

Exhibit A
University of Tulsa Proposal
Hydrate Performance Flowloop Cold Flow Program

Background: The University of Tulsa will utilize its Flow Assurance Loop (FAL) to conduct the work proposed in the scope of work. The FAL was constructed in 1999 and several tests were made by BP, CSM and Marathon before Marathon made a decision to terminate its flow assurance research program in late 2000. This facility, Figure 1, was moved to Tulsa in June 2002 and reconstructed during the summer. The facility is a 3 inch-diameter flow loop, mounted on a 80-ft long tilt table as shown in Figure 2. The flow loop is 160-ft long and has an operating pressure of 2,200 psig. A Leistritz multiphase twin-screw pump circulates the fluids with a velocity up to 15 ft/s (Figure 3) and can generate the various flow patterns typically encountered in subsea pipelines. The flow loop is fully jacketed and the flow loop temperature is controlled with glycol circulating inside the annulus space. A 20-ton chilling system is used for cooling purposes and a steam heat exchanger and steam coils are used for heating. The fluid addition systems (oil, water, gas, additives, solvents) are located inside the process equipment building (Figures 4 - 6). These systems are used to initially charge the flow loop with oil, water, additives and gas, as well as to add make-up gas during the hydrate formation process. The entire facility is remotely operated from a control trailer (Figures 7 and 8).

Besides the necessary safety instrumentation, the facility is equipped with pressure, differential pressure and temperature transducers at various locations along the loop. Drops in pressure are recorded to monitor the hydrate formation process; flowing pressure drops can be monitored for studies on slurries and hydrate transports. Four view ports and three gamma-densitometers are available on the flow loop to visually observe the fluid distribution and hydrate structure and to monitor the fluid densities.

The flow loop can be operated in a circulation mode using the multiphase pump or in the rocking mode to simulate slugs and restart conditions. Cooling ramps can be programmed with the chiller to simulate pipeline cool down after shutdown; different cooling rates can simulate different insulation efficiencies. As hydrates are formed, gas is consumed and the loop pressure will decrease; the gas addition system has the capability of adding make-up gas to maintain a constant pressure in the flow loop, thus adding more gas to form more hydrates and eventually generate plugs. Should plugs occur, the flow loop can be depressurized and plug dissociation studies can be performed.

An additive addition system is used to study the effect of various inhibitors on the hydrate formation process. All recorded parameters provide information on the kinetics of hydrate formation/dissociation; an accompanying hydrate laboratory cell will provide additional data, making it possible to attempt scale up of existing and developed models to process conditions.



Figure 1: FAL Facility



Figure 2: Flow Assurance Loop Mounted on Tilt Table



Figure 3: Leistritz Multiphase Pump



Figure 4: Process Equipment Building



Figure 5: Gas Addition System



Figure 6: Process Equipment Building – Gas/Water Injection System



Figure 7: Control Trailer



Figure 8: Control Trailer Overlooking Flow Assurance Loop



Figure 9: 100 bbl Storage Tanks

Scope of Work: Perform a flow loop test program series to provide benchmark data for kinetic model validation, and rheological assessment of slurry flow. This information will expand the database of benchmark data beyond gas and gas condensate systems typically encountered in the deepwater Gulf of Mexico. In conjunction with D. Sloan of CSM, data from this project will be used to validate their hydrate formation and kinetic behavior model as well as their dissociation model for hydrate slurry blockages.

Test apparatus

A 3 inch - 160-ft long flow loop will be used to conduct the experiments. This flow loop has been designed, constructed and operated by Marathon Oil Company and donated to the University of Tulsa. The proposed experiments will be tied into a Joint Industry Project on Hydrates Flow Performance to reduce project costs.

Pressure, temperatures and pressure drops are measured along the flow loop. Three densitometers and 4 sapphire windows will provide additional and visual observations. Hydrate particles morphology can be observed through the sapphire windows.

Test procedure

The flow loop will be charged with oil, water and gas at an initial temperature to be specified. A period of cooling and steady-state flow conditions will begin the test, followed by a 24-hour shut-in. The flow will then be restarted progressively at increasing rates. A step-up restart is recommended to determine the critical shear rate, since a restart at high rates may lead to shearing of hydrate particles during the process and affect test results at the lower rates. The step-up process prevents the shearing of the hydrate particles until flow is resumed. Tests will be conducted with and without additives. After each test, the flow loop will be cleaned and prepared for the next experiment.

For planning purposes, each test conducted with the above procedure is assumed to take 5 to 7 working days to complete, including test preparation and cleanup.

Test matrix

The proposed test matrix to provide benchmark data for kinetic model validation is defined in Table 1 below while the test matrix for additive testing is shown in Table 2.

Test #	Water cut			Cooling rate		Test procedure		Long shut-in time	
	<15%	20-40%	80%	5 F/hr	40 F/hr	Cte V	Cte P		
1	X			X		X			
2	X			X			X		
3	X				X	X			
4	X				X		X		
5		X		X		X			
6		X		X			X		
7		X			X	X			
8		X			X		X		
9			X	X			X		
10			X		X		X		
11		X		X			X		X
12		X			X		X		X

Table 1: Proposed test matrix for one crude oil

Benchmark tests will be conducted on four oils. Both constant volume and constant pressure tests will be conducted at three water cuts and two cooling rates. Two of the tests will have long shut-in times of around 5 days with the rest will be 24 hour shut-ins.

Test#	Water Cut		Salinity			Concentration		OeP
	<15%	20-40%	Base	Max	>Max	Hgh	Low	
1	X		X			X		X
2	X		X				X	X
3	X			X		X		X
4	X				X	X		X
5		X	X			X		X
6		X	X				X	X
7		X		X		X		X
8		X			X	X		X

Table 2 Proposed Test Matrix for One Chemical Additive

Two different water cuts will be tested, each one of these with two additive concentrations, plus an additional baseline test with no additive. These tests will be conducted on four crude oils. Each test will be conducted at a maximum of 2,200 psig and a temperature of about 40 °F.

Deliverables:

The technical evaluation, databases and test data for hydrate slurry oil systems will be documented in a technical report that includes:

- Hydrate formation and growth data under different conditions and different oil chemistries
- Comparison of lab test data to flow loop data and field data
- Rheological assessment of slurry flow
- Dissociation data of hydrate blockages
- Better understanding of hydrate inhibition with additives (anti-agglomerates) and additive selection criteria
- Better understanding of hydrate growth structure under different conditions
- Better understanding of characteristics within oil systems that promote or prevent plugging

This data will be used to validate hydrate formation and kinetic behavior models as well as dissociation models for hydrate slurry blockages in collaboration with Colorado School of Mines. The validated models will be downloaded on CD's and attached to the report.

Organization and Key Personnel: The organization to carryout the proposed work is shown in Figure 10.

Dr. Volk is the Manager of Research and Technology Development program at the University. Before joining the University of Tulsa, Volk worked 20 years in the oil and gas industry. His resume is attached in Appendix II. Volk will serve as PI and will act as project manager/technical coordinator and be responsible for project management, budget compliance and reporting. He will also interact and collaborate with the co-PI, post doc, project engineer, graduate students and participants. Volk performs similar duties for the multi million dollar Coking JIP in which he is the PI and the Paraffin Deposition JIP in which he is a co-PI.

Dr. Sarica is the Director of the Fluid flow Projects and an Associate Professor of Petroleum Engineering. After serving as an Assistant Professor of Petroleum Engineering at ITU, he joined the research staff at Tulsa University as an Associate Director of Fluid Flow until 1998 when he joined the faculty at Penn State University. He returned to the University of Tulsa in 2001. As a co-PI, Sarica will be responsible for interfacing with the Petroleum Engineering Department and serve as the chairman of graduate student research committees. He will also interact and collaborate with the PI, post doc and graduate students. Sarica performs similar duties for the paraffin JIP in which he is the PI.

Emmanuel Delle Case is a project engineer for the Petroleum Engineering Department. He served as a research scholar from 1996-1998 in the paraffin deposition JIP before returning to TotalFinaElf as a process lab engineer where he was responsible for proposing and conducting various flow assurance studies including paraffin, asphaltenes, emulsions and oil/water separation. He returned to the University of Tulsa in 2000. Emmanuel will be responsible for the safety program, coordinate the work of the technicians and flow loop operators and provide data quality control. Delle Case performs similar duties for the paraffin and fluid flow projects.

Dr. Dendy Sloan and a post doctoral candidate will collaborate with the University of Tulsa. The post doctoral candidate will be housed at the University of Tulsa. The CSM Center for Hydrate Research is well known for both its fundamental and applied research on hydrates. They will use the benchmark data from the experiments to validate hydrate formation and kinetic behavior models as well as dissociation models for hydrate slurry blockages.

All key personnel are available for the project as specified in the man-hours chart in Table 3.

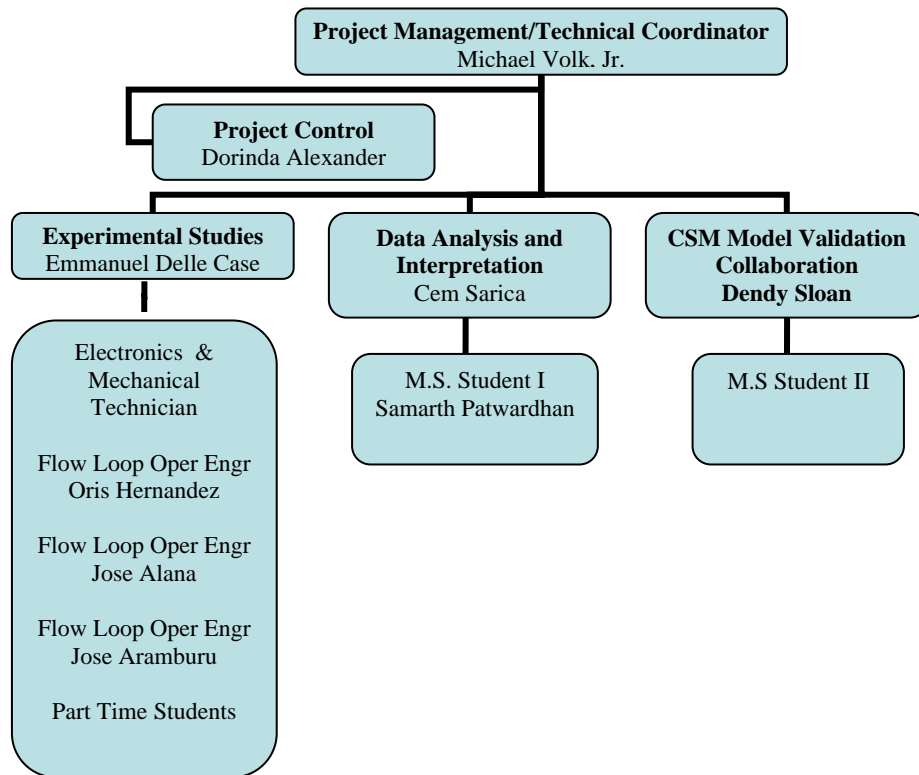


Figure 10: Organizational Structure

Project Schedule: The proposed work for this project will be conducted in conjunction with the JIP. The participants will receive the deliverables outlined above. The timing for completing these tasks is superimposed on the Gantt chart shown in Figure 11. This chart shows that four oils could be studied in a two year period. Tests will start with the Troika oil that is in-house. The next series of tests will be conducted with BP’s Buttermilk oil. Discussions will be held with the participants regarding what oils should be used for the last two tests.

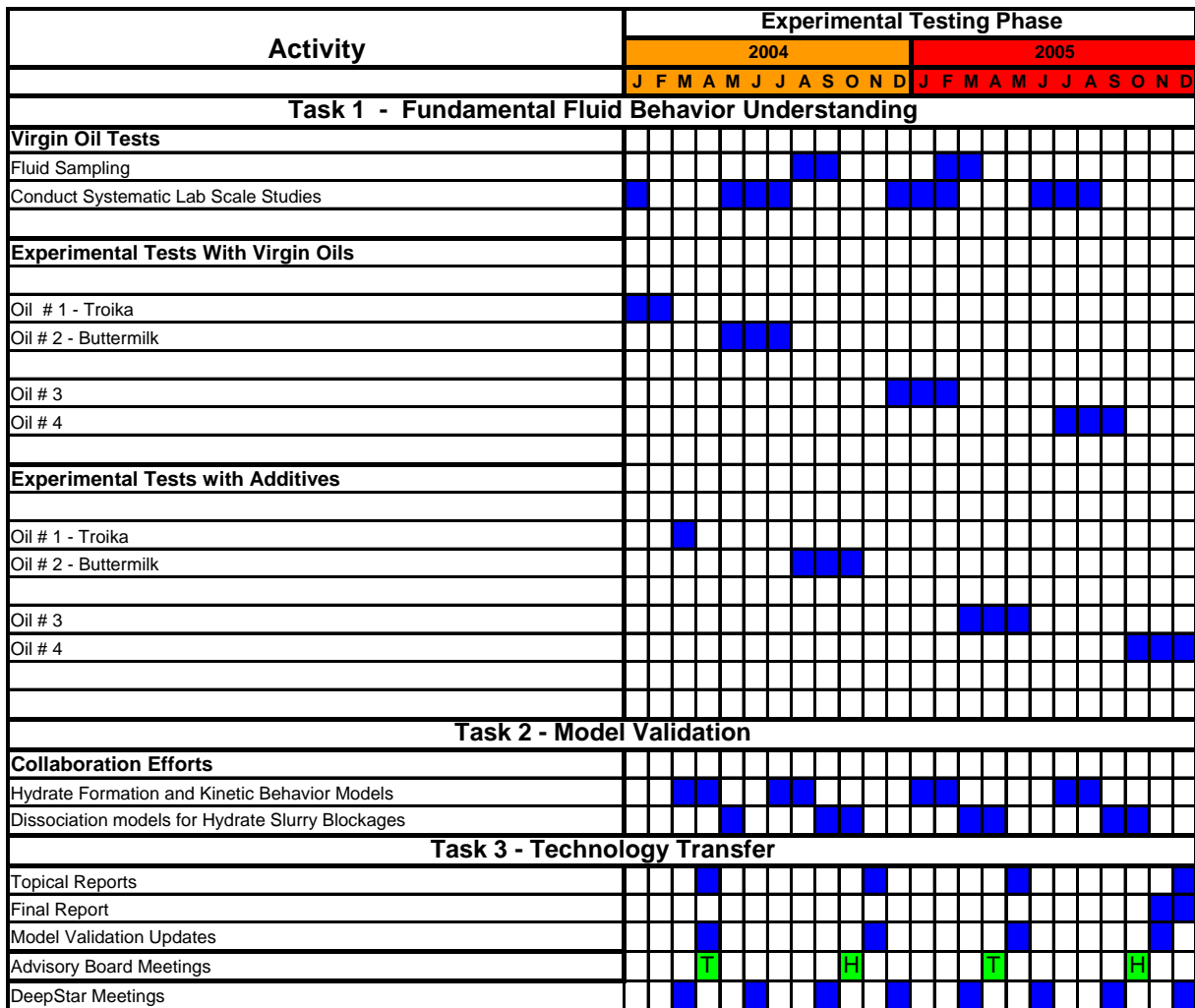


Figure 11: Hydrate Studies Gantt Chart

Estimated Number of Hours: Primarily graduate students (2), flow loop operators (3), post-Doctoral Research Associates (1), and faculty members (3) will conduct the research in this project. A project engineer will coordinate the activities of the flow loop operators as well as the data analysis and interpretation, the two technicians (mechanical and electrical), and the part-time students that will be involved in the project. A part-time secretarial/administrative person will be involved for invoicing, accounting, and report preparation. The principal investigator will be responsible for project management, personnel issues and overseeing data quality. The co-pi's responsibility will be to advise the two graduate students. The post-doc's main function will be model validation. The project engineer will co-ordinate the effort of the mechanical and electrical technicians who will maintain the facility, the three flow loop operators that will keep the loop running 24 hours a day for extended (up to two weeks) periods of time and part time students that will assist the operators during the runs. He will also be responsible for data quality control.

The key individuals (three faculty members, project engineer, flow loop operators, the mechanical and electrical technicians and the secretary/administrative person) are currently

employees of the University as is a pool of highly qualified graduate students. The staffing plan by labor category and the hours required for each task is provided in Table 3.

Task No.	PI	Co-PI	Post Doc	Mech Tech	Elec Tech	Flow Loop Oper I	Flow Loop Oper II	Flow Loop Oper III	Project Engr	Secy/Administrative	MS 1	MS 2	Part Time Students	Total
Effect of Oil Chemistry/Additive Screening Tests														
1a	40	0	0	80	0	0	0	0	80	20	0	0	0	220
1b	120	20	100	0	0	0	0	0	40	40	100	0	0	420
1c	30	5	60	0	0	0	0	0	0	10	50	0	0	155
Total	190	25	160	80	0	0	0	0	120	70	150	0	0	795
Benchmarking Experimental Studies														
2a	40	20	80	120	200	325	325	325	120	0	100	150	400	2205
2b	60	30	120	170	170	475	475	475	140	0	0	250	750	3115
2c	60	30	120	170	170	475	475	475	140	0	0	250	750	3115
2d	60	30	120	170	170	475	475	475	140	0	0	250	750	3115
2e	40	20	80	0	0	175	175	175	20	80	0	230	0	995
Total	260	130	520	630	710	1925	1925	1925	560	80	100	1130	2650	12545
Experimental Tests with Additives														
3a	40	20	80	50	50	325	325	325	120		150	100	300	1885
3b	60	30	120	160	160	475	475	475	120		250	0	750	3075
3c	60	30	120	160	160	475	475	475	120		250	0	750	3075
3d	60	30	120	160	160	475	475	475	120		250	0	750	3075
3e	40	20	80	0	0	175	175	175	20	80	230	0	0	995
Total	260	130	520	530	530	1925	1925	1925	500	80	1130	100	2550	12105
Modeling/Collaboration Efforts														
4	240	100	2460	0	0	93	93	93	200	200	200	350	0	4029
Technology Transfer														
5	300	64	500	0	0	217	217	217	300	400	500	500	0	3215
Total Hrs	1250	449	4160	1240	1240	4160	4160	4160	1680	830	2080	2080	5200	32689
Man Years	0.6	0.22	2	0.6	0.6	2	2	2	0.81	0.4	1	1	2.5	15.72

Table 3 - Man-hours by Task

Tasks 1 through 4 relate to concept development while task 5 relates to transferring the knowledge gained from the project. A discussion of the labor distribution by task is provided below.

Task 1 is related to obtaining and then analyzing the oils used in this study to gain an understanding of their chemistry. It is also related to the screening tests that the service companies will perform on the four crude oils. Co-ordination with the chemical service companies is required as well as personnel (project engineer) to go to the well site while the samples are being taken. The PI will co-ordinate the work with the service companies while the

post doc and students will utilize their results in the study to gain an understanding of hydrate formation and dissociation. 2.5% of the total man hours is related to this effort.

Task 2 generates the data that will provide an understanding as to what is taking place in pipelines as hydrates form, are transported, and possibly result in blockages. Dissociation data will be gathered on any blockages formed. The data will be generated by the flow loop operators, graduate students and part time students. The post doc, flow loop operators and two graduate students will analyze the data and develop the correlations and models. 38.4% of the total man hours are related to this task.

Task 3 generates data that will show how the oils will behave when additives are added. The data will be generated by the flow loop operators, graduate students and part time students. The post doc, flow loop operators and two graduate students will analyze the data. 37% of the total man hours are related to this task.

Task 4 is related to the collaboration efforts with Dendy Sloan at the Colorado School of Mines. Data from the flow loop experiments will be used to validate their hydrate formation and kinetic behavior model as well as their dissociation model for hydrate slurry blockages. Guidance for these efforts will be provided by the PI, co-PI and post doc. The students will be involved in these efforts because they will be generating the data to validate the models as well as assisting in performing the validation. This effort will examine the kinetic, formation growth and transport aspects of hydrate modeling efforts. 12.3% of the total man hours are related to this task.

Task 5 is related to meetings and reporting. Four advisory board meetings will be held. Presentations will also be made at the quarterly DeepStar meetings. A topical report will be provided upon completion of testing with each fluid that will also include the findings from the model validation updates. 9.8% of the total man hours are related to this task.

Rate Schedule: The overall budget for a two year period is shown in Table 4. This budget was developed for the scope of work where 20 tests per fluid are conducted, 12 base case tests and 8 tests with inhibitors. In addition to the DeepStar participants, two government agencies (DOE and MMS), Chemical Service Companies (Champion Technologies, Baker Petrolite and Nalco), other universities (CSM), and other oil and gas companies that are not members of DeepStar (BHP) will participate. The current leveraging is approximately 1:1. The University of Tulsa will analyze four fluids in a two year period. Total cost for analyzing four fluids is \$1,400,000. The budgets showing how these costs break out by funding entity are shown in Tables 5 – 6.

Year 2004 & 2005

Expense Category	DOE	MMS	TU	Industry (JIP)	DeepStar	Total
Salary - Full Time	9,744	0	0	76,382	399,911	486,037
Salary-Graduate Students	94,140	0	0	0	0	94,140
Total Salaries	103,884	0	0	76,382	399,911	580,177
Fringe Benefits	3,021	0	0	24,442	127,971	155,434
IDC	52,981	0	0	41,628	217,951	312,561
Total Salaries, IDC & Fringe	159,885	0	0	142,453	745,833	1,048,172
Other Direct Costs						
Equipment	0	0	0	35,000	0	35,000
Travel, Meetings & Entertainment	0	0	0	40,000	0	40,000
Tuition	0	0	52,200	0	0	52,200
Materials & Supplies	5,968	80,000	0	78,492	0	164,460
Publication Cost/Distribution	11,992	0	0	0	0	11,992
Outside Services	0	0	0	10,000	0	10,000
Computer Services	2,000	0	0	9,500	0	11,500
Maintenance	20,155	0	0	4,555	4,167	28,877
Total Other Direct Costs	40,115	80,000	52,200	177,547	4,167	354,029
Total Expenses	200,000	80,000	52,200	320,000	750,000	1,402,201

Table 4 Total Costs for Cold Flow Project

YEAR 2004

Expense Category	DOE	MMS	TU	Industry (JIP)	DeepStar	Total
Salary - Full Time	4,800	0	0	29,400	201,073	235,273
Salary-Graduate Students	46,800	0	0	0	0	46,800
Total Salaries	51,600	0	0	29,400	201,073	282,073
Fringe Benefits	1,488	0	0	9,408	64,343	75,239
IDC	26,316	0	0	16,023	109,585	151,924
Total Salaries, IDC & Fringe	79,404	0	0	54,831	375,000	509,235
Other Direct Costs						
Equipment	0	0	0	35,000	0	35,000
Travel, Meetings & Entertainment	0	0	0	18,500	0	18,500
Tuition	0	0	24,360	0	0	24,360
Materials & Supplies	1,984	40,000	0	39,996	0	81,980
Publication Cost/Distribution	5,996	0	0	0	0	5,996
Outside Services	0	0	0	5,000	0	5,000
Computer Services	2,000	0	0	4,000	0	6,000
Maintenance	10,616	0	0	3,673	0	14,289
Total Other Direct Costs	20,596	40,000	24,360	106,169	0	191,125
Total Expenses	100,000	40,000	24,360	161,000	375,000	700,360

Table 5 – Hydrate Budget for Year 1 (2004)

Year 2005

Expense Category	DOE	MMS	TU	Industry (JIP)	DeepStar	Total
Salary - Full Time	4,944	0	0	46,982	198,838	250,764
Salary-Graduate Students	47,340	0	0	0	0	47,340
Total Salaries	52,284	0	0	46,982	198,838	298,104
Fringe Benefits	1,533	0	0	15,034	63,628	80,195
IDC	26,665	0	0	25,605	108,367	160,637
Total Salaries, IDC & Fringe	80,481	0	0	87,622	370,833	538,937
Other Direct Costs						
Equipment	0	0	0	0	0	0
Travel, Meetings & Entertainment	0	0	0	21,500	0	21,500
Tuition	0	0	27,840	0	0	27,840
Materials & Supplies	3,984	40,000	0	38,496	0	82,480
Publication Cost/Distribution	5,996	0	0	0	0	5,996
Outside Services	0	0	0	5,000	0	5,000
Computer Services	0	0	0	5,500	0	5,500
Maintenance	9,539	0	0	882	4,167	14,588
Total Other Direct Costs	19,519	40,000	27,840	71,378	4,167	162,904
Total Expenses	100,000	40,000	27,840	159,000	375,000	701,841

Table 6 - Hydrate Budget for Year 2 (2005)

Appendix I - Technical Approach

(1) Approach and Work Plan - A state of the art test facility was developed by Marathon for conducting flow assurance research. The FAL was constructed in 1999 and Marathon made a decision to terminate its flow assurance research program in late 2000. In January 2001, TU received a Request for Proposal from Marathon Oil Company to transfer their new Flow Assurance Loop (FAL) from Littleton, Colorado for the purpose of conducting flow assurance research. In June 2001, the proposal submitted by The University of Tulsa was selected. Facility relocation began in June 2002. During 2003, the facility was commissioned, shakedown test were conducted and hydrate experiments begun.

The FAL has the following characteristics: 2200 psia working pressure; 2.9-in. ID; 162-ft long flow loop; 20 tons of chilling; Leistritz multiphase pump with circulating rate yielding flow velocity of 15 ft/s; 4 sapphire, 1.5-in. diameter viewing ports; pressure, temperature and density instrumentation; and substructure that permits angle changes and rocking motion.

This facility will be utilized to gather large quantities of data to better understand hydrate formation kinetics in live oil, water and gas systems using four black oil fluids in subsea cold flow systems. Two oils will have low water cut plugging tendencies and two will have high water cut plugging tendencies. A low water cut plugging tendency oil, as defined by Shell, is one that is expected to form hydrate blockages at water cuts < 1%. For this study, low water cut oils are defined as those that will form blockage at water cuts < 10 – 20%. A high water cut plugging tendency oil is one that will not form a hydrate blockage until the water cut is in excess of 50 to 70%.

The strategy that will be used to solve this flow assurance problem is one that incorporates the hydrate modeling expertise of Dendy Sloan and his staff at the Colorado School of Mines and the Fluid Flow and Flow Assurance Loop Operation expertise of Jim Brill, Cem Sarica and Mike Volk and their staff at the University of Tulsa. It builds upon the ongoing work being performed for DeepStar and the Hydrate JIP at the University of Tulsa. Integration of this expertise with the experts within DeepStar in a collaborative effort will ensure that a high quality product will be delivered. This collaborative effort also involves the chemical service companies who will screen the additives that will be utilized in the study as well as determine how their lab tests scale-up.

The general approach will be to start the effort with a general workshop. During this workshop the test matrix will be discussed and modified if necessary to ensure the suite of tests conducted will generate the data necessary to understand the issues related to producing in the hydrate domain, during shutdown and restart of production systems, preventing hydrate formation and dissociating blockages.

The experimental tests will be modeled prior to initiation. Results from the experiments will be processed and evaluated continuously to guide the test program. Results will be reviewed regularly with the participants and input sought to result in an effective experimental and model validation program.

The project will focus on different hydrate production issues with the intent of providing valuable information to oil producers for a more economical approach of deep-water developments. These issues can be grouped into three categories:

Producing in the Hydrate Domain - Most oil producers today take precautionary measures to avoid producing in the hydrate formation region (inhibitors, insulation), resulting in higher

capital or operating costs. Considerable savings can be achieved through better understanding and confidence in the hydrate formation process under deep-water flowing conditions. The JIP will study the impact of different parameters, such as oil chemistry, salinity, water cut, cooling rates, multiphase flow patterns and subcooling, on the hydrate formation process. Qualitative information, such as morphology of the hydrates formed, and quantitative information on hydrate formation kinetics and transportation data will be generated from the flow loop tests.

Shutdown and Restart of Production Systems - While designed to avoid the formation of hydrates under flowing conditions, deep-water systems become vulnerable if shut down occurs. Hydrates may form during the shut-in time as the temperature drops and plugging may occur on restart. The Marathon flow loop is very well suited to study the formation of hydrates under static conditions and study the restart process. Effects of shut-in time, cooling rates, water cut, salinity, and oil chemistry on hydrate formation and accumulation while restarting will be studied. In an attempt to provide information on the best strategies to restart plugged pipelines, dissociation data will be gathered, if and when, hydrate plugs occur.

Preventing Hydrate Formation - Finally, many different additives or inhibitors can be used to prevent or delay the hydrate formation process, or to prevent accumulation of hydrate particles, eventually leading to the formation of a hydrate plug. More qualitative and quantitative information is needed on the performance of these chemicals under various conditions. The study of additives will be included in this project to identify the key parameters involved in the selection process and in their performance, and help oil operators and chemical companies improve their selection process.

(2) Project Schedule and Milestones - The schedule for completing the complex and interrelated tasks is shown in Figure 1. The objective will be to develop an understanding of fluid behavior during well start-up and shut-in conditions to prevent flowline plugging during these operations. This understanding is expected to yield improved and safer operating procedures. It will also help in the most effective placement of chemical treatment systems. A kinetic model will also be developed that will allow the industry to advance its understanding of the key factors in hydrate kinetics in industrial systems. The study will last two years, finishing in 2005. Figure 1 also shows when significant deliverables in the form of reports, models, and data will be provided to the participants. The tasks shown in Figure 1 were established based on industry feedback from several workshops with oil & service companies' representatives. Several parameters were identified as being of interest in the hydrate formation phenomena. These parameters are: Hydrocarbon composition/chemistry; Brine salinity or composition; Water cut (wc); Cooling rates; Flow patterns; Steady state vs. transient phenomena (shut-in/restart); Effect of chemicals; Shut-in duration; Subcooling; Pressure; and Temperature.

To establish a test matrix, the interest in the above-mentioned parameters had to be prioritized, since it would be impossible to study the effects of all these variables within the timeframe of this study. There was a consensus among industrial participants that there is a more immediate need to study oil systems than gas systems, since gas systems have been studied for quite some time and are better understood than oil systems. Moreover, gas systems can be

Proposed Hydrate Studies with Marathon Flow Loop

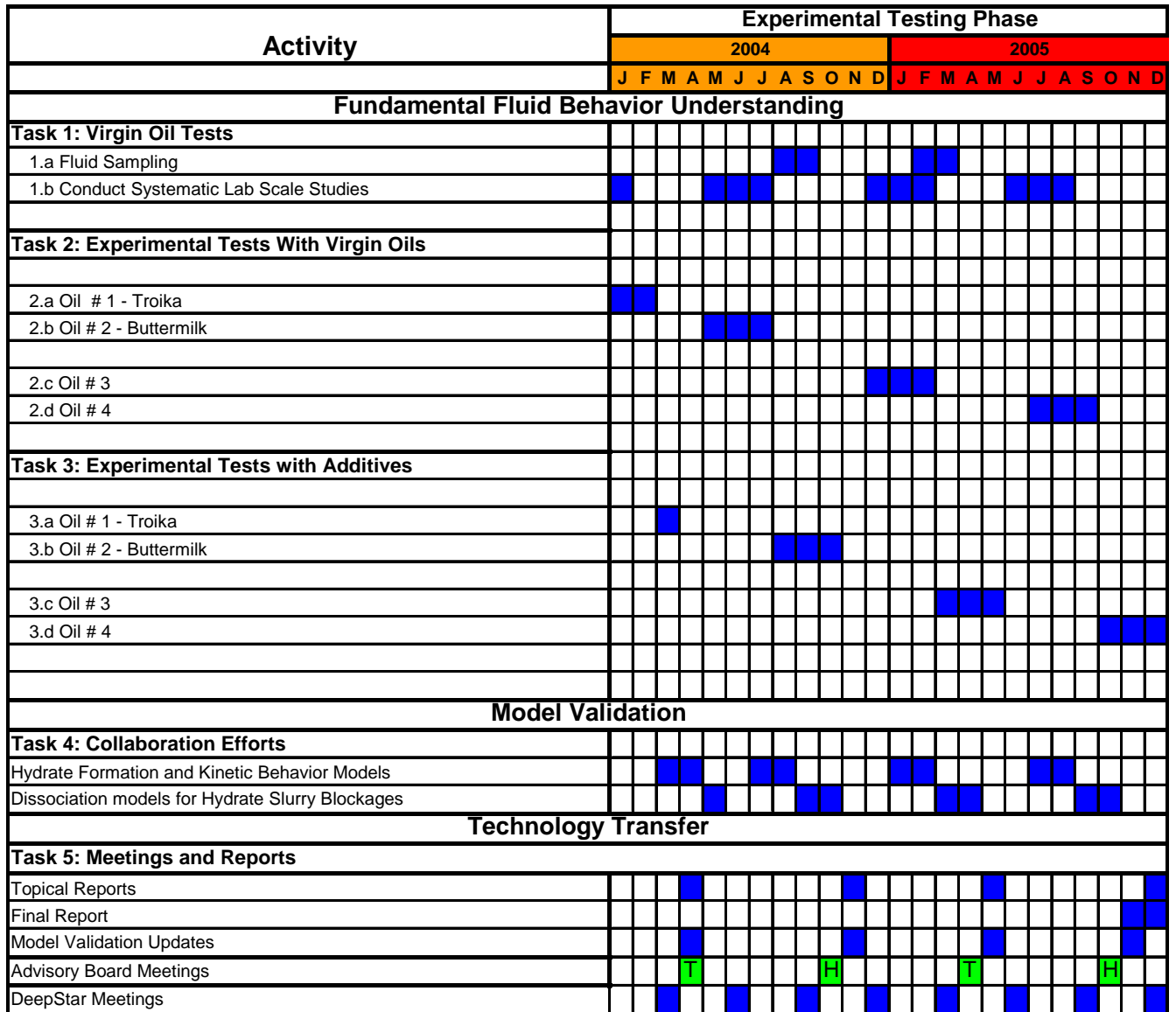


Figure 1: Proposed Hydrate Studies Gantt Chart

depressurized more easily than oil systems and the research effort therefore appears less critical than for oil production systems.

Task 1 - Virgin Oil Tests - Oil chemistry plays an important role in the hydrate formation process. In order to gather data on different types of crude oils, four types of crude oils will be selected. It is believed that the amount and type of surfactants present in the crude will play an important role in the transportability of the hydrate solid phase. Focus will be made on wax and asphaltenic properties, as proposed in Table 1 below:

Types of Oils	WAX	Asphaltenes
Low Water Cut Plugging Tendencies		
First crude	Low	Low
Second crude	High	Low
High Water Cut Plugging Tendencies		
Third crude	Low	High
Fourth crude	High	High

Table 1: Effect of Oil Chemistry

Subtask 1a - Fluid Sampling - Four fluids will be studied. Two will have low water cut plugging tendencies and two will have high water cut plugging tendencies. Participants will be queried for donation of potential fluids. Fifty (50) barrels of Troika are currently available in house. Ten (10) barrels of Buttermilk are currently being taken and are scheduled to arrive in Tulsa the first quarter of 2004. Donation of two additional crude oils will be sought from the Participants. At a minimum, 10 barrels of fluid should be taken and sent to the University of Tulsa for utilization in the study.

Subtask 1b - Conduct Systematic Lab Scale Studies – Collaboration efforts have been established with the chemical service companies not only because of their expertise in oil field chemistry issues but because they will be the manufacturer/distributor of the anti-agglomerants. A committee has been formed with the industrial participants to systematically identify modeling/experimental tasks that probe into what in the oil is responsible for non-plugging behavior. The four selected candidate oils with known plugging and non-plugging tendencies will be analyzed. SARA data, oil-water IFT data, resin/asphaltene ratio, wax content, natural surfactant content, emulsion forming tendencies, etc. for the oils will be measured to see if there are any correlation(s) to plugging tendency. The answer to this issue is in the oil phase and this effort will progress under that assumption.

Subtask 1c - Deliverables - The deliverable would be a report on the experimental findings, any correlations identified and conclusions.

Task 2 - Experimental studies: Discussed below is a description of the proposed test matrix. Table 2 below summarizes the different fluid charges considered to study the effect of water cut and cooling rate at one salinity. Three different water cuts will be studied for each oil. Low water cut tests range from less than 1% water up to 15%; high water cut tests are defined as 50% water and higher. Medium water cut tests are considered to have water cuts between 20 and 40%. Two additional tests will be

conducted to study the effect of “long-term” shut-in time on the hydrate formation and flow restart processes.

Test #	Water cut			Cooling rate		Test procedure		Long shut-in time
	<15%	20-40%	80%	5 F/hr	40 F/hr	Cte V	Cte P	
1	X			X		X		
2	X			X			X	
3	X				X	X		
4	X				X		X	
5		X		X		X		
6		X		X			X	
7		X			X	X		
8		X			X		X	
9			X	X			X	
10			X		X		X	
11		X		X			X	X
12		X			X		X	X

Table 2: Fluid Charges

Subtasks 2a – 2b – Flow Loop Tests to Generate Benchmark Data - Tests 1 to 10 are designed to investigate hydrate formation with the virgin oils with increasing water cuts. The purpose of these tests is to 1) study the effect of water cuts and cooling rates on the hydrate formation process, 2) generate different kinetic data by running constant volume and constant pressure tests, and 3) serve as a reference for additive performance tests and lab tests comparisons.

For each of the three water cuts considered, hydrate formation tests will be conducted at two different cooling rates to simulate insulated vs bare pipe conditions. For each fluid charge, constant volume tests will be run first; hydrates will then be melted and the last test will be a constant pressure test. When conducting a constant pressure test (i.e. with continuous gas addition), it is necessary to vent the gas when melting the hydrates in order to not exceed the maximum operating pressure of the flow loop. This venting will modify the composition of the system, and therefore the charge should be replaced after such a test. The possibility of conducting consecutive tests at a constant pressure without re-charging the flow loop will be discussed with the participants. Should this possibility be accepted, more tests could be conducted within the same time frame.

Test 11 and 12 will focus on longer shut-in periods followed by increasing pumping rates to determine any critical shear rate of the hydrates. Constant pressure tests are more representative of this type of situation.

It will take a minimum of two months to experiments 1 to 12. To account for repeat tests and possible dissociation studies, three months is allotted. The study of four

oils will take approximately one year leaving one year for the studies with additives. Maintenance and shutdown times have been estimated and included in the test matrix. Since tests will be run consecutively, it is necessary to insure that any problems with the facility or the instrumentation be fixed before proceeding to the next experiment. This is only possible if the data are processed immediately after each experiment. Data processing will be performed between experiments, especially during the hydrates dissociation, cool down, cleaning and charging phases. Simulations with existing models will be run for comparisons of experimental results and predictions of other experiments.

Subtask 2e - Deliverable (Report) - The tests conducted in the JIP will provide a large database on hydrate formation and growth kinetics as well as their transport. From this database, model enhancements may be derived. A report on the experimental findings, model validations and enhancements and conclusions will be provided.

Tasks 3 - Experimental Tests with Additives - Following each virgin oil test, tests with additives (anti-agglomerants) will also be conducted. The purpose of these tests are to (1) identify parameters of importance in the selection of additives, (2) identify operating limits with respect to water cut and salinity for the additive, and (3) compare the flow loop results with the laboratory results. For each crude oil, participating chemical companies will conduct screening tests (rolling ball and autoclave) using a generic additive.

Subtasks 3a – 3d – Flow Loop Tests with Additives - Discussed below is a description of the proposed test matrix for the flow loop additive tests. Table 4 below summarizes the different fluid charges considered to study the effect of water cut, salinity and additive concentration.

Test #	Water Cut		Salinity			Concentration		OeP
	<15%	20-40%	Base	Max	>Max	Hgh	Low	
1	X		X			X		X
2	X		X				X	X
3	X			X		X		X
4	X				X	X		X
5		X	X			X		X
6		X	X				X	X
7		X		X		X		X
8		X			X	X		X

Table 4 Test matrix for Additive Studies

All the tests will be run at constant pressure conditions. Two series of four tests will be conducted using a low and a medium water cut. For each water cut, tests will be conducted at a base case salinity, at the maximum salinity and subcooling conditions under which the additive is claimed to be efficient, and at a salinity greater than the maximum salinity. The goal of these tests is to help identify parameters of importance in the selection of additives and to compare the flow loop results with laboratory results conducted by the participating chemical companies. The final test matrix will be subject to modifications based on previous results and discussions with the participants. Modifications or extensions of the test matrix will be discussed and approved by the Committees. Additive tests are planned on all four oils.

Subtask 3e - Repeated tests with chemicals will demonstrate the inhibition effects of the chemicals selected. A report on the experimental findings and conclusions will be provided.

Task 4 - Collaboration Efforts - Collaboration efforts with Dendy Sloan at the Colorado School of mines have been established. Data from the flow loop experiments will be used to validate their hydrate formation and kinetic behavior model as well as their dissociation model for hydrate slurry blockages. Collaboration efforts with CSM will be sought where data from the project will be exchanged to further validate their models for the right to use them in this study. The test data may also point out improvements that could be made to the models. Should improvements be identified, they will be incorporated into the model.

Subtask 4a - Deliverables - The deliverable would be a report on the model validation results and any enhancements identified. Data for the four donated fluids would be utilized as a check of the model predictions vs. data. A report on the model findings and conclusions will be provided.

Task 5 - Technology Transfer - Technology transfer will occur through several means. There will be four semi-annual advisory board meetings; two in Tulsa and two in Houston. Presentations will also be made at the quarterly DeepStar meetings. A topical report will be provided upon completion of testing with each fluid that will also include the findings from the model validation updates.

Appendix II – Resumes of Key Personnel

Three key individuals will be involved in the project. They are Dr. Michael Volk, Jr. (PI), Dr. Cem Sarica (Co-PI), and Mr. Emmanuel Delle Case (Project Engineer). Resume for these individuals follow. The fourth key person is the Post Doc. This person will be hired and more than likely will be one of Dendy Sloan’s Students.

Dr. Michael Volk

Principal Investigator

Education

Institution	Degree	Year
Penn State University	Ph.D. – Chemical Engineering	1976
Penn State University	M.S. – Mechanical Engineering	1973
Penn State University	B.S. – Mechanical Engineering	1972

Research and Professional Positions

Year	Company	Position
1994 – Present	The University of Tulsa	Manager, Research and Technology Development
1987 – 1994	Amerada Hess Corp.	Manager, Formation Evaluation Department
1985 – 1987	Terra Tek	General Manager
1980 – 1985	NL/Erco	Executive Vice President/General Manager
1977 – 1980	Cities Service Company	Senior Reservoir Engineer
1975 – 1977	Williams Brothers Process Services	Process Engineer

Publications

- 1) Matzain A., Zhang, H.-Q., **Volk, M.**, Redus, C.L., Brill, J.P., Apte, M.S., Creek, J.L.: “Multiphase Flow Wax Deposition Modeling,” BHRG Multiphase Tech. Conf., Banff, Alberta, Canada (June 2000).
- 2) Matzain A., Apte, M.S., Zhang, H.-Q., **Volk, M.**, Creek, J.L. and Brill, J.P.: “Investigation of Paraffin Deposition during Multiphase Flow — Part1 — Experiments,” presented at ETCE 2000, 2000, New Orleans, LA. (February, 2000).
- 3) Apte, M.S., Matzain A., Zhang, H.-Q., **Volk, M.**, Creek, J.L. and Brill, J.P.: “Investigation of Paraffin Deposition during Multiphase Flow — Part2 — Modeling,” presented at ETCE 2000, New Orleans, LA. (February, 2000).
- 4) Creek, J.L., Matzain A., Apte, M.S., Zhang, H.-Q., **Volk, M.**, Brill, J.P.: “Wax Deposition in Multiphase Flowing Gas-Oil Systems — New Experimental Data,” presented at ISCO’99 in Mexico (1999).
- 5) Apte, M.S., Matzain A., Delle Case, E., **Volk, M.**, Creek, J.L. and Brill, J.P.: “Investigation of Multiphase Flow Paraffin Deposition,” paper presented at BHRG Multiphase Technology Conference, Cannes, France (June 1999).
- 6) Creek, J.L., Lund, H.J., Brill, J.P., **Volk, M.**: “Wax Deposition in Single Phase Flow,” Proceedings of the 8th International Conference on Properties and Phase Equilibria for Product and Process Design, (June 1999)

- 7) E Kuru, S. Miska, M. Pickell, N. Takack, **M. Volk**, E. Ozbayoglu, “New Directions in Foam and Aerated Mud Research and Development”, SPE 53963 to be presented at the 1999 SPE Latin American and Caribbean Petroleum Engineering Conference held in Caracas, Venezuela, 21-23 April 1999.
- 8) Creek, J.L., Matzain A., Apte, M.S., Brill, J.P., **Volk, M.**, Delle Case, E. and Lund, H.: “Mechanisms for Wax Deposition,” presented at AIChE, National Spring Meeting, Houston, TX (March 1999).
- 9) B. Matzain, M. Apte, E. Delle Case, J. P. Brill, **M. Volk**, J. Wilson, J. Creek, X. T. Chen, “Design and Operation of a High Pressure Paraffin Deposition Multiphase Flow Loop” presented at 1st North American Conference on Multiphase Technology, Banff, Canada, June 10 – 12, 1998.
- 10) “Wax Deposition in Single Phase Flow” presented at the Eighth International Conference on Properties and Phase Equilibria for Product and Process Design, Noordwijkerhout, The Netherlands.
- 11) X. T. Chen, T. Butler, **M. Volk**, and J. P. Brill, “Techniques for Measuring Wax Thickness During Single and Multiphase Flow”, SPE 38773 presented at the 1997 SPE Annual Technical Conference, San Antonio, TX, 5 - 8, October, 1997.

Dr. Cem Sarica

Co-Principal Investigator

Institution	<u>Education</u> Degree	Year
The University of Tulsa.	Ph.D. – Petroleum Engineering	1990
Istanbul Technical University	M.S. – Petroleum Engineering	1984
Istanbul Technical University	B.S. – Petroleum Engineering	1982

Research and Professional Positions

Year	Company	Position
2001 – Present	The University of Tulsa	<i>Associate Professor, Director of TUFFP&TUPDP</i>
1998–2001	The Pennsylvania State University	<i>Associate Professor & Director of Stripper Well Consortium</i>
1992-1998	The University of Tulsa	<i>Associate Director of TUFFP & Adjunct Professor</i>
1990-1992	Istanbul Technical University	<i>Assistant Professor</i>

PUBLICATIONS

- Over 20 peer-reviewed publications, and over 25 conference papers and presentations.

Selected publications are listed below:

- 1) **Sarica, C.**, and Shoham, O.: “A Simplified Transient Model for Pipeline-Riser Systems,” *Chemical Engineering Science*, 46, No: 9, pp. 2167-2179, 1991.
- 2) Ansari, A. M., Sylvester, N. D., **Sarica, C.**, Shoham, O., and Brill, J. P.: “A Comprehensive Mechanistic Model for Upward Two-Phase Flow in Wellbores,” *SPE Production & Facilities*, May 1994 pp. 143-152.
- 3) Trallero, J. L., **Sarica, C.**, and Brill, J. P.: “A Study of Oil-Water Flow Patterns in Horizontal Pipes,” *SPE Production & Facilities*, pp. 165-172 August 1997.
- 4) Flores, G. J., **Sarica, C.**, Chen, X. T., and Brill, J. P.: “Investigation of Holdup and Pressure Drop behavior for Oil-Water Flow in Vertical and Deviated Wells,” *Journal of Energy Resources Technology, ASME*, pp. 8-15, March 1998.
- 5) Tengedal, J. O., **Sarica, C.**, Schmidt, Z. and Doty, D.: “A Mechanistic Model for Predicting Pressure Drop in Vertical Upward Two-Phase Flow,” *Journal of Energy Resources Technology, ASME*, pp. 1-9, March 1999.
- 6) Flores, G. J., Chen, X. T., **Sarica, C.**, and Brill, J. P.: “Characterization of Oil-Water Flow Patterns in Vertical and Deviated Wells,” *SPE Production & Facilities*, pp. 102-110, May 1999.
- 7) Tengedal, J. O., Kaya, A. S., and **Sarica, C.**: “Flow Pattern Transition and Hydrodynamic Modeling of Churn Flow,” SPE 53504, *Society of Petroleum Engineers Journal* December 1999.
- 8) Kaya, A. S., Chen, X. T., **Sarica, C.**, and Brill, J. P.: “An Investigation of Annular Flow Transition and a New Transition Model” *Journal of Energy Resources Technology*, March 2000.
- 9) Taitel, Y., **Sarica, C.**, and Brill, J. P.: “Slug Flow Modeling for Downward Inclined Pipe Flow: Theoretical Considerations,” *International Journal of Multiphase Flow*, pp. 833-844, **26/5** April 2000.
- 10) Kaya, A. S, **Sarica, C.**, and Brill, J. P.: “Mechanistic Modeling of Two-Phase Flow in Deviated Wells,” *SPE Production & Facilities Journal*, August 2001.

Professional Service

- Associate Editor of *Journal of Energy Resources Technology*. 1998 – Present.
- Member of Editorial Board of *SPE Journal*, 1998 – Present.
- SPE Books Committee Member 1999 – Present, and Editor of the book titled “*Wellbore Fluid and Heat Flows in Production Operations*” to be published by SPE.
- SPE Production Operations Committee Member, 1996 –1999.
- ASME’s ETCE’98, ETCE’99, ETCE & OMAE 2000, ETCE 2001, and ETCE 2002 Symposium Steering Committee Member.

Emmanuel Delle Case

Project Engineer

Institution	<u>Education</u> Degree	Year
E.N.S.E.E.I.H.T – France	Process Control Engineering Diploma	1996
E.N.S.I.G.C. - France	Engineer diploma (M.S.) – Chemical Engineering	1995

<u>Research and Professional Positions</u>		
Year	Company	Position
2000 – Present	The University of Tulsa	Sr. Research Associate – Fluid Flow & Paraffin Deposition Projects
1998 – 2000	Elf Exploration Production.	Fluid processing laboratory engineer
1996 – 1998	The University of Tulsa	Research Assistant – Paraffin Deposition Projects

Publications

- 1) Apte, M.S., Matzain A., **Delle Case, E.**, Volk, M., Creek, J.L. and Brill, J.P.: “Investigation of Multiphase Flow Paraffin Deposition,” paper presented at BHRG Multiphase Technology Conference, Cannes, France (June 1999).
- 2) Creek, J.L., Matzain A., Apte, M.S., Brill, J.P., Volk, M., **Delle Case, E.** and Lund, H.: “Mechanisms for Wax Deposition,” presented at AIChE, National Spring Meeting, Houston, TX (March 1999).
- 3) B. Matzain, M. Apte, **E. Delle Case**, J. P. Brill, M. Volk, J. Wilson, J. Creek, X. T. Chen, “Design and Operation of a High Pressure Paraffin Deposition Multiphase Flow Loop” presented at 1st North American Conference on Multiphase Technology, Banff, Canada, June 10 – 12, 1998.

Exhibit B Deliverables

The technical evaluation, databases and test data for hydrate slurry oil systems will be documented in a technical report that includes:

- Hydrate formation and growth data under different conditions and different oil chemistries
- Comparison of lab test data to flow loop data and field data
- Rheological assessment of slurry flow
- Dissociation data of hydrate blockages
- Better understanding of hydrate inhibition with additives (anti-agglomerates) and additive selection criteria
- Better understanding of hydrate growth structure under different conditions
- Better understanding of characteristics within oil systems that promote or prevent plugging

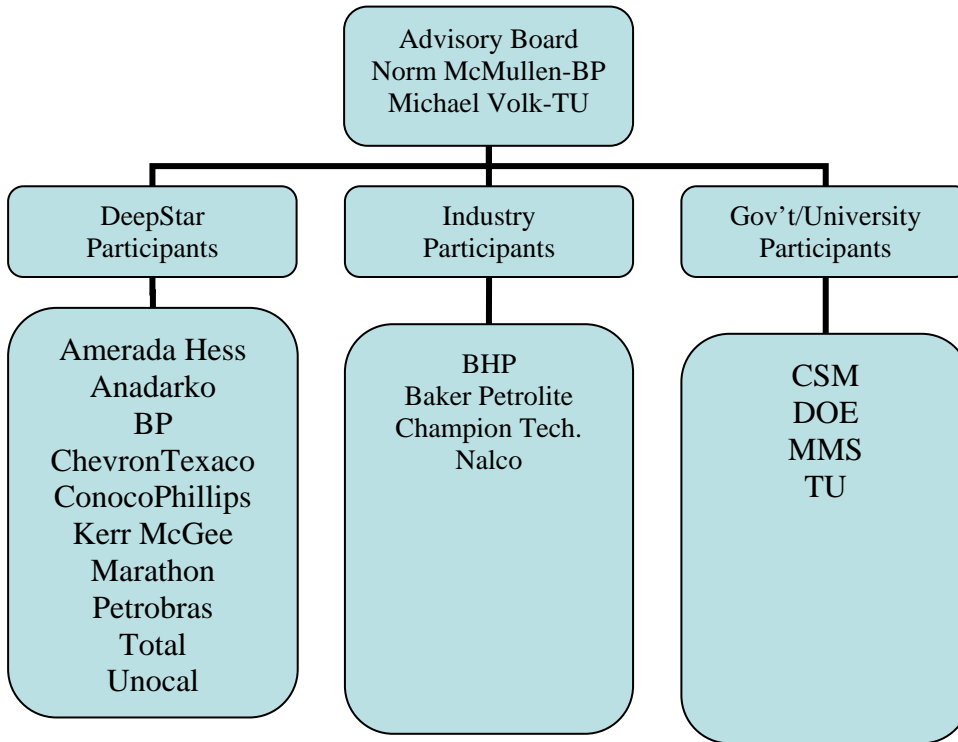
This data will be used to validate hydrate formation and kinetic behavior models as well as dissociation models for hydrate slurry blockages in collaboration with Colorado School of Mines. The validated models will be downloaded on CD's and attached to the report.

**Exhibit C
Project Schedule and Milestones**

Proposed Hydrate Studies with Marathon Flow Loop

Activity	Experimental Testing Phase																							
	2004												2005											
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Fundamental Fluid Behavior Understanding																								
Task 1: Virgin Oil Tests																								
1.a Fluid Sampling																								
1.b Conduct Systematic Lab Scale Studies																								
Task 2: Experimental Tests With Virgin Oils																								
2.a Oil # 1 - Troika																								
2.b Oil # 2 - Buttermilk																								
2.c Oil # 3																								
2.d Oil # 4																								
Task 3: Experimental Tests with Additives																								
3.a Oil # 1 - Troika																								
3.b Oil # 2 - Buttermilk																								
3.c Oil # 3																								
3.d Oil # 4																								
Model Validation																								
Task 4: Collaboration Efforts																								
Hydrate Formation and Kinetic Behavior Models																								
Dissociation models for Hydrate Slurry Blockages																								
Technology Transfer																								
Task 5: Meetings and Reports																								
Topical Reports																								
Final Report																								
Model Validation Updates																								
Advisory Board Meetings																								
DeepStar Meetings																								

**Exhibit D
Advisory Board**



**Exhibit E
Rate Schedule**

Year	Industry Members	DeepStar	MMS	DOE
2004	\$40,000	\$375,000	\$40,000	\$100,000
2005	\$40,000	\$375,000	\$40,000	\$100,000
Total	\$80,000	\$750,000	\$80,000	\$200,000

**Exhibit F
Project Funding**

Year	Industry Members	DeepStar	MMS	DOE	Total
2004	\$160,000	\$375,000	\$40,000	\$100,000	\$675,000
2005	\$160,000	\$375,000	\$40,000	\$100,000	\$675,000
Total	\$320,000	\$750,000	\$80,000	\$200,000	\$1,350,000