TUFFP

TULSA UNIVERSITY FLUID FLOW PROJECTS

NEWSLETTER

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Directory

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TUFFp Talk

Tony Butler Joins TUFFP

Tony Butler joined TUFFP as the new electronics technician in May. Previously, he owned his own electronics consulting business. Mr. Butler has experience in both digital and analog equipment, which is valuable in dealing with the various test facilities of TUFFP.

Although Tony has been with TUFFP only a few months, he has already completed several major tasks. He has improved all instrumentation in the hilly terrain test facility. He provided valuable assistance during the Lummus-Crest contract project. Tony also designed and developed an improved capacitance sensor. The new sensor is more immune to environmental conditions, and less susceptible to surrounding signal noise.

Tony says, "I enjoy the work at TUFFP. It's demanding but also very exciting". His wife is also an electronics technician, and they have two children, a son and a daughter.

TUFFP Announces Dates for Advisory Board Meetings

The next two Advisory Board meetings will be held November 14-15, 1989 and May 8-9, 1990. Both meetings will be held at the Sheraton Kensington Hotel in Tulsa, Oklahoma. Request for Information forms will be mailed to member companies approximately six weeks prior to each meeting to determine attendance. The forms will be accompanied by information pertaining to hotel reservations and travel to and from the airport.

The Advisory Board meetings will begin at 8:30 a.m. and will adjourn at 4:30 p.m. A pre-meeting cocktail party will be held at the Sheraton Kensington Hotel 5:30-7:30 p.m. on Tuesday, November 14, 1989 and May 8, 1990. Tours of TUFFP test facilities will also be held on Tuesday afternoons from 3:00-4:30 p.m.

The above meeting dates were selected to accommodate those member companies who also attend Advisory Board meetings of other cooperative research programs at The University of Tulsa. The following is a summary of these meetings for November 1989.

- Erosion/ Corrosion — Monday, Nov. 13, 1989
- TUPREP — Monday, Nov. 13, 1989
- TUDRP — Tuesday, Nov. 14, 1989
- **TUFFP** — Wednesday Nov. 15, 1989
- TUALP — Thursday, Nov. 16, 1989

TUFFP Advisory Board meeting brochures will be mailed to all members prior to the meetings. They will contain sufficient information to enable each attendee to actively participate in discussions on current and future research projects, financial matters, and operating procedures. Brochures containing slide copy for all presentations will be distributed at the meetings but will not be mailed to members.

1989 Questionnaire

The 1989 Questionnaire was distributed to the official Advisory Board Representative for each member company with this Newsletter. Members were asked to express their relative interests in both existing and possible future research projects. Results will be tabulated and summarized in the November Advisory Board meeting brochure.

TUFFP Magnetic Tape and Users Manuals Distributed

A 9-track, 6250 bpi ASCII magnetic tape was mailed to the official Advisory Board Representative of all TUFFP member companies the early part of August. A brief description of each file was included with the tape.

At the present time we are attempting to reduce the size of the Prudhoe Bay data files. Originally it was thought that all files would fit on one magnetic tape. Now it appears that several tapes will be required. Rather than delay the mailing, we chose to distribute the one magnetic tape. The Prudhoe Bay data files will be sent as soon as they can be reduced in size and written to magnetic tapes, possibly by the end of August.

The following are manuals that were distributed to TUFFP members during the period June through August, 1989.

- "Modeling Slug Growth in Pipelines Software Users Manual" by Stuart L. Scott
- "Prudhoe Bay Large Diameter Slug Flow Experiments and Data Base System Users Manual" by Stuart L. Scott
- CORE (version 2.0) Software Users Manual
- Errata for the CORE (version 2.0) Software Users Manual

Calendar For Two-Phase Flow Technical Meetings

Several conferences are scheduled for the remainder of 1989 and early 1990 which include technical sessions involving multiphase flow in pipes. A calender of these events is given below.

1989	October 8-11	SPE Annual Technical Conference and Exhibition - San Antonio, Texas
	October 19-20	PSIG Meeting - El Paso, Texas
	November 5-10	AIChE Annual Meeting - San Francisco, California
	November 13	TUPREP ABM - Tulsa, Oklahoma
	November 14	TUDRP ABM - Tulsa, Oklahoma
	November 15	**TUFFP ABM** - Tulsa, Oklahoma
	November 16	TUALP ABM - Tulsa, Oklahoma
	November 22-24	BHRA International Conference on Phase Behavior and Transport Properties Related to Hydrocarbon Reservoirs and Transportation Systems - London, UK
1990	January 8-11	AIAA 28th Aerospace Sciences Meeting - Reno, Nevada
	May 9	**TUFFP ABM** - Tulsa, Oklahoma
	May 10	TUALP ABM - Tulsa, Oklahoma
	May 21-25	**TUFFP Short Course** - Tulsa, Oklahoma
	August 19-24	9th International Heat Transfer Conference - Jerusalem, Israel

TUFFP Short Course in Tulsa A Success

A successful short course on "Two-Phase Flow in Pipes" was held in Tulsa, Oklahoma May 22-26, 1989. The course was attended by 22 engineers, including 14 from six TUFFP members and eight from non-member companies. Unfortunately, the same course scheduled to be taught in London, England June 12-16, 1989 was cancelled for lack of enrollment. Income from the course in Tulsa was just enough to pay all expenses incurred for both of the courses.

On the basis of our experience in 1989, we have decided to again offer the course, "Two-Phase Flow in Pipes," in Tulsa at the Sheraton Kensingon Hotel May 21-25, 1990. The same pricing structure used for the 1989 Tulsa course will be employed for 1990. Although a free enrollment to TUFFP members will no longer be offered, member companies will be permitted to enroll two people for nearly the same cost as two enrollments in previous years. More information pertaining to the short course will be presented at the November 1989 Advisory Board meeting. At this time we do not plan to offer a course on "Two-Phase Flow in Pipes" in Europe during 1990.

Commercial Design Major Prepares Newsletter

Elizabeth Ahow

Elizabeth Ahow, a junior commercial design major attending The University of Tulsa, designed and prepared this edition of the TUFFP newsletter.

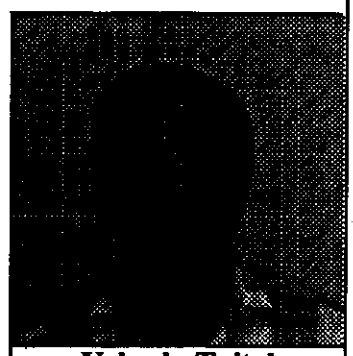
Elizabeth, who has a strong background in graphics communication, also designed and implemented a much needed database of piping component icons. This database of computer illustrations is accessible from each student's office Macintosh. The database ensures that all the symbols used in TUFFP illustrations will remain consistent for each student. The database will also pre-vent students from spending unnecessary time cre-ating symbols that perhaps another student has already created.

Miss Ahow worked for TUFFP during the summer, and will continue assisting the students with their technical drawing needs throughout the school year.

BHRA Meeting Provides Unique Multiphase Flow Forum

Over 130 engineers and scientists from 15 countries converged on Nice, France June 19-21, 1989 to attend the BHRA 4th International Conference on Multiphase Flow. Included in the meeting were over 30 excellent papers dealing with a broad range of topics including hydrates, flow through equipment (pumps, separators, piping components), slug flow, transient simulation, and a variety of mechanistic modeling papers. TUFFP was represented by Dr. James Brill (a Conference Organizer and Session Chairman), Dr. Ovadia Shoham (presented a paper on Two-Phase Flow in a Vertical Annulus) and Mr. Ibere Alves (presented a paper on Mechanistic Modelling of Flow Behavior in Campos Basin Wells). A bound copy of the proceedings will be available from BHRA later this fall.

Dr. Yehuda Taitel Consults for TUFFP



Yehuda Taitel

Dr. Yehuda Taitel will again serve as a consultant to TUFFP for the period July 15 - September 15, 1989. During this period he will provide invaluable assistance to all TUFFP graduate students in modeling a variety of two-phase flow phenomena. His work will include some initial modeling of multiphase flow behavior in horizontal wells.

TUFFP Adds Two New MS Students

Mr. Masaru Ihara has joined the TUFFP research staff to pursue an M.S. program in Petroleum Engineering. Mr. Ihara is funded by the Japan National Oil Corporation (JNOC), a TUFFP member company. JNOC has an interest in pursuing research on two-phase flow in horizontal wells. Although this topic has not received a high priority in past questionnaires, it represents an opportunity for TUFFP to conduct research in this area without having to fund the entire cost. Mr. Ihara will begin his graduate program in September 1989 for a period of approximately two years.

Mr. Kristian Brekke from Norway began his M.S. program in Petroleum Engineering during the summer term 1989. His research project pertaining to some unique concepts in 3-stage separator transporter system for multiphase flow is proprietary and funded by his employer, Aker Engineering. The extent of TUFFP involvement in this project is that Dr. Shoham will direct Mr. Brekke's research and TUFFP will provide computing and office facilities. Aker Engineering is a potential future member of TUFFP.

Bits & Bytes

TUFFP *Computer Resource News*

Computer Committee Formed

A computer commitee was formed to assist Dr. Brill and Dr. Shoham in ascertaining TUFFP computing needs. The committee is made up of computer resources manager Lorri Jefferson, and PHd candidates Jupe Arirachakaran and Cem Sarica.

The committee meets weekly, and produces an internal "Bits & Bytes" newsletter to keep all TUFFP students and staff informed of their recommendations. The committee is continuously striving to provide students with the best computer resources available. Close contact is kept with all students to satisfy their computing needs and end any computing problems they might be faced with.

Library Search Database To Be Available on Appletalk Network

The library search database currently on the Apollo network will be transferred to the Appletalk network. The database, developed by Lorri Jefferson, allows you to search for TUFFP books, journals, papers and software by title, author, subject, or partial word.

Students who wish to check out books or determine availability information, can access the database from their offices. Check-out information will be recorded in the database, so that other students may know the whereabouts of the book. By transfering the database to Big Mac (the Appleshare file server), the search facilities should be utilized more. The database will also assist us in keeping track of TUFFP literature and software.

Mac II To Be Used in Data Acquisition

TUFFP recently obtained a Macintosh II from the Petroleum Engineering Department. Ibere Alves will be using the Motorola 68020 cpu, 40 megabyte hard disk with 5 megabytes of RAM machine in data acquisition for the Slug Flow in Directional Wells project.

Currently, as in the past, all data acquisition by TUFFP utilized PC based systems. This meant that students had to produce large amounts of customized Fortran code to obtain data. This fact limited their data acquisition programs to one project only.

LabVIEW, the software chosen by Mr. Alves, is a much improved approach to data acquisition. The software is an object-oriented, graphical programming language, and is much easier to use. Moreover, the acquisition system is icon-driven, and can be used by other projects for different types of research. The graphical approach will reduce the amount of time necessary for programming and setting up the system, allowing Mr. Alves more time for research.

TUFFP Moves to Cartridge Media

A decision was made by the TUFFP Computer Committee to do away with magnetic tape use. All important data and files in the tape library will be transferred to cartridges. This will improve our space problems in the Computer Room, and also prevent us from possible disaster if our tape drive fails in the future.

Bits & Bytes (continued)

Macintosh IIcx Purchased for Computer Room

A Macintosh IIcx, the latest and greatest from the Macintosh family, was recently purchased by TUFFP. The 68030 machine has an 80 megabyte hard disk, apple hi-resolution color monitor and 4 megabytes of RAM. The machine is a powerhouse, yet compact in size with a footprint equivalent to a Mac Plus or Mac SE.

The new computer has been placed in the computer room, where it is available for all students to use. It will greatly improve such time oriented tasks as scanning, desktop publishing, complex graphics and manipulation of large spreadsheets or databases.

Graphical Plotting Package Developed by Jefferson

A much needed plotting package for the Apollo workstations has been developed by TUFFP's Computer Resources Manager, Lorri Jefferson. Lorri's package is menu-driven and follows the Macintosh interface in its user friendliness.

Lorri Jefferson

The software takes x,y data values from a data file and plots them to the screen. The user can then specify axis titles, data ranges, colors, legend labels, font used, type of curve fit, etc., through the use of pull-down menus. The image can then be output to the HP plotter, or Apple LaserWriter.

Cartesian, log-log and semi-log plots can be created. Jin Jang Xiao assisted Miss Jefferson with the design of the menu interface, and log-log plot.

Apollo Network Output Capabilities Enhanced

Student files on the Apollos may now be output to an Apple LaserWriter. This capability provides students with high-quality, graphic capability output, at a speed of 8 pages per minute. Output service to a 300 line-per-minute Harris line printer, and HP plotter is also available.

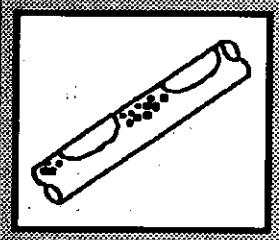
Complete Computer Networking To Be Achieved by TUFFP

In the next few weeks, complete networking of all TUFFP computers will be achieved. Currently, two networks are maintained: an Apollo token ring network, and a Macintosh Appletalk network. All the offices are networked on Appletalk, and the Apollo workstations are connected via a token ring network. Data transfer capabilities exist between the two networks.

However, the PC's used in data acquisition, located in the outside labs, are not networked with the Apollos. Therefore, students must transfer their data from PC to Apollo by using floppies or Kermit, which is an extremely slow process. Cable is being run to all the PC's, so that they too will be included in the Apollo network. PC ringboards will be placed in all PC's, enabling them to act as nodes of the computer room Apollo network.

This networking of the PC's with the Apollos is a vast improvement over the old method of transfering data. Students prefer to do their data analysis on the Apollos, which are much faster and contain more storage space. An obvious bottleneck existed surrounding the transfer of data from the outside PC's. However, this will now be eliminated as data is transferred from 3,000 feet at token ring speed.

Research Projects



Slug Flow in Directional Wells

Ibere Alves

This project consists of a theoretical and experimental study of slug flow in upward, sharply inclined pipes. Slug flow is one of the most common flow patterns in wellbores and pipelines, occurring over a wide range of flow rates.

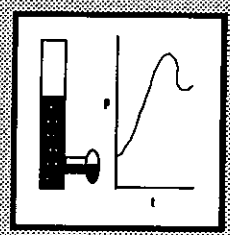
As the inclination angle of the wellbore varies from vertical to off-vertical, changes in the two-phase flow phenomena occur. Due to gravity, the gas phase tends to accumulate in the upper cross section of the pipe. This tends to cause significant changes in the flow characteristics. For example, the Taylor bubble rise velocity changes significantly, increasing as the inclination angle deviates from the vertical, and reaching a maximum at about 50°. With further increase in the inclination angle, the Taylor bubble rise velocity decreases.

This peculiar behavior can have a substantial effect on the overall flow characteristics. Since the liquid holdup is strongly dependent on the Taylor bubble rise velocity, the pressure gradient of the flow is also affected in the same manner. Prediction of the overall flow behavior is thus complex and challenging. A prior knowledge of the characteristics of slug flow is essential for a proper design.

The design of the experimental test facility has been completed, and the construction is underway. The previous test facility and the metering section were removed, and new ones are now in place. Also, the old instrumentation building was replaced. The new building is more suitable for housing the computer based data acquisition system.

This project will utilize a new data acquisition system, based on a Macintosh computer. The hardware is manufactured by National Instruments and will be installed in a new Macintosh II computer. The resolution of this new system is 16 bit. The software, LabVIEW, was also developed by National Instruments and is very versatile. LabVIEW has a new programming concept, a new graphic language and overall is easier to use.

The first data that will be obtained are the measurement of the Taylor bubble rise velocity. Preliminary results will be presented at the next Advisory Board meeting.



Wellbore Phase Separation Phenomena in Pressure Buildup Tests

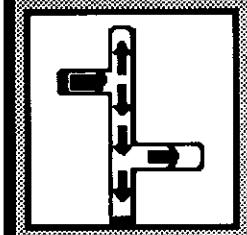
Metin Gokdemir

The objective of this study is to develop a mechanistic model for predicting the effects of wellbore phase redistribution on bottomhole pressure buildup behavior. The phenomenon of wellbore phase redistribution occurs in a well operating under two-phase flow conditions. Surface shut-in of wells for pressure buildup tests can cause phase separation in wellbores, which produces an increase in bottomhole pressure. This increase manifests itself as a hump in pressure buildup curves, making their interpretation more difficult.

The long term objective of TUFFP in investigating wellbore phase separation phenomenon will be carried out in two phases. The first phase (current study) will include the development of an initial mechanistic model for the wellbore only. In this

phase, the reservoir component will be isolated and not taken into consideration. In the second phase, an experimental study will be conducted and data will be acquired for phase separation in a wellbore, again excluding the reservoir component. Finally, a comparison of the model with the experimental results will be presented .

Since the last Advisory Board meeting, an analysis has been carried out for phase redistribution and pressure buildup, for the simple case where the entire wellbore is under bubble flow conditions prior to shut in. Future work will include analyses of other flow patterns, such as slug flow, and the general case where various flow patterns occur along the wellbore.



Slug Flow Splitting Phenomena in Side-Arm & Impacting Tees

Jupe Arirachakaran

Slug flow splitting at a regular, horizontal, side-arm tee is the primary objective of this study. A physically-based model which describes preferential liquid movement through this pipe tee configuration will be developed, compared with other applicable published models, and verified with the currently acquired and other published experimental data.

A decision was made to switch the data acquisition unit, both hardware and software, from Isaac and Labsoft to LabMaster, which is currently the TUFFP standard in all other PC-based data acquisition systems. The unit was transferred from Mr. Alves' system, when he decided to experiment with a Mac II data acquisition package. Efforts are being made to ensure that all available instruments, with the exception of the capacitance sensors, will be properly interfaced to this new data acquisition unit by early August.

The air-water capacitance sensors, which are still being modified and tested as of mid-July, have experienced a major setback. The electronic problems which were encountered during the assembly and calibration processes of the modified air-water circuit for the 2-in. capacitance sensor prototype persisted and could not be corrected using the present circuit configuration. Steps are now being taken to pursue both short-term and long-term solutions. The short-term solution involves the modification and addition of certain electronic components in the present air-water circuit to achieve a fairly stable and reliable circuit prototype. The long-term solution is to completely redesign the circuit to account for all the shortcomings encountered thus far. These steps will permit acquiring certain sets of experimental data immediately using the modified circuit. Remaining data will be obtained with the redesigned circuit.

The comparison study of other published models and correlations has continued throughout the summer. Both the Saba and Lahey physically-based empirical model, and the Seeger et al. correlations have been coded into the Apollo computer system. Four sets of experimental data from Johansen, Saba and Lahey, Seeger et al., and Hwang et al., have been processed and analyzed. They are currently being grouped into a database format for future usage. Efforts are being made to program the proposed slug flow splitting model, which consists of two algorithms. The first algorithm is the split of the slug body, which will be approximated initially by a pseudo single-phase, homogeneous splitting model. The second routine is the split of the gas pocket or film region, and follows the Shoham et al. stratified splitting model. Most of these routines are expected to be fully coded by the end of the summer.

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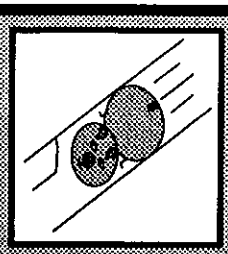


Modeling Pigging Dynamics in Two-Phase Pipelines

Kazu Minami

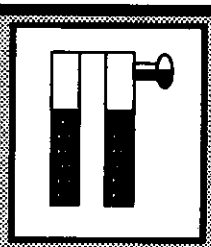
The objective of this project is to investigate theoretically and experimentally the complex transient phenomena that occur during a two-phase pipeline pigging operation. Knowledge of the flowing characteristics of the various flow sections will enable proper design of wet-gas pipelines and liquid handling facilities.

The theoretical part will include the development of models for predicting pressure, liquid holdup and velocity along the pipe. The experimental part will include collecting transient flow and pigging data on the 1400 ft long, 3 in. diameter pipeline, with or without hills, using a kerosene-air mixture.

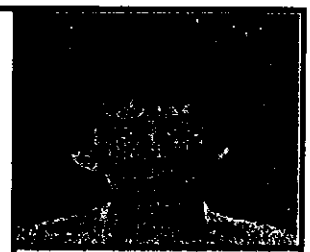
The pigging model will consist of separate models for each flowing section present in a pigging operation, namely undisturbed two-phase flow section; liquid slug section; gas flow section; and, redeveloping two-phase flow section. For the last two sections, the simplified transient model developed by Taitel et al. has been found to be suitable, and will be used with certain modifications. A model for predicting slug characteristics in the slug section ahead of the pig was completed during the spring, and was presented at the May Advisory Board meeting.

During the summer, efforts have been made to complete the design of the additional piping and instrumentation needed for this project. A new remote operated pig launcher was designed by Burt Vernooy & Associates, Inc., and will be constructed at TUFFP. Several additional instruments will be wired into the data acquisition system. These include: a weighing tank output; a pig launching system; capacitance sensors; and, pressure transducers.

The data gathering phase will be divided into two stages. Transient data without pigs will first be acquired. Test runs with pigs will then be conducted. The initial set of experimental data for the first stage was previously scheduled to be taken during this summer, but will be slightly delayed for two reasons. First, the line is still in use by Mr. Zheng for the "Two-Phase Slug Flow in Hilly Terrain Pipelines" project. Second, the modifications on the line will only be possible after Mr. Butler, the new TUFFP electronics technician, finishes working on the new improved capacitance sensor.



Mechanistic Model for Determination of Bottom Hole Pressure in Pumping Wells



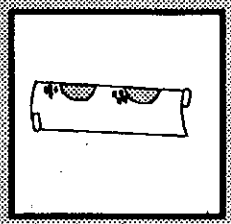
D. Papadimitriou

The objective of this study is to develop a mechanistic model for the prediction of bottomhole pressures in pumping wells. Recent developments in two-phase flow, such as flow through an annulus configuration and other important operational parameters, will be considered in this model.

Since the May Advisory Board meeting, a literature search on this project has been completed. The first part of the computer program for this study, which determines the pressure drop in the single phase gas region at the top section of the annulus, has been written.

Efforts are now being focused on studying the two-phase flow section of the annulus. This includes determination of the liquid holdup and pressure drop in this section, due to the gas flowing through the casing-tubing annulus liquid column. It is expected that the two-phase flow section and the entire model will be completed by the end of September.

Hopefully, the developed model can be checked against field data provided by member companies. The final report of this study is scheduled for December.



Evaluation of Slug Models for Horizontal Pipes

Carlos Daza

The objective of this project is to formulate a horizontal slug flow model to be used by TUFFP in the future. This objective will be met in two steps.

The first step involves generating a slug flow measurements database. This will consist of previous data taken at TUFFP, data from Prudhoe Bay, and additional data from other laboratory and field sources.

The second step involves evaluating existing horizontal slug flow models against the experimental database, and making modifications to the models as necessary to formulate an improved slug flow model.

The following work has been completed since the May Advisory Board meeting:

1. The slug flow database has been established and includes:

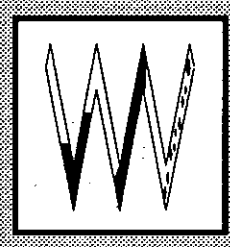
• The TUFFP 3 in. diameter air-kerosene data collected by Kouba. The data consist of over 50 runs, including operational and slug flow characteristics data such as velocities, lengths, frequency, holdup and pressure drop.

• The Prudhoe Bay data for slug flow in large diameter pipes. These data include 13 tests from a 16 in. diameter pipe and from a lower pressure experiment in a 24 in. diameter pipe.

2. A review of the models for slug flow in horizontal pipes has been completed. The models considered in this study are the classical Hubbard and Dukler model (1975), the Creare model (1986), and the Prudhoe Bay model. Other simplified models will also be considered.

3. Efforts have also been made to develop Fortran codes for each of the models to be evaluated against the database.

The remaining part of this project is to run all the models against the database and to develop the standard slug flow model to be used by TUFFP.



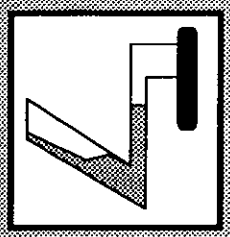
Two-Phase Flow in Low Velocity Hilly Terrain Pipelines

Cem Sarica

The primary objective of this study is to investigate two-phase flow in low velocity hilly terrain pipelines. This includes development of a model to predict the complex nature of the flow in such systems, in particular the development of steady vs. unsteady flow conditions in the pipeline. The model will be the basis for a computer simulator suitable for design purposes. Finally, since the model is based on physical principles, it can be compared with results from more general, elaborate numerical schemes.

Hilly terrain pipelines with low flow rates of gas and liquid are often encountered in offshore fields. The flow in these pipelines is gravity dominated. Thus, pressure behavior and both liquid and gas distributions in the pipe are governed primarily by gravity. Liquid tends to accumulate in the lower sections or valleys, with gas above it. The flow behavior of such low velocity pipelines can be complex, even for constant input flow rates. Possible unsteady conditions may develop in the upward inclined sections (risers) due to accumulation of compressible gas in upstream portions of the pipeline.

Since the May Advisory Board meeting, efforts have continued to develop a new model that is able to predict superficial velocities in each section. Simulation test runs of an air-water hilly terrain system have been conducted for steady state flow conditions. A good agreement between results from the Taitel study (1988) and the present study has been obtained for steady state conditions.



Elimination of Severe Slugging in a Pipeline-Riser Sytem

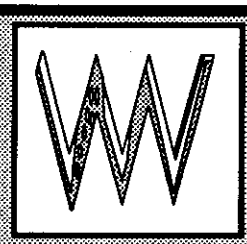
Finn Erik Jansen

Phase I of this study focused on the occurrence of severe slugging. The objective of Phase II, the current study, is to investigate, experimentally and theoretically, the elimination of severe slugging in a pipeline-riser system. The work will concentrate on collecting data for the elimination of severe slugging based on choking, gas lift and increased back pressure. These data will then be used to test the available model and modify it as necessary.

The first task during phase II of this project was to carefully study the operation of the experimental facility, data acquisition system and testing procedures. Several system modifications have been carried out during this phase of the study. The locations of the orifice meters relative to the valves have been changed and the orifice meters are now placed approximately 12.5 in. upstream of the valves. This was done to eliminate a problem occurring in the original facility, in which the flow readings were found to vary considerably due to pressure oscillations in the system caused by the motion of the slugs. Thus, the placement of the valves downstream of the orifice meters will provide damping when pulsating flow occurs. An additional pressure transducer has been installed upstream of the valve that serves as a choke. Measurements of the pressure drop across the choke at the top of the riser will provide a means to determine the choke coefficient required by the model.

A severe slugging flow pattern map originally obtained by Vierkandt in phase I of the study has been regenerated. Excellent agreement between the two sets of data has been achieved. Thus, it is now possible to proceed with the acquisition of the severe slugging elimination test runs.

Preliminary data for severe slugging elimination by choking has recently been acquired. The test runs clearly demonstrate the feasibility of this method. More data and analysis will be presented at the November Advisory Board meeting.



Comprehensive Mechanistic Model for Two-Phase Flow in Pipelines

J. Xiao

In the past, prediction of pressure drop for two-phase flow in pipelines was mainly based on empirical correlations. The objective of this project is to develop a comprehensive mechanistic model for two-phase flow in horizontal and near-horizontal pipelines. The model will be able to predict the flow pattern and also predict the flow characteristics such as liquid holdup and pressure drop for each flow pattern. A pipeline data bank will be generated, against which the model will be evaluated.

The following have been accomplished since the May 1989 Advisory Board meeting:

1. Several interfacial friction correlations found in the literature have been added to the stratified flow program. These will be used later for comparison against the data bank.

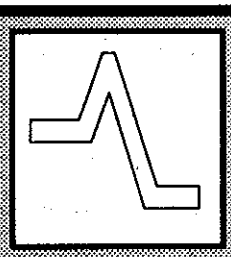
2. The program for flow pattern determination, "FLOPAT", originally developed in 1984, has been updated to satisfy TUFFP programming standards.

3. A program for statistical analysis of results has been developed.

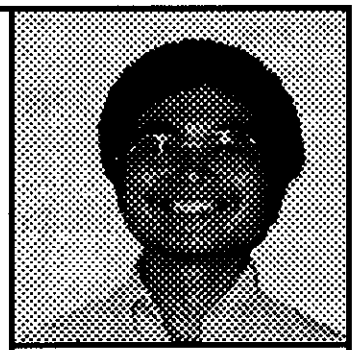
In addition, the review and evaluation of the A.G.A. data bank are underway. A reliable data

bank will be established by combining the A.G.A. data and data from other sources.

The slug flow model developed by Daza will soon become available. This model will be combined with this work to form a comprehensive mechanistic model which will be evaluated against the data bank. Preliminary results will be presented in the November Advisory Board Meeting.



Two-Phase Slug Flow in Hilly Terrain Pipelines



Guohua Zheng

This project examines, experimentally and theoretically, the effect of pipe inclination angle on slug flow characteristics in upward, shallow inclined pipelines. For this purpose, a large versatile test facility was fabricated which enables inclination angles between -1° and +5° from the horizontal. Extensive instruments, including nine ring capacitance sensors and eight pressure transducers, are installed for the two-phase flow measurements. A microcomputer based data acquisition and control system is utilized.

Nearly 40 new tests have been conducted since the last Advisory Board meeting. More tests are still being carried out. The new data also include measurements from two newly-installed capacitance sensors in a station upstream from the separator. For each inclination angle, a combination of 21 tests were taken with V_{SL} = 1.0, 2.0, 4.0 ft/sec, and V_{SG} ranging from 4.0 to 14.0 ft/sec with an interval of 2.0 ft/sec. These tests represent a wide range of the slug flow regime. A large quantity of data, consisting of 1000 or more slugs per test, have also been acquired for three tests per inclination angle. The acquisition of such a unique size of data will permit better statistical analysis on slug frequency distribution, slug length distribution, etc. The entire data acquisition process is expected to be finished by early August.

The data will be analyzed in terms of slug characteristics such as slug length, slug translational velocity, and liquid holdups in the slug and film. A model for slug flow in upward inclined pipes will then be developed.

Evaluation and Refinement of Capacitance Sensors

Capacitance sensors have proven to be an invaluable tool in measuring liquid holdup in laboratory experiments involving two-phase flows. Unfortunately, they have also proven to be one of the more difficult instruments to set up, calibrate and keep operating reliably. Despite TUFFP's long term pioneering efforts in capacitance sensor development, a completely satisfactory standardized model has eluded production. Recently, a TUFFP study team was formed to evaluate the capacitance sensors and recommend refinements to produce a more robust, reliable and accurate model.

The team consisted of Tony Butler (newly hired electronics technician), Widjaja Sugiri (summer hire EE graduate student) and Gene Kouba (former TUFFP student/staff member now with Chevron Exploration and Production Services).

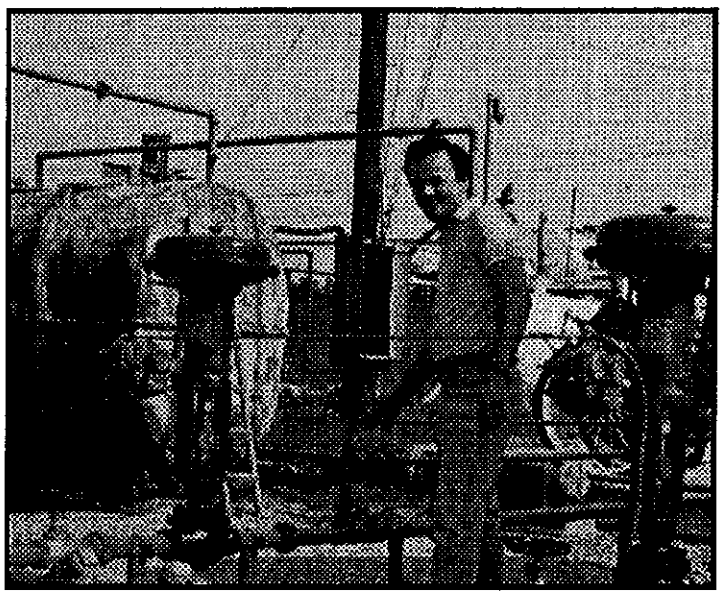
One of the first tasks was to interview the research staff to establish measurement objectives and requirements. Priorities were set to aid in determining essential sensor features. A literature review revealed a few additional design considerations in both electrode geometry and sensor electonics.

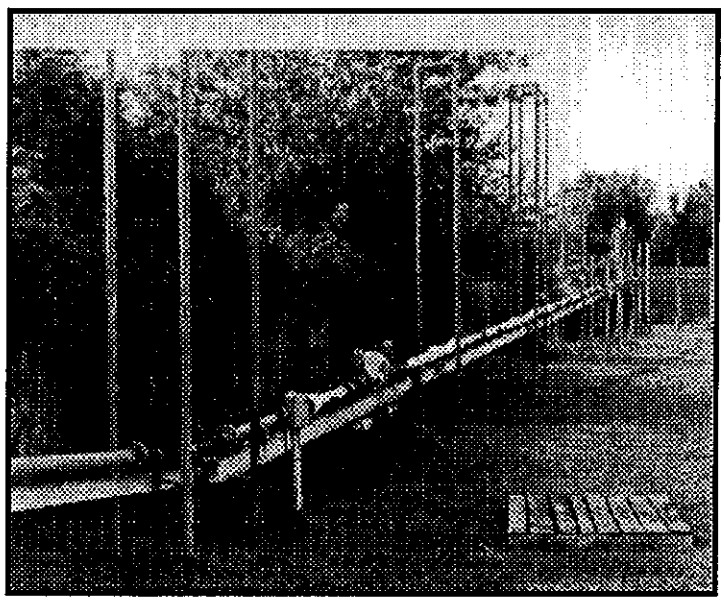
Existing sensors, including present portable

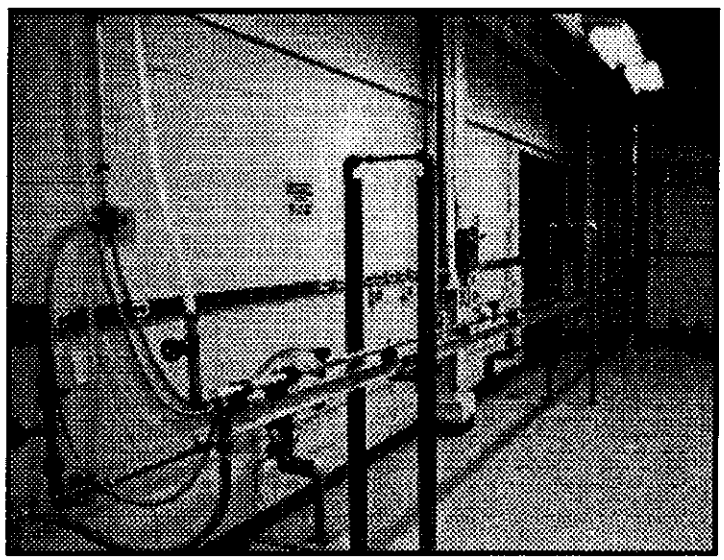
models and past prototype models, were evaluated for performance, convenience and reliablity. Lists of actual faults, potential problems and successful features were compiled. It was found that the basic design of the prototype sensors, including ring geometry and circuit design, were sound, but that several modifications implemented in the production models introduced numerous problems. Attempting to produce a highly portable sensor resulted in inability to adequately seal the sensing rings from the environment on virtually all portable models. This in turn resulted in unpredictable sensor drift requiring frequent recalibration. Poor circuit layout and electrical connections also contributed to the poor reliability of the portable sensors.

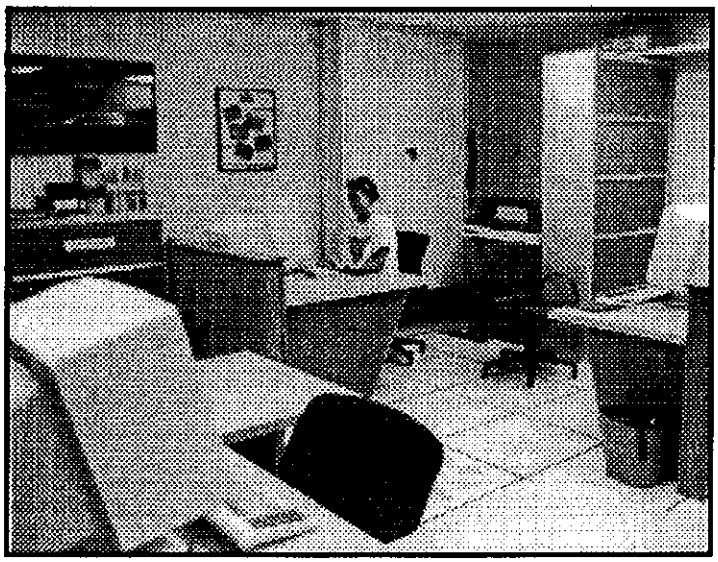
From the above information, the criteria for capacitance sensors operation was established and several designs of more refined (yet in many ways simpler) capacitance sensors emerged. Based on operational considerations and time constraints, the ring electrode configuration and electrical circuit previously used by Kouba were selected as best choices for the new sensors. These sensors are axi-symetrical and small enough to follow fast changes in holdup. A bandpass filter was added to the circuit to further reduce sensitivity to noise.

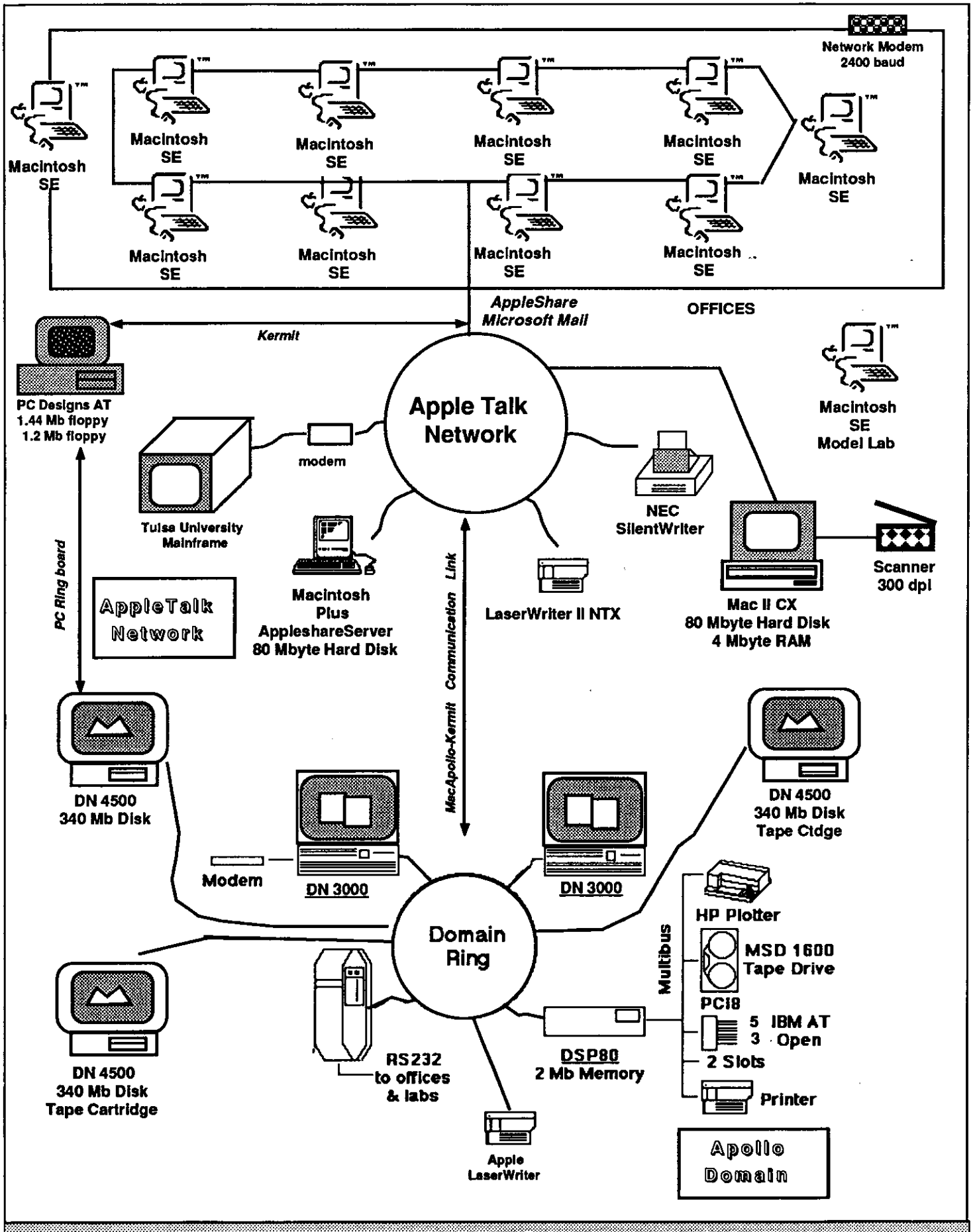
Quick Snaps











TUFFP Computing Network

1989 TUFFP Members

Amoco Production Co.
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Arabian Oil Co., Ltd.
ARCO Oil and Gas Co.
British Petroleum International Ltd.
British Gas Corp.
Chevron Oil Field Research Co.
China National Oil & Gas E. & D. Corp.
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Phillips Petroleum Co.
Shell Internationale Petroleum MIJ B.V.
Statoil
Simulation Sciences, Inc.
Texaco
Texas Gas Transmission Corp.
Unocal

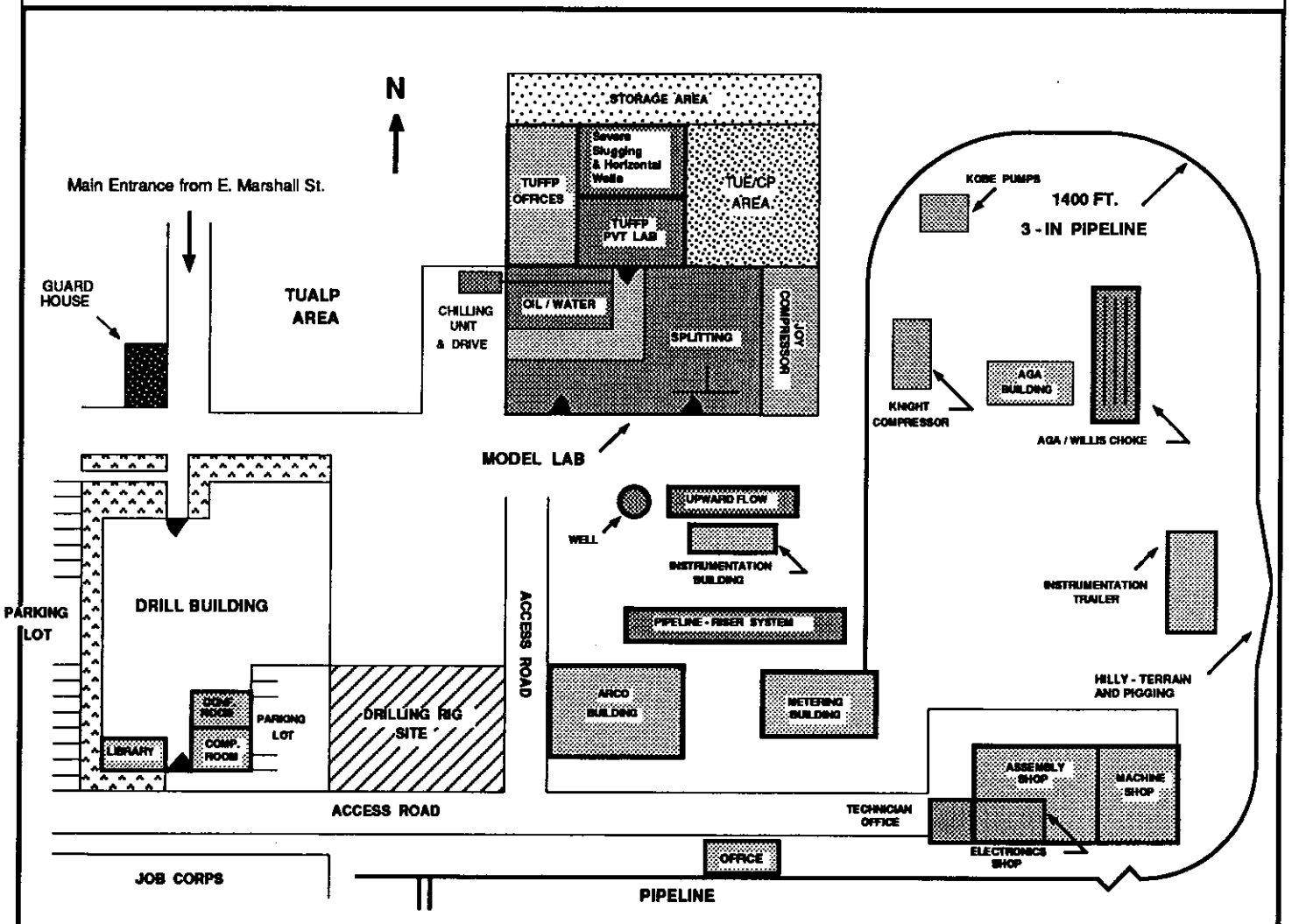

Illustration of TUFFP Test Facilities