Flomeko 2000 - IMEKO TC9 Conference
Salvador, Bahia, BRAZIL
4-8 June, 2000

ATALAIA MULTIPHASE FLOW TEST FACILITY: DESCRIPTION, RECENT WORKS AND FUTURE TESTS

Ibere Nascentes Alves, Paulo José Pinto Ribeiro, Valdir Estevam, Alcemir Costa de Souza

Petrobrás- Petróleo Brasileiro S.A.
Rio de Janeiro e Aracaju, Brazil

Abstract: This work presents the facilities of the "Sitio de Teste de Atalaia" (Atalaia test site) from Petrobras, located in Aracaju, Brazil. It was installed in 1994 to investigate the performance and endurance of different equipments related to artificial lift systems or multiphase flow installations, such as gas lift valves, meters, boosters and pumps. A large scale flow loop, 220-meters long and 6-inches of internal diameter, was designed to conduct two and three-phase flow tests. The multiphase flow loop is capable of flowing natural gas, crude oil and water simultaneously, at pressures up to 45 bar. Maximum flow rates are 400 STD m^3/h of gas, 120 m^3/h of oil and 76 m^3/h of water. With these flow rates and pressure ranges, all multiphase flow patterns encountered in operating pipelines can be obtained. A control & data acquisition system is used to acquire data from any equipment under test and from several resident measurement devices. It also provides the necessary control for the flow loop. Experience shows that a very good control of all the flow variables is achieved with this system. The following equipment were tested in the last four years at Atalaia: multiphase flowmeters from Fluenta, Framo and Mixmeter; two-phase flowmeter from ITT Barton; Bornemann's multiphase pumping system; and VASPS separation system (using both Agip and Petrobras-Unicamp designs). The following activities are scheduled for the year 2000: drilling and completion of a testing well 300-meters deep; testing of a WEMD-Leistritz subsea multiphase pumping system; testing of multiphase flowmeters from Framo, DUET and MFI; and phase II of the gas lift valves performance tests.
Keywords: Test Site, Multiphase Flow, Artificial Lift, and Meters

Atalaia Test Site Facility

The Atalaia **Test Site Facility** allows equipment to be tested under simulated oil field conditions using real fluids in a loop test monitored and controlled. The facility provides excellent test conditions for evaluating new technologies prior to deploying them in the field and for trouble shooting problems encountered in field operations with industry accepted equipment. The fluids presently used in flow loop consist of crudes, natural gas and fresh or salty water. These can be changed to meet to requirements of any particular test.
The broad test capabilities of the facility are:
1- ***Multiphase Test System***
2- ***Test Well Facility***
3- ***Gas Lift Valves Test System***
The basic multiphase flow test components of the Atalaia facility are: (1) a plant including one three - phase separator, liquid/gas separators, gas scrubbers, liquid phase pumps and metering, (2) a test stations for pumps, (3) a horizontal piping run which are approximately 220 meter long, (4) loop control and data acquisition systems.
The Atalaia Test Site is being supported by **IPT** (Instituto de Pesquisas Tecnológicas**)** to obtain the measurement certificates from **INMETRO** (Instituto Nacional de Metrologia**).**

1. Multiphase Test System

The Atalaia Multiphase Test Facility (see Figure 01) has a 6-inch pipe multiphase flow loop in which the oil and water flows in a closed loop. A three-phase separator, oil and water storage tanks, multiphase and single-phase pumps, valves mass and volumetric flow meters in the oil, water and gas lines, and a slug detector are also included in this loop.

The Site has two parts: a fixed one and an adaptable one. The fixed part is composed by the oil and water storage tanks, the three- phase separator, mass and volumetric flow meters oil and water contamination meters.

The adaptable part is where equipment to be tested is installed. The structure of this part can be adapted to meet the requirements of the equipment to be tested.

In the fixed part, several parameters are measured such as these include flow rates, densities, pressures and temperatures. The oil, water and gas flow rates are fundamental reference parameters of Atalaia test conditions an accurate and repeatable measurement of these parameters is essential for effective testing.

The efficiency of the separators generally does not reach 100%, resulting in traces of oil in the water line and of water in the oil line. This separation unefficiency introduces systematic errors in the oil and water flow rate measurements unless the contaminants in each line are accurately metered.

The measurement of the water contamination in the oil line with a **WIOM (**Water-in-Oil-Meter**)** and of the oil contamination in the water line with an **OIWM** (Oil-in-Water-Meter) are used to compensate errors. Furthermore, the **WIOM** and **OIWM** provide important data to other tasks in oil production facilities and reservoir evaluations.

The loop is recognised as being a world class facility for evaluating multiphase production and production equipment such as multiphase pumps, multiphase meters and gas-liquid separators (See Figure 02).

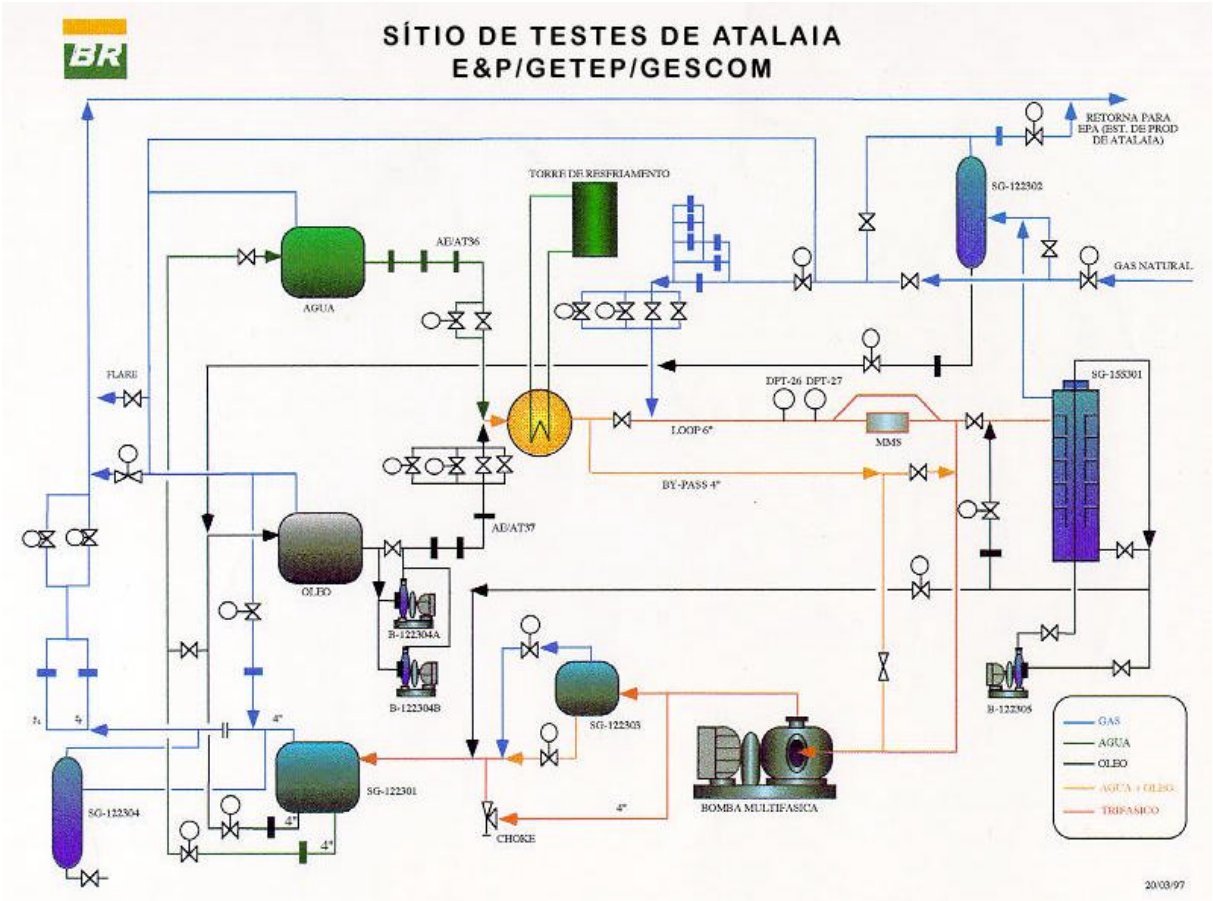

Figure 01- Flow Diagram: Atalaia Multiphase Flow Test Facility

Technical Specifications:

Oil Flow Rate		0 to 2500 m3/d
Water Flow Rate		0 to 1500 m3/d
Gas Flow Rate		0 to 45000 Nm3/d
Maximum Pressure		45 bar
Temperature Range		6 °C to 33 °C (Ambient)
Loop	(horizontal)	220 m
	(vertical well)	300 m

Applications:

- Multiphase Pump Performance
- Electric Submersible Pumps Performance
- Progressive Cavity Pumps Performance
- Multiphase Water-Cut Meter Performance
- Gas-Liquid Separator Evaluation & Development
- Production Equipment Comparisons
- Flow Meter Comparisons
- Multiphase Technology Instrumentation Development
- Hydraulic and Mechanical Centrifuge Separation
- Permanent Bottom Hole Gauge Development

Figure 02: Main view of Atalaia Multiphase Flow Test Facility

2. Test Well Facility (in execution)

The **Test Well Facility** provides the means to evaluate downhole equipment such as electric submersible pumps (ESP), downhole gas separator, down hole instrumentation and to study multiphase flow technologies. The well is 300 -m deep with a 20 -in., 133 lb/ft X-56 Bk-06 casing string cemented at the bottom. A 9-5/8 in., 43.5 lb/ft N-80 BT casing string is hung from the 20 in. casing. The other equipments are: spoon 21 1/4" x 2000 psi, 13 5/8" x 5000 psi, head 21 1/4" x 2000 psi, adapter A4 13 5/8" x 5000 psi - 11" x 5000 psi, wellhead production TFF-FC-OO 11" x 7 1/16" x 5000 psi. A 5 1/2 in. 17 lb/ft N-80 tubing string is onsite. Different sizes of tubing can be run if desired. A mandrel-style electric fedd-thry conducts power through the tree.

Liquid and gas are injected into the 9-5/8 in. casing separately, the liquid flowing down a tubing 3 1/2 in. tubing, while the gas goes through a 2 3/8 in. pipe. The maximum liquid flowrate is 1,100 m3/d and the maximum gas flow rate is 45,000 Nm3/d. All equipment up to casing injection point is rated to 3,000 psi. and 200 º C.

The multiphase mixture flows a 1-1/2 in. 5,000 psi choke into a two-phase separator. The choke can be converted to 2 inches. The liquid phase is then measured with a vortex meter and the gas phase is measured through dual gas orifice meters.

At the wellhead, the casing pressure, the tubing pressure and temperature, and the choke discharge pressure and temperature are measured. Pump intake pressure and the downhole fluid gradient can then be measured via differential pressure meters mounted at the wellhead. (See Figure 03)

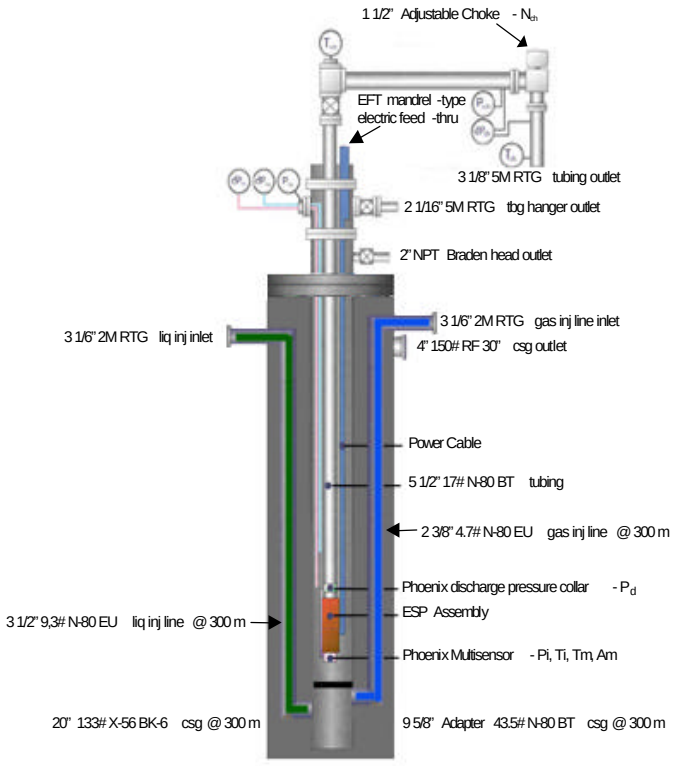

Figure 03. Well Test Facility

3. Gas Lift Valves Test System

The Gas Lift Valves Test Unit (see Figure 04) was designed and built to obtain the gas lift valves performance curves and to observe their durability. Gas is provided by the Atalaia Compressors Plant from the high pressure pipeline (160 bar) .The basic components of the Gas Lift Valves Test include: (1) four pressure vessels, (2) four endurance test blocks, (3) one performance test block, (4) control and data acquisition systems.

Technical Specifications

Pressure vessels	2,5 m^3 each
Temperature	33 °C (ambient)
Maximum Pressure	160 bar

Applications

- Endurance Test
- Performance Curves
- High Pressure Choke Test
- High Pressure Calibration Performance Test
- New Valves Development

Figure 04 - Gas Lift Valve Test Unit

4. Mains Tests Realized

- Multiphase Pump Performance and EnduranceTest - **Bornemann** October/1994 to August/1996
- Oil in Water Monitor Performance Test - **Fluenta** - October to November/1996
- Multiphase Meter Performance Test - **Fluenta SMFM-1000** - January to March/1997
- Subsea Separator System Performance Test - **Agip VASPS -** March to June/1997
- Water in Oil Monitor Performance Test - **Fluenta** - July to August/1997
- Subsea Separator System Performance Test - **BR-Unicamp VASPS -** August to September/1997
- Multiphase Meter Performance Test - **Fluenta MPFM-1900** - December/1997 to January/1998
- Two-Phase Meter Performance Test - **ITT Barton** - March to April1998
- Multiphase Meter Performance Test - **BR - E&P-AM** - July to September/1998
- Multiphase Meter Performance Test - **Fluenta MPFM-1900 phase 2** - February to April/1999
- Multiphase Meter Performance Test - **Framo Schulumberger** - June to July/1999
- Gas Lift Valves Performance Test - **BR- E&P phase 1 -** June to September/1999
- Multiphase Meter Performance Test - **Kvaerner Duet** - February to March/2000
- Gas Lift Valves Performance Test - **BR- E&P phase 2 -** " in course"

5. Test Program in 2000

- Gas Lift Valves Endurance Test - **BR- E&P -** May to December
- Multiphase Pump Performance & Endurance Test - **Westinghouse SBMS-500 -** June to September
- Multiphase Meter Performance Test - **Flowsys** - November to December
- Multiphase Meter Performance Test - **Framo** - June to July
- Gas Hundle Performance Test -- **BR- E&P -** November to December

6. Conclusions

The Atalaia Test site was designed to be representative of an actual Operational Production Unit. It is a mixing of field scale - 6" pipe, high pressure, real fluids - and laboratory accuracy. It was conceived to allow a high operational flexibility and it uses advanced instrumentation and latest generation computers to menage both data acquisition and the control of every flow parameter.

AUTHOR (S): Eng. Dr Ibere Nascentes Alves, Eng Paulo José Pinto Ribeiro, Eng. Ms Alcemir Costa de Souza, Eng. Ms Valdir Estevam Petrobras- Petróleo Brasileiro S.A Av. Rep. Chile 65 Centro 20031-970, Rio de Janeiro, RJ, Brazil, phone xx55-21-5343720. E-mail:Ibere@ep.petrobras.com.br, pjpr@ep.petrobras.com.br, alcemir@ep-seal.petrobras.com.br, vestevam@ep.petrobras.com.br.