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Principal Authors:
Troy Reed, Principal Investigator
Stefan Miska, Co-Principal Investigator
Nicholas Takach, Co-Principal Investigator
Kaveh Ashenayi, Co-Principal Investigator
Mark Pickell, Project Engineer
Len Volk
Mike Volk
Lei Zhou
Zhu Chen
Crystal Redden
Aimee Washington

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The University of Tulsa
600 South College Avenue
Tulsa, Oklahoma 74104

DISCLAIMER

1. SUMMARY OF CURRENT TASKS FOR ACTS PROJECT

This is the second quarterly progress report for Year-4 of the ACTS Project. It includes a review of progress made in: 1) Flow Loop construction and development and 2) research tasks during the period of time between October 1, 2002 and Dec . 30, 2002.

This report presents a review of progress on the following specific tasks.

a) Design and development of an Advanced Cuttings Transport Facility
 Task 3: Addition of a Cuttings Injection/Separation System,
 Task 4: Addition of a Pipe Rotation System.

b) New research project (**Task 9b**): "Development of a Foam Generator/Viscometer for Elevated Pressure and Elevated Temperature (EPET) Conditions".

d) Research project (**Task 10**): "Study of Cuttings Transport with Aerated Mud Under Elevated Pressure and Temperature Conditions".

e) Research on three instrumentation tasks to measure:
 - Cuttings concentration and distribution in a flowing slurry (**Task 11**), and
 - Foam texture while transporting cuttings. (**Task 12**),
 - Viscosity of Foam under EPET (**Task 9b**).

f) New Research project (**Task 13**): "Study of Cuttings Transport with Foam under Elevated Pressure and Temperature Conditions".

g) Development of a Safety program for the ACTS Flow Loop.
 Progress on a comprehensive safety review of all flow-loop components and operational procedures. (**Task 1S**).

h) Activities towards technology transfer and developing contacts with Petroleum and service company members, and increasing the number of JIP members.

Note: Research Tasks 6, 7, 8 and 9a were completed during the first three years of this five-year project.

2. EXECUTIVE SUMMARY OF PROGRESS

Flow Loop Construction
Experiments are continuing. Improvements to the software for data acquisition are being made as additional experience with three-phase flows is gained.

Modifications are being made to the Cuttings Injection System in order to improve control and the precision of cuttings injection.

New construction plans for the drill-pipe Rotation System are moving ahead on-schedule.

The contractor for five high-pressure view ports are reporting that all of the glass elements have been made, and they are now being assembled in their metal housings and will be pressure tested. They are promising that delivery is imminent.

The SWACO Company has renewed their efforts to secure us a Super-Auto Choke. Additional discussion of the Flow Loop is given in Section 3 of this report.

Development of a Foam Generator/Viscometer for EPET Conditions, (**Task 9b**).
A US Patent was filed on October 28, 2002 for a new design for an instrument that can generate a variety of foams under elevated pressures and temperatures and then transfer the test foam to a viscometer for measurements of viscosity. A description of this new Foam Generator/Viscometer was provided in the previous Quarterly Report (first quarter of Year-4, dated Oct. 30, 2002).

Currently, negotiations are underway between Tulsa University and a company to manufacture the first version of the Foam Generator. In addition, a high-pressure (1500 psi) and high-temperature (150 C) rheometer is currently being calibrated in preparation for tests with foam. One of the objectives of this research task is to determine the relationship between surface roughness and "wall-slip". In order to achieve these objectives four additional rheometer cups and cylindrical rotors are being made with difference surface roughness. The initial tests will be conducted over a range of foam parameters that include: foam quality, bubble size, shear rates, wall roughness, and one or more surfactants. The test foams for these initial tests will be generated by using the existing Dynamic Test Facility, a small-scale flow loop. When the Foam Generator becomes available, additional tests will be conducted over a broad range of pressures and temperatures. This research project is discussed further in Section 4.

Study of Cuttings Transport with Aerated Mud Under Elevated Pressure and Temperature Conditions, (**Task 10**).
Modifications and calibration of the Injection/Collection system are in progress. Preliminary air/water/cuttings flows were carried out for the purpose of calibrating the cuttings injection auger. The Three-Phase Holdup System has been tested to trap

mixtures in the annular section and then measure the volume fractions of solids, liquid and gas. Calibrations of the load cells were performed by carefully measuring the weight of known amounts of water. Additional discussion of this task is provided in Section 5.

Study of Cuttings Transport with Foam under Elevated Pressure and Elevated Temperature Conditions, (**Task 13**).

A literature review on foam rheology and cuttings transport with foam has been conducted, and this review confirms that research in this field is very limited and there is a definite need for research on this subject.

A detailed research proposal report was prepared and presented at the November 19^{th} ABM Meeting to the ACTS JIP members. This research proposal was considered to be acceptable and suggestions were received during the meeting.

Preliminary experiments with two candidate aqueous foam formulations were conducted. Two types of polymers were added to a base fluid consisting of water and a surfactant. A Fann 35 viscometer was used to measure viscosity of the base fluid. In addition, foam stability test were also performed. Results from these experiments are still being analyzed, but one of the definite conclusions is that polymers greatly enhanced the stability of the foam, i.e., the half-life time of a foam increases greatly when polymers are added.

Plans are being made for future experiments on foam rheology and cuttings transport in the ACTS Flow Loop. Additional discussion of this task is provided in Section 6.

Research on Instrumentation to Measure Cuttings Concentration and Distribution in a Flowing Slurry, (**Task 11**).

Modifications and testing of the printed circuit board and firmware are continuing. The printed circuit board is having two different noise problems. There is a ground noise, and there is also the primary signal sound generated by the transmitters at 75kHz that is a second source of noise. The board is being modified and tested to eliminate these interferences.

Development of the data acquisition software has been slowed by the circuit board design problems, but it is progressing. The preliminary results indicate that it is possible to distinguish between different sand concentrations.

To account for the nonlinear nature of a slurry flow, a neural network algorithm will be used to analyze the dynamic test data. A review of progress on this task is given in Section 7.

Research on Instrumentation to Measure Foam Properties while Transporting Cuttings, (**Task 12**).

Problems with corrosion and the deposition of corrosion products on the glass windows are being addressed. Modifications to the Dynamic Testing Facility will make development of the new electro-optical techniques for measuring foam properties easier. The status of this work is reviewed in Section 8.

Safety Program for the ACTS Flow Loop, (**Task 1S**)
The Action Plan and subsequent training has been the primary focus of Task 1S. An excerpt from the Action plan is included as an illustration. The status of the Safety Program is reviewed in Section 9

Activities towards Technology Transfer, Developing Contacts with Petroleum & Service Company Members, and Addition of JIP Members.
The November 2002 Advisory Board Meeting was well attended. In addition to existing JIP members (see Section 10), a number of companies attended as guests. In particular, ExxonMobil, Anadarko Petroleum and Varco International had representatives attend this meeting. Although MI Drilling Fluids did not send a representative, they have requested detailed information on ACTS membership, and their management is actively considering joining both TUDRP and the ACTS Project. Contacts with other petroleum and service companies are being pursued. This subject is discussed further in Section 10 of this report.

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3. ACTF DESIGN AND CONSTRUCTION ACCOMPLISHMENTS

A large number of experiments have been conducted this past quarter. As these experiments have progressed, a number of software improvements have been identified which have made real-time test-loop operations more precise and the data output considerably easier to interpret. The nature of these improvements are all essentially related to how the computer calculates and presents to the operator: 1) the instantaneous cuttings injection rates and the corresponding totals, and 2) cuttings collection rates and totals. The ease of interpreting the results has been greatly enhanced.

Figure 3.1 - Cuttings Injection Hopper (right) and Separation Tower

Experience gained during this quarter has also allowed us to refine our techniques for cuttings transfer from the collection tower back to the injection hopper and considerable experience has been gained in draining and winterizing the system and starting back up again because on many days it has been below freezing at night. Indeed we are regularly having a number of days when we cannot run at all either because it doesn't get warm enough at all or the length of time when it is warm enough is simply too short to justify the effort. This combined with performing maintenance items (such as replacing a 1 ¼-inch tee in the suction piping that froze and broke) has limited our ability of conduct useful tests.

All-in-all, system performance has been satisfactory with the exception of control of the cuttings-injection rate, which has been running approximately ± 10%. We're convinced that we can and should do better than that especially since the injection rates vary within that tolerance on their own initiative. We've initiated two modifications that will be implemented within the next two weeks. One is to install a smaller gear on the hydraulic motor, which powers the auger. This will give us better auger speed control at slower rpm. The other modification is to install a sleeve around the auger. As shown below in Figure 3.2, only one third (1/3) of the auger is currently restricted inside close fitting piping:

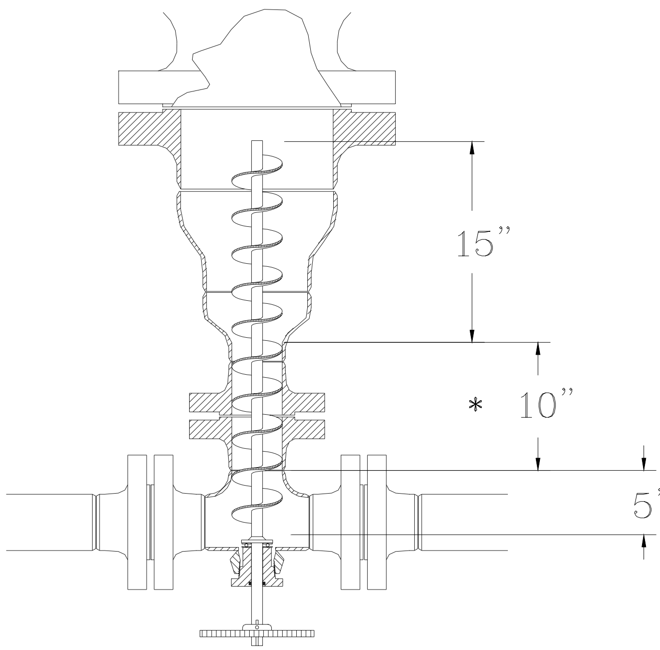

Figure 3.2 – Current Auger underneath Cuttings Injection Hopper

Although this has the appearance of being more than adequate for the task, in fact, it has been proven to be inadequate for high flow rates, especially high flow rates of liquid combined with air. This arrangement provides injection rates that are higher than the target values for some of the desired tests.

The design is being altered to include a sleeve that covers more of the auger length, so that over two thirds (2/3) is restricted inside close fitting piping. This modification is shown in Figure 3.3.

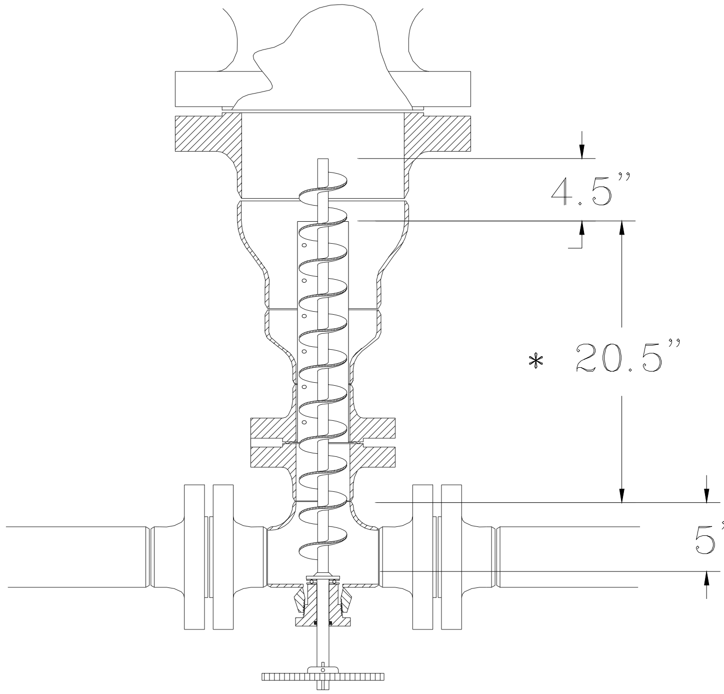

Figure 3.3 - Modified Auger underneath Cuttings Injection Hopper

This is expected to significantly reduce the tendency for the cuttings to “self-feed” and provide a much more precise and controllable feed rate.

New construction plans for drill-pipe rotation are moving ahead on-schedule. United States Steel (USS) is being exceptionally helpful in assisting us in obtaining the drill pipe to meet our special requirements. A Teflon supplier has been identified. Suppliers for the drive system and other component parts have been identified.

Installation of strainers in the piping, that returns flow to tankage after passage through the flow loop, is still pending an appropriate time when this activity will not interfere with experiments.

According to the contractor, fabrication of new glass elements for 5 view ports have been accomplished and are being assembled in metal housings for pressure testing. As reported last quarter, a problem was identified with the tolerances in the glass components that resulted in failures when they were pressure tested. The causes were identified, and a new design was created. New fixtures were made for the glass supplier, new glass was manufactured, and we are now waiting on assembly, testing and shipping which we believe to be imminent.

SWACO has re-confirmed their intention to donate to the ACTS Project a Super-Auto Drilling Choke. Some internal company problems, unknown to us, kept this from happening six months ago. However our contact has renewed his effort and has promised results.

4. DEVELOPMENT OF A FOAM GENERATOR/VISCOMETER FOR ELEVATED PRESSURE AND ELEVATED TEMPERATURE CONDITIONS (Task 9b)

Investigators: Mark Pickell, Troy Reed and Leonard Volk

OBJECTIVES

1. Develop a new instrument that will enable the generation of foams with a controllable bubble size and under elevated pressures and temperatures.

2. Develop a process that will enable measurements of the viscous properties of foams that are free of the influences of drainage (syneresis) and bubble coalescence and can quantify the effects of surface roughness on "wall slip".

4.1 The Need for New Instrumentation and a Process

One of the important findings from Research Task #9, flow-loop tests with foam, is that bubble size has a primary effect on the apparent viscosity of a foam. This identified the need to have an instrument that can generate foam with a controlled bubble size and then measure its rheological properties. This has led to the development of a new concept for achieving these objectives. In particular, there is currently a need for an instrument that can generate a foam and measure its viscous properties. The instrument should be capable of controlling the following six variables independently. 1) foam quality (ratio of gas to liquid), 2) pressure, 3) temperature, 4) surfactants and other additives, 5) bubble size, and 6) surface roughness inside a viscometer. A survey of different manufacturers of viscometers and rheometers revealed that there is currently no commercially available instruments designed to accomplish the above list of measurements for foams.

As noted above the apparatus is termed a Foam Generator/Viscometer. It provides a means by which the rheology of foams, emulsions or other shear-sensitive media may be measured. Liquid components (such as surfactant and water) are selectively combined with a gas (such as nitrogen, air or other gases) in various ratios, mixed to a desired consistency, and allowed to flow under controlled conditions (pressure, temperature, and flow rate) through a modified (variable surface roughness) Couette-type rotary Viscometer at such a rate that the viscosity of the foam is determined while its properties (bubble size, quality, pressure, temperature, and viscosity) are maintained constant.

4.2 Progress – Foam Generator

Tulsa University is currently drafting an agreement with a company TEMCO to manufacture the Foam Generator. TEMCO has a great deal of experience making high-pressure cells for a variety of instruments and applications. The details of the design will be finalized via design review meetings with TEMCO engineers. It is expected that the first prototype will be delivered to the ACTS Project sometime in the early spring of this year.

4.3 Progress – Viscometer

Investigator: Aimee Washington (MS Student)

Project Title: "An Experimental Study of the Viscosity of Drilling Foam Using a Foam Generator/Viscometer"

Part of TASK 9b OBJECTIVES

- Discover a method of applying a uniform rough surface to the inside of the cup and the outside of the rotor in a Couette-type Viscometer.
- Discover a way to quantify the rough surface
- Calibrate the RS300 rheometer that will be used for viscosity measurements.
- Conduct preliminary tests using commercially available foams
- Connect the Rheometer and Foam Generator, develop the procedures that are necessary to control bubble size, and measure the viscous properties of a foam under controlled pressure and temperature conditions.

A Thermo-Haake RS300 Rheometer has been selected to measure the viscosity of foams. This rheometer was chosen because it has three essential features. It is designed to: 1) allow flow through the pressurized viscometer cup, 2) operate at pressures up to 100 bars (1500 psi), and 3) at temperatures up to 150 C. It is a Couette type of viscometer with rotors that turn inside a stationary cup.

Part of the research plan is to fabricate up to 4 additional rotors and cups with different amounts of roughness machined on to their surfaces. The purpose is to investigate how this affects the "slip" of foam at a solid boundary. It is known that when slip occurs within a viscometer, the viscosity of a foam will be underestimated because it shears less than a fluid that has no wall slip.

Another factor that is different for a foam compared to conventional liquids is that a foam tends to fill the space between the cup boundaries and the internal rotor. The RS300 is designed to test conventional liquids that are placed in the pressurized cup cell to a level that is only slightly above the rotor. At the top end of the rotor, there is a round magnet that is rotated by an external magnetic drive system. The clearance between the lid to the cup and this rotor magnet is relatively small. When foam fills this space it adds additional drag on the rotor. The purpose of calibrating this device with one or more calibration fluids, that have a certified viscosity, is to correct for end effects and bearing drag. Since the standard calibration fluids are liquids that do not slip at the solid boundaries, they provide corrections that are too high compared to a foam, if the foam is allowed to slip above and below the gap between the wall of the cup and the outer surface of the cylindrical rotor, the primary measurement area. For this reason, the internal surfaces above and below the rotor must have a surface roughness that will not allow wall slip for any of the foam test conditions.

A relative large roughness for the surfaces above and below the rotor has been selected and will be machined inside the four additional cups and rotors. In addition, different values of surface roughness will be machined on the cup and rotor surfaces that face each other to form the gap that constitutes the primary measurement area for determining viscosity. The advantage of machining the roughness is that it maintains the gap clearance between the cup surface and the rotor's cylindrical surface. In addition, it is easier to achieve a uniform roughness on all of the surfaces.

Three calibration fluids (approximately 10 cP, 50 cP and 100 cP) have been used to calibrate the standard RS300 40 mm cup with a 36 mm cylindrical rotor. It has been found that completely filling the space between cup and rotor results in approximately 40% higher drag on the rotor compared to only filling the fluid to a level slightly above the top of the cylindrical surface of the rotor.

4.4 Future Plans

The RS300 is currently being connected to the small-scale Dynamic Test Facility (DTF) flow loop that has been developed as part of Task #12. This loop is currently being used to generate foams and measure their physical properties such as bubble size. Since the Foam Generator will not be available until later in the year, the DTF will be used as a foam generator at low pressures and ambient temperatures. It is anticipated that dynamic measurements of foam viscosity will be obtained during the next quarter and reported in the 3rd Quarter Progress Report.

In addition, design details for the Foam Generator will be finalized and a prototype will be built. The modified RS300 will then be connected to this device and new foam viscosity data will be obtained. The initial tests will attempt to repeat the data obtained with the DTF.

5. STUDY OF CUTTINGS TRANSPORT WITH AREATED MUD UNDER ELEVATED PRESSURE AND TEMPERATURE CONDITIONS (TASK 10)

Investigator: Lei Zhou (Ph.D. Candidate)

OBJECTIVES

1. Develop two-phase flow model for aerated fluids at elevated pressure and temperature inside annuli in a horizontal position without pipe rotation.

2. Determine experimentally the cuttings transport ability of aerated fluids under elevated pressure and temperature conditions.

3. Determine the optimum gas/liquid flow rates for cuttings transport.

4. Develop a computational tool to calculate pressure loss in aerated fluids flowing under elevated pressure and temperature conditions.

5.1 Calibration of Cuttings Injection & Separation Systems

Calibration work is in progress to obtain the desired cuttings injection rate. The purpose of the calibration work is to relate the auger RPM to the cuttings injection rate. In other word, we need to find out how many cuttings will be injected into the flow loop at a given RPM

During the calibration test, the mixture of water and air flows through a 4 inches pipe, which is at the bottom of the cuttings injection auger. Figure 5.1 shows the detailed configuration.

By turning the motor-driving auger, which is installed in the vertical position of cuttings injection tower, cuttings will fall into the 4 inches pipe and flow with the air/water mixture. Then the three-phase mixture flows into the annular section (5.76’’ x 3.5’’).

At both ends of the annular section, two quick close valves are installed to trap the three-phase mixture. Two nuclear densitometers are installed in the annular section to measure the mixtures’ density. However, the information of mixture density is not sufficient to determine the mixture volumetric concentration of the three components. Another parameter is needed to solve the problem. The holdup system was tested successfully. The three-phase mixture was trapped in the annuli with small pressure change.

An air expansion tank, which is connected to the annular section by a small tube, is used to measuring the volume of air trapped in the annular section. Based on the equation-of-state, by measuring the pressure changes in the annular section and air expansion tank, the volume of air in the annular section can be determined.

The air expansion operation has been tested successfully. A noticeable pressure drop in the annular section was observed. Also, as expected, the pressure increased in the air expansion tank. The expansion tank is working well when the annular pressure is below 250psi. When the annular pressure is higher than 250 psi, the larger pressure difference causes some water to be drawn into the air expansion tank during the expansion operation. A needle valve is needed in the expansion tube to eliminate this suction effect.

Since the sum of the concentrations of each phase should equal to one, and the mixture density is measured by using the nuclear densitometers, the volumetric concentration of each phase can be obtained. By assuming there is a uniform cuttings bed under steady-state condition, the cuttings bed height can be calculated.

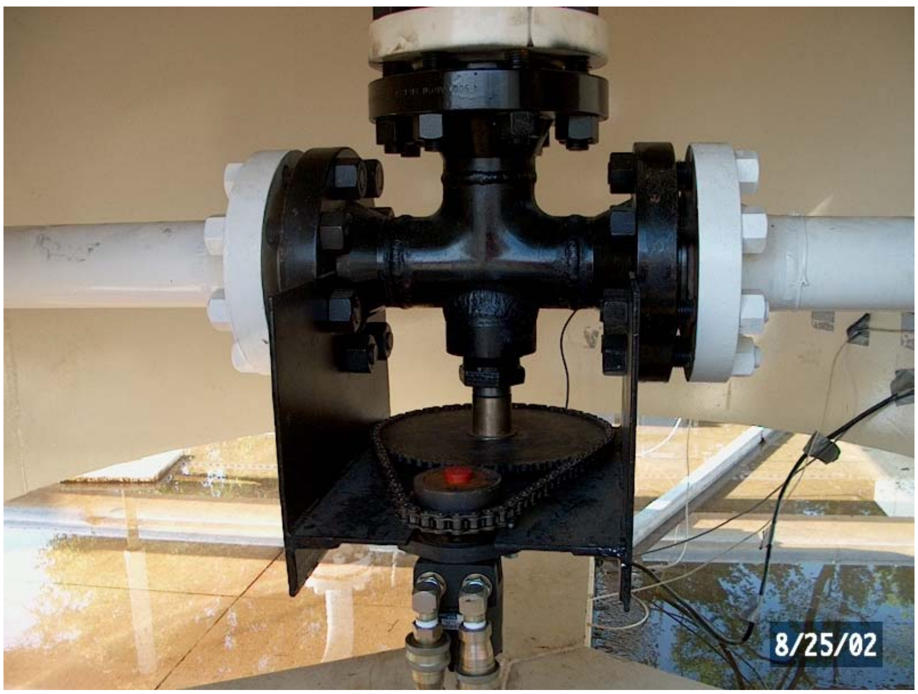

Figure 5.1 – Cuttings Injection into 4-inch Flowline

The first step of calibration test is to load the cuttings to the injection tower, which is being conducted by using a transfer auger. Before starting to inject cuttings, the lid of the injection tower is opened to measure the height of the cuttings in the tower. The net weights of the injection tower and collection tower are set to zero. So the weight change caused by cuttings injection and collection can be easily observed from the load-cell readings.

Before injection of cuttings is initialed, a 12 inches valve is opened to allow the cuttings to fall down from the tower to auger. In principle, the driving motor rotational speed is set by LabView software to achieve the computed cuttings injection rate.

During the tests, air/water flow rates were well controlled. And water was heated to 80 F. The back pressure was held at 100 psi. The buildup and washout of beds of cuttings "were observed" in the annular section by watching readings from the nuclear densitometers and the differential pressure gauges.

As mentioned earlier, a flushing system is installed in the annular section. The reason to use the flushing system is to measure the weight of cuttings trapped in the annular section. Because of the configuration of the flow loop, cuttings flow through the annular section first, then through a 4-inch pipe, and on to the collection tower.

Figure 5.2 - Flushing System for ACTS Flow Loop

In order to measure the cuttings' weight in the annular section, the flushing procedure should be as follow: flush the 4 inches pipe first, to clean the cuttings which are accumulated in the 4 inches pipe. Until the weight of collection tower is no longer to change, tare the collection tower, then flush the cuttings, which accumulated in the annular section, and read the measured change in weight of the collection tower. As shown in Figure 5.2, there are two valves that control flow through the flushing lines. The upper valve is for flushing of the annular test section; and the lower valve is for flushing the 4-inch pipe.

At the end of the test, after shutting off the air/water flow and the cuttings injection auger, the lid of the injection tower is opened again to visually measure the cuttings level in the injection tower. This is considered to another reliable parameter can be used to evaluate the cuttings injection rate.

Figure 5.3 is a sample of calibration data. The test condition is as follows: the air flow rate is 60 SCFM, the water flow rate is 150 GPM, back pressure is 100psi, and the temperature is 80 F.

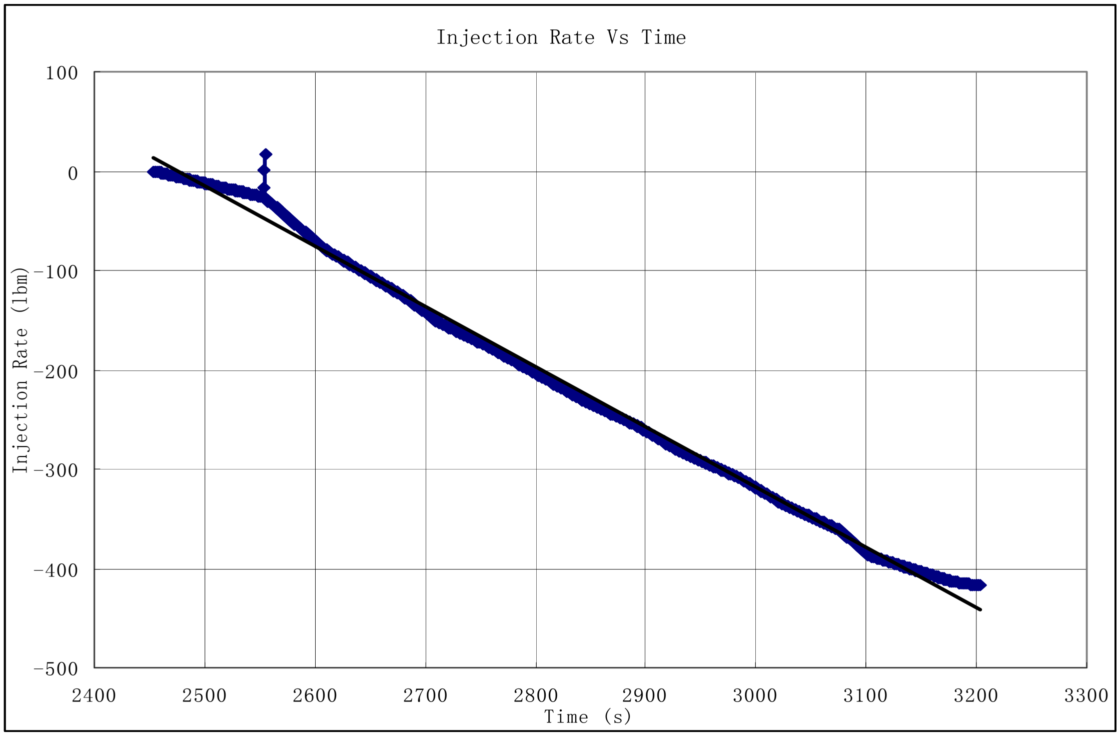

Figure 5.3 - Cuttings Injection Rate vs Time

5.3 Calibration of Load Cells

At the bottom of both the injection and collection towers, three load cells are located around the circumference at 120^o degree apart to measure the weight of each tower. The real time readings of the weights of the towers can be shown on the computer screen. A simple procedure is taken to calibrate the load cell.

During the calibration, all the valves connected to the injection tower were closed. The injection tower was filled with water from the bottom valve. The water level in the tower was measured with a DP transducer. Then the tower was drained from the bottom valve under ambient pressure. The changes of differential pressure in the tower and weight change of the tower were recorded with respect to time. The test results indicate that the weight measurement of load cell is rather accurate.

Figure 5.4 – One of Three Load Cells under Injection Tower

5.4 FUTURE WORK

1. Calibration of cuttings injection/collection system.

2. Air/water/cuttings three-phase test at EPET conditions.

3. Data analysis.

5.5 DELIVERABLES

1. Semi-annual Advisory Board Meeting (ABM) reports.

2. Two-phase flow model for aerated fluids under elevated pressure and temperature conditions.

3. Practical guidelines and/or graphs to determine the optimum gas/liquid rate to get the maximum cuttings transport capacity of aerated fluids under elevated pressure and temperature conditions.

4. A computational tool to calculate frictional pressure drops inside an annulus for aerated fluids flowing over the range of experimental conditions.

6. Study of Cuttings Transport With Foam Under Elevated Pressure and Elevated Temperature Conditions (Task 13)

Investigator: Zhu Chen

6.1 Introduction

This research is a continuation of the two research projects (Tasks #6 and #9) done in the University of Tulsa Drilling Research Projects (TUDRP) on foam rheology and cuttings transport. Task 6 investigated cuttings transport with foam under low pressure and ambient temperature conditions, and Task 9 studied foam rheology under Elevated Pressure and Elevated Temperature (EPET) conditions.

Foam is a currently being used as drilling fluid in Underbalanced Drilling (UBD) because it can provide downhole pressured that are less than formation pressures, which is the definition of "underbalanced". Foam can also provide control of the Equivalent Circulating Density (ECD). Drilling with foam has demonstrated that it can provide such advantages as minimizing formation damage, increasing rate of penetration and preventing lost circulation, etc. However, when compared with traditional incompressible fluids, such as water-based or oil-based drilling fluids, foams are significantly more complex. There is no general agreement on a foam rheology model, and little research has been done on foam rheology for practical downhole conditions. Furthermore, there is an absence of reliable data on cuttings transport with foam. Little work has been done, and there is almost no publicly available knowledge on foam cuttings transport properties under practical down-hole conditions. A better understanding of foam cuttings transport characteristics may lead to advancements in the technology of underbalanced drilling with foams.

In order to meet the increasing interest in foam drilling by the petroleum industry, based on the issues discussed above, the University of Tulsa ACTS/JIP proposes an extended research program in this field. The title of this project is indicated above. It includes two research areas: foam rheology study under EPET conditions and cuttings transport study with foam under EPET conditions.

6.2 Objectives

The objectives of this research are to:

1. Conduct an experimental investigation of foam rheology in pipes and an annulus under ETEP conditions.

2. Experimentally determine and numerically predict volumetric requirements for effective cuttings transport with foam in horizontal wellbores under EPET conditions, initially without pipe rotation.

3. Develop a mechanistic cuttings-transport computer simulator for EPET applications.

4. Verify the computer simulator via comparisons with experimental data.

6.3 Approach

Polymers will be included in the water-base surfactant solutions. This is expected to make make a significant difference compared to the two previous TUDRP studies of foam. Polymers are expected to enhance foam stability and resist breakage of the foam when there is an influx of formation fluids. Currently 2 foam formulations are being considered:

1. Formulation A: 1-2% surfactant solution + 2.5 g/L Xanthan + 1 g/L Aquapac regular + 0.5 g/L Nacl (pH 9) ,

2. Formulation B: 1-2% surfactant solution + 2 g/L Xanthan + 0.5 g/L Nacl (pH 9) .

The ACTS Flow Loop will be used to conduct foam rheology and cuttings transport studies under EPET conditions. A Fann 75 HPHT viscometer will be used to measure the viscosity of mixtures of the base fluids and polymers at ambient pressures and temperatures. In addition, the new TU design for a "Foam Generator/ Viscometer" (Task 9b) will also be used to study foam rheology, foam texture and the influence of wall roughness on foam rheology at EPET. The new "Foam Generator/ Viscometer" is an advanced instrument that is designed to measure foam viscosity and study foam rheology. This new instrument is currently being developed (see Section 4) and is expected to provide essential data on the characteristics of foams.

6.4 Summary of Recent Work

Literature review on foam rheology and cuttings transport with foam has been conducted and is currently being studied. This review indicates that foam rheology has been studied extensively and many researchers have investigated foam properties from different aspects, but there is no "best" model to characterize the rheology of foams. Furthermore, there are only a limited number of papers addressing the problem of foam rheology characterization under EPET conditions. In addition, no literature has been found on cuttings transport with foam under EPET conditions. Therefore, the literature review indicates that this research is needed in order to advance the technology of drilling with foams.

A detailed research proposal report was prepared and presented at the November 19th ABM Meeting to the ACTS JIP members. This research proposal was considered to be acceptable and suggestions were received during the meeting.

Preliminary experiments with two candidate aqueous foam formulations were conducted (see Formulation A and Formulation B above). Two types of polymers were added to a base fluid consisting of water and a surfactant. A Fann 35 viscometer was used to measure viscosity of the base fluid. In addition, foam stability test were also performed. Results from these experiments are still being analyzed, but one of the definite conclusions is that polymers greatly enhanced the stability of the foam, i.e., the half-life time of a foam increases greatly when polymers are added.

Plans are being made for future experiments on foam rheology and cuttings transport in the ACTS Flow Loop. As part of the preparations for this test, the student investigator is participating in the tests for Research Task 10. In addition, he is becoming familiar with the features of the Fann 75. Additional accessories have also been ordered for this instrument that will extend the range of viscosities that can be measured.

6.5 Future Plans

The literature review on foam rheology, foam texture, foam flow models, cuttings transport, the influence of temperature and pressure on foam rheology and cuttings transport will be continued. Indoor laboratory tests on different base liquids with polymers will be conducted using a Fann 35 and a Fann 75 viscometers. Also, stability of the foams will be investigated.

Continuing the process of learning about the ACTS Flow Loop and how to conduct tests. Develop a test plan for foam rheology and cuttings transport tests.

Finally, become familiar with the foam hydraulics model developed by Ozbayoglu as part of Research Task 6., and prepare to compare this simulator with test data from the ACTS at EPET. Based on these comparisons, then decide whether to improve the existing model or develop a new model. The objective is to develop a mechanistic simulator of foam flow and cuttings transport with foam at EPET that is valid for a wide range of drilling applications.

7. DEVELOPMENT OF CUTTINGS MONITORING METHODOLOGY (Task 11)

Investigators: Kaveh Ashenayi and Gerald Kane (Profs Electrical Engr.)

Objectives

The ultimate objective of this task (Task 11) is to develop a non-invasive technique for quantitatively determining the location of cuttings in the annular (drilling) section of the ACTS Flow Loop. There are four different techniques that could be examined. However, as it was pointed out in the previous reports only three have good potential for success. These are Ultrasound, X-Ray/Gamma-Ray and Optical. Of these, we are concentrating on Ultrasound Transmitters and Sensors for Task 11.

Team Composition:

The team responsible for developing instrumentation to measure cuttings concentration and distribution within an annulus consists of Dr. Gerald R. Kane and Dr. Kaveh Ashenayi. Both are registered professional engineers and professors of Electrical Engineering Department at the University of Tulsa. MS level graduate students are assisting them. These students have BS degrees in EE and Computer Science. This particular combination works well since successful completion of this project requires skills from both disciplines. To achieve the objectives of this task, we will need to develop a very complicated electronic hardware/sensor and a software package that correctly interprets the ultra-sonic data received.

7.1 Approach

In subtask one of Instrumentation Task 11, we are to develop a static (followed by a dynamic) radial test cell and to develop a preliminary set of instruments to detect the presence of cuttings in this cell.

The main approach to be investigated is the ultrasound transmission. The need for an inner ring will be further investigated by comparing the results of two experiments. The first experiments will be done with a set of rings mounted only on the outer pipe. The angle, at which the sound is being transmitted, will be rotated relative to the sand collection. We will measure the sound received will be measured and compared with the transmitted sound. After suitable data processing, it should be possible to get an acceptable picture of what is inside the pipe. This is very similar to the MRI technique used by physicians.

In the second experiment we will repeat the same experiment except we will add one or more rings of sensors on the inner pipe. The inner ring will act as a source and the outer ring will act as receivers. Then we will repeat the experiments.

7.2 Progress to Date:

The sensor control board developed by our team was assembled and tested. There are two noise signals that are interfering with the proper operation of the sensors. The first is a high frequency (300 kHz) ground noise that can be filtered out. The second signal is at 75 kHz. This is the main problem. The noise is radiated by the inductors that are required for the proper operation of the sensors.

Revisions and improvements in the data-collection software are proceeding, but this work has been slowed by the circuit board problems. The software starts by allowing the user to setup the communication characteristics of the system. Next it allows a user to identify the number of boards connected. The data received from the sensor board is in the form of ASCII characters. A conversion algorithm enables the calculation of numerical values of voltage corresponding to the character combinations that are received.

Verification tests have been conducted with the existing circuit board and software. The results indicate the instrumentation can distinguish between different concentrations of sand. In addition, tests indicate that this ultra-sonic measurement system may work satisfactorily without mounting sensors on the inner pipe of an annulus.

7.3 Future Work:

We plan to work with an external expert on minimizing circuit-board noise to eliminate the radiated noise. Then we will test the new hardware and firmware. At the same time we are implementing our data analysis software.

Two sets of experiments will be conducted with a clear plastic cell. First, a set of rings will be installed on the outer pipe. Then the sound received will be measured and compared with sound transmitted. After suitable data processing, it should be possible to get an acceptable picture of what is inside the pipe.

In the second experiment, a similar experiment will be conducted except an inner ring of sensors will also be mounted on the inner pipe. The inner ring will act as source and the outer ring will act as receivers. We will use the same setup for calibrating the system.

We will use neural networks to model the effects of fluid flow on the signal received as well as the shape of the sand collection. This is needed due to the highly nonlinear nature of a slurry flow. It has been shown that neural networks can successfully model this type of nonlinear systems.

A uniform bed of sand will be established at the bottom of the clear plastic pipe. Shaking the pipe and allowing the sand to settle in water can accomplish this objective. Next, a number of measurements will be made. This process will be repeated for different sand volumes. This will provide test data for different heights of sand at the bottom of the pipe. This constitutes the static test conditions.

8. DEVELOPMENT OF A METHOD FOR CHARACTERIZING BUBBLES IN ENERGIZED FLUIDS (TASK 12)

Investigator: Leonard Volk (ACTS Research Associate)

8.1 Introduction

Bubbles (as foam or aerated fluid) will be moving at a high rate (up to 6 ft/sec) in the drilling section of the ACTF, and may be very small (down to 0.01 mm). The bubble size and size distribution influence the fluid rheology and the ability of the fluid to transport cuttings. Bubbles in a shear field (flowing) may tend to be ellipsoidal which might alter both the rheology and transport characteristics.

This project is Task 12 (Develop a Method for Characterizing Bubbles in Energized Fluids in the ACTF During Flow) in the Statement of Work, and is divided into four subtasks:

- Subtask 12.1. Develop/test a microphotographic method for static conditions;
- Subtask 12.2. Develop/test a method for dynamic conditions;
- Subtask 12.3. Develop simple, noninvasive methods for bubble characterization;
- Subtask 12.4. Provide technical assistance for installation on ACTF.

Subtask 12.1 includes (1) magnifying and capturing bubble images, (2) measuring bubble sizes and shapes, and (3) calculating the size distribution and various statistical parameters.

Subtask 12.2 develops the methods needed to apply the results of Subtask 12.1 to rapidly moving fluids, especially the method of “freezing” the motion of the bubbles. A dynamic testing facility will be developed in conjunction with Task 11 for development and verification.

Subtask 12.3, added in year 3, develops simple, inexpensive and small-in-size methods for characterizing bubbles. This task was previously referred to as “New Techniques”.

Techniques and methods developed under Subtask 12.2 and 3 will be applied to the drilling section of the ACTF in Subtask 12.4.

8.2 Objectives

One of the primary objectives of this task is to develop the methodology and apparatus needed to measure the bubble size, size distribution and shape during cuttings transport experiments.

A second objective is to establish standards for when a hazards review for the ACTS Flow Loop should be repeated.

A third objective is to develop a safety training course for all personnel that are involved in using the ACTS Flow Loop and equipment.

8.3 Project Status

8.3.2 Dynamic Bubble Characterization

8.3.2.1 Dynamic Imaging

Imaging software from Optimas has allowed foam bubbles to be processed by others(1). A temporary copy has been ordered to see if it will be useful in capturing the various parameters we need for characterizing foam. In the mean time, the average bubble size can be calculated by hand from bubble images captured by our frame grabber.

8.3.2.2 Dynamic Testing Facility

The loop just upstream of the optical cell has been modified to better accommodate prototype cells for measuring the average bubble size and foam quality. This modification will also facilitate relocating the prototypes to another part of the loop once the ultrasonic cuttings tomography devices are ready for dynamic testing. The polycarbonate safety shields for the optical cell and sight cell have been constructed and installed.

During disassembly of the loop, considerable deposition of corrosion products were noticed on the windows of the optical cell and average bubble size prototype. Tests have been designed to check for the deposition of corrosion products in the presence of pipe dope, cutting oil residue and corrosion inhibitor. Microscope slides will be placed at an angle inside 1-1/2" diameter by 2" long sections of pipe to examine the deposition on the top and under side of the slides as corrosion occurs. Deposition/corrosion in water will serve as a reference. Figure 8.1 shows the typical setup.

8.3.3 Novel Techniques for Bubble Characterization

Average bubble size. A second light source (Dolan-Jenner PL 900) has been received. It has a DC power supply for increased lamp stability.

Foam Quality. The latest concept for measuring the foam quality optically was presented last quarter as Figure 8.2 and is shown below as Figure 8.2. We are looking for a local vender to cut and polish a short section of glass rod so that the foam quality measurement device can be constructed. A 3000# 1-1/2" pipe cross has been tapped to accept a ½" fitting in preparation for the foam quality optical fitting.

8.4 Planned Activities

8.4.2 Dynamic Bubble Characterization

- Locate a vendor with software adequate for our use.
- Locate a camera to give us clearer microscopic images.

8.4.3 Novel Techniques for Bubble Characterization

- Determine optimum method of maintaining clean optical windows
- Calibrate the average bubble size prototype
- Complete construction for the foam quality prototype and calibrate.

8.4.4 References

1. Herzhaft, B., “Correlation Between Transient Shear Experiments and Structure Evolution of Aqueous Foams”, Journal of Colloid and Interface Science, **247**, 412-423 (2002)

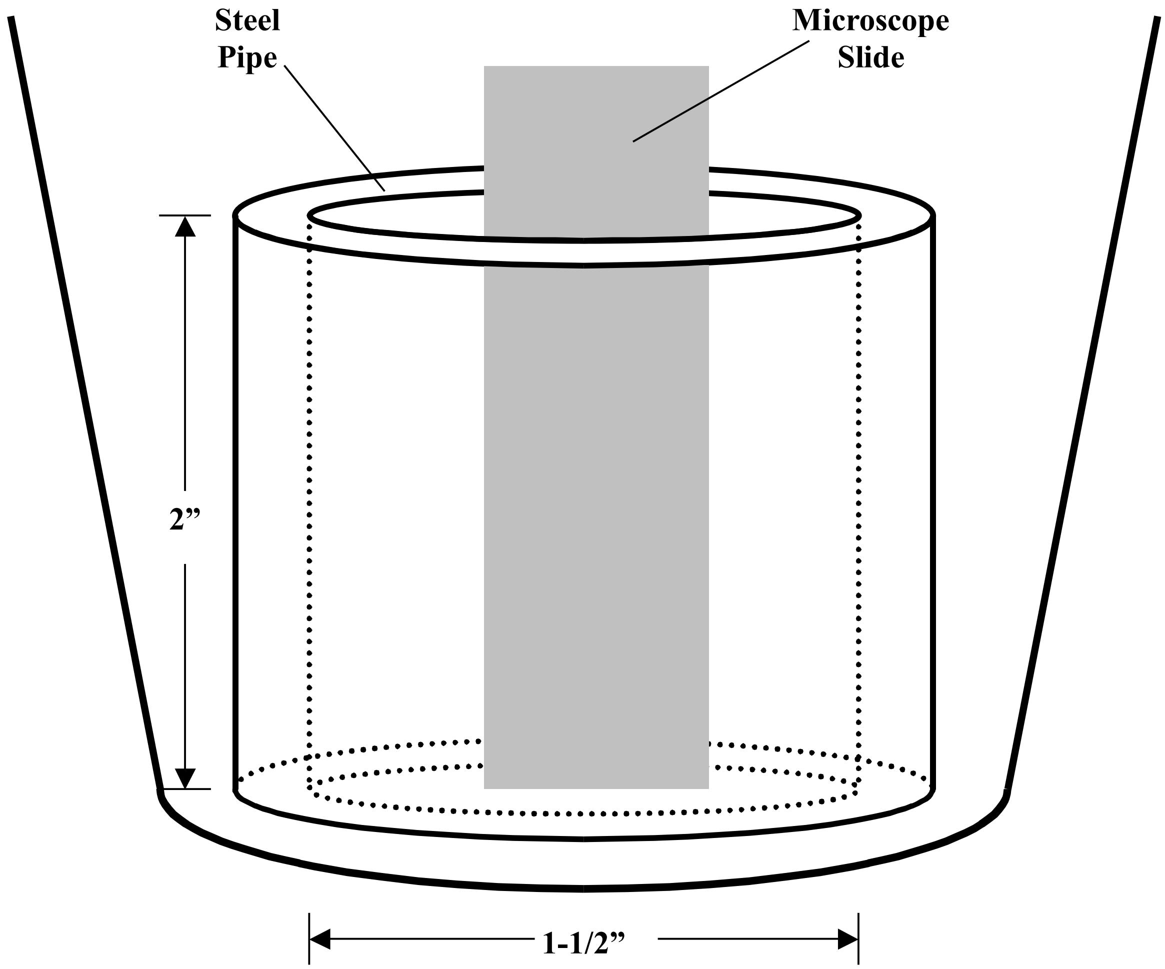

Figure 8.1 - Microscope slide placed inside pipe section for corrosion test

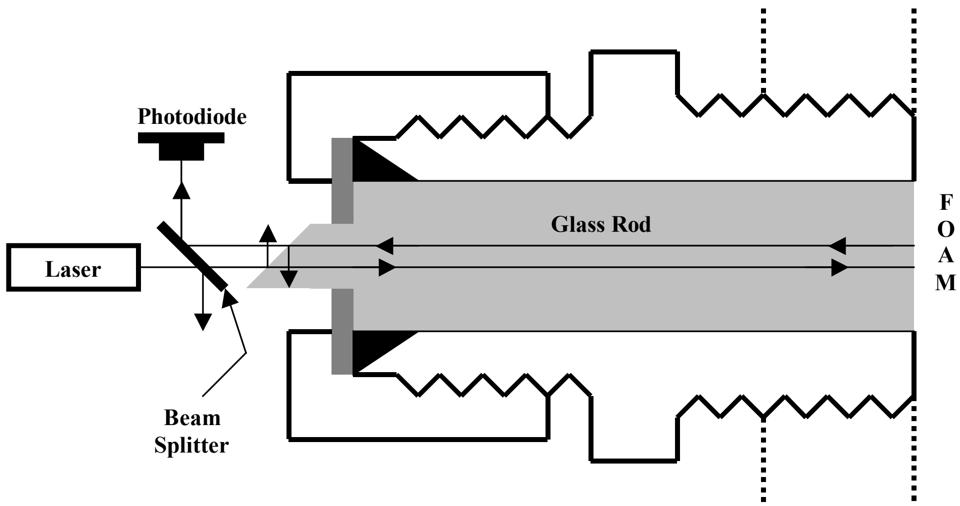

Figure 8.2 - Method for determining the quality of foam

9. SAFETY PROGRAM (TASK 1S)

Chairman, Process Hazards Review Team: Leonard Volk (ACTS R.A.)

9.1 Introduction

This project was initiated during the fourth quarter of 2000 to assess the hazards associated with the Advanced Cuttings Transport Facility (ACTF) and develop an Action Plan to address problems discovered during this Hazards Review. A Hazards Review is an industry accepted method used to improve the overall safety characteristics and reduce the possibilities of accidents in the work place. Each individual component of the ACTF is examined as to the effect and consequences on safety, health, and the environment, of the component in all possible operational modes. A Hazards Review can result in equipment modification, inspection and testing, documentation, personal protective equipment, personnel training, and/or emergency training. The hazards review process begins by selecting a review method. Next a team of qualified individuals must be formed. This team should include those knowledgeable in the review process and those familiar with the process to be reviewed. Prior to beginning the review, all available documentation needs to be gathered. This includes schematics, organized training, periodic inspections and testing results, design and construction documents, operating procedures, etc. Once the schematics have been verified and the operator of the equipment or process has reviewed its operation with the team, the Hazards Review begins. The review should continue uninterrupted until completed. After the findings and recommendations have been completed, a draft report is issued and reviewed by all team members, and the operator of the process or equipment. Following this review, any changes are incorporated and a final report issued. This completes the Hazard Review process. The operator then needs to develop an action plan to implement the recommendations from the Hazard Review. In our case, team members will participate in developing this plan.

9.2 Objective

The first objective of this task is to identify problems (findings) that might result in injury, property damage or the release of environmentally damaging materials and provide recommendations to minimize them, and to develop an action plan based on these recommendations.

A second objective is to establish standards for when a hazards review for the ACTS Flow Loop should be repeated.

A third objective is to develop a safety training course for all personnel that are involved in using the ACTS Flow Loop and equipment.

9.3 Project Status

Activities this quarter continue to be the implementation of the Action Plan, responding to the several findings listed in the Hazard Review. Table 8.1 contains an excerpt from the Action Plan to illustrate how findings are addressed.

Table 1. Example of Finding in Action Plan

Finding, Line 143: No MSD sheets available on site

Description of Finding
MSD sheets for all chemicals on site need to be in a binder or file, and located at this site.

Personnel Addressing Finding
NickolasTakach, Len Volk

Solution

- Identify all chemicals on site. The ACTS project has three “locations”: the ACTF, a mud lab and the DTF.

- Locate the MSD sheets for these chemicals. Vendors/suppliers/manufacturers must supply MSD sheets for chemicals the supply. MSD sheets for most commercially available chemicals can be found on line.

- Place these in a loose-leaf binder marked “MSDS – Location”. Organize these in some logical way, such as alphabetically by chemical name.

- Have an index listing the chemicals by the order that they appear. One method would be to create an Excel spreadsheet so that it can be updated as the chemicals on site change. This compilation of MSD sheets could also be incorporated as an appendix into the chemical inventory, and the chemical inventory could serve as an index to the MSD sheets.

Action Required
Create a Chemical Inventory listing all chemical by site.
Locate all MSD sheets & place in a binder on site.
Create an index for MSD sheets.

Estimated Cost
Materials: One loose-leaf notebook per site

Manhours: Since we have most of the MSD sheets, we would only need to acquire the remainder, organize them and place them into a binder. Additional man-hours will be required to assemble the Chemical Inventory.
Estimated man-hours: 10.

Contractor: None

Date	Status
Jun 02	MSDS - DTF: In binder and located on lab bench across from DTF
Jul 02	MSDS - ACTF: In binder and located on tool shed
Oct 02	MSDS - Mud Lab: Old and unneeded chemicals removed. MSD sheets being located for remainder of chemicals
Dec 02	Chemical Inventory – DTF: In progress
Dec 02	Chemical Inventory – ACTF: In progress

9.4 Planned Activities

- Continue implementation of the Action Plan
- Prepare for review of latest modifications to the ACTF
- Continue designing and preparation for a safety training course.

10. TECHNOLOGY TRANSFER

Meetings with Petroleum and Service Companies

ExxonMobil attended the November ABM, but they have not yet decided to join the Acts Project. MI Drilling Fluids has asked for all of the details about joining and are in the process of making a decision. We expect to hear of their decision during the next quarter.

There are presently some concerns about Intevep being unable to continue their participation owing to the well-publicized political problems within Venezuela. At this time, we have not received any indication that they intend to discontinue their ACTS membership

Unfortunately, the merger between Conoco and Phillips has caused them to delay a decision about participating in the TU JIP Projects. A major restructuring of the company is underway. Since the merged companies will become the third largest petroleum company in the US, we will continue to be alert for the right timing to reinitiate our efforts to attract the new ConocoPhillips. In the mean time, we will continue to identify and contact other petroleum and service companies that will benefit by participating in this project.

ACTS-JIP Advisory Board Meeting

The next Advisory Board Meeting will held on May 20, 2003. In addition to the DOE, there are currently 10 member companies participating in the ACTS-JIP Project. They are: 1) British Petroleum, 2) Baker-Hughes , 3) ChevronTexaco, 4) Schlumberger Dowell, 5) Halliburton, 6) Intevep, 7) Petrobras, 8) Statoil, 9) TotalFina-Elf, and 10) Weatherford International.