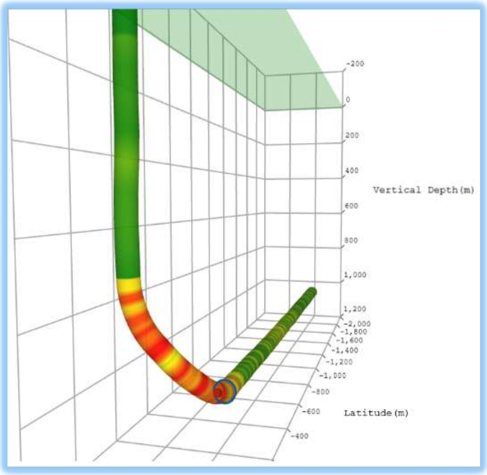
TECHNICAL BULLETIN

DIRECTIONAL SURVEY | LS-TB-047

LIFTING SOLUTIONS

BULLETIN NO.	TOPIC	ISSUE DATE	ISSUED BY
LS-TB-047	OPEN HOLE, CASED HOLE	MAY 29, 2025	TAS

BACKGROUND



In rod driven artificial lift systems, a rod string is deployed from surface to the bottom hole pump to transmit dynamic forces required for pump operation. During operation, the rod string is subjected to a combination of axial, torsional, and bending stresses due to its dynamic motion, which contribute to cumulative metal fatigue and eventual failure. Bending fatigue and rod/tubing wear, particularly in deviated wells, are significant contributors to this degradation. Since wellbore deviation directly influences the magnitude and frequency of fatigue inducing loads, a comprehensive understanding of wellbore geometry and deviation severity is essential for accurately assessing rodstring fatigue life and mitigating premature failures.

During the drilling phase of a well, traditional directional surveying instruments are run within non-magnetic drill collars to capture position data at specified intervals while the borehole remains open (i.e., uncased). These open hole surveys provide the initial baseline directional measurements for the well. However, they often contain sparse data points with limited accuracy. In applications requiring detailed wellbore modeling or deviation analysis, higher resolution cased hole gyro surveys are warranted.

MEASUREMENT ACCURACY & ERROR

Directional surveys generate the critical spatial data - measured depth, inclination (degrees from vertical), and azimuth (compass heading) - used to construct the 3D well path. Open hole directional instruments utilize magnetic sensors, which must be deployed in a magnetically neutral environment to avoid distortion from casing or nearby wellbores. Consequently, these measurements are taken only at select intervals during drilling due to instrument limitations and to minimize rig time, resulting in widely spaced data points.

In horizontal wells, survey intervals typically range from 12-20 mKB in the build and lateral sections, and 40-80 mKB in the vertical section. This wide spacing introduces interpolation error, particularly in areas with rapid deviation changes. Consequently, calculated dogleg severity (DLS) values may be underestimated when critical deviation zones are missed between measurements.

Additional sources of error include the age and preservation format of legacy surveys, which may exist only as paper records. Transcription or digitization of such data can introduce further inaccuracies.

SURVEYING INSTRUMENTS

Magnetic

Magnetic survey instruments rely on detecting the Earth's magnetic field to determine azimuth and orientation. These tools must be run in uncased, non-magnetic environments and are commonly categorized as follows:

- Single-Shot
- Multi-Shot
- Measurement While Drilling (MWD)

These devices are housed in non-magnetic drill collars positioned above the bit. Single and multi-shot tools can be mechanical or electronic, while MWD systems are exclusively electronic.

Mechanical compass systems are cost effective but present notable limitations. Accurate readings require the drill string to be stationary (i.e., in slips during a connection), making survey intervals equivalent to the stand length of drill pipe. In contrast, electronic compass systems enable real time data transmission to surface via mud pulse telemetry. Although widely adopted in modern drilling, MWD systems face constraints such as limited bandwidth and battery life. As a result, directional data is collected at prioritized intervals, leading to variable data density.

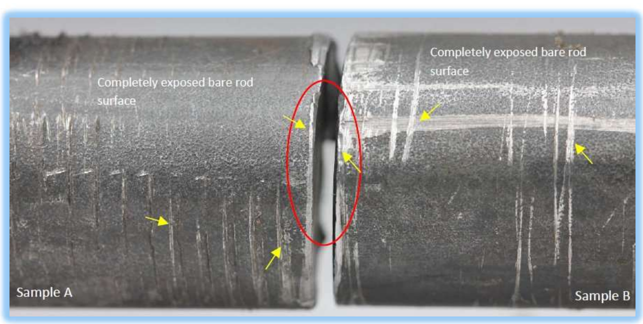
Gyroscopic

In cases where magnetic survey data is insufficient, gyroscopic tools offer a viable alternative. Gyros operate independently of the Earth's magnetic field, using an electrically driven gyroscopic disc to determine orientation. These tools can be run in cased (or "tubed") wells, making them ideal for post drill surveys or for wells with known survey quality concerns.

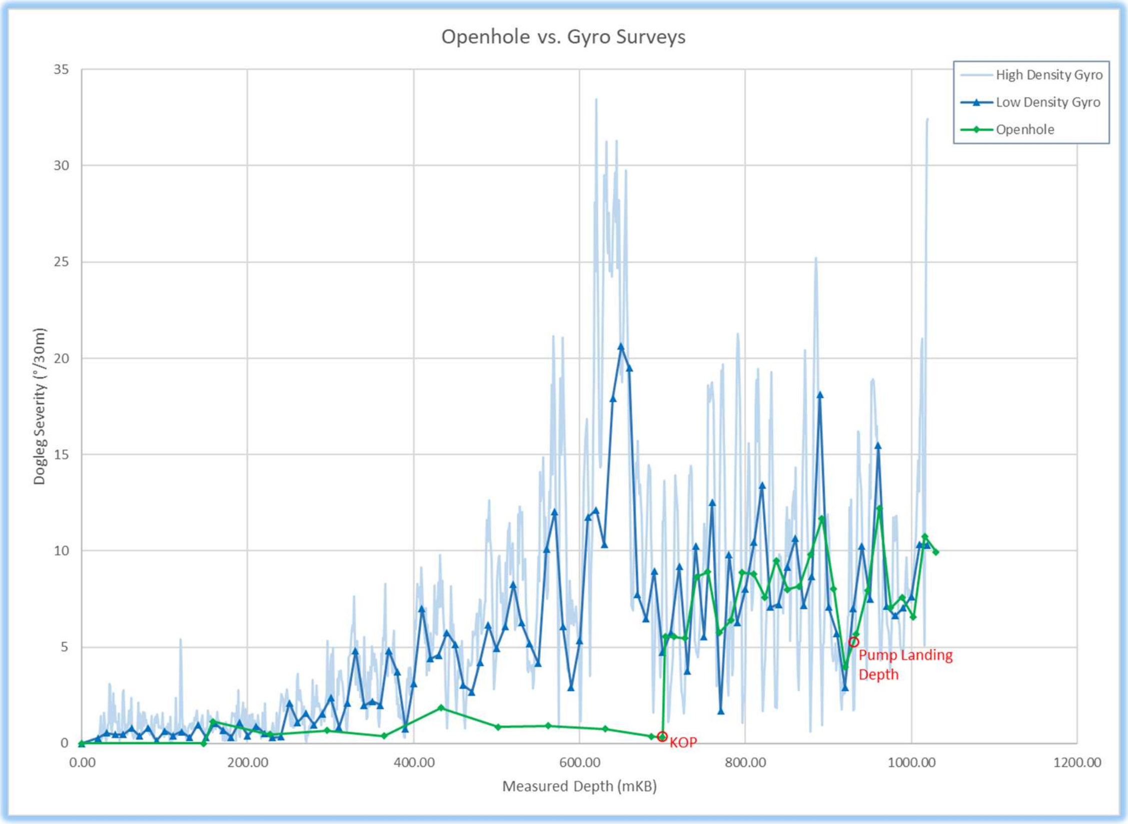
Because gyro tools are often deployed to validate or supplement magnetic surveys, they are typically run with a higher measurement density. While magnetic tools commonly record at 10-20 m intervals, gyros can acquire data at 1 m intervals, offering significantly improved resolution for modeling complex wellbore paths.

FIELD OBSERVATIONS

The Lifting Solutions technical and engineering team investigated a case of repeated rod string failures in a horizontal well, where the frequency and location of failures rendered the application marginally uneconomical. Failures occurred consistently at a similar depth and after a similar number of operational cycles, irrespective of whether new or used rods were installed. One such failure - characterized by a typical fatigue fracture at a 90° angle - was documented and inspected.



These failures consistently occurred around 630 mKB, which is above the kickoff point (KOP). However, the open hole directional survey did not indicate significant deviation in this interval. Recognizing the potential for underestimated DLS due to sparse survey intervals, a cased hole gyro survey was commissioned during a subsequent workover, with both low and high density measurement runs conducted.



The resulting Measured Depth vs. Dogleg Severity plot clearly demonstrated that, in the vertical section previously assumed to be near true vertical, severe deviation was present. High density gyro data (1 m spacing) revealed localized doglegs exceeding 30°/30 m, corresponding to the depth of the repeated rod failures. The low-density gyro data has 10 m spacing.

This represented an extreme and rare deviation scenario that was not captured by the initial survey. Due to the severity and proximity of the deviation to surface, standard mitigation strategies - such as raising the pump - were not viable. Alternative rodless lift solutions such as Electrical Submersible Pumps (ESP) or ESPCP systems were recommended for evaluation.

CONCLUSION

Wellbore deviation significantly influences rod fatigue life and wear, particularly in deviated and horizontal applications. Accurate and high-resolution surveying is essential for diagnosing unexplained rod failures or wear patterns. In wells with persistent rod string failures at unexpected depths, deploying a higher-density gyro can provide a more accurate wellbore model, enabling better correlation between mechanical stress zones and rod performance issues.

A precise understanding of wellbore geometry enables more effective rod/tubing design and failure mitigation strategies, ultimately reducing workovers, non-productive time, and overall operating costs.