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PROGRESS REPORT
NO. 1

September 1, 1982-November 30, 1982

A FEASIBILITY STUDY ON THE USE OF MEASUREMENTS WHILE DRILLING (MWD) TECHNOLOGY IN WELL CONTROL OPERATIONS ON FLOATING DRILLING VESSELS

PHASE 1

Contract No. 14-08-001-21169
Effective Date: August 26, 1982
Expiration Date: August 25, 1983
Funded Amount: $90,000

Submitted to

The United States Geological Survey
Department of the Interior

Reston, Virginia

A. T. Bourgoyne, Jr.
William R. Holden

PETROLEUM ENGINEERING DEPARTMENT
Louisiana State University
Baton Rouge, Louisiana 70803

December, 1982

RESEARCH OBJECTIVES

The primary objective of the research is the experimental study of feasibility of combining the measurements while drilling (MWD) and well control technology to produce an automatic system capable of maintaining bottom hole pressure nearly constant during well control operations on a deepwater floating drilling vessel. In particular, the study concentrates on critical periods occurring during pump startup and when a gas kick reaches the subsea blowout preventer stack.

PROGRESS

The only commercially available automatic choke at the current time is manufactured by Cameron, Inc. At present this choke is designed to hold a desired surface drill pipe pressure during well control operations. The use of MWD with well control operations would mean that for the first time, bottom-hole pressure could be made available as a control parameter for an automatic choke.

During this reporting period, the Cameron choke was modified to accept bottom hole pressure as a control parameter instead of drill pipe pressure. A Sperry Sun Pressure Transmission System was used to supply the MWD simulated bottom hole pressure signal to the Cameron automatic choke. Several runs were made to check out the experimental system.

SIGNIFICANT PROBLEMS

No significant problems have been encountered during this report period.

SIGNIFICANT CHANGES

No changes in the project are felt to be needed at this time.

Adam T. Bourgoyne, Jr.
Professor and Chairman

PROGRESS REPORT
NO. 2

December 1, 1982-February 28, 1983

A FEASIBILITY STUDY OF THE USE OF MEASUREMENTS WHILE DRILLING (MWD) TECHNOLOGY IN WELL CONTROL OPERATIONS ON FLOATING DRILLING VESSELS

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Reston, Virginia

A. T. Bourgoyne, Jr.
William R. Holden

PETROLEUM ENGINEERING DEPARMENT
Louisiana State University
Baton Rouge, Louisiana 70803

March, 1983

RESEARCH OBJECTIVES

The primary objective of the research is the experimental study of feasibility of combining the measurements while drilling (MWD) and well control technology to produce an automatic system capable of maintaining bottom hole pressure nearly constant during well control operations on a deepwater floating drilling vessel. In particular, the study concentrates on critical periods occurring during pump startup and when a gas kick reaches the subsea blowout preventer stack.

PROGRESS

During this period, the experimental system developed was used to study pump start-up by means of an automatic Cameron choke. Several choke adjustment step sizes and time delay settings between adjustments were tried. To date, the Cameron Automatic Choke has not been made to operate as efficiently as an experienced human operator.

SIGNIFICANT PROBLEMS

No significant problems have been encountered during this reporting period.

SIGNIFICANT CHANGES

No changes in the project are felt to be needed at this time.

Adam T. Bourgoyne, Jr.
Professor and Chairman

PROGRESS REPORT
NO. 3

March 1, 1983-May 31, 1983

A FEASIBILITY STUDY ON THE USE OF MEASUREMENTS WHILE DRILLING (MWD) TECHNOLOGY IN WELL CONTROL OPERATIONS ON FLOATING DRILLING VESSELS

PHASE 1

Contract No. 14-08-001-21169
Effective Date: August 26, 1982
Expiration Date: August 25, 1983
Funded Amount: $90,000

Submitted to

The United States Geological Survey
Department of the Interior

Reston, Virginia

A. T. Bourgoyne, Jr.
William R. Holden

PETROLEUM ENGINEERING DEPARTMENT
Louisiana State University
Baton Rouge, Louisiana 70803

June, 1983

RESEARCH OBJECTIVES

The primary objective of the research is the experimental study of feasibility of combining the measurements while drilling (MWD) and well control technology to produce an automatic system capable of maintaining bottom hole pressure nearly constant during well control operations on a deepwater floating drilling vessel. In particular, the study concentrates on critical periods occurring during pump startup and when a gas kick reaches the subsea blowout preventer stack.

PROGRESS

During this period, the experimental system developed was used to study well control pump out procedures, with special emphasis on events occurring when gas reaches the sea floor. Several choke adjustment step sizes and time delay settings between adjustments were tried, for several kick sizes and pressure ranges. In all of the tests, the Cameron Automatic System did not operate as efficiently as an experienced human operator. Apparently, the process control logic in the Cameron Automatic Choke is not advanced enough to maintain close control.

Swaco is now in the process of developing a new automatic choke. Plans are being made to include some testing of the prototype at the facility. Research into improved process control logic for automatic drilling chokes has also been initiated.

SIGNIFICANT PROBLEMS

No significant problems have been encountered during this reporting period.

SIGNIFICANT CHANGES

No changes in the project are felt to be needed at this time.

Adam T Bourgoyne Jr

Adam T. Bourgoyne, Jr.
Professor and Chairman

PROGRESS REPORT

NO. 4

June 1, 1983-Aug. 25, 1983

A FEASIBILITY STUDY ON THE USE OF MEASUREMENTS WHILE DRILLING (MWD) TECHNOLOGY IN WELL CONTROL OPERATIONS ON FLOATING DRILLING VESSELS

PHASE I

Contract No. 14-08-001-21169
Effective Date: August 26, 1982
Expiration Date: August 25, 1983
Funded Amount: $90,000

Submitted to

The United States Minerals Management Service
Department of the Interior
Reston, Virginia

A. T. Bourgoyne, Jr.
William R. Holden

PETROLEUM ENGINEERING DEPARTMENT
Louisiana State University
Baton Rouge, Louisiana 70803

RESEARCH OBJECTIVES

The primary objective of the research is the experimental study of the feasibility of combining the measurements while drilling (MWD) and well control technology to produce an automatic system capable of maintaining bottom hole pressure nearly constant during well control operations on a deepwater floating drilling vessel. In particular, the study concentrates on critical periods occurring during pump startup and when a gas kick reaches the subsea blowout preventer stack.

PROGRESS

During this period, a prototype automatic choke under development by SWACO was studied using the LSU experimental facility. This equipment differed from the previously studied equipment in that it was controlled by a programmable electronic microprocessor rather than by pneumatic and fluidic logic circuits. Thus, this process control logic was more easily altered. However, changing the logic was still found to be somewhat awkward because the microprocessor was programmed in machine language and ROM had to be burned in order to change the software. This greatly slowed the rate at which alternate procedures could be tried.

The new equipment was tested both in the pump start-up mode and in the gas-pump-out mode. The equipment was modified from its normal configuration to utilize bottom hole pressure in place of casing pressure in the pump start-up mode and bottom hole pressure in place of drill pipe pressure in the gas-pump-out phase.

The experimental work was moderately successful in developing automatic pump start-up utilizing bottom hole pressure signals.

If pump speed was not changed too quickly, the automatic choke could handle pump start-up about as well as a skilled choke operator. However, a satisfactory gas-pump-out algorithm has not yet been obtained. Experimental work in this area will be extended into the next phase of the project.

SIGNIFICANT PROBLEMS

No significant problems have been encountered during this reporting period.

SIGNIFICANT CHANGES

No changes in the project are felt to be needed at this time.

Adam T Bourgoyne Jr

Adam T. Bourgoyne, Jr.
Campanile Professor of Offshore
Mining and Petroleum Engineering

PROGRESS REPORT

NO. 5

September 1, 1983-Nov. 30, 1983

MMS Contract 14-08-001-21169, Mod. 2
(LSU Project No. 127-45-5115)
Effective Date: Aug. 26, 1982
Expiration Date: October 1, 1987
Funded Amount: $509,118

on

THE DEVELOPMENT OF IMPROVED BLOWOUT PREVENTION SYSTEMS FOR OFFSHORE DRILLING OPERATIONS

Submitted to
The Minerals Management Service
United States Department of the Interior
Reston, Virginia

Adam T. Bourgoyne, Jr.
William R. Holden
Julius P. Langlinais

Petroleum Engineering Department
Louisiana State University

RESEARCH OBJECTIVES

In October, 1983, Modification 2 of this contract was issued to expand the research objectives. This expansion was in keeping with a five-year research plan developed at an MMS Research Workshop conducted at LSU in March of 1982. The general research goals include:

1. The development of an improved blowout prevention system through the integration of measurements while drilling (MWD) and well control technologies.
2. The development of improved diverter systems for offshore opearations.

PROGRESS

Several new graduate students were recruited to work on the newly funded portion of the research project. The diverter project was broken into three separate subtasks. One subtask is a review of existing diverter equipment, arrangements, operating procedures, and past failures. The second subtask is a study of erosion problems associated with the use of diverters. The third subtask is the development of computer models of the diverter/well/reservoir system. Work to date in all of these areas included a review of the available published literature pertaining to these areas and consulting with oil company personnel. Existing computer subroutines for modeling the reservoir, wellbore, and fluid properties were collected to form a starting point for the computer program development work. Experimental work was conducted which was needed to develop improved emperical correlations for simultaneous flow of gas and a non-Newtonian drilling fluid in a vertical wellbore annulus or choke line. Publication of this work in a refereed journal is being sought.

Work on the integration of measurements while drilling (MWD) and well control technologies was continued in three related areas. Dr. Holden and a student working under his supervision is focusing on the development of

improved computer control equipment and interfaces. What has been learned in the previous experimental testing of existing automatic choke equipment is being used to greatly improve the available technology in this area. Dr. Bourgoyne and students working under his supervision are focusing on (1) additional experimental work on gas kick behavior and (2) the development of improved process control algorithms.

SIGNIFICANT PROBLEMS

No significant problems have been encountered during this reporting period.

SIGNIFICANT CHANGES

No significant changes in the project are felt to be needed at this time.

Adam T Bourgoyne Jr

Adam T. Bourgoyne, Jr.
Campanile Professor of Offshore
Mining and Petroleum Engineering

PROGRESS REPORT
NO. 6

December 1, 1983-February 28, 1984

MMS Contract 14-08-001-21169, Mod. 2
(LSU Project No. 127-45-5115)
Effective Date: Aug. 26, 1982
Expiration Date: October 1, 1987
Funded Amount: $509,118

on

THE DEVELOPMENT OF IMPROVED BLOWOUT PREVENTION SYSTEMS FOR OFFSHORE DRILLING OPERATIONS

Submitted to
The Minerals Management Service
United States Department of the Interior
Reston, Virginia

Adam T. Bourgoyne, Jr.
William R. Holden
Julius P. Langlinais

Petroleum Engineering Department
Louisiana State University

RESEARCH OBJECTIVES

The primary objectives of the research are:

1. The development of an improved blowout prvention system through the integration of measurements while drilling (MWD) and well control technologies.
2. The development of improved diverter systems for offshore operations.

PROGRESS

During this period, two trips were made to the MMS District Office in Metairie to obtain the available files on diverter designs and diverter failures collected by field inspectors. In addition, information from several oil companies was obtained. Several designs for model diverter systems needed for the planned experimental study were considered by the research group. It was decided to start with experiments in 1-in. and 2-in. diameter pipes. It was felt that data from this work would be necessary to properly design the full scale 6-in. system planned for next year, as well as provide information for scaling up from 6-in. diverters to 3, 10, and 12-in. sizes sometimes used in today's drilling practices.

The feasibility of installing a horizontal flow loop for experimental study of MWD mud pulse systems at the LSU Research Facility was studied during this period. In particular, it was felt to be highly desirable to integrate the fluidic mud pulser development work of Al Holmes into the next phase of this project. Several alternative sites and designs were studied and their impact on the adjacent LSU Dairy Science Department were considered with LSU Agriculture Center Personnel. A final design was selected which would serve the research objectives and have minimal impact on the Dairy Science program. Cost information was developed based on this final design and it was determined that a 10,000 ft loop would cost approximately $85,000.

SIGNIFICANT CHANGES

A gas storage well is needed for use with (1) the planned model diverter system, and (2) to provide secondary kicks in the experimental well control study. The preliminary design of this facility called for the use of 3000 ft. of 3.5-in., N-80, 10.3 lb/ft integral joint tubing, at an estimated cost of $40,000. Research results to date have indicated that a larger system will be needed. Fortunately, larger diameter high pressure pipe has become available through the Federal Surplus System. Surplus casing having an O.D. of 5-in. and 7-in. which were originally planned for use in the geothermal well research program will also be suitable for use in our research program, and was purchased through the Federal Surplus System at a fraction of its value. The cost of installing the larger gas storage system will be higher, so the total cost will be almost the same as in the originial estimate.

Because of unanticipated work scheduling conflicts between our instructional program and our research program, Dr. Langlinais will not be able to devote as much of his time to this project as originally planned. Fortunately, Dr. Walter Whitehead has become available for work on the project and some of the work initially scheduled for Dr. Langlinais will be performed by Dr. Whitehead. Dr. Whitehead has considerable expertise and experience in blowout control technology. Thus, this change should strengthen our overall effort.

SIGNIFICANT PROBLEMS

No significant prcblems have been encountered during this reporting period.

Adam T Bourgoyne, Jr

Adam T. Bourgoyne, Jr.
Campanile Professor Of Offshore
Mining and Petroleum Engineering

PROGRESS REPORT
NO. 7

March 1, 1984-May 31, 1984

MMS Contract 14-08-001-21169, Mod. 2
(LSU Project No. 127-45-5115)
Effective Date: Aug. 26, 1982
Expiration Date: October 1, 1987
Funded Amount: $509,118

on

THE DEVELOPMENT OF IMPROVED BLOWOUT PREVENTION SYSTEMS FOR OFFSHORE DRILLING OPERATIONS

Submitted to
The Minerals Management Service
United States Department of the Interior
Reston, Virginia

Adam T. Bourgoyne, Jr.
William R. Holden
Julius P. Langlinais

Petroleum Engineering Department
Louisiana State University

RESEARCH OBJECTIVES

The primary objectives of the research are:

1. The development of an improved blowout prevention system through the integration of measurements while drilling (MWD) and well control technologies.
2. The development of improved diverter systems for offshore operation.

PROGRESS

Construction of a straight 2-in. model diverter section having a length of 42 ft. was completed and the system was instrumented with six pressure transducers and two temperature probes. The diverter was fed remotely by a 200 ft. long 3-in. gas pipeline which could offload 2400 psi gas simultaneously from two CNG trailers, each having a capacity of 150,000 SCF of natural gas. Experimental measurements of supersonic exit pressures for multiphase flow conditions were started. These data indicated that existing correlations for predicting the pressure in a diverter system could yield considerable error.

Design of the 6-in. model diverter system was continued. Realistic modelling of this system will require extremely high gas flow rates. Obtaining such rates from CNG trailers was determined not to be feasible and alternative sources of gas were explored. The operating costs of all temporary systems was found to be so high that the economics favored the installation of a 6-in. natural gas pipeline between the research facility and a 16-in. natural gas pipeline owned by Sugarbowl, but passing near the LSU Campus. Such a pipeline would serve several other needs in addition to the MMS research project. Construction should be possible without the need for any MMS funds being allocated to this permanent upgrade of our facility.

Construction of the gas storage wells was delayed to allow time for further study of the Model Diverter System. The automatic choke work has still

not advanced to the phase where the gas storage wells are needed to test secondary kicks. Also, it is now planned to install the gas storage wells and the model diverter system at the same time.

SIGNIFICANT PROBLEMS

No significant problems have been encountered during this reporting period.

SIGNIFICANT CHANGES

No changes in the project are felt to be needed at this time.

Adam T. Bourgoyne, Jr.
Campanile Professor of Offshore
Mining and Petroleum Engineering

PROGRESS REPORT
NO. 8

June 1, 1984-Aug. 31, 1984

MMS Contract 14-08-001-21169, Mod. 2
(LSU Project No. 127-45-5115)
Effective Date: Aug. 26, 1982
Expiration Date: October 1, 1987
Funded Amount: $509,118

on

THE DEVELOPMENT OF IMPROVED BLOWOUT PREVENTION SYSTEMS FOR OFFSHORE DRILLING OPERATIONS

Submitted to
The Minerals Management Service
United States Department of the Interior
Reston, Virginia

Adam T. Bourgoyne, Jr.
William R. Holden
Julius P. Langlinais

by

Petroleum Engineering Department
Louisiana State University

RESEARCH OBJECTIVES

The primary objectives of the research are:

1. The development of an improved blowout prevention system through the integration of measurements while drilling (MWD) and well control technologies.
2. The development of improved diverter systems for offshore operations.

Funding to date has included the following subtasks:

1.1.1 Determine the data requirements (parameters and speed of transmission) for automated well control system. Experimental study, (without secondary kicks) of parameters needed, time urgency, accuracy requirements, redundancy requirements, and trade offs.

1.1.2 Determination of additional data requirements for overall well control strategy including surface data.

1.2.1 Evaluate electrical telemtery technique as high data rate alternative to conventional mud pulse telemetry.

2.1 Review of available technology and current field practices on design and use of diverters on offshore drilling rigs.

2.2 Review failures and cause of failures that have occurred in offshore diverter systems.

2.3 Use of systems analysis approach to develop computer model of reservoir/well/diverter system.

2.6 Literature and experimental study of erosion reduction techniques in diverter system (including bends).

PROGRESS

Subtasks 1.1.1, 1.1.2, 1.2.1, and 2.2 have now been completed while the remaining subtasks are nearing completion.

The development of a computer controlled drilling choke continued to evolve.

A Zenith Z-100 micorcomputer has now been dedicated to this project so that program logic, written in BASIC, can be easily modified, even while experimentation is under way. Software has been written to allow the real time well control data to be both graphically displayed and stored on disk for later analysis and study.

Electronic interfacing between the computer and analog inputs and outputs has been completed. Additional interfacing equipment for computer control of pump speed and choke position is on-hand and is being tested. Interfacing between pump pressure, casing pressure, drill pipe pressure, kill line pressure, bottom hole pressure, pump rate, mud flow out, and gas flow out is also being tested. A detailed experimental study of errors caused by gauge protectors used to separate the drilling fluid from the pressure gauges and transducers is also approaching completion.

The key which will allow many advances in well control technology is the real time measurement of bottom hole pressure while drilling and during well control operations. The main technological hurdle which must be overcome to make this a reality is the development of a rapid data telemetry system for transmitting bottom hole pressure measurements from the bottom of the borehole to the surface. In this project, two techniques for accomplishing this that are being considered include (1) the high data rate fluidic mud pressure pulser under development at Harry Diamond Labs, and (2) an electrical telemetry concept of Ocean Electronic Applications, Inc. During this period, bid proposals have been prepared and advertised for construction of a flow loop for testing the fluidic mud pulser. Also during this period, the Phase I experimental test program of the electrical telemetry concept has been successfully completed. The experimental results are very encouraging.

Experimental work was completed on a straight section of a small scale

model diverter system to improve our correlations for handling multiphase super sonic flow. Gas rates of up to 20 MMSCF/D and water gas ratios as high as 4400 bbl/MMSCF were investigated. Construction of the next phase of the experimental diverter study is nearing completion. The line diameter will be kept at 2-in., but the effect of bends will be studied. Short radius ells, long radius ells, targeted tees, and vortice ell fittings will all be used. Errosion effects as well as pressure drop effects will be studied.

The design has been finalized and bids have also been advertised for construction of the large scale model diverter system, and the vertical sub-curface gas storage cylinders.

SIGNIFICANT CHANGES

Clerical support for this project was originally schedulef for Mrs. Brenda Macon. It has become necessary to replace Mrs. Macon by Mrs. Mary Haynes as the clerical support person for this project.

SIGNIFICANT PROBLEMS

The budget planning update submitted in March, 1984 requested $85,000 of MMS funds for completion of the 10,000 ft. experimental flow loop and $95,000 for construction of the model diverter system. Prices for these projects are considerably lower than normal because of the depressed oil related economy during 1983-84. However, because of recent lease sales, business is beginning to pick up and prices are expected to go up in the near future. We will be opening bids on these projects within the next few days. If funding for these projects is not authorized within the next few weeks, it may be necessary to restart the bidding procedure. Substancial increases in the costs of these projects would be expected if this is required.

Adam T. Bourgoyne, Jr.

Adam T. Bourgoyne, Jr.
Campanile Professor of Offshore
Mining and Petroleum Engineering