PROGRESS REPORT

August 23, 1978-April 23, 1979

# Development of Improved Blowout Prevention Procedures for Deep Water Drilling Operations

Contract No. 14-08-0001-17225
Effective Date: August 23, 1979
Expiration Date: November 20, 1979
Funded Amount - $90,785

Sponsored by

The United States Geological Survey

The Department of Interior

Reston, Virginia

Principal Investigators:

William R. Holden, Professor
Petroleum Engineering Department

A.T. Bourgoyne, Professor and Chairman
Petroleum Engineering Department

Bill R. Hise, Professor
Petroleum Engineering Department

April 24, 1979

## RESEARCH OBJECTIVES

As the search for petroleum reserves has moved into the offshore environment, the blowout control problems associated with exploratory and develpment drilling has continued to increase in complexity. In addition, the difficulties in confining an offshore oil spill makes the environmental consequences of a blowout more important. Modern well control equipment was largely developed for land based drilling operations. This equipment can also be applied with minor modifications to bottom supported exploratory drilling vessels such as jackups and development rigs operating on an offshore platform. More significant modifications in blowout prevention equipment were required for exploratory drilling done from floating drilling vessels capable of drilling in water depths beyond the range of bottom supported vessels. One major modification was the location of the blowout preventer valves on the sea floor rather than at the surface. Subsea flowlines are used to connect the blowout preventer stack to the adjustable choke at the surface.

A number of new blowout control problems are associated with moving into deep water drilling operations with floating drilling vessels. These problems become much more severe as the water depth increases, because of the increased length of the marine riser and subsea flowlines and the increased susceptibility of shallow formations to fracture. The primary objectives of the proposed research are the development of improved well

| Task | Description |
|---|---|
| 4 | Experimental study of shut-in procedures for blowout control on floating drilling vessels in deep water |
| a. | Experimental determination of frictional area coefficient profile of modern adjustable chokes and HCR valves used in blowout control operations |
| b. | Experimental determination of frictional area coefficient profile of modern annular blowout preventers during closure. |

During the course of the research being done, it became apparent that one important aspect of the shut-in phase of the well control operation which badly needed further study had been left out of the original work plan. This work concerns the experimental study of a proposed method for safely handling the upward migration of a gas kick in a shut-in well when a meaningful drill pipe pressure reading was not available. The method, first proposed in the early seventies, is commonly called the volumetric method. Examples of applicable situations include kicks taken with the drill string at least partially out of the hole, or wells involving mechanical problems in the drill string such as a plugged bit or a leak (washout) at a pipe joint. Thus, the research plan was enlarged to include an experimental study of the volumetric method of handling upward gas migration.

ACCOMPLISHMENTS

Tasks 1a and 1b have been essentially completed. The design of the well was aided by computer simulations of (1) a large number of well control operations for a large variety of deep water drilling operations, and (2) a variety of model well geometries. A model well configuration representative of field cases of practical interest was then selected. A current "state of the art" well control model was used in these simulations. This computer model assumes (1) that any formation gas which enters the well remains as a continuous slug which occupies the entire cross sectional area of the annulus during all of the well control operation and (2) that the gas does not slip with respect to the drilling fluid during the well control operations. While these assumptions are not entirely valid, the results obtained are felt to be sufficiently valid to allow a representative model well geometry to be selected. A stated research objective of the model well is to allow an improved mathematical model of the well control process for floating drilling operations to be developed.

A 9000 ft well cased with 7-5/8 in. steel casing has been acquired on the LSU campus which is suitable for use in the well facility needed to model the deep water well control process. The well, which has a value in excess of $400,000 was given to the Petroleum Engineering Department at LSU by GoldKing Production Company after completion of a deep test which did not yield commercial hydrocarbon production. The Petroleum Engineering Department has been allocated a 1.4 acre tract of land

containing the well by the university to support the development of the improved research facility. In return, the Petroleum Engineering Department and the Blowout Prevention Training Center have provided approximately $20,000 of the funds needed for relocating the Dairy Science fences and structures on this property. No USGS funds were needed for the relocation of the Dairy Science fences and structures. The acquisition of this well from Gold King Production Company will eliminate approximately 60 percent of the estimated well construction cost for Task 2 quoted on page 38 of the original proposal.

The design of the surface support equipment needed for the research well has also been essentially completed. Considerable input was obtained from personnel with several major oil companies during the design phase of the project. A site visit was made to an Exxon blowout control training facility in Texas, which at present is the facility most similar to the planned research well. Site development plans including needed excavation and foundations, drainage, and utilities was prepared by a consulting firm which the university uses for this purpose. Specifications and cost estimates on the needed surface equipment have been obtained.

The experimental work needed for Task 4a has begun at the existing training well facility. Preliminary results are very promising and some minor flow loop modifications are under way which will allow data to be taken over a wider range of flow rates and choke pressures. Experimental work needed to complete Task 4b cannot be started until the planned flow loop modifications

have been completed.

The experimental study of the volumetric method of handling upward gas migration has also been started. A portion of the needed equipment modifications has been completed and considerable data on one variation of the volumetric method has been obtained. The results have significantly increased our understanding of the actual well behavior during upward gas migration and a technical publication presenting our results is being prepared.

PROBLEMS

No significant problems have been encountered to date. The project is only slightly behind schedule and it is anticipated that the initial tasks funded can be completed without exceeding the initial budget request by more than about $10,000.

CHANGES

The only significant changes made in the project are:

(1) The inclusion of Dr. Dan Yannitell as a co-principal investigator on the project.

(2) Movement of the planned research well facility site from the existing Blowout Control Training Center to the site of the newly acquired GoldKing No. 1 well.

(3) The use of a civil engineering consultant firm to perform some of the cost estimates needed for the planned research well facility.

(4) The inclusion of an experimental study of the volumetric method of handling upward gas migration into the research objectives.

Dr. Dan Yannitell (See Attachment I) is an Associate Professor in the Mechanical Engineering Department and is an expert in the area of Hydraulic Engineering. He has provided some additional background in hydraulics to the research team. The existing funds for personnel salaries were reallocated to allow Dr. Yannitell to work on the project one-eighth time for one semester.

The movement of the planned research well facility site (See Attachment II) was made to take advantage of the new well provided by GoldKing Production Company. The cost savings achieved through use of the donated well will be offset by the costs of additional surface equipment at the new site. Thus it appears at

present that the overall cost ($280,000) of the planned research facility is approximately the same as in the original proposal. However, use of the donated well will allow the use of slightly larger diameter well tubulars and many operational advantages will result from separating the research facility from the training facility.

The use of the civil engineering consulting firm for surveying the newly acquired well site and estimating the cost of excavation, drainage, foundation, and utilities was the most cost effective way to accomplish the objective. University policy often dictates such work be done prior to approving any construction.

The experimental study of the volumetric method of handling upward gas migration was started under the existing contract because the initial phase of this work could be completed with only minor additional instrumentation of the existing training well facility. This initial work could be done without adding significantly to the cost of the existing contract. Additional experimental work on this important study will be proposed in our next requested contract.

Adam T Bourgoyne, Jr

Adam T. Bourgoyne, Jr., Chairman
Petroleum Engineering Department

Attachment I

## Professional Resume

Daniel W. Yannitell
Mechanical Engineering Department
Louisiana State University
Baton Rouge, Louisiana 70803

### Personal Information

Born September 26, 1941, Johnson City, New York
Married, two children

### Education

B.S. in Naval Architecture and Marine Engineering, 1962
Webb Institute of Naval Architecture

Ph.D. in Theoretical and Applied Mechanics, 1967
Cornell University

### Experience-Academic

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|---|---|
| 1977-present | Associate Professor, Department of Mechanical Engineering, Louisiana State University, Baton Rouge, Louisiana |
| 1972-1977 | Associate Professor, Department of Engineering Science, Louisiana State University, Baton Rouge, Louisiana |
| 1967-72 | Assistant Professor, Department of Engineering Science, Louisiana State University, Baton Rouge, Louisiana |
| 1966-67 | Instructor and Research Associate Department of Theoretical and Applied Mechanics, Cornell University, Ithaca, New York |
| 1962-65 | Teaching Assistant, Department of Theoretical and Applied Mechanics, Cornell University, Ithaca, New Tork |

## Other Experience

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|---|---|
| 1974 (August) | Research Consultant, Cornell University, Ithaca, New York. (Laminar combustion theory) |
| 1972 (June-July) | Consultant, Bell-Aerospace Corp. S.E.S. Division, New Orleans, Louisiana, and Louisiana State University, Baton Rouge, Louisiana. (Hydrodynamic slamming) |
| 1965-1966 (Summers) | Research Assistant, Cornell University, Theoretical and Applied Mechanics Department, Ithace, New York. (Magnetohydrodynamics) |
| 1962-1964 (Summers) | Physics Technologist, I.B.M. Corp. Glendale Lab, Endicott, New York. (Exo-emission and electron tunnelling) |
| 1962 (January-February) | Hydrodynamicist, Stevens Institute of Technology - Davidson Laboratory, Hoboken, New Jersey. (Naval hydrodynamics) |
| 1961 (January-February) | Stress Analyst, Electric Boat Corporation, Groton, Connecticut. (Experimental stress analysis) |
| 1960 (January-February) | Engine Cadet, American Export Lines, Hoboken, New Jersey. (Shipboard engine room operation) |
| (1959 January-February) | Trainee, New York Naval Shipyard, New York, New York. |

## Sabbatical Leave Activity

| | |
|---|---|
| 1974 | Visiting Associate Professor of Theoretical and Applied Mechanics, Cornell University, Ithaca, New York. Participated in Graduate Fluid Mechanics Seminar, studied laminar combustion theory. |

## Honors and Recognitions

National Merit Scholar
Member of Sigma Xi
Member of Tau Beta Pi (Eminent Engineer)
Mention in "American Men and Women of Science"
Mention in "Who's Who in the South and Southwest"
Member of American Academy of Mechanics

## Activities at LSU

### Courses Taught

Statics, Dynamics, Mechanics of Materials, Fluid Mechanics, Vibrations, Intermediate Dynamics, Advanced Dynamics, Applied Elasticity, Energy Methods in Mechanics and Boudary Layer Theory.

### Theses Directed

Pei-Chong Shih: "The MHD Rayleigh Problem with Unsteady Wall Motion", Ph.D. 1970.

Phillip Patillo: "The Critical Speed of a Circular Shaft Rotating in a Viscous Fluid", M.S. 1970.

David L. Garrett: "Investigation of Certain Two-Dimensional Exterior Flows by the Finite Element Method", M.S. 1971.

John T. Franques: "A Finite Element Model for Two- DimensionalSteady Flow Through Contractions in Natural Channels", Ph.D. 1971.

Gary R. Wooley: "A Finite Element Analysis of Steady, Two-Dimensional, Incompressible, Laminar Flow", Ph.D. 1971.

Cary S. Gipson: "Investigation of Electric Field Distribution in a Field-Ion Microscope by the Finite Element Method", M.S. 1978.

## Publications

"The Super-Alfvenic Nature of Sears-Resler Flow," with G.S.S. Ludfor, Journal de Mecanique, 1967.

"The Effect of Non-Zero $Pr_m$ on Hydromagnetic Airfoil Theory," with G.S.S. Ludford, A.I.A.A. Journal, 1967.

"Canonical Transformations without Hamilton's Principle", with G.S.S. Ludford, American Journal of Physics, 1967.

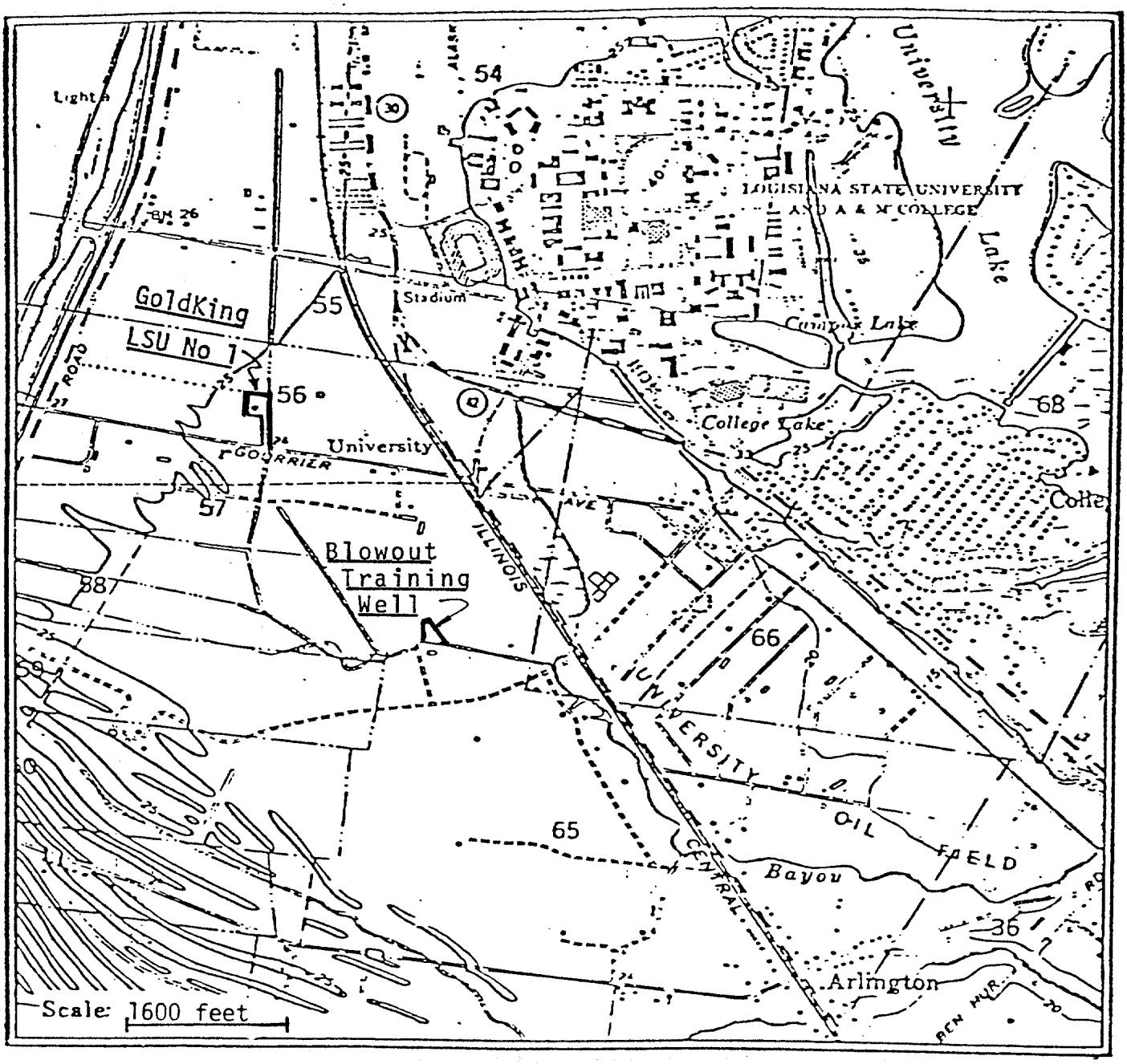
"Two-Dimensional Analysis of Backwater at Bridges," with J.T. Franques, A.S.C.E. Journal, 1974.

"The Decomposition of a Cold Monopropellant in an Inert Atmosphere," with B.S.S. Ludford and J.D. Buckmaster, Combustion Science and Technology, 1976.

"The Decomposition of a Hot Monopropellant in an Inert Atmosphere," with B.S.S. Ludford and J.D. Buckmaster, Combustion Science and Technology, 1976.

"On the Electric Field Distribution within the Field Ion Microscope and Near the Surface of Field Emitters," with G.S. Gipson and H.C. Eaton, accepted by Journal of Physics D: Applied Physics, to be published.

ATTACHMENT II




LOCATION OF PROPOSED RESEARCH WELL FACILITY
FOR DEPARTMENT OF PETROLEUM ENGINEERING
(GOLDKING LSU NO. 1)