DRILEX	**PRODUCT TECHNICAL BULLETIN TB-002**
	Air Drilling with a Drilex Power Section Revision: A

SUBJECT: Air Drilling with a Drilex Power Section

CHANGE / DESCRIPTION / REASON: To provide written documentation for the operation of Drilex power sections with a 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 sections 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, Drilex has designed it's power sections with all applications in mind. The aggressive 7:8 and 9:10 designs of the Drilex power sections have been successfully utilized in all drilling environments including water-base and oil-base drilling fluids, brine fluids, as well as air or foam as a circulating media and in underbalanced applications using nitrogen (N_2).

Drilex utilizes two different types of elastomer for stators: A Standard (DSR) compound and a High Performance (DHX) compound. The standard DSR compound is versatile and field proven formulation. It has excellent mechanical properties, good resistance to aromatics, and perform well in oil and water based applications. The Drilex High Performance DHX elastomer is formulated for use in use in extreme applications. It is ideal for 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 Drilex power section and can operate up to 400 degrees, albeit for a limited period. (Contact your Drilex Representative for recommendations should your application exceed 350°F (175°C).)

AIR / FOAM DRILLING APPLICATIONS: Because air is a compressible media, the power section 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 power section and motor will have the following characteristics:

- Higher pressure are required to operate (2X over drilling with a liquid)

- Higher flow rates are required to operate (3X to 4X the flow rate of a liquid)
- The power section will run at higher RPMs
- The power section will stall at a lower pressure (less operating torque)
- The motor will be more weight sensitive
- The motor will require less WOB to drill

AIR VOLUME CALCULATION: All Drilex power section specifications are based using a liquid volume flow rate (gallons per minute or GPM). To run the power section 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 calculations to convert the power section flow rate from GPM to CFM:

1 GPM of fluid equals approximately 4.25 CFM of air (1GPM ≈ 4.25 CFM)

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 power section in air without adequate lubrication will result in severe damage to the stator and possibly the internal components of the motor. 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 power section 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 of internal components.

PRE-OPERATIONAL ASSEMBLY: When considering a power section 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 power section. The goal is the reduction of the internal temperature within the elastomer to obtain optimum performance and maximum downhole life. This can be accomplished by:

- Utilizing a 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.

MOTOR OPERATIONAL CONSIDERATIONS: Before turning on the compressor, set the motor on bottom. Apply light WOB while pumping air. Do not allow the motor to run off bottom. If the motor is allowed to run freely off bottom, the rotational speed of the drill bit will rapidly increase as the compressed air expands through the power section. As stated earlier, excessive RPMs can damage the power section and possibly the motor components. Also, it is recommended that the lubrication be implemented before the motor is operated off bottom. Because air is compressible, the power section 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 a typical water or oil based application. It is for this reason the power section should be assembled with a decreased interference (clearance) between the rotor and the stator in air applications.

As the motor continues to operate, increased WOB can be applied, using care to avoid stalling of the power section. Stalling a power section, 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 power section 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 connections may back-off downhole.

DRILLING WITH NITROGEN (N_2): Permeation of the elastomer with any compressible media (air or N_2) is always a concern with a power section. 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 power section is re-run, severe chunking of the stator elastomer is almost certain. Consequently, it is the policy of Drilex 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 stator life. Application, drilling media, additive, 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. Drilex power sections have consistently performed beyond customer expectations. Every effort is made by Drilex 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:

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