual.

Stall Pressure:

If the driller overloads the bit, a stall will occur. The backpressure in the drilling fluid will deform the rubber in the stator and flow straight through without turning the rotor. The pressure gauge will rise abruptly, and then remain stationary, even if more weight is added to the bit. When a stall occurs, reactionary torque is trapped in the drilling motor. To insure that a motor connection does not back off, the following procedure should be performed:

1.Do not pull off bottom! Immediately shut down rotary table/top drive.

2.Shut the pumps off.

3.Allow the drill-string to bleed off pressure by slowly opening the fill-up line and release torque by allowing the rotary table to turn backwards or by slowly turning the top drive to the left.

4.Slowly lift the bit off bottom.

Following the above procedure soon after the motor stalls will significantly reduce the possibility of connection back-offs and additional motor damage.

Caution:
Operating for an extended period of time in a stalled condition will cause damage to the stator and weaken additional connections raising the risk of connection back-offs.

Reaming:

Reaming is not recommended for more than 20 – 25 hours with a motor. Extended reaming can result in bearing or transmission failure due to extreme "Stick Slip".

Rotating the Motor:

Steerable applications and many vertical (straight-hole) applications require rotation of the drillstring and motor for directional control, reduced drillstring torque / drag, cuttings transport, and differential sticking. It is recommended that drillstring rpm be minimized to prolong motor life. A maximum drillstring speed of 60 RPM is recommended, for straight motors, although speeds up to 120 RPM may be permissible in some areas. The allowable rotary table speed is reduced according to the degree to which a motor is bent. A maximum rotary table speed of 50 RPM is recommended for bends of less than 1.80 degrees. It is not recommended to rotate above 2.0 degrees. The two most common problems associated with drillstring rotation with high bends are component fatigue and connection backoff. Fatigue is a function of stress level and the number of cycles at that level. * If possible, do not rotate the drillstring at a higher rpm than is produced by the motor as stator damage can occur.

Factors That Affect Build Rate

Many factors affect build rate such as tool-size to hole-size ratio, drilling fluid type, flow rate, hole erosion, formation inconsistencies, placement of stabilizers or pads, bottom hole assembly (BHA), motor bend angle, distance from bit to bend, and the type of bit used. Following these recommendations can minimize these factors affecting build rate:

- The lower the tool-size to hole-size ratio, the better the building capabilities.

- Changing the WOB can cause the build rate to change. Generally, an increase to the WOB can cause the build rate to increase.

- The placement of pads and use of stabilizers on the OD of the bottom hole assembly can play a critical role in achieving good build rates.

- Build rate can be better predicted if formation-class empirical data are available. Some formations prohibit good build rate, and these types of formations should be identified while planning the drilling program.

- Build rate is related to motor bend angle and distance from the bend to the bit.

Increasing RPM increases the number of stress cycles within a given period of time, thereby potentially reducing component life. In steerable applications, the angle of the bend housing can have a large impact on the stress level of a motor component. To prolong motor life, drillstring rotation should be kept to a minimum when the motor is set in a bent position. **Connection backoff may occur when the drillstring momentarily stalls, then breaks free and momentarily accelerates. Backoff normally occurs when drilling through ledges, tight spots, or formation stringers.** The condition, also known as "stick-slip" causes severe lateral vibration, which may result in connection backoff.

Note:

When drilling through stringers or other formation conditions known to cause drillstring stalling or stick-slip, reduce rotary speed as much as possible. Reducing rotary speed reduces the energy available to cause problems.

POWER SECTION PERFORMANCE FACTORS

Although ADT RMK positive-displacement motors are designed to operate in a wide variety of downhole drilling environments, several factors that affect power section performance and operating life must be considered. These factors include:

- Drilling Muds
- Air, foam, or mist
- Fluid pressure limitations (stalled motor)
- Excessive flow rates
- Temperature

Drilling Muds: While RMK motors are suitable for a wide range of drilling muds, the following factors should be considered:

Mud Solids: Drilling-fluid properties should be maintained within the same constraints as when rotary drilling. However, the following special precautions should also be observed.

•The mud should be free of plugging agents, as well as foreign bodies.

•The use of a drillpipe screen is recommended.

•The fluid should have the least possible sand content (1% or is less is recommended).

•Drilling fluid additives should be used only in limited amounts. Excessive amounts of drilling fluid additives, such as lost circulation material (LCM), can affect tool performance. Drilled solids and / or abrasive additives should be kept to a minimum. A rule of thumb for acceptable LCM concentration is 12% - 15% of fluid volume or 50lbs LCM per bbl of drilling fluid. Never use abrasive LCM such as walnut shells. Low gravity solids (or cuttings) should be kept below 7% by volume. Other mud properties which will decrease stator life are high mud weight; 12 ppg or greater, and a PH lower than 4 or higher than 10. **A poorly mixed slug of weighted material or LCM can cause nearly instantaneous termination of an otherwise good motor run by plugging up the motor.** Where possible, hematite-weighting materials should not be used. These materials have been shown to greatly reduce motor life.

Oil-Based Muds

Oil-based muds and muds that contain oil can reduce stator life. The degree of stator damage depends on the specific chemistry of the oils used. One measure of an oil's aggressiveness in damaging elastomers in the oil's aniline point. The aniline point of a material may be defined as the lowest temperature at which equal volumes of freshly distilled aniline and the oil being tested are completely miscible.

As an oil's aniline point decreases, the oil becomes more damaging. While aniline point is a useful measure, some oil-based muds are still aggressive despite a high aniline point.

Mud Additives

Certain amine-based additives, such as emulsifiers, corrosion inhibitors, and scavengers, can (even in very small quantities) cause elastomer failure.

Brine or Fresh-Water Muds: Brine and fresh-water muds (but not bentonite gels) provide little lubrication for motor stator elastomers, so abrasive wear between rotor and stator can be a concern. Additionally, the adhesives used to bond elastomers to metals can undergo hydrolysis when exposed to water, especially at temperatures in excess of 200°F. Bond-strength degradation can trigger a multitude of problems, some minor and some causing catastrophic failure of the downhole motor. Brine drilling fluids in excess of 150,000 PPM (Clorides) will also cause corrosion of rotors, dump valves, or other components. Carbide rotors are recommended when drilling with a salt based mud.

Air, Foam, or Mist: The use of air, foam, or mist may adversely affect motor performance unless guidelines are followed concerning motor lubrication, air-volume requirements, and WOB.

•**Air with Foam:** When using air with foam, it is recommended that 3 ½ - 4 ½ SCFM of air plus 10 – 100 GPM of injected foam be used.

•**Air Volume Requirement:** Air flow requirement in (SCFM) is 4 to 4 ½ times the max liquid motor flow rate in (GPM). Example: 500 gal/min = 2000 – 2250 cfm of air.

Lubricants – General Recommendations

Using dry air causes high rotor/stator friction and can result in short runs. It is recommended that a minimal amount of lubricant (consistent with formation capability, available equipment, etc.) be run. The most successful lubricants used have been:

- Liquid soap – 0.5 to 1 gal/bbl of water
- Graphite – 4 to 6 lb/bbl of water
- Gel – 0.5 to 1 lb/bbl of water
- Oil – 0.1 to 0.6 gal/hr

Lubricants should be injected in fresh water downstream of the air compressors.

Air Operation Factors: When operated on air, the motor will

- Be more weight sensitive than in fluid
- Stall out at lower pressure
- Require less WOB to drill

Motor Selection: Best results have been obtained with high torque slow speed motors. To reduce pressure requirements on the air compressor, jets should be used in the bit.

Operational Precautions
Start the motor by applying a light weight on the bit and pumping air. Do not allow the motor to run freely off-bottom. If the motor is allowed to run freely off-bottom, the bit speed will increase rapidly as air expands through the motor, and potential damage may result. Such damage may include:

- Stator damage due to friction / heat

- Bearing damage if weight is applied suddenly to the bit

Before picking up off-bottom, turn off the air compressor and allow the air pressure to bleed off until standpipe pressure is equal to annulus pressure.

High-Temperature Environments

Positive Displacement Motors are designed with an interference fit between the rotor and stator, establishing a seal. For the motor to operate efficiently, the interference fit must remain within a specified range. A high bottom-hole temperature can increase the interference fit, which can result in stator damage or reduced operating life. As temperature increases, motor life decreases. Although a motor may be operated for a limited time at temperatures above the designed operating temperature, shortened life can be expected. Motors are designed for specific temperature ranges, generally, below approximately 250°F in most applications. For optimum performance, the motor fit should be selected according to the temperature range in which it is expected to operate.

Hot Hole Procedure: For a bottom hole circulating temperature (BHCT) exceeding 250°F (120°C), the following guidelines apply:

•Contact an ADT service representative for preparation of a hot-hole motor.

•Stage in the hole:

 ◦When reaching the depth where temperature is estimated to be approximately 250°F (120°C), stop and circulate cool fluid to the motor.

 ◦Continue pumping for a few minutes (at low volume) to reduce equipment temperature.

 ◦Continue this process in stages of 500 to 1,000 ft. until reaching operating depth.

•Non –circulating periods (surveying, orienting, etc.) must be as short and as infrequent as possible.

Sacrificial Motors

One type of special drilling operation includes the use of a drilling motor on a sacrificial BHA. The motor is run at the end of a casing drill string that is then left in the hole as a sacrificial element.

Theoretical Build Rate Tables

The following are some notes regarding the build rate prediction tables given in the motor specification sheets.

- The build rate prediction values will vary as the gauge and placement of the motor stabilizers, sleeves, or pads are changed.

- While the motor is sliding, it is assumed that an in-gauge hole is drilled.

- A short-gauge bit will produce better directional tendencies than an extended-gauge bit.

- The formation is assumed to be homogeneous.

- The formation is assumed to be a hard formation.

- The tables assume all stabilizers are 1/8" under-gauge.

- The build rate prediction values should be regarded as estimates and should only be used for general guidance. Formation characteristics, bit profile, BHA design, and drilling parameters can all affect the directional response.

- The units for Theoretical Build Rate Prediction are in degrees per 100 ft.