**SUBJECT:** Air Drilling with a Toro Downhole Motor

**CHANGE; DESCRIPTION; REASON:** To provide written documentation for the operation of Toro motors with compressible media.

**OPERATION / INSTRUCTIONS:** Downhole drilling motors have been utilized in air drilling applications with mixed success for over 50 years. During that time, a large amount of empirical data has been gathered that, when properly utilized, can result in significant performance when drilling with air.

In the past, many power section companies have designed stators and rotors specifically for air drilling hoping to improve operational performance and downhole life. However, actual operational results have been less than acceptable.

Given the historical data, the lessons learned, and over 150 years combined downhole motor experience, Toro has designed it's Motor power sections with all applications in mind. The aggressive 9:10 design of the Toro power sections have been successfully utilized in all drilling environments including water and oil base drilling fluid, brine fluids as well as air or foam as a circulating media and in underbalanced applications (N2).

Toro utilizes two different types of elastomer for stators: A Standard compound and a High Performance compound. The Toro Standard compound is a versatile and field proven formulation. It has excellent mechanical properties, good resistance to aromatics, and performs well in oil and water based applications.

The Toro High Performance elastomer is formulated for use in oil-based applications where high temperature is an issue and is capable of sustaining temperatures up to 350°F [175°C]. Properly equipped and operated, a Toro motor can operate at even higher temperatures, though for only a limited time. (*Contact you Toro representative for recommendations should your application exceed 350°F [175°C].*)

## AIR / FOAM DRILLING APPLICATIONS

Because air is a compressible media, the motor will operate and behave differently than normal. In addition, the pressure required with air drilling is approximately twice the pressure required when standard drilling fluids are used.

When operated on air, the drilling motor will have the following characteristics:

- Will require higher pressure to operate (2X over drilling with a liquid)
- Will require higher flow rates (3X to 4X the flow rate of a liquid)
- Will run at higher RPMs
- Be more weight sensitive
- Stall at a lower pressure (less operating torque)
- Require less WOB to drill

## AIR VOLUME CALCULATION

All Toro motor specifications are based using a liquid volume flow rate (gallons per minute or GPM). To run the motor on air, the liquid volume flow rate must be converted to an air volume flow rate (cubic feet per minute or CFM). Use the following calculation to convert the motor flow rate from GPM to CFM:

1 GPM of fluid equals approximately 4.25 CFM of air

*For example: 400 GPM X 4.25 = 1,700 CFM (estimated)*

## AIR / FOAM VOLUME CALCULATION

When using air with foam as a the circulating media, it is recommended that 3 ½ to 4 ½ CFM of air plus 10 to 100 GPM of injected foam be utilized.

## LUBRICANT RECOMMENDATIONS

Running the motor in air without adequate lubrication will result in severe damage to the internal components. It is extremely important that a minimal amount of lubricant (consistent with formation capability, available equipment, etc.) be used. Below are a list of lubricants that can be used successfully in a motor running on air:

- 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 (non hydrocarbon based)— 0.1 to 0.6 gal/hr.

Lubricants should always be injected downstream of the air compressors to prevent any contamination. Also, since there are large volumes of oxygen present in air drilling, corrosion of the drilling equipment can be a concern. Oxidizing inhibitors should be utilized to minimize corrosion. Toro utilizes carbide coated rotors to alleviate corrosion within the power section.

## PRE-OPERATIONAL ASSEMBLY

When considering a motor for an air drilling application, pre-operational data is of critical importance. As much data as possible should be gathered and examined prior to assembling the motor. The goal is the reduction of the internal temperature within the elastomer to obtain operational performance and maximum downhole life.

This can be accomplished by:

- Utilizing reduced interference fits to allow for frictional and elevated well bore temperature swelling of the elastomer
- Utilizing the maximum amount of lubricant possible
- Avoiding “free running” of the motor to limit RPM’s
- Where elevated downhole temperature is a concern, avoiding extended periods of non-circulation

Failure to follow these recommendations can result in hysteresis (liquefying of the stator elastomer due to heat build-up ) and the eventual chunking of the stator.

## TEMPERATURE CONSIDERATIONS

When drilling with air, a reduction in inference fit is mandatory (as previously addressed). Additionally, when encountering static bottom hole temperatures greater than 250°F (121° C) a high temperature elastomer may be considered.

## OPERATIONAL CONSIDERATIONS

Before turning on the compressor, set the motor on bottom. Apply light WOB while pumping air. Additionally, do not allow the motor to run off bottom. If the motor is allowed to run freely off bottom, the rotational speed of the bit will rapidly increase as the compressed air expands through the motor. As stated earlier, excessive RPMs can damage the motor. Also, it is recommended that lubrication be started before the motor is operated off bottom.

Because air is compressible, the motor will be stall sensitive. Therefore, when initially running the motor, WOB should be added carefully until frictional swelling of the stator elastomer occurs. Frictional swelling of the elastomer occurs as the rotor rotates within the stator. The friction temperature generated between these two components is greater than water or oil based applications, so the motor is assembled with a decreased interference or clearance between the rotor and the stator.

Also, the reduction in the lubricity when utilizing mist or foam results in increased friction, and therefore, increased swelling of the stator elastomer. As the motor continues to run, increased WOB can be applied, using care to avoid stalling of the motor. Stalling a Motor, even for a short time, can lead to tearing or chunking of the elastomer.

Once a stator has chunked, motor performance will dramatically decrease. Repeated stalling may lead to the motor ceasing to function.

Once drilling operations have ceased, the compressor should be shut down and allowed to "bleed off" compressed air in the drill string. Failure to do so may result in excessive RPMs and threaded connection back-off downhole.

## DRILLING WITH NITROGEN (N2)

Permeation of the elastomer with any compressible media (air or N2) is always a concern when using a downhole motor. Depending upon depth and length of run, explosive decompression (gas bubbles) may occur due to tripping out of the hole too quickly. The gas trapped within the elastomer is not allowed to dissipate slowly resulting in a violent tearing the stator elastomer appearing as "bubbles" in the surface. Once this has occurred, if the motor is re-run, severe chunking of the stator elastomer is almost certain. Consequently, it is the policy of Toro to replace all stators run with any compressible media.

## CONCLUSION

Stator life is determined by application and experience. As with all elastomeric products, it is difficult, if not impossible, to predict component life. Application, drilling media, additives, drill bit types, formation, and temperature are all examples of the issues that affect Stator life.

With adequate pre-run information, appropriate service assembly procedures, and proper drilling practices, operating a motor with air or gas can be accomplished to meet or exceed expectations.

Toro motors have consistently performed beyond customer expectations. Every effort is made by Toro to quantify every component in our products for each application in order to provide equipment that meets or exceeds customer requirements.

All inquiries should be directed to:

**Toro Downhole Tools**

**16626 FM 2920**

**Tomball, TX 77377**

**Attn: Technical Services**

**(281) 580-8676**

**www.: torotools.com**