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Reconfiguration of LSU No. 1 Test Well

by

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Objective

The objective of this project was to workover LSU Well No. 1 into a configuration that will accommodate planned research and training. The well was specifically designed for extensive use in the completion of several research topics contained in the recently proposed and approved LSU/MMS research program titled "Development of Improved Procedures for Detecting and Handling Underground Blowouts in a Marine Environment."

Introduction

The LSU Well No. 1 was initially completed in January, 1981, by the Department of Petroleum Engineering to provide a near full scale system for studying well-control procedures that could be applied to deep-water drilling environments. The well was donated to the LSU Department of Petroleum Engineering by Goldking Production Company after an unsuccessful attempt to extend the productive limits of the University Field. The department completed the well using a design that would model a well being drilled at a depth of 6,000 feet from a floating vessel in 3,000 feet of water. The ensuing research utilizing this well resulted in a number of technical papers during the eighties.

In addition to deep water well control related research, the LSU Well No. 1 has been used extensively for basic well control training of personnel such as is required by the MMS prior to working for offshore drilling operations. Also, special deep water well control schools which utilized Well No. 1 have been conducted for Exxon, Tenneco, Arco, Conoco, Zapata, Amoco, and Phillips Petroleum. Basic well control training has been and continues to be made available to LSU students as part of the Petroleum Engineering 4060 Well Control Laboratory. Training wells of this type are especially important for students with limited field experience because they are able to experience realistic well behavior during well control operations while utilizing actual field equipment for controlling the well.

In 1988, the tubing string used to model drill pipe in the LSU Well No. 1 parted above joint 100, just below the triple parallel flow tube. Fortunately, the research program originally planned for this well was already complete, but the tubing failure limited training to utilizing only the upper 3,100 feet of the well. However in 1993, a leak developed in or near the triple parallel flow tube located at 3,000 feet, rendering the well useless for both training and research as long as it remained in that condition.

About the time of the tubing failure, concepts were being developed at LSU for a new five year LSU/MMS research program that would follow the then current five year research program

which was drawing to a close. A new well design was being developed to accommodate the emerging research program. As early as April 1993, initial proposals were submitted to the MMS and to LSU's Petroleum Engineering Industry Advisory Board for rework of one of the wells at LSU's research and training well facility. In March and April of 1994, the revised well design was proposed to both the MMS and the industry advisory board. The design submitted was for retrofitting LSU Well No. 1, providing a reconfigured well that would facilitate accomplishing part of the research objectives described in the newly proposed five year LSU/MMS research program and would also accommodate barite settling research being considered by Petrobras. The initial cost estimate projected for the re-work was $150,000 with the objectives for the workover being defined to:

- correct the mechanical problems that developed in the LSU Well No. 1,
- implement a new completion that would support LSU's research plan for the next decade, and
- provide a well facility that can effectively and economically accommodate well control training.

It should also be noted that the new configuration was designed meet the current MMS drilling and well workover training/simulator requirements for MMS well control certification.

Proposed Well Design

The well design proposed in 1994 is shown in Figure 1. The design proposed would utilize the upper 2,800 feet of LSU Well No. 1 with the lower portion being plugged.

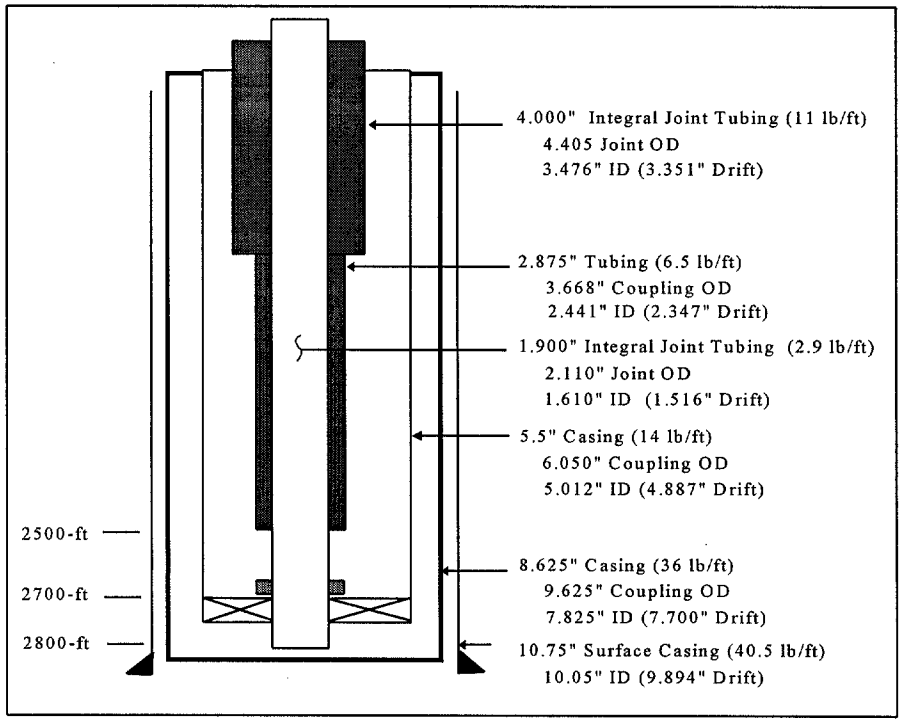

Figure 1 - Initially Proposed Tubular Configuration for LSU Well No. 1

Continual review of the applications associated with this design indicated little interest in the barite settling studies, yet the technical considerations to accomplish this task were numerous, adding significant risk to the design. The decision was made not to install a packer at the base of the 5.5-in casing. The initial idea was that the 1.9-in tubing could be stung into the packer if a leak-proof seal is required at the bottom of the 5.5-in casing or raised (unseated) if circulation is required into the 5.5-in / 8.625-in casing annulus. Dropping the packer concept resulted in the well configuration shown in Figure 2 being designed and implemented.

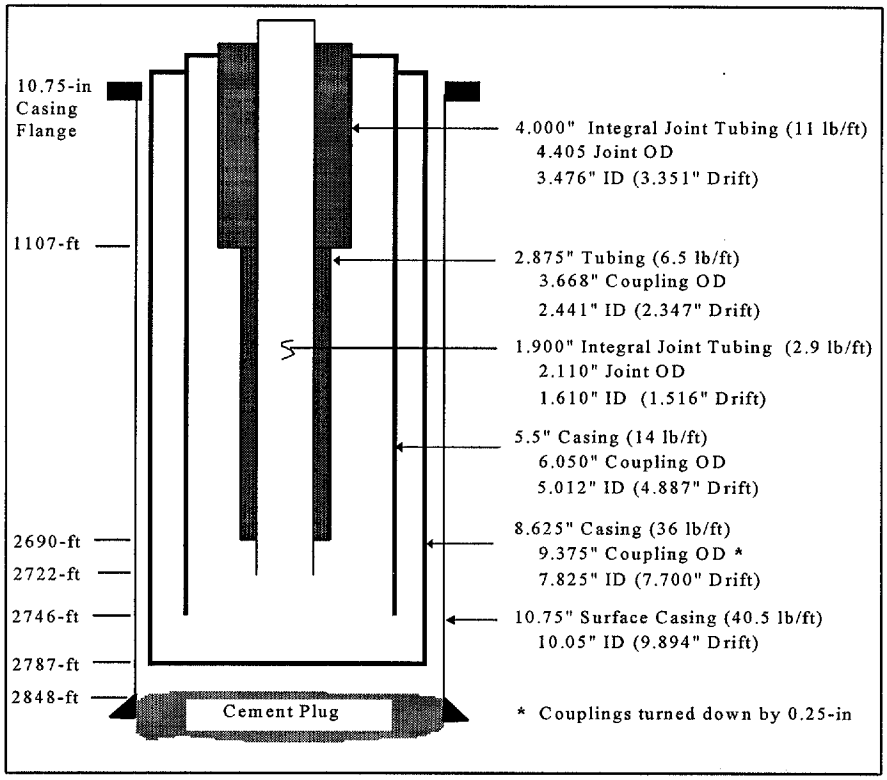

Figure 2 - LSU Well No. 1 Completed Configuration

Recompletion of the well began with a cement plug being set at 2,848 feet, referenced to the 10.75-in casing flange. A pressure test was completed such that both the plug and the 10.75-in casing were tested for a 24-hour period with no pressure loss detected. A 2,787-ft string of 8.625-in, 36-lb/ft, J-55 casing with a bull-plug sealing the lower end was then suspended inside the 10.75-in surface casing. It should be noted that all experiments and training exercises will be contained within this 8.625-in string, which has a burst rating of 4,460 psig. The 10.75-in by 8.625-in. annulus was filled with corrosion inhibited fresh water and will be used only for detecting leaks within the 8.625-in casing. A 2,746-ft string of 5.5-in, 14-lb/ft, K-55 casing was run open ended inside of the 8.625-in casing such that the 8.625-in by 5.5-in annulus can be used to monitor bottom-hole pressure or to simulate a weak (lost circulation) zone in the well during

well control training exercises. A tapered string consisting of 1,583-ft of 2.875-in, J-55 tubing and 1,107-ft of 4-in, 11-lb/ft, J-55 integral joint tubing was run concentric within the 5.5-in casing to a depth of 2,690 feet. The final string, a 1.9-in, 2.9-lb/ft, J-55 integral joint tubing was run inside of and extending through the tapered string to a depth of 2,722 feet.

Operationally, the tapered string by 1.9-in tubing annulus is planned for injecting gas kicks during typical well control exercises. However, it can and will be used as an fluid injection string for certain research configurations. The 1.9-in tubing will typically be used to simulate the drill string during well control exercises in addition to serving as wash pipe to clean the well when needed. The tapered string by 5.5-in casing annulus will be typically used for returns to the surface during normal well control exercises and as a injection string for bullheading research and training. The outer annulus, 5.5-in by 8.625-in, will be used to monitor bottom hole pressure as well as provide a flow path to simulate lost returns

The well itself has been completed in full but has not been tied into the choke and pump manifolds. The materials required to complete the tie-in have been donated and began arriving on May 17, 1995. As soon as all the valves, chicksan, swivels, etc., have arrived, the tie-in will be promptly completed.

Contributors to the Workover of LSU Well No. 1

The projected cost for the workover of LSU Well No. 1 will be approximately $180,000, including upgrading the data collection system, modifying the gas vent metering system, and adding another computer controlled choke to control the returns from the 8.625-in by 5.5-in annulus. This effort to complete this project has truly been a joint effort by the MMS, industry and LSU. The following agencies and companies contributed in this effort (listed in alphabetical order):

1. ABB Vetco Gray, Inc.
2. Baroid Drilling Fluids
3. Cooper Cameron
4. EXXON Company, U.S.A.
5. FMC Corporation
6. Halliburton Energy Services
7. Hornback Specialty Company, Inc.
8. Kinley Caliper
9. Minerals Management Service
   U.S. Department of the Interior
10. Mobil Oil Corporation
11. Patterson Rental Tools
12. Patterson Truck Lines
13. LSU Foundation-
    Roy "Phatz" Sullins Memorial Fund
14. Supreme Contractors
15. SWACO
16. Texaco USA

Donations and approvals for donations have been received for the past 18 months in the completion of this project.

Features of the New Design

The new configuration will permit the following training exercises to be conducted (those shown with an asterisk are new capabilities that were not available for the original completion):

- Conventional Circulation of a Gas Kick
- Pump Start-up Procedure for Deepwater Locations
- Conventional Circulation of Gas Kick for Deepwater Locations
- Bull-Heading Operations*
- Conventional Circulation of Gas Kick with Loss Circulation Zone*
- Leak-off Test or Pressure Integrity Test
- Gas Migration in Shut-in Well with Drill String on Bottom
- Volumetric Method of Handling Gas Migration
- Reverse Circulation of Gas Kick during Workover Operations*
- Bull-Heading during Workover Operations*

In addition, the following research projects will be supported by the new configuration:

- Computer Assisted Detection of Underground Blowouts
- Development of Hybrid Well Control Simulator
- Experimental Study of Bull-heading Operations*
- Requirements for Dynamic Kill of Underground Blowouts*
- Experimental Study of Critical Velocity for Mud Unloading by Gas

A lower gas injection pressure of 1440-psig is now possible for generating kicks, which will greatly simplify and reduce LSU's maintenance costs associated with valve repair in the high pressure (5000-psig) gas system. The working pressure of the high pressure system was earlier reduced from 10,000-psig to 5,000-psig because of excessive maintenance costs. However, these costs have remained much higher than expected. In addition, the lower gas injection pressure and smaller casing size will reduce the amount of gas consumed, yet provide valid results for the research projects planned and training exercises to be offered.

Detailed technical specifications and projected operational characteristics of the new design were presented at the LSU/MMS Well Control Workshop held during March 30-31, 1994. Each anticipated type research and training exercise was discussed in detail.

Additional Facility Modifications

Maximizing the utility of the newly configured well required that the facility's data collection system be upgraded and that additional gas measuring devices be installed to get higher resolution gas-out data. Funding for these upgrades has been provided by Petrobras (as

part of a research project), the MMS (as part of this year's research budget), LSU, and by equipment donations by SWACO, Drillogic Inc., and Daniels Industries. The newly acquired computer system and data collection system provide the capacity for 32 analog input data channels, 6 analog output data channels, 24 digital input channels and 24 digital output channels. The total cost for this upgrade approximates $14,000 with the majority of the funding coming from LSU and Petrobras. This upgrade increases the data collection capacity of the LSU's electronic system by a factor of four.

The high pressure choke manifold is being modified to accept an additional drilling choke that will be automated for computer control. This choke is the SWACO 10K Kick Killer and was provided to the university by SWACO. This additional choke will permit precise control of the fluid flow out of the 5.5-in by 8.625 annulus when simulating lost returns or underground blowouts. This will be a new feature not presently available at the facility.

As part of the current retrofit, the degassing system has been modified to eliminate gas blow-by through the degasser and into the mud pits, thereby minimizing gas loss when making gas-out measurements. Also, two additional gas metering stations are being installed in the gas vent line to enhance the accuracy of the gas-out measurements over a wider range of gas flow rates. The new design for the degasser system is shown in Figure 3. The degasser system as is now designed will hold up to approximately 15-psig backpressure in the degasser/separator without gas blow-by and do it without the use of a float valve, thereby reducing the risk for failure.

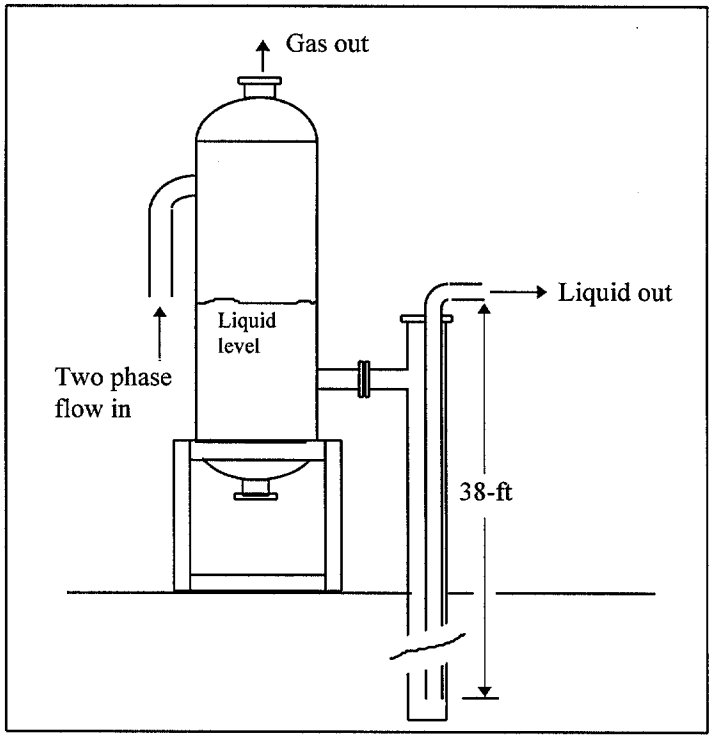

Figure 3 - Modified Degasser System

Modifications are also being made in the gas-out or vent line gas measuring system. The current system only has a 12-in senior orifice meter installed, but the new design will accommodate two additional measuring devices, a 4-in junior orifice meter and either a 2-in turbine meter or a positive-displacement-meter. This system will allow different meters to be reading the gas-out values, optimizing the meter size used with the gas-out rate, such that reading errors will be minimized. Figure 4 depicts how the new design will look upon completion. In the event of pneumatic failure, the 12-in valve is designed to fail-open; but should the valve remain closed for some reason, only a maximum of 15-psig gas pressure would build up before blow-by through the degasser would occur. The three valves shown in Figure 4 will be controlled by the computer so as to optimize gas measurement via quick identification and response.

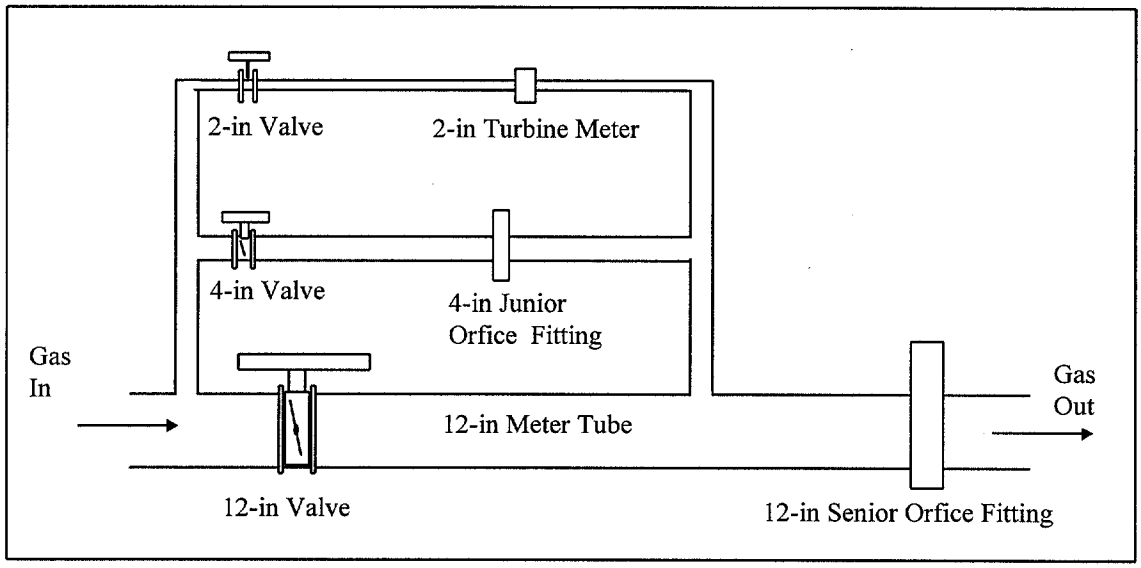

Figure 4 - Gas-Out Meter Tube Modification

Only one other significant change is planned for the near future, the acquisition of a gas compressor which will be used to elevate the 650-psig pipeline gas pressure to as high as 3,500-psig for use in gas kick research and training. LSU funds will be used to purchase this item with the purchase and installation anticipated within four weeks.

Project Status

Recompletion of LSU Well No. 1 as funded by the MMS is complete. No additional work or spending for this project will occur on the 5-year contract extension which ended March 31, 1995.