DOE/MC/29252 -- 5010
(DE96000564)

Development of a Near-Bit MWD System

Quarterly Report
October - December 1994

William J. McDonald
Gerard T. Pittard

May 1995

Work Performed Under Contract No.: DE-AC21-93MC29252

For
U.S. Department of Energy
Office of Fossil Energy
Morgantown Energy Technology Center
Morgantown, West Virginia

By
Maurer Engineering, Inc.
Houston, Texas

DISCLAIMER

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TECHNICAL PROGRESS REPORT

PROBLEM STATEMENT

The success of horizontal drilling in increasing oil and gas production rates in low permeability formations and in mitigating problems such as water-coning and sand production, has led to its industry-wide acceptance as a viable recovery technique.

Correspondingly, as horizontal drilling and completion technology has improved through evolution, the length of the horizontal sections has grown longer and the need for more accurate directional placement become more critical. The reliance on examining formation conditions and borehole directional data some 50 to 80 feet above the bit (see Figure 1) becomes less acceptable as turning radii decrease and target sands become thinner, This is because the impact of stand-off distance, namely, looking at what has occurred instead of what is now transpiring, can result in missing thin targets, falling outside of productive seams identified from gamma-ray logs, or dipping into the water or gas cap. Corrections may entail adding one to two hundred feet more drilling or in more critical instances, plugging back and redrilling the lower portion of the hole. Figure 2 illustrates some typical borehole guidance problems caused by monitoring hole conditions from locations spatially separated from the drill bit.

The above problems can be circumvented by placing the data gathering transducers and measurement-while-drilling telemetry system directly behind the drill bit. The requires design of a special bit sub which houses and protects the borehole environment measuring sensors and communications electronics from damage that can be caused by the torsional, axial and bending loads developed at the bit-rock interface.

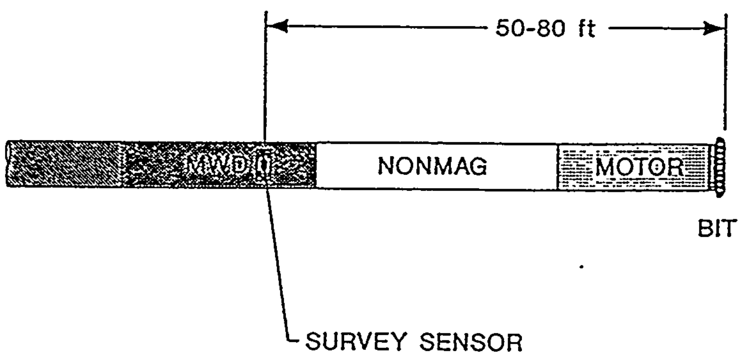

Figure 1. Conventional MWD Drill-String Location

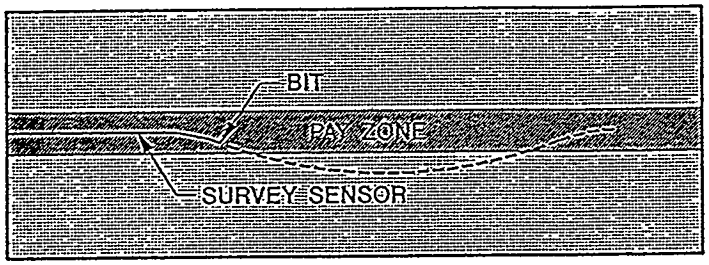

Figure 2. Borehole Guidance Problems

OBJECTIVE

The project objective is to develop a measurements-while-drilling module that can reliably provide real-time reports of drilling conditions at the bit. The module is to support multiple types of sensors and to sample and encode their outputs in digital form under microprocessor control. The assembled message will then be electronically transmitted along the drill string back to a standard mud-pulse or EM-MWD tool for data integration and relay to the surface.

The development effort will consist of reconfiguring the AccuNav® EM MWD Directional System manufactured by Guided Boring Systems, Inc. of Houston, Texas for near-bit operation followed by the inclusion of additional sensor types (e.g., natural gamma ray, formation resistivity, etc.) in Phase II.

To maintain focus and provide the desired level of project control, work is divided into two phases. The current Phase I goal is to define system requirements followed by design, fabrication and lab testing of a functioning prototype. This minimizes risk to METC and allows demonstrating that the required form, functionality and fit have been achieved prior to embarking on the field test program. To minimize costs, the Phase I prototype will be configured with accelerometers, temperature and pressure sensors. The accelerometers provide a means for accurately measuring inclination angle which, in conjunction with natural gama-ray logs and formation resistivity measurements, are the most sought after near-bit data elements.

Phase II will consist of incorporating a selected data suite (adding other sensors such a gamma ray or formation resistivity) and performing a series of field experiments. Before proceeding to the field test stage, a series of vibration cycle and shock tests will be performed to identify areas to strengthen through redesign and packaging modifications. Pending success of the field tests, final design modifications will be implemented and the system commercialized.

SUMMARY OF TECHNICAL PROGRESS

The near-bit MWD prototype fabrication was completed and the system assembled and calibrated. The unit was then subjected to vibration and shock testing for a period in excess of 200 hours. The vibrations were maintained between 5 Hz and 10 Hz for the test duration. Sensor output data was periodically recorded to diskette and compared with pre-test data to determine if their was any fall off in system performance and accuracy. In addition, the unit was completely disassembled and inspected at the conclusion of the reliability tests to assess damage or wear.

The unit operation after the vibrational testing was the same as at the start of testing. No fall off in performance or damage to the electronics or battery pack were found. As a result, an even more rigorous testing cycle will be performed in Phase II. This series of tests verified the effectiveness of the shock damping designs employed in the prototype in the first order. The Phase II tests will seek to increase the g-load levels - particularly in the transverse axis direction.

The performance of the telemetry link was also assessed. The tests successfully demonstrated the ability to transmit and receive error-free data over a transmitter-to-receiver separation distance of 100 feet for both liquid-filled and dry boreholes. Successful reception was obtained for both direct and capacitive signal coupling experiments. Inductive coupling was also successful in liquid-filled boreholes but did so at dramatically lower S/N ratios at the transmitting frequencies employed.

As the final tasks of the Phase I program, work was directed at preparing a plan for commercializing the technology at the conclusion of Phase II and the Phase I Final Report. Both of these documents will be submitted to DOE METC under separate cover.