

Acoustic Wireless Telemetry Reduces Uncertainty in Deepwater Drillstem Tests

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The drillstem test (DST) is one of the oldest methods used to test a formation's capability to produce hydrocarbons. An early patent filed on drillstem testing in 1926 describes it as a method for "testing the productivity of formations encountered in drilling oil and other deep wells." While frontiers such as deepwater drilling were far in the future, the industry was already seeking methods and equipment that were more efficient and economical than those in use then. Technology has continued to advance from mechanical openhole testing to modern annulus pressure controlled cased hole drillstem testing.

An impressive array of annulus pressure-operated downhole test tools is available and provides operators with versatility and flexibility in drillstem testing. Downhole tool technology has advanced to extreme limits, with tools capable of handling bottomhole conditions of 35,000 psi and 500°F.

Meanwhile, drilling technology has also progressed, with wells drilled to greater depths and in deeper water. Operating conditions pose new challenges to cost efficiency and annular pressure limitations.

The inherent complexity of deepwater DST operations implies that a significant number of downhole test tools require some form of annular pressure manipulation. Tubing string tester valves, primary and backup circulating valves, bottomhole sampler triggers, and primary and backup firing heads for tubing-conveyed perforating are some examples.

In deep water, the maximum allowable casing pressure has become the limiting factor in an increasing number of

instances, and this reduces flexibility in designing the downhole test string.

Advances in acoustic wireless telemetry have led to a novel and reliable alternative approach to operating downhole test tools in drillstem testing and providing real-time feedback of tool status, bottomhole pressure and temperature, and bottomhole fluid sample conditions.

Wireless Telemetry

Although wireless telemetry for downhole applications in the oil industry has been used since the 1940s, it did not gain much traction until the 1990s. Different wireless technologies have been studied and tested. Mud pulse telemetry found little use in drillstem testing because of low bandwidth and operational limitations. Electromagnetic telemetry saw some early use but also had limited data transmission capabilities, and the method does not work in subsurface salt layers.

The biggest wireless telemetry advances have occurred in acoustic telemetry, in which acoustic signals are sent through the tubing string. Acoustic telemetry systems use a modular concept with acoustic repeaters providing bidirectional communication between nodes placed along the length of the tubing string.

Typically spaced 1,500 ft apart, the repeaters help overcome the attenuation and distortion that occurs when acoustic waves travel along the tubing string. The placement of the repeaters along the string depends on well characteristics such as depth and deviation, casing configuration, the outside diameter of the tubing, downhole tool configuration, toolstring tension and compression, and downhole noise.

Reduced Uncertainty

By using acoustic wireless telemetry to control the DST assembly, the numerous risks involved in actuating downhole tools with annular pressure are eliminated. Thus, casing pressure limitations do not pose a problem and pressure transmissivity through heavy muds is not a concern because the acoustic signal does not depend on mud weight or wellbore fluid conditions.

An added benefit of acoustic wireless telemetry methods is that they reduce or eliminate wireline operations during drillstem testing and thereby reduce safety risks, particularly in deep water.

The bidirectional communication protocol not only allows for data to be sent downhole to operate equipment, such as opening and closing ball valves or activating firing heads, but also for diagnostic feedback signals to be sent to the surface to indicate the completion of certain downhole tasks. Thus, successful valve openings and closures or sampler triggering operations can be confirmed.

Operators no longer need to rely on assumptions of what is happening downhole. Acoustic wireless telemetry enables direct operator control of the DST assembly. In deep water, the control capability and real-time feedback reduce uncertainty and create operational efficiencies that result in optimized DST procedures and, in some cases, reductions in rig time.

Measure and Analyze

The first application of wireless telemetry during drillstem testing was in data acquisition. Acquiring reservoir data, including pressure, temperature, and fluid, is the essence of a DST.



Fig. 1—The RezConnect Well Testing System uses acoustic wireless telemetry to control drillstem test (DST) tools, with the measurement and analysis of well test data in real time. The DST is monitored on a screen at the surface, left frame, and a downhole tool is actuated, right, by a signal from the surface. Communication is bidirectional, middle, with actuation and control commands sent from the surface and signals returned by the tool to confirm the completion of certain tasks. *Image courtesy of Halliburton.*

Traditionally, data were acquired with electronic memory gauges and downloaded once retrieved at the surface at the end of the DST. Similarly, bottomhole fluid samples would be transferred and analyzed once obtained at the surface. The quality of the data would become apparent upon completion of the DST. If the data were inconclusive or erroneous, the reacquisition of data would be difficult and often impossible because of cost and logistical factors, especially in deep water.

The use of acoustic wireless telemetry enables near real-time and continuous surface readout of multiple bottomhole sensors such as the dual sensors on downhole quartz gauges, which provide pressure and temperature data.

More recently, acoustic wireless systems have enabled the acquisition of qualitative fluid composition from bottomhole samplers. These data streams, with their high sampling frequency, allow the operator to monitor and measure bottomhole conditions in near real time at the surface. This capability directly translates into enhanced and faster decision making during drillstem testing.

Case History

Recently, a DST that is controlled and monitored in real time with acoustic wireless telemetry by the Halliburton RezConnect Well Testing System (Fig. 1) was successfully executed in more than 7,000 ft of water offshore South America.

Multiple acoustic repeaters along the tubing string provided communi-

cation between the surface and downhole test tools, such as real-time gauges, multicycle tester and circulating valves, and bottomhole fluid samplers.

Acoustic repeaters were also installed above the subsea test tree, ensuring acoustic continuity across the tree in case of an emergency subsea disconnect and relatch operation. This enabled full acoustic control of multiple downhole drillstem testing operations, involving opening and closing the tester valve during various flow and buildup periods, and opening and closing circulation ports to clean the well.

Throughout the operation, the position of each individual downhole valve was known at the surface. In addition, three sets of three 400-cc single-phase bottomhole fluid samplers were individually actuated with acoustic sampler triggers. The use of acoustic wireless telemetry provided unsurpassed timing accuracy in triggering the samplers, which was critical to the success of the bottomhole fluid sampling.

By having full acoustic wireless control of the DST, none of the operations compromised the maximum allowable casing pressure limitations, and the real-time data reduced uncertainty and allowed speedier decision making.

The use of real-time data enabled the operator to optimize the length of the well test flow- and pressure-buildup periods and confirm the need for acid stimulation. This resulted in improved well productivity and provided the ability to evaluate post-stimulation well performance. The added flexibility in the

design of the DST led to an estimated rig time savings of 5 days.

Summary

Drillstem testing continues to be a vital process that accurately characterizes reservoirs and assesses their production potential. In deepwater wells, substantial hydrostatic pressure can often limit the ability to apply additional annular pressure while staying below the maximum allowable casing pressure. The ability to activate multiple DST tools by conventional methods, such as annular pressure, is likewise limited.

Using a wireless downhole sensor and actuator network with acoustic repeaters placed along the work string to form a fully bidirectional communication and control system, operators can get a live view of the formation response during drillstem testing. Acoustic wireless telemetry provides real-time surface verification of the test tools' operational status and can acoustically actuate downhole test tools and bottomhole fluid samplers. With a reduced need to apply annular pressure, the safety of DST operations is improved, especially in deep water.

The ability to make immediate and accurate decisions during drillstem testing enables operators to achieve their well test objectives more efficiently, with less rig time compared with conventional DST methods. Operators no longer need to rely on their assumptions of what is happening thousands of feet downhole. With the use of acoustic wireless telemetry during drillstem testing, they can now have a "dialogue" with their reservoir. **JPT**