

Marathon, partners adapt RFID technology for downhole drilling, completion applications

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RADIO FREQUENCY

Identification (RFID) has become commonplace in many areas, such as package and asset tracking, identifying cars on toll roads, and even keeping track of pets and livestock. **Marathon Oil Company** recognized the significant benefits of adapting key elements of this technology for the oil and gas industry, particularly in the downhole drilling and completion environment. The efforts of Marathon's Technology Services Organization and their business partners are now becoming reality. Field tests in Alaska and the North Sea have proven successful, and two service companies, very much focused on this technology, are assisting Marathon.

Over the years people utilized RFID tags — with mixed results — in surface oilfield applications such as drill pipe and asset tracking. Marathon is progressing something different — using the technology for the downhole well operations environment. There are two similar-sounding yet significantly different areas being developed, each with its own technical challenges.

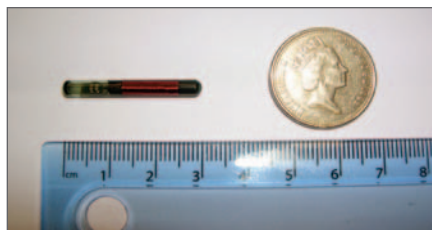
In "Type I" applications, downhole RFID chips (or other unique identification codes) are placed in the drill string or casing string, and a subsequently conveyed reader can perform an operation at a specific downhole location when the correct code is identified.

In "Type II" applications, a downhole tool is configured with a reader, and the tool actuates when the correct chip or unique identification code is noted. Typically the oil industry has primarily utilized mechanical systems, hydraulic pressure and fluid pulses to actuate downhole equipment. Use of the RFID technology allows a completely new thought process to occur. This article discusses only the "Type II" applications. "Type I" applications are just as intriguing but are a little more difficult to reliably implement.

Although Marathon holds a significant worldwide RFID intellectual property portfolio and has licensed aspects of patents and know-how included in this port-



Marathon Oil has been working with partners to adapt radio frequency identification (RFID) technology for use in the oil and gas industry. A tool developed in this effort is the circulating sub, which is activated by passing pre-programmed RFID tags through.



RFID tag used in CNR's application looks like a small glass pill about 3 mm in diameter and 3 cm in length. The tag and a scale are shown above.

folio to others, the company's primary driver is ensuring that this technology is available to industry. The company chose to become involved because of the potential for this technology to improve well operations by reducing costs and rig time for not only themselves but for other oil and gas operators as a whole. The Technology Services Organization estimated that a major oil and gas operator could realize at least \$17 million in annual savings, as well as improved operational safety benefits, with even limited acceptance and use. Many of the RFID tools can displace existing infrastructure, and Marathon did not want to see the technology shelved or to otherwise be slow coming to market.

Marathon joined with prior investors in a company called **In Depth Systems Inc** to progress RFID for the downhole well environment. Four years ago, Marathon fired a downhole external perforating gun using RFID technology in its Escape Completion Process on an 8,000-ft deviated gas well near Kenai, Alaska, which is believed to be the first overall commercial use of the technology in the oil industry. This stirred interest and additional research and development. Two North Sea service companies are now licensed to apply additional engineering expertise to "Type II" applications. **Petrowell**, primarily a well completions company, is developing RFID uses in the completion arena. **IIITec** is a new company whose sole business is developing RFID applications for drilling and coiled tubing operations.

SPECIFIC APPLICATIONS

Circulating Sub: One of the first tools developed by the North Sea service companies was a downhole circulating sub, utilized for well clean-up. The design concept is fairly simple: A very robust downhole circulating sub is run as part of the drill string. It is activated by passing small pre-programmed RFID Tags through the RFID circulation sub.

The signal received by the reader built into the circulation tool activates both the electronics and mechanical devices inside the tool, which in turn opens or closes a sleeve depending on the coding of the RFID tag. The RFID tags can be programmed easily on-site to either open or close the circulation sub, adding operational flexibility. The tool is very similar in appearance to other components of the drilling assembly.

During the August 2005 drilling and completion of CNR's N46z well (approximately 15,000 ft on the Ninian North platform in the UK sector of the North Sea), an RFID circulating sub was run during the clean-up operation prior to running the completion string. This was the first application of such technology in the oil and gas industry, and the operation was performed flawlessly.

Following circulation of the well from 12.7 lb/gallon oil-based drilling mud to seawater, several pre-programmed RFID tags (all with the same code) were dropped and circulated down the well to electronically activate the circulating sub located immediately above the liner top at approximately 10,100 ft. After allowing sufficient circulating time to circulate to bottom, a large pressure drop was observed at the rig pumps as the circulating sub opened successfully. With the circulating ports fully opened, the circulating rates were greatly increased to circulate the rest of the well out with inhibited seawater.

Programmed RFID tags were then dropped to close the circulating sub once the required well circulation was complete. A short time later, the circulation pressure increased suddenly, indicating the RFID circulation sub had closed successfully. The tool was successfully pulled from the well and actuated in the shop approximately 50 more times over the course of several months, all without failure.

Multiple RFID circulating subs can be run in a single tubing string that can each be controlled individually at any time by the coding of the RFID tags dropped downhole. The RFID tag used in CNR's application looks like a small glass pill about 3 mm in diameter and 3 cm in length.

This is the first of many planned RFID actuated drilling tools, which will come to market for use by oil and gas operators, and efforts are under way to set up a worldwide distribution and service net-

work. Additional technology development of circulating subs is directed towards being able to split the fluid streams to both the bit and the circulating sub and to finitely control them.

OTHER APPLICATIONS

Petrowell and IIITec have made key observations that give indications of the myriad of opportunities which exist:

- It is possible to build the RFID chips (as well as other unique identification codes) small enough to survive being pumped through a drilling motor. Tools below the motor then can be actuated via RFID.

- Feedback from operators so far suggests the need to actuate tools in air-and-foam drilling applications, where conventional fluid pulse or pressure activated systems are ineffective. RFID systems will still operate effectively in this environment.

- If operators and contractors are willing to accept an insert in the drill string, the same RFID reader and mechanical power actuation system can be adapted to many industry needs.

Here are a few potential tools being designed. Obviously, priority will be on perceived needs and operator champions.

- Drill string disconnects

It is possible to have several disconnects in the drill string, and the design of these tools is under way. Initial design is for an RFID tag to be dropped, requesting to disconnect at the lowermost point, such as immediately above the bit. The downhole tool is programmed to disconnect and attempt to reconnect after the rig has had time to determine if the pipe is free above this point. If the pipe is pulled loose, obviously the tool cannot reconnect. Multiple other disconnects up the string will allow the rig to retrieve as much of the assembly as possible, yet still have the lower assemblies connected when and if fishing operations resume.

- Expandable and retractable stabilizers

Downhole tools can be configured to require, for example, 100 pulses to move from fully closed to fully open. RFID chips can be pumped, telling the downhole tools to open (or close) on a set number of pulses, which can be correlated to the expansion or contraction of the

tool. It is perceived there is a significant need to potentially open and close such downhole equipment, as well as similar devices such as underreamers. Not only can these tools be opened, closed or retracted, it will allow finite control of desired assembly changes. The tools will also be able to work at any circulation rate, which is not always the case with some of today's tools.

- Changing orientations

Tools are being designed where RFID chips can change drilling assembly orientations by controlling azimuth orientation for adjustable bent subs. The real need may be in air-and-foam drilling applications, where there are few good options in today's marketplace.

- Other applications and path forward

Obviously, there are many more applications in the drilling arena, such as cement stage collars, locking and unlocking drilling jars, coiled tubing tools, indexing fishing tools, changing fishing grapple sizes, retracting casing scrapers near nipple profiles, actuating hydrostatic bailers and a host of other ideas.

Marathon's Worldwide Drilling organization is now in the process of identifying projects it perceives as the highest value for its operations to champion, and the company's completion organization is challenged with the same task. These projects will be under development with RFID-licensed service companies by 1 March 2007. For completions, the licensed service company is already developing a zonal isolation device (such as for gravel packing) where the downhole valve will close when the assembly with the RFID tag passes the isolation valve, which contains the reader device. All companies involved to date hope that operating oil companies and drilling contractors become more aware of the technology being developed and will provide their perspectives and input into the progress of specific applications that are of the highest value to the entire oilfield community.

Karen Fraley is an engineering technician and focuses much of her efforts on technology transfer and assisting in new technology implementation and documentation for the company. Phil Snider is a senior technical consultant has worked for the company in various drilling and completion capacities for 28 years. Both are with Marathon's Technology Services organization.

This article is based on a presentation made at the 2006 DEA Workshop, 20-21 June 2006 in Galveston, Texas. ♠